What New Algorithms Will be Required?

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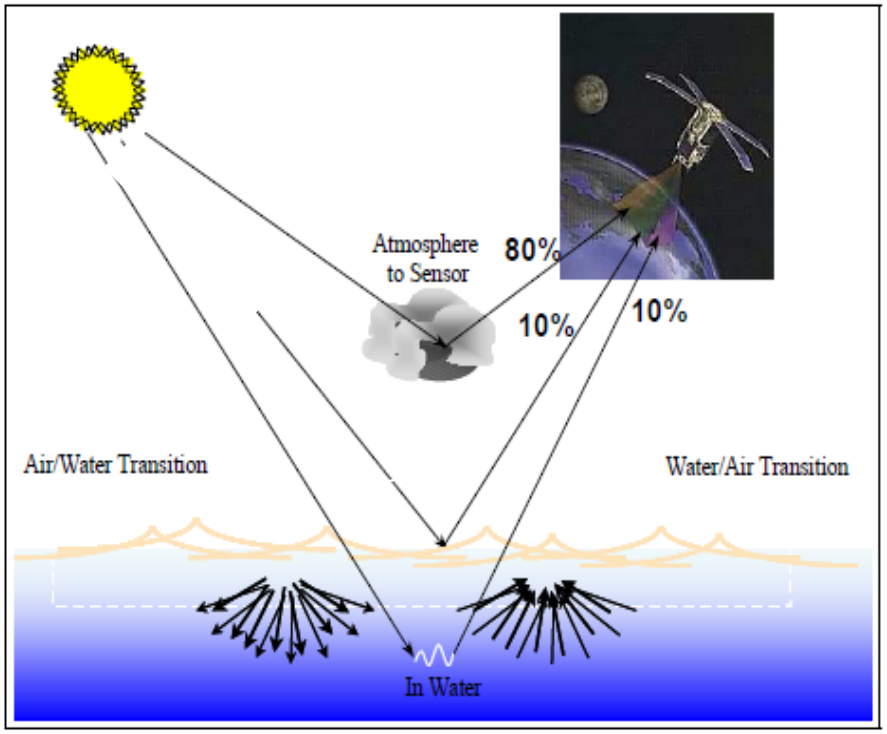
Remote Sensing of Coastal Waters

- Remotely sensed signal components
  - Sensor
  - Atmosphere
  - Inverse modeling

- Science-quality in-water products require rigorous monitoring of the performance of
  - **the sensor**
  - **the retrieval algorithms**

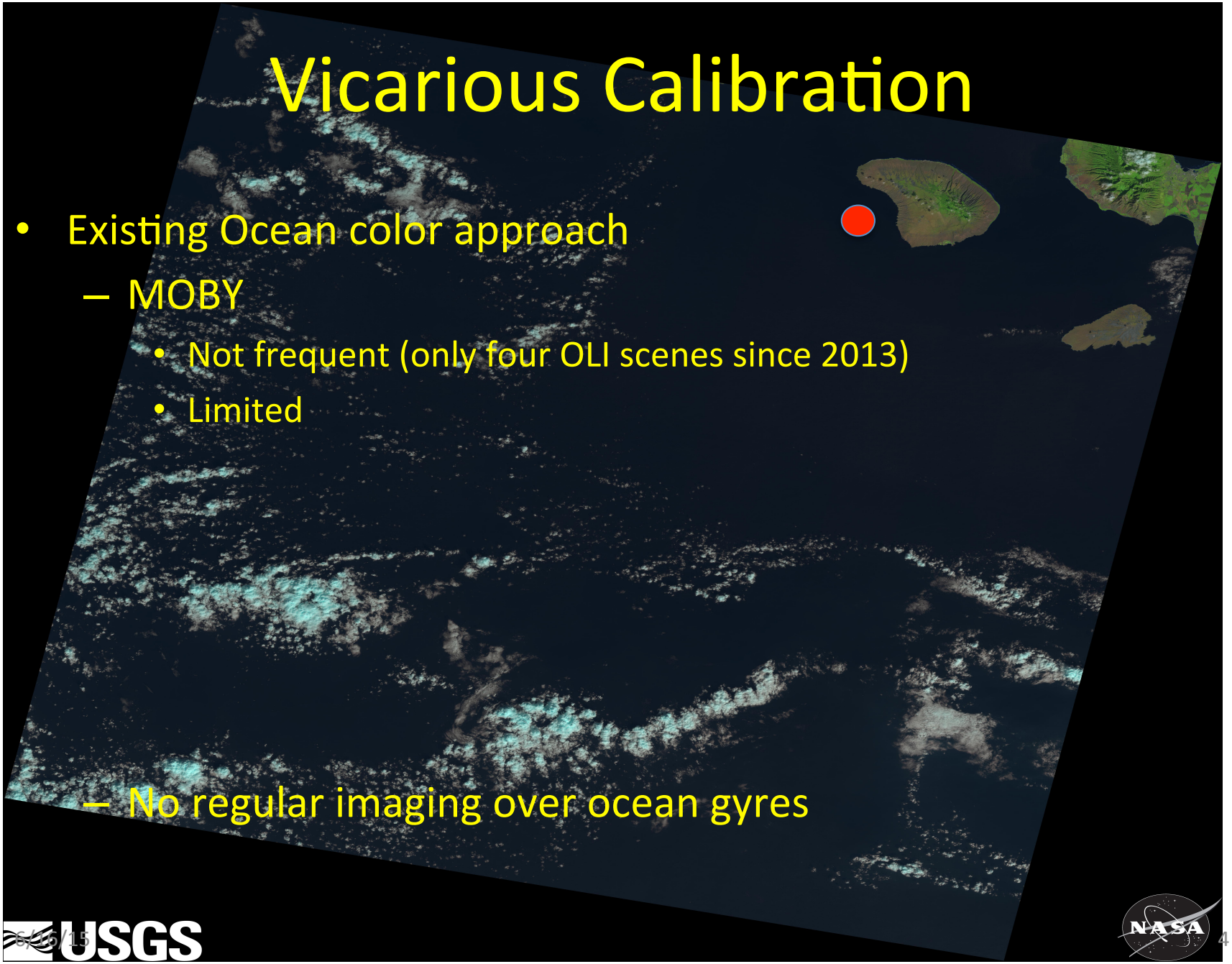


Sensor: OLI

- To obtain science-quality products, we need an instrument with
  - Pre- and post-launch calibration (<0.5%)
  - High Stability
  - Minimal striping/banding

Courtesy of NASA

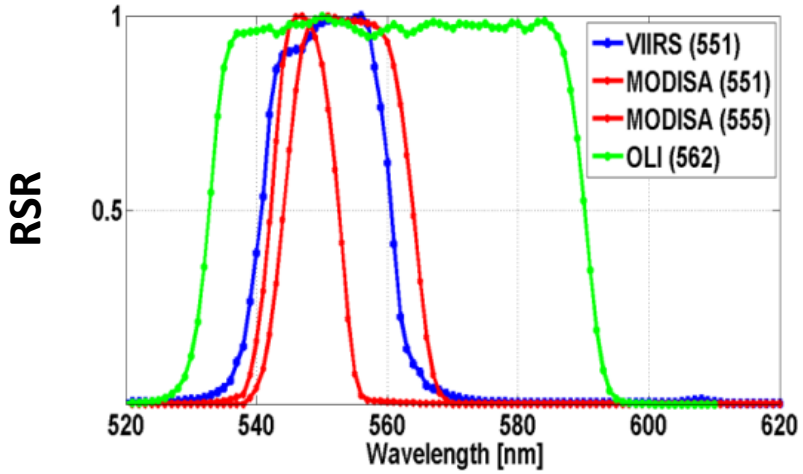
Vicarious Calibration

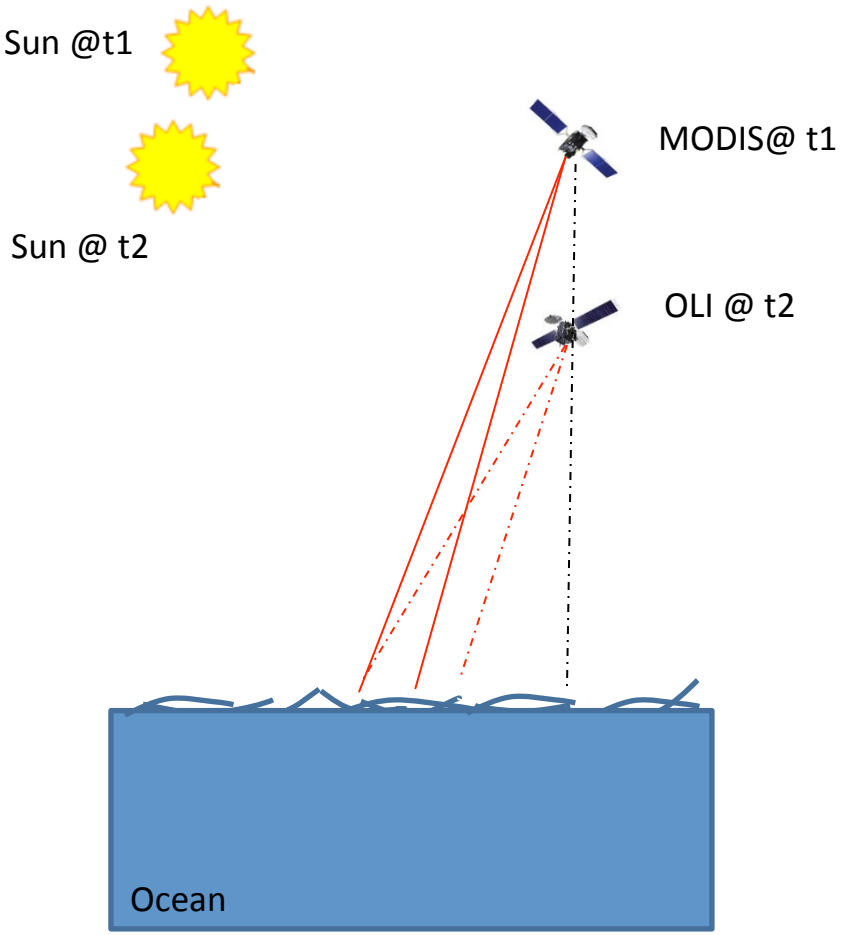


- Existing Ocean color approach
  - MOBY
    - Not frequent (only four OLI scenes since 2013)
    - Limited
  - No regular imaging over ocean gyres

Cross-calibration Opportunities with Ocean Color Missions

- Inherent differences in the …
  - overpass times (t1-t2 < 20min)
  - imaging geometry (α < 7.5°)
  - Spatial sampling
  - Spectral responses

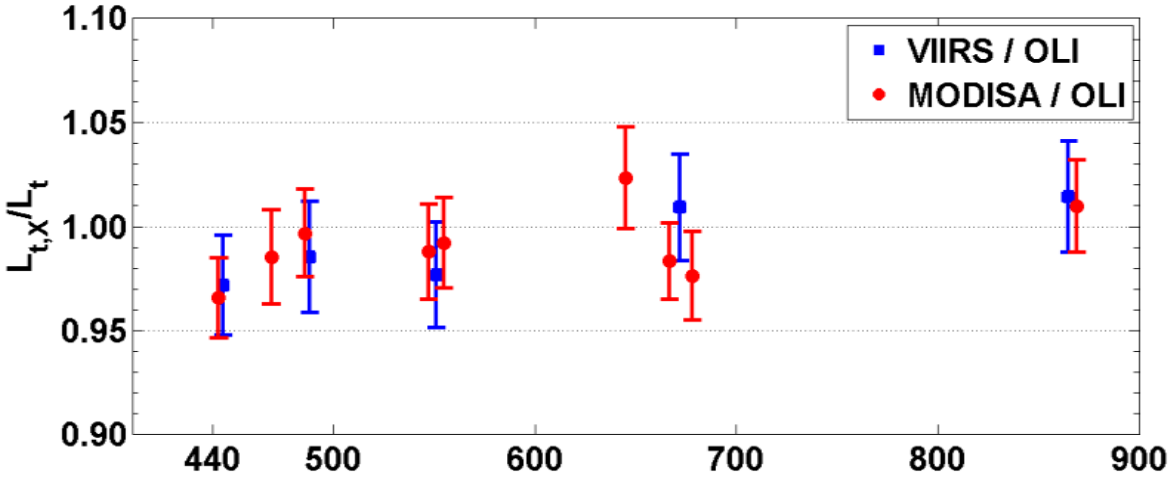




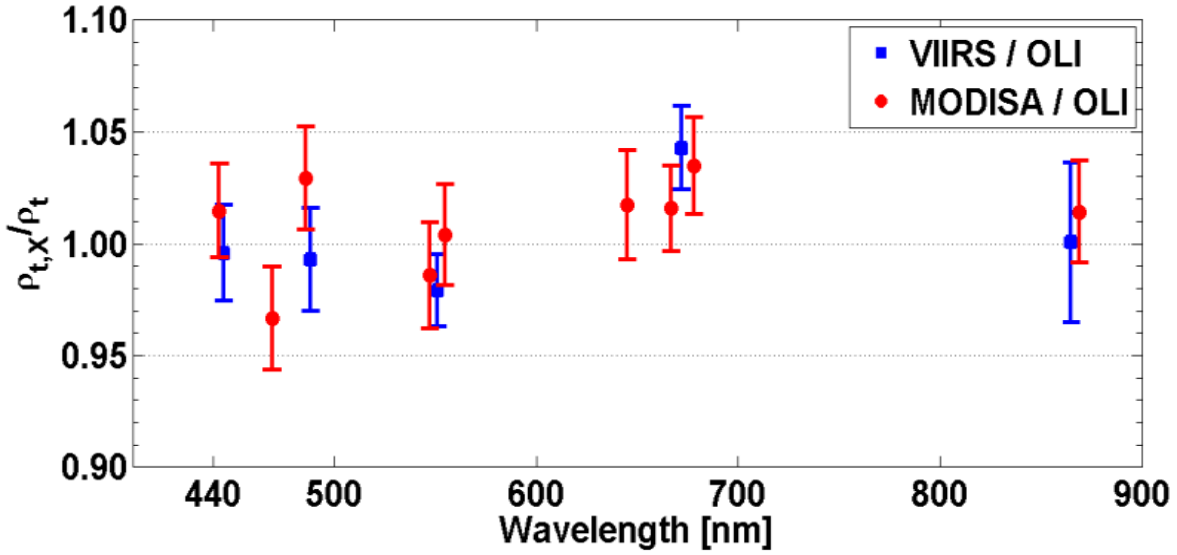
USGS science for a changing world

OLI – MODIS/VIIRS Cross Calibration

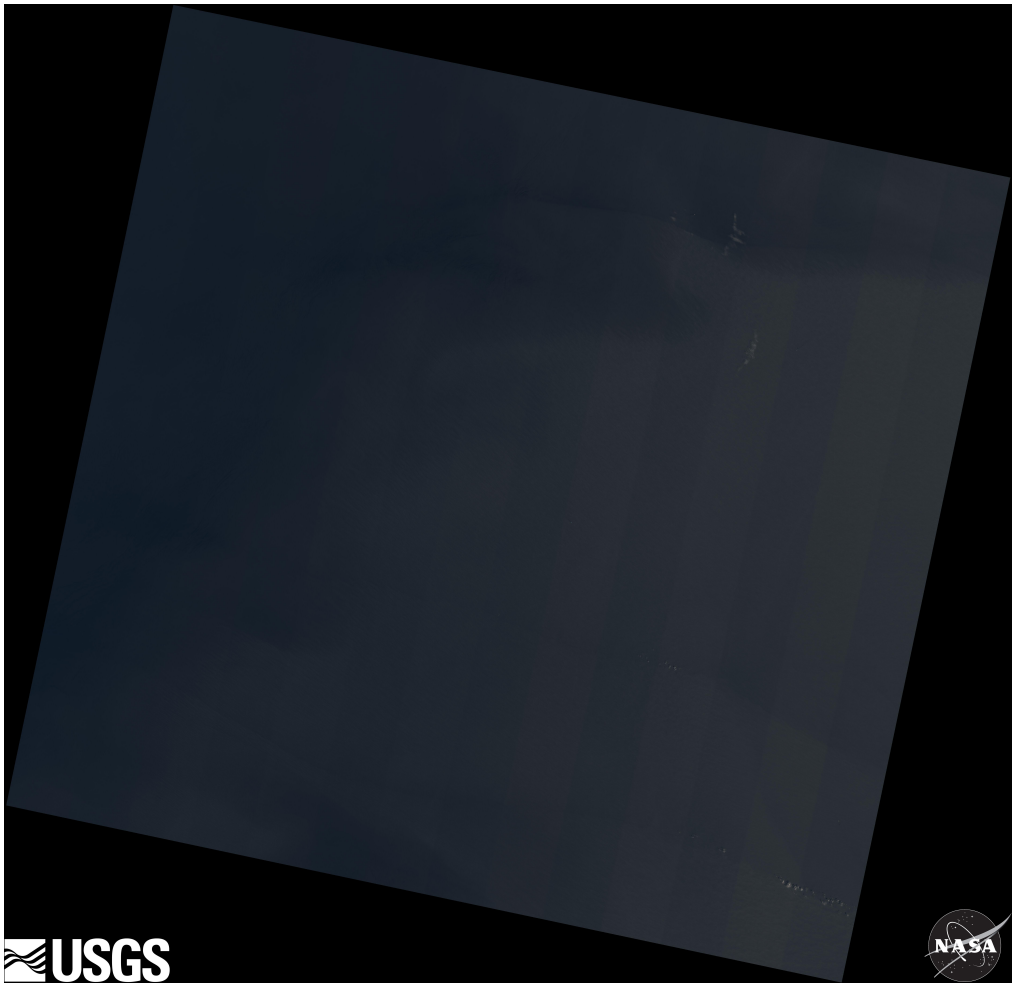
Radiance



Reflectance



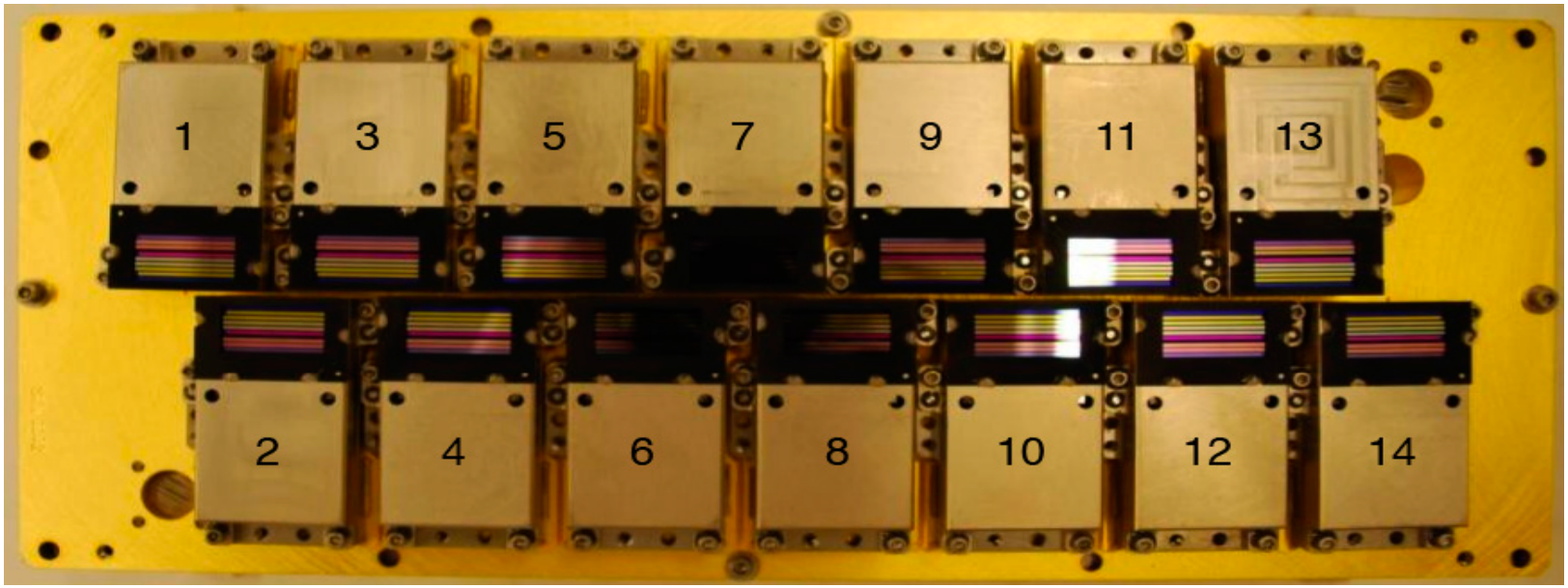
OLI Striping/Banding



OLI Striping/Banding

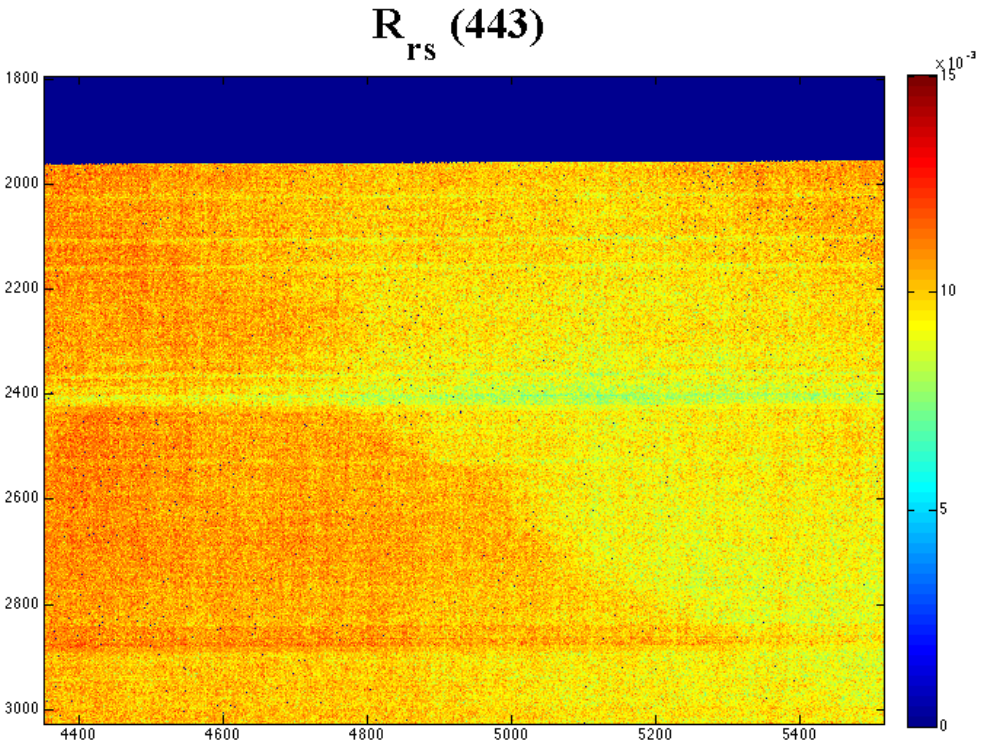
- Inherent to pushbroom design
- Estimated to be < 0.3% @ TOA
- MultiSpectral Instrument (MSI) onboard Sentinel-2 has a similar design

~ 185 km OLI Swath

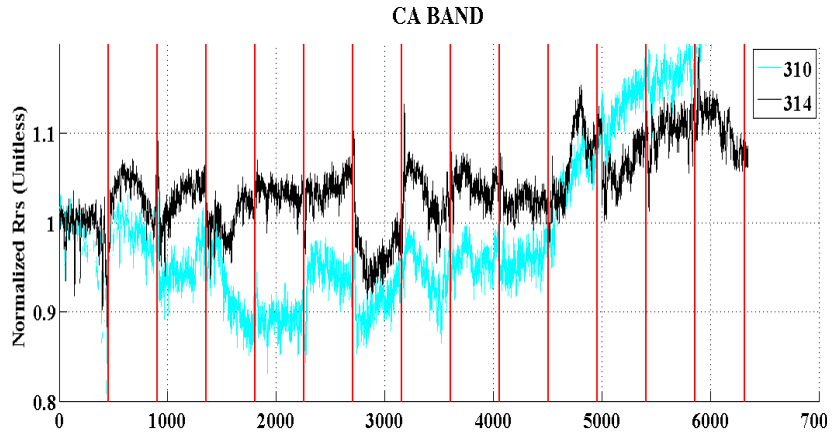


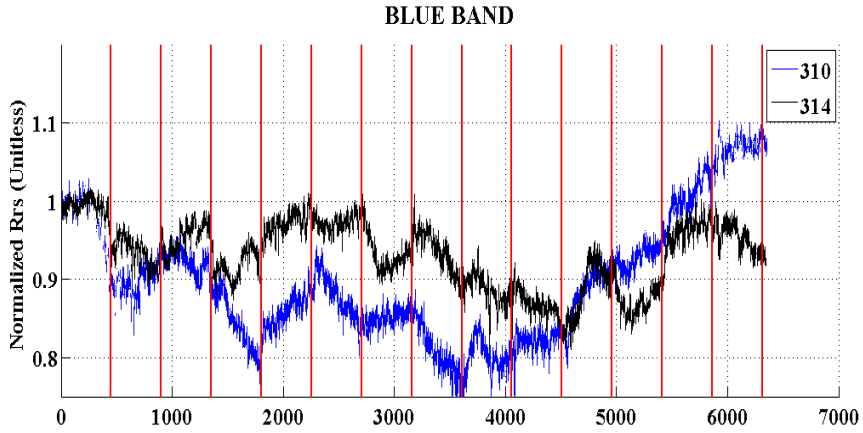
Barsi et. al. (2014). The Spectral Response of the Landsat-8 Operational Land Imager

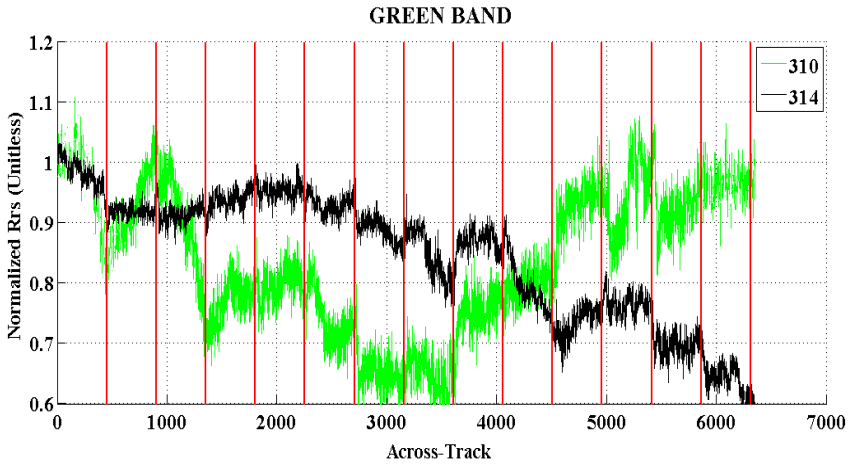
OLI Striping/Banding

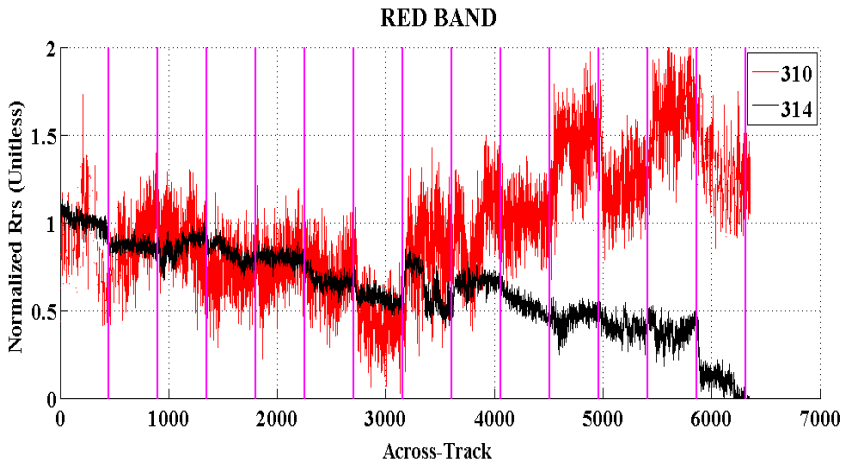


OLI Striping/Banding









Possible Solutions

- Banding
  - Incorporate accurate geometry information into the processing
  - Cross-calibration @ TOA
- Striping
  - Flat-field OLI-derived Rrs against OC-derived Rrs for > 50 scenes

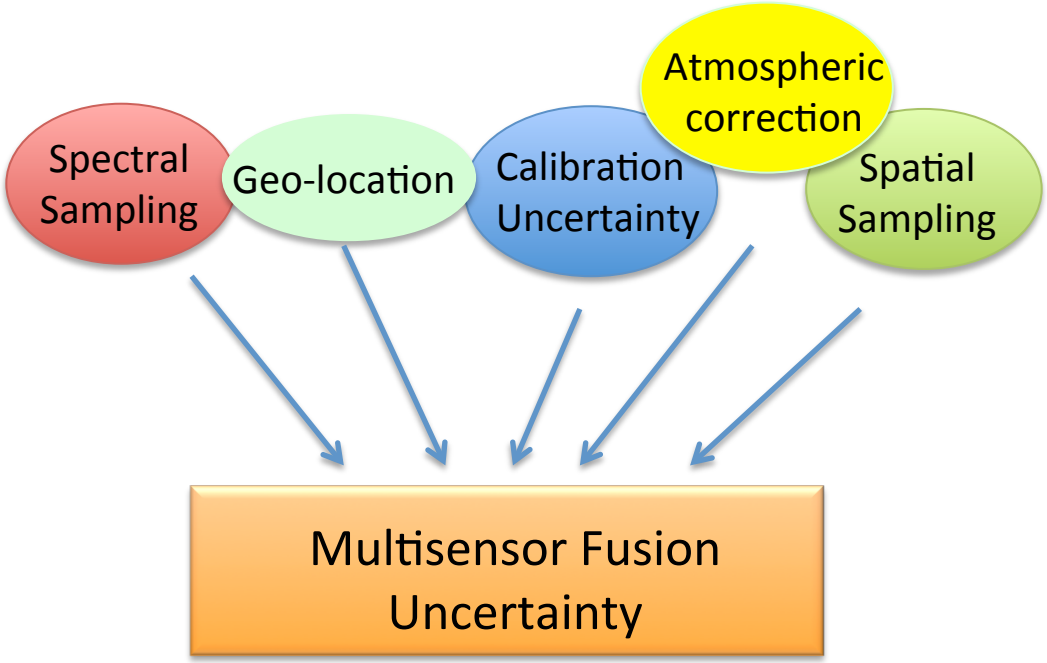
Multisensor Fusion: Challenges

- Geolocation
  - OLI: < 18m (Storey et. al. 2014)
- Band-to-band registration
  - OLI: < 4m

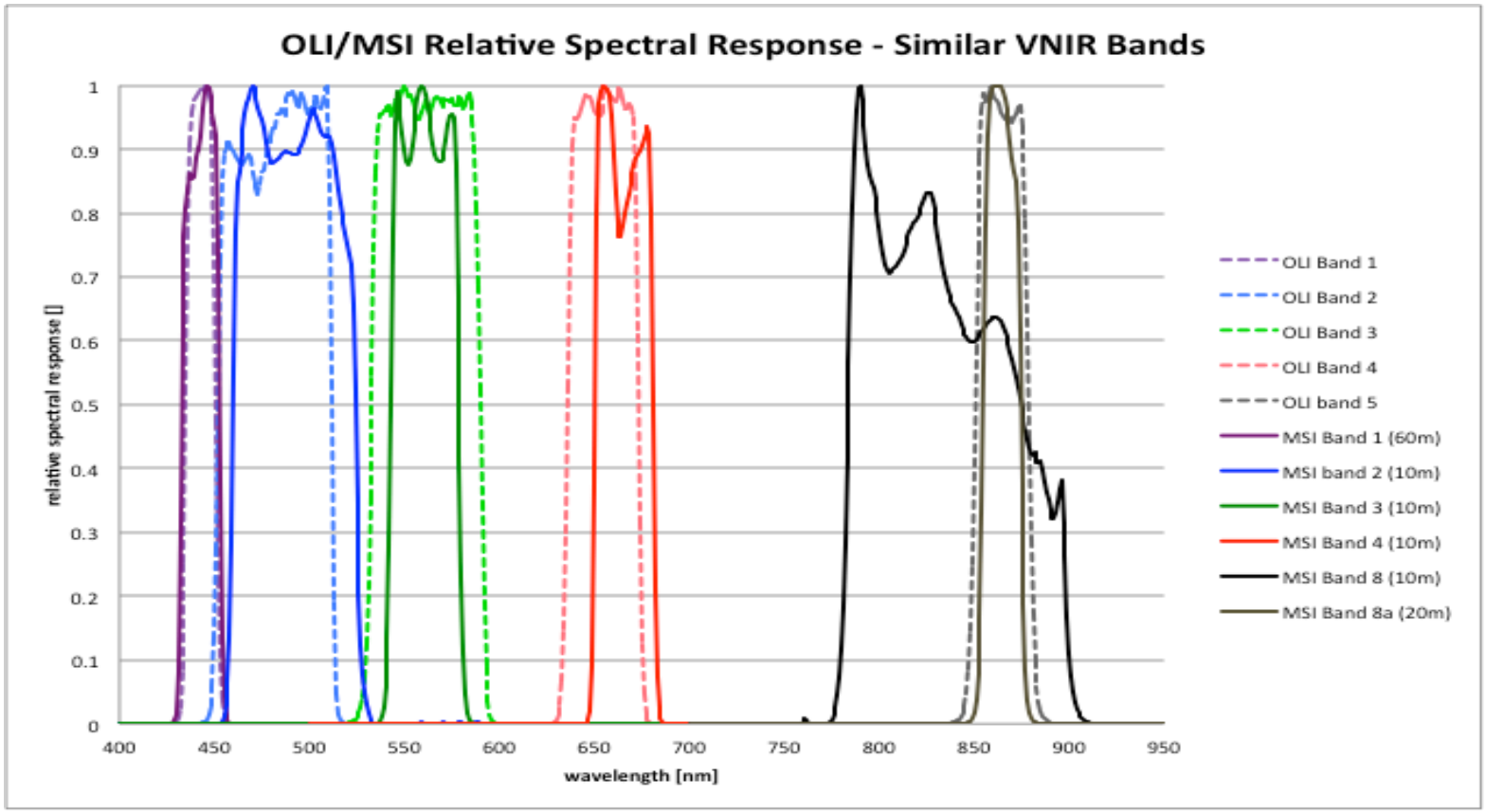
- Calibration
- Atmospheric correction

- Spatial sampling
  - Point spread function
  - Viewing geometry

- Spectral sampling



OLI Vs. MSI Spectral Bands



Courtesy of Brian Markham and Julia Barsi, NASA GSFC / SSAI

European Space Agency

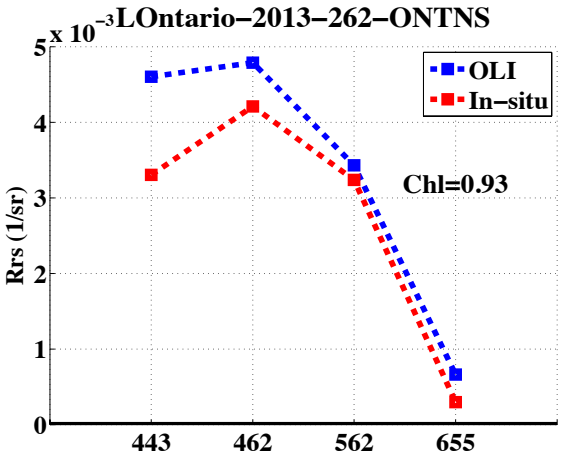
Algorithm Development

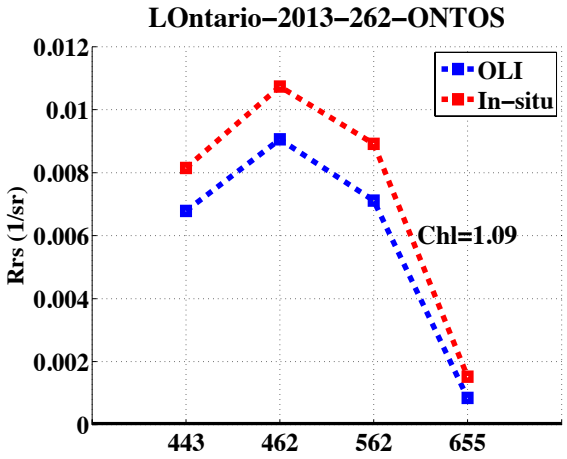
- Requires an internationally collaborative effort

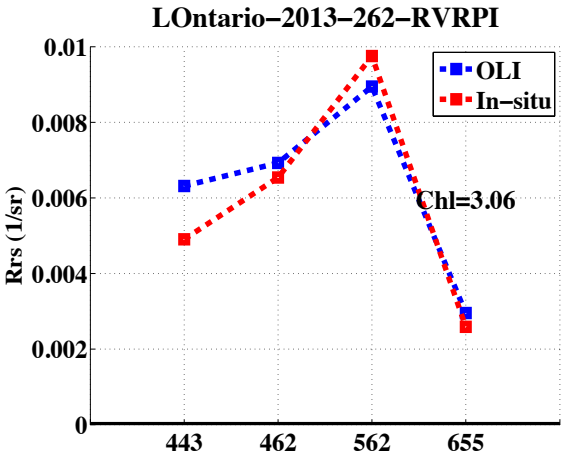
- In-situ Rrs validations from different groups
  - Uncertainties!!!

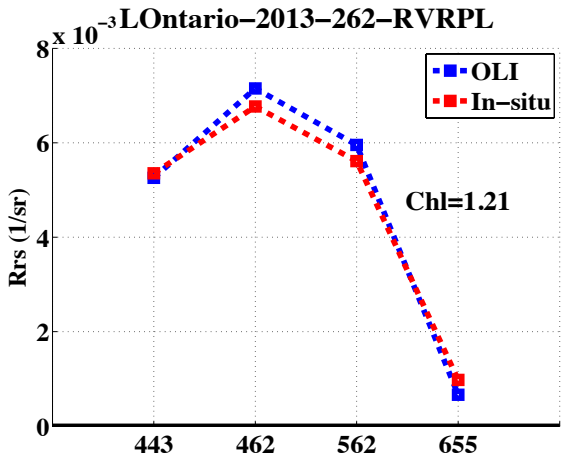
- Currently available Atmospheric corrections
  - SWIR-based (ACOLITE / SeaDAS)

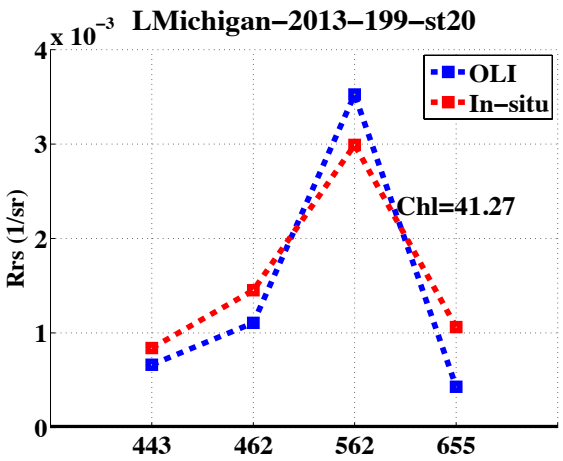
Relatively Eutrophic/Turbid

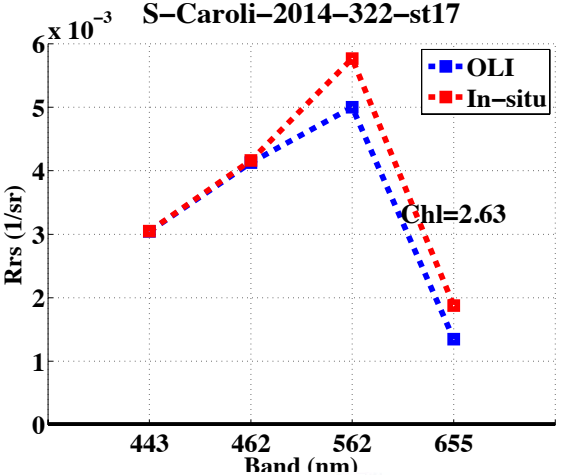




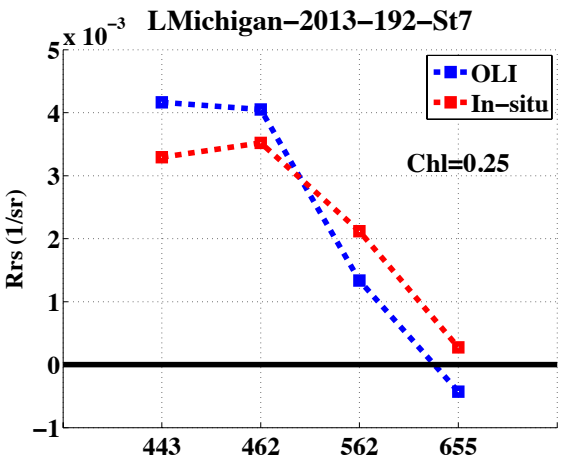


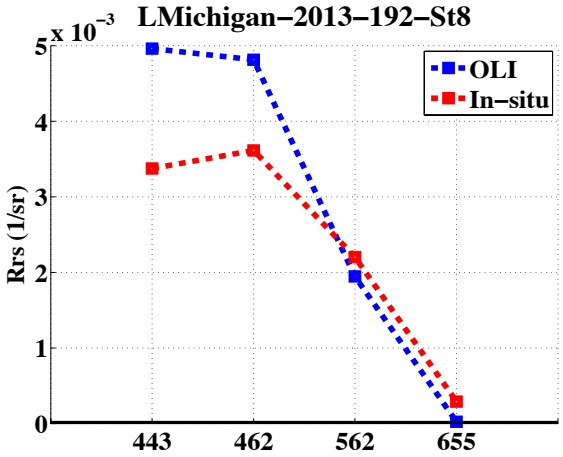


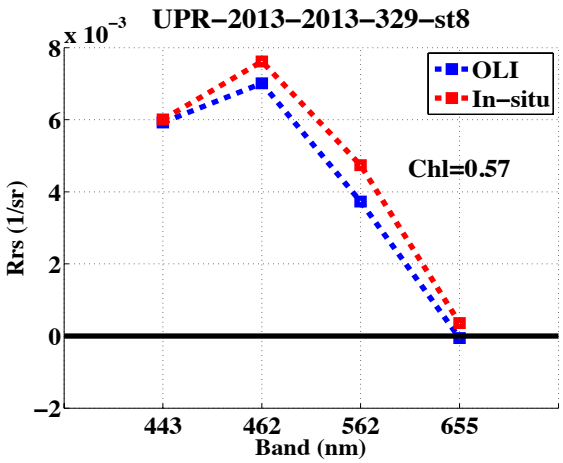


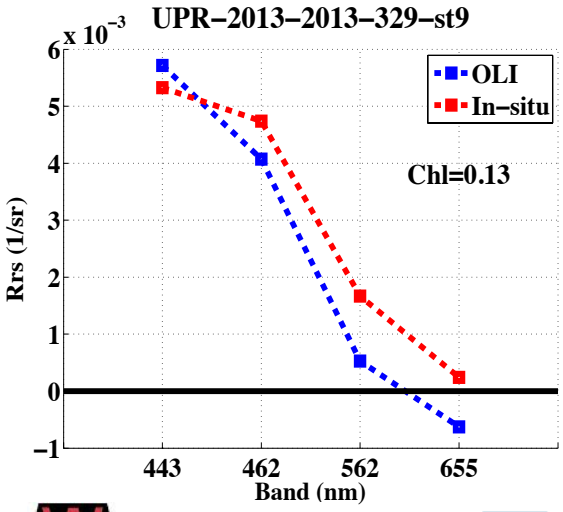


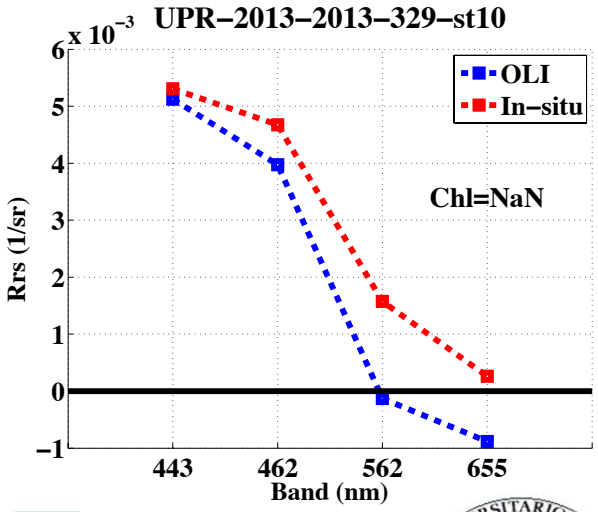
Relatively Clear Waters

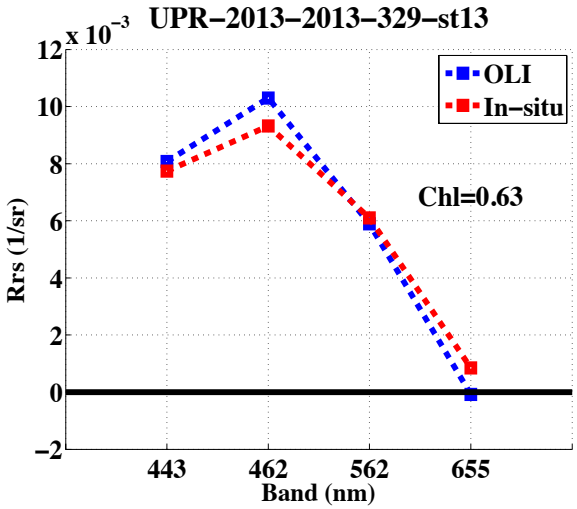




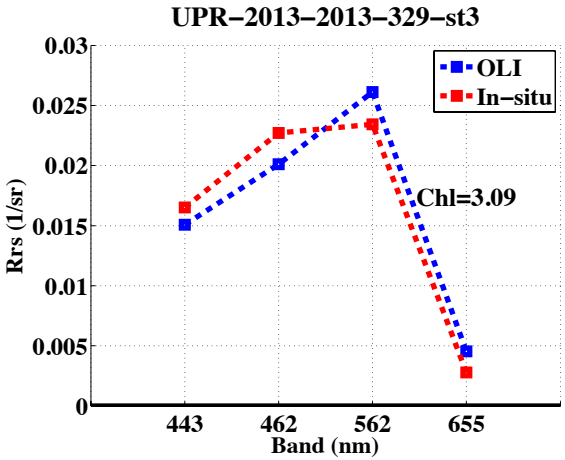


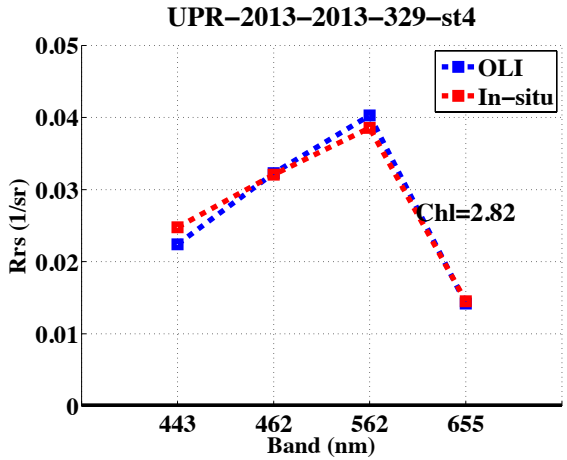


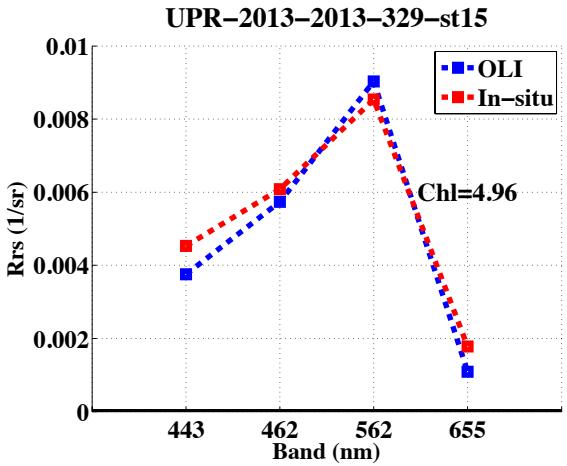


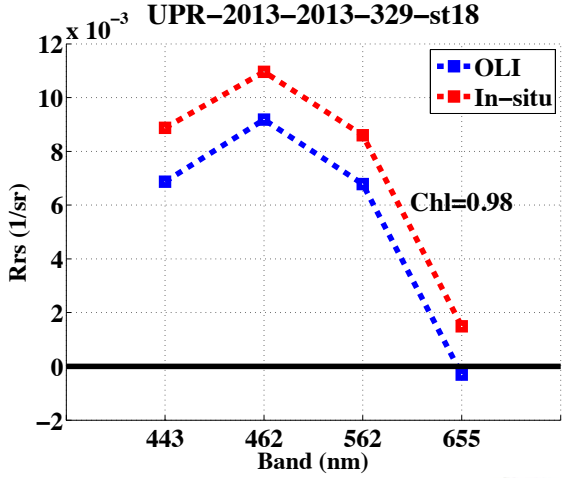


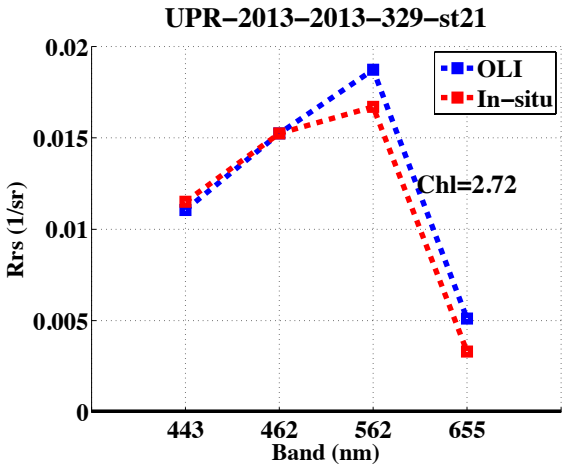
Seagrass/Corals/Sand – Puerto Rico





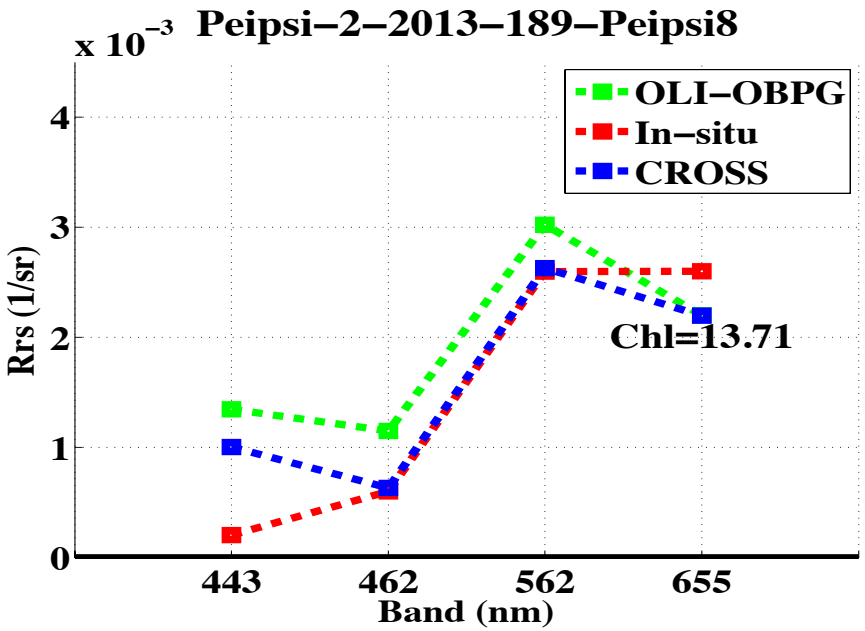






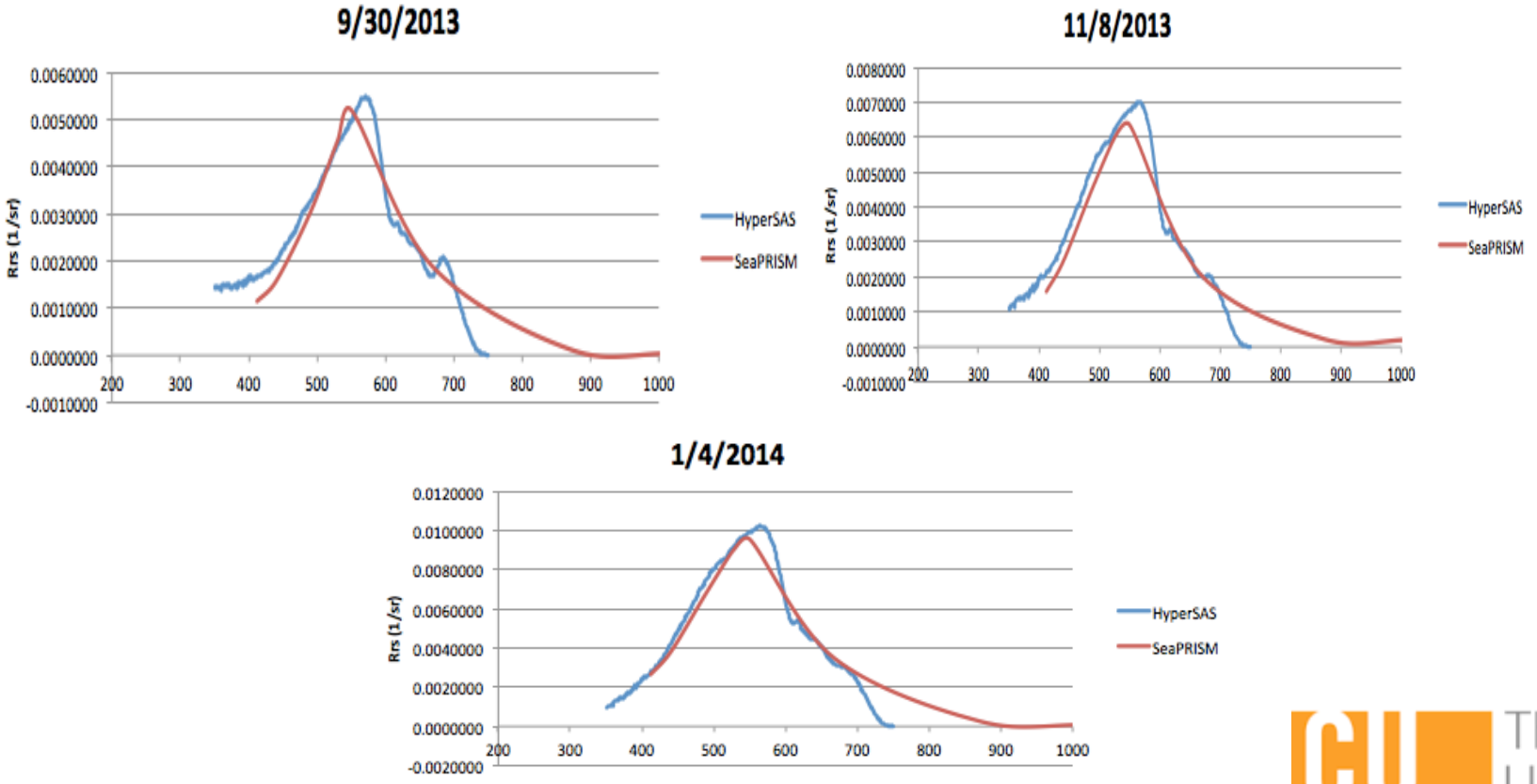
CDOM-rich: Lake Peipsi, Estonia

- NIR-SWIR atmospheric correction



SeaPrism Vs. HyperSAS

- Beware of OLI/MSI (**broad**) broad spectral bands



The City University of New York

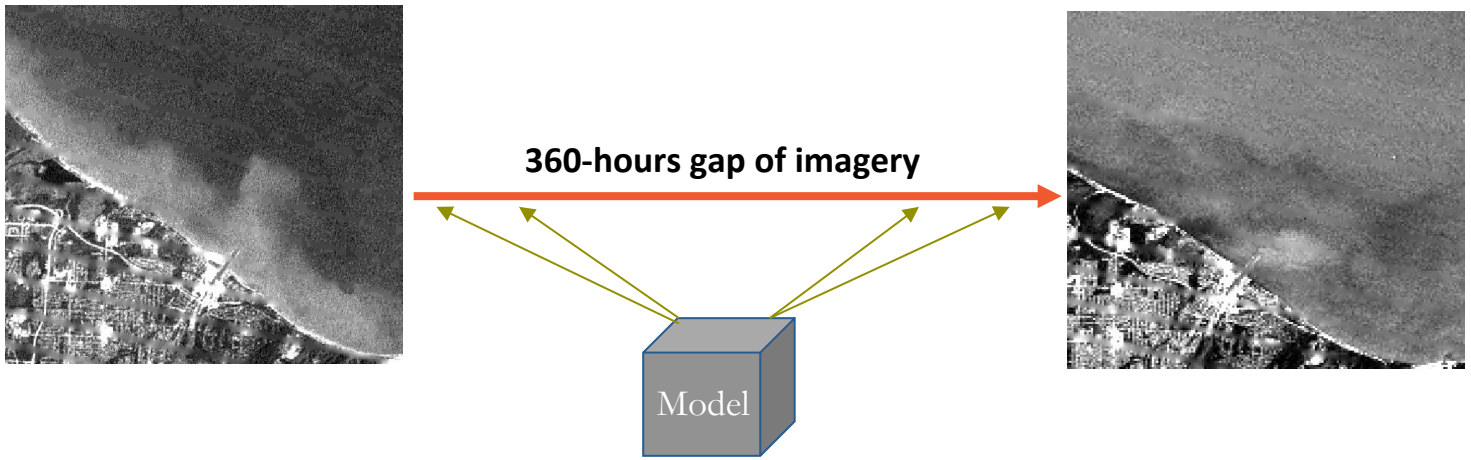
Acknowledgements

- Insitu data provided by:
  - Zhongping Lee, Jianwei Wei (UMB)
  - John Schott, Javier Concha (RIT)
  - Steve Greb, DNR Wisconsin
  - Roy Armstrong, UPR
  - Alex Gilerson, Sam Ahmad, R. Foster (CUNY)
  - Tiit Kutser, U. Tartu

- More insitu data to come from
  - Nick Tufillaro (ORU) … Hawaii, San Francisco Bay
  - Leif Olmanson (UMN) … CDOM-rich lakes
  - Robert Chen, (UMB) … Boston Harbor
  - Steve Greb (DNR) … Wisconsin lakes
  - David O'Donnell (UFI)… NY lakes
  - Michael.ondrusek (NOAA) … Chesapeake Bay
  - Janet Anstee (CSIRO)… Australia
  - Tingwei Cui (FIO) …China

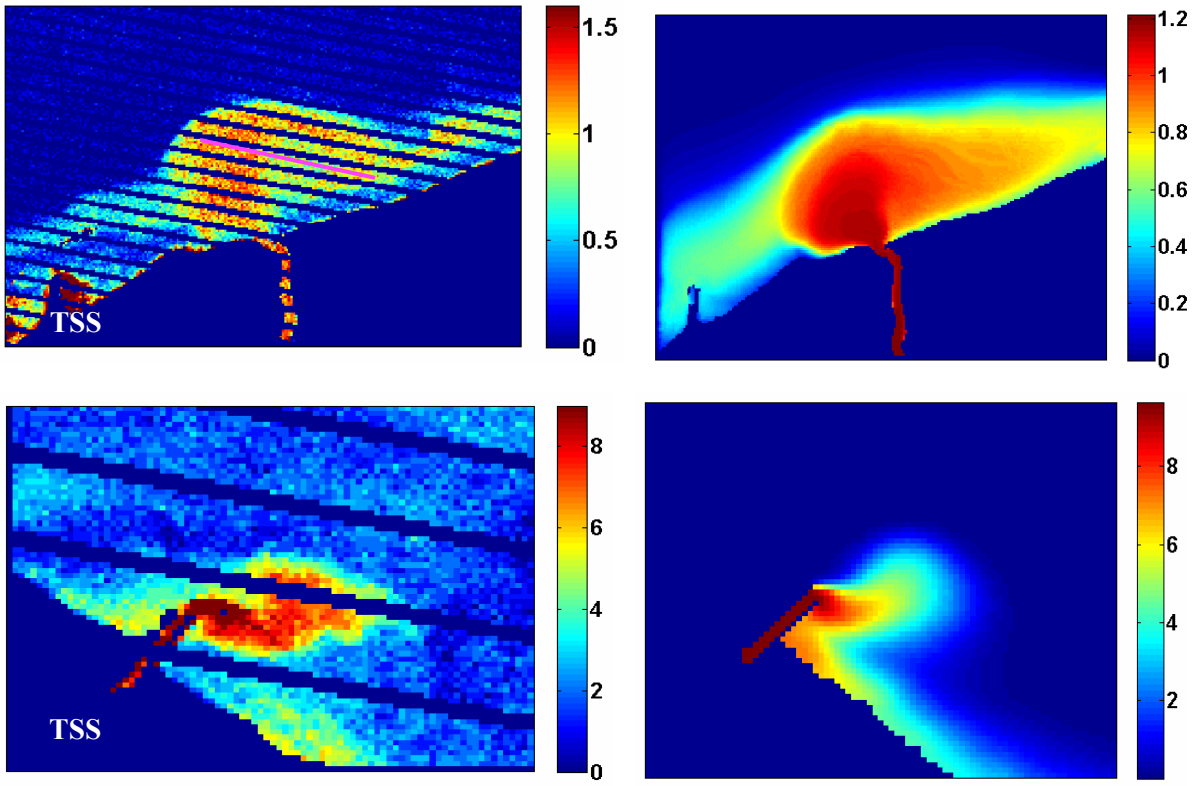
New Applications: Data Assimilation

- Leverage improved temporal frequency:
  - Integrate products with hydro-bio-optical models to enhance forecasting (data assimilation)



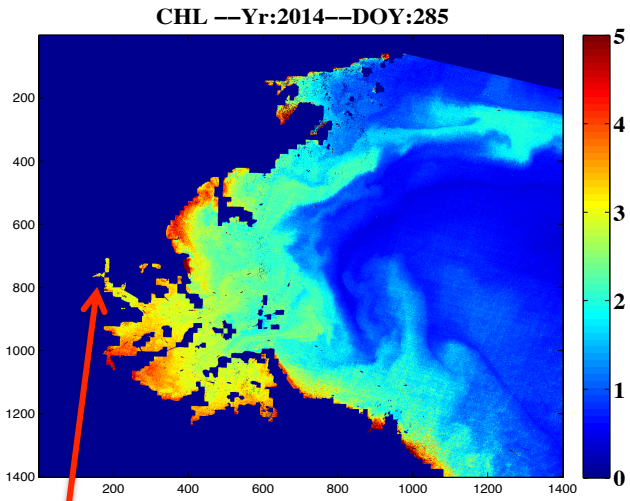
Examples from Landsat 7

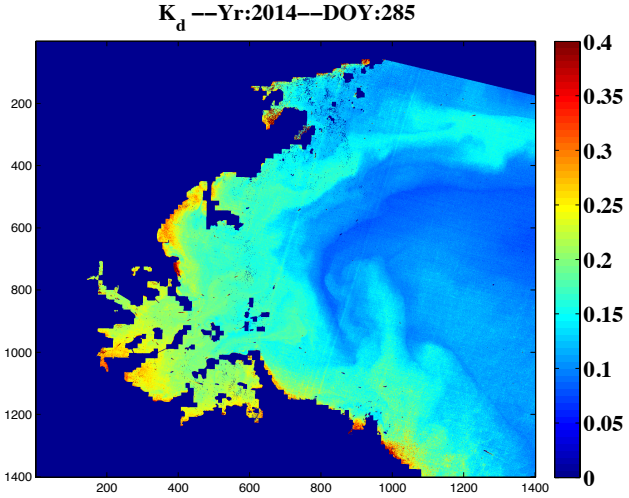
- Genesee and Niagara River Discharges into Lake Ontario



Algorithms

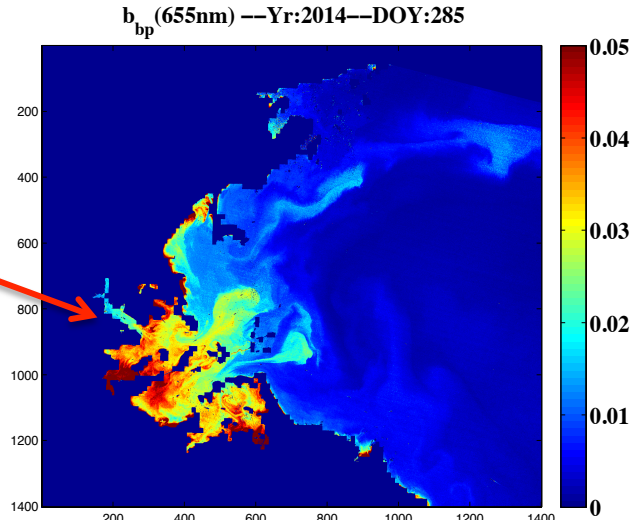
- Global Vs. Regional (parameterization)



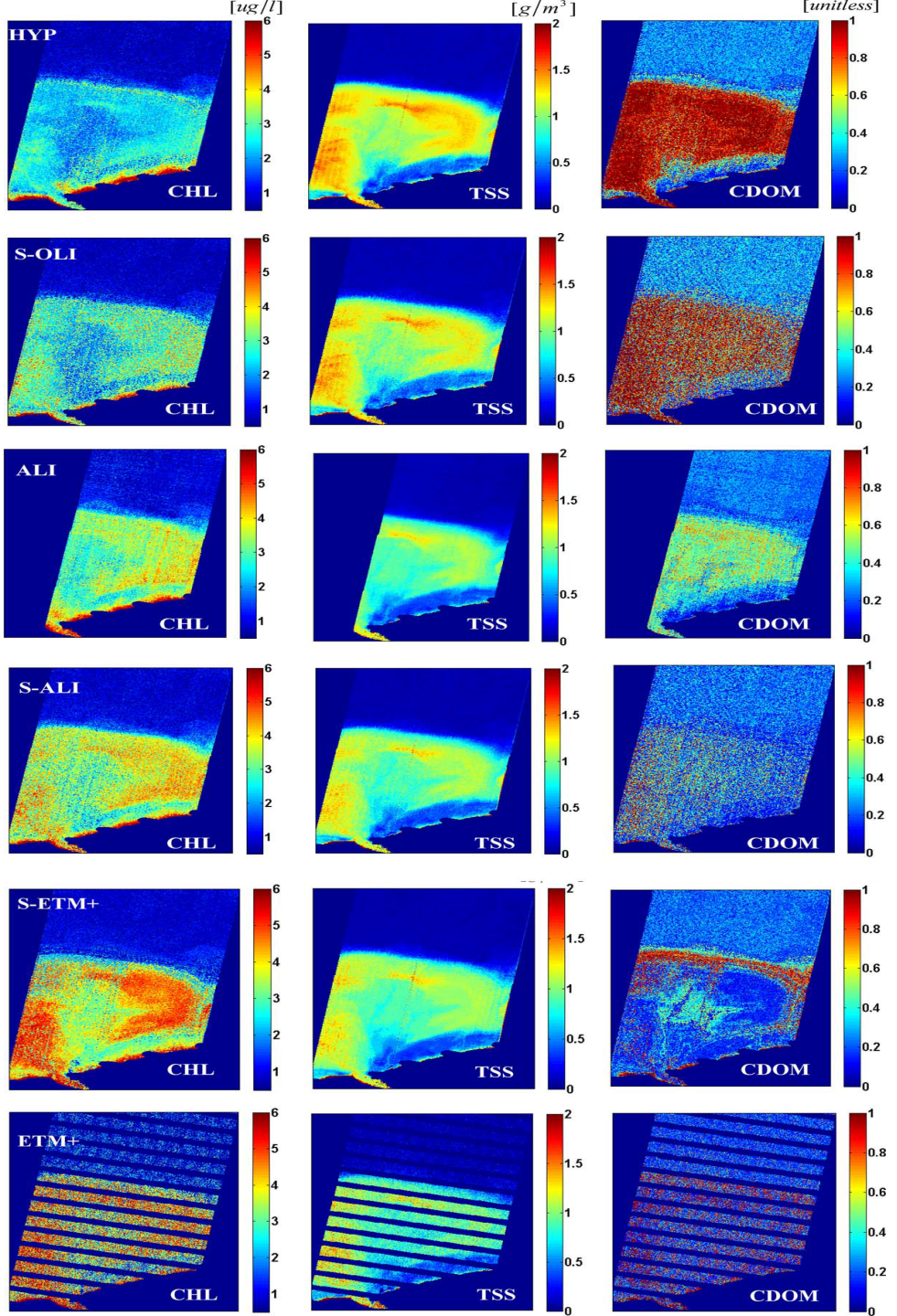


Boston Harbor

Charles River



LUT-based approach using spectral matching for OLI bands:
443,462,561,655nm



Past…

- Have we fully explored TM and ETM+ data over inland and coastal waters?
  - Limited number of bands but…
  - Atmospheric correction (ACOLITE) will be available soon…

Future…

- **While committing to working with existing data,**
  - **What do we need for future Landsat 9 - 10, Sentinel 2C, 2D?**
    - More spectral measurements:
      - Add a few bands to the existing systems
        - » 350nm?
        - » 412nm?
        - » 625nm?
        - » 720nm?
    - More temporal coverage
    - Off-nadir acquisitions to reduce glint
      - Landsat-8 is capable of collecting off-nadir < 15^{o}

- **Bottom Line: We cannot have everything**
  - **Action for prioritization….**