



**PACE**

# A Sea of Data with PACE

**The Plankton, Aerosol, Cloud, ocean Ecosystem mission**

**Observing the microscopic living (and non-living) ocean from space**

**Bridget Seegers**  
NASA Ocean Ecology Lab

November 29, 2023





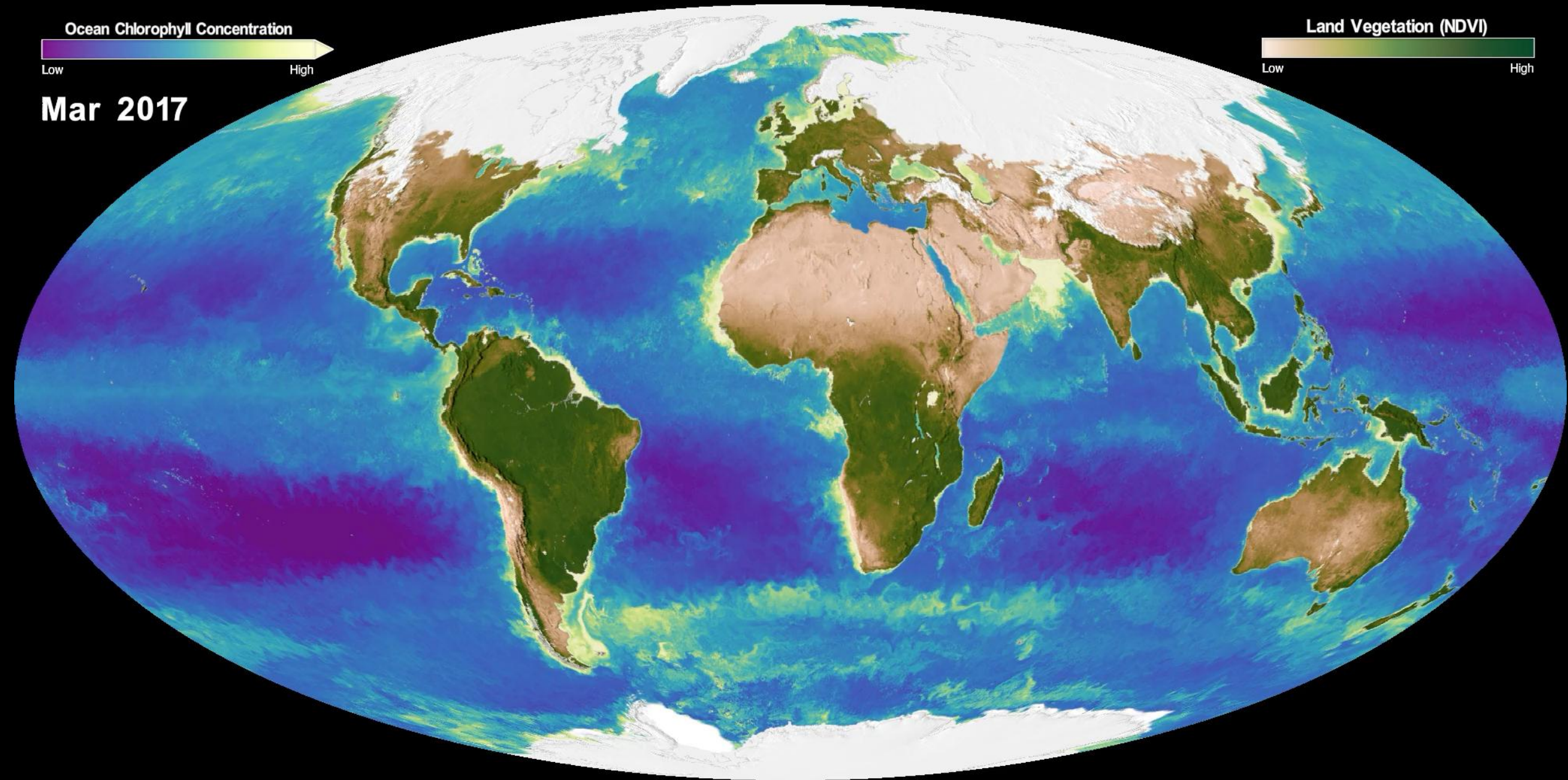
Ocean Chlorophyll Concentration



Land Vegetation (NDVI)



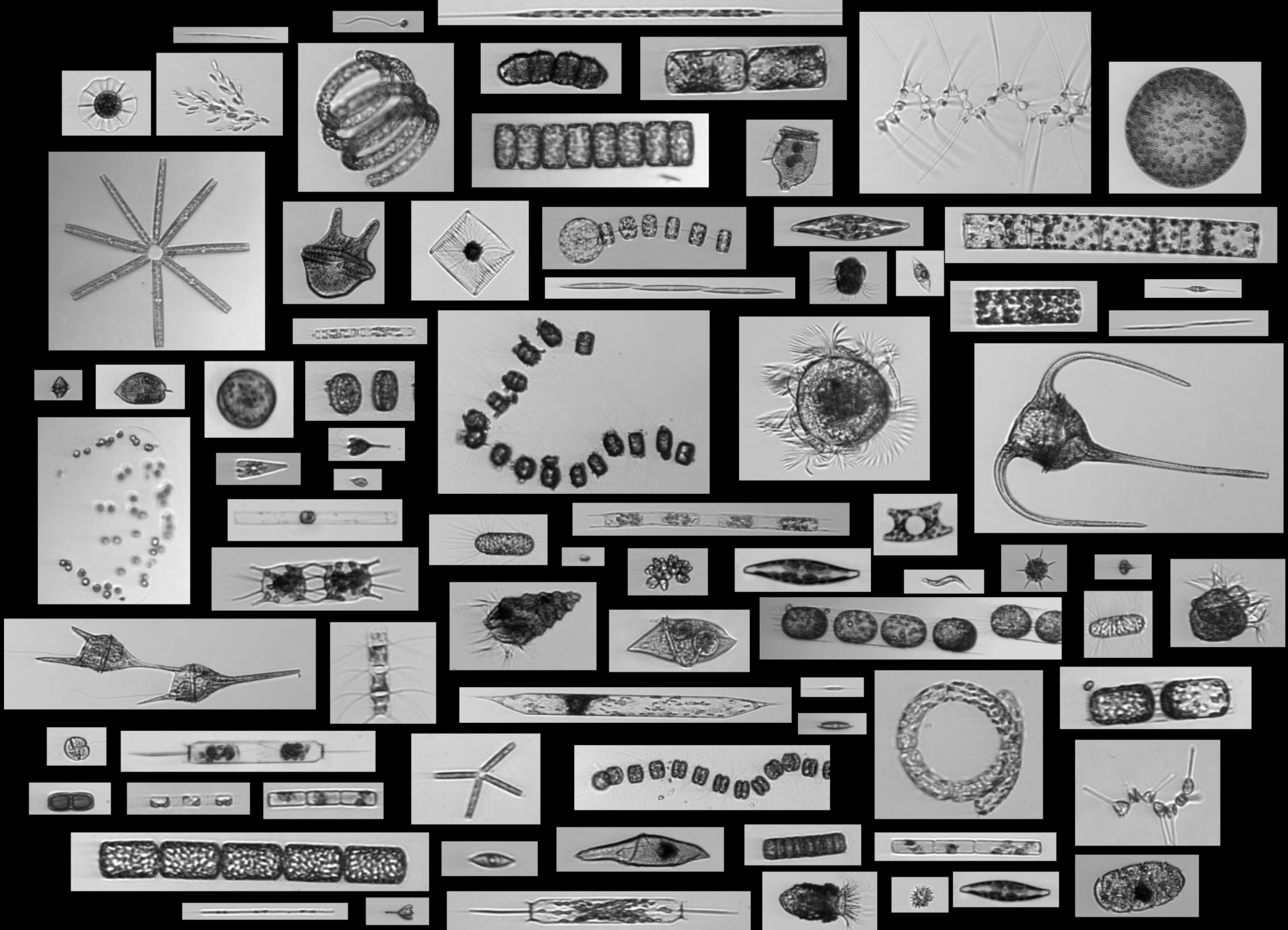
Mar 2017











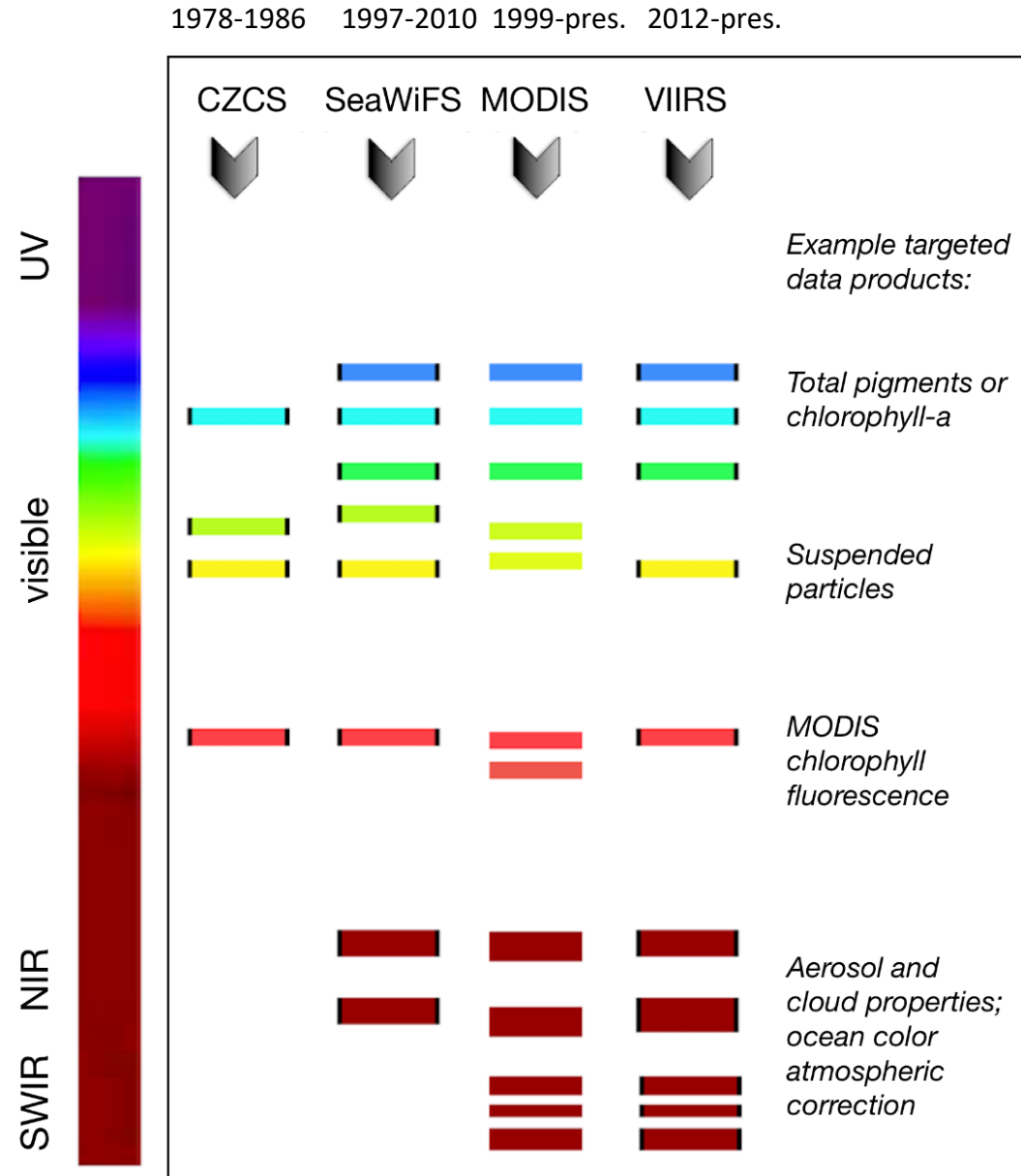
Credit: Heidi Sosik (WHOI)







# moving from multi-spectral to hyperspectral radiometry





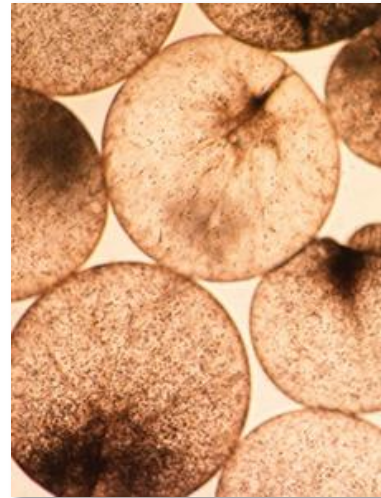
# moving from multi-spectral to hyperspectral

Example diatom

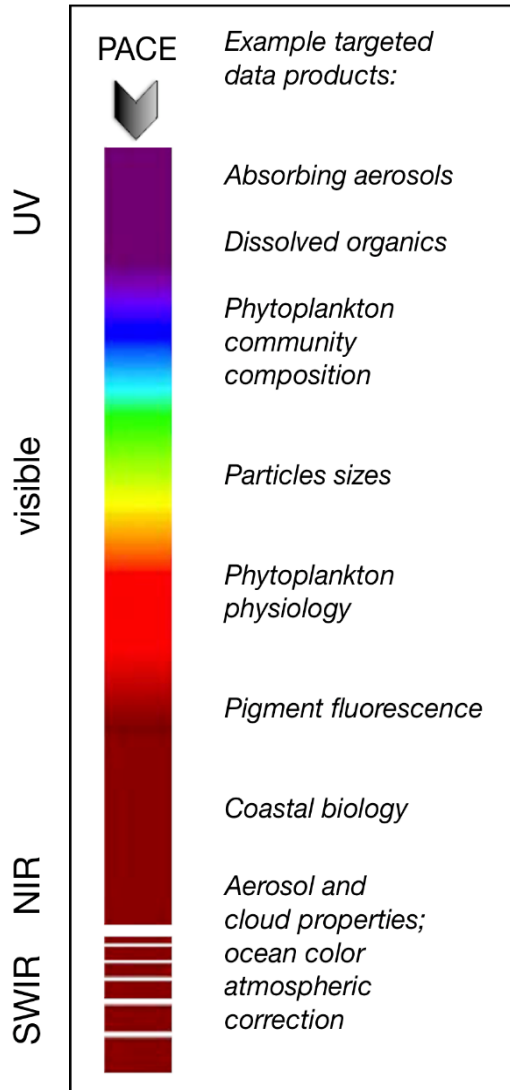


Linda Armbrecht, abc.com.au

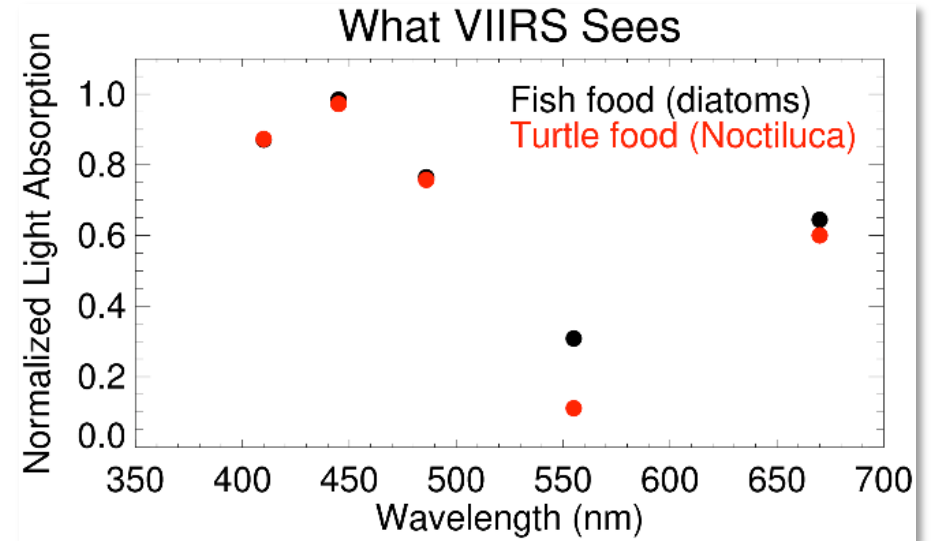
Example Noctiluca



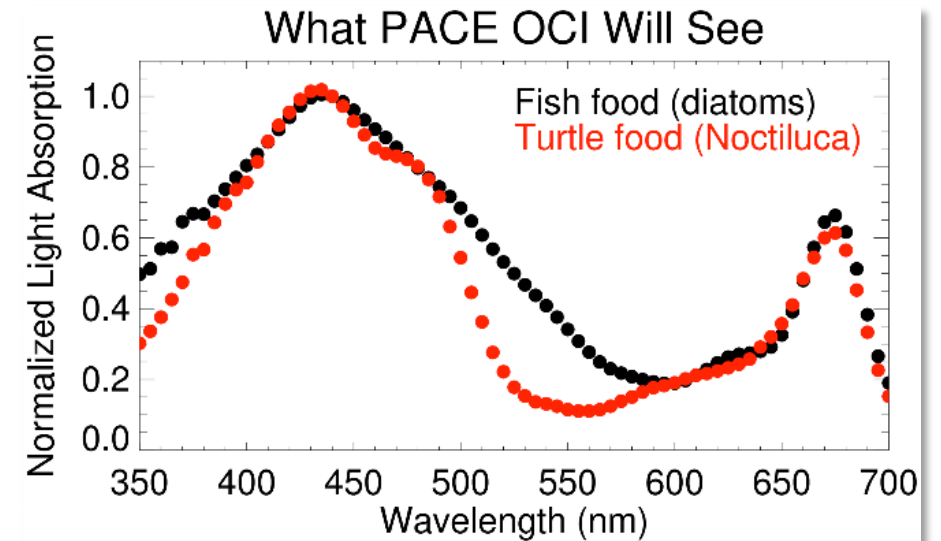
● 1 mm ●  
Joaquim Goes, LDEO



Historic  
and  
Current

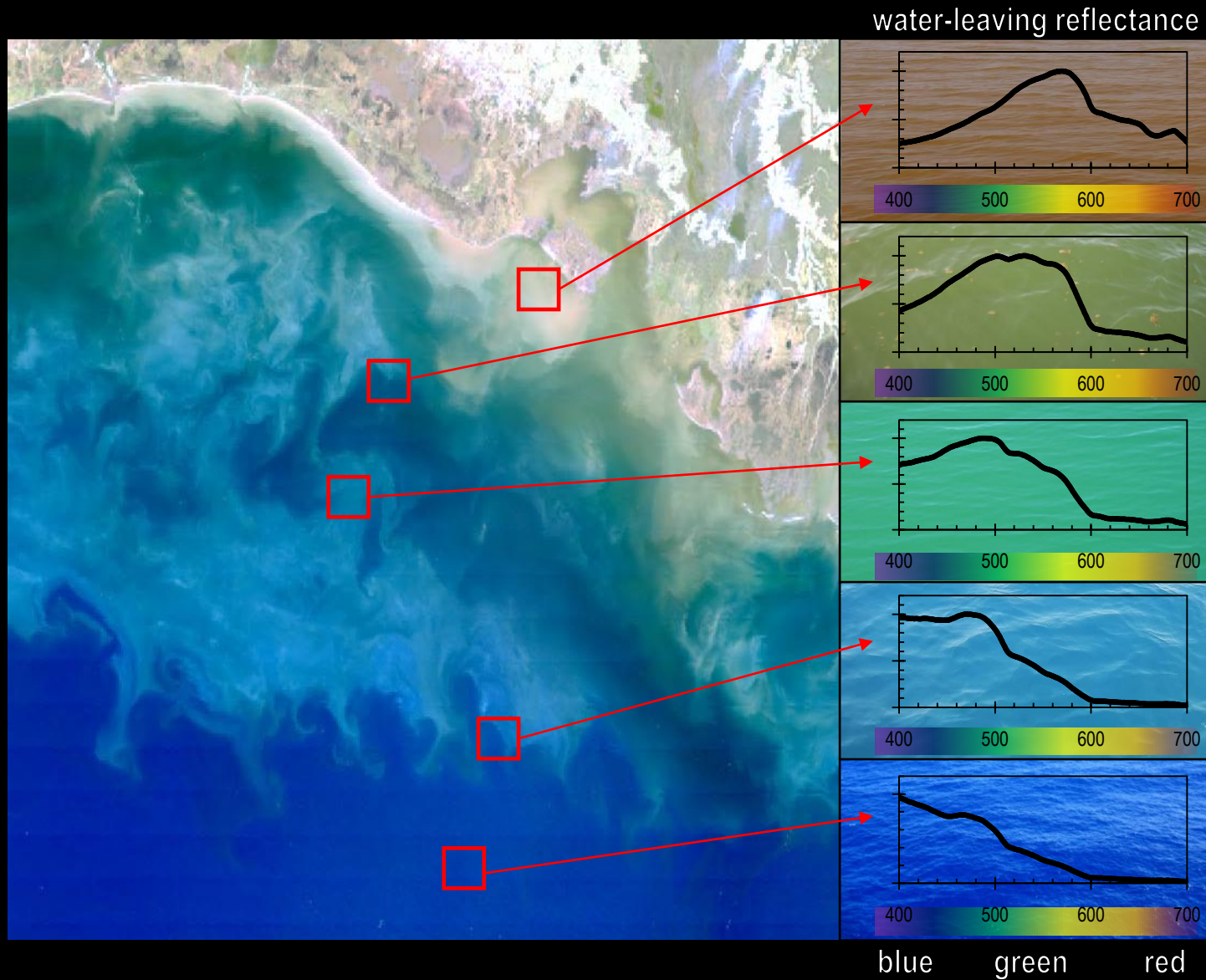


Future





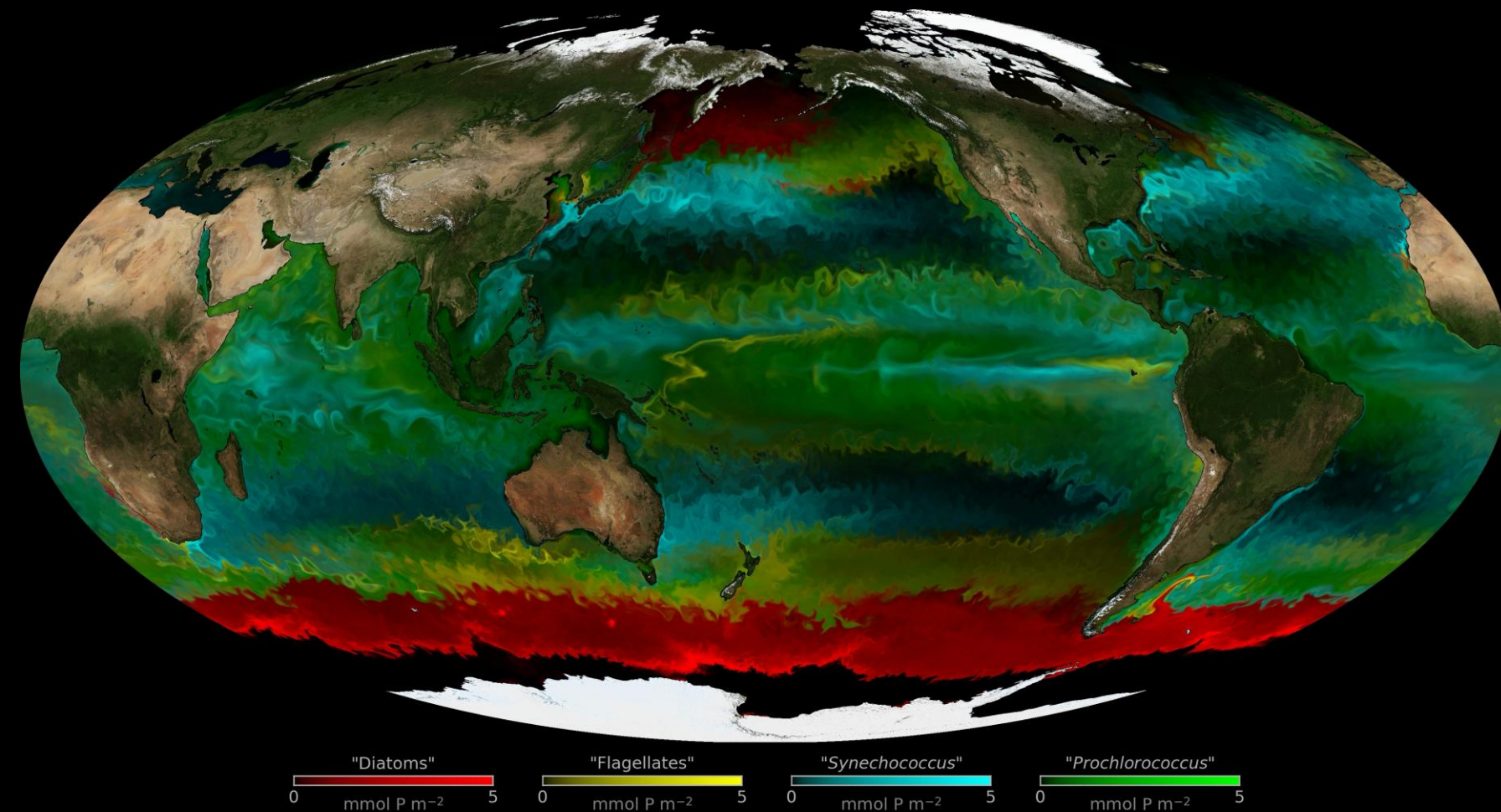
## Variations in the color of the ocean



*The color of the ocean is a function of light that is absorbed or scattered as a result of what is in the water.*

- *Phytoplankton and pigments*
- *Dissolved organic matter*
- *Detritus (fecal pellets, dead cells)*
- *Inorganic particles (sediment)*
- *Water absorption*



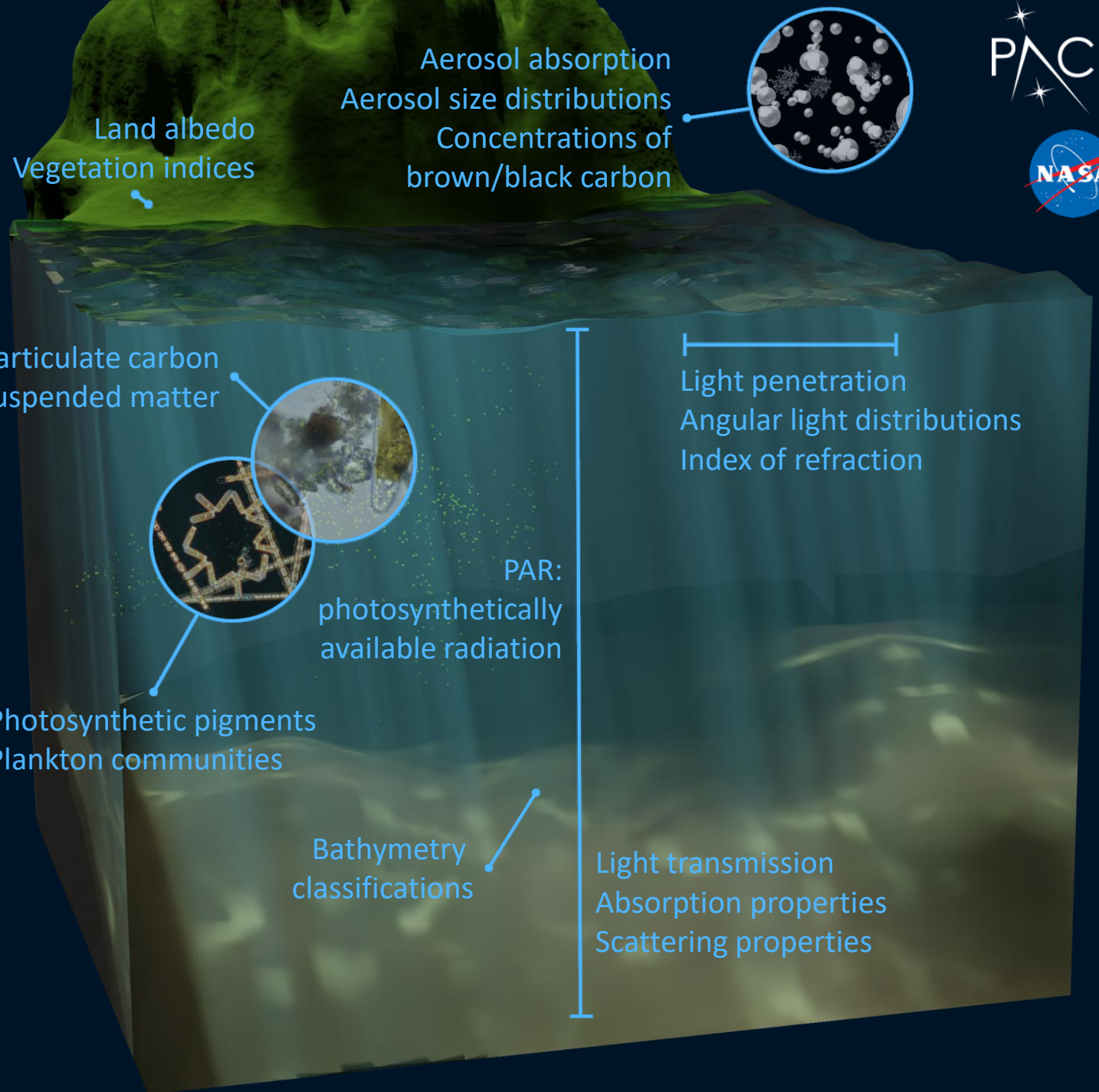


PACE will provide data products for **aquatic applications**, including the management & understanding of:

- Phytoplankton community composition
- Harmful algal blooms
- Fisheries and aquaculture
- Ecosystem and watershed health
- Coastal tourism



# PACE DATA PRODUCTS



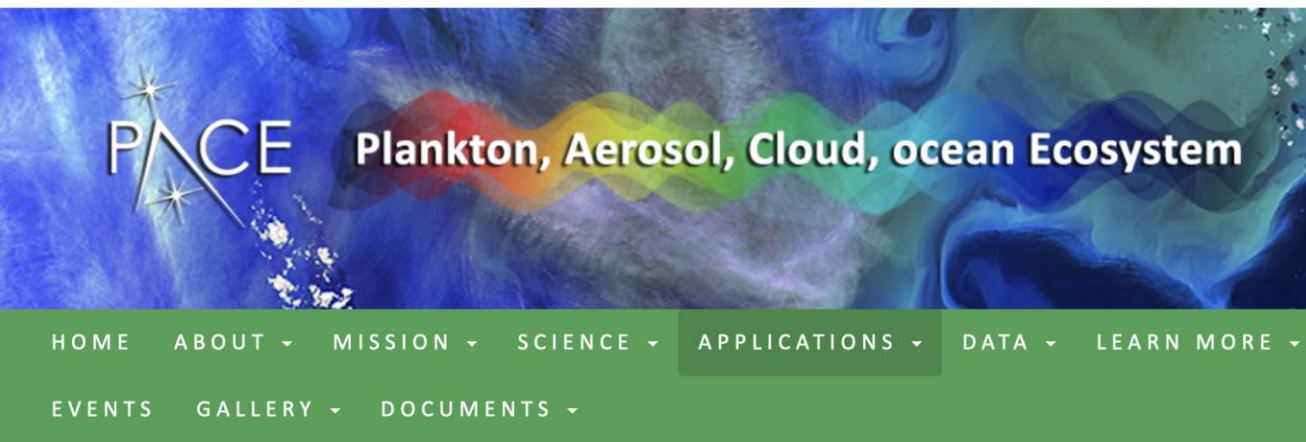
Water Quality

Marine Spatial Planning for  
Protected Areas  
aquaculture

Bathymetry  
classifications

Light transmission  
Absorption properties  
Scattering properties





## Early Adopters

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.

**Have a direct, clearly-defined need for PACE data;**

**Have an existing application or new ideas for novel PACE-related applications that directly benefit society;**

[https://pace.oceansciences.org/app\\_adopters.htm](https://pace.oceansciences.org/app_adopters.htm)



**Elizabeth Ferguson**

Coastal and offshore Oregon marine mammal ecological study »



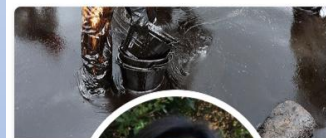
**Joaquim Goes**

Decision and Information System for Coastal waters of Oman (DISCO) - an integrative tool for managing coastal resources experiencing climate change »



**Heather Holmes**

Modeling spatial and temporal exposure to air pollution in the western U.S. »



**Chuanmin Hu**

Detecting and differentiating oil slicks through PACE measurements »



**Jason Jolliff**

Ocean colorimetry with PACE »



**Antar Jutla**

Predictive assessment of clinically active biotreats in coastal and ocean waters using PACE data »



# Applied Remote Sensing Training (ARSET)

Since 2009, the program has reached over 50,000 participants from 170 countries and more than 8,500 organizations worldwide.



## ARSET

EARTH SCIENCE  
APPLIED SCIENCES



## Remote Sensing Basics

### Fundamentals of Remote Sensing



Participants will become familiar with satellite orbits, types, resolutions, sensors, and processing levels. In addition to a conceptual understanding of remote sensing, attendees will also be able to articulate its advantages and disadvantages. Participants will also have a basic understanding of NASA satellites, sensors, data, tools, portals, and applications to environmental monitoring and management.



**ARSET Website**





# ARSET

EARTH SCIENCE  
APPLIED SCIENCES



ARSET Website

## Table of Contents (click to navigate)

### Climate & Resilience .....

#### Disasters .....

Wildfires .....

Floods .....

SAR .....

Urban Heat Islands .....

Other .....

### Health & Air Quality .....

### Ecological Conservation .....

Biodiversity & Ecosystems .....

Coastal & Oceans .....

Land Cover & Change Detection .....

SAR .....

### Water Resources .....

Hydrology & Agriculture .....

River Basins & Water Bodies .....

**Water Quality .....**

### Capacity Building .....

## Water Resources - Water Quality

### Introduction to Remote Sensing of Harmful Algal Blooms



Harmful algal blooms (HABs) can have a negative impact on the ecosystem and human health. Satellite remote sensing is able to collect data frequently and over a large area to identify impaired water quality from HABs. This data can help decision-makers decide where to take water samples, determine what toxins are in the water, decide whether they need to

Introductory  
2017



EARTH SCIENCE  
APPLIED SCIENCES



### Monitoring Coastal and Estuarine Water Quality



This intermediate-level training series provides a comprehensive overview of satellite remote sensing of coastal and estuarine water quality. It includes a time series, spatial variability, and differences in water quality monitoring between coastal and estuarine environments.

### Processing Satellite Imagery for Monitoring Harmful Algal Blooms



This webinar series covers the processing of satellite imagery to identify indicators of harmful algal blooms, including water temperature and chlorophyll-a concentrations. This information is used to monitor and predict HABs.

### Integrating Remote Sensing into a Water Quality Assessment



This webinar series covers the integration of satellite remote sensing into a water quality assessment. This will include monitoring water temperature and chlorophyll-a concentrations. Attendees can also use

TRAINING

# ARSET - Remote Sensing of Coastal Ecosystems

PROGRAM AREA: ECOLOGICAL CONSERVATION WATER RESOURCES

2017

HOME / GET INVOLVED / TRAINING

Welcome to the International Ocean Colour Coordinating Group



## Training and Education

[HOME](#) » [WHAT WE DO](#) » [TRAINING AND EDUCATION](#)

A major focus of the IOCCG is to broaden the user community for ocean-colour data, particularly in developing countries, through the coordination and sponsoring of advanced training courses.

The IOCCG has sponsored and coordinated a number of specialized ocean-colour training courses, providing comprehensive training to a large number of students from around 60 different countries. Generally the courses are one to two weeks in duration and are aimed at undergraduate and postgraduate students, university lecturers and researchers.

### IOCCG Training Initiatives

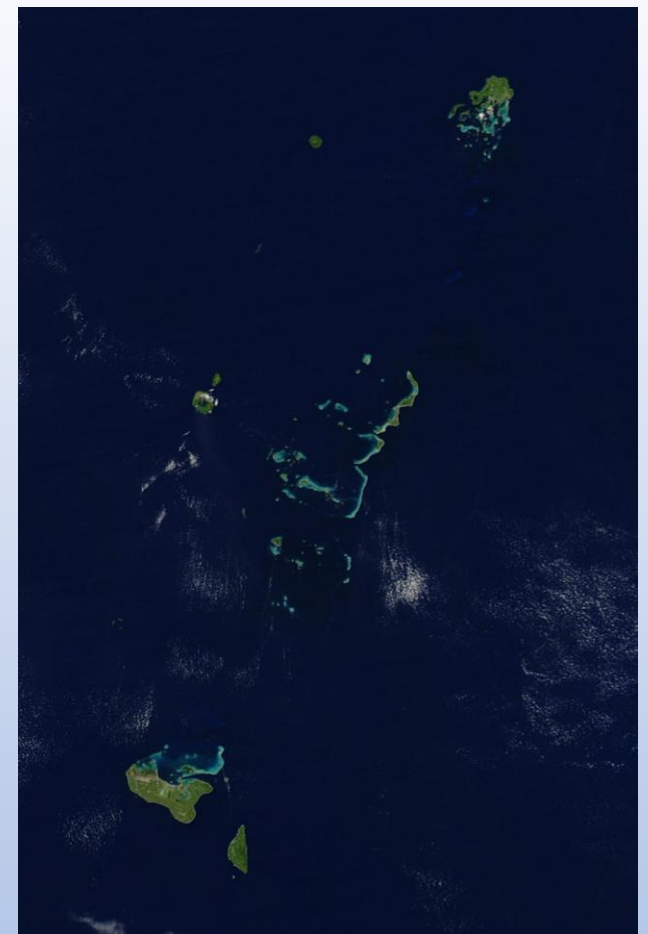
- Trevor Platt Memorial Scholarship
- IOCCG Summer Lecture Series
- Reports of Past IOCCG Training Courses and Workshops
- IOCCG Scholarship & Fellowship Recipients

### Training Resources

- Lecture material from previous IOCCG ocean-colour courses
- Handbook of Satellite Remote Sensing Image Interpretation (PRESPO/IOCCG).
- Links to online tutorials, books and

### Other Training Opportunities

- Upcoming and on-going training opportunities from other organizations



Scholarships  
And  
Fellowships



# NASA DEVELOP



DEVELOP PROJECTS

## APPLYING EARTH OBSERVATIONS

HOME / WHAT WE DO / CAPACITY BUILDING / ABOUT DEVELOP

### BENEFITS OF WORKING WITH DEVELOP

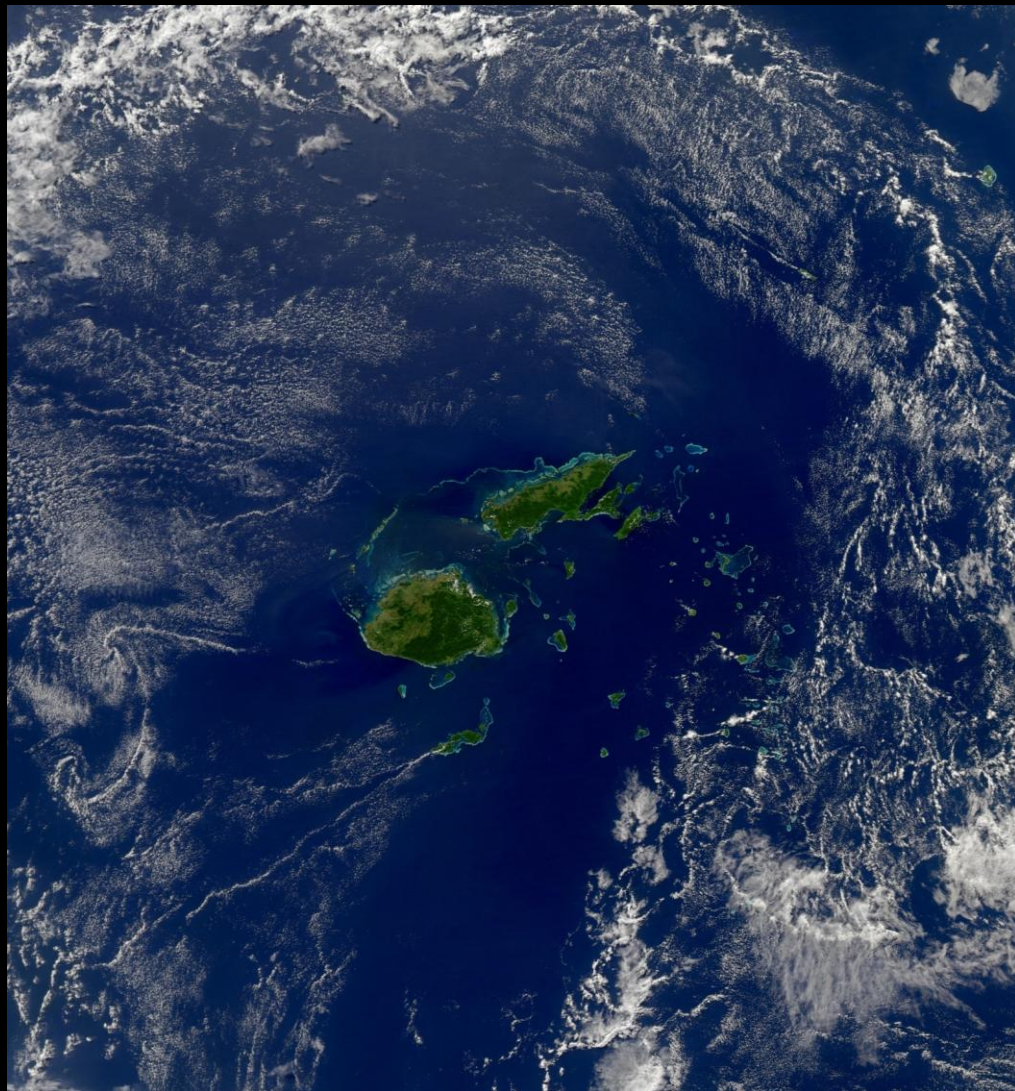
DEVELOP offers partners an opportunity to explore new ideas and innovations with NASA's Applied Sciences' experience and support. This can help partners decrease costs, streamline decision making and fill in data gaps. Some of the other important benefits include:

- Increased understanding of how to use NASA Earth science data
- Enhanced decision support tools
- New methods to augment current practices
- Time- and money-saving methodologies
- Access to free data sources
- Access to a pipeline of skilled early career candidates

<https://appliedsciences.nasa.gov/what-we-do/capacity-building/develop>



We love data. But even more we love people using our data.



Thank you  
Vinaka



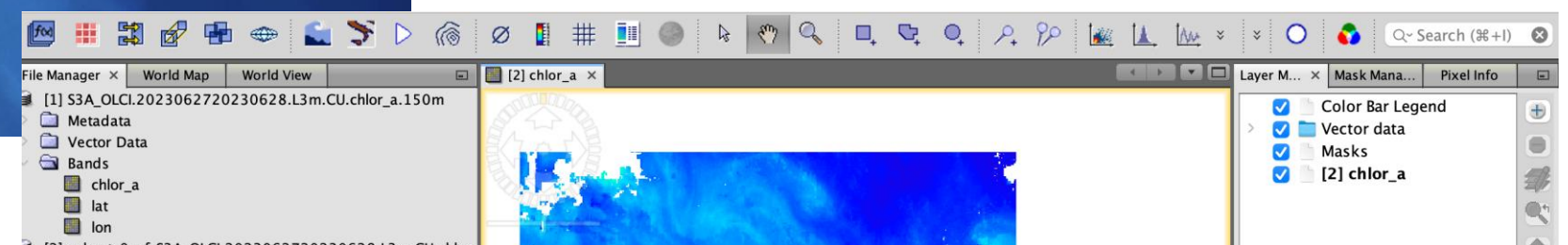
Me

PACE

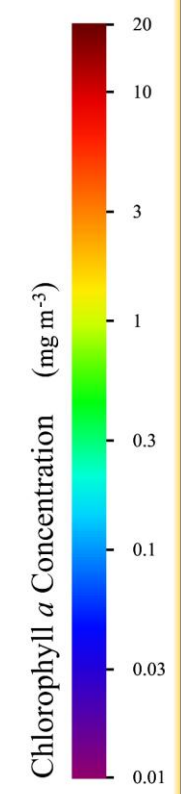
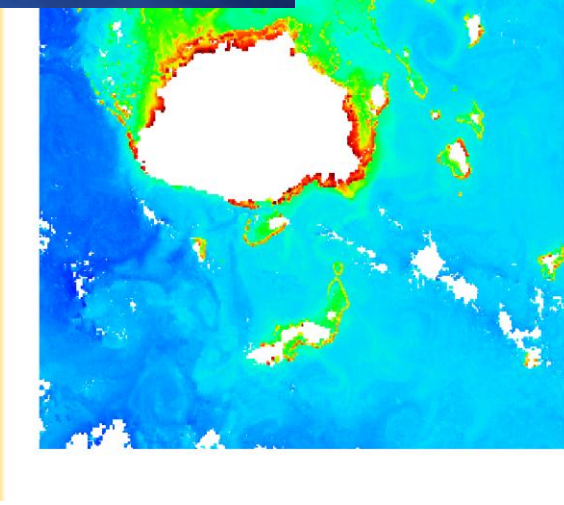
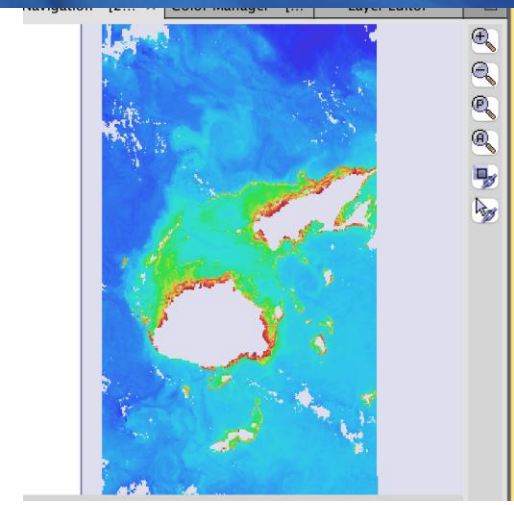
acknowledgements: the NASA GSFC Ocean Ecology Laboratory & PACE Project







- Installation Guide
- Video Tutorials & Demos
- How to Cite
- Outreach
  - Presentation Material
  - Workshop/Conference Posters



Layer M... x Mask Mana... Pixel Info

- Color Bar Legend
- Vector data
- Masks
- [2] chlor\_a

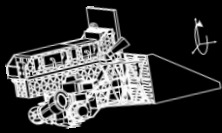
Transparency: 0% 50% 100%

Swipe:



**OCI**

340-890 nm in 2.5 nm steps  
7 discrete SWIR, 940-2260 nm  
1-2 day coverage  $\pm 20^\circ$  tilt, 1 km



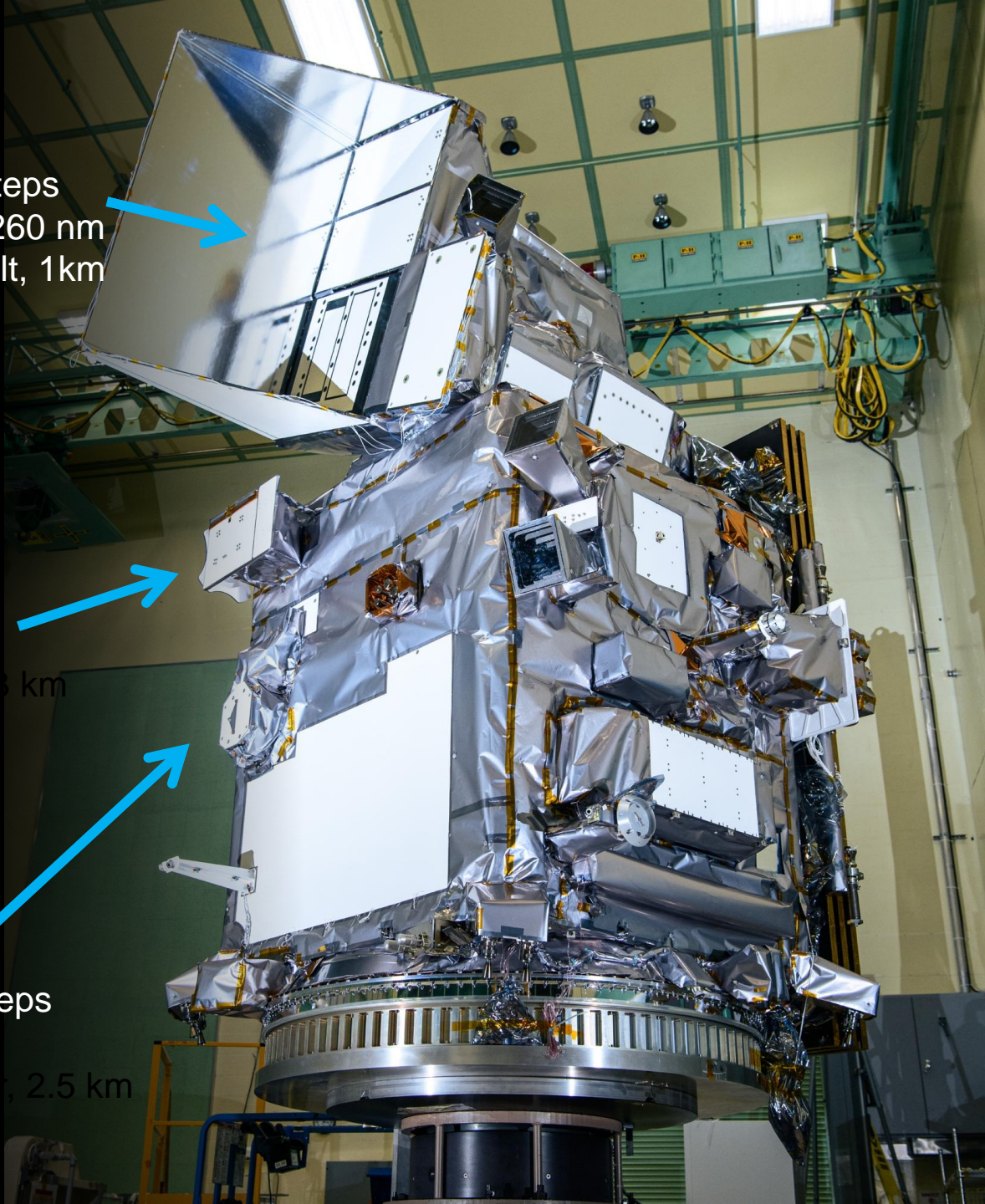
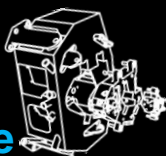
**HARP2**

440, 550, 670, 870 nm



**SPEXone**

380-770 nm in 2-4 nm steps







# Plankton, Aerosol, Cloud, and Ocean Ecosystem

**PACE will revolutionize global marine and atmospheric science**

**PACE is a mission of discovery across Earth system science.**

Aquatic

Atmospheric & Air Quality

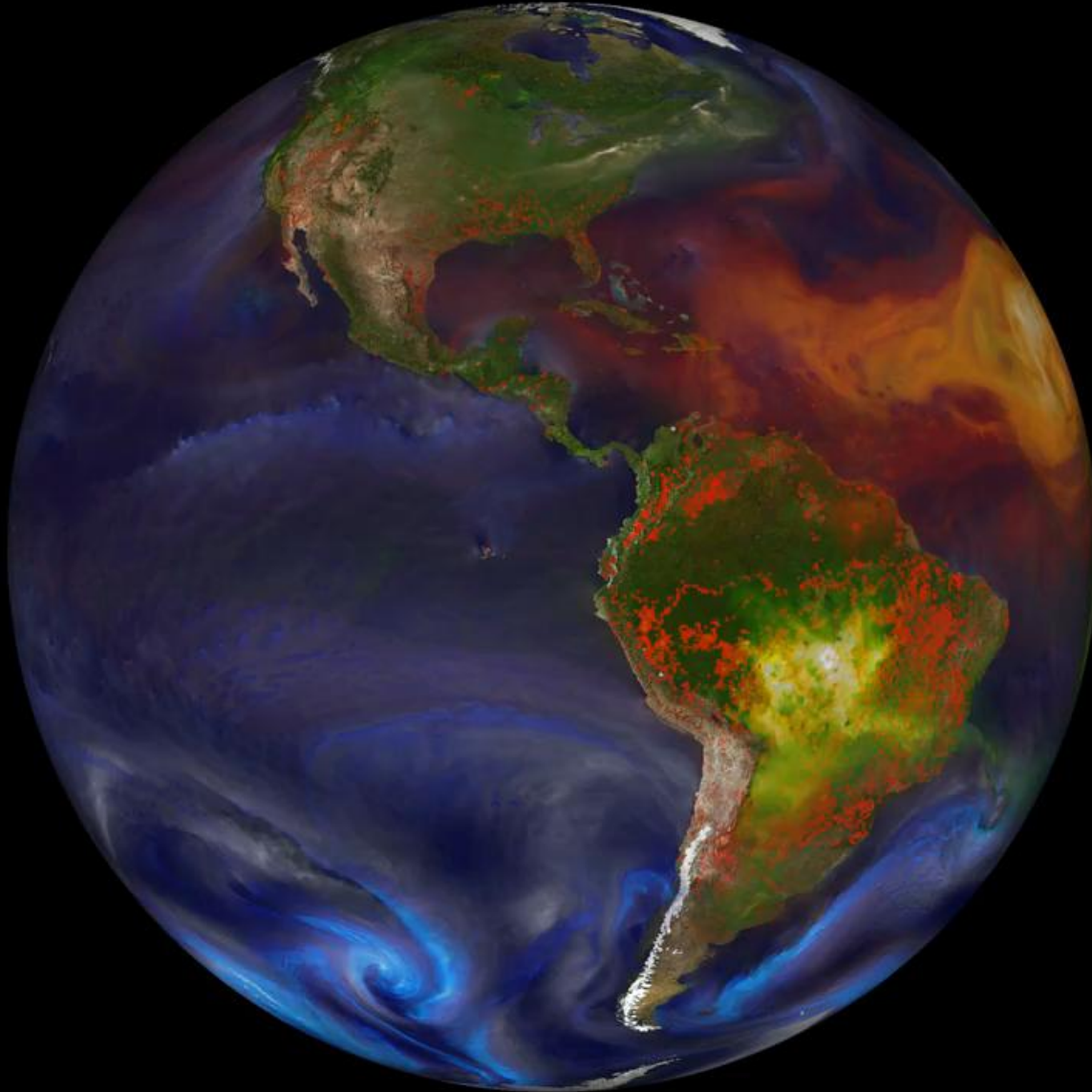
Terrestrial

Climate



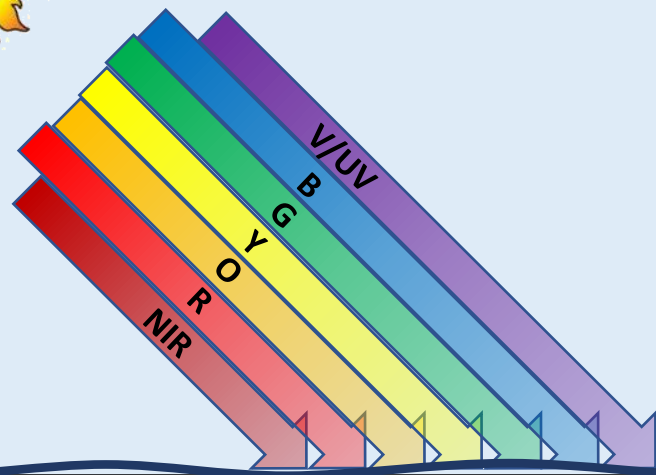
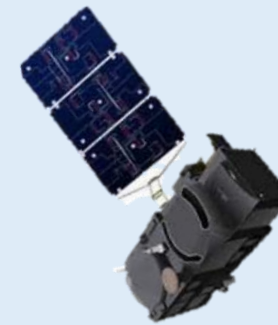


# Atmospheric & Air Quality Applications



PACE will provide aerosol measurements for understanding **aerosols, clouds, & air quality and its impacts on human health:**

- Estimating particulate matter (PM) for air quality advisories
- Location, altitude, and magnitude of particulate matter such as wildfire smoke or volcanic ash



AIR

WATER

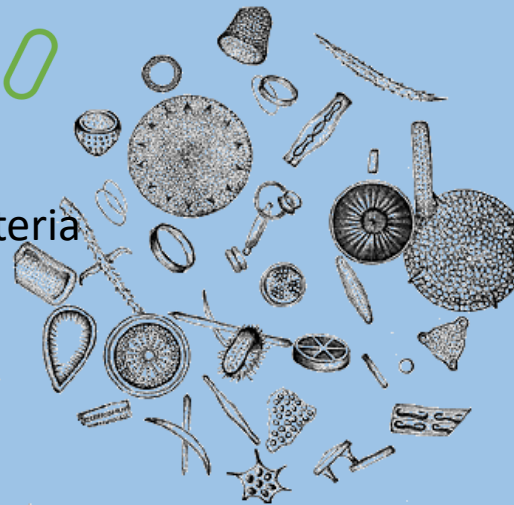
**Two possible things happen to a photon in water**

ABSORPTION (a)

SCATTERING (b<sub>s</sub>)



cyanobacteria



Phytoplankton  
Organic Matter  
Detritus