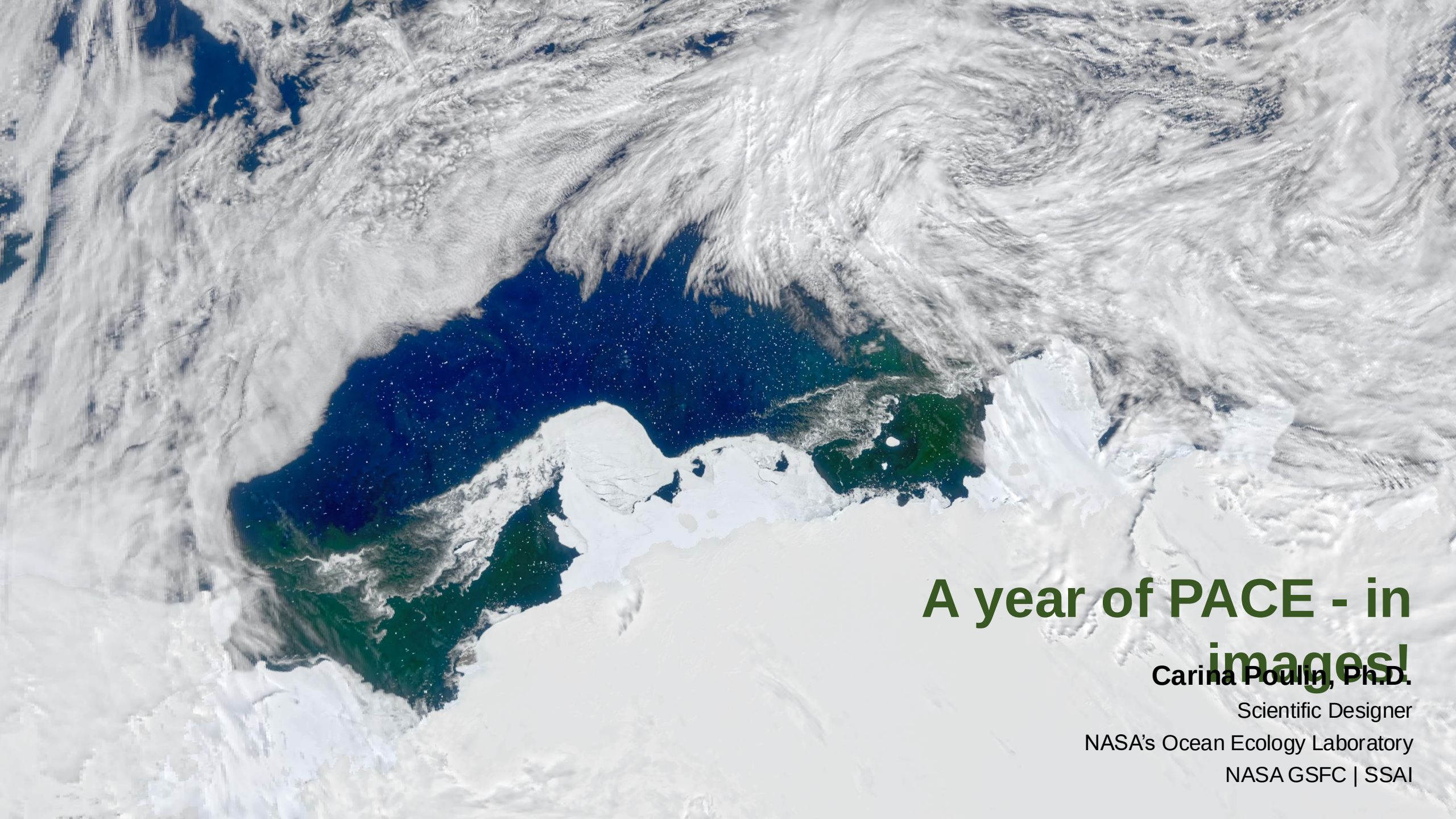
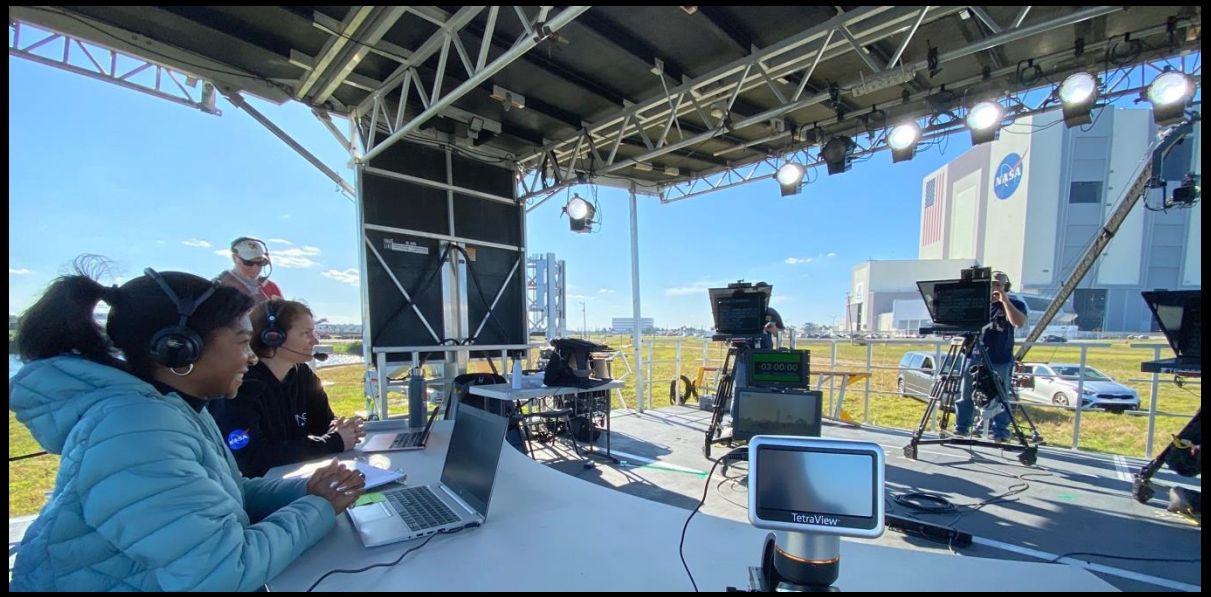


A year of PACE - in images!

Carina Poulin, Ph.D.
Scientific Designer
NASA's Ocean Ecology Laboratory
NASA GSFC | SSAI


NASA
4K FUJINON

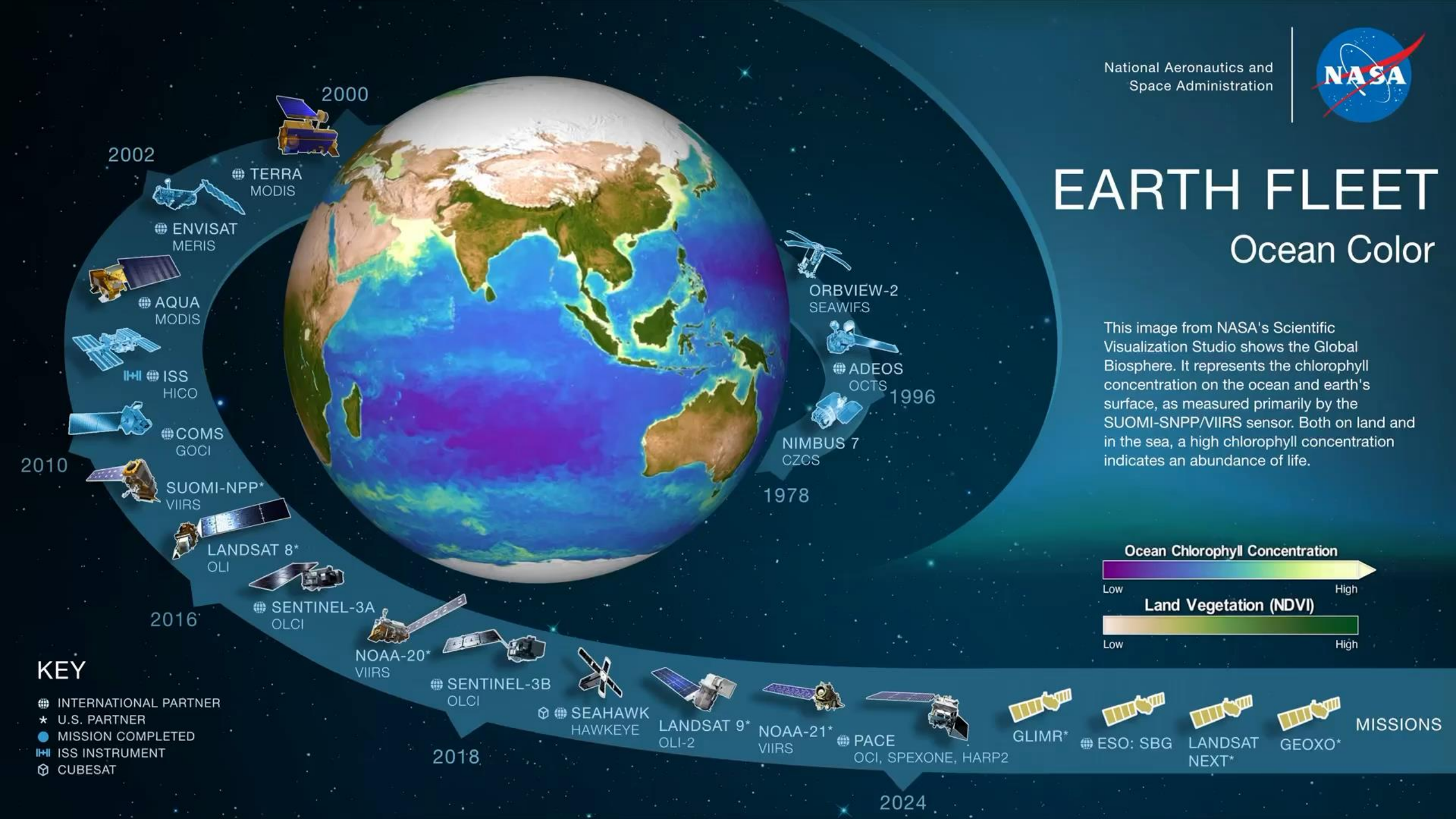

NASA
TetraView


Plankton, Aerosol, Cloud,
PACE
NASA
NASA
NASA


Advanced Measurements of Sea & Sky
Plankton, Aerosol, Cloud, ocean Ecosystem
PACE
NASA/GSFC • UMBC • SRON/Airbus NL
NASA



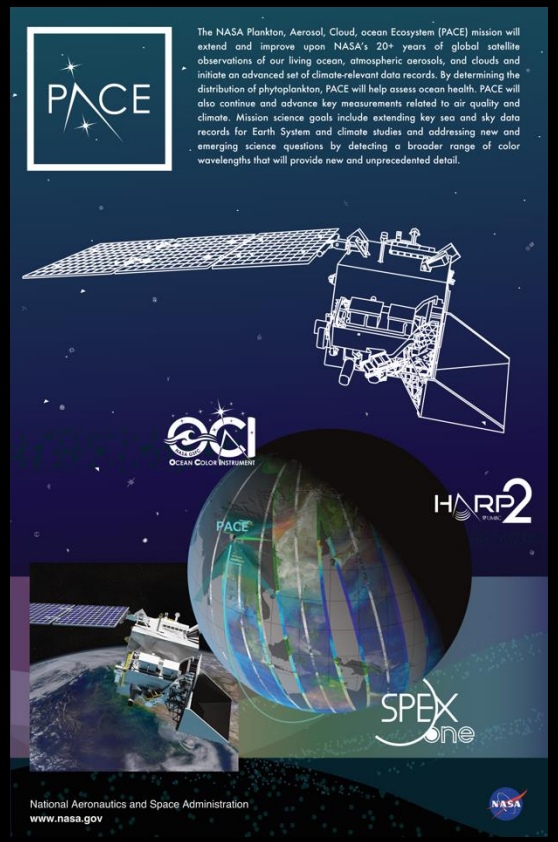


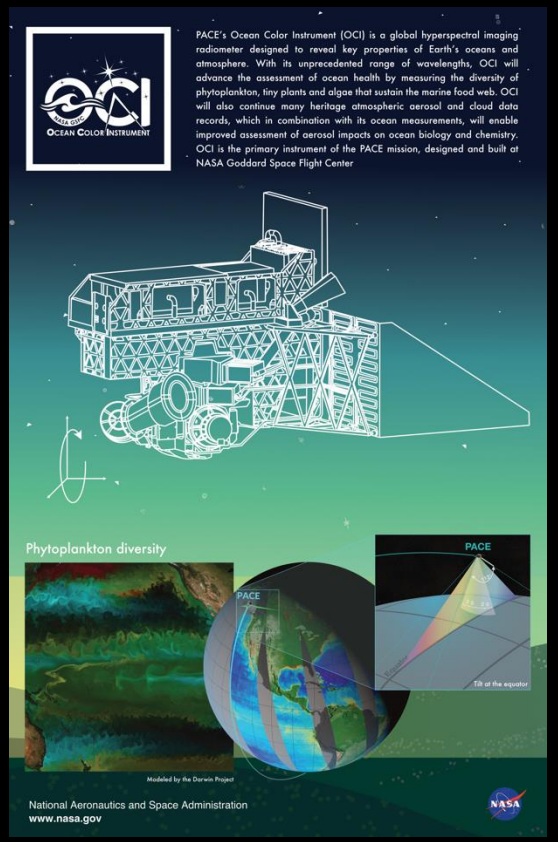

National Aeronautics and Space Administration
NASA
EARTH FLEET
Ocean Color
This image from NASA's Scientific Visualization Studio shows the Global Biosphere. It represents the chlorophyll concentration on the ocean and earth's surface, as measured primarily by the SUOMI-SNPP/VIIRS sensor. Both on land and in the sea, a high chlorophyll concentration indicates an abundance of life.
Ocean Chlorophyll Concentration
Low
High
Land Vegetation (NDVI)
Low
High
2000
TERRA
MODIS
2002
ENVISAT
MERIS
AQUA
MODIS
ISS
HICO
COMS
GOCI
2010
SUOMI-NPP*
VIIRS
LANDSAT 8*
OLI
SENTINEL-3A
OLCI
2016
NOAA-20*
VIIRS
SENTINEL-3B
OLCI
SEAHAWK
HAWKEYE
2018
LANDSAT 9*
OLI-2
NOAA-21*
VIIRS
PACE
OCI, SPEXONE, HARP2
2024
GLIMR*
ESO: SBG
LANDSAT NEXT*
GEOXO*
MISSIONS
ORBVIEW-2
SEAWIFS
ADEOS
OCTS
1996
NIMBUS 7
CZCS
1978
KEY
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U.S. PARTNER
MISSION COMPLETED
ISS INSTRUMENT
CUBESAT

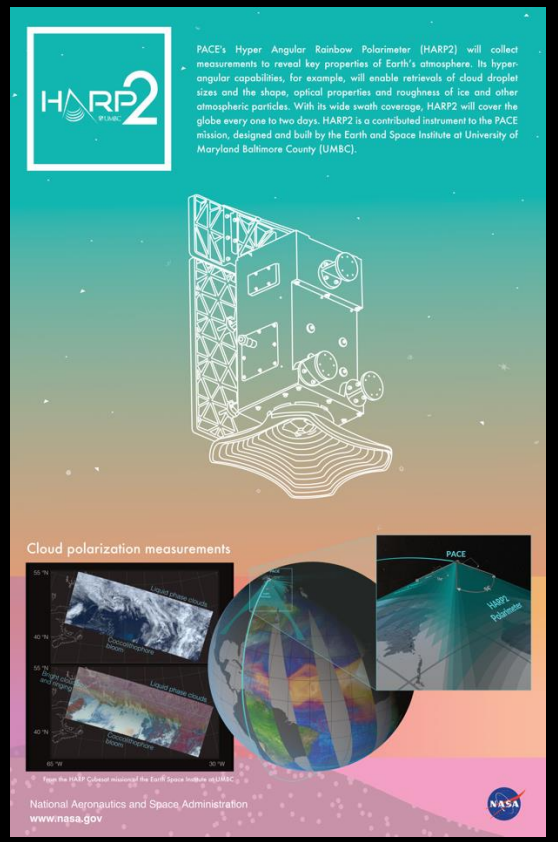


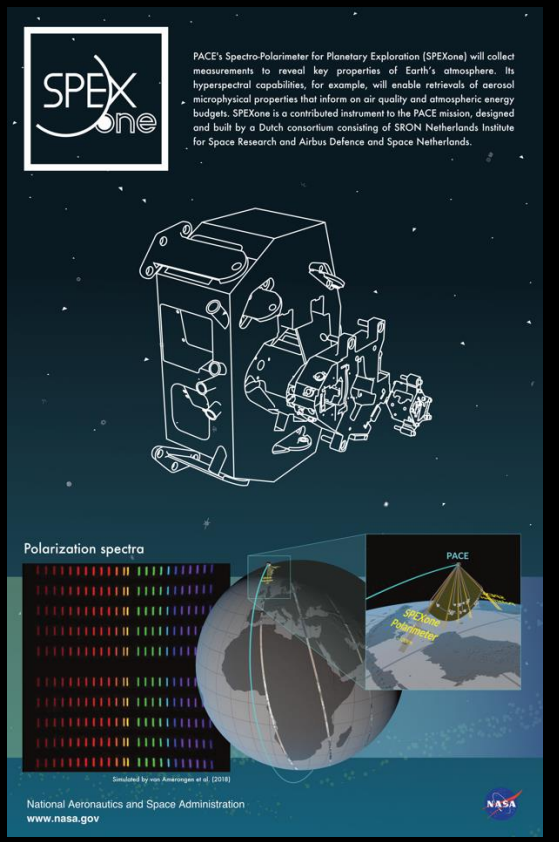
SPEXone

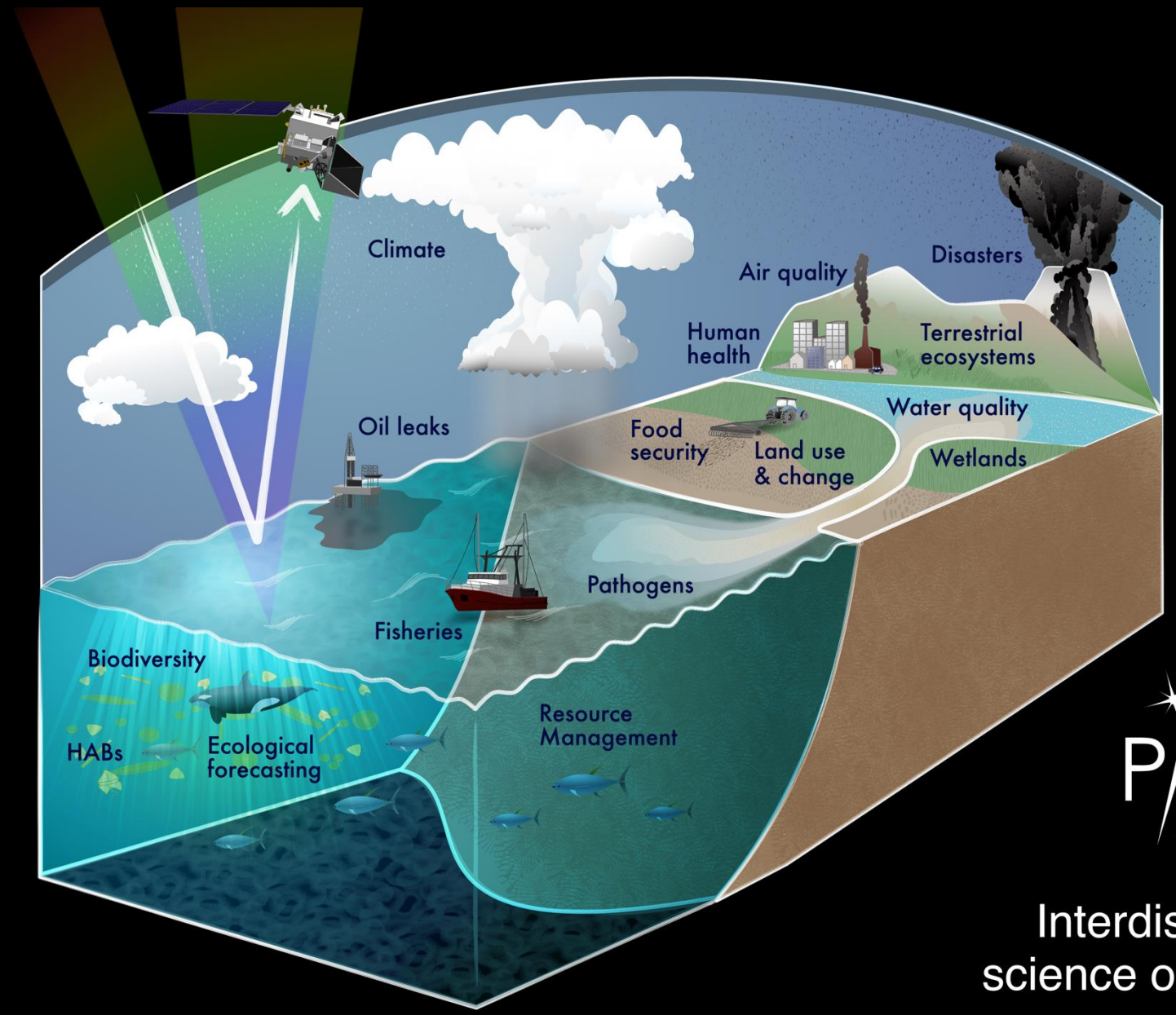
Orbit: 06 elapsed: 08 hours 28 minutes


PACE
The NASA Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission will extend and improve upon NASA's 20+ years of global satellite observations of our living ocean, atmospheric aerosols, and clouds and initiate an advanced set of climate-relevant data records. By determining the distribution of phytoplankton, PACE will help assess ocean health. PACE will also continue and advance key measurements related to air quality and climate. Mission science goals include extending key sea and sky data records for Earth System and climate studies and addressing new and emerging science questions by detecting a broader range of color wavelengths that will provide new and unprecedented detail.
OCI
Ocean Color Instrument
HARP2
PACE
SPEXone
National Aeronautics and Space Administration
www.nasa.gov


OCI
Ocean Color Instrument
PACE's Ocean Color Instrument (OCI) is a global hyperspectral imaging radiometer designed to reveal key properties of Earth's oceans and atmosphere. With its unprecedented range of wavelengths, OCI will advance the assessment of ocean health by measuring the diversity of phytoplankton, tiny plants and algae that sustain the marine food web. OCI will also continue many heritage atmospheric aerosol and cloud data records, which in combination with its ocean measurements, will enable improved assessment of aerosol impacts on ocean biology and chemistry. OCI is the primary instrument of the PACE mission, designed and built at NASA Goddard Space Flight Center
Phytoplankton diversity
PACE
Tilt at the equator
Modeled by the Darwin Project
National Aeronautics and Space Administration
www.nasa.gov


HARP2
PACE's Hyper Angular Rainbow Polarimeter (HARP2) will collect measurements to reveal key properties of Earth's atmosphere. Its hyper-angular capabilities, for example, will enable retrievals of cloud droplet sizes and the shape, optical properties and roughness of ice and other atmospheric particles. With its wide swath coverage, HARP2 will cover the globe every one to two days. HARP2 is a contributed instrument to the PACE mission, designed and built by the Earth and Space Institute at University of Maryland Baltimore County (UMBC).
Cloud polarization measurements
PACE
HARP2 Polarimeter
National Aeronautics and Space Administration
www.nasa.gov


SPEXone
PACE's Spectro-Polarimeter for Planetary Exploration (SPEXone) will collect measurements to reveal key properties of Earth's atmosphere. Its hyperspectral capabilities, for example, will enable retrievals of aerosol microphysical properties that inform on air quality and atmospheric energy budgets. SPEXone is a contributed instrument to the PACE mission, designed and built by a Dutch consortium consisting of SRON Netherlands Institute for Space Research and Airbus Defence and Space Netherlands.
Polarization spectra
PACE
SPEXone Polarimeter
National Aeronautics and Space Administration
www.nasa.gov

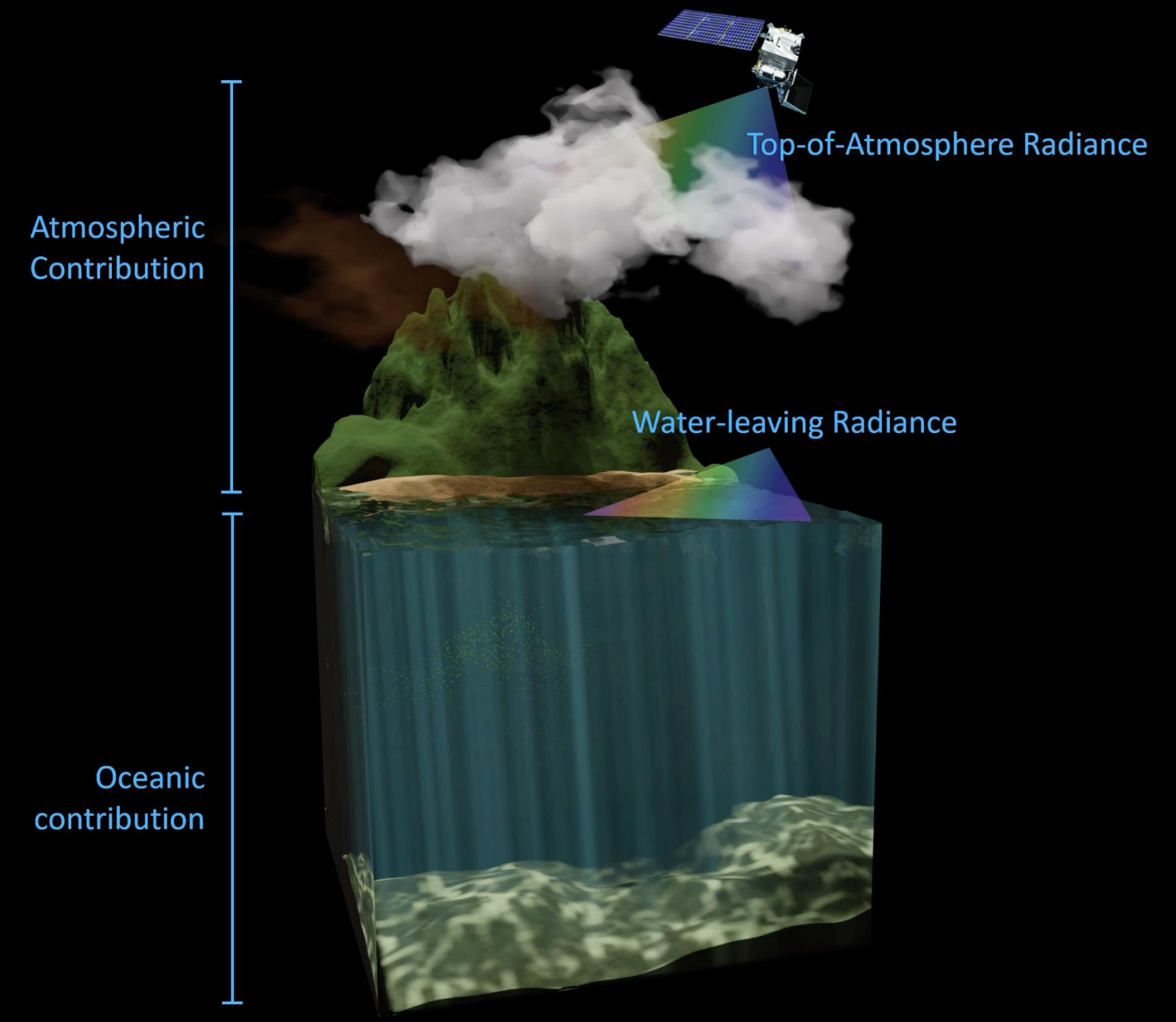


PACE

Interdisciplinary science objectives

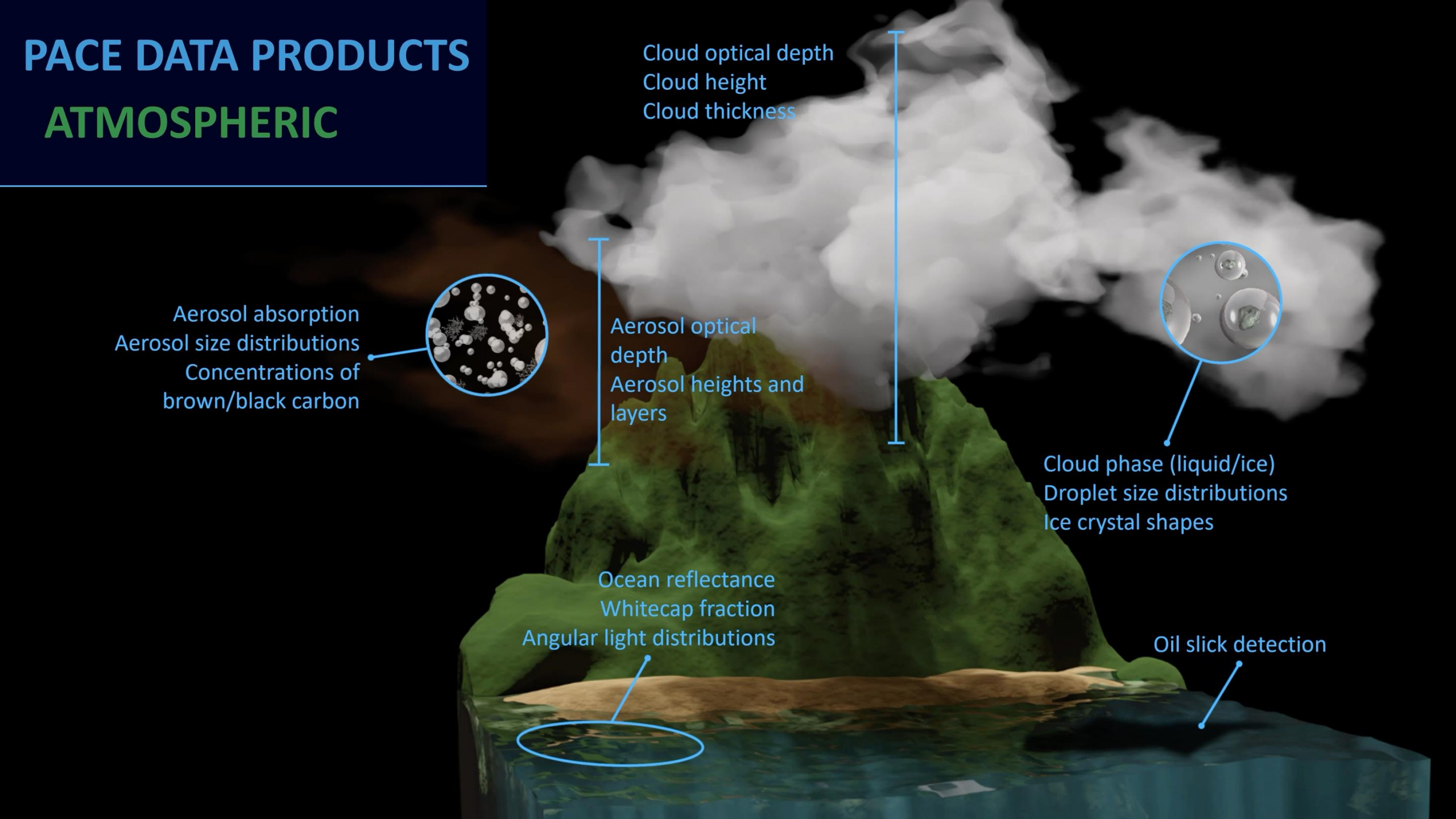
PACE DATA PRODUCTS

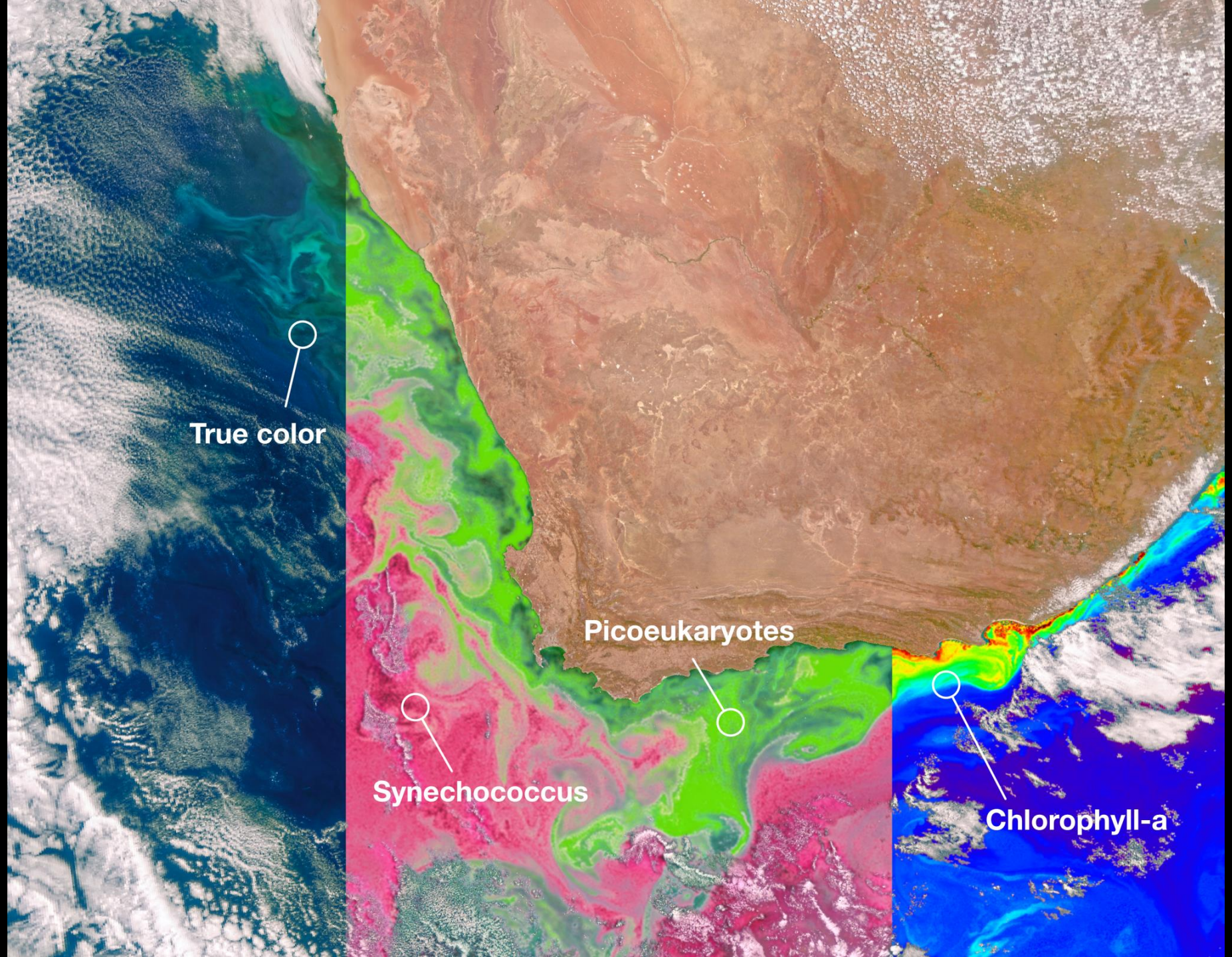
ATMOSPHERIC
OCEAN COLOR

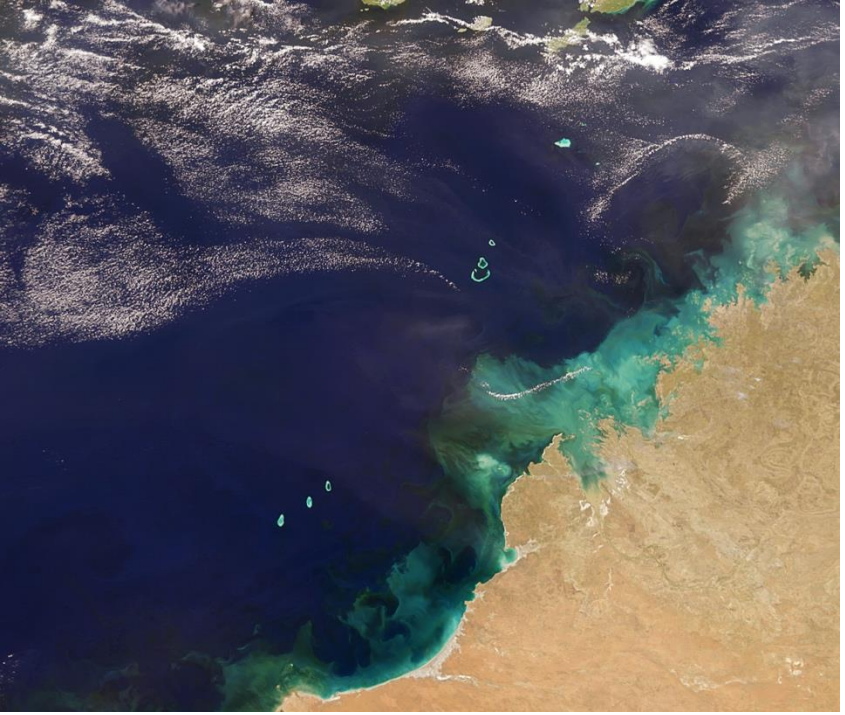
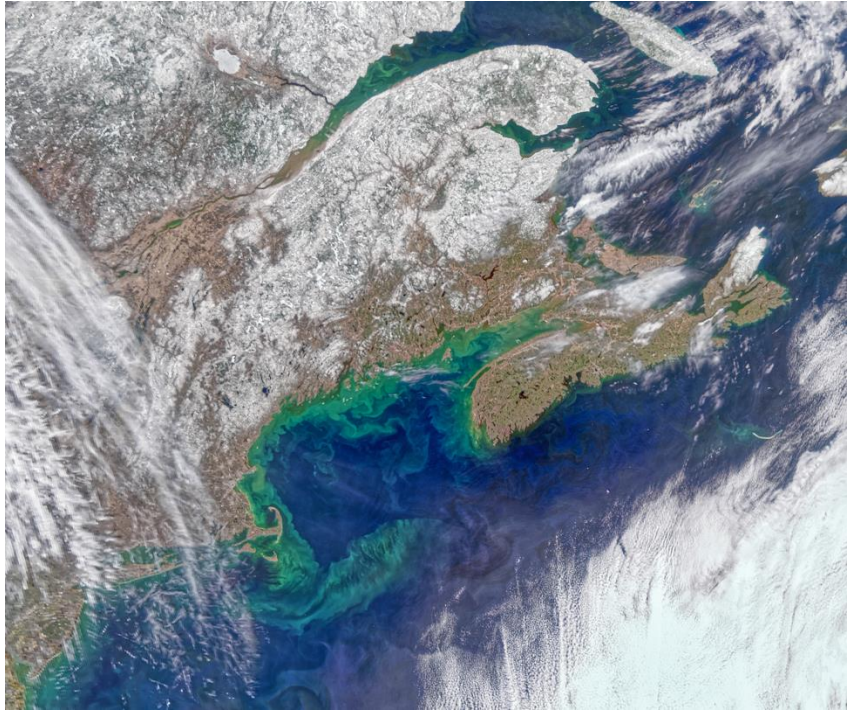
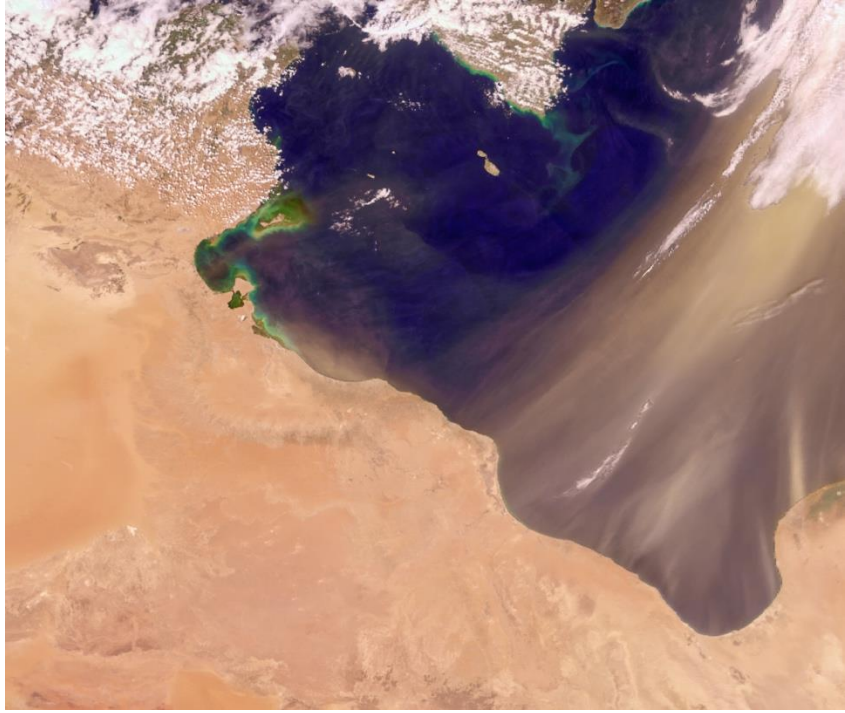
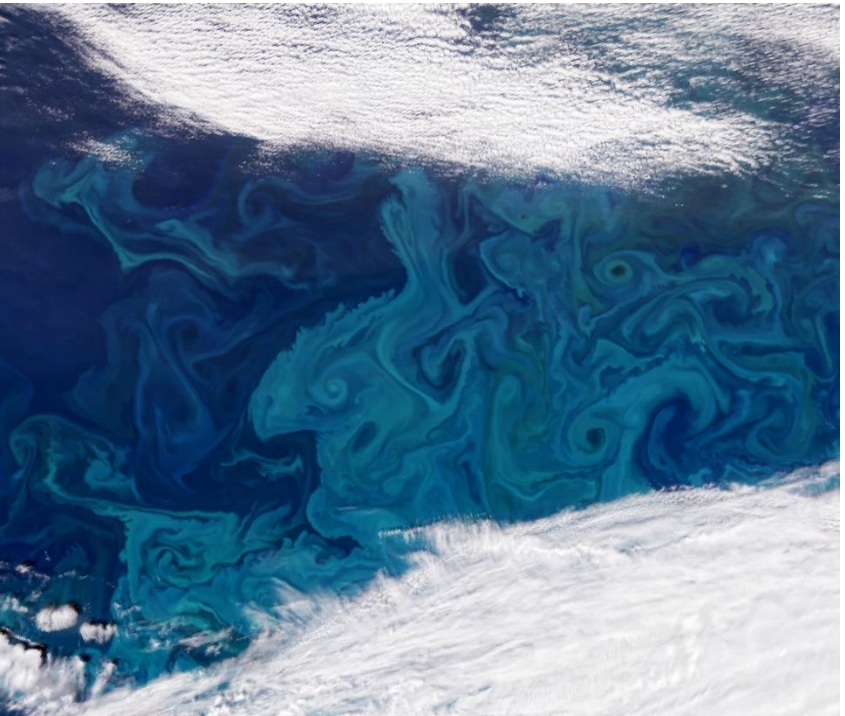
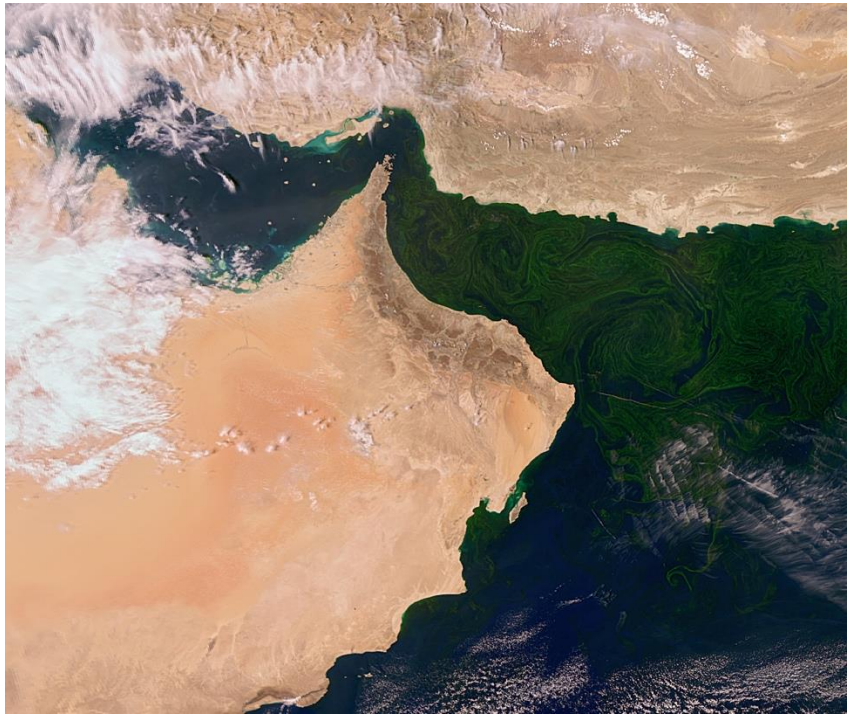
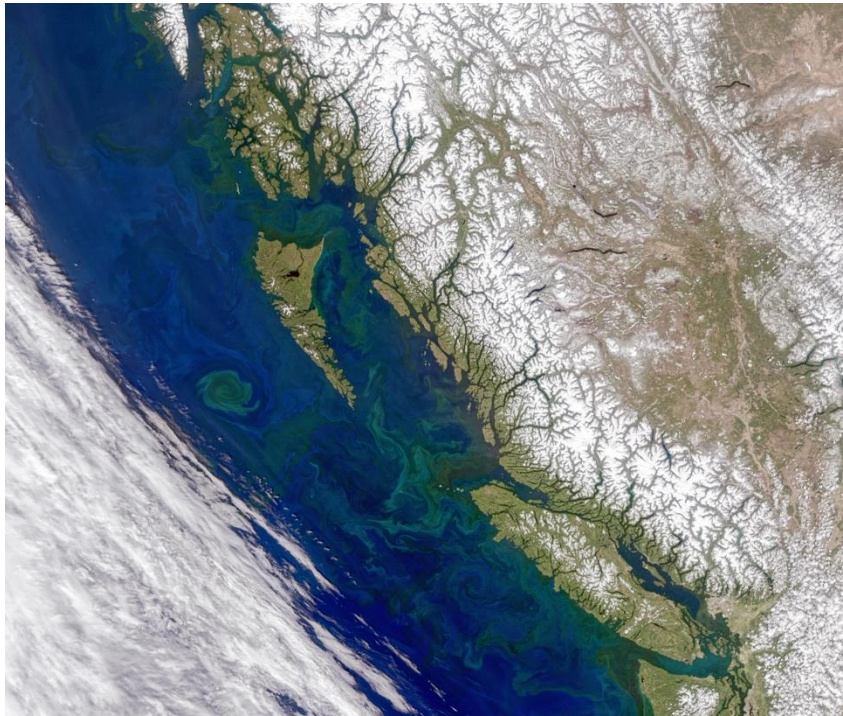


PACE DATA PRODUCTS

ATMOSPHERIC



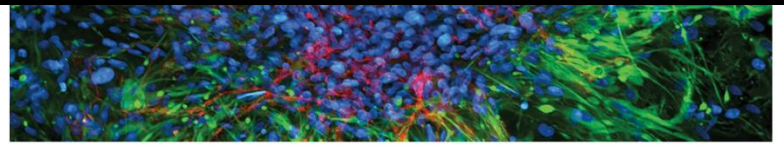

True color
Picoeukaryotes
Synechococcus
Chlorophyll-a

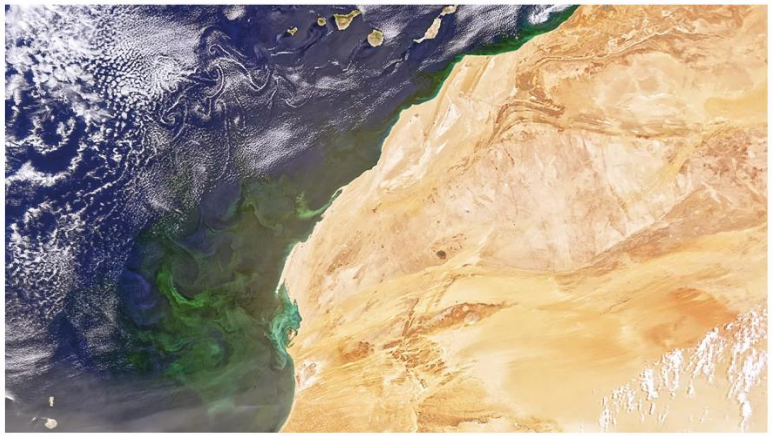








National Aeronautics and
Space Administration
2025
NASA
SCIENCE
www.nasa.gov

Research Center

Learn more about Space Biology





Air and Ocean Views

NASA's Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) satellite, launched on February 8, 2024, collects data on microscopic life in the ocean and particles in the air, advancing researchers' understanding of issues including fisheries' health, harmful algal blooms, air pollution, and wildfire smoke. With PACE, scientists also investigate how the ocean and atmosphere interact with each other and are affected by a changing climate.

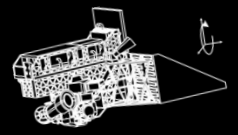
Image and text credit: NASA's Goddard Space Flight Center/PACE;
Image processing: Carina Poulin

Engage more with PACE

Cool as Ice

Every winter, a layer of carbon dioxide frost (dry ice) forms on the surface of Mars. At its greatest extent in midwinter, this frost reaches from the poles down to the middle latitudes, until it is too





OCI

340-890 nm in 2.5 nm steps
7 discrete SWIR: 940-2260 nm
1-2 day coverage; ±20° tilt; 1km
NASA Goddard Space Flight Center



HARP2

440, 550, 670, 870 nm
10-60 viewing angles
wide swath polarimeter; 3 km
University of Maryland Baltimore Co.



SPEXone

380-770 nm in 2-4 nm steps
5 viewing angles
narrow swath polarimeter; 2.5 km
SRON, Airbus NL

PACE (re)processing and data product release status

Initial data release on 4 Apr 2024

- Radiometry from all instruments
- Heritage ocean color from OCI

First reprocessing (V2) in Jul 2024

- First use of on-orbit calibrations
- Second wave of products: surface reflectances, terrestrial vegetation indices, cloud properties

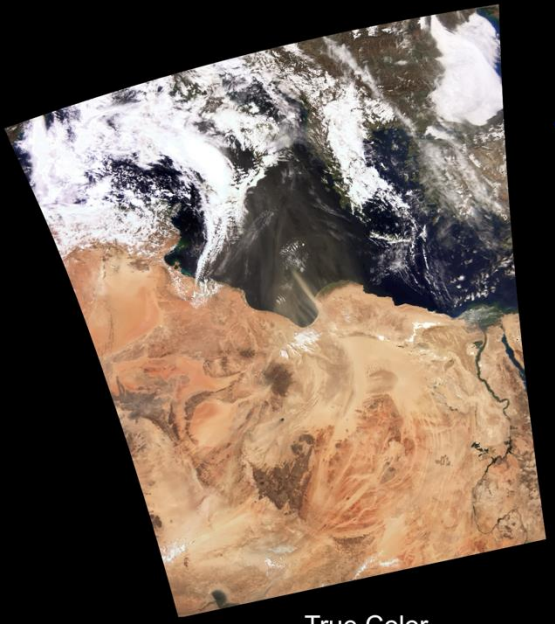
Second reprocessing (V3) ongoing

- Updated calibrations
- New/updated products to follow

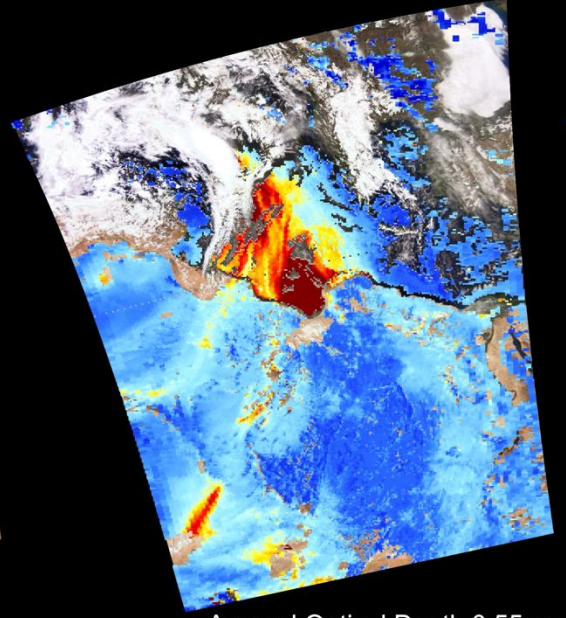
Data access via NASA Earth Data Search

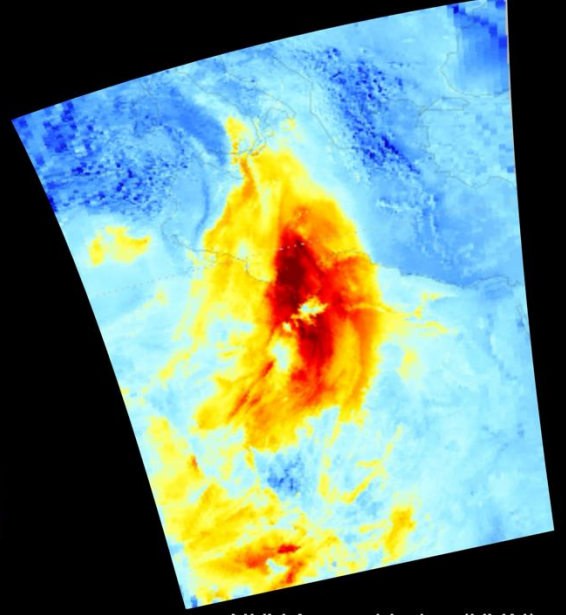
polar, ascending, 98° inclination
13:00 local Equatorial crossing time
676.5 km altitude
6-9 hrs data latency

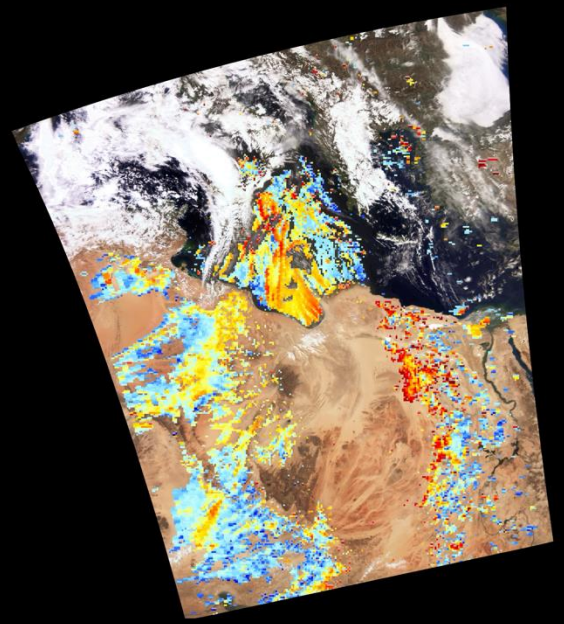
Advanced aerosol retrievals from OCI

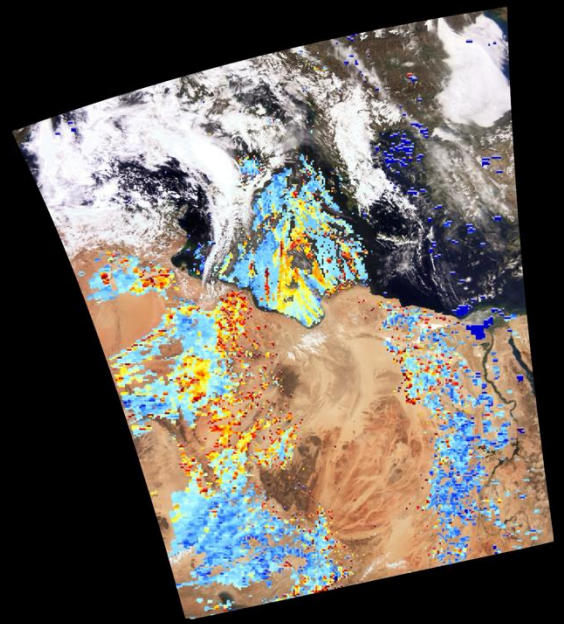


True Color







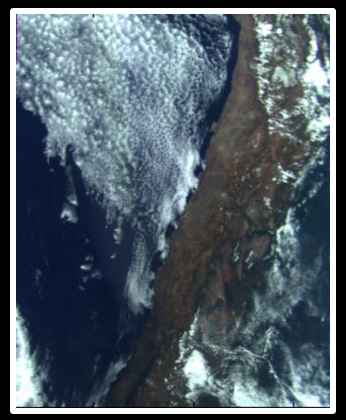


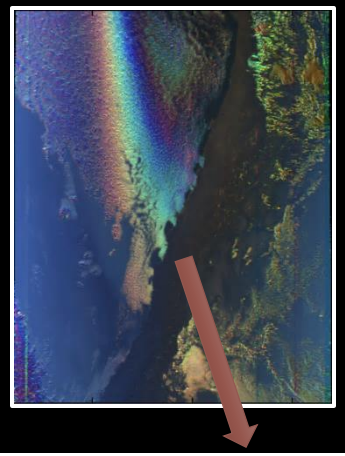
Preliminary results from Lorraine Remer and team's "Unified Aerosol Algorithm"

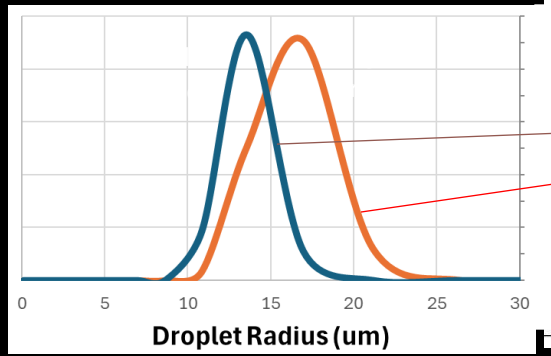
Provides some quantification of aerosol **absorption** and **altitude**

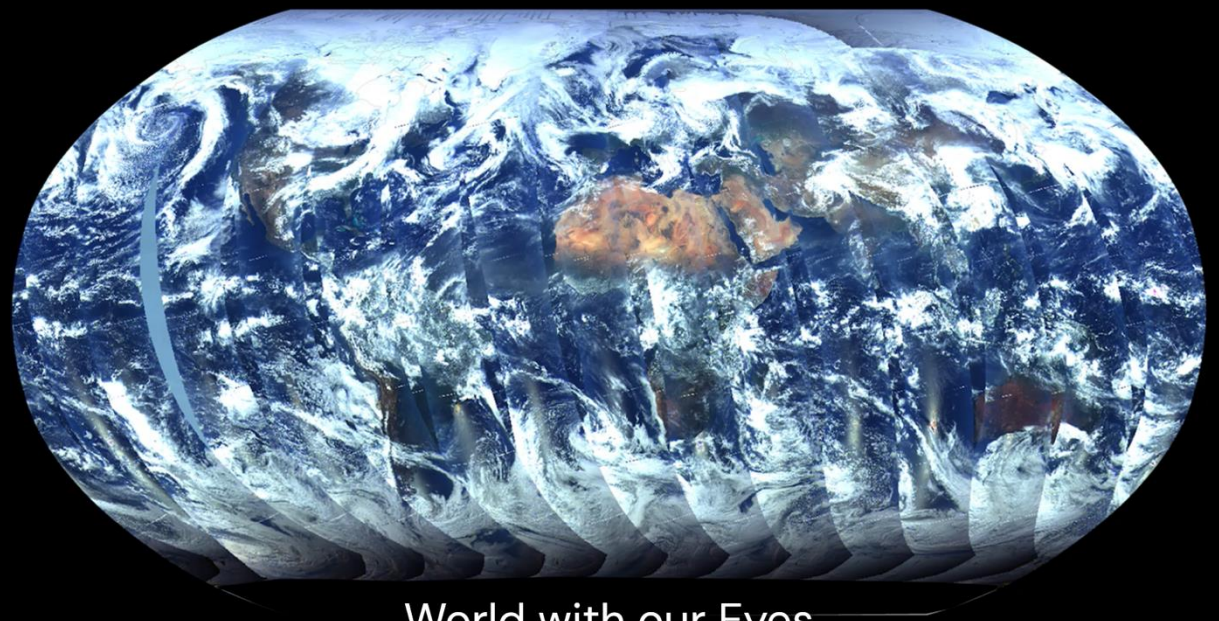
Currently in implementation/testing

HARP2 Cloud and Aerosol Measurements



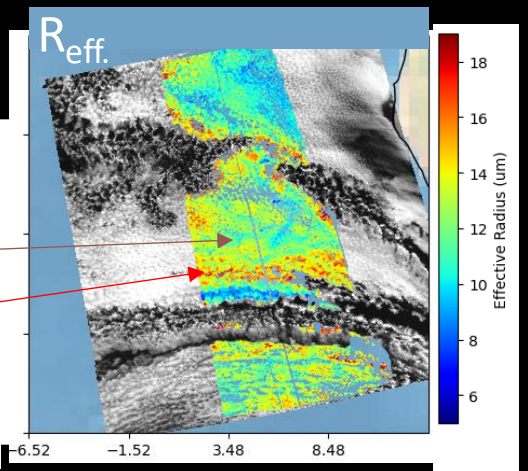


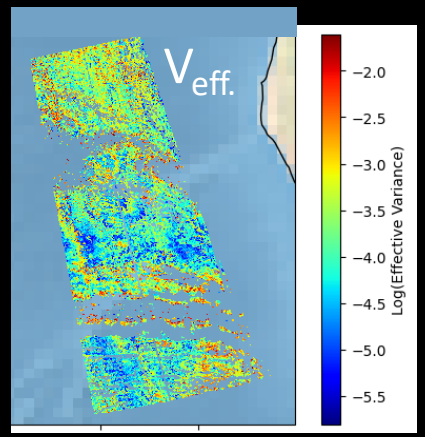


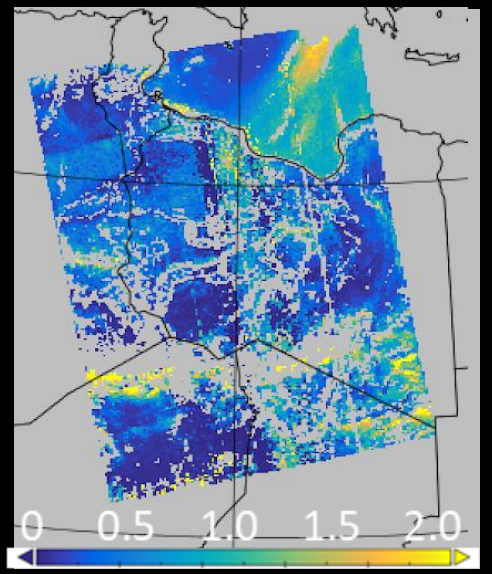


World with our Eyes

Cloud Droplet sizes

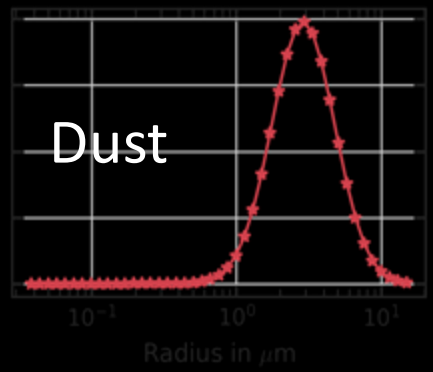


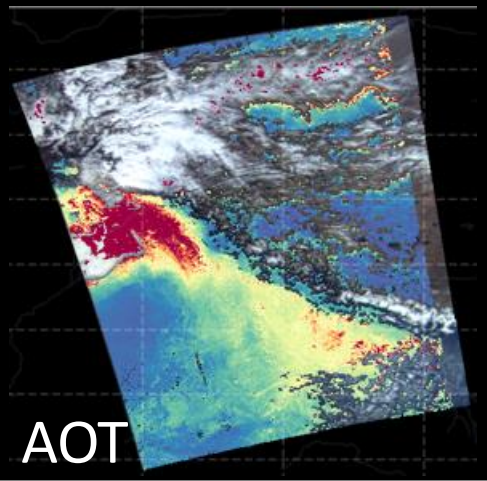


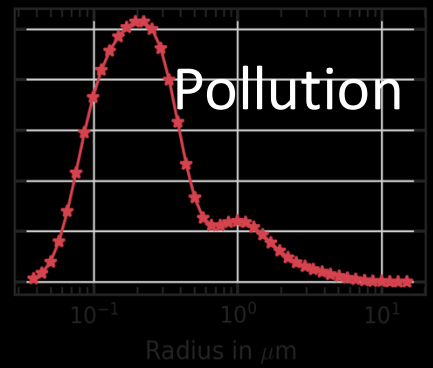


AOT

Particle sizes

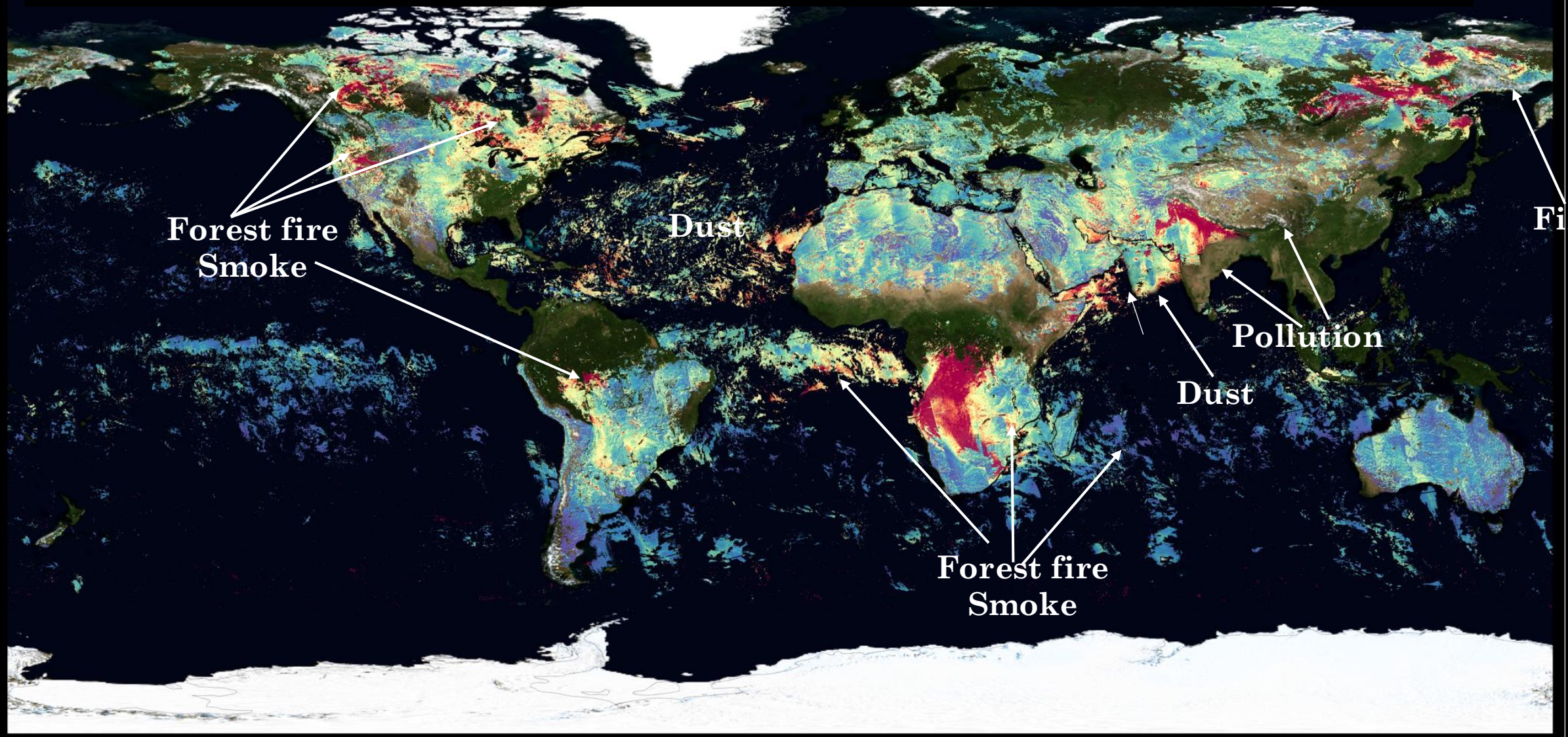




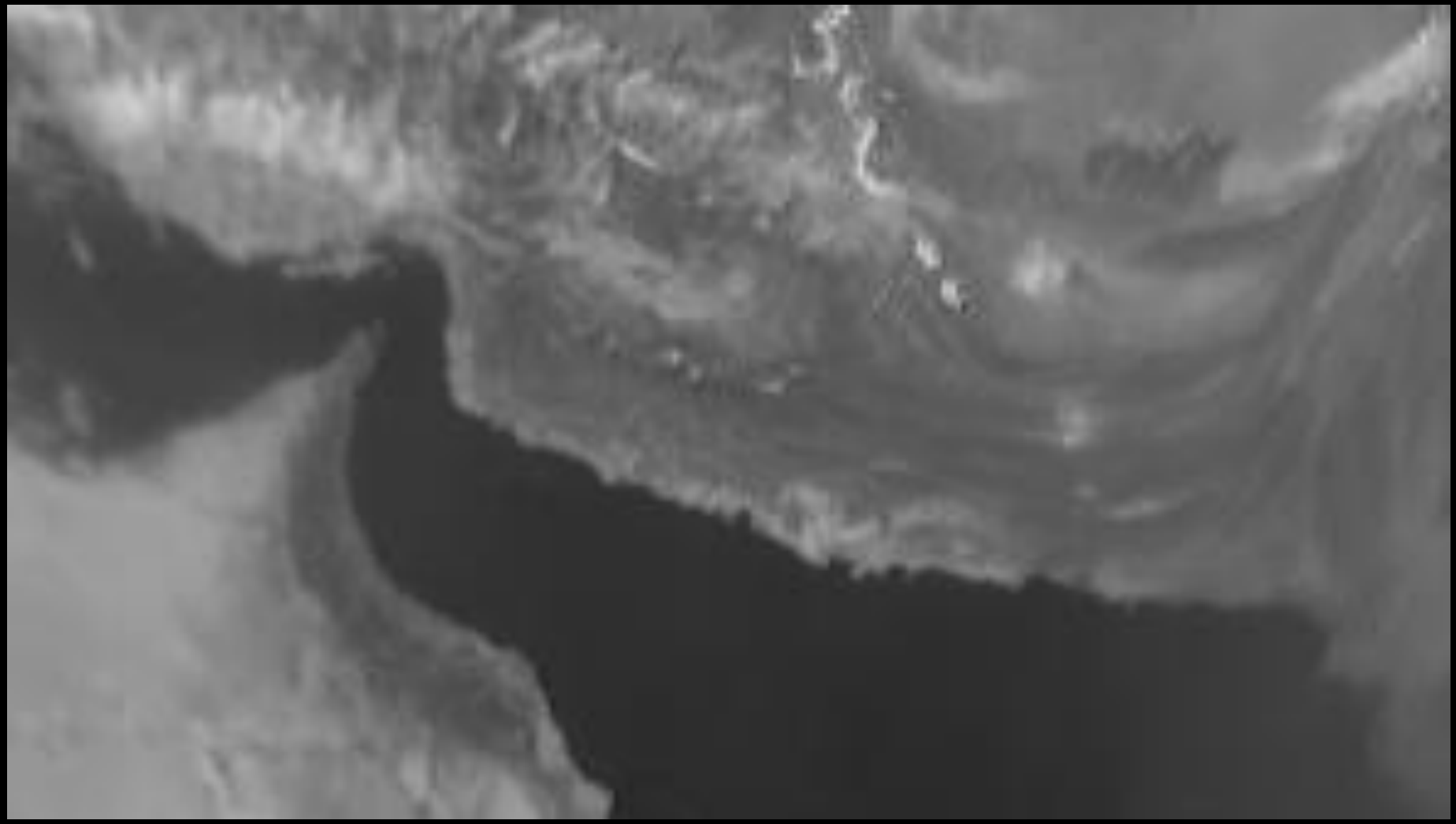




Results: PACE HARP2 data products – aerosols

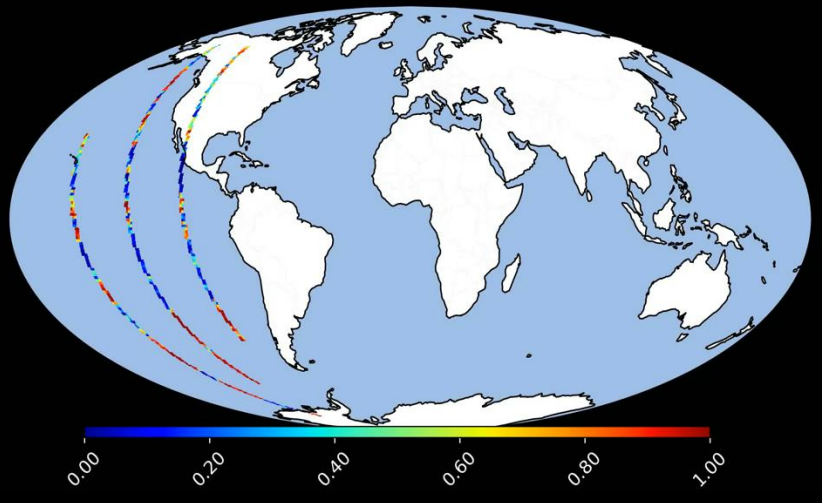


Results: PACE HARP2 cloud 3D structure

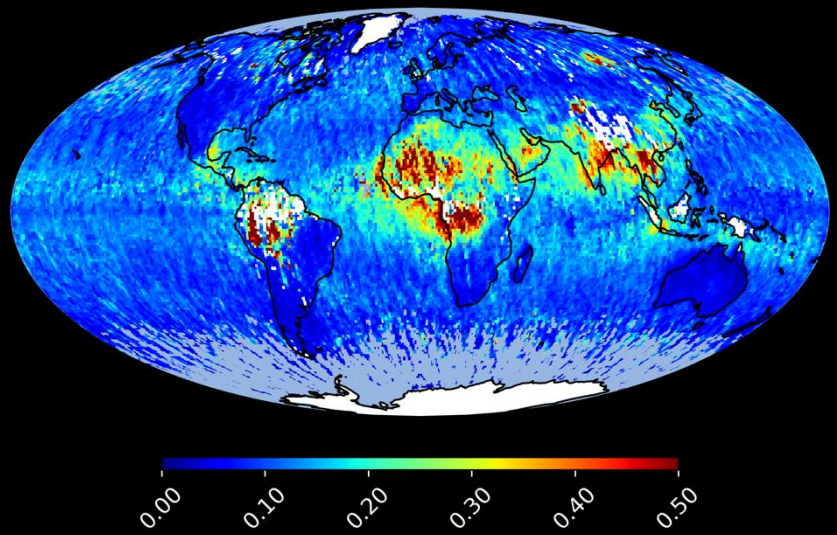


Results: PACE SPEXone data products – aerosols

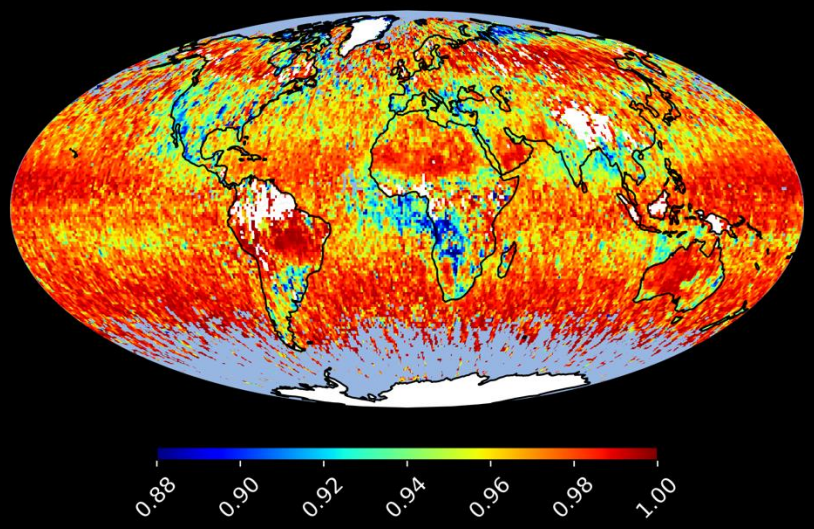
Cloud Fraction



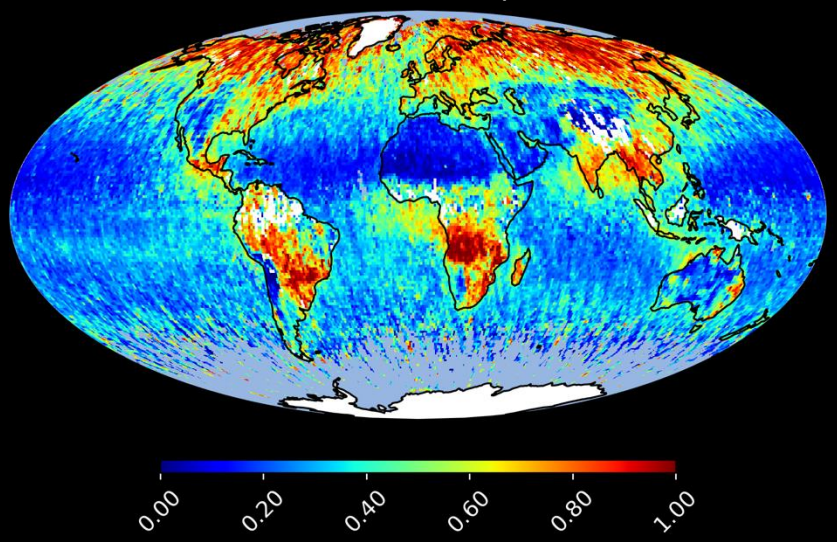
Aerosol Optical Depth (Amount)



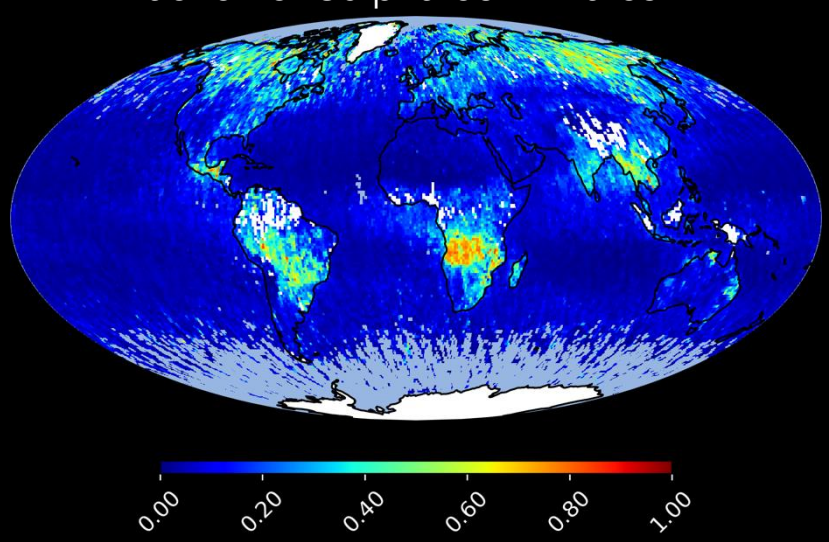
Single Scattering Albedo (absorption)



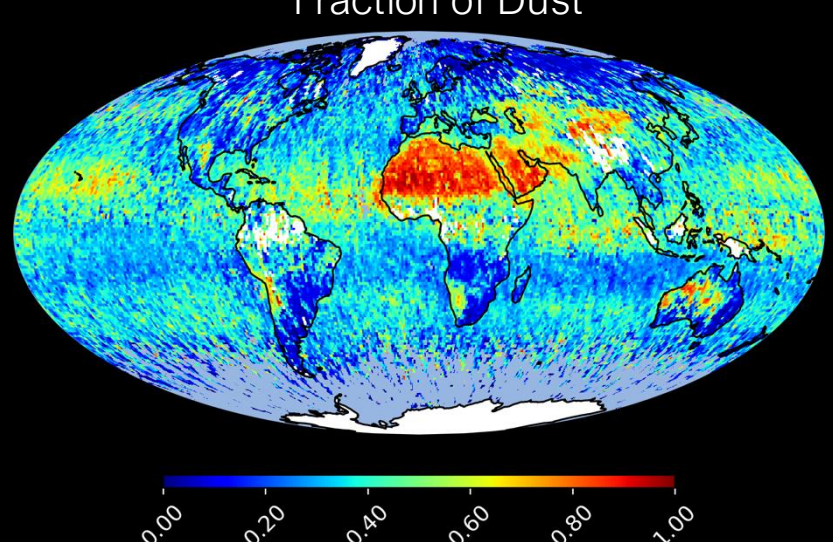
Fraction of fine particles



Fraction of Sulphates+Nitrates

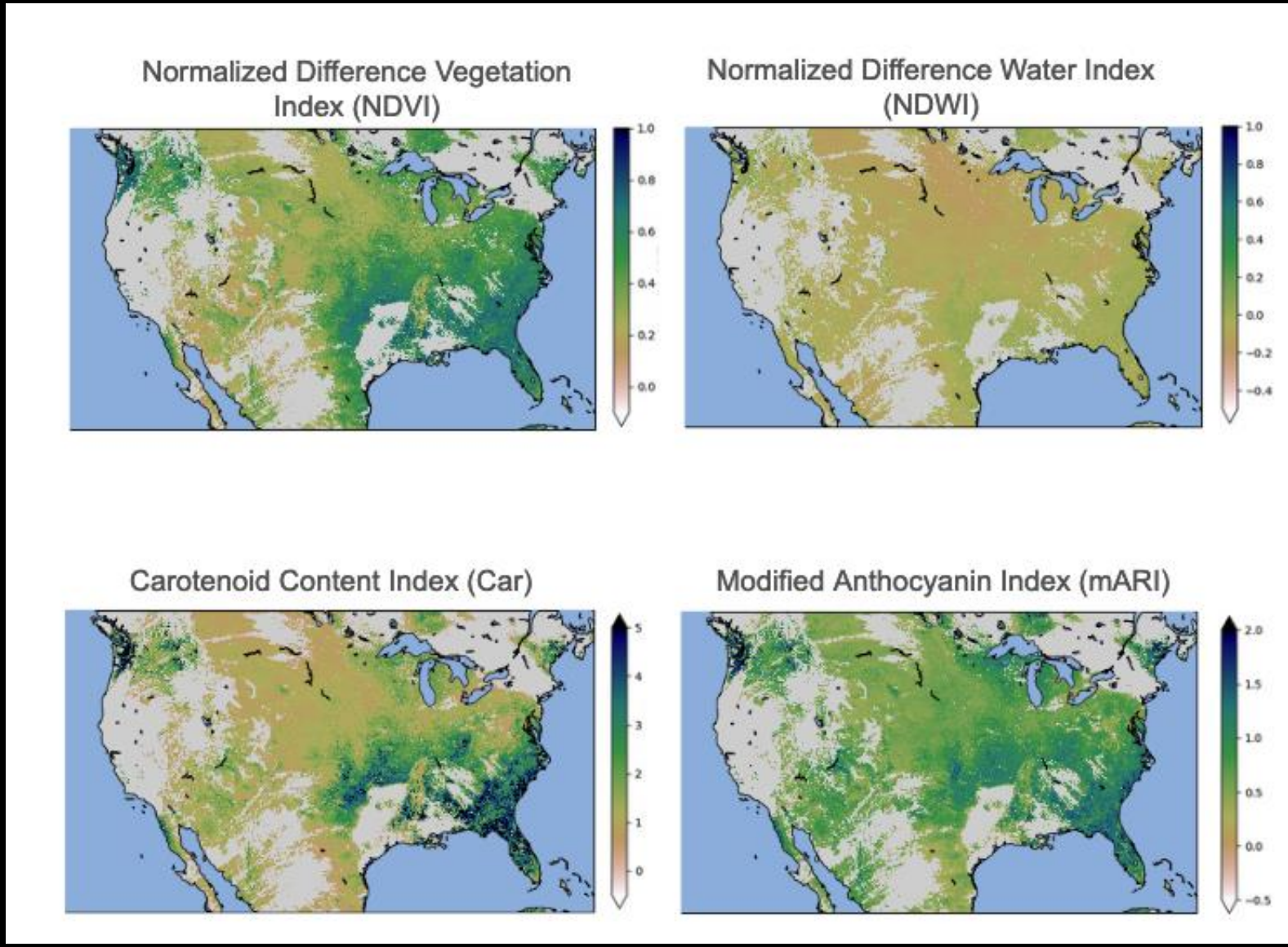


Fraction of Dust

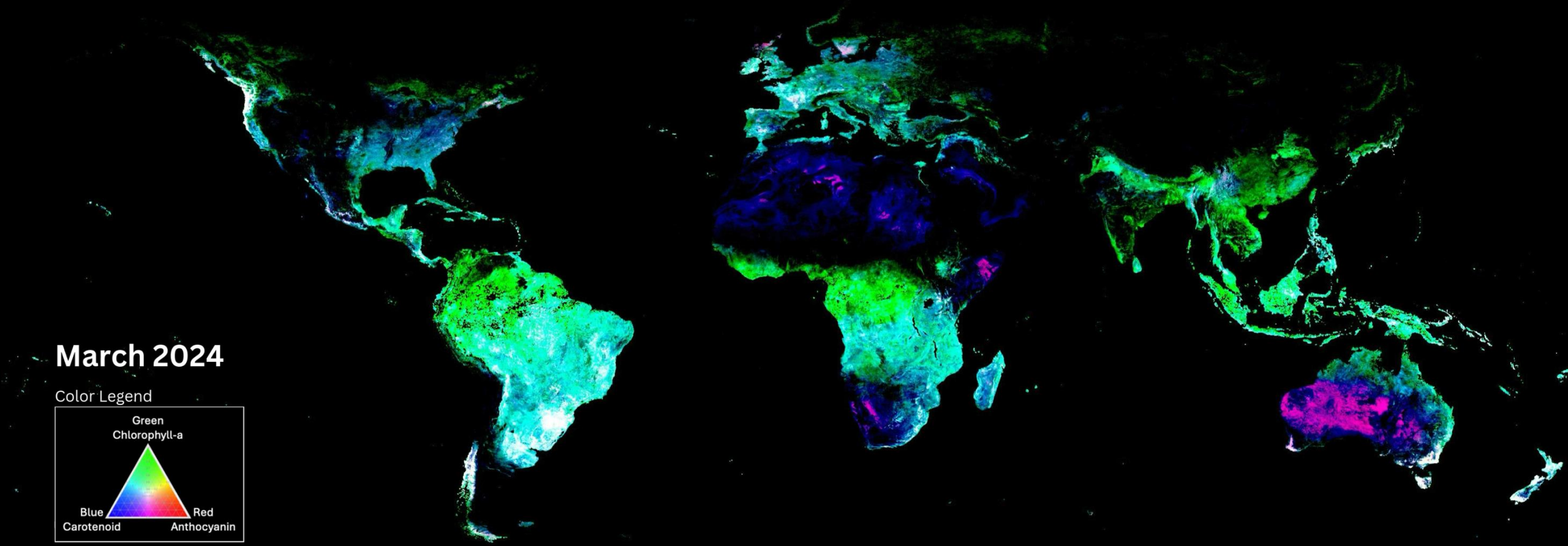


Terrestrial products

- 1st global (almost) hyperspectral coverage every 1-2 days
- 4 new vegetation pigment indices (mARI, Car, PRI, CIRE) and hyperspectral reflectance
- 6 classic vegetation indices: NDWI, NDVI/EVI, NDII, CCI, NDSI



Results: OCI data products – Vegetation indices



PACE's advanced pigment indices contain information on vegetation type, productivity, health status, and leaf area. Only PACE can provide this information globally, every 1-2 days.

Data Credit: Fred Huemmrich (NASA/UMBC)

Results: PACE data products – plankton groups

National Aeronautics and Space Administration



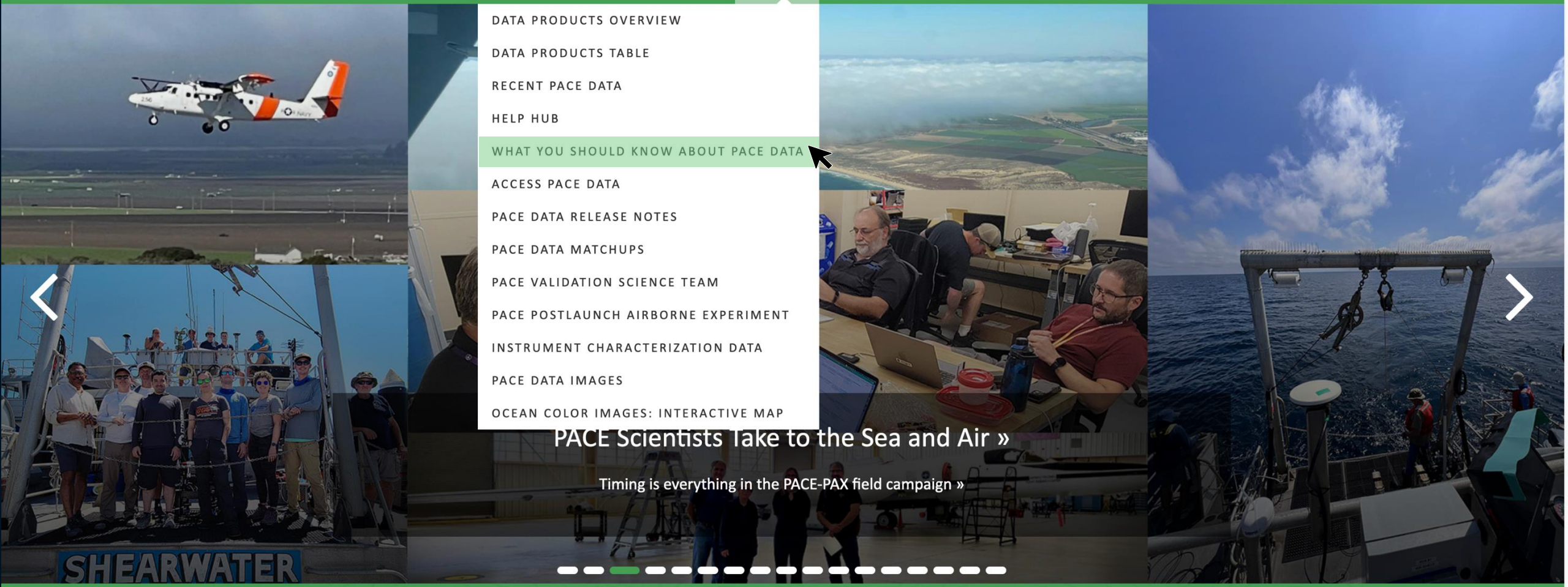
Rolling 32-day average
April 2024

National Aeronautics and Space Administration

PACE Plankton, Aerosol, Cloud, ocean Ecosystem

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PACE Scientists Take to the Sea and Air »

Timing is everything in the PACE-PAX field campaign »

MISSION ELAPSED TIME	DAYS	HR	MIN
	371	12	59

ORBIT NUMBER	5442

APPROXIMATE POSITION	LAT	LON
	-63	-82

SATELLITE LIGHTING	DAY

CLICK TO SEE ON MAP

PACE DATA PRODUCTS – WHAT TO KNOW

What you should know about PACE data

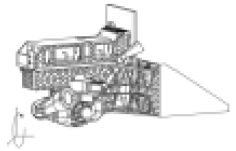
This is a summary of the general information one needs to use PACE data. See the complete release notes for the most current PACE data on the OB.DAAC website. (Updated Feb 06 2025)

Orbit

The PACE satellite is in a Sun-synchronous polar orbit, with a local Equatorial solar crossing time of 1 pm for the ascending (daytime) note. The descending orbital node happens during local nighttime, and none of PACE's sensors collect science data at night.

PACE Instruments

OCI
Ocean Color Instrument



HARP-2
Hyper Angular Rainbow Polarimeter



SPEXone
Spectro-Polarimeter for Planetary EXploration



OB.DAAC data processing levels

Level 1A
Raw instrument data and spacecraft telemetry in native

Level-1B
Calibrated & geolocated instrument data

Level-1C
Calibrated, geolocated, and co-registered to a common grid

Level-2
Derived geophysical science data products

Level-3
Temporally and spatially composited (binned and mapped) global products

Level-4
Geophysical products derived from combined Level-3 inputs and/or models

Currently available product maturity levels..

PACE Science Data Reprocessing: Version 3

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

PACE DATA PRODUCTS – WHAT TO KNOW

OB.DAAC data processing levels

Level 1A	Level-1B	Level-1C	Level-2	Level-3	Level-4
Raw instrument data and spacecraft telemetry in netCDF4	Calibrated & geolocated instrument data	Calibrated, geolocated, and co-registered to a common grid	Derived geophysical science data products	Temporally and spatially composited (binned and mapped) global products	Geophysical products derived from combined Level-3 inputs and/or models

Currently available product maturity levels..

Provisional

Results have been reviewed and are in family with heritage data products or other basis of expectation, but which have not yet been validated and may still contain significant errors...

Test

Results have not yet been reviewed by algorithm developers and or may be known to have substantial errors in implementation that are under investigation.

Diagnostic

Products that are produced to support analysis of algorithm behavior, but that are not intended for science.

Known data issues

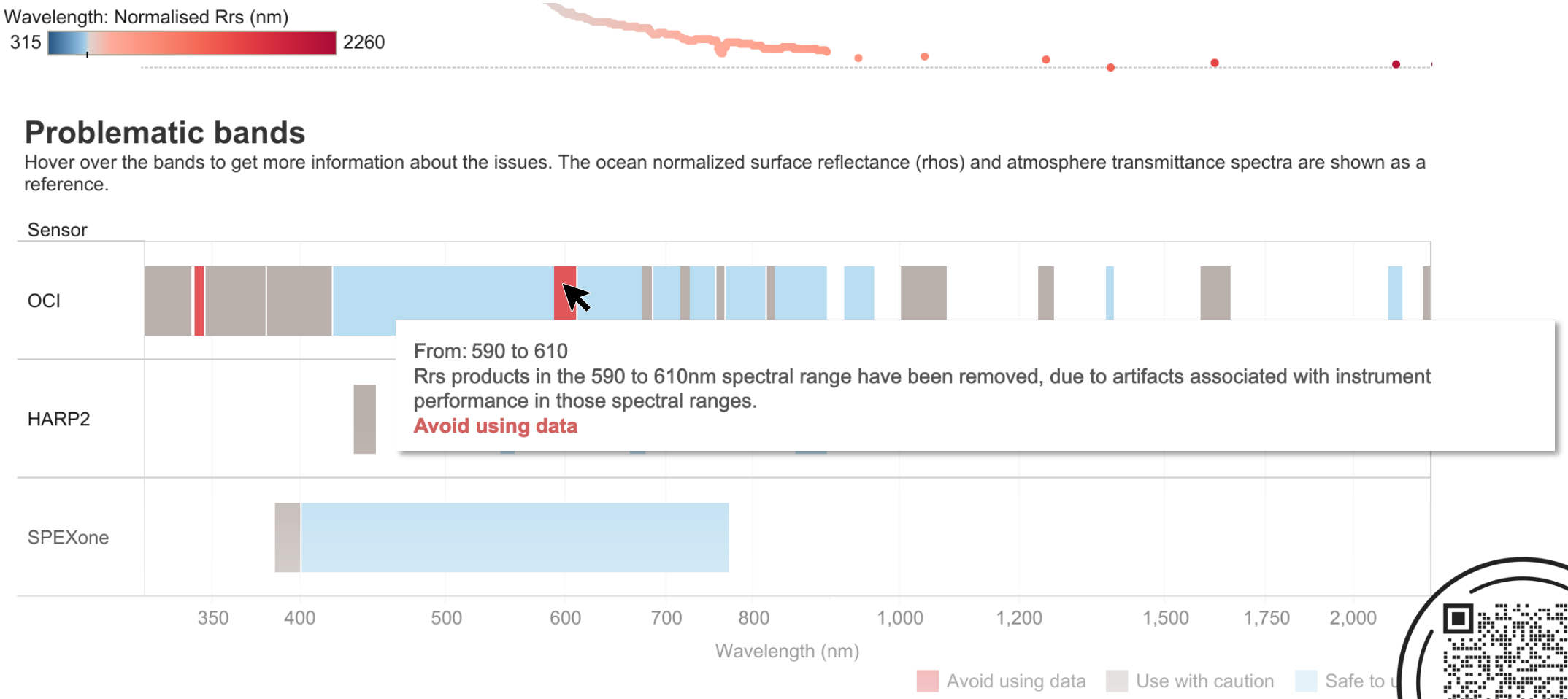
PACE is already providing high-quality data. However, some issues have to be noted before using it. Some particular bands, influenced by instrument or atmospheric characteristics, should be avoided for the moment.
Other issues affect the entire dataset, and some events affect data availability. See below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

Reference spectra (for indicative purposes)

PACE Science Data Reprocessing: Version 3

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

PACE DATA PRODUCTS – WHAT TO KNOW



[PACE Science Data Reprocessing: Version 3]

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

PACE DATA PRODUCTS – WHAT TO KNOW

Issues affecting all bands

Sensor	Processing le..	Product suite..	Issue details
HARP2	Level 1A/B/C	NA	Alignment related false polarization needs further evaluation and improvement
			Polarimetric performance is subject to comprehensive evaluation, particularly in the accuracy of DoLP and reference plane orientation.
			The red scale factor trends higher than the non-red factor by about 25%. This will result in a larger subtraction of the red data as compared to the non-red data. This will affect the radiometric data and we need to test the new correction.
OCI	Level 1A/B/C	All	Horizontal striping can occur for bands between 650nm and 900nm for scan angles from +3.9deg to +14.6deg (scan pixels 680 to 800). For open ocean scenes, the TOA signal usually varies less than 1%, but close to bright sources (such as a coastline) the striping over ocean can be severa..
			Occasional outliers are seen in OCI dark data, especially in the area of the South Atlantic Anomaly. These outliers can corrupt the background subtraction for a complete scan line, leading to striping in the L1B data. The algorithm to calculate the background subtraction in the L1B cod..
		NA	The optical design of the OCI SWIR detector assembly (SDA) causes the bands to view different locations along-scan at a given time, and the data are packetized by time. The bands are pixel-shifted into alignment with the hyperspectral bands. This results in fill pixels at the start or ..
	Level 2	All	The current processing extends to higher view zenith angles than the heritage sensors. The atmospheric correction becomes increasingly difficult at these extreme geometries, and erroneously elevated reflectance has been observed in red wavelengths near scan edge. These..
			When the OCI instrument tilt changes, near the subsolar point of the PACE orbit, the sensor passes through extreme glint conditions (direct specular reflection). This results in systematic artifacts in the Rrs retrievals due to error in the atmospheric correction. In V2, these cases were ..
		LANDVI (Land Surface Indices)	Contribution from aerosols is not currently removed from surface reflectance data, which may cause residual artifacts in vegetation index calculations.
			Data is cloud masked using the “Cloud and Cloud-Adjacent" product, which will mask extra pixels in the vicinity of clouds and bright targets.
			The NDSI algorithm does not currently incorporate a snow impossible mask.

Filter Sensor or Processing Level

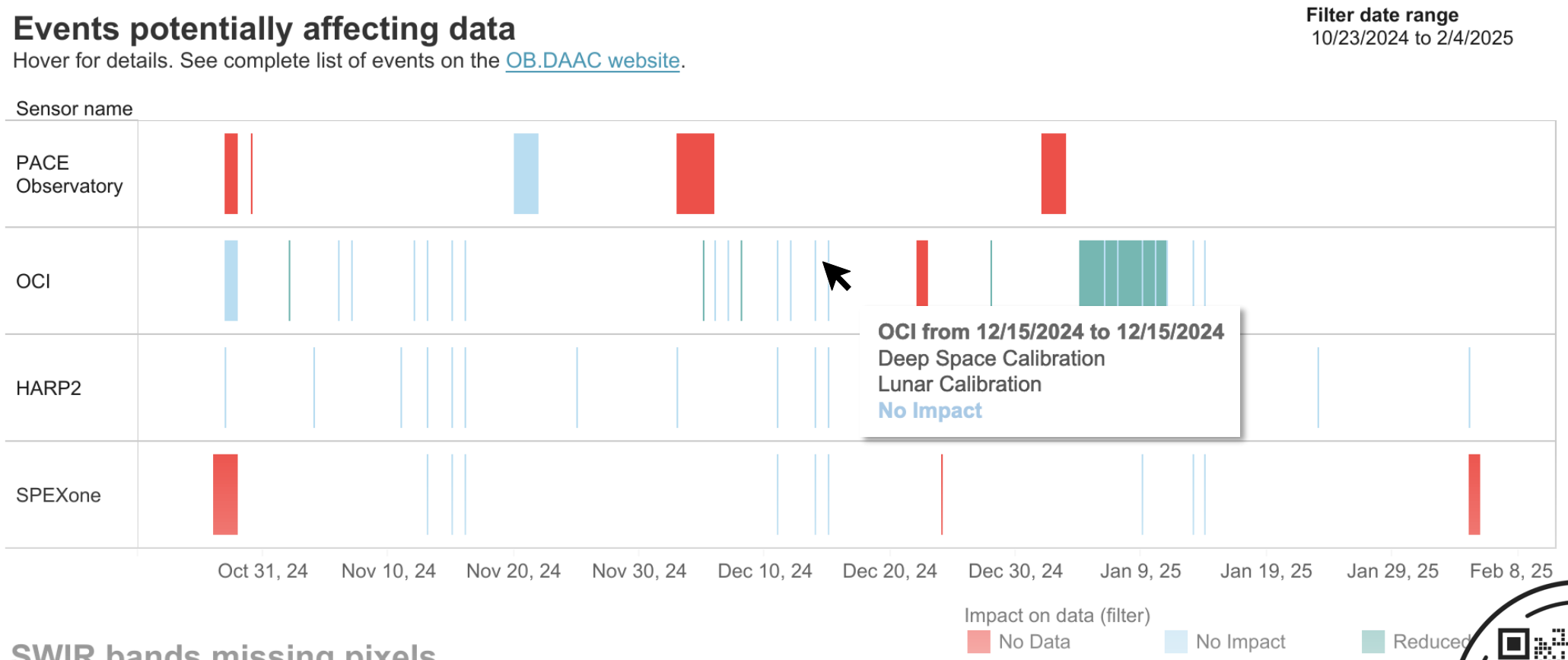
Sensor
- [x] HARP2
- [x] OCI
- [x] SPEXone

Processing level
- [x] Level 1A/B/C
- [x] Level 2
- [x] Level 3

[PACE Science Data Reprocessing: Version 3]

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

PACE DATA PRODUCTS – WHAT TO KNOW



[PACE Science Data Reprocessing: Version 3]

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

PACE DATA PRODUCTS – WHAT TO KNOW

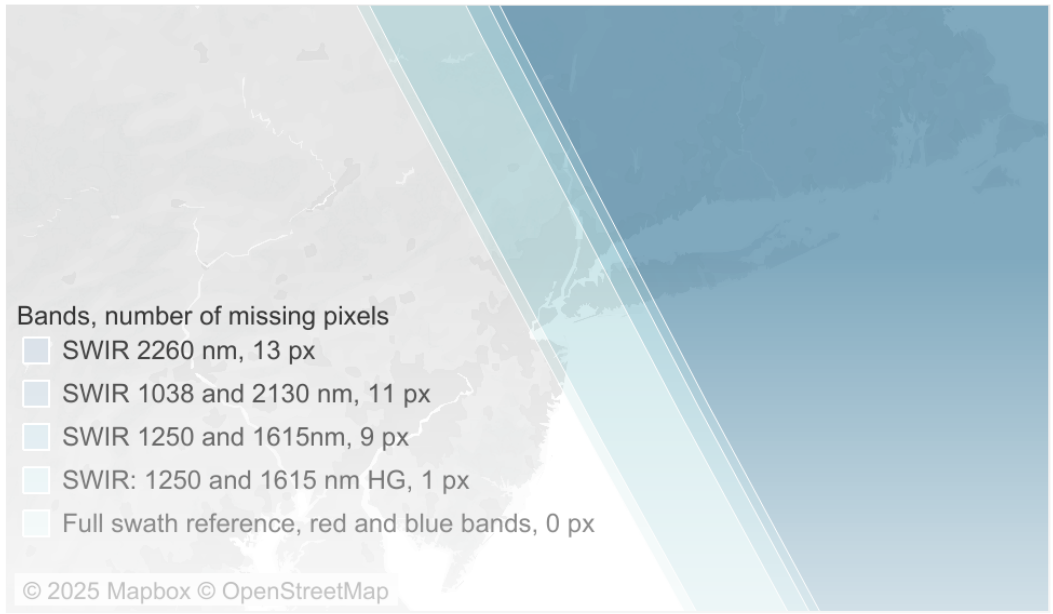
SWIR bands missing pixels

No Data No Impact Reduced Quality

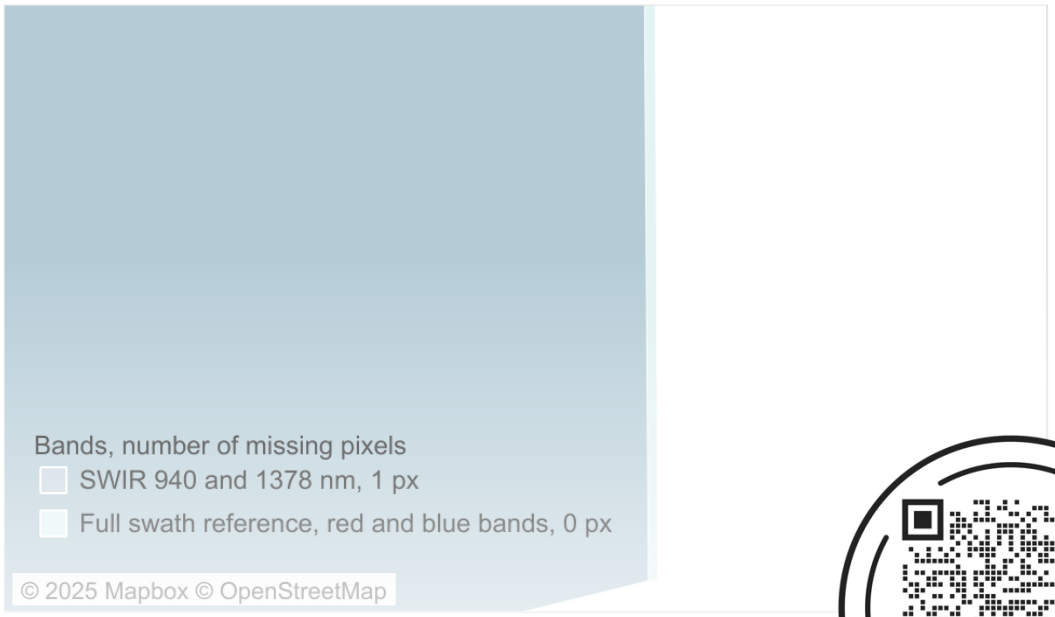
Some SWIR bands have missing pixels on either edge of the swath in L1B files. This is due to the fact SWIR have a different detector and are not registered to OCI's CCD bands. See L1A User Guide for more technical details.

Bands affected

on western edge of swath



on eastern edge of swath



PACE Science Data Reprocessing: Version 3

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

HELP HUB

Satellite data processing can be difficult.

We're here to help you climb out of that hole!



PACE

OCEAN COLOR
OB.DAAC | OBPG

NASA

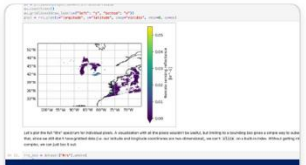
Help Hub Core

PACE | MODIS | Python | Interactive

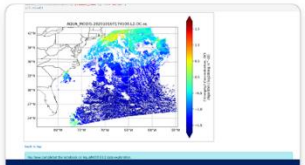
Learn the essential things you need to know to access and process data in this series of Jupyter Notebooks.



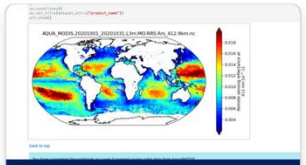
Cloud Data Access (OCI Example)



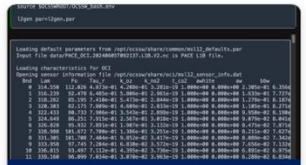
File Structure (OCI Example)



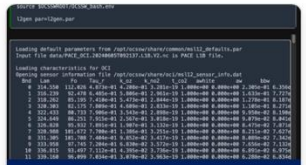
Explore Level-2 Ocean Color Data



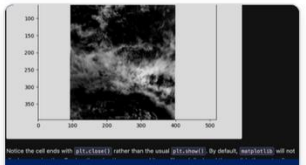
Explore Level-3 Ocean Color Data



Installing the SeaDAS Command Line Tools (OCSSW)



Processing with the SeaDAS Command Line Tools (OCSSW)



HARP2 Data Visualization

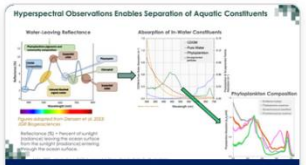
ARSET - Introduction to Plankton, Aerosol, Cloud, Ocean Ecosystem (PACE) Hyperspectral Observations for Water Quality Monitoring

PACE | Python | Interactive | SeaDAS

Follow the tutorials presented during the ARSET - Introduction to Plankton, Aerosol, Cloud, Ocean Ecosystem (PACE) Hyperspectral Observations for Water Quality Monitoring. Video recordings are available for all tutorials and slides and Jupyter Notebooks are available when relevant.



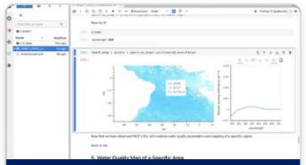
ARSET Training Home Page



Part 1: Introduction to the PACE Mission for Water Quality Monitoring



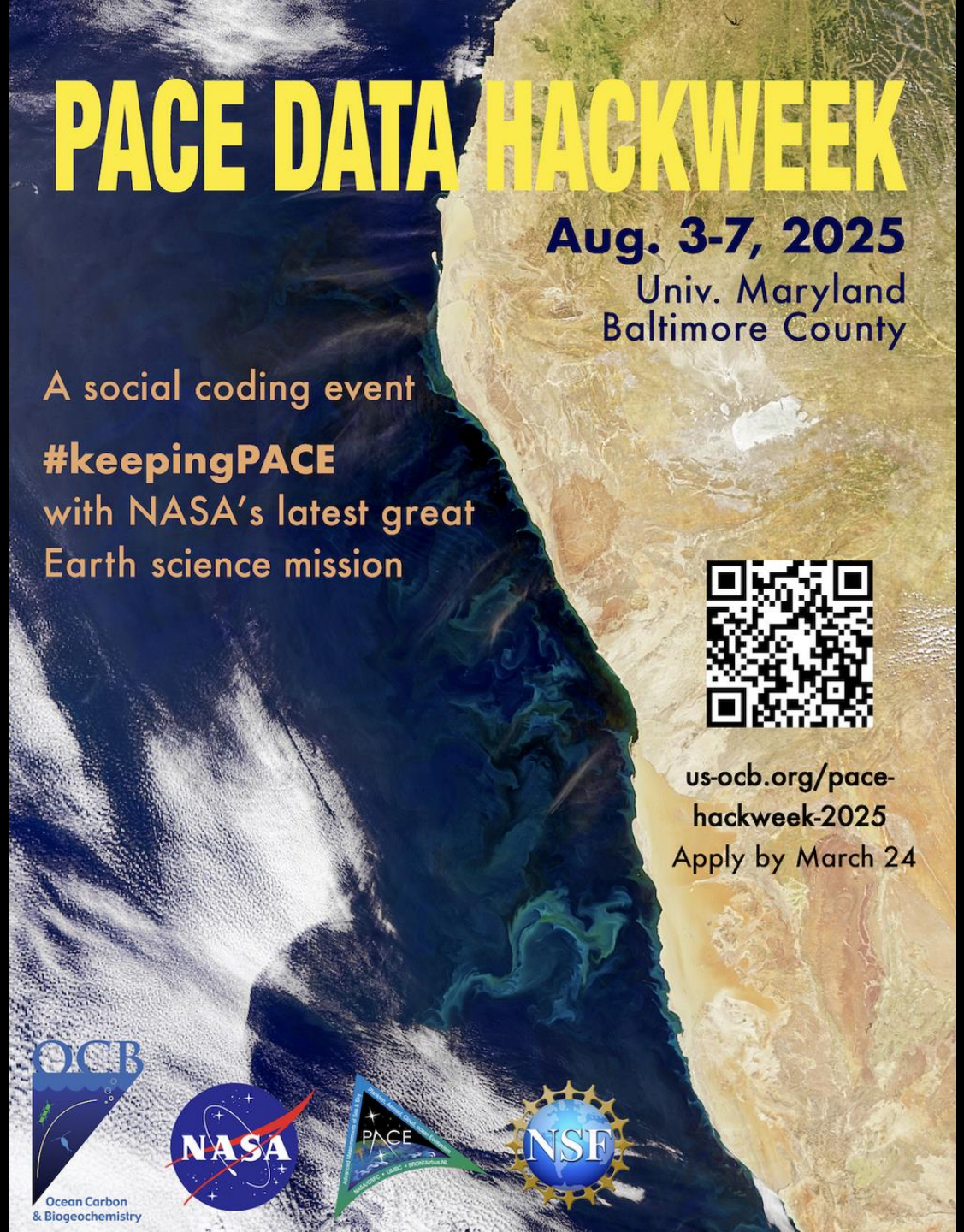
Part 2: Overview, Access, and Analysis of PACE Ocean Color Data Products



Part 3: Access and Visualization of PACE/OCI Data using Python/Jupyter Notebook Software



https://oceancolor.gsfc.nasa.gov/resources/docs/tutorials/


PACE DATA HACKWEEK
Aug. 3-7, 2025
Univ. Maryland
Baltimore County
A social coding event
#keepingPACE
with NASA's latest great
Earth science mission
us-ocb.org/pace-
hackweek-2025
Apply by March 24
OCB
Ocean Carbon
& Biogeochemistry
NASA
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NSF


Join the **PACE Community of Practice**
to stay updated on the mission
PACE