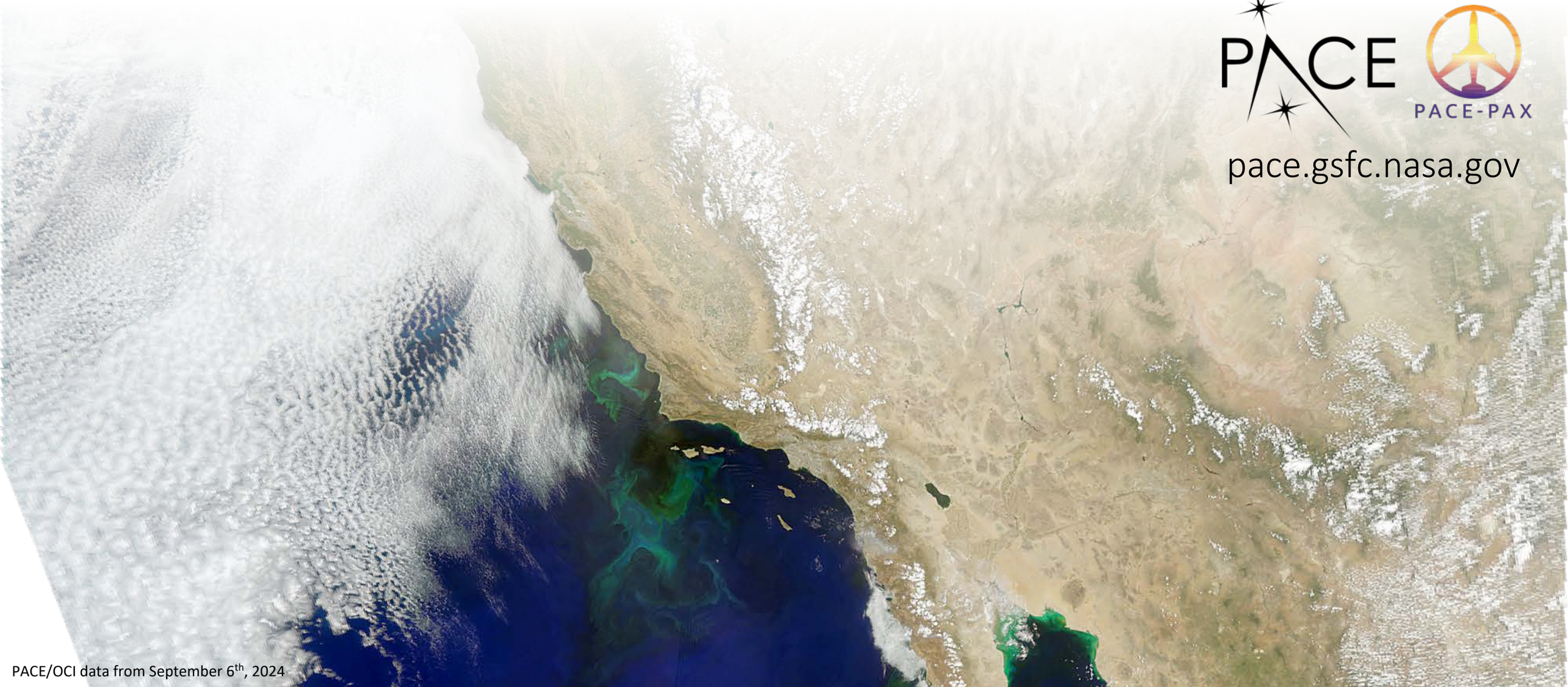
PACE Polarimetry ~~and PACE-PAX~~

(to be covered in a future talk)

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

pace.gsfc.nasa.gov



PACE/OCI data from September 6th, 2024

PACE Polarimetry and PACE-PAX

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

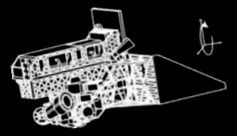
CalCOFI cruise off S. California

Walvis Bay, Namibia

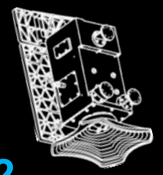
São Tomé, São Tomé and Príncipe

PACE/OCI data from September 6th, 2024

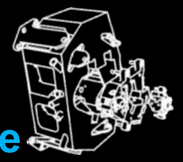
Part 1: PACE polarimetry



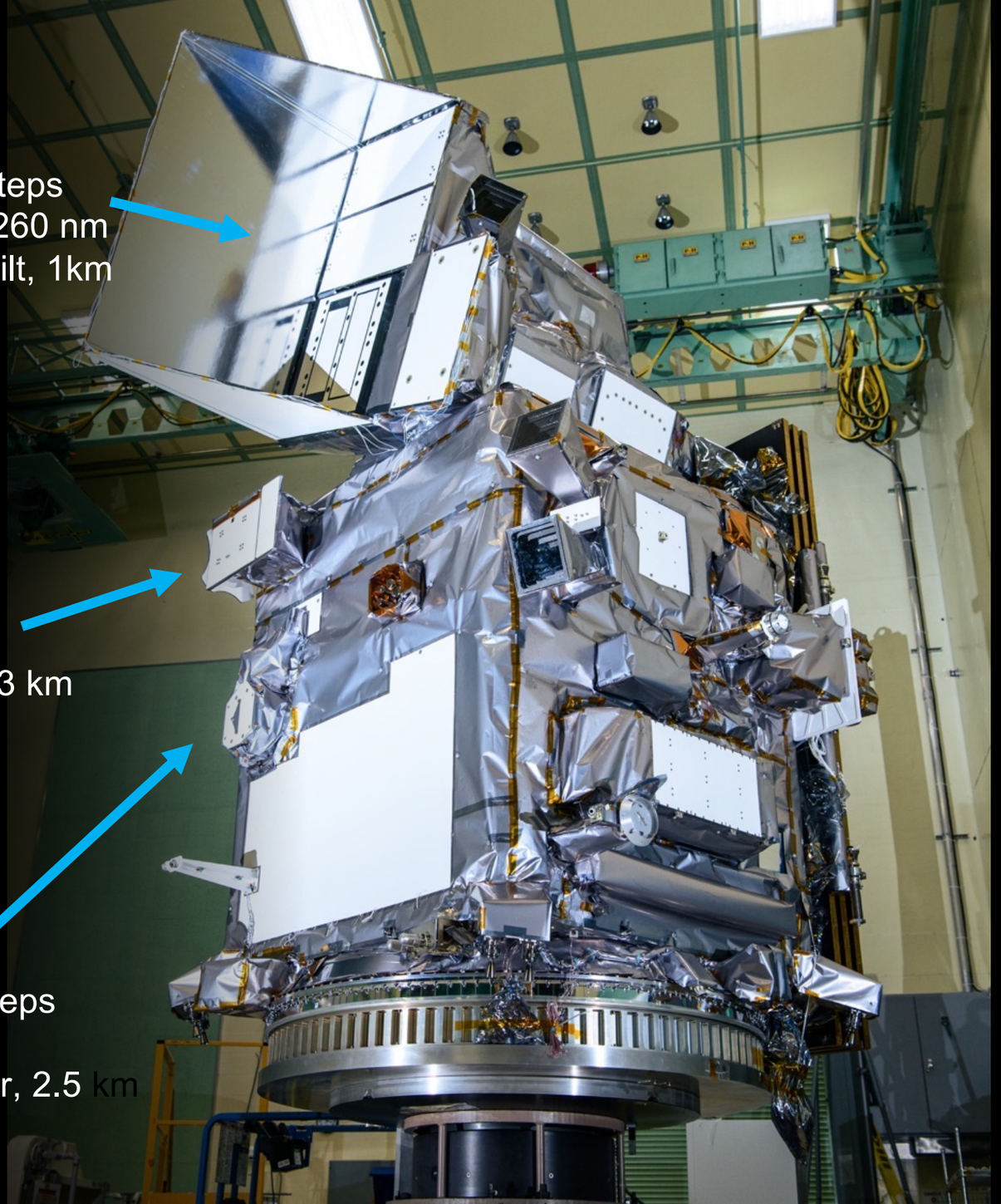
OCI
340-890 nm in 2.5 nm steps
7 discrete SWIR, 940-2260 nm
1-2 day coverage ±20° tilt, 1km



HARP2
440, 550, 670, 870 nm
10-60 viewing angles
wide swath polarimeter, 3 km



SPEXone
380-770 nm in 2-4 nm steps
5 viewing angles
narrow swath polarimeter, 2.5 km

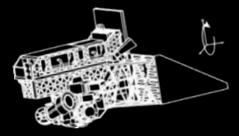


NASA Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission

PACE will extend key systematic ocean color, aerosol, & cloud climate data records, reveal the diversity of organisms fueling marine food webs, and introduce new methods to observe aerosols and clouds, the largest source of climate uncertainty.

Characteristics:

- February 8th launch, April 11th data release
- 676.5 km, polar, ascending orbit, 98°
- Sun synchronous, 13:00 Equatorial crossing
- Global (land and ocean) data
- Data to OB.DAAC (oceancolor.gsfc.nasa.gov)



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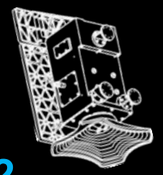

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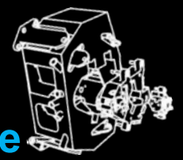


SPEXone
380-770 nm in 2-4 nm steps
5 viewing angles
narrow swath polarimeter, 2.5 km

PACE (multi-angle) Polarimeters

- What do HARP2 and SPEXone measure, and why?
- What exactly is polarization, and why do we measure it?
- What 'products' do we make with the polarimeters?
- How do we validate those data products?

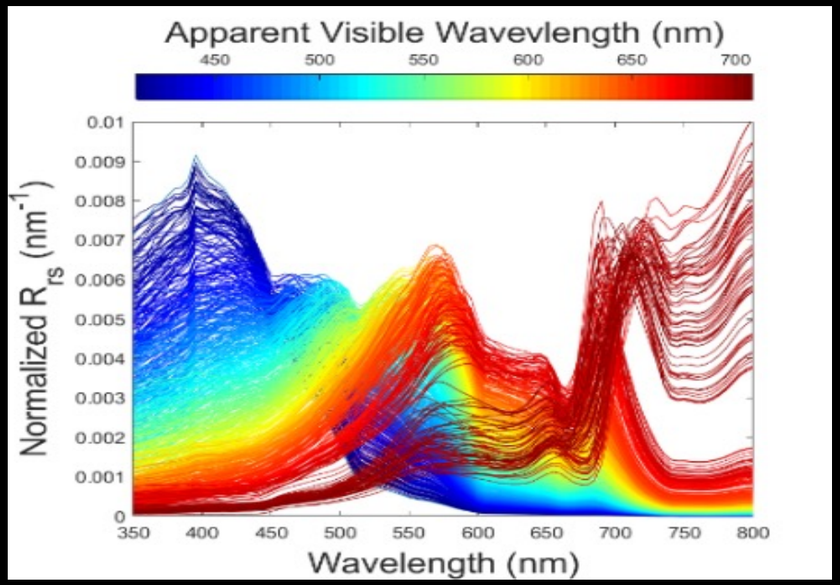
One way: the PACE Postlaunch Airborne Experiment (PACE-PAX)

PACE-PAX

To observe ocean biology, we must be able to resolve the many subtle colors of the ocean

Municipal Wharf, Santa Cruz California

PACE's OCI does this by measuring detailed spectra

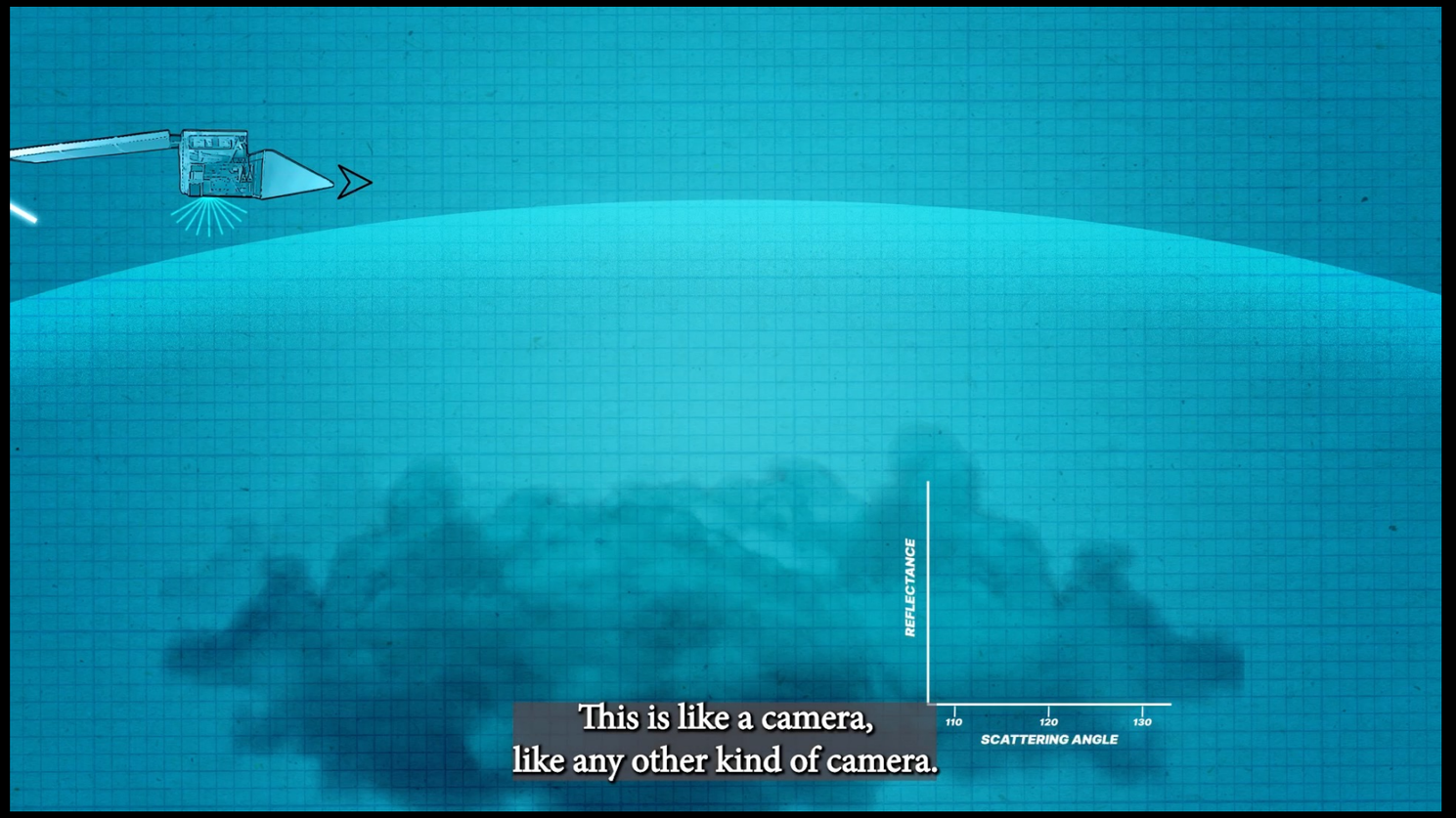


Vandermuelen et al., 2020

OCI sees many colors, maximizing spectral information content

Other ways to maximize information content

Observe from different angles



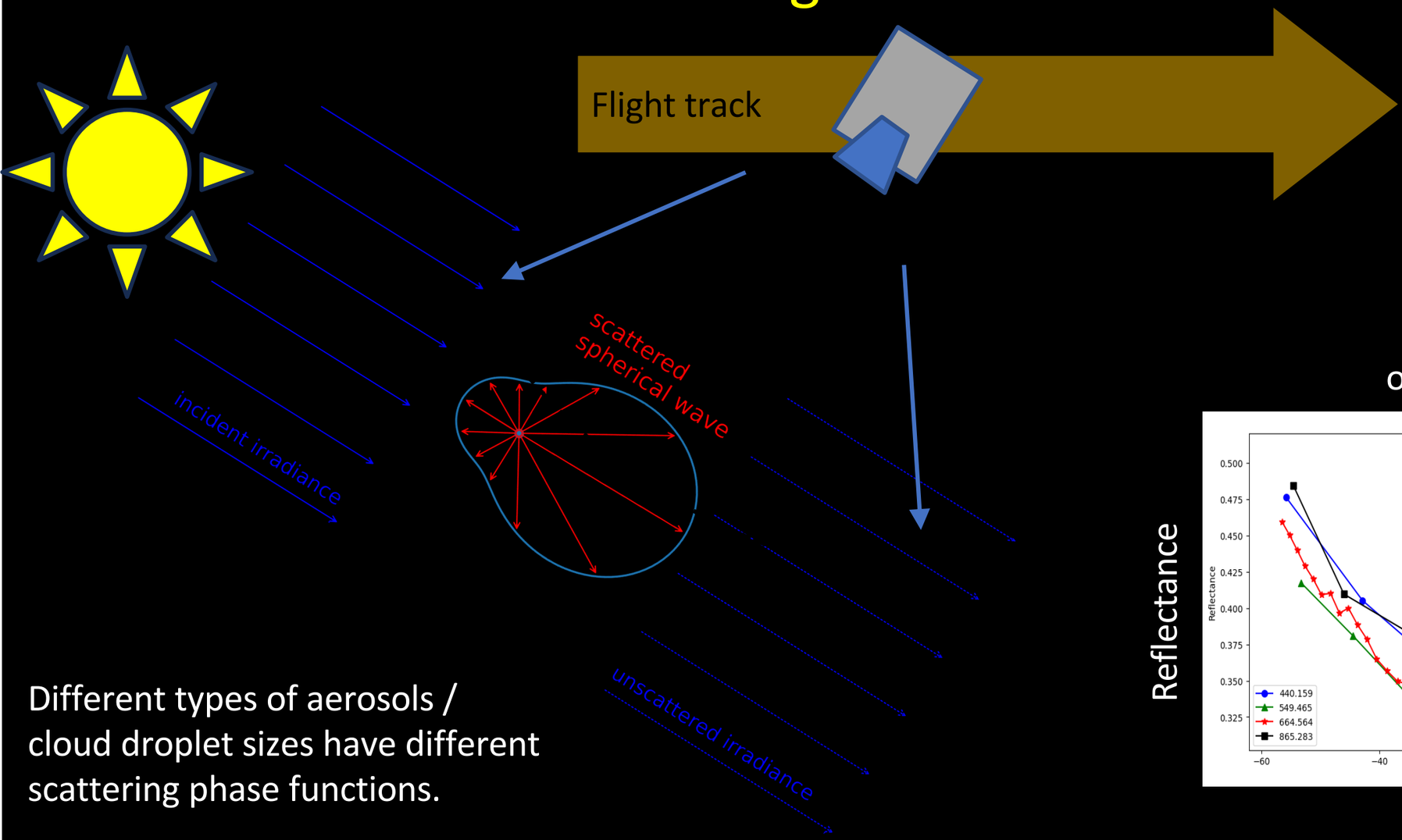
https://svs.gsfc.nasa.gov/14454

PACE/HARP2 Version 1/first light animation
669nm multi-angle reflectance, 2024/03/17

Not shown are polarimetric data and other spectral channels. The AOS polarimeter would have UV, SWIR and better spatial resolution.

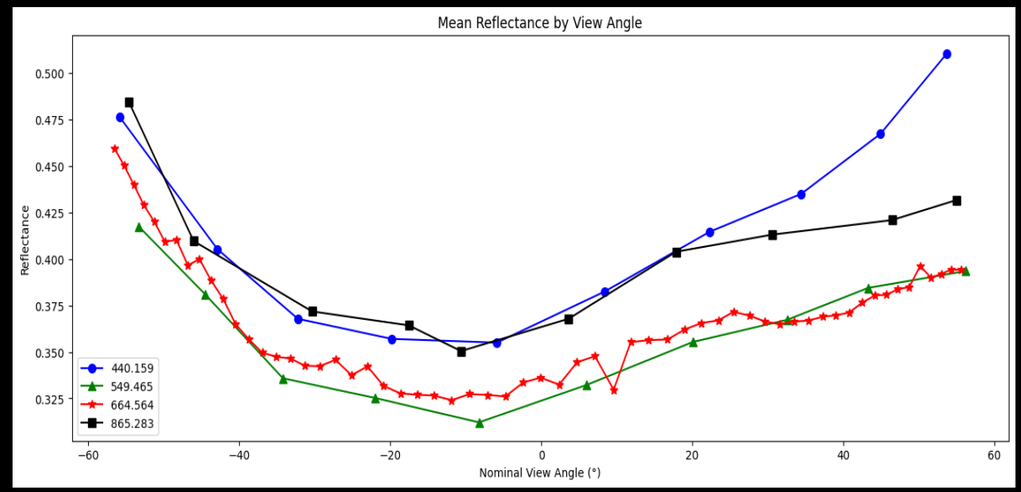
Other ways to maximize information content

Observe from different angles



Different types of aerosols / cloud droplet sizes have different scattering phase functions.

What a single pixel observation might look like

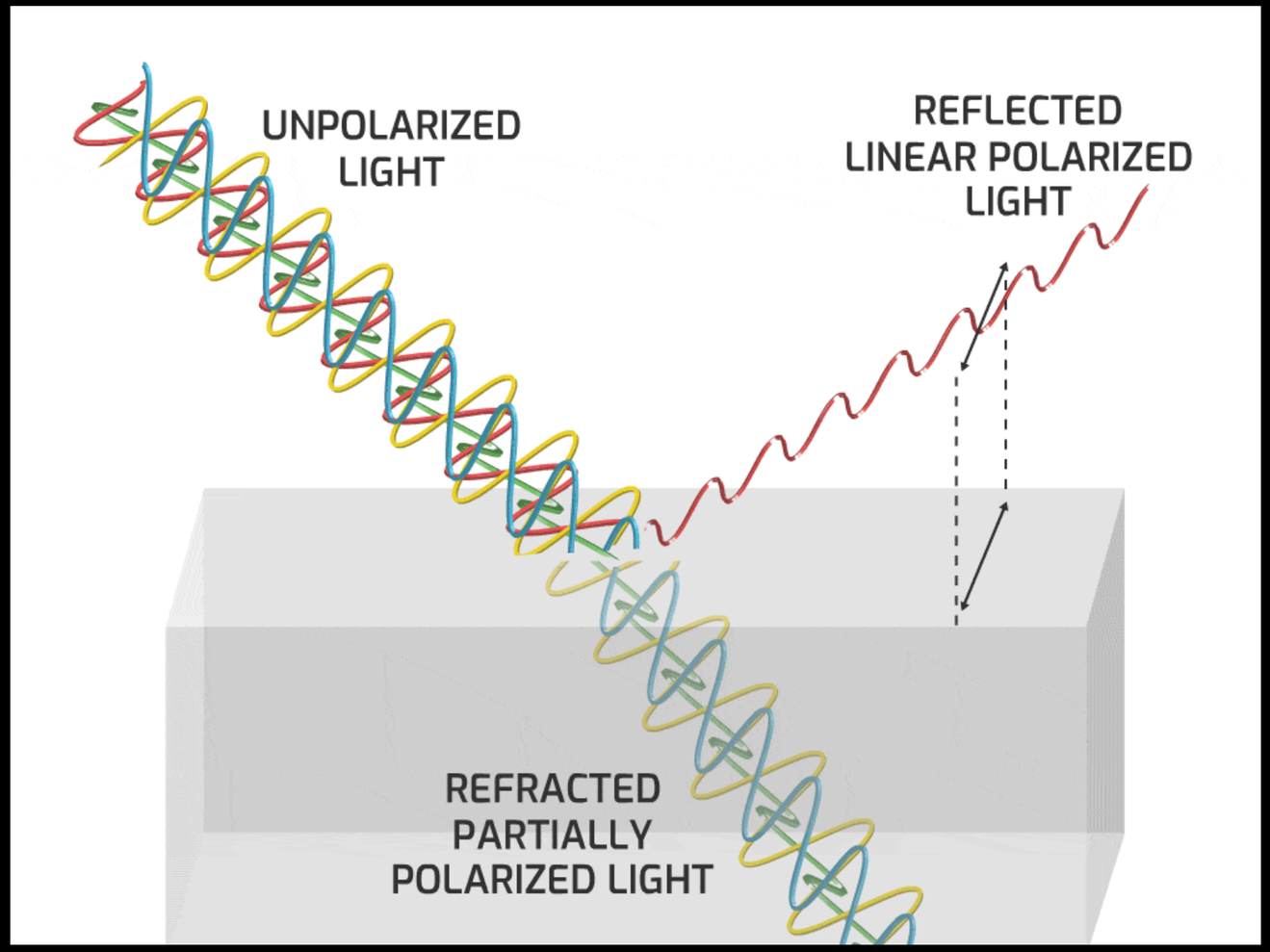


Reflectance

Sensor view angle

Other ways to maximize information content

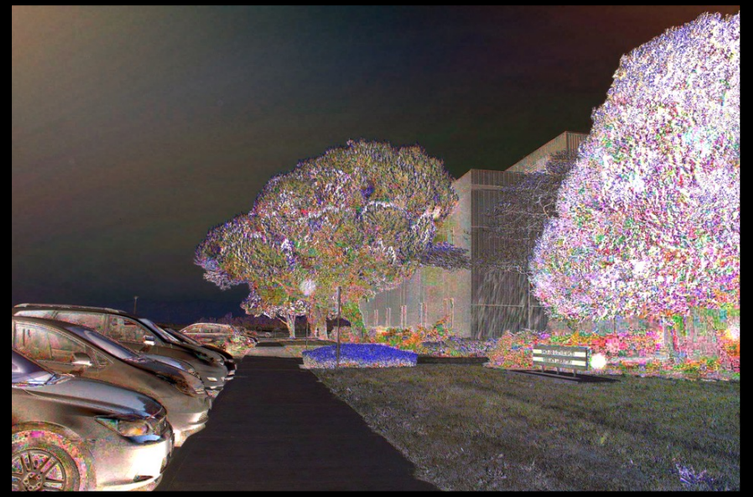
Have sensitivity to light polarization



https://thinklucid.com/tech-briefs/polarization-explained-sony-polarized-sensor/

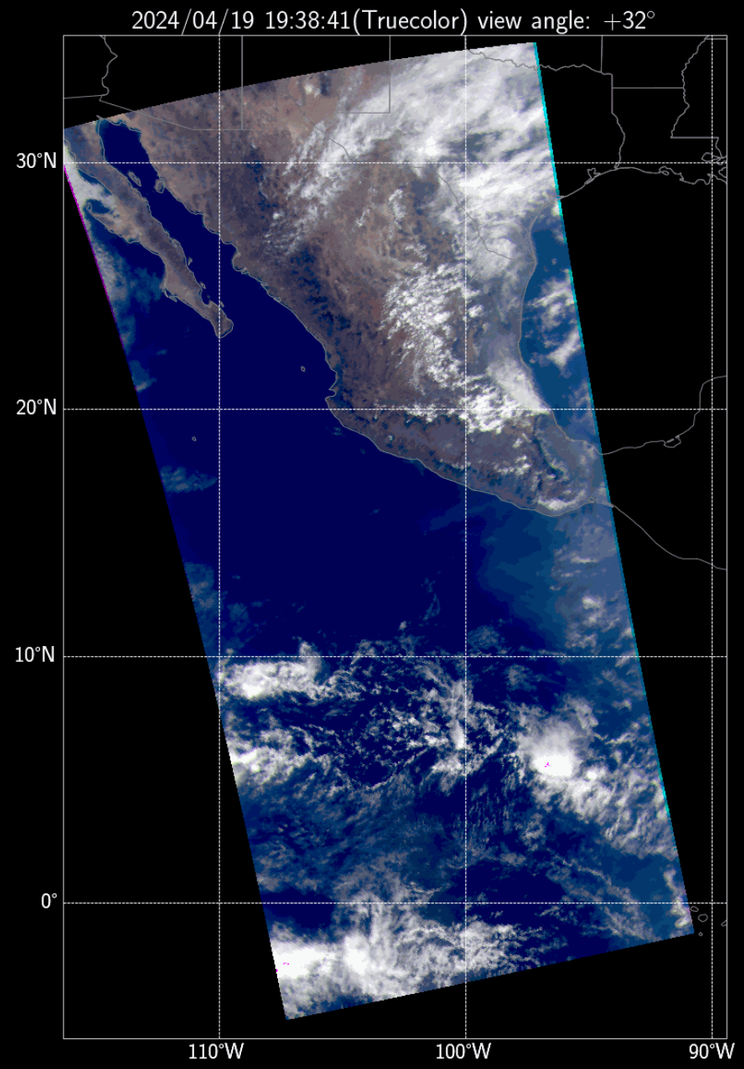
'total' unpolarized

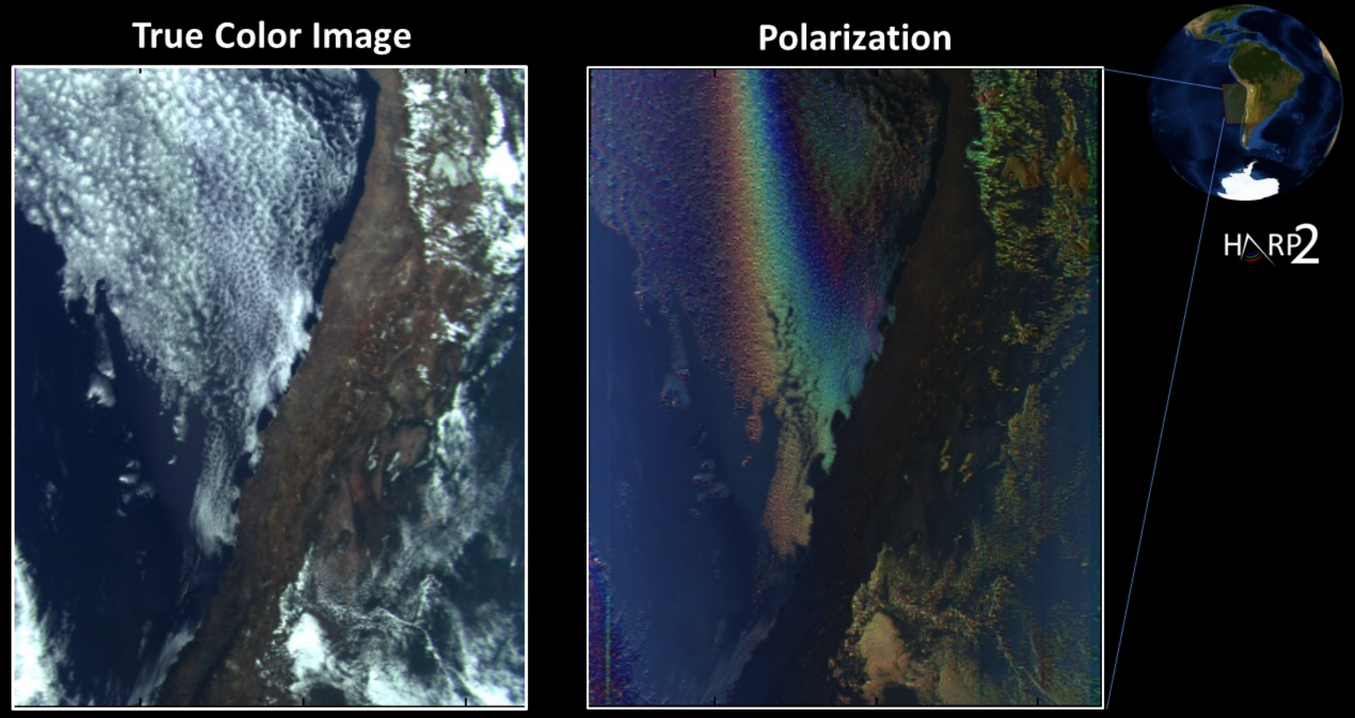
Degree of linear polarization



Other ways to maximize information content

Have sensitivity to light polarization

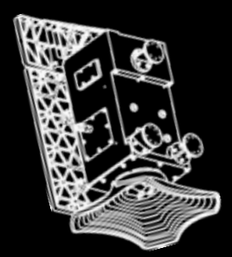




Polarization contains information about both aerosols and clouds.
See: https://pace.oceansciences.org/gallery_more.htm?id=2187

← PACE/HARP2 reflectance+DoLP,
2024/04/19

The PACE polarimeters



	HARP-2	SPEXone
UV-NIR range	440, 550, 670, 870 nm	Continuous from 385-770 nm in 5 nm steps
SWIR range	None	None
Polarized bands	All	Continuous from 385-770 nm in 15-45 nm steps
Number of viewing angles [degrees]	10 for 440, 550, 870 nm; 60 for 670 nm [spaced over 114°]	5 [-57°, -20°, 0°, 20°, 57°]
Swath width	±47° [1556 km at nadir]	±4.5° [106 km at nadir]
Global coverage	2 days	30+ days

For more detail, see the PACE Data Products Table:
pace.oceansciences.org/data_table.htm

Available now: GPC, RemoTAP, FastMAPOL

In development: MAPP, GRASP

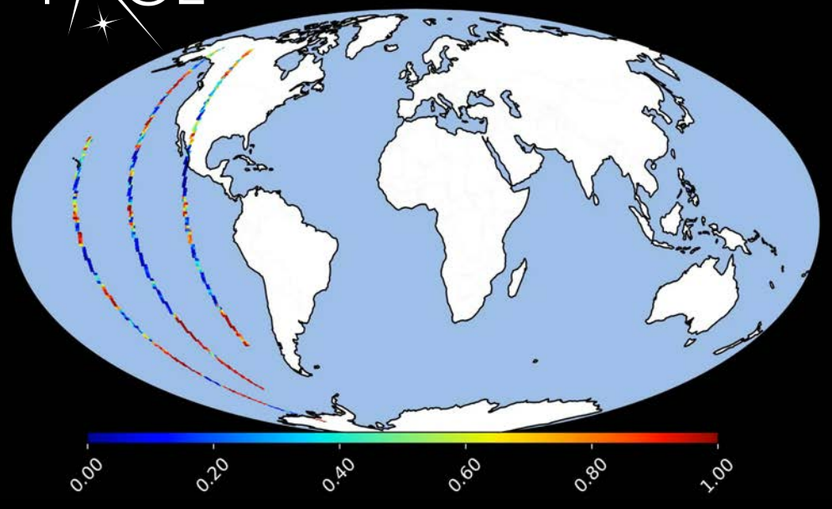
Cloud algorithms:	GPC	
Aerosol (over land):	GRASP	RemoTAP
Aerosol (over ocean):	FastMAPOL, MAPP	FastMAPOL, RemoTAP

1 YEAR OF SPEXone from PACE: ADVANCING AEROSOL IDENTIFICATION

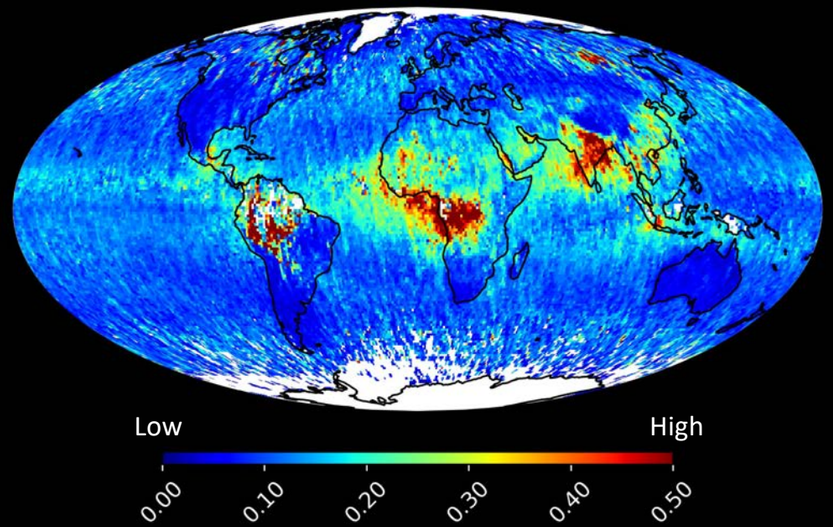
SRON SPACE RESEARCH ORGANISATION NETHERLANDS

PACE

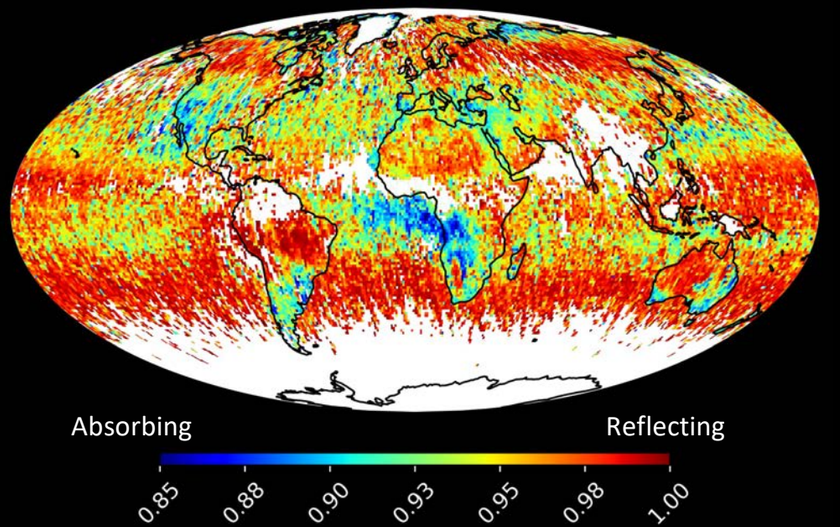
Cloud Fraction



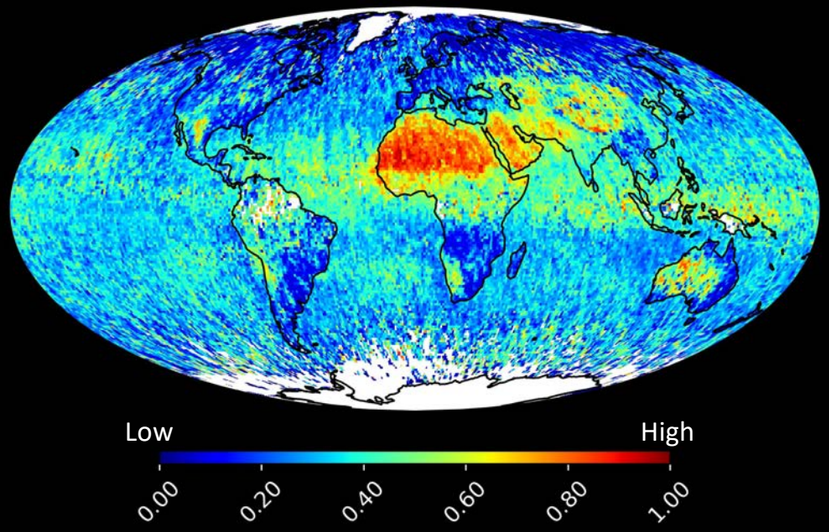
Aerosol Optical Depth (Amount)



Single Scattering Albedo (absorption)

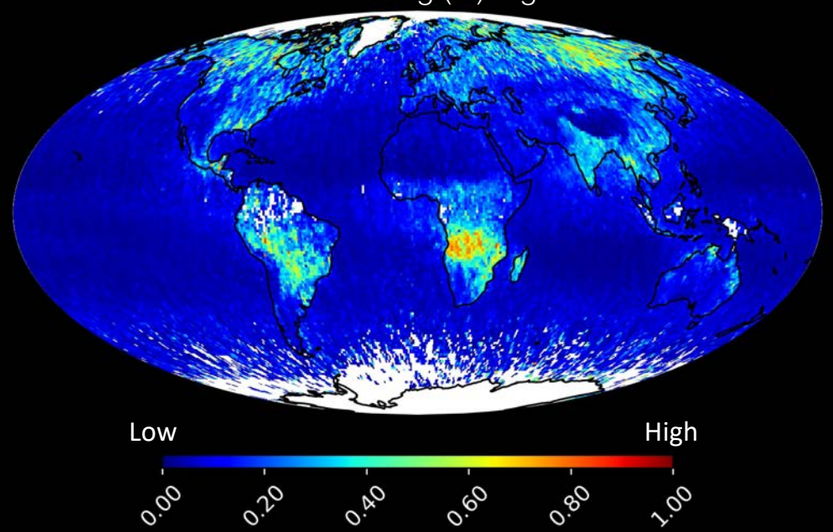


Dust Fraction

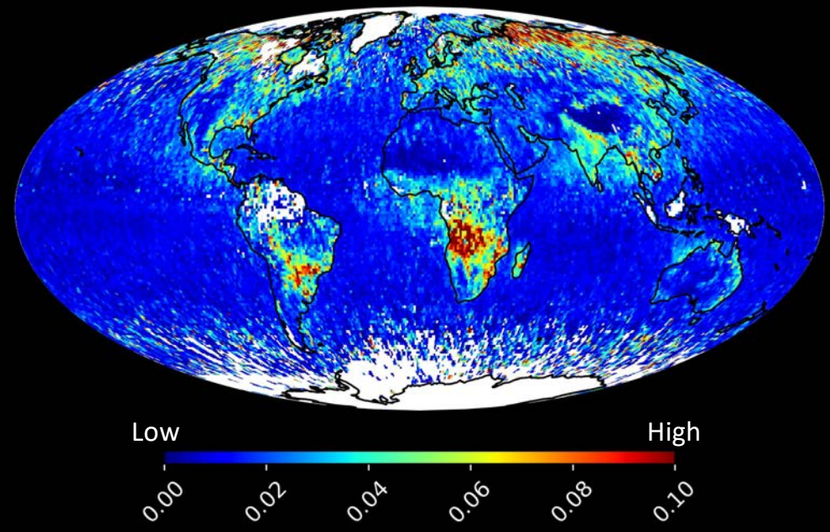


Small particles

non-absorbing (in) organic



Black Carbon & Brown Carbon

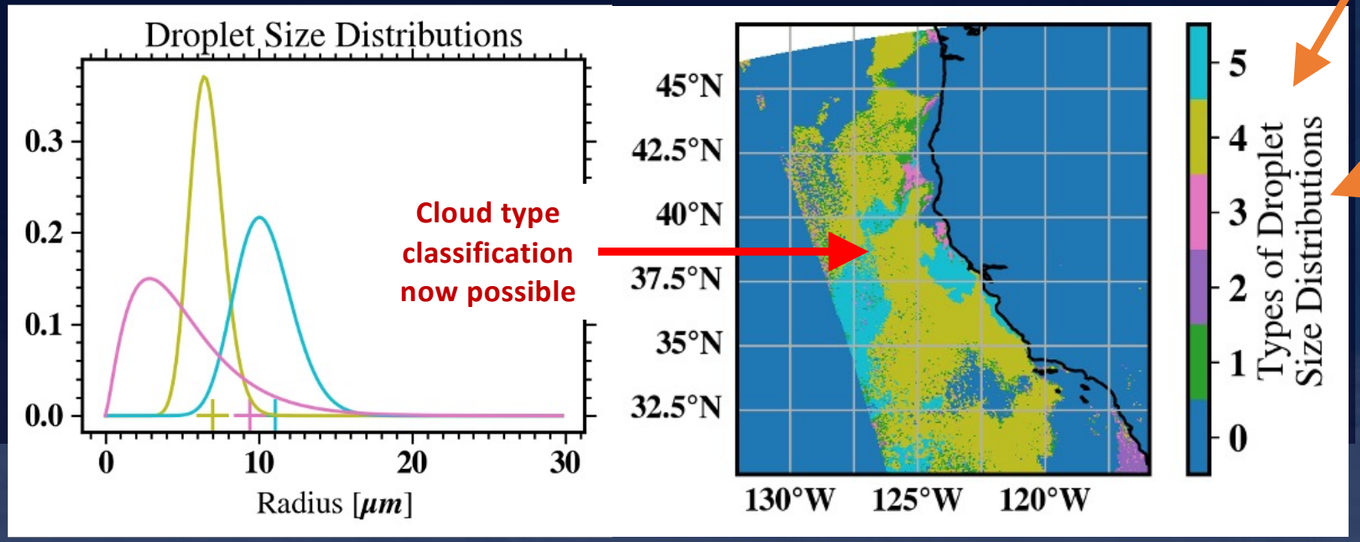


Fu, G. et al, 2024, doi:10.1029/2024GL113525

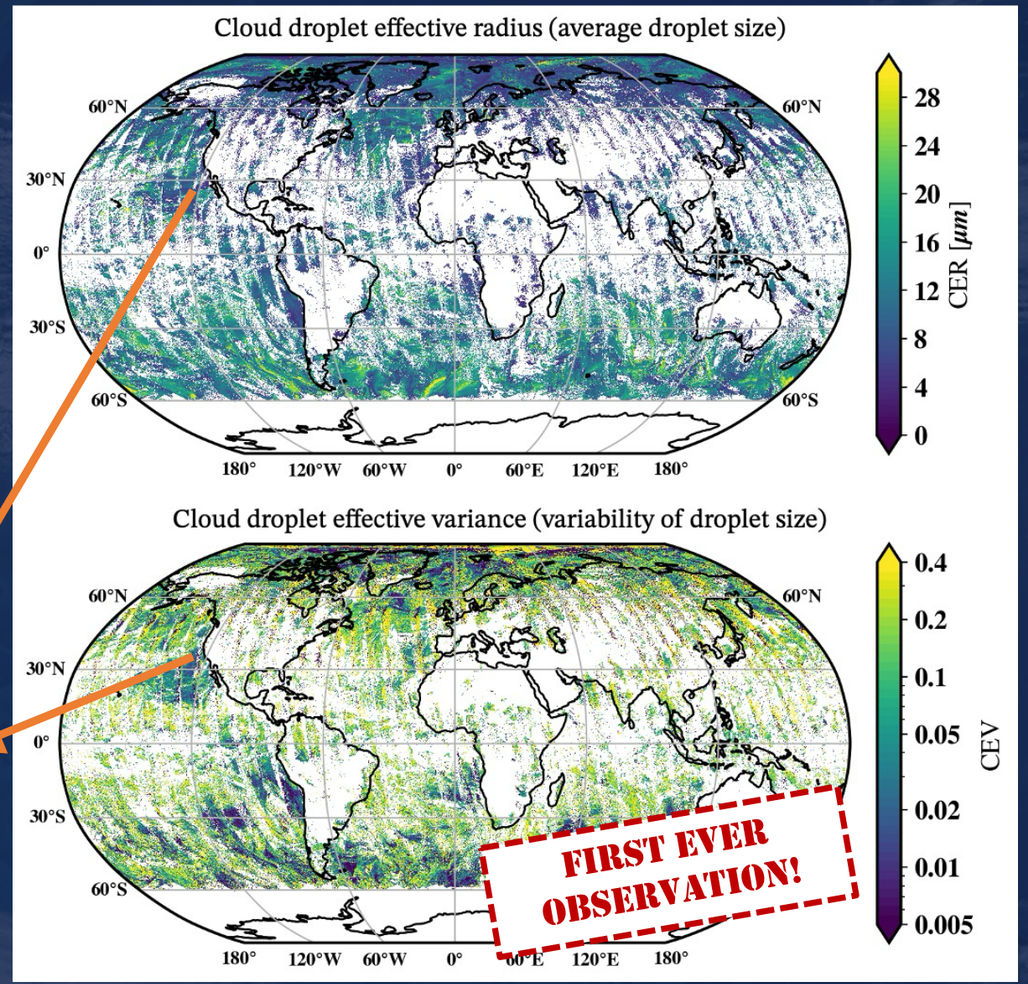
NEW CLOUD PROPERTY PRODUCTS PACE HARP-2 POLARIMETER

Cloud droplet size from PACE - a first ever observation from space!

- Cloud droplet sizes are determined from multi-angle, polarization-sensitive measurements by HARP-2
- **Cloud droplet effective radius** (average droplet size) is observed by other sensors (including PACE OCI) using a spectral technique. This polarization approach promises fewer artifacts.
- **Cloud droplet effective variance** (variability of droplet size) observations from space have never been made at this (5.2km) resolution
- Both offer new insight into cloud properties, precipitation, aerosol-cloud interactions, and the Earth's energy balance



Global 3-day Average PACE CLOUD_GPC Product
July 3-5, 2025*



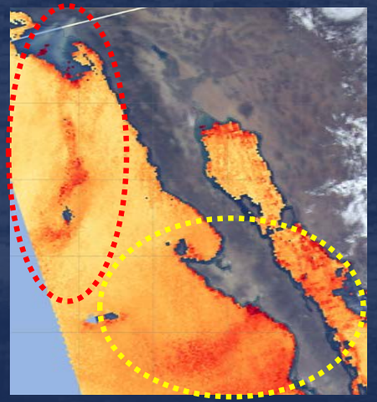
*Algorithm doi: 10.1016/j.rse.2012.07.012

PACE'S MULTI-DISCIPLINARY VIEW OF THE JANUARY 2025 LOS ANGELES WILDFIRES

THE PACE/HARP2 MULTI ANGLE POLARIMETER MONITORS SMOKE

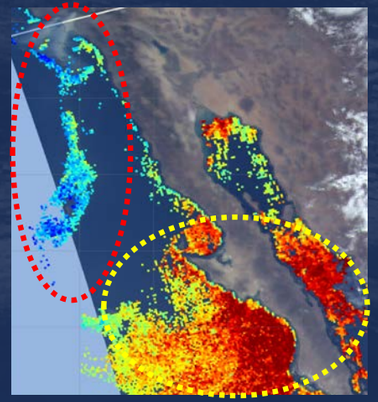
By applying the NASA-developed FastMAPOL algorithm to HARP2's advanced data, we can distinguish between smoke and other types of atmospheric particulate pollution like dust

Aerosol optical depth (550nm)
(Aerosol quantity)



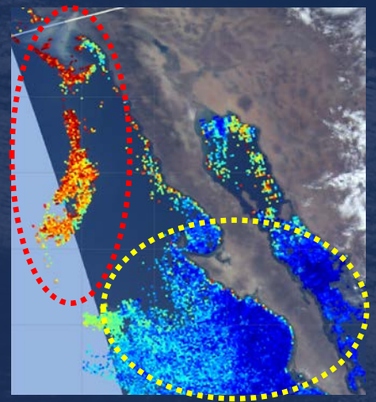
Less aerosols *More aerosols*

Single scattering albedo (550nm)
(Aerosol light absorption)



Scattering aerosols *Absorbing aerosols*

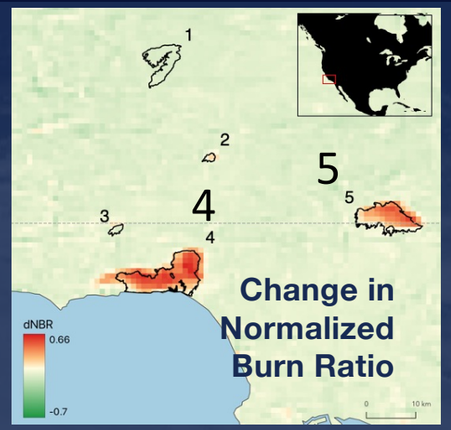
Fine mode fraction
(Dominant aerosol size)

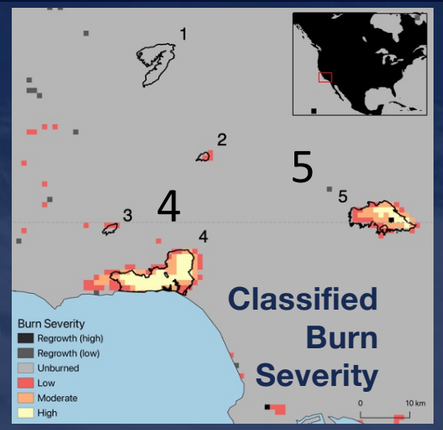


Small aerosols *Large aerosols*

THE PACE/OCI HYPERSPECTRAL IMAGER MONITORS BURN SEVERITY

Change in Normalized Burn Ratio (dNBR) indicates burn severity. Due to PACE/OCI's global coverage and high temporal revisit, dNBR can be assessed rapidly following a fire.





4. Palisades Fire (1/07/2025)

5. Eaton Fire (1/07/2025)