VIIRS Polarization Sensitivity Assessment

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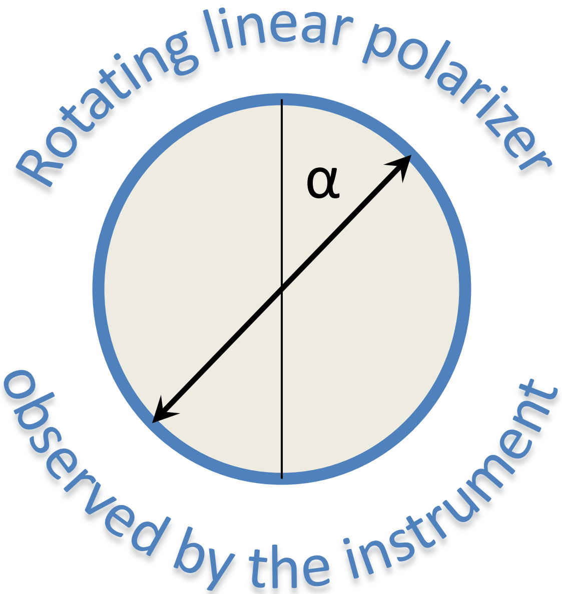
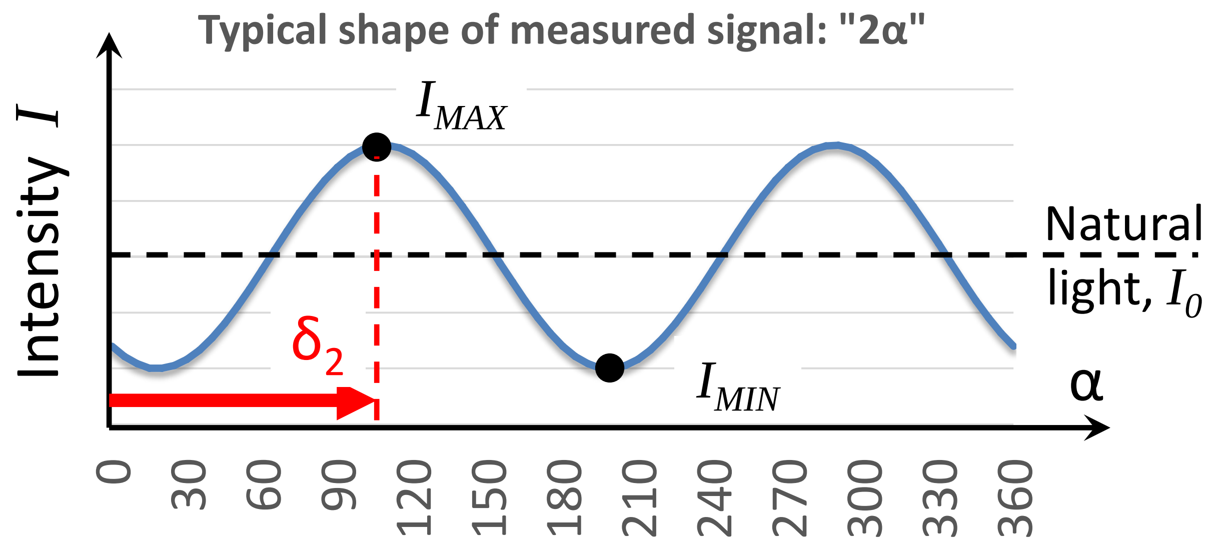
Basic Concepts for Polarization Sensitivity and Correction





• Plane α=0 determines coordinate system for VIIRS polarization sensitivity studies.

• Polarization correction algorithm uses the VRTE coordinate system: α=90.

$$I_M = I_T\left[1 + m_{12}Q_T / I_T + m_{13}U_T / I_T\right]$$

Polarization phase and polarization factor, a_2,

$$a_2 = \frac{I_{\max} - I_{\min}}{I_{\max} + I_{\min}}$$

determine polarization sensitivity of the system.

The Stokes Vector in the VRTE Coordinate System

$$\begin{bmatrix} I \\ Q \\ U \end{bmatrix} = \begin{bmatrix} 1 & m_{12} & m_{13} \\ \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -1 \end{bmatrix} \frac{1}{2} \begin{bmatrix} I_0 \\ I_0 \cos 2\alpha \\ I_0 \sin 2\alpha \end{bmatrix}$$

VIIRS matrix in the VRTE coordinate system

Rotation of the coordinate system

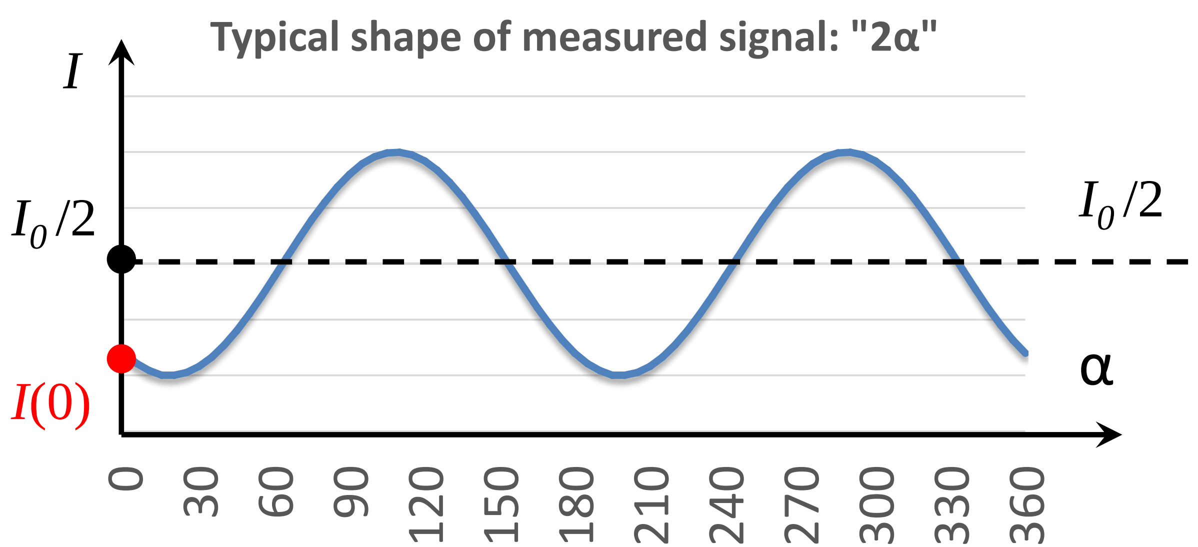
Linear polarized beam

$$I = 0.5 I_0 - m_{12} 0.5 I_0 \cos 2\alpha - m_{13} 0.5 I_0 \sin 2\alpha$$

Sign of m12:

$$I(0) = \frac{1}{2} I_0 - m_{12} \frac{1}{2} I_0 < \frac{1}{2} I_0$$

$$m_{12} > 0$$



How to Get the Mueller Matrix from Measured Data

VCST_TECH_REPORT_14_012, “Methodology”: $dn = \frac{1}{2} c_0 \left[1 + a_2 \cos(2\alpha - \delta_2)\right]$

In our notation **(*)**: $$I = \frac{1}{2} I_0 - m_{12} \frac{1}{2} I_0 \cos 2\alpha - m_{13} \frac{1}{2} I_0 \sin 2\alpha$$

We define: $$D = \sqrt{\left[m_{12} \frac{1}{2} I_0\right]^2 + \left[m_{12} \frac{1}{2} I_0\right]^2}; \; \cos\delta_2 = \frac{-m_{12} \frac{1}{2} I_0}{D}; \; \sin\delta_2 = \frac{-m_{13} \frac{1}{2} I_0}{D}$$

Rewrite **(*)**: $I = \frac{1}{2} I_0 + D\left[\cos\delta_2 \cos 2\alpha - \sin\delta_2 \sin 2\alpha\right] = \frac{1}{2} I_0 \left[1 + \sqrt{m_{12}^2 + m_{13}^2} \cos(2\alpha - \delta_2)\right]$

Comparing red and blue, we get a system of equations for m12 and m13.

From the system, one immediately gets (note the sign at m12):

$$m_{12} = +\sqrt{\frac{a_2}{1 + \tan^2\delta_2}}; \qquad m_{13} = m_{12} \tan\delta_2$$

Polarization Effect

(Based on algorithm developed by GSFC ocean color team)

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

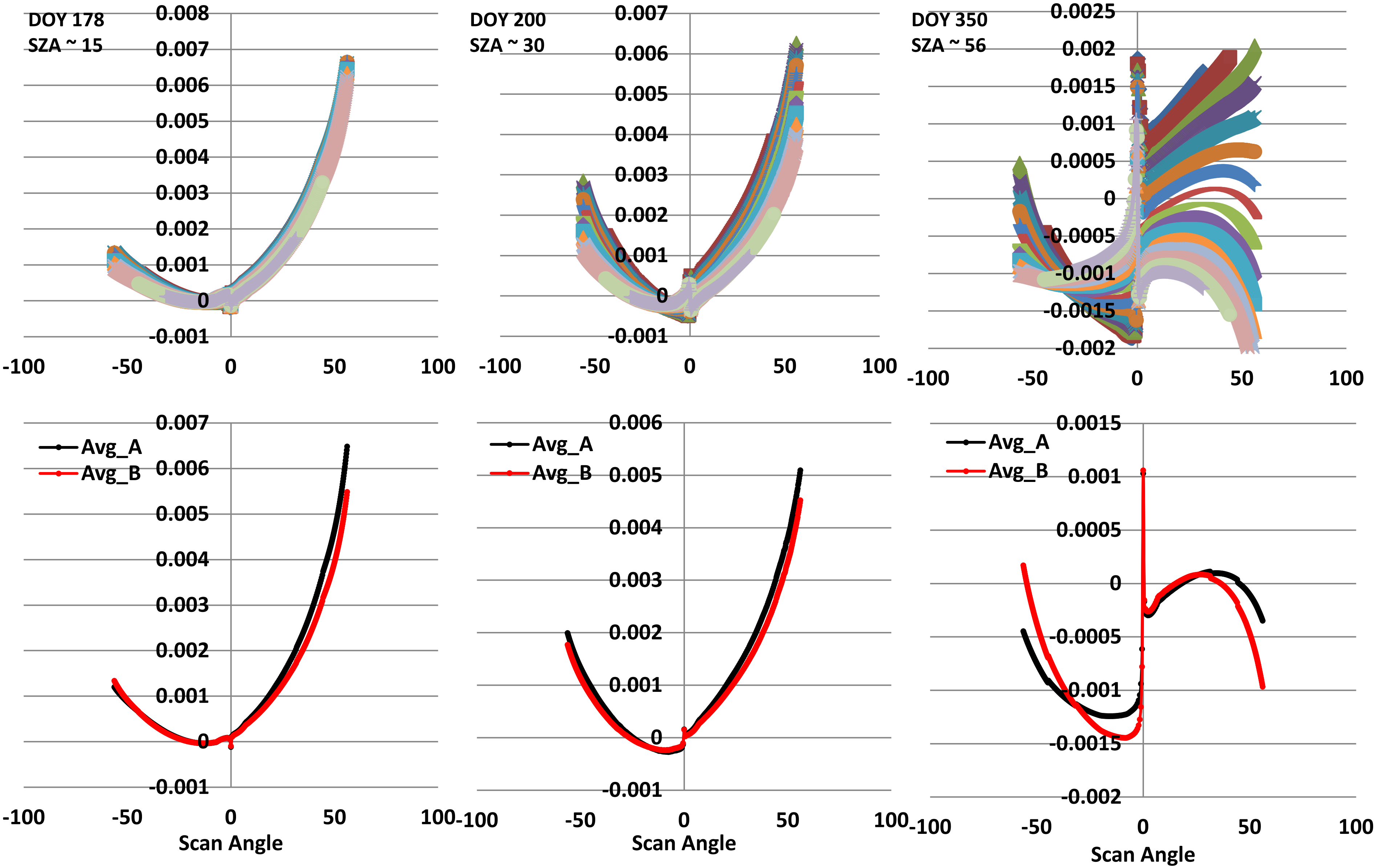
L_m: TOA radiance to be measured by J1

L_t: ideal TOA radiance (NPP VIIRS)

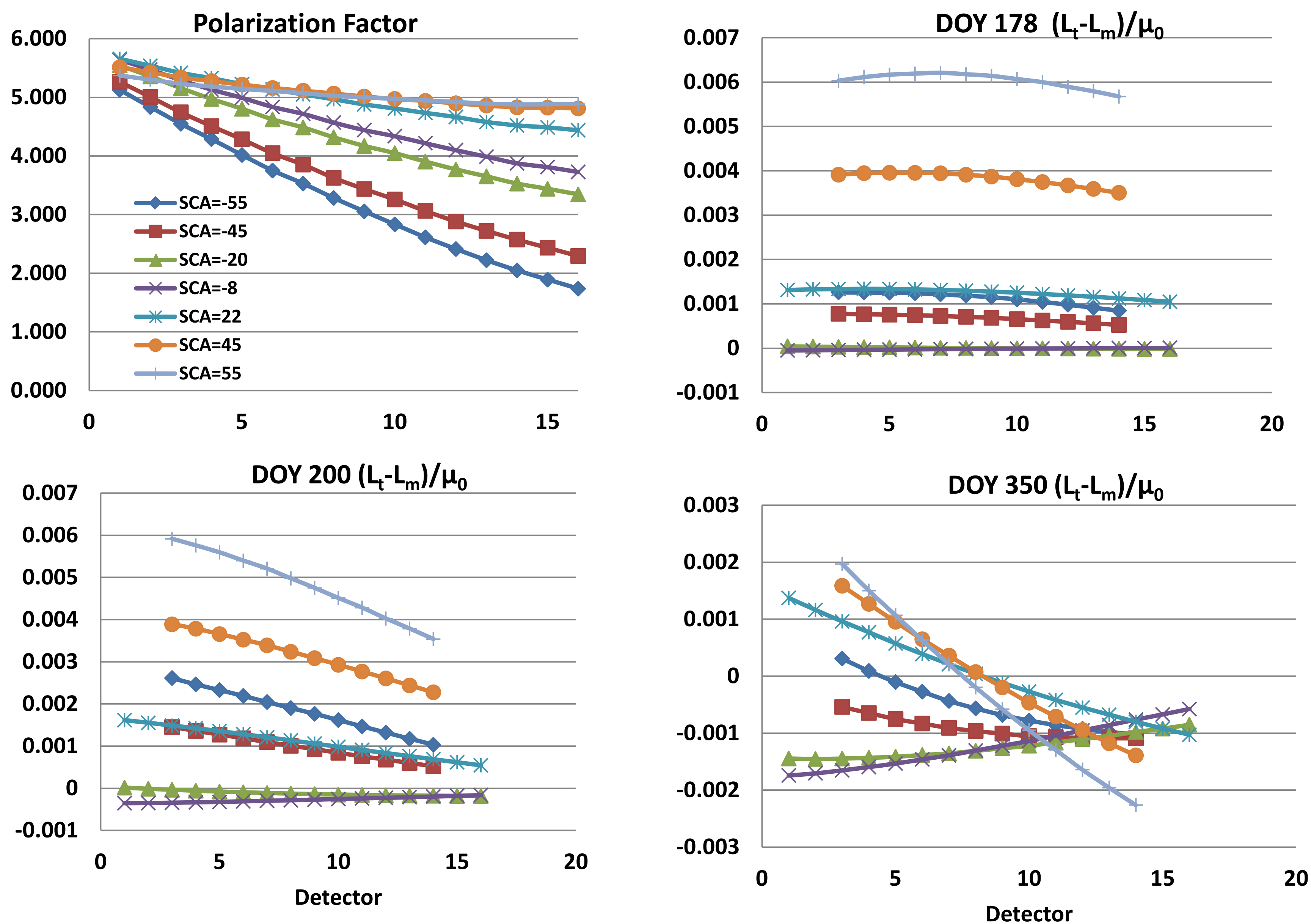
Q, U : linear Stokes vector components, modeled from Rayleigh and glint over water

m_{12}, m_{13} : describe instrument polarization sensitivity (depend on band, MS, detector, scan angle)

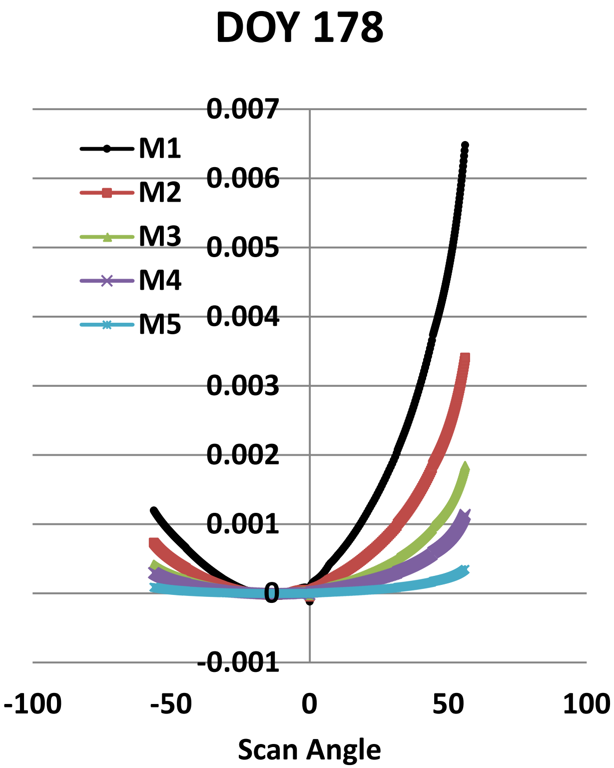
Angular and Seasonal Sensitivity [M1 (412nm), $(L_t-L_m)/\mu_0$]

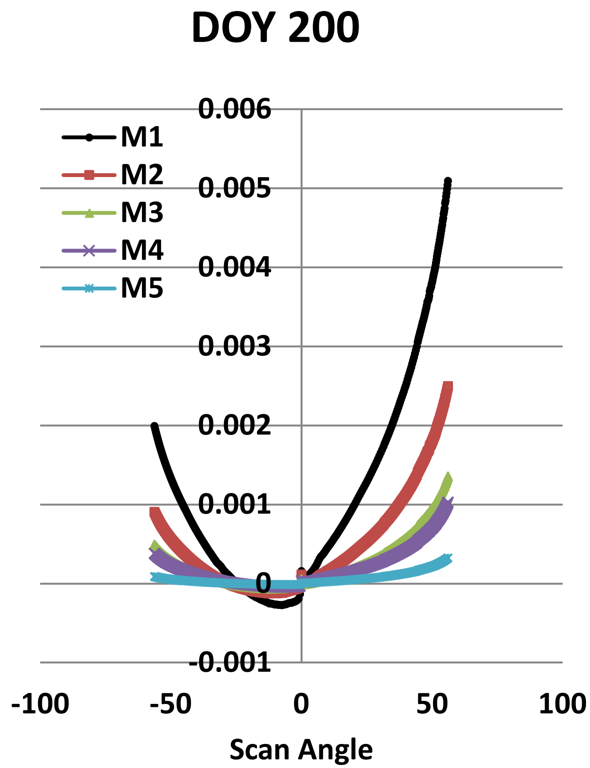


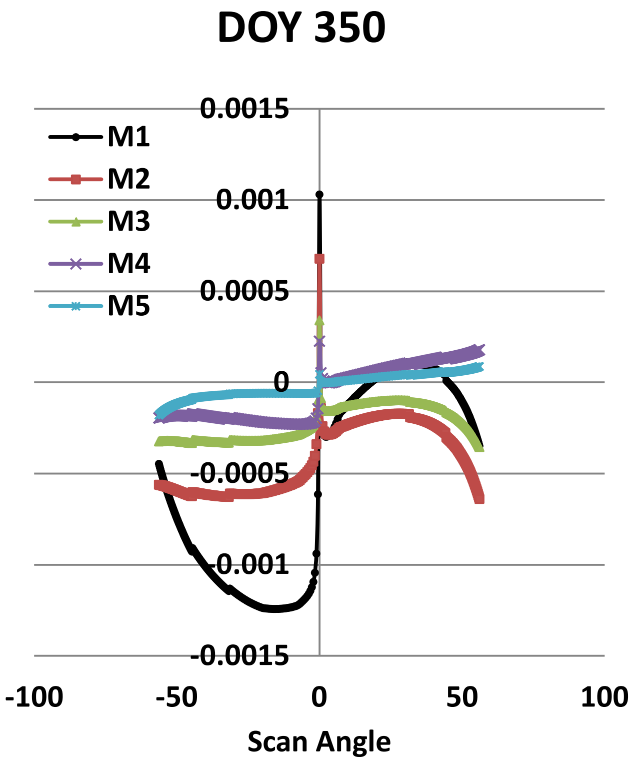
Polarization Differences among Detectors [M1 (412nm), $(L_t-L_m)/\mu_0$]



Polarization Spectral Sensitivity $[(L_t-L_m)/\mu_0]$



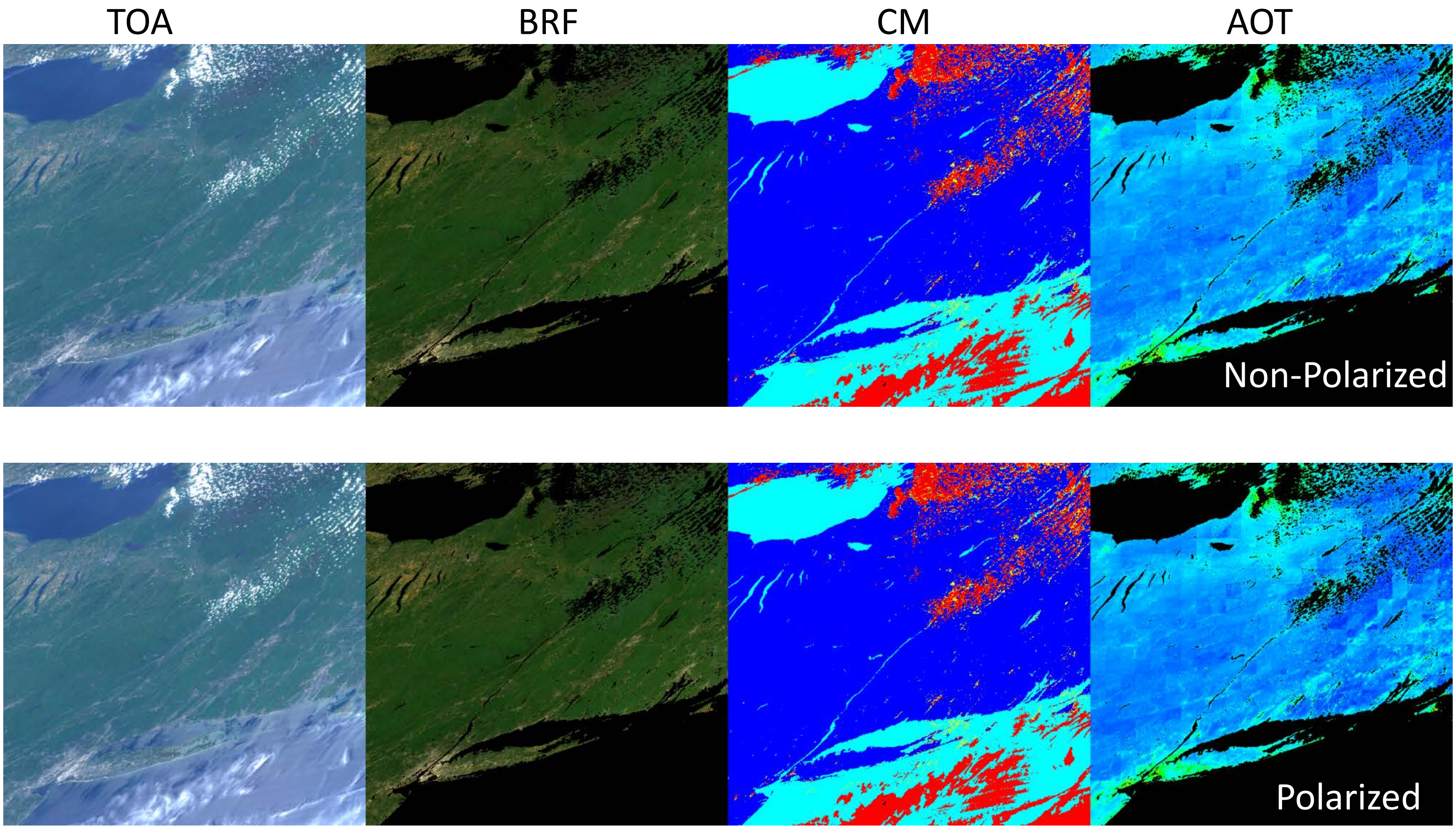




Estimate of Maximum Sensitivity $[(L_t - L_m)/\mu_0]$

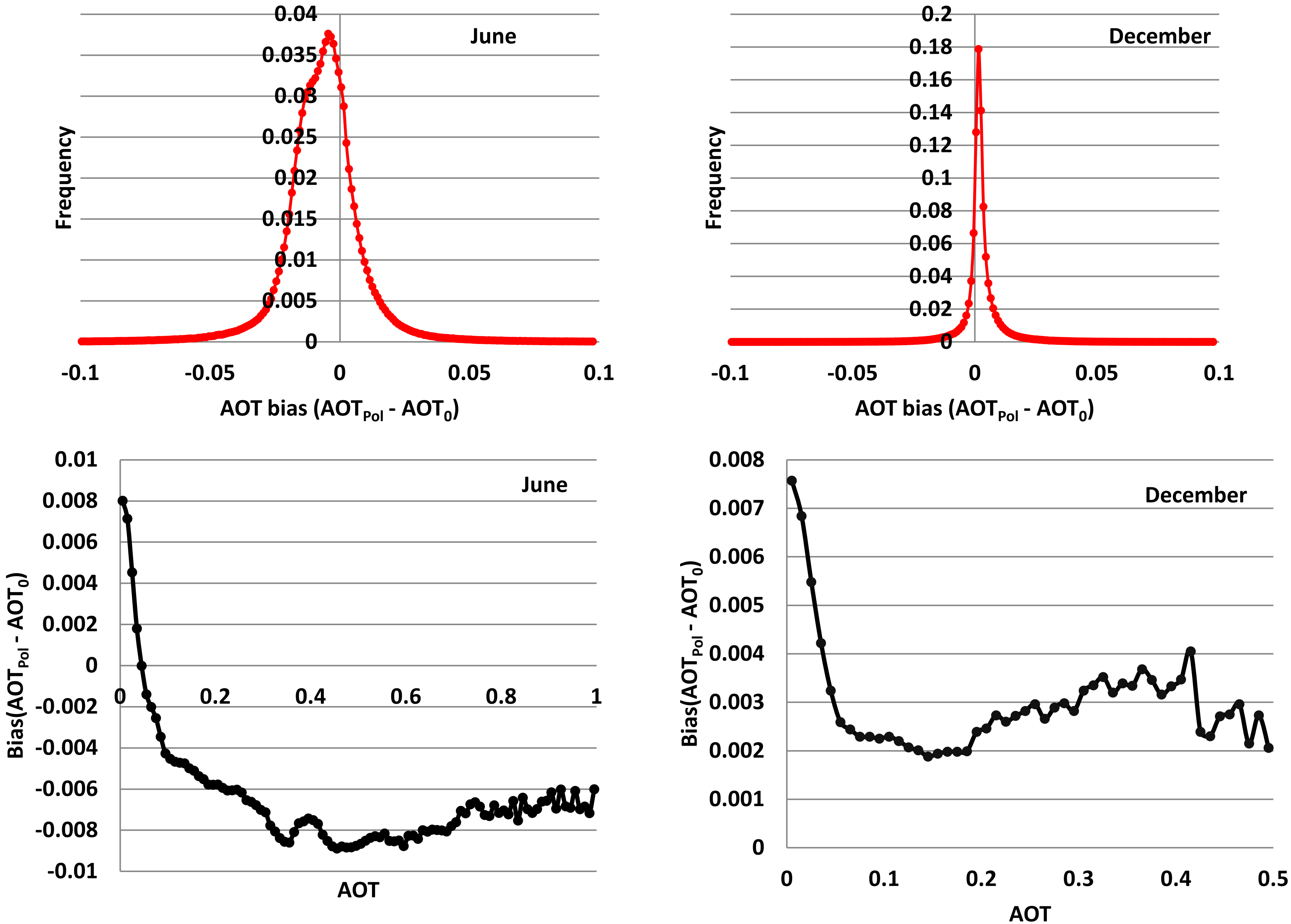
	M1	M2	M3	M4	M5
Angular	0.007	0.004	0.002	0.0015	0.0004
Mirror Side difference	0.001	0.0003	0.0002	0.0001	0.00005
variation among Detectors	0.004	0.004	0.002	0.0015	0.00015

MAIAC Land Process

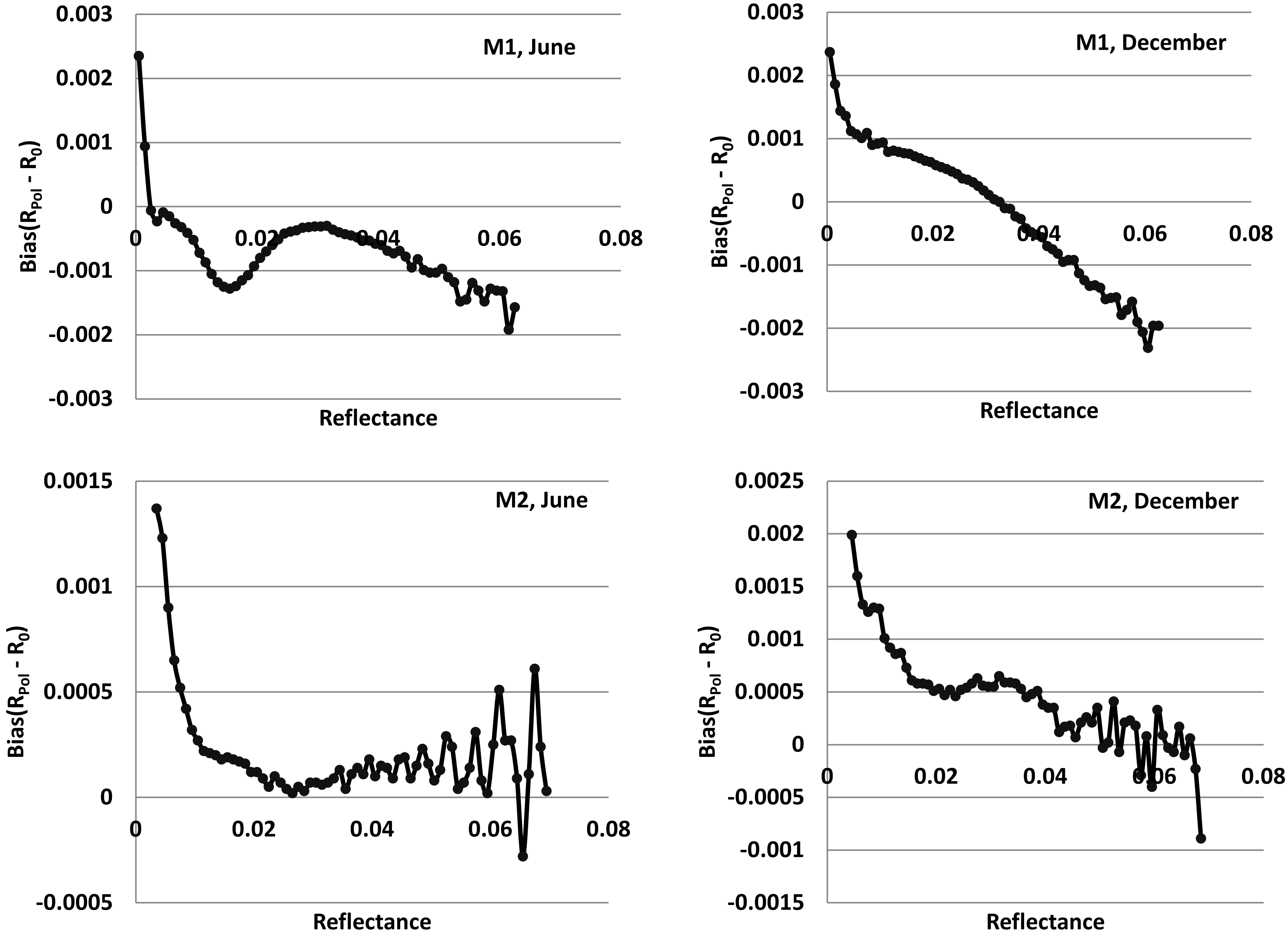


New England Area (450x450KM^2), 2012, day 138

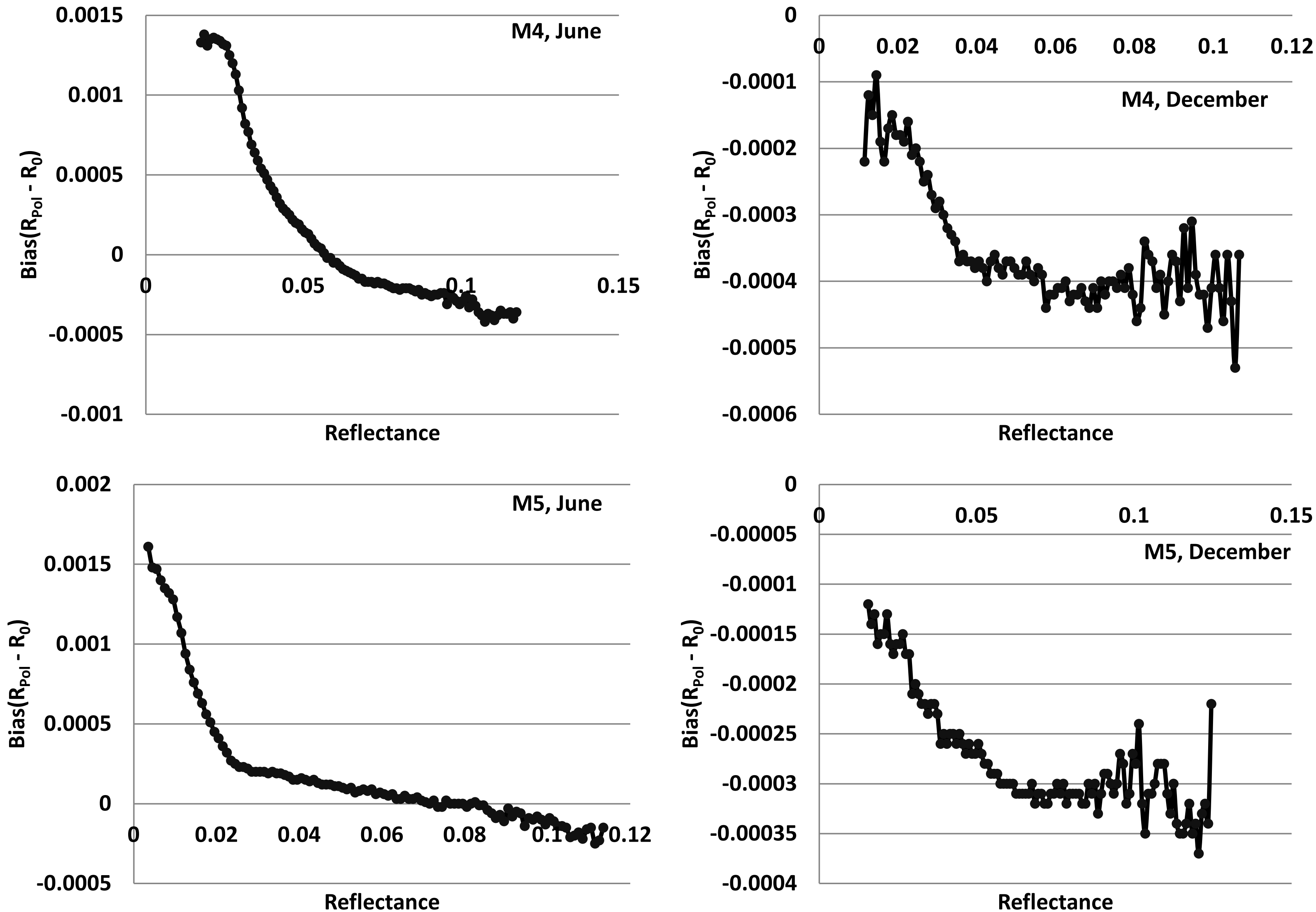
Impacts on AOT Retrieval



Impacts on Surface Reflectance



Impacts on Surface Reflectance (cont.)



Summary

- Polarization effect strongly depends on Sun-view geometry and sensor polarization features.
- At low sun angle, detector to detector variation increases (more striping).
- The maximum polarization effect at TOA is around 0.007 for M1 band.
- Polarization may create bias up to 0.01 on AOT retrieval and this bias is seasonal dependent.
- Polarization effects on surface reflectance is small except for M1 band, which could reach 0.002.