NASA PACE Mission & Application Program

Leveraging Science to Advance Society

Erin Urquhart
PACE Applications Coordinator

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PACE Applications Deputy Coordinator

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

Primary hyperspectral radiometer:

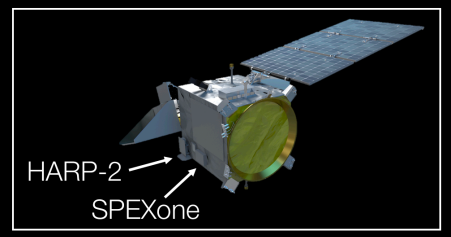
- Ocean Color Instrument (OCI) (GSFC)

2 contributed multi-angle polarimeters:

- HARP2 (UMBC)
- SPEXone (SRON/Airbus)

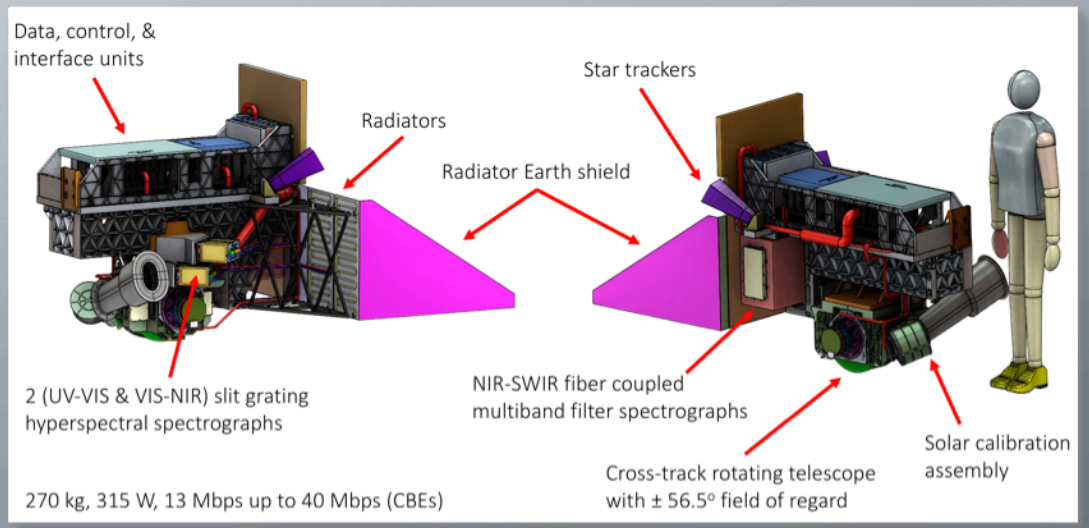
Key characteristics:

- 2023 estimated launch
- 676.5 km altitude
- Polar, ascending, Sun synchronous orbit; 98^{o} inclination
- 13:00 local Equatorial crossing
- 3-yr design life; 10-yr propellant

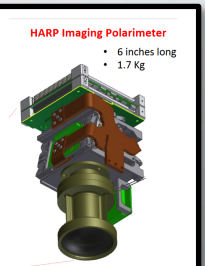


https://pace.gsfc.nasa.gov
@NASAOcean

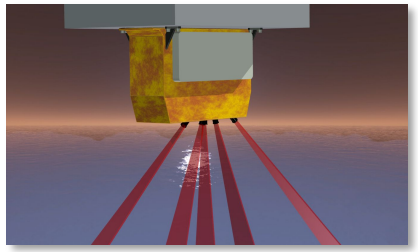
- hyperspectral scanning radiometer
- 340 – 890 nm, 5 nm resolution, 2.5 nm steps
- plus, 940, 1038, 1250, 1378, 1615, 2130, and 2250 nm
- 1 – 2-day global coverage
- ground pixel size of 1 km^2 at nadir
- ± 20º fore/aft tilt to avoid Sun glint
- twice monthly lunar calibration
- daily on-board solar calibration
- built at NASA Goddard Space Flight Center



UMBC Hyper Angular Rainbow Polarimeter (HARP-2)



SRON Spectro-polarimeter for Planetary Exploration (SPEXone)



PACE polarimeters *NOT* in 2017 Decadal Survey Program of Record

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

PACE science products

Required products with uncertainty requirements
Hyperspectral remote-sensing reflectances 2.5 nm spectral steps with 5 nm spectral resolution
Total aerosol optical depth at 380, 440, 500, 550 and 675 nm
Fraction of AOD(550) from fine mode aerosols over oceans
Cloud layer detection for optical depth > 0.3
Cloud top pressure of opaque (optical depth > 3) clouds
Optical thickness of liquid clouds
Optical thickness of ice clouds
Effective radius of liquid clouds
Effective radius of ice clouds

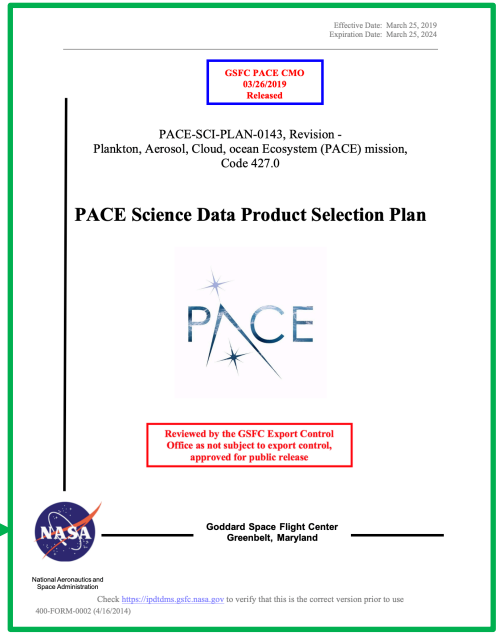
these are required for mission success & drive OCI design

Additional required heritage products to be generated
Chlorophyll concentration
Spectral diffuse attenuation coefficients
Spectral absorption coefficients (phytoplankton, CDOM+NAP)
Spectral backscattering coefficients
Fluorescence line height
Water path of liquid, ice clouds
Shortwave radiative effect

Other heritage & expected new / advanced data products
Phytoplankton community composition
Carbon stocks & primary production
Radiometric products (PAR, surface albedo, UV, others)
Aerosols properties
Land properties
Polarimetric products (atmospheres + oceans)
Applications products
…

Heritage approaches implemented, with goal of updating / replacing (e.g., SAT contributions)

Describes product and algorithm selection process


Effective Date: March 25, 2019
Expiration Date: March 25, 2024

GSFC PACE CMO
03/26/2019
Released

PACE-SCI-PLAN-0143, Revision -
Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission,
Code 427.0

PACE Science Data Product Selection Plan

PACE

Reviewed by the GSFC Export Control Office as not subject to export control, approved for public release

NASA

Goddard Space Flight Center
Greenbelt, Maryland

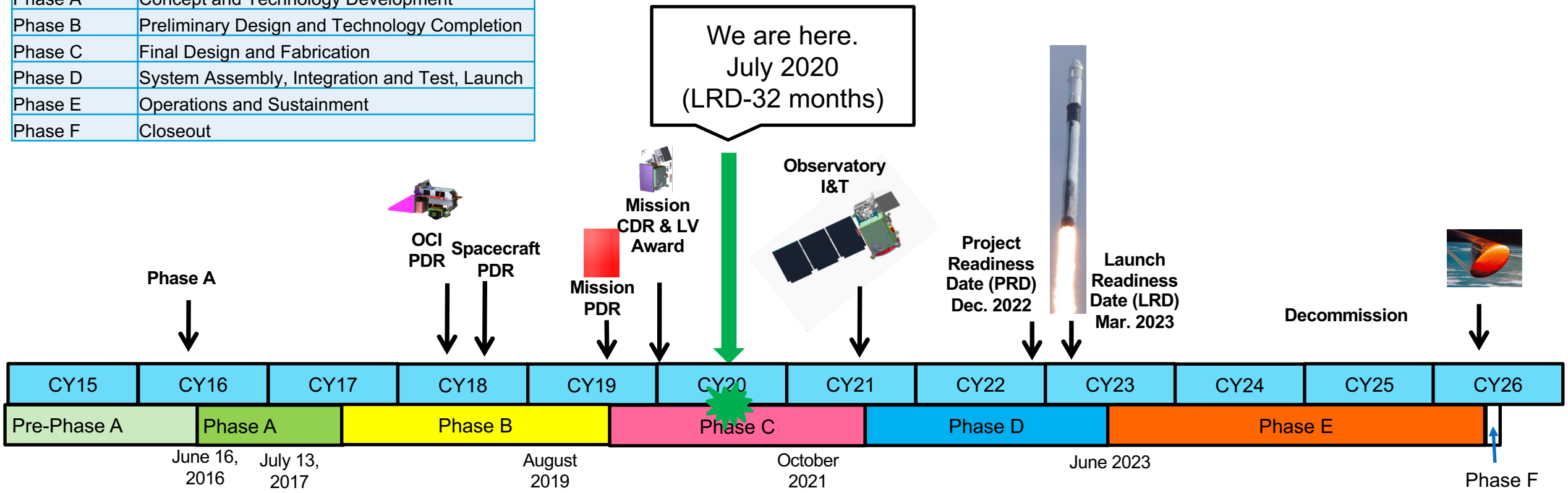
National Aeronautics and Space Administration

Check https://ipddms.gsfc.nasa.gov to verify that this is the correct version prior to use

400-FORM-0002 (4/16/2014)

PACE Development History

NASA Flight Project Life Cycle	
Pre-Phase A	Concept Studies
Phase A	Concept and Technology Development
Phase B	Preliminary Design and Technology Completion
Phase C	Final Design and Fabrication
Phase D	System Assembly, Integration and Test, Launch
Phase E	Operations and Sustainment
Phase F	Closeout



Let's Talk Science

- **Basic Science** is the systematic investigation of scientific theories and hypotheses for the sake of growing humanity's collective knowledge and understanding on a topic.

- **Applied Science** is the application of existing scientific knowledge to develop and advance practical technologies or inventions for the benefit of society.

What is an Application?

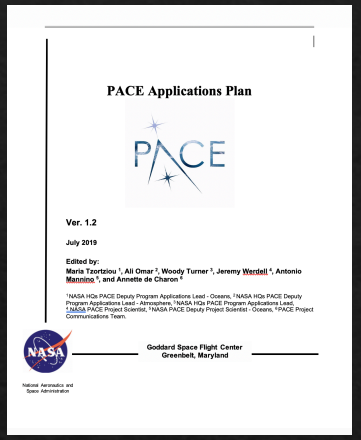
- **Applications** are innovative uses of NASA PACE data products to complement and improve *decision-making activities and provide practical solutions to meet societal needs.*

- **Applied Research** provides *fundamental knowledge* of how PACE data products may be scaled & integrated into *users'* policy, business, and management activities to improve decision-making.

- **End-user communities** include
  - Individuals & groups
  - Public & private sectors
  - National & international organizations
  - Local & global scales


Ecological Forecasting
Air Quality
Disasters
PACE
Water Resources
Climate

PACE Applications Program



PACE Applications Plan

PACE

Ver. 1.2

July 2019

Edited by:

Maria Tzortziou [1], Ali Omar [2], Woody Turner [3], Jeremy Werdell [4], Antonio Mannino [5], and Annette de Charon [6]

[1]NASA HQs PACE Deputy Program Applications Lead - Oceans, [2]NASA HQs PACE Deputy Program Applications Lead - Atmosphere, [3]NASA HQs PACE Program Applications Lead, [4]NASA PACE Project Scientist, [5]NASA PACE Deputy Project Scientist - Oceans, [6]PACE Project Communications Team.

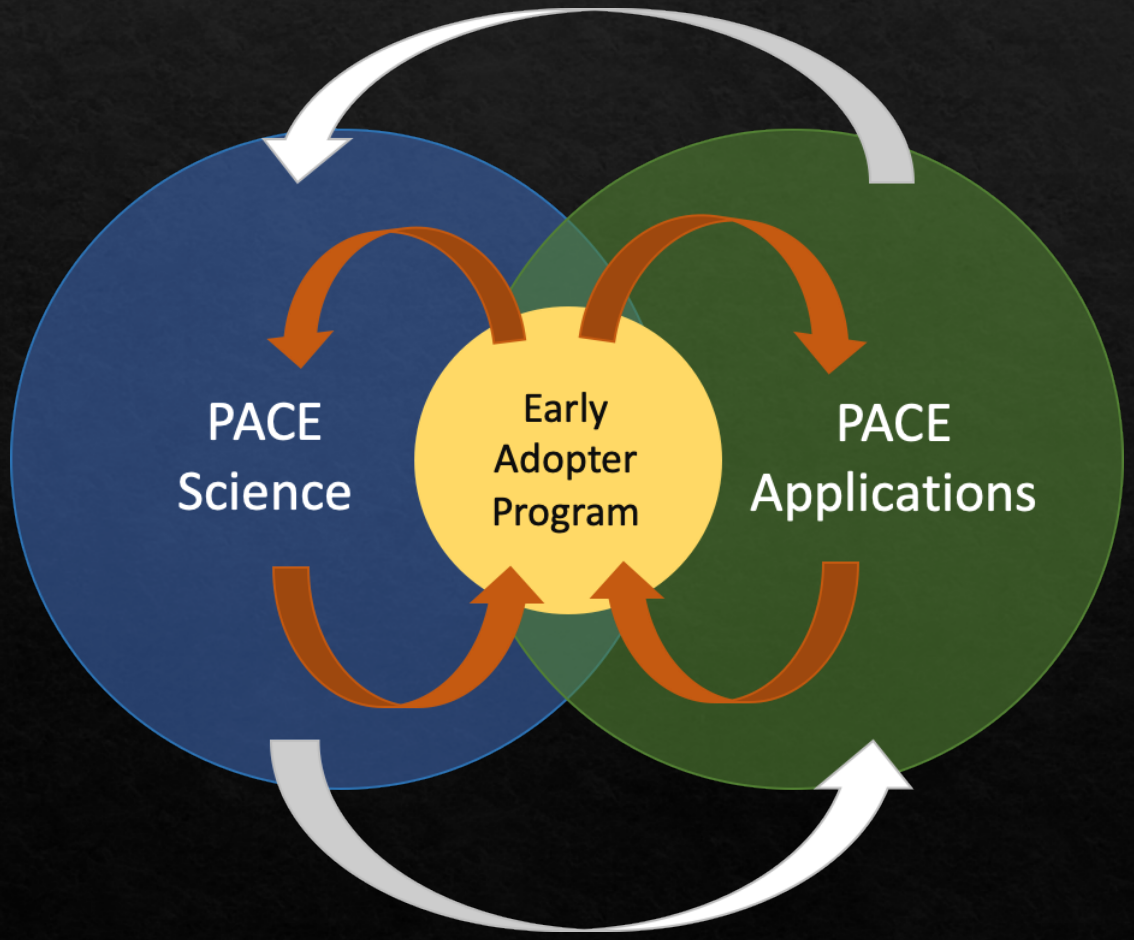
Goddard Space Flight Center
Greenbelt, Maryland

National Aeronautics and Space Administration

- *Address community user needs* & concerns with PACE data products
- *Grow relevance* & sustainability of PACE
- *Demonstrate the societal value* & utility of PACE

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.

PACE Early Adopter Program



The goal of the Early Adopter program is to:

- Expand the user communities with practical applications that would benefit from the use of PACE data sets
- Facilitate feedback on PACE data products pre-launch
- Accelerate the use of PACE products in applications post-launch by conducting pre-launch applied research

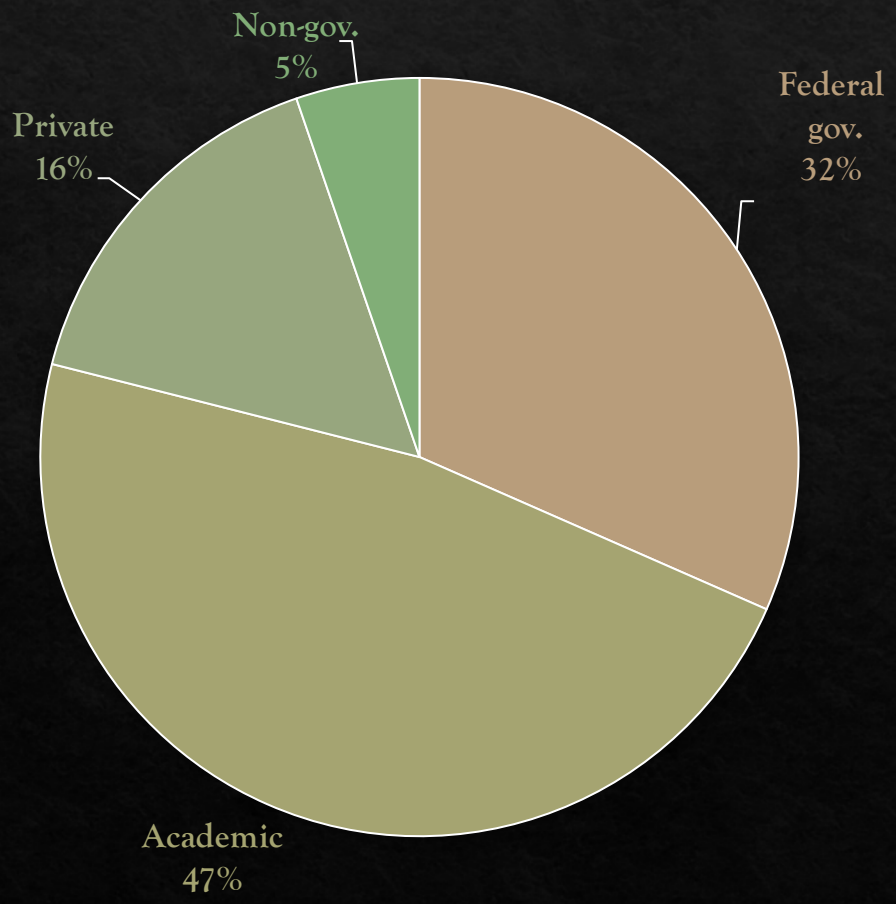
Early Adopters are individuals/groups who:

- Have a direct, clearly defined need for PACE data products
- Have an existing application or a new idea for PACE-related applications
- Have an existing user for their application
- Have existing resources to demonstrate the utility of PACE data in their application

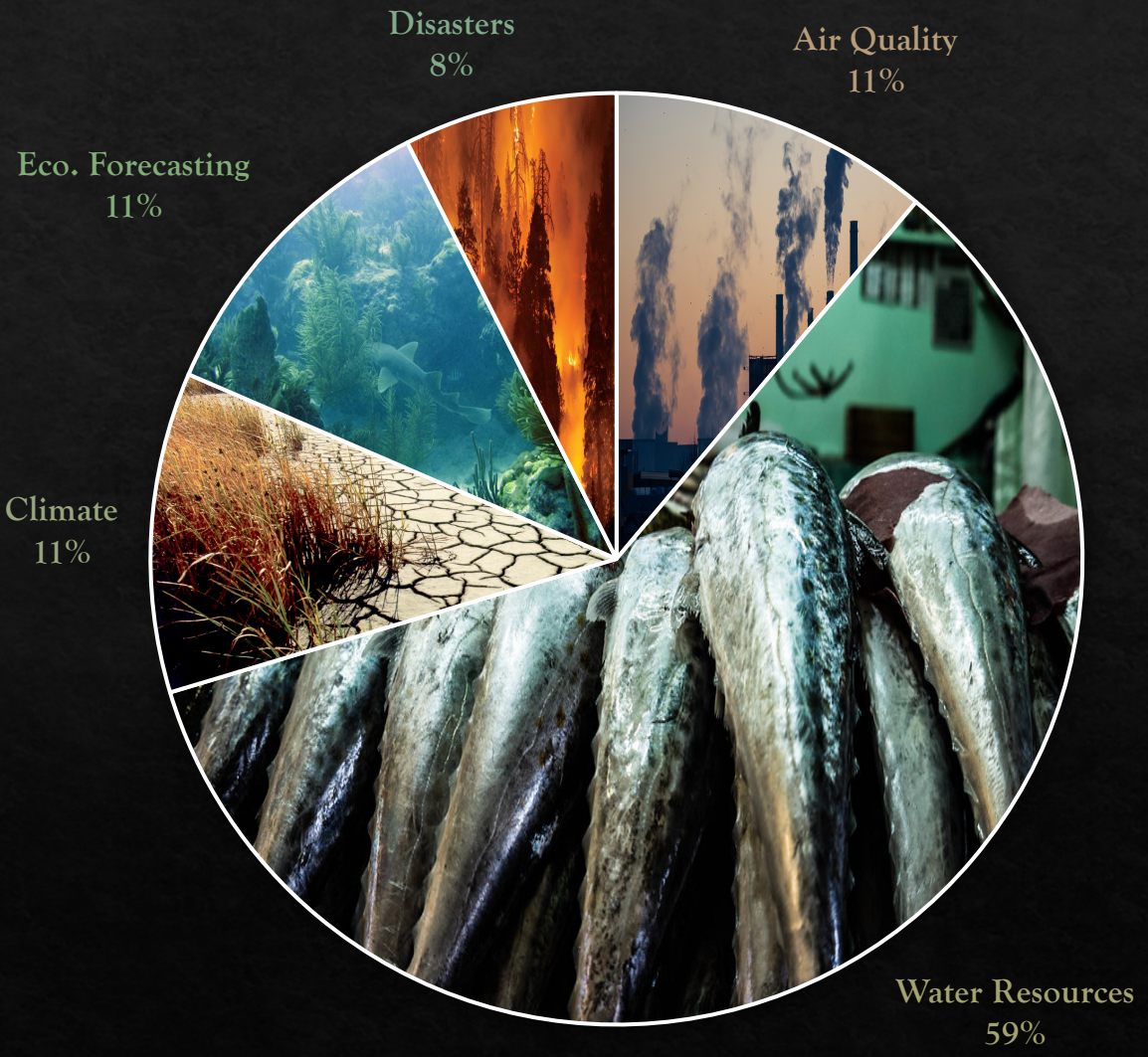
PACE Early Adopters

Early Adopters at a Glance

Affiliation



Applied Science Area



EA Project Profile: *Aquaculture Site Prospecting: Applying PACE products to sustainable aquaculture site selection*

Damian Brady
University of Maine; https://umaine.edu/coastalsat/

Application: Aquaculture site selection tool for Gulf of Maine.

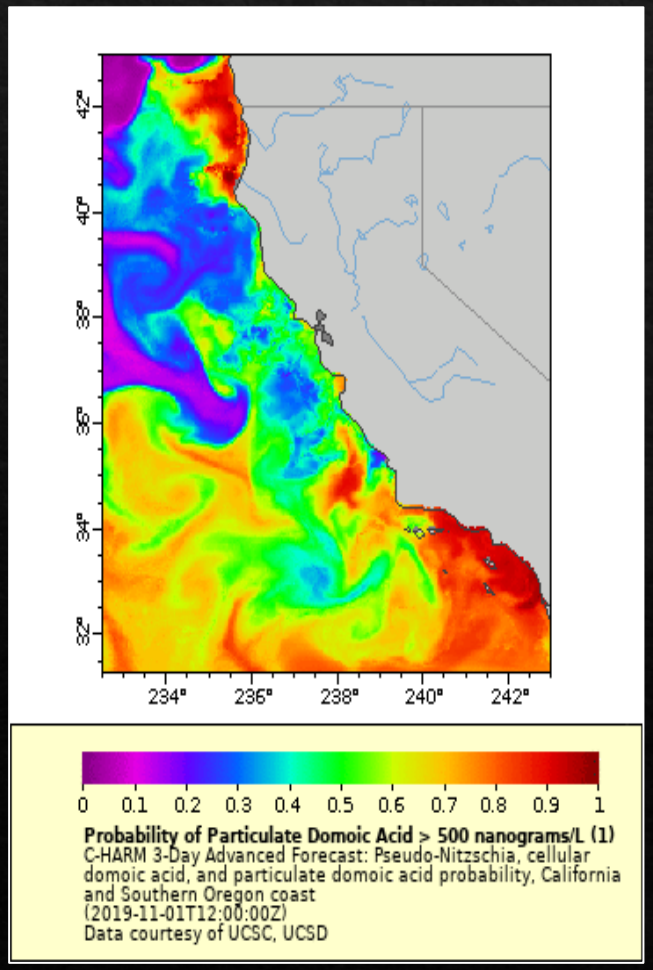
Significance: By choosing optimal aquaculture sites with the best available information, our tool can save prospective oyster, mussel, and scallop growers money and time.

Why PACE: Sea scallop aquaculture is a promising field of bivalve aquaculture due to our large sea scallop trade deficit and the potential market for cultured sea scallops. This species will be cultured in offshore waters due to their temperature preference. PACE resolution would be optimal for site selection tools for these species if we can relate phytoplankton size to feeding rates.

Stakeholder(s): End-users change each year and with over 600 Limited Purpose Aquaculture License holders in the state of Maine.

EA Project Profile: *Applying PACE products to the CA Harmful Algae Risk Mapping (C-HARM) System*

Clarissa Anderson
Scripps Institution of Oceanography; https://sccoos.org/



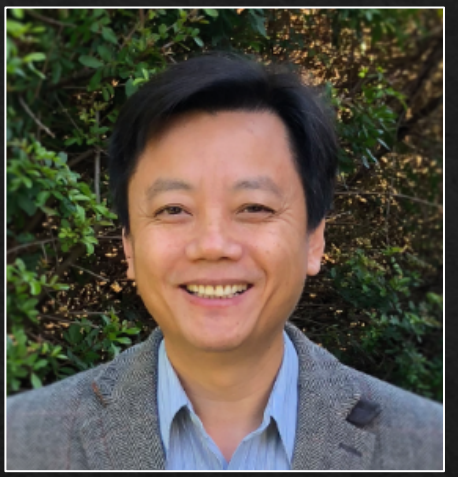
Application: Short and long-time HAB forecasting tool to protect ecosystem health and understand the future of coastal ocean ecology in a changing climate.

Significance: C-HARM is used for wide range of including, but not limited to: shellfish growing operations, marine mammal rescue decisions, retrospective analysis, public health sampling decisions, and is incorporated into the widely subscribed California HAB Bulletin that is disseminated to federal, state, and regional partners.

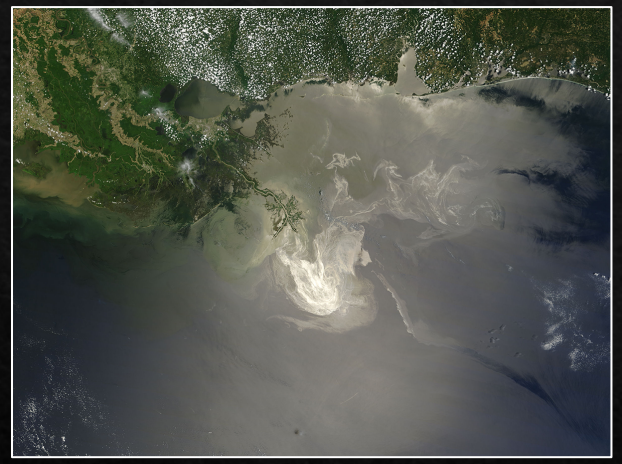
Why PACE: PACE will provide continuity of ocean color currently in use from MODIS and VIIRS. Simulated PACE geophysical variables (L0-L2) will be processed and then subscened and projected (L3) for the California domain.

Stakeholders: CA Department of Fish and Wildlife, CA Department of Public Health (CDPH), CA Office of Environmental Health and Hazard Assessment (OEHHA).

EA Project Profile: *Detecting and differentiating oil slicks through PACE measurements*



Chuanmin Hu
University of South Florida; https://www.usf.edu/



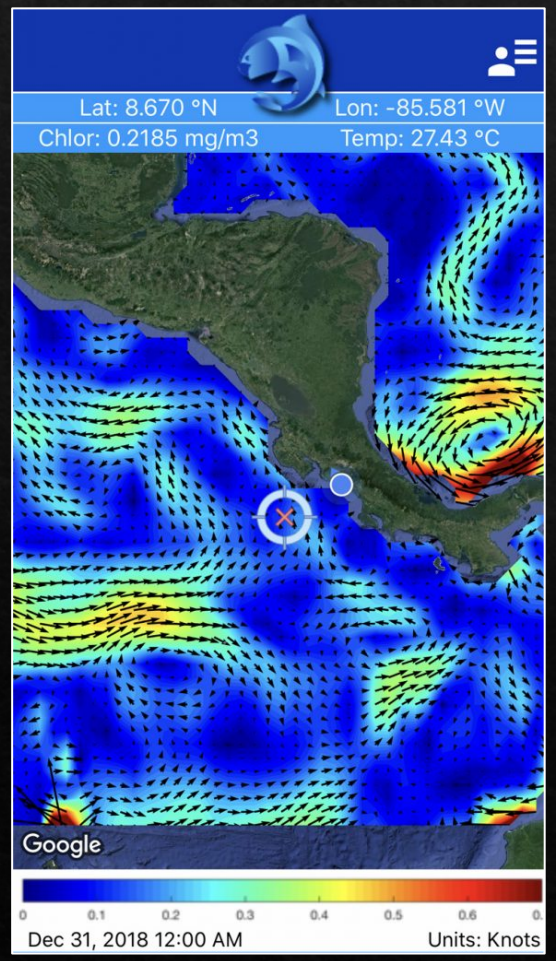
Application: Different oil spill or seep types (e.g. - oil sheens, thick crude oil, oil-in-water emulsions, and water-in-oil emulsions) have different spectral shapes in the visible-NIR-SWIR spectral regions.

Significance: Improved detection and differentiation of natural oil seeps or oil spill accidents can be used in disaster response, mitigation, and clean-up efforts.

Why PACE: PACE with hyperspectral bands covering the 380 - 1000 nm spectral region and the shortwave infrared (1.2 & 1.6 mm) can spectrally differentiate various types of oil slicks and quantify oil thickness. These oil-sensitive wavelengths have not been available on prior multi-band sensors, such as MODIS, VIIRS, or OLCI.

Stakeholders: Oil companies; Oil management agencies (BOEM, BSEE); NOAA NRDA; NOAA CoastWatch; Environmental Protection Agency; Department of Health

EA Project Profile: *PezCA - Near real time satellite data distribution platform for Central America fisheries*



Marina Marrari
FECOP; https://fishcostarica.org

Application: A free mobile app serving NRT satellite data (e.g. - SST, *Chl*, currents, altimetry, bathymetry, and thermocline depth, as well as tide forecasts, moon phase, & fishing information).

Significance: Support of recreational fishing sector, government organizations, and decision-making processes in Costa Rica (monitoring of oceanographic conditions, climate change, effects of El Niño).

Why PACE: PACE will represent a valuable source of operational ocean color data to eventually replace MODIS in our current workflow and will expand the products we serve (e.g. – PFTs, red tide detection, etc.).

Stakeholders: Recreational anglers, commercial fishermen, eco-tourism planners & agents

EA Project Profile: *Predictive assessment of clinically active biothreats in coastal and ocean waters using PACE data*

Antar Jutla
University of Florida
https://faculty.eng.ufl.edu/antarpreet-jutla/

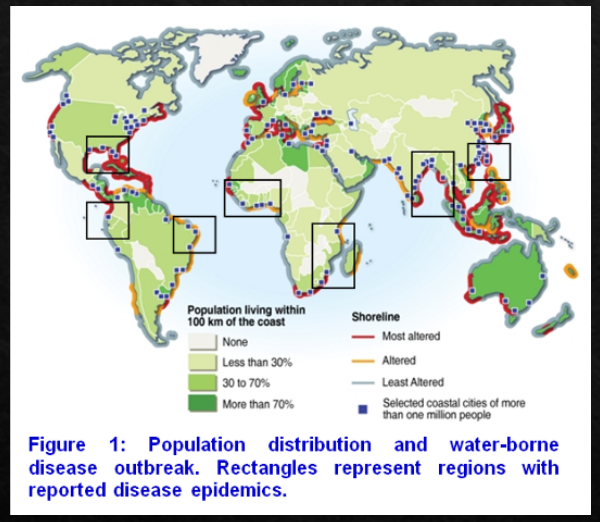


Figure 1: Population distribution and water-borne disease outbreak. Rectangles represent regions with reported disease epidemics.

Application: Predictive risk assessment for coastal pathogens/biothreats/HABs In Florida and the Chesapeake Bay.

Significance: Our work has been used by several UN agencies to make real time decisions of when and where to initiate relief and mitigation activities. Our cholera work is used by UNCEF for making decisions on where and when to provide safe water and sanitation access to population.

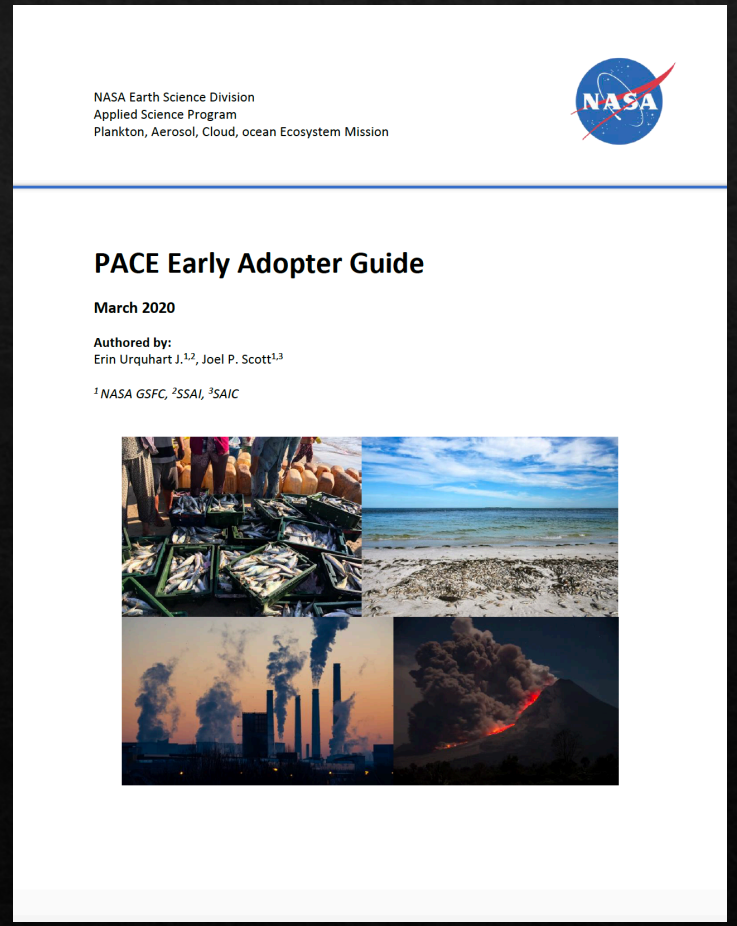
Why PACE: Hyperspectral capabilities of OCI will enhance existing prediction models (for Vibrio cholera) by integrating speciation level information of plankton and plankton health into algorithms.

Stakeholders: United Nations Office for Coordinator of Humanitarian Affairs (UNOCHA); WHO; UNCEF

PACE Early Adopter Program

Early Adopter Benefits:

- Engage with PACE Mission & Project Science
- Interact with other members of the Early Adopter team and *PACE Science & Application Team*
- Participate in PACE Applications workshops, focus sessions, & tutorials
- Access pre-launch simulated & proxy PACE data
- Updates on the PACE mission, science data products, & field campaigns



NASA Earth Science Division
Applied Science Program
Plankton, Aerosol, Cloud, ocean Ecosystem Mission

PACE Early Adopter Guide

March 2020

Authored by:
Erin Urquhart J.[1,2], Joel P. Scott[1,3]

[1] NASA GSFC, [2]SSAI, [3]SAIC

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

Upcoming Applications Events

1st PACE Applications Workshop

September 23-24th, 2020
Online

The ***Plankton, Aerosol, Cloud, ocean Ecosystem*** Mission (PACE) will host its first virtual Applications Workshop on the 23rd and 24th of September 2020. This two-day workshop will provide an opportunity for early engagement with PACE end-users exploring topics of air quality, public health, water quality and resources, disasters, climate modeling, and ecological forecasting. The workshop will build a transdisciplinary dialogue centered on how PACE data products may be integrated into applications that advance society and inform decision-making processes. This workshop will encourage open collaboration from individuals and organizations across diverse backgrounds including universities, government agencies, and commercial, non-profit, and private sectors.

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

Concluding Thoughts

PACE Applications are a *measure of mission success* to NASA, used to advocate and justify continued support for the mission

Pre-launch applied science from PACE Early Adopters provides feedback & guidance to the mission, *saving time & resources post-launch*

Early engagement between data producers & data users builds partnerships to *advance applications for society & decision-makers*

How can PACE Applications help you??

Erin Urquhart & Joel Scott
PACE-applications@oceancolor.gsfc.nasa.gov
https://pace.gsfc.nasa.gov