CLARREO Reflected Solar Spectrometer: Reference Inter-Calibration Activities

Constantine Lukashin

NASA LaRC, Hampton, VA
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.
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:
\[ \chi = \begin{cases} 
\tan^{-1} \left( \frac{U}{Q} \right) / 2 & \text{if } Q > 0 \\
\tan^{-1} \left( \frac{U}{Q} \right) / 2 + \pi / 2 & \text{if } Q < 0 
\end{cases} \]

Correction due to Polarization:
\[ L_{sensor} = (1 + mP) L_0 \]

Relative Uncertainty:
\[ \frac{\sigma_{sensor}}{L_{sensor}} = \sqrt{\left( \frac{\sigma_0}{L_0} \right)^2 + \frac{P^2 \sigma_m^2 + m^2 \sigma_{pdm}^2}{(1 + mP)^2}} \]

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

- PARASOL data from 2006.04.01
- $\lambda = 670$ 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)
- $\chi$ (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 to 10;

c) Overcast ice clouds over ocean with cloud optical depth from 5 to 10.

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?
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.

\[ q1 \text{ and } q2 \text{ range } +/- 75^\circ \]
\[ SZA < 75^\circ \]
\[ \text{Duration } > 30 \text{ seconds} \]
\[ N \text{ Opportunities } = 712 \]
\[ \Delta T \text{ within } 5 \text{ minutes} \]
\[ \Delta VZA < 1.5^\circ \]
\[ \Delta RAZ < 1.5^\circ \]
Gimbal Slew Rates (absolute values): q1 – Pitch, q2 Roll
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).

2) Publication of completed work: