Variability in MODIS-VIIRS Intercalibration for Clear Sky Over Ocean Cases

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Motivation and Data Sources

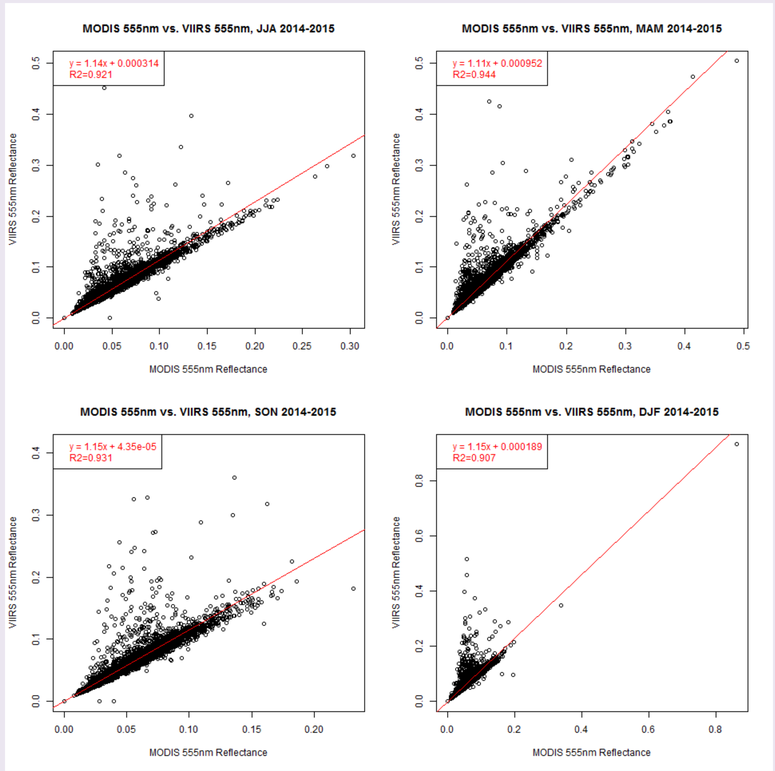
- Many aspects of climate studies require long-term data spanning multiple decades. Any such satellite record will depend on well-understood transitions to successive instruments, in order to produce continuous data products over time periods longer than the lifespan of an individual satellite.
- Dark Target aerosol retrieval algorithm was developed for MODIS, but intended to be portable.
- MODIS and VIIRS operate at different wavelengths, different fields of view, and different orbital timing.
- Wisconsin SIPS data matches MODIS and VIIRS overpasses by location, time and viewing angle.
- Cloud-free cases with a marine background have the fewest possible natural sources of disagreement between MODIS and VIIRS retrievals.
- Compared median values for clear sky over ocean pixels according to 1st byte of MODIS cloud mask.

MODIS band (μm) and native resolution	How used within MODIS DT algorithm	VIIRS band (μm) and native resolution	How used within VIIRS-IDPS aerosol algorithm
B8: 0.41 (1 km)		M1: 0.41 (0.75 km)	V_L
B9: 0.44 (1 km)		M2: 0.44 (0.75 km)	V_L
B3: 0.47 (0.5 km)	DT_L		
B10: 0.49 (1 km)		M3: 0.49 (0.75 km)	V_L
B11: 0.53 (1 km)			
B12: 0.55 (1 km)			
B4: 0.55 (0.5 km)	DT_O	M4: 0.55 (0.75 km)	
		I1: 0.64 (0.375 km)	
B1: 0.65 (0.25 km)	DT_L, DT_O		
B13: 0.67 (1 km)		M5: 0.67 (0.75 km)	V_L, V_O
B14: 0.68 (1 km)			
B15: 0.75 (1 km)		M6: 0.75 (0.75 km)	V_O
B2: 0.86 (0.25 km)	DT_L, DT_O	M7: 0.86 (0.75 km)	V_L, V_O
B16: 0.87 (1 km)		I2: 0.86 (0.375 km)	
B17: 0.90 (1 km)			
B18: 0.94 (1 km)			
B19: 0.94 (1 km)			
B5: 1.24 (0.5 km)	DT_L, DT_O Snow/Ice/Sediment/ Cirrus mask	M8: 1.24 (0.75 km)	V_O and Snow/Ice/ Sediment/Cirrus mask
B26: 1.38 (1 km)	Cirrus mask	M9: 1.38 (0.75 km)	Cirrus mask
		I3: 1.60 (0.375 km)	
		M10: 1.60 (0.75 km)	V_O
B6: 1.63 (0.5 km)	DT_O		
B7: 2.11 (0.5 km)	DT_L, DT_O		
		M11: 2.26 (0.75 km)	V_L, V_O, bright surface mask

From Levy et al. (2015), table 3. Wavelengths and resolutions of MODIS and VIIRS reflectance bands and their use in aerosol retrieval algorithms. DT_O and DT_L: Dark Target ocean and land, respectively; V_O and V_L: VIIRS-IDPS ocean and land.

Seasonality

- Sources and transport of aerosol vary seasonally, such as smoke from wildfires, desert dust storms.
- Disagreement in how MODIS and VIIRS retrieve different. aerosol types would appear as seasonal contrast in MODIS-VIIRS intercomparison.
- No evidence of a seasonal cycle in matched cases.

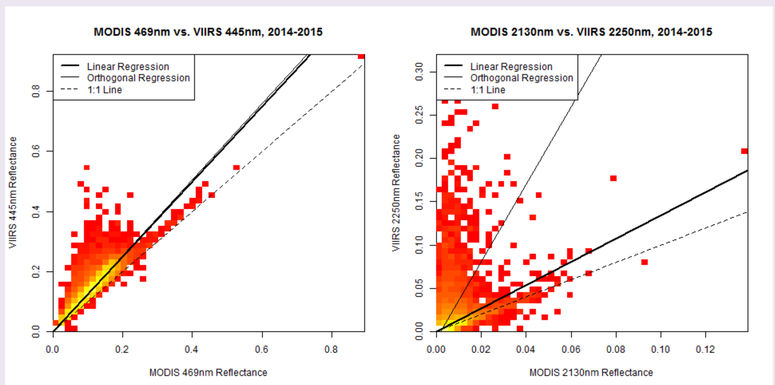


Reflectances for MODIS B4 vs. VIIRS M4 in matched cases, by season 2014-2015. Slope, intercept and R^2 values of linear regression remain nearly constant throughout the year.

Wavelength and Outliers

- Quality of fit between MODIS and VIIRS depends strongly on band, with excellent agreement at short wavelengths ($R^2 > 0.90$) declining to weak correlation in infrared ($R^2 < 0.30$).
- Most matched values lie close to the 1:1 line, but outliers accumulate with increasing wavelength.
- Most outliers show VIIRS >> MODIS.
- What causes the outliers? Can they be excluded from analysis ?

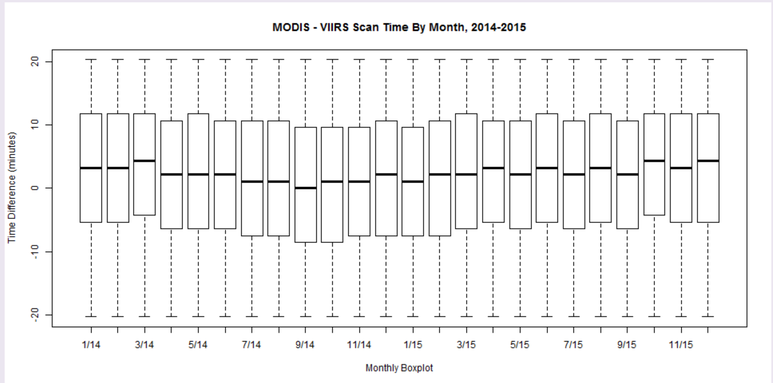
2D histograms on a $\log_{10}$ scale for MODIS B3 vs. VIIRS M2 (left) and MODIS B7 vs. VIIRS M11 (right). Other Dark Target bands show a steady increase in VIIRS >> MODIS outliers with increasing wavelength, and a corresponding decline in agreement between MODIS and VIIRS for clear sky over ocean reflectances.



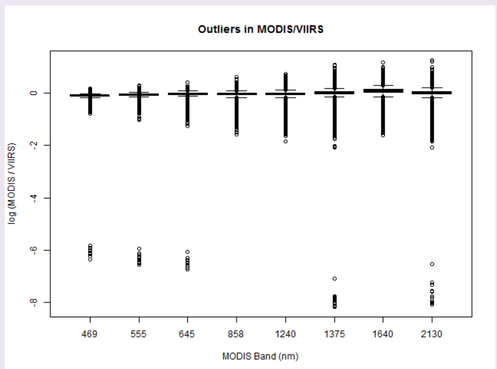
Match Times

- Tolerance for MODIS-VIIRS matches is ±20 minutes, but time differences are not evenly distributed.
- Suomi NPP orbits several minutes ahead of Aqua but makes different adjustments, causing the median gap in minutes to vary over time.
- Longer time gaps are disproportionately represented in reflectance outliers, but not exclusive to them.
- Removing them improves the fit slightly, but does not explain the majority of outliers.

Boxplots showing summary statistics of the time gap (MODIS – VIIRS) between matched scans, separated by month 2014-2015.



Boxplots showing summary statistics of the ratio (MODIS/VIIRS) on a $\log_{10}$ scale, separated by paired bands. Longer wavelengths have more and greater outliers, sometimes by orders of magnitude, almost always VIIRS >> MODIS. This is consistent with cloud contamination in VIIRS.



Future Work

- Clear sky over ocean pixels are determined solely from MODIS cloud mask so far. Cloud contamination in VIIRS is possible, and would explain outlier results especially at infrared wavelengths.
- Using the VIIRS cloud mask, or a statistical strategy to remove pixels that VIIRS would mark cloudy and MODIS mark clear, may greatly improve the agreement in reflectances.
- Gas correction requires separate lookup tables for each instrument, and may also correct some of the disagreement between them without removing data points from the comparison.
- Likewise, Rayleigh correction will eventually be applied separately to each instrument.