Simulation of CLARREO Benchmark and Inter-Calibration Capabilities Using SCIAMACHY Data

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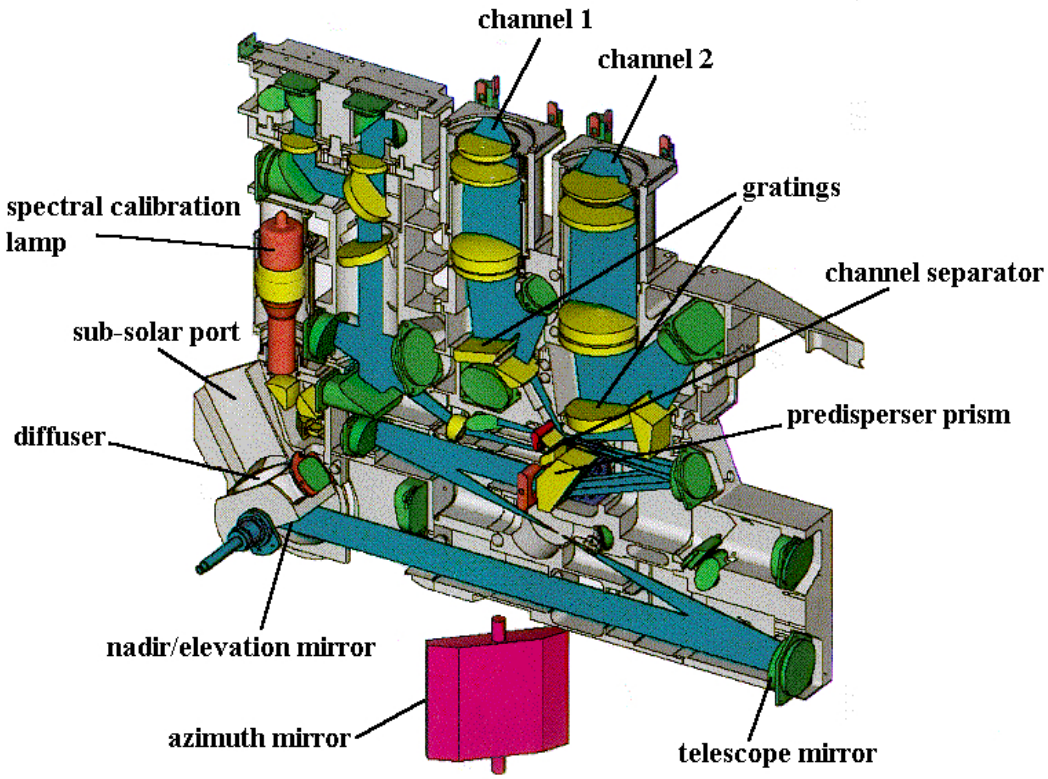
GOAL

Use high spectral resolution SCIAMACHY measured reflectance over time period from 2002 to 2007 to answer key questions on requirements for CLARREO mission in solar spectral range.

Key Activities

- **Providing validation data for modelers.**
- **Simulation of CLARREO inter-calibration capability in 300 - 1750 nm spectral range, define CLARREO algorithms and spectral resolution requirement.**
- **CLARREO benchmarck study: requirements for spatial, temporal and angular coverage. Finding out natural variability of nadir reflectance spectra.**

SCIAMACHY Optical Arragement, Level 1



SCIAMACHY Features

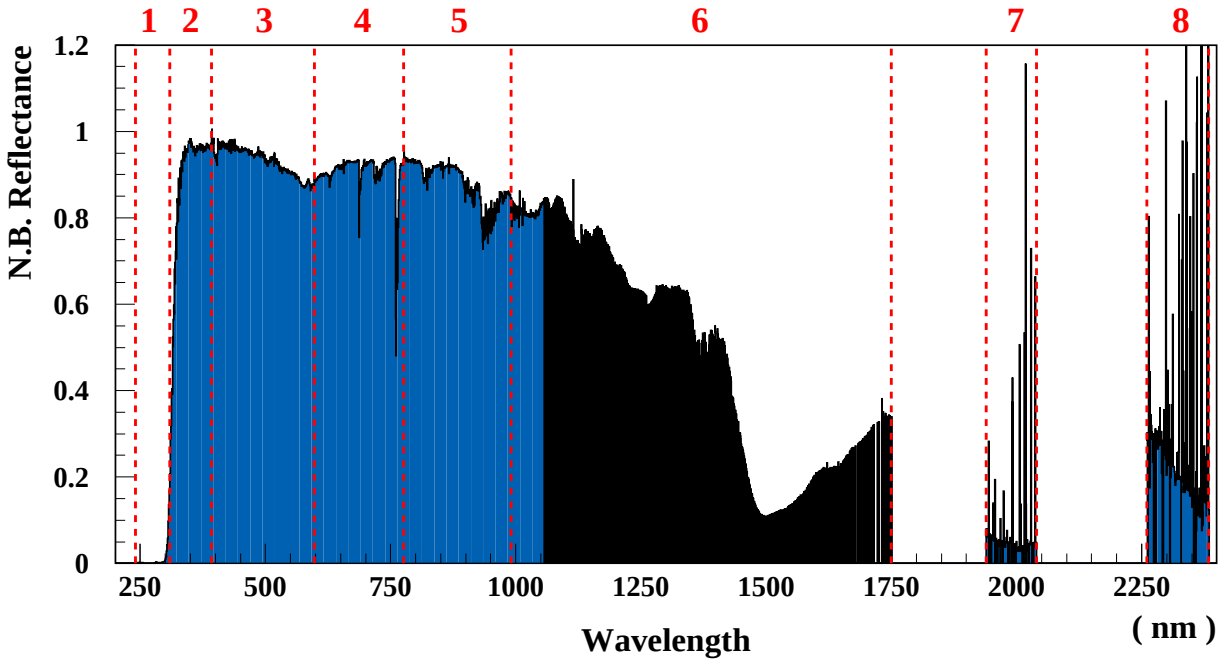
- **ENVISAT SSP at 800 km altitude, 10 a.m. mean local solar time.**
- **FOV = 30 km (along-track) × 240 km (cross-track) with integration time 1s.**
- **Swath = 960 km (Nadir measurements), 5 integrations.**
- **Coverage: Global (in 3-4 days).**
- **Data volume = 6 Gb per day (SCI_NL_1P, Level-1B data product).**

Channel	Spectral Range (nm)	Spectral Resolution (nm)	Spectral Stability (nm)	Reflectance Errors (%)
1	240 - 314	0.24	0.003	3
2	309 - 404	0.26	0.003	2
3	392 - 605	0.44	0.004	3
4	598 - 790	0.48	0.005	2
5	776 - 1056	0.54	0.005	6
6	991 - 1750	1.48	0.015	4
7	1940 - 2040	0.22	0.003	? Light Leak
8	2260 - 2384	0.26	0.003	?

Table 1: SCIAMACHY channel spectral boundaries, resolution, stability, radiometric uncertainties, and cluster definition for Nadir measrements.

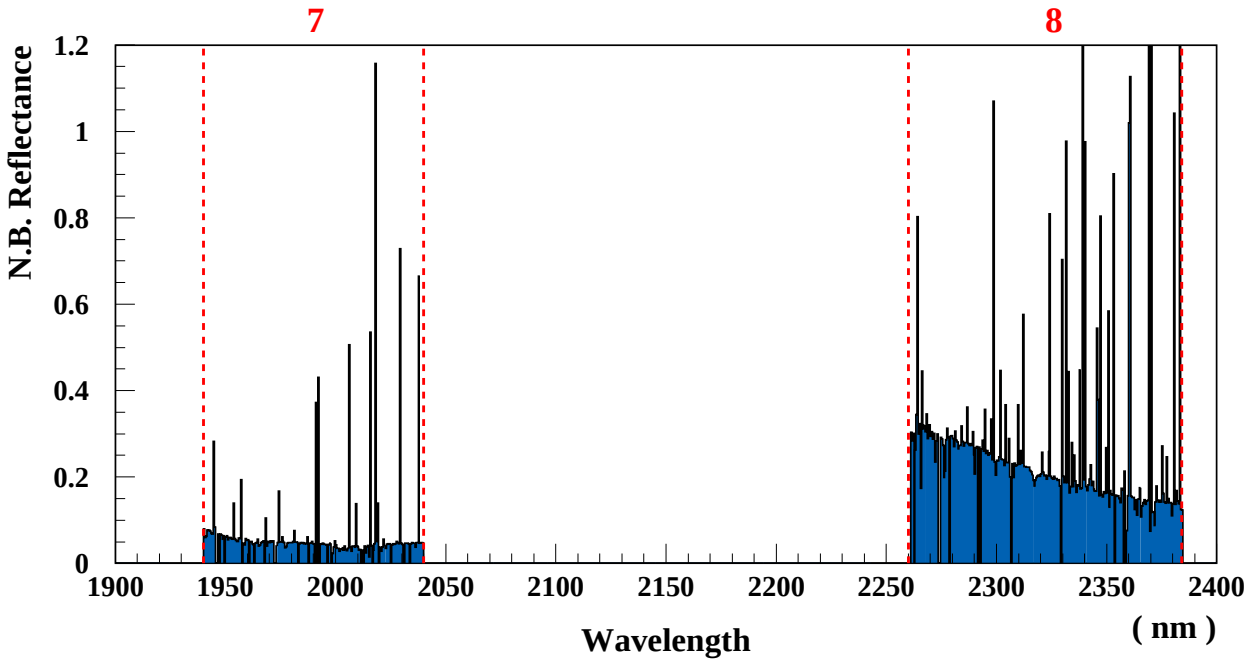
SCIAMACHY Reflectance Spectra

(DCC over Ocean footprint, full measurement)



SCIAMACHY Reflectance Spectra

(DCC over Ocean footprint, Channels 7 and 8)



TOA Nadir Radiance Spectra Loss beyond 1750 nm

Scene Type	Fraction (%)
Clear Ocean	0.04
Clear Veg. Land	3.99
Clear Desert	4.66
Clear Snow	1.21
DCC Clouds	1.76
Cloudy Ocean	3.67
Cloudy Land	3.37

Table 2: Energy fraction beyond 1750 nm in the TOA nadir radiance from MODTRAN (SZA = 6°; Mid-lat atmosphere; Mid-lat average cloud properties in June for cloudy skies; DCC re = 50 μm).

Bad Pixels Masks

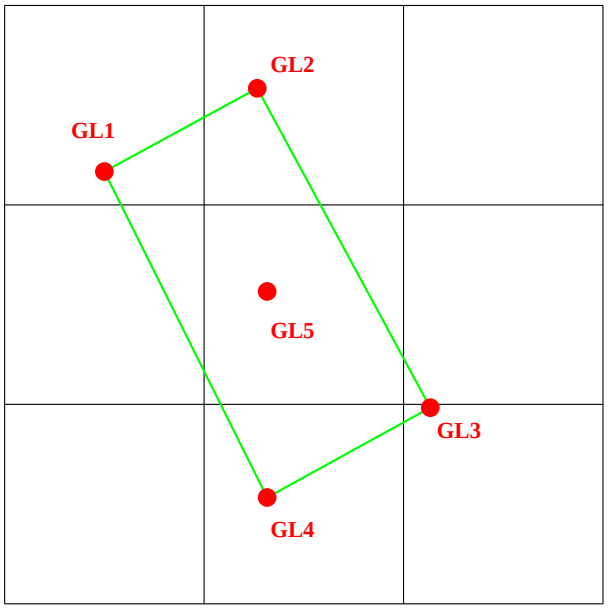
- **Implemented: daily Solar and Nadir (ir)radiance bad pixel masks for spectral range from 300 to 1750 nm (channels 1 - 6).**

Scene Identification Parameters

Rough scene identification is based on averages and STDs from CERES/*Terra* SSF on $1^\circ \times 1^\circ$ grid. *Terra* is on sun-synchronous polar orbit with 10:30 a.m. mean local solar time.

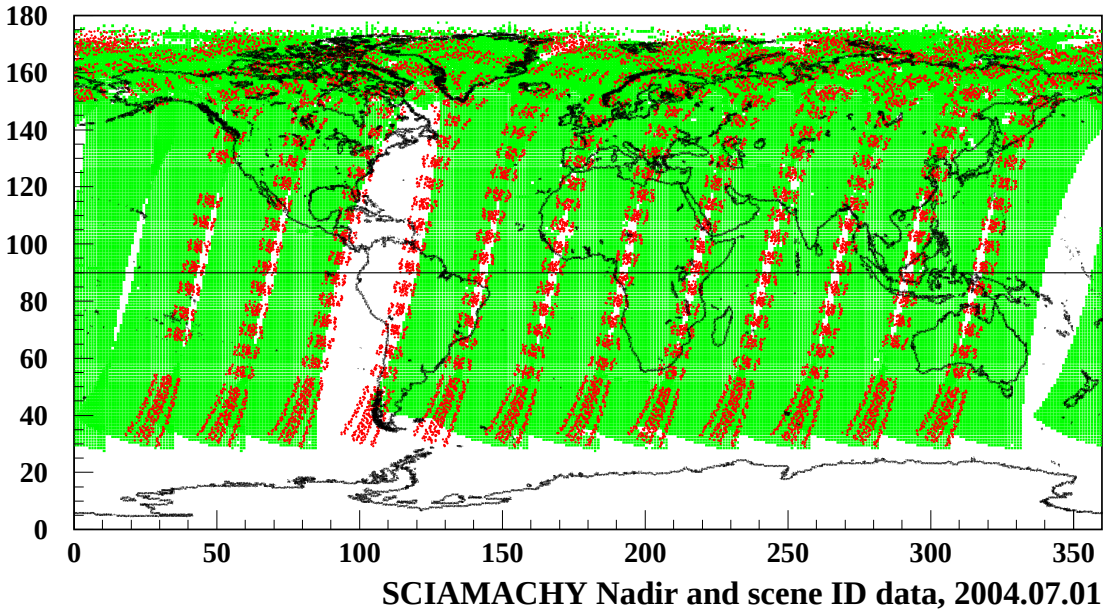
- **Dominant surface type (its percentile), geolocation and viewing geometry.**
- **Clear-sky: wind speed, surface skin temperature, precipitable water (GEOS4).**
- **Clouds: cloud fraction, number of of cloud layers (max = 2), optical depth, particle phase, cloud-top temperature, effective cloud height, cloud-top pressure, radius of water droplet (ice particle diameter).**
- **Aerosol (MODIS, C4): optical depth, fine-mode fraction over ocean, cover for 4 aerosol types over land (mixed, sulfates, dust, smoke), Angstrom exponent.**

SCIAMACHY Footprint (5 geolocation points)

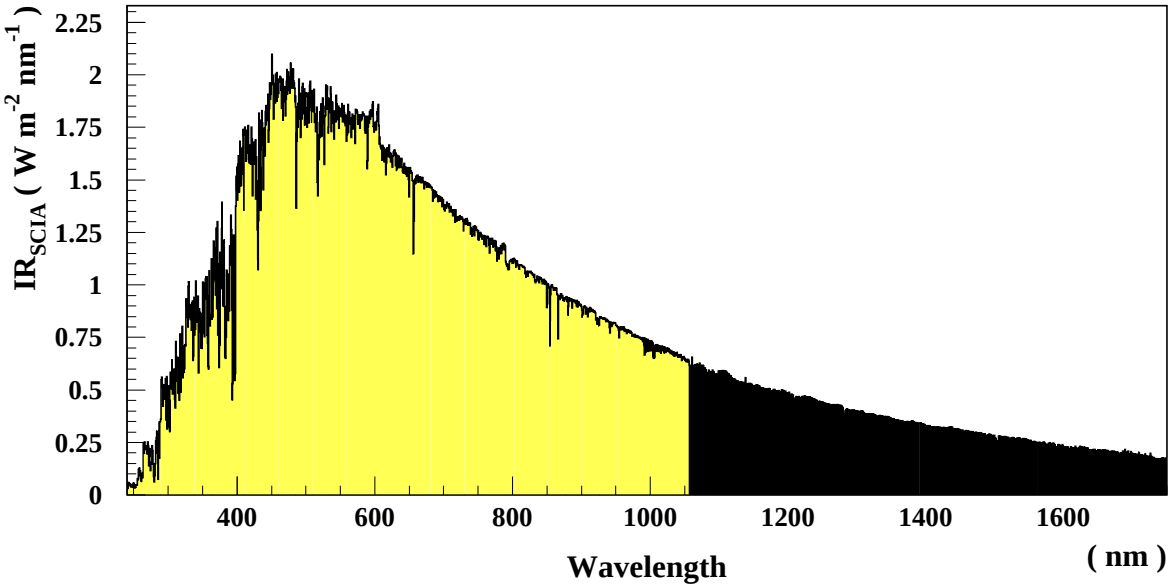


SCIAMACHY FOOTPRINT 30 x 230 km

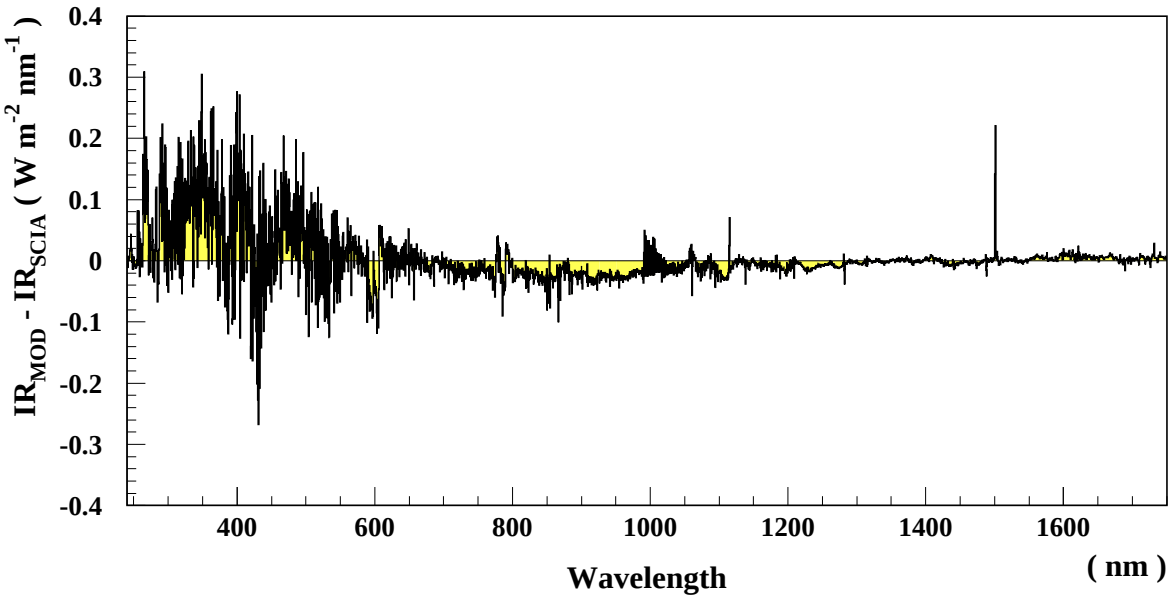
SCIAMACHY Nadir Data (SZA $< 90^{\circ}$) and Scene ID Coverage for 2004.07.01



SCIAMACHY D0 (daily) Solar Spectrum 2004.07.01

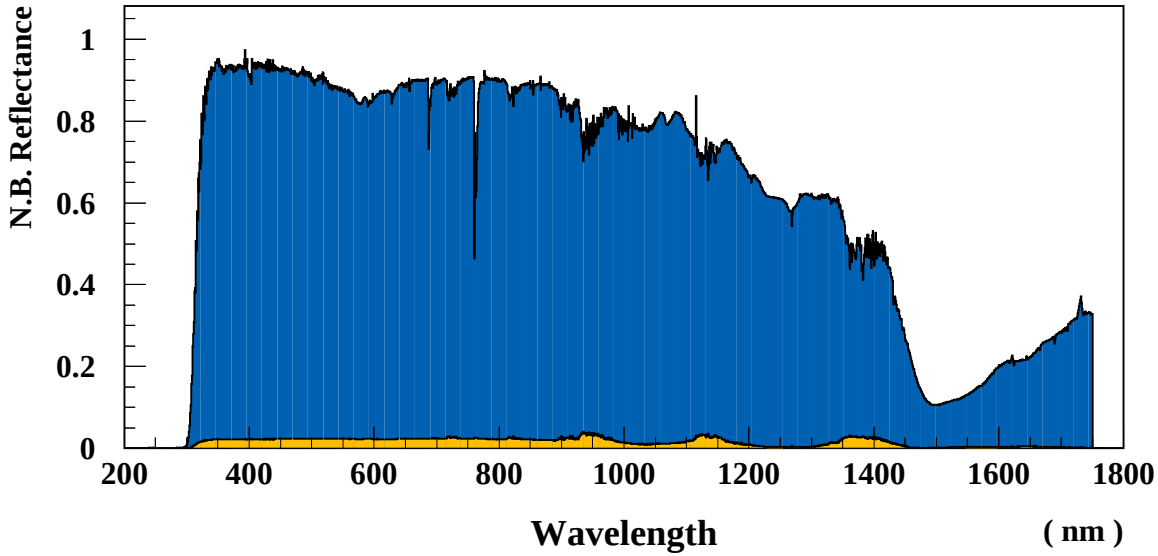


Difference in SCIAMACHY (D0) and MODTRAN (NewKur) Solar Spectrum



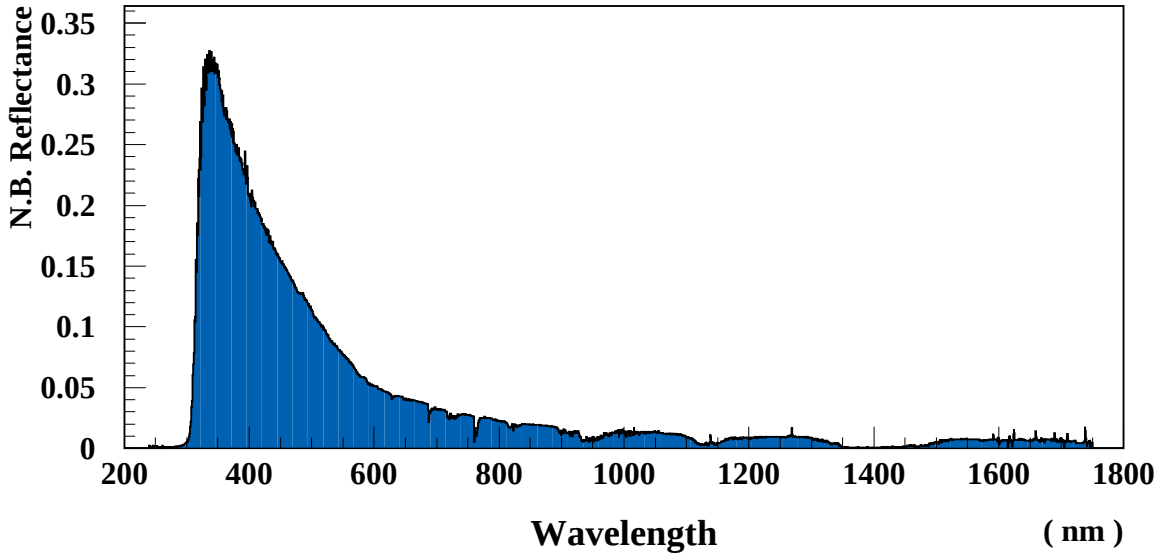
SCIAMACHY Reflectance Spectra

(2004.07.01, DCC system over ocean, N FOV = 4)



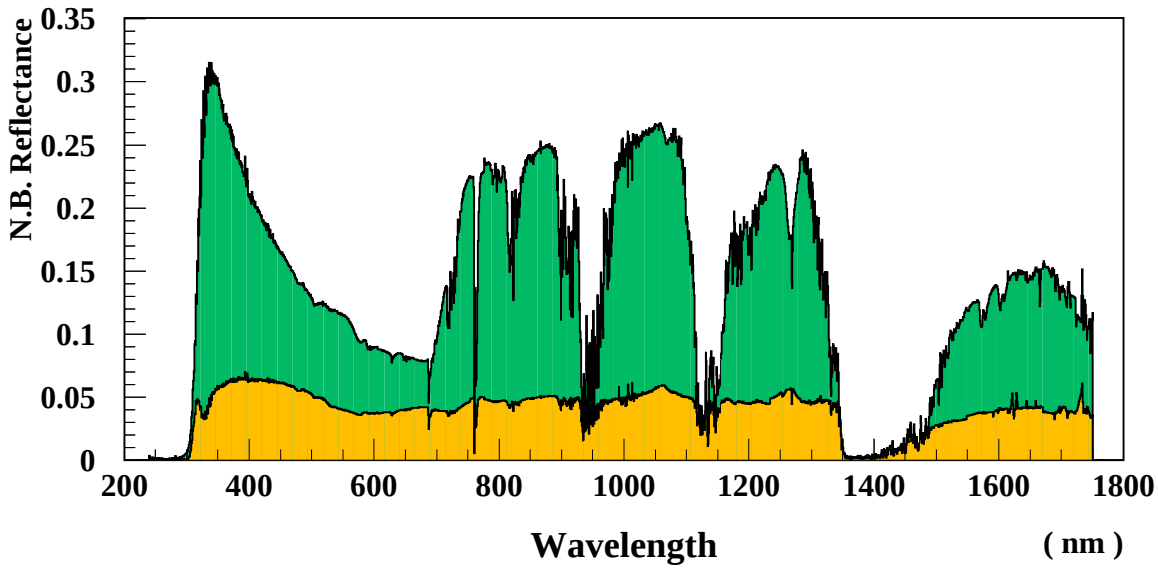
SCIAMACHY Reflectance Spectra

(2004.07.01, clear-sky ocean, N FOV = 1)



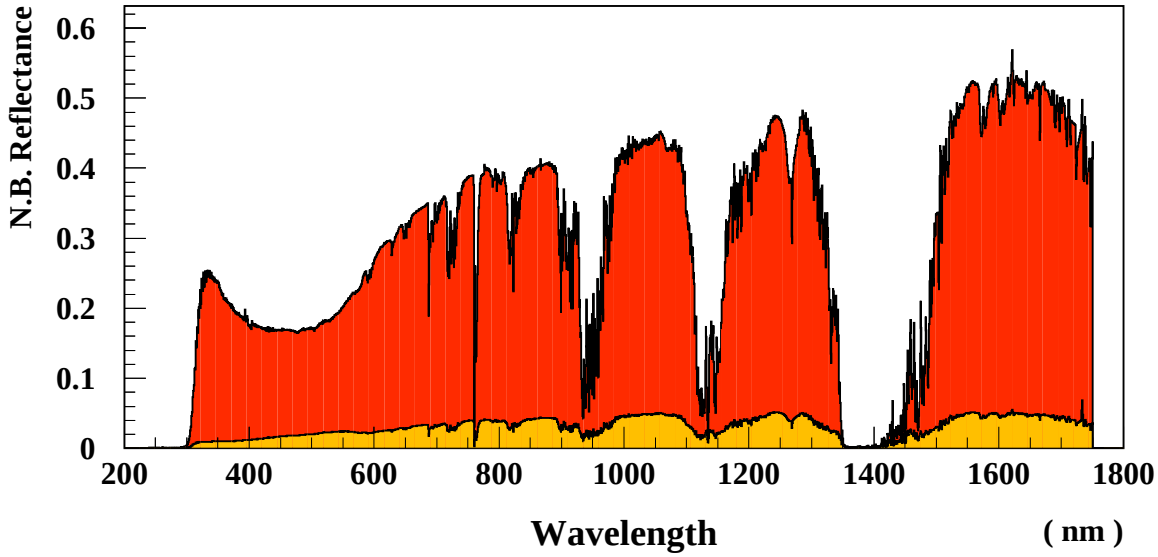
SCIAMACHY Reflectance Spectra

(2004.07.01, clear-sky forest, N FOV = 16)

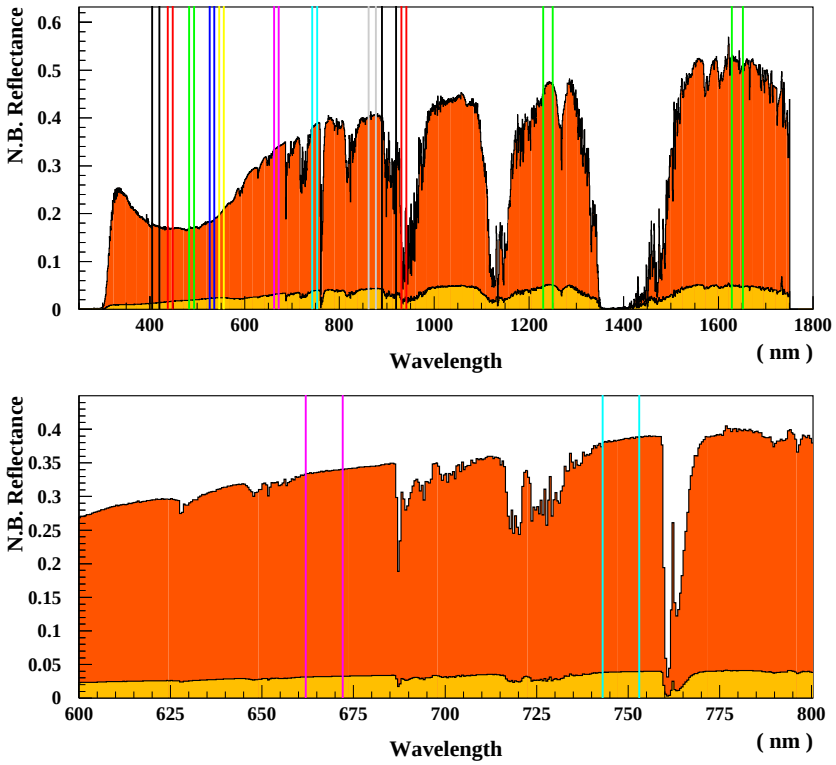


SCIAMACHY Reflectance Spectra

(2004.07.01, clear-sky desert, N FOV = 34)



SCIAMACHY Reflectance Spectra with MODIS bands



Future Work:
Database of Target SCIAMACHY Spectra

Create Database of well-restricted by scene type SCIAMACHY spectra (instantaneous measurements and averaged) which should include:

- **SCIAMACHY daily D0 solar spectrum (original and 0.5 nm resolution).**
- **SCIAMACHY FOV scene type ID (center and 4 corner points of the FOV).**
- **SCIAMACHY nadir radiance spectra (original and 0.5 nm resolution).**
- **SCIAMACHY reflectance spectra (0.5 nm resolution with interpolation).**
- **For spectra averaged over a scene type: STD of radiance and reflectance spectra (0.5 nm resolution).**

Schedule:

- **Create database (version 1) by Summer 2008 (add to it as we go).**

Future Work:
CLARREO Re-Calibration Capability

- SCIAMACHY data is considered to be CLARREO *true* spectra.

- Process SCIAMACHY data through nominal instrument response simulator (CERES, MODIS, VIIRS, SeaWiFS; spectral response function, offset, gain) to generate *nominal* dataset (A). GSFC collaboration on spectral response for MODIS, VIIRS, SeaWiFS, and on calibration results.

- Corrupt instrument response parameters and generate *corrupted* dataset (B).

- Compare *nominal* and *corrupted* signals (datasets A and B).

- Effects to be included in simulation:
  - electronics offset change
  - electronics gain change
  - spectral shift
  - optics contamination/darkening (e.g. surface contaminant)
  - optics darkening (radiaton damage in depth)
  - interference filter delamination effects
  - cross-talk between channels

  - vary CLARREO spectral resolution to test impact on ability to calibrate other sensors

Future Work (continued): CLARREO Re-Calibration Capability

- **Formulate CLARREO calibration algorithms to test the ability to recover instrument changes in orbit or errors in original calibration.**

Schedule:

- **Initial offset/gain/spectral shift/contamination results by Fall, 2008.**
- **Varying CLARREO spectral resolution - Winter 2008/2009.**
- **Crosstalk / Delamination effects - Summer 2009.**

Future Work:
CLARREO Benchmark Capability

- **Import 4 months per year, 5 years of SCIAMACHY Level-1B data (3.6 Tb).**

- **Process SCIAMACHY data with the latest available calibration (v. 6.03).**

- **Create database of monthly averaged spectra (with STDs):**
  - **all-sky zonal spectra over ocean (5° latitude bands)**
  - **all-sky zonal spectra over land (5° latitude bands)**
  - **clear-sky zonal spectra over ocean (5° latitude bands)**
  - **clear-sky zonal spectra over land (5° latitude bands)**
  - **all-sky regional spectra (5°×30° grid ?)**
  - **clear-sky regional spectra (5°×30° grid ?)**

- **CLARREO sampling study: compare results from SCIAMACHY full swath and nadir only data (spatial sampling) and various viewing angles (angular sampling).**

- **Determine natural variability of monthly zonal and regional spectra.**

- **Comparison of the SCIAMACHY derived and model based results.**

- **Formulate CLARREO algorithms to identify spectral benchmark signatures.**

Future Work (continued): CLARREO Benchmark Capability

Schedule:

- Import, calibrate, process SCHIAMACHY data for CLARREO: Summer, 2008 and continue.
- Spectra regional, zonal, global interannual variability: Winter, 2008/2009.
- Benchmark signature algorithms (with LASP) Spring, 2009.
- SCHIAMACHY/MODEL closure study Summer, 2009.