Landsat/Sentinel-2 Aquatic Science Products: Validation Efforts

Nima Pahlevan GSFC/ SSAI

Colleagues/Collaborators:

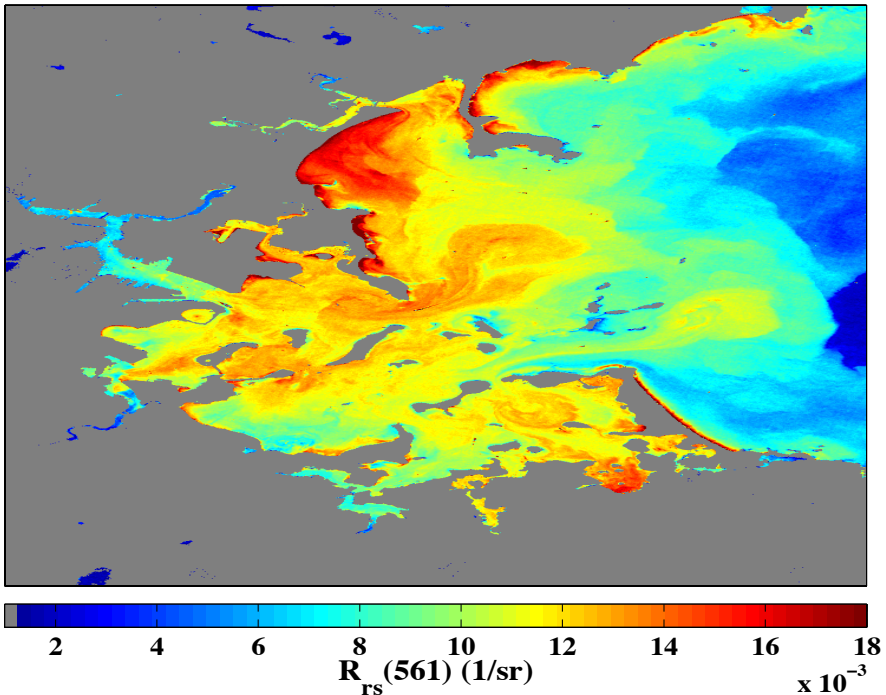
GSFC/EROS: Landsat Cal/Val Team
GSFC Ocean Ecology Lab: Bryan Franz and Sean Bailey
RIT: John Schott
UMass Boston: Crystal Schaaf, Robert Chen, and Zhongping Lee
Florida Atlantic University: James Sullivan, Mike Twardowski, and Mingshun Jiang
University of New Hampshire: Tim Moore
DNR Wisconsin: Steve Greb
Old Dominion University: Victoria Hill
Stanford University: Kevin Arrigo
Oregon State University: Nick Tufillaro and Curtiss Davis
University of Quebec Rimouski: Simon Belanger
Joint Research Centre of the European Union: Giuseppe Zibordi
Royal Belgian Institute of Natural Science: Kevin Ruddick and Quinten Vanhellemont

science for a changing world

Objective

- Validate OLI-derived products in coastal/inland waters through…
  - intercomparisons against MODIS/VIIRS products
  - observations at AERONET-OC
  - in-situ data

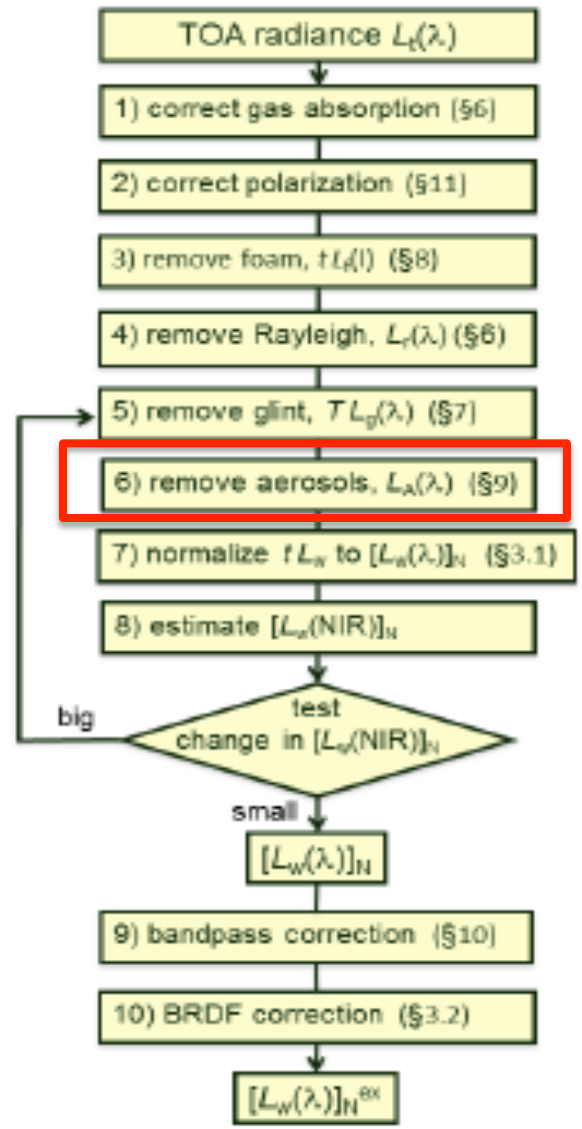
OLI-derived products (Boston Harbor)



Best-practice Atmospheric Correction (GW94)

$$L_t = \left(L_r + [L_a + L_{ra}] + t_{dv} L_{wc} + t_{dv} L_w\right) t_{gv} t_{gs} f_p$$

- More than a decade of heritage
- Aerosol removal using band ratios of
  - NIR + SWIR bands, or
  - two SWIR bands
- R_{rs} [1/sr]: the ratio of water-leaving radiance and total downwelling irradiance just above the surface
- Implemented in SeaDAS (GSFC)



Courtesy of NASA GSFC/OBPG

References

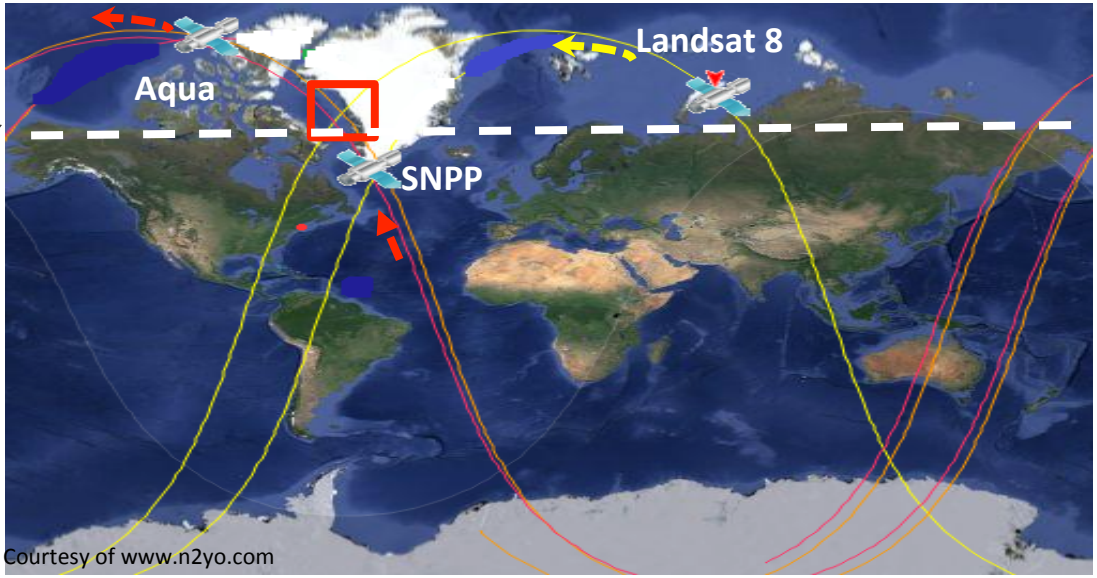
- Gordon, H.R., & Wang, M. (1994). Retrieval of water-leaving radiance and aerosol optical thickness over the oceans with SeaWiFS: a preliminary algorithm. *Appl. Opt., 33*, 443-452
- Franz, B.A., Bailey, S.W., Kuring, N., & Werdell, P.J. (2015). Ocean color measurements with the Operational Land Imager on Landsat-8: implementation and evaluation in SeaDAS. *Journal of Applied Remote Sensing, 9*, 096070-096070
- Bailey, S.W., Franz, B.A., & Werdell, P.J. (2010). Estimation of near-infrared water-leaving reflectance for satellite ocean color data processing. *Optics express, 18*, 7521-7527

Validation Vs. MODIS/VIIRS

- Simultaneous nadir overpasses (SNO) within 2013-2015 timeframe
  - 95 OLI-MODISA scene pairs
  - 72 OLI-VIIRS scene pairs

	Landsat-SNPP	Landsat-Aqua
Time difference	**< 20 mins**	**~14 mins**
Latitude	**68° < Φ < 74°**	**Φ = 72.2°**

L8-Aqua Crossing at 72.2°N



OLI Focal Plane Layout

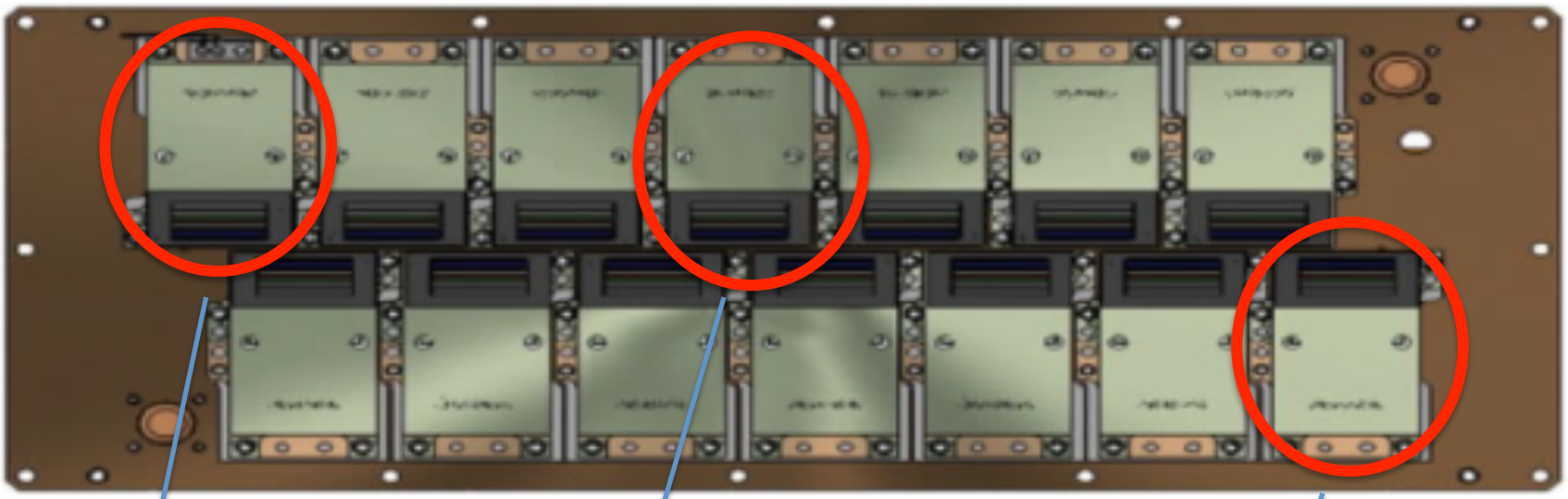


Fig. 2. Drawing of the OLI focal plane (Courtesy of Ball Aerospace & Technologies Corporation).

Focal Plane Module (FPM) 1

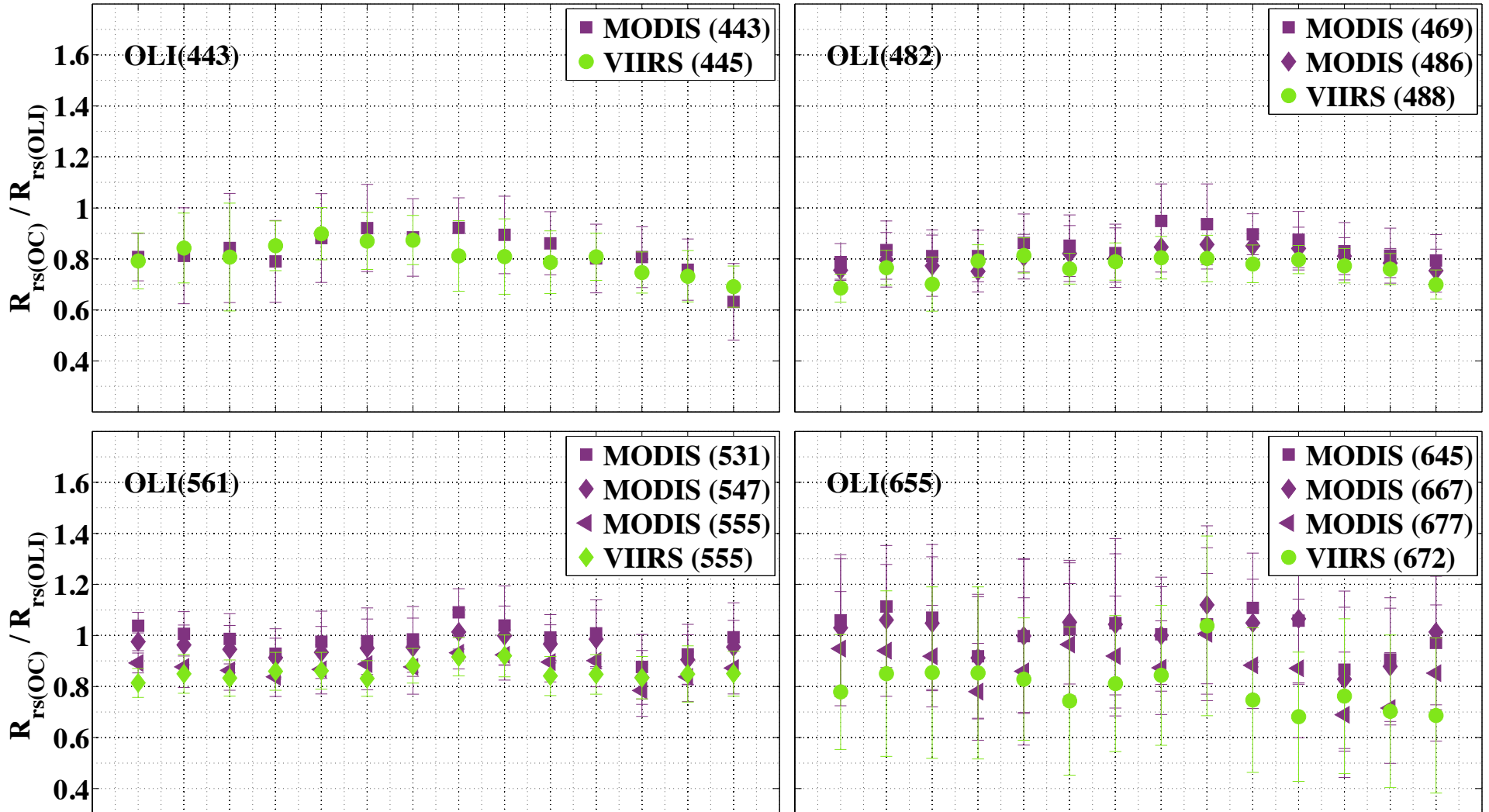
Focal Plane Module (FPM) 7

Focal Plane Module (FPM) 14

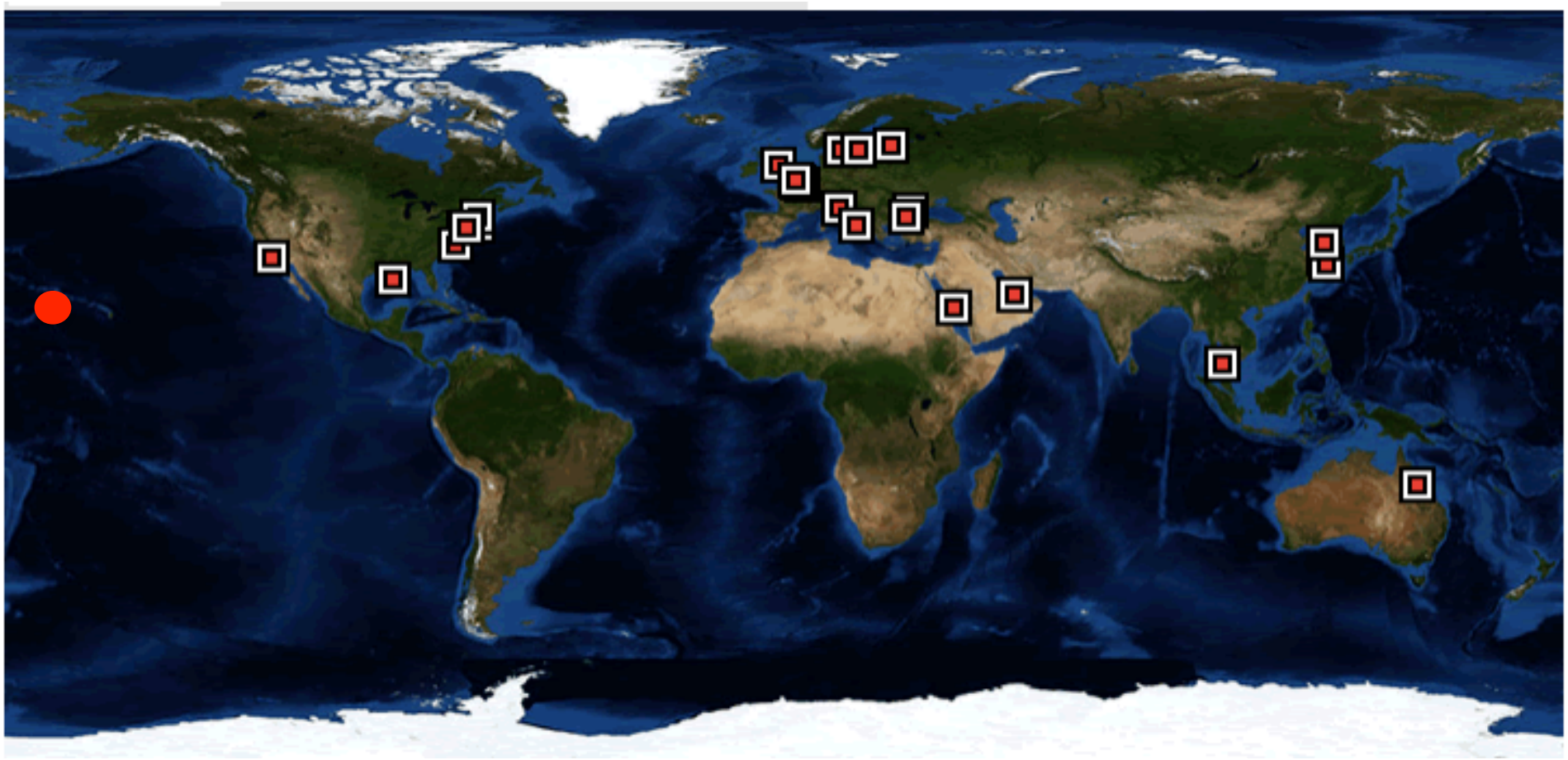
West

East

Consistency Metric: Ratio of Products

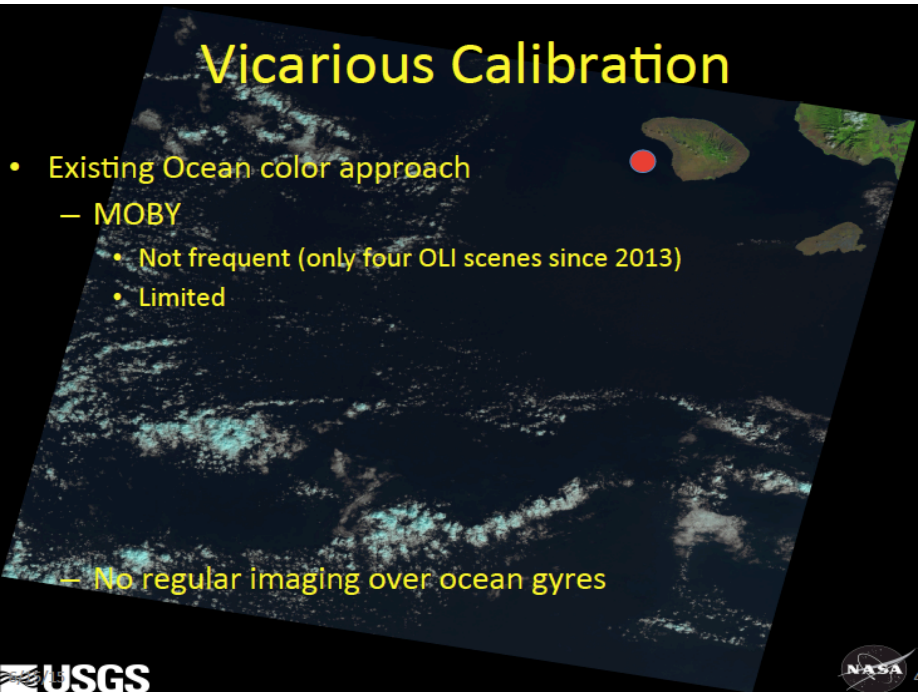


Calibration Adjustments at AERONET-OC Sites

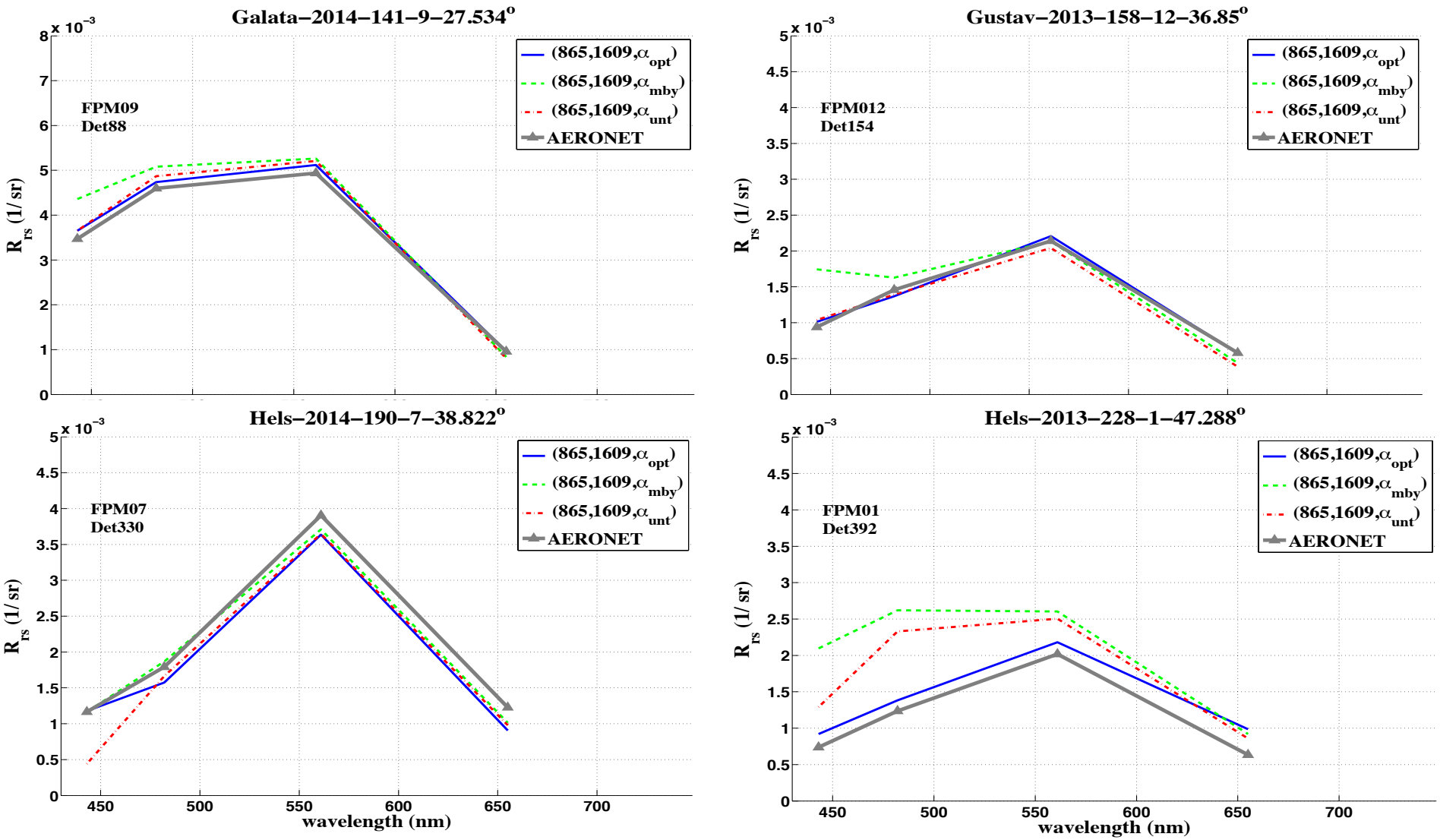


Method

- Retrieve R_{rs} from OLI by applying
  - MOBY gains (derived from three OLI scenes)
  - Adjusted MOBY gains by fitting R_{rs} to observations (blue curves)
  - Unity gains (OLI as is)



Results: Calibration Adjustments



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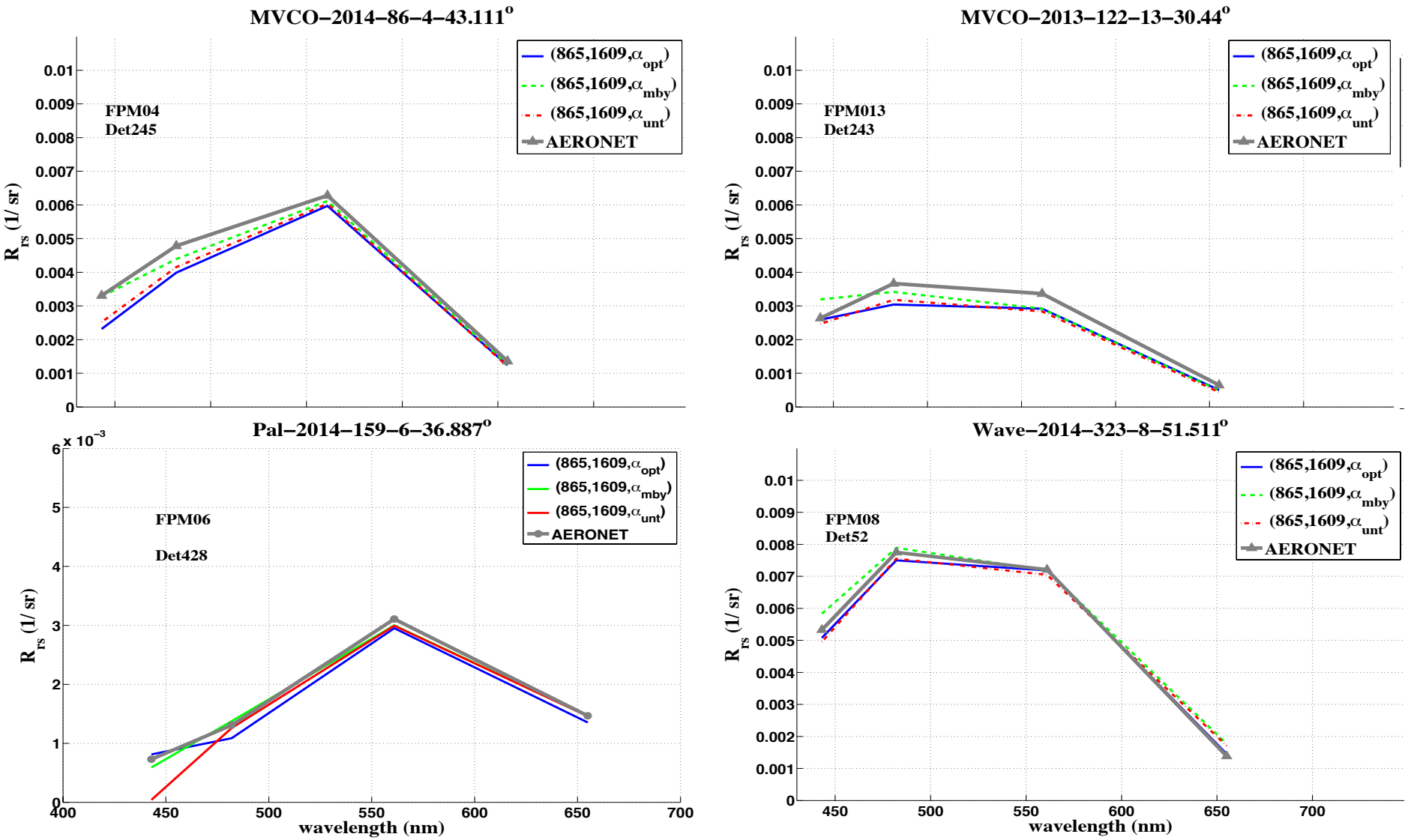
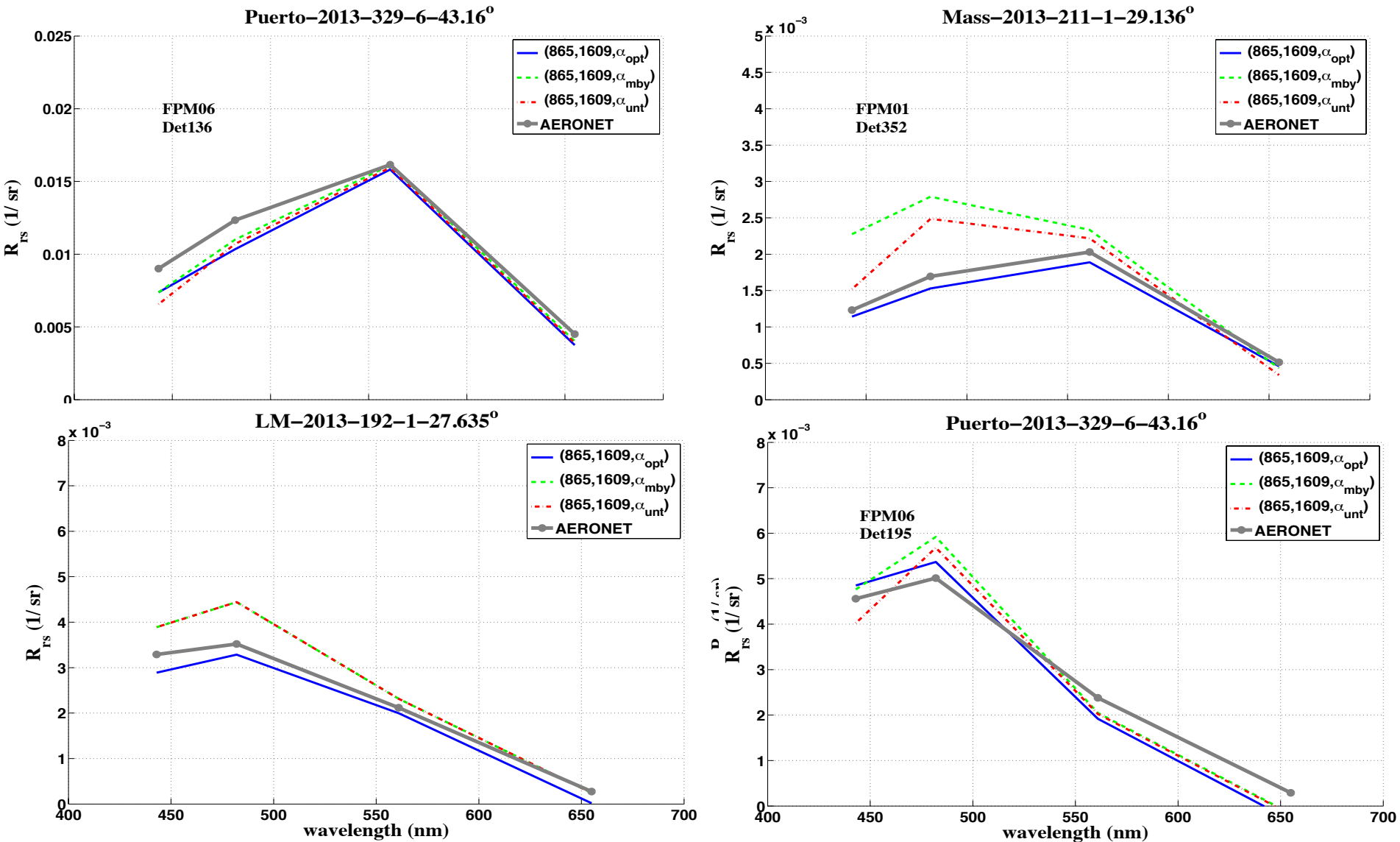


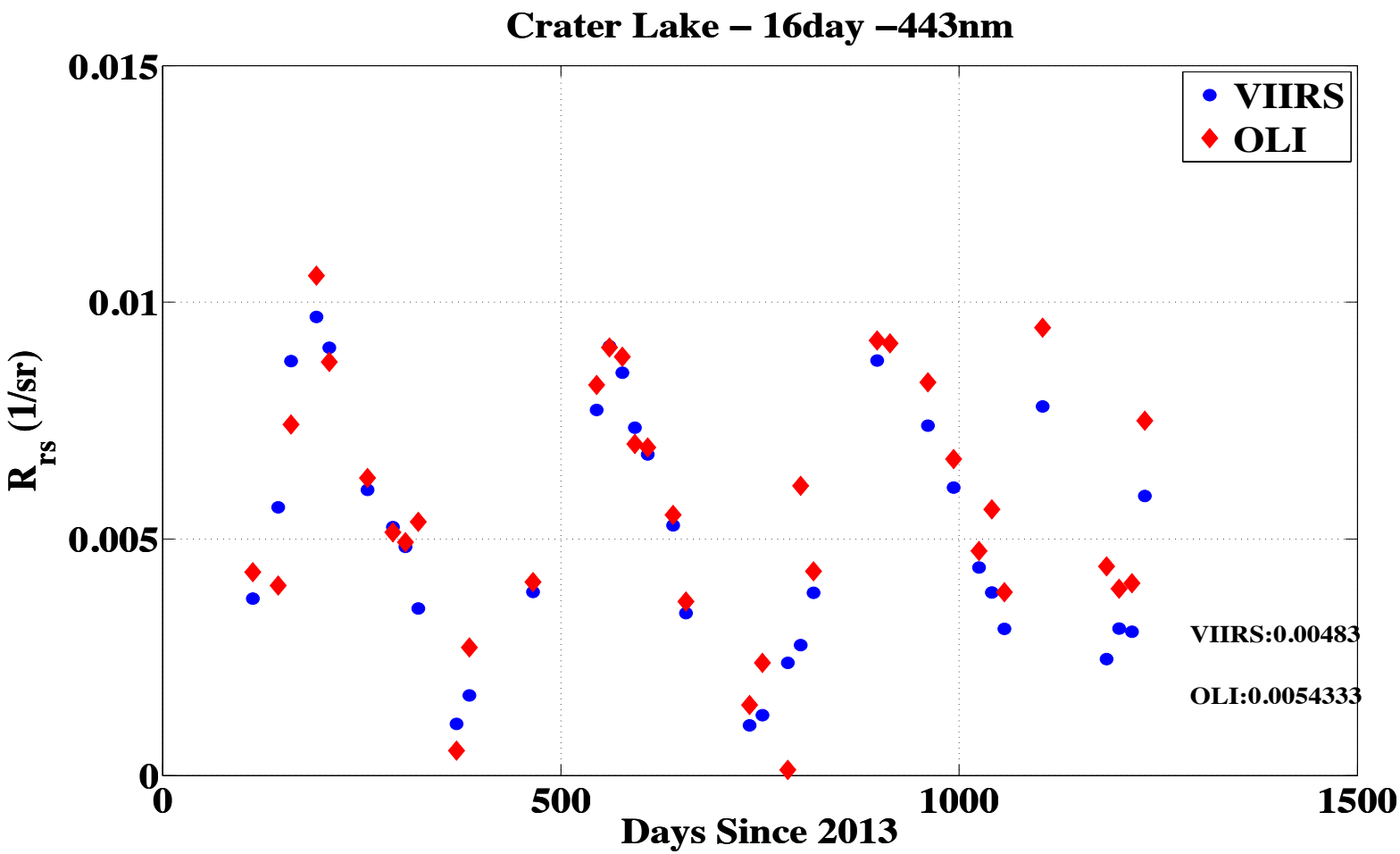
Validation: Independent In-situ Data



Temporal Stability in OLI-derived R_{rs} Products

- Intercomparison against VIIRS products over select inland waters
  - Crater Lake
    - oligotrophic (chl < 0.15)
  - Lake Tahoe
    - mesotrophic (chl < 0.5)
  - Lake Garda (Italy)
    - mesotrophic (1 < chl < 5)
  - Lake Dengizkul (Uzbekistan)
    - eutrophic (3 < chl < 10)
  - Lake Victoria (Australia)
    - Eutrophic (3 < chl < 10)

Temporal Trends



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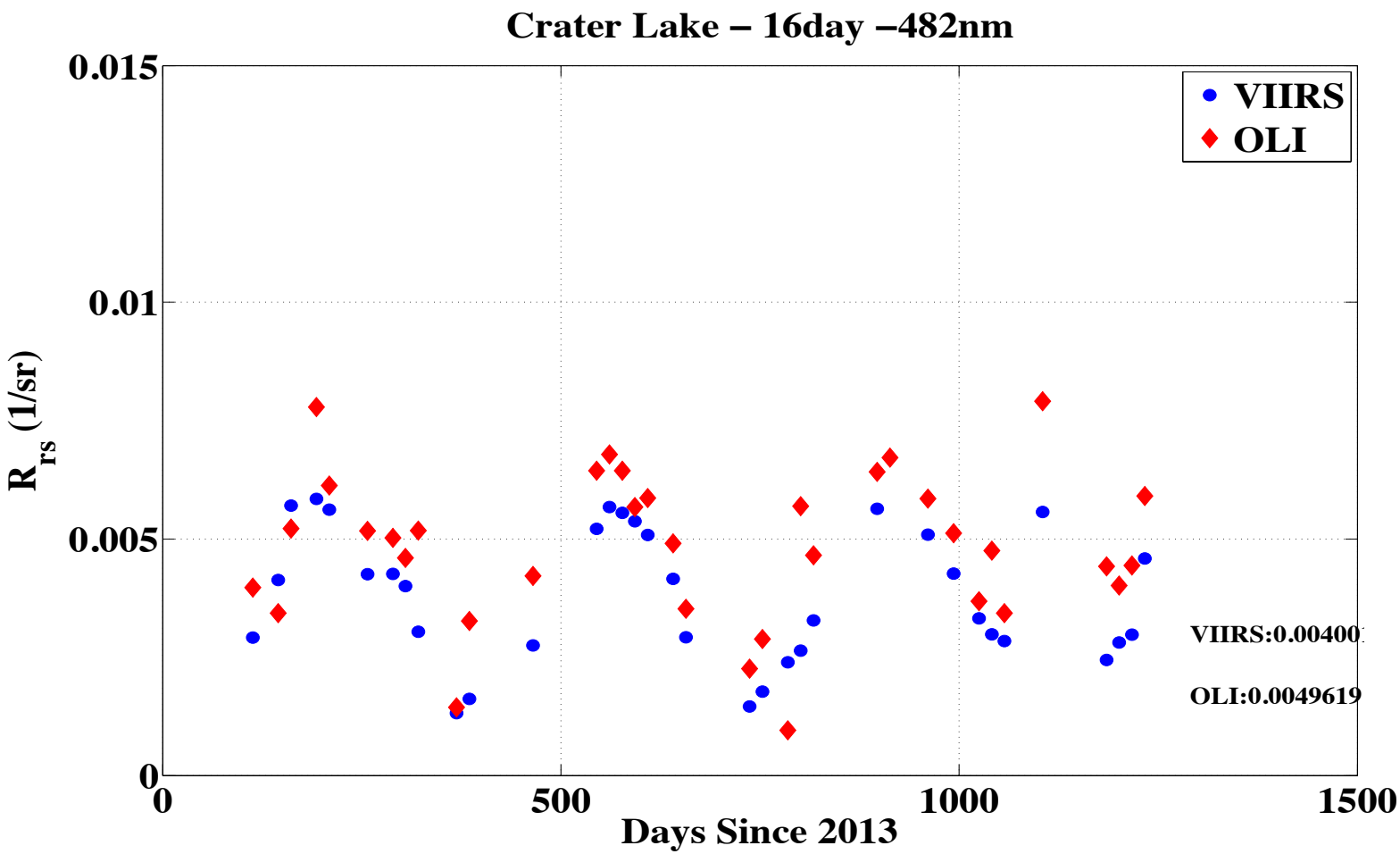

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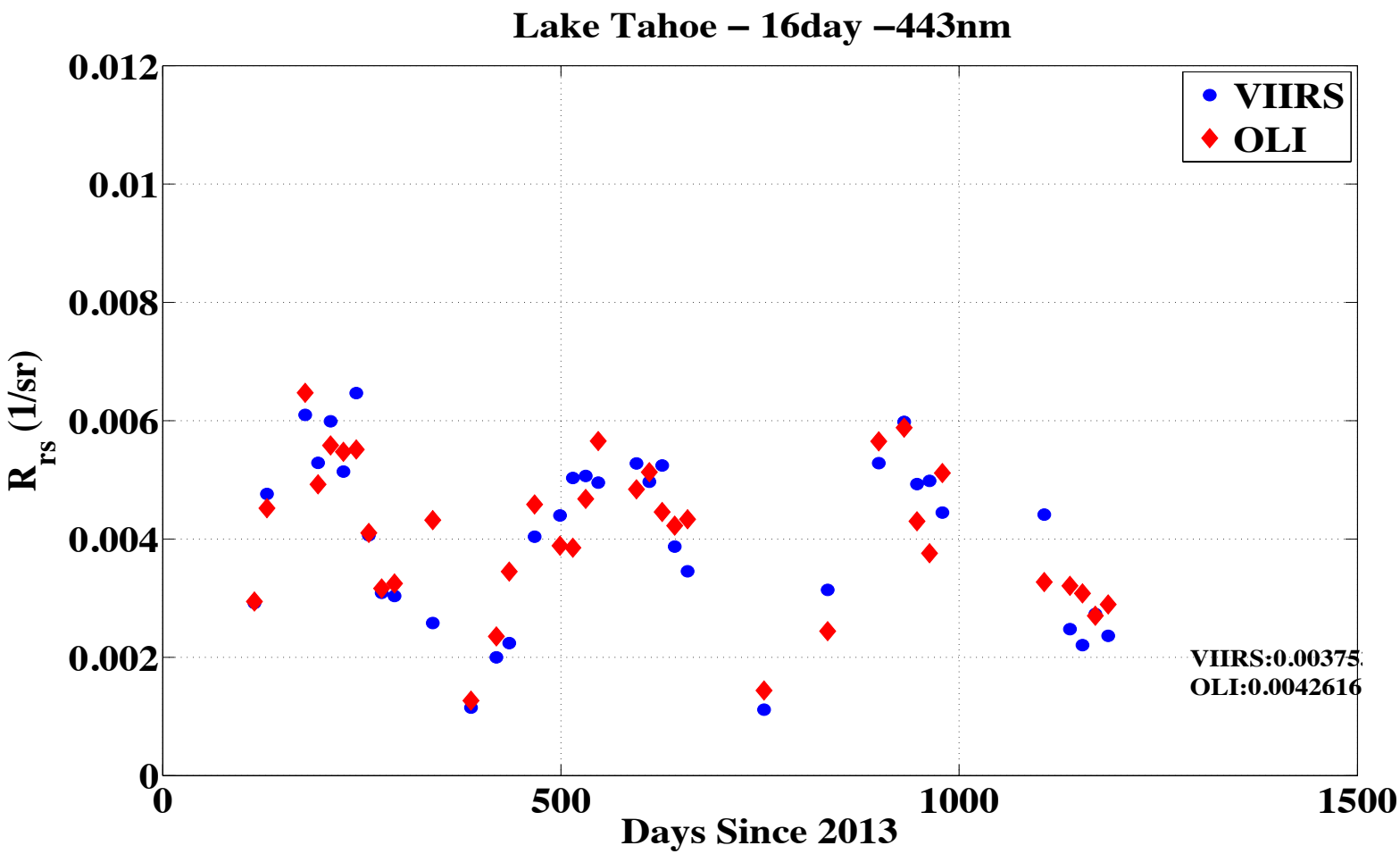
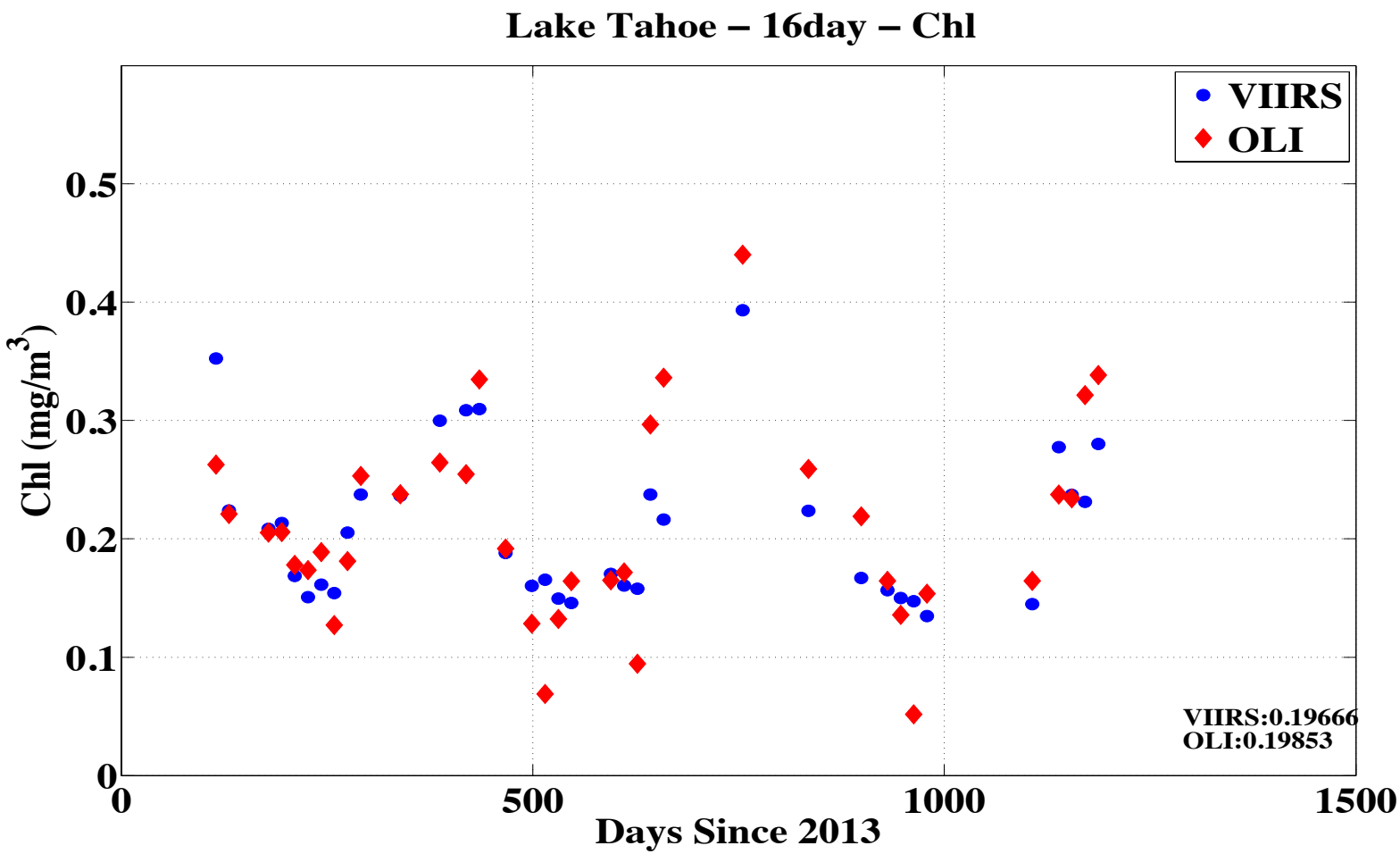


Temporal Trends



Summary & Conclusions

- OLI-derived R_{rs} are consistent with those obtained from MODIS/VIIRS
- < 10% error in R_{rs} (< 600nm) is expected in clear atmospheric conditions using NIR+SWIR bands
- More detail to come in a manuscript to be submitted to RSE **"Towards consistent Aquatic Science Products (ASP) from inland/near-shore waters to open ocean: Intercomparison of OLI, MODIS, and VIIRS Products"**

- Recommendation
  - Provide science/user community with Aquatic Science Products (ASPs) generated via **best-practice atmospheric correction** method implemented in SeaDAS (R_{rs} products as a first step).
  - Notify users about using LSR products for aquatic science/applications

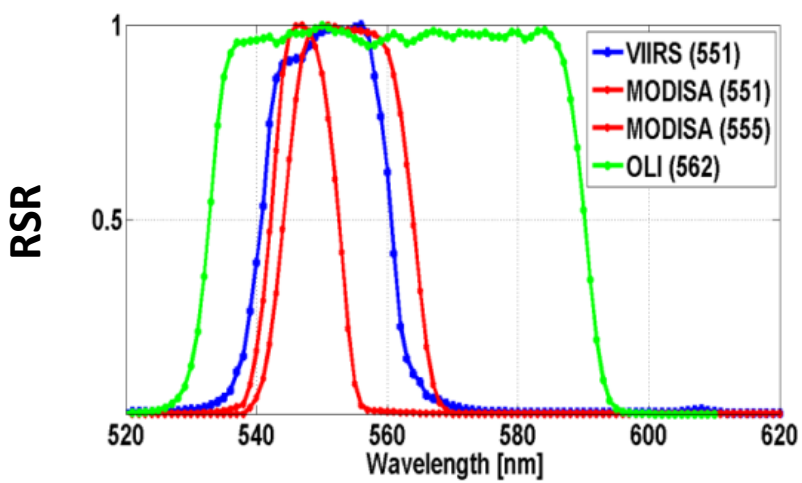
- Ongoing efforts
  - Implementing ACO for Sentinel-2A/B
  - Further validate/monitor OLI performance
  - Improve on atmospheric correction (e.g., modifying aerosol LUTs)

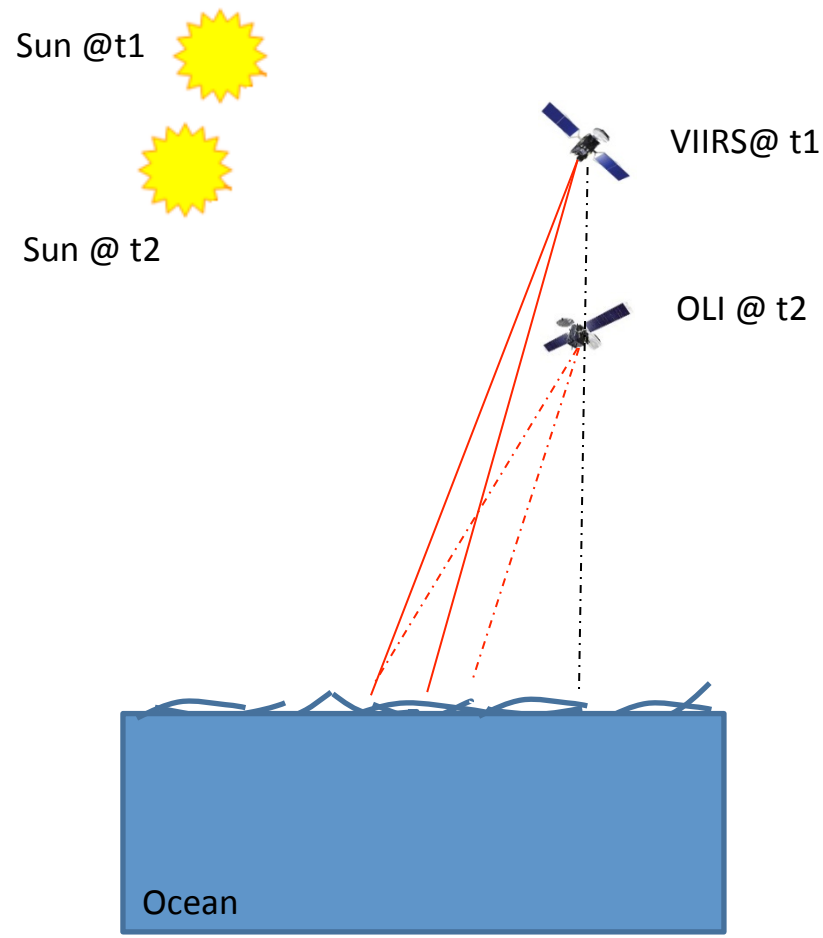
- Other considerations (L10)
  - Help save lives by adding a **620nm (20-25nm) channel** to capture toxic cyanobacteria bloom
  - **Sun glint** at high solar angles is a **major problem**. Couple of degrees tilt (west) can improve applications for mapping coral reefs, seagrass beds, water quality etc. and estimating blue carbon.

Backup

Cross-calibration

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

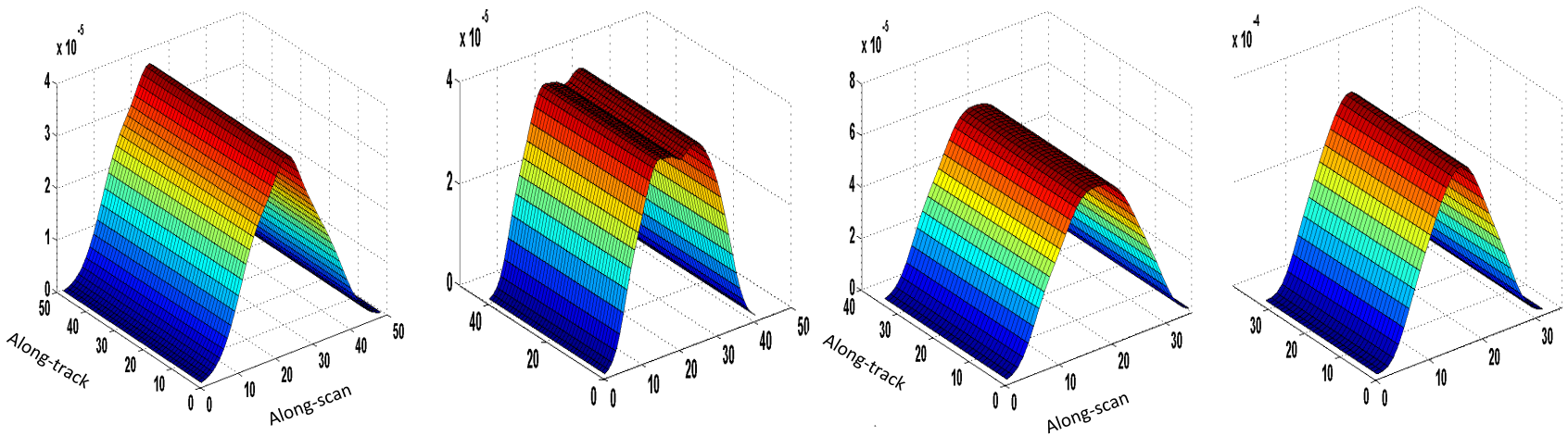




Spatial Sampling

- Nominal GSD
  - MODIS @ 1km
  - VIIRS @ 750m
  - OLI @ 30m

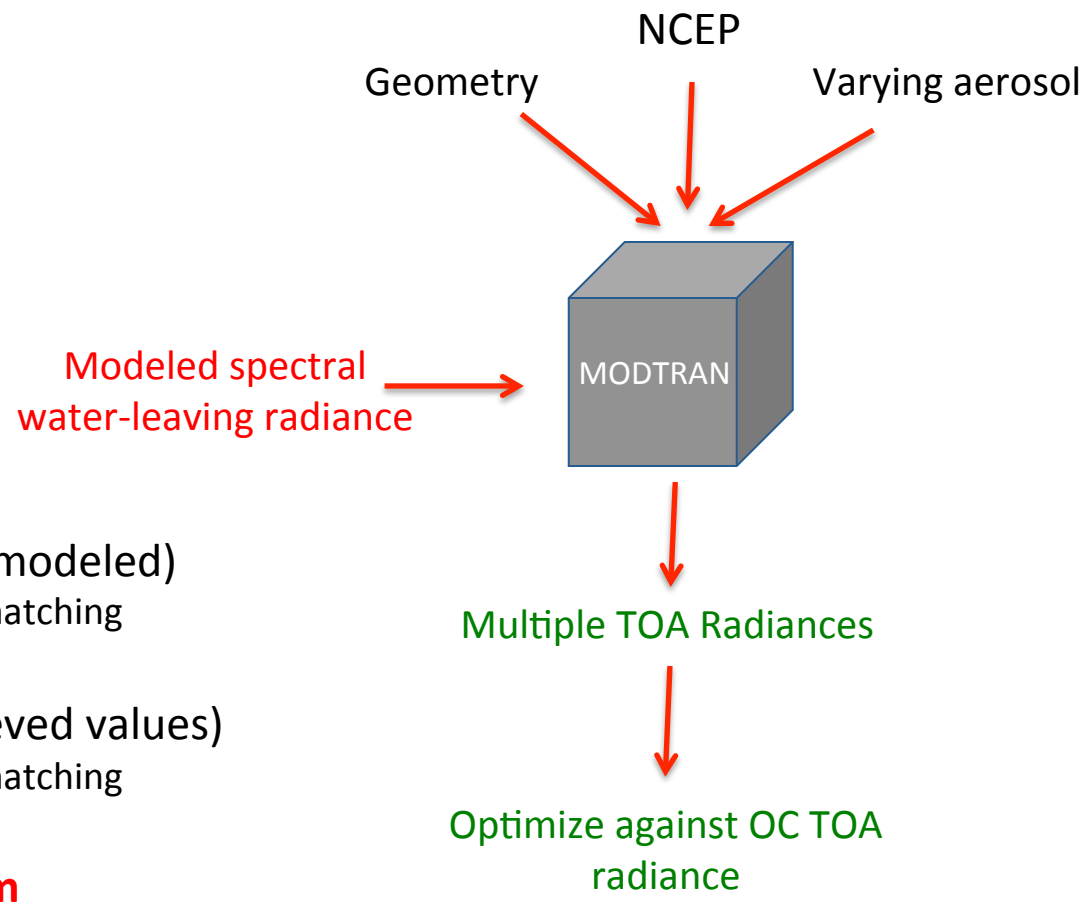
- MODIS and VIIRS pixels are averaged over 3km x 3km areas
- Spatially sample OLI scenes with MODIS/VIIRS PSFs and the corresponding azimuth angles



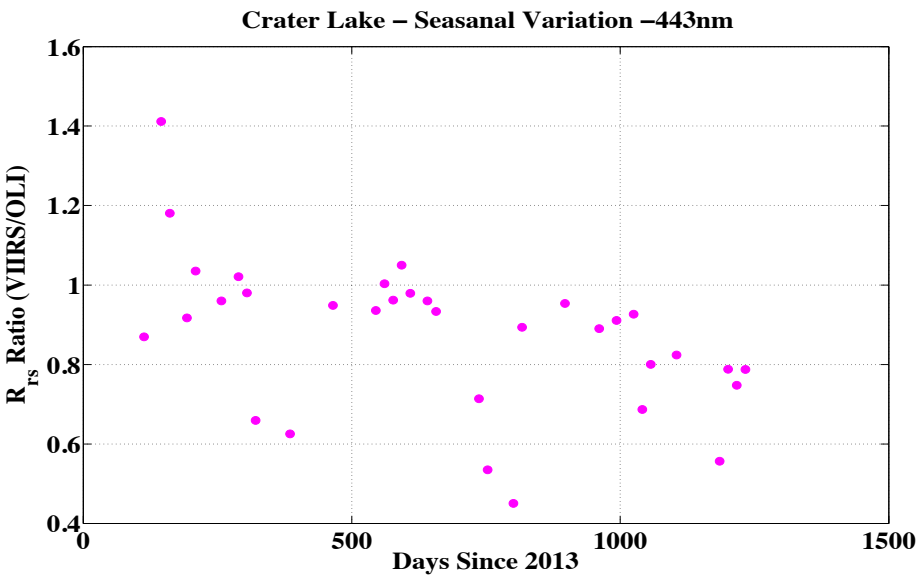
MODIS VIIRS 3Agg VIIRS 2Agg VIIRS 1Agg

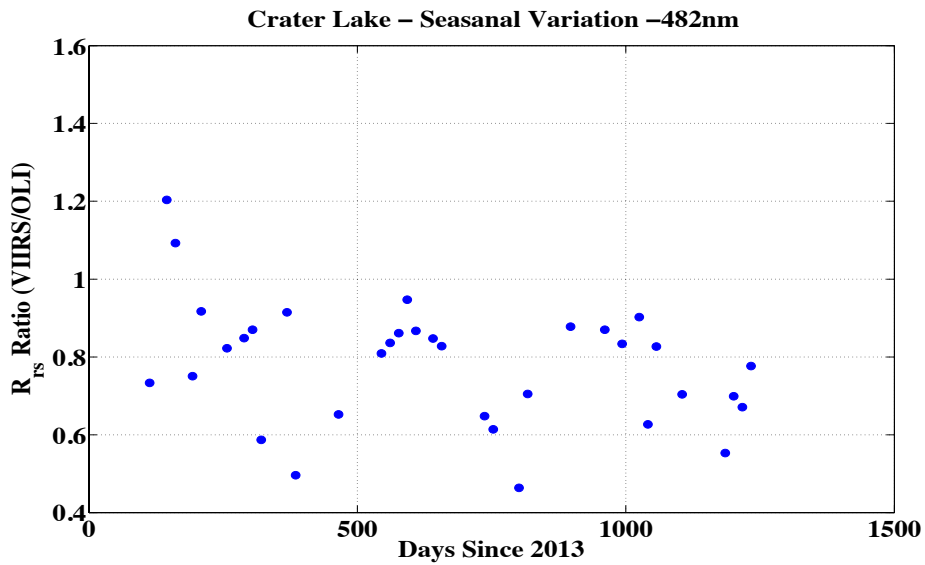
Differences in Spectral Samplings (SBAF)

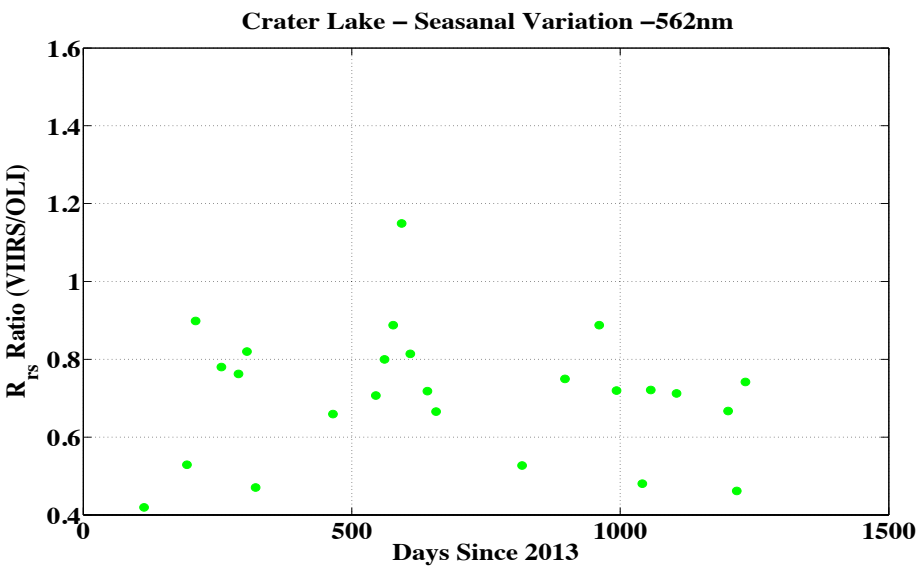
- Forward RT simulations
  - Imaging geometries
    - Orbit Altitude
    - Relative azimuth angle
  - NCEP Data
    - Water vapor
    - O3
    - Wind speed (Cox-Monk BRDF)
  - Input water-leaving radiance (modeled)
    - Find the best fit by "spectral" matching
  - Vary aerosol (+/- 20% of retrieved values)
    - Find the best fit by "spectral" matching
  - Convolve with RSRs at **0.001nm**

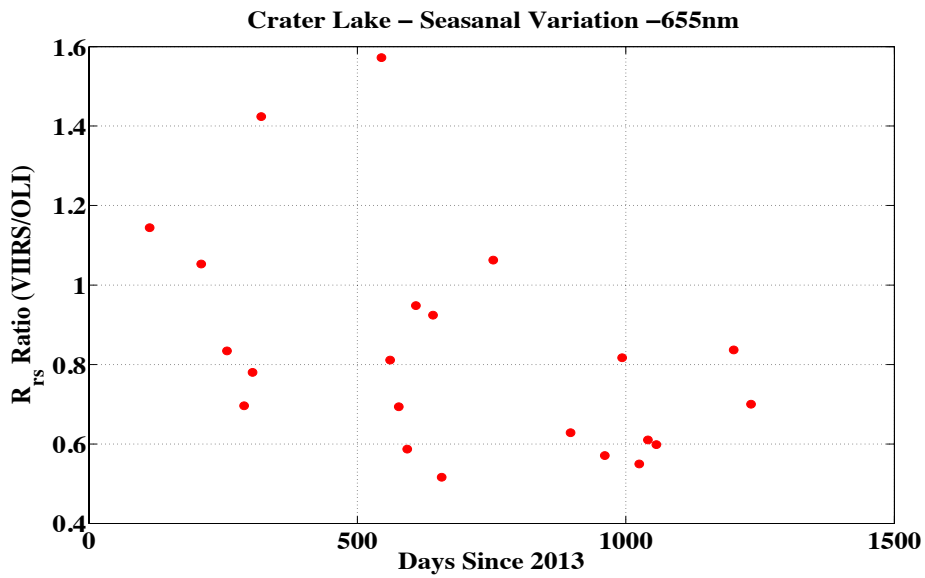


Signal-dependent changes @ Level 2?

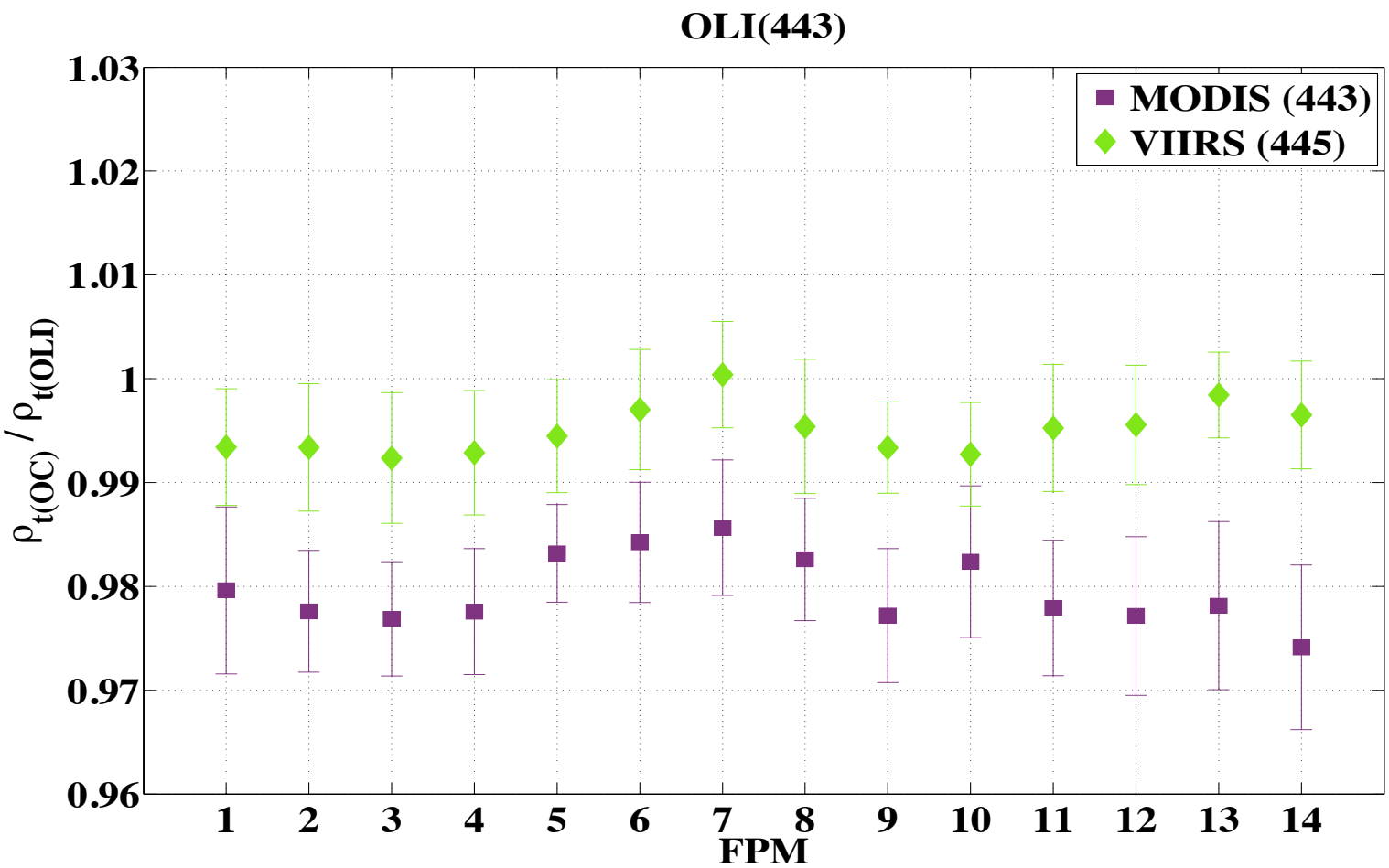








Three-year Average Ratio at TOA



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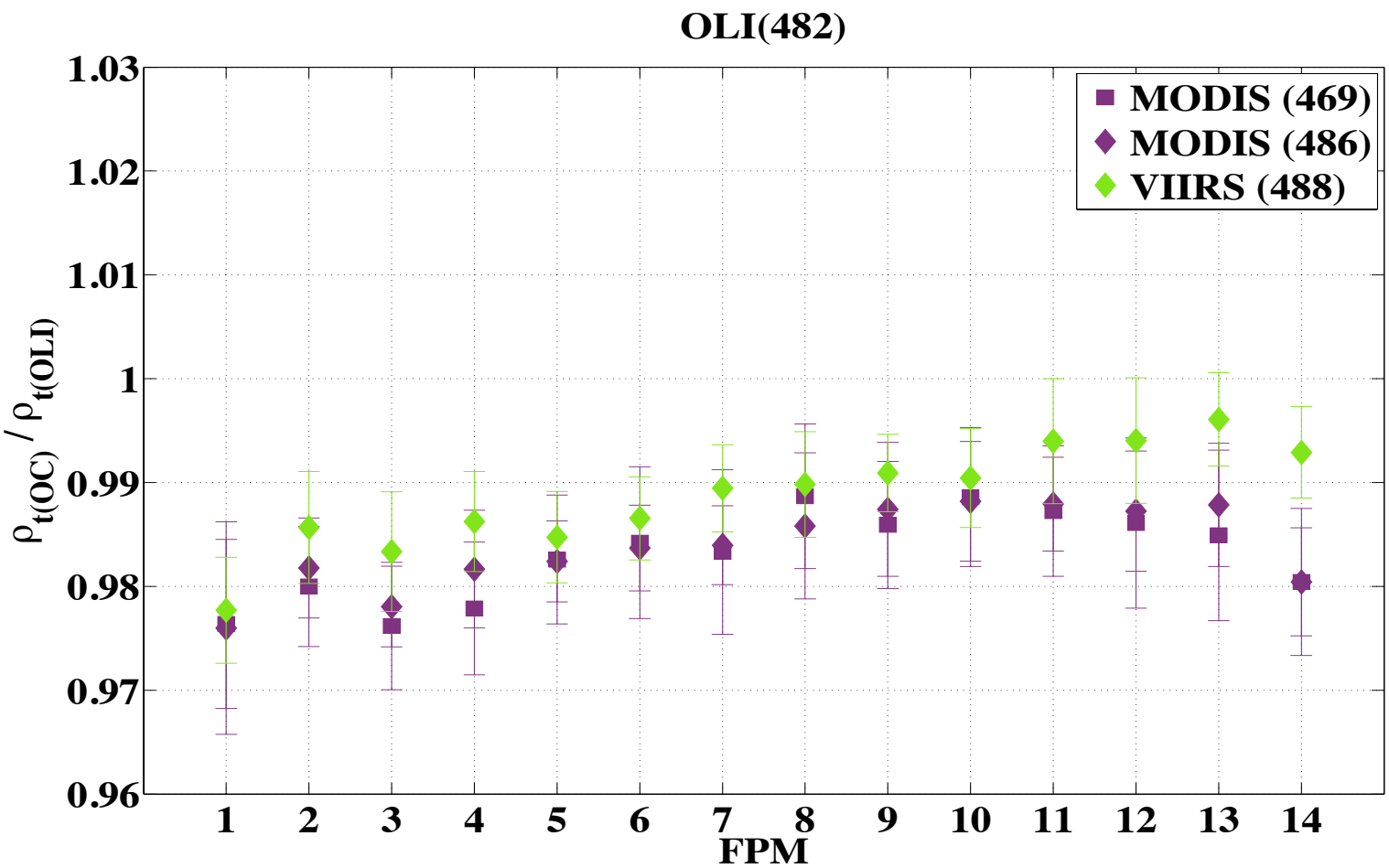

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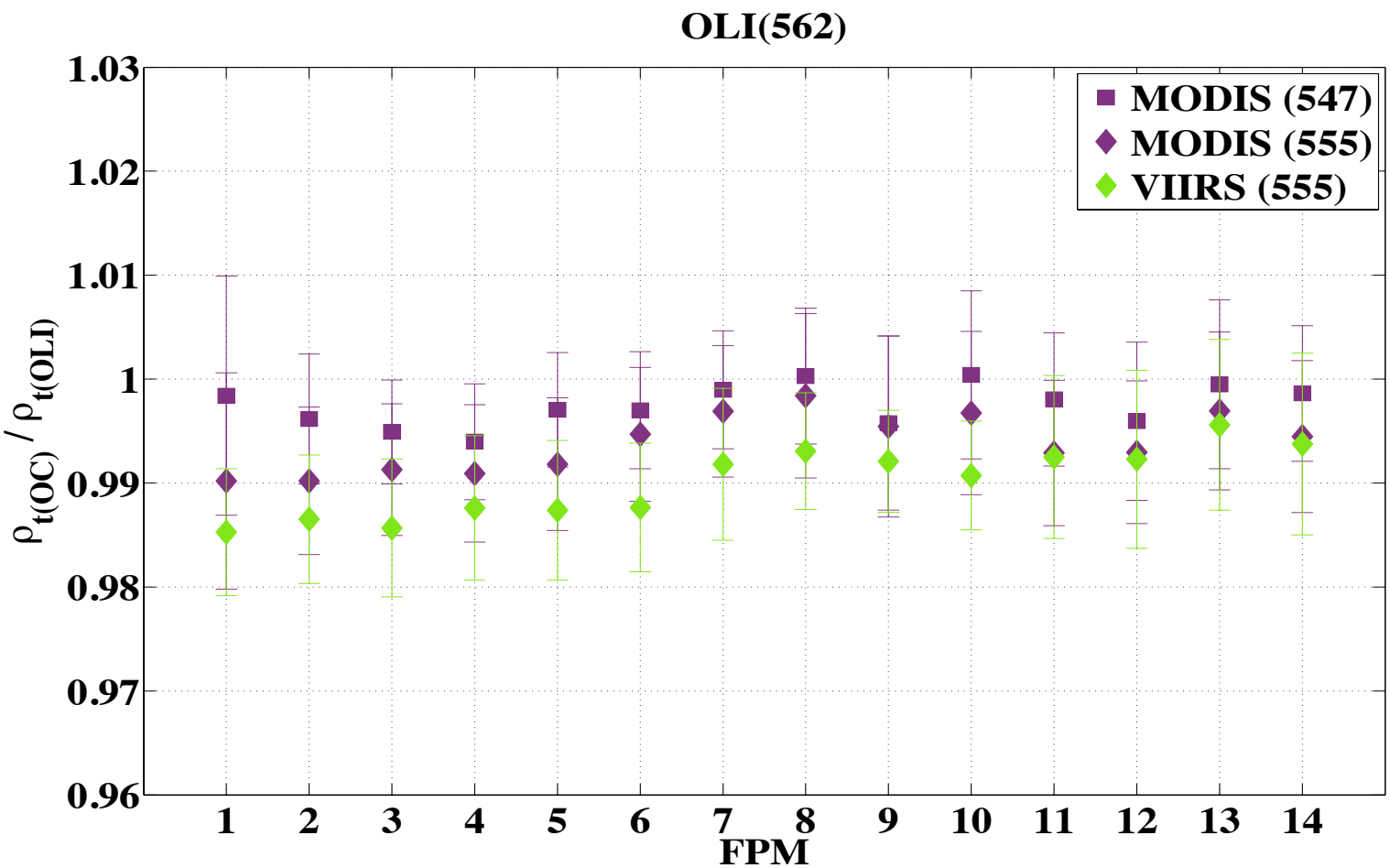

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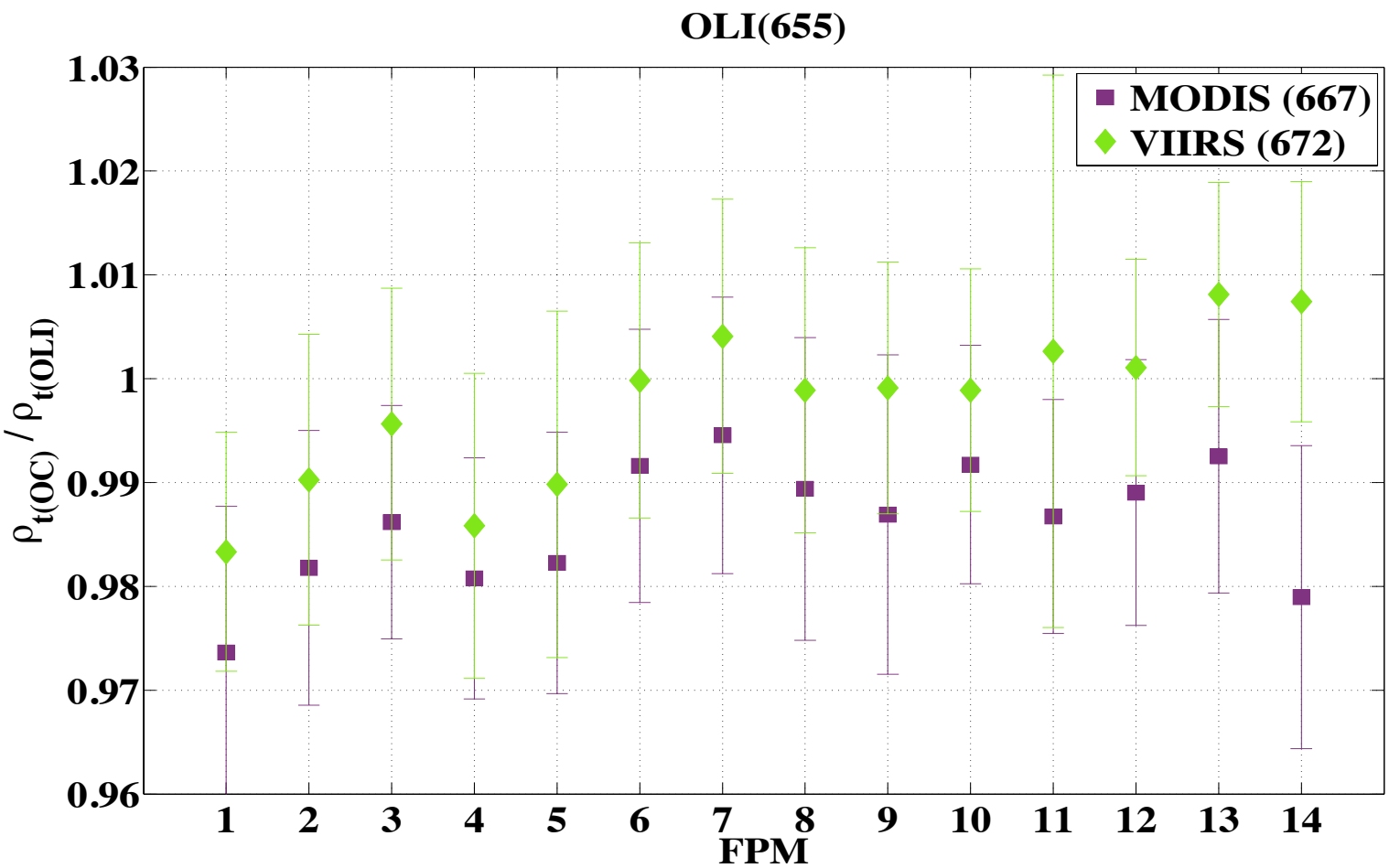

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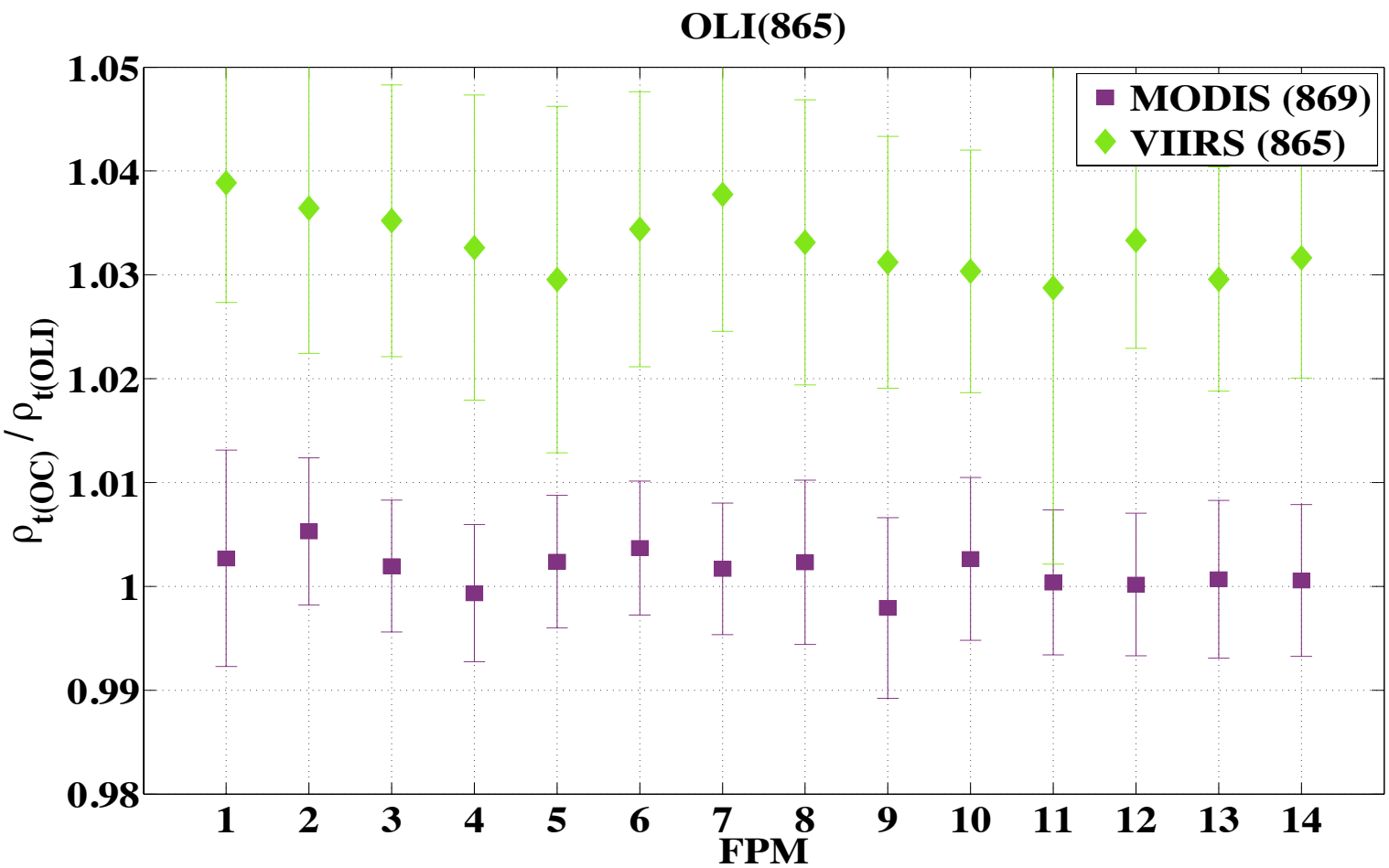
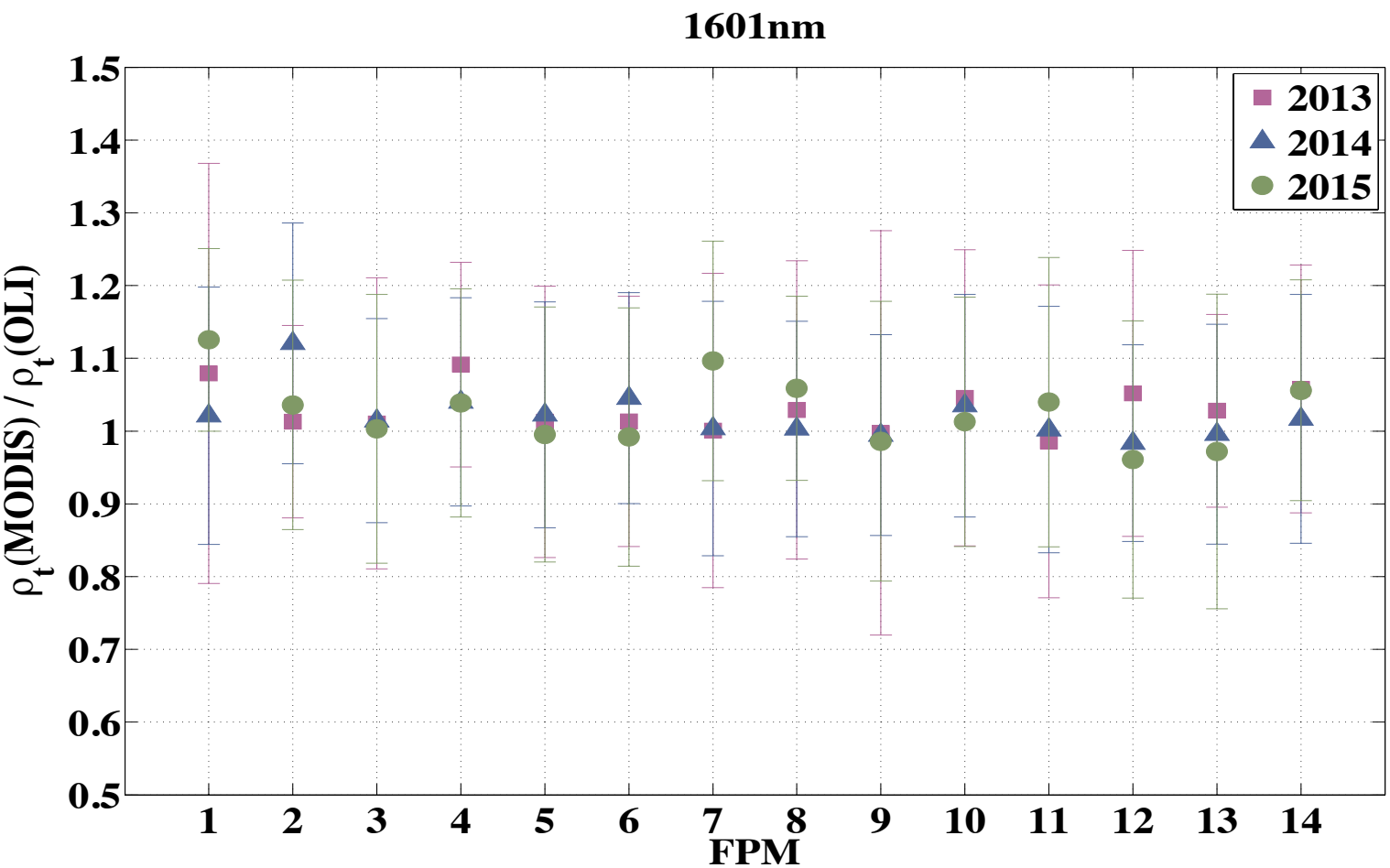
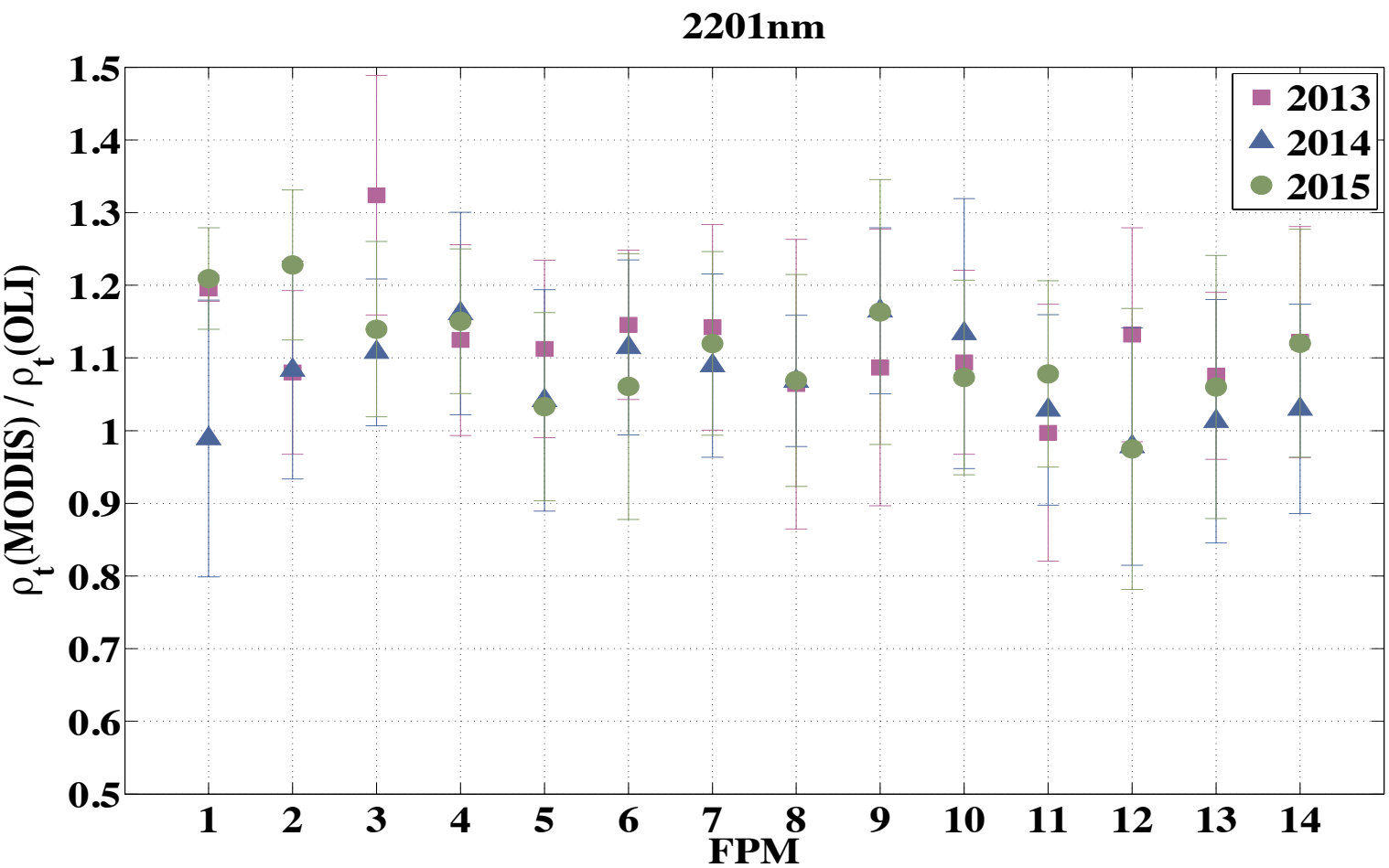


Average Ratio at TOA



Average Difference at TOA



Vicarious Calibration

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

USGS

NASA