ESA FDR4ATMOS Project

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February 25, 2023

Outline

Introduction

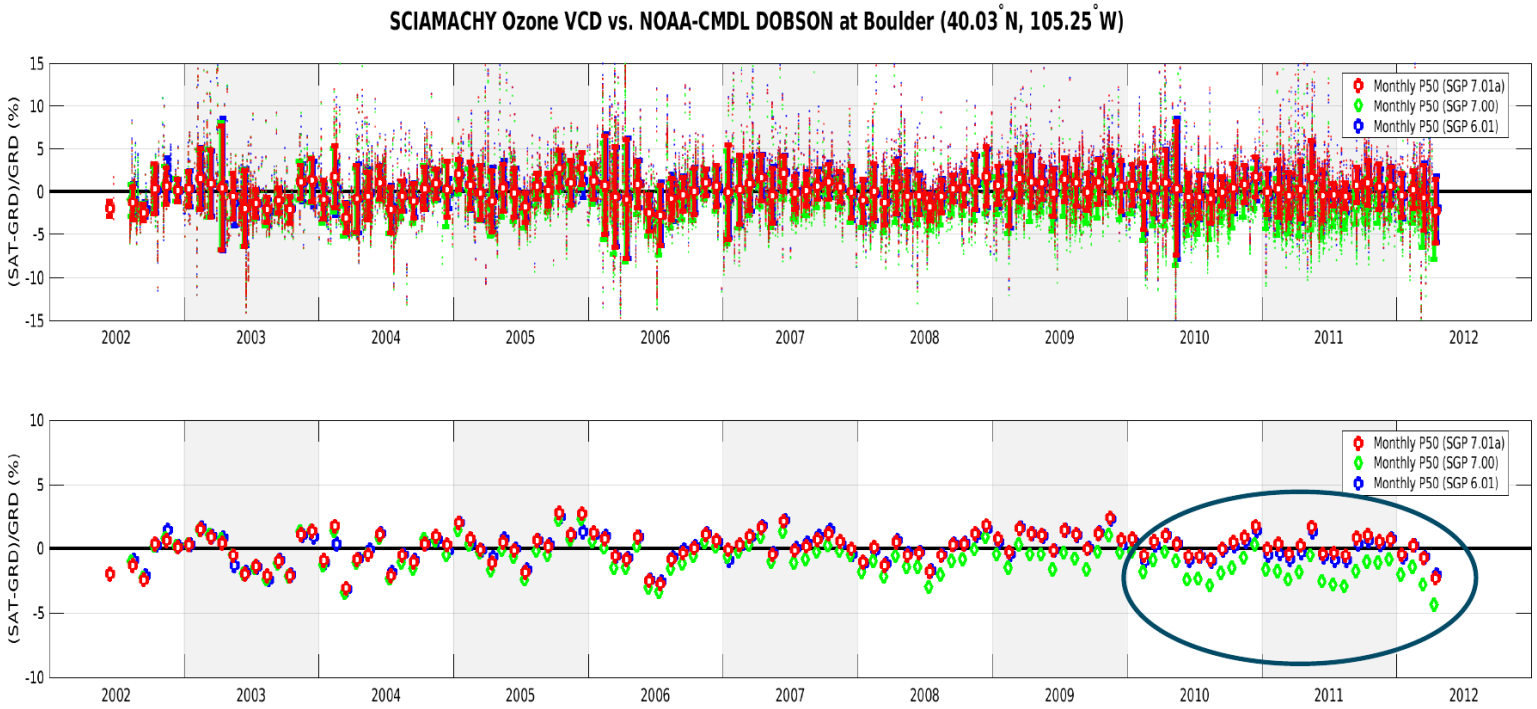
- The Fundamental Data Record for ATMOSpheric Composition (FDR4ATMOS) project is part of the ESA Long Term Data Preservation (LTDP) programme
- It has two main tasks
  - Task A: Correction of SCIAMACHY degradation and incorporation of lunar data
  - Task B: Creating a cross instrument time series of Level 1 data for GOME-1 and SCIAMACHY

→ Reminder GOME-1, SCIAMACHY

Goals Task A

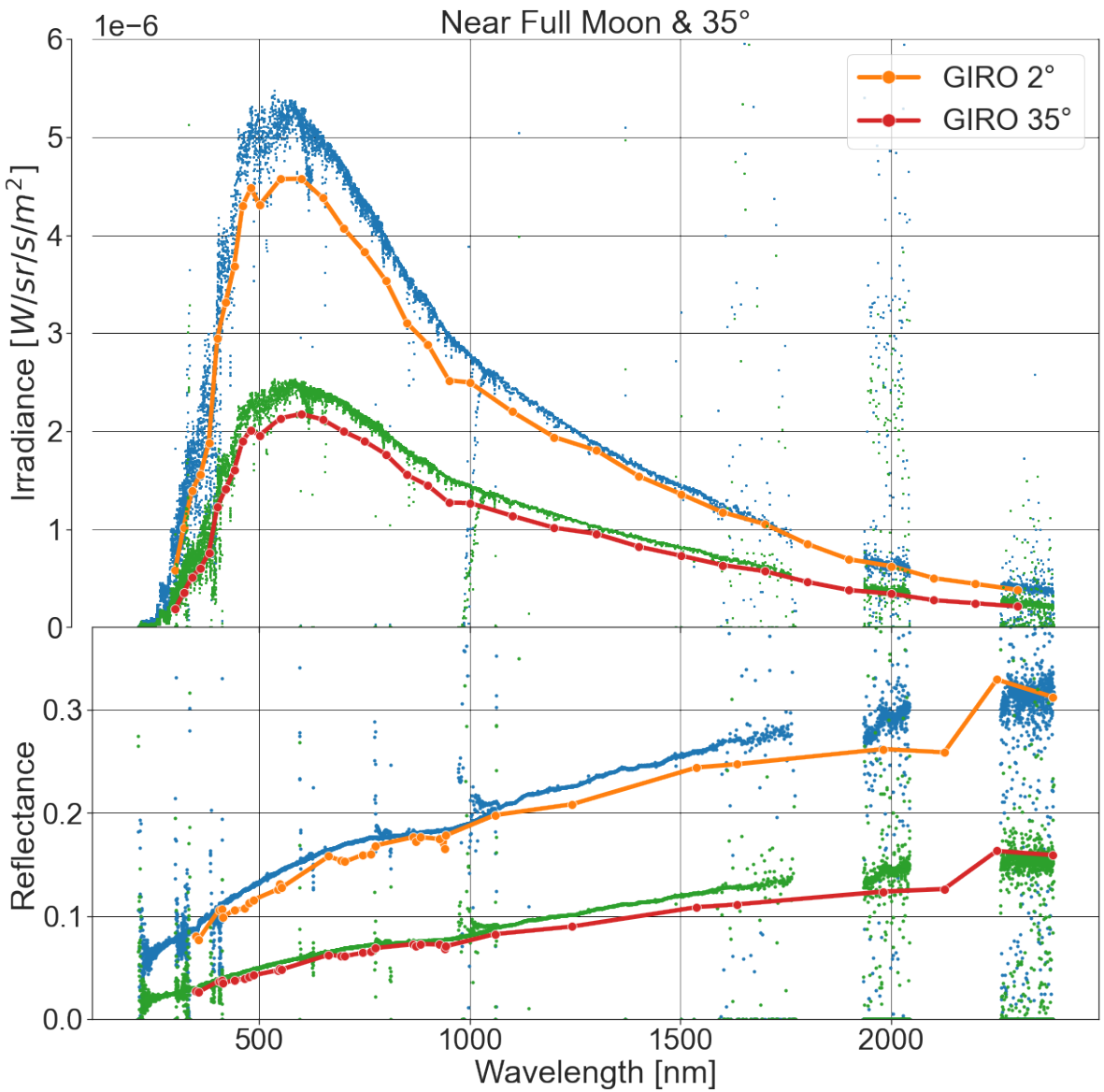
- After the re-processing of SCIAMACHY data with the previous processor version, O_3 total column data showed a drift
- Validation showed that in the updated version the O_3 drift is removed
- Lunar data covering the whole mission from 2002-2012 were calibrated and will be released
  - in the SCIAMACHY Level 1b products
  - separately containing individual lunar measurements and disk averaged data
  - and additionally a data product with only averaged data in a format as currently discussed in GSICS
- The data will be released as soon as the final format is defined

Task A O3 trend removal



Green: Erroneous product V7.0, Red: Corrected V7.1, Blue: old V6. Difference monthly global values Dobson/NDACC and SCIAMACHY. In V.7.0 a clear trend is visible expecially at the end of the mission. Corrected in version 7.1, which is also a slight improvement vs V6.

Task A Lunar Data Validation



Goals Task B

- The main objective of the FDR4ATMOS project is to develop a cross-instrument Level 1 product for GOME-1 and SCIAMACHY
- The FDR product will contain *harmonised* irradiances and reflectances
- The focus is on the spectral windows in the UV, VIS and NIR used for O3, SO2, NO2 total column retrieval and the determination of cloud properties.
- The FDR4ATMOS products will be based on Level 1, i.e. on irradiances and reflectances.

Why Level 1?

- Up to now projects that aim at the harmonisation of atmospheric trace gas data have done this on Level 2
- However, starting at Level 1 offers some advantages:
  - Harmonisation on Level 2 often depend on the specific Level 2 algorithms
  - If data are properly harmonised on reflectance or radiance level, this restriction no longer applies, i.e. the harmonised data could also be used for future, still to be developed Level 2 algorithms
  - Direct assimilation of radiometric data into models is possible independent of the instrument

Challenges

- Contrary to previous cross-calibrations (e.g. FIDUCEO project) harmonisation has to be done on a highly resolved spectral grid without changing the spectral structures used for retrieval
- GOME-1 and SCIAMACHY do not have exact co-locations (different orbits)
- To avoid a bias due to instrument effects comparison scenes have to cover
  - different observation geometries
  - different signal intensities
  - different signal polarisations

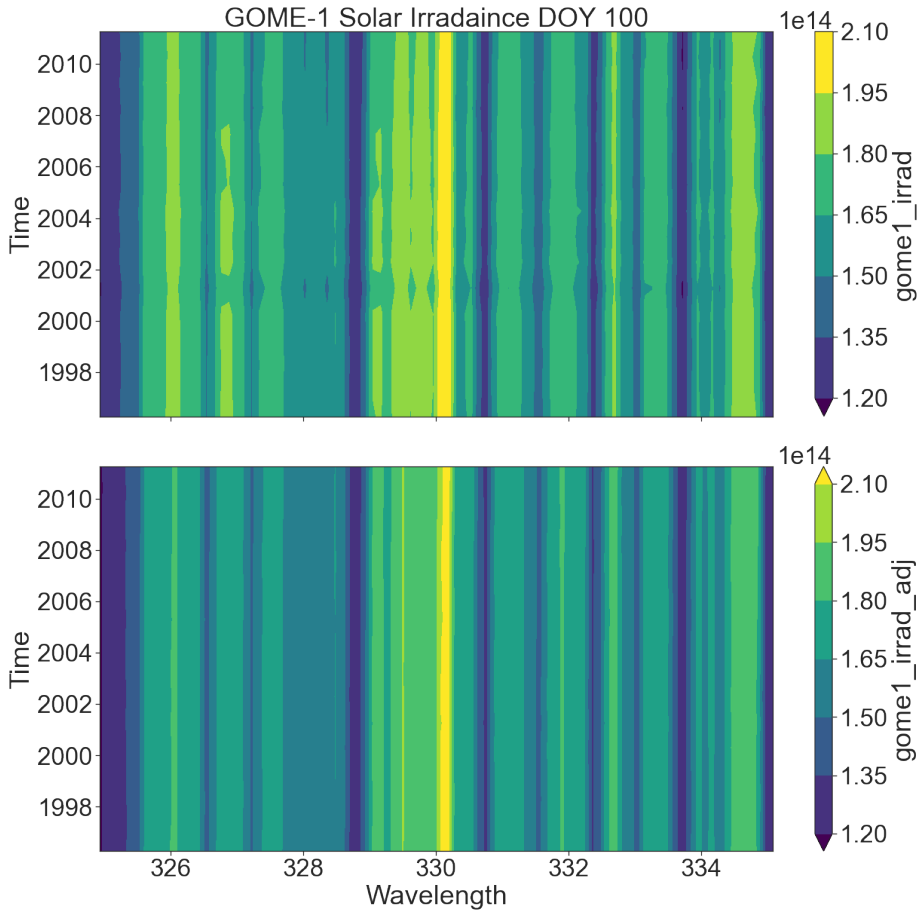
General Method

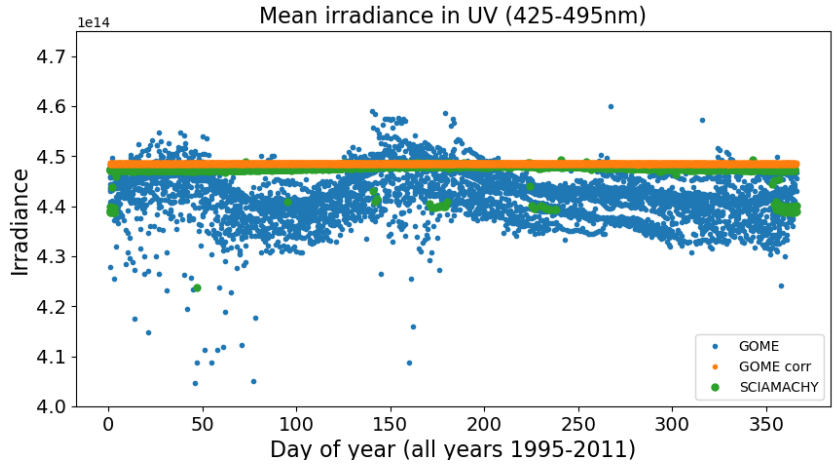
- Generic Formula:

$$S_{inst1} = S_{inst2} \times C_{\Delta inst} \times C_{1,scene}(geometry, S_{inst1.2}, \ldots) + C_{2,scene}$$

- Goal: Harmonise the broadband signal offset while keeping spectral structures
- Steps:
  - Align the spectral grids of both instruments
  - Ratio GOME and SCIAMACHY spectra
  - Smooth Ratio by convolution with Gaussian kernel $\Rightarrow$ Scaling factors
  - For reflectance: Investigate scene dependent effects
  - Apply to fully resolved spectra

Harmonisation Solar Irradiances - Results





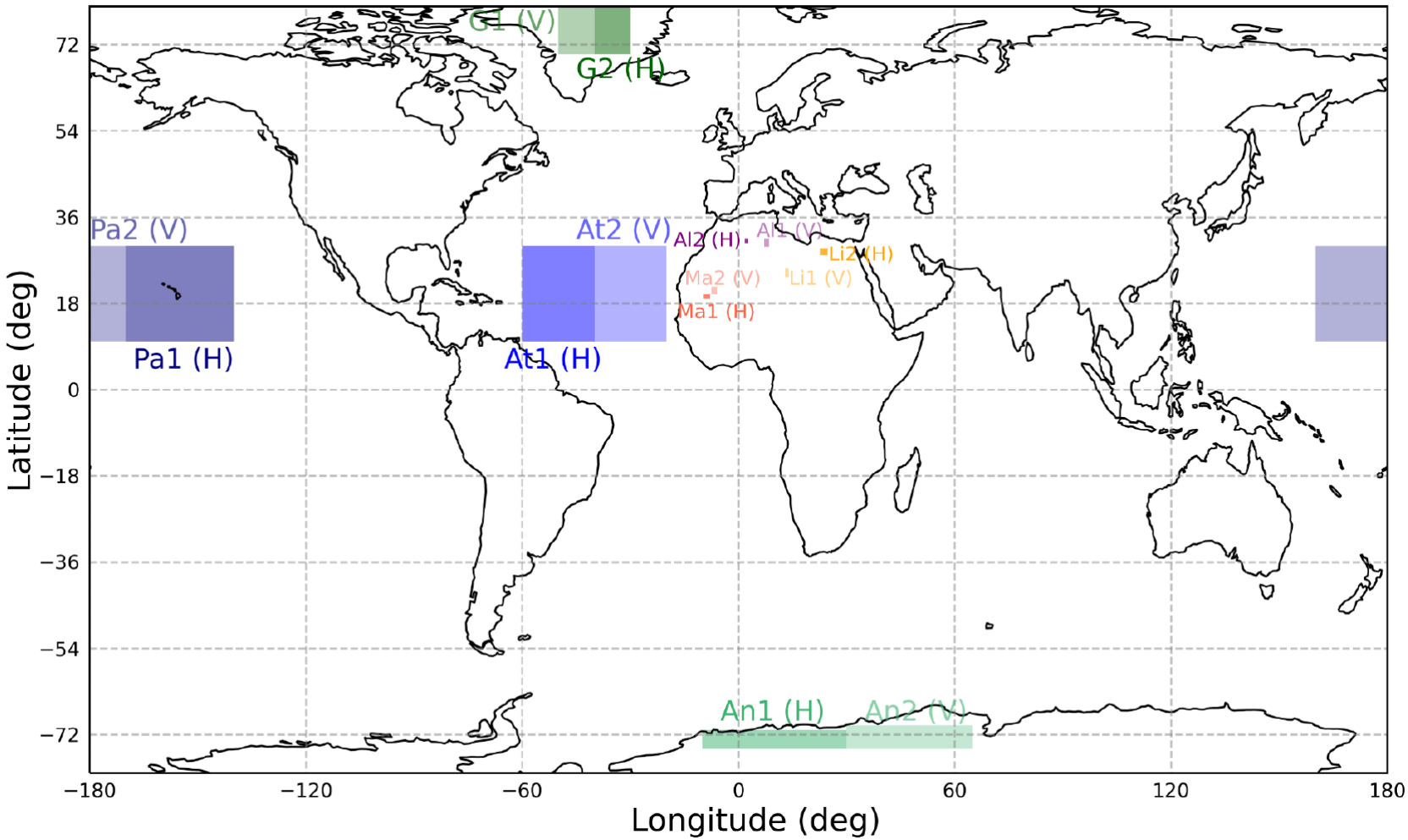
Mean irradiance VIS for every DOY showing BSDF correction related pattern (blue) and harmonised irradiance with patterns removed

UV irradiance for every day and wavelength before (top) and after harmonisation.

Study Set-up Reflectances

- Harmonisation will be done on reflectances (cancels GOME-1 etalon)
- Contrary to solar irradiance, scene dependent effects have to be taken into account
- Therefore, "matching scenes" with homogeneous signal have been defined to
  - cover different signal levels to avoid instrumental biases due to e.g. non-linearity
  - cover different observation geometries
- The data from these scenes will be used to identify scene effects

Matching Scene Areas



Study Set-up Reflectances

- Half of the matching scenes are reserved for validation purposes to avoid circular reasoning
- The year 2003 was chosen as the “golden year” to be used in the investigations
- Additional data before and after 2003 will be used to study effects from insufficient degradation corrections
- Tests using Level 2 retrievals will also be performed to check the usefulness of the harmonised data

Summary & Conclusions

- The FDR4ATMOS project aims to deliver FDRs on Level 1 Basis
- Using SCIAMACHY the solar spectra from GOME-1 were harmonised removing artefacts
- The harmonisation of the reflectances is on-going
- We will generate and publish products containing a harmonised reflectance and irradiance for the spectral retrieval windows of O3, SO2 (UV), NO2 (VIS) and cloud parameters (NIR) for both SCIAMACHY and GOME-1
- FDR4ATMOS is a pathfinder project to explore how and how far spectrally resolved data can be harmonised and be used for Level 2 retrievals
- A follow-on project to include GOME-2 observations from Earth, Sun and Moon is planned starting in the 2nd half of 2023

FDR4ATMOS Team

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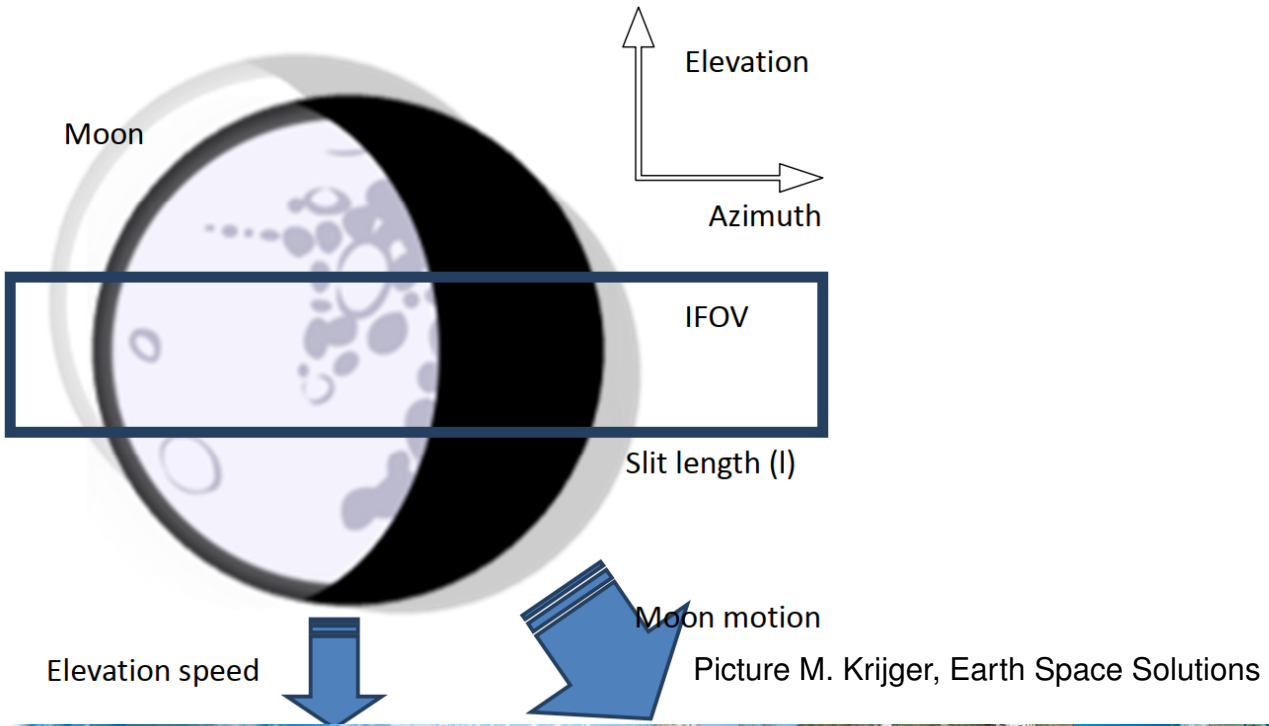
Additional Slides

Lunar Data - Background

- SCIAMACHY made regular Moon measurements and covered a large range of observation parameters
- The spectral range and resolutions of the observations constitute a unique data set
- The lunar disk fills part of the slit and was scanned, each individual observation had a 2 second integration time

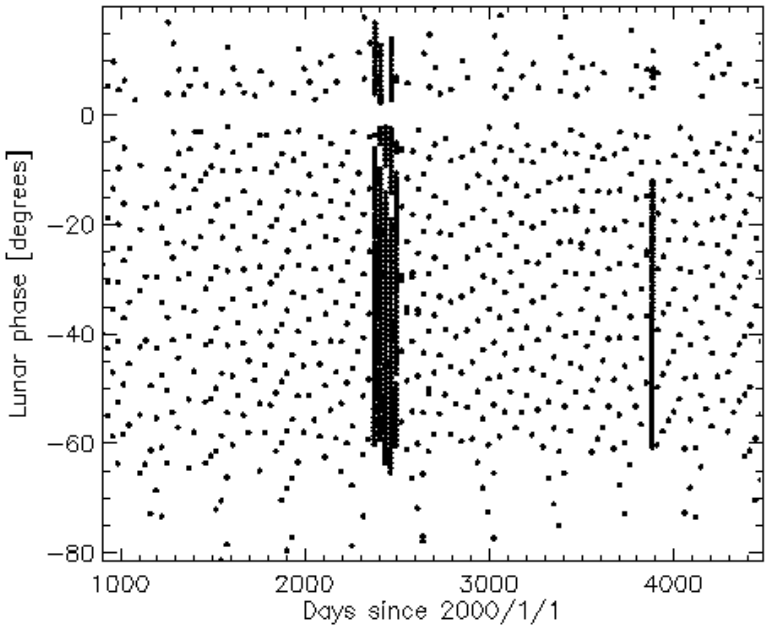


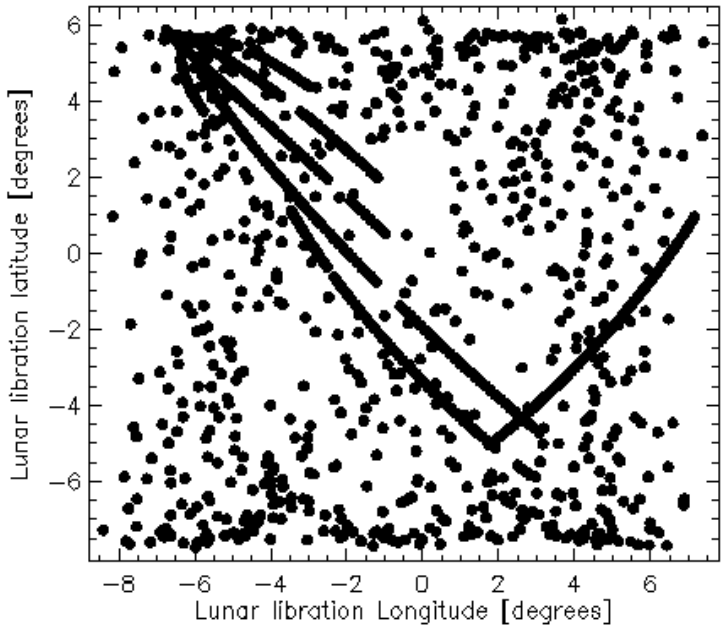
Lunar Data - Plans

- Provide averaged and individual Moon measurements in the L1b files (not calibrated)
- Implement algorithms for the user tool scial1c to generate Level 1c data with
  - correction of instrumental effects (dark signal, memory effect etc)
  - correction for slit filling
  - calculation of full disk irradiance
- Goal: Provide the users with spectrally resolved Lunar irradiances for the time from 2002 - 2012

Lunar Data - Coverage of Geometries

SCIAMACHY observations cover a large part of lunar phases lunar views





Plot M. Krijger, Earth Space Solutions

What is an FDR?

Definition (Original)

An FDR is a long-term record of selected EO Level 1 parameters, possibly multi-instrument, which provides improvements of performance with respect to the individual mission datasets.

Definition (Proposed by C. Merchant at CEOS and CGMS WGC Meeting)

An FDR consists of a consistently reprocessed record of uncertainty-quantified sensor observations that are calibrated to physical units and located in time and space, together with all ancillary and lower level instrument data used to calibrate and locate the observations and to estimate uncertainty.

Reminder GOME-1 and SCIAMACHY

Both instruments span 17 years of data. The table shows only the relevant channels for FDR4ATMOS

	GOME	SCIAMACHY
Launch	April 21st 1995	March 1st 2002
End of Mission	July 2nd 2011	April 8th 2012
Orbit	sun-synchronous, 790 km	sun-synchronous, 799.8km
Local Time (DNX)	10:30 am	10:00 am ± 5 Min
Observation Geometries	Nadir	Nadir, Limb, Occultation
Ground Pixel Size	40 × 320 km^2	32 × 233 km^2 to 26 × 30 km^2
Number of channels	4	8
Pixel Per Channel	1024	1024
Total Spectral Range	237 - 793 nm	212 - 2386 nm
UV Channel Range/Resolution	311 - 405 nm/0.17 nm	300 - 412 nm/0.26 nm
VIS Channel Range/Resolution	405 - 611 nm/0.29 nm	383 - 628 nm/0.44 nm
NIR Channel Range/Resolution	595 - 793 nm/0.33 nm	595 - 812 nm/0.48 nm

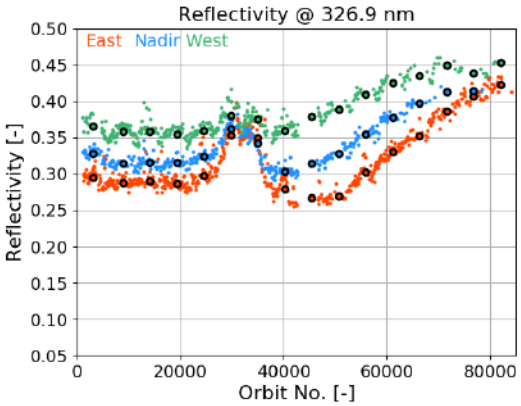
GOME reflectance at PICS Libya-4 (Sahara desert)

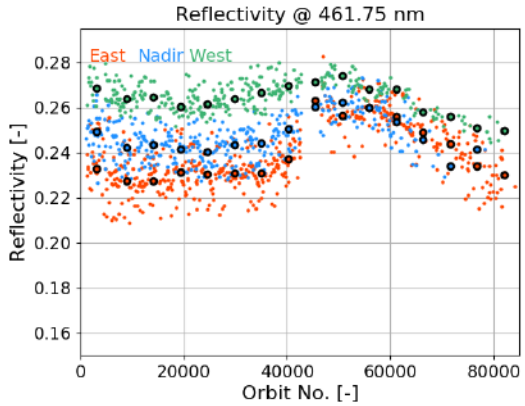
UV (326.9nm)

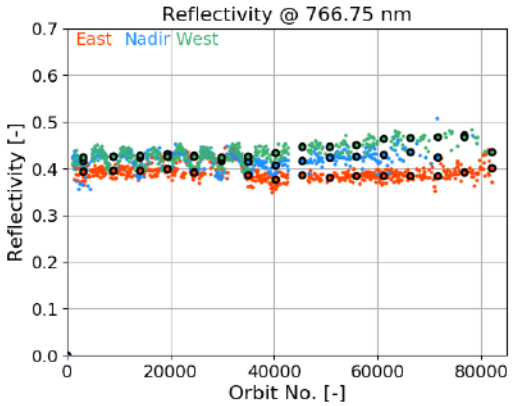
VIS (461.75nm)

NIR (766.75nm)

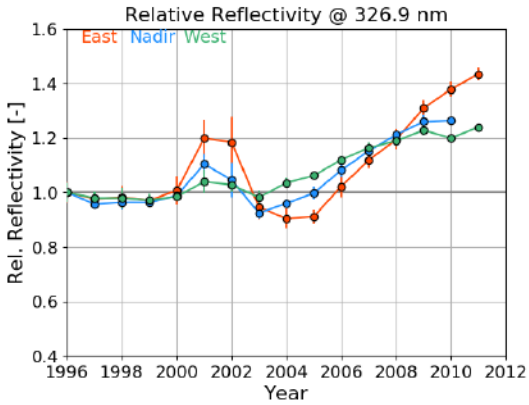
Reflectivity

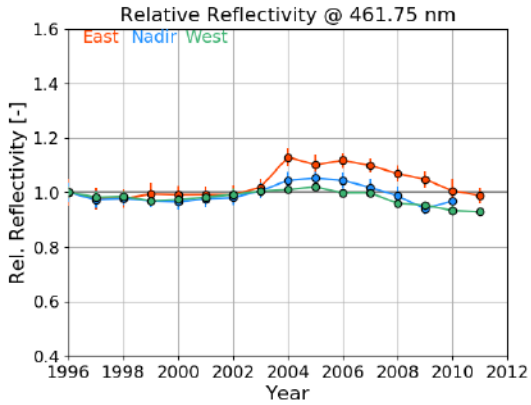


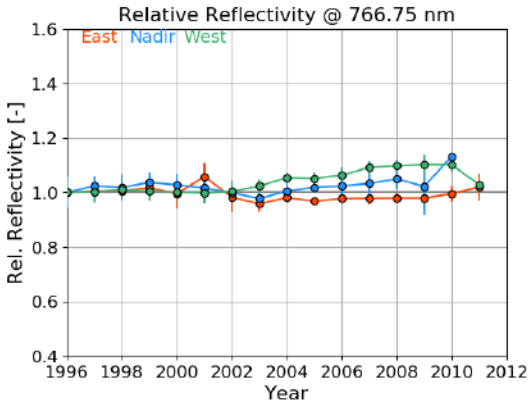




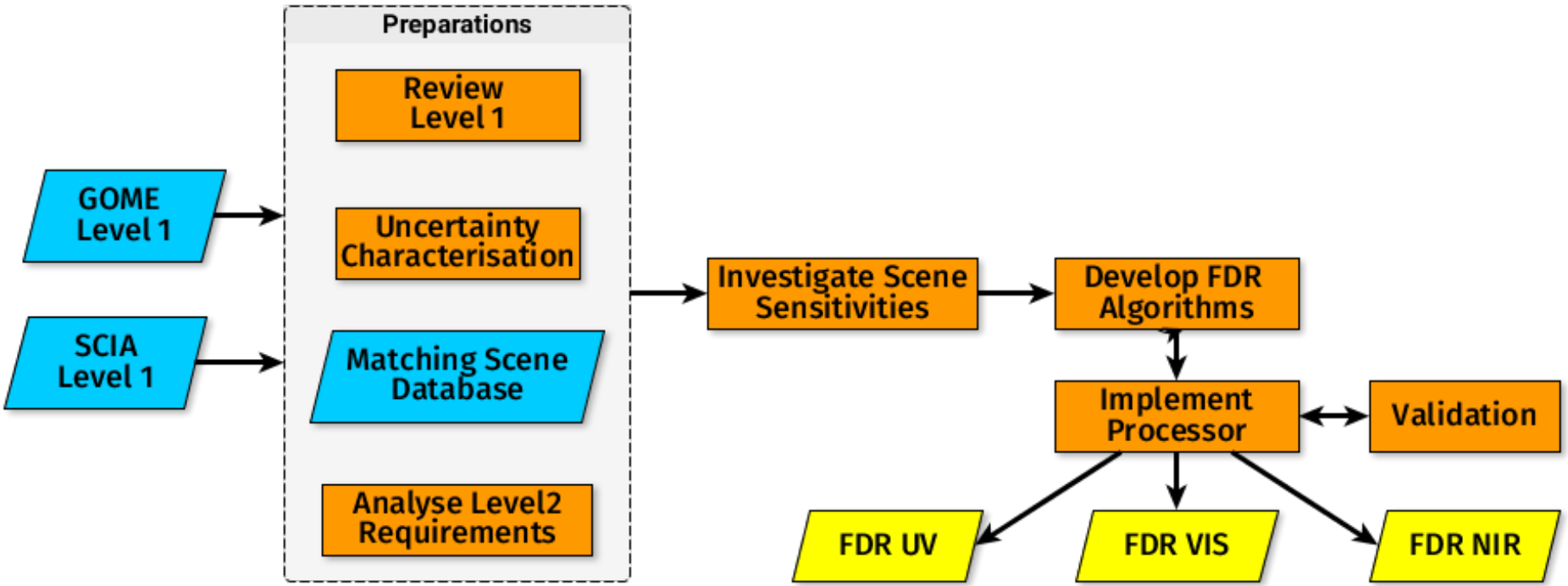
Relative reflectivity w.r.t 1995







Simplified Flow



FDR Product Content

Level 1a shall at least contain:

- Radiances & irradiances needed for the reflectances
- Intermediate results needed for Level-1b, e.g. harmonisation conversion factors
- Intermediate uncertainties that are needed for Level 1b

Level 1b shall at least contain:

- Harmonised GOME-1 and SCIAMACHY reflectances & irradiances
- Uncertainties
- SRF (spectral response functions) that may enable a user to obtain fully homogenised reflectances

Data of known bad quality (e.g. SCIAMACHY decontaminations) are *removed from L1b*.

Uncertainties in the FDR Product

Metrological best practice will be followed to determine the FDR uncertainties:

1. A measurement function (or series of functions within a process) is defined that converts raw signal to the base sensor output, or FDR product.
2. A diagram is used to document the traceability and sources of uncertainty
3. For each source of uncertainty identified in the diagrams, an 'effects table' will be filled with (as far as they are known)
   - 3.1 the magnitude of the uncertainty
   - 3.2 its sensitivity and pdf
   - 3.3 error correlations

Uncertainty Tree Diagram

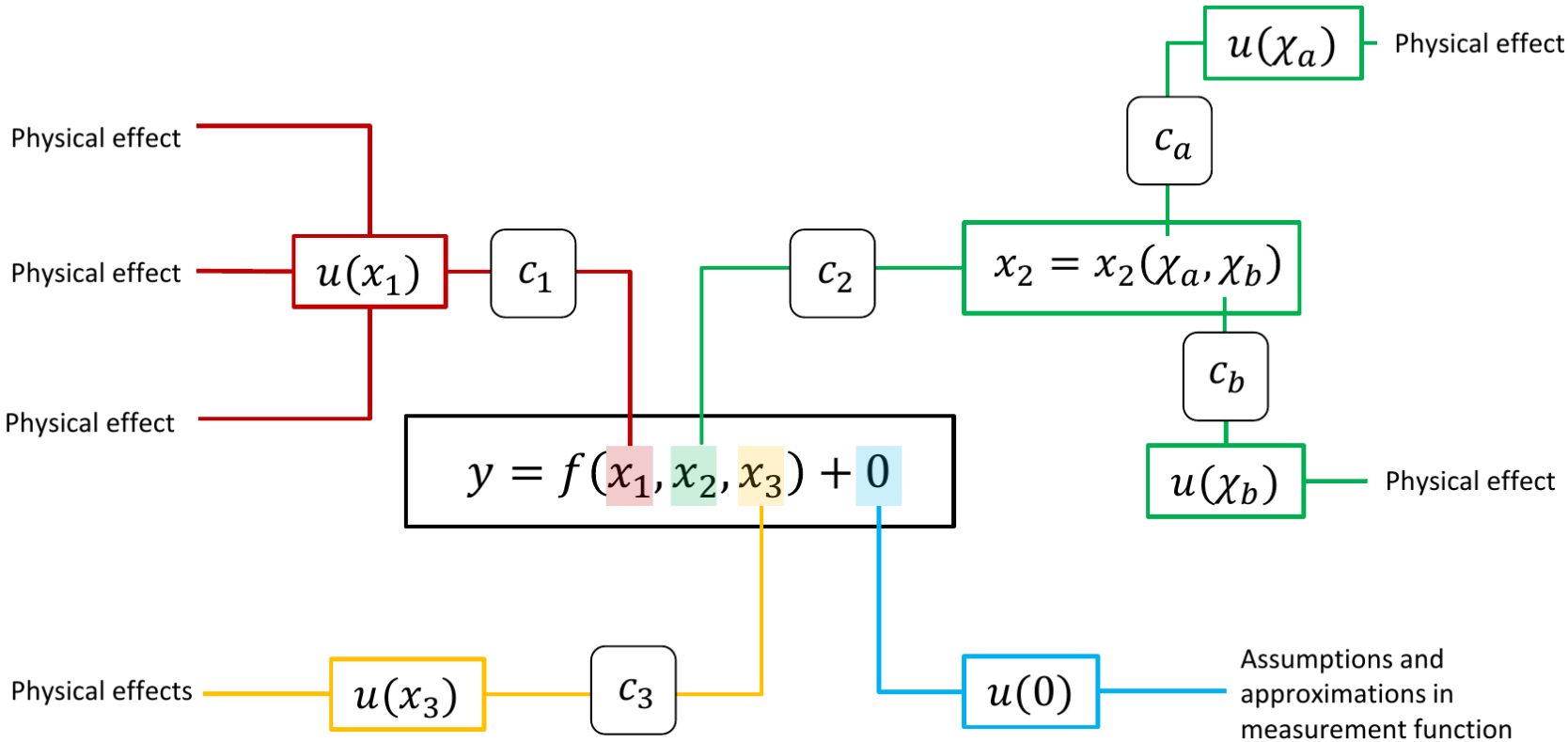


Figure by NPL UK