MODIS Terra Ocean Color

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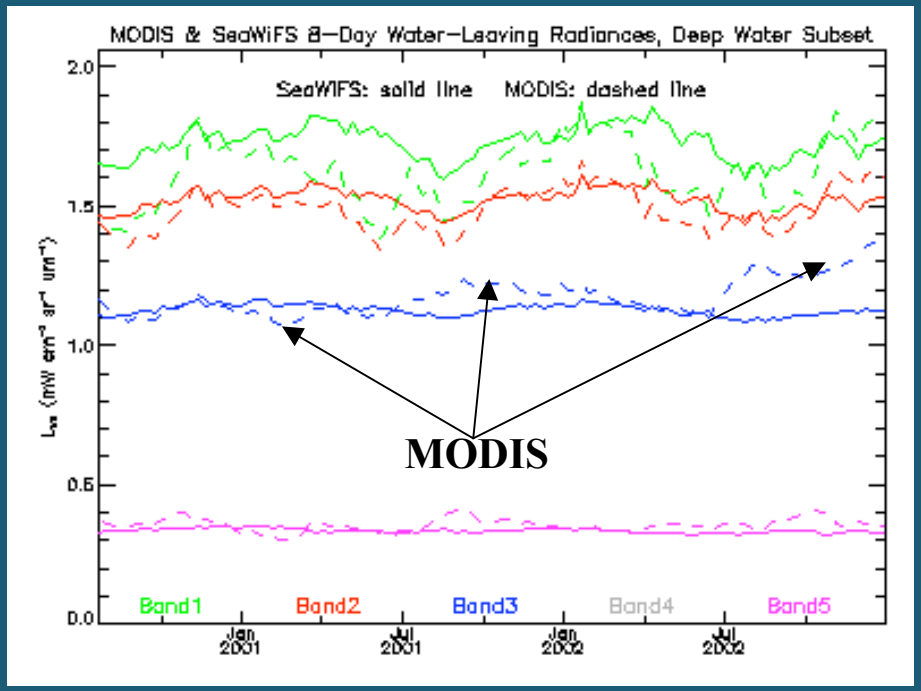
NASA Ocean Biology Processing Group

Ocean Color Research Team Meeting, Seattle WA, 11-13 April 2007

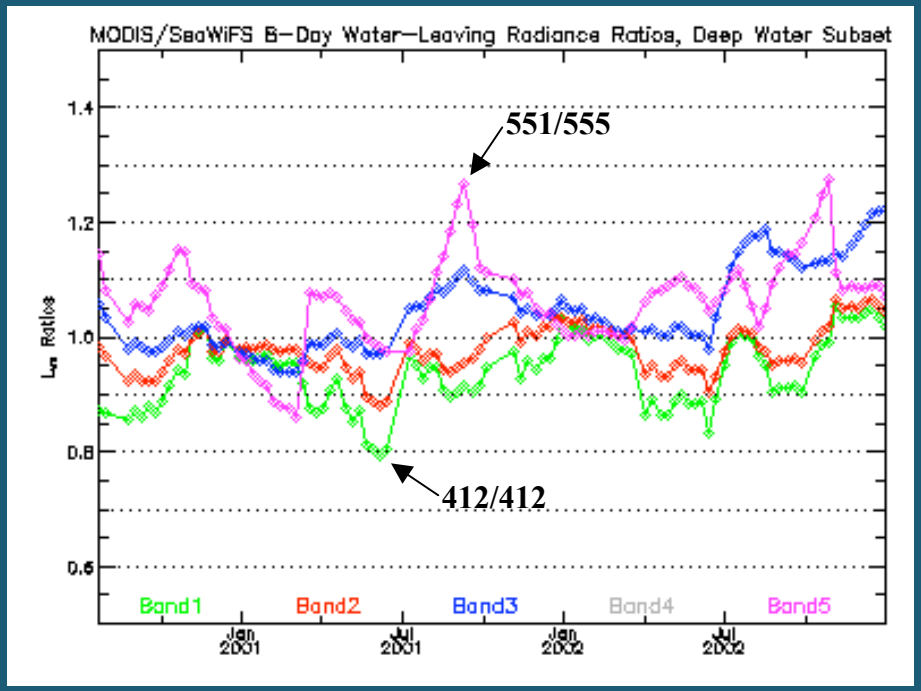
Deep-Water nLw Trends

MODIS-Terra Collection 4.1 vs SeaWiFS Reprocessing 4

SeaWiFS & MODIST



MODIST / SeaWiFS



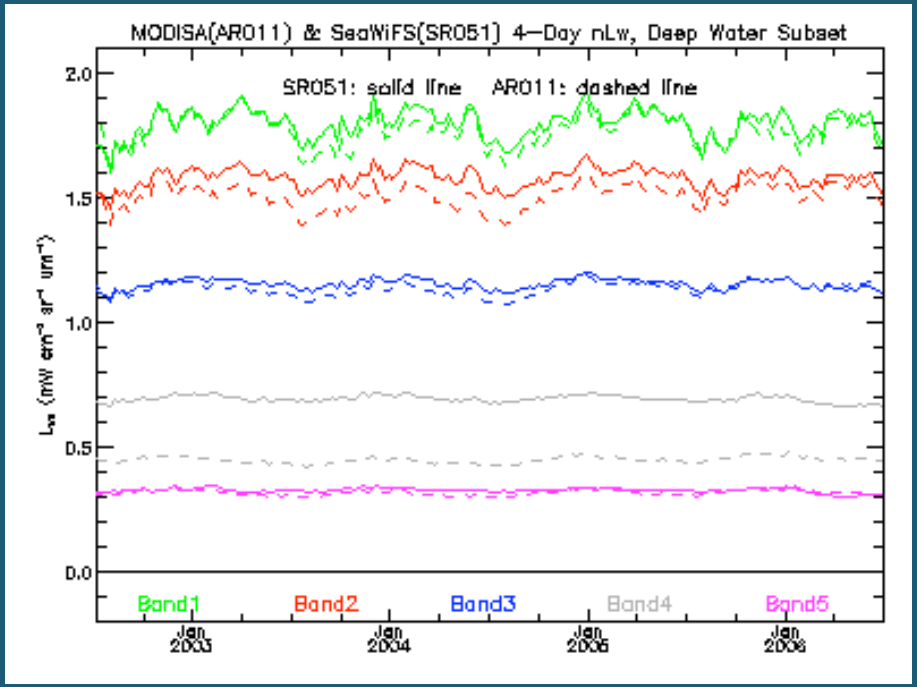
NASA discontinued MODIS-Terra Ocean Color processing and directed the OBPG to concentrate on MODIS-Aqua ....

ASLO-TOS, Feb 2004

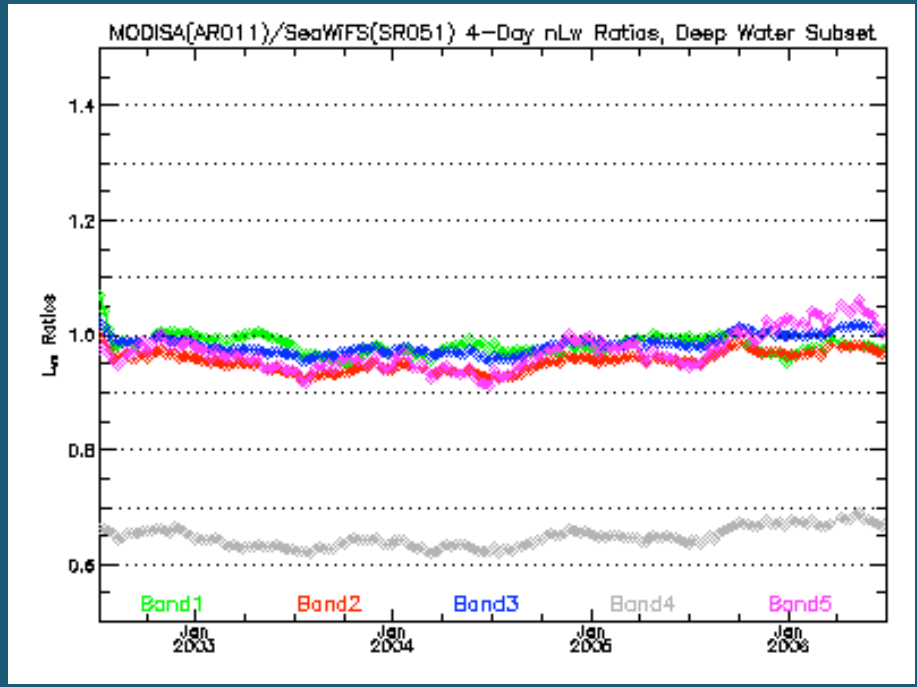
Deep-Water nLw Trends

MODIS-Aqua Reprocessing 1.1 vs SeaWiFS Reprocessing 5.1

SeaWiFS & MODISA



MODISA / SeaWiFS



With lessons learned from MODIS-Aqua, NASA decided to revisit MODIS-Terra Ocean Color processing ....

Major Issues with MODIS-Terra for OC

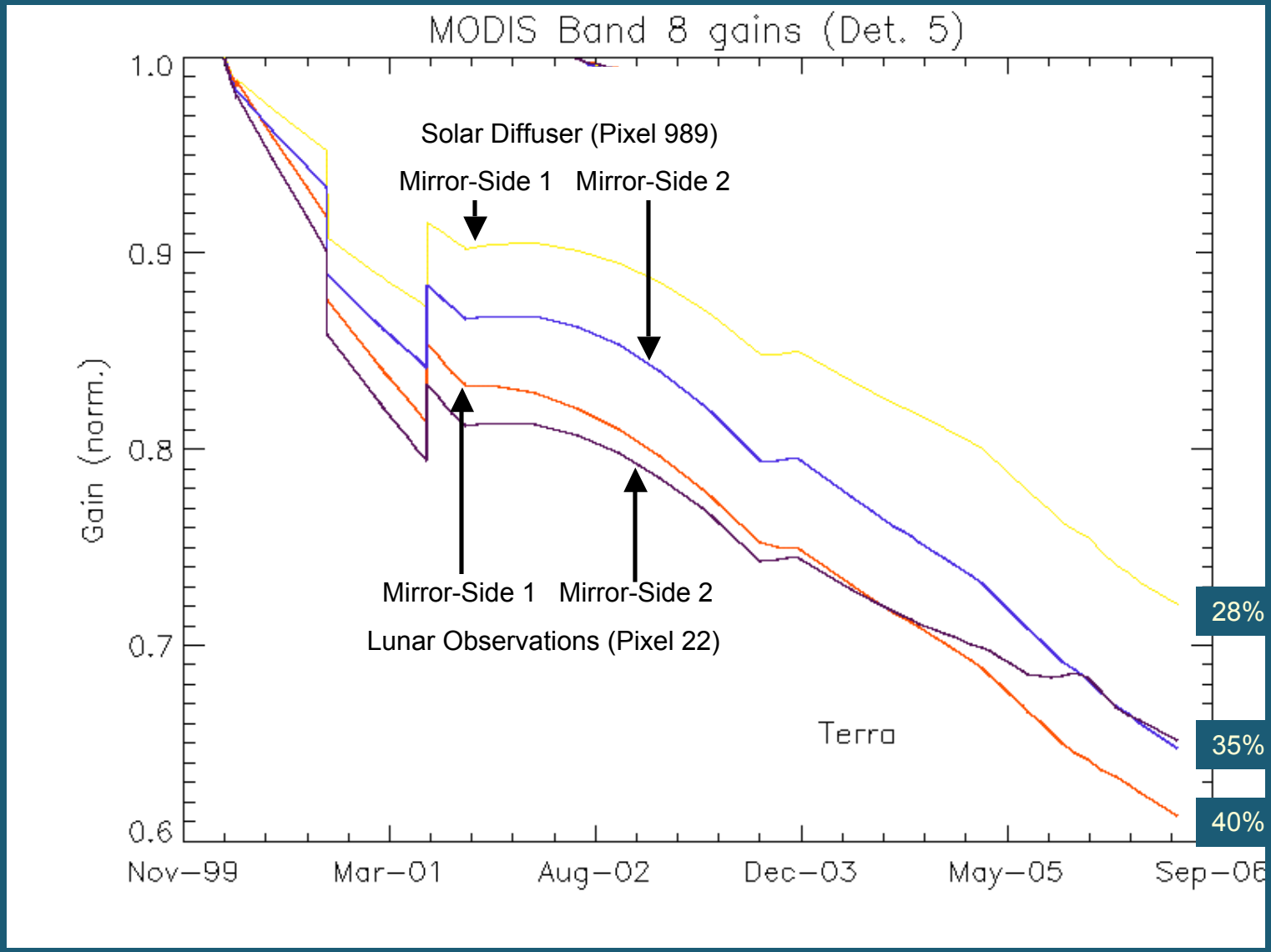
- Instrument state changes introduce calibration epochs
- Substantial temporal degradation of instrument response in some spectral bands
- Overheating event in pre-launch testing "smoked" the mirror, subsequent to pre-launch characterization

Approach to MODIS-Terra OC Development

- Concentrate on forward stream (Jan 2005 to present)
- Review and revise pre-launch characterization (polarization)
- Work with MCST to develop and evaluate on-orbit calibration
- Apply common (MODIS-SeaWiFS) software and algorithms
- Apply common vicarious calibration approach
  - SIO/SPG, MOBY, mission averaged gain
- Test and evaluate changes on global scale

MODIS Temporal Degradation at 412 nm

Lunar and Solar Calibration Trends

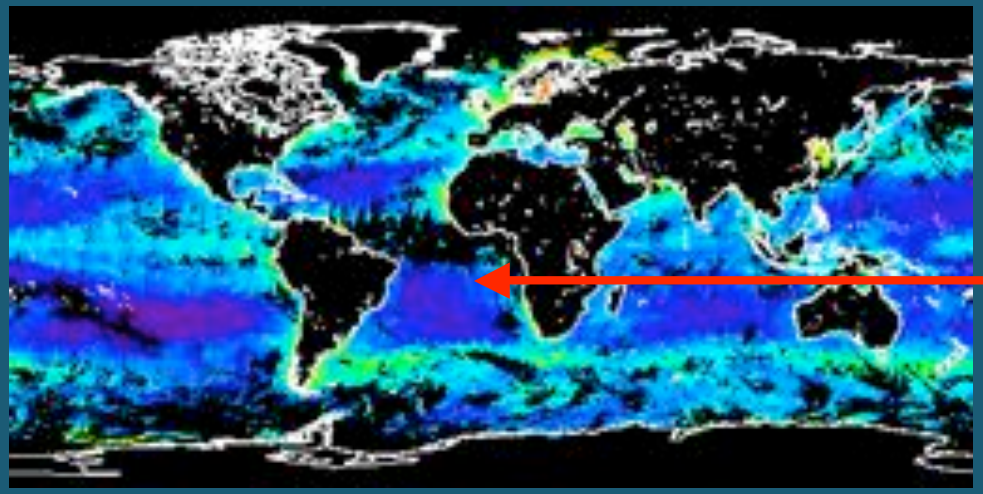


- Instrument response has degraded by as much as 40% (412nm), presumably due to changes in mirror coatings
- Mirror-sides degrading at significantly different rates, with larger changes in mirror side 2
- Change in mirror implies loss of characterization knowledge
  - response versus scan angle (RVS)
  - polarization sensitivity
- Need to quantify relative variability between mirror sides and with respect to scan angle
  - evaluate impact to derived products

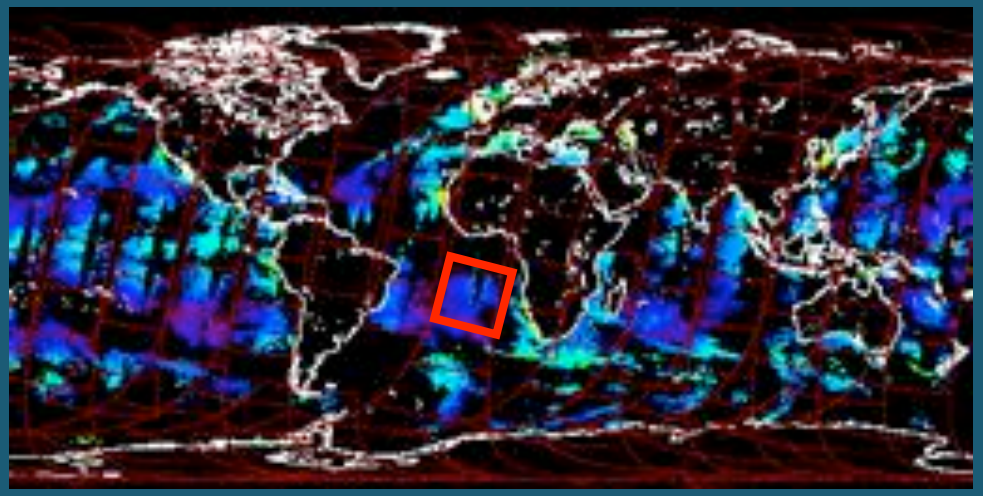
Level-2 to Level-3 Match-up Analysis

Assessment of Residual RVS, Mirror-Side Differences, and Detector Striping

7-Day Composite Level-3 Bin Product



Central Day

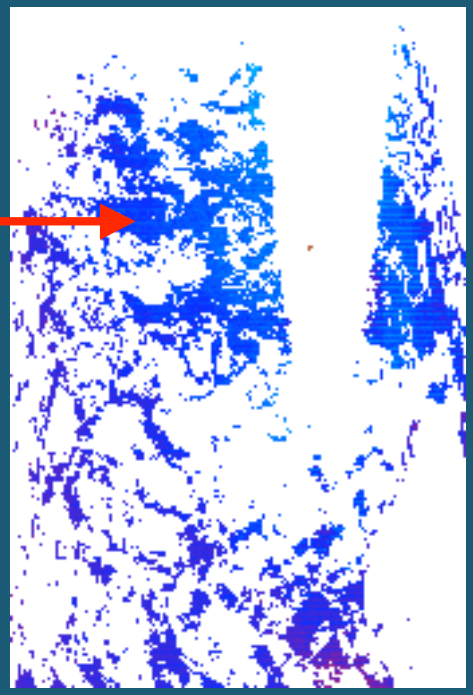


[*L2, L3*] $nL_w(\lambda)$, τ_a, ε, C_a

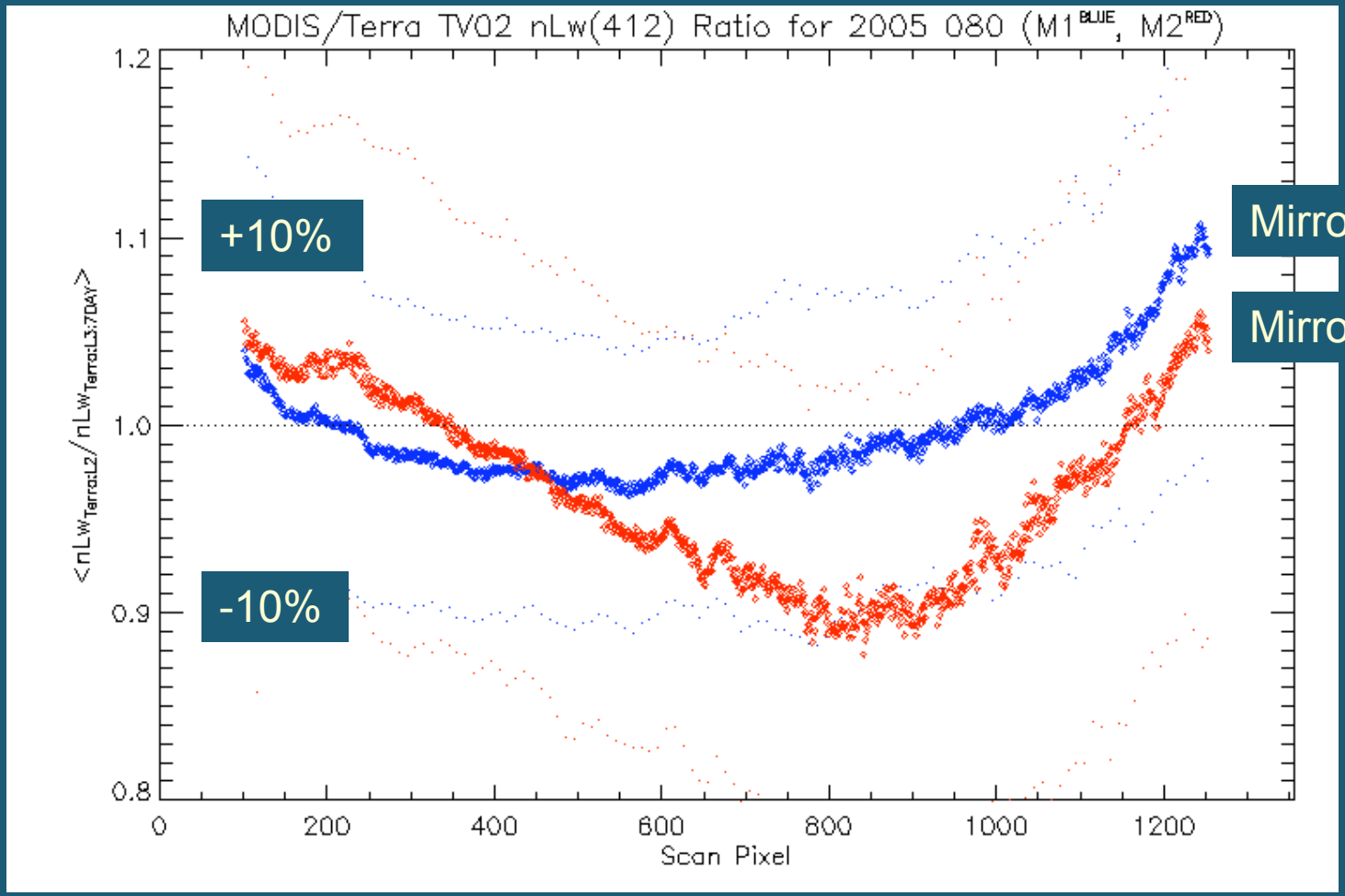
[*L2*] det #, m-side, scan pix

[*L2*] radiant path geometry

Level-2 Granule



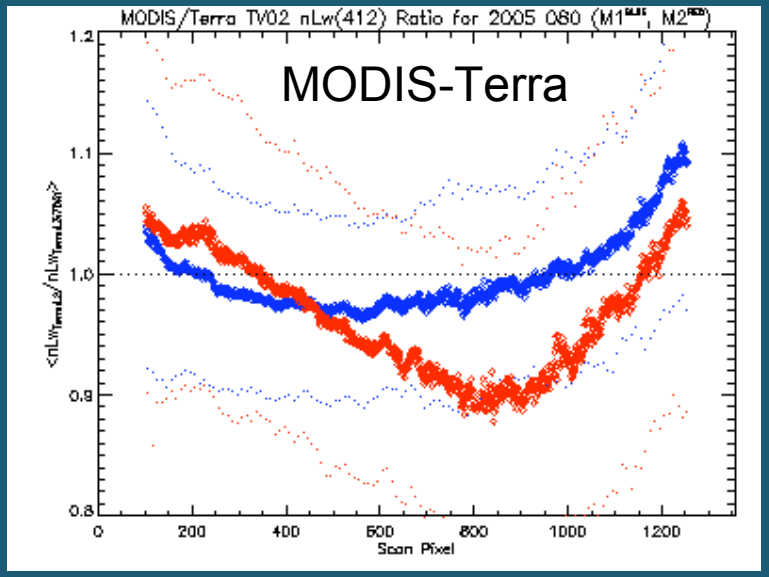
Residual RVS - nLw(412)

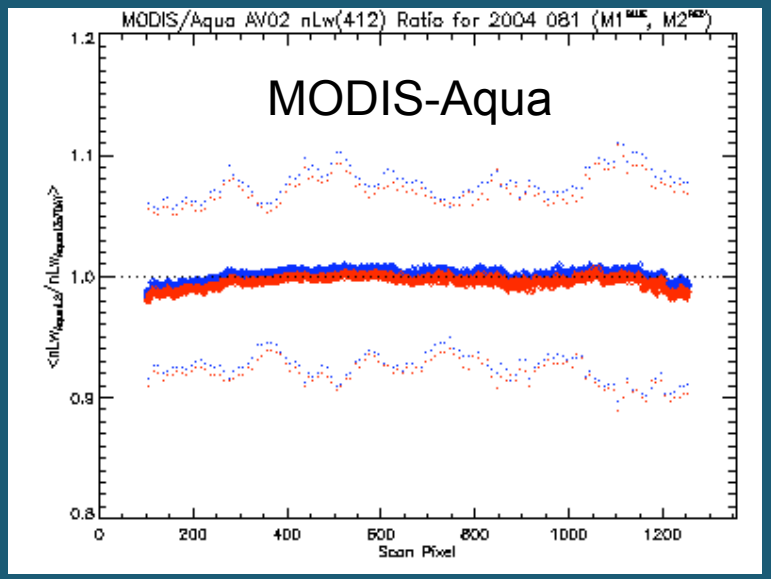


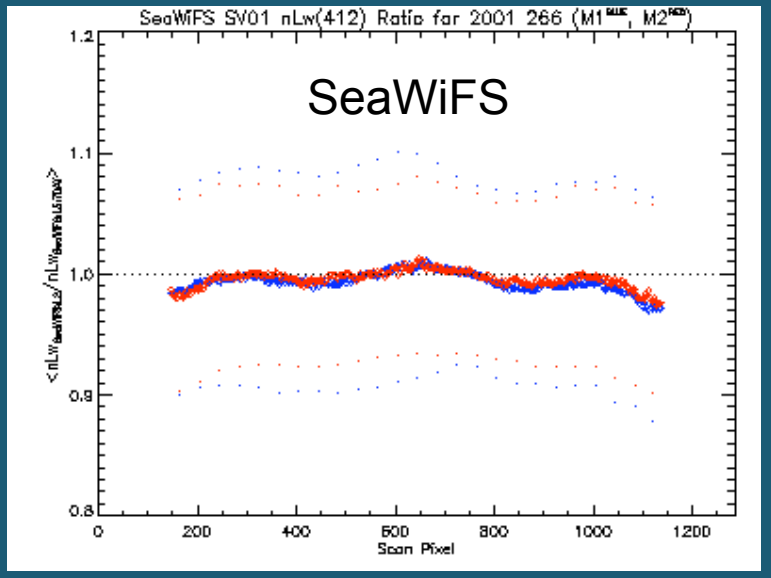
L2 / L3

Scan Pixel

Residual RVS - nLw(412)



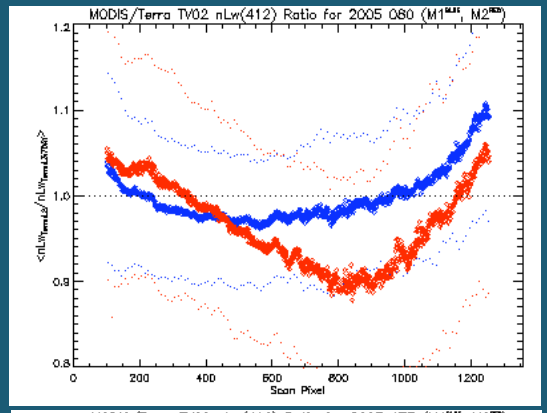




Residual RVS

nLw(412)

2005 080



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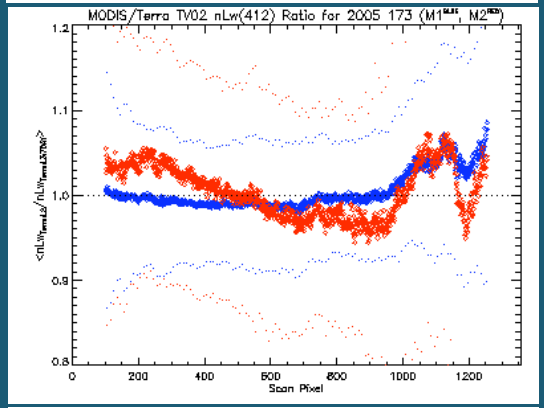

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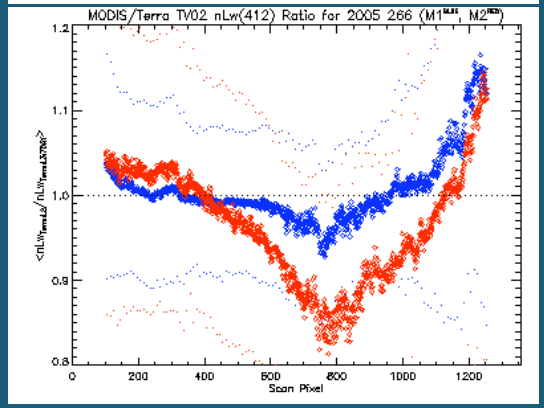
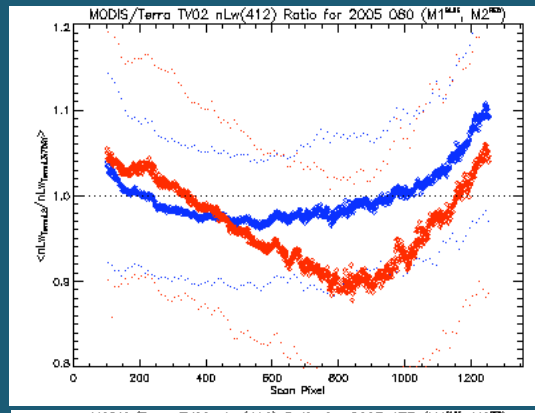
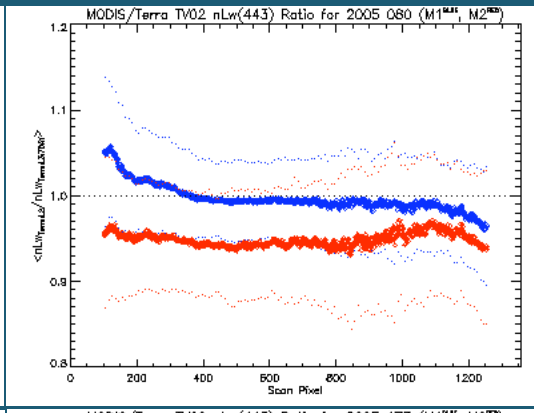
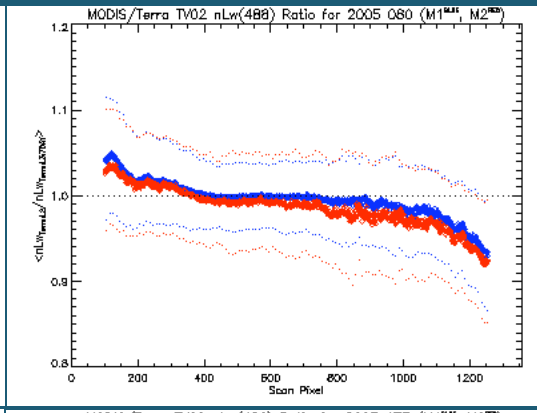
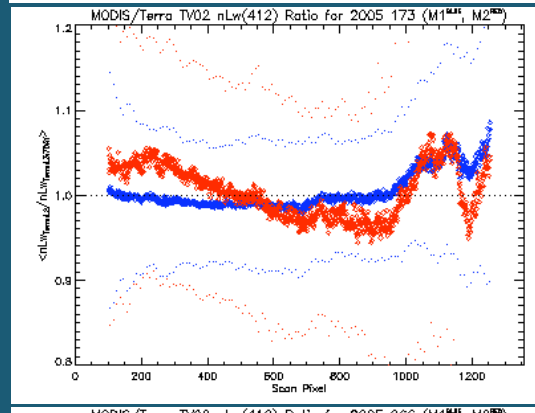
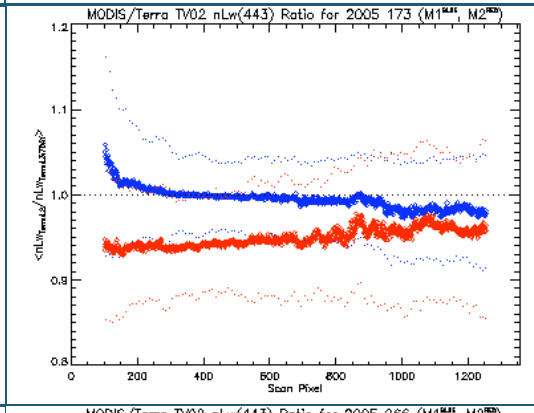
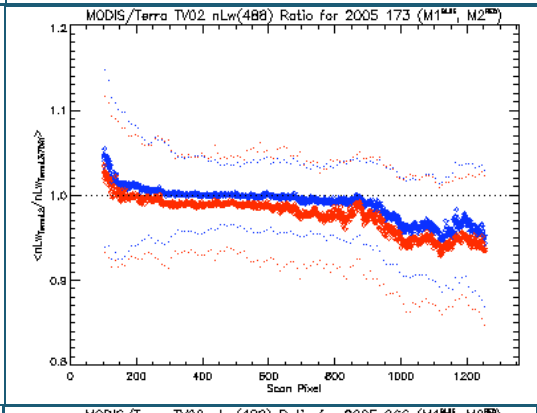
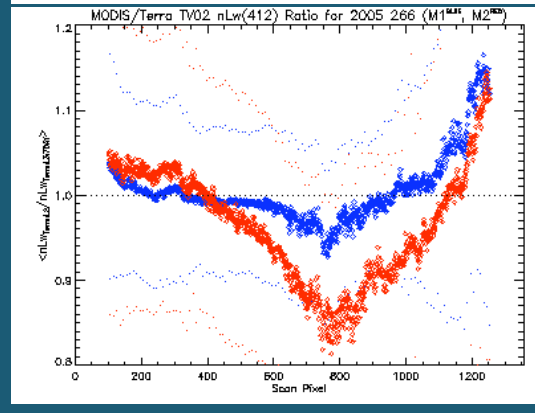
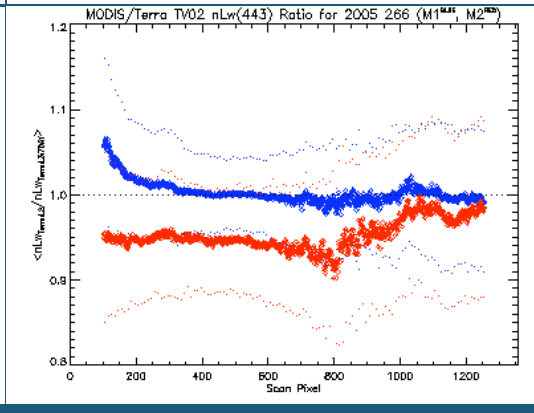
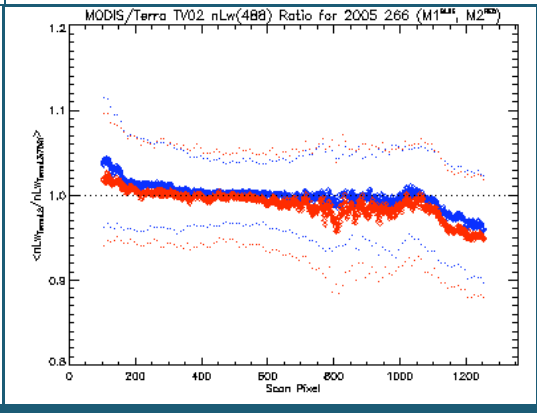
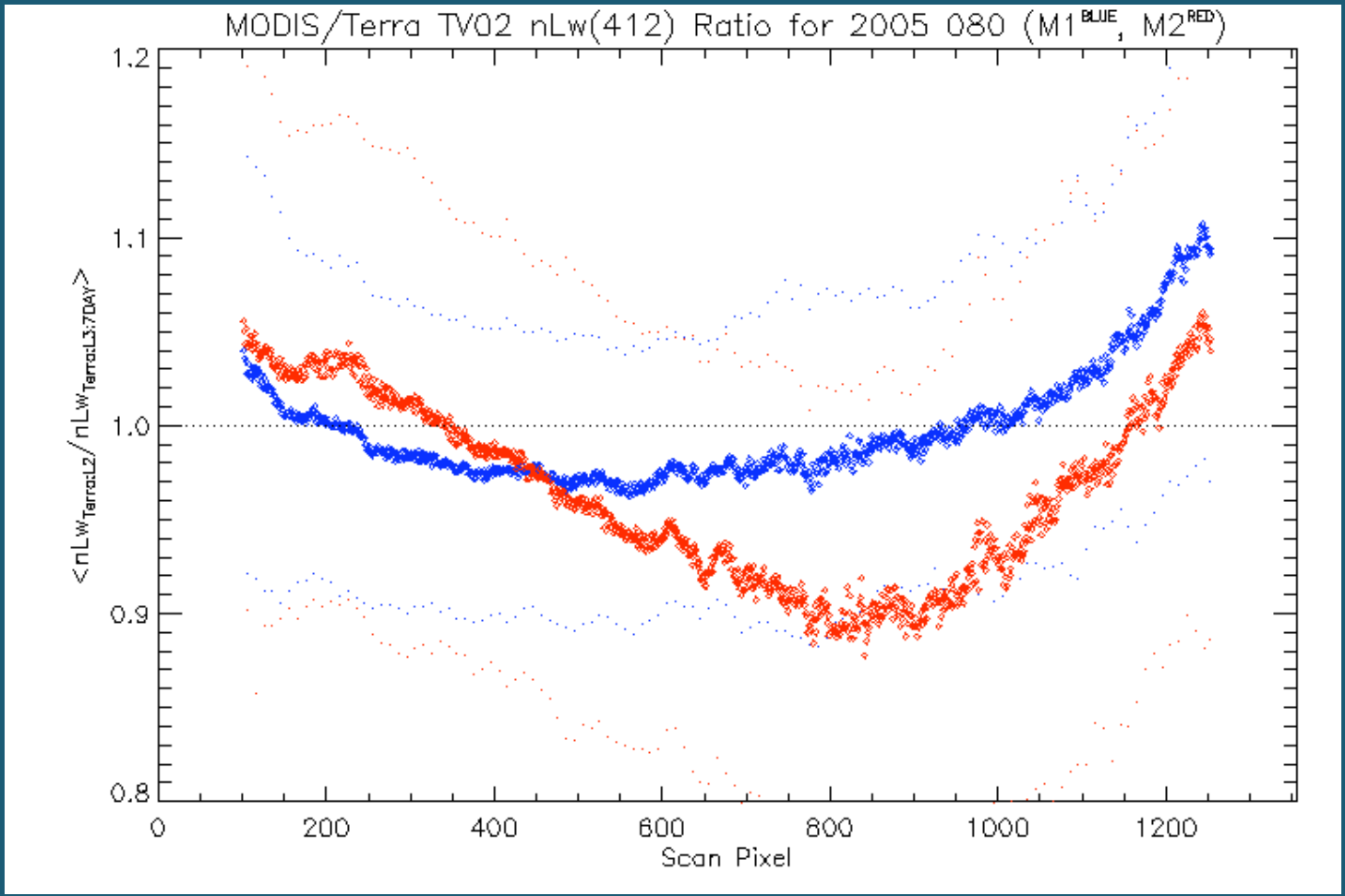


Residual RVS

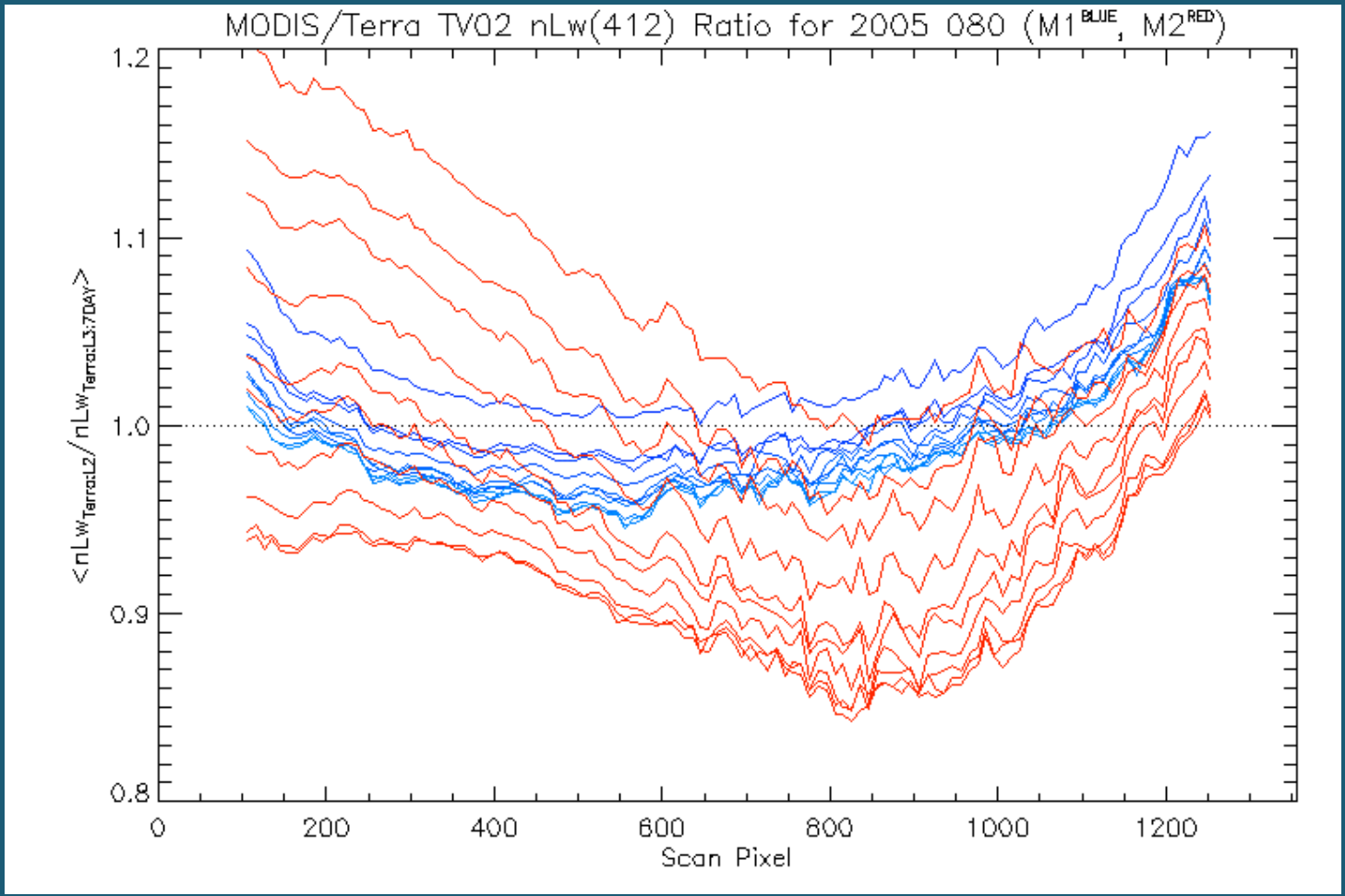
	nLw(412)	nLw(443)	nLw(488)
2005 080			
2005 173			
2005 266			

Residual RVS - nLw(412)



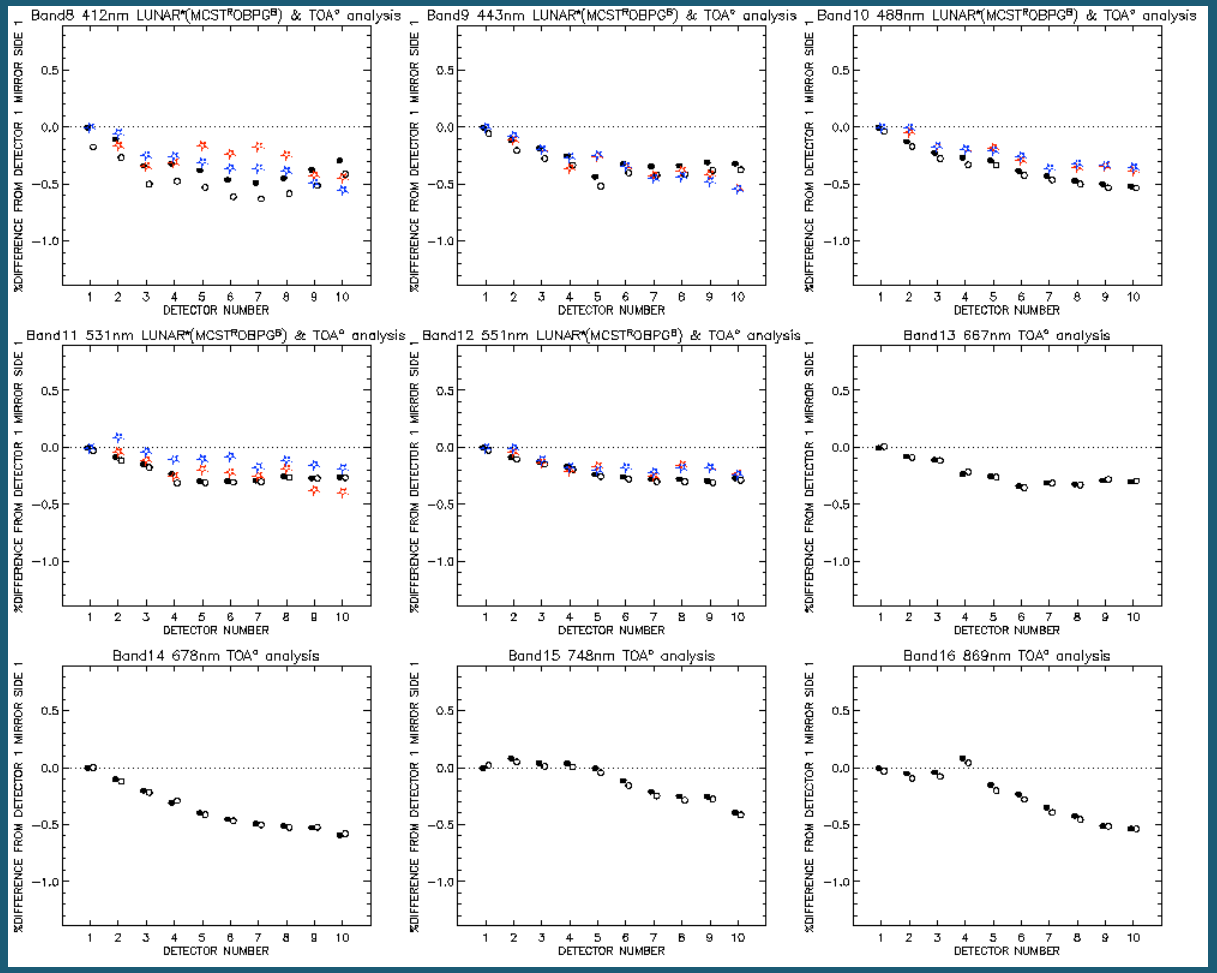
Due to error in instrument RVS characterization and/or polarization ?

Residual RVS per Detector - nLw(412)



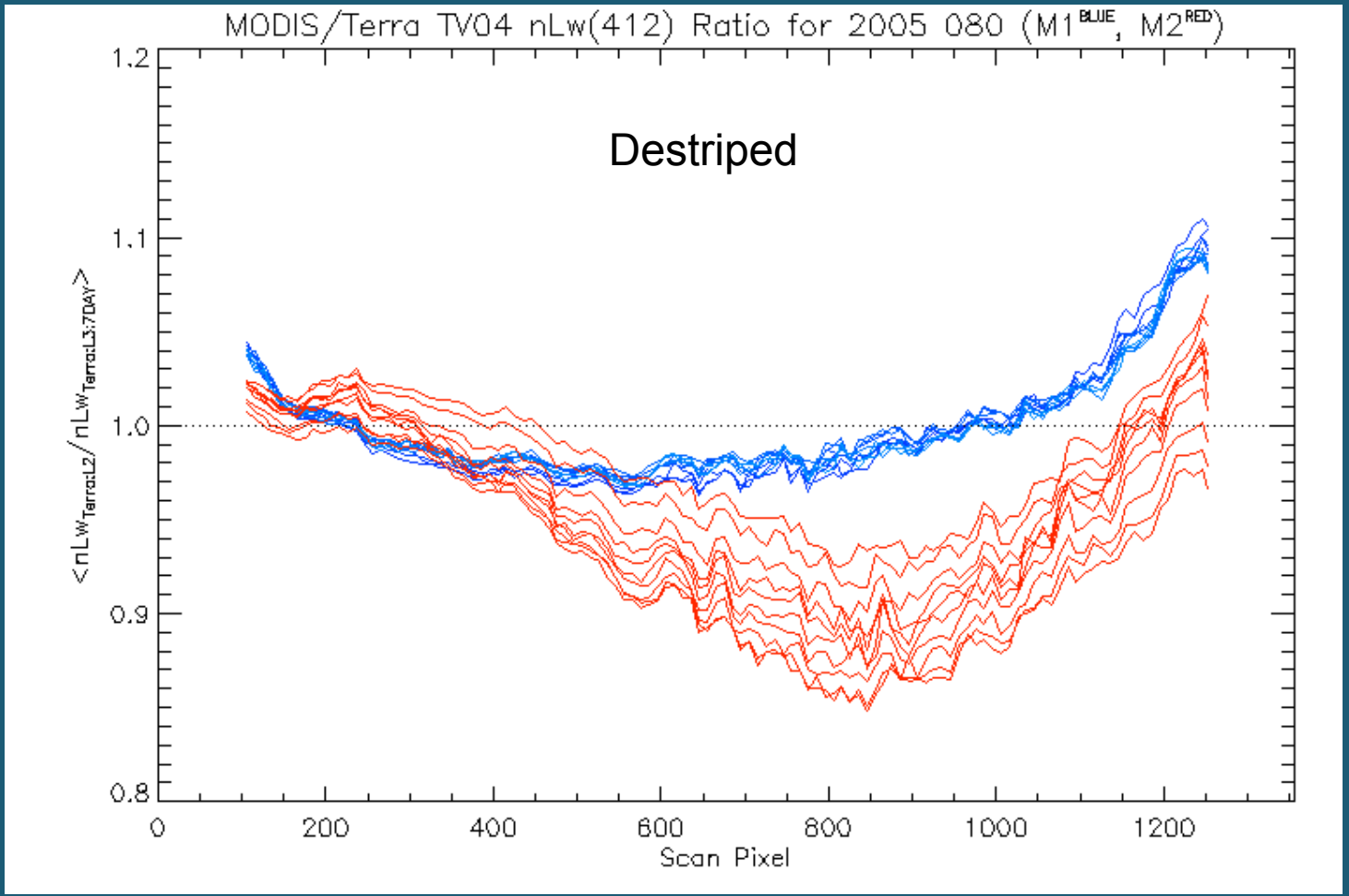
Detector Destriping Correction for Aqua

statistical TOA analysis verified with lunar observations
temporally constant, implemented in Level-1B LUT

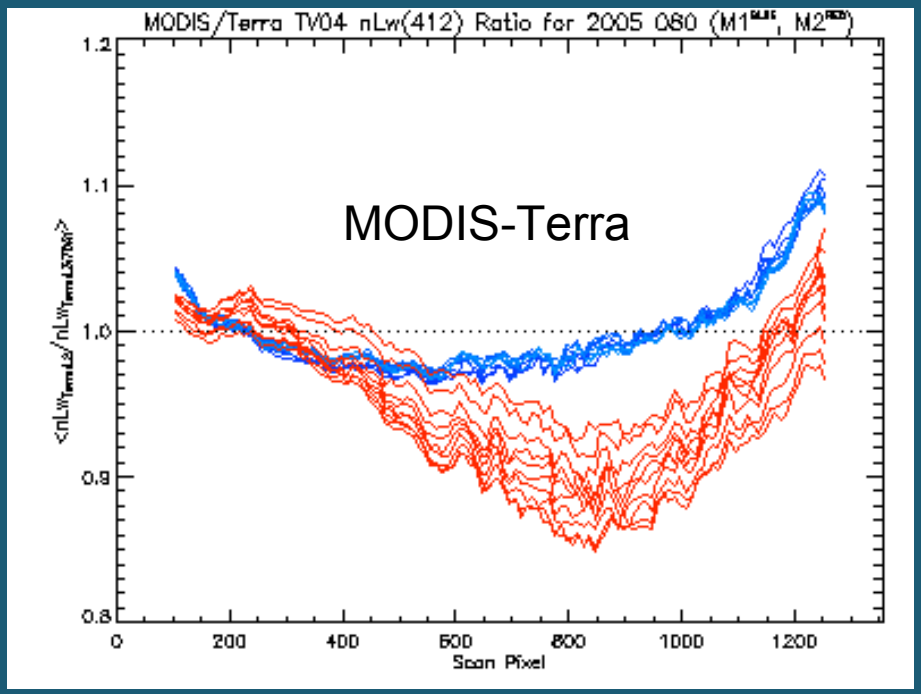


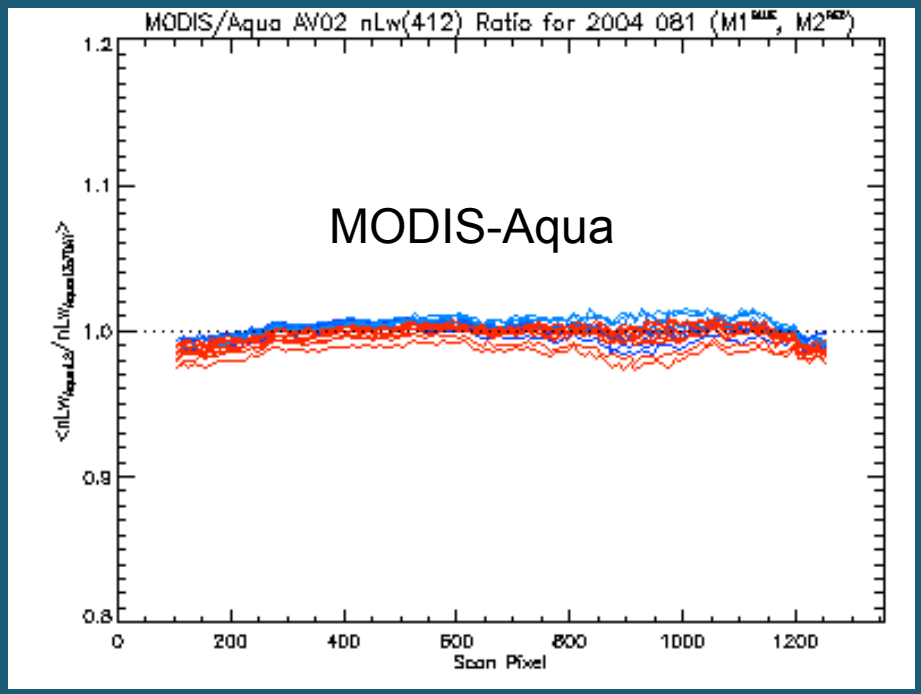
Meister, G., W. Kwiatkowsak, and C.R. McClain (2006). Analysis of image striping due to polarization correction artifacts in remotely sensed ocean scenes. in proc. SPIE Earth Observing Systems XI, San Diego, Ca, 14-16 August 2006.

Residual RVS per Detector - nLw(412)



All things being equal ...





We require a method to derive MODIS-Terra instrument RVS and polarization sensitivities on-orbit ...

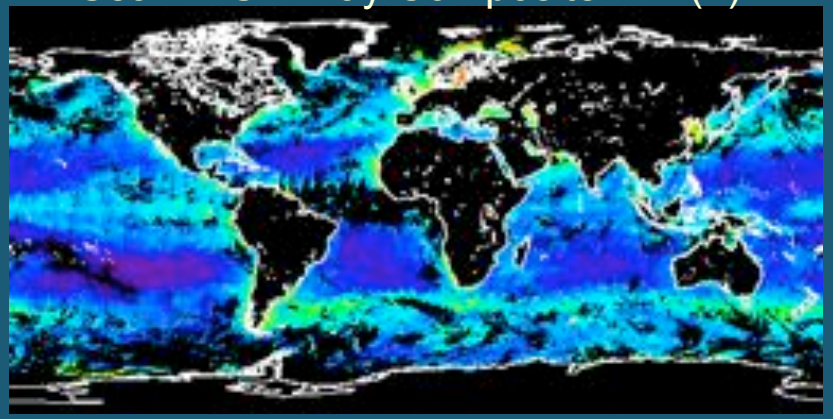
$$L_m(\lambda) = M_{11}L_t(\lambda) + M_{12}(Q_t(\lambda)\cos 2\alpha - U_t(\lambda)\sin 2\alpha) + M_{13}(Q_t(\lambda)\sin 2\alpha + U_t(\lambda)\cos 2\alpha)$$

Vicarious Cross-Calibration Approach

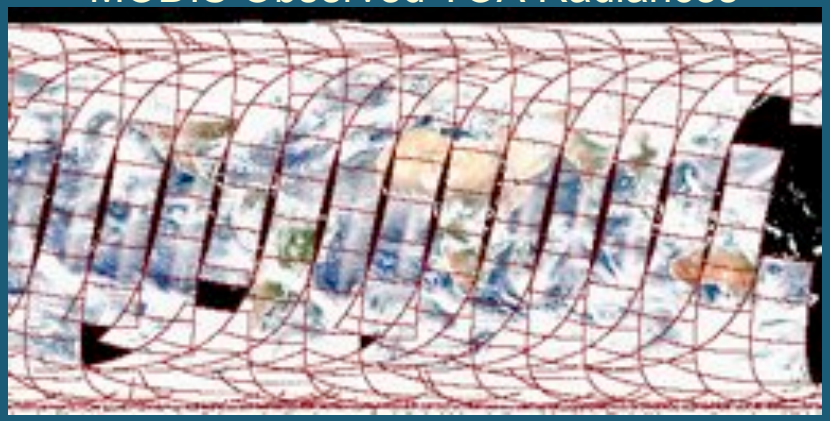
on-orbit characterization of instrument RVS and polarization

$$L_m(\lambda) = M_{11}L_t(\lambda) + M_{12}(Q_t(\lambda)\cos 2\alpha - U_t(\lambda)\sin 2\alpha) + M_{13}(Q_t(\lambda)\sin 2\alpha + U_t(\lambda)\cos 2\alpha)$$

SeaWiFS 7-Day Composite nLw(λ)



MODIS Observed TOA Radiances



Vicarious calibration:

given $L_w(\lambda)$ and MODIS geometry, we can predict $L_t(\lambda)$

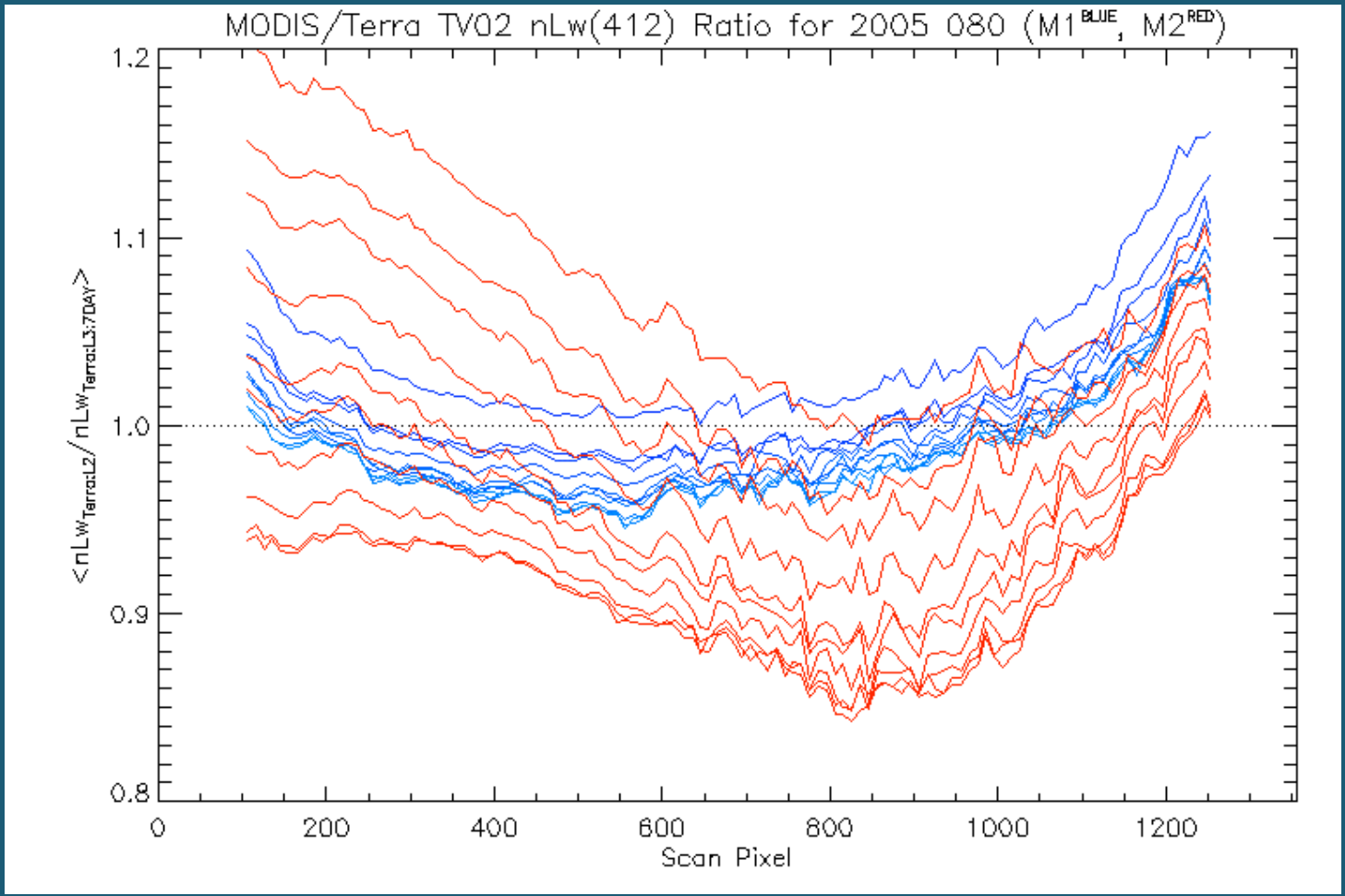
Global optimization:

find best fit M_{11}, M_{12}, M_{13} to relate $L_m(\lambda)$ to $L_t(\lambda)$

where M_{xx} = fn(mirror aoi)

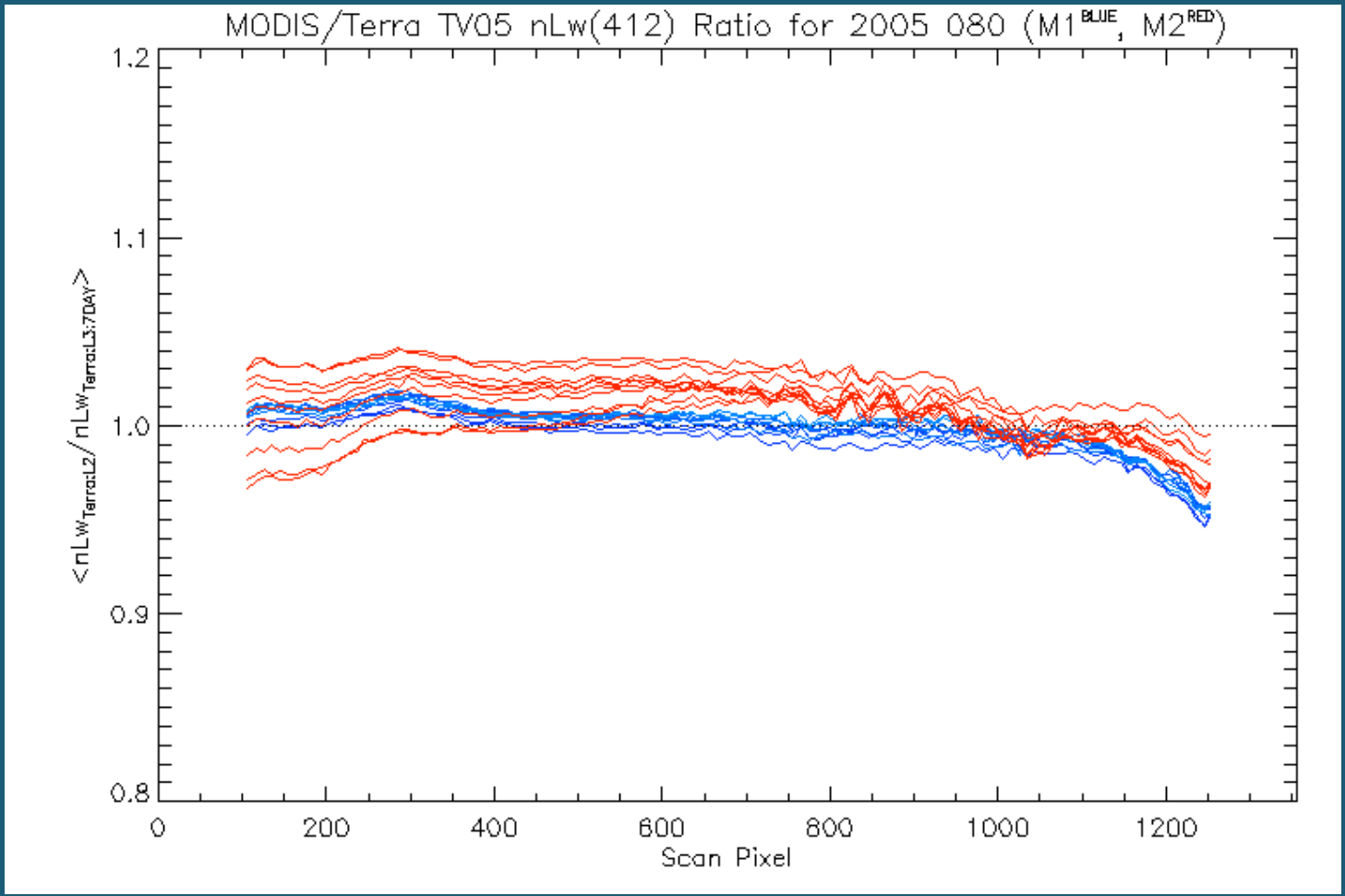
per band, detector, and m-side

Residual RVS per Detector - nLw(412)

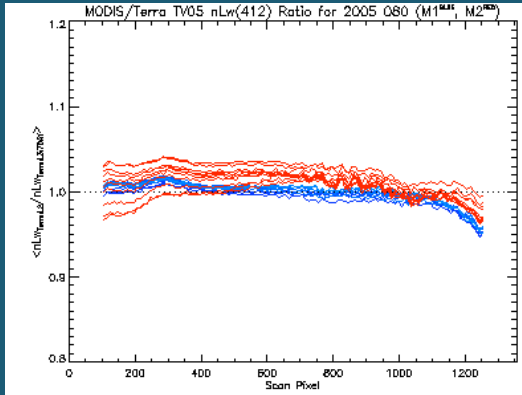
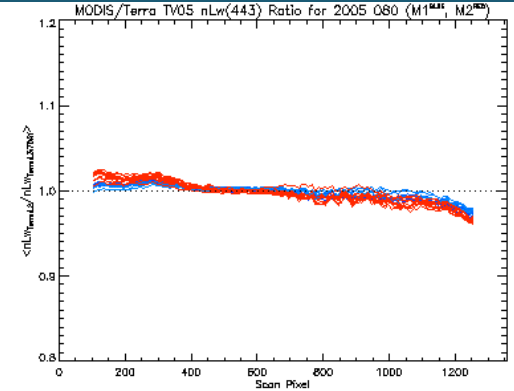
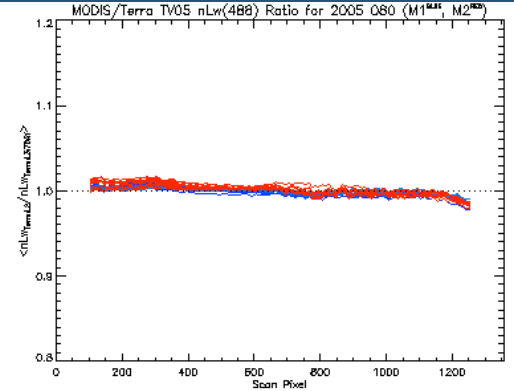
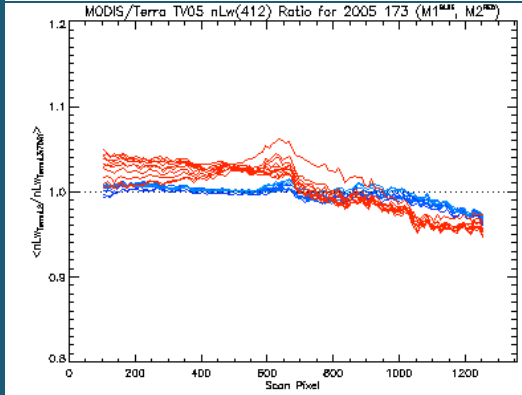
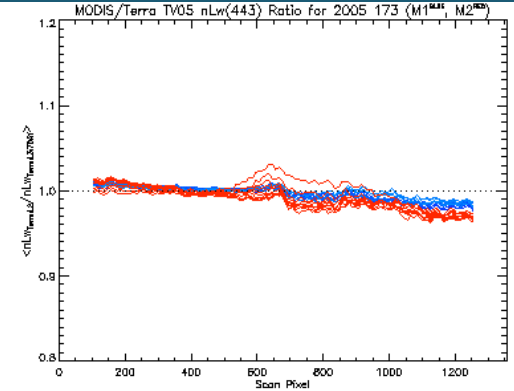
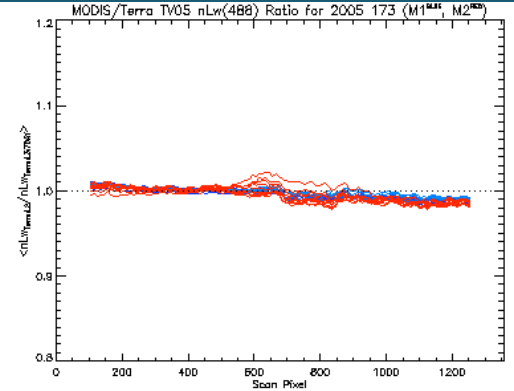
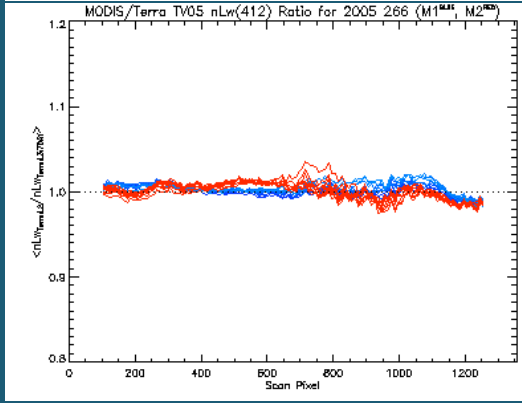
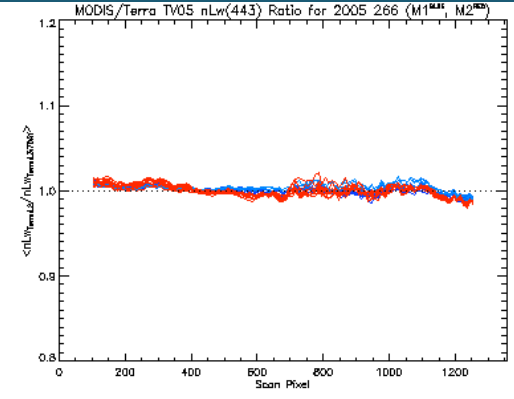
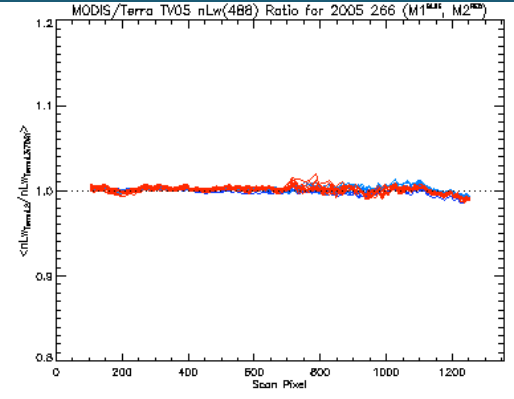


the depths of despair ...

Residual RVS per Detector - nLw(412)
after vicarious characterization



Residual RVS (after vicarious characterization)

	nLw(412)	nLw(443)	nLw(488)
2005 080			
2005 173			
2005 266			

Residual RVS (before vicarious characterization)

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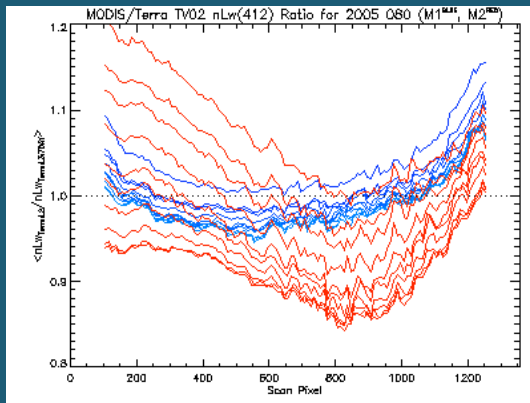
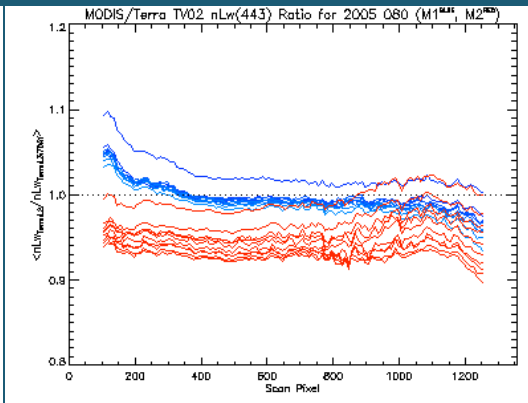
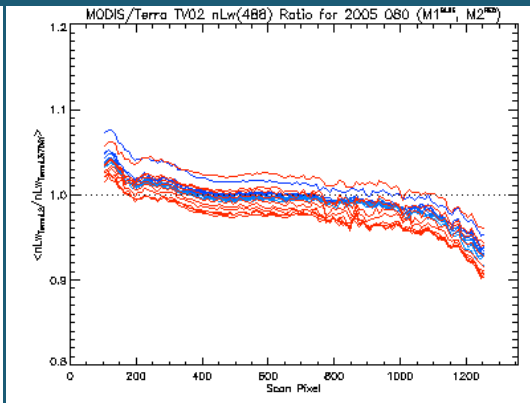
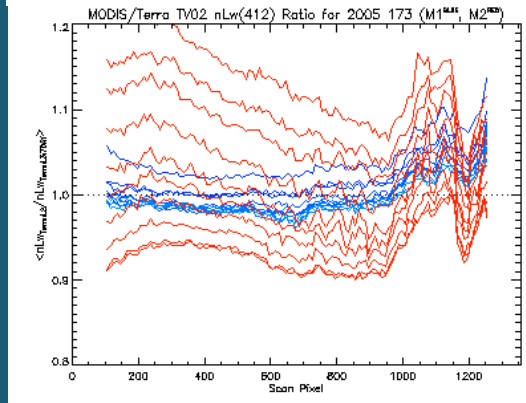
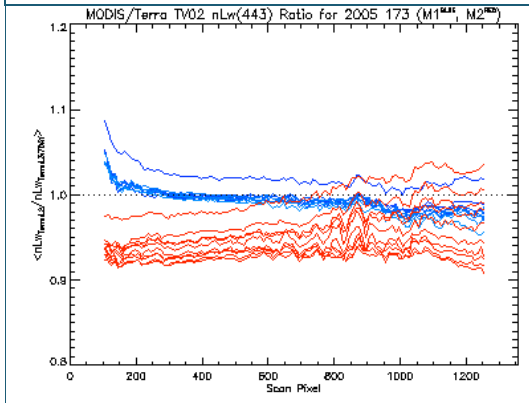
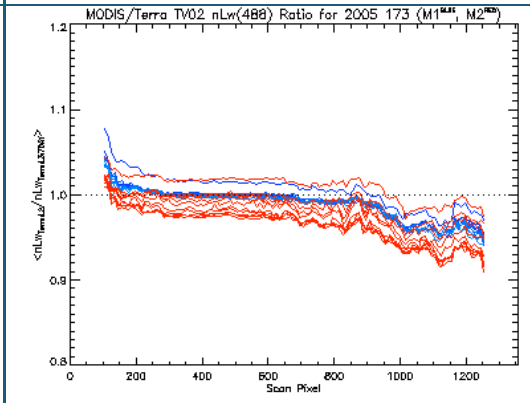
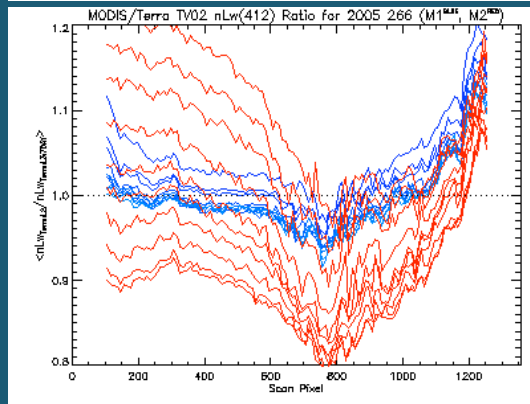
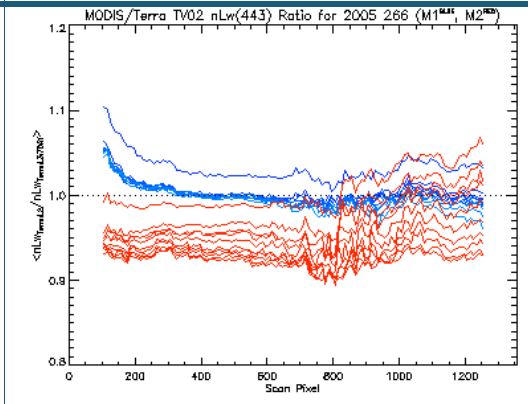
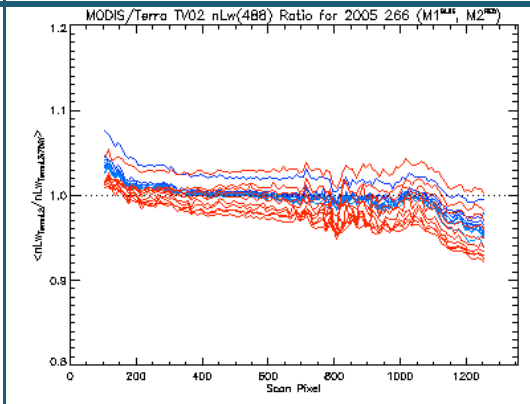
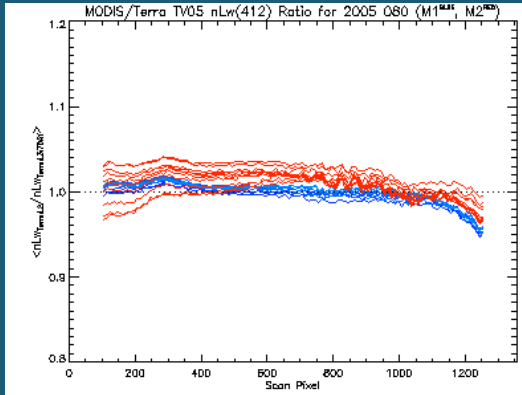
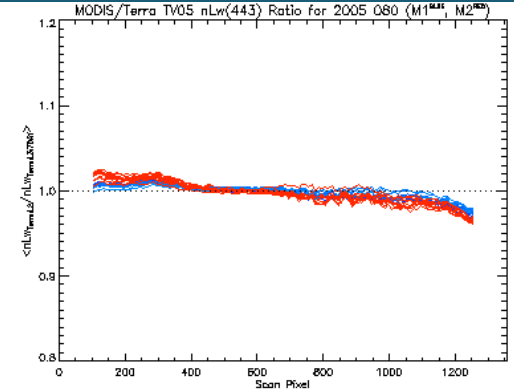
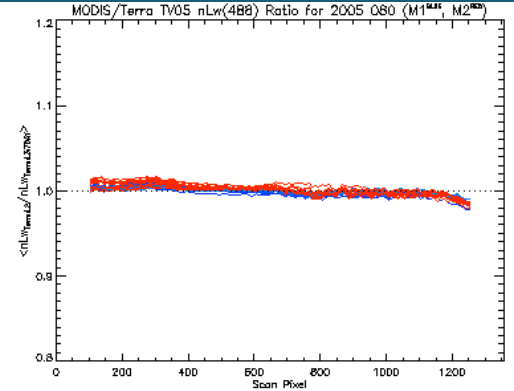
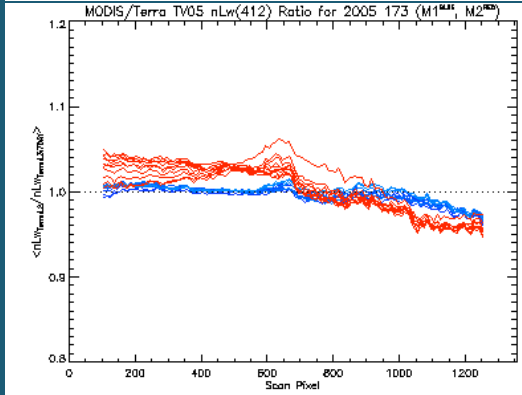
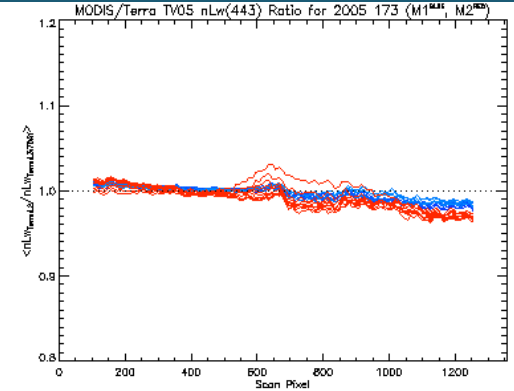
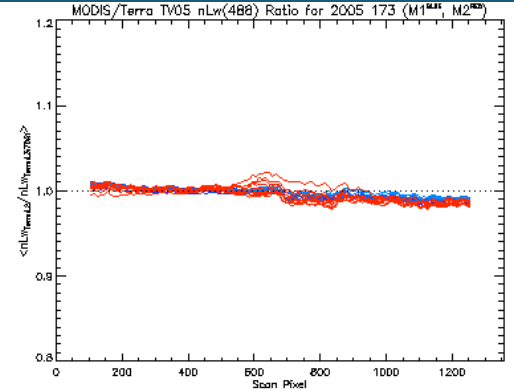
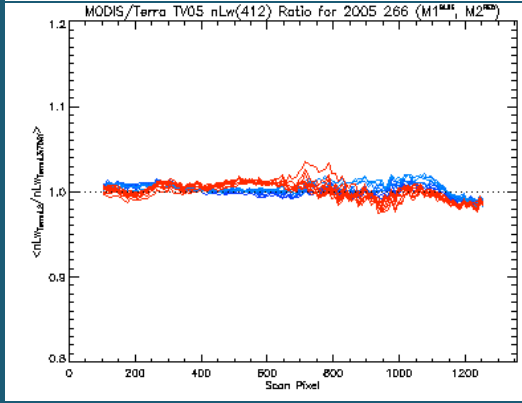
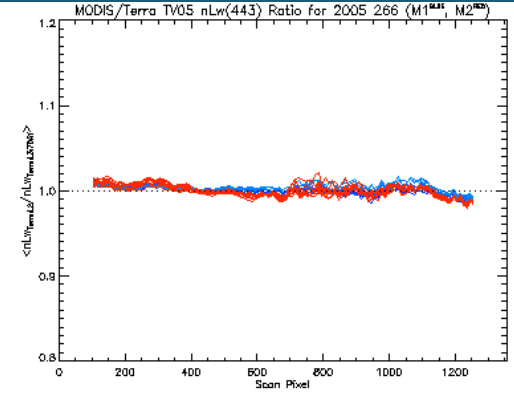
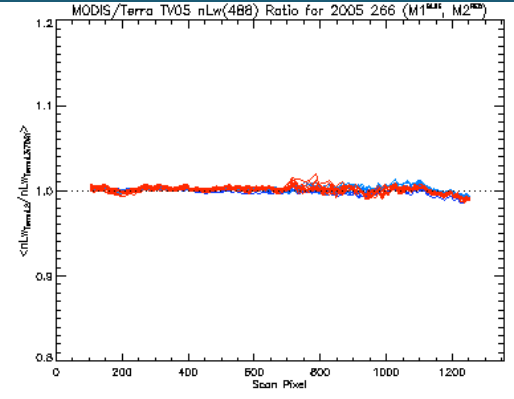
2005 080			
2005 173			
2005 266			

Residual RVS (after vicarious characterization)

	nLw(412)	nLw(443)	nLw(488)
2005 080			
2005 173			
2005 266			

Future Plans

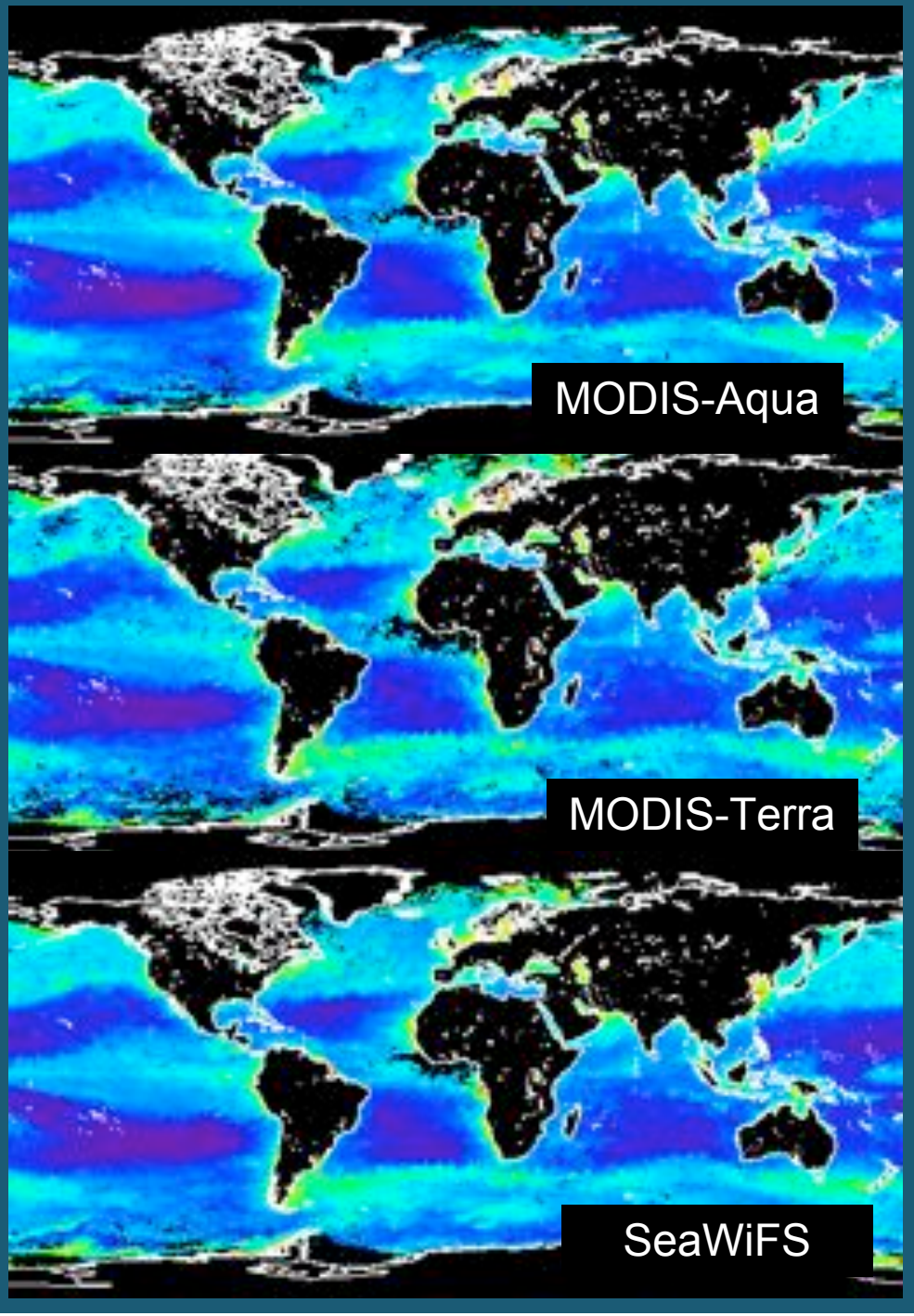
- Examine stability of vicarious on-orbit characterization with time
  - derive on annual or seasonal basis
- Are results physically realistic?
- Expand analysis to full-mission
  - full Terra L0 archive now in-house
- Begin detailed analysis of temporal trends

In parallel with OBPG cal/val efforts:

MODIS-Terra data is being distributed to the community via the ocean color web browsers, for qualitative use

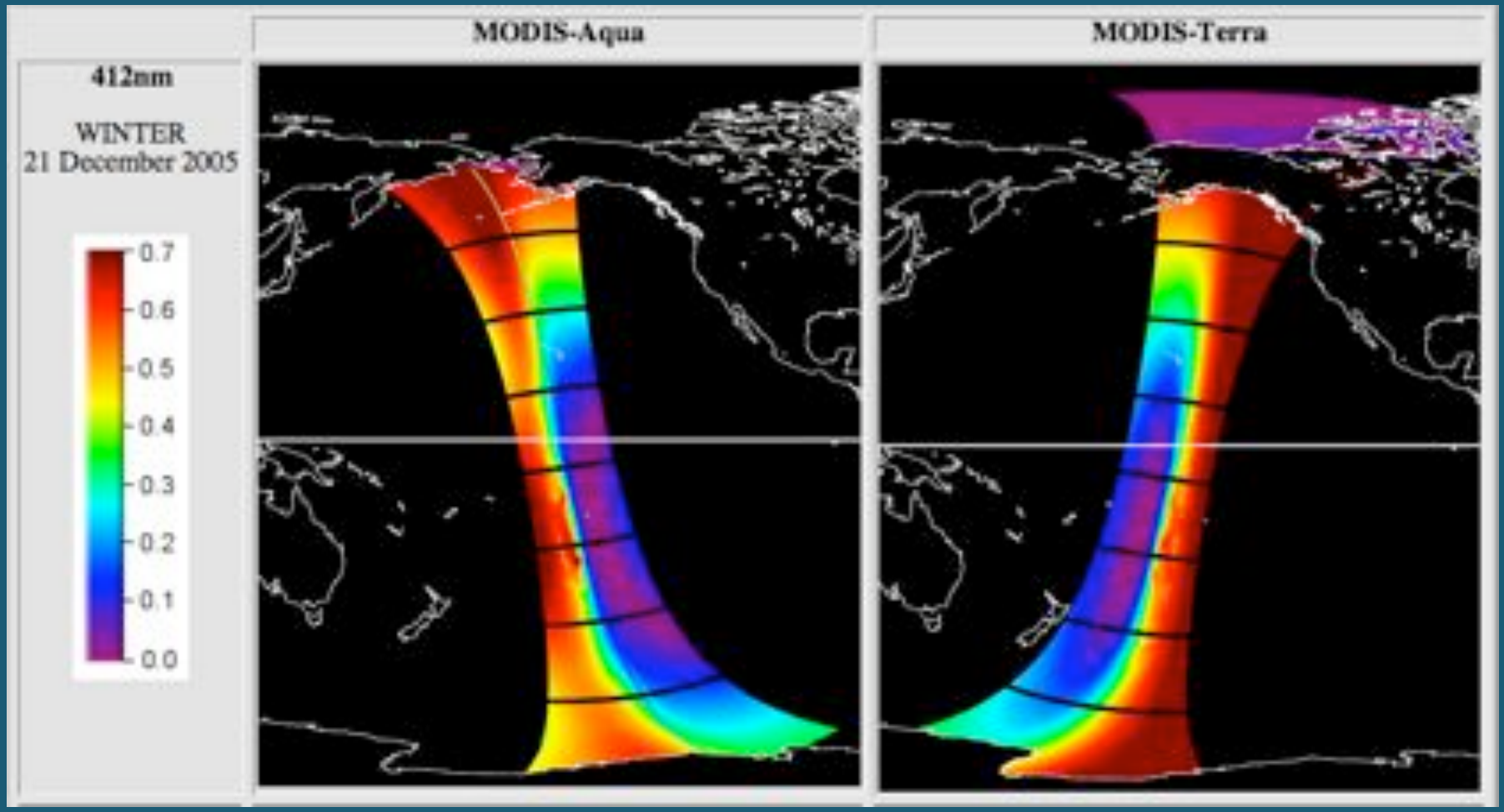
Full processing (L0-L3) and display support also provided in SeaDAS.

These products do not include recent OBPG characterization efforts (MCST characterization + vicarious calibration)



Thank You!

Degree of polarization for Rayleigh atmosphere and sun-glint observed by the sensors



nLw only
operational polarization sensitivity and calibration for NIR bands and no polarization correction for VIS bands (because it is to be derived)
Q and U polarization components included aerosol polarization (aerosol polarization may not be particularly important)
derived M11, M12, and M13 approximated by 3rd deg. polynomial fit along MODIS scan

$$Lm = M11Lt + M12(Qt\cos 2\alpha - Ut\sin 2\alpha) + M13(Qt\sin 2\alpha + Ut\cos 2\alpha)$$

where M are MODIS Mueller matrix componenets representing instrument gain, M11, and polarization sensitivity, M12 and M13

Residual RVS - nLw(412)