CLARREO Reflected Solar Spectrometer: Reference Inter-Calibration Activities

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Presentation Outline

- PDM development to account for Imager Sensitivity to Polarization on orbit (MODIS/Aqua and VIIRS/NPP).

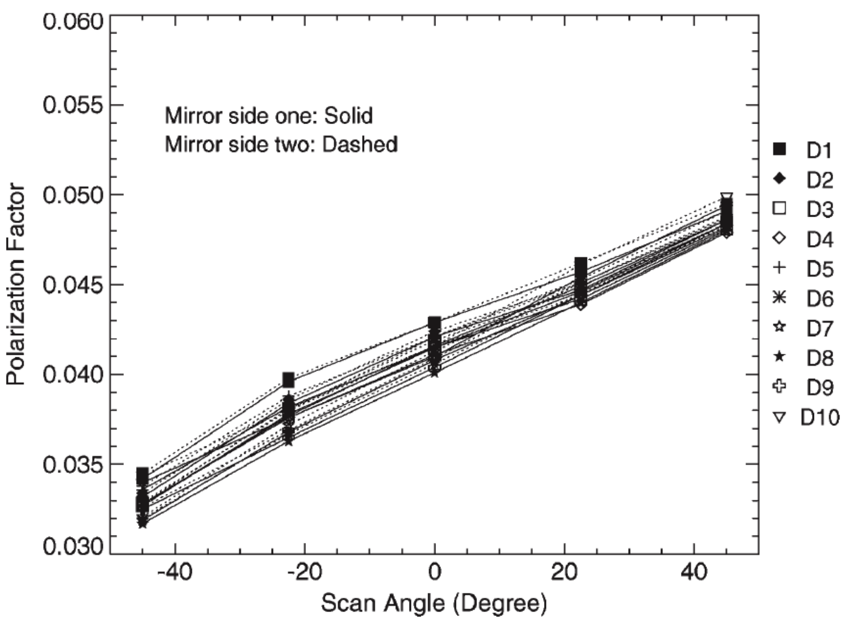
- CLARREO RS Reference Inter-calibration Sampling from the ISS:

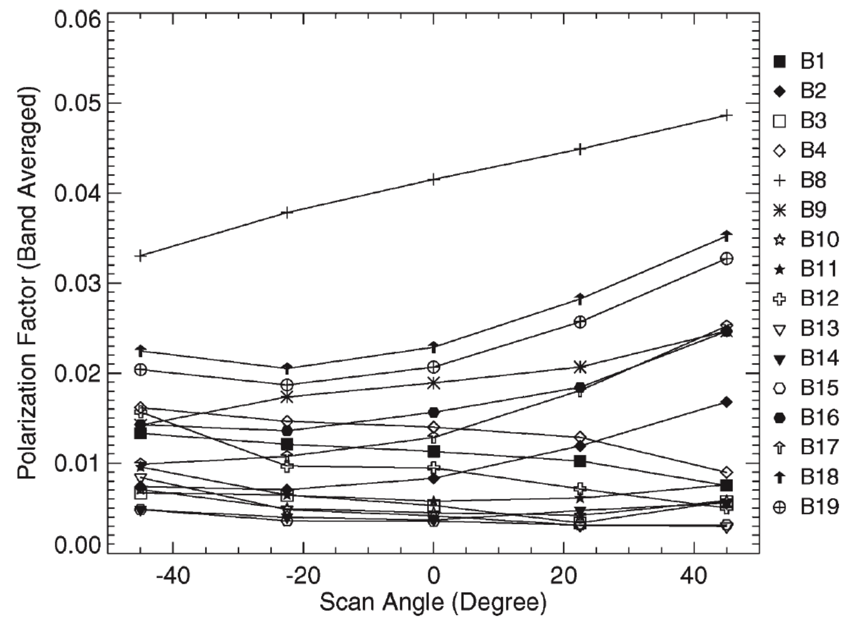
  - Alternative 2D pointing: Pitch & Roll gimbal (C. Roithmayr)
  - Sampling estimates for VIIRS/JPSS inter-calibration (C. Lukashin)

- SCIAMACHY/ENVISAT Level-1 Spectral Reflectance data: update.

- Summary of planned future studies and publications.

Development of Polarization Models to Account for Imager Sensitivity to Polarization on Orbit





(a) Polarization factors for Aqua band 8. **(b) Detector-averaged polarization factors for Aqua.**

Sun and Xiong: "MODIS Polarization-Sensitivity Analysis", IEEE Trans. on Geo. and Rem. Sensing, v. 45, No. 9, 2007.

Study Objective: **Take into account MODIS/Aqua & VIIRS/NPP sensitivity to polarization by providing Polarization information on orbit (function of viewing geometry and scene type). Improve Accuracy of Level-1B data product, show effect on the Level-2 Aerosol data products.**

Development of Polarization Models to Account for Imager Sensitivity to Polarization on Orbit

Degree of Polarization:

$$P = \frac{L_p}{L} = \frac{\sqrt{Q^2 + U^2}}{L}$$

Angle of Polarization:

$$\chi = \begin{cases} tan^{-1}\left(U/Q\right)/2 & \\ tan^{-1}\left(U/Q\right)/2 + \pi/2 & \text{if } Q < 0 \end{cases}$$

Correction due to Polarization:

$$L^{sensor} = \left(1 + mP\right) L_0$$

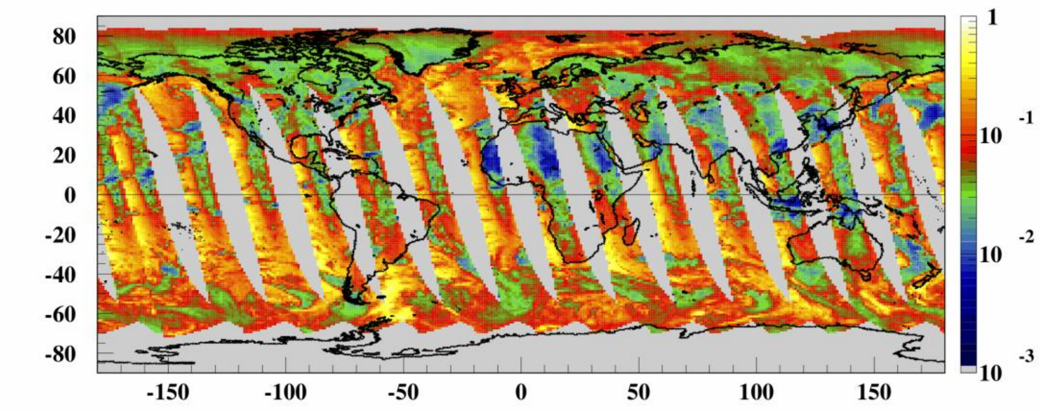
Relative Uncertainty:

$$\frac{\sigma^{sensor}}{L^{sensor}} = \sqrt{\left(\frac{\sigma_0}{L_0}\right)^2 + \frac{P^2\sigma_m^2 + m^2\sigma_{pdm}^2}{\left(1 + mP\right)^2}}$$

To enable radiometric corrections information on polarization is required on orbit.

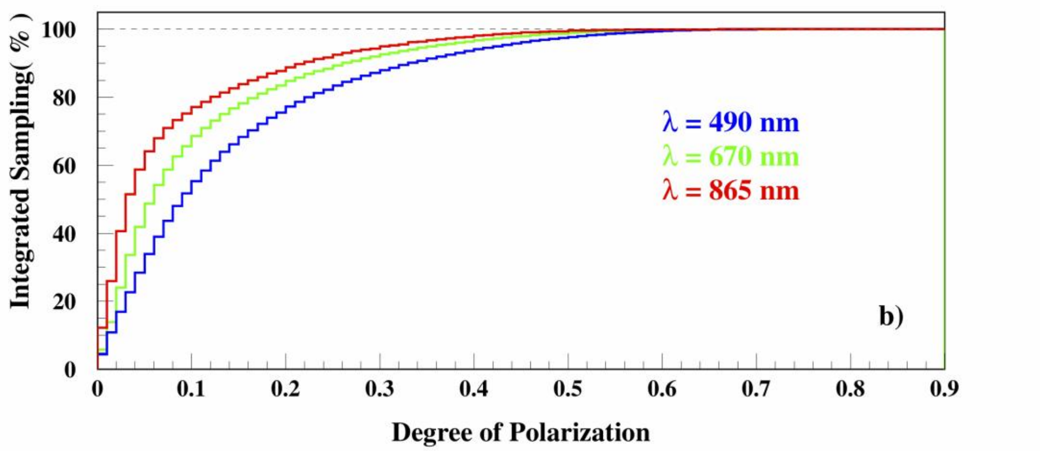
Development of Polarization Models to Account for Imager Sensitivity to Polarization on Orbit

Existing Polarization Observations from PARASOL



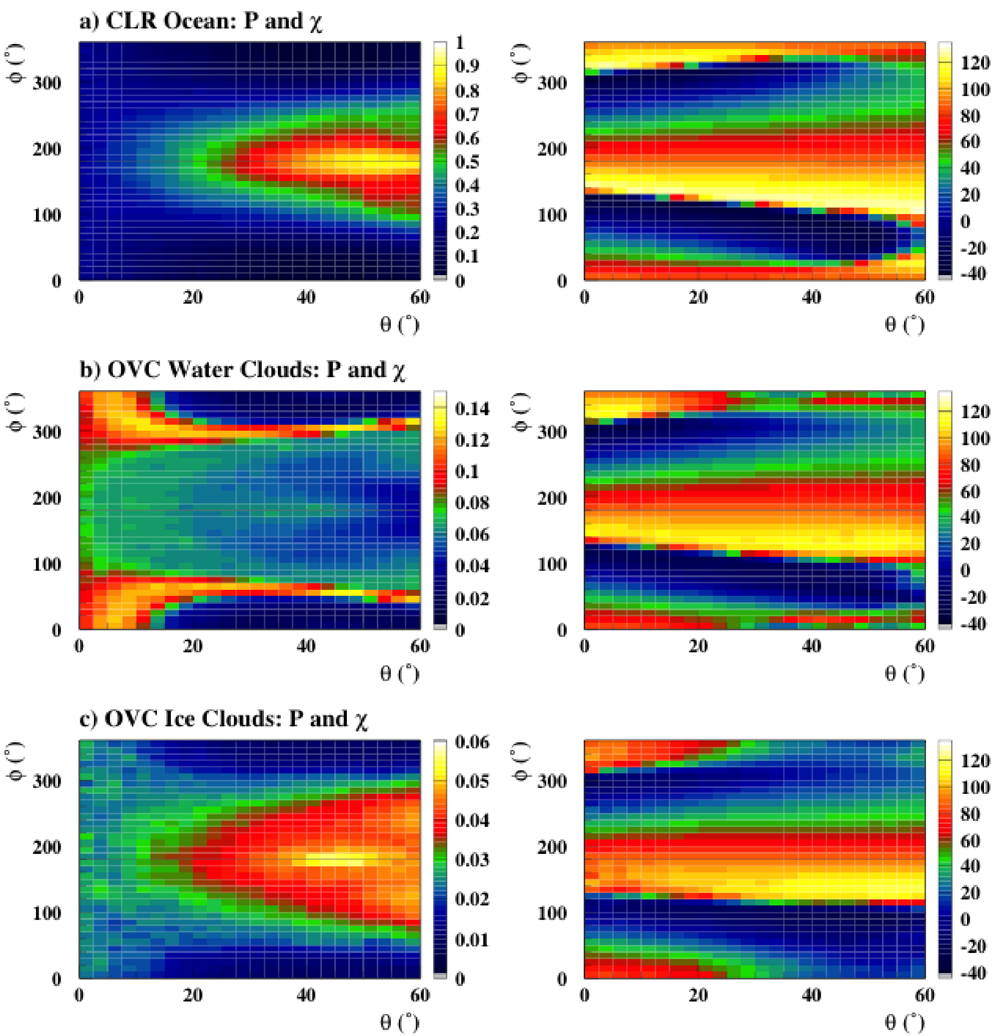
a) 2006.04.01: Degree of polarization at λ = 670 nm

- PARASOL data from 2006.04.01
- λ = 670 nm
- Cross-Track data taking mode.
- Max DOP about 0.6 – 0.7.



Relative sampling frequency versus DOP for three PARASOL bands:
- 490 nm (blue),
- 670 nm (green)
- 865 nm (red)

Development of Polarization Models to Account for Imager Sensitivity to Polarization on Orbit



PDM Examples:

- 670 nm wavelength
- mean *P* (left panels)
- *χ* (right panels)

Solar zenith angle range 40 < SZA < 50:

a) Clear ocean, surface wind speed limited to below 2.5 m/s;

b) Overcast water clouds over ocean, with cloud optical depth from 5 to10;

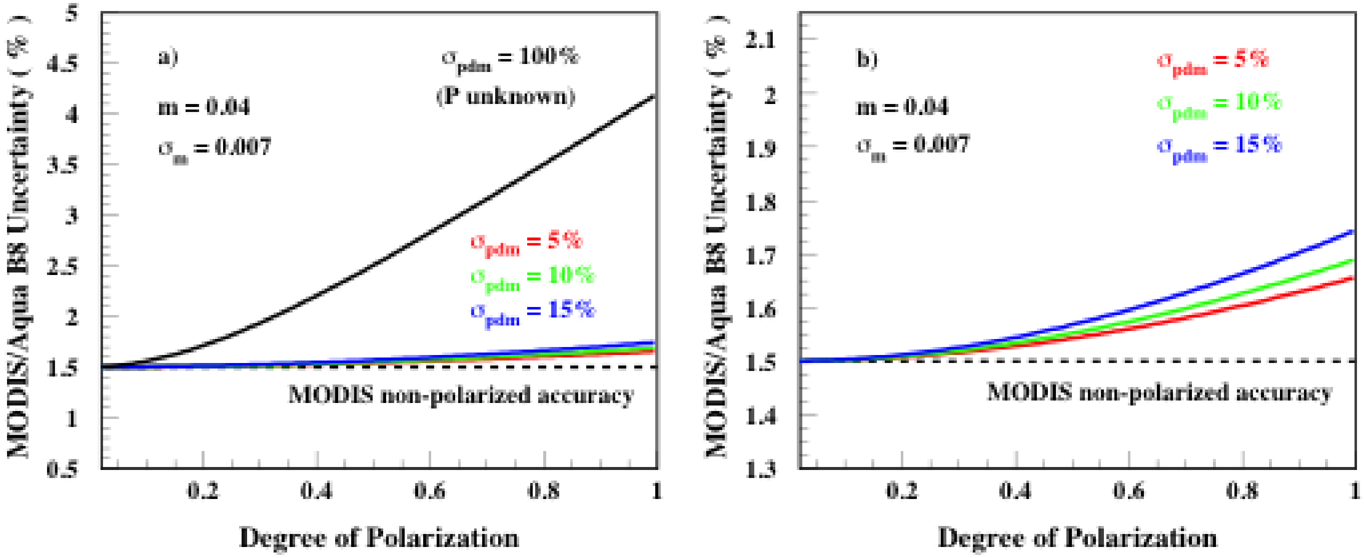
c) Overcast ice clouds over ocean with cloud optical depth from 5 to10.

PDM values are shown by color scale as function of viewing angle, and solar azimuth.

How does the PDM uncertainty affect the total radiometric error ?

Development of Polarization Models to Account for Imager Sensitivity to Polarization on Orbit

Radiometric Uncertainty



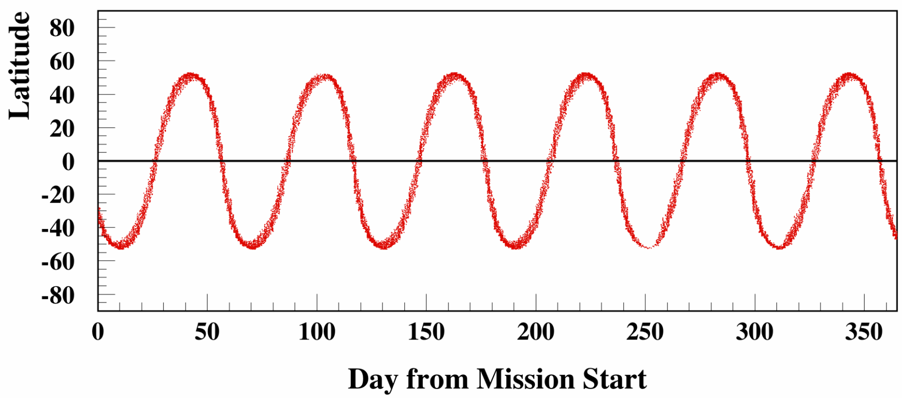
Calculated MODIS/Aqua Band-8 radiometric uncertainty including contribution due to polarization. Red, green and blue curves show imager uncertainty for PDM accuracy/precision at 5%, 10%, and 15%, respectively (a and b).

The black curve (a) shows imager uncertainty when polarization is not known.

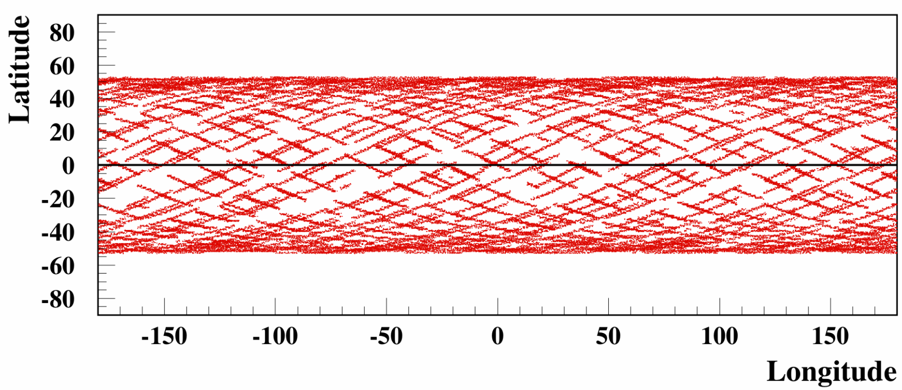
CLARREO RS Reference Inter-calibration from the ISS

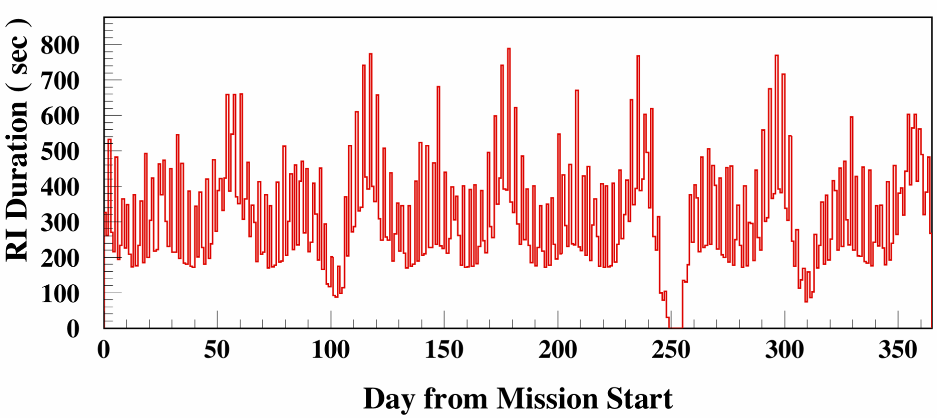
C. Roithmayr and C. Lukashin

- CLARREO on the ISS (51° inclination, 400 km altitude).
- Alternative pointing: Pitch & Roll 2D gimbal.
- 790 Inter-calibration opportunities (total).
- Sampling estimates for VIIRS/JPSS inter-calibration.



q1 and q2 range +/- 75°
SZA < 75°
Duration > 30 seconds
N Opportunities = 712
Delta T within 5 minutes
Delta VZA < 1.5°
Delta RAZ < 1.5°

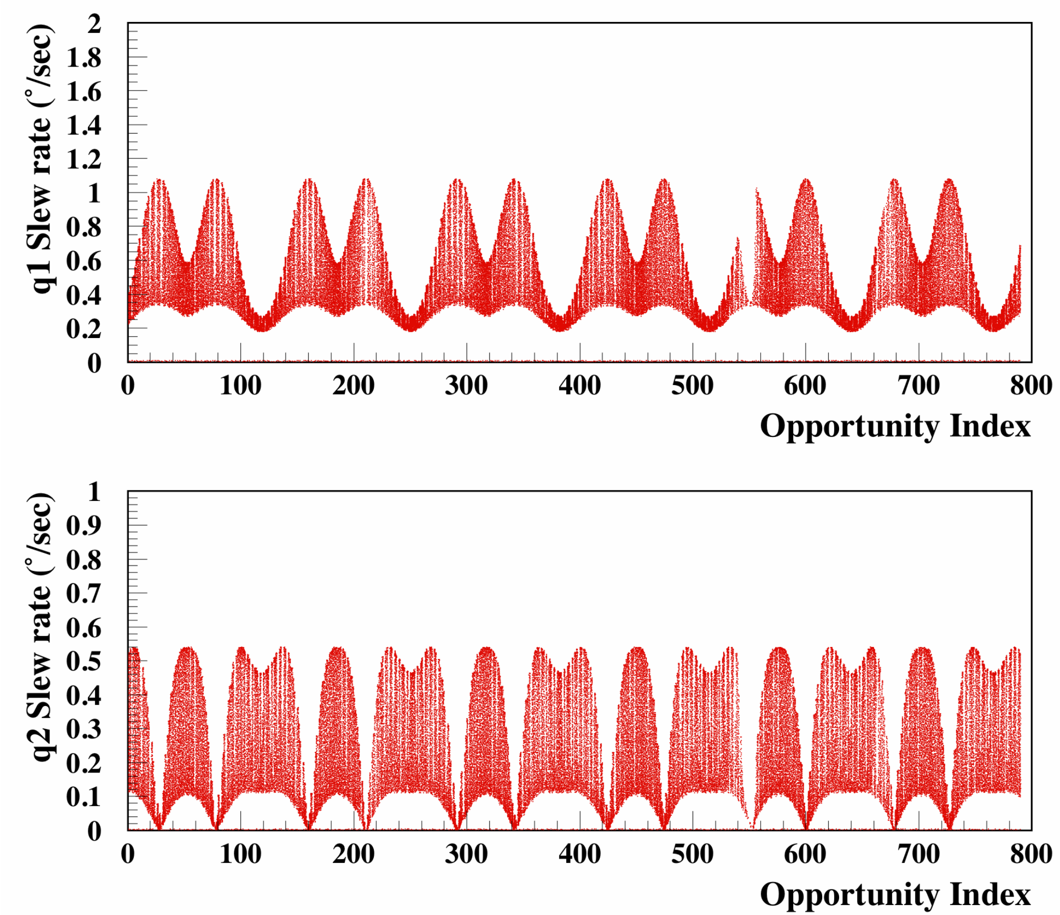




CLARREO RS Reference Inter-calibration from the ISS

C. Lukashin and C. Roithmayr

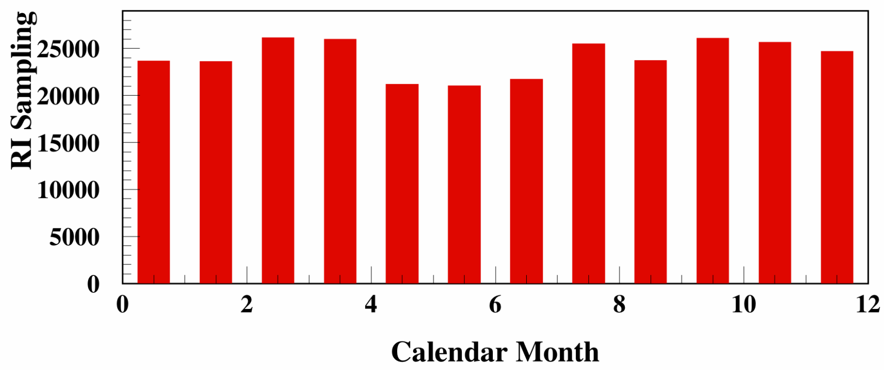
Gimbal Slew Rates (absolute values): q1 – Pitch, q2 Roll

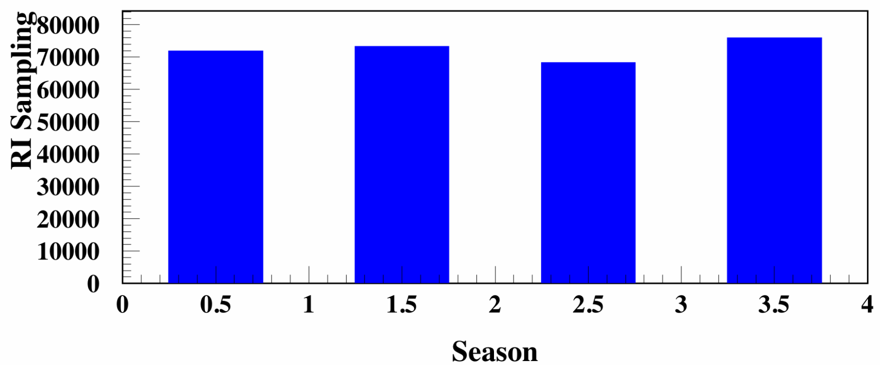


CLARREO RS Reference Inter-calibration from the ISS

C. Lukashin and C. Roithmayr

RI Sampling for CLARREO/ISS and VIIRS/JPSS (conservative estimate)





- 2D Pointing with Pitch & Roll gimbal can be considered as an alternative for LEO inter-calibration.

- Sampling for GEO inter-calibration should be modeled separately.

SCIAMACHY Level-1 Spectral Radiance Data

SCIAMACHY/ENVISAT nadir observations:

Spectral Reflectance from 240 nm to 1750 nm

- POC at NASA LaRC: Constantine Lukashin
- Data version: 7.01 (optics degradation: M-factors v. 7.03)
- Time period: 2002.08 – 2010.12 Done !
- Data format at LaRC: binary (made on little-endian system)
- Expected data set volume: about 4 Tb
- Example of reader code + set of functions available:
  - in C++ from C. Lukashin (optional ROOT applications)
  - in FORTRAN-90 from Z. Jin
  - MODIS-based scene description (separate files)
- SCHIAMACHY derived Cloud data products now available:
  CFr, CPr, COT, CPh, etc. Anybody interested ?
- Access from outside NASA LaRC:
  - Method: NASA VPN account + access to CLARREO SCF
  - Registration at ESA for SCI_NL__1P data product is REQUIRED
  - POC: J. Trinkle and A. Durand

CLARREO Reference Inter-Calibration: Future Work

1) Baseline CLARREO RS RI activities at NASA LaRC (direct funding):

- Empirical and theoretical modeling of polarization at TOA for RI (C. Lukashin, W. Sun).

- Demonstration of RI algorithms in RS using SCIAMACHY, CERES, PARASOL, MODIS and VIIRS data. (C. Lukashin, D. Doelling, Z. Jin, J.C. Currey, W. Sun, X. Xiong, J. Butler, P. Speth, C. Roithmayr, et al.), depends on CLARREO funding.

2) Publication of completed work:

- C. Lukashin, Z. Jin, W. Sun, K. Thome, B.A. Wielicki, D.F. Young: "Uncertainty Estimates for Imager Reference Inter-calibration with CLARREO Reflected Solar Spectrometer".

- C. Lukashin, Z. Jin, D.G. Macdonnell, K. Thome, B.A. Wielicki, D.F. Young: "Restriction on Instrument Sensitivity to Polarization for Climate Observing System in Reflected Solar" (requirement for CLARREO RS instrument).

- W. Sun, C. Lukashin, et al.: "Modeling Polarization at TOA for Inter-calibration of Spaceborne Sensors" (theoretical and empirical polarization modeling).

- C. Roithmayr, C. Lukashin, P. Speth, B.A. Wielicki, D.F. Young: "CLARREO Approach for Inter-Calibration of Reflected Solar Radiation on Orbit" (RS inter-calibration sampling).