PACE Mission Overview & Updates

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PACE Applications
NASA Goddard Space Flight Center / SSAI

May 28th, 2025

NASA Biodiversity and Ecological Conservation Annual Team Meeting, Washington DC

Plankton Aerosol Cloud ocean Ecosystem (PACE) Observatory

- Global, 13:00 local equatorial crossing
- 3 yr mission (~10 yrs of propellant)
- Data products are free to all

3 instruments aboard:

- Hyperspectral scanning radiometer, OCI
- 2 multi-angular polarimeters, HARP-2 & SPEXone

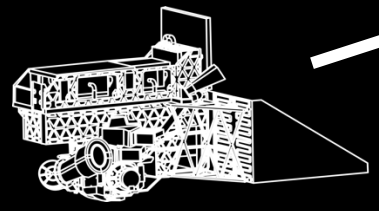
Science Goals:

PACE is NASA's next great investment to advance and extend ocean biological, ecological, and biogeochemical data records, as well as cloud, aerosol, [and terrestrial!] data records.

Ocean Color Instrument (OCI)

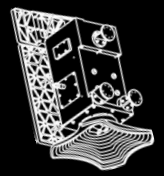
NASA Goddard Space Flight Center

- Hyperspectral scanning radiometer
- **Spectral:** 340-890nm (UV-NIR), 5nm bandwidth at 2.5nm steps, plus 7 SWIR bands
- **Temporal:** 1-2 day global
- **Spatial:** 1.2 km^2 at nadir



Hyper Angular Rainbow Polarimeter (HARP2)

University of Maryland, Baltimore County

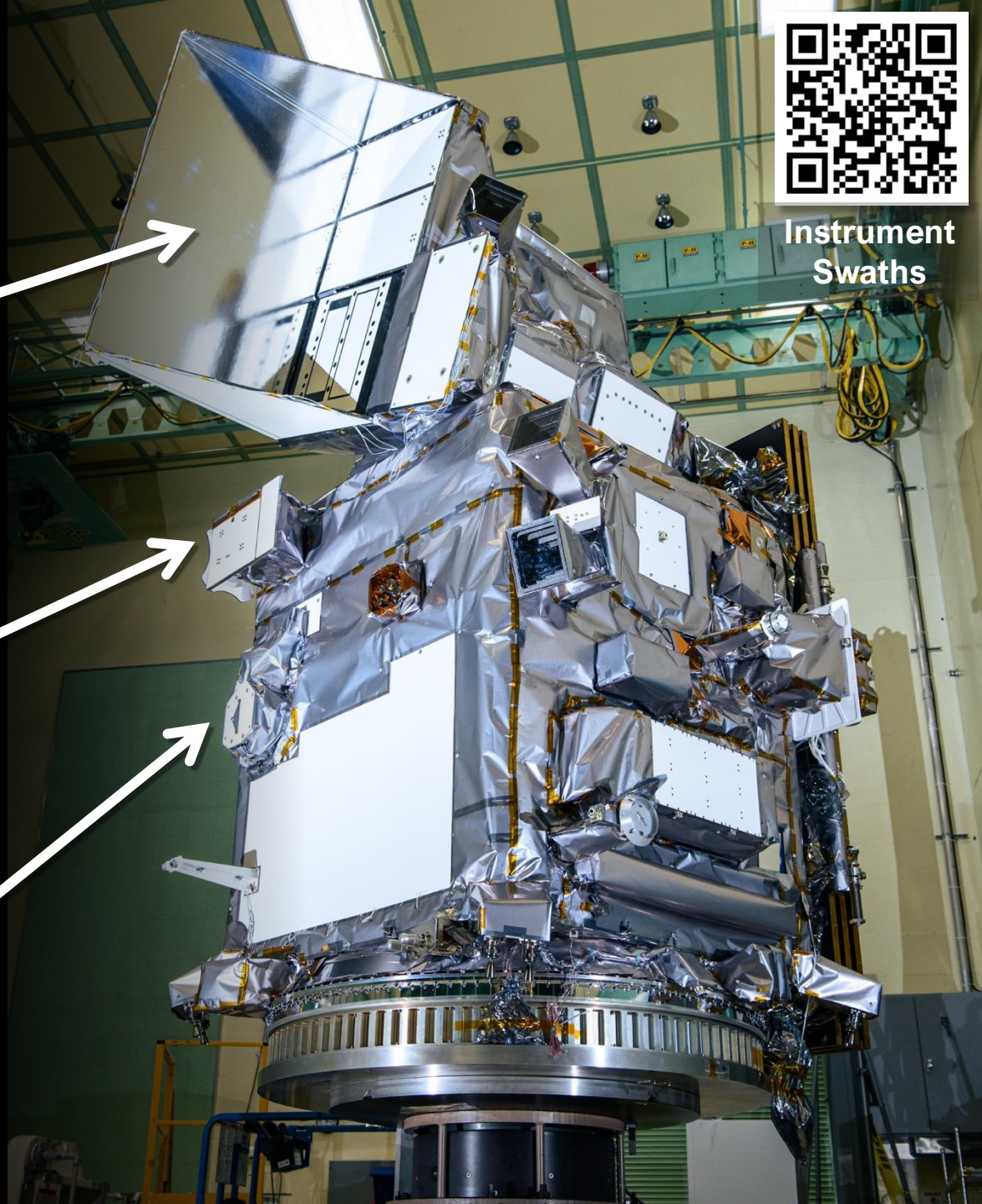


- Wide-swath, hyper-angular polarimeter
- 4 bands; 2 day global; 3 km^2 at nadir

Spectro-polarimeter for Planetary Exploration (SPEXone)

SRON/AIRBUS

- Narrow-swath, hyperspectral 380-770 nm (UV-NIR), 2-4 nm steps
- 5 viewing angles, >30 day global, 2.5 km^2 at nadir



Instrument Swaths

PACE products support applications across water, air, and land

We provide advanced products only from PACE as well as heritage products (e.g. from MODIS)

Ocean & large inland waters

Unique Product Examples: phytoplankton community composition, spectral remote sensing reflectance, etc

- Water quality monitoring
- Harmful algal bloom identification
- Fisheries support
- Post-disaster water quality impacts (hurricanes, wildfires, etc)

Clouds, Aerosols

Unique product examples: nitrogen dioxide, aerosol size distribution, aerosol type, aerosol absorption

- Air quality
- Aviation
- Disasters:
  - Volcanoes
  - Wildfires

Land

Unique product examples: enhanced vegetation indexes, spectral reflectance of land

- Terrestrial Ecosystem monitoring & management
- Agriculture
- Forestry
- Land cover type, burn area
- Continues heritage indexes such as NDVI, EVI, NDWI from MODIS

←**PACE DATA PRODUCT TABLE** https://pace.oceansciences.org/data_table.htm

*Up-to-date list of all **currently available** & **future** PACE data products. More added over time.*

*** Not all products shown above are available yet. See PACE Data Product Table for the latest.*

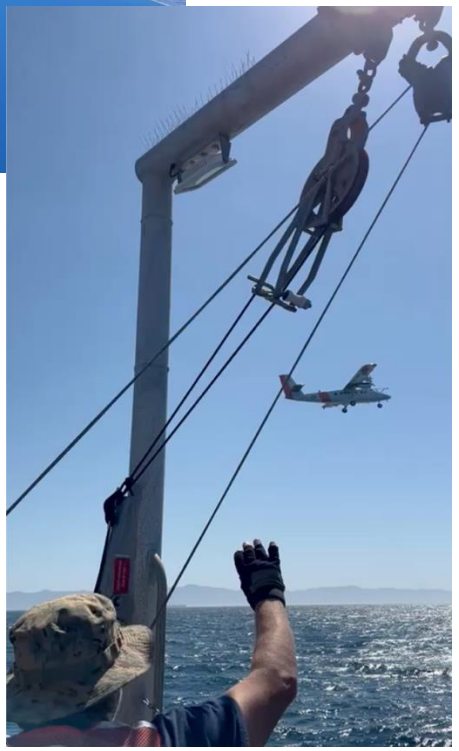
PACE Data Products: Status

- **Provisional data available for coasts, large inland waters, oceans on NASA Earthdata**
- Incrementally rolling out new data products every few months; ~14 months of data available
- **Data Version 3 (early 2025):** With each version data quality and number of available data products are elevated
- **Data quality:** PACE-PAX calibration & validation field campaign in southern California (Sept ’24, right images); also PACE Validation Science Team groups worldwide

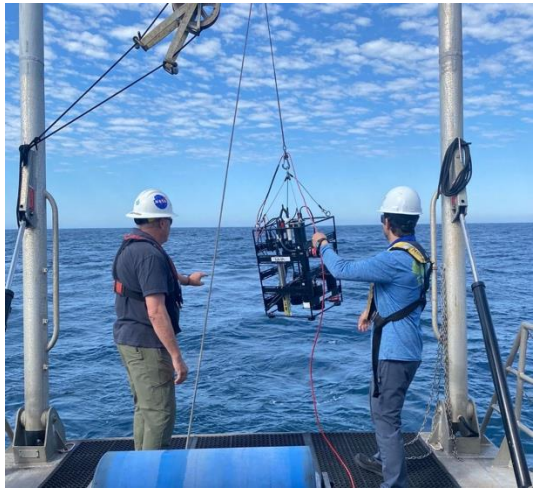
Left: *Santa Barbara, California & Channel Islands from ER-2 high-altitude aircraft*

Below: *Twin Otter aircraft flying over R/V Shearwater*

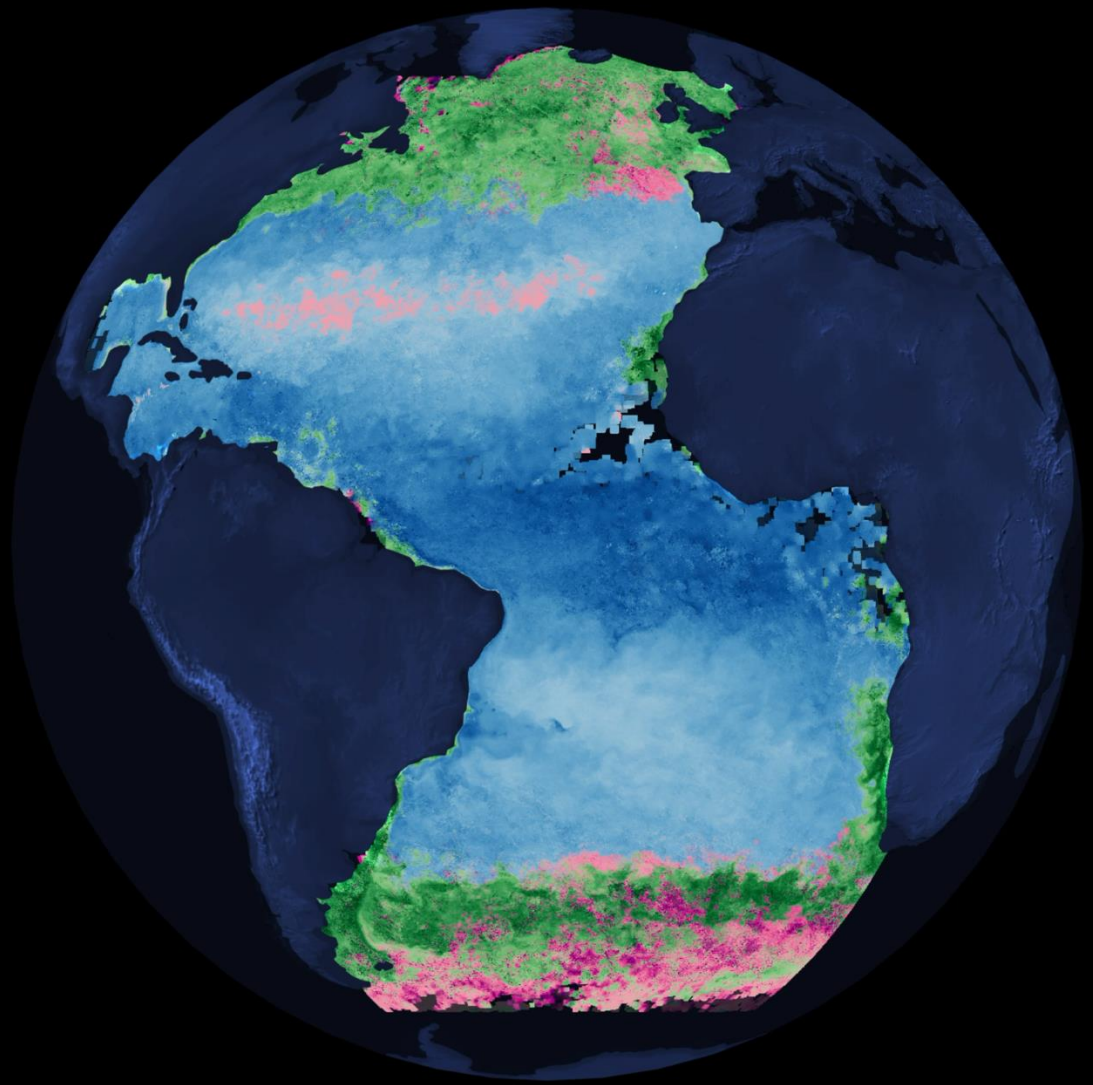
Credit: Ivona Cetinic



Below*: Water sampling aboard R/V Shearwater. Credit Kelsey McBeain*



National Aeronautics and Space Administration



RELATIVE DOMINANCE OF INDIVIDUAL PLANKTON GROUPS

Picoeukaryotes
Synechococcus
Prochlorococcus

0 1

Normalized abundance

MOANA algorithm PACE - OCI

Rolling 32-day average

April 2024

BINGQING LIU, UNIV OF LOUISIANA: PACE SCIENCE & APPLICATIONS TEAM

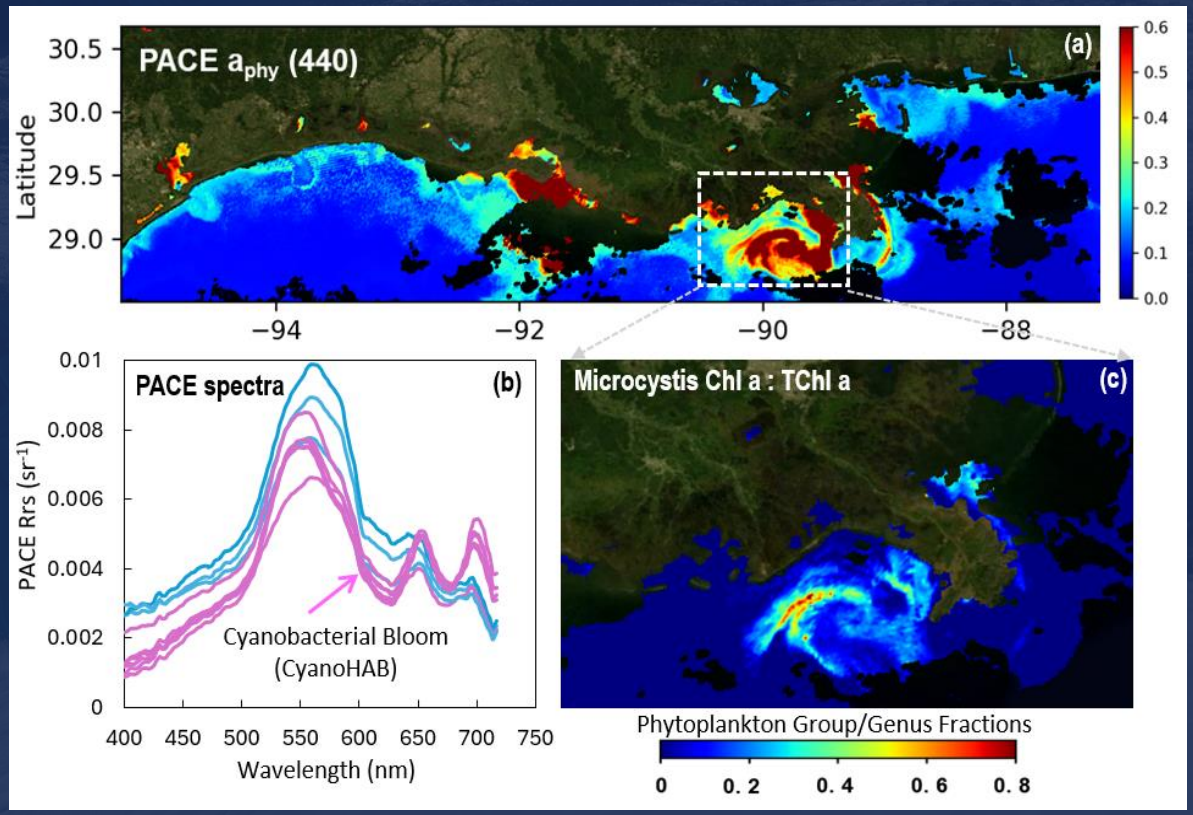
MONITORING WATER QUALITY IN LOUISIANA

The Problem: The U.S. imports up to 85% of its seafood. Strengthening domestic aquaculture is critical for food security & coastal economies but depends on effective management of water quality risks.

The Solution: PACE provides spectral signatures of algal blooms and sedimentation, which supports aquaculture (e.g., oyster beds) operations and response to water quality risks.

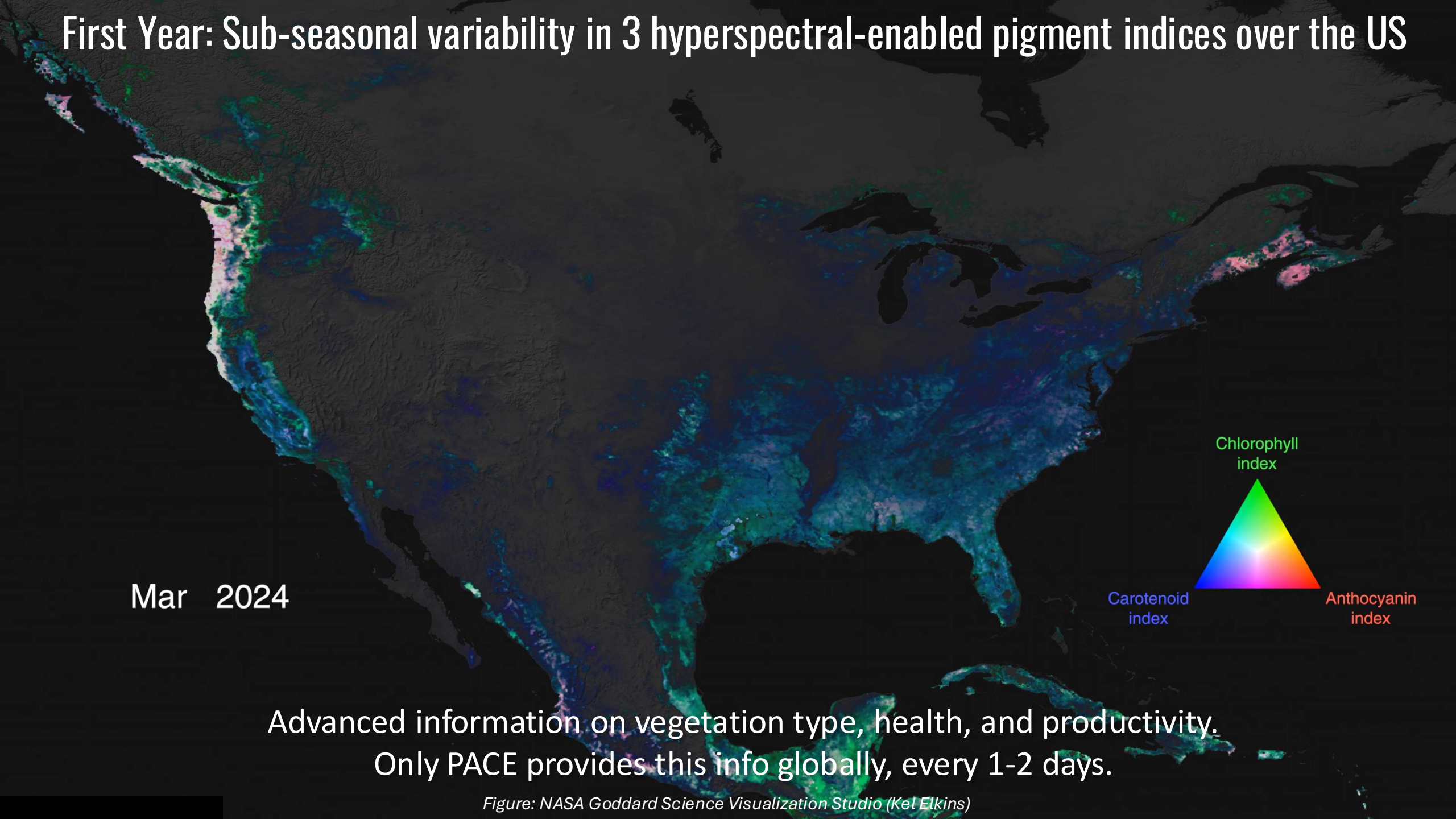
An unexplained oyster die-off in January 2020, accompanied by blue-green algae bloom in Louisiana's lower Barataria Bay (NOLA.com).

Off the southern coast of Louisiana (top image) PACE's enhanced spectral detail (bottom left) identifies a cyanobacterial harmful bloom (bottom right)



(a) PACE imagery of phytoplankton absorption at 440 nm derived from Machine learning model (Lou et al., 20) over Mississippi Delta; (b) PACE spectral signatures of CyanoHAB; and (c) Chl-a concentrations predicted for Microcystis spp.

First Year: Sub-seasonal variability in 3 hyperspectral-enabled pigment indices over the US



Advanced information on vegetation type, health, and productivity.
Only PACE provides this info globally, every 1-2 days.

Figure: NASA Goddard Science Visualization Studio (Kel Elkins)

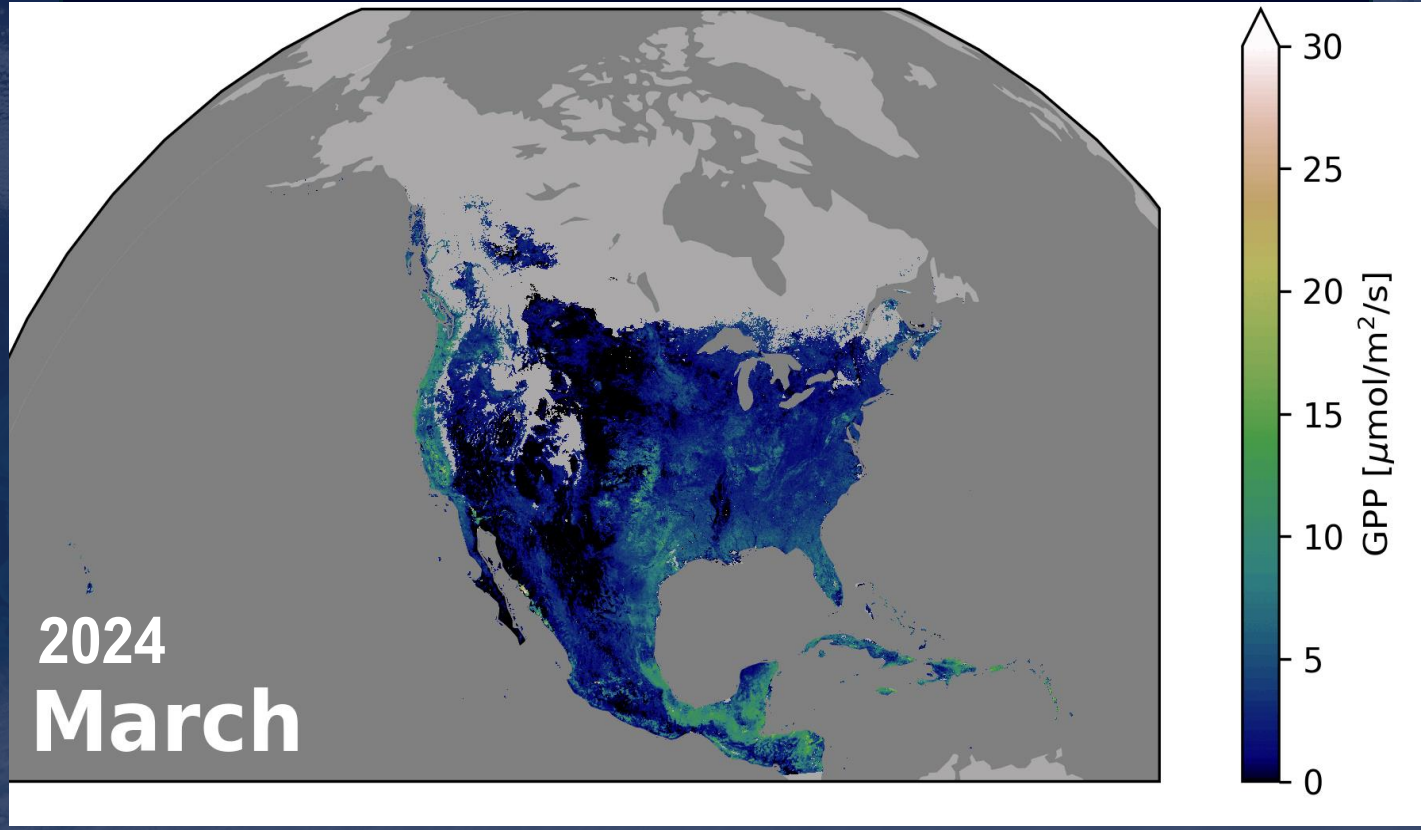
FRED HUEMMRICH, UMBC, PACE SCIENCE & APPLICATIONS TEAM

NEW TERRESTRIAL ECOSYSTEM PRODUCTIVITY ALGORITHM

Ecosystem productivity is the foundation of the food chain & the energy that provides ecosystem services.

- New algorithm relates PACE OCI spectral reflectance with gross primary production (GPP) from eddy covariance flux data from 47 towers spanning the USA's major ecosystem types
- **PACE OCI's unique data collection provides far more sites, better temporal coverage for training, and the repeated observations needed for continental scale maps.**
- GPP from PACE supports agriculture and forestry applications by independently describing seasonal and transient variability in productivity

New PACE GPP product (below), is **uniquely calculated only on spectral reflectance**, hence is an **independent measurement,** unlike previous satellite GPP models that rely on ancillary environmental data.



Work supported by NASA PACE Science & Applications Team through GESTAR-II Coop Agreement Award #80NSSC22M0001.

In review at IEEE Geoscience and Remote Sensing Letters
Preprint: DOI: 10.36227/techrxiv.174345071.16031701/v1

ZACH FASNACHT, SSAI: PACE SCIENCE & APPLICATIONS TEAM #2

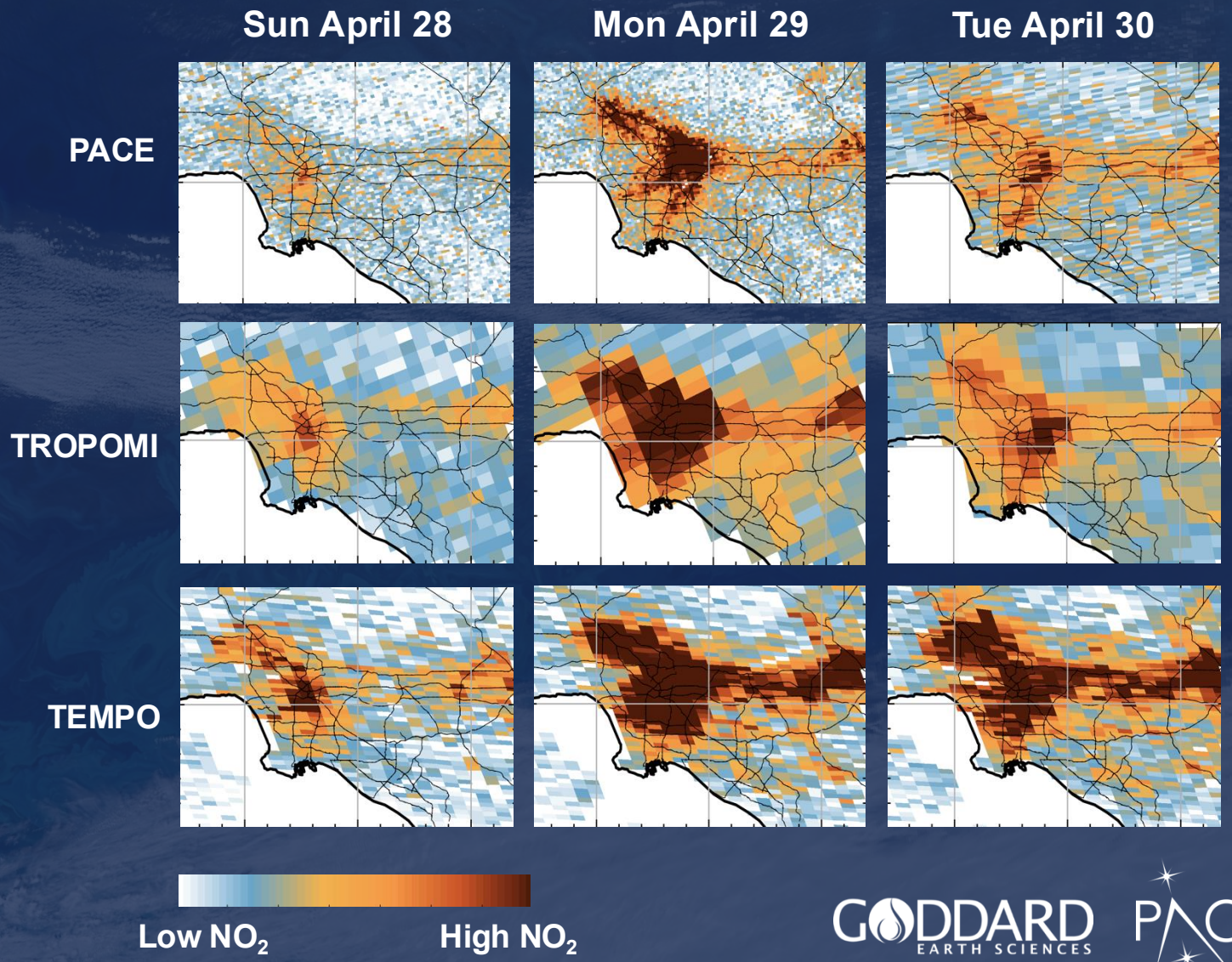
NOVEL, HIGH SPATIAL RESOLUTION NITROGEN DIOXIDE (NO_2)

Ground-breaking, high-resolution NO_2 data: reveals emission sources at scales of individual highways (right) & point-source factory emissions that are not always visible using other satellites

Enabled by Earth observation synergy: NO_2 from PACE is made possible by machine learning using NASA's TROPOMI satellite retrievals & OCI's uniquely hyperspectral & high spatial resolution (compared to TROPOMI) observations

EXCITING NEW AIR QUALITY PRODUCT POTENTIAL

NO_2 from PACE can enable synergistic identification of emission sources (PACE OCI) and direction of plume movement (TEMPO) at uniquely high time/space scales **directly relevant to on-the-ground air quality applications needs**



Credit: Fasnacht et al.

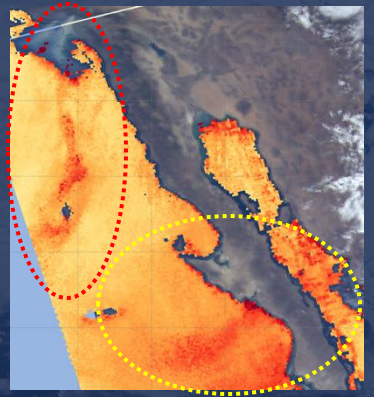
GODDARD EARTH SCIENCES PACE

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

THE PACE/HARP2 MULTI ANGLE POLARIMETER MONITORS SMOKE

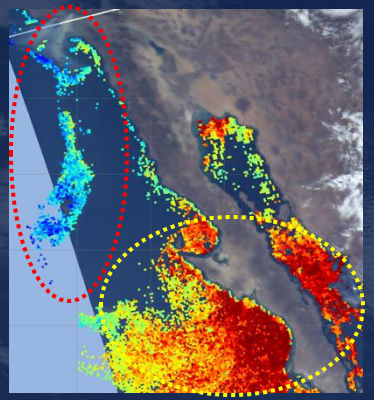
By applying the NASA-developed FastMAPOL algorithm to HARP2's advanced data, we can distinguish between smoke and other types of atmospheric particulate pollution like dust

Aerosol optical depth (550nm)
(Aerosol quantity)



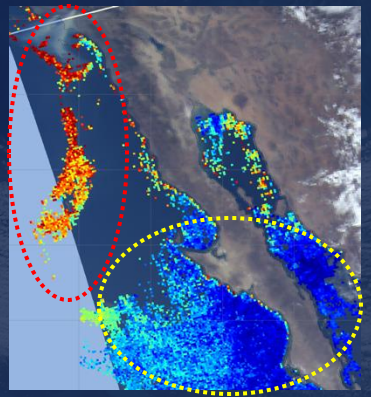
Less aerosols *More aerosols*

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



Absorbing aerosols *Scattering aerosols*

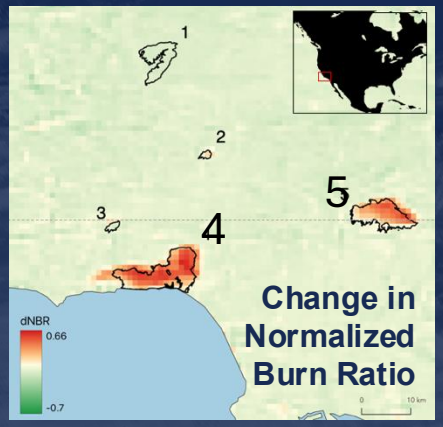
Fine mode fraction
(Dominant aerosol size)

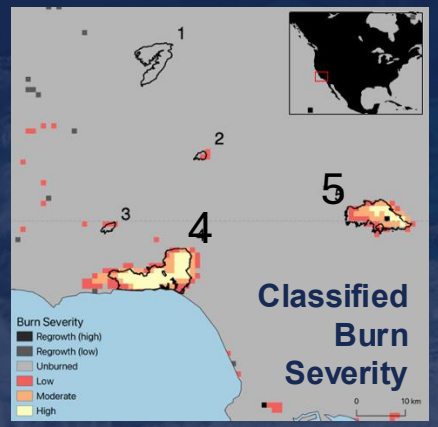


Small aerosols *Large aerosols*

THE PACE/OCI HYPERSPECTRAL IMAGER MONITORS BURN SEVERITY

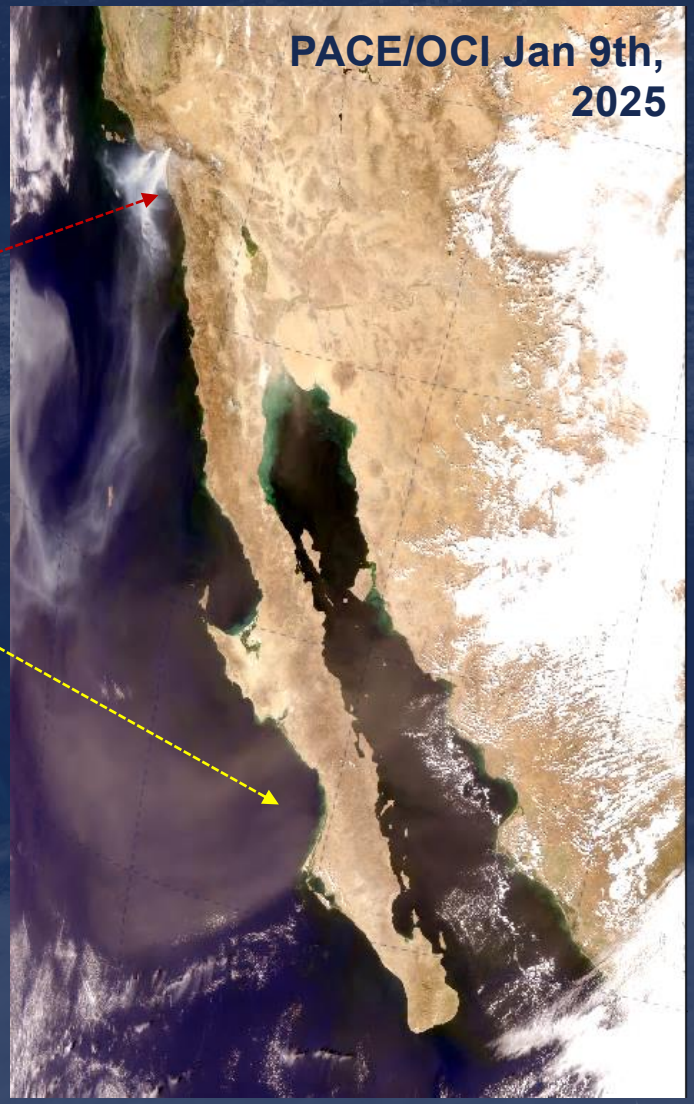
Change in Normalized Burn Ratio (dNBR) indicates burn severity. Due to PACE/OCI's global coverage and high temporal revisit, dNBR can be assessed rapidly following a fire.





4. Palisades Fire (1/07/2025)

5. Eaton Fire (1/07/2025)



GODDARD EARTH SCIENCES PACE

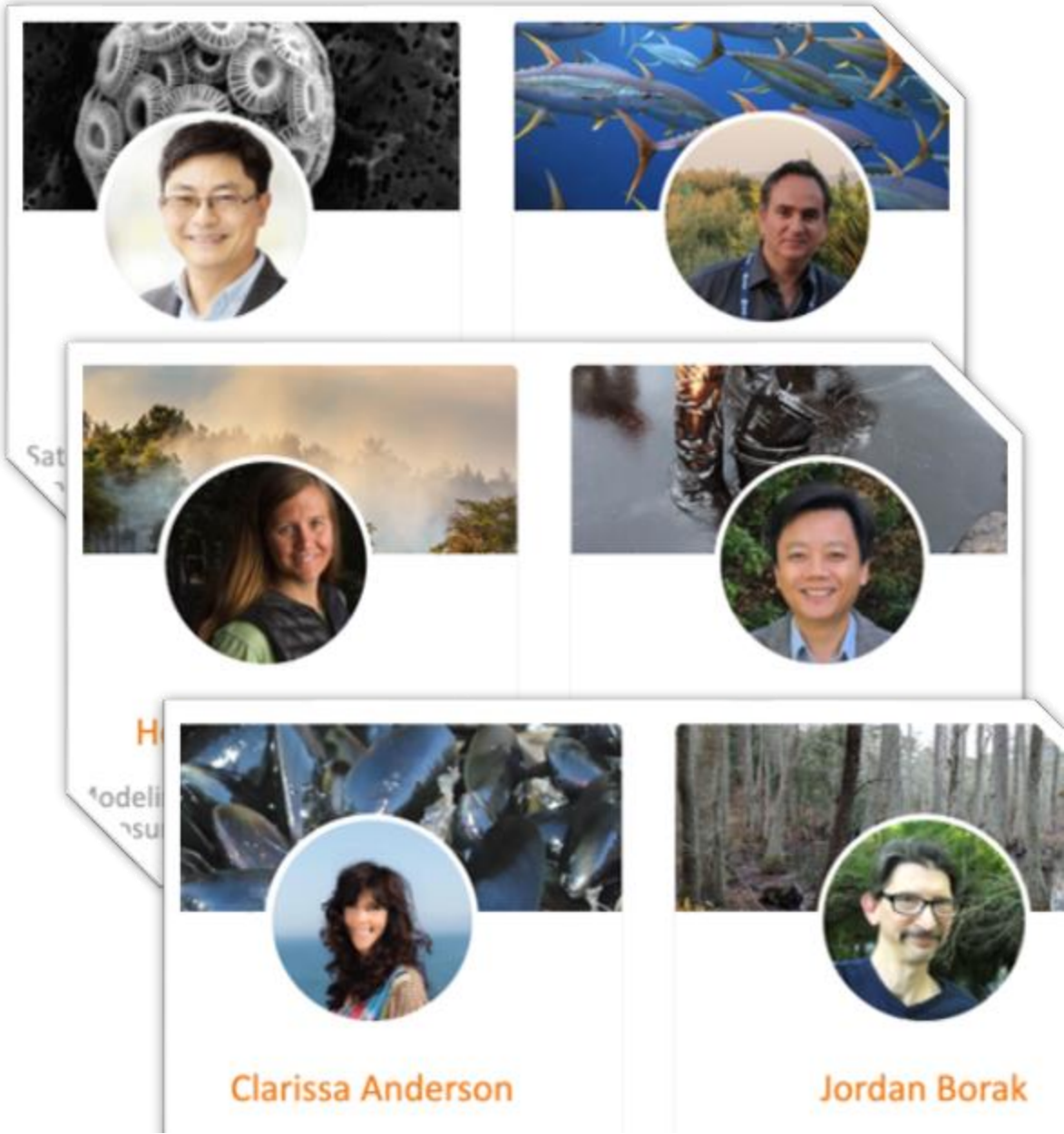
PACE Applications Partners

JOIN US, become a PACE Applications Partner:

- **PACE Applications works with individuals and groups across public, private, non-profit, university, etc. sectors** who are looking integrate PACE data into decision-making, business, resource management and more.
- **Does your applied project have direct health, economic, and/or other benefits to society?**
- **Partnerships specifically amplify applied research and development efforts** and accelerate the translation of PACE observations into action

← Learn more, see examples of Applications Partners, and consider APPLYING!

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



Upcoming PACE Applications Events

Receive Event Updates & Access via PACE-Community mailing list

Email pace-community-join@lists.nasa.gov with "subscribe" in the subject

Events also announced at: https://pace.oceansciences.org/events.htm

Join our mailing list

July 1st, PACE Land data Users' Group Meeting, 2-3pm ET (2nd meeting)

- Topics: PACE & GEE, GIS; PACE data conversion tutorial; guest land applications speaker

July 24th, PACE-SWOT Tutorial, 2-4pm ET

- Learn each missions' capabilities & how they're complimentary; gain hands-on experience with SWOT & PACE data via a live, interactive session in Jupyter Notebooks.

August 14th, PACE Community of Practice Quarterly Telecon, 2-3pm ET

- Mission & Applications Updates; PACE polarimetric data & applications

September 24th & 26th: 6th Annual PACE Applications Workshop

- Save-the-date! Virtual workshop.

Key PACE Resources: Data Access, Tutorials, Applications, Events

- PACE Data Access Page (START HERE; live page, read through, one stop for data access info): https://pace.oceansciences.org/access_pace_data.htm
- PACE Data Product Table (live page; all current/planned PACE products): https://pace.oceansciences.org/data_table.htm
- OB.DAAC Help Hub (Jupyter Notebooks and other tutorials for accessing & visualizing PACE data): https://oceancolor.gsfc.nasa.gov/resources/docs/tutorials/
- PACE Upcoming Events: https://pace.oceansciences.org/events.htm
- PACE Applications Partners – *Join us!* https://pace.oceansciences.org/app_adopters.htm
- PACE Applications Events Archive: https://pace.oceansciences.org/event_archive/index.htm

PACE

- **The next generation of space-based science & applications is here with PACE**
- PACE uniquely provides global, hyperspectral coverage of the land & oceans every 1-2 days, plus hyperspectral/hyperangular polarimetry
- PACE will benefit society via **advancements in space-based applications** across land, air & water.

https://pace.gsfc.nasa.gov

Follow us: @NASAOcean

Archive of the 1st PACE Land data Users' Group Meeting (April 14th)

Stay up-to-date!
Join the PACE Community email list!

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