Overview of the NASA Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission

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2021 2030 United Nations Decade of Ocean Science for Sustainable Development

GODDARD EARTH SCIENCES

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

PACE will extend **key systematic ocean color, aerosol, & cloud (& land) climate data records**.

PACE will reveal the **diversity of organisms fueling marine food webs** & how ecosystems respond to change.

Looking at the ocean, clouds, land & aerosols together will improve knowledge of the roles each plays in our planet.

Key characteristics:

- *Launched 8 February 2024*
- 3 year design life; 10+ years of propellant
- 676.5 km altitude
- Polar, ascending, 98° inclination
- Sun synchronous, 13:00 Equatorial crossing time
- Managed by NASA Goddard Space Flight Center

Legacies:

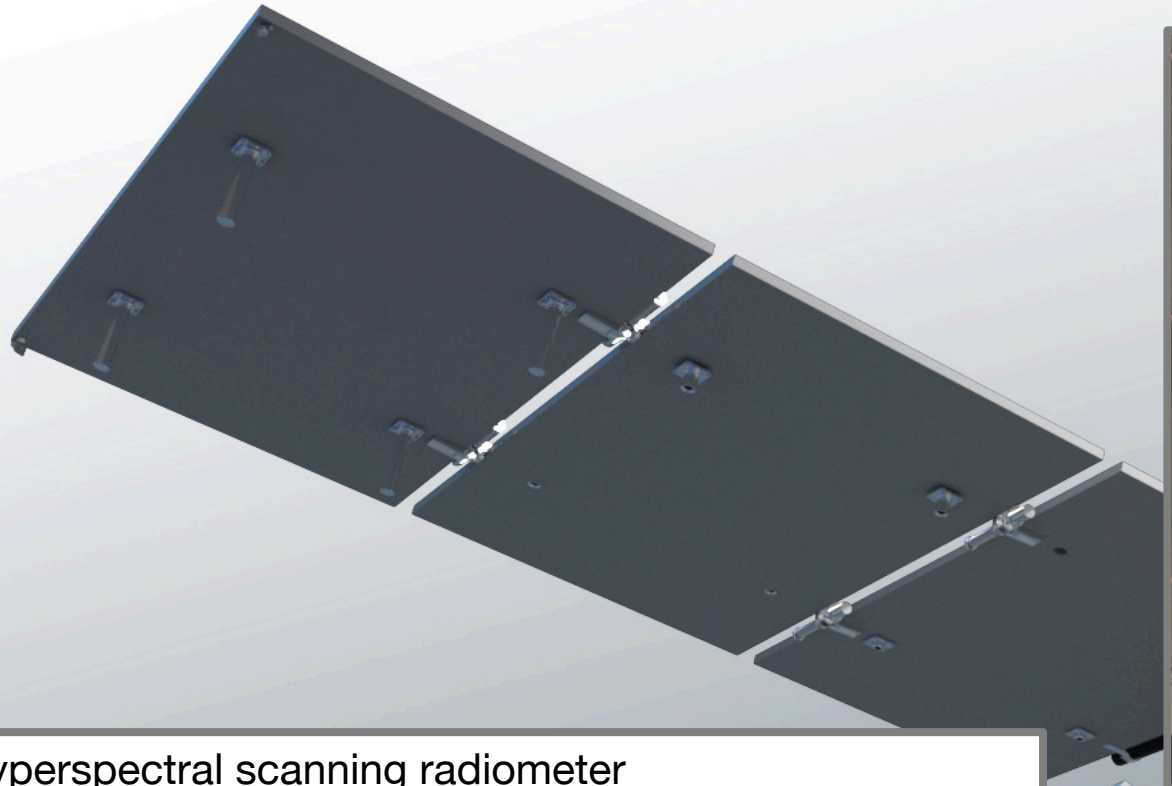
- CZCS, SeaWiFS, MODIS, VIIRS
- MISR, POLDER

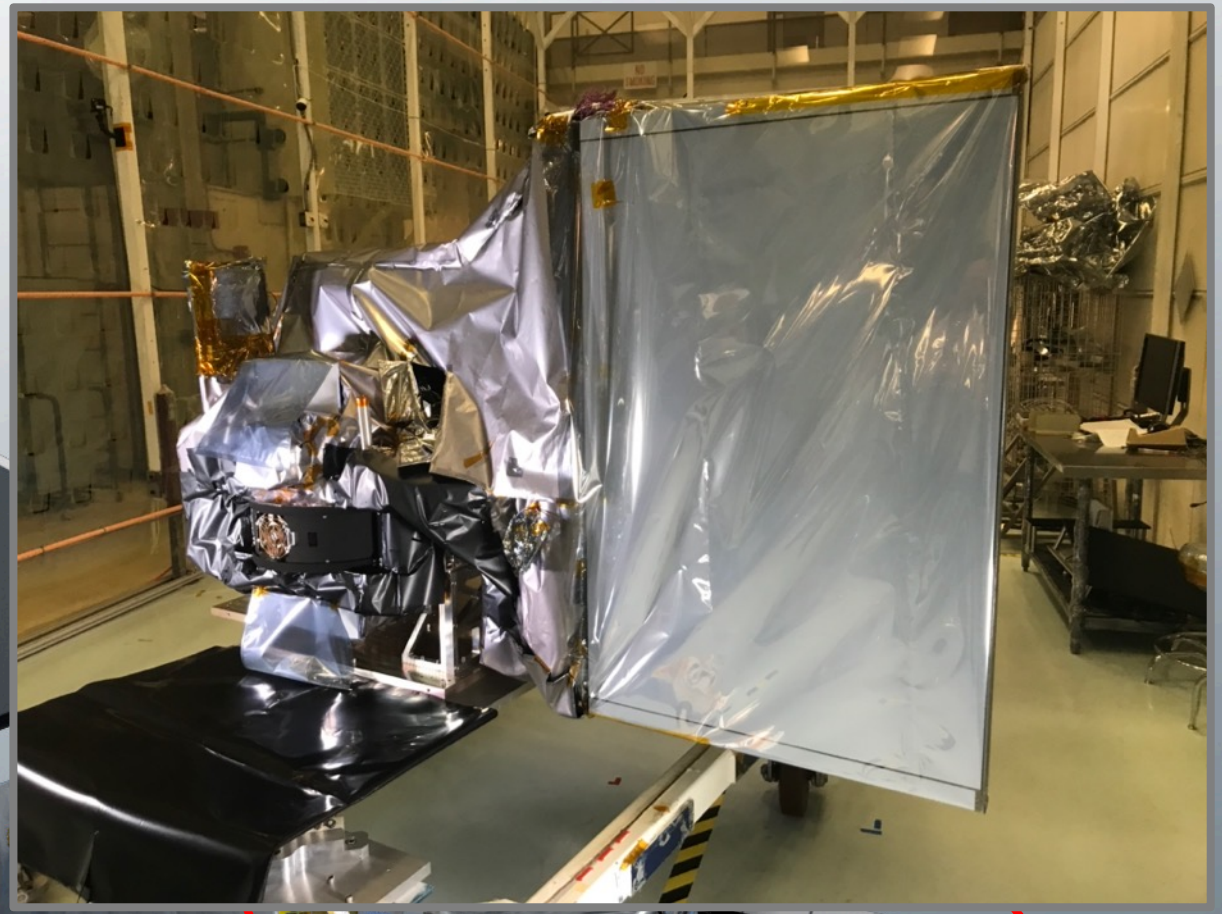
The PACE Ocean Color Instrument (OCI):

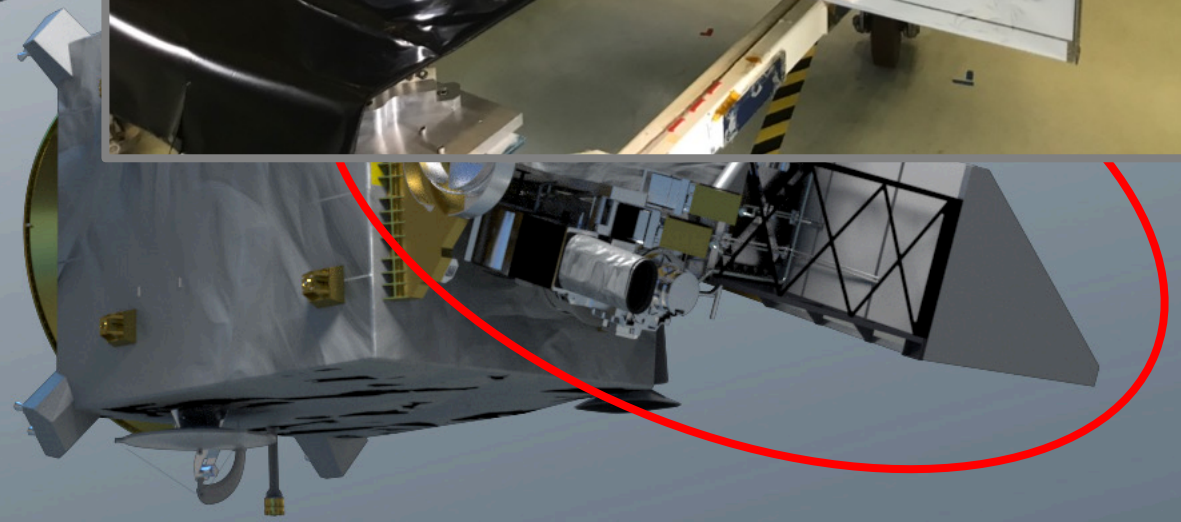
- 315-890 nm @ 5 nm resolution in 1.25/2.5 nm spectral steps
- Plus 940, 1038, 1250, 1378, 1615, 2130, & 2250 nm
- 2-day global coverage; 1.2-km^2 @ nadir; ±20° fore/aft tilt
- *Performance driven by ocean color science requirements*

2 contributed multi-angle polarimeters:

- **HARP-2 (UMBC)**
  4 visible-NIR bands
  Wide swath; 2.5 km @ nadir
  Hyper-angular
  Cloud capabilities beyond OCI
- **SPEXone (SRON/Airbus)**
  Hyperspectral UV-NIR
  Narrow swath; 3 km @ nadir
  5 angles
  Aerosol capabilities beyond OCI







- hyperspectral scanning radiometer
- (315) 340 – 890 nm, 5 nm resolution, 2.5 nm steps+
- plus, 940, 1038, 1250, 1378, 1615, 2130, and 2250 nm
- *single science pixel to mitigate image striping*
- 1 – 2 day global coverage
- ground pixel size of 1.2 km^2 at nadir
- ± 20° fore/aft tilt to avoid Sun glint
- twice monthly lunar calibration
- daily on-board solar calibration
- <0.5% total system error for VIS-NIR
- SNRs optimized for ocean color science
- simulated top-of-atmosphere data available

+ with 1.25 nm steps in several spectral regions

* developed primarily for mechanical processing assessments

learn more about OCI

OCI functional requirements: https://pace.oceansciences.org/requirements.htm

OCI papers: https://pace.oceansciences.org/oci.htm

OCI prelaunch characterizations: https://oceancolor.gsfc.nasa.gov/data/pace/characterization/

OCI reprocessing history and release notes: https://oceancolor.gsfc.nasa.gov/data/reprocessing/

useful NASA Technical Memoranda: https://pace.oceansciences.org/documents.htm?id=memo

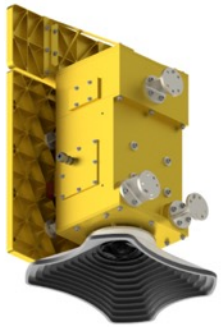
the PACE polarimeters

- Excellent for cloud droplet size and ice particle shape/roughness retrievals
- Provides cloud capabilities beyond those required of OCI
- Wide swath matches OCI, offering potentially improved atmospheric correction

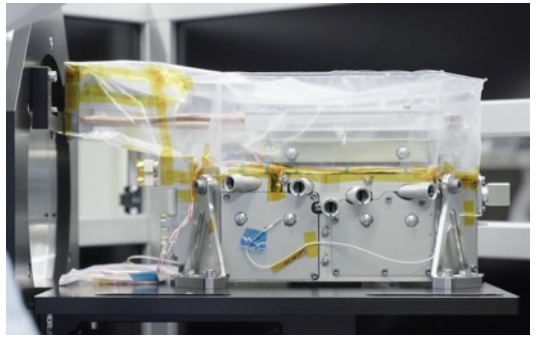
	HARP-2	SPEXone
UV-NIR range	440, 550, 670, 870 nm	Continuous from 385-770 nm in 5 nm steps
SWIR range	None	None
Polarized bands	All	Continuous from 385-770 nm in 15-45 nm steps
Number of viewing angles [degrees]	10 for 440, 550, 870 nm; 60 for 670 nm [spaced over 114°]	5 [-57°, -20°, 0°, 20°, 57°]
Swath width	±47° [1556 km at nadir]	±4.5° [106 km at nadir]
Global coverage	2 days	30+ days
Ground pixel	3 km	2.5 km
Heritage	AirHARP, Cubesat	AirSPEX

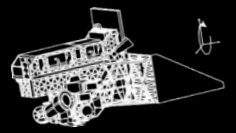
- Excellent for aerosol characterization
- Addresses aerosol climate objectives beyond those required of OCI

UMBC Hyper Angular Rainbow Polarimeter (HARP-2)



SRON/Airbus Spectro-polarimeter for Planetary Exploration (SPEXone)





OCI
315-890 nm in 2.5 nm steps
7 discrete SWIR: 940-2260 nm
1-2 day coverage; ±20° tilt; 1.2km

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

PACE fills niches not currently addressed at home or abroad

Moving from multi- to hyper-spectral radiometry is essential for observing aquatic systems

No current or planned hyper-spectral radiometer provides **1-2 day global** coverage

UV & two 2-μm bands realize atmospheric improvements over heritage instruments

Multi-angle polarimetry adds dimensions of information (as well as provides a pathfinder)

Tilt is essential for capturing marine system dynamics

PACE data products

data products list: https://pace.oceansciences.org/data_table.htm

What do colors in the "Availability" column mean?

Available	Coming soon!	Currently implementing and evaluating	No approach currently identified

Calibrated Radiometry and Polarimetry

Calibrated and geolocated radiometry and polarimetry as observed at sensor.

Product	L2 Suite	Description and Use	Units	Availability	Status	Additional Info
Spectral top-of-atmosphere radiances from OCI	*N/A*	Spectral radiance observed at the top of the atmosphere.	$W\ m^{-2}\ um^{-1}\ sr^{-1}$	Level-1B 1-km at nadir; daily - Level-1C; daily	Provisional	Level-1C draft data format and examples
Spectral top-of-atmosphere radiances and polarimetry from SPEXone	*N/A*	Spectral radiance and polarimetry observed at the top of the atmosphere, for all sensor viewing angles.	Various	Level-1B TBD; daily - Level-1C; daily	Provisional	Level-1C draft data format and examples
Spectral top-of-atmosphere radiances and polarimetry from HARP2	*N/A*	Spectral radiance and polarimetry observed at the top of the atmosphere, for all sensor viewing angles.	Various	Level-1B TBD; daily - Level-1C; daily	Provisional	Level-1C draft data format and examples

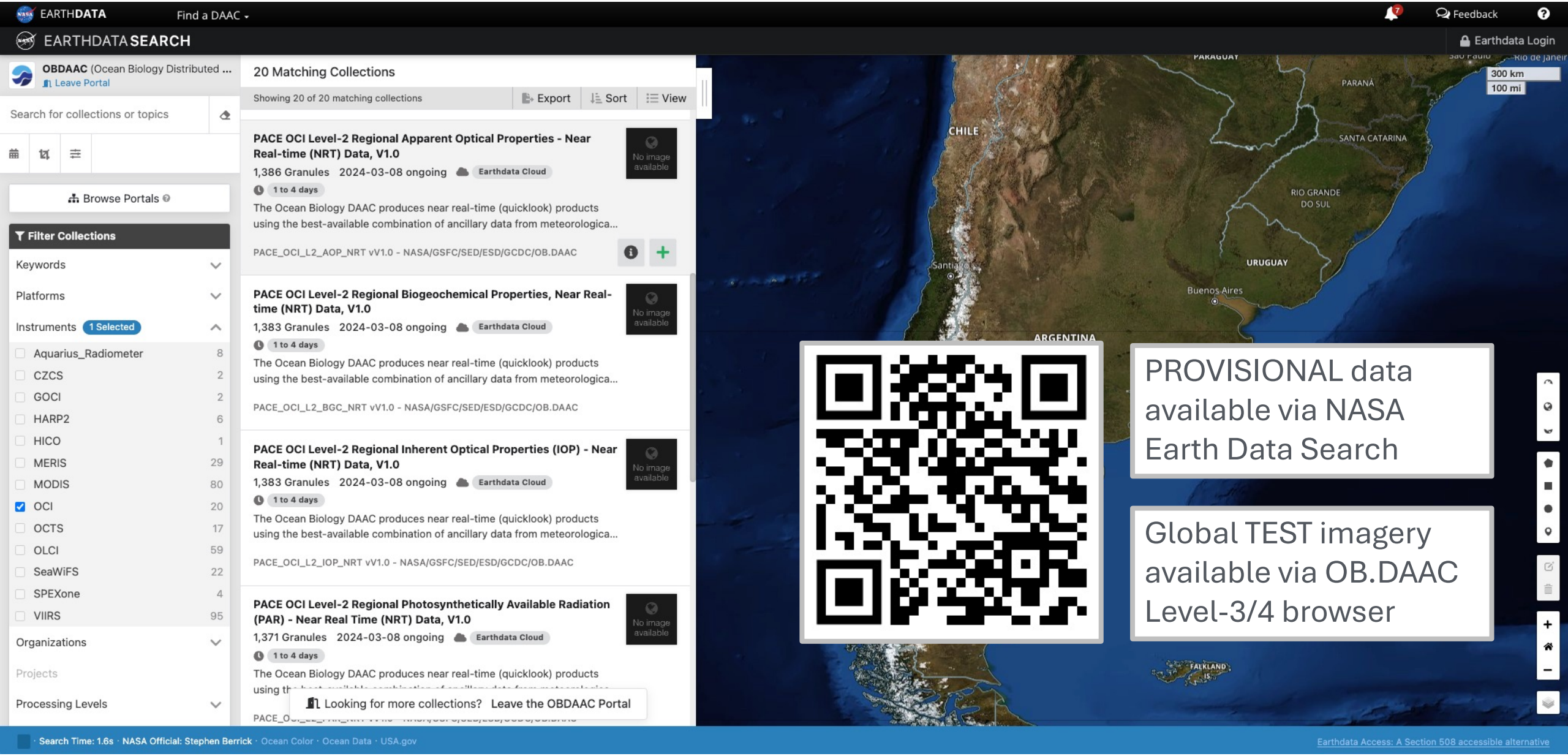
Ocean Properties to be Produced by OCI

Bio-optical and biogeochemical properties of seawater constituents in the sunlit upper ocean.

Product	L2 Suite	Description and Use	Units	Availability	Status	Additional Info
Spectral remote sensing reflectances	OC_AOP	Spectral color of the ocean in the ultraviolet-to-near infrared spectral range. Used as input into algorithms to retrieve information about colored dissolved organic matter, phytoplankton, non-algal particles, and other aquatic constituents. Provided in continuous 2.5-nm steps from 350 to 717.5-nm with a resolution (bandwidth) of 5-nm.	sr^{-1}	Level-2 1-km at nadir; daily - Level-3 4-km; daily, 8-day, monthly, annual	Provisional	ATBD SAT members: Boss, Zhai, Krotkov, Chowdhary, Stamnes, Zhang In situ measurement protocols

Algorithm Theoretical Basis Documents: https://oceancolor.gsfc.nasa.gov/resources/atbd/

PACE data access



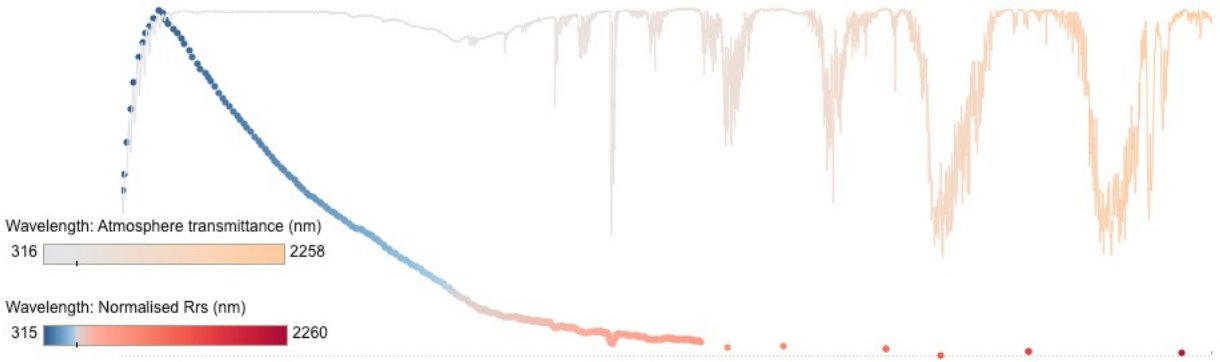
“ what you should know about PACE data”

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

Known data issues

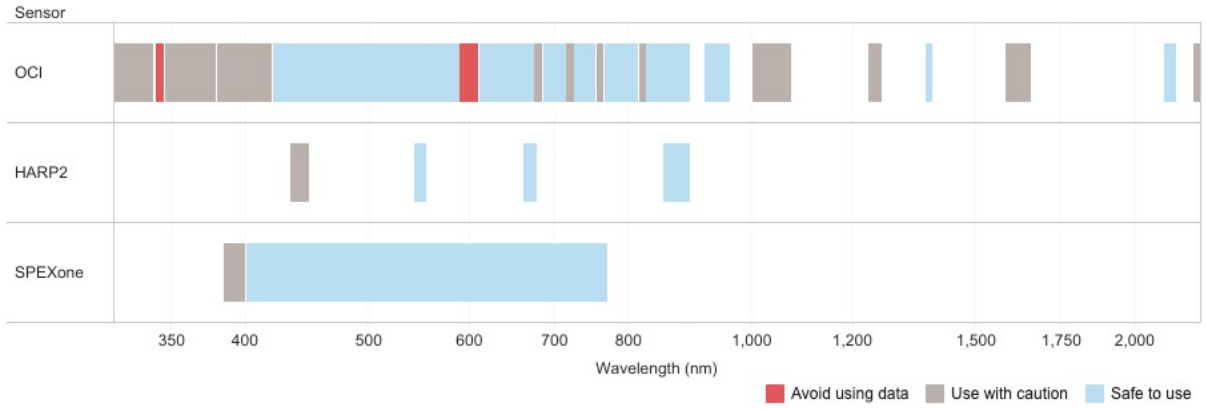
PACE is already providing high-quality data. However, some issues have to be noted before using it. Some particular bands, influenced by instrument or atmospheric characteristics, should be avoided for the moment.
Other issues affect the entire dataset, and some events affect data availability. See below for details.

Reference spectra (for indicative purposes)



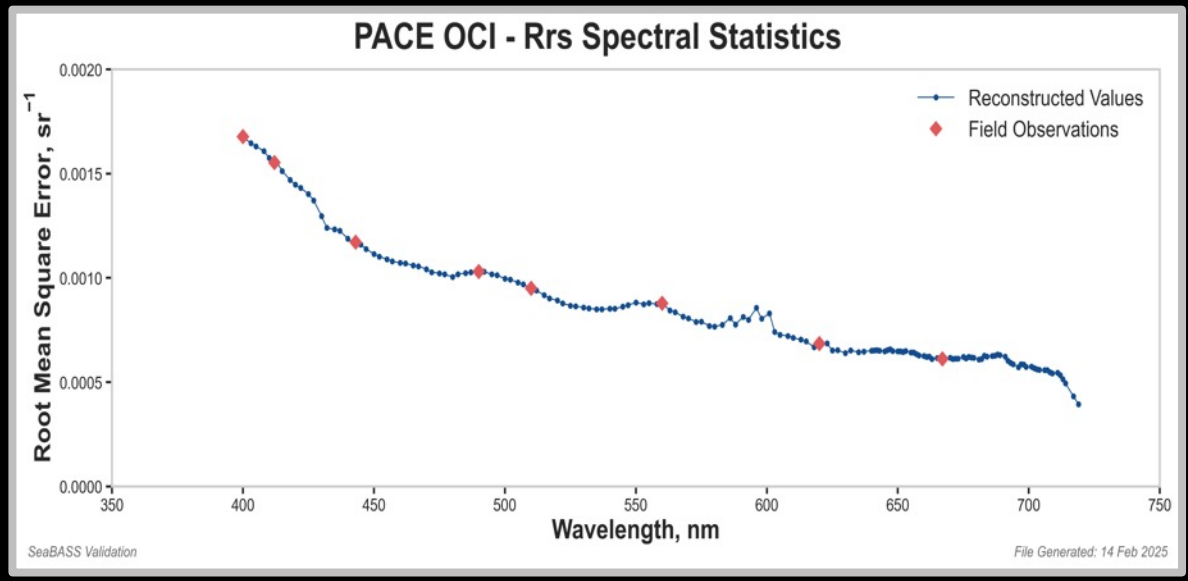
Problematic bands

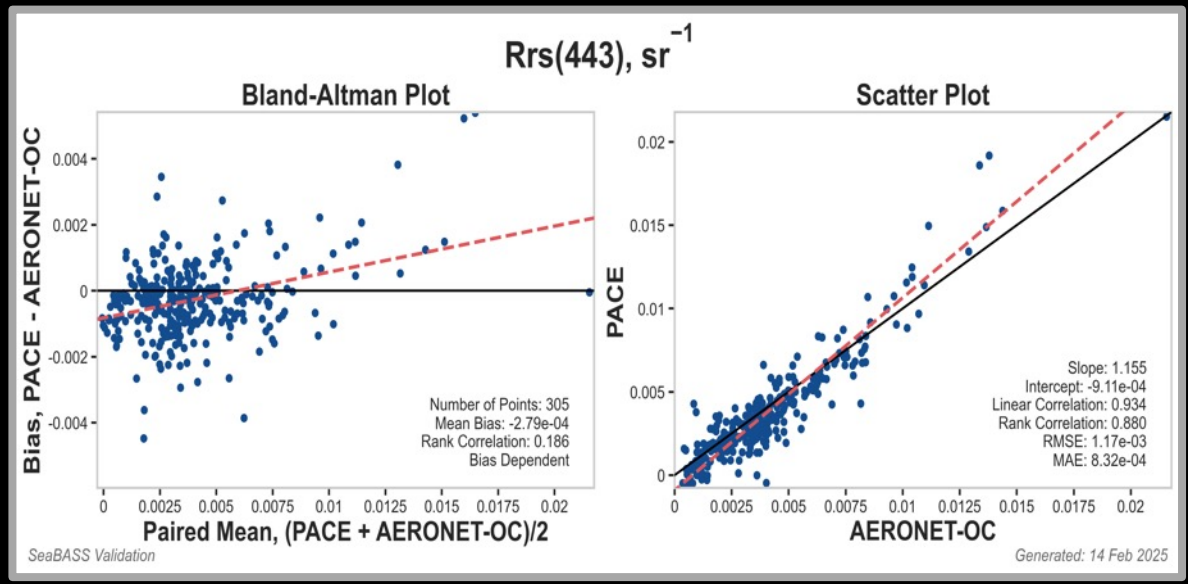
Hover over the bands to get more information about the issues. The ocean normalized surface reflectance (rhos) and atmosphere transmittance spectra are shown as a reference.



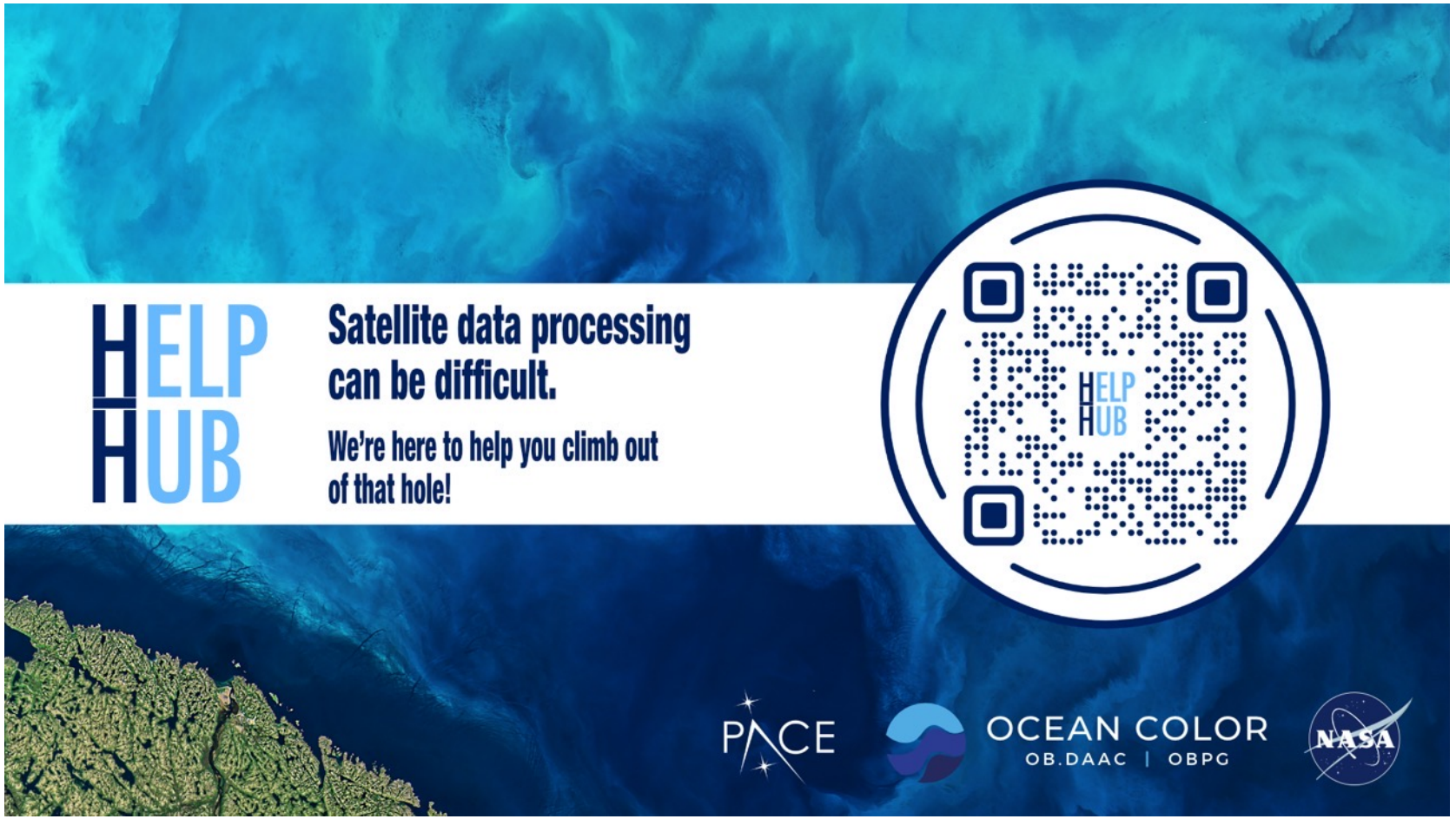
preliminary performance assessments

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





PACE Help Hub, Web site, email list



https://pace.gsfc.nasa.gov

PACE community listserv: email **pace-community@lists.nasa.gov** (subject "subscribe")