

Analysis of image striping due to polarization correction artifacts in MODIS Aqua ocean scenes

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Background

- Ocean color has stringent calibration requirements of about 0.2% (85-95% of TOA signal is subtracted)
- Even if nLw accuracy is within specification (5%), we often see striping in the images
- Striping can be caused by inaccuracies in calibration or characterization (e.g. polarization: local striping)

MODIS detector residuals

- Primary calibration source: solar diffuser (SD) measurements for each detector
- Secondary calibration source: lunar measurements, applied as a scan angle correction averaged over detectors
- Lunar detector residuals to SD calibration: detector 1 is about 0.5% higher than detector 10 (MCST result)

MODIS Aqua TOA Analysis:

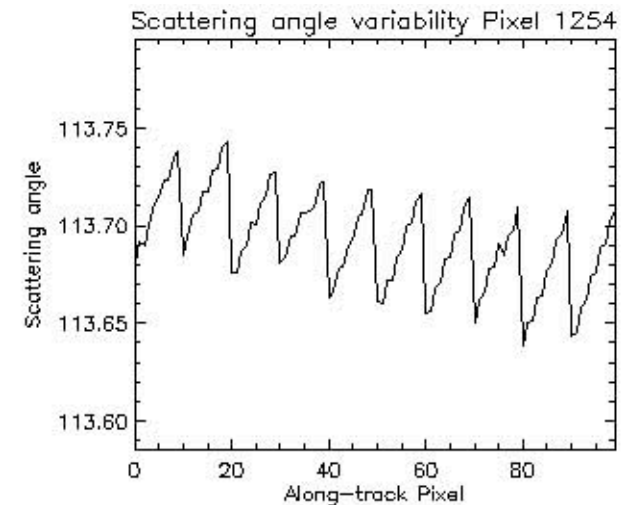
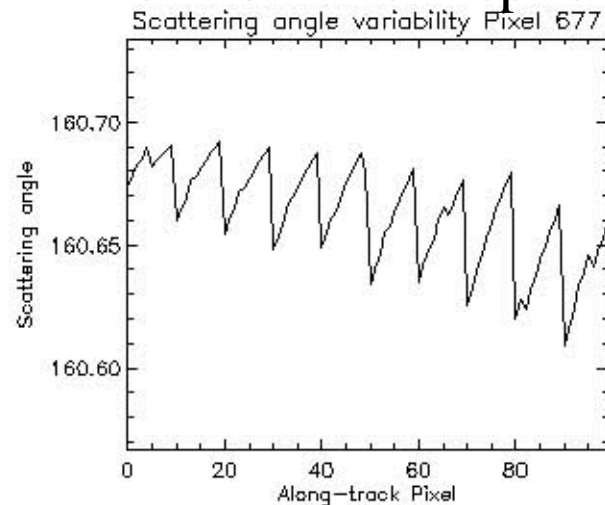
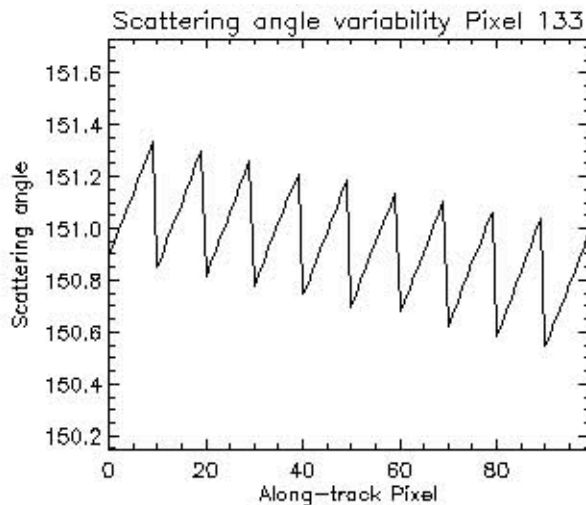
- Goal: quantify Aqua detector dependency for all ocean bands including the NIR bands for earthview TOA radiances (Lt's)
- Method:
 - find runs of 20 pixels along the track which meet strict flag and low chlorophyll/AOT requirements
 - for each run calculate percent differences between the Lt at mirror side 1 detector 1 and the Lt's at the other pixels in the run
 - average percent differences for all the runs found

Aqua detector/mirror-side dependency – scattering angle

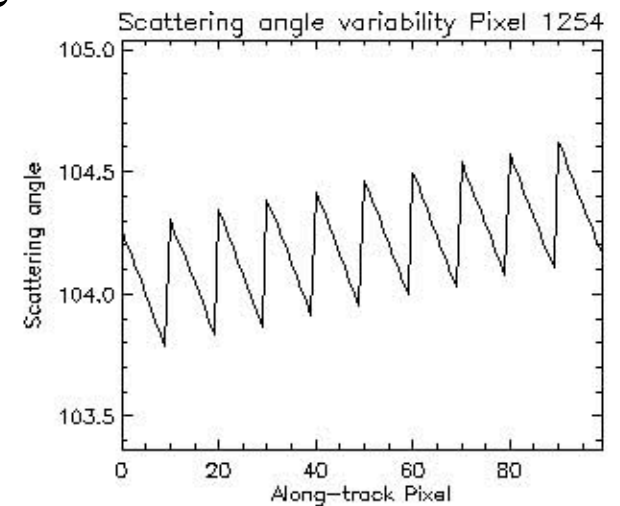
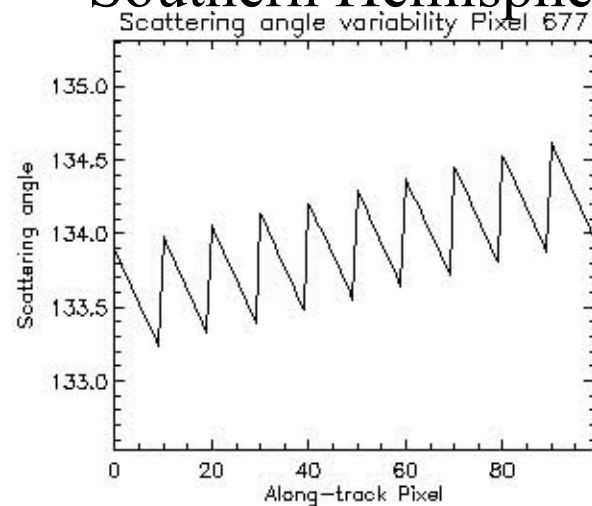
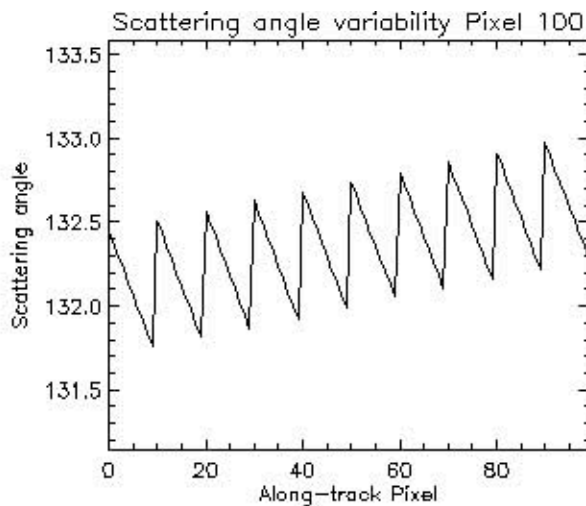
beginning of the scan

middle of the scan
Northern Hemisphere

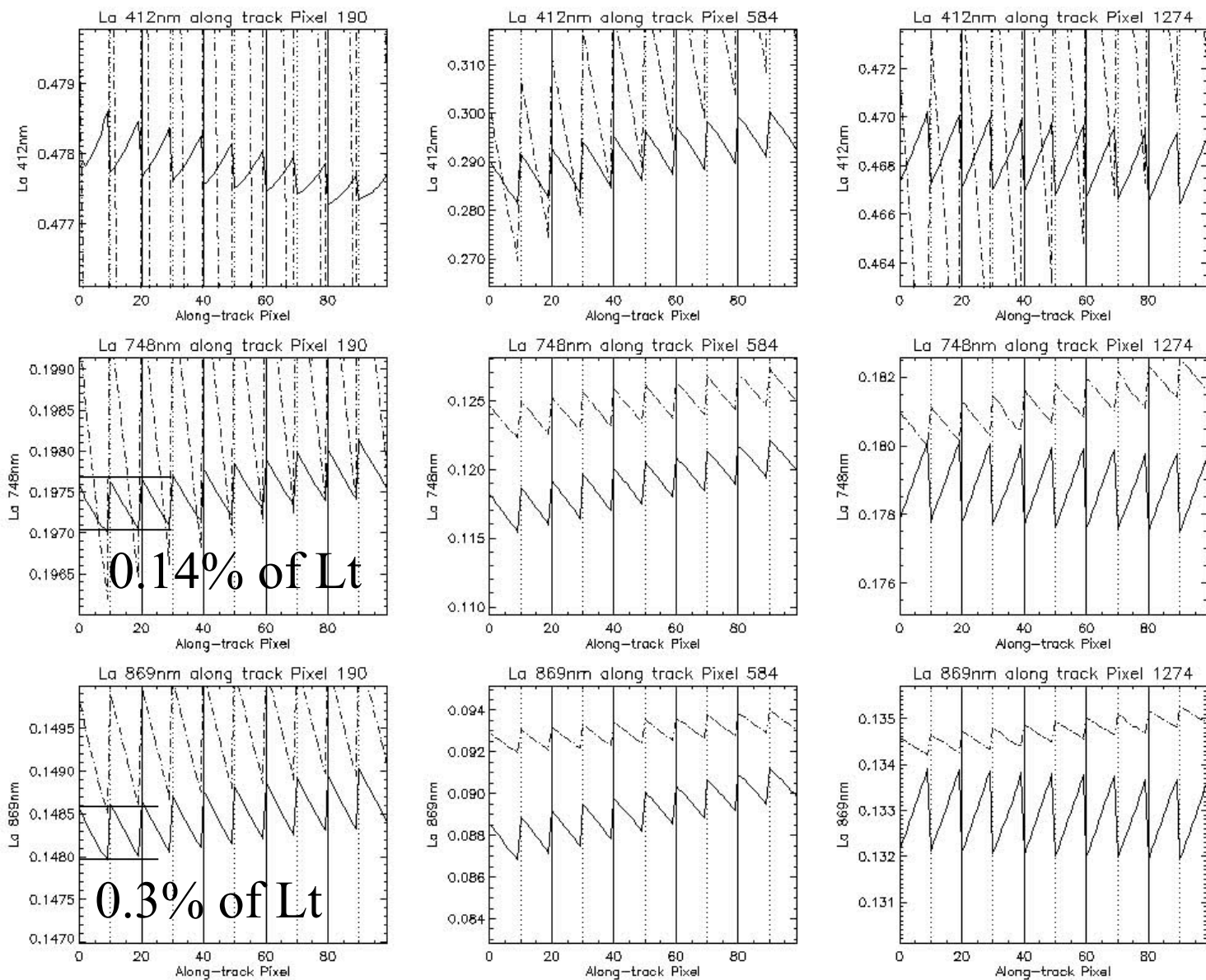
end of the scan



Southern Hemisphere



Aqua detector/mirror-side dependency Rayleigh and aerosol radiances

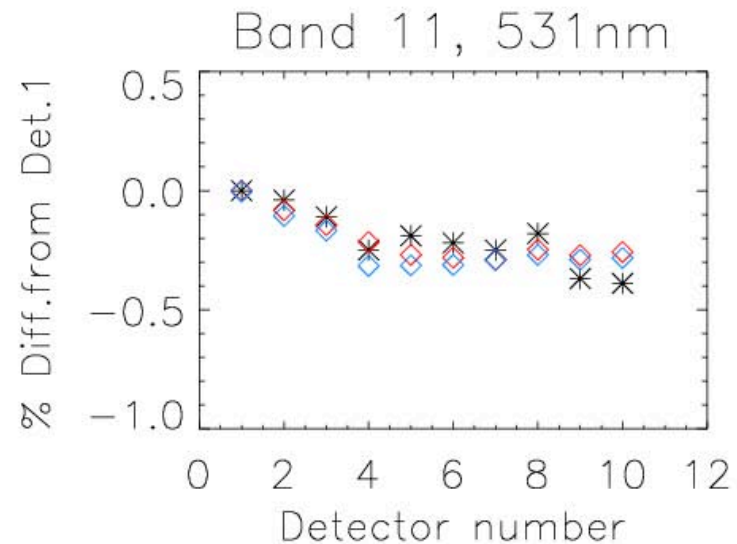
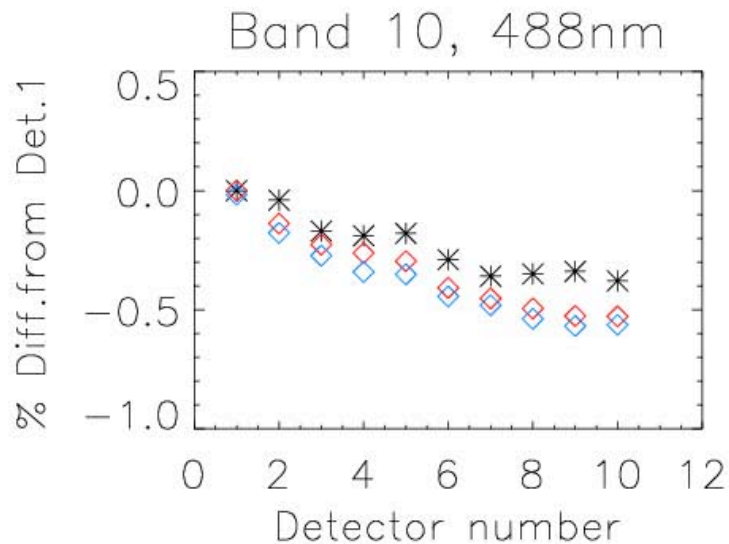
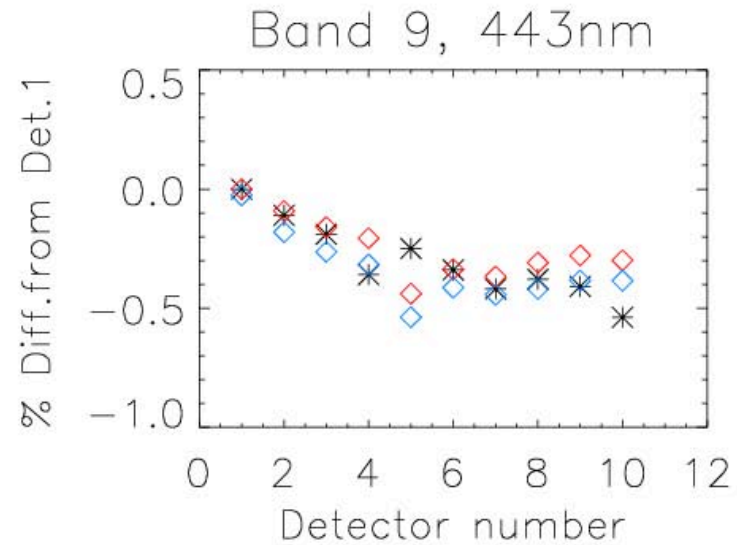
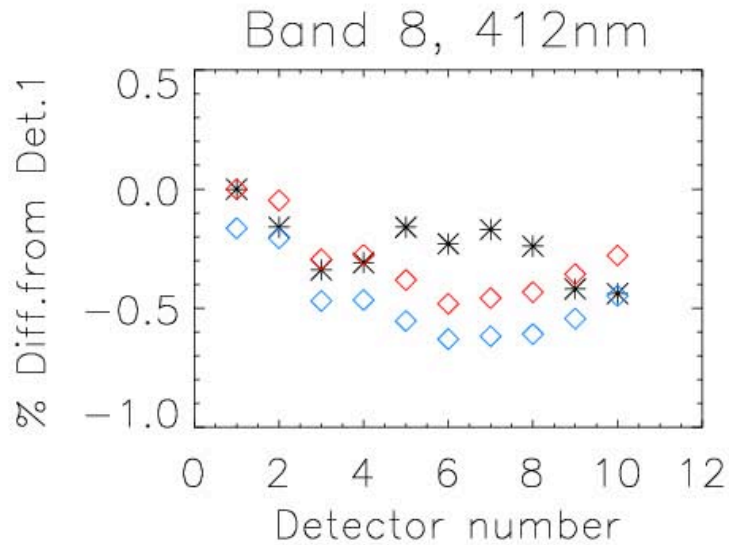


Southern Hemisphere

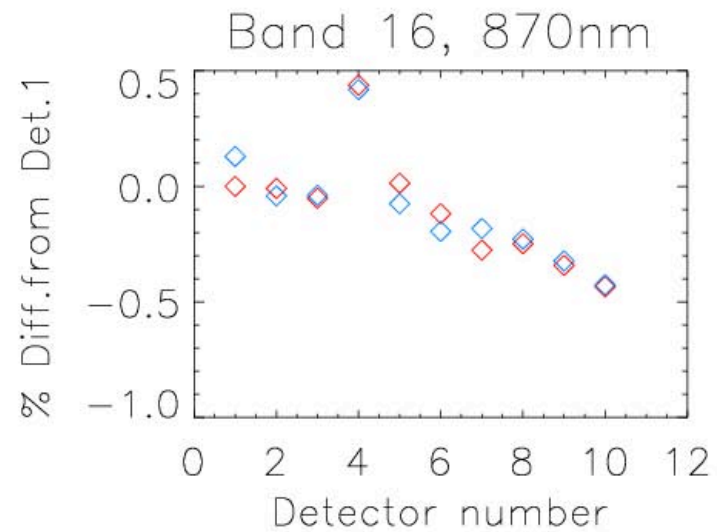
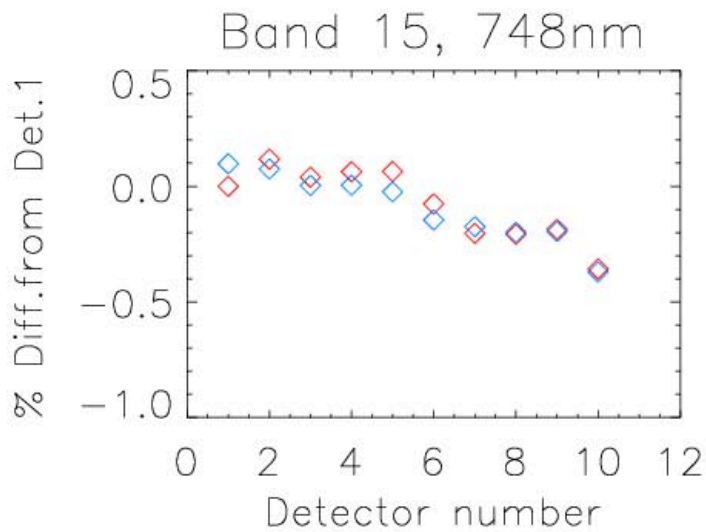
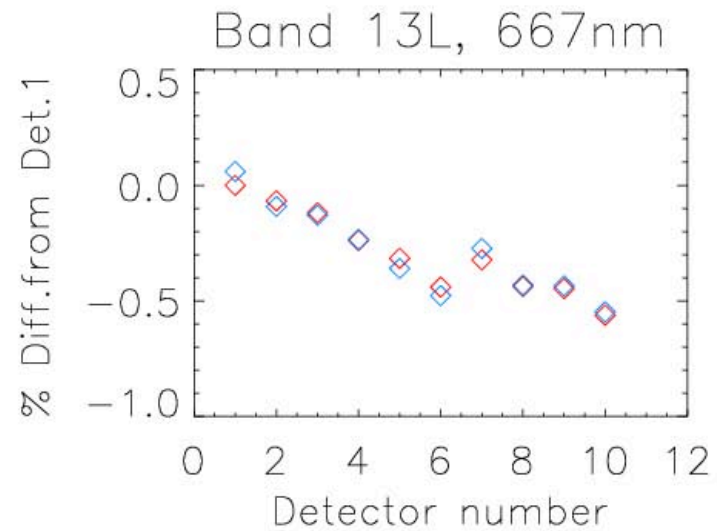
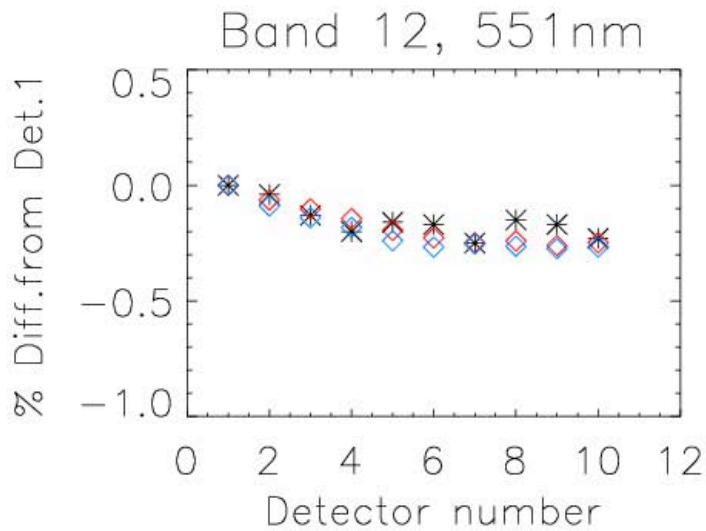
La - solid lines (aerosols)

Rayleigh - broken lines shifted down from original radiance (can correct for Rayleigh easily)

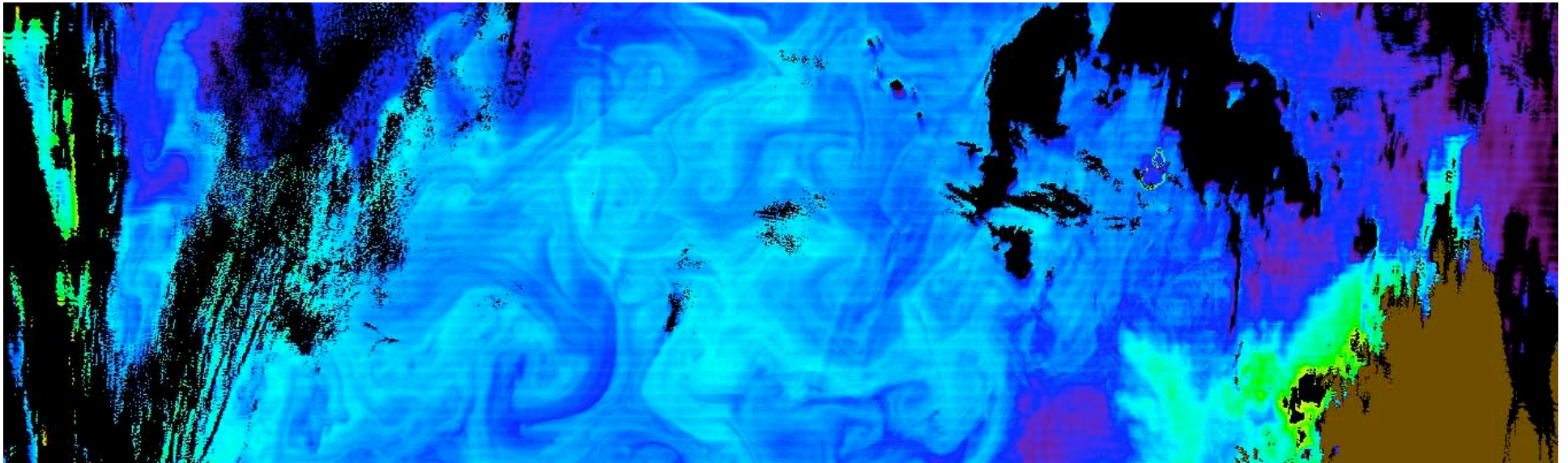
Residuals of TOA and lunar analysis:



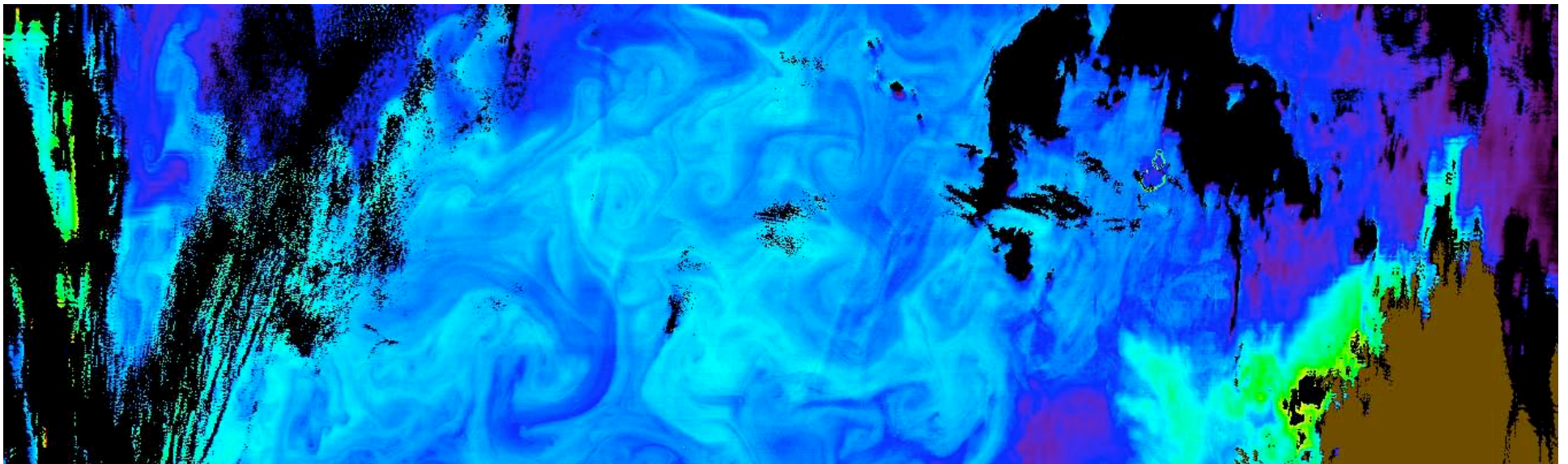
Residuals of TOA and lunar analysis:



MODIS Aqua nLw 412nm, before correction:

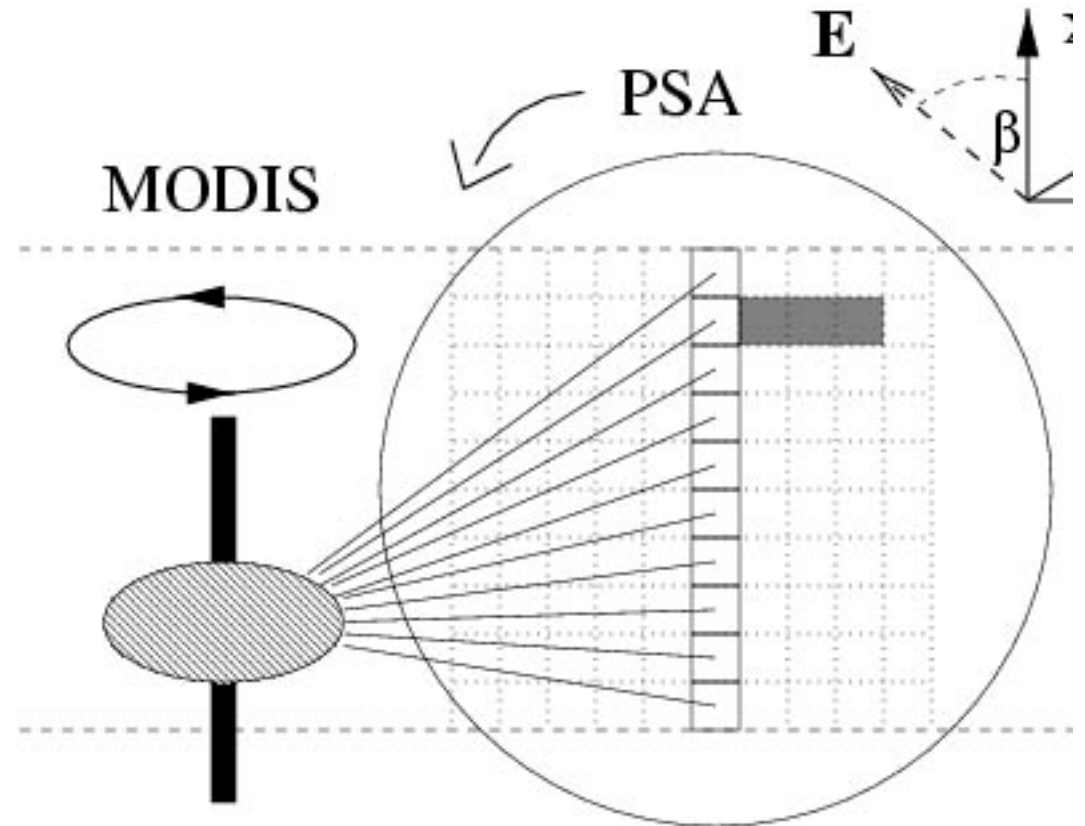


After correction:

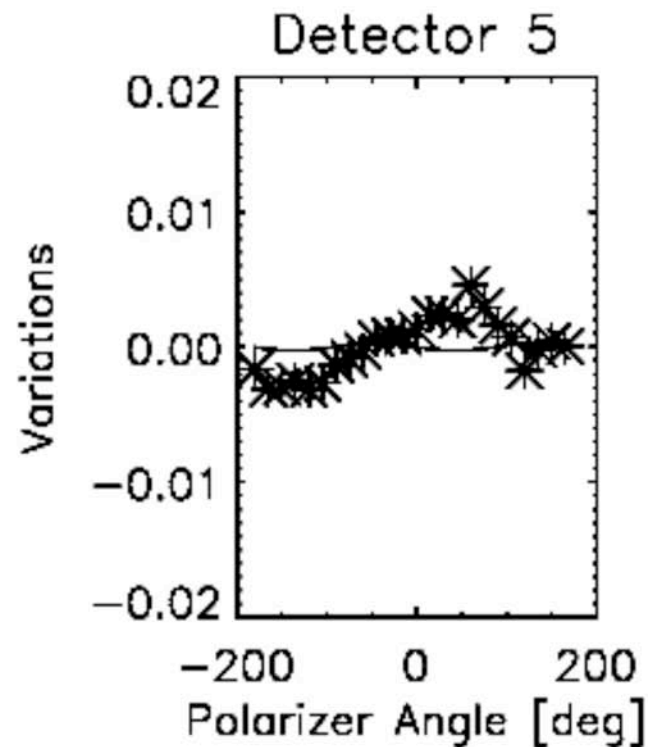
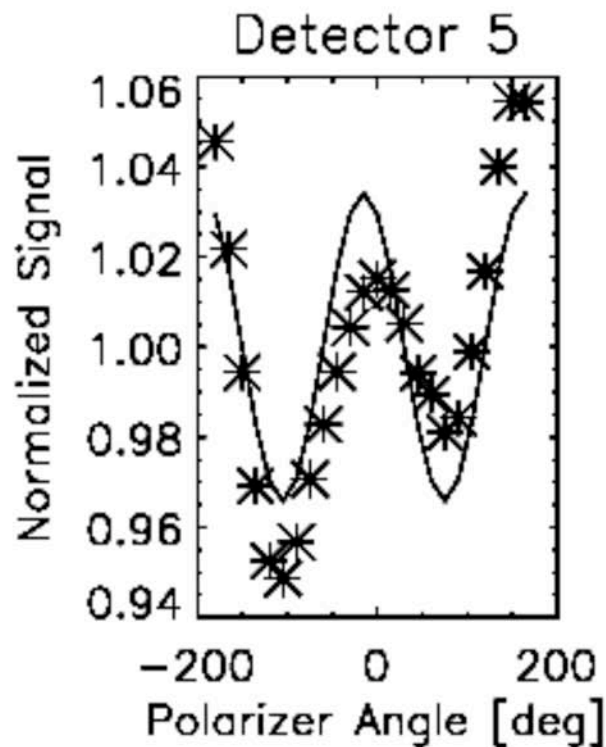


MODIS Polarization Characterization

- Detector dependency of prelaunch characterization questionable
- OBPG only uses band-specific characterization



MODIS Aqua Detector Specific Polarization Measurements



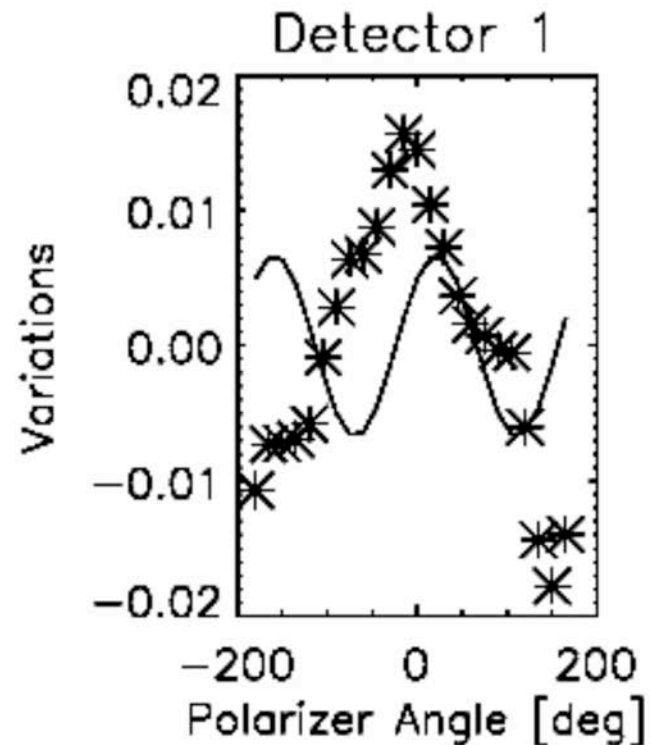
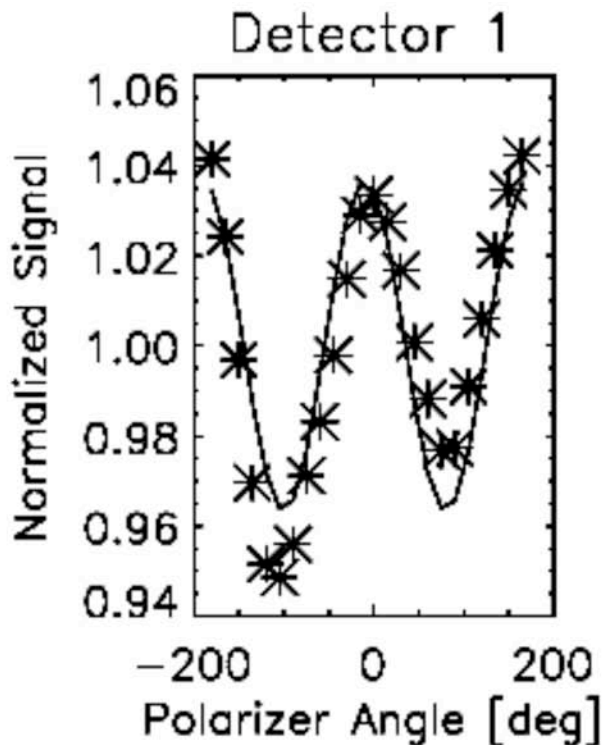
Left:

Stars = Measurements
Solid line = Fourier fit

Right:

Stars = Difference of measurements
From detector averaged measurements
Solid line = Diff. of fit from avg.¹¹ fit

MODIS Aqua Detector Specific Polarization Measurements



Left:

Stars = Measurements
Solid line = Fourier fit

Right:

Stars = Difference of measurements
From detector averaged measurements
Solid line = Diff. of fit from avg.¹² fit

MODIS Aqua Detector Specific Polarization Measurements

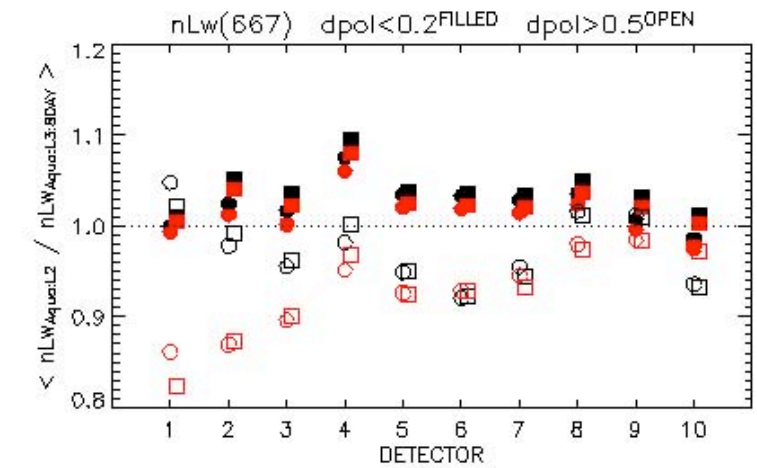
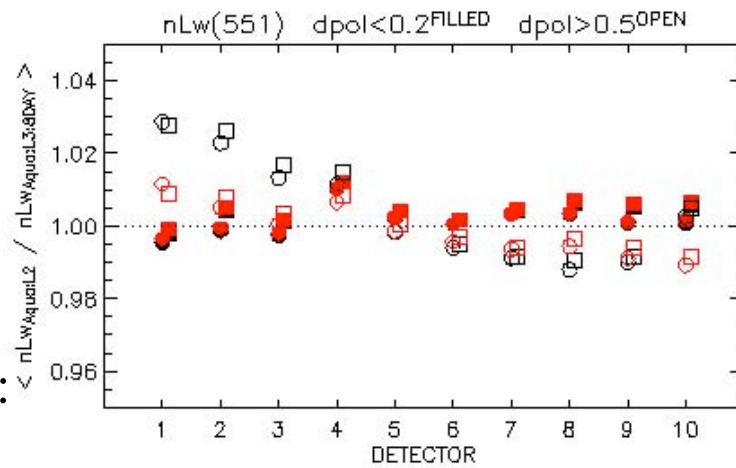
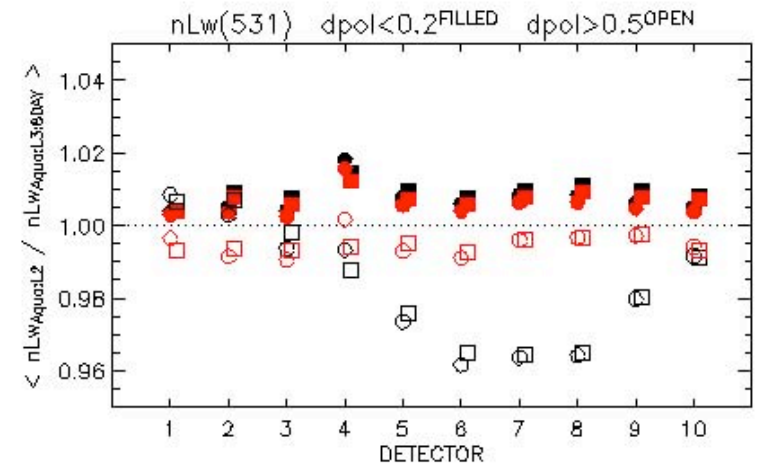
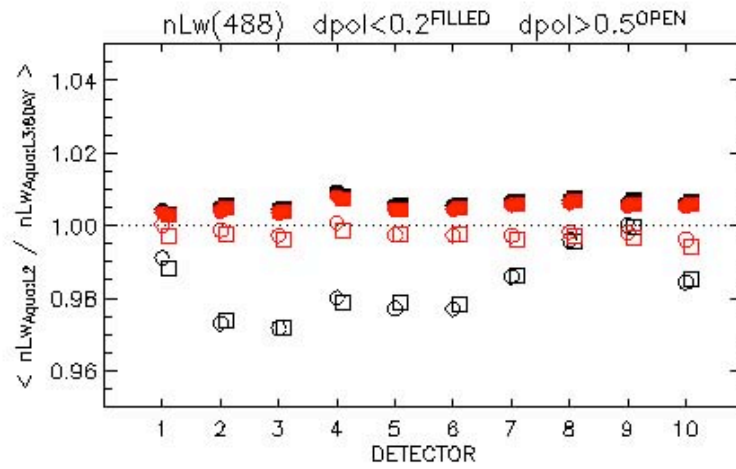
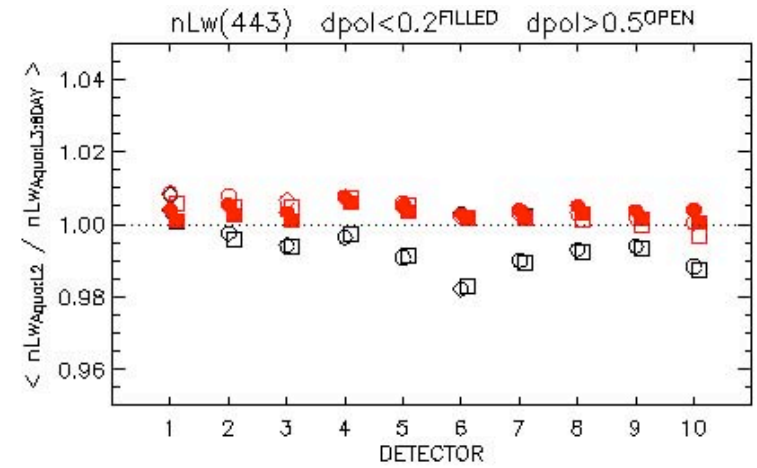
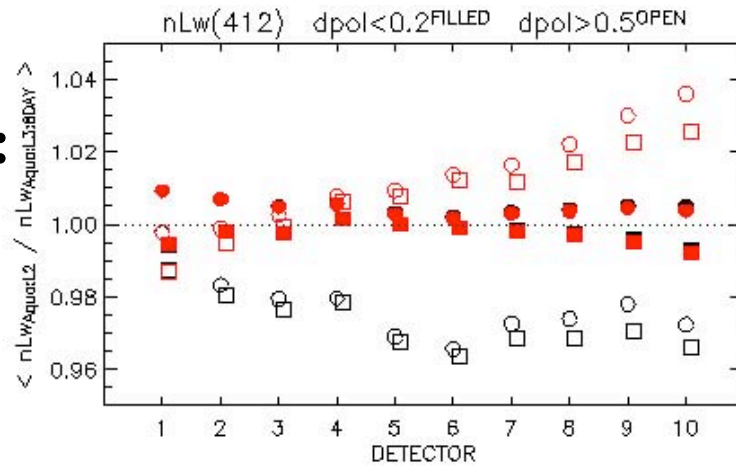
Level 2 Validation:

Red:
Band
specific
polarization

Black:
Detector
specific
polarization

Full symbols:
Low pol.

Open symbols:
High pol.



Discussion

- L2 validation shows problem with current polarization correction implementation at 412nm
- Correction of problem difficult because
 - a) NIR bands influence VIS bands
 - b) nature of polarization correction does not allow easy inversion:

$$L_m = L_t * p_c$$
$$p_c = (1 + p_a d_p \cos(2 \beta - 2 \delta))$$

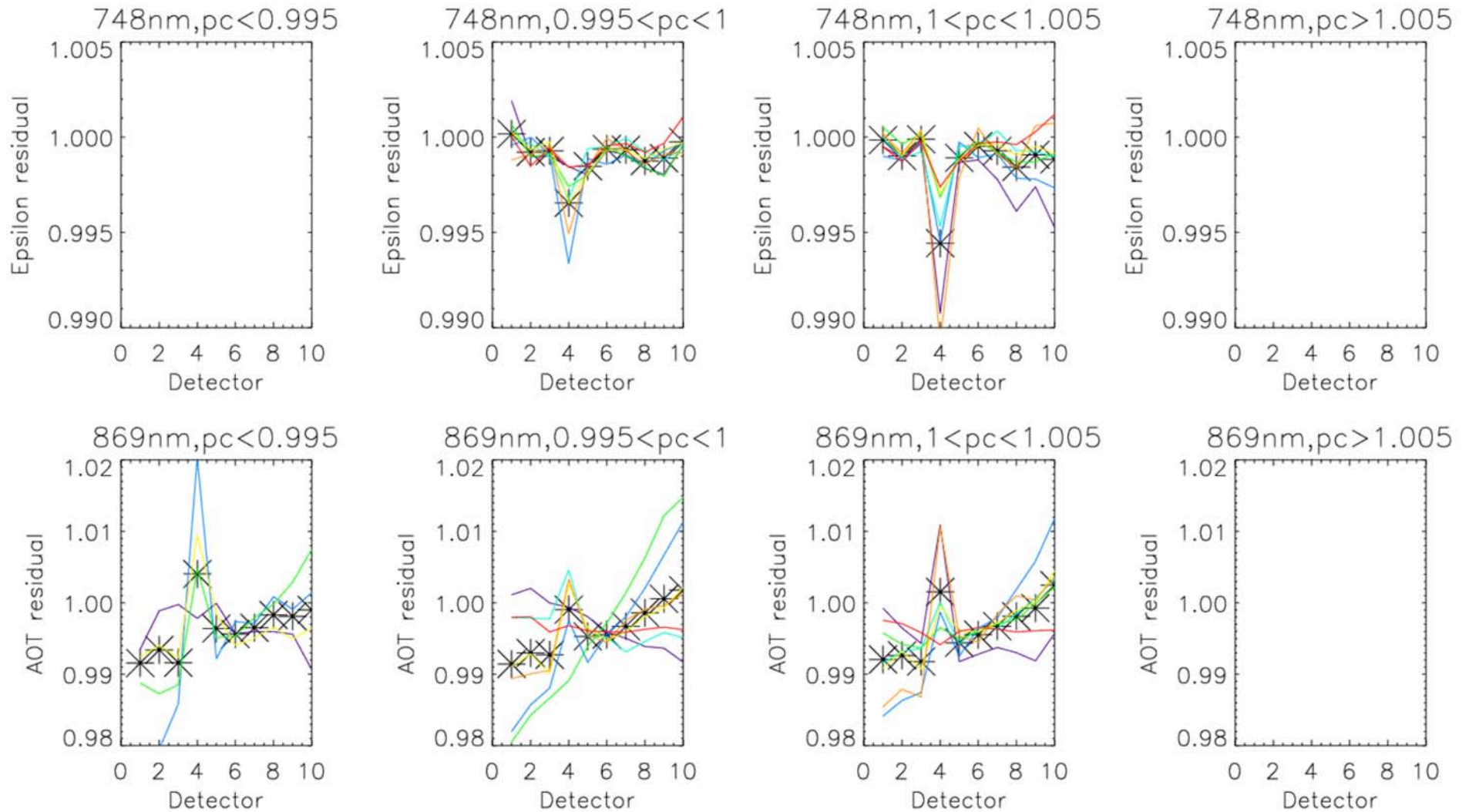
Simplified approach:

- Assume that phase angle delta is approximately correct
- Separate L2 analysis into two cases: $p_c > 1$ and $p_c < 1$
- Striping should reverse between two cases
- Striping should allow us to determine whether p_a is too high or too low

Implementation for MODIS Aqua:

- Select granules with low cloud coverage (2 from northern, 5 from southern hemisphere)
- Select frames where nLw from all 10 detectors are constant (standard deviation less than 5%)
- Classify selected frames into 4 p_c classes
- Calculate average over all (normalized) frames for each class for each detector (when number of frames is > 1000)

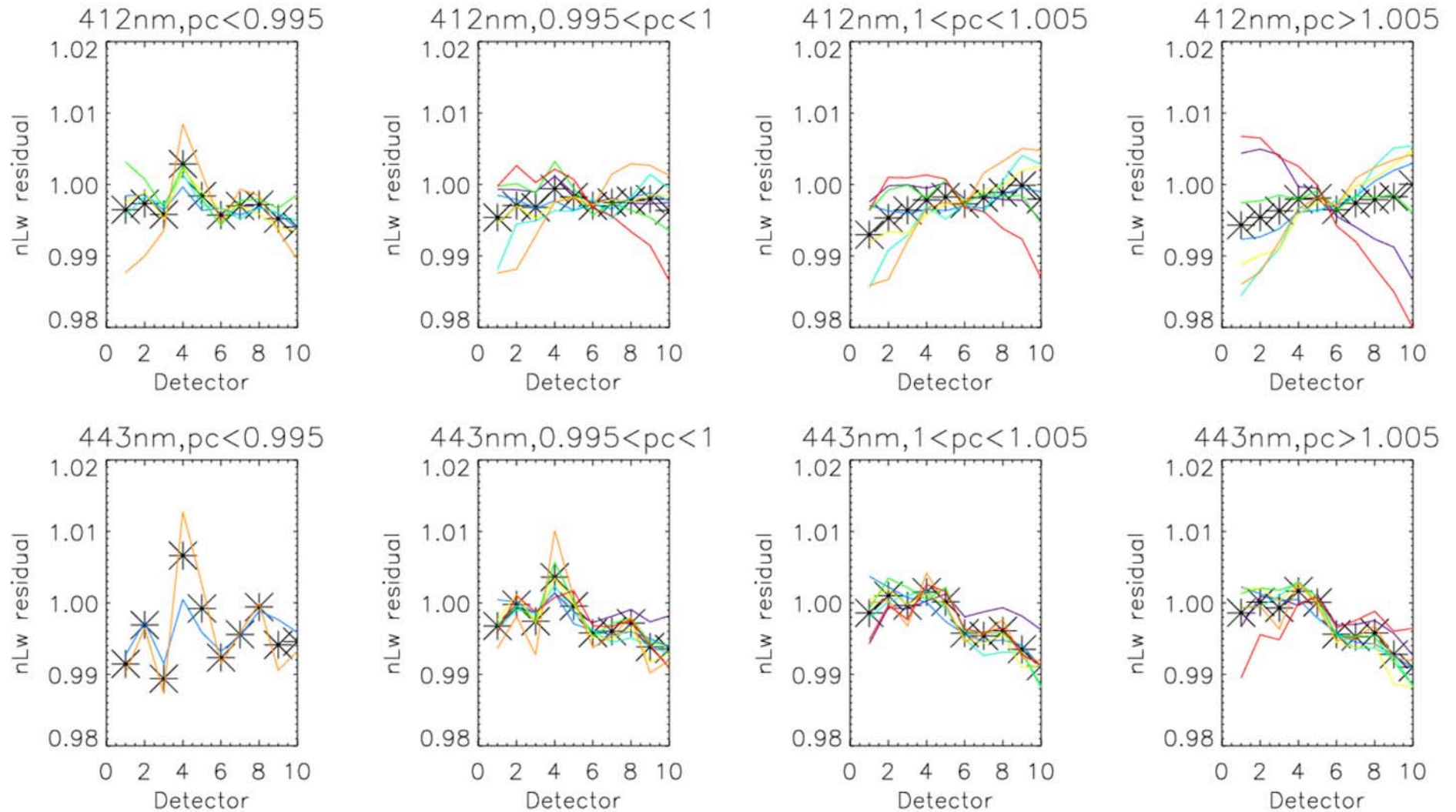
L2 analysis results for atm. Corr. products



Results for atm. Corr. Products:

- Band 15 has low polarization sensitivity $\Rightarrow p_c$ almost always between 0.995 and 1.005
- Band 16 has no entries for $p_c > 1.005$, possibly due to noise threshold
- AOT detector 4 is often outlier, can also be seen in epsilon (derived from B15/B16 ratio), probably not a polarization problem (can be seen for all p_c classes)
- Different trends for AOT for northern and southern hemisphere

L2 analysis results for nLw products



Results for nLw products:

- Strong difference between northern and southern hemisphere for 412nm, but not for 443nm
- **No clear reversal of striping between $p_c < 0.995$ and $p_c > 1.005$ for 412nm**
- Very low residual striping for 443nm (agrees with global L2 validation)

Summary

- MODIS Aqua ocean color products are still affected by residual striping, which appears to be partly related to polarization
- Methodology presented here leads to inconclusive results, probably because differences between northern and southern hemisphere dominate striping pattern
- We expect that this method will provide better results for MODIS Terra mirror side differences, where polarization characteristics are largely unknown at 412nm after 30% degradation

Acknowledgements

- Thanks to members of MCST and OBPG for their support

Backup Slides

MODIS SD Measurement Setup (Waluschka et al., 2004)

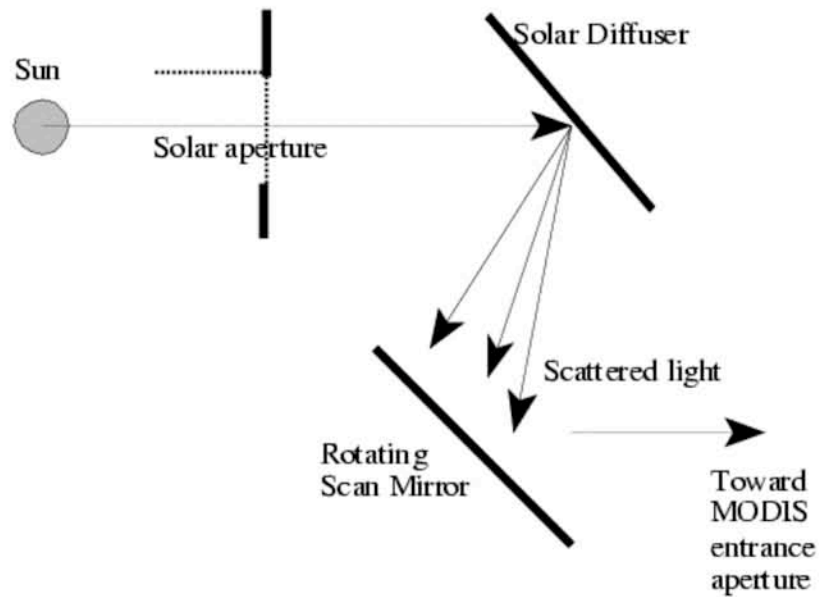


Fig. 4: Light path

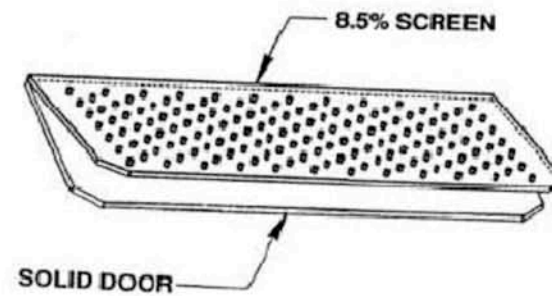
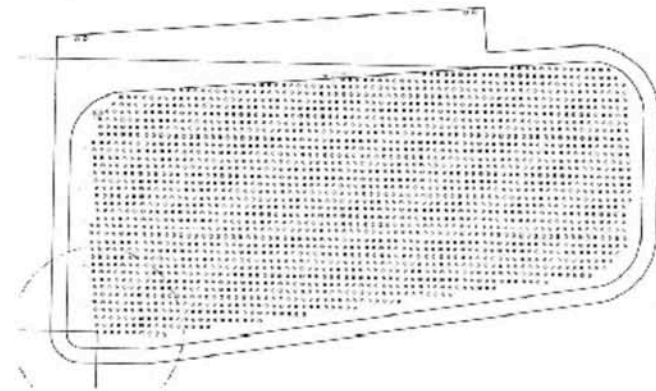


Fig. 5: Attenuation screen

Lunar Measurements:

Detector residuals
to SD calibration:
detector 1 is about
0.5% higher than
detector 10
(MCST result)



MODIS scan:

