PACE FastMAPOL Polarimetry Data Product: Status and Challenges

Meng Gao (SSAI/NASA GSFC) on behalf of PACE team

FastMAPOL

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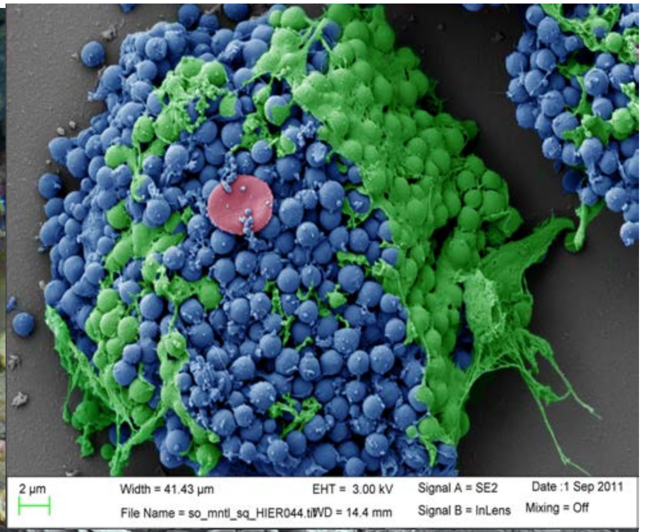
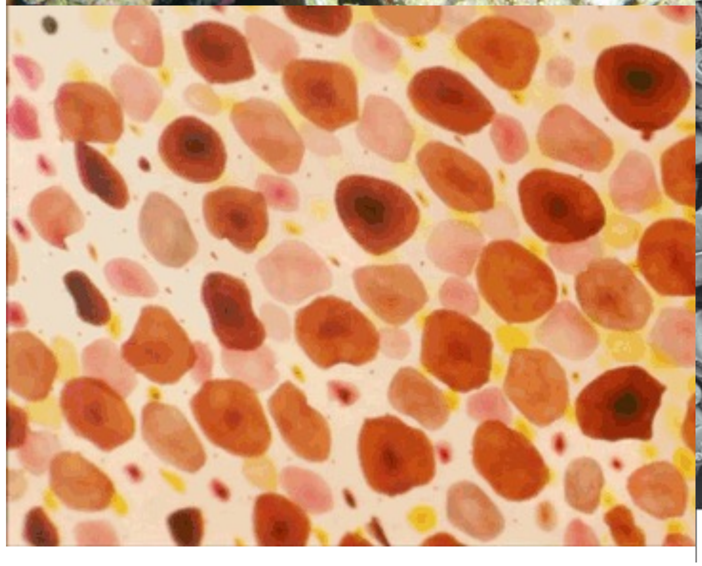
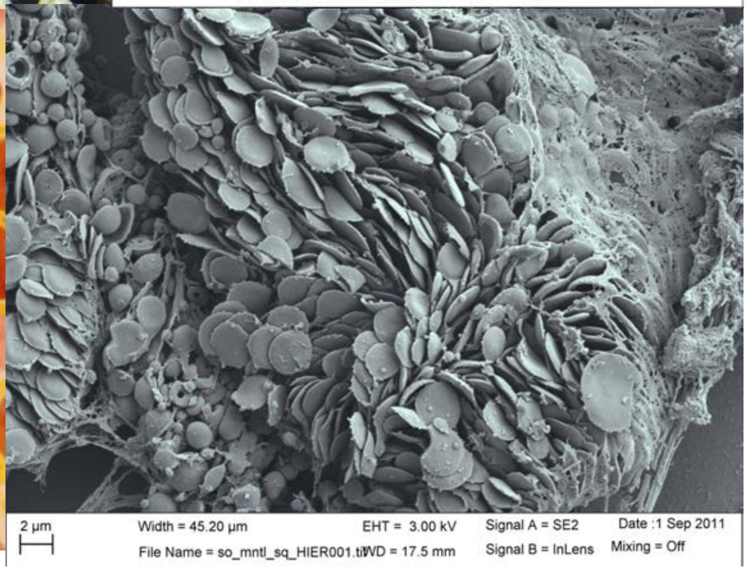
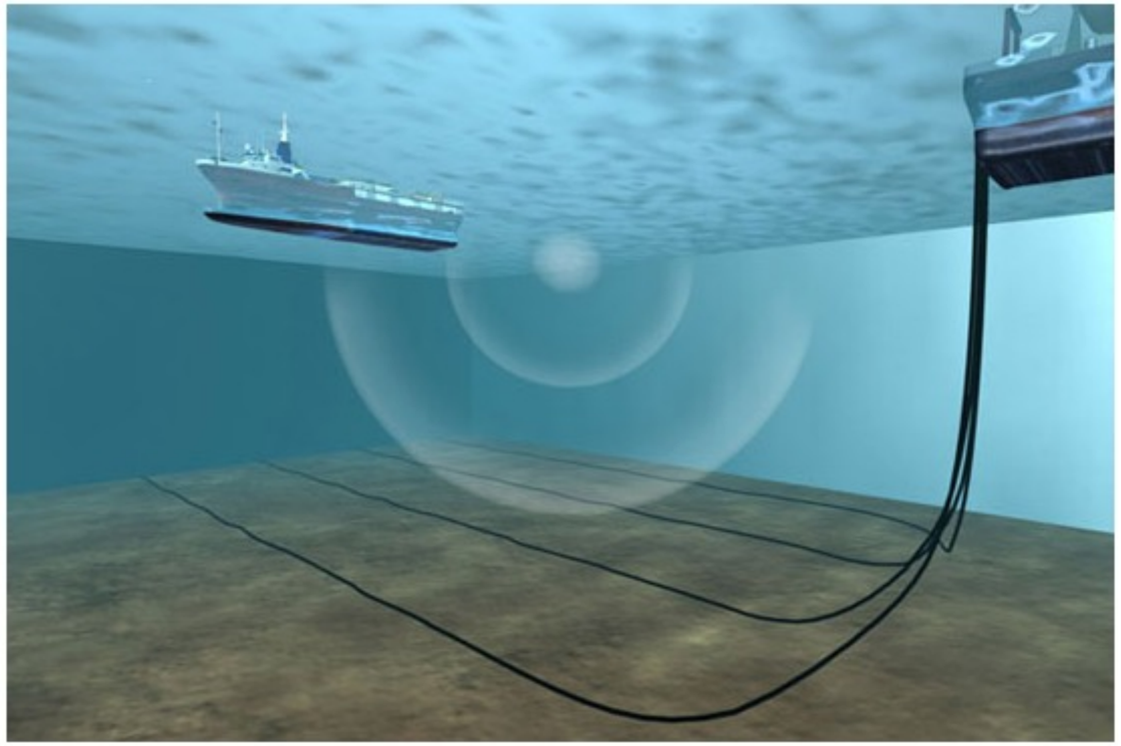
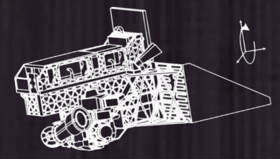


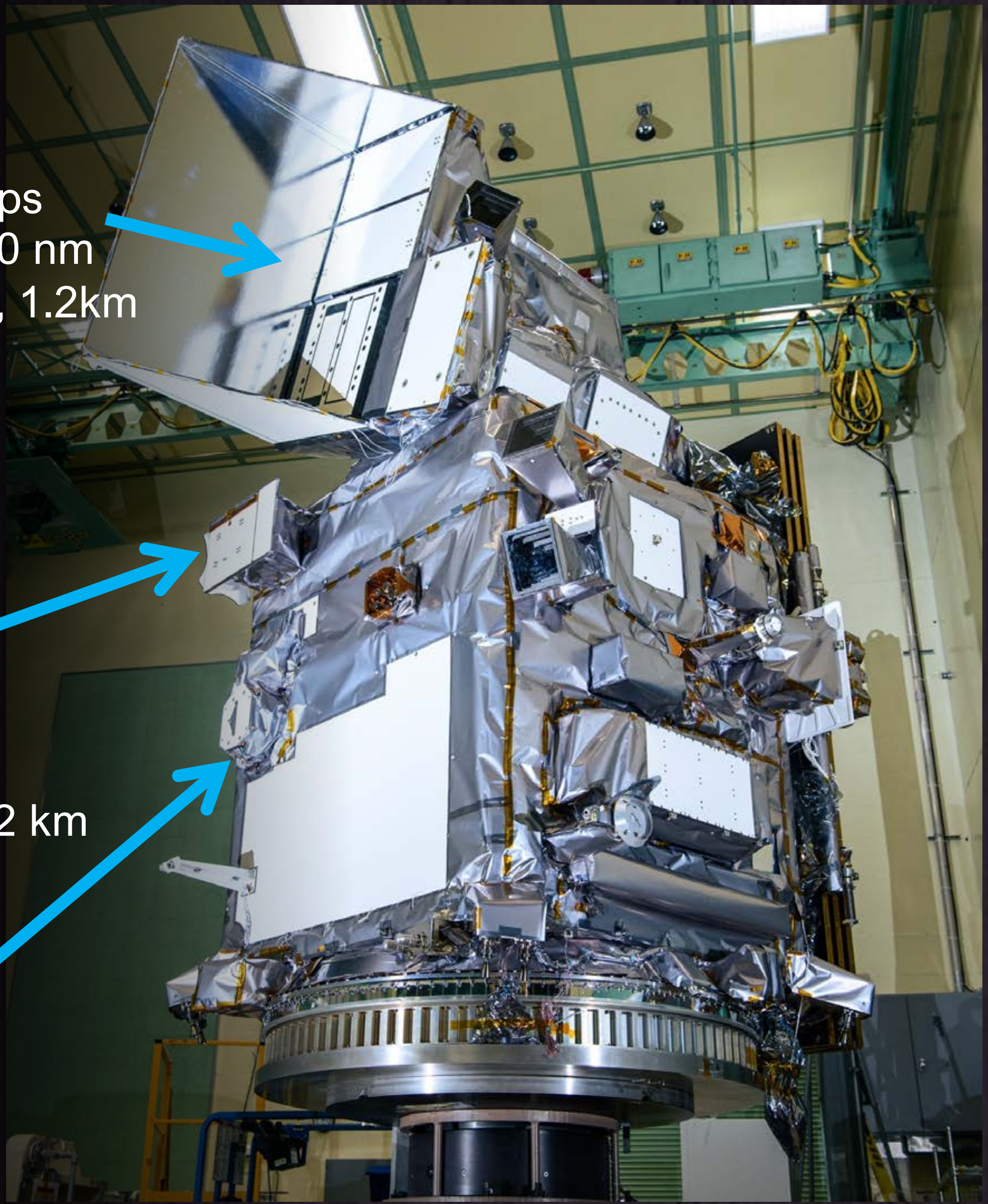


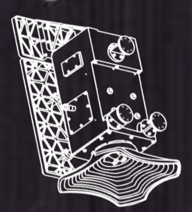




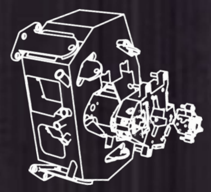


OCI
340-890 nm in 2.5 nm steps
7 discrete SWIR, 940-2260 nm
1-2 day coverage ±20° tilt, 1.2km

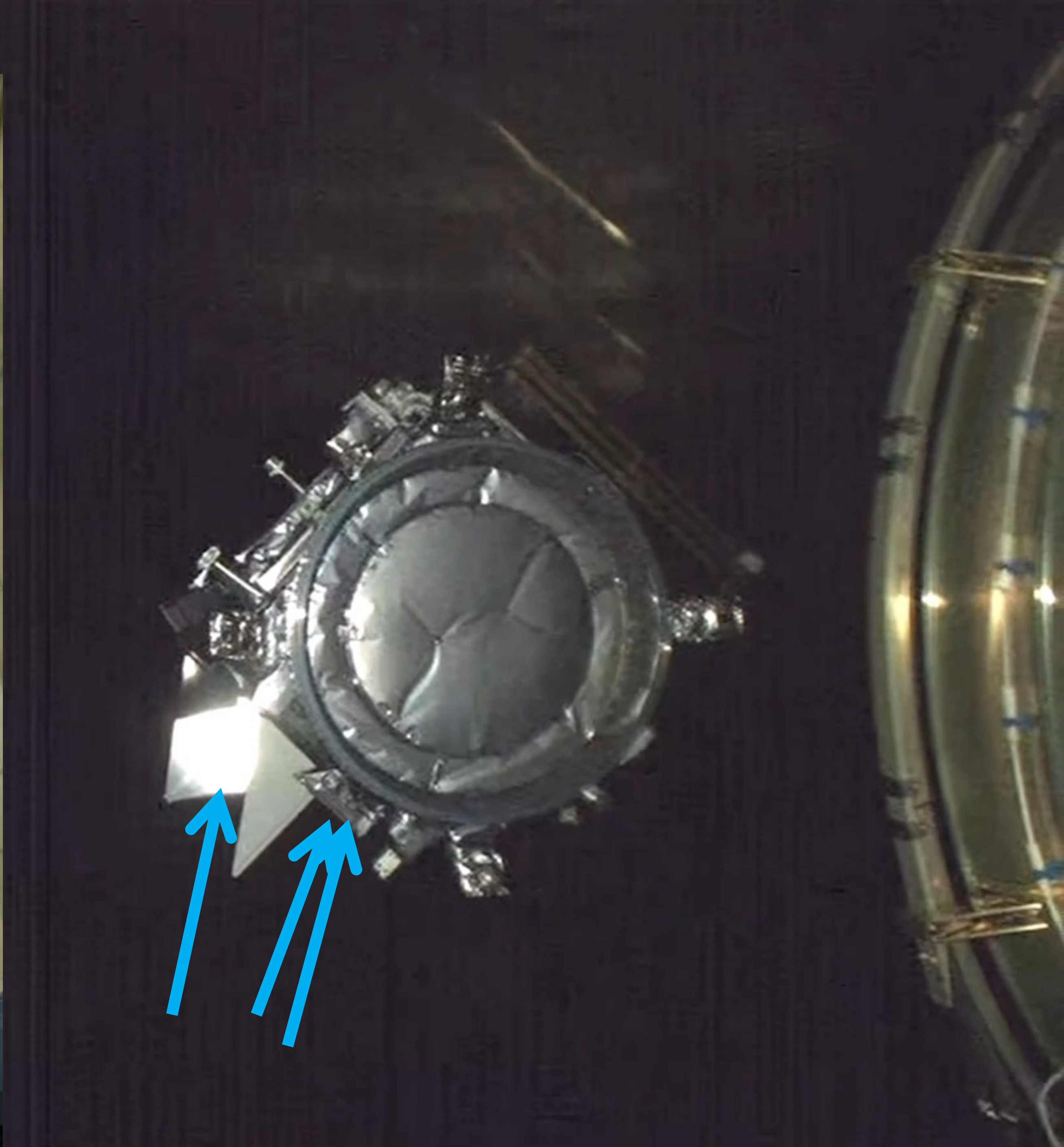




HARP2 (UMBC)
440, 550, 670, 870 nm
10-60 viewing angles
wide swath polarimeter, 5.2 km



SPEXone (SRON)
380-770 nm in 2-4 nm steps
5 viewing angles
narrow swath polarimeter, 5.2 km



Feb 8 2024

PACE polarimeter Level 2 aerosol/surface data product

PACE NASA

Data product table:

- Fine/coarse mode spectral AOD, SSA
- Fine/coarse mode **size, shape, complex refractive index**
- Aerosol layer height
- Surface properties (land & ocean)

L2 Processing algorithms:

- RemoTAP (SRON): OB.DAAC & earth data cloud
- FastMAPOL (GSFC): OB.DAAC (ocean only)
- GRASP (UMBC): soon
- MAPP (LaRC): soon

https://pace.oceansciences.org/data_table.htm

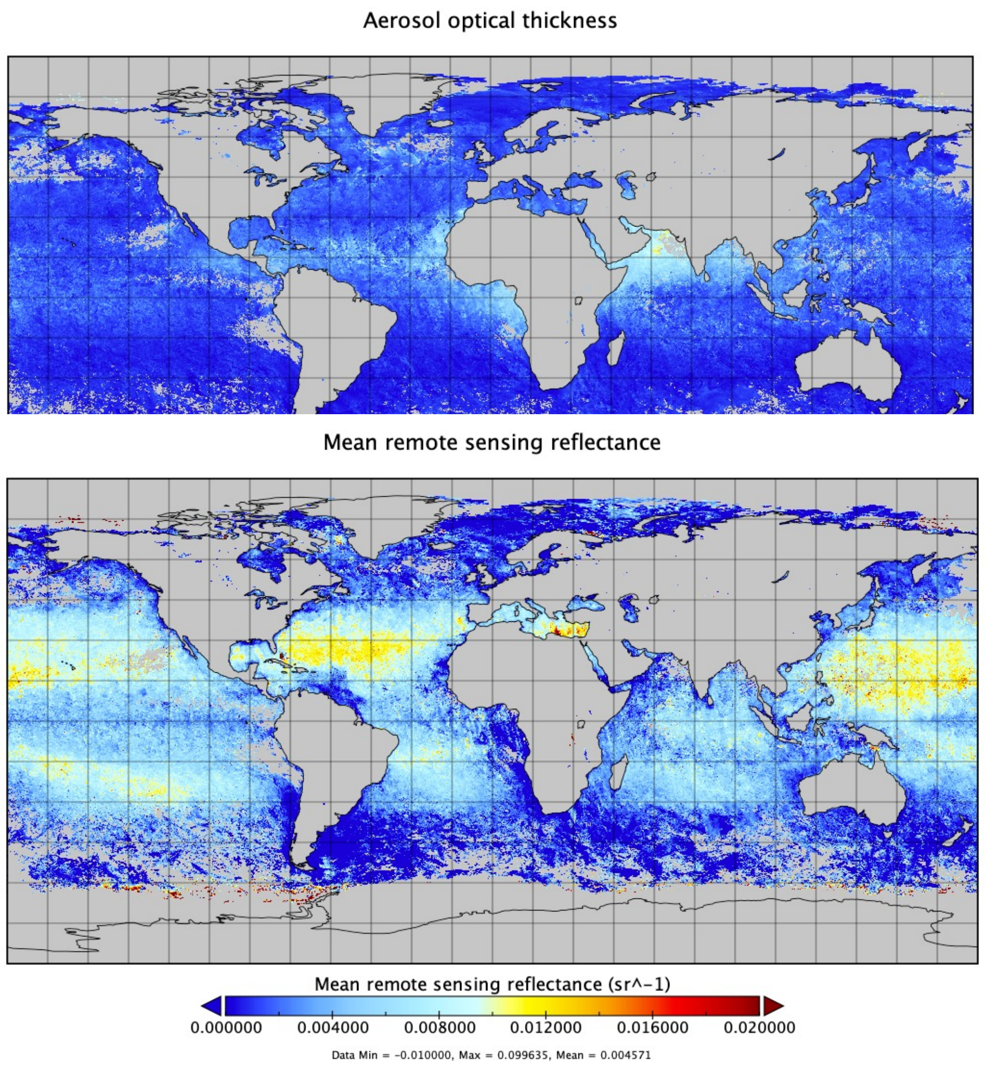
FastMAPOL data product status, access and tutorials

L2 data access(2024/09,2025/01, 2025/07 forward):
https://oceancolor.gsfc.nasa.gov/data/find-data/

L2 Data latency (1 day)
https://oceandata.sci.gsfc.nasa.gov/directdataaccess/Level-2/PACE-HARP2/2025/03-Sep-2025/

L3 data access (2025/07 forward, provisional):
https://oceandata.sci.gsfc.nasa.gov/l3/

Jupyter notebook tutorial (PACE Hackweek 2025)
https://pacehackweek.github.io/pace-2025/presentations/notebooks/harp2_l2_aerosol_product.html



PACE Radiative Transfer simulator

ORIGINAL RESEARCH article
Front. Remote Sens., 14 February 2022
Sec. Satellite Missions
Volume 3 - 2022 |
https://doi.org/10.3389/frsen.2022.840188

This article is part of the Research Topic
Polarization of Light as a Tool for Characterizing Different Facets of the Atmosphere-Ocean System
View all 9 Articles >

A Radiative Transfer Simulator for PACE: Theory and Applications

Peng-Wang Zhai[1]* Meng Gao[2,3] Bryan A. Franz[2] P. Jeremy Werdell[2] Amir Ibrahim[2] Yongxiang Hu[4] Jacek Chowdhary[5,6]

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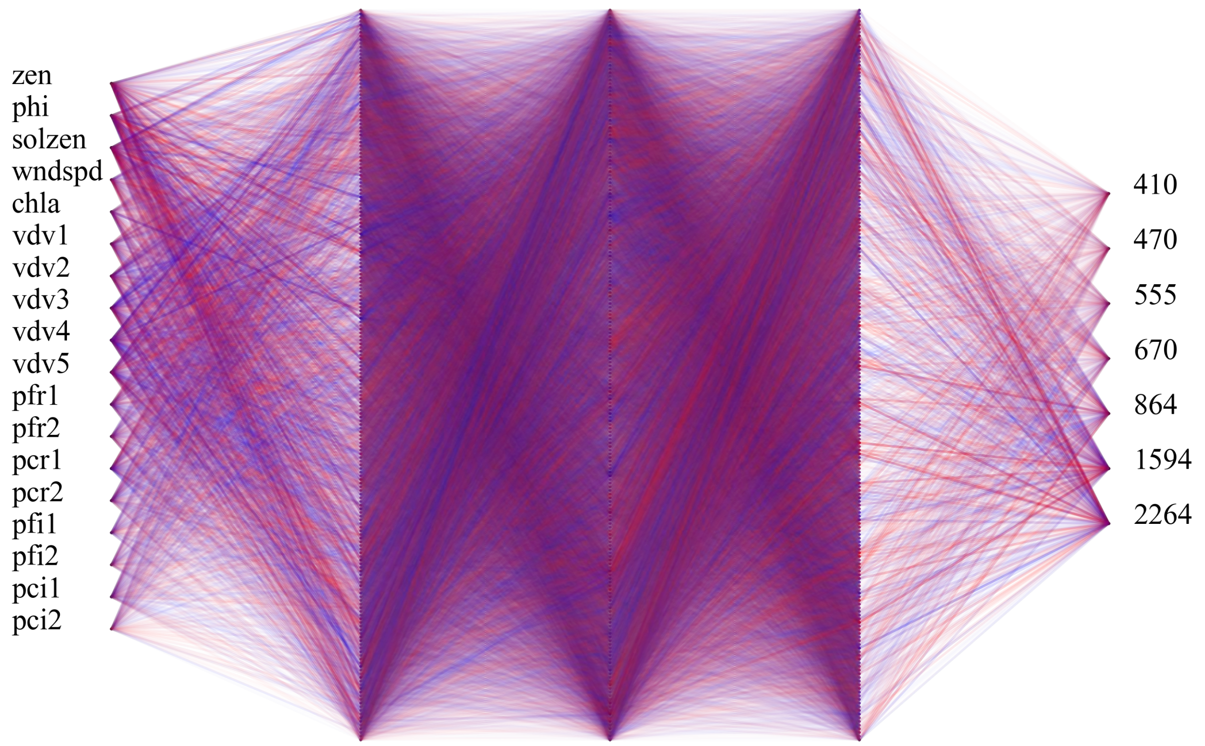
https://doi.org/10.3389/frsen.2022.840188

- **Vector radiative transfer model** based on the successive order of scattering (RTSOS) for all three PACE instruments.
- Accounts for **atmosphere and ocean/land coupling, spherical geometry, polarization, and gas absorption, inelastic scattering, etc**
- Provide theoretical foundation on data simulation, retrieval and uncertainty analysis for PACE.

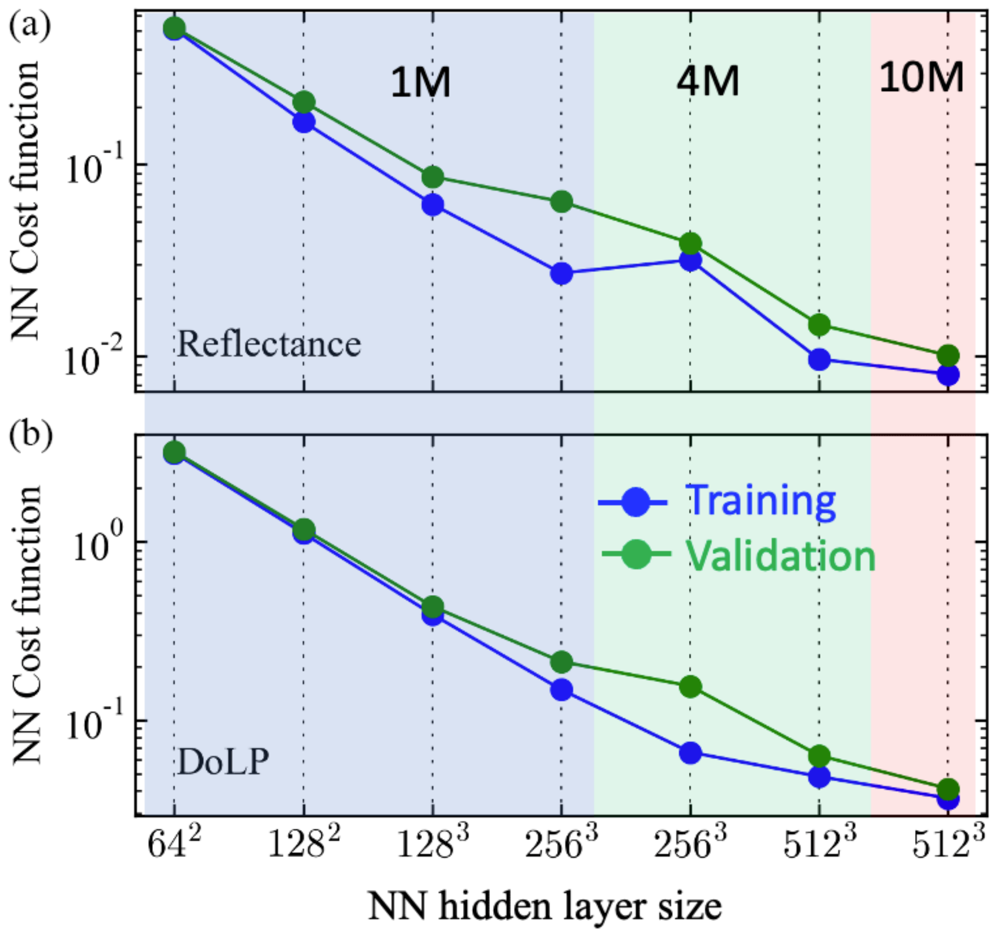
Zhai et al 2009-2010
Zhai et al 2022

Fast and accurate neural network RT emulator

To achieve high speed and high accuracy, radiative transfer model is trained into a NN emulator with high accuracy << measurement uncertainty



NN performance depends on NN complexity, training data size, etc



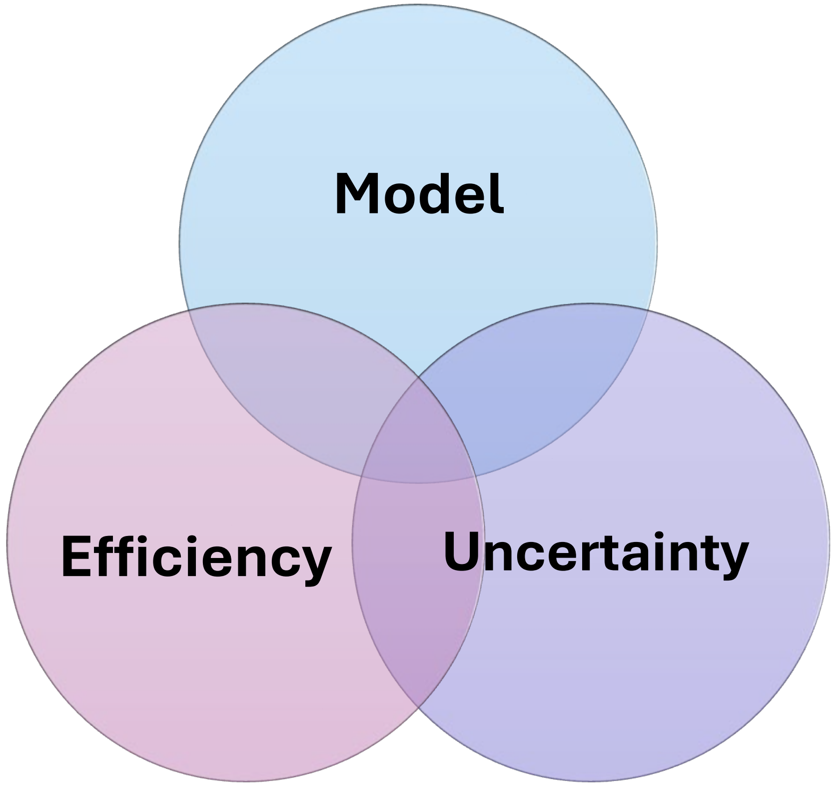
Gao et al AMT 2023

FastMAPOL: Fast PACE retrievals driven by NN models

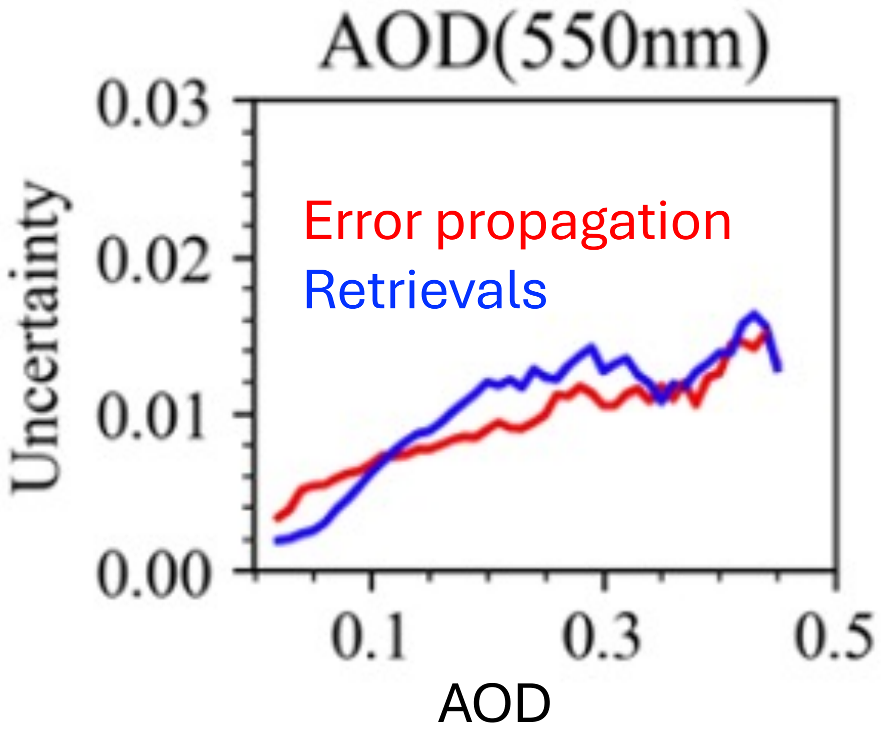
Model:
- Aerosol/Ocean model (Gao et al, 2017-2019)
- Complex aerosol/Coastal(Aryal et al, 2024)

Efficiency:
- Neural network: Gao et al, AMT 2021,2023
- Analytical Jacobians: Frontiers 2022
- Cascading NN for first guess: AMT 2023

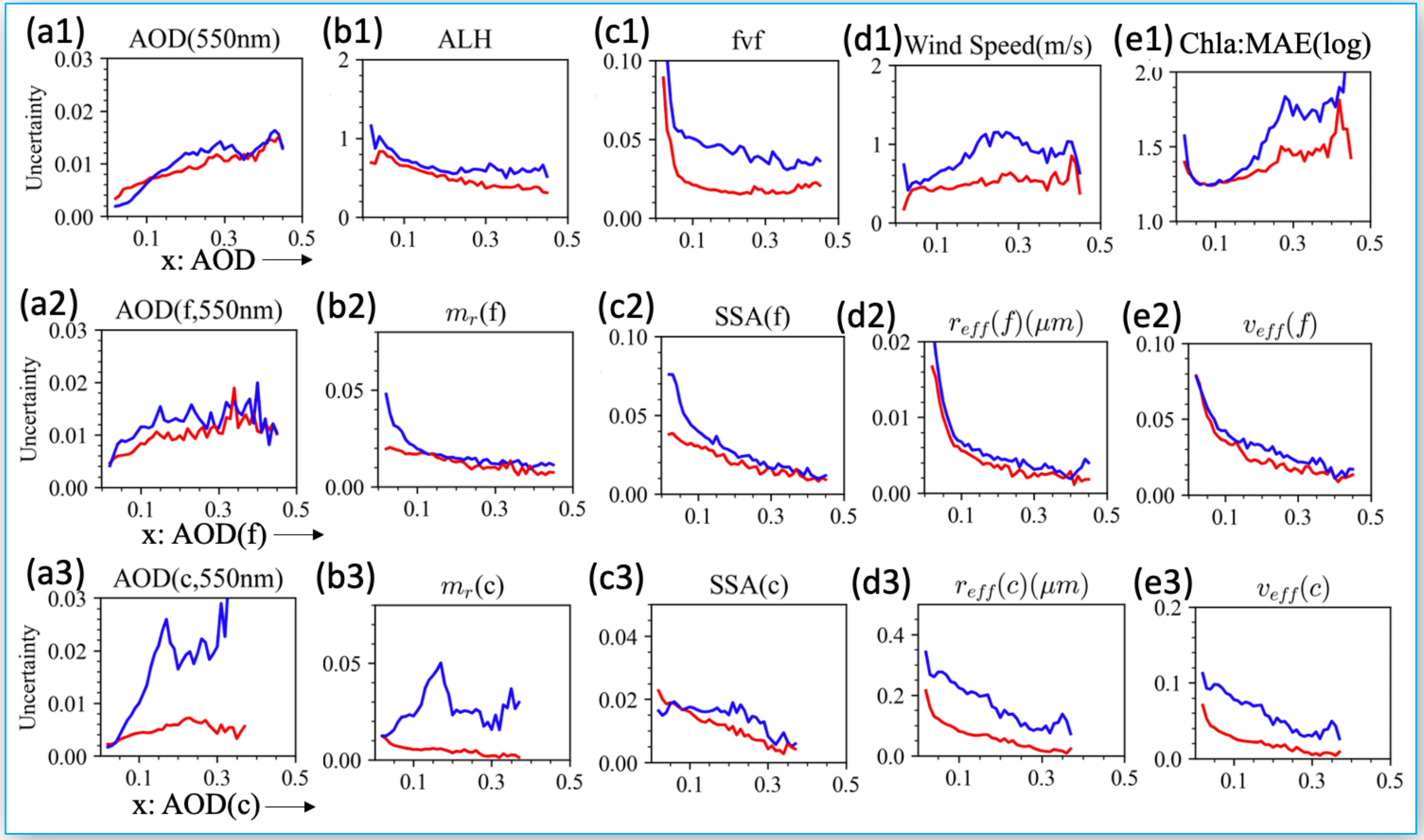
Uncertainty:
- Error propagation & Monte Carlo: AMT 2022
- Impacts of number of angles: Frontiers 2022
- Impacts of orbit geometry: AMT 2023
- Impact of noise correlation: AMT 2023



Uncertainty analysis from Day-In-The-Life test

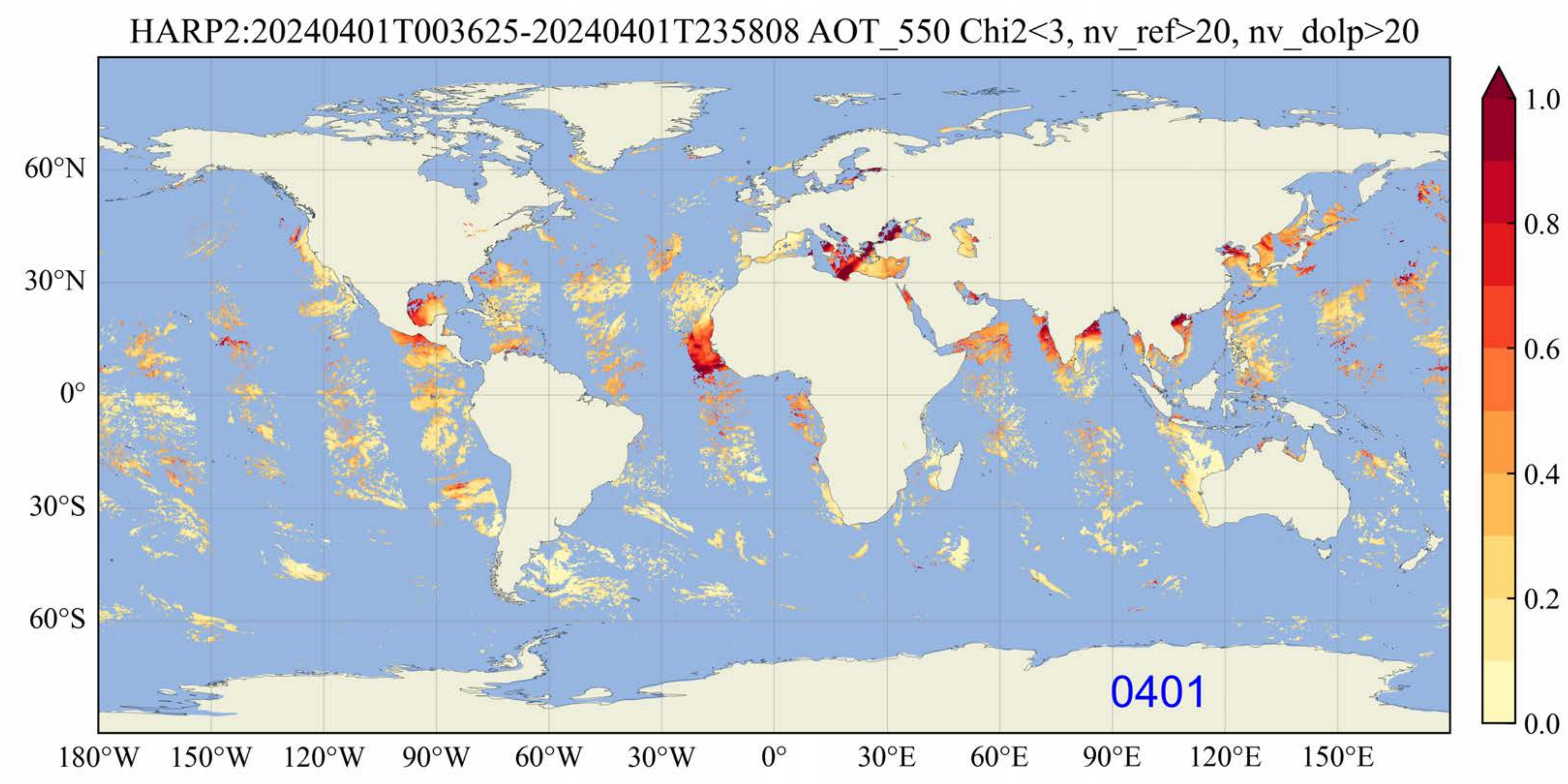


Realistic uncertainty evaluation for HARP2 L2 products based on global simulation using MERRA2 aerosol as inputs.



(Gao et al, 2023)

Aerosol optical and microphysical retrievals

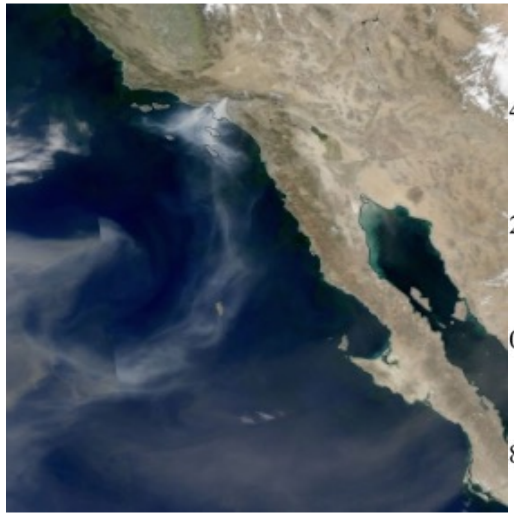


- Identify aerosol transport through the HARP2 wide swath measurements.
- Evaluate different aerosol types with various AOD, absorption, size etc

Aerosol optical and microphysical retrievals

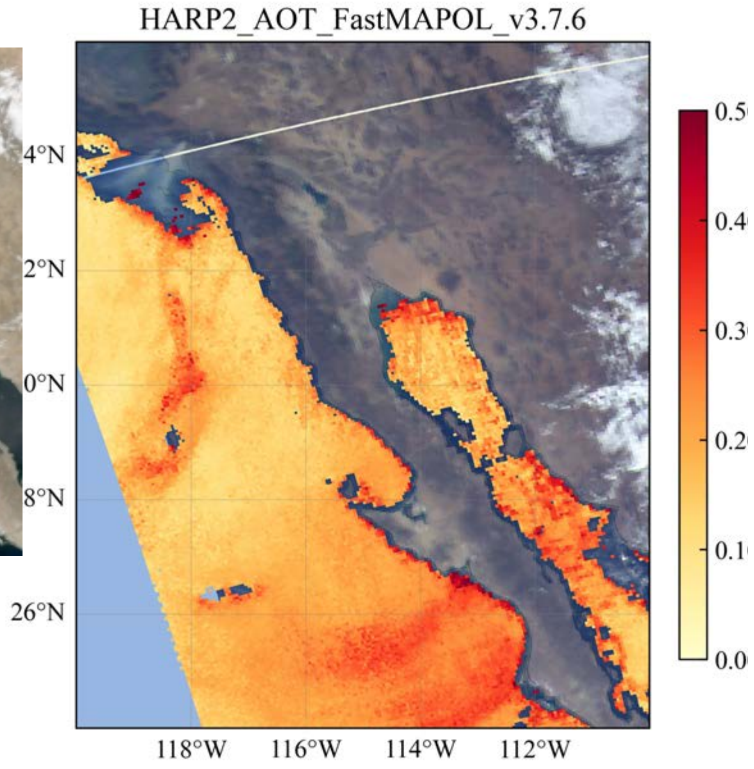
2025/01/09

RGB

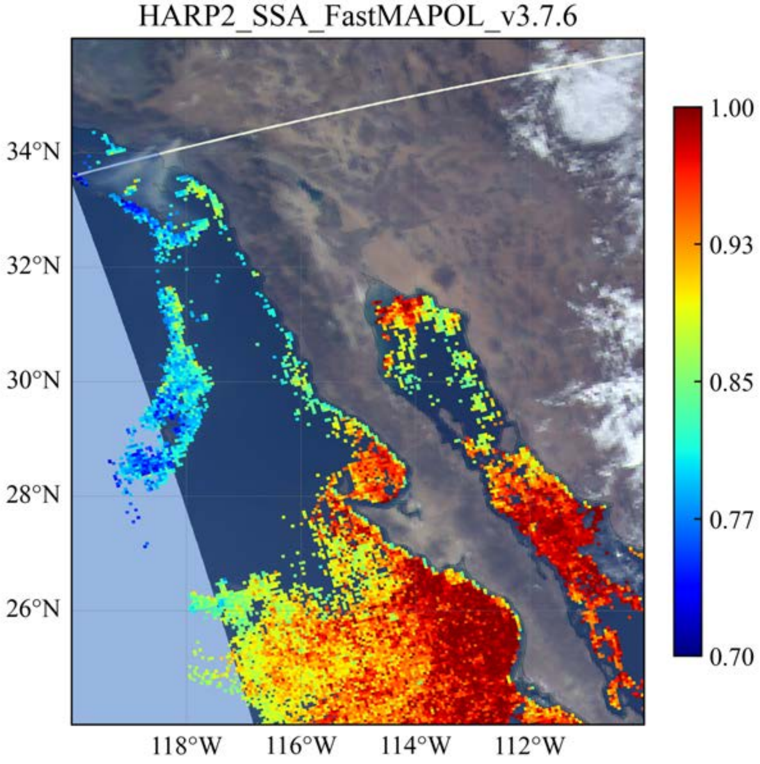


(2025/01/09)

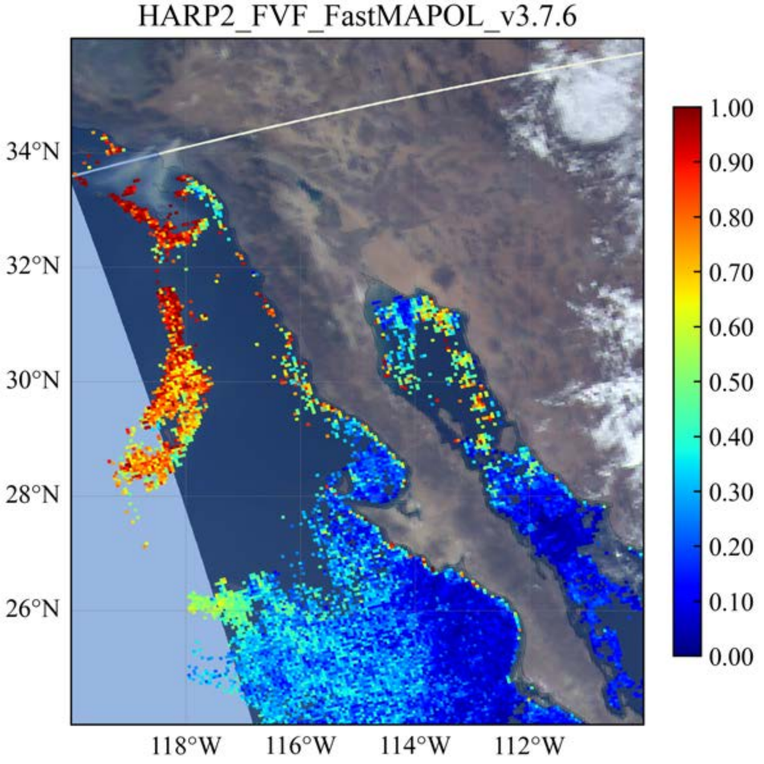
AOD



SSA



Fine mode fraction



See Jupyter notebook demonstration

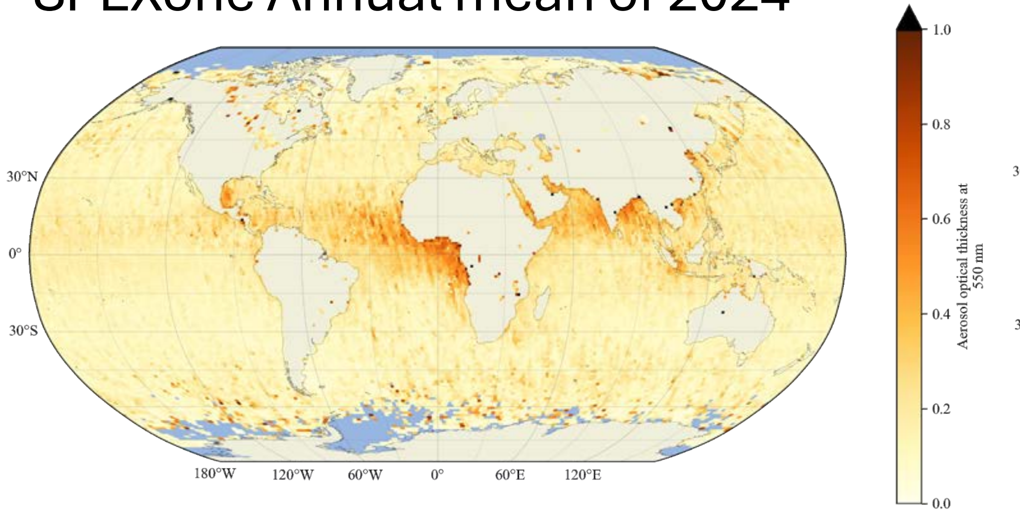
https://pacehackweek.github.io/pace-2025/presentations/notebooks/harp2_l2_aerosol_product.html

Joint aerosol and ocean color retrievals

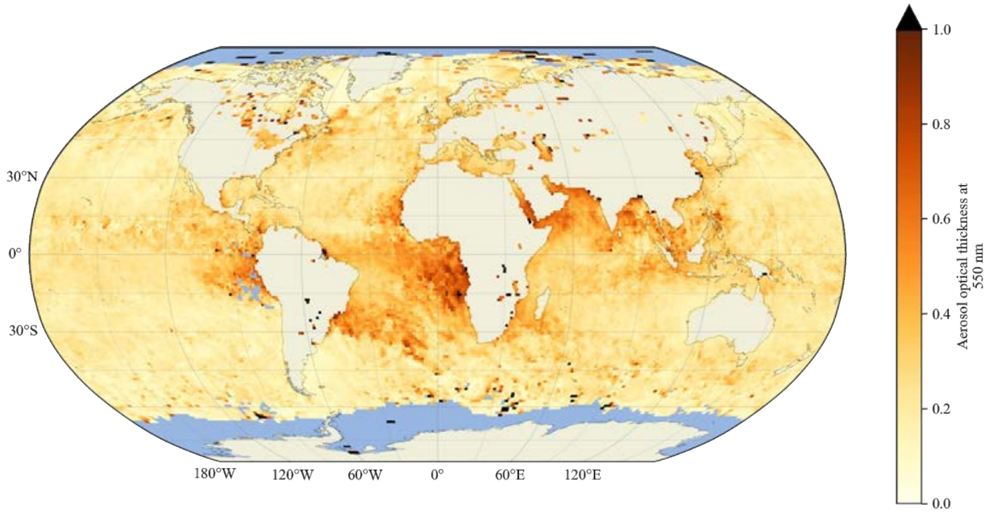
- **Angular Rrs are derived from multi-angle atmospheric correction.**
  - Rrs1: before BRDF correction
  - Rrs2: after BRDF correction
- Improve understanding of ocean color anisotropy and BRDF correction (Zhang et al 2025)

Aerosol optical depth (550nm)

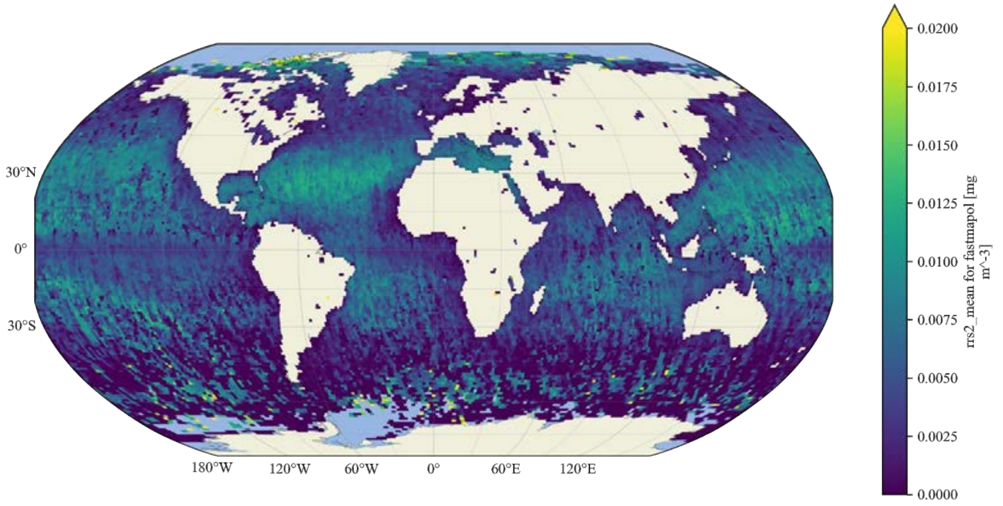
SPEXone Annual mean of 2024

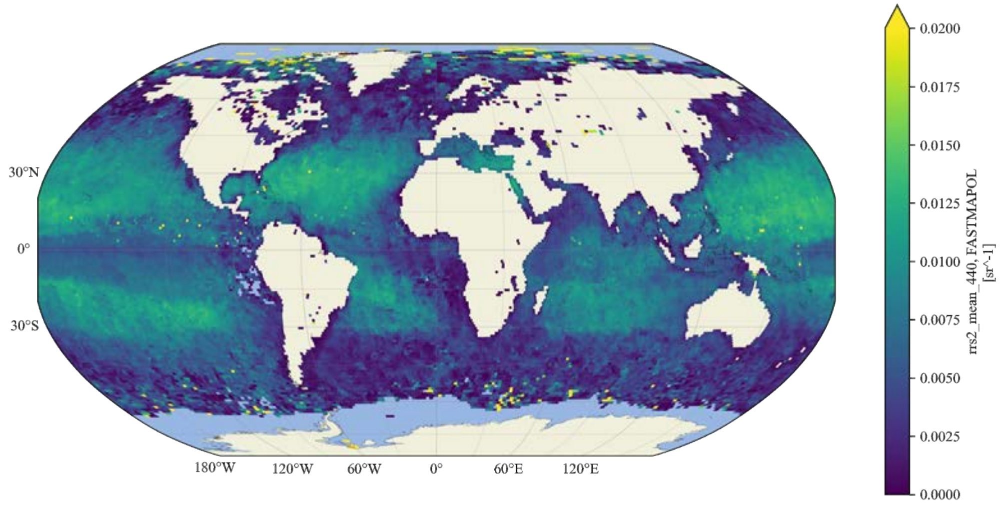


HARP2 Monthly mean of 2024/09



Multi-angle water leaving signal (Rrs2 440nm, angular mean)





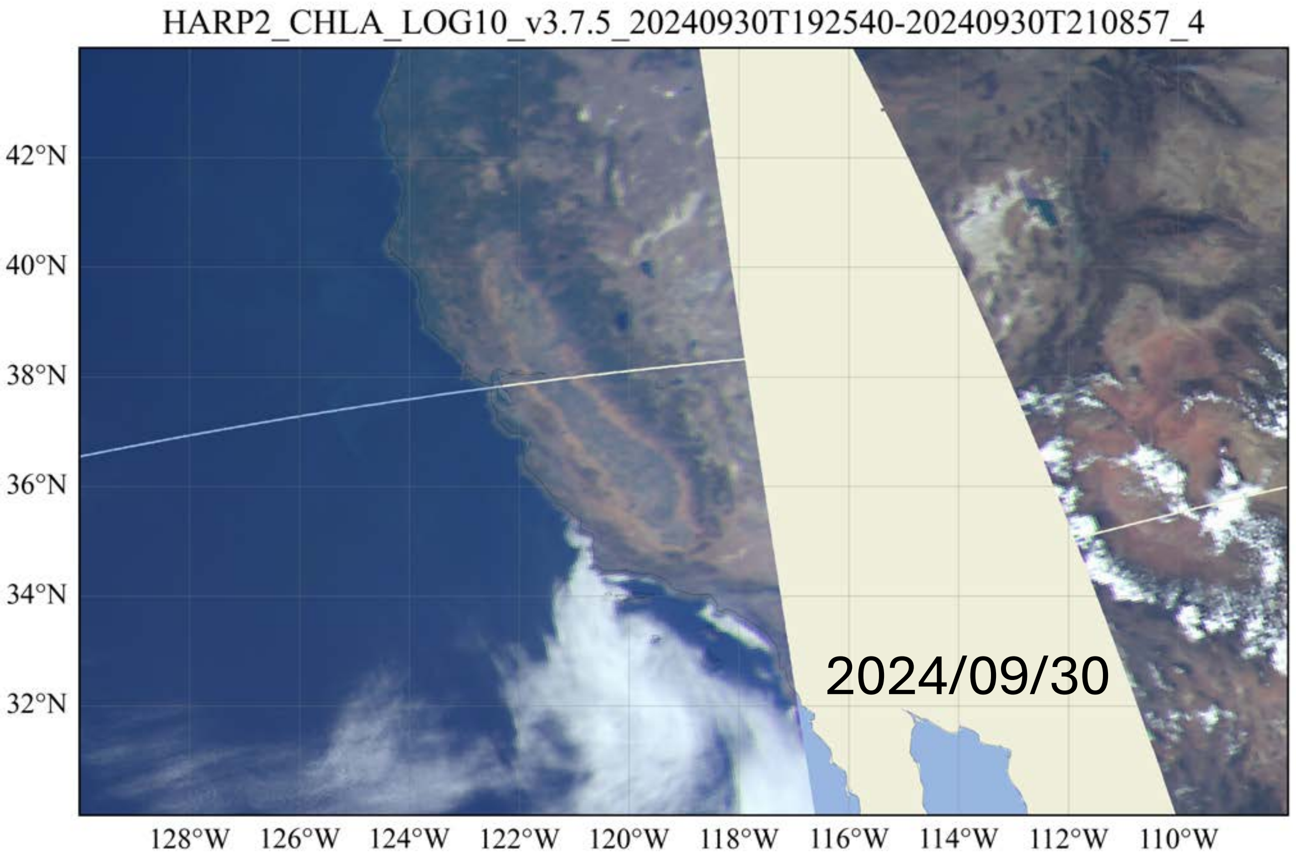
FastMAPOL data validation effort and plan

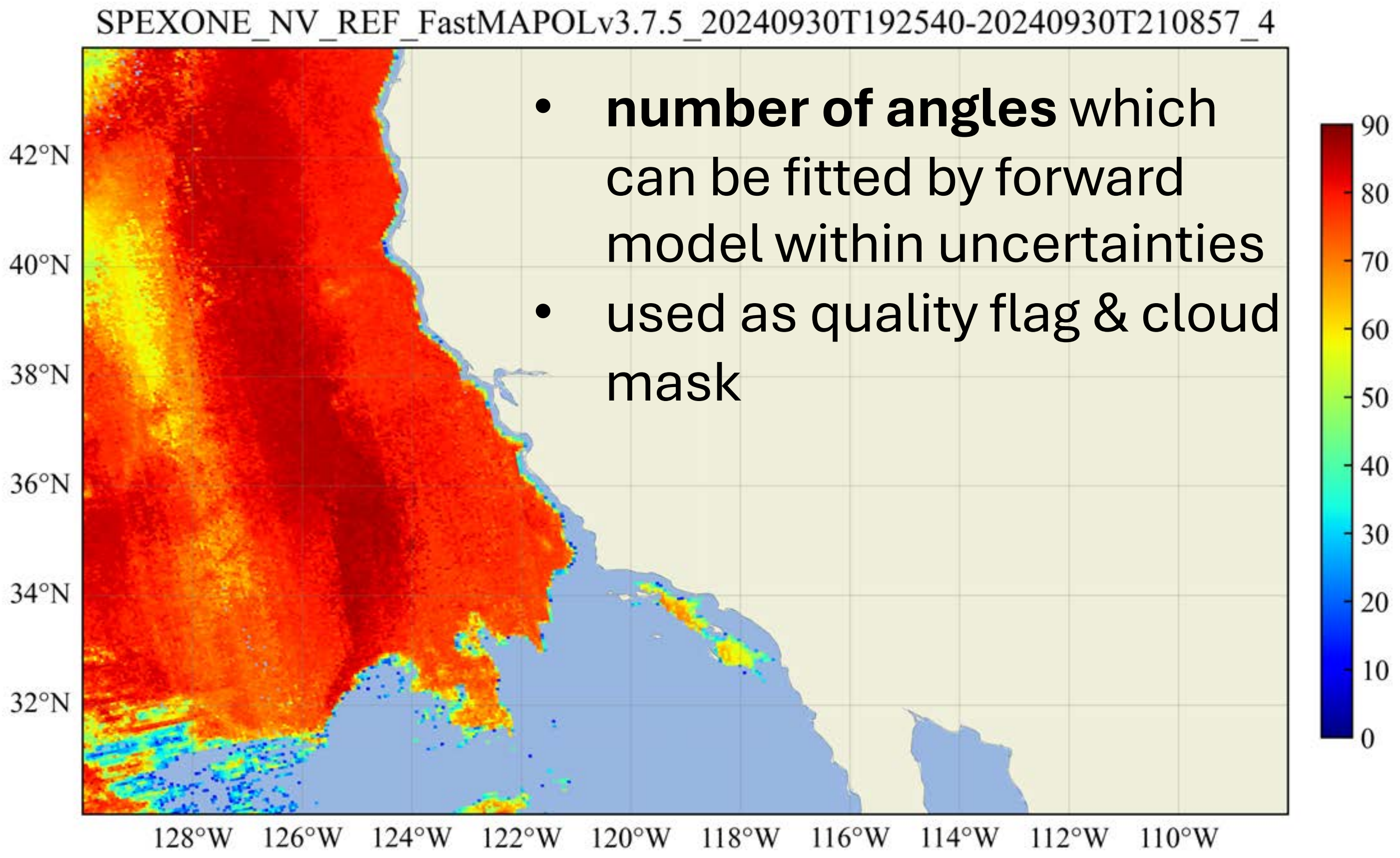
- L1 :
  - Compare between PACE instruments
  - **Compare with RT model (quality mask is part of L2 products)**
  - Compare with airborne instruments
- L2 :
  - **Compare with HSRL-2 (PACE-PAX), AERONET (OC)**
  - Compare between instruments and algorithms
- L3 :
  - **Evaluate pattern and magnitude**
  - Compare with other satellite (Earth Care, 3MI, etc)
  - Compare with global models (GEOS,etc)

PACE-PAX

Compare with RT model : fitting performance on HARP2

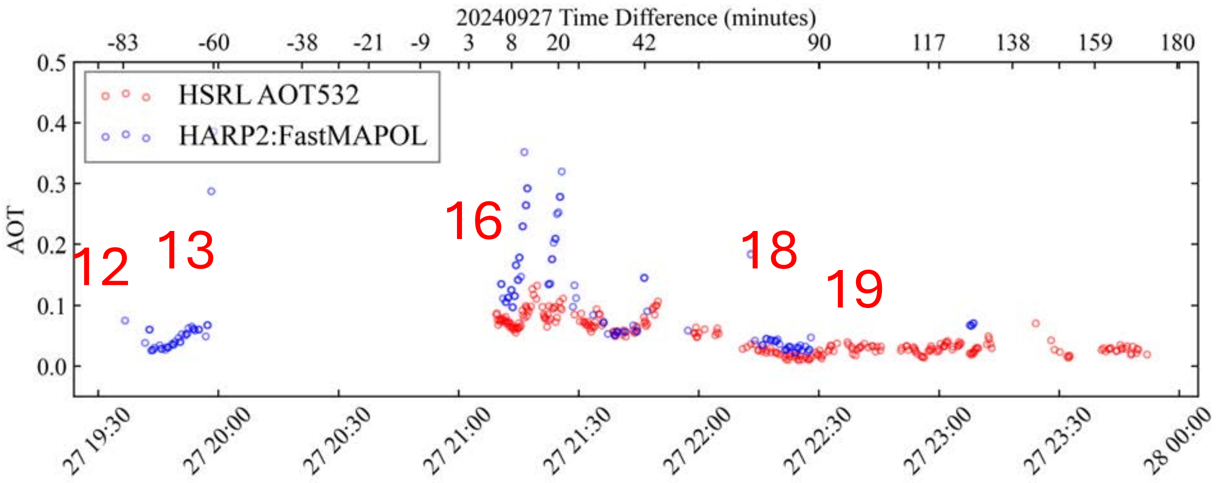
- Forward model fitting is better with reflectance than polarization(nv_ref & nv_dolp).
- Fitting performance depend on view angles (mask_ref & mask_dolp).

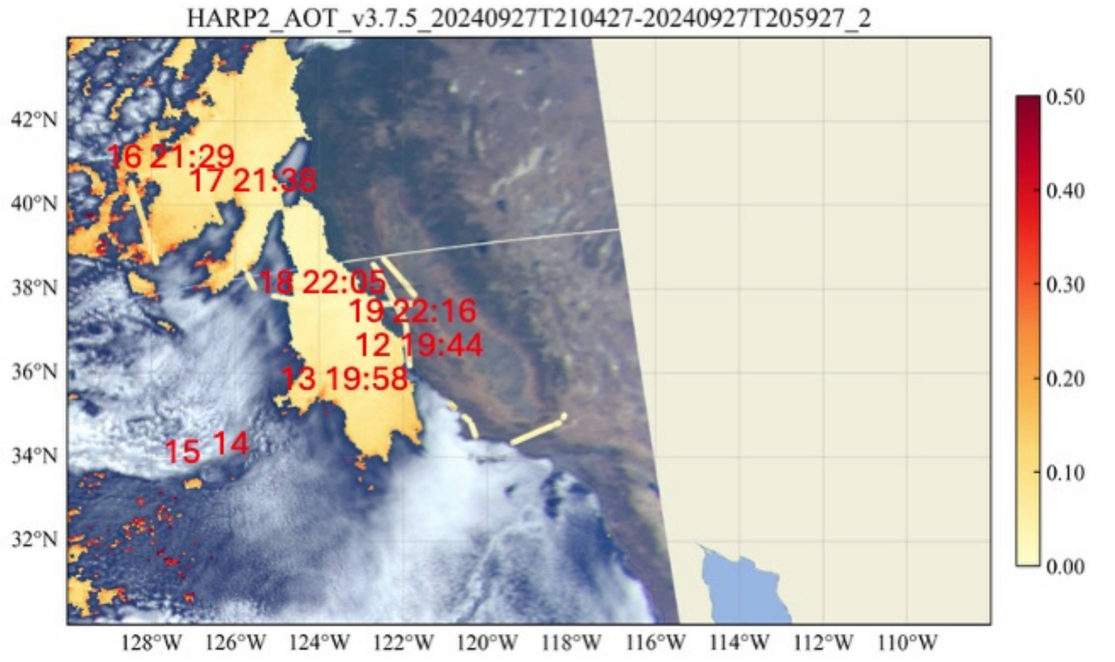


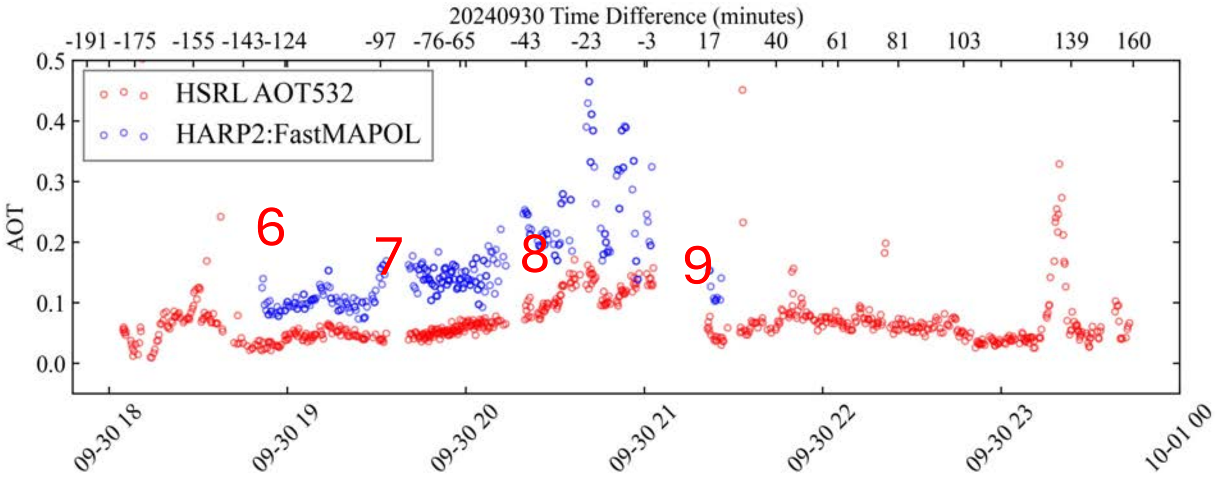


Validation with HSRL-2/PACE-PAX: Prelim results

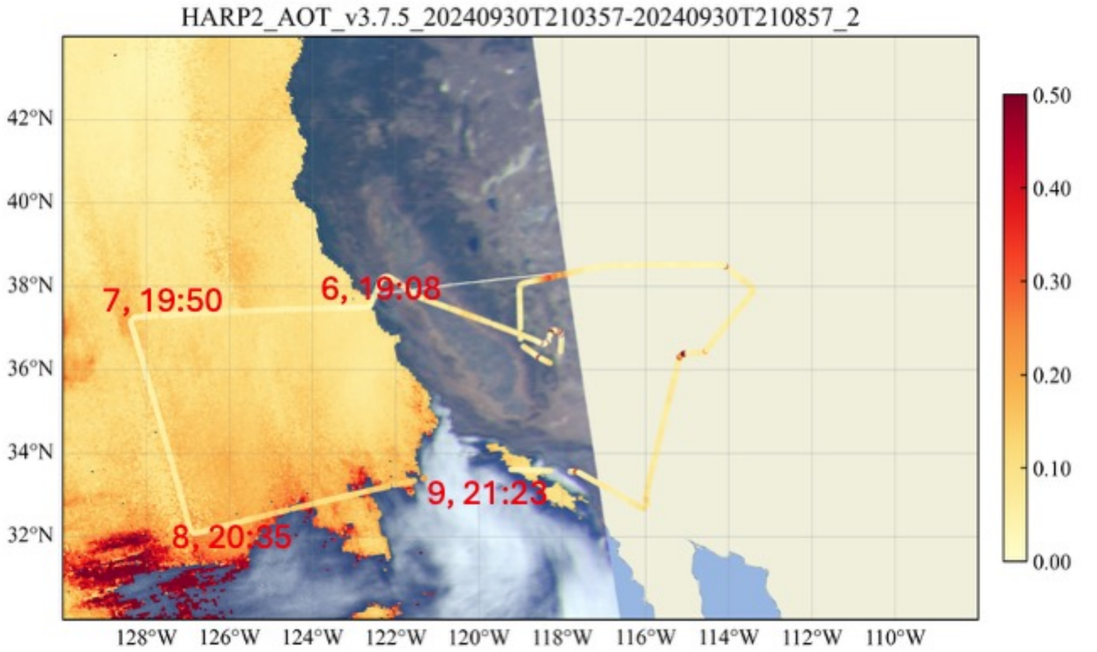
- PACE-PAX campaign provides great opportunity to validate products from polarimetric algorithms.
- Overall patten seems agree with HSRL-2/PACE-PAX.





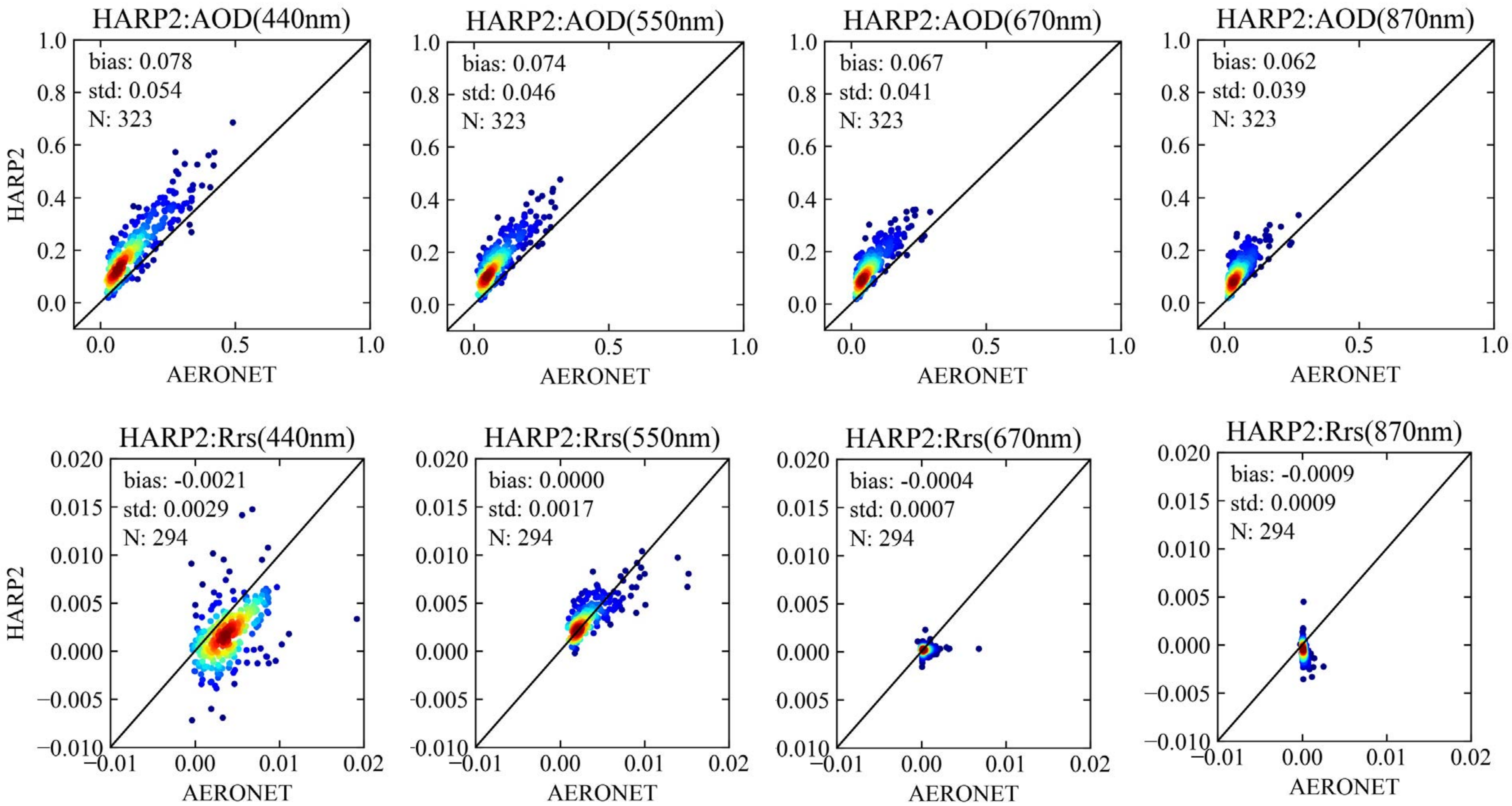


bias may be due to impact of high wind speed over sunglint etc



Validate atmosphere and ocean products together: HARP2

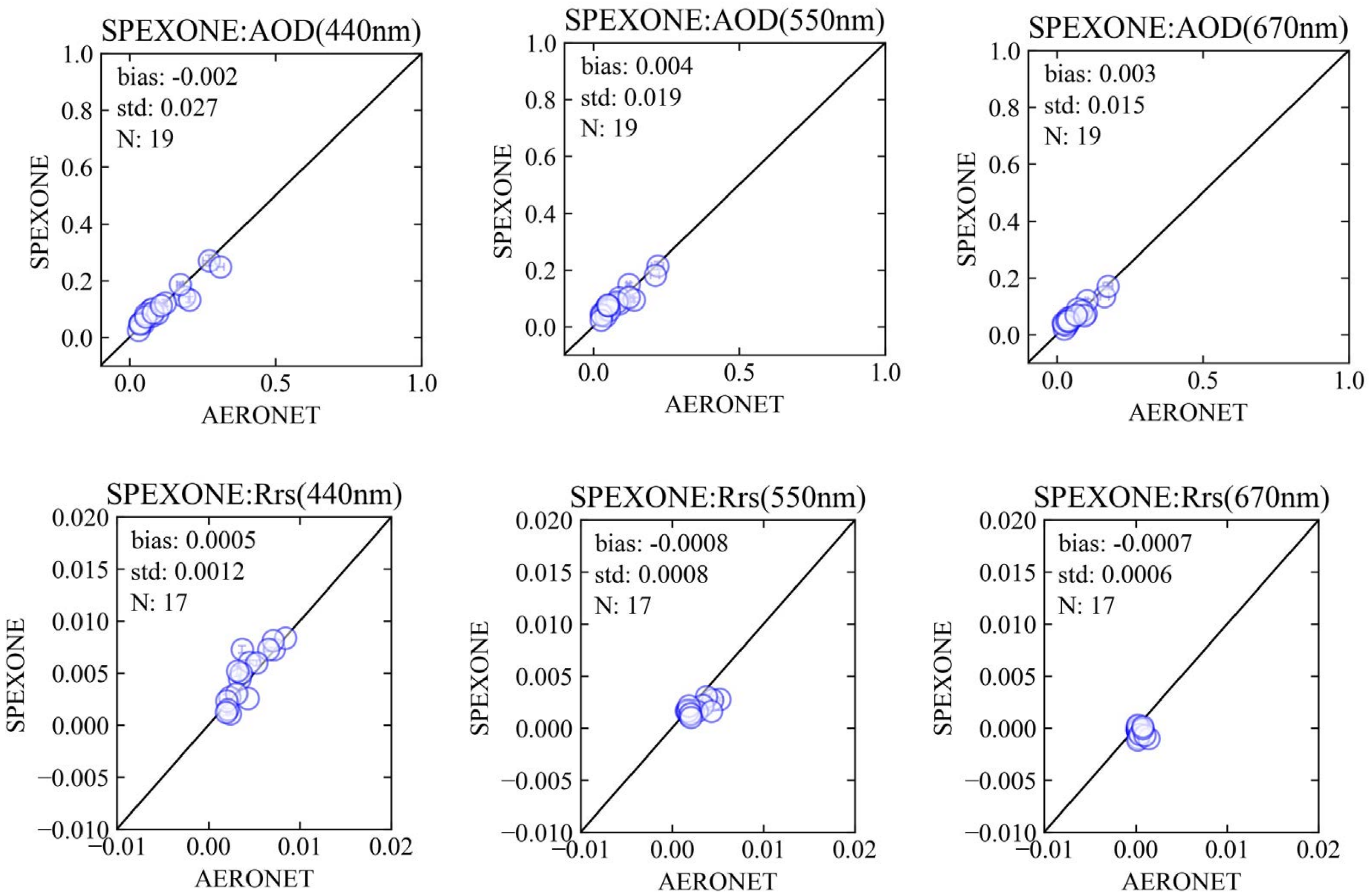
Validation with AERONET OC sites (thank to supports from SeaBASS team, James, Inia, Chris)



Biases under investigation: **calibration, model assumption**, etc

Validate atmosphere and ocean products together: SPEXone

Validation with AERONET OC sites (thank to supports from SeaBASS team, James, Inia, Chris)



PACE provides synergistic products from **different algorithms**, and **different instruments**, which can help evaluate measurement validation, and retrieval model assumptions.

FastMAPOL data product status, access and tutorials

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https://oceancolor.gsfc.nasa.gov/data/find-data/

L2 Data latency (1 day)
https://oceandata.sci.gsfc.nasa.gov/directdataaccess/Level-2/PACE-HARP2/2025/03-Sep-2025/

L3 data access (2025/07 forward, provisional):
https://oceandata.sci.gsfc.nasa.gov/l3/

Jupyter notebook tutorial (PACE Hackweek 2025)
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