Sustainable Fisheries
Freshwater and inland quality

Smoke monitoring
Harmful algal blooms

Sea ice monitoring
Visibility

Land products (NDVI, NDWI)
Climate

Freshwater and inland quality
Water quality

Coral reef conservation
Harmful algal blooms

Sediment products (particle size, type)
Navigation

Intercontinental Transport of Pollution
Trichodesmium blooms

Eutrophication, dead zones

Fire monitoring

Habitat management

Air quality, type, plumes

PACE: How can we do our Science in a way that will maximize its utility

Maria Tzortziou (CCNY/GSFC, Applied Science lead for PACE-Ocean)
Ali Omar (NASA/LARC, Applied Science lead for PACE-Atmosphere)
Woody Turner (NASA HQs –Applied Science Program Lead for PACE Mission)
The significance of PACE – Ocean Applications

Achieve consensus recommendations within the Science Team on the spectrum of applications we can address with PACE measurements and retrieval approaches (Werdell et

Ecosystem and Human Health
- Fisheries management
- Detection of harmful algal blooms (HABs)
- Monitoring of sea ice extent and passages
- Mapping of currents/applications to shipping industry, scheduling/fuel economy strategies
- Search And Rescue Satellite Aided Tracking
- Improved models of pathogens, bacteria

Disasters
- Impacts of storms and hurricanes
- Oil-spills and seeps
- Flood disaster response.

Water Resources & Quality
- Water quality monitoring, eutrophication, hypoxic/anoxic conditions
- Management of water resources in lakes, coastal areas, open oceans

Climate System
- Mapping/assessment of C sources/fluxes
- Improvement of climate models skills
- Ecosystem vulnerability assessments
- Support for policy analyses, development of climate change adaptation strategies

Ecological Forecasting
- Forecasting and early warnings of HABs
- Forecasting of endangered species
- Ecosystem response to future pressures
Factors that might increase or decrease the applications value of a mission
(from Mission Applications Review: October 2016)

- Inclusion of a polarimeter would allow enhanced measurements of atmospheric composition and pollutants that would increase the value of applications relevant to air-quality & human health

  Currently under consideration by the PACE Team

- Increased spatial resolution (50-150 m) would improve coverage of global coastal and estuarine areas, increasing applications value relevant to water quality

  Coastal Scanner (125 m spatial resolution, threshold) still under consideration

- Low latency would allow for faster satellite data product distribution to end users, near-real time applications, and increased mission applications value.
Assessing the impact of GSD on information content and mission applications value

Q1: What is the value of 500 m vs 1 km?

*Required to study coastal processes, ecosystems, resources at the land-ocean interface.*

For example,

- capture the **factor of 2 change in carbon** components at land-estuary interface
- monitor processes in **coastal waters** (EPA requires 500m GSD for coastal applications: HAB detection/identification, invasive species, water clarity, hypoxia, pathogen indicators)
- track **river plumes, sediments**

Q2: What is the value of 100 m?

*To study estuarine and inland processes, hazards, disasters (more ‘frequent’ events/stronger gradients).*

For example:

- Capture the **more than a factor of 5 change in carbon** components at land-estuary interface
- **Estuarine water quality, HABs** in most estuaries (not just the few largest)
- For **inland applications**, in most (80% total area) of lakes
- **Oils spills**, to capture the **more frequent** events
- **Habitat mapping/monitoring, coral reefs**, design/evaluation of **marine protected areas**
PACE Coastal Ocean Color Instrument (COCI) User and Science Team Meeting (June 1-2, 2016)

Meeting was jointly hosted by NASA, the Canadian Space Agency (CSA) and the Naval Research Laboratory (NRL), to explore the possibility of launching a high-spatial resolution (100 m GSD) coastal ocean color instrument, largely contributed from CSA and NRL, as part of the PACE mission concept.

The PACE AWG

→ provided input on the recommended instrument capabilities and high priority Applied Science objectives that COCI would aim to resolve.

→ contributed White Papers submitted to NASA HQs to inform NASA Program Management about the science and applications value of the accommodation of COCI on PACE
PACE: Increased Spatial Resolution for Coastal Ocean Applications

PACE Coastal Ocean Color Instrument (COCI) User and Science Team Meeting (June 1-2, 2016)

PACE COCI Applied Science Objectives:

- Identify and track harmful algal blooms (HABs) and nuisance algal blooms

**Summary**

While PACE will continue our monitoring of the global ocean and atmosphere for the impacts of climate change, **COCI zooms in on the nearshore ocean, estuaries, rivers and large lakes and reservoirs** where we are already seeing the impacts of human populations on a large scale on the water supply, fisheries, air quality, recreational activities and human health for over half of the world’s population that lives near the coast. COCI on PACE provides a unique opportunity to achieve “new, high quality information on the biogeochemical properties of coastal waters and their implications for ecosystem and human health” as recommended for the PACE mission in the NASA Climate-Centric Architecture document (NASA 2010, p. 20)

- Observe aerosol/cloud interaction and characterize the transition zone between aerosols and clouds
- Determine properties of highly variable aerosol plumes (e.g., smoke)
- Terrestrial ecosystem diversity, biochemistry, and function

human health.
New PACE White Papers relevant to COCI

PACE MISSION APPLICATIONS - Harmful Algal Blooms

Who: Coast economy
Who: The corn
What: An 11 and 10 percent over
A wide range of data
Who: The corn
Who: The corn
Who: The corn
Who: The corn
Who: The corn
Who: The corn
Who: The corn

Application Question: How can we improve monitoring of inland water quality, as needed for assessing the ecological integrity, trophic status, and recreational value of lakes, and improving management and sustainable use of our national water resources?

Who Cares and Why?
Lakes are vital resources for their ecosystem services and their profound impact on the economy and quality of life. They provide water regulation, erosion control, waste treatment, disturbance prevention, sediment formation, fish and wildlife habitats. Lake conditions affect property values, drinking water supplies, recreational activities, and the economic status of entire communities. Lake St. Clair in Michigan provides approximately 5 million people with fresh drinking water, and boating-related activities alone generate $20 billion.

One of the most widespread ecological problems of inland waters is eutrophication. To protect our natural resources, state and federal agencies have been working on improving methods for monitoring the biological, chemical, physical, and recreational condition of lakes. Such information is needed by decision makers and the public to decide on the best allocation of available funds for environmental protection and restoration.

The NASA Response
The Coastal Ocean Color Imager (COCI), developed by the Canadian Space Agency (CSA) and the Naval Research Laboratory (NRL), and proposed to be launched as part of NASA's PACE satellite mission, will offer the environmental monitoring and water resource management communities an unprecedented opportunity to observe monthly to seasonal changes in lake conditions across spatial scales not feasible with field-based monitoring and statistical surveys.

With 100 spatial resolutions, COCI will be able to provide satellite ocean color imagery over 800 of the surface area of world lakes. COCI's hyper-spectral ocean color capabilities in the 350-1000 nm spectral range will allow us to differentiate between dissolved organic material, suspended sediments, and phytoplankton pigments in lake waters, providing improved retrievals of parameters such as chlorophyll-a, CDOM, turbidity, color, phytoplankton groups, and cyanobacteria that are key indicators of the ecological condition and water quality of lakes. On a polar orbit, COCI will rely on 24 days with the capability of 2 days revisit for target sites/events providing a unique vantage for periodic (bi-weekly to seasonal) and synoptic assessment of the condition of our Nation's lakes.

Combined with the daily, medium spatial resolution (1 km at nadir), global retrievals from the PACE Ocean Color Instrument (OCI), observations will provide a new capability for monitoring lake water resources from space. Integrated with field surveys, PACE will result in improved monitoring of lake conditions and more accurate assessments of the environmental and ecological benefits of water-quality regulations.

Comments? Thoughts?
For additional information about PACE mission ocean applications or this particular application, please contact Maria Tzortziou at: maria.tzortziou@nasa.gov

Pace MISSION APPLICATIONS - Marine ecosystem resources: Fisheries

Application Question: How can we improve monitoring of air quality in coastal urban areas where there are large gradients in atmospheric composition?

Who Cares and Why?
In 1999, 55%-60% of Americans lived in 772 counties adjacent to the Atlantic and Pacific Oceans, the Gulf of Mexico, and the Great Lakes. By the year 2025, nearly 75% of Americans are expected to live in coastal counties. These counties already contain 14 of the country's 25 largest metropolitan areas. In urban coastal areas where there are no ground measurements of particulate matter (PM) in the atmosphere at the sub-kilometer scale, the public has no indication of the extent of air pollution and therefore no ability to protect vulnerable populations from exposure to harmful pollution. Satellite-based observations of atmospheric aerosol optical depth (AOD) at 550 nm can be used to estimate PM in such areas, and to develop a finer spatial scale of the daily air quality index (AQI). The latest surveys show 75-85% of the American public is aware of AQI and 50% report taking action based on the AQI.

Needed Measurement(s)
Satellite-based measurements of AOD at a spatial resolution of less than 200 m and spectral range that includes several wavelengths in the visible and near-infrared are needed for estimates of PM concentration and size relevant for air quality monitoring, forecasting, and management. The spectral range of the AOD, particularly between 500 nm and 1000 nm provides information on the size of the particles and the corresponding intra-urban gradients of these sizes. Though some of these measurements are available from current satellites, albeit at a coarser resolution, these measurements may not be available when PACE is launched. Measurements from the Coastal Ocean Color Imager (COCI) could be used to extend the current satellite-based PM2.5 estimates, provide insights into the temporal and spatial trends in population exposure to PM2.5, and assess the effectiveness of pollution reduction initiatives and regulations.

The NASA Response
The Coastal Ocean Color Imager (COCI), developed by the Canadian Space Agency (CSA) and the Naval Research Laboratory (NRL), is designed to be launched as part of NASA's PACE mission, will provide AOD at an accuracy of ±0.05 at a horizontal resolution of approximately 100 m. These high spatial resolution measurements will improve the estimates of PM2.5 and result in a much improved AQI for the public. The 100 m spatial resolution of COCI measurements will be particularly useful in urban areas where there are large gradients in air pollution. Understanding the gradients of particulate matter (PM) in the atmosphere in coastal regions will become even more critical in a changing climate.

PM with aerodynamic diameters less than 2.5 µm (PM2.5) are federally regulated pollutants due to their deleterious effects on human health. Retrievals of PM2.5 concentrations using space-based measurements of AOD are relatively mature. The spectral range of the COCI measurements of AOD (350-1000 nm) is sufficient to separate fine mode particles from coarse mode particles and make an estimate of particle type, e.g., coarse mode more likely to be particles of a crustal origin (such as dust) and fine mode particles more likely to be fossil fuel based pollution (such as sulfate, nitrate particles).

Combined with the PACE Ocean color instrument (OCI) and polarimeter, COCI will provide the critical high spatial and high spectral resolution data set that is needed to improve these satellite retrievals of atmospheric composition and study gradients of coastal air pollution and its transport.

Comments? Thoughts?
For additional information about PACE mission air quality applications or this particular application, please contact All M. Omar at aomar@nasa.gov

Pace MISSION APPLICATIONS - Air Quality

Pace MISSION APPLICATIONS - Urban Air Quality Gradients

Images showing the plume rise from a point source in an urban area for cases (a) with light winds and neutral stability and (b) with strong winds and neutral stability, highlighting the potential for large air pollution gradients due to point sources and environmental conditions.

Application Question: How can we improve monitoring of air quality in coastal urban areas where there are large gradients in atmospheric composition?
New PACE White Papers relevant to COCI

**PACE MISSION APPLICATIONS - Inland ecosystem resources: Water Quality**

Satellite ocean color imagery at 200 m resolution from HICO (Hyperspectral Imager for the Coastal Ocean) provided an unprecedented view of lakes on a global scale (2009-2014). Left to right: Lake of the Woods in Canada; Lakes Oneida, Skaneateles and Oswego in New York; Lake Tashu in China; Lake Winnipeg in Canada; Lake Michigan in Michigan; Lake Tuz Golu in Turkey; Klamath Lake in Oregon; Red Lake in Minnesota; Lakes Winnibigou, Butte des Morts and Rush in Wisconsin (Credit: OSU HICO website, http://hico.coas.oregonstate.edu/)

**Application Question:** How can we improve monitoring of inland water quality, as needed for assessing the ecological integrity, trophic status, and recreational value of lakes, and improving management and sustainable use of our national water resources?

**Who Cares and Why?**

Lakes are vital resources for both their ecosystem services and their profound impact on the economy and quality of life. They provide water regulation, erosion control, waste treatment, disturbance prevention, soil formation, fish and wildlife habitats. Lake conditions affect property values, drinking water supplies, recreational activities, and the economic status of entire communities. Lake St. Clair in Michigan provides approximately 5 million people with fresh drinking water, and boating-related activities alone generate $560 million.

One of the most widespread ecological problems of inland waters is eutrophication. To protect our natural resources, state and federal agencies have been working on improving methods for monitoring the biological, chemical, physical, and recreational conditions of lakes. Such information is needed by decision makers and the public to decide the best allocation of available funds for environmental protection and restoration.

**Needed Measurements**

Water quality monitoring programs have identified a suite of chemical, physical, and biological indicators to assess the biological integrity, trophic state, and recreational value of lakes. These include chlorophyll-a, CDOM, turbidity, total suspended solids, water-clarity, algae toxins, cyanobacteria. Measurements are typically collected through field surveys conducted every few years. Providing more frequent and synoptic information on the status of, and change in, lake conditions in large geographic areas is a major challenge.

Currently operational satellite sensors allow frequent, quasi-synoptic observations on a global scale, but often lack the spatial and spatial resolution required to monitor water-quality indicators in lakes. Hyperspectral observations at high (~100 m) spatial resolution are needed to assess inland water quality conditions from space.

**The NASA Response**

The Coastal Ocean Color Imager (COCI), developed by the Canadian Space Agency (CSA) and the Naval Research Laboratory (NRL) and proposed to be launched as part of NASA’s PACE satellite mission, will offer the environmental monitoring and water resource management communities an unprecedented opportunity to observe monthly to seasonal changes in lake conditions across spatial scales not feasible with field-based monitoring and statistical surveys.

With 100 m spatial resolution, COCI will be able to provide satellite ocean color imagery over 80% of the surface area of world lakes. COCI’s hyperspectral ocean color capabilities in the 350-1000 nm spectral range will allow us to differentiate between dissolved organic material, suspended sediments, and phytoplankton pigments in lake waters, providing improved retrievals of parameters such as chlorophyll-a, CDOM, turbidity, color, phytoplankton groups and cyanobacteria that are key indicators of the ecological condition and water quality of lakes. On a polar orbit, COCI, will have a revisit of 15 days (with the capability of 2-3 days revisits for target sites/events) providing a unique tool for periodic (bi-weekly to seasonal) and synoptic assessment of the condition of our Nation’s lakes.

Combined with the daily, medium spatial resolution (1-km at nadir), global retrievals from the PACE Ocean Color Instrument, COCI observations will provide a new capability for monitoring lake water resources from space. Integrated with field surveys, PACE will result in improved monitoring of lake conditions and more accurate assessments of the environmental and ecological benefits of water-quality regulations.

**Comments? Thoughts?**

For additional information about PACE mission ocean applications or this particular application, please contact Maria Tzortziou at: maria.a.tzortziou@nasa.gov

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**Agencies collaborate on satellite sensor and potential with National Aquatic Resource Surveys**

NASA, the U.S. Naval Research Laboratory, and the Canadian Space Agency are considering the inclusion of a Coastal Ocean Color Imager (COCI) on NASA’s Pre-Aerosols Clouds and ocean Ecosystems (PACE) satellite mission, set to launch in 2022. COCI uses an instrument that separates light into many wavelength channels, which reveals information about the composition of water quality along the Earth’s coastlines. This information can be helpful to scientists with the U.S. Environmental Protection Agency, who use data from COCI for water quality monitoring, forecasting, risk analyses, and assessments.

**Measurements needed for National Aquatic Resource Surveys**

To demonstrate the utility of including the COCI on NASA’s PACE satellite mission, EPA scientists are exploring how the satellite-derived geophysical variables from COCI could complement the National Aquatic Resource Surveys (NARS) program — a collaborative effort between EPA, states, and tribes to regularly assess the quality of the nation’s coastal waters, lakes and reservoirs, rivers and streams, and wetlands using a statistical survey design. NARS provide nationally-consistent data on the nation’s waters and provide data to inform water quality monitoring programs across the country. In conducting NARS, EPA scientists usually gather measurements through field surveys using a probability-based sampling design to randomly select a subset of waterbodies that represent the condition of water quality across the continental United States. The EPA-NARS program has identified a suite of indicators for assessing the biological condition, recreational suitability, trophic state, and key stressors of various water bodies. Biological indicators include chlorophyll-a as physical indicators include water clarity; chemical indicators include colored dissolved organic matter; and recreational indicators include cyanobacteria.

How can satellite-derived geophysical variables complement EPA’s National Aquatic Resource Surveys?

The COCI sensor offers 100 meter spatial resolution, 400-1000 nanometer spectral range at a 10 nanometer bandwidth, with 12 day revisits and pointing capability. These sensor characteristics are similar to the Hyperspectral Imager for the Coastal Ocean (HICO) on the International Space Station, which EPA recently used to test potential water quality applications. The HICO tests prepared EPA to use COCI, which may improve the ability to differentiate between dissolved organic material, suspended sediments, and phytoplankton pigments in inland and estuarine waters. COCI may provide data for about 6 percent of U.S. lakes and reservoirs that are greater than one hectare.

How can EPA’s National Aquatic Resource Surveys complement the COCI satellite?

The EPA’s NARS field surveys could support validation of COCI-derived geophysical variables. New indicators could be developed based on this new hyperspectral technology to assess the biological condition, suitability for recreation, trophic state, and key stressors of these water bodies. EPA is also willing to consider new field-based measures to complement the calibration and validation of this sensor. NARS surveys that are most likely to complement satellite measurements from COCI include the National Lakes Assessment and National Coastal Condition Assessment.

**Contacts**

For additional information about this PACE application, contact Blake Schaeffer (blake.schaeffer@epa.gov), Darryl Keith (darryl.keith@epa.gov), or Amina Pollard (Pollard.amena@epa.gov).


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**The U.S. Environmental Protection Agency has experience using satellite data to understand water quality on Earth and recently collaborated with the U.S. Naval Research Laboratory to develop a proof-of-concept demonstration of HICO (hyperspectral imager for the Coastal Ocean) at 100 meter spatial resolution with hyperspectral capabilities specific to coastal estuaries. Left: HICO-derived total light attenuation at 100 meter resolution in the Florida St. Andrew Bay system, March 2, 2011. Center: Example MODIS image at 250 meter resolution in Pensacola Bay, Florida highlighting the data gap at the land-water interface. Right: Example HICO chlorophyll-a image at 100 meter resolution in Pensacola Bay.
PACE Applications Plan

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Plankton, Aerosols, Clouds, and ocean Ecosystem (PACE) Mission Applications Plan

Edited by:
Maria Tzortziou 1,2, Ali Omar 1,2, Woody Turner 3, Jeremy Werdell 4 ...
1 PACE Applications Working Group Chair, 2 PACE Applications DPA, 3 PACE Applications PA, 4 PACE Project Scientist ...

Goddard Space Flight Center
Greenbelt, Maryland

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Applications activities will be planned and conducted during the different development phases of the PACE mission based on the maturity of mission products with respect to the project objectives for product applications, and in accordance with the ESD Directive on Project Applications Program (Table 1).

Table 1: PACE Applications products by development phase

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Next steps:
- Assessment of the community
- Workshops and webinars on PACE, targeting the users community
- Development of Early Adopters program
PACE: How can we do our Science in a way that will maximize its utility

Maria Tzortziou (CCNY/GSFC, Applied Science lead for PACE-Ocean)
Ali Omar (NASA/LARC, Applied Science lead for PACE-Atmosphere)
Woody Turner (NASA HQs –Applied Science Program Lead for PACE Mission)
The significance of PACE – Atmosphere Applications

The PACE atmospheric data will be vital for...

Continuity of the EOS aerosol & cloud data

Disaster response

- Fernandina Volcano, Galapagos Islands - SeaWiFS
- Southern California Wildfires - MODIS

Air quality forecasting & monitoring
Ground based PM$_{2.5}$ measurements augmented by MODIS AOD measurements to produce Air Quality Indices (Courtesy of AirNow) for public health

Boys et al., ES&T, 2014

Eastern US PM$_{2.5}$ Anomaly (μg m$^{-3}$) - SeaWiFS & MISR

Air quality trend studies to inform policy

Continuity of the EOS aerosol & cloud data

Disaster response
Factors that might increase or decrease the applications value of a mission
(from Mission Applications Review: October 2016)

- **Inclusion of a polarimeter** would allow enhanced measurements of atmospheric composition and pollutants that would increase the value of applications relevant to air-quality & human health

  Currently under consideration by the PACE Team

- **Increased spatial resolution** (50-150 m) would improve coverage of global coastal and estuarine areas, increasing applications value relevant to water quality

  Coastal Scanner (125 m spatial resolution, threshold) still under consideration

- **Low latency** would allow for faster satellite data product distribution to end users, near-real time applications, and increased mission applications value.
# NASA Earth Science Division Directive for Project Applications

**DIRECTIVE ON PROJECT APPLICATIONS PROGRAM**

Approved by:

Michael Freilich  
Director, Earth Science Division  
Science Mission Directorate, NASA Headquarters

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Modified June 2018 by 8

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3rd PACE ST Meeting
### Deliverables:

- **Community Assessment**
- **Project Studies**
- **Application Plan**
- **Application Traceability Matrix**
- **Project Applications Workshops**
- **Focus Sessions**
- **Tutorials**
- **Event Reports**
- **Community Contact List (working Group)**

### Early Adopter Program
- Use Cases/Case Studies
- Project Application Posters/White Papers
- Simulated Products
- Early Adopter Workshop
- Early Adopter Benchmark Meeting
- Data Workshops
- Short Courses
- Post-Launch EA program
- Impact Workshop

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**NASA Earth Science Division Directive for Project Applications**

| Missions | Person | Flight | Launch | Community Assessment | Project Studies | Application Plan | Application Traceability Matrix | Project Applications Workshops | Focus Sessions | Tutorials | Event Reports | Community Contact List (working Group) | Early Adopter Program | Use Cases/Case Studies | Project Application Posters | Simulated Products | Early Adopter Workshop | Early Adopter Benchmark Meeting | Data Workshops | Short Courses | Post Launch EA program | Impact Workshop |
|----------|--------|--------|--------|-----------------------|----------------|----------------|-----------------------------|-----------------------------|----------------|----------|----------------|---------------------------------|----------------------|----------------------|-----------------------------|----------------------|----------------------|-------------------------------|----------------|--------------|-----------------------|----------------|---|
| CRYTO-PP | Bruce Walch | Pre-A | 2023 | X                     | X              | X              | X                          | X                          | X              |         |         | Community Contact List (working Group) | X                     | X                  | X                          | X                  | X            | X                                | X              | X            | X                                  | X              | X |
|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|---------------------------------------------------|-----------------------------------------------|-------------------|-------------------------------|-----|-----------------------------|
| What is the air quality forecast for particulate matter (PM) predicted? Are PM measurements of the vertical optical depth (VOD) applicable? How can VOD measurements of PM be used? | The Environmental Protection Agency produces a daily air quality index that combines the observed particulate matter concentrations in regions where there are no direct measurements of PM, and the PM measurements of VOD can be used to estimate air quality. | Observations of VOD at spatial resolutions of less than 1 km and accuracy of less than 1% are required. | Public Health and Air Quality                      | Environmental Protection Agency (EPA), NASA       | Aerosol Optical Depth | 200 km horizontal resolution of 250 m | 3   | Aerosol optical depth, Surface PM concentrations at a low inversion |
| How do changes in food, water, and housing influence pollution and nutrient loadings, water quality, and ecosystem resilience of coastal waters? | The EPA's State and Local Water Resource Information Program (SLWRI) aims to develop a comprehensive database of water resource inventories and characteristics, as well as to deliver data and tools to a range of stakeholders. | Observations of CHN (nitrogen) are needed to locate local estimates. Coastal (2 km) Coverage needed. | Water Resources, Coastal Ecosystems, and Human Health | Environmental Protection Agency (EPA), NASA       | Aerosol Optical Depth | 200 km horizontal resolution of 250 m | 3   | Aerosol optical depth, Vertical distribution, NO2, O3 concentrations, atmospheric correction |
| How does the implementation of the Clean Air Act (CAA) and the Clean Water Act (CWA) impact the implementation of clean energy strategies and, in turn, regional economic development? | The Clean Air Act and the Clean Water Act are critical for the implementation of clean energy strategies and regional economic development. | Observations of CO2 are needed to monitor CO2 emissions. Coastal (2 km) Coverage needed. | Ecological Forecasting                            | National Oceanic and Atmospheric Administration (NOAA), NASA | Aerosol Optical Depth | 200 km horizontal resolution of 250 m | 3   | Aerosol optical depth, Vertical distribution, NO2, O3 concentrations, atmospheric correction |
| GIS monitoring, remote sensing, and data analyses to support monitoring and observational approaches. How is the data collected and stored? | The data collected and stored to support monitoring and observational approaches. | Observations of visitation density are needed to monitor CO2 emissions. Coastal (2 km) Coverage needed. | Disaster Resilience                               | NOAA, NASA, Google, CED, NOAA | Web-based infrastructure | 200 km horizontal resolution of 250 m | 3   | Aerosol optical depth, Vertical distribution, NO2, O3 concentrations, atmospheric correction |

Categories: Disaster Mitigation, Ecological Forecasting, Health and Air Quality, Water Management, Agriculture, Climate, Energy, Oceans, and Weather

Justification for ARL: 3. Proof of Application Concept: Validation of established feasibility studies to assess the potential viability and impact of the application has been conducted.
PACE Applications Questions & Concepts

What is the air quality forecast of particulate matter (PM) predicted from PACE measurements of the aerosol optical depth (AOD) in regions where there are no direct measurements of PM?

The EPA produces a daily air quality index which comprises both the ozone and PM concentrations. In regions where there are no direct measurements of particulate matter, satellite measurements of AOD can be used to estimate PM.

**Application Readiness Level:** 3
**Applied Sciences Category:** Public Health and Air Quality
**Potential Host Agency:** EPA (James Szykman)

- **Mission Data Product:** Aerosol Optical Depth
- **Spatial resolution:** < 1 km
- **Latencies:** < 1 hour
- **Projected Mission Performance:** AOD within +/- 0.02 at a horizontal resolution of 250 m
- **Ancillary Measurements:** Aerosol vertical distributions, Surface PM concentrations (at a few locations)

What is the volcanic ash concentration during and after a volcanic eruption? Is there an impact on air quality as a result of a volcanic material deposited in coastal/populated regions?

Measurements collected to support PACE atmospheric corrections in coastal regions may be used to quantify the concentration of material associated with volcanic eruptions. These data may be useful in enabling prudent ash-related aviation hazard mitigation policies and advisories.

**Application Readiness Level:** 3
**Applied Sciences Category:** Disaster Mitigation, Public Health and Air Quality
**Potential Host Agency:** FAA, EPA, NOAA, International Civil Aviation Organization, Volcanic Ash Advisory Centers (Shobha Kandragunta, NOAA)

- **Mission Data Product:** Aerosol Optical Depth
- **Spatial resolution:** < 1 km
- **Latencies:** < 1 hour

How do exchanges across the land-ocean interface influence carbon and nutrient loadings, water quality, and ecosystem dynamics in coastal waters?

The EPA Safe and Sustainable Water Resources Research Program aims at developing core indicators of water resource integrity and sustainability as well as indicators of key drivers and pressures across a range of spatial and temporal scales for use in integrated assessments. Integration of satellite observations with field measurements and modeling tools is needed to demonstrate assessment of sustainability and integrity of water resources.

**Application Readiness Level:** 3
**Applied Sciences Category:** Water Resources, Oceans, Coasts, Great Lakes, Ecosystems and Human Health
**Potential Host Agency:** EPA (Blake Schoefer)

- **Mission Data Products:** Chl-a, K_90 (water quality)
- **Spatial resolution:** Estuaries: ≤250 m
  Coastal Waters: ≤500 m
- **Coverage:** Minimum distance: 5.5 km
  Maximum distance: 22 km
- **Latencies:** 0.5-12 hours
- **Projected Mission Performance:** 0.5 hour data latency, direct broadcast of 5 nanometer resolution data, spatial resolution of 1 km (≤15%) at all angles across track. Along track spatial resolution of 250 m to ≤1 km
- **Ancillary Measurements:** Aerosols (spectral shape, vertical distribution), NO_2, O_3 concentrations for atmospheric correction

How are the productivity and biodiversity of coastal ecosystems changing, and how do these changes relate to natural and anthropogenic forcing, including local to regional impacts of climate variability?

PACE satellite-derived optics and biogeochemical variables may be assimilated into operational seasonal-to-interannual computer models. As a result, PACE data may improve model skills and forecasting ability (e.g., ocean-biogeochemical model performance)

**Application Readiness Level:** 3
**Applied Sciences Category:** Water Resources, Oceans, Coasts, Great Lakes, Ecosystems and Human Health
**Potential Host Agency:** EPA (Blake Schoefer)

- **Mission Data Products:** Chl-a, K_90
- **Spatial resolution:** 1 km
- **Projected Mission Performance:** 0.5 hour data latency, direct broadcast of 5 nanometer resolution data, spatial resolution of 1 km (≤15%) at all angles across track. Along track spatial resolution of 250 m to ≤1 km
**NASA Sets the PACE for Advanced Studies of Earth’s Ocean and Atmosphere**

The Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission will deliver the most comprehensive look at global ocean color measurements in NASA’s history. Not only will PACE monitor the health of our ocean, its science data will expand atmospheric studies by sensing our skies over an exceptionally broad spectrum of wavelengths.

Being built and tested at the Goddard Space Flight Center, PACE will expand our knowledge of key climate variables such as aerosol particles and clouds. It will extend NASA’s long-term record of the phytoplankton pigment, chlorophyll, while providing new insights on ocean biodiversity.
Consider joining the PACE Early Adopter Program!

- Engage in pre-launch research that will enable integration of PACE data into your application after launch
- Participate in discussions of PACE data products related to application needs
- Take a lead role in PACE applications research, meetings, workshops, and related activities
- Receive simulated PACE data products & calibration/validation data from PACE field campaigns, modeling, and synergistic studies
PACE Applications Working Group

PACE Science Team Applications Sub-Group:

Steve Ackleson (CASE II waters)
Emmanuel Boss (global datasets)
Heidi Dierssen (cyanobacteria, suspended sediments, floating vegetation, floating plastics etc)
Deric Gray (NRL, military applications, diver visibility, etc)
Olga Kalashnikova (polarization, atmosphere)
Robert Levy (Air Quality, Atmospheric composition)
Dave Miller (NRL, military applications etc)
Ali Omar (Air Quality, Volcanic Ash)
Mike Ondrusek (NOAA, operational, water quality, fisheries)
Steve Platnick (clouds, climate)
Lorraine Remer (aerosols, air-quality)
Mike Twardowski (WETLabs, wide range of users)
Maria Tzortziou (Coastal systems)
PACE relevant manuscripts and presentations

Manuscripts:

1. J. Wei, Z. Lee, M. Ondrusek, A. Mannino, and M. Tzortziou, 2016, Spectral slopes of the absorption coefficient of colored dissolved and detrital material inverted from UV-visible remote sensing reflectance, *JGR–Oceans*


Presentations:


