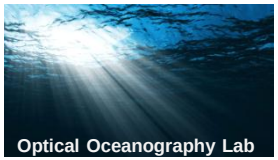
Investigating Consistency between VIIRS and MODIS over the Oceans: The Sensor/Environmental Data Records



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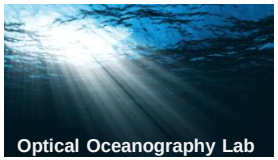
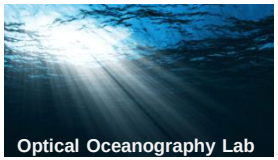
93rd Annual AMS Meeting
Ninth Annual Symposium on Future Operational Environmental Satellite Systems
Austin, TX

Outline

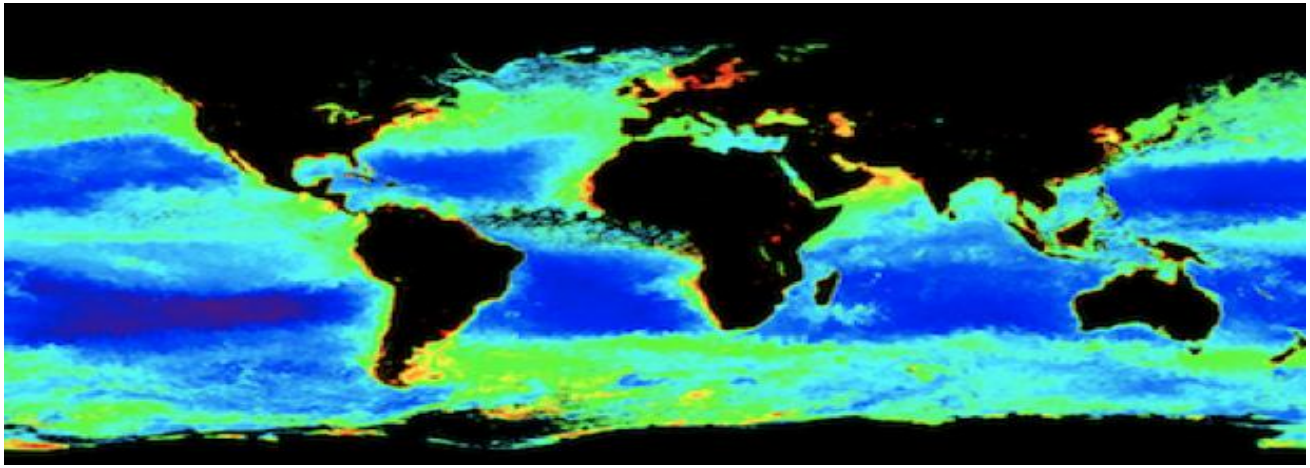


- Introduction
  - NPP Mission
  - Ocean color remote sensing
  - Inter-sensor cross-validation
- Objectives
- Background
- Approach
  - Overview
  - TOA comparison
- Results
  - SDR trends
  - EDR trends
  - Spatial variability
  - Chlorophyll-a products
- Conclusions

NPP Mission



- The Suomi National Polar-orbiting Partnership (Suomi-NPP) is a sun-synchronous satellites carrying five different instruments, one of which is the Visible Infrared Imaging Radiometer Suite (VIIRS).
- One of the VIIRS primary missions is the continuity in providing the science community with the global Environmental Data Records (EDRs) over oceanic waters to assess
  - Climatology
  - Global warming
  - Net Primary Production (NPP)



NASA, GSFC- OBPG

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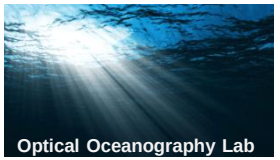
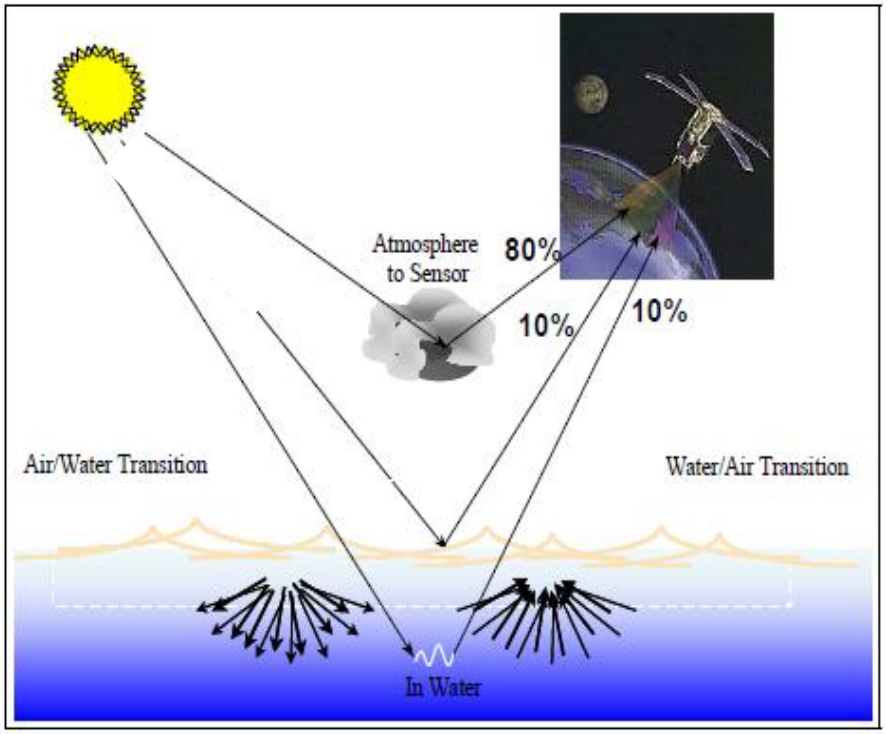
Ocean Color Remote Sensing



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

- Science-quality ocean color products requires rigorous monitoring of the performance of
  - The sensor (SDR)
  - The retrieval algorithms (EDR)



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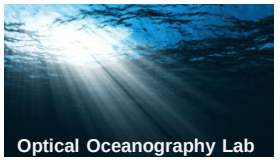
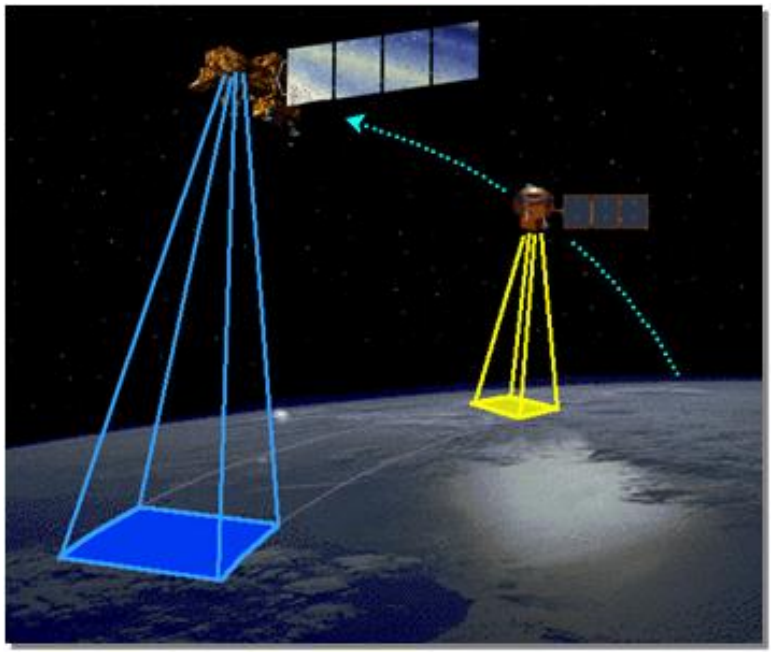
Inter-sensor Cross-validation



- NPP and Aqua are parts of the Afternoon-Train (A-Train) constellation

- Advantages
  - Quick post-launch assessment
  - Inexpensive
  - Complements other calibration activities (OC cal/val, NASA (OBPG), SDR Team)



- Aqua-MODIS
  - well-characterized over the oceans
  - Relatively stable performance

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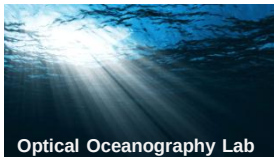
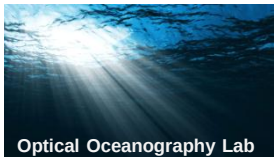
Objectives



- Cross-validate VIIRS products with the heritage Aqua-MODIS sensor for March-November 2012
  - Top-of-atmosphere Radiance
  - Surface/In-water products (IDPS)
    - Absorption (Abs) and Backscattering (Sct)
    - Chlorophyll-a (CHL)

❖ Note that MODIS OC products are derived from NRL processing system

Background: Ocean Color Properties

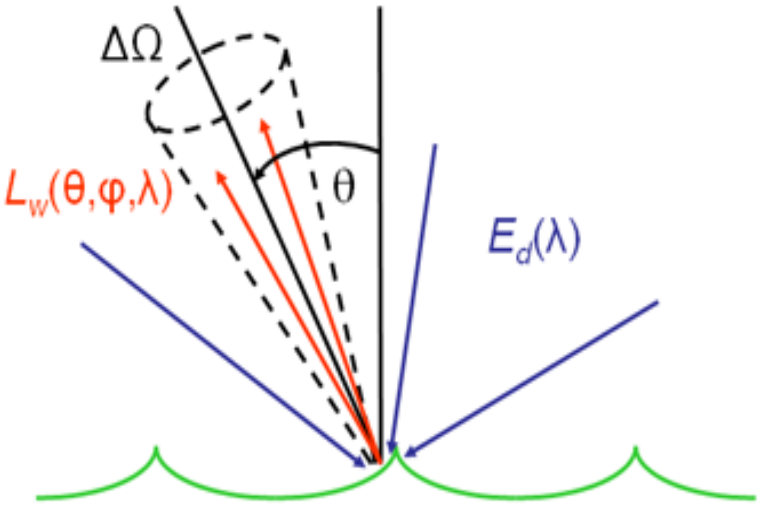


- Top-of-atmosphere (TOA) ⟶ Remote sensing reflectance (R_{rs})

- Inverse modeling

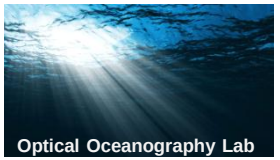
$$R_{rs} = \frac{L_w(\theta, \varphi, \lambda)}{E_d(\lambda)} \propto \frac{b_b}{a + b_b}$$

  - Inherent Optical Properties (IOPs)
    - ✓ Absorption, a
    - ✓ Backscattering, b_b



- CHL and particle properties can be estimated from the IOPs

Approach: Schematic Overview



VIIRS

MODIS

Common areas over the Indian Ocean, South Atlantic, North Pacific, etc.

Masking

Cloud/atmosphere

Local variability

Near-nadir areas

Ratio 1.24 μm bands

Difference in scan angles ($< 5^{\circ}$)

ONLY near-nadir

VIIRS

MODIS

Percent Difference (PD) = 100*(VIIRS- MODIS) /MODIS

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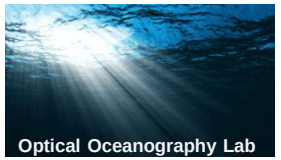
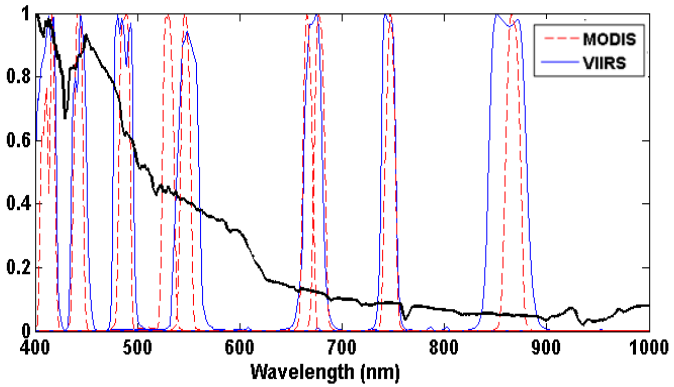
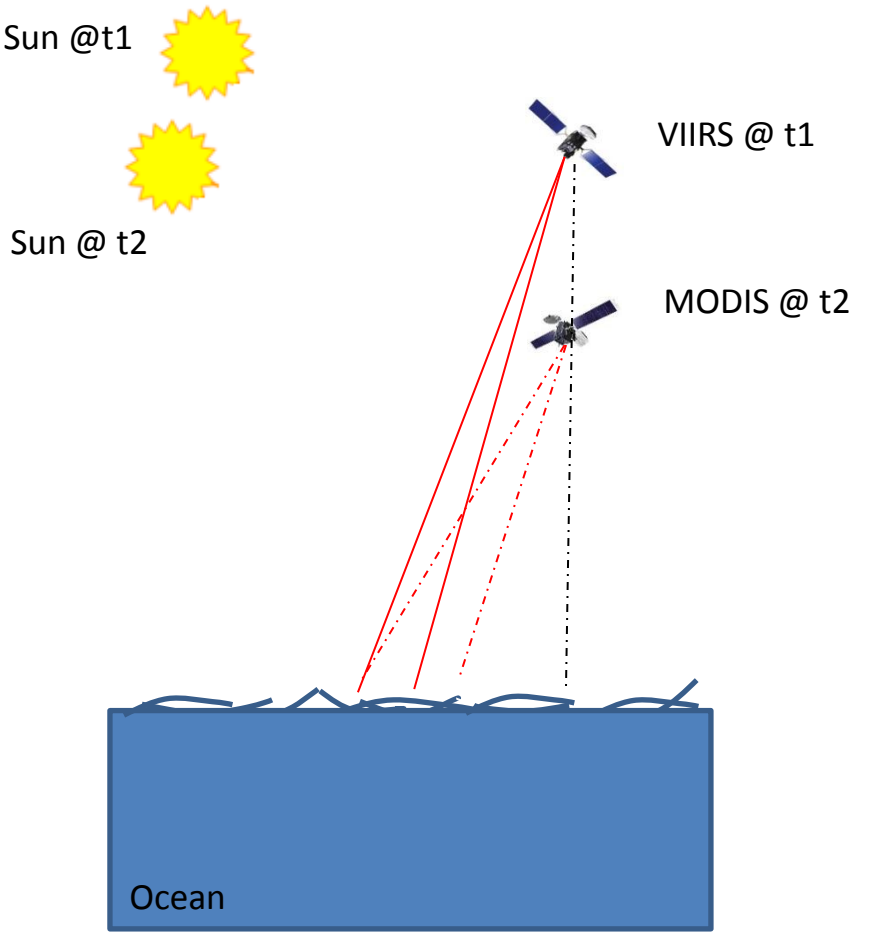
Approach: TOA Comparisons



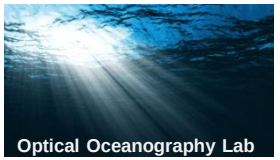
- Inherent differences in…
  - The overpass times (t1-t2 < 15min)
  - The imaging geometry
  - The instruments

  are simulated (forward modeling)

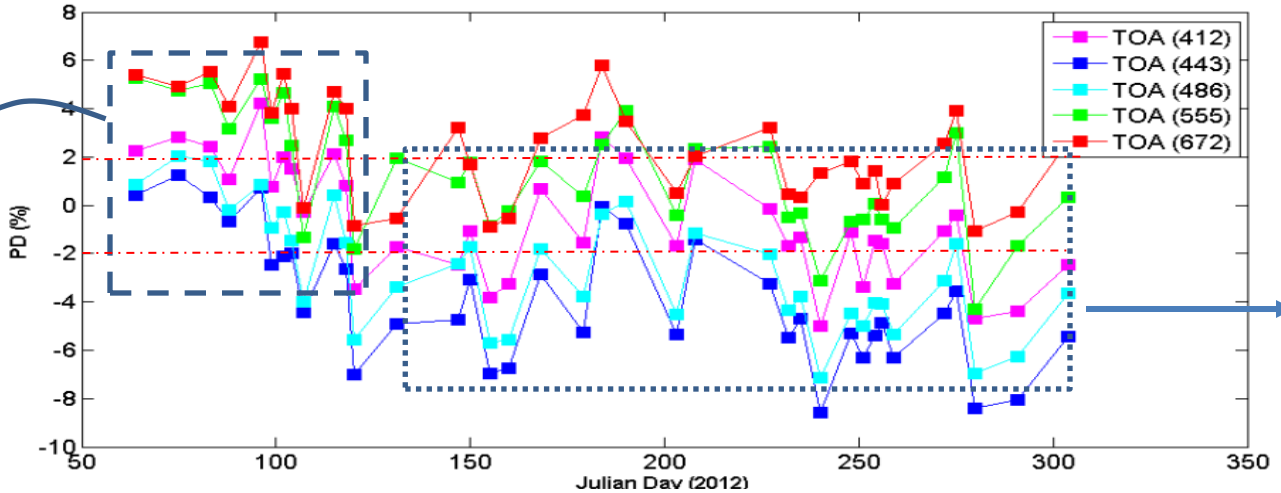




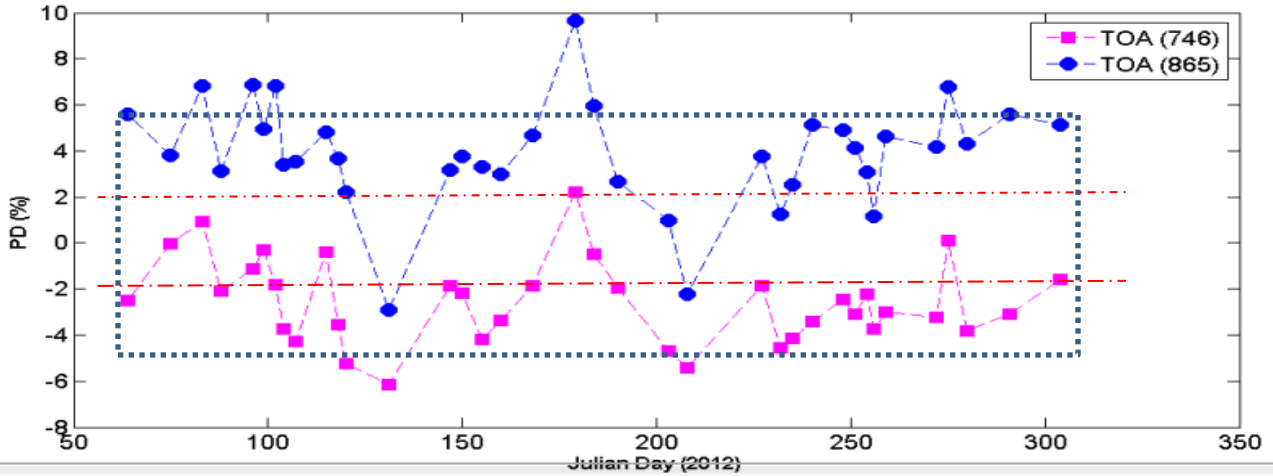
Results: SDR Trends



VIIRS > MODIS for DOY<120



VIIRS < MODIS for DOY>120



The red dashed lines indicate margins

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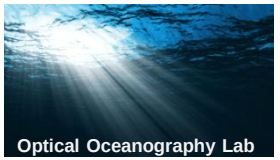
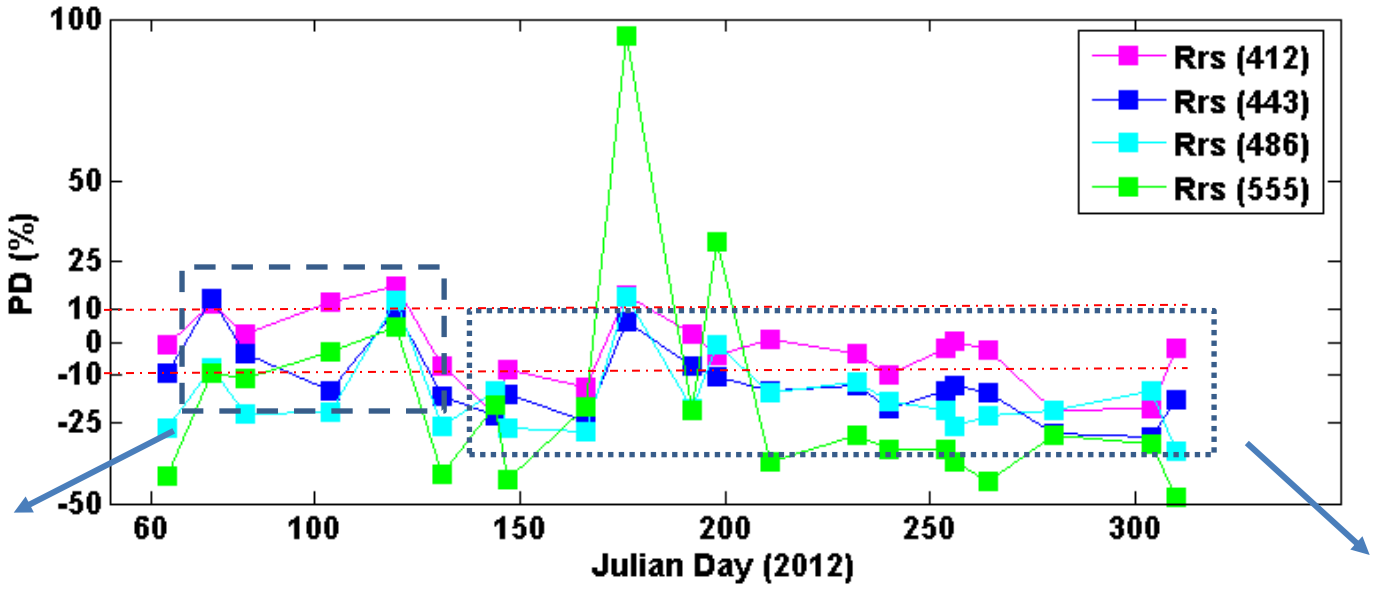
Results: EDR Trends (Rrs)



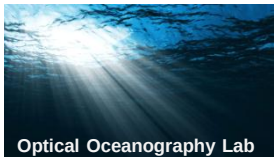
- Consistent with the SDR trends



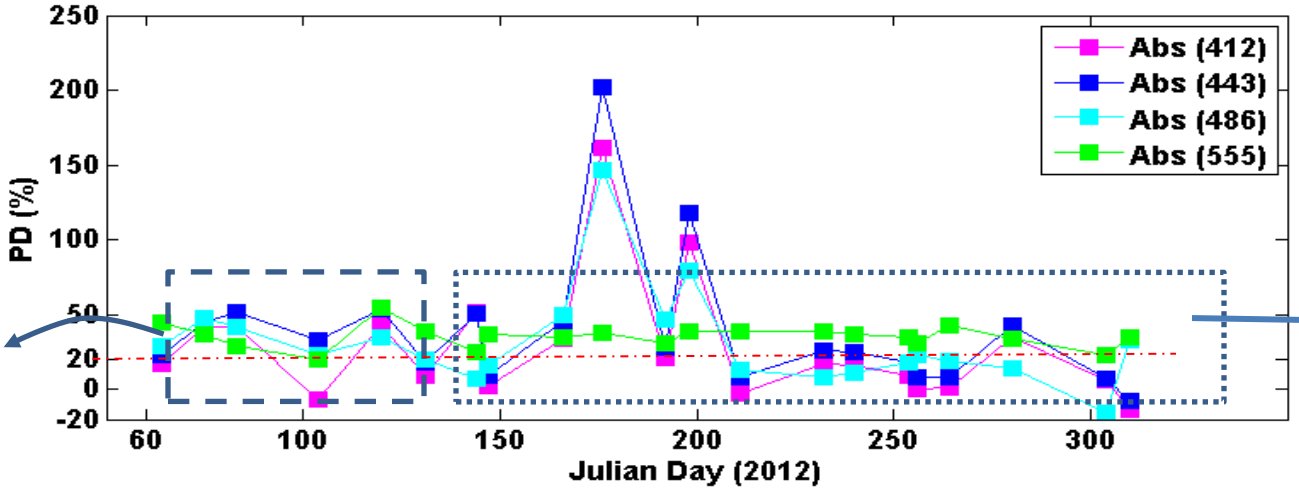
DOY<120

DOY> 120

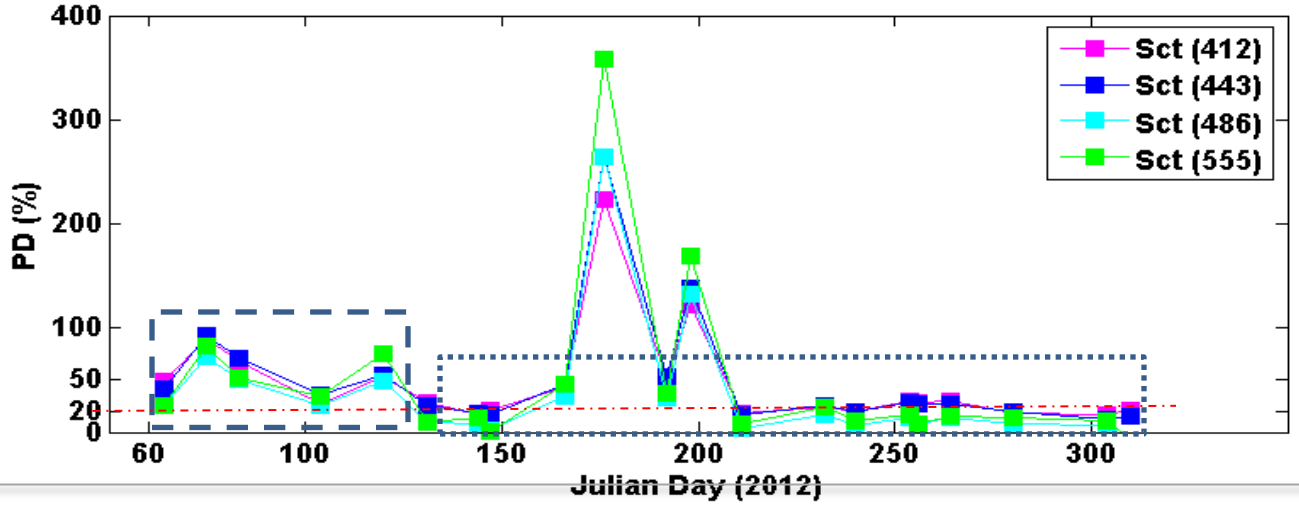
Results: EDR Trends (IOPs)



DOY<120



DOY> 120



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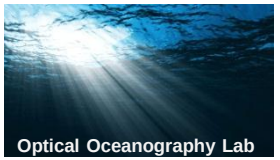
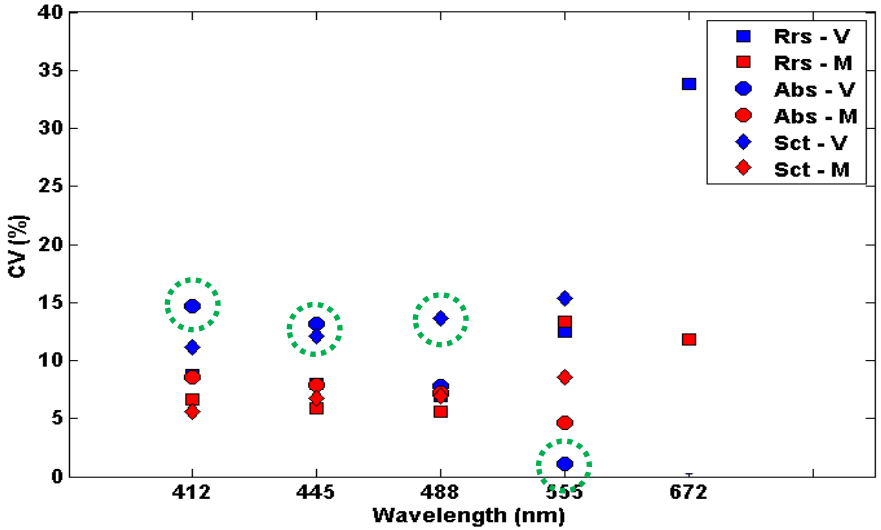
Spatial Variability in Rrs/IOPs: VIIRS Vs. MODIS



- Analyze striping and banding effects
  - The coefficient of variation (CV) was computed for all the areas utilized in the study
  - Some spatial variability is expected due to the nature of oceanic waters



  - Rrs are consistent except for M5, i.e., Rrs(672)

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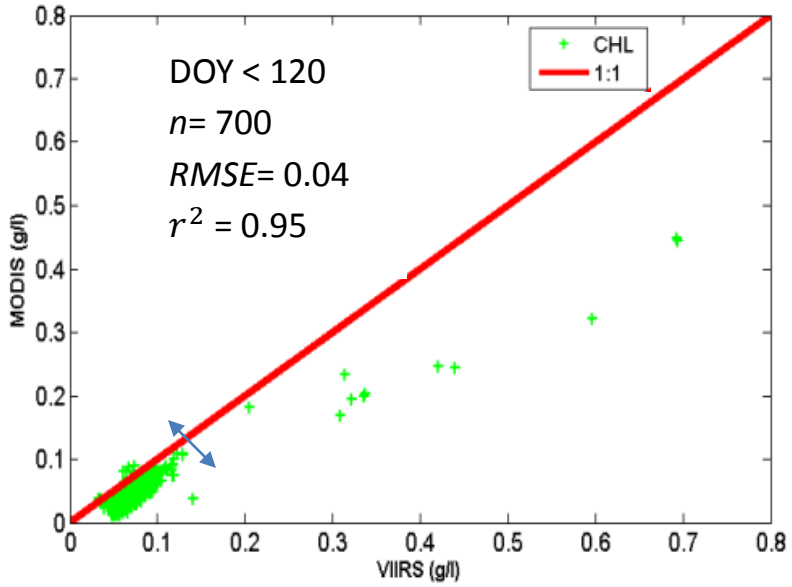
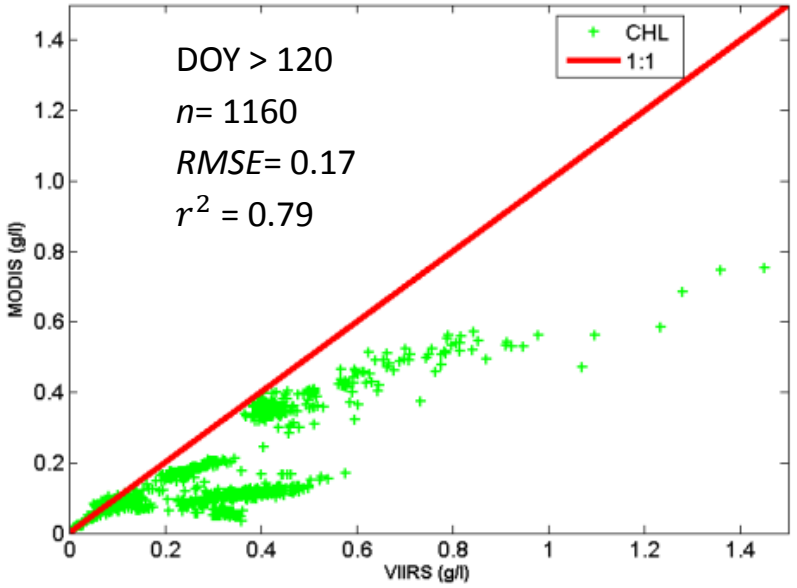
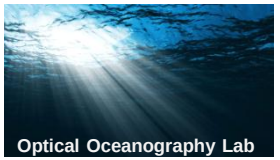
CHL Products

- The CHL products are relatively in a good agreement during DOY <120, although there is a bias in that obtained from VIIRS
- The CHL products for DOY>120 were found inconsistent



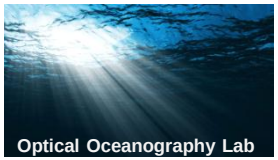


Sources of Uncertainties



- SDR Trends
  - Forward atmospheric simulations
    - Upper-air atmosphere
    - Aerosols
  - Inconsistencies in the atmospheric conditions
  - Differences in the pathlengths
- EDR Trends
  - Differences in the IOP retrieval algorithms. ~10% - 15% disparity is expected

Conclusions



- SDR
  - Assuming stable performance of MODIS
    - Spectral-dependent variations in the VIIRS radiometric response (visible)
    - The trends in the NIR exhibit weak correlation with those in the visible

- EDR
  - Temporal patterns in the SDR is also seen in the R_{rs} and the *Sct* products
  - The VIIRS-derived spatial variability is different from that of MODIS due to
    - The differences in the algorithms
    - The striping and banding effects
  - VIIRS-derived CHL products are relatively consistent with those from MODIS for DOY<120. The CHL products from VIIRS are overestimated for DOY>120 because of
    - The low responses of the VIIRS blue/green bands

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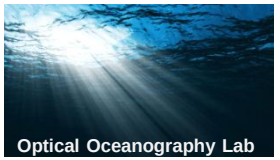

- NRL-Stennis
- Ocean color cal/val Team
- NOAA-STAR

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