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PACE Technical Report Series, Volume 16

Editors:
Ivona Cetinić, GESTAR II/Morgan State University, Baltimore, Maryland
Charles R. McClain, retired from NASA Goddard Space Flight Center, Greenbelt, Maryland
P. Jeremy Werdell, NASA Goddard Space Flight Center, Greenbelt, Maryland

The PACE Postlaunch Airborne eXperiment (PACE-PAX): post campaign report

Kirk Knobelspiesse, NASA Goddard Space Flight Center, Greenbelt, Maryland
Brian Cairns, NASA Goddard Institute for Space Studies, New York, New York
Ivona Cetinić, GESTAR II/Morgan State University, Baltimore, Maryland
Samuel LeBlanc, Bay Area Environmental Research Institute, Moffett Field, California
PACE-PAX team

December 2025

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National Aeronautics and
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Greenbelt, MD 20771-0001

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Samuel LeBlanc, NASA Ames Research Center / BAER Institute
with contributions from the PACE-PAX team (see Appendix C**: Team members**)

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1. Introduction

The PACE Postlaunch Airborne eXperiment (PACE-PAX) was a field campaign conducted in September, 2024 in California. The primary goal of PACE-PAX was to collect validation data in support of the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission (Werdell et al, 2019, 2024). While PACE validation was the scope of the original field campaign design, additional flight hours were provided to support validation of the ESA Earth, Cloud, Aerosol and Radiation Explorer (EarthCARE) mission (Wehr et al, 2023). Additionally, other field campaign activities chose to coordinate operations with PACE-PAX to further their independent objectives.

Figure 1 PACE-PAX photo montage. Clockwise from top left: Mike Ondrusek (NOAA), mission scientist of the R/V Shearwater, waves to the Navy Postgraduate School (NPS) Twin Otter as it samples at low altitude. Photo of the Bridge fire from NASA ER-2 pilot Kirt Stalling. Carl Goodwin (JPL) performs calibration reference measurements at Ivanpah Playa, California. Scott Freeman (GSFC) and Harrison Smith (GSFC) deploy instrumentation from the R/V Shearwater in the Santa Barbara Channel. Instrument integration on the NASA ER-2 in preparation for PACE-PAX. San Francisco observed by the NPS Twin Otter as it samples at low altitude over the San Francisco Bay. The R/V Shearwater seen from the NPS Twin Otter

PACE-PAX utilized two aircraft, a research vessel, and other ocean and ground assets to make coordinated observations, often during satellite overpasses by PACE and EarthCARE. During the month of September, 2024, the NASA ER-2 flew 13 research flights, totaling 80.9 flight hours, from the NASA Armstrong Research Center (AFRC) in Lancaster, California. The Navy Postgraduate School CIRPAS Twin Otter flew 17 research flights totaling 60 flight hours from Marina, California. The NOAA research vessel R/V Shearwater made 15 day trips from Santa Barbara, California.

In addition to the abovementioned funded efforts, others participated in the campaign with external support. The R/V Blissfully made 9 day trips from Long Beach, California. A team from the Jet Propulsion Laboratory made coordinated surface measurements from the Ivanpah playa in Southern California. Many overflights were made of Aerosol Robotic Network (AERONET) ground sites, as well as National Ecological Observatory Network (NEON) field sites and the Navy Postgraduate School's Coastal Environmental Observation Station (CEOBS) near Watsonville, California. Extensive overflights were made of the Railroad Valley land surface characterization site. The HyperNAV vicarious calibration system was temporarily deployed to coastal Southern California, and University of Delaware in water gliders were operated near the R/V Shearwater. Finally, elements of the PACE Validation Science Team (PVST) either operated on the R/V Shearwater (such as Navy Research Laboratory instrumentation) or independently, such as rapid response deployments from Santa Barbara (UCSB) or on the R/V Rachel Carson in Monterey Bay SIO.

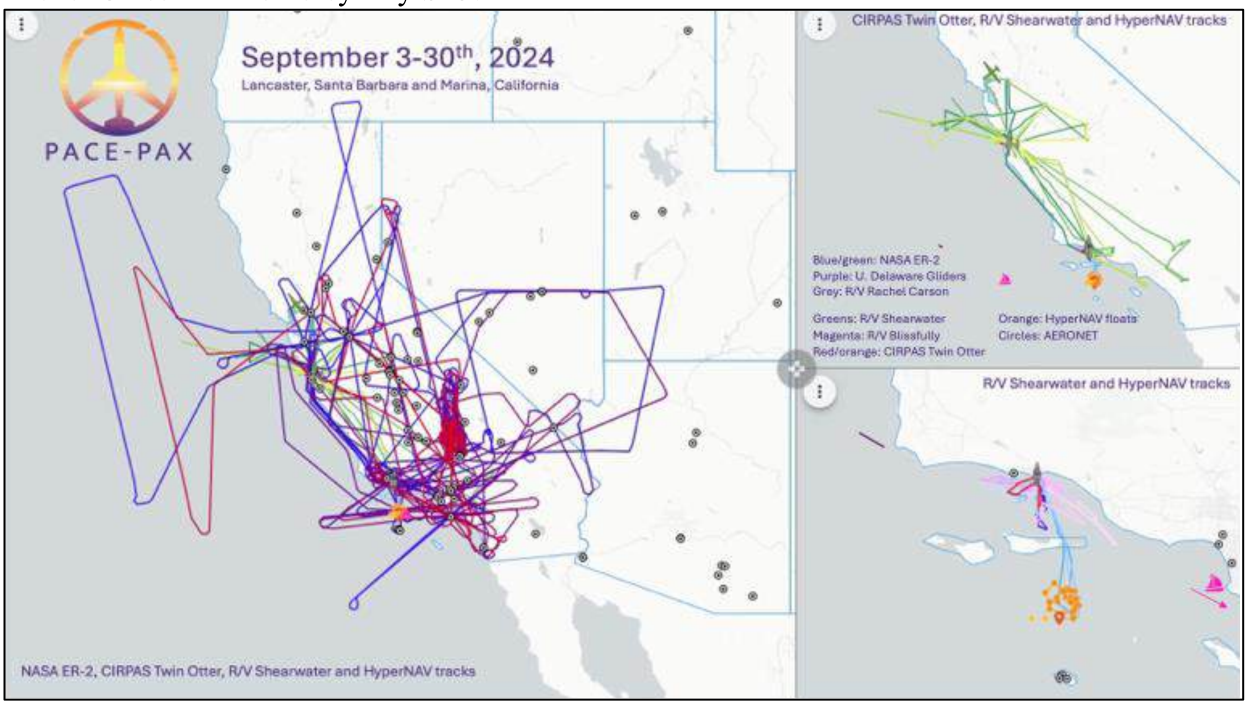


Figure 2 PACE-PAX flight tracks. The panel at left is the tracks of the NASA ER-2 (red-blue), NPS Twin Otter (green-yellow) and R/V Shearwater (pink-purple-blue). Black circles indicate AERONET and/or NEON sites. The panel at top right indicates NPS Twin Otter and R/V Shearwater tracks (only), while the panel at bottom right indicates surface based assets only. R/V Shearwater tracks as before are in pink-purple-blue, HyperNAV locations are in orange, and the R/V Blissfully was deployed outside the plot to the south-east.

The campaign achieved 16 days of coordinated observations between airborne and surface assets and the PACE satellite, and 6 days of coordination with EarthCARE (see Figure 1 and Figure 2). Overall conditions were somewhat typical for California in September, with extensive offshore marine stratocumulus cloud cover and relatively cloud free conditions with variable aerosol loads over land. Several extreme wildfires in the Los Angeles region were observed, as well as red tide events in Monterey Bay.

PACE-PAX was led by Kirk Knobelspiesse (NASA Goddard Space Flight Center, GSFC), Ivona Cetinić (NASA GSFC), and Brian Cairns (NASA Godard Institute for Space Studies, GISS) with participation from academia (University of Maryland, Baltimore County, UMBC), other government agencies (Navy Postgraduate School, NPS, National Oceanographic and Atmospheric Administration, NOAA), foreign space agencies (Space Research Office Netherlands, SRON) and other NASA involvement by GSFC, the Langley Research Center (LaRC), Armstrong Flight Research Center (AFRC), Ames Research Center (ARC), and the Jet Propulsion Laboratory (JPL).

1.1 Purpose of this document

This document captures all relevant material pertaining to the campaign, or points to other relevant documentation. It includes details on the PACE and EarthCARE missions, the validation strategies for both missions, and the design of the PACE-PAX campaign to support those activities (Sections 1 and 2). Section 3 describes the mission implementation, including extensive details on all measurement platforms and instruments. Section 4 contains an assessment of field campaign performance, including summaries of specific activities and measurement conditions. This document has four appendices. Appendix A contains the risk tables that were used to guide the mission prior to deployment. Appendix B contains the Validation Traceability Matrix (VTM, see section 2.1) cue card summaries. Appendix C has the flight reports from each day of operations, while Appendix D lists all those who contributed to the campaign.

Other documents also contain relevant information for the PACE-PAX field campaign. They are:

1. **The PACE Postlaunch Airborne Experiment (PACE-PAX) pre-campaign white paper (PCWP)**. Establishes the need and implementation details for PACE-PAX. Some details differed from actual campaign implementation. https://ntrs.nasa.gov/citations/20230008223 *Note: some material from this document is reused in the current document.*
2. **Field campaign design and implementation with traceability matrix decision support (DSA)** Describes the Validation Traceability Matrix field campaign design and implementation approach. Knobelspiesse et al, 2025, submitted to JTECH
3. **PACE-PAX page on PACE website** Contains further data links, flight reports, and an operations summary table https://pace.oceansciences.org/pace-pax.htm
4. **PACE Level 1C data format (L1C)** data format specification for multi-angle level 1 data produced by PACE and PACE-PAX. https://ntrs.nasa.gov/citations/20240003353
5. **PACE Science Data Product Validation Plan (PVP)**, establishes the validation approach for PACE to meet PACE requirements established in the Program Level Requirements Agreement (PLRA) and the Mission Requirements Document (MRD). https://pace.oceansciences.org/docs/PACE_Validation_Plan_14July2020.pdf
6. **PACE Science Data Product Selection Plan (SDPSP)**, describes the flow of and process for the selection and implementation of science data products for the PACE mission. Its scope encompasses threshold/standard mission products and baseline/advanced mission products https://ntrs.nasa.gov/citations/20205007069
7. **Pre-Aerosol, Clouds, and ocean Ecosystem (PACE) Mission Science Definition Team (SDT) Report,** describes the initial scope of the science objectives for the PACE. Del Castillo, C. (Chair), 2018. https://ntrs.nasa.gov/citations/20190000977
8. **NASA Risk Management Handbook** https://ntrs.nasa.gov/citations/20120000033
9. **EarthCARE Scientific Validation Implementation Plan (VIP)**, Robert Koopman, European Space Agency (ESA), EC-PL-ESA-SYS-1049, 2024 https://earth.esa.int/eogateway/documents/d/earth-online/earthcare-scientific-validation-implementation-plan.

1.2 PACE Mission overview

The original definition of the PACE mission is included in Responding to the Challenge of Climate and Environmental Change: NASA's Plan for Climate-Centric Architecture for Earth Observations and Applications from Space, as a bridge mission to aerosol (particulate matter in the atmosphere), cloud, and ocean ecosystem observing mission(s) described in the National Research Council's 2007 Decadal Survey of Earth Science for NASA, NOAA and USGS, entitled Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond. As such, PACE produces heritage products that provide continuity with existing climate and Earth system records and also create new advanced products for emerging science questions related to the Earth's changing climate.

The PACE observatory includes three instruments. The Ocean Color Instrument (OCI) is a hyper-spectral scanning radiometric imager that measures from the ultraviolet (UV) to shortwave infrared (SWIR) with a view-angle tilt to avoid ocean surface reflected sun glint. OCI is the primary instrument on PACE, and it was developed at the NASA Goddard Space Flight Center (GSFC). OCI produces heritage ocean, aerosol and cloud products, and advanced products that take advantage of hyper-spectral and UV sensitivity. PACE also includes two contributed multi-angle polarimeters (MAP), instruments that maximize observed information with the use of multiple geometry measurements and determination of the polarization state of light. Developed at the University of Maryland, Baltimore County (UMBC), the Hyper-Angular Rainbow Polarimeter (HARP2) instrument is a wide swath imager intended for determination of cloud and aerosol optical parameters through the utilization of hyper-angle measurement capability. The Spectro-Polarimeter for Exploration (SPEXone) is a highly accurate (although narrow swath) hyperspectral MAP intended for the identification of detailed aerosol (and other) parameters. It was developed by a consortium in the Netherlands that includes Airbus and the Netherlands Institute for Space Research (SRON). Table 1 contains details on the measurement characteristics of each instrument.

*Table 1 Recreated from Table 2 of Werdell et al., 2019. * The mission carries a goal of extending the shortest wavelength to 320nm. + There is a 2-day coverage when limited to solar and sensor viewing angles of 75˚ and 60˚, respectively.*

	OCI	HARP2	SPEXone
UV-NIR range (bandwidth)	Continuous from 340 to 890nm* in 5-nm steps (5)	440, 550, 670 (10), and 870 (40) nm	Continuous from 385 to 770 nm in 2-4nm steps
SWIR channels (bandwidth)	940 (45), 1,038 (75), 1,250 (30), 1,378 (15), 1,615 (75), 2,130 (50) and 2,260 (75) nm	None	None
Polarized bands	None	All	Continuous from 385 to 770 nm in 15-45nm steps
Number of along track viewing angles	One, with fore-aft instrument tilt of ±20˚ to avoid sun glint	10 for 440, 550 and 870 nm and 60 for 670 nm (spaced over 114˚)	5 (-57˚, -20˚, 0˚, 20˚, 57˚)
Swath width	±56.6˚ (2,663 km at 20˚ tilt)	±47˚ (1,556km at nadir, varies with view angle)	±4˚ (100 km at nadir)
Global coverage	1-2+ days	2 days	~30 days
Ground pixel	1.1 km at nadir	Binned to 5.2x5.2 km	Binned to 5.2x5.2 km
Institution	GSFC	UMBC	SRON/Airbus

On February 8, 2024, PACE was launched into an ascending polar orbit at a nominal spacecraft altitude of 676.5 kilometers, with a local crossing time of 13:00 and inclination angle of 98°. Observations cover the globe regularly, and the length of time required to observe the entire globe depends on the instrument swath. As shown with other instrument characteristics in Table 1, the wider swath OCI and HARP2 instruments require 1-2 days for global coverage, while the narrow swath SPEXone instrument will require roughly 30 days. For that instrument, overflights of fixed ground validation sites will be much less frequent.

PACE is classified as a Category 2 mission, per the criteria in NASA Procedural Requirement (NPR) 7120.5E, NASA Space Flight Program and Project Management Requirements. The mission classification is C according to NPR 8705.4B, Risk Classification for NASA Payloads.

1.3 PACE validation plan

The PACE Program Level Requirements Agreement (PLRA) and Mission Requirements Document (MRD) provide the requirements pertaining to the PACE Science Data Product Validation Program:

> *"Post-launch field validation work is required to evaluate the PACE science data products in Tables 1 and 2 within 12 months of commissioning. The PACE validation programs (provided by HQ PACE Science) shall include the following for the mission duration:*
>
> *a) Shipboard and aircraft campaigns as required to collect the data products defined in Tables 1 and 2.*
> *b) Autonomous instrument systems that collect continuous records of any of the individual data products defined in Tables 1 and 2."*

Tables 1 and 2 referenced in this quote are replicated as Tables 2 and 3, respectively, in this document. These are the required data products to be produced by the PACE Project Science (PS) and Science Data Segments (SDS). Project Science is responsible for data product quality and must therefore validate by comparing to independent observations. In addition, NASA Headquarters (HQ) PACE Program Science competes both the PACE Science and Applications Team (SAT) and the PACE Validation Science Team (PVST) which contribute algorithms, data, insight, and other guidance to the PS and SDS to ensure date quality.

The required products in Tables 2 and 3 must be validated within 12 months of PACE spacecraft commissioning. These required products are only for the OCI sensor, and, with some exceptions, can be considered 'Heritage,' that is, produced by previously launched missions. The MAP instruments (HARP2 and SPEXone) are contributed to the PACE mission with requirements limited to "do no harm" to the rest of the spacecraft, so there are no required products from those instruments. However, expected PACE products represent new measurements and science that all three PACE sensors (OCI, HARP2, and SPEXone) may address. The science and algorithms supporting many of these products are in development by the SAT, PS, and instrument teams. An important aspect of this development is the validation of these new products. Some, but not all, can be validated using the resources called for in the PVP. The remainder require additional efforts and resources, as described in this document. An evolving list of products are captured on the PACE website (https://pace.oceansciences.org/data_table.htm). The process by which algorithms are selected, tested, and implemented in the PACE SDS is described in the PACE Science Data Product Selection Plan (SDPSL).

Table 2 Required OCI ocean color data products. The requirements for ocean color products stated in this table are defined for 50% or more of the observable deep ocean (depth>1000 m).

Data Product	Baseline Uncertainty
Water-leaving reflectances centered on (±2.5 nm) 350, 360, and 385 nm (15 nm bandwidth)	0.0057 or 20%
Water-leaving reflectances centered on (±2.5 nm) 412, 425, 443, 460, 475, 490, 510, 532, 555, and 583 (15 nm bandwidth)	0.0020 or 5%
Water-leaving reflectances centered on (±2.5 nm) 617, 640, 655, 665 678, and 710 (15 nm bandwidth, except for 10 nm bandwidth for 665 and 678 nm)	0.0007 or 10%
Ocean Color Data Products to be Derived from Water-leaving Reflectances	
Concentration of chlorophyll-a	
Diffuse attenuation coefficients 400-600 nm	
Phytoplankton absorption 400-600 nm	
Non-algal particle plus dissolved organic matter absorption 400-600 nm	
Particulate backscattering coefficient 400-600 nm	
Fluorescence line height	

Table 3 Required OCI aerosol and cloud data products. The requirements in this table are defined for 65% or more of the observable atmosphere. Each requirement is defined as the maximum of the absolute and relative values when both are provided. This table represents threshold aerosol and cloud data products, all of which can be produced by OCI alone

Data Product	Range	Baseline Uncertainty
Total aerosol optical depth at 380 nm	0.0 to 5	0.06 or 40%
Total aerosol optical depth at 440, 500, 550 and 675 nm over land	0.0 to 5	0.06 or 20%
Total aerosol optical depth at 440, 500, 550 and 675 nm over oceans	0.0 to 5	0.04 or 15%
Fraction of visible aerosol optical depth from fine mode aerosols over oceans at 550 nm	0.0 to 1	±25%
Cloud layer detection for optical depth > 0.3	NA	40%
Cloud top pressure of opaque (optical depth > 3) clouds	100 to 1000 hPa	60 hPa
Optical thickness of liquid clouds	5 to 100	25%
Optical thickness of ice clouds	5 to 100	35%
Effective radius of liquid clouds	5 to 50 µm	25%
Effective radius of ice clouds	5 to 50 µm	35%
Atmospheric data products to be derived from the above		
Water path of liquid clouds		
Water path of ice clouds		

1.4 EarthCARE mission overview

The Earth Cloud, Aerosol and Radiation Explorer (EarthCARE) mission is a cooperative effort of the European Space Agency (ESA), Japan Aerospace Exploration Agency (JAXA) and the National Institute of Information and Communications Technology (NICT) that was launched on May 28th, 2024. EarthCARE is in sun-synchronous polar orbit, with a daytime descending equator crossing time of roughly 14:00 local. The EarthCARE spacecraft payload contains four instruments: the ATMospheric LIDar (ATLID), Cloud Profiling Radar (CPR), Multi-Spectral Imager (MSI), and Broad-Band Radiometer (BBR) (Wehr et al, 2023, Eisinger et al, 2024, Mason et al, 2024).

Table 4 Summary of EarthCARE instrument capabilities.

	ATLID	CPR	MSI	BBR
Measurement type	High Spectral Resolution Lidar (HSRL)	Doppler radar	Multi-spectral passive imager	Broadband radiometer
Wavelength or Frequency	355nm	94 GHz	0.67, 0.865, 1.65, 2.21, 8.8, 10.8, 12.0µm	Solar (0.25 - 4µm) and emitted thermal broadband (4 - >50µm)
Products	Ice water content and effective radius; aerosol profiles; extinction, backscatter, depolarization; target classification; aerosol layer descriptor; cloud top height	Feature mask and corrected reflectivity; Doppler measurements; target classification; cloud profiles	Cloud optical properties; cloud mask; aerosol optical thickness	Reflected solar and emitted thermal radiation
Swath and resolution	Lidar curtain, 3˚ off-nadir, 280m footprint horizontally, 100-500m vertically	Radar curtain, ~800m horizontal footprint at ground, oversampled 500m vertical resolution	150km swath, tilted cross track to minimize sunglint, 500m resolution	Three views, scene size configurable, requirement for 10km x 10km
Institution	ESA	JAXA/NICT	ESA	ESA

EarthCARE has an extensive calibration and validation plan, included dedicated funding from both ESA and JAXA to support validation efforts. The ESA EarthCARE Validation Team (ECVT) tracks validation efforts on: https://earth.esa.int/eogateway/missions/earthcare/data/calibration-validation and has summarized efforts and plans thus far in Koopman, 2024.

24 additional ER-2 aircraft flight hours were added to PACE-PAX roughly six months before field deployment to contribute to EarthCARE validation efforts. EarthCARE specific validation objectives were added to the overall list of objectives, and regular communication and coordination with the ECVT was established to ensure success.

2 Mission design

There are several reasons for augmenting ground and ocean-based validation measurements with a dedicated airborne field campaign. These include, but are not limited to:

1. **PACE is producing new and untested products.** They need to be validated to assess quality and guide algorithm development. Dedicated field campaigns can make specific observations to this end. Furthermore, many of these products are from multi-parameter algorithms, and retrieval capability for one geophysical property may depend on another, e.g., the accuracy of ocean chlorophyll-a pigment concentration products depends on the quantity and characteristics of atmospheric aerosols that are a part of atmospheric correction. Field campaigns that gather concurrent observations of multiple geophysical parameters enable a useful assessment of new products, particularly if they are made with airborne analogs of PACE instruments.
2. **Field campaigns that include airborne assets can provide for a different scale of observation** (spatial and temporal) than other validation sources, and a link between point measurements at the surface and the PACE orbital observatory.
3. **Airborne field campaigns can reposition assets within the spacecraft swath.** Due to its narrow swath, PACE's SPEXone instrument will have relatively few coincident observations with ground validation sites within the 3-year mission lifetime. Airborne assets can be directed to fly within the SPEXone swath during an overpass, adding many validation observations to an otherwise limited dataset.
4. **Airborne assets can validate PACE radiometric and polarimetric observations** prior to their use for retrieval of geophysical parameters.
5. **Remote sensing success depends on observation geometry, season, and time of day**, which can be directly targeted with field campaigns.
6. **Field campaigns can focus on specific systems, processes, or phenomena** to verify they are properly accounted for in the satellite retrieval scheme.

In the early stages of planning for PACE-PAX, Leadership, Project Science Office and Science and Applications teams had extensive discussions on how to design the campaign. Four top level objectives were identified:

- **Objective 1: Validate new retrieval parameters.** This is the primary focus of PACE-PAX, addressing the output from algorithms described in the PACE data products table (https://pace.oceansciences.org/data_table.htm) that are not a part of the required products in Table 2Table 3. We limit our scope to radiometric and polarimetric products, with a focus on observations that can be made from aircraft and those that are complementary to aircraft observations. New products start with test, then provisional maturity. Validation is necessary to ensure further maturity (see https://science.nasa.gov/earth-science/earth-science-data/data-maturity-levels). An important component of this is the use of airborne proxies of the instruments on PACE. With these proxies, algorithms can be tested in controlled (or at least known) environments, without the need for concurrent PACE measurements. Furthermore, many algorithms retrieve multiple parameters simultaneously, while others require the output of other algorithms as an input (e.g. Fu et al., 2025). Validation of these algorithms thus requires simultaneous observation of multiple parameters to meet this objective.

- **Objective 2: Validate within the instrument swath of all PACE and EarthCARE instruments.** While the OCI and HARP2 instruments have a wide swath with 1-to-2-day global coverage, SPEXone has a much narrower (~100km at nadir) swath, resulting in an approximately 30-day global coverage. This means that comparisons of SPEXone to fixed ground locations (such as

AERONET) will be infrequent. The solution is to position validation assets within the swath of an expected SPEXone observation. This is even more of the case for EarthCARE, for which three instruments have narrow, single 'pixel' wide swaths.

- **Objective 3: Validate radiometric and polarimetric parameters** prior to their use for retrieval of geophysical parameters with instrument proxies. This activity supports PACE in-flight calibration activities. This type of characterization is routinely used to directly validate satellite observations uncertainty models or be used to characterize airborne proxy remote sensing instruments which are subsequently compared to satellite observations. In PACE-PAX, we overflew bright land surface calibration sites (Railroad Valley, Nevada and Ivanpah Playa, California), as well as the oceangoing PACE vicarious calibration system (HyperNAV, Barnard et al, 2024a, 2024b).

- **Objective 4: Focus on specific processes or phenomena** to verify they are properly accounted for in the satellite retrieval scheme. A variety of atmospheric, ocean, and land surface parameters are retrieved from PACE observations, and data processing must have the capability to identify when the appropriate algorithms are to be used. Furthermore, those algorithms must be robust for the range of possible conditions that are to be observed. Dedicated field campaigns can seek to observe specific geophysical conditions and ensure retrieval success.

Note that the pre-campaign PACE-PAX technical memo identified six objectives. For the sake of simplicity, two of those objectives were incorporated into the four that were ultimately used to plan PACE-PAX. One had to do with assessment of spatial and temporal scale impact on validation, while the other the impact of time of day and observation geometry.

2.1 The Validation Traceability Matrix

Based on the four main objectives described in the previous section, a Validation Traceability Matrix (VTM) was created to guide the design and implementation of PACE-PAX. The VTM is based on the concept of a Science Traceability Matrix (STM, Weiss et al., 2005). This approach traces top level validation objectives to what is required to successfully meet them. The VTM is expressed as a table containing description of the objective to requirement flow. We also numerically parameterized aspects of the table in terms of importance (w, larger is greater), required observation time (h, in terms of flight hours), completeness (c, between 0 and 1 where 1 is a fully complete observation) and probability of success (p, between 0 and 1 where 1 is absolute probability of success).

Table 5 PACE-PAX Validation Traceability Matrix summary. From Knobelspiesse et al, 2025. For the full VTM, see https://pace.oceansciences.org/pace-pax.htm

ID	Measurement objective	*w*	*h*	*c*	*p*
1a	New products: land surface properties	8	2.0	1.0	0.50
1b	New products: ocean radiometric properties	10	8.0	1.0	0.50
1c	New products: aerosol properties over the ocean	12	8.0	1.0	0.50
1d	New products: aerosol properties over land	12	8.0	1.0	0.75
1e	New products: cloud properties	12	8.0	1.0	0.50
1f	New products: ocean surface properties	1	8.0	0.5	0.25
2a	Simultaneous PACE observations: aerosol properties over the ocean	10	8.0	1.0	0.50

2b	Simultaneous PACE observations: aerosol properties over land	10	8.0	1.0	0.50
2c	Simultaneous PACE observations: cloud properties	5	2.0	1.0	0.50
2d	Simultaneous EarthCARE observations: aerosol properties	8	4.0	1.0	0.25
2e	Simultaneous EarthCARE observations: cloud properties	8	4.0	1.0	0.25
3a	Radiometric and polarimetric properties: large reflectances	6	2.0	1.0	0.50
3b	Radiometric and polarimetric properties: large reflectance high polarization	6	2.0	1.0	0.75
3c	Radiometric and polarimetric properties: large reflectance low polarization	6	2.0	1.0	0.75
3d	Radiometric and polarimetric properties: vicarious calibration sites	6	4.0	1.0	0.25
4a	Specific phenomena: High aerosol loading over land	4	2.0	1.0	0.50
4b	Specific phenomena: High aerosol loading over ocean	4	2.0	1.0	0.50
4c	Specific phenomena: Multiple aerosol layers	1	2.0	1.0	0.50
4d	Specific phenomena: Aerosols under thin cirrus clouds	2	2.0	1.0	0.50
4e	Specific phenomena: Aerosols above liquid cloud	4	2.0	1.0	0.25
4f	Specific phenomena: Broken clouds with complex structure	4	2.0	1.0	0.75
4g	Specific phenomena: Dust aerosols over ocean	4	2.0	1.0	0.25
4h	Specific phenomena: Aerosol, ocean properties, turbid water	2	2.0	1.0	0.50
4i	Specific phenomena: Aerosol, ocean properties, biologically productive water	4	2.0	1.0	0.25
4j	Specific phenomena: Smoke aerosols over ocean	1	2.0	1.0	0.25

Based upon our VTM and this parameterization scheme, we devised metrics that support the optimal design of the mission prior to departing for the field (the pre-campaign decision support algorithm, PC-DSA), and to help plan activities while in the field (the underway decision support algorithm, U-DSA). These are described in more detail in Knobelspiesse et al, 2025 and summarized in the following sections.

2.2 The Pre-Campaign Decision Support Algorithm

The Pre-Campaign Decision Support Algorithm (PC-DSA) has two elements to quantify the overall potential success of a field campaign design (Figure 3). The Maximum Potential Success, S_{max}, is a simple scalar metric describing the value of a mission design. It is based on how completely a design satisfies each objective in the VTM, weighted by the importance assigned to each VTM objective. A more detailed value metric is the Potential Success, $S(t)$, which describes success as a function of assigned flight hours (t). In addition to importance and weighting, this metric incorporates the amount of flight hours needed to satisfy an objective, and the probability of encountering favorable conditions at any time during the campaign.

The PACE-PAX mission design was based upon that of the Aerosol Characterization from Polarimeter and Lidar campaign (ACEPOL, Knobelspiesse et al., 2020). ACEPOL deployed the ER-2 aircraft from Palmdale, California during the fall of 2017. ACEPOL gathered data to develop multi-angle polarimeter algorithms. To design PACE-PAX, we added instruments that increased the S_{max} and $S(t)$ scores while minimizing increase to budget and complications to schedule and operations. We found that the optimal solution was to add a proxy for OCI to the ER-2 in the PRISM and PICARD instruments (see Sections 3.7.3 and 3.7.4), and a low altitude aircraft for in situ sampling of aerosols and clouds. Additional elements that were supported outside the budget, such as a research vessel making ocean optics measurements and extensive overflights of ground networks such as AERONET, were found to significantly increase mission success as well.

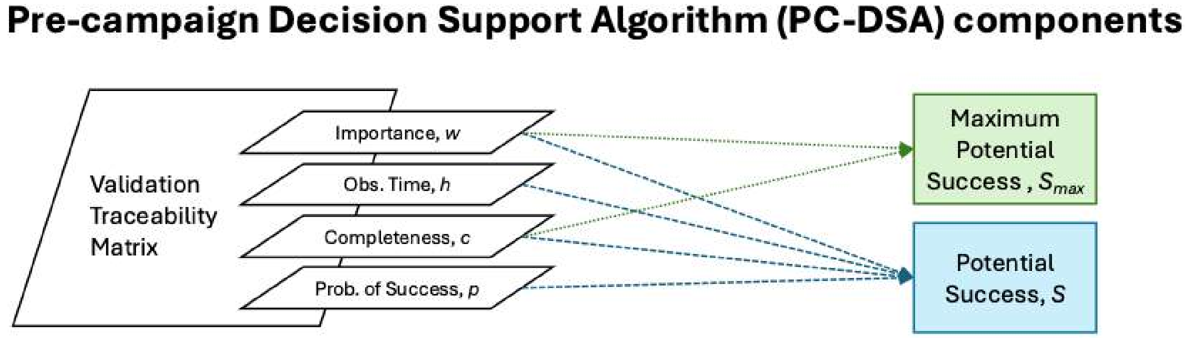


Figure 3 The PACE-PAX Pre-campaign decision support algorithm components, and their relationship to scoring metrics in the VTM. From Knobelspiesse et al, 2025.

The PC-DSA was also used to support trade studies. For example, we considered a partial or full redeployment from California to Hawaii. The potential benefit would have been increased opportunity to sample over deep ocean waters and in the vicinity of PACE vicarious calibration buoys. However, doing so would also decrease the scoring of other aspects of the VTM, such as the ability to sample urban aerosols or extensive terrestrial sites. This, and the large potential cost of the relocation, was the reason the decision was made to hold PACE-PAX in California, with each measurement platform operating out of its home base.

2.3 The Underway Decision Support Algorithm

The Underway Decision Support Algorithm (U-DSA) is comprised of metrics that combine the numerical parameters in the VTM with information about field campaign available flight hours, flight days, probability of favorable conditions (based, for example, on weather forecasts), and a record of success thus far in a campaign.

Figure 4 shows the general concepts of the U-DSA. Like the PC-DSA, the U-DSA makes use of the four parameters included in the VTM. It also makes use of knowledge of parameters specific to a given point in a campaign, such flight hours used this far, flight hours planned for the next flight, probability of observation success in the next planned flight, and flight hours and days remaining. Four metrics are derived from this. The Achievement function, A, is an overall metric expressing the fraction of S_{max} achieved so far. The Remaining Objective function, R, is defined for each measurement objective in the VTM. It indicates the amount of observations that still need to be made for that objective, weighted by the objective's importance. The Expectation function, E_x, and Climatological Expectation function, E_c, are used for flight planning decisions. The amount of expected achievement in a planned flight (E_x) is compared to the opportunity cost of flying that day (E_c). If E_x is greater than E_c, then the planned flight should be made. The progression of U-DSA parameters during PACE-PAX is shown in Figure 5. As will be discussed in Section 4, PACE-PAX achieve most of its objectives, with objectives 2a and 2e finishing with the largest Remaining Objective.

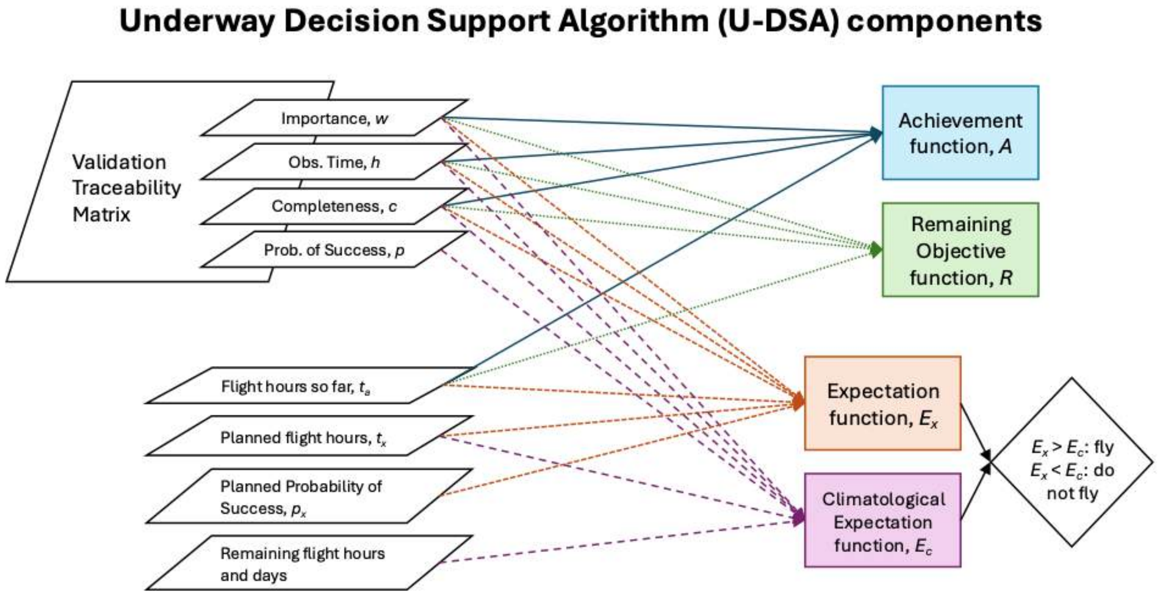


Figure 4 The Underway Decision Support Algorithm (U-DSA) and its connection to VTM parameters and other metrics defining conditions at a given point in a field campaign. From Knobelspiesse et al. 2025.

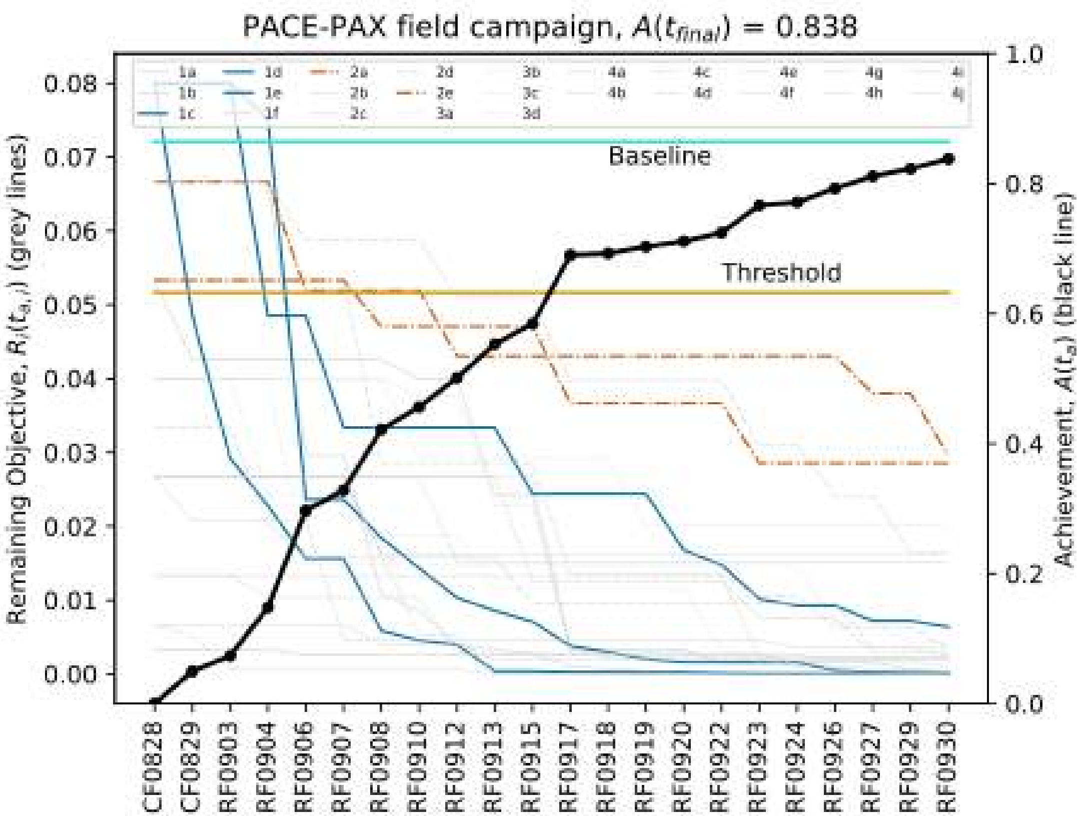


Figure 5 Underway Decision Support Algorithm (U-DSA) for PACE-PAX. The overall Achievement function (A, black) shows progressive accomplishment throughout each flight in the campaign (indicated by the flight ID's at the bottom). The Remaining Objective functions, R, are in blue, orange or grey, and they show which objectives should be the highest priority for subsequent flights.

3 Implementation

3.1 Concept of operations

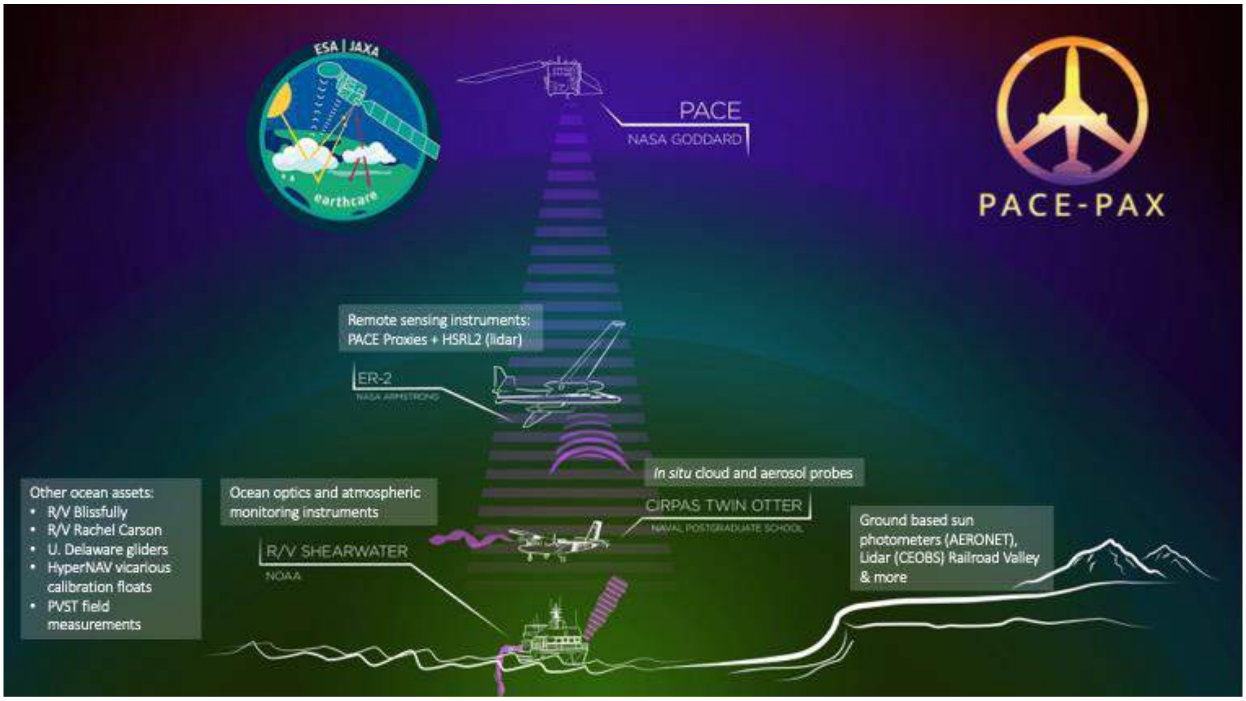


Figure 6 PACE-PAX concept of operations, annotated from NASA GSFC produced video still "PACE Scientists Take to the Sea and Air (and Really High Air)" https://youtu.be/cCsuck3dJU4?feature=shared

The PACE-PAX mission design relied on the VTM, the PC-DSA, and insight from prior campaigns by the planning team. The Aerosol Characterization from Polarimeter and Lidar (ACEPOL, Knobelspiesse et al, 2020) was the starting point. ACEPOL deployed the ER-2 with a compliment of multi-angle polarimeters and lidar, using the ER-2's home field in California. This PC-DSA assessment of this configuration satisfied roughly half of the PACE-PAX VTM. Modifications and additions to the ACEPOL configuration were tested with the PC-DSA, resulting in a design that made the following modifications:

- One polarimeter and one lidar were removed from the ER-2, and replaced with PRISM and PICARD instruments (see Sections 3.7.3 and 3.7.4), which together acted as a proxy for PACE/OCI. For more details on the ER-2, see Section 3.7. We continued to operate the ER-2 from its home airfield at Armstrong Flight Research Center (AFRC) in Lancaster, California.
- A low-altitude *in situ* sampling aircraft was added. Ultimately, we used the Navy Postgraduate School's (NPS) CIRPAS Twin Otter and added more instrumentation to that aircraft's facility instrument package (see Section 3.6). The Twin Otter was flown from its home airfield in Marina, California, near the Monterey Bay. The range of the Twin Otter is considerably smaller than that of the ER-2, so flights were designed such that the ER-2 would flight to the Twin Otter area of operations.
- The National Oceanographic and Atmospheric Administration (NOAA) made the coastal research vessel R/V Shearwater available for use. This ship made day trips from its home in Santa Barbara, California. A variety of in and above water optical instrumentation were deployed on the R/V

Shearwater, by teams from NOAA, NASA, the Naval Research Laboratory, and Universities. The R/V Shearwater operated in the Santa Barbara Channel, which the ER-2 could reach easily and the Twin Otter could reach if it stopped to refuel on the return to Northern California.

These components, along with expectations of sampling near established ground sites such as AERONET and Railroad Valley, brought the PC-DSA score to nearly 100% of the goal. The overall concept of operations is shown in Figure 6.

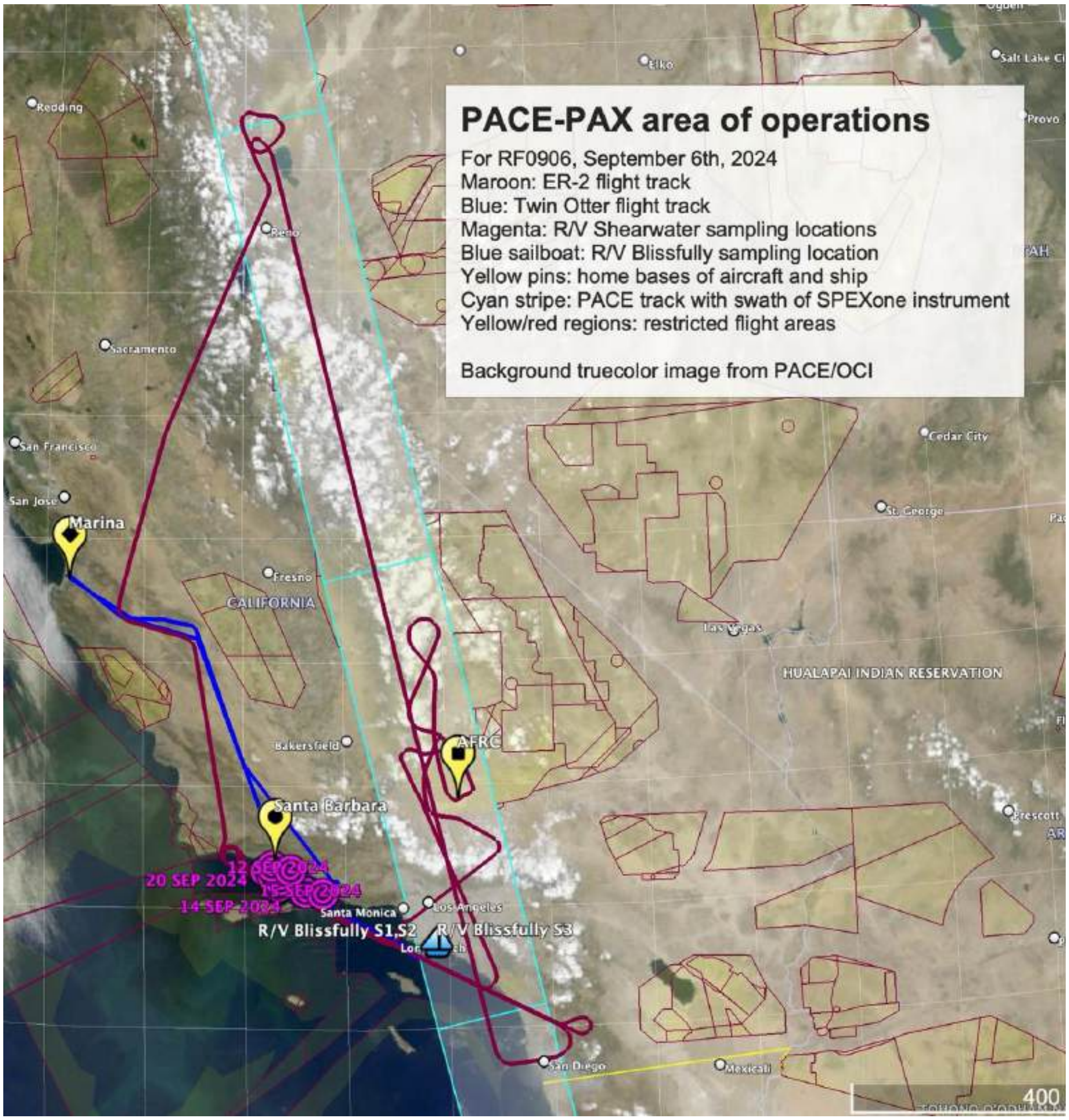


Figure 7 Example PACE-PAX area of operations, with flight tracks from September 6th, 2024. On this day, the ER-2 (maroon track) flew along the PACE orbit track within the swath of the PACE/SPEXone instrument and performed coordinated operations with the Twin Otter (blue track), R/V Shearwater (magenta circles) and R/V Blissfully (blue sailboat). Background imagery is from PACE/OCI, and yellow/red regions indicate restricted flight areas. On this day, the Twin Otter made two sorties, stopping for fuel on the return portion to Marina from the Santa Barbara Channel. On other days, flight operations extended further West over the Pacific Ocean, and further East over Arizona and Nevada.

3.2 Management structure

The PACE-PAX field campaign was funded by the PACE mission and thus responded to objectives and budgets allocated by the mission. The management structure is outlined in Figure 8. Leadership was chosen from within the PACE Project Science office (Knobelspiesse, Cetinić) or from the leadership of the mission itself (Cairns). The Earth Science Project Office (ESPO, Nicholas, Alfter and others) was assigned to support PACE-PAX. Other team elements were selected by PACE-PAX leadership and funded from the PACE mission. Several externally supported groups also participated in the mission, notably NOAA provided the R/V Shearwater and scientific personnel and equipment, while the NASA GSFC Global Modeling and Assimilation Office (GMAO) and NASA Mission Tools Suite (MTS) provided weather forecasts and aircraft management software, respectively. Some elements of the PACE Validation Science Team included collaboration with PACE-PAX as part of their validation activities, while others participated with funds from other sources. For a full list of mission participants and their institutions, see Appendix D.

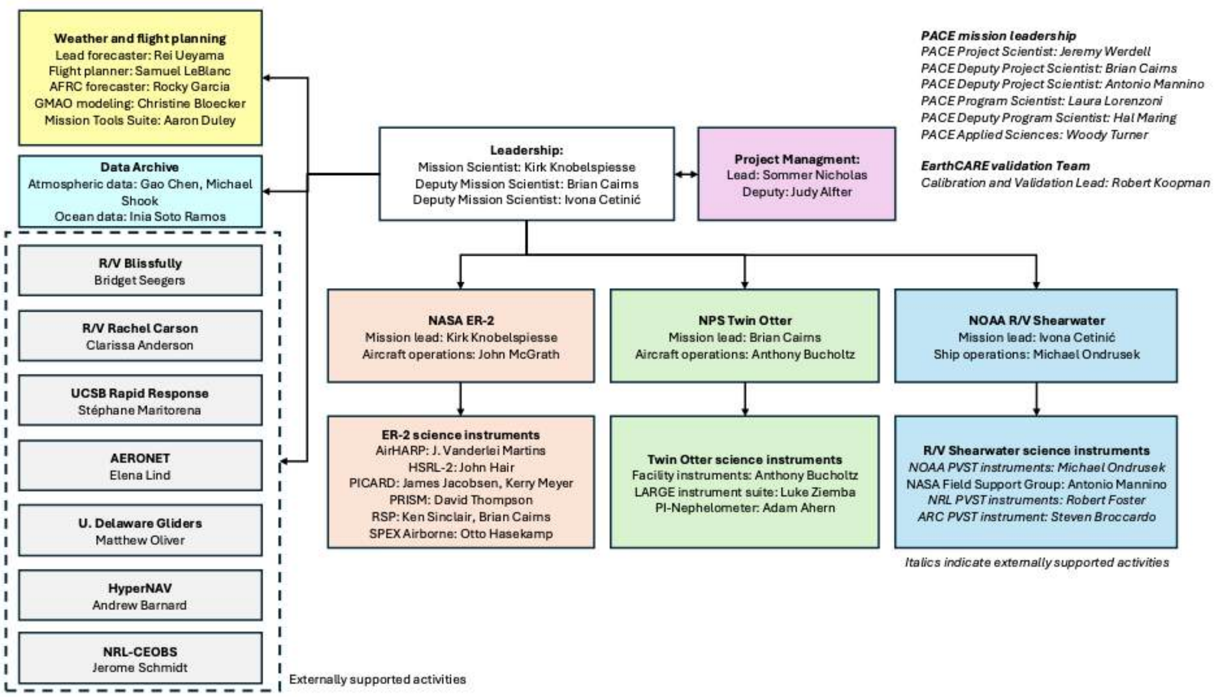


Figure 8 The PACE-PAX organizational chart. See Appendix D for full affiliation and contact information.

3.3 Timeline

The initial concept of PACE-PAX evolved out of discussions held during meetings of the first PACE Science and Applications Team (2014-2016), where the lack of complete data for the development and testing of multi-angle polarimeter aerosol retrieval algorithms was noted. The PACE PLRA (see Section 1.3) called for field campaigns, including airborne field campaigns, to support validation activities. In 2019, the Mission Scientist was selected, and preparations for the field campaign that became PACE-PAX began.

Table 6 PACE-PAX field campaign timeline, with field operations highlighted in yellow.

2014-2016	**PACE Science and Applications Team, initial concept discussions**
2015	**PACE PLRA issued, calling for an airborne field campaign to support PACE validation**
July 2020	Initial PACE field campaign concept presented to PACE Program Scientists
April 2021	Draft first white paper presented to PACE Project Science office, PACE-PAX name selected
May 2021	Initial Science Operations Flight Request System (SOFRS) for use of the ER-2 submitted
July 2021	**PACE-PAX VTM designed, guides initial studies on implementation**
July 2021	Concept studies and organizational plan presented to PACE Program Scientists
August 2021	Decision to include an in-situ sampling aircraft as part of PACE-PAX
September 2021	PACE-PAX white paper draft completed and presented to PACE Program Scientists
October 2021	PACE-PAX concept and white paper presented to PACE Science and Applications Team
February 2022	PACE-PAX concept refined with input from PACE Science and Applications Team
2022	PACE-PAX team formed, statements of work and budget established
January 2023	**PACE-PAX team finalized, kickoff meeting**
Sept. 11-15 2023	**First virtual field campaign dry run**
Feb. 8 2024	**PACE launch**
February 2024	**EarthCARE validation added to PACE-PAX objectives**
March 4-8 2024	**First PACE-PAX science team meeting and second field campaign dry run**
May 2024	NASA AFRC site visit, Santa Barbara and Marina site visits follow
Summer 2024	Pre campaign logistical preparation
August 5-27 2024	ER-2 instrument upload
Aug. 26-28 2024	Twin Otter instrument upload
Aug. 28-29 2024	ER-2 aircraft check flights
August 29 2024	Twin Otter check flight
Sept. 3 2024	**First Twin Otter science flight**
Sept. 4 2024	**First ER-2 science flight, first PACE underflight**
Sept. 3-5 2024	R/V Shearwater mobilization
Sept. 6 2024	**First R/V Shearwater cruise, R/V Blissfully cruise, Glider deployment**
Sept. 8 2024	**First EarthCARE underflight**
Sept. 10 2024	HyperNAV first observation
Sept. 19 2024	Last R/V Blissfully cruise
Sept. 23 2024	HyperNAV last observation
Sept. 26 2024	**Last R/V Shearwater cruise**
Sept. 27 2024	**Last Twin Otter science flight**
Sept. 27 2024	R/V Shearwater demobilization
Sept. 30, 2024	**Last ER-2 flight, last Glider deployment**
October 1-3, 2024	ER-2 instrument offload
Dec. 31 2024	Preliminary data due to archive
Feb. 18-21 2025	**Second PACE-PAX science team meeting**
March 31 2025	**Final data due to archive. Data become publicly available at SSD-AC**
Summer 2025	**Data migrate to final archive at ASDC**

As noted in Table 6, instrument installation and other immediate preparations for fieldwork began in August, 2024. The first data collection for science day was September 3rd. The last day of operations was September 30th, and instrument de-installation and other activities were completed by the beginning of October. Preliminary data were due to the archive on December 31st, 2024, and final data by March 31st, 2025. Migration to the permanent archive (at the NASA Atmospheric Science Data Center, ASDC) was completed in the summer/fall of 2025.

3.4 Risk management

Risks to the success of PACE-PAX were assessed, tracked and mitigated as described in the NASA Risk Management Handbook (see Section 1.1). Individual risks were identified, their likelihood and consequence assessed, and should they be realized, response or mitigations prepared. Each risk was assigned a point of contact (POC) to monitor the evolution of the assigned risk during the project. We also made use of nested risk management for individual PACE-PAX elements. For example, each individual instrument team came up with their own risk assessment. The top-level risk risks assessed the consequence of that element considering the importance to the overall mission, while the likelihood used the largest likelihood associated with a total instrument loss.

Table 7 Risk management likelihood and consequence scoring criteria

Likelihood scoring criteria		
Score	Likelihood	Probabilistic likelihood
1	Not likely	<20%
2	Low likelihood	20% - 40%
3	Likely	40% - 60%
4	Highly Likely	60% - 80%
5	Near Certainty	> 80%
Consequence scoring criteria		
Score	Consequence	
1	Minimal consequence to objectives/goals	
2	Minor consequence to objectives/goals	
3	Unable to achieve a particular objective/goal, but remaining objective goals represent better than minimum success or outcome	
4	Unable to achieve multiple objectives/goals but minimum success can still be achieved or claimed	
5	Unable to achieve objectives/goals such that minimum success cannot be achieved or claimed	

Overall, 25 individual risks were identified for PACE-PAX (see Table 56 in the Appendix). Four of those risks were retired prior to the campaign as they had to do with a successful launch and operations of the PACE spacecraft, or the completion of Inter-agency agreements between NASA and other US Federal Government agencies. We should note that the risk for Inter-agency agreements was always high, an in one case (between NASA and NPS) the agreement was only secured on the last possible day before impact to operations.

Otherwise, two risks were realized, so their mitigation plans were put into place. One of those risks (Q in Figure 9) had to do with the schedule of the ARCSIX field campaign in Greenland, which used some of the same equipment and personnel as PACE-PAX. This was mitigated with tight logistical support, as ESPO was managing both campaigns. The other realized risk (J in Figure 9) had to do with the relocation of the ER-2 from Building 703, a leased hangar at

Palmdale Municipal Airport, to the AFRC main facility at Edwards Air Force Base. Mitigation of this risk was complex and involved many actions from both a logistical and operational perspective (see Section 4.6.1.3 for more details on how this was managed).

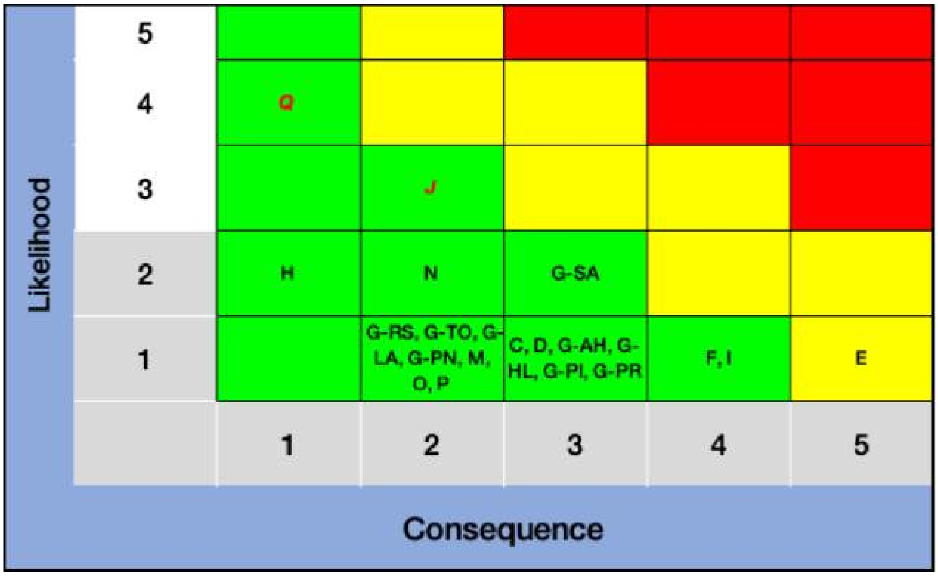


Figure 9 PACE-PAX risk table graphic. Realized risks are indicated in red italics. See Table 56 for a description of individual risks.

3.5 Platforms and instruments

3.5.1 The NOAA R/V Shearwater

NOAA provided the R/V Shearwater (Figure 10) for 15-day use during the PACE-PAX experiment (targeting the period from September 6th to 28th, 2024). The R/V Shearwater is a Channel Island Marine Sanctuary vessel, that operates out of Santa Barbara, California. This 62-foot high-speed catamaran can support a range of oceanographic research activities in Santa Barbara Channel and wider area of Channel Island Sanctuary (60 nautical miles range). This research vessel has upper (fly bridge) deck space, aft deck space, dry and wet lab space (with seawater sink), science winch, CTD winch, A-frame and crane that were used during the campaign. For this experiment, the R/V Shearwater was additionally equipped with a diaphragm pump that provided underway clean seawater for the suite of optical instruments deployed in the wet lab.

While it has the capability to support overnight trips, during PACE-PAX R/V Shearwater operations were limited to day trips, focusing on the area of Santa Barbara Channel with a single trip to the HyperNAV area of operation. More information on the R/V Shearwater, and her capabilities can be found here: https://channelislands.noaa.gov/research/vessels.html.

Figure 10 R/V Shearwater photographed in the Channel Island Sanctuary (Photo from NOAA.gov).

3.5.2 NOAA supported instrumentation

3.5.2.1 Instrument background

NOAA provided the NOAA Ship R/V Shearwater for use during the PACE-PAX experiment. The R/V Shearwater is a 62 foot high-speed catamaran which operates out of Santa Barbara, CA. The ship was chartered for 15 days to be used during the period from September 6 to 28, 2024. Forty stations were occupied during this period conducting PACE satellite, flyover and other in-water instrument validation measurements. In addition to NOAA scientist, investigators from National Aeronautic Space Agency (NASA) and Lamont Doherty Earth Observatory (LDEO), measured inherent optical properties, phytoplankton composition and pigments and a range of other in situ constituents. Investigators from the City College of New York (CCNY) and the Naval Research Laboratory (NRL) conducted polarization measurements.

NOAA operated two Satlantic/Seabird HyperPro II profiling systems to measure Rrs that were used to directly validate ocean color satellite data concentrating on PACE and VIIRS sensors. The HyperpPro profilers had downward looking HyperOCR radiometers that measures Lu(λ) and upward looking HyperOCI irradiance sensors to measure Ed(λ) in the water column. In addition, the systems had upward looking irradiance sensors mounted on a telescoping pole on deck. While the ship was drifting, the profilers were deployed simultaneously into the water by hand using conducting cables. The instruments were allowed to drift approximately 20 m from the ship to avoid ship shadowing then were allowed to free fall to 10 meters, and then is pulled back up to the surface. This up and down profiling was repeated 10 to 15 times, then the instruments were retrieved.

Figure 12 Science Party of the R/V Shearwater. From left to right: Scott Freeman, Jeremy Werdell, Joaquin Chavez, Eric Stengel, Kelsey McBeain, Ethan Taylor, Ahmed El-Habashi, Harrison Smith, Eder Herrera, and Michael Ondrusek. (photo by Grace Weikert)

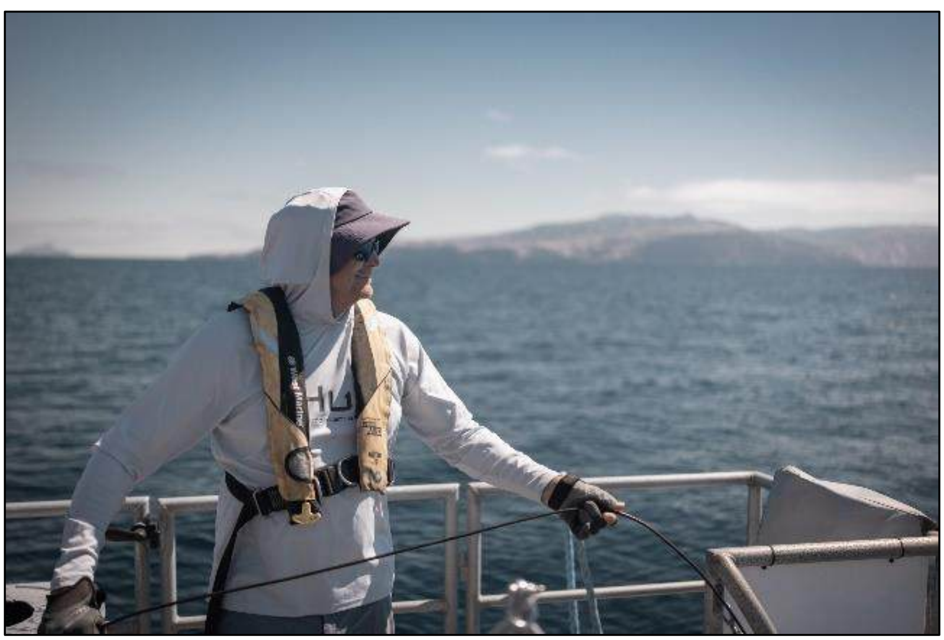


Figure 11 Eric Stengel from NOAA/NESDIS conducts Remote Sensing Reflectance measurements using hand deployed Seabird HyperPro II profiling radiometers. (photo by Grace Weikert)

3.5.2.2 Data
All HyperPro data were submitted to SeaBass at the level 2 processing of upwelled radiances with depth for NASA processing to Rrs using Virtual SeaBass (VSB). This data is archived at: https://seabass.gsfc.nasa.gov/archive/NOAA_NESDIS/ondrusek/PACE-PAX/PACE-PAX_SHEARWATER/archive
These data are also processed by NOAA using the Seabird processing system, Prosoft V8.16. The NOAA processed data is archived in the NOAA In-Situ Ocean Color Optical (ISOCO) Database.

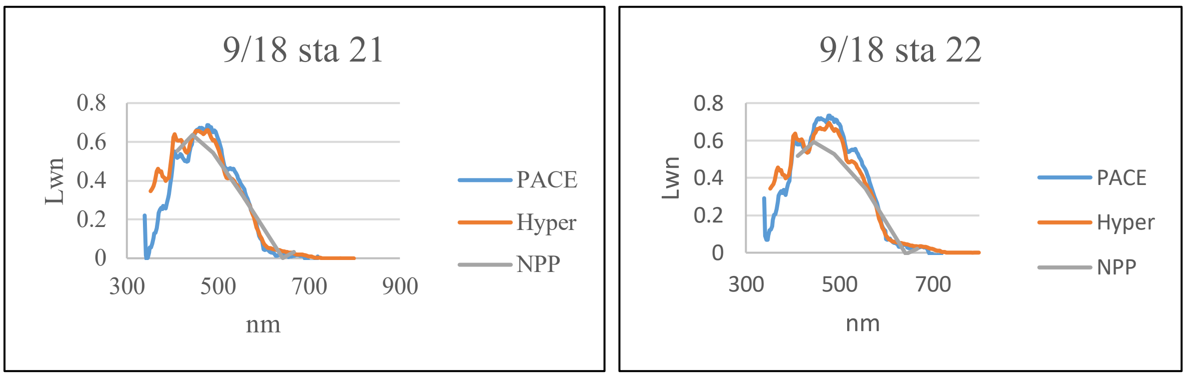


Figure 13 Examples of Satellite matchups with HyperPro measurements from PACE-PAX collected on 9/18/2024. Hyper is HyperPro and NPP is VIIRS data.

3.5.2.3 Analysis
PACE Rrs data is directly compared to PACE and VIIRS satellite data measured at the time and location of the in-situ measurement to assess satellite performance. This is done for PACE and VIIRS satellites. Next steps are to compare the NOAA's Prosoft HyperPro processing to NASA's VSB.

3.5.3 NASA Field Support group

Our primary aim for participating on the R/V Shearwater PACE-PAX field campaign in September 2024 was to collect a suite of state-of-the-art measurements for the validation of NASA PACE satellite mission data products. With advanced remote sensing capabilities, PACE's daily global Earth observations enable advanced understanding of ocean ecosystems and vulnerable coastal regions. Our field measurements include ocean radiometry, absorption, attenuation, scattering, phytoplankton pigments, organic carbon, and phytoplankton community composition, biomass and physiology. Our team collected hyperspectral UV-VIS water-leaving reflectance and seawater absorption, attenuation, and backscatter coefficients.

Ensuring the quality of ocean color satellite data products and developing and validating the associated algorithms requires a substantial volume of high quality *in situ* data. Our field program support team (FSG), funded by NASA and located within the NASA Goddard Space Flight Center (GSFC) Ocean Ecology Laboratory (OEL), performs various functions including the collection of *in situ* measurements, co-development of international community measurement protocols, *in situ* data quality evaluation, and field measurement intercomparisons to quantify uncertainties. Since field measurements are employed to develop the satellite algorithms and to validate NASA's multi-mission satellite data products, the errors in the field data contribute to the overall uncertainty of the satellite data products.

In collection and analysis of field data, our team adheres to rigorous and community-vetted measurement protocols (IOCCG protocols) to ensure the lowest possible measurement uncertainties. Our data are publicly available and follow NASA's open data policy. The FSG team has followed an open data policy for 20 years and counting.

3.5.3.1 Measured parameters

3.5.3.1.1 Phytoplankton pigments, biomass, taxonomy, and physiology; biogeochemical

Near-surface clean seawater sample collections on station at 3 or more times per day for various analyses (Figure 14):

- HPLC analysis of phytoplankton pigments: These samples were analyzed using high-performance liquid chromatography (HPLC) to identify and quantify different phytoplankton pigments.
- POC, PIC, DOC, TSM and spectral absorption: Samples for laboratory analysis were collected to measure particulate organic carbon (POC), particulate inorganic carbon (PIC), dissolved organic carbon (DOC), total suspended matter (TSM), and spectral absorption coefficients for phytoplankton (aφ), particles (ap), and colored dissolved organic matter (ag).
- Imaging Flow cytometry, particle size distribution, and phytoplankton community composition (PCC) and biomass: Continuous (and preserved samples on station) measurements with an Imaging FlowCytoBot (IFCB) were taken over the course of the campaign. These techniques enable the determination of abundance and taxonomy of different phytoplankton community composition and biomass. Preserved samples were collected for analysis with FlowCam in the laboratory.
- Fast repetition rate fluorometry: On-board continuous measurement of phytoplankton physiological parameters, including maximum potential of efficiency of photosystem-II, were conducted from the flowthrough sample water. Semitransparent bottles of sample seawater were also collected at each station and dark-adapted under low light conditions for ~2-4 hours before measurement.
- S3e Flow Cytometer: Analysis of formalin preserved seawater samples with the BioRad S3e flow cytometer enable small phytoplankton enumeration and taxonomy (0.3 to 10 micron particles) for complete size spectrum quantitation of PCC, size and biovolume.

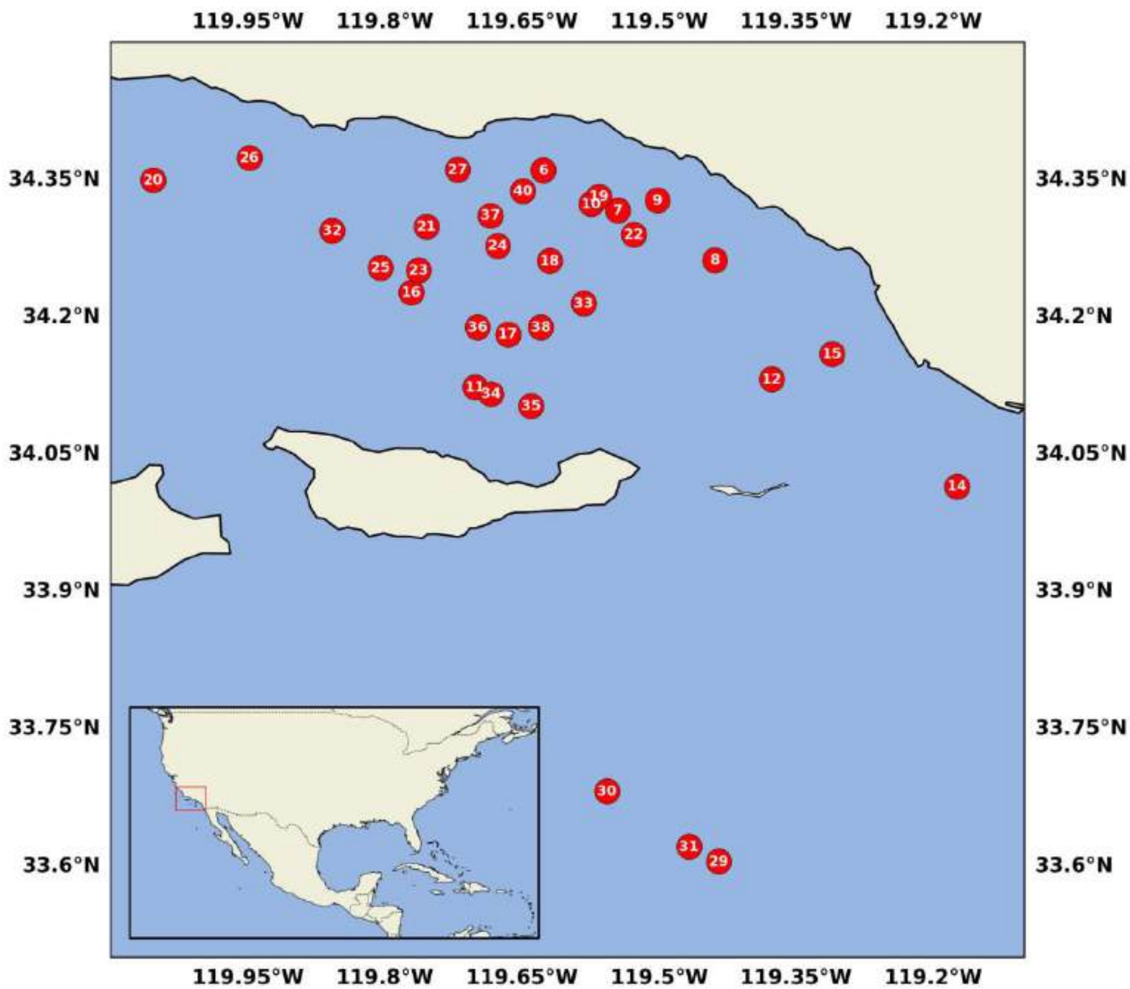


Figure 14 Map of stations sampled by the R/V Shearwater during the PACE-PAX campaign

3.5.3.1.2 Bio-optical measurements

3.5.3.1.2.1 Inherent optical properties (IOPs; scattering and absorption coefficients) - Continuous underway sampling

A diaphragm pump supplied clean science seawater to an underway system setup in the wet lab for IOP measurements at a flow rate of ~3-4 Liters per minute (Figure 15). The seawater first passed through a Vortex Debubbler to remove the optical signature of bubbles before reaching the instruments. Instruments integrated into the underway flowthrough system were a thermosalinograph (TSG), Sequoia Hyper-BB (backscatter 430-700 nm), Hyper-a (hyperspectral UV-VIS [360-750nm] absorption), Seabird ac-s (absorption and attenuation 400-700 nm), a Soliense benchtop LIFT-FRR fluorometer for phytoplankton physiology (with combined excitation wavelengths of 445 nm and 470 nm), and an Imaging FlowCytoBot (IFCB) to image plankton between ~6 to 150 micron size. Instruments were calibrated with MilliQ water twice daily.

Note that as the part of the continuous system, we operated two instruments by PVST funded Joaquim Goes, Flow Cam (collecting information on the phytoplankton community composition) and FiRE, which collects fluorometric data on phytoplankton physiology.

Figure 15 Underway measurement instrumental set up used during PACE-PAX cruise, including a) TSG, b) Hyper-bb, c) Hyper-a, d) ac-s, e) LIFT-FRRF, f) IFCB, and g) GPS

3.5.3.1.2.2 Inherent optical properties (IOPs; scattering and absorption coefficients) – Vertical profiles

Vertical IOP profiles were conducted at each station using two separate cages (see Figure 16). The first cage contained a Seabird ac-s, a Sequoia Hyper-a, and three In-situ Marine Optics SC-6 bb instruments. The ac-s measures absorption and attenuation (and total scattering by difference) at ~80 wavelengths between 400 and 740 nm, the Hyper-a measures hyperspectral UV-Vis absorption between 360 and 750 nm, and the SC-6 measures backscattering at six unique wavelengths spanning from the UV to visible (365, 440, 510, 560, 660, and 730 nm, with an angular field of view centered at around 124°). This cage was first lowered to ~10 m to purge bubbles, then it was raised to just below sea surface and again lowered to ~20 m to record the profile. The second cage contained a Sequoia LISST-VSF that was lowered to ~15 m and held at depth for 10 minutes. The LISST-VSF measures the volume scattering function, beam attenuation (c), and scattering coefficient (b) at ~515 nm in 32 log-spaced angles from 0.1 to 15° and from 15 to 150° in 1° steps.

3.5.3.1.2.3 Apparent optical properties (AOPs; up/downwelling radiance/irradiance)

Continuous AOP/radiometry measurements were collected using a PySAS above-water radiometer system (Figure 17). The PySAS measures hyperspectral surface radiance, sky radiance, and solar irradiance at 3.3 nm steps between 350 and 750 nm autonomously while underway and on station from the bow.

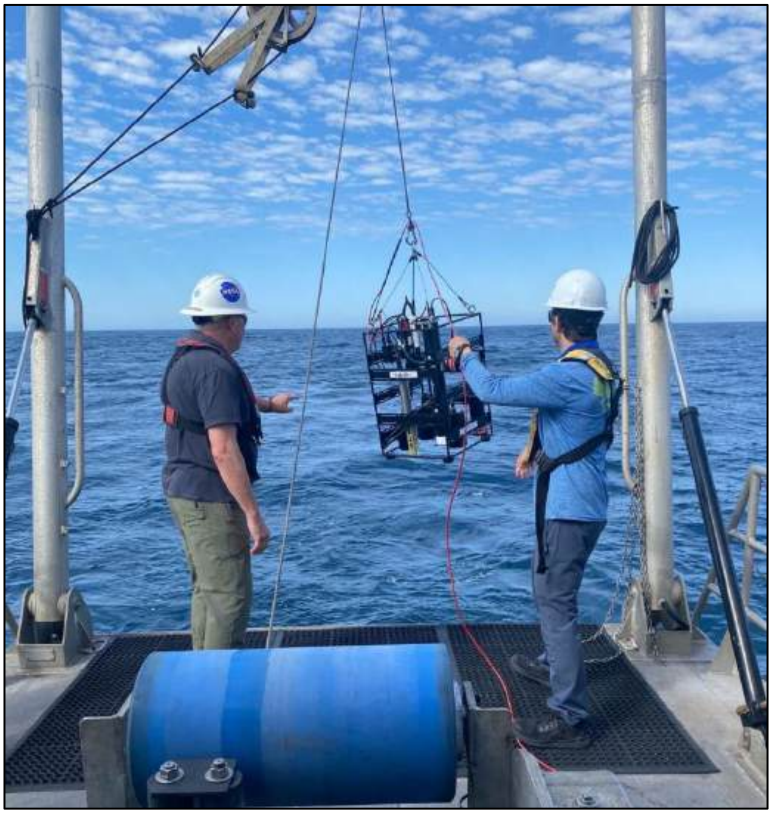


Figure 16 Scott Freeman (left) and Harrison Smith (right) deploy the IOP cage containing the Hyper-a, ac-s, 3x SC-6 bb, and CTD on station.

Figure 17 PySAS above-water radiometry system measuring (1) water-leaving (upwelling) radiance, (2) sky radiance and (3) downwelling solar irradiance, which are used to derive aquatic remote sensing reflectance (Rrs), the most fundamental ocean color data product from which all other products are derived.

*Table 8 Summary of OEL instrumentation deployed, and measurements taken during PACE-PAX campaign. *Denotes measurements performed at our OEL laboratories from samples collected and preserved at sea.*

Instrument/Sample	Measurements	Sample Type	# Samples
PySAS	water-leaving radiance (L_t), sky radiance (L_i), solar irradiance (E_d) – 350-750 nm	continuous (hourly)	N/A
IOP-Underway (TSG, Hyper-bb, Hyper-a, ac-s)	temperature, salinity, backscattering (b_b), absorption (a), and attenuation (c)	continuous (hourly)	N/A
IOP-Profiler (hyper-a, ac-s, 3x SC-6 bb, CTD; LISST-VSF)	temperature, salinity, depth, absorption (a), attenuation (c), and backscatter coefficients (b_b), and volume scattering function	vertical profile	71
HPLC*	phytoplankton pigments, community compositions	discrete surface	108
Particle Absorption*	total particle (a_p), detritus/non algal (a_d), and phytoplankton (a_{ph}) absorption – 290-850 nm	discrete surface	45
CDOM Absorption*	spectral absorption of colored dissolved organic matter (a_g) – 250-700 nm	discrete surface	19
POC*	particulate organic carbon	discrete surface	45
PIC*	particulate inorganic carbon	discrete surface	56
DOC*	dissolved organic carbon	discrete surface	57
TSM*	total suspended matter	discrete surface	60
S3e Flow Cytometry*	community composition	discrete surface	19
FlowCam*	community composition	discrete surface	15
IFCB	community composition	continuous	N/A

LIFT-FRRF	phytoplankton physiological parameters	continuous	N/A

3.5.3.2 Data

All data collected by the FSG from the R/V Shearwater are available on the NASA SeaBASS data archive (https://seabass.gsfc.nasa.gov/archive/NASA_GSFC/PACE-PAX/PACE-PAX_SHEARWATER/archive).

Table 9 Status of NASA Field Support Group collected data as of Dec 2025.

Instrument	Status	Activities
PySAS	Available	Match-ups created
HyperPro	Available	QA/QC & validation, Match-ups created
HPLC	Available	Match-ups created
ap/ad	Available	Match-ups created
ag discrete	Available	Match-ups created
IOP-underway (ac-s, bb)	Available	QA/QC & validation
IOP-profiles (hyper-a, ac-s, bb)	Available	
Flow cytometry	Pending	
IFCB	Pending	
DOC	Pending	
POC	Available	Match-ups created

3.5.3.3 PANDORA Instrument

Pandora spectrometer instrument spectroscopy is used to measure columnar amounts of trace gases in the atmosphere. These gases (O3, NO2, CH2O) absorb specific wavelengths of light from the sun in the ultraviolet-visible spectrum. Instrument was deployed for the duration of the R/V Shearwater deployment on the top deck of the vessel, with unobstructed view of the sky. Pandora instrument was provided by the NASA GSFC Pandora Project (PI: Thomas F Hanisco), and the same team processed the data. PANDORA dataset is available at Atmospheric Science Data Center PACE-PAX page: https://doi.org/10.5067/ASDC/PACE-PAX/RV-Shearwater/Pandora.

3.5.4 PVST funded NRL/CCNY team

The Naval Research Laboratory (NRL) and the City College of New York (CCNY) operate a comprehensive suite of instrumentation to measure and characterize the uncertainty of polarized and unpolarized radiations, as well as, aerosol optical thickness (AOT), particle size distributions (PSDs), and advanced chlorophyll fluorescence analysis.

3.5.4.1 Instrument background

3.5.4.1.1 Above water instruments

The Aerosol sun-photometer (Microtops), was used to provide the aerosol optical thickness at 440, 675, 870, 936, 1020 nm bands.

The ASD FieldSpec HandHeld 2 spectroradiometer were used to provide upwelling radiance, downwelling irradiance and remote sensing reflectance in the range 350-800 nm with 1 nm spectral resolution.

Two similar polarimetric systems (Figure 18) were operated on board of the Shearwater vessel. The first polarimetric system consists of a polarimetric cameras with discrete filters at 442, 494, 550, and 665 nm and an imaging polarimeter captures hyperspectral wavelengths from 402 to 902 nms. The Camera is the average of 100 video frames recorded, and the Imager is a "snapshot" measurement, so no temporal averaging. The second polarimetric system consist of a polarimetric camera with color filters matching Hyper-Angular Research Polarimeter #2 (HARP2) bands at 440, 550, 650, 685, 710, 873 nm, and a high precision spectro-polarimeter that provides continuous wavelengths coverage of the polarized radiances in the range 300-1100 nm with less than 0.7 nm spectral resolution.

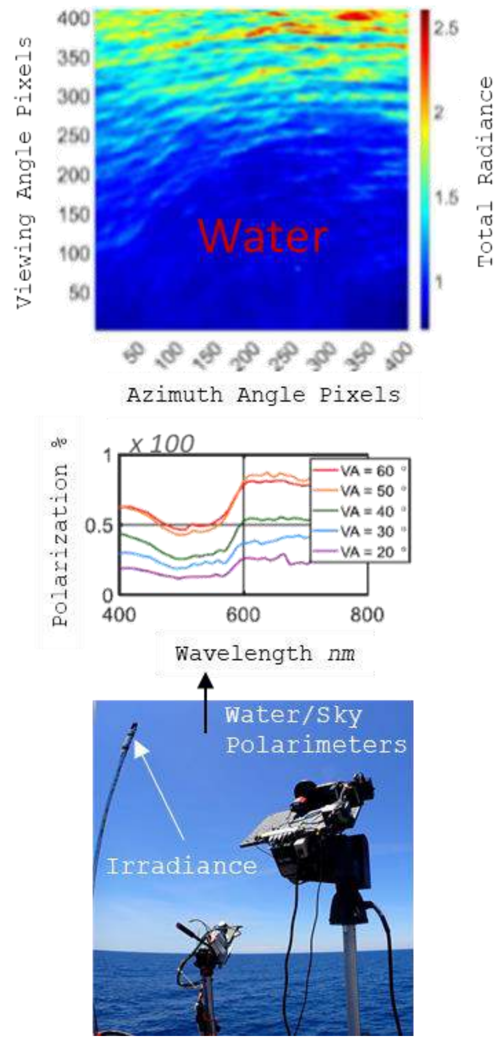


Figure 18 Example data from the polarimetric system: op shows angular distribution of total radiance above water surface; middle shows hyperspectral Degree of Linear Polarization of water surface at different viewing angles; bottom shows the polarimeter

3.5.4.1.2 In-water flow-through instruments

The Laser In-Situ Scattering and Transmissometry, LISST 100x, was used to provide continuous particle size distributions in the size bins ranging between 1.09 and 184 µm covering the upper pico size scale (< 2 µm), all of the nano size scale (2-20 µm), and most of the micro size scale (20 – 200 µm) size ranges as well as the red beam attenuation at 670 nm.

The CLASS instruments, Zinger Enterprises, was used to provide continuous measurements of chlorophyll concentration and chlorophyll fluorescence.

3.5.4.2 Data

Measurements of polarized and unpolarized radiations, as well as, aerosol optical thickness (AOT), particle size distributions (PSDs), and advanced chlorophyll fluorescence analysis are available in seabass: (https://seabass.gsfc.nasa.gov/cruise/PACE-PAX_SHEARWATER/). Mean and standard deviation of data are provided. Submitted data are listed below:

Table 10 Measurements made by the NRL/CCNY team on the R/V Shearwater

Data	Comments
Aerosol Optical Thickness (AOT) at 440, 675, 870, 936, 1020 nm	
Imager sky and water Stokes Parameters, I, Q, and U	Data collected above water approximately at 5m height. The imager has 410(V)x410(H) pixels and each pixel has 164 wavelength bands. Averages from 40(V)x100(H) pixels in the center at 7 different VA [55,50,45,40,35,30,25] are provided. Data is provided for 126 bands from 402nm to 902nm. Stokes1, stokes2, stokes3 represent the Stokes vector components I, Q, and U respectively
Camera sky and water Stokes Parameters, I, Q, and U	Data collected above water approximately at 5m height and at 4 wavelengths 442, 494, 550 and 655 nm. The camera was operated in the video mode with 100 frames recorded. Averages from 100x100 pixels in the center at 7 different VA [55,50,45,40,35,30,25] and for 100 frames are provided.
Upwelling radiance, Lu (350-800 nm)	
Downwelling irradiance, Ed, (350-800 nm)	
Remote Sensing Reflectance, Rrs, (350-800 nm)	Remote sensing reflectance was computed using full solar-sensor geometries and wind speed dependence Mobley, 1999 model, Spectral standard deviation was calculated from five replicate scans, with outliers removed.
Particle Size Distributions (PSD) in the size bins ranging between 1.09 and 184 μm	
Chlorophyll concentration	
Chlorophyll fluorescence	
Normalized Fluorescence Line Height (nFLH)	Calculated as the difference between the observed normalized water leaving radiance at 678 nm, nLw(678), and a linearly interpolated nLw(678) from two surrounding bands (Behrenfeld, et al. 2009)

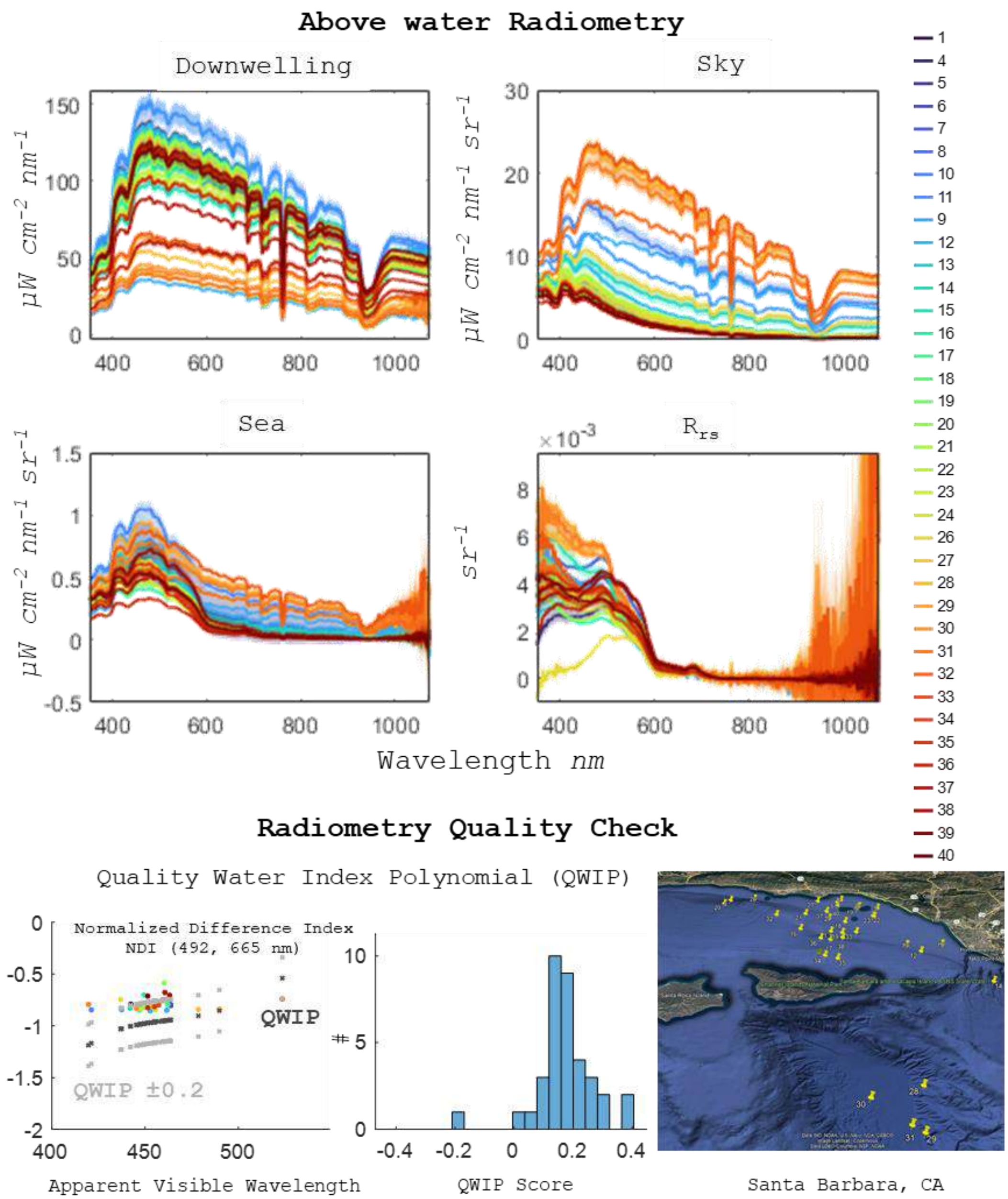


Figure 19 NRL/CCNY R/V Shearwater above water measurements made during PACE-PAX, showing radiometric variability across the 40 stations

3.6 The NPS/CIRPAS Twin Otter

The Naval Postgraduate School (NPS) Center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) Twin Otter (TO) supports atmospheric and oceanographic research for Office of Naval Research, National Science Foundation, Department of Energy, National Oceanographic and Atmospheric Administration, NASA, and others. The aircraft is instrumented to measure meteorological state variables, flight path and platform attitude, turbulence, aerosol particle concentration and size spectra, cloud and precipitation drop concentration and size spectra and sea surface temperature. The typical operational speed for the CIRPAS TO during PACE-PAX was roughly 50 m/sec. Spirals between minimum altitude and 10,000 feet over AERONET sites were the primary module used to provide validation data for PACE aerosols retrievals with the AERONET site providing the total column optical depth as a context for the vertical profiles of aerosol microphysical and scattering properties. Porpoises (saw tooth profiles) from below cloud base (BCB) to above cloud top (ACT) and then back down from ACT to BCB were the primary module used to provide validation data for PACE cloud retrievals. While the PACE polarimeter cloud retrievals are primarily sensitive to cloud droplet size near cloud top, the PACE OCI cloud retrievals are sensitive to most of the cloud depth for the clouds typically observed during PACE-PAX, which requires the full depth profiles of cloud properties for proper validation of OCI cloud retrievals. Typical ascent/descent speeds were about 500 feet per minute for both the spirals and the porpoises.

Figure 20 Rendering of the NPS CIRPAS Twin Otter, with indicated instrument inlet placement. Renderings available at https://airbornescience.nasa.gov/3d-models .

3.6.1 Facility instrumentation

The primary facility instruments used by PACE-PAX are the wing mounted aerosol and cloud probes (PCASP, CIP, HW, CAS and PVM-100) that are listed in Table 11and described in more detail below.

Table 11 NPS/CIRPAS Twin Otter facility instrumentation. All sizes listed in this table are diameters.

Instrument	Manufacturer	Description	Range
Passive Cavity Aerosol Spectrometer Probe (PCASP) - SPP200	PMS, Inc	Particle Size Distribution	0.1 - 3.4 µm

Cloud Droplet Probe (CDP)	DMT, Inc	Cloud Droplet Size Distribution	2.0 - 47.0 µm
Cloud Imaging Probe (CIP)	DMT, Inc	Cloud Drop Size Distribution	15.45µm-1.55mm @25µm resolution
Cloud and Aerosol Spectrometer (CAS)	DMT, Inc	Particle and Drop Size Distribution	0.5µm-80µm
HotWire (HW) Liquid Water Content	DMT, Inc	Liquid Water Content of clouds	0.01 – 3 g/m3
Ultrafine Condensation Particle Counter (3025)	TSI, Inc	Particle concentration	Dp > 0.003 µm
Temperature	Rosemount	Total Temperature	-50 to +50 C
Dew Point Temperature	EdgeTech	Chilled Mirror device	-50 to +50 C
PVM-100A	Gerber Scientific, Inc	Liquid Water Content of clouds: cloud PSA (particle surface area), LWC (liquid water content), Re (effective radius)	0.002-10 g/m^3 5-20,000 cm^2/m^3 3-50 µm diameter range.
Barometric, Dynamic, and Radome-Angle Pressures	Setra	Barometric and differential transducers	600-1100 mb +/- 75 mb
Wind	Radome, flow angle probe	TAS, Mean Wind, Slip- and Attack angles.	m/s
TANS Vector platform attitude	Trimble, Inc	GPS, Pitch, Roll, Heading	
NovAtel GPS PROPAC	NovAtel, Inc	GPS, Lat, Long, Alt, ground speed and track	
C-MIGITS-III, GPS/INS	Systron, Inc.	Lat, Long, Alt, ground speed and track, pitch, roll, heading,	
Heitronics KT 19.85 Pyrometer (downlooking/nadir)	Heiman	Sea surface temperature	-5 to 45 deg C adjustable
SPN-1 Sunshine Pyranometer	Delta-T Devices	Global (Total) and Diffuse solar irradiance (W/m2)	0.4-2.7 µm
Cockpit and wing cameras		Forward and down view of environmental and surface conditions	visual video

3.6.1.1 Data

'R0' 1 Hz MetNav files contain all the meteorological and navigational measurements from the Twin Otter facility instruments together with the data from the Gerber PVM probe, the integrated volume and number concentrations from the CAS and CIP sensors and the sea surface temperature and downwelling solar irradiance measurements from the sensors listed in Table 11 above.

'R0' 1 Hz data from the PCASP, CAS and CIP wing probes (described in the following subsections) are located in the LaRC PACE-PAX archive. These files contain counts per channel for the given probe providing aerosol, cloud and precipitation size distributions respectively.

The cockpit forward video and wing-mounted down-looking video were provided to LaRC personnel on an external hard drive for eventual submission to the LaRC PACE-PAX archive.

3.6.1.1.1 Gerber Particulate Volume Monitor (PVM) 100A

The Gerber PVM (Gerber, 1991; Gerber et al., 1994) wing probe provides simultaneous measurements of the liquid water content (LWC) and integrated particle surface area (PSA) together with the cloud droplet effective radius that is derived from the ratio of the two measurements. The sample volume is 1.25 cm^3 and the measurements are made with a bandwidth of 5 KHz that is averaged up to the reported 1 Hz sample rate. The PVM does not count droplets, but rather detects a signal that is proportional to the number of scatterers that are illuminated in its sample volume. Two separate channels, using annularly varying transmission masks that are constructed to generated signals that are proportional to the volume and the projected surface area of the scattering particles create signals that are proportional to the LWC and the PSA respectively. The large sample volume and rapid response make the PVM probe a robust sensor for the determination of LWC, PSA and effective radius.

3.6.1.1.2 Particle Measuring Systems Inc., Passive Cavity Aerosol Spectrometer Probe (PCASP)

PCASP is a wing-mounted aerosol probe that uses a standard PMS canister. Sample air enters the forward-facing inlet and decelerates by ~10x. A side-facing "scarf" tube provides suction for continuous flushing of the air to provide fast time response. During cloud penetrations, the splash-breakup of cloud particles can produce large concentrations of spurious particles, and some of these can enter the PCASP air sample as contamination. An internal diaphragm pump drives air flow through the optical cavity providing a sample rate of ~1 cm^3/sec within a particle-free sheath flow of 15 cm^3/sec. The PCASP is of the general class of instruments called optical particle counters (OPCs) that detect single particles and size them by measuring the intensity of light that the particle scatters when passing through a light beam. A laser beam is focused to a small diameter at the center an aerodynamically focused particle laden air stream. Particles that encounter this beam scatter light in all directions and some of this light is collected by a relay mirror over scattering angles from about 35° - 135° i.e. side-scattering angles since this sensor is focused on aerosol, not cloud, particles. The collected light is focused onto a photodetector and the size of the particle is determined by measuring the light scattering intensity as a function of scattering angle and using Mie scattering theory to relate this intensity distribution to the particle size (Cai et al., 2013). Based on the angular sampling, the PCASP provides the size distribution and concentration of aerosol particles from ~0.1 to 3.4 µm diameter in 20 size bins.

3.6.1.1.3 Droplet Measurement Technologies (DMT) Inc., Hot Wire (HW) Probe

The Hot Wire (HW) probe is a liquid water content (LWC) detector (LWC: 0.01 – 3 g/m3). The HW probe uses the technique described by King et al. (1978) to measure LWC, with a cylindrical rod wrapped in fine wire that is mounted on the edge of a rectangular strut that provides stability and low vibration at aircraft speeds. The temperature of the fine wire in the HW probe is maintained constant by utilizing a 40-kHz signal with fixed amplitude of 28 V but with a duty cycle that varies between approximately 10% and 90%. This ensures that the element is not overheated when the aircraft is at rest with no convective cooling. The power required to maintain the temperature of the fine wire is proportional to the liquid water content of the droplets that impact the cylindrical rod, with a correction for heat transferred to the cooler air moving past the wire, which is described in detail in King et al. (1978).

3.6.1.1.4 Droplet Measurement Technologies (DMT) Inc., Cloud and Aerosol Spectrometer (CAS)

The Cloud and Aerosol Spectrometer (CAS) sizes particles from 0.5-80 µm using the collection of forward scattered light (4-13° scattering angle) from single particles passing through a focused laser beam. The sample volume of the CAS is defined with a pinhole aperture (Baumgardner et al., 2001) and is used to select only the most intense section of the laser beam, providing a sample area of 0.118 mm2. The CAS has an additional set of optics and detectors that measure backscattered light (5 – 14° phase angle). The size of each particle is determined using Mie scattering theory and by assuming spherical particles of known refractive index (i.e. liquid water). The size is determined from both forward- and backward-scattered light, and a comparison of the sizes derived from the two signals provides an error check as well as the potential for estimating the refractive index of the particle (Baumgardner et al., 1996). The CAS has a time response of 0.1 µs which eliminates particle under-sizing caused by electronic time response limitations in earlier generations of sensors. Another issue for in situ aerosol and cloud sensors is counting losses, as a result of electronics dead time, that can occur at high concentrations. The CAS utilizes a first-in, first-out buffer that allows, at typical CIRPAS TO airspeeds of 50 m/s, particle concentrations of up 26,000 cm-3 to be counted without dead time losses. Finally, the CAS provides the arrival time frequency distribution calculated for every time period. The frequency distribution of the time intervals between particles is an independent measure of the concentration (Brenguier et al., 1994) and also provides a measure of small-scale inhomogeneities (Paluch and Baumgardner, 1989).

3.6.1.1.5 Droplet Measurement Technologies (DMT) Inc., Cloud Imaging Probe (CIP)

The Cloud Imaging Probe CIP measures particle images by capturing the shadow of the particles that pass through a focused laser, i.e. it is a 2D optical array probe (OAP). A collimated laser beam is aligned to a linear array of 64 diodes. Each time the array moves a distance of 25 µm (the probe resolution), the on – off state of each of the diodes is recorded as the particle image moves across the array. When the light level decreases by 70%, the diode state is recorded as ‘‘on.’’ This 70% threshold was implemented to decrease the sizing uncertainty associated with 2D OAPs (Korolev et al., 1998). By capturing images of particles the CIP provides sizing of particles over the range 15.45µm-1.55mm. The CIP is designed to be stable against vibration, have large sample volume, fast response time and limited dead time. The 45-mW diode laser provides increased intensity compared to previous generations of 2D-OAPs and eliminates false triggering of the probe that has been a problem with OAPs when vibration causes movement of the beam across the array. The use of a a 64-diode array in the CIP allows for a large size range, and also a large sample volume. The fast electronic time response of the CIP eliminates the dependency of the depth of field (DOF) on airspeed (Baumgardner and Korolev, 1997). The ‘‘overload’’ period, i.e. the amount of time the CIP is not taking data while downloading a buffer, has been minimized by increasing the number of images stored in a buffer, using real-time data compression and increasing the transmission rate for downloading images. The CIP thus, provides overlap with the size range characterized by the CAS and extends the size range of cloud particles characterized during PACE-PAX to precipitation sized particles.

3.6.2 LARGE

3.6.2.1 Instrument background

During PACE-PAX, The Langely Aerosol Research Group Experiment (LARGE) operated a suite of aerosol optical and microphysical property instruments sampling from the CIRPAS community aerosol inlet (Table 12, Figure 21 LARGE instruments on the CIRPAS Twin Otter during PACE-PAX).

Table 12 LARGE instruments and measurement characteristics

Measured Parameter	Instrument	Uncertainty	Size Range (µm)
Dry Aerosol Size Distributions	DMT UHSAS	20%	0.06-1.05
	TSI-3321 APS		0.53-5.7
Total Dry Scattering Coefficient (450, 550, and 700 nm)	TSI-3563 Nephelometer at RH < 40%	1 Mm^{-1}, 20%	< 5
f(RH) for Scattering at 550nm	Tandem TSI-3563 Nephelometers w/85% humidification	10%	< 5
Total Dry Absorption Coefficient (470, 532, 660nm)	Brechtel TAP at RH < 40%	2 Mm^{-1}, 15%	< 5
Sub-micron Dry Extinction Coefficient and Scattering Coefficient at 532nm	Aerodyne CAPS-PM_{SSA} at RH < 40%	1 Mm^{-1}, 10%	< 1.0

Figure 21 LARGE instruments on the CIRPAS Twin Otter during PACE-PAX

3.6.2.2 Data

Data collected by the LARGE group is organized into five datasets or "dataIDs": PACEPAX-LARGE-APS, PACEPAX-LARGE-UHSAS, PACEPAX-LARGE-POPS, PACEPAX-LARGE-MICROPHYSICAL, and PACEPAX-LARGE-OPTICAL. All data are available in ICARTT format via the campaign data archive and DOIs located at the NASA ASDC. Additionally, all variables have been time synced to the CASF_DNCN variable in the PACEPAX-MetNav dataset. No corrections have been applied for potential inlet particle loss effects.

3.6.2.2.1 Individual datasets/instrument operation

3.6.2.2.1.1 PACEPAX-LARGE-APS

The APS dataset consists of normalized aerodynamic size distribution data (528-5661nm diameter) from the Aerodynamic Particle Sizer instrument (APS; Model 3321, TSI, Inc.) operated on the CIRPAS community aerosol inlet, as well as integrated statistics of particle number, surface area, and volume concentrations. All APS measurements are reported at STP conditions (i.e., 0°C and 1013.25 hPa) and can be converted back to ambient conditions by dividing by the reported stdPT conversion factor. APS size distribution data is normalized as dN/dlogDp and reported in units of cm^{-3}. Sizing is measured in aerodynamic diameter, which can be converted to geometric diameter using the following formula

$$D_{geo} = D_{aero}\sqrt{\frac{S}{\rho}} \qquad \textit{Eq. 1}$$

where S is the shape factor and ρ is the particle density.

APS size distributions are calibrated and processed with respect to midpoint NIST-traceable polystyrene latex (PSL) sphere-equivalent aerodynamic diameters, rebinned from the native instrument bins to a standard rebinning scheme (i.e., dlogDp for diameters less than 1000 nm is 0.05 (20 channels per decade) and dlogDp for diameters greater than or equal to 1000 nm is 0.1 (10 channels per decade)) and assuming spherical particles with a density of 1 g cm^{-3}. Integrated statistics are computed by multiplying the number concentration of particles in each bin by the appropriate formula for the surface area and volume of a sphere. Then, the number, surface area, and volume concentrations are summed across the full instrument detection range to derive the integrated statistics.

$$IntegN = \sum_{Dp}\frac{dN}{dlogDp}dlogDp \qquad \textit{Eq. 2}$$

$$IntegS = \sum_{Dp}(\frac{dN}{dlogDp}dlogDp)(\pi Dp^2) \qquad \textit{Eq. 3}$$

$$IntegV = \sum_{Dp}(\frac{dN}{dlogDp}dlogDp)(\frac{\pi}{6}Dp^3) \qquad \textit{Eq. 4}$$

The sample flow for the APS is passively dried to generally less than 50% RH due to ram heating and warmer-than-ambient cabin/chassis temperature. The actual RH for APS measurements is consistent with the RH_Sc variable in the PACEPAX-LARGE-OPTICAL dataset. Bin bounds and midpoint diameters are reported in the file headers.

3.6.2.2.1.2 PACEPAX-LARGE-UHSAS

The UHSAS dataset consists of normalized optical size distribution data (59.2-1054.4nm diameter) from the Ultra High Sensitivity Aerosol Spectrometer instrument (UHSAS; Model UHSAS-0.055, Droplet Measurement Technologies) operated on the CIRPAS community aerosol inlet, as well as integrated statistics of particle number, surface area, and volume concentrations. All UHSAS measurements are reported at STP conditions (i.e., 0°C and 1013.25 hPa) that can be converted to ambient conditions by dividing by the reported stdPT conversion factor. UHSAS size distribution data is normalized as dN/dlogDp and reported in units of cm^{-3}. Sizing is calibrated and processed with respect to midpoint ammonium-sulfate-equivalent optical diameters (i.e., assuming a refractive index of 1.52). The size distributions have been rebinned from the native instrument bins to a standard rebinning scheme (i.e., dlogDp is 0.05 (20 channels per decade), consistent with the APS dataset in this size range). Integrated surface area and volume concentrations are calculated by assuming spherical particles. The sample flow for the UHSAS is passively dried to generally less than 50% RH due to ram heating and warmer-than-ambient cabin/chassis temperature. The actual RH for UHSAS measurements is consistent with the RH_Sc variable in the PACEPAX-LARGE-OPTICAL dataset. Bin bounds and midpoint diameters are reported in the file headers.

3.6.2.2.1.3 PACEPAX-LARGE-POPS

Caveat: due to the nature of the POPS and its sampling location, this dataset should not be interpreted as the ambient aerosol size distribution. The data should be used to aid interpretation and demonstrate consistency between passively and actively dried aerosol instruments on the aircraft.

The POPS dataset consists of normalized optical size distribution data (254-3084nm diameter) from a UTLS-modified Printed Optical Particle Spectrometer instrument (POPS; Handix) operated on the CIRPAS community aerosol inlet, as well as integrated statistics of particle number, surface area, and volume concentrations. All POPS measurements are reported at STP conditions (i.e., 0°C and 1013.25 hPa) that can be converted to ambient conditions by dividing by the reported stdPT conversion factor. POPS size distribution data is normalized as dN/dlogDp and reported in units of cm^{-3}. Sizing is calibrated and processed with respect to midpoint NIST-traceable polystyrene latex (PSL) sphere-equivalent optical diameters (i.e., assuming a refractive index of 1.59). Size distributions are reported at the native instrument binning scheme with a dlogDp of 0.12 (~8.3 bins per decade), note that this binning scheme is not consistent with the standard LARGE rebinning scheme applied to the UHSAS and APS. Bins with centers less than 300nm have been removed due to size calibration and sensitivity issues. Integrated surface area and volume concentrations are calculated by assuming spherical particles. The sample flow for the POPS is actively dried with a nafion drier shared with the dry tandem nephelometer (described below). Bin bounds and midpoint diameters are reported in the file headers. Discrepancies between the POPS and APS size distributions are indicative of particle loss in the nafion drier or improper approximation of geometric diameters.

3.6.2.2.1.4 PACEPAX-LARGE-MICROPHYSICAL

The MICROPHYSICAL dataset consists of integrated statistics of particle number, surface area, and volume concentration within selected diameter ranges from the UHSAS and APS instruments. The selected size ranges for the two instruments are 100-1000nm (inclusive) and greater than 1000nm, generally representing the accumulation and coarse aerosol modes, respectively. Equations 1-3 are applied to the normalized UHSAS and APS size distribution data for the selected size ranges. All other corrections and reporting conditions that apply to the instrument size distribution datasets also apply to the microphysical integrated statistics (e.g., dry STP conditions, etc.).

3.6.2.2.1.5 PACEPAX-LARGE-OPTICAL

The OPTICAL dataset consists of measured aerosol scattering, absorption, and extinction coefficients, as well as derived optical parameters. Extrinsic parameters (i.e., scattering, absorption, and extinction coefficients) are reported at STP conditions that can be converted to ambient temperature and pressure by dividing by the reported stdPT conversion factor. Intrinsic parameters (i.e., Angstrom exponents, single scattering albedos, and hygroscopicity parameters) do not need to be converted.

The scattering coefficient at three wavelengths (450, 550, and 700nm) is measured by a TSI-3563 Nephelometer operated on the CIRPAS community aerosol inlet. The nephelometer sample flow is passively dried from ram heating and cabin temperature to generally less than 50%. The exact instrument RH is reported by the RH_Sc variable, which should be consistent across LARGE instruments that are not actively dried (i.e., UHSAS and APS). The scattering coefficients are corrected for truncation errors using Anderson & Ogren (1998). Scattering coefficients are relevant to bulk aerosol (i.e., all particles sampled by the aircraft inlet).

Absorption coefficient at three wavelengths (465, 520, and 640nm) is measured by a Brechtel Manufacturing, Inc. Tricolor Absorption Photometer (TAP, Model 2901) operated on the CIRPAS community aerosol inlet. The TAP sample flow is actively dried by heating the optical block to 35°C. The data were corrected for aerosol scattering following Equation 7 in the TAP manual (Brechtel Manufacturing Inc., 2022). Absorption coefficients have been smoothed using a 9 s boxcar algorithm for consistency with previous campaigns and are relevant to bulk aerosol.

Angstrom exponents for scattering and absorption are derived from the blue-to-red and blue-to-green wavelengths for each instrument. A 30 s smoothing is first applied to the coefficients, and Angstrom exponents are only computed when the relevant coefficients at both wavelengths are at least 2 Mm^{-1}. Only the blue-to-red Angstrom exponent is reported for brevity. Angstrom exponents are relevant to bulk aerosol. The scattering Angstrom exponent is relevant to the RH_Sc specified relative humidity, and the absorption Angstrom exponent is relevant to dry (< 40%) relative humidity.

$$AE = -\frac{\log_{10}(\frac{C_1}{C_2})}{\log_{10}\left(\frac{\lambda_1}{\lambda_2}\right)} \quad \textit{Eq. 5}$$

where C_1 and C_2 are scattering (or absorption) coefficients at λ_1 and λ_2 wavelengths.

Single scattering albedo (SSA) at three wavelengths (450, 550, and 700nm) is derived from scattering and absorption coefficients at blue, green, and red wavelengths, respectively. A 30 s smoothing is first applied to the coefficients, and then the absorption coefficients are adjusted to the scattering wavelengths using an assumed Angstrom exponent of 1. SSA at a given wavelength is only computed when both the scattering and absorption coefficient (after smoothing and wavelength adjustment) at that wavelength are at least 2 Mm^{-1}. SSAs are relevant to bulk aerosol and the RH_Sc specified relative humidity.

$$SSA_\lambda = \frac{C_{scat,\lambda}}{C_{scat,\lambda} + C_{abs,\lambda}} \quad \textit{Eq. 6}$$

The dry extinction coefficient at 532nm is derived from the sum of nephelometer scattering and TAP absorption. The green absorption coefficient was adjusted from 520nm to 532nm using an assumed absorption Angstrom exponent of 1. The green scattering coefficient was adjusted from 550nm to 532nm using the calculated scattering Angstrom exponent between 450nm and 550nm; therefore, an implicit threshold of at least 2 Mm^{-1} scattering coefficient (after 30 s smoothing) is used to calculate the extinction coefficient. To improve data coverage, if the absorption coefficient is unavailable, the extinction coefficient is reported as the wavelength-adjusted scattering coefficient (i.e., assuming the green absorption coefficient is 0 Mm^{-1}). The dry extinction coefficient is relevant to bulk aerosol and the RH_Sc specified relative humidity.

Hygroscopicity is derived using tandem nephelometers (TSI-3563), with the sample of one nephelometer dried to less than 40% (RH) using a FC200-780 Series Perma Pure drier (the “low-RH nephelometer”) and a custom humidification system to humidify the sample of the other to ~85% RH (the “high-RH nephelometer”). The gamma hygroscopicity parameter is calculated using the scattering coefficients at both relative humidities. Gamma is only reported when both the low-RH and high-RH scattering coefficients are at least 5 Mm^{-1}, the RH in the high-RH nephelometer is between 75% and 95%, and the RH of the high-RH nephelometer is greater than the RH of the low-RH nephelometer by at least 25% RH.

$$GAMMA_{\lambda} = \frac{\ln(\frac{C_{scat,highRH,\lambda}}{C_{scat,lowRH,\lambda}})}{\ln(\frac{100 - RH_{lowRH}}{100 - RH_{highRH}})} \qquad \textit{Eq. 7}$$

The hygroscopic growth function for light scattering, f(RH), is the amplification factor in scattering coefficient due to RH and is calculated from gamma using 20% and 80% RH. Gamma and f(RH) are relevant to bulk aerosol and are only reported for the 550nm wavelength.

$$f(RH)_{20,80} = (\frac{100 - 80}{100 - 20})^{-GAMMA} \qquad \textit{Eq. 8}$$

Ambient scattering coefficient at 550nm is derived from the bulk scattering coefficient at 550nm (and associated RH_Sc relative humidity), the gamma parameter, and the ambient RH as reported by the Relative_Humidity_Ambient variable in the MetNav dataset. A f(RH) parameter between the instrument RH and the ambient RH is computed first, which is then applied to the bulk scattering coefficient. Ambient scattering coefficient is only calculated when the ambient RH is below 95%, and only green ambient scattering coefficient is reported.

$$f(RH)_{RH\_Sc,amb} = (\frac{100 - RH_{amb}}{100 - RH\_Sc})^{-GAMMA} \qquad \textit{Eq. 9}$$

$$C_{scat,amb} = C_{scat,RH\_Sc} \cdot f(RH)_{RH\_Sc,amb} \qquad \textit{Eq. 10}$$

The derived ambient extinction coefficient, scattering Angstrom exponent, and SSA are calculated in the same way as their specified relative humidity counterparts, except that ambient scattering coefficients replace the specified RH ones in the calculations. These parameters are only reported when the ambient RH is below 95%. Caution should be used when interpreting ambient parameters in conditions below 0°C.

Additionally, a heavily modified Aerodyne CAPS-PM_{SSA} instrument operated at 530nm was flown as part of this payload. However, the resulting scattering and absorption coefficients are considered redundant, and the data are not reported pending further QA/QC.

3.6.2.2.2 Future plans

The LARGE group plans analysis (ongoing) to determine the cut size of the CIRPAS community inlet using data from the Twin Otter as well as instrumentation stationed at the Marina control tower during low approaches performed at the beginning and end of flights at the Marina airport.

3.6.3 LI-Nephelometer

3.6.3.1 Instrument background

The Laser Imaging Nephelometer (LiNeph, Ahern et al. 2022) was part of the payload aboard the CIRPAS Twin Otter. Like most integrating nephelometers, the LiNeph measures the light scattered by aerosols that it draws into its sample cavity through a sampling inlet. However, the LiNeph measures not only the intensity of the scattered light, but also the directionality with ~0.5° resolution. This is typically reported as the aerosol scattering phase function (P11). The LiNeph also reports the degree of linear polarization, which aids in further constraining the optical properties of the aerosol. An important caveat of the LiNeph measurement is that the aerosol must be brought into the aircraft before the phase function and DoLP can be measured. Because this perturbs the relative humidity, and therefore the composition and size of the potentially hygroscopic particles, it is generally best practice to reduce the sample flow to a relative humidity of <40% RH. Further, a key assumption to the operating principle of the LiNeph is that the aerosol within the instrument is uniformly mixed. However, for aerosol populations with small concentrations of large particles, this is unlikely to be true. To address this, we use an aerosol impactor upstream of the LiNeph which removes particles with diameters greater than 1.5μm.

3.6.3.2 Data

We have submitted the scattering phase functions at 405 and 660 nm for dry particles with diameters less than 1.5 μm as final data R1. We use a nearest-neighbor approximation to account for truncation (Ahern et al., 2022). From those scattering phase functions, we can directly calculate three aerosol optical properties at each wavelength: the aerosol scattering coefficient (σ_{sca}), the aerosol scattering asymmetry parameter (g), and the hemispheric backscatter fraction (b).

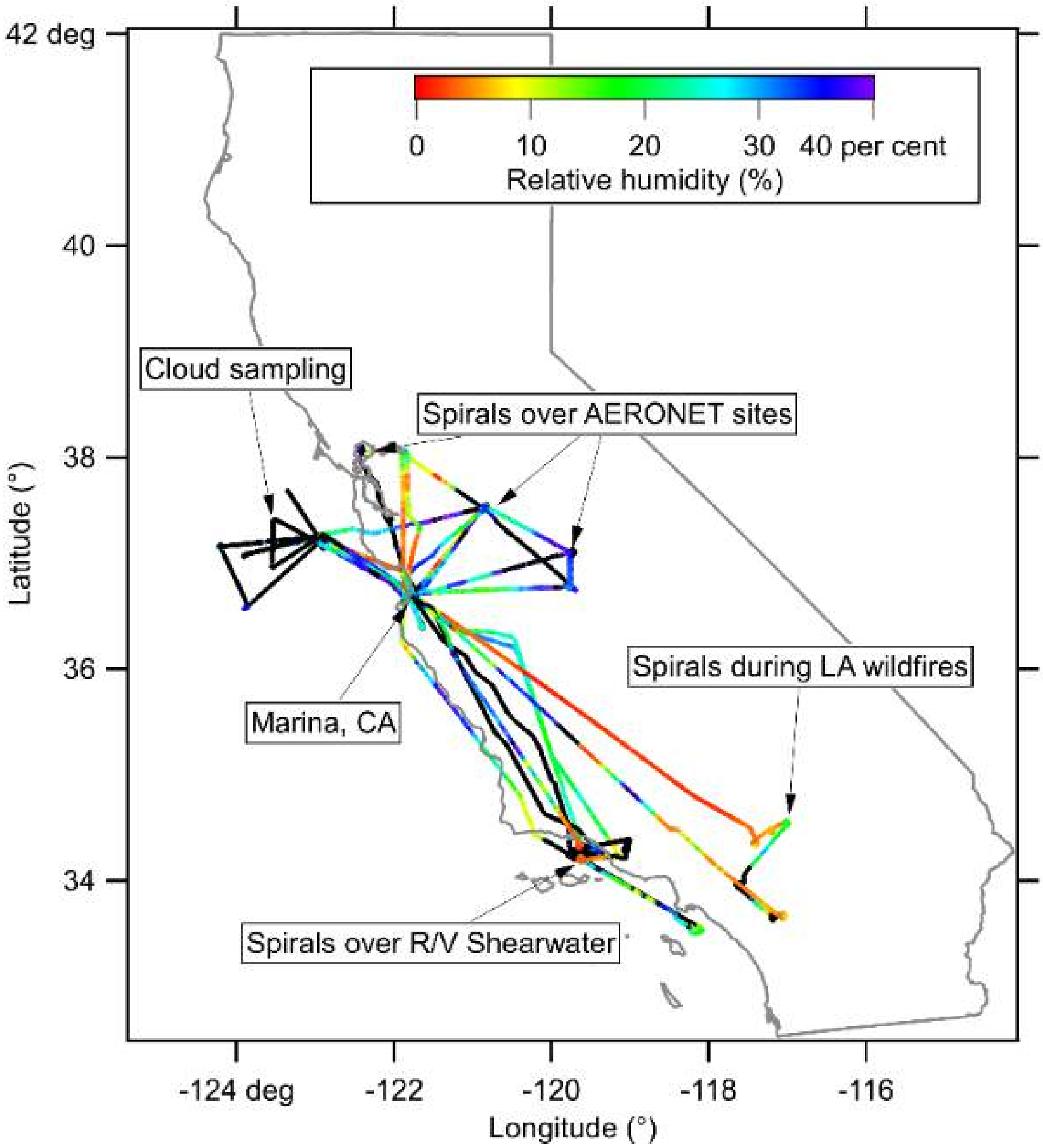


Figure 22 Flight tracks of the CIRPAS Twin Otter during PACE-PAX. Colored points indicate when ambient relative humidity was <40% and can be directly compared to retrieval algorithms.

3.6.3.3 Analysis and Future plans

Future work will be focused on developing flags for comparisons with remote sensors and outputs from the GRASP retrieval algorithm (Dubovik et al. 2021). The flags for the remote sensing community will indicate that measurements of the relative humidity and particle size distributions indicate that the phase functions measured by the LiNeph are representative of what is expected in ambient conditions, i.e. that there is negligible contribution of scattering from larger particles and the relative humidity was <40% RH (see Figure 22) . The GRASP retrieval program has been used previously with LiNeph data to infer the real refractive index of aerosols (Ahern et al., 2025). When combined with additional measurements of aerosol absorption, it can also retrieve the imaginary component of the complex refractive index (Espinosa et al., 2019).

These retrieved values will be made available and will be compared with the products from the ISARA team using in situ measurements from the NASA Langley Aerosol Research Group.

3.6.4 ATC tower facility

During PACE-PAX, LARGE operated a suite of aerosol optical and microphysical property instruments sampling from the control tower at Marina Municipal Airport (KOAR). Objectives for the tower sampling were threefold: 1) provide aerosol context during PACE-PAX flight activities, 2) assess the sampling efficiency of the Twin Otter aircraft inlet, and 3) test developmental hyperspectral optical instrumentation.

Sample flow for all instruments was provided by an omnidirectional URG PM10 inlet (model URG-2000-30DBN-A) mounted on the roof of the tower, except for the SpEx instrument that sampled from a simple downward-facing 1.75 cm ID conductive silicone tube with a coarse metal screen to inhibit insect activity. Each inlet was approximately 18 m above ground level (i.e., 60 m above mean sea level), with instruments operating in the enclosed control room one floor below. All transport tubing was made of conductive silicone, and bends were intentionally gradual to minimize particle losses.

Figure 23 LARGE Instruments in the control tower at Marina Municipal Airport during PACE-PAX

3.6.4.1 Data

Data collected by the LARGE group is organized into six datasets or "dataIDs": PACEPAX-LARGE-APS, PACEPAX-LARGE-UHSAS, PACEPAX-LARGE-MICROPHYSICAL, PACEPAX-LARGE-OPTICAL, PACEPAX-LARGE-SpEx, and PACEPAX-LARGE-SALAD. All datasets are available in ICARTT format via the campaign data archive, and DOIs are located at the NASA ASDC. Hyperspectral datasets will also be archived in NetCDF format. Instrument computer times were manually synced on a regular basis, but individual measurements have not been time shifted relative to each other (e.g., for differences in residence time between the instruments and the inlet). Caution should be used when examining variability at resolutions faster than ~1 minute. Note that the data have not been evaluated for potential impacts from cloud/fog and precipitation. No corrections have been applied for potential inlet particle loss effects.

3.6.4.1.1 PACEPAX-LARGE-APS

The APS dataset consists of normalized aerodynamic size distribution data (597- 11028nm diameter) from the Aerodynamic Particle Sizer instrument (APS; Model 3321, TSI, Inc.) operated on the PM10 inlet on the Marina control tower, as well as integrated statistics of particle number, surface area, and volume concentrations. All APS measurements are reported at STP conditions (i.e., 0°C and 1013.25 hPa). APS size distribution data is normalized as dN/dlogDp and reported in units of cm^{-3}. Sizing is measured in aerodynamic diameter, which can be converted to geometric diameter using the following formula: $D_{geo} = D_{aero}\sqrt{\frac{S}{\rho}}$, where S is the shape factor and ρ is the particle density. APS size distributions are calibrated and processed with respect to midpoint NIST-traceable polystyrene latex (PSL) sphere-equivalent aerodynamic diameters, rebinned from the native instrument bins to a standard rebinning scheme (i.e., dlogDp for diameters less than 1000 nm is 0.05 (20 channels per decade) and dlogDp for diameters greater than or equal to 1000 nm is 0.1 (10 channels per decade)) and assuming spherical particles with a density of 1 g cm^{-3}. Integrated statistics are computed by multiplying the number concentration of particles in each bin by the appropriate formula for the surface area and volume of a sphere. Then, the number, surface area, and volume concentrations are summed across the full instrument detection range to derive the integrated statistics.

$$IntegN = \sum_{Dp} \frac{dN}{dlogDp} dlogDp \quad \text{Eq. 11}$$

$$IntegS = \sum_{Dp} (\frac{dN}{dlogDp} dlogDp)(\pi Dp^2) \quad \text{Eq. 12}$$

$$IntegV = \sum_{Dp} (\frac{dN}{dlogDp} dlogDp)(\frac{\pi}{6} Dp^3) \quad \text{Eq. 13}$$

The sample flow for the APS is not dried and therefore is at roughly ambient relative humidity. Actual RH for APS measurements is consistent with the RH_Sc variable in the PACEPAX-LARGE-OPTICAL dataset. Bin bounds and midpoint diameters are reported in the file headers.

3.6.4.1.2 PACEPAX-LARGE-UHSAS

The UHSAS dataset consists of normalized optical size distribution data (84.3-1054.4nm diameter) from the Ultra High Sensitivity Aerosol Spectrometer instrument (UHSAS; Model UHSAS-0.055, Droplet Measurement Technologies) operated on the PM10 inlet on the Marina control tower, as well as integrated statistics of particle number, surface area, and volume concentrations. All UHSAS measurements are reported at STP conditions (i.e., 0°C and 1013.25 hPa). UHSAS size distribution data is normalized as dN/dlogDp and reported in units of cm^{-3}. Sizing is calibrated and processed with respect to midpoint ammonium-sulfate-equivalent optical diameters (i.e., assuming a refractive index of 1.52). The size distributions have been rebinned from the native instrument bins to a standard rebinning scheme (i.e., dlogDp is 0.05 (20 channels per decade), consistent with the APS dataset in this size range). Integrated surface area and volume concentrations are calculated by assuming spherical particles. The sample flow for the UHSAS is actively dried using a Nafion drier to reduce the RH to less than 40%. Bin bounds and midpoint diameters are reported in the file headers.

3.6.4.1.3 PACEPAX-LARGE-MICROPHYSICAL

The MICROPHYSICAL dataset consists of integrated statistics of particle number, surface area, and volume concentration within selected diameter ranges from the UHSAS and APS instruments, as well as total number concentration of particles greater than 10nm diameter from a condensation particle counter (CPC; Model 3772, TSI, Inc.). The selected size ranges for the UHSAS and APS are 100-1000nm (inclusive) and greater than 1000nm, generally representing the accumulation and coarse aerosol modes, respectively. Equations 1-3 are applied to the normalized UHSAS and APS size distribution data for the selected size ranges. All other corrections and reporting conditions that apply to the instrument size distribution datasets also apply to the microphysical integrated statistics (e.g., STP conditions, etc.).

3.6.4.1.4 PACEPAX-LARGE-OPTICAL

The OPTICAL dataset consists of measured aerosol scattering, absorption, and extinction coefficients, as well as derived optical parameters. Extrinsic parameters (i.e., scattering, absorption, and extinction coefficients) are reported at STP conditions.

Scattering coefficient at three wavelengths (450, 550, and 700nm) is measured by a TSI-3563 Nephelometer operated on the PM10 inlet on the Marina control tower. The nephelometer sample flow is not dried and therefore is at roughly ambient relative humidity; the exact instrument RH is reported by the RH_Sc variable, which should be consistent across LARGE instruments that are not actively dried (i.e., APS). The scattering coefficients are corrected for truncation errors using Anderson & Ogren (1998). Scattering coefficients are relevant to bulk aerosol (i.e., all particles sampled by the PM10 inlet).

Absorption coefficient at three wavelengths (465, 520, and 640nm) is measured by a Brechtel Manufacturing, Inc. Tricolor Absorption Photometer (TAP, Model 2901) operated on the PM10 inlet on the Marina control tower. The TAP sample flow is actively dried by heating the optical block to 35°C. The data were corrected for aerosol scattering following Equation 7 in the TAP manual (Brechtel Manufacturing Inc., 2022). Absorption coefficients have been smoothed using a 9 s boxcar algorithm for consistency with previous campaigns and are relevant to bulk aerosol.

Angstrom exponents for scattering and absorption are derived from the blue-to-red and blue-to-green wavelengths for each instrument. A 30 s smoothing is first applied to the coefficients, and Angstrom exponents are only computed when the relevant coefficients at both wavelengths are at least 2 Mm-1. Only the blue-to-red Angstrom exponent is reported for brevity. Angstrom exponents are relevant to bulk aerosol. The scattering Angstrom exponent is relevant to the RH_Sc specified relative humidity, and the absorption Angstrom exponent is relevant to dry (< 40%) relative humidity.

$$AE = -\frac{\log_{10}\left(\frac{C_1}{C_2}\right)}{\log_{10}\left(\frac{\lambda_1}{\lambda_2}\right)} \qquad \text{Eq. 14}$$

where C_1 and C_2 are scattering (or absorption) coefficients at λ_1 and λ_2 wavelengths.

Single scattering albedo (SSA) at three wavelengths (450, 550, and 700nm) is derived from scattering and absorption coefficients at blue, green, and red wavelengths, respectively. A 30 s smoothing is first applied to the coefficients, and then the absorption coefficients are adjusted to the scattering wavelengths using an assumed Angstrom exponent of 1. SSA at a given wavelength is only computed when both the scattering and absorption coefficient (after smoothing and wavelength adjustment) at that wavelength are at least 2 Mm-1. SSAs are relevant to bulk aerosol and the RH_Sc specified relative humidity.

$$SSA_\lambda = \frac{C_{scat,\lambda}}{C_{scat,\lambda}+C_{abs,\lambda}} \qquad \text{Eq. 15}$$

Extinction coefficient at 532nm is derived from the sum of nephelometer scattering and TAP absorption. The green absorption coefficient was adjusted from 520nm to 532nm using an assumed absorption Angstrom exponent of 1. The green scattering coefficient was adjusted from 550nm to 532nm using the calculated scattering Angstrom exponent between 450nm and 550nm; therefore, an implicit threshold of at least 2 Mm-1 scattering coefficient (after 30 s smoothing) is used to calculate the extinction coefficient. To improve data coverage, if the absorption coefficient is unavailable, the extinction coefficient is reported as the wavelength-adjusted scattering coefficient (i.e., assuming the green absorption coefficient is 0 Mm-1). The extinction coefficient is relevant to bulk aerosol and the RH_Sc specified relative humidity.

Additionally, a 530nm Aerodyne CAPS-PMSSA instrument was operated as part of this payload. However, the resulting scattering and absorption coefficients are considered redundant, and the data are not reported pending further QA/QC.

3.6.4.1.5 PACEPAX-LARGE-SpEx

The LARGE Spectral Aerosol Extinction (SpEx) instrument is a custom built in-situ instrument to measure extinction coefficient spectra (300 - 800 nm at ~0.8 nm resolution) using a White-type optical cell (Jordan et al., 2015). SpEx provides an extinction spectrum every 4 minutes with an uncertainty of approximately ±5 Mm-1 over the full wavelength range. This implies a detection limit of 15 Mm-1, but averaging allows for measurements in cleaner conditions. All aerosols were measured at ambient conditions, and actual RH for SpEx measurements is assumed to be consistent with the RH_Sc variable in the PACEPAX-LARGE-OPTICAL dataset. SpEx did not sample behind the PM10 inlet used for all other tower instrumentation and thus is not limited to particles with diameter < 10um. Hourly mean spectra and their standard deviations are provided in the archive throughout the tower deployment. These spectra are provided at native wavelength resolution, while single scattering albedo (SSA) is calculated at 5nm resolution when spectral absorption data is also available from the LARGE SALAD instrument. All extinction data from SpEx are reported at STP conditions (i.e., 0°C and 1013.25 hPa).

The size of SpEx and its low temporal resolution limits its deployment to ground-based platforms. Thus, for the first time, a more compact version (SpEx-2) intended for airborne platforms was assembled and tested at Marina tower. This deployment yielded important information on the SpEx-2 configuration and operation, but not science quality data. Hence, no SpEx-2 data is present in the archive. Note that the LARGE SpEx instruments are unrelated to the polarimeters on PACE or on the NASA ER-2 with similar names, and we apologize for any confusion.

3.6.4.1.6 PACEPAX-LARGE-SALAD

The LARGE Spectral Aerosol Light Absorption Detector (SALAD) instrument is still under development, with its first science field deployment in early 2024 for the ASIA-AQ field campaign. It is intended to be paired with SpEx-2 for airborne sampling of spectral aerosol absorption coefficients and deriving SSA spectra. For this dataset, SALAD is paired with the original LARGE SpEx to provide valuable 5nm-resolution SSA. Hourly-averaged absorption spectra and their standard deviations are provided in the data archive at native 0.8 nm wavelength resolution. These data are normalized to TAP absorption coefficients to account for aerosol scattering and filter effects. Details on the instrument uncertainty will be provided in the metadata of the archived files and in the upcoming publication with the full instrument description. All SALAD aerosols were measured using the PM10 inlet at ambient conditions, and all absorption data from SALAD are reported at STP conditions (i.e., 0°C and 1013.25 hPa).

Table 13 Overall payload specifications, ATC tower facility

Measured Parameter	Instrument	Uncertainty	Size Range (µm)
Total Aerosol Number Concentration	TSI-3772 CPC	10%	> 0.01
Aerosol Size Distributions	DMT UHSAS	20%	0.08-1.05
	TSI-3321 APS		0.59-11.0
Total Scattering Coefficient (450, 550, and 700 nm)	TSI-3563 Nephelometer at RH < 40%	1 Mm^{-1}, 20%	< 10
Total Dry Absorption Coefficient (470, 532, 660nm)	Brechtel TAP at RH < 40%	2 Mm^{-1}, 15%	< 10
Sub-micron Dry Extinction Coefficient and Scattering Coefficient at 532nm	Aerodyne CAPS-PM_{SSA} at RH < 40%	1 Mm^{-1}, 10%	< 1.0
Total Aerosol Hyperspectral Absorption Coefficient (300-800 nm)	Spectral Aerosol Light Absorption Detector (SALAD)	*	< 10
Total Aerosol Hyperspectral Extinction Coefficient (300-800 nm)	Spectral aerosol Extinction (SpEx)	5 Mm^{-1}	*
	Spectral aerosol Extinction-2 (SpEx-2)	N/A*	< 10

3.6.4.2 Future plans

The LARGE group plans analysis (ongoing) to determine the cut size of the CIRPAS community inlet using coincident data from the Twin Otter and the Marina control tower. Low approach maneuvers were performed at the beginning and/or end of numerous flights at the Marina airport when conditions and flight operations allowed, with the aircraft flying directly over the runway at the same height as the control tower instrumentation. Fifteen low approaches were identified, with 6 providing satisfactory data for analysis. Coarse-mode particle concentrations were not sufficient for analysis on the remaining approaches.

The PACE-PAX mission and tower deployment provided an invaluable opportunity to assess the performance of the hyperspectral optical instruments discussed above. Analysis of the data from SpEx and SALAD will be ongoing and published when appropriate.

3.7 The NASA ER-2

The ER-2 is a high altitude aircraft this is operated by the NASA Airborne Science Program (ASP). Two aircraft are based at the NASA Armstrong Flight Research Center (AFRC), and it was from there that ER-2 #806 was flown for PACE-PAX. The ER-2, which is a modified version of the Lockheed U-2, is capable of flying above 60,000 feet and lists a range and duration of 3,000 nautical miles and 8 hours. However, during PACE-PAX operational constraints limited flight duration to 6.7 hours or less. The maximum payload is roughly 1,100 kg (Navarro, 2007, ER-2 Airborne Experimenter Handbook). Two PACE-PAX instruments were installed in the nose and fuselage (aka Q bay), while the other four instruments were installed in the wing super pods (see Figure 24).

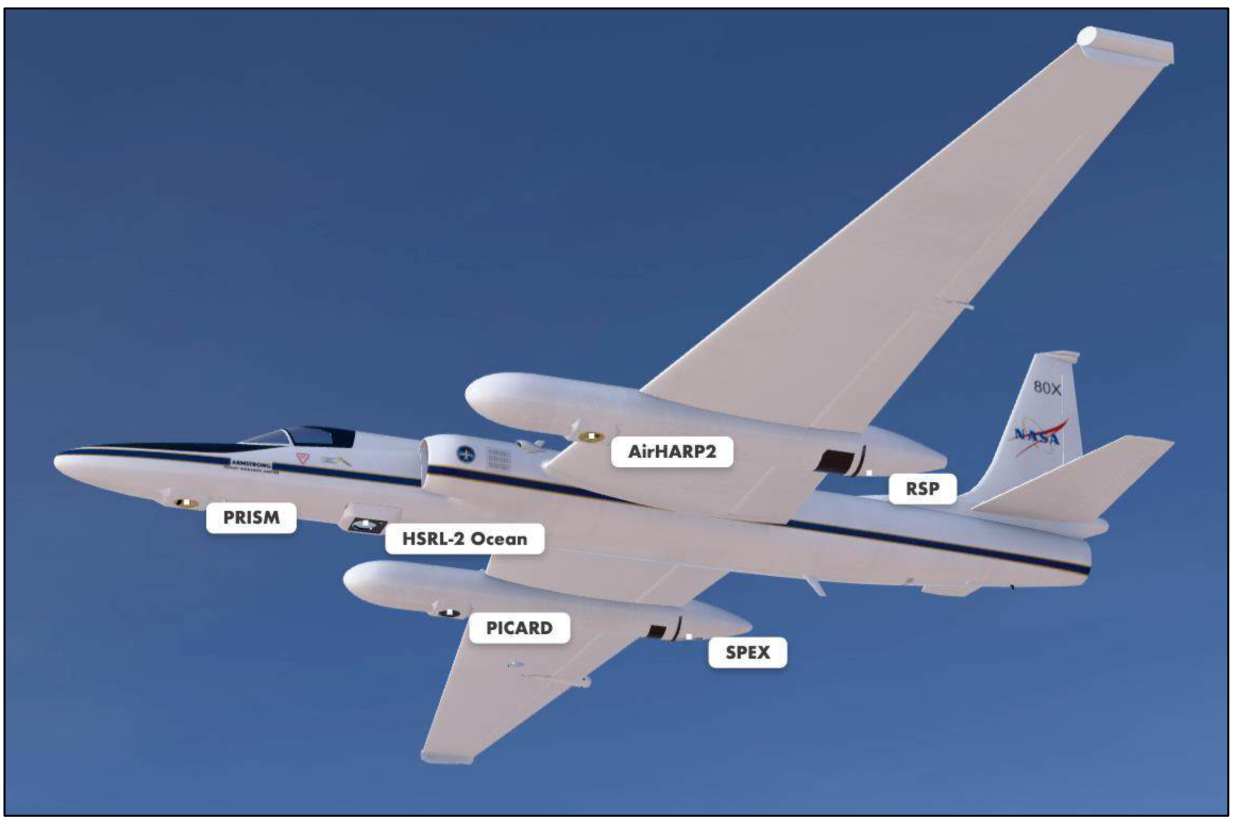


Figure 24 Rendering of the NASA AFRC ER-2, with indicated instrument placement. Renderings available at https://airbornescience.nasa.gov/3d-models

3.7.1 AirHARP

3.7.1.1 Instrument background

The AirHARP2 instrument is a wide-field of view (FOV) imaging polarimeter. It is a near 1:1 copy of the HARP2 instrument on the NASA PACE mission. AirHARP2 samples at four nominal spectral channels: 440 (15), 550 (9), 670 (11), and 870 (40) nm (parentheses indicate full-width half-maximum bandwidths). These channels are distributed over 90 discrete cross-track regions of the detector. 670 nm has 60 views forward-to-aft, with ~2° mean separation in viewing zenith angle. The other three channels have 10 views each, with ~12° mean separation in viewing zenith angle. As the instrument flies, the detectors take sequential images. Data in a given view are stitched together along-track to make a pushbroom of the scene from that specific angle. The AirHARP2 FOV spans 114° (94°) along-track (cross-track), with a nadir full-resolution pixel size of ~20 m from ER-2 altitude of 20 km. This translates to a 62 (43) km single-image along-track (cross-track) swath. The science data acquisition of AirHARP2 employs onboard binning technique, known as modified time-delayed integration (MTDI). The footprint of binned pixel on the ground is in the range of 100-200 meters depending on the field of view, prior to L1C processing.

The AirHARP2 was designed for detailed characterization of cloud and aerosol microphysical properties. The hyper-angular 670 nm channel is optimized to study the polarized cloudbow, a unique ring-like signal generated at the top of liquid water clouds (McBride et al. 2020). Cloudbow signals have tight oscillations that depend on solar and instrument viewing angles. They encode information about the droplet size distribution (DSD) of the cloud top. The DSD is a direct link between the cloud microphysics and radiation and a critical parameter related to cloud feedback, forcings, and the interaction between aerosols and clouds.

AirHARP2 multi-spectral and -angular data also allows for deeper aerosol retrievals than radiance-only instruments such as MODIS or VIIRS. In conjunction with advanced algorithms like GRASP (Puthukkudy et al. 2020), AirHARP2 data can be used to retrieve single-scattering albedo, size-discriminated aerosol optical thickness, real and imaginary refractive indices, sphericity, and particle size distribution (among others) at the pixel level and across a large spatial field.

The wide FOV, polarization, and spectral content in the data may expand and complement current and prior studies of land and vegetation, ocean, bi-directional reflectance and polarization distribution function (BRDF/BPDF) of Earth's surface, and atmosphere, as well. The wide FOV is especially suitable for cross-comparison and validation of L1 and L2 products between AirHARP2 and other co-located remote sensors.

The following table outlines the sampling characteristics of AirHARP2 and any major differences compared to HARP2 on PACE.

Table 14 AirHARP and HARP2 characteristics

Characteristic	AirHARP2	HARP2 (PACE)
Spectral Range (nm)	440 (15), 550 (9), 670 (11), 870 (40)	
Polarized Bands	All	
Number of View Angles (deg)	10* (440, 550, 870 nm), 60 (670 nm)	
Imaging Swath Width (deg)	114 (along), 94 (cross)	
Platform Height (km)	20	700
Native Nadir Pixel GSD (km)	0.02	0.7
Ground Swath Width (km)	45	1550
Instantaneous FOV (deg)	0.055	
Level 1C Resolution (km)	0.250 (R0)	5.2
Radiometric Accuracy (I, Q, U)	0.03	
Polarization Accuracy (DOLP)	0.005	
Current Data Version**	R0	V3
***Configurable **As of this writing**		

3.7.1.2 Data

The L1C data product is calibrated, geolocated, and multi-view co-located spectral radiances (W m-2 µm-1 sr-1). The quantitative calibration analysis for AirHARP2 follows the HARP2 pipeline. Details can be found at Sienkiewicz et al. (2025) and McBride et al. (2024a), with intuition from HARP2 on-orbit trending (Martins et al. 2024, McBride et al. 2024b). At each pixel, AirHARP2 produces total intensity (I) and components of linearly polarized radiance along 0-90° axes (Q) and 45-135° axes (U). These metrics are combined in other derived products: the degree of linear polarization (DoLP) and the angle of linear polarization (AoLP). The L1C data product was designed by the PACE project with the three PACE instruments in mind: OCI, HARP2, and SPEXone. The PACE L1C georegisters all three instrument data onto a common latitude-longitude grid and spatial resolution (5.2 km). The AirHARP2 L1C follows the same processing heritage, and L1C granules are segmented into 5-minute observations. However, unlike PACE, the AirHARP2 is not co-registered with other ER-2 assets or at a common spatial resolution. In R0, the L1C ground spatial resolution is 250 m. This data is located on the Langley archive under MARTINS.VANDERLEI and contains a data quality statement for version R0 as of this writing (PACEPAX-AH2MAP-L1C_ER2_DataQualityStatement_R0.pdf).

As of this writing, the AirHARP2 L1C quicklooks for the PACE-PAX campaign are hosted at on a public UMBC-based server here:https://aether.esi-cloud.org/pace-pax. Users can search by folder date and all images contain data timestamps. This server also includes HARP2 L1C quicklooks for ease of colocation: https://aether.esi-cloud.org/pace-harp2/1541. Users can search by year and date for HARP2 imagery. The content on each server may change based on current data version.

3.7.1.3 Future plans

- AirHARP2 comparisons with PVST multi-angle polarimeter assets (Forster/Al-Habashi) over ocean for vicarious calibration, glint BRDF/BPDF
- Characterize HARP2 calibration against PACE underflights (esp. for off-nadir angles)

• Assessment of aerosol and pyrocumulus events from PACE-PAX with GRASP and cloud retrieval techniques, and in conjunction with Twin Otter assets (LARGE/Li-Neph)

3.7.2 HSRL-2

3.7.2.1 Instrument background

NASA Langley Research Center's (LaRC) second-generation airborne High Spectral Resolution Lidar (HSRL-2) builds on the heritage of the LaRC HSRL-1 instrument (Hair et al, 2008). HSRL-2 uses the HSRL technique to independently retrieve aerosol and tenuous cloud extinction and backscatter (Grund et al, 1991, She et al, 1992, Shipley et al, 1983) without a priori assumptions on aerosol type or extinction-to-backscatter ratio. The LaRC HSRL-2 employs the HSRL technique at 355 and 532 nm and the standard backscatter technique at 1064 nm. It also measures aerosol and cloud depolarization at all three wavelengths. The fundamental resolution of the lidar provides profiles at 0.5 seconds ($\Delta x \sim 100$ m for typical ER-2 aircraft velocities) and vertical sampling rate of 120MHz ($\Delta z \sim 1.25$ m).

HSRL 2 provides vertically resolved measurements of the following extensive and intensive aerosol parameters below the aircraft; nominal measurement parameters are shown in Table 15.

Parameter	Wavelength (nm)	Approximate Precision	Horizontal Resolution	Vertical Resolution
Aerosol Backscatter	355/532/1064	0.2 $Mm^{-1}sr^{-1}$	2 km	30 m
Aerosol Extinction	355/532	0.01 km^{-1}	12 km	300 m
Aerosol Depolarization	355/532/1064	0.01	2 km	30 m
Aerosol Optical Depth	355/532	0.01	12 km	
Aerosol Type (e.g., marine, dust, smoke)	N/A	Qualitative	12 km	300 m
Cloud Top Height (upper layer)	532	15 m	100 m	15 m
Cloud Top Phase (upper layer)	355/532/1064	Qualitative	100 m	15 m

Table 15 Measurement parameters, wavelengths, resolutions, and precision for archived products. Note that the resolutions can be tailored with trades on precision.

The HSRL-2 instrument was carefully designed so that it does not rely on any target for calibration (Hair et al, 2008), unlike standard elastic backscatter lidars that must assume negligible aerosol in a calibration region. All the depolarization channels and the aerosol and molecular measurements at 532 nm are self-calibrating, while the 1064 nm backscatter measurement and the 355 nm HSRL measurements take advantage of the calibrated HSRL measurement at 532 nm. The overall systematic error associated with the backscatter and depolarization calibration is estimated to be less than 3%. Under typical conditions, the total systematic error for extinction is estimated to be less than 0.01 km1 at 532 nm. The random errors for all aerosol products are typically less than 10% for the backscatter and depolarization ratios (Hair et al, 2008). A study designed to validate the HSRL extinction coefficient profiles (Rogers et al, 2009) found that the HSRL extinction profiles are within the typical state-of-the-art systematic error at visible wavelengths (Schmid et al, 2006). HSRL-2 also provides column AOD values which are in excellent agreement with coincident measurements from the Aerosol Robotic Network (AERONET) (e.g. Sawamura et al, 2017).

Additional HSRL-2 derived and archived products include: 1) cloud top heights based on the gradient of particulate backscatter, and 2) aerosol type, which uses a classification algorithm to interpret the information about aerosol physical properties indicated by the HSRL-2 aerosol intensive parameters to qualitatively infer aerosol type (Burton et al, 2012), ocean 10m windspeed derived from the surface reflectance (Dimitrovic et al, 2024).

3.7.2.2 Data

HSRL-2 L2 data products are provided in a single Hierarchal Data Format Version 5 file for each flight. Full flight browse images for most of the data products are included to show the vertical curtain along the flight path as a function of time. Data are provided at 10 second intervals and all data products have been interpolated to the same uniform altitude grid above sea level (DataProducts/Altitude) and horizontally averaged or interpolated to the GPS times (Nav_Data/gps_time). Horizontal and vertical resolutions of the data products are found in the attributes of each scientific data set. Archived data files include interpolated MERRA2 reanalysis (see http://gmao.gsfc.nasa.gov/) state parameters along the flight path. The MERRA2 state parameters are used in the calculations of HSRL-2 aerosol and cloud data products. The data archive also includes a readme file that has specific information on PACE-PAX with recommendations for HSRL-2 data use.

Data Archive: DOI: 10.5067/ASDC/SUBORBITAL/PACE-PAX/DATA001/ER2/AircraftRemoteSensing/HSRL2_1
Field Data Archive: https://www-air.larc.nasa.gov/missions/pacepax/index.html

Instrument and Retrieval References: Hair et al, 2008, Burton et al, 2018

3.7.3 PICARD

3.7.3.1 Instrument background

The Pushbroom Imager for Cloud and Aerosol Research and Development (PICARD) was developed to support scientific studies of cloud and aerosol properties. PICARD observes the contiguous solar reflected spectrum from the visible/near-infrared (VNIR) through the shortwave-infrared (SWIR) (i.e. 400-2400nm) with a spectral resolution and signal-to-noise ratio (SNR) appropriate for retrieving cloud and aerosol geophysical variables (GVs). This is combined with a relatively wide-swath (approximately 50 degree FOV) that increases the general utility for scene context and enables a variety of studies and field campaigns (see Guerin et al., 2011 for concept design details). A summary of the PICARD instrument characteristics is provided in Figure 46.

Table 16 PICARD instrument characteristics

PICARD VNIR-SWIR Airborne Imaging Spectrometer	
Platform:	NASA ER-2, G-V, G-III
Ground Speed:	Variable (depending on altitude)
Altitude:	1 - 20 Km (5,000 - 65,000 Ft)
Pixel Spatial Resolution:	5 - 50 Meters (depending on altitude)

Pixels per Spectral Band:	412 (roll corrected)
Integration Time:	5.2 - 80mSec (limited by frame rate/altitude)
Swath Width:	2 - 16 Km (depending on altitude)
Field of View:	50°
Effective Focal Length	30.4mm
Instantaneous FOV (cross track):	2.12 mrad
Instantaneous FOV (along track):	1.00 mrad
Roll Correction:	+/- 15°
Spectral Bands:	204 (digitized to 16-bit resolution)
VNIR Spectrometer:	64 10nm FWHM bands, 370 - 990nm
SWIR Spectrometer:	140 10nm FWHM bands, 1.00 - 2.40µm
Frame Rate:	6.25 - 100Hz (depending on integration time)
Dimensions:	16.5"H, 10" W, 25.5" long
Weight:	91 lbs (76 lbs PICARD + 15 lbs POS-AV)

The primary purpose of the PICARD instrument is to:

- Collect high spectral resolution VSWIR (Visible to Shortwave Infrared) airborne imagery while also providing higher spatial resolution than spaceborne datasets to enable scaling studies and validation experiments. The system is capable to fly at various altitudes and has successfully flown - for high-altitude missions on the ER-2 platforms and is being reconfigured for integration on the G-III/G-V platforms. The spectral information of this system includes coverage of current MODIS, VIIRS, PACE OCI, Landsat, and like spaceborne imager spectral bands including future SBG VSWIR instrument that support land, cloud, aerosol, and atmospheric water studies.
- Underfly current and future suites of spaceborne hyperspectral imaging sensors to provide an additional radiometric calibration reference to assist with satellite instrument performance characterization. This is an important part of performance tracking and validation that the Airborne Sensor Facility has a decades long legacy of involvement within the airborne science community.

3.7.3.2 Data

The PICARD data products supporting PACE-PAX include Level-1B (L1B) geolocated and calibrated spectral radiances. These data files are included in the PACE-PAX campaign archive at the NASA LaRC Suborbital Science Data for Atmospheric Composition site, with long-term archival planned along with the other PACE-PAX datasets at ASDC.

Additional information on PICARD and its observations and data products is available at https://asapdata.arc.nasa.gov/picard/index.html, with PACE-PAX campaign and flight summaries and RGB quicklook browse imagery at https://asapdata.arc.nasa.gov/picard/data/deploy_html/pace-pax.html.

3.7.3.3 Analysis

Initial radiometric comparisons against PACE OCI have been performed for the 4 September 2024 underflight of the PACE observatory. Additional comparisons against co-located PRISM have been performed for select flight segments, as well as comparisons against ground-based RadCalNet observations from periodic overflights of Railroad Valley, Nevada.

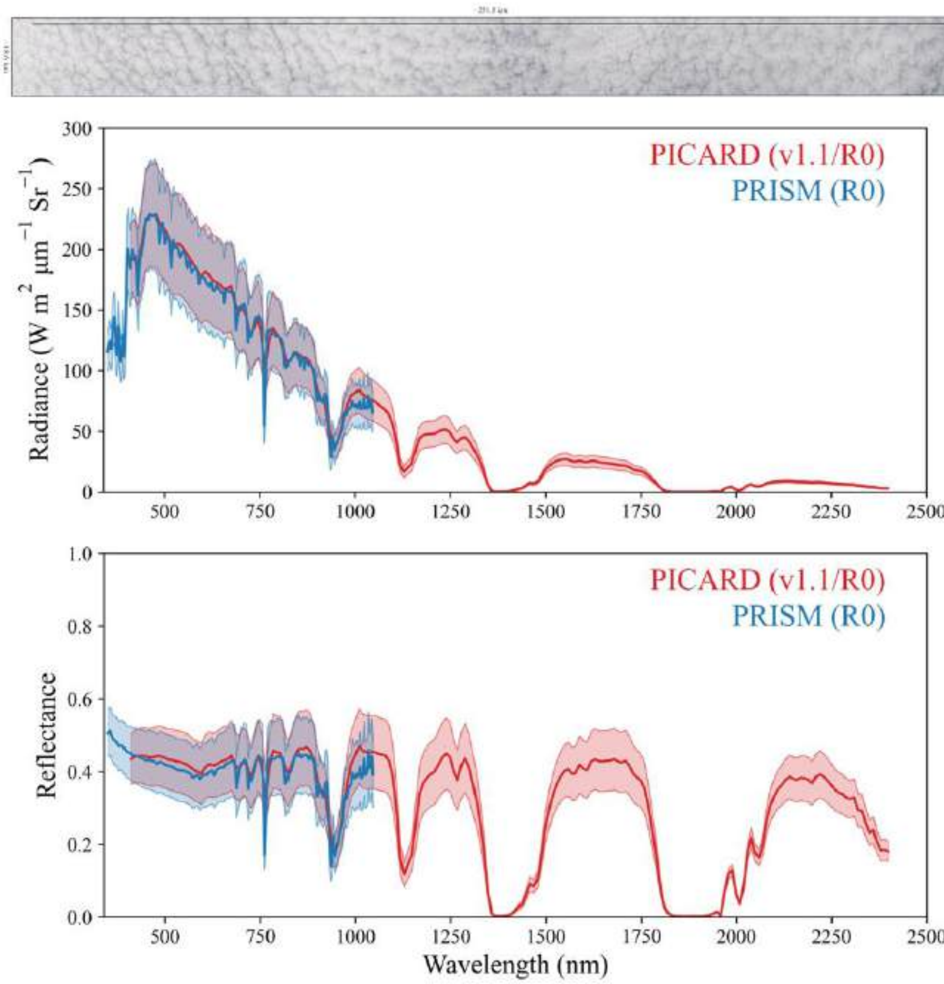


Figure 25 PRISM/PICARD comparison

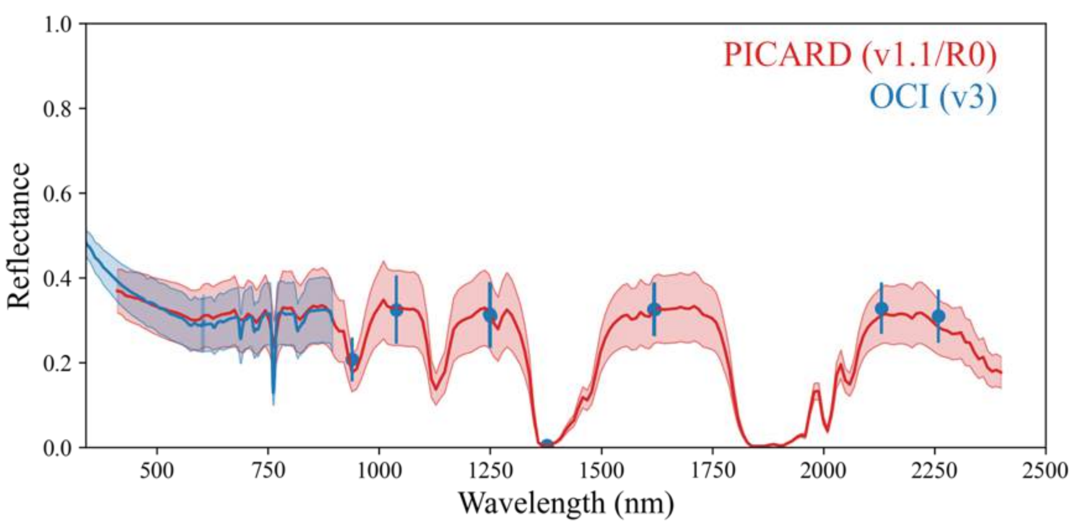


Figure 26 PICARD/OCI comparison

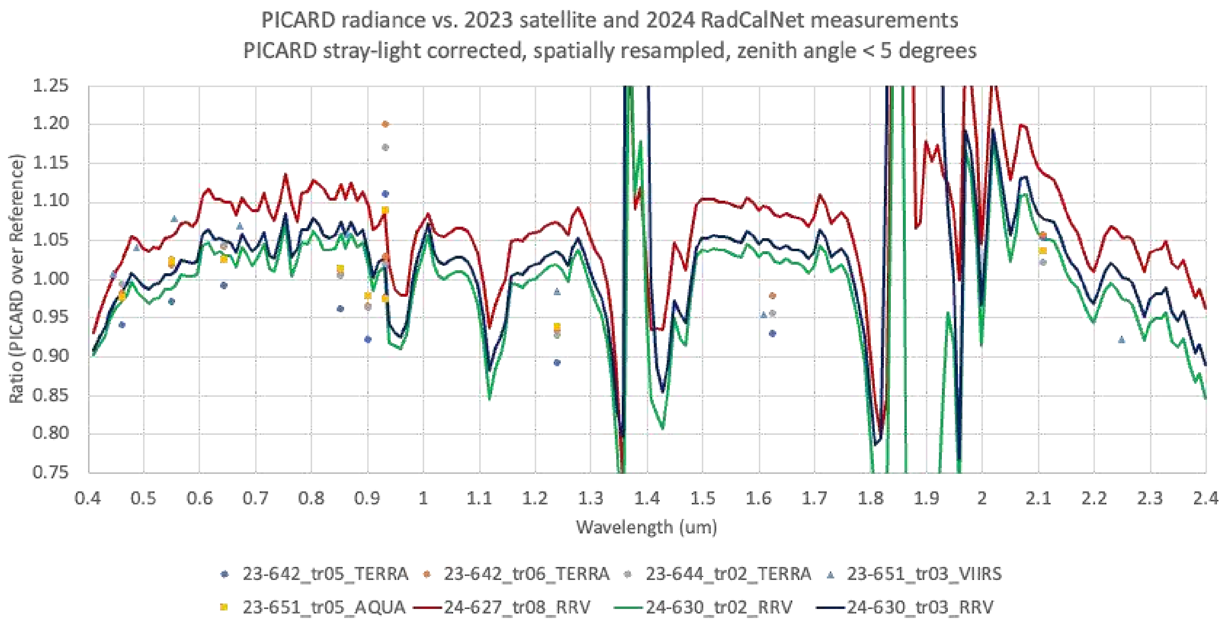


Figure 27 Figure 27: Ratio of PICARD radiance measurements over satellite radiance measurements (MODIS TERRA, MODIS AQUA, and NOAA-20 VIIRS) and USGS RadCalNet modeled at-sensor radiance.

3.7.3.4 Future plans

Future plans include production of cloud property retrievals using algorithms consistent with MODIS/VIIRS, efforts that also include development of new approaches for cloud detection, cloud thermodynamic phase classification, and cloud-top height retrievals. In addition, we plan to pursue comparisons of cloud droplet microphysical retrievals against co-located Twin Otter cloud probe observations, along with an exploration of enhanced microphysical information content leveraging the full spectral observations across the SWIR.

3.7.4 PRISM

3.7.4.1 Instrument background

The Portable Remote Imaging Spectrometer (PRISM) is a compact, high-throughput (F/1.8), high-uniformity, and polarization-insensitive Dyson pushbroom imaging spectrometer designed for coastal ocean and aquatic remote sensing from an airborne platform. It captures data across the near-ultraviolet to near-infrared spectral range (350–1050 nm) with ~3nm spectral resolution, making it an ideal analog for the PACE OCI VIS/NIR hyperspectral spectrometer. Over the last decade, PRISM has been deployed in a range of aircraft and NASA campaigns including CORAL, S-MODE, and BioSCape, demonstrating versatility in various aquatic observations.

Table 17 PRISM measurement characteristics

Spectral		
	Sampling	2.83 nm
	Resolution (FWHM)	3.5 nm typ
	Calibration uncertainty	<0.1 nm
Spatial	Field of view	30.7°
	Instantaneous FOV sampling	0.882 mrad
	IFOV resolution (FWHM)	0.97 mrad
	Cross-track spatial pixels	608
Radiometric	Range	0 – 99% R
	Sampling	14 bit
	Calibration uncertainty	<2%
	Signal to Noise Ratio	500 @ 450 nm
	Polarization variation	<1%
Uniformity	Spectral cross-track uniformity	>95%
	Spectral IFOV mixing uniformity	>95%

3.7.4.2 Data

L1B radiance data has been delivered to the archive, including both ortho-corrected and non-orthocorrected products. The radiance NetCDFs contain non-orthorectified radiance data along with latitude/longitude information and Ground Look Table (GLT) data. OBS file uploads are also accessible via the archive. The team performed an in-situ field calibration at Ivanpah playa during coordinated passes of PACE and the PACE-PAX ER-2, with raw .asd files, a .csv with the processed spectra, and a .csv with Microtops data available. PRISM quicklooks are publicly available through the PRISM VISIONS portal at https://popo.jpl.nasa.gov/mmgis-aviris/?mission=PRISM. The PRISM team collaborates with the PICARD team and GSFC to facilitate a merged L1C product (see Section 3.11.2), including associated data quality documentation.

3.7.4.3 Analysis

The PRISM data were analyzed using the standard calibration procedure developed for PRISM from other airborne imaging spectrometers like the AVIRIS-NG/AVIRIS-3 series. The basic procedure is described in Chapman et al. (2019). First, a dark (closed-shutter) frame and a series of electronic corrections first establish the zero point of the data, i.e. the signal level when no photons are received at the aperture. Then, a flat field normalizes spatial variability in the focal plane array response. Finally, radiometric calibration coefficients translate the dark-subtracted DNs into radiance units. To obtain the wavelength assignment of each channel, we feed a laboratory integrating sphere with lasers of known wavelengths and measure their peak locations as a function of cross track position. Spatial variability of the wavelength calibration is very small, so that the spectral response functions can be considered uniform across the instrument field of view. Each pixel is geolocated independently by tracing the look direction of that Focal Plane Array (FPA) element geometrically to the Earth's surface, using a Global Positioning System / Inertial Measurement Unit affixed to the Focal Plane Array to determine the sensor pose.

3.7.5 RSP

3.7.5.1 Instrument background

The Research Scanning Polarimeter (RSP) makes extremely accurate hyper-angular polarimetric and radiometric observations in nine spectral bands from the deep blue to the Short Wave InfraRed (SWIR). The RSP was developed to be an airborne simulator for the Earth Observing Scanning Polarimeter that was part of the original manifest of instruments for the NASA Earth Observing System. Subsequently, the RSP served as the functional design for the Aerosol Polarimetry Sensor on the NASA Glory satellite mission. The first RSP sensor, RSP1, was completed in 1999 with a second sensor, RSP2, beginning its operational life in 2001. Both sensors had an inflight polarimetric calibrator and a cover to protect the optics added in 2002. The two RSP sensors have since participated successfully in more than 35 field deployments over the last 25 years. The RSP1 sensor has been primarily based on the East coast of the United States and flown on platforms (Cessna 210, British Aerospace Jetstream 31, Lockheed P-3, Lockheed C-130, King Air 200) where an operator can control the cover, check the data and provide basic cloud remote sensing retrievals. The RSP2 sensor has been based on the West coast and has been operated on high altitude aircraft (Scaled Composites Proteus, NASA ER-2) where operations are controlled by the pilot.

The RSP is designed to make inherently highly accurate polarimetric measurements (Cairns et al. 1999) and the details of the sensor performance are given in Table 18, below. The RSP scanner uses a crossed mirror configuration such that the transmission through the scanner is the same no matter what the orientation of the polarization of the incident light. Wollaston prisms with an extinction efficiency of 10,000:1 are used as the polarization analyzers. The detectors measure orthogonal polarizations using pairs of photodiodes on the same chip to ensure matched performance for the two channels. To measure the Stokes parameters I, Q and U, the RSP uses one telescope to measure and I and Q and a second telescope to measure I and U. There are therefore redundant measurements of the intensity that can be used to increase the signal to noise ratio of the intensity observations. To provide measurements of I, Q and U in multiple spectral bands each telescope uses dichroic beam splitters and bandpass filters to define three spectral bands in each telescope. It therefore requires two telescopes to measure I, Q and U in three spectral bands and the RSP uses a total of six telescopes to provide measurements of I, Q and U in nine spectral bands: six bands in the visible/near infrared spectral range and three bands in the SWIR range. Seven of the nine RSP spectral bands are in atmospheric windows so that they can be used for remote sensing of clouds (Alexandrov et al. 2012a, 2012b, 2018), aerosols (Waquet et al. 2009, Knobelspiesse et al. 2011, Wu et al. 2016, Stamnes et al. 2018) and characterization of land surfaces (Elias et al. 2004, Knobelspiesse et al. 2008, Litvinov et al. 2010, 2011). The other two spectral bands are in water vapor absorption bands at 940 nm and 1880 nm. The observations at 940 nm are used to estimate column water vapor and those at 1880nm to detect thin cirrus clouds. The RSP provides contiguous Earth view observations every 0.8° over ±60° from nadir. Additional, a dark reference and a polarimetric calibrator are observed on every rotation of the scanner so that the calibration state of the observations can be continuously tracked. The scan period is 0.8409 seconds so that at the typical operational speed (220 m/s) and altitude (20 km) of the NASA ER-2 consecutive nadir views are 33% overlapped. A detailed description of the RSP sensor model and its measurement uncertainties including the signal to noise ratio as a function of radiance is provided at https://data.giss.nasa.gov/pub/rsp/rsp-utilities/documents/RSP_Sensor_Error_Model_v3.pdf.

Table 18 RSP instrument performance parameters

Description	Performance Parameter
# Earth View Samples	152
# Dark View Samples	10
# Inflight Polarimetric Calibrator Samples	10
Spectral Band Centers (nm)	410.3, 469.1, 555.0, 670.0, 863.5, 961.6, 1588.9, 1884.5, 2264.4
Instantaneous Field of View (mrad)	14
Spatial Resolution (nadir, m)	280
Spatial Sampling (nadir, m)	185
Polarimetric Accuracy (DoLP, %)	0.2
Radiometric Accuracy (%)	3.0

3.7.5.2 Data

The RSP data that has been submitted to the archive are L1B, L1C and L2 cloud retrieval files. L1B data is time ordered, calibrated and each viewing angle is provided with the geolocation of that view to the surface. L1C data has the multiple views collocated to the nearest nadir pixel, such that a multi-angle view of the same scene is provided and is in the format that is specified for the PACE mission L1C files. For both L1B, L1C and L2 cloud data each file consists of a single straight flight leg section. All the files for a given day and file type are provided in a zip file on the data archive. L1B data from aircraft turns can be provided if desired, but typically this type of data is only used when flying at low altitude, in order to characterize surface polarized bidirectional reflectance distribution function.

The L1B files contain observed normalized radiances, degree of linear polarization, angle of polarization and the Stokes parameters Q and U (in normalized radiance units) for each viewing angle and wavelength. The L1B files also contain aircraft_platform (GPS location and attitude of the aircraft), bin_attributes (time stamps for each observation), calibration (the calibration coefficients used to convert from digital numbers to calibrated radiance and polarization), engineering (instrument diagnostics including temperatures and voltages), geolocation_data (which includes geolocation of each view, solar and viewing geometry, angle to rotate Q and U into the scattering plane and terrain height of each view at the surface), retrievals (duplicate solar geometry data and values defining start and end of unvignetted observations data) and sensor_view_bands (spectral band centers) groups. The L1C data have the same groups as the L1B data and have all viewing angles collocated to the nearest nadir view of the surface, or cloud top when clouds are present. The L2 cloud data includes parametric retrievals of cloud droplet effective radius and variance and estimates of their uncertainty (Alexandrov et al. 2012a), statistics that can be used to assess the quality of the parametric retrievals, bispectral retrievals of cloud droplet effective radius and optical depth using non-absorbing (865 nm) and absorbing (1588.9 and 2264.4 nm) bands (Meyer et al. 2025) and cloud droplet size distributions estimated using the Rainbow Fourier Transform technique (Alexandrov et al. 2012b). In addition, total column water vapor estimates are provided that use both the total and polarized radiance in the 960 nm RSP spectral band and auxiliary products such as cloud albedo, lidar ratio and droplet extinction cross section that are derived from the droplet size retrievals.

3.7.5.3 Analysis

Initial comparisons between airborne RSP cloud droplet effective radius retrievals and PACE mission OCI and HARP2 cloud products show good agreement with a small high bias for both HARP2 and OCI (Figure 28, Figure 29).

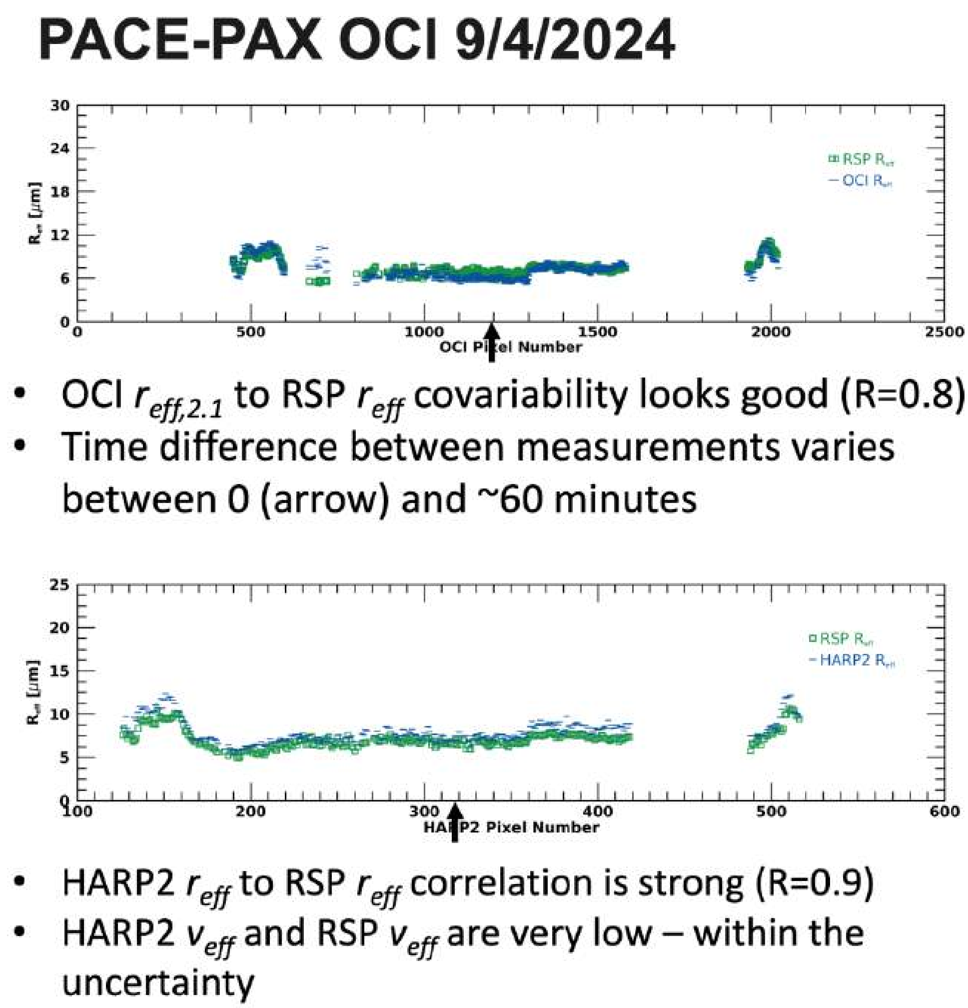


Figure 28 Initial comparison between PACE/OCI and RSP cloud property retrievals, for September 9th, 2024

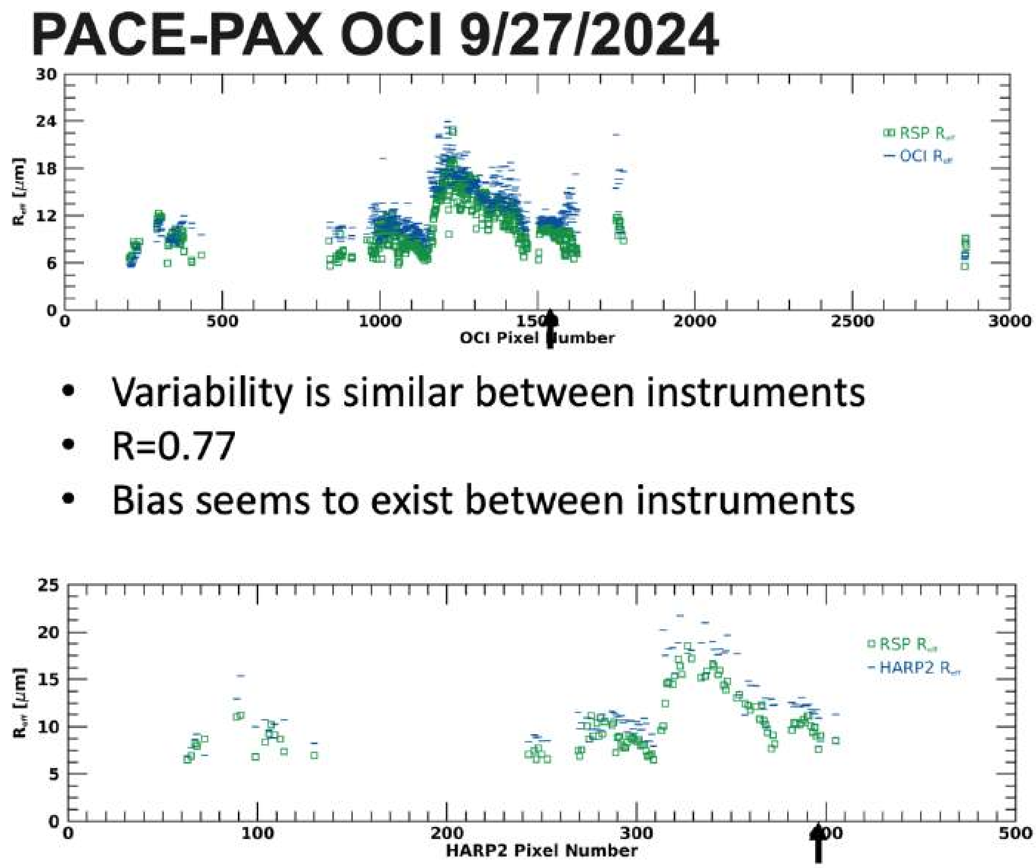


Figure 29 Initial comparison between PACE/OCI and RSP cloud property retrievals, for September 27th, 2024

3.7.5.4 Future plans

We are currently evaluating the ability to retrieve liquid water path and droplet number concentration from RSP, OCI and HARP2 observations by comparison to in situ observations from the CIRPAS Twin Otter during PACE-PAX. We expect to provide L2 aerosol retrievals over ocean and land using the MAPP retrieval algorithm (Stamnes et al. 2018).

3.7.6 SPEX Airborne

SPEX airborne is a spectro-polarimeter instrument providing hyperspectral, multi-angular radiometric and polarimetric data in the visual wavelength range. The instrument was originally developed as a prototype "SPEX" to detect and characterize Martian atmospheric dust, using spectral modulation as a means to determine the degree of linear polarization (Laan et al, 2017, Rietjens et al, 2010, Smit et al, 2019). When laboratory measurements indicated that sub-percent accuracy measurements of DoLP were possible, the SPEX-concept became a candidate for an aerosol-instrument for Earth observation. The optical module of the SPEX prototype was subsequently complemented to a complete system "SPEX airborne" to operate from NASA's high-altitude research aircraft ER-2. After the maiden flight in 2016, it has participated in the ACEPOL campaign in 2018 (Fu et al, 2020, Knobelspiesse et al, 2020), and in the SCARBO flight campaign in 2020. The ACEPOL campaign included also RSP and airMSPI polarimeters, allowing for inter-instrument data comparisons at measurement level Smit et al, 2019 and at derived aerosol product level (Fu et al, 2020). This showed excellent performance of SPEX airborne and paved the way for the space-borne member of the SPEX family: SPEXone on board NASA's PACE mission, launched in 2024 (van Amerongen et al, 2019, Rietjens et al, 2021, 2022, Hasekamp et al, 2019, Tsikerdekis et al, 2022, Fu et al, 2025).

SPEX airborne instrument specifications are listed in Table 19 below. When operating from the ER-2 at 20km cruising altitude, it provides measurements from nine viewing directions nominally aligned with the ground-track. The viewing directions are distributed equally over a total viewing range of -56º to +-56º, and data are sampled for each viewing angle in push-broom mode. With each viewing angle having an equal across-track angular width of ~7º, the projected swath on ground varies from 2.4km at Nadir to 4.5km at the outermost viewing angles. The optical design provides an iFOV of one square degree (350x350 m @ Nadir). Spectra are captured in the focal plane with 2072x2072 CCD sensor, with the 7º swath heavily oversampled with ~60 pixels. This allows geolocation with an accuracy down to 0.1º (35m) by analyzing pushbroom imagery at the highest available spatial resolution to derive possible misalignments and subsequently adjusting the geolocation of L1 data. To achieve adequate SNR, data sampled with an effective exposure time of 1.75 seconds, which is 340 m along-track at the cruise speed of 200 m/s. Geolocated radiance and polarimetric data are combined to a common grid to a L1C product, which is typically just a few ground-pixels wide, but nevertheless accurately co-registered. Note in Table 19 that hyperspectral radiometric and polarimetric data have different spectral resolutions.

Table 19 SPEX Airborne instrument, L1C data specifications

Data	Spectral radiance & DoLP
# viewing angles	9 (0°, ±14°, ±28°,±42°,±56°)
Field of View	7° x 1° (2.4km x 350m @Nadir, 20 km)
Spatial resolution (optics)	1°×1° (350m x 350m, @Nadir)
Spatial sampling	0.2°×1° (140m x 350m, @Nadir)
Ground pixel size L1C	500 or 1000 m
Spectral range	400-760 nm
Spectral resolution radiance	3 nm
Spectral resolution DoLP	7-30 nm
Accuracy (DoLP)	0.002 (lab) – 0.005 (flight)
Accuracy (Radiometric)	4%

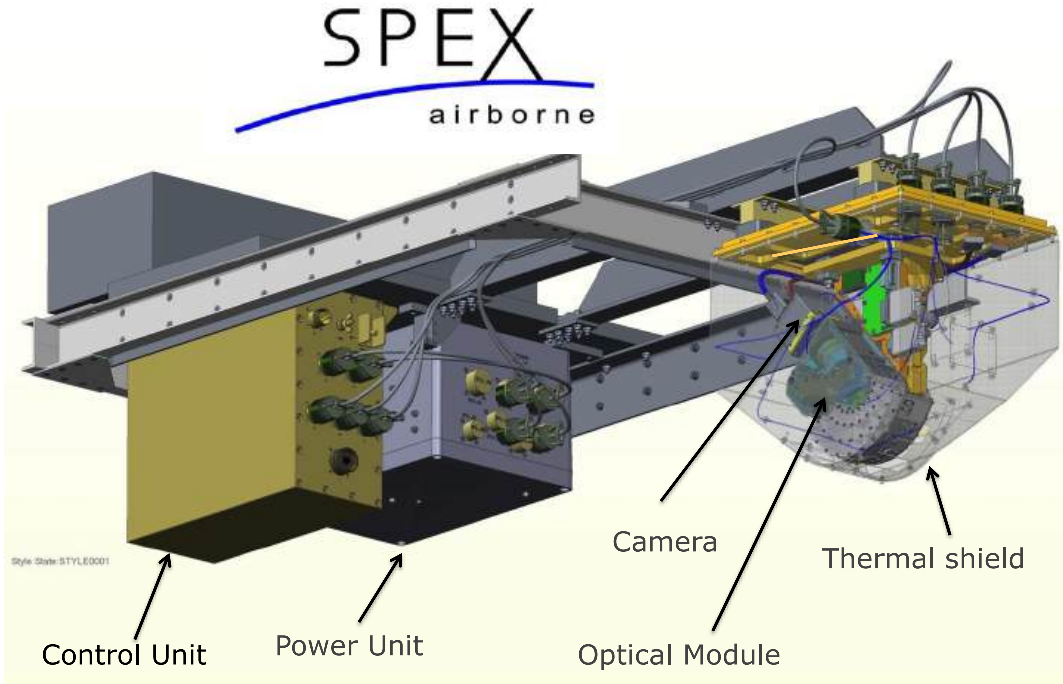


Figure 30 SPEX Airborne layout in the ER-2 wing pod.

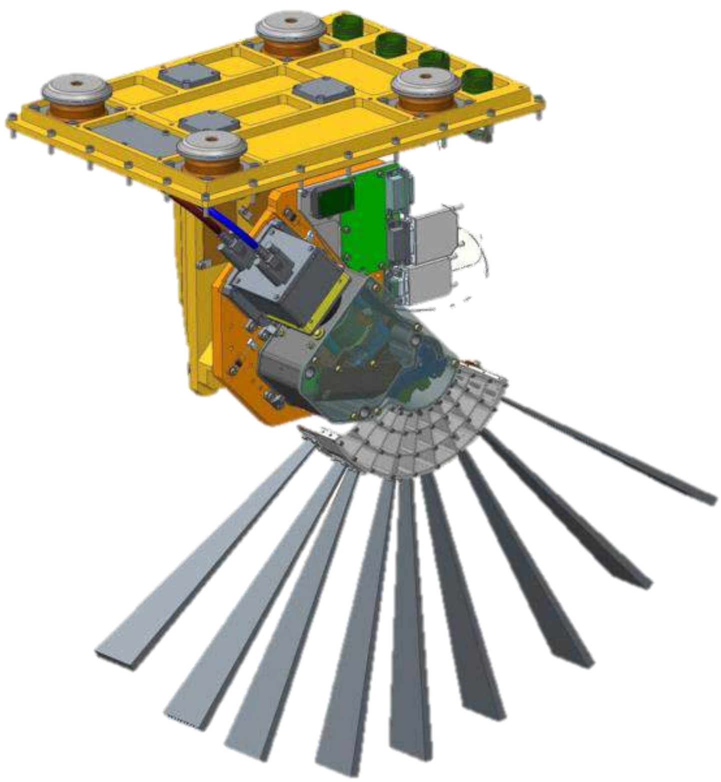


Figure 31 SPEX Airborne optical layout, including multi-angle fields of view.

3.7.6.1 Data

Submitted to the PACE-PAX data repository are SPEX airborne Level-1C and Level-2 aerosol data files. The flights are broken up in straight flight leg sections and each section is stored in a separate file.

The L1C files contain observed radiances, degree of linear polarization and angle of polarization for each viewing angle and wavelength. SPEX airborne L1C data follow the same format as SPEXone L1C data files, as described in https://oceancolor.gsfc.nasa.gov/files/PACE_L1C_Users_Guide.pdf The L1C data have all viewing angles collocated to the surface and data are aggregated to 1 km 'pixels' on the surface. Note that data over clouds is provided, but these are not collocated to cloud top. Note that number of viewing angles and wavelengths are different compared to SPEXone. Although the wavelength range extends further, the calibration outside the wavelength range 407-760 nm is uncertain and dats at these wavelengths should be used with caution. The SPEX airborne files also contain an extra group called "aircraft_platform" with information of the platform, such as altitude and pitch. Note that for geolocation and attitude, the IMU on the Picard instrument is used, instead of the aircraft attitude. Since Picard was mounted on the same wing, using this attitude also account for the flexing of the wing. Hence the "wingflex" parameter in the "aircraft_platform" only contains fill values.

L2 aerosol files are also provided. Here, the RemoTAP algorithm that is applied to SPEXone is also used for SPEX airborne. The algorithm is described in RemoTAP SPEXone ATBD: https://doi.org/10.5067/6U80A7NY53RF We also refer to Fu et al. (2025) for details of the algorithm and performance analysis for SPEXone.

In RemoTAP as it is applied to SPEX airborne, the aerosol properties are described by three modes, namely a fine mode, a soluble coarse mode (representing coarse sea salt) and an insoluble coarse mode (representing dust), as further described in the RemoTAP ATBD. Retrieval products include the column number concentration, effective radius and variance of the size distribution, the refractive index, fraction of non-spherical particles and an aerosol layer height. For details on which parameter is retrieved for which mode, we refer to the RemoTAP ATBD and Fu et al. (2025). Note that SPEX airborne data below 407 nm is ignored for the aerosol retrievals. It is important to also note that the data need to be filtered for goodness-of-fit, using the "chi2" parameter, requiring chi<1.5 above land and CHI2<2.0 above ocean. Finally, no cloud filters have been applied to the data. While the Chi2 filter is expected to filter out most clouds, some filtered data may still be affected by clouds.

3.8 Supporting efforts

3.8.1 R/V Blissfully

3.8.1.1 Platform and Instrument background

The R/V Blissfully is a 30-foot sailboat with a crew of two that supported PACE-PAX from 6 Sept to 19 Sept 2024 (9 sampling days). R/V Blissfully sampled 19 stations in the San Pedro Channel near the USC SEAPRISM instrument on an offshore oil rig. R/V Blissfully had an assortment of instruments and sampled a variety of variables, and had nine successful station match-ups with PACE OCI.

Details about the day to day on RV Blissfully are available on the NASA Earth Observatory blog: https://earthobservatory.nasa.gov/blogs/fromthefield/2024/09/24/twenty-one-hours-a-day-on-30-foot-floating-science-lab/?src=fromthefield-rss

Figure 32 Crew of R/V Blissfully Bridget Seegers and Gordon Ackland (Photo by Bridget Seegers)

3.8.1.2 Overview Summary

- The instruments included a HyperPro. This instrument completed 19 casts, includeding deep casts, for a total of 114 yos (ups and downs).
- RV Blissfully had a limited number of Microtops sun photometer measurements.
- RV Blissfully took discrete samples from 19 stations that were sent back to Ocean Ecology Lab at GSFC for further analysis. This included triplicate HPLC, triplicate particle absorption (Ap/Ad), flow cytometry bacteria community composition, and plankton species composition via FlowCam.
- Bridget Seegers from the RV Blissfully crew remotely visited 3 classrooms for PACE-PAX outreach.

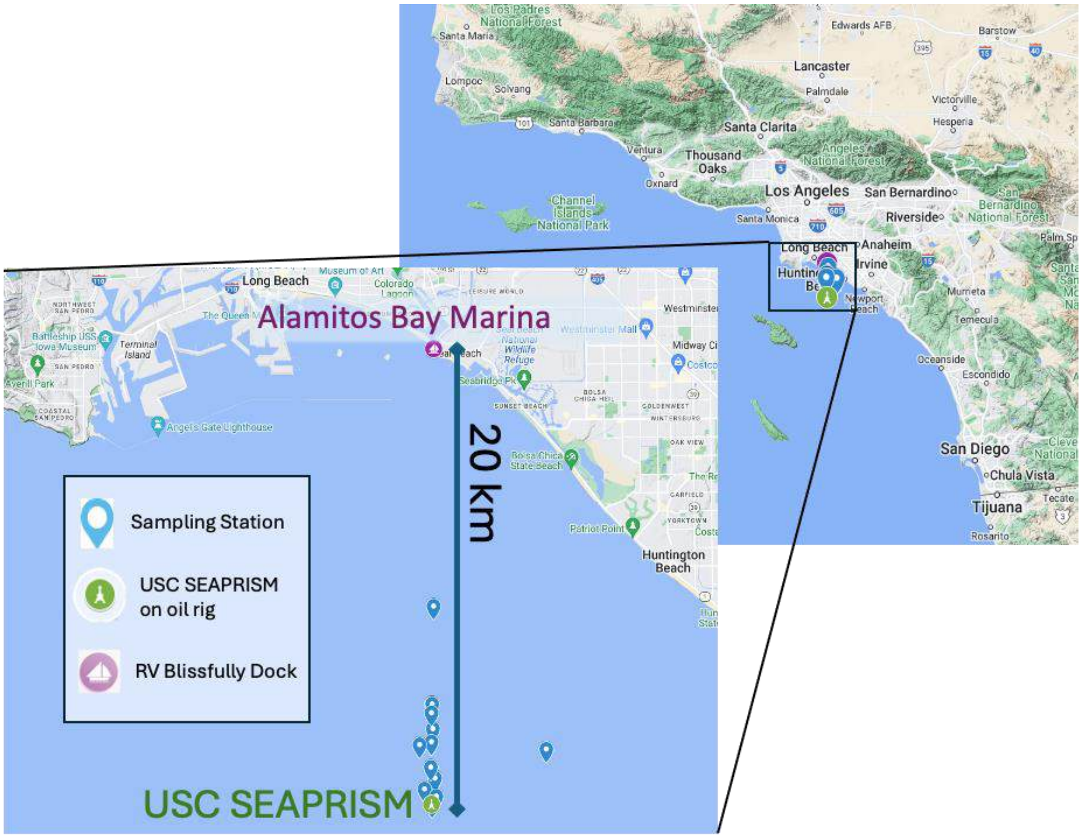


Figure 33 Maps of sampling area and stations sampled by RV Blissfully in the San Pedro Channel around the USC SEAPRISM site off the Southern California coast.

3.8.1.3 Instrument Details

The HyperPro deployed from RV Blissfully was a Satlantic Profiler II, which is a free-falling optical profiler deployed with two HyperOCR optical sensors measuring downwelling irradiance and upwelling radiance. In addition, RV Blissfully had a surface irradiance sensor mounted on a pole on deck. The operational manual and instrument details are available Satlantic's "Operation manual for: profiler ii document number: SAT-DN-00223," (2009).

All data and triplicate samples were sent to NASA's Ocean Ecology Lab (OEL) at Goddard Space Flight Center. The discrete samples were run by OEL's field support group. The HyperPro data were also processed by the field support group.

Table 20 R/V Blissfully instrumentation

Instrument/sample	Measurements	Sample Type
HyperPro	downwelling irradiance (Ed), upwelling radiance (Lu), surface irradiance (Es)	profiling
HPLC	phytoplankton pigments, community compositions	discrete surface
Particle absorption	Total particle (a_p), detritus/non algal (a_d), and phytoplankton (a_{ph}) absorption	discrete surface
Flow cytometry vial	bacteria community composition	discrete surface
Lugol's preserved whole water	community composition with flow cam	discrete surface
Microtops	aerosol optical thickness	1 successful day

3.8.1.4 Data

RV Blissfully data is archived in NASA SeaBASS. The archived data includes Hyperpro radiometric casts, Ap/Ad, and HPLC pigment results.
https://seabass.gsfc.nasa.gov/archive/NASA_GSFC/PACE-PAX/PACE-PAX_BLISSFULLY/archive

3.8.2 HyperNAV

3.8.2.1 Instrument background

The HyperNav autonomous profiling system provides vertical measurements of upwelling radiance in the ocean covering the 350 – 900 nm spectral range, at a sampling interval of ~ 0.41 nm and resolution of 2.2 nm. Additional measurements include vertical profiles of temperature, salinity and pressure (Barnard et. al, 2024). The data from this system is publicly available (https://misclab.umeoce.maine.edu/HyperNAV/) and is currently being provided to NASA for PACE OCI system vicarious calibration processing. The HyperNav system typically provides daily profiles of the above parameters, from ~500m to the surface of the ocean. The system is programmed to reach the surface with +/- 1 hour co-incident with the PACE OCI satellite overpass at our area of deployment.

3.8.2.2 Data

All data products from the HyperNav were made available within 2 hours after observation. All data is also available on the HyperNav Portal (https://misclab.umeoce.maine.edu/HyperNAV/science). All of the HyperNav data are archived on internal data servers housed at the University of Maine, including all raw transmitted data, processed data, metadata, and QA/QC data associated with each observation. All of the above data is available in both a netcdf or cvs version, which can be accessed readily using the Download button on the HyperNav Science page. Additionally, entire deployment data sets or subsets of data can be made available by contacting the data system administrator (Nils Haentjens).

3.8.2.3 Analysis

The HyperNav system (Barnard et al, 2024a, 2024b) was deployed in the basin just south of the Santa Barbara Channel region (Figure 34). The deployment period was from August 31, 2024 through September 22, 2024 for a total of 19 daily profiles, typically between 11:30 and 13:00 local time.

Of the 19 days of deployment, most of the days of the HyperNav observations were under cloudy/overcast skies and were QA/QC'd as poor quality for a matchup with the PACE OCI coverage (Table 21). Additionally, one of the days with clear skies unfortunately wasn't observed by PACE OCI due to the orbit cycle over the region.

Figure 34 Left panel: Locations of the HyperNav profiles made during the PACE PAX experiment. Each dot shows the location of the HyperNav observation made from August 31, 2024 through September 21, 2024. Right panel: The HyperNav system aboard the small vessel that was used to deploy the system.

For the 5 matchups with OCI, a radiative transfer code, ARTDECO, was used to simulate the surface spectral downwelling irradiance at the same resolution as the HyperNav radiance observations to derive remote sensing reflectance. MERRA2 AOT, Aerosol type, ozone, water vapor, wind speed, surface pressure, SZA and Chl were used to derive from HyperNav Rrs. Figure 35 HyperNav measurements of Lw (left), ARTDECO simulations of Es (center), and derived Rrs (right) at OCI resolution (5 nm).shows the HyperNav radiance observations at the sea surface, the modeled surface downwelling irradiance and the derived Rrs.

Table 21 List of PACE-PAX HyperNav/OCI match-ups, showing date/time/location of HyperNav measurements and time of OCI observations. OCI observations were acquired in clear sky conditions, with valid remote sensing (Rrs) observations.

HyperNAV filename	Datetime start	Datetime surface	Datetime end	Lat.	Long.	OCI time	OCI conditions
3311_0059.20240904T202000.SD	9/4/24 18:40	9/4/24 20:05	9/4/24 20:07	33.716	-119.46	20:56:35	Clear/valid L2 Rrs
3311_0059.20240905T202500.SD	9/5/24 18:45	9/5/24 20:11	9/5/24 20:11	33.709	-119.43	19:52:41	Clear/valid L2 Rrs
3311_0059.20240906T202230.SD	9/6/24 18:45	9/6/24 20:09	9/6/24 20:09	33.672	-119.41	20:27:04	Clear/valid L2 Rrs
3311_0059.20240910T202640.SD	9/10/24 18:45	9/10/24 20:09	9/10/24 20:11	33.651	-119.61	N/A	N/A
3311_0059.20240916T202340.SD	9/16/24 18:39	9/16/24 20:08	9/16/24 20:09	33.795	-119.58	21:15:27	Clear/valid L2 Rrs
3311_0059.20240917T201800.SD	9/24/24 18:39	9/24/24 20:03	9/24/24 20:05	33.758	-119.51	20:11:28	Clear/valid L2 Rrs

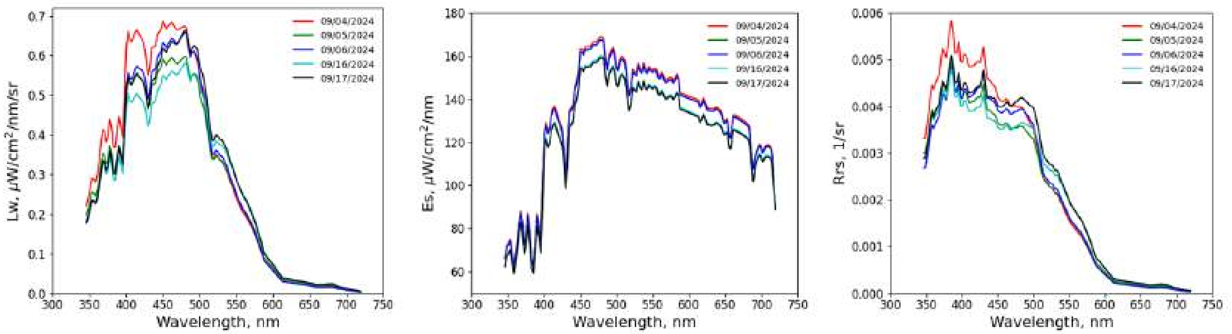


Figure 35 HyperNav measurements of Lw (left), ARTDECO simulations of Es (center), and derived Rrs (right) at OCI resolution (5 nm).

3.8.3 U. Delaware ocean gliders

3.8.3.1 Instrument background

Orris is a Teledyne-Marine generation 3 Slocum glider carrying both optical and acoustic sensors (Figure 36). The WBAT-mini has an upward looking split beam transducer centered at 200 kHz (frequency range 160-260 kHz) and an upward looking split beam transducer centered at 333 kHz (frequency range 280-440 kHz) This installation required an extended flooded bay, as well as an extended energy bay. Orris also carries an RBR CTD, a Seabird multispectral ocean color radiometer configured for downwelling irradiance measurement 380 nm, 470 nm, 532 nm, and PAR. It also carries a SeaBird radiometer configured for upwelling radiance at 380 nm, 470 nm, 532 nm and 664 nm. Orris also carries a SeaBird ECO-Triplet measuring backscatter at 532 nm and 700 nm, as well as chlorophyll fluorescence.

Figure 36 Orris after recovery during PACE-PAX. The forward upward looking transducers are the WBAT-mini. The mid-section has the upward looking irradiance sensors. Under glider are the downward looking radiance sensors, CTD, and ECO-Triplet.

Measurement	Units	Frequency
Conductivity	mS/cm	1 Hz
Temperature	C	1 Hz
Pressure	dBar	1 Hz
Salinity	PSU	1 Hz
Density	kg/m^3	1 Hz
Irradiance @380nm	uw/cm^2/nm	1 Hz
Irradiance @470nm	uw/cm^2/nm	1 Hz
Irradiance @532nm	uw/cm^2/nm	1 Hz
Irradiance @PAR	uw/cm^2/nm	1 Hz
Radiance @380nm	uw/cm^2/nm/sr	1 Hz
Radiance @470nm	uw/cm^2/nm/sr	1 Hz
Radiance @532nm	uw/cm^2/nm/sr	1 Hz
Radiance @664nm	uw/cm^2/nm/sr	1 Hz
Chlorophyll Flourescence	mg/m^3	1 Hz
Optical Backscatter @532	1/m sr	1 Hz
Optical Backscatter @700	1/m sr	1 Hz
*Acoustic Backscatter @200kHz	dB	1Hz
*Acoustic Backscatter @333kHz	dB	1Hz

*Figure 38 Measurements by the Orris Slocum glider. * indicates data not yet fully processed.*

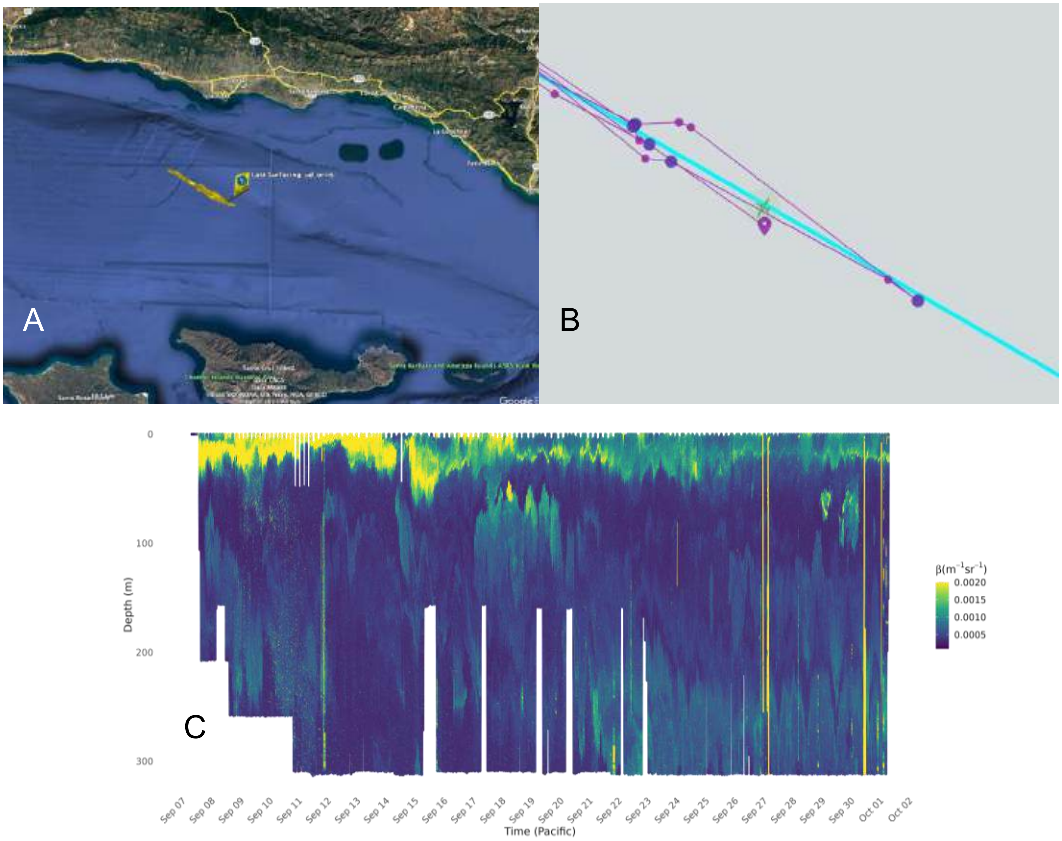


Figure 37 Location of Orris deployment along a 10 km track. B. Example of ER2 overflight of Orris. C. Optical backscatter patterns at 532 nm during the Orris deployment

Orris was deployed along a 10 km transect line from September 7 – October 1, 2024 (25 days). During this time, it was overflown by the ER2 10 times (Figure 37).

3.8.3.2 Data and future plans

Orris flight and science data are available at:
https://gliders.ioos.us/erddap/tabledap/ud_orris-20240907T1638.html

Additionally, quality controlled data will be uploaded to SeaBASS. In the coming year, the team will be working on matchups with PACE and the NASA HSRL-2.

3.8.4 CEOBS

Scientists at the Naval Research Laboratory's Marine Meteorology Division have established a coastal research site for acquiring long-term 24-7 measurements of the coastal boundary layer and cloud systems in support of basic research, model validation, tactical decision aids, and educational outreach applications. Located on the immediate coastline of the Monterey Bay (see

Figure 39), the site provides a complementary combination of active and passive sensors that include the ProSensing scanning Ka-band Doppler radar, the Halo Photonics scanning Doppler lidar, the Vaisala CL51 ceilometer, Dial Lidar, and PWD22 visibility sensors, the Radiometrics MP3000A microwave radiometer, the Metek Micro Rain radar, the Droplet Measurement Technologies FM120 Fog Monitor and Handix Scientific POPS1120 aerosol probe, the CIMEL Sun Photometer, the Prede All-sky camera, and Li-Cor Biomet Flux tower comprised of the Gill sonic anemometer, the LiCor 7500DS gas analyzer, the Zipp & Konen net radiometer, Hukesflux soil heat flux plate, and the Stevens Hydra Probe soil moisture sensors. The site also includes a drone package equipped with a sonic anemometer, OPC-N2 aerosol probe, and sensors for standard meteorological variables including pressure, temperature, and humidity. A unique aspect of the NRL-CEOBS site is the special overlying FAA airspace the permits drone flights to 10,000'; a factor that greatly enhances synergistic profiling capabilities through and well above the shallow marine boundary layer. Examples of data collected at the NRL-CEOBS site include merged radar, lidar, and radiometer data sets that are useful for acquiring vertically coherent eddy structures in cloud covered boundary layers as well as for acquiring standard boundary layer parameters that govern turbulence closure schemes.

A host site for CEOBS data is currently in development. Until that site exists, data are available upon request to the PI.

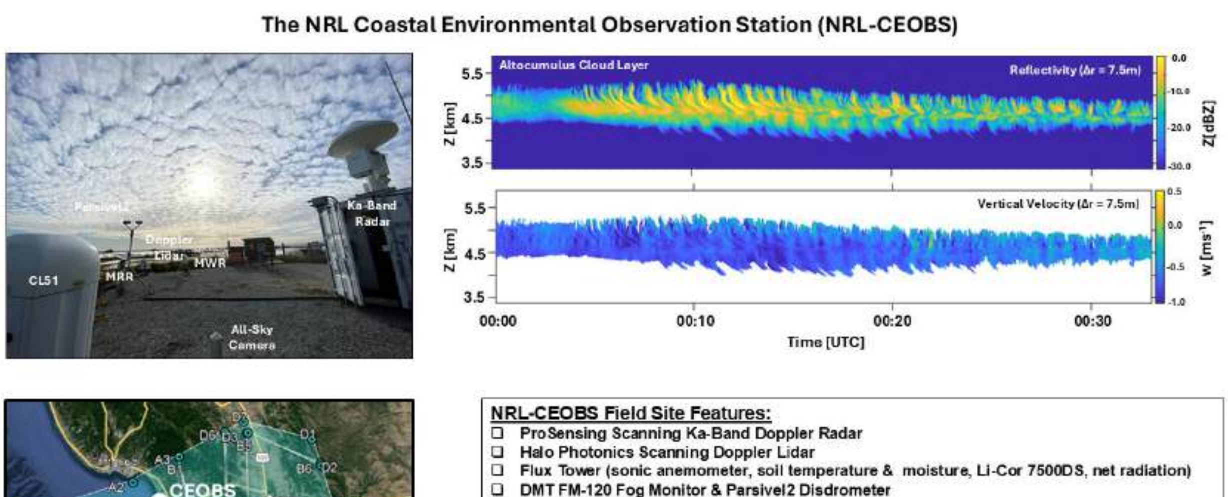


Figure 39 Details of the NRL Coastal Environmental Observation Station (NRL-CEOBS) co-located CA66 airport along the immediate shoreline of the Monterey Bay directly west of Watsonville, CA. The upper left panel shows a site image taken on a day (not during PACE-PAX) exhibiting extensive mid-level cloud layer that was observed by the instrumental network. Results from this time are displayed from the ProSensing scanning Ka-Band Doppler radar which reveals the complex reflectivity (top) and velocity (bottom) signatures from the thin pictured altocumulus layer. Note the extensive subcloud virga layer that extends over a kilometer below cloud base (upper right panels). Circulations within and below the cloud layer likely impact local aerosol redistribution and processing within both the cloud and subcloud layers.

The location of the NRL-CEOBS site is revealed in the lower left panel along with the special FAA airspace that covers the site (shown as region highlighted by the light green shaded areas). A list of instruments at the site is highlighted in the lower right portion of this image. This instrumental array is well-suited for the study of a number of coastal phenomena including land-falling atmospheric rivers, local land-sea breeze circulations, terrain induced mesoscale eddy circulations, high-amplitude gravity waves, dust and smoke intrusion events, and winter-time shallow post-frontal convective systems among others.

3.8.5 AERONET, AERONET-OC

The AERONET (AErosol RObotic NETwork) program is a federation of ground-based remote sensing aerosol networks established by NASA and PHOTONS (PHOtométrie pour le Traitement Opérationnel de Normalisation Satellitaire; Univ. of Lille 1, CNES, and CNRS-INSU) and is greatly expanded by networks, calibration centers, and collaborators (e.g., RIMA, AeroSpan, APAC, AEROCAN, AEROSPAIN, NEON, and CARSNET) from national agencies, institutes, universities, individual scientists, and partners. For more than 25 years, the project has provided long-term, continuous, and readily accessible public domain database of aerosol optical, microphysical and radiative properties for aerosol research and characterization, validation of satellite retrievals, and synergism with other databases. The network imposes standardization of instruments, calibration, processing and distribution.

AERONET collaboration provides globally distributed observations of spectral aerosol optical depth (AOD), inversion products, and precipitable water in diverse aerosol regimes. Version 3 AOD data are computed for three data quality levels: Level 1.0 (unscreened), Level 1.5 (cloud-screened and quality-controlled), and Level 2.0 (quality-assured). Inversions, precipitable water, and other AOD-dependent products are derived from these levels and may implement additional quality checks.

The AERONET - Ocean Color (AERONET-OC) is another component of the AERONET program, provides the additional capability of measuring the radiance emerging from the sea (i.e., normalized water-leaving radiance) with sun-photometers installed on offshore platforms like lighthouses, oceanographic and oil towers. Similarly, the Maritime Aerosol Network (MAN) component of the AERONET program provides ship-borne aerosol optical depth measurements from the Microtops II sun photometers. These instruments have been deployed periodically on ships of opportunity and research vessels to monitor aerosol properties over the World's Oceans.

Many PACE-PAX flights were designed to overfly AERONET sites, which provide an aerosol or ocean surface reflectance validation reference. The AERONET project specifically supported PACE-PAX by ensuring as many field sites as possible were operational, particularly AERONET-OC and AERONET instruments with UV spectral capability. AERONET also built a website with tools to specifically assess AERONET data in the PACE-PAX region (https://aeronet.gsfc.nasa.gov/new_web/PACE-PAX.html). Figure 40 is an example from that site.

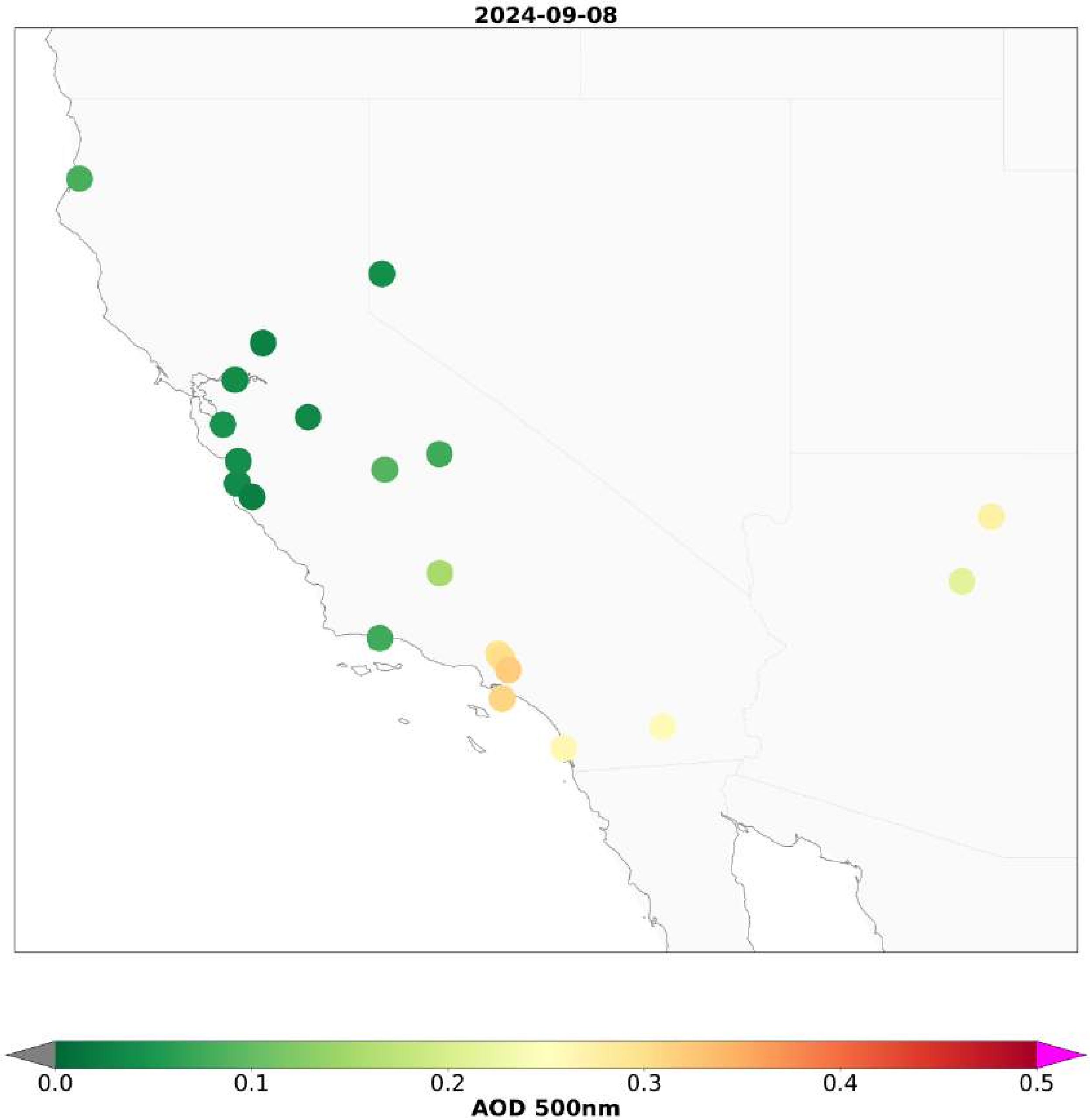


Figure 40 AERONET data visualization from September 8, 2024 as displayed on the AERONET PACE-PAX website. https://aeronet.gsfc.nasa.gov/new_web/PACE-PAX.html

AERONET MAN instruments were also made from the R/V Shearwater and R/V Blissfully, and available at the abovementioned AERONET link. The geographical extent of these observations is shown in Figure 41.

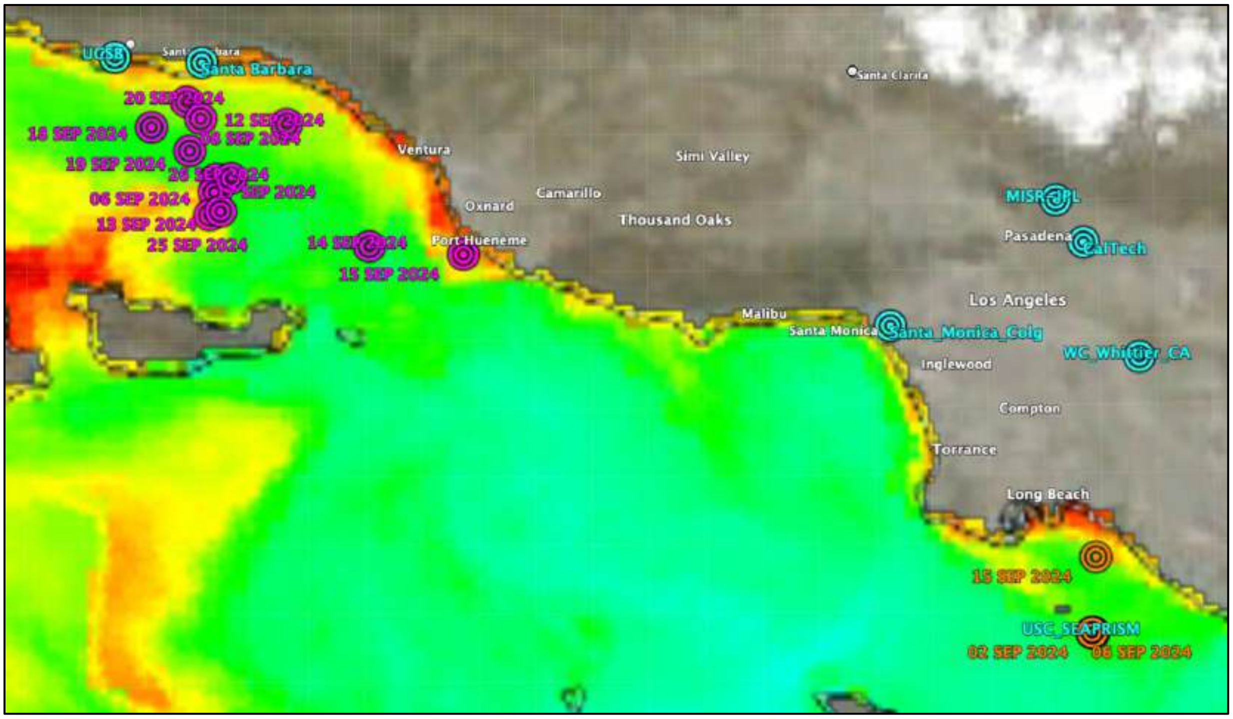


Figure 41 AERONET and AERONET MAN observations in coastal Southern California during PACE-PAX. AERONET sites are shown in turquoise (not all sites shown), MAN observations from the R/V Shearwater are shown in magenta, and MAN observations from the R/V Blissfully are shown in orange. PACE OCI imagery from September 6th, 2024, is shown as background, with the truecolor product over land and chlorophyll-a product over the ocean.

3.8.6 PVST: Rapid response

The UCSB Earth Research Institute (ERI) contributed to the PACE-PAX effort through two cruises in the Santa Barabara Channel as part of its PVST-SBCR activities. The cruises took place on 9/5/2025 (2 stations) and 9/20/2025 (2 stations) using small boats from UCSB's Marine Operations fleet.

During the cruises, the UCSB team deployed 2 radiometers:

1) A Compact Optical Profiling System (C-OPS, BioSpherical Instruments Inc.) which is a multispectral optical profiling system that measures in-water upwelling radiance and downwelling irradiance and on deck incident irradiance. The system also includes ancillary sensors for water temperature, chlorophyll-a natural fluorescence, PAR, pressure and pitch and roll for both the in-water and surface units. The radiometers measure light at the same 18 wavelengths (in nanometers): 320, 340, 380, 395, 412, 443, 465, 490, 510, 532, 555, 560, 625, 665, 670, 683, 710, 780.

2) A HyperPro II (SeaBird Scientific) which is a hyperspectral radiometer system that can operate either as a free-falling profiler or as a surface buoy. In profiling mode, the HyperPro II collects in-water hyperspectral upwelling radiance, $L_u(\lambda, z)$, and downwelling irradiance, $E_d(\lambda, z)$, along with in-air surface irradiance, $E_s(\lambda, z)$. The three radiometers are HyperOCR sensors.

Each of the sensors on the HyperPro II system has 137 channels in the 350 to 805 nm range. The profiling unit also records pressure, tilt, roll, conductivity and water temperature.

Water samples were also collected at each station for HPLC pigments analysis.All the profile and ancillary data, derived products (Rrs, Kd), and pigments data were submitted to the NASA SeaBASS repository.

The UCSB group also provided lab space and access to a pure water system to the NASA team onboard the Shearwater.

3.8.7 PVST: R/V Rachel Carson

3.8.7.1 Instrumentation background

The HyperPro/HyperOCR (Sea-Bird Scientific) was deployed on three consecutive day cruises on 25-27 September on the R/V Rachel Carson from Moss Landing Harbor in Monterey Bay, CA. Samples were collected along a southeast by northwest transect in Monterey Bay (Figure 42), coordinates are included in Table 22.

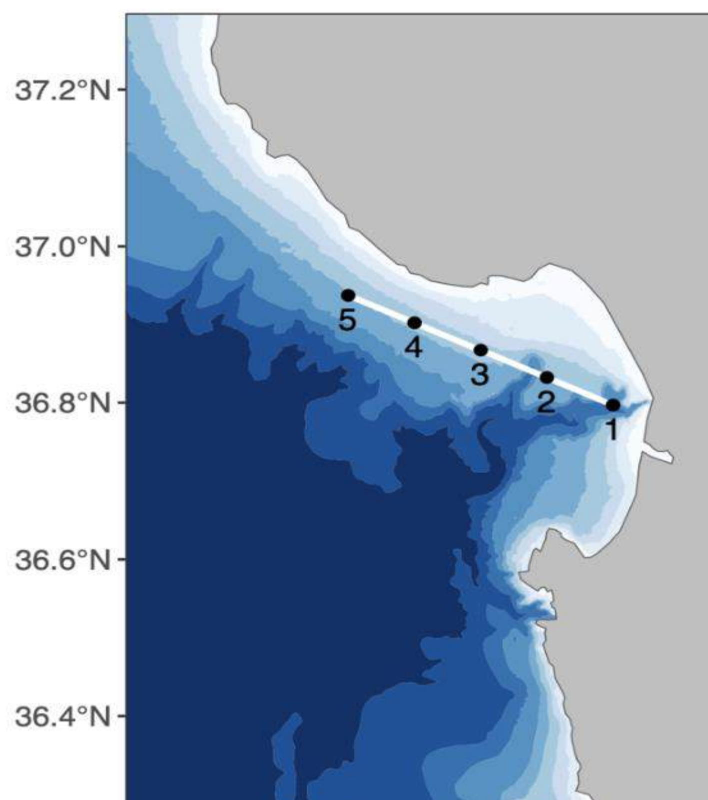


Figure 42 Map of R/V Rachel Carson sampling locations, Monterey Bay, CA

Overflights of the Twin Otter and NASA ER-2 aircraft coincided with sampling on the 27th of September (Figure 44). The HyperPro characteristics are listed in Table 23 and were accompanied by a suite of leveraged measurements. The Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) project is focused on understanding toxic Pseudo-nitzschia bloom dynamics in the California Current Ecosystem using advanced molecular techniques, in situ bloom detection with remote vehicles, and shipboard measurements of plankton community composition, toxins, nutrients, and ‘omics parameters. This is a relevant pairing for PACE-PAX validation of advanced NASA ocean color products even though the ECOHAB project was not initially planned for incorporation into the PACE-PAX field campaign.

Table 22 Cast locations for the R/V Rachel Carson ECOHAP daily cruises

Station Number	Latitude	Longitude	Parameters Taken
1	36.797	-121.847	Chlorophyll, RNA, DNA, Particulate Metabolites, Total Metabolites, Flow Cytometric Microbial Counts, Domoic Acid
2	36.832	-121.941	Chlorophyll, RNA, DNA, Particulate Metabolites, Total Metabolites, Flow Cytometric Microbial Counts, Domoic Acid
3	36.867	-122.035	Chlorophyll, RNA, DNA, Particulate Metabolites, Total Metabolites, Flow Cytometric Microbial Counts, Domoic Acid
4	36.902	-122.129	Chlorophyll, RNA, DNA, Particulate Metabolites, Total Metabolites, Flow Cytometric Microbial Counts, Domoic Acid
5	36.937	-122.223	Chlorophyll, RNA, DNA, Particulate Metabolites, Total Metabolites, Flow Cytometric Microbial Counts, Counts, Domoic Acid

Table 23 Seabird Hyperspectral Ocean Color Radiometer instrument characteristics

Spectral range	350-800 nm
Spectral resolution	10 nm
Spectral accuracy	0.3 nm
Field of view	Irradiance Water - Cosine RMS Error - 3% 0 - 60º 10% 60 - 85º (350-800 nm) Radiance - 8º Half angle Half-radiance
Frame rate and integration time methods	3 Hz (at 128 ms integration time)
Cosine response	Fully characterized

Figure 43 Photo of the PVST sampling crew on board the R/V Rachel Carson, Monterey Bay, CA

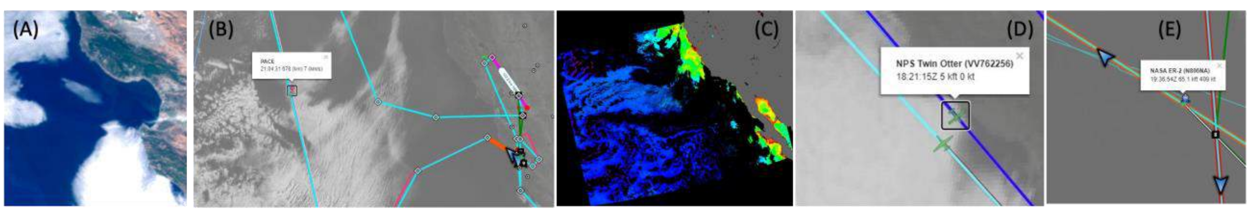


Figure 44 (A) VIIRS True Color Image, Monterey Bay, 27 September 2024; (B, C) Shiptrack and PACE overpass on 27 September 2024; (D) NPS Twin Otter overpass (courtesy of Sam LeBlanc); (E) NASA ER-2 overpass (note ship icon) on 27 September 2024.

3.8.7.2 Data

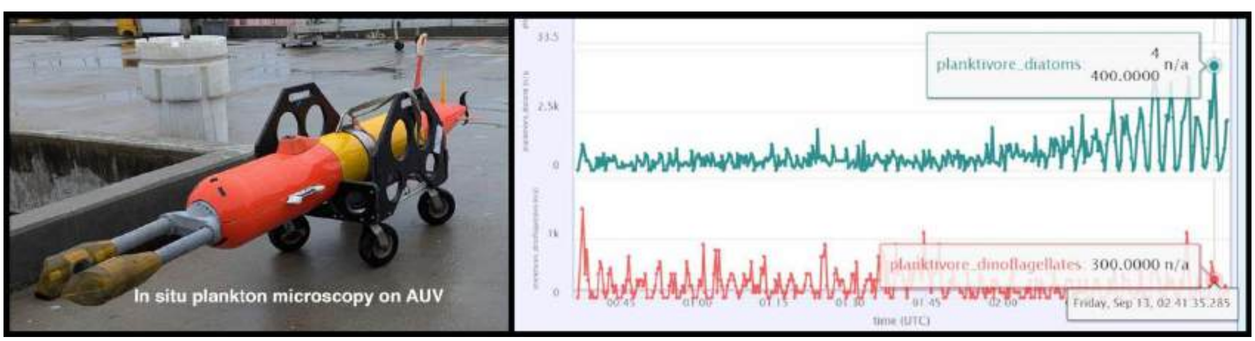
Data were collected September 25-27, 2024. NASA-supported HyperPro/HyperOCR casts at three stations. Table 24 lists the in situ optical profile measurements taken at stations 1-5 in Monterey Bay, CA.

Table 24 HyperPro casts coinciding NASA ER-2 overpass includes two at station 1 and three at station 2, and an additional three casts at station 3 during Twin Otter overpass. HyperPro cast data were processed using ProSoft-8.1.6_1. The resulting 8 SeaBASS files contain these fields.

Field	Unit	Description
wavelength	nm	
Es	uW/cm^2/nm/sr	spectral downwelling surface irradiance
Kl	1/m	diffuse attenuation coefficient of Lu
Kl_SE	1/m	standard error of regression slope (Kl)

Kd	1/m	diffuse attenuation coefficient of Ed
Kd_SE	1/m	standard error of regression slope (Kd)
Ku	1/m	diffuse attenuation coefficient of Eu
Ku_SE	1/m	standard error of regression slope (Ku)
Lu(0-)	uW/cm^2/nm/sr	extrapolated upwelling radiance just below sea surface
Ed(0-)	uW/cm^2/nm	extrapolated downwelling irradiance just below sea surface
Eu(0-)	uW/cm^2/nm	extrapolated upwelling irradiance just below sea surface
Lw	uW/cm^2/nm/sr	extrapolated upwelling radiance above sea surface (water leaving radiance)
Lw-SE	uW/cm^2/nm/sr	lower bound of extrapolated upwelling radiance above sea surface (less standard error)
Lw+SE	uW/cm^2/nm/sr	upper bound of extrapolated upwelling radiance above sea surface (plus standard error)
Ed(0+)	uW/cm^2/nm	extrapolated downwelling irradiance above sea surface
Eu(0+)	uW/cm^2/nm	extrapolated upwelling irradiance above sea surface
F0	uW/cm^2/nm	extraterrestrial solar irradiance
Lwn	uW/cm^2/nm/sr	normalized water leaving radiance
Q	sr	ratio of upwelling irradiance to radiance just below sea surface

In situ plankton microscopy on Long Range AUV data (MBARI) were collected on 11-14 September and 23-27 September as part of the ECOHAB project, collecting highly useful phytoplankton community composition data that align with advanced NASA data products.



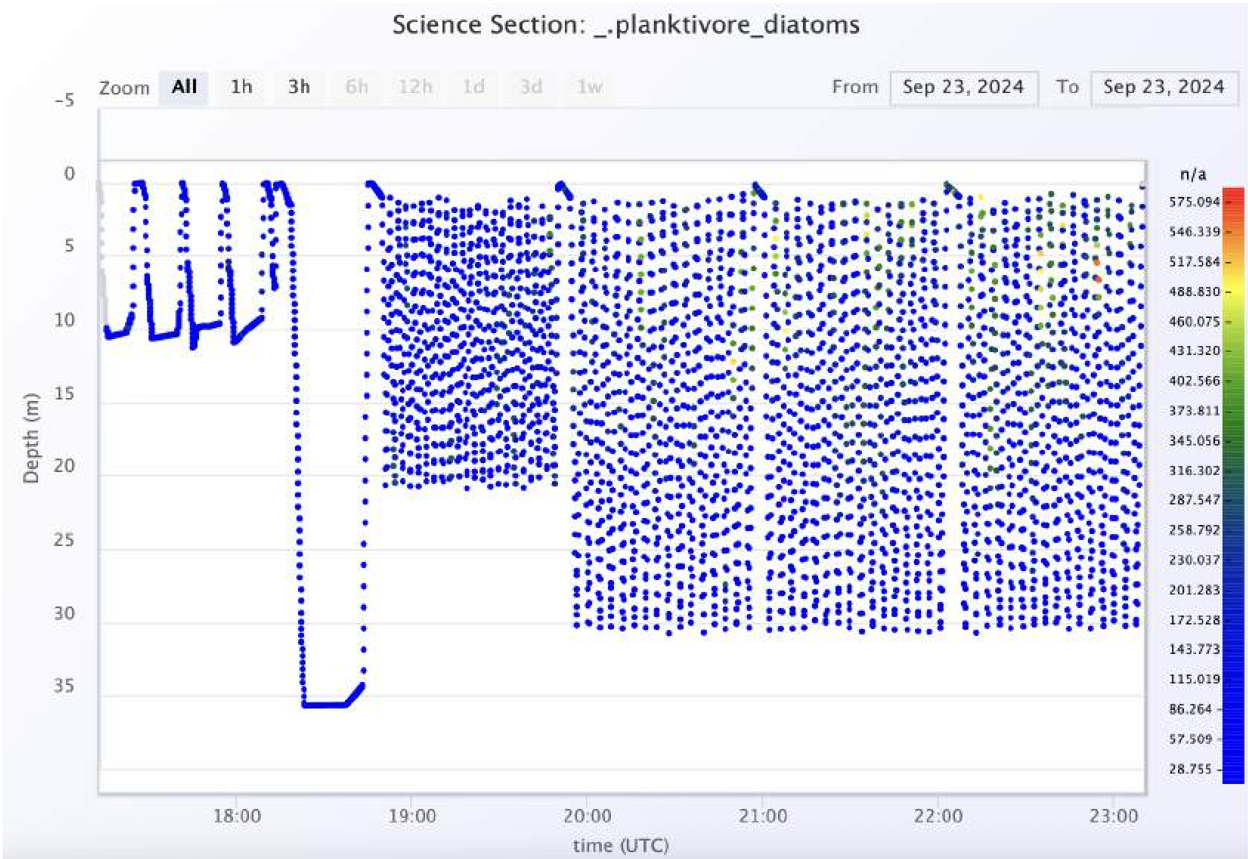


Figure 45 (Upper left) A microscope (Planktivore), equipped with onboard detection and classification was deployed on a long range autonomous underwater vehicle (LRAUV) for bloom detection and characterization during multiple missions during September. (Upper right) Phytoplankton community composition data from the Planktivore camera as seen on 13 September, which were used to guide ECOHAB ship sampling. (Bottom) Section of diatom detection on 23 September, along the transect shown in Figure 42.

3.9 Weather forecasting and modeling support

3.9.1 Weather forecasting from the NASA Ames meteorological forecasting group

The NASA Ames Research Center (ARC) meteorological forecasting group provided meteorological and aerosol forecasting support for the Plankton, Aerosol, Cloud, ocean Ecosystem Post launch Airborne eXperiment (PACE-PAX) mission. The main objectives of our work were to inform the Mission Scientists about relevant atmospheric conditions that were expected for flight planning during the deployment and to provide meteorological context to the Science Team for interpreting the collected measurements. The tasks were completed in three stages: (1) preparations before the deployment, (2) in-field support, and (3) post-campaign analysis support.

3.9.1.1 Forecasting preparations

We conducted a climatological study to inform the Science Team of the expected meteorological conditions during the PACE-PAX deployment. Analyses of cloud fraction (CF) and aerosol optical depth (AOD) from MODIS Terra and Aqua satellites over the PACE-PAX domain during September 2003-2024 (Figure 46) revealed significant cloud cover off the coast of California (i.e., marine stratocumulus), particularly between Monterey and Santa Barbara (CF ~0.6-0.7) with relatively few clouds along southern California coast (CF ~0.3-0.4). Cloud fractions were expected to be very low over land (CF <0.2). AOD exhibited large interannual variability over the PACE-PAX domain, primarily driven by smoke emissions from large wildfire events. In general, we expected a relatively low AOD of ~0.1-0.2 throughout the domain (Figure 46 a), with the possibility of intermittent larger loads due to biomass burning.

Forecasting preparations included setting up a repository of various forecasting products in a publicly accessible NASA ARC server (https://bocachica.arc.nasa.gov/PACE-PAX/). This site was frequently accessed by the team for PACE-PAX relevant forecast information. Among the available forecasts included customized maps of low/mid/high cloud fractions from GFS and NASA GEOS-5 data. In addition to the forecast products, we also prepared customized satellite imagery of the standard channels (e.g., IR, visible, water vapor) and derived products (e.g., cloud top height and base) over the PACE-PAX domain (https://satcorps.larc.nasa.gov/cgi-bin/site/showdoc?docid=4&cmd=field-experiment-homepage&exp=PACE-PAX).
The forecasting and flight planning workflow was tested and refined during two dry run sessions in September 2023 and March 2024. These sessions also served to train new forecasters and identify the needs for additional forecast products.

3.9.1.2 In-field support

The forecasting team provided support for two aircraft and research vessels during the September 2024 deployment. Daily weather briefings were performed primarily at NASA Armstrong Flight Research Center (AFRC) in coordination with the NASA AFRC ER-2 weather forecasting team. Daily weather briefings also included aerosol forecasts from NASA Global Modeling and Assimilation Office (GMAO) at Goddard Space Flight Center (GSFC), requiring close coordination with their Framework for Live User-Invoked Data (FLUID) team. We also provided relevant meteorological and aerosol forecast and satellite products to be displayed in NASA Mission Tools Suite to enable real-time tracking and monitoring.

3.9.1.3 Post-campaign analysis support

As part of our post-campaign analysis support, we have archived the relevant forecasts and weather briefings generated during the deployment on our publicly accessible NASA ARC mission support server. To assist with the interpretation of PACE-PAX data, we have also archived and generated animation web pages of satellite and MERRA-2 aerosol data from 18 August – 3 October 2024.

Product	URL
Satellite – RGB (false color daytime + nighttime):	https://bocachica.arc.nasa.gov/PACE-PAX/satcorps_cloud_prod/2024/RGB_anim.html
Satellite – IR (infrared):	https://bocachica.arc.nasa.gov/PACE-PAX/satcorps_cloud_prod/2024/IRC_anim.html

Satellite – RGBT (true color visible):	https://bocachica.arc.nasa.gov/PACE-PAX/satcorps_cloud_prod/2024/RGBT_anim.html
MERRA2 total aerosol extinction (550 nm):	https://bocachica.arc.nasa.gov/PACE-PAX/PostMission/AOT/index.html

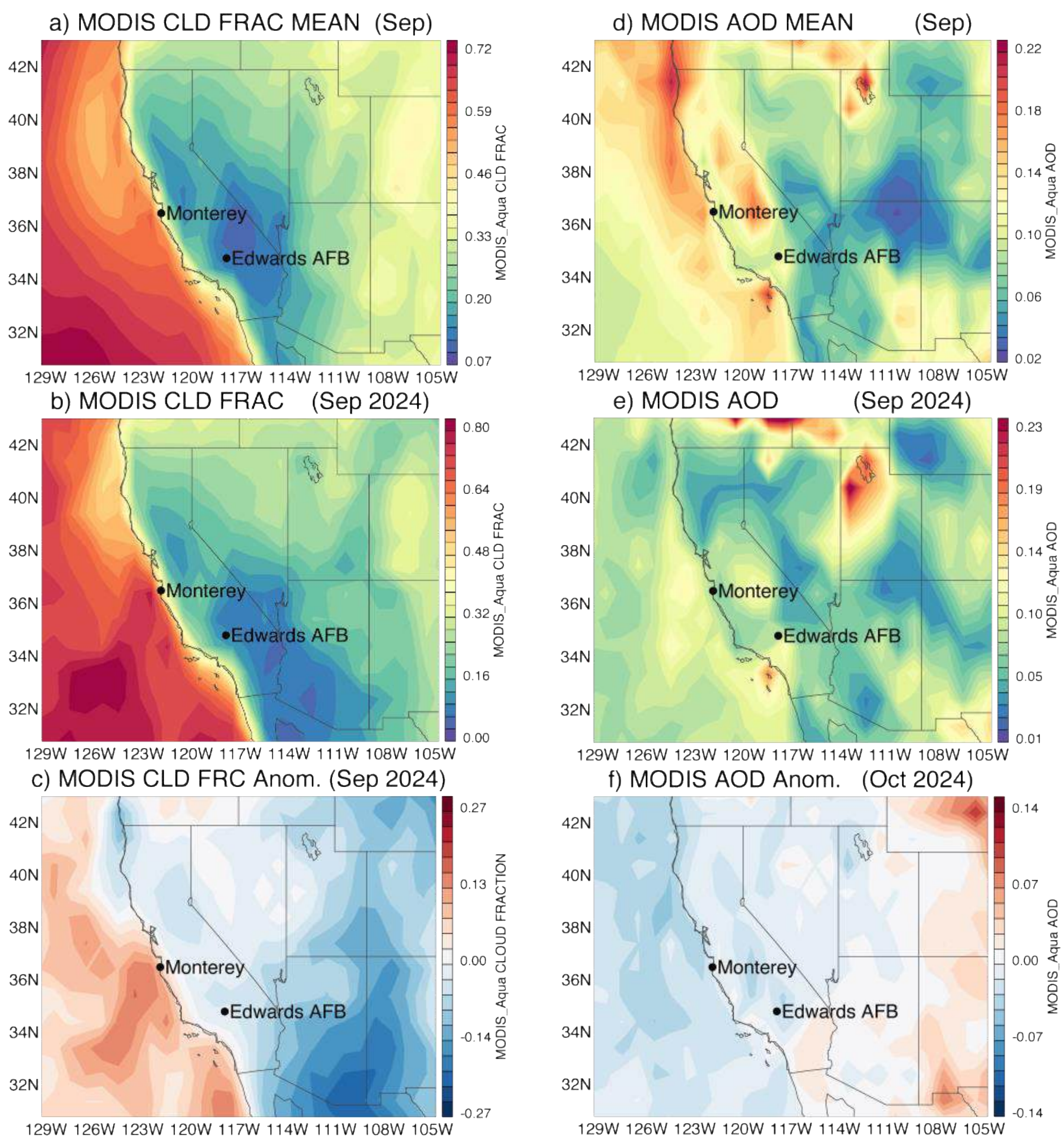


Figure 46 MODIS Aqua satellite measurements of (left: a, b, c) cloud fraction and (right: d, e, f) aerosol optical depth (AOD) over the PACE-PAX domain: (a) climatological (2003-2024) September mean, (b) September 2024, and (c) September 2024 anomaly (departures from climatological mean).

To provide meteorological context to the PACE-PAX measurements, we compared cloud and aerosol conditions during September 2024 compared to September climatology. Analysis of

MODIS cloud fraction during September 2024 indicates anomalously high cloud cover over the ocean, especially off the coast of Monterey and southern CA, during PACE-PAX compared to climatology (Figure 46 a-c). Cloud fractions over land were near normal. AOD was relatively low (<0.12) over the flight domain in September 2024, except for localized peak (~0.15) near Catalina Island associated with southern California wildfires (e.g., Bridge Fire, Line Fire, Airport Fire) (Figure 46 d-f).

3.9.2 NASA Armstrong airfield forecasting team

In addition to the PACE-PAX supported weather forecasting team from NASA Ames, NASA Armstrong provided its own weather forecasting team. The focus of this team was to ensure operational safety. An important part of these forecasts were the surface winds for ER-2 takeoff and landing at AFRC. That aircraft has wind speed limits, with vary based on wind direction. During PACE-PAX, winds exceeding these limits often curtailed operations, and several flights ended operations early due to generally increasing wind speeds in late afternoon. Also important was surface temperature, which on some days exceeded 105˚F and limited the length of time pilots and crew could be exposed on the runway. Other considerations were surface visibility, lightning, and pilot safety due to high altitude radiation, and ocean surface wind speed and ocean temperature should the pilot have to bail out.

3.9.3 GMAO support

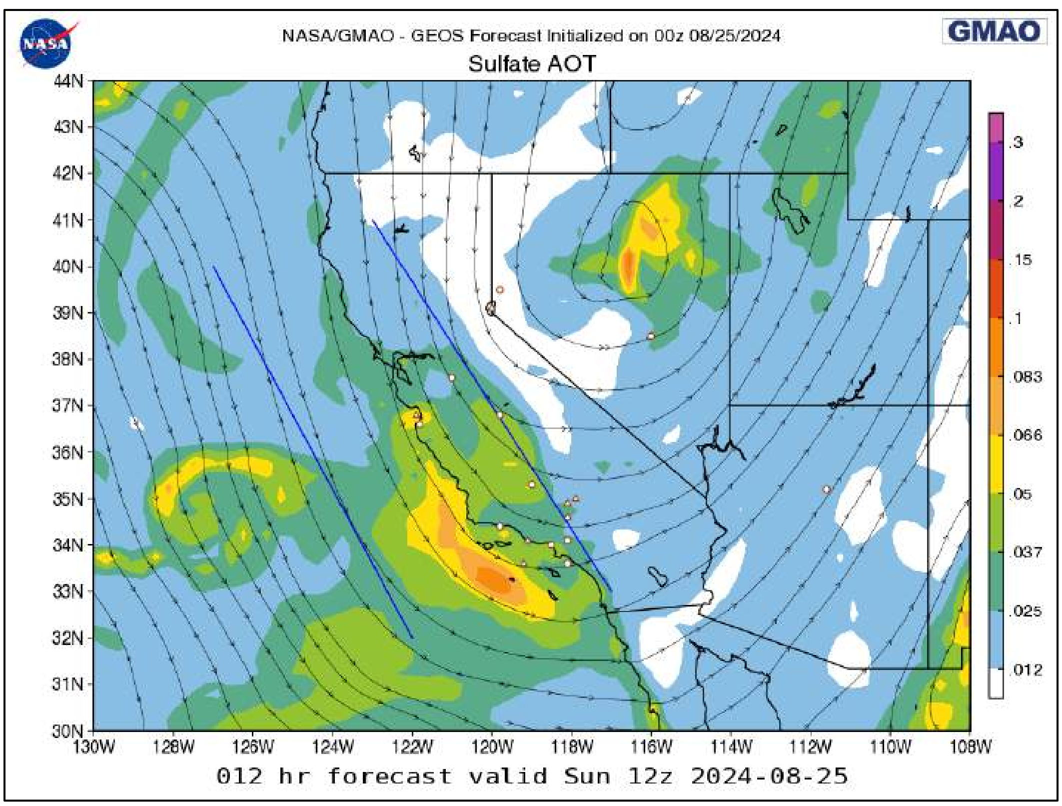


Figure 47 Example sulfate aerosol optical thickness (AOT) forecast from GMAO FLUID.

Weather and atmospheric composition forecast support was provided using the Goddard Earth Observing System (GEOS) Forward Processing (FP) global prediction model at NASA's Global Modeling and Assimilation Office (GMAO). FP generates a 10-day forecast of meteorological and atmospheric composition fields at 00z each day, with shorter forecasts generated at 06z, 12z, and 18z. Imagery was centered over California and the southwest US and hosted on GMAO's Framework for Live User-Invoked Data (FLUID). In addition to providing standard datagrams at stations of interest and 2D forecast maps, GMAO also provided a custom page showing inland and offshore cross-sections of carbon, sulfates, dust, and sea salt along planned observing routes used by the research vessels and planes. FLUID was also used to pre-generate model imagery for rapid browsing and ingest using the Mission Tools Suite (MTS) system in near real-time.

3.10 Other activities

3.10.1 Flight planning and coordination

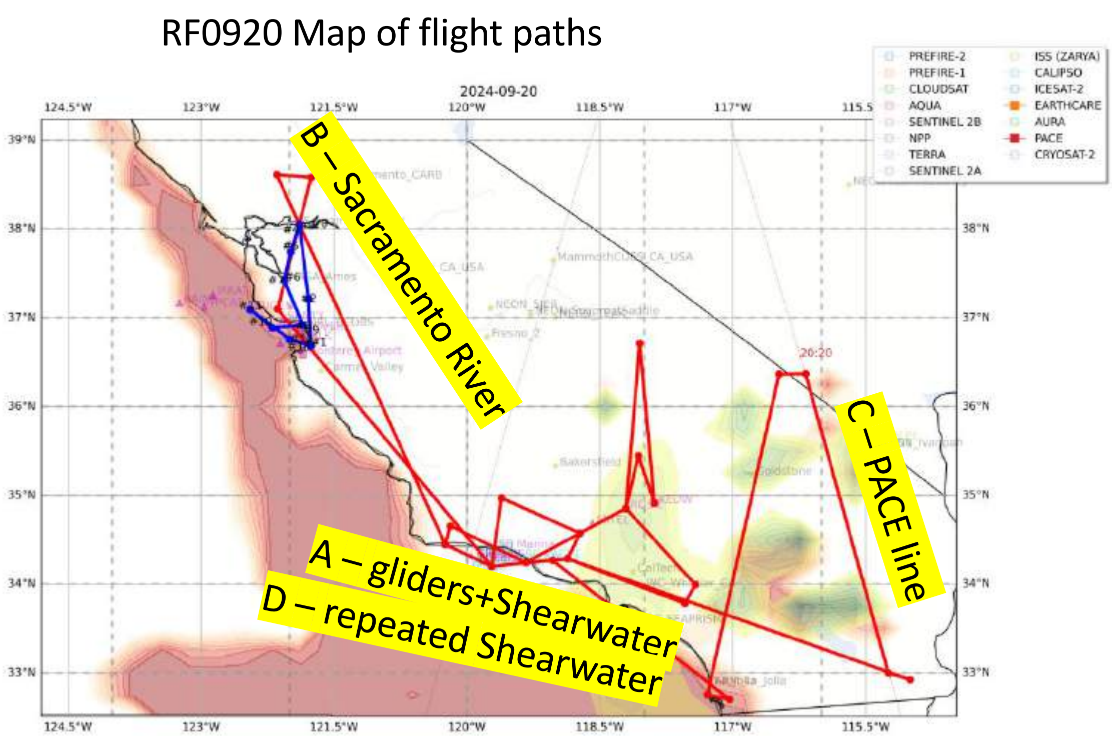


Figure 48 Annotated example flight plan output from moving lines for RF0920 (September 20, 2024). The ER-2 flight track is shown in red, Twin Otter flight track in blue. The background overlay is cloud cover forecast from the GEOS model, with low level clouds in red and higher-level clouds in yellow and green. Satellite tracks are noted with thin color lines. On this day, the PACE track (red) was targeted.

A research flight planning tool 'moving lines' (LeBlanc, 2018) has been used and modified for use during PACE-PAX to build the flight plans for the ER-2 and Twin Otter to coordinate with PACE overpass, R/V Shearwater, and R/V Blissfully. This flight planning tool focuses on building coordinated airborne sampling strategies for better resolving the radiative environment and remote sensing of aerosol, clouds, radiation, ocean color, and atmospheric dynamics. The most recent moving lines version has been upgraded with enhanced coordination graphics for timing, and specialty ER-2 waypoints output formats. This software has 134 downloads and has been used throughout multiple other NASA field campaigns, e.g., ORACLES, ACEPOL, NAAMES, CAMP2Ex, FIREX-AQ, IMPACTS, TRACER-AQ, and ARCSIX. The time and effort required scientists to decide on flight paths according to science objectives, aircraft performance, airspace availability, meteorological and sampling conditions, airborne instruments needs, and coordination with other airborne research platforms leads to unneeded distraction from accomplishing the science objectives.

Moving lines, built as an open-source python library with a graphical user interface portraying mapping in various projections and interfaces through simple spreadsheets (Microsoft Excel). The fundamental interface is one spreadsheet tab per desired flight path, often used as different aircraft, for planning coordinated science observations, including multiple waypoints for identifying latitudes and longitudes of sampling in concert with the vertical aircraft location, solar angles, and satellite viewing geometries. Moving lines incorporate a parameterized set of aircraft characteristics, like typical cruise speed, altitude, turn bank angles, flight speed as a function of altitude, and climb rate for the different research aircrafts in addition to solar geometry calculations, satellite overpass predictions, common flight modules, model/satellite imagery overplotting, and multiple aircraft plans. It also expands with pre-determined flight sampling modules, for which many were custom designed for PACE-PAX. During the building of the flight plans, moving lines calculates the flight time, from the parameterized aircraft parameters and sampling design, and can output pilot friendly files for easier dissemination, and multitude of figures and summary presentation for scientific feedback. Improvements to moving liens for PACE-PAX include the combination of the Mission Support System (MSS; Bauer et al., 2022) server-side for ingesting and plotting multiple forecast model fields, from GEOS-FP, and adding plotting of profiles along planned-flight tracks of numerous cloud, aerosol, and atmospheric parameters.

3.10.2 Mission tools suite

The NASA Airborne Science Mission Tool Suite (MTS) is a web-based platform that provides a common operating picture for NASA's Airborne Science Missions. The tool supports the Airborne Science Program (ASP) and the Earth Science Division of the NASA Science Mission Directorate (SMD). As the ground complement to the NASA SensorNet project, MTS helps improve situational awareness for all mission participants, from scientists and engineers to managers and the public. For the PACE-PAX campaign, MTS served as the central hub for real-time tracking and situational awareness. It provided a single source for tracking a diverse range of assets from multiple organizations, including NASA's own ER-2 aircraft and other airborne platforms like the NPS CIRPAS Twin Otter. MTS's value extended to tracking various ocean science assets, including research vessels like the R/V Shearwater, R/V Paragon and R/V Rachel Carson, along with ocean gliders and Hypernav floats deployed by the University of Maine. This ability to integrate data from airborne, surface, and marine platforms into one view was a vital part of mission operations. In addition to tracking, MTS was used to visualize important data for mission planning and coordination. It displayed satellite position estimates for the PACE and EarthCare satellites, which was essential for coordinating airborne and surface measurements with satellite overpasses. The tool also brought together various data products, such as satellite imagery, radar, airspace information, and GEOS-FP models, all within a single environment. An additional contribution of MTS was the development of PACE-PAX 3D models and public communication and outreach materials. Ultimately, MTS played a central role in the PACE-PAX campaign by fostering better communication and collaboration. The improved mission awareness and real-time operational discussion helped the entire team conduct more responsive and effective scientific measurements, maximizing the campaign's overall value.

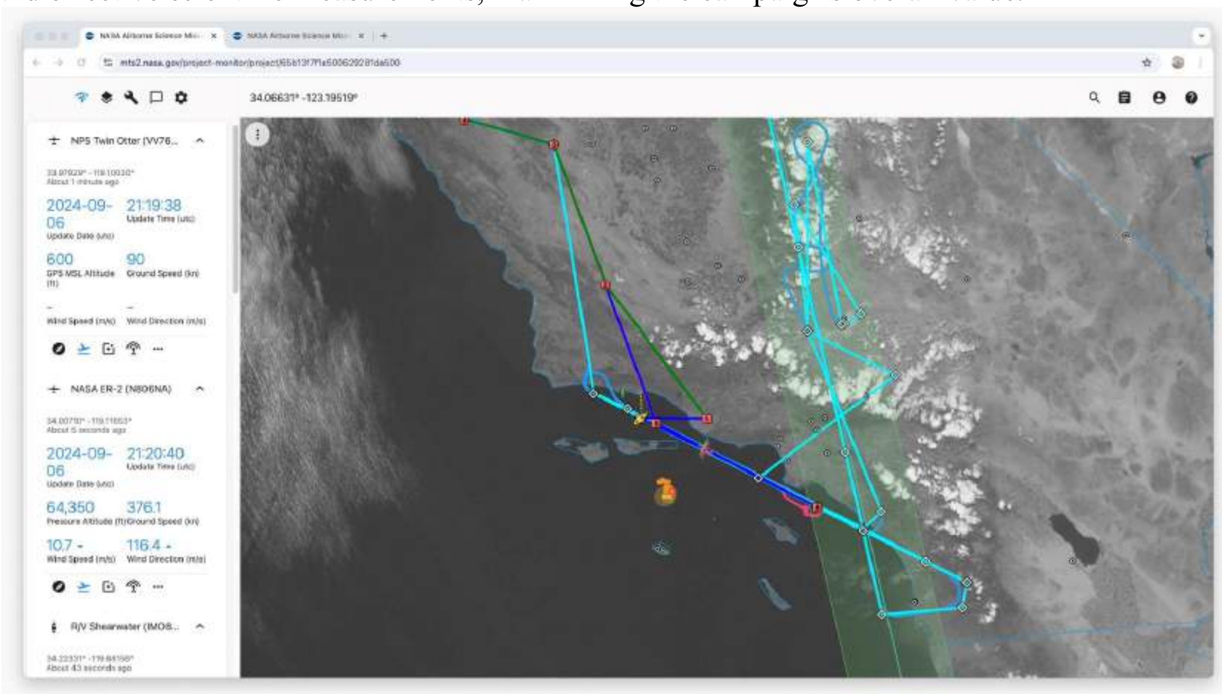


Figure 49 Example MTS display from September 6th, 2024, for coincident ER-2 and Twin Otter observations. Planned flight tracks are shown for the Twin Otter (green and blue), ER-2 (Turquoise), while actual aircraft locations are shown in red and green. The location of the R/V Shearwater is in yellow, the R/V Blissfully in red, and HyperNAV floats in orange. The light green bar at right shows the PACE track and PACE/SPEXone swath. Imagery is from GOES-West.

3.10.3 Logistical support (ESPO)

The Earth Science Project Office (ESPO) at NASA Ames Research Center provides project management for NASA's Science Mission Directorate, Earth Science Division. This includes planning, implementation, and post-mission support for large, complex, multi-agency, domestic and international field campaigns.

ESPO has led over 60 successful field campaigns, dating back to 1987. ESPO supports several of the NASA Earth Science Division’s programs, including Upper Atmosphere Research, Tropospheric Chemistry, Radiation Sciences, Weather and Atmospheric Dynamics, Ocean Biology and Biochemistry, Airborne Science, and the Earth System Science Pathfinder Program.

The PACE-PAX field campaign involved intricate coordination of multiple aircraft, research vessels, and other ocean and ground sensors. ESPO played a pivotal role in project management and provided comprehensive operational and logistical support.

ESPO's support encompassed a wide array of critical services: from supplying gases and cryogens at each deployment site, to overseeing an effort to clean up a long abandoned and dilapidated air traffic control tower. By transforming this neglected space, ESPO enabled one of the instrument teams to effectively utilize the tower to conduct vital coincident ground measurements. Their expertise also extended to the crucial setup and tear-down of operations before and after the field campaign. From logistical coordination to administrative backing and on-site problem-solving, ESPO's unwavering commitment allowed scientists to immerse themselves fully in data collection, analysis, and the pursuit of groundbreaking discoveries without the distraction of operational concerns.

3.11 Data processing and archival

3.11.1 ISARA Twin Otter data synergy effort

3.11.1.1.1 Background

The In-Situ Aerosol Retrieval Algorithm (ISARA) (Dmitrovic et al, 2024) is designed to take in-situ aerosol size distribution and scattering and absorption coefficient measurements, most of which are measured at relative humidities (RHs) that are drier than ambient, to retrieve ambient aerosol optical and microphysical properties that can be compared to aerosol remote sensing products. The aerosol remote sensing products from PACE-PAX that are of interest for validation using ISARA are the aerosol single-scattering albedos, size distributions and Angstrom exponents retrieved from the SPEXone and HARP2 polarimeters onboard the NASA PACE satellite, and by AirHARP, SPEXairborne and the NASA Research Scanning Polarimeter onboard the NASA ER-2. In addition, validation of the High Spectral Resolution Lidar (HSRL-2) extinction profiles and lidar ratios is an important contribution of ISARA to ensuring the accuracy of the PACE-PAX dataset.

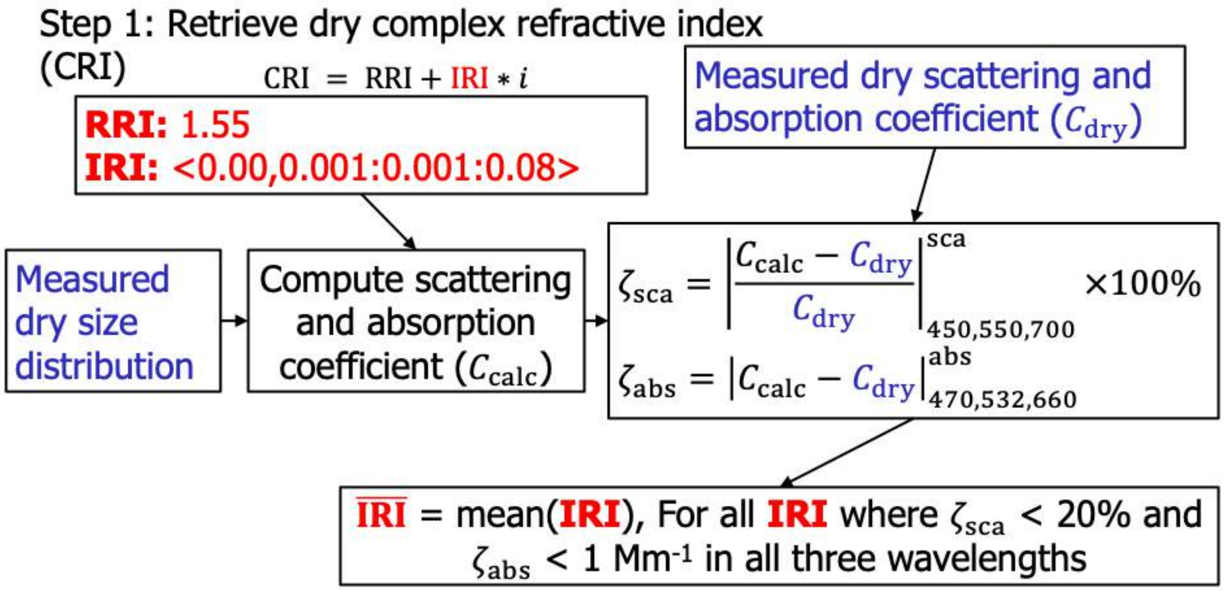


Figure 50 In Step 1 of the ISARA aerosol retrieval algorithm, we retrieve the dry imaginary refractive index using the measured dry size distribution (n^0) and dry scattering and absorption coefficients (C).The IRI is varied from 0.0 to 0.001 and then in steps of 0.001 up to 0.08.

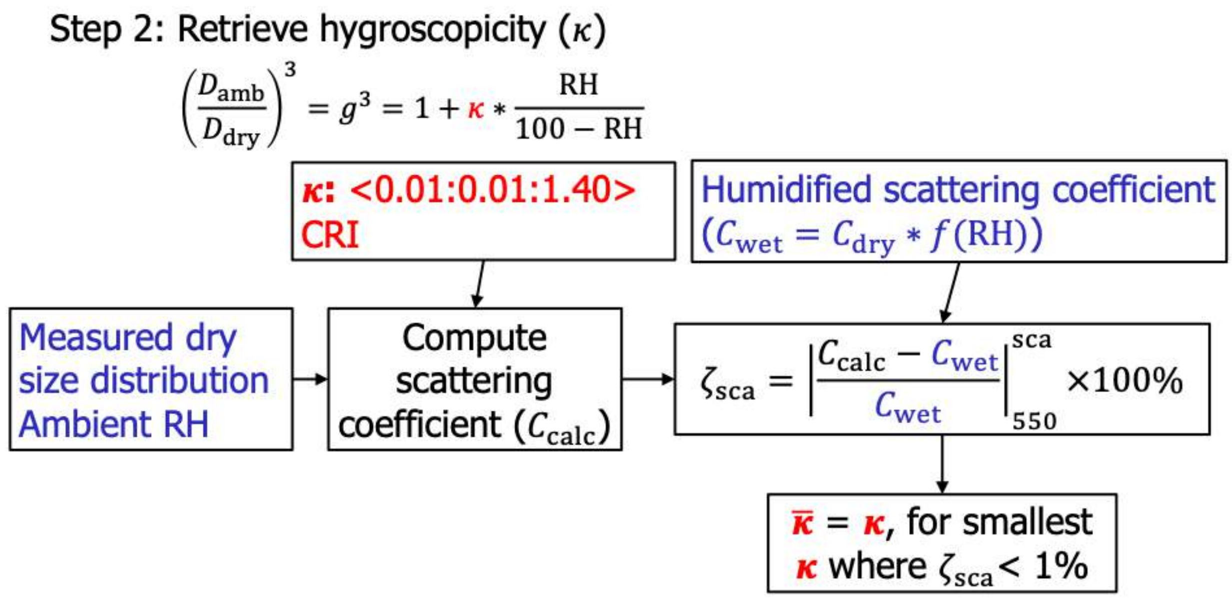


Figure 51 In Step 2 of the ISARA aerosol retrieval algorithm, we retrieve the hygroscopicity parameter (κ) by calculating the humidified size distribution, $n^0(D_{amb})$ from the dry size distribution, $n^0(D_{dry})$, using the equation above, and comparing the measured "wet" scattering coefficient C_{wet} to the calculated one. The hygroscopicity parameter (κ) is varied from 0.01 to 1.4 in steps of 0.01 and the retrieved value is the average of all values of κ for which the measured and calculated "wet" scattering coefficients agree within 1%. The hygroscopic amplification factor (f) used to provide the scattering coefficient at a specified "wet" relative humidity of 80% is derived from simultaneous measurements of the scattering coefficient under dry and wet conditions (see description of tandem nephelometer measurements and eqs.(7) and (8) in Section 3.6.2.2.1.5). .

3.11.1.1.2 Data

The ISARA data products have been submitted to the PACE-PAX archive. The aerosol retrieval parameters include the ambient aerosol number, surface area and volume size distributions, absorption, scattering and extinction coefficients, the aerosol cross-sections, the ambient aerosol complex refractive index, and the ambient single-scattering albedo. The ISARA process and these products are summarized in Figure 50, Figure 51 and 47. The first step in the process is to determine the dry aerosol complex refractive index (CRI) which is composed of the Real Refractive Index (RRI) and the Imaginary Refractive Index (IRI). The complex refractive index is estimated by calculating the scattering and absorption coefficients (C) from the measured dry size distributions and the calculated (Gasteiger and Wiegner, 2018) scattering and absorption cross-sections for each measured size bin for a range of RRI and IRI. The values of RRI and IRI for which the match between calculated and measured scattering coefficients at 450, 550 and 700 nm are all within 20% and calculated and measured absorption coefficients at 470, 532 and 660 nm are all within 1 Mm^{-1} are then averaged together to get a best estimate of the CRI. The second step in the process is the estimation of the kappa (κ) Kohler coefficient (Petters and Kreidenweis, 2007) that controls the growth of dry aerosols by the condensation of water onto their surface. This coefficient is estimated by using the first equation in Figure 46 to calculate the wet size distribution and volume weighted wet CRI that are then used to calculate the wet scattering coefficient. The calculated values are then compared to the measured wet scattering coefficient and all the kappa values for which the calculated and measured wet scattering coefficients at 550 nm agree within 1% are then included in the calculation of an average value. The average kappa value is the one that is reported in the ISARA data products and is used to generate the aerosol ambient properties listed in Figure 47.

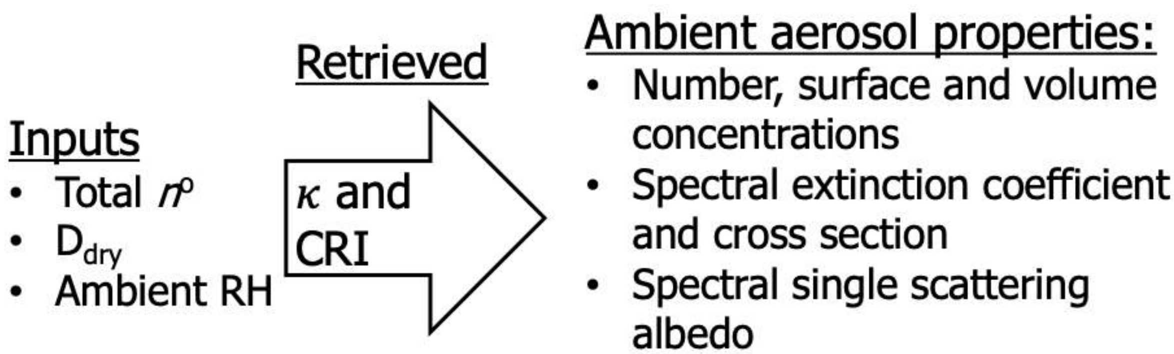


Figure 52 ISARA ambient aerosol retrieval products

3.11.1.1.3 Future plans

We also plan to publish a paper on the ISARA aerosol products for PACE-PAX from the Twin Otter aircraft, with comparisons to NASA PACE polarimeter aerosol products and PACE-PAX ER-2 High-Spectral-Resolution Lidar (HSRL-2) and Research Scanning Polarimeter (RSP) remote sensing products. Joseph Schlosser will be the first author. We are working on a draft of this paper, and the ISARA results are expected to be publishable once the inlet corrections are available.

3.11.2 PICARD and PRISM data merger

3.11.2.1 Background

PRISM and PICARD are pushbroom grating spectrometers that provide contiguous radiance observations across parts or most of the shortwave spectrum. Collectively, their spectral coverage is sufficient to serve as an analog for nearly the entirety of the OCI spectral channels, including both the UV/VIS/NIR spectrometer and the NIR/SWIR narrowbands. Specific details on each instrument can be found in their respective sections (3.7.3 for PICARD, 3.7.4 for PRISM). To facilitate the implementation of OCI algorithms on coupled PRISM/PICARD PACE-PAX observations, a merged Level-1C (L1C) data product has been developed that provides physically co-located top-of-atmosphere reflectance along with geolocation, angles, and other associated datasets.

Key instrument characteristic differences between PRISM and PICARD (and OCI) have important implications on the approach taken for merging their respective L1B datasets into an L1C data file. These include differences in pixel size (roughly 19.4 m for PRISM versus 42 m for PICARD) and swath width (roughly 11 km for PRISM versus 18.4 km for PICARD) that necessitate geographically co-locating and spatially averaging PRISM into the coarser-resolution and wider swath PICARD inherent fields-of-view (IFOVs). In addition, spectrally averaging the PICARD observations into the OCI NIR/SWIR narrowband channels using OCI's relative spectral responses (RSRs) also is required. Figure 53 shows example mean radiance spectra from PRISM (blue line/shading) and PICARD (red line/shading) for a marine stratocumulus scene (PICARD RGB image at top) observed during the 4 September 2024 PACE-PAX science flight. Also shown is the spectral mapping of the PRISM and PICARD imagers to OCI spectral analogs, specifically PRISM providing the contiguous UV/VIS/NIR observations (gray shading covering 350-895 nm) and PICARD providing observations spectrally averaged into the OCI NIR/SWIR channel relative spectral responses (RSRs, dashed gray curves).

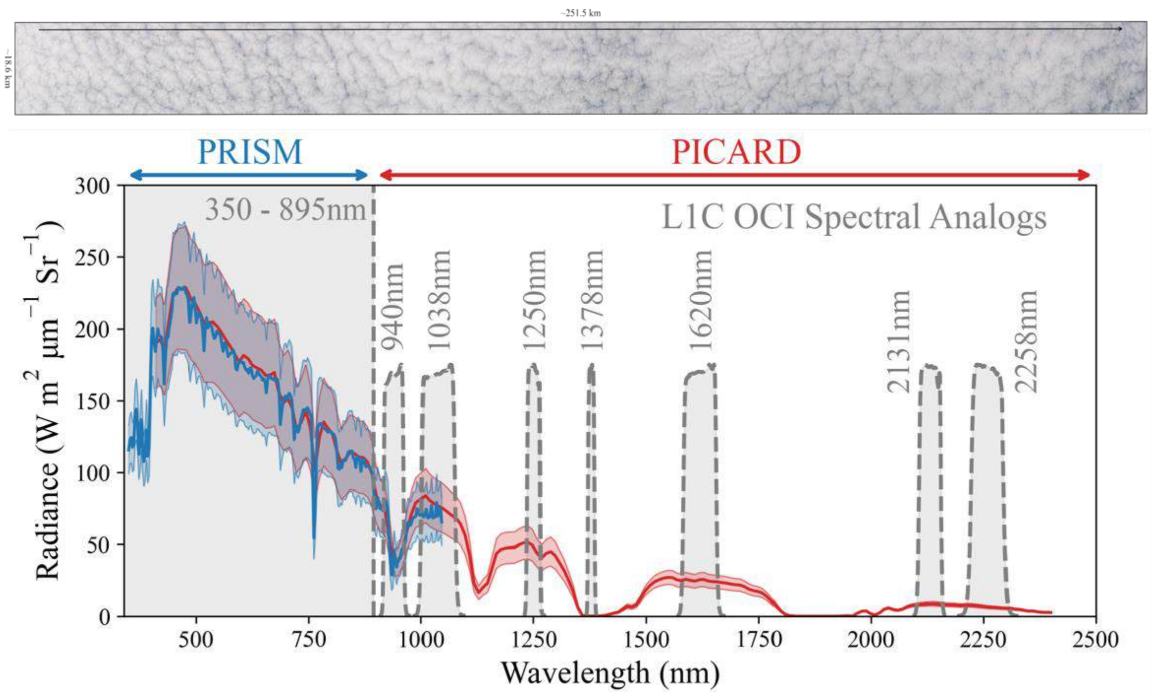


Figure 53 Example radiance and reflectance spectra from PRISM (blue lines/shade) and PICARD (red lines/shade) for a marine stratocumulus scene observed during the 4 September 2024 (21:13-21:54 UTC flight track) PACE-PAX science flight. The RGB from PICARD for this flight segment is shown at top. The bolded lines denote the mean radiance/reflectance from the near-nadir (view zenith angle < 10°) pixels from each imager over the full length of the segment, while the thin lines plus shading denote ±1σ (standard deviation). Also shown is the spectral mapping of the PRISM and PICARD imagers to OCI spectral analogs (gray shaded regions).

3.11.2.2 Data

A description of the L1C data products, including specific details on the co-location and spectral/spatial averaging approaches, L1C file contents, naming convention, etc., can be found in the data description document hosted alongside the L1C data products in the PACE-PAX archive.

3.11.3 Underway archive: LaRC Suborbital Science Data for Atmospheric Composition (SSD-AC)

The Suborbital Science Data for Atmospheric Composition group (SSD-AC) provided a field data repository for PACE-PAX to facilitate both data exchange among science team members and partners as well as data processing that led to production of publication quality or “final” data. As part of this field data repository, SSD-AC implemented a data upload tool to verify ICARTT format compliance for in-situ measurements and download tools supporting large files, batch access, and direct viewing of metadata prior to download. Additionally, SSD-AC deployed an online merge tool, which combines variables from different files into an individual file with a common time base, to facilitate data processing of in-situ measurements. For ER-2 passive remote sensor measurements, SSD-AC developed and deployed online tools to check their level of compliance to PACE L1C format standards.

SSD-AC provided tools and tailored support to help the science team to enhance the interoperability and usability of the PACE-PAX data products, especially to improve ER-2 passive remote sensor data files compliance with PACE L1C format standards and in-situ measurement data compliance with the ICARTT format standard.

The SSD-AC URL is: https://www-air.larc.nasa.gov/missions/pacepax/

3.11.4 Permanent archive: NASA Atmospheric Science Data Center

The Atmospheric Science Data Center (ASDC) is one of NASA's Distributed Active Archive Centers (DAACs). Located at NASA's Langley Research Center (LaRC), the ASDC archives and distributes data from past and current Earth-observing satellites and suborbital missions in the areas of Radiation Budget, Aerosols, Clouds, and Tropospheric Chemistry. The ASDC currently supports over 50 projects and provides access to more than 1,000 archived collections. The ASDC supports the ingest, archive, and distribution of PACE-PAX data. PACE-PAX data products distributed by the ASDC includes the ER-2 and CIRPAS-Twin Otter (CIRPAS-TO) data, Marina Tower, Ivanpah Playa, and Analysis data.

Table 25 lists all the DOIs that have been registered by the ASDC to support the public release of PACE-PAX data. The first DOI, 10.5067/SUBORBITAL/PACE-PAX/DATA001 is the campaign-level DOI for PACE-PAX. This DOI can be used to refer to all data collected during the campaign. The rest of the rows include the collection-level DOIs, which refer to specific subsets of the PACE-PAX data (i.e., subsets of the campaign-level DOI).

Table 25 DOI's and collection names for PACE-PAX data stored in the ASDC

DOI	Collection	Data Products Included
10.5067/SUBORBITAL/PACE-PAX/DATA001	N/A	PACE-PAX Campaign Data
10.5067/ASDC/SUBORBITAL/PACE-PAX/ER2/MetNav_AircraftInSitu_1	PACE-PAX_MetNav_AircraftInSitu_ER2_Data_1	In-Situ Meteorology and Navigation Data for the ER-2
10.5067/ASDC/SUBORBITAL/PACE-PAX/ER2/AircraftRemoteSensing/AirHARP2-MAP_1	PACE-PAX_AircraftRemoteSensing_ER2_AirHARP2-MAP_Data_1	Airborne Hyper-Angular Rainbow Polarimeter-2 (AirHARP-2)
10.5067/ASDC/SUBORBITAL/PACE-PAX/ER2/AircraftRemoteSensing/PRISM-PICARD-L1C_1	PACE-PAX_AircraftRemoteSensing_ER2_PRISM-PICARD-L1C_Data_1	Portable Remote Imaging Spectrometer (PRISM) and Pushbroom Imager for Cloud and Aerosol Research and Development (PICARD) L1C Data
10.5067/ASDC/SUBORBITAL/PACE-PAX/CIRPAS-TO/LiNeph_AircraftInsitu_1	PACE-PAX_LiNeph_AircraftInSitu_CIRPAS-TO_Data_1	Laser Imaging Nephelometer (LI Neph)

10.5067/ASDC/SUBORBITAL/PACE-PAX/CIRPAS-TO/CIRPAS-Facility_AircraftInsitu_1	PACE-PAX_CIRPAS-Facility_AircraftInSitu_CIRPAS-TO_Data_1	In-Situ Aerosol Number Concentration; In-Situ Meteorology and Navigation Data for the CIRPAS-TO
10.5067/ASDC/SUBORBITAL/PACE-PAX/CIRPAS-TO/LARGE-Aerosol_AircraftInsitu_1	PACE-PAX_LARGE-Aerosol_AircraftInSitu_CIRPAS-TO_Data_1	In-Situ Aerosol Optical Size Distribution; In-Situ Aerosol Optical Properties; In-Situ Aerosol Aerodynamic Size Distribution Data (CIRPAS-TO)
10.5067/ASDC/SUBORBITAL/PACE-PAX/Marina-Tower/LARGE-Aerosol_1	PACE-PAX_LARGE-Aerosol_Marina-Tower_Data_1	In-Situ Aerosol Optical Size Distribution; In-Situ Aerosol Optical Properties; In-Situ Aerosol Aerodynamic Size Distribution Data (Marina Tower)
10.5067/ASDC/SUBORBITAL/PACE-PAX/Analysis/CIRPAS-TO_1	PACE-PAX_Analysis_CIRPAS-TO_Data_1	CIRPAS-TO Collocation Flags
10.5067/ASDC/SUBORBITAL/PACE-PAX/Analysis/ER2_1	PACE-PAX_Analysis_ER2_Data_1	ER-2 Collocation Flags
10.5067/ASDC/SUBORBITAL/PACE-PAX/Ivanpah-Playa_1	PACE-PAX_Ivanpah-Playa_Data_1	Ivanpah Playa Ground Site Data
10.5067/ASDC/SUBORBITAL/PACE-PAX/Analysis/ISARA_1	PACE-PAX_Analysis_ISARA_Data_1	In-Situ Aerosol Retrieval Algorithm (ISARA) Analysis
10.5067/ASDC/SUBORBITAL/PACE-PAX/ER2/AircraftRemoteSensing/SPEXAIRBORNE_1	PACE-PAX_AircraftRemoteSensing_ER2_SPEXAIRBORNE_Data_1	Spectro-Polarimeter for Exploration Airborne (SPEX Airborne)
10.5067/ASDC/SUBORBITAL/PACE-PAX/ER2/AircraftRemoteSensing/RSP_1	PACE-PAX_AircraftRemoteSensing_ER2_RSP_Data_1	Research Scanning Polarimeter (RSP)
10.5067/ASDC/SUBORBITAL/PACE-PAX/DATA001/ER2/AircraftRemoteSensing/HSRL2_1	PACEPAX_AircraftRemoteSensing_ER2_HSRL2_Data_1	High Spectral Resolution Lidar-2 (HSRL-2)

3.11.5 Permanent archive: SeaBASS

The SeaWiFS Bio-optical Archive and Storage System (SeaBASS) operates as a component of NASA's Ocean Biology Distributed Active Archive Center (OB.DAAC) within the Earth Observing System Data and Information System (EOSDIS) framework. The SeaBASS fulfills dual functions: it provides long-term archival and data distribution services for the ocean color research community through OB.DAAC, while also collecting and managing datasets essential for calibrating and validating ocean color satellite missions such as PACE.

Oceanographic (and some atmospheric) observations collected during the PACE-PAX campaign from research vessels, floats or gliders are archived in SeaBASS under a single experiment DOI: https://doi.org/10.5067/SeaBASS/PACE-PAX/DATA001 . Data are also accessible at https://seabass.gsfc.nasa.gov/experiment/PACE-PAX

3.11.6 Online presence and data discovery support

In addition to the archives mentioned above, the PACE Project Science office maintains an informational website to assist in data discovery: https://pace.oceansciences.org/pace-pax.htm . Furthermore, some of the instrument teams maintain data quicklook sites listed in Table 26. We should note, however, that neither these website nor the PACE Project Science office website can be expected to be maintained as such in the long term.

Table 26 Instrument quicklook URLs

Instrument	Platform	POC	POC email	Quicklook location
PICARD	ER-2	James Jacobson	james.d.jacobson@nasa.gov	https://asapdata.arc.nasa.gov/picard/data/deploy_html/pace-pax.html
RSP	ER-2	Brian Cairns	brian.cairns@nasa.gov	https://data.giss.nasa.gov/pub/rsp/data/PACEPAX/
HyperNAV radiometry suite	HyperNAV	Andrew Bernard	barnaran@oregonstate.edu	https://misclab.umeoce.maine.edu/HyperNAV/science
HSRL-2	ER-2	Taylor Shingler or John Hair	taylor.j.shingler@nasa.gov or johnathan.w.hair@nasa.gov	https://www-air.larc.nasa.gov/cgi-bin/ArcView/pacepax?ER2=1#HAIR.JOHNATHAN/
SpexAirborne	ER-2			
AirHARP	ER-2	Vanderlei Martins	Martins@umbc.edu	PACE-PAX AirHARP2: https://aether.esi-cloud.org/pace-pax PACE HARP2 L1C: https://aether.esi-cloud.org/pace-harp2/1541
PRISM	ER-2	David Thompson	david.r.thompson@jpl.nasa.gov	https://popo.jpl.nasa.gov/mmgis-aviris/?mission=PRISM
PRISM+PICARD	ER-2	Kerry Meyer	kerry.meyer@nasa.gov	https://modis-images.gsfc.nasa.gov/arnold/activeProjects/picard/pacepax/picard_prism/index1.htm
ASP (MVIS)	ER-2			https://asp-archive.arc.nasa.gov/PACEPAX/

4 Performance

4.1 Tabulated VTM objective observations

This section contains tabulated objectives that were successfully observed during PACE-PAX. The rubric for scoring observed time is described in Table 27. Furthermore, the scored time was adjusted as described in the rubric in Table 28. Note tabulated hours in blue were scored less than 1.0, meaning the measurement was somewhat deficient.

Table 27 Measurement time rubric used for scoring VTM observations. From Knobelspiesse et al., 2025

Measurement time, h	Observation
0.5	ER-2 overflight of a ground site, such as AERONET
1.0	ER-2 overflight over ground site, with additional aerosol advection sampling
1.5	ER-2 overflight of Twin Otter performing sampling maneuver
1.5	Ship (Shearwater or Blissfully) sampling during satellite overpass
1.5	Ship (Shearwater or Blissfully) sampling during aircraft (ER-2 or Twin Otter) overpass
2.0	ER-2 underflight along satellite track

In the VTM descriptions, ‘low’ aerosol loads were those for which mid-visible wavelength AOD < 0.1, while ‘moderate’ aerosol loads had 0.1 < AOD < 0.2, and ‘high’ aerosol loads > 0.2.

Table 28 VTM time scoring multiplier rubric, based on measurement success

Score multiplier	
0	No validation likely
0.25-0.5	Somewhat confident or partial single pathway to satisfy validation/measurement objective
0.75	Somewhat confident or partial, but multiple, pathways to satisfy validation/measurement objective
0.90	Confident single pathway to satisfy validation/measurement objective
0.95	Confident single pathway to satisfy validation/measurement objective, somewhat confident or partial secondary pathway available
1.0	Multiple pathways to satisfy this validation/measurement objective, including meeting all mission requirements

Table 29 Notations and abbreviations

Abbreviation	Description
ER2	ER-2 aircraft
HN	HyperNAV
PACE-O	Within the swath of PACE/OCI (only)
PACE-OH	Within the swath of PACE/OCI and PACE/HARP2 (only)
PACE-OHS	Withing the swath of all PACE instruments (OCI, HARP2, SPEXone)
RB	R/V Blissfully
RS	R/V Shearwater
TO	Twin Otter aircraft

4.1.1 VTM 1a: land surface properties

Importance (*w*): 8
Threshold required measurement time (*h*): 2

Actual measurement time (t_a): 11.125
Measurement time fulfillment (f): 99.6%
Baseline requirement exceeded

Table 30 Observations of VTM objective 1a: Validate new retrieval products, land surface properties

Flight ID	Date	Time	Platform	Hours	Description
CF0829	29-Aug-24	18:43	ER2	0.5	Overfly NEON SJER. Moderate AOD=0.18
RF0910	10-Sep-24	17:21	ER2	0.125	Overfly Ivanpah Playa. Possible aerosol load. Small clouds partly obscure scene
RF0913	13-Sep-24	20:18:30	ER2	1	ER2 over Railroad Valley, AERONET AOD(440)=0.05
RF0913	13-Sep-24	21:59	ER2	0.5	ER2 overflites WC_Whittier_CA AERONET site, AOD(500)=0.35 high load
RF0917	17-Sep-24	20:02	ER2, Ivanpah	2	ER-2 overflies Ivanpah Playa with JPL surface team present for characterization. Clear skies, low AOD
RF0917	17-Sep-24	20:40	ER2, Ivanpah	2	ER-2 2nd overflies Ivanpah Playa with JPL surface team present for characterization. Clear skies, low AOD, roughly 90° from last overpass.
RF0922	22-Sep-24	17:25	ER2	0.5	ER-2 over Railroad Valley. No Clouds. AERONET AOD(500)=0.055
RF0922	22-Sep-24	17:45	ER2	0.5	ER-2 over Railroad Valley. No Clouds. AERONET AOD(500)=0.056
RF0922	22-Sep-24	19:13	ER2	0.5	ER-2 over NEON_SJER AERONET site, AOD(500)=0.11
RF0929	29-Sep-24	18:37	ER2	0.5	ER-2 overflies NEON_SJER AERONET site. AOT(500)=0.13
RF0929	29-Sep-24	20:39	ER2, PACE-OHS	1	ER-2 overflies NEON_SJER AERONET site. AOT(500)=0.12
RF0930	30-Sep-24	18:25	ER2	0.5	ER2 over NEON_SJER AERONET site, AOT(500)=0.11
RF0930	30-Sep-24	22:13	ER2	0.25	Over Ivanpah Playa calibration site (no ground team)
RF0930	30-Sep-24	22:59	ER2	1	Over Railroad valley calibration and AERONET site. AOT(500)=0.05
RF0930	30-Sep-24	23:33	ER2	0.25	Over NEON_TEAK (neon land surface site) AERONET site, AOT(500)=0.1 (variations through the day likely linked to happy fire)

4.1.2 VTM 1b: ocean radiometric properties

Importance (w): 10
Threshold required measurement time (h): 8
Actual measurement time (t_a): 75.75
Measurement time fulfillment (f): 100%

Baseline requirement exceeded

Table 31 Observations of VTM objective 1b: Validate new retrieval products, ocean radiometric properties

Flight ID	Date	Time	Platform	Hours	Description
RF0904	4-Sep-24	19.47	ER2	0.5	Sacramento River AERONET-OC, AOT=0.05
RF0905	5-Sep-24	19:55	PACE,UCSB	1	PACE overpass (first)
RF0905	5-Sep-24	21:32	UCSB,PACE	1	PACE overpass (2nd)
RF0906	6-Sep-24	18:01	ER2, RB	1	ER-2 over RB and USC_SeaPRISM AERONET-OC AOD(510)=0.15. Partly cloudy
RF0906	6-Sep-24	20:30	ER2	1	Over ocean section in PACE-OHS swath., Cloud free. Ocean params partially satisfied with HSRL2
RF0906	6-Sep-24	20:30	RB	1	RB + USC_SeaPRISM AERONET-OC AOD(510)=0.13 in PACE-OHS swath
RF0906	6-Sep-24	20:55	ER2, RB	0.5	ER2 overfly R/V Blissfully & USC_SeaPRISM AERONET-OC, AOD(510)=0.12
RF0906	6-Sep-24	21:03	ER2, RS	1	ER-2 over R/V Shearwater
RF0906	6-Sep-24	21:27	ER2, RB	1	ER-2 over R/V Blissfully and USC_SeaPRISM AERONET-OC
RF0906	6-Sep-24	21:42	ER2, RS, TO	1	ER-2 over R/V Shearwater and Twin Otter spiral
RF0906	6-Sep-24	22:01	ER2, RS	1	ER-2 over R/V Shearwater
RF0908	8-Sep-24	19:32	ER2, RB	2	Overpass USC_Seaprism Aeronet high AOD(490)=0.36; Blissfully on station with HyperPro, etc.
RF0908	8-Sep-24	19:47	ER2,Gliders	1	ER2 overfly Glider line
RF0908	8-Sep-24	19:48	ER2,RS	1.5	ER2 overfly Shearwater with IOP and AERONET
RF0908	8-Sep-24	20:01	ER2,RS	1.5	ER2 overfly Shearwater with IOP and AERONET
RF0908	8-Sep-24	20:16	ER2, RB	2	Overpass USC_Seaprism Aeronet high AOD(490)=36; Blissfully on station with HyperPro, etc. mostly smoke
RF0910	10-Sep-24	18:47	ER2, SB	0.5+1.5	ER-2 overfly R/V Blissfully and USC_SeaPRISM AERONET site, AOD(490nm)=0.10
RF0911	11-Sep-24	20:19	HN	0.5	Profile up, nearest AOD (USC_SEAPRISM)=0.055
RF0912	12-Sep-24	20:23	RB	1.5	R/V Blissfully station begins. Near USC_SeaPRISM Aeronet-OC site, and in PACE-OH swath. AOD(490)=0.13
RF0912	12-Sep-24	20:37	RS	1.5	R/V Shearwater ends station #7 in PACE-OH swath. Station started at 18:49
RF0912	12-Sep-24	20:39	TO	1.5	Start ascend over Sacramento_River AERONET-OC site. Water very turbid. Within PACE-OHS swath. Small amounts of dust in spiral. AOD(532)=0.04

RF0912	12-Sep-24	21:00	RS	1.5	R/V Shearwater starts station #8 in PACE-OH swath. Station ends at 22:54
RF0913	13-Sep-24	21:14	RB	1.5	Blissfully sampling adjacent to USC_SeaPRISM site during PACE overpass (OCI only) with cloud-free skies. AOT(490)=0.18, moderate aod, smoke from fires
RF0913	13-Sep-24	21:14	RS	1.5	Shearwater on station 11 from 20:45 to 22:01 during PACE overpass. Cloud free
RF0913	13-Sep-24	21:48	ER2, RB	1.5	ER-2 overpass of Blissfully and USC_SeaPRISM. Cloud free skies, AOT(490)=0.19, moderate aod, smoke from fires
RF0915	15-Sep-24	19:57	RB	1.5	On station for PACE overpass near USC_SeaPRISM. no USC_SeaPRISM archived data.
RF0915	15-Sep-24	20:00	RS	0.75	On station until 21:28. Partly cloudy conditions with PACE overpass.
RF0915	15-Sep-24	20:41	ER2	1	ER-2 overflies surfacing HyperNAV during PACE overpass. Partial cloudy HyperNAV profile, but clear at surface.
RF0917	17-Sep-24	18:02	ER2, RS	1	ER-2 overpass of RS at station #16. Biologically productive waters
RF0917	17-Sep-24	18:03	ER2, Glider	1	ER-2 over glider in biologically productive waters and clear skies. Outside of PACE overpass +/-2hours by a few minutes.
RF0917	17-Sep-24	18:26	RB	1	Blissfully on station RB_14, ER-2 overhead in clear skies. Nearby USC_SeaPRISM inoperable
RF0917	17-Sep-24	19:12	ER2, RS	1	ER-2 over Shearwater in clear skies and biologically productive waters
RF0917	17-Sep-24	19:19	ER2, glider	1	ER-2 over glider in biologically productive waters and clear skies
RF0917	17-Sep-24	19:58	RB	1	Blissfully on station RB_15, PACE overhead in clear skies. Nearby USC_SeaPRISM inoperable
RF0917	17-Sep-24	20:18	RS	1	Shearwater on station 18 in clear skies, remains until 20:39. PACE overpass
RF0917	17-Sep-24	21:22	ER2, RS	1	ER-2 over Shearwater in clear skies and biologically productive waters
RF0918	18-Sep-24	19:29	RS	2	Station 21 until 21:12. PACE-OH Overpass. Minimal Clouds. Possible lack of AERONET/Cimel measurements.
RF0918	18-Sep-24	20:56	RB	1	Station #18 until 21:55. PACE-OH Overpass. No clouds.
RF0919	19-Sep-24	19:00	RB	1	Blissfully on station for PACE-O overpass. No USC_SeaPRISM data
RF0919	19-Sep-24	19:43	TO, RS, PACE-O	2	Twin Otter spiral over Shearwater during PACE-O overpass. Cloud free at this point, relatively clean aerosols.
RF0919	19-Sep-24	20:40	RS	2	On station 23 until 22:41, with Twin Otter spiral over top plus PACE-O

RF0920	20-Sep-24	20:23	RS	2	Arrives on station 27. PACE-O overpass. Mostly clear. Departure 21:47
RF0925	25-Sep-24	18:36-19:58	RS, PACE-OH	2	Station #34, clear skies
RF0925	25-Sep-24	20:04-21:33	RS, PACE-OH	2	Station #35, clear skies
RF0925	25-Sep-24	21:50-22:47	RS, PACE-OH	2	Station #36, clear skies
RF0926	26-Sep-24	18:06	ER2, RS	1.5	ER-2 over Shearwater station #39 (SHER1) in clear skies
RF0926	26-Sep-24	19:25	TO, RS	1.5	TO spirals up from 100 to 10000ft over Shearwater at #39 (SHER1) at top 19:50
RF0926	26-Sep-24	19:35	ER2,RS	3	ER-2 over Shearwater at station #40 (SHER2), at location for Twin Otter (also previously overflew this site at ~19:23). Some glint.
RF0926	26-Sep-24	20:00	TO	1.5	TO spirals over red tide offshore near Oxnard, CA.
RF0926	26-Sep-24	20:20	TO	1.5	TO spirals up from 100 to 10000ft over Shearwater at #40 (SHER2) at top 20:59
RF0926	26-Sep-24	21:03	ER2	0.5	Over Sacramento_River AERONET-OC site. AOD(500)=0.03
RF0927	27-Sep-24	19:36	ER2, RC	1	ER-2 over R/V Rachel Carson in biologically productive Monterey Bay conditions
RF0927	27-Sep-24	20:30	ER2, PACE-OHS	1	Begins ~ 1 hour PACE track. Roughly 2/3 cloudy, 1/3 cloud free. Ends at 21:21
RF0927	27-Sep-24	20:39	TO, PACE-OH	1.5	Twin Otter spiral over R/V Rachel Carson (PACE overpass). Top of spiral at 21:09, multiple aerosol layers
RF0927	27-Sep-24	22:38	ER2	0.5	Over Sacramento_River AERONET-OC site. AOT(490)=0.05
RF0929	29-Sep-24	19:02	ER2	0.5	ER-2 overflies Sacramento_River AERONET site. AOT(490)=0.05
RF0929	29-Sep-24	21:07	ER2, Gliders	1	PACE overflies gliders in biologically productive waters. Glint
RF0929	29-Sep-24	21:47	ER2	0.5	Over USC_SeaPRISM site, AOT(490)=0.05, Glint, Partial aerosol within PACE-OHS (in between clouds, from 20:35 overpass)
RF0929	29-Sep-24	22:44	ER2	0.5	Over USC_SeaPRISM site, AOT(490)=0.05
RF0929	29-Sep-24	23:40	ER2, Gliders	1	ER2 overflies gliders in biologically productive waters, where previous PACE-OHS/OH
RF0930	30-Sep-24	18:42	ER2	0.5	ER2 over Sacramento_River AERONET-OC site. AOT(490)=0.07
RF0930	30-Sep-24	18:53	ER2	0.5	Transit to PACE (jn PACE-OH swath) track along cloud free and gradient of very high Chl waters to much lower concentrations on the line. End 19:31. Scored but reduced due to time difference.

RF0930	30-Sep-24	19:34	ER2	1.5	Transit within PACE-OHS swath. Cloud free with a gradient of more to less Chl-a from start (North) to end (South). Ends 20:17

4.1.3 VTM 1c: aerosol properties over the ocean

Importance (w): 12
Threshold required measurement time (h): 8
Actual measurement time (t_a): 63.875
Measurement time fulfillment (f): 100%
Baseline requirements exceeded

Table 32 Observations of VTM objective 1c: Validate new retrieval products, aerosol properties over the ocean

Flight ID	Date	Time	Platform	Hours	Description
RF0904	4-Sep-24	19.47	ER2	0.5	Sacramento River AERONET-OC, AOT=0.05
RF0906	6-Sep-24	18:01	ER2, RB	0.5	ER-2 over RB and USC_SeaPRISM AERONET-OC AOD(510)=0.15. Partly cloudy
RF0906	6-Sep-24	20:30	ER2	1	Over ocean section in PACE-OHS swath., Cloud free. Ocean params partially satisfied with HSRL2
RF0906	6-Sep-24	20:30	RB	0.5	RB + USC_SeaPRISM AERONET-OC AOD(510)=0.13 in PACE-OHS swath
RF0906	6-Sep-24	20:37	ER2	0.5	ER2 over AERONET (La_Jolla) AOD(500nm) ~0,4
RF0906	6-Sep-24	20:55	ER2, RB	0.5	ER2 overfly R/V Blissfully & USC_SeaPRISM AERONET-OC, AOD(510)=0.12
RF0906	6-Sep-24	20:56	ER2, TO,RB	1.5	ER2 overfly TO as it is doing a spiral down over USC_SeaPRISM and RV Blissfully
RF0906	6-Sep-24	21:03	ER2, RS	1	ER-2 over R/V Shearwater
RF0906	6-Sep-24	21:27	ER2, RB	1	ER-2 over R/V Blissfully and USC_SeaPRISM AERONET-OC
RF0906	6-Sep-24	21:42	ER2, RS, TO	2.5	ER-2 over R/V Shearwater and Twin Otter spiral
RF0906	6-Sep-24	22:01	ER2, RS	1	ER-2 over R/V Shearwater
RF0908	8-Sep-24	19:32	ER2, RB	0.5	Overpass USC_Seaprism Aeronet high AOD(490)=0.36; Blissfully on station with HyperPro, etc.
RF0908	8-Sep-24	19:48	ER2,RS	0.5	ER2 overfly Shearwater with IOP and AERONET
RF0908	8-Sep-24	20:01	ER2,RS	0.5	ER2 overfly Shearwater with IOP and AERONET
RF0908	8-Sep-24	20:16	ER2, RB	0.5	Overpass USC_Seaprism Aeronet high AOD(490)=36; Blissfully on station with HyperPro, etc. mostly smoke

RF0910	10-Sep-24	18:47	ER2, SB	0.5+1.5	ER-2 overfly R/V Blissfully and USC_SeaPRISM AERONET site, AOD(490nm)=0.10
RF0912	12-Sep-24	20:23	RB	0.5	R/V Blissfully station begins. Near USC_SeaPRISM Aeronet-OC site, and in PACE-OH swath. AOD(490)=0.13
RF0912	12-Sep-24	20:37	RS	0.5	R/V Shearwater ends station #7 in PACE-OH swath. Station started at 18:49
RF0912	12-Sep-24	21:00	RS	0.5	R/V Shearwater starts station #8 in PACE-OH swath. Station ends at 22:54
RF0912	12-Sep-24	22:06	TO	1.125	Missed approach and ascend at Moffett Field, NASA_Ames AERONET site AOD(500)=0.04. Can extend this value using HSRL to validate over turbid water retrievals in SF bay.
RF0913	13-Sep-24	21:14	RB	1.5	Blissfully sampling adjacent to USC_SeaPRISM site during PACE overpass (OCI only) with cloud-free skies. AOT(490)=0.18, moderate aod, smoke from fires
RF0913	13-Sep-24	21:14	RS	1.5	Shearwater on station 11 from 20:45 to 22:01 during PACE overpass. Cloud free
RF0913	13-Sep-24	21:48	ER2, RB	1.5	ER-2 overpass of Blissfully and USC_SeaPRISM. Cloud free skies, AOT(490)=0.19, moderate aod, smoke from fires
RF0913	13-Sep-24	21:59	ER2	0.5	ER2 overflites WC_Whittier_CA AERONET site, AOD(500)=0.35 high load
RF0915	15-Sep-24	19:57	RB	0.75	On station for PACE overpass near USC_SeaPRISM. no USC_SeaPRISM archived data.
RF0915	15-Sep-24	20:00	RS	0.75	On station until 21:28. Partly cloudy conditions with PACE overpass.
RF0917	17-Sep-24	18:02	ER2, RS	1	ER-2 overpass of RS at station #16. Biologically productive waters
RF0917	17-Sep-24	18:03	ER2, Glider	0.5	ER-2 over glider in biologically productive waters and clear skies. Outside of PACE overpass +/-2hours by a few minutes.
RF0917	17-Sep-24	18:26	RB	0.5	Blissfully on station RB_14, ER-2 overhead in clear skies. Nearby USC_SeaPRISM inoperable
RF0917	17-Sep-24	18:44	ER2	0.25	ER-2 over La_Jolla (coastal site) AERONET site. moderate AOD(500)=0.14
RF0917	17-Sep-24	19:12	ER2, RS	1	ER-2 over Shearwater in clear skies and biologically productive waters
RF0917	17-Sep-24	19:19	ER2, glider	0.5	ER-2 over glider in biologically productive waters and clear skies
RF0917	17-Sep-24	19:58	RB	0.5	Blissfully on station RB_15, PACE overhead in clear skies. Nearby USC_SeaPRISM inoperable

RF0917	17-Sep-24	21:22	ER2, RS	1	ER-2 over Shearwater in clear skies and biologically productive waters
RF0918	18-Sep-24	19:29	RS	1	Station 21 until 21:12. PACE-OH Overpass. Minimal Clouds. Possible lack of AERONET/Cimel measurements.
RF0918	18-Sep-24	20:56	RB	1	Station #18 until 21:55. PACE-OH Overpass. No clouds.
RF0919	19-Sep-24	19:00	RB	0.5	Blissfully on station for PACE-O overpass. No USC_SeaPRISM data
RF0919	19-Sep-24	19:43	TO, RS, PACE-O	1.5	Twin Otter spiral over Shearwater during PACE-O overpass. Cloud free at this point, relatively clean aerosols.
RF0919	19-Sep-24	20:40	RS	1.5	On station 23 until 22:41, with Twin Otter spiral over top plus PACE-O
RF0920	20-Sep-24	20:23	RS	2	Arrives on station 27. PACE-O overpass. Mostly clear. Departure 21:47
RF0925	25-Sep-24	18:36-19:58	RS, PACE-OH	2	Station #34, clear skies
RF0925	25-Sep-24	20:04-21:33	RS, PACE-OH	2	Station #35, clear skies
RF0925	25-Sep-24	21:50-22:47	RS, PACE-OH	2	Station #36, clear skies
RF0926	26-Sep-24	18:06	ER2, RS	1.5	ER-2 over Shearwater station #39 (SHER1) in clear skies
RF0926	26-Sep-24	19:07	ER2, TO	0.5	ER2 overpass (at 19:17) of TO west of Santa Barbara, while TO is descending into boundary layer
RF0926	26-Sep-24	19:25	TO, RS	1.5	TO spirals up from 100 to 10000ft over Shearwater at #39 (SHER1) at top 19:50
RF0926	26-Sep-24	19:35	ER2,RS	3	ER-2 over Shearwater at station #40 (SHER2), at location for Twin Otter (also previously overflew this site at ~19:23). Some glint.
RF0926	26-Sep-24	20:00	TO	1.5	TO spirals over red tide offshore near Oxnard, CA.
RF0926	26-Sep-24	20:20	TO	1.5	TO spirals up from 100 to 10000ft over Shearwater at #40 (SHER2) at top 20:59
RF0926	26-Sep-24	20:35	ER2, PACE-OHS	0.25	Over pyramid lake (turbid), under PACE-OHS, nearby Univ_of_Nevada-Reno AERONET AOD(500)=0.04
RF0926	26-Sep-24	21:03	ER2	0.5	Over Sacramento_River AERONET-OC site. AOD(500)=0.03
RF0927	27-Sep-24	19:36	ER2, RC	1	ER-2 over R/V Rachel Carson in biologically productive Monterey Bay conditions
RF0927	27-Sep-24	20:30	ER2, PACE-OHS	1	Begins ~ 1 hour PACE track. Roughly 2/3 cloudy, 1/3 cloud free. Ends at 21:21

RF0927	27-Sep-24	20:39	TO, PACE-OH	1.5	Twin Otter spiral over R/V Rachel Carson (PACE overpass). Top of spiral at 21:09, multiple aerosol layers
RF0927	27-Sep-24	21:40	ER2	1	Begin ER2 cloud free segment in PACE-OH swath
RF0927	27-Sep-24	21:43	TO	1.5	Start of spiral down over Sacramento_River AERONET-OC site. ER-2 overpass after spiral (22:38), multiple aerosol layer.
RF0927	27-Sep-24	22:38	ER2	0.5	Over Sacramento_River AERONET-OC site. AOT(490)=0.05
RF0927	27-Sep-24	22:50	TO	0.75	Twin Otter begins CEOBS spiral with ER-2 overhead(23:07). Cloud free. Partially above water.
RF0929	29-Sep-24	19:02	ER2	0.5	ER-2 overflies Sacramento_River AERONET site. AOT(490)=0.05
RF0929	29-Sep-24	21:07	ER2, Gliders	1	PACE overflies gliders in biologically productive waters. Glint
RF0929	29-Sep-24	21:47	ER2	0.5	Over USC_SeaPRISM site, AOT(490)=0.05, Glint, Partial aerosol within PACE-OHS (in between clouds, from 20:35 overpass)
RF0929	29-Sep-24	22:44	ER2	0.5	Over USC_SeaPRISM site, AOT(490)=0.05
RF0929	29-Sep-24	23:40	ER2, Gliders	1	ER2 overflies gliders in biologically productive waters, where previous PACE-OHS/OH
RF0930	30-Sep-24	18:42	ER2	0.5	ER2 over Sacramento_River AERONET-OC site. AOT(490)=0.07
RF0930	30-Sep-24	18:53	ER2	0.5	Transit to PACE (jn PACE-OH swath) track along cloud free and gradient of very high Chl waters to much lower concentrations on the line. End 19:31. Scored but reduced due to time difference.
RF0930	30-Sep-24	19:34	ER2	1.5	Transit within PACE-OHS swath. Cloud free with a gradient of more to less Chl-a from start (North) to end (South). Ends 20:17

4.1.4 VTM 1d: aerosol properties over land

Importance (w): 12
Threshold required measurement time (h): 8
Actual measurement time (t_a): 90.1
Measurement time fulfillment (f): 100%
Baseline requirement exceeded

Table 33 Observations of VTM objective 1d: Validate new retrieval products: aerosol properties over land

Flight ID	Date	Time	Platform	Hours	Description

CF0829	29-Aug-24	18:26	ER2	0.5	Overfly (nearby) Bakersfield. Moderate AOD=0.13
CF0829	29-Aug-24	18:41	ER2	0.5	Overfly Fresno_2. Moderate AOD=0.188
CF0829	29-Aug-24	18:43	ER2	0.5	Overfly NEON SJER. Moderate AOD=0.18
CF0829	29-Aug-24	19:02	ER2	0.5	Overfly Fresno_2. Moderate AOD=0.176
CF0829	29-Aug-24	19:16	ER2	0.5	Overfly (nearby) Bakersfield. Moderate AOD=0.13
CF0829	29-Aug-24	21:33	TO	1.5	Spiral performed over Watsonville NPS CEOBS site with scattering coefficient of 15-20 Mm-1 up to 9 kft then clean at altitude limit of 10 kft.
RF0903	3-Sep-24	19:44	TO	1.5	Spiral down at Fresno2 AERONET site ending with touch and go at Fresno airport. AOD~=0.12. 6c at 0.75 completeness due to time difference from overpass
RF0903	3-Sep-24	19:55	TO	0.5	Spiral down at SJER starts AOD~=0.08, multiple aerosol layers
RF0903	3-Sep-24	20:27	PACE	1	PACE overpass, in OCI and HARP2 swath
RF0903	3-Sep-24	20:56	TO	1,5	Begin spiral down at Turlock AERONET site AOD~=0.18
RF0904	4-Sep-24	19:18	ER2	0.5	Overfly Fresno_2 AERONET. AOT=0.11
RF0904	4-Sep-24	19:26	ER2	0.5	Overfly Turlock AERONET. AOT=0.08
RF0904	4-Sep-24	19:29	ER2	0.5	Overfly Modesto AERONET. AOT=0.07
RF0904	4-Sep-24	19:38	ER2	0.5	Overfly Sacramento CARB AERONET, AOT=0.13
RF0904	4-Sep-24	22:18	ER2, Marina	1	Overfly Marina Airport aerosol tower measurements (APS volume for particles greater than 1000 nm at 11 um^3/cm^3)
RF0904	4-Sep-24	22:34	ER2	0.5	Overfly Fresno AERONET. AOT=0.10
RF0906	6-Sep-24	18:36	ER2, TO	1	ER-2 overfly TO line, although ER-2 is late by ~20 min.
RF0906	6-Sep-24	18:51	ER2	0.5	ER-2 overflight of Turlock_CA AERONET site AOD(500)=0.19
RF0906	6-Sep-24	19:11	ER2	0.5	ER-2 overflight of U. Nevada Reno CA AERONET site AOD(500)=0.18, over pyramid lake
RF0906	6-Sep-24	19:51	ER2	0.5	ER-2 overflight of Mammoth CUES AERONET site AOD(500)=0.12, possible cloud
RF0906	6-Sep-24	20:18	ER2	1	Over land section in PACE-OHS swath, mostly cloud free but with broken clouds in sections
RF0906	6-Sep-24	22:32	ER2	0.5	ER-2 over CalTech AERONET, AOD(500)=0.13
RF0908	8-Sep-24	19:10	ER2	0.5	Overpass CalTech Aeronet high AOD(500)=0.4
RF0908	8-Sep-24	19:59	ER2	0.5	Overpass UCSB Aeronet low AOD(500)=0.09
RF0908	8-Sep-24	20:23	ER2	0.5	Overpass CalTech Aeronet high AOD(500)=0.26
RF0908	8-Sep-24	20:36	ER2	0.5	Overpass Bakersfield Aeronet moderate AOD(500)=0.15
RF0908	8-Sep-24	21:01	ER2	0.5	Overpass CEOBS Aeronet AOD(500)=0.035

RF0908	8-Sep-24	21:31	TO	1.35	Spiral down over Carmel Valley AERONET-OC site (first data at 22:10, AOD(500)=0.025), spiral end at 21:31
RF0908	8-Sep-24	21:38	ER2	0.5	Overpass UCSB Aeronet low AOD(500)=0.09
RF0908	8-Sep-24	22:06	TO	1.5	Spiral(s) over CEOBS site with ER-2 and EarthCARE overpass. Top of spiral at 22:23, then spiral down ending at 22:43. AOD=0.045 (then interrupted).
RF0908	8-Sep-24	22:22	ER2	0.5	Overpass CEOBS AERONET AOD(500)=0.045
RF0908	8-Sep-24	22.53	ER2	0.5	Overpass Modesto Aeronet AOD(500)=0.04
RF0908	8-Sep-24	22.54	ER2	0.5	Overpass Turlock Aeronet AOD(500)=0.04
RF0908	8-Sep-24	23.03	ER2	0.5	Overpass Fresno Aeronet AOD(500)=0.04
RF0910	10-Sep-24	17:39	ER2	0.5	Overfly extremely high aerosol loads downwind of the Line, Bridge and Airport fires. 17:44 overflies Line fire
RF0910	10-Sep-24	18:53	ER2	0.75	Overfly extremely high aerosol loads downwind of the Airport fires. Evidence of pyrocumulus cloud in imagery
RF0910	10-Sep-24	19:16	ER2	0.75	Overfly extremely high aerosol loads downwind of the Airport fires. Edge of plume observed by previous line
RF0912	12-Sep-24	20:00	TO	1.125	Spiral ends at Turlock. Just outside ideal +/- 30 min PACE overpass window but probably ok since aerosol load is so small.
RF0912	12-Sep-24	20:39	TO	1.5	Start ascend over Sacramento_River AERONET-OC site. Water very turbid. Within PACE-OHS swath. Small amounts of dust in spiral. AOD(532)=0.04
RF0912	12-Sep-24	21:39	TO	1.125	End spiral down over San Pablo bay, , then proceed at low level over San Francisco Bay southward to NASA_Ames/Moffett field
RF0912	12-Sep-24	22:06	TO	1.5	Missed approach and ascend at Moffett Field, NASA_Ames AERONET site AOD(500)=0.04. Can extend this value using HSRL to validate over turbid water retrievals in SF bay.
RF0913	13-Sep-24	17:53	ER2, TO	3	ER-2 overpass of Twin Otter double spiral in smoke east of Bridge fire. TO spiral down 17:39-17:53, up starting at 17:53. At least two distinct smoke layers observed. ER-2 observes this location at 18:18
RF0913	13-Sep-24	18:18	ER2, TO	3	ER-2 overpass of Twin Otter double spiral in second location in smoke east of Bridge fire. Similar to prior spirals, at least two distinct smoke layers observed, but this time even greater loads. ER-2 observes this location at 18:18
RF0913	13-Sep-24	18:54	ER2	1	Extremely long leg (to 19:36) over LA basin, Bridge fire and following path of smoke as it is advected east and north

RF0913	13-Sep-24	18:58	ER2	1	ER-2 overfly CalTech AERONET site. AOD(500)=0.48
RF0913	13-Sep-24	19:05	ER2, TO	3	ER-2 overpass of Twin Otter double spiral in third location in smoke east of Bridge fire. ER-2 observes this location at 19:05
RF0913	13-Sep-24	19:45	ER2	1	Start second long leg perpendicular to leg starting at 18:54. Catches other pathway of advected smoke at the time of PACE overpass. Within OCI swath and edge of HARP2 swath. Leg ends at about 20:05
RF0913	13-Sep-24	20:18:30	ER2	1	ER2 over Railroad Valley, AERONET AOD(440)=0.05
RF0913	13-Sep-24	21:05	ER2	2	Third long ER2 leg over smoke. This time southward over eastern LA basin with smoke from Bridge and Airport fires, ending at 21:22 near San Diego. Includes PACE overpass at OCI edge.
RF0913	13-Sep-24	21:12	ER-2, TO	3	ER-2 overpass of Twin Otter spiral down in smoke east of Airport fire. Similar double layer structure as observed at other spirals. ER-2 observes this location at 21:40. PACE overpass as well.
RF0913	13-Sep-24	21:39	ER-2, TO	3	ER-2 overpass of Twin Otter spiral up in smoke east of Airport fire. Similar double layer structure as observed at other spirals. ER-2 observes this location at 21:39. PACE overpass as well.
RF0913	13-Sep-24	21:55	ER2	1	Final long ER-2 leg starting at Long Beach and heading northeast over smoke from Airport and Bridge fires. End leg at 22:19
RF0913	13-Sep-24	21:59	ER2	0.5	ER2 overflites WC_Whittier_CA AERONET site, AOD(500)=0.35 high load
RF0917	17-Sep-24	18:44	ER2	0.5	ER-2 over La_Jolla (coastal site) AERONET site. moderate AOD(500)=0.14
RF0917	17-Sep-24	18:59	ER2	0.5	ER-2 over CalTech AERONET site. moderate AOD(500)=0.12
RF0917	17-Sep-24	20:02	ER2, Ivanpah	0.5	ER-2 overflies Ivanpah Playa with JPL surface team present for characterization. Clear skies, low AOD
RF0917	17-Sep-24	20:15	ER2	1	ER-2 in PACE-OHS swath in Western Arizona. Low AOD
RF0917	17-Sep-24	20:40	ER2, Ivanpah	0.5	ER-2 2nd overflies Ivanpah Playa with JPL surface team present for characterization. Clear skies, low AOD, roughly 90° from last overpass.
RF0917	17-Sep-24	21:58	ER2	0.5	ER-2 over Turlock AERONET site. moderate AOD(500)=0.15 (again at 22:15)
RF0919	19-Sep-24	22:17	TO, EarthCARE	1.5	After a first attempt to spiral down with aerosols but cloud below (which aircraft couldn't enter with IFR rules), found a second cloud free location to spiral during EarthCARE

					overpass. Spiral down to 2kft. Some cloud information on split TO spiral along EarthCARE
RF0922	22-Sep-24	17:25	ER2	0.5	ER-2 over Railroad Valley. No Clouds. AERONET AOD(500)=0.055
RF0922	22-Sep-24	17:45	ER2	0.5	ER-2 over Railroad Valley. No Clouds. AERONET AOD(500)=0.056
RF0922	22-Sep-24	18:03	ER2	0.5	ER-2 over Turlock AERONET site, AOD(500)=0.09
RF0922	22-Sep-24	18:09	TO, ER2	1.5	Begin spiral down over Turlock, ER2 overpass at 18:23. end at 18:31
RF0922	22-Sep-24	18:44	TO, ER2	1.5	Long leg in central valley ,18:44 over Merced, with ER-2 overhead.
RF0922	22-Sep-24	19:11	TO	1.5	Spiral up at Fresno, AOD(500)=0.12. Variable angstrom exponent.
RF0922	22-Sep-24	19:13	ER2	0.5	ER-2 over NEON_SJER AERONET site, AOD(500)=0.11
RF0922	22-Sep-24	19:14	ER2, TO	0.5	ER-2 overflight of TO flight path (19:40) between Fresno and NEON_SJER (AOD~0.11) – agricultural dust
RF0922	22-Sep-24	19:44	TO, PACE-O	1.5	Spiral down over NEON_SJER AERONET AOD(500)=0.11, site during PACE-O overpass.
RF0923	23-Sep-24	18:07	ER2	0.5	ER-2 over Monterey (AOD(500)=0.07), Marina Tower, and CEOBS site, cloud free. No Aeronet data at CEOBS,
RF0923	23-Sep-24	18:51:30	ER2	0.5	ER-2 over NASA_Ames AERONET site, AOD(500)=0.07
RF0923	23-Sep-24	19:00:17	ER2	0.5	ER-2 over Turlock AERONET site, AOD(500)=0.11
RF0923	23-Sep-24	19:23	ER2, TO	1.5	ER-2 over Turlock AERONET site, AOD(500)=0.11 plus spiraling Twin Otter
RF0923	23-Sep-24	20:18	ER2	1	Begin PACE-OHS line, continues until 20:48. PACE overpass at 20:25. Cirrus over northern edge.
RF0926	26-Sep-24	17:53	ER2	0.5	ER-2 over CalTech AERONET site possibly with remnant smoke and urban pollution. AOD(500)=0.13
RF0926	26-Sep-24	18:33	ER2, TO	1	ER-2 over Monterey AERONET site, AOD(500)=0.07. Over line previously sampled by Twin Otter (roughly 50 min prior)
RF0926	26-Sep-24	20:06	ER2, PACE-OHS	1	ER2 on PACE line over Sierra Nevada mountains up to Reno area. Overpass just south of Lake Tahoe. Line ends at 20:36. Cloud free, low AOD. Over MammothCUES_CA_USA AERONET station, AOD(500)=0.025 (20:15). Additional instrumentation at DRI/Reno, contact Hans Moosemueller
RF0926	26-Sep-24	21:10	ER2	0.5	Over NASA_Ames AERONET-OC site. AOD(500)=0.04
RF0926	26-Sep-24	21:28	ER2	0.5	Over CEOBS site. AERONET not functional, but ground Lidar and other instruments ok
RF0926	26-Sep-24	21:39	ER2	0.5	Over Turlock AERONET site. AOD(500)=0.05

RF0926	26-Sep-24	22:09	ER2, EarthCARE	2	Start EarthCARE line, ends 22:40. Cloud free, low aerosol loads.
RF0927	27-Sep-24	19:18	ER2	0.5	ER-2 overflies Monterey AERONET site. AOT(500)=0.05
RF0927	27-Sep-24	19:22	ER2	0.5	ER-2 overflies CEOBS site. AERONET instrument not functional, but lidar, etc. are.
RF0927	27-Sep-24	22:50	TO	1.5	Twin Otter begins CEOBS spiral with ER-2 overhead(23:07). Cloud free. Partially above water.
RF0927	27-Sep-24	23:01	ER2	0.5	ER-2 over NASA Ames AERONET site, AOD(500)=0.05
RF0929	29-Sep-24	18:37	ER2	0.5	ER-2 overflies NEON_SJER AERONET site. AOT(500)=0.13
RF0929	29-Sep-24	18:46	ER2	0.5	ER-2 overflies Turlock AERONET site. AOT(500)=0.045
RF0929	29-Sep-24	18:55	ER2	0.5	ER-2 overflies NASA_Ames AERONET site. AOT(500)=0.075
RF0929	29-Sep-24	19:48	ER2, PACE	3	ER-2 on long PACE track, which ends at 20:58. Intentionally offset from satellite ground track (but within PACE-OHS) to validate other portions of SPEXone swath. Cloud free, low to moderate (smoke) aerosols.
RF0929	29-Sep-24	20:39	ER2, PACE-OHS	1	ER-2 overflies NEON_SJER AERONET site. AOT(500)=0.12
RF0929	29-Sep-24	20:50	ER2, PACE-OHS	0.5	ER-2 overflies Bakersfield AERONET site. AOT(500)=0.11, near the end of the PACE line, multiple aerosol layers
RF0929	29-Sep-24	21:30	ER2	0.5	Over WC_Whittier_CA (which apparently survived fires) AERONET site. AOT(500)=0.12
RF0929	29-Sep-24	22:58	ER2	0.25	Over smoke plume, but no AEROENT
RF0929	29-Sep-24	23:25	ER2	0.5	Over CalTech AERONET site. AOT(500)=0.07
RF0930	30-Sep-24	18:25	ER2	0.5	ER2 over NEON_SJER AERONET site, AOT(500)=0.11
RF0930	30-Sep-24	18:32	ER2	0.5	ER2 over Turlock AERONET site, AOT(500)=0.07 (note later in the day a high AOT plume moves in, with high fine mode fraction, presumably smoke
RF0930	30-Sep-24	21:48	ER2	1	ER2 begins EarthCARE line. Line ends 22:20. Elevated aerosols that HSRL indicates are "dusty mix". Cloud free.
RF0930	30-Sep-24	21:54	ER2	0.5	Over Salton Sea AERONET site, AOT(500)=0.1
RF0930	30-Sep-24	22:59	ER2	0.5	Over Railroad valley calibration and AERONET site. AOT(500)=0.05
RF0930	30-Sep-24	23:09	ER2	0.25	Line over smoke from "Happy" fire observed earlier. End 23:23
RF0930	30-Sep-24	23:27	ER2	0.5	Over Mammoth_CUES_CA_USA AERONET site, AOT(500)=0.06

RF0930	30-Sep-24	23:33	ER2	0.5	Over NEON_TEAK (neon land surface site) AERONET site, AOT(500)=0.1 (variations through the day likely linked to happy fire)

4.1.5 VTM 1e: cloud properties

Importance (w): 12
Threshold required measurement time (h): 8
Actual measurement time (t_a): 21.75
Measurement time fulfillment (f): 93.4%
Baseline requirement met

Table 34 Observations of VTM objective 1e: Validate new retrieval products, cloud properties

Flight ID	Date	Time	Platform	Hours	Description
RF0904	4-Sep-24	19:38	TO	1	Top of spiral at CEOBS site and begin porpoise in clouds
RF0904	4-Sep-24	20:59	ER2, TO, PACE	1	PACE underpass 20:59. 1e for TO & ER-2, ER-2 only for other VTM elements
RF0904	4-Sep-24	22:08	ER2, TO	2	Coordination between ER-2 and Twin Otter, while the latter is porpoising in clouds
RF0906	6-Sep-24	20:18	ER2	1	Over land section in PACE-OHS swath, mostly cloud free but with broken clouds in sections
RF0907	7-Sep-24	21:04	TO	3	PACE-OH overpass (21:04). Track ~280km west of TO location
RF0915	15-Sep-24	19:39	ER2, PACE	0.5	In solar principal plane PACE-OH line extending to 19:57. Counting half because of time difference with PACE overpass. Marine Strat. Clouds with high cloudsand some aerosol layer under – based on HSRL-2
RF0915	15-Sep-24	20:10	ER2, PACE	0.5	Two legs withing PACE-OHS swath. Ends 20:20. Appears to be high/ice clouds over low clouds, No TO
RF0915	15-Sep-24	20:30	ER2, PACE	1	Final leg, now in PACE-OH swath Marine stratocumulus. , possibly high clouds too.
RF0920	20-Sep-24	19:47	TO	3	Begin operations: spiral down outsize ADIZ line, then porpoising NW from there, turn and return at 20:33, concluding at 20:56. Within PACE-O swath, aerosol above clouds.
RF0922	22-Sep-24	19:50	ER2	1	ER2 over Shearwater, but fully cloudy. Scored for cloud retrievals because in PACE-O swath for overpass.
RF0923	23-Sep-24	18:20	ER2, TO	1.5	ER-2 overpass of Twin Otter spiraling through clouds
RF0923	23-Sep-24	18:44	ER2, TO	1.5	ER-2 overpass of Twin Otter spiraling through clouds

RF0924	24-Sep-24	20:43	TO	0.5	Start of spiral at PIRAT to support potential aerosol above cloud retrievals in the PACE-OH swath. Spiral into clouds
RF0924	24-Sep-24	21:00-21:30	TO	0.25	Porpoising in PACE-OH cross track direction. Thick clouds with significant cloud top liquid water content (~ 0.5 g/m^3) until 21:30.
RF0924	24-Sep-24	21:30-21:46	TO	0.5	Porpoising on PACE-OH along satellite track direction with significantly different, thinner clouds (~ 0.1 g/m^3) than previous leg.
RF0927	27-Sep-24	20:30	ER2, PACE-OHS	2	Begins ~ 1 hour PACE track. Roughly 2/3 cloudy, 1/3 cloud free. Ends at 21:21
RF0929	29-Sep-24	21:41	ER2	0.5	Begin long leg over the ocean. Lots of cloud observations here. Backtrack on same line ending roughly at 22:42. Although no comparison the amount of data results in a partial score.
RF0930	30-Sep-24	20:20	ER2	1	Return to shore line from PACE track, over marine stratocumulus clouds. Cloudy in all coastal sites of interest (HyperNAV location, SeaPRISM site) clouds ends ~21:24. Some clear areas until cross coast at 21:32

4.1.6 VTM 1f: ocean surface properties

Importance (w): 1
Threshold required measurement time (h): 8
Actual measurement time (t_a): 3.5
Measurement time fulfillment (f): 35.4%
Threshold requirement not met

Table 35 Observation of VTM objective 1f: Validate new retrieval products, ocean surface properties

Flight ID	Date	Time	Platform	Hours	Description
RF0906	6-Sep-24	20:58	ER2	2	Much of this line has significant sunglint
RF0926	26-Sep-24	18:05	ER2	0.5	ER-2 over sunglint
RF0926	26-Sep-24	19:35	ER2,RS	1	ER-2 over Shearwater at station #40 (SHER2), at location for Twin Otter (also previously overflew this site at ~19:23). Some glint.

4.1.7 VTF 2a: aerosol properties over the ocean (PACE)

Importance (w): 10
Threshold required measurement time (h): 8
Actual measurement time (t_a): 5.5

Measurement time fulfillment (*f*): 49.7%
Threshold requirement not met

Table 36 Observations of VTM objective 2a: Validate in a narrow swath, aerosol properties over the ocean (PACE)

Flight ID	Date	Time	Platform	Hours	Description
RF0906	6-Sep-24	20:30	ER2	1	Over ocean section in PACE-OHS swath., Cloud free. Ocean params partially satisfied with HSRL2
RF0906	6-Sep-24	20:30	RB	1	RB + USC_SeaPRISM AERONET-OC AOD(510)=0.13 in PACE-OHS swath
RF0912	12-Sep-24	20:39	TO	1.5	Start ascend over Sacramento_River AERONET-OC site. Water very turbid. Within PACE-OHS swath. Small amounts of dust in spiral. AOD(532)=0.04
RF0926	26-Sep-24	20:35	ER2, PACE-OHS	0.25	Over pyramid lake (turbid), under PACE-OHS, nearby Univ_of_Nevada-Reno AERONET AOD(500)=0.04
RF0927	27-Sep-24	20:30	ER2, PACE-OHS	1	Begins ~ 1 hour PACE track. Roughly 2/3 cloudy, 1/3 cloud free. Ends at 21:21
RF0929	29-Sep-24	21:47	ER2	0.25	Over USC_SeaPRISM site, AOT(490)=0.05, Glint, Partial aerosol within PACE-OHS (in between clouds, from 20:35 overpass)
RF0930	30-Sep-24	18:53	ER2	0.5	Transit to PACE (jn PACE-OH swath) track along cloud free and gradient of very high Chl waters to much lower concentrations on the line. End 19:31. Scored but reduced due to time difference.
RF0930	30-Sep-24	19:34	ER2	1. 5	Transit within PACE-OHS swath. Cloud free with a gradient of more to less Chl-a from start (North) to end (South). Ends 20:17

4.1.8 VTM 2b: Aerosol properties overland (PACE)

Importance (*w*): 10
Threshold required measurement time (*h*): 8
Actual measurement time (t_a): 9.625
Measurement time fulfillment (*f*): 70.0%
Threshold requirement met

Flight ID	Date	Time	Platform	Hours	Description
RF0906	6-Sep-24	20:18	ER2	1	Over land section in PACE-OHS swath, mostly cloud free but with broken clouds in sections
RF0912	12-Sep-24	20:00	TO	1.125	Spiral ends at Turlock. Just outside ideal +/- 30 min PACE overpass window but probably ok since aerosol load is so small.

RF0917	17-Sep-24	20:15	ER2	2	ER-2 in PACE-OHS swath in Western Arizona. Low AOD
RF0923	23-Sep-24	20:18	ER2	1	Begin PACE-OHS line, continues until 20:48. PACE overpass at 20:25. Cirrus over northern edge.
RF0926	26-Sep-24	20:06	ER2, PACE-OHS	1	ER2 on PACE line over Sierra Nevada mountains up to Reno area. Overpass just south of Lake Tahoe. Line ends at 20:36. Cloud free, low AOD. Over MammothCUES_CA_USA AERONET station, AOD(500)=0.025 (20:15). Additional instrumentation at DRI/Reno, contact Hans Moosemueller
RF0929	29-Sep-24	19:48	ER2, PACE	3	ER-2 on long PACE track, which ends at 20:58. Intentionally offset from satellite ground track (but within PACE-OHS) to validate other portions of SPEXone swath. Cloud free, low to moderate (smoke) aerosols.
RF0929	29-Sep-24	20:50	ER2, PACE-OHS	0.5	ER-2 overflies Bakersfield AERONET site. AOT(500)=0.11, near the end of the PACE line, multiple aerosol layers

4.1.9 VTM 2c: cloud properties (PACE)

Importance (w): 5
Threshold required measurement time (h): 2
Actual measurement time (t_a): 5
Measurement time fulfillment (f): 91.8%
Baseline requirement exceeded

Table 37 Observations of VTM objective 2c: Validate in a narrow swath, cloud properties (PACE)

Flight ID	Date	Time	Platform	Hours	Description
RF0904	4-Sep-24	20:59	ER2, TO, PACE	1	PACE underpass 20:59. 1e for TO & ER-2, ER-2 only for other VTM elements
RF0906	6-Sep-24	20:18	ER2	1	Over land section in PACE-OHS swath, mostly cloud free but with broken clouds in sections
RF0915	15-Sep-24	20:10	ER2, PACE	0.5	Two legs withing PACE-OHS swath. Ends 20:20. Appears to be high/ice clouds over low clouds, No TO
RF0927	27-Sep-24	20:30	ER2, PACE-OHS	2	Begins ~ 1 hour PACE track. Roughly 2/3 cloudy, 1/3 cloud free. Ends at 21:21
RF0930	30-Sep-24	20:20	ER2	0.5	Return to shore line from PACE track, over marine stratocumulus clouds. Cloudy in all coastal sites of interest (HyperNAV location, SeaPRISM site) clouds ends ~21:24. Some clear areas until cross coast at 21:32

4.1.10 VTM 2d: Aerosol properties (EarthCARE)

Importance (w): 8
Threshold required measurement time (h): 4
Actual measurement time (t_a): 12.5
Measurement time fulfillment (f): 95.6%
Baseline requirement exceeded

Table 38 Observation of VTM objective 2d: Validate in a narrow swath, aerosol properties (EarthCARE)

Flight ID	Date	Time	Platform	Hours	Description
RF0908	8-Sep-24	22:06	TO	1.5	Spiral(s) over CEOBS site with ER-2 and EarthCARE overpass. Top of spiral at 22:23, then spiral down ending at 22:43. AOD=0.045 (then interrupted).
RF0908	8-Sep-24	22:21	ER2	1	Long track along EarthCARE line, mostly low AOD over California Central Valley
RF0917	17-Sep-24	22:27	ER2,EC	3	Very long out and back along EarthCARE line. Moderate AOD, some thin cirrus reported by HSRL with aerosol under cloud.
RF0919	19-Sep-24	22:17	TO, EarthCARE	1.5	After a first attempt to spiral down with aerosols but cloud below (which aircraft couldn't enter with IFR rules), found a second cloud free location to spiral during EarthCARE overpass. Spiral down to 2kft. Some cloud information on split TO spiral along EarthCARE
RF0923	23-Sep-24	21:34	ER2	1	ER2 on EarthCARE line until 22:05. Some parts clear, some with thin cirrus, others with mid-level clouds
RF0926	26-Sep-24	22:09	ER2, EarthCARE	2	Start EarthCARE line, ends 22:40. Cloud free, low aerosol loads.
RF0930	30-Sep-24	21:48	ER2	2	ER2 begins EarthCARE line. Line ends 22:20. Elevated aerosols that HSRL indicates are "dusty mix". Cloud free.
RF0930	30-Sep-24	21:54	ER2	0.5	Over Salton Sea AERONET site, AOT(500)=0.1

4.1.11 VTM 2e: Cloud properties (EarthCARE)

Importance (w): 8
Threshold required measurement time (h): 4
Actual measurement time (t_a): 3.25
Measurement time fulfillment (f): 55.6%
Threshold requirement not met

Table 39 Observations of VTM objective 2e: Validate in a narrow swath, cloud properties (EarthCARE)

Flight ID	Date	Time	Platform	Hours	Description
RF0908	8-Sep-24	22:17	ER2	0.5	Small section of ER-2 along EarthCARE track over clouds in Monterey Bay
RF0917	17-Sep-24	22:27	ER2,EC	1	Very long out and back along EarthCARE line. Moderate AOD, some thin cirrus reported by HSRL with aerosol under cloud.
RF0919	19-Sep-24	22:17	TO, EarthCARE	0.75	After a first attempt to spiral down with aerosols but cloud below (which aircraft couldn't enter with IFR rules), found a second cloud free location to spiral during EarthCARE overpass. Spiral down to 2kft. Some cloud information on split TO spiral along EarthCARE
RF0923	23-Sep-24	21:34	ER2	1	ER2 on EarthCARE line until 22:05. Some parts clear, some with thin cirrus, others with mid-level clouds

4.1.12 VTM 3a: Validate large reflectances

Importance (w): 6
Threshold required measurement time (h): 2
Actual measurement time (t_a): 7.25
Measurement time fulfillment (f): 97.3%
Baseline requirements exceeded

Table 40 Observations of VTM objective 3a: Validate radiometric and polarimetric parameters, large reflectances

Flight ID	Date	Time	Platform	Hours	Description
RF0910	10-Sep-24	17:21	ER2	0.25	Overfly Ivanpah Playa. Possible aerosol load Small clouds partly obscure scene
RF0913	13-Sep-24	20:18:30	ER2	1	ER2 over Railroad Valley, AERONET AOD(440)=0.05
RF0917	17-Sep-24	20:02	ER2, Ivanpah	2	ER-2 overflies Ivanpah Playa with JPL surface team present for characterization. Clear skies, low AOD
RF0917	17-Sep-24	20:40	ER2, Ivanpah	2	ER-2 2nd overflies Ivanpah Playa with JPL surface team present for characterization. Clear skies, low AOD, roughly 90° from last overpass.
RF0922	22-Sep-24	17:25	ER2	0.5	ER-2 over Railroad Valley. No Clouds. AERONET AOD(500)=0.055
RF0922	22-Sep-24	17:45	ER2	0.5	ER-2 over Railroad Valley. No Clouds. AERONET AOD(500)=0.056
RF0923	23-Sep-24	21:03:08	ER2	0.25	ER2 over Railroad Valley Aeronet, partial cirrus. No aeronet data, after 20.5UTC, AOD(500)=0.035.

RF0930	30-Sep-24	22:13	ER2	0.25	Over Ivanpah Playa calibration site (no ground team)
RF0930	30-Sep-24	22:59	ER2	0.5	Over Railroad valley calibration and AERONET site. AOT(500)=0.05

4.1.13 VTM 3b: Validate large reflectances with high polarization

Importance (w): 6
Threshold required measurement time (h): 2
Actual measurement time (t_a): 6
Measurement time fulfillment (f): 95.0%
Baseline requirement exceeded

Table 41 Observations of VTM objective 3b: Validate radiometric and polarimetric parameters, large reflectances with high polarization

Flight ID	Date	Time	Platform	Hours	Description
RF0906	6-Sep-24	20:58	ER2	2	Much of this line has significant sunglint
RF0910	10-Sep-24	18:03	ER2	1	Overfly HyperNAV location (surfaces at 20:26), possible sunglint
RF0910	10-Sep-24	19:58	ER2	0.5	Ovefly UCSB AERONET. AOD(490)=0.1, sunglint
RF0926	26-Sep-24	18:05	ER2	0.5	ER-2 over sunglint
RF0926	26-Sep-24	19:35	ER2,RS	1	ER-2 over Shearwater at station #40 (SHER2), at location for Twin Otter (also previously overflew this site at ~19:23). Some glint.
RF0929	29-Sep-24	21:07	ER2, Gliders	0.5	PACE overflies gliders in biologically productive waters. Glint
RF0929	29-Sep-24	21:47	ER2	0.5	Over USC_SeaPRISM site, AOT(490)=0.05, Glint, Partial aerosol within PACE-OHS (in between clouds, from 20:35 overpass)

4.1.14 VTM 3c: Validate large reflectances with low polarization

Importance (w): 6
Threshold required measurement time (h): 2
Actual measurement time (t_a): 9
Measurement time fulfillment (f): 98.9%

Table 42 Observations of VTM objective 3c: Validate radiometric and polarimetric parameters, large reflectances with low polarization

Flight ID	Date	Time	Platform	Hours	Description
RF0904	4-Sep-24	20:59	ER2, TO, PACE	1	PACE underpass 20:59. 1e for TO & ER-2, ER-2 only for other VTM elements
RF0908	8-Sep-24	22:17	ER2	0.5	Small section of ER-2 along EarthCARE track over clouds in Monterey Bay
RF0913	13-Sep-24	20:18:30	ER2	1	ER2 over Railroad Valley, AERONET AOD(440)=0.05
RF0922	22-Sep-24	18:17	RS, ER2	0.5	Shearwater on station #30 for first ER-2 overpass and PACE overpass (19:41). Station ends at 19:58. Fully cloudy, not scored.
RF0922	22-Sep-24	19:41	ER2, gliders	0.5	ER-2 over gliders. Cloudy. Scored for cloud reference.
RF0922	22-Sep-24	20:21	RS, ER2	0.5	Shearwater on station #31. HyperNAV surfaces nearby at 20:13. ER-2 overpass. Cloudy. Scored for cloud reference.
RF0922	22-Sep-24	20:31	ER2	0.5	Another attempt at overpass of Shearwater, still cloudy .Scored for cloud reference.
RF0922	22-Sep-24	20:55	ER2	0.5	Another attempt at overpass of Shearwater, still cloudy, Scored for cloud reference.
RF0922	22-Sep-24	21:31	ER2	0.5	Another attempt at overpass of Shearwater, still cloudy. Scored for cloud reference.
RF0923	23-Sep-24	17:39	ER2	0.5	ER-2 over Shearwater, but cloudy. Scored as bright/low polarization target
RF0923	23-Sep-24	19:52	ER2, Glider	0.5	ER-2 over glider, but cloudy. Scored as bright/low polarization target
RF0923	23-Sep-24	19:56	ER2, RS	0.5	ER-2 over Shearwater, but cloudy. Scored as bright/low polarization target
RF0927	27-Sep-24	23:16	ER2	0.5	ER-2 return over cloudy (marine strato-cumulus) coast.
RF0927	27-Sep-24	23:36	ER2, gliders	0.5	ER-2 over gliders, but cloudy
RF0930	30-Sep-24	20:20	ER2	1	Return to shore line from PACE track, over marine stratocumulus clouds. Cloudy in all coastal sites of interest (HyperNAV location, SeaPRISM site) clouds ends ~21:24. Some clear areas until cross coast at 21:32

4.1.15 VTM 3d: Overfly vicarious calibration sites

Importance (w): 6
Threshold required measurement time (h): 4
Actual measurement time (t_a): 2
Measurement time fulfillment (f): 46.5%

Threshold requirement not met

Table 43 Observations of VTM objective 3d: Validate radiometric and polarimetric parameters, overfly vicarious calibration sites

Flight ID	Date	Time	Platform	Hours	Description
RF0910	10-Sep-24	18:03	ER2	0.5	Overfly HyperNAV location (surfaces at 20:26), possible sunglint
RF0910	10-Sep-24	19:35	ER2	1	Overfly HyperNAV location (surfaces at 20:26)
RF0915	15-Sep-24	20:41	ER2	0.5	ER-2 overflies surfacing HyperNAV during PACE overpass. Partial cloudy HyperNAV profile, but clear at surface.
RF0930	30-Sep-24	22:59	ER2	0.5	Over Railroad valley calibration and AERONET site. AOT(500)=0.05

4.1.16 VTM 4a: High aerosol loads over land

Importance (w): 4
Threshold required measurement time (h): 2
Actual measurement time (t_a): 24.5
Measurement time fulfillment (f): 100%
Baseline requirement exceeded

Table 44 Observations of VTM objective 4a: Focus on specific processes or phenomena, high aerosol loads over land

Flight ID	Date	Time	Platform	Hours	Description
RF0908	8-Sep-24	19:10	ER2	0.5	Overpass CalTech Aeronet high AOD(500)=0.4
RF0908	8-Sep-24	20:23	ER2	0.5	Overpass CalTech Aeronet high AOD(500)=0.26
RF0910	10-Sep-24	17:39	ER2	0.5	Overfly extremely high aerosol loads downwind of the Line, Bridge and Airport fires. 17:44 overflies Line fire
RF0910	10-Sep-24	18:53	ER2	0.75	Overfly extremely high aerosol loads downwind of the Airport fires. Evidence of pyrocumulus cloud in imagery
RF0910	10-Sep-24	19:16	ER2	0.75	Overfly extremely high aerosol loads downwind of the Airport fires. Edge of plume observed by previous line
RF0913	13-Sep-24	17:53	ER2, TO	3	ER-2 overpass of Twin Otter double spiral in smoke east of Bridge fire. TO spiral down 17:39-17:53, up starting at 17:53. At least two distinct smoke layers observed. ER-2 observes this location at 18:18
RF0913	13-Sep-24	18:18	ER2, TO	3	ER-2 overpass of Twin Otter double spiral in second location in smoke east of Bridge fire.

					Similar to prior spirals, at least two distinct smoke layers observed, but this time even greater loads. ER-2 observes this location at 18:18
RF0913	13-Sep-24	18:54	ER2	1	Extremely long leg (to 19:36) over LA basin, Bridge fire and following path of smoke as it is advected east and north
RF0913	13-Sep-24	18:58	ER2	1	ER-2 overfly CalTech AERONET site. AOD(500)=0.48
RF0913	13-Sep-24	19:05	ER2, TO	3	ER-2 overpass of Twin Otter double spiral in third location in smoke east of Bridge fire. ER-2 observes this location at 19:05
RF0913	13-Sep-24	19:45	ER2	1	Start second long leg perpendicular to leg starting at 18:54. Catches other pathway of advected smoke at the time of PACE overpass. Within OCI swath and edge of HARP2 swath. Leg ends at about 20:05
RF0913	13-Sep-24	21:05	ER2	2	Third long ER2 leg over smoke. This time southward over eastern LA basin with smoke from Bridge and Airport fires, ending at 21:22 near San Diego. Includes PACE overpass at OCI edge.
RF0913	13-Sep-24	21:12	ER-2, TO	3	ER-2 overpass of Twin Otter spiral down in smoke east of Airport fire. Similar double layer structure as observed at other spirals. ER-2 observes this location at 21:40. PACE overpass as well.
RF0913	13-Sep-24	21:39	ER-2, TO	3	ER-2 overpass of Twin Otter spiral up in smoke east of Airport fire. Similar double layer structure as observed at other spirals. ER-2 observes this location at 21:39. PACE overpass as well.
RF0913	13-Sep-24	21:55	ER2	1	Final long ER-2 leg starting at Long Beach and heading northeast over smoke from Airport and Bridge fires. End leg at 22:19
RF0929	29-Sep-24	18:30	ER2	0.5	Starting line over central valley, beginning near smoke from “Happy” fire

4.1.17 VTM 4b: High aerosol loads over ocean

Importance (w): 4
Threshold required measurement time (h): 2
Actual measurement time (t_a): 1.5
Measurement time fulfillment (f): 52.8%
Threshold requirement not met

Table 45 Observations of VTM objective 4b: Focus on specific processes or phenomena, high aerosol loads over the ocean

Flight ID	Date	Time	Platform	Hours	Description
RF0906	6-Sep-24	20:37	ER2	0.5	ER2 over AERONET (La_Jolla) AOD(500nm) ~0,4
RF0908	8-Sep-24	19:32	ER2, RB	0.5	Overpass USC_Seaprism Aeronet high AOD(490)=0.36; Blissfully on station with HyperPro, etc.
RF0908	8-Sep-24	20:16	ER2, RB	0.5	Overpass USC_Seaprism Aeronet high AOD(490)=36; Blissfully on station with HyperPro, etc. mostly smoke

4.1.18 VTM 4c: Multiple aerosol layers

Importance (w): 1
Threshold required measurement time (h): 2
Actual measurement time (t_a): 32.625
Measurement time fulfillment (f): 100%
Baseline requirement exceeded

Table 46 Observations of VTM objective 4c: Focus on specific processes or phenomena, multiple aerosol layers

Flight ID	Date	Time	Platform	Hours	Description
RF0903	3-Sep-24	19:44	TO	0.75	Spiral down at Fresno2 AERONET site ending with touch and go at Fresno airport. AOD~=0.12. 6c at 0.75 completeness due to time difference from overpass
RF0903	3-Sep-24	20:27	PACE	1.5	PACE overpass, in OCI and HARP2 swath
RF0903	3-Sep-24	20:56	TO	1.5	Begin spiral down at Turlock AERONET site AOD~=0.18
RF0910	10-Sep-24	18:53	ER2	0.125	Overfly extremely high aerosol loads downwind of the Airport fires. Evidence of pyrocumulus cloud in imagery
RF0913	13-Sep-24	17:53	ER2, TO	3	ER-2 overpass of Twin Otter double spiral in smoke east of Bridge fire. TO spiral down 17:39-17:53, up starting at 17:53. At least two distinct smoke layers observed. ER-2 observes this location at 18:18
RF0913	13-Sep-24	18:18	ER2, TO	3	ER-2 overpass of Twin Otter double spiral in second location in smoke east of Bridge fire. Similar to prior spirals, at least two distinct smoke layers observed, but this time even greater loads. ER-2 observes this location at 18:18

RF0913	13-Sep-24	18:54	ER2	1	Extremely long leg (to 19:36) over LA basin, Bridge fire and following path of smoke as it is advected east and north
RF0913	13-Sep-24	18:58	ER2	1	ER-2 overfly CalTech AERONET site. AOD(500)=0.48
RF0913	13-Sep-24	19:05	ER2, TO	3	ER-2 overpass of Twin Otter double spiral in third location in smoke east of Bridge fire. ER-2 observes this location at 19:05
RF0913	13-Sep-24	19:45	ER2	1	Start second long leg perpendicular to leg starting at 18:54. Catches other pathway of advected smoke at the time of PACE overpass. Within OCI swath and edge of HARP2 swath. Leg ends at about 20:05
RF0913	13-Sep-24	21:05	ER2	2	Third long ER2 leg over smoke. This time southward over eastern LA basin with smoke from Bridge and Airport fires, ending at 21:22 near San Diego. Includes PACE overpass at OCI edge.
RF0913	13-Sep-24	21:12	ER-2, TO	3	ER-2 overpass of Twin Otter spiral down in smoke east of Airport fire. Similar double layer structure as observed at other spirals. ER-2 observes this location at 21:40. PACE overpass as well.
RF0913	13-Sep-24	21:39	ER-2, TO	3	ER-2 overpass of Twin Otter spiral up in smoke east of Airport fire. Similar double layer structure as observed at other spirals. ER-2 observes this location at 21:39. PACE overpass as well.
RF0913	13-Sep-24	21:55	ER2	1	Final long ER-2 leg starting at Long Beach and heading northeast over smoke from Airport and Bridge fires. End leg at 22:19
RF0922	22-Sep-24	18:44	TO, ER2	1.5	Long leg in central valley ,18:44 over Merced, with ER-2 overhead.
RF0922	22-Sep-24	19:11	TO	1.5	Spiral up at Fresno, AOD(500)=0.12. Variable angstrom exponent.
RF0922	22-Sep-24	19:44	TO, PACE-O	1.5	Spiral down over NEON_SJER AERONET AOD(500)=0.11, site during PACE-O overpass.
RF0927	27-Sep-24	20:39	TO, PACE-OH	1.5	Twin Otter spiral over R/V Rachel Carson (PACE overpass). Top of spiral at 21:09, multiple aerosol layers
RF0927	27-Sep-24	21:43	TO	1.5	Start of spiral down over Sacramento_River AERONET-OC site. ER-2 overpass after spiral (22:38), multiple aerosol layer.
RF0929	29-Sep-24	20:50	ER2, PACE-OHS	0.25	ER-2 overflies Bakersfield AERONET site. AOT(500)=0.11, near the end of the PACE line, multiple aerosol layers

4.1.19 VTM 4d: Aerosol under thin cirrus

Importance (w): 2
Threshold required measurement time (h): 2
Actual measurement time (t_a): 4.25
Measurement time fulfillment (f): 88.1%
Threshold requirement met

Table 47 Observations of VTM objective 4d: Focus on specific processes or phenomena, aerosols under thin cirrus clouds

Flight ID	Date	Time	Platform	Hours	Description
RF0915	15-Sep-24	19:39	ER2, PACE	0.25	In solar principal plane PACE-OH line extending to 19:57. Counting half because of time difference with PACE overpass. Marine Strat. Clouds with high cloudsand some aerosol layer under – based on HSRL-2
RF0917	17-Sep-24	22:27	ER2,EC	0.5	Very long out and back along EarthCARE line. Moderate AOD, some thin cirrus reported by HSRL with aerosol under cloud.
RF0923	23-Sep-24	19:23	ER2, TO	1.5	ER-2 over Turlock AERONET site, AOD(500)=0.11 plus spiraling Twin Otter
RF0923	23-Sep-24	20:18	ER2	0.5	Begin PACE-OHS line, continues until 20:48. PACE overpass at 20:25. Cirrus over northern edge.
RF0923	23-Sep-24	21:03:08	ER2	0.5	ER2 over Railroad Valley Aeronet, partial cirrus. No aeronet data, after 20.5UTC, AOD(500)=0.035.
RF0923	23-Sep-24	21:34	ER2	1	ER2 on EarthCARE line until 22:05. Some parts clear, some with thin cirrus, others with mid-level clouds

4.1.20 VTM 4e: Aerosol above liquid phase cloud

Importance (w): 4
Threshold required measurement time (h): 2
Actual measurement time (t_a): 6
Measurement time fulfillment (f): 95.0%
Baseline requirements exceeded

Table 48 Observations of VTM objective 4e: Focus on specific processes or phenomena, aerosol above liquid cloud

Flight ID	Date	Time	Platform	Hours	Description

CF0829	29-Aug-24	21:33	TO	1.5	Spiral performed over Watsonville NPS CEOBS site with scattering coefficient of 15-20 Mm-1 up to 9 kft then clean at altitude limit of 10 kft.
RF0907	7-Sep-24	21:04	TO	3	PACE-OH overpass (21:04). Track ~280km west of TO location
RF0913	13-Sep-24	18:52	ER2,RB	0.25	ER-2 overwater (turning) with smoke aerosol over clouds
RF0920	20-Sep-24	19:47	TO	0.75	Begin operations: spiral down outsize ADIZ line, then porpoising NW from there, turn and return at 20:33, concluding at 20:56. Within PACE-O swath, aerosol above clouds.
RF0924	24-Sep-24	20:43	TO	0.5	Start of spiral at PIRAT to support potential aerosol above cloud retrievals in the PACE-OH swath. Spiral into clouds

4.1.21 VTM 4f: Broken clouds with complex structure

Importance (w): 4
Threshold required measurement time (h): 2
Actual measurement time (t_a): 5.5
Measurement time fulfillment (f): 93.6%
Baseline requirement exceeded

Table 49 Observations of VTM objective 4f: Focus on specific processes or phenomena, broken clouds with complex structure

Flight ID	Date	Time	Platform	Hours	Description
RF0906	6-Sep-24	20:18	ER2	1	Over land section in PACE-OHS swath, mostly cloud free but with broken clouds in sections
RF0915	15-Sep-24	19:39	ER2, PACE	0.5	In solar principal plane PACE-OH line extending to 19:57. Counting half because of time difference with PACE overpass. Marine Strat. Clouds with high cloudsand some aerosol layer under – based on HSRL-2
RF0915	15-Sep-24	20:30	ER2, PACE	1	Final leg, now in PACE-OH swath Marine stratocumulus. , possibly high clouds too.
RF0923	23-Sep-24	21:34	ER2	1	ER2 on EarthCARE line until 22:05. Some parts clear, some with thin cirrus, others with mid-level clouds
RF0927	27-Sep-24	20:30	ER2, PACE-OHS	2	Begins ~ 1 hour PACE track. Roughly 2/3 cloudy, 1/3 cloud free. Ends at 21:21

4.1.22 VTM 4g: Dust aerosols over ocean

Importance (w): 4
Threshold required measurement time (h): 2
Actual measurement time (t_a): 1
Measurement time fulfillment (f): 39.3%
Threshold requirement not met

Table 50 Observations of VTM objective 4g: Focus on specific processes or phenomena, dust aerosols over ocean

Flight ID	Date	Time	Platform	Hours	Description
RF0904	4-Sep-24	22:18	ER2, Marina	1	Overfly Marina Airport aerosol tower measurements (APS volume for particles greater than 1000 nm at 11 um^3/cm^3)

4.1.23 VTM 4h: Aerosol and ocean properties over turbid waters

Importance (w): 2
Threshold required measurement time (h): 2
Actual measurement time (t_a): 9.25
Measurement time fulfillment (f): 99.0%
Baseline requirement exceeded

Table 51 Observations of VTM objective 4h: Focus on specific processes or phenomena, aerosol, ocean properties in turbid waters

Flight ID	Date	Time	Platform	Hours	Description
RF0912	12-Sep-24	20:39	TO	1.125	Start ascend over Sacramento_River AERONET-OC site. Water very turbid. Within PACE-OHS swath. Small amounts of dust in spiral. AOD(532)=0.04
RF0904	4-Sep-24	19.47	ER2	0.5	Sacramento River AERONET-OC, AOT=0.05
RF0906	6-Sep-24	19:11	ER2	0.5	ER-2 overflight of U. Nevada Reno CA AERONET site AOD(500)=0.18, over pyramid lake
RF0906	6-Sep-24	19:47	ER2	0.5	ER-2 overflly of Mono lake turbid waters, within 1h from PACE
RF0912	12-Sep-24	20:39	TO	1.5	Start ascend over Sacramento_River AERONET-OC site. Water very turbid. Within PACE-OHS swath. Small amounts of dust in spiral. AOD(532)=0.04
RF0912	12-Sep-24	22:06	TO	1.125	Missed approach and ascend at Moffett Field, NASA_Ames AERONET site AOD(500)=0.04. Can extend this value

					using HSRL to validate over turbid water retrievals in SF bay.
RF0926	26-Sep-24	20:35	ER2, PACE-OHS	0.25	Over pyramid lake (turbid), under PACE-OHS, nearby Univ_of_Nevada-Reno AERONET AOD(500)=0.04
RF0926	26-Sep-24	21:03	ER2	0.5	Over Sacramento_River AERONET-OC site. AOD(500)=0.03
RF0927	27-Sep-24	21:43	TO	1.5	Start of spiral down over Sacramento_River AERONET-OC site. ER-2 overpass after spiral (22:38), multiple aerosol layer.
RF0927	27-Sep-24	22:38	ER2	0.5	Over Sacramento_River AERONET-OC site. AOT(490)=0.05
RF0929	29-Sep-24	19:02	ER2	0.5	ER-2 overflies Sacramento_River AERONET site. AOT(490)=0.05
RF0930	30-Sep-24	18:42	ER2	0.5	ER2 over Sacramento_River AERONET-OC site. AOT(490)=0.07
RF0930	30-Sep-24	18:53	ER2	0.25	Transit to PACE (jn PACE-OH swath) track along cloud free and gradient of very high Chl waters to much lower concentrations on the line. End 19:31. Scored but reduced due to time difference.

4.1.24 VTM 4i: Aerosol and ocean properties over biologically productive waters

Importance (w): 4
Threshold required measurement time (h): 2
Actual measurement time (t_a): 17.25
Measurement time fulfillment (f): 100%
Baseline requirements exceeded

Table 52 Observations of VTM objective 4i: Focus on specific processes or phenomena, aerosol, ocean properties in biologically productive waters

Flight ID	Date	Time	Platform	Hours	Description
RF0917	17-Sep-24	18:02	ER2, RS	1	ER-2 overpass of RS at station #16. Biologically productive waters
RF0917	17-Sep-24	18:03	ER2, Glider	0.5	ER-2 over glider in biologically productive waters and clear skies. Outside of PACE overpass +/-2hours by a few minutes.
RF0917	17-Sep-24	19:12	ER2, RS	1	ER-2 over Shearwater in clear skies and biologically productive waters
RF0917	17-Sep-24	19:19	ER2, glider	0.5	ER-2 over glider in biologically productive waters and clear skies
RF0917	17-Sep-24	21:22	ER2, RS	1	ER-2 over Shearwater in clear skies and biologically productive waters

RF0918	18-Sep-24	19:29	RS	1	Station 21 until 21:12. PACE-OH Overpass. Minimal Clouds. Possible lack of AERONET/Cimel measurements.
RF0925	25-Sep-24	18:36-19:58	RS, PACE-OH	2	Station #34, clear skies
RF0925	25-Sep-24	20:04-21:33	RS, PACE-OH	2	Station #35, clear skies
RF0925	25-Sep-24	21:50-22:47	RS, PACE-OH	2	Station #36, clear skies
RF0926	26-Sep-24	20:00	TO	1.5	TO spirals over red tide offshore near Oxnard, CA.
RF0927	27-Sep-24	19:36	ER2, RC	1	ER-2 over R/V Rachel Carson in biologically productive Monterey Bay conditions
RF0927	27-Sep-24	20:39	TO, PACE-OH	1.5	Twin Otter spiral over R/V Rachel Carson (PACE overpass). Top of spiral at 21:09, multiple aerosol layers
RF0929	29-Sep-24	21:07	ER2, Gliders	1	PACE overflies gliders in biologically productive waters. Glint
RF0929	29-Sep-24	23:40	ER2, Gliders	1	ER2 overflies gliders in biologically productive waters, where previous PACE-OHS/OH
RF0930	30-Sep-24	18:53	ER2	0.25	Transit to PACE (jn PACE-OH swath) track along cloud free and gradient of very high Chl waters to much lower concentrations on the line. End 19:31. Scored but reduced due to time difference.

4.1.25 VTM 4j: Smoke aerosols over ocean

Importance (w): 1
Threshold required measurement time (h): 2
Actual measurement time (t_a): 5.5
Measurement time fulfillment (f): 93.6%
Baseline requirement exceeded

Table 53 Observations of VTM objective 4j: Focus on specific processes or phenomena, smoke aerosols over ocean

Flight ID	Date	Time	Platform	Hours	Description
RF0906	6-Sep-24	20:37	ER2	0.5	ER2 over AERONET (La_Jolla) AOD(500nm) ~0,4
RF0908	8-Sep-24	19:32	ER2, RB	0.5	Overpass USC_Seaprism Aeronet high AOD(490)=0.36; Blissfully on station with HyperPro, etc.

RF0908	8-Sep-24	20:16	ER2, RB	0.5	Overpass USC_Seaprism Aeronet high AOD(490)=36; Blissfully on station with HyperPro, etc. mostly smoke
RF0913	13-Sep-24	21:14	RB	1.5	Blissfully sampling adjacent to USC_SeaPRISM site during PACE overpass (OCI only) with cloud-free skies. AOT(490)=0.18, moderate aod, smoke from fires
RF0913	13-Sep-24	21:48	ER2, RB	1.5	ER-2 overpass of Blissfully and USC_SeaPRISM. Cloud free skies, AOT(490)=0.19, moderate aod, smoke from fires
RF0929	29-Sep-24	21:47	ER2	0.5	Over USC_SeaPRISM site, AOT(490)=0.05, Glint, Partial aerosol within PACE-OHS (in between clouds, from 20:35 overpass)
RF0929	29-Sep-24	22:44	ER2	0.5	Over USC_SeaPRISM site, AOT(490)=0.05

4.2 Summary of activities by day

See flight reports in Appendix E

4.3 Summary of activities by satellite underpass

4.3.1 PACE underpasses

Flight ID	Date	Time	Platform	Hours	Description
CF0829	29-Aug-24	**20:49**	**PACE**		**PACE-OH overpass**
RF0903	3-Sep-24	20:27	PACE	1	PACE overpass, in OCI and HARP2 swath
RF0903	3-Sep-24	20:27	PACE	1.5	PACE overpass, in OCI and HARP2 swath
RF0903	3-Sep-24	20:27	**PACE**		**PACE-OH overpass**
RF0904	4-Sep-24	20:59	ER2, TO, PACE	1	PACE underpass 20:59. 1e for TO & ER-2, ER-2 only for other VTM elements
RF0904	4-Sep-24	20:59	ER2, TO, PACE	1	PACE underpass 20:59. 1e for TO & ER-2, ER-2 only for other VTM elements
RF0904	4-Sep-24	20:59	ER2, TO, PACE	1	PACE underpass 20:59. 1e for TO & ER-2, ER-2 only for other VTM elements
RF0904	4-Sep-24	**21:00**	**PACE**		**PACE-OHS overpass**

RF0906	6-Sep-24	20:18	ER2	1	Over land section in PACE-OHS swath, mostly cloud free but with broken clouds in sections
RF0906	6-Sep-24	20:18	ER2	1	Over land section in PACE-OHS swath, mostly cloud free but with broken clouds in sections
RF0906	6-Sep-24	20:18	ER2	1	Over land section in PACE-OHS swath, mostly cloud free but with broken clouds in sections
RF0906	6-Sep-24	20:18	ER2	1	Over land section in PACE-OHS swath, mostly cloud free but with broken clouds in sections
RF0906	6-Sep-24	20:18	ER2	1	Over land section in PACE-OHS swath, mostly cloud free but with broken clouds in sections
RF0906	6-Sep-24	20:30	ER2	1	Over ocean section in PACE-OHS swath., Cloud free. Ocean params partially satisfied with HSRL2
RF0906	6-Sep-24	20:30	ER2	1	Over ocean section in PACE-OHS swath., Cloud free. Ocean params partially satisfied with HSRL2
RF0906	6-Sep-24	20:30	ER2	1	Over ocean section in PACE-OHS swath., Cloud free. Ocean params partially satisfied with HSRL2
RF0906	6-Sep-24	20:30	RB	1	RB + USC_SeaPRISM AERONET-OC AOD(510)=0.13 in PACE-OHS swath
RF0906	6-Sep-24	20:30	RB	0.5	RB + USC_SeaPRISM AERONET-OC AOD(510)=0.13 in PACE-OHS swath
RF0906	6-Sep-24	20:30	RB	1	RB + USC_SeaPRISM AERONET-OC AOD(510)=0.13 in PACE-OHS swath
RF0906	6-Sep-24	**20:30**	**PACE**		**PACE-OHS overpass**
RF0906	6-Sep-24	20:37	ER2	0.5	ER2 over AERONET (La_Jolla) AOD(500nm) ~0,4
RF0906	6-Sep-24	20:37	ER2	0.5	ER2 over AERONET (La_Jolla) AOD(500nm) ~0,4
RF0906	6-Sep-24	20:37	ER2	0.5	ER2 over AERONET (La_Jolla) AOD(500nm) ~0,4
RF0907	7-Sep-24	21:04	TO	3	PACE-OH overpass (21:04). Track ~280km west of TO location
RF0907	7-Sep-24	21:04	TO	3	PACE-OH overpass (21:04). Track ~280km west of TO location
RF0907	7-Sep-24	**21:04**	**PACE**		**PACE-OH overpass**
RF0912	12-Sep-24	20:00	TO	1.125	Spiral ends at Turlock. Just outside ideal +/- 30 min PACE overpass window but probably ok since aerosol load is so small.
RF0912	12-Sep-24	20:00	TO	1.125	Spiral ends at Turlock. Just outside ideal +/- 30 min PACE overpass window but

					probably ok since aerosol load is so small.
RF0912	12-Sep-24	20:23	RB	1.5	R/V Blissfully station begins. Near USC_SeaPRISM Aeronet-OC site, and in PACE-OH swath. AOD(490)=0.13
RF0912	12-Sep-24	20:23	RB	0.5	R/V Blissfully station begins. Near USC_SeaPRISM Aeronet-OC site, and in PACE-OH swath. AOD(490)=0.13
RF0912	12-Sep-24	20:37	RS	1.5	R/V Shearwater ends station #7 in PACE-OH swath. Station started at 18:49
RF0912	12-Sep-24	20:37	RS	0.5	R/V Shearwater ends station #7 in PACE-OH swath. Station started at 18:49
RF0912	12-Sep-24	20:39	TO	1.5	Start ascend over Sacramento_River AERONET-OC site. Water very turbid. Within PACE-OHS swath. Small amounts of dust in spiral. AOD(532)=0.04
RF0912	12-Sep-24	20:39	TO	1.5	Start ascend over Sacramento_River AERONET-OC site. Water very turbid. Within PACE-OHS swath. Small amounts of dust in spiral. AOD(532)=0.04
RF0912	12-Sep-24	20:39	TO	1.5	Start ascend over Sacramento_River AERONET-OC site. Water very turbid. Within PACE-OHS swath. Small amounts of dust in spiral. AOD(532)=0.04
RF0912	12-Sep-24	20:39	TO	1.125	Start ascend over Sacramento_River AERONET-OC site. Water very turbid. Within PACE-OHS swath. Small amounts of dust in spiral. AOD(532)=0.04
RF0912	12-Sep-24	20:39	TO	1.5	Start ascend over Sacramento_River AERONET-OC site. Water very turbid. Within PACE-OHS swath. Small amounts of dust in spiral. AOD(532)=0.04
RF0912	12-Sep-24	**20:39**	**PACE**		**PACE-OHS overpass**
RF0912	12-Sep-24	21:00	RS	1.5	R/V Shearwater starts station #8 in PACE-OH swath. Station ends at 22:54
RF0912	12-Sep-24	21:00	RS	0.5	R/V Shearwater starts station #8 in PACE-OH swath. Station ends at 22:54

RF0913	13-Sep-24	19:05	ER2, TO	3	ER-2 overpass of Twin Otter double spiral in third location in smoke east of Bridge fire. ER-2 observes this location at 19:05
RF0913	13-Sep-24	19:05	ER2, TO	3	ER-2 overpass of Twin Otter double spiral in third location in smoke east of Bridge fire. ER-2 observes this location at 19:05

RF0913	13-Sep-24	19:05	ER2, TO	3	ER-2 overpass of Twin Otter double spiral in third location in smoke east of Bridge fire. ER-2 observes this location at 19:05
RF0913	13-Sep-24	**19:36**	**PACE**		**PACE-O overpass east of target region**
RF0913	13-Sep-24	19:45	ER2	1	Start second long leg perpendicular to leg starting at 18:54. Catches other pathway of advected smoke at the time of PACE overpass. Within OCI swath and edge of HARP2 swath. Leg ends at about 20:05
RF0913	13-Sep-24	19:45	ER2	1	Start second long leg perpendicular to leg starting at 18:54. Catches other pathway of advected smoke at the time of PACE overpass. Within OCI swath and edge of HARP2 swath. Leg ends at about 20:05
RF0913	13-Sep-24	19:45	ER2	1	Start second long leg perpendicular to leg starting at 18:54. Catches other pathway of advected smoke at the time of PACE overpass. Within OCI swath and edge of HARP2 swath. Leg ends at about 20:05

RF0913	13-Sep-24	21:05	ER2	2	Third long ER2 leg over smoke. This time southward over eastern LA basin with smoke from Bridge and Airport fires, ending at 21:22 near San Diego. Includes PACE overpass at OCI edge.
RF0913	13-Sep-24	21:05	ER2	2	Third long ER2 leg over smoke. This time southward over eastern LA basin with smoke from Bridge and Airport fires, ending at 21:22 near San Diego. Includes PACE overpass at OCI edge.
RF0913	13-Sep-24	21:05	ER2	2	Third long ER2 leg over smoke. This time southward over eastern LA basin with smoke from Bridge and Airport fires, ending at 21:22 near San Diego. Includes PACE overpass at OCI edge.
RF0913	13-Sep-24	21:12	ER-2, TO	3	ER-2 overpass of Twin Otter spiral down in smoke east of Airport fire. Similar double layer structure as observed at other spirals. ER-2 observes this location at 21:40. PACE overpass as well.
RF0913	13-Sep-24	21:12	ER-2, TO	3	ER-2 overpass of Twin Otter spiral down in smoke east of Airport fire. Similar double layer structure as observed at other spirals. ER-2 observes this location at 21:40. PACE overpass as well.

RF0913	13-Sep-24	21:12	ER-2, TO	3	ER-2 overpass of Twin Otter spiral down in smoke east of Airport fire. Similar double layer structure as observed at other spirals. ER-2 observes this location at 21:40. PACE overpass as well.
RF0913	13-Sep-24	21:14	RB	1.5	Blissfully sampling adjacent to USC_SeaPRISM site during PACE overpass (OCI only) with cloud-free skies. AOT(490)=0.18, moderate aod, smoke from fires
RF0913	13-Sep-24	21:14	RB	1.5	Blissfully sampling adjacent to USC_SeaPRISM site during PACE overpass (OCI only) with cloud-free skies. AOT(490)=0.18, moderate aod, smoke from fires
RF0913	13-Sep-24	21:14	RB	1.5	Blissfully sampling adjacent to USC_SeaPRISM site during PACE overpass (OCI only) with cloud-free skies. AOT(490)=0.18, moderate aod, smoke from fires
RF0913	13-Sep-24	21:14	RS	1.5	Shearwater on station 11 from 20:45 to 22:01 during PACE overpass. Cloud free
RF0913	13-Sep-24	21:14	RS	1.5	Shearwater on station 11 from 20:45 to 22:01 during PACE overpass. Cloud free
RF0913	13-Sep-24	**21:14**	**PACE**		**PACE-O overpass west of target region**
RF0913	13-Sep-24	21:39	ER-2, TO	3	ER-2 overpass of Twin Otter spiral up in smoke east of Airport fire. Similar double layer structure as observed at other spirals. ER-2 observes this location at 21:39. PACE overpass as well.
RF0913	13-Sep-24	21:39	ER-2, TO	3	ER-2 overpass of Twin Otter spiral up in smoke east of Airport fire. Similar double layer structure as observed at other spirals. ER-2 observes this location at 21:39. PACE overpass as well.
RF0913	13-Sep-24	21:39	ER-2, TO	3	ER-2 overpass of Twin Otter spiral up in smoke east of Airport fire. Similar double layer structure as observed at other spirals. ER-2 observes this location at 21:39. PACE overpass as well.

RF0915	15-Sep-24	19:39	ER2, PACE	0.5	In solar principal plane PACE-OH line extending to 19:57. Counting half because of time difference with PACE overpass. Marine Strat. Clouds with high cloudsand some aerosol layer under – based on HSRL-2

RF0915	15-Sep-24	19:39	ER2, PACE	0.5	In solar principal plane PACE-OH line extending to 19:57. Counting half because of time difference with PACE overpass. Marine Strat. Clouds with high cloudsand some aerosol layer under – based on HSRL-2
RF0915	15-Sep-24	19:39	ER2, PACE	0.25	In solar principal plane PACE-OH line extending to 19:57. Counting half because of time difference with PACE overpass. Marine Strat. Clouds with high cloudsand some aerosol layer under – based on HSRL-2
RF0915	15-Sep-24	19:57	RB	1.5	On station for PACE overpass near USC_SeaPRISM. no USC_SeaPRISM archived data.
RF0915	15-Sep-24	19:57	RB	0.75	On station for PACE overpass near USC_SeaPRISM. no USC_SeaPRISM archived data.
RF0915	15-Sep-24	20:00	RS	0.75	On station until 21:28. Partly cloudy conditions with PACE overpass.
RF0915	15-Sep-24	20:00	RS	0.75	On station until 21:28. Partly cloudy conditions with PACE overpass.
RF0915	15-Sep-24	20:10	ER2, PACE	0.5	Two legs withing PACE-OHS swath. Ends 20:20. Appears to be high/ice clouds over low clouds, No TO
RF0915	15-Sep-24	20:10	ER2, PACE	0.5	Two legs withing PACE-OHS swath. Ends 20:20. Appears to be high/ice clouds over low clouds, No TO
RF0915	15-Sep-24	20:30	ER2, PACE	1	Final leg, now in PACE-OH swath Marine stratocumulus. , possibly high clouds too.
RF0915	15-Sep-24	20:30	ER2, PACE	1	Final leg, now in PACE-OH swath Marine stratocumulus. , possibly high clouds too.
RF0915	15-Sep-24	20:41	ER2	0.5	ER-2 overflies surfacing HyperNAV during PACE overpass. Partial cloudy HyperNAV profile, but clear at surface.
RF0915	15-Sep-24	20:41	ER2	1	ER-2 overflies surfacing HyperNAV during PACE overpass. Partial cloudy HyperNAV profile, but clear at surface.
RF0915	15-Sep-24	**20:44**	**PACE**		**PACE overpass**
RF0917	17-Sep-24	19:58	RB	1	Blissfully on station RB_15, PACE overhead in clear skies. Nearby USC_SeaPRISM inoperable
RF0917	17-Sep-24	19:58	RB	0.5	Blissfully on station RB_15, PACE overhead in clear skies. Nearby USC_SeaPRISM inoperable
RF0917	17-Sep-24	20:02	ER2, Ivanpah	2	ER-2 overflies Ivanpah Playa with JPL surface team present for characterization. Clear skies, low AOD

RF0917	17-Sep-24	20:02	ER2, Ivanpah	0.5	ER-2 overflies Ivanpah Playa with JPL surface team present for characterization. Clear skies, low AOD
RF0917	17-Sep-24	20:02	ER2, Ivanpah	2	ER-2 overflies Ivanpah Playa with JPL surface team present for characterization. Clear skies, low AOD
RF0917	17-Sep-24	**20:14**	**PACE**		**PACE-OHS overpass**
RF0917	17-Sep-24	20:15	ER2	1	ER-2 in PACE-OHS swath in Western Arizona. Low AOD
RF0917	17-Sep-24	20:15	ER2	2	ER-2 in PACE-OHS swath in Western Arizona. Low AOD
RF0917	17-Sep-24	20:18	RS	1	Shearwater on station 18 in clear skies, remains until 20:39. PACE overpass
RF0918	18-Sep-24	19:29	RS	2	Station 21 until 21:12. PACE-OH Overpass. Minimal Clouds. Possible lack of AERONET/Cimel measurements.
RF0918	18-Sep-24	19:29	RS	1	Station 21 until 21:12. PACE-OH Overpass. Minimal Clouds. Possible lack of AERONET/Cimel measurements.
RF0918	18-Sep-24	19:29	RS	1	Station 21 until 21:12. PACE-OH Overpass. Minimal Clouds. Possible lack of AERONET/Cimel measurements.
RF0918	18-Sep-24	**20:49**	**PACE**		**PACE Overpass**
RF0918	18-Sep-24	20:56	RB	1	Station #18 until 21:55. PACE-OH Overpass. No clouds.
RF0918	18-Sep-24	20:56	RB	1	Station #18 until 21:55. PACE-OH Overpass. No clouds.
RF0919	19-Sep-24	19:00	RB	1	Blissfully on station for PACE-O overpass. No USC_SeaPRISM data
RF0919	19-Sep-24	19:00	RB	0.5	Blissfully on station for PACE-O overpass. No USC_SeaPRISM data
RF0919	19-Sep-24	19:43	TO, RS, PACE-O	2	Twin Otter spiral over Shearwater during PACE-O overpass. Cloud free at this point, relatively clean aerosols.
RF0919	19-Sep-24	19:43	TO, RS, PACE-O	1.5	Twin Otter spiral over Shearwater during PACE-O overpass. Cloud free at this point, relatively clean aerosols.
RF0919	19-Sep-24	**19:45**	**PACE**		**PACE overpass (east of operations region)**
RF0919	19-Sep-24	20:40	RS	2	On station 23 until 22:41, with Twin Otter spiral over top plus PACE-O
RF0919	19-Sep-24	20:40	RS	1.5	On station 23 until 22:41, with Twin Otter spiral over top plus PACE-O
RF0919	19-Sep-24	**21:23**	**PACE**		**PACE overpass (west of operations region)**
RF0920	20-Sep-24	19:47	TO	3	Begin operations: spiral down outsize ADIZ line, then porpoising NW from

					there, turn and return at 20:33, concluding at 20:56. Within PACE-O swath, aerosol above clouds.
RF0920	20-Sep-24	19:47	TO	0.75	Begin operations: spiral down outsize ADIZ line, then porpoising NW from there, turn and return at 20:33, concluding at 20:56. Within PACE-O swath, aerosol above clouds.
RF0920	20-Sep-24	**20:20**	**PACE**		**PACE overpass (east of operations region)**
RF0920	20-Sep-24	20:23	RS	2	Arrives on station 27. PACE-O overpass. Mostly clear. Departure 21:47
RF0920	20-Sep-24	20:23	RS	2	Arrives on station 27. PACE-O overpass. Mostly clear. Departure 21:47
RF0922	22-Sep-24	19:44	TO, PACE-O	1.5	Spiral down over NEON_SJER AERONET AOD(500)=0.11, site during PACE-O overpass.
RF0922	22-Sep-24	19:44	TO, PACE-O	1.5	Spiral down over NEON_SJER AERONET AOD(500)=0.11, site during PACE-O overpass.
RF0922	22-Sep-24	19:50	ER2	1	ER2 over Shearwater, but fully cloudy. Scored for cloud retrievals because in PACE-O swath for overpass.
RF0922	22-Sep-24	**19:50**	**PACE**		**PACE overpass east of observed area**
RF0923	23-Sep-24	20:18	ER2	1	Begin PACE-OHS line, continues until 20:48. PACE overpass at 20:25. Cirrus over northern edge.
RF0923	23-Sep-24	20:18	ER2	1	Begin PACE-OHS line, continues until 20:48. PACE overpass at 20:25. Cirrus over northern edge.
RF0923	23-Sep-24	20:18	ER2	0.5	Begin PACE-OHS line, continues until 20:48. PACE overpass at 20:25. Cirrus over northern edge.
RF0923	23-Sep-24	**20:25**	**PACE**		**PACE Overpass**
RF0924	24-Sep-24	20:43	TO	0.5	Start of spiral at PIRAT to support potential aerosol above cloud retrievals in the PACE-OH swath. Spiral into clouds
RF0924	24-Sep-24	20:43	TO	0.5	Start of spiral at PIRAT to support potential aerosol above cloud retrievals in the PACE-OH swath. Spiral into clouds
RF0924	24-Sep-24	**20:59**	**PACE**		**PACE Overpass**
RF0924	24-Sep-24	21:00-21:30	TO	0.25	Porpoising in PACE-OH cross track direction. Thick clouds with significant cloud top liquid water content (~ 0.5 g/m^3) until 21:30.

RF0924	24-Sep-24	21:30-21:46	TO	0.5	Porpoising on PACE-OH along satellite track direction with significantly different, thinner clouds (~ 0.1 g/m^3) than previous leg.
RF0925	25-Sep-24	18:36-19:58	RS, PACE-OH	2	Station #34, clear skies
RF0925	25-Sep-24	18:36-19:58	RS, PACE-OH	2	Station #34, clear skies
RF0925	25-Sep-24	18:36-19:58	RS, PACE-OH	2	Station #34, clear skies
RF0925	25-Sep-24	**19:55**	**PACE-OH**		**PACE overpass (east)**
RF0925	25-Sep-24	20:04-21:33	RS, PACE-OH	2	Station #35, clear skies
RF0925	25-Sep-24	20:04-21:33	RS, PACE-OH	2	Station #35, clear skies
RF0925	25-Sep-24	20:04-21:33	RS, PACE-OH	2	Station #35, clear skies
RF0925	25-Sep-24	**21:33**	**PACE-OH**		**PACE overpass (west)**
RF0925	25-Sep-24	21:50-22:47	RS, PACE-OH	2	Station #36, clear skies
RF0925	25-Sep-24	21:50-22:47	RS, PACE-OH	2	Station #36, clear skies
RF0925	25-Sep-24	21:50-22:47	RS, PACE-OH	2	Station #36, clear skies
RF0926	26-Sep-24	20:06	ER2, PACE-OHS	1	ER2 on PACE line over Sierra Nevada mountains up to Reno area. Overpass just south of Lake Tahoe. Line ends at 20:36. Cloud free, low AOD. Over MammothCUES_CA_USA AERONET station, AOD(500)=0.025 (20:15). Additional instrumentation at DRI/Reno, contact Hans Moosemueller
RF0926	26-Sep-24	20:06	ER2, PACE-OHS	1	ER2 on PACE line over Sierra Nevada mountains up to Reno area. Overpass just south of Lake Tahoe. Line ends at 20:36. Cloud free, low AOD. Over MammothCUES_CA_USA AERONET station, AOD(500)=0.025 (20:15). Additional instrumentation at DRI/Reno, contact Hans Moosemueller
RF0926	26-Sep-24	20:00	TO	1.5	TO spirals over red tide offshore near Oxnard, CA.
RF0926	26-Sep-24	20:00	TO	1.5	TO spirals over red tide offshore near Oxnard, CA.

RF0926	26-Sep-24	20:00	TO	1.5	TO spirals over red tide offshore near Oxnard, CA.
RF0926	26-Sep-24	20:20	TO	1.5	TO spirals up from 100 to 10000ft over Shearwater at #40 (SHER2) at top 20:59
RF0926	26-Sep-24	20:20	TO	1.5	TO spirals up from 100 to 10000ft over Shearwater at #40 (SHER2) at top 20:59
RF0926	26-Sep-24	**20:31**	**PACE**		**PACE overpass, inland California**
RF0926	26-Sep-24	20:35	ER2, PACE-OHS	0.25	Over pyramid lake (turbid), under PACE-OHS, nearby Univ_of_Nevada-Reno AERONET AOD(500)=0.04
RF0926	26-Sep-24	20:35	ER2, PACE-OHS	0.25	Over pyramid lake (turbid), under PACE-OHS, nearby Univ_of_Nevada-Reno AERONET AOD(500)=0.04
RF0926	26-Sep-24	20:35	ER2, PACE-OHS	0.25	Over pyramid lake (turbid), under PACE-OHS, nearby Univ_of_Nevada-Reno AERONET AOD(500)=0.04
RF0927	27-Sep-24	20:30	ER2, PACE-OHS	1	Begins ~ 1 hour PACE track. Roughly 2/3 cloudy, 1/3 cloud free. Ends at 21:21
RF0927	27-Sep-24	20:30	ER2, PACE-OHS	1	Begins ~ 1 hour PACE track. Roughly 2/3 cloudy, 1/3 cloud free. Ends at 21:21
RF0927	27-Sep-24	20:30	ER2, PACE-OHS	2	Begins ~ 1 hour PACE track. Roughly 2/3 cloudy, 1/3 cloud free. Ends at 21:21
RF0927	27-Sep-24	20:30	ER2, PACE-OHS	1	Begins ~ 1 hour PACE track. Roughly 2/3 cloudy, 1/3 cloud free. Ends at 21:21
RF0927	27-Sep-24	20:30	ER2, PACE-OHS	2	Begins ~ 1 hour PACE track. Roughly 2/3 cloudy, 1/3 cloud free. Ends at 21:21
RF0927	27-Sep-24	20:30	ER2, PACE-OHS	2	Begins ~ 1 hour PACE track. Roughly 2/3 cloudy, 1/3 cloud free. Ends at 21:21
RF0927	27-Sep-24	20:39	TO, PACE-OH	1.5	Twin Otter spiral over R/V Rachel Carson (PACE overpass). Top of spiral at 21:09, multiple aerosol layers
RF0927	27-Sep-24	20:39	TO, PACE-OH	1.5	Twin Otter spiral over R/V Rachel Carson (PACE overpass). Top of spiral at 21:09, multiple aerosol layers
RF0927	27-Sep-24	20:39	TO, PACE-OH	1.5	Twin Otter spiral over R/V Rachel Carson (PACE overpass). Top of spiral at 21:09, multiple aerosol layers
RF0927	27-Sep-24	20:39	TO, PACE-OH	1.5	Twin Otter spiral over R/V Rachel Carson (PACE overpass). Top of spiral at 21:09, multiple aerosol layers
RF0927	27-Sep-24	**21:04**	**PACE**		**PACE overpass, offshore California**
RF0927	27-Sep-24	21:40	ER2	1	Begin ER2 cloud free segment in PACE-OH swath
RF0929	29-Sep-24	19:48	ER2, PACE	3	ER-2 on long PACE track, which ends at 20:58. Intentionally offset from satellite ground track (but within PACE-OHS) to validate other portions of SPEXone

					swath. Cloud free, low to moderate (smoke) aerosols.
RF0929	29-Sep-24	19:48	ER2, PACE	3	ER-2 on long PACE track, which ends at 20:58. Intentionally offset from satellite ground track (but within PACE-OHS) to validate other portions of SPEXone swath. Cloud free, low to moderate (smoke) aerosols.
RF0929	29-Sep-24	**20:35**	**PACE**		**PACE Sierra Nevadas and California Central Valley**
RF0929	29-Sep-24	20:39	ER2, PACE-OHS	1	ER-2 overflies NEON_SJER AERONET site. AOT(500)=0.12
RF0929	29-Sep-24	20:39	ER2, PACE-OHS	1	ER-2 overflies NEON_SJER AERONET site. AOT(500)=0.12
RF0929	29-Sep-24	20:50	ER2, PACE-OHS	0.5	ER-2 overflies Bakersfield AERONET site. AOT(500)=0.11, near the end of the PACE line, multiple aerosol layers
RF0929	29-Sep-24	20:50	ER2, PACE-OHS	0.5	ER-2 overflies Bakersfield AERONET site. AOT(500)=0.11, near the end of the PACE line, multiple aerosol layers
RF0929	29-Sep-24	20:50	ER2, PACE-OHS	0.25	ER-2 overflies Bakersfield AERONET site. AOT(500)=0.11, near the end of the PACE line, multiple aerosol layers
RF0929	29-Sep-24	21:07	ER2, Gliders	1	PACE overflies gliders in biologically productive waters. Glint
RF0929	29-Sep-24	21:07	ER2, Gliders	1	PACE overflies gliders in biologically productive waters. Glint
RF0929	29-Sep-24	21:07	ER2, Gliders	0.5	PACE overflies gliders in biologically productive waters. Glint
RF0929	29-Sep-24	21:07	ER2, Gliders	1	PACE overflies gliders in biologically productive waters. Glint
RF0929	29-Sep-24	23:40	ER2, Gliders	1	ER2 overflies gliders in biologically productive waters, where previous PACE-OHS/OH
RF0929	29-Sep-24	23:40	ER2, Gliders	1	ER2 overflies gliders in biologically productive waters, where previous PACE-OHS/OH
RF0929	29-Sep-24	23:40	ER2, Gliders	1	ER2 overflies gliders in biologically productive waters, where previous PACE-OHS/OH

RF0930	30-Sep-24	18:53	ER2	0.5	Transit to PACE (jn PACE-OH swath) track along cloud free and gradient of very high Chl waters to much lower concentrations on the line. End 19:31. Scored but reduced due to time difference.
RF0930	30-Sep-24	18:53	ER2	0.5	Transit to PACE (jn PACE-OH swath) track along cloud free and gradient of very high Chl waters to much lower

RF0930	30-Sep-24	18:53	ER2	0.5	concentrations on the line. End 19:31. Scored but reduced due to time difference. Transit to PACE (jn PACE-OH swath) track along cloud free and gradient of very high Chl waters to much lower concentrations on the line. End 19:31. Scored but reduced due to time difference.
RF0930	30-Sep-24	18:53	ER2	0.25	Transit to PACE (jn PACE-OH swath) track along cloud free and gradient of very high Chl waters to much lower concentrations on the line. End 19:31. Scored but reduced due to time difference.
RF0930	30-Sep-24	18:53	ER2	0.25	Transit to PACE (jn PACE-OH swath) track along cloud free and gradient of very high Chl waters to much lower concentrations on the line. End 19:31. Scored but reduced due to time difference.
RF0930	30-Sep-24	19:34	ER2	1.5	Transit within PACE-OHS swath. Cloud free with a gradient of more to less Chl-a from start (North) to end (South). Ends 20:17
RF0930	30-Sep-24	19:34	ER2	1.5	Transit within PACE-OHS swath. Cloud free with a gradient of more to less Chl-a from start (North) to end (South). Ends 20:17
RF0930	30-Sep-24	19:34	ER2	1. 5	Transit within PACE-OHS swath. Cloud free with a gradient of more to less Chl-a from start (North) to end (South). Ends 20:17
RF0930	30-Sep-24	**21:09**	**PACE**		**PACE offshore California**
RF0930	30-Sep-24	20:20	ER2	1	Return to shore line from PACE track, over marine stratocumulus clouds. Cloudy in all coastal sites of interest (HyperNAV location, SeaPRISM site) clouds ends ~21:24. Some clear areas until cross coast at 21:32
RF0930	30-Sep-24	20:20	ER2	0.5	Return to shore line from PACE track, over marine stratocumulus clouds. Cloudy in all coastal sites of interest (HyperNAV location, SeaPRISM site) clouds ends ~21:24. Some clear areas until cross coast at 21:32
RF0930	30-Sep-24	20:20	ER2	1	Return to shore line from PACE track, over marine stratocumulus clouds. Cloudy in all coastal sites of interest (HyperNAV location, SeaPRISM site) clouds ends ~21:24. Some clear areas until cross coast at 21:32

4.3.2 EarthCARE underpasses

Flight ID	Date	Time	Platform	Hours	Description
RF0908	8-Sep-24	22:06	TO	1.5	Spiral(s) over CEOBS site with ER-2 and EarthCARE overpass. Top of spiral at 22:23, then spiral down ending at 22:43. AOD=0.045 (then interrupted).
RF0908	8-Sep-24	22:06	TO	1.5	Spiral(s) over CEOBS site with ER-2 and EarthCARE overpass. Top of spiral at 22:23, then spiral down ending at 22:43. AOD=0.045 (then interrupted).
RF0908	8-Sep-24	22:17	ER2	0.5	Small section of ER-2 along EarthCARE track over clouds in Monterey Bay
RF0908	8-Sep-24	22:17	ER2	0.5	Small section of ER-2 along EarthCARE track over clouds in Monterey Bay
RF0908	8-Sep-24	22:21	ER2	1	Long track along EarthCARE line, mostly low AOD over California Central Valley
RF0908	8-Sep-24	22:22	ER2	0.5	Overpass CEOBS AERONET AOD(500)=0.045
RF0908	8-Sep-24	**22:39**	**EarthCARE**		**EarthCARE overpass, orbit #1602**
RF0917	17-Sep-24	22:27	ER2,EC	3	Very long out and back along EarthCARE line. Moderate AOD, some thin cirrus reported by HSRL with aerosol under cloud.
RF0917	17-Sep-24	22:27	ER2,EC	1	Very long out and back along EarthCARE line. Moderate AOD, some thin cirrus reported by HSRL with aerosol under cloud.
RF0917	17-Sep-24	22:27	ER2,EC	0.5	Very long out and back along EarthCARE line. Moderate AOD, some thin cirrus reported by HSRL with aerosol under cloud.
RF0917	17-Sep-24	**22:27**	**Earthcare**		**EarthCARE overpass, orbit #1742**
RF0919	19-Sep-24	22:17	TO, EarthCARE	1.5	After a first attempt to spiral down with aerosols but cloud below (which aircraft couldn't enter with IFR rules), found a second cloud free location to spiral during EarthCARE overpass. Spiral down to 2kft. Some cloud information on split TO spiral along EarthCARE
RF0919	19-Sep-24	22:17	TO, EarthCARE	1.5	After a first attempt to spiral down with aerosols but cloud below (which aircraft couldn't enter with IFR rules), found a second cloud free location to spiral during EarthCARE overpass. Spiral down

					to 2kft. Some cloud information on split TO spiral along EarthCARE
RF0919	19-Sep-24	22:17	TO, EarthCARE	0.75	After a first attempt to spiral down with aerosols but cloud below (which aircraft couldn't enter with IFR rules), found a second cloud free location to spiral during EarthCARE overpass. Spiral down to 2kft. Some cloud information on split TO spiral along EarthCARE
RF0919	19-Sep-24	**22:15**	**EarthCARE**		**Earthcare overpass, orbit # 1773**
RF0923	23-Sep-24	21:34	ER2	1	ER2 on EarthCARE line until 22:05. Some parts clear, some with thin cirrus, others with mid-level clouds
RF0923	23-Sep-24	21:34	ER2	1	ER2 on EarthCARE line until 22:05. Some parts clear, some with thin cirrus, others with mid-level clouds
RF0923	23-Sep-24	21:34	ER2	1	ER2 on EarthCARE line until 22:05. Some parts clear, some with thin cirrus, others with mid-level clouds
RF0923	23-Sep-24	21:34	ER2	1	ER2 on EarthCARE line until 22:05. Some parts clear, some with thin cirrus, others with mid-level clouds
RF0923	23-Sep-24	**21:53**	**EarthCARE**		**EarthCARE overpass, orbit 1853**
RF0924	24-Sep-24	21:00-21:30	TO	0.25	Porpoising in PACE-OH cross track direction. Thick clouds with significant cloud top liquid water content (~ 0.5 g/m^3) until 21:30.
RF0924	24-Sep-24	21:30-21:46	TO	0.5	Porpoising on PACE-OH along satellite track direction with significantly different, thinner clouds (~ 0.1 g/m^3) than previous leg.
RF0924	24-Sep-24	**22:53**	**EarthCARE**		**EarthCARE overpass, orbit 1851**
RF0926	26-Sep-24	22:09	ER2, EarthCARE	2	Start EarthCARE line, ends 22:40. Cloud free, low aerosol loads.
RF0926	26-Sep-24	22:09	ER2, EarthCARE	2	Start EarthCARE line, ends 22:40. Cloud free, low aerosol loads.
RF0926	26-Sep-24	**22:22**	**EarthCARE**		**EarthCARE overpass, Orbit #1882**
RF0930	30-Sep-24	21:48	ER2	1	ER2 begins EarthCARE line. Line ends 22:20. Elevated aerosols that HSRL indicates are "dusty mix". Cloud free.
RF0930	30-Sep-24	21:48	ER2	2	ER2 begins EarthCARE line. Line ends 22:20. Elevated aerosols that HSRL indicates are "dusty mix". Cloud free.
RF0930	30-Sep-24	21:54	ER2	0.5	Over Salton Sea AERONET site, AOT(500)=0.1

RF0930	30-Sep-24	21:54	ER2	0.5	Over Salton Sea AERONET site, AOT(500)=0.1
RF0930	30-Sep-24	**22:02**	**EarthCARE**		**EarthCARE California/Nevada border. Orbit 1944**
RF0930	30-Sep-24	22:13	ER2	0.25	Over Ivanpah Playa calibration site (no ground team)
RF0930	30-Sep-24	22:13	ER2	0.25	Over Ivanpah Playa calibration site (no ground team)

4.4 Summary of activities by platform configuration

4.4.1 Twin Otter + R/V Shearwater

Flight ID	Date	Time	Platform	Hours	Description
RF0906	6-Sep-24	21:42	ER2, RS, TO	2.5	ER-2 over R/V Shearwater and Twin Otter spiral
RF0919	19-Sep-24	19:43	TO, RS, PACE-O	2	Twin Otter spiral over Shearwater during PACE-O overpass. Cloud free at this point, relatively clean aerosols.
RF0919	19-Sep-24	20:40	RS	2	On station 23 until 22:41, with Twin Otter spiral over top plus PACE-O
RF0926	26-Sep-24	19:25	TO, RS	1.5	TO spirals up from 100 to 10000ft over Shearwater at #39 (SHER1) at top 19:50

4.4.2 Twin Otter + ER-2

Flight ID	Date	Time	Platform	Hours	Description
RF0904	4-Sep-24	20:59	ER2, TO, PACE	1	PACE underpass 20:59. 1e for TO & ER-2, ER-2 only for other VTM elements
RF0904	4-Sep-24	22:08	ER2, TO	2	Coordination between ER-2 and Twin Otter, while the latter is porpoising in clouds
RF0906	6-Sep-24	18:36	ER2, TO	1	ER-2 overfly TO line, although ER-2 is late by ~20 min.
RF0906	6-Sep-24	20:56	ER2, TO,RB	1.5	ER2 overfly TO as it is doing a spiral down over USC_SeaPRISM and RV Blissfully
RF0906	6-Sep-24	21:42	ER2, RS, TO	2.5	ER-2 over R/V Shearwater and Twin Otter spiral
RF0913	13-Sep-24	17:53	ER2, TO	3	ER-2 overpass of Twin Otter double spiral in smoke east of Bridge fire. TO spiral down 17:39-17:53, up starting at 17:53. At least two distinct smoke layers observed. ER-2 observes this location at 18:18

RF0913	13-Sep-24	18:18	ER2, TO	3	ER-2 overpass of Twin Otter double spiral in second location in smoke east of Bridge fire. Similar to prior spirals, at least two distinct smoke layers observed, but this time even greater loads. ER-2 observes this location at 18:18
RF0913	13-Sep-24	19:05	ER2, TO	3	ER-2 overpass of Twin Otter double spiral in third location in smoke east of Bridge fire. ER-2 observes this location at 19:05
RF0913	13-Sep-24	21:12	ER2, TO	3	ER-2 overpass of Twin Otter spiral down in smoke east of Airport fire. Similar double layer structure as observed at other spirals. ER-2 observes this location at 21:40. PACE overpass as well.
RF0913	13-Sep-24	21:39	ER2, TO	3	ER-2 overpass of Twin Otter spiral up in smoke east of Airport fire. Similar double layer structure as observed at other spirals. ER-2 observes this location at 21:39. PACE overpass as well.
RF0922	22-Sep-24	18:09	TO, ER2	1.5	Begin spiral down over Turlock, ER2 overpass at 18:23. end at 18:31
RF0922	22-Sep-24	18:44	TO, ER2	1.5	Long leg in central valley ,18:44 over Merced, with ER-2 overhead.
RF0922	22-Sep-24	19:14	ER2, TO	0.5	ER-2 overflight of TO flight path (19:40) between Fresno and NEON_SJER (AOD~0.11) – agricultural dust
RF0923	23-Sep-24	18:20	ER2, TO	1.5	ER-2 overpass of Twin Otter spiraling through clouds
RF0923	23-Sep-24	18:44	ER2, TO	1.5	ER-2 overpass of Twin Otter spiraling through clouds
RF0923	23-Sep-24	19:23	ER2, TO	1.5	ER-2 over Turlock AERONET site, AOD(500)=0.11 plus spiraling Twin Otter
RF0926	26-Sep-24	18:33	ER2, TO	1	ER-2 over Monterey AERONET site, AOD(500)=0.07. Over line previously sampled by Twin Otter (roughly 50 min prior)
RF0926	26-Sep-24	19:07	ER2, TO	0.5	ER2 overpass (at 19:17) of TO west of Santa Barbara, while TO is descending into boundary layer

4.4.3 ER-2 + R/V Shearwater

Flight ID	Date	Time	Platform	Hours	Description
RF0906	6-Sep-24	21:03	ER2, RS	1	ER-2 over R/V Shearwater
RF0906	6-Sep-24	21:42	ER2, RS, TO	2.5	ER-2 over R/V Shearwater and Twin Otter spiral

RF0906	6-Sep-24	22:01	ER2, RS	1	ER-2 over R/V Shearwater
RF0908	8-Sep-24	19:48	ER2,RS	1.5	ER2 overfly Shearwater with IOP and AERONET
RF0908	8-Sep-24	20:01	ER2,RS	1.5	ER2 overfly Shearwater with IOP and AERONET
RF0917	17-Sep-24	18:02	ER2, RS	1	ER-2 overpass of RS at station #16. Biologically productive waters
RF0917	17-Sep-24	19:12	ER2, RS	1	ER-2 over Shearwater in clear skies and biologically productive waters
RF0917	17-Sep-24	21:22	ER2, RS	1	ER-2 over Shearwater in clear skies and biologically productive waters
RF0922	22-Sep-24	18:17	RS, ER2	0.5	Shearwater on station #30 for first ER-2 overpass and PACE overpass (19:41). Station ends at 19:58. Fully cloudy, not scored.
RF0922	22-Sep-24	20:21	RS, ER2	0.5	Shearwater on station #31. HyperNAV surfaces nearby at 20:13. ER-2 overpass. Cloudy. Scored for cloud reference.
RF0923	23-Sep-24	19:56	ER2, RS	0.5	ER-2 over Shearwater, but cloudy. Scored as bright/low polarization target
RF0926	26-Sep-24	18:06	ER2, RS	1.5	ER-2 over Shearwater station #39 (SHER1) in clear skies
RF0926	26-Sep-24	19:35	ER2,RS	3	ER-2 over Shearwater at station #40 (SHER2), at location for Twin Otter (also previously overflew this site at ~19:23). Some glint.

4.4.4 ER-2 + gliders or R/V Blissfully

Flight ID	Date	Time	Platform	Hours	Description
RF0906	6-Sep-24	18:01	ER2, RB	1	ER-2 over RB and USC_SeaPRISM AERONET-OC AOD(510)=0.15. Partly cloudy
RF0906	6-Sep-24	20:55	ER2, RB	0.5	ER2 overfly R/V Blissfully & USC_SeaPRISM AERONET-OC, AOD(510)=0.12
RF0906	6-Sep-24	20:56	ER2, TO,RB	1.5	ER2 overfly TO as it is doing a spiral down over USC_SeaPRISM and RV Blissfully
RF0906	6-Sep-24	21:27	ER2, RB	1	ER-2 over R/V Blissfully and USC_SeaPRISM AERONET-OC
RF0908	8-Sep-24	19:32	ER2, RB	0.5	Overpass USC_Seaprism Aeronet high AOD(490)=0.36; Blissfully on station with HyperPro, etc.
RF0908	8-Sep-24	19:47	ER2,Gliders	1	ER2 overfly Glider line
RF0908	8-Sep-24	20:16	ER2, RB	2	Overpass USC_Seaprism Aeronet high AOD(490)=36; Blissfully on station with HyperPro, etc. mostly smoke
RF0913	13-Sep-24	18:52	ER2,RB	0.5x0.5	ER-2 overwater (turning) with smoke aerosol over clouds

RF0913	13-Sep-24	21:48	ER2, RB	1.5	ER-2 overpass of Blissfully and USC_SeaPRISM. Cloud free skies, AOT(490)=0.19, moderate aod, smoke from fires
RF0917	17-Sep-24	18:03	ER2, Glider	1	ER-2 over glider in biologically productive waters and clear skies. Outside of PACE overpass +/-2hours by a few minutes.
RF0917	17-Sep-24	19:19	ER2, glider	0.5	ER-2 over glider in biologically productive waters and clear skies
RF0922	22-Sep-24	19:41	ER2, gliders	0.5	ER-2 over gliders. Cloudy. Scored for cloud reference.
RF0923	23-Sep-24	19:52	ER2, Glider	0.5	ER-2 over glider, but cloudy. Scored as bright/low polarization target
RF0927	27-Sep-24	23:36	ER2, gliders	0.5	ER-2 over gliders, but cloudy
RF0929	29-Sep-24	21:07	ER2, Gliders	1	PACE overflies gliders in biologically productive waters. Glint
RF0929	29-Sep-24	23:40	ER2, Gliders	1	ER2 overflies gliders in biologically productive waters, where previous PACE-OHS/OH

4.4.5 ER-2 or Twin Otter + CEOBS

Flight ID	Date	Time	Platform	Hours	Description
RF0904	4-Sep-24	19:38	TO	1	Top of spiral at CEOBS site and begin porpoise in clouds
RF0908	8-Sep-24	21:01	ER2	0.5	Overpass CEOBS Aeronet AOD(500)=0.035
RF0908	8-Sep-24	22:06	TO	1.5	Spiral(s) over CEOBS site with ER-2 and EarthCARE overpass. Top of spiral at 22:23, then spiral down ending at 22:43. AOD=0.045 (then interrupted).
RF0908	8-Sep-24	22:17	ER2	0.5	Small section of ER-2 along EarthCARE track over clouds in Monterey Bay
RF0908	8-Sep-24	22:21	ER2	1	Long track along EarthCARE line, mostly low AOD over California Central Valley
RF0908	8-Sep-24	22:22	ER2	0.5	Overpass CEOBS AERONET AOD(500)=0.045
RF0908	8-Sep-24	**22:39**	**EarthCARE**		**EarthCARE overpass, orbit #1602**
RF0923	23-Sep-24	18:07	ER2	0.5	ER-2 over Monterey (AOD(500)=0.07), Marina Tower, and CEOBS site, cloud free. No Aeronet data at CEOBS,
RF0923	23-Sep-24	18:20	ER2, TO	1.5	ER-2 overpass of Twin Otter spiraling through clouds
RF0923	23-Sep-24	18:44	ER2, TO	1.5	ER-2 overpass of Twin Otter spiraling through clouds
RF0926	26-Sep-24	21:28	ER2	0.5	Over CEOBS site. AERONET not functional, but ground Lidar and other instruments ok
RF0926	26-Sep-24	**22:22**	**EarthCARE**		**EarthCARE overpass, Orbit #1882**

RF0927	27-Sep-24	19:22	ER2	0.5	ER-2 overflies CEOBS site. AERONET instrument not functional, but lidar, etc. are.
RF0927	27-Sep-24	22:50	TO	1.5	Twin Otter begins CEOBS spiral with ER-2 overhead(23:07). Cloud free. Partially above water.

4.4.6 ER-2 + Railroad valley, Ivanpah Playa or NEON site

Flight ID	Date	Time	Platform	Hours	Description
CF0829	29-Aug-24	18:43	ER2	0.5	Overfly NEON SJER. Moderate AOD=0.18
RF0910	10-Sep-24	17:21	ER2	0.25	Overfly Ivanpah Playa. Possible aerosol load? Small clouds partly obscure scene
RF0913	13-Sep-24	20:18:30	ER2	1	ER2 over Railroad Valley, AERONET AOD(440)=0.05
RF0917	17-Sep-24	20:02	ER2, Ivanpah	2	ER-2 overflies Ivanpah Playa with JPL surface team present for characterization. Clear skies, low AOD
RF0917	17-Sep-24	**20:14**	**PACE**		**PACE-OHS overpass**
RF0917	17-Sep-24	20:40	ER2, Ivanpah	2	ER-2 2nd overflies Ivanpah Playa with JPL surface team present for characterization. Clear skies, low AOD, roughly 90° from last overpass.
RF0922	22-Sep-24	17:25	ER2	0.5	ER-2 over Railroad Valley. No Clouds. AERONET AOD(500)=0.055
RF0922	22-Sep-24	17:45	ER2	0.5	ER-2 over Railroad Valley. No Clouds. AERONET AOD(500)=0.056
RF0922	22-Sep-24	19:13	ER2	0.5	ER-2 over NEON_SJER AERONET site, AOD(500)=0.11
RF0922	22-Sep-24	19:44	TO, PACE-O	1.5	Spiral down over NEON_SJER AERONET AOD(500)=0.11, site during PACE-O overpass.
RF0923	23-Sep-24	**20:25**	**PACE**		**PACE Overpass**
RF0923	23-Sep-24	21:03:08	ER2	0.5	ER2 over Railroad Valley Aeronet, partial cirrus. No aeronet data, after 20.5UTC, AOD(500)=0.035.
RF0929	29-Sep-24	18:37	ER2	0.5	ER-2 overflies NEON_SJER AERONET site. AOT(500)=0.13
RF0929	29-Sep-24	20:39	ER2, PACE-OHS	1	ER-2 overflies NEON_SJER AERONET site. AOT(500)=0.12
RF0930	30-Sep-24	18:25	ER2	0.5	ER2 over NEON_SJER AERONET site, AOT(500)=0.11
RF0930	30-Sep-24	22:13	ER2	0.25	Over Ivanpah Playa calibration site (no ground team)
RF0930	30-Sep-24	22:59	ER2	0.5	Over Railroad valley calibration and AERONET site. AOT(500)=0.05
RF0930	30-Sep-24	23:33	ER2	0.5	Over NEON_TEAK (neon land surface site) AERONET site, AOT(500)=0.1

	(variations through the day likely linked to happy fire)

4.5 Activities not quantified in the VTM

PACE-PAX collected data relevant not just for the purposes of validation outlined in the VTM. Two major events occurred during PACE-PAX. While they were the focus of observations useful for validation, as a whole they are useful to study a larger phenomena. In mid-September, several large fires burned simultaneously North, East and South of Los Angeles, and the smoke from these fires advected throughout the region. Later in the month, a large Red tide even occurred in the Monterey Bay and to the North in the Gulf of the Farallones. This Red tide was confirmed by in situ measurements by the R/V Rachel Carson and PACE satellite data.

4.5.1 Southern California biomass burning

September, 2024 saw several severe fires near Los Angeles which were observed multiple times during PACE-PAX. Three major fires occurred in Los Angeles and San Bernardino counties simultaneously. One fire was North of downtown LA, one South, and one East. In terms of acres burned, the Bridge fire was the 3rd largest in California in 2024, while the Line fire was 4th and the Airport fire was 7th (see Table 54). PACE had an anomaly and was in safe-hold from September 8th to 11th, but observations were made without PACE overflights during that time range, or with PACE after the 11th.

Table 54 Major fires encountered during PACE-PAX.

Fire name	Location	Start time	Acres burned	Calfire URL
Bridge	34.2396˚N 117.7625˚W	2024/09/08	56,030	https://www.fire.ca.gov/incidents/2024/9/8/bridge-fire
Line	34.121119˚N 117.154705˚W	2024/09/05	43,978	https://www.fire.ca.gov/incidents/2024/9/5/line-fire
Airport	33.6676762˚N 117.566221˚W	2024/09/09	23,526	https://www.fire.ca.gov/incidents/2024/9/9/airport-fire

Three days of observations relevant to these fires and their smoke were made, on Sept. 8th, 10th and 13th. On the 13th, PACE had recently become operational and the primary focus of that day was observations of smoke. The R/V Blissfully and R/V Shearwater were operating in their typical areas near the USC_SeaPRISM AERONET-OC site and the Santa Barbara Channel – generally smoke was advected over these offshore areas. The Twin Otter made a double sortie down to southern California, and did multiple spirals and other maneuvers through the smoke plumes. The ER-2 overflew the region multiple times, often with long level flight capturing a smoke plume from its greatest concentration at the source to dissipation downwind. Figure 54 and Figure 55 are photos from both aircraft, while Table 55 Observations of Bridge, Line and Airport fires in Southern Californialists specific observations relevant to these fires.

Figure 54 Smoke from the Line fire prior to a spiral down into the plume by the Twin Otter on September 13th, 2024. Photo by Adam Ahern.

Figure 55 The Bridge fire in the San Gabriel mountains as seen from the NASA ER-2 on September 10, 2024. Credit: NASA and pilot Kirt Stallings

Table 55 Observations of Bridge, Line and Airport fires in Southern California

Flight ID	Date	Time	Platform	Description
RF0908	8-Sep-24	19:10	ER2	Overpass CalTech Aeronet high AOD(500)=0.4
RF0908	8-Sep-24	19:32	ER2, RB	Overpass USC_Seaprism Aeronet high AOD(490)=0.36; Blissfully on station with HyperPro, etc.
RF0908	8-Sep-24	20:16	ER2, RB	Overpass USC_Seaprism Aeronet high AOD(490)=36; Blissfully on station with HyperPro, etc. mostly smoke
RF0908	8-Sep-24	20:23	ER2	Overpass CalTech Aeronet high AOD(500)=0.26
RF0908	8-Sep-24	20:36	ER2	Overpass Bakersfield Aeronet moderate AOD(500)=0.15
RF0910	10-Sep-24	17:39	ER2	Overfly extremely high aerosol loads downwind of the Line, Bridge and Airport fires. 17:44 overflies Line fire
RF0910	10-Sep-24	18:53	ER2	Overfly extremely high aerosol loads downwind of the Airport fires. Evidence of pyrocumulus cloud in imagery
RF0910	10-Sep-24	18:53	ER2	Overfly extremely high aerosol loads downwind of the Airport fires. Evidence of pyrocumulus cloud in imagery
RF0910	10-Sep-24	19:16	ER2	Overfly extremely high aerosol loads downwind of the Airport fires. Edge of plume observed by previous line
RF0913	13-Sep-24	17:53	ER2, TO	ER-2 overpass of Twin Otter double spiral in smoke east of Bridge fire. TO spiral down 17:39-17:53, up starting at 17:53. At least two distinct smoke layers observed. ER-2 observes this location at 18:18
RF0913	13-Sep-24	18:18	ER2, TO	ER-2 overpass of Twin Otter double spiral in second location in smoke east of Bridge fire. Similar to prior spirals, at least two distinct smoke layers observed, but this time even greater loads. ER-2 observes this location at 18:18
RF0913	13-Sep-24	18:52	ER2,RB	ER-2 overwater (turning) with smoke aerosol over clouds
RF0913	13-Sep-24	18:54	ER2	Extremely long leg (to 19:36) over LA basin, Bridge fire and following path of smoke as it is advected east and north
RF0913	13-Sep-24	18:58	ER2	ER-2 overfly CalTech AERONET site. AOD(500)=0.48
RF0913	13-Sep-24	19:05	ER2, TO	ER-2 overpass of Twin Otter double spiral in third location in smoke east of Bridge fire. ER-2 observes this location at 19:05
RF0913	13-Sep-24	**19:36**	**PACE**	**PACE-O overpass east of target region**
RF0913	13-Sep-24	19:45	ER2	Start second long leg perpendicular to leg starting at 18:54. Catches other pathway of advected smoke at the time of PACE overpass. Within OCI swath and edge of HARP2 swath. Leg ends at about 20:05
RF0913	13-Sep-24	21:05	ER2	Third long ER2 leg over smoke. This time southward over eastern LA basin with smoke from Bridge and Airport fires, ending at 21:22 near San Diego. Includes PACE overpass at OCI edge.
RF0913	13-Sep-24	21:12	ER-2, TO	ER-2 overpass of Twin Otter spiral down in smoke east of Airport fire. Similar double layer structure as observed at other spirals. ER-2 observes this location at 21:40. PACE overpass as well.
RF0913	13-Sep-24	21:14	RB	Blissfully sampling adjacent to USC_SeaPRISM site during PACE overpass (OCI only) with cloud-free skies. AOT(490)=0.18, moderate aod, smoke from fires
RF0913	13-Sep-24	**21:14**	**PACE**	**PACE-O overpass west of target region**

RF0913	13-Sep-24	21:39	ER-2, TO	ER-2 overpass of Twin Otter spiral up in smoke east of Airport fire. Similar double layer structure as observed at other spirals. ER-2 observes this location at 21:39. PACE overpass as well.
RF0913	13-Sep-24	21:48	ER2, RB	ER-2 overpass of Blissfully and USC_SeaPRISM. Cloud free skies, AOT(490)=0.19, moderate aod, smoke from fires
RF0913	13-Sep-24	21:55	ER2	Final long ER-2 leg starting at Long Beach and heading northeast over smoke from Airport and Bridge fires. End leg at 22:19
RF0913	13-Sep-24	21:59	ER2	ER2 overflites WC_Whittier_CA AERONET site, AOD(500)=0.35 high load

4.5.2 Harmful algal blooms

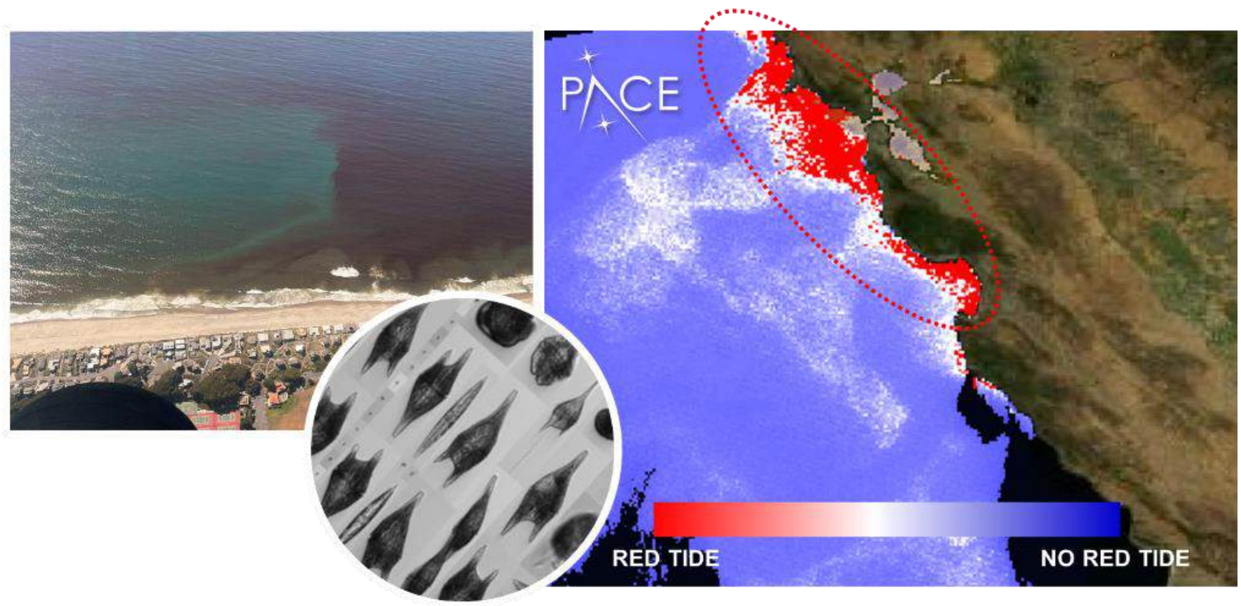


Figure 56 Red tide blooms in Northern California as seen from three remote sensing tools during PACE-PAX. On the left is the image taken by the team from Twin Otter on September 24th, on the right is the PACE OCI image collected on September 27th, with modified red-tide index applied to OCI data (Kahru et al., 2021), and in center inset is the image taken by the Imaging FlowCytobot IFCB on September 27th at Santa Cruz Pier.

A red tide was observed on several occasions in Monterrey Bay during the overflights by NPS/CIRPAS Twin Otter (times are dated based on the image collection).
September 23, 2024, 20:43 (PACE overpass at 20:59)
September 27, 2024, 20:55 (PACE overpass at 21:04)

During the second observation (September 27, 2024), R/V Rachel Carson was in the area, with PVST team lead by Clarissa Anderson and their collaborators from ECOHAP project, collecting a large suite of biological and optical measurements (see subsection PVST: R/V Rachel Carson (Anderson)).

The red tide was confirmed using in-water images of red tide cells (circle above) from a PACE Validation Team led by Clarissa Anderson (Scripps Institution of Oceanography) from the shore deployed automatic microscope (IFCB) at two locations in Monterey Bay. This data is available through the CalOOS data portal/CalHABMAP, both for Monterey Wharf and Santa Cruz Wharf.

4.6 Critical assessment and lessons learned

4.6.1 ER-2

PACE-PAX utilized NASA ER-2 806 in Hangar 4802 on the main campus of NASA Armstrong Flight Research Center (AFRC). This is a change from recent experience where the ER-2 was based at Palmdale Regional Airport (aka Building 703). From our understanding, PACE-PAX was the first deployment of the ER-2 after its return to Hagar 4802 with a full complement of instruments.

The purpose of this section is to highlight what may be different about deployments out of Hangar 4802 compared to Building 703, so that future experimenters will know what to expect. This is NOT meant to be a criticism of AFRC or its personnel. We met our mission objectives and are satisfied with the support and performance of the ER-2 platform, pilots and crew. In some cases, there were heroic efforts by AFRC personnel to achieve mission success. Limitations we encountered may be symptoms of the recent move and may be addressed prior to subsequent deployment. We would also like to note that AFRC reached out to the PACE-PAX team to perform a 'lessons learned' for future deployments, indicating a desire for continuous improvement.

Figure 57 Palmdale Regional Airport (building 703) is roughly 35 miles and 45 minutes – 1 hour south of AFRC Hangar 4802

4.6.1.1 Logistical adjustment

AFRC Hangar 4802 is roughly 35 miles north of Building 703, a drive of 45 minutes to an hour. Some of the logistical impacts that this entails include:

- Building 703 is standalone with NASA security and access rules. Hangar 4802 is on the main AFRC campus within Edwards Air Force Base. Foreign National (FN) access is thus more complicated, and certified FN escorts are required at a ratio of 6:1. However, in PACE-PAX we did have an instrument team comprised of Foreign Nationals and encountered no issues, other than the need for additional logistical coordination for escorts.
- Building 703 is closer to hotels in Palmdale and Lancaster. Teams need to budget for longer transit times to Hangar 4802.
- Food options are more limited near Hangar 4802.

4.6.1.2 Airfield differences

At Building 703, ER-2 preflight operations were performed directly outside the hangar. Preflight operations at Hangar 4802 are performed at 'Pad 4', roughly a mile away along the flight line. It takes roughly 30 minutes to tow the ER-2 to Pad 4. This has several implications:

- In warm temperatures, instruments are at risk of overheating. A mobile AC system was devised to manage temperature.
- Instrument team members supporting preflight operations must be transported to Pad 4 in a vehicle driven by AFRC personnel with a flight line driver's permit.
- Pad 4 has a support building with power and AC. During PACE-PAX, we made use of an ESPO-supplied Starlink unit, so that instrument teams cloud monitor status and communicate with team members back at Hangar 4802.

The ER-2 has limits on wind speed and cross wind direction which often constrained operations. During PACE-PAX, this meant several flights were cut short so that the ER-2 could be on the ground before these limits were exceeded. While these limits are the same regardless of airfield, Palmdale Regional Airport has the advantage that its pair of runways have different headings, meaning that susceptibility to exceeding cross wind limits is somewhat less.

4.6.1.3 Operations at AFRC

- Crew duty limits and other matters limited ER-2 flight length to 6.5 hours, and crew duty limits were 60 hours per week.
- A maximum of two back-to-back flight days were possible. Additionally, a planned flight on the day following a holiday was not possible.
- Because of a compressed schedule and many flight hours, PACE-PAX opted to provide funding for operations on weekends and Regular Days Off (RDO). Without such funding operations would be limited to 4 or 5 days per week. This was described as 'deployment in place', although in practice this was more limited than a true field deployment. Deployment elsewhere would have entailed greater schedule availability and flexibility. Obviously, this would have come with higher costs. Some aspects of the limitations of AFRC "deployment in place" included:

    - Permission to fly in the EAFB airfield is granted by the Air Force. While this permission was granted when it was needed for PACE-PAX, it required advance notice and effort to make this request, and such permission was not guaranteed.
    - Unlike a true field deployment, AFRC personnel had non-PACE-PAX obligations affecting their attention and availability. For example, ER-2 pilots were also flying other aircraft during the campaign.
- Hangar 4802's laboratory was cramped for PACE-PAX's team of six instruments. There is less space than what was available in Building 703. Additionally, only wing pod instruments could fit through the doors to the laboratory, instruments in the nose must either enter through an exterior door (involving transit outside) or remain on the hangar floor.
- There was no separate space available for ESPO or PACE-PAX leadership, further adding to cramped conditions in the laboratory. There was no dedicated conference room or meeting space, and occasionally the room we used was unavailable. Upon request, a private room for the weather forecasting team was made available on another floor of the building.
- Wired internet connections were not available in the Hangar 4802 laboratory. Wireless internet worked 90% of the time, the remainder relied on ESPO provided Starlink.
- Upload and download times on the ER-2 were necessary, but sufficient.
- Photography, by both professionals and team members, was subject to review before release, which in some cases took weeks.

4.6.1.4 Recommendations

- ESPO supplied Starlink internet units, both at the Hangar 4802 laboratory and Pad 4, were crucial means to enable reliable internet. FN's needed to use the Starlink internet.
- Group chat tools (we used WhatsApp) allowed for smooth communications among personnel in multiple locations.
- Arrive at AFRC with a clear understanding of flight length, crew duty and schedule limits.
- Request science team and ESPO inclusion in the Operational Readiness Review (ORR). PACE-PAX science leadership and ESPO were not included in the ORR for PACE-PAX.
- Request and verify that all necessary AFRC personnel are included in mailing lists and chat tools.

5 Summary and conclusions

The PACE Postlaunch Airborne eXperiment (PACE-PAX) field campaign, validating atmospheric, ocean and land surface observations from the newly launched PACE and ESA EarthCARE satellites, successfully concluded on September 30th in California. The project utilized two aircraft, two research vessels, and other ocean and ground assets to make coordinated observations, often during satellite overpasses by PACE and EarthCARE.

During PACE-PAX

- The NASA ER-2 flew 13 research flights, totaling over 80.9 flight hours
- The NPS/CIRPAS Twin Otter flew 17 research flights totaling 60 flight hours.
- The R/V Shearwater performed 15 day trips.
- The R/V Blissfully performed 9 day trips.
- 16 days of coordinated observations were made during a PACE overpass
- 6 days of coordinated observations were made during an EarthCARE overpass

- A ground based team from JPL was deployed to Ivanpah Playa for vicarious calibration and validation of land surface reflectances. Additional flights were also made over Railroad Valley.
- Coordinated observations were made with components of the PACE Validation Science Team as they were deployed.
- Coordinated observations were made with the HyperNAV vicarious calibration float system.
- Many overflights were made of AERONET and other ground stations.
- Several flights were flown around active wildfires in southern California, including the Bridge, Line and Airport fires.
- Measurements were made during a Red tide bloom in Monterey Bay.

The campaign was led by the PACE Project Science office (NASA GSFC and NASA GISS) with participation from academia (UMBC), other government agencies (NPS, NOAA), foreign space agencies (SRON) and other NASA involvement by GSFC, LaRC, AFRC, ARC, and JPL.

PACE-PAX data are finalized and available in multiple archives. Airborne data and some ground data were ingested into the NASA Suborbital Science Data for Atmospheric Composition archive (https://www-air.larc.nasa.gov/missions/pacepax/index.html). While this archive will be maintained, the data have been copied to their permanent home at the NASA Atmospheric Science Data Center (https://asdc.larc.nasa.gov/project/PACE-PAX). The latter means data are accessible through NASA's Earthdata file search and access infrastructure. Ocean data are archived at SeaBASS (https://seabass.gsfc.nasa.gov/experiment/PACE-PAX/).

Analysis of PACE-PAX data are ongoing and are actively being used by PACE algorithm developers, among others, for validation. This document is intended to capture all relevant information while it remains accessible. A forthcoming peer-reviewed field campaign overview manuscript is underway.

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7 Appendix A: List of acronyms

ac-s - Absorption and attenuation meter
AEROCAN - AErosol RObotic NETwork Canada
AERONET - AErosol RObotic NETwork
AERONET-OC - AERONET Ocean Color
AEROSPAIN - AERONET Spain
AFRC - Armstrong Flight Research Center
AirHARP - Airborne Hyper-Angular Rainbow Polarimeter
AirHARP2 - Airborne Hyper-Angular Rainbow Polarimeter 2
AoLP - Angle of Linear Polarization
AOD - Aerosol Optical Depth
AOT - Aerosol Optical Thickness

APAC - Asia-Pacific Aerosol Characterization Experiment
APS - Aerodynamic Particle Sizer
ARC - Ames Research Research Center
ARTDECO - Automated Radiative Transfer Data for Earth and Climate Observations
ASDC - Atmospheric Science Data Center
ATBD - Algorithm Theoretical Basis Document
BAERI - Bay Area Environmental Research Institute
CAPS-PMSSA - Cavity Attenuated Phase Shift Particle Matter Single Scattering Albedo
CARSNET - China Aerosol Remote Sensing Network
CCNY - City College of New York
CEOBS - Coastal Environmental Observing Station
Chl - Chlorophyll
CIRPAS - Center for Interdisciplinary Remotely-Piloted Aircraft Studies
CNES - Centre National d'Études Spatiales
CNRS-INSU - Centre National de la Recherche Scientifique - Institut National des Sciences de l'Univers
C-OPS - Compact Optical Profiling System
CTD - Conductivity Temperature Depth
DoLP - Degree of Linear Polarization
Ed - Downwelling irradiance
ER-2 - Earth Resources 2
ERI - Earth Research Institute
Es - Surface irradiance
ESSD - Earth System Science Data
Eu - Upwelling irradiance
FDOM - Fluorescent Dissolved Organic Matter
F0 - Extraterrestrial solar irradiance
GEOS - Goddard Earth Observing System
GISS - Goddard Institute for Space Studies
GMAO – Global Modeling and Assimilation Office
GPS - Global Positioning System
GRASP - Generalized Retrieval of Atmosphere and Surface Properties
GSFC - Goddard Space Flight Center
HARP - Hyper-Angular Rainbow Polarimeter
HARP2 - Hyper-Angular Rainbow Polarimeter 2
HPLC - High Performance Liquid Chromatography
HSRL - High Spectral Resolution Lidar
IFCB - Imaging FlowCytobot
IMU - Inertial Measurement Unit
IOP - Inherent Optical Properties
ISARA - In-situ and Satellite-based Aerosol Research Algorithms
ISOCO - In-Situ Ocean Color Optical
JPL - Jet Propulsion Laboratory
Kd - Diffuse attenuation coefficient of Ed
Kl - Diffuse attenuation coefficient of Lu
Ku - Diffuse attenuation coefficient of Eu

L1B - Level 1B
L1C - Level 1C
L2 - Level 2
LaRC - Langley Research Center
LARGE - Langley Aerosol Research Group Experiment
LDEO - Lamont-Doherty Earth Observatory
LiNeph - Laser imaging Nephelometer
Lu - Upwelling radiance
Lw - Water-leaving radiance
Lwn - Normalized water-leaving radiance
MBARI - Monterey Bay Aquarium Research Institute
MERRA2 - Modern-Era Retrospective analysis for Research and Applications, Version 2
MODIS - Moderate Resolution Imaging Spectroradiometer
MTS - Mission Tools Suite
NASA - National Aeronautics and Space Administration
NEON - National Ecological Observatory Network
NESDIS - National Environmental Satellite, Data, and Information Service
NOAA - National Oceanographic and Atmospheric Administration
NPP - NPOESS Preparatory Project
NPS - Naval Postgraduate School
NRL - Naval Research Laboratory
NRLMMD - Naval Research Laboratory Marine Meterology Division
NSF NCAR - National Science Foundation National Center for Atmospheric Research
OCI - Ocean Color Instrument
OEL - Ocean Ecology Lab
PACE - Plankton, Aerosol, Cloud, ocean Ecosystem
PACE-PAX - PACE Postlaunch Airborne Experiment
PAR - Photosynthetically Active Radiation
PHOTONS - PHOtométrie pour le Traitement Opérationnel de Normalisation Satellitaire
PICARD - Portable Imaging CAmeRA for Detector characterization
PII - Personally Identifiable Information
POPS - Printed Optical Particle Spectrometer
PRISM - Portable Remote Imaging SpectroMeter
PVST - PACE Validation Science Team
PVST-SBCR - PACE Validation Science Team - Santa Barbara Channel Rapid Response
PySAS - Python Shipboard Automated Sampling
QA/QC - Quality Assurance/Quality Control
RemoTAP - Remote sensing of Trace gas and Aerosol Products
RF - Research Flight
RH - Relative Humidity
RIMA - Red Iberoamericana de Medida fotométrica de Aerosoles
RNA - Ribonucleic Acid
Rrs - Remote sensing reflectance
RSP - Research Scanning Polarimeter
RV - Research Vessel
SC-6 - Scattering sensor

SeaBASS - SeaWiFS Bio-optical Archive and Storage System
SEAPRISM - Sea-viewing Wide Field-of-view Sensor Autonomous Measurements of Radiation and Insolation Program
SPEX - Spectropolarimeter for Planetary Exploration
SPEXone - SPEX One
SRON - Space Research Organisation of the Netherlands
SSD-AC - Suborbital Science Data for Atmospheric Composition
SSAI - Science Systems and Applications Inc.
SSA - Single Scattering Albedo
SZA - Solar Zenith Angle
TAP - Tricolor Absorption Photometer
TSG - ThermoSalinoGraph
TSI - Total Sky Imager
UCSB - University of California Santa Barbara
UCSD - University of California San Diego
UMBC - University of Maryland Baltimore County
USC - University of Southern California
UTC - Coordinated Universal Time
UV - Ultraviolet
VIIRS - Visible Infrared Imaging Radiometer Suite
VSB - Validation of Satellite Biology
VTM - Validation Traceability Matrix

8 Appendix B: Risk table

Table 56 PACE-PAX top level risk table

ID	Risk	Background	Response/Mitigation	L	C
C	Individual PACE instrument failure	Full individual instrument failure upon successful launch	Potential descope of PACE-PAX, or proceed with diminished expectations	1	3
D	PACE instrument data delivery delay	Fully calibrated data not available at the planned time point	Delay	1	3
E	Remote sensing platform (ER-2) unavailable	ER-2 becomes unavailable close to beginning or during PACE-PAX	Delay	1	5
F	In situ platform (Twin Otter) unavailable	Twin Otter becomes unavailable close to beginning or during PACE-PAX	Delay	1	4
G-AH	Individual PACE-PAX instrument failure: AirHARP	AirHARP on ER-2 fails to operate prior to or during the mission	Accept. Implications on mission success depend on instrument	1	3

G-HL	Individual PACE-PAX instrument failure: HSRL2	HSRL2 on ER-2 fails to operate prior to or during the mission	Accept. Implications on mission success depend on instrument	1	3
G-PI	Individual PACE-PAX instrument failure: PICARD	PICARD on ER-2 fails to operate prior to or during the mission	Accept. Implications on mission success depend on instrument	1	3
G-PR	Individual PACE-PAX instrument failure: PRISM	PRISM on ER-2 fails to operate prior to or during the mission	Accept. Implications on mission success depend on instrument	1	3
G-RS	Individual PACE-PAX instrument failure: RSP	RSP on ER-2 fails to operate prior to or during the mission	Accept. Implications on mission success depend on instrument	1	2
G-SA	Individual PACE-PAX instrument failure: SPEXAir	SPEXAir on ER-2 fails to operate prior to or during the mission	Accept. Implications on mission success depend on instrument	1	3
G-TO	Individual PACE-PAX instrument failure: Twin Otter	Facility Instruments on Twin Otter fails to operate prior to or during the mission	Accept. Implications on mission success depend on instrument	1	2
G-LA	Individual PACE-PAX instrument failure: LARGE	LARGE Instruments on Twin Otter fails to operate prior to or during the mission	Accept. Implications on mission success depend on instrument	1	2
G-PN	Individual PACE-PAX instrument failure: LI-Neph	LI-Neph Instrument on Twin Otter fails to operate prior to or during the mission	Accept. Implications on mission success depend on instrument	1	2
H	Optimal observation conditions are not encountered	Measurement conditions required in the VTM are not encountered (e.g., insufficient aerosol loads)	Accept. Schedule margin included based on climatological assessments	2	1
I	Unexpected extreme weather events or other events	Extended suspension of flight operations due to act of god (e.g., earthquake)	Delay	1	4
M	R/V Shearwater unavailable	NOAA research ship becomes unavailable	Accept. Note implications for meeting objectives	1	2
N	HyperNAV unavailable	HyperNAV floats cannot be deployed	Accept. Note implications for meeting objectives	2	2
O	AFRC cost increase	Cost increase for ER-2 operations	Accept. Reduce flight hours with implications for meeting objectives	1	2
P	Construction delays converting office space to lab space	Hangar 4802 at NASA AFRC at EAFB requires construction to convert current office space to lab space.	Accept. Unlikely to occur, but if the lab space is not ready by the time PACE-PAX integration begins, it may be possible to utilize space on the hangar floor.	1	2
Realized risks					

J	ER-2 deployment site moves to Edwards	AFRC B703 lease runs to 2025, but the move to Edwards may begin in 2024.	Accept	3	2
Q	ARCSIX Schedule Risk	The ARCSIX project shares some instruments and project personnel and is scheduled to end after PACE-PAX integration has begun	Accept.	4	1
Retired risks					
A	PACE launch delay	PACE launch or comissioning sufficiently delayed such that commissioning is not complete prior to start of PACE-PAX	Delay	1	4
B	PACE spacecraft failure	Full launch or spacecraft failure of the PACE mission	Accept	1	5
K	Inter-Agency Agreement - NPS	Interagency Agreement with NPS may not be done on time. CIRPAS TO needs early funding starting in FY23	Accept. Loss of Twin Otter aircraft.	2	5
L	Inter-Agency Agreement - NOAA	Interagency Agreement with NOAA may not be done on time. LI-Neph needs funding starting in FY24	Accept. Loss of PI-Nephelometer on Twin Otter.	1	3

9 Appendix C: Team members

Leadership

Mission scientist / point of contact

Kirk Knobelspiesse, NASA Goddard Space Flight Center, kirk.knobelspiesse@nasa.gov

Deputy mission scientists

Ivona Cetinić, NASA Goddard Space Flight Center, Morgan State University, Ivona.cetinic@nasa.gov

Brian Cairns, NASA Goddard Institute for Space Studies, brian.cairns@nasa.gov

PACE mission leadership

Laura Lorenzoni, NASA Headquarters, laura.lorenzoni@nasa.gov

Hal Maring, NASA Headquarters, hal.maring@icloud.com

Woody Turner, NASA Headquarters, woody.turner@nasa.gov

P. Jeremy Werdell, NASA Goddard Space Flight Center, jeremy.werdell@nasa.gov
Antonio Mannino, NASA Goddard Space Flight Center, antonio.mannino-1@nasa.gov

NASA Airborne Science Program
Bruce Tagg, NASA Headquarters, bruce.a.tagg@nasa.gov
Meiying Melissa Martin, NASA Headquarters, melissa.yang@nasa.gov

NASA Goddard Space Flight Center leadership
Carlos Del Castillo, NASA Goddard Space Flight Center, carlos.e.delcastillo@nasa.gov
Dalia Kirshbaum, NASA Goddard Space Flight Center, dalia.b.kirschbaum@nasa.gov
Tom Neumann, NASA Goddard Space Flight Center, thomas.neumann@nasa.gov

EarthCARE validation team
Principal investigator / point of contact
Robert Koopman, European Space Agency, ESA-ESTEC, Rob.Koopman@esa.int

Other team members
Stephanie Rusli, European Space Agency, stephanie.rusli@ext.esa.int
Timon Hummel, European Space Agency, timon.hummel@esa.int
Montserrat Pinol Sole, European Space Agency, Montserrat.Pinol.Sole@esa.int

NOAA R/V Shearwater team and PACE Validation Science Team members
Principal investigator / point of contact
Michael Ondrusek, NOAA/NESDIS/STAR, michael.ondrusek@noaa.gov

Other team members
Eric Stengel, NOAA/NESDIS/STAR, eric.stengel@noaa.gov
Stephen Broccardo, NASA Ames Research Center, stephen.p.broccardo@nasa.gov
Robert Foster, Naval Research Laboratory, robert.j.foster190.civ@us.navy.mil
Ahmed El-Habashi, Naval Research Laboratory, ahmed.m.el-habashi.civ@us.navy.mil
Eder Herrera Estrella, City College of New York, eherrer002@citymail.cuny.edu
Alex Gilerson, City College of New York, gilerson@ccny.cuny.edu
Joaquim Goes, Columbia University, jig@ldeo.columbia.edu
Daniel Lucas, National Oceanic and Atmospheric Administration, voc.cinms@noaa.gov
Lucas Dutton, National Oceanic and Atmospheric Administration, lucas.dutton@noaa.gov
Zacary Montgomery, National Oceanic and Atmospheric Administration, zac.montgomery@noaa.gov
Matt Howard, National Oceanic and Atmospheric Administration, matt.b.howard@noaa.gov
Todd Jacobs, National Oceanic and Atmospheric Administration, todd.jacobs@noaa.gov

NASA Field Support Group
Principal investigator / point of contact

Antonio Mannino, NASA Goddard Space Flight Center, antonio.mannino-1@nasa.gov

Other team members
Dirk Aurin, NASA Goddard Space Flight Center, GESTAR II Morgan State University, dirk.a.aurin@nasa.gov
Joaquin Chaves, NASA Goddard Space Flight Center, Science Systems and Applications, Inc, joaquin.e.chavescedeno@nasa.gov
Scott Freeman, NASA Goddard Space Flight Center, Science Systems and Applications, Inc, scott.a.freeman@nasa.gov
Kelsey Allen, NASA Goddard Space Flight Center, Science Systems and Applications, Inc, kelsey.a.mcbeain@nasa.gov
Harrison Smith, NASA Goddard Space Flight Center, Science Systems and Applications, Inc, harrison.d.smith@nasa.gov
Ethan Taylor, NASA Goddard Space Flight Center, Science Systems and Applications, Inc, ethan.n.taylor@nasa.gov
Crystal Thomas, NASA Goddard Space Flight Center, Science Systems and Applications, Inc, crystal.s.thomas@nasa.gov
Graham Trolley, NASA Goddard Space Flight Center, Science Systems and Applications, Inc, graham.r.trolley@nasa.gov
Vanessa Strohm, NASA Goddard Space Flight Center, Science Systems and Applications, Inc, vanessa.r.strohm@nasa.gov
Chris Kenemer, NASA Goddard Space Flight Center, Science Systems and Applications, Inc, christopher.kenemer@nasa.gov

NPS Twin Otter aircraft and instrument team
Principal investigator / point of contact
Anthony Bucholtz, Naval Postgraduate School, Anthony.bucholtz@nps.edu

Other team members
Roy K. Woods, Naval Postgraduate School, rkwoods@nps.edu
Jeff Martin, Naval Postgraduate School, garrisonmartin@gmail.com
Bryce Kujat, Naval Postgraduate School, bryce.kujat@gmail.com
Gregory Cooper , Naval Postgraduate School, gcooper@cirpas.org

NPS Twin Otter LARGE instrument team
Principal investigator / point of contact
Luke D. Ziemba, NASA Langley Research Center, luke.ziemba@nasa.gov

Other team members
Michael A. Shook, NASA Langley Research Center, michael.shook@nasa.gov
Edward L. Winstead, NASA Langley Research Center/AMA, Inc., edward.l.winstead@nasa.gov
Francesca Gallo, NASA Langley Research Center/AMA, Inc., francesca.gallo@nasa.gov
Carolyn E. Jordan, NASA Langley Research Center/AMA, Inc., carolyn.jordan@nasa.gov

Matthew D. Brown, NASA Langley Research Center/AMA, Inc., matthew.d.brown-1@nasa.gov

NPS Twin Otter LiNeph instrument team

Principal investigator / point of contact

Adam Ahern, Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado, Boulder, Colorado 80309, NOAA Chemical Sciences Laboratory (CSL), 325 Broadway, Boulder, Colorado 80305, Adam.Ahern@colorado.edu

Other team members

Cecile Carlson, Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado, Boulder, Colorado 80309, NOAA Chemical Sciences Laboratory (CSL), 325 Broadway, Boulder, Colorado 80305, Cecile.Carlson@colorado.edu

Daniel M. Murphy, NOAA Chemical Sciences Laboratory (CSL), 325 Broadway, Boulder, Colorado 80305, Daniel.M.Murphy@noaa.gov

NASA ER-2 AirHARP instrument team

Principal investigator / point of contact

J. Vanderlei Martins, Earth and Space Institute, University of Maryland Baltimore County, martins@umbc.edu

Author team members

Brent A. McBride, Earth and Space Institute, University of Maryland Baltimore County, mcbride1@umbc.edu

Xiaoguang Xu, Earth and Space Institute, University of Maryland Baltimore County, xxu@umbc.edu

Anin Puthukkudy, Earth and Space Institute, University of Maryland Baltimore County, anin1@umbc.edu,

Lorraine Remer, Earth and Space Institute, University of Maryland Baltimore County, remer@umbc.edu

Non-author team members

Rachel E. Smith, Earth and Space Institute, University of Maryland Baltimore County, rsmith12@umbc.edu

Danny Nelson, Earth and Space Institute, University of Maryland Baltimore County, dnelson@umbc.edu

Noah Sienkiewicz, Earth and Space Institute, University of Maryland Baltimore County, noahs3@umbc.edu

CJ Escobar, Earth and Space Institute, University of Maryland Baltimore County, escobar6@umbc.edu

J. Dominik Cieslak, Earth and Space Institute, University of Maryland Baltimore County, cieslak@umbc.edu

Ian Decker, Earth and Space Institute, University of Maryland Baltimore County, deck2@umbc.edu

Roberto Fernandez-Borda, Earth and Space Institute, University of Maryland Baltimore County, rfborda@umbc.edu
Jet Thompson, Earth and Space Institute, University of Maryland Baltimore County, jensent1@umbc.edu
Lars Sobieski, Earth and Space Institute, University of Maryland Baltimore County, larso1@umbc.edu
Jacob Thomas, Earth and Space Institute, University of Maryland Baltimore County, jthoma17@umbc.edu
Erik Crowe, Department of Physics, University of Maryland Baltimore County, ejcrowe@umbc.edu

NASA ER-2 HSRL-2 instrument team

Principal investigator / point of contact

Taylor J. Shingler, NASA Langley Research Center, Hampton, VA, Taylor.j.shingler@nasa.gov
Johnathan W. Hair, NASA Langley Research Center, Hampton, VA, Johnathan.w.hair@nasa.gov

Author team members

Richard A. Ferrare, NASA Langley Research Center, Hampton, VA, Richard.a.ferrare@nasa.gov
Brian L. Collister, NASA Langley Research Center, Hampton, VA, Brian.collister@nasa.gov
Sharon P. Burton, NASA Langley Research Center, Hampton, VA, Sharon.p.burton@nasa.gov
Anthony L. Cook (retired), NASA Langley Research Center, Hampton, VA, Anthcook99@gmail.com
David B. Harper, NASA Langley Research Center, Hampton, VA, David.b.harper@nasa.gov
Marta A. Fenn, NASA Langley Research Center/Coherent Applications, Inc., Hampton, VA, Marta.a.fenn@nasa.gov
Amy Jo Scarino, NASA Langley Research Center/Coherent Applications, Inc., Hampton, VA, Amy.jo.scarino@nasa.gov

NASA ER-2 PICARD instrument team

Principal investigator / point of contact

Dr. Kerry G. Meyer, NASA Goddard Space Flight Center, kerry.meyer@nasa.gov

Author team members

Dr. Steven E. Platnick, NASA Goddard Space Flight Center, steven.e.platnick@nasa.gov
James D. Jacobson, NASA Ames Research Center/Bay Area Environmental Research Institute, james.d.jacobson@nasa.gov
Thomas Ellis, thomas.ellis@nasa.gov, NASA Ames Research Center/ Bay Area Environmental Research Institute

Non-author team members

Dr. Gary Hoffmann, gary.d.hoffmann@nasa.gov, NASA Ames Research Center/ Bay Area Environmental Research Institute, (ok for author list)
Dr. Alok Shrestha, alok.k.shrestha@nasa.gov, NASA Ames Research Center, (ok for author list)

Dr. Haiping Su, su@baeri.org, Bay Area Environmental Research Institute
Dr. Edward Hildum, edward.a.hildum@nasa.gov, NASA Ames Research Center/ Bay Area Environmental Research Institute
Jeffrey Grose, jeffrey.grose@nasa.gov, NASA Ames Research Center/ Bay Area Environmental Research Institute
Jian Zheng, jian.zheng@nasa.gov, NASA Ames Research Center/ Bay Area Environmental Research Institute

NASA ER-2 PRISM instrument team

Principal investigator

David R. Thompson, Jet Propulsion Laboratory, California Institute of Technology david.r.thompson@jpl.nasa.gov

Point of contact

Holly A. Bender, Jet Propulsion Laboratory, California Institute of Technology, holly.a.bender@jpl.nasa.gov

Other team members

Niklas Bohn, Jet Propulsion Laboratory, California Institute of Technology, urs.n.bohn@jpl.nasa.gov
Eric Brunner, Jet Propulsion Laboratory, California Institute of Technology, eric.d.brunner@jpl.nasa.gov
John Chapman, Jet Propulsion Laboratory, California Institute of Technology, john.w.chapman@jpl.nasa.gov
Regina Eckert, Jet Propulsion Laboratory, California Institute of Technology, regina.f.eckert@jpl.nasa.gov
Evan Greenberg, Jet Propulsion Laboratory, California Institute of Technology, evan.greenberg@jpl.nasa.gov
Daniel Jensen, Jet Propulsion Laboratory, California Institute of Technology, daniel.j.jensen@jpl.nasa.gov
Kelly Luis, Jet Propulsion Laboratory, California Institute of Technology, kelly.m.luis@jpl.nasa.gov
Luis Rios, Jet Propulsion Laboratory, California Institute of Technology, luis.m.rios@jpl.nasa.gov
Charles Sarture, Jet Propulsion Laboratory, California Institute of Technology, Charles.M.Sarture@jpl.nasa.gov
Zachary Small, Jet Propulsion Laboratory, California Institute of Technology, zachary.small@jpl.nasa.gov

NASA ER-2 RSP instrument team

Principal investigator

Brian Cairns, NASA Goddard Institute for Space Studies (GISS), brian.cairns@nasa.gov

Other team members

Mikhail Alexandrov, Columbia University/NASA GISS, mda14@columbia.edu

Igor Geogdzhayev, Columbia University/NASA GISS, ig117@columbia.edu
Kenneth Sinclair, Columbia University/NASA GISS, kas2237@columbia.edu
Andrzej Wasilewski, Autonomic Integra LLC/NASA GISS, Andrzej.p.wasilewski@nasa.gov

NASA ER-2 SPEX Airborne instrument team

Principal investigator

Bastiaan van Diedenhoven, SRON Space Research Organisation Netherlands, b.van.diedenhoven@sron.nl

Other team members

Brecht G. Simon, SRON Space Research Organisation Netherlands
Jasper Mens, SRON Space Research Organisation Netherlands
Martijn Smit, SRON Space Research Organisation Netherlands
Guangliang Fu, SRON Space Research Organisation Netherlands
Jeroen Rietjens, SRON Space Research Organisation Netherlands
Martin Grim, SRON Space Research Organisation Netherlands
Tim Vonsée, SRON Space Research Organisation Netherlands
Alexander Eigenraam, SRON Space Research Organisation Netherlands
Jelle Talsma, SRON Space Research Organisation Netherlands
Rob Wolfs, SRON Space Research Organisation Netherlands
Otto Hasekamp, SRON Space Research Organisation Netherlands

R/V Blissfully team

Principal investigator / point of contact

Bridget N. Seegers, NASA Goddard Space Flight Center / GESTAR II Morgan State University, bridget.n.seegers@nasa.gov

Other team member

Gordon V. Ackland, gvackland@gmail.com

HyperNAV team

Principal investigator / point of contact

Andrew Barnard, Oregon State University, barnaran@oregonstate.edu

Other team members

Alexander Bailess, Oregon State University, bailessa@oregonstate.edu
Robert Frouin, Scripps Institution of Oceanography, University of California San Diego, rfrouin@ucsd.edu
Emmanuel Boss, University of Maine, Emmanuel.boss@maine.edu
Jing Tan, Scripps Institution of Oceanography, University of California San Diego, jit079@ucsd.edu
Nils Haentjens, University of Maine, nils.haentjens@maine.edu

U. Delaware glider team
Principal investigator / point of contact
Matthew Oliver, University of Delaware, School of Marine Science and Policy, moliver@udel.edu

Other team members
Yuleny Gomez, University of Delaware, School of Marine Science and Policy, ygomezro@udel.edu
Rebecca Walsh, University of Delaware, School of Marine Science and Policy, walshreb@udel.edu

NRL CEOBS site
Principal investigator / point of contact
Jerome Schmidt, Navy Research Laboratory, jerome.schmidt18.civ@us.navy.mil

AERONET team
Principal investigator / point of contact
Elena Lind, NASA Goddard Space Flight Center, elena.lind@nasa.gov
Pawan Gupta, NASA Goddard Space Flight Center, pawan.gupta@nasa.gov

Other team members
Christopher Bennett, NASA Goddard Space Flight Center, Science Systems and Applications, Inc., Christopher.bennett@nasa.gov
Thomas F. Eck, NASA Goddard Space Flight Center, University of Maryland, Baltimore County, thomas.f.eck@nasa.gov
Petar T Grigorov, NASA Goddard Space Flight Center, Science Systems and Applications, Inc., petar.t.grigorov@nasa.gov
Alexander Kelley, NASA Goddard Space Flight Center, Science Systems and Applications, Inc., alexander.v.kelly@nasa.gov
Jason Kraft, NASA Goddard Space Flight Center, Fibertek, Inc., Jason.kraft@nasa.gov
Joel S. Schafer, NASA Goddard Space Flight Center, Science Systems and Applications, Inc., joel.schafer@nasa.gov
Amy Scully, NASA Goddard Space Flight Center, Science Systems and Applications, Inc., amy.m.scully@nasa.gov
Aliaksandr Siniuk, NASA Goddard Space Flight Center, Science Systems and Applications, Inc., aliaksandr.siniuk-1@nasa.gov
Ilya Slutsker, NASA Goddard Space Flight Center, Science Systems and Applications, Inc., Ilha Slutsker@nasa.gov
Alexander Smirnov, NASA Goddard Space Flight Center, Science Systems and Applications, Inc., alexander.smirnov-1@nasa.gov
Mikhail Sorokin, NASA Goddard Space Flight Center, Science Systems and Applications, Inc., mikhail.g.sorokin@nasa.gov

PVST: UCSB team

Principal investigator / point of contact

Stéphane Maritorena, Earth Research Institute/University of California Santa Barbara, stephane.maritorena@ucsb.edu

Other team member

Stuart Halewood, Earth Research Institute/University of California Santa Barbara, stuart.halewood@ucsb.edu

PVST: SIO team on R/V Rachel Carson

Principal investigator / point of contact

Clarissa R. Anderson, Scripps Institution of Oceanography, University of California San Diego, clrander@ucsd.edu

Other team members

John Ryan, Monterey Bay Aquarium Research Institute (MBARI), ryjo@mbari.org

Rasmus Swalethrop, Scripps Institution of Oceanography, University of California San Diego, rswalethorp@ucsd.edu

Kelsey Vogel, Scripps Institution of Oceanography, University of California San Diego, kdvogel@ucsd.edu

Samuel Levine, Scripps Institution of Oceanography, University of California San Diego, sjlevine@ucsd.edu

Amaya Ellis, Scripps Institution of Oceanography, University of California San Diego, a2ellis@ucsd.edu

Ian Brunjes, Scripps Institution of Oceanography, University of California San Diego, ibrunjes@ucsd.edu

Brian Greg Mitchell, Scripps Institution of Oceanography, University of California San Diego, gmitchell@ucsd.edu

Mati Kahru, Scripps Institution of Oceanography, University of California San Diego, mkahru@ucsd.edu

Andrew Allen, Scripps Institution of Oceanography, University of California San Diego, aallen@ucsd.edu

Steffaney Wood, Scripps Institution of Oceanography, University of California San Diego, smwood@ucsd.edu

NASA Ames Research Center weather forecasting team

Principal investigator / point of contact

Rei Ueyama, NASA Ames Research Center, rei.ueyama@nasa.gov

Other team members

Ju-Mee Ryoo, Bay Area Environmental Research Institute / NASA Ames Research Center, ju-mee.ryoo@nasa.gov

Mijeong Park, National Science Foundation National Center for Atmospheric Research (NSF NCAR), mijeong@ucar.edu
Leslie Lait, NASA Ames Research Center, leslie.r.lait@nasa.gov
Louis Nguyen, NASA Langley Research Center, l.nguyen@nasa.gov

NASA Armstrong Flight Center weather forecasting team

Rocky Garcia, NASA Armstrong Flight Research Center, rocky.l.garcia@nasa.gov
Wesley James, NASA Armstrong Flight Research Center, wesley.r.james@nasa.gov

NASA Goddard Space Flight Center Global Modeling and Assimilation Office support

Principal investigator / point of contact

Christine Bloecker, NASA Goddard Space Flight Center / Science Systems and Applications, Inc., Christine.Bloecker@nasa.gov

Other team members

Joseph Ardizzone, NASA Goddard Space Flight Center / Science Systems and Applications, Inc., joseph.v.ardizzone@nasa.gov
Robert Lucchesi, NASA Goddard Space Flight Center / Science Systems and Applications, Inc., robert.a.lucchesi@nasa.gov

Flight Planning

Principal investigator / point of contact:

Samuel Elie LeBlanc, NASA Ames Research Center / Bay Area Environmental Research Institute, Samuel.leblanc@nasa.gov

Mission Tools Suite

Leads and Point of contact

Aaron Duley, NASA Ames Research Center, aaron.r.duley@nasa.gov

Other team members

Patrick Finch, NASA Ames Research Center, Bay Area Environmental Research Institute, patrick.e.finch@nasa.gov
Andrew G. Lindsay, NASA Ames Research Center, KBR Wyle Services, andrew.g.lindsay@nasa.gov
Eugene Turkov, NASA Ames Research Center, eugene.turkov@nasa.gov

ESPO logistics team

Leads and Point of contact

Sommer Nicholas, NASA Ames Research Center, sommer.l.beddingfield@nasa.gov
Judy Alfter, NASA Ames Research Center, Bay Area Environmental Research Institute, judy.alfter@nasa.gov

Other team members

Marilyn Vasques, NASA Ames Research Center, marilyn.vasques@nasa.gov
Jhony Zavaleta , NASA Ames Research Center, jhony.r.zavaleta@nasa.gov
Quincy Allison, NASA Ames Research Center, quincy.allison@nasa.gov
Erin Czech, NASA Ames Research Center, erin.czech@nasa.gov
Roy Johnson, NASA Ames Research Center, roy.r.johnson@nasa.gov
Andrian Liem, NASA Ames Research Center, Bay Area Environmental Research Institute, andrian.c.liem@nasa.gov
Daisy Gonzalez, NASA Ames Research Center, Bay Area Environmental Research Institute, daisy.gonzalez@nasa.gov
Jaden Ta, NASA Ames Research Center, Bay Area Environmental Research Institute, ta@baeri.org
Bradford Bulger, NASA Ames Research Center, Bay Area Environmental Research Institute, bradford.bulger@nasa.gov
Ayuta Padhi, NASA Ames Research Center, Bay Area Environmental Research Institute, ayuta.padhi@nasa.gov
Katja Drdla, NASA Ames Research Center, katja.drdla@nasa.gov
Stevie Phothisane, NASA Ames Research Center, Bay Area Environmental Research Institute, s.s.phothisane@nasa.gov
Dan Chirica, NASA Ames Research Center, dan.chirica@nasa.gov
Samuel Kim, NASA Ames Research Center, Bay Area Environmental Research Institute, samuel.s.kim@nasa.gov
Vidal Salazar, NASA Ames Research Center, vidal.salazar@nasa.gov
Lynn Kennedy, NASA Ames Research Center, Bay Area Environmental Research Institute, lynn.kennedy@nasa.gov

ISARA team

Principal investigator / point of contact

Snorre Stamnes, NASA Langley Research Center, Hampton VA 23666, snorre.a.stamnes@nasa.gov

Other team member

Joseph Schlosser, NASA Postdoctoral Program, NASA Langley Research Center, Hampton VA 23666, joseph.s.schlosser@nasa.gov

PRISM/PICARD data synergy team

Principal investigator / point of contact

Kerry G. Meyer, NASA Goddard Space Flight Center, kerry.meyer@nasa.gov

Other team members

G. Thomas Arnold, SSAI/NASA GSFC, tom.arnold@nasa.gov
Galina Wind, SSAI/NASA GSFC, gala.wind@nasa.gov

Suborbital Science Data for Atmospheric Composition group (SSD-AC)

Principal investigator / point of contact
Michael A. Shook, NASA Langley Research Center, Michael.a.shook@nasa.gov

Other team members
Gao Chen, NASA Langley Research Center, gao.chen@nasa.gov
Ali Aknan, AMA/NASA Langley Research Center, ali.a.aknan@nasa.gov
Morgan Silverman, AMA/NASA Langley Research Center, morgan.l.silverman@nasa.gov

10 Appendix D: VTM cue cards

1. Validate new retrieval properties

Validation objectives	ID	Measurement objectives	Importance, w	Objective total
1. Validate new retrieval properties	a	Land surface properties	8	55
	b	Ocean radiometric properties	10	
	c	Aerosol properties over the ocean	12	
	d	Aerosol properties over land	12	
	e	Cloud properties	12	
	f	Ocean surface properties	1	

This is the primary focus of PACE-PAX, addressing the output from algorithms described in the PACE data products table that are not included as required PACE products. We limit our scope to radiometric and polarimetric products, with a focus on observations that can be made from aircraft and those that are complementary to aircraft observations. Many of the products will be produced by algorithms of provisional maturity, validation is necessary to ensure further maturity. An important component of this is the use of airborne proxies of the instruments on PACE. With these proxies, algorithms can be tested in controlled (or at least known) environments, without the need for concurrent PACE measurements. This has been the only feasible approach to validate developing algorithms in the PACE prelaunch era and will remain important after launch.

Furthermore, many algorithms retrieve multiple properties simultaneously while others require the output of other algorithms as an input. Validation of these algorithms thus requires simultaneous observation of multiple properties to meet this objective.

1a. **Validate new retrieval properties:** Land surface properties

Satellite	PACE/OCI PACE/SPEXone PACE/HARP2	
Aircraft	AirHARP, PICARD, PRISM, RSP, SPEX Air *HSRL-2*	Heading < 20° from solar principal plane
	No clouds Minimal aerosol load	
Ground	AERONET + NEON site or Railroad Valley	

Geophysical properties
Surface reflectance, UV-SWIR
BRDF/albedo properties
BPDF

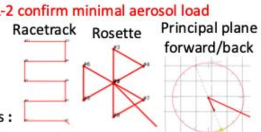
Importance	Hours
8	1

Either ER-2 OR PACE

Intended to validate ISOFIT or similar OCI algorithms + future efforts making use of multi-angle polarimetry

AERONET and HSRL-2 confirm minimal aerosol load

Potential ER2 flight patterns over ground sites :



Method 1: Satellite underpass

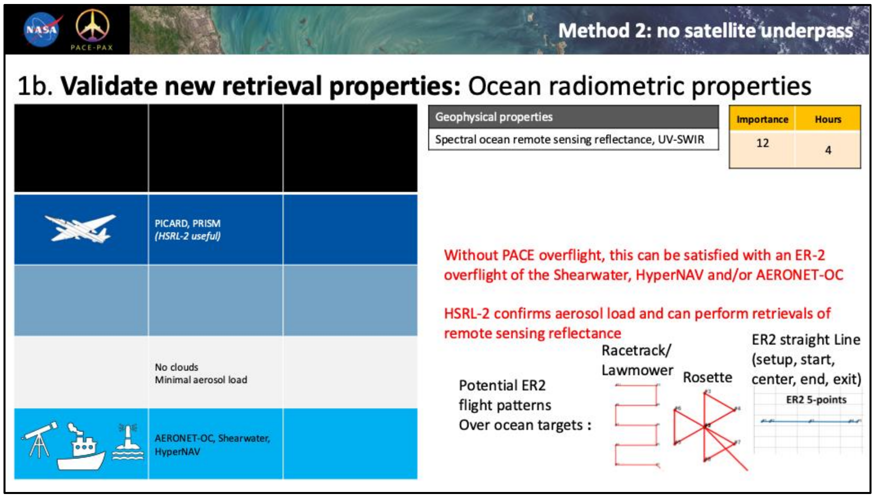
1b. **Validate new retrieval properties:** Ocean radiometric properties

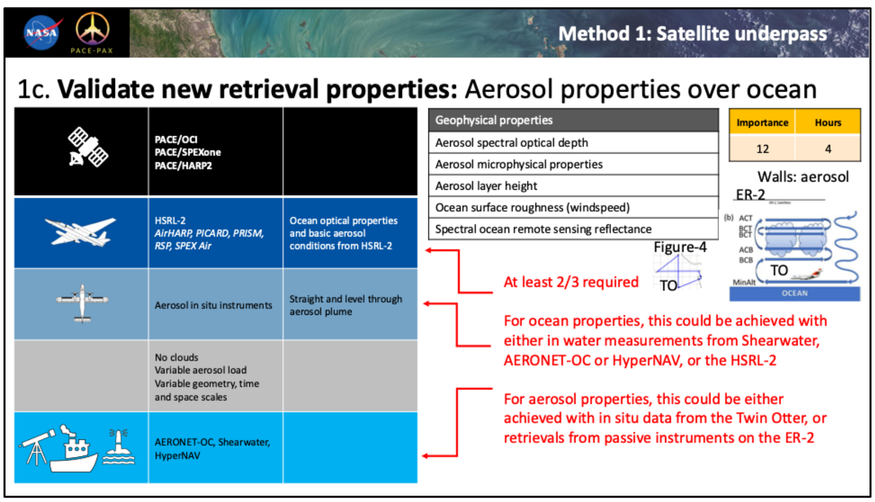
Satellite	PACE/OCI PACE/SPEXone	
	No clouds Minimal aerosol load	
Ground/ship/buoy	AERONET-OC, Shearwater, HyperNAV	

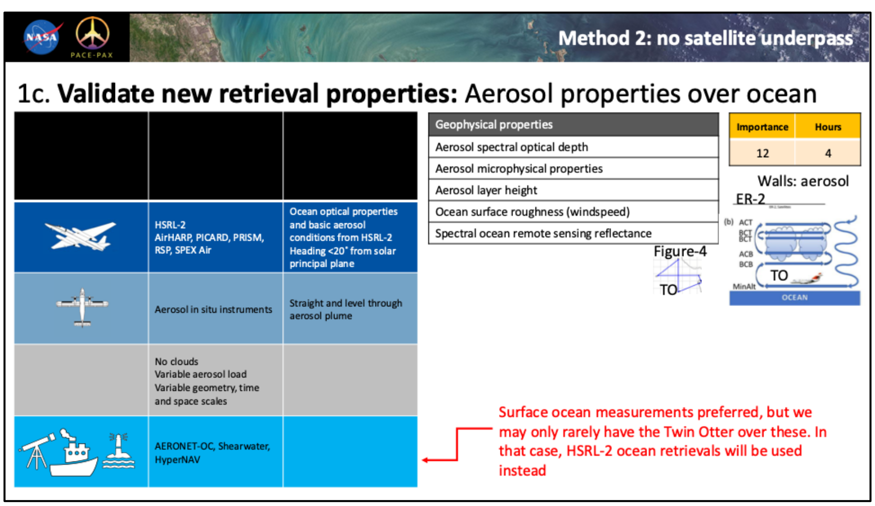
Geophysical properties
Spectral ocean remote sensing reflectance, UV-SWIR

Importance	Hours
10	4

Shearwater, HyperNAV alone with a PACE overflight satisfies this objective


Method 2: no satellite underpass
1b. Validate new retrieval properties: Ocean radiometric properties
Geophysical properties
Spectral ocean remote sensing reflectance, UV-SWIR
Importance
Hours
12
4
PICARD, PRISM
(HSRL-2 useful)
No clouds
Minimal aerosol load
AERONET-OC, Shearwater, HyperNAV
Without PACE overflight, this can be satisfied with an ER-2 overflight of the Shearwater, HyperNAV and/or AERONET-OC
HSRL-2 confirms aerosol load and can perform retrievals of remote sensing reflectance
Potential ER2 flight patterns Over ocean targets :
Racetrack/ Lawmower
Rosette
ER2 straight Line (setup, start, center, end, exit)
ER2 5-points


Method 1: Satellite underpass
1c. Validate new retrieval properties: Aerosol properties over ocean
PACE/OCI
PACE/SPEXone
PACE/HARP2
Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance
Importance
Hours
12
4
HSRL-2
AirHARP, PICARD, PRISM, RSP, SPEX Air
Ocean optical properties and basic aerosol conditions from HSRL-2
Aerosol in situ instruments
Straight and level through aerosol plume
No clouds
Variable aerosol load
Variable geometry, time and space scales
AERONET-OC, Shearwater, HyperNAV
Walls: aerosol
ER-2
TO
OCEAN
Figure-4
TO
At least 2/3 required
For ocean properties, this could be achieved with either in water measurements from Shearwater, AERONET-OC or HyperNAV, or the HSRL-2
For aerosol properties, this could be either achieved with in situ data from the Twin Otter, or retrievals from passive instruments on the ER-2


Method 2: no satellite underpass
1c. Validate new retrieval properties: Aerosol properties over ocean
Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance
Importance
Hours
12
4
HSRL-2
AirHARP, PICARD, PRISM, RSP, SPEX Air
Ocean optical properties and basic aerosol conditions from HSRL-2
Heading <20° from solar principal plane
Aerosol in situ instruments
Straight and level through aerosol plume
No clouds
Variable aerosol load
Variable geometry, time and space scales
AERONET-OC, Shearwater, HyperNAV
Walls: aerosol
ER-2
TO
OCEAN
Figure-4
TO
Surface ocean measurements preferred, but we may only rarely have the Twin Otter over these. In that case, HSRL-2 ocean retrievals will be used instead

Method 2: no satellite underpass

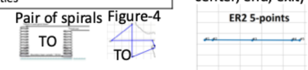
1d. **Validate new retrieval properties:** Aerosol properties over land

	AirHARP, HSRL-2, PICARD, PRISM, RSP, SPEX Air	Heading <20° from solar principal plane
	Aerosol in situ instruments, Cloud in situ instruments	Straight and level through aerosol plume
	No clouds Variable aerosol load Variable geometry, time and space scales	
	AERONET, NEON, Railroad valley, NRL-CEOBS	

Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Surface reflectance UV-SWIR
BRDF / albedo properties

Importance	Hours
12	4

ER2 straight Line (setup, start, center, end, exit)



Ground sites necessary if Twin Otter not available

Method 1: Satellite underpass

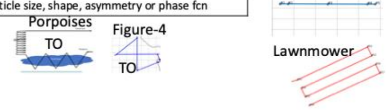
1e. **Validate new retrieval properties:** Cloud properties

	PACE/OCI PACE/HARP2	
	AirHARP, HSRL-2, PICARD, PRISM, RSP	
	Cloud in situ instruments	TBD flight plan
	Cloud cover with variable properties Variable geometry, time and space scales	

Geophysical properties
Cloud detection, top height
Cloud physical thickness
Cloud phase
Liquid, ice, cloud optical depth
Liquid droplet size distribution
Liquid/Ice water path
Ice particle size, shape, asymmetry or phase fcn

Importance	Hours
12	4

ER2 straight Line (setup, start, center, end, exit)



Method 2: no satellite underpass

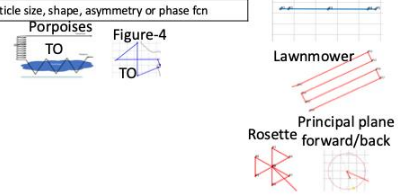
1e. **Validate new retrieval properties:** Cloud properties

	AirHARP, HSRL-2, PICARD, PRISM, RSP	Heading <20° from solar principal plane
	Cloud in situ instruments	TBD flight plan
	Cloud cover with variable properties Variable geometry, time and space scales	

Geophysical properties
Cloud detection, top height
Cloud physical thickness
Cloud phase
Liquid, ice, cloud optical depth
Liquid droplet size distribution
Liquid/Ice water path
Ice particle size, shape, asymmetry or phase fcn

Importance	Hours
12	4

ER2 straight Line (setup, start, center, end, exit)



1f. **Validate new retrieval properties:** Ocean surface properties

	PACE/HARP2	
	AirHARP, RSP	Heading <20° from solar principal plane
	No clouds low aerosol load	
	NOAA buoy network	

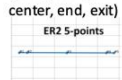
Geophysical properties
Ocean surface refractive index
Ocean surface roughness

Importance	Hours
1	4

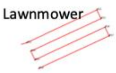
Unclear how to make ocean surface refractive index measurements. At most we could check consistency between PACE/HARP2 and airborne polarimeters.

Requires oil slicks, natural seeps exist near Santa Barbara

ER2 straight Line (setup, start, center, end, exit)



Lawnmower



2. Validate in a narrow swath

Validation objectives	ID	Measurement objectives	Importance, w	Objective total
2. Validate in a narrow swath	**a**	Aerosol parameters over the ocean (PACE)	10	41
	b	Aerosol parameters over land (PACE)	10	
	c	Cloud parameters (PACE)	5	
	d	Aerosol parameters (EarthCARE)	8	
	e	Cloud parameters (EarthCARE)	8	

While the OCI and HARP2 instruments have a wide swath with 1-to-2-day global coverage, SPEXone has a much narrower (~100km at nadir) swath, resulting in an approximately 30-day global coverage. This means that comparisons of SPEXone to fixed ground locations (such as AERONET) will be infrequent. As an example of the consequences of this narrow swath, […] 1,164 and 916 matchups can be found with the subset of MODIS measurements corresponding to OCI and HARP2 swaths, respectively. Restricting to the SPEXone swath results in only 80 matchups in the same time period. Three years is the planned PACE observatory lifetime, which calls into question the ability to validate narrow swath observations with ground measurements alone. The solution is to position validation assets within the swath of an expected SPEXone observation. This has been a successful approach for other narrow swath instrumentation, such as for the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation instrument (CALIPSO).

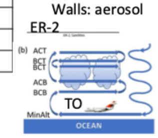
2a. **Validate in a narrow swath:** Aerosol properties over ocean (PACE)

	PACE/SPEXone	All corresponding observations within 50km of ground track
	HSRL-2 *AirHARP, PICARD, PRISM, RSP, SPEX Air*	Ocean optical properties and basic aerosol conditions from HSRL-2
	Aerosol in situ instruments	Straight and level through aerosol plume
	No clouds Variable aerosol load	
	AERONET-OC, Shearwater, HyperNAV	

Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance

Importance	Hours
10	4

Walls: aerosol



At least 2/3 required

For ocean properties, this could be achieved with either in water measurements from Shearwater, AERONET-OC or HyperNAV, or the HSRL-2

For aerosol properties, this could be either achieved with in situ data from the Twin Otter, or retrievals from passive instruments on the ER-2

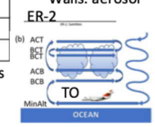
2b. **Validate in a narrow swath:** Aerosol properties over land (PACE)

	PACE/SPEXone	All corresponding observations within 50km of ground track
	AirHARP, HSRL-2, PICARD, PRISM, RSP, SPEX Air	
	Aerosol in situ instruments, Cloud in situ instruments	Straight and level through aerosol plume
	No clouds Variable aerosol load	
	AERONET, NEON, Railroad valley, NRL-CEOBS	

Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Surface reflectance UV-SWIR
BRDF / albedo properties

Importance	Hours
10	4

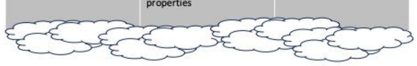
Walls: aerosol



Either ER-2 for land surface and aerosol profile information
Or
AERONET, NEON for the same

2c. **Validate in a narrow swath:** Cloud properties (PACE)

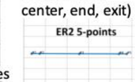
	PACE/SPEXone	All corresponding observations within 50km of ground track
	AirHARP, HSRL-2, PICARD, PRISM, RSP	
	Cloud in situ instruments	TBD flight plan
	Cloud cover with variable properties	

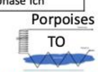


Geophysical properties
Cloud detection, top height
Cloud physical thickness
Cloud phase
Liquid, ice, cloud optical depth
Liquid droplet size distribution
Liquid/Ice water path
Ice particle size, shape, asymmetry or phase fcn

Importance	Hours
5	1

ER2 straight Line (setup, start, center, end, exit)





Currently, only cloud algorithms from OCI and HARP2 are in the works. Continue with this for potential future SPEXone algorithms?

Method 1: over ocean

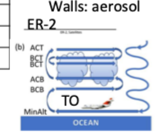
2d. **Validate in a narrow swath:** Aerosol properties (EarthCARE)

	EarthCARE	All corresponding observations within 50km of ground track
	HSRL-2 *AirHARP, PICARD, PRISM, RSP, SPEX Air*	Ocean optical properties and basic aerosol conditions from HSRL-2
	Aerosol in situ instruments	Straight and level through aerosol plume
	No clouds Variable aerosol load	
	AERONET-OC, Shearwater, HyperNAV	

Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance

Importance	Hours
8	4

Walls: aerosol



At least 2/3 required

For ocean properties, this could be achieved with either in water measurements from Shearwater, AERONET-OC or HyperNAV, or the HSRL-2

For aerosol properties, this could be either achieved with in situ data from the Twin Otter, or retrievals from passive instruments on the ER-2

Method 2: over land

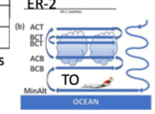
2d. **Validate in a narrow swath:** Aerosol properties over land (EarthCARE)

	EarthCARE	All corresponding observations within 50km of ground track
	AirHARP, HSRL-2, PICARD, PRISM, RSP, SPEX Air	
	Aerosol in situ instruments, Cloud in situ instruments	Straight and level through aerosol plume
	No clouds Variable aerosol load	
	AERONET, NEON, Railroad valley, NRL-CEOBS	

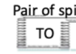
Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Surface reflectance UV-SWIR
BRDF / albedo properties

Importance	Hours
8	4

Walls: aerosol



Pair of spirals



Either ER-2 for land surface and aerosol profile information
Or
AERONET, NEON for the same

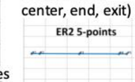
2e. **Validate in a narrow swath:** Cloud properties (EarthCARE)

	EarthCARE	All corresponding observations within 50km of ground track
	AirHARP, HSRL-2, PICARD, PRISM, RSP	
	Cloud in situ instruments	TBD flight plan
	Cloud cover with variable properties	

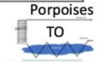
Geophysical properties
Cloud detection, top height
Cloud physical thickness
Cloud phase
Liquid, ice, cloud optical depth
Liquid droplet size distribution
Liquid/Ice water path
Ice particle size, shape, asymmetry or phase fcn

Importance	Hours
8	4

ER2 straight Line (setup, start, center, end, exit)



Porpoises



Currently, only cloud algorithms from OCI and HARP2 are in the works. Continue with this for potential future SPEXone algorithms?

3. Validate radiometric and polarimetric properties

Validation objectives	ID	Measurement objectives	Importance, w	Objective total
3. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	24
	b	Validate large reflectances with high polarization	6	
	c	Validate large reflectances with low polarization	6	
	d	Overfly vicarious calibration sites	6	

This activity supports PACE in-flight calibration activities. For example, during the ACEPOL field campaign, a team characterized the reflectance of Rosamond Dry Lake in California, providing a bright surface calibration reference. This type of characterization is routinely used to directly validate satellite observations uncertainty models or be used to characterize airborne proxy remote sensing instruments which are subsequently compared to satellite observations.

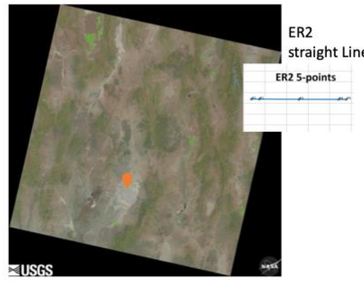
Impacted instruments: AirHARP, PICARD, PRISM, RSP and SPEX Airborne

3a. **Validate radiometric and polarimetric properties**: large reflectances

	AirHARP, PICARD, PRISM, RSP, SPEX Air	Various headings (rosette?)
	Cloud free conditions, Minimal aerosol load,	
	AERONET at Railroad Valley	

Geophysical properties
Reflectance of bright uniform land surface

Importance	Hours
6	1



Any bright surface, not just railroad valley

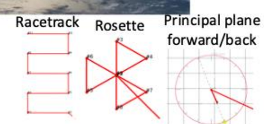
3b. **Validate radiometric and polarimetric properties**: large reflectances with high polarization

	AirHARP, PICARD, PRISM, RSP, SPEX Air	
	Cloud free conditions, Minimal aerosol load,	
	Sunglint	

Geophysical properties
Sunglint

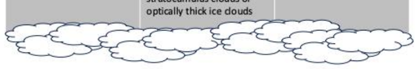
Importance	Hours
6	1

Potential ER2 flight patterns over glint :



3c. **Validate radiometric and polarimetric properties**: large reflectances with low polarization

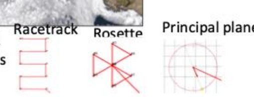
	AirHARP, PICARD, PRISM, RSP, SPEX Air	Far (~90°) from solar principal plane
	Uniform marine stratocumulus clouds or optically thick ice clouds	



Geophysical properties
Uniform marine stratocumulus clouds or optically thick ice clouds

Importance	Hours
6	1

Potential ER2 flight patterns over cloud:

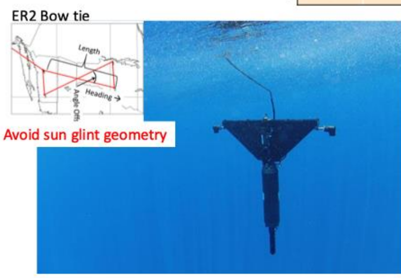


3d. **Validate radiometric and polarimetric properties**: overfly vicarious calibration sites

	AirHARP, PICARD, PRISM, RSP, SPEX Air	
	Cloud free conditions, Minimal aerosol load	
	Overfly HyperNAV vicarious calibration floats	

Geophysical properties
Vicarious calibration floats

Importance	Hours
6	2



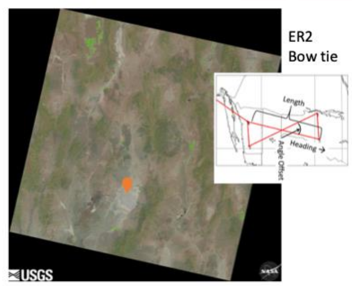
https://blog.seabird.com/hypernav-hyperspectral-radiometer/

3d. **Validate radiometric and polarimetric properties**: overfly vicarious calibration sites

	AirHARP, PICARD, PRISM, RSP, SPEX Air	Various headings (rosette?)
	Cloud free conditions, Minimal aerosol load,	
	AERONET at Railroad Valley	

Geophysical properties
Reflectance of bright uniform land surface

Importance	Hours
6	2



https://calval.cr.usgs.gov/apps/railroad-valley

4. Focus on specific processes or phenomena

Validation objectives	ID	Measurement objectives	Importance, w	Objective total
4. Focus on specific processes or phenomena	a	High aerosol loads over land	4	30
	b	High aerosol loads over ocean	4	
	c	Multiple aerosol layers	1	
	d	Aerosol under thin cirrus	2	
	e	Aerosol above liquid phase cloud	4	
	f	Broken clouds with complex structure	4	
	g	Dust aerosols over ocean	4	
	h	Aerosol and ocean properties over turbid waters	2	
	i	Aerosol and ocean properties over biologically productive waters	4	
	j	Smoke aerosols over ocean	1	

A variety of atmospheric, ocean, and land surface properties will be retrieved from PACE observations, and data processing must have the capability to identify when the appropriate algorithms are to be used. Furthermore, those algorithms must be robust for the range of possible conditions that are to be observed. Dedicated field campaigns can seek to observe specific geophysical conditions and ensure retrieval success.

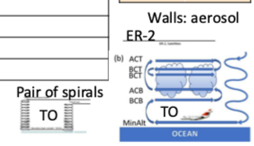
Method 1: Satellite underpass

4a. **Focus on specific processes or phenomena:** High aerosol loads over land

	PACE/OCI PACE/SPEXone PACE/HARP2	
	AirHARP, HSRL-2, PICARD, PRISM, RSP, SPEX Air	Heading <20° from solar principal plane
	Aerosol in situ instruments, Cloud in situ instruments	Straight and level through aerosol plume
	No clouds High aerosol load	
	AERONET, NEON, Railroad valley, NRL-CEOBS	

Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Surface reflectance UV-SWIR
BRDF / albedo properties

Importance	Hours
4	1



Either ER-2 for land surface and aerosol profile information
Or
AERONET, NEON for the same

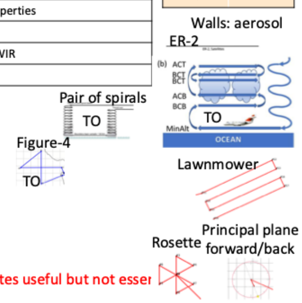
Method 2: no satellite underpass

4a. **Focus on specific processes or phenomena:** High aerosol loads over land

	AirHARP, HSRL-2, PICARD, PRISM, RSP, SPEX Air	Heading <20° from solar principal plane
	Aerosol in situ instruments, Cloud in situ instruments	Straight and level through aerosol plume
	No clouds High aerosol load	
	AERONET, NEON, Railroad valley, NRL-CEOBS	

Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Surface reflectance UV-SWIR
BRDF / albedo properties

Importance	Hours
4	1



Ground sites useful but not esser

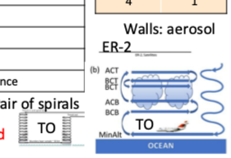
Method 1: Satellite underpass

4b. **Focus on specific processes or phenomena:** High aerosol loads over ocean

	PACE/OCI PACE/SPEXone PACE/HARP2	
	HSRL-2 *AirHARP, PICARD, PRISM, RSP, SPEX Air*	Ocean optical properties and basic aerosol conditions from HSRL-2
	Aerosol in situ instruments	Straight and level through aerosol plume
	No clouds High aerosol load	
	AERONET-OC, Shearwater, HyperNAV	

Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance

Importance	Hours
4	1



At least 2/3 required

For ocean properties, this could be achieved with either in water measurements from Shearwater, AERONET-OC or HyperNAV, or the HSRL-2

For aerosol properties, this could be either achieved with in situ data from the Twin Otter, or retrievals from passive instruments on the ER-2

Method 2: no satellite underpass

4b. **Focus on specific processes or phenomena:** High aerosol loads over ocean

HSRL-2 AirHARP, PICARD, PRISM, RSP, SPEX Air		Ocean optical properties and basic aerosol conditions from HSRL-2 Heading <20° from solar principal plane
	Aerosol in situ instruments	Straight and level through aerosol plume
	No clouds high aerosol load	
	AERONET-OC, Shearwater, HyperNAV	

Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance

Importance	Hours
4	1

Walls: aerosol

Pair of spirals

Surface ocean measurements preferred, but we may only rarely have the Twin Otter over these. In that case, HSRL-2 ocean retrievals will be used instead

Method 1: Satellite underpass

4c. **Focus on specific processes or phenomena:** multiple aerosol layers

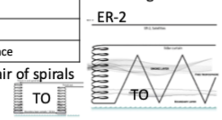
	PACE/OCI PACE/SPEXone PACE/HARP2	
	HSRL-2 *AirHARP, PICARD, PRISM, RSP, SPEX Air*	Ocean optical properties and basic aerosol conditions from HSRL-2
	Aerosol in situ instruments	Straight and level through aerosol plume
	No clouds Multiple aerosol layers	
	AERONET-OC, Shearwater, HyperNAV	

Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance

Importance	Hours
1	1

Walls: large sawtooth

Pair of spirals



At least 2/3 required

For ocean properties, this could be achieved with either in water measurements from Shearwater, AERONET-OC or HyperNAV, or the HSRL-2

For aerosol properties, this could be either achieved with in situ data from the Twin Otter, or retrievals from passive instruments on the ER-2

Method 1: Satellite underpass

4c. **Focus on specific processes or phenomena:** multiple aerosol layers

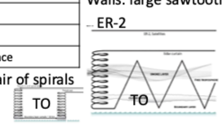
	PACE/OCI PACE/SPEXone PACE/HARP2	
	HSRL-2 *AirHARP, PICARD, PRISM, RSP, SPEX Air*	Ocean optical properties and basic aerosol conditions from HSRL-2
	Aerosol in situ instruments	Straight and level through aerosol plume
	No clouds Multiple aerosol layers	
	AERONET + NEON site or Railroad Valley	

Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance

Importance	Hours
1	1

Walls: large sawtooth

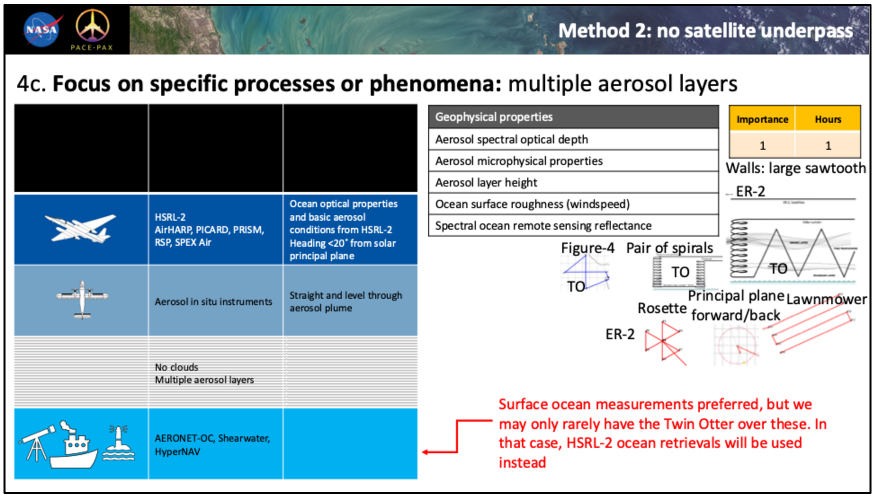
Pair of spirals

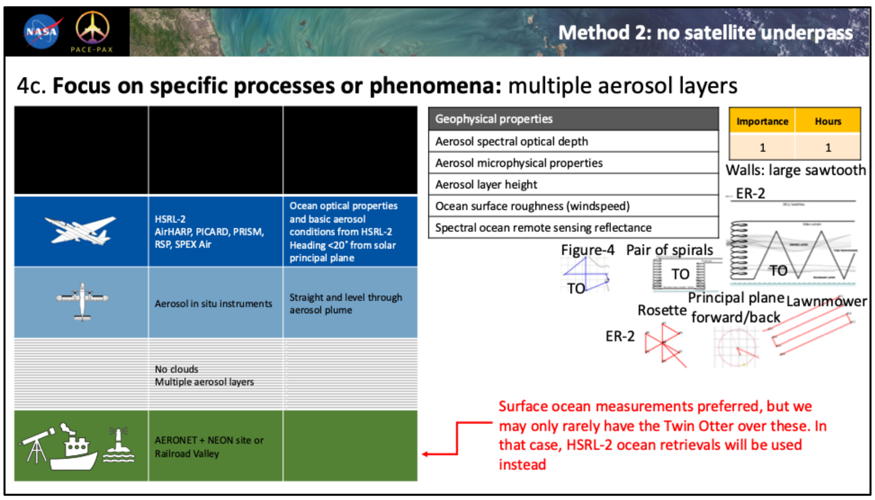


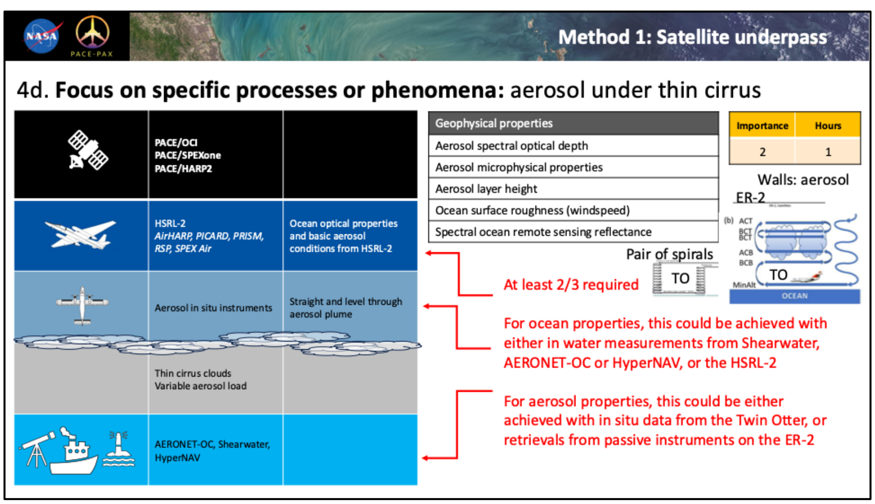
At least 2/3 required

For ocean properties, this could be achieved with either in water measurements from Shearwater, AERONET-OC or HyperNAV, or the HSRL-2

For aerosol properties, this could be either achieved with in situ data from the Twin Otter, or retrievals from passive instruments on the ER-2


Method 2: no satellite underpass
4c. Focus on specific processes or phenomena: multiple aerosol layers
HSRL-2
AirHARP, PICARD, PRISM, RSP, SPEX Air
Ocean optical properties and basic aerosol conditions from HSRL-2
Heading <20° from solar principal plane
Aerosol in situ instruments
Straight and level through aerosol plume
No clouds
Multiple aerosol layers
AERONET-OC, Shearwater, HyperNAV
Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance
Importance
Hours
1
1
Walls: large sawtooth
ER-2
Figure-4
Pair of spirals
TO
TO
TO
Principal plane
forward/back
Lawnmower
Rosette
ER-2
Surface ocean measurements preferred, but we may only rarely have the Twin Otter over these. In that case, HSRL-2 ocean retrievals will be used instead


Method 2: no satellite underpass
4c. Focus on specific processes or phenomena: multiple aerosol layers
HSRL-2
AirHARP, PICARD, PRISM, RSP, SPEX Air
Ocean optical properties and basic aerosol conditions from HSRL-2
Heading <20° from solar principal plane
Aerosol in situ instruments
Straight and level through aerosol plume
No clouds
Multiple aerosol layers
AERONET + NEON site or Railroad Valley
Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance
Importance
Hours
1
1
Walls: large sawtooth
ER-2
Figure-4
Pair of spirals
TO
TO
TO
Principal plane
forward/back
Lawnmower
Rosette
ER-2
Surface ocean measurements preferred, but we may only rarely have the Twin Otter over these. In that case, HSRL-2 ocean retrievals will be used instead


Method 1: Satellite underpass
4d. Focus on specific processes or phenomena: aerosol under thin cirrus
PACE/OCI
PACE/SPEXone
PACE/HARP2
HSRL-2
AirHARP, PICARD, PRISM, RSP, SPEX Air
Ocean optical properties and basic aerosol conditions from HSRL-2
Aerosol in situ instruments
Straight and level through aerosol plume
Thin cirrus clouds
Variable aerosol load
AERONET-OC, Shearwater, HyperNAV
Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance
Importance
Hours
2
1
Walls: aerosol
ER-2
Pair of spirals
TO
TO
OCEAN
At least 2/3 required
For ocean properties, this could be achieved with either in water measurements from Shearwater, AERONET-OC or HyperNAV, or the HSRL-2
For aerosol properties, this could be either achieved with in situ data from the Twin Otter, or retrievals from passive instruments on the ER-2

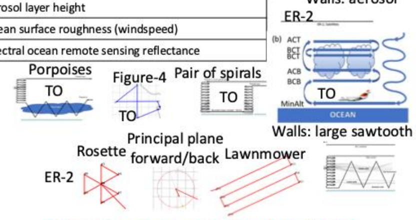
Method 2: no satellite underpass

4d. **Focus on specific processes or phenomena:** aerosol under thin cirrus

	HSRL-2 AirHARP, PICARD, PRISM, RSP, SPEX Air	Ocean optical properties and basic aerosol conditions from HSRL-2 Heading <20° from solar principal plane
	Aerosol in situ instruments	Straight and level through aerosol plume
	Thin cirrus clouds Variable aerosol load	
	AERONET-OC, Shearwater, HyperNAV	

Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance

Importance	Hours
2	1



Surface ocean measurements preferred, but we may only rarely have the Twin Otter over these. In that case, HSRL-2 ocean retrievals will be used instead

Method 1: Satellite underpass

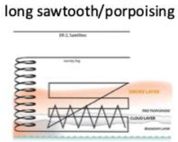
4e. **Focus on specific processes or phenomena:** aerosol above liquid cloud

	PACE/OCI PACE/SPEXone PACE/HARP2	
	HSRL-2 *AirHARP, PICARD, PRISM, RSP, SPEX Air*	HSRL-2 for cloud top height
	Aerosol in situ instruments	Straight and level through aerosol plume TBD?
	Variable aerosol load above liquid phase cloud	

Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Cloud top height
Cloud optical thickness
Cloud droplet size distribution

Importance	Hours
4	1

Walls: Cloud-aerosol
long sawtooth/porpoising



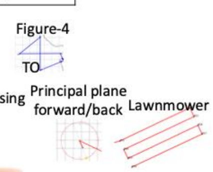
Method 2: no satellite underpass

4e. **Focus on specific processes or phenomena:** aerosol above liquid cloud

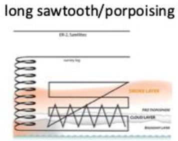
	HSRL-2 AirHARP, PICARD, PRISM, RSP, SPEX Air	HSRL-2 for cloud top height Heading <20° from solar principal plane
	Aerosol in situ instruments	Straight and level through aerosol plume
	Variable aerosol load above liquid phase cloud	

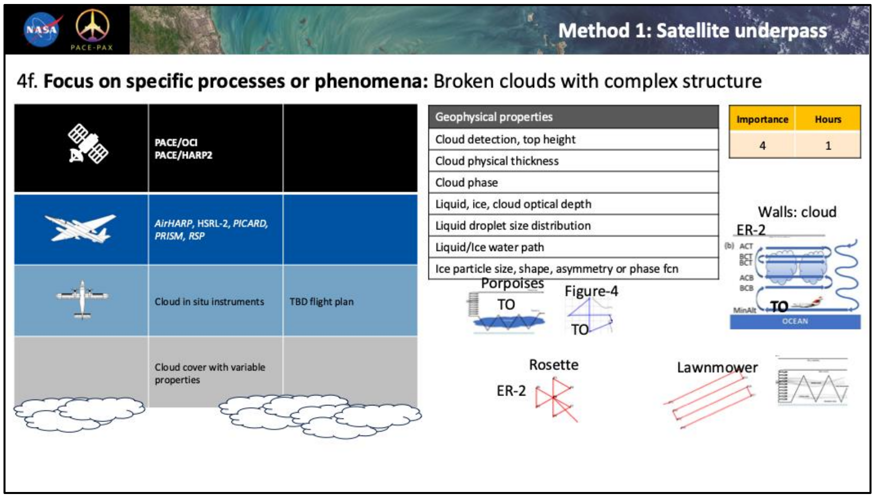
Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance

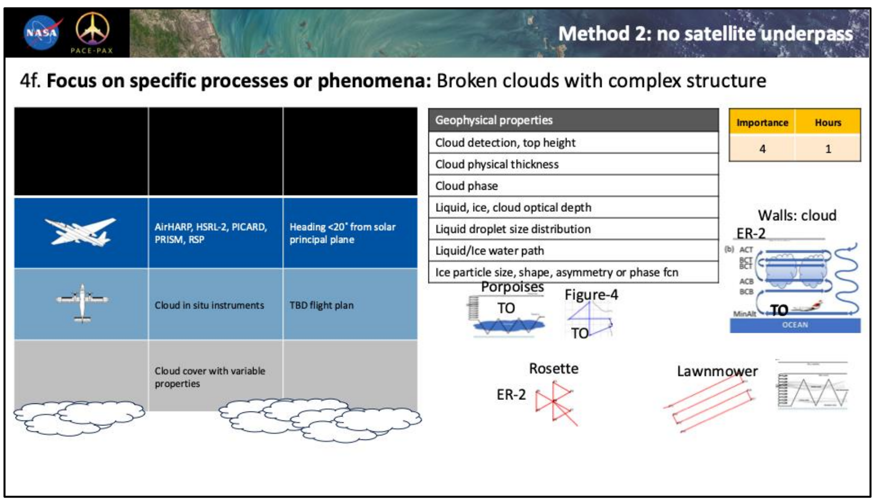
Importance	Hours
4	1

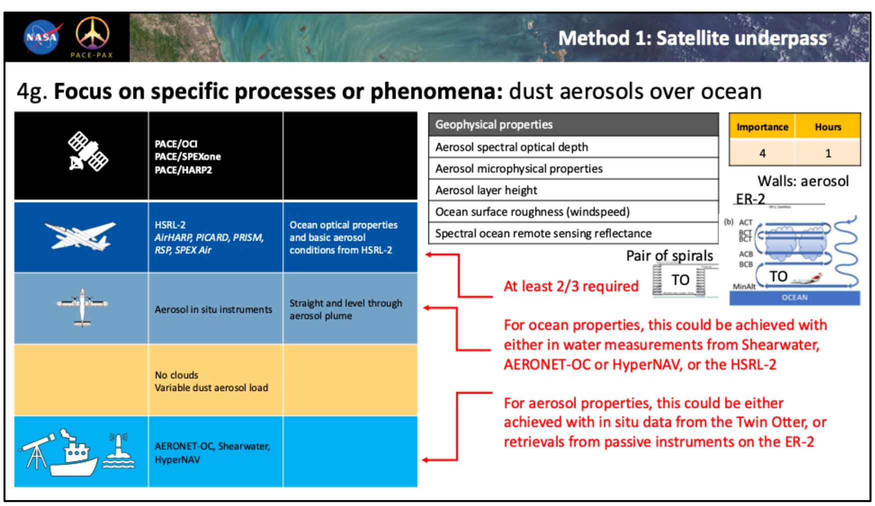


Walls: Cloud-aerosol
long sawtooth/porpoising




Method 1: Satellite underpass
4f. Focus on specific processes or phenomena: Broken clouds with complex structure
PACE/OCI
PACE/HARP2
AirHARP, HSRL-2, PICARD, PRISM, RSP
Cloud in situ instruments
TBD flight plan
Cloud cover with variable properties
Geophysical properties
Cloud detection, top height
Cloud physical thickness
Cloud phase
Liquid, ice, cloud optical depth
Liquid droplet size distribution
Liquid/Ice water path
Ice particle size, shape, asymmetry or phase fcn
Importance
Hours
4
1
Walls: cloud
ER-2
TO
OCEAN
Porpoises
TO
Figure-4
TO
Rosette
ER-2
Lawnmower


Method 2: no satellite underpass
4f. Focus on specific processes or phenomena: Broken clouds with complex structure
AirHARP, HSRL-2, PICARD, PRISM, RSP
Heading <20° from solar principal plane
Cloud in situ instruments
TBD flight plan
Cloud cover with variable properties
Geophysical properties
Cloud detection, top height
Cloud physical thickness
Cloud phase
Liquid, ice, cloud optical depth
Liquid droplet size distribution
Liquid/Ice water path
Ice particle size, shape, asymmetry or phase fcn
Importance
Hours
4
1
Walls: cloud
ER-2
TO
OCEAN
Porpoises
TO
Figure-4
TO
Rosette
ER-2
Lawnmower


Method 1: Satellite underpass
4g. Focus on specific processes or phenomena: dust aerosols over ocean
PACE/OCI
PACE/SPEXone
PACE/HARP2
HSRL-2
AirHARP, PICARD, PRISM, RSP, SPEX Air
Ocean optical properties and basic aerosol conditions from HSRL-2
Aerosol in situ instruments
Straight and level through aerosol plume
No clouds
Variable dust aerosol load
AERONET-OC, Shearwater, HyperNAV
Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance
Importance
Hours
4
1
Walls: aerosol
ER-2
TO
OCEAN
Pair of spirals
TO
At least 2/3 required
For ocean properties, this could be achieved with either in water measurements from Shearwater, AERONET-OC or HyperNAV, or the HSRL-2
For aerosol properties, this could be either achieved with in situ data from the Twin Otter, or retrievals from passive instruments on the ER-2

Method 2: no satellite underpass

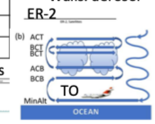
4g. **Focus on specific processes or phenomena:** dust aerosols over ocean

	HSRL-2 AirHARP, PICARD, PRISM, RSP, SPEX Air	Ocean optical properties and basic aerosol conditions from HSRL-2 Heading <20° from solar principal plane
	Aerosol in situ instruments	Straight and level through aerosol plume
	No clouds Variable dust aerosol load	
	AERONET-OC, Shearwater, HyperNAV	

Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance

Importance	Hours
4	1

Walls: aerosol



Pair of spirals

Surface ocean measurements preferred, but we may only rarely have the Twin Otter over these. In that case, HSRL-2 ocean retrievals will be used instead

Method 1: Satellite underpass

4h. **Focus on specific processes or phenomena:** aerosol and ocean properties over turbid waters

	PACE/OCI PACE/SPEXone PACE/HARP2	
	HSRL-2 *AirHARP, PICARD, PRISM, RSP, SPEX Air*	Ocean optical properties and basic aerosol conditions from HSRL-2
	Aerosol in situ instruments	Straight and level through aerosol plume
	No clouds Variable aerosol load	
	AERONET-OC, Shearwater, HyperNAV	Turbid water

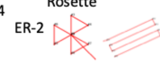
Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance

Importance	Hours
2	1

Pair of spirals

Figure-4

Rosette



At least 2/3 required

For ocean properties, this could be achieved with either in water measurements from Shearwater, AERONET-OC or HyperNAV, or the HSRL-2

For aerosol properties, this could be either achieved with in situ data from the Twin Otter, or retrievals from passive instruments on the ER-2

Method 2: no satellite underpass

4h. **Focus on specific processes or phenomena:** aerosol and ocean properties over turbid waters

	HSRL-2 AirHARP, PICARD, PRISM, RSP, SPEX Air	Ocean optical properties and basic aerosol conditions from HSRL-2 Heading <20° from solar principal plane
	Aerosol in situ instruments	Straight and level through aerosol plume
	No clouds Variable aerosol load	
	AERONET-OC, Shearwater, HyperNAV	Turbid water

Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance

Importance	Hours
2	1

Pair of spirals

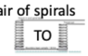
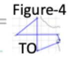
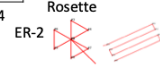


Figure-4



Rosette



Surface ocean measurements preferred, but we may only rarely have the Twin Otter over these. In that case, HSRL-2 ocean retrievals will be used instead

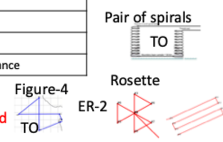
Method 1: Satellite underpass

4i. **Focus on specific processes or phenomena:** aerosol and ocean properties over biologically productive waters

(satellite)	PACE/OCI PACE/SPEXone PACE/HARP2	
(ER-2)	HSRL-2 *AirHARP, PICARD, PRISM, RSP, SPEX Air*	Ocean optical properties and basic aerosol conditions from HSRL-2
(Twin Otter)	Aerosol in situ instruments	Straight and level through aerosol plume
	No clouds Variable aerosol load	
(surface)	AERONET-OC, Shearwater, HyperNAV	Biologically productive water

Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance

Importance	Hours
4	1



At least 2/3 required

For ocean properties, this could be achieved with either in water measurements from Shearwater, AERONET-OC or HyperNAV, or the HSRL-2

For aerosol properties, this could be either achieved with in situ data from the Twin Otter, or retrievals from passive instruments on the ER-2

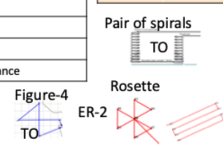
Method 2: no satellite underpass

4i. **Focus on specific processes or phenomena:** aerosol and ocean properties over biologically productive waters

(ER-2)	HSRL-2 AirHARP, PICARD, PRISM, RSP, SPEX Air	Ocean optical properties and basic aerosol conditions from HSRL-2 Heading <20° from solar principal plane
(Twin Otter)	Aerosol in situ instruments	Straight and level through aerosol plume
	No clouds Variable aerosol load	
(surface)	AERONET-OC, Shearwater, HyperNAV	Biologically productive water

Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance

Importance	Hours
4	1



Surface ocean measurements preferred, but we may only rarely have the Twin Otter over these. In that case, HSRL-2 ocean retrievals will be used instead

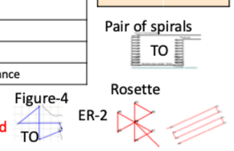
Method 1: Satellite underpass

4j. **Focus on specific processes or phenomena:** smoke aerosols over ocean

(satellite)	PACE/OCI PACE/SPEXone PACE/HARP2	
(ER-2)	HSRL-2 *AirHARP, PICARD, PRISM, RSP, SPEX Air*	Ocean optical properties and basic aerosol conditions from HSRL-2
(Twin Otter)	Aerosol in situ instruments	Straight and level through aerosol plume
	No clouds Variable smoke aerosol load	
(surface)	AERONET-OC, Shearwater, HyperNAV	

Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance

Importance	Hours
1	1



At least 2/3 required

For ocean properties, this could be achieved with either in water measurements from Shearwater, AERONET-OC or HyperNAV, or the HSRL-2

For aerosol properties, this could be either achieved with in situ data from the Twin Otter, or retrievals from passive instruments on the ER-2

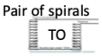
4j. **Focus on specific processes or phenomena:** dust aerosols over ocean

	HSRL-2 AirHARP, PICARD, PRISM, RSP, SPEX Air	Ocean optical properties and basic aerosol conditions from HSRL-2 Heading <20° from solar principal plane
	Aerosol in situ instruments	Straight and level through aerosol plume
	No clouds Variable smoke aerosol load	
	AERONET-OC, Shearwater, HyperNAV	

Geophysical properties
Aerosol spectral optical depth
Aerosol microphysical properties
Aerosol layer height
Ocean surface roughness (windspeed)
Spectral ocean remote sensing reflectance

Importance	Hours
1	1

Pair of spirals



Walls: aerosol

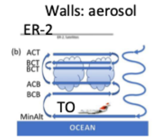


Figure-4

Rosette

Surface ocean measurements preferred, but we may only rarely have the Twin Otter over these. In that case, HSRL-2 ocean retrievals will be used instead

11 Appendix E: Operational reports

This section contains operational reports for each day of the PACE-PAX. Reports were written individually for each platform, then collected during the campaign. Following the campaign, the reports were reviewed for accuracy and completeness. Note that any data and figures contained within the reports are preliminary and intended for context, not scientific analysis.

Flight reports ID's have the naming convention of [X]F[MM][DD], where X=C for aircraft check flights, and X=R for research flights. For example, RF0910 is for operations on September 10, 2025. Note that not all measurement platforms operated at the same time and place.

Table 57 Daily summary of PACE-PAX operations

ID	Date	Flight hours	Surface	Overpass time	Summary
CF0828	2024-08-28	1.3 (ER-2)			ER-2: 2.5 hour planned check flight, starting with a quick pair of lines over the USC_Seaprism site, followed by two long lines up and down the central valley. Expected cloud free throughout and moderate aerosol loads in central valley.
CF0829	2024-08-29	2.8 (ER-2), 2.4 (Twin Otter)			ER-2: 2.5 hour planned check flight, starting with a quick pair of lines over the USC_Seaprism site, followed by two long lines up and down the central valley. Expected cloud free throughout and moderate aerosol loads in central valley. TO: Evaluated payload performance over temperature and altitude range to facilitate planning for future science flights; demonstrate capability to perform maneuvers expected to be used during science flights (e.g. spirals, touch and go landings); check that facility instruments perform well in cloud.
RF0903	2024-09-03	3.4 (Twin Otter)			TO: Profiles of aerosol scattering and absorption and size distributions together with scattering (polarized) phase functions above AERONET sites, with at least one spiral occurring during the PACE overpass for OCI and HARP2 aerosol retrieval algorithm validation. Spirals planned at Fresno, SJED and Turlock with primary spiral in highest aerosol optical depths at SJED.
RF0904	2024-09-04	4.7 (ER-2), 3.8 (Twin Otter)		21:00 (PACE)	Coordinated TO + ER2 flight including an underpass of PACE over a marine stratocumulus covered ocean in the SPEXone swath for the ER2, followed by coordination with the Twin Otter offshore. Some overflight of aeronet in central valley with ER-2 as well.
RF0905	2024-09-05		UCSB rapid response		Radiometry data and water samples for HPLC pigments analysis were collected at 2 stations. UCSB rapid response ship
RF0906	2024-09-06	6.2 (ER-2), 7 (Twin Otter)	R/V Shearwater, R/V Blissfully, Gliders	20:29 (PACE)	Coordinated TO + ER2 + RS + RB + PACE operations. TO double sortie to Santa Barbara channel (Shearwater) and USC_SeaPRISM/Blissfully latter aligned with PACE overpass. ER2 overflies all in mostly cloud free conditions, including operations further north near a fire. PACE track along partly cloudy Sierra Nevada mts and over ocean near USC_SeaPRISM/Blissfully. TO RTB after refueling in Camarillo.

ID	Date	Flight hours	Surface	Overpass time	Summary
RF0907	2024-09-07	3.9 (Twin Otter)	Gliders	21:05 (PACE)	ER-2: 2.5 hour planned check flight, starting with a quick pair of lines over the USC_Seaprism site, followed by two long lines up and down the central valley. Expected cloud free throughout and moderate aerosol loads in central valley.
RF0908	2024-09-08	5.3 (ER-2), 1.7 (Twin Otter)	R/V Shearwater, R/V Blissfully, Gliders	22:39 (EarthCare Orbit 1602)	Coordinated ER2+TO+EarthCARE; ER2+RB+RS+gliders. Smoke over SoCal Fires, lots of high AOD both inland and over USC_SeaPRISM. Good matchup with EarthCARE.
RF0910	2024-09-09	4.3 (ER-2)	HyperNAV, R/V Blissfully, Gliders		Short ER2 flight in Southern California focusing on extremely active Line, Airport and Bridge fires, with overpass of R/V Blissfully and HyperNAV offshore. Intense smoke from fires in eastern LA basin and downwind to the East and North, with imagery indicating creation of pyrocumulus. Overpass of Ivanpah Playa with possible moderate aerosol load. Over ocean is relatively cloud free with low aerosol optical depths.
RF0911	2024-09-11		HyperNAV, Gliders	20:49 (PACE)	Only autonomous ocean platforms in operation
RF0912	2024-09-12	3.7 (Twin Otter)	R/V Shearwater, HyperNAV, R/V Blissfully, Gliders	20:39 (PACE)	Planned ER-2 activities cancelled due to an aircraft issue just prior to takeoff. Twin Otter, R/V Shearwater and R/V Blissfully activities commenced regardless. All performed measurements during the PACE overpass (20:39 UTC) regardless, in most cases within the SPEXone swath. The Twin Otter performed spirals over Turlock, Sacramento_River AERONET sites, and a missed approach at NASA Ames Research Center (aka Moffett Field), the location of another AERONET instrument (NASA_Ames). R/V Shearwater performed three stations, station #7 and #8 were within 30min of the PACE overpass and within the PACE OCI and HARP swaths. Similarly station RB_9 was sampled by the R/V Blissfully at the time of overpass in the OCI and HARP swaths.
RF0913	2024-09-13	6.3 (ER-2), 7.5 (Twin Otter)	R/V Shearwater, HyperNAV, R/V Blissfully, Gliders	19:36, 21:14 (PACE swath edge)	Focus on Southern California, which has extremely large fires (Bridge, Line and Airport) producing large amounts of smoke. Twin Otter does a double sortie to the Los Angeles Basin. R/V Shearwater, R/V Blissfully and Gliders all collect data offshore, with clouds clearing as the day progresses. PACE overpass (19:36; 21:14) are far from the observation region, but data are collected during overpass for PACE/OCI validation. Additionally, an overpass is made of Railroad Valley in Nevada.
RF0915	2024-09-15	5.2 (ER-2)	R/V Shearwater, HyperNAV, R/V Blissfully, Gliders	20:42 (PACE)	ER2 samples SoCal smoke on line with marine stratus near coast, on to overpasses of blissfully, shearwater, hypernav but unfortunately clouds. Then up north for PACE track over clouds and return to hypernav location for time of PACE overpass. Cloudy HyperNAV profile. After that RTB due to surface winds, missing planned EarthCARE lines.
RF0917	2024-09-17	6.2 (ER-2)	R/V Shearwater, HyperNAV, R/V Blissfully, Gliders	20:15 (PACE), 22:47 (EarthCare; Orbit 1742)	Successful ER-2 and ship (R/V Shearwater, R/V Blissfully, glider) operations with a PACE-OHS and EarthCARE (orbit 1742) underpass. Additionally, the ER-2 overflew Ivanpah Playa with a team from JPL characterizing the surface conditions. Conditions were clear with low AOD so this component is considered a success.

ID	Date	Flight hours	Surface	Overpass time	Summary
RF0918	2024-09-18		R/V Shearwater, HyperNAV, R/V Blissfully, Gliders	20:49 (PACE)	Ocean only operations with R/V Shearwater, R/V Blissfully, HyperNAV and gliders in generally cloud free conditions during PACE overpass.
RF0919	2024-09-19	5.9 (Twin Otter)	R/V Shearwater, HyperNAV, R/V Blissfully, Gliders	19:45, 21:23 (PACE)	Planned ER2+TO+Shearwater+Blissfully operations mainly offshore in southern california. Perfect aligned EarthCARE track over Santa Barbara Channel (Orbit 1773). Double sortie of Twin Otter to get south. Unfortunately, the ER-2 flight scrubbed due to aircraft issue.
RF0920	2024-09-20	2.1 (Twin Otter)	R/V Shearwater, HyperNAV, Gliders	20:20 (PACE)	Planned ER2 +Shearwater and ER2+TO operations offshore in southern California (Shearwater) and in cloudy conditions near the Monterey Bay (TO). PACE track inland (20:20). Unfortunately ER-2 flight scrubbed due to NASA-wide grounding of all ER-2's due to potential engine issue. Inspection showed no issue, to aircraft ready for next day. TO operations modified to be a short flight at the time of PACE overpass.
RF0922	2024-09-22	6.4 (ER-2), 3.5 (Twin Otter)	R/V Shearwater, HyperNAV, Gliders	19:50, 21:28 (PACE)	ER2 + Shearwater + HyperNAV in attempt to combine observations outside the Santa Barbara channel. Most likely unsuccessful due to clouds. This was the last chance at observations in the restricted flight area where the HyperNAV was located, which was why it was attempted (unsuccessfully) in potentially cloudy conditions. In the Central Valley, ER2 and Twin Otter coordinate for observations of smoke+dust, plus an overpass of Railroad Valley by the ER2.
RF0923	2024-09-23	6.2 (ER-2), 4.1 (Twin Otter)	R/V Shearwater, HyperNAV, Gliders	20:25 (PACE), 21:53 (EarthCare; Orbit 1835)	Coordinated observations with ER-2 and Twin Otter with clouds and aerosols over land, then PACE and EarthCARE underpasses over land. Latter has some clouds. Clouds styme coordination with Gliders and R/V Shearwater in Santa Barbara channel.
RF0924	2024-09-24	3.1 (Twin Otter)	Gliders	20:59 (PACE), 22:33 (EarthCare; Orbit 1851	Operations for Twin Otter aircraft only, offshore cloud observations during PACE and EarthCARE overpasses. Spiral over Monterey bay at end of flight to provide vertical aerosol profile context for any retrievals of HABs in Monterey Bay made during PACE overpass.
RF0925	2024-09-25		R/V Shearwater, Gliders	19:55, 21:33 (PACE)	This was a R/V Shearwater only operations day. The ship occupied 3 stations in clear skies.
RF0926	2024-09-26	6.4 (ER-2), 5.1 (Twin Otter)	R/V Shearwater, Gliders	20:31 (PACE), 22:22 (EarthCare; Orbit 1882)	Last full coordination between ER-2, Twin Otter, Shearwater with PACE and EarthCARE overpasses. Generally cloud free with low aerosol optical depths. Twin Otter spirals above Shearwater and a potential red tide during PACE overpass.
RF0927	2024-09-27	6.5 (ER-2), 3.1 (Twin Otter	R/V Rachel Carson, Gliders	21:04 (PACE)	Last coordination between ER-2 and Twin Otter. ER-2 on PACE track. For the first time, overflights of R/V Rachel Carson in the Monterey Bay (PACE PVST PI Clarissa Anderson).
RF0929	2024-09-29	6.7 (ER-2)	Gliders	20:35 (PACE)	ER-2 (alone) flight with a long PACE track overflight along the Sierra Nevada mountains and California Central Valley. Generally cloud free, low aerosol loading

ID	Date	Flight hours	Surface	Overpass time	Summary
					over land and marine stratocumulus clouds over ocean. Good coordination with gliders.
RF0930	2024-09-30	6.5 (ER-2)	Gliders	21:09 (PACE), 22:02 (EarthCare; Orbit 1994)	Successful ER-2 (alone) flight with under flights by of PACE (o?shore) and EarthCARE (California/Arizona border). Generally cloud free onshore and limited cloud cover in offshore section. Also observations of smoke from “Happy” fire and Railroad Valley calibration reference.

PACE-PAX check flight report 2024/08/28

Compiled by Kirk Knobelspiesse, last update 2024/09/07
DRAFT

ER-2: 2.5 hour planned check flight, starting with a quick pair of lines over the USC_Seaprism site, followed by two long lines up and down the central valley. Expected cloud free throughout and moderate aerosol loads in central valley.

ER-2: Unsuccessful check flight. RTB early because of potential over-pressure issue with HSRL instrument (valves not working). On the ground, a relatively simple fix and replacement of valves means the same flight plan will be attempted again on 08/29

ER-2
Takeoff: 17:00
Landing: 19:33
Duration: 1.3
Instrument status: HSRL pressure issue forcing RTB
Mission Scientist: Kirk Knobelspiesse
Pilot: Kirt Stallings

PACE-PAX check flight report 2024/08/29

Compiled by Kirk Knobelspiesse, 2024/08/29. Latest update 2024/09/07

ER-2: 2.5 hour planned check flight, starting with a quick pair of lines over the USC_Seaprism site, followed by two long lines up and down the central valley. Expected cloud free throughout and moderate aerosol loads in central valley.

TO: Objectives: Evaluate payload performance over temperature and altitude range to facilitate planning for future science flights; demonstrate capability to perform maneuvers expected to be used during science flights (e.g. spirals, touch and go landings); check that facility instruments perform well in cloud.

Summary: Spiral performed over Watsonville with scattering coefficient of 15-20 Mm^{-1} up to 9 kft then clean at altitude limit of 10 kft. Transit southeast at 10kft for 30 minutes. Spiral down at King City with peak scattering coefficient of 30 Mm^{-1} at 8 kft. Reverse heading and transit back northwest at 1.5 kft then 1 kft (adjusted to stay in higher aerosol scattering). Outside air temperatures were 28°C at the southern end of the run and 17°C further north, while cabin temperatures and turbulence remained acceptable for instrumentation. Scattering coefficient 20-40 Mm^{-1} at low altitude and quite variable. Did a touch-and-go maneuver at Salinas. Sampled aerosols at 2kft over marine cloud layer, with a significant gradient in scattering (increasing westward). Reverse heading, with good consistent cloud run over ocean starting at 4:05 pm (local) at 1.5kft demonstrated facility instrument cloud probe performance. Touch-and-Go at Marina airport followed by landing.

a good cloud run from 18.1-18.26 UTC with optical depths from 5-25 and small (5 μm) drops with an effective variance of ~ 0.05

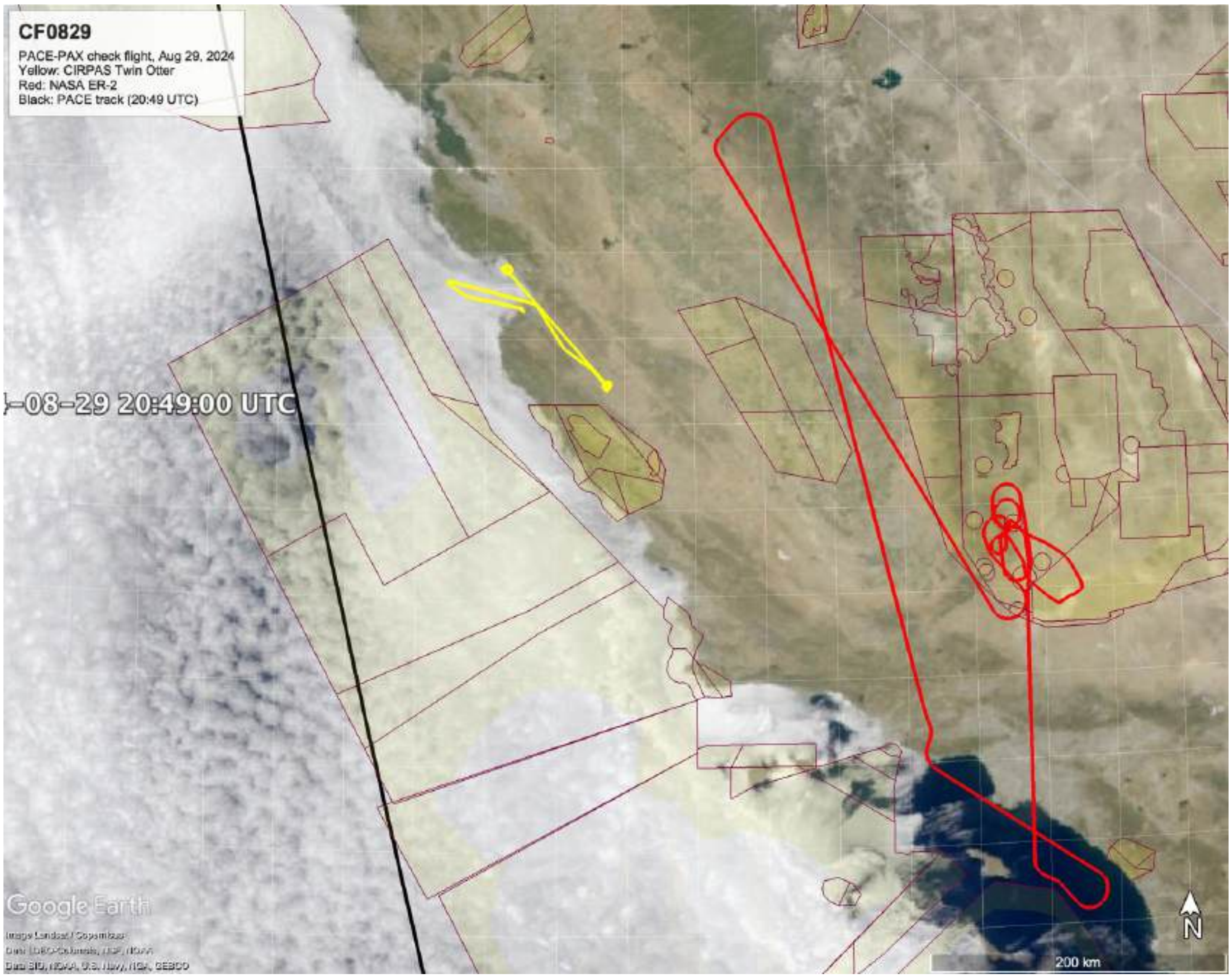
ER-2: Check flight successful. Minor issues all resolvable. TO: Successful check flight

ER-2
Takeoff: 17:11
Landing: 19:57
Duration: 2.8
Instrument status: PRISM had GPS issues possibly with impact to orthorectification. All other issues minor.
Mission Scientist: Kirk Knobelspiesse
Pilot: Tim Williams

Twin Otter
Takeoff: 21:00
Landing: 23:27
Duration: 2.4
Instrument status: nominal

Mission Scientist: Anthony Bucholtz
Pilot: Bryce Kujat, Jeff Martin

PACE
Overpass: 20:49
Orbit track west offshore



All times are in UTC, VTM elements in **black** satisfied, **blue** partially satisfied and **red** not satisfied.

Time	Platform	VTM	
17:11	ER2		Departs
17:56	ER2	4c	Overfly USC_SeaPRISM. Cloudy
18:09	ER2	4c	Overfly USC_SeaPRISM in SPP. Cloudy
18:26	ER2	1d	Overfly (nearby) Bakersfield. Moderate AOD=0.13
18:41	ER2	1d	Overfly Fresno_2. Moderate AOD=0.188
18:43	ER2	1a, 1d	Overfly NEON SJER. Moderate AOD=0.18

19:02	ER2	1d	Overfly Fresno_2. Moderate AOD=0.176
19:16	ER2	1d	Overfly (nearby) Bakersfield. Moderate AOD=0.13
19:57	ER2		Land
20:49	**PACE**		**Overpass over cloudy ocean west of Monterey Bay**
21:00	TO		Takeoff
21:33	TO	1d, 6e	Spiral performed over Watsonville NPS CEOBS site with scattering coefficient of 15-20 Mm-1 up to 9 kft then clean at altitude limit of 10 kft.
22:11	TO		Spiral down at King City with peak scattering coefficient of 30 Mm-1 at 8 kft.
22:29	TO		Head back north at 1.5 kft then 1 kft. Outside air temperatures were 28°C at the southern end of the run and 17°C further north. Scattering coefficient 20-40 Mm^{-1} at low altitude and quite variable.
22:48	TO		Did a touch and go landing at Salinas.
23:06	TO		Some clouds over Watsonville then a better, good cloud run over ocean starting at 4:05 pm demonstrated facility instrument cloud probe performance.
23:28	TO		Land

SPP: Solar Principal Plane

Assessment:

- 5.7% of objectives satisfied. Not bad for a check flight!

PACE-PAX progress tracking

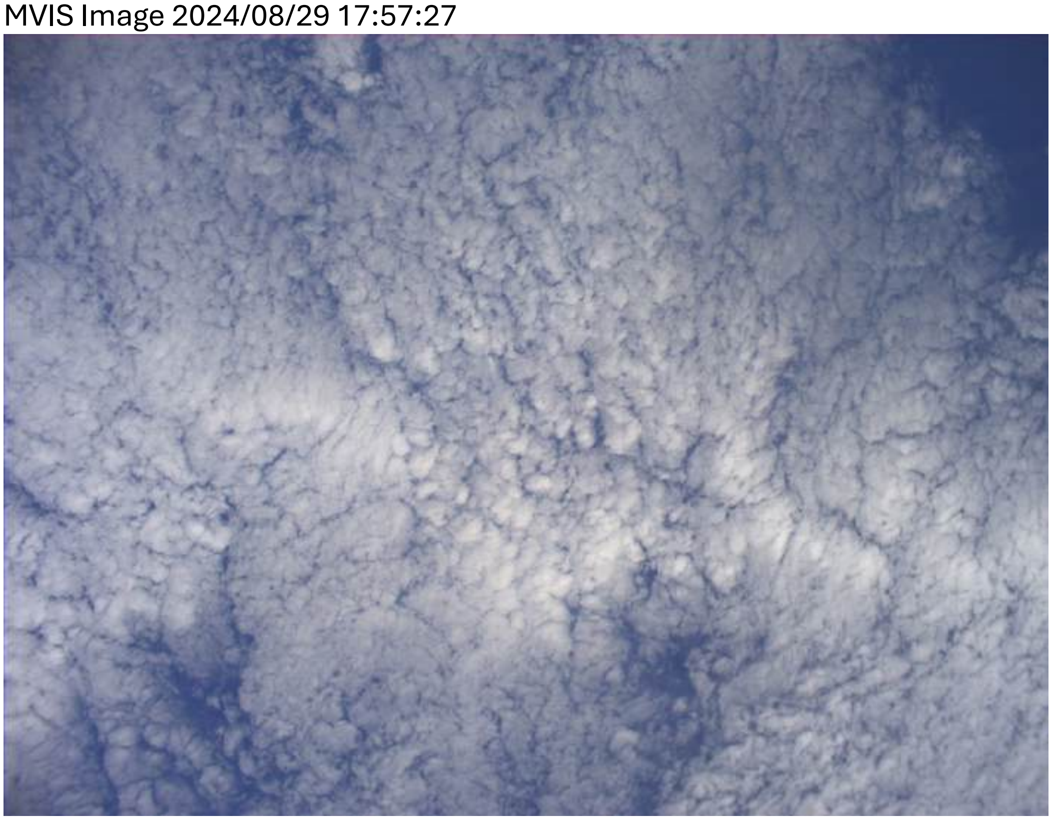
Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 8/29	Fractional success 9/3	Fractional success 9/4	Fractional success 9/5	Fractional success 9/6	Fractional success 9/7	Fractional success 9/8	Total success	Remaining score
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	0.5	**20.1%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**20.1%**	**6.4**
	b	Ocean radiometric parameters	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**10.0**
	c	Aerosol parameters over the ocean	12	8.0	0.5	0.0%	0.0%	**6.1%**	0.0%	0.0%	0.0%	0.0%	**6.1%**	**11.3**
	d	Aerosol parameters over land	12	8.0	10.0	**39.3%**	**24.4%**	**6.2%**	0.0%	0.0%	0.0%	0.0%	**70.0%**	**3.6**
	e	Cloud parameters	12	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**12.0**
	f	Ocean surface parameters	1	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**1.0**
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**10.0**
	b	Aerosol parameters over land (PACE)	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**10.0**
	c	Cloud parameters (PACE)	5	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**5.0**
	d	Aerosol parameters (EarthCARE)	8	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**8.0**
	e	Cloud parameters (EarthCARE)	8	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**8.0**
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**6.0**
	b	Validate large reflectances with high polarization	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**6.0**
	c	Validate large reflectances with low polarization	6	2.0	0.5	**22.1%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**22.1%**	**4.7**
	d	Overfly vicarious calibration sites	6	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**6.0**
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**4.0**
	b	High aerosol loads over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**4.0**
	c	Multiple aerosol layers	1	2.0	4.5	0.0%	**87.3%**	0.0%	0.0%	0.0%	0.0%	0.0%	**87.3%**	**0.1**
	d	Aerosol under thin cirrus	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**2.0**
	e	Aerosol above liquid phase cloud	4	2.0	0.5	**22.1%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**22.1%**	**3.1**
	f	Broken clouds with complex structure	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**4.0**
	g	Dust aerosols over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**4.0**
	h	Aerosol and ocean parameters over turbid waters	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**2.0**
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**4.0**
	k	Smoke aerosols over ocean	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**1.0**
		total:	**150**	**98**	**16.5**	**5.7%**	**2.5%**	**1.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**9.2%**	
														total
				ER-2 flight hours		2.8	0	0	0	0	0	0	0	**2.8**
				TO flight hours		2.5	0	0	0	0	0	0	0	**2.5**
				Shearwater days		0	0	0	0	0	0	0	0	**0**

Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

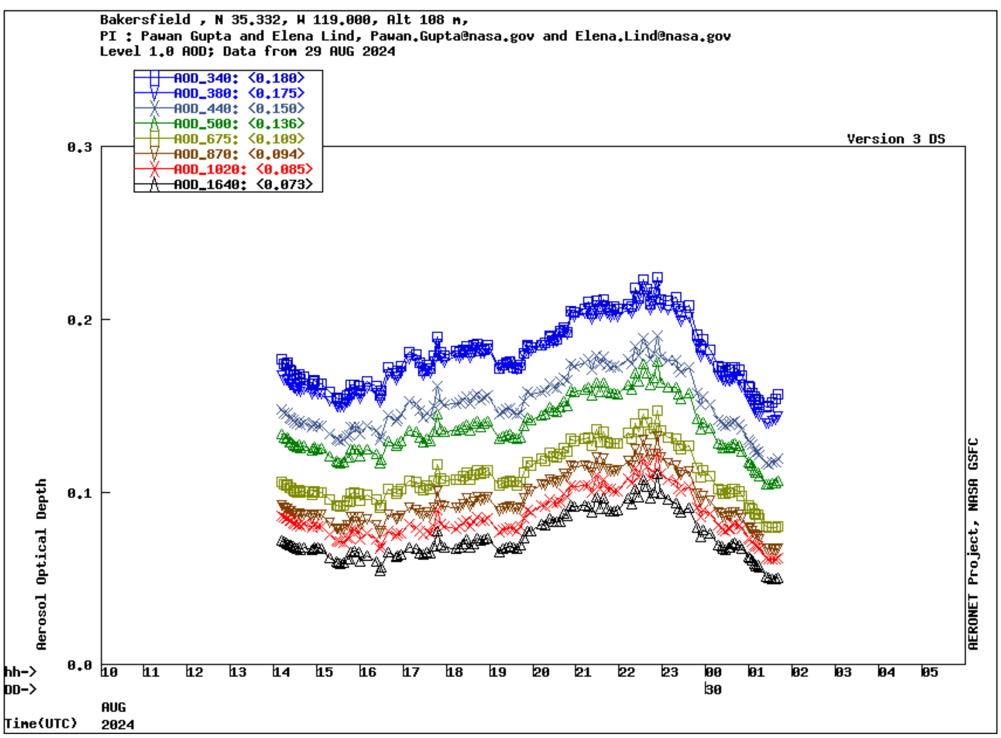
https://www-air.larc.nasa.gov/missions/pacepax/index.html

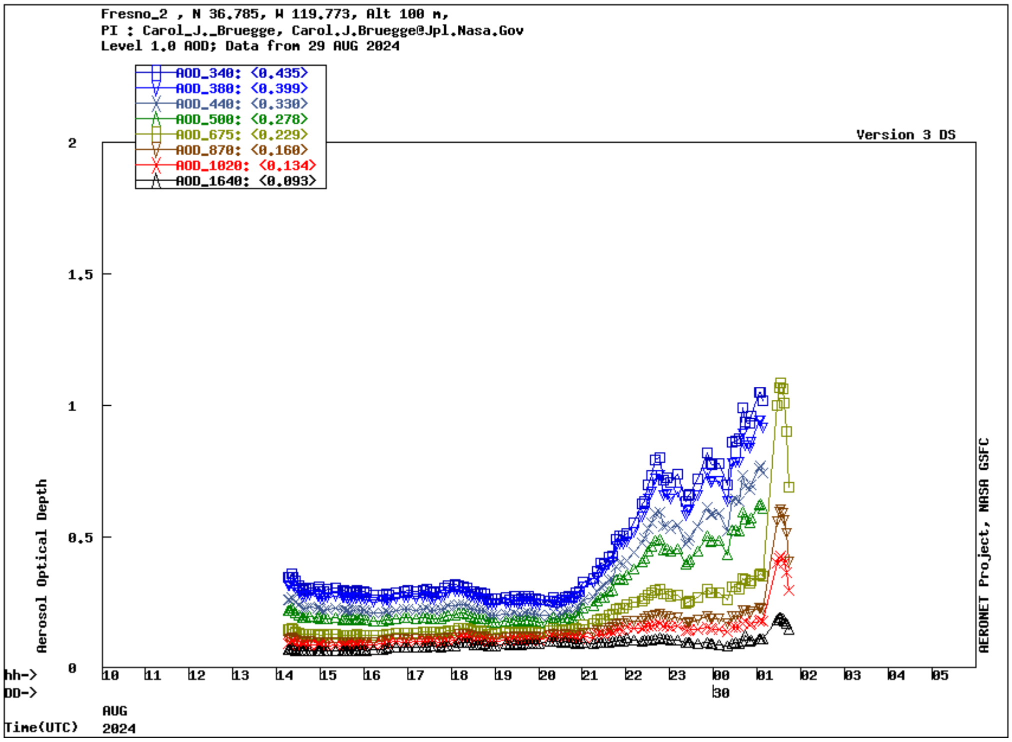
MVIS image 2024/08/29 17:55:43

MVIS Image 2024/08/29 17:57:27

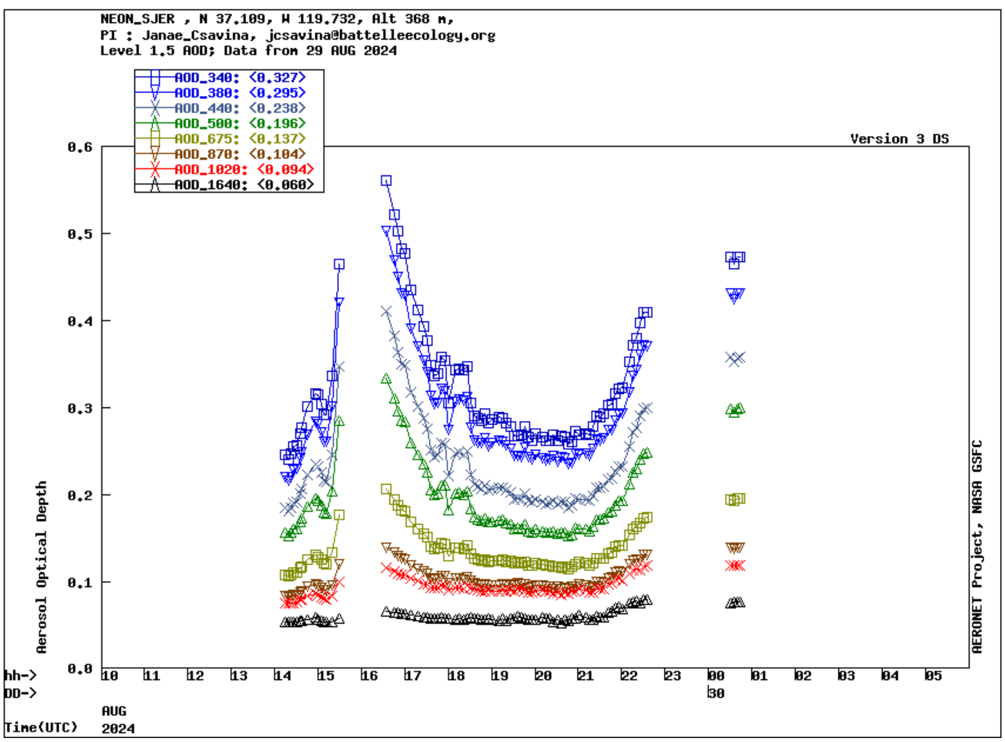


MVIS Image 20240829 17:59:17





Fresno_2 , N 36.785, W 119.773, Alt 100 m,
PI : Carol_J._Bruegge, Carol.J.Bruegge@Jpl.Nasa.Gov
Level 1.0 AOD; Data from 29 AUG 2024
AOD_340: <0.435>
AOD_380: <0.399>
AOD_440: <0.330>
AOD_500: <0.278>
AOD_675: <0.229>
AOD_870: <0.160>
AOD_1020: <0.134>
AOD_1640: <0.093>
Version 3 DS
Aerosol Optical Depth
AERONET Project, NASA GSFC
hh->
DD->
Time(UTC)
AUG
2024



NEON_SJER , N 37.109, W 119.732, Alt 368 m,
PI : Janae_Csavina, jcsavina@battelleecology.org
Level 1.5 AOD; Data from 29 AUG 2024
AOD_340: <0.327>
AOD_380: <0.295>
AOD_440: <0.238>
AOD_500: <0.196>
AOD_675: <0.137>
AOD_870: <0.104>
AOD_1020: <0.094>
AOD_1640: <0.060>
Version 3 DS
Aerosol Optical Depth
AERONET Project, NASA GSFC
hh->
DD->
Time(UTC)
AUG
2024

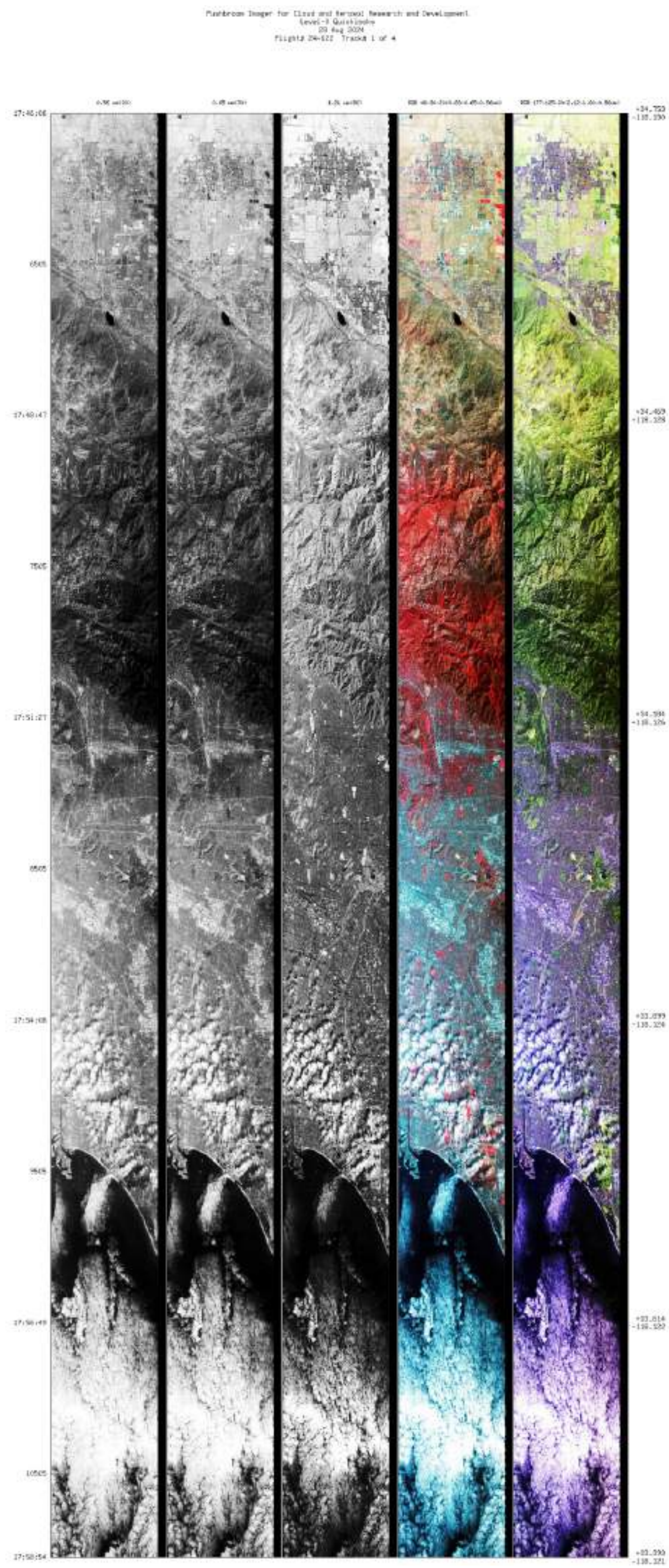
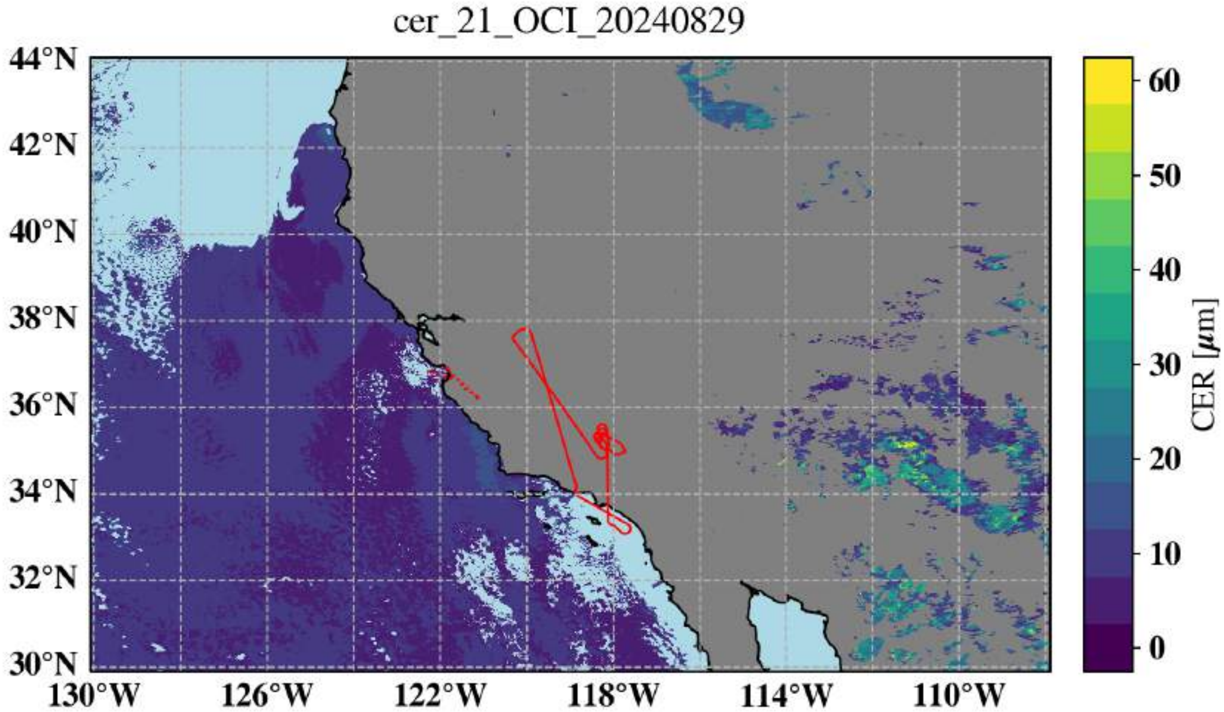
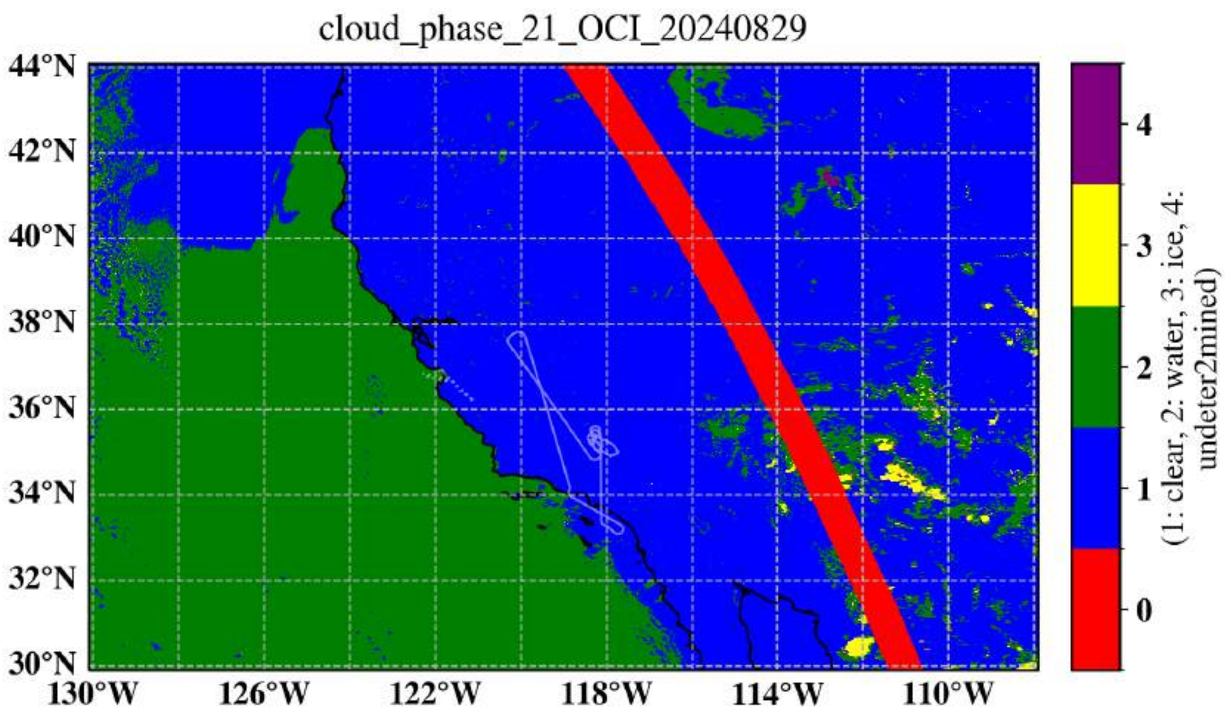
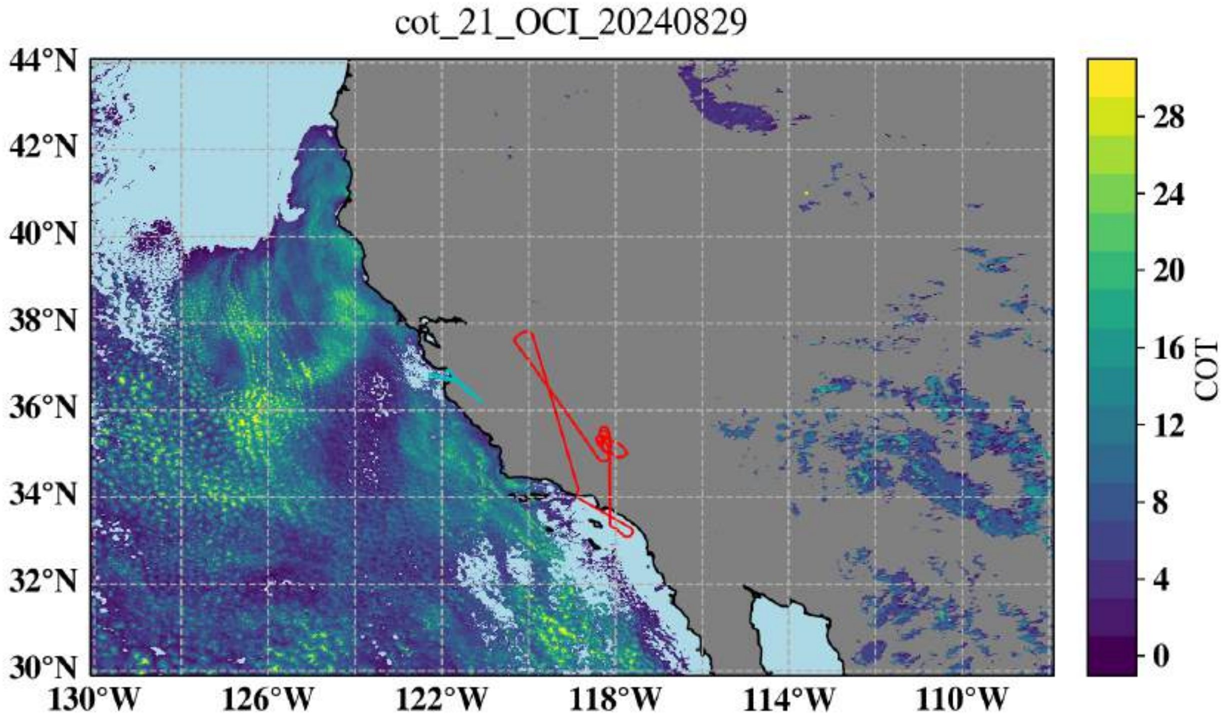


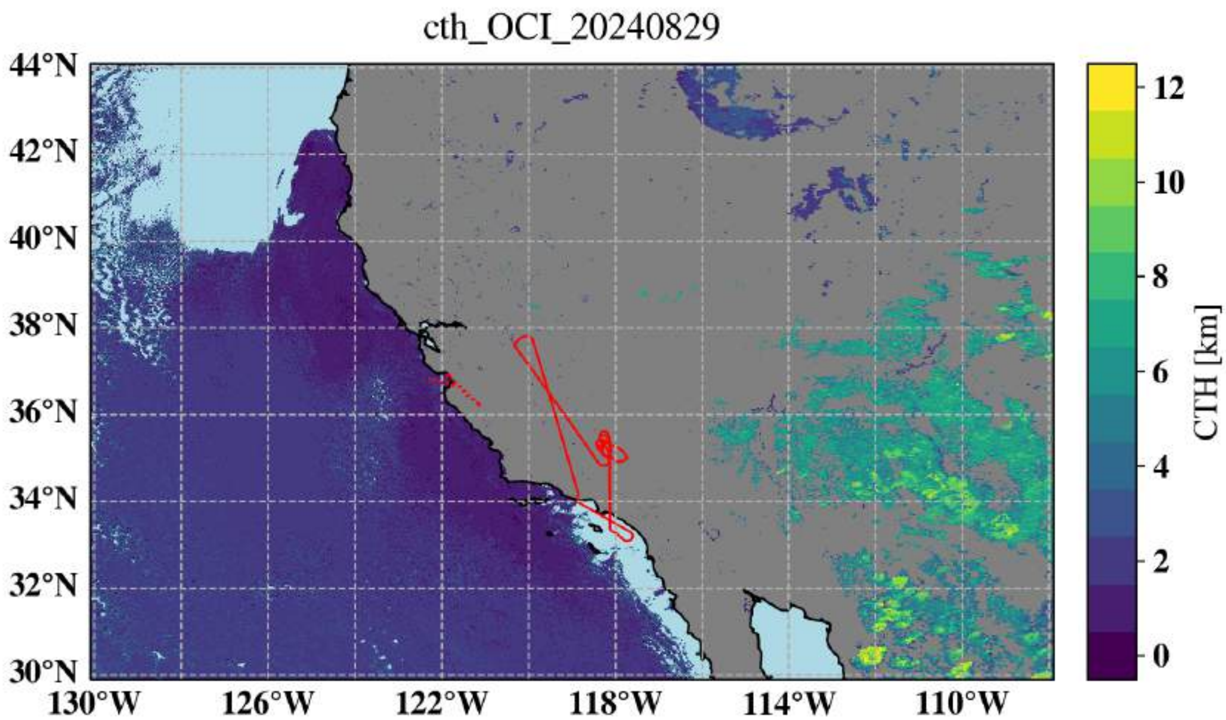
Figure 1 PICARD quicklook for ER-2 takeoff, over the Antelope Valley, LA Basin, and (cloudy) USC_SeaPRISM site. More quicklooks here: https://asapdata.arc.nasa.gov/picard/data/flt_html/24622.html

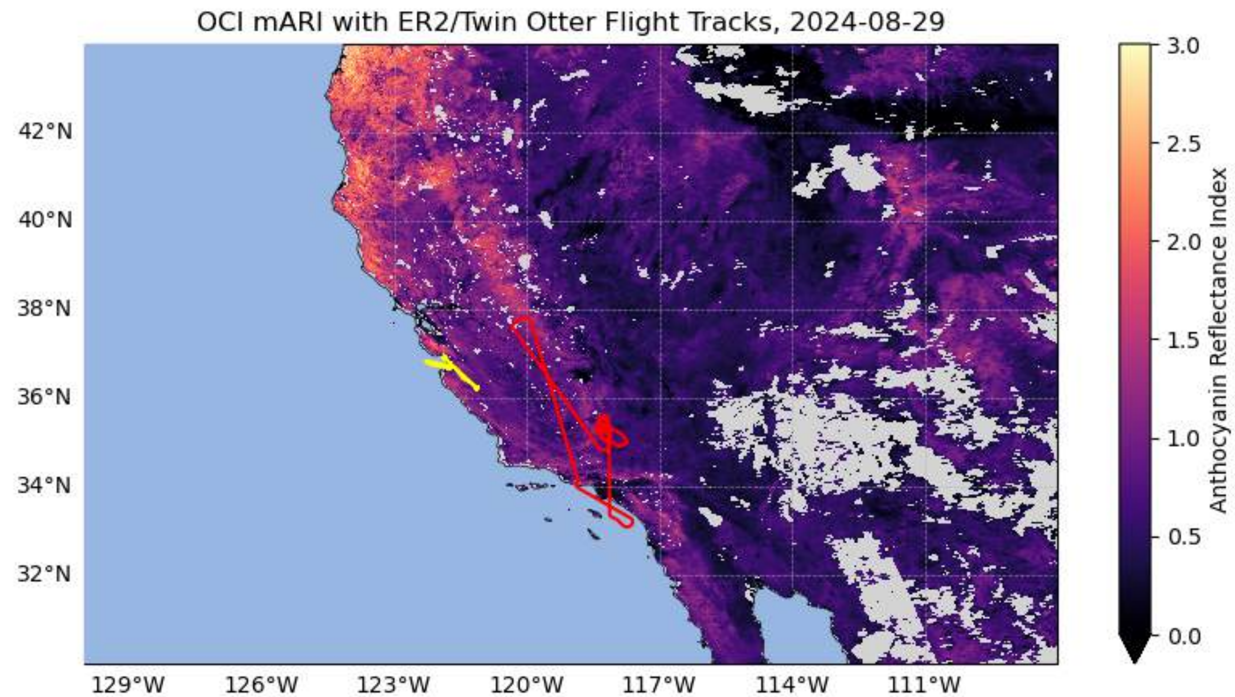
PACE satellite quicklooks






cot_21_OCI_20240829
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0
4
8
12
16
20
24
28
COT


cth_OCI_20240829
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0
2
4
6
8
10
12
CTH [km]


OCI mARI with ER2/Twin Otter Flight Tracks, 2024-08-29
42°N
40°N
38°N
36°N
34°N
32°N
129°W
126°W
123°W
120°W
117°W
114°W
111°W
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Anthocyanin Reflectance Index


OCI NDVI with ER2/Twin Otter Flight Tracks, 2024-08-29
42°N
40°N
38°N
36°N
34°N
32°N
129°W
126°W
123°W
120°W
117°W
114°W
111°W
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Normalized Difference
Vegetation Index

PACE-PAX check flight report 2024/09/03

Compiled by Kirk Knobelspiesse, Brian Cairns, 2024/09/04, last update 2024/09/07
Reviewed by Samuel LeBlanc

Objectives: Profiles of aerosol scattering and absorption coefficients and size distributions together with scattering (polarized) phase functions above AERONET sites, with at least one spiral occurring during the PACE overpass for OCI and HARP2 aerosol retrieval algorithm validation. Spirals planned at Fresno, SJER and Turlock with the primary spiral in highest AOT at SJER.

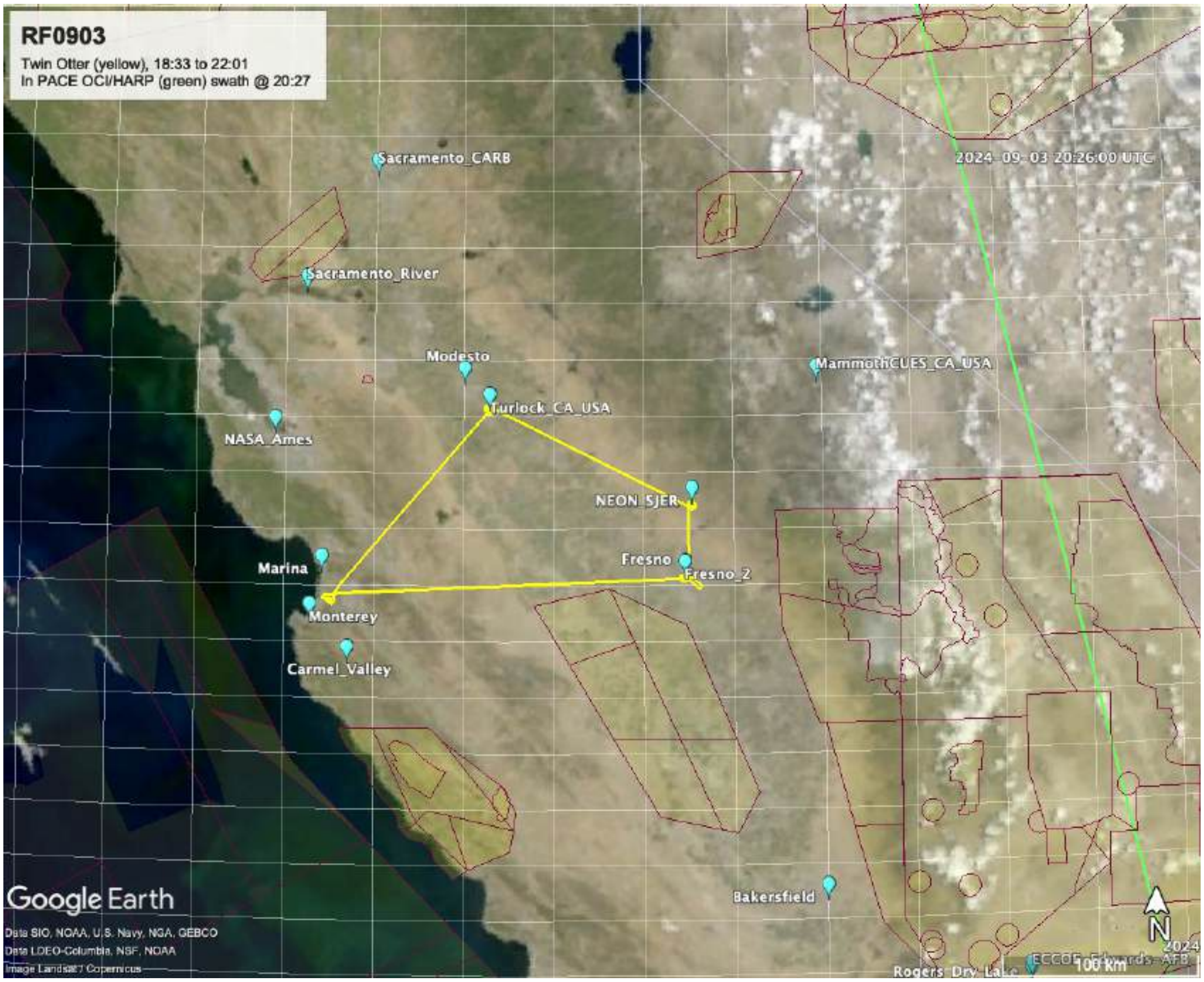
Summary: Instruments at nominal performance passing through 4 kft after takeoff. Ascended out of aerosol by 6 kft on the way to Fresno during which time the cabin temperatures were pleasant. The Fresno AERONET site was showing a mid-visible AOT of 0.12 shortly before the spiral down. Scattering coefficients of 6 Mm^{-1} were measured passing through first part of the descent (this value noted at 8 and 6 kft), and then a peak of 150 Mm^{-1} was observed at 3.6 kft in a very shallow layer at the top of the boundary layer. Scattering coefficients of 30-40 Mm^{-1} were measured at altitudes below this peak, with a well-mixed boundary layer, and the measurements were extended to the near-surface through a missed approach at 19:44 UTC. Transit to SJER in the “soup” at 3 kft but no significant scattering peak (e.g. 150 Mm^{-1} at Fresno) was observed during transit. Spiral at SJER started at 19:55 UTC with a slower ascent rate to ensure that we are in position during the PACE overpass. Very different vertical structure at SJER compared to Fresno with no peak at top of boundary layer and 6 Mm^{-1} scattering at 7 kft. SJER spiral ends at 20:27 UTC. Spiral down at Turlock started at 20:56 UTC, and a small agricultural fire was observed out of the window at 21:05 UTC. Back into (presumed) smoke during spiral at 5.7 kft with 270 Mm^{-1} scattering coefficient. Five distinct layers were observed down to 3.3 kft and quite clean (10 Mm^{-1}) at 2.5 kft (and below). Ascended up to 5 kft on the return to Marina to observe scattering layers with smoke again at 3.6 kft, but at much lower concentrations. During the missed approach at Marina to provide comparisons with tower measurements we observed a 15 Mm^{-1} scattering coefficient with agreement between tower and CIRPAS TO.

Overall, the flight plan was executed by the pilots and the science team extremely well. This flight provides examples of highly diverse vertical profiles of aerosol scattering coefficients that will be a good test to validate the capabilities of passive satellite remote sensing retrieval in the presence of complex detached layers versus well-mixed boundary layers.

Twin Otter
Takeoff: 11:33:10 (18:33:10 UTC)
Landing: 15:01:47 (22:01:47 UTC)
Duration: 3.4 hrs.
Instrument status: nominal

Manifest: Luke Ziemba (QNC), Adam Ahern (QNC)
Pilot: Bryce Kujat, Jeff Martin

PACE
Overpass: 20:27
Orbit track east on CA/Nevada border. Operations within OCI and HARP2 swath



All times are in UTC, VTM elements in **black** satisfied, **blue** partially satisfied and **red** not satisfied.

Time	Platform	VTM(hrs)	
18:33	TO		Takeoff
19:22	TO		Spiral down to Fresno2 AERONET site from 10kft
19:44	TO	1d, 6c(0.75) at 0.75 completeness due to time	Spiral down at Fresno2 AERONET site ending with touch and go at Fresno airport. AOD~=0.12

		difference from overpass	
19:48	TO		Transit to NEON SJER AERONET site in the ‘soup’ at 3kft. (over 1000 #/cm^2)
19:55	TO	1d(0.5)	Spiral down at SJER starts AOD~=0.08, multiple aerosol layers
20:27	**PACE**		**PACE-OH overpass**
20:27	PACE	1d, 6c(1.5)	PACE overpass, in OCI and HARP2 swath
20:27	TO		Spiral ends at SJER
20:56	TO	1d, 6c(1.5)	Begin spiral down at Turlock AERONET site AOD~=0.18
22:01	TO		Land

Assessment:

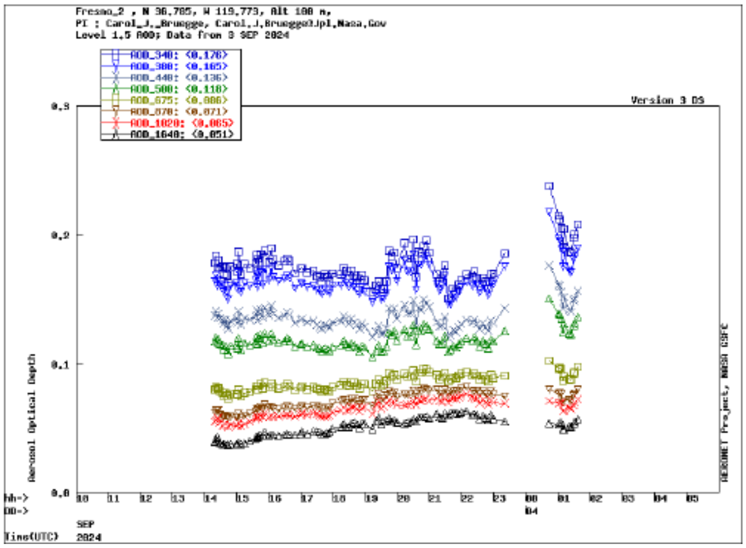
- Additional 2.5% validation objectives satisfied

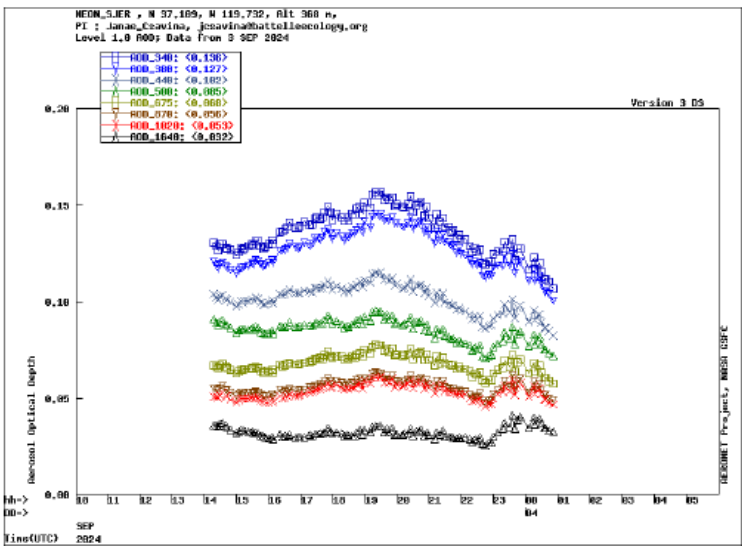
E-PAX progress tracking

Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 8/29	Fractional success 9/3	Fractional success 9/4	Fractional success 9/5	Fractional success 9/6	Fractional success 9/7	Fractional success 9/8	Total success	Remaining score
Land surface parameters	8	2.0	0.5	**20.1%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**20.1%**	**6.4**
Ocean radiometric parameters	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**10.0**
Aerosol parameters over the ocean	12	8.0	0.5	0.0%	0.0%	**6.1%**	0.0%	0.0%	0.0%	0.0%	**6.1%**	**11.3**
Aerosol parameters over land	12	8.0	10.0	**39.3%**	**24.4%**	**6.2%**	0.0%	0.0%	0.0%	0.0%	**70.0%**	**3.6**
Cloud parameters	12	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**12.0**
Ocean surface parameters	1	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**1.0**
Aerosol parameters over the ocean (PACE)	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**10.0**
Aerosol parameters over land (PACE)	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**10.0**
Cloud parameters (PACE)	5	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**5.0**
Aerosol parameters (EarthCARE)	8	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**8.0**
Cloud parameters (EarthCARE)	8	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**8.0**
Validate large reflectances	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**6.0**
Validate large reflectances with high polarization	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**6.0**
Validate large reflectances with low polarization	6	2.0	0.5	**22.1%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**22.1%**	**4.7**
Overfly vicarious calibration sites	6	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**6.0**
High aerosol loads over land	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**4.0**
High aerosol loads over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**4.0**
Multiple aerosol layers	1	2.0	4.5	0.0%	**87.3%**	0.0%	0.0%	0.0%	0.0%	0.0%	**87.3%**	**0.1**
Aerosol under thin cirrus	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**2.0**
Aerosol above liquid phase cloud	4	2.0	0.5	**11.8%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**11.8%**	**3.5**
Broken clouds with complex structure	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**4.0**
Dust aerosols over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**4.0**
Aerosol and ocean parameters over turbid waters	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**2.0**
Aerosol and ocean parameters over biologically productive waters	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**4.0**
Smoke aerosols over ocean	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**1.0**
total:	**150**	**98**	**16.5**	**5.4%**	**2.5%**	**1.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**8.9%**	
												total
		ER-2 flight hours		2.8	0	0	0	0	0	0	0	**2.8**
		TO flight hours		2.5	0	0	0	0	0	0	0	**2.5**
		Shearwater days		0	0	0	0	0	0	0	0	**0**

Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

https://www-air.larc.nasa.gov/missions/pacepax/index.html


Fresno_2 , N 36.785, W 119.773, Alt 100 m,
PI : Carol_J._Bruegge, Carol.J.Bruegge@Jpl.Nasa.Gov
Level 1.5 AOD; Data from 3 SEP 2024
AOD_340: <0.176>
AOD_380: <0.165>
AOD_440: <0.136>
AOD_500: <0.118>
AOD_675: <0.086>
AOD_870: <0.071>
AOD_1020: <0.065>
AOD_1640: <0.051>
Version 3 DS
0.3
0.2
0.1
0.0
Aerosol Optical Depth
AERONET Project, NASA GSFC
hh->
DD->
10 11 12 13 14 15 16 17 18 19 20 21 22 23 00 01 02 03 04 05
04
SEP
2024
Time(UTC)


NEON_SJER , N 37.109, W 119.732, Alt 368 m,
PI : Janae_Csavina, jcsavina@battelleecology.org
Level 1.0 AOD; Data from 3 SEP 2024
AOD_340: <0.136>
AOD_380: <0.127>
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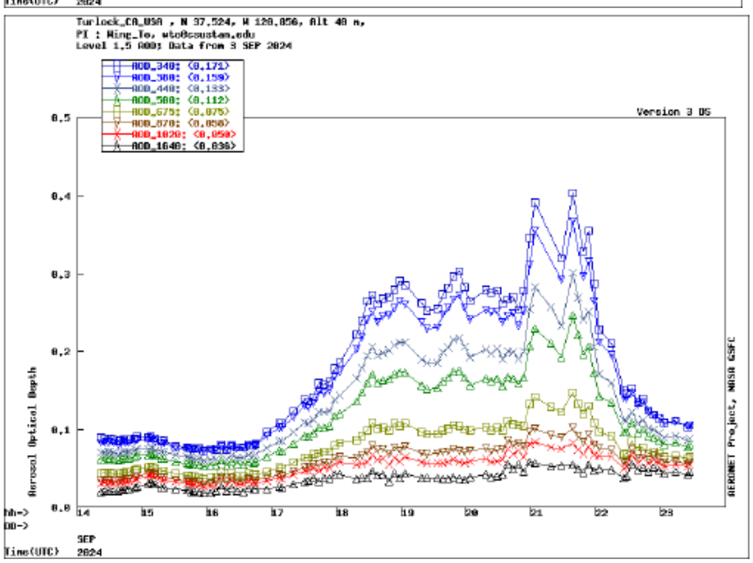
AOD_500: <0.085>
AOD_675: <0.068>
AOD_870: <0.056>
AOD_1020: <0.053>
AOD_1640: <0.032>
Version 3 DS
0.20
0.15
0.10
0.05
0.00
Aerosol Optical Depth
AERONET Project, NASA GSFC
hh->
DD->
10 11 12 13 14 15 16 17 18 19 20 21 22 23 00 01 02 03 04 05
04
SEP
2024
Time(UTC)


Turlock_CA_USA , N 37.524, W 120.856, Alt 40 m,
PI : Wing_To, wto@csustan.edu
Level 1.5 AOD; Data from 3 SEP 2024
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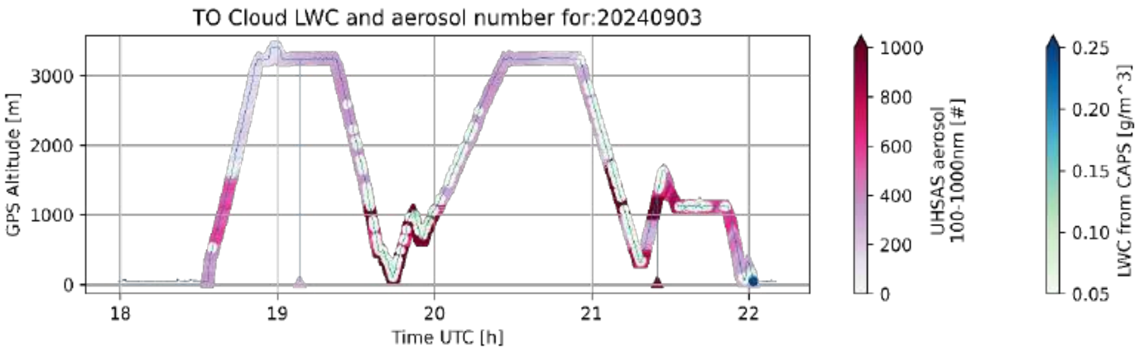
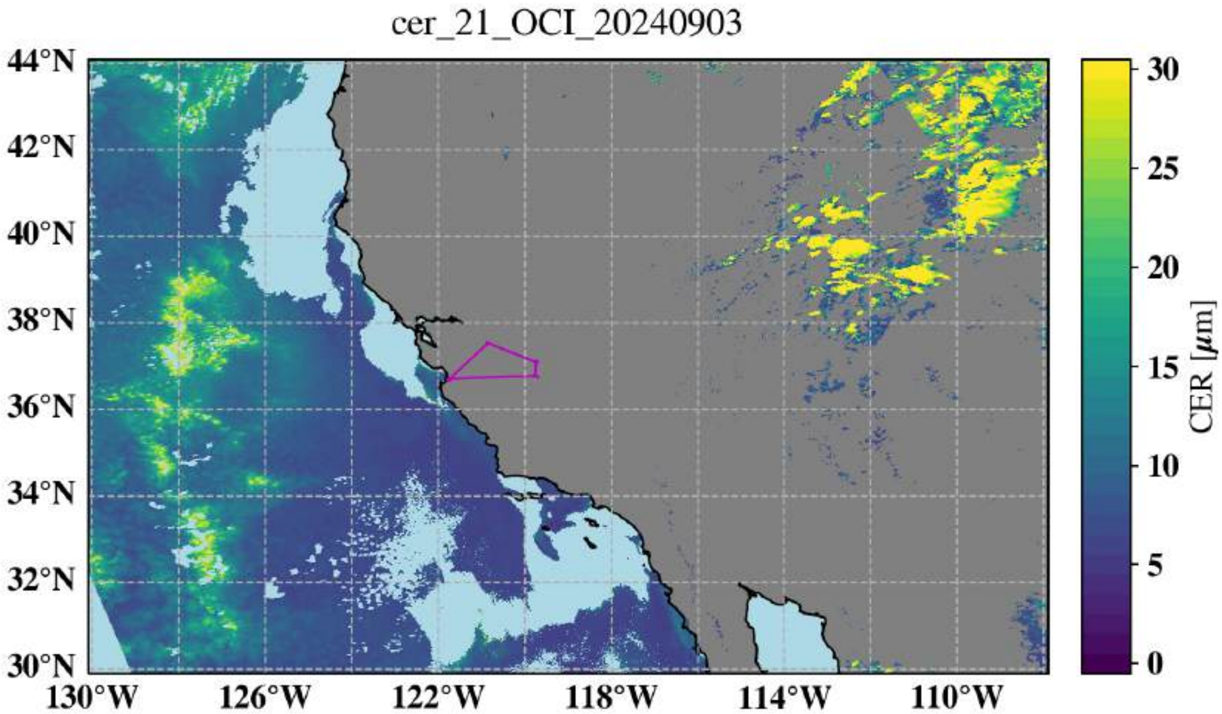
AOD_675: <0.075>
AOD_870: <0.058>
AOD_1020: <0.050>
AOD_1640: <0.036>
Version 3 DS
0.5
0.4
0.3
0.2
0.1
0.0
Aerosol Optical Depth
AERONET Project, NASA GSFC
hh->
DD->
14 15 16 17 18 19 20 21 22 23
SEP
2024
Time(UTC)

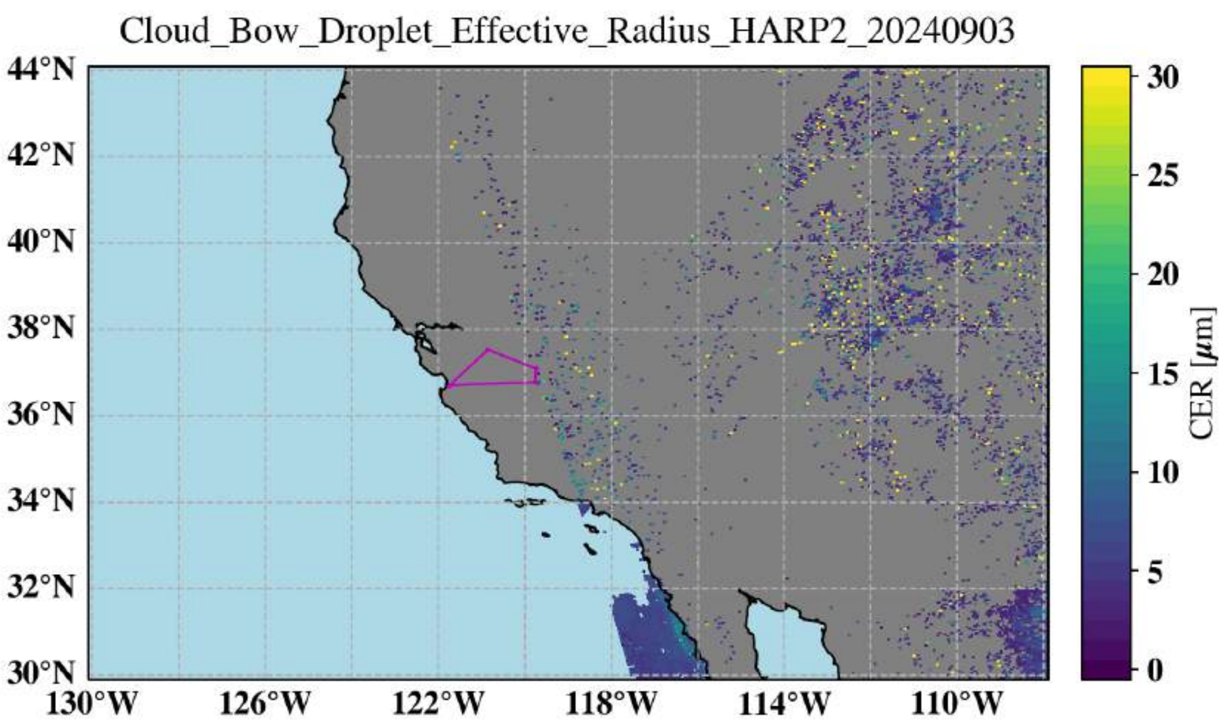


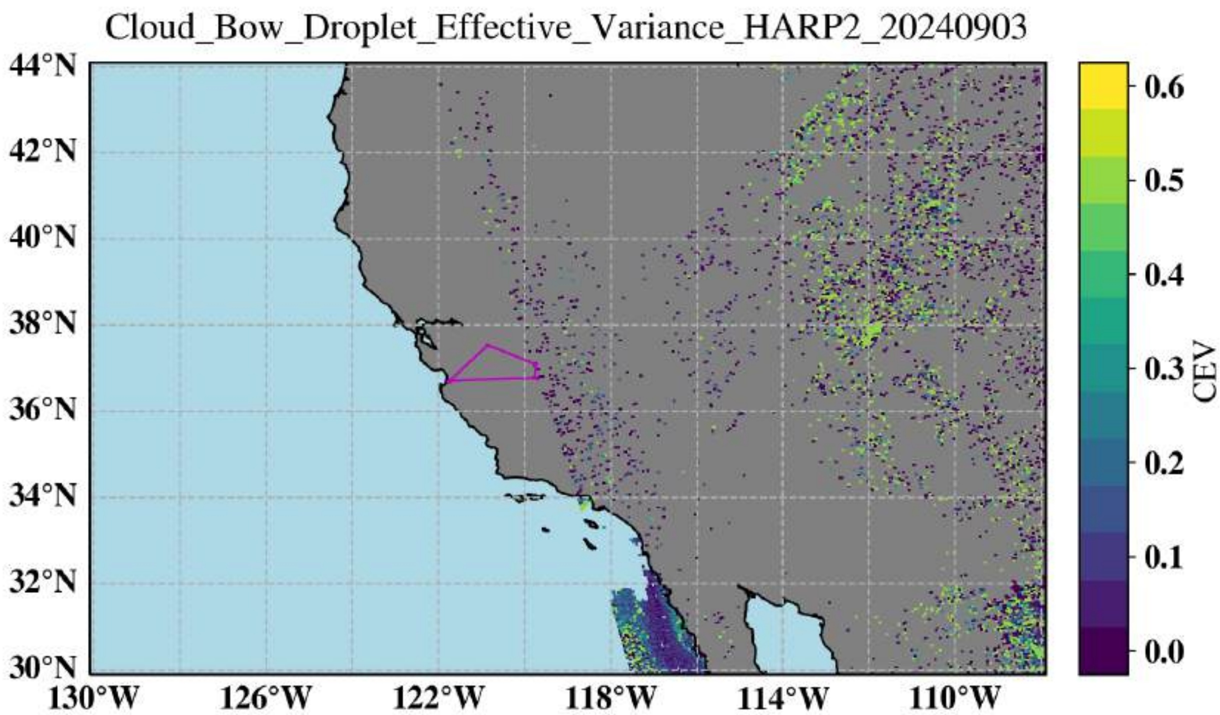
TO Cloud LWC and aerosol number for:20240903
GPS Altitude [m]
0
1000
2000
3000
18
19
20
21
22
Time UTC [h]
1000
800
600
400
200
0
UHSAS aerosol
100-1000nm [#]
0.25
0.20
0.15
0.10
0.05
LWC from CAPS [g/m^3]

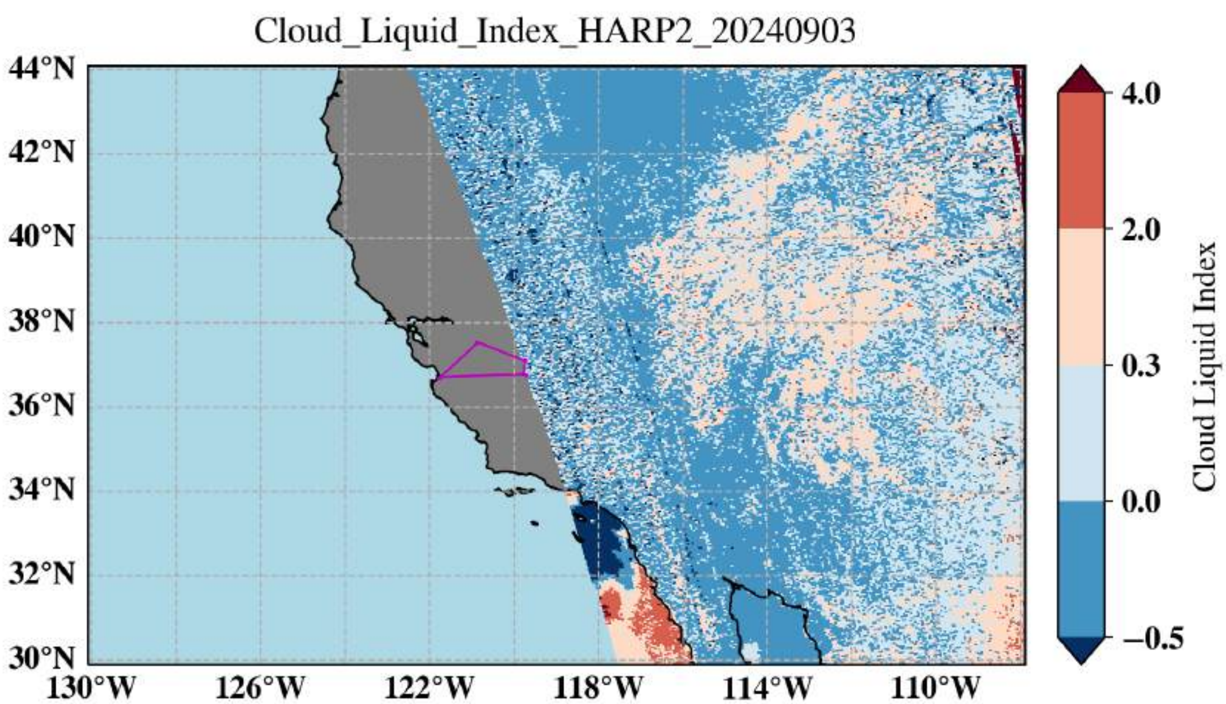
PACE quicklooks

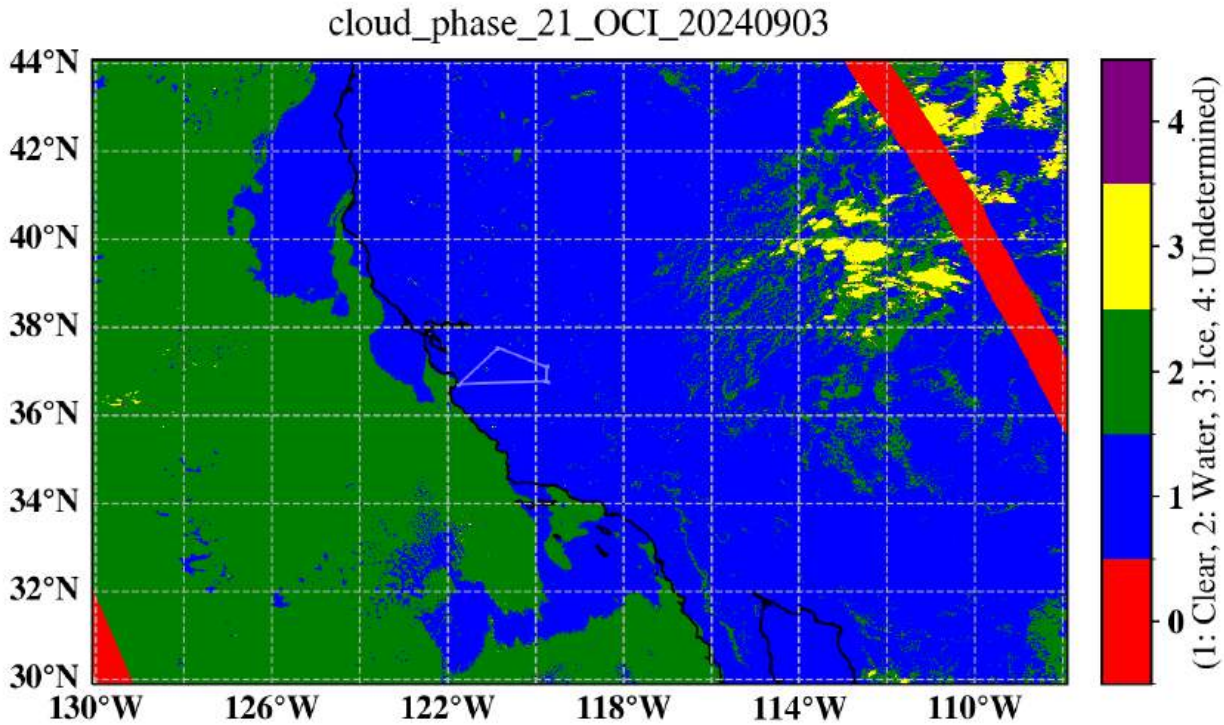
Note: PACE quicklooks include data that are not officially released and may have errors. They are included for illustrative purposes only and are not for use elsewhere

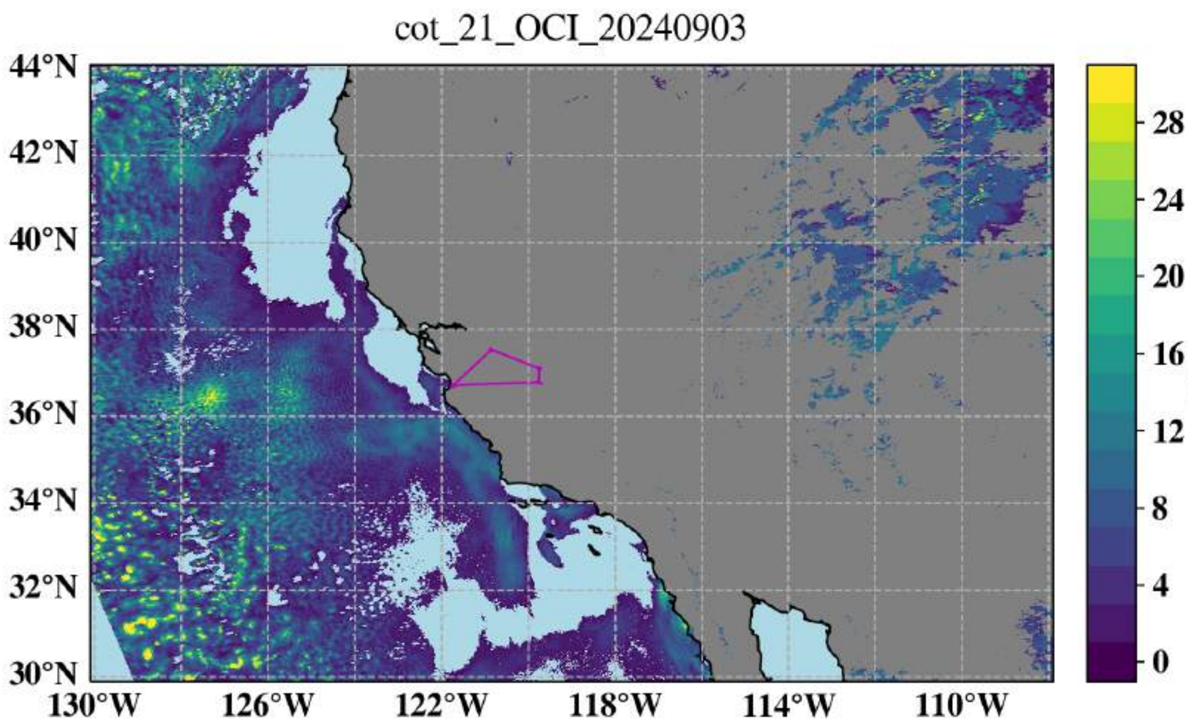


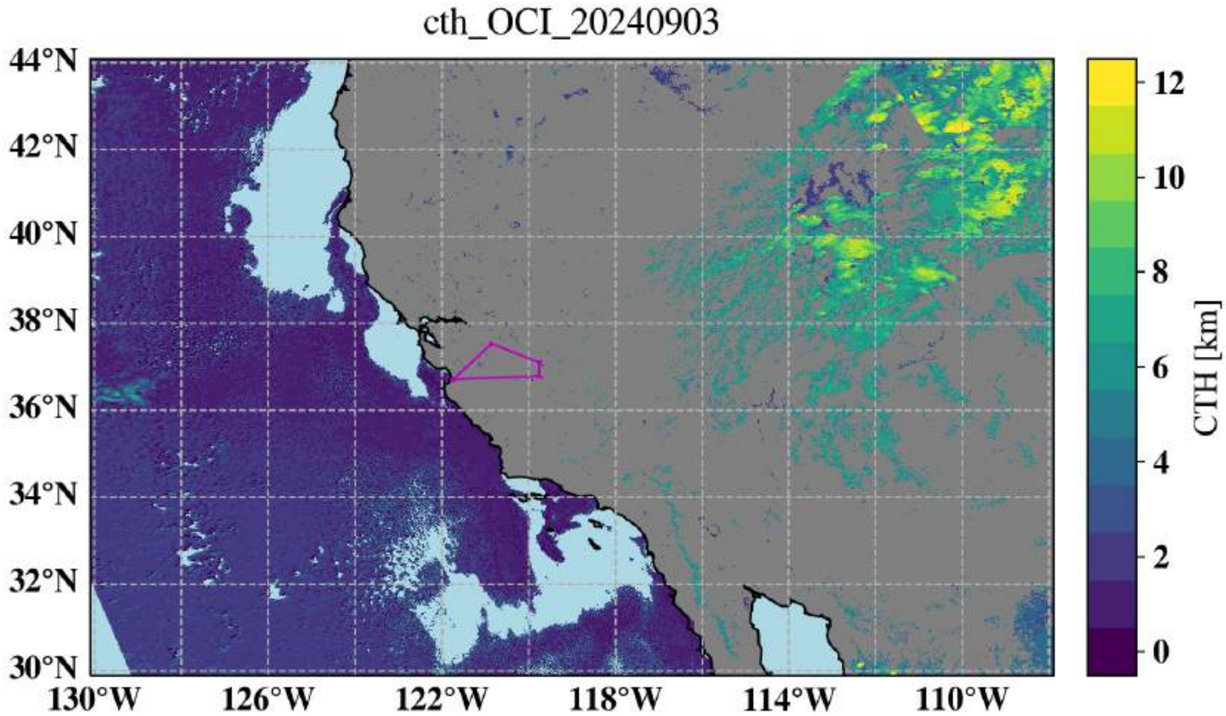



Cloud_Bow_Droplet_Effective_Variance_HARP2_20240903
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0.6
0.5
0.4
0.3
0.2
0.1
0.0
CEV


Cloud_Liquid_Index_HARP2_20240903
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
4.0
2.0
0.3
0.0
−0.5
Cloud Liquid Index


cloud_phase_21_OCI_20240903
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0
1
2
3
4
(1: Clear, 2: Water, 3: Ice, 4: Undetermined)


cot_21_OCI_20240903
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0
4
8
12
16
20
24
28
COT


cth_OCI_20240903
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
12
10
8
6
4
2
0
CTH [km]

PACE-PAX research flight report 2024/09/04

Compiled by Kirk Knobelspiesse, Brian Cairns, 2024/09/07
Reviewed by Samuel LeBlanc

Coordinated TO + ER2 flight including an underpass of PACE over a marine stratocumulus covered ocean in the SPEXone swath for the ER2, followed by coordination with the Twin Otter offshore. Some overflight of aeronet in central valley with ER-2 as well.

Delay of takeoff for ER-2 due to fueling issue, this was mitigated by delaying TO takeoff slightly and cutting short a segment in the ER-2. Coordination still happened as planned. TO instruments nominal, ER-2 had major problem with HSRL (no data due to cooling issue) and minor problems with PICARD (overheating, resolvable with reconfigured settings).

Twin Otter

Objectives: Profiles of aerosol scattering and absorption coefficients and size distributions together with scattering (polarized) phase functions above CEOBS site and over marine stratocumulus clouds. Extensive profiles of marine cloud microphysical properties and liquid water content for validation of cloud remote sensing retrievals.

Summary: Cloud top after take-off at 900 ft. At 1500 ft scattering coefficient was 10-15 Mm^{-1}. Profile done at CEOBS with scattering coefficient down to zero at 4500 ft through 10000 ft. Top of spiral reached at 12:38 local time (19:38 UTC) then inline descent to do porpoise maneuvers in cloud region west of Marina. Cloud top reached at 1000 ft. Orbit maneuver performed at 20:05 for overpass timing. Extensive porpoising performed, profiling at 500 ft/min with 10-second level legs in clear air above and below clouds. Cloud bases initially at 400 ft altitude, tops at 1100 ft. Continued porpoising before and after the PACE overpass time of 13:59 local time (20:59 UTC). LWC observed 0.25-0.4 g/m3. Aerosol scattering initially ~10 Mm-1 both below and above cloud layer, nearly zero Mm-1 in-cloud (presumably due to cloud scavenging or activation). At the west side of flight track, cloud bases/tops increased in height to ~1000/1500ft, and below-cloud aerosol scattering increased to 20 Mm-1. At 20:40 UTC, inserted orbit maneuver for coordination timing. Spiral maneuver performed at 21:12 UTC (up and down), with aerosol scattering extending to just below 5000 ft altitude. Aircraft in porpoising maneuver during ER2 overpass at 15:08 local time (22:08 UTC). Spiral up at PIRAT waypoint for ATC communications, then start transit back to KOAR. Descended to 2000 ft on the way back to land at Marina to see if there were any aerosols present, but very little observed (~5 Mm-1 scattering). Missed approach at Marina tower was planned, but aborted due to cloud cover.

Clouds were ideal for PACE validation with overcast conditions and peak liquid water content of 0.4 g/m^3 indicative of relatively thick, opaque, clouds and relatively large droplets. Cloud altitude increased from East to West with base of 400 ft and top at 1100 ft in the East and base of 1000 ft and top at 1500 ft in the West. All instrumentation performed nominally for the full flight.

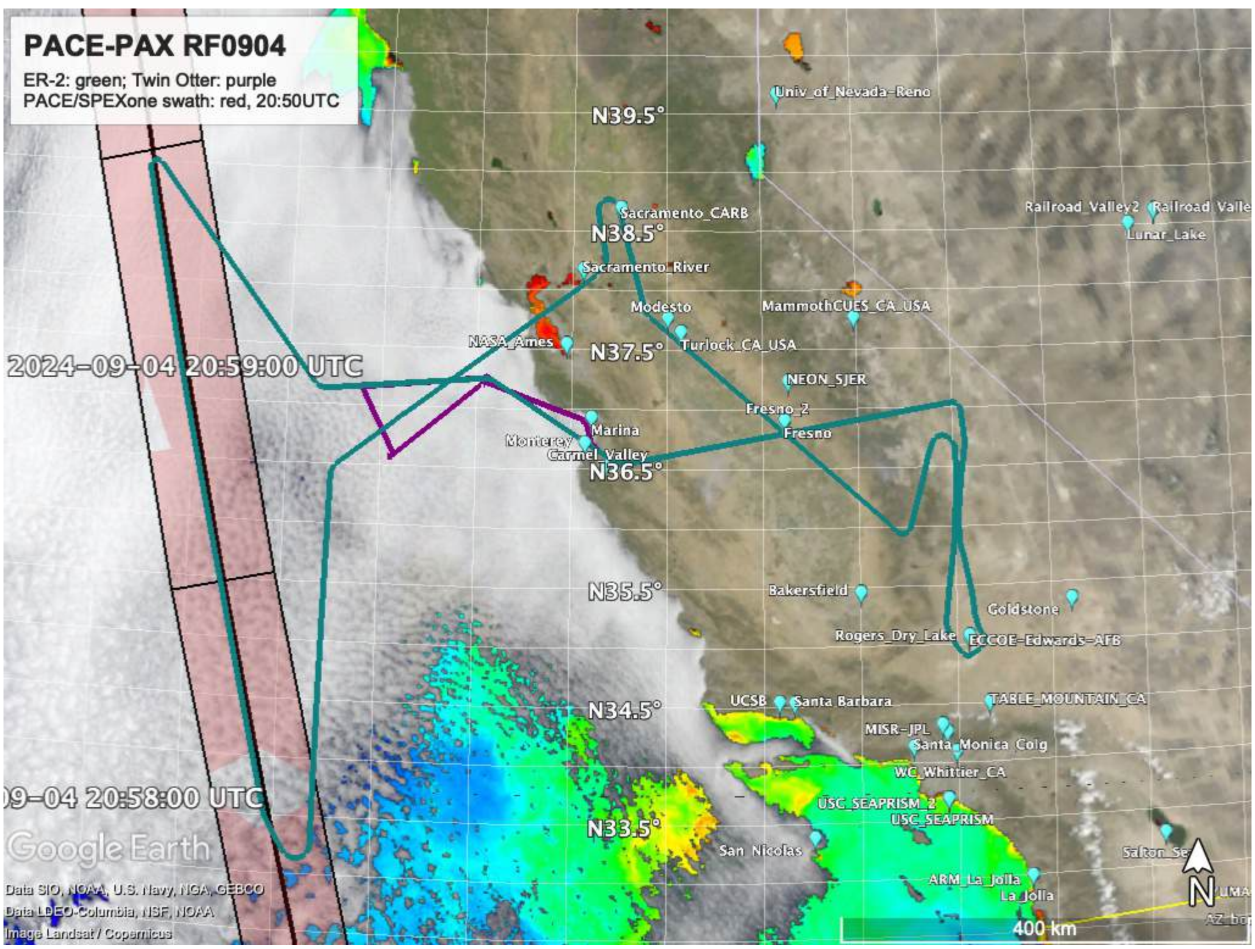
ER-2

Takeoff: 18:34
Landing: 23:15
Duration: 4.7

Instrument status: HSRL: coolenol pump failed, no data gathered. PICARD: overheating, some loss of data. SPEXairborne: data transmission issue resulting in loss of ¼ data. All other instruments operated successfully.
Mission Scientist: Kirk Knobelspiesse
Pilot: James Nelson (Coach)
Mobile Pilot: Tim Williams

Twin Otter
Take off: 12:10:49 (19:10:49 UTC)
Landing: 15:56:27 (22:56:27 UTC)
Duration = 3.8 hrs
Instrument status: nominal
Manifest: Bryce Kujat (pilot), Jeff Martin (pilot), Luke Ziemba (QNC), Michael Shook (QNC)

PACE
Overpass: 20:59
Orbit track west offshore



All times are in UTC, VTM elements in **black** satisfied, **blue** partially satisfied and **red** not satisfied.

Time	**Platform**	**VTM**	
18:34	ER2		Takeoff
19:10	TO		Takeoff
19:18	ER2	1d	Overfly Fresno_2 AERONET. AOT=0.11
19:26	ER2	1d	Overfly Turlock AERONET. AOT=0.08
19:29	ER2	1d	Overfly Modesto AERONET. AOT=0.07
19:38	TO	1e	Top of spiral at CEOBS site and begin porpoise in clouds
19:38	ER2	1d	Overfly Sacramento CARB AERONET, AOT=0.13
19:47	ER2	1b, 1c, 6h	Sacramento River AERONET-OC, AOT=0.05
20:43	ER2		Start PACE-OHS line
20:59	ER2, TO	1e, 3c, 4c	PACE underpass 20:59. 1e for TO & ER-2, ER-2 only for other VTM elements
21:00	**PACE**		**PACE overpass**
21:32	ER2		End PACE-OHS line
22:08	ER2, TO	1e	Coordination between ER-2 and Twin Otter, while the latter is porpoising in clouds
22:18	ER2, Marina	1d, 6g	Overfly Marina Airport aerosol tower measurements (APS volume for particles greater than 1000 nm at 11 um^3/cm^3)
22:34	ER2	1d	Overfly Fresno AERONET. AOT=0.10
23:28	TO		Land

SPP: Solar Principal Plane

PACE-OHS: PACE track withing swaths of OCI, HARP2 and SPEXone

Assessment:

- 7.1% objectives satisfied for cloud flight. Coordination worked well, even with delayed start of ER-2

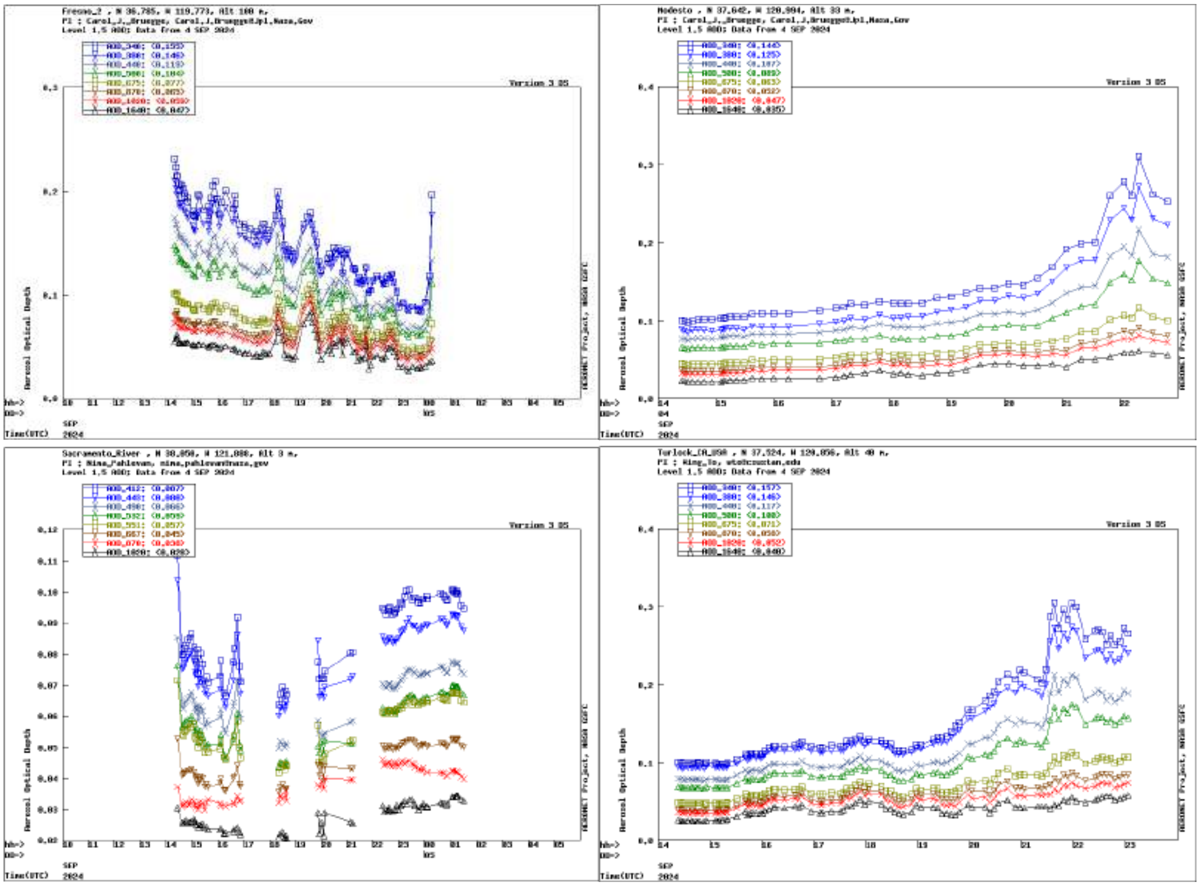
PACE-PAX progress tracking

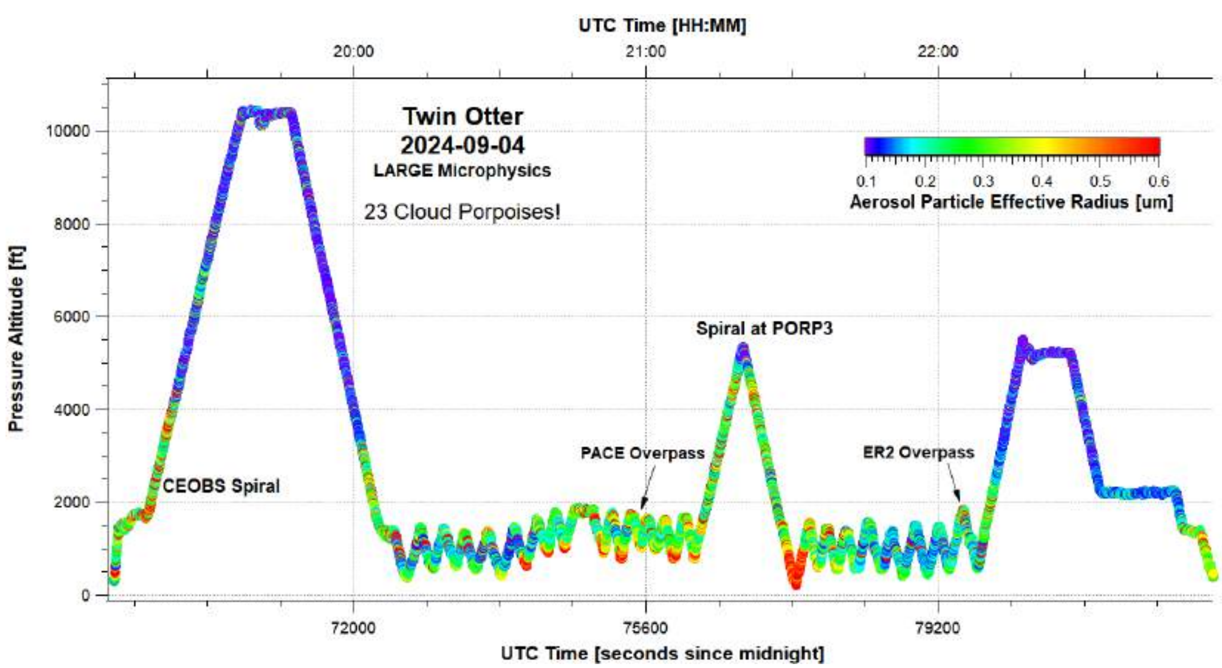
Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 8/29	Fractional success 9/3	Fractional success 9/4	Fractional success 9/5	Fractional success 9/6	Fractional success 9/7
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	0.5	**20.1%**	0.0%	0.0%	0.0%	0.0%	0.0%
	b	Ocean radiometric parameters	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	c	Aerosol parameters over the ocean	12	8.0	0.5	0.0%	0.0%	**6.1%**	0.0%	0.0%	0.0%
	d	Aerosol parameters over land	12	8.0	10.5	**39.3%**	**24.4%**	**8.0%**	0.0%	0.0%	0.0%
	e	Cloud parameters	12	8.0	4.0	0.0%	0.0%	**39.3%**	0.0%	0.0%	0.0%
	f	Ocean surface parameters	1	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	b	Aerosol parameters over land (PACE)	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	c	Cloud parameters (PACE)	5	2.0	1.0	0.0%	0.0%	**39.3%**	0.0%	0.0%	0.0%
	d	Aerosol parameters (EarthCARE)	8	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	e	Cloud parameters (EarthCARE)	8	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	b	Validate large reflectances with high polarization	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	c	Validate large reflectances with low polarization	6	2.0	1.5	**22.1%**	0.0%	**30.6%**	0.0%	0.0%	0.0%
	d	Overfly vicarious calibration sites	6	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	b	High aerosol loads over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	c	Multiple aerosol layers	1	2.0	4.5	0.0%	**87.3%**	0.0%	0.0%	0.0%	0.0%
	d	Aerosol under thin cirrus	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	e	Aerosol above liquid phase cloud	4	2.0	0.5	**22.1%**	0.0%	0.0%	0.0%	0.0%	0.0%
	f	Broken clouds with complex structure	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	g	Dust aerosols over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	h	Aerosol and ocean parameters over turbid waters	2	2.0	0.5	0.0%	0.0%	**22.1%**	0.0%	0.0%	0.0%
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	k	Smoke aerosols over ocean	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		total:	**150**	**98**	**23.5**	**5.7%**	**2.5%**	**7.1%**	**0.0%**	**0.0%**	**0.0%**
					prior to this week						
				ER-2 flight hours	1.3	2.8	0	4.7	0	0	0
				TO flight hours	0	2.4	3.4	3.8	0	0	0
				Shearwater days		0	0	0	0	0	0

PACE-PAX overall objectives satisfied: 15.3%

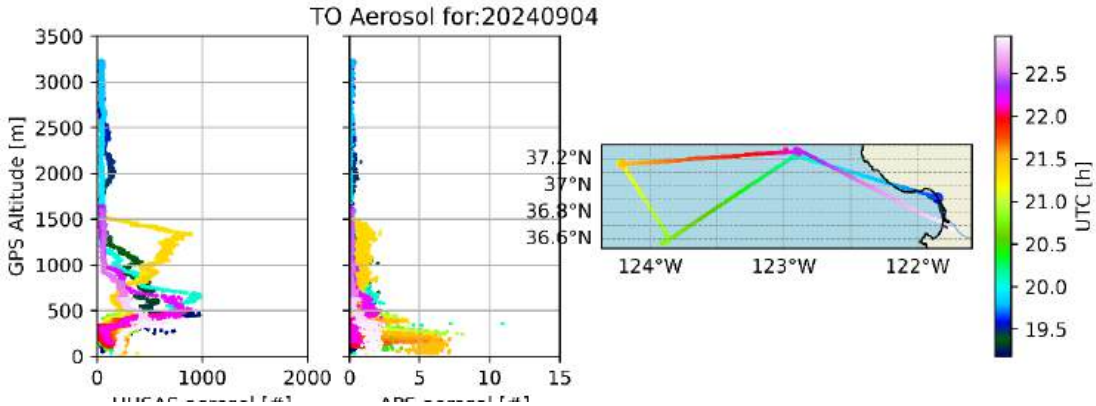
Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

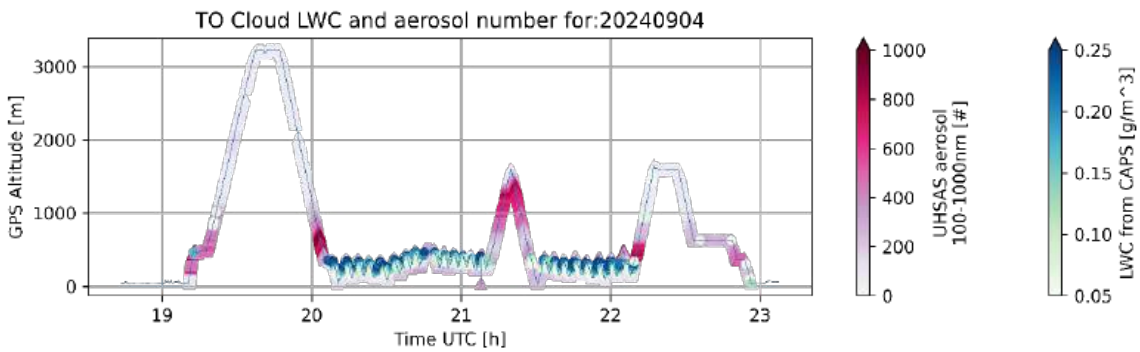
https://www-air.larc.nasa.gov/missions/pacepax/index.html





UTC Time [HH:MM]
20:00
21:00
22:00
Twin Otter
2024-09-04
LARGE Microphysics
23 Cloud Porpoises!
0.1 0.2 0.3 0.4 0.5 0.6
Aerosol Particle Effective Radius [um]
Pressure Altitude [ft]
10000
8000
6000
4000
2000
0
Spiral at PORP3
PACE Overpass
ER2 Overpass
CEOBS Spiral
72000
75600
79200
UTC Time [seconds since midnight]

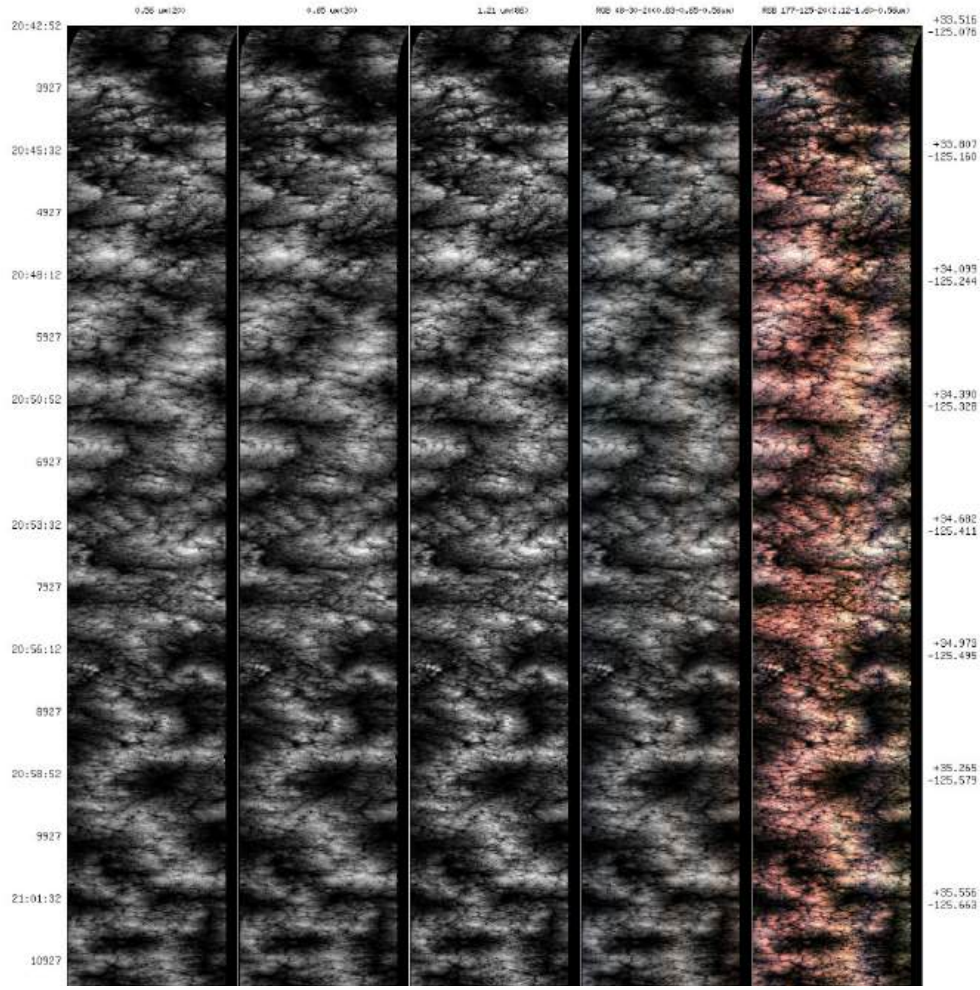


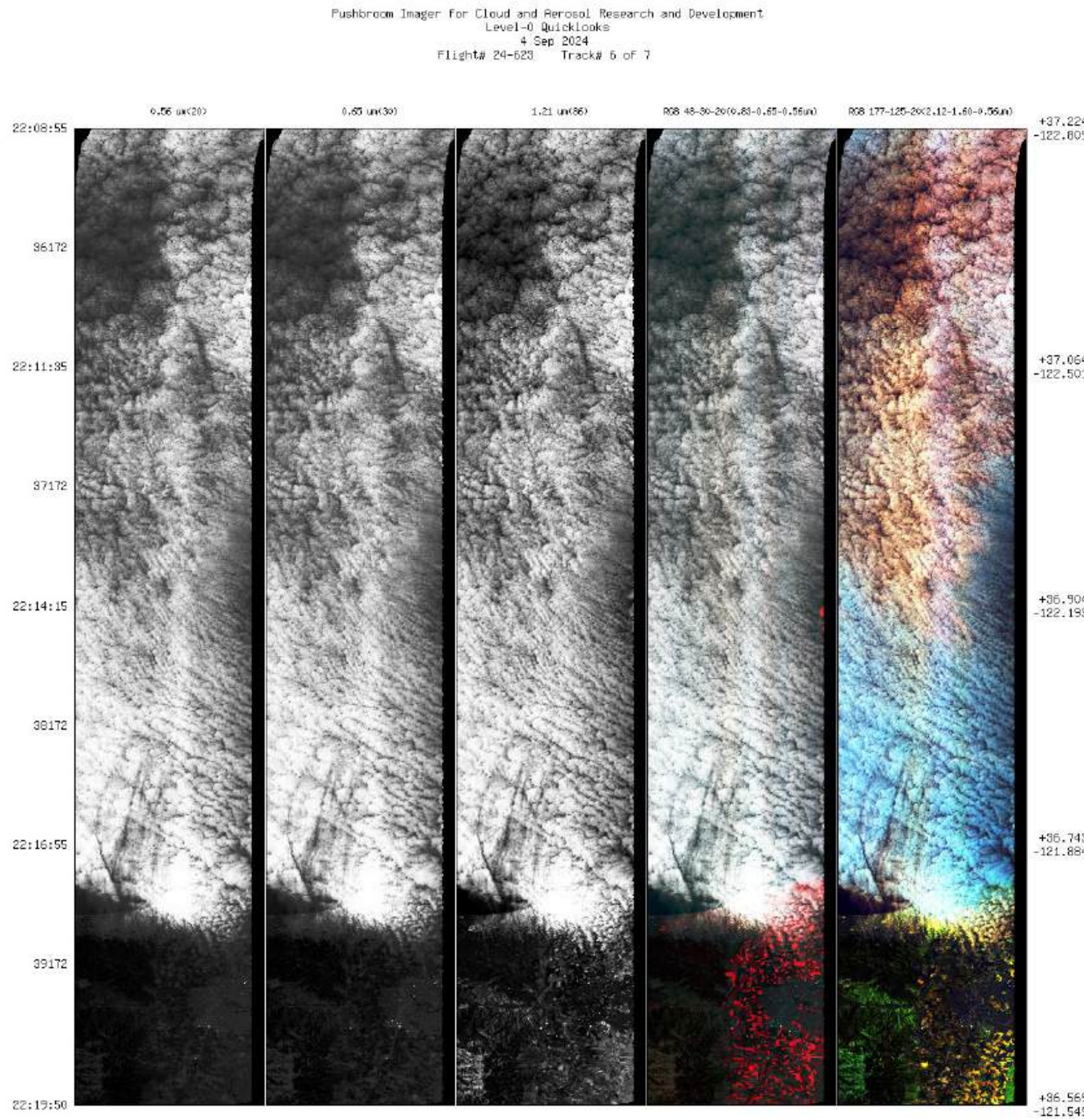


A portion of the PRISM quicklook along the PACE overpass line (left: south, right: north)

A portion of the PICARD quicklook along the PACE overpass line. More quicklooks at: https://asapdata.arc.nasa.gov/picard/data/flt_html/24623.html

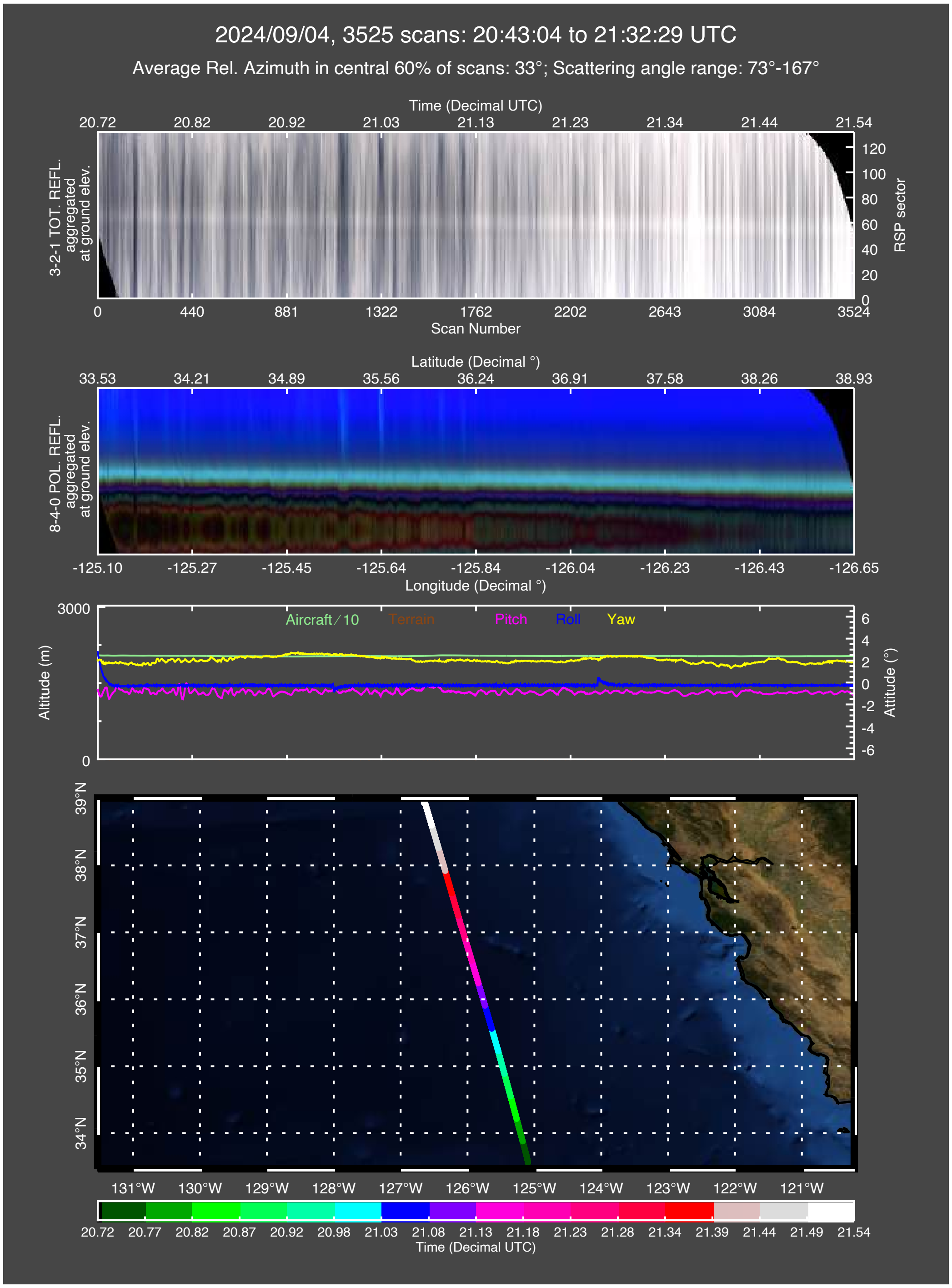
Pushbroom Imager for Cloud and Aerosol Research and Development
Level-0 Quicklooks
4 Sep 2024
Flight# 24-623 Track# 3 of 7





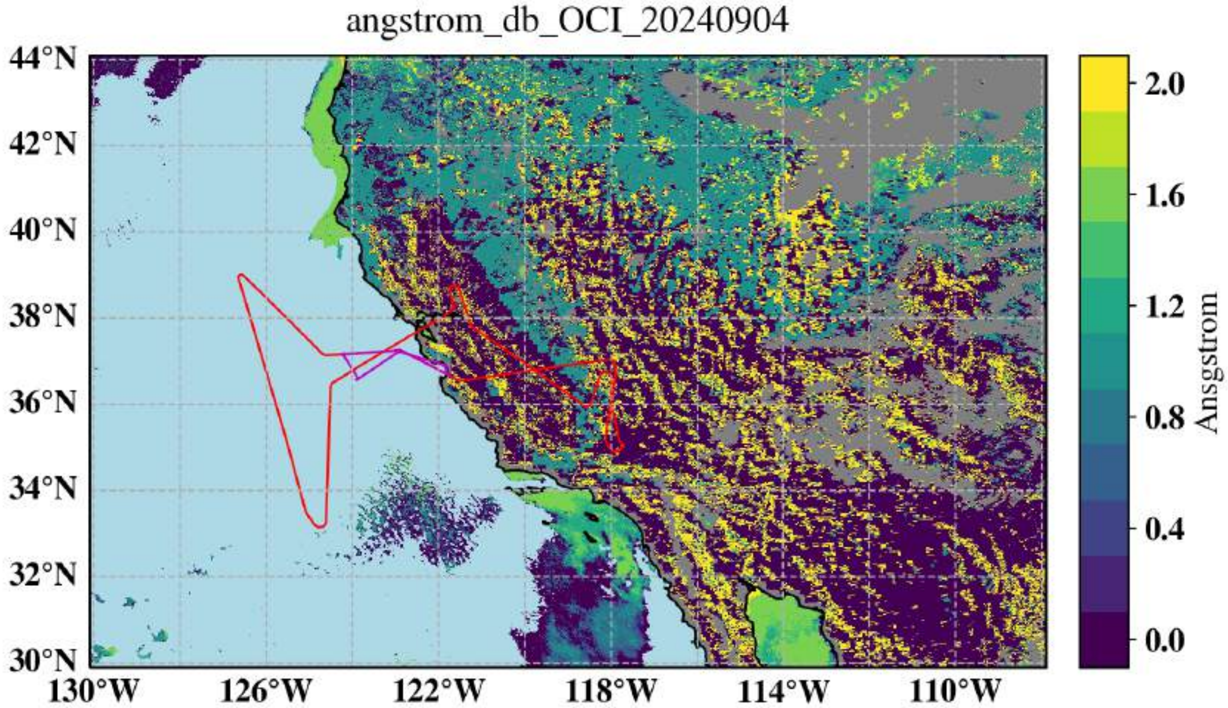
Over the Marina airport, at the south edge of marine stratocumulus

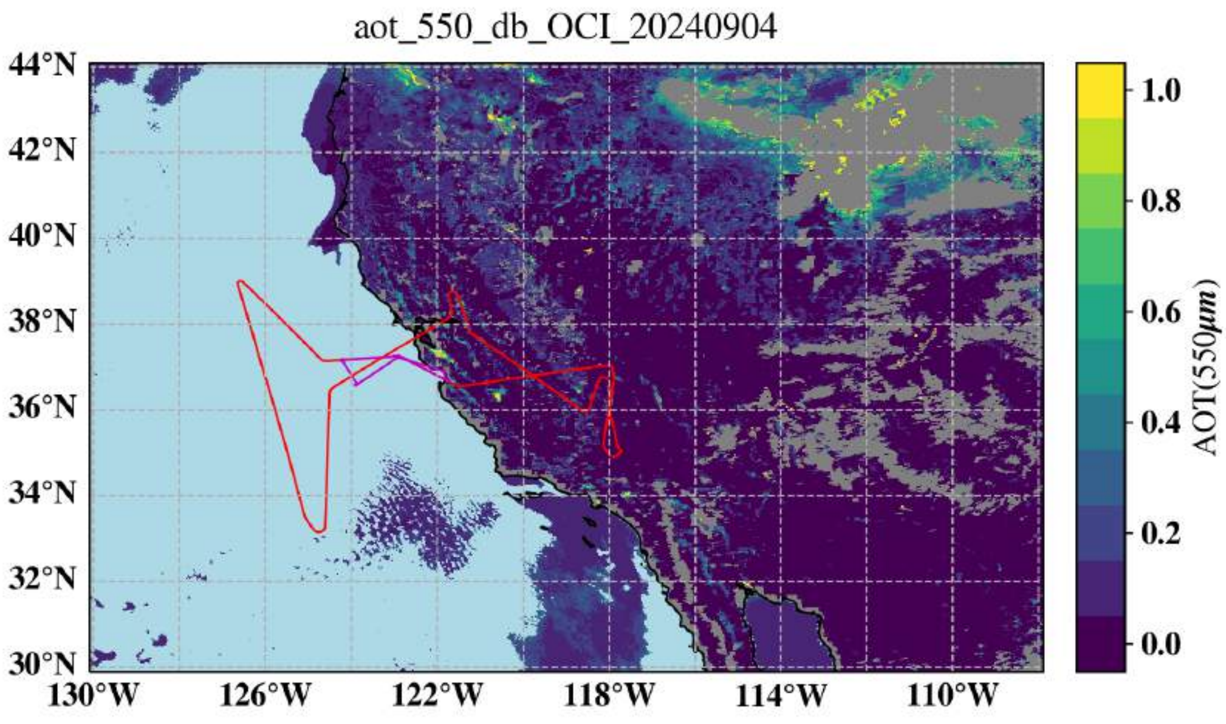
RSP quicklook along the PACE satellite track. More quicklooks:
https://data.giss.nasa.gov/pub/rsp/data/PACEPAX/quicklooks/

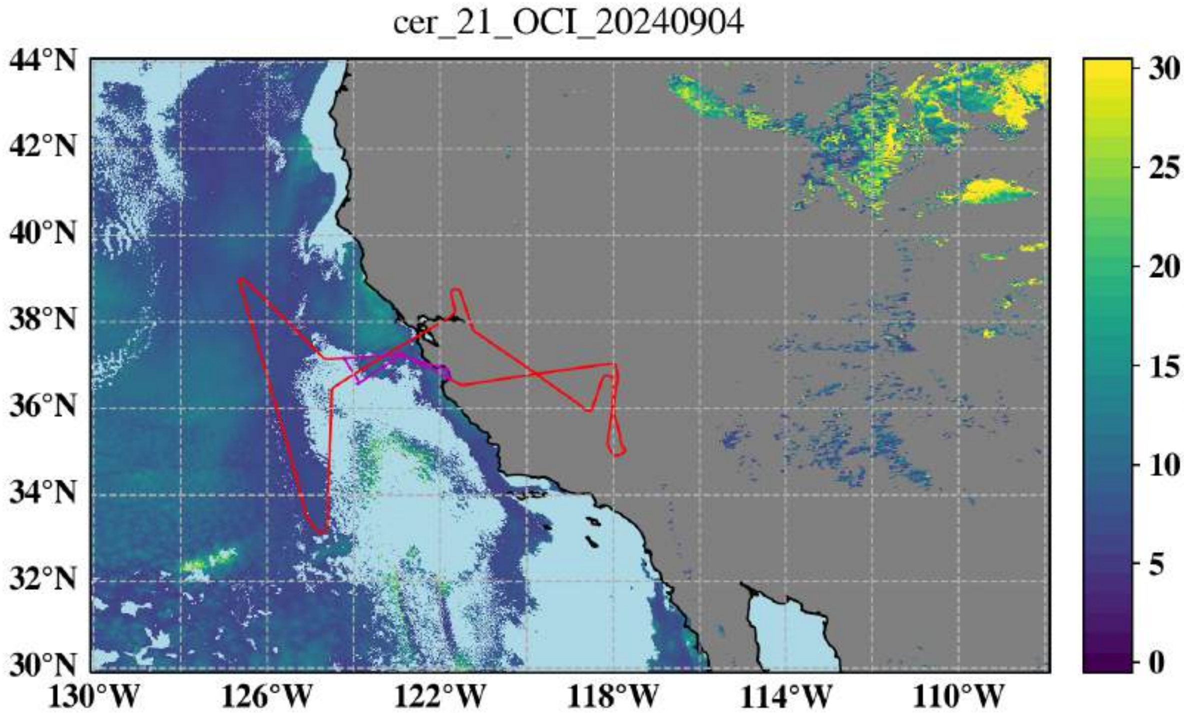


PACE satellite quicklooks

Note: PACE quicklooks contain unreleased data with unverified quality. They are intended for qualitative purposes only and are not for distribution.



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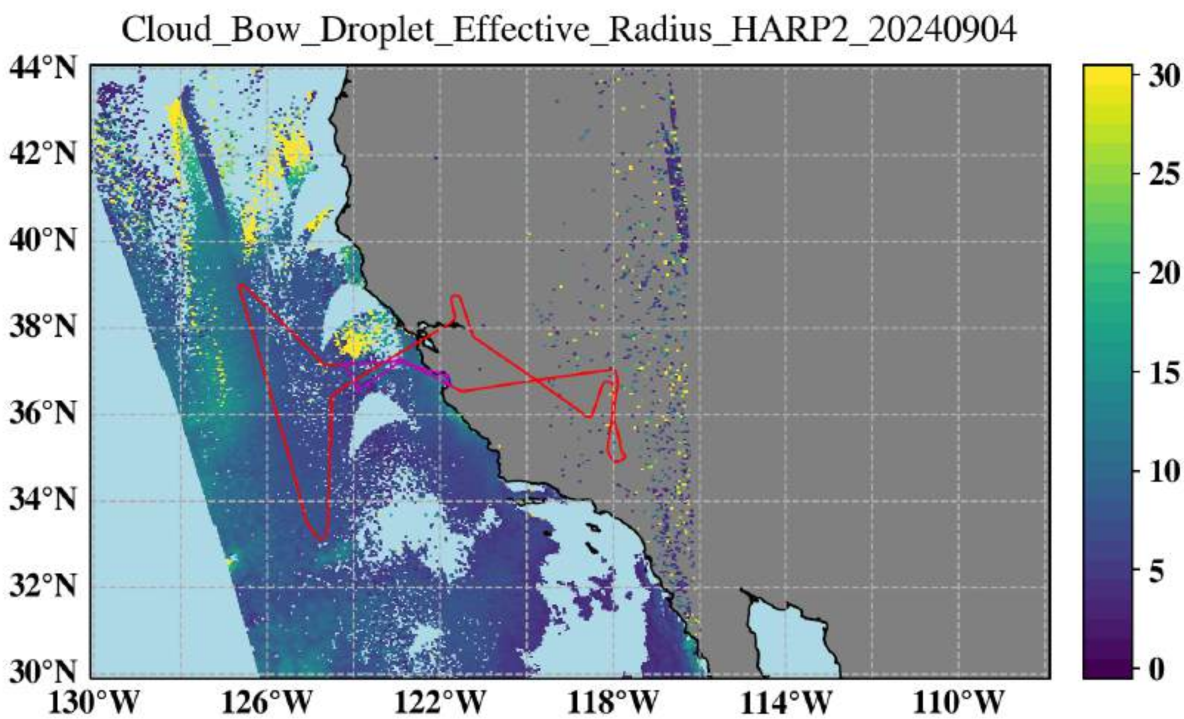
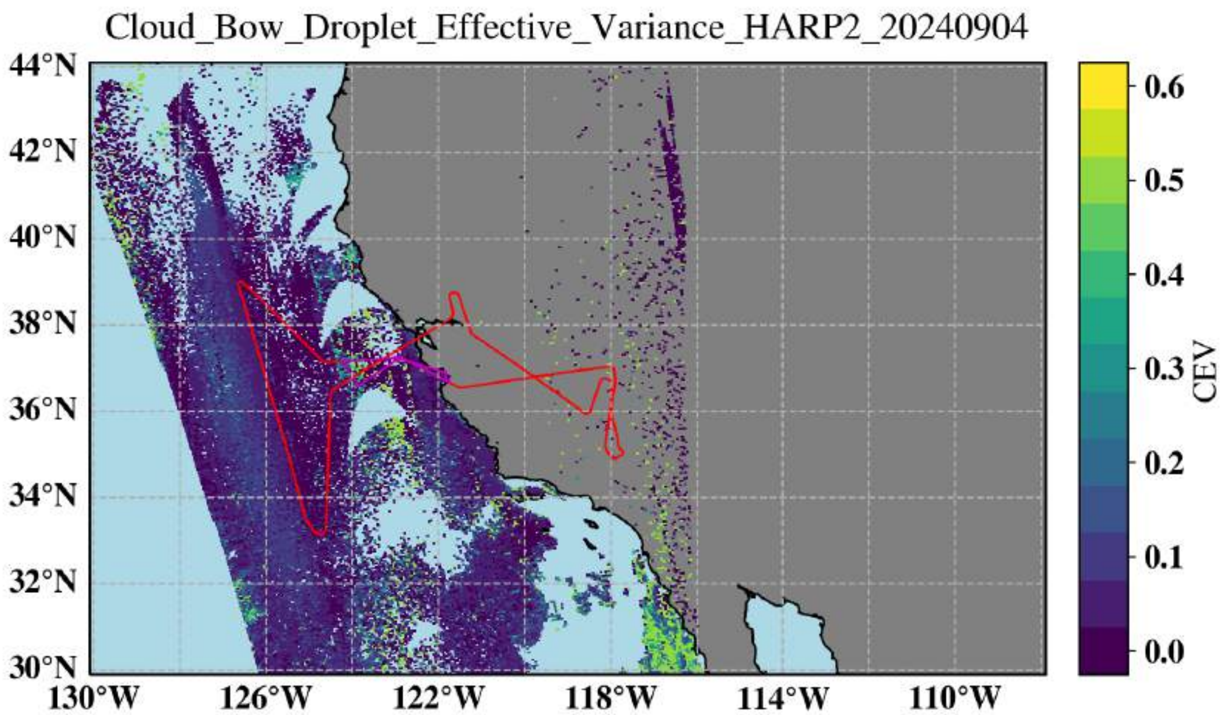
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
CER [μm]
0
5
10
15
20
25
30


Cloud_Bow_Droplet_Effective_Radius_HARP2_20240904
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
CER [μm]
0
5
10
15
20
25
30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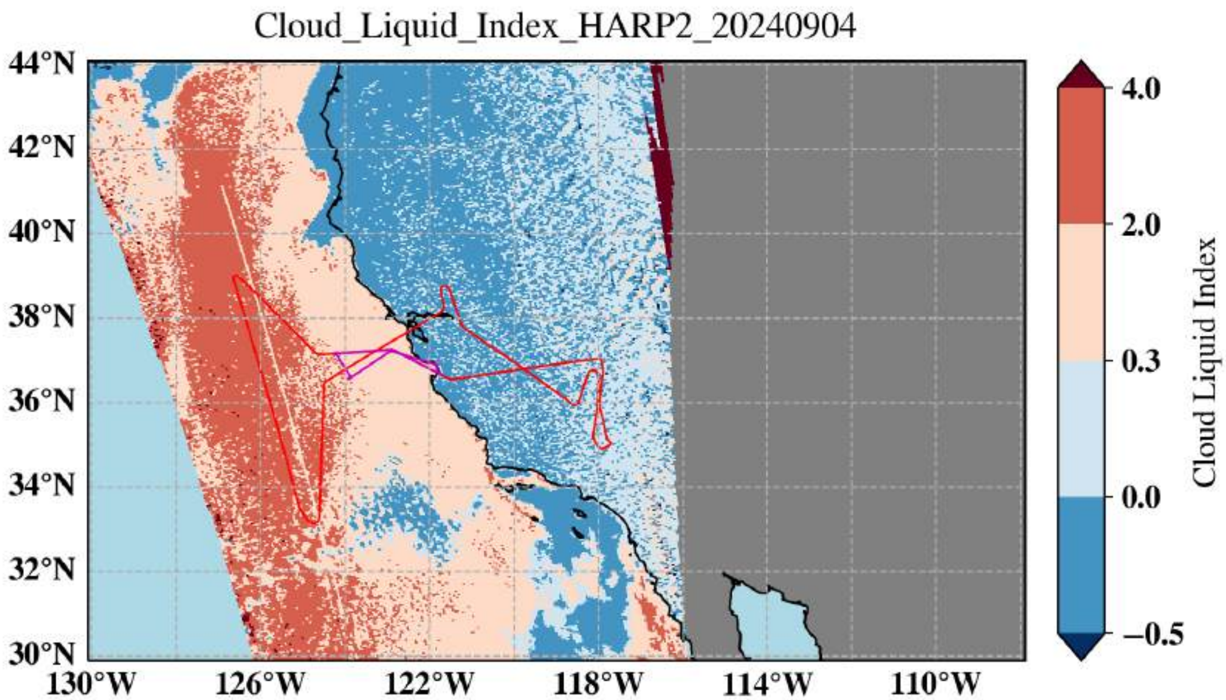
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0.6
0.5
0.4
0.3
0.2
0.1
0.0
CEV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40°N
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36°N
34°N
32°N
30°N
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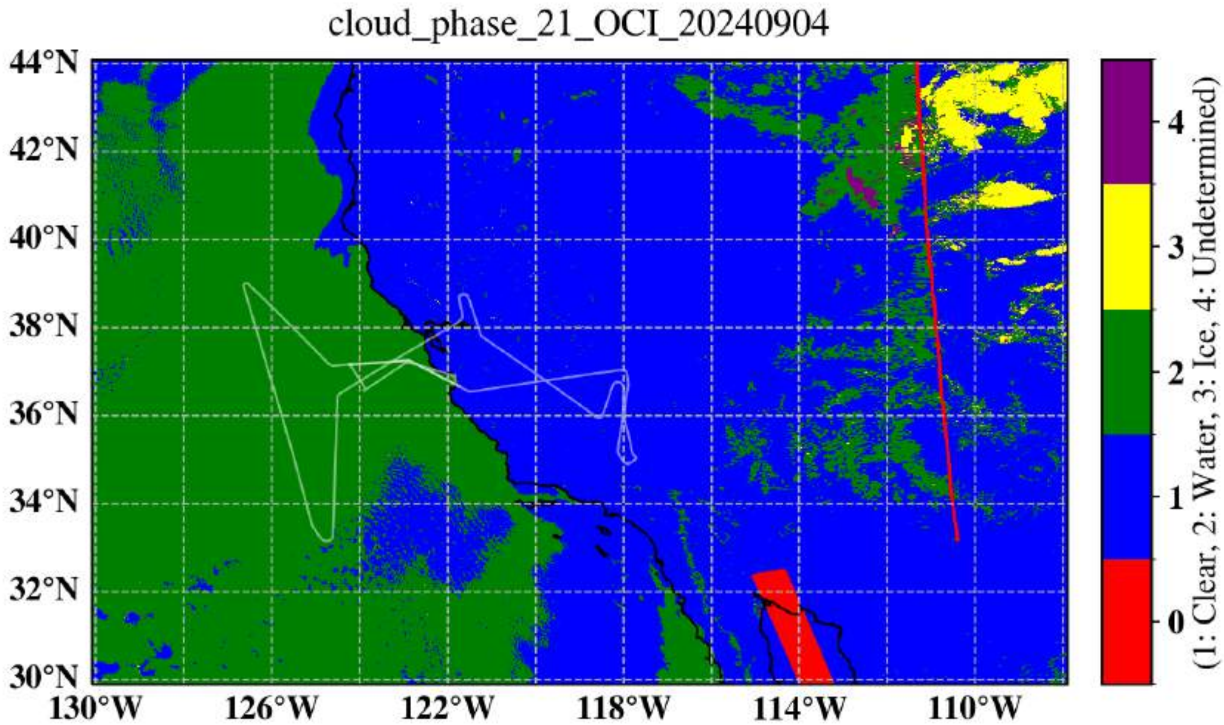
122°W
118°W
114°W
110°W
4.0
2.0
0.3
0.0
−0.5
Cloud Liquid Index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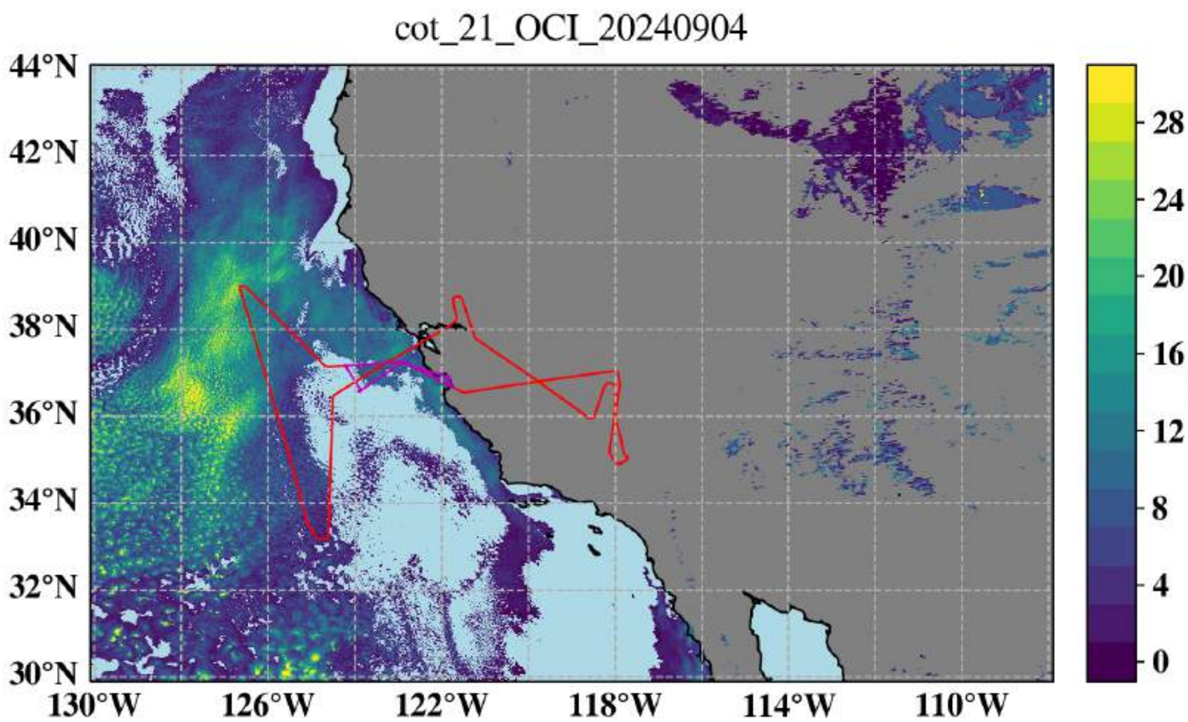
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
(1: Clear, 2: Water, 3: Ice, 4: Undetermined)
0
1
2
3
4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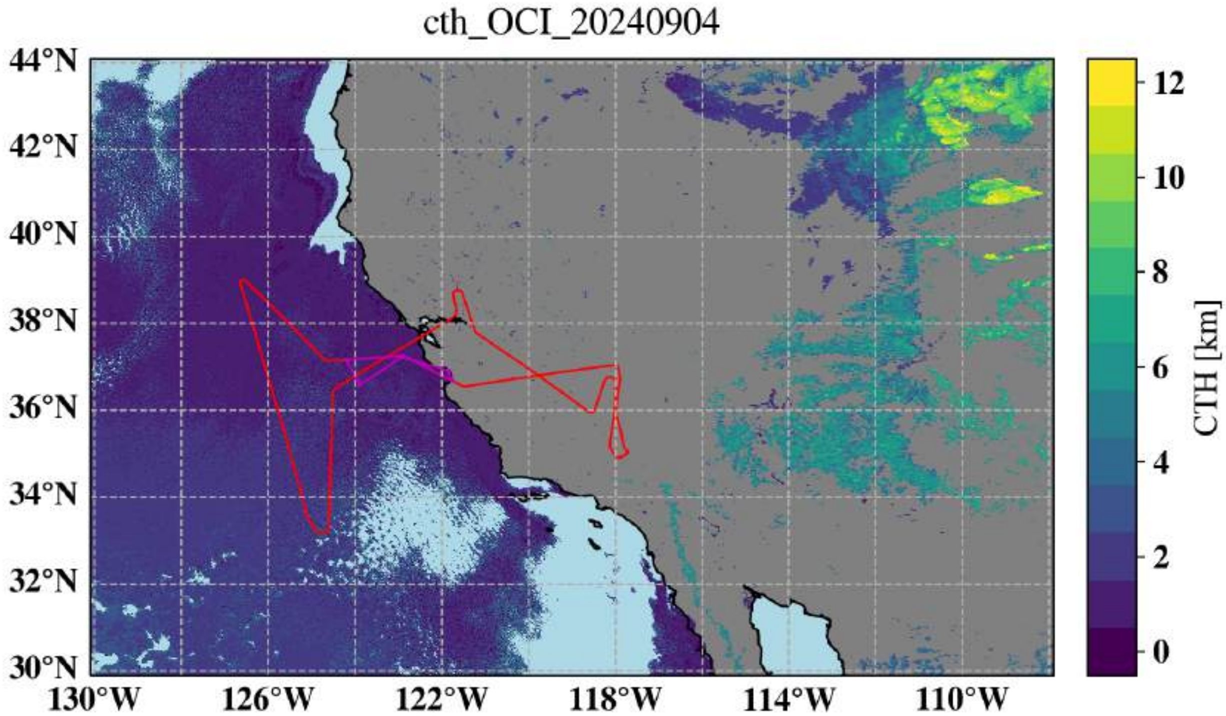
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
COT
0
4
8
12
16
20
24
28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40°N
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34°N
32°N
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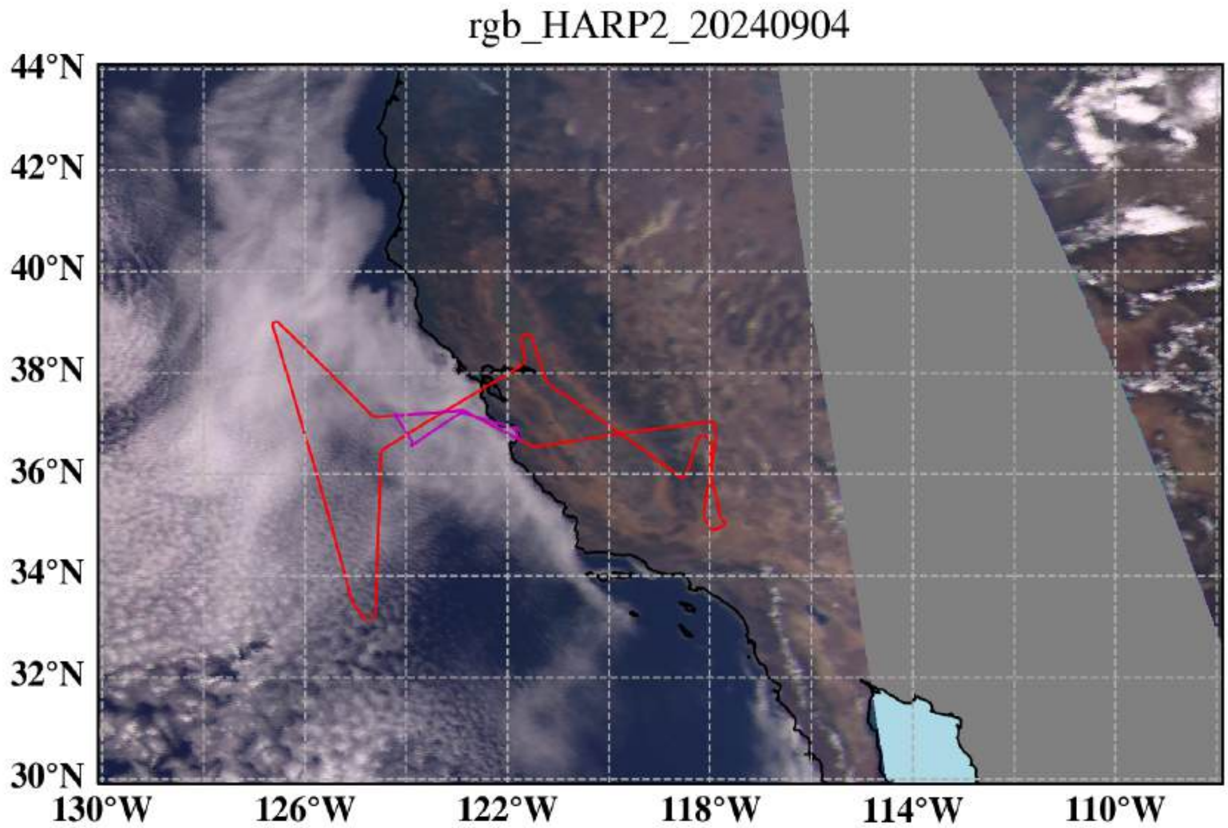
130°W
126°W
122°W
118°W
114°W
110°W
CTH [km]
0
2
4
6
8
10
12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44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W

PACE-PAX Research Flight report 2024/09/04

Twin Otter Flight

Manifest:

Bryce Kujat (pilot)

Jeff Martin (pilot)

Luke Ziemba (QNC)

Michael Shook (QNC)

Take off: 12:10:49 (19:10:49 UTC)

Landing: 15:56:27 (22:56:27 UTC)

Duration = 3.8 hrs.

Objectives: Profiles of aerosol scattering and absorption coefficients and size distributions together with scattering (polarized) phase functions above CEOBS site and over marine stratocumulus clouds. Extensive profiles of marine cloud microphysical properties and liquid water content for validation of cloud remote sensing retrievals.

Summary: Cloud top after take-off at 900 ft. At 1500 ft scattering coefficient was 10-15 Mm^{-1}. Profile done at CEOBS with scattering coefficient down to zero at 4500 ft through 10000 ft. Top of spiral reached at 12:38 local time (19:38 UTC) then inline descent to do porpoise maneuvers in cloud region west of Marina. Cloud top reached at 1000 ft. Orbit maneuver performed at 20:05 for overpass timing. Extensive porpoising performed, profiling at 500 ft/min with 10-second level legs in clear air above and below clouds. Cloud bases initially at 400 ft altitude, tops at 1100 ft. Continued porpoising before and after the PACE overpass time of 13:59 local time (20:59 UTC). LWC observed 0.25-0.4 g/m3. Aerosol scattering initially ~10 Mm-1 both below and above cloud layer, nearly zero Mm-1 in-cloud (presumably due to cloud scavenging or activation). At the west side of flight track, cloud bases/tops increased in height to ~1000/1500ft, and below-cloud aerosol scattering increased to 20 Mm-1. At 20:40 UTC, inserted orbit maneuver for coordination timing. Spiral maneuver performed at 21:12 UTC (up and down), with aerosol scattering extending to just below 5000 ft altitude. Aircraft in porpoising maneuver during ER2 overpass at 15:08 local time (22:08 UTC). Spiral up at PIRAT waypoint for ATC communications, then start transit back to KOAR.

Descended to 2000 ft on the way back to land at Marina to see if there were any aerosols present, but very little observed (~5 Mm-1 scattering). Missed approach at Marina tower was planned, but aborted due to cloud cover.

Clouds were ideal for PACE validation with overcast conditions and peak liquid water content of 0.4 g/m^3 indicative of relatively thick, opaque, clouds and relatively large droplets. Cloud altitude increased from East to West with base of 400 ft and top at 1100 ft in the East and base of 1000 ft and top at 1500 ft in the West. All instrumentation performed nominally for the full flight.

PACE-PAX research flight report 2024/09/05

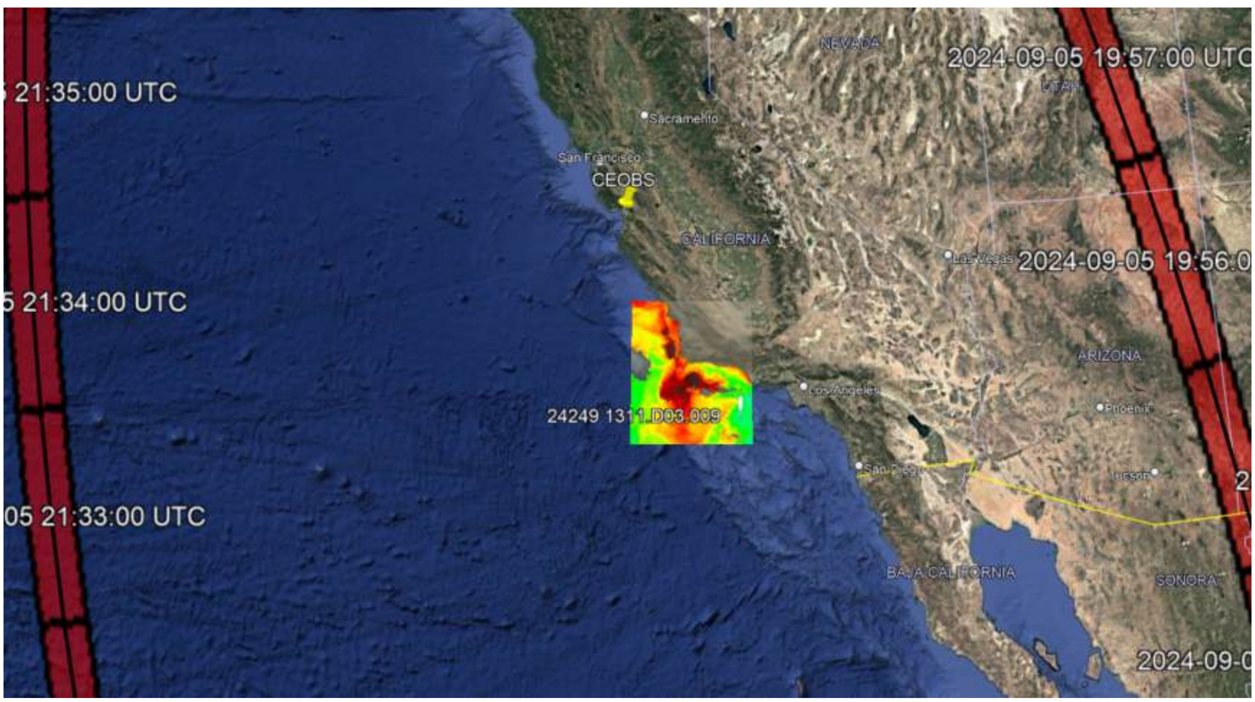
Compiled by Samuel LeBlanc, 2025/08/29
Summary: UCSB only outing – high chlorophyll

ER-2
No flight

Twin Otter
No flight

R/V UCSB
Creator: Stéphane Maritorena, Reviewed by Samuel LeBlanc
Cruise ID: RF0905-SB
Sailed out: 1050 PDT / 1750 UTM
Back in port: 1415 1515 PDT / 2115 2215 UTM

PACE
Overpass: 19:55, 21:32
Orbit track over Nevada and west offshore



All times are in UTC, VTM elements in **black** satisfied, **blue** partially satisfied and **red** not satisfied.

Time	Platform	VTM	
17:50	UCSB		Departs, UCSB Aeronet AOD=0.09
18:45	UCSB		First station
19:55	PACE,UCSB	1b	PACE overpass (first)
20:05	UCSB		End of first station
20:35	UCSB		Start of second station
21:32	UCSB,PACE	1b	PACE overpass (2nd)
21:55	UCSB		End of second station
22:15	UCSB		return

SPP: Solar Principal Plane

Assessment:

- 4.8% of objectives satisfied. Not bad for a check flight!

	PACE-PAX progress tracking														29-Aug		
															Flight details		
Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 8/29	Fractional success 9/3	Fractional success 9/4	Fractional success 9/5	Fractional success 9/6	Fractional success 9/7	Fractional success 9/8	Total success	Remaining score	time	completeness	success
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	0.5	20.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.1%	6.4	0.5	0.9	1.6
	b	Ocean radiometric parameters	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0	0.0	1.0	0.0
	c	Aerosol parameters over the ocean	12	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.0	0.0	1.0	0.0
	d	Aerosol parameters over land	12	8.0	3.0	31.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	31.3%	8.2	3.0	1.0	3.8
	e	Cloud parameters	12	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.0	0.0	1.0	0.0
	f	Ocean surface parameters	1	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0	0.0	1.0	0.0
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0	0.0	1.0	0.0
	b	Aerosol parameters over land (PACE)	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0	0.0	1.0	0.0
	c	Cloud parameters (PACE)	5	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0	0.0	1.0	0.0
	d	Aerosol parameters (EarthCARE)	8	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.0	0.0	1.0	0.0
	e	Cloud parameters (EarthCARE)	8	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.0	0.0	1.0	0.0
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0	0.0	1.0	0.0
	b	Validate large reflectances with high polarization	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0	0.0	1.0	0.0
	c	Validate large reflectances with low polarization	6	2.0	0.5	22.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22.1%	4.7	0.5	1.0	1.3
	d	Overfly vicarious calibration sites	6	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0	0.0	1.0	0.0
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0	0.0	1.0	0.0
	b	High aerosol loads over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0	0.0	1.0	0.0
	c	Multiple aerosol layers	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0	0.0	1.0	0.0
	d	Aerosol under thin cirrus	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0	0.0	1.0	0.0
	e	Aerosol above liquid phase cloud	4	2.0	0.5	11.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.8%	3.5	0.5	0.5	0.5
	f	Broken clouds with complex structure	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0	0.0	1.0	0.0
	g	Dust aerosols over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0	0.0	1.0	0.0
	h	Aerosol and ocean parameters over turbid waters	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0	0.0	1.0	0.0
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0	0.0	1.0	0.0
	k	Smoke aerosols over ocean	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0	0.0	1.0	0.0
		total:	150	98	4.5	4.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.8%		Accomplished		0.048
														total			
				ER-2 flight hours		2.8	0	0	0	0	0	0	0	2.8			
				TO flight hours		2.5	0	0	0	0	0	0	0	2.5			
				Shearwater days		0	0	0	0	0	0	0	0	0			
		PACE-PAX overall objectives satisfied:		4.8%													

UCSB station picture:

Cruise ID: RF0905-SB

Sailed out: 1050 PDT / 1750 UTM AOD~0.09 at UCSB AERONET

Back in port: 1515 PDT / 2215 UTM

Radiometry data and water samples for HPLC pigments analysis were collected at 2 stations.

Station 1: 34.3094 -119.7701 1845 – 2005 UTM – PACE Overpass at 19:55 UTM

Cloud-free sky, wind ~8-10 m/s, waves/swell: 1-2 m

Deployed a HyperPro radiometer as a buoy. Also did one profile with the HyperPro to test the pressure sensor. Pressure sensor is not working (not a problem for deployments as a float).

Deployed a C-OPS radiometer and did 2 profiles.

Collected 3 water samples at the surface for HPLC pigments analysis.

Station 2: 34.3395 -119.701 2035-2155 UTM - – 2nd PACE Overpass at 21:32 UTM

Cloud-free sky, wind ~10 m/s, waves/swell: 1-2 m

Did 2 casts with the C-OPS radiometer.

Collected 3 water samples at the surface for HPLC pigments analysis.

Did not deploy the HyperPro at station 2 as sea and wind conditions were worsening with the boat drifting significantly.

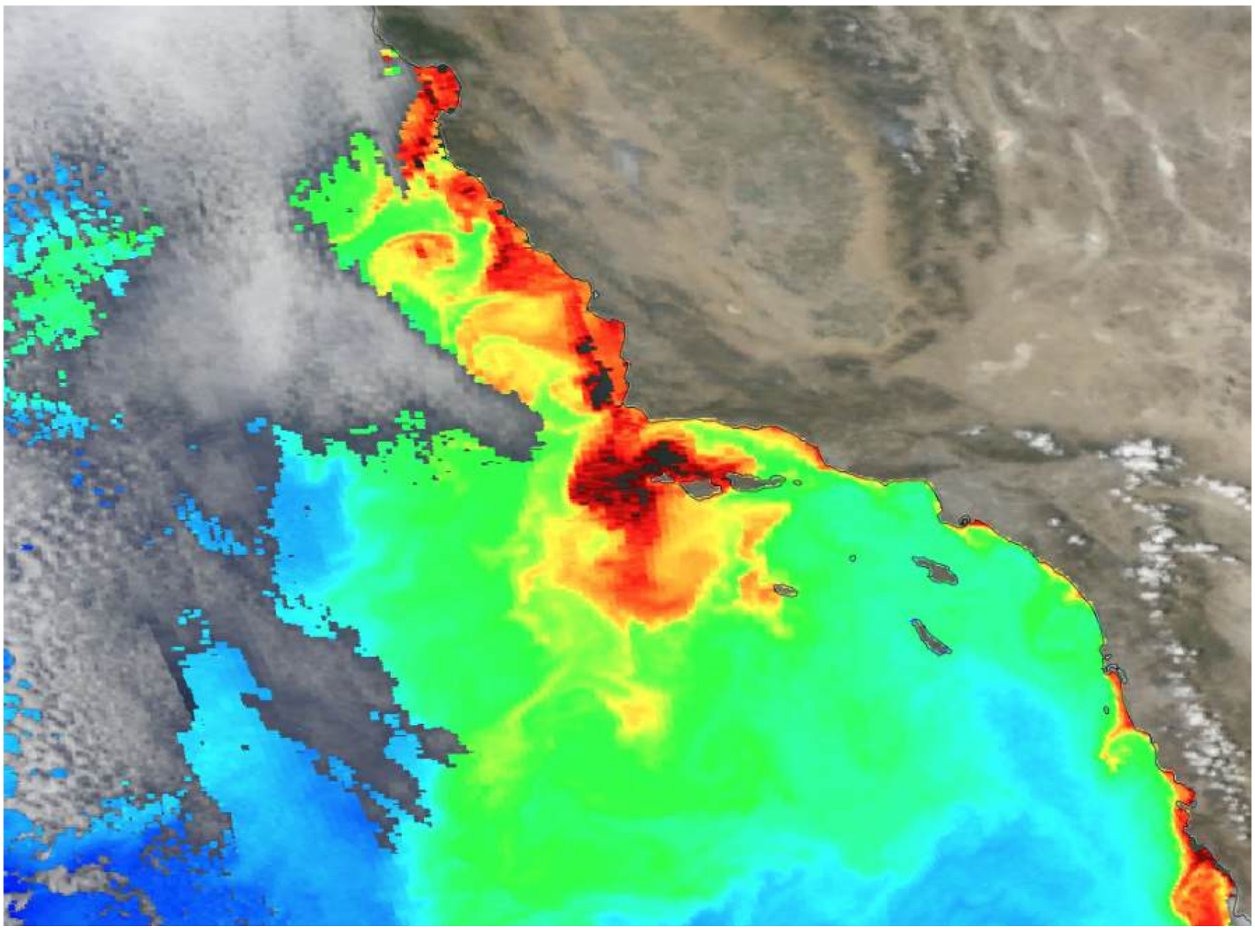
After the cruise, back at UCSB, water samples were filtered and stored in liquid nitrogen.

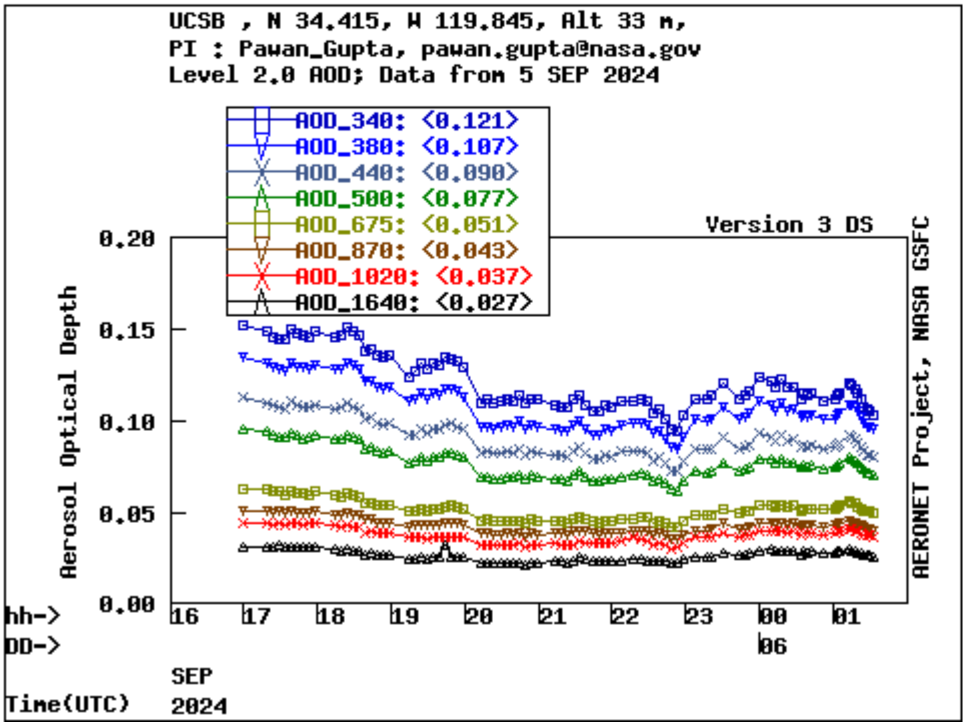
Ship plans for the coming days

Tentative days are scheduled for September 10, 12, 17, 19, 24 and 26. Go/No Go for these dates will depend on sky and weather conditions, predicted PACE overpass and scheduled PACE-PAX overflights.

System Status

The pressure sensor on the HyperPro is not working. In agreement with the PACE Validation team, the instrument has been sent back to the manufacturer for repair.





PACE satellite quicklooks

PACE-PAX research flight report 2024/09/06

Compiled by Kirk Knobelspiesse, Brian Cairns, Ivona Cetinic, Bridget Seegers, Michael Ondrusek, 2024/09/09 DRAFT
Reviewed by Samuel LeBlanc

Coordinated TO + ER2 + RS + RB + PACE operations. TO double sortie to Santa Barbara channel (Shearwater) and USC_SeaPRISM/Blissfully latter aligned with PACE overpass. ER2 overflies all in mostly cloud free conditions, including operations further north near a fire. PACE track along partly cloudy Sierra Nevada mts and over ocean near USC_SeaPRISM/Blissfully. TO RTB after refueling in Camarillo, with an intercept of smoke aerosol along return track over the Diablo mountain range.

ER-2/HSRL coolenol issue resolved. ER-2/PICARD lost some of last leg for unknown data issues. TO Humidifier not operational, no f(RH). 1st day of Shearwater operations, late departure and some instruments not yet operational.

ER-2
Takeoff: 17:03, Landing: 23:06, Duration: 6.1
Instrument status: HSRL issue from previous flight resolved. PRISM lost last data leg, issue under investigation. All other instrments good.
Mission Scientist: Kirk Knobelspiesse
Pilot: Kirt Stallings, Mobile Pilot: James ‘Coach’ Nelson

Twin Otter
First sortie
Takeoff: 17:16, Landing: 22:16, Duration: 5
Instrument status: humidifier nonfunctional, no f(rh)
Second sortie
Takeoff: 23:15, Landing: 01:04 (2024/09/07), Duration: 2
Instrument status: humidifier nonfunctional, no f(rh). PCASP off to prevent overheating.
Mission Scientist: Anthony Bucholtz
Manifest: Bryce Kujat (pilot), Jeff Martin (pilot), Luke Ziemba (QNC), Anthony Bucholtz (QNC)
See end for full Twin Otter report

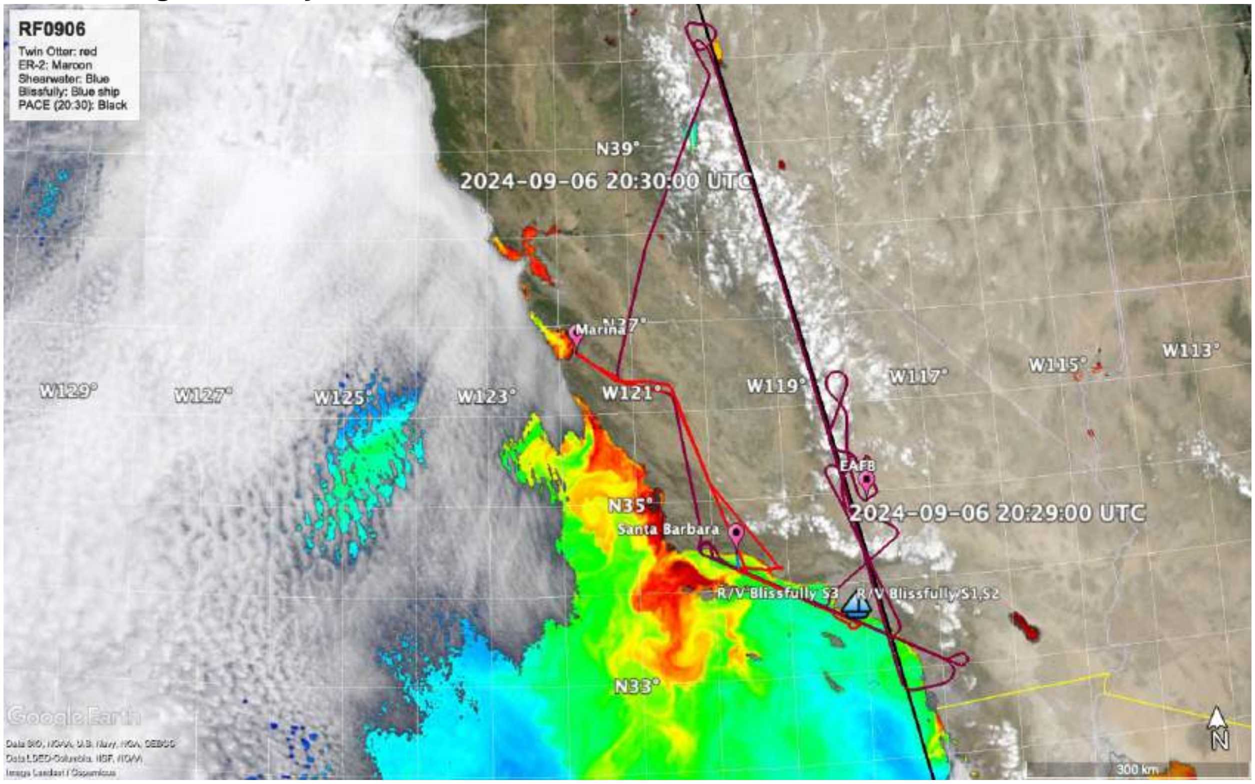
R/V Shearwater
Departure: 20:00, Return 00:19 (09/07/2024), Duration 4.3
Mission Scientist: Michael Ondrusek
See end for full R/V Shearwater report

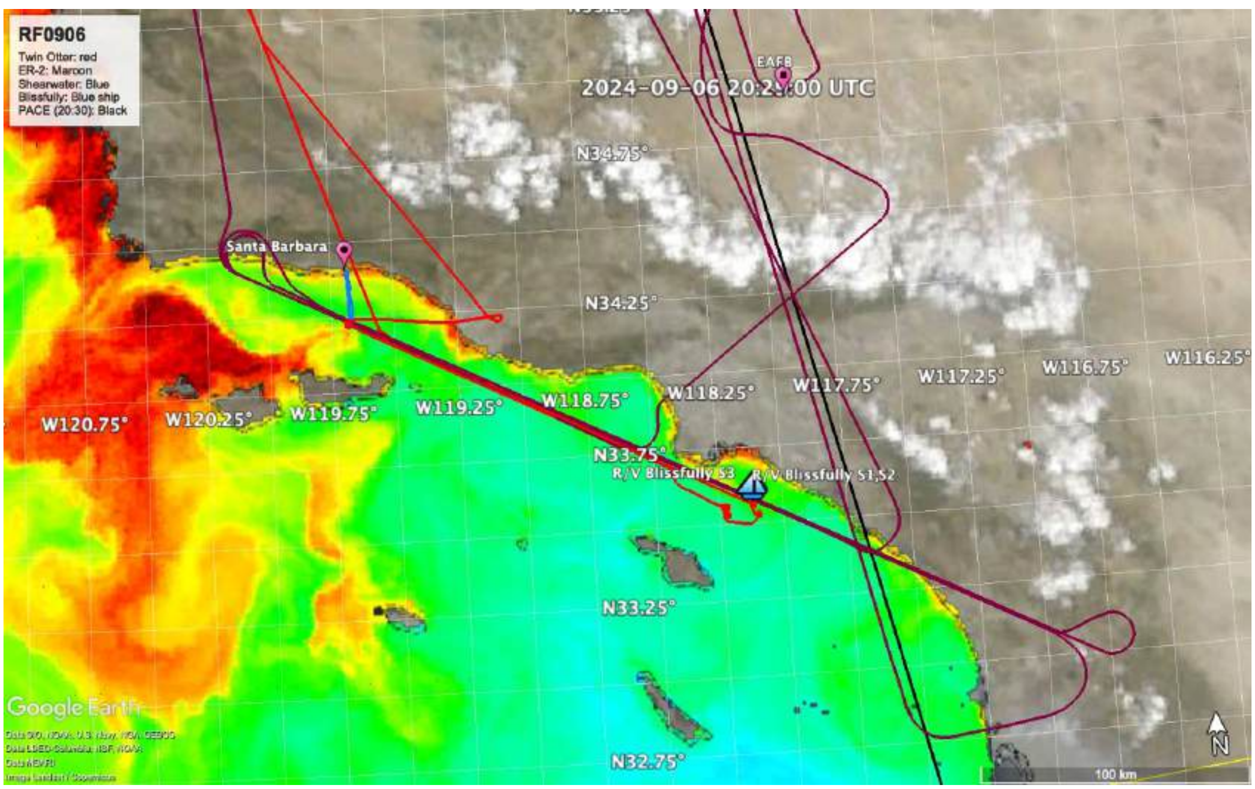
R/V Blissfully
Departure: 15:11, Return: 01:35 (09/07/24), Duration: 7.3
Instrument status: nominal
Captain/Mission Scientist: Bridget Seegers
See end for full R/V Blissfully report

PACE
Overpass: 20:30

Orbit track along Sierra Nevada mountains, East of Los Angeles, then over ocean by USC_SeaPRISM site.

Overall image summary





Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

https://www-air.larc.nasa.gov/missions/pacepax/index.html

Validation Traceability Matrix itemized objectives

VTM elements in **black** satisfied, **blue** partially satisfied and **red** not satisfied

Time	Platform	VTM(hrs)	
15:11	RB		Departure
17:03	ER2		Takeoff
17:16	TO		Takeoff (sortie 1)
18:01	ER2, RB	1b(1.0), 1c(0.5)	ER-2 over RB and USC_SeaPRISM AERONET-OC AOD(510)=0.15. Partly cloudy
18:36	ER2, TO	1d(1.0)	ER-2 overfly TO line, although ER-2 is late by ~20 min.
18:51	ER2	1d(0.5)	ER-2 overflight of Turlock_CA AERONET site AOD(500)=0.19
19:11	ER2	1d(0.5),6h(0.5)	ER-2 overflight of U. Nevada Reno CA AERONET site AOD(500)=0.18, over pyramid lake
19:47	ER2	6h(0.5)	ER-2 overflly of Mono lake turbid waters, within 1h from PACE
19:51	ER2	1d(0.5)	ER-2 overflight of Mammoth CUES AERONET site AOD(500)=0.12, possible cloud
20:00	RS		Departure
20:18	ER2	1d(1.0),1e(1.0), 3b(1.0),3c(1.0), 6f(1.0)	Over land section in PACE-OHS swath, mostly cloud free but with broken clouds in sections
20:30	ER2	1b(1.0),1c(1.0), 3a(1.0)	Over ocean section in PACE-OHS swath., Cloud free. Ocean params partially satisfied with HSRL2
20:30	RB	1b(1.0),1c(0.5), 3a(1.0)	RB + USC_SeaPRISM AERONET-OC AOD(510)=0.13 in PACE-OHS swath
20:30	**PACE**		**Overpass**
20:37	ER2	1c(0.5),6b(0.5),6k(0.5)	ER2 over AERONET (La_Jolla) AOD(500nm) ~0,4
20:55	ER2, RB	1b(0.5), 1c(0.5)	ER2 overfly R/V Blissfully & USC_SeaPRISM AERONET-OC, AOD(510)=0.12
20:56	ER2, TO,RB	1c(1.5)	ER2 overfly TO as it is doing a spiral down over USC_SeaPRISM and RV Blissfully
20:58	ER2	1f(2.0), 4b(2.0)	Much of this line has significant sunglint
21:03	ER2, RS	1b(1.0), 1c(1.0)	ER-2 over R/V Shearwater
21:27	ER2, RB	1b(1.0), 1c(1.0)	ER-2 over R/V Blissfully and USC_SeaPRISM AERONET-OC
21:42	ER2, RS, TO	1b(1.0), 1c(2.5)	ER-2 over R/V Shearwater and Twin Otter spiral
22:01	ER2, RS	1b(1.0), 1c(1.0)	ER-2 over R/V Shearwater
22:16	TO		Landing (sortie 1)
22:32	ER2	1d(0.5)	ER-2 over CalTech AERONET, AOD(500)=0.13
23:06	ER2		Landing
23:15	TO		Takeoff (sortie 2)

23:40	TO		Transiting back along same path as L1, within the smoke aerosol layer
00:19	RS		Return
00:30	TO		Again in smoke layer on transit back
01:04	TO		Landing (sortie 2)
01:35	RB		Return

PACE-OHS: within PACE OCI, HARP2 and SPEXone swath
SPP: Solar Principal Plane
ER2: ER-2
TO: Twin Otter
RS: R/V Shearwater
RB: R/V Blissfully

Assessment:

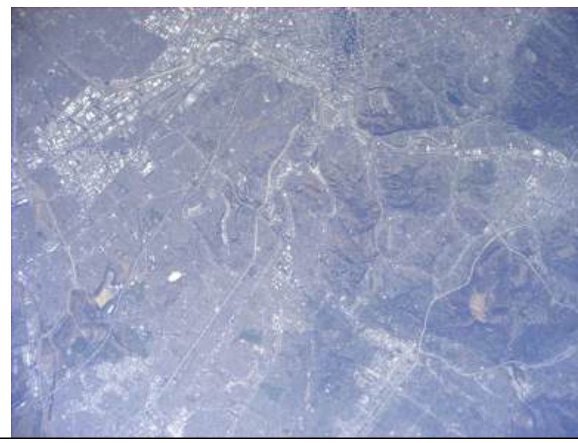
- 14.9% of objectives satisfied. Most successful day of operations thus far.
- Value of bringing TO down to Southern California shown, although we should note that a spiral of TO over an ocean asset without a satellite or ER-2 overpass has little value.
- Top remaining objectives: PACE aerosol in narrow swath (3a,b), EarthCARE (3d,3e) and cloud validation (1e)

PACE-PAX progress tracking

Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 8/29	Fractional success 9/3	Fractional success 9/4	Fractional success 9/5	Fractional success 9/6	Fractional success 9/7	Fractional success 9/8	Total success	Remaining score
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	0.5	20.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.1%	6.4
	b	Ocean radiometric parameters	10	8.0	14.5	0.0%	0.0%	0.0%	0.0%	55.6%	0.0%	28.1%	83.7%	1.6
	c	Aerosol parameters over the ocean	12	8.0	11.8	0.0%	0.0%	6.1%	0.0%	64.4%	0.0%	6.5%	77.0%	2.8
	d	Aerosol parameters over land	12	8.0	21.0	39.3%	24.4%	8.0%	0.0%	8.8%	0.0%	12.1%	92.7%	0.9
	e	Cloud parameters	12	8.0	7.0	0.0%	0.0%	39.3%	0.0%	0.0%	19.0%	0.0%	58.3%	5.0
	f	Ocean surface parameters	1	8.0	2.0	0.0%	0.0%	0.0%	0.0%	22.1%	0.0%	0.0%	22.1%	0.8
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	2.0	0.0%	0.0%	0.0%	0.0%	22.1%	0.0%	0.0%	22.1%	7.8
	b	Aerosol parameters over land (PACE)	10	8.0	1.0	0.0%	0.0%	0.0%	0.0%	11.8%	0.0%	0.0%	11.8%	8.8
	c	Cloud parameters (PACE)	5	2.0	1.5	0.0%	0.0%	39.3%	0.0%	13.4%	0.0%	0.0%	52.8%	2.4
	d	Aerosol parameters (EarthCARE)	8	4.0	2.5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	46.5%	46.5%	4.3
	e	Cloud parameters (EarthCARE)	8	4.0	0.5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.8%	11.8%	7.1
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0
	b	Validate large reflectances with high polarization	6	2.0	2.0	0.0%	0.0%	0.0%	0.0%	63.2%	0.0%	0.0%	63.2%	2.2
	c	Validate large reflectances with low polarization	6	2.0	2.0	22.1%	0.0%	30.6%	0.0%	0.0%	0.0%	10.4%	63.2%	2.2
	d	Overfly vicarious calibration sites	6	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	2.0	1.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	39.3%	39.3%	2.4
	b	High aerosol loads over ocean	4	2.0	1.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	39.3%	39.3%	2.4
	c	Multiple aerosol layers	1	2.0	4.1	0.0%	87.3%	0.0%	0.0%	0.0%	0.0%	0.0%	87.3%	0.1
	d	Aerosol under thin cirrus	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0
	e	Aerosol above liquid phase cloud	4	2.0	3.5	22.1%	0.0%	0.0%	0.0%	0.0%	60.5%	0.0%	82.6%	0.7
	f	Broken clouds with complex structure	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0
	g	Dust aerosols over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0
	h	Aerosol and ocean parameters over turbid waters	2	2.0	0.5	0.0%	0.0%	22.1%	0.0%	0.0%	0.0%	0.0%	22.1%	1.6
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0
	k	Smoke aerosols over ocean	1	2.0	1.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	39.3%	39.3%	0.6
		total:	150	98	79.3	0.057	0.025	0.071	0.000	0.149	0.031	0.092	0.427	
					prior to this week									total
				ER-2 flight hours	1.3	2.8	0	4.7	0	6.1	0	5.3	0	18.9
				TO flight hours	0	2.4	3.4	3.8	0	7	3.9	1.7	0	22.2
				Shearwater days		0	0	0	0	1	0	1	0	2

PACE-PAX overall objectives satisfied: 0.427

ER-2/MVIS images

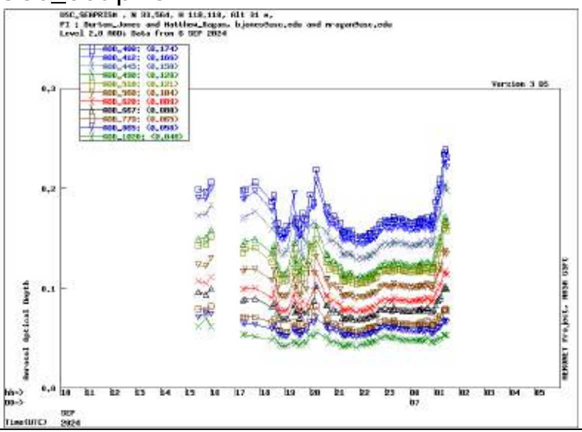
18:01:00 	20:30:00 PACE overpass 
20:56:00 ER2+TO+RB+USC_SeaPRISM 	22:32 ER-2 over CalTech Aeronet 

Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

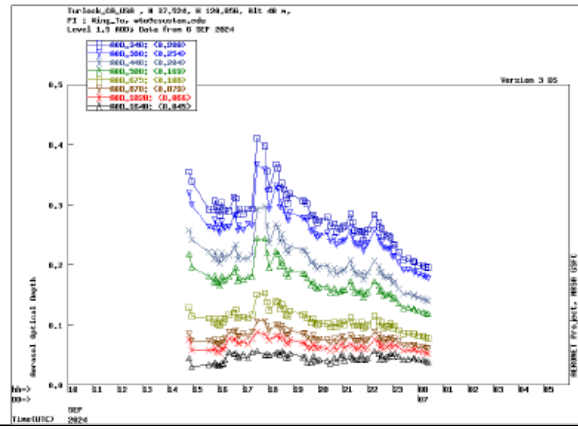
https://www-air.larc.nasa.gov/missions/pacepax/index.html

AERONET quicklooks

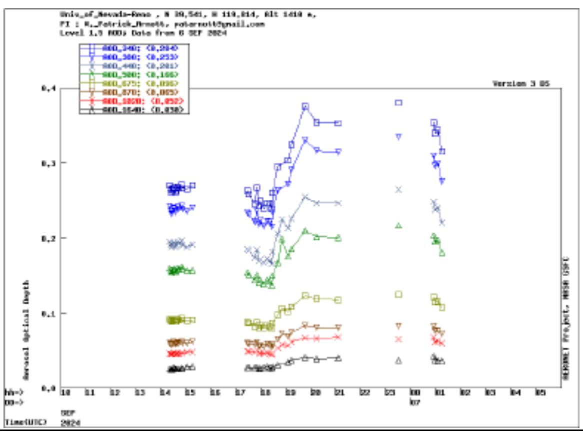
Usc_seaprism



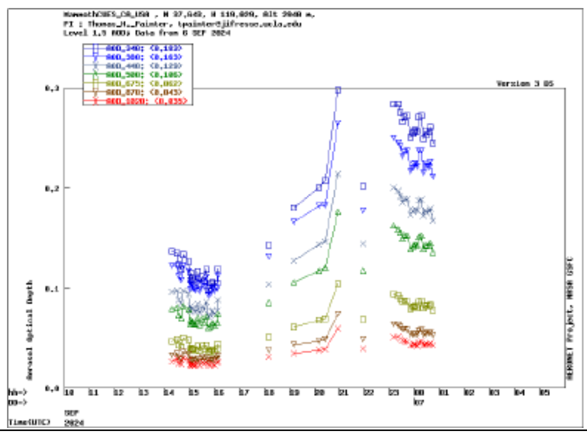
Turlock



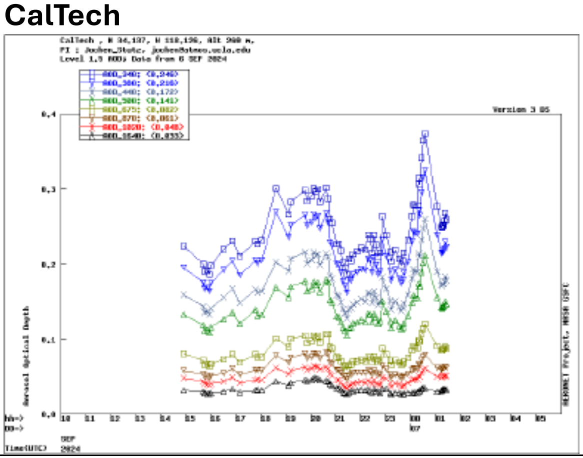
U. Nevada Reno



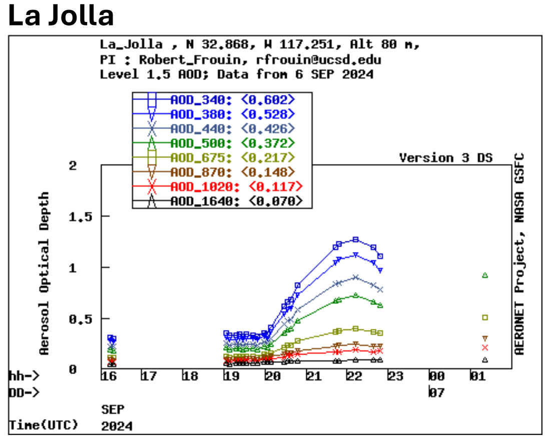
Mammoth CUES



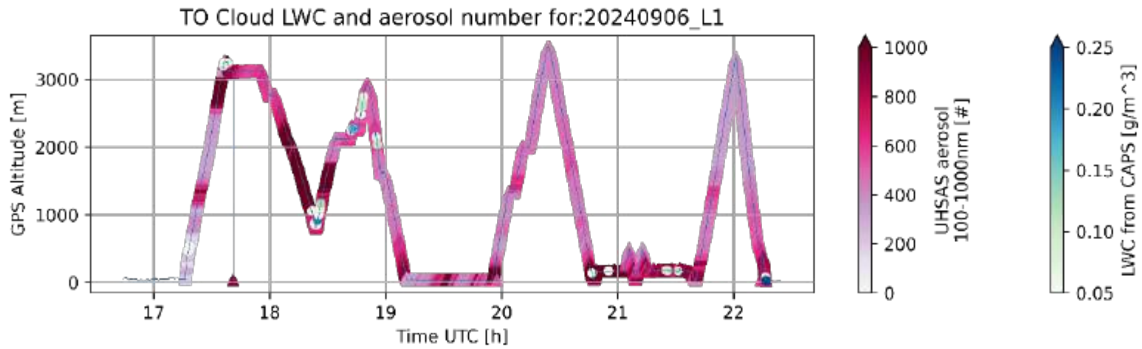
CalTech

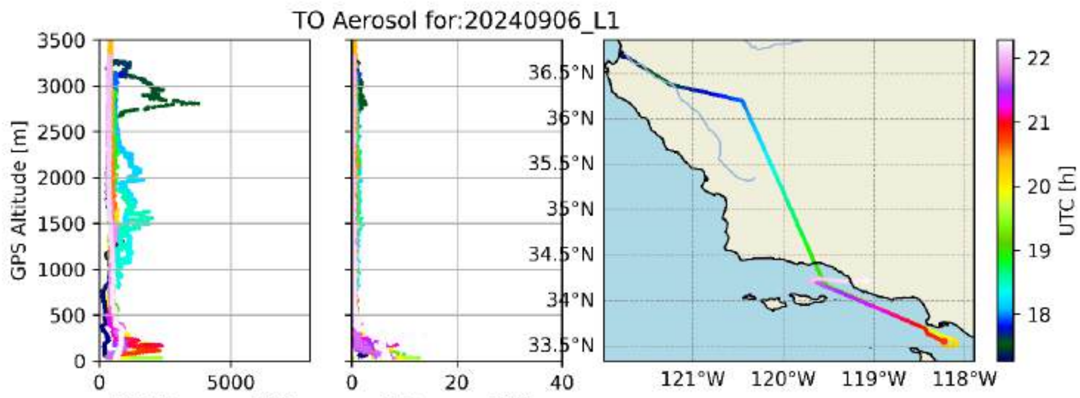


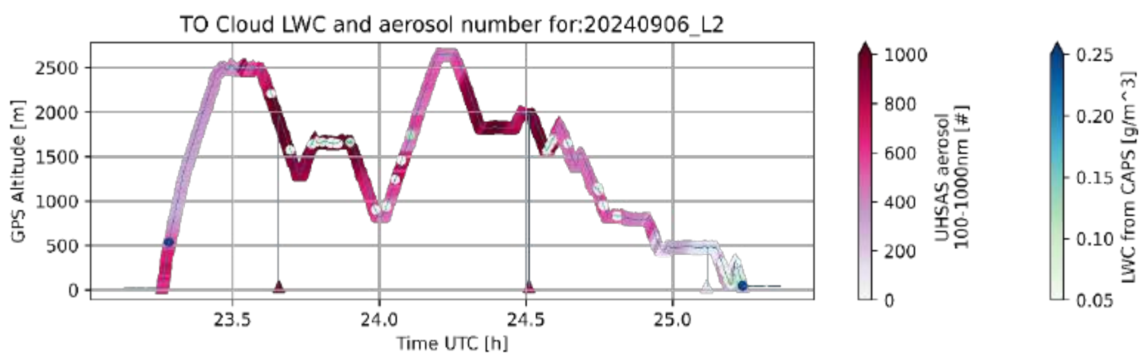
La Jolla

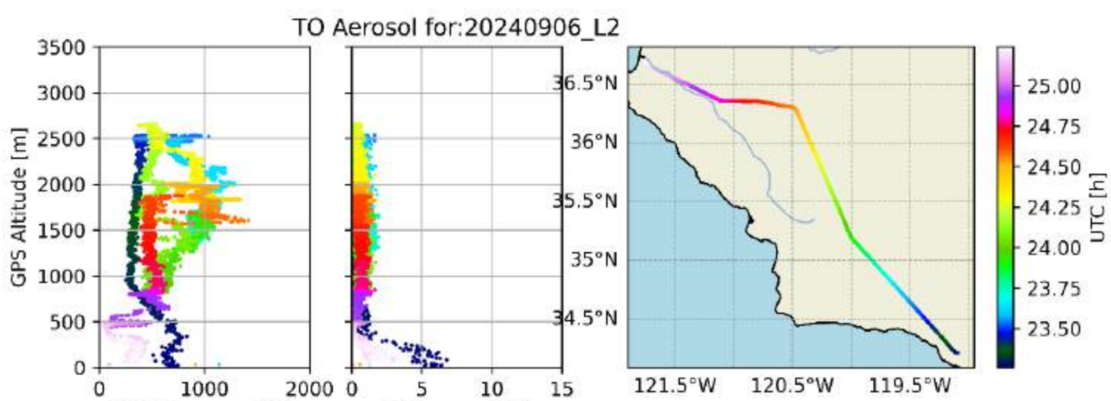


TO Quicklooks

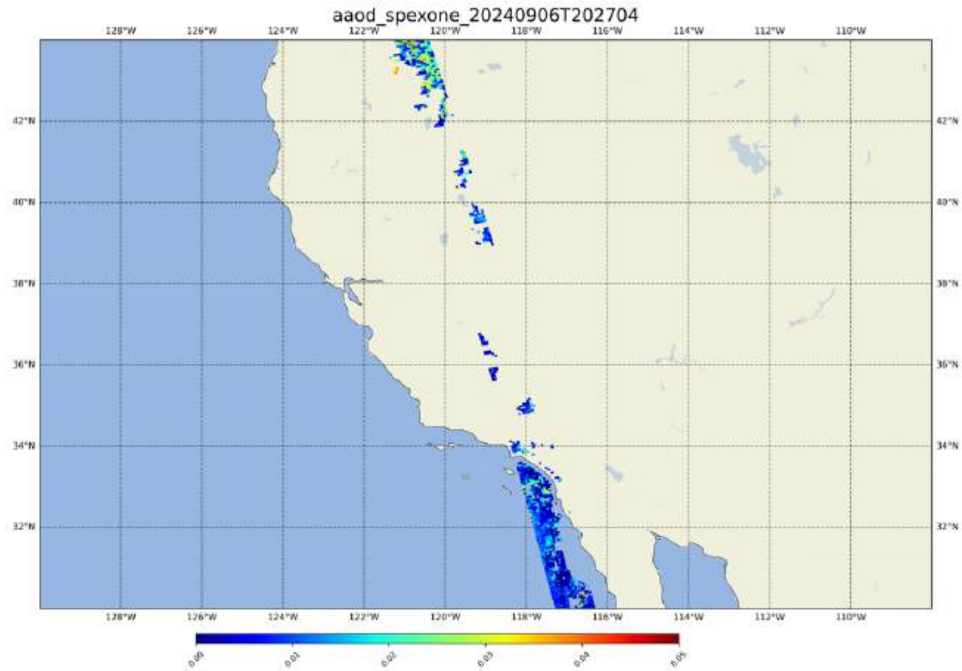


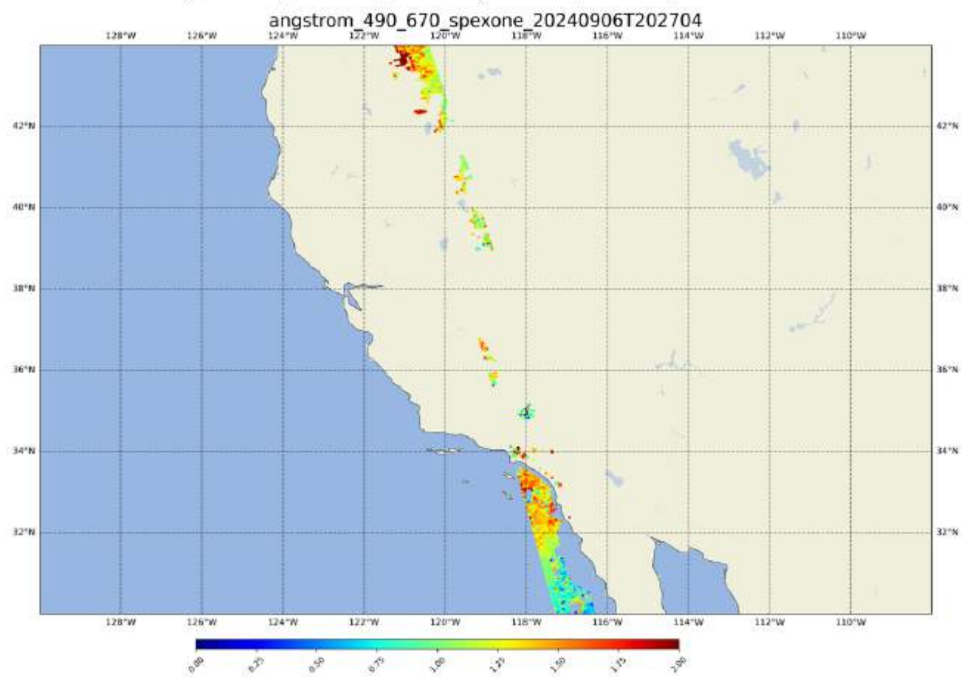


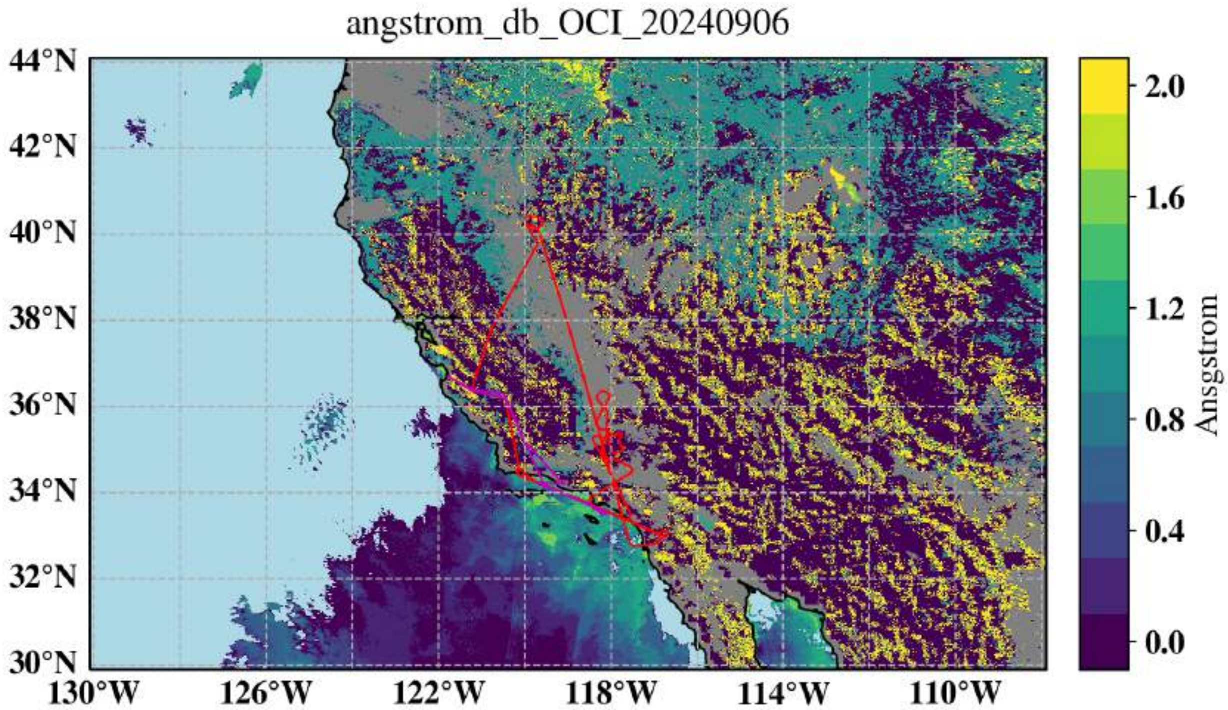




PACE Satellite products







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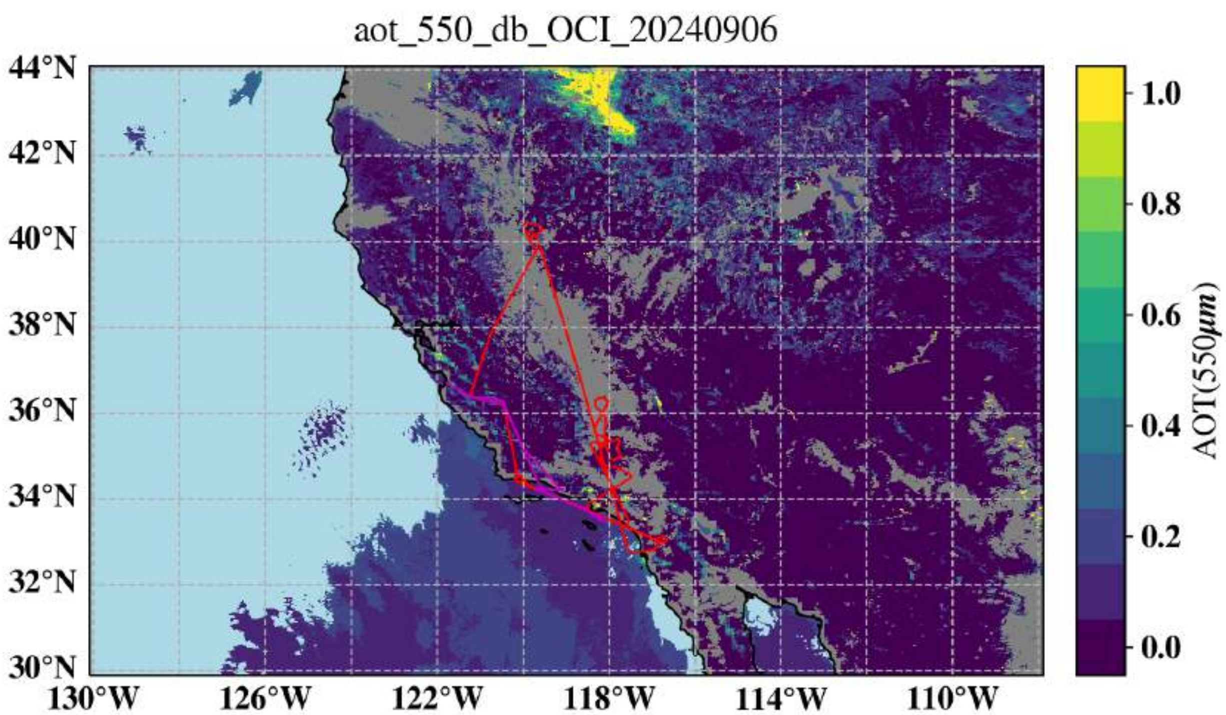
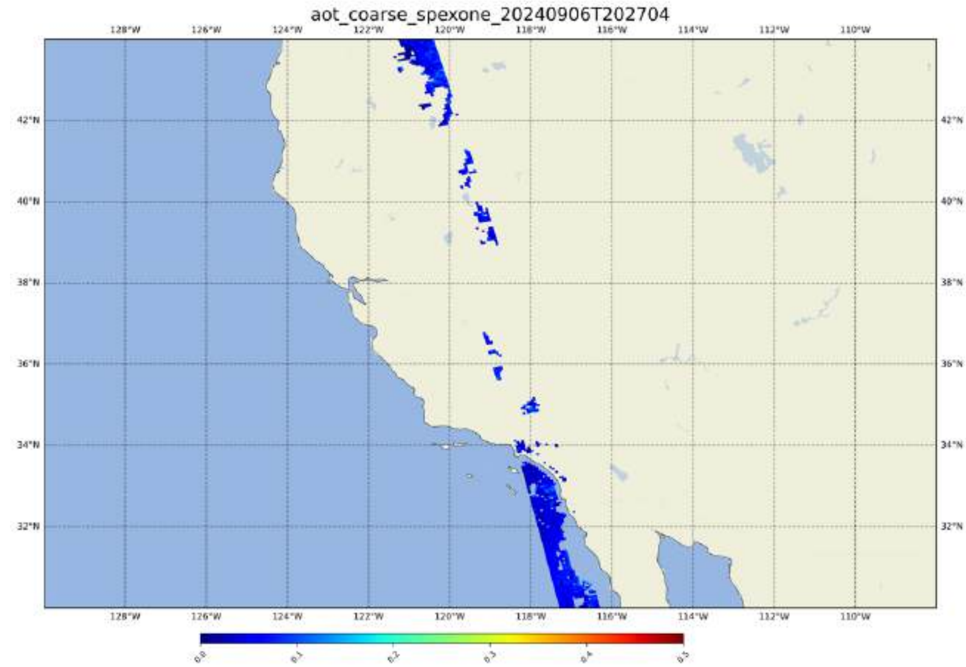
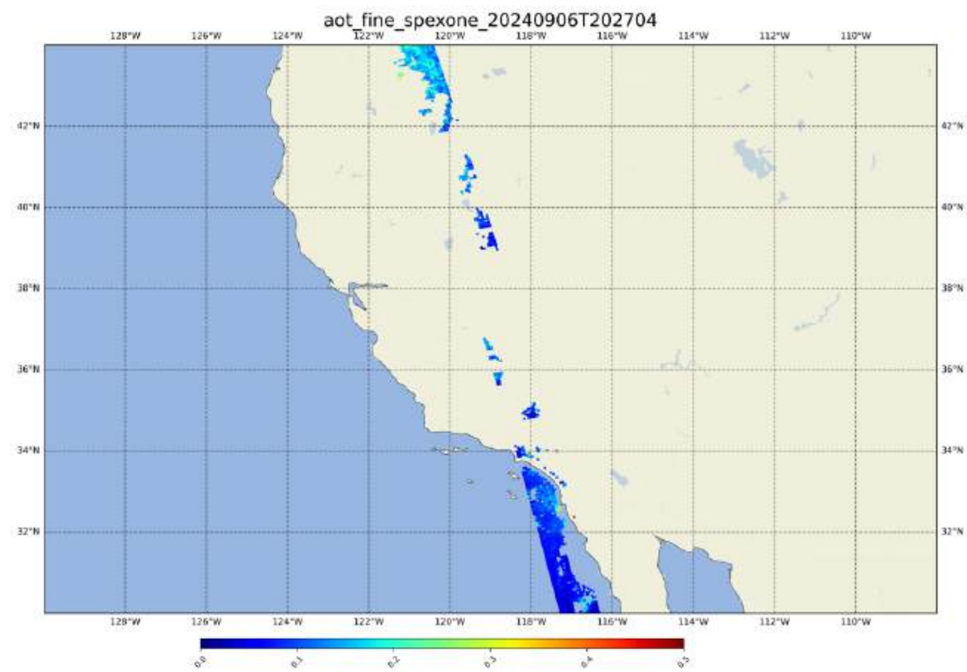
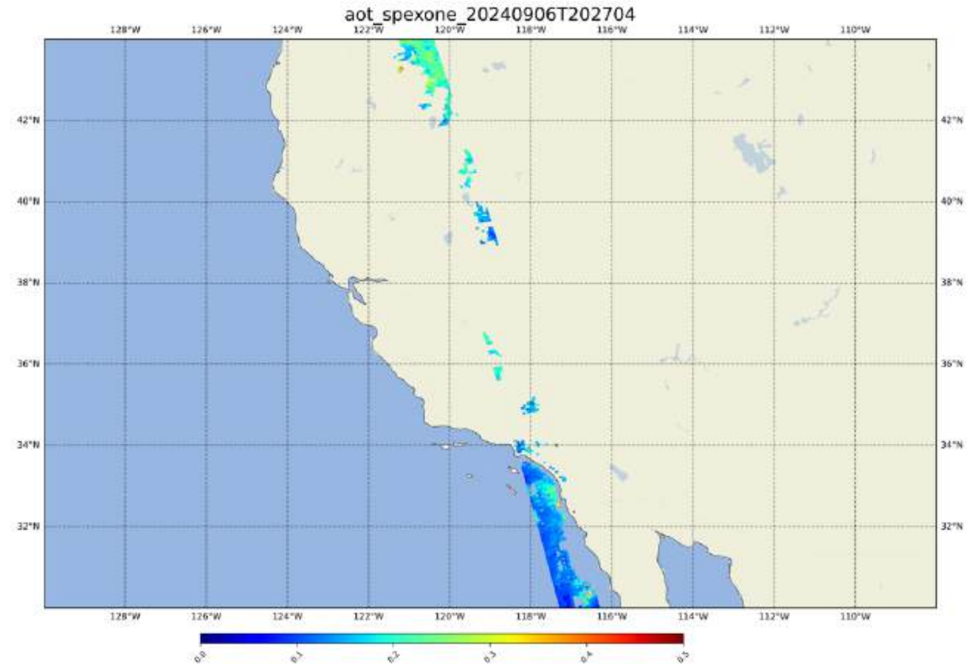
Ansgstrom

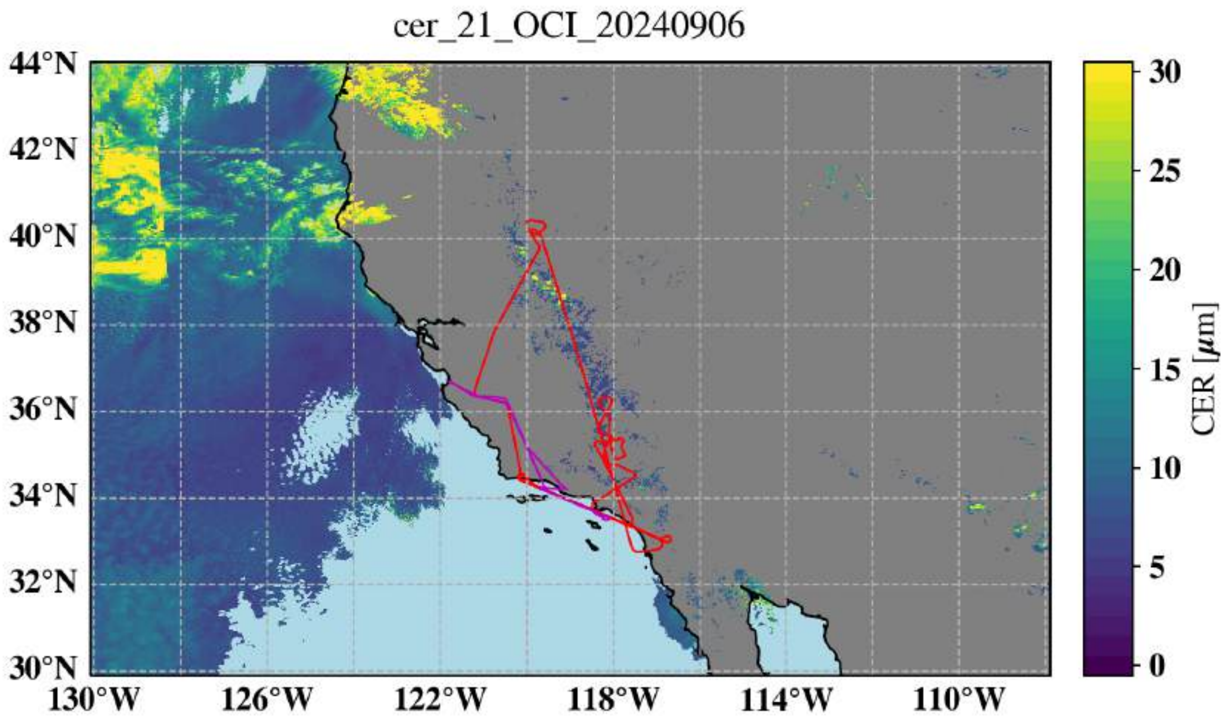


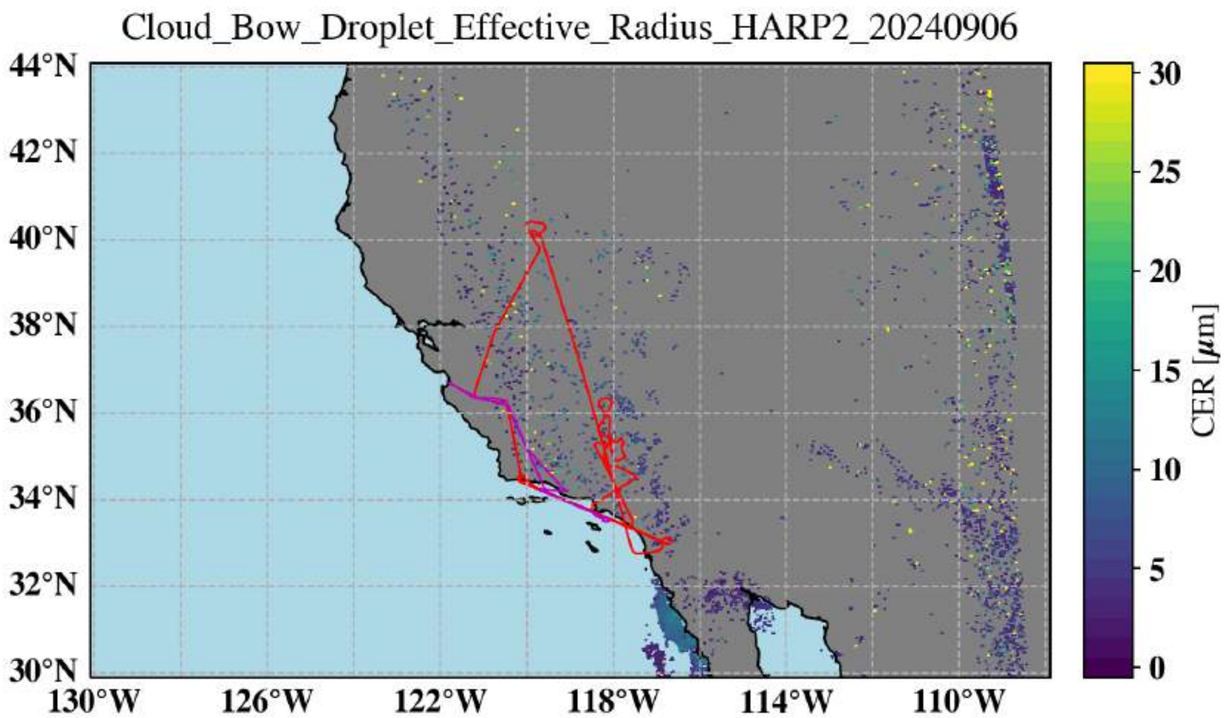
aot_550_db_OCI_20240906
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
1.0
0.8
0.6
0.4
0.2
0.0
AOT(550μm)

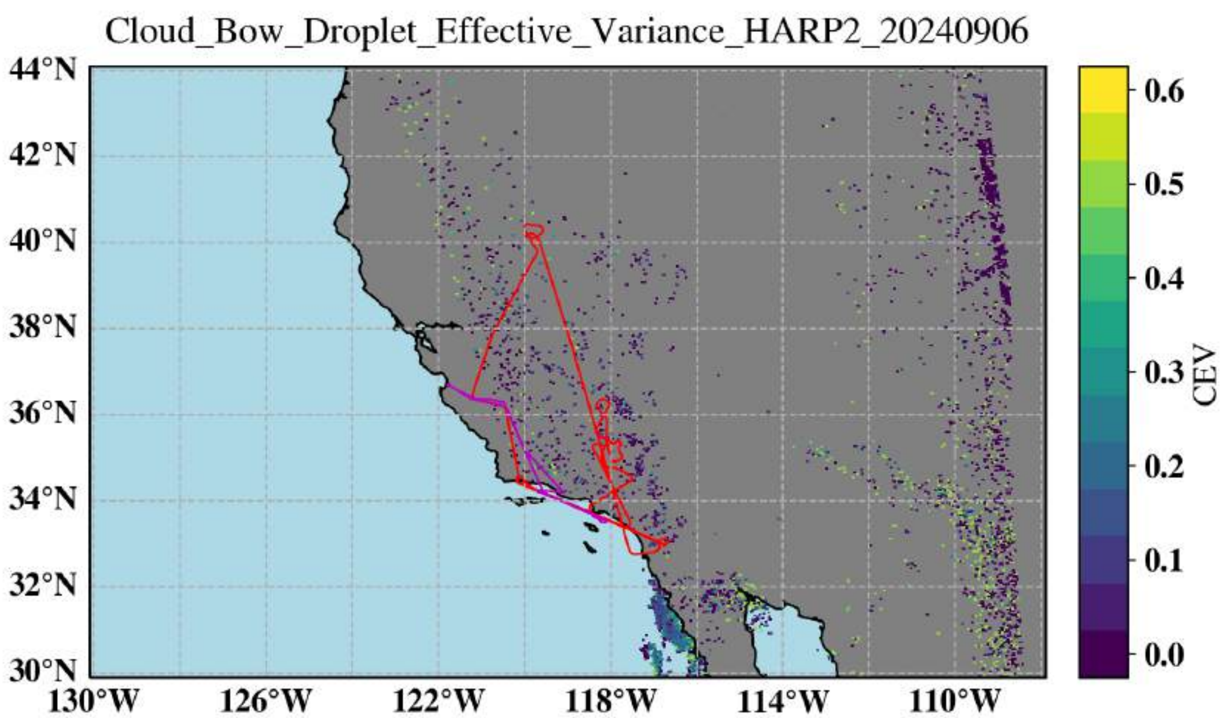

aot_coarse_spexone_20240906T202704

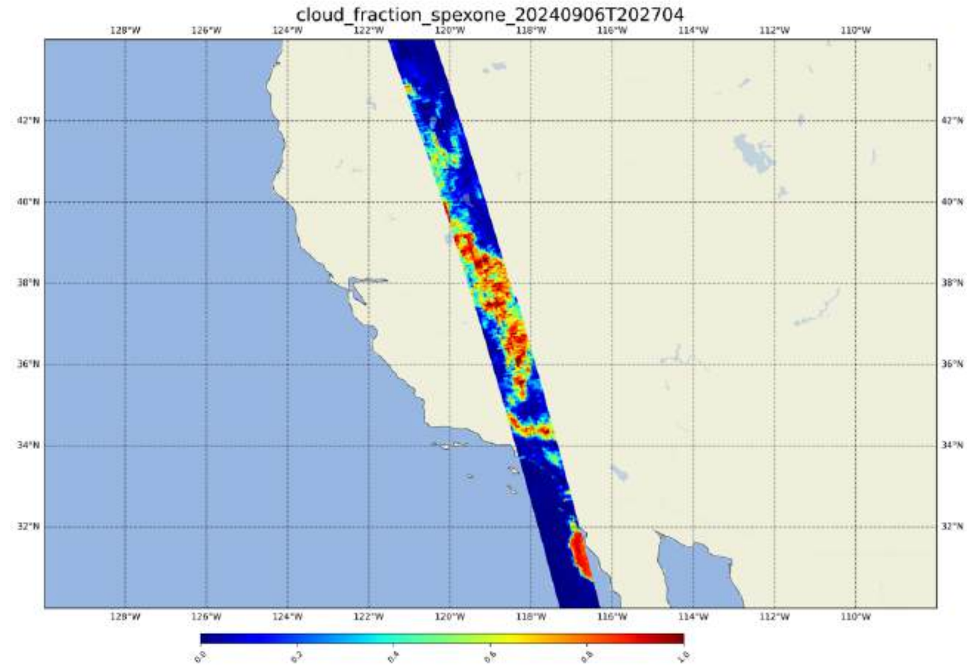

aot_fine_spexone_20240906T202704

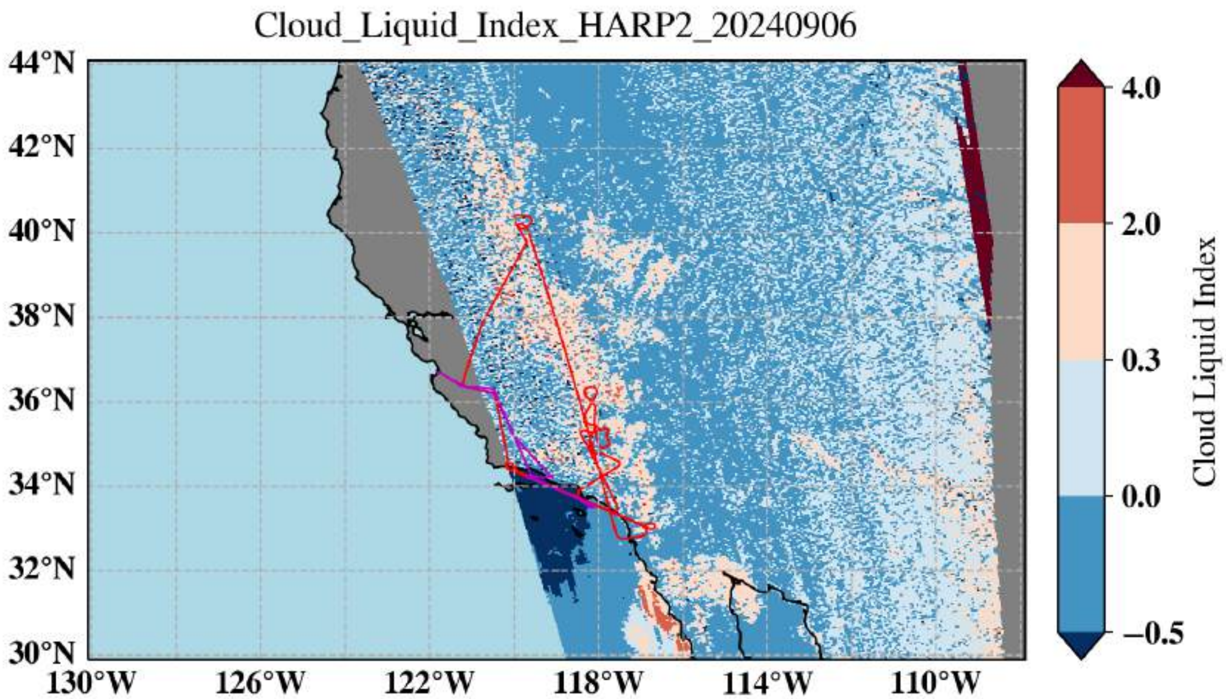

aot_spexone_20240906T202704
128°W
126°W
124°W
122°W
120°W
118°W
116°W
114°W
112°W
110°W
42°N
40°N
38°N
36°N
34°N
32°N

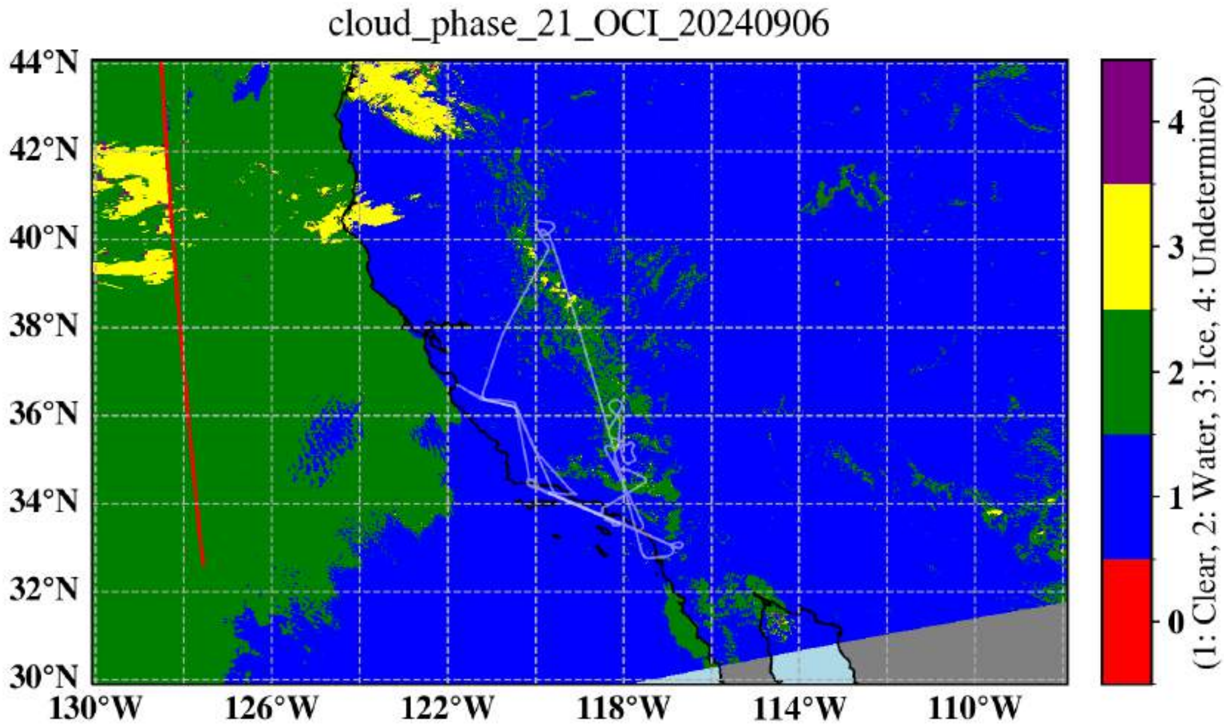

cer_21_OCI_20240906
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
CER [μm]
30
25
20
15
10
5
0

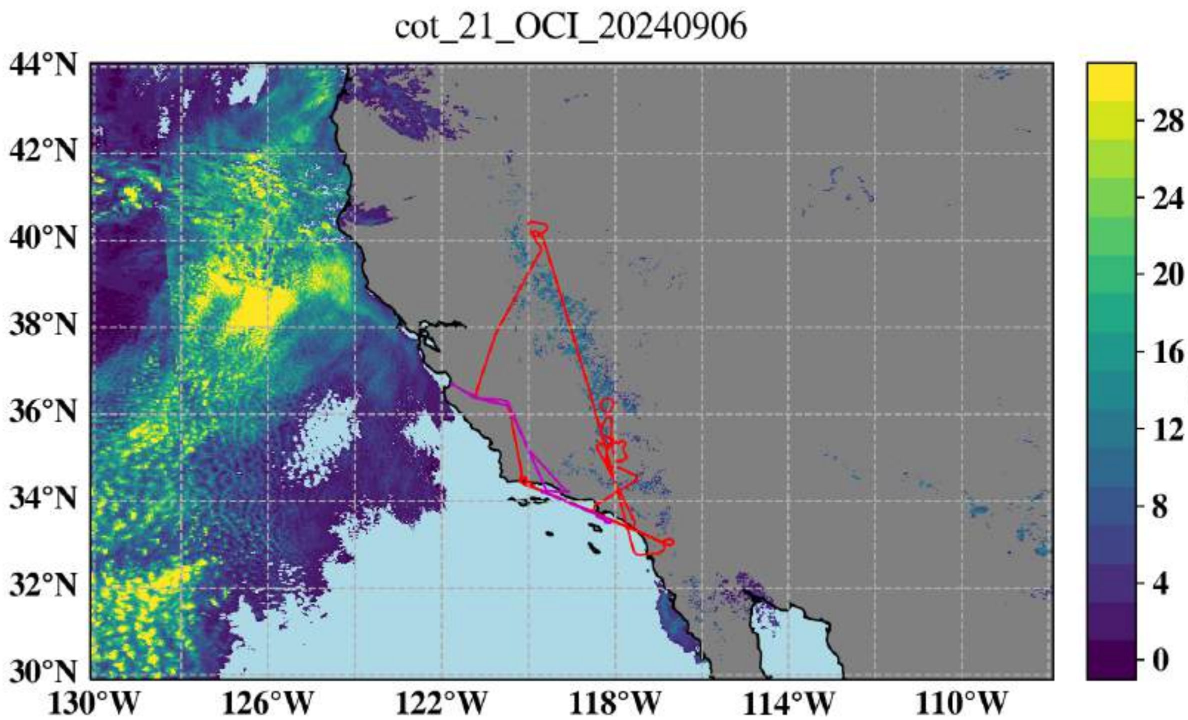

Cloud_Bow_Droplet_Effective_Radius_HARP2_20240906
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
30
25
20
15
10
5
0
CER [μm]

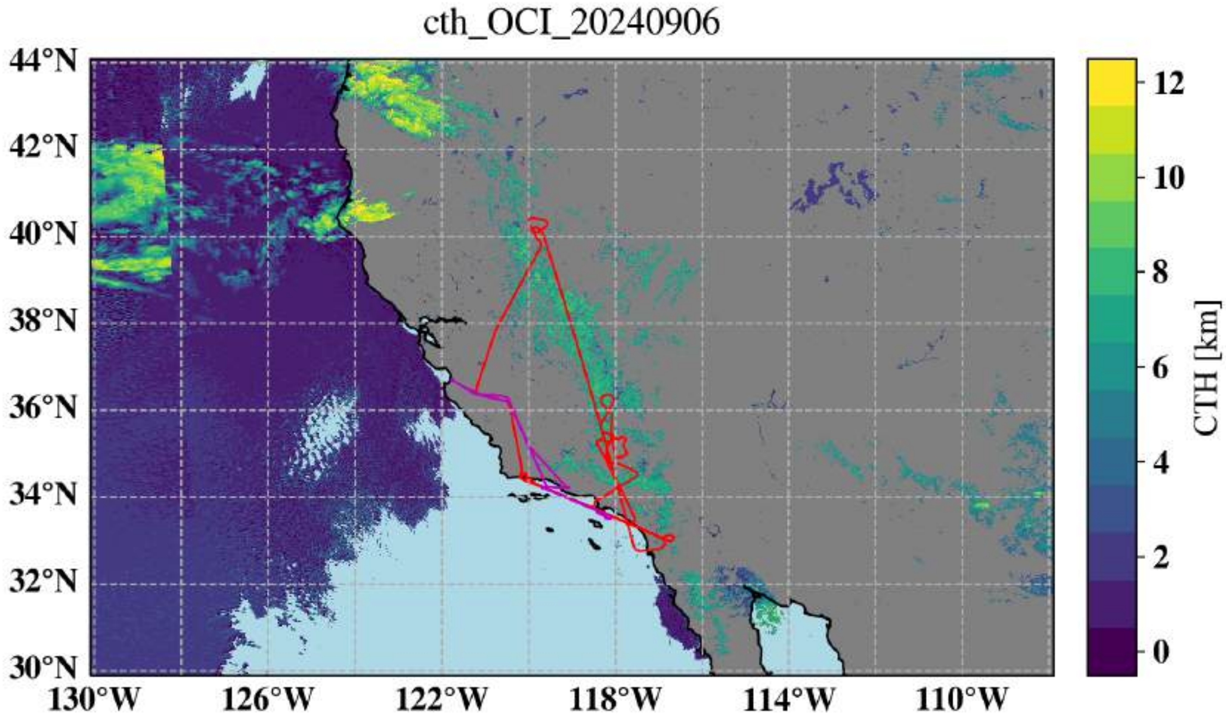

Cloud_Bow_Droplet_Effective_Variance_HARP2_20240906
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0.6
0.5
0.4
0.3
0.2
0.1
0.0
CEV


cloud_fraction_spexone_20240906T202704

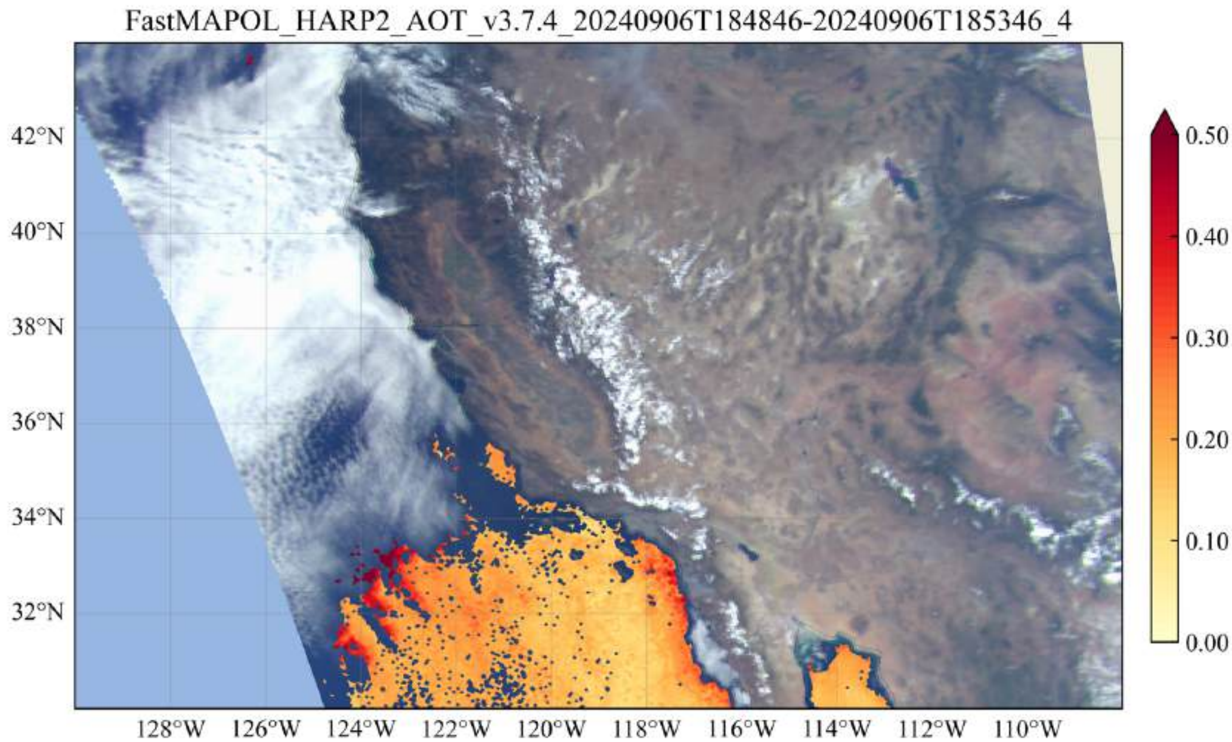

Cloud_Liquid_Index_HARP2_20240906
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
4.0
2.0
0.3
0.0
−0.5
Cloud Liquid Index


cloud_phase_21_OCI_20240906
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0
1
2
3
4
(1: Clear, 2: Water, 3: Ice, 4: Undetermined)

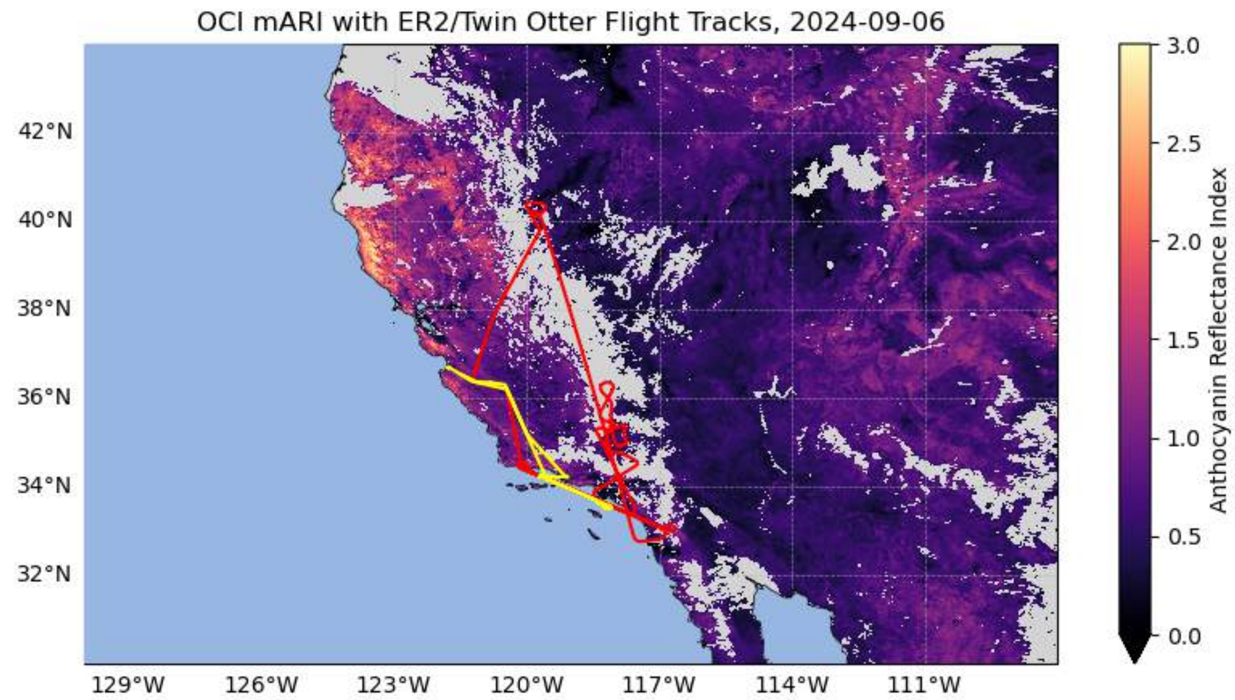

cot_21_OCI_20240906
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0
4
8
12
16
20
24
28
COT

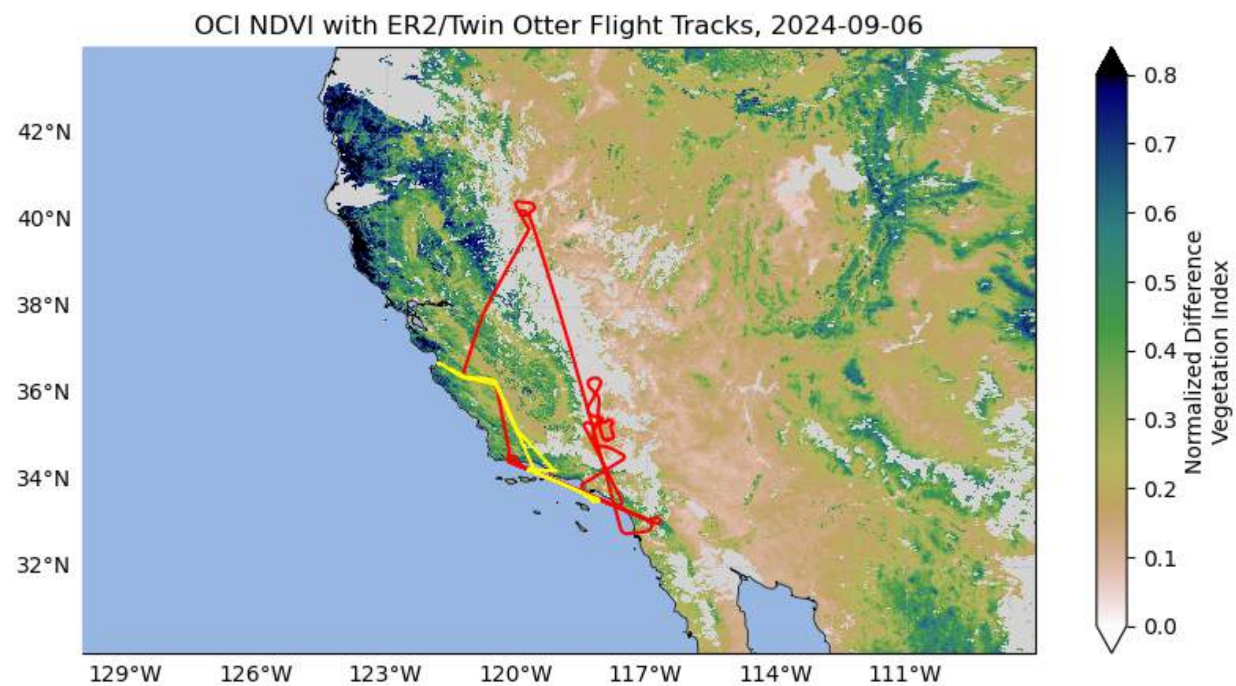


cth_OCI_20240906
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
CTH [km]
0
2
4
6
8
10
12

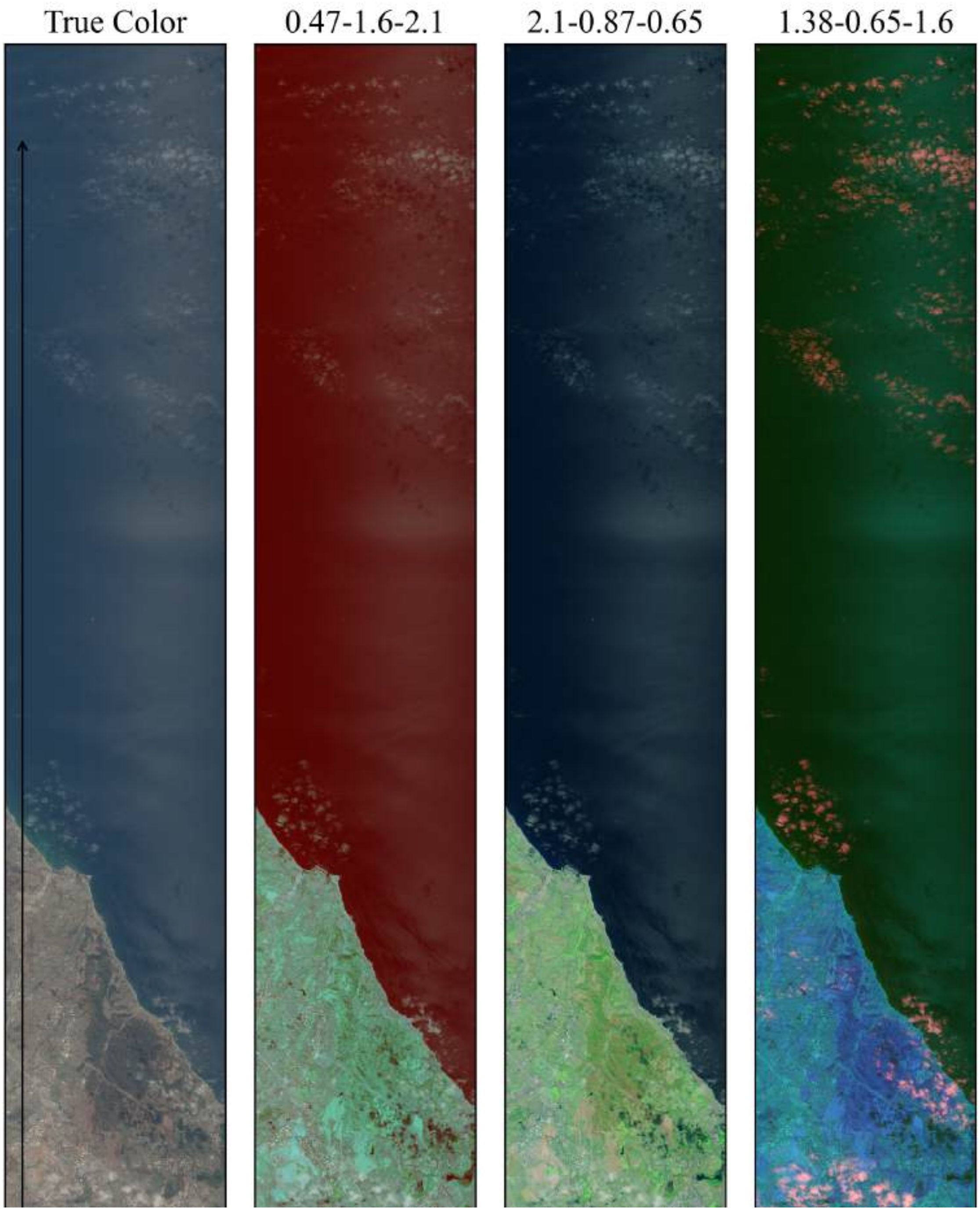


FastMAPOL_HARP2_AOT_v3.7.4_20240906T184846-20240906T185346_4
42°N
40°N
38°N
36°N
34°N
32°N
128°W
126°W
124°W
122°W
120°W
118°W
116°W
114°W
112°W
110°W
0.50
0.40
0.30
0.20
0.10
0.00


OCI mARI with ER2/Twin Otter Flight Tracks, 2024-09-06
42°N
40°N
38°N
36°N
34°N
32°N
129°W
126°W
123°W
120°W
117°W
114°W
111°W
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Anthocyanin Reflectance Index

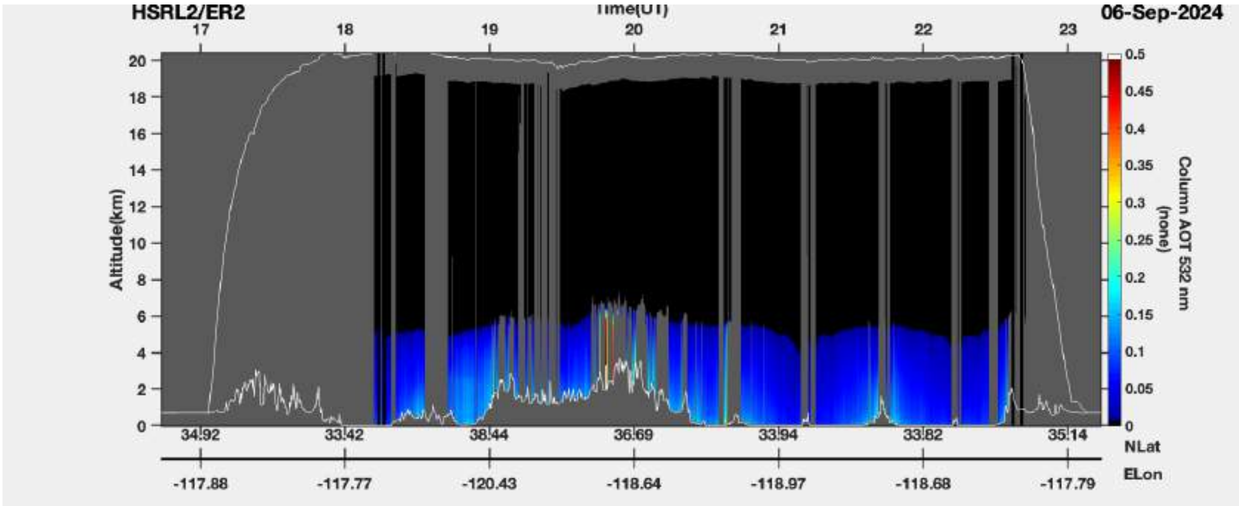

OCI NDVI with ER2/Twin Otter Flight Tracks, 2024-09-06
42°N
40°N
38°N
36°N
34°N
32°N
129°W
126°W
123°W
120°W
117°W
114°W
111°W
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Normalized Difference
Vegetation Index

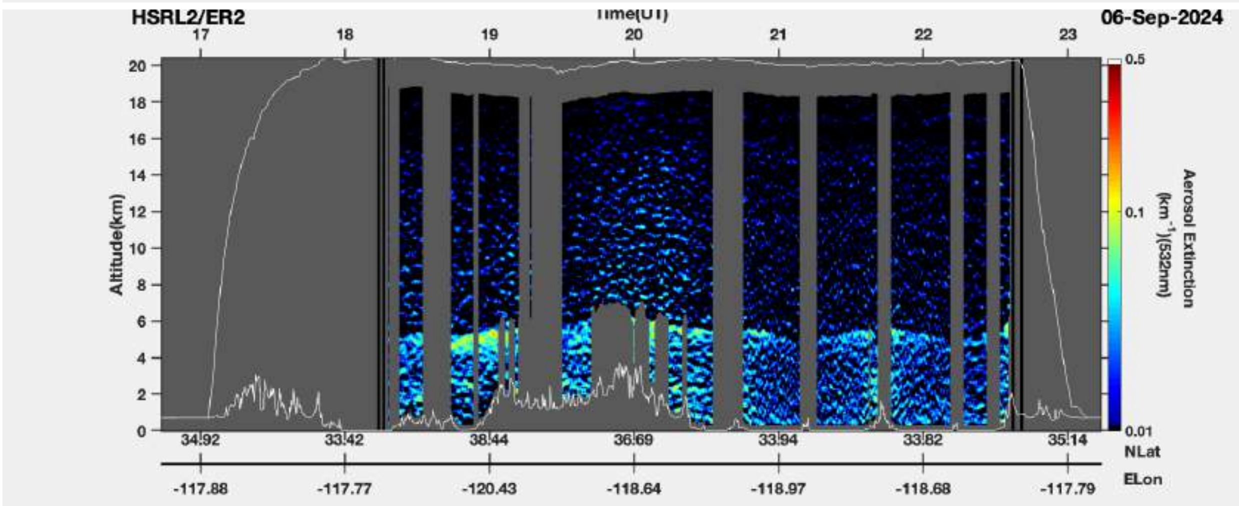
PACE-PAX quicklooks

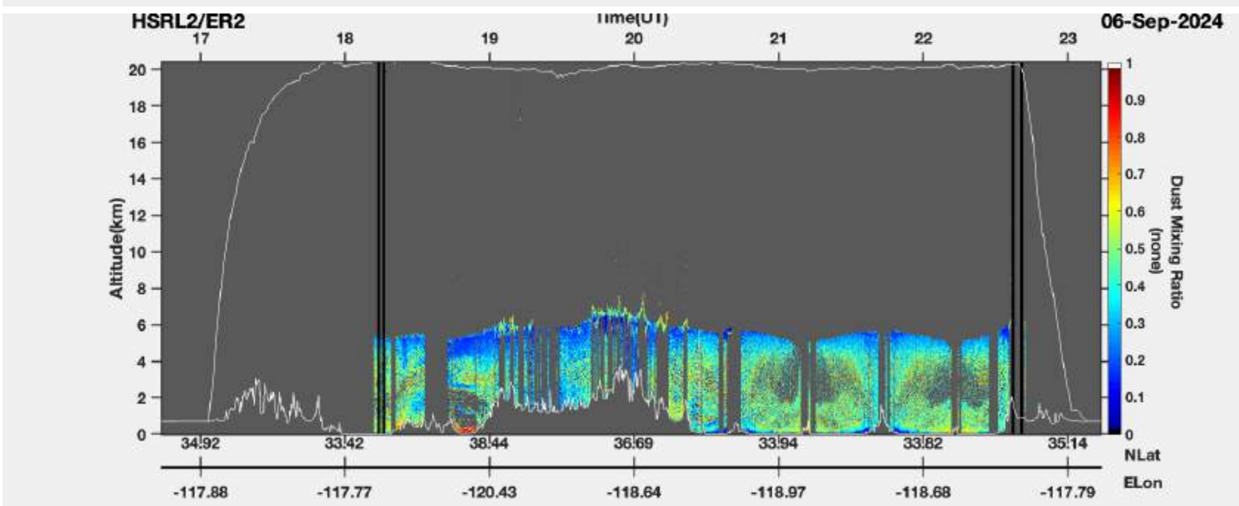


PICARD end of PACE track line. More PICARD quicklooks here:
https://asapdata.arc.nasa.gov/picard/data/flt_html/24622.html

ER2 / HSRL quicklooks







Twin otter flight report

PACE-PAX Research Flight report 2024/09/06

Double-Sortie Twin Otter Flight

Manifest:

Bryce Kujat (pilot)

Jeff Martin (pilot)

Luke Ziemba (QNC)

Anthony Bucholtz (QNC)

Launch 1:

Take off: 10:16:15 (17:16:15 UTC) Marina Airport (OAR)

Landing: 15:16:54 (22:16:54 UTC) Camarillo Airport (CMA)

Duration = 5.0 hrs.

Objectives: Profiles of aerosol scattering and absorption coefficients and size distributions together with scattering (polarized) phase functions above the SeaPRISM site and the RV Shearwater. Characterization of microphysical properties of smoke from the Boon fire.

Summary: Out of aerosol quickly after takeoff with 4 Mm^{-1} scattering coefficient at 2 kft. Aerosol layer at 4.2 kft with 25 Mm^{-1} scattering coefficient, then clean passing through 8 kft during ascent out of Marina. Smoke layer at 9 kft with 120 Mm^{-1} scattering coefficient near (northwest of) the Boon fire, then at the top of the smoke layer at 9.5 kft with 20 Mm^{-1} scattering coefficient. See picture of smoke at 11:04 local time (18:04 UTC). Temporary flight restriction (TFR) did not allow sampling below 9.5 kft in fire area. Descended past (south of) the TFR with scattering coefficients of 10 Mm^{-1} at 8 kft then 35 Mm^{-1} at 7 kft in an aerosol layer. The slant column at 18:08 UTC relevant for ER-2 lidar comparison.

After flying high over a ridge, observed multiple aerosol layers on the way to coast with scattering coefficient of 50 M-1 at 4.8 kft. In line descent to minimum safe altitude at the Shearwater waypoint, although the Shearwater was not yet in position. Scattering coefficient of 30 Mm-1 at 100 ft and boundary layer cloud free. Very shallow marine boundary layer (MBL) topped by sharp temperature inversion. Transit to the SeaPRISM site at the top of the MBL (at 100 ft) with scattering coefficient varying between 30-50 Mm^{-1}. Aerosol size distribution appeared quite broad with mix of sea salt and pollution and a scattering Angstrom exponent of 0.5. Started spiral up at SeaPRISM site at 12:55 local time (19:55 UTC) in a cloud free area with an aerosol layer at 500 ft and decreasing scattering through 2 kft. Not allowed to climb above 4 kft at SeaPRISM site (by ATC) so spiral continued where airspace allowed; first to the SE and then closer to Catalina Island. Immediately spiraled down without re-positioning during PACE overflight at 20:29 UTC. Reverse heading track done mostly at 500 ft altitude. ER-2 overflies at 13:56 local time (20:56 UTC). Aerosol at 500 ft was very different from that at 100 ft with smaller particles (scattering Angstrom exponent 1.8). Small porpoise maneuver at 21:03 UTC between 1500 ft and 100 ft to profile the MBL structure and contrast the surface and elevated aerosol properties. Cargo ship on nose at 21:07; no obvious emissions sampled. Overflight of the RV Shearwater (see picture below) at 14:42 local time (21:42 UTC) followed by spiral up to 10 kft and transit to land at Camarillo Airport (CMA) for re-fueling. Spiral ended at 14:54 local time (21:54 UTC) and ER2 flew over at 15:08 local time (22:08 UTC). During landing, observed VERY thick dust just east of the airfield that seemed to be trapped by surrounding mountains; 100 Mm^{-1} scattering sampling just at the edge of this dust plume. Sampled dust during taxi to FBO after landing.

Launch 2:

Take off: 16:15:28 (23:15:28 UTC) Camarillo Airport (CMA)

Landing: 18:14:22 (25:14:22 UTC) Marina Airport (OAR)

Duration = 2.0 hrs.

Objectives: Measurements of aerosol scattering and absorption coefficients and size distributions together with scattering (polarized) phase functions of smoke emissions from Boon Fire in Central California. Ferry aircraft home.

Summary: 7.5 kft altitude over mountains at 23:36 UTC. Porpoise maneuvers when possible, with 25 Mm^{-1} scattering at 6 kft; 10 Mm^{-1} at 7.5kft. Altered flight path to be clear of the TFR, north and east of previous turn-point. Descended to 5.5 kft (lowest safe altitude) around fire region at 24:20 UTC, but did not find any obvious smoke emissions in the area. Smoke was presumably trapped in valley and not able to be sampled. Descended into Salinas Valley at 24:49 UTC, but conditions were very clean: 3 Mm^{-1} scattering at 1.0 kft at 25:10. Performed missed approach at 25:12:05 UTC for tower comparison at ~14 Mm^{-1} scattering.

LARGE humidifier not functioning during flight, therefore no f(RH) data will be archived. PCASP was turned off for second sortie to prevent overheating. All other instruments functioned nominally.

Smoke near the Boon fire at 11:04 local time taken by Luke Ziemba from the CIRPAS Twin Otter.

Picture of the CIRPAS Twin Otter about to start spiral up at the SeaPRISM site. Taken by Bridget Seegers on the RV Blissfully at 13:16 local time.

Picture of the RV Shearwater taken from the CIRPAS Twin Otter by Luke Ziemba at 14:42 local time.

R/V Blissfully report

PACE-PAX R/V Blissfully day report

Date: 09/06/2024

Creator: Bridget Seegers

Cruise ID: RF0906-RB

Sailed out: 15:11

Back in port: 01:35 09/07/2024

Today, the ship accomplished....

Collection of vertical radiometry profiles and discrete sample collection (HPLC + ap) on three stations in proximity of SeaPRISM site. Each station has three sets of 5 HyperPro profiles to 20m and a single deep cast to 60m. Each station discrete water samples include triplicate HPLC + ap and duplicate community composition Lugol's preserved and paraformaldehyde samples for flow cytometry.

Station 1:

- arrival 17:17, 33° 33.74' N, 118° 7.18' W witch patchy sky
- ER-2 overflight 18:02

Station 2:

- Location same as station 1 17:17, 33° 33.74' N, 118° 7.18' W
- arrival 19:10, patchy sky
- Twin otter overflight 19:56


- PACE overpass @ 20:29
- ER-2 overpass @ 21:27

Station 3:
to 33° 34.12' N 118° 6.96' W

- arrival 21:22 , blue clear sky

Tomorrow,

the R/V Blissfully will not sail.

Ship plans through the next 3 days…

Sail on the next ER-2 flight day

System Status…

All operational, no time for microtops measurements.

Group Status…

Spirit is high.

R/V Shearwater report

PACE-PAX R/V Shearwater day report

Date: 09/06/2024

Creator: Michael Ondrusek

Cruise ID: RF0906-RS

Sailed out: 1300 PT/ 2000 UTC

Back in port: 1719 PT/ 0019 UTC 09/07/2024

Today, the ship occupied two stations. The first station was approximately 10 nm of shore and the second one was 4 nm offshore.

Station 1: 34.22472° -119.67931° ~2100 UTC

Station 2: 34.34414° -119.67253° ~2300 UTC

At each station we collected radiometry data with one hyperpro profiling, one floating and with C-OPS. Seawater was also collected for laboratory analysis. The flow through system was not operating yet.

Flyovers were observed from the twin otter and ER2 while collecting data on the first station. The twin otter conducted an ascending spiral over the ship, and there were 3 overflights of the ER-2.

Tomorrow, the survey ship will remain in port to work on equipment.

In upcoming days - ship plans to sample off Santa Barbara on 0908, 0909, and 0910

System Status:

Depth sensor on one hyperpro was not operating. Sent for a new cable to be delivered next week.

Issues with flow through water system.

Group Status: All groups were operating as expected. Joaquim Goes participated on the days activities

PACE-PAX research flight report 2024/09/07
RF0907
Compiled by Kirk Knobelspiesse, Brian Cairns, 2024/09/14 DRAFT
Reviewed by Samuel LeBlanc

Twin Otter only flight out over the ocean to sample forecasted (smoke) aerosols above marine stratocumulus clouds west of the Monterey Bay during the PACE overpass (within OCI and HARP2 but not SPEXone swath). GEOS had moderate (AOD 0.1 to 0.2) smoke aerosols from fires in Oregon and Idaho lofted to about 3000m above sea level, the Twin Otter found a smaller amount of aerosols concentrated at cloud top and only existing at small amounts up to 2800m.

ER-2
No flight

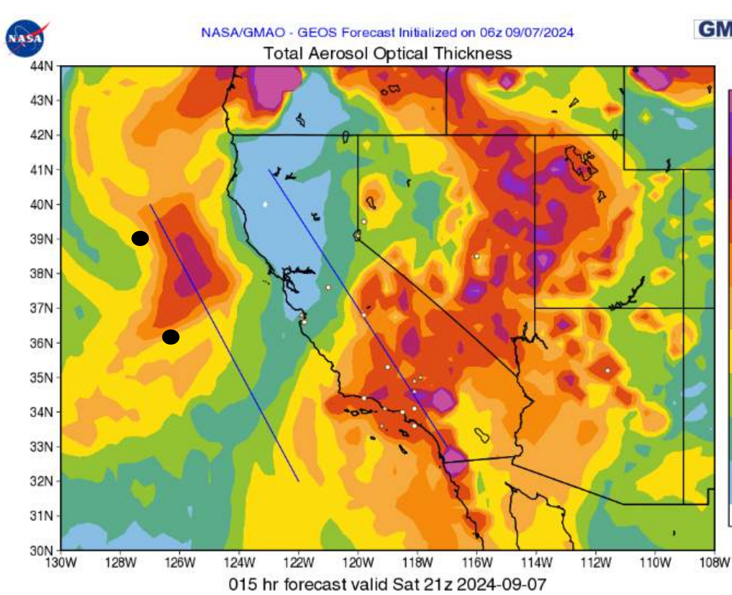
Twin Otter
Takeoff: 19:13, Landing: 23:04, Duration: 3.9
Instrument status: Dewpoint Temperature sensor was not operational for this flight, while all other instrumentation (including humidifier and f(RH)) operated nominally.
Manifest: Bryce Kujat (pilot)Jeff Martin (pilot)
Luke Ziemba (QNC)
Edward Winstead (QNC)

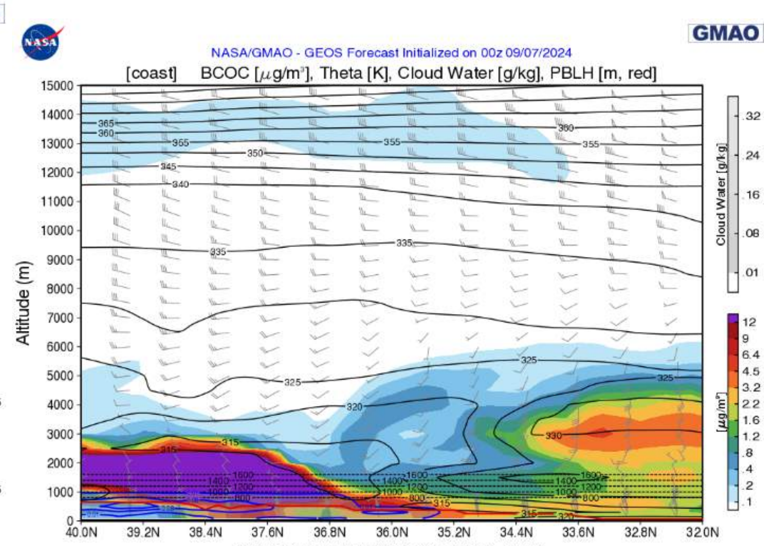
See end for full Twin Otter report

R/V Shearwater
No operations

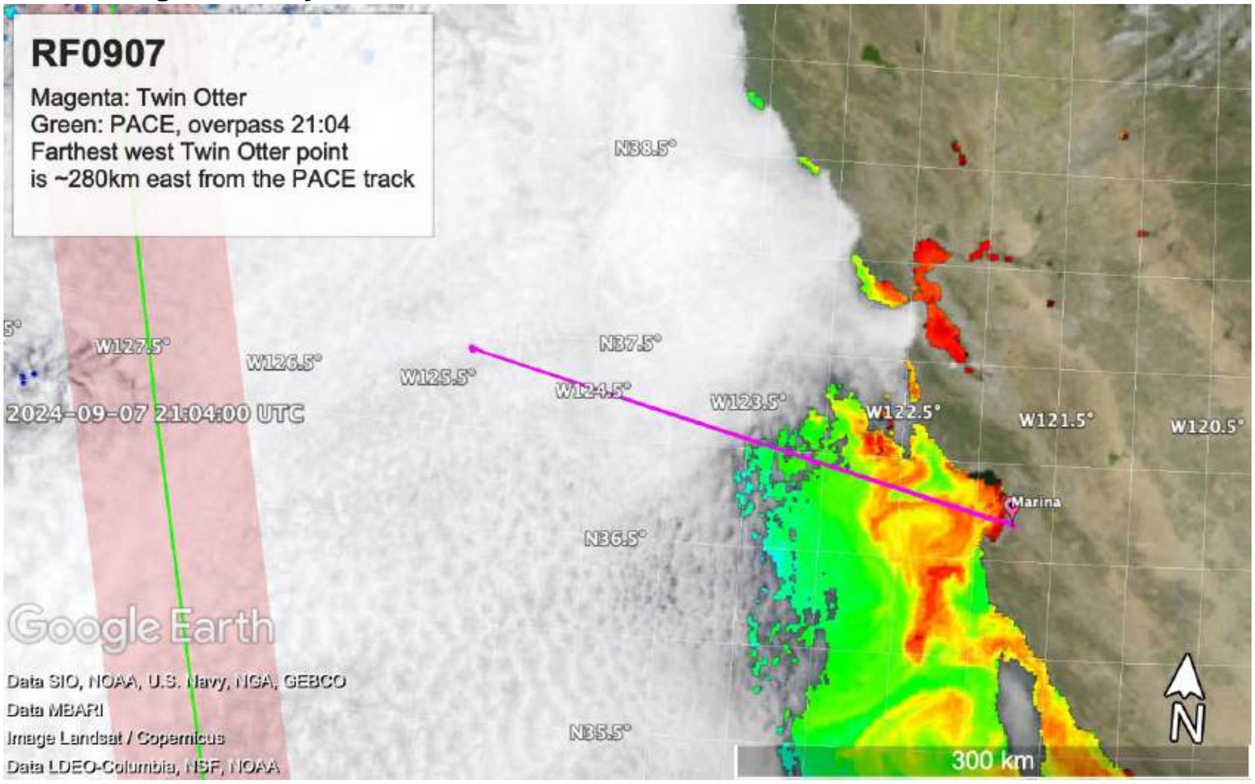
R/V Blissfully
No operations

PACE
Overpass: 21:04
Orbit track along Sierra Nevada mountains





Overall image summary



Validation Traceability Matrix itemized objectives

VTM elements in **black** satisfied, **blue** partially satisfied and **red** not satisfied

Time	Platform	VTM(hrs)	
19:13	TO		Takeoff
20:58	TO		Start spiral down from clean aerosol region
21:04	TO	1e(3.0), 6e(3.0)	PACE-OH overpass (21:04). Track ~280km west of TO location
21:04	**PACE**		**PACE-OH**
22:54	TO		Fly by AERONET Monterey, AOD(500 nm) = 0.03
23:04	TO		Landing

PACE-OH: within PACE OCI, HARP2 but not SPEXone swath
TO: Twin Otter

Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

https://www-air.larc.nasa.gov/missions/pacepax/index.html

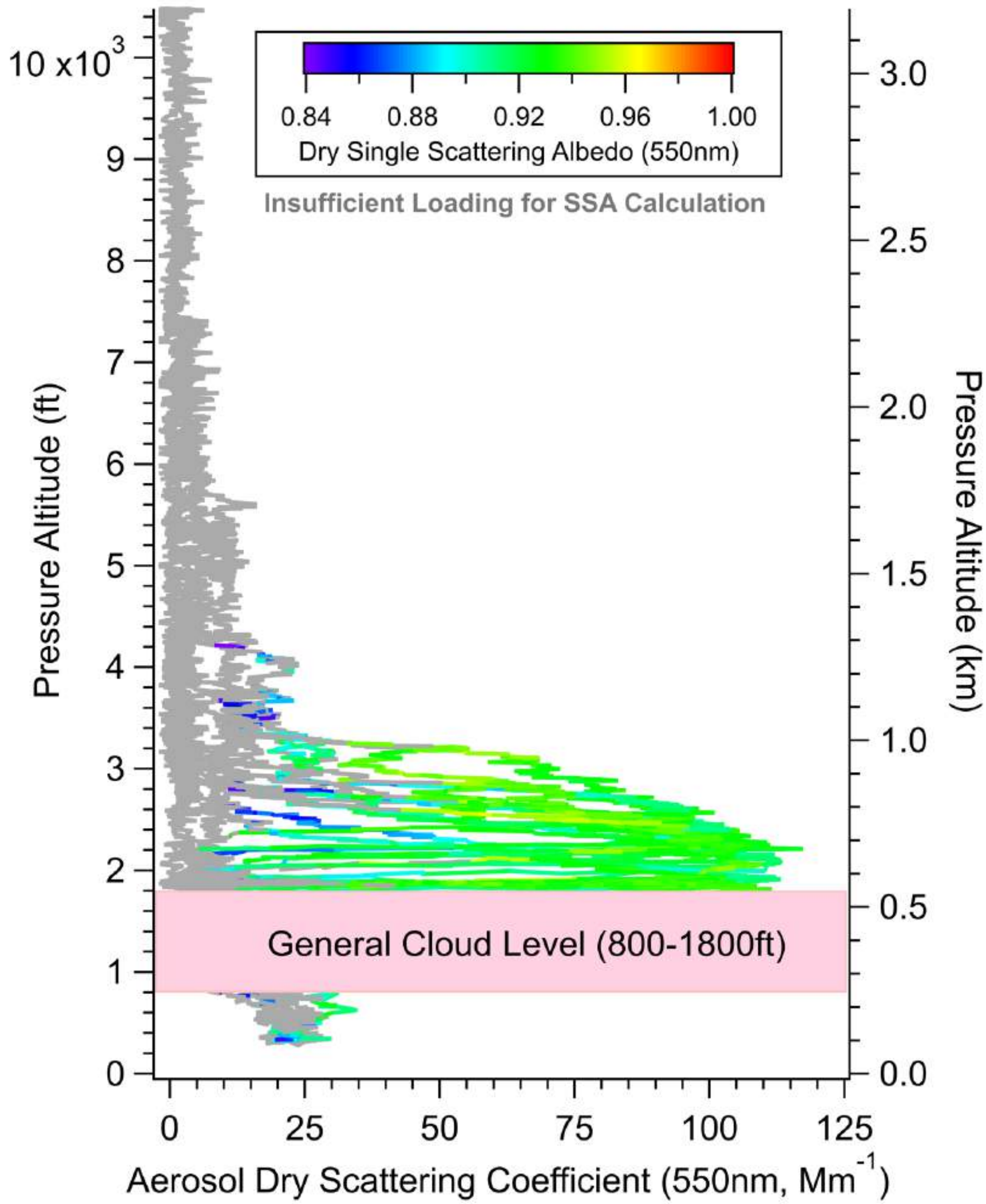
Assessment:

- 3.1% of objectives satisfied. Reasonable given the limited operations (TO only) and unique nature of aerosol above cloud observations.
- Top remaining objectives: PACE aerosol in narrow swath (3a,b), EarthCARE (3d,3e)

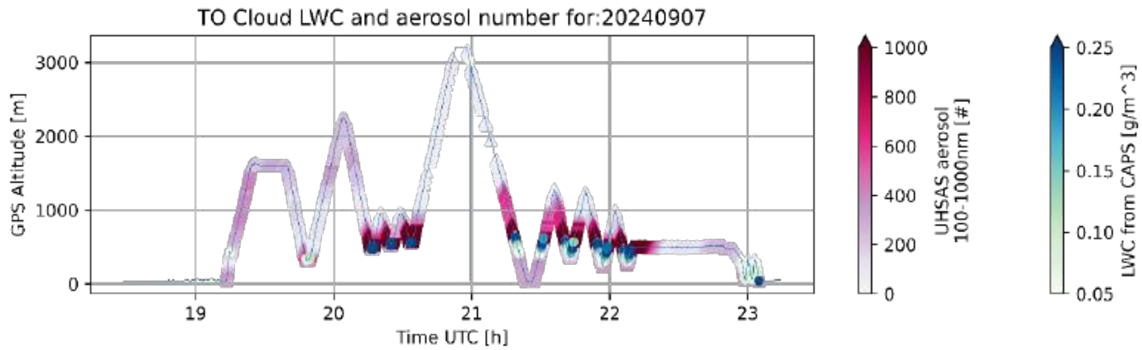
PACE-PAX progress tracking

Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 8/29	Fractional success 9/3	Fractional success 9/4	Fractional success 9/5	Fractional success 9/6	Fractional success 9/7	Fractional success 9/8	Total success	Remaining score
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	0.5	20.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.1%	6.4
	b	Ocean radiometric parameters	10	8.0	6.5	0.0%	0.0%	0.0%	0.0%	55.6%	0.0%	0.0%	55.6%	4.4
	c	Aerosol parameters over the ocean	12	8.0	9.8	0.0%	0.0%	6.1%	0.0%	64.4%	0.0%	0.0%	70.4%	3.5
	d	Aerosol parameters over land	12	8.0	13.5	39.3%	24.4%	8.0%	0.0%	8.8%	0.0%	0.0%	80.6%	2.3
	e	Cloud parameters	12	8.0	7.0	0.0%	0.0%	39.3%	0.0%	0.0%	19.0%	0.0%	58.3%	5.0
	f	Ocean surface parameters	1	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	2.0	0.0%	0.0%	0.0%	0.0%	22.1%	0.0%	0.0%	22.1%	7.8
	b	Aerosol parameters over land (PACE)	10	8.0	1.0	0.0%	0.0%	0.0%	0.0%	11.8%	0.0%	0.0%	11.8%	8.8
	c	Cloud parameters (PACE)	5	2.0	1.5	0.0%	0.0%	39.3%	0.0%	13.4%	0.0%	0.0%	52.8%	2.4
	d	Aerosol parameters (EarthCARE)	8	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.0
	e	Cloud parameters (EarthCARE)	8	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.0
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0
	b	Validate large reflectances with high polarization	6	2.0	1.0	0.0%	0.0%	0.0%	0.0%	39.3%	0.0%	0.0%	39.3%	3.6
	c	Validate large reflectances with low polarization	6	2.0	1.5	22.1%	0.0%	30.6%	0.0%	0.0%	0.0%	0.0%	52.8%	2.8
	d	Overfly vicarious calibration sites	6	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0
	b	High aerosol loads over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0
	c	Multiple aerosol layers	1	2.0	4.5	0.0%	87.3%	0.0%	0.0%	0.0%	0.0%	0.0%	87.3%	0.1
	d	Aerosol under thin cirrus	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0
	e	Aerosol above liquid phase cloud	4	2.0	3.5	22.1%	0.0%	0.0%	0.0%	0.0%	60.5%	0.0%	82.6%	0.7
	f	Broken clouds with complex structure	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0
	g	Dust aerosols over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0
	h	Aerosol and ocean parameters over turbid waters	2	2.0	0.5	0.0%	0.0%	22.1%	0.0%	0.0%	0.0%	0.0%	22.1%	1.6
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0
	k	Smoke aerosols over ocean	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0
		total:	150	98	52.8	5.7%	2.5%	7.1%	0.0%	13.8%	3.1%	0.0%	32.3%	

Stratocumulus cloud deck observed at 20:21 UTC. Note smoke layer possibly visible on north horizon (Photo = Ziemba)

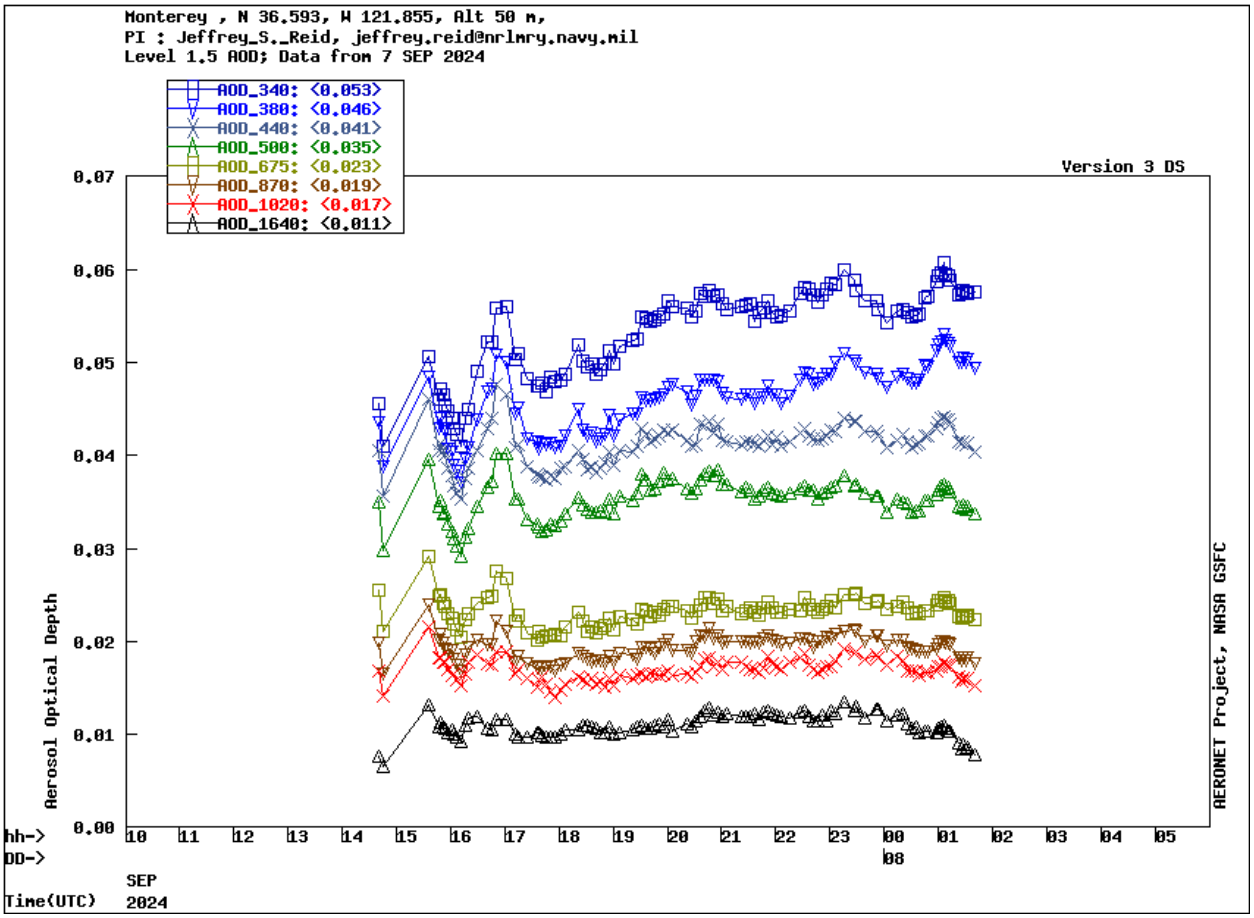


10 x10³
9
8
7
6
5
4
3
2
1
0
Pressure Altitude (ft)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Pressure Altitude (km)
0.84
0.88
0.92
0.96
1.00
Dry Single Scattering Albedo (550nm)
Insufficient Loading for SSA Calculation
General Cloud Level (800-1800ft)
0
25
50
75
100
125
Aerosol Dry Scattering Coefficient (550nm, Mm⁻¹)

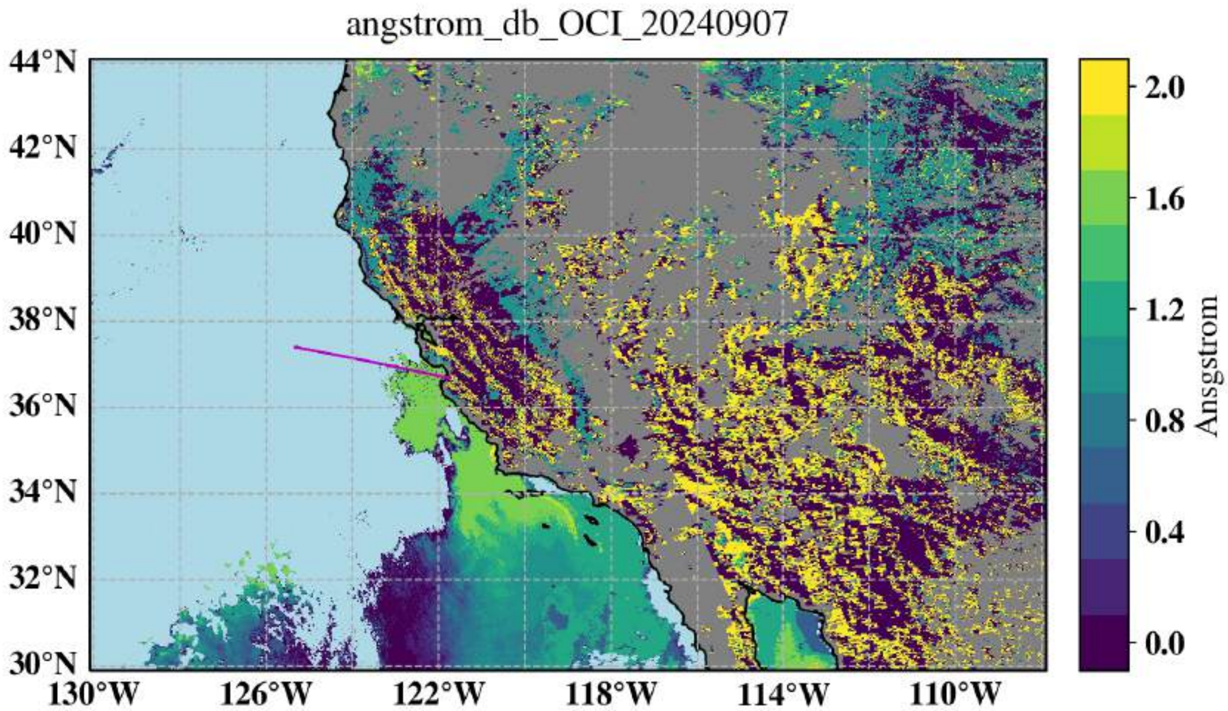

TO Cloud LWC and aerosol number for:20240907
GPS Altitude [m]
Time UTC [h]
UHSAS aerosol
100-1000nm [#]
LWC from CAPS [g/m^3]

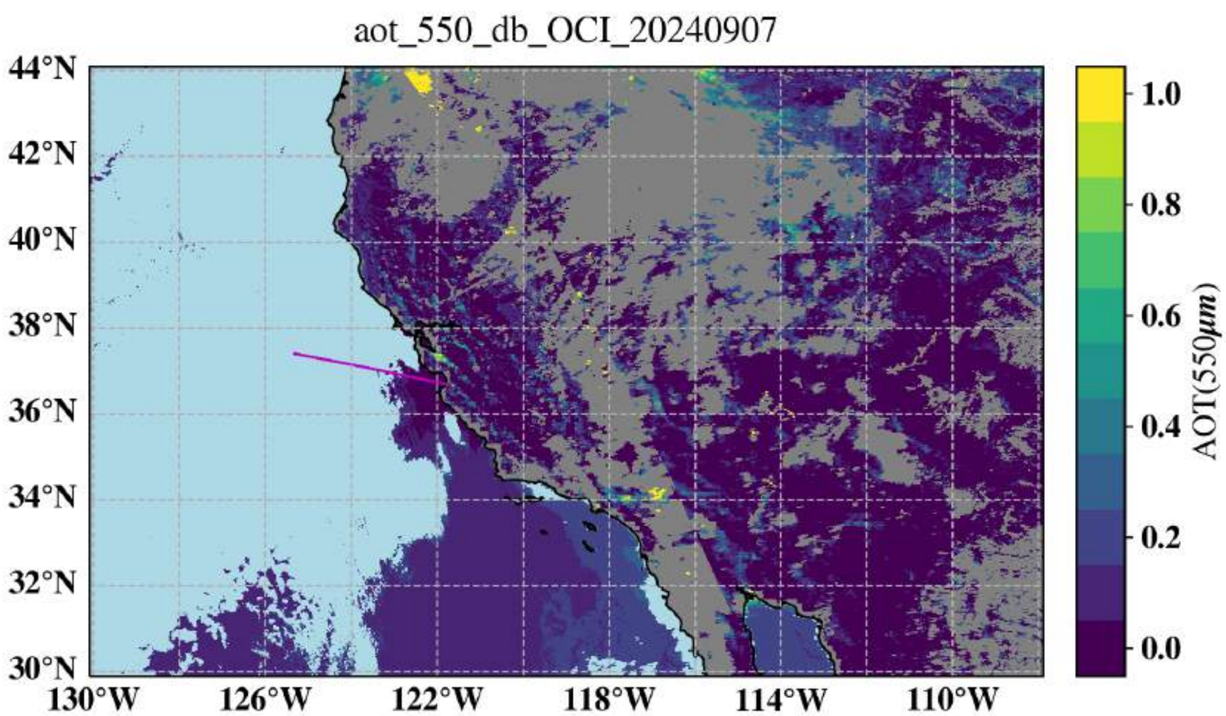
AERONET

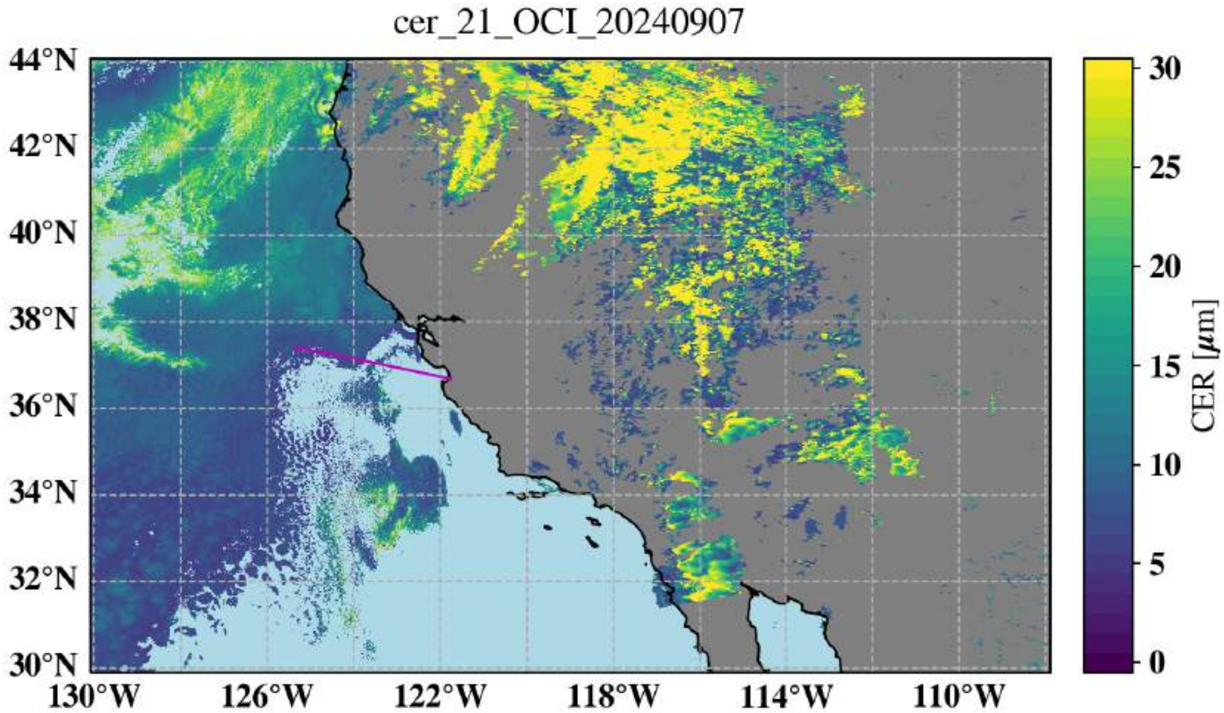
Monterey

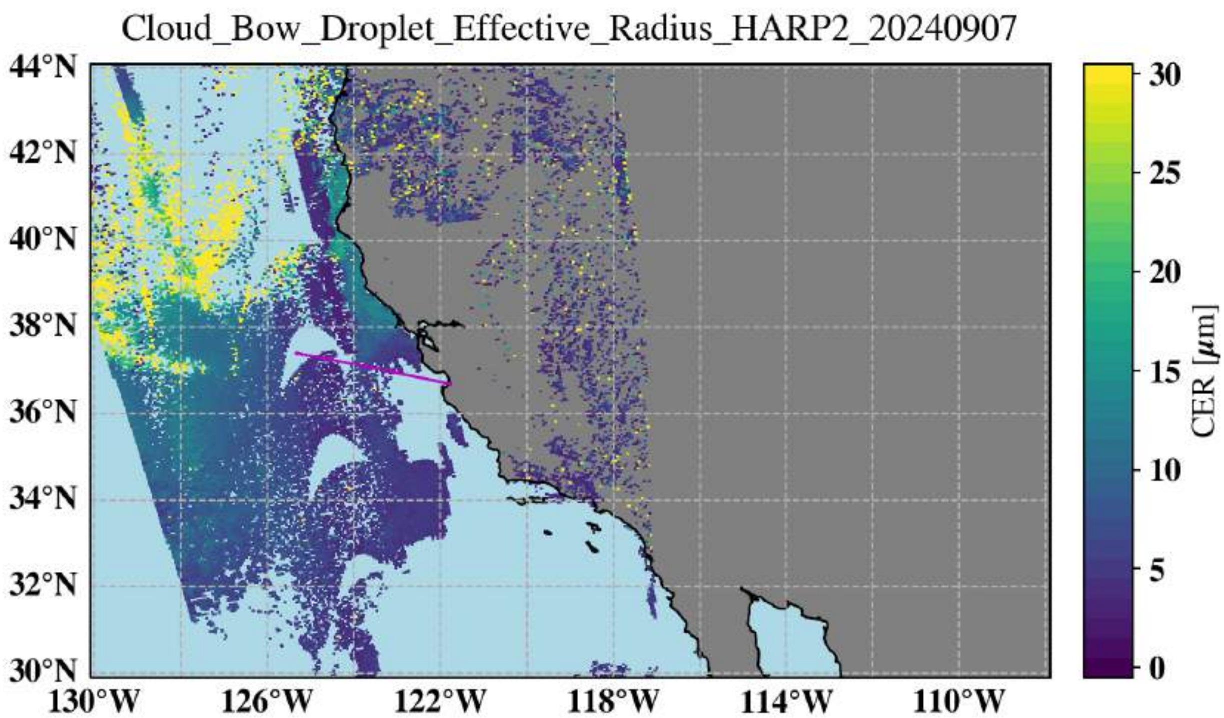


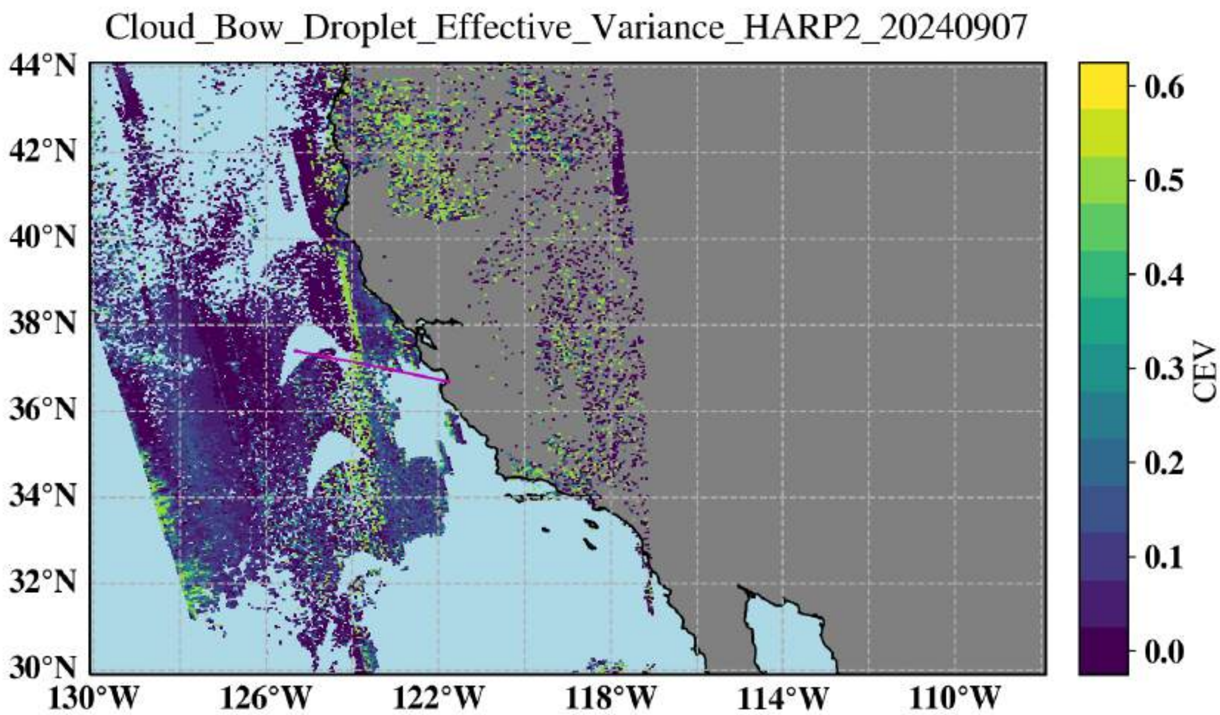
PACE Satellite products

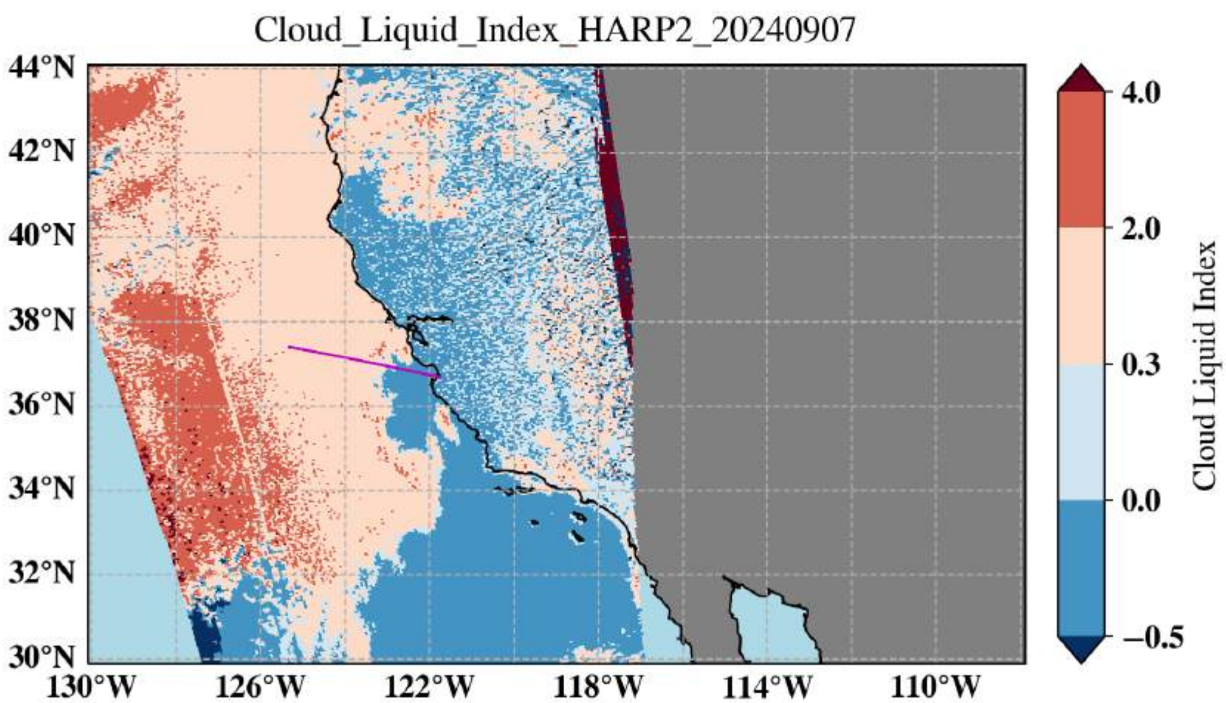


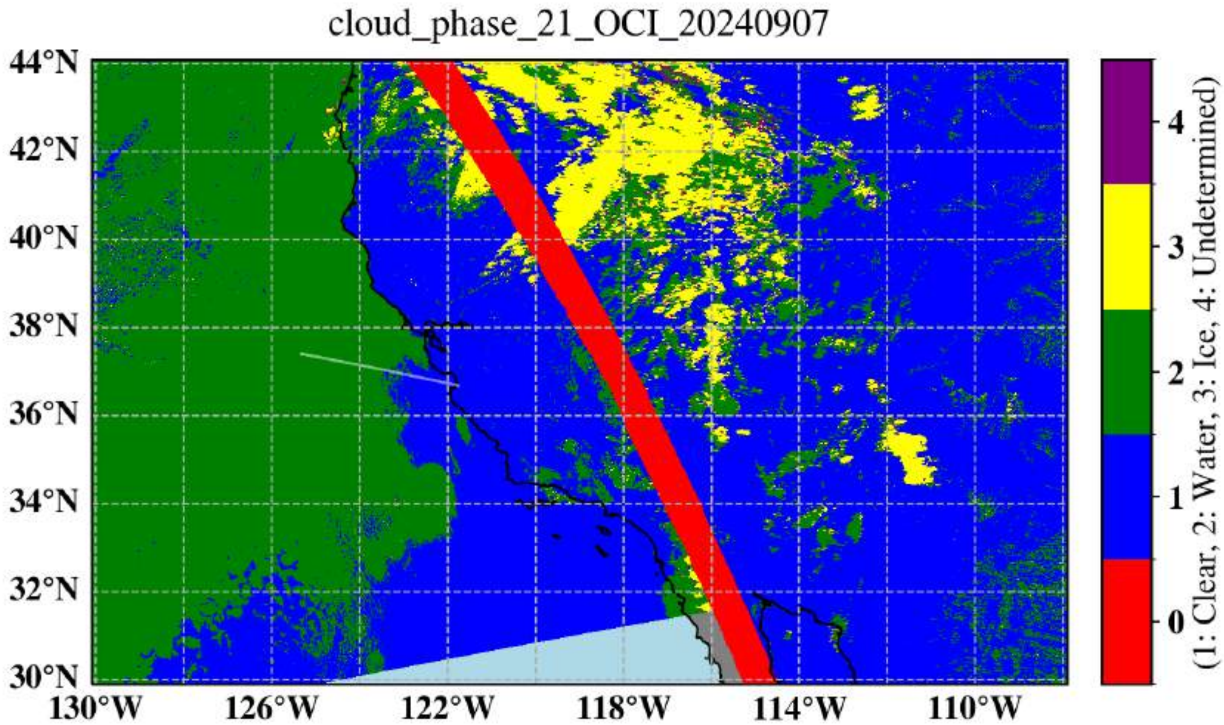


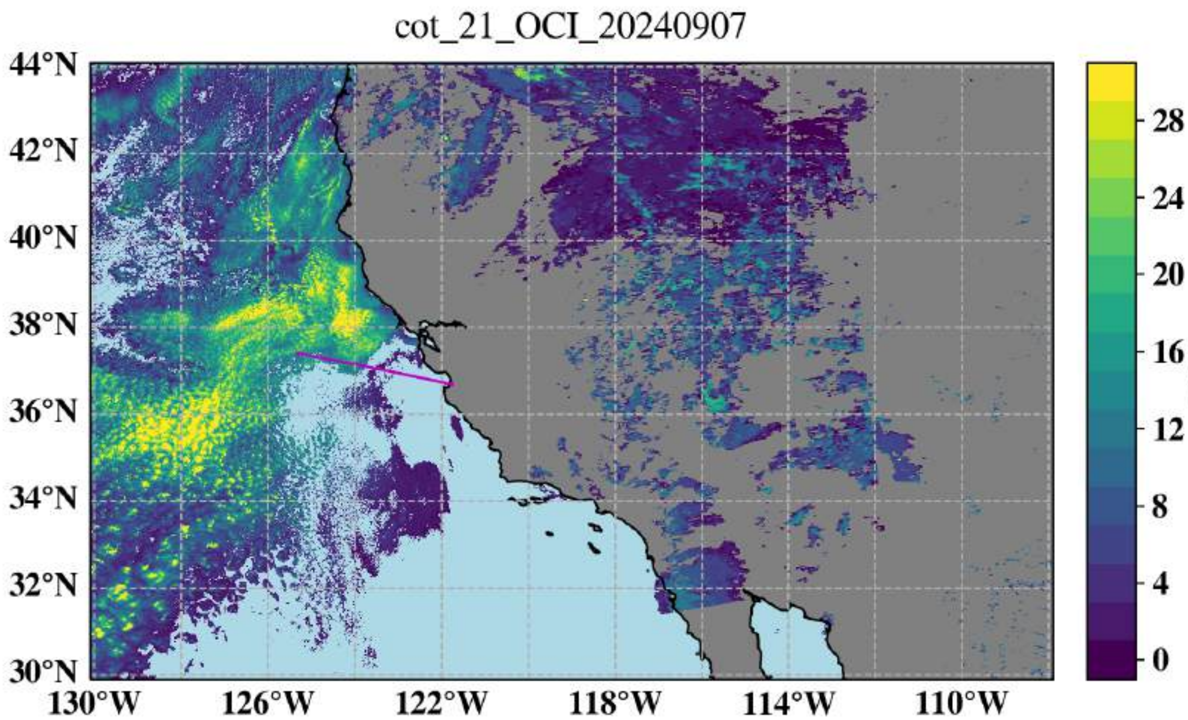

cer_21_OCI_20240907
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
30
25
20
15
10
5
0
CER [μm]

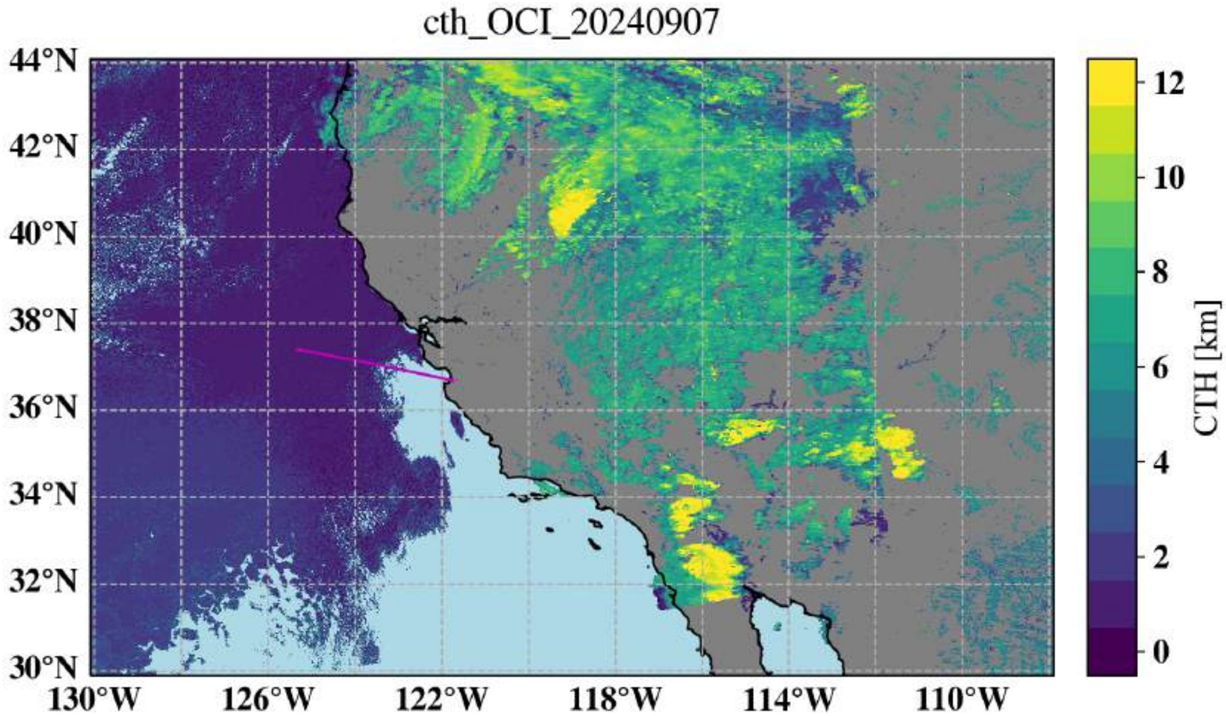

Cloud_Bow_Droplet_Effective_Radius_HARP2_20240907
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
30
25
20
15
10
5
0
CER [μm]

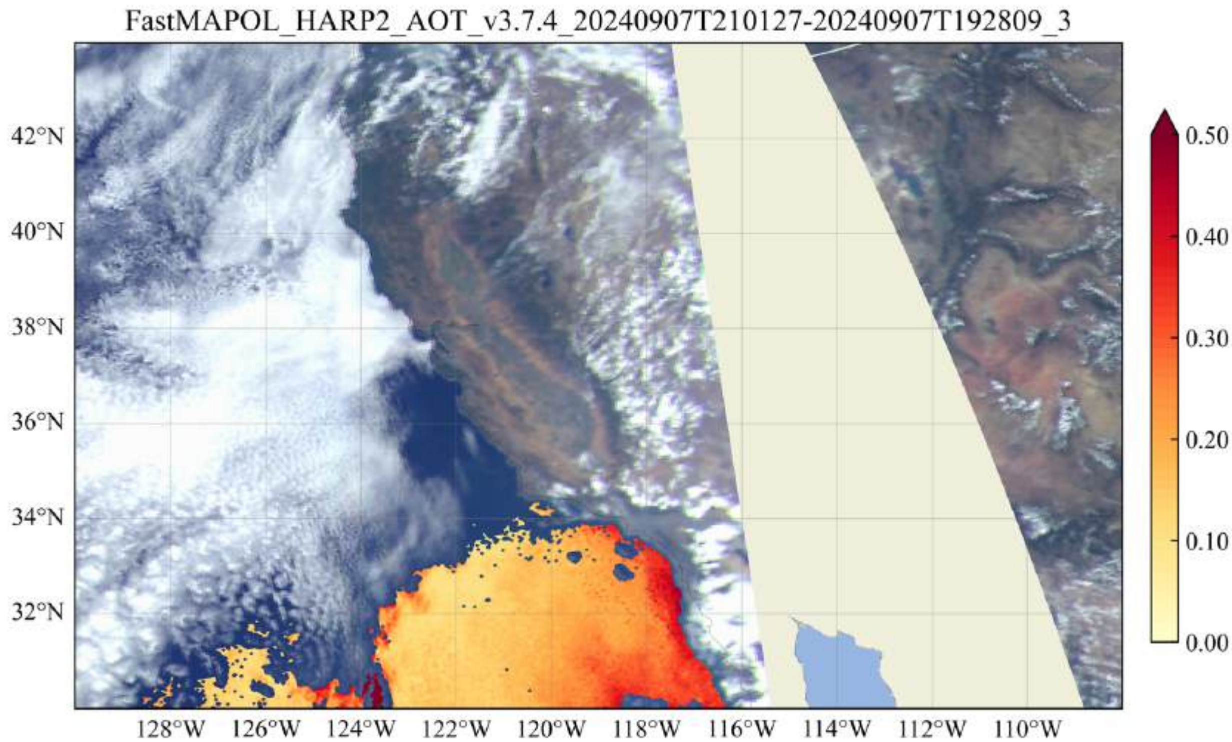

Cloud_Bow_Droplet_Effective_Variance_HARP2_20240907
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0.6
0.5
0.4
0.3
0.2
0.1
0.0
CEV


Cloud_Liquid_Index_HARP2_20240907
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
4.0
2.0
0.3
0.0
−0.5
Cloud Liquid Index


cloud_phase_21_OCI_20240907
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0
1
2
3
4
(1: Clear, 2: Water, 3: Ice, 4: Undetermined)


cot_21_OCI_20240907
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0
4
8
12
16
20
24
28
COT


cth_OCI_20240907
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
CTH [km]
0
2
4
6
8
10
12


FastMAPOL_HARP2_AOT_v3.7.4_20240907T210127-20240907T192809_3
42°N
40°N
38°N
36°N
34°N
32°N
128°W
126°W
124°W
122°W
120°W
118°W
116°W
114°W
112°W
110°W
0.50
0.40
0.30
0.20
0.10
0.00

Twin Otter flight report

PACE-PAX Research Flight report 2024/09/07

Twin Otter Flight

Manifest:

Bryce Kujat (pilot)

Jeff Martin (pilot)

Luke Ziemba (QNC)

Edward Winstead (QNC)

Take off: 12:13:22 (19:13:22 UTC) Marina Airport (OAR)

Landing: 16:04:55 (23:04:55 UTC) Marina Airport (OAR)

Duration = 3.9 hrs.

Objectives: Profiles of aerosol scattering and absorption coefficients and size distributions together with scattering (polarized) phase functions of transported smoke plume over stratocumulus clouds. Coordinated spiral profile with PACE overpass.

Summary:

Very low and sparse clouds observed over bay at takeoff, mostly clear. 4 Mm-1 scattering at 2kft at 19:17 UTC. Clouds now below aircraft, and some smoke potentially observed on the NW horizon at 19:31 UTC. Start large porpoises at 19:39 UTC to look for smoke. Cloud tops 1270 ft at 19:47, with 30 Mm-1 scattering just above cloud top. No smoke in the free troposphere up to 7kft during porpoising. Smoke observed at 20:16 UTC just above cloud top (at 1600 ft), 80 Mm-1 scattering! Smoke extended up to 2800 ft in a very thin layer. Smoke layer 90 Mm-1 scattering at 20:24 UTC, LWC 0.5 g/m3 in underlying cloud. Smoke layer height fairly consistent at 2800 ft at 20:32 UTC. Cloud top at 1830 ft, 80-90 Mm-1 scattering, 200-250nm diameter smoke particles at 20:33 UTC. Ascending up to 10 kft at 20:44 UTC to setup for PACE spiral, very clean FT above smoke. 20:58 UTC start spiral down; PACE overpass at 21:05 UTC during descent. Clouds here are very uniform, some small gaps but generally filled-in stratocumulus. Aerosol layer top at 4000ft at 21:14, but fairly diffuse until just above cloud top. Cloud for PACE: top 2100ft, bottom 1300 ft. 20 Mm-1 scattering below cloud, interesting the particles still look like smoke with AE = 1.5; presumably sea salt is only a minor component. 10°C inversion observed at 2000ft. Continued porpoising eastward, profiling from just-below cloud bottom to above smoke layer (generally 1000ft to 4000ft). Level leg at 1600ft started at 22:11 at 80 Mm-1 scattering; maintained this altitude until no smoke was present. Observed underlying clouds break up coincident with smoke dissipation. Performed two missed-approaches before landing.

Interesting case with smoke aerosol over stratocumulus clouds. Smoke was fairly concentrated (90 Mm-1 scattering), but in a very thin layer resulting in low presumed AODs. While the spatial extent of the smoke seemed well represented in forecast models, the predicted vertical extent showed large discrepancies with observations.

Dewpoint Temperature sensor was not operational for this flight, while all other instrumentation (including humidifier and f(RH)) operated nominally.

Sparse clouds (streets?) observed over Monterey Bay at 19:20 UTC (Photo = Ziemba)

Stratocumulus cloud deck observed at 20:21 UTC. Note smoke layer possibly visible on north horizon (Photo = Ziemba)

KOAR airfield and ground-measurement tower location during missed approaches (Photo = Ziemba)

PACE-PAX research flight report 2024/09/08

Compiled by Kirk Knobelspiesse, Brian Cairns, Ivona Cetinic, Bridget Seegers, Michael Ondrusek, 2024/09/14 DRAFT
Reviewed by Samuel LeBlanc

Coordinated TO + ER2 + RS + RB + EarthCARE operations. PACE had an onboard anomaly preventing data collection/download early that morning, so planned activities at PACE/OCI (swath edge) overpass times were still flown, but are not scored as successful in the VTM. EarthCARE along track flight (22:39). Large AOD from fires in LA basin and offshore near USC_SeaPRISM site.

ER-2
Takeoff: 18:37, Landing: 23:56, Duration: 5.3
Instrument status: PRISM had a minor switch issue, RSP had data logger issue (no data?), HARP had minor error affecting depolarization measurement, all else good.
Mission Scientist: Kirk Knobelspiesse
Pilot: Tim Williams; Mobile: Kirt Stallings

Twin Otter
Takeoff: 21:13, Landing: 22:56, Duration: 1.7
Instrument status: Good
Manifest: Bryce Kujat (pilot), Jeff Martin (pilot), Adam Ahern (QNC), Edward Winstead (QNC)
See end for full Twin Otter report

R/V Shearwater
Departure: 16:05, Return 23:39
Instrument status: Hyperpro depth sensor problem. AERONET Cimel acquisition issues (TBC)
Mission Scientist: Michael Ondrusek
See end for full R/V Shearwater report

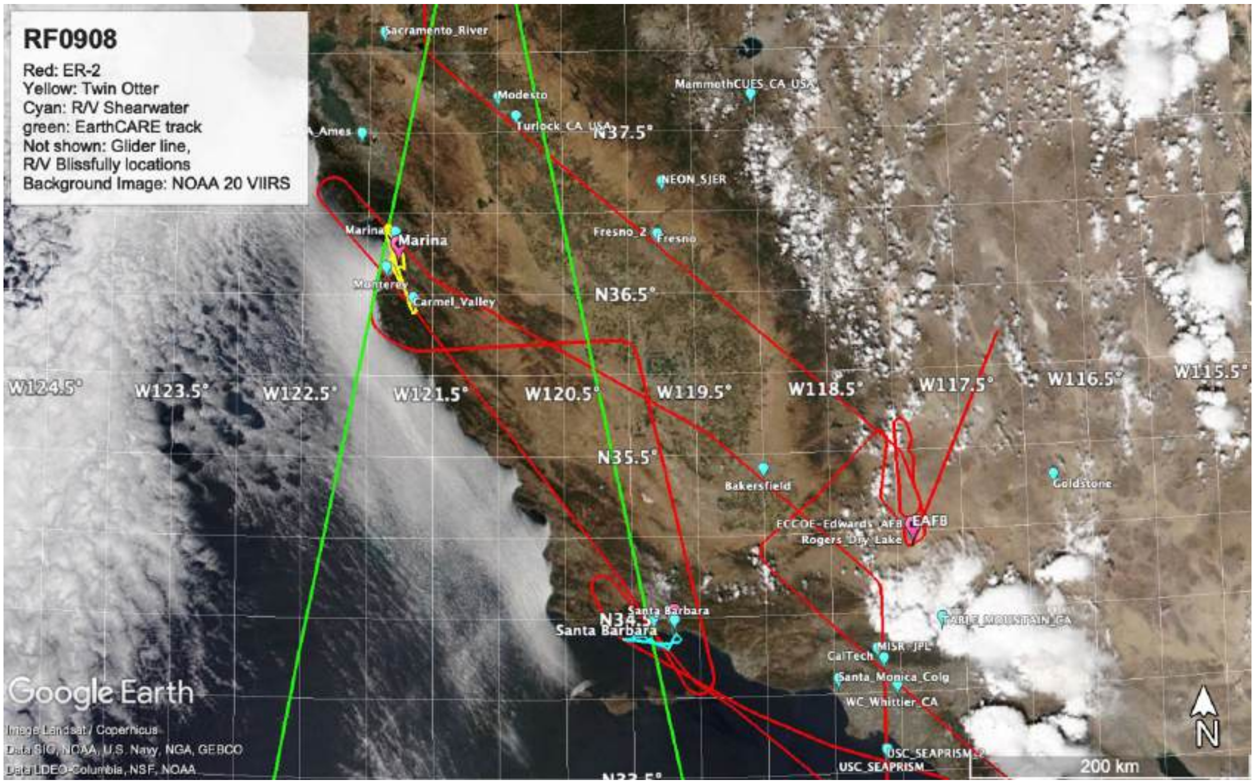
R/V Blissfully
Departure: 15:10, Return: 00:14 (09/09/24), Duration: 7.3
Instrument status: good, no time for microtops measurements
Captain/Mission Scientist: Bridget Seegers
See end for full R/V Blissfully report

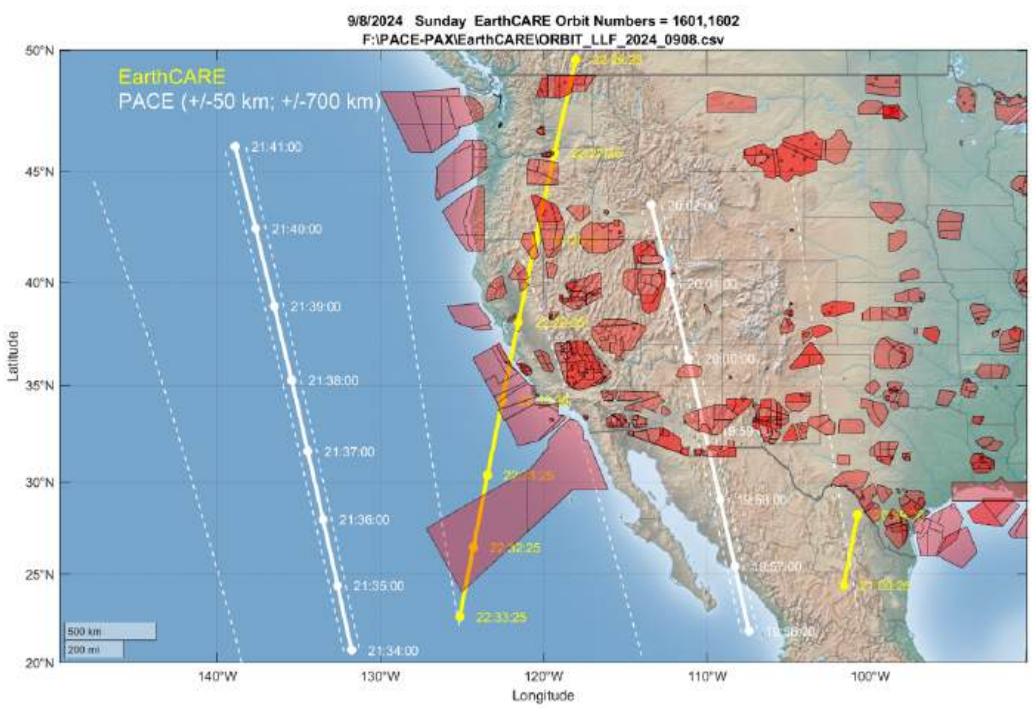
PACE
PACE has problem, Ka band not transmitting, no science data collection

EarthCARE
Overpass 22:39 from Monterey Bay NNE through California Central Valley, under-flight was priority of operations this day. **Orbit 1602**

Gliders
operational

Overall image summary





Validation Traceability Matrix itemized objectives

VTM elements in **black** satisfied, **blue** partially satisfied and **red** not satisfied

Time	Platform	VTM(hrs)	
15:10	RB		Departure
16:05	RS		Departure
18:37	ER2		Takeoff
19:10	ER2	1d(0.5), 6a(0.5)	Overpass CalTech Aeronet high AOD(500)=0.4
19:32	ER2, RB	1b(0.5+1.5), 1c(0.5), 6b(0.5), 6k(0.5)	Overpass USC_Seaprism Aeronet high AOD(490)=0.36; Blissfully on station with HyperPro, etc.
19:47	ER2,Gliders	1b(1.0)	ER2 overfly Glider line
19:48	ER2,RS	1b(1.5),1c(0.5)	ER2 overfly Shearwater with IOP and AERONET
19:59	ER2	1d(0.5)	Overpass UCSB Aeronet low AOD(500)=0.09
20:00	PACE		PACE-O overpass (pace not collecting data)
20:01	ER2,RS	1b(1.5),1c(0.5)	ER2 overfly Shearwater with IOP and AERONET
20:16	ER2, RB	1b(0.5+1.5), 1c(0.5), 6b(0.5), 6k(0.5)	Overpass USC_Seaprism Aeronet high AOD(490)=0.36; Blissfully on station with HyperPro, etc. mostly smoke
20:23	ER2	1d(0.5), 6a(0.5)	Overpass CalTech Aeronet high AOD(500)=0.26
20:36	ER2	1d(0.5)	Overpass Bakersfield Aeronet moderate AOD(500)=0.15
21:01	ER2	1d(0.5)	Overpass CEOBS Aeronet AOD(500)=0.035
21:13	TO		Takeoff
21:16	ER2		Overpass Carmel Valley with TO starting spiral in 15 min
21:31	TO	1d(1.5*0.9)	Spiral down over Carmel Valley AERONET-OC site (first data at 22:10, AOD(500)=0.025), spiral end at 21:31
21:38	PACE		PACE-O overpass (pace not collecting data)
21:38	ER2	1d(0.5)	Overpass UCSB Aeronet low AOD(500)=0.09
22:06	TO	1d(1.5), 3d(1.5)	Spiral(s) over CEOBS site with ER-2 and EarthCARE overpass. Top of spiral at 22:23, then spiral down ending at 22:43. AOD=0.045 (then interrupted).
22:17	ER2	3e(0.5), 4c(0.5)	Small section of ER-2 along EarthCARE track over clouds in Monterey Bay
22:21	ER2	3d(1)	Long track along EarthCARE line, mostly low AOD over California Central Valley
22:22	ER2	1d(0.5)	Overpass CEOBS AERONET AOD(500)=0.045
22:39	**EarthCARE**		**Overpass**
22.53	ER2	1d(0.5)	Overpass Modesto Aeronet AOD(500)=0.04
22.54	ER2	1d(0.5)	Overpass Turlock Aeronet AOD(500)=0.04
22:56	TO		Landing
23.03	ER2	1d(0.5)	Overpass Fresno Aeronet AOD(500)=0.04
23:56	ER2		Landing
23:39	RS		Return
00:14	RB		Return

PACE-OHS: within PACE OCI, HARP2 and SPEXone swath
SPP: Solar Principal Plane
ER2: ER-2
TO: Twin Otter
RS: R/V Shearwater
RB: R/V Blissfully

Assessment:

- 9.2% of objectives satisfied. First validation of EarthCARE
- Top remaining objectives: PACE aerosol in narrow swath (3a,b), EarthCARE cloud (3e) land surface (1e) large reflectances (4a), vicarious calib site (4d)

PACE-PAX progress tracking

Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 8/29	Fractional success 9/3	Fractional success 9/4	Fractional success 9/5	Fractional success 9/6	Fractional success 9/7	Fractional success 9/8	Total success	Remaining score
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	0.5	20.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.1%	6.4
	b	Ocean radiometric parameters	10	8.0	14.5	0.0%	0.0%	0.0%	0.0%	55.6%	0.0%	28.1%	83.7%	1.6
	c	Aerosol parameters over the ocean	12	8.0	11.8	0.0%	0.0%	6.1%	0.0%	64.4%	0.0%	6.5%	77.0%	2.8
	d	Aerosol parameters over land	12	8.0	21.4	39.3%	24.4%	8.0%	0.0%	8.8%	0.0%	12.1%	92.7%	0.9
	e	Cloud parameters	12	8.0	7.0	0.0%	0.0%	39.3%	0.0%	0.0%	19.0%	0.0%	58.3%	5.0
	f	Ocean surface parameters	1	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	2.0	0.0%	0.0%	0.0%	0.0%	22.1%	0.0%	0.0%	22.1%	7.8
	b	Aerosol parameters over land (PACE)	10	8.0	1.0	0.0%	0.0%	0.0%	0.0%	11.8%	0.0%	0.0%	11.8%	8.8
	c	Cloud parameters (PACE)	5	2.0	1.5	0.0%	0.0%	39.3%	0.0%	13.4%	0.0%	0.0%	52.8%	2.4
	d	Aerosol parameters (EarthCARE)	8	4.0	2.5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	46.5%	46.5%	4.3
	e	Cloud parameters (EarthCARE)	8	4.0	0.5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.8%	11.8%	7.1
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0
	b	Validate large reflectances with high polarization	6	2.0	1.0	0.0%	0.0%	0.0%	0.0%	39.3%	0.0%	0.0%	39.3%	3.6
	c	Validate large reflectances with low polarization	6	2.0	2.0	22.1%	0.0%	30.6%	0.0%	0.0%	0.0%	10.4%	63.2%	2.2
	d	Overfly vicarious calibration sites	6	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	2.0	1.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	39.3%	39.3%	2.4
	b	High aerosol loads over ocean	4	2.0	1.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	39.3%	39.3%	2.4
	c	Multiple aerosol layers	1	2.0	4.5	0.0%	87.3%	0.0%	0.0%	0.0%	0.0%	0.0%	87.3%	0.1
	d	Aerosol under thin cirrus	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0
	e	Aerosol above liquid phase cloud	4	2.0	3.5	22.1%	0.0%	0.0%	0.0%	0.0%	60.5%	0.0%	82.6%	0.7
	f	Broken clouds with complex structure	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0
	g	Dust aerosols over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0
	h	Aerosol and ocean parameters over turbid waters	2	2.0	0.5	0.0%	0.0%	22.1%	0.0%	0.0%	0.0%	0.0%	22.1%	1.6
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0
	k	Smoke aerosols over ocean	1	2.0	1.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	39.3%	39.3%	0.6
		total:	150	98	77.1	5.7%	2.5%	7.1%	0.0%	13.8%	3.1%	9.2%	41.6%	
					prior to this week									total
				ER-2 flight hours	1.3	2.8	0	4.7	0	6.1	0	5.3	0	18.9
				TO flight hours	0	2.4	3.4	3.8	0	7	3.9	1.7	0	22.2
				Shearwater days		0	0	0	0	1	0	1	0	2
		PACE-PAX overall objectives satisfied:		41.6%										

Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

https://www-air.larc.nasa.gov/missions/pacepax/index.html

ER-2/MVIS images

<table>
<tr><td></td><td></td></tr>
<tr><td>21:16 ER2+TO+Carmel Aeronet
</td><td>22:17 cloudy start of EarthCARE line
</td></tr>
<tr><td>22:22 second CEOBS overpass, EarthCARE cloud free line
</td><td>22:36 near end of EarthCARE line near Sacramento
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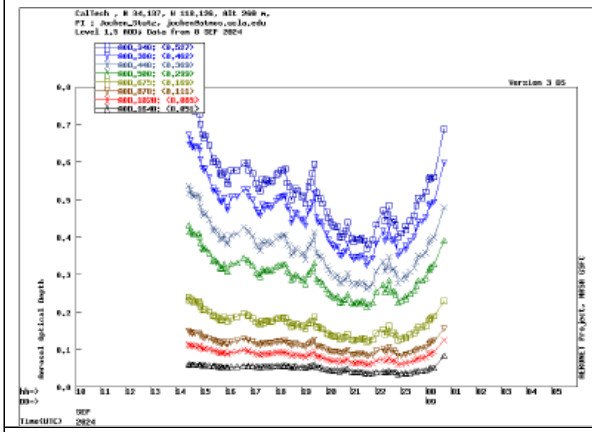
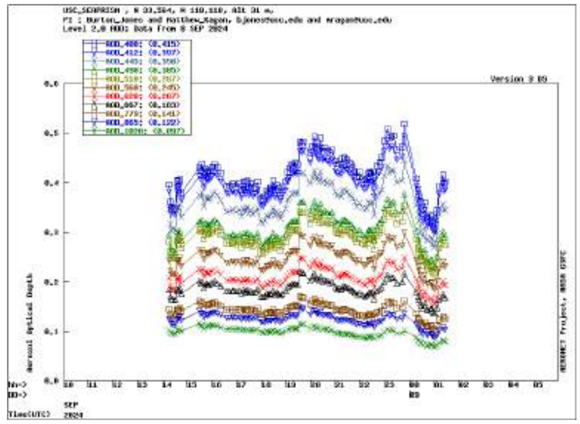
AERONET quicklooks

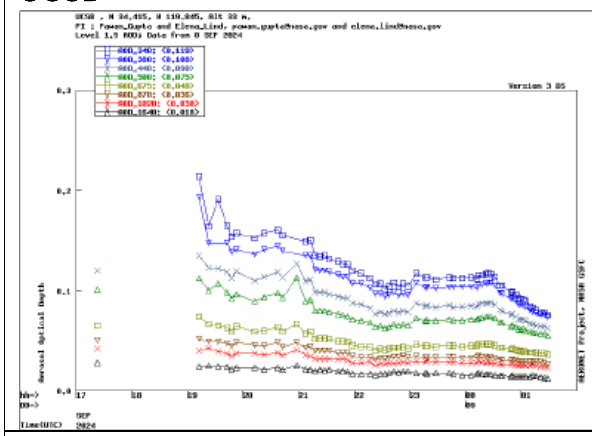
CalTech



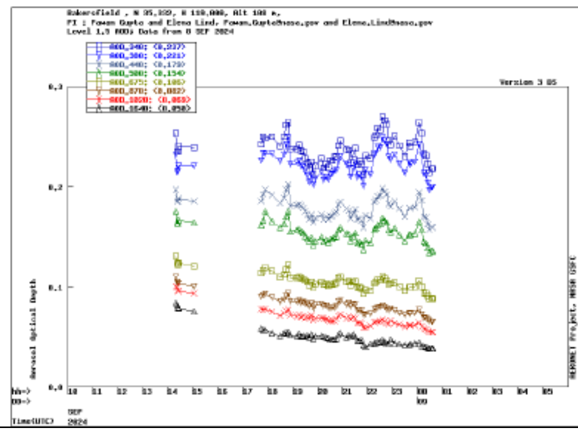
USC_SeaPRISM



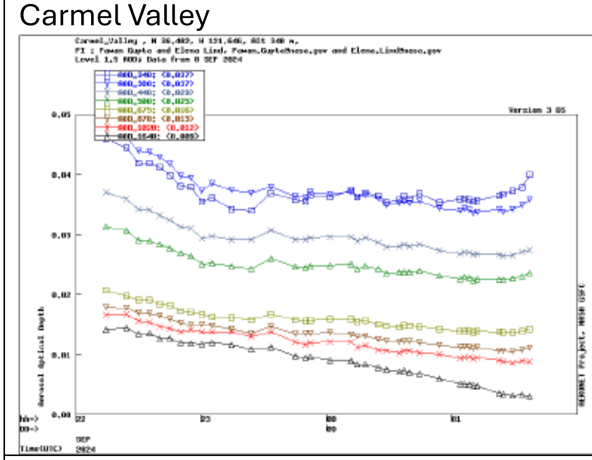
UCSB



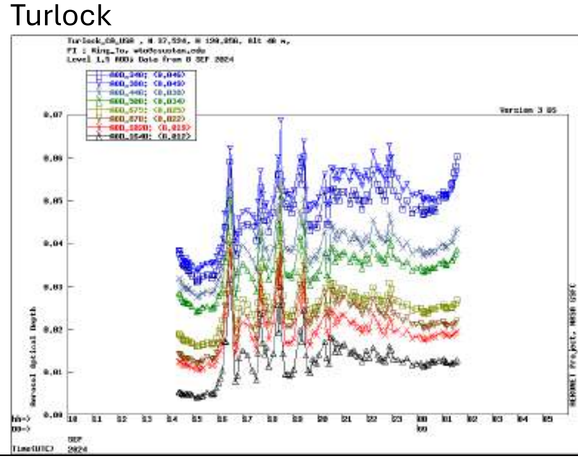
Bakersfield



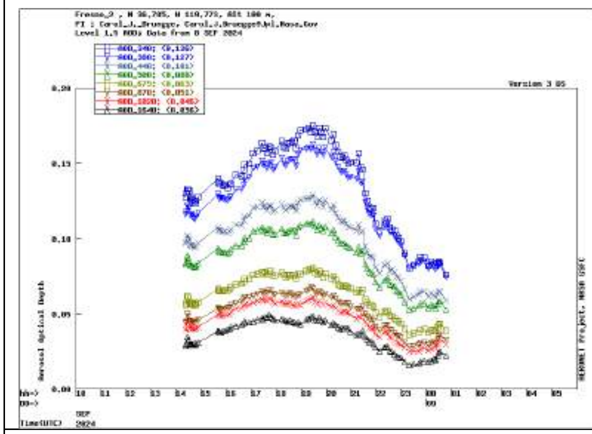
Carmel Valley



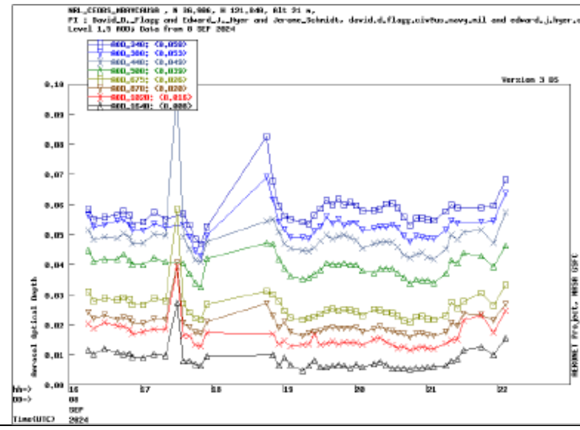
Turlock



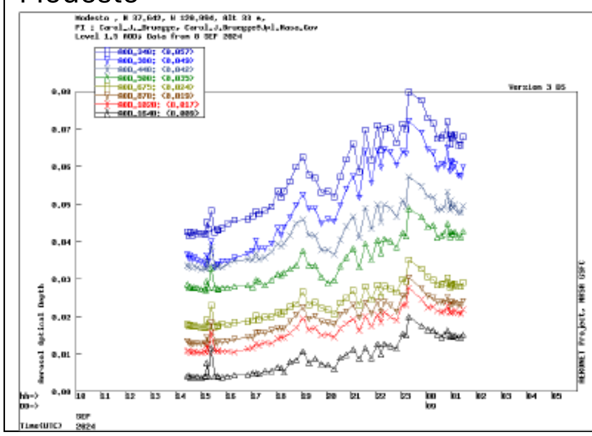
Fresno



CEOBS_NSRL

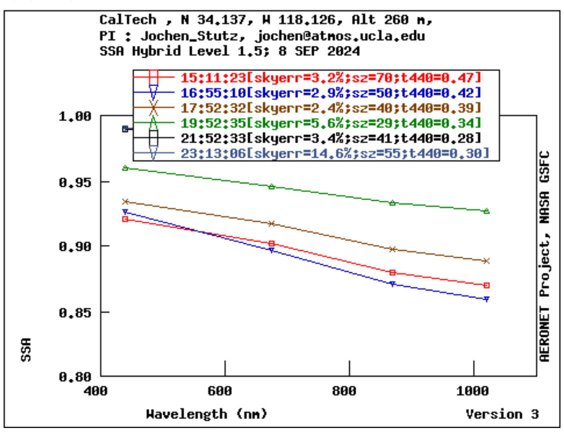


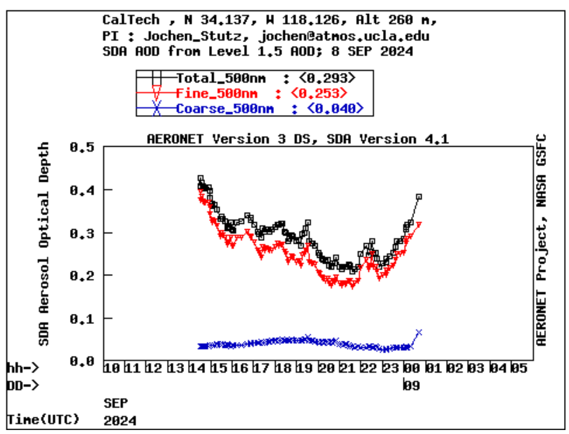
Modesto



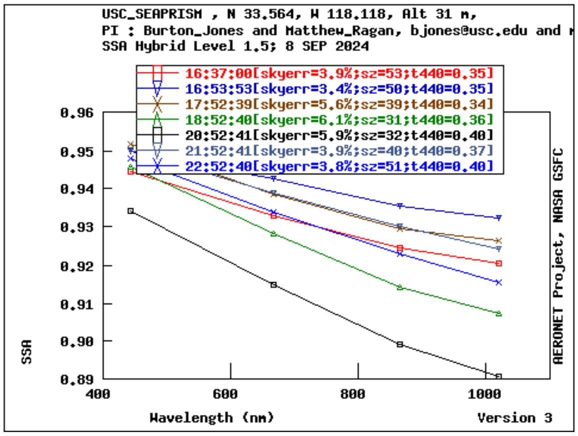
AERONET aerosol inversion

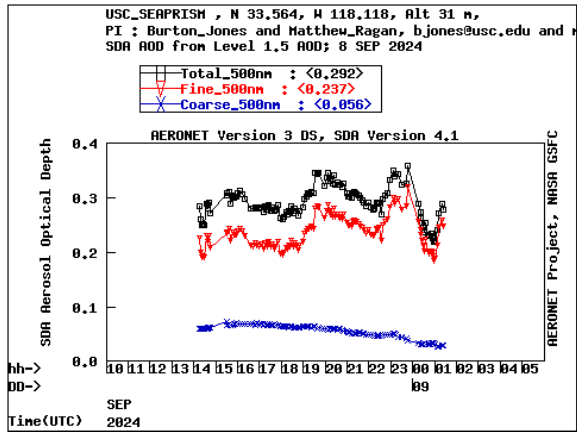
CalTech



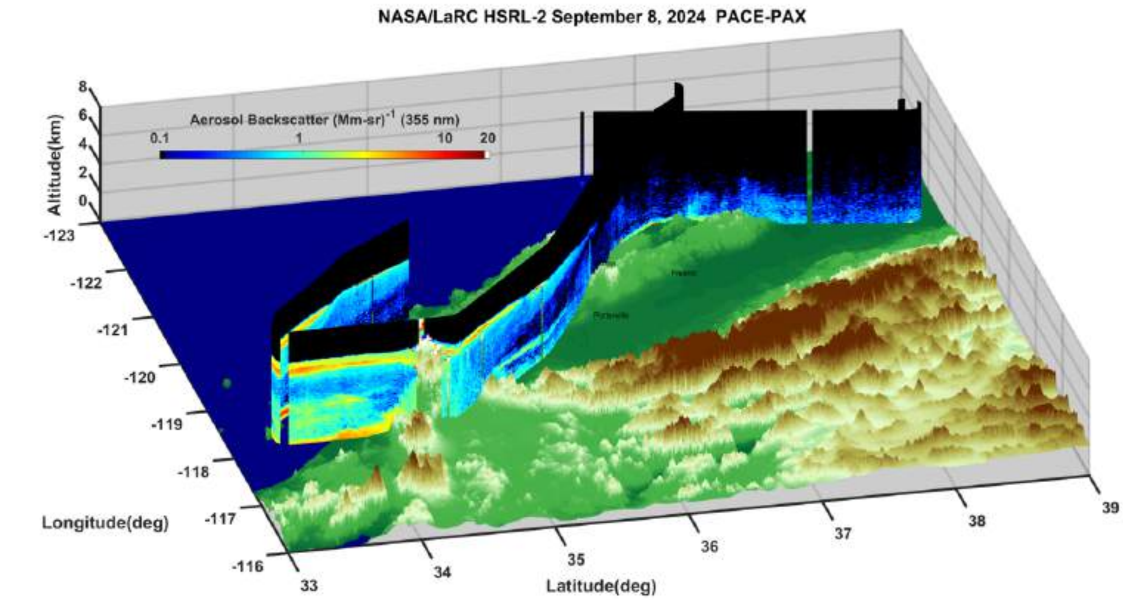


USC SEAPRISM

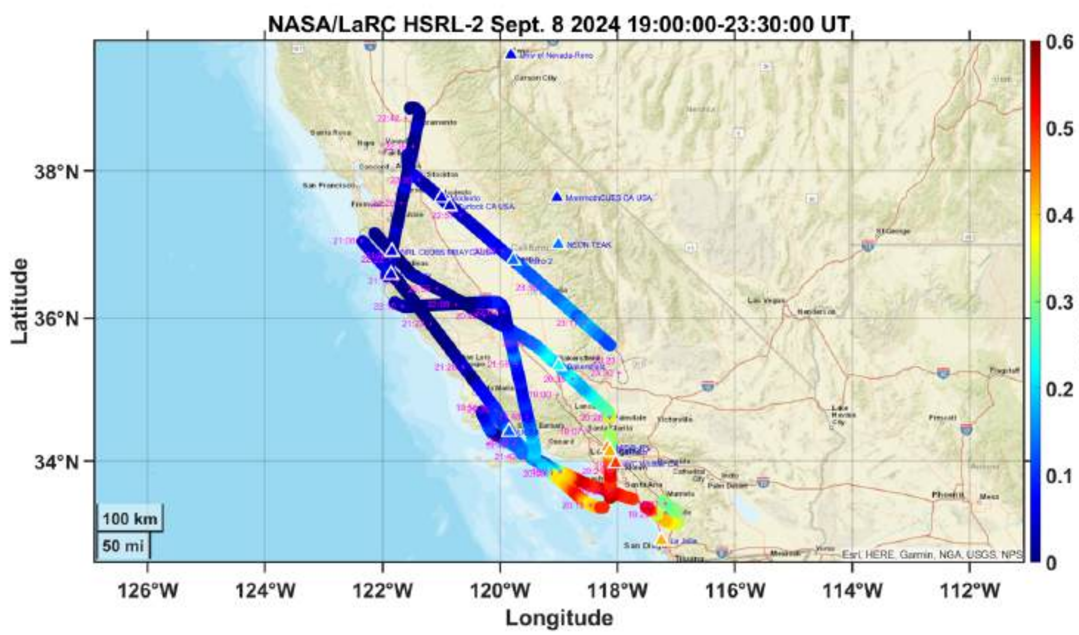

USC_SEAPRISM , N 33.564, W 118.118, Alt 31 m,
PI : Burton_Jones and Matthew_Ragan, bjones@usc.edu and
SSA Hybrid Level 1.5; 8 SEP 2024
16:37:00[skyerr=3.9%;sz=53;t440=0.35]
16:53:53[skyerr=3.4%;sz=50;t440=0.35]
17:52:39[skyerr=5.6%;sz=39;t440=0.34]
18:52:40[skyerr=6.1%;sz=31;t440=0.36]
20:52:41[skyerr=5.9%;sz=32;t440=0.40]
21:52:41[skyerr=3.9%;sz=40;t440=0.37]
22:52:40[skyerr=3.8%;sz=51;t440=0.40]
SSA
Wavelength (nm)
Version 3
AERONET Project, NASA GSFC


USC_SEAPRISM , N 33.564, W 118.118, Alt 31 m,
PI : Burton_Jones and Matthew_Ragan, bjones@usc.edu and
SDA AOD from Level 1.5 AOD; 8 SEP 2024
Total_500nm : <0.292>
Fine_500nm : <0.237>
Coarse_500nm : <0.056>
AERONET Version 3 DS, SDA Version 4.1
SDA Aerosol Optical Depth
hh->
DD->
SEP
2024
Time(UTC)
AERONET Project, NASA GSFC

ER2/HSRL2

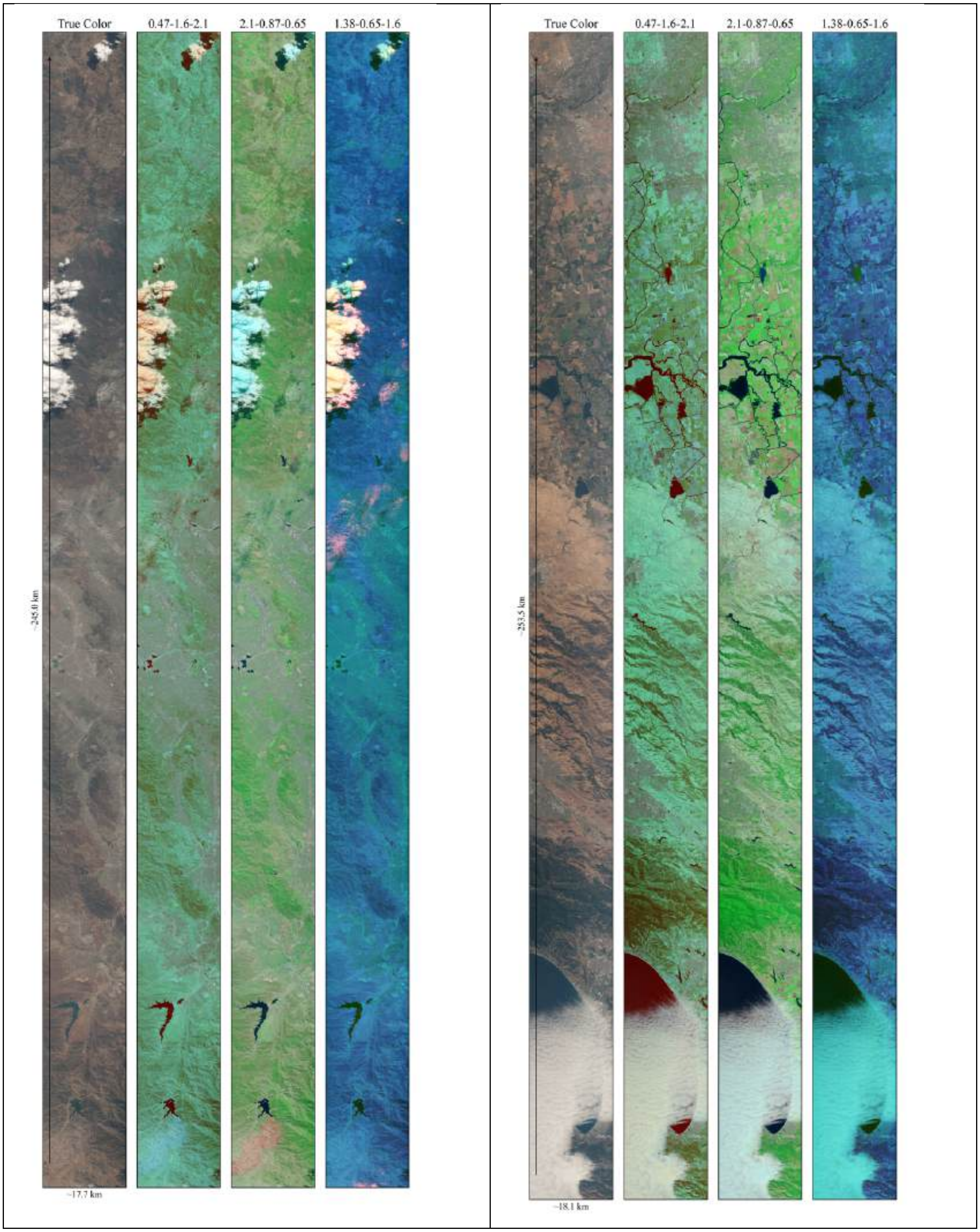


NASA/LaRC HSRL-2 September 8, 2024 PACE-PAX
Aerosol Backscatter (Mm-sr)$^{-1}$ (355 nm)
0.1
1
10
20
Altitude(km)
Longitude(deg)
Latitude(deg)



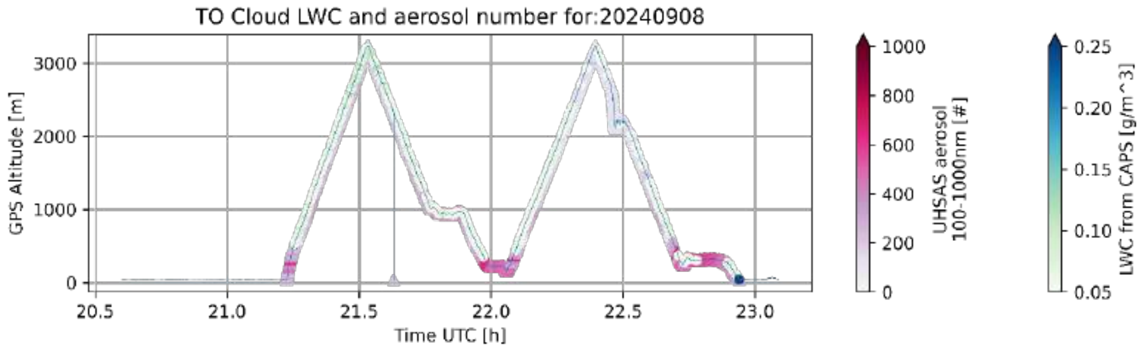
NASA/LaRC HSRL-2 Sept. 8 2024 19:00:00-23:30:00 UT
Latitude
Longitude
AOT (355 nm)
100 km
50 mi
Esri, HERE, Garmin, NGA, USGS, NPS

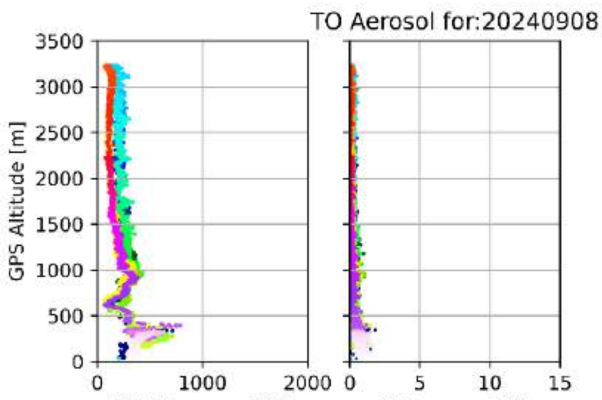
ER2/PICARD

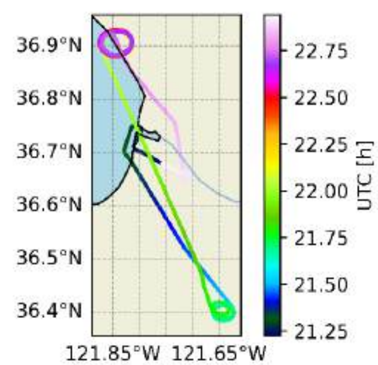

True Color
0.47-1.6-2.1
2.1-0.87-0.65
1.38-0.65-1.6
~245.0 km
~17.7 km
True Color
0.47-1.6-2.1
2.1-0.87-0.65
1.38-0.65-1.6
~253.5 km
~18.1 km

ER2/PRISM

TO Quicklooks







Twin Otter flight report

PACE-PAX Research Flight report 2024/09/08

Twin Otter Flight

Manifest:

Bryce Kujat (pilot)

Jeff Martin (pilot)

Adam Ahern (QNC)

Edward Winstead (QNC)

Take off: 14:13:30 (21:13:30 UTC) Marina Airport (OAR)

Landing: 15:56:24 (22:56:24 UTC) Marina Airport (OAR)

Duration = 1.7 hrs.

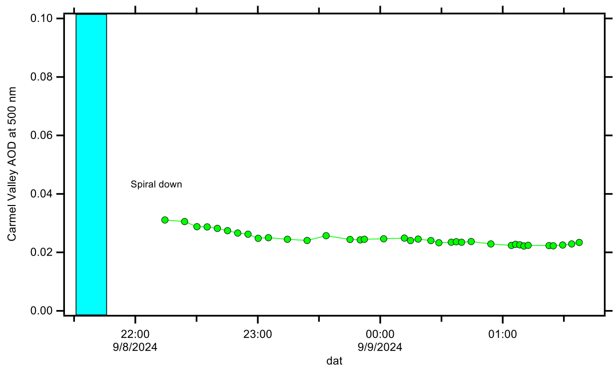
Objectives: Profiles of aerosol scattering, absorption coefficients, and size distributions together with scattering (polarized) phase functions of optically thin aerosol over two AERONET sites. Coordinated spiral profile with PACE (Ka band not transmitting, no science data) overpass at Carmel Valley and EarthCare at CEOBS site at 22:29 UTC. ER-2 will overpass Carmel Valley at 22:16 UTC, 15 minutes before Twin Otter is on site. ER-2 will overpass CEOBS at 22:22 UTC while Twin Otter is spiraling.

Summary:

Less than 5 Mm^{-1} scattering during takeoff at 21:16 UTC, consistent while climbing out to Carmel Valley AERONET site. Spiral down started at 21:31 UTC in clear sky. Bottom of spiral was 21:31 UTC at 3200 ft due to terrain limitation with a maximum of 6 Mm^{-1} of scattering. Transit to CEOBS at minimum safe altitude, ~1000 ft after clearing the mountains. Observed clouds underneath the plane starting at 21:55 UTC, ~20 Mm^{-1} scattering, potentially the same old smoke that was sampled 2024/09/07. 20:03 UTC clear of clouds, descend to 500 ft. Aerosol scattering drops to 10 Mm^{-1} over land at 22:05 UTC. Start spiraling up at 22:06 UTC, full spiral up to 10,000 ft ending at 22:23 UTC, immediately begin spiral down. ER2 overpass at 22:22. EarthCARE overpass at 22:29. Bottom of spiral was at 500 ft at 22:43 UTC, at which point we climbed to ~1000 ft for return to base via Spreckler. No tower fly-by was attempted due to limited visibility caused by fog. Landing was at 22:56:24 UTC. All instruments aboard the Twin Otter were operating nominally throughout the flight.

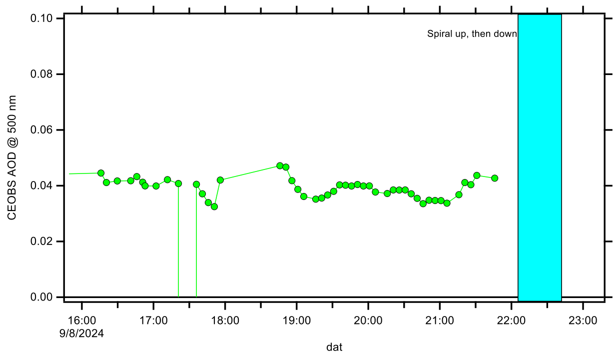
Unfortunately, the Carmel Valley AERONET was not sampling during our spiral down and the CEOBS AERONET shows no data in the level 1.5 product during our spirals, suggesting contamination by clouds. Coincidence with EarthCARE and ER-2 were successful.

21:43 UTC – Spiraling down over Carmel Valley AERONET. (Photo = Ahern)



Carmel Valley level 1.5 AOD @ 500 nm shows very low AOD after spiral.

22:10 UTC – Mid spiral showing partial incursion of clouds. (Photo = Ahern)



CEOBS level 1.5 AOD @ 500 nm shows very low AOD before spiral and cloud contamination after 22:00.

R/V Shearwater report

PACE-PAX R/V Shearwater day report

Date: 09/08/2024

Creator: Michael Ondrusek

Cruise ID: RF0908-RS

Sailed out: 1605 UTC (0905 PST)

Back in port: 2339 UTC (1639 PST)

Today, the ship occupied three stations.

Station #3 34.369073°, -119.638635°, arrival 1656 UTC

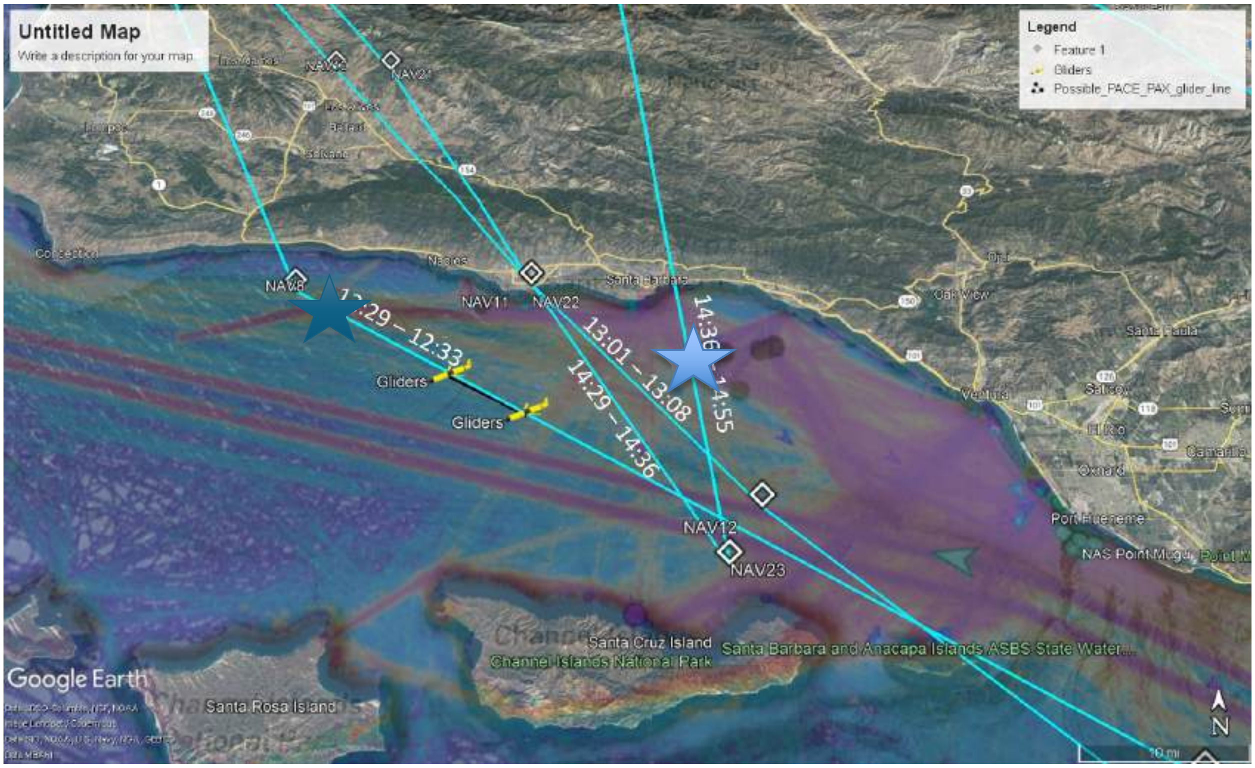
The first station was approximately 10 nm off shore. We conducted IOP profiles under cloudy conditions then decided to steam 1.5 hours west to 12:29 to 12:33 ER2 line where skies were clear (see stars on figure below).

Station #4 34.377946°, -120.077298°, 1900 UTC

We conducted a full station including AOPs, IOPs, and water filtrations. We were able to get out of the clouds to the east and had clear skies during the entire station. ER-2 o verflight at 17:50

Station #5 34.369073°, -119.638635, 2323 UTC

After the station #4, we had just enough time to get back to the 4th ER-2 overpass (14:36 to 14:55) line about 7 Nm offshore, same location as station #3. This location now had clear skies and again a complete station was run.



The Shearwater did not go out on the 9th or 10th due to high winds. We plan to go out on the 11th but will most likely stay near shore due to high swells.

System Status: New Hyperpro cable was delivered and will be replaced to see if it resolves the depth sensor problem. If not, will use the second Hyperpro in float mode only. Will be making adjustments to Aeronet on boat for better reception at dock.

Group Status: All groups were operating as expected.

R/V Blissfully report

PACE-PAX R/V Blissfully day report

Date: 09/08/2024

Creator: Bridget Seegers

Cruise ID: RF0908-RB

Sailed out: 15:10

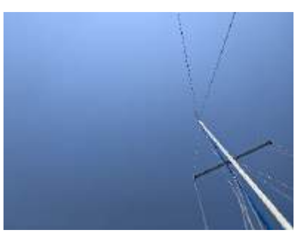
Back in port: 00:14 (09/09/2024)

Today, the ship accomplished....

Collection of vertical radiometry profiles and discrete sample collection (HPLC + ap) on 3 stations in proximity of SeaPRISM site. Each station has three sets of 5 HyperPro profiles to 20m and a single deep cast to 60m. Each station discrete water samples include triplicate HPLC + ap and duplicate community composition Lugol's preserved and paraformaldehyde samples for flow cytometry.

Station 1 (campaign station 4);

- arrival 17:17, 33° 33.74' N, 118° 7.18' W , clear skies



- ER-2 overflight 19:33

Station 2 (campaign station 5):

- Arrival 19:10 same location as station 1 17:17, 33° 33.74' N, 118° 7.18' W , clear skies

Station 3 (campaign station 6):

- Arrival 20:40 at 33° 34.12' N.   118° 6.96' W, about one km north of SeaPRISM site, clear skies
- PACE overpass 20:20
- ER-2 overflight 21:17

Tomorrow,

the R/V Blissfully will not sail.

Ship plans through the next 3 days…

Sail on the next ER-2 flight day

System Status…

All operational, no time for microtops measurements.

Group Status…

Pirate life for me.

PACE-PAX research flight report 2024/09/10

Compiled by Kirk Knobelspiesse, Ivona Cetinic, Bridget Seegers
2024/09/17
Reviewed by Samuel LeBlanc

Short ER2 flight in Southern California focusing on extremely active Line, Airport and Bridge fires, with overpass of R/V Blissfully and HyperNAV offshore. Intense smoke from fires in eastern LA basin and downwind to the East and North, with imagery indicating creation of pyrocumulus. Overpass of Ivanpah Playa with possible moderate aerosol load. Over ocean is relatively cloud free with low aerosol optical depths. Due to a data downlink issue, PACE was not ingesting science data on this day. High surface winds at AFRC necessitated an early return to base; no EarthCARE underpass possible.

ER-2
Takeoff: 16:27, Landing: 20:43, Duration: 4.3
Instrument status: RSP had a data logging / computer issue, no valid data collected. All other instruments operating well.
Mission Scientist: Kirk Knobelspiesse
Pilot: Kirt Stallings; Mobile: Tim Williams

Twin Otter
No flight

R/V Shearwater
No operations

R/V Blissfully
Departure: 15:19, Return: 21:01, Duration: 5.6
Instrument status: good
Captain/Mission Scientist: Bridget Seegers
See end for full R/V Blissfully report

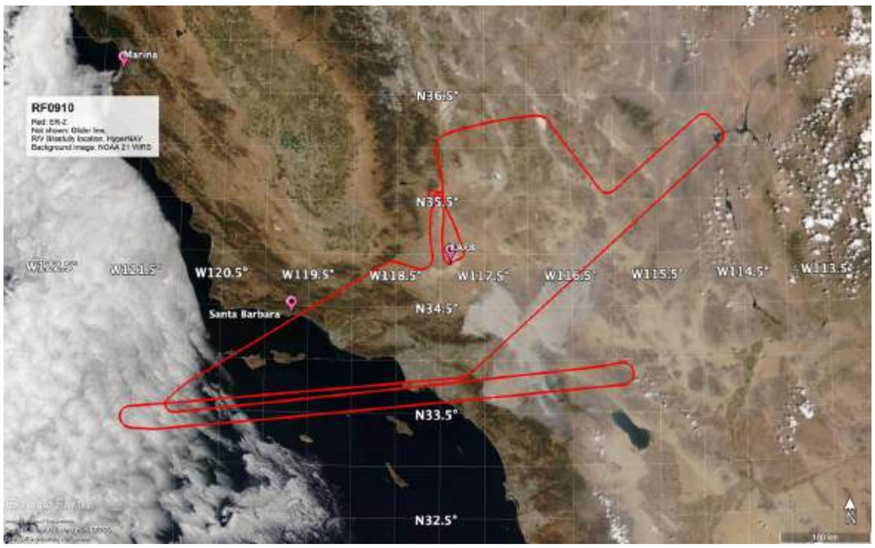
PACE
PACE has problem, Ka band not transmitting, no science data collection

EarthCARE
No underpass

Gliders
Operational

HyperNAV
Operational

Overall image summary



Bridge fire, photo from ER-2 pilot Kirt Stallings

Validation Traceability Matrix itemized objectives

VTM elements in **black** satisfied, **blue** partially satisfied

Time	Platform	VTM(hrs)	
15:19	RB		Departure
16:27	ER2		Takeoff
17:21	ER2	1a(0.5x0.25), 4a(0.5x0.50)	Overfly Ivanpah Playa. Possible aerosol load? Small clouds partly obscure scene
17:39	ER2	1d(1.0x0.50) 6a(1.0x0.50)	Overfly extremely high aerosol loads downwind of the Line, Bridge and Airport fires. 17:44 overflies Line fire
18:03	ER2	4d(0.5) 4b(1.0)	Overfly HyperNAV location (surfaces at 20:26), possible sunglint
18:47	ER2, SB	1b(0.5+1.5), 1c(0.5+1.5)	ER-2 overfly R/V Blissfully and USC_SeaPRISM AERONET site, AOD(490nm)=0.10
18:53	ER2	1d(1.0x0.75) 6a(1.0x0.75) 6c(0.5x0.25)	Overfly extremely high aerosol loads downwind of the Airport fires. Evidence of pyrocumulus cloud in imagery
19:16	ER2	1d(1.0x0.75) 6a(1.0x0.75)	Overfly extremely high aerosol loads downwind of the Airport fires. Edge of plume observed by previous line
19:35	ER2	4d(1.0)	Overfly HyperNAV location (surfaces at 20:26)
19:58	ER2	4b(0.5)	Ovefly UCSB AER0NET. AOD(490)=0.1, sunglint
20:43	ER2		Landing
21:01	RB		Return

ER2: ER-2
RB: R/V Blissfully

Commented [SL1]: No TO, so only half

Commented [SL2]: Evidence of multiple aerosol layers in HSRL, but no TO

Assessment:

- Top remaining objectives (score above 6.0): PACE aerosol in narrow swath (3a,b), EarthCARE cloud (3e), land surface (1a)

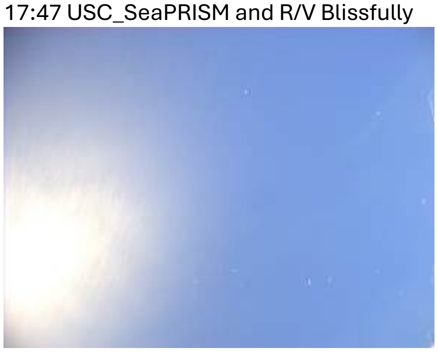
PACE-PAX progress tracking

Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 9/9	Fractional success 9/10	Fractional success 9/11	Fractional success 9/12	Fractional success 9/13	Fractional success 9/14	Fractional success 9/15	Total success	Remaining score
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	0.6	0.0%	4.8%	0.0%	0.0%	0.0%	0.0%	0.0%	25.0%	6.0
	b	Ocean radiometric parameters	10	8.0	22.5	0.0%	3.6%	0.0%	6.7%	0.0%	0.0%	0.0%	94.0%	0.6
	c	Aerosol parameters over the ocean	12	8.0	16.4	0.0%	5.1%	0.0%	5.0%	0.0%	0.0%	0.0%	87.1%	1.5
	d	Aerosol parameters over land	12	8.0	27.2	0.0%	1.7%	0.0%	2.3%	0.0%	0.0%	0.0%	96.6%	0.4
	e	Cloud parameters	12	8.0	7.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	58.3%	5.0
	f	Ocean surface parameters	1	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	3.5	0.0%	0.0%	0.0%	13.3%	0.0%	0.0%	0.0%	35.4%	6.5
	b	Aerosol parameters over land (PACE)	10	8.0	2.1	0.0%	0.0%	0.0%	11.6%	0.0%	0.0%	0.0%	23.3%	7.7
	c	Cloud parameters (PACE)	5	2.0	1.5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	52.8%	2.4
	d	Aerosol parameters (EarthCARE)	8	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	46.5%	4.3
	e	Cloud parameters (EarthCARE)	8	4.0	0.5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.8%	7.1
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	2.0	0.1	0.0%	6.1%	0.0%	0.0%	0.0%	0.0%	0.0%	6.1%	5.6
	b	Validate large reflectances with high polarization	6	2.0	1.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	39.3%	3.6
	c	Validate large reflectances with low polarization	6	2.0	2.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	63.2%	2.2
	d	Overfly vicarious calibration sites	6	4.0	1.3	0.0%	26.8%	0.0%	0.0%	0.0%	0.0%	0.0%	26.8%	4.4
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	2.0	3.3	0.0%	41.0%	0.0%	0.0%	0.0%	0.0%	0.0%	80.3%	0.8
	b	High aerosol loads over ocean	4	2.0	1.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	39.3%	2.4
	c	Multiple aerosol layers	1	2.0	4.1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	87.3%	0.1
	d	Aerosol under thin cirrus	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0
	e	Aerosol above liquid phase cloud	4	2.0	3.5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	82.6%	0.7
	f	Broken clouds with complex structure	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0
	g	Dust aerosols over ocean	4	2.0	1.1	0.0%	0.0%	0.0%	43.0%	0.0%	0.0%	0.0%	43.0%	2.3
	h	Aerosol and ocean parameters over turbid waters	2	2.0	3.1	0.0%	0.0%	0.0%	56.9%	0.0%	0.0%	0.0%	79.0%	0.4
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0
	k	Smoke aerosols over ocean	1	2.0	1.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	39.3%	0.6
		total:	150	98	102.7	0.0%	3.4%	0.0%	4.6%	0.0%	0.0%	0.0%	49.6%	
														total
				ER-2 flight hours	18.9	0	4.3	0	0	0	0	0	0	4.3
				TO flight hours	22.2	0	0	0	3.7	0	0	0	0	3.7
				Shearwater days	2	0	1	0	1	0	0	0	0	2
		PACE-PAX overall objectives satisfied:		49.6%										

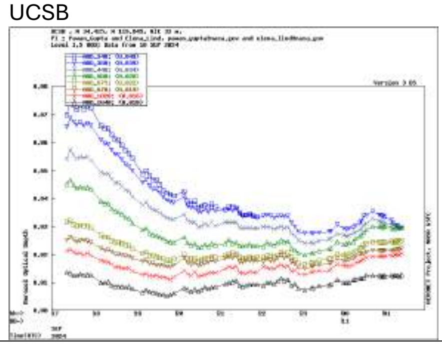
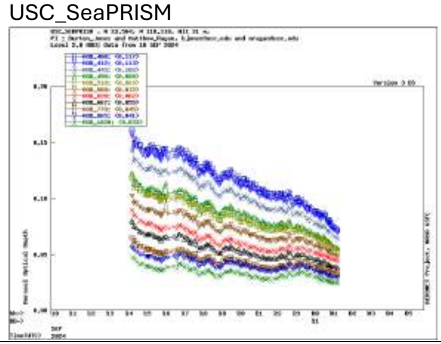
Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

https://www-air.larc.nasa.gov/missions/pacepax/index.html

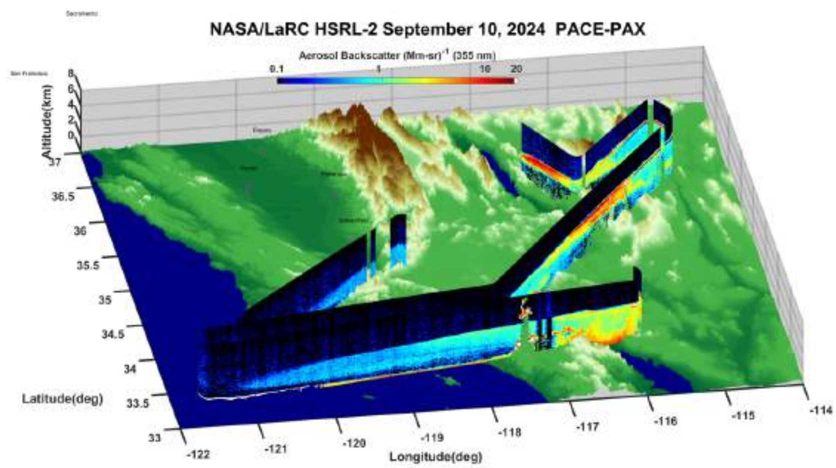
ER-2/MVIS images

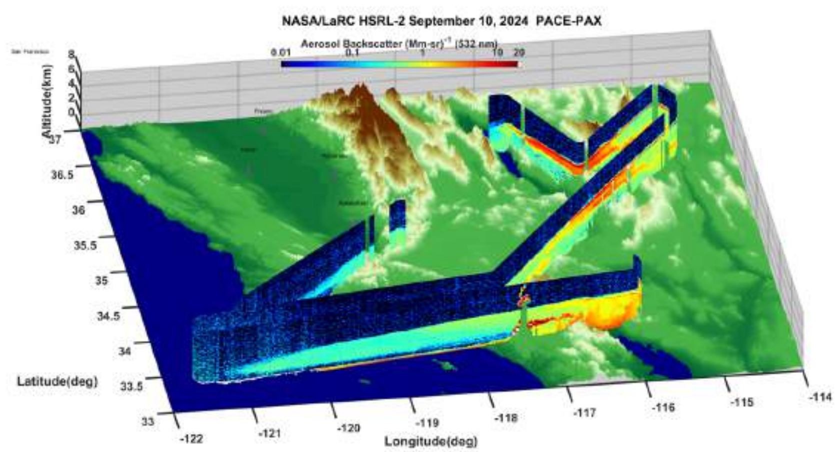
17:25:19 Ivanpah Playa 	17:43:17 Line fire 
17:47 USC_SeaPRISM and R/V Blissfully 	18:52:39 Airport fire with pyrocu 
19:59:58 Overfly UCSB Aeronet location 	

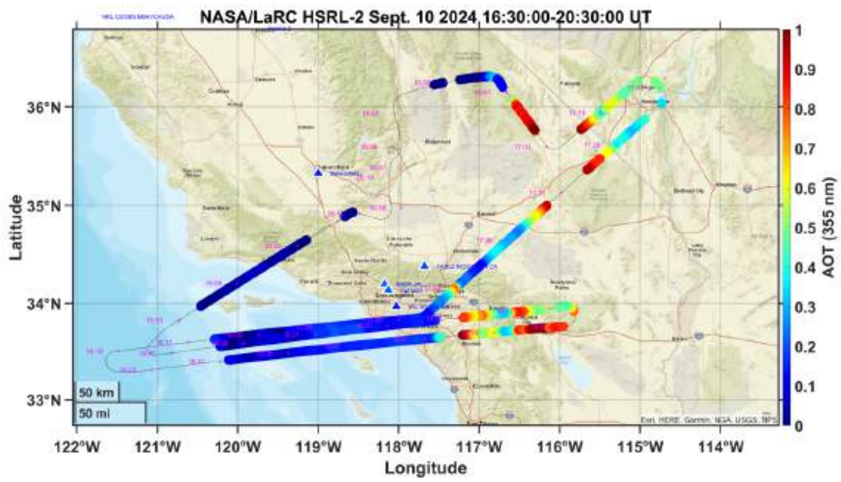
AERONET quicklooks

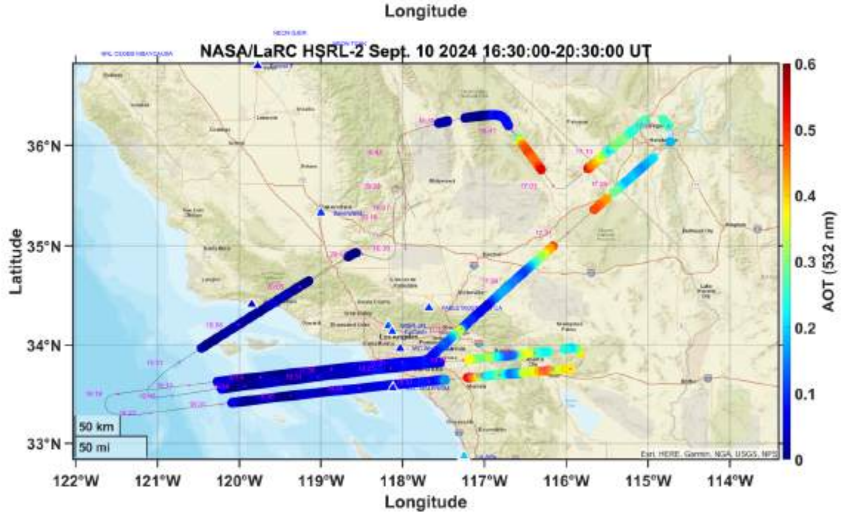
UCSB	USC_SeaPRISM
	

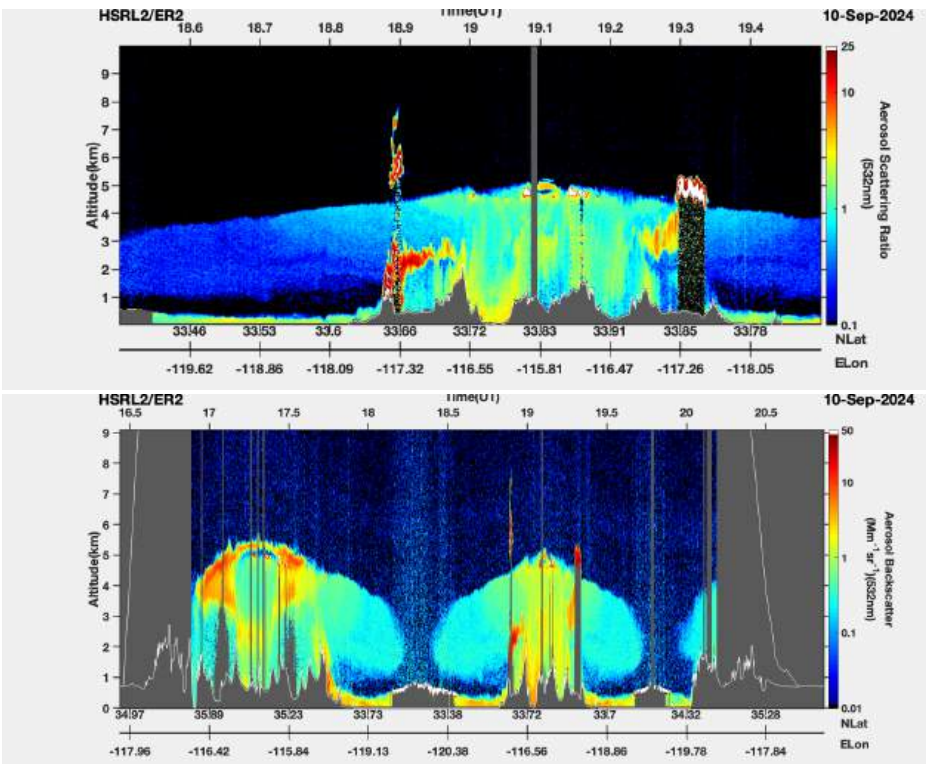
ER2/HSRL2


NASA/LaRC HSRL-2 September 10, 2024 PACE-PAX
Aerosol Backscatter (Mm-sr)^-1 (355 nm)
0.1
1
10
20
Altitude(km)
8
6
4
2
0
37
36.5
36
35.5
35
34.5
34
33.5
33
Latitude(deg)
-122
-121
-120
-119
-118
-117
-116
-115
-114
Longitude(deg)

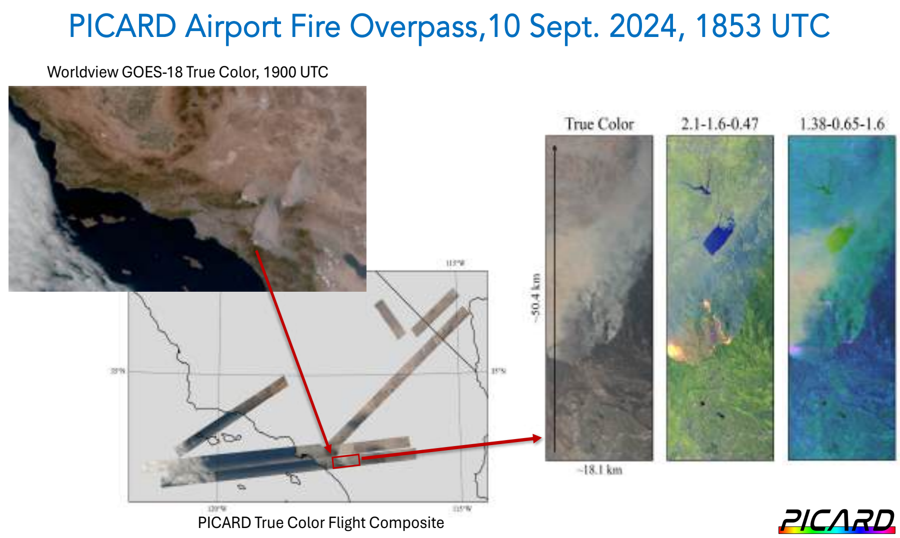

NASA/LaRC HSRL-2 September 10, 2024 PACE-PAX
Aerosol Backscatter (Mm-sr)^-1 (532 nm)
0.01
0.1
1
10
20
Altitude(km)
8
6
4
2
0
37
36.5
36
35.5
35
34.5
34
33.5
33
Latitude(deg)
-122
-121
-120
-119
-118
-117
-116
-115
-114
Longitude(deg)

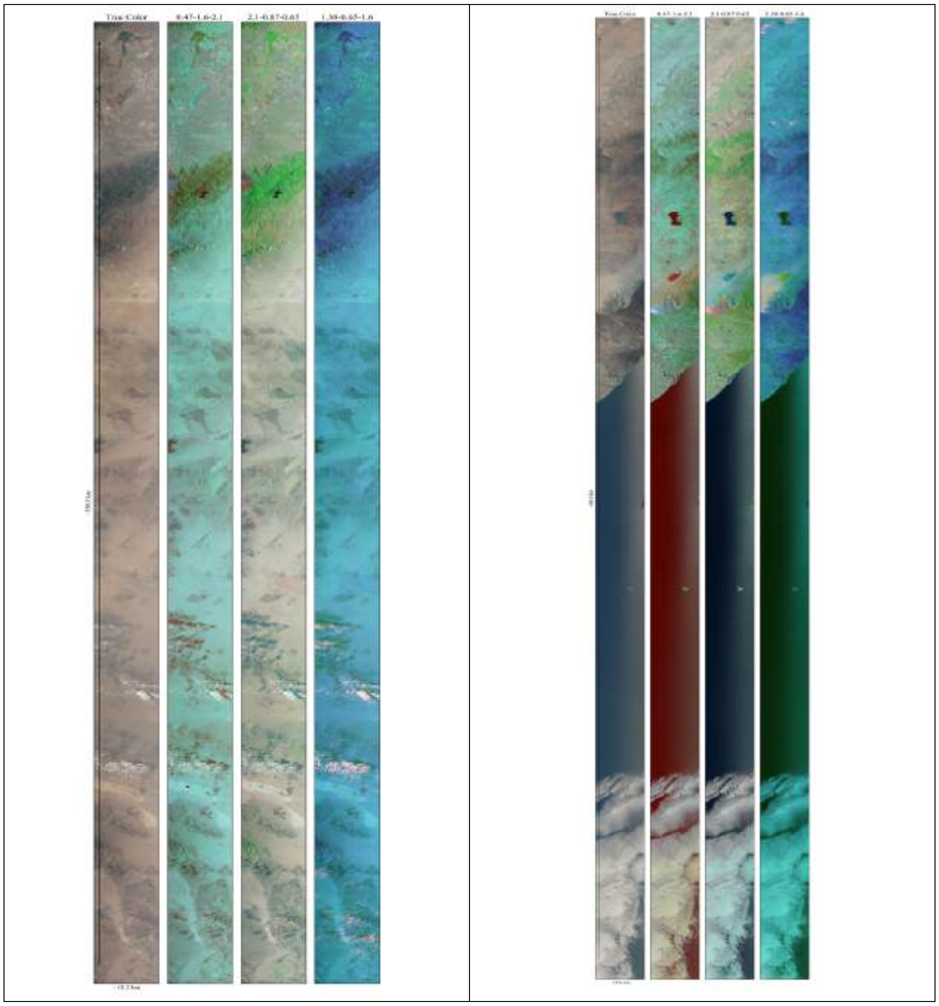

NASA/LaRC HSRL-2 Sept. 10 2024 16:30:00-20:30:00 UT
Latitude
Longitude
AOT (355 nm)
50 km
50 mi


NASA/LaRC HSRL-2 Sept. 10 2024 16:30:00-20:30:00 UT
Latitude
Longitude
AOT (532 nm)
50 km
50 mi


HSRL2/ER2
Time(UT)
10-Sep-2024
Altitude(km)
Aerosol Scattering Ratio (532nm)
NLat
ELon
HSRL2/ER2
Time(UT)
10-Sep-2024
Altitude(km)
Aerosol Backscatter (Mm⁻¹ sr⁻¹)(532nm)
NLat
ELon

ER2/PICARD


PICARD Airport Fire Overpass,10 Sept. 2024, 1853 UTC
Worldview GOES-18 True Color, 1900 UTC
True Color
2.1-1.6-0.47
1.38-0.65-1.6
~50.4 km
~18.1 km
PICARD True Color Flight Composite
PICARD


True Color
0.47-1.6-2.1
2.1-0.87-0.65
1.38-0.65-1.6

R/V Blissfully report

PACE-PAX R/V Blissfully day report

Date: 09/10/2024

Creator: Bridget Seegers

Cruise ID: RF0910-RB

Sailed out: 15:19

Back in port: 21:01

Today, the ship accomplished....

Collection of vertical radiometry profiles and discrete sample collection (HPLC + ap) on a single station in proximity of SeaPRISM site (2 nm north due to flight path). The station had three sets of 5 HyperPro profiles to 20m and a single deep cast to 60m and discrete water samples included triplicate HPLC + ap and duplicate community composition Lugol's preserved and paraformaldehyde samples for flow cytometry.

Station 1 - 33.597871°, -118.117673°, arrival at 17:34

Sampling happened parallel to the ER-2 overflight at 18:47

Tomorrow, RV Blissfully is taking a day off

Ship plans through the next 3 days...

Sampling in coordination with rest of the experiment

System Status...

All good

Group Status...

All great

PACE-PAX research report 2024/09/11

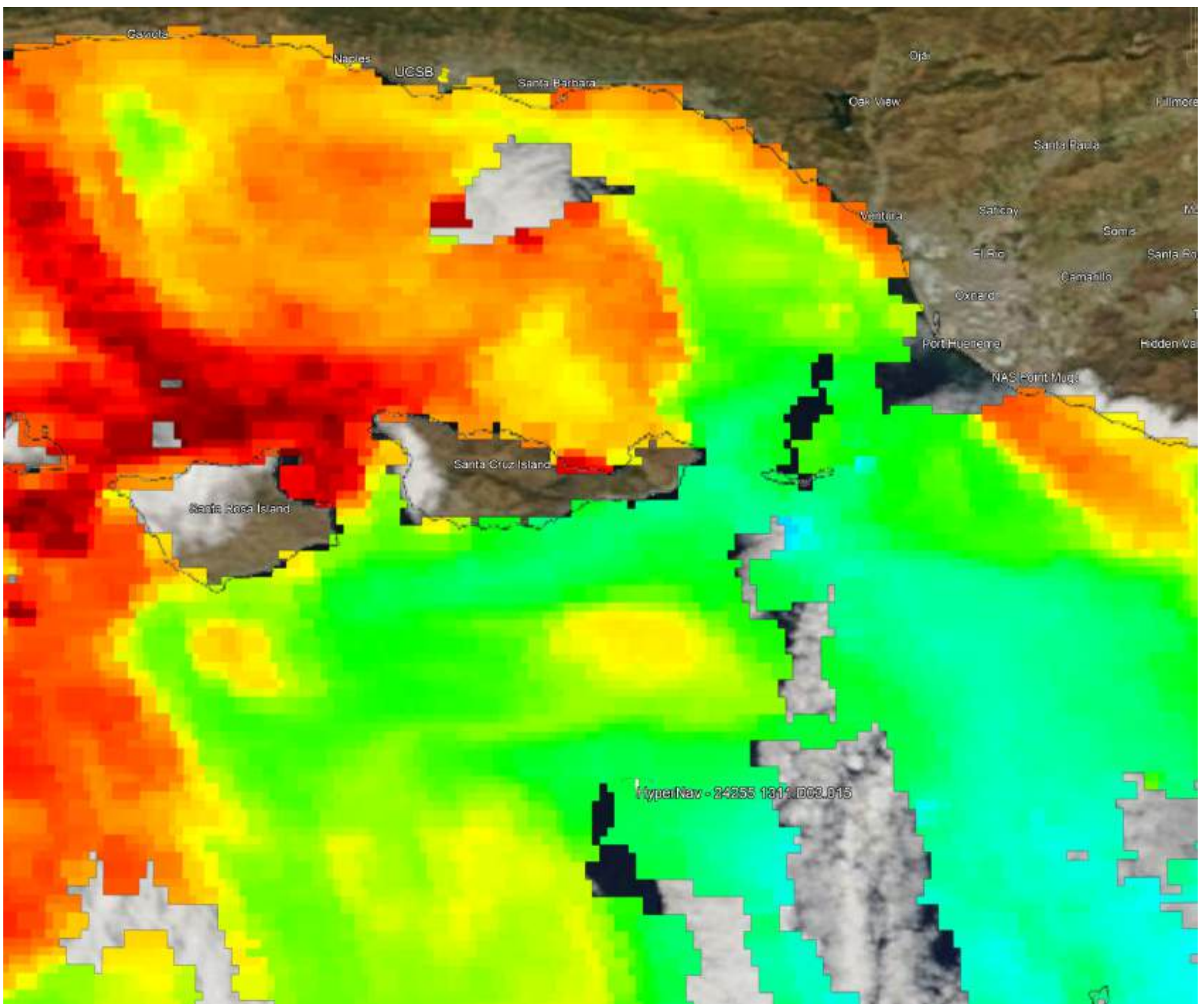
Compiled by Samuel LeBlanc, 2025/09/08

Summary: HyperNAV at PACE overpass in clear waters

ER-2
None

Twin Otter
None

PACE
Overpass: 20:49
Orbit track west offshore



All times are in UTC, VTM elements in **black** satisfied, **blue** partially satisfied and **red** not satisfied.

Time	Platform	VTM	
20:05	PACE		Overpass
20:19	HN	1b(0.5)	Profile up, nearest AOD (USC_SEAPRISM)=0.055

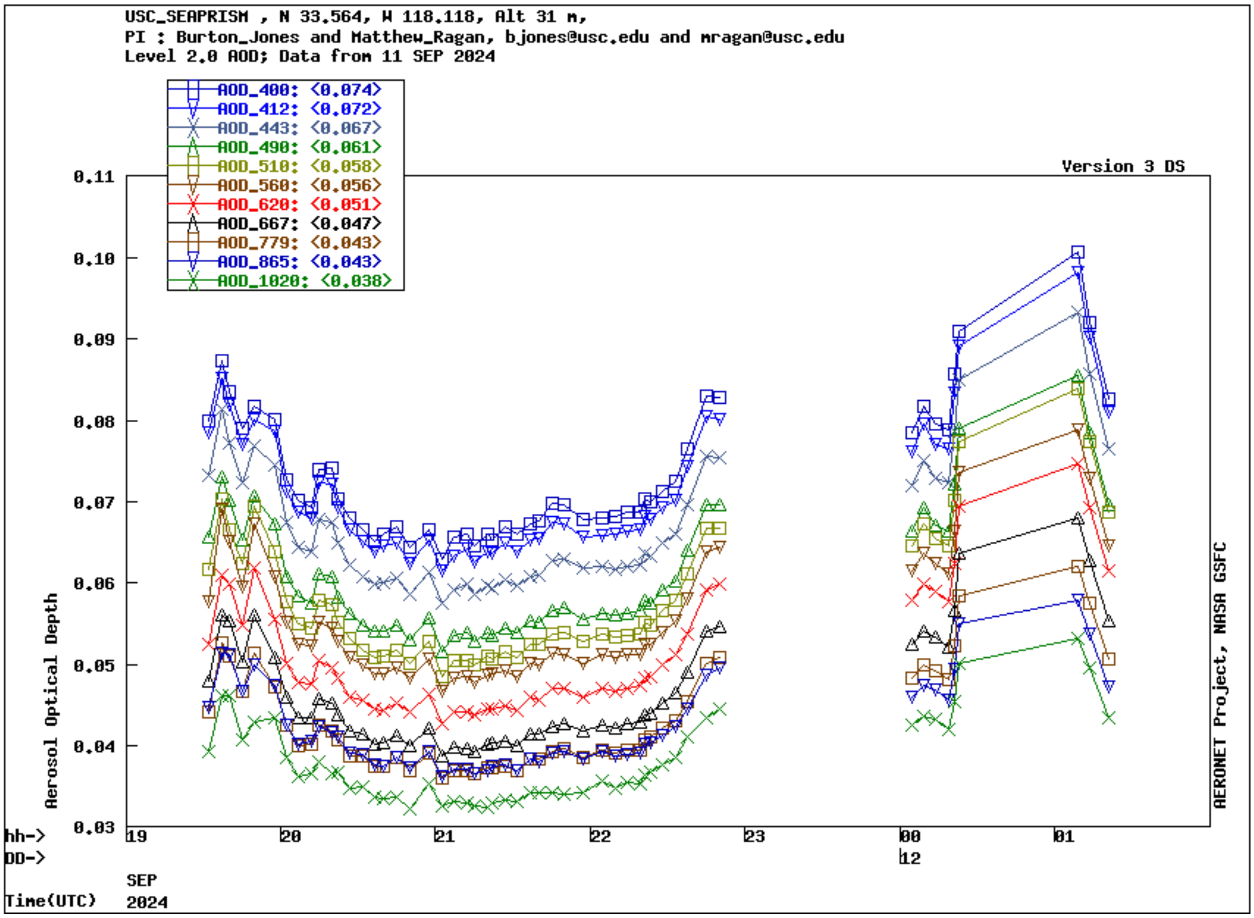
HN: HyperNAV

Assessment:

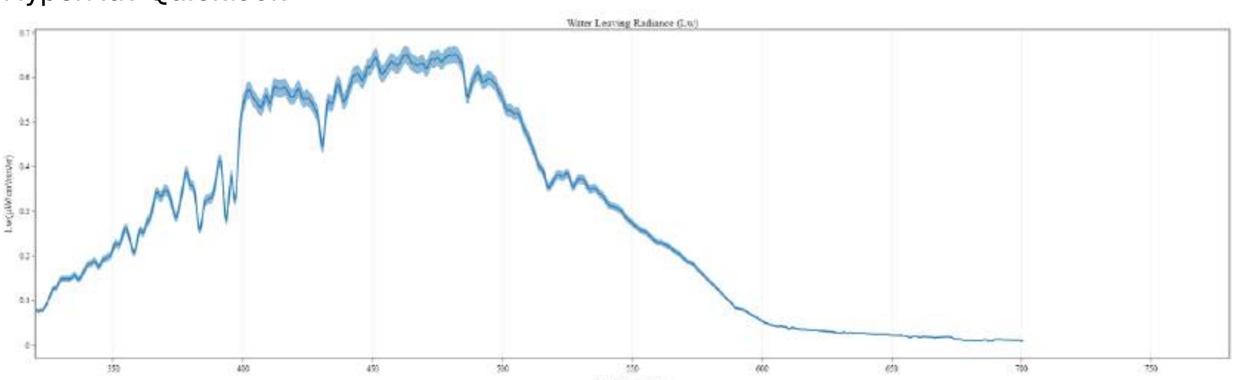
		PACE-PAX progress tracking														29-Aug		
Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 8/29	Fractional success 9/3	Fractional success 9/4	Fractional success 9/5	Fractional success 9/6	Fractional success 9/7	Fractional success 9/8	Total success	Remaining score		Flight details		
																time	completeness	success
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	0.5	**20.1%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**20.1%**	6.4		0.5	0.9	1.6
	b	Ocean radiometric parameters	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0		0.0	1.0	0.0
	c	Aerosol parameters over the ocean	12	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.0		0.0	1.0	0.0
	d	Aerosol parameters over land	12	8.0	3.0	**31.3%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**31.3%**	8.2		3.0	1.0	3.8
	e	Cloud parameters	12	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.0		0.0	1.0	0.0
	f	Ocean surface parameters	1	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0		0.0	1.0	0.0
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0		0.0	1.0	0.0
	b	Aerosol parameters over land (PACE)	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0		0.0	1.0	0.0
	c	Cloud parameters (PACE)	5	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0		0.0	1.0	0.0
	d	Aerosol parameters (EarthCARE)	8	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.0		0.0	1.0	0.0
	e	Cloud parameters (EarthCARE)	8	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.0		0.0	1.0	0.0
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0		0.0	1.0	0.0
	b	Validate large reflectances with high polarization	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0		0.0	1.0	0.0
	c	Validate large reflectances with low polarization	6	2.0	0.5	**22.1%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**22.1%**	4.7		0.5	1.0	1.3
	d	Overfly vicarious calibration sites	6	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.0		0.0	1.0	0.0
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0		0.0	1.0	0.0
	b	High aerosol loads over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0		0.0	1.0	0.0
	c	Multiple aerosol layers	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0		0.0	1.0	0.0
	d	Aerosol under thin cirrus	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0		0.0	1.0	0.0
	e	Aerosol above liquid phase cloud	4	2.0	0.5	**11.8%**	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**11.8%**	3.5		0.5	0.5	0.5
	f	Broken clouds with complex structure	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0		0.0	1.0	0.0
	g	Dust aerosols over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0		0.0	1.0	0.0
	h	Aerosol and ocean parameters over turbid waters	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0		0.0	1.0	0.0
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0		0.0	1.0	0.0
	k	Smoke aerosols over ocean	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0		0.0	1.0	0.0
		total:	**150**	**98**	**4.5**	**4.8%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**4.8%**			**Accomplished**		**0.048**
														total				
				ER-2 flight hours		2.8	0	0	0	0	0	0	0	**2.8**				
				TO flight hours		2.5	0	0	0	0	0	0	0	**2.5**				
				Shearwater days		0	0	0	0	0	0	0	0	**0**				

PACE-PAX overall objectives satisfied: 4.8%

AERONET Quicklook



HyperNav Quicklook



PACE satellite quicklooks

PACE-PAX research flight report 2024/09/12

Compiled by Kirk Knobelspiesse, Ivona Cetinić, Brian Cairns
2024/09/18
Reviewed by Samuel LeBlanc

Planned ER-2 activities cancelled due to an aircraft issue just prior to takeoff. Twin Otter, R/V Shearwater and R/V Blissfully activities commenced regardless. All performed measurements during the PACE overpass (20:39 UTC) regardless, in most cases within the SPEXone swath. The Twin Otter performed spirals over Turlock, Sacramento_River AERONET sites, and a missed approach at NASA Ames Research Center (aka Moffett Field), the location of another AERONET instrument (NASA_Ames). R/V Shearwater performed three stations, station #7 and #8 were within 30min of the PACE overpass and within the PACE OCI and HARP swaths. Similarly station RB_9 was sampled by the R/V Blissfully at the time of overpass in the OCI and HARP swaths.

ER-2
The ER-2 flight was scrubbed due to a pressure seal problem. This was resolved prior to the subsequent flight on 9/13.

Twin Otter
Takeoff: 18:59, Landing: 22:38, Duration: 3.7
Instrument status: Good
Manifest: Bryce Kujat (pilot), Jeff Martin (pilot), Luke Ziemba (QNC), Ed Winstead (QNC)
See end for full Twin Otter report

R/V Shearwater
Departure: 15:49, Return:, Duration: 23:45
Instrument status: good
Captain/Mission Scientist: Michael Ondrusek
See end for full R/V Shearwater report

R/V Blissfully
Departure: 15:59, Return: 23:35, Duration: 7.5
Instrument status: good
Captain/Mission Scientist: Bridget Seegers
See end for full R/V Blissfully report

PACE
Overpass at 20:39 within SPEX swath for Twin Otter and OCI/HARP swath for Shearwater and Blissfully

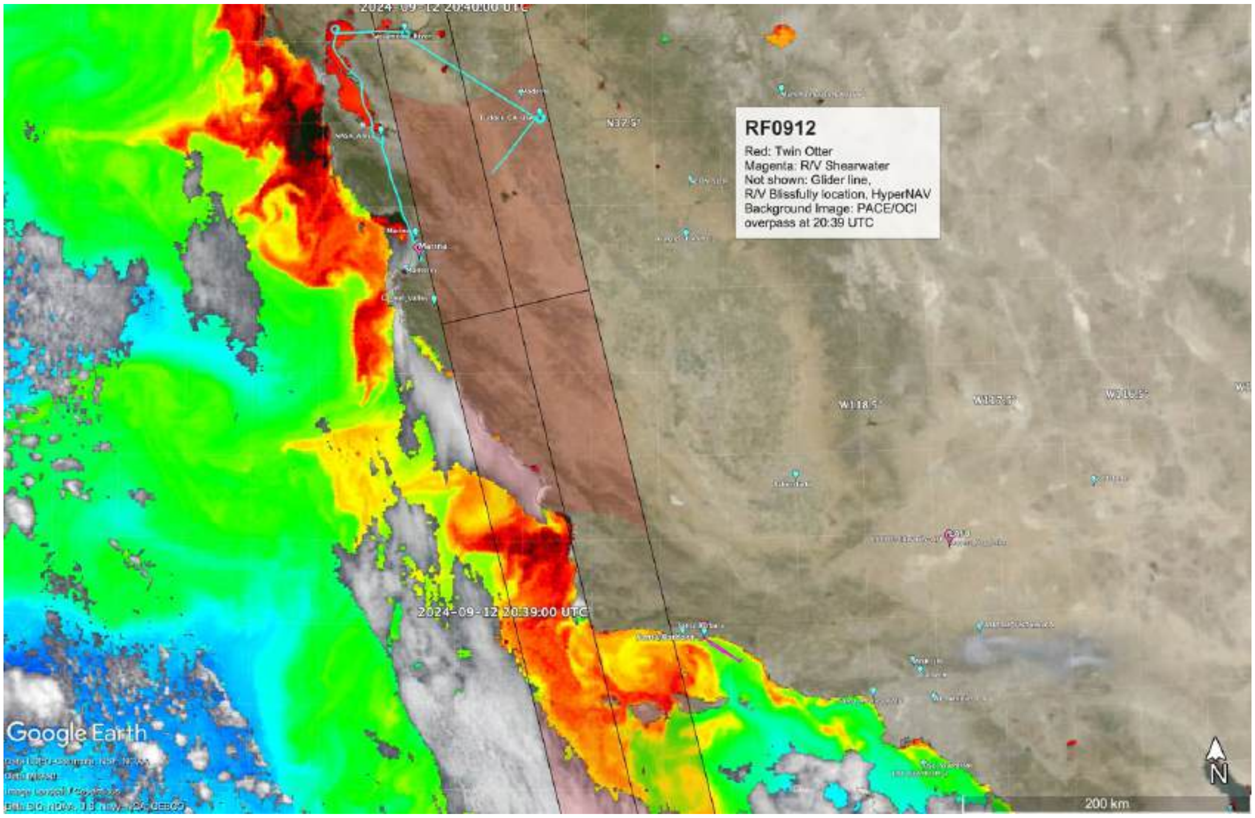
EarthCARE
No underpass

Gliders
Operational

HyperNAV

Operational

Overall image summary



Validation Traceability Matrix itemized objectives

VTM elements in **black** satisfied, **blue** partially satisfied

Time UTC	Platform	VTM(hrs)	
15:49	RS		Departure
15:59	RB		Departure
18:59	TO		Takeoff
19:38	TO		Begin spiral down at Turlock AERONET site. AOD(500)=0.05
20:00	TO	1d(1.5*0.75), 3b(1.5*0.75)	Spiral ends at Turlock. Just outside ideal +/- 30 min PACE overpass window but probably ok since aerosol load is so small.
20:23	RB	1b(1.5), 1c(0.5)	R/V Blissfully station begins. Near USC_SeaPRISM Aeronet-OC site, and in PACE-OH swath. AOD(490)=0.13
20:37	RS	1b(1.5) 1c(0.5)	R/V Shearwater ends station #7 in PACE-OH swath. Station started at 18:49
20:39	TO		PACE overpass, TO @ Turlock and Sacramento River in PACE-OHS swath, Shearwater and Blissfully withing PACE-OH swath
20:39	TO	1b(1.5), 1d(1.5), 3a(1.5), 6g(1.5*0.75), 6h(1.5)	Start ascend over Sacramento_River AERONET-OC site. Water very turbid. Within PACE-OHS swath. Small amounts of dust in spiral. AOD(532)=0.04
20:38	TO		End spiral over Sacramento_River
20:39	**PACE**		**PACE-OHS overpass**
21:00	RS	1b(1.5) 1c(0.5)	R/V Shearwater starts station #8 in PACE-OH swath. Station ends at 22:54
21:15	TO		Spiral down over San Pablo Bay
21:39	TO	1d(1.5*0.75)	End spiral down over San Pablo bay, , then proceed at low level over San Francisco Bay southward to NASA_Ames/Moffett field
22:06	TO	1d(1.5), 1c(1.5*0.75), 6h(1.5*0.75)	Missed approach and ascend at Moffett Field, NASA_Ames AERONET site AOD(500)=0.04. Can extend this value using HSRL to validate over turbid water retrievals in SF bay.
22:38	TO		Landing
	RS		Return
20:23	RB		Return

PACE-OHS: within swath of PACE's OCI, HARP2 and SPEXone instruments
PACE-OH: within swath of PACE's OCI and HARP2 instruments
TO: CIRPAS Twin Otter
RB: R/V Blissfully
RS: R/V Shearwater

Assessment:

- 4.6% of objectives satisfied, despite lack of ER-2. Good use of satellite overpass, especially for TO observations over turbid water.
- Top remaining objectives (score above 6.0): PACE aerosol in narrow swath (3a,b), EarthCARE cloud (3e), land surface (1a)

PACE-PAX progress tracking

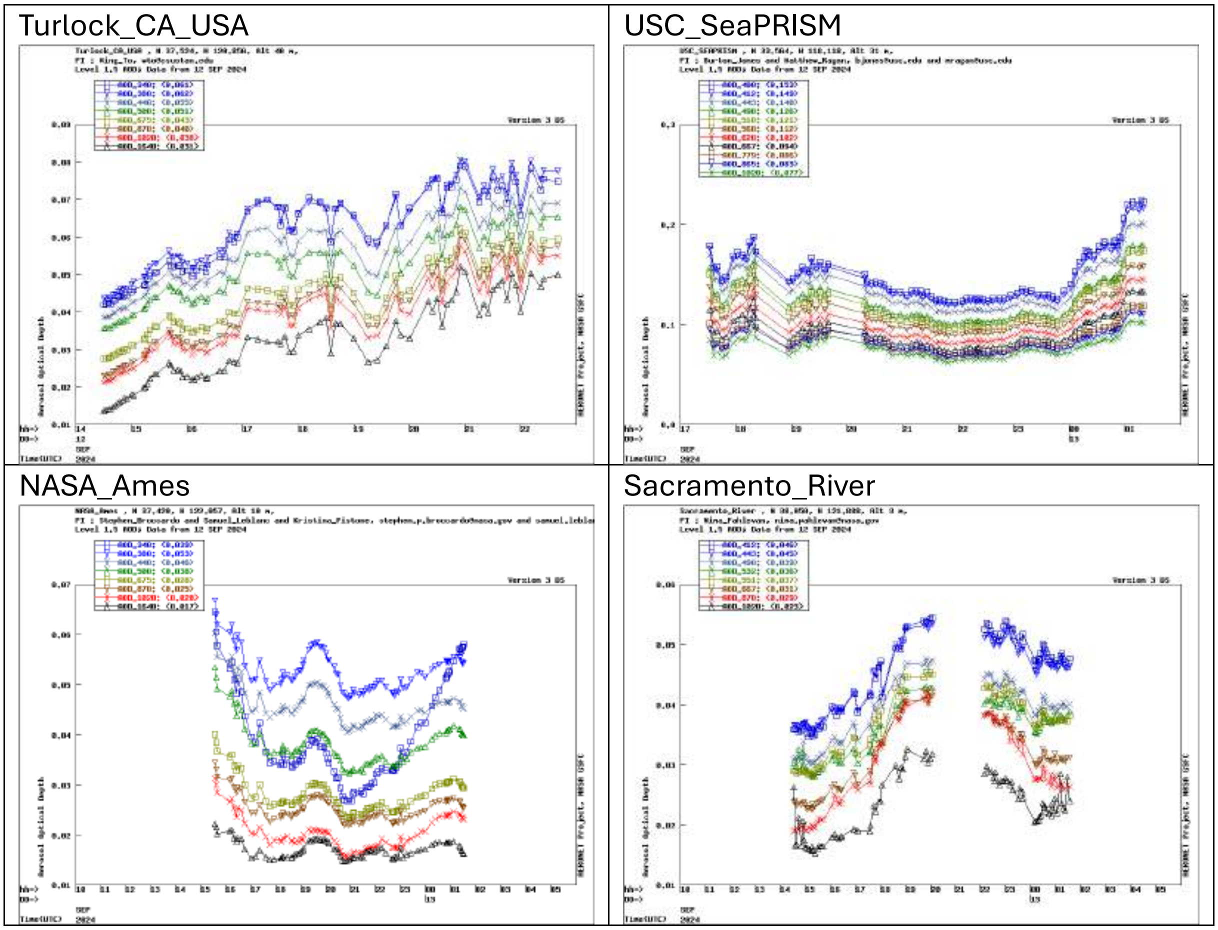
Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 9/9	Fractional success 9/10	Fractional success 9/11	Fractional success 9/12	Fractional success 9/13	Fractional success 9/14	Fractional success 9/15	Total success	Remaining score
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	0.6	0.0%	4.8%	0.0%	0.0%	0.0%	0.0%	0.0%	25.0%	6.0
	b	Ocean radiometric parameters	10	8.0	22.5	0.0%	3.6%	0.0%	6.7%	0.0%	0.0%	0.0%	94.0%	0.6
	c	Aerosol parameters over the ocean	12	8.0	16.4	0.0%	5.1%	0.0%	5.0%	0.0%	0.0%	0.0%	87.1%	1.5
	d	Aerosol parameters over land	12	8.0	27.2	0.0%	1.7%	0.0%	2.3%	0.0%	0.0%	0.0%	96.6%	0.4
	e	Cloud parameters	12	8.0	7.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	58.3%	5.0
	f	Ocean surface parameters	1	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	3.5	0.0%	0.0%	0.0%	13.3%	0.0%	0.0%	0.0%	35.4%	6.5
	b	Aerosol parameters over land (PACE)	10	8.0	2.1	0.0%	0.0%	0.0%	11.6%	0.0%	0.0%	0.0%	23.3%	7.7
	c	Cloud parameters (PACE)	5	2.0	1.5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	52.8%	2.4
	d	Aerosol parameters (EarthCARE)	8	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	46.5%	4.3
	e	Cloud parameters (EarthCARE)	8	4.0	0.5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.8%	7.1
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	2.0	0.1	0.0%	6.1%	0.0%	0.0%	0.0%	0.0%	0.0%	6.1%	5.6
	b	Validate large reflectances with high polarization	6	2.0	1.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	39.3%	3.6
	c	Validate large reflectances with low polarization	6	2.0	2.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	63.2%	2.2
	d	Overfly vicarious calibration sites	6	4.0	1.3	0.0%	26.8%	0.0%	0.0%	0.0%	0.0%	0.0%	26.8%	4.4
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	2.0	3.3	0.0%	41.0%	0.0%	0.0%	0.0%	0.0%	0.0%	80.3%	0.8
	b	High aerosol loads over ocean	4	2.0	1.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	39.3%	2.4
	c	Multiple aerosol layers	1	2.0	4.1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	87.3%	0.1
	d	Aerosol under thin cirrus	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0
	e	Aerosol above liquid phase cloud	4	2.0	3.5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	82.6%	0.7
	f	Broken clouds with complex structure	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0
	g	Dust aerosols over ocean	4	2.0	1.1	0.0%	0.0%	0.0%	43.0%	0.0%	0.0%	0.0%	43.0%	2.3
	h	Aerosol and ocean parameters over turbid waters	2	2.0	3.1	0.0%	0.0%	0.0%	56.9%	0.0%	0.0%	0.0%	79.0%	0.4
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0
	k	Smoke aerosols over ocean	1	2.0	1.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	39.3%	0.6
		total:	150	98	102.7	0.0%	3.4%	0.0%	4.6%	0.0%	0.0%	0.0%	49.6%	
														total
				ER-2 flight hours	18.9	0	4.3	0	0	0	0	0	0	4.3
				TO flight hours	22.2	0	0	0	3.7	0	0	0	0	3.7
				Shearwater days	2	0	1	0	1	0	0	0	0	2

PACE-PAX overall objectives satisfied: 49.6%

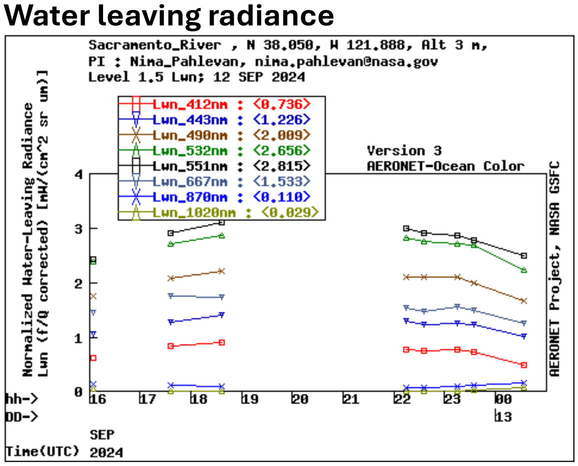
Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

https://www-air.larc.nasa.gov/missions/pacepax/index.html

AERONET quicklooks



Water leaving radiance



Twin Otter photos

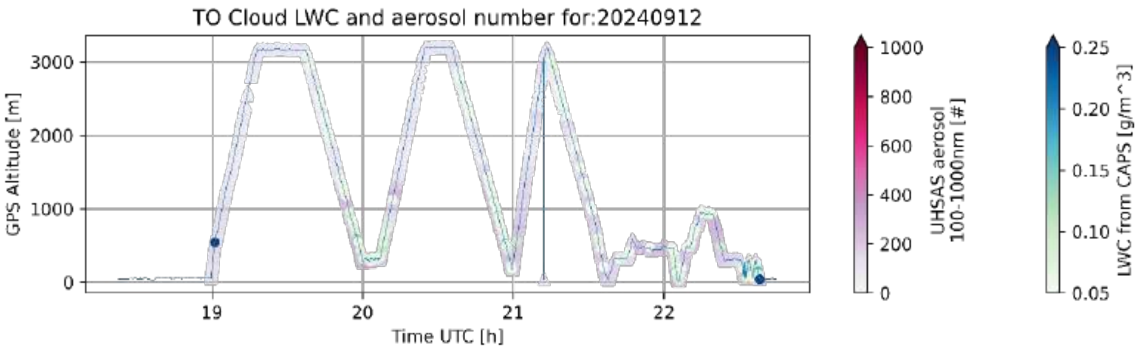
Sacramento River at 20:37 UTC; photo taken by Luke Ziemba 	Golden Gate Bridge at 21:13 UTC; photo taken by Luke Ziemba 
San Pablo Bay at 21:37 UTC; photo taken by Luke Ziemba 	Oakland and the bay taken at 21:47 UTC; photo taken by Luke Ziemba 
Approach for missed approach at Moffett Field taken at 22:03 UTC; photo taken by Luke Ziemba 	Moffett Field after the missed approach taken at 22:09 UTC; photo taken by Luke Ziemba 

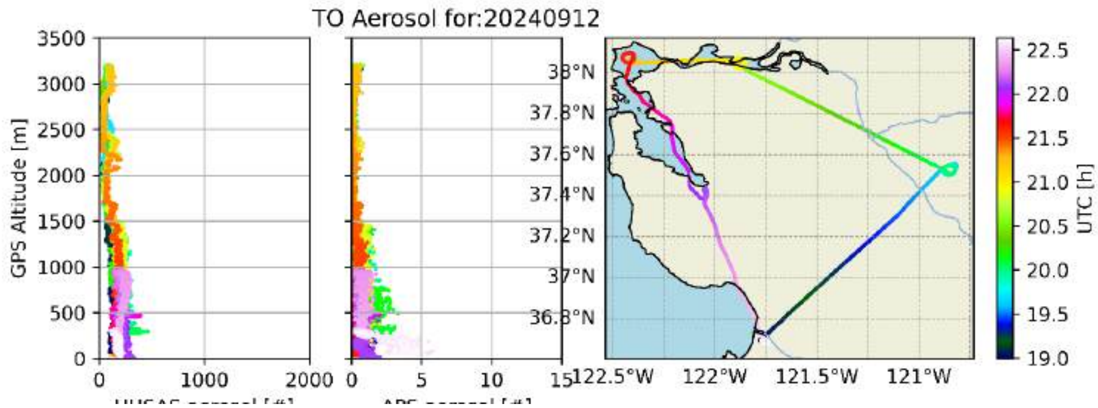
Flying by Aptos, California en route to Marina Airfield at 22:21 UTC; photo taken by Luke Ziemba 	

R/V Blissfully photos

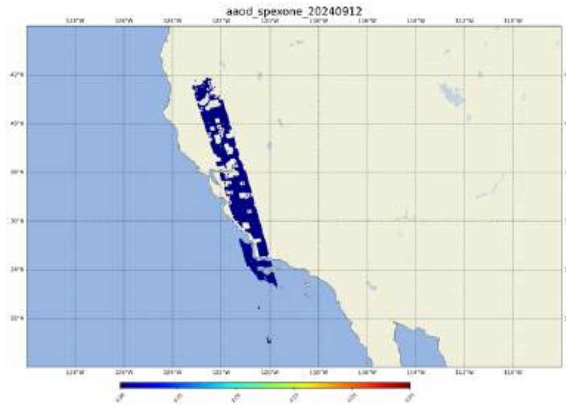
Station 2 (cruise station RB_9) 33° 35.858'N, 118° 7.047' W (33.59763, -118.11745), arrival at 20:23UTC (PACE overpass at 20:39UTC)

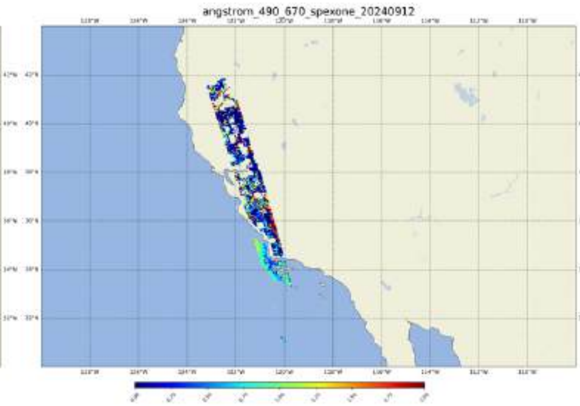
TO Quicklooks

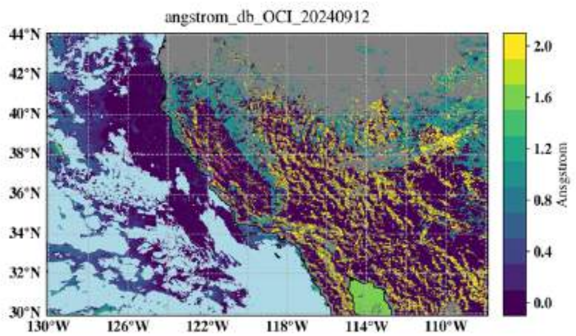


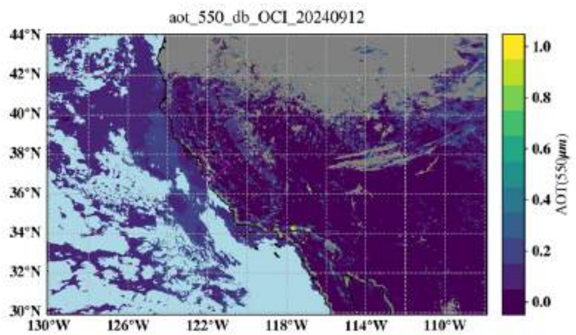


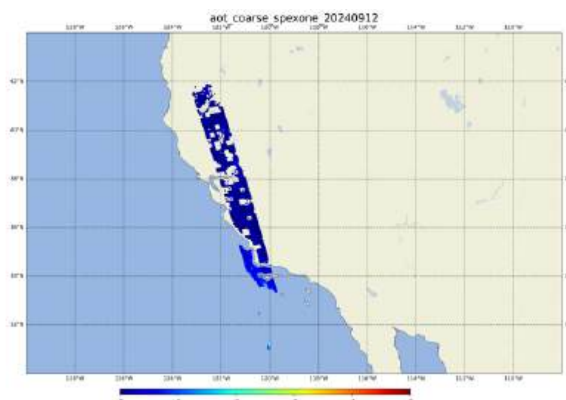
PACE Satellite products

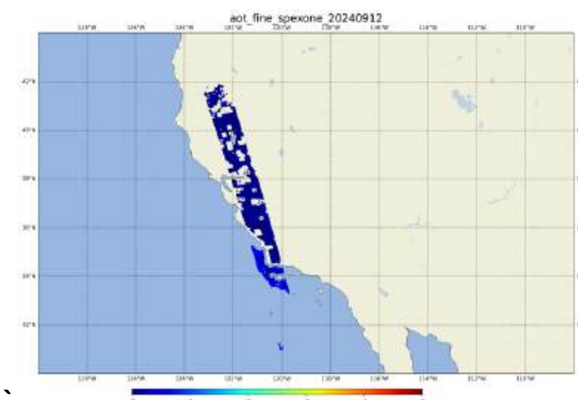


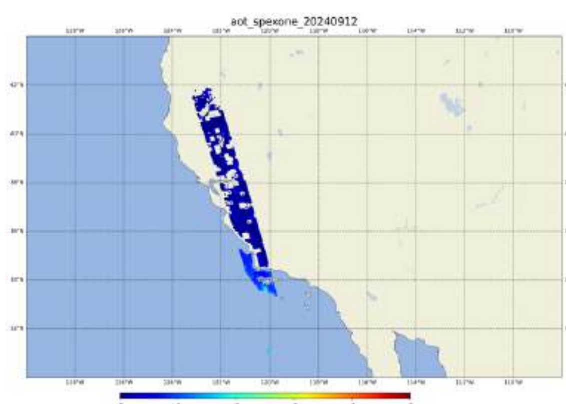


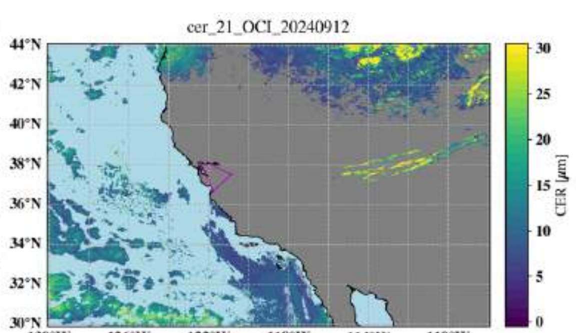


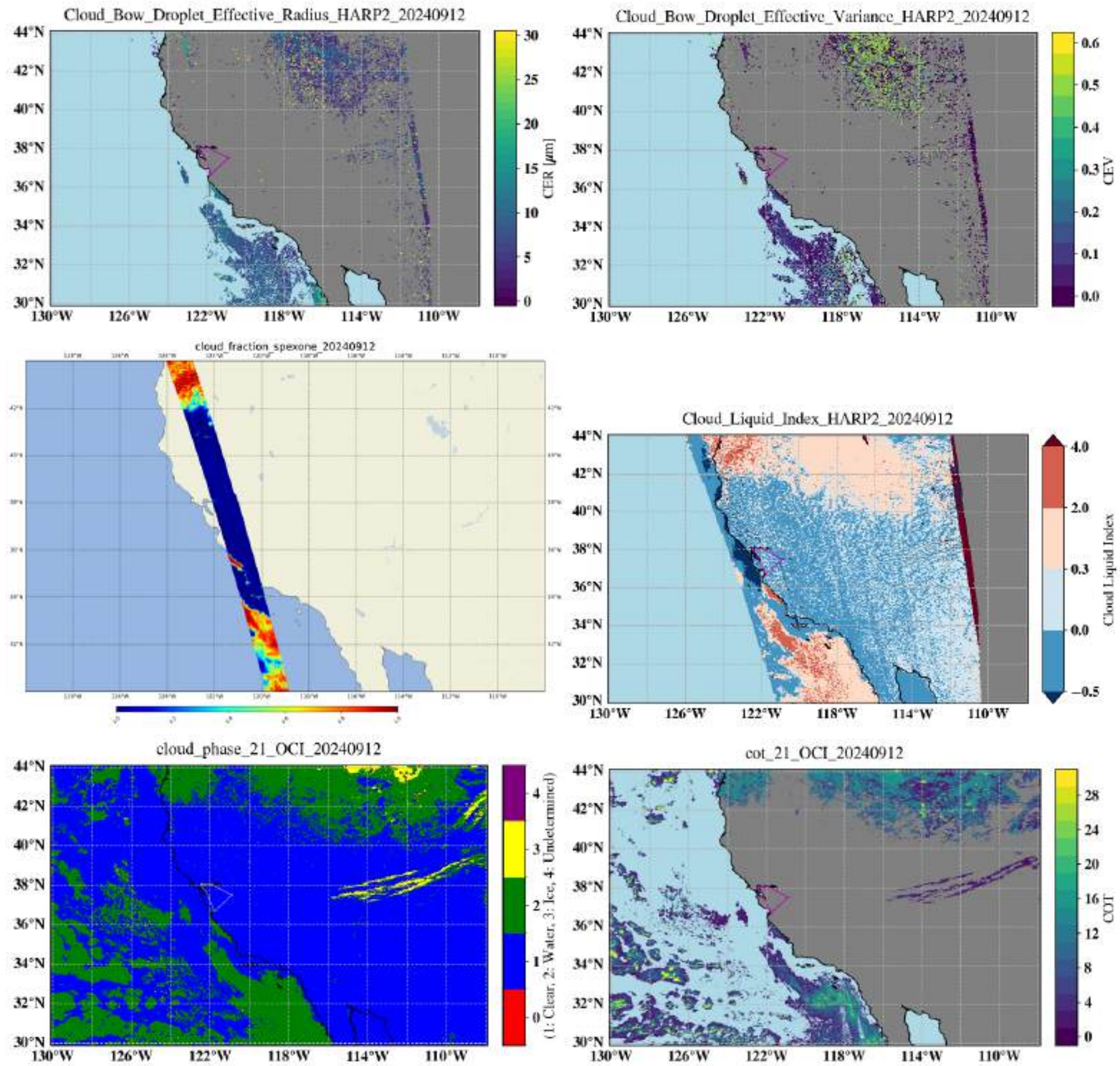


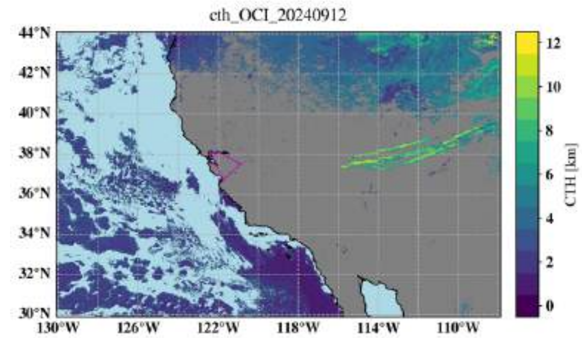


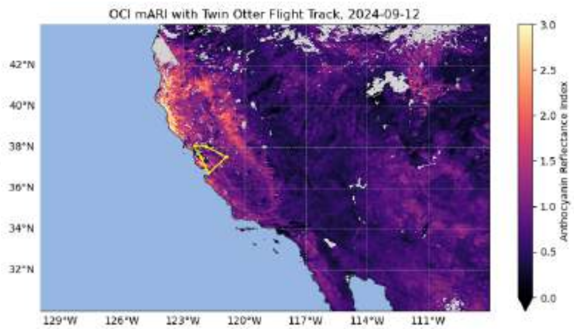


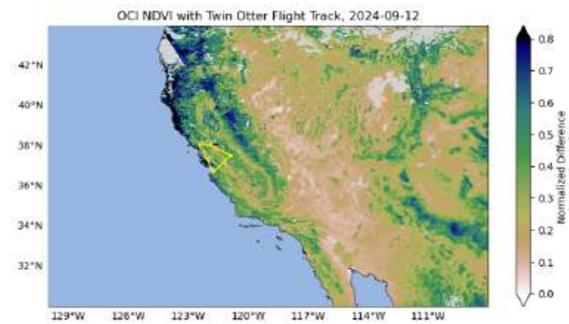





Cloud_Bow_Droplet_Effective_Radius_HARP2_20240912
CER [μm]
Cloud_Bow_Droplet_Effective_Variance_HARP2_20240912
CEV
cloud_fraction_spexone_20240912
Cloud_Liquid_Index_HARP2_20240912
Cloud Liquid Index
cloud_phase_21_OCI_20240912
(1: Clear, 2: Water, 3: Ice, 4: Undetermined)
cot_21_OCI_20240912
COT


cth_OCI_20240912
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
CTH [km]
0
2
4
6
8
10
12


OCI mARI with Twin Otter Flight Track, 2024-09-12
42°N
40°N
38°N
36°N
34°N
32°N
129°W
126°W
123°W
120°W
117°W
114°W
111°W
Anthocyanin Reflectance Index
0.0
0.5
1.0
1.5
2.0
2.5
3.0


OCI NDVI with Twin Otter Flight Track, 2024-09-12
42°N
40°N
38°N
36°N
34°N
32°N
129°W
126°W
123°W
120°W
117°W
114°W
111°W
Normalized Difference Vegetation Index
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

Twin Otter report

PACE-PAX Research Flight report 2024/09/12

Twin Otter Flight

Manifest:

Bryce Kujat (pilot)

Jeff Martin (pilot)

Luke Ziemba (QNC)
Ed Winstead (QNC)

Take off: 11:59:37 (18:59:37 UTC) Marina Airport (OAR)

Landing: 15:38:12 (22:38:12 UTC) Marina Airport (OAR)

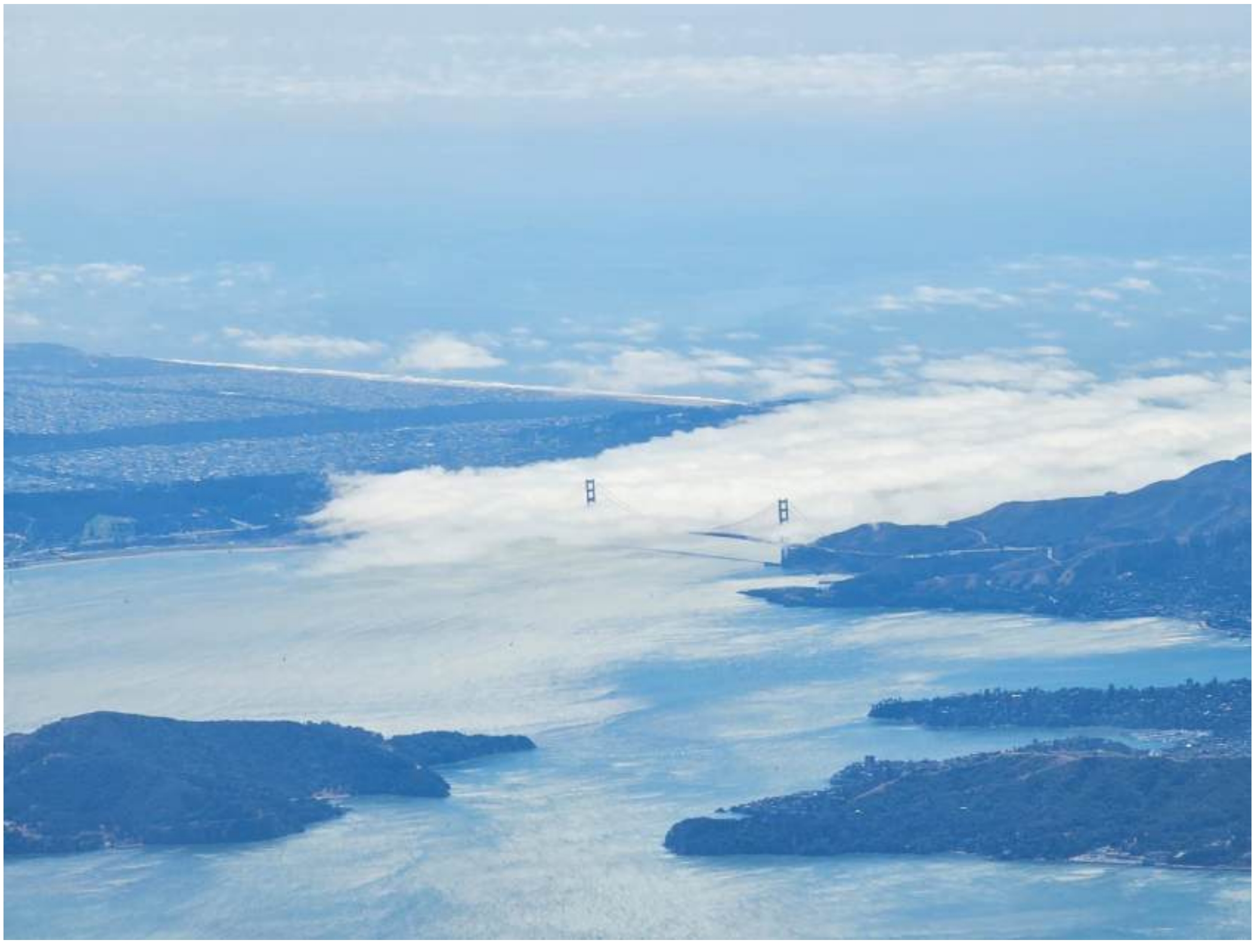
Duration = 3.6 hrs.

Objectives: Profiles of aerosol scattering, absorption coefficients, and size distributions together with scattering (polarized) phase functions of optically thin aerosol over AERONET sites. Coordinated PACE overpass with spiral close in time to Turlock and during Sacramento River spiral. An additional spiral at San Pablo bay, low-level run over San Francisco Bay, and a missed approach at Moffat Field completed the flight objectives.

Summary:

Clean at the surface and then 3 Mm^{-1} scattering coefficient passing through 3 kft at 19:40 UTC. Level at 10 kft at 19:18 UTC with no scattering through the profile up. Spiral down at Turlock started at 19:38 UTC. Aerosol Optical Depth (AOD) at the Turlock AERONET site was 0.045 at 500 nm. A scattering “layer” with 2 Mm^{-1} scattering coefficient was detected at 8.5 kft. Scattering increased to 4 Mm^{-1} scattering coefficient at 4.5 kft, and 8 Mm^{-1} scattering coefficient at 3 kft with some structure below 3 kft and 12 Mm^{-1} scattering coefficient at 1 kft. It looked dusty at the surface with tractors visibly kicking up aerosols with particles out to 7 µm diameter. Spiral complete at 20:00 UTC. Aircraft stayed low for a five minutes to sample dusty air before starting to ascend at 20:09 UTC for Sacramento River spiral at PACE overpass time. Out of aerosols at 3 kft with interesting dust in the spiral and with a scattering Angstrom exponent close to zero. Over Sacramento River at 20:38 UTC with complex (very green) waters. During spiral down scattering coefficients of 1, 5 and 8 Mm^{-1} at 5.5, 4 and 2 kft respectively with spiral complete at 20:58 UTC. Golden Gate bridge was in sight at 21:04 UTC with clouds spilling into the bay. San Pablo spiral down starting at 10 kft at 21:15 UTC with a few small aerosol layers observed during the descent, 4-6 Mm^{-1} scattering coefficient through 3 kft and spiral completed at 100 ft at 21:39 UTC. Proceeded down the bay under Air Traffic Control at 1 kft then up to 2.5 kft over Oakland Coliseum then passing directly over Oakland Airport with the bay still looking pretty green before doing a missed approach at Moffett field. Scattering coefficient of 10 Mm^{-1} at 50 ft during the missed approach. AOD at the Moffett Field (NASA Ames Research Center) AERONET site was 0.04 at 500 nm. After the missed approach at Moffett Field the aircraft returned to Marina Airfield via Santa Cruz. At Marina Airfield two missed approaches were performed to compare with measurement being made in the control tower. Aircraft and tower measurements agreed on 15 Mm^{-1} scattering coefficient with coarse mode aerosols out to 5 µm diameter which is good for evaluating inlet efficiency.

Sacramento River at 20:37 UTC; photo taken by Luke Ziemba



Golden Gate Bridge at 21:13 UTC; photo taken by Luke Ziemba

San Pablo Bay at 21:37 UTC; photo taken by Luke Ziemba

Oakland and the bay taken at 21:47 UTC; photo taken by Luke Ziemba

Approach for missed approach at Moffett Field taken at 22:03 UTC; photo taken by Luke Ziemba

Moffatt Field after the missed approach taken at 22:09 UTC; photo taken by Luke Ziemba

Flying by Aptos, CA en route to Marina Airfield at 22:21 UTC; photo taken by Luke Ziemba

R/V Shearwater report

PACE-PAX R/V Shearwater day report

Date: 09/12/2024

Creator: Michael Ondrusek

Cruise ID: RF0912-RS

Sailed out: 15:49 UTC (8:49 PST)

Back in port: UTC (PST) 23:45

Today, the ship occupied three stations.

Station #6 34.357533°, -119.624300° arrival 16:14 UTC (9:14 PST) àdeparture 1829 UTC (11:29 PST). Occupied west ER2 line. Wind 10 to 12 kts. Swells less than 1m. IOPs, profiles, then Polarimagers.

Station #7 34.377946°, -120.077298,° arrival 1849 UTC (11:49 PST) à departure 2037 UTC (16:37 PST) Occupied along same line. Start with IOPs, then polarimagers, then profiles. Only C-OPS and one hyperpro. MPR 86 run as float for 5 min after profiles due to pressure problems at sta 6. Clear skies, 1 -2 ft seas, 3kt winds.

Station #8 34.260800°, -119.439533°, arrival 2100 UTC (14:00 PST)à departure 2254 UTC (15:54 PST). Clear skies, 0.5 ft seas, 3 kt winds. Profilers, floater, polarimager, then IOPs.

System Status:

Issue with tracker – restarted at 11:34 PST

No ER-2 overflight

Group Status: Good day.


R/V Shearwater
09/12
Legend
Feature 1
SBMAR
SBMAR
SW Station
SW1NR
SW1FR
SW2NR
SW2FR
SBMAR
SBMAR
12:00 to 12:20
12:55 to 13:05
Google Earth
N
10 mi


R/V Shearwater
09/12
Legend
Feature 1
SBMAR
SBMAR
SW Station
SW1NR
SW1FR
SW2NR
SW2FR
SBMAR
SBMAR
12:00 to 12:20
12:55 to 13:05
Google Earth
N
10 mi

R/V Blissfully report

PACE-PAX R/V Blissfully day report

Date: 09/10/2024

Creator: Bridget Seegers

Cruise ID: RF0912-RB

Sailed out: 15:59 UTC

Back in port: 23:35 UTC

Today, the ship accomplished....

Collection of vertical radiometry profiles and discrete sample collection (HPLC + ap) on two stations in proximity of SeaPRISM site. The station had three sets of 5 HyperPro profiles to 20m and a single deep cast to 60m and discrete water samples included triplicate HPLC + ap and duplicate community composition Lugol's preserved and paraformaldehyde samples for flow cytometry.

Station 1 (cruise station RB_8) 33° 34.376'N, 118° 7.085'W (33.5729, -118.11808), arrival 18:43UTC

Station 2 (cruise station RB_9) 33° 35.858'N, 118° 7.047' W (33.59763, -118.11745), arrival at 20:23UTC (PACE overpass at 20:39UTC)

Tomorrow, RV Blissfully

Ship plans through the next 3 days…

Sampling in coordination with rest of the experiment

System Status…

All good

No ER-2 overflight

Group Status…

All great

PACE-PAX research flight report 2024/09/13

Compiled by Kirk Knobelspiesse, Ivona Cetinić, Michael Ondrusek, Brian Cairns 2024/09/21

Reviewed by Samuel LeBlanc

Focus on Southern California, which has extremely large fires (Bridge, Line and Airport) producing large amounts of smoke. Twin Otter does a double sortie to the Los Angeles Basin. R/V Shearwater, R/V Blissfully and Gliders all collect data offshore, with clouds clearing as the day progresses. PACE overpass (19:36; 21:14) are far from the observation region, but data are collected during overpass for PACE/OCI validation. Additionally, an overpass is made of Railroad Valley in Nevada.

ER-2
Takeoff: 16:41, Landing: 22:57, Duration: 6.3
Instrument status: RSP inoperable, all others good
Pilot: Greg Nelson, mobile pilots Kirt Stallings and Tim Williams

Twin Otter
Sortie 1: takeoff: 15:29, Landing: 19:25, Duration: 3.9 (land Chino CNO)
Sortie 2: takeoff: 20:45, Landing: 00:21, Duration: 3.6
Instrument status: Good, descent into Chino may have been faster than the dewpoint monitor would prescribe, aerosol concentrations may have been too high for some of the particle counters.
Manifest: Bryce Kujat (pilot), Jeff Martin (pilot), Anthony Bucholtz (QNC), Adam Ahern (QNC), Edward Winstead (QNC)
See end for full Twin Otter report

R/V Shearwater
Departure: 15:57, Return:23:03, Duration:
Instrument status: good
Captain/Mission Scientist: Michael Ondrusek
See end full R/V Shearwater report

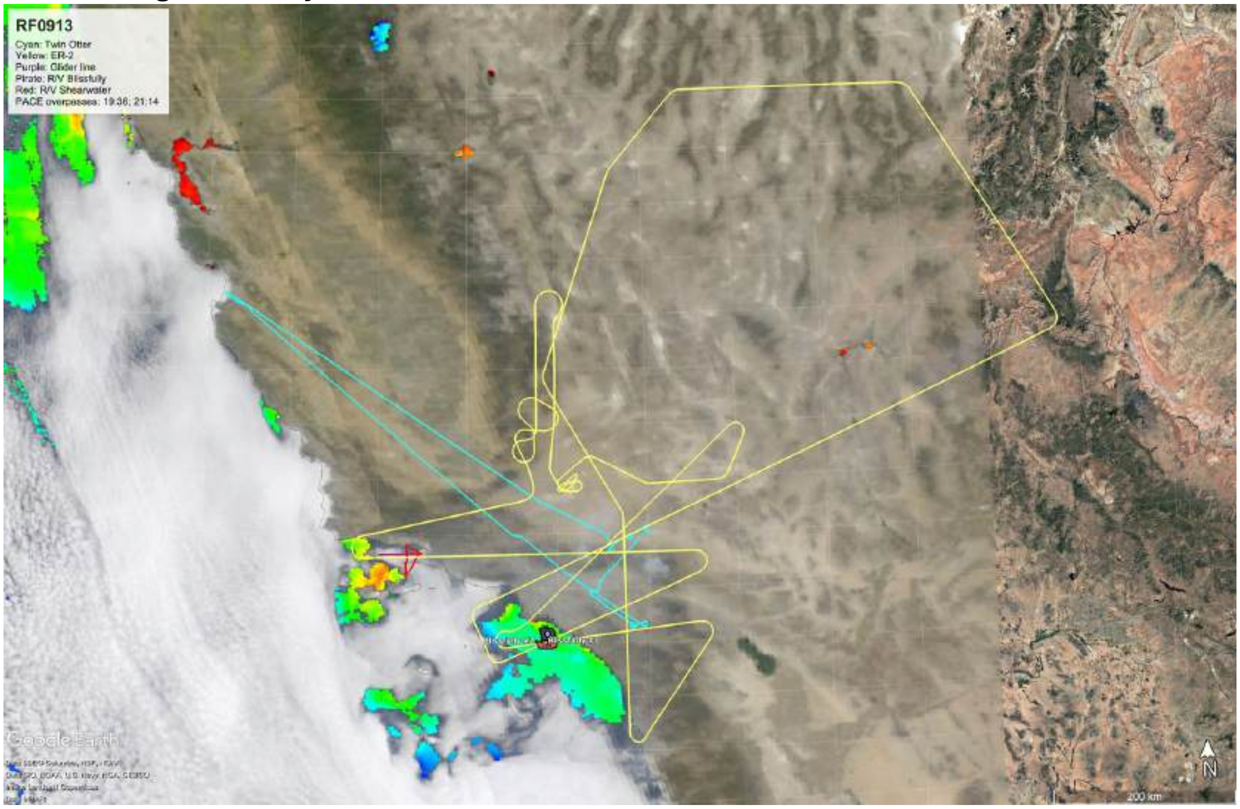
R/V Blissfully
Departure: 15:59, Return: 01:01 (2024/09/14), Duration: 7.0
Instrument status: good
Captain/Mission Scientist: Bridget Seegers
See end for full R/V Blissfully report

PACE
Overpass at 19:36 (east of target region)
Overpass at 21:14 (west of target region)

EarthCARE
No targeted underpass

Gliders
Operational
HyperNAV
Operational

Overall image summary



Validation Traceability Matrix itemized objectives

VTM elements in **black** satisfied, **blue** partially satisfied

Time UTC	Platform	VTM(hrs)	
15:29	TO		Takeoff (sortie 1)
15:57	RS		Departure
15:59	RB		Departure
16:41	ER2		Takeoff
18:01	ER2, gliders		ER-2 over gliders, cloudy
18:02	ER2, RS		ER-2 overpass of Shearwater at station 9, cloudy
17:53	ER2, TO	1d(3.0), 6a(3.0), 6c(3.0)	ER-2 overpass of Twin Otter double spiral in smoke east of Bridge fire. TO spiral down 17:39-17:53, up starting at 17:53. At least two distinct smoke layers observed. ER-2 observes this location at 18:18
18:15	ER2		ER-2 overflies Table_Mountain_CA AERONET site. Site is inoperable~~, possibly destroyed due to fire.~~ Edit: was not destroyed by fire, just not acquiring data.
18:18	ER2, TO	1d(3.0), 6a(3.0), 6c(3.0)	ER-2 overpass of Twin Otter double spiral in second location in smoke east of Bridge fire. Similar to prior spirals, at least two distinct smoke layers observed, but this time even greater loads. ER-2 observes this location at 18:18
18:42	ER2, RB		ER-2 overpass of Blissfully, USC_SeaPRISM. Cloudy.
18:52	ER2,RB	6e(0.5x0.5)	ER-2 overwater (turning) with smoke aerosol over clouds
18:54	ER2	1d(1.0), 6a(1.0), 6c(1.0)	Extremely long leg (to 19:36) over LA basin, Bridge fire and following path of smoke as it is advected east and north

18:58	ER2	1d(1.0), 6a(1.0), 6c(1.0)	ER-2 overfly CalTech AERONET site. AOD(500)=0.48
19:05	ER2, TO	1d(3.0), 6a(3.0), 6c(3.0)	ER-2 overpass of Twin Otter double spiral in third location in smoke east of Bridge fire. ER-2 observes this location at 19:05
19:25	TO		Landing (sortie 1, Chino)
19:36	RS		Shearwater on station 10 from 18:44 to 19:57 during PACE overpass. Partly cloudy, satellite image cloudy
19:36	**PACE-O**		**PACE overpass**
19:45	ER2	1d(1.0), 6a(1.0, 6c(1.0)	Start second long leg perpendicular to leg starting at 18:54. Catches other pathway of advected smoke at the time of PACE overpass. Within OCI swath and edge of HARP2 swath. Leg ends at about 20:05
20:18:30	ER2	1a(1.0), 1d(1.0), 4a(1.0), 4c(1.0)	ER2 over Railroad Valley, AERONET AOD(440)=0.05
20:45	TO		Takeoff (sortie 2, Chino)
21:05	ER2	1d(2.0), 6a(2.0), 6c(2.0)	Third long ER2 leg over smoke. This time southward over eastern LA basin with smoke from Bridge and Airport fires, ending at 21:22 near San Diego. Includes PACE overpass at OCI edge.
21:12	ER-2, TO	1d(3.0), 6a(3.0), 6c(3.0)	ER-2 overpass of Twin Otter spiral down in smoke east of Airport fire. Similar double layer structure as observed at other spirals. ER-2 observes this location at 21:40. PACE overpass as well.
21:14	RB	1b(1.5), 1c(1.5), 6k(1.5)	Blissfully sampling adjacent to USC_SeaPRISM site during PACE overpass (OCI only) with cloud-free skies. AOT(490)=0.18, moderate aod, smoke from fires
21:14	RS	1b(1.5), 1c(1.5)	Shearwater on station 11 from 20:45 to 22:01 during PACE overpass. Cloud free
21:14	**PACE-O**		**PACE overpass**
21:20	TO		Overfly La_Jolla AERONET site with high AOD(500)=0.22. However, no AERONET mesurements after 19:30 due to broken clouds
21:39	ER-2, TO	1d(3.0), 6a(3.0), 6c(3.0)	ER-2 overpass of Twin Otter spiral up in smoke east of Airport fire. Similar double layer structure as observed at other spirals. ER-2 observes this location at 21:39. PACE overpass as well.
21:48	ER2, RB	1b(1.5), 1c(1.5), 6k(1.5)	ER-2 overpass of Blissfully and USC_SeaPRISM. Cloud free skies, AOT(490)=0.19, moderate aod, smoke from fires
21:55	ER2	1d(1.0), 6a(1.0, 6c(1.0)	Final long ER-2 leg starting at Long Beach and heading northeast over smoke from Airport and Bridge fires. End leg at 22:19
21:59	ER2	1d(0.5), 1a(0.5), 1c(0.5)	ER2 overflites WC_Whittier_CA AERONET site, AOD(500)=0.35 high load
22:57	ER2		Landing
00:21	TO		Landing (sortie 2)
	RS		Return
01:01	RB		Return

PACE-O: within swath of PACE's OCI instruments
TO: CIRPAS Twin Otter
RB: R/V Blissfully
RS: R/V Shearwater

ER2: NASA ER-2

Assessment:

- 4.9% of objectives satisfied. EXCELLENT observation of smoke from the Bridge, Airport and Line fires – beyond PACE validation this could be the source of a paper or more. Scoring does not reflect the amount of data in this regard – we have maxed out “aerosol parameters over land (1d)”, “High aerosol loads over land (6a)” and “Multiple aerosol layers (6c)”. Also good observation of railroad valley (high reflectance calibration site) and smoke over water.
- Top remaining objectives (score above 6.0): PACE aerosol in narrow swath (3a,b), EarthCARE cloud (3e)

PACE-PAX progress tracking

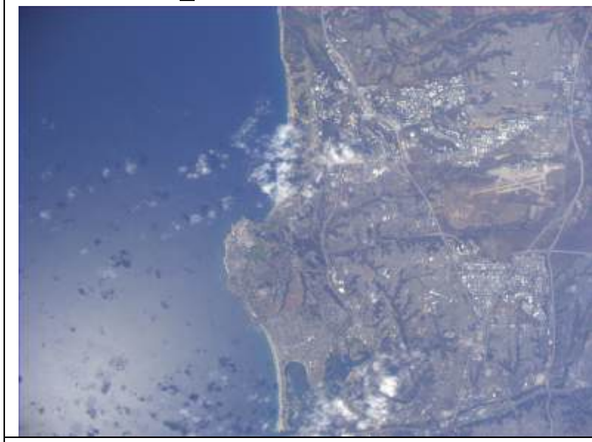
Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 9/9	Fractional success 9/10	Fractional success 9/11	Fractional success 9/12	Fractional success 9/13	Fractional success 9/14	Fractional success 9/15	Total success	Remaining score
1. Validate new retrieval properties	a	Land surface parameters	8.000	2.000	1.575	0.000	0.048	0.000	0.000	0.295	0.000	0.000	0.545	3.640
	b	Ocean radiometric parameters	10.000	8.000	24.000	0.000	0.036	0.000	0.067	0.010	0.000	0.000	0.950	0.498
	c	Aerosol parameters over the ocean	12.000	8.000	17.875	0.000	0.051	0.000	0.050	0.022	0.000	0.000	0.893	1.285
	d	Aerosol parameters over land	12.000	8.000	45.663	0.000	0.017	0.000	0.023	0.030	0.000	0.000	0.997	0.040
	e	Cloud parameters	12.000	8.000	7.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.583	5.002
	f	Ocean surface parameters	1.000	8.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10.000	8.000	3.500	0.000	0.000	0.000	0.133	0.000	0.000	0.000	0.354	6.456
	b	Aerosol parameters over land (PACE)	10.000	8.000	2.125	0.000	0.000	0.000	0.116	0.000	0.000	0.000	0.233	7.667
	c	Cloud parameters (PACE)	5.000	2.000	1.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.528	2.362
	d	Aerosol parameters (EarthCARE)	8.000	4.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.465	4.282
	e	Cloud parameters (EarthCARE)	8.000	4.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.118	7.060
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6.000	2.000	1.125	0.000	0.061	0.000	0.000	0.370	0.000	0.000	0.430	3.419
	b	Validate large reflectances with high polarization	6.000	2.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.393	3.639
	c	Validate large reflectances with low polarization	6.000	2.000	3.000	0.000	0.000	0.000	0.000	0.145	0.000	0.000	0.777	1.339
	d	Overfly vicarious calibration sites	6.000	4.000	1.250	0.000	0.268	0.000	0.000	0.000	0.000	0.000	0.268	4.390
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4.000	2.000	20.750	0.000	0.410	0.000	0.000	0.197	0.000	0.000	1.000	0.000
	b	High aerosol loads over ocean	4.000	2.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.393	2.426
	c	Multiple aerosol layers	1.000	2.000	21.625	0.000	0.000	0.000	0.000	0.127	0.000	0.000	1.000	0.000
	d	Aerosol under thin cirrus	2.000	2.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.000
	e	Aerosol above liquid phase cloud	4.000	2.000	3.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.826	0.695
	f	Broken clouds with complex structure	4.000	2.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.000
	g	Dust aerosols over ocean	4.000	2.000	1.125	0.000	0.000	0.000	0.430	0.000	0.000	0.000	0.430	2.279
	h	Aerosol and ocean parameters over turbid waters	2.000	2.000	3.125	0.000	0.000	0.000	0.569	0.000	0.000	0.000	0.790	0.419
	i	Aerosol and ocean parameters over biologically productive waters	4.000	2.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.000
	k	Smoke aerosols over ocean	1.000	2.000	2.500	0.000	0.000	0.000	0.000	0.320	0.000	0.000	0.713	0.287
		total:	150.000	98.000	163.738	0.000	0.034	0.000	0.046	0.049	0.000	0.000	0.545	
														total
				ER-2 flight hours	18.900	0.000	4.300	0.000	0.000	6.300	0.000	0.000	0.000	10.600
				TO flight hours	22.200	0.000	0.000	0.000	3.700	7.500	0.000	0.000	0.000	11.200
				Shearwater days	2.000	0.000	1.000	0.000	1.000	1.000	0.000	0.000	0.000	3.000
		PACE-PAX overall objectives satisfied:		0.545										

Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

https://www-air.larc.nasa.gov/missions/pacepax/index.html

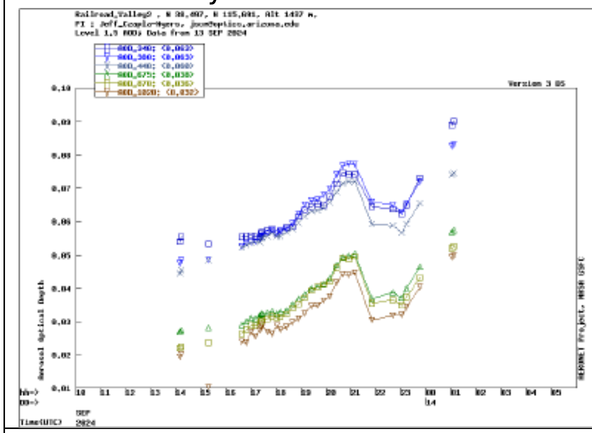
ER-2 MVIS quicklooks

18:02 R/V Shearwater 	18:18 Bridge fire smoke with Twin Otter 
18:42 USC_SeaPRISM; R/V Blissfully 	18:57 CalTech AERONET site, smoke 
19:05 downwind Bridge fire smoke w. TO 	20:18:30 Railroad Valley 

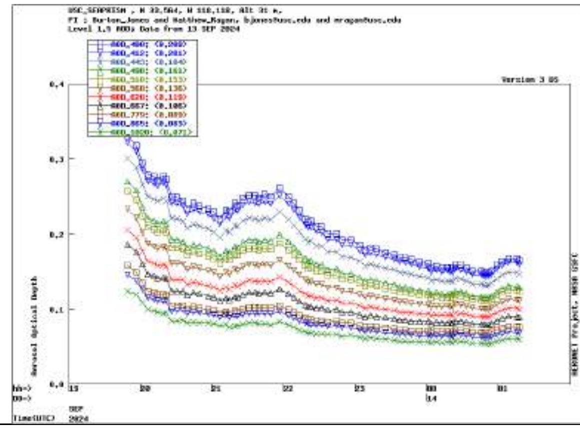
21:21:18 La_Jolla AERONET	21:48 USC_SeaPRISM; R/V Blissfully
	

AERONET quicklooks

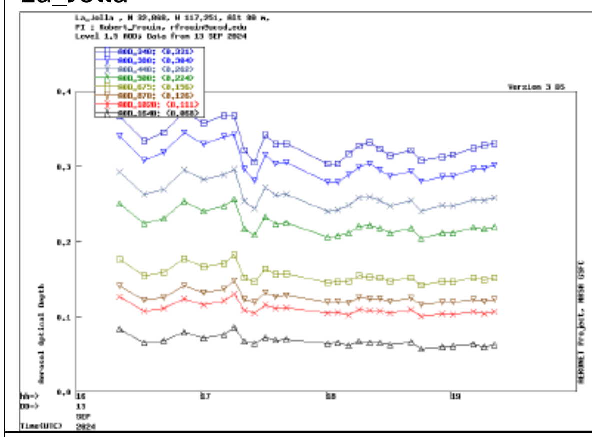
Railroad Valley



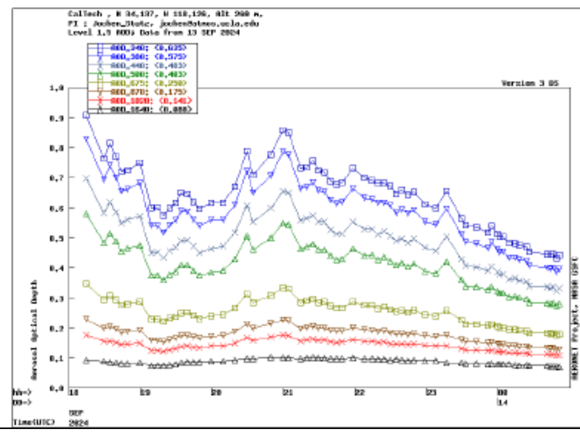
USC_SeaPRISM



La_Jolla

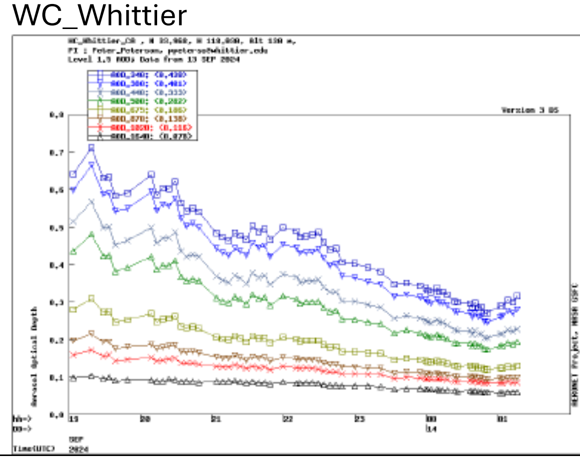


CalTech

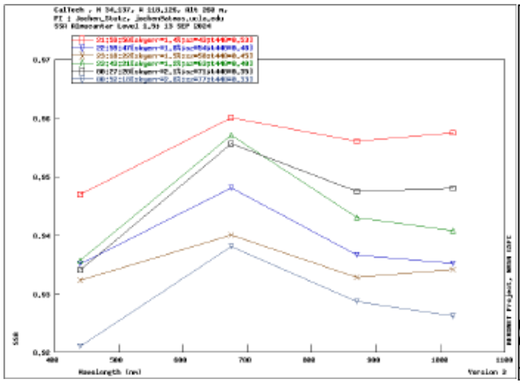


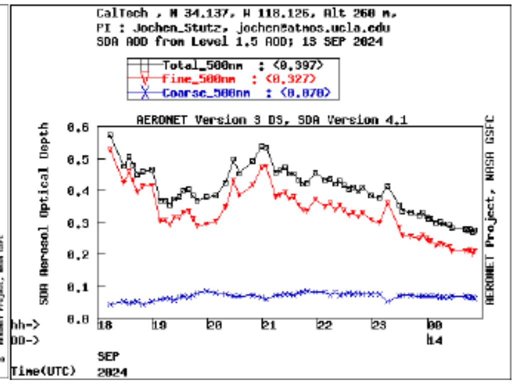
Table_Mountain_ca (inoperable)

WC_Whittier

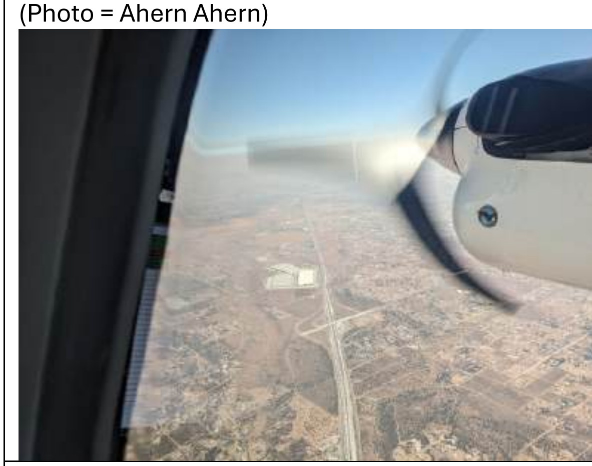


AERONET retrieval quicklook



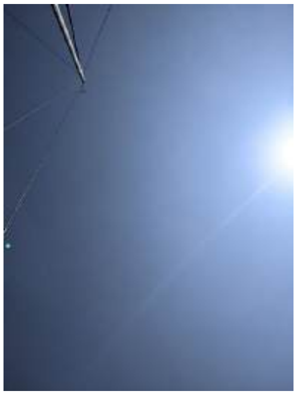


Twin Otter photos

Heading into the smoke at 10 kft, 17:21 UTC. (Photo = Adam Ahern) 	View of the Bridge Fire during the first spiral 17:35:29 UTC. LA basin full of smoke. 
17:40:40 Two layers of aerosol visible during descent of first spiral. Photo isn't great, but it was an observable phenomenon during the spirals. (Photo = Ahern Ahern) 	Distinct aerosol layer visible during spiral down east of Airport fire at 21:11. (Photo = Adam Ahern) 
Two layers of aerosol visible at 22:50 UTC during transit back from LA. (Photo = Adam Ahern) 	

R/V Blissfully photos

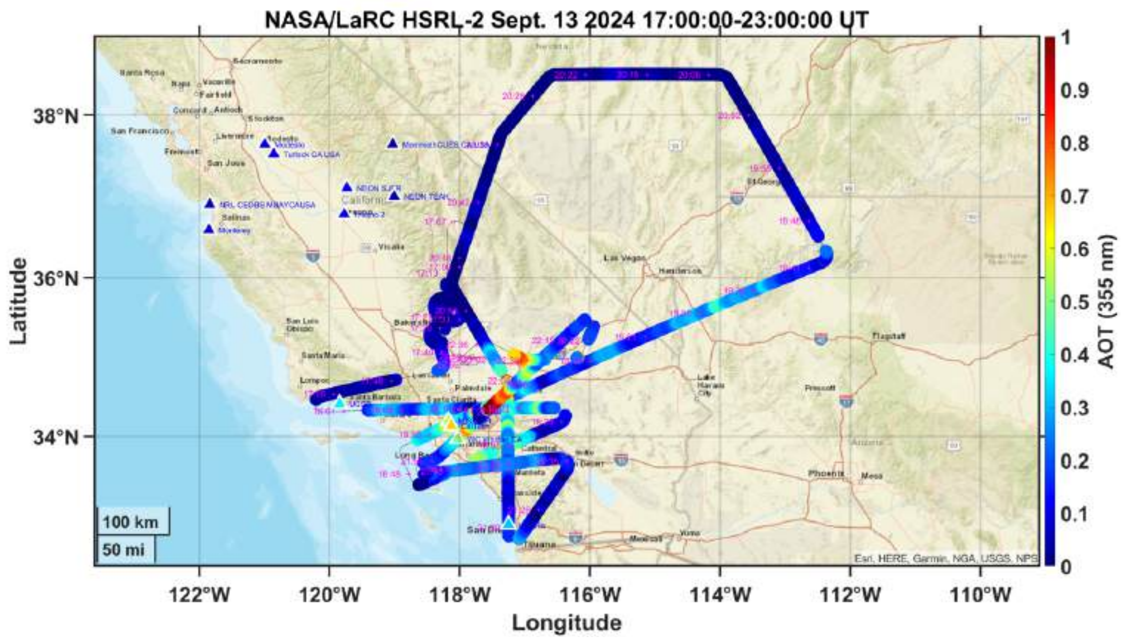
Station 2b (cruise station RB_11)   33.558371°, -118.117538, repeated same location for the ER-2 overpass 21:48 UTC



ER-2/PICARD

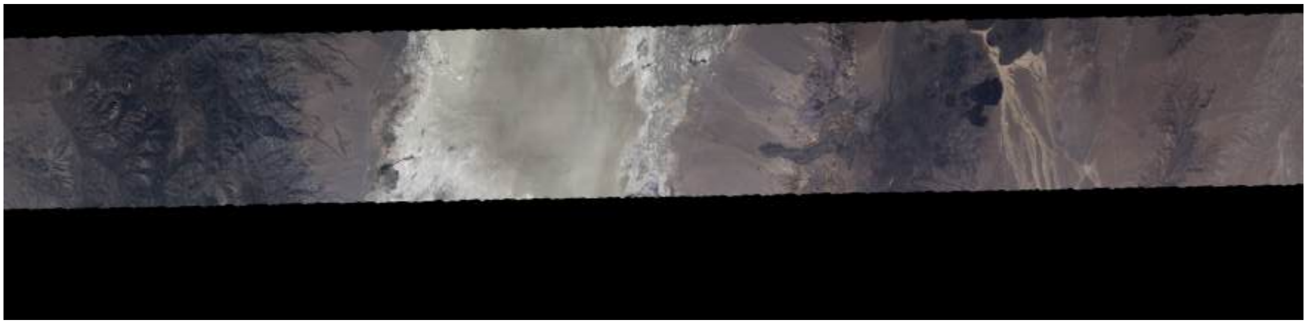

PICARD Bridge Fire Overpasses,13 September 2024
Worldview GOES-18 True Color, 1820 UTC
True Color
(469, 548, 665nm)
False Color
(2110, 872, 665nm)
1817 UTC
PICARD

ER-2/HSRL

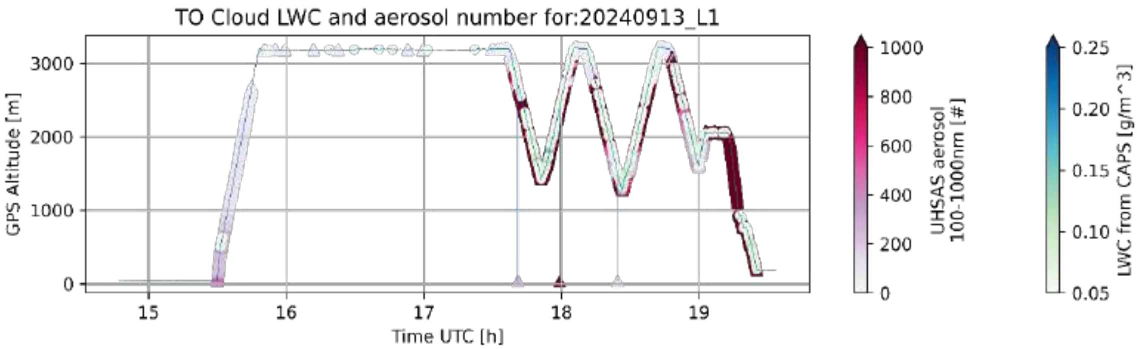

NASA/LaRC HSRL-2 Sept. 13 2024 17:00:00-23:00:00 UT
Latitude
38°N
36°N
34°N
Longitude
122°W
120°W
118°W
116°W
114°W
112°W
110°W
AOT (355 nm)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
100 km
50 mi
Esri, HERE, Garmin, NGA, USGS, NPS

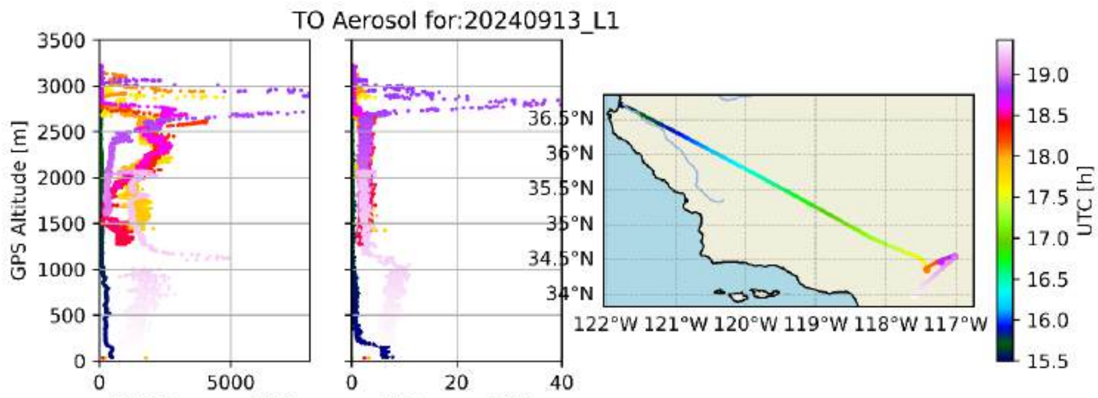

NASA/LaRC HSRL-2 Sept. 13 2024 17:00:00-23:00:00 UT
Latitude
38°N
36°N
34°N
Longitude
124°W
122°W
120°W
118°W
116°W
114°W
112°W
110°W
AOT (532 nm)
0
0.1
0.2
0.3
0.4
0.5
0.6
100 km
50 mi
Esri, HERE, Garmin, NGA, USGS, NPS

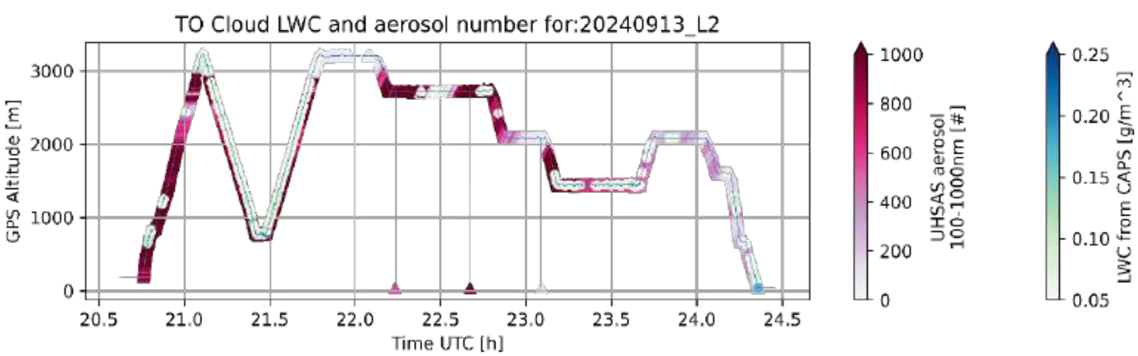
ER-2/PRISM
Railroad valley(20:19UTC)

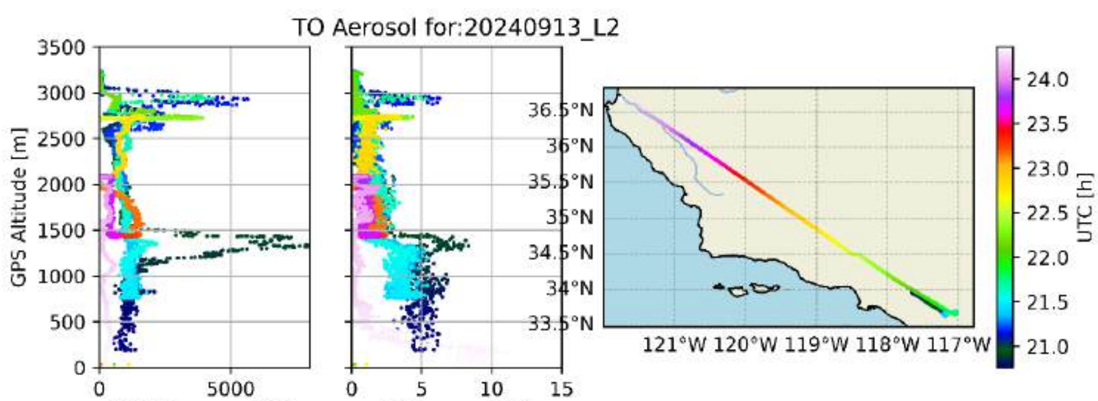


TO Quicklooks

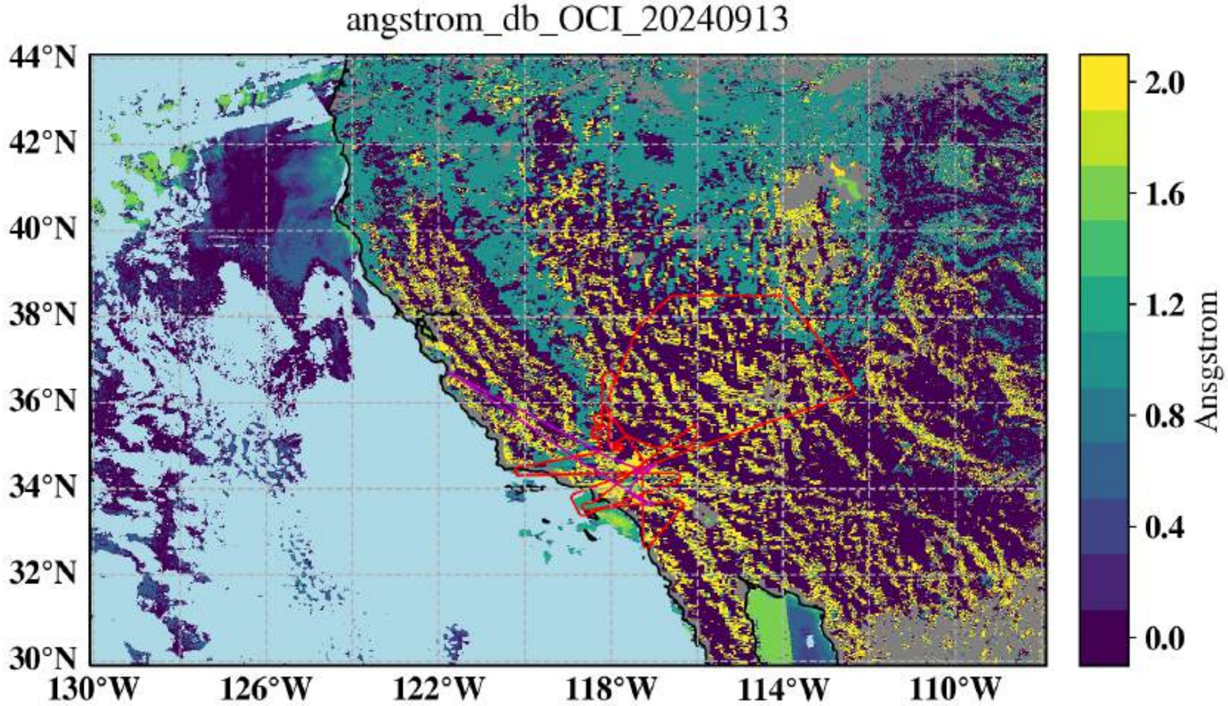


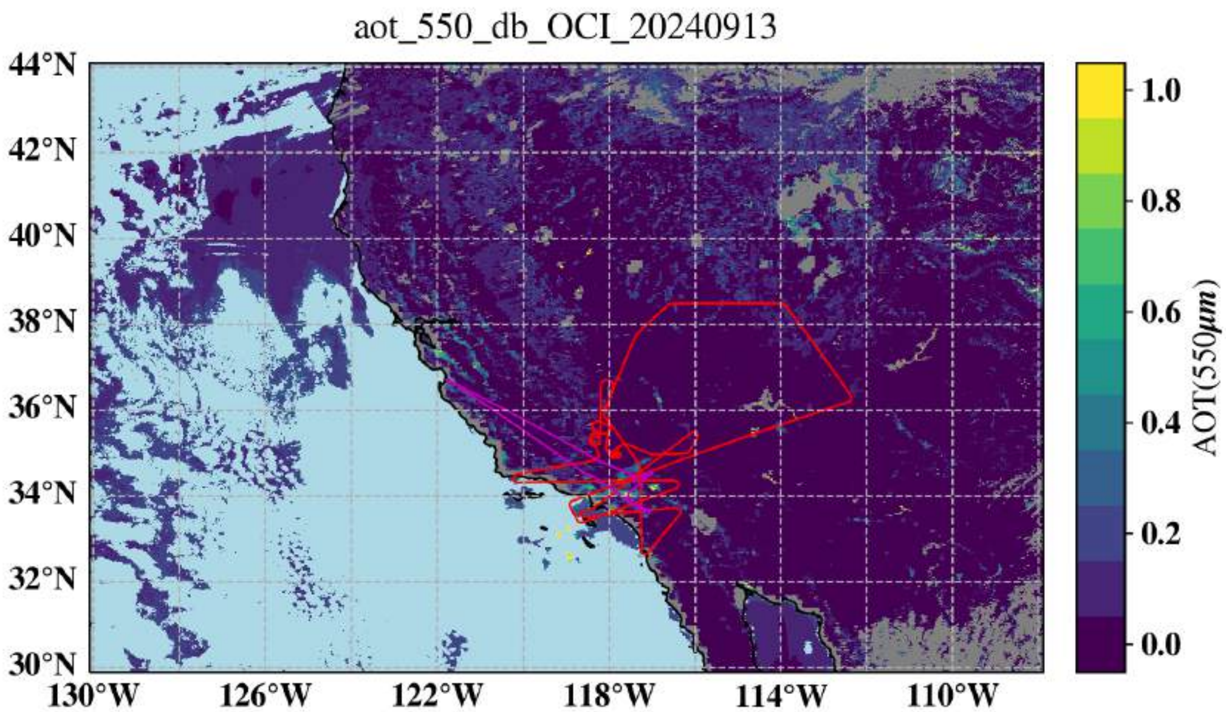


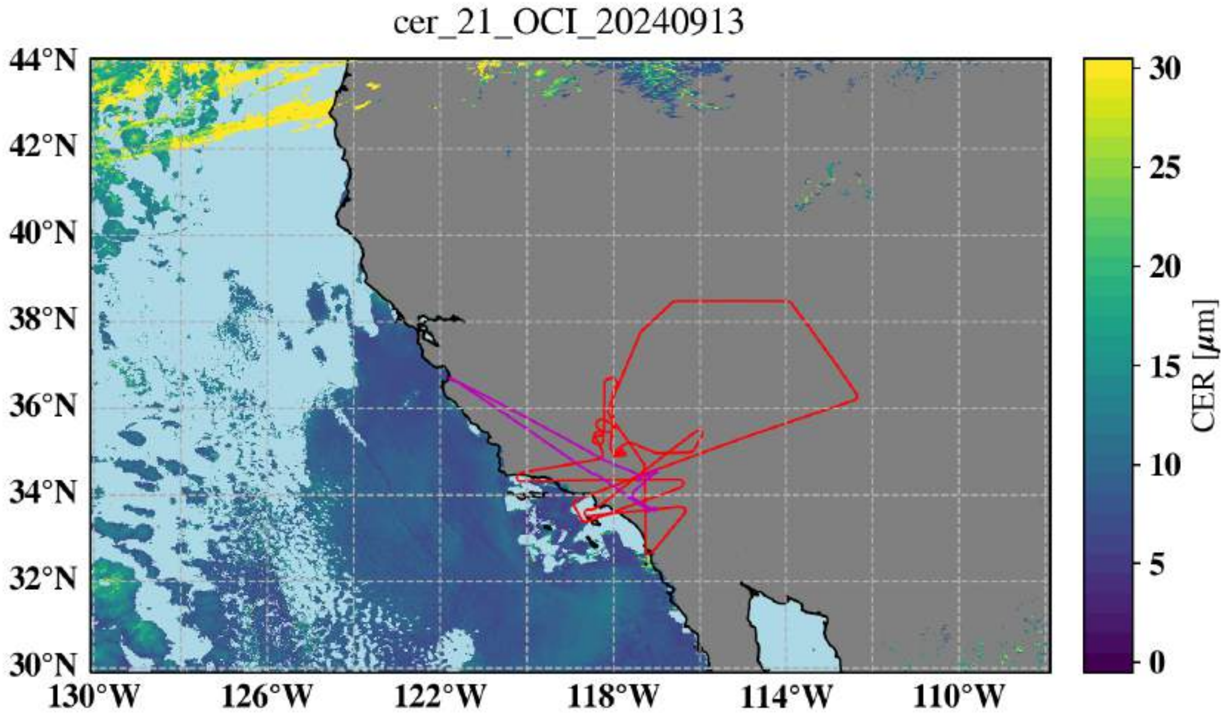




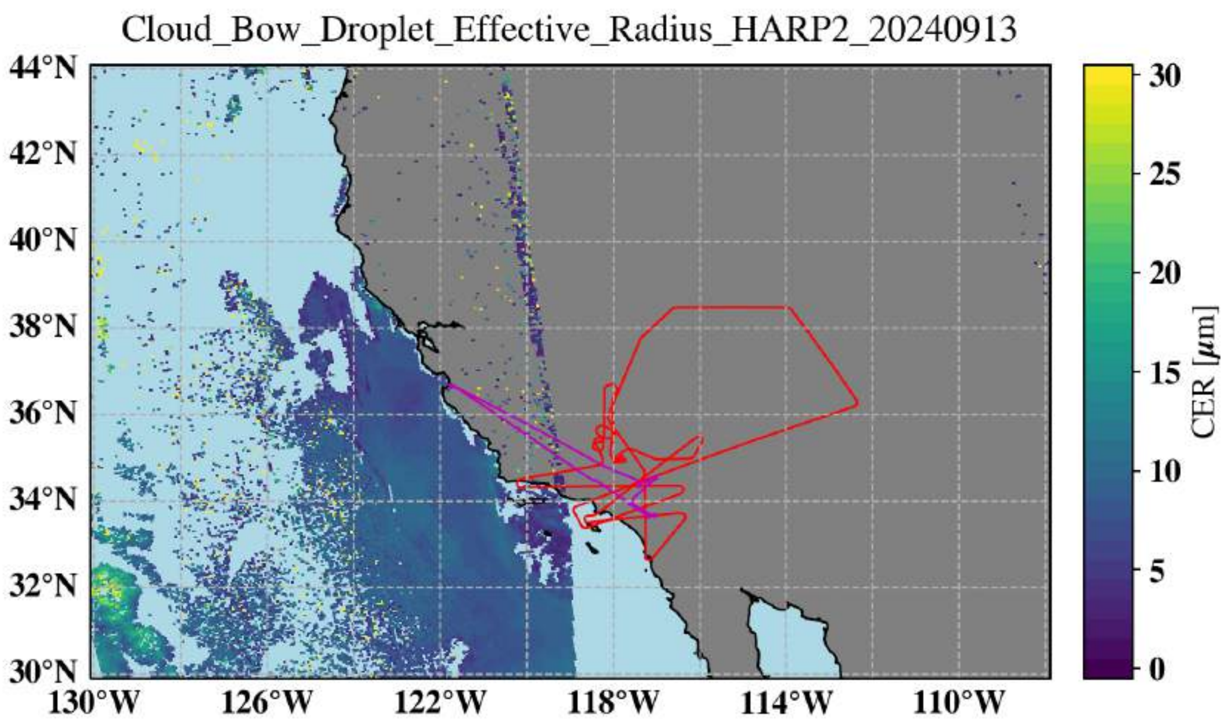
PACE Satellite products



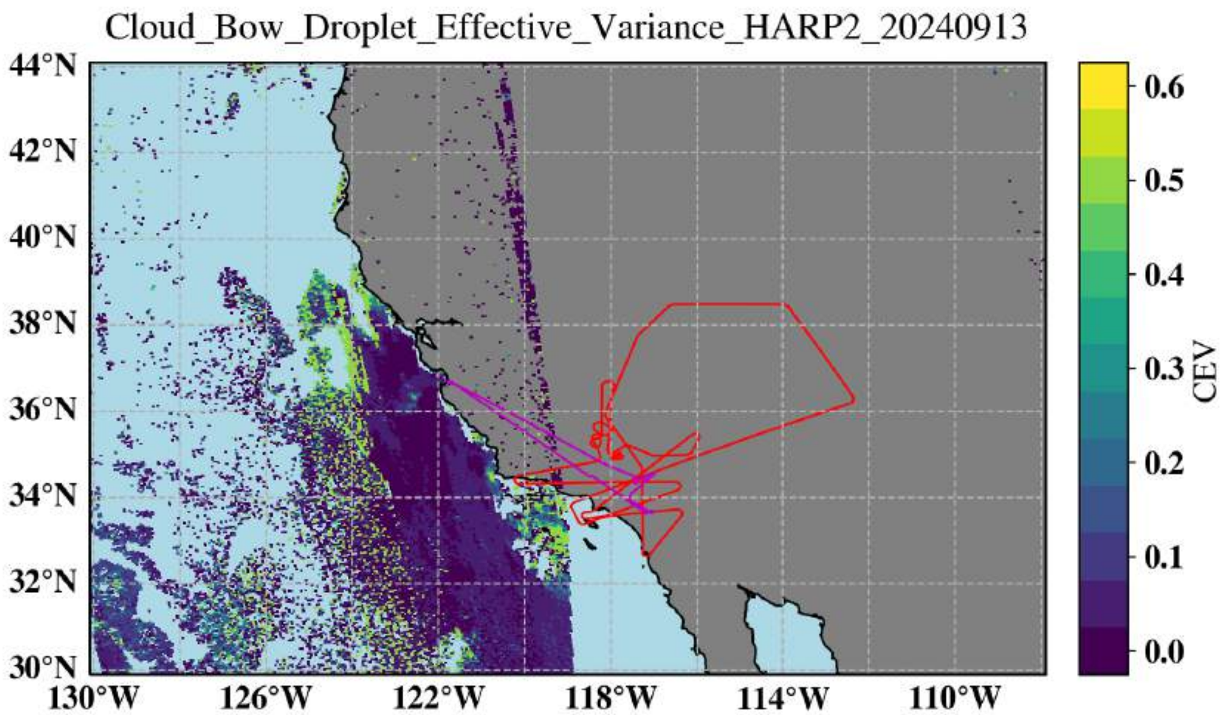


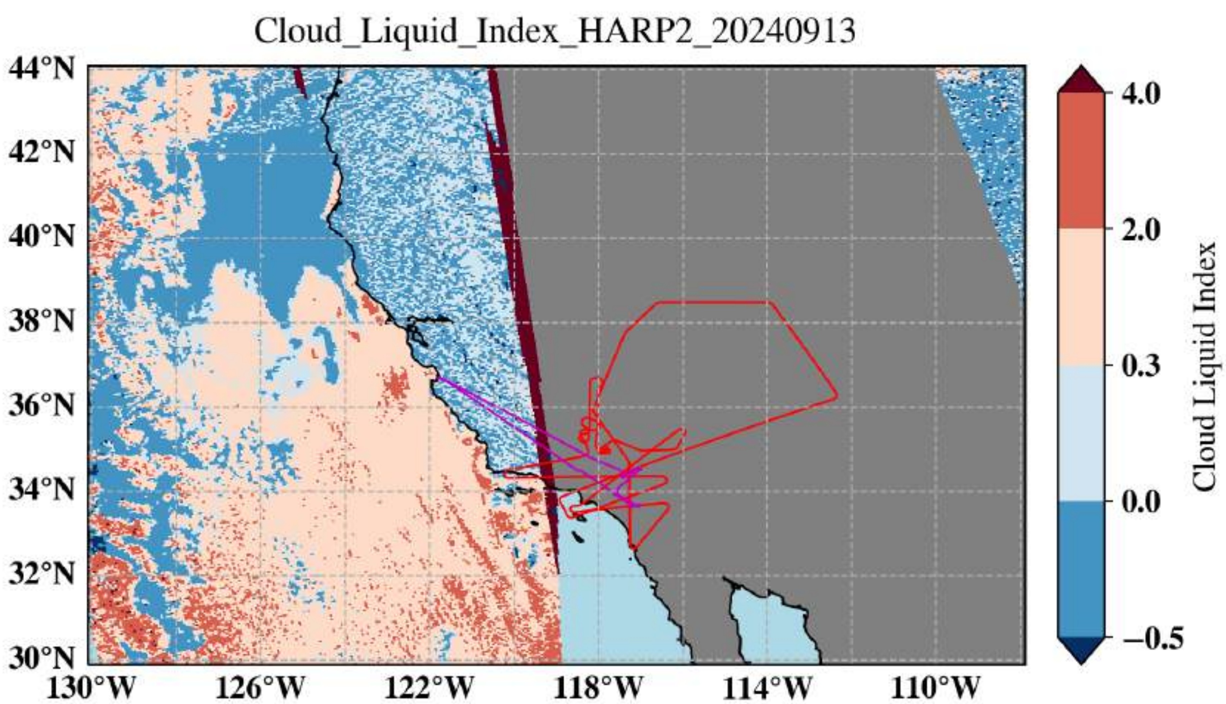


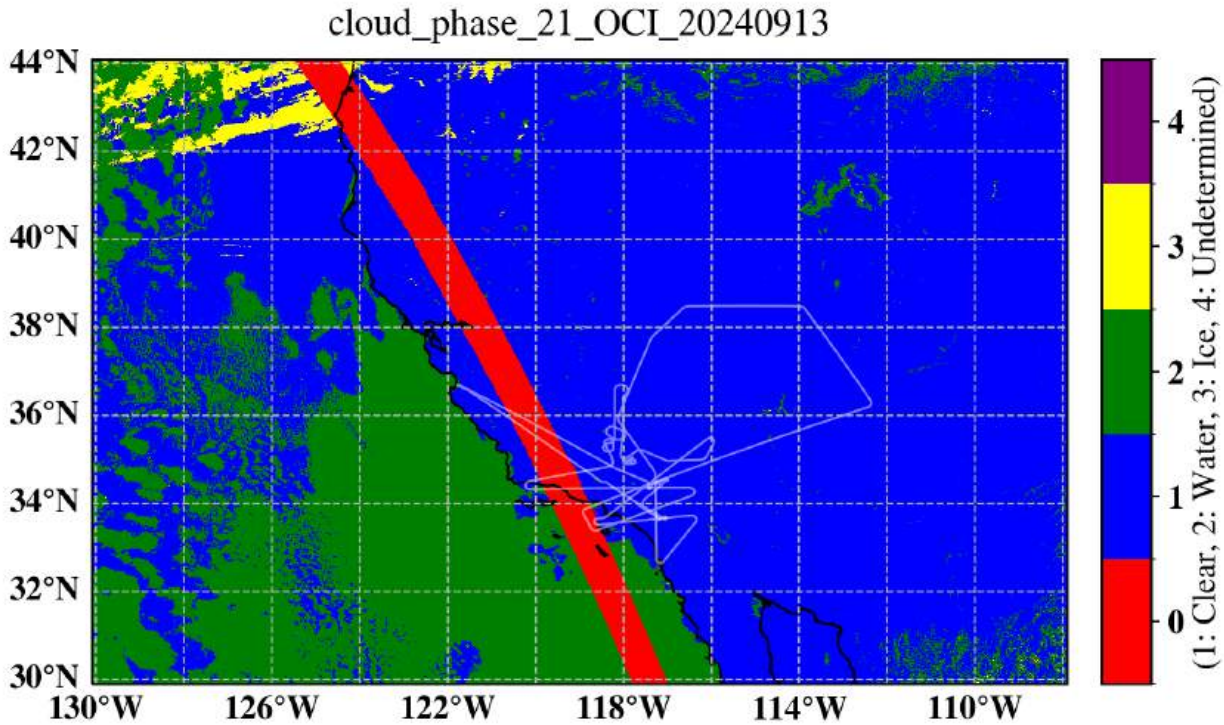
cer_21_OCI_20240913
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
30
25
20
15
10
5
0
CER [μm]

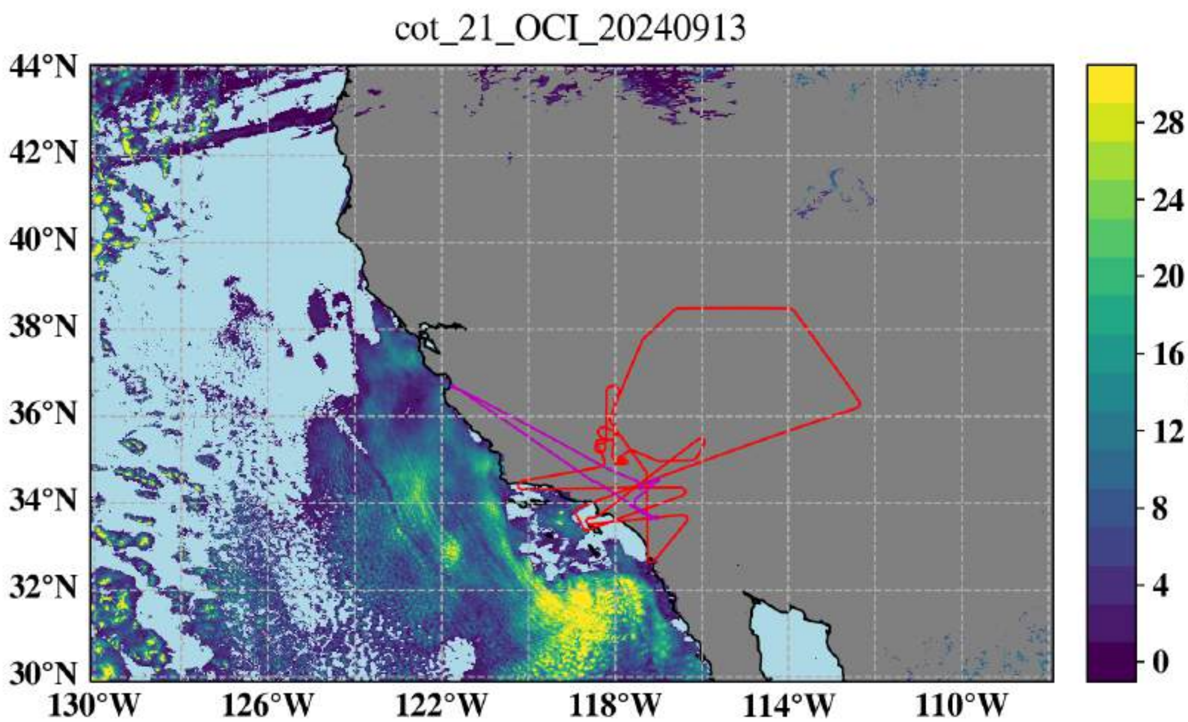


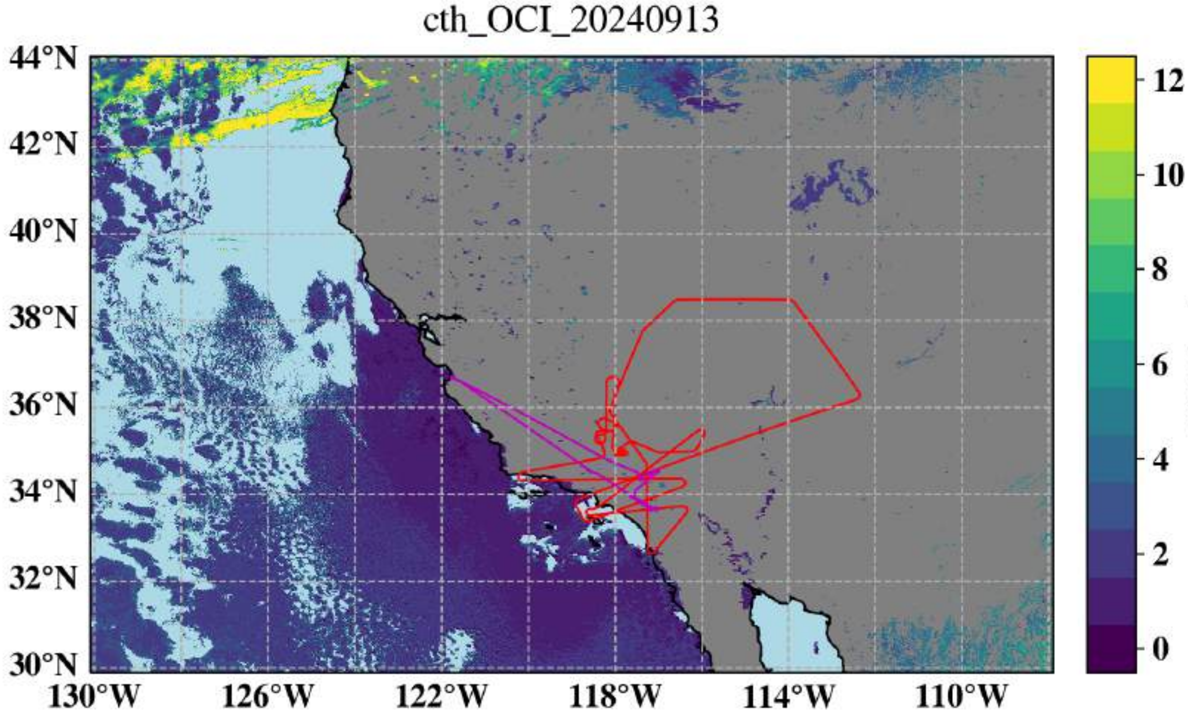
Cloud_Bow_Droplet_Effective_Radius_HARP2_20240913
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
30
25
20
15
10
5
0
CER [μm]

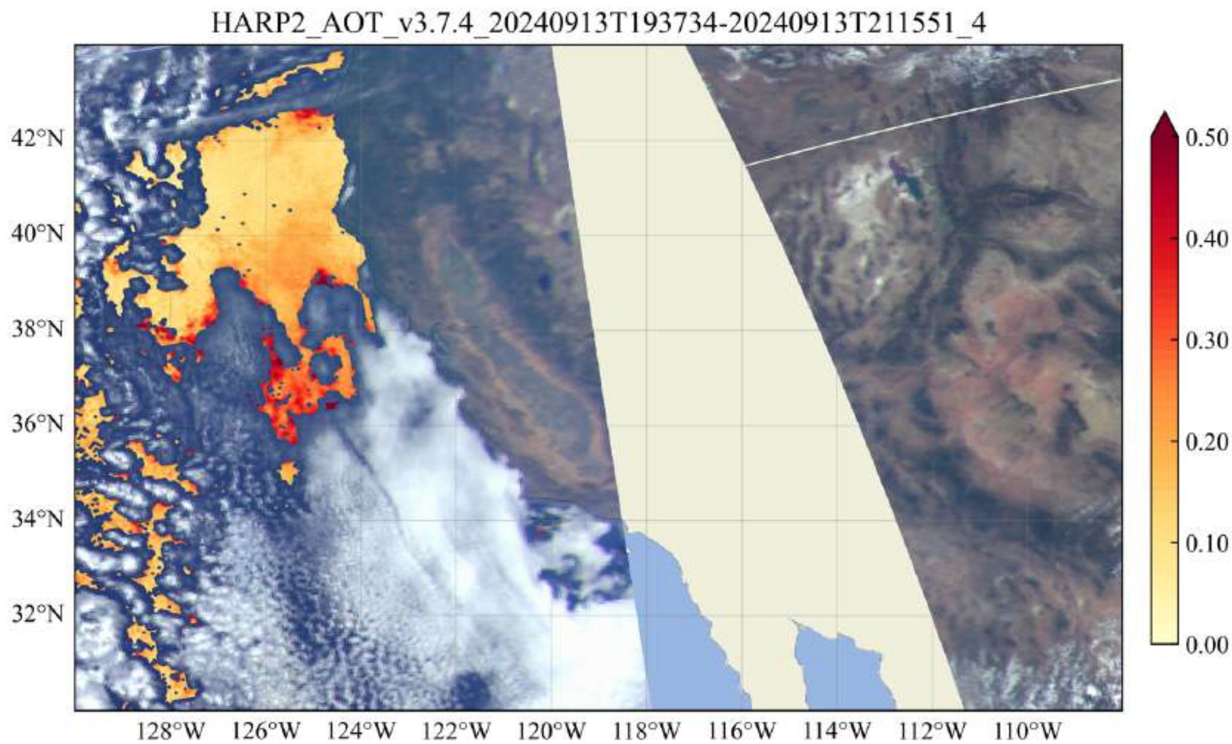

Cloud_Bow_Droplet_Effective_Variance_HARP2_20240913
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0.6
0.5
0.4
0.3
0.2
0.1
0.0
CEV

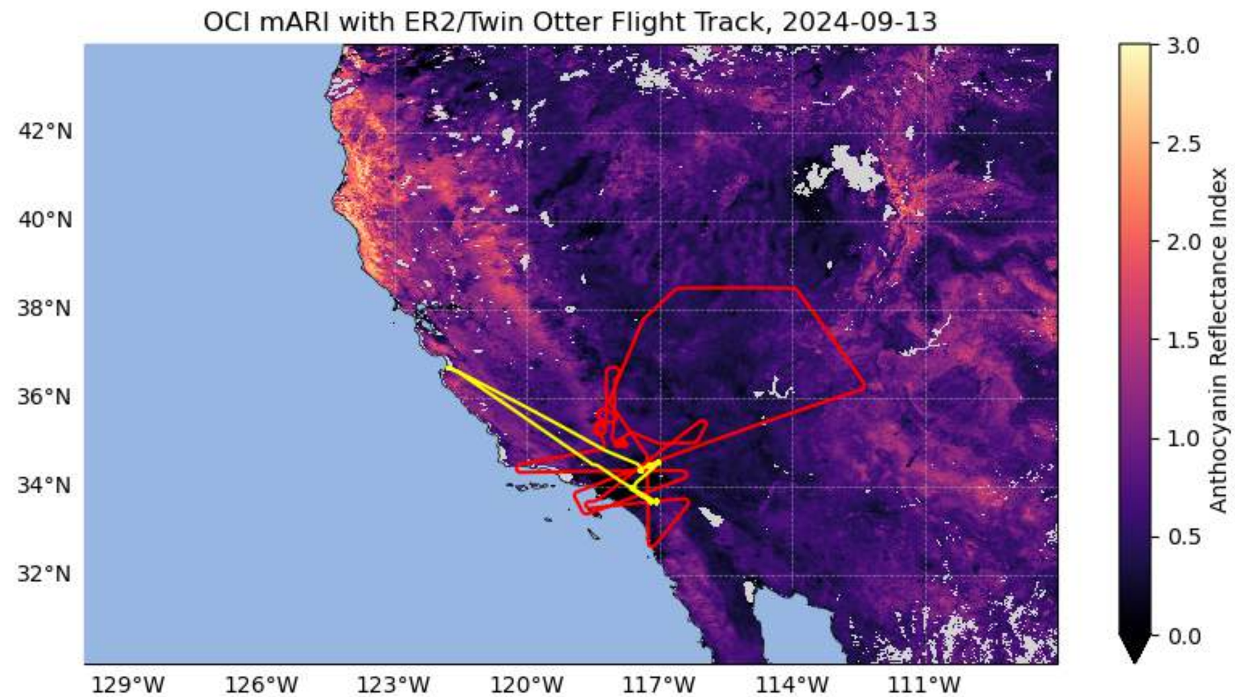

Cloud_Liquid_Index_HARP2_20240913
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
4.0
2.0
0.3
0.0
−0.5
Cloud Liquid Index

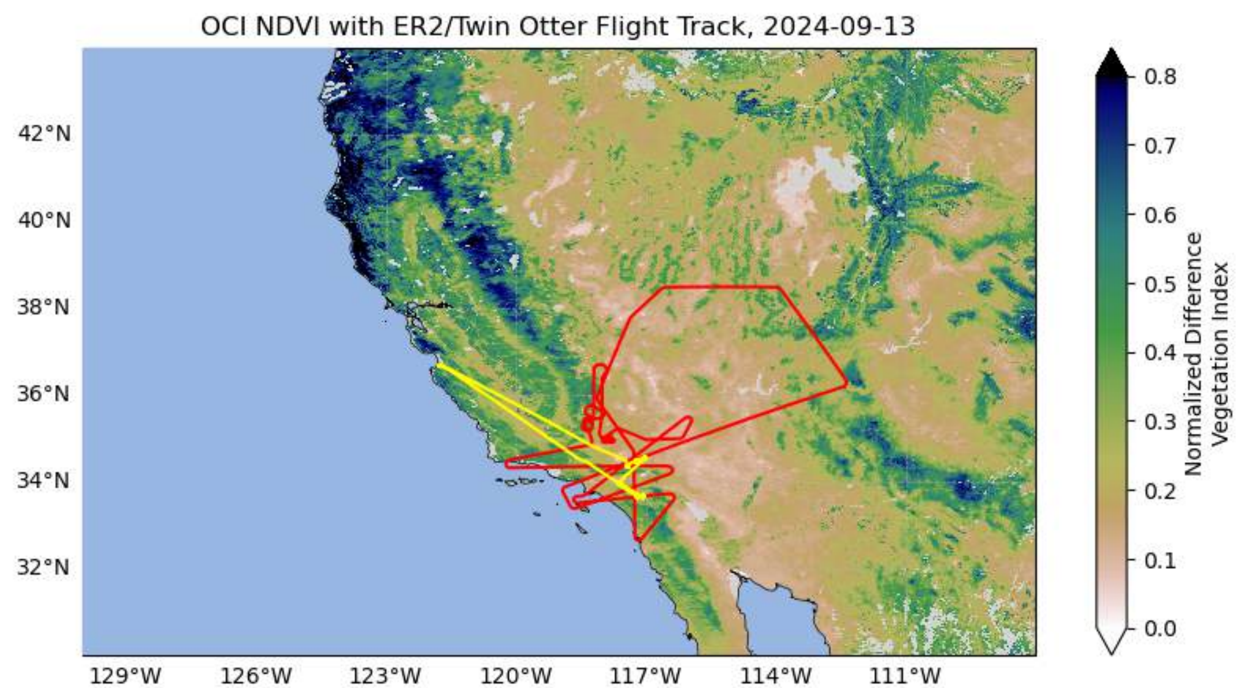

cloud_phase_21_OCI_20240913
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0
1
2
3
4
(1: Clear, 2: Water, 3: Ice, 4: Undetermined)


cot_21_OCI_20240913
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0
4
8
12
16
20
24
28
COT


cth_OCI_20240913
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
12
10
8
6
4
2
0
CTH [km]


HARP2_AOT_v3.7.4_20240913T193734-20240913T211551_4
42°N
40°N
38°N
36°N
34°N
32°N
128°W
126°W
124°W
122°W
120°W
118°W
116°W
114°W
112°W
110°W
0.50
0.40
0.30
0.20
0.10
0.00


OCI mARI with ER2/Twin Otter Flight Track, 2024-09-13
42°N
40°N
38°N
36°N
34°N
32°N
129°W
126°W
123°W
120°W
117°W
114°W
111°W
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Anthocyanin Reflectance Index


OCI NDVI with ER2/Twin Otter Flight Track, 2024-09-13
42°N
40°N
38°N
36°N
34°N
32°N
129°W
126°W
123°W
120°W
117°W
114°W
111°W
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Normalized Difference Vegetation Index

Twin Otter flight report

PACE-PAX Research Flight report 2024/09/13

Double-Sortie Twin Otter Flight

Manifest:

Bryce Kujat (pilot)

Jeff Martin (pilot)

Anthony Bucholtz (QNC)

Adam Ahern (QNC)

Edward Winstead (QNC)

Launch 1:

Take off: 08:29:51 (15:29:51 UTC) Marina Airport (OAR)

Landing: 12:25:12 (19:25:12 UTC) Chino Airport (CNO)

Duration: 3.9 hrs.

Objectives: Profiles of aerosol scattering and absorption coefficients, and size distributions together with scattering (polarized) phase functions of aged and fresh smoke from wildfires outside of Los Angeles. First flight down to the Los Angeles (LA) area will be made at altitude, allowing for coordination with the ER2 (planned 17:46 UTC) during the first spiral down that is east of the Bridge Fire. Two additional spirals are planned along the ER2 flight track, downwind of the Bridge Fire and north of the Line Fire. After completing spirals, as fuel allows, land in Chino, CA for fuel.

Summary: Takeoff at 15:29:51 UTC with very little aerosol present during the climb out from Marina, CA. Transit to LA at 10 kft was very clean, although dust aerosol was visually identified below in the Central Valley. Smoke from the wildfires becomes visible at 16:10 UTC, with local landmarks showing that the smoke layer was just below San Antonio Mountain which has a height of 10,064 ft. During the first spiral down, we observed three distinct layers of smoke. The first was a very sharp increase to ~90 Mm^{-1} of scattering ~9.2 kft, followed by clean air, then another thick layer ~80 Mm^{-1}, which then transitioned into a fairly well mixed boundary layer. The bottom of the spiral was at 4.8 kft due to terrain. Since we were early and had plenty of fuel, we repeated the spiral back up and observed similar structure. We headed to the second planned location a few miles east and spiraled down and then back up. During this second spiral we were overflown by the ER2. We saw similar structure but with much denser smoke at the second spiral, both down and up. We moved slightly further east to waypoint BFIR3 and spiraled down, seeing the highest scattering of the flight at 1100 Mm^{-1}. After spiraling down, we headed to Chino, CA (KCNO) for fuel. Transitioning from the Antelope Valley into the LA basin showed a distinct increase in aerosol loadings, ~124 Mm^{-1}. We landed at KCNO at 19:25:12.

Launch 2:

Take off: 13:45:37 (20:45:37 UTC) Chino Airport (CNO)

Landing: 17:21:35 (24:21:35 UTC) Marina Airport (OAR)

Duration: 3.6

Objectives: Second sortie is planned for coincidence with PACE satellite overpass (21:14 UTC, OCI only) during a spiral down just east of the Airport Fire. A second spiral is planned further east of the Airport Fire with an ER2 overpass. Two passes at the Marina airport tower will be done if time and conditions allow.

Summary: We took off from KCNO at 20:45:37, ascending through significant smoke, with scattering coefficient ~60 Mm^{-1}. We climbed to 10 kft and were directed by ATC to move further east to avoid an active skydiving zone. We observed the same vertical distribution of aerosol as we did east of the mountains, going from ~2 Mm^{-1} at 10 kft increasing to ~150 Mm^{-1} at 9.2 kft, clean air, then another layer of better mixed smoke. Bottom of spiral was 2.5 kft, at which point we transited at that altitude to over Diamond Valley Lake and spiraled up. At the top of the spiral we turned back towards Marina and descended to 8.5 kft to try and be in the smoke. Once clear of LA airspace, we descended as low as terrain would allow, including 20 minutes at 4.5 kft when we measured what appeared to be marine inflow characterized by large particles that may have been sea salt. We landed at 24:21:35 (on September, 14th 2024 in UTC time). No passes at the tower were possible due to the presence of fog.

All instruments aboard the Twin Otter were operating nominally throughout both flights, except during the descent into Chino CA which may have been faster than the dewpoint monitor could respond to, and the aerosol concentrations may have been too high for some of the particle counters.

Heading into the smoke at 10 kft, 17:21 UTC; photo taken by Adam Ahern

View of the Bridge Fire during the first spiral 17:35:29 UTC. LA basin full of smoke; photo taken by Adam Ahern

17:40:40 Two layers of aerosol visible during descent of first spiral. Photo isn't great, but it was an observable phenomenon during the spirals; photo taken by Adam Ahern.

Distinct aerosol layer visible during spiral down east of Airport fire at 21:11; photo taken by Adam Ahern.


Two layers of aerosol visible at 22:50 UTC during transit back from LA; photo taken by Adam Ahern.

R/V Shearwater report

PACE-PAX R/V Shearwater day report

Date: 09/13/2024

Creator: Michael Ondrusek

Cruise ID: RF0913-RS

Sailed out: 15:57 UTC (8:57 PST)

Back in port: 23:00 UTC (16:00PST)

Today, the ship occupied three stations.

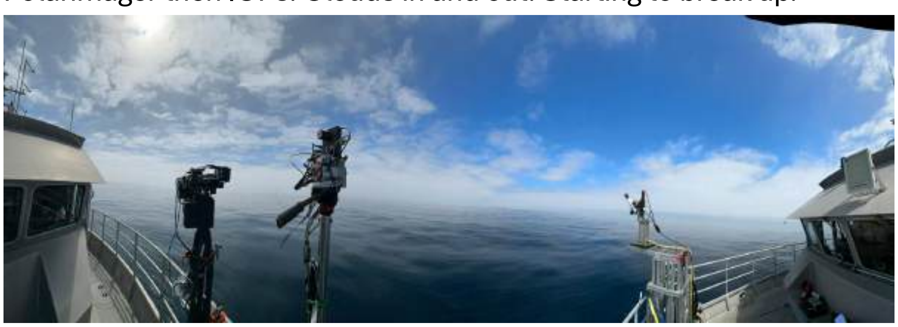
Station #9 34.327250, -119.503281 arrival 16:37 UTC (9:37 PST) →departure 18:27 UTC (11:27 PST) occupied station at eastern end of ER2 line. Swell < 1ft. Wind 1 to 3 kts. Completely overcast. IOPs first then profiles with consistent lighting, the polarimagers.

Arrival photo:

Departure photos

Station #10 34.32317, -119.57417, arrival 18:44 UTC (11:44 PST) → departure 19:57 UTC (12:57 PST) 5 Nm west on line. Profiles first, then

Polarimager then IOPs. Clouds in and out. Starting to break up.

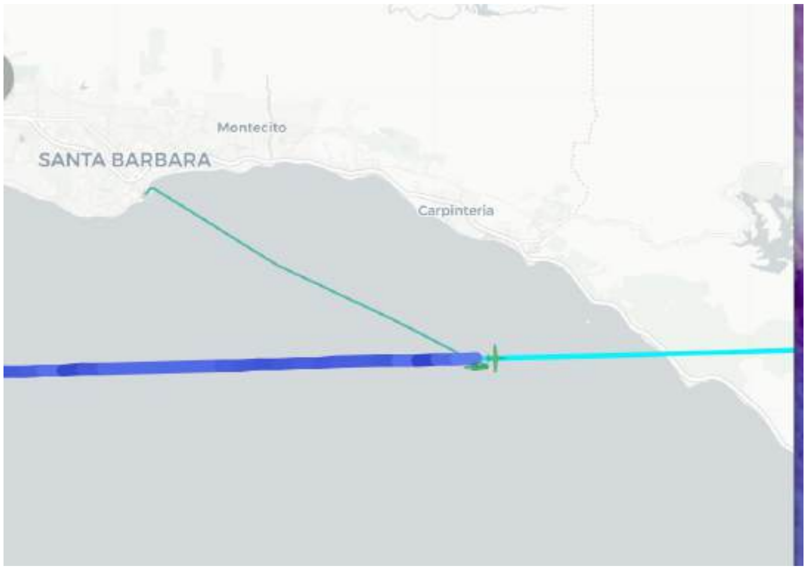


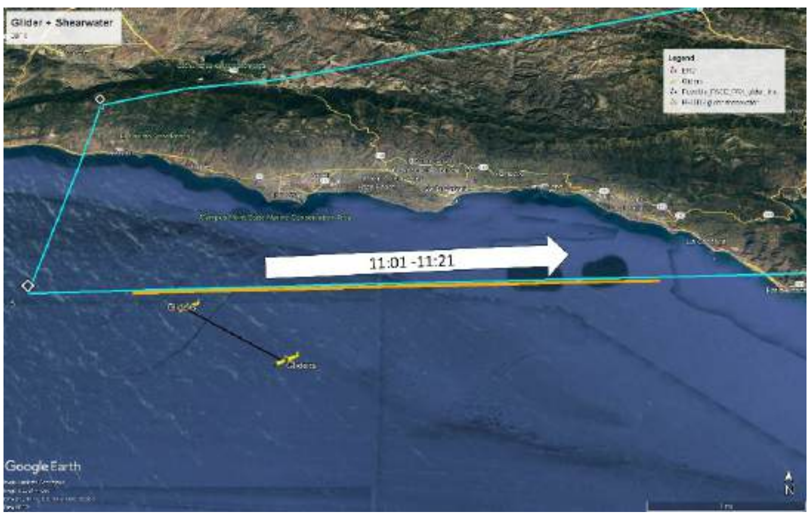
Station #11 34.12268°, -119.70124°, arrival 20:45:40 UTC (13:45 PST)→ departure 22:01:40 UTC (15:01 PST) Just North of Santa Cruz between Island and shipping channel. Winds 11.5 kts.

Clear sun but some haze. Green water. Did profiles, the polarimager then IOPs.

System Status:

ER-2 overflight at 18:03 UTC (11:03 PST)





Group Status: All's well

R/V Blissfully report

PACE-PAX R/V Blissfully day report

Date: 09/13/2024

Creator: Bridget Seegers

Cruise ID: RF0913-RB

Sailed out: 15:59 UTC

Back in port: 01:01 UTC

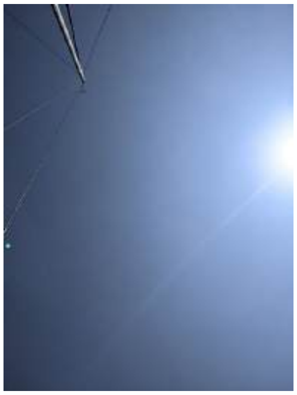
Today, the ship accomplished....

Collection of vertical radiometry profiles and discrete sample collection (HPLC + ap) on two stations in proximity of SeaPRISM site. The station had three sets of 5 HyperPro profiles to 20m and a single deep cast to 60m and discrete water samples included triplicate HPLC + ap and duplicate community composition Lugol's preserved and paraformaldehyde samples for flow cytometry.

Station 1 33.563581°, -118.117805° , no sampling because of clouds, ER-2 overflight 18:42 UTC


Initial conditions, sampling delay

Station 2a (cruise station RB_10) 33.558371°, -118.117538, sampling started at 20:14 UTC,
Station 2b (cruise station RB_11) 33.558371°, -118.117538, repeated same location for the ER-2 overpass 21:48 UTC



Tomorrow, RV Blissfully

Ship plans through the next 3 days...

Sampling in coordination with rest of the experiment

System Status...

All good

No ER-2 overflight

Group Status...

All great

PACE-PAX research flight report 2024/09/15

Compiled by Kirk Knobelspiesse, Ivona Cetinić, Michael Ondrusek, Bridget Seegers
2024/09/21
Reviewed by Samuel LeBlanc

ER2 samples SoCal smoke on line with marine stratus near coast, on to overpasses of blissfully, shearwater, hypernav but unfortunately clouds. Then up north for PACE track over clouds and return to hypernav location for time of PACE overpass. Cloudy HyperNAV profile. After that RTB due to surface winds, missing planned EarthCARE lines.

ER-2
Takeoff: 16:24, Landing: 21:37, Duration: 5.2
Early return due to high surface winds at AFRC
Instrument status: RSP possibly functional, all others good
Pilot: Tim Williams, mobile pilot: Kirt Stallings

Twin Otter
No flight day

R/V Shearwater
Mission Scientist: Michael Ondrusek
Sailed out: 17:35 UTC
Back in port: 00:40 (09/16)PACE UTC
See end for full R/V Shearwater report

R/V Blissfully
Mission Scientist: Bridget Seegers
Sailed out: 14:59 UTC
Back in port: 21:04 UTC
See end for full R/V Blissfully report

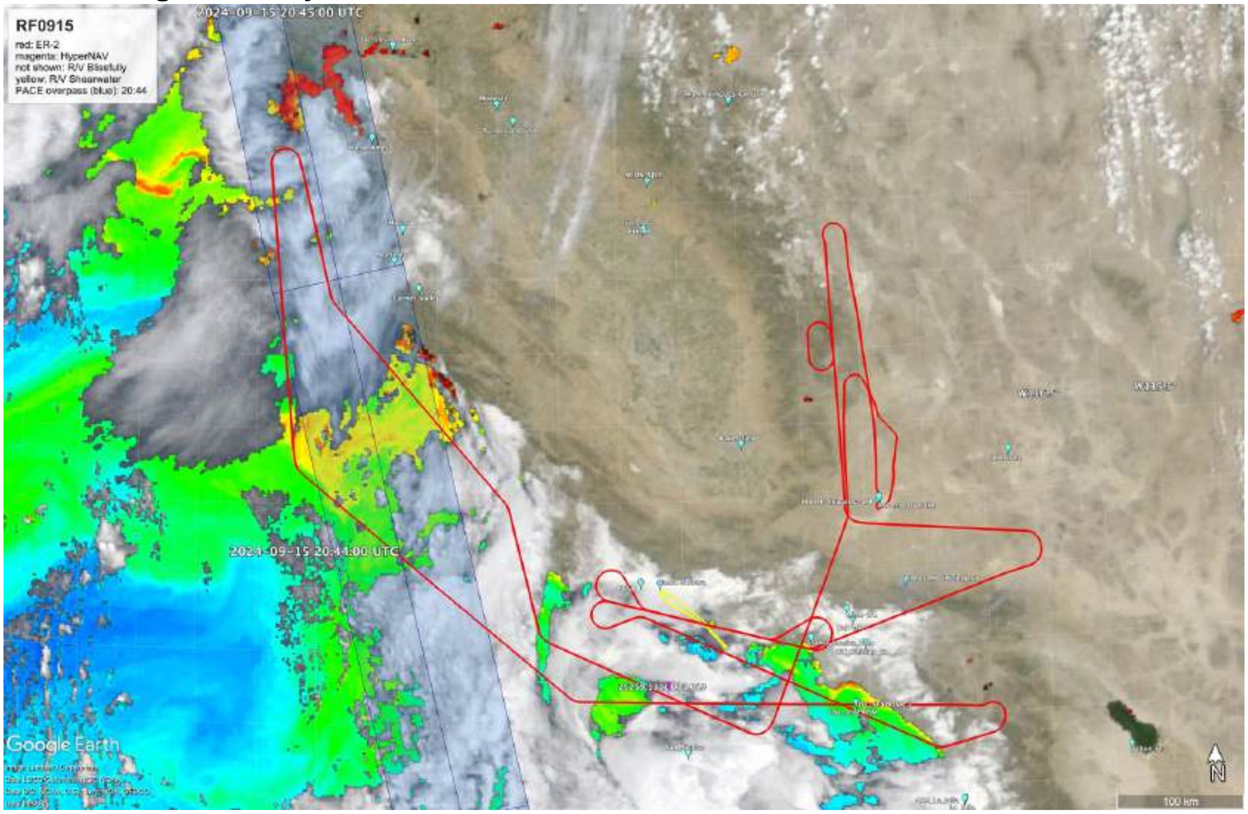
PACE
Overpass at 20:44 (offshore)

EarthCARE
No targeted underpass

Gliders
Operational

HyperNAV
Operational

Overall image summary



Validation Traceability Matrix itemized objectives

VTM elements in **black** satisfied, **blue** partially satisfied, red to be confirmed

Time UTC	Platform	VTM(hrs)	
14:59	RB		Departure
16:24	ER2		Takeoff
17:35	RS		Departure
17:38	ER2		Line over smoke and low clouds. Passes over CalTech AERONET site but there are clouds.
18:35	ER2, gliders		ER-2 over gliders, cloudy
18:45	ER2, RB		ER-2 over R/V Blissfully, but cloudy. Repeat of same at 19:04
19:39	ER2, PACE	1e(1*0.5), 6f(1.0*0.5), 6d(0.5*0.5)	In solar principal plane PACE-OH line extending to 19:57. Counting half because of time difference with PACE overpass. Marine Strat. Clouds with high cloudsand some aerosol layer under – based on HSRL-2
19:57	RB	1b(1.5), 1c(1.5*0.5)	On station for PACE overpass near USC_SeaPRISM. no USC_SeaPRISM archived data.
20:00	RS	1b(1.5*0.5), 1c(1.5*0.5),	On station until 21:28. Partly cloudy conditions with PACE overpass.
20:10	ER2, PACE	1e(1.0*0.5), 3c(1.0*0.5)	Two legs withing PACE-OHS swath. Ends 20:20. Appears to be high/ice clouds over low clouds, No TO
20:30	ER2, PACE	1e(1.0), 6f(1.0)	Final leg, now in PACE-OH swath Marine stratocumulus. , possibly high clouds too.
20:17	HyperNAV		Surfaces

20:41	ER2	4d(1.0*0.5), 1b(1.0)	ER-2 overflies surfacing HyperNAV during PACE overpass. Partial cloudy HyperNAV profile, but clear at surface.
20:44	**PACE**		**PACE overpass**
21:28	RB		On station until 22:23 near USC_SeaPRISM
21:37	ER2		Landing
22:11	RS		On station until 23:07, partly cloudy to clear skies
22:25	RS		Return
21:04	RB		Return

PACE-O: within swath of PACE's OCI instrument
PACE-OH: within swath of PACE's OCI and HARP2 instruments
PACE-OHS: within swath of PACE's OCI, SPEXone and HARP2 instruments
RB: R/V Blissfully
RS: R/V Shearwater
ER2: NASA ER-2

Assessment:

- 3.1% of objectives observed. Largely foiled by clouds over HyperNAV site and other ocean locations. Did manage some cloud observations in PACE-OHS swath.
- Top remaining objectives (score above 6.0): PACE aerosol in narrow swath (3a,b), EarthCARE cloud (3e)

PACE-PAX progress tracking

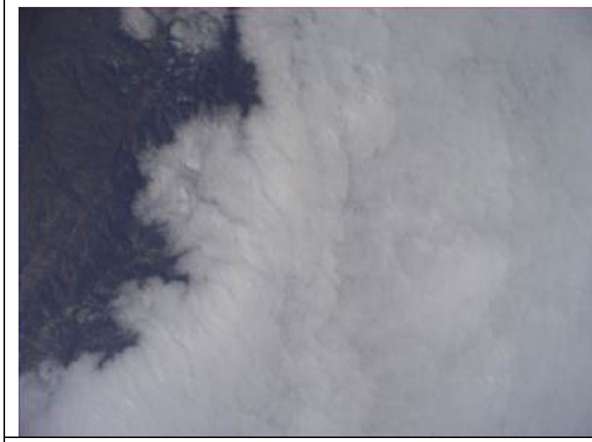
Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 9/9	Fractional success 9/10	Fractional success 9/11	Fractional success 9/12	Fractional success 9/13	Fractional success 9/14	Fractional success 9/15	Total success	Remaining score
1. Validate new retrieval properties	a	Land surface parameters	8.000	2.000	1.575	0.000	**0.048**	0.000	0.000	**0.295**	0.000	0.000	**0.545**	**3.640**
	b	Ocean radiometric parameters	10.000	8.000	25.500	0.000	**0.036**	0.000	**0.067**	**0.010**	0.000	**0.009**	**0.959**	**0.413**
	c	Aerosol parameters over the ocean	12.000	8.000	19.375	0.000	**0.051**	0.000	**0.050**	**0.022**	0.000	**0.018**	**0.911**	**1.065**
	d	Aerosol parameters over land	12.000	8.000	45.663	0.000	**0.017**	0.000	**0.023**	**0.030**	0.000	0.000	**0.997**	**0.040**
	e	Cloud parameters	12.000	8.000	9.500	0.000	0.000	0.000	0.000	0.000	0.000	**0.112**	**0.695**	**3.660**
	f	Ocean surface parameters	1.000	8.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**1.000**
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10.000	8.000	3.500	0.000	0.000	0.000	**0.133**	0.000	0.000	0.000	**0.354**	**6.456**
	b	Aerosol parameters over land (PACE)	10.000	8.000	2.125	0.000	0.000	0.000	**0.116**	0.000	0.000	0.000	**0.233**	**7.667**
	c	Cloud parameters (PACE)	5.000	2.000	2.500	0.000	0.000	0.000	0.000	0.000	0.000	**0.186**	**0.713**	**1.433**
	d	Aerosol parameters (EarthCARE)	8.000	4.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.465**	**4.282**
	e	Cloud parameters (EarthCARE)	8.000	4.000	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.118**	**7.060**
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6.000	2.000	1.125	0.000	**0.061**	0.000	0.000	**0.370**	0.000	0.000	**0.430**	**3.419**
	b	Validate large reflectances with high polarization	6.000	2.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.393**	**3.639**
	c	Validate large reflectances with low polarization	6.000	2.000	3.000	0.000	0.000	0.000	0.000	**0.145**	0.000	0.000	**0.777**	**1.339**
	d	Overfly vicarious calibration sites	6.000	4.000	1.250	0.000	**0.268**	0.000	0.000	0.000	0.000	0.000	**0.268**	**4.390**
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4.000	2.000	20.750	0.000	**0.410**	0.000	0.000	**0.197**	0.000	0.000	**1.000**	**0.000**
	b	High aerosol loads over ocean	4.000	2.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.393**	**2.426**
	c	Multiple aerosol layers	1.000	2.000	21.625	0.000	0.000	0.000	0.000	**0.127**	0.000	0.000	**1.000**	**0.000**
	d	Aerosol under thin cirrus	2.000	2.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**2.000**
	e	Aerosol above liquid phase cloud	4.000	2.000	3.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.826**	**0.695**
	f	Broken clouds with complex structure	4.000	2.000	1.500	0.000	0.000	0.000	0.000	0.000	0.000	**0.528**	**0.528**	**1.889**
	g	Dust aerosols over ocean	4.000	2.000	1.125	0.000	0.000	0.000	**0.430**	0.000	0.000	0.000	**0.430**	**2.279**
	h	Aerosol and ocean parameters over turbid waters	2.000	2.000	3.125	0.000	0.000	0.000	**0.569**	0.000	0.000	0.000	**0.790**	**0.419**
	i	Aerosol and ocean parameters over biologically productive waters	4.000	2.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**4.000**
	k	Smoke aerosols over ocean	1.000	2.000	2.500	0.000	0.000	0.000	0.000	**0.320**	0.000	0.000	**0.713**	**0.287**
		total:	**150.000**	**98.000**	**171.738**	**0.000**	**0.034**	**0.000**	**0.046**	**0.049**	**0.000**	**0.031**	**0.577**	
														total
				ER-2 flight hours	18.900	0.000	4.300	0.000	0.000	6.300	0.000	0.000	0.000	**10.600**
				TO flight hours	22.200	0.000	0.000	0.000	3.700	7.500	0.000	0.000	0.000	**11.200**
				Shearwater days	2.000	0.000	1.000	0.000	1.000	1.000	0.000	0.000	0.000	**3.000**
		PACE-PAX overall objectives satisfied: 0.577												

Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

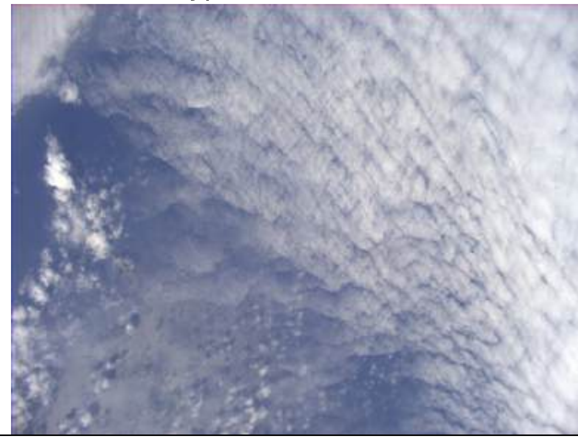
https://www-air.larc.nasa.gov/missions/pacepax/index.html

ER-2 MVIS quicklooks

17:38 over CalTech aeronet



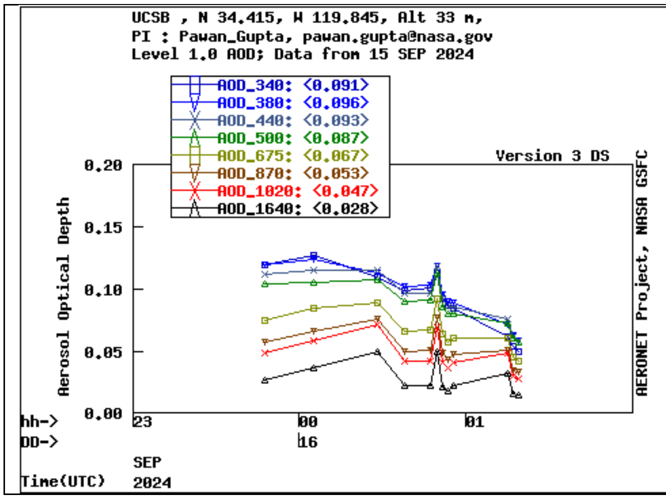
18:35 Over HyperNAV



20:24 in PACE-OHS swath

20:41 over HyperNAV

AERONET quicklooks

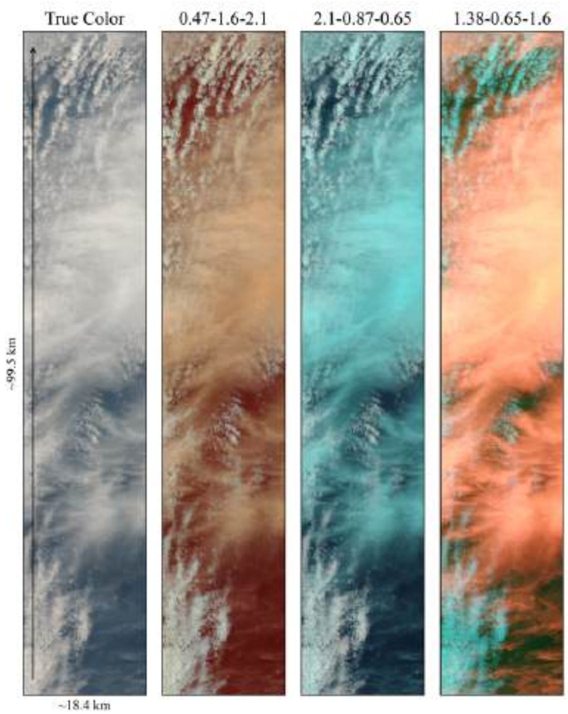


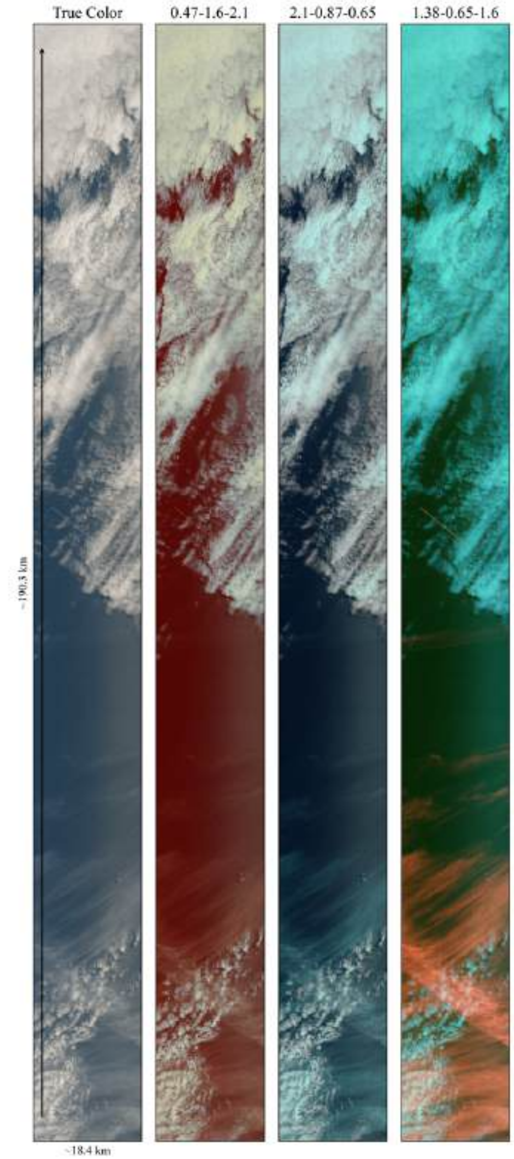
R/V Blissfully photos

a) PACE overflight 20:44 UTC – sampling started at 19:57 utc

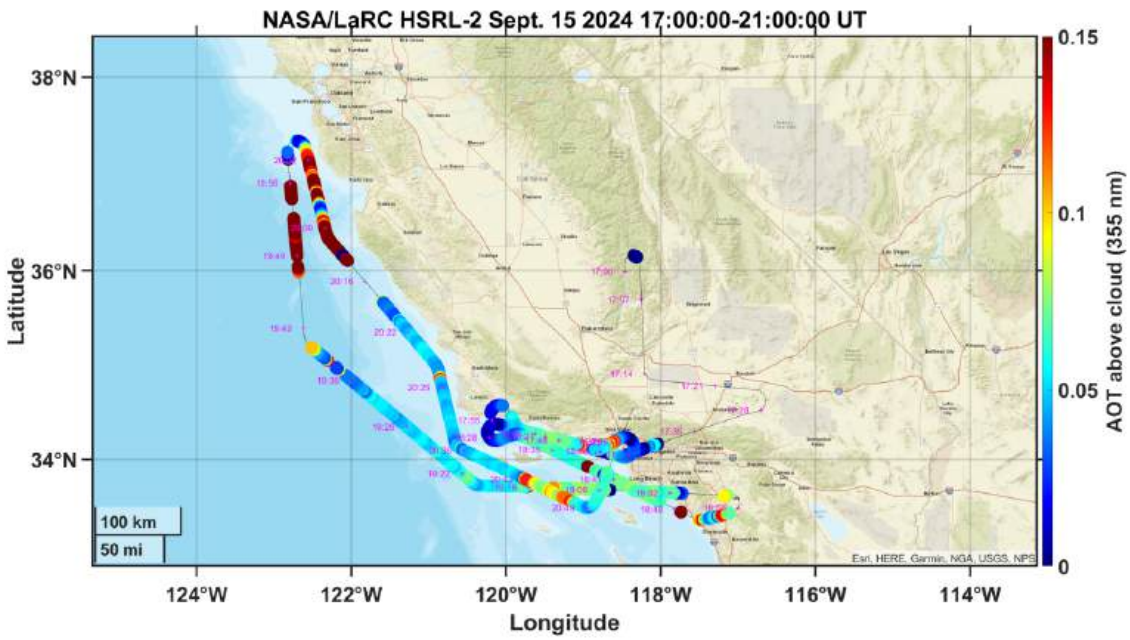
 clear skies for PACE

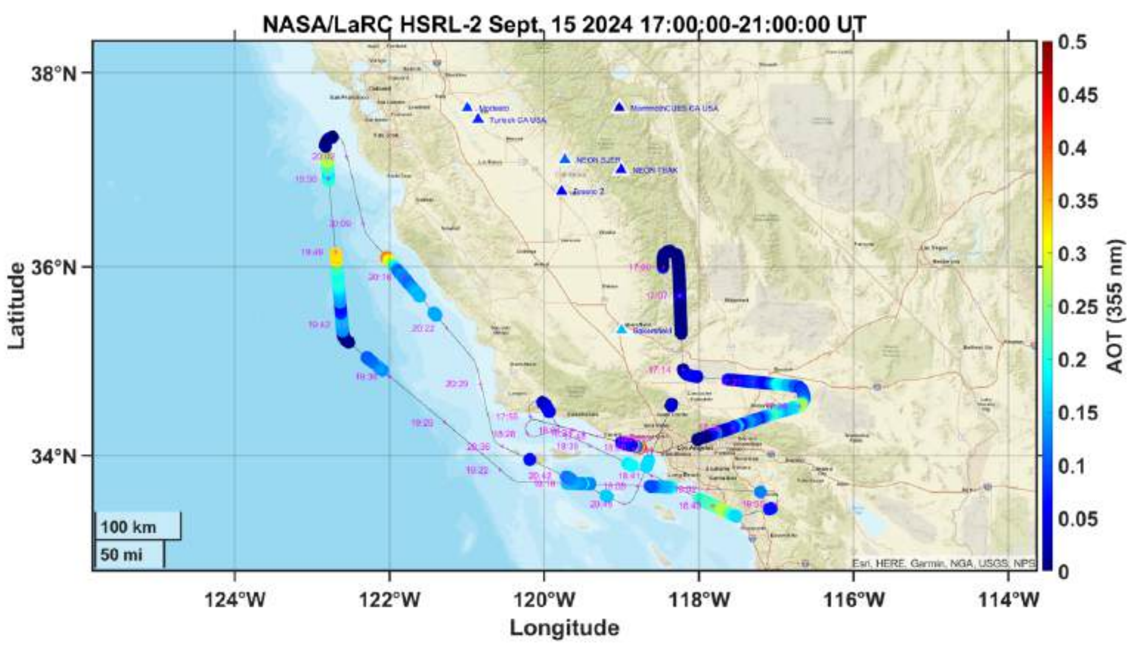
ER-2/PICARD, PACE swath



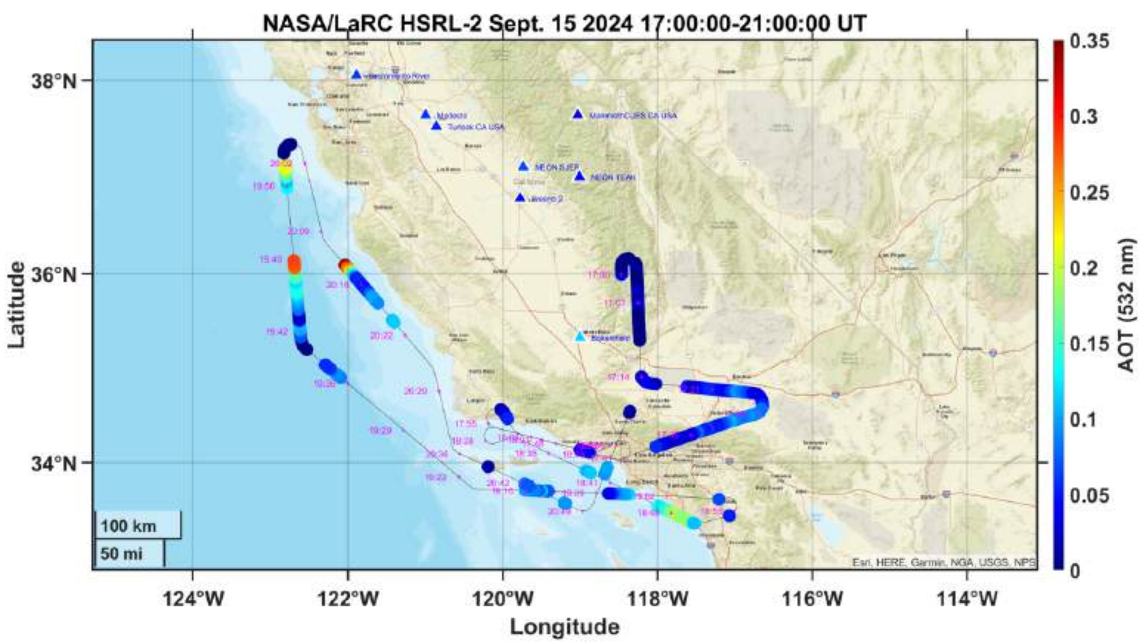


ER-2/HSRL

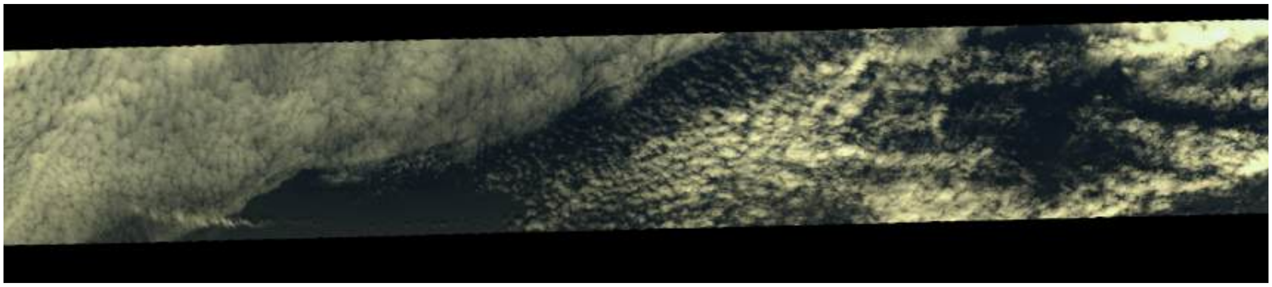

NASA/LaRC HSRL-2 Sept. 15 2024 17:00:00-21:00:00 UT
38°N
36°N
34°N
Latitude
124°W
122°W
120°W
118°W
116°W
114°W
Longitude
100 km
50 mi
Esri, HERE, Garmin, NGA, USGS, NPS
AOT above cloud (355 nm)
0.15
0.1
0.05
0


NASA/LaRC HSRL-2 Sept. 15 2024 17:00:00-21:00:00 UT
38°N
36°N
34°N
Latitude
124°W
122°W
120°W
118°W
116°W
114°W
Longitude
100 km
50 mi
Esri, HERE, Garmin, NGA, USGS, NPS
AOT (355 nm)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0

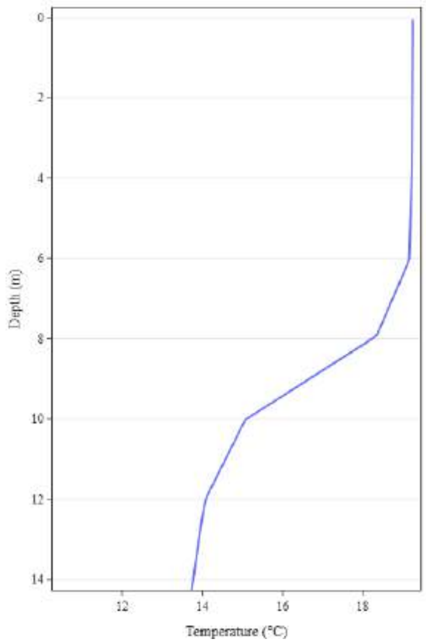

NASA/LaRC HSRL-2 Sept. 15 2024 17:00:00-21:00:00 UT
38°N
36°N
34°N
Latitude
124°W
122°W
120°W
118°W
116°W
114°W
Longitude
100 km
50 mi
Esri, HERE, Garmin, NGA, USGS, NPS
AOT above cloud (532 nm)
0.15
0.1
0.05
0

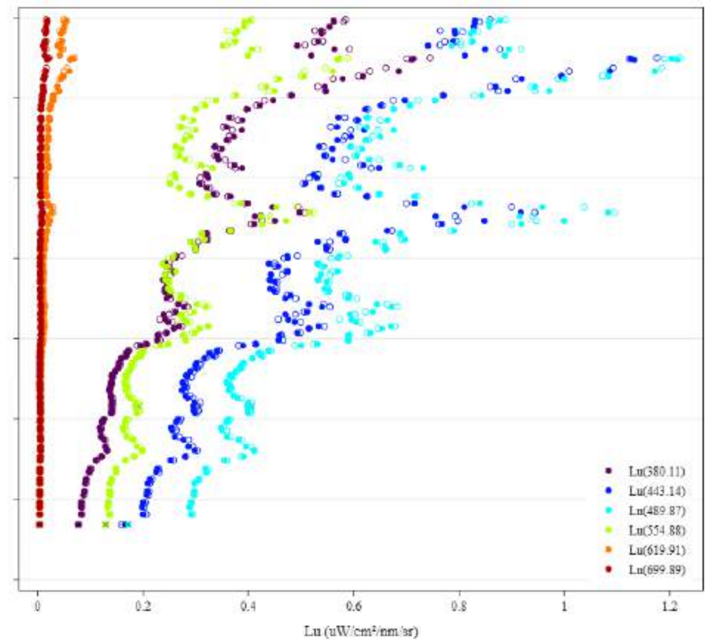

NASA/LaRC HSRL-2 Sept. 15 2024 17:00:00-21:00:00 UT
38°N
36°N
34°N
Latitude
124°W
122°W
120°W
118°W
116°W
114°W
Longitude
100 km
50 mi
Esri, HERE, Garmin, NGA, USGS, NPS
AOT (532 nm)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0

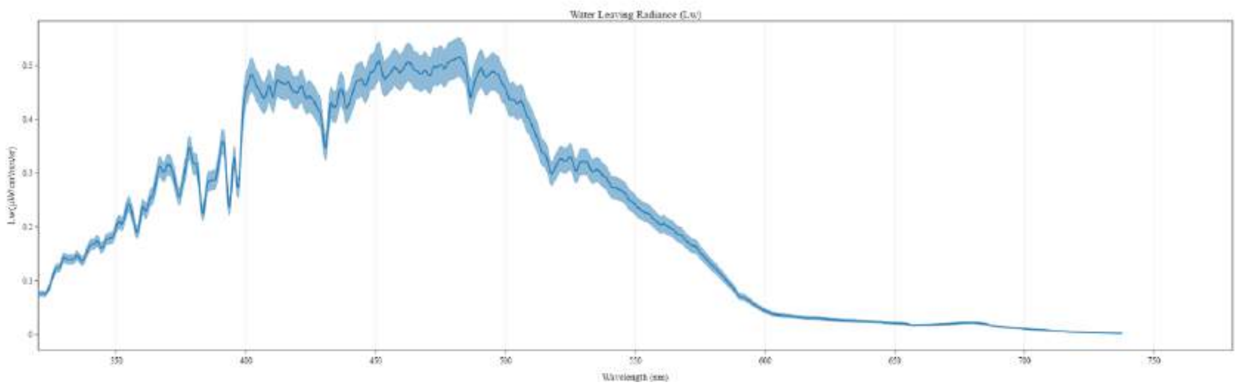
ER-2/PRISM
HyperNAV location



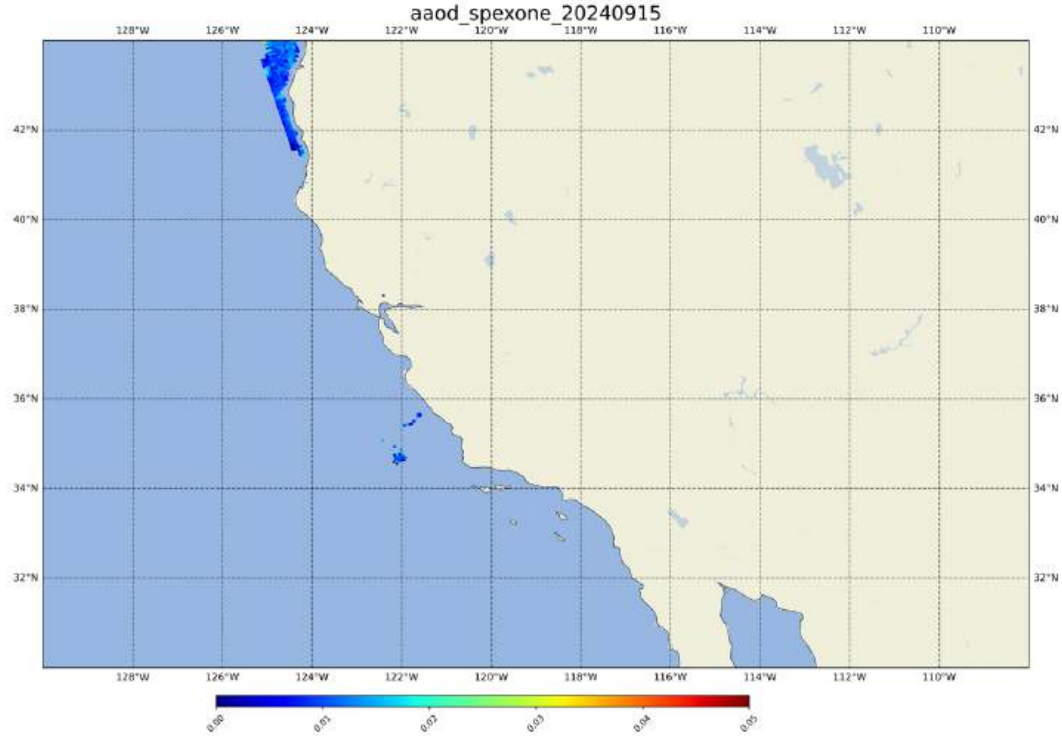
HyperNAV quicklook

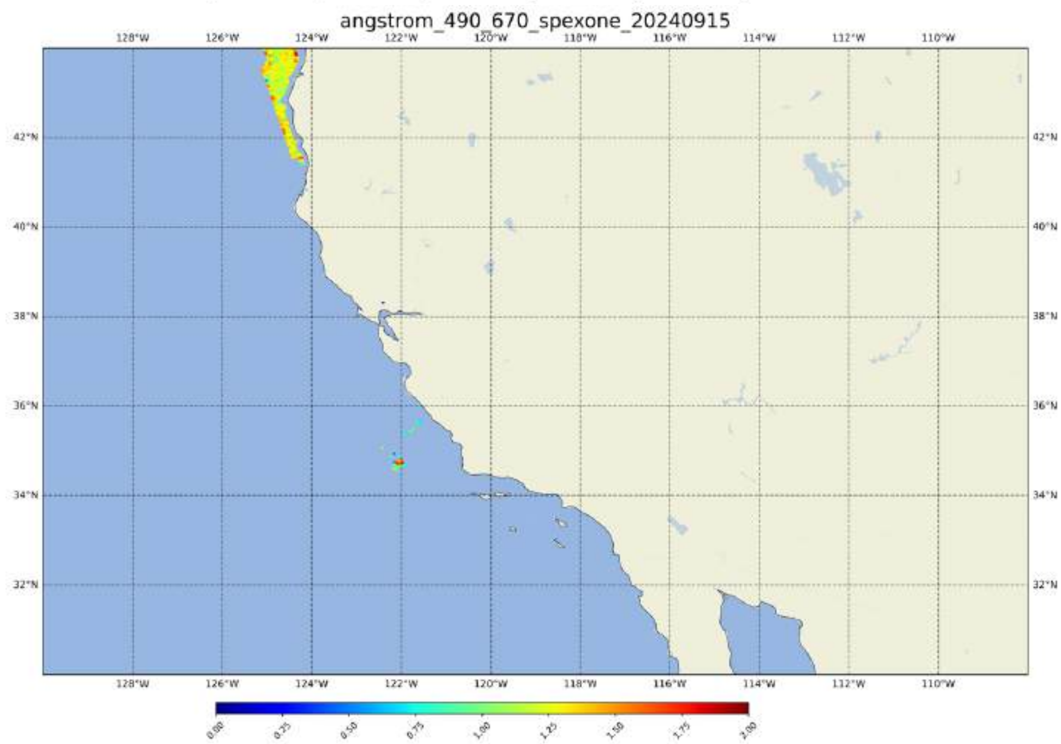


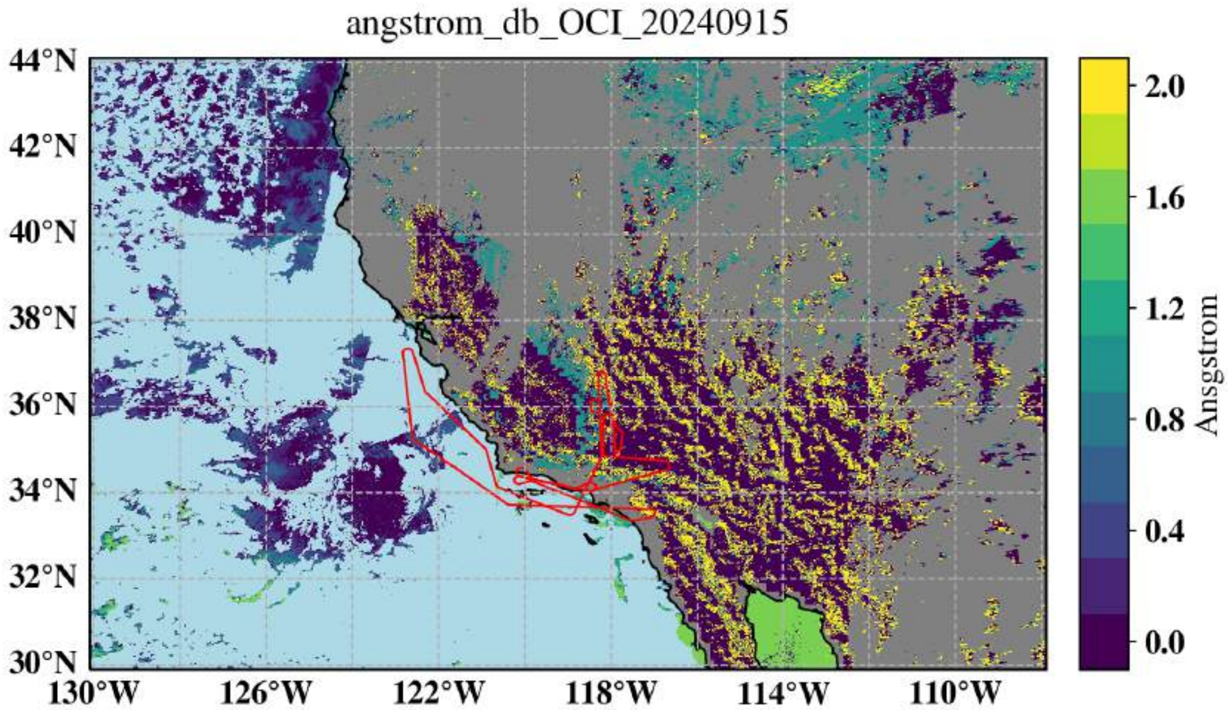


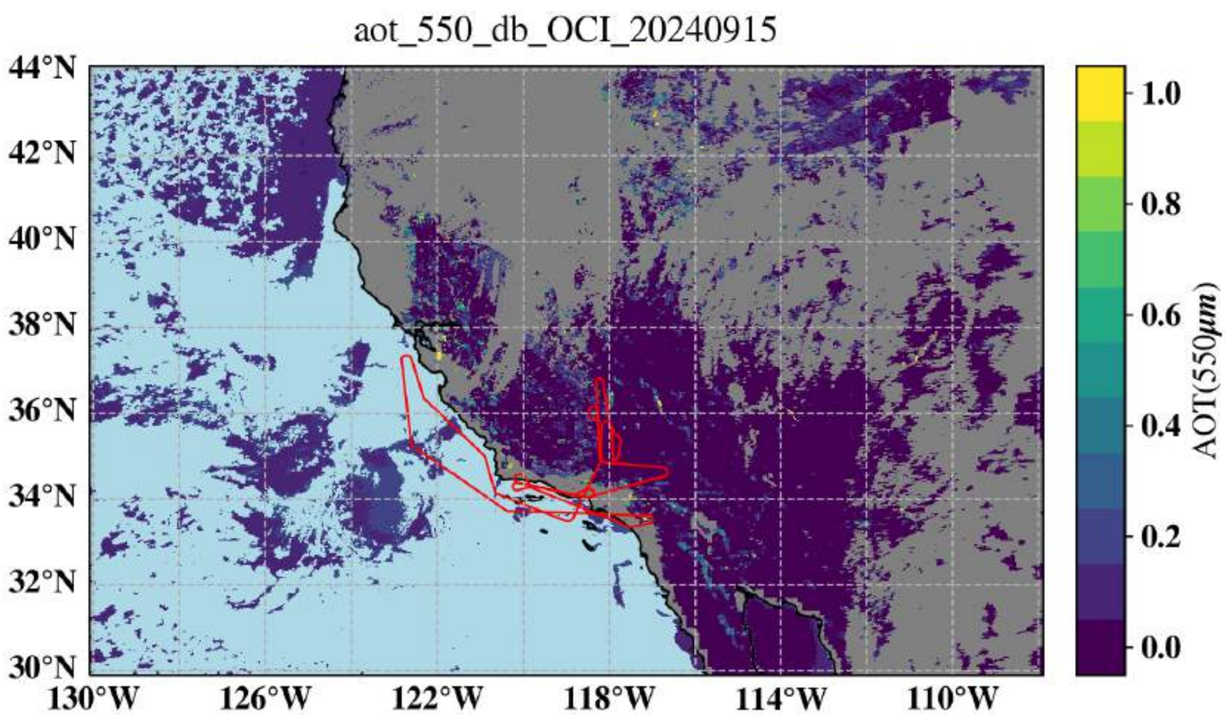


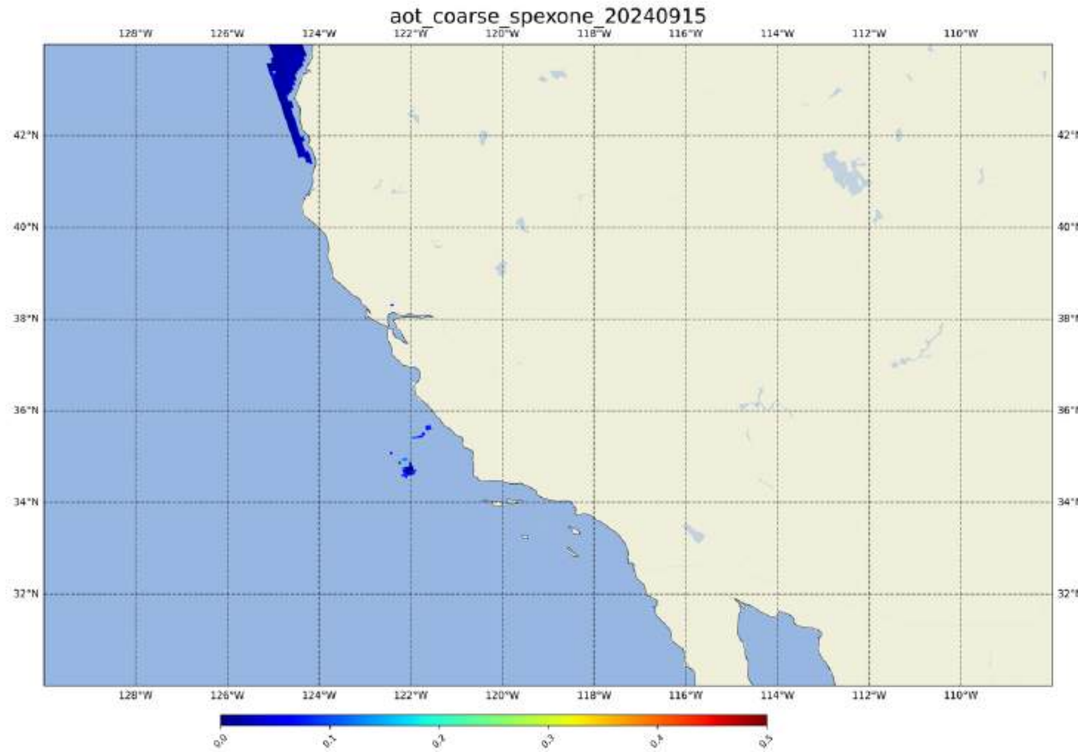
PACE Satellite products

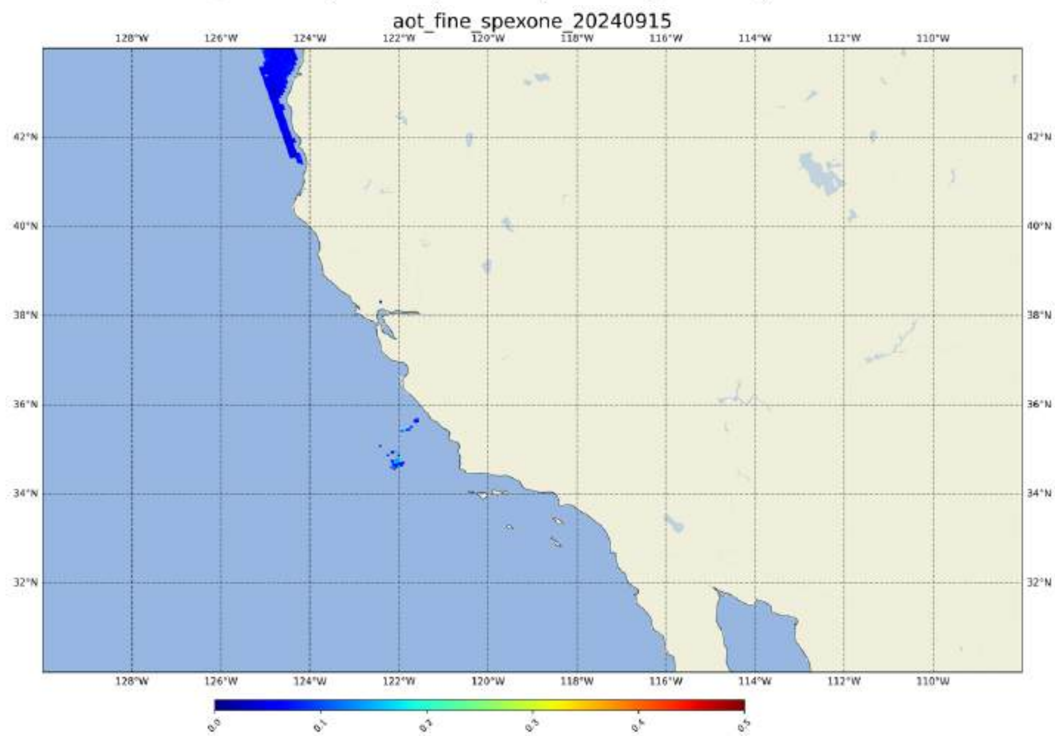


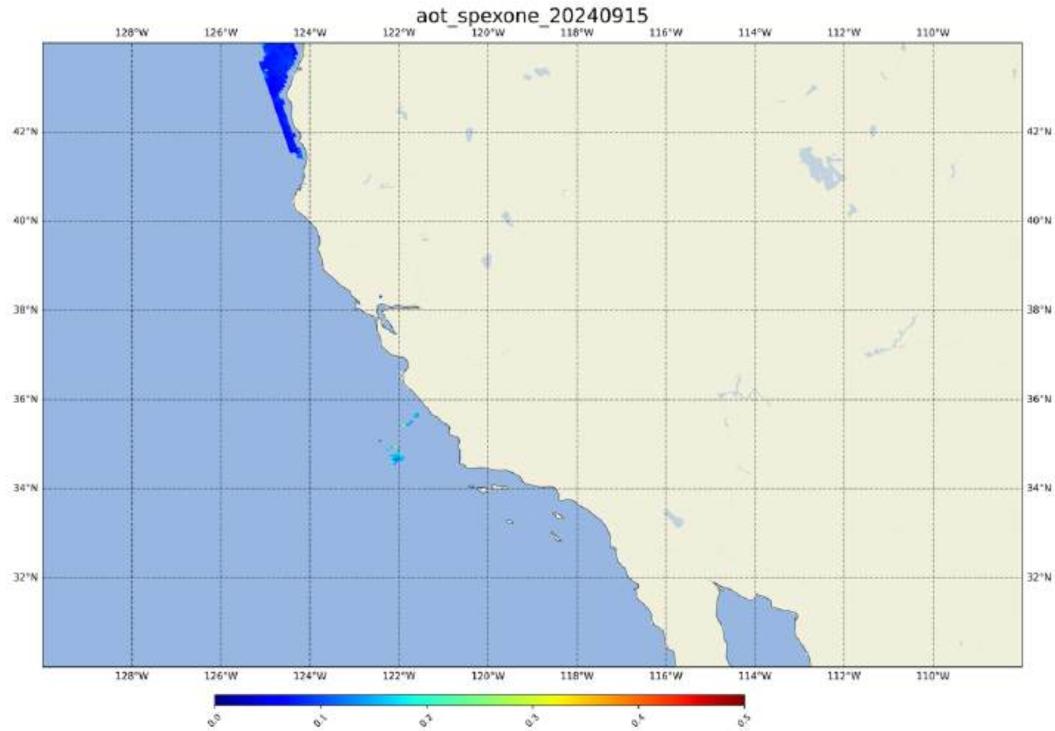


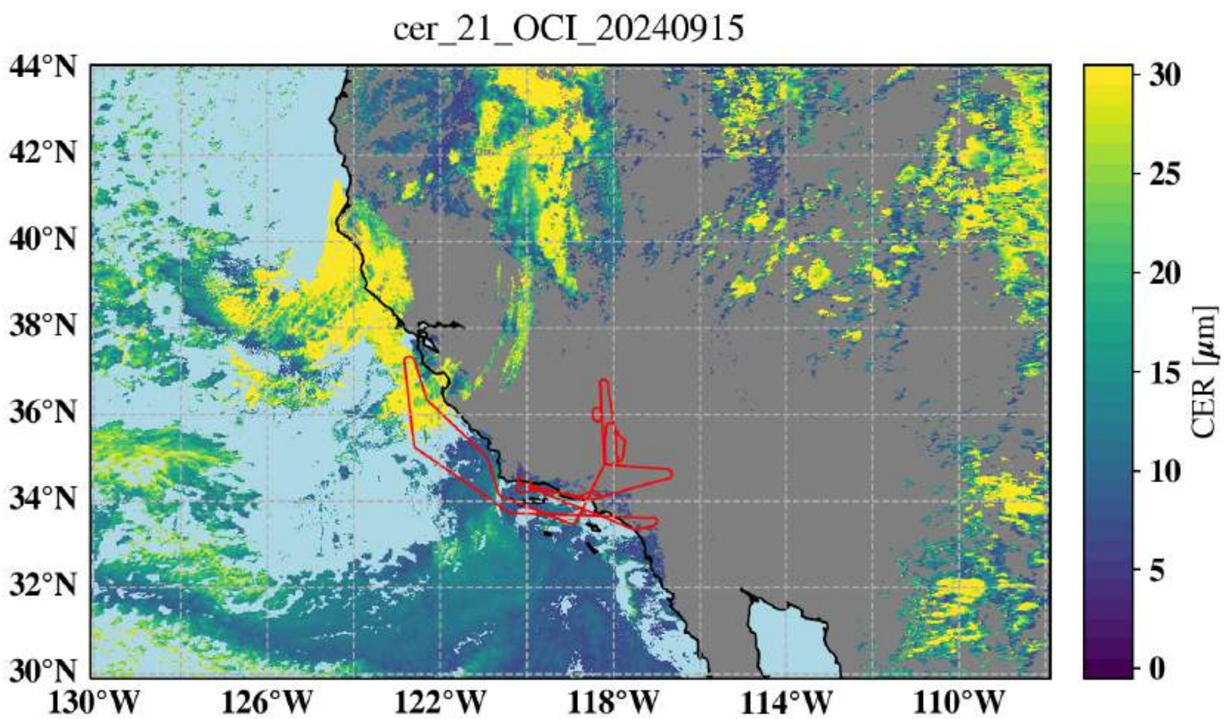

angstrom_db_OCI_20240915
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
2.0
1.6
1.2
0.8
0.4
0.0
Angstrom


aot_550_db_OCI_20240915
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
1.0
0.8
0.6
0.4
0.2
0.0
AOT(550μm)


aot_coarse_spexone_20240915
128°W
126°W
124°W
122°W
120°W
118°W
116°W
114°W
112°W
110°W
42°N
40°N
38°N
36°N
34°N
32°N
0.0
0.1
0.2
0.3
0.4
0.5


aot_fine_spexone_20240915
128°W
126°W
124°W
122°W
120°W
118°W
116°W
114°W
112°W
110°W
42°N
40°N
38°N
36°N
34°N
32°N
0.0
0.1
0.2
0.3
0.4
0.5


aot_spexone_20240915
128°W
126°W
124°W
122°W
120°W
118°W
116°W
114°W
112°W
110°W
42°N
40°N
38°N
36°N
34°N
32°N
0.0
0.1
0.2
0.3
0.4
0.5


cer_21_OCI_20240915
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
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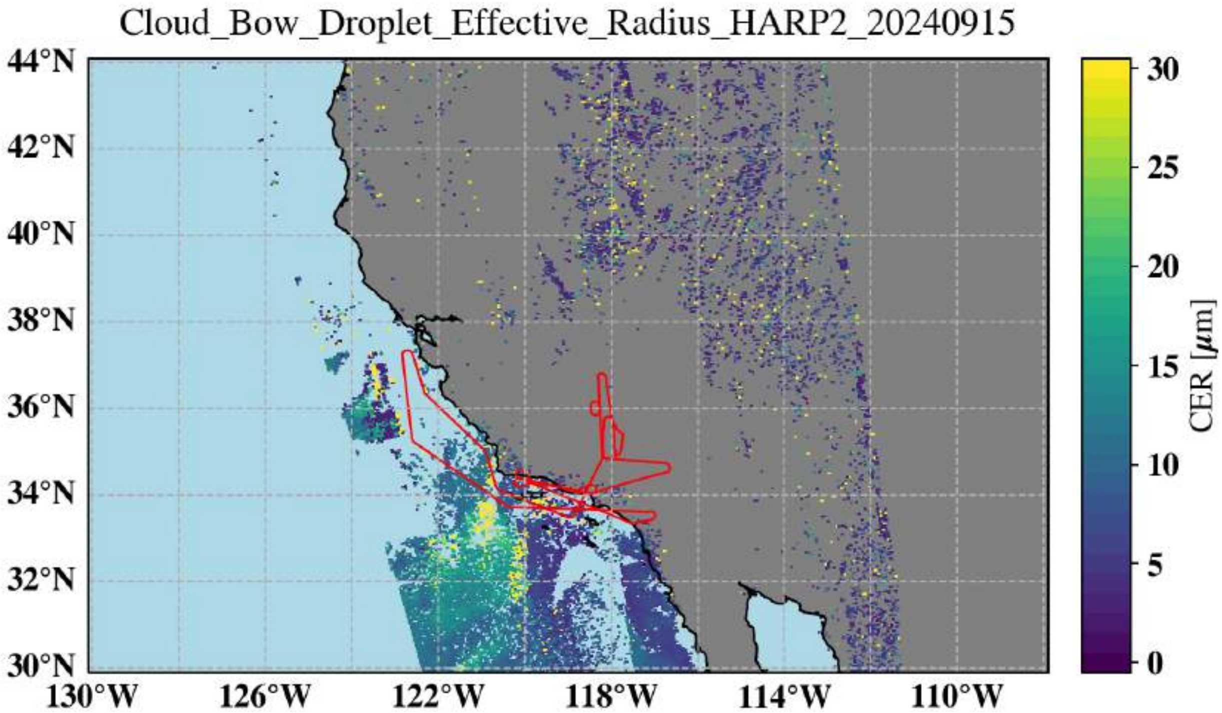
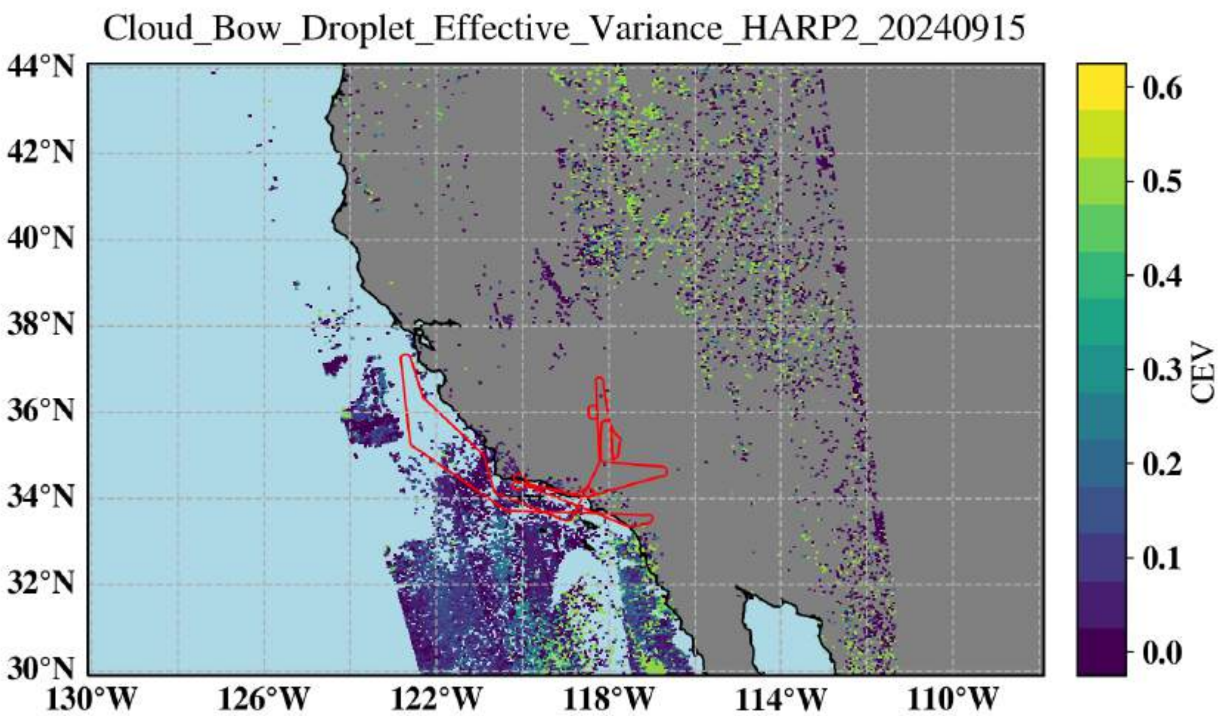
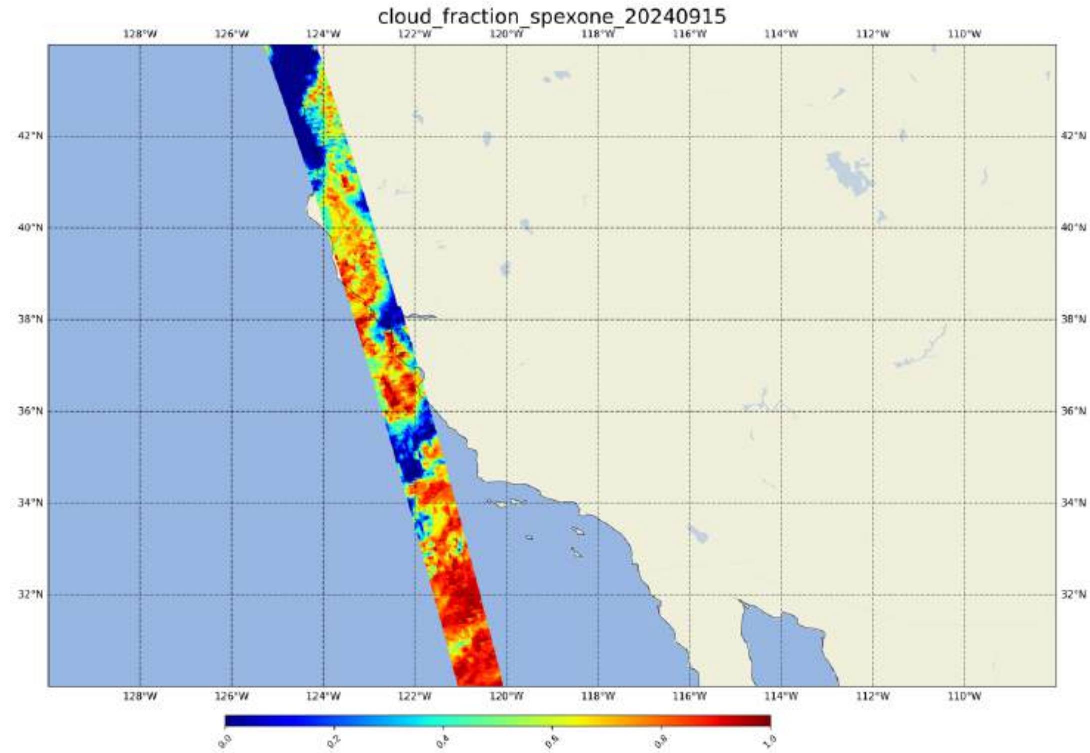
122°W
118°W
114°W
110°W
CER [μm]
30
25
20
15
10
5
0

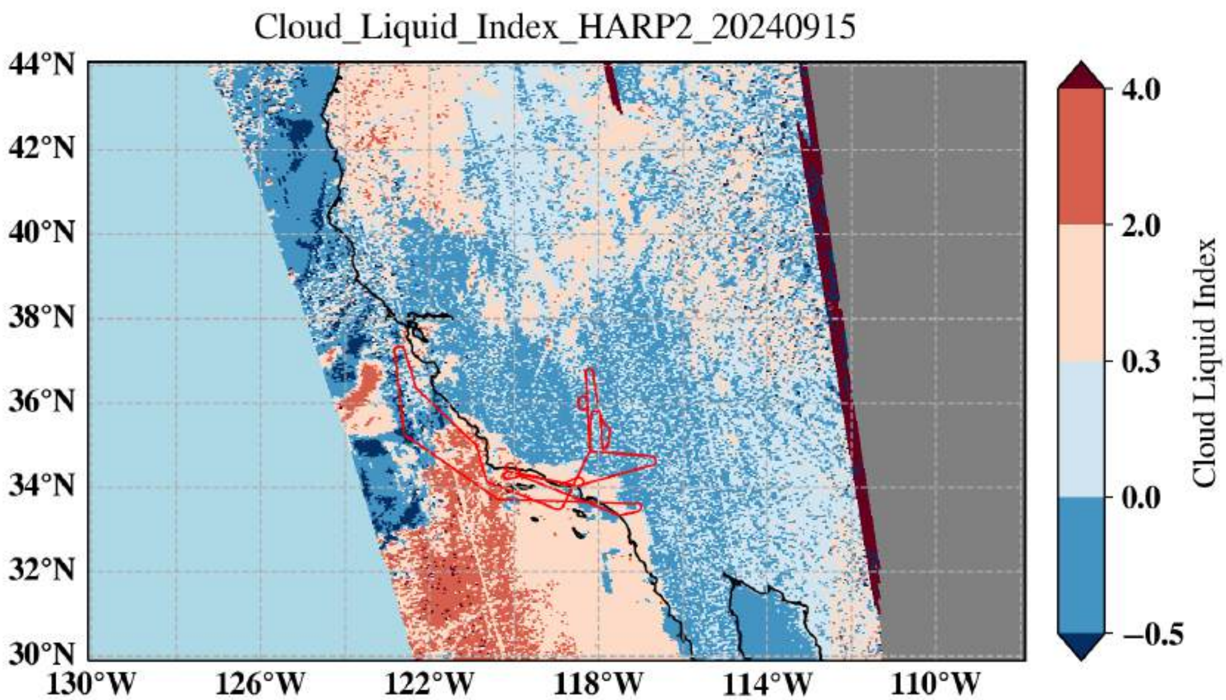


Cloud_Bow_Droplet_Effective_Radius_HARP2_20240915
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
30
25
20
15
10
5
0
CER [μm]



Cloud_Bow_Droplet_Effective_Variance_HARP2_20240915
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0.6
0.5
0.4
0.3
0.2
0.1
0.0
CEV


cloud_fraction_spexone_20240915
128°W
126°W
124°W
122°W
120°W
118°W
116°W
114°W
112°W
110°W
42°N
40°N
38°N
36°N
34°N
32°N
0.0
0.2
0.4
0.6
0.8
1.0


Cloud_Liquid_Index_HARP2_20240915
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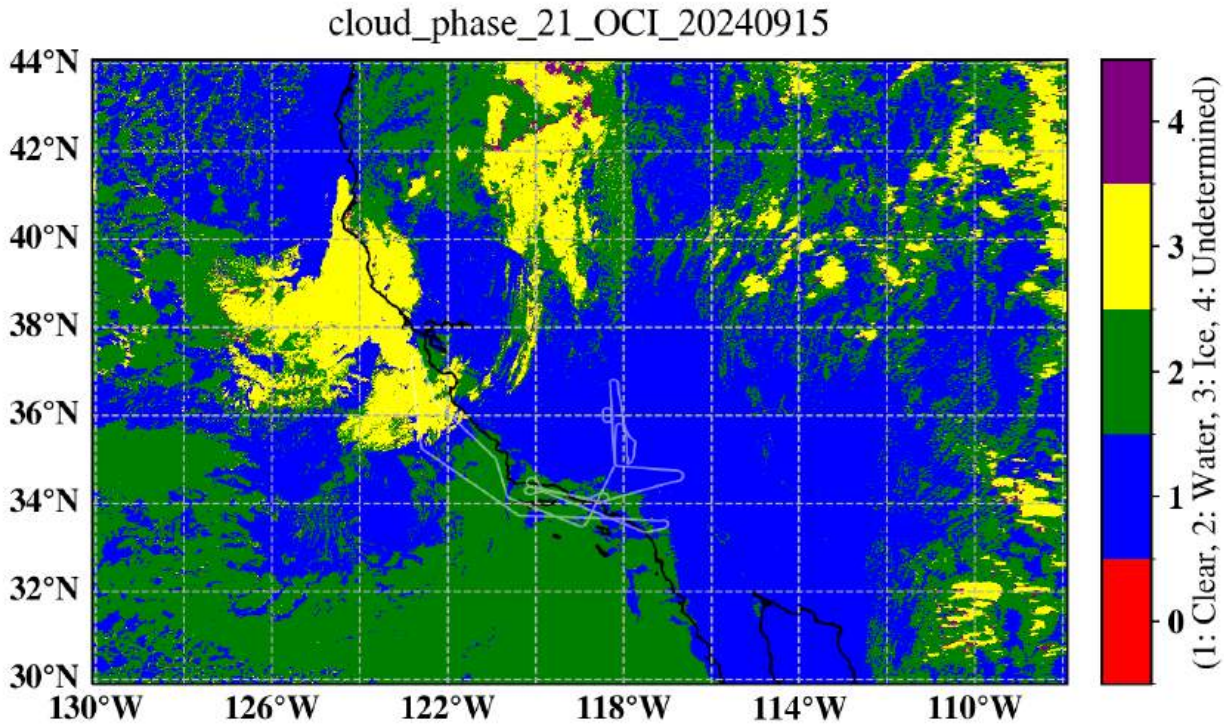
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
4.0
2.0
0.3
0.0
−0.5
Cloud Liquid Index


cloud_phase_21_OCI_20240915
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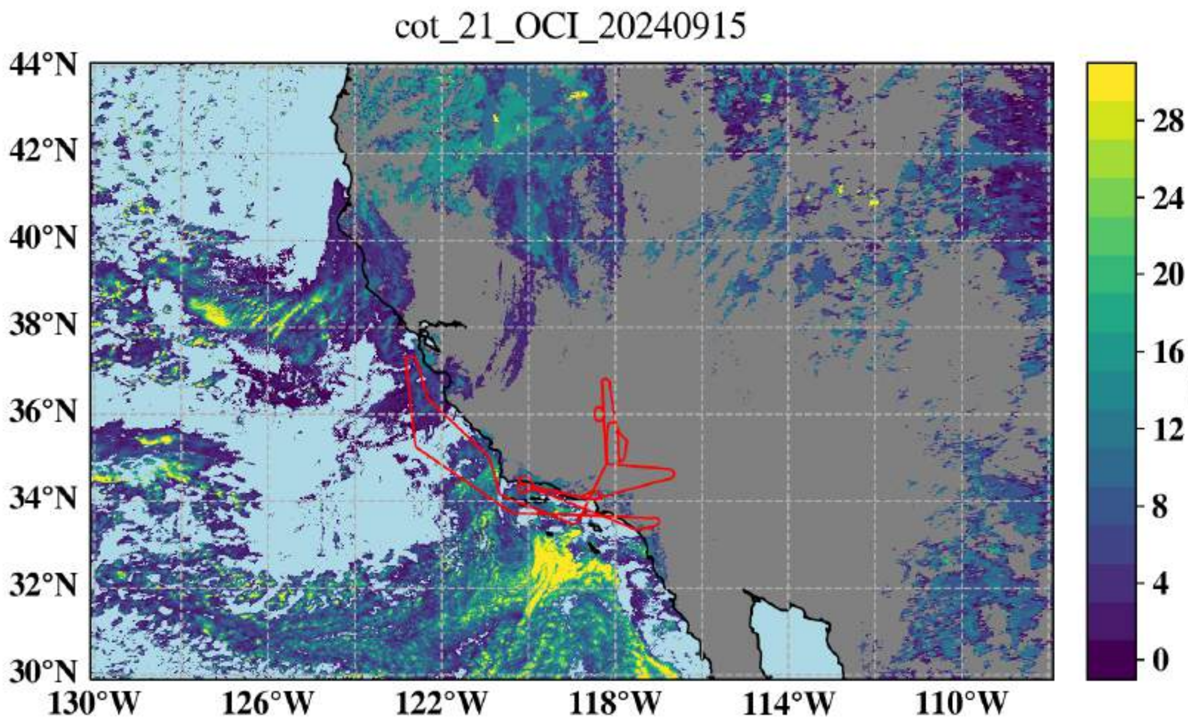
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0
1
2
3
4
(1: Clear, 2: Water, 3: Ice, 4: Undetermined)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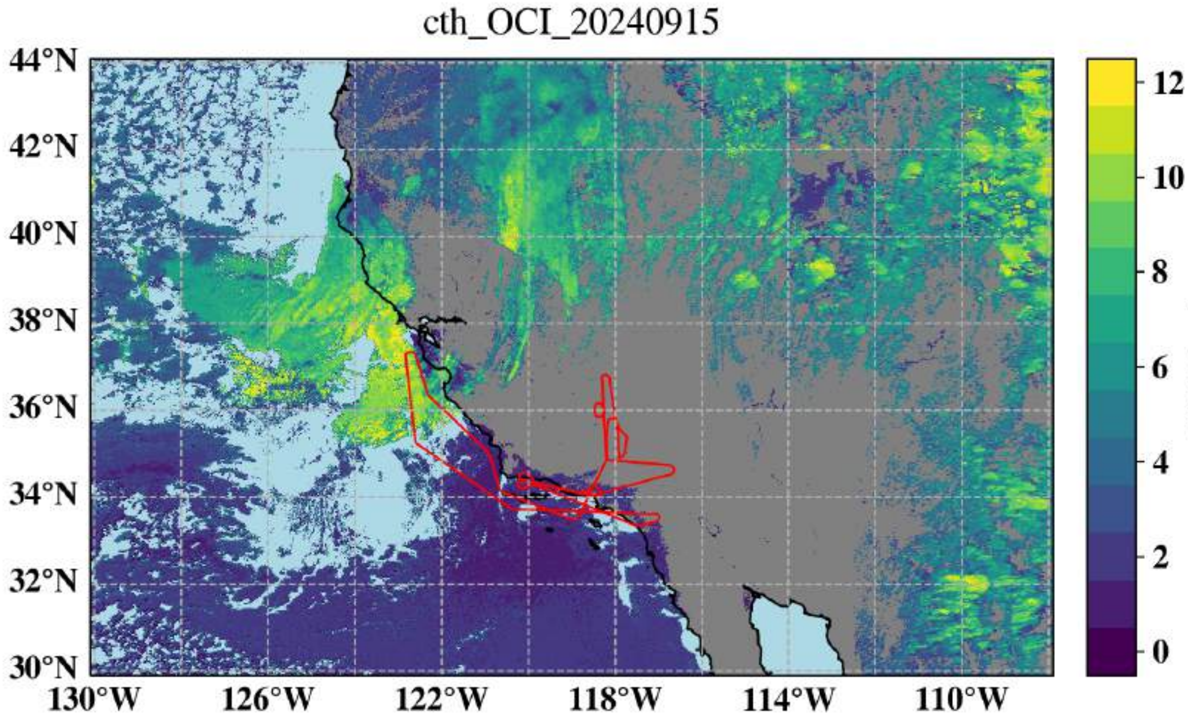
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0
4
8
12
16
20
24
28
COT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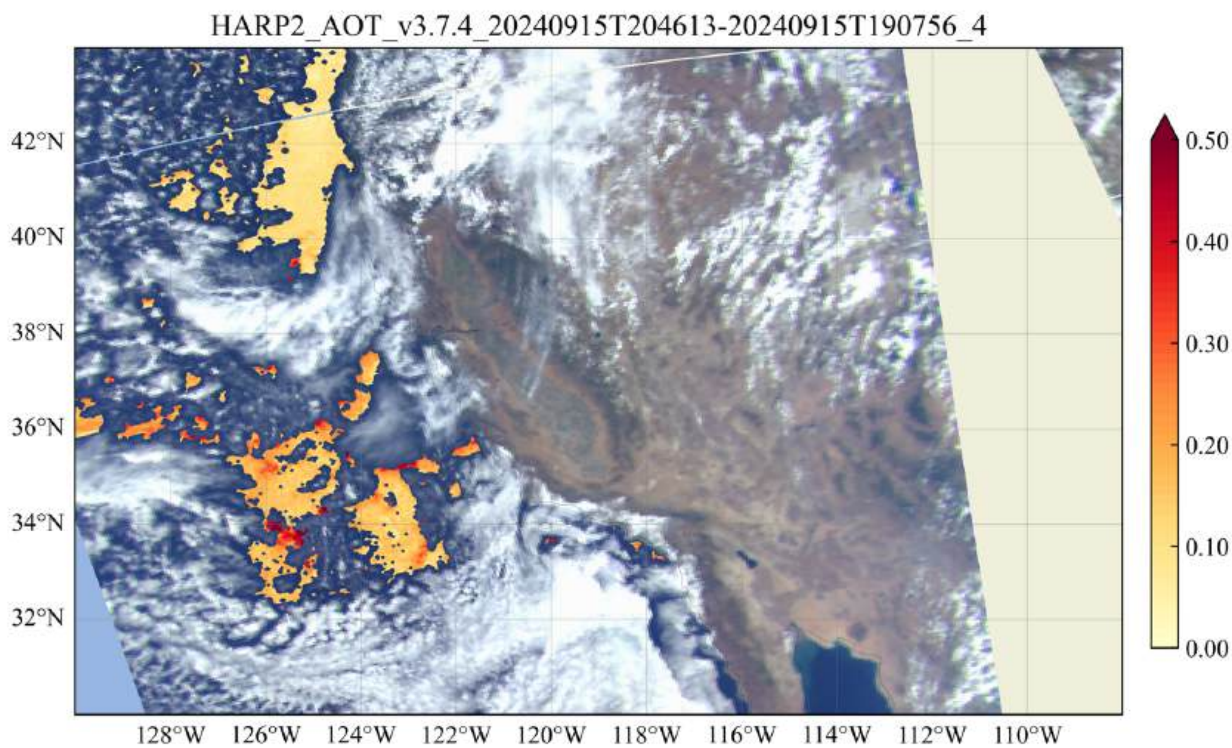
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
CTH [km]
0
2
4
6
8
10
12


HARP2_AOT_v3.7.4_20240915T204613-20240915T190756_4
42°N
40°N
38°N
36°N
34°N
32°N
128°W
126°W
124°W
122°W
120°W
118°W
116°W
114°W
112°W
110°W
0.50
0.40
0.30
0.20
0.10
0.00

R/V Shearwater report

PACE-PAX R/V Shearwater day report

Date: 09/15/2024

Creator: Michael Ondrusek

Cruise ID: RF0915-RS

Sailed out: 1035 PST

Back in port: 1725 PST

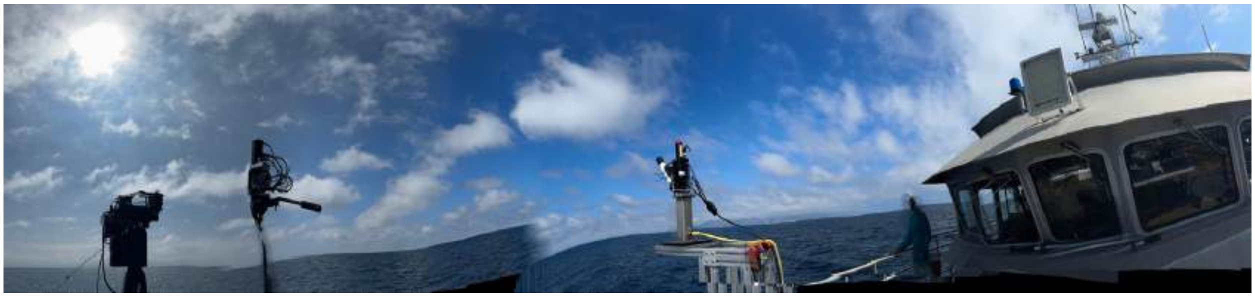
Today, the ship occupied two stations

Station #14 34° 00.891', -119° 10.441' arrival 20:00 UTC →departure 21:28 UTC.

Cloudy all morning. Did profiles first in and out of clouds. Then did polarimager then IOP's.

Arrival photo:

Departure photo (departure location - 34° 00.890', -119° 09.368')



Station #15 34° 09.595' -119° 16.653', arrival 22:11 UTC→ departure 23:07 UTC

Found hole on way back in that was clear during the 1415 VIIRS overpass. NRL Hyperpro quit on second set so continues with mpr 179 and C-Ops. Did IOPs and then polarimager.

Arrival photo:

Departure photo:

System Status:

Problems with 179 Hyuperpro.

Group Status: All’s well.

R/V Blissfully report

PACE-PAX R/V Blissfully day report

Date: 09/15/2024

Creator: Bridget Seegers

Cruise ID: RF0915-RB

Sailed out: 14:59 UTC

Back in port: 21:04 UTC

Today, the ship accomplished....

Collection of vertical radiometry profiles and discrete sample collection (HPLC + ap) on two stations in proximity of SeaPRISM site. The station had three sets of 5 HyperPro profiles to 20m and a single deep cast to ~35m, because of shallow bottom. Discrete water samples included triplicate HPLC + ap and duplicate community composition Lugol's preserved and paraformaldehyde samples for flow cytometry.

Stations:

33.651571°, -118.117143°, arrival at 18:53 UTC, delayed sampling (cruise station RB_12) until 19:57 with clear skies PACE window

a) ER-2 overflight 19:03 UTC – sampling delayed, cloudy (see below)


b) PACE overflight 20:44 UTC – sampling started at 19:57 utc

 clear skies for PACE

Station #2 (cruise station RB_13) 33.63638, -118.116617, arrival 21:28, departure 22:23 UTC

Tomorrow, RV Blissfully

Ship plans through the next 3 days...

Sampling in coordination with rest of the experiment

System Status...

All good

Group Status...

All great

PACE-PAX research flight report 2024/09/17

Compiled by Kirk Knobelspiesse, Ivona Cetinić, Michael Ondrusek, Bridget Seegers
2024/09/22
Reviewed by Samuel LeBlanc

Successful ER-2 and ship (R/V Shearwater, R/V Blissfully, glider) operations with a PACE-OHS and EarthCARE (orbit 1742) underpass. Additionally, the ER-2 overflew Ivanpah Playa with a team from JPL characterizing the surface conditions. Conditions were clear with low AOD so this component is considered a success.

ER-2
Takeoff: 17:05, Landing: 23:19, Duration: 6.2
Instrument status: good
Pilot: Dean Neeley, mobile pilot: Kirt Stallings

Twin Otter
No flight day

R/V Shearwater
Mission Scientist: Michael Ondrusek
Sailed out: 15:42 UTC
Back in port: 23:04 UTC
See end for full R/V Shearwater report

R/V Blissfully
Mission Scientist: Bridget Seegers
Sailed out: 16:08 UTC
Back in port: 00:26 UTC
See end for full R/V Blissfully report

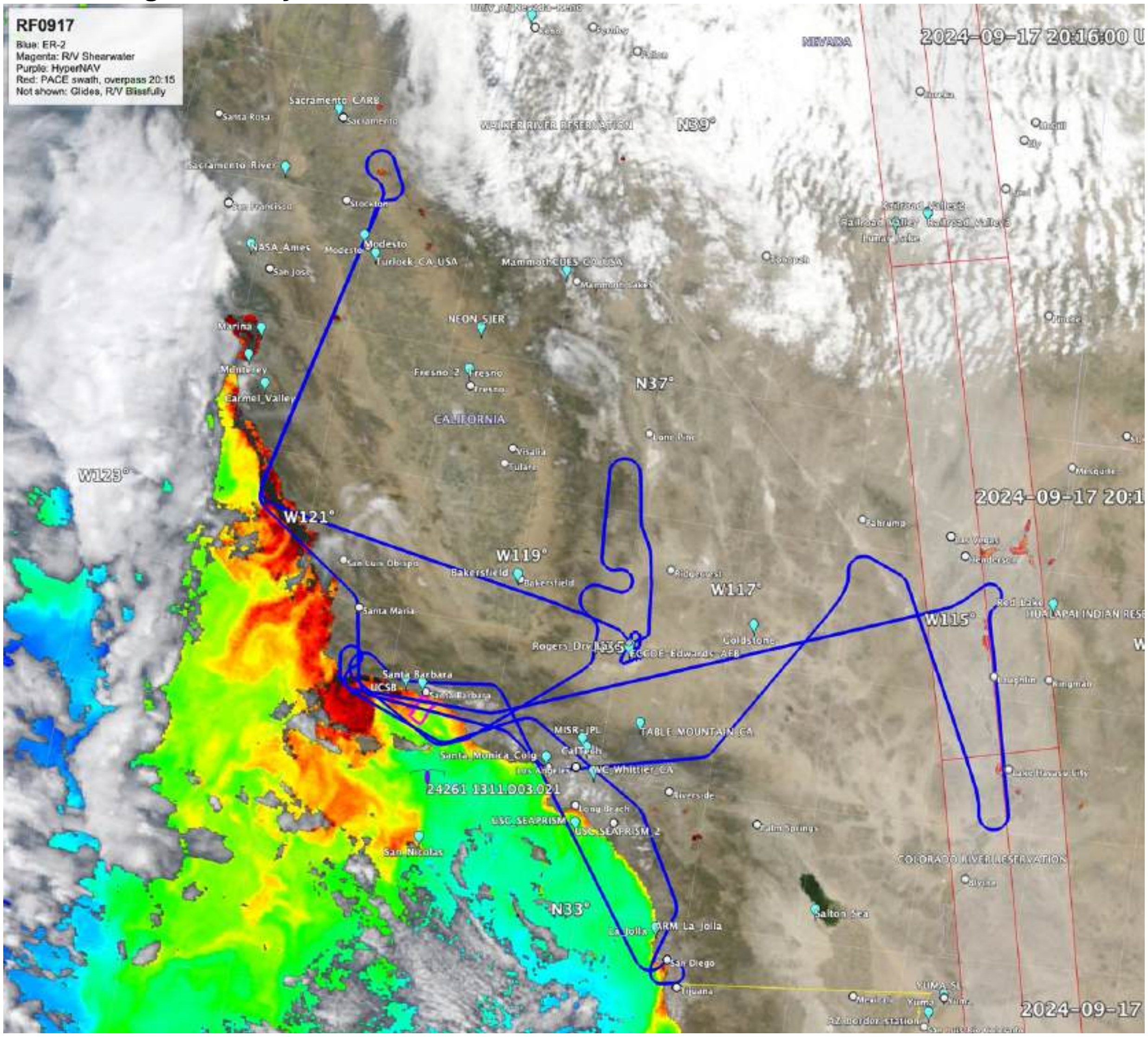
PACE
Overpass at 20:14 (Arizona)

EarthCARE
Overpass at 22:27 (Central California), orbit 1742

Gliders
Operational

HyperNAV
Operational

Overall image summary



Note: not shown is the EarthCARE track, which followed the NW most line of the ER-2 and had its overpass at 22:27

Validation Traceability Matrix itemized objectives

VTM elements in **black** satisfied, **blue** partially satisfied, red to be confirmed

Time UTC	Platform	VTM(hrs)	
15:42	RS		Shearwater departspowe
16:08	RB		Blissfully departs
16:35	RS		Shearwater on station #16 in clear skies, remains until 18:15.
17:05	ER2		Takeoff
18:02	ER2, RS	1b(1.0), 1c(1.0), 6i(1.0)	ER-2 overpass of RS at station #16. Biologically productive waters

18:03	ER2, Glider	1b(1.0), 1c(1.0*0.5), 6i(1.0*0.5)	ER-2 over glider in biologically productive waters and clear skies. Outside of PACE overpass +/-2hours by a few minutes.
18:26	RB	1b(1.0), 1c(1.0*0.5)	Blissfully on station RB_14, ER-2 overhead in clear skies. Nearby USC_SeaPRISM inoperable
18:44	ER2	1d(0.5),1c(0.5*0.5)	ER-2 over La_Jolla (coastal site) AERONET site. moderate AOD(500)=0.14
18:59	ER2	1d(0.5)	ER-2 over CalTech AERONET site. moderate AOD(500)=0.12
18:39	RS		Shearwater on station 17 in clear skies, remains until 20:00
19:12	ER2, RS	1b(1.0), 1c(1.0), 6i(1.0)	ER-2 over Shearwater in clear skies and biologically productive waters
19:19	ER2, glider	1b(1.0), 1c(1.0*0.5), 6i(1.0*0.5)	ER-2 over glider in biologically productive waters and clear skies
19:58	RB	1b(1.0), 1c(1.0*0.5)	Blissfully on station RB_15, PACE overhead in clear skies. Nearby USC_SeaPRISM inoperable
20:02	ER2, Ivanpah	1a(2.0), 1d(0.5), 4a(2.0)	ER-2 overflies Ivanpah Playa with JPL surface team present for characterization. Clear skies, low AOD
20:14	**PACE**		**PACE overpass**
20:15	ER2	1d(1.0), 3b(2.0)	ER-2 in PACE-OHS swath in Western Arizona. Low AOD
20:18	RS	1b(1.0)	Shearwater on station 18 in clear skies, remains until 20:39. PACE overpass
20:40	ER2, Ivanpah	1a(2.0), 1d(0.5), 4a(2.0)	ER-2 2nd overflies Ivanpah Playa with JPL surface team present for characterization. Clear skies, low AOD, roughly 90° from last overpass.
20:51	RS		Shearwater on station 19 in clear skies, remains until 22:21
21:08	RB		Blissfully on station RB_16 in clear skies
21:22	ER2, RS	1b(1.0), 1c(1.0), 6i(1.0)	ER-2 over Shearwater in clear skies and biologically productive waters
21:58	ER2	1d(0.5)	ER-2 over Turlock AERONET site. moderate AOD(500)=0.15 (again at 22:15)
22:27	**EarthCARE**		**EarthCARE overpass**
22:27	ER2,EC	3d(3.0), 3e(1.0), 6d(1.0*0.5)	Very long out and back along EarthCARE line. Moderate AOD, some thin cirrus reported by HSRL with aerosol under cloud.
22:50	ER2		ER-2 over Bakersfield AERONET site. No AOD reported
23:04	RS		Return
23:19	ER2		ER-2 lands
00:26	RB		Return

PACE-O: within swath of PACE's OCI instrument
PACE-OH: within swath of PACE's OCI and HARP2 instruments
PACE-OHS: within swath of PACE's OCI, SPEXone and HARP2 instruments
RB: R/V Blissfully
RS: R/V Shearwater
ER2: NASA ER-2

Assessment:

- 11.9% of objectives observed. Largely successful new observations of aerosol+ocean conditions in biologically active areas, both PACE and EarthCARE underpass, overfight of Ivanpah Playa with JPL team.
- Top remaining objectives (score above 6.0): PACE aerosol in narrow swath (3a,b)

PACE-PAX progress tracking

Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 9/16	Fractional success 9/17	Fractional success 9/18	Fractional success 9/19	Fractional success 9/20	Fractional success 9/21	Fractional success 9/22	Total success	Remaining score
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	4.0	0.0%	39.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.938	0.5
	b	Ocean radiometric parameters	10	8.0	8.0	0.0%	2.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.985	0.2
	c	Aerosol parameters over the ocean	12	8.0	5.0	0.0%	4.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.952	0.6
	d	Aerosol parameters over land	12	8.0	3.0	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.998	0.0
	e	Cloud parameters	12	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.695	3.7
	f	Ocean surface parameters	1	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.000	1.0
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.354	6.5
	b	Aerosol parameters over land (PACE)	10	8.0	2.0	0.0%	17.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.403	6.0
	c	Cloud parameters (PACE)	5	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.713	1.4
	d	Aerosol parameters (EarthCARE)	8	4.0	3.0	0.0%	52.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.992	0.1
	e	Cloud parameters (EarthCARE)	8	4.0	1.0	0.0%	19.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.313	5.5
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	2.0	4.0	0.0%	49.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.923	0.5
	b	Validate large reflectances with high polarization	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.393	3.6
	c	Validate large reflectances with low polarization	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.777	1.3
	d	Overfly vicarious calibration sites	6	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.268	4.4
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.000	0.0
	b	High aerosol loads over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.393	2.4
	c	Multiple aerosol layers	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.000	0.0
	d	Aerosol under thin cirrus	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.000	2.0
	e	Aerosol above liquid phase cloud	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.826	0.7
	f	Broken clouds with complex structure	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.528	1.9
	g	Dust aerosols over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.430	2.3
	h	Aerosol and ocean parameters over turbid waters	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.790	0.4
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	4.0	0.0%	86.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.865	0.5
	k	Smoke aerosols over ocean	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.713	0.3
		total:	150	98	34.0	0.0%	11.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.695	
														total
				ER-2 flight hours	15.8	0	0	0	0	0	0	0	0	15.8
				TO flight hours	11.2	0	0	0	0	0	0	0	0	11.2
				Shearwater days	4	0	0	0	0	0	0	0	0	4

PACE-PAX overall objectives satisfied: 0.695

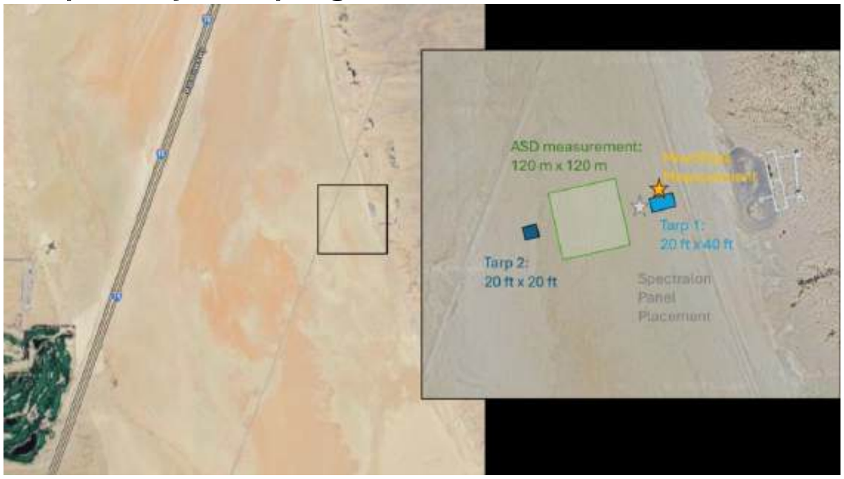
Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

https://www-air.larc.nasa.gov/missions/pacepax/index.html

ER-2 MVIS quicklooks

18:02 R/V Shearwater station 16 + glider 	20:02 1st overpass of Ivanpah Playa 
20:40 2nd overpass of Ivanpah Playa 	22:27 EarthCARE overpass 

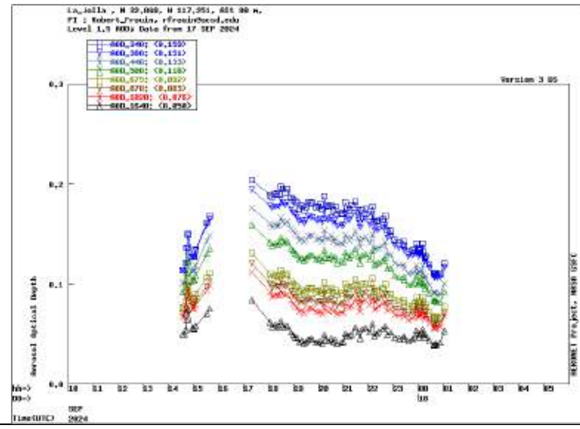
Ivanpah Playa sampling



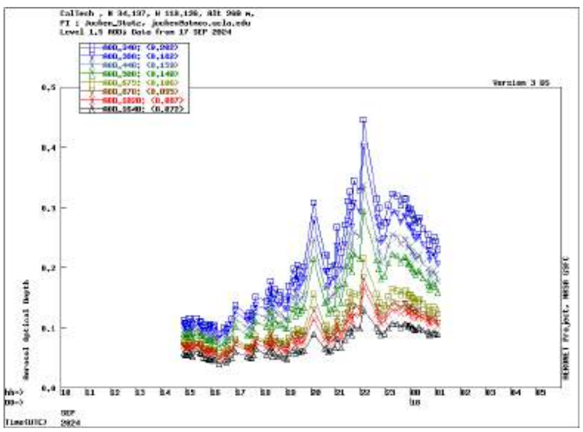
AERONET quicklooks

USC_SeaPRISM site inoperable

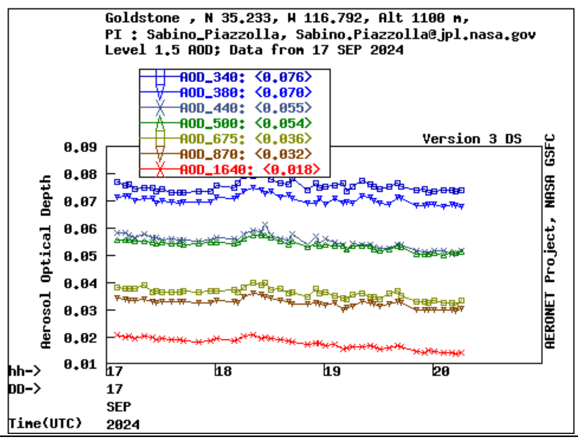
La_Jolla



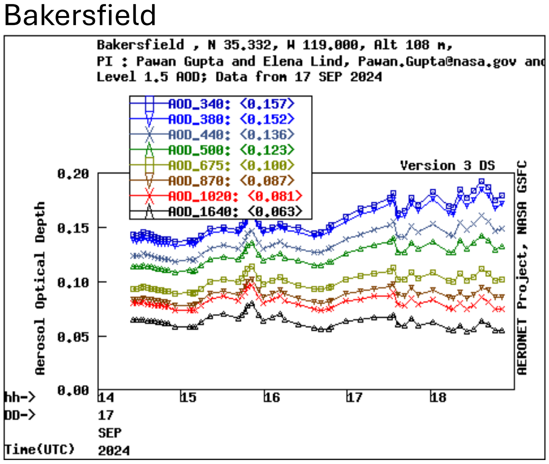
CalTech



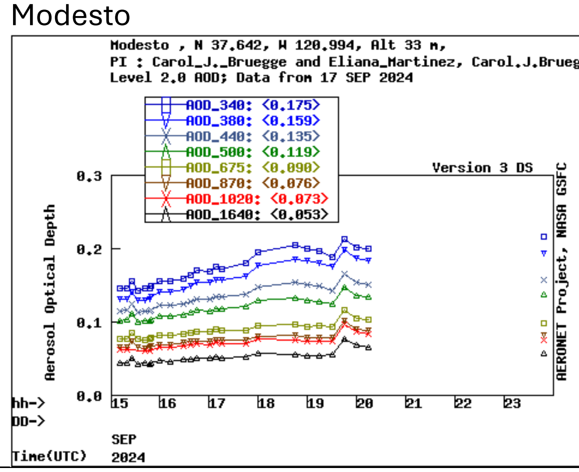
Goldstone



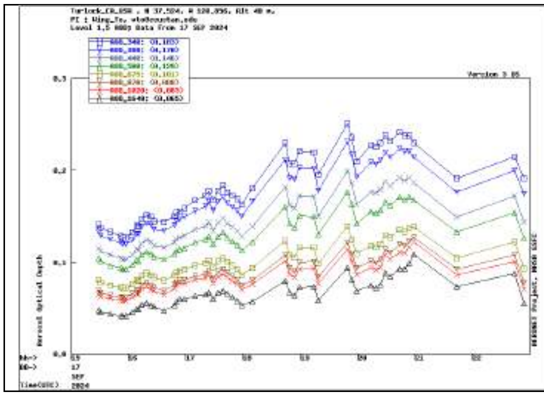
Bakersfield



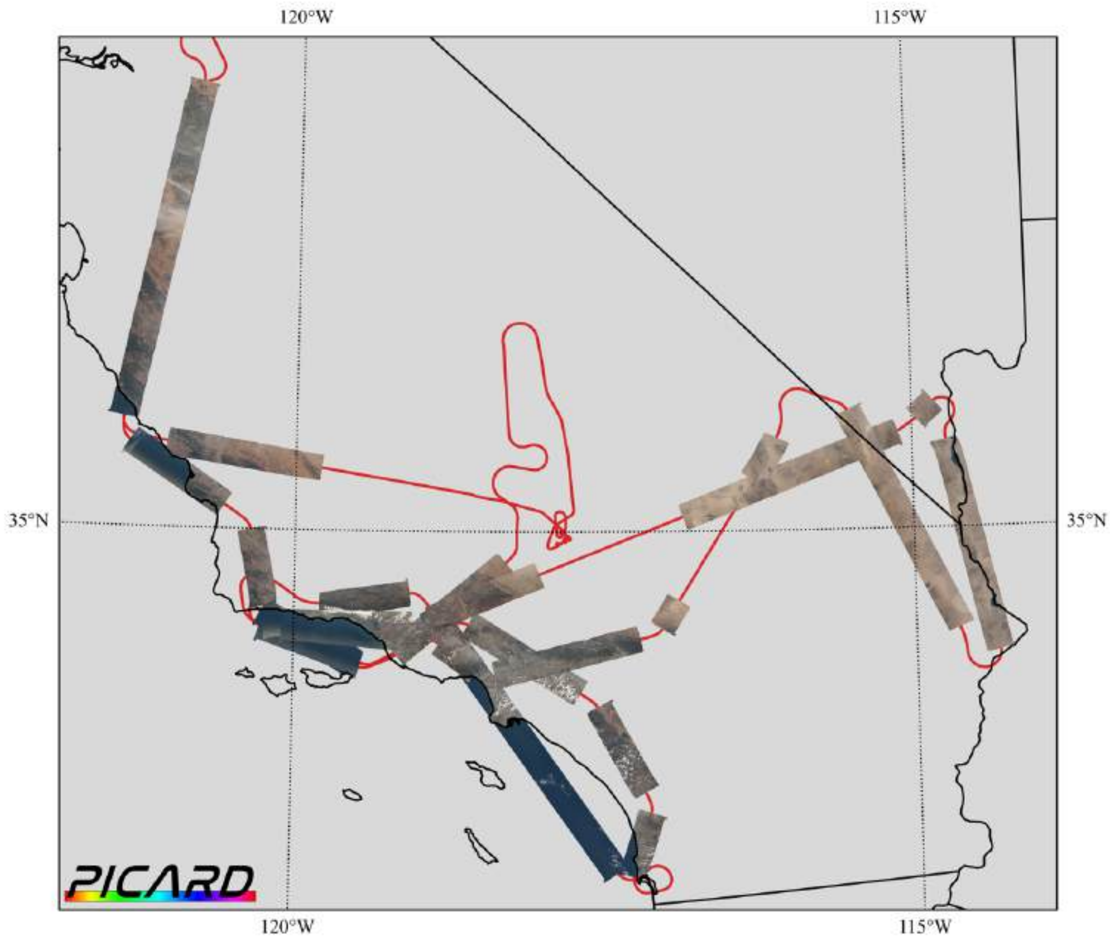
Modesto



Turlock

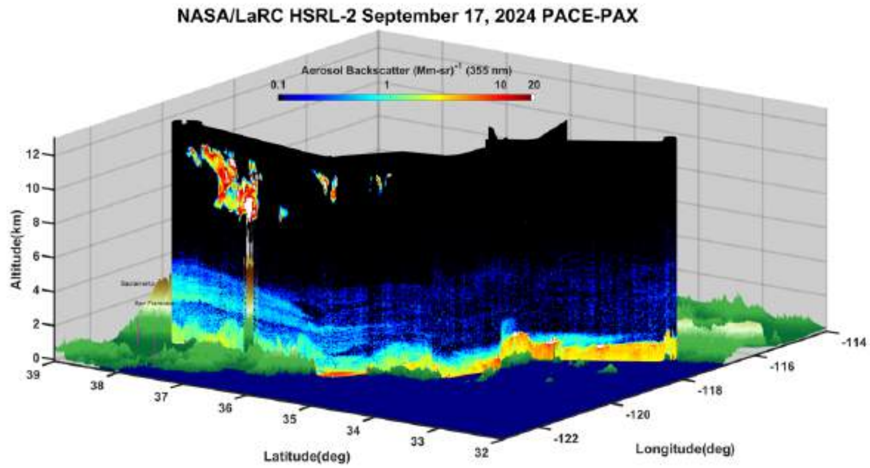

Level 1.5 AOD Data from 17 SEP 2024
Version 3
0.3
0.2
0.1
0.0
Aerosol Optical Depth
17
SEP
2024
Time(UTC)

ER-2/PICARD, PACE swath



Pushbroom Imager for Cloud and Aerosol Research and Development
PACE-PAX, NASA Armstrong Flight Research Center
17 September 24

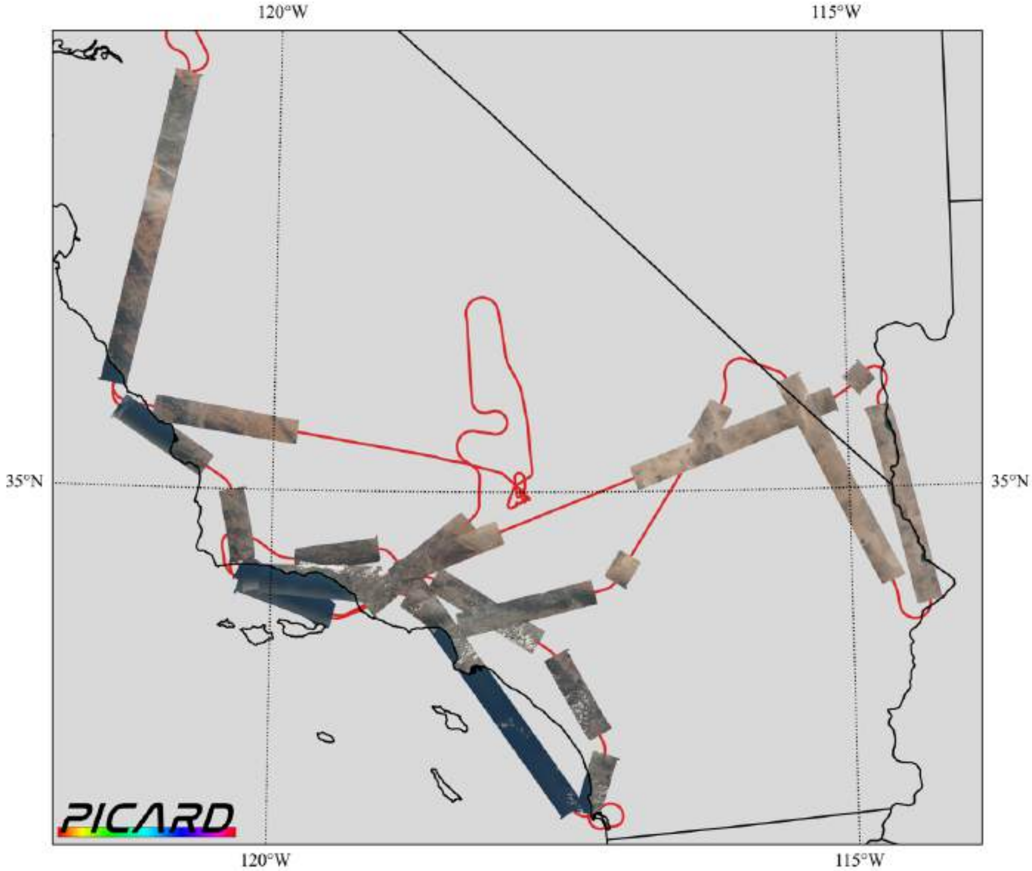
ER-2/HSRL


NASA/LaRC HSRL-2 September 17, 2024 PACE-PAX
Aerosol Backscatter (Mm-sr)$^{-1}$ (355 nm)
0.1
1
10
20
Altitude(km)
Latitude(deg)
Longitude(deg)


NASA/LaRC HSRL-2 Sept. 17 2024 17:30:00-23:00:00 UT
Latitude
Longitude
AOT (355 nm) *
100 km
50 mi
38°N
36°N
34°N
32°N
124°W
122°W
120°W
118°W
116°W
114°W
112°W
0.25
0.2
0.15
0.1
0.05
0

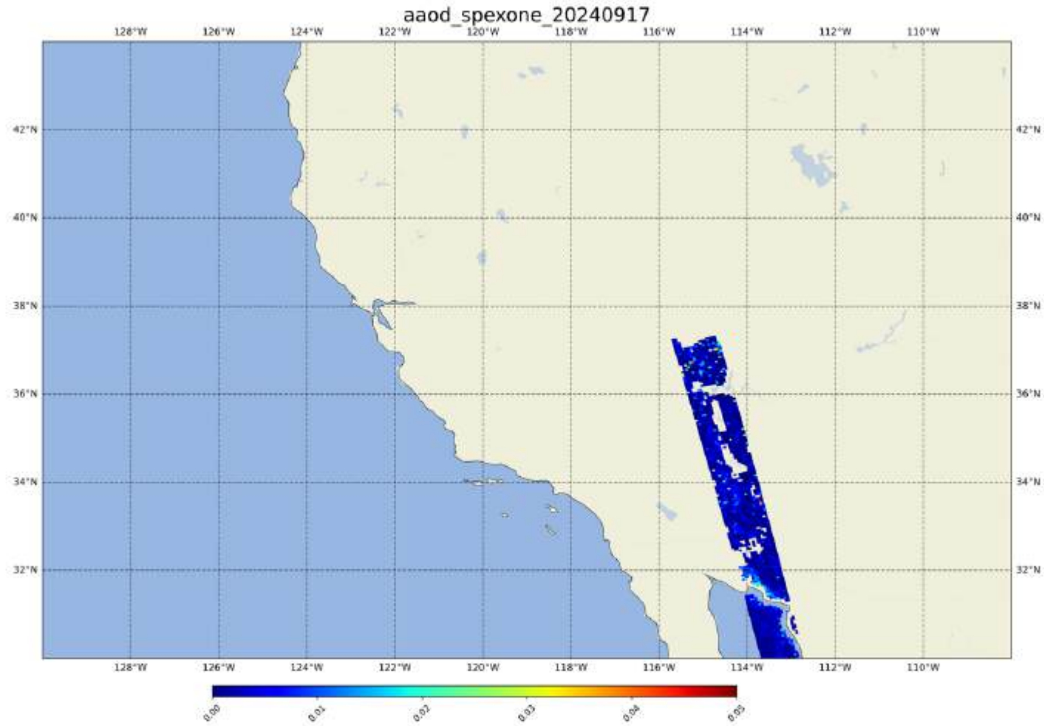

NASA/LaRC HSRL-2 Sept. 17 2024 17:30:00-23:00:00 UT
Latitude
Longitude
AOT (532 nm) *
100 km
50 mi
38°N
36°N
34°N
32°N
124°W
122°W
120°W
118°W
116°W
114°W
112°W
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0

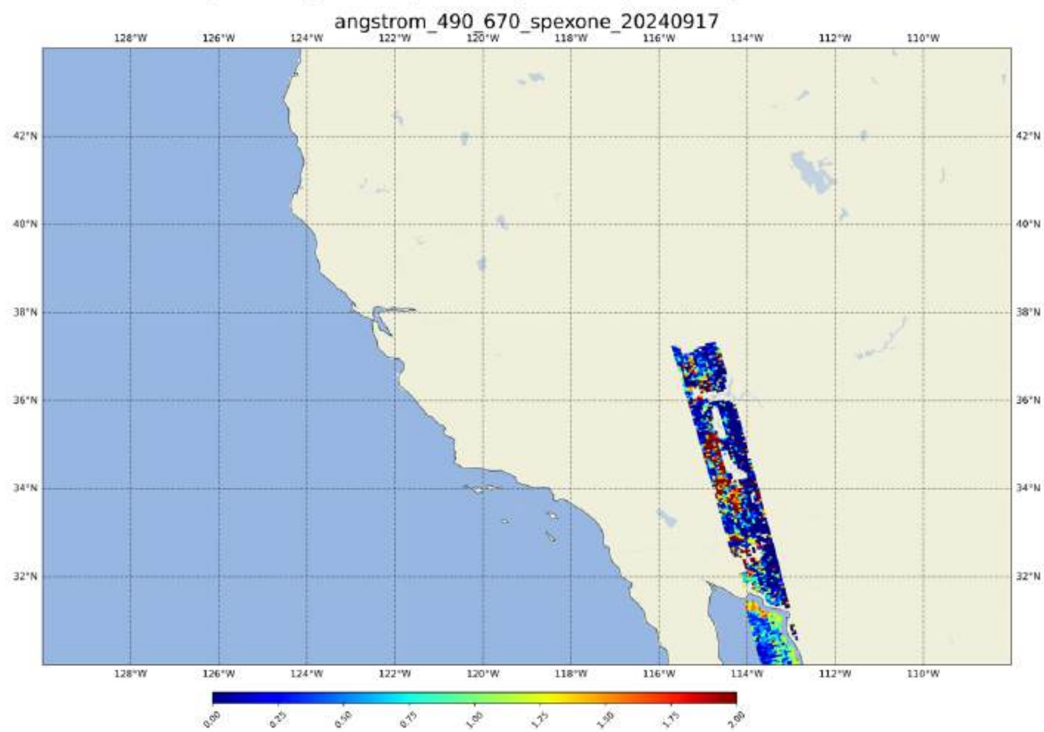
PICARD

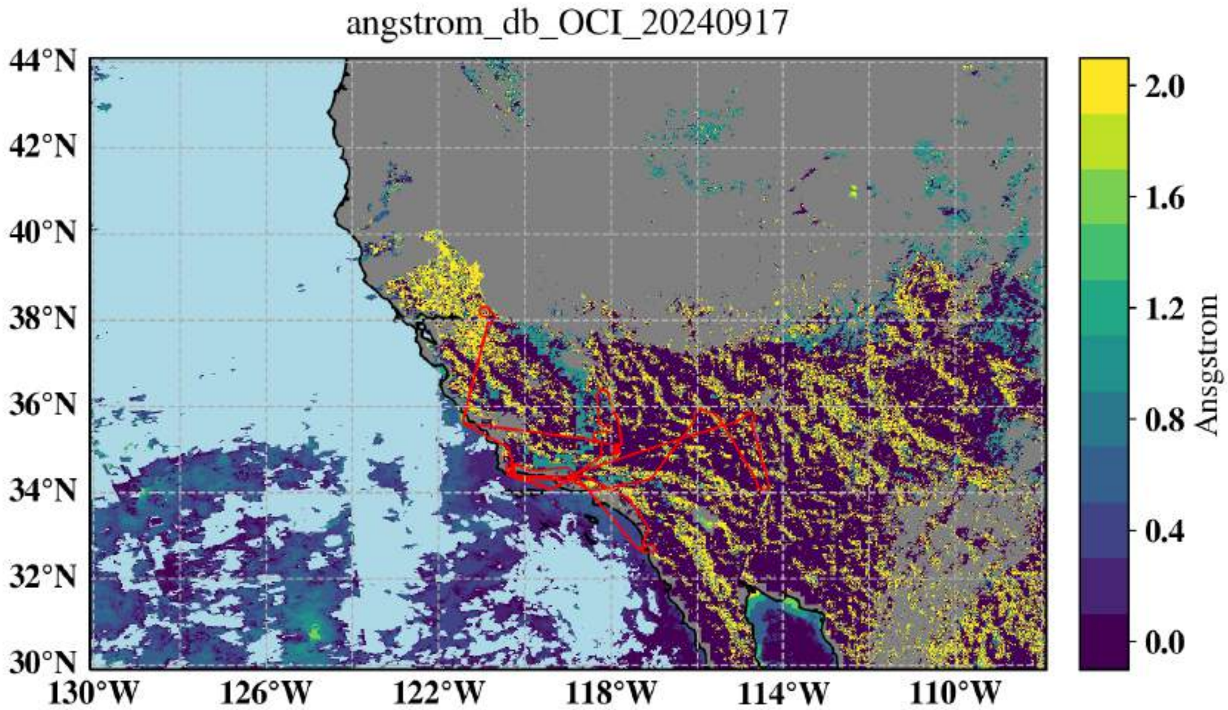


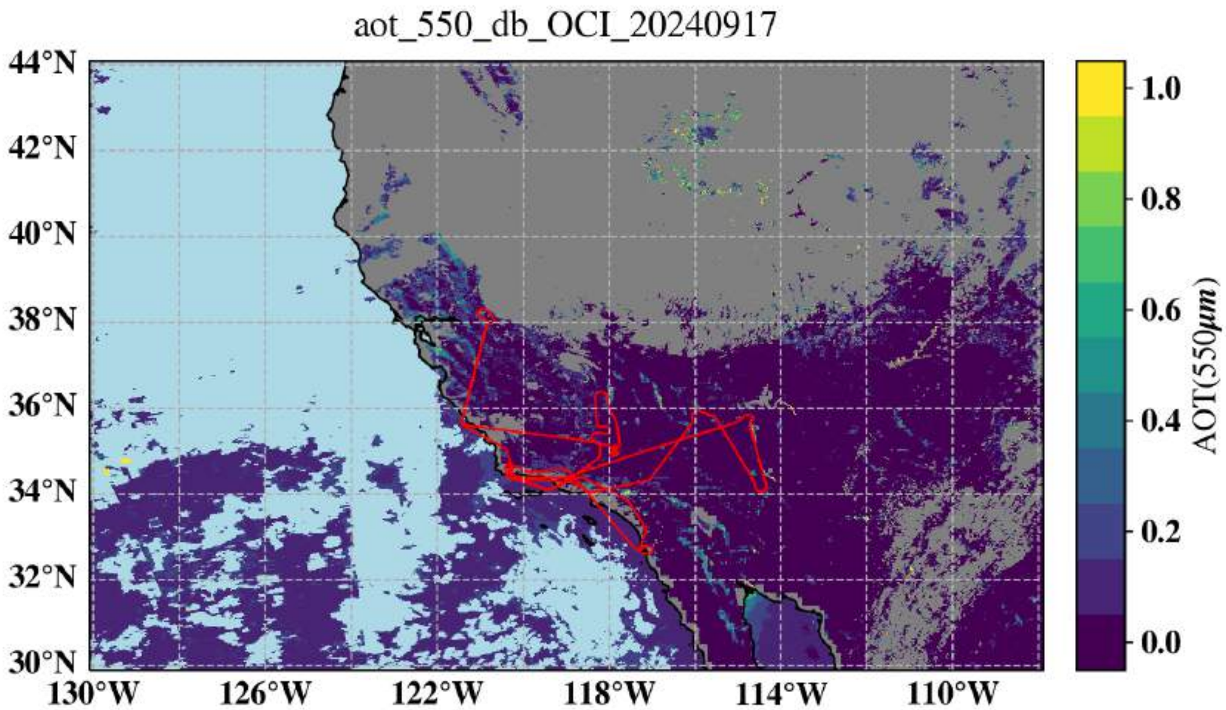
Pushbroom Imager for Cloud and Aerosol Research and Development
PACE-PAX, NASA Armstrong Flight Research Center
17 September 24

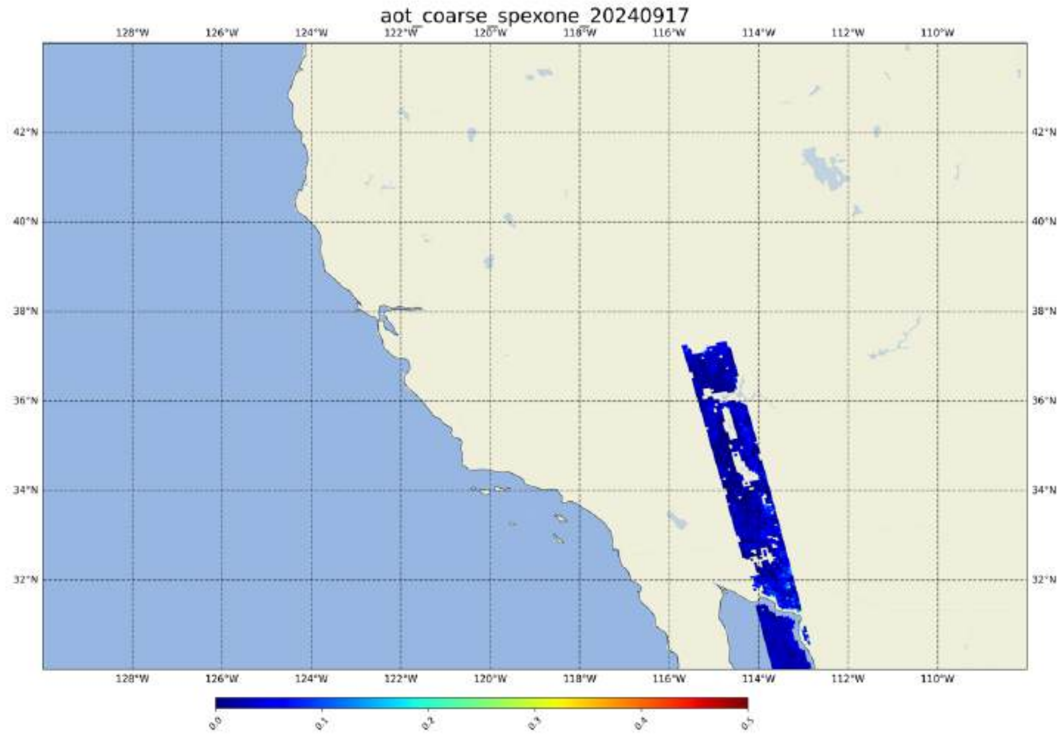
PACE Satellite products






angstrom_db_OCI_20240917
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
2.0
1.6
1.2
0.8
0.4
0.0
Angstrom


aot_550_db_OCI_20240917
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
1.0
0.8
0.6
0.4
0.2
0.0
AOT(550μm)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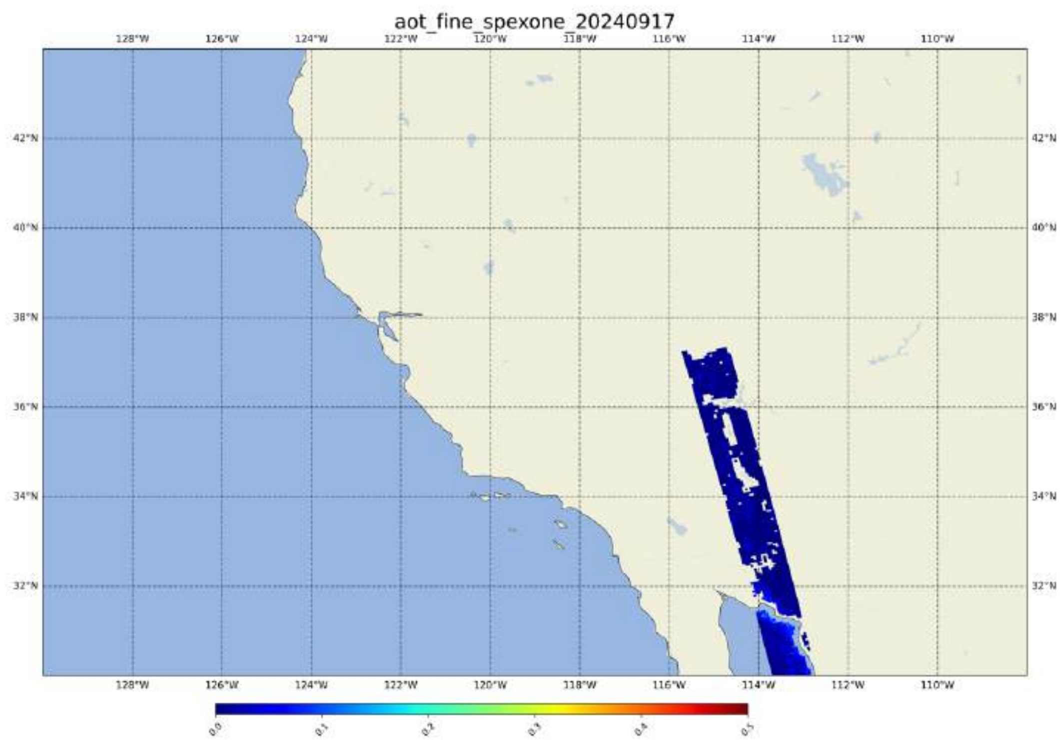
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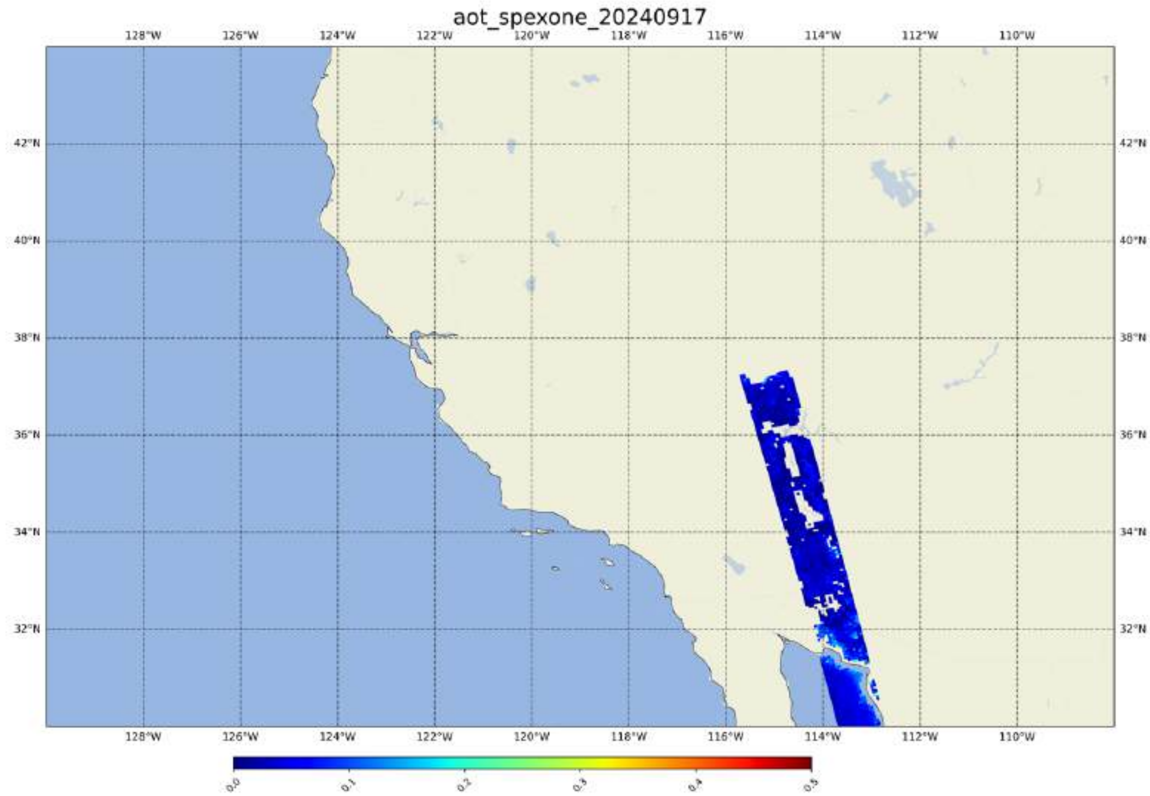
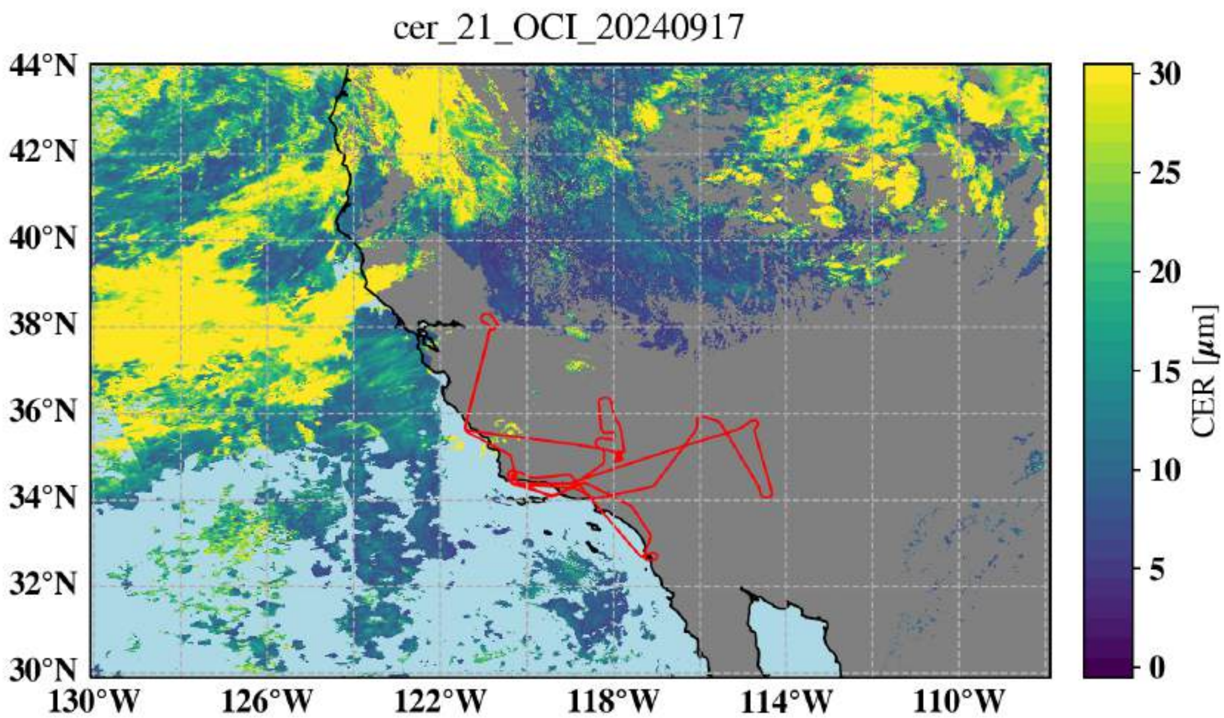

aot_spexone_20240917
128°W
126°W
124°W
122°W
120°W
118°W
116°W
114°W
112°W
110°W
42°N
40°N
38°N
36°N
34°N
32°N
0.0
0.1
0.2
0.3
0.4
0.5


cer_21_OCI_20240917
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42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
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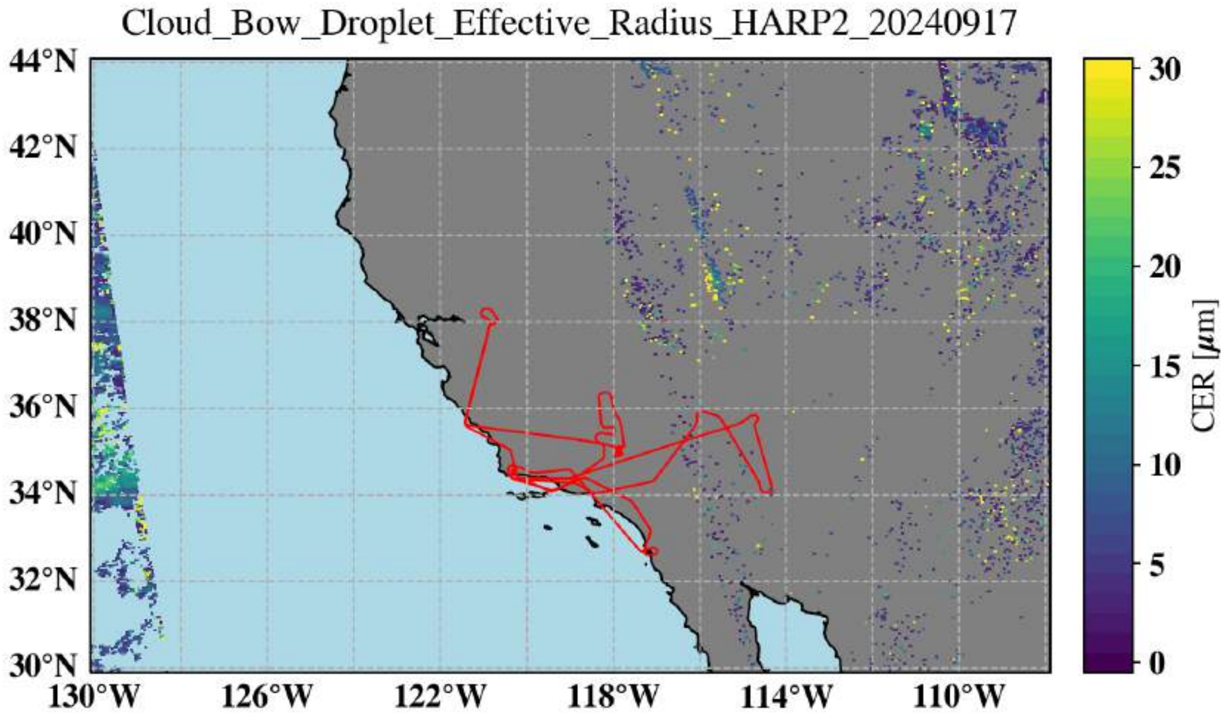
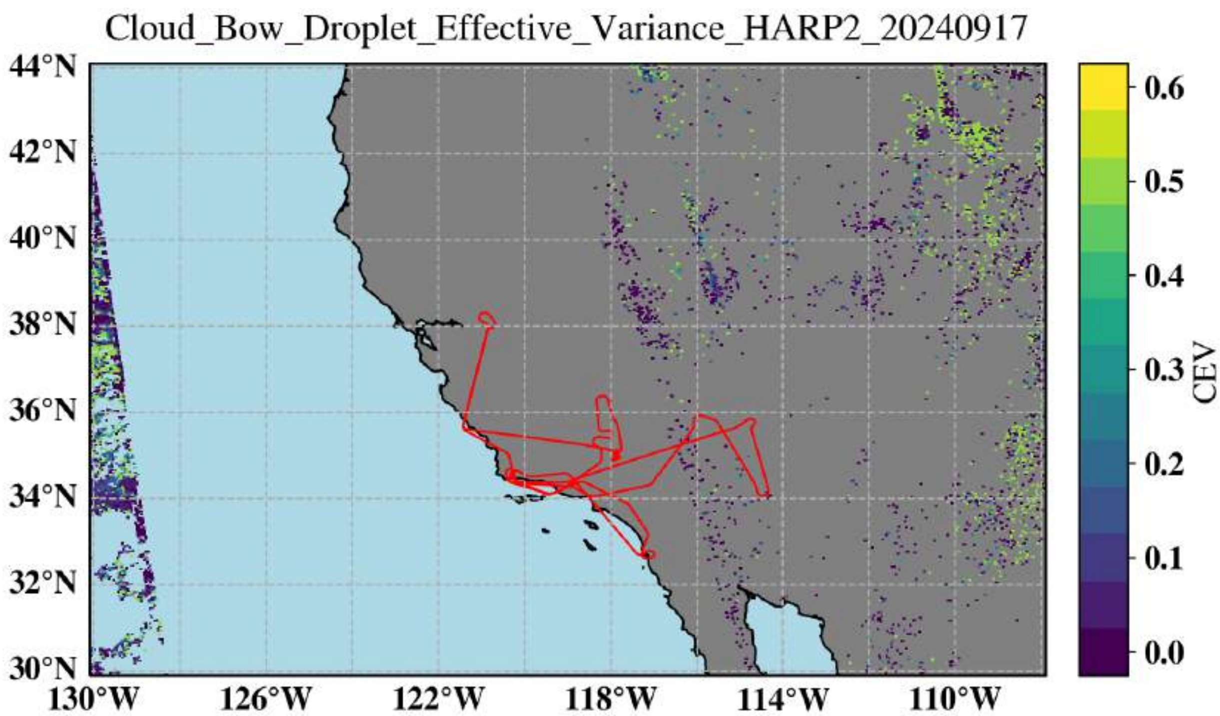
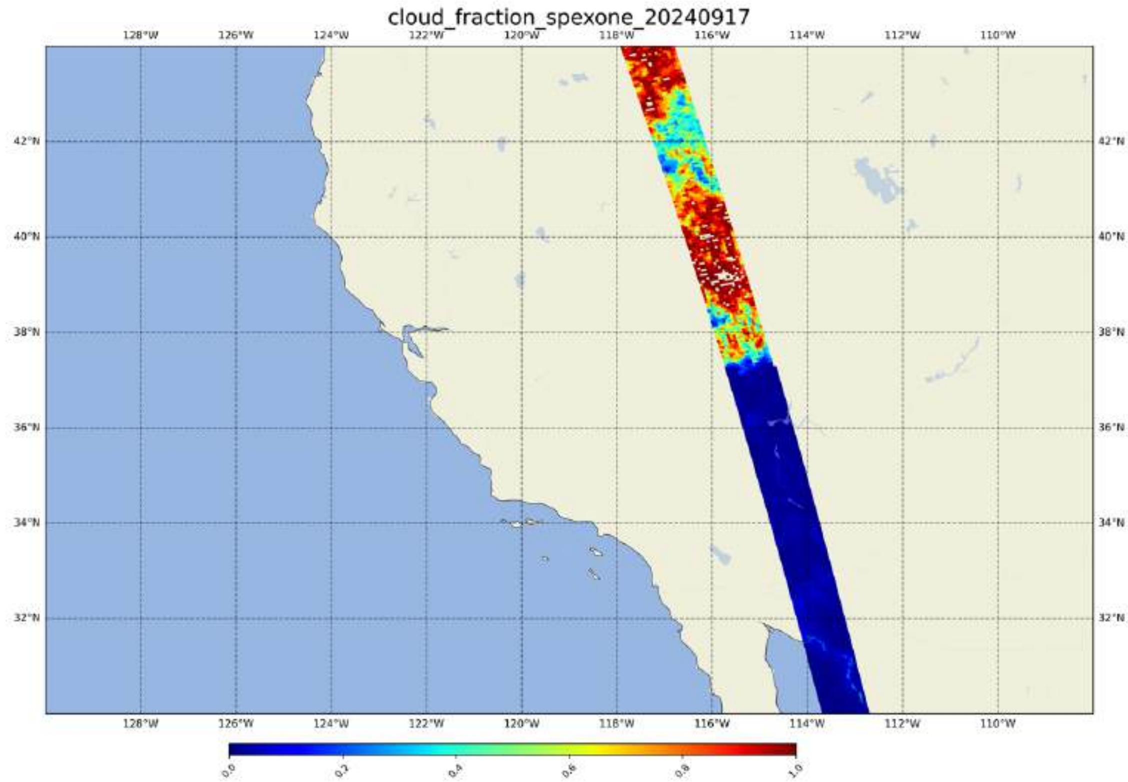
122°W
118°W
114°W
110°W
CER [μm]
30
25
20
15
10
5
0


Cloud_Bow_Droplet_Effective_Radius_HARP2_20240917
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
30
25
20
15
10
5
0
CER [μm]


Cloud_Bow_Droplet_Effective_Variance_HARP2_20240917
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0.6
0.5
0.4
0.3
0.2
0.1
0.0
CEV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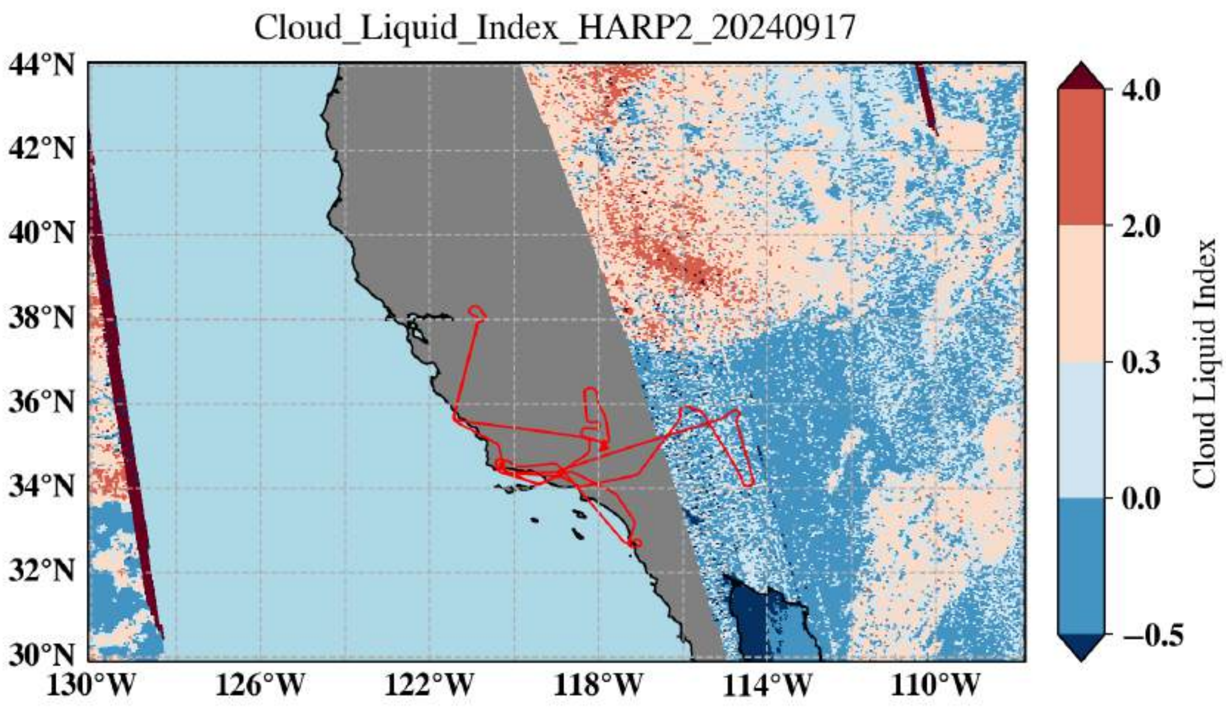
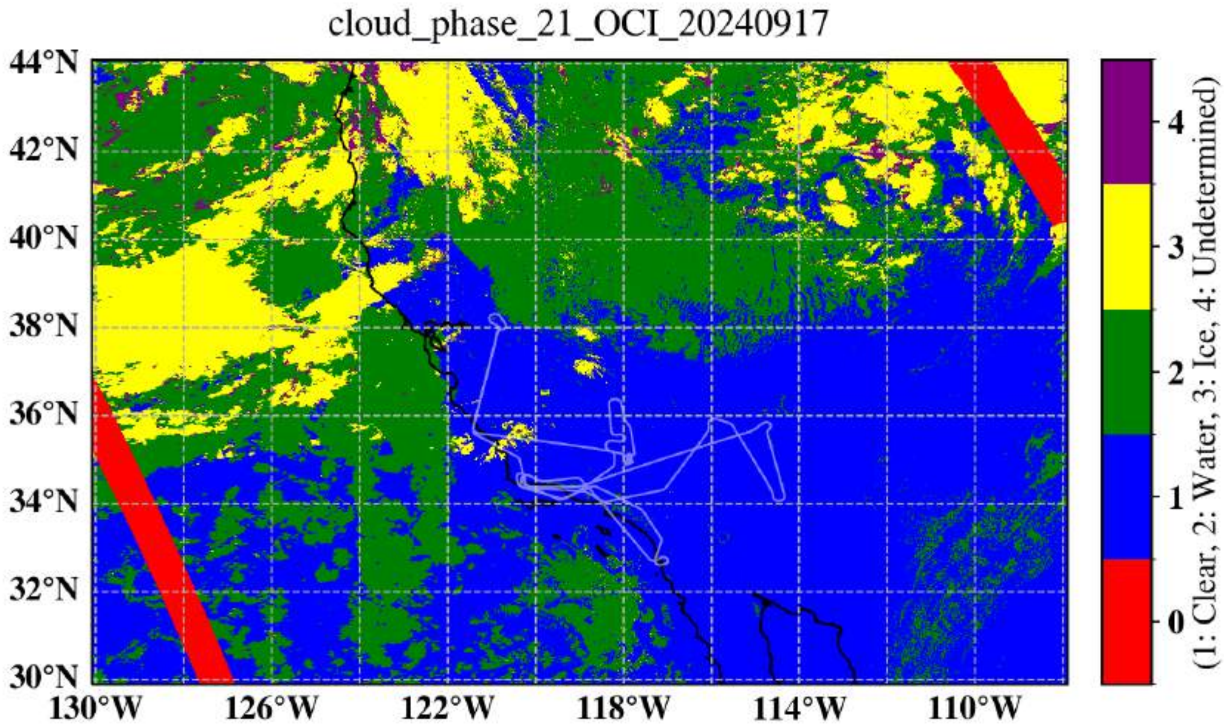
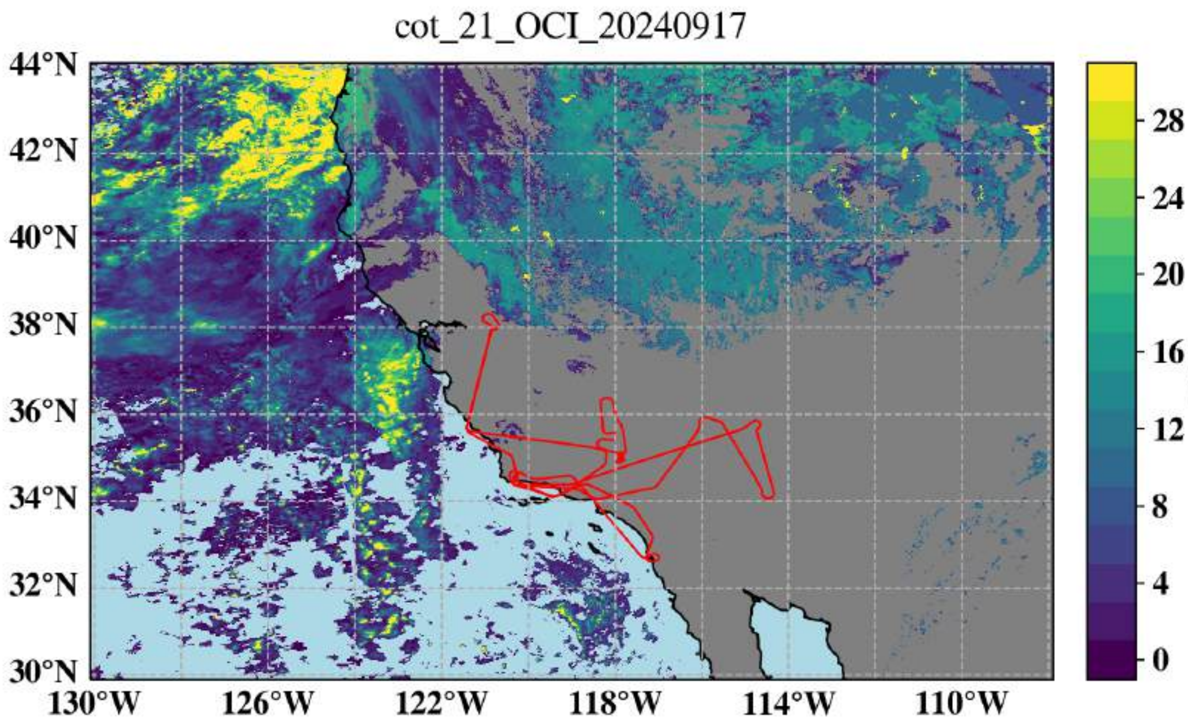
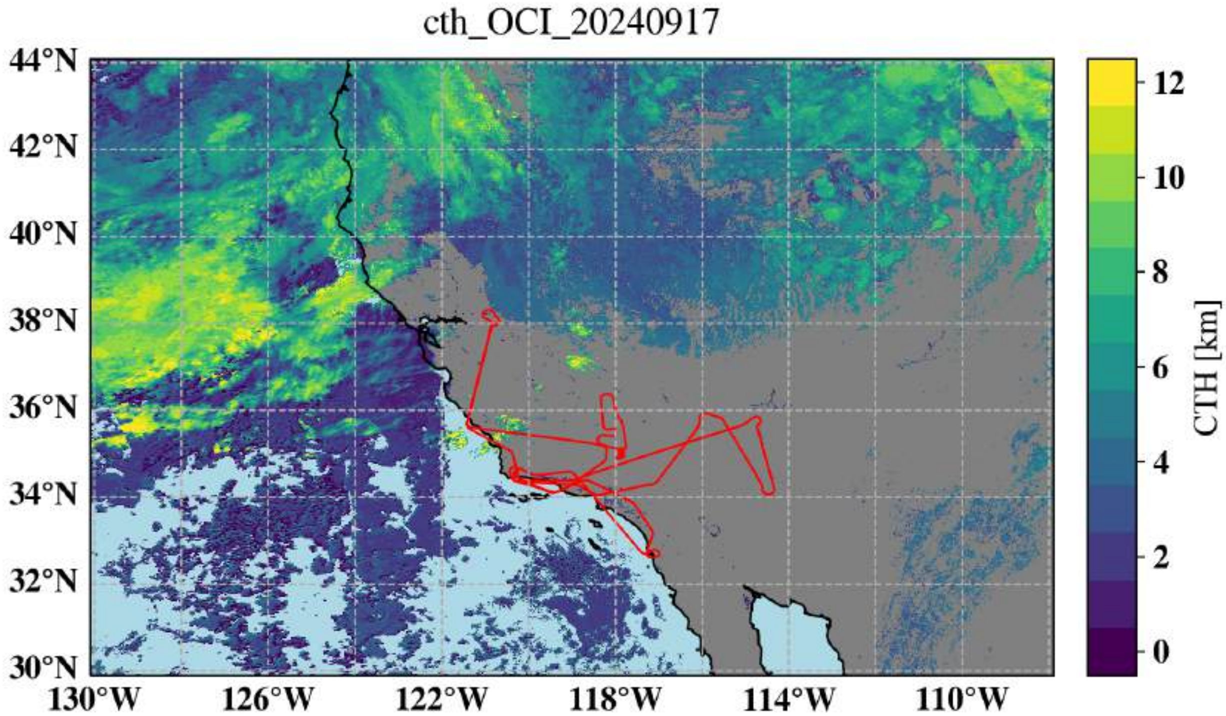
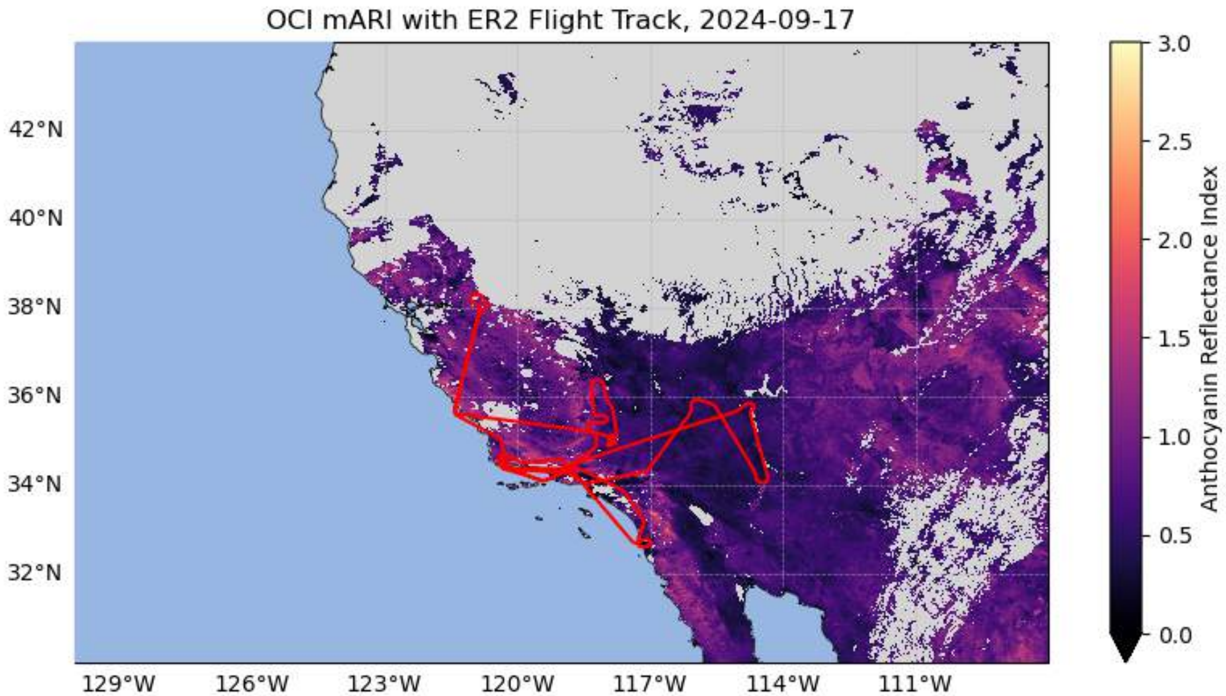
128°W
126°W
124°W
122°W
120°W
118°W
116°W
114°W
112°W
110°W
42°N
40°N
38°N
36°N
34°N
32°N
0.0
0.2
0.4
0.6
0.8
1.0

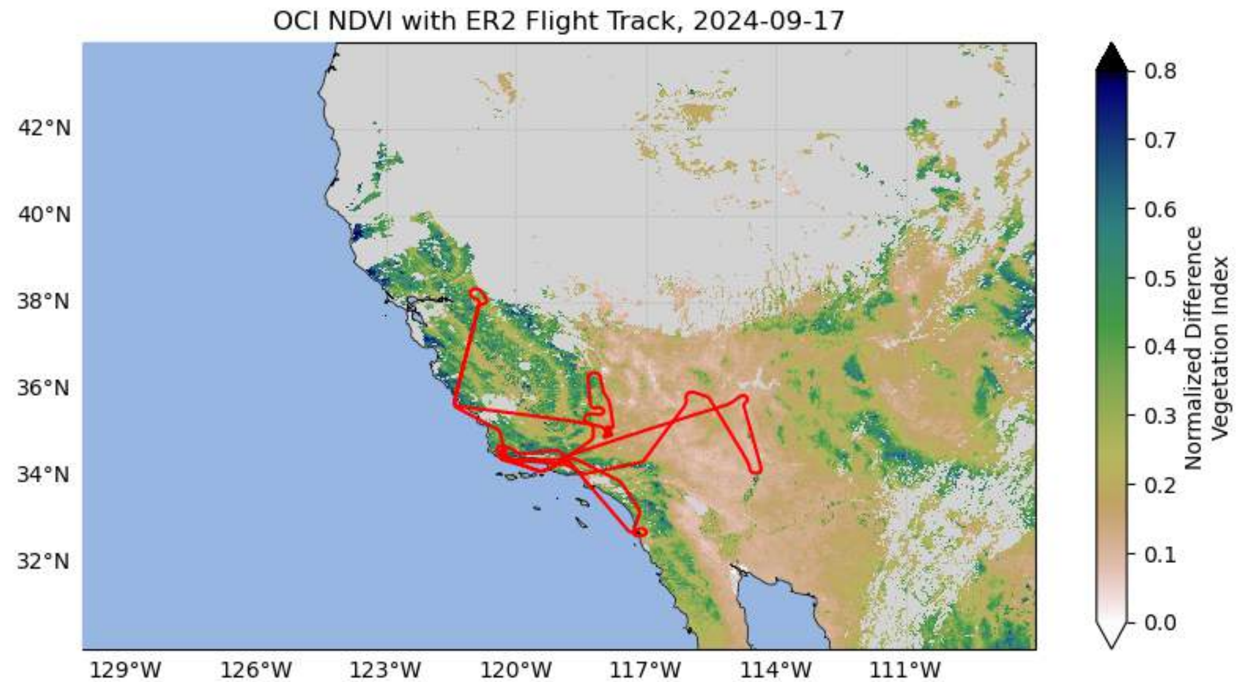

Cloud_Liquid_Index_HARP2_20240917
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
4.0
2.0
0.3
0.0
−0.5
Cloud Liquid Index


cloud_phase_21_OCI_20240917
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0
1
2
3
4
(1: Clear, 2: Water, 3: Ice, 4: Undetermined)


cot_21_OCI_20240917
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0
4
8
12
16
20
24
28
COT


cth_OCI_20240917
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
CTH [km]
0
2
4
6
8
10
12


OCI mARI with ER2 Flight Track, 2024-09-17
42°N
40°N
38°N
36°N
34°N
32°N
129°W
126°W
123°W
120°W
117°W
114°W
111°W
Anthocyanin Reflectance Index
0.0
0.5
1.0
1.5
2.0
2.5
3.0



OCI NDVI with ER2 Flight Track, 2024-09-17
42°N
40°N
38°N
36°N
34°N
32°N
129°W
126°W
123°W
120°W
117°W
114°W
111°W
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Normalized Difference
Vegetation Index

R/V Shearwater report

PACE-PAX R/V Shearwater day report

Date: 09/17/2024

Creator: Michael Ondrusek

Cruise ID: RF0917-RS

Sailed out: 0842 PST

Back in port: 1600 PST

Today, the ship occupied four stations:

Station #16 34° 13.557', -119° 46.505' arrival 16:31UTC →departure 18:15 UTC

ER-2 overflight at 18:00. Clear skies, 3 to 4 ft. swell. Polarimager, IOPs then profiles. Clear sun for all cast.

Arrival photo:

Departure photo (departure location - 34° 13.600', -119° 46.400')

Station #17 34° 10.816' , - 119° 39.920', arrival 18:39 UTC → departure 20:00 UTC

ER-2 overpass at 19:12 Hit the 1209 ER2 line approximately 5 Nm from Sta. 16. Clear skies, calm seas and 1 to 2 ft. swells. Profiles, polarimagers then IOP's.

Arrival photo:

Departure photo: (34° 11.026', - 119° 39.425')

Station #18 34° 15.586', 119° 37.214' arrival 20:18 UTC→ departure 20:39 UTC

PACE overpass at 20:14. This is halfway to ER2 line so stopped to do profiles and pigment only. Seas 1-2m, winds 8 -10 kts., and clear skies.

Arrival photo:

Departure photo (34° 15.914' -119° 37.402'):

Station #19. 34° 19.581', -119° 35.363', Arrival 20:51 UTC → departure 22:21 UTC. Sample on 1420 ER2 line. Just East of SB Harbor. Polarimager, profiles, then IOPs.

Arrival photo:

Departure photo (34° 19.559', -119° 33.723')

Group Status: No issues.

R/V Blissfully report

PACE-PAX R/V Blissfully day report

Date: 09/17/2024

Creator: Bridget Seegers

Cruise ID: RF0917-RB

Sailed out: 16:08 UTC

Back in port: 00:26 UTC

Today, the ship accomplished....

Collection of vertical radiometry profiles and discrete sample collection (HPLC + ap) on three stations in proximity of SeaPRISM site. The stations had three sets of 5 HyperPro profiles to 20m and a single deep cast to 60m. Station discrete water samples included triplicate HPLC + ap and duplicate community composition Lugol's preserved and paraformaldehyde samples for flow cytometry.

Stations:

Station #RB_14 - 33.5943, -118.1177°, arrival at 18:26 UTC, ER-2 overflight 18:26 UTC


Station #RB_15: 33° 33.859',-118° 7.275', arrival 19:58. PACE overflight at 20:14

Station #RB_16: 33° 34.96548', -118 7.06062' arrival 21:08

Tomorrow, RV Blissfully will sample for PACE overpass

Ship plans through the next 3 days… RV Blissfully will continue to sample to support overpasses until Sept 19. Then, will head back to home harbor in San Diego.

System Status…

All good

Group Status…

All great

PACE-PAX research report 2024/09/18

Compiled by Kirk Knobelspiesse, Ivona Cetinić, Michael Ondrusek, Bridget Seegers 2024/09/28
Reviewed by Samuel LeBlanc

Ocean only operations with R/V Shearwater, R/V Blissfully and gliders in generally cloud free conditions during PACE overpass.

ER-2
No flight

Twin Otter
No flight

R/V Shearwater
Mission Scientist: Michael Ondrusek
Sailed out: 15:42 UTC
Back in port: 00:00 UTC
See end for full R/V Shearwater report

R/V Blissfully
Mission Scientist: Bridget Seegers
Sailed out: 16:13 UTC
Back in port: UTC
See end for full R/V Blissfully report

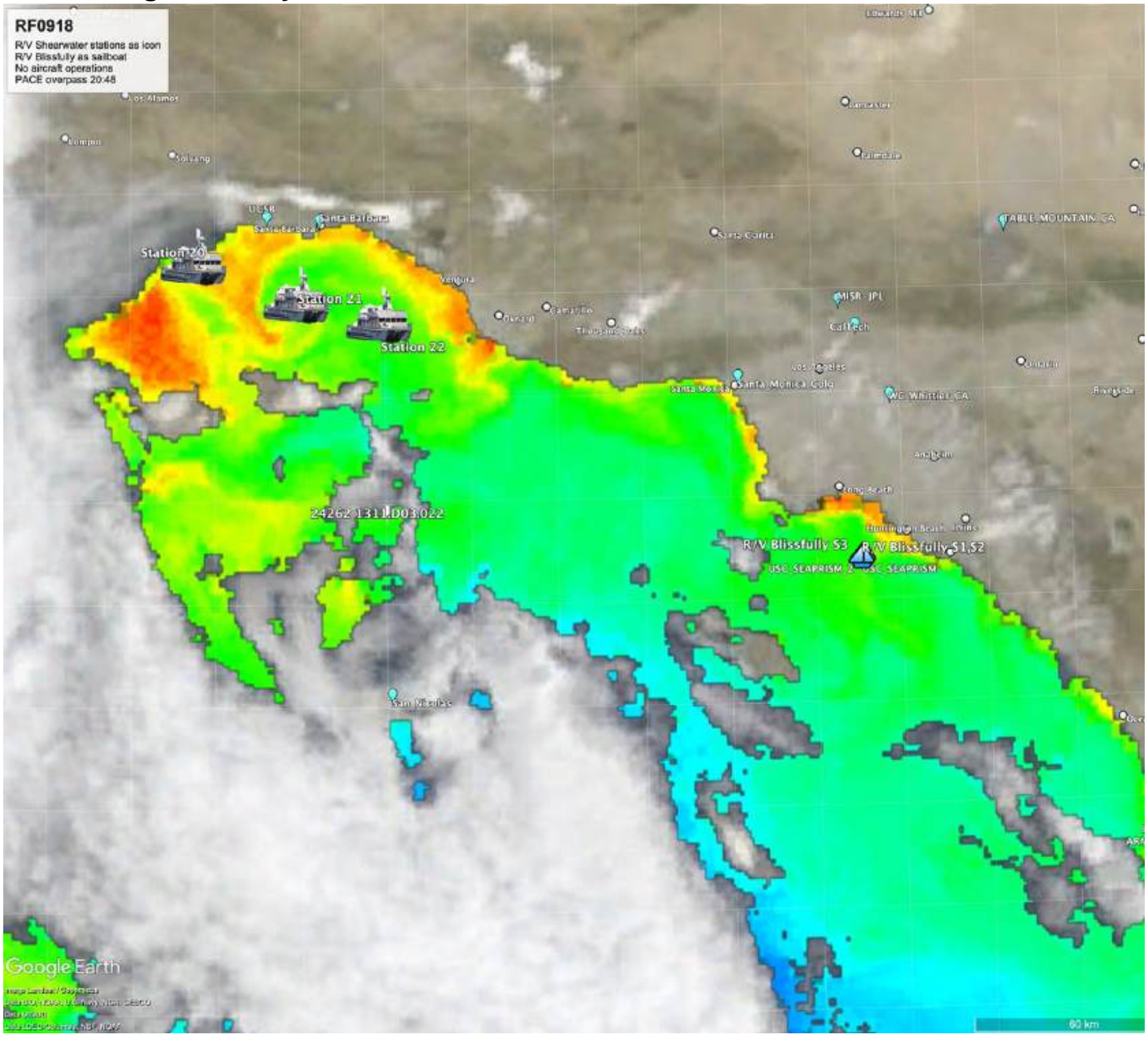
PACE
Overpass at 20:49, offshore to west

EarthCARE
Far from sample region

Gliders
Operational

HyperNAV
Operational

Overall image summary



Note: not shown is the PACE track, which was to the west over the ocean

Validation Traceability Matrix itemized objectives

VTM elements in **black** satisfied, **blue** partially satisfied, red to be confirmed

Time UTC	Platform	VTM(hrs)	
15:42	RS		Shearwater departs, UCSB AERONET AOD(500)=0.1
16:13	RB		Blissfully departs
19:29	RS	1b(2.0), 1c(2.0*0.5), 6i(2.0*0.5)	Station 21 until 21:12. PACE-OH Overpass. Minimal Clouds. Possible lack of AERONET/Cimel measurements.
20:49	**PACE**		**PACE overpass offshore**
20:56	RB	1b(1.0), 1c(1.0)	Station #18 until 21:55. PACE-OH Overpass. No clouds.
00:00	RS		Return
	RB		Return

PACE-O: within swath of PACE's OCI instrument

PACE-OH: within swath of PACE's OCI and HARP2 instruments
PACE-OHS: within swath of PACE's OCI, SPEXone and HARP2 instruments
RB: R/V Blissfully
RS: R/V Shearwater

Assessment:

- 0.3% of objectives observed, as expected for ship only PACE overpass scenario.
- Top remaining objectives (score above 6.0): PACE aerosol in narrow swath (3a,b)

PACE-PAX progress tracking

Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 9/16	Fractional success 9/17	Fractional success 9/18	Fractional success 9/19	Fractional success 9/20	Fractional success 9/21	Fractional success 9/22	Total success	Remaining score
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	4.0	0.0%	39.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.938	0.5
	b	Ocean radiometric parameters	10	8.0	11.0	0.0%	2.6%	0.5%	0.0%	0.0%	0.0%	0.0%	0.990	0.1
	c	Aerosol parameters over the ocean	12	8.0	7.0	0.0%	4.1%	1.1%	0.0%	0.0%	0.0%	0.0%	0.963	0.4
	d	Aerosol parameters over land	12	8.0	3.0	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.998	0.0
	e	Cloud parameters	12	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.695	3.7
	f	Ocean surface parameters	1	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.000	1.0
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.354	6.5
	b	Aerosol parameters over land (PACE)	10	8.0	2.0	0.0%	17.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.403	6.0
	c	Cloud parameters (PACE)	5	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.713	1.4
	d	Aerosol parameters (EarthCARE)	8	4.0	3.0	0.0%	52.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.992	0.1
	e	Cloud parameters (EarthCARE)	8	4.0	1.0	0.0%	19.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.313	5.5
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	2.0	4.0	0.0%	49.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.923	0.5
	b	Validate large reflectances with high polarization	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.393	3.6
	c	Validate large reflectances with low polarization	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.777	1.3
	d	Overfly vicarious calibration sites	6	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.268	4.4
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.000	0.0
	b	High aerosol loads over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.393	2.4
	c	Multiple aerosol layers	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.000	0.0
	d	Aerosol under thin cirrus	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.000	2.0
	e	Aerosol above liquid phase cloud	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.826	0.7
	f	Broken clouds with complex structure	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.528	1.9
	g	Dust aerosols over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.430	2.3
	h	Aerosol and ocean parameters over turbid waters	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.790	0.4
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	5.0	0.0%	86.5%	5.3%	0.0%	0.0%	0.0%	0.0%	0.918	0.3
	k	Smoke aerosols over ocean	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.713	0.3
		total:	150	98	40.0	0.0%	11.9%	0.3%	0.0%	0.0%	0.0%	0.0%	0.698	
														total
				ER-2 flight hours	15.8	0	0	0	0	0	0	0	0	15.8
				TO flight hours	11.2	0	0	0	0	0	0	0	0	11.2
				Shearwater days	4	0	0	0	0	0	0	0	0	4

PACE-PAX overall objectives satisfied: 0.698

Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

https://www-air.larc.nasa.gov/missions/pacepax/index.html

R/V Shearwater photos

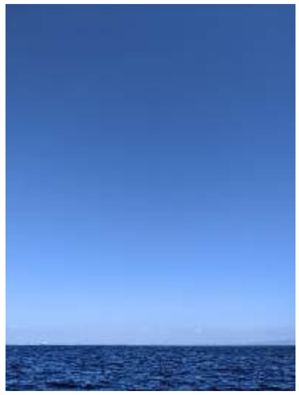
Station #21 34° 17.827' ,-119° 45.022' , arrival 19:29 UTC → departure 21:12 UTC

Arrival photo:

Departure photo: (34° 18.510', -119 45.695')

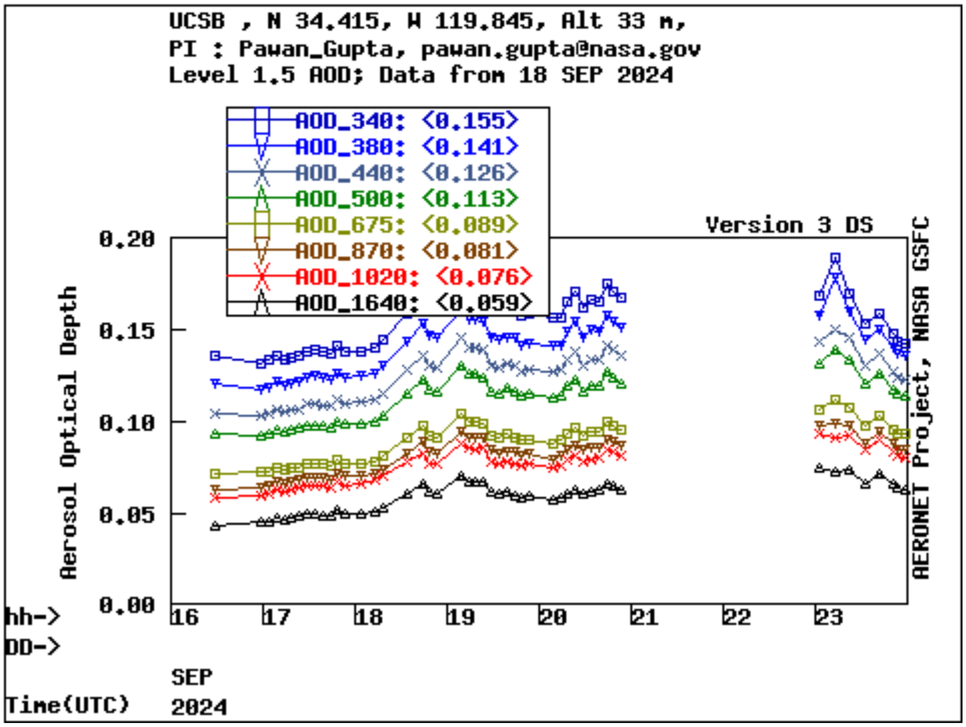
R/V Blissfully photos

Station #RB_18: 33° 34.8096', - 118° 3.684', arrival 20:56 UTC, departure 21:55. PACE overpass at 20:49:09

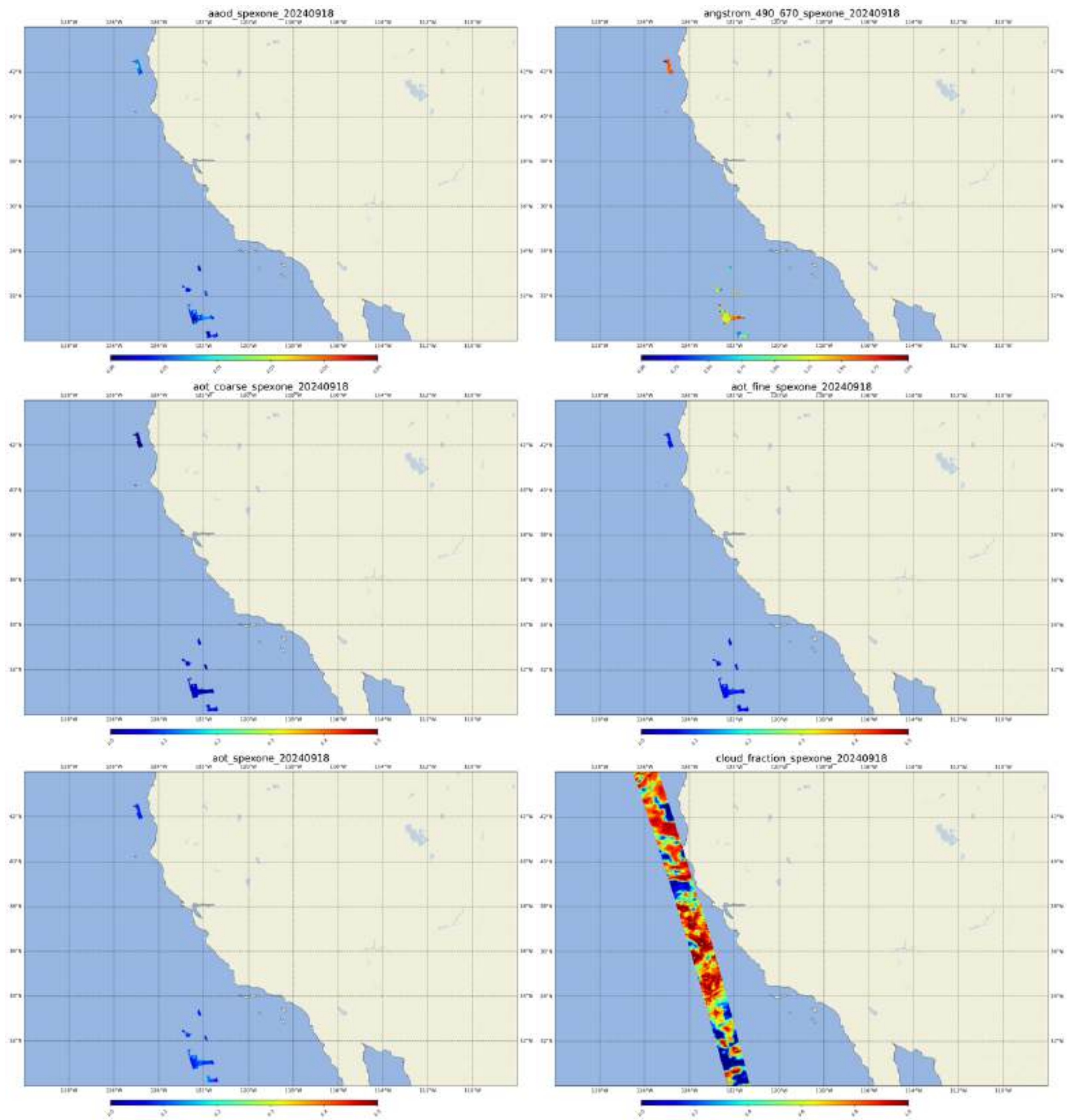



AERONET quicklooks

UCSB



PACE Satellite products


aaod_spexone_20240918
angstrom_490_670_spexone_20240918
aot_coarse_spexone_20240918
aot_fine_spexone_20240918
aot_spexone_20240918
cloud_fraction_spexone_20240918

R/V Shearwater report

PACE-PAX R/V Shearwater day report

Date: 09/18/2024

Creator: Michael Ondrusek

Cruise ID: RF0918-RS

Sailed out: 15:42 UTC

Back in port: 00:00 UTC (09/19/2024)

Today, the ship occupied three stations:

Station #20 34° 20.935', 120° 03.225', arrival 17:10 UTC →departure 18:35 UTC

Arrival photo:

Departure photo (departure location - 34° 21.896', - 120° 03.430')

Station #21 34° 17.827' ,-119° 45.022' , arrival 19:29 UTC → departure 21:12 UTC

Arrival photo:

Departure photo: (34° 18.510', -119 45.695')

Station #22 34° 17.216', -119° 31.875', arrival 21:51 UTC → departure 23:08 UTC

Arrival photo:

Departure photo: (34° 17.199', -119° 31.035')

Tomorrow, RV Shearwater will

Ship plans through the next 3 days...

System Status...

All good

Group Status...

All great

RV Blissfully report

PACE-PAX R/V Blissfully day report

Date: 09/18/2024

Creator: Bridget Seegers

Cruise ID: RF0918-RB

Sailed out: 16:13 UTC

Back in port: UTC

Today, the ship accomplished....

Collection of vertical radiometry profiles and discrete sample collection (HPLC + ap) on three stations in proximity of SeaPRISM site. The stations had three sets of 5 HyperPro profiles to 20m and a single deep cast to 60m. Station discrete water samples included triplicate HPLC + ap and duplicate community composition Lugol's preserved and paraformaldehyde samples for flow cytometry.

Stations:

Station #RB_17 33° 33.693' -118° 6.925' arrival at 19:27 UTC, departure 20:16

Station #RB_18: 33° 34.8096', - 118° 3.684', arrival 20:56 UTC, departure 21:55. PACE overpass at 20:49:09

Tomorrow, RV Blissfully will

Ship plans through the next 3 days… RV Blissfully will continue to sample to support overpasses until Sept 19. Then, will head back to home harbor in San Diego.

System Status…

All good

Group Status…

All great

PACE-PAX research report 2024/09/19

Compiled by Kirk Knobelspiesse, Ivona Cetinić, Michael Ondrusek, Bridget Seegers 2024/09/28

Reviewed by Samuel LeBlanc

Planned ER2+TO+Shearwater+Blissfully operations mainly offshore in southern california. Perfect aligned EarthCARE track over Santa Barbara Channel (Orbit 1773). Double sortie of Twin Otter to get south. Unfortunately ER-2 flight scrubbed due to aircraft issue.

ER-2

ER-2 flight scrubbed due to aircraft issue relating to cabin pressure. Fixed and resolved to be ready for flight next day.

Twin Otter

Double sortie
Take off: 11:07:20 (18:07:20 UTC) Marina Airport (OAR)
Landing: 15:43:17 (22:43:17 UTC) Camarillo Airport (CMA), Duration 4.6 hrs
Take off: 16:45:37 (23:40:30 UTC) Camarillo Airport (CMA)
Landing: 18:03:07 (25:03:07 UTC) Marina Airport (OAR), Duration 1.3 hrs
Manifest: Bryce Kujat (pilot), Jeff Martin (pilot) , Anthony Bucholtz (QNC), Adam Ahern (QNC), Edward Winstead (QNC)
See end for full Twin Otter report

R/V Shearwater

Mission Scientist: Michael Ondrusek
Sailed out: 15:54 UTC
Back in port: 23:15 UTC
See end for full R/V Shearwater report

R/V Blissfully

Mission Scientist: Bridget Seegers
Sailed out: 16:29 UTC
Back in port: 00:06 (2024/09/20) UTC
See end for full R/V Blissfully report

PACE

Overpass at 19:45, to east
Overpass at 21:23, offshore to west

EarthCARE

22:15 over Pt. Mugu. Orbit 1773

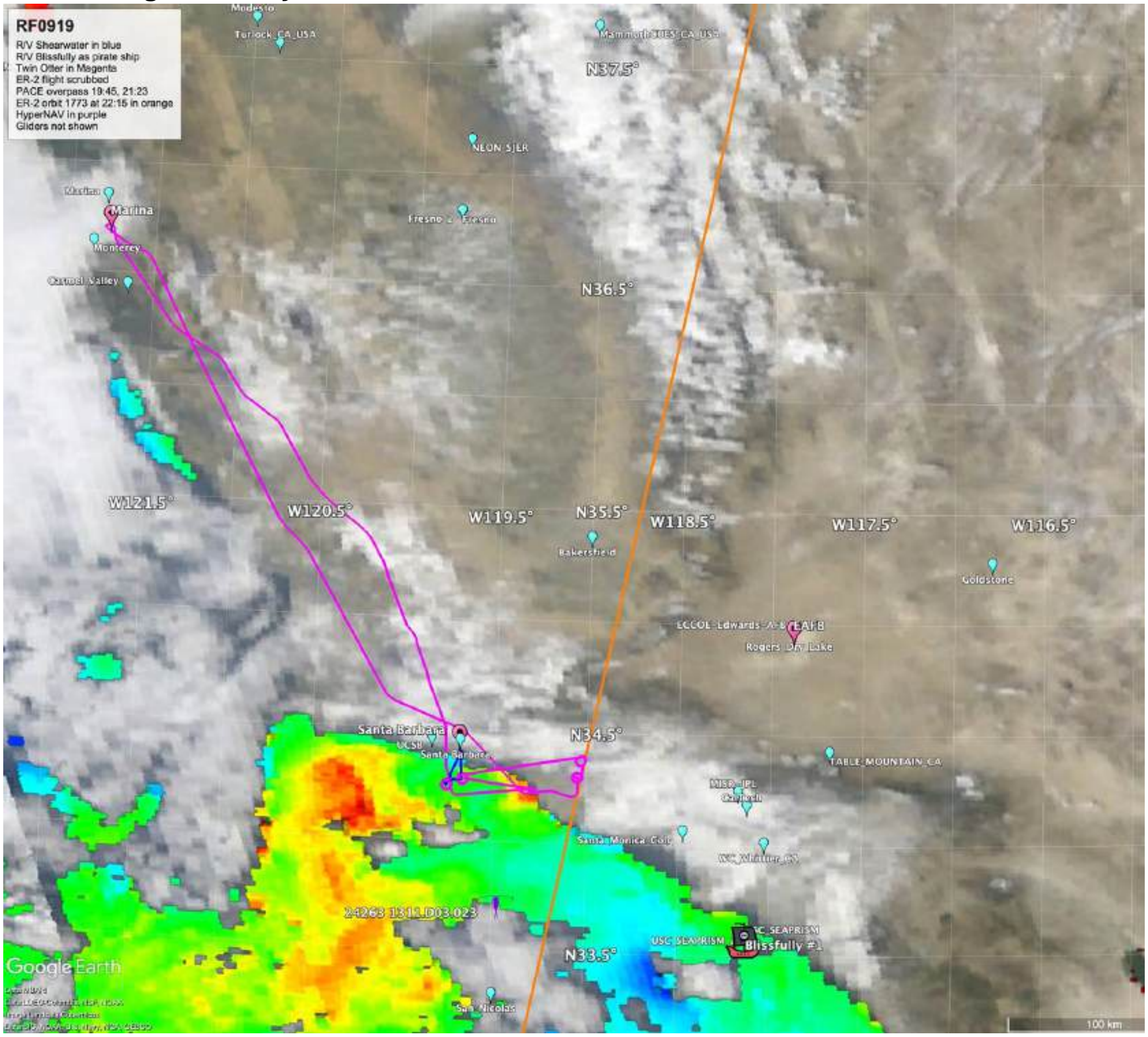
Gliders

Operational

HyperNAV

Operational

Overall image summary



Note: not shown is the PACE tracks outside of range

Validation Traceability Matrix itemized objectives

VTM elements in black satisfied, **blue** partially satisfied, red to be confirmed

Time UTC	Platform	VTM(hrs)	
15:54	RS		Shearwater departs
16:29	RB		Blissfully departs; engine problems delay arrival on station
17:17	RS		Shearwater on station 22 until 20:20, with Twin Otter spiral over top plus PACE-O
18:07	TO		Takeoff from Marina
19:00	RB	1b(1.0), 1c(1.0*0.5)	Blissfully on station for PACE-O overpass. No USC_SeaPRISM data
19:43	TO, RS, PACE-O	1b(2.0), 1c(1.5)	Twin Otter spiral over Shearwater during PACE-O overpass. Cloud free at this point, relatively clean aerosols.

19:45	**PACE**		**PACE overpass (east of operations region)**
20:40	RS	1b(2.0), 1c(1.5)	On station 23 until 22:41, with Twin Otter spiral over top plus PACE-O
19:00	RB	1b(1.0), 1c(1.0*0.5)	Blissfully on station for PACE-O overpass. No USC_SeaPRISM data
21:23	**PACE**		**PACE overpass (west of operations region)**
22:17	TO, EarthCARE	1d(1.5), 3d(1.5), 3e(1.5*0.5)	After a first attempt to spiral down with aerosols but cloud below (which aircraft couldn't enter with IFR rules), found a second cloud free location to spiral during EarthCARE overpass. Spiral down to 2kft. Some cloud information on split TO spiral along EarthCARE
22:43	TO		Twin Otter lands for refueling in Camarillo
23:15	RS		Shearwater back in port
23:40	TO		Takeoff Camarillo
01:03 (2024/09/20)	TO		Landed Marina

PACE-O: within swath of PACE's OCI instrument
PACE-OH: within swath of PACE's OCI and HARP2 instruments
PACE-OHS: within swath of PACE's OCI, SPEXone and HARP2 instruments
RB: R/V Blissfully
RS: R/V Shearwater

Assessment:

- 0.5% of objectives observed, as expected with no ER-2 operations. Unfortunate as this would have resulted in a very successful day otherwise.
- Top remaining objectives (score above 6.0): PACE aerosol in narrow swath (3a,b)

PACE-PAX progress tracking

Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 9/16	Fractional success 9/17	Fractional success 9/18	Fractional success 9/19	Fractional success 9/20	Fractional success 9/21	Fractional success 9/22	Total success	Remaining score
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	4.0	0.0%	39.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.938	0.5
	b	Ocean radiometric parameters	10	8.0	15.0	0.0%	2.6%	0.5%	0.4%	0.0%	0.0%	0.0%	0.994	0.1
	c	Aerosol parameters over the ocean	12	8.0	10.0	0.0%	4.1%	1.1%	1.2%	0.0%	0.0%	0.0%	0.975	0.3
	d	Aerosol parameters over land	12	8.0	4.5	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.998	0.0
	e	Cloud parameters	12	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.695	3.7
	f	Ocean surface parameters	1	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.000	1.0
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.354	6.5
	b	Aerosol parameters over land (PACE)	10	8.0	2.0	0.0%	17.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.403	6.0
	c	Cloud parameters (PACE)	5	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.713	1.4
	d	Aerosol parameters (EarthCARE)	8	4.0	4.5	0.0%	28.2%	0.0%	7.9%	0.0%	0.0%	0.0%	0.826	1.4
	e	Cloud parameters (EarthCARE)	8	4.0	1.0	0.0%	19.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.313	5.5
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	2.0	4.0	0.0%	49.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.923	0.5
	b	Validate large reflectances with high polarization	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.393	3.6
	c	Validate large reflectances with low polarization	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.777	1.3
	d	Overfly vicarious calibration sites	6	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.268	4.4
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.000	0.0
	b	High aerosol loads over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.393	2.4
	c	Multiple aerosol layers	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.000	0.0
	d	Aerosol under thin cirrus	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.000	2.0
	e	Aerosol above liquid phase cloud	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.826	0.7
	f	Broken clouds with complex structure	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.528	1.9
	g	Dust aerosols over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.430	2.3
	h	Aerosol and ocean parameters over turbid waters	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.790	0.4
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	5.0	0.0%	86.5%	5.3%	0.0%	0.0%	0.0%	0.0%	0.918	0.3
	k	Smoke aerosols over ocean	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.713	0.3
		total:	150	98	50.0	0.0%	10.6%	0.3%	0.5%	0.0%	0.0%	0.0%	0.690	
														total
				ER-2 flight hours	15.8	0	0	0	0	0	0	0	0	15.8
				TO flight hours	11.2	0	0	0	0	0	0	0	0	11.2
				Shearwater days	4	0	0	0	0	0	0	0	0	4

PACE-PAX overall objectives satisfied: 0.690

Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

https://www-air.larc.nasa.gov/missions/pacepax/index.html

R/V Shearwater photos

Station #23 34° 15.038', -119° 45.721', arrival 17:17 UTC →departure 20:20 UTC Twin otter overflight + spiral

Arrival photo:

Departure photo (departure location - 34° 16.017', -119 46.988')

Station #24 34° 16.681' N, - 119° 40.640' , arrival 20:40 Z UTC → departure 22:41 UTC Twin otter spiral.

Arrival photo:

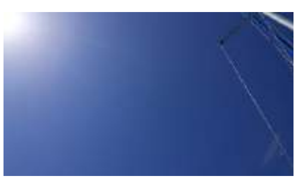
Departure photo: (34° 16.670', -119° 40.479' W)

R/V Blissfully photos

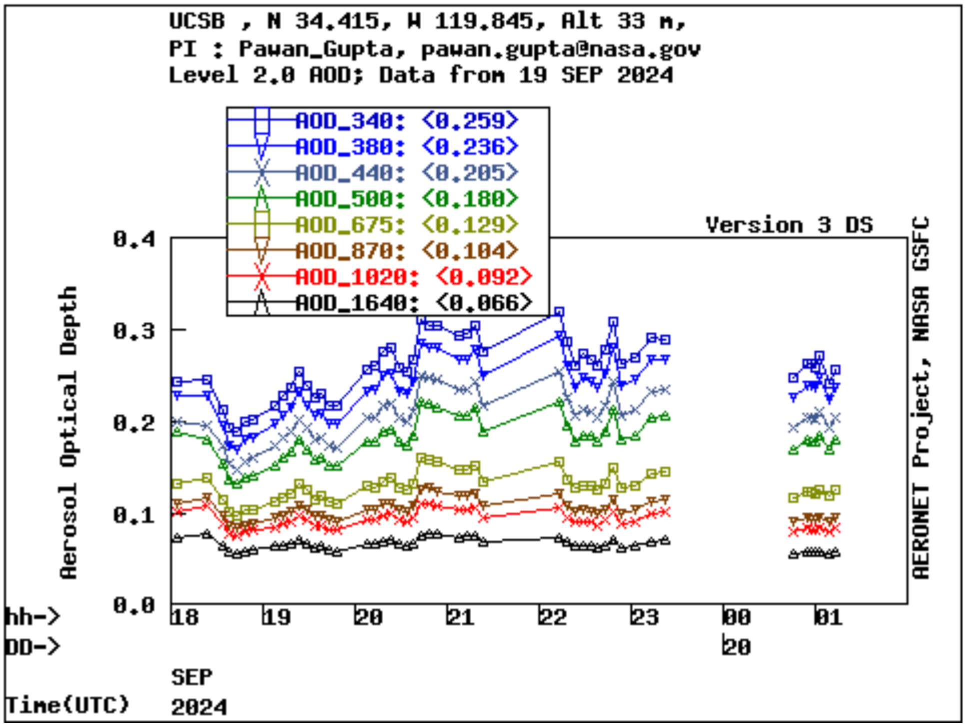
Stations:

Station #RB_19 33° 34.907', -118° 7.413' arrival, 19:00 UTC

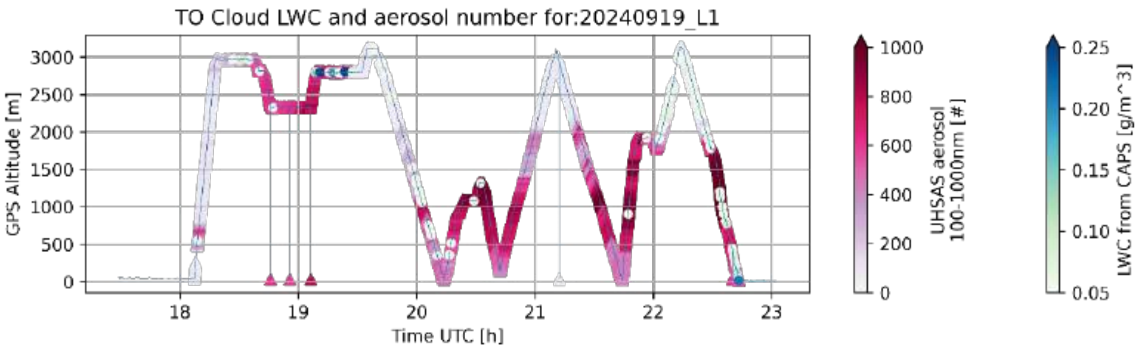
Tomorrow, Heading back to home harbor in San Diego.

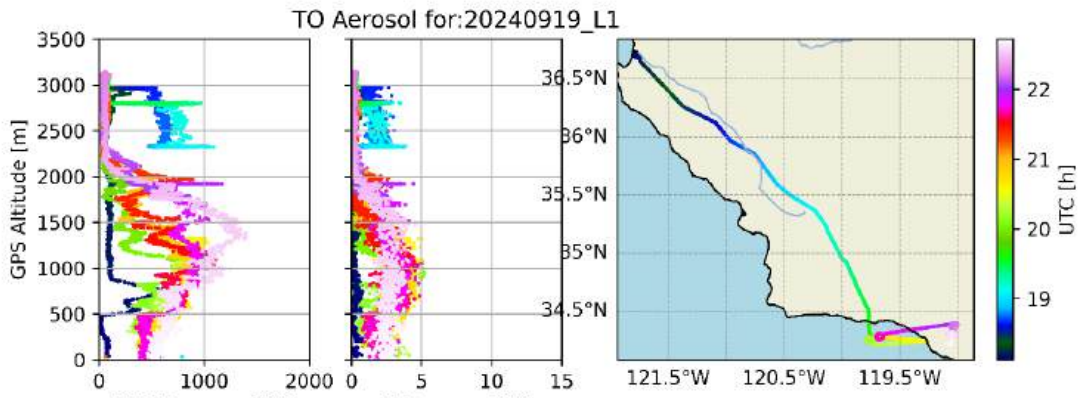


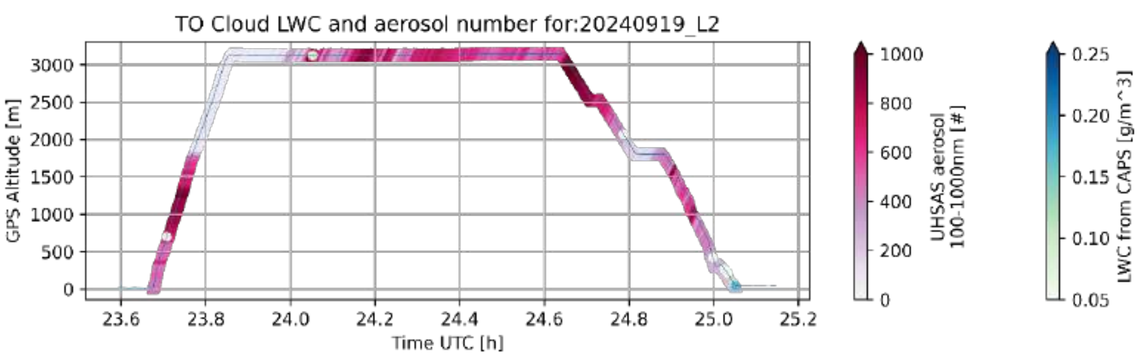
AERONET Quicklooks

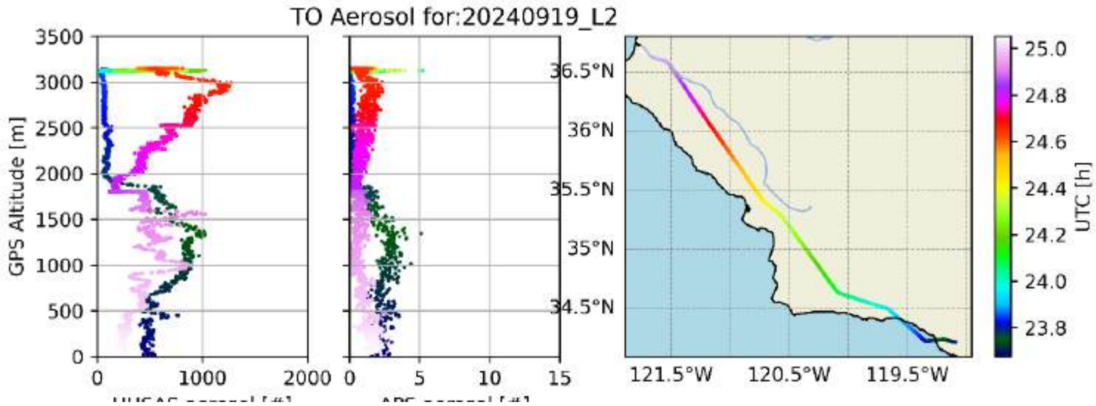


TO Quicklooks





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2000
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0
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2000
5
10
15
36.5°N
36°N
35.5°N
35°N
34.5°N
121.5°W
120.5°W
119.5°W
25.0
24.8
24.6
24.4
24.2
24.0
23.8
UTC [h]

Twin Otter flight report

PACE-PAX Research Flight report 2024/09/19

Twin Otter Flight

Manifest:

Bryce Kujat (pilot)

Jeff Martin (pilot)

Anthony Bucholtz (QNC)

Adam Ahern (QNC)

Edward Winstead (QNC)

Note: AERONET at UCSB might not be working – taking data

Take off: 11:07:20 (18:07:20 UTC) Marina Airport (OAR)

Landing: 15:43:17 (22:43:17 UTC) Camarillo Airport (CMA)

Duration = 4.6 hrs

Take off: 16:45:37 (23:40:30 UTC) Camarillo Airport (CMA)

Landing: 18:03:07 (25:03:07 UTC) Marina Airport (OAR)

Duration: 1.3 hrs

Objectives: Profiles of aerosol scattering, absorption coefficients, and size distributions together with scattering (polarized) phase functions of dust and/or smoke south of Santa Barbara. Slow spirals were made above the R/V Shearwater at two locations during two PACE overpasses. Between the two PACE overpasses, sampling of dust in level/porpoise maneuvers to gain statistics for the phase functions and size distributions of dust aerosols. After second PACE overpass, transit at altitude of interest for aerosols during EarthCARE overpass and spiral before landing at Camarillo. After refueling in Camarillo, return to Marina Airport.

Summary:

Takeoff was uneventful with limited aerosol observed during climb out at 9.7 kft scattering coefficients were ~10 Mm^{-1}. Small diversions around weather and clouds during transit to Santa Barbara. We observed scattering coefficients of about 15 Mm^{-1} of aerosol above thick clouds until reaching the shore at 19:22 UTC. Upon reaching R/V Shearwater which was at waypoint SHER1, we began a slow spiral (200 ft/min) down at 19:40 UTC. PACE overpass occurred during the spiral down. Climbed in-line towards T1906 (near Oxnard Beach) into thickest aerosol, 3.0 kft. At 20:21 UTC we were forced to climb to 3.5 kft for traffic, but stayed in the thickest aerosol with scattering coefficients of ~32 Mm-1. At the end of the way point we climbed up to 4.25 kft to try to sample a different layer of aerosol, but it appeared to be the same layer – no decrease in scattering was observed. Instead we headed down to 500' to start the spiral over the Shearwater in the second location (SHER2.) We spiraled up to 10 kft and then back down again. PACE overpass was at 21:23 UTC just as we started spiraling into the thicker aerosol with scattering coefficients of ~15 Mm^{-1}. Note that the aerosol had a slightly different magnitude of scattering profile on the way down than it did on the spiral up.

After the spiral down, we headed towards the EART4, climbing rapidly to get over the clouds on the shore. We reached 6.2 kft trying to hit the upper layer of aerosol on the way to the EART4 overpass location. We had broken clouds underneath us at 21:54 UTC, and overcast cloud cover at 21:56 UTC. We descended to the cloud top at 22:00 UTC before spiraling up, with the aerosol layer thinning at 7.5 kft to having scattering coefficients of ~ 2.5 Mm^{-1}. We could not go into the clouds without IFR. After spiraling up, we transitioned to coordinates provided by Sam Leblanc via the chat for clearer skies to spiral down to 2.0 kft. We landed at 22:43:17 UTC at Camarillo, CA.

After refueling at Camarillo, we took off at 23:27:51 UTC. Since there were no coincident measurements, we exceeded science speed of 100 kts, ~160 kts indicated. We observed a consistent layer of aerosol around 10 kft with scattering coefficients of ~10 Mm^{-1}. We were forced to take an odd course, out to sea and then diverting again inland due to traffic and then weather. We saw some clear aerosol spikes where the angstrom exponent went to 0 at 24:15 UTC and 24:20 UTC. We landed at Marina at 25:03:07 UTC, no missed approach at the tower.

Beginning first spiral down – R/V Shearwater from 10000 ft; photo taken by Adam Ahern.

R/V Shearwater at ~1000’; photo taken by Adam Ahern.

Quicklook from CIRPAS Instrument Suite showing three layers of aerosols.

R/V Shearwater report

PACE-PAX R/V Shearwater day report

Date: 09/19/2024

Creator: Michael Ondrusek

Cruise ID: RF0919-RS

Sailed out: 15:54 UTC

Back in port: 23:14 UTC (09/19/2024)

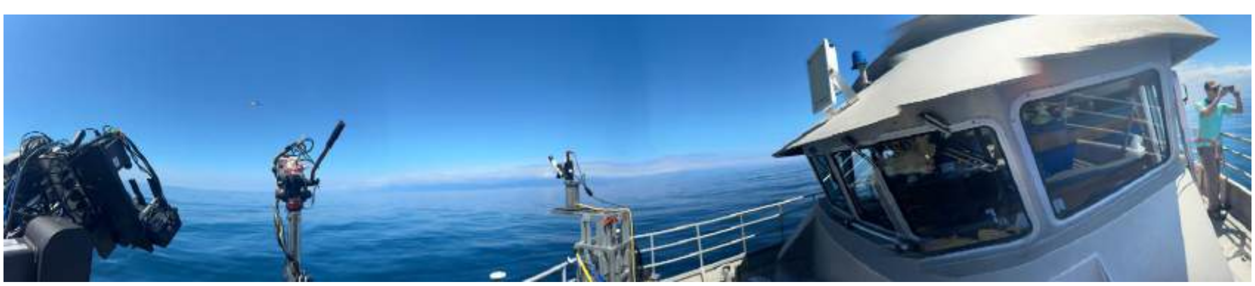
Today, the ship occupied two stations:

Station #23 34° 15.038', -119° 45.721', arrival 17:17 UTC →departure 20:20 UTC

- Twin otter overflight + spiral
-

Arrival photo:

Departure photo (departure location - 34° 16.017', -119 46.988')



Station #24 34° 16.681' N, - 119° 40.640' , arrival 20:40 Z UTC → departure 22:41 UTC

- Twin otter spiral.

Arrival photo:

Departure photo: (34° 16.670', -119° 40.479' W)

Tomorrow, RV Shearwater will

Ship plans through the next 3 days…

System Status…

All good

Group Status…

All great

Photo of the beginning of the first spiral over the station 23, at 19:45

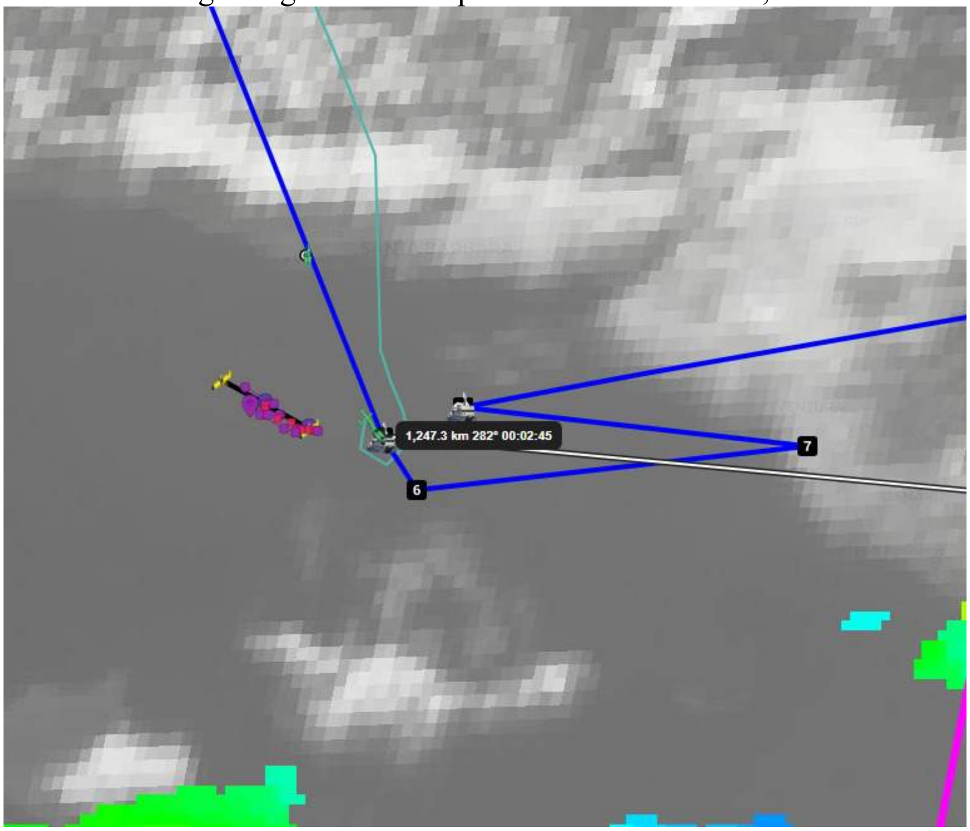
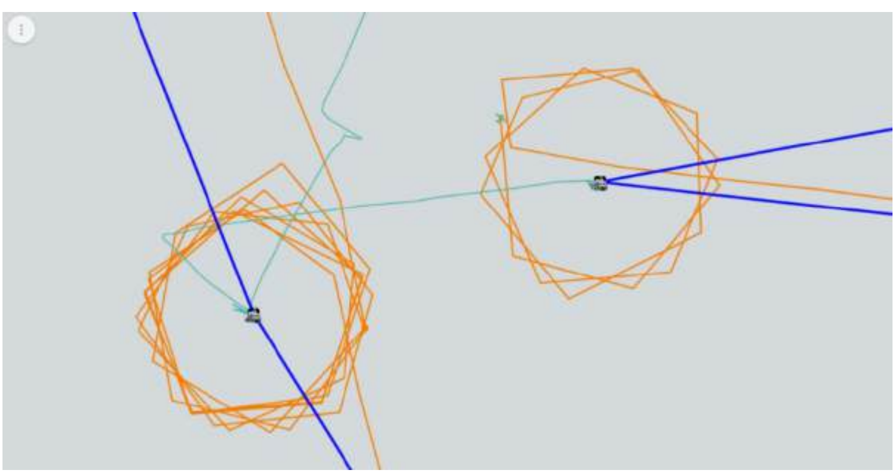


Photo from MTS during the second spiral over the station 24, at 21:00



R/V Blissfully report

Date: 09/19/2024

Creator: Bridget Seegers

Cruise ID: RF0919-RB

Sailed out: 16:29 UTC/17:49 UTC

Back in port: 00:06 UTC (09/20/2024)

Today, the ship accomplished....

Collection of vertical radiometry profiles and discrete sample collection (HPLC + ap) on three stations in proximity of SeaPRISM site. The stations had three sets of 5 HyperPro profiles to 20m and a single deep cast to 60m. Station discrete water samples included triplicate HPLC + ap and duplicate community composition Lugol's preserved and paraformaldehyde samples for flow cytometry. Slight issues with the engine caused the return to the port and later sail-out at 17:49

Stations:

Station #RB_19 33° 34.907', -118° 7.413' arrival, 19:00 UTC

Tomorrow, Heading back to home harbor in San Diego.

Ship plans through the next 3 days... Heading back to home harbor in San Diego.

System Status...

All good

Group Status... All great

PACE-PAX research report 2024/09/20

Compiled by Kirk Knobelspiesse, Ivona Cetinić, Brian Cairns, Michael Ondrusek, 2024/09/28
Reviewed by Samuel LeBlanc

Planned ER2 +Shearwater and ER2+TO operations offshore in southern California (Shearwater) and in cloudy conditions near the Monterey Bay (TO). PACE track inland (20:20). Unfortunately ER-2 flight scrubbed due to NASA-wide grounding of all ER-2's due to potential engine issue. Inspection showed no issue, to aircraft ready for next day. TO operations modified to be a short flight at the time of PACE overpass.

ER-2
ER-2 flight scrubbed due to fleetwide grounding of ER-2's for potential engine issue. Inspected and resolved to be ready for flight next day.

Twin Otter
Take off: 12:17:48 (19:17:48 UTC) Marina Airport (OAR)
Landing: 15:43:17 (21:25:33 UTC) Marina Airport (OAR)
Duration = 2.1 hrs
Manifest: Bryce Kujat (pilot), Jeff Martin (pilot) , Michael Shook (QNC), Francesca Gallo (QNC), Edward Winstead (QNC)
See end for full Twin Otter report

R/V Shearwater
Mission Scientist: Michael Ondrusek
Sailed out: 15:54 UTC
Back in port: 22:56 UTC
See end for full R/V Shearwater report

R/V Blissfully
Operations concluded

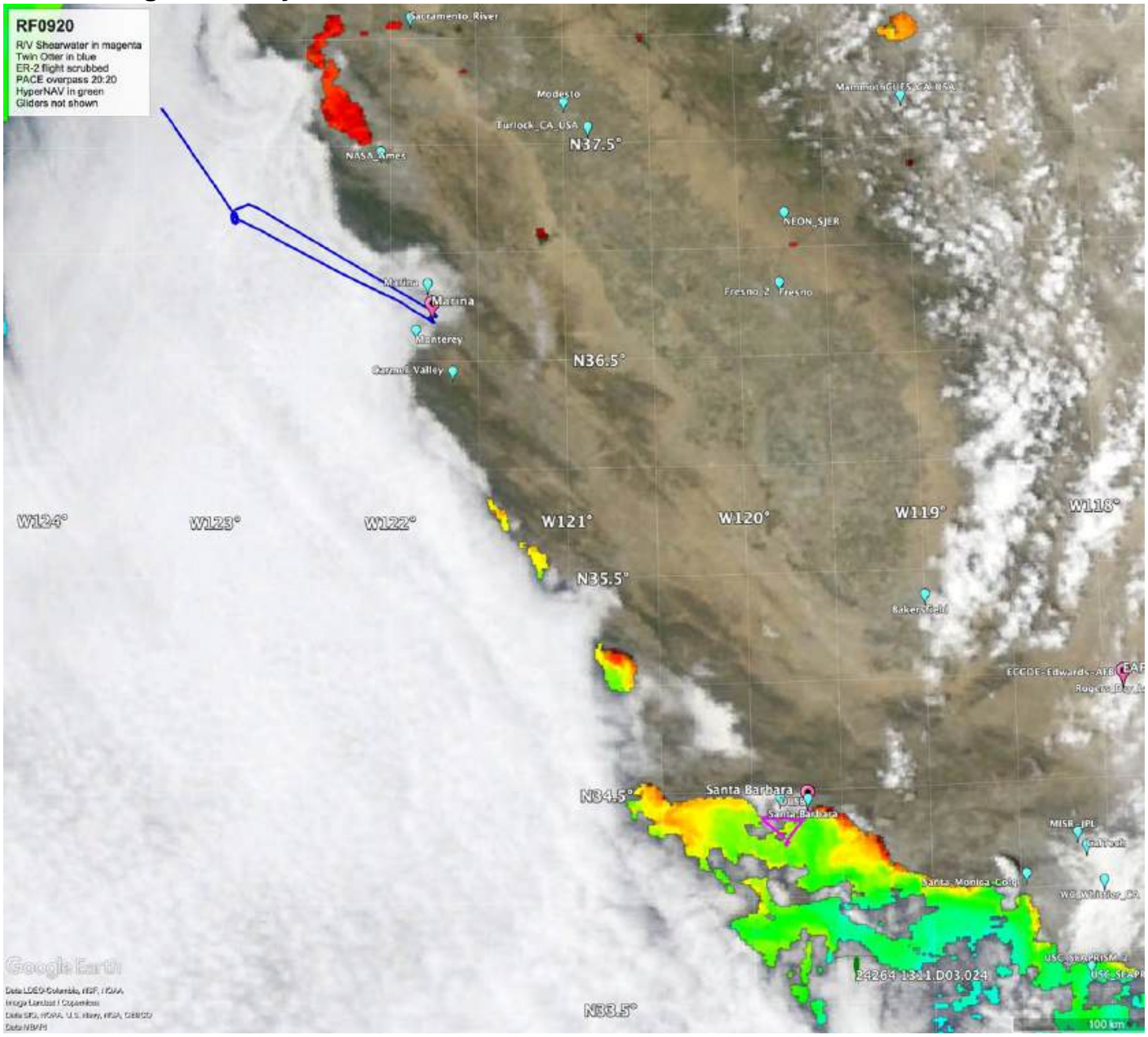
PACE
Overpass at 20:20, east along California/Nevada border

EarthCARE
Far from operations area, not targeted

Gliders
Operational

HyperNAV
Operational

Overall image summary



Note: not shown is the PACE tracks outside of range

Validation Traceability Matrix itemized objectives

VTM elements in **black** satisfied, **blue** partially satisfied, red to be confirmed

Time UTC	Platform	VTM(hrs)	
15:54	RS		Shearwater departs
16:50	RS		Arrives on station 25. Planned ER-2 overpass scrubbed. Departure 17:13. Partly cloudy.
18:01	RS		Arrives on station 26. Planned ER-2 overpass scrubbed. Departure 19:38. Mostly cloudy.
19:17	TO		Takeoff from Marina
19:47	TO	1e(3), 6e(1.5*0.5)	Begin operations: spiral down outsize ADIZ line, then porpoising NW from there, turn and return at 20:33, concluding at 20:56. Within PACE-O swath, aerosol above clouds.
20:20	**PACE**		**PACE overpass (east of operations region)**

20:23	RS	1b(2), 1c(2)	Arrives on station 27. PACE-O overpass. Mostly clear. Departure 21:47
21:25	TO		Landed Marina
23:15	RS		Shearwater back in port

PACE-O: within swath of PACE's OCI instrument
PACE-OH: within swath of PACE's OCI and HARP2 instruments
PACE-OHS: within swath of PACE's OCI, SPEXone and HARP2 instruments
TO: Twin Otter
RB: R/V Blissfully
RS: R/V Shearwater

Assessment:

- 0.8% of objectives observed, as expected with no ER-2 operations.
- Top remaining objectives (score above 6.0): PACE aerosol in narrow swath (3a,b)

PACE-PAX progress tracking

Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 9/16	Fractional success 9/17	Fractional success 9/18	Fractional success 9/19	Fractional success 9/20	Fractional success 9/21	Fractional success 9/22	Total success	Remaining score
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	4.0	0.0%	39.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.938	0.5
	b	Ocean radiometric parameters	10	8.0	17.0	0.0%	2.6%	0.5%	0.4%	0.1%	0.0%	0.0%	0.995	0.0
	c	Aerosol parameters over the ocean	12	8.0	12.0	0.0%	4.1%	1.1%	1.2%	0.6%	0.0%	0.0%	0.980	0.2
	d	Aerosol parameters over land	12	8.0	4.5	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.998	0.0
	e	Cloud parameters	12	8.0	3.0	0.0%	0.0%	0.0%	0.0%	9.5%	0.0%	0.0%	0.790	2.5
	f	Ocean surface parameters	1	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.000	1.0
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.354	6.5
	b	Aerosol parameters over land (PACE)	10	8.0	2.0	0.0%	17.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.403	6.0
	c	Cloud parameters (PACE)	5	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.713	1.4
	d	Aerosol parameters (EarthCARE)	8	4.0	4.5	0.0%	28.2%	0.0%	7.9%	0.0%	0.0%	0.0%	0.826	1.4
	e	Cloud parameters (EarthCARE)	8	4.0	1.0	0.0%	19.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.313	5.5
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	2.0	4.0	0.0%	49.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.923	0.5
	b	Validate large reflectances with high polarization	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.393	3.6
	c	Validate large reflectances with low polarization	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.777	1.3
	d	Overfly vicarious calibration sites	6	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.268	4.4
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.000	0.0
	b	High aerosol loads over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.393	2.4
	c	Multiple aerosol layers	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.000	0.0
	d	Aerosol under thin cirrus	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.000	2.0
	e	Aerosol above liquid phase cloud	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.826	0.7
	f	Broken clouds with complex structure	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.528	1.9
	g	Dust aerosols over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.430	2.3
	h	Aerosol and ocean parameters over turbid waters	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.790	0.4
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	5.0	0.0%	86.5%	5.3%	0.0%	0.0%	0.0%	0.0%	0.918	0.3
	k	Smoke aerosols over ocean	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.713	0.3
		total:	150	98	57.0	0.0%	10.6%	0.3%	0.5%	0.8%	0.0%	0.0%	0.699	
														total
				ER-2 flight hours	15.8	0	0	0	0	0	0	0	0	15.8
				TO flight hours	11.2	0	0	0	0	0	0	0	0	11.2
				Shearwater days	4	0	0	0	0	0	0	0	0	4

PACE-PAX overall objectives satisfied: 0.699

Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

https://www-air.larc.nasa.gov/missions/pacepax/index.html

R/V Shearwater photos

Station #25 34° 15.188', -119° 48.275' , arrival 16:50 UTC →departure 17:13 UTC

Arrival photo:

Departure photo (departure location - 34° 15.302', -119° 48.158')

Station #26 34° 16.681' N, - 119° 40.640', arrival 18:01 UTC → departure 19:38 UTC

Arrival photo:

Departure photo: (34° 22.557', 119° 56.966')

Station #27 34° 21.636', 119° 43.193', arrival 20:23 UTC → departure 21:47 UTC

PACE overpass at 20:21

Arrival photo:

Departure photo: (34° 21.887',- 119° 43.463')

Twin Otter photos

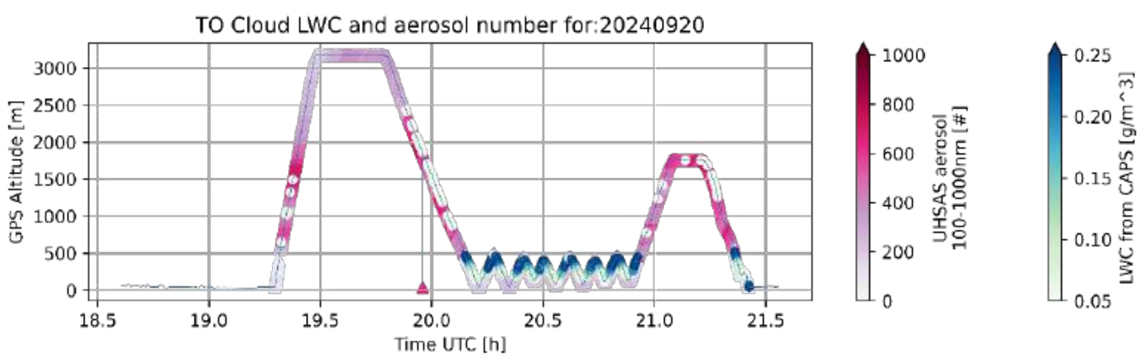
Cloud top over Salinas after taking off at 19:19UTC (~1600ft) ; photo taken by Francesca Gallo.

Below cloud while porpoising north parallel to the ADIZ line at 20:20 UTC at ~600ft (Sca ~25Mm^{-1}) ; photo taken by Francesca Gallo.

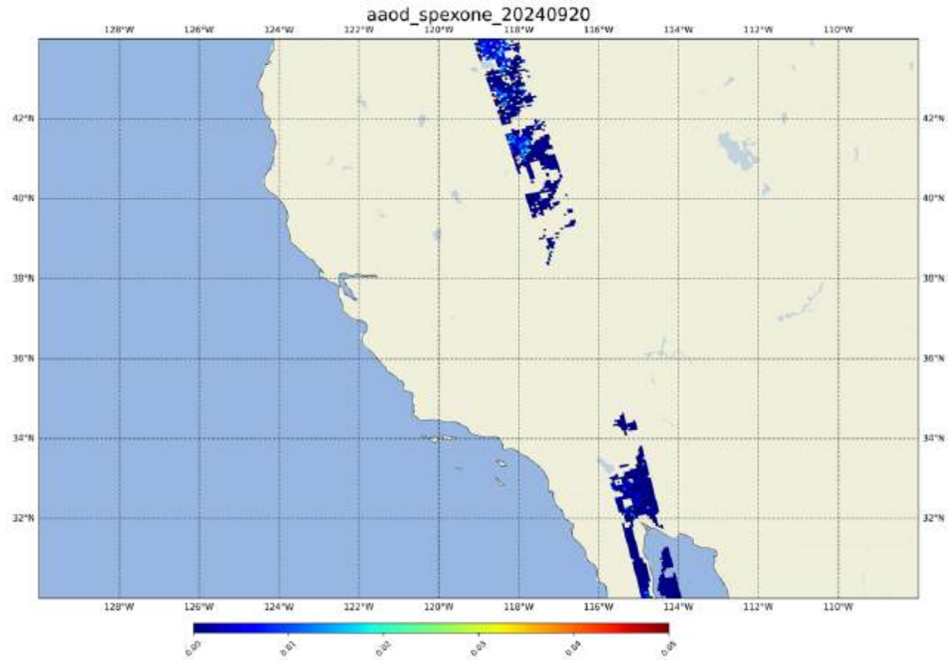
Approaching Marina Airport at 21:23 UTC; photo taken by Francesca Gallo.

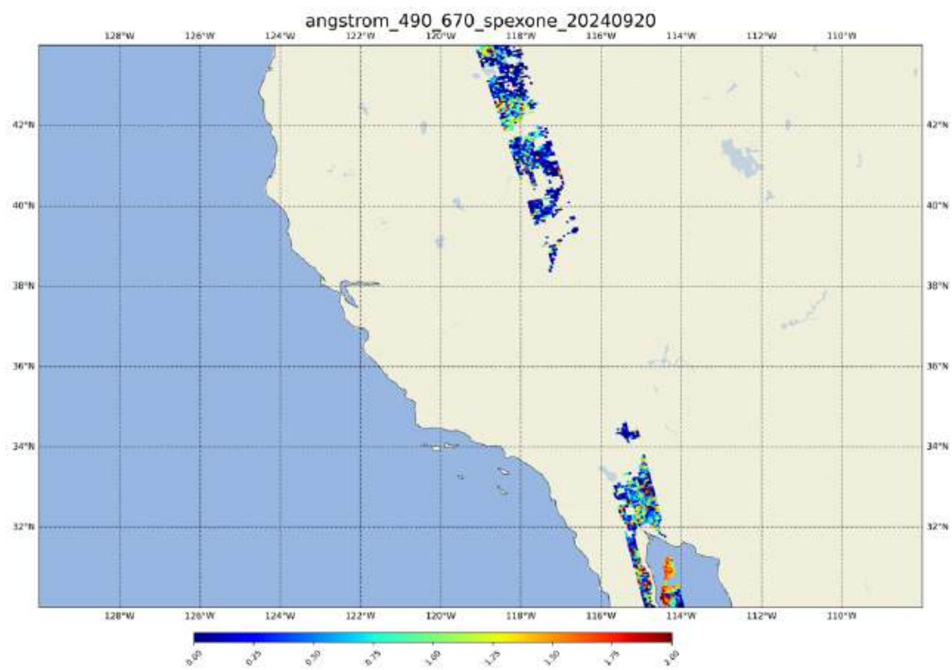
Landing at Marina Airport at 21:25:33 UTC; photo taken by Francesca Gallo.

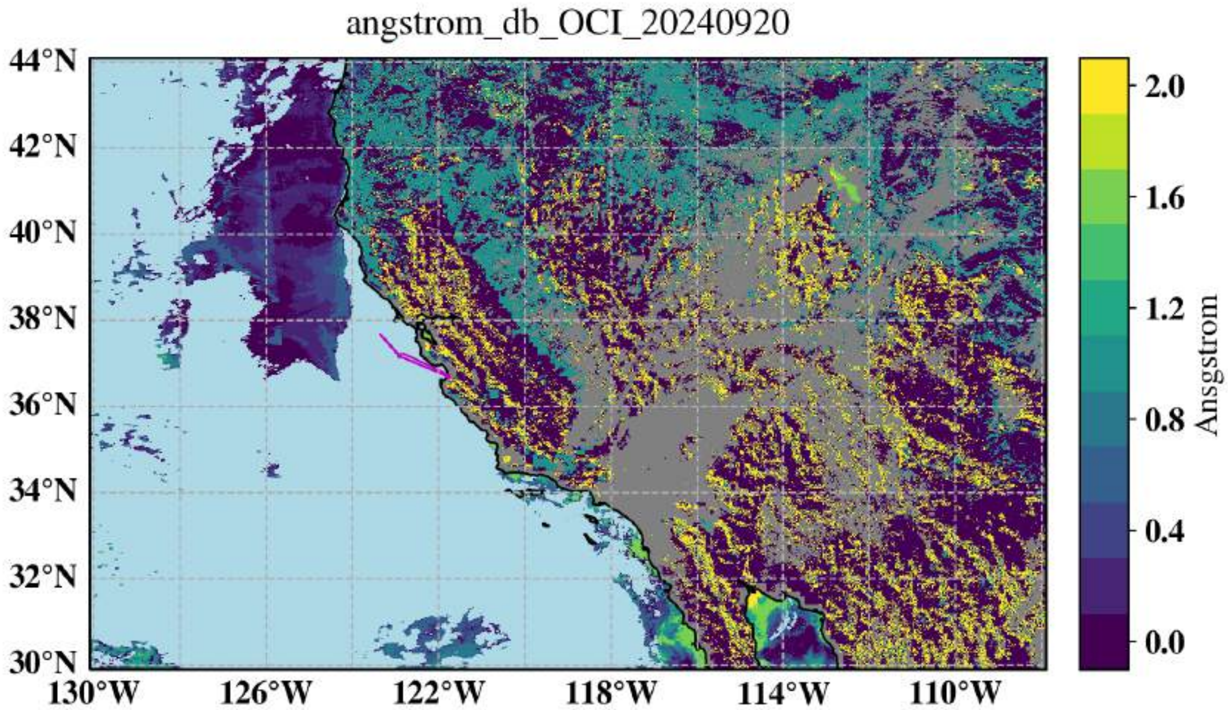
Twin Otter quicklook (Cloud liquid water content (LWC) and aerosol number from UHSAS)



PACE quicklooks



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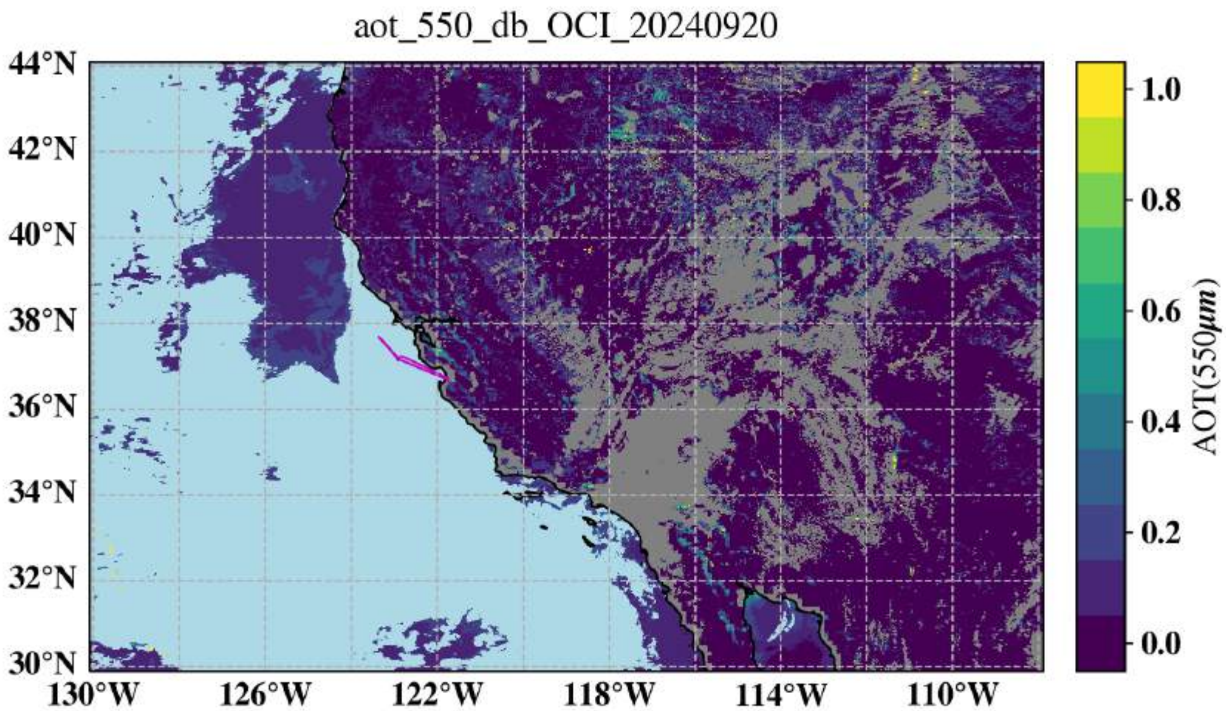
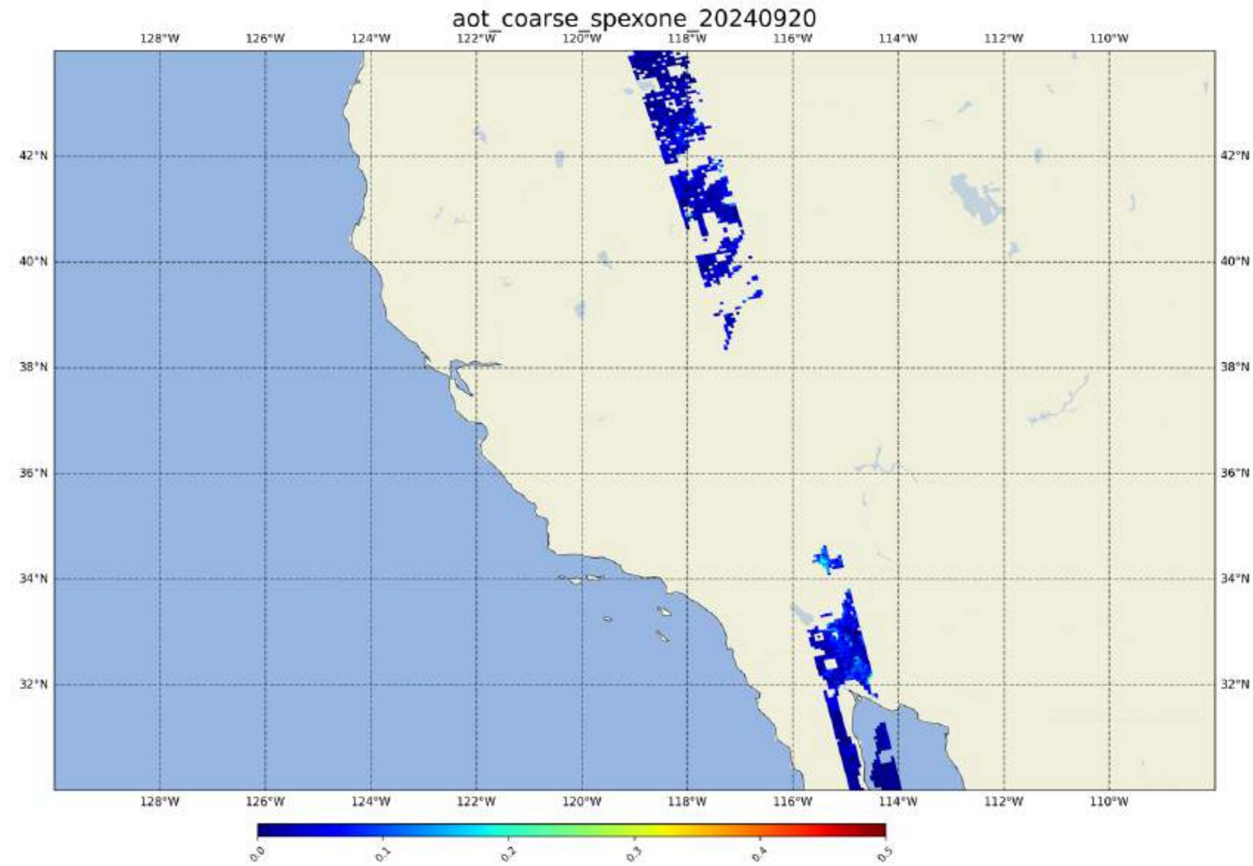
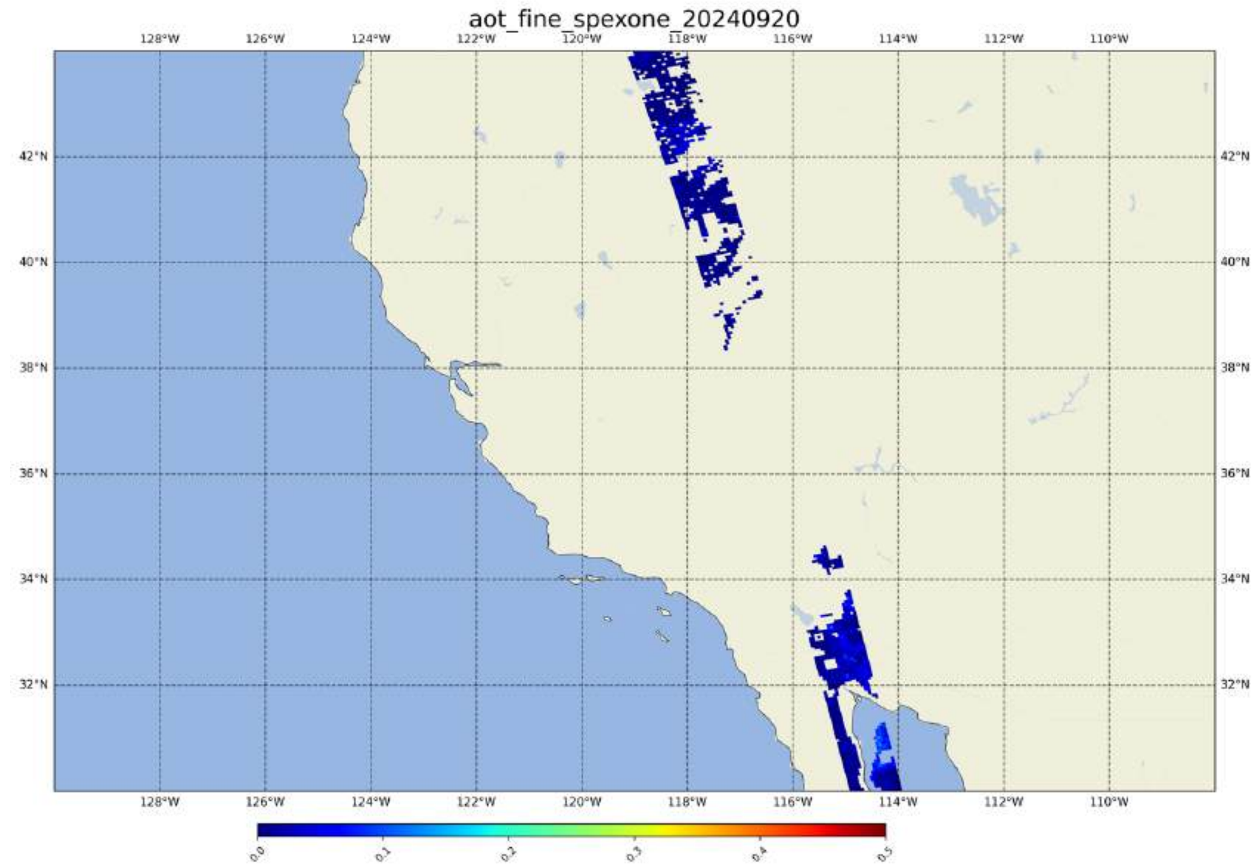
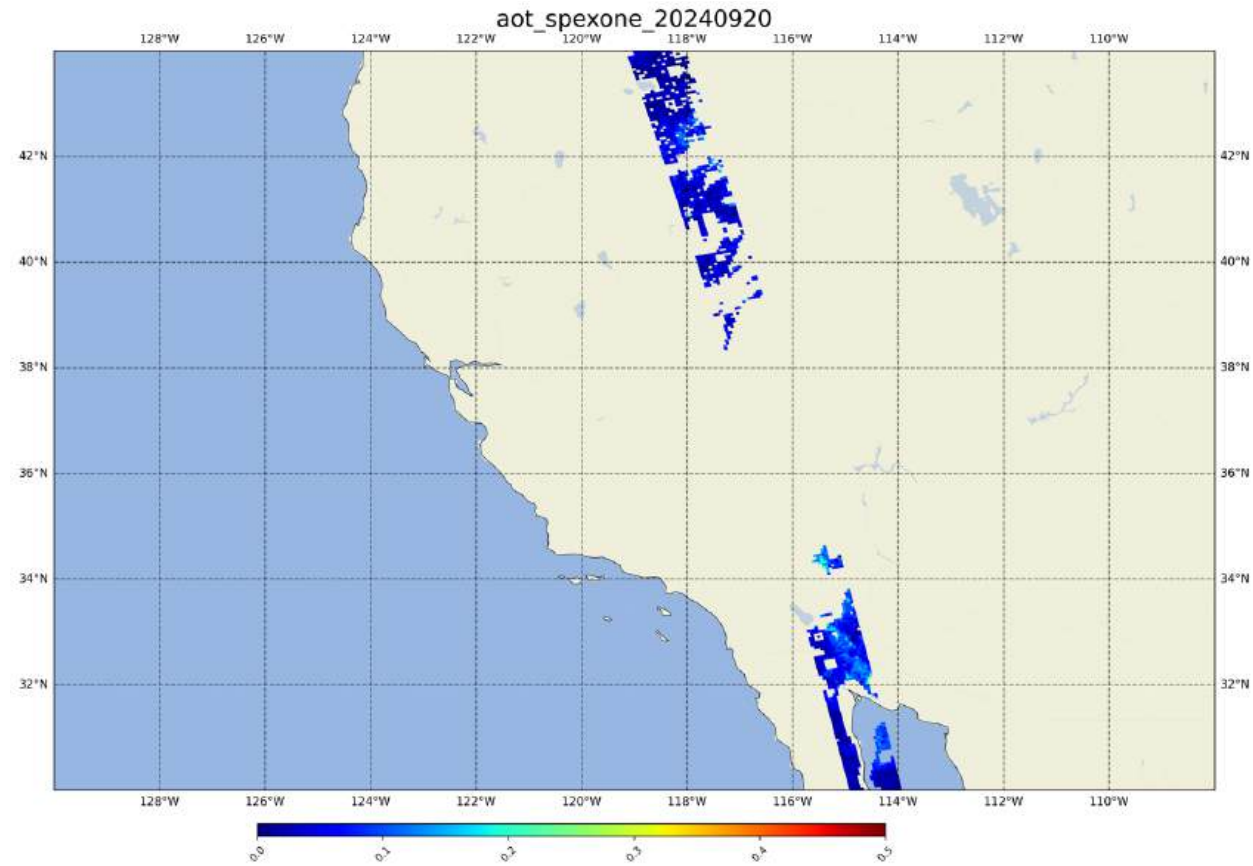
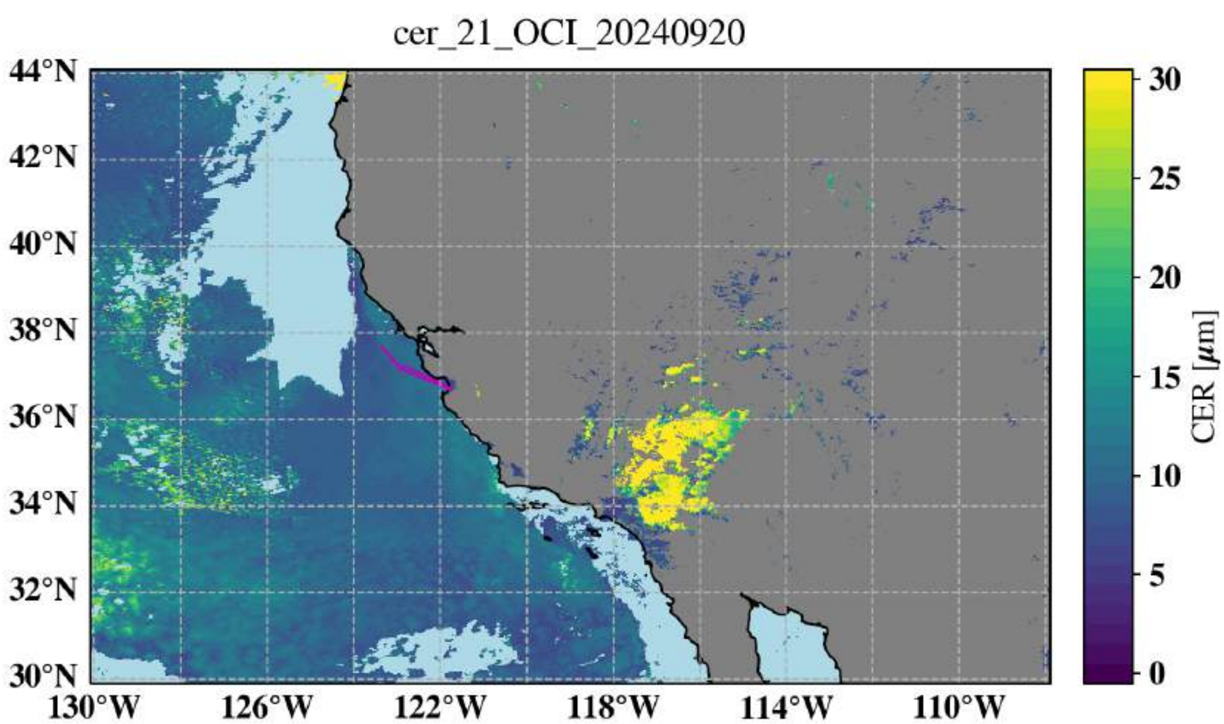
0.0
Ansgstrom

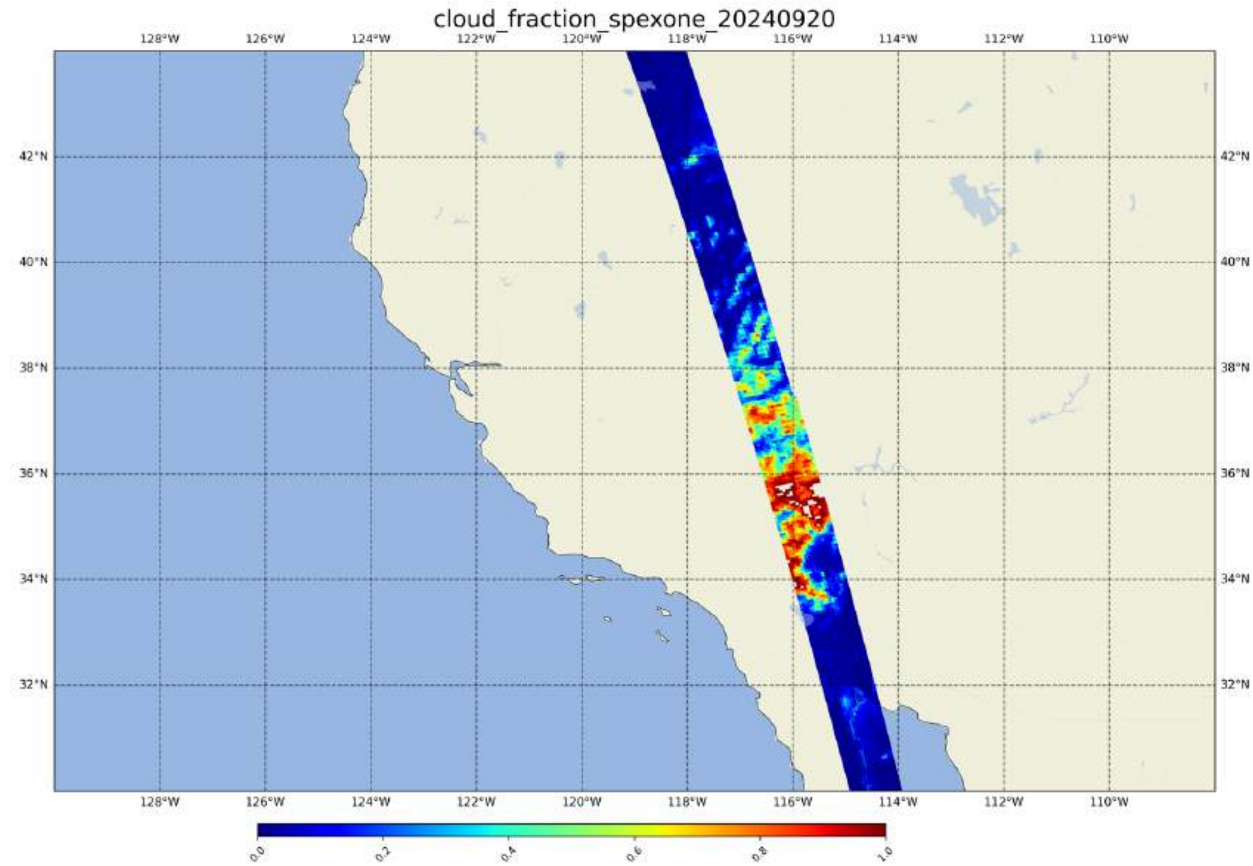

aot_550_db_OCI_20240920
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
1.0
0.8
0.6
0.4
0.2
0.0
AOT(550μm)

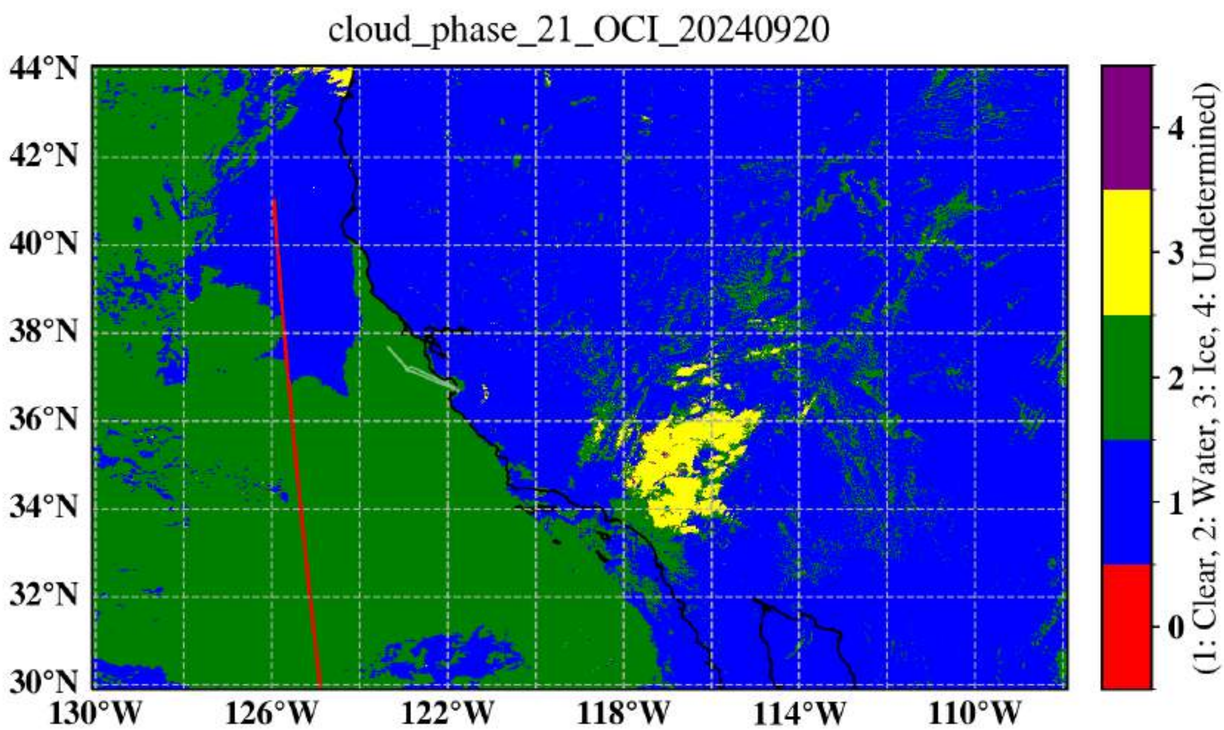

aot_coarse_spexone_20240920
128°W
126°W
124°W
122°W
120°W
118°W
116°W
114°W
112°W
110°W
42°N
40°N
38°N
36°N
34°N
32°N
0.0
0.1
0.2
0.3
0.4
0.5

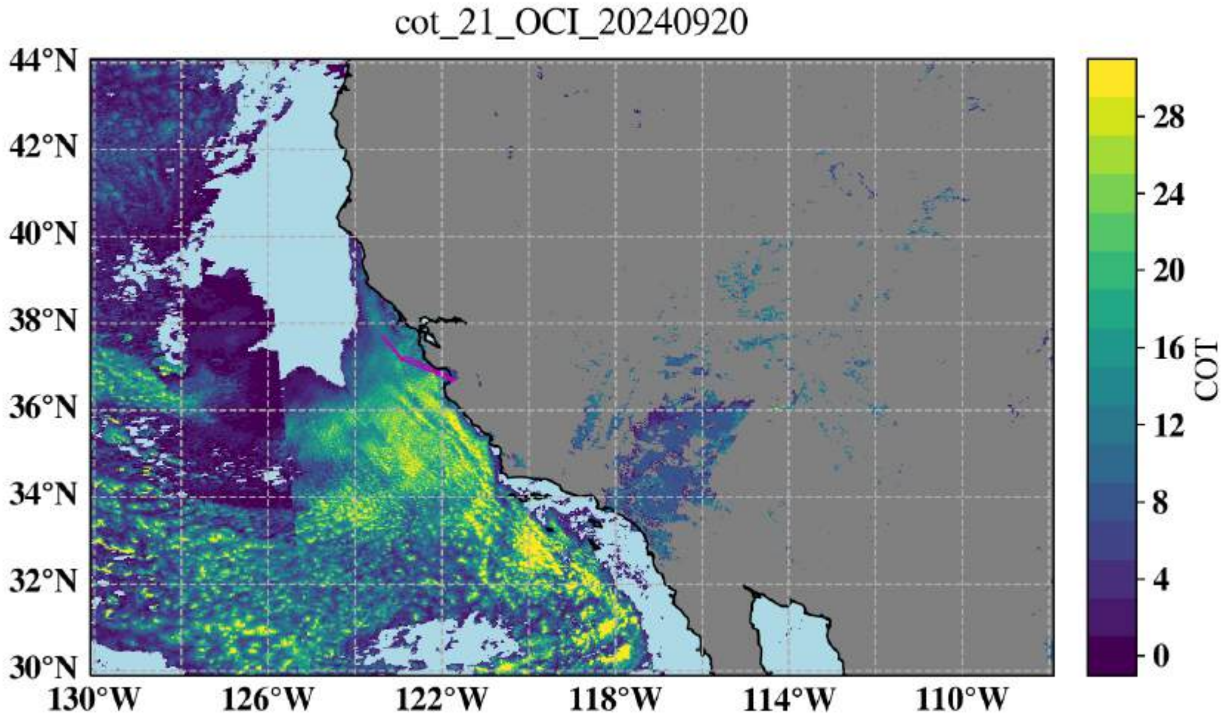

aot_fine_spexone_20240920
128°W
126°W
124°W
122°W
120°W
118°W
116°W
114°W
112°W
110°W
42°N
40°N
38°N
36°N
34°N
32°N
0.0
0.1
0.2
0.3
0.4
0.5

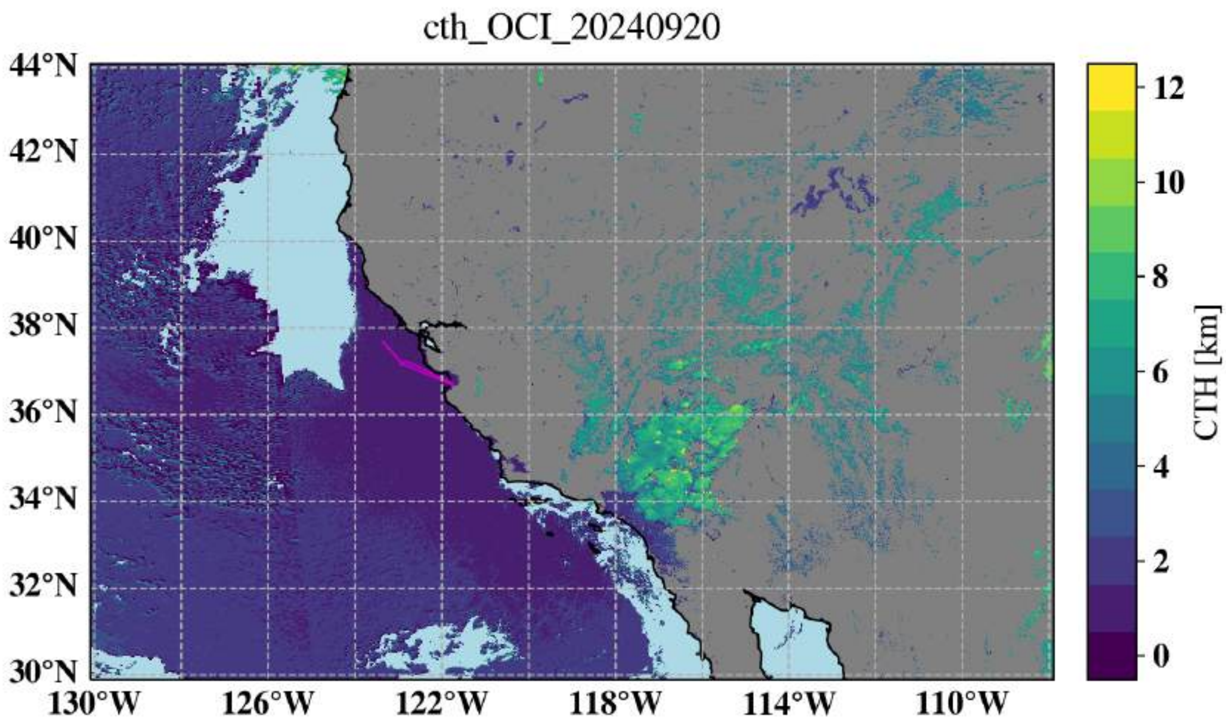

aot_spexone_20240920
128°W
126°W
124°W
122°W
120°W
118°W
116°W
114°W
112°W
110°W
42°N
40°N
38°N
36°N
34°N
32°N
0.0
0.1
0.2
0.3
0.4
0.5

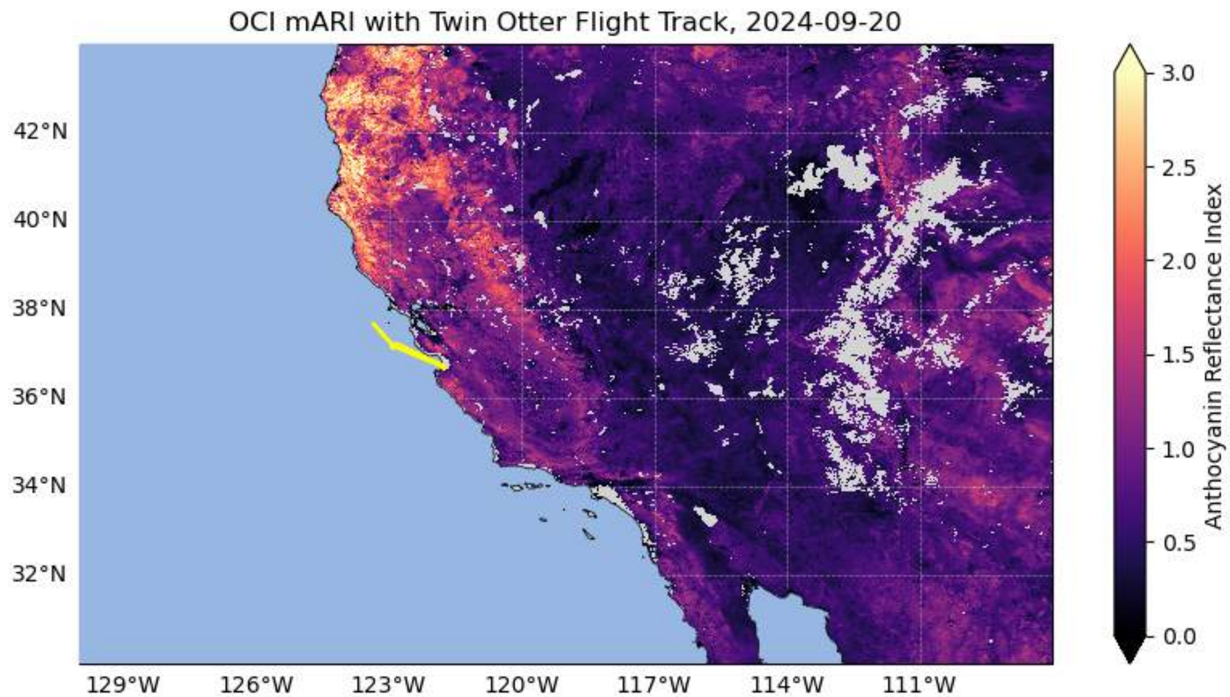

cer_21_OCI_20240920
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
CER [μm]
30
25
20
15
10
5
0

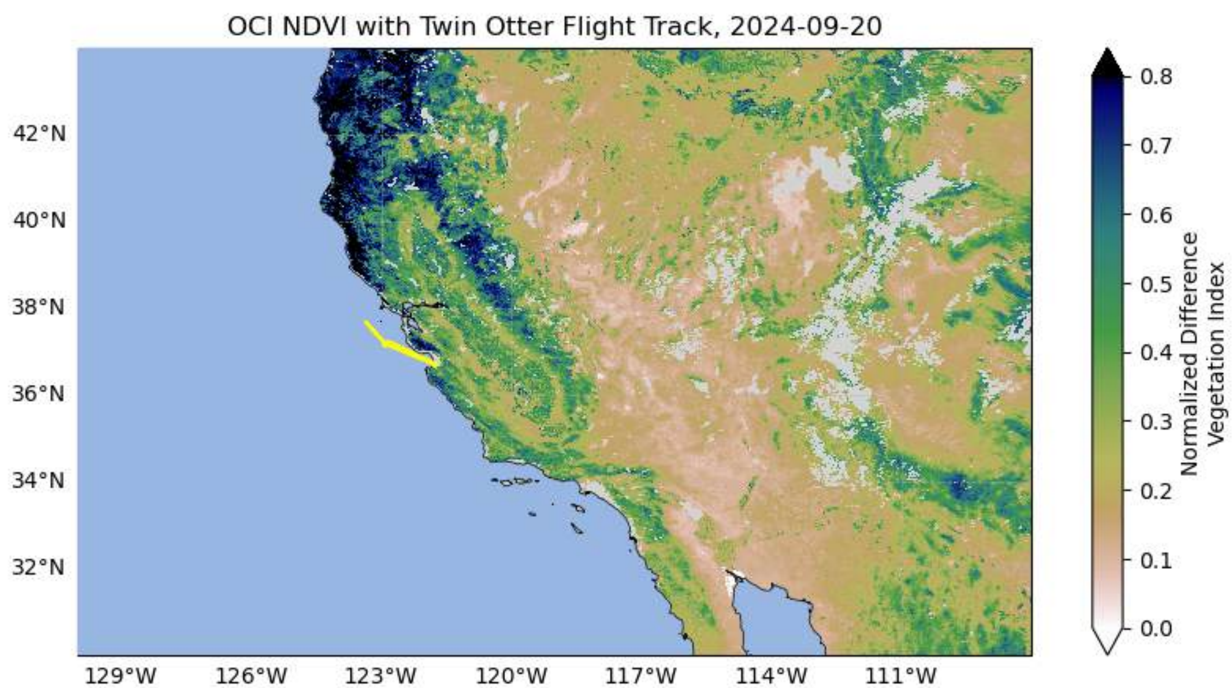

cloud_fraction_spexone_20240920
128°W
126°W
124°W
122°W
120°W
118°W
116°W
114°W
112°W
110°W
42°N
40°N
38°N
36°N
34°N
32°N
0.0
0.2
0.4
0.6
0.8
1.0


cloud_phase_21_OCI_20240920
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0
1
2
3
4
(1: Clear, 2: Water, 3: Ice, 4: Undetermined)


cot_21_OCI_20240920
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0
4
8
12
16
20
24
28
COT


cth_OCI_20240920
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
0
2
4
6
8
10
12
CTH [km]


OCI mARI with Twin Otter Flight Track, 2024-09-20
42°N
40°N
38°N
36°N
34°N
32°N
129°W
126°W
123°W
120°W
117°W
114°W
111°W
Anthocyanin Reflectance Index
3.0
2.5
2.0
1.5
1.0
0.5
0.0


OCI NDVI with Twin Otter Flight Track, 2024-09-20
42°N
40°N
38°N
36°N
34°N
32°N
129°W
126°W
123°W
120°W
117°W
114°W
111°W
Normalized Difference
Vegetation Index
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0

Twin Otter report

PACE-PAX Research Flight report 2024-09-20

Twin Otter Flight

Manifest:

Bryce Kujat (pilot)

Jeff Martin (pilot)

Michael Shook (QNC)

Francesca Gallo (QNC)

Edward Winstead (QNC)

Note: This was a planned ER2 underflight, but the ER2 scrubbed.

Take off: 12:17:48 (19:17:48 UTC) Marina Airport (OAR)

Landing: 15:43:17 (21:25:33 UTC) Marina Airport (OAR)

Duration = 2.1 hrs

Objectives: Cloud microphysics under PACE. Perform a full altitude extent spiral profile down to minimum altitude just past the ADIZ line, then porpoise through the marine stratus to obtain cloud microphysics statistics for ~30 minutes before and after the PACE overpass time. After completing the porpoising, ascend to cross the ADIZ line, then return to Marina Airport.

Summary:

After taking off, we ascended in line to 10 kft. Once we leveled off, conditions were fairly clean, with green scattering coefficient ~4Mm^{-1} and a few supermicron particles. We crossed the ADIZ line near PIRAT and began a spiral descent to 100 ft around 19:47 UTC. During the descent, we observed a gradual increase in scattering coefficient up to about 10Mm^{-1} at around 7.5 kft, before decreasing back down to around 5 Mm^{-1} at about 4.5 kft. The cloud top during the spiral was about 1.5 kft with a cloud base at around 500 ft, and a Liquid Water Content (LWC) at cloud top around 0.3 g/m^3. With no point or track requirement for the PACE underpass, we decided to porpoise north parallel to the ADIZ line. Due to the focus on microphysics and the minimal extinction above cloud top, we chose to sample for ~10 secs. above and below cloud during the porpoises. Cloud top height descended from ~1500 ft at the south end of our track to ~1250 ft at the north end; cloud bases were quite ragged, with bases ranging from ~500 ft at the south end to ~200 ft at the north end. Cloud top LWC remained fairly constant at around ~0.35g/m^3 and up to 0.4g/m^3, with LWC decreasing with altitude (LWC ~0.25g/m^3 at 1.0 kft, ~0.12 ~0.25g/m^3 at ~800 ft, and ~0.18 ~0.25g/m^3 at 650 ft) Several large cargo ships were observed in the area. Above-cloud scattering coefficients were relatively constant at around 10 Mm^{-1}, with below-cloud scattering coefficients at around 25 Mm^{-1} and higher hygroscopicity. We turned to head back south along the same track around 20:33 UTC, with conditions consistent with previous observations. Porpoising concluded at 20:56 UTC, when we ascended to 4.5 kft to cross the ADIZ line and return to Marina. No missed approaches were possible at the tower due to local weather.

Passing Marina Airport Tower before taking off at 19:41UTC; photo taken by Francesca Gallo.

Cloud top over Salinas after taking off at 19:19UTC (~1600ft) ; photo taken by Francesca Gallo.

Below cloud while porpoising north parallel to the ADIZ line at 20:20 UTC at ~600ft (Sca ~25Mm^{-1}) ; photo taken by Francesca Gallo.

Approaching Marina Airport at 21:23 UTC; photo taken by Francesca Gallo.

Landing at Marina Airport at 21:25:33 UTC; photo taken by Francesca Gallo.

R/V Shearwater report

PACE-PAX R/V Shearwater day report

Date: 09/20/2024

Creator: Michael Ondrusek

Cruise ID: RF0920-RS

Sailed out: 15:54 UTC

Back in port: UTC ()

Today, the ship occupied three stations. Note that planned ER-2 overflights were canceled after the departure of R/V Shearwater from the dock.

Station #25 34° 15.188', -119° 48.275' , arrival 16:50 UTC →departure 17:13 UTC

Arrival photo:

Departure photo (departure location - 34° 15.302', -119° 48.158')

Station #26 34° 16.681' N, - 119° 40.640', arrival 18:01 UTC → departure 19:38 UTC

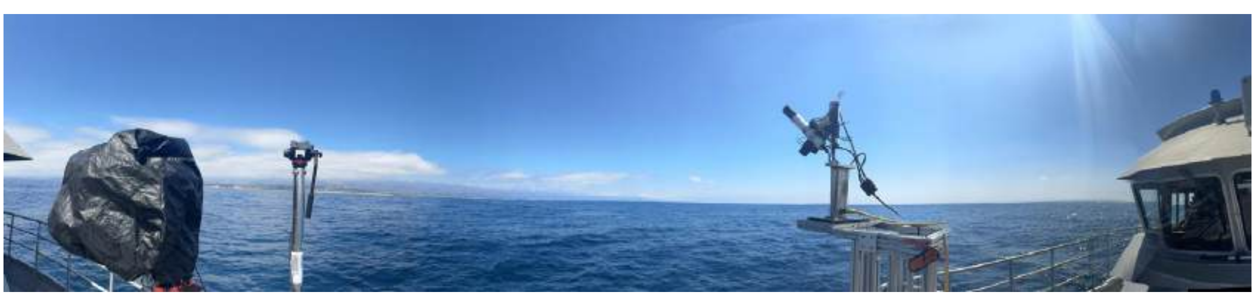
Arrival photo:

Departure photo: (34° 22.557', 119° 56.966')

Station #27 34° 21.636', 119° 43.193', arrival 20:23 UTC → departure 21:47 UTC

PACE overpass at 20:21

Arrival photo:



Departure photo: (34° 21.887’,- 119° 43.463’)

Tomorrow, RV Shearwater will

Ship plans through the next 3 days…

System Status…

All good

Group Status…

All great

PACE-PAX research report 2024/09/22

Compiled by Kirk Knobelspiesse, Ivona Cetinić, Brian Cairns, Michael Ondrusek, 2024/09/28
Reviewed by Samuel LeBlanc

ER2 + Shearwater + HyperNAV in attempt to combine observations outside the Santa Barbara channel. Most likely unsuccessful due to clouds. This was the last chance at observations in the restricted flight area where the HyperNAV was located, which was why it was attempted (unsuccessfully) in potentially cloudy conditions. In the Central Valley, ER2 and Twin Otter coordinate for observations of smoke+dust, plus an overpass of Railroad Valley by the ER2.

ER-2
Take off: 16:30
Landing: 22:54
Pilot: Dean Neeley, mobile: Kirt Stallings

Twin Otter
Take off: 10:31:30 (17:31:30 UTC)
Landing: 13:59:17 (20:59:17 UTC)
Duration = 3.5 hrs.
Manifest: Bryce Kujat (pilot), Jeff Martin (pilot), Michael Shook (QNC), Ed Winstead (QNC), Francesca Gallo (QNC)
See end for full Twin Otter report

R/V Shearwater
Mission Scientist: Michael Ondrusek
Sailed out: 15:33 UTC
Back in port: 00:44 (09/22)UTC
See end for full R/V Shearwater report

R/V Blissfully
Operations concluded

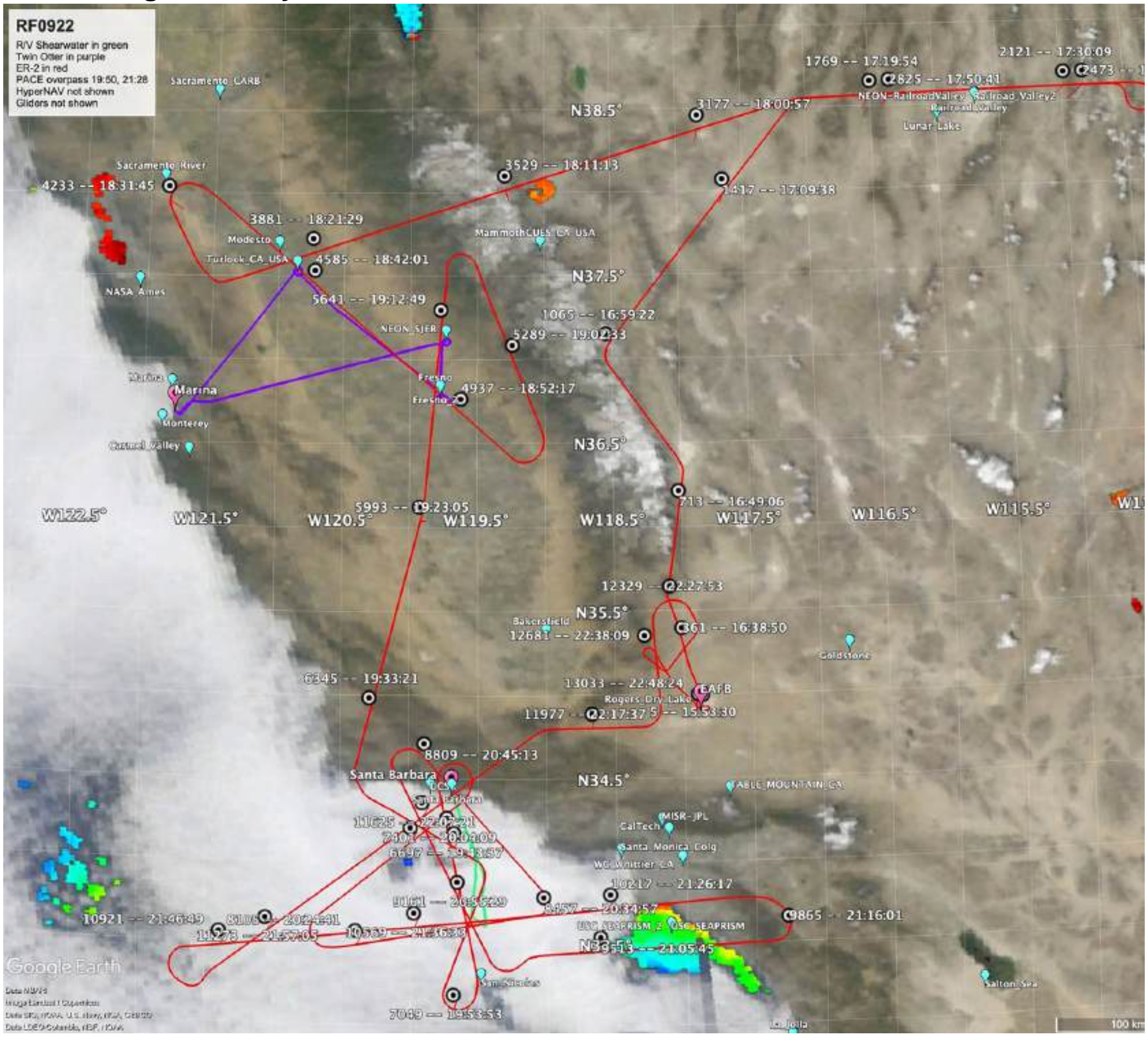
PACE
19:50, 21:28, OCI swath only

EarthCARE
Far from operations area and high surface winds, not targeted

Gliders
Operational

HyperNAV
Operational

Overall image summary



Note: not shown is the PACE tracks outside of range

Validation Traceability Matrix itemized objectives

VTM elements in **black** satisfied, **blue** partially satisfied, red to be confirmed

Time UTC	Platform	VTM(hrs)	
15:33	RS		Shearwater departs
16:30	ER2		Takeoff. 15min delay
17:25	ER2	1a(0.5), 1d(0.5), 4a(0.5)	ER-2 over Railroad Valley. No Clouds. AERONET AOD(500)=0.055
17:31	TO		Takeoff
17:45	ER2	1a(0.5), 1d(0.5), 4a(0.5)	ER-2 over Railroad Valley. No Clouds. AERONET AOD(500)=0.056
18:09	TO, ER2	1d(1.5)	Begin spiral down over Turlock, ER2 overpass at 18:23. end at 18:31
18:03	ER2	1d(0.5)	ER-2 over Turlock AERONET site, AOD(500)=0.09

18:17	RS, ER2	4c(0.5)	Shearwater on station #30 for first ER-2 overpass and PACE overpass (19:41). Station ends at 19:58. Fully cloudy, not scored.
18:44	TO, ER2	1d(1.5), 6c(1.5)	Long leg in central valley ,18:44 over Merced, with ER-2 overhead.
19:11	TO	1d(1.5), 6c(1.5)	Spiral up at Fresno, AOD(500)=0.12. Variable angstrom exponent.
19:13	ER2	1a(0.5), 1d(0.5)	ER-2 over NEON_SJER AERONET site, AOD(500)=0.11
19:41	ER2, gliders	4c(0.5)	ER-2 over gliders. Cloudy. Scored for cloud reference.
19:14	ER2, TO	1d(0.5)	ER-2 overflight of TO flight path (19:40) between Fresno and NEON_SJER (AOD~0.11) – agricultural dust
19:44	TO, PACE-O	1d(1.5), 6c(1.5)	Spiral down over NEON_SJER AERONET AOD(500)=0.11, site during PACE-O overpass.
19:50	**PACE**		**PACE overpass east of observed area**
19:50	ER2	1e(1.0)	ER2 over Shearwater, but fully cloudy. Scored for cloud retrievals because in PACE-O swath for overpass.
20:21	RS, ER2	4c(0.5)	Shearwater on station #31. HyperNAV surfaces nearby at 20:13. ER-2 overpass. Cloudy. Scored for cloud reference.
20:31	ER2	4c(0.5)	Another attempt at overpass of Shearwater, still cloudy .Scored for cloud reference.
20:55	ER2	4c(0.5)	Another attempt at overpass of Shearwater, still cloudy, Scored for cloud reference.
20:59	TO		Twin Otter lands.
21:10	ER2		ER-2 over USC_SeaPRISM in cloud free conditions, however, SeaPRISM is non-functional.
21:31	ER2	4c(0.5)	Another attempt at overpass of Shearwater, still cloudy. Scored for cloud reference.
21:42	RS		Returns
22:54	ER2		Lands

PACE-O: within swath of PACE's OCI instrument
PACE-OH: within swath of PACE's OCI and HARP2 instruments
PACE-OHS: within swath of PACE's OCI, SPEXone and HARP2 instruments
TO: Twin Otter
RB: R/V Blissfully
RS: R/V Shearwater

Assessment:

- of objectives observed. Successful coordination between ER-2 and TO not scored highly because aerosol over land objectives have largely been met, however, the long run down the valley is a different version of this and useful. Many attempts at overflying HyperNAV and Shearwater, but clouds ruined the day. Salvaged somewhat in that those data can be used to validate bright surfaces, low polarization (4c)
- Top remaining objectives (score above 6.0): PACE aerosol in narrow swath (3a,b)

PACE-PAX progress tracking

Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 9/16	Fractional success 9/17	Fractional success 9/18	Fractional success 9/19	Fractional success 9/20	Fractional success 9/21	Fractional success 9/22	Total success	Remaining score
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	5.5	0.0%	**39.3%**	0.0%	0.0%	0.0%	0.0%	**3.2%**	**0.971**	**0.2**
	b	Ocean radiometric parameters	10	8.0	17.0	0.0%	**2.6%**	**0.5%**	**0.4%**	**0.1%**	0.0%	0.0%	**0.995**	**0.0**
	c	Aerosol parameters over the ocean	12	8.0	12.0	0.0%	**4.1%**	**1.1%**	**1.2%**	**0.6%**	0.0%	0.0%	**0.980**	**0.2**
	d	Aerosol parameters over land	12	8.0	12.5	0.0%	**0.1%**	0.0%	**0.0%**	0.0%	0.0%	**0.1%**	**0.999**	**0.0**
	e	Cloud parameters	12	8.0	4.0	0.0%	0.0%	0.0%	0.0%	**9.5%**	0.0%	**2.5%**	**0.815**	**2.2**
	f	Ocean surface parameters	1	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.000	**1.0**
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.354**	**6.5**
	b	Aerosol parameters over land (PACE)	10	8.0	2.0	0.0%	**17.0%**	0.0%	0.0%	0.0%	0.0%	0.0%	**0.403**	**6.0**
	c	Cloud parameters (PACE)	5	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.713**	**1.4**
	d	Aerosol parameters (EarthCARE)	8	4.0	4.5	0.0%	**28.2%**	0.0%	**7.9%**	0.0%	0.0%	0.0%	**0.826**	**1.4**
	e	Cloud parameters (EarthCARE)	8	4.0	1.0	0.0%	**19.5%**	0.0%	0.0%	0.0%	0.0%	0.0%	**0.313**	**5.5**
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	2.0	5.0	0.0%	**49.3%**	0.0%	0.0%	0.0%	0.0%	**3.0%**	**0.953**	**0.3**
	b	Validate large reflectances with high polarization	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.393**	**3.6**
	c	Validate large reflectances with low polarization	6	2.0	2.5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**15.9%**	**0.936**	**0.4**
	d	Overfly vicarious calibration sites	6	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.268**	**4.4**
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**1.000**	**0.0**
	b	High aerosol loads over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.393**	**2.4**
	c	Multiple aerosol layers	1	2.0	4.5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**	**1.000**	**0.0**
	d	Aerosol under thin cirrus	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.000	**2.0**
	e	Aerosol above liquid phase cloud	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.826**	**0.7**
	f	Broken clouds with complex structure	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.528**	**1.9**
	g	Dust aerosols over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.430**	**2.3**
	h	Aerosol and ocean parameters over turbid waters	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.790**	**0.4**
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	5.0	0.0%	**86.5%**	**5.3%**	0.0%	0.0%	0.0%	0.0%	**0.918**	**0.3**
	k	Smoke aerosols over ocean	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.713**	**0.3**
		total:	**150**	**98**	**75.5**	**0.0%**	**10.6%**	**0.3%**	**0.5%**	**0.8%**	**0.0%**	**1.1%**	**0.710**	
														total
				ER-2 flight hours	15.8	0	0	0	0	0	0	0	0	**15.8**
				TO flight hours	11.2	0	0	0	0	0	0	0	0	**11.2**
				Shearwater days	4	0	0	0	0	0	0	0	0	**4**

PACE-PAX overall objectives satisfied: 0.710

Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

https://www-air.larc.nasa.gov/missions/pacepax/index.html

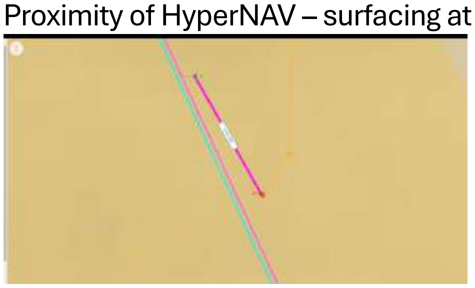
R/V Shearwater photos

Station #30 33 40.879’, -119° 33.409’ , arrival 18:17 UTC →departure 19:48 UTC
ER-2 overpass at 19:50, same as PACE first overpass
Just after departure another overpass at 19:58 UTC

Arrival photo:

Departure photo (departure location - 33° 37.427’, -119° 29.292’)

Station #31 33 37.301’, 119° 28.080’, arrival 20:21 UTC → departure 21:42 UTC
Proximity of HyperNAV – surfacing at 20:13:50.



ER-2 overflight at 20:59

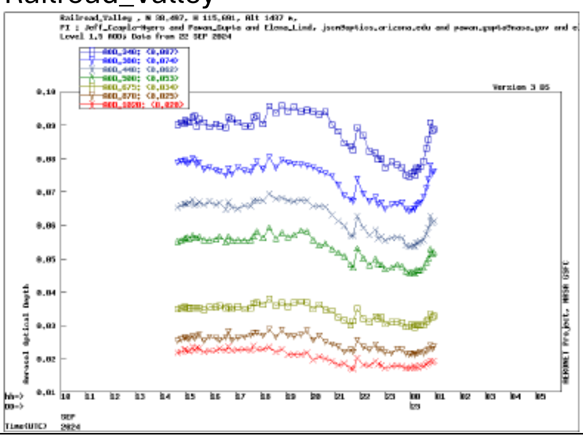
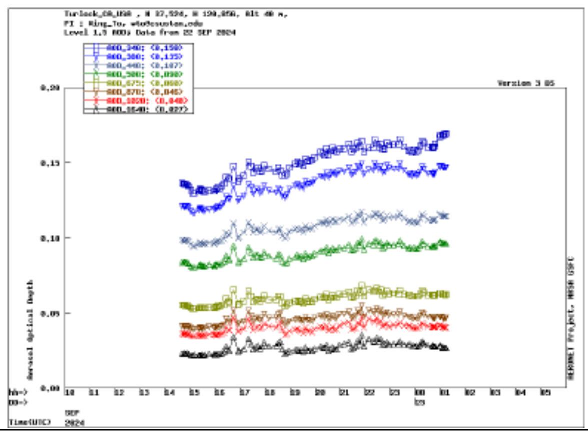
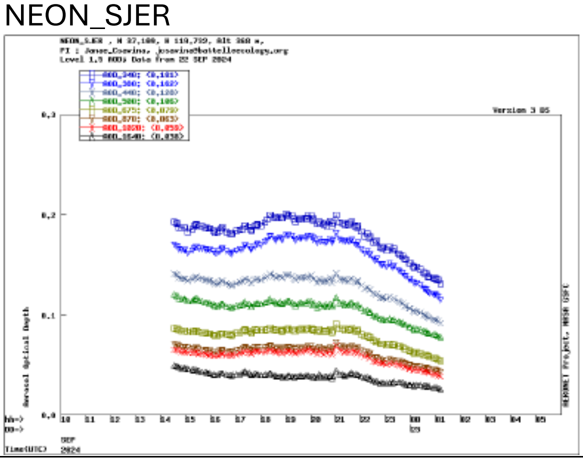
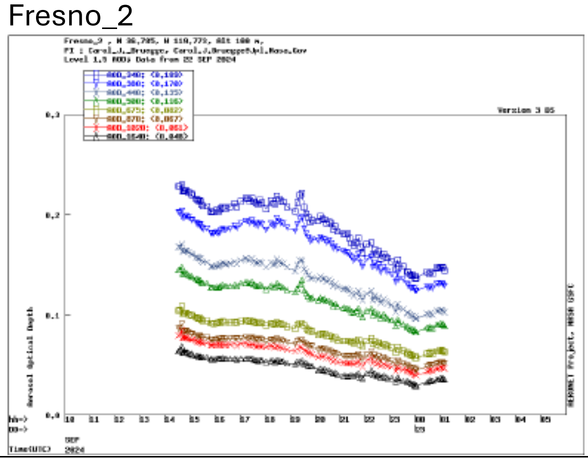
Arrival photo:

Departure photo: (33 37.176’, -119° 26.766’)

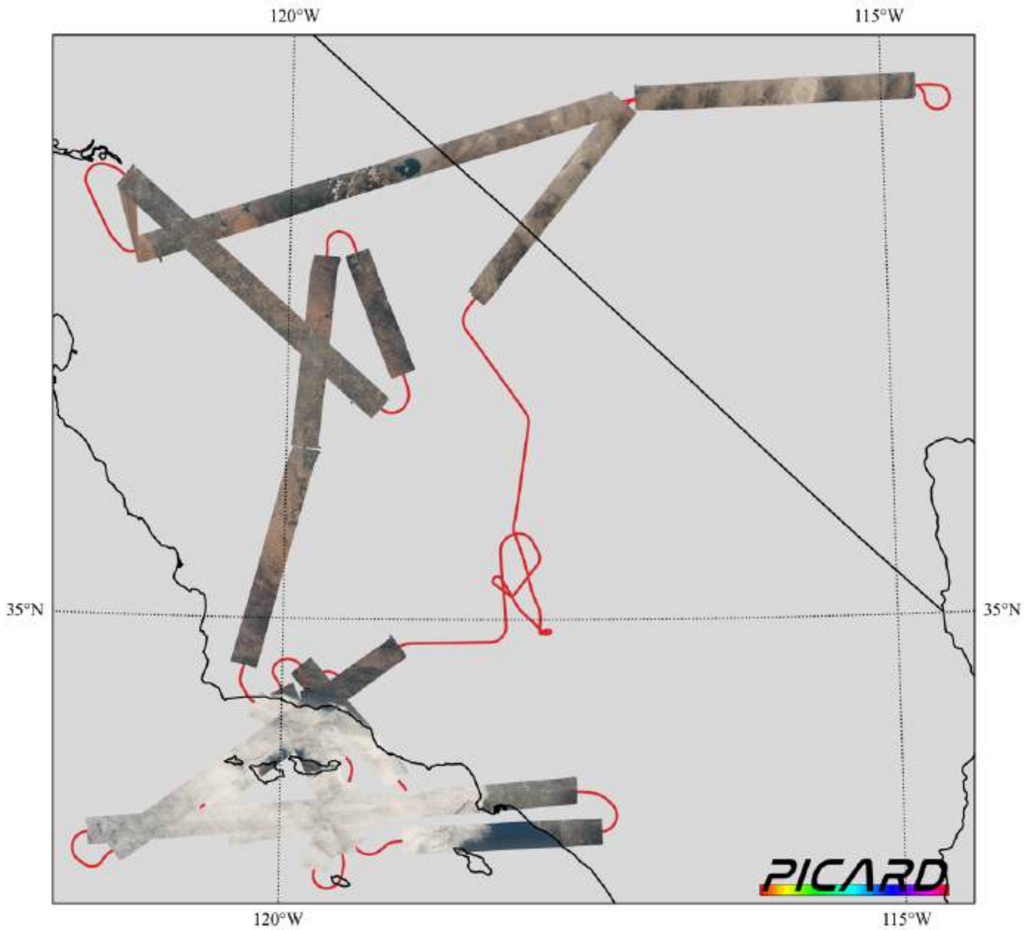
Twin Otter photos

ER-2 co-ordination was extremely good and widespread dust was observed throughout the flight in the boundary layer. One source of dust was tree shaking operations, see photos in full report at end.

AERONET plots

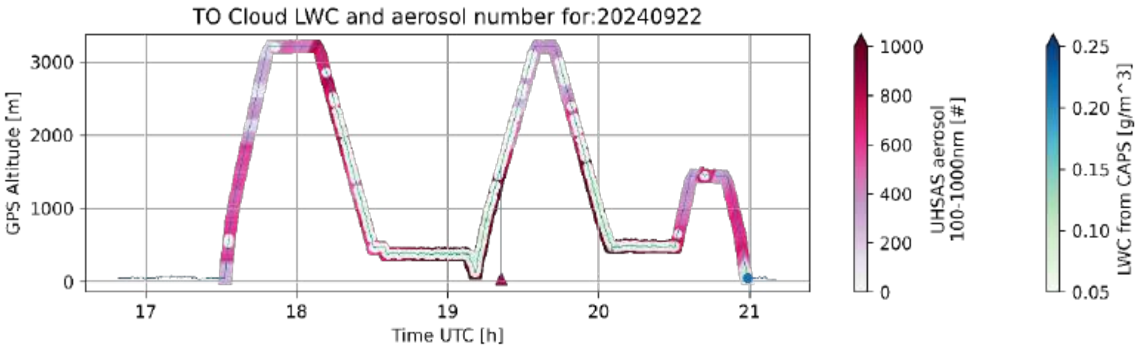
Railroad_Valley 	Turlock 
NEON_SJER 	Fresno_2 
USC_SeaPRISM Not operational	

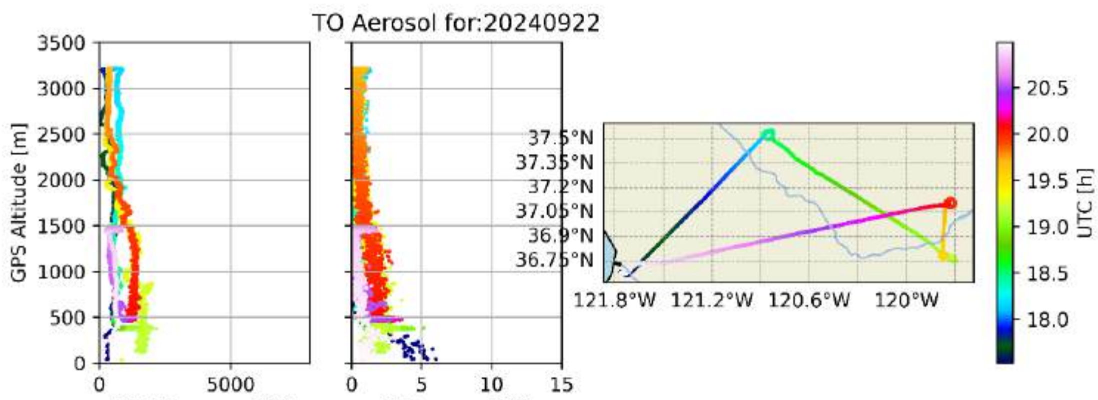
PICARD quicklooks



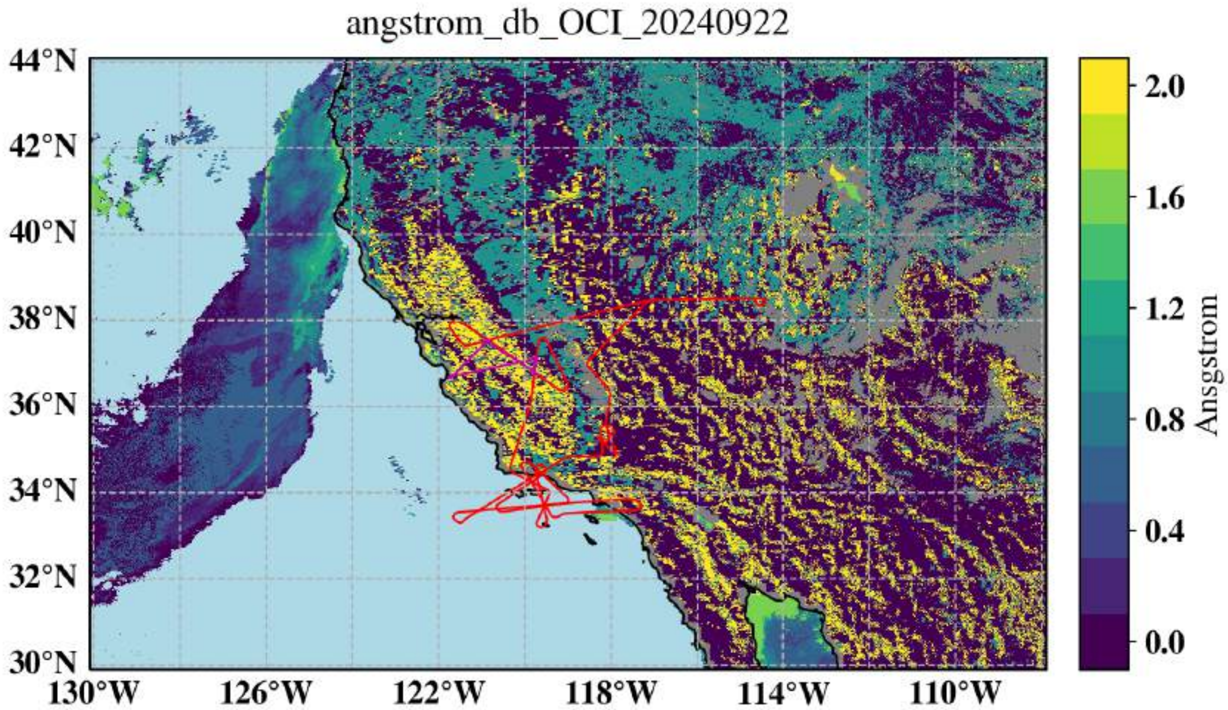
Pushbroom Imager for Cloud and Aerosol Research and Development
PACE-PAX, NASA Armstrong Flight Research Center
22 September 2024

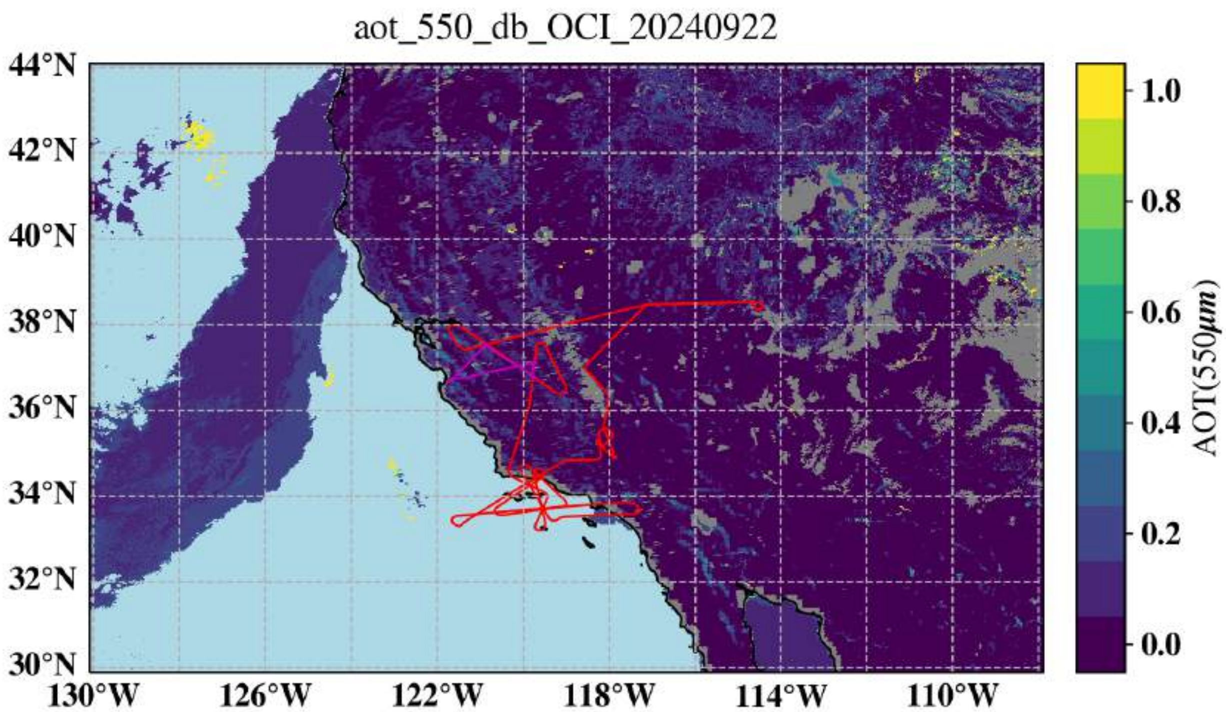
TO quicklooks

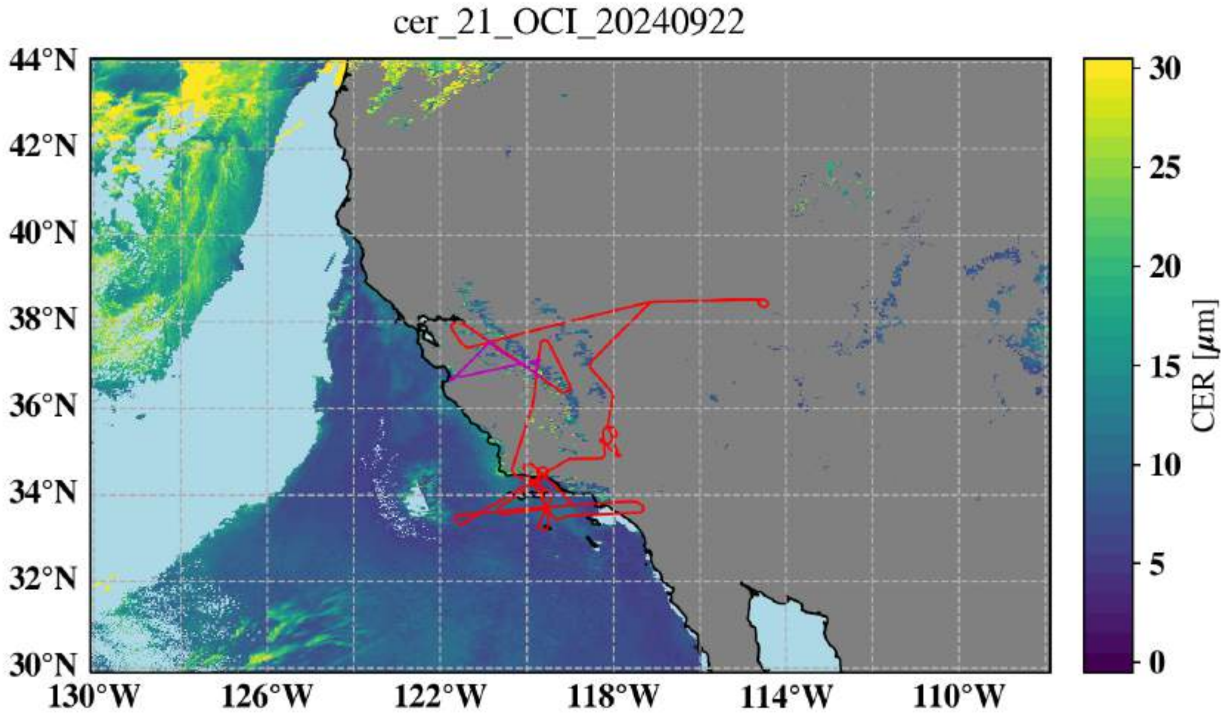




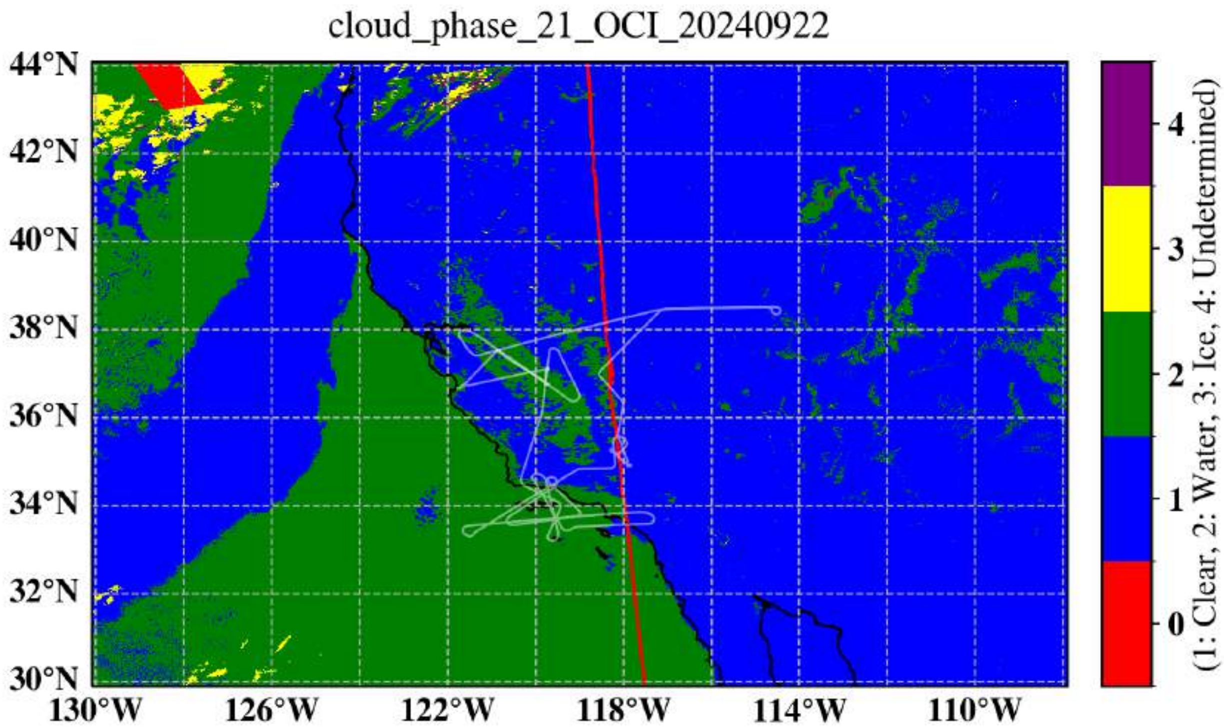
PACE quicklooks



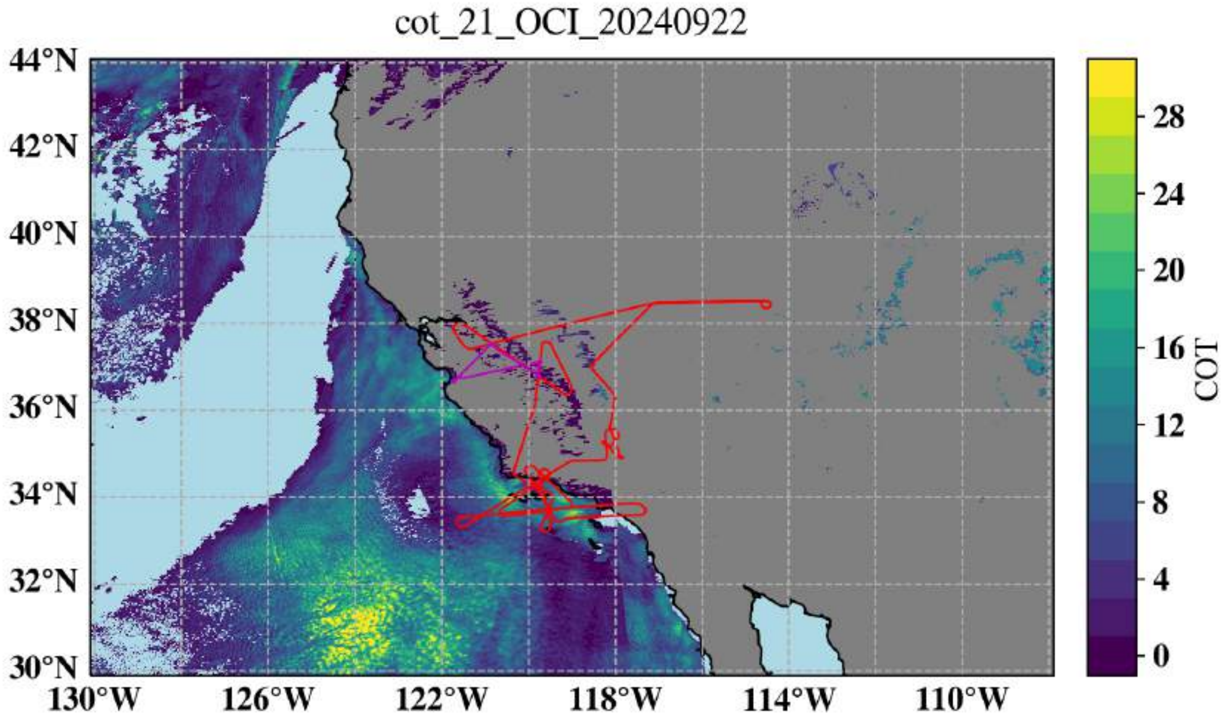


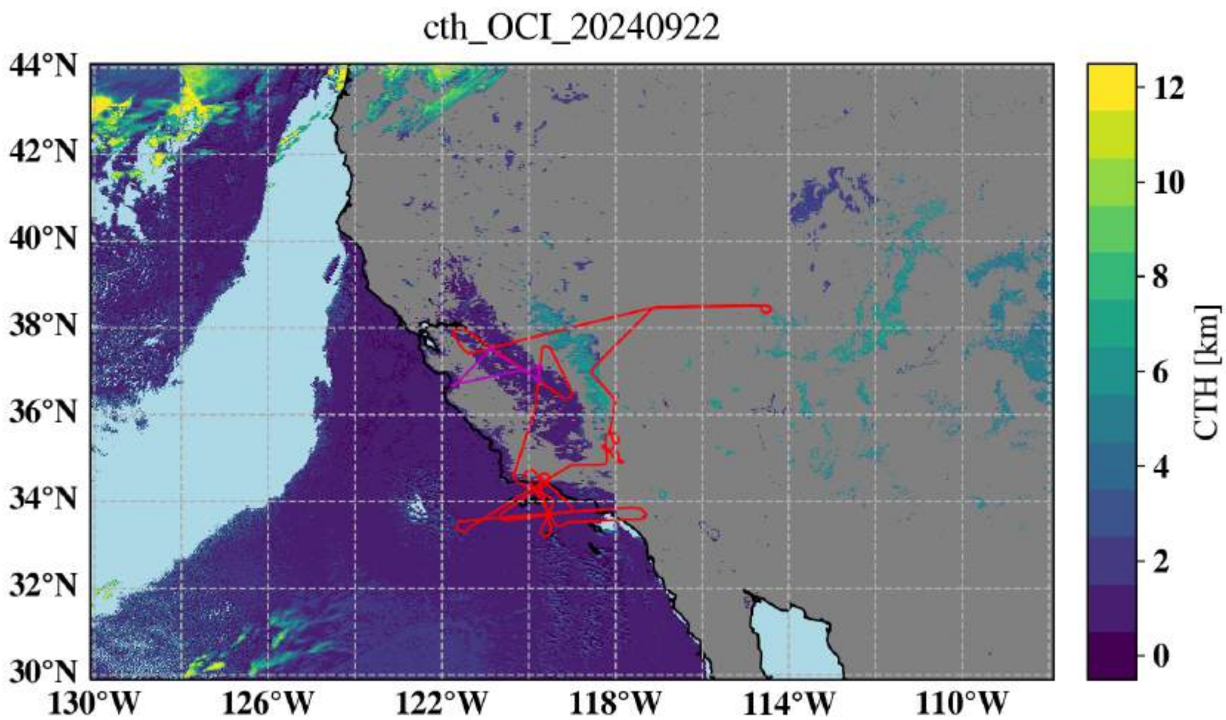


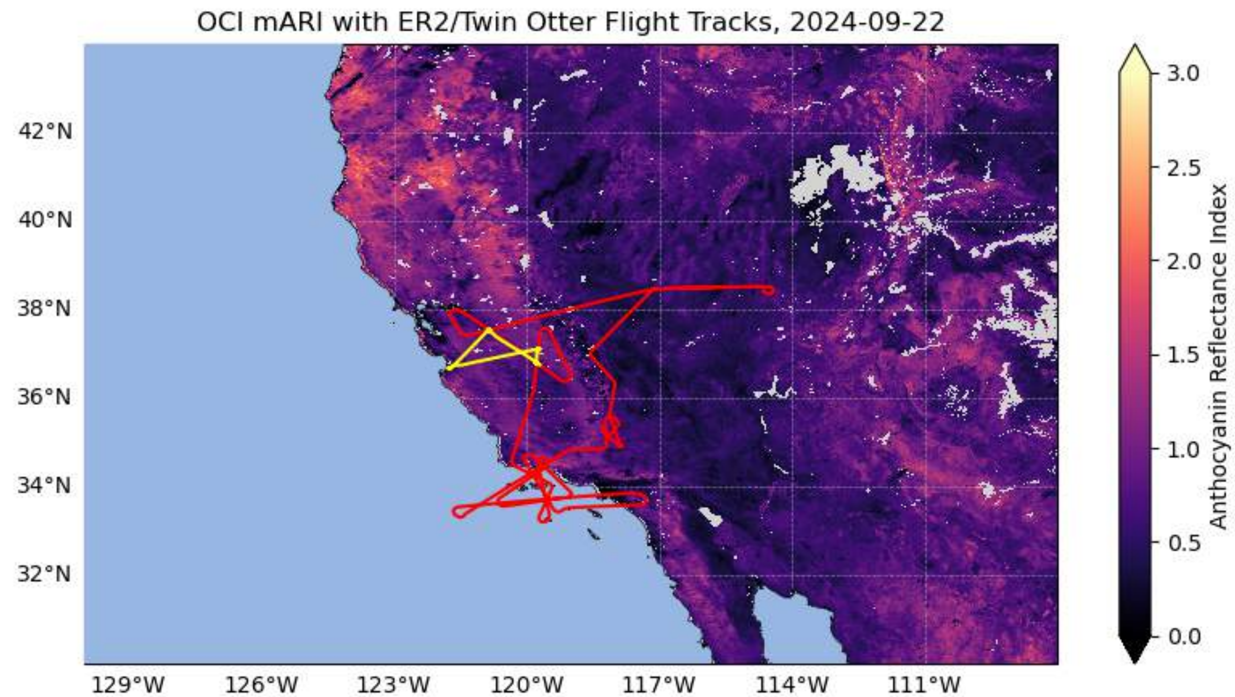
cer_21_OCI_20240922
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
CER [μm]
30
25
20
15
10
5
0

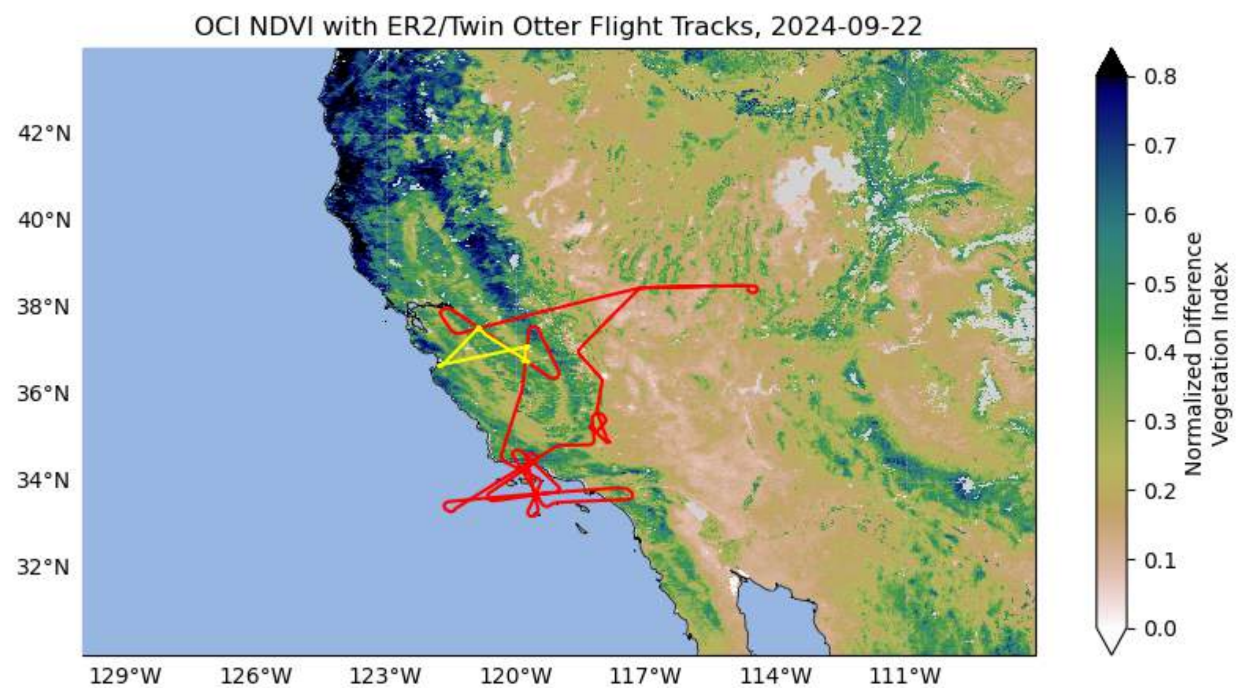


cloud_phase_21_OCI_20240922
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
(1: Clear, 2: Water, 3: Ice, 4: Undetermined)
4
3
2
1
0

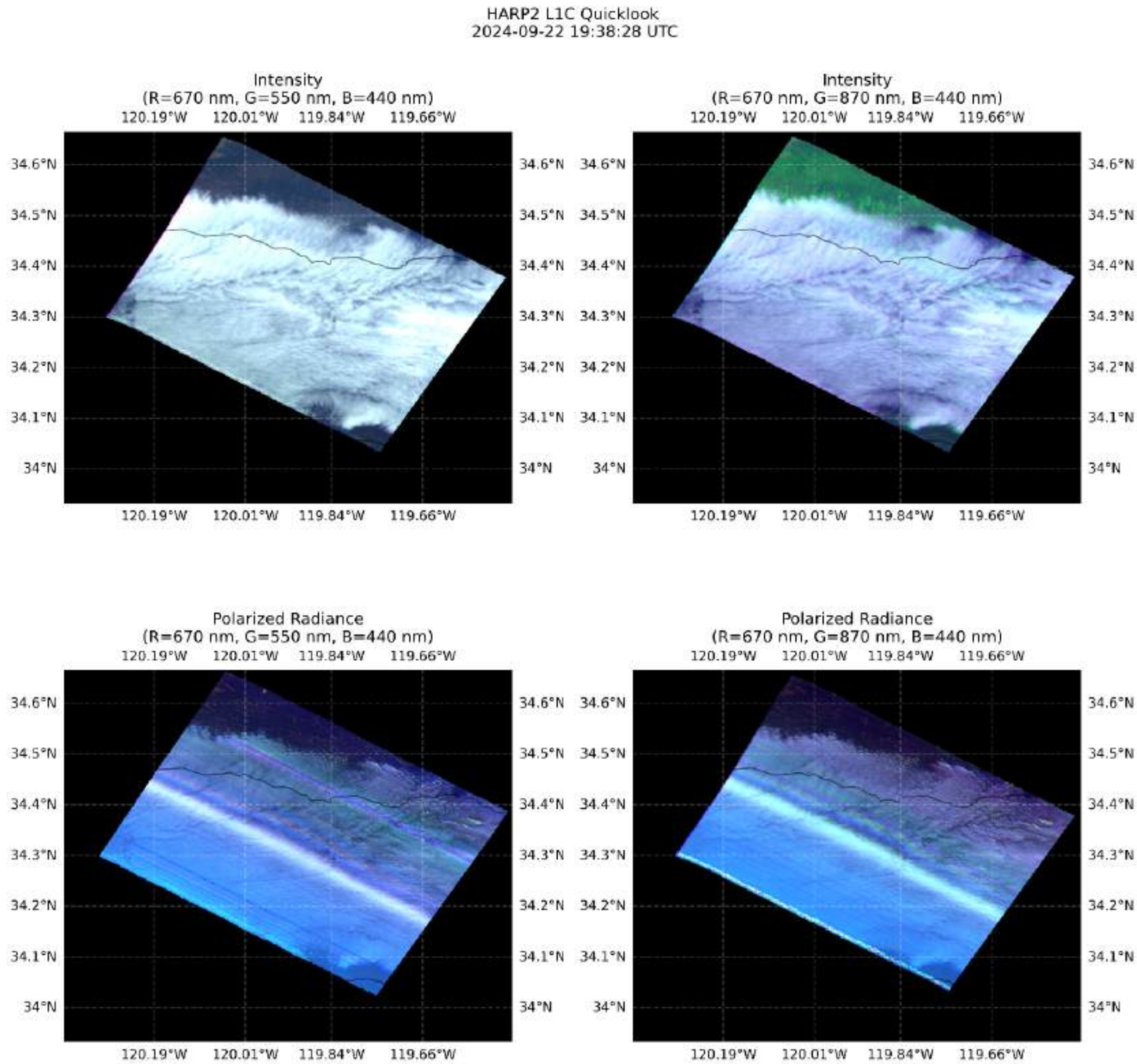

cot_21_OCI_20240922
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
28
24
20
16
12
8
4
0
COT


cth_OCI_20240922
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
12
10
8
6
4
2
0
CTH [km]


OCI mARI with ER2/Twin Otter Flight Tracks, 2024-09-22
42°N
40°N
38°N
36°N
34°N
32°N
129°W
126°W
123°W
120°W
117°W
114°W
111°W
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Anthocyanin Reflectance Index

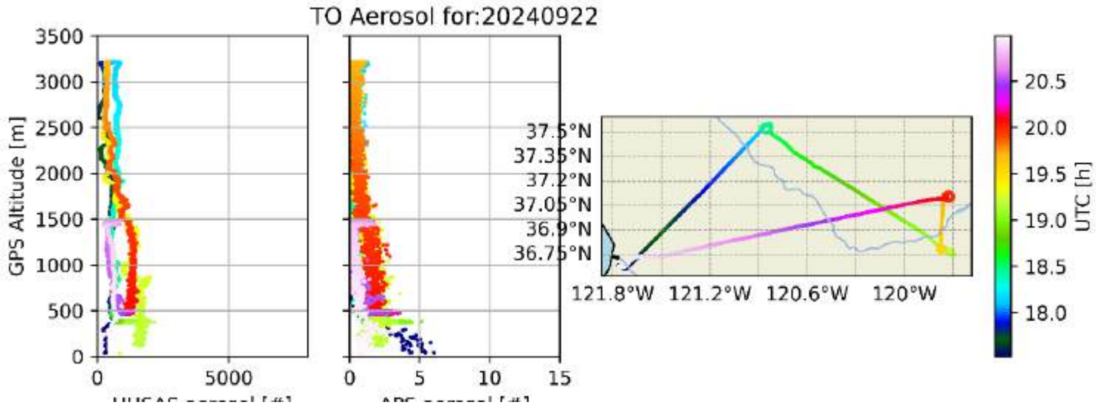

OCI NDVI with ER2/Twin Otter Flight Tracks, 2024-09-22
42°N
40°N
38°N
36°N
34°N
32°N
129°W
126°W
123°W
120°W
117°W
114°W
111°W
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Normalized Difference
Vegetation Index

AirHARP Quicklooks



(Showing high polarization and white background for the 18:17 UTC

TO aerosol vertical profile



Twin Otter full report

PACE-PAX Research Flight report 2024/09/22

Twin Otter Flight

Manifest:

Bryce Kujat (pilot)

Jeff Martin (pilot)

Michael Shook (QNC)

Ed Winstead (QNC)

Francesca Gallo (QNC)

Take off: 10:31:30 (17:31:30 UTC)

Landing: 13:59:17 (20:59:17 UTC)

Duration = 3.5 hrs.

Objectives: Profiles of aerosol scattering and absorption coefficients and size distributions together with scattering (polarized) phase functions using spiral ascents and descents over Turlock, Fresno and the San Joaquin Experimental range (SJER) field site located approximately 40 km (25 mi.) north of Fresno, CA. Spirals over Turlock and Fresno to be coordinated with ER-2 overpasses, and the SJER spiral to be coordinated with a PACE overpass.

Summary: Climb to 10 kft after takeoff en route to Turlock. During cruise at 10 kft it was quite clean with a scattering coefficient of 2 Mm^{-1}. The Turlock spiral down began at 11:09 local (18:09 UTC) with the ER-2 about 6 minutes away and seen by the Twin Otter on ADSB. Spiraling down green scattering coefficient was relatively constant (~10/12 Mm^{-1}). The HSRL2 on the ER-2 was showing a lower aerosol layer at 1 kft. ER-2 overpass took place at about 18:23 during the spiral. A second ER-2 overpass took place near Merced, which had to be avoided because of air traffic. Scattering coefficient during ER2 overpass at 18:44UTC was ~20 Mm^{-1}, and up to 25 Mm^{-1} over Merced. Descended to 1.2 kft during transit from Turlock to Fresno to get in the boundary layer with scattering coefficients of ~ 25 Mm^{-1} observed. A lot of agricultural activity was observed during the transit with scattering coefficients of 20-35 Mm-1 observed during set up for low approach at Fresno. Aerosol Optical Depth (AOD) at Fresno was ~ 0.14 with the Angstrom coefficient being "all over the place and centered about unity". Low approach at Fresno was completed at 12:11 local (19:11 UTC) with scattering coefficients consistent throughout the approach at 35 Mm^{-1}. Spiral up near Fresno with boundary layer top at 3 kft and ER-2 overpass during the spiral. Scattering coefficient dropped from 35 Mm-1 to 20-25 Mm-1 as we left the boundary layer, and decrease with increase in altitude (~10 Mm^{-1} at 5 kft, ~5Mm^{-1} at 7 kft). Spiral at Fresno was completed at 12:35 local (19:35 UTC) with scattering coefficient of 4 Mm^{-1} and particle number concentrations of 1000 cc^{-1} at 10 kft during transit to SJER. Spiral down at SJER began at 12:44 local (19:44 UTC). Satcom lost at 12:53 local (19:53 UTC) and restored at 12:55 (19:55 UTC) after power cycle. SJER spiral was completed at 13:04 local (20:04 UTC) at 1.5 kft with scattering coefficients of 25 Mm^{-1} and particle concentrations of 5000 cc^{-1}. Climbed to 4.5 kft to avoid terrain during transit back to Marina (scattering coefficient ~3/4 Mm^{-1} at 4.5 kft). No low approaches were done prior to landing because of poor weather conditions. Landed at Marina at 13:59:17 local (20:59:17 UTC).

ER-2 co-ordination was extremely good and widespread dust was observed throughout the flight in the boundary layer. One source of dust was tree shaking operations, see photo below.

Dust devil southeast of Turlock at 18:41 UTC; photo taken by Michael Shook

Dust generated by tree shaking activities in the Central Valley; photo taken by Francesca Gallo.

Missed approach at Fresno; photo taken by Francesca Gallo.

San Joaquin Experimental range taken from 9 kft; photo taken by Francesca Gallo.

Landing at Marina Airport at 20:59:17 UTC; photo taken by Francesca Gallo.

R/V Shearwater full report

Date: 09/22/2024

Creator: Michael Ondrusek

Cruise ID: RF0922-RS

Sailed out: 15:33 UTC

Back in port: UTC (09/23/2024)

Today, the ship occupied 2 stations in proximity of HyperNAV

Station #30 33 40.879', -119° 33.409' , arrival 18:17 UTC →departure 19:48 UTC

ER-2 overpass at 19:50, same as PACE first overpass

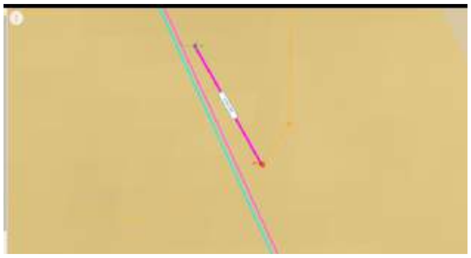
Just after departure another overpass at 19:58 UTC

Arrival photo:

Departure photo (departure location - 33° 37.427', -119° 29.292')

Station #31 33 37.301', 119° 28.080', arrival 20:21 UTC → departure 21:42 UTC

Proximity of HyperNAV – surfacing at 20:13:50.



ER-2 overflight at 20:59

Arrival photo:

Departure photo: (33 37.176’, -119° 26.766’)

Tomorrow, RV Shearwater will

Ship plans through the next 3 days…

System Status…

All good

Group Status…

All great

PACE-PAX research report 2024/09/23

Compiled by Kirk Knobelspiesse, Ivona Cetinić, Brian Cairns, Michael Ondrusek, 2024/09/28, updated 2024/10/24
Reviewed by Samuel LeBlanc

Coordinated observations with ER-2 and Twin Otter with clouds and aerosols over land, then PACE and EarthCARE underpasses over land. Latter has some clouds. Clouds styme coordination with Gliders and R/V Shearwater in Santa Barbara channel.

ER-2
Take off: 16:47
Landing: 23:00
Duration: 6.2 hrs
Pilot: Tim Williams, mobile: James Nelson

Twin Otter
Take off: 16:46
Landing: 20:49
Duration = 4.1 hrs
Manifest: Bryce Kujat (pilot), Jeff Martin (pilot), Michael Shook (QNC), Ed Winstead (QNC), Adam Ahern (QNC)
See end for full Twin Otter report

R/V Shearwater
Mission Scientist: Michael Ondrusek
Sailed out: 15:54 UTC
Back in port: 21:20 UTC
See end for full R/V Shearwater report

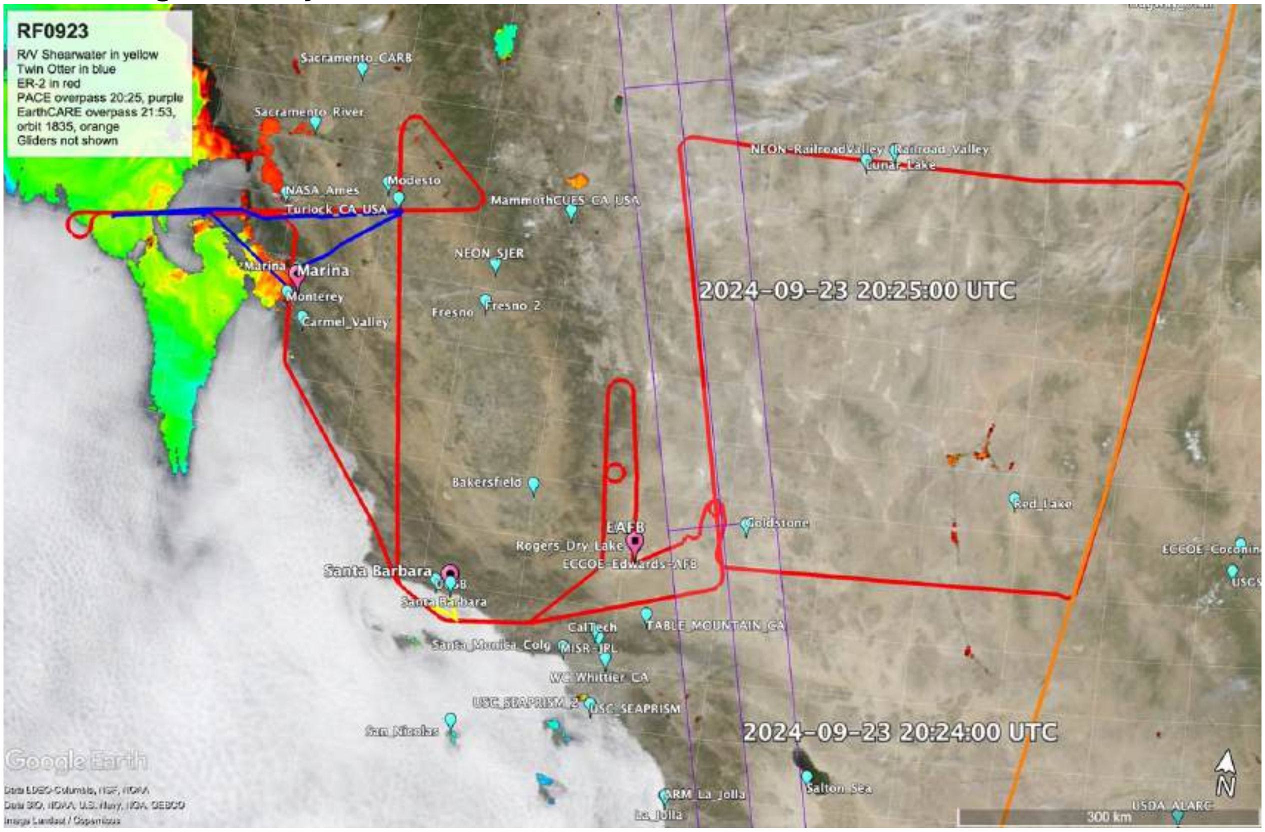
PACE
20:25, California/Nevada

EarthCARE
21:53, Utah/Arizona, orbit 1835

Gliders
Operational

HyperNAV
Operations concluded

Overall image summary



Validation Traceability Matrix itemized objectives

VTM elements in **black** satisfied, **blue** partially satisfied, red to be confirmed

Time UTC	Platform	VTM(hrs)	
15:54	RS		Shearwater departs
16:46	TO		Twin Otter takeoff
16:46	RS		Arrives on station #32, departure 18:11. Cloudy for entire stay, ER-2 overpass (scored below)
16:47	ER2		ER-2 takeoff
17:39	ER2	4c(0.5)	ER-2 over Shearwater, but cloudy. Scored as bright/low polarization target
18:07	ER2	1d(0.5)	ER-2 over Monterey (AOD(500)=0.07), Marina Tower, and CEOBS site, cloud free. No Aeronet data at CEOBS,
18:20	ER2, TO	1e(1.5)	ER-2 overpass of Twin Otter spiraling through clouds
18:44	ER2, TO	1e(1.5)	ER-2 overpass of Twin Otter spiraling through clouds
18:51:30	ER2	1d(0.5)	ER-2 over NASA_Ames AERONET site, AOD(500)=0.07
19:00:17	ER2	1d(0.5)	ER-2 over Turlock AERONET site, AOD(500)=0.11
19:10	RS		Shearwater on station #33, departure 20:30
19:22	TO		Begin Twin Otter spiral down over Turlock.
19:23	ER2, TO	1d(1.5). 6d(1.5)	ER-2 over Turlock AERONET site, AOD(500)=0.11 plus spiraling Twin Otter
19:52	ER2, Glider	4c(0.5)	ER-2 over glider, but cloudy. Scored as bright/low polarization target
19:56	ER2, RS	4c(0.5)	ER-2 over Shearwater, but cloudy. Scored as bright/low polarization target

20:18	ER2	1d(1.0), 3b(1.0), 6d(0.5)	Begin PACE-OHS line, continues until 20:48. PACE overpass at 20:25. Cirrus over northern edge.
20:25	**PACE**		**PACE Overpass**
20:49	TO		Twin Otter lands
21:03:08	ER2	6d(0.5), 4a(0.5*0.5)	ER2 over Railroad Valley Aeronet, partial cirrus. No aeronet data, after 20.5UTC, AOD(500)=0.035.
21:20	RS		Shearwater returns
21:34	ER2	3d(1.0), 3e(1.0), 6d(1.0), 6f(1.0)	ER2 on EarthCARE line until 22:05. Some parts clear, some with thin cirrus, others with mid-level clouds
21:53	**EarthCARE**		**EarthCARE overpass, orbit 1853**
23:00	ER2		ER-2 lands

PACE-O: within swath of PACE's OCI instrument
PACE-OH: within swath of PACE's OCI and HARP2 instruments
PACE-OHS: within swath of PACE's OCI, SPEXone and HARP2 instruments
TO: Twin Otter
RB: R/V Blissfully
RS: R/V Shearwater

Assessment:

- 4.1% of objectives observed. Successful coordination between ER-2 and TO, underpasses of PACE and EarthCARE. First ever measurements of aerosol under cloud. Attempts at observations over ship and glider stymied by clouds.
- Top remaining objective (score above 6.0): PACE aerosol in narrow swath over ocean (3a)

PACE-PAX progress tracking

Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 9/23	Fractional success 9/24	Fractional success 9/25	Fractional success 9/26	Fractional success 9/27	Fractional success 9/29	Fractional success 9/30	Total success	Remaining score
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.971	0.2
	b	Ocean radiometric parameters	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.995	0.0
	c	Aerosol parameters over the ocean	12	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.980	0.2
	d	Aerosol parameters over land	12	8.0	6.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.000	0.0
	e	Cloud parameters	12	8.0	3.0	5.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.873	1.5
	f	Ocean surface parameters	1	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.000	1.0
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.354	6.5
	b	Aerosol parameters over land (PACE)	10	8.0	2.0	13.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.535	4.7
	c	Cloud parameters (PACE)	5	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.713	1.4
	d	Aerosol parameters (EarthCARE)	8	4.0	1.0	3.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.865	1.1
	e	Cloud parameters (EarthCARE)	8	4.0	1.0	15.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.465	4.3
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.953	0.3
	b	Validate large reflectances with high polarization	6	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.632	2.2
	c	Validate large reflectances with low polarization	6	2.0	1.5	3.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.970	0.2
	d	Overfly vicarious calibration sites	6	4.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.268	4.4
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.000	0.0
	b	High aerosol loads over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.393	2.4
	c	Multiple aerosol layers	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.000	0.0
	d	Aerosol under thin cirrus	2	2.0	3.5	82.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.826	0.3
	e	Aerosol above liquid phase cloud	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.826	0.7
	f	Broken clouds with complex structure	4	2.0	1.0	18.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.713	1.1
	g	Dust aerosols over ocean	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.430	2.3
	h	Aerosol and ocean parameters over turbid waters	2	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.790	0.4
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.918	0.3
	k	Smoke aerosols over ocean	1	2.0	0.0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.713	0.3
		total:	150	98	19.0	4.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	76.0%	
														total
				ER-2 flight hours		2.8	0	0	0	0	0	0	0	2.8
				TO flight hours		2.5	0	0	0	0	0	0	0	2.5
				Shearwater days		0	0	0	0	0	0	0	0	0

PACE-PAX overall objectives satisfied: 80.1%

Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

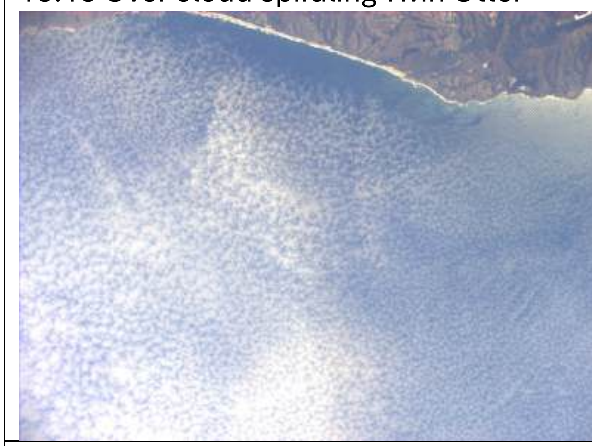
https://www-air.larc.nasa.gov/missions/pacepax/index.html

MVIS imagery

17:39 over R/V Shearwater

18:10 over CEOBS site

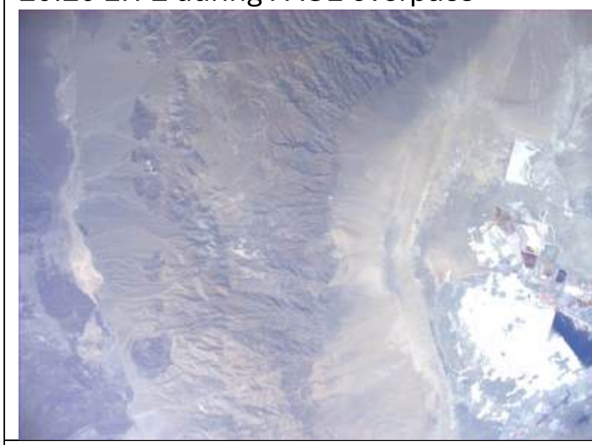
18:18 Over cloud spiraling Twin Otter



18:44 Over cloud spiraling Twin Otter

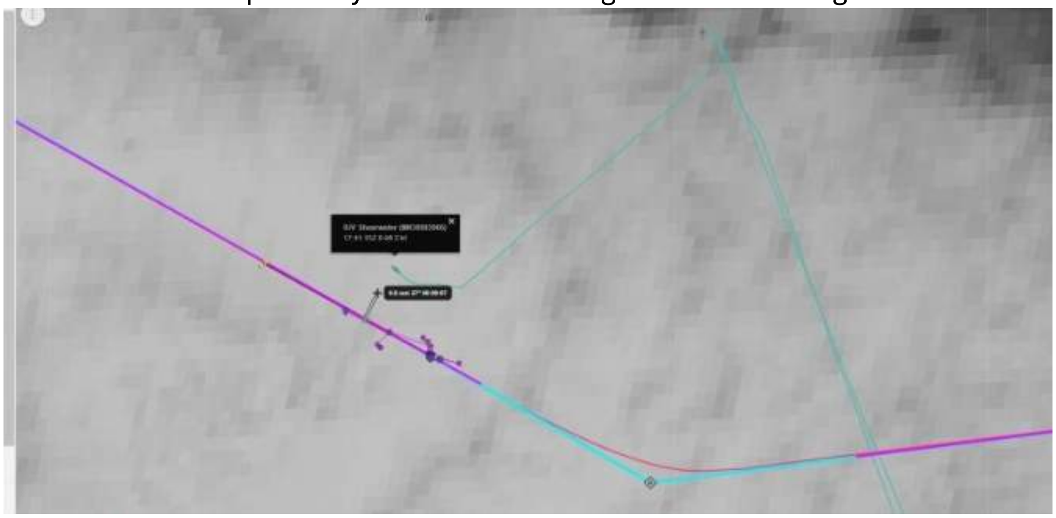
18:51:30 over NASA_Ames AERONET

19:00:17 over Turlock AERONET

<table>
<tr><td>19:23 over Turlock AERONET and Twin Otter. Very diffuse cirrus according to HSRL
</td><td>19:52 ER-2 over gliders (too cloudy)
</td></tr>
<tr><td>20:20 ER-2 during PACE overpass
</td><td>21:41 ER-2 on EarthCARE line
</td></tr>
<tr><td></td><td></td></tr>
</table>

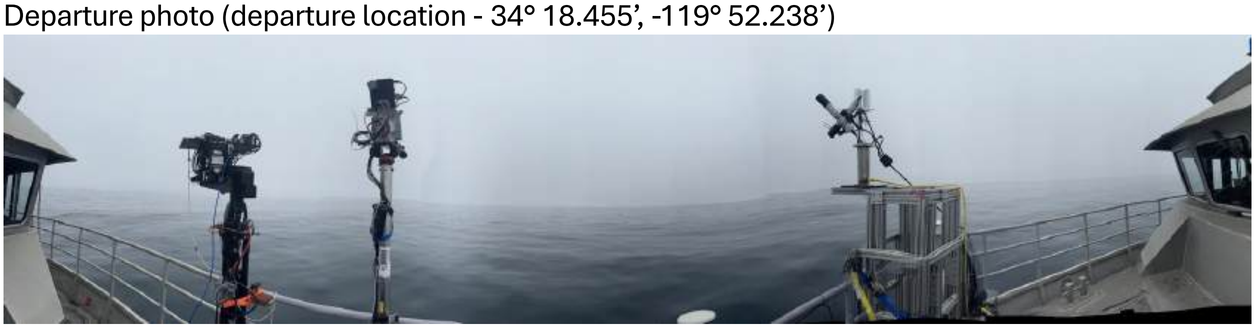
R/V Shearwater photos

Station #32 34° 17.646’, -119° 51.478’, arrival 16:46 UTC →departure 18:11 UTC
This station was in proximity of the UDelaware glider. ER-2 overflight at 17:38.

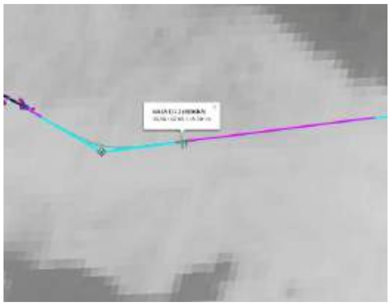


Arrival photo:

Departure photo (departure location - 34° 18.455’, -119° 52.238’)



Station #33 34° 12.840’, -119° 34.943’, arrival 19:10 UTC → departure 20:30 UTC
ER-2 overflight at 19:56

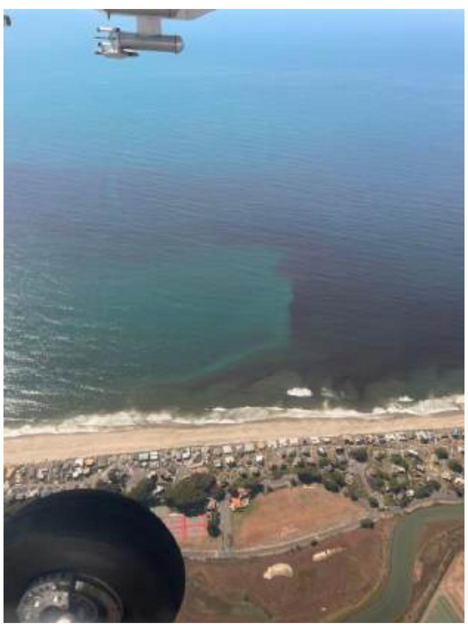


Arrival photo:

Departure photo: (34° 13.074’, -119° 35.744’)

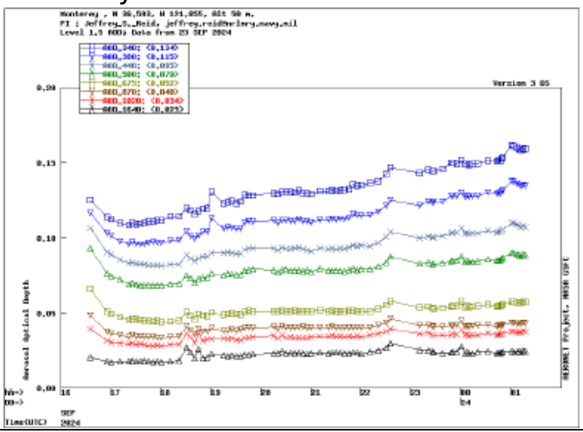
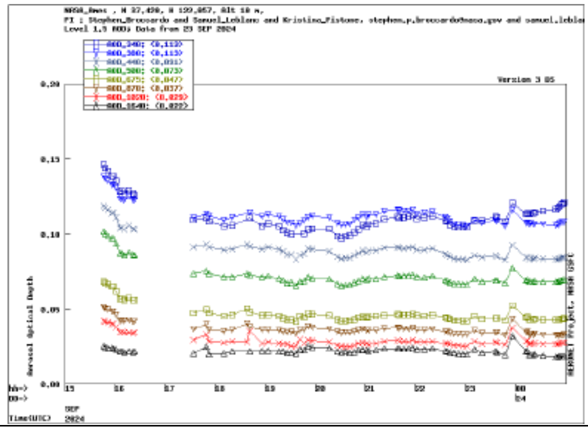
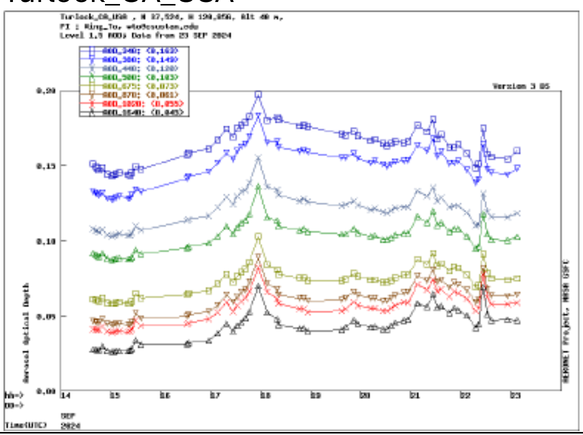
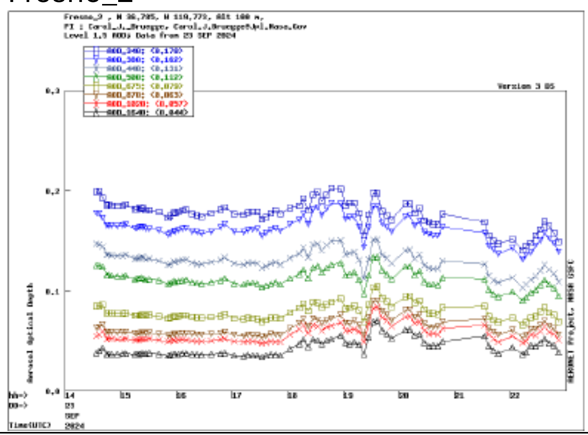
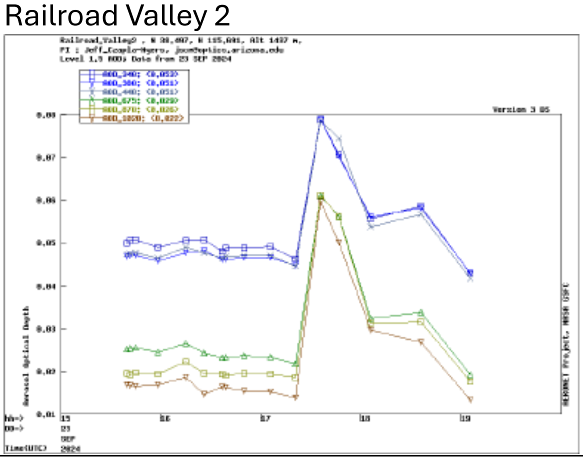
Twin Otter photos

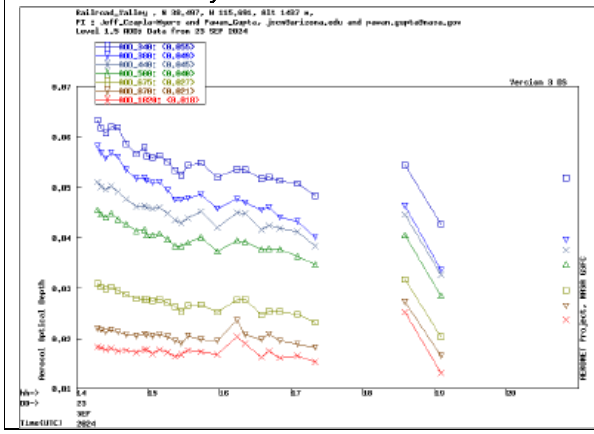
Very thin clouds near the ADIZ line at 17:21 UTC; photo by Michael Shook



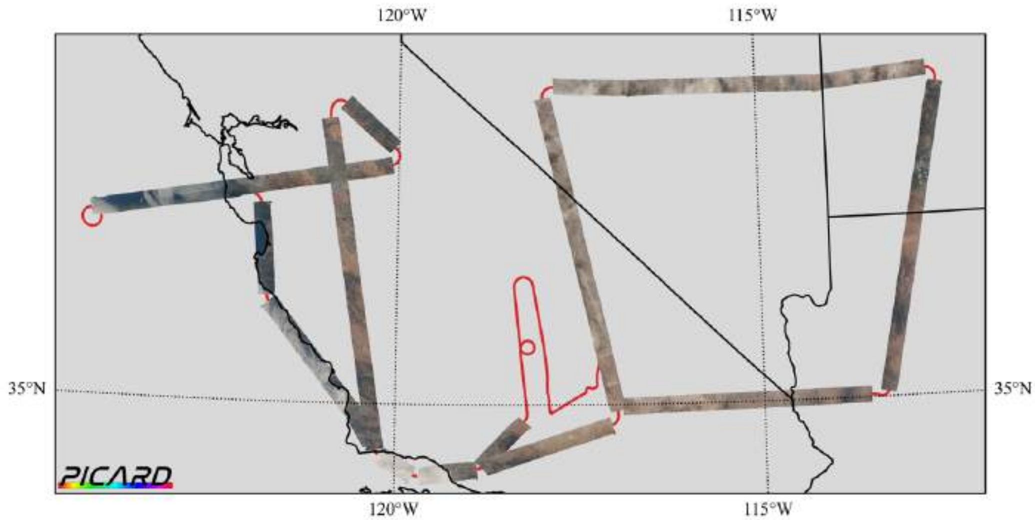
Potential harmful algae bloom near the CEOBS spiral; photo by Eddie Winstead

AERONET plots

Monterey 	NASA_Ames 
Turlock_CA_USA 	Fresno_2 
Railroad Valley 2 	NRL_CEOBS_MBAYCAUSA Missing data?

Railroad Valley 	

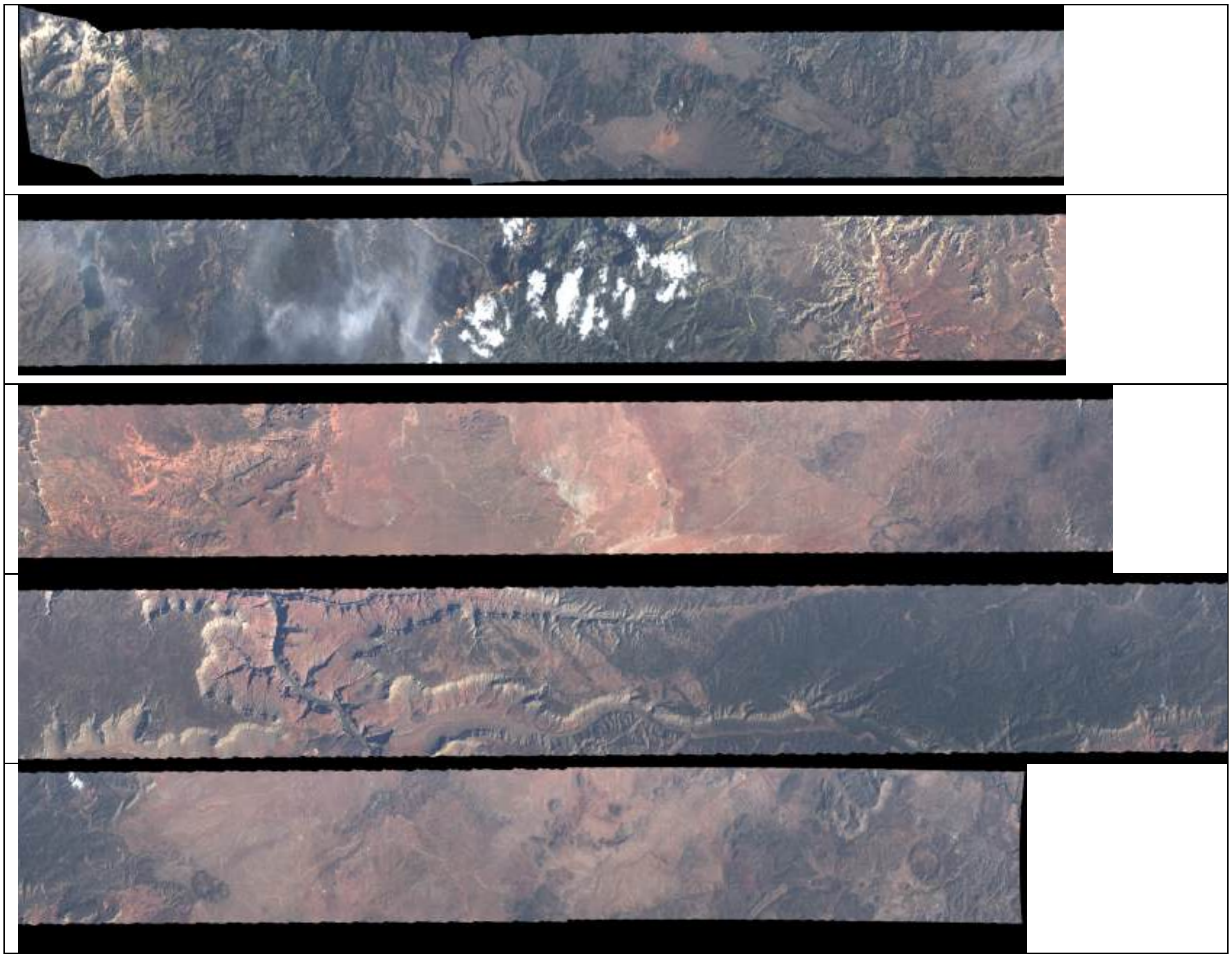
PICARD quicklooks



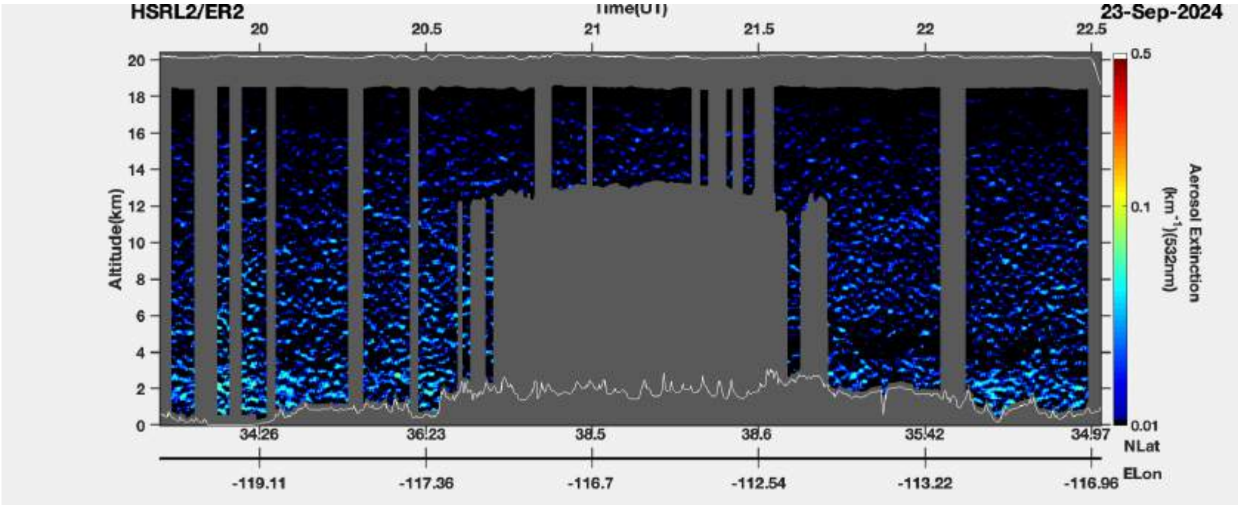
22:05:17 -> 22:29:36

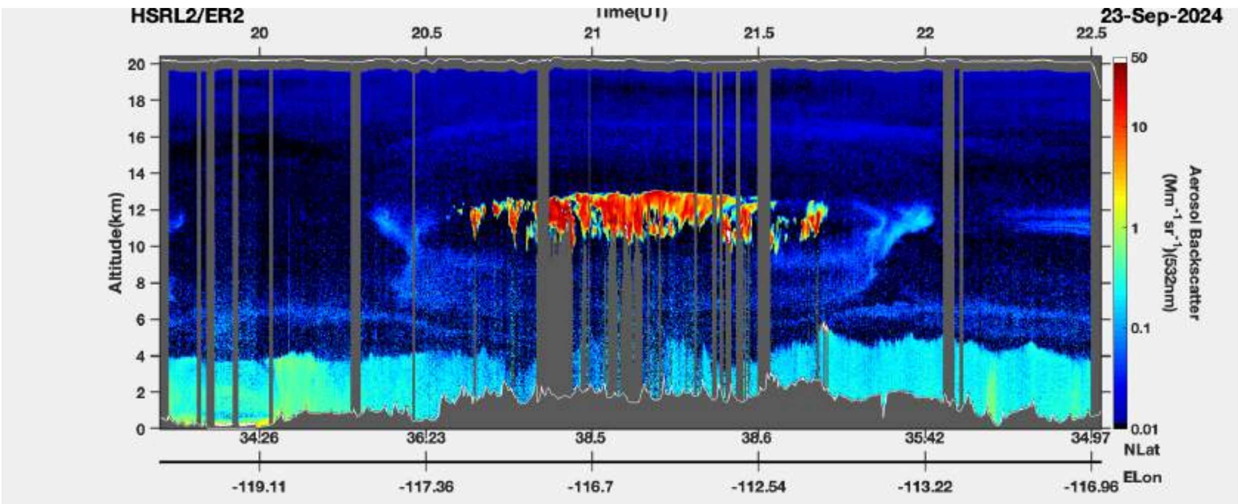
PRISM quicklooks

EarthCARE track, starting from north to south

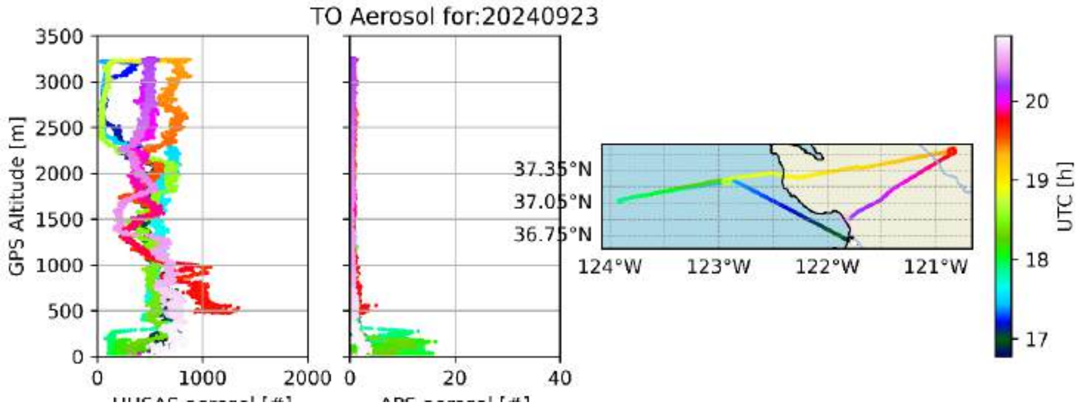


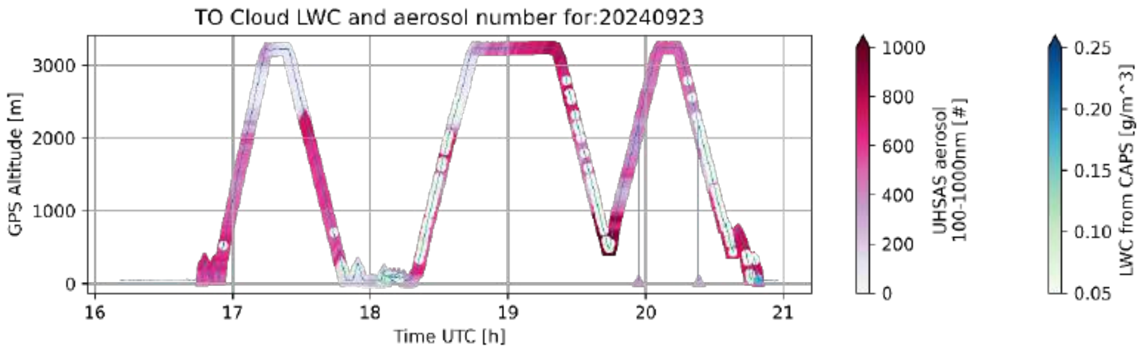
HSRL-2 Quicklooks



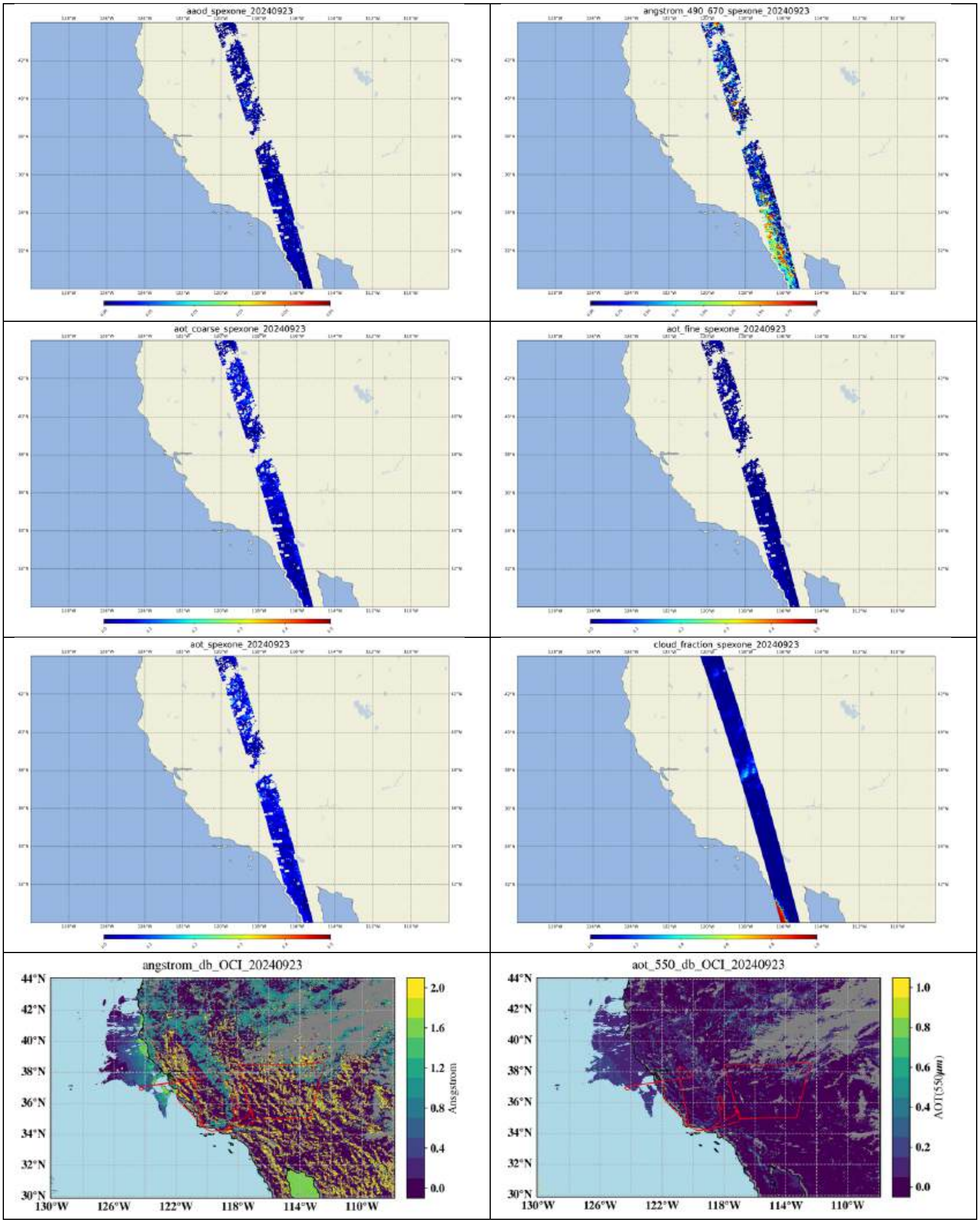


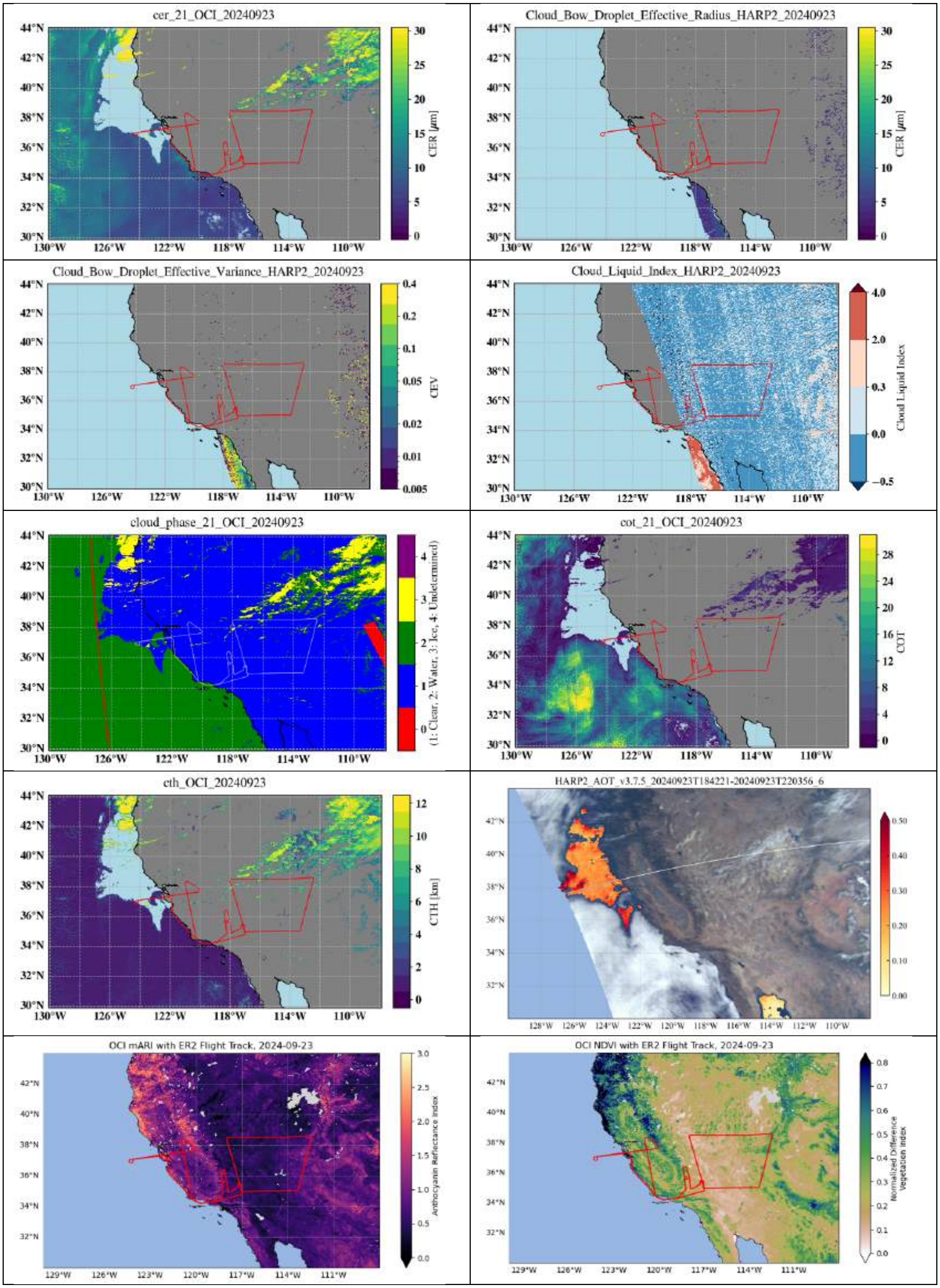
TO Quicklooks





PACE quicklooks




cer_21_OCI_20240923
CER [μm]
Cloud_Bow_Droplet_Effective_Radius_HARP2_20240923
CER [μm]
Cloud_Bow_Droplet_Effective_Variance_HARP2_20240923
CEV
Cloud_Liquid_Index_HARP2_20240923
Cloud Liquid Index
cloud_phase_21_OCI_20240923
(1: Clear, 2: Water, 3: Ice, 4: Undetermined)
cot_21_OCI_20240923
COT
cth_OCI_20240923
CTH [km]
HARP2_AOT_v3.7.5_20240923T184221-20240923T220356_6
OCI mARI with ER2 Flight Track, 2024-09-23
Anthocyanin Reflectance Index
OCI NDVI with ER2 Flight Track, 2024-09-23
Normalized Difference Vegetation Index

Twin Otter flight report

PACE-PAX Research Flight report 2024-09-23

Twin Otter Flight

Manifest:

Bryce Kujat (pilot)

Jeff Martin (pilot)

Michael Shook (QNC)

Adam Ahern (QNC)

Edward Winstead (QNC)

Note: This flight had coordination with the ER-2.

Take off: 09:46:35 (16:46:35 UTC) Marina Airport (OAR)

Landing: 13:49:05 (20:49:05 UTC) Marina Airport (OAR)

Duration = 4.1 hrs

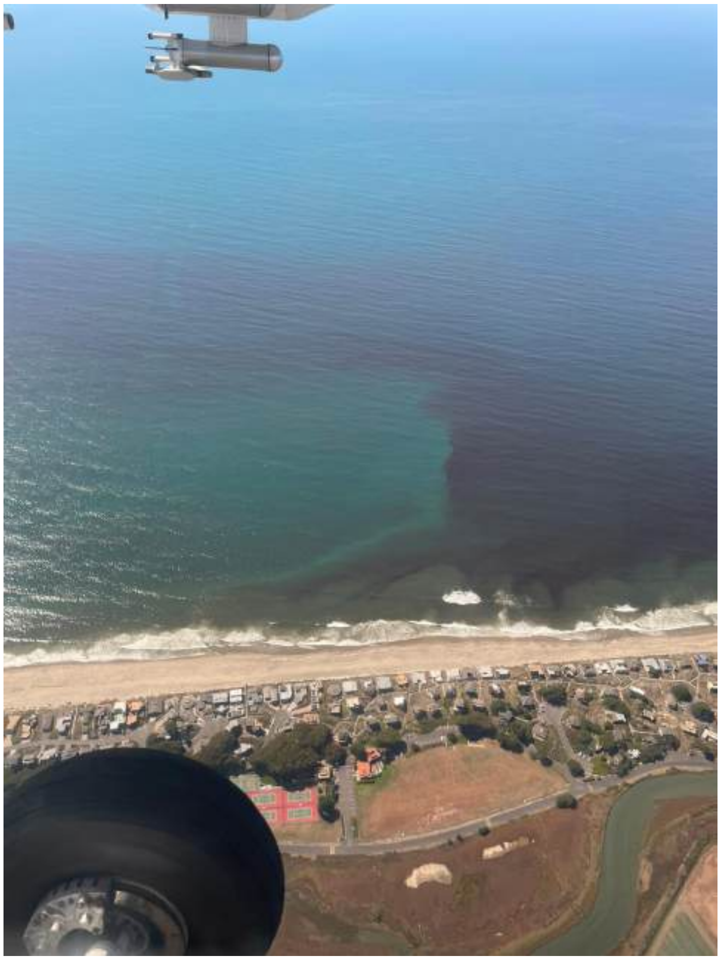
Objectives: Low clouds and aerosol under cirrus. Planned cloud work includes porpoising west of the ADIZ line and a spiral up to 10kft near PIRAT underneath an ER-2 overpass at approximately 11:15 local (18:15 UTC). Then transit east to Turlock and spiral down underneath another ER-2 overpass at approximately 12:18 local (19:18 UTC). After that, ascend in-line to the CEOBS site and spiral down from 10kft to minimum altitude, with a PACE overpass at 13:25 local (20:25 UTC). If possible, perform low approaches at Marina prior to landing.

Summary: After taking off, we performed two low approaches at the Marina airport. Green scattering coefficient was ~30Mm^{-1} in the boundary layer and 15Mm^{-1} above it. Boundary layer height was estimated at 500 ft. As we climbed out, scattering coefficient dropped below 5Mm^{-1} by 17:07 UTC and eventually to ~0 Mm^{-1} with ~400 particles/cm^3 by 17:10 UTC before increasing to 4Mm^{-1} and 750 particles/cm^3 at 17:13 UTC. At 17:24 UTC we crossed the ADIZ line near PIRAT and began our in-line descent to 100 ft. Around 17:31 UTC, we encountered a layer at 7500 ft with ~10Mm^{-1} scattering coefficient and f(RH) near 1, with little to no absorption; pilots reported winds at that time were out of 90° (almost straight off the coast). By 17:36 UTC it was apparent that our descent rate was too slow to reach 100 ft at our planned turn point, and that we would be quite early to the PIRAT spiral, so we decided to extend our descent to the west. We encountered the clouds around 17:48 UTC, with tops at 740 ft and bases at 400 ft; below cloud, scattering coefficient was ~35Mm^{-1} with relatively high f(RH). We reached 100 ft, turned to the east, and began porpoising (profiling through the cloud, with ~10 seconds level and clear of cloud above and below). However, by 17:57 UTC we ran out of clouds, so we stayed at 100 ft to get the best aerosol sampling. At 18:04 UTC, we had to climb due to fog, with the top around 400 ft with a Liquid Water Content (LWC) around 0.24 g/m^3. Because of the low visibility in the fog, we then began modified porpoising by flying in cloud tops for 1 minute and above cloud for 10 seconds. The cloud/fog was quite low and patchy, with tops around 200 ft and areas of no cloud. Scattering coefficient appeared lower in areas of no cloud, while it was ~30Mm^{-1} above clouds.

At 18:18 UTC, we began our PIRAT spiral above cloud top, with ~35Mm^{-1} scattering coefficient. Very sparse cirrus was visible to the east. The ER-2 passed overhead at 18:18 UTC, just as we were leaving the boundary layer. Scattering again dropped to zero around 7500 ft this time in the climb. The ER-2 passed over again at 18:44 UTC just as we were reaching 10kft. At this point, we were slightly behind for our next spiral time at Turlock, so we transited faster than our normal science sampling speed. We were vectored several times by ATC near the San Jose airport for traffic.

We began our Turlock spiral at 19:22 UTC just as the ER-2 flew over, with 10Mm^{-1} scattering coefficient. Again, there was very sparse cirrus in view around; diffuse radiation was estimated at 10% of total radiation from SPN. Turlock AERONET reported 0.12 AOD, and HSRL just saw very diffuse cirrus just at the overpass. By 19:39 UTC we had reached the boundary layer, where scattering coefficient was 18Mm^{-1}, and completed the spiral at 19:44 UTC. Not as much agricultural activity or dust was observed compared to the previous day. We then ascended in-line to the west to begin our CEOBS spiral at 20:15 UTC and ended at 20:39 UTC. As we transited back to Marina, the water below appeared to have a red tint, perhaps indicative of a harmful algal bloom. One low approach was performed at the Marina airport, where the scattering coefficient peaked to about 30Mm^{-1}.

Very thin clouds near the ADIZ line at 17:21 UTC; photo by Michael Shook



Potential harmful algae bloom near the CEOBS spiral; photo by Eddie Winstead

R/V Shearwater report

Date: 09/23/2024

Creator: Michael Ondrusek

Cruise ID: RF0923-RS

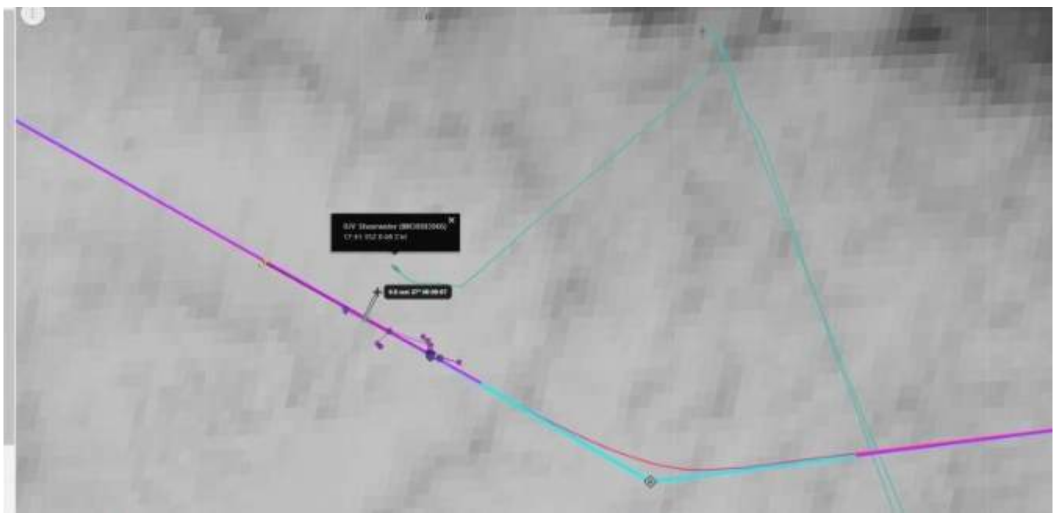
Sailed out: 15:54 UTC

Back in port: 21:20 UTC

Today, the ship occupied 2 stations along the ER-2 line, in cloudy covered Santa Barbara channel.

Station #32 34° 17.646', -119° 51.478', arrival 16:46 UTC →departure 18:11 UTC

This station was in proximity of the UDelaware glider. ER-2 overflight at 17:38.

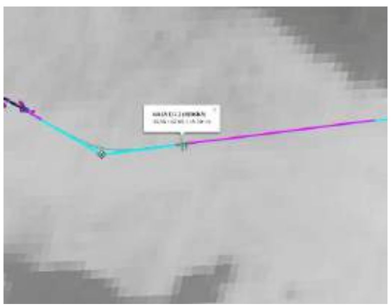


Arrival photo:

Departure photo (departure location - 34° 18.455', -119° 52.238')

Station #33 34° 12.840’, -119° 34.943’, arrival 19:10 UTC → departure 20:30 UTC

ER-2 overflight at 19:56



Arrival photo:

Departure photo: (34° 13.074’, -119° 35.744’)

Tomorrow, RV Shearwater will

Ship plans through the next 3 days…

System Status...

All good

Group Status...

All great

PACE-PAX research report 2024/09/24

Compiled by Kirk Knobelspiesse, Brian Cairns
2024/10/06
Reviewed by Samuel LeBlanc

Operations for Twin Otter aircraft only, offshore cloud observations during PACE and EarthCARE overpasses. Spiral over Monterey bay at end of flight to provide vertical aerosol profile context for any retrievals of HABs in Monterey Bay made during PACE overpass.

ER-2
No flight

Twin Otter
Takeoff: 20:09
Landing: 23:14
Duration: 3.1 hours
See end for full Twin Otter report

R/V Shearwater
No operations

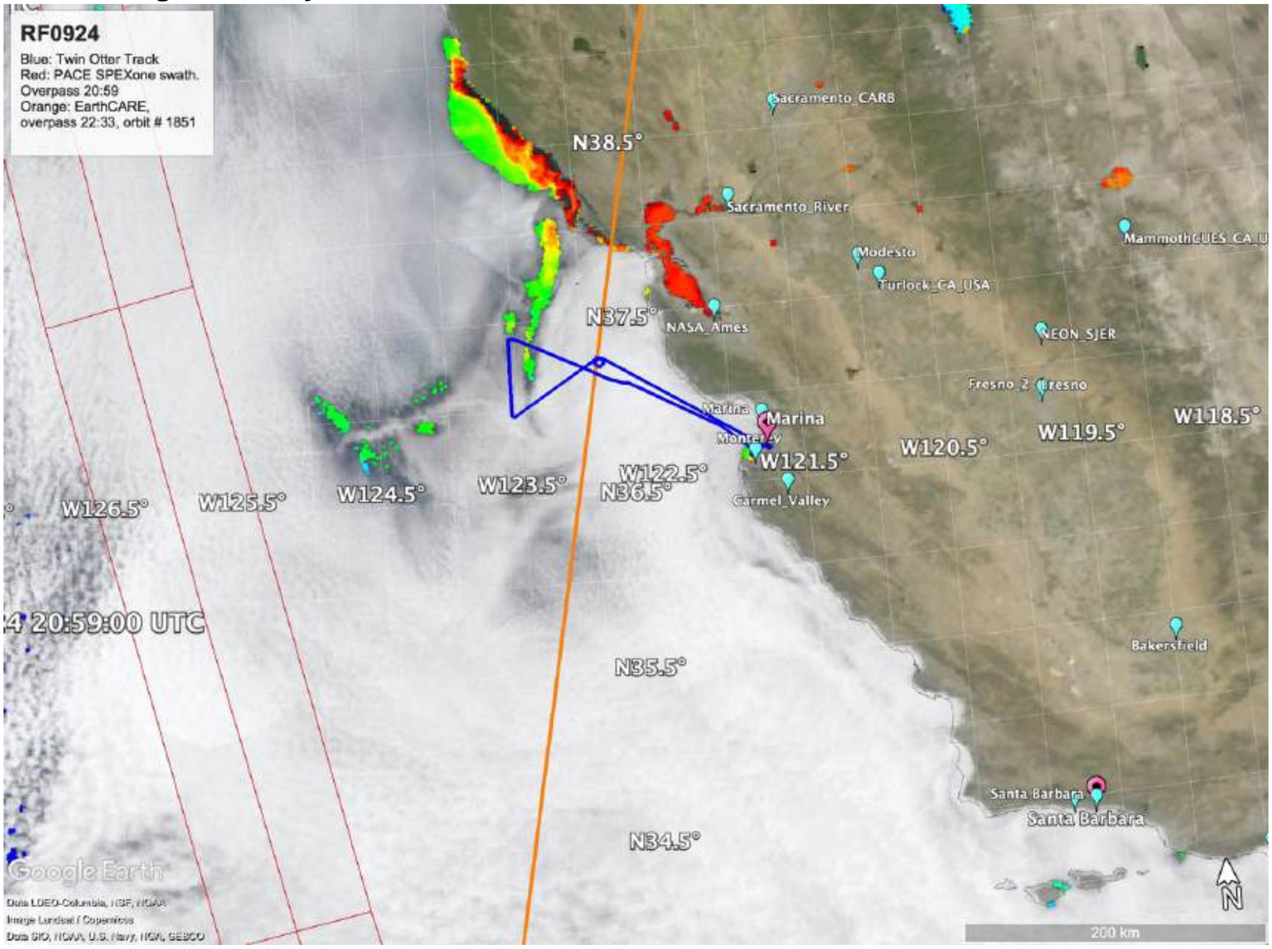
PACE
20:59, Offshore. Monterey Bay is in PACE-OH swath

EarthCARE
22:33, offshore Northern California, orbit 1851

Gliders
Operational

HyperNAV
Operations concluded

Overall image summary



Validation Traceability Matrix itemized objectives

VTM elements in **black** satisfied, **blue** partially satisfied, red to be confirmed

Time UTC	Platform	VTM(hrs)	
20:09	TO		Twin Otter takeoff with low approach after take off at the Marina airport to characterize TO inlet
20:43	TO	6e(1.0*0.5) 1e(1.0*0.5)	Start of spiral at PIRAT to support potential aerosol above cloud retrievals in the PACE-OH swath. Spiral into clouds
20:59	**PACE**		**PACE Overpass**
21:00	TO		Spiral terminated at 500 ft due to the lack of visibility at that altitude
21:00-21:30	TO	1e(0.5*0.5)	Porpoising in PACE-OH cross track direction. Thick clouds with significant cloud top liquid water content (~ 0.5 g/m^3) until 21:30.
21:30-21:46	TO	1e(0.5)	Porpoising on PACE-OH along satellite track direction with significantly different, thinner clouds (~ 0.1 g/m^3) than previous leg.
22:53	**EarthCARE**		**EarthCARE overpass, orbit 1851**

23:40-22:54	TO	6h(1.5),6i (1.5)	EarthCARE overpass location was not workable because of low cloud tops so spiral was done in Monterey Bay at 36° 39'N, 121° 51.5'W starting at 23:40. Purpose: to provide evaluation of vertical profile in Monterey Bay where harmful algal blooms would have been observable during the PACE overpass.
23:14:40	TO		Landing at 23:14:40 after low approach at the Marina airport to characterize TO inlet.

PACE-O: within swath of PACE's OCI instrument
PACE-OH: within swath of PACE's OCI and HARP2 instruments
PACE-OHS: within swath of PACE's OCI, SPEXone and HARP2 instruments
TO: Twin Otter

Assessment:

- 0.005 objectives observed. Successful underpasses of PACE-OH and EarthCARE in cloudy conditions. Aerosol above clouds present during first spiral at PACE overpass, but not very opaque aerosol layers. Data during second spiral probably not useable by EarthCARE radar team because cloud tops are too low (within the first range bin of the surface).
- Top remaining objective (score above 6.0): PACE aerosol in narrow swath over ocean (3a)

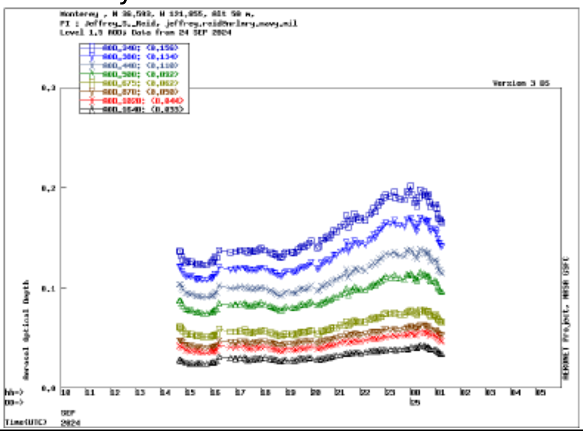
PACE-PAX progress tracking

Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 9/23	Fractional success 9/24	Fractional success 9/25	Fractional success 9/26	Fractional success 9/27	Fractional success 9/29	Fractional success 9/30	Total success	Remaining score
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	3.0	0.000	0.000	0.000	0.000	0.000	0.015	0.007	0.994	0.1
	b	Ocean radiometric parameters	10	8.0	18.0	0.000	0.000	0.000	0.003	0.001	0.000	0.000	0.999	0.0
	c	Aerosol parameters over the ocean	12	8.0	20.5	0.000	0.000	0.000	0.014	0.003	0.001	0.001	0.998	0.0
	d	Aerosol parameters over land	12	8.0	22.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.0
	e	Cloud parameters	12	8.0	6.8	0.058	0.011	0.000	0.000	0.026	0.000	0.011	0.920	1.0
	f	Ocean surface parameters	1	8.0	1.5	0.000	0.000	0.000	0.133	0.000	0.000	0.000	0.354	0.6
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	3.0	0.000	0.000	0.000	0.000	0.076	0.000	0.126	0.556	4.4
	b	Aerosol parameters over land (PACE)	10	8.0	7.0	0.132	0.000	0.000	0.103	0.000	0.113	0.000	0.751	2.5
	c	Cloud parameters (PACE)	5	2.0	2.5	0.000	0.000	0.000	0.000	0.181	0.000	0.023	0.918	0.4
	d	Aerosol parameters (EarthCARE)	8	4.0	5.5	0.038	0.000	0.000	0.053	0.000	0.000	0.038	0.956	0.4
	e	Cloud parameters (EarthCARE)	8	4.0	1.0	0.152	0.000	0.000	0.000	0.000	0.000	0.000	0.465	4.3
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	2.0	1.0	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.972	0.2
	b	Validate large reflectances with high polarization	6	2.0	1.5	0.000	0.000	0.000	0.194	0.000	0.000	0.000	0.826	1.0
	c	Validate large reflectances with low polarization	6	2.0	2.5	0.034	0.000	0.000	0.000	0.000	0.000	0.012	0.982	0.1
	d	Overfly vicarious calibration sites	6	4.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.268	4.4
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	2.0	0.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.0
	b	High aerosol loads over ocean	4	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.393	2.4
	c	Multiple aerosol layers	1	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.0
	d	Aerosol under thin cirrus	2	2.0	3.5	0.826	0.000	0.000	0.000	0.000	0.000	0.000	0.826	0.3
	e	Aerosol above liquid phase cloud	4	2.0	0.5	0.000	0.038	0.000	0.000	0.000	0.000	0.000	0.865	0.5
	f	Broken clouds with complex structure	4	2.0	3.0	0.186	0.000	0.000	0.000	0.181	0.000	0.000	0.895	0.4
	g	Dust aerosols over ocean	4	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.430	2.3
	h	Aerosol and ocean parameters over turbid waters	2	2.0	3.8	0.000	0.111	0.000	0.022	0.017	0.013	0.015	0.968	0.1
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	6.8	0.000	0.043	0.000	0.020	0.013	0.002	0.000	0.997	0.0
	k	Smoke aerosols over ocean	1	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.713	0.3
		total:	150	98	113.8	0.041	0.005	0.000	0.021	0.019	0.009	0.014	0.827	
														total
				ER-2 flight hours		6.2	0	0	6.4	6.5	6.7	6.5	0	32.3
				TO flight hours		4.1	3.1	0	5.1	3.1	0	0	0	15.4
				Shearwater days		0	0	0	0	0	0	0	0	0
		PACE-PAX overall objectives satisfied:		0.827										

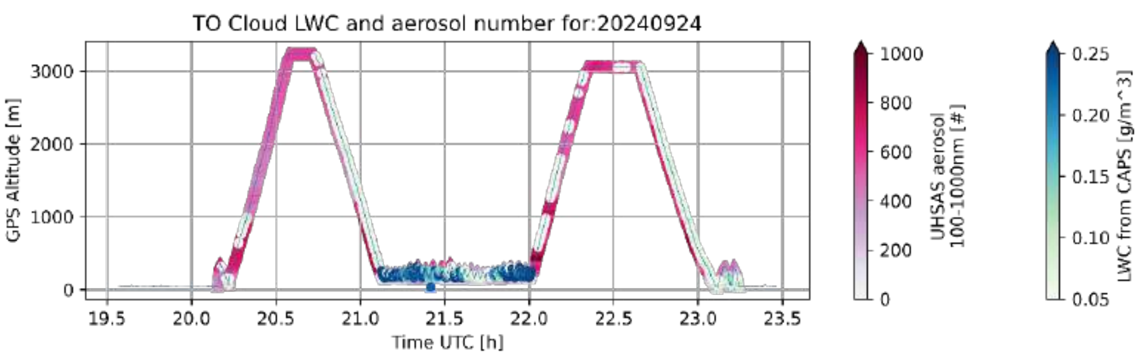
Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

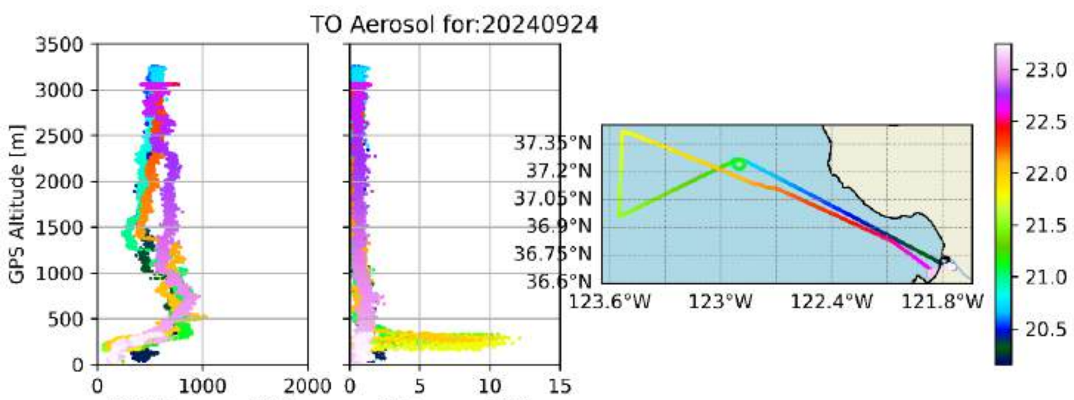
https://www-air.larc.nasa.gov/missions/pacepax/index.html

AERONET plots

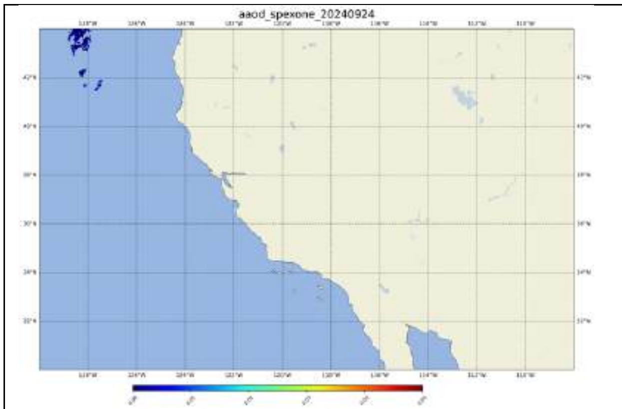
Monterey	
	

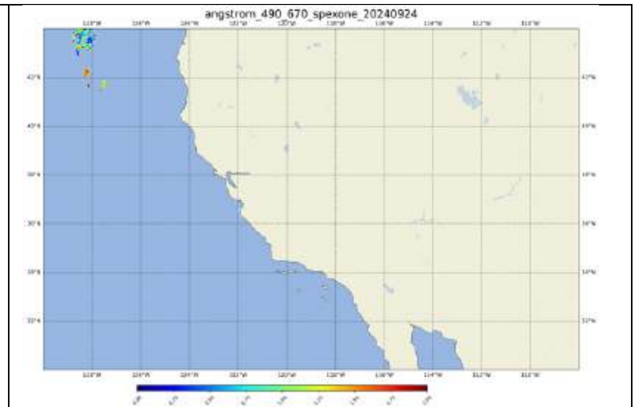
TO Quicklooks

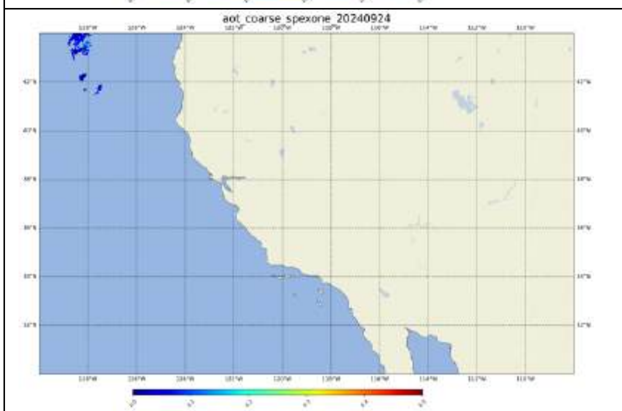


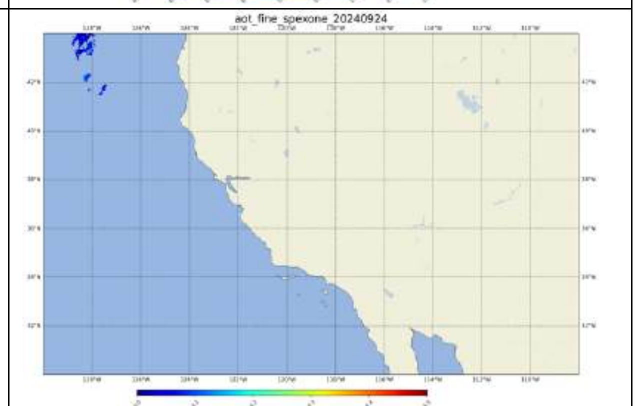


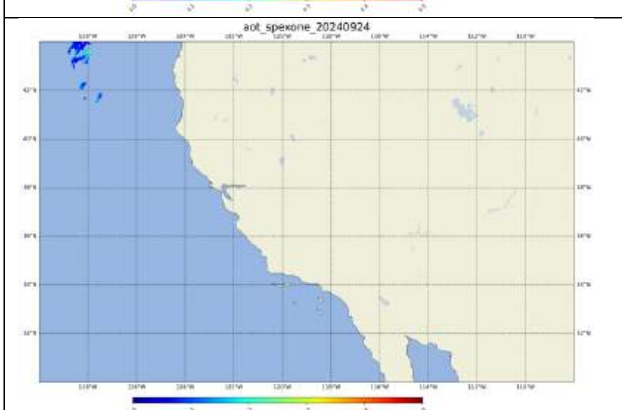
PACE quicklooks

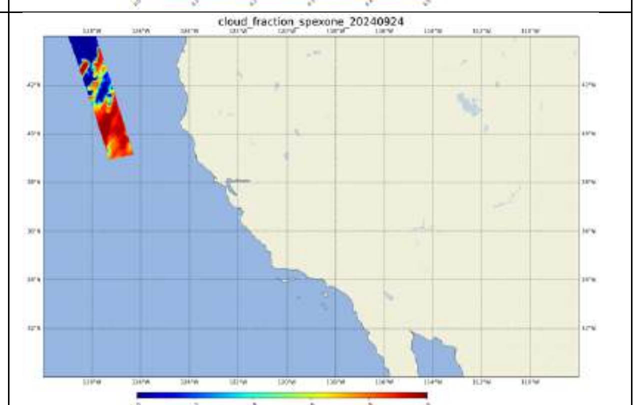












Twin Otter full report

PACE-PAX Research Flight report 2024-09-24

Manifest:

Bryce Kujat (pilot)

Jeff Martin (pilot)

Michael Shook (QNC)

Elizabeth Wilk (QNC)

Edward Winstead (QNC)

Note: The ER-2 did not fly this day.

Take off: 13:09:13 (20:09:13 UTC) Marina Airport (OAR)

Landing: 16:14:40 (23:14:40 UTC) Marina Airport (OAR)

Duration = 3.1 hrs

Objectives: In-line ascent to PIRAT, then spiral down beneath PACE at 21:00 UTC. Porpoise in cloud along and perpendicular to PACE swath west of the ADIZ line. Spiral up under EarthCARE at 22:23 UTC in clouds with tops at least 1000-1200 ft if available OR spiral in clear air over the Monterey Bay in the vicinity of the algae bloom (if there are no suitable clouds under the EarthCARE line and there is a spot clear of clouds in the bay). If possible, perform low approaches at Marina after takeoff and prior to landing.

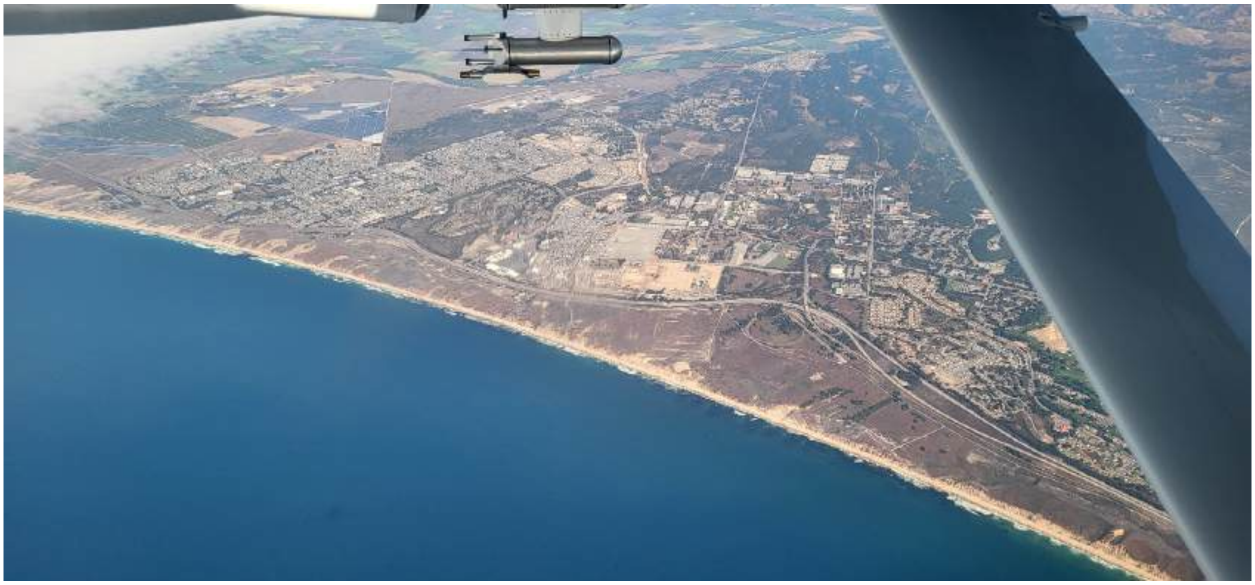
Summary: After taking off, we performed a low approach at the Marina airport. Green scattering coefficient was ~15Mm^{-1}, and some coarse mode particles were measured by the APS. Cloud tops in the bay were estimated at less than 1000 ft. As we climbed towards PIRAT, we experienced unusual turbulence and shear at about 3300 ft at 20:19 UTC; the temperature profile indicated that this coincided with a second inversion above the boundary layer. By 20:21 UTC (above the second inversion), scattering coefficient had dropped to 8Mm^{-1}. We reached the top of the PIRAT spiral at 20:43 UTC, where scattering coefficient was still 8Mm^{-1} and some super-micron particles were detected. By 20:58 UTC, the scattering coefficient had decreased to 4Mm^{-1}. At the PACE overpass time of 21:00 UTC, scattering coefficient had increased again to ~10Mm^{-1}, with f(RH) ~ 1.3; an inversion was present at about 2200 ft. Cloud top was about 850 ft, and we were unable to descend below 500 ft due to the lack of visibility at that altitude. We began profiling (descending to 500 ft, ascending above the cloud, and remaining level above cloud top for ~10 seconds before descending again) west along the cross-track line, and cloud tops increased from ~700 ft to 900-1000 ft. Scattering coefficient above cloud top varied from 15-30Mm^{-1}, and Liquid Water Content (LWC) at cloud top was about 0.40-0.48 g/m^3.

At about 21:30 UTC, we transitioned into a clearly different cloud deck. Cloud tops dropped by about 200 ft, and cloud top LWC dropped to about 0.25 g/m^3. It was also significantly hazier above the cloud, making it hard to determine where cloud top was. About this time, we turned north to begin the along-track leg. LWC continued to decrease to about 0.08 g/m^3. At our northernmost point (21:46 UTC), the cloud had thinned to barely 200 ft thick, and the surface was visible at 500 ft. However, as we headed southeast towards the ADIZ line, the cloud thickened again with tops around 700-800 ft, and LWC around 0.28 g/m^3. Around 21:51 UTC, we transitioned back into the cloud deck with tops around 900-1000 ft and LWC 0.4-0.5 g/m^3.

At 22:00 UTC, we determined that cloud tops were too low for a useful EarthCARE spiral, so we stopped porpoising and ascended to cross the ADIZ line. Scattering coefficient was ~30Mm^{-1} right above cloud top as we climbed, with a particle size mode in the APS. Scattering dropped as we climbed to about 8Mm^{-1}. We leveled off at 9500 ft at 22:21 UTC and saw 1800 particles/cm^3. We were able to find a small area of clear air in the Monterey Bay, so we began spiraling down to 100 ft at 22:40 UTC. The spiral was centered roughly at 36° 39'N, 121° 51.5'W, just off the coast of Monterey; the spiral location did not appear to be above any algae bloom, which we observed the previous flight farther north in the bay. The first temperature inversion in the profile was at about 3500 ft, and clouds to the west of the profile were estimated to have tops at 700 ft and bases at 300 ft or lower. Once we descended to/below the level of the clouds at 23:08 UTC, scattering coefficient dropped to 5Mm^{-1}. Finally, we transited to the Marina airport and did one low approach, where scattering coefficient was about 7 Mm^{-1}.

Low clouds in Monterey Bay just after takeoff; photo by Eddie Winstead

Monterey and Seaside, CA coastline at 22:39 UTC; photo by Michael Shook



Marina, CA coastline at 22:41; photo by Michael Shook

Missed approach at Marina airport with marine layer that extended over CEOBS in the background; photo by Brian Cairns

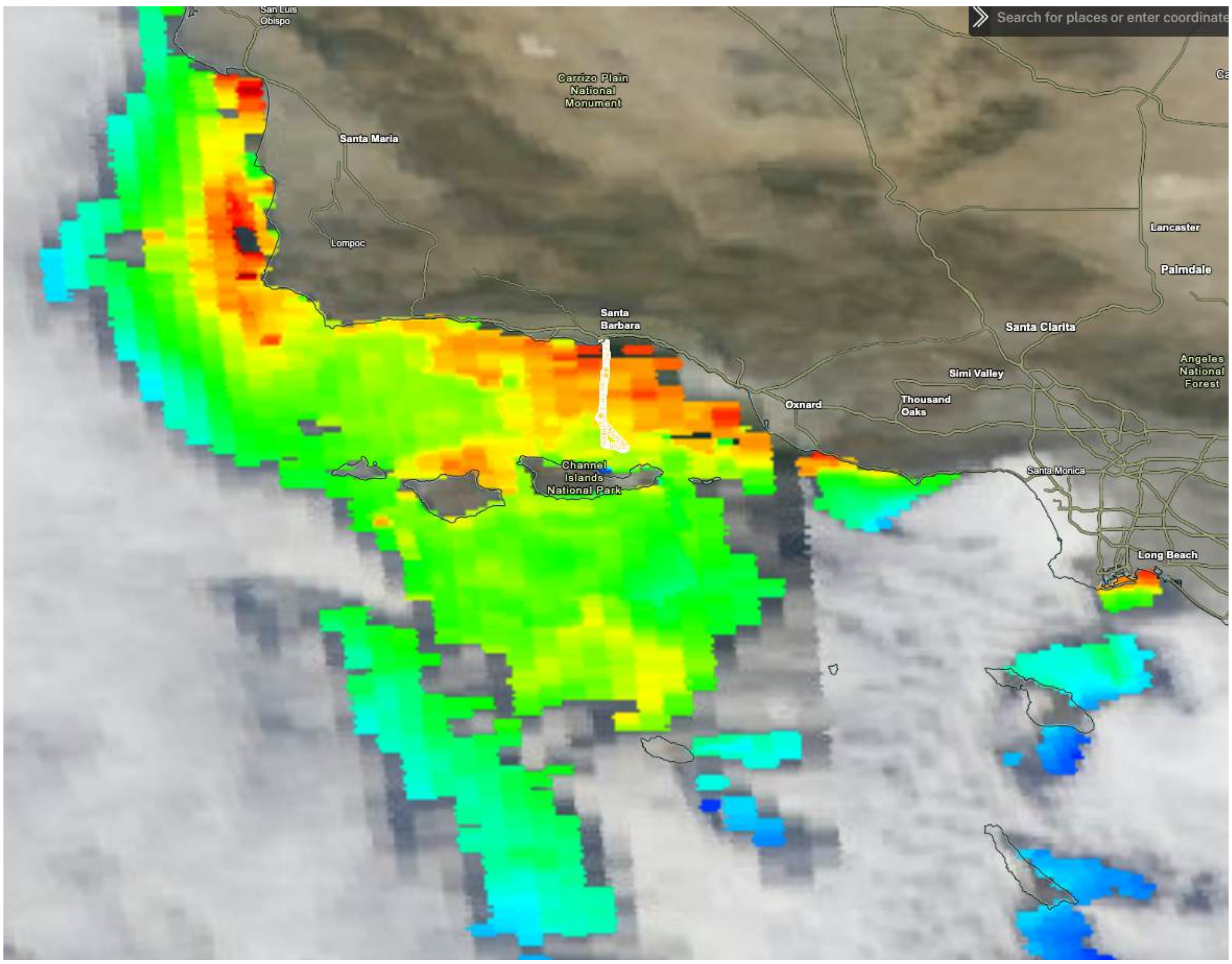
PACE-PAX research flight report 2024/09/25

Compiled by Kirk Knobelspiesse, 2025/09/20

This was a R/V Shearwater only operations day. The ship occupied 3 stations in clear skies.

R/V Shearwater
Creator: Michael Ondrusek
Cruise ID: RF0925-RS
Sailed out: 17:32 UTC
Back in port: 00:40 UTC (09/26/2024)

PACE
Overpass: 19:55, 21:33
Orbit track east inland and west offshore



All times are in UTC, VTM elements in **black** satisfied, **blue** partially satisfied and **red** not satisfied.

Time	Platform	VTM	
17:32	RS		Sailed out
18:36-19:58	RS, PACE-OH	1b(2.0), 1c(2.0), 6i(2.0)	Station #34, clear skies
19:55	**PACE-OH**		**PACE overpass (east)**
20:04-21:33	RS, PACE-OH	1b(2.0), 1c(2.0), 6i(2.0)	Station #35, clear skies
21:33	**PACE-OH**		**PACE overpass (west)**
21:50-22:47	RS, PACE-OH	1b(2.0), 1c(2.0), 6i(2.0)	Station #36, clear skies
23:09-00:08	RS		Station 37, clear skies
00:40	RS		Back in port

Station #34 34° 07.013' N, -119° 41.147, arrival 18:36 UTC →departure 19:58 UTC

PACE overpass 19:55

Arrival photo:

Departure photo (departure location - 34 06.627', -119° 40.733')

Station #35 34.10129° -119.63777°, arrival 20:04 UTC → departure 21:28 UTC

PACE overpass at 21:33

Live call in into show and tell.

Arrival photo: No photo

Departure photo: (34 06.177', -119° 37.356')

Station #36 34° 11.262', -119° 41.929' arrival 21:50 UTC → departure 22:47 UTC

Arrival photo:

Departure photo: (34° 11.462', -119° 41.466')

Station #37 34° 18.590', -119° 41.084' arrival 23:09 UTC → departure 00:08 UTC (09/26/2024)

Arrival photo:

Departure photo: 34° 18.603’, -119° 41.090’

Tomorrow, RV Shearwater will

Ship plans through the next 3 days...

System Status...

All good

Group Status...

All great

PACE-PAX research report 2024/09/26

Compiled by Kirk Knobelspiesse, Ivona Cetinić, Brian Cairns, Michael Ondrusek, 2024/10/06

Reviewed by Samuel LeBlanc

Last full coordination between ER-2, Twin Otter, Shearwater with PACE and EarthCARE overpasses. Generally cloud free with low aerosol optical depths. Twin Otter spirals above Shearwater and a potential red tide during PACE overpass.

ER-2
Take off: 17:01
Landing: 23:23
Duration: 6.4 hrs
Pilot: Kirt Stallings, mobile: Dean Neeley
All instruments operated successfully

Twin Otter
Take off: 17:25
Landing: 22:29
Duration = 5.1 hrs
Manifest: Bryce Kujat (pilot), Jeff Martin (pilot), Elizabeth Wilk (QNC), Adam Ahern (QNC), Edward Winstead (QNC)
See end for full Twin Otter report

R/V Shearwater
Mission Scientist: Michael Ondrusek
Sailed out: 15:54 UTC
Back in port: 22:15 UTC
See end for full R/V Shearwater report

PACE
20:31, California inland

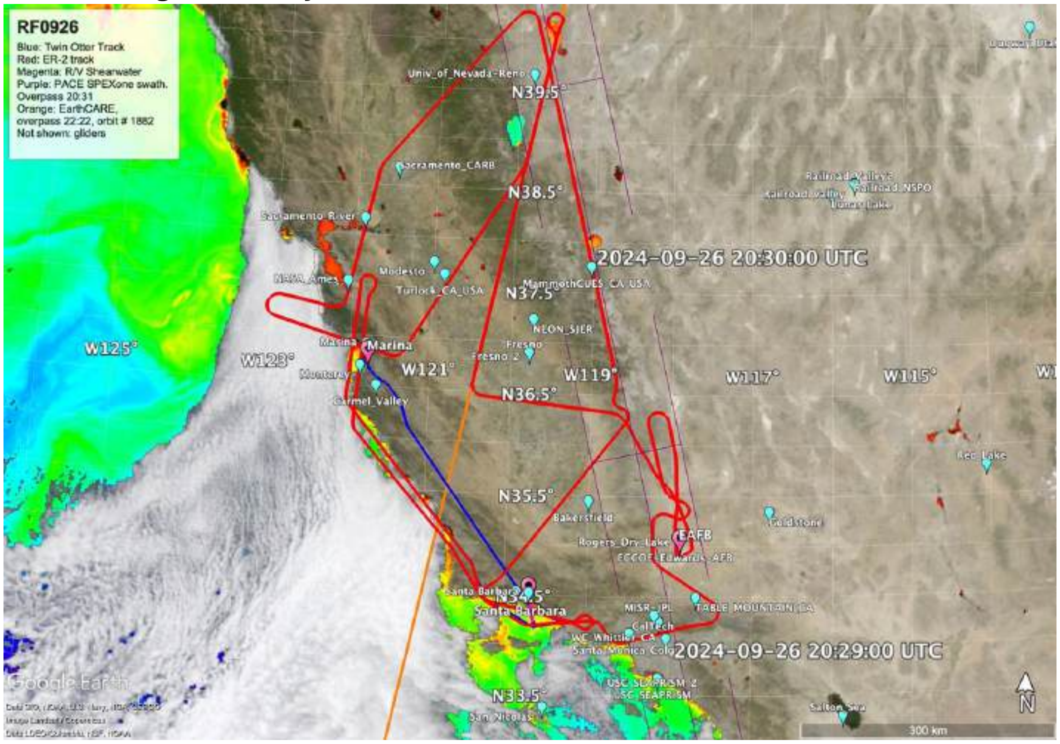
EarthCARE
22:22, Lake Tahoe to California central coast. Orbit #1882

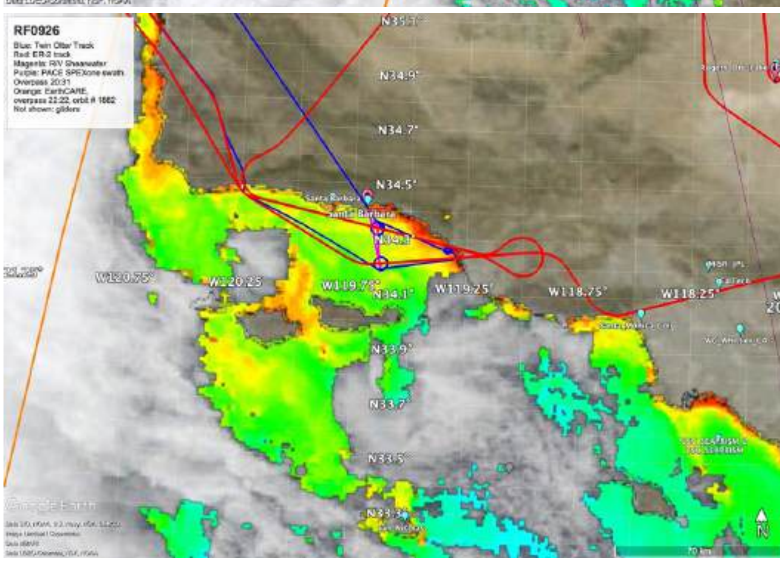
Gliders
Operational

Additionally at Reno: (from email Hans.Moosmuller@dri.edu)
At UNR, Pat Arnott is running our AERONET station and in addition photoacoustic plus nephelometer measurements of aerosol absorption and scattering at 532 nm (https://www.patarnott.com/pas532/). In addition, there are the Washoe County Air Monitoring stations (https://www.nnph.org/programs-and-services/air-quality/air-monitoring-stations.php) with Reno4 at 1450 Stewart Street in Reno being the core station with the most instruments and data. The NWS Reno office (next to DRI, just north of Reno ~500' above valley floor) does the usual

twice a day met balloon soundings. Weather is calm and clear and predicted to stay this way with likely only a few ug/m^3 of PM2.5.

Overall image summary





Validation Traceability Matrix itemized objectives

VTM elements in **black** satisfied, **blue** partially satisfied, red to be confirmed

Time UTC	Platform	VTM(hrs)	
15:54	RS		R/V Shearwater departs
16:36	RS		Station #38, departure 17:30. Mostly clear.
17:01	ER2		ER-2 takeoff
17:25	TO		Twin Otter takeoff

17:35	RS		Station #39 (SHER1), departure 19:46. ER-2 and TO overpass (scored below). Clear skies
17:53	ER2	1d(0.5)	ER-2 over CalTech AERONET site possibly with remnant smoke and urban pollution. AOD(500)=0.13
18:05	ER2	1f(0.5), 4b(0.5)	ER-2 over sunglint
18:06	ER2, RS	1b(1.5), 1c(1.5)	ER-2 over Shearwater station #39 (SHER1) in clear skies
18:07	ER2, glider		ER-2 over gliders. Potentially cloudy?
18:33	ER2, TO	1d(1.0)	ER-2 over Monterey AERONET site, AOD(500)=0.07. Over line previously sampled by Twin Otter (roughly 50 min prior)
19:07	ER2, TO	1c(0.5)	ER2 overpass (at 19:17) of TO west of Santa Barbara, while TO is descending into boundary layer
19:25	TO, RS	1b(1.5), 1c(1.5)	TO spirals up from 100 to 10000ft over Shearwater at #39 (SHER1) at top 19:50
19:35	ER2,RS	1b(3.0), 1c(3.0), 1f(1.0), 4b(1.0)	ER-2 over Shearwater at station #40 (SHER2), at location for Twin Otter (also previously overflew this site at ~19:23). Some glint.
20:06	ER2, PACE-OHS	1d(1.0), 3b(1.0)	ER2 on PACE line over Sierra Nevada mountains up to Reno area. Overpass just south of Lake Tahoe. Line ends at 20:36. Cloud free, low AOD. Over MammothCUES_CA_USA AERONET station, AOD(500)=0.025 (20:15). Additional instrumentation at DRI/Reno, contact Hans Moosemueller
20:12	RS		Station #40 (SHER2) depart 21:39. Clear
20:00	TO	1b(1.5), 1c(1.5), 6i(1.5)	TO spirals over red tide offshore near Oxnard, CA.
20:20	TO	1b(1.5), 1c(1.5)	TO spirals up from 100 to 10000ft over Shearwater at #40 (SHER2) at top 20:59
20:31	**PACE**		**PACE overpass, inland California**
20:35	ER2, PACE-OHS	1c(0.25), 3a(0.25), 6h(0.25)	Over pyramid lake (turbid), under PACE-OHS, nearby Univ_of_Nevada-Reno AERONET AOD(500)=0.04
21:03	ER2	1b(0.5), 1c(0.5), 6h(0.5)	Over Sacramento_River AERONET-OC site. AOD(500)=0.03
21:10	ER2	1d(0.5)	Over NASA_Ames AERONET-OC site. AOD(500)=0.04
21:28	ER2	1d(0.5)	Over CEOBS site. AERONET not functional, but ground Lidar and other instruments ok
21:39	ER2	1d(0.5)	Over Turlock AERONET site. AOD(500)=0.05
22:09	ER2, EarthCARE	1d(2.0), 3d(2.0)	Start EarthCARE line, ends 22:40. Cloud free, low aerosol loads.
22:22	**EarthCARE**		**EarthCARE overpass, Orbit #1882**
23:23	ER2		ER-2 lands

PACE-O: within swath of PACE's OCI instrument
PACE-OH: within swath of PACE's OCI and HARP2 instruments
PACE-OHS: within swath of PACE's OCI, SPEXone and HARP2 instruments
TO: Twin Otter
RB: R/V Blissfully
RS: R/V Shearwater

Assessment:

- 0.021 of objectives observed. Successful coordination between ER-2 Shearwater and TO, underpasses of PACE and EarthCARE.
- Top remaining objective (score above 6.0): PACE aerosol in narrow swath over ocean (3a)

PACE-PAX progress tracking

Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 9/23	Fractional success 9/24	Fractional success 9/25	Fractional success 9/26	Fractional success 9/27	Fractional success 9/29	Fractional success 9/30	Total success	Remaining score
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.971	0.2
	b	Ocean radiometric parameters	10	8.0	8.0	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.998	0.0
	c	Aerosol parameters over the ocean	12	8.0	9.5	0.000	0.000	0.000	0.014	0.000	0.000	0.000	0.994	0.1
	d	Aerosol parameters over land	12	8.0	13.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.0
	e	Cloud parameters	12	8.0	4.8	0.058	0.025	0.000	0.000	0.000	0.000	0.000	0.898	1.2
	f	Ocean surface parameters	1	8.0	1.5	0.000	0.000	0.000	0.133	0.000	0.000	0.000	0.354	0.6
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.354	6.5
	b	Aerosol parameters over land (PACE)	10	8.0	4.0	0.132	0.000	0.000	0.103	0.000	0.000	0.000	0.638	3.6
	c	Cloud parameters (PACE)	5	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.713	1.4
	d	Aerosol parameters (EarthCARE)	8	4.0	3.0	0.038	0.000	0.000	0.053	0.000	0.000	0.000	0.918	0.7
	e	Cloud parameters (EarthCARE)	8	4.0	2.5	0.152	0.167	0.000	0.000	0.000	0.000	0.000	0.632	2.9
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.953	0.3
	b	Validate large reflectances with high polarization	6	2.0	1.5	0.000	0.000	0.000	0.194	0.000	0.000	0.000	0.826	1.0
	c	Validate large reflectances with low polarization	6	2.0	1.5	0.034	0.000	0.000	0.000	0.000	0.000	0.000	0.970	0.2
	d	Overfly vicarious calibration sites	6	4.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.268	4.4
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.0
	b	High aerosol loads over ocean	4	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.393	2.4
	c	Multiple aerosol layers	1	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.0
	d	Aerosol under thin cirrus	2	2.0	3.5	0.826	0.000	0.000	0.000	0.000	0.000	0.000	0.826	0.3
	e	Aerosol above liquid phase cloud	4	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.826	0.7
	f	Broken clouds with complex structure	4	2.0	1.0	0.186	0.000	0.000	0.000	0.000	0.000	0.000	0.713	1.1
	g	Dust aerosols over ocean	4	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.430	2.3
	h	Aerosol and ocean parameters over turbid waters	2	2.0	0.5	0.000	0.000	0.000	0.046	0.000	0.000	0.000	0.837	0.3
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	1.5	0.000	0.000	0.000	0.043	0.000	0.000	0.000	0.961	0.2
	k	Smoke aerosols over ocean	1	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.713	0.3
		total:	150	98	55.8	0.041	0.011	0.000	0.021	0.000	0.000	0.000	0.793	
														total
				ER-2 flight hours		2.8	0	0	0	0	0	0	0	2.8
				TO flight hours		2.5	0	0	0	0	0	0	0	2.5
				Shearwater days		0	0	0	0	0	0	0	0	0
		PACE-PAX overall objectives satisfied:		0.793										

Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

https://www-air.larc.nasa.gov/missions/pacepax/index.html

MVIS imagery

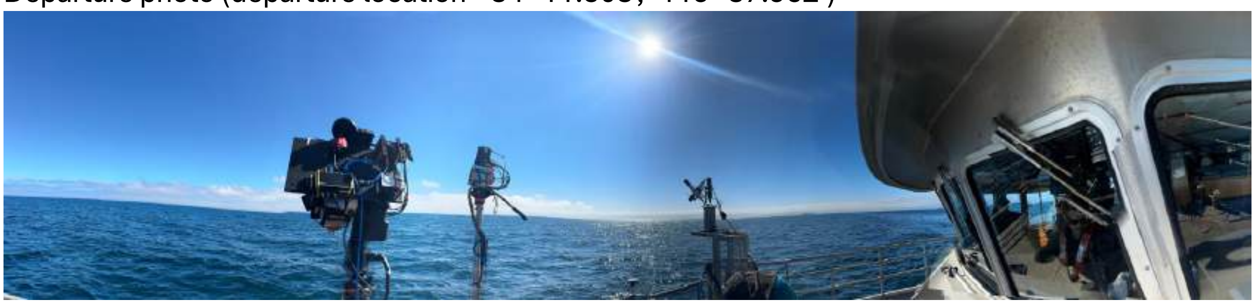
18:06 over R/V Shearwater 	18:07 over glider 
18:33 over Monterey AERONET site 	19:35 over Shearwater, TO spiral location 
20:31 PACE overpass (S. of Pyramid Lake) 	21:03:28 Sacramento_River AERONET-oc 

<table>
<tr><td>21:28 CEOBS site
</td><td>22:22 EarthCARE overpass
</td></tr>
<tr><td></td><td></td></tr>
</table>

R/V Shearwater photos

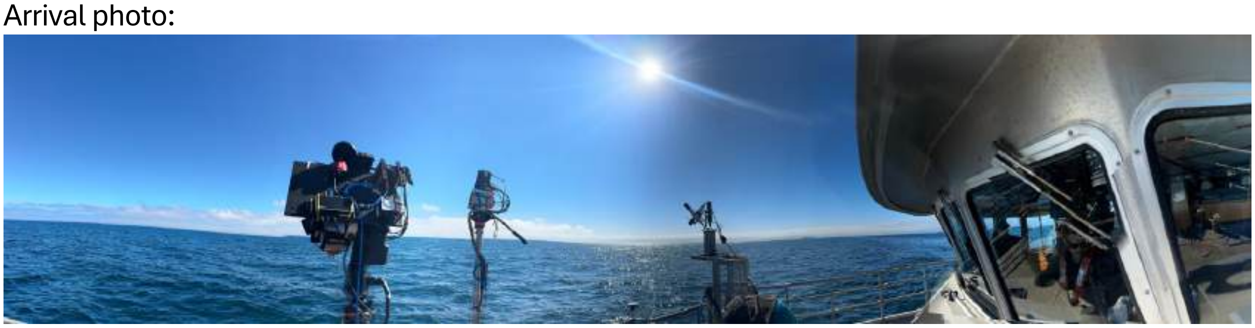
Station #38 34° 11.308' N, -119° 37.773', arrival 16:36 UTC →departure 17:30 UTC
Arrival photo:

Departure photo (departure location - 34° 11.508', -119° 37.962')



Station #39 (SHER1) 34° 12.461', -119° 37.559', arrival 17:35 UTC → departure 19:46 UTC
ER-2 overflight at 18:06
Twin otter spiral at 19:25

Arrival photo:



Departure photo: (34 12.897', -119° 37.947')

Station #40 (SHER2) 34 20.197', -119° 38.960' arrival 20:12 UTC → departure 21:39 UTC
ER-2 overpass prior to arrival to station @19:34 UTC
Twin otter spiral 13:22 start
PACE overpass at 13:29

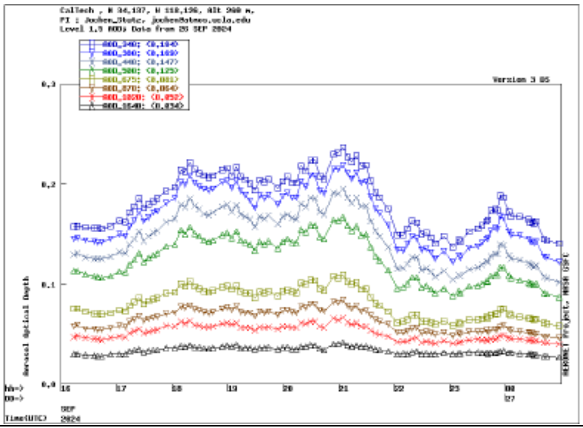
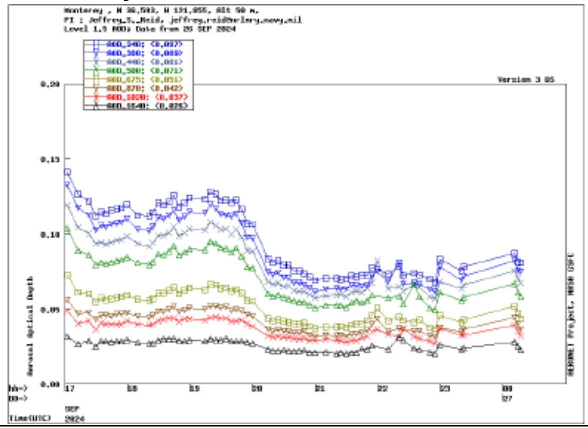
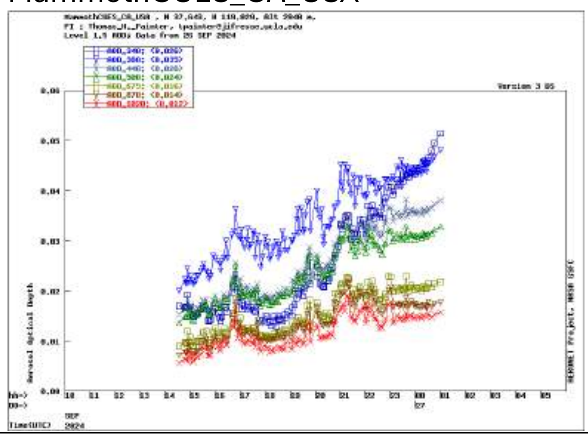
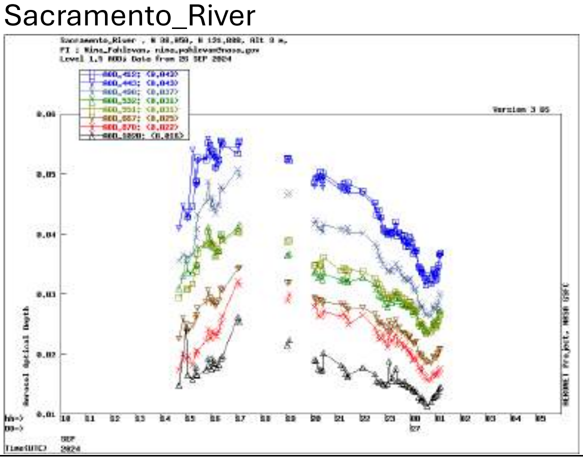
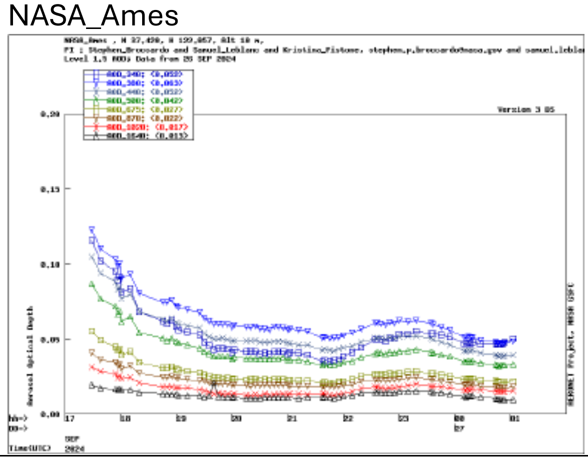
Arrival photo:

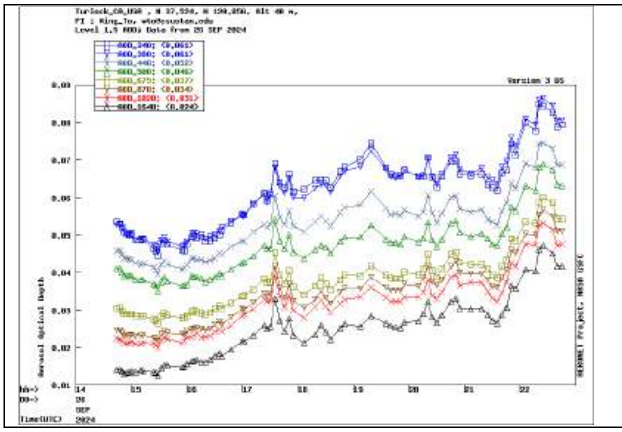
Departure photo: (34 20.201', -119° 38.964')

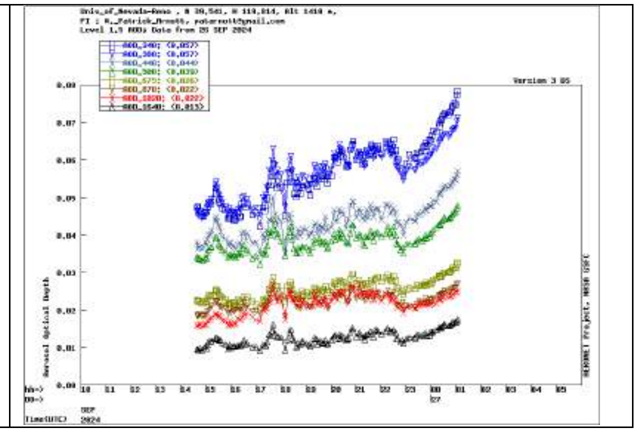
Twin Otter photos

20:01:17 UTC – Spiral over red tide near Oxnard between RV Shearwater spirals 1 and 2. Photo Adam Ahern

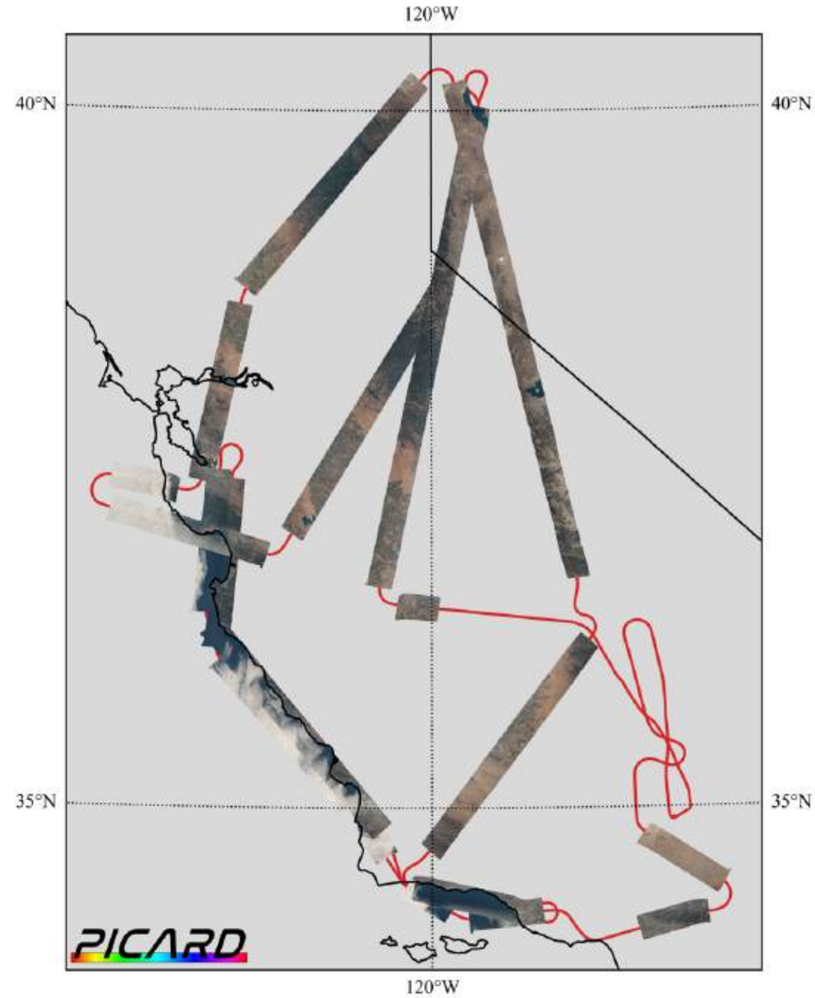
AERONET plots

CalTech 	Monterey 
NRL_CEOBS_MBAYCAUSA No data	MammothCUES_CA_USA 
Sacramento_River 	NASA_Ames 
Turlock_CA_USA	Univ_of_Nevada-Reno


Aerosol Optical Depth
AERONET Project, NASA GSFC
Time(UTC)
SEP
2024

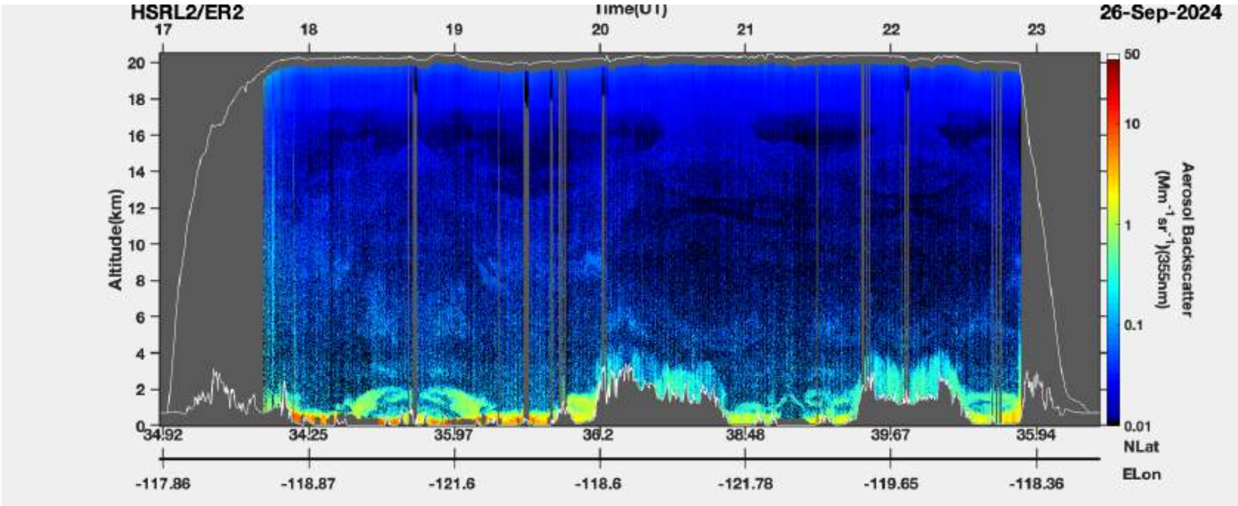

Aerosol Optical Depth
AERONET Project, NASA GSFC
Time(UTC)
SEP
2024

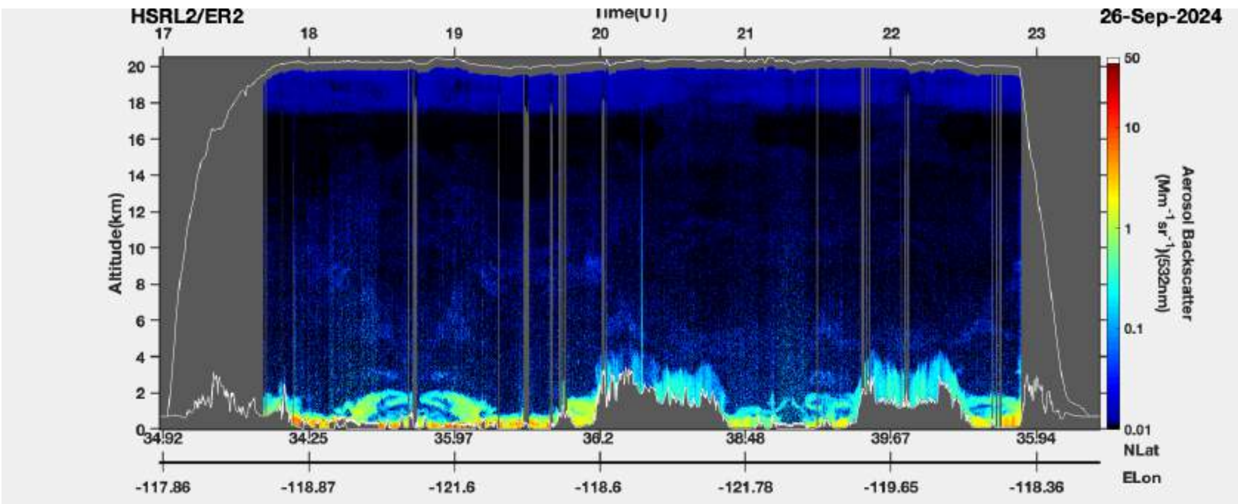
PICARD quicklooks

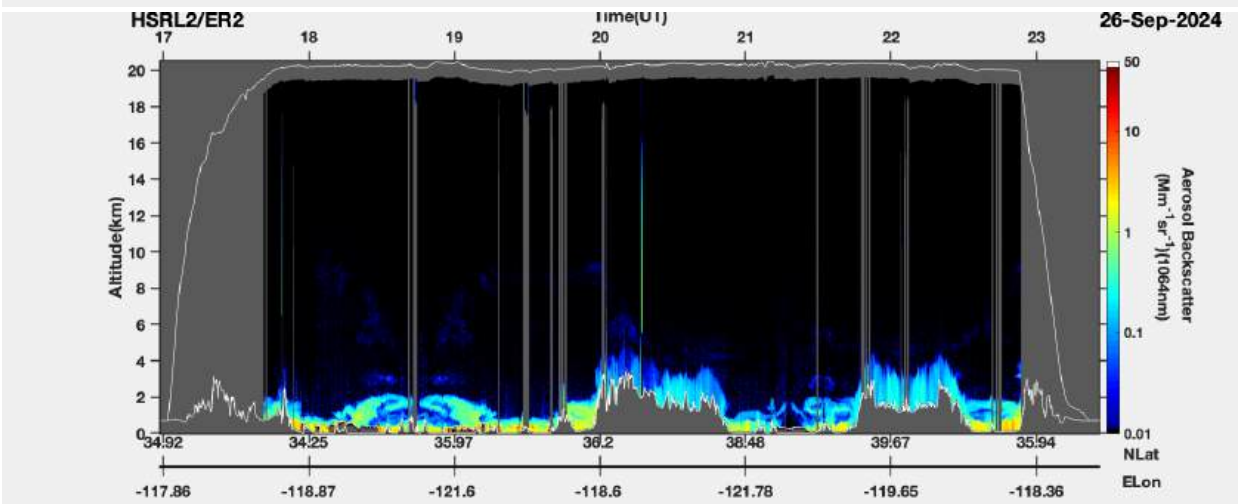


Pushbroom Imager for Cloud and Aerosol Research and Development
PACE-PAX, NASA Armstrong Flight Research Center
26 September 2024

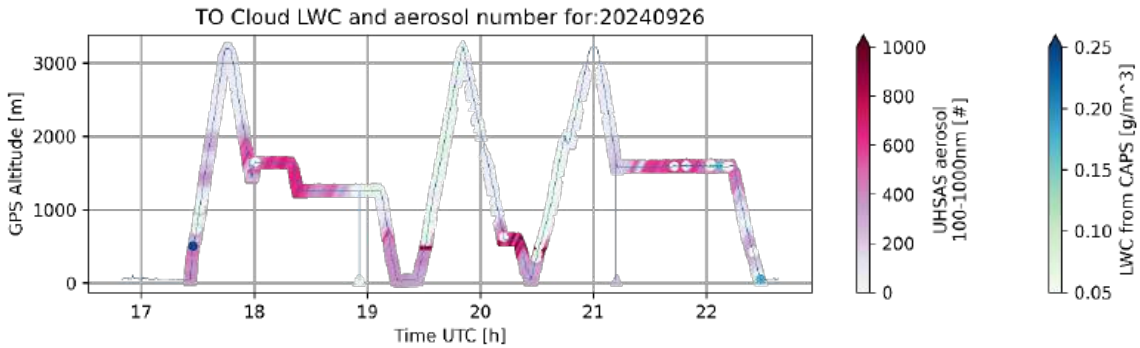
HSRL quicklooks

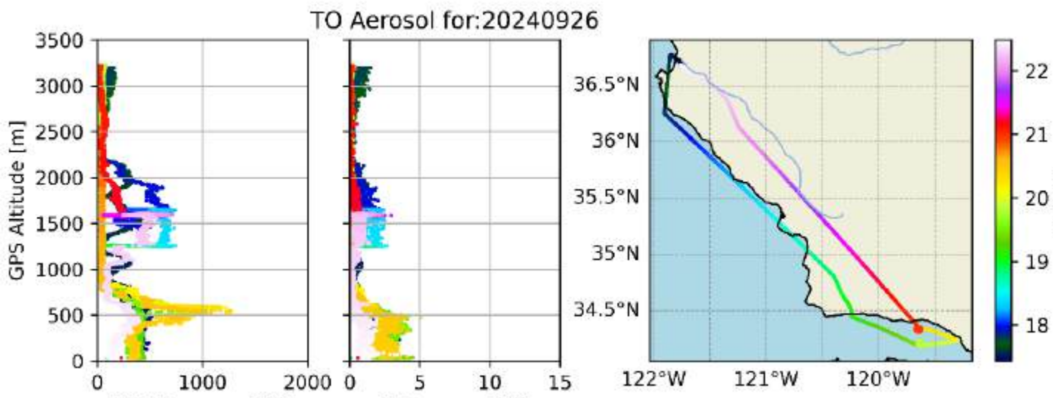




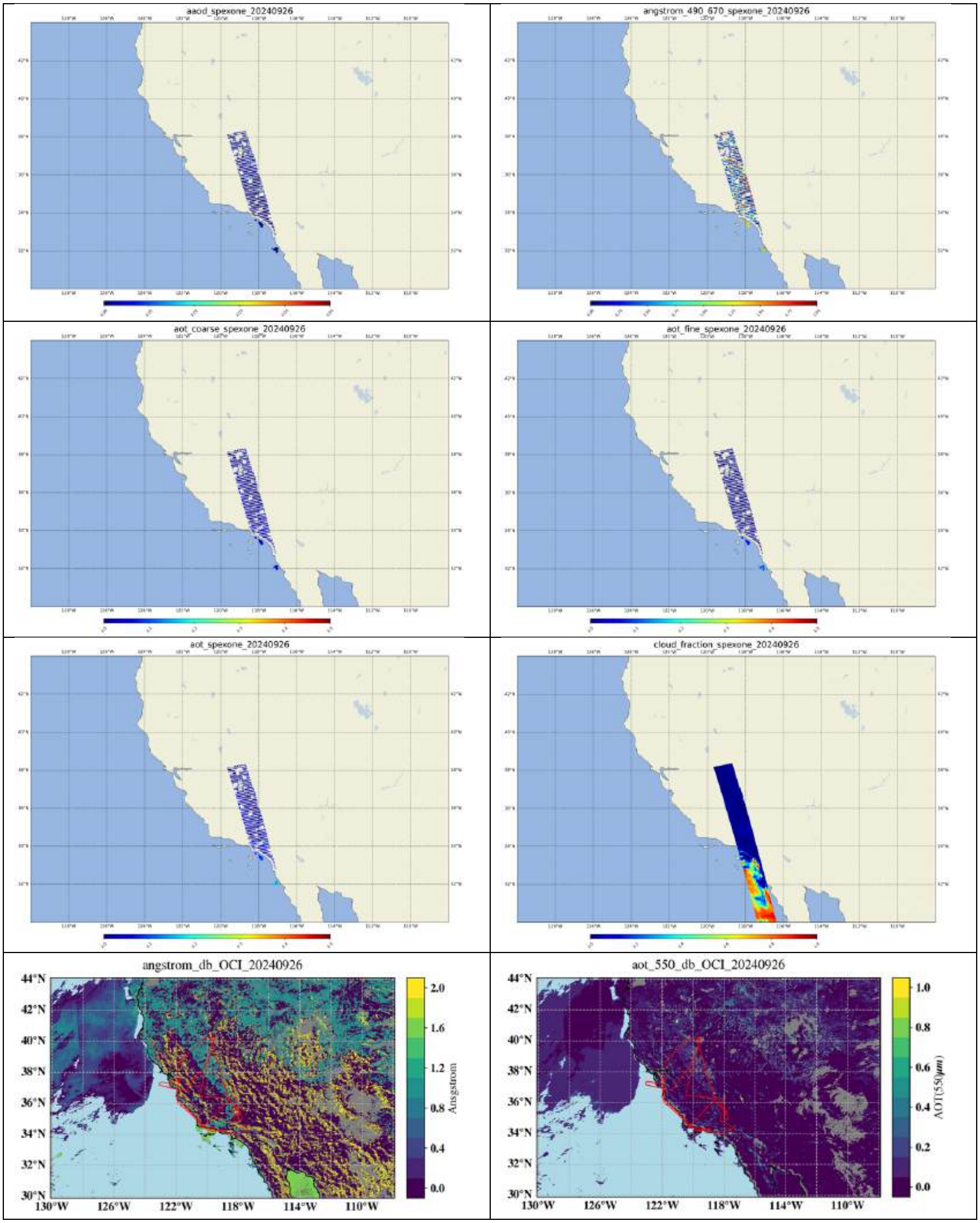


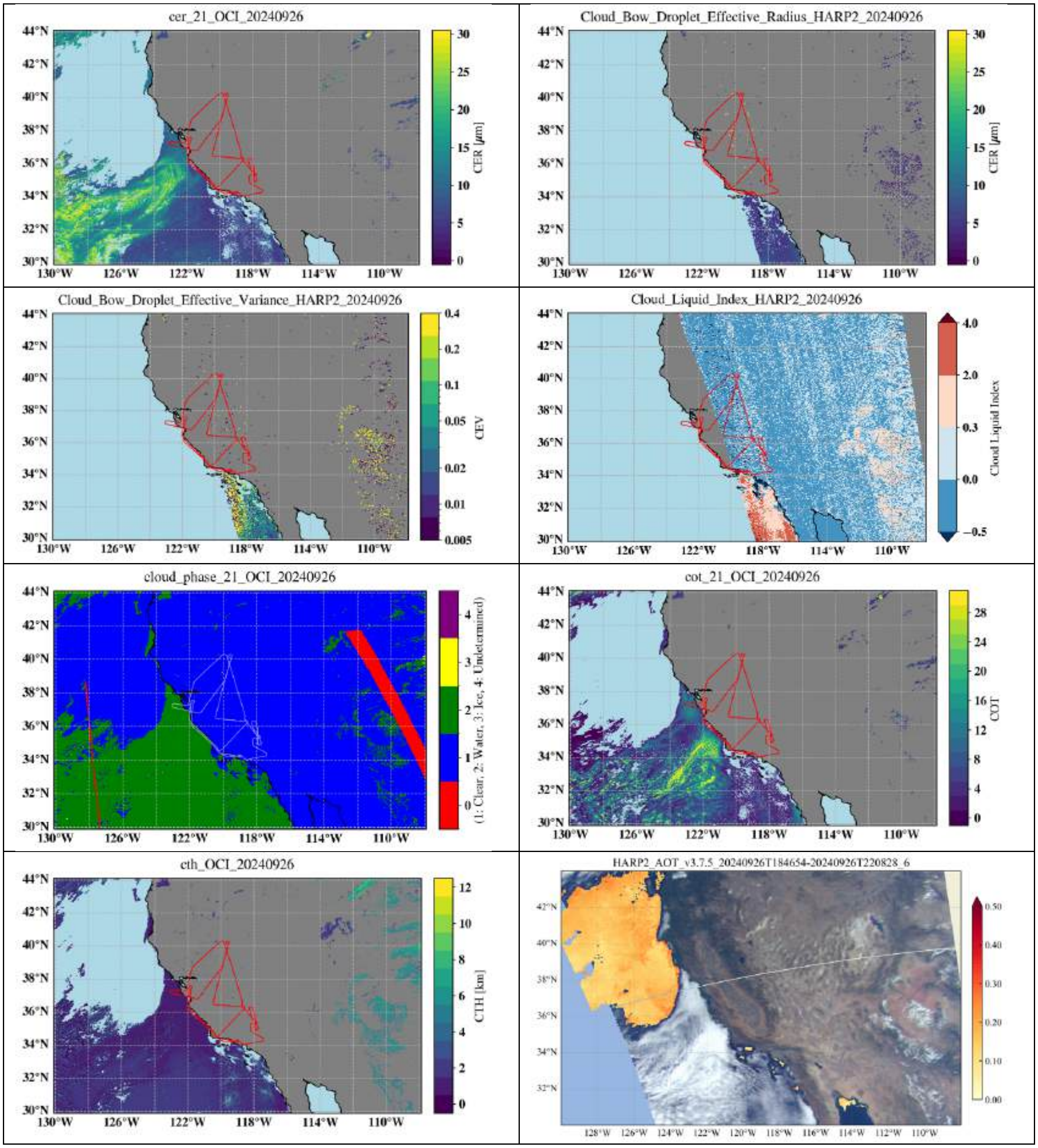
TO Quicklooks





PACE quicklooks





cer_21_OCI_20240926
CER [μm]
Cloud_Bow_Droplet_Effective_Radius_HARP2_20240926
CER [μm]
Cloud_Bow_Droplet_Effective_Variance_HARP2_20240926
CEV
Cloud_Liquid_Index_HARP2_20240926
Cloud Liquid Index
cloud_phase_21_OCI_20240926
(1: Clear, 2: Water, 3: Ice, 4: Undetermined)
cot_21_OCI_20240926
COT
cth_OCI_20240926
CTH [km]
HARP2_AOT_v3.7.5_20240926T184654-20240926T220828_6

Twin Otter flight report

PACE-PAX Research Flight report 2024-09-26

Twin Otter Flight

Manifest:

Bryce Kujat (pilot)

Jeff Martin (pilot)

Elizabeth Wilk (QNC)

Adam Ahern (QNC)

Edward Winstead (QNC)

Note: This flight had coordination with the ER-2 and RV Shearwater.

Take off: 10:25:52 (17:25:52 UTC) Marina Airport (OAR)

Landing: 15:29:03 (22:29:03 UTC) Marina Airport (OAR)

Duration = 5.1 hrs

Spiral 1 – Over RV Shearwater (SHER1, revised) from 100 ft (19:25 UTC) to 10000 ft (19:50 UTC)

Spiral 2 – Over Red Tide near Oxnard CA

Spiral 3 – Over RV Shearwater (SHER2, revised) from 100 ft (20:20) to 10000 ft (20:59 UTC)

Objectives: The Twin Otter was targeting air masses predicted to contain optically thin levels of aerosols over water 1) under the ER-2's future flight path over water and 2) in spirals over the RV Shearwater off the coast of Santa Barbara. PACE overpass will occur during a spiral over the RV Shearwater at 20:29 UTC inside the HARP2 swath but outside the SPEXone swath. Missed approaches at the Marina tower are a target of opportunity.

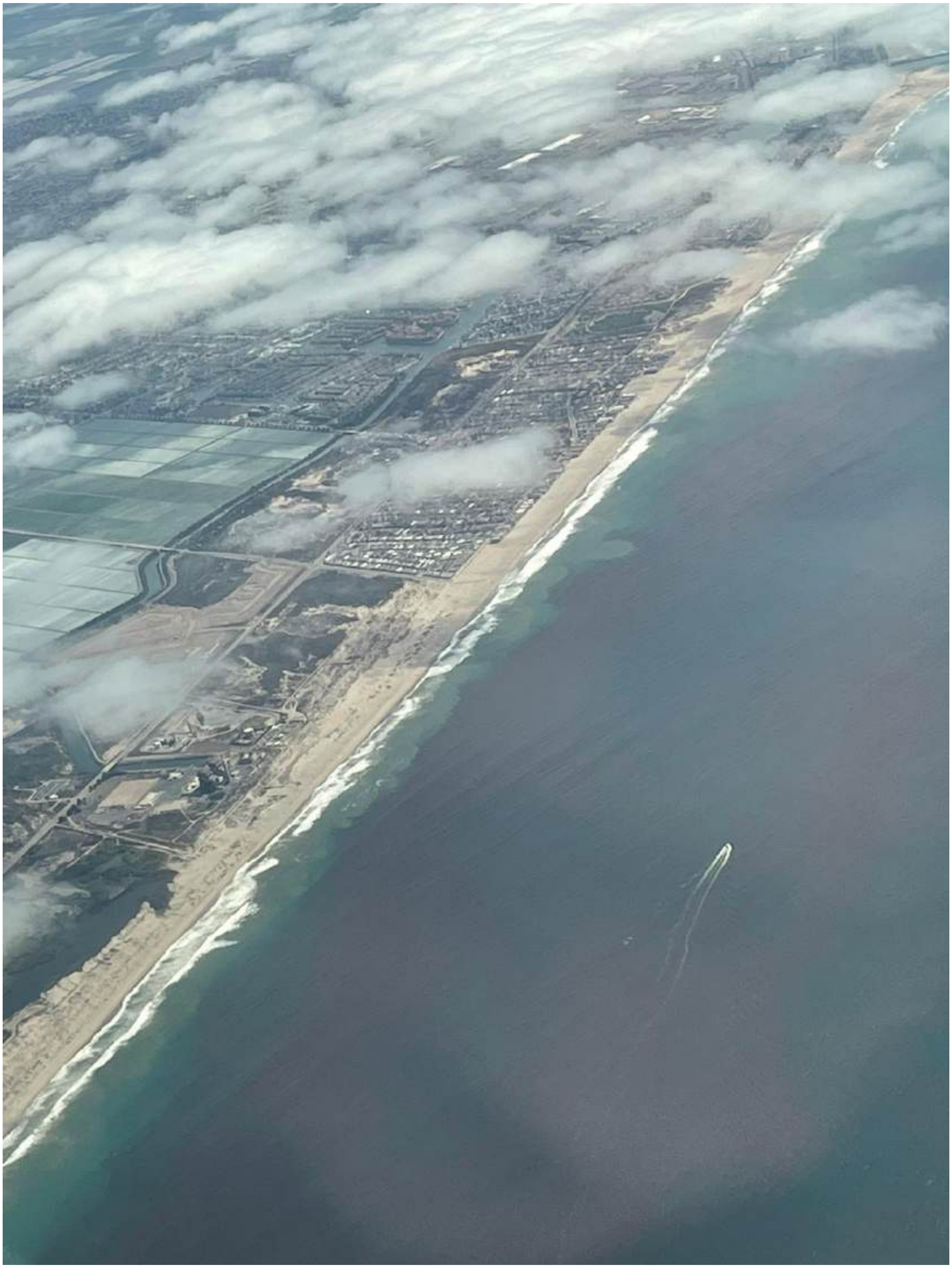
Summary: Prior to and during takeoff, a large mode (D_{opt} ~300 nm) was observed with a scattering coefficient of 40 Mm^{-1} at 550 nm. After takeoff, we observed this layer to an altitude of 1600 ft. We continued to climb and turn towards the coast, observing several thin layers up to 7000 ft, see CIRPAS quickplot below. En route to the rendezvous with the RV Shearwater at SHER1, we tried to sample the aerosol layer observed at 5100' with an observed scattering coefficient of 15 Mm^{-1}. At the same time, the ER-2 was on an offset flight path to the west of the Twin Otter and observed a thick aerosol layer at 4000'. We descended to 4000' but did not see any increase from 15 Mm^{-1} of aerosol scattering. When we crossed overland the aerosol layer dissipated.

We descended in-line towards the RV Shearwater, reaching an altitude of 100 ft. During the first spiral over the RV Shearwater, we observed a thick layer up to 3000 ft, with a maximum scattering coefficient of 30 Mm^{-1} at 1960 ft and 19:31 UTC. The ER2 overflew us during the spiral. Very little aerosol was observed from 3000 ft up to 10000 ft. We descended inline towards Oxnard airport and identified a red tide (toxic algal bloom) off the shore. We spiraled down above it before continuing to the 2nd Shearwater coordination point at 2000' measuring scattering coefficients of ~25 Mm^{-1}. When we reached the RV Shearwater we descended to 100 ft and began our spiral up, which showed a profile consistent with that observed in the first spiral. We climbed all the way to 10000 ft then headed back towards KOAR. We had to hold at 6000 ft for a few minutes during the spiral due to traffic. We were in the spiral in the aerosol layer over the RV Shearwater during the PACE overpass at 20:30 UTC. We returned to KOAR at 5000 ft and measured on average a scattering coefficient of 10 Mm^{-1}. Missed approaches weren't possible due to weather at KOAR.

17:39:17 UTC – Climb and turn from KOAR - Layer of larger particles below 1600', with layers of optically thinner aerosol above were observed.

19:15:54 UTC – Descending in-line towards RV Shearwater shows a well mixed aerosol layer below 2600 ft.

20:01:17 UTC – Spiral over red tide near Oxnard between RV Shearwater spirals 1 and 2. Photo Adam Ahern



20:16 UTC – Another picture of the red tide near Oxnard; photo taken by Eddie Winstead.

R/V Shearwater report

Date: 09/26/2024

Creator: Michael Ondrusek

Cruise ID: RF0926-RS

Sailed out: 15:54 UTC

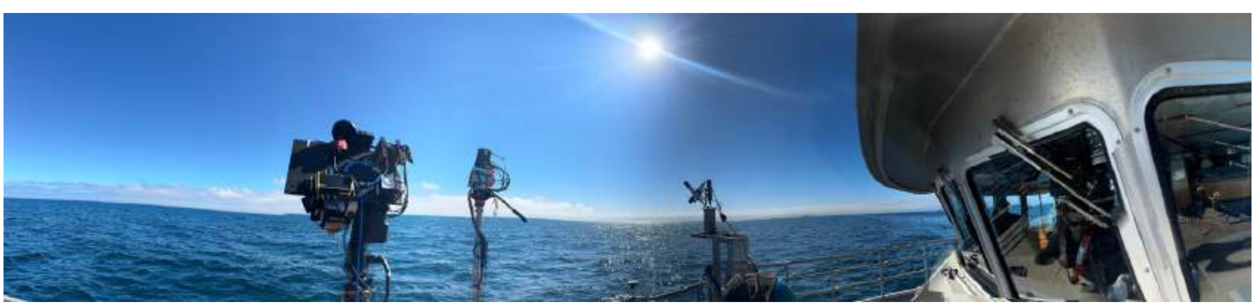
Back in port: 22:15 UTC

Today, the ship occupied 3 stations in clear skies!!!

Station #38 34° 11.308' N, -119° 37.773', arrival 16:36 UTC →departure 17:30 UTC

Arrival photo:

Departure photo (departure location - 34° 11.508', -119° 37.962')



Station #39 (SHER1) 34° 12.461', -119° 37.559', arrival 17:35 UTC → departure 19:46 UTC

ER-2 overflight at 18:06

Twin otter spiral at 19:25

Arrival photo:

Departure photo: (34 12.897', -119° 37.947')

Station #40 (SHER2) 34 20.197', -119° 38.960' arrival 20:12 UTC → departure 21:39 UTC

ER-2 overpass prior to arrival to station @19:34 UTC

Twin otter spiral 13:22 start

PACE overpass at 13:29

Arrival photo:

Departure photo: (34 20.201’, -119° 38.964’)

Tomorrow, RV Shearwater will demob and pack.

Ship plans through the next 3 days… No plans – demob end of the cruise.

System Status…

All good

Group Status…

All great

PACE-PAX research report 2024/09/27

Compiled by Kirk Knobelspiesse, Ivona Cetinić, Brian Cairns, Michael Ondrusek, 2024/10/06
Reviewed by Samuel LeBlanc

Last coordination between ER-2 and Twin Otter. ER-2 on PACE track. For the first time, overflights of R/V Rachel Carson in the Monterey Bay (PACE PVST PI Clarissa Anderson).

ER-2
Take off: 17:56
Landing: 00:26
Duration: 6.4 hrs
Pilot: Dean Neeley, mobile: Kirt Stallings
All instruments operated successfully

Twin Otter
Take off: 20:27
Landing: 23:31
Duration = 3.1 hrs
Manifest: Bryce Kujat (pilot), Jeff Martin (pilot) , Michael Shook (QNC), Elizabeth Wilk (QNC), Edward Winstead (QNC)
See end for full Twin Otter report

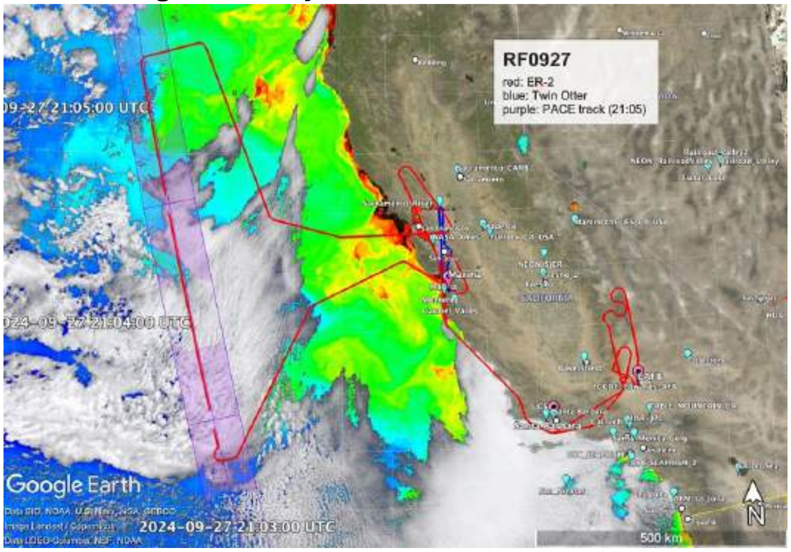
R/V Shearwater
Operations concluded

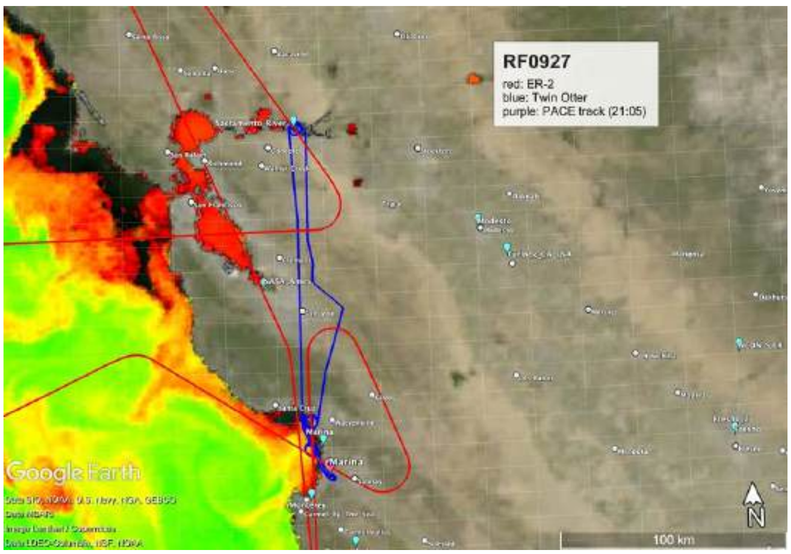
PACE
21:04, offshore California

EarthCARE
Not targeted

Gliders
Operational

Overall image summary





Validation Traceability Matrix itemized objectives

VTM elements in **black** satisfied, **blue** partially satisfied, red to be confirmed

Time UTC	Platform	VTM(hrs)	
17:56	ER2		ER-2 takeoff
18:54	ER2, gliders		ER-2 overflies gliders. Cloudy
19:18	ER2	1d(0.5)	ER-2 overflies Monterey AERONET site. AOT(500)=0.05
19:22	ER2	1d(0.5)	ER-2 overflies CEOBS site. AERONET instrument not functional, but lidar, etc. are.
19:36	ER2, RC	1b(1.0), 1c(1.0), 6i(1.0)	ER-2 over R/V Rachel Carson in biologically productive Monterey Bay conditions
20:27	TO		Twin Otter takeoff
20:30	ER2, PACE-OHS	1b(1.0), 1c(1.0), 1e(2.0), 3a(1.0), 3c(2.0), 6f(2.0)	Begins ~ 1 hour PACE track. Roughly 2/3 cloudy, 1/3 cloud free. Ends at 21:21
20:39	TO, PACE-OH	1b(1.5), 1c(1.5), 6i(1.5), 6c(1.5)	Twin Otter spiral over R/V Rachel Carson (PACE overpass). Top of spiral at 21:09, multiple aerosol layers

21:01	RS		Rachel Carson begins optical profiles
21:04	**PACE**		**PACE overpass, offshore California**
21:40	ER2	1c(1.0)	Begin ER2 cloud free segment in PACE-OH swath
21:43	TO	1c(1.5), 6c(1.5), 6h(1.5)	Start of spiral down over Sacramento_River AERONET-OC site. ER-2 overpass after spiral (22:38), multiple aerosol layer.
22:38	ER2	1b(0.5), 1c(0.5), 6h(0.5)	Over Sacramento_River AERONET-OC site. AOT(490)=0.05
22:50	TO	1d(1.5), 1c(1.5*0.5)	Twin Otter begins CEOBS spiral with ER-2 overhead(23:07). Cloud free. Partially above water.
23:01	ER2	1d(0.5)	ER-2 over NASA Ames AERONET site, AOD(500)=0.05
23:16	ER2	4c(0.5)	ER-2 return over cloudy (marine strato-cumulus) coast.
23:31	TO		Twin Otter landed
23:36	ER2, gliders	4c(0.5)	ER-2 over gliders, but cloudy
24:23	ER2		ER-2 lands

PACE-O: within swath of PACE's OCI instrument
PACE-OH: within swath of PACE's OCI and HARP2 instruments
PACE-OHS: within swath of PACE's OCI, SPEXone and HARP2 instruments
TO: Twin Otter
RB: R/V Blissfully
RS: R/V Shearwater

Assessment:

- 0.019 of objectives observed. Successful coordination between ER-2, R/V Rachel Carson and TO, plus underpass of PACE.
- No scores above 6.0. Largest is still PACE aerosol in narrow swath over ocean (3a) at 5.7

PACE-PAX progress tracking

Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 9/23	Fractional success 9/24	Fractional success 9/25	Fractional success 9/26	Fractional success 9/27	Fractional success 9/29	Fractional success 9/30	Total success	Remaining score
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.971	0.2
	b	Ocean radiometric parameters	10	8.0	12.0	0.000	0.000	0.000	0.003	0.001	0.000	0.000	0.999	0.0
	c	Aerosol parameters over the ocean	12	8.0	14.5	0.000	0.000	0.000	0.014	0.003	0.000	0.000	0.997	0.0
	d	Aerosol parameters over land	12	8.0	16.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.0
	e	Cloud parameters	12	8.0	6.8	0.058	0.025	0.000	0.000	0.023	0.000	0.000	0.920	1.0
	f	Ocean surface parameters	1	8.0	1.5	0.000	0.000	0.000	0.133	0.000	0.000	0.000	0.354	0.6
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	1.0	0.000	0.000	0.000	0.000	0.076	0.000	0.000	0.430	5.7
	b	Aerosol parameters over land (PACE)	10	8.0	4.0	0.132	0.000	0.000	0.103	0.000	0.000	0.000	0.638	3.6
	c	Cloud parameters (PACE)	5	2.0	2.0	0.000	0.000	0.000	0.000	0.181	0.000	0.000	0.895	0.5
	d	Aerosol parameters (EarthCARE)	8	4.0	3.0	0.038	0.000	0.000	0.053	0.000	0.000	0.000	0.918	0.7
	e	Cloud parameters (EarthCARE)	8	4.0	2.5	0.152	0.167	0.000	0.000	0.000	0.000	0.000	0.632	2.9
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.953	0.3
	b	Validate large reflectances with high polarization	6	2.0	1.5	0.000	0.000	0.000	0.194	0.000	0.000	0.000	0.826	1.0
	c	Validate large reflectances with low polarization	6	2.0	1.5	0.034	0.000	0.000	0.000	0.000	0.000	0.000	0.970	0.2
	d	Overfly vicarious calibration sites	6	4.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.268	4.4
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.0
	b	High aerosol loads over ocean	4	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.393	2.4
	c	Multiple aerosol layers	1	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.0
	d	Aerosol under thin cirrus	2	2.0	3.5	0.826	0.000	0.000	0.000	0.000	0.000	0.000	0.826	0.3
	e	Aerosol above liquid phase cloud	4	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.826	0.7
	f	Broken clouds with complex structure	4	2.0	3.0	0.186	0.000	0.000	0.000	0.181	0.000	0.000	0.895	0.4
	g	Dust aerosols over ocean	4	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.430	2.3
	h	Aerosol and ocean parameters over turbid waters	2	2.0	1.0	0.000	0.000	0.000	0.046	0.036	0.000	0.000	0.873	0.3
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	4.0	0.000	0.000	0.000	0.043	0.028	0.000	0.000	0.989	0.0
	k	Smoke aerosols over ocean	1	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.713	0.3
		total:	150	98	77.8	0.041	0.011	0.000	0.021	0.019	0.000	0.000	0.812	
														total
				ER-2 flight hours		2.8	0	0	0	0	0	0	0	2.8
				TO flight hours		2.5	0	0	0	0	0	0	0	2.5
				Shearwater days		0	0	0	0	0	0	0	0	0

PACE-PAX overall objectives satisfied: 0.812

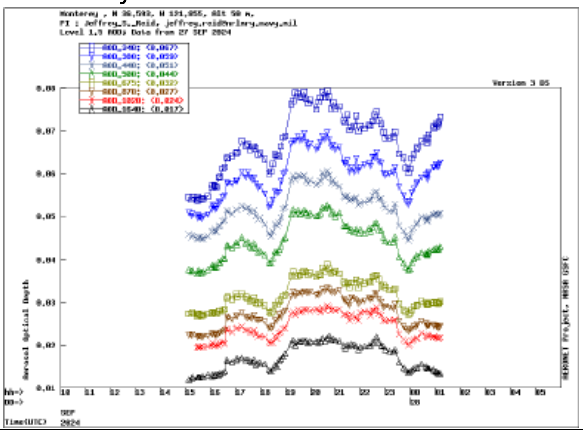
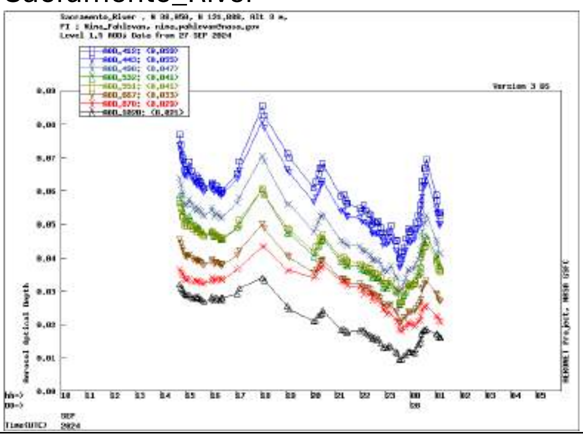
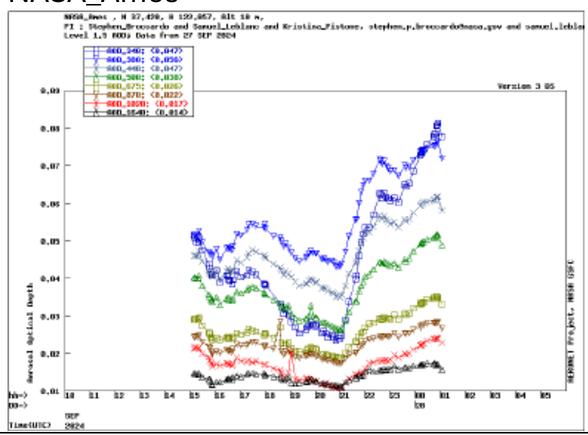
Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

https://www-air.larc.nasa.gov/missions/pacepax/index.html

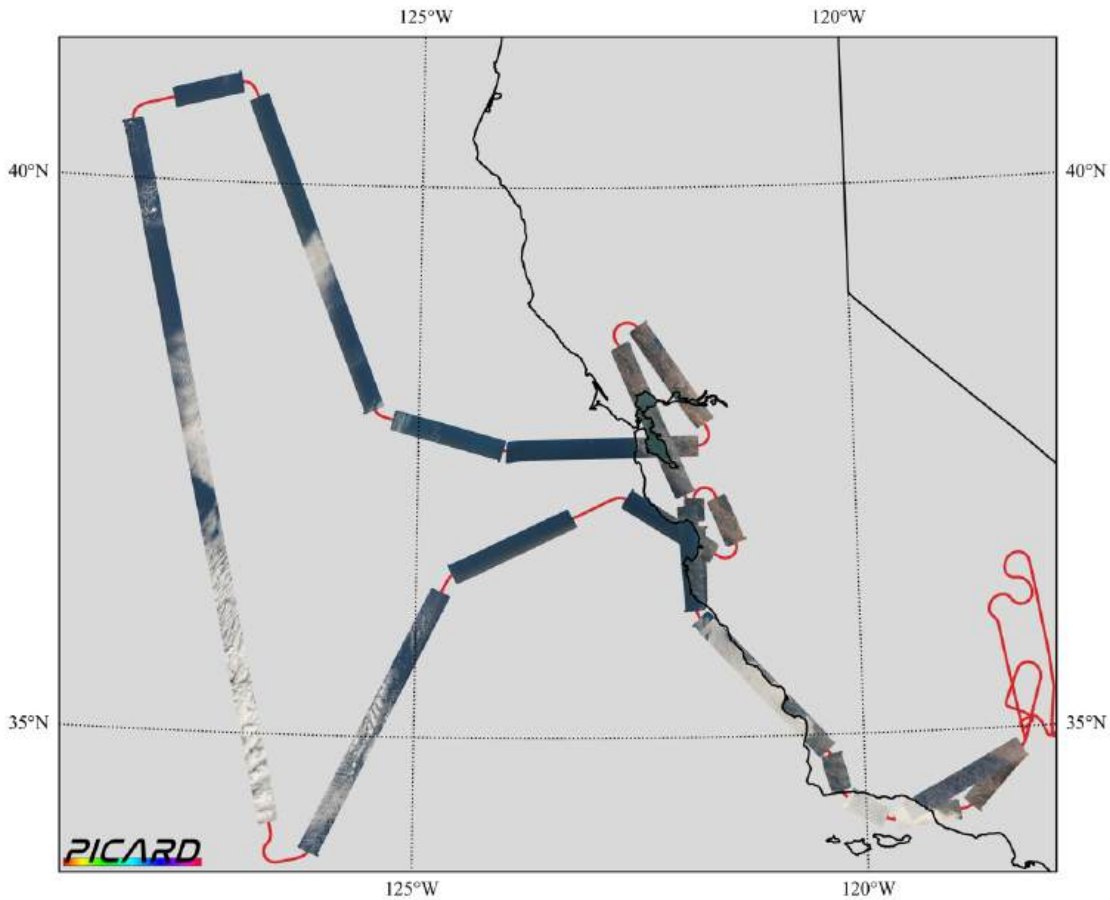
MVIS imagery

19:22 CEOBS site 	19:36 R/V Rachel Carson 
20:32 start of PACE track 	21:21 end of PACE track 
22:38:30 Sacramento_River AERONET-OC 	23:01:30 NASA_Ames AERONET 

AERONET plots

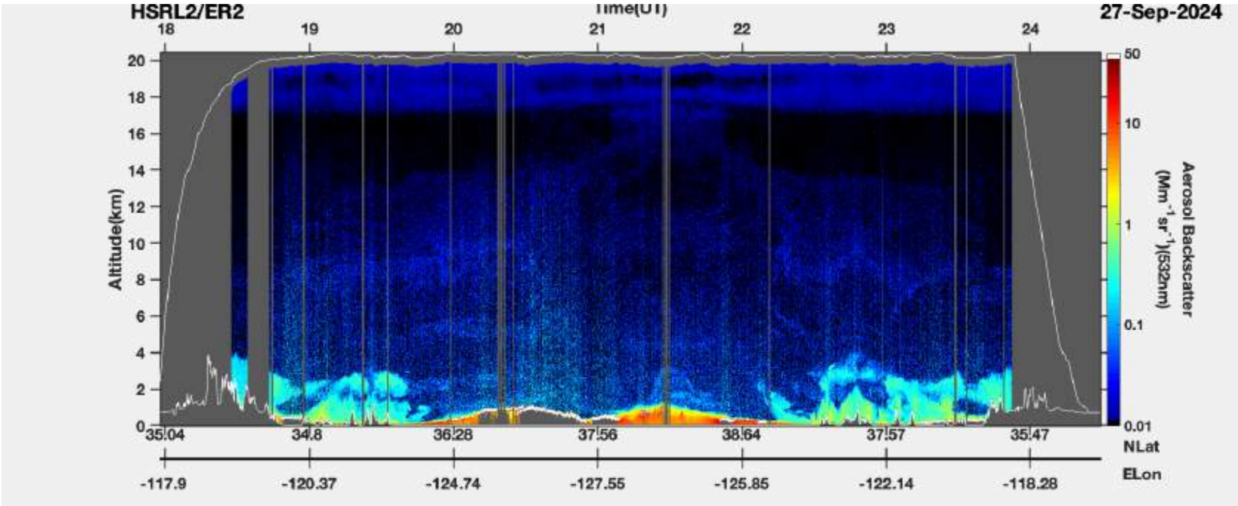
Monterey 	NRL_CEOBS_MBAYCAUSA Not operational
Sacramento_River 	NASA_Ames 

PICARD quicklooks

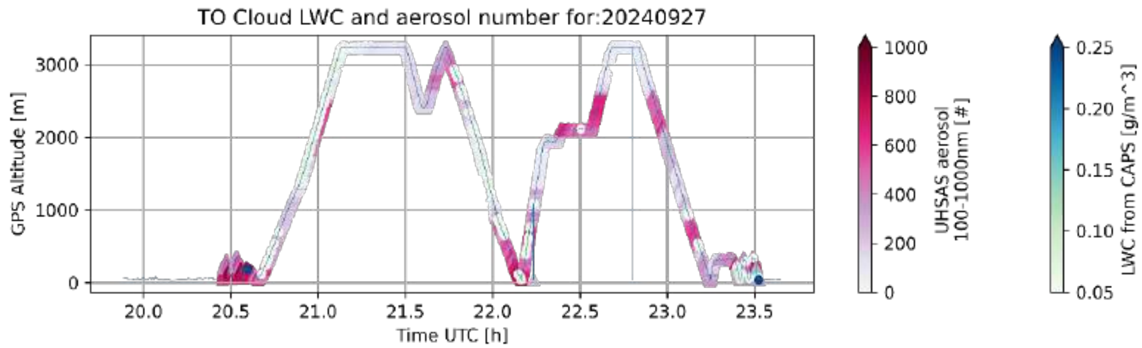


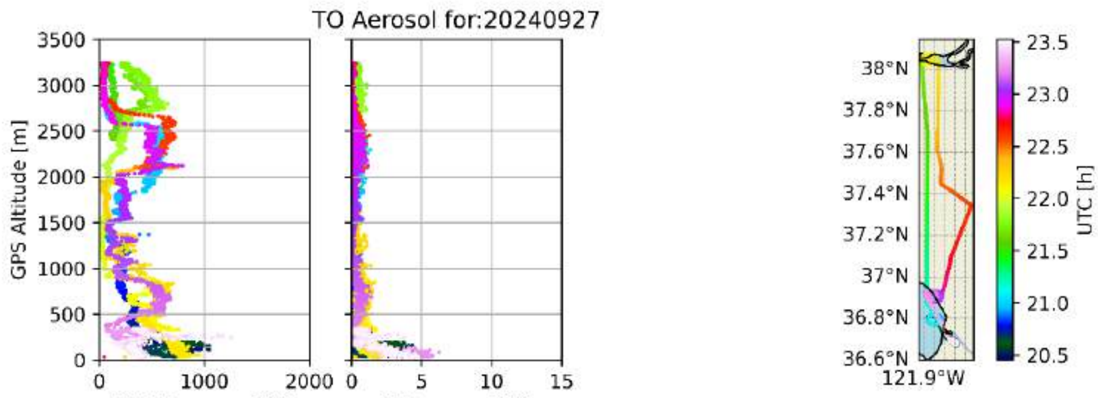
Pushbroom Imager for Cloud and Aerosol Research and Development
PACE-PAX, NASA Armstrong Flight Research Center
27 September 2024

HSRL quicklooks

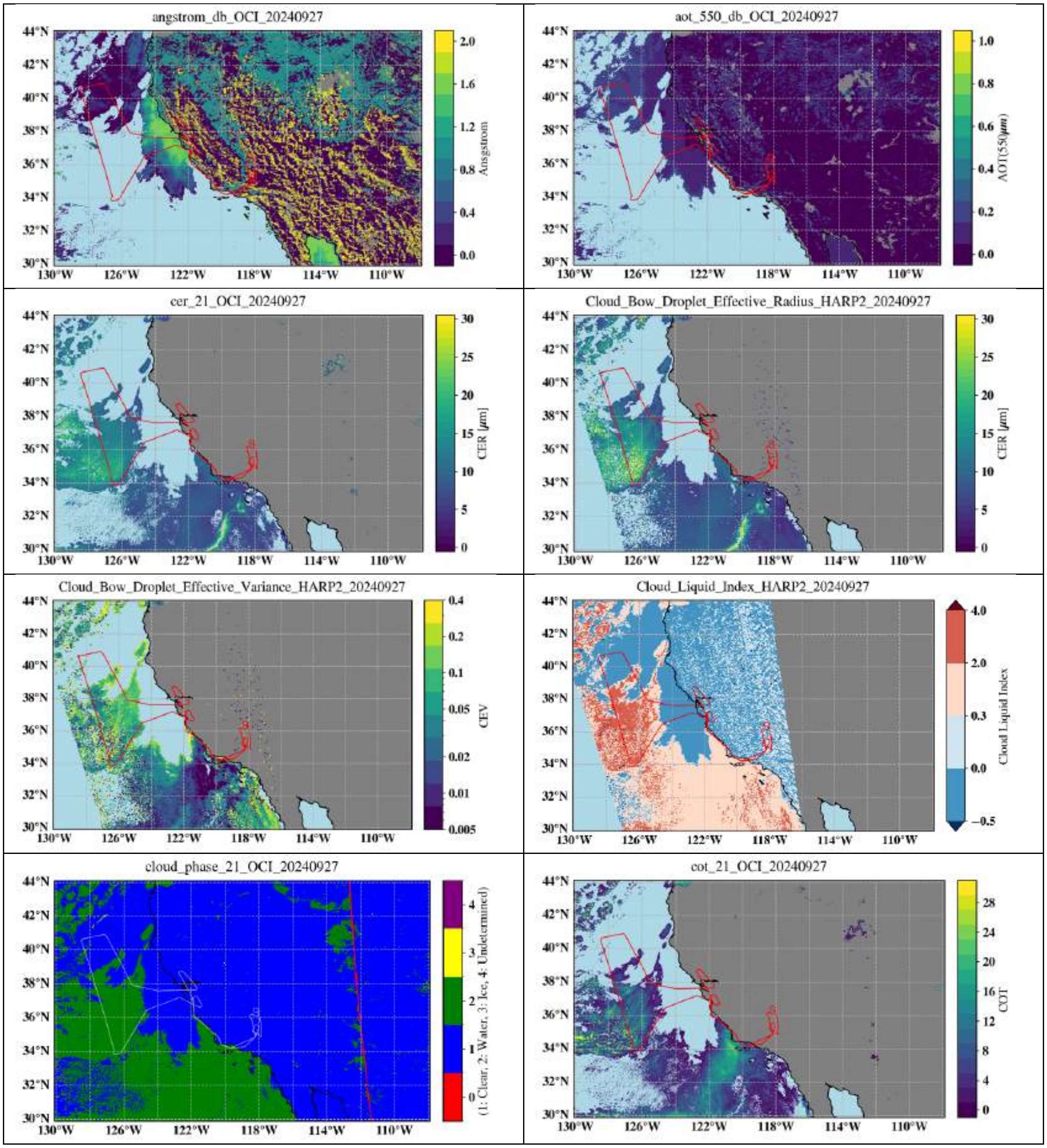


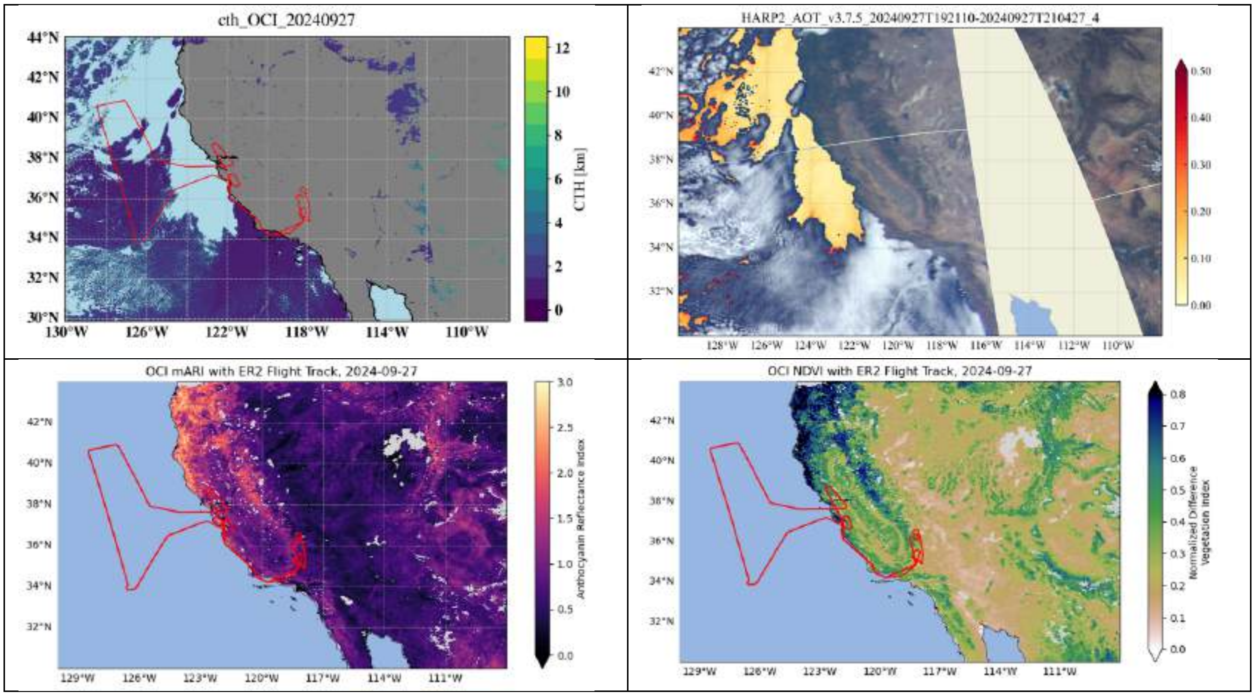
TO Quicklooks





PACE quicklooks




cth_OCI_20240927
CTH [km]
HARP2_AOT_v3.7.5_20240927T192110-20240927T210427_4
OCI mARI with ER2 Flight Track, 2024-09-27
Anthocyanin Reflectance Index
OCI NDVI with ER2 Flight Track, 2024-09-27
Normalized Difference Vegetation Index

PACE-PAX Research Flight report 2024-09-27

Twin Otter Flight

Manifest:

Bryce Kujat (pilot)

Jeff Martin (pilot)

Michael Shook (QNC)

Elizabeth Wilk (QNC)

Edward Winstead (QNC)

Note: This flight had coordination with the ER-2.

Take off: 13:27:07 (20:27:07 UTC) Marina Airport (OAR)

Landing: 16:31:24 (23:31:24 UTC) Marina Airport (OAR)

Duration = 3.1 hrs

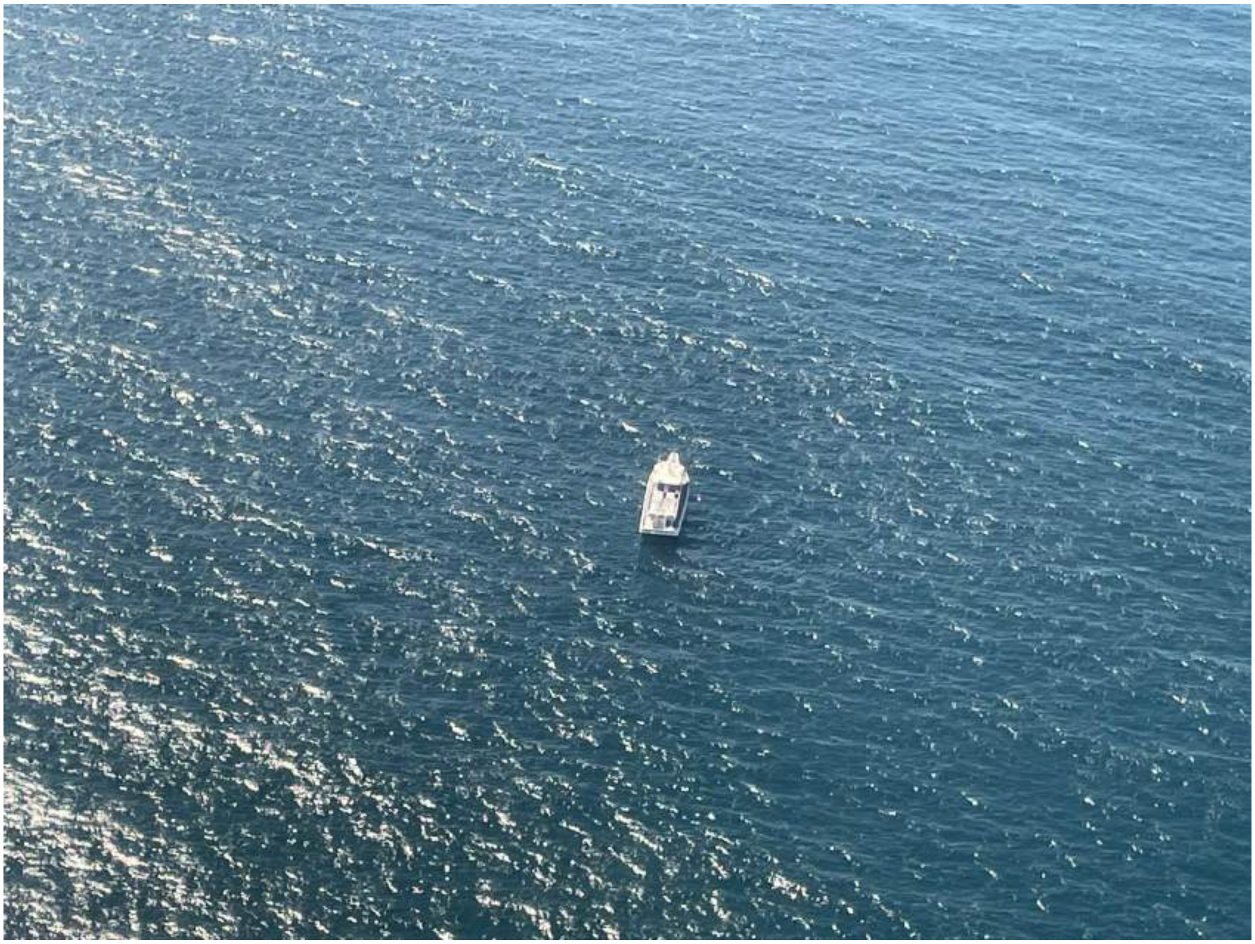
Objectives: Perform low approaches at Marina after takeoff. Transit out to the R/V Rachel Carson in the Monterey Bay and spiral up over it during the PACE overpass at 21:05 UTC. Spiral down over the Sacramento River AERONET site under the future ER-2 flight track. In-line ascent to CEOBS, then spiral down during the ER-2 overpass at about 23:08 UTC. If possible, perform low approaches at Marina prior to landing.

Summary: After taking off, we performed two low approaches at the Marina airport. Green scattering coefficient was 25-30Mm^{-1} in the boundary layer, and some coarse mode particles were measured by the APS. The boundary layer height was estimated at 550 ft. During the low approaches, the PI-Neph experienced two restarts, but remained stable the rest of the flight. We then transited at 500 ft to the R/V Rachel Carson in the Monterey Bay, at approximately 36° 47.82'N, 121° 50.83W, and began our spiral up at 20:39:20 UTC. Initially we climbed at slower than our normal 500 ft/minute to insure we would still be in the spiral at the PACE overpass time. The water appeared red near the coast at Moss Landing (potential "red tide"/harmful algal bloom).

Scattering coefficient in the profile was low and variable, starting at 7-15Mm^{-1} near the surface, then a layer with close to 0Mm^{-1} and 700 particles/cm^3, then a layer of 8Mm^{-1}, then clean again near the top. We completed the spiral at 21:09 UTC and headed to the Sacramento River AERONET location at 10kft.

Conditions were very clean during this transit, with scattering coefficient near zero. At 21:30 UTC we descended to 7500 ft to try and sample an aerosol layer we could see visually on the right-hand side of the aircraft, but no significant increase was observed, so we started climbing back to 10kft at 21:37 UTC to reach the spiral top. At 21:44 UTC, we started the Sacramento River spiral from 10 kft. The boundary layer height was estimated at 2900 ft. We completed the profile at 100 ft at 22:10 UTC and began an in-line ascent to the south. During the spiral and in-line ascent, conditions remained fairly clean (scattering coefficient 10Mm-1 or less). Some different aerosol populations were observed (e.g., particle number concentration increased while scattering remained the same), but nothing was distinct or identifiable.

As we transited south towards CEOBS, we were vectored and controlled in altitude several times by ATC near San Jose. We arrived at CEOBS and started our spiral down from 10kft at 22:50 UTC. Again, scattering was variable but minimal in most of the profile, and more potential red tide was observed in this area. The ER-2 passed over the location at about 23:07 UTC. The temperature profile indicated that the marine layer was about 500 ft deep, and scattering coefficient had jumped to 20Mm^{-1} at 250 ft. We completed the spiral around 23:19 UTC and climbed to 1000 ft towards Marina. We performed two low passes at Marina, where scattering coefficient was about 17Mm^{-1}.

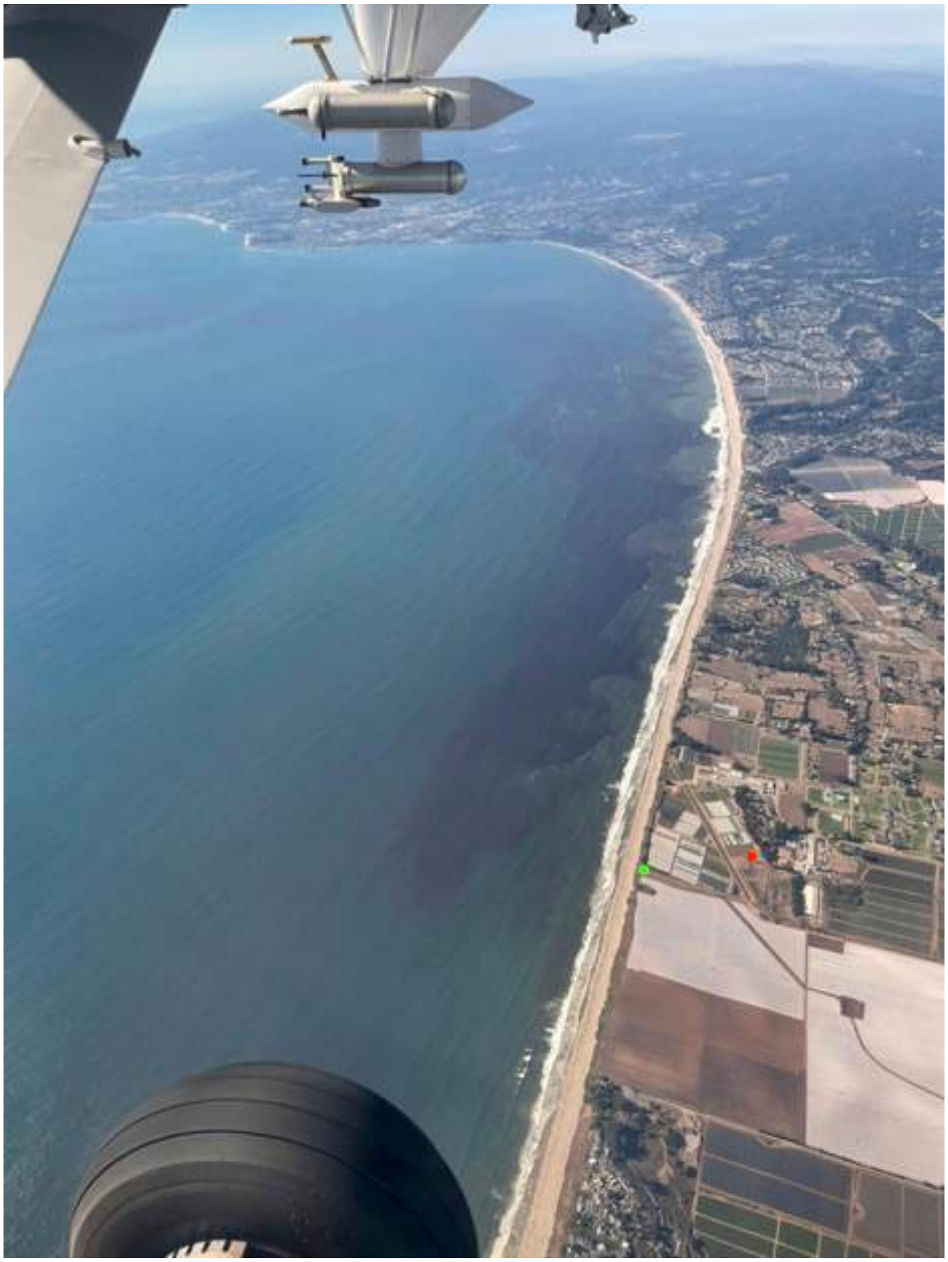


The R/V Rachel Carson; photo by Eddie Winstead

Red tide near Moss Landing; photo by Michael Shook

Sacramento River Aeronet spiral location; photo by Eddie Winstead

Red tide near CEOBS; photo by Eddie Winstead



Red tide near CEOBS. CEOBS primary site is marked by a red circle and the secondary site where a wind profiler is located is marked by a green circle; photo by Eddie Winstead

PACE-PAX research report 2024/09/29

Compiled by Kirk Knobelspiesse, Ivona Cetinić, Brian Cairns
2024/10/08
Reviewed by Samuel LeBlanc

ER-2 (alone) flight with a long PACE track overflight along the Sierra Nevada mountains and California Central Valley. Generally cloud free, low aerosol loading over land and marine stratocumulus clouds over ocean. Good coordination with gliders.

ER-2
Take off: 17:48
Landing: 00:30
Duration: 6.7 hrs
Pilot: Tim Williams, mobile: Dean Neeley
All instruments operated successfully

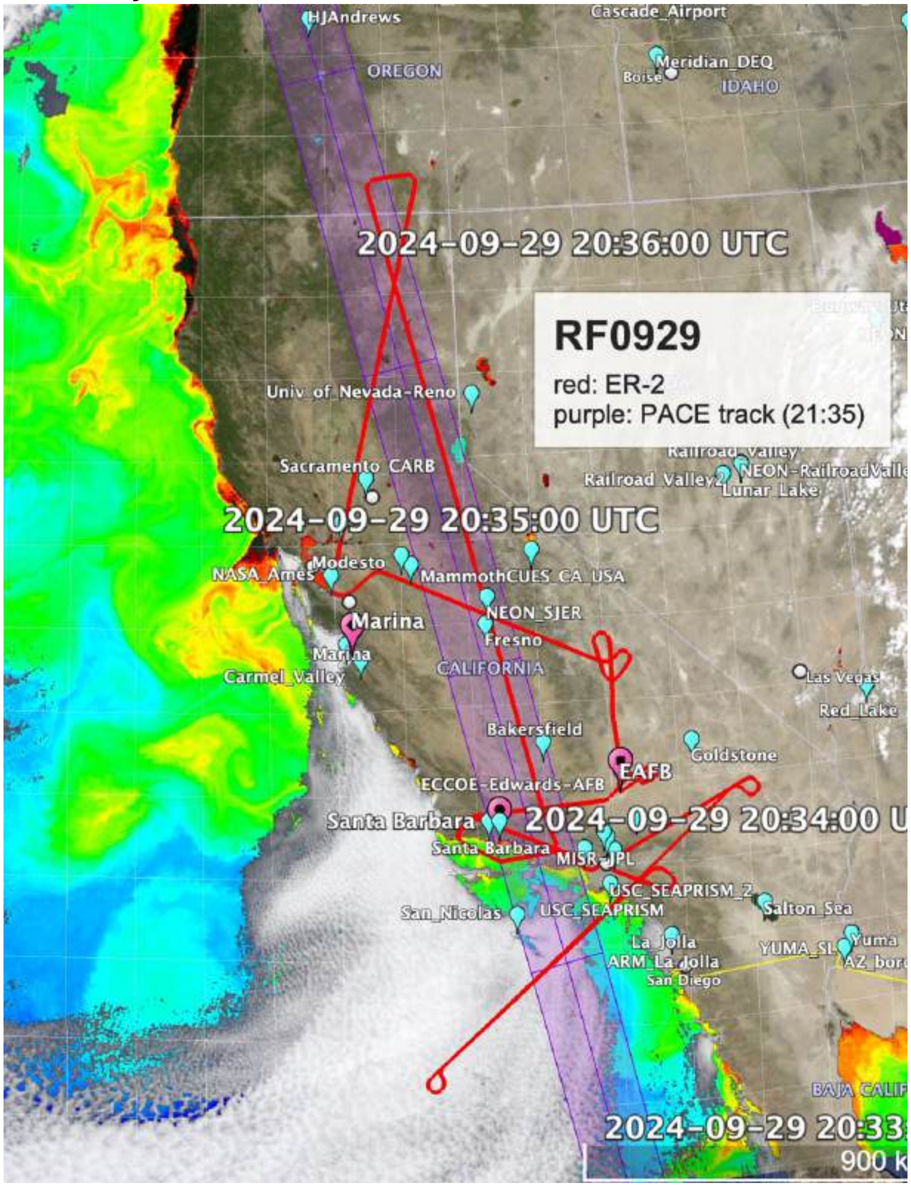
Twin Otter
Operations concluded

PACE
20:35 California. ER-2 ground track intentionally observes a line offset from the center swath, but still within the PACE-OHS swath.

EarthCARE
Not targeted

Gliders
Operational

Overall image summary



Validation Traceability Matrix itemized objectives

VTM elements in **black** satisfied, **blue** partially satisfied, red to be confirmed

Time UTC	Platform	VTM(hrs)	
17:48	ER2		ER-2 takeoff
18:30	ER2	6a(0.5)	Starting line over central valley, beginning near smoke from “Happy” fire
18:37	ER2	1a(0.5), 1d(0.5)	ER-2 overflies NEON_SJER AERONET site. AOT(500)=0.13
18:46	ER2	1d(0.5)	ER-2 overflies Turlock AERONET site. AOT(500)=0.045
18:55	ER2	1d(0.5)	ER-2 overflies NASA_Ames AERONET site. AOT(500)=0.075
19:02	ER2	1b(0.5), 1c(0.5), 6h(0.5)	ER-2 overflies Sacramento_River AERONET site. AOT(490)=0.05
19:48	ER2, PACE	1d(3.0), 3b(3.0)	ER-2 on long PACE track, which ends at 20:58. Intentionally offset from satellite ground track (but within

			PACE-OHS) to validate other portions of SPEXone swath. Cloud free, low to moderate (smoke) aerosols.
20:35	**PACE**		**PACE Sierra Nevadas and California Central Valley**
20:39	ER2, PACE-OHS	1a(1.0), 1d(1.0)	ER-2 overflies NEON_SJER AERONET site. AOT(500)=0.12
20:50	ER2, PACE-OHS	1d(0.5), 3b(0.5), 6c(0.5*0.5)	ER-2 overflies Bakersfield AERONET site. AOT(500)=0.11, near the end of the PACE line, multiple aerosol layers
21:07	ER2, Gliders	1b(1.0), 1c(1.0), 4b(0.5), 6i(1.0)	PACE overflies gliders in biologically productive waters. Glint
21:12	ER2		Begin line inland from Santa Barbara down to eastern LA basin. Latter portion has smoke. Line ends 21:38
21:30	ER2	1d(0.5)	Over WC_Whittier_CA (which apparently survived fires) AERONET site. AOT(500)=0.12
21:41	ER2	1e(1.0*0.5)	Begin long leg over the ocean. Lots of cloud observations here. Backtrack on same line ending roughly at 22:42. Although no comparison the amount of data results in a partial score.
21:47	ER2	1b(0.5), 1c(0.5), 4b(0.5), 6k(0.5), 3a(0.5*0.5)	Over USC_SeaPRISM site, AOT(490)=0.05, Glint, Partial aerosol within PACE-OHS (in between clouds, from 20:35 overpass)
22:44	ER2	1b(0.5), 1c(0.5), 6k(0.5)	Over USC_SeaPRISM site, AOT(490)=0.05
22:45	ER2		Long line over smoke from LA basin fires, ends 23:02
22:58	ER2	1d(0.5*0.5)	Over smoke plume, but no AEROENT
23:10	ER2		Long line over smoke from LA basin fires, ends 23:26
23:25	ER2	1d(0.5)	Over CalTech AERONET site. AOT(500)=0.07
23:40	ER2, Gliders	1b(1.0), 1c(1.0), 6i(1.0)	ER2 overflies gliders in biologically productive waters, where previous PACE-OHS/OH
00:30	ER2		ER-2 lands

PACE-O: within swath of PACE's OCI instrument
PACE-OH: within swath of PACE's OCI and HARP2 instruments
PACE-OHS: within swath of PACE's OCI, SPEXone and HARP2 instruments
TO: Twin Otter
RB: R/V Blissfully
RS: R/V Shearwater

Assessment:

- 0.009 of objectives observed. Successful coordination between ER-2 and gliders, plus underpass of PACE.
- No scores above 6.0. Largest is still PACE aerosol in narrow swath over ocean (3a) at 5.7

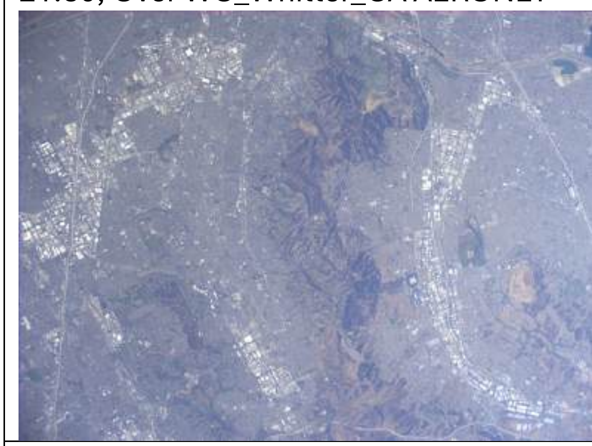
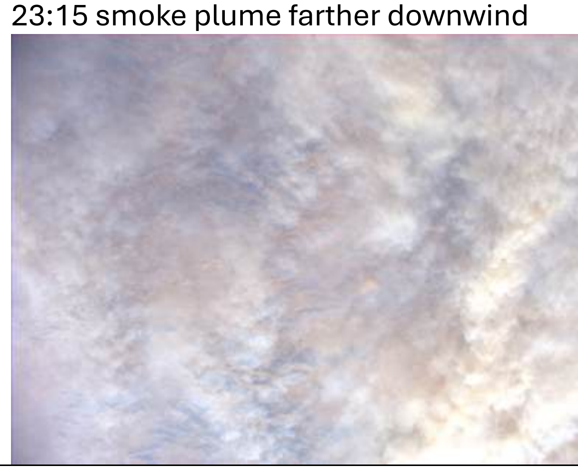
PACE-PAX progress tracking

Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 9/23	Fractional success 9/24	Fractional success 9/25	Fractional success 9/26	Fractional success 9/27	Fractional success 9/29	Fractional success 9/30	Total success	Remaining score
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	1.5	0.000	0.000	0.000	0.000	0.000	**0.015**	0.000	**0.986**	**0.1**
	b	Ocean radiometric parameters	10	8.0	15.5	0.000	0.000	0.000	**0.003**	**0.001**	**0.000**	0.000	**0.999**	**0.0**
	c	Aerosol parameters over the ocean	12	8.0	18.0	0.000	0.000	0.000	**0.014**	**0.003**	**0.001**	0.000	**0.998**	**0.0**
	d	Aerosol parameters over land	12	8.0	19.0	**0.000**	0.000	0.000	**0.000**	**0.000**	**0.000**	0.000	**1.000**	**0.0**
	e	Cloud parameters	12	8.0	6.8	**0.058**	**0.025**	0.000	0.000	**0.023**	0.000	0.000	**0.920**	**1.0**
	f	Ocean surface parameters	1	8.0	1.5	0.000	0.000	0.000	**0.133**	0.000	0.000	0.000	**0.354**	**0.6**
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	1.0	0.000	0.000	0.000	0.000	**0.076**	0.000	0.000	**0.430**	**5.7**
	b	Aerosol parameters over land (PACE)	10	8.0	7.0	**0.132**	0.000	0.000	**0.103**	0.000	**0.113**	0.000	**0.751**	**2.5**
	c	Cloud parameters (PACE)	5	2.0	2.0	0.000	0.000	0.000	0.000	**0.181**	0.000	0.000	**0.895**	**0.5**
	d	Aerosol parameters (EarthCARE)	8	4.0	3.0	**0.038**	0.000	0.000	**0.053**	0.000	0.000	0.000	**0.918**	**0.7**
	e	Cloud parameters (EarthCARE)	8	4.0	2.5	**0.152**	**0.167**	0.000	0.000	0.000	0.000	0.000	**0.632**	**2.9**
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.953**	**0.3**
	b	Validate large reflectances with high polarization	6	2.0	1.5	0.000	0.000	0.000	**0.194**	0.000	0.000	0.000	**0.826**	**1.0**
	c	Validate large reflectances with low polarization	6	2.0	1.5	**0.034**	0.000	0.000	0.000	0.000	0.000	0.000	**0.970**	**0.2**
	d	Overfly vicarious calibration sites	6	4.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.268**	**4.4**
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	2.0	0.5	0.000	0.000	0.000	0.000	0.000	**0.000**	0.000	**1.000**	**0.0**
	b	High aerosol loads over ocean	4	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.393**	**2.4**
	c	Multiple aerosol layers	1	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**1.000**	**0.0**
	d	Aerosol under thin cirrus	2	2.0	3.5	**0.826**	0.000	0.000	0.000	0.000	0.000	0.000	**0.826**	**0.3**
	e	Aerosol above liquid phase cloud	4	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.826**	**0.7**
	f	Broken clouds with complex structure	4	2.0	3.0	**0.186**	0.000	0.000	0.000	**0.181**	0.000	0.000	**0.895**	**0.4**
	g	Dust aerosols over ocean	4	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.430**	**2.3**
	h	Aerosol and ocean parameters over turbid waters	2	2.0	1.5	0.000	0.000	0.000	**0.046**	**0.036**	**0.028**	0.000	**0.901**	**0.2**
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	5.0	0.000	0.000	0.000	**0.043**	**0.028**	**0.004**	0.000	**0.993**	**0.0**
	k	Smoke aerosols over ocean	1	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.713**	**0.3**
		total:	**150**	**98**	**94.3**	**0.041**	**0.011**	**0.000**	**0.021**	**0.019**	**0.009**	**0.000**	**0.821**	
														total
				ER-2 flight hours		2.8	0	0	0	0	0	0	0	**2.8**
				TO flight hours		2.5	0	0	0	0	0	0	0	**2.5**
				Shearwater days		0	0	0	0	0	0	0	0	**0**
		PACE-PAX overall objectives satisfied:		0.821										

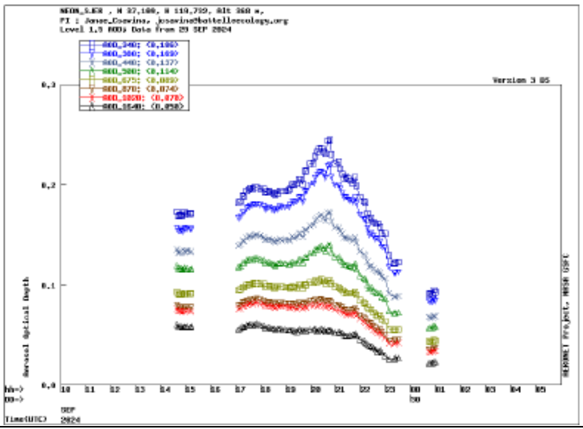
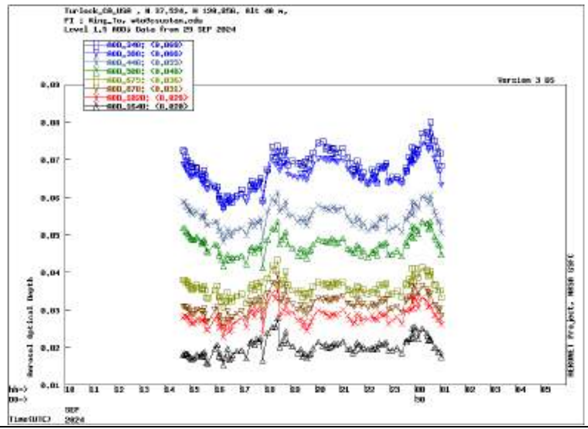
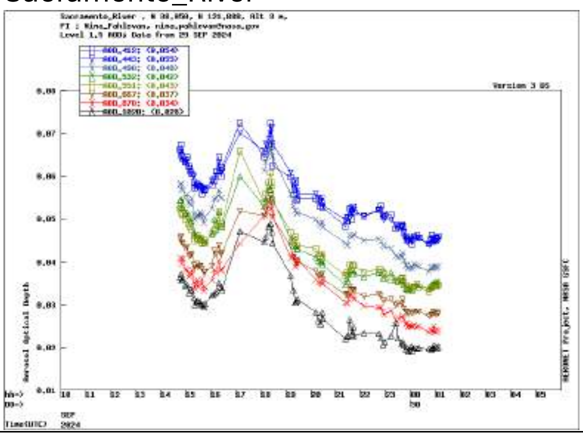
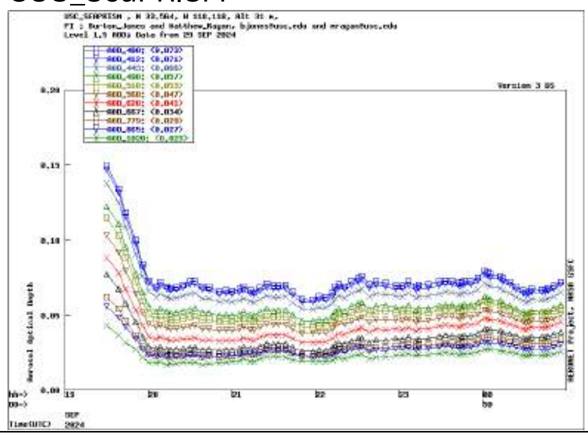
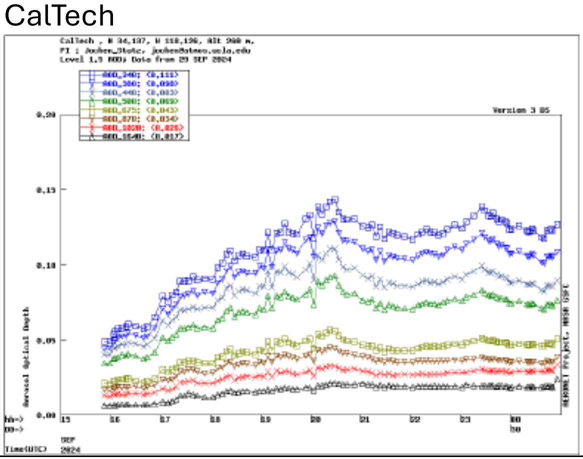
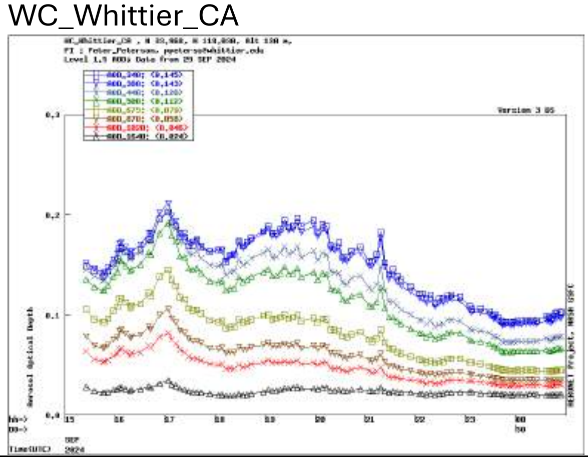
Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

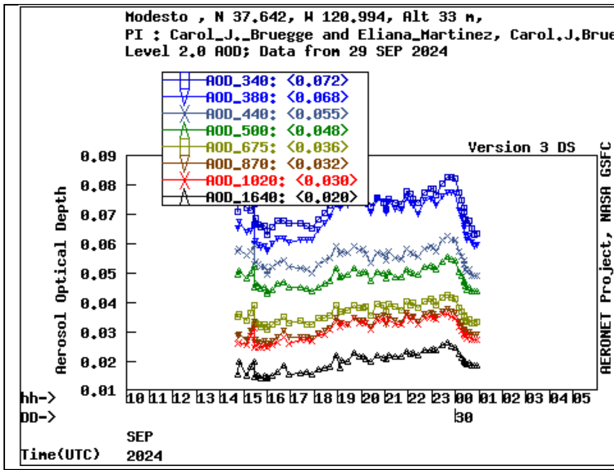
https://www-air.larc.nasa.gov/missions/pacepax/index.html

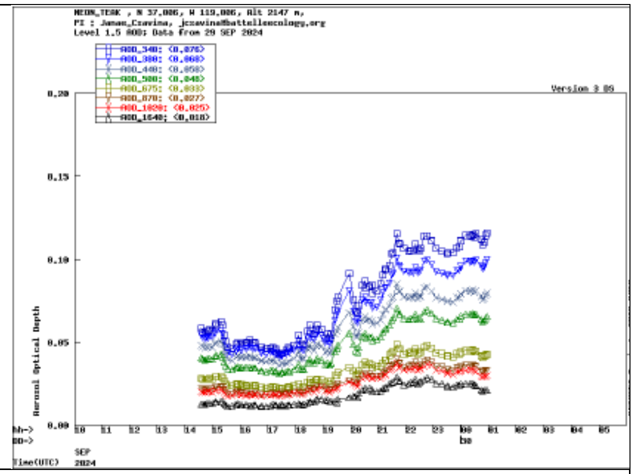
MVIS imagery

20:35, PACE overpass 	21:07, over gliders 
21:30, Over WC_Whitter_CA AERONET 	21:47 USC_SeaPRISM 
22:58 smoke plume 	23:15 smoke plume farther downwind 

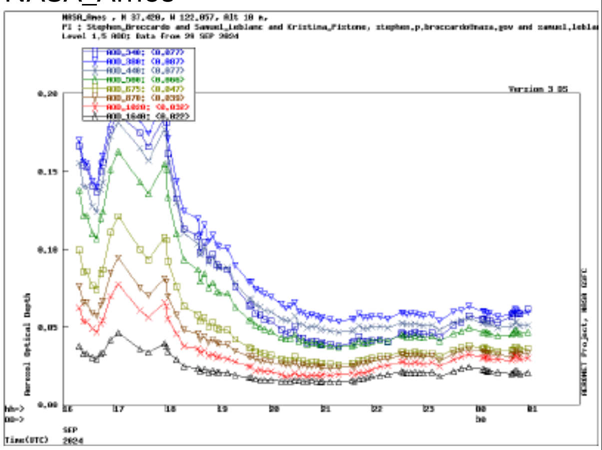
AERONET plots

NEON_SJER	Turlock_CA_USA
	
Sacramento_River	USC_SeaPRISM
	
CalTech	WC_Whittier_CA
	
Modesto	NEON_Teak

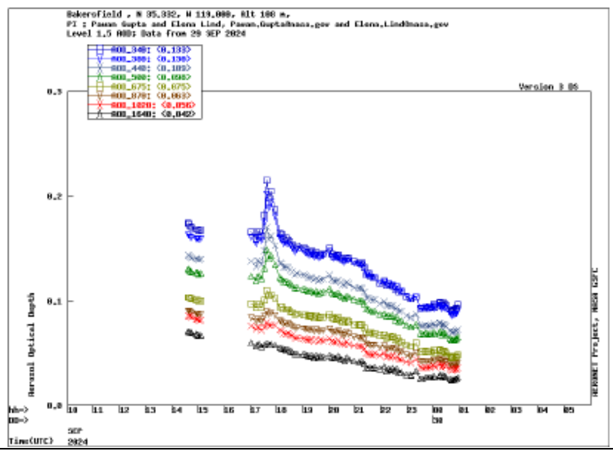




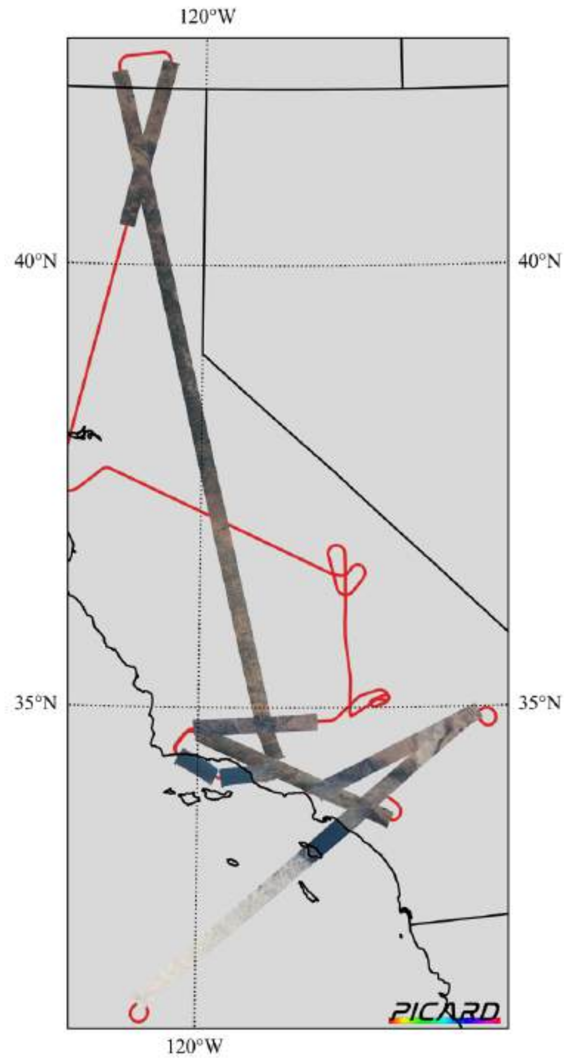
NASA_Ames



Bakersfield

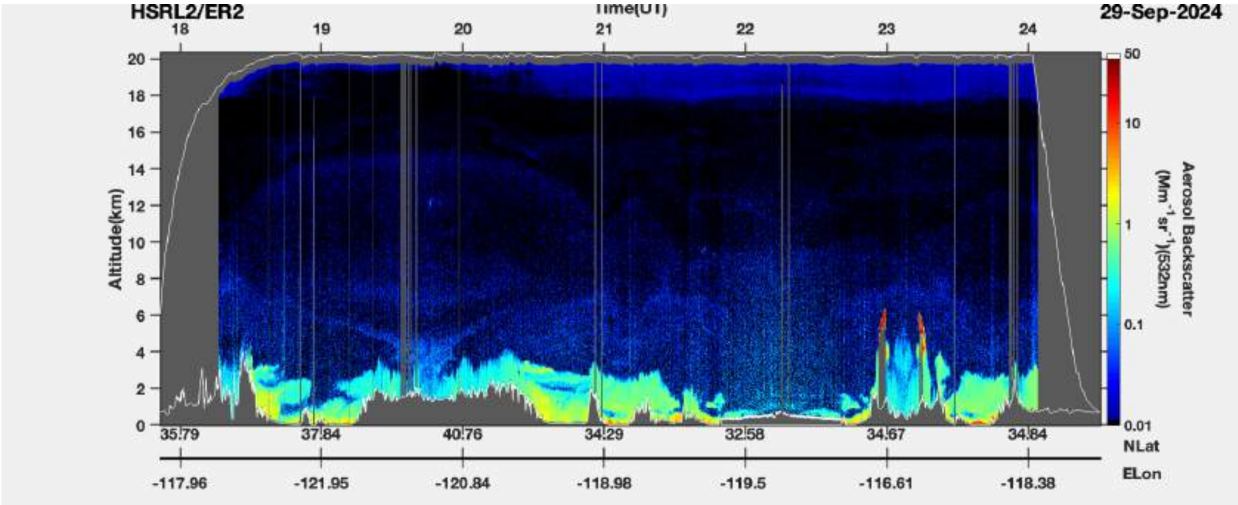


PICARD quicklooks

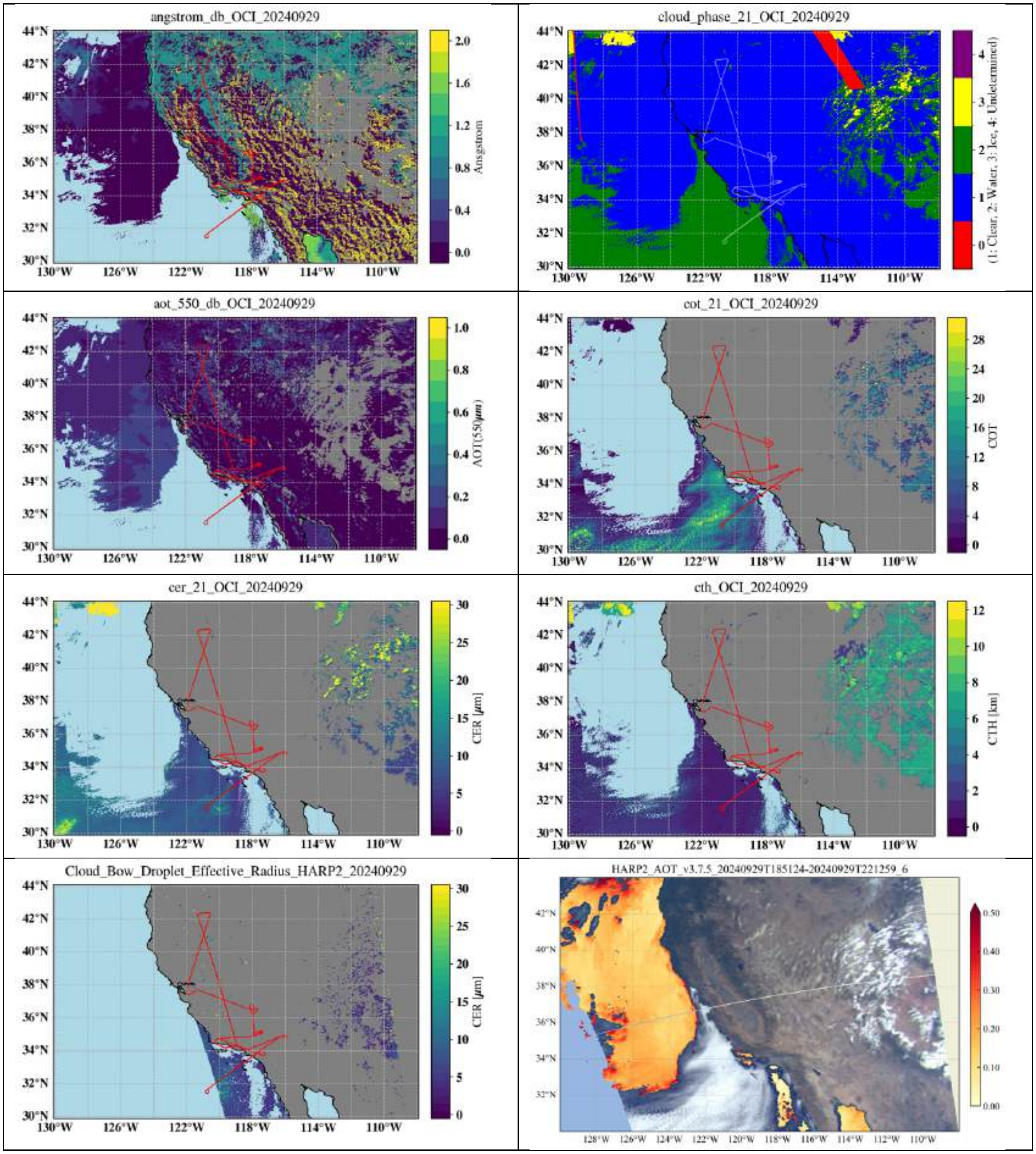


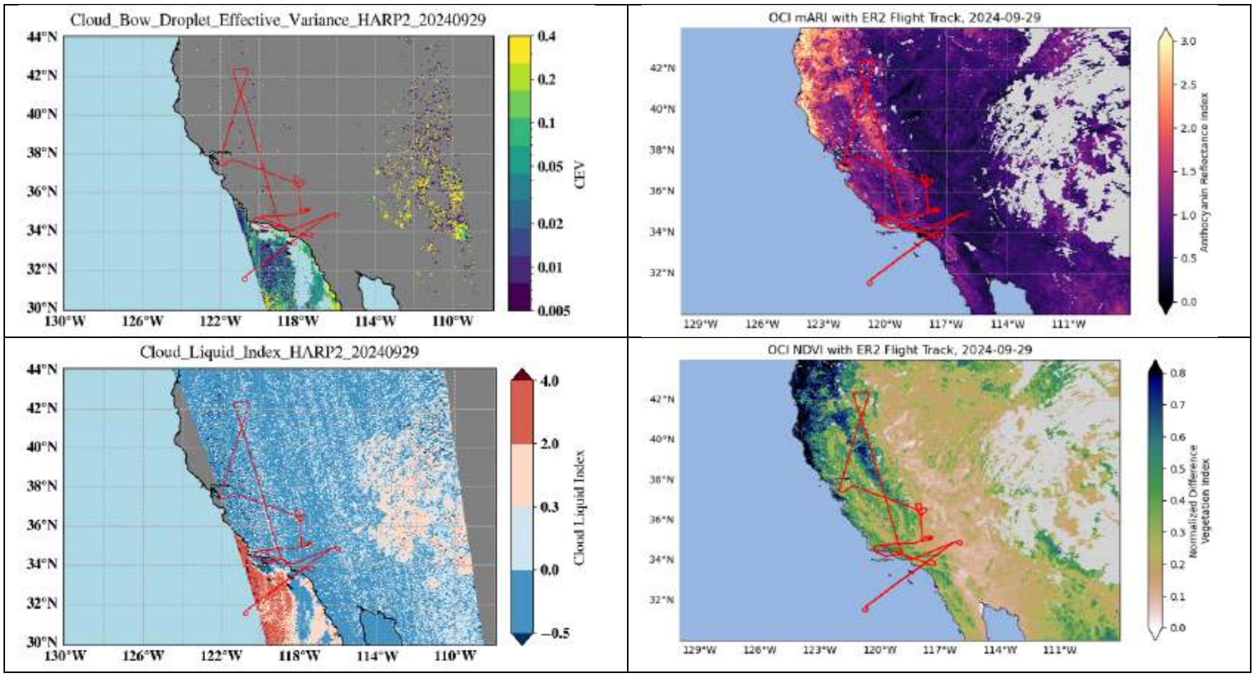
Pushbroom Imager for Cloud and Aerosol Research and Development
PACE-PAX, NASA Armstrong Flight Research Center
29 September 2024

HSRL quicklooks



PACE quicklooks




Cloud_Bow_Droplet_Effective_Variance_HARP2_20240929
CEV
0.4
0.2
0.1
0.05
0.02
0.01
0.005
OCI mARI with ER2 Flight Track, 2024-09-29
Anthocyanin Reflectance Index
Cloud_Liquid_Index_HARP2_20240929
Cloud Liquid Index
4.0
2.0
0.3
0.0
−0.5
OCI NDVI with ER2 Flight Track, 2024-09-29
Normalized Difference Vegetation Index
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
129°W
123°W
120°W
117°W
111°W

PACE-PAX research report 2024/09/30

Compiled by Kirk Knobelspiesse, Ivona Cetinić, Brian Cairns
2024/10/08
Reviewed by Samuel LeBlanc

Successful ER-2 (alone) flight with under flights by of PACE (offshore) and EarthCARE (California/Arizona border). Generally cloud free onshore and limited cloud cover in offshore section. Also observations of smoke from "Happy" fire and Railroad Valley calibration reference.

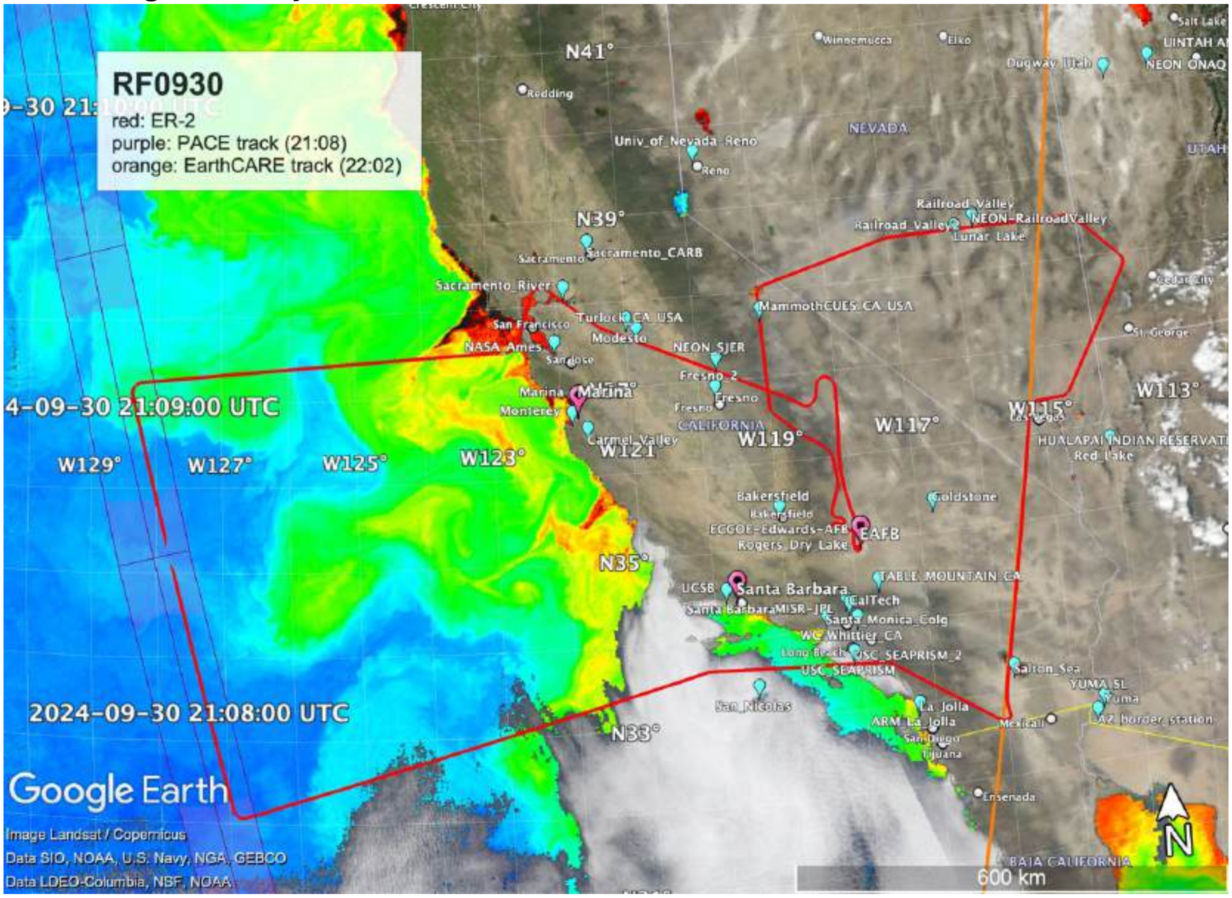
ER-2
Take off: 17:43
Landing: 00:10
Duration: 6.5 hrs
Pilot: Kirt Stallings, mobile: Greg Nelson
All instruments operated successfully. Last flight!

PACE
21:09 offshore California. ER-2 ground track intentionally observes a line offset from the center swath, but still within the PACE-OHS swath.

EarthCARE
22:02 California/Nevada border. Orbit 1944

Gliders
Operational

Overall image summary



Validation Traceability Matrix itemized objectives

VTM elements in **black** satisfied, **blue** partially satisfied, red to be confirmed

Time UTC	Platform	VTM(hrs)	
17:43	ER2		ER-2 takeoff
18:24	ER2		Beginning of line over California Central Valley. Smoke lofted in start of line, with geographically distinct layers
18:25	ER2	1a(0.5), 1d(0.5)	ER2 over NEON_SJER AERONET site, AOT(500)=0.11
18:32	ER2	1d(0.5)	ER2 over Turlock AERONET site, AOT(500)=0.07 (note later in the day a high AOT plume moves in, with high fine mode fraction, presumably smoke
18:42	ER2	1b(0.5), 1c(0.5), 6h(0.5)	ER2 over Sacramento_River AERONET-OC site. AOT(490)=0.07
18:53	ER2	1b(1.0*0.5), 1c(1.0*0.5), 3a(1.0*0.5), 6h(0.5*0.5), 6i(0.5*0.5)	Transit to PACE (jn PACE-OH swath) track along cloud free and gradient of very high Chl waters to much lower concentrations on the line. End 19:31. Scored but reduced due to time difference.
19:34	ER2	1b(1.5), 1c(1.5), 3a(1. 5)	Transit within PACE-OHS swath. Cloud free with a gradient of more to less Chl-a from start (North) to end (South). Ends 20:17
21:09	**PACE**		**PACE offshore California**

20:20	ER2	1e(1.0), 3c(0.5), 4c(1.0)	Return to shore line from PACE track, over marine stratocumulus clouds. Cloudy in all coastal sites of interest (HyperNAV location, SeaPRISM site) clouds ends ~21:24. Some clear areas until cross coast at 21:32
21:48	ER2	1d(1.0), 3d(2.0)	ER2 begins EarthCARE line. Line ends 22:20. Elevated aerosols that HSRL indicates are "dusty mix". Cloud free.
21:54	ER2	1d(0.5), 3d(0.5)	Over Salton Sea AERONET site, AOT(500)=0.1
22:02	**EarthCARE**		**EarthCARE California/Nevada border. Orbit 1944**
22:13	ER2	1a(0.5*0.5), 4a(0.5*0.5)	Over Ivanpah Playa calibration site (no ground team)
22:59	ER2	1a(1.0),1d(0.5), 4a(0.5), 4d(0.5)	Over Railroad valley calibration and AERONET site. AOT(500)=0.05
23:09	ER2	1d(0.5*0.5)	Line over smoke from "Happy" fire observed earlier. End 23:23
23:27	ER2	1d(0.5)	Over Mammoth_CUES_CA_USA AERONET site, AOT(500)=0.06
23:33	ER2	1a(0.5*0.5), 1d(0.5)	Over NEON_TEAK (neon land surface site) AERONET site, AOT(500)=0.1 (variations through the day likely linked to happy fire)
00:10	ER2		ER-2 lands

PACE-O: within swath of PACE's OCI instrument
PACE-OH: within swath of PACE's OCI and HARP2 instruments
PACE-OHS: within swath of PACE's OCI, SPEXone and HARP2 instruments
TO: Twin Otter
RB: R/V Blissfully
RS: R/V Shearwater

Assessment:

- 0.014 of objectives observed. Successful ER-2 under flights by of PACE (offshore) and EarthCARE (California/Arizona border). Generally cloud free
- No scores above 6.0. Although this flight contributed, the largest remaining is still PACE aerosol in narrow swath over ocean (3a) at 4.4

PACE-PAX progress tracking

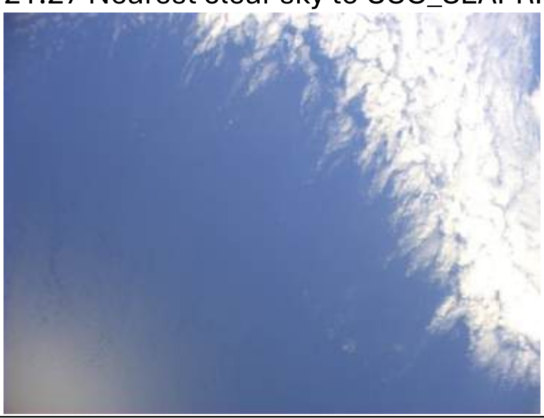
Validation objectives	ID	Measurement objectives	Importance, w	Observation time, h (hours)	Total observed (hours)	Fractional success 9/23	Fractional success 9/24	Fractional success 9/25	Fractional success 9/26	Fractional success 9/27	Fractional success 9/29	Fractional success 9/30	Total success	Remaining score
1. Validate new retrieval properties	a	Land surface parameters	8	2.0	3.0	0.000	0.000	0.000	0.000	0.000	0.015	0.007	0.994	0.1
	b	Ocean radiometric parameters	10	8.0	18.0	0.000	0.000	0.000	0.003	0.001	0.000	0.000	0.999	0.0
	c	Aerosol parameters over the ocean	12	8.0	20.5	0.000	0.000	0.000	0.014	0.003	0.001	0.001	0.998	0.0
	d	Aerosol parameters over land	12	8.0	22.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.0
	e	Cloud parameters	12	8.0	7.8	0.058	0.025	0.000	0.000	0.023	0.000	0.009	0.930	0.8
	f	Ocean surface parameters	1	8.0	1.5	0.000	0.000	0.000	0.133	0.000	0.000	0.000	0.354	0.6
3. Validate in a narrow swath	a	Aerosol parameters over the ocean (PACE)	10	8.0	3.0	0.000	0.000	0.000	0.000	0.076	0.000	0.126	0.556	4.4
	b	Aerosol parameters over land (PACE)	10	8.0	7.0	0.132	0.000	0.000	0.103	0.000	0.113	0.000	0.751	2.5
	c	Cloud parameters (PACE)	5	2.0	2.5	0.000	0.000	0.000	0.000	0.181	0.000	0.023	0.918	0.4
	d	Aerosol parameters (EarthCARE)	8	4.0	5.5	0.038	0.000	0.000	0.053	0.000	0.000	0.038	0.956	0.4
	e	Cloud parameters (EarthCARE)	8	4.0	2.5	0.152	0.167	0.000	0.000	0.000	0.000	0.000	0.632	2.9
4. Validate radiometric and polarimetric properties	a	Validate large reflectances	6	2.0	1.0	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.972	0.2
	b	Validate large reflectances with high polarization	6	2.0	1.5	0.000	0.000	0.000	0.194	0.000	0.000	0.000	0.826	1.0
	c	Validate large reflectances with low polarization	6	2.0	2.5	0.034	0.000	0.000	0.000	0.000	0.000	0.012	0.982	0.1
	d	Overfly vicarious calibration sites	6	4.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.268	4.4
6. Focus on specific processes or phenomena	a	High aerosol loads over land	4	2.0	0.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.0
	b	High aerosol loads over ocean	4	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.393	2.4
	c	Multiple aerosol layers	1	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.0
	d	Aerosol under thin cirrus	2	2.0	3.5	0.826	0.000	0.000	0.000	0.000	0.000	0.000	0.826	0.3
	e	Aerosol above liquid phase cloud	4	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.826	0.7
	f	Broken clouds with complex structure	4	2.0	3.0	0.186	0.000	0.000	0.000	0.181	0.000	0.000	0.895	0.4
	g	Dust aerosols over ocean	4	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.430	2.3
	h	Aerosol and ocean parameters over turbid waters	2	2.0	2.3	0.000	0.000	0.000	0.046	0.036	0.028	0.031	0.932	0.1
	i	Aerosol and ocean parameters over biologically productive waters	4	2.0	5.3	0.000	0.000	0.000	0.043	0.028	0.004	0.001	0.994	0.0
	k	Smoke aerosols over ocean	1	2.0	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.713	0.3
		total:	150	98	112.8	0.041	0.011	0.000	0.021	0.019	0.009	0.014	0.835	
														total
				ER-2 flight hours		6.2	0	0	6.4	6.5	6.7	6.5	0	32.3
				TO flight hours		4.1	3.1	0	5.1	3.1	0	0	0	15.4
				Shearwater days		0	0	0	0	0	0	0	0	0

PACE-PAX overall objectives satisfied: 0.835

Note: images and data presented in this report are preliminary, and not for publication, presentation, or scientific use. The PACE-PAX data archive is:

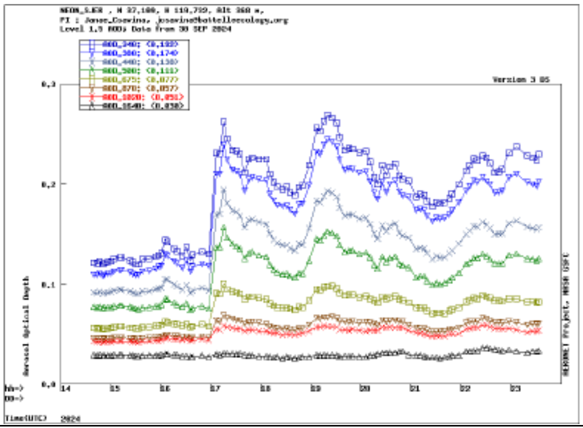
https://www-air.larc.nasa.gov/missions/pacepax/index.html

MVIS imagery

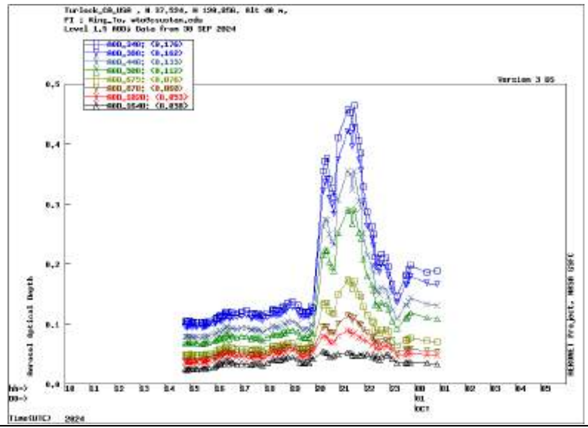
19:34 Start of PACE-OHS line 	20:19 End of PACE-OHS line 
21:27 Nearest clear sky to USC_SEAPRISM 	21:53:30 Salton Sea 
22:13:30 Ivanpah Playa 	23:00 Railroad valley 

AERONET plots

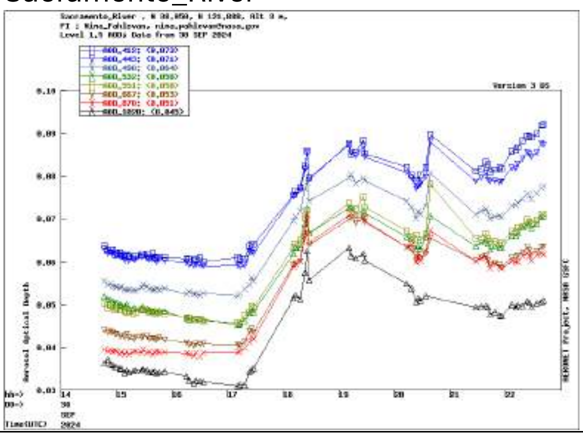
NEON_SJER



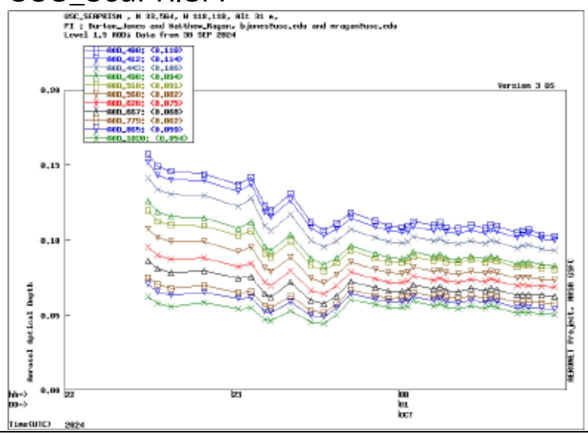
Turlock_CA_USA



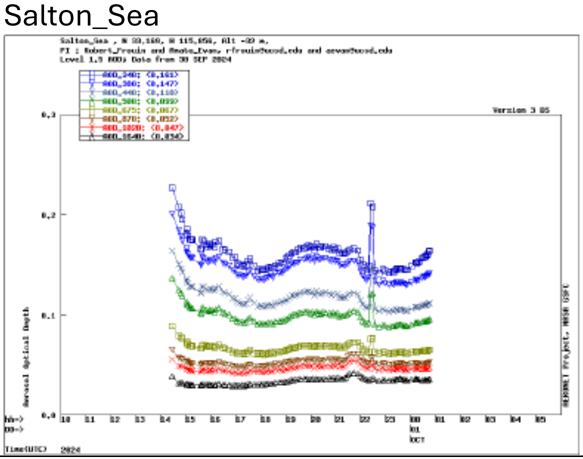
Sacramento_River



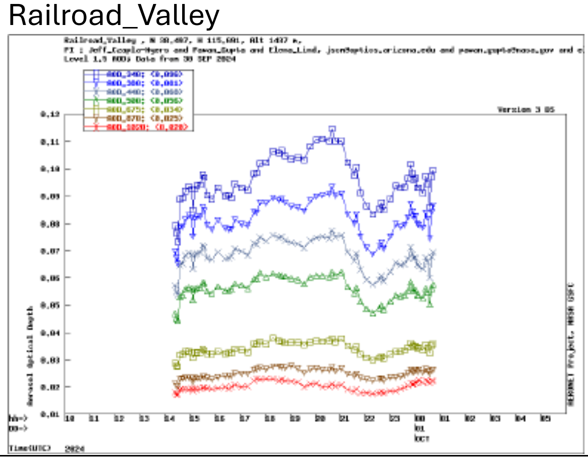
USC_SeaPRISM



Salton_Sea

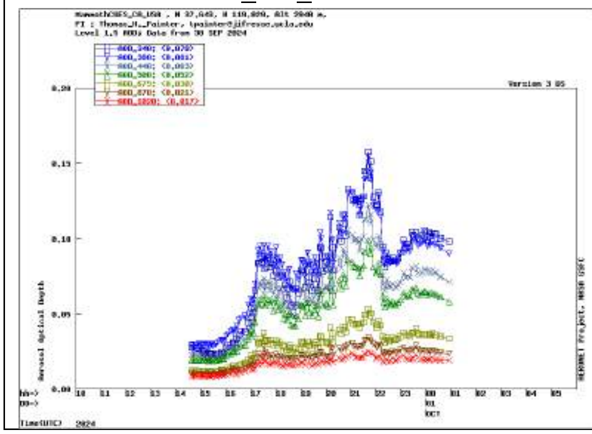


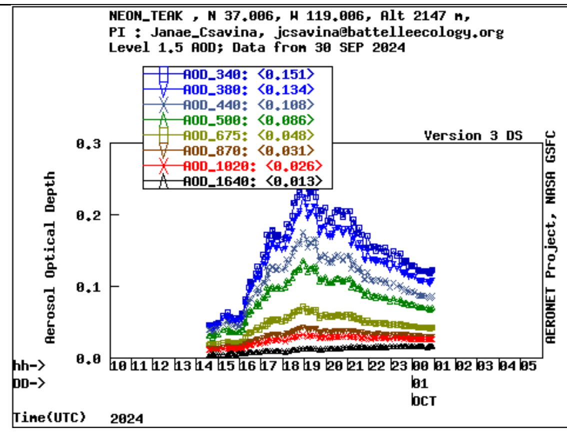
Railroad_Valley



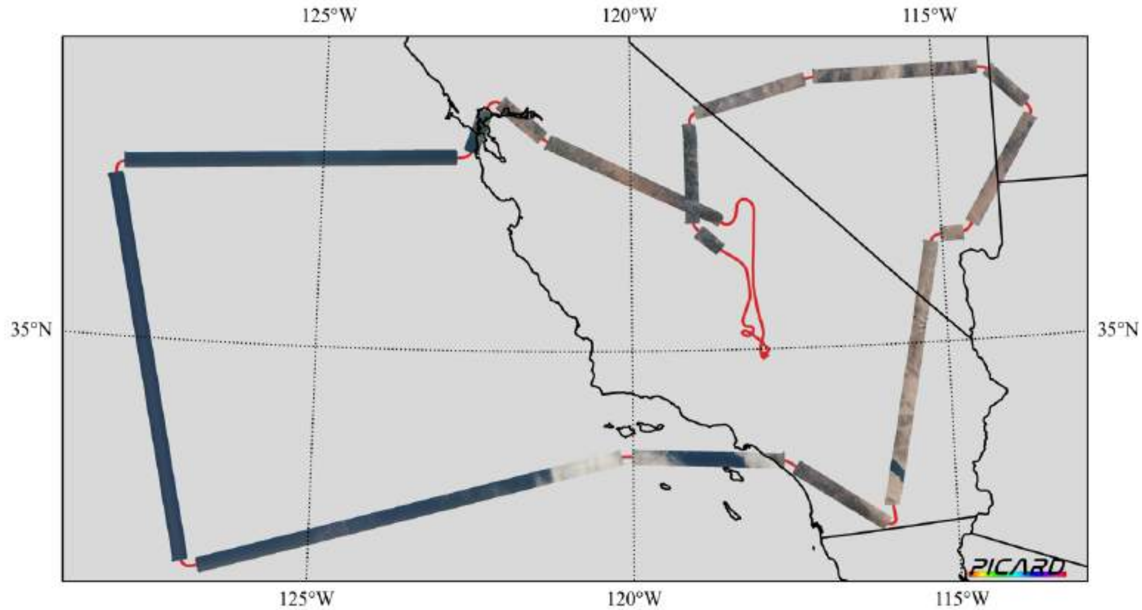
NEON_TEAK

MammothCUES_CA_USA



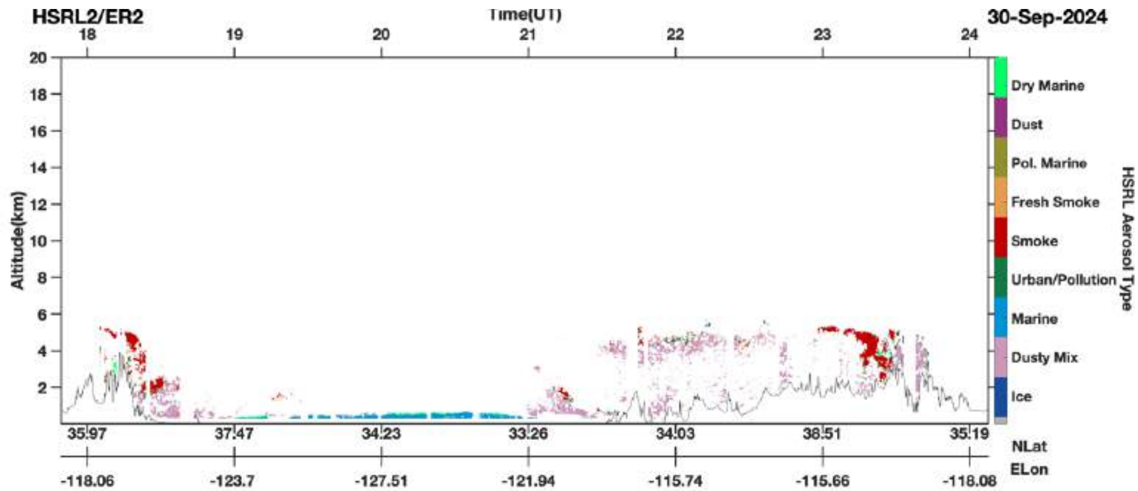


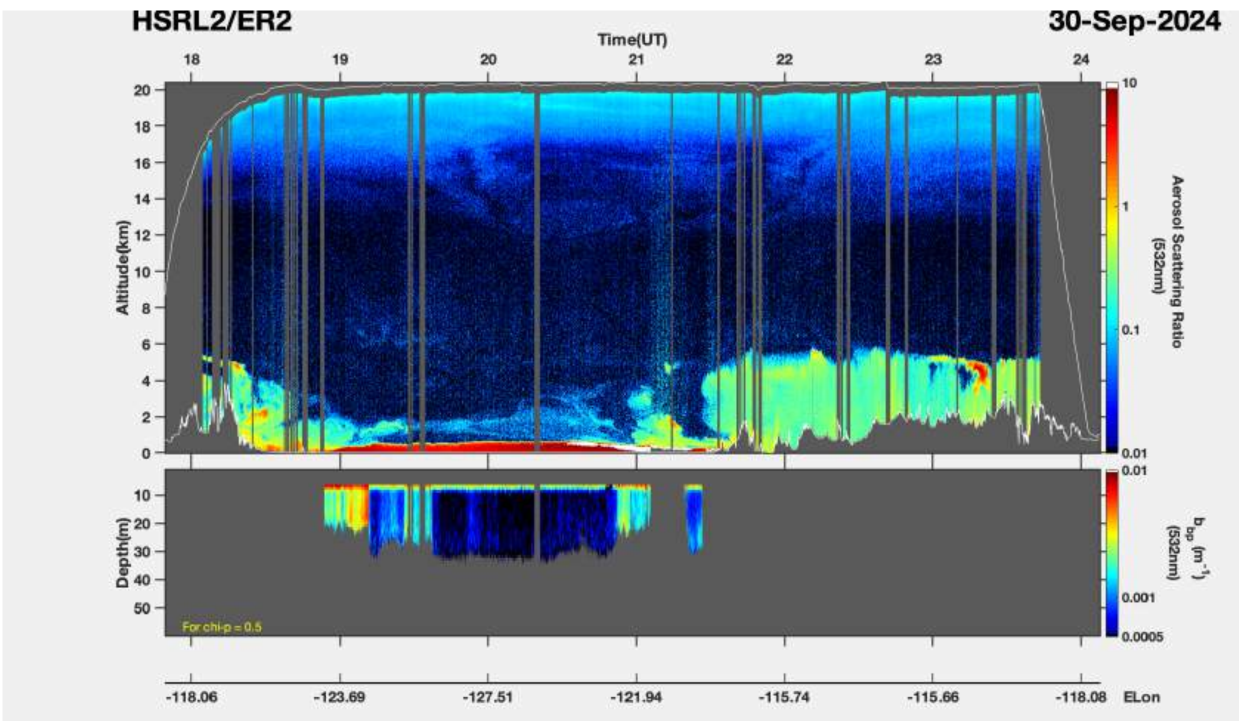
PICARD quicklooks



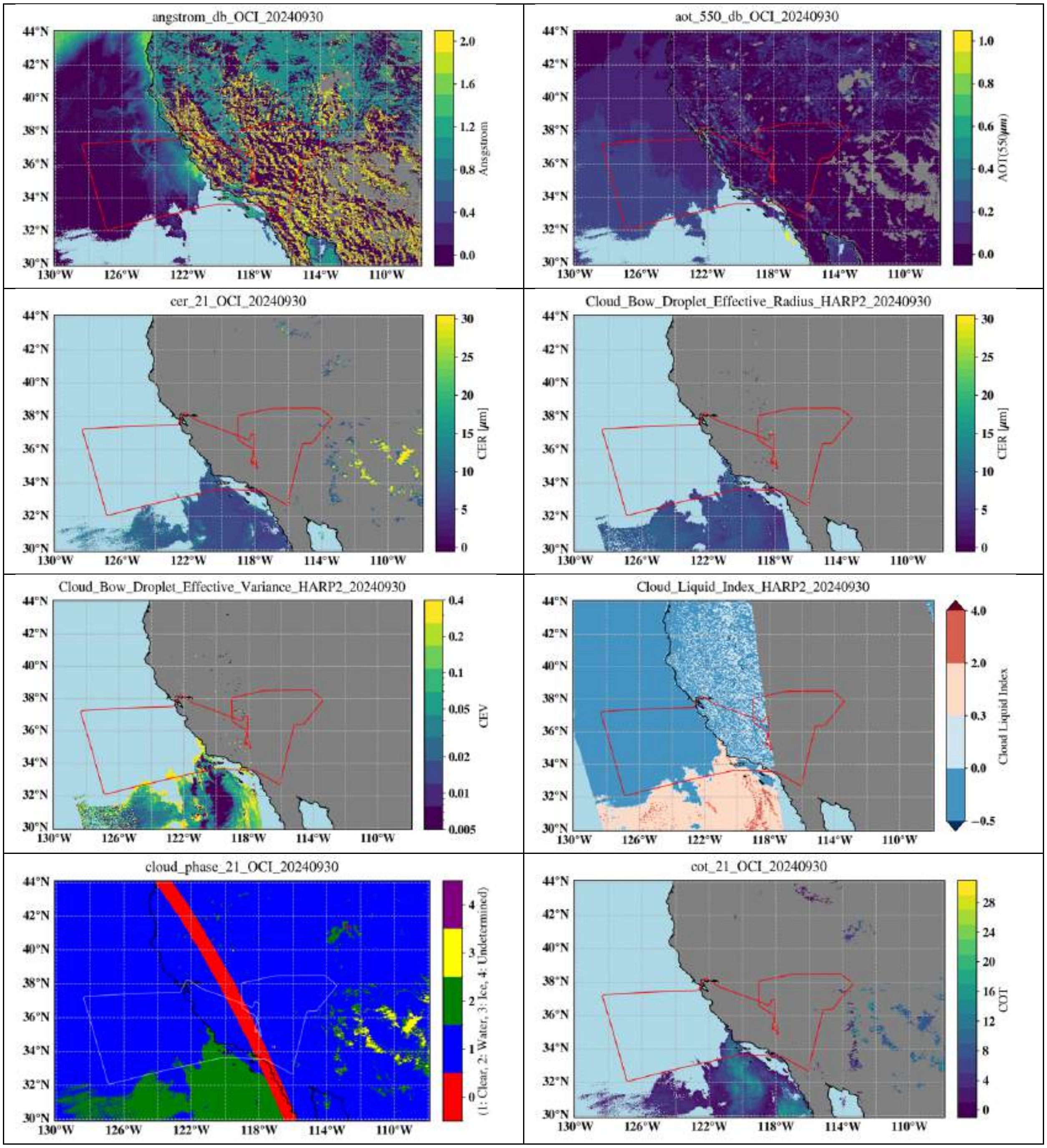
Pushbroom Imager for Cloud and Aerosol Research and Development
PACE-PAX, NASA Armstrong Flight Research Center
30 September 2024

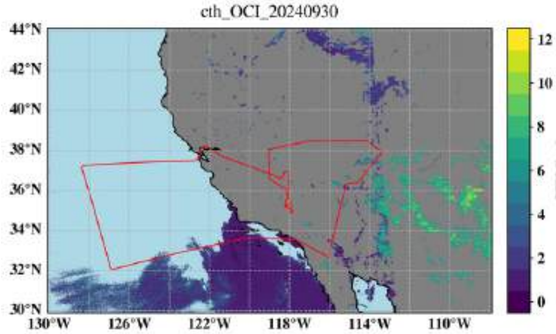
HSRL2 quicklooks

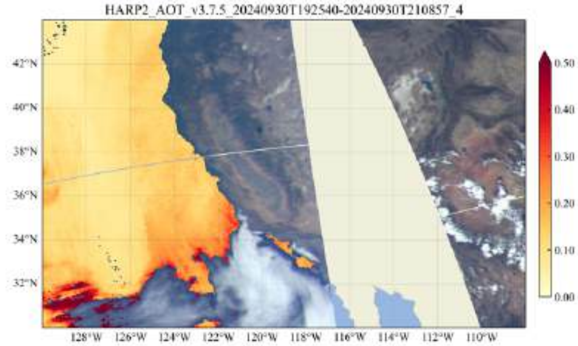




PACE quicklooks




cth_OCI_20240930
44°N
42°N
40°N
38°N
36°N
34°N
32°N
30°N
130°W
126°W
122°W
118°W
114°W
110°W
CTH [km]
12
10
8
6
4
2
0


HARP2_AOT_v3.7.5_20240930T192540-20240930T210857_4
42°N
40°N
38°N
36°N
34°N
32°N
128°W
126°W
124°W
122°W
120°W
118°W
116°W
114°W
112°W
110°W
0.50
0.40
0.30
0.20
0.10
0.00

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Volume 1 *April 2018*	ACE Ocean Working Group recommendations and instrument requirements for an advanced ocean ecology mission
Volume 2 *May 2018*	Pre-Aerosol, Clouds, and ocean Ecosystem (PACE) Mission Science Definition Team Report
Volume 3 *October 2018*	Polarimetry in the PACE mission: Science Team consensus document
Volume 4 *October 2018*	Cloud retrievals in the PACE mission: Science Team consensus document
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Volume 6 *December 2018*	Data Product Requirements and Error Budgets
Volume 7 *December 2018*	Ocean Color Instrument (OCI) Concept Design Studies
Volume 8 *September 2020*	The PACE Science Data Product Selection Plan
Volume 9 *October 2020*	PACE Application Plan
Volume 10 *March 2022*	ACE Ocean Product Accuracy Assessments: A record of the state of the art circa 2010
Volume 11 *June 2023*	The PACE Postlaunch Airborne eXperiment (PACE-PAX)
Volume 12 *March 2024*	The PACE Level 1C data format
Volume 13 *July 2024*	PACE OCI Calibration and Geolocation Operational Algorithm Description
Volume 14 *December 2025*	PACE Science Operations Plan - Revision C
Volume 15 *December 2025*	PyTOAST: Python Top Of Atmosphere Simulation Tool