Dependence of satellite ocean color data products on viewing angles: A comparison between SeaWiFS, MODIS, and VIIRS

Brian B Barnes and Chuanmin Hu

Optical Oceanography Lab, College of Marine Science, University of South Florida, 140 7th Avenue South, St Petersburg, Florida, 33701, USA

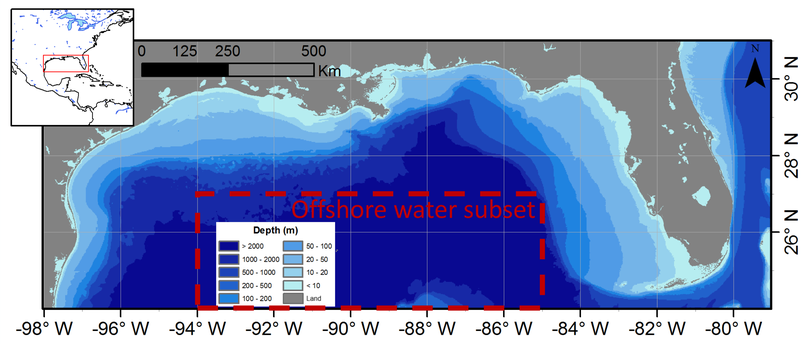
bbarnes4@mail.usf.edu, huc@usf.edu, www.optics.marine.usf.edu

Introduction & Objective

Satellite-derived radiance and geophysical products may show errors according to sensor viewing geometry, causing variable uncertainties in derived time series as well as regional or global means. Angular dependence assessment is also necessary to inform future geostationary satellite design. Furthermore, assessment of continuity between various satellites is critical for production of continuous, multi-decadal datasets.

The objective of this study was to assess angular dependence of SeaWiFS, MODIS, and VIIRS using single- and merged-sensor datasets.

Study Area



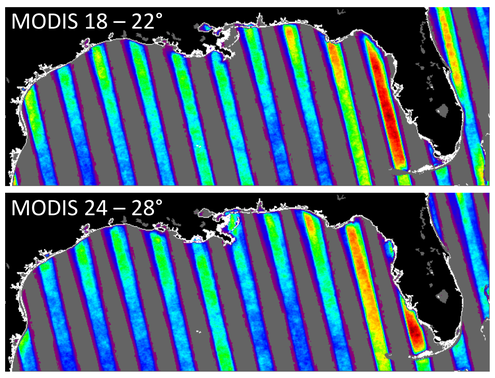
Method

1. Download SeaWiFS (1997 – 2010), MODISA (2002 – 2014), and VIIRS (2012 – 2014) Level-2 HDFs covering study area from NASA GSFC
2. Map reflectance (R_{rs}), chlorophyll (CHL_{OCI} [1] and CHL_{OCx} [2]), water attenuation (K_d_lee [3]), QAA IOPs (a_t and b_b [4]), and sensor zenith (SZA) products to Level-3 at 1km resolution. Rescale green band R_{rs} to 555nm.
3. Remove questionable data, 3x3 median filter, subsample to 3km resolution
4. Subset Low Chla ($CHL_{OCI} \leq 0.25$ mg m^{-3}) and High Chla ($CHL_{OCI} > 0.25$ mg m^{-3})
5. Calculate regional means according to sensor zenith
6. Find cross-sensor matchups (collocated data measured within 1 hour)
7. Assess angular dependence using: variation in

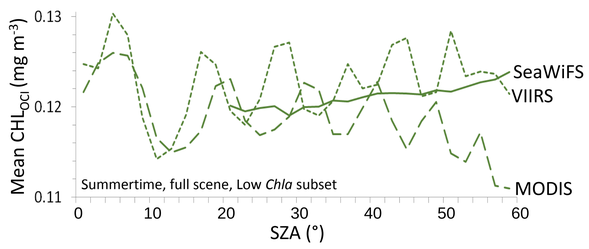
   UPD = Unbiased Percent Difference = $1/N \sum 200 * |(y_i - x_i)| / (y_i + x_i)$

   MRD = Mean Relative Difference = $1/N \sum 100 * (y_i - x_i) / x_i$

Geographic component to angular dependence

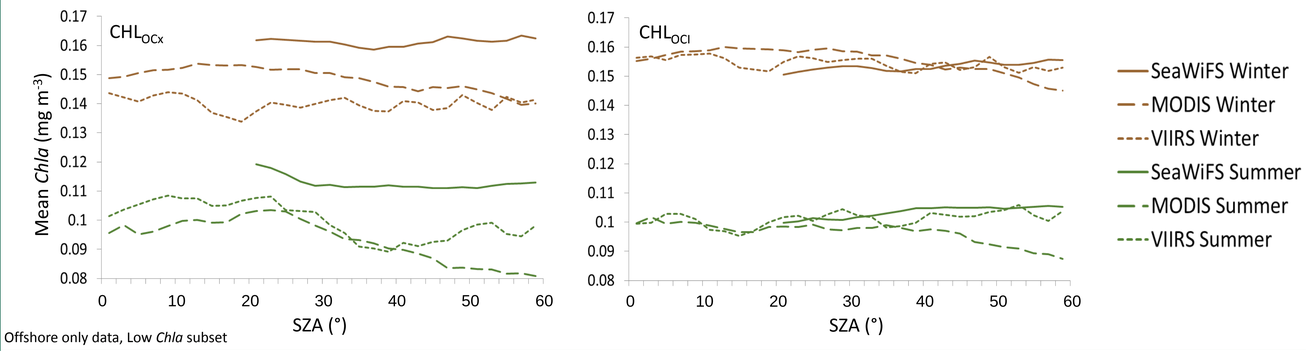


For MODIS & VIIRS, most locations viewed from only ~6 SZAs. In this region, due to orientation of Florida, this causes oscillations in means according to sensor zenith



Single sensor trends according to SZA - *Chla*

Compared to CHL_{OCx} and $R_{rs}(\lambda)$, CHL_{OCI} shows great agreement between sensors and little angular dependence



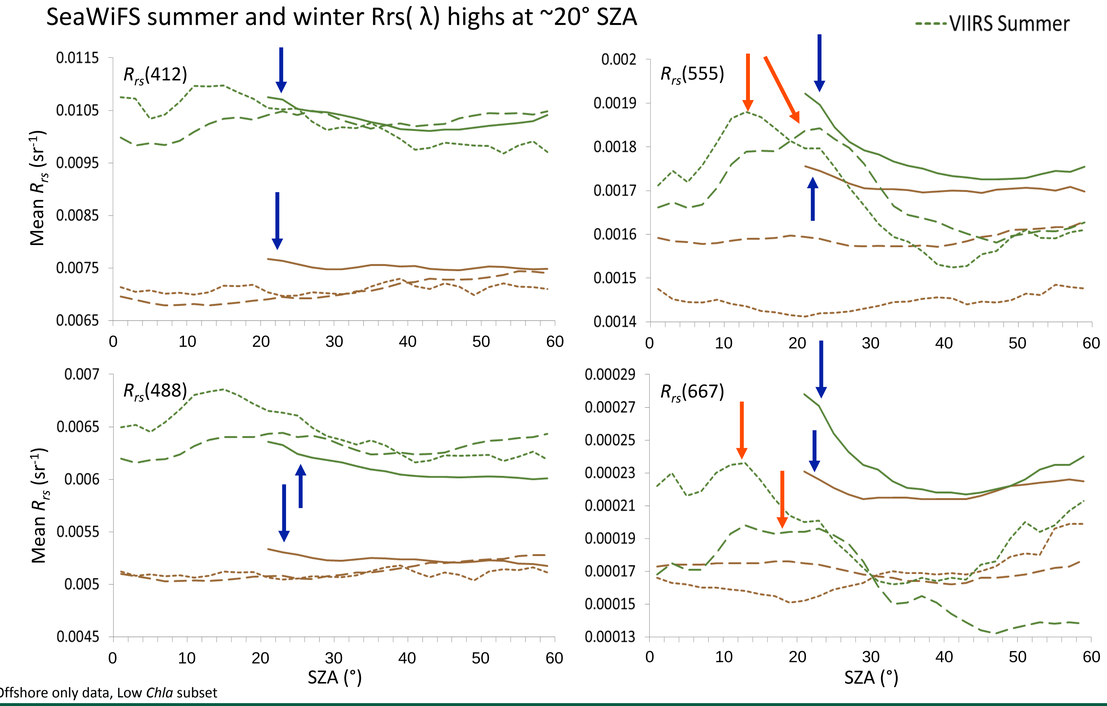
Offshore only data, Low *Chla* subset

Single sensor trends according to SZA - R_{rs}

- Using offshore waters removes geographic component to SZA dependence
- Angular dependence still seen for all sensors, variable by product and season
- Potential sun glint effects

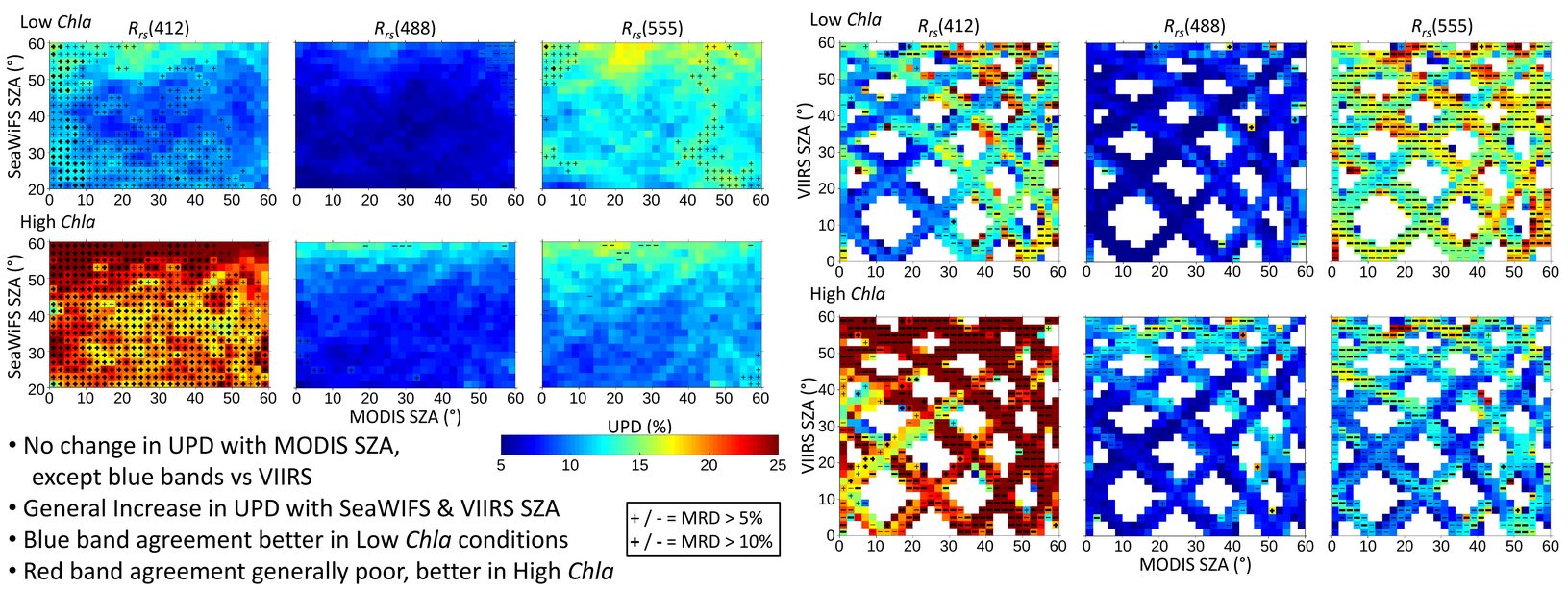
  MODIS & VIIRS summertime-only peaks in $R_{rs}(555)$ and $R_{rs}(667)$ at ~20° SZA
- Potential residual BRDF uncertainties

  SeaWiFS summer and winter Rrs(λ) highs at ~20° SZA



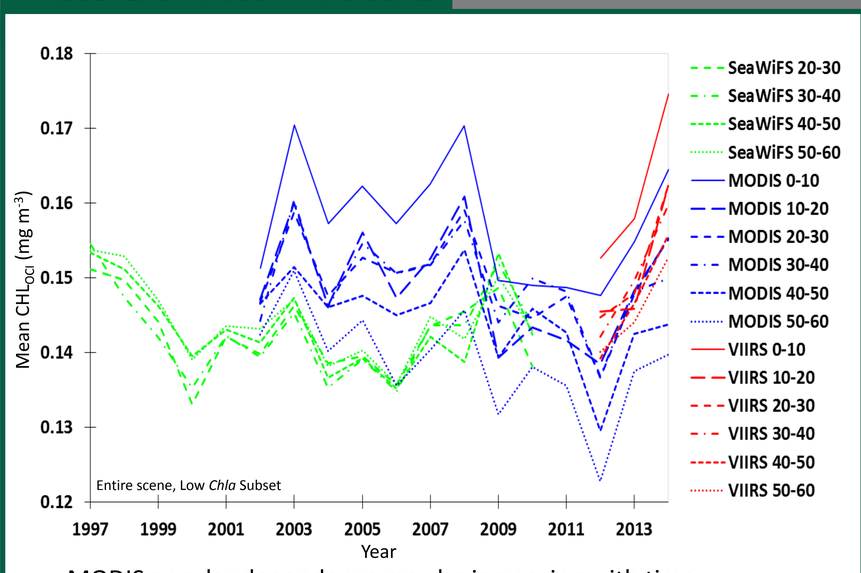
Offshore only data, Low *Chla* subset

Cross-Sensor Agreement - R_{rs}



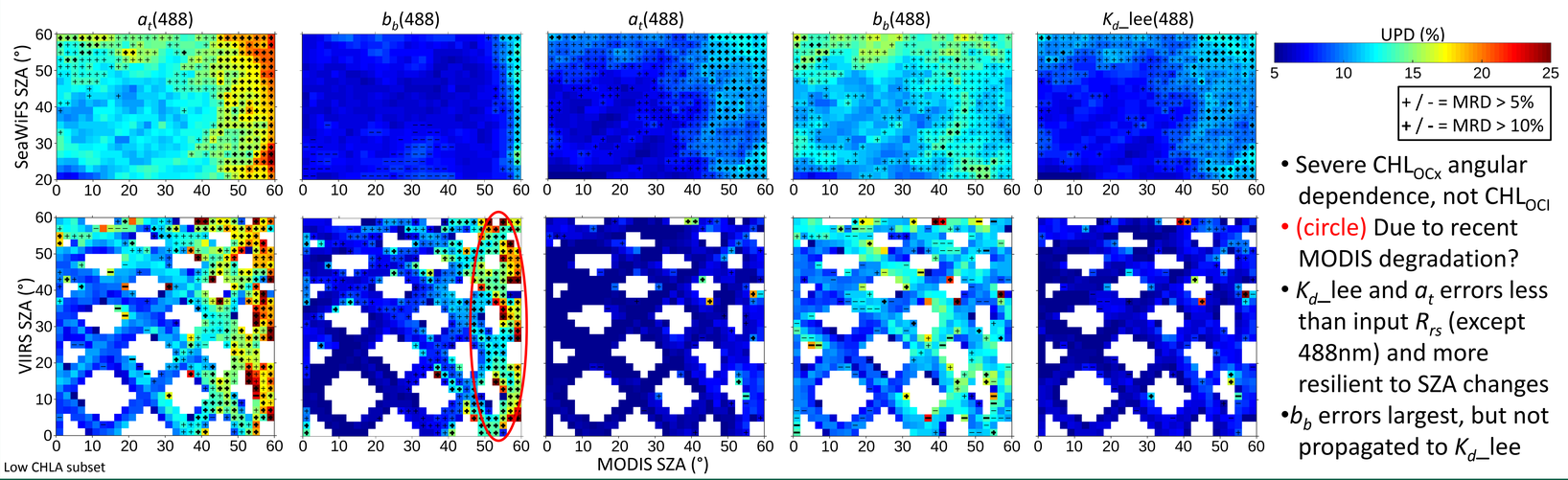
- No change in UPD with MODIS SZA, except blue bands vs VIIRS
- General Increase in UPD with SeaWIFS & VIIRS SZA
- Blue band agreement better in Low *Chla* conditions
- Red band agreement generally poor, better in High *Chla*

Time Series of angular dependence



MODIS angular dependence may be increasing with time

Cross-Sensor Agreement – *Chla*, QAA, & K_d_lee



- Severe CHL_{OCx} angular dependence, not CHL_{OCI}
- (circle) Due to recent MODIS degradation?
- K_d_lee and a_t errors less than input R_{rs} (except 488nm) and more resilient to SZA changes
- b_b errors largest, but not propagated to K_d_lee

Summary & Conclusions

- Angular dependence observed for all sensors
  - Potentially due to sun glint (MODIS & VIIRS) and BRDF (SeaWiFS)
- Impressive overall continuity for R_{rs}, with UPD generally < 10%
- MRD for R_{rs} generally < 5%, with SeaWiFS > MODIS > VIIRS
- Most angular dependence for SZA > 40°
- CHL_{OCI} much more resilient to angular dependence than CHL_{OCx}
  - Recent MODIS degradation may reduce continuity with VIIRS
  - Consider validating MODIS Rrs with VIIRS
- SZA dependence in R_{rs} does not propagate to QAA and K_d_lee products

Acknowledgment & References

This work was supported by the NASA OBB program and Water Quality program, and by the VIIRS cal/val program of NOAA NESDIS.

[1] Hu et al.(2012) *J. Geophys. Res.*, **117**:C01011
[2] O'Reilly et al (2000) NASA Technical Memorandum 2000-206892
[3] Z. Lee et al. (2005) *J. Geophys. Res.*, **110**:C02016
[4] Z. Lee et al. (2002) *Appl. Optics, **41**:5755-5772*