Corrections to the calibration of MODIS Aqua ocean color bands derived from MODIS Aqua L3 data

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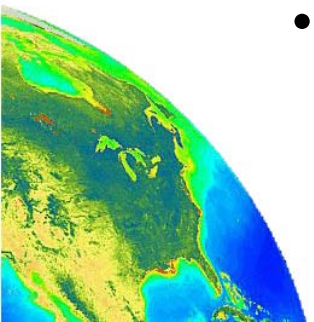
Calibration Breakout

Ocean Biology Processing Group:

- NASA Code 616, Ocean Sciences Research, Hydrospheric and Biospheric Sciences Research, Goddard Space Flight Center
- Responsible for producing Ocean Color (OC) products at NASA (CZCS, SeaWiFS, MODIS Aqua and Terra, MERIS, etc.)
- Website: oceancolor.gsfc.nasa.gov

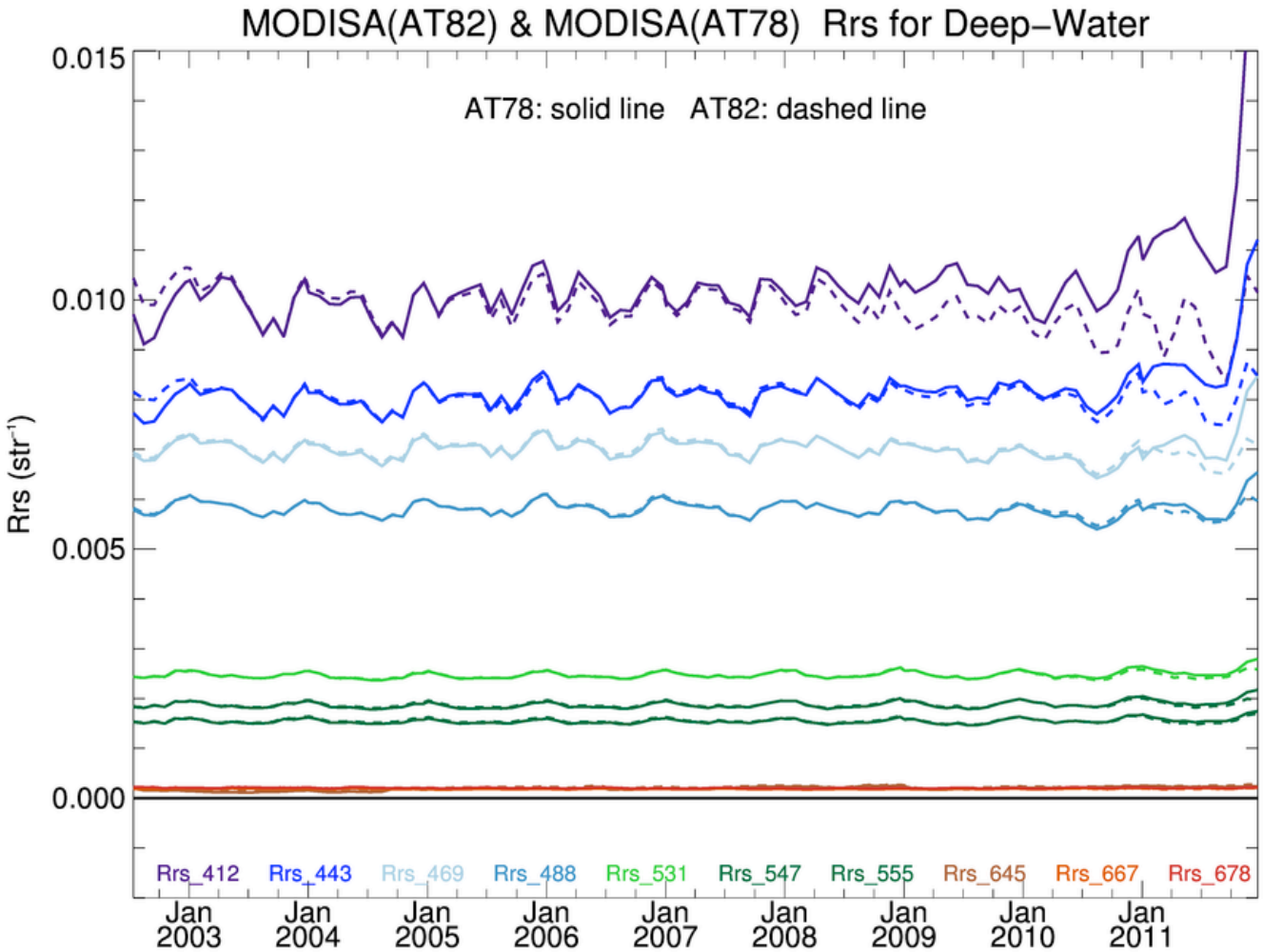
Background:

- Previous: MCST lunar and SD trending (coll. 6, but Approach I)
- MODIS Aqua crosscalibrated to SeaWiFS (as for Terra in Kwiatkowska et al., Applied Optics, 2008)
- Approach: Use SeaWiFS L3 nLw, bring to TOA, adjust MODIS calibration for every month of the mission (7-day L3)
- Only bands 8 and 9 (412nm and 443nm) needed temporal corrections, for bands 10-14 time-independent scan angle corrections are sufficient
- Method did not work after demise of SeaWiFS (end of 2010)



Globally averaged reflectances

Solid line: operational (old) using Approach I and xcal to SeaWiFS



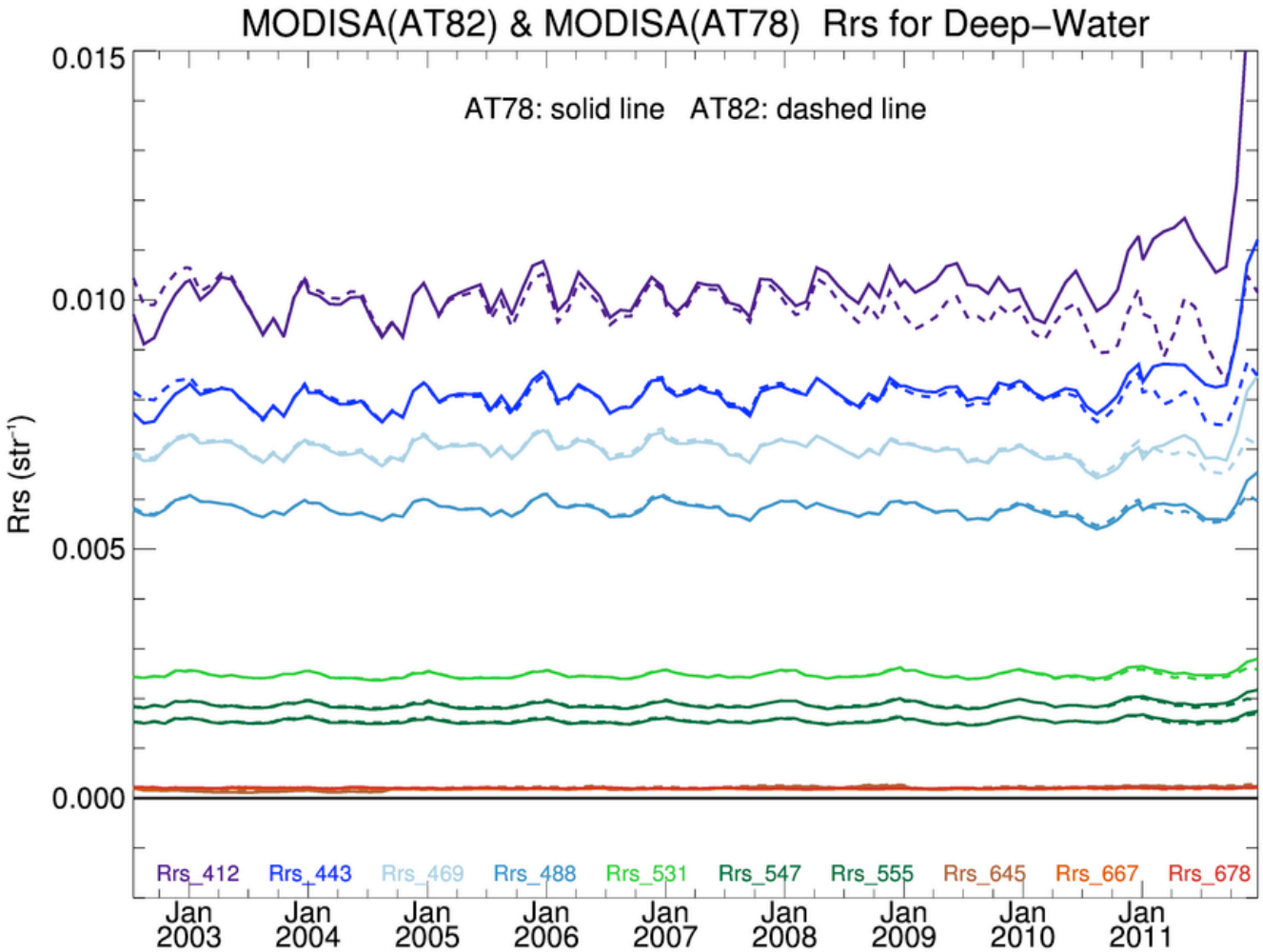
50% increase in Rrs at 412nm

MCST Approach II:

- MCST lunar, SD, **and desert** (for bands 8 and 9) trending (coll. 6, Approach II)
- Largest difference to Approach I is in the center of the scan (between lunar and SD angles)
- Qualitatively, results are very similar to OBPG crosscalibration for SeaWiFS period
- OBPG derived a **time-independent** scan angle correction using a crosscalibration to a SeaWiFS climatology
- Approach II + **time-independent** scan angle correction: Temporal trends of global ocean color products look good even beyond SeaWiFS period, except for a downward trend in 412nm band (and possibly at the beginning of the mission for 443nm)
- The above is **NOT** our final approach

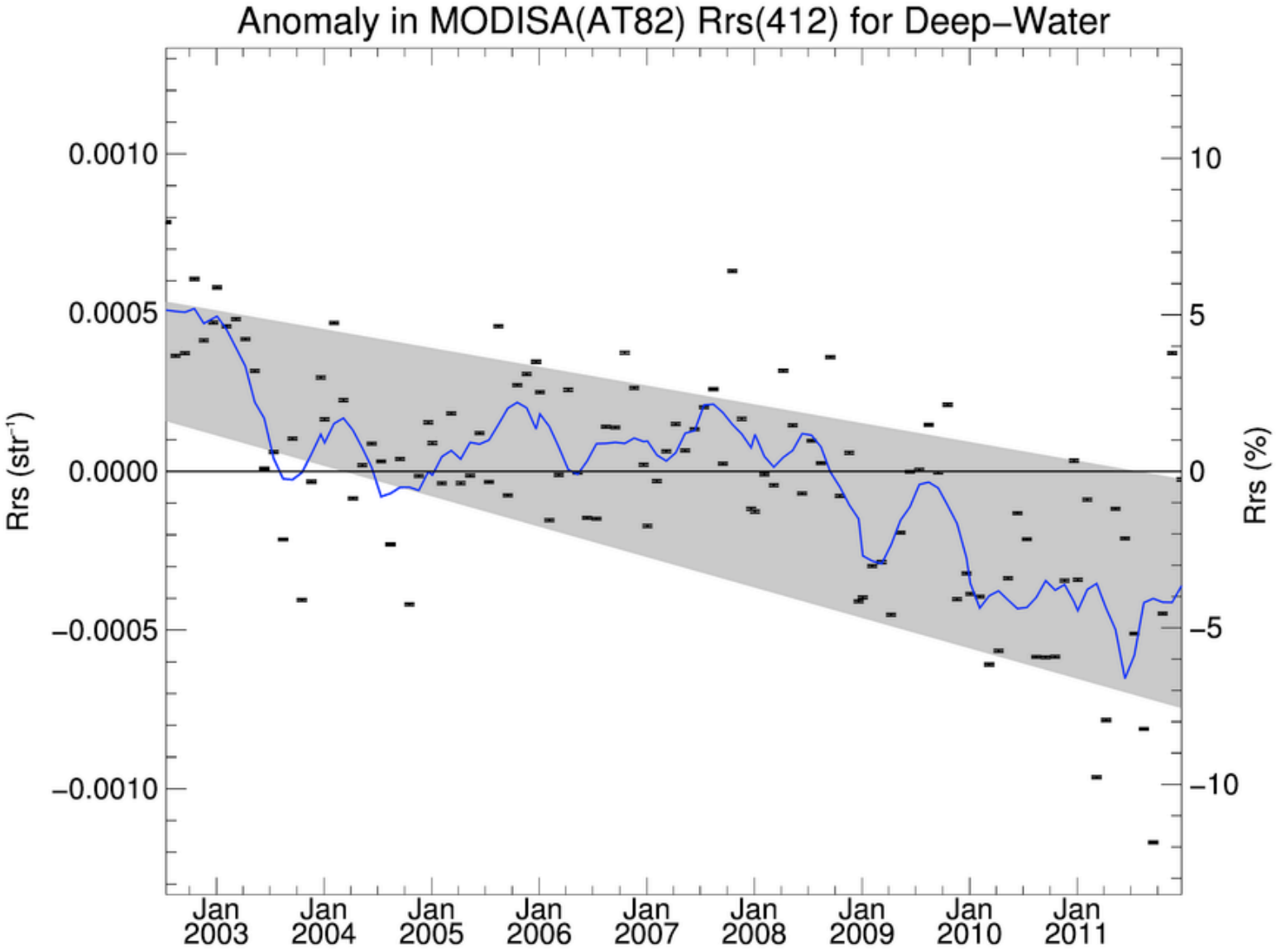
Globally averaged reflectances

Dashed line: Approach II and time-indep. xcal to SeaWiFS climatology

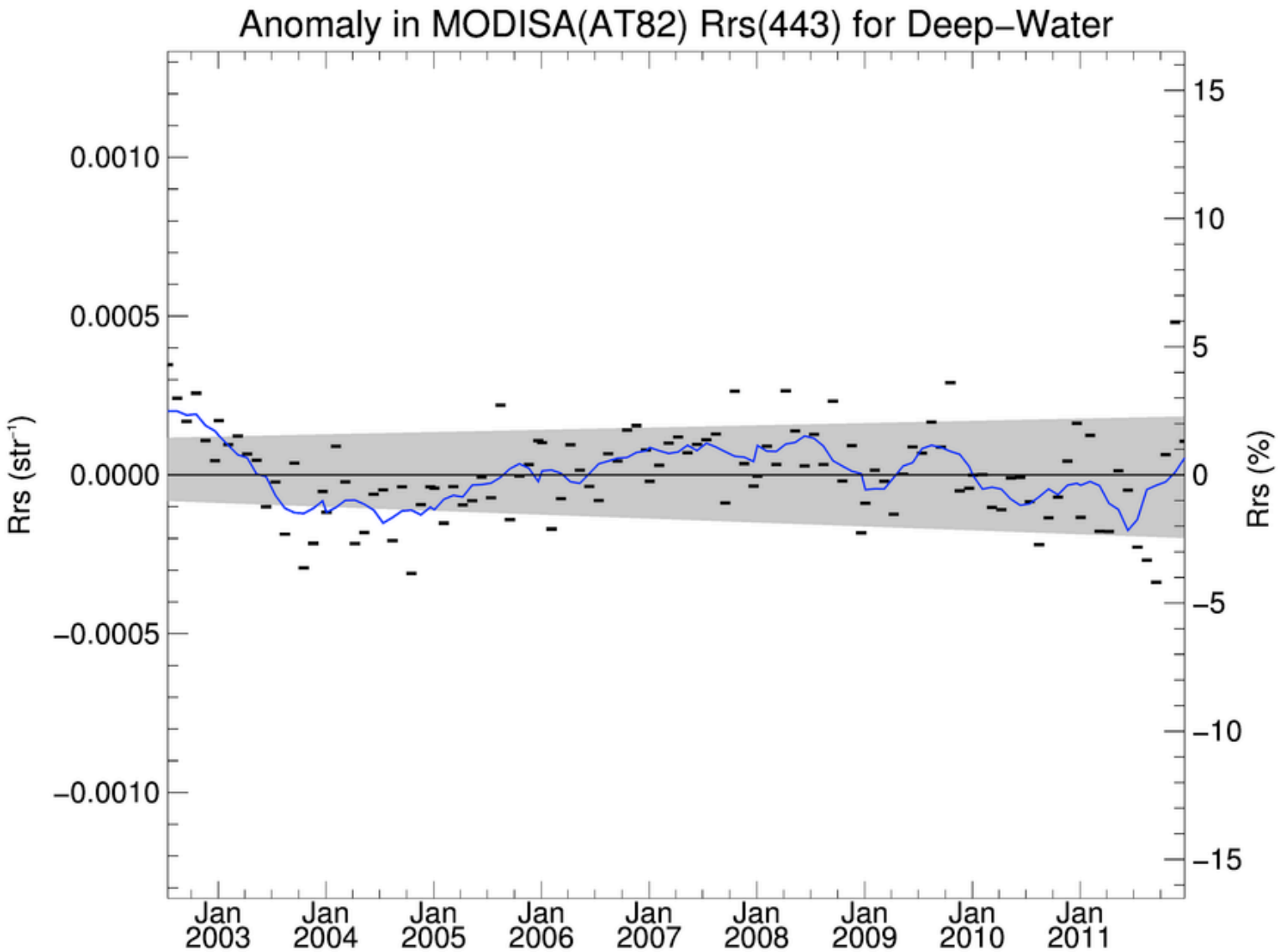


50% increase in Rrs at 412nm eliminated, but now downward trend

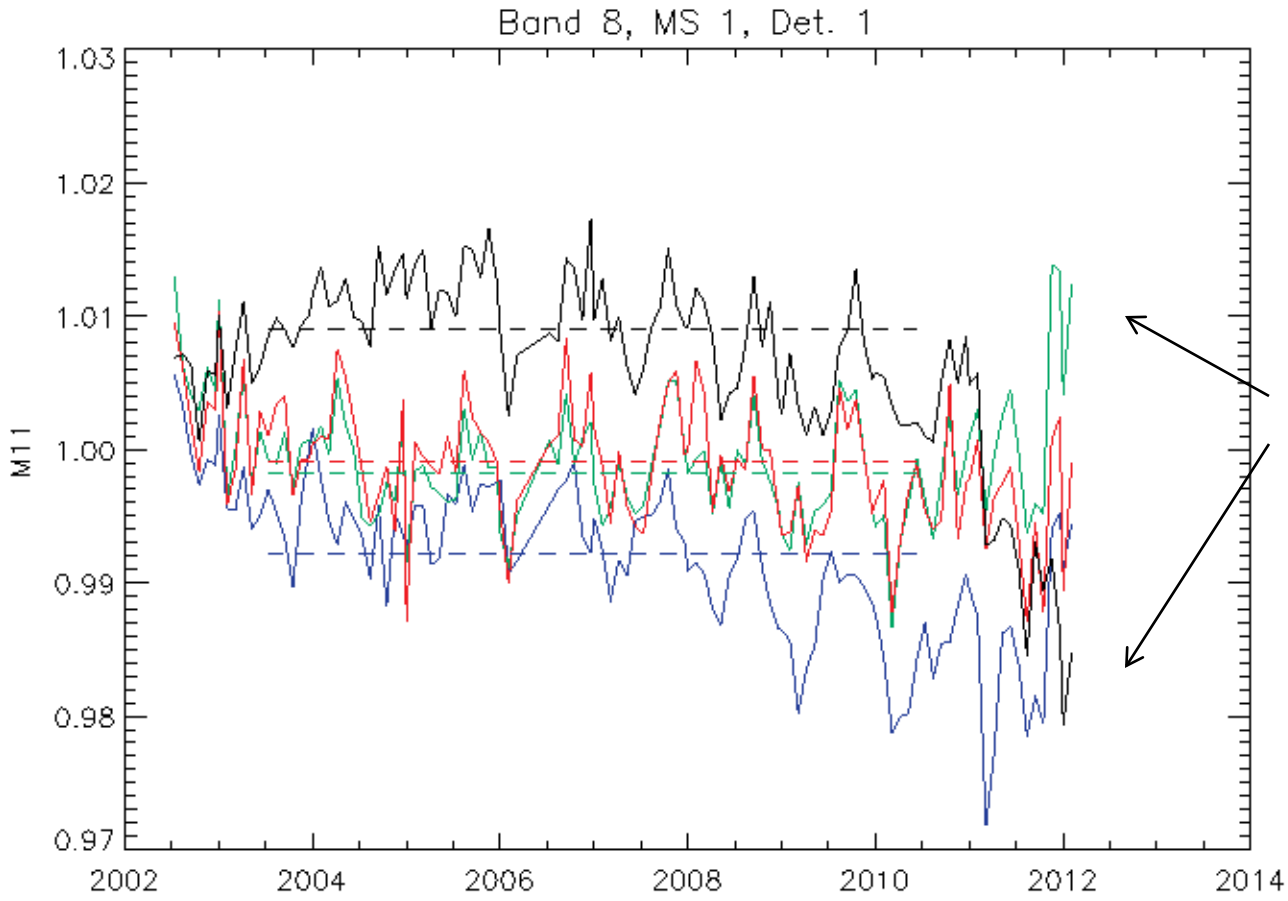
Temporal anomaly for 412nm reflectance



Temporal anomaly for 443nm reflectance



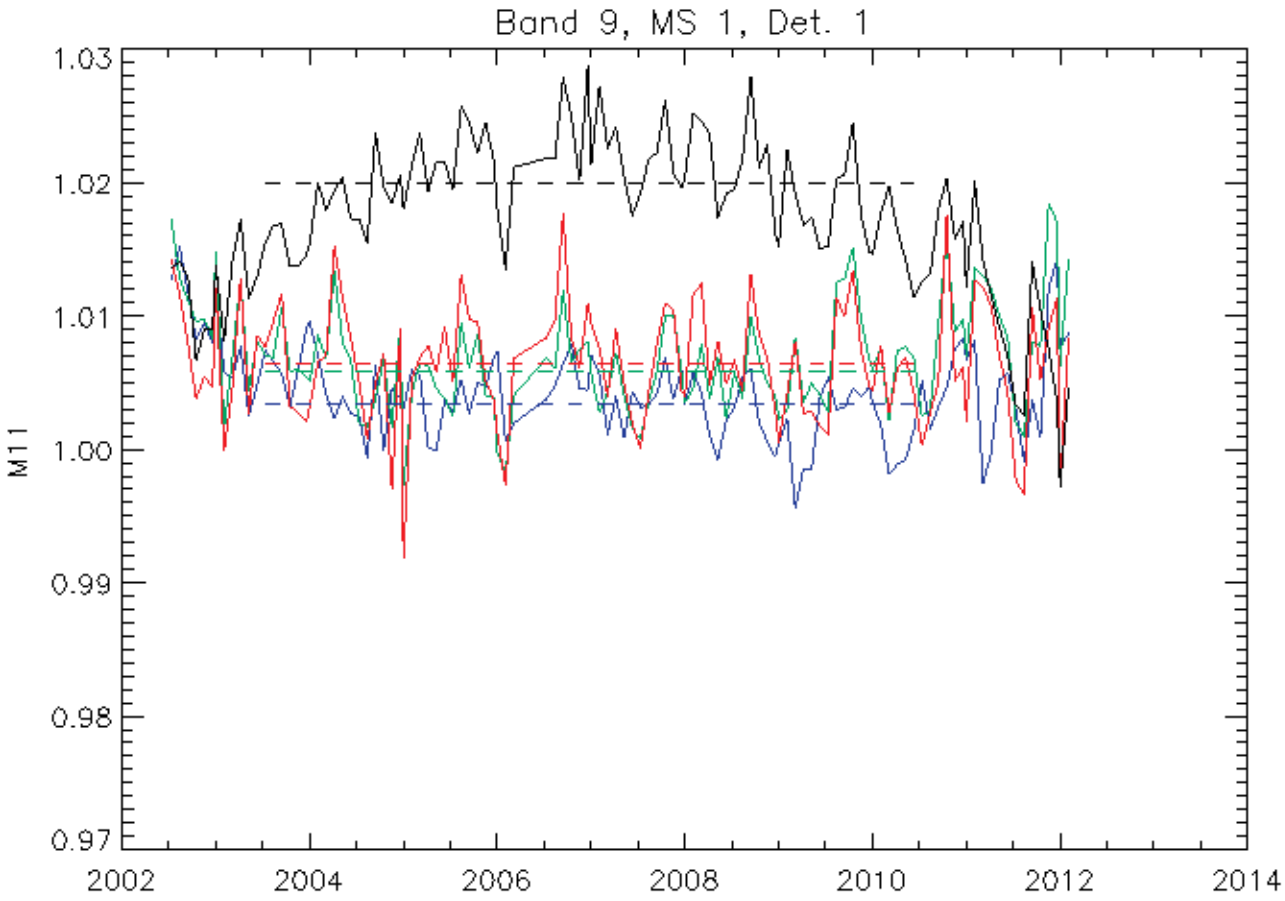
Crosscalibration of MCST Approach II to SeaWiFS climatology: gain corrections for 412nm



3% change in M11 for end-of-scan

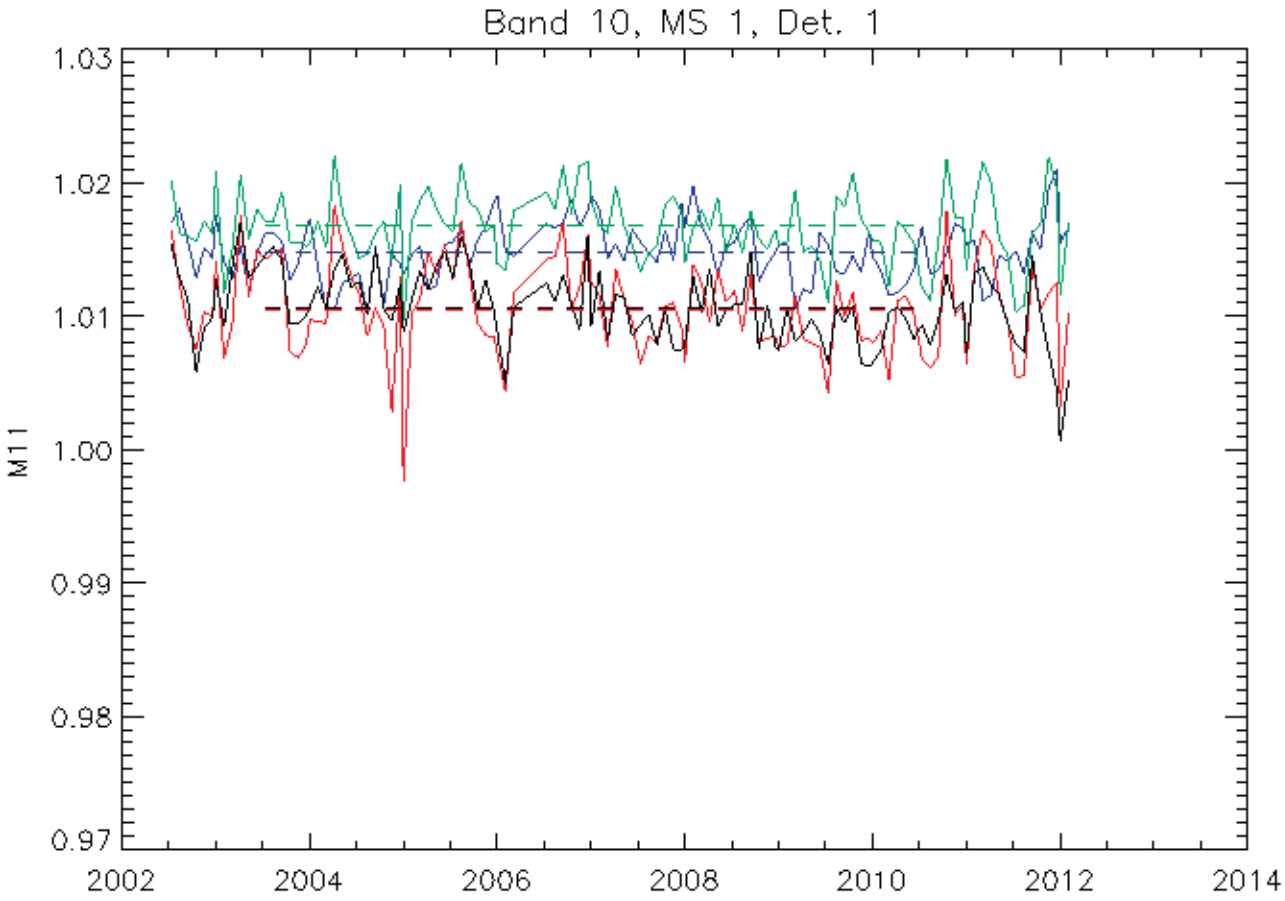
Scan angles (frame): lunar (22), nadir (675), Solar diffuser (989), end-of-scan (1250)

Crosscalibration of MCST Approach II to SeaWiFS climatology: gain corrections for 443nm



Scan angles (frame): lunar (22), nadir (675), Solar diffuser (989), end-of-scan (1250)

Crosscalibration of MCST Approach II to SeaWiFS climatology: gain corrections for 488nm

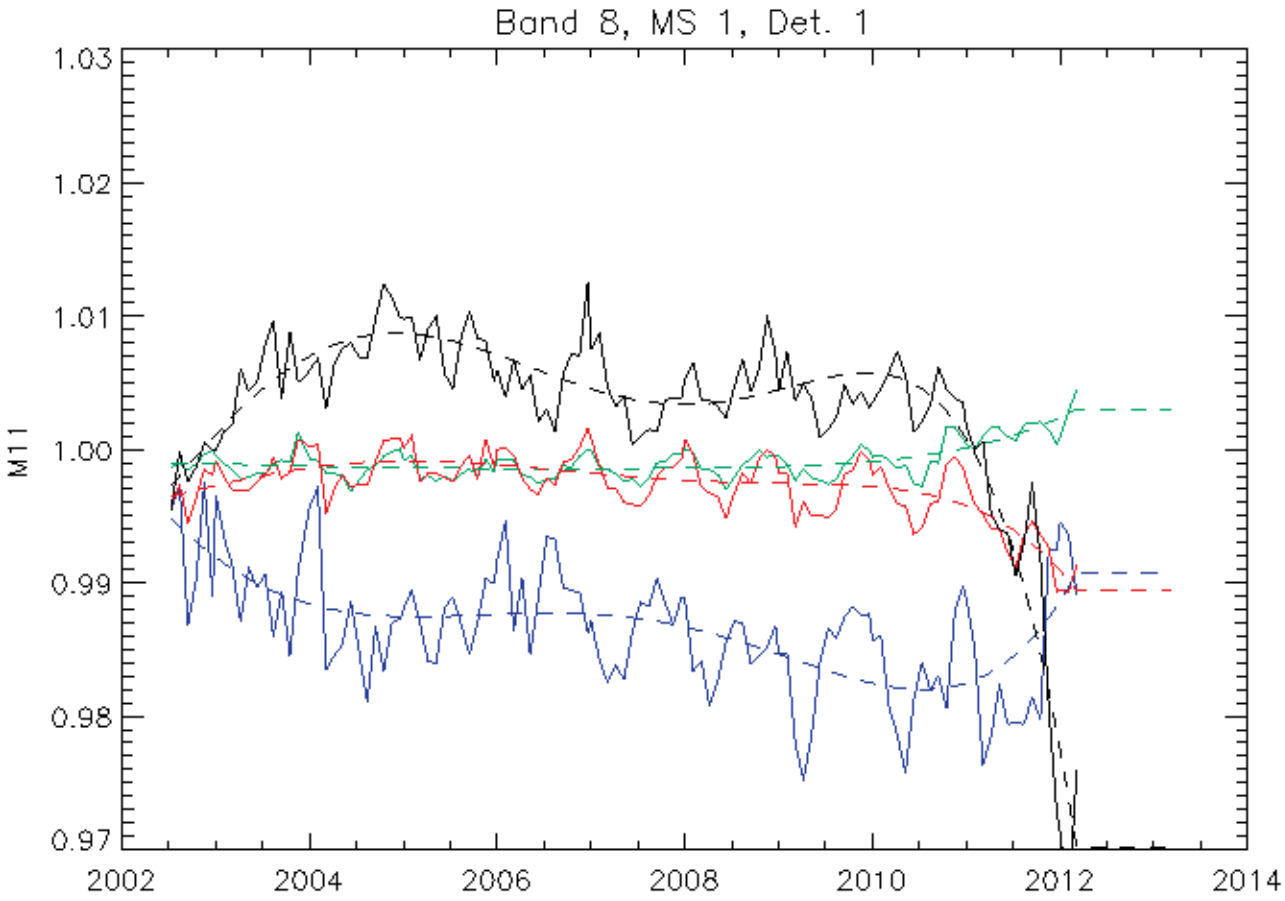


Scan angles (frame): lunar (22), nadir (675), Solar diffuser (989), end-of-scan (1250)

OBPG approach for MODISA 2012.0 reprocessing:

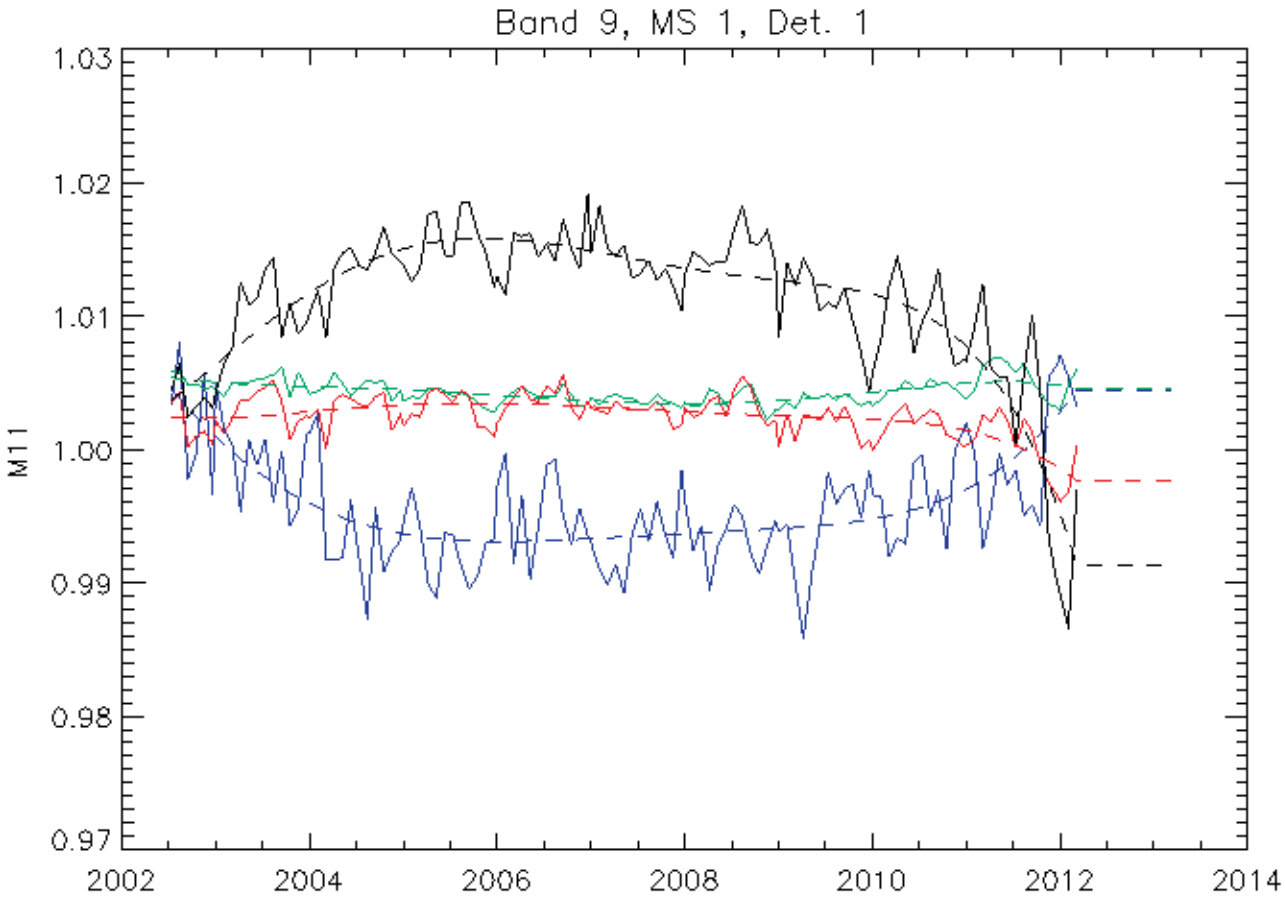
- Basis: MCST Approach II provides trending consistent with SeaWiFS climatology for central part of the scan (frames 300-1050)
- New approach: use Approach II to calculate MODIS Aqua L3 using only L2 from frames 300-1050, then derive crosscalibration coefficients for MODIS Aqua using these L3
- Resulting time series is independent of SeaWiFS trend, temporal trend is completely based on the MCST Approach II calibration for frames 300-1050

Crosscalibration of MCST Approach II to its central frames: gain corrections for 412nm



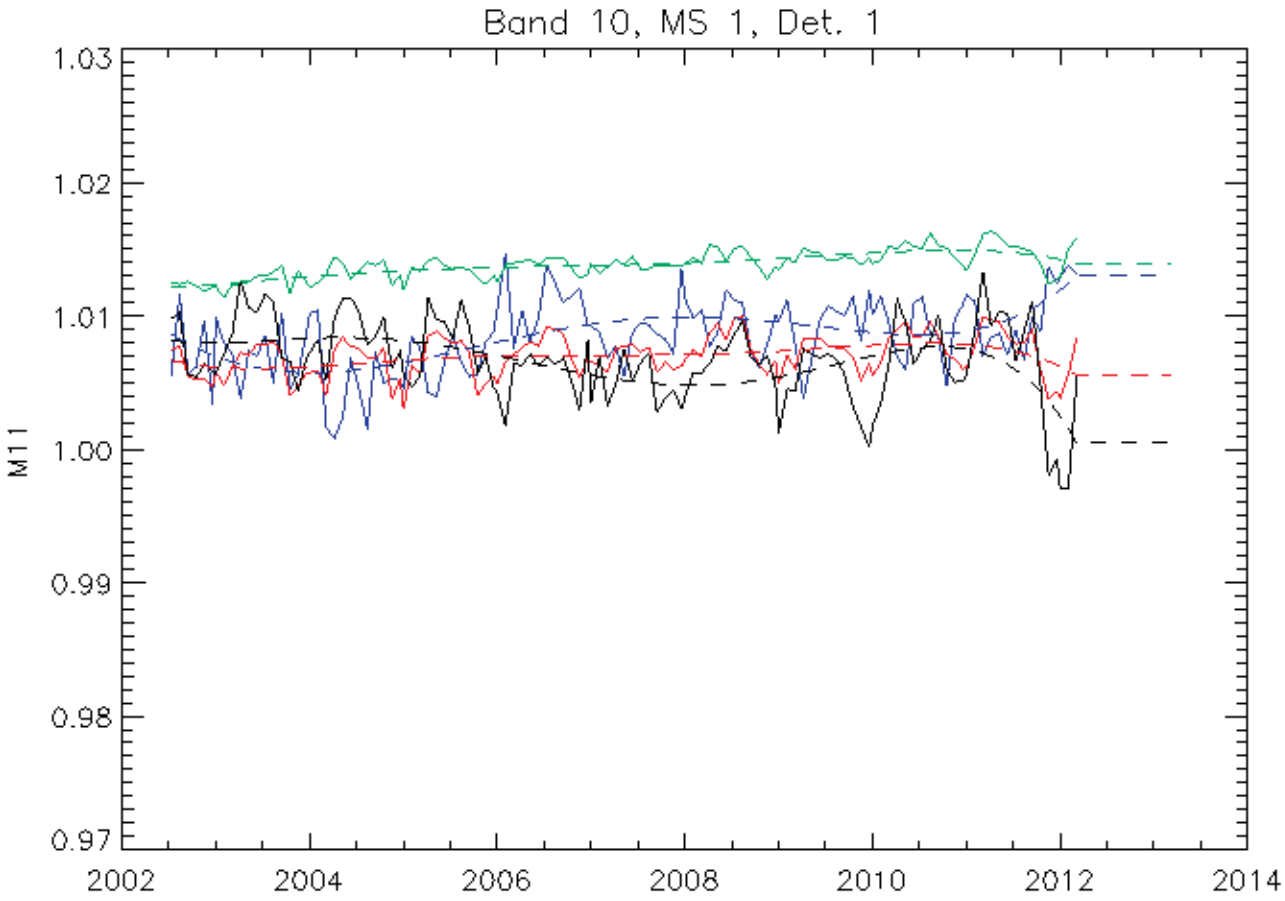
Scan angles (frame): lunar (22), nadir (675), Solar diffuser (989), end-of-scan (1250)

Crosscalibration of MCST Approach II to its central frames: gain corrections for 443nm



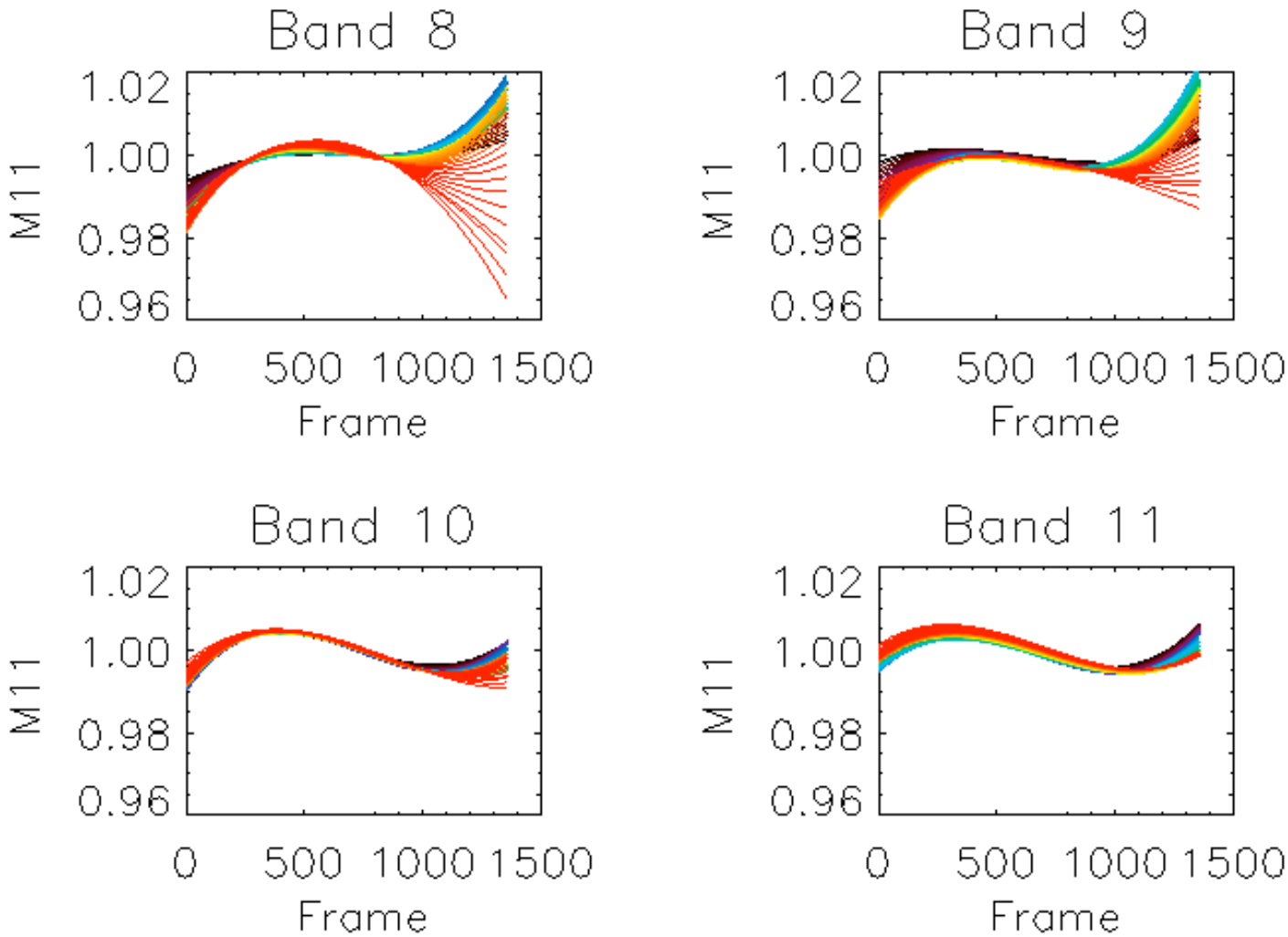
Scan angles (frame): lunar (22), nadir (675), Solar diffuser (989), end-of-scan (1250)

Crosscalibration of MCST Approach II to its central frames: gain corrections for 488nm



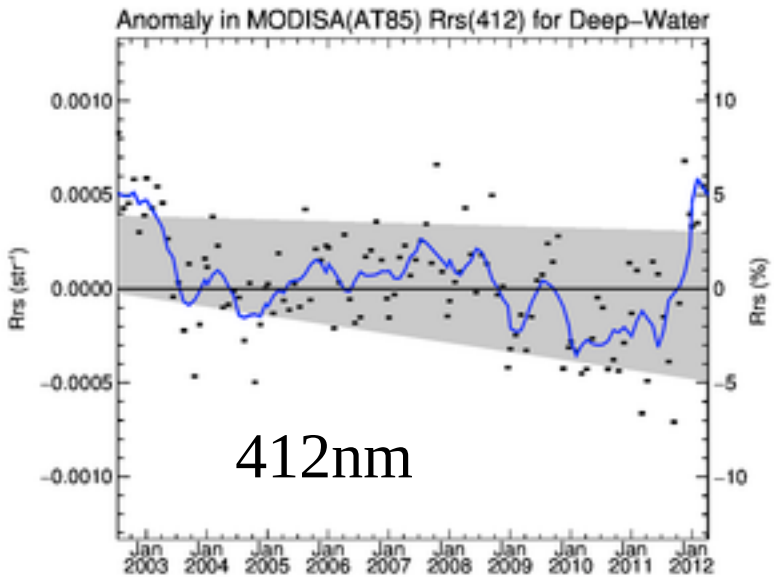
Scan angles (frame): lunar (22), nadir (675), Solar diffuser (989), end-of-scan (1250)

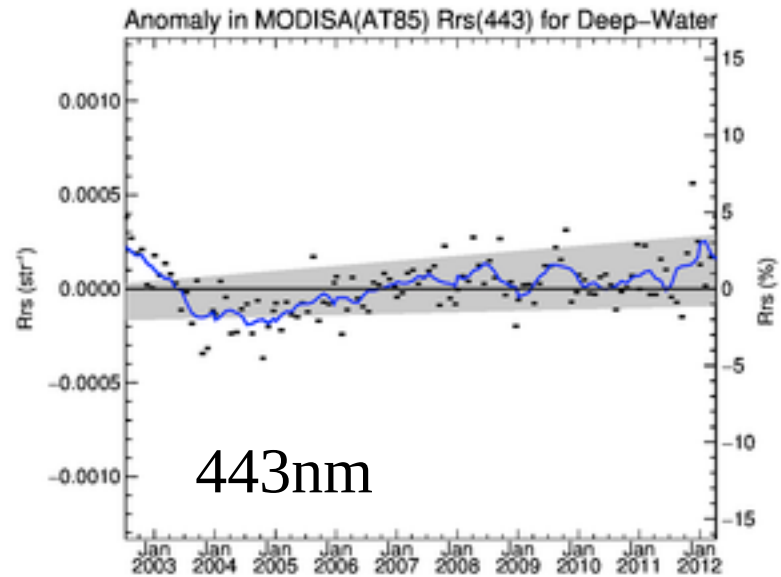
Crosscalibration of MCST Approach II to its central frames: gain corrections for 412-531nm

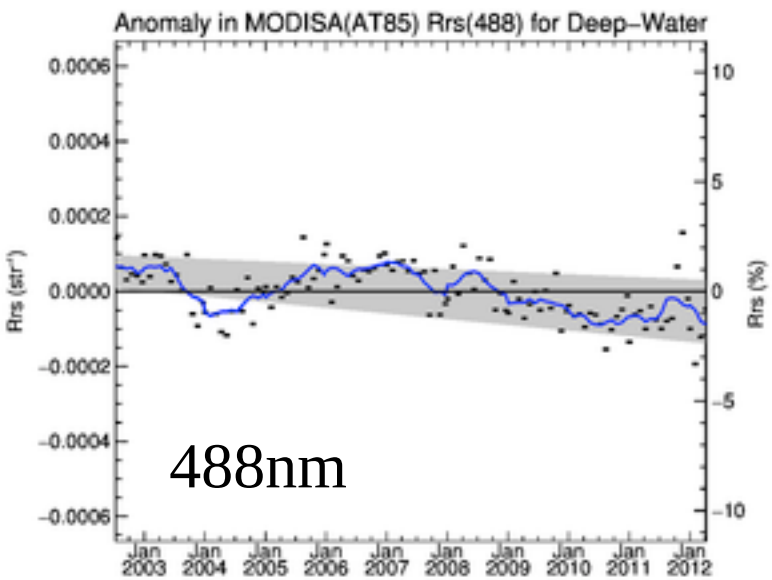


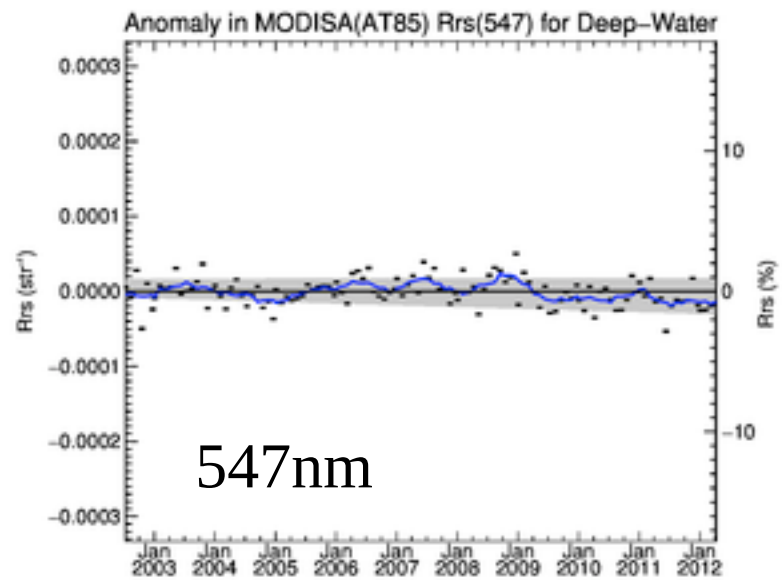
Color scale: black/blue=2002, red=2012

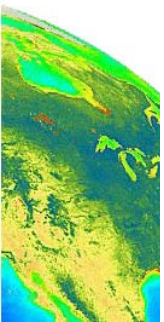
MODISA R2012.0: Rrs deep-water anomalies



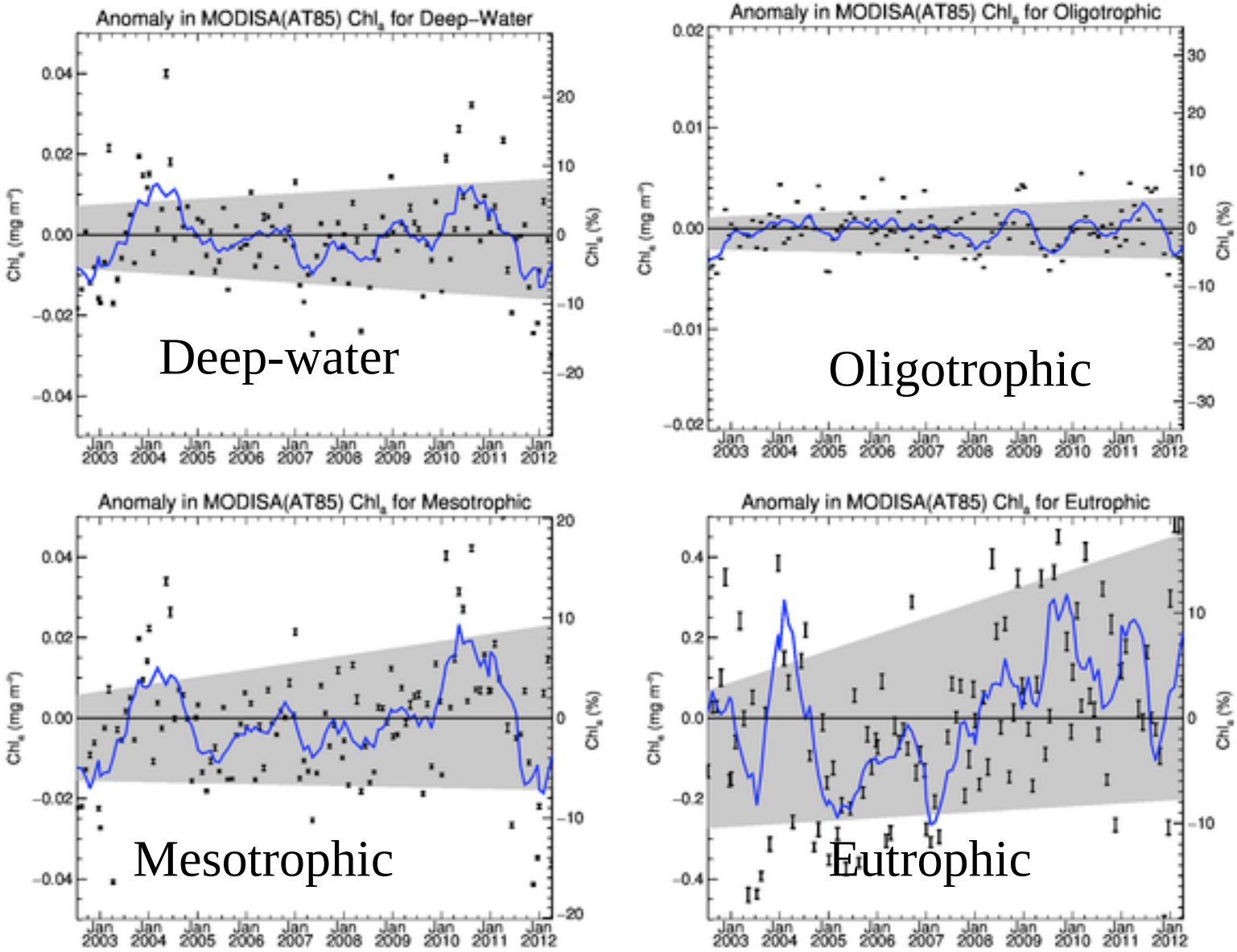






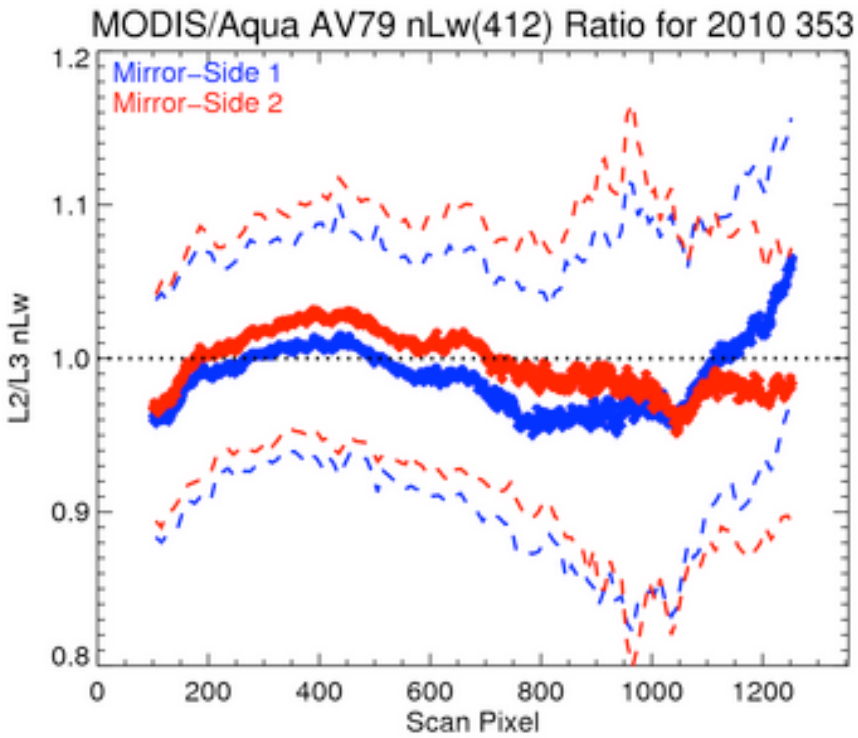


MODISA R2012.0: Chlorophyll anomalies

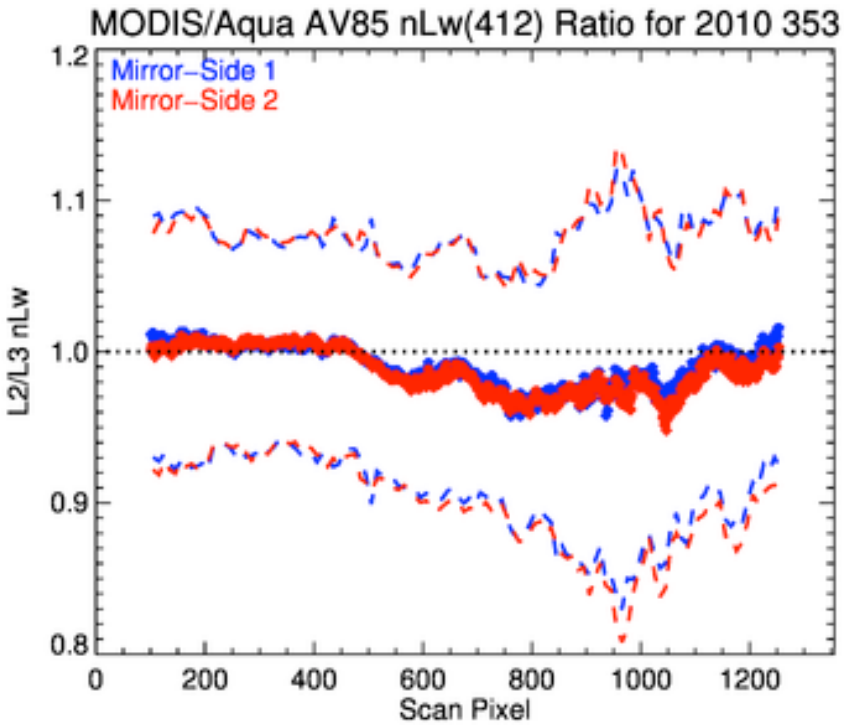


MODISA R2012.0: Scan angle dependency

nLw 412nm from C6:

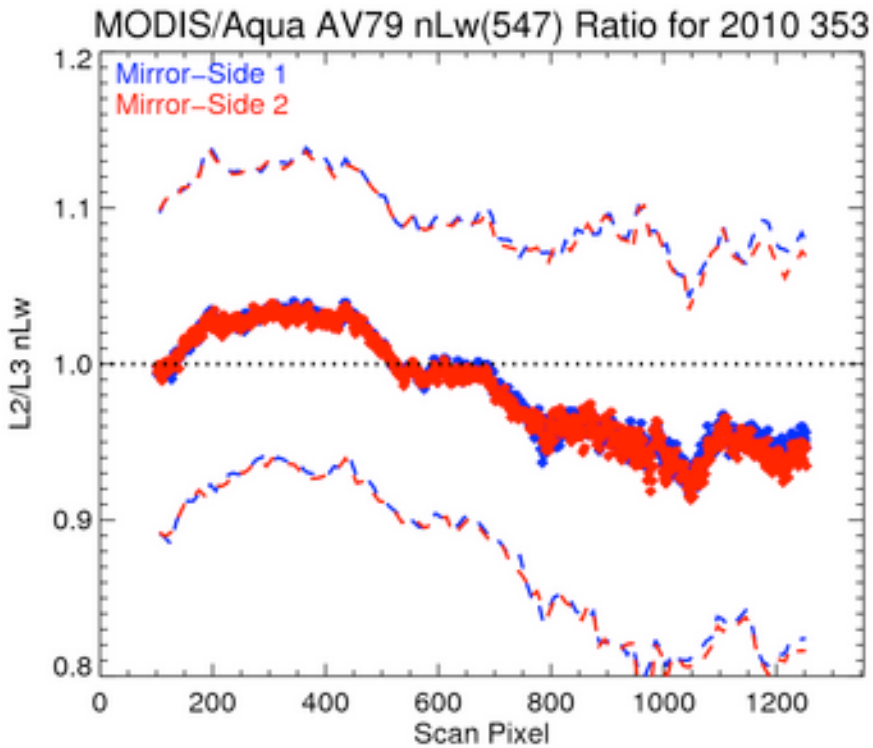


nLw 412nm from C6+xcal:

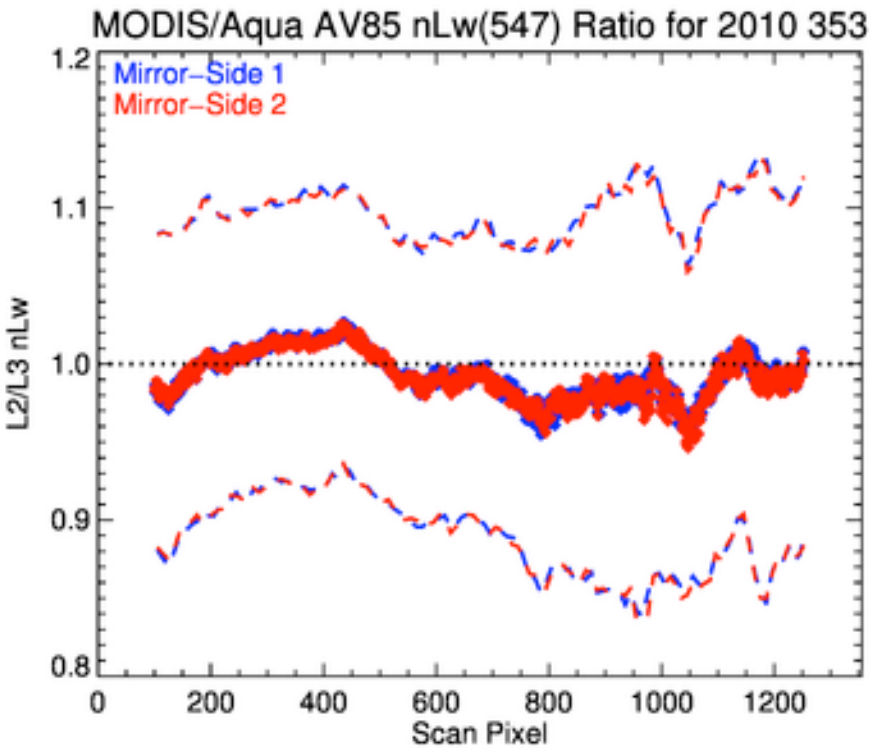


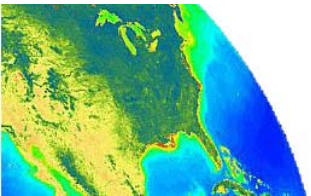
MODISA R2012.0: Scan angle dependency

nLw 547nm from C6:



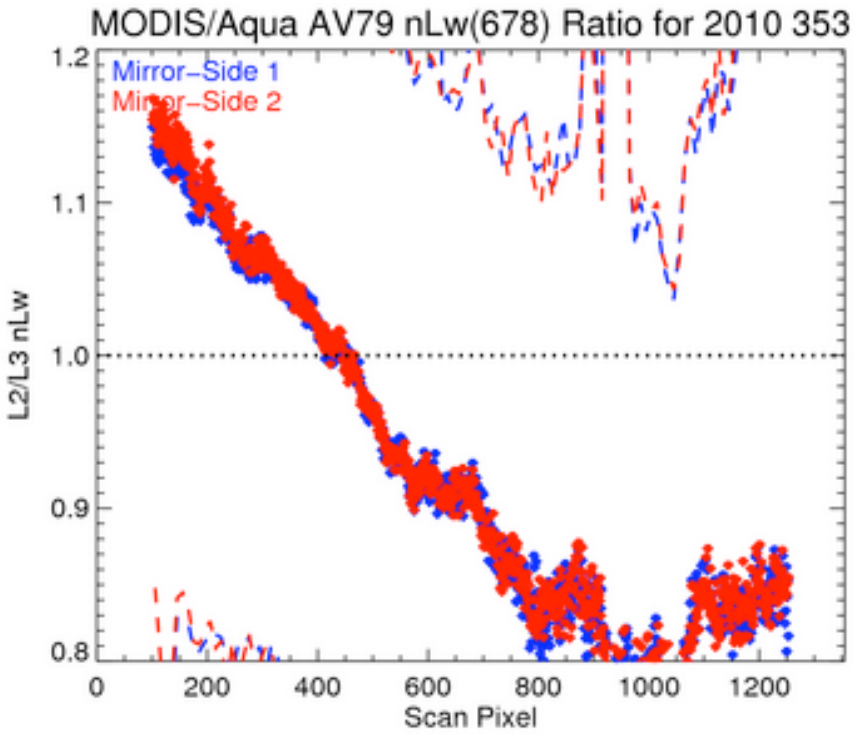
nLw 547nm from C6+xcal:



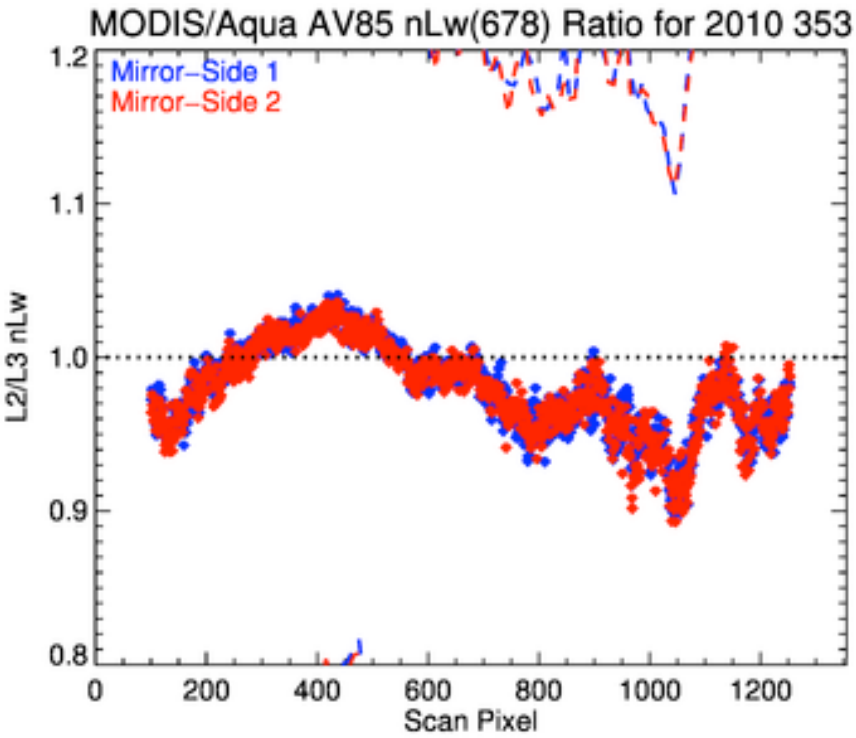


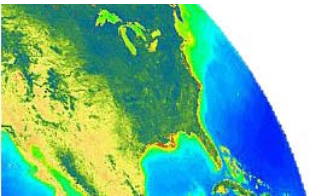
MODISA R2012.0: Scan angle dependency

nLw 678nm from C6:



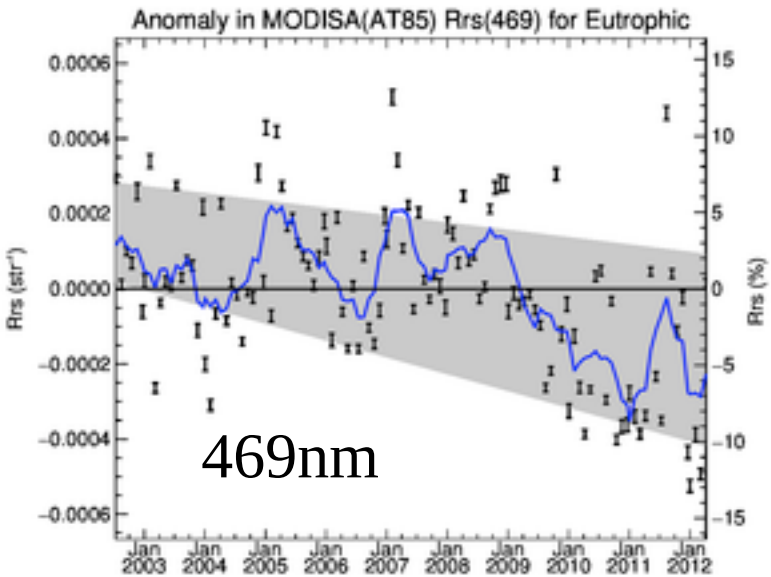
nLw 678nm from C6+xcal:

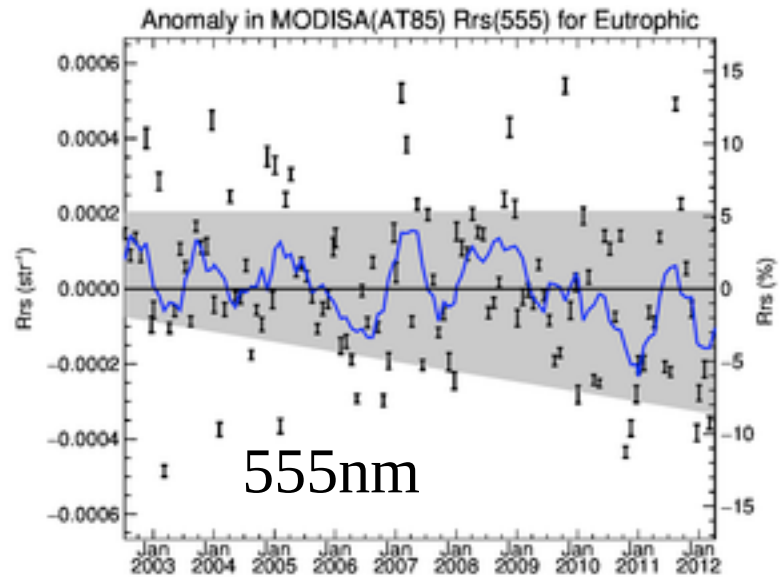


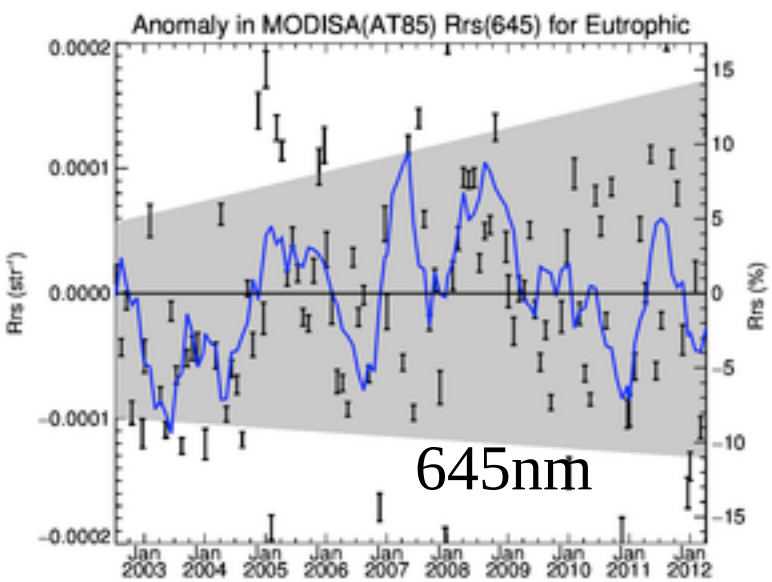


AV results for 667nm and 678nm: better than ever

MODISA R2012.0: Land bands

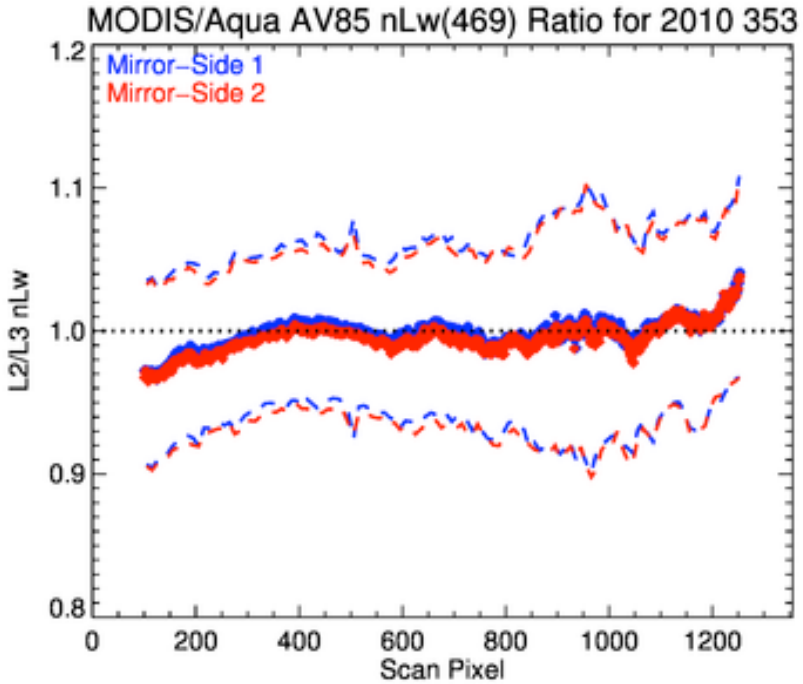


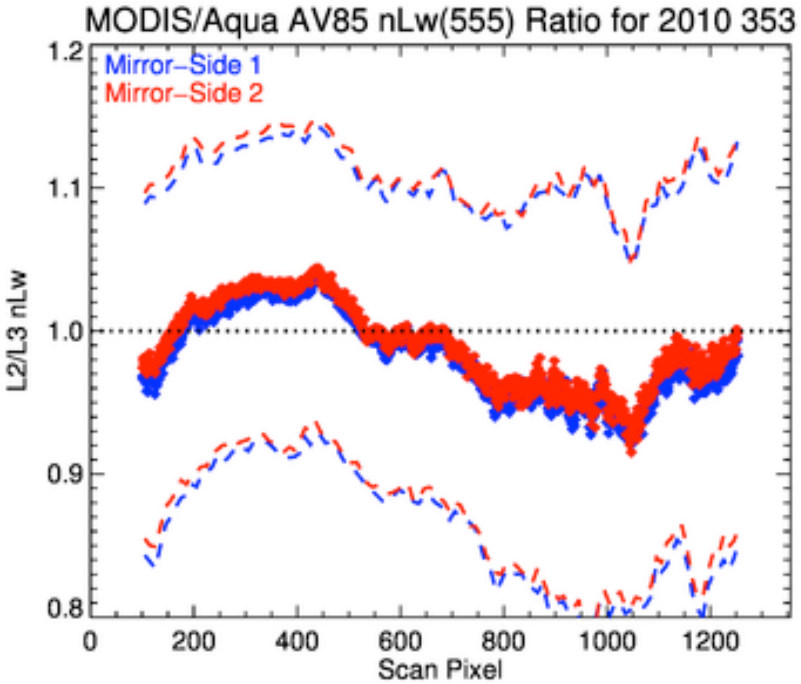


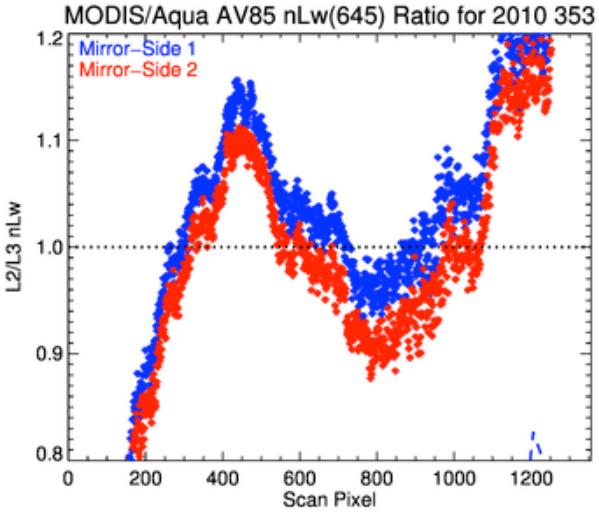


- Pure MCST calibration
- Exception: Striping correction added (needs improvement)
- Mainly used in coastal areas
  => plots for eutr. regions
- Possibly a trend in 469nm (also in olig. Region, not shown)

MODISA R2012.0: Scan angle dependency







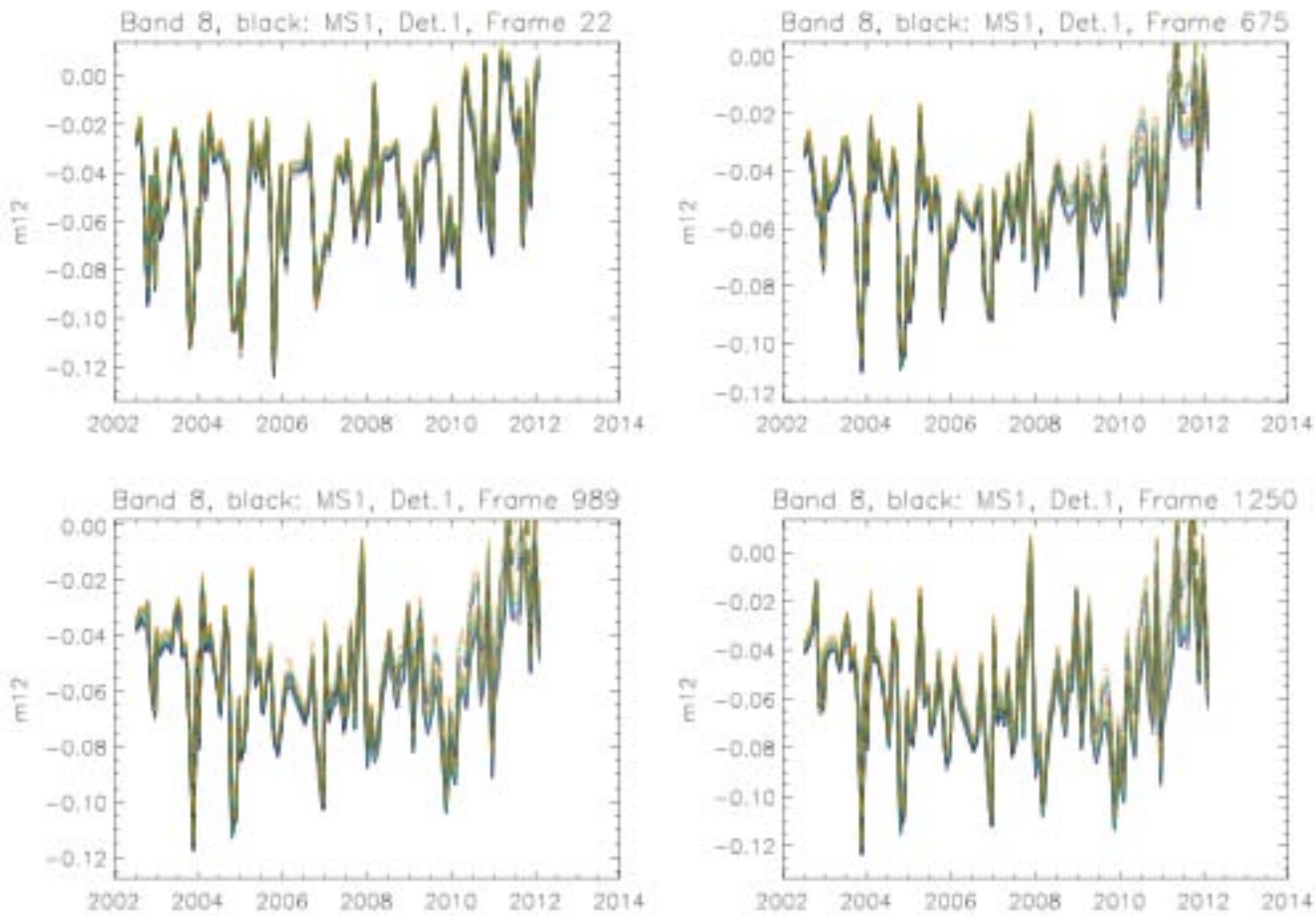
Land band scan angle dependency:
-Derived for first time
-Looks quite good (no corrections applied)

Summary:

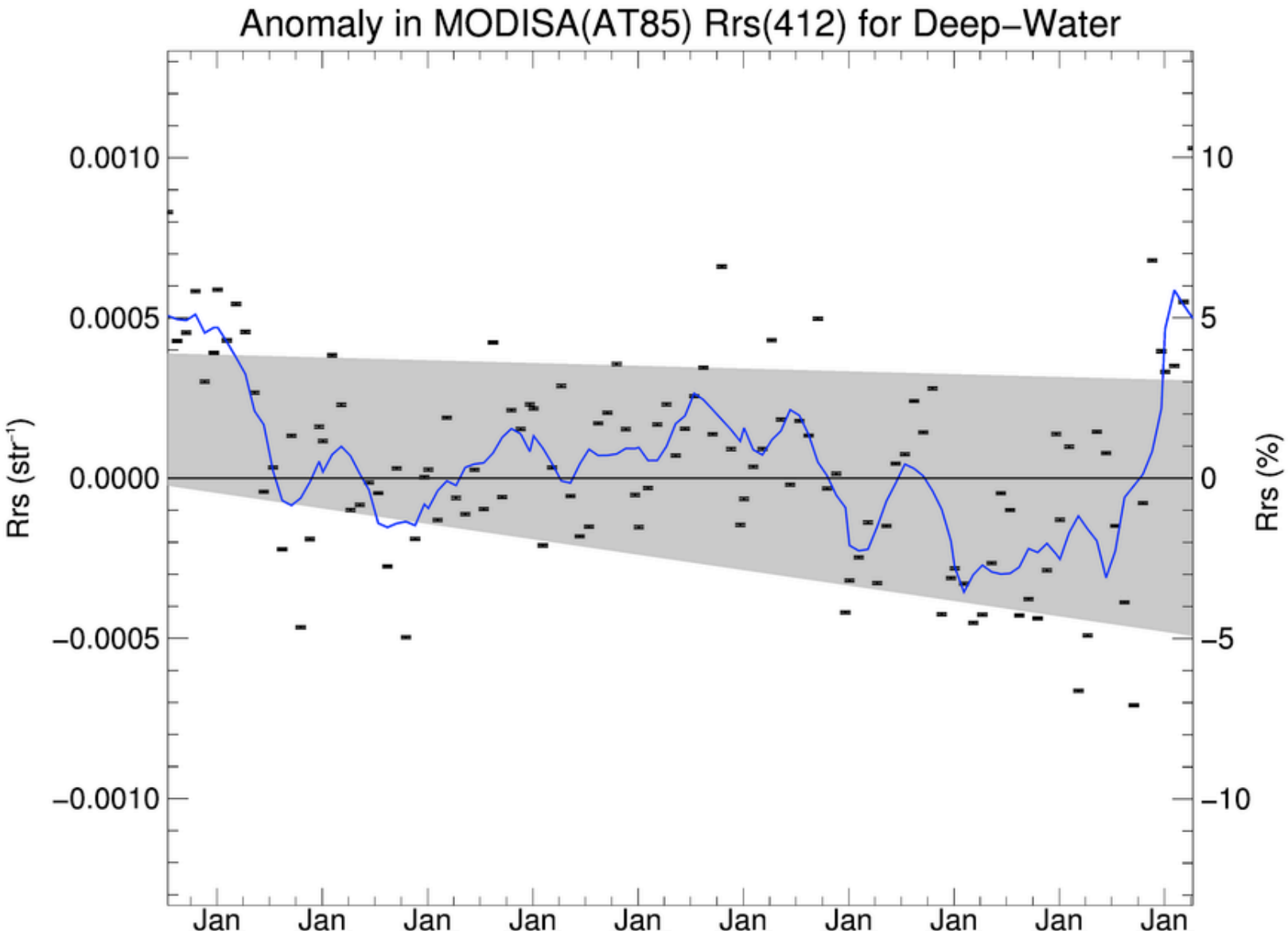
- New MCST calibration approach (Approach II, desert site trending) results in reasonable trends for ocean color products (huge improvement compared to previous approach)
- OBPG applies time-dependent correction by adjusting the scan angle dependency (this modifies mainly the scan edges; overall trend is determined by MCST calibration for frames 300-1050)
- OBPG corrections result in small improvement to Rrs 412nm trend; scan angle dependency of most bands is improved, especially red bands
- Land bands are not corrected by OBPG; scan angle dependency still quite reasonable

Backup

Polarization trending for MODISA



MODISA R2012.0: Rrs(412nm) anomaly



Modeling of TOA Stokes vector over oceans

air aerosol whitecap glint water gas

$$\begin{bmatrix} L_t \\ Q_t \\ U_t \\ 0 \end{bmatrix} \quad L_t(\lambda) = [\, L_r(\lambda) + L^a(\lambda) + tL_f(\lambda) + TL_g(\lambda) + t_d(\lambda)L^w(\lambda) \,] \cdot t_g(\lambda)$$

from MODIS NIR
assumes MCST NIR band characterization

$\lambda' \rightarrow \lambda$
fit based on bio-optical models

$L^{wn}(\lambda')$

SeaWiFS
4-day mean

Crosscalibration approach:

$$L_m/M_{11} = L_t + m_{12}*Q + m_{13}*U$$

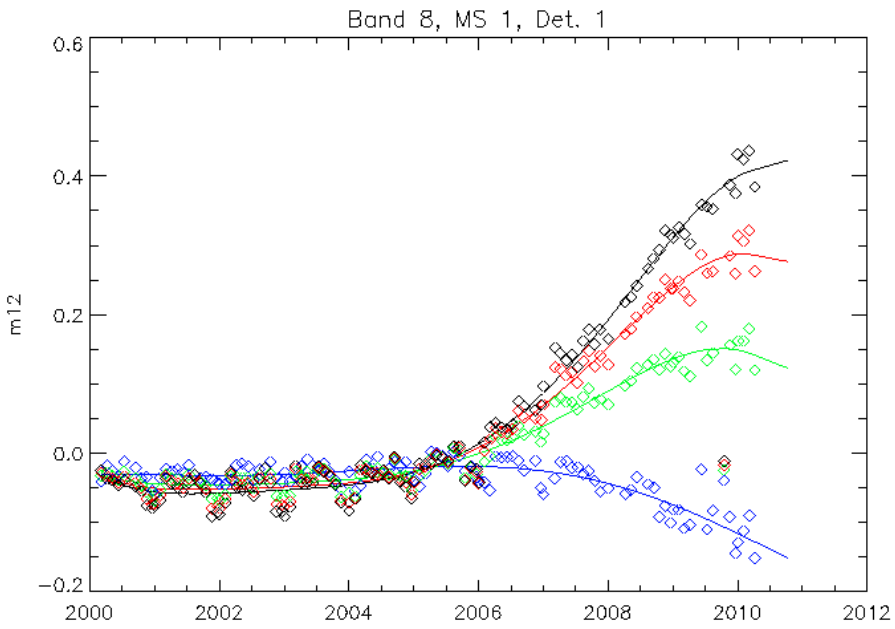
L_m: measured TOA radiance (MODIS)

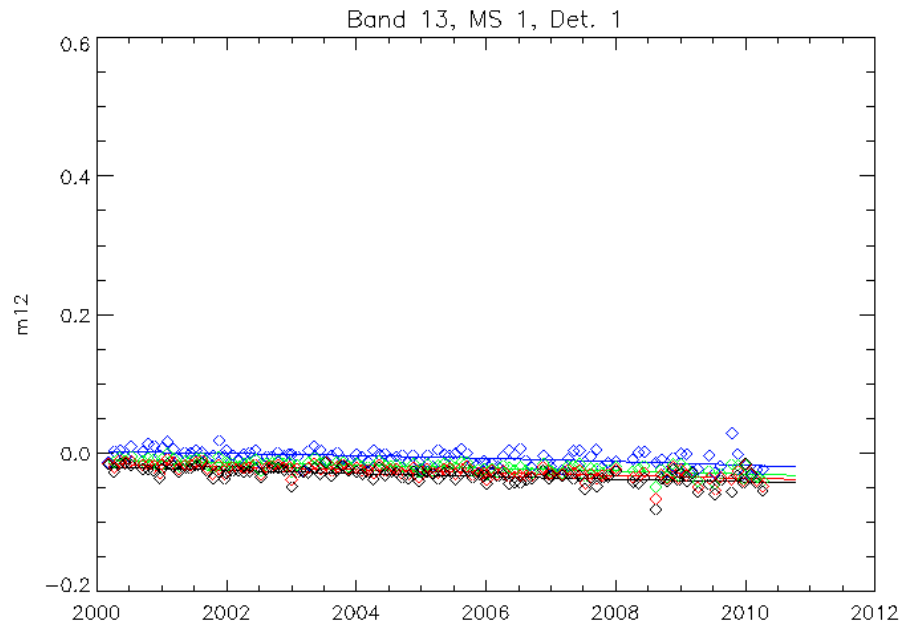
L_t: true TOA radiance (from SeaWiFS)

Q, U : linear Stokes vector components, modeled from Rayleigh and glint

M_{11}, m_{12}, m_{13} : fitted instrument characterization parameters (depend on band, MS, detector, scan angle)

Comparison to MODIS Terra polarization sensitivity as a function of time at different view angles:



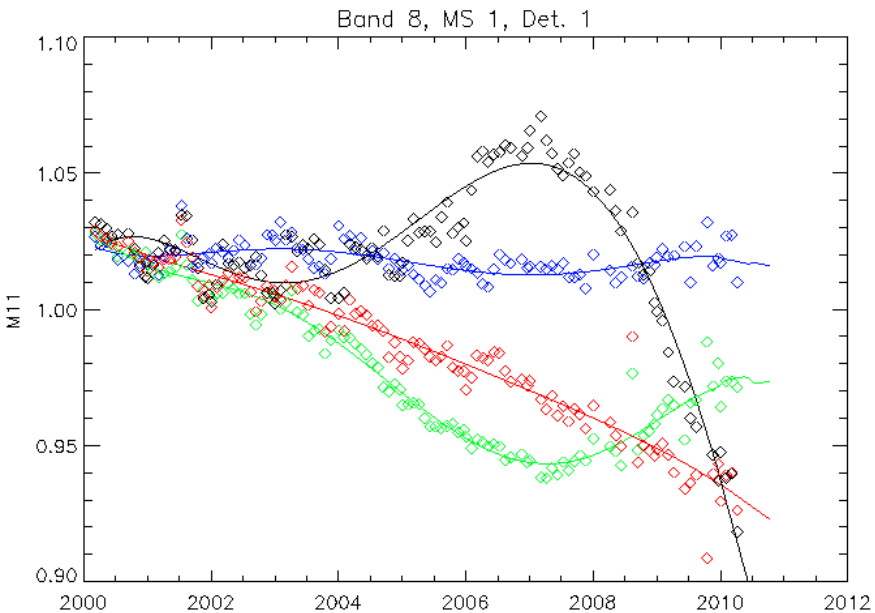


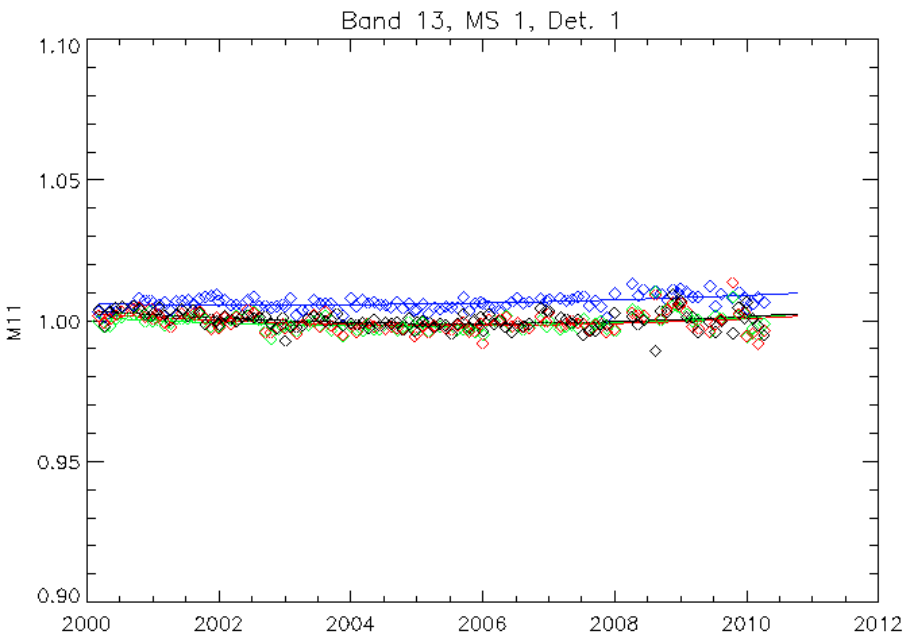
Color coding: Frames (pixels) 22 675 989 1250 (out of 1354)

Solid line is a fit to the measurements of each month (diamonds)

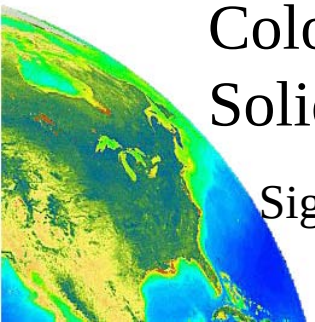
Significant variations in the blue (up to 40% at the end of scan at 412nm (band 8)), very small corrections for the red (band 13 at 667nm)

Comparison to MODIS Terra radiometric corrections as a function of time at different view angles:





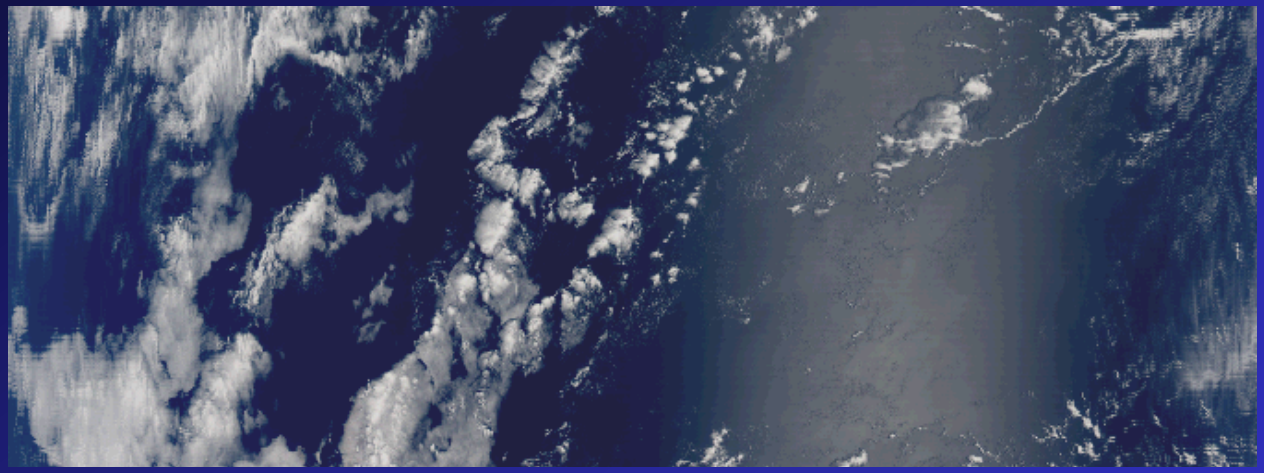
Color coding: Frames (pixels) 22 675 989, 1250 (out of 1354)
Solid line is a fit to the measurements of each month (diamonds)



Significant corrections in the blue (up to 10% at 412nm (band 8)), very small corrections for the red (band 13 at 667nm)

Surface Effects

Sun Glint



White Caps

Corrections based on statistical models (wind & geometry)