Remote Sensing of Water Quality in Coastal Areas

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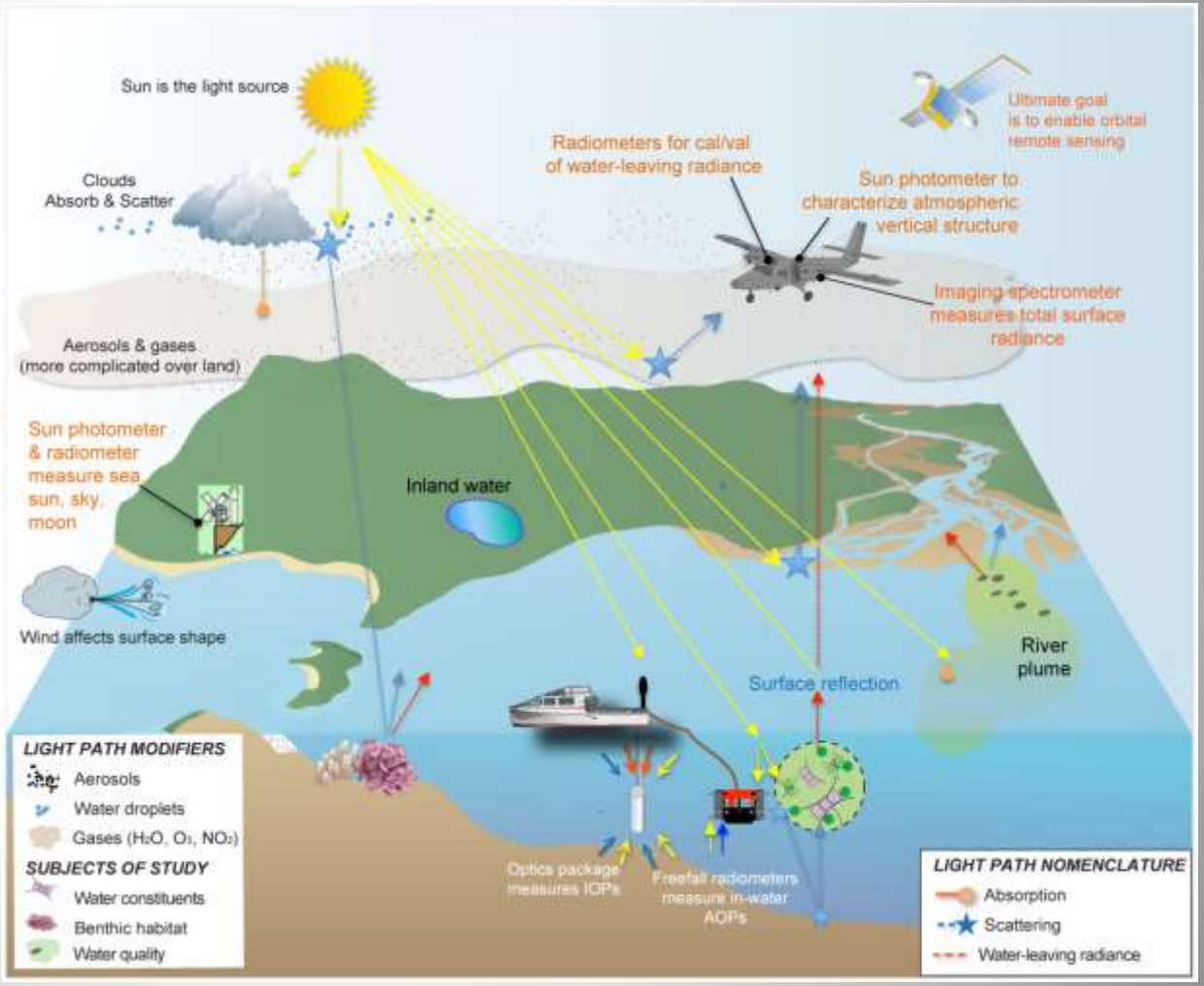
Coastal Remote Sensing Observations

Remote sensing radiance spectra are composites of radiance (reflectance) from:

1. **the atmosphere (gas molecules, particulates, aerosols, water vapor);**
2. **the sea surface;**
3. **the water column (water molecules, phytoplankton, colored dissolved organic matter); and**
4. **the bottom**

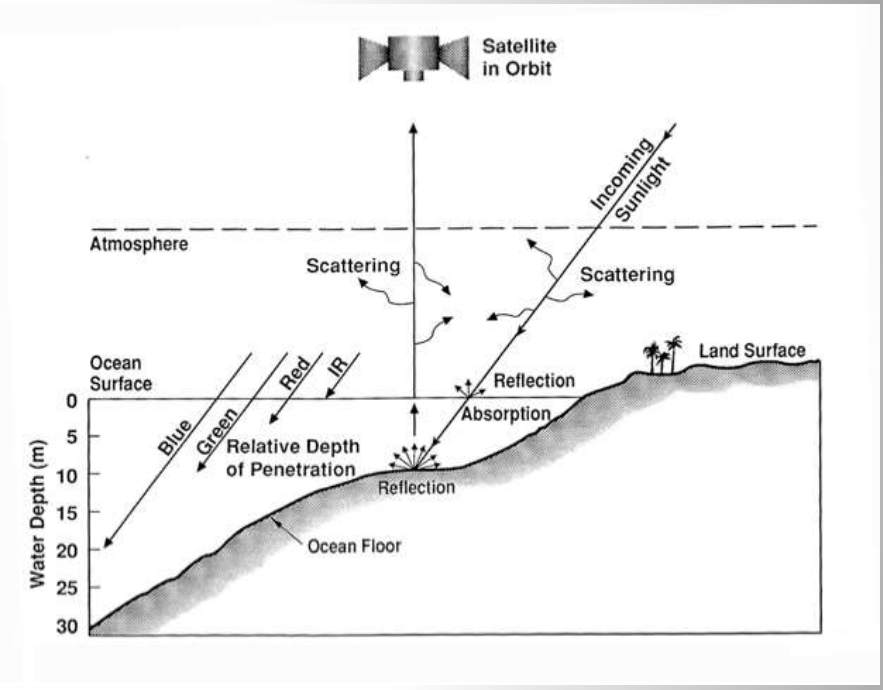
~80% of the signal is scattered or absorbed by the atmosphere



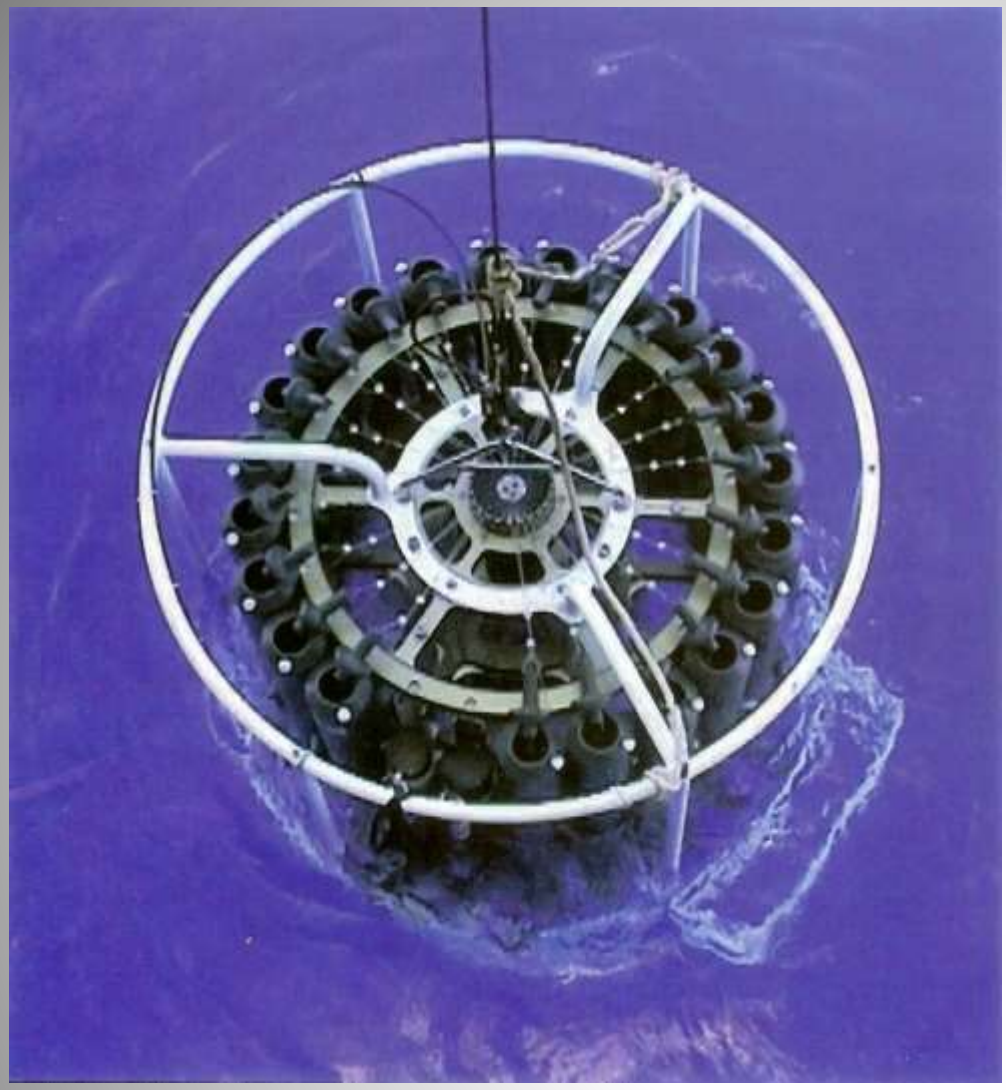
Challenges of Coastal Remote Sensing

- Water is a dark target with high sensor signal (SNR) requirements
- Two factors that limit the accuracy of retrievals for coastal ocean color:

1. accurate atmospheric correction (aerosol and trace gas plumes from continental sources)
2. accurate retrieval of water column and benthic ecosystem reflectance

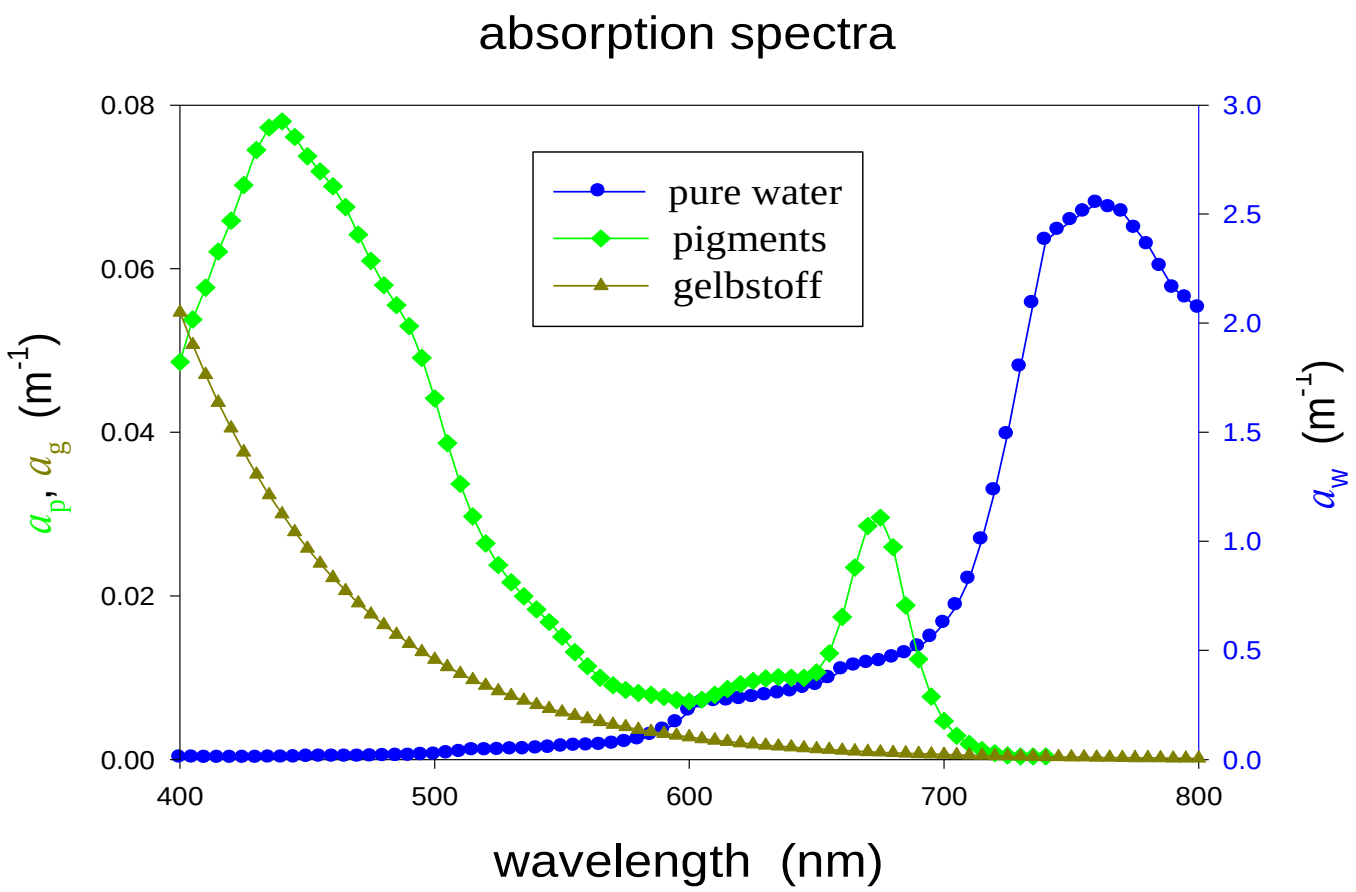


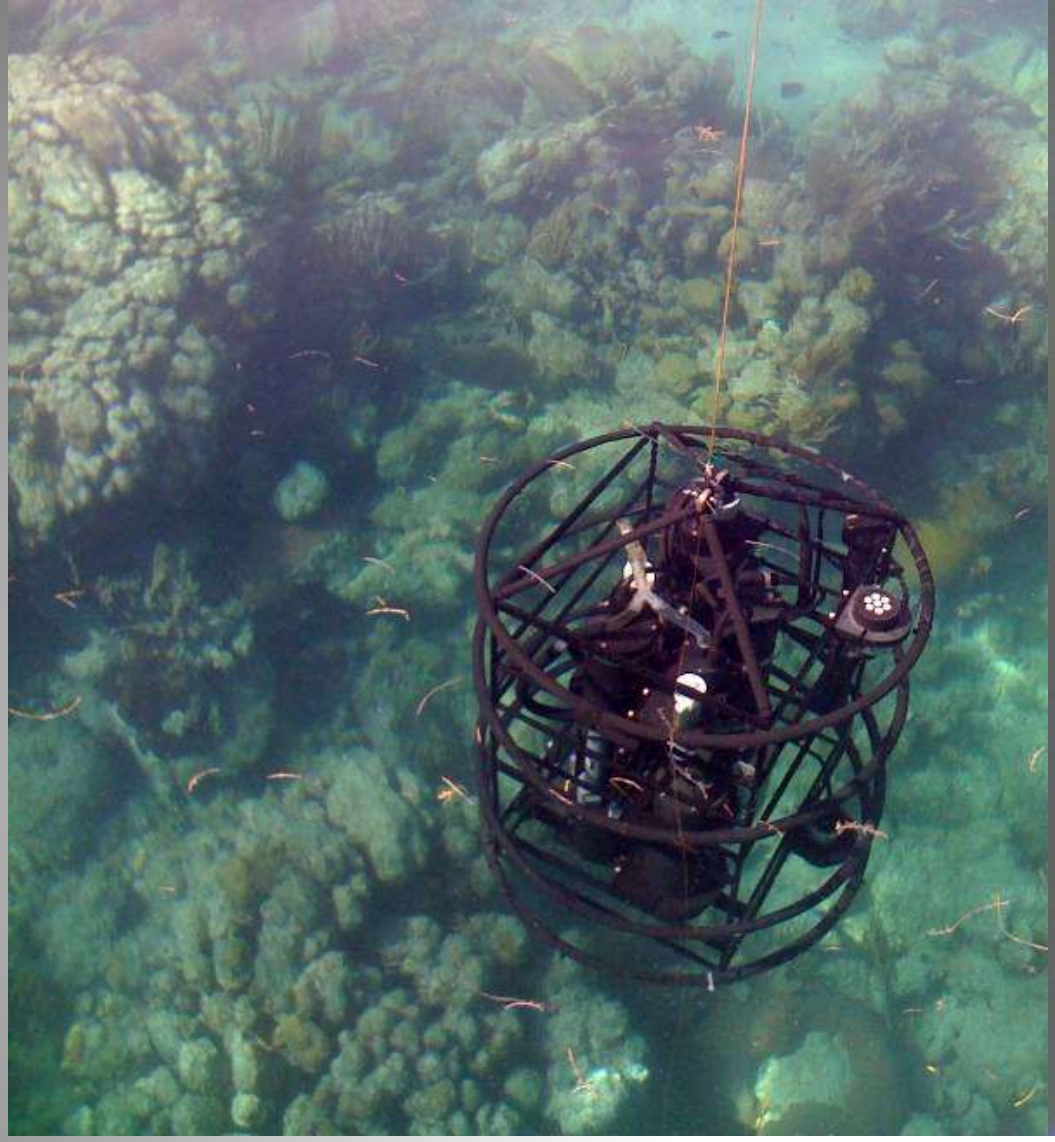
- Need for sensors with high dynamic range for benthic habitats under variable bathymetry and with adequate spatial resolution



What does the color of the water tells us?

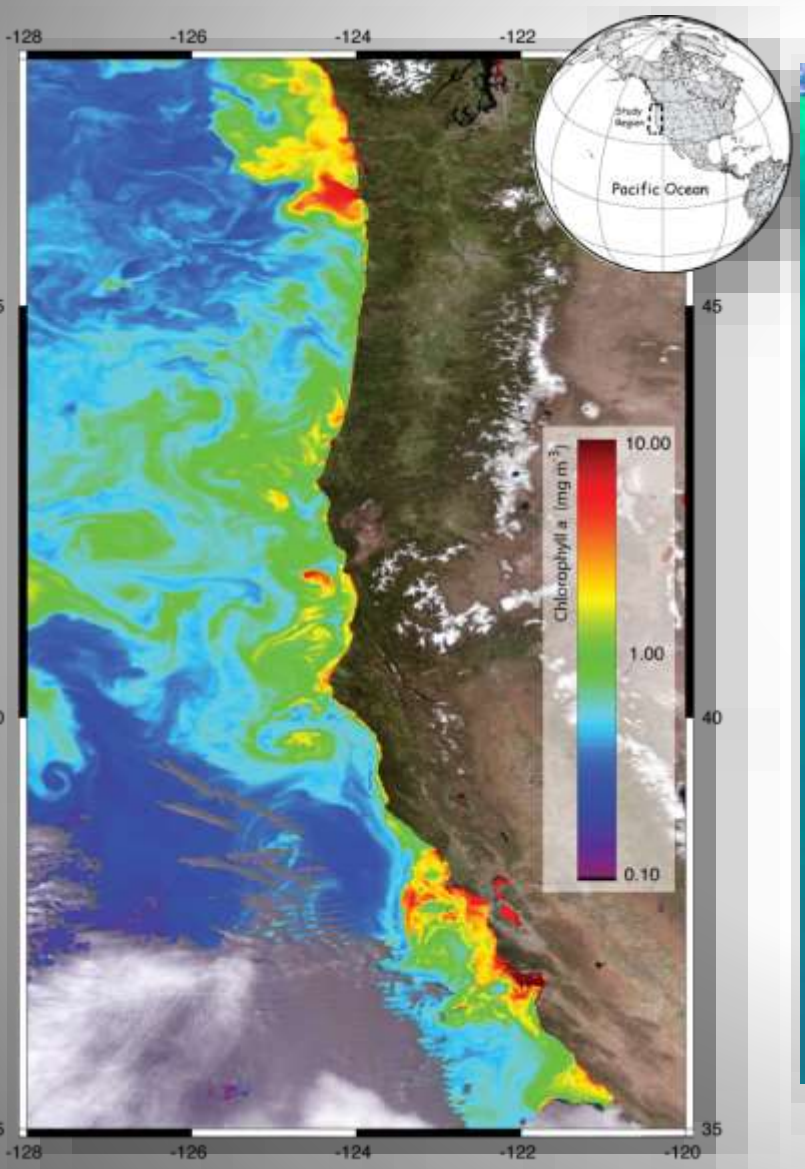
Absorption spectra for water, CDOM, and phytoplankton

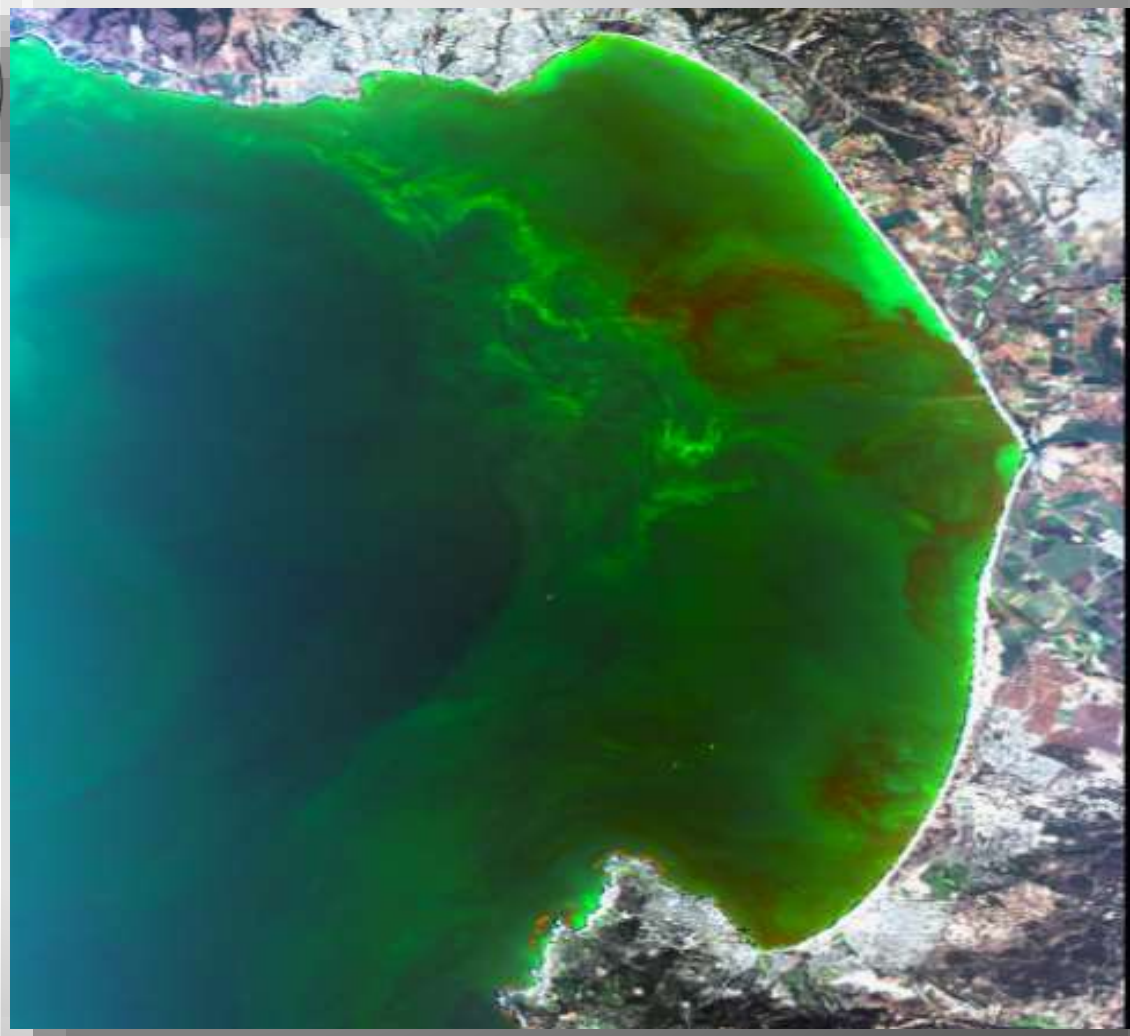




Optically-shallow vs. optically-deep waters

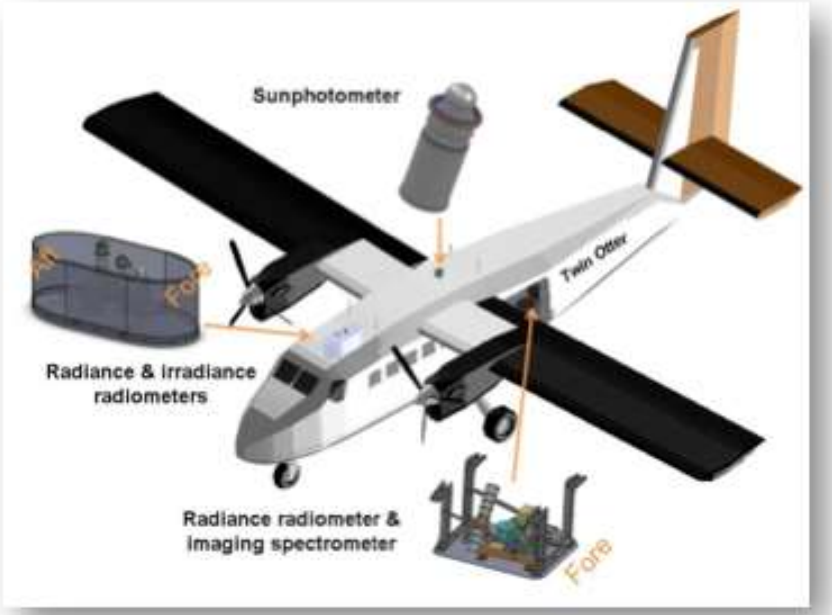
Case Study: Monterey Bay, California





Ship and Airborne-based Measurements: Monterey Bay

- Underway T, S, Fluorescence
- At each station (2-3 stations per day):
  - Size fractionated chlorophyll, phytoplankton species ID
  - CDOM, absorption spectra, nutrients
  - Sun photometer spectra
  - HyperPro cast, C-OPS cast
    - Water-leaving radiance, profile data
  - Backscatter/ac-s casts
  - ASD surface reflectance

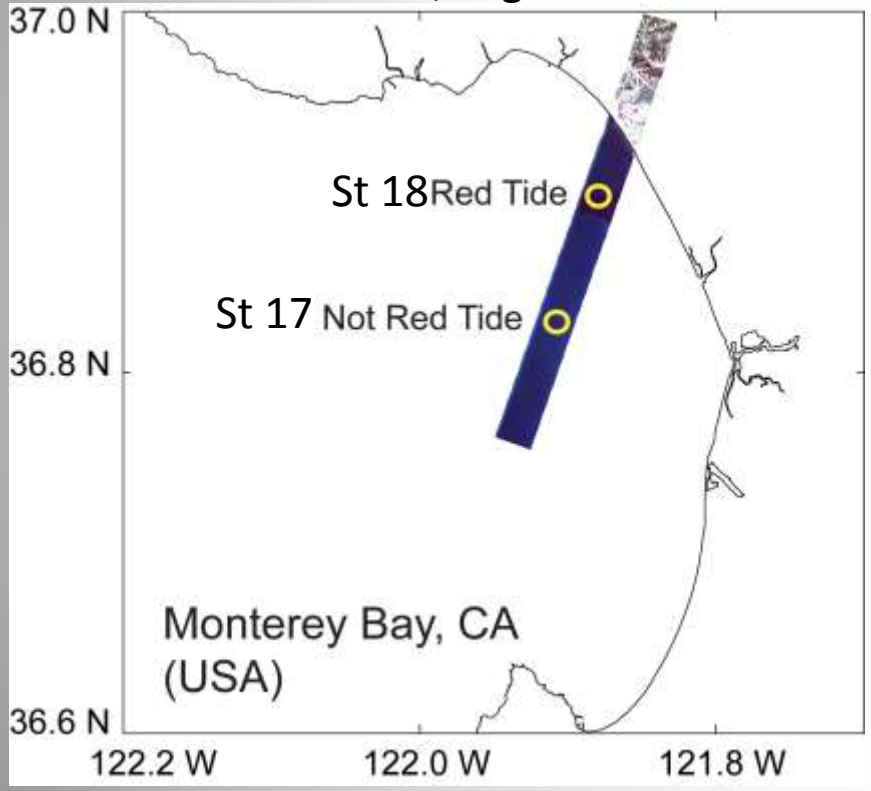


NASA COAST October 28, 2011

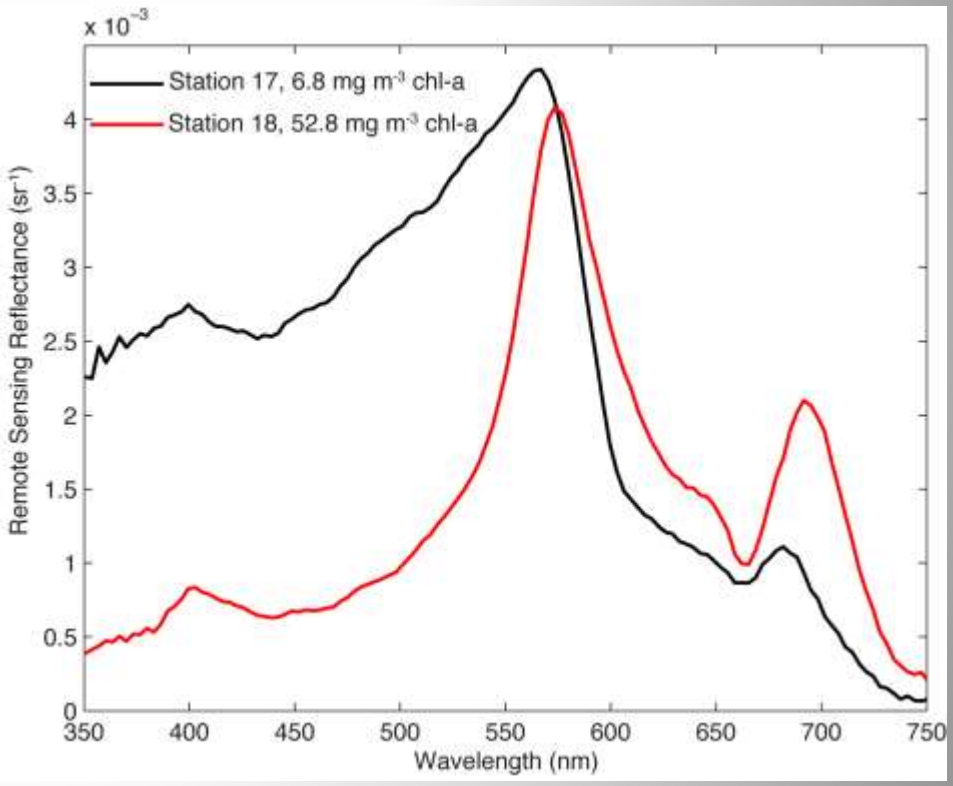
Imaging Spectrometer Imagery, Site Location, Sea-truth Measurements

Not Red Tide = Station 17, Flightline 29

Red Tide = Station 18, Flightline 28



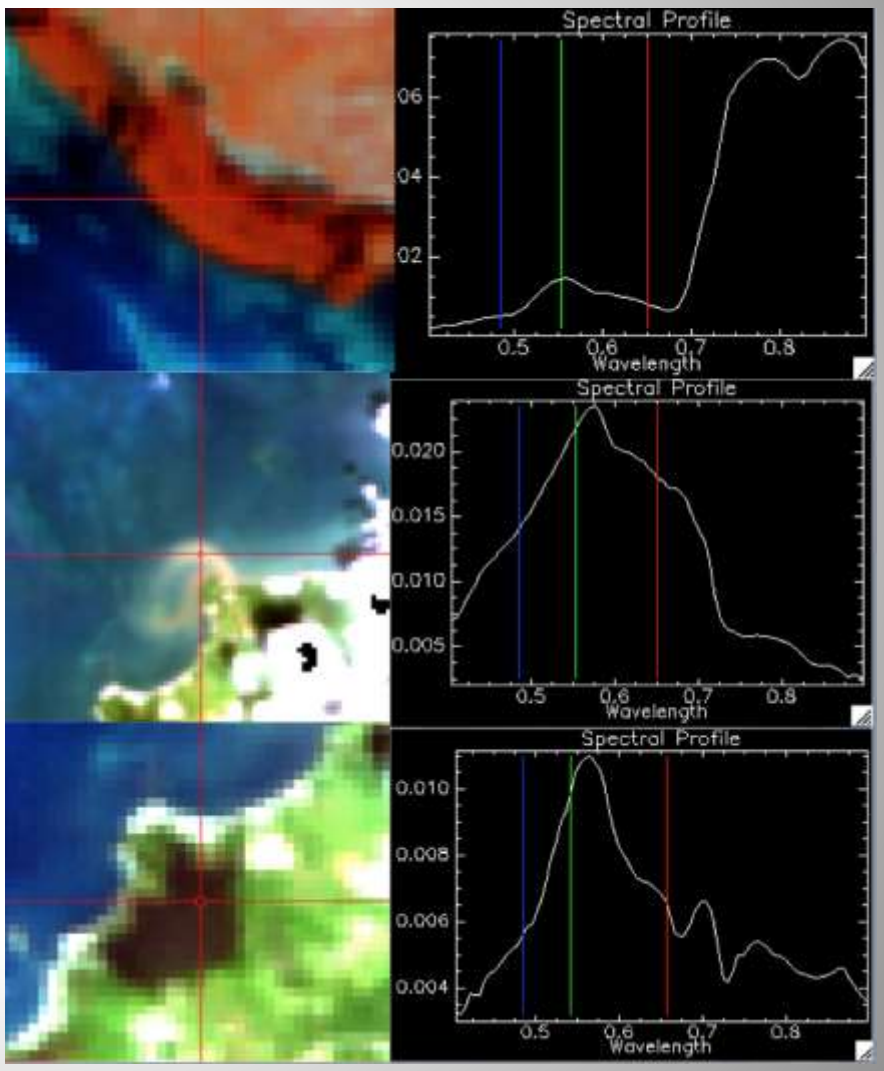
Ship-based HyperPro II measurements



Airborne measurements of water-leaving radiance (imaging spectrometer) were collected at the same time as AOD and CWV from a sun photometer. Ship-based measurements (red tide, not red tide) collected +/- 30 min of airborne data collection.

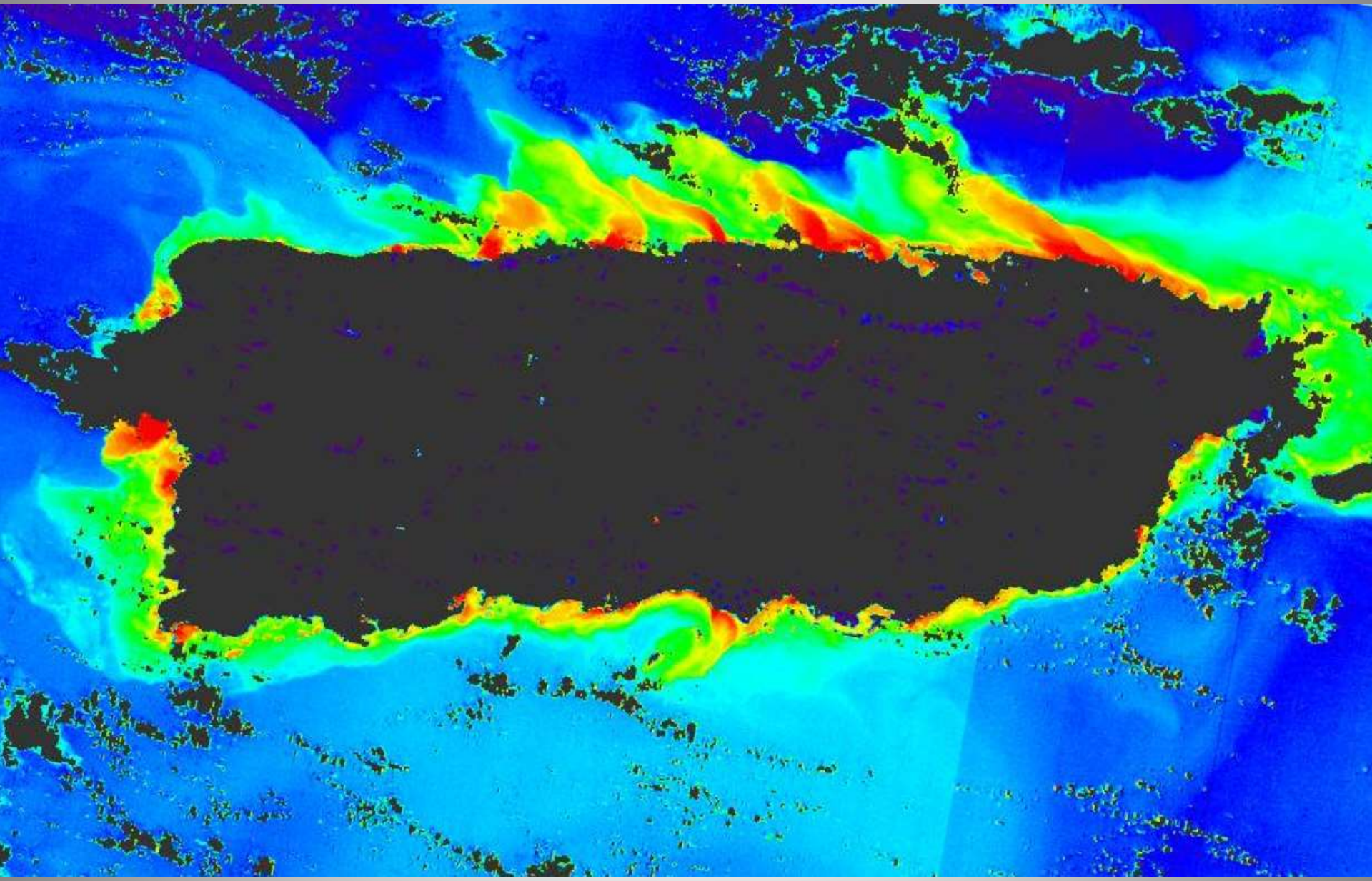
Requirements for Water Quality Remote Sensing

- Measurements over spatial extents from < 10 m to 100s of meters. However, most satellite ocean color data have a spatial resolution of about 1 km
- Coastal ocean phenomena are measured at different temporal scales
  - Timing is important for capturing transient phenomena (e.g. hours to days) – hence the need for high resolution geostationary data
- Optically-complex coastal waters require hyperspectral data for spectrally separating the signals from optically-competing water column parameters



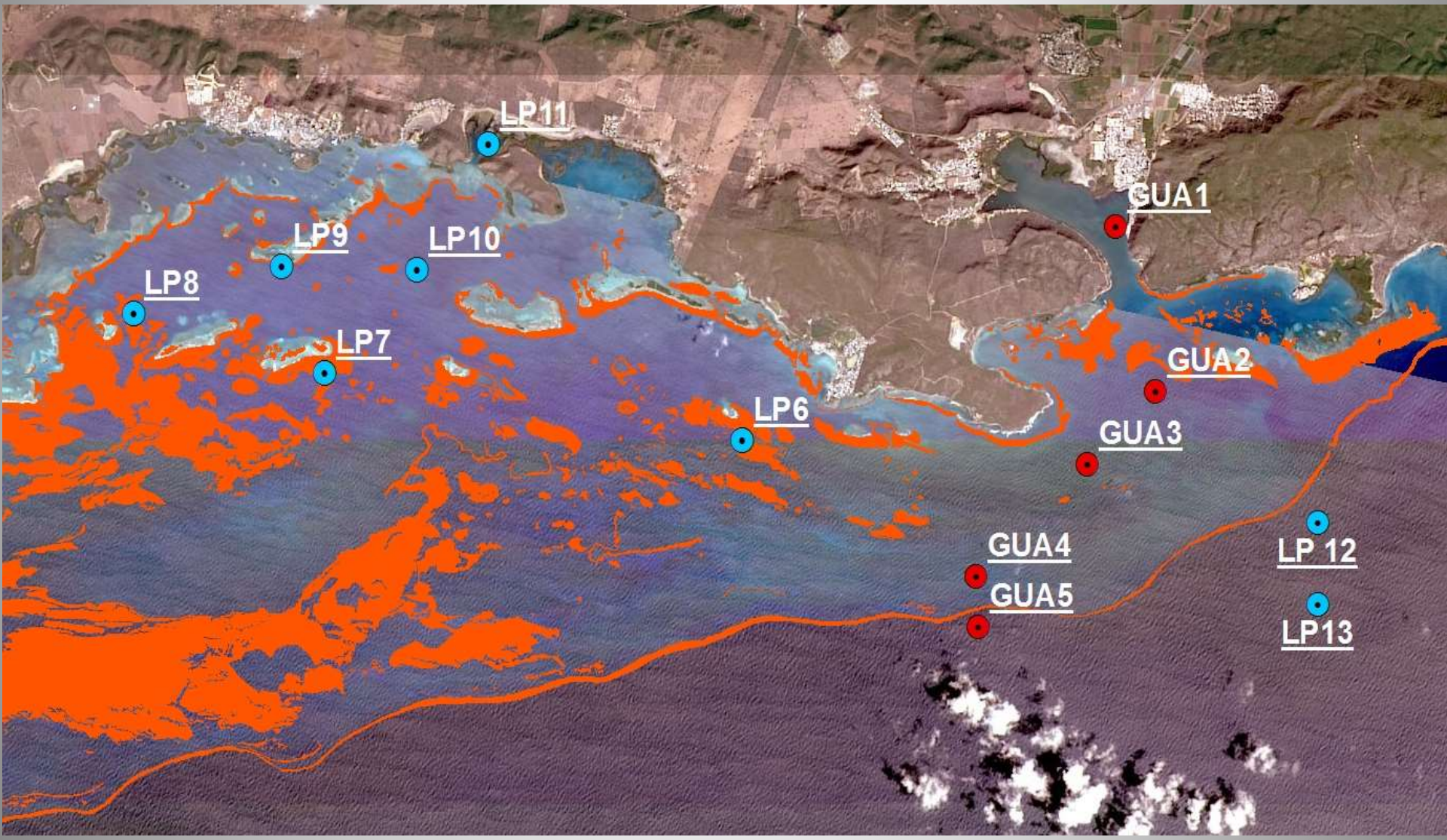
ISS HICO Data

Case Study: Southwestern Puerto Rico



December 12, 2007

Sampling Stations – SW Puerto Rico



Ship-based Measurements: SW Puerto Rico

Biogeochemical Properties

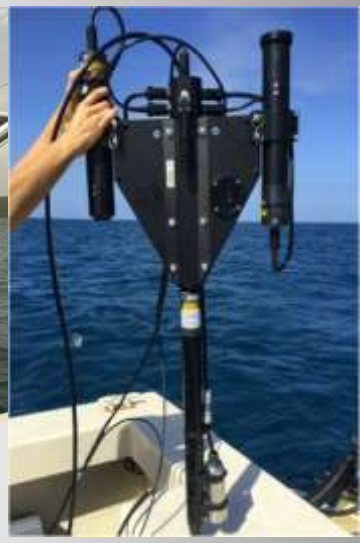
Surface water samples are used for measuring CDOM, Total Suspended Matter, and Chlorophyll.

IOPs: a, c, b_b

Profiling sensor package that includes a CTD, a WetStar fluorometer, an ac-9 for absorption and attenuation, and a HydroScat-6 for backscattering.

AOP: Lu, Ed, Rrs

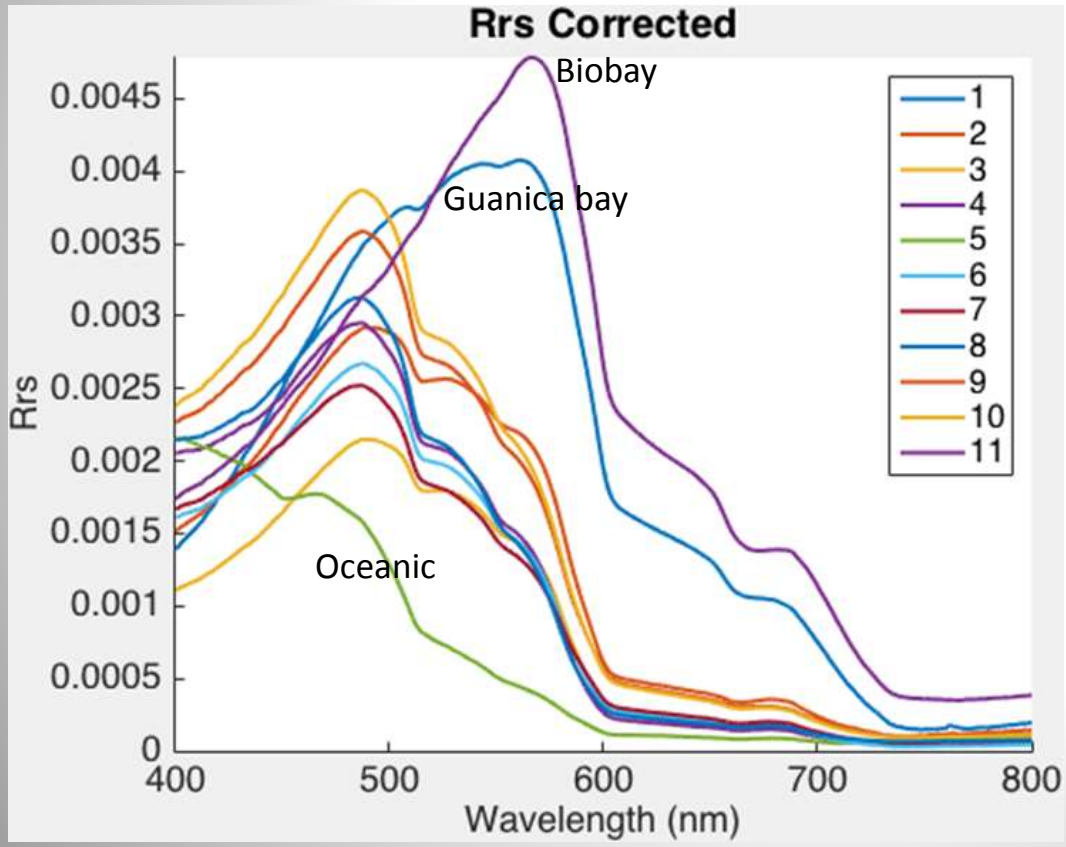
GER-1500 spectroradiometer measures Lu, Ls, and Ed. This is used to calculate Rrs.



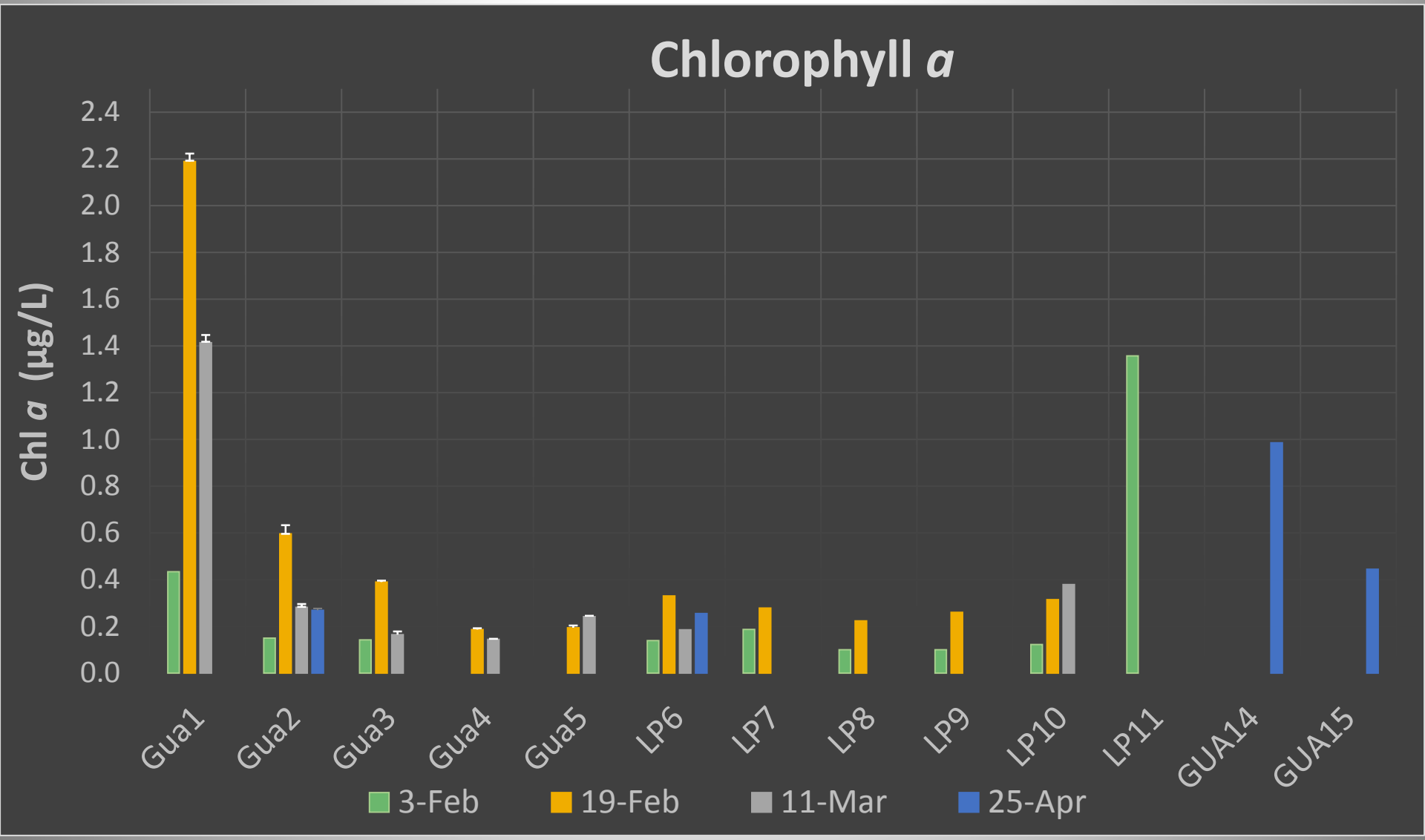
Satlantic HyperPro Profiling Spectroradiometer.

Results- Field Sampling

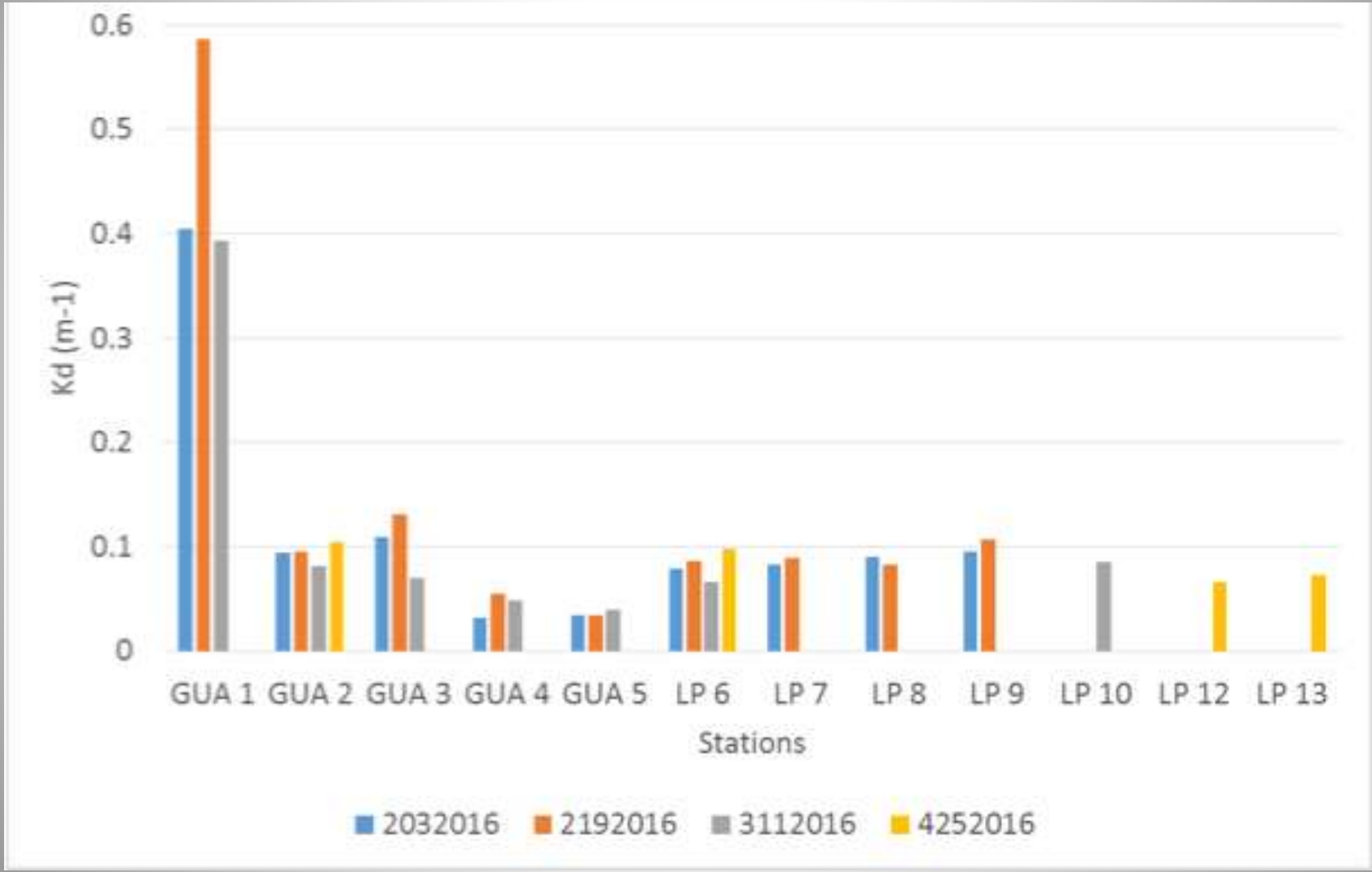
GER1500 surface remote sensing reflectance



Water Quality-Chlorophyll



Kd (490) Values (Turbidity)



Conclusions

- Coastal ocean color algorithms are sensitive to errors in atmospheric correction models, the presence of nearby clouds, sensor calibration, low sensor signal, and sunglint correction.
- Spatial resolution of existing satellite ocean color sensors is usually too coarse for coastal zone studies.
- Sampling frequency of existing satellite sensors can be inadequate for capturing transient phenomena such as red tides and algal blooms.
- Cloud cover limits the amount of usable imagery.
- Optically-complex coastal waters require hyperspectral data for separating the signals from water column parameters.

Acknowledgements

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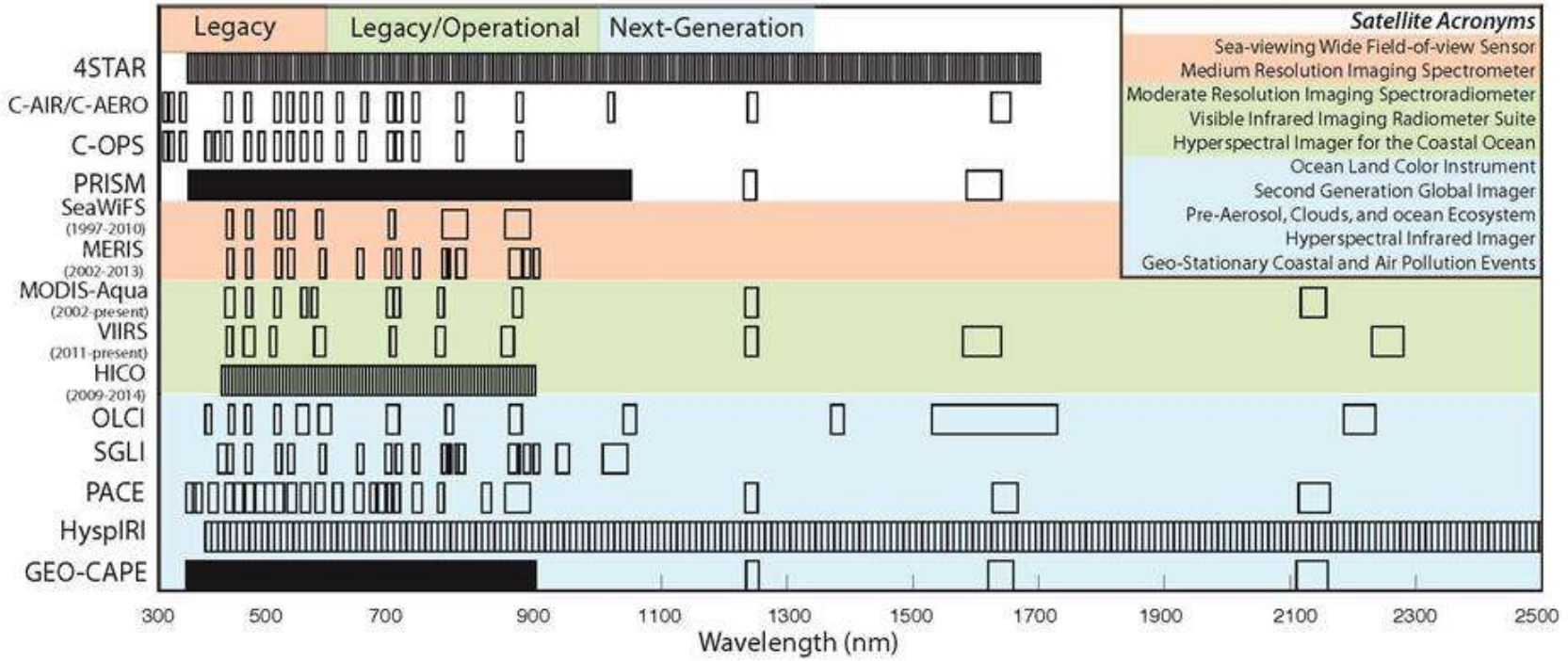
  NASA HARPOONS

  Puerto Rico Sea Grant

  NOAA EPP/SSIO


Legacy
Legacy/Operational
Next-Generation
4STAR
C-AIR/C-AERO
C-OPS
PRISM
SeaWiFS
(1997-2010)
MERIS
(2002-2013)
MODIS-Aqua
(2002-present)
VIIRS
(2011-present)
HICO
(2009-2014)
OLCI
SGLI
PACE
HyspIRI
GEO-CAPE
300
500
700
900
1100
1300
1500
1700
1900
2100
2300
2500
Wavelength (nm)
Satellite Acronyms
Sea-viewing Wide Field-of-view Sensor
Medium Resolution Imaging Spectrometer
Moderate Resolution Imaging Spectroradiometer
Visible Infrared Imaging Radiometer Suite
Hyperspectral Imager for the Coastal Ocean
Ocean Land Color Instrument
Second Generation Global Imager
Pre-Aerosol, Clouds, and ocean Ecosystem
Hyperspectral Infrared Imager
Geo-Stationary Coastal and Air Pollution Events