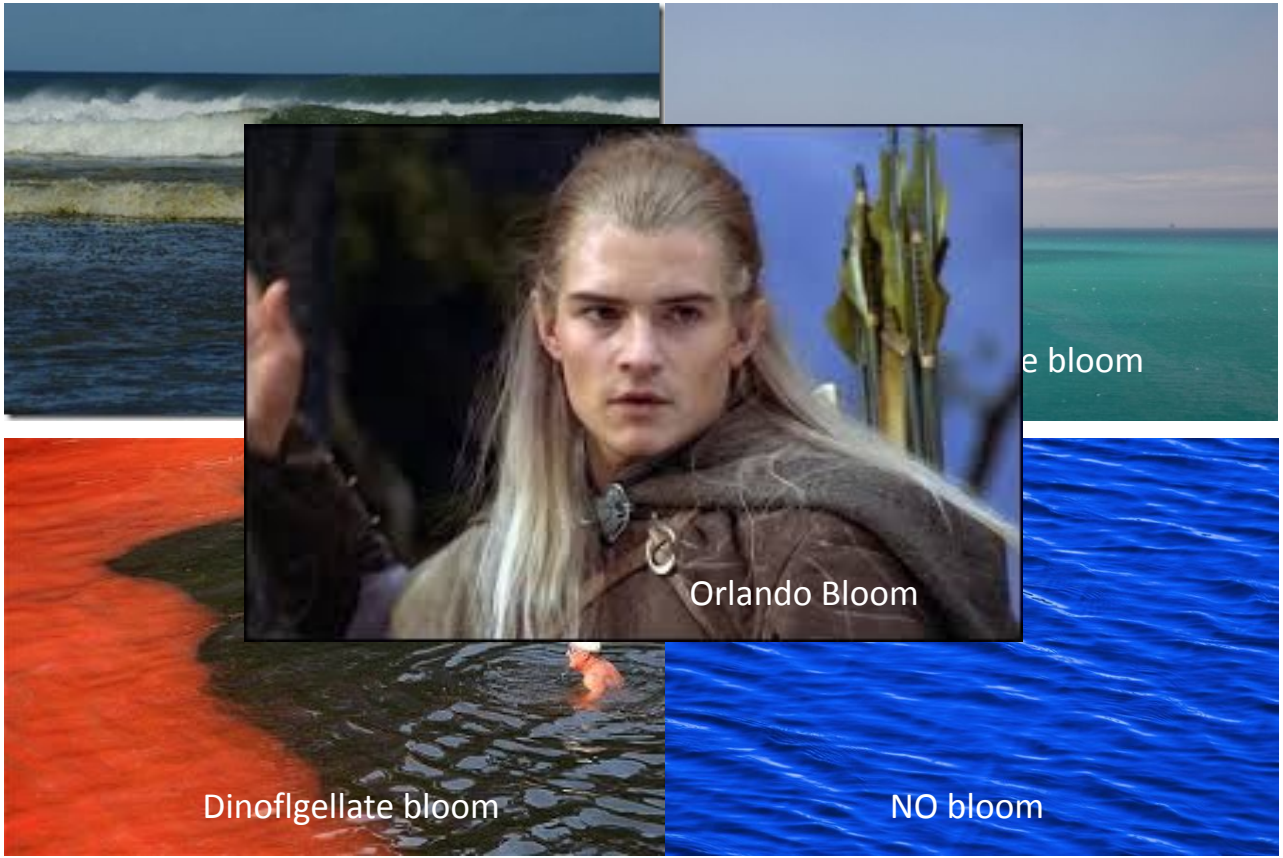
PRISM, PACE, and ECOSTRESS for aquatic biodiversity

Erin Hestir

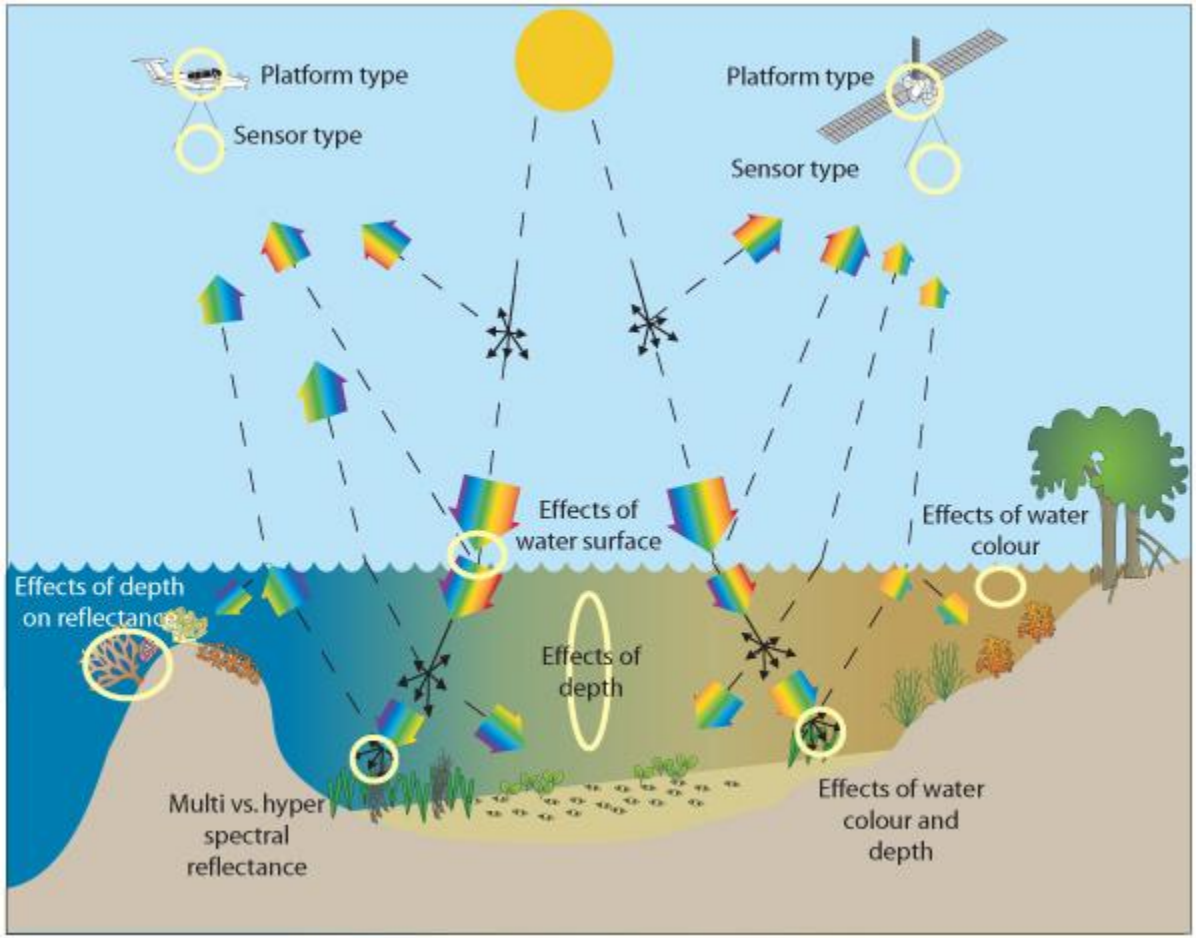
What color is the water?

Isn’t it blue?

The ‘color’ of phytoplankton

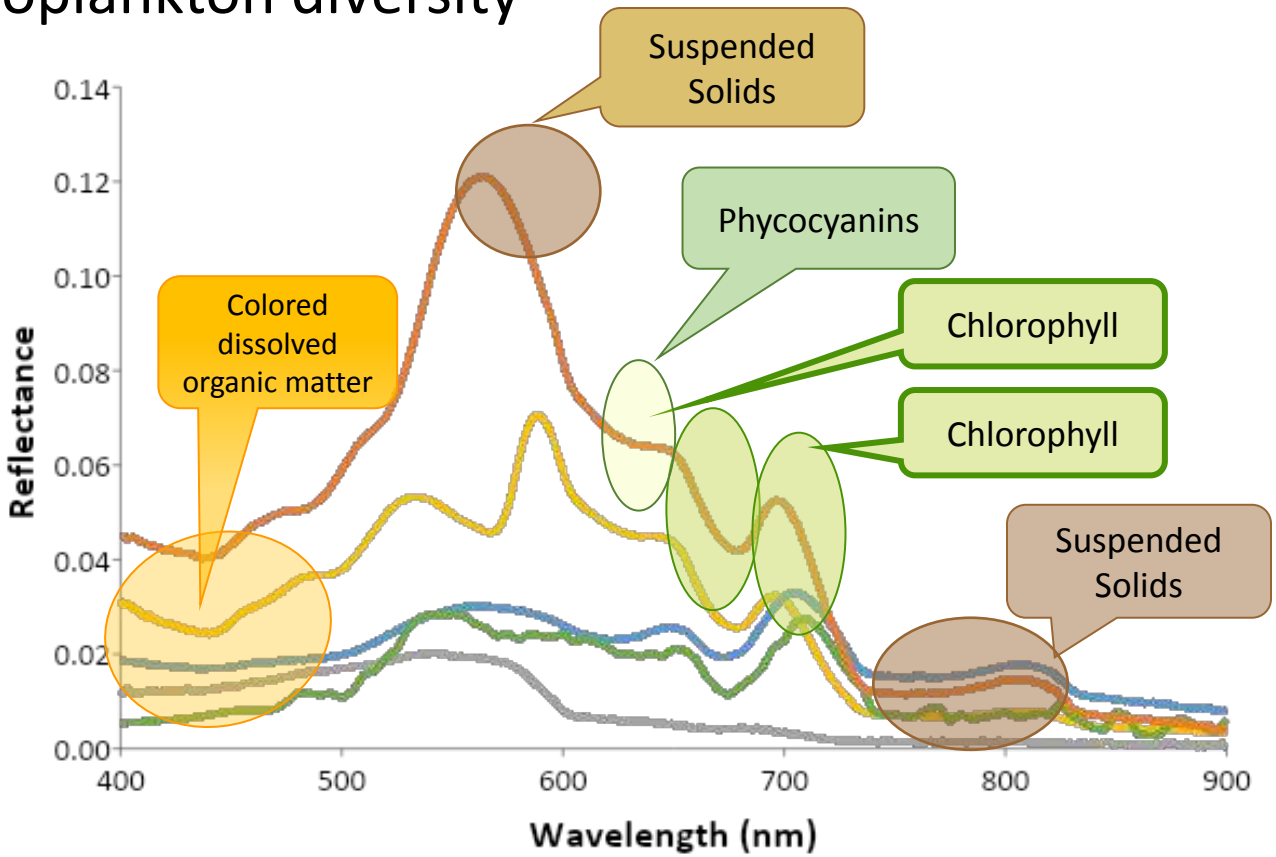


How do we measure color?



https://sees-rsrc.science.uq.edu.au/rstoolkit/en/html/marine/resources/what-is-remote-sensing.html

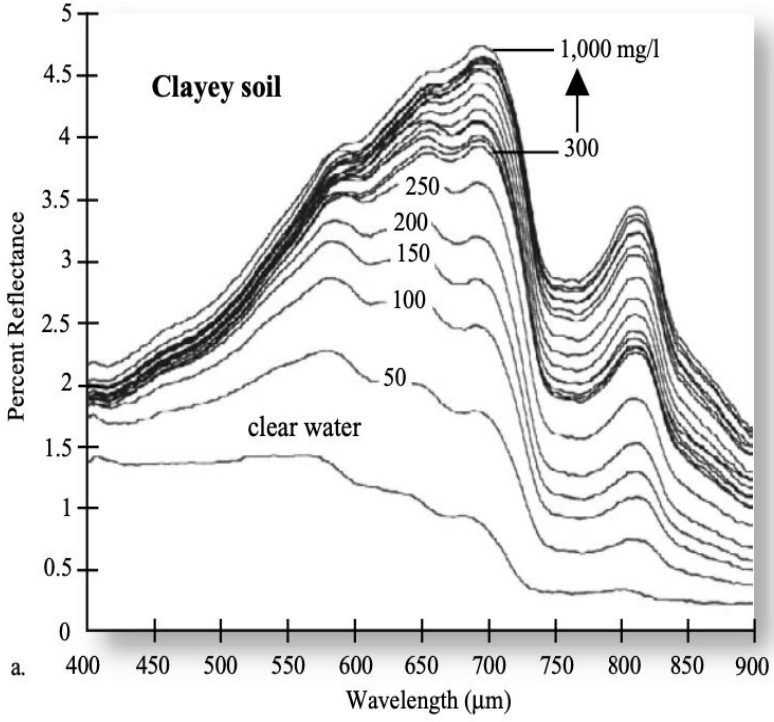
Imaging spectroscopy enables better water quality measurements + and phytoplankton diversity

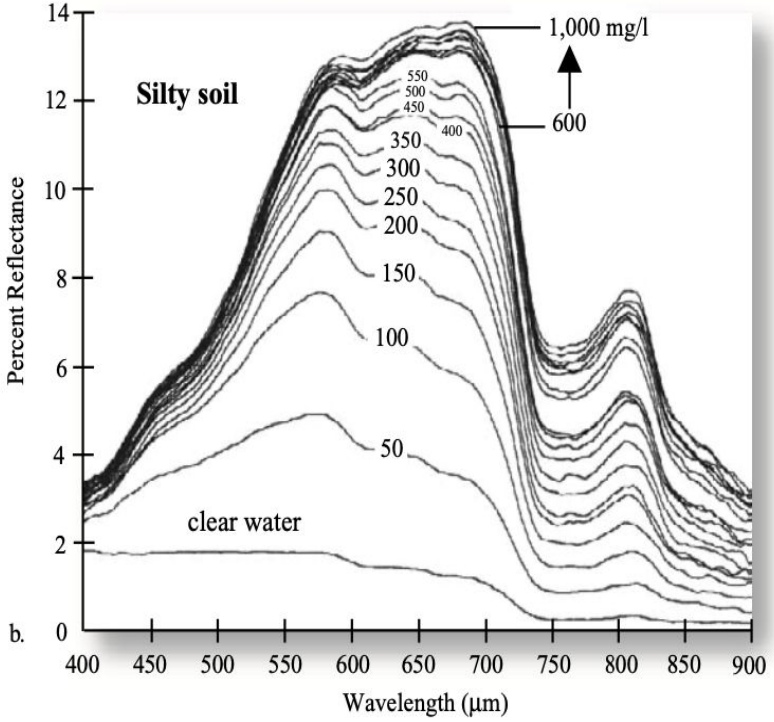


Hestir et al. 2015a Remote Sensing of Environment

bioscape.io

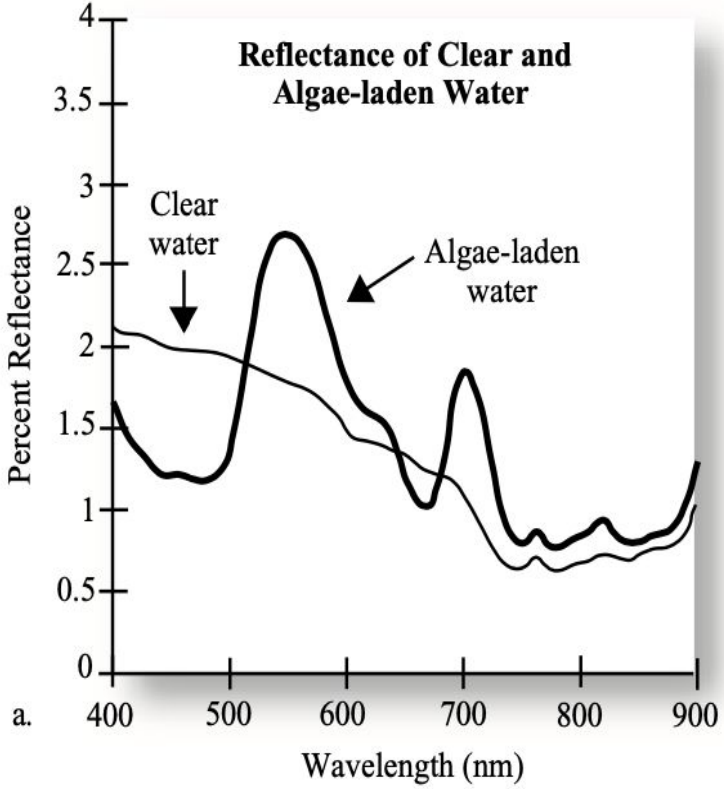
Spectral response of water as a function of suspended minerals

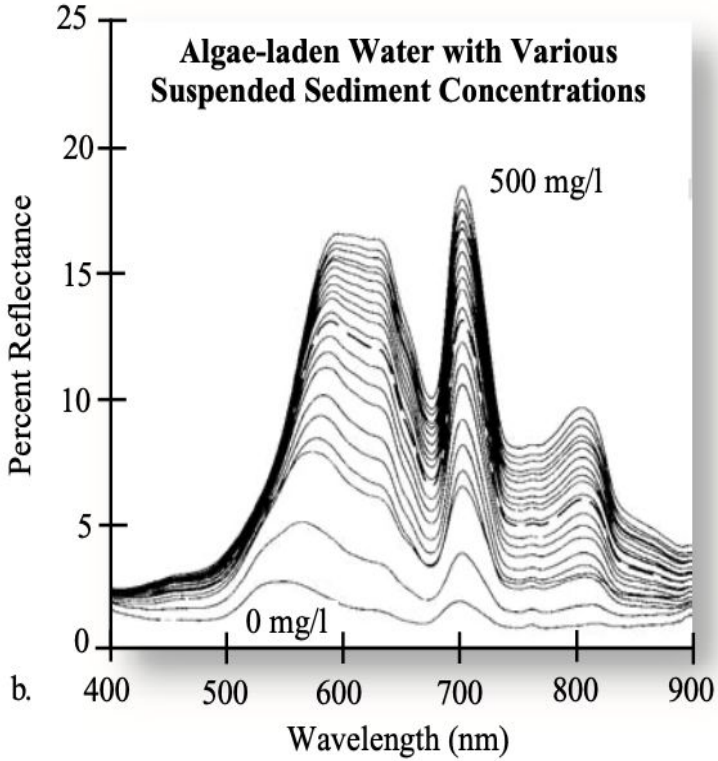




Jensen 2007, Remote Sensing of the Environment

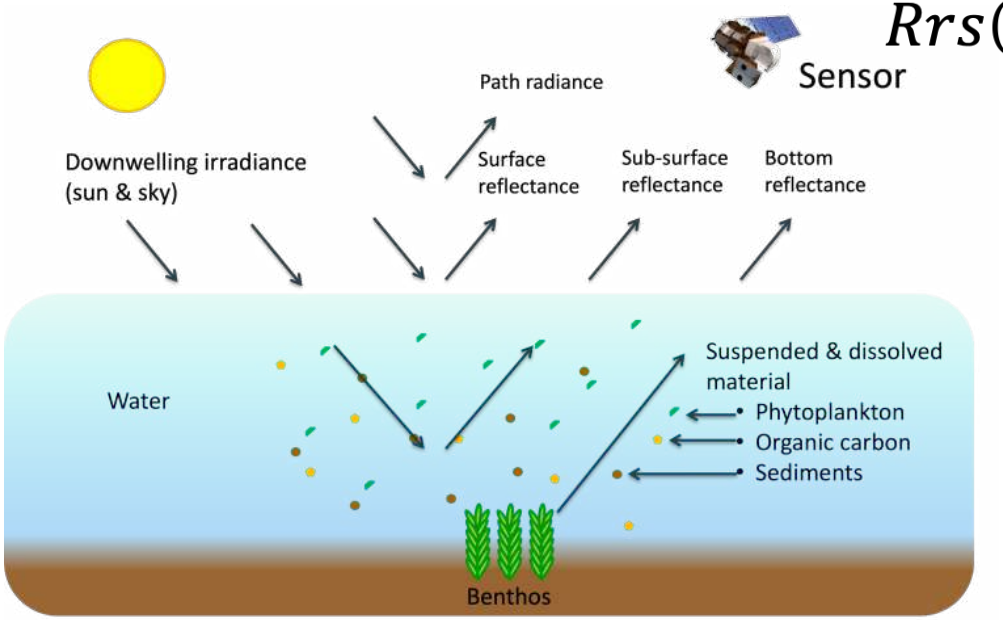
Spectral response of water as a function of chlorophyll





Jensen 2007, Remote Sensing of the Environment

Remote sensing reflectance (Rrs)
aka“ocean color”



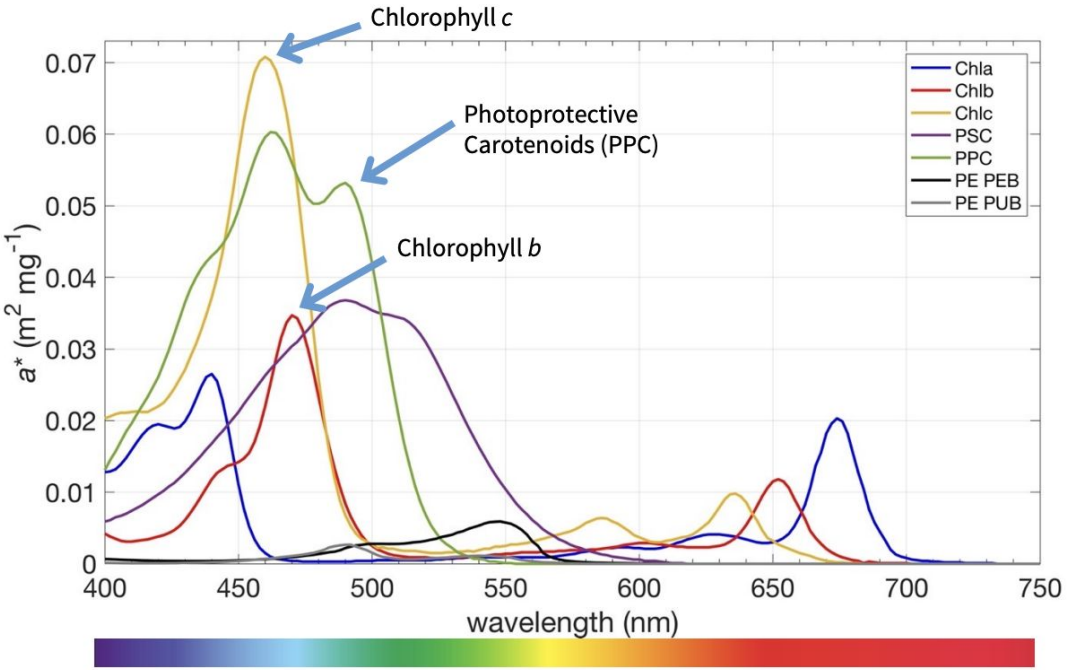
$$Rrs(\lambda, 0^+) \cong C \frac{b_b(\lambda)}{a(\lambda) + b_b(\lambda)}$$

$$a = a_{phy} + a_{nap} + a_{CDOM} + a_w$$

$$b = b_{water} + b_{particles}$$

Beyond chlorophyll: discriminating phytoplankton functional types

Phytoplankton pigments drive spectral absorption features

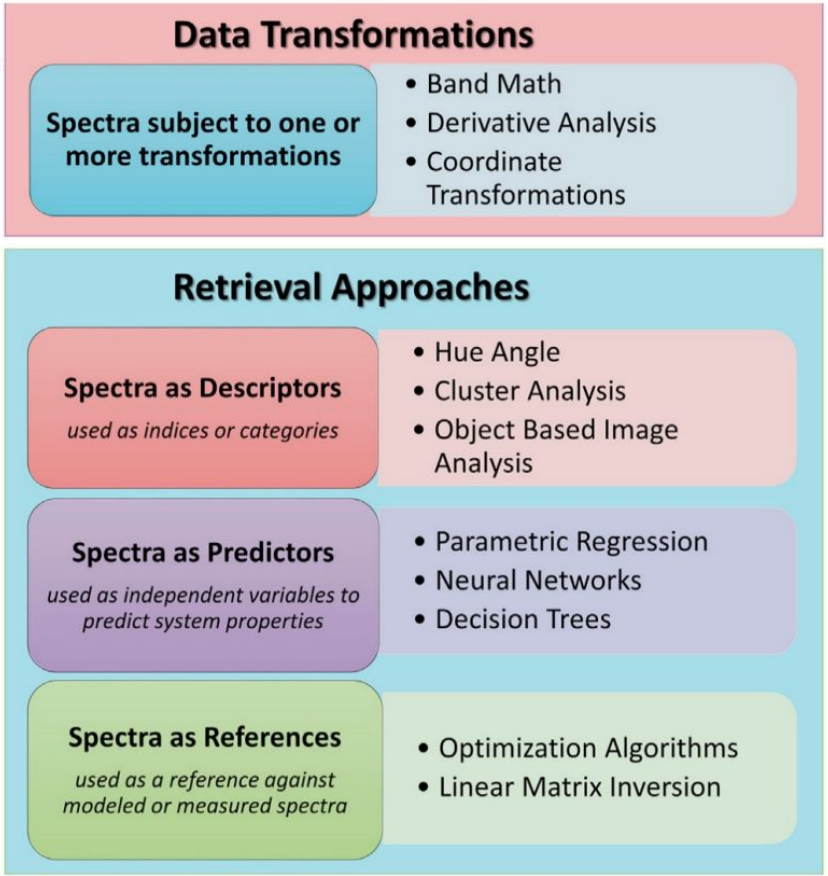


Slide from Ali Chase, IOCCG 2022 Summer School. https://ioccg.org/wp-content/uploads/2022/09/chase_ioccg_sls_2022_hyperspectral_perspectives.pdf

$$a = a_{phy} + a_{nap} + a_{CDOM} + a_w$$

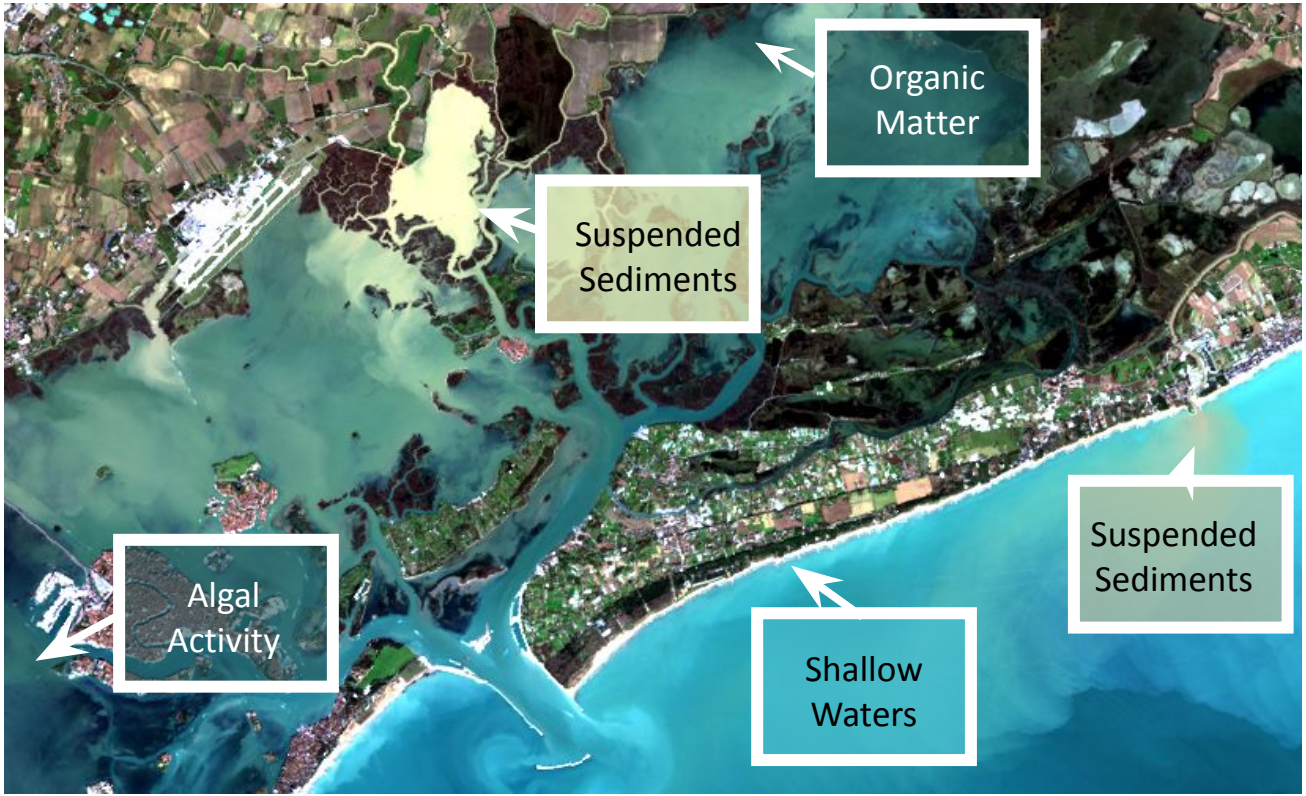
Living up to the Hype of Hyperspectral Aquatic Remote Sensing: Science, Resources and Outlook

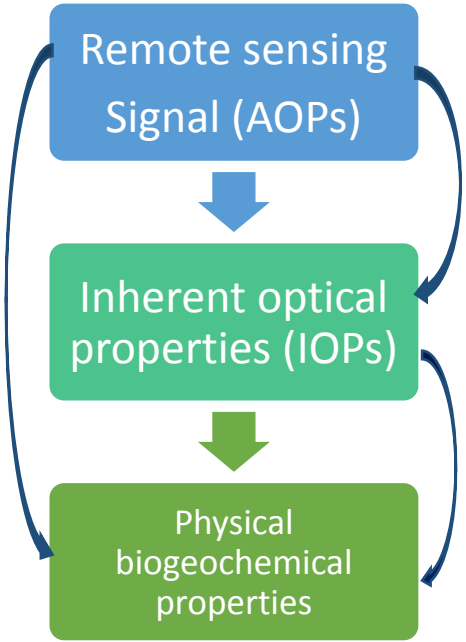
Heidi M. Dierssen[1], Steven G. Ackleson[2], Karen E. Joyce[3], Erin L. Hestir[4] Alexandre Castagna[5], Samantha Lavender[6] and Margaret A. McManus[7]*



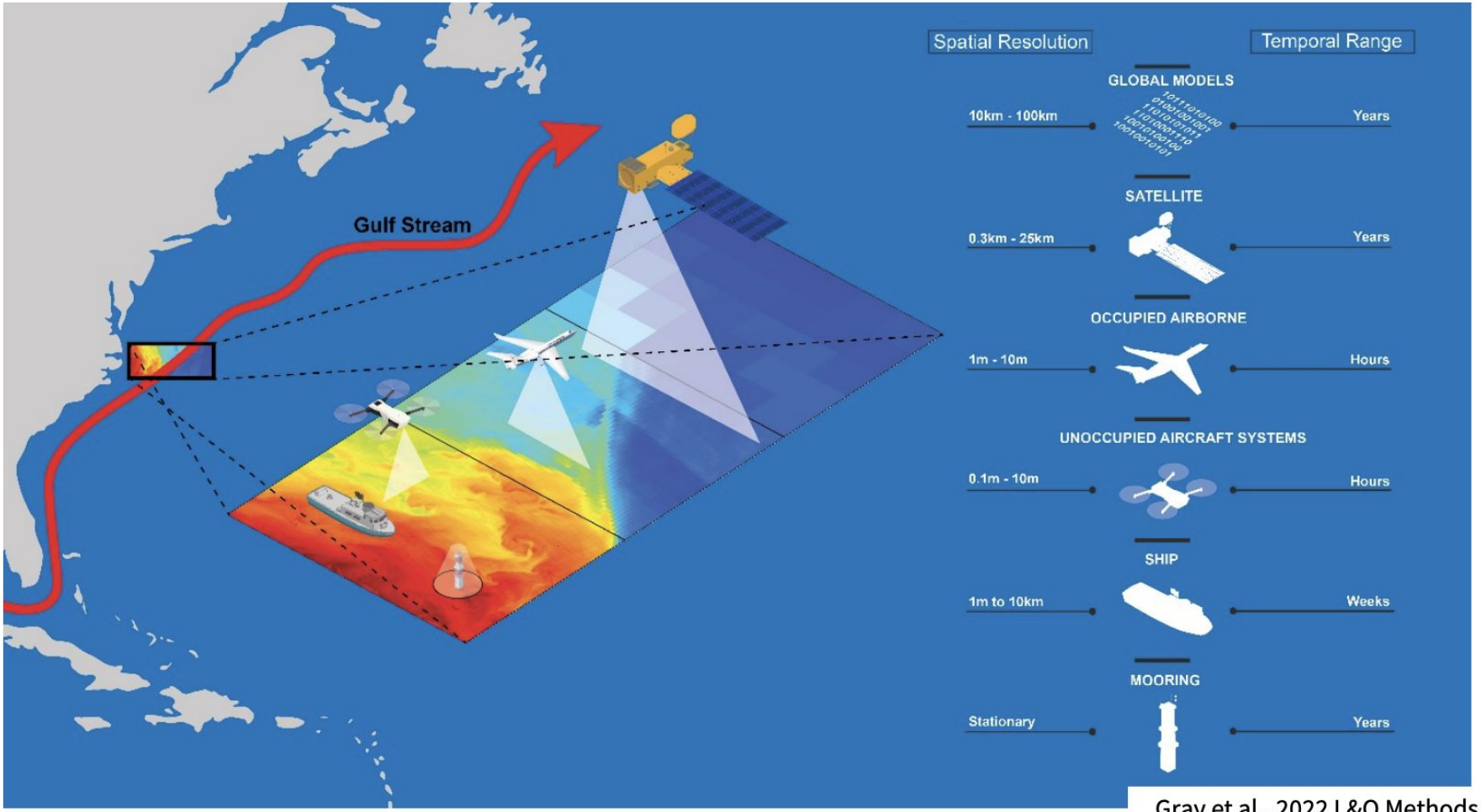
Dierssen et al. 2021

Water quality & phytoplankton diversity from space (or planes or…)



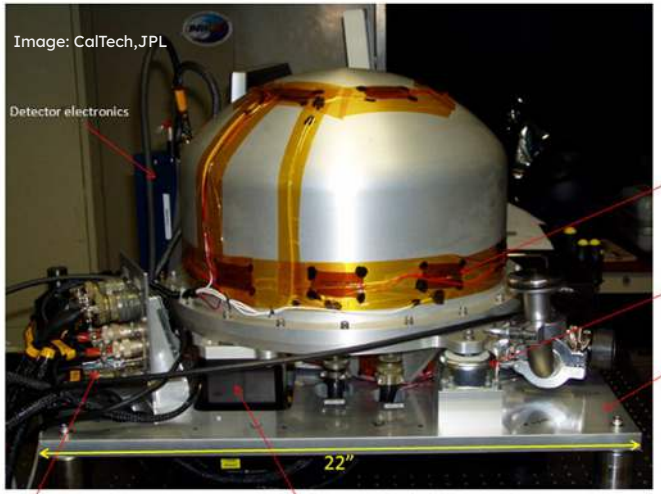


Transfer coefficients are often regional/ temporally dependent



Gray et al., 2022 L&O Methods

Portable Remote Imaging Spectrometer (PRISM)



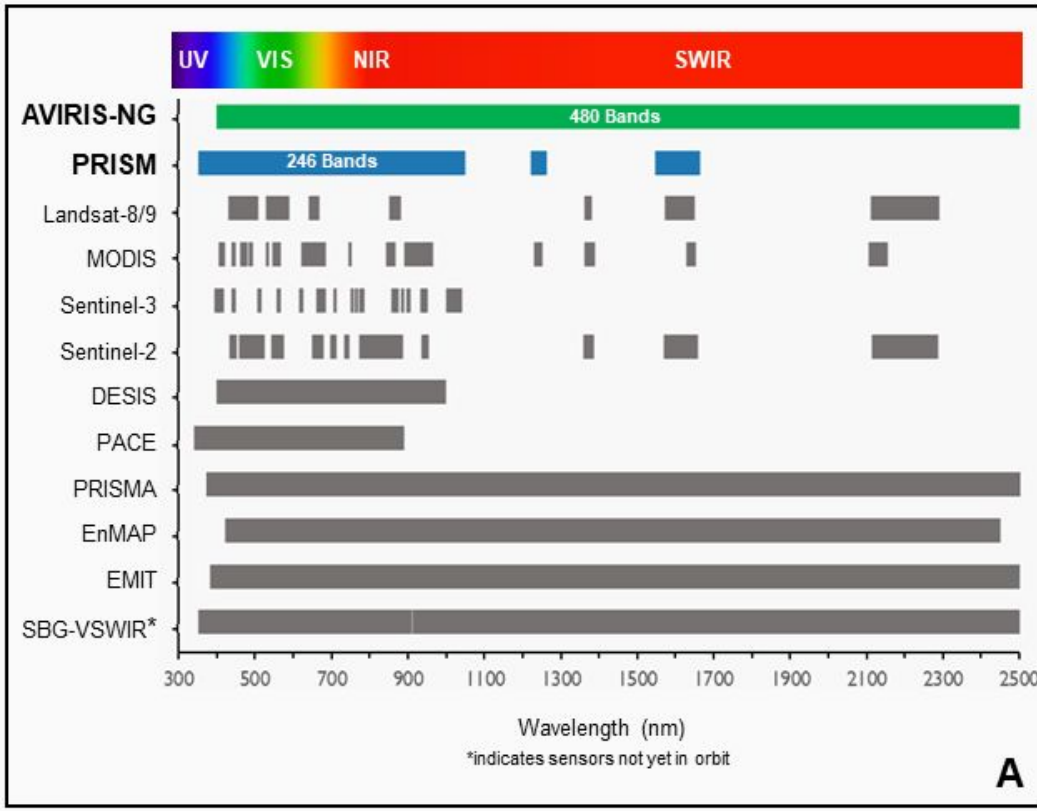
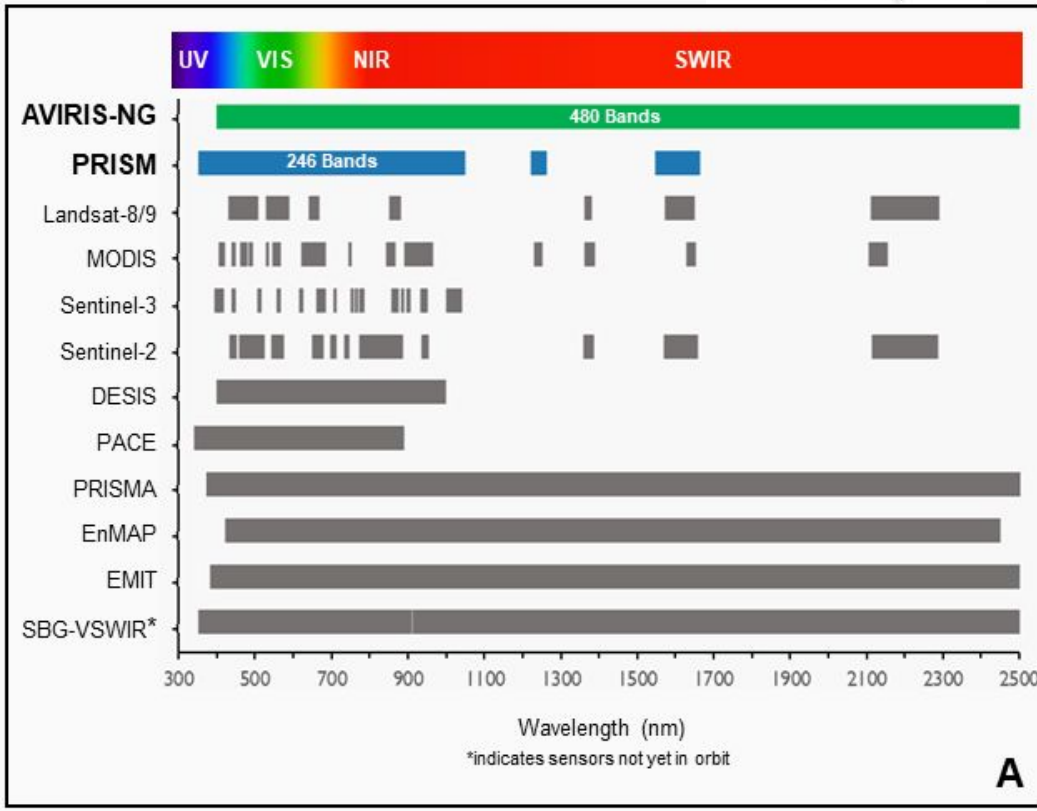


Figure: J. Nesslage

Designed especially for aquatic environments!

- Very high spectral sampling (< 3 nm, 3.5 nnm FWHM)
- Very high SNR for water

Phytoplankton Aerosol Cloud ocean Ecosystem (PACE)

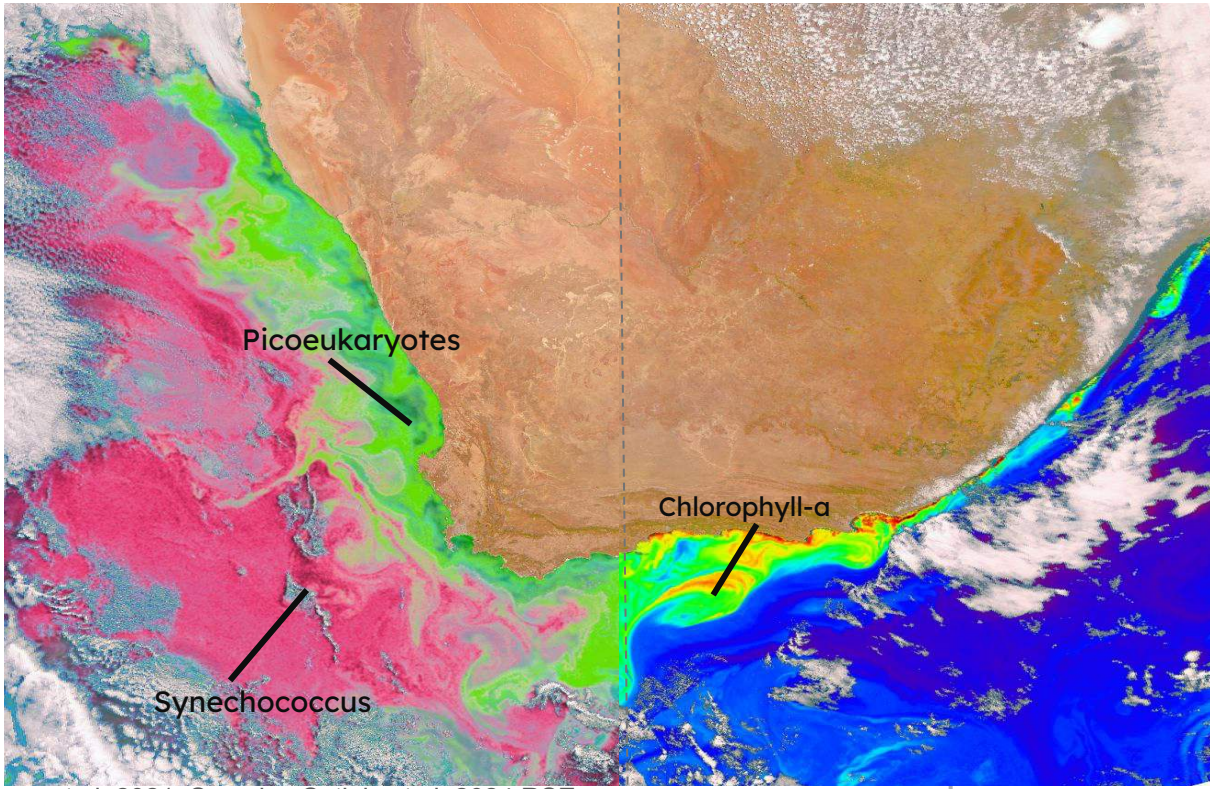


Designed especially for oceans!

- Launched Jan 20204
- 1 km pixels
- Community composition data are coming…

Phytoplankton Aerosol Cloud ocean Ecosystem (PACE)

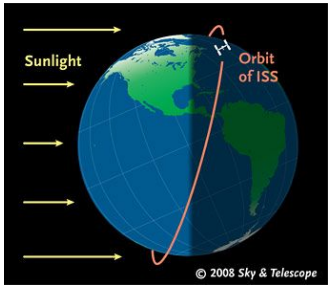
Global change	• latitudinal distributional shifts • phenology shifts • bloom dynamics
Biogeochemical modeling	• phytoplankton community composition • nutrient cycling • export of particles
Ecological processes	• rates of primary production • nitrogen fixers, DMS producers, silicifiers, calcifiers • trophic dynamics & food web efficiency
Ecological indicators	• hypoxia • eutrophication • informed monitoring and assessment
Environmental reporting	• meeting thresholds • species composition • detecting anomalies
Hazard Monitoring	• detection and tracking of harmful algal blooms • assessing storm impacts • monitoring oil spill extent and cleanup
Food Security	•finding pelagic and benthic habitats for fisheries •locations/monitoring for aquaculture •food safety & toxin production

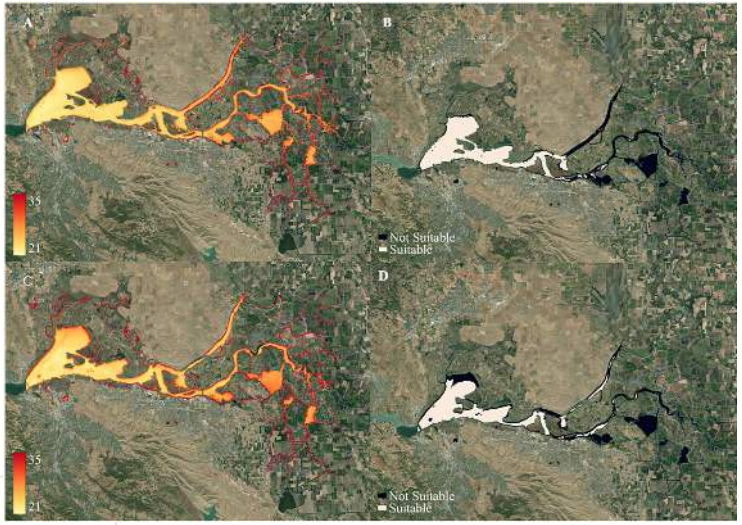


Dierssen et al. 2021. See also Cetinic et al. 2024 RSE

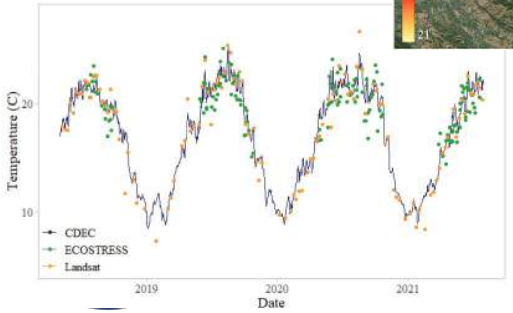
ECOSTRESS Surface Temperature

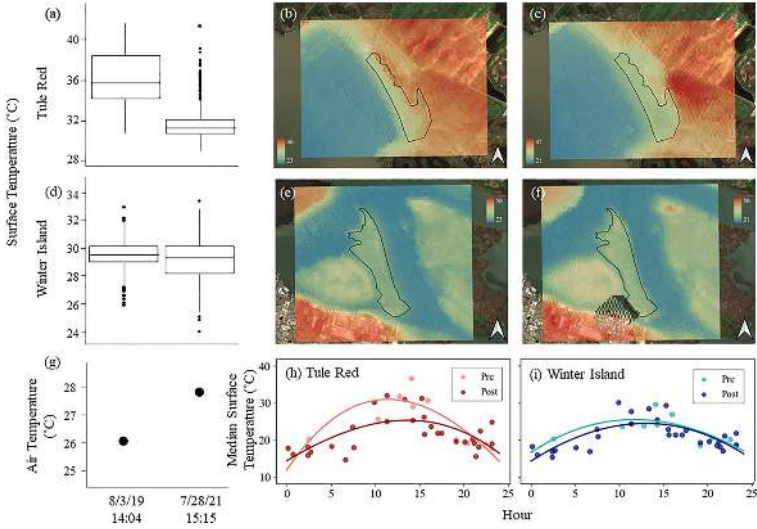
Modeling diurnal bulk temperature variability, fish habitat thermal suitability and restoration outcomes





Gustine et al. 2021





Gustine et al. 2023

Resources: IOCCG

Includes links to online NASA ARSET courses on Intro to RS, RS of Water Quality, & more

International Ocean Color Coordinating Committee

Includes training courses, tutorials, free textbooks, practicals and more! Almost a one-stop shop!

- https://ioccg.org/what-we-do/training-and-education/

Working Group Reports & Protocols : plain language summaries of state of science, measurement protocols

- https://ioccg.org/what-we-do/ioccg-publications/

Information on missions, sensors contributed by countries and agencies around the world (including NASA)

- https://ioccg.org/resources/missions-instruments/

Resources: NASA Ocean Color DAAC

OCEAN COLOR
OB.DAAC | OBPG

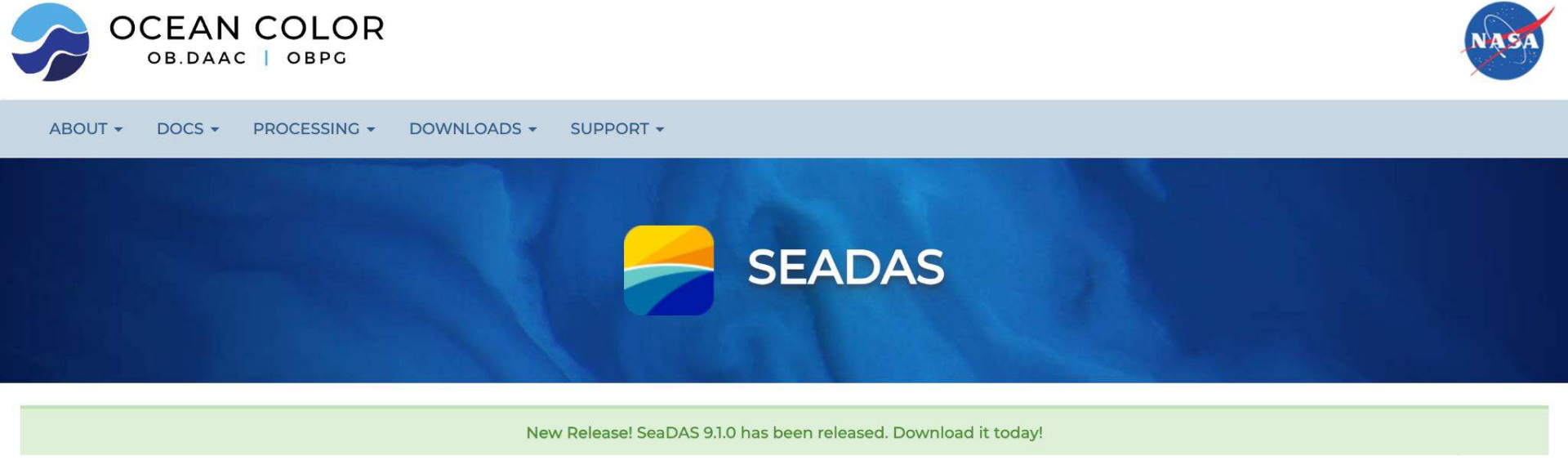
https://oceancolor.gsfc.nasa.gov/resources/docs/tutorials/

- Earthdata cloud access
- Working with Jupyter Notebooks
- Match-ups with in situ data
- Machine Learning
- Parallel and larger than memory computing
- Collaboration with Git & GitHub
- **Working with SeaDAS**
- Working with PACE data
- Working with MODIS data
- And more…

Resources: (free) Software

SeaDAS

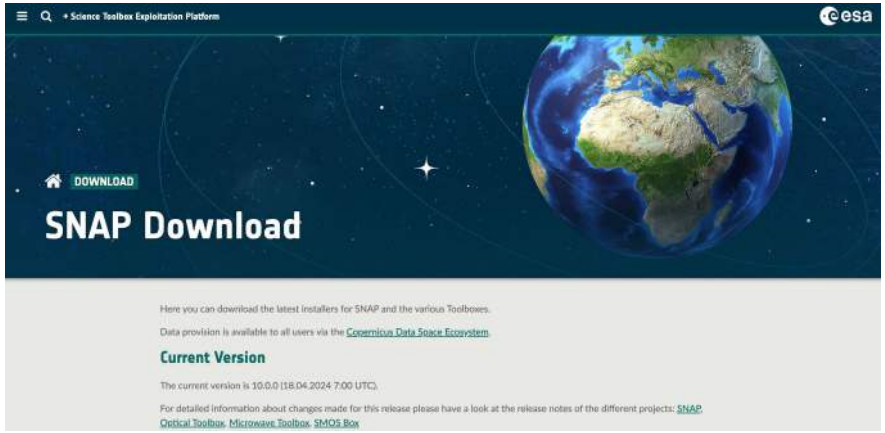
https://seadas.gsfc.nasa.gov/

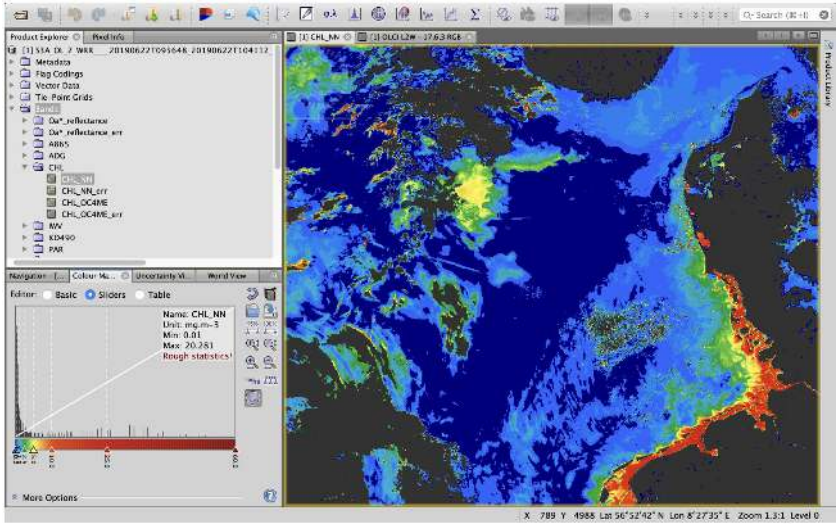


Resources: (free) Software

SNAP: ESA Sentinel Application Platform

https://step.esa.int/main/download/snap-download/



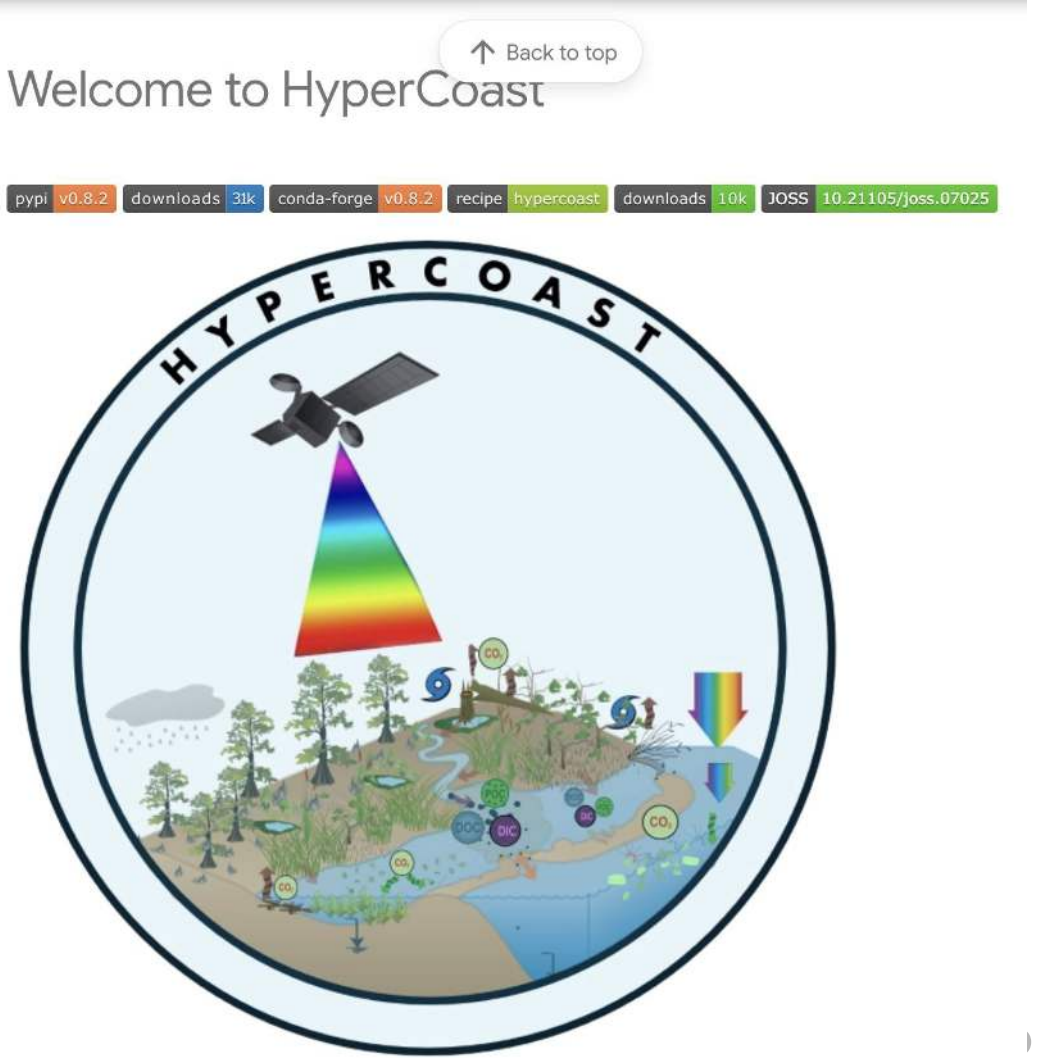


Resources: (free) Software

Hypercoast: A Python Package for Visualizing and Analyzing Hyperspectral Data in Coastal Environments

hypercoast.org

By Bingqing Liu



Hypercoast continued

Lots of examples, including two nice workshop examples online for working with EMIT & PACE data

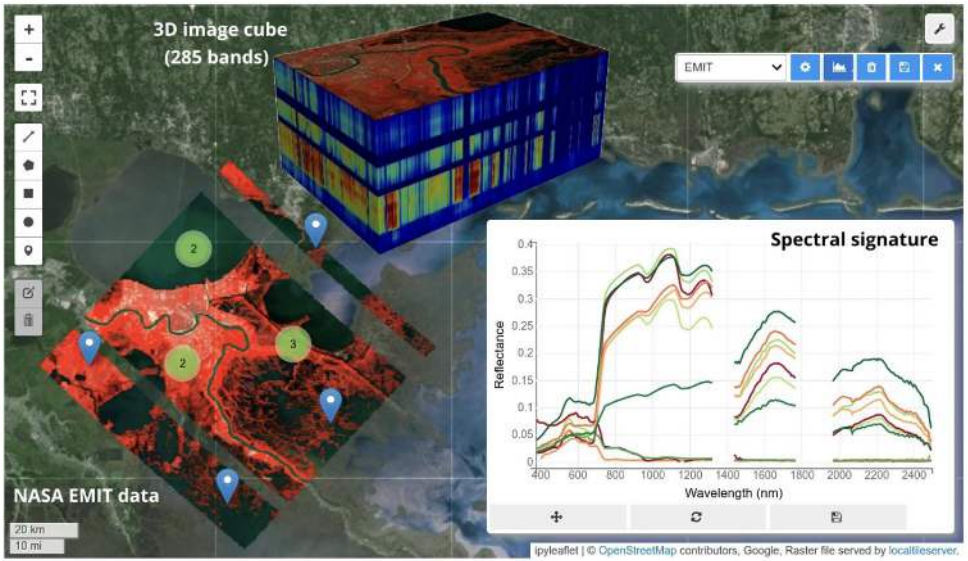
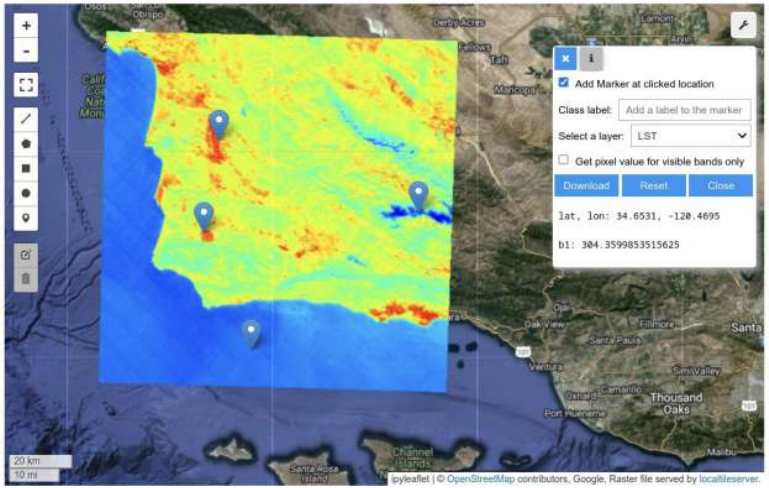


Figure 1. An example of visualizing NASA EMIT hyperspectral data using HyperCoast.

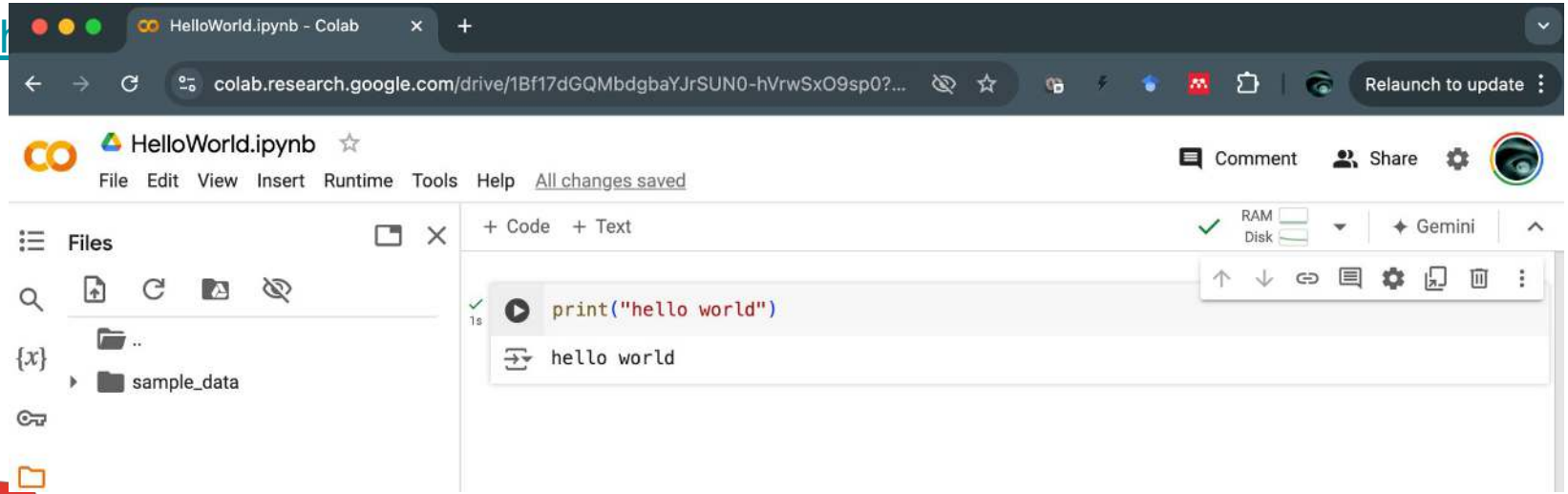
Visualize the data with HyperCoast.

```
In [ ]: m = hypercoast.Map()
        m.add_basemap("HYBRID")
        m.add_raster(filepath, colormap="jet", layer_name="LST")
        m.add("spectral")
        m
```



Resources: (free) Cloud Compute

Google Colaboratory: An AWS alternative for when you want to analyze non-BioSCape data



BioSCape Special Collection in JGR Biogeosciences

Deadline to complete:
Friday 11 October

Google form:
tinyurl.com/manuscriptform