Hyperspectral & polarimetric ocean observations from space!

How the NASA PACE Mission will advance environmental & societal applications in disaster management

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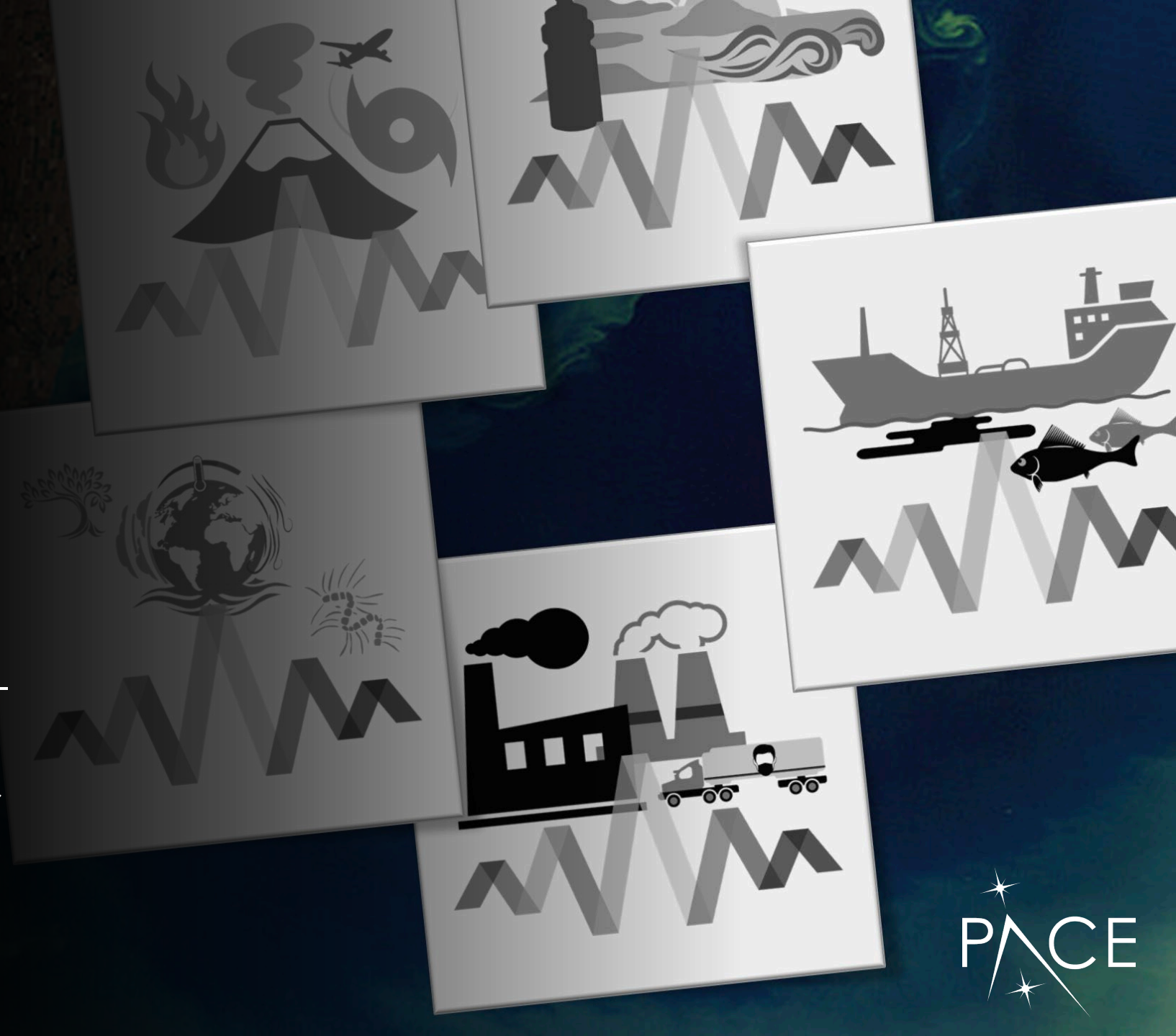
Annual Climate Prediction Applications Science Workshop

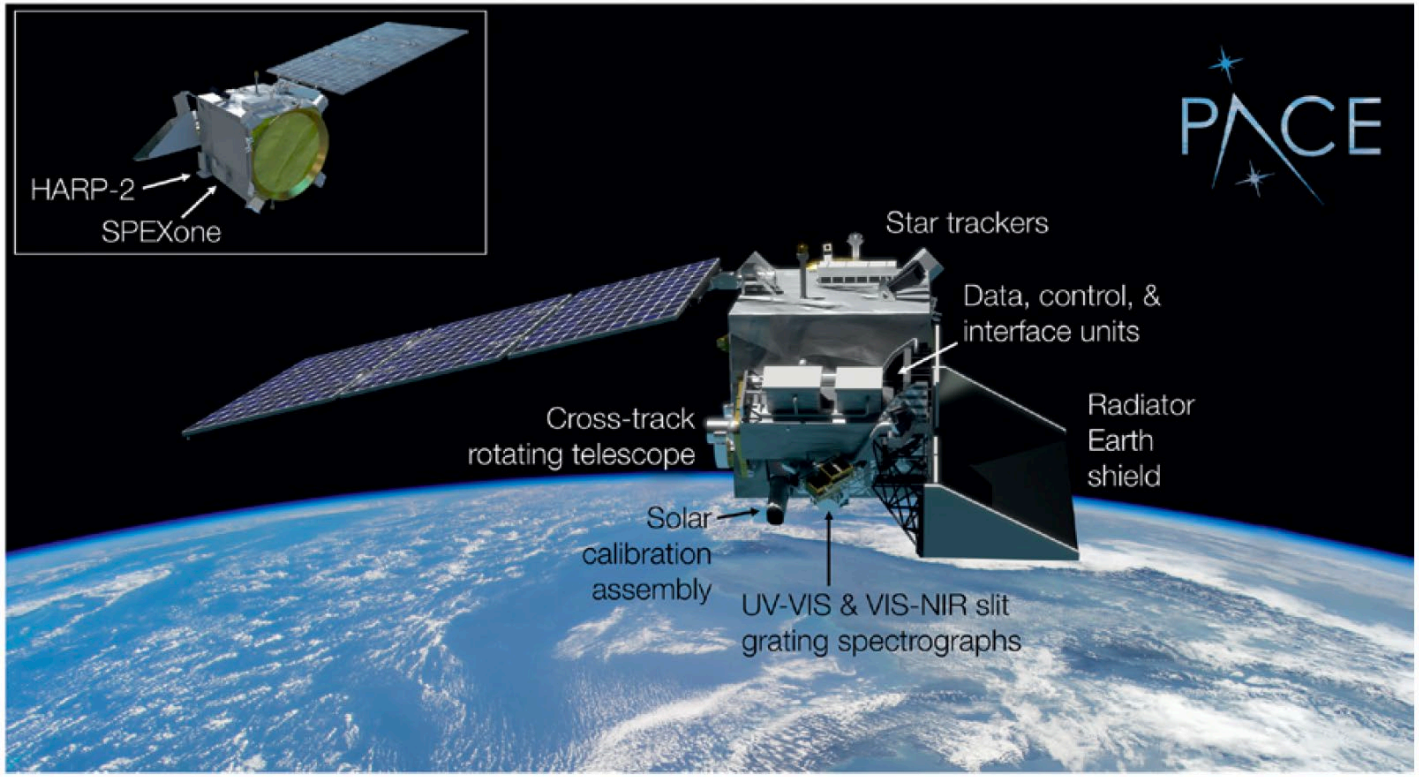
May 11, 2023



PACE Observatory

- Anticipated Launch: **January 9, 2024**
- 13:00 local Equatorial crossing; Global
- 3yr mission, BUT at least 10yrs of propellant
- **Instruments:**
  - Hyperspectral imager: **Ocean Color Instrument (OCI)-** 5 nm for 340-890 nm at 2.5 nm steps
    - 2-day global coverage
    - 1 km^2 at nadir
  - Two multi-angle polarimeters:
    - **HARP-2** (wide-swath, hyper-angular, 4 bands; 3km^2 nadir)
    - **SPEXone (**Narrow swath, 5 viewing angles, hyperspectral (UV-NIR), 2.5km^2 nadir)
- **Data will be free & open to all**
  - All products will be hosted at the GSFC Ocean Biology Distributed Active Archive Center (OB.DAAC) and be available via other portals such as NASA Worldview

PACE is NASA's next great investment to extend ocean biological, ecological, & biogeochemical data records, as well as cloud & aerosol data records!



Extend key systematic **ocean** biological, ecological, & biogeochemical climate data records, as well as **cloud** & **aerosol climate data records**

Make **new global measurements of ocean color** that are essential for understanding the global carbon cycle & ocean ecosystem responses to a changing climate

Collect **global observations of aerosol & cloud properties**, focusing on reducing the largest uncertainties in climate & radiative forcing models of the Earth system

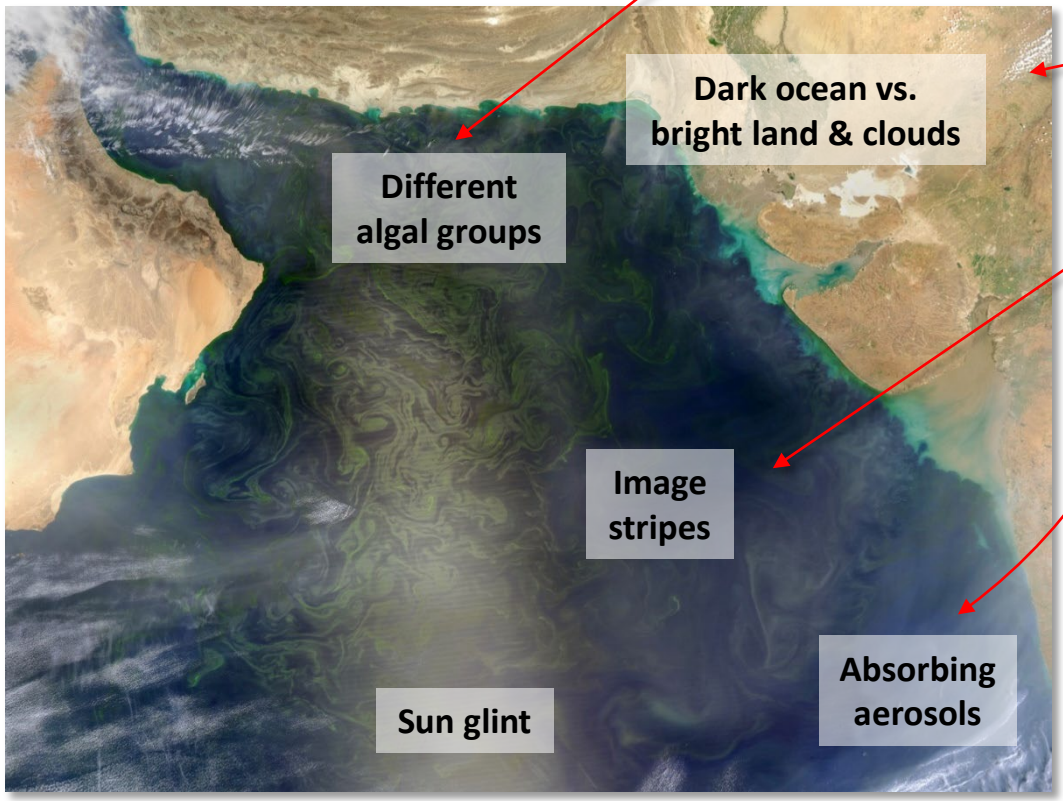
GSD of 1 ± 0.1 km^2 at nadir

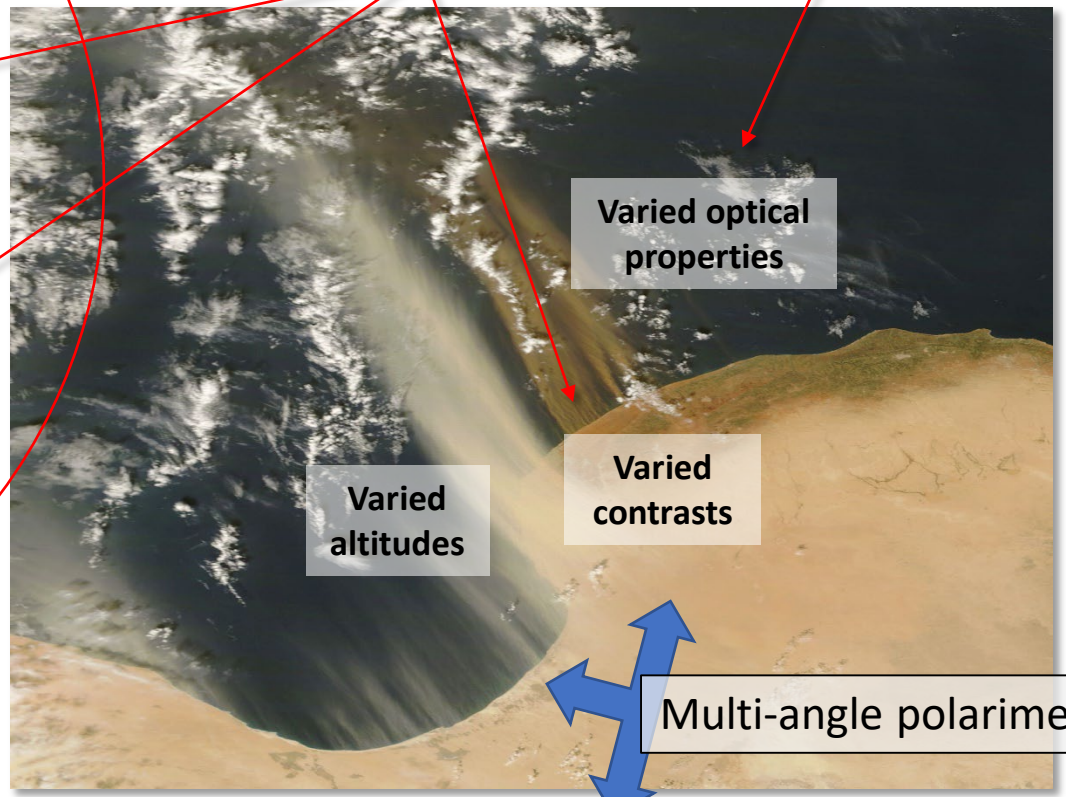
Twice-monthly lunar calibration & onboard solar calibration (daily, monthly, dim)

Spectral range from ≤340-890 @ ≤5 nm

940, 1038, 1250, 1378, 1615, 2130, 2260 nm

Instrument performance requirements

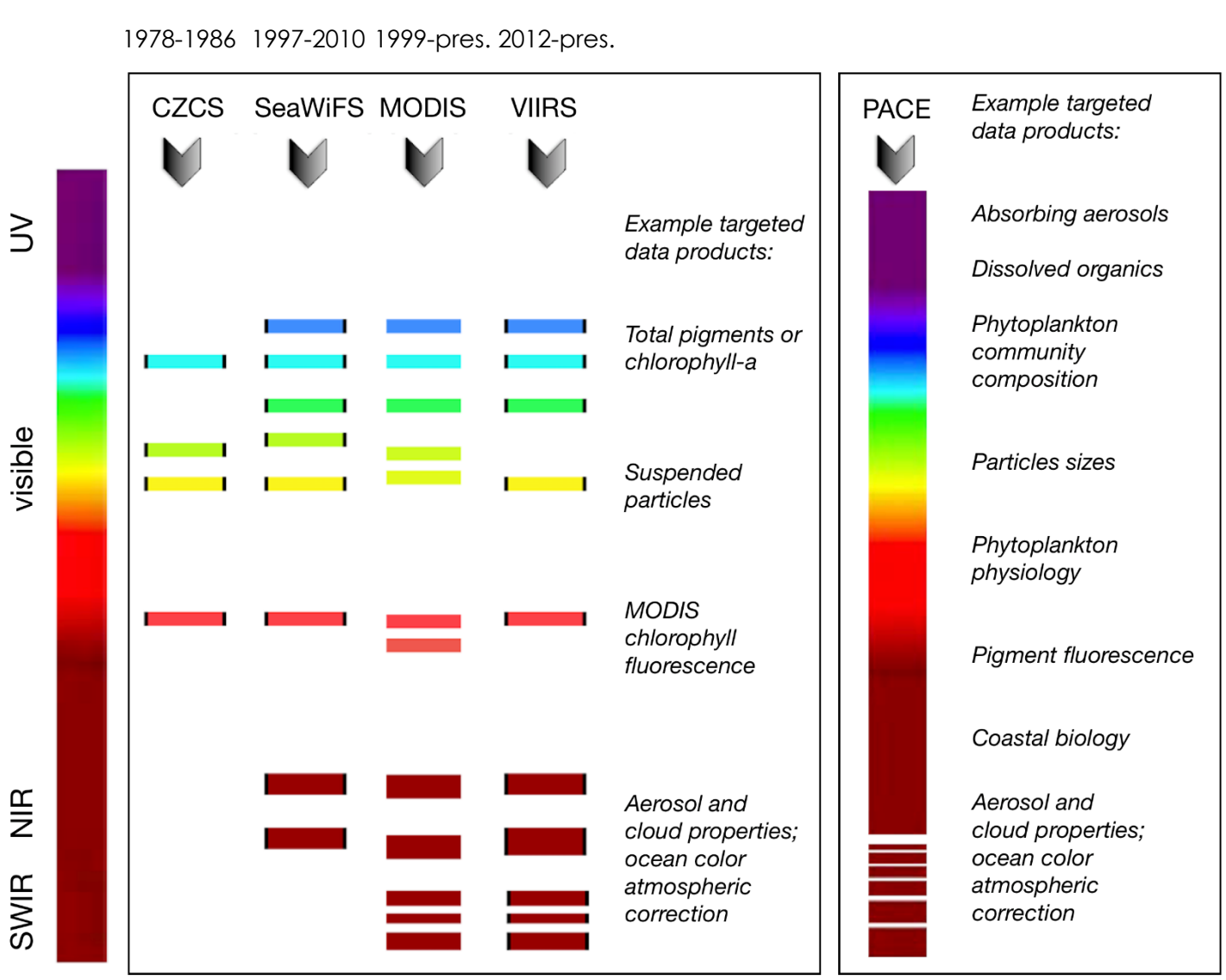




Tilt ± 20°

Improve our understanding of how **aerosols influence ocean ecosystems & biogeochemical cycles** and how **ocean biological & photochemical processes affect the atmosphere**

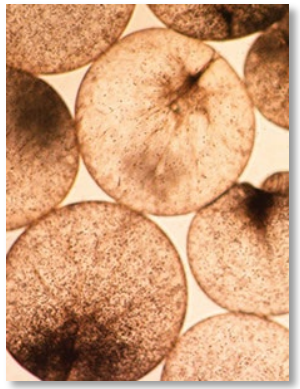
Moving from multi-spectral radiometry to spectroscopy



Example diatom

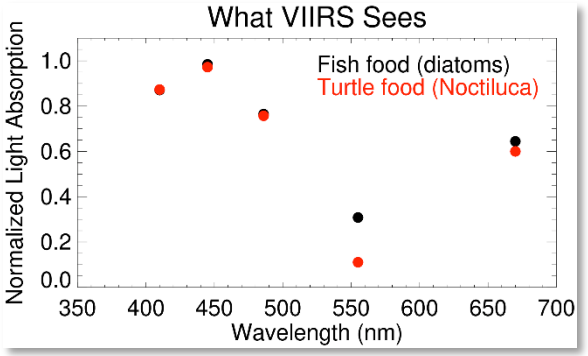
Linda Armbrecht, abc.com.au

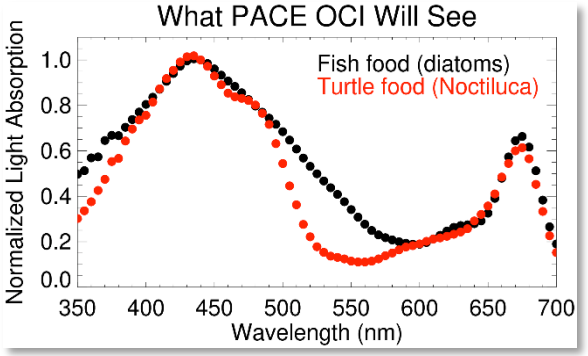
Example Noctiluca



Joaquim Goes, LDEO

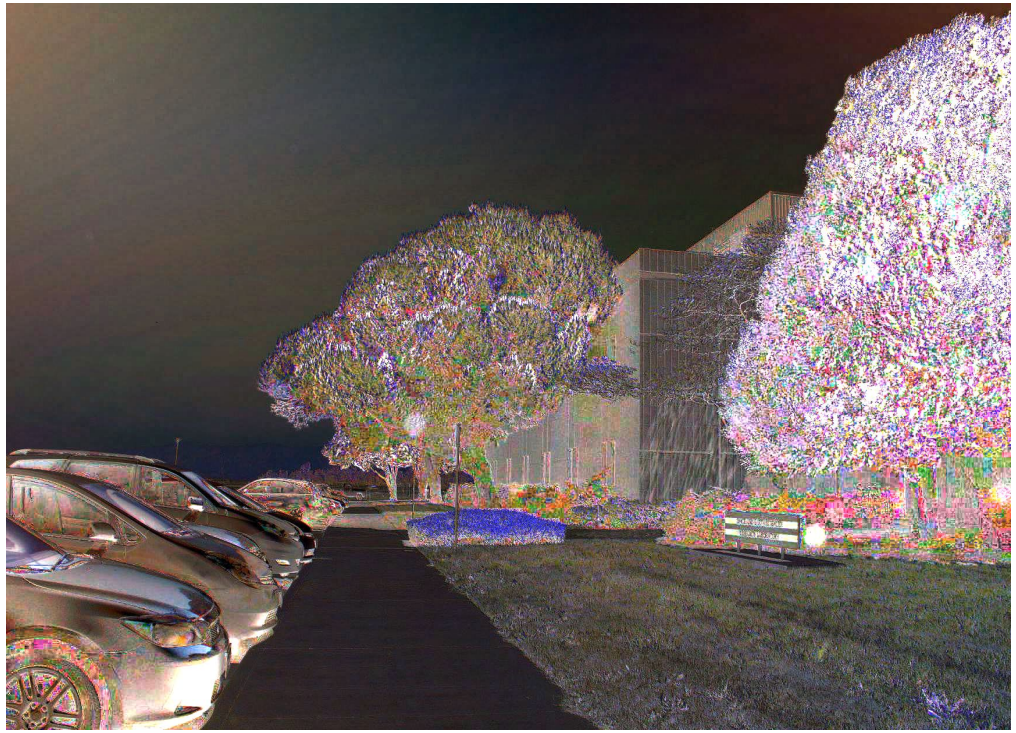
Signals from the water are small & differentiating between constituents requires additional information relative to what we have today





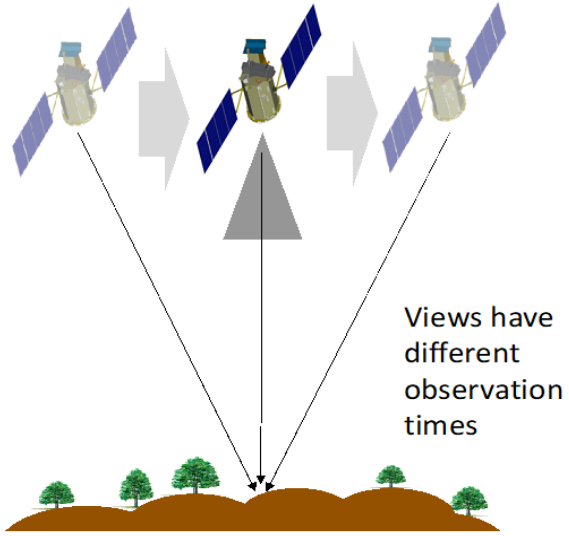
Polarimetry

Similarly, *polarization* provides another dimension of information.

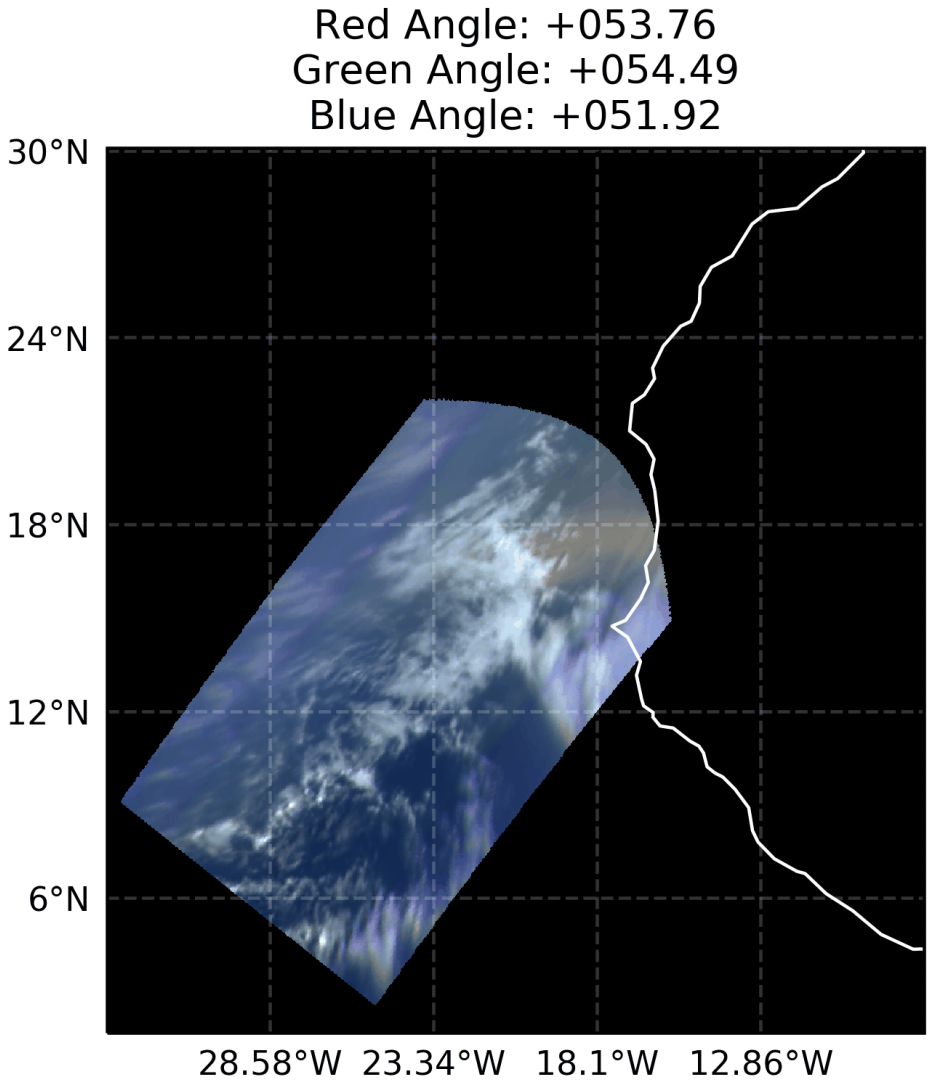


Multi-Angle Remote Sensing

The *multi-angle* aspect of PACE's polarimetry further improves characterization of aerosol particles, clouds, and surface cover.



HARP Cubesat RGB image
J. V. Martins (UMBC) and team



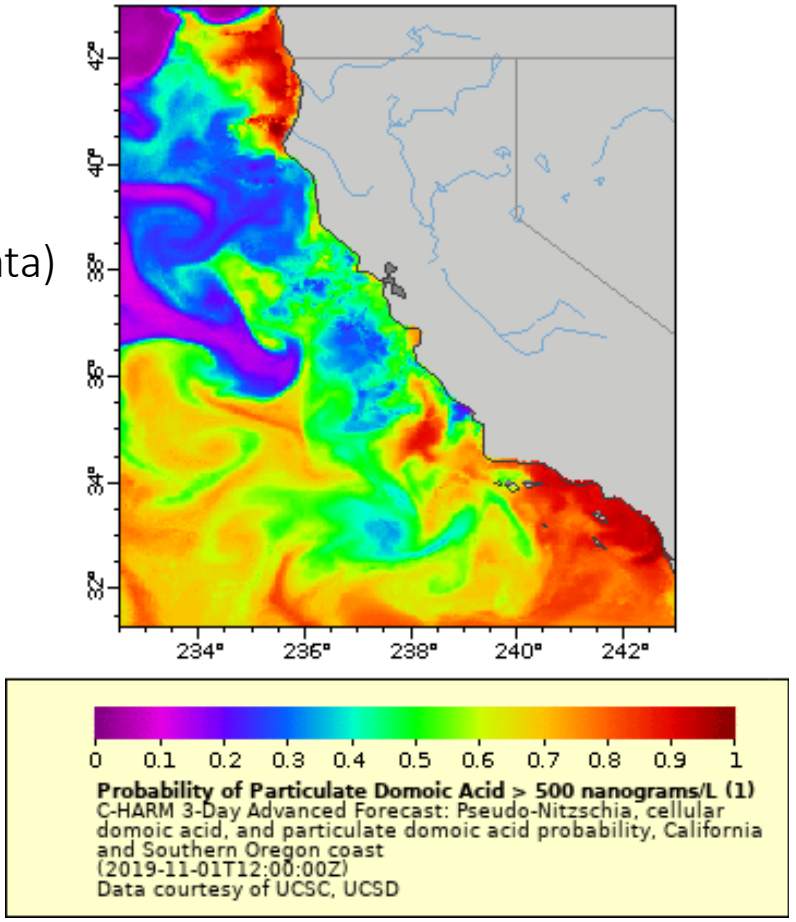
New PACE Technology = Interdisciplinary Applied Science Objectives

PACE Applications: Disasters

Informing Applications with PACE Data: Monitoring and Managing Disasters

Applicable across application areas, PACE will provide data on that can inform disaster risk management, including reduction, mitigation, and response of disasters such as:

- Wildfire smoke (aerosol data)
- Volcanic ash emissions pre- or post-eruption (aerosol, SO2 data)
- Harmful algal blooms and fish kills/hypoxia (phytoplankton, chlorophyll data)
- Oil seeps and spills (optical properties, reflectance)
- Hurricane/weather monitoring (cloud data)



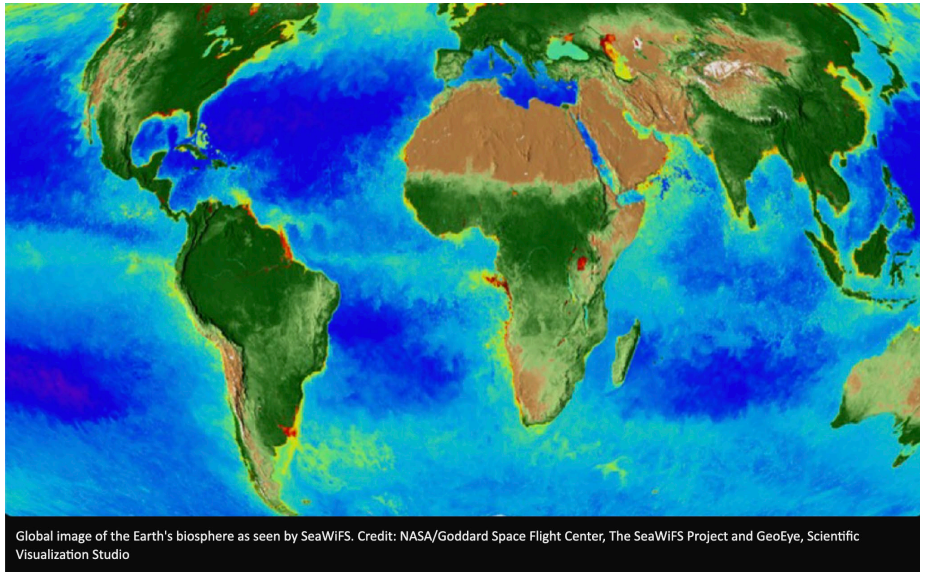
Left: *Smoke plume rising over Reno, Nevada.*
Middle: *Thick blooms of green Noctiluca scintillans threaten water quality, public health, tourism, and the operations of many coastal industries in Oman.*
Right: *Animation showing the probability of particulate Domoic Acid concentration greater than 500 nanograms per liter in seawater off the U.S. west coast during Nov 2019. Reds and oranges indicate higher probabilities while purples and blues show lower probabilities.*

PACE Applications: Terrestrial/Land

Informing Applications with PACE Data: Monitoring and Managing Terrestrial/Land Ecosystems

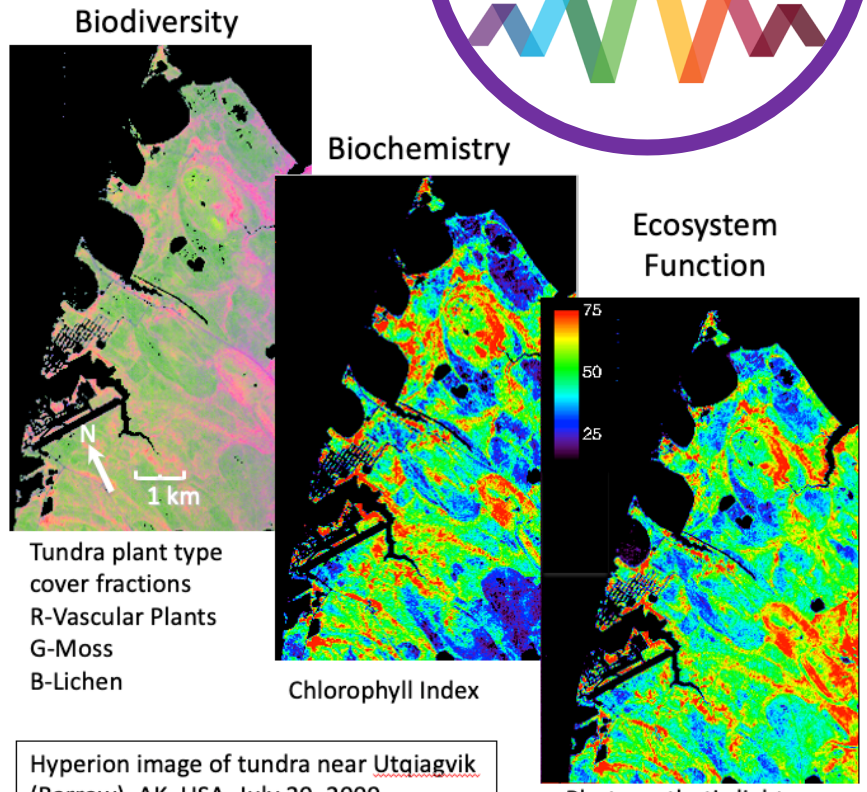
PACE will provide data on surface vegetation, including surface reflectance, BRDF, NDVI, and other indices, which can describe dynamics of key terrestrial vegetation biochemical and functional characteristics. This can benefit, inform, or improve:

- Monitoring watershed health for best management practices, including impacts to wetlands, forests (cover and type), and other ecosystems from insect outbreaks, fires, seasonal changes, or other land use changes or stressors
- Monitoring agricultural practices, cover, and crop health
- Understanding impacts from land to coastal or aquatic environments



Global image of the Earth's biosphere as seen by SeaWiFS. Credit: NASA/Goddard Space Flight Center, The SeaWiFS Project and GeoEye, Scientific Visualization Studio

Above: Bald Cypress Swamp, First Landing State Park, Virginia Beach, VA.



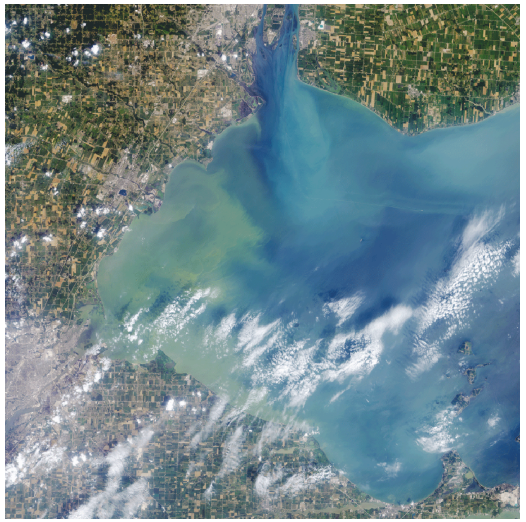
Hyperion image of tundra near Utqiagvik (Barrow), AK, USA, July 20, 2009
Huemmrich et al. JSTARS 2013

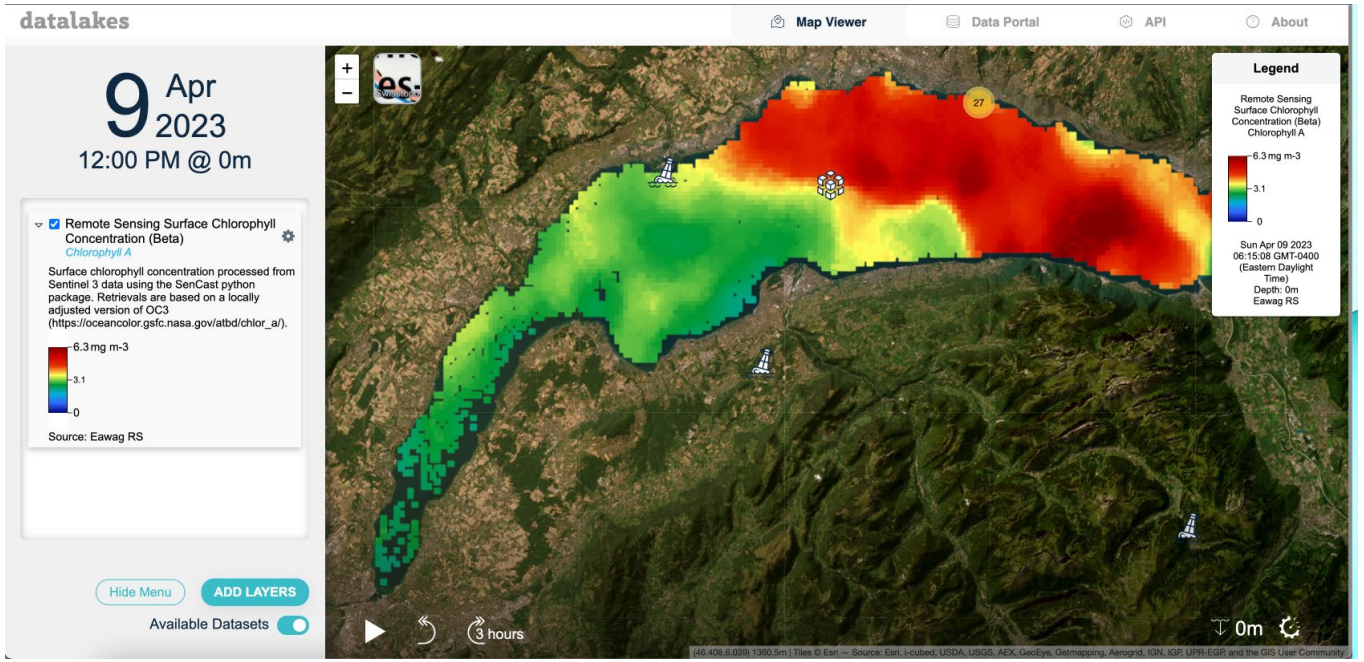
PACE Applications: Water Monitoring

Informing Applications with PACE Data: Monitoring and Managing Aquatic Ecosystems

PACE will provide chlorophyll-*a*, CDOM, phytoplankton community composition, pigments, reflectance, and other data products for understanding and protecting aquatic ecosystems, which can benefit and/or inform:

- Health and citing of fisheries or aquaculture
- Monitoring food webs, ecosystem health, aquatic biodiversity, and watershed health for best management practices (including based on water clarity and particle size)
- Monitoring of drinking water quality and advising water treatment operators
- Advising local health departments
- Monitoring effects of nutrient/agricultural runoff into large lakes





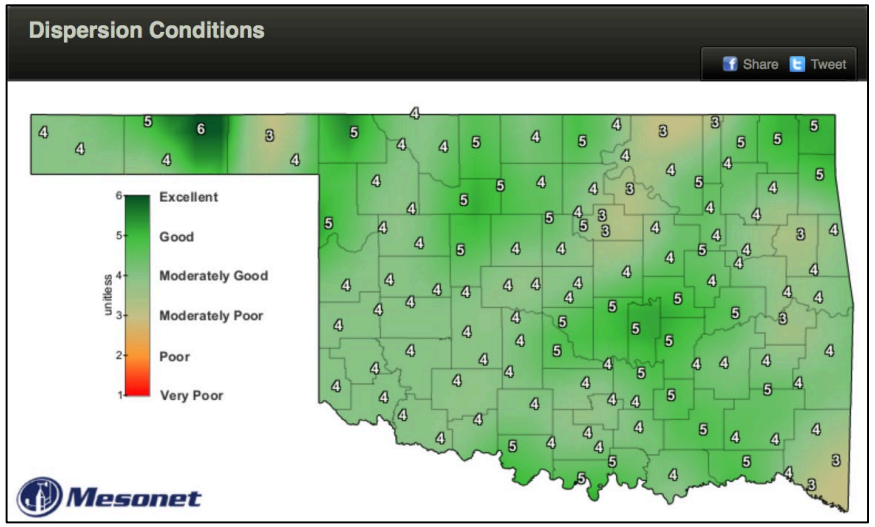
Left: Landsat natural color image of microcystis bloom in Lake Erie. (Photo courtesy of NASA Earth Observatory)
Right: datalakes Lake Geneva decision support tool that will incorporate Chlorophyll A from PACE.

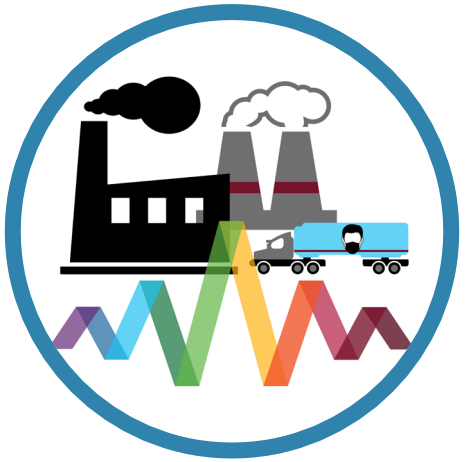
PACE Applications: Health & Air Quality

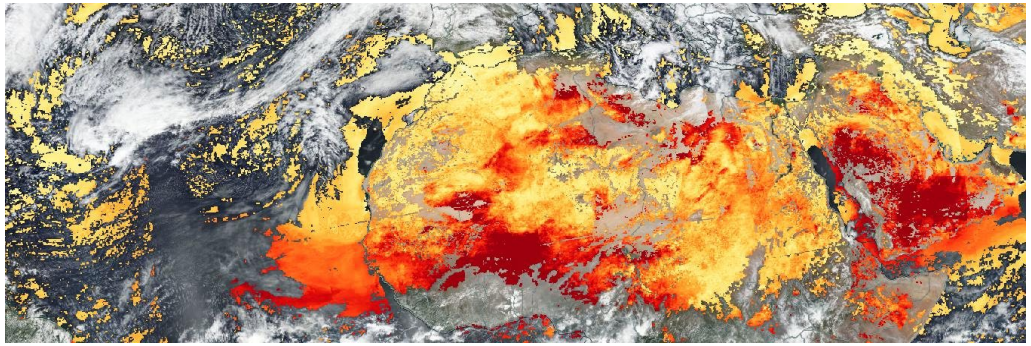
Informing Applications with PACE Data: Monitoring and Managing Air Quality

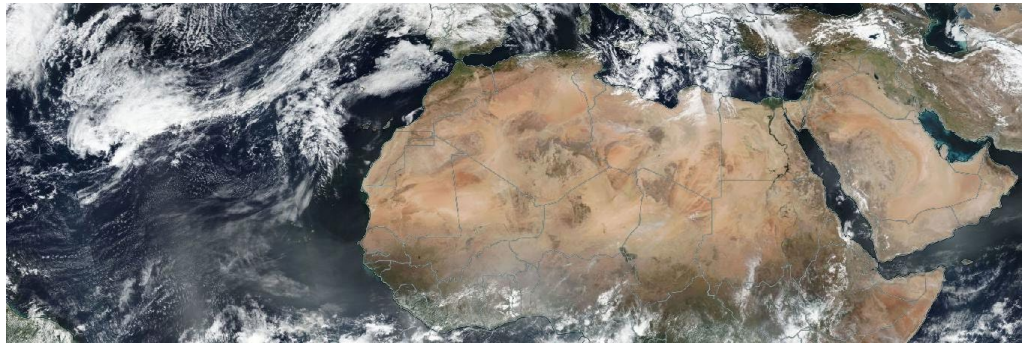
PACE will provide aerosol measurements (such as total column aerosol amount, aerosol layer height, and aerosol optical depth) for understanding air quality and its impacts on human health, which can benefit and/or inform:

- Estimating particulate matter (PM) for air quality advisories
- The impact of aerosols on the climate
- The location, altitude, and magnitude of particulate matter such as wildfire smoke or volcanic ash





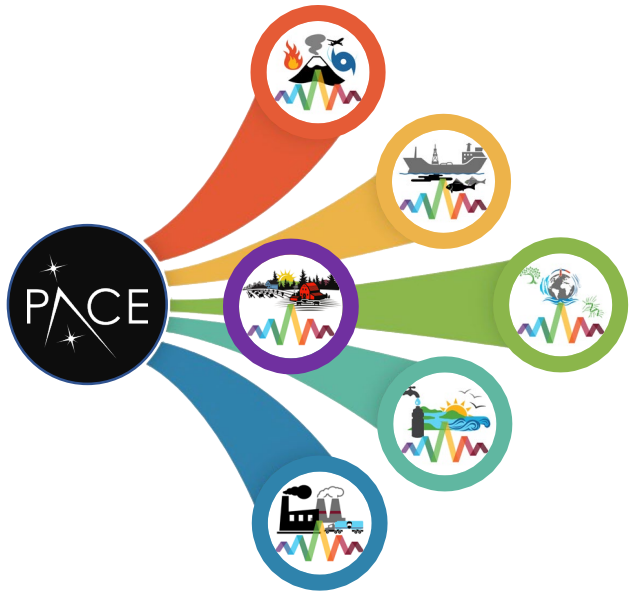




Top: *Mesonet map showing dispersion conditions over Oklahoma, or the ability of the atmosphere to dilute airborne particles (i.e. smoke, pollution, pesticides). Higher dispersion means faster atmospheric dilution is likely.*
Bottom: *PACE will extend MODIS and VIIRS heritage aerosol optical depth retrievals.*

PACE Applications Program and Community Engagement

The goal of the PACE Applications Program is to foster new partnerships and out-of-the-box thinking that will generate inventive solutions that aid society.



Community of Practice: Those interested in using and applying future PACE data (open to anyone in applications or research)

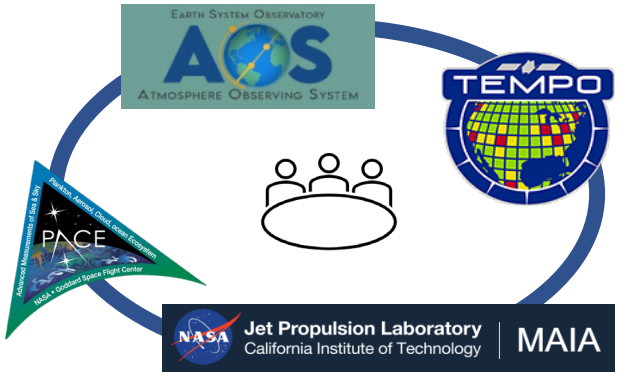
Early Adopters: Select pre-launch applied users of PACE data

Science & Applications Team: Funded scientists working on algorithm development, applications, validation, etc. (depending on solicitation cycle)

Community of Potential: Those unfamiliar with satellite data products and PACE capabilities but interested in leveraging and benefiting from PACE data products

PACE Applications Events

Community Focus Sessions, Community Needs Assessments, Annual Workshops…

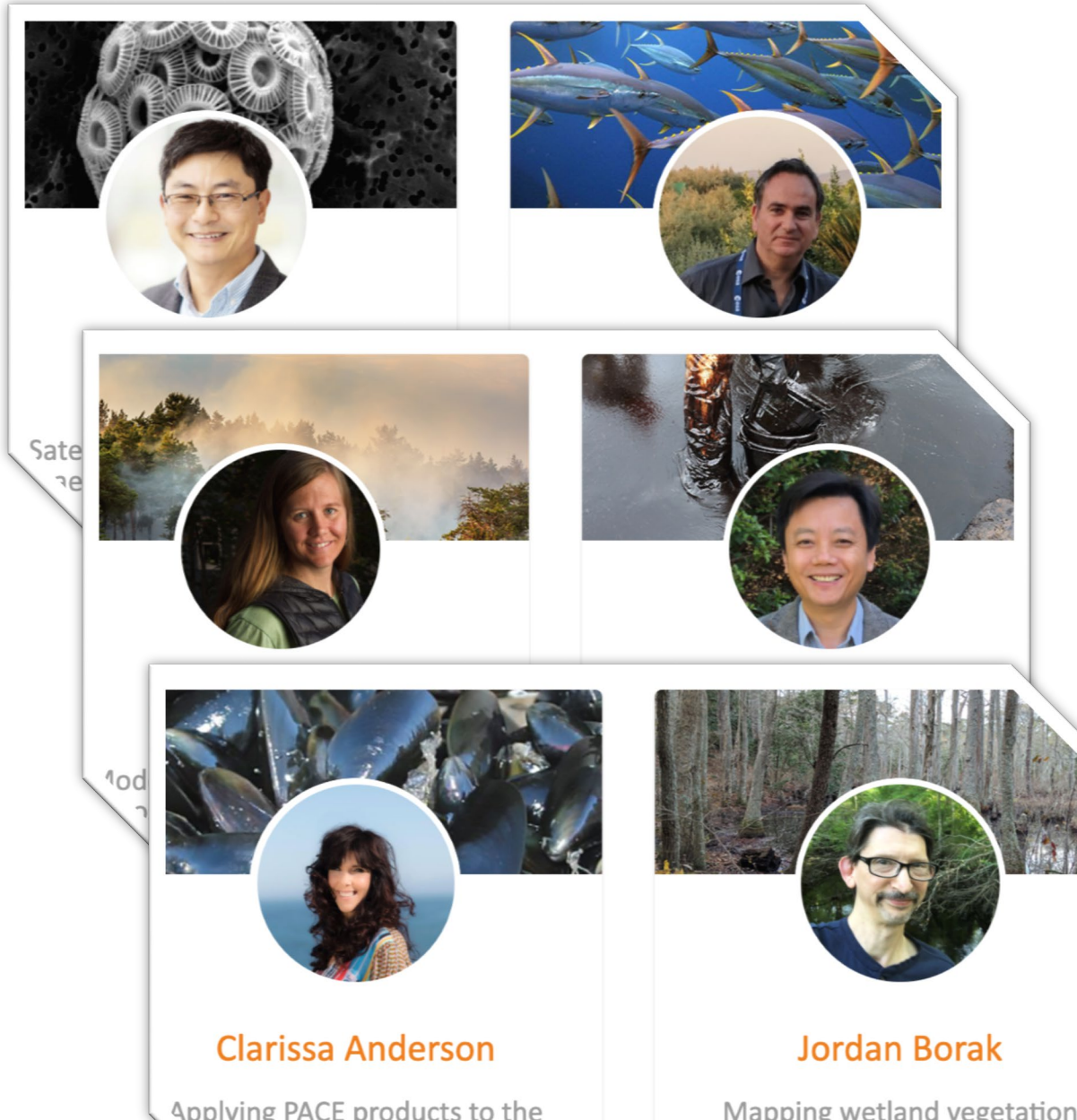


PACE Early Adopter Program

The PACE Early Adopter program promotes applied science and applications research designed to scale and integrate PACE data into policy, business, and management activities that benefit society and inform decision making.

GOALS:

- PROVIDE OPPORTUNITIES TO PARTNER WITH MISSION SCIENTISTS
- PROVIDE THE MISSION WITH FEEDBACK ON UTILITY OF DATA
- SUPPORT EARLY ADOPTERS AND BUILD CAPACITY TO ACCELERATE DATA UPTAKE
- EXPAND MISSION VISIBILITY AND PARTNERSHIPS WITH NEW USER COMMUNITIES
- ENHANCE MISSION DATA PRODUCTS AND SERVICES BASED ON USER FEEDBACK



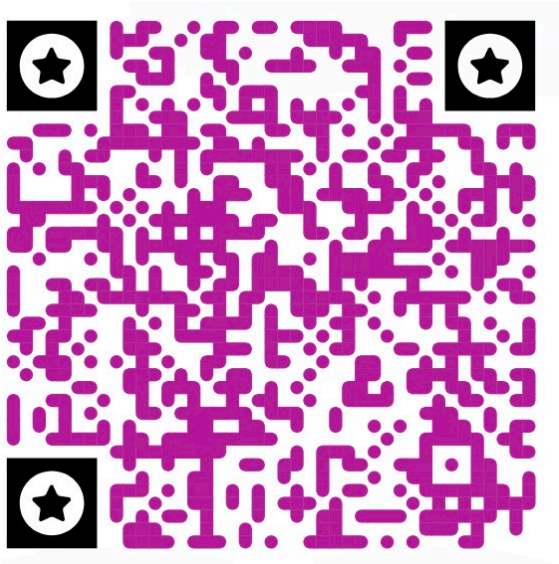
Get Involved in this YEAR OF LAUNCH!

- **Trainings and tutorials** to prepare the PACE community for data access, analysis, and visualization with PACE data

- **Community conversations around thematic areas** to further identify and build out innovative applications areas (and develop white papers and case study documents)

- **End-user engagement** to continue to build out the PACE Community of Practice and prepare for the Community of Potential post-launch

Join the PACE CoP and/or Early Adopters Program!



Thank you!

Registration opens June

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