FDR4ATMOS Status

G. Lichtenberg & FDR4Atmos Team

March 31, 2021

Outline

1. Introduction
2. Goals Task A
3. Task A: Lunar Data
4. Goals Task B
5. Tasks B Breakdown
6. Uncertainties
7. Matching Scenes
8. FDR Definition
9. Summary and Conclusions
10. FDR4ATMOS Team
11. Additional Slides

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
- The project successfully concluded phase 1 with prepatory work
- Phase 2 has started with an end in October 2022

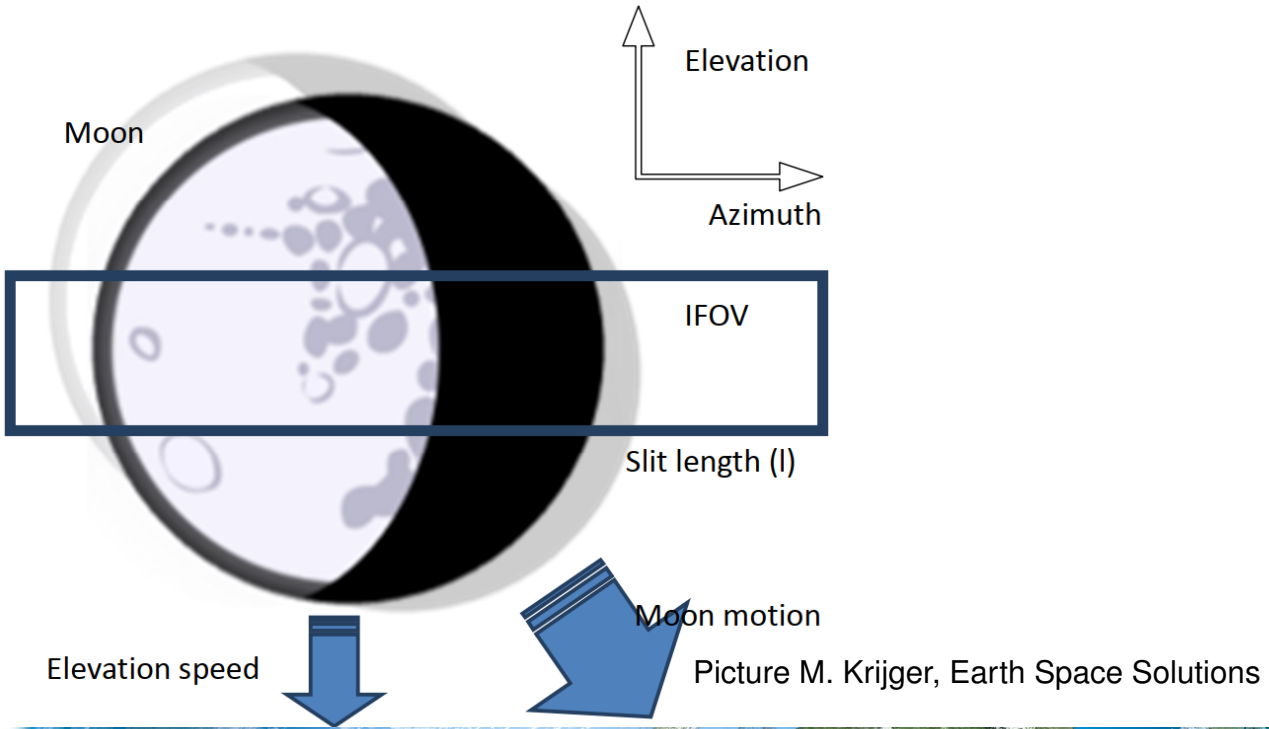
→ Reminder GOME-1, SCIAMACHY

Goals Task A

- After the re-processing of SCIAMACHY data with the latest processor version, O_3 total column data showed a drift
- An updated degradation correction is implemented and tests show that it removes the O_3 drift
- We will additionally include lunar data in the Level 1 product

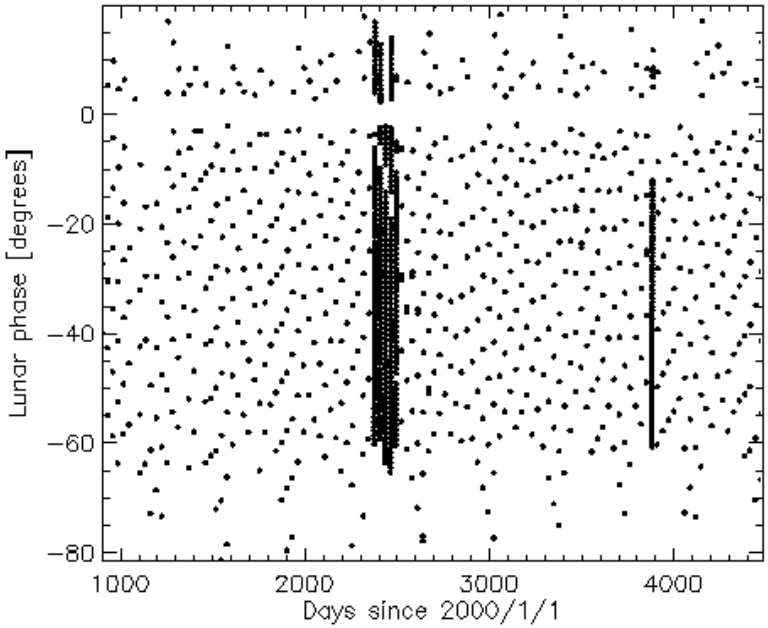
Lunar Data - Background

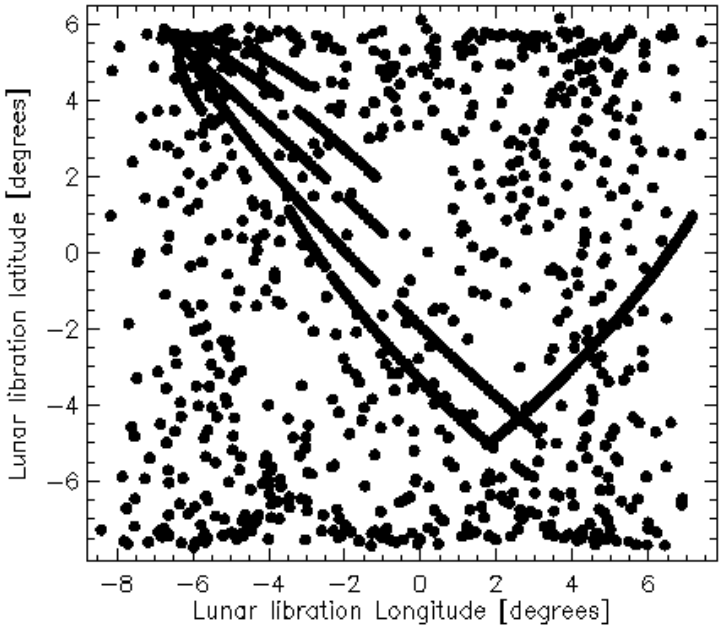
- SCIAMACHY made regular Moon measurements and covered a large range of observation parameters
- The spectral range and resolutions of the observations constitute a unique data set
- The lunar disk fills part of the slit and was scanned, each individual observation had a 2 second integration time



Lunar Data - Coverage of Geometries

SCIAMACHY observations cover a large part of lunar phases lunar views





Plot M. Krijger, Earth Space Solutions

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

Goals Task B

- The main objective of the FDR4ATMOS project is to develop a cross-instrument Level 1 product for GOME-1 and SCIAMACHY for the UV, VIS and NIR spectral range
- The focus is on the spectral windows used for O3, SO2, NO2 total column retrieval and the determination of cloud properties.
- Contrary to other projects, we do not aim to build harmonised time series based on Level 2 products (geophysical parameters)
- The FDR4ATMOS products will be based on Level 1, i.e. radiances and reflectances.

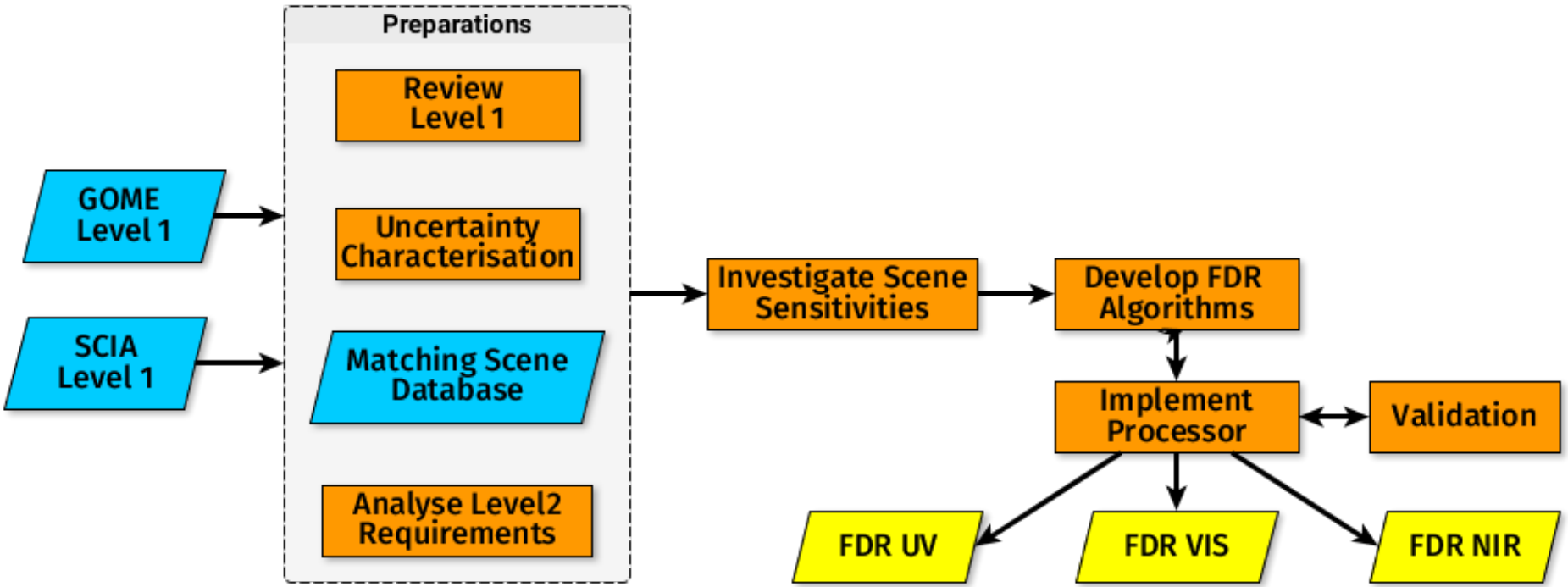
Why Level 1?

- 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
- Spatial resolution of GOME-1 is coarse, but downscaling SCIAMACHY is not useful for Level 2

Simplified Flow



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

→ Example SCIA SMR

Uncertainty Tree Diagram

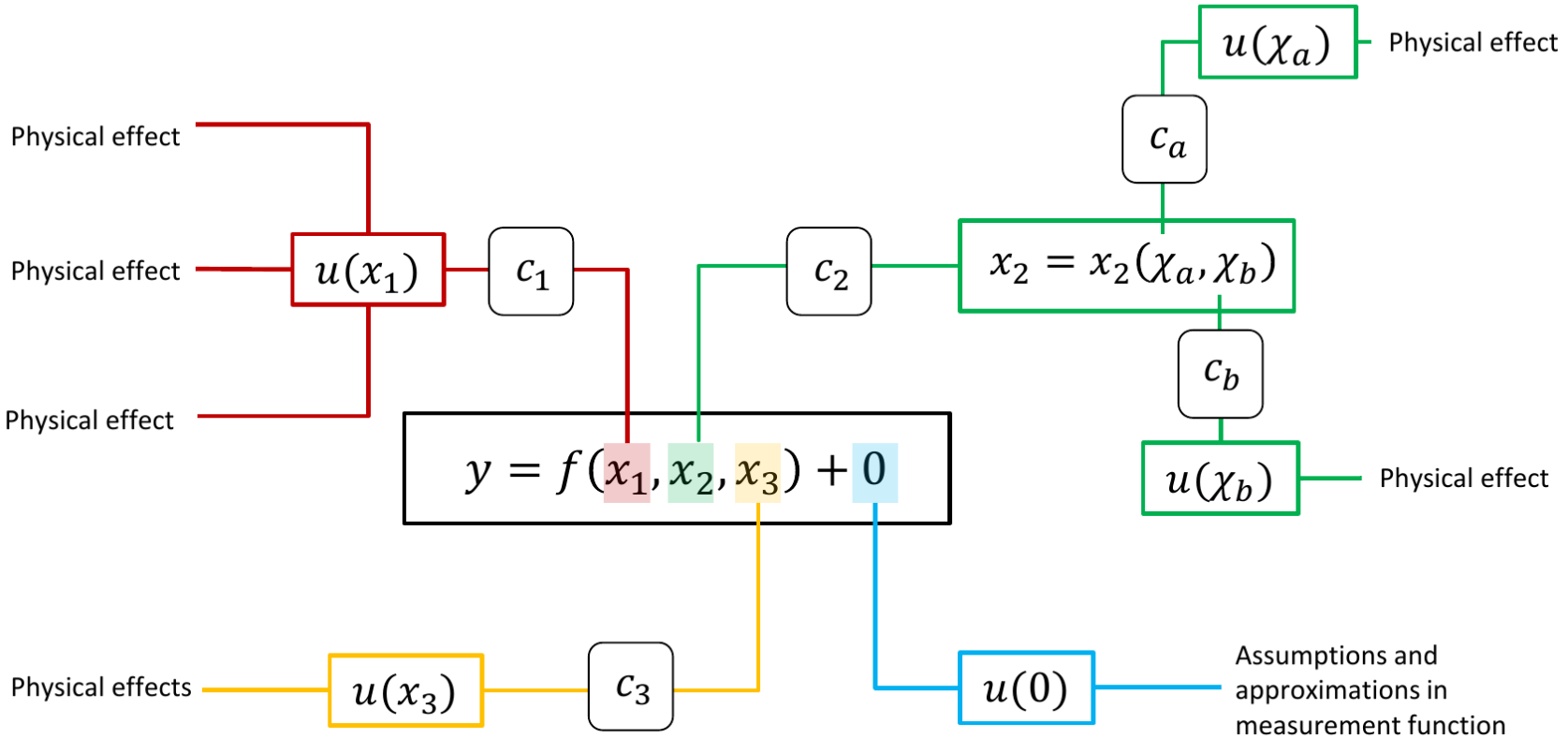


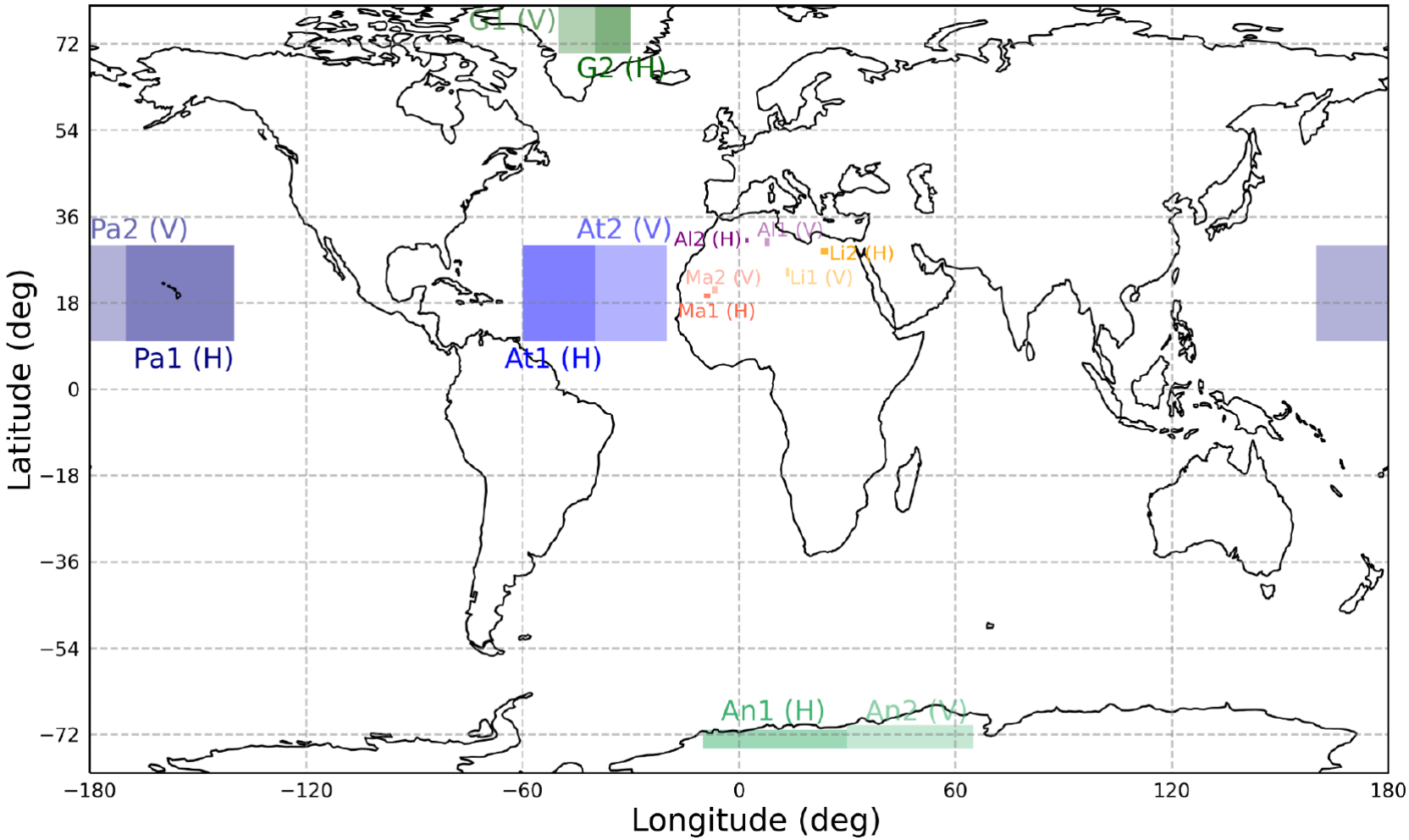
Figure by NPL UK

Matching Scenes (I)

Matching scenes have to

- cover different signal levels to avoid instrumental biases due to e.g. non-linearity
- cover different observation geometries
- be more or less homogeneous in albedo and terrain on the finest resolution (usually SCIAMACHY)
- be fully clouded (for comparison scenes using cloud cover) or cloud free on both ground pixel sizes (for all other scenes)
- have a large geometrical overlap

Matching Scene Areas (II)



→ Table

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

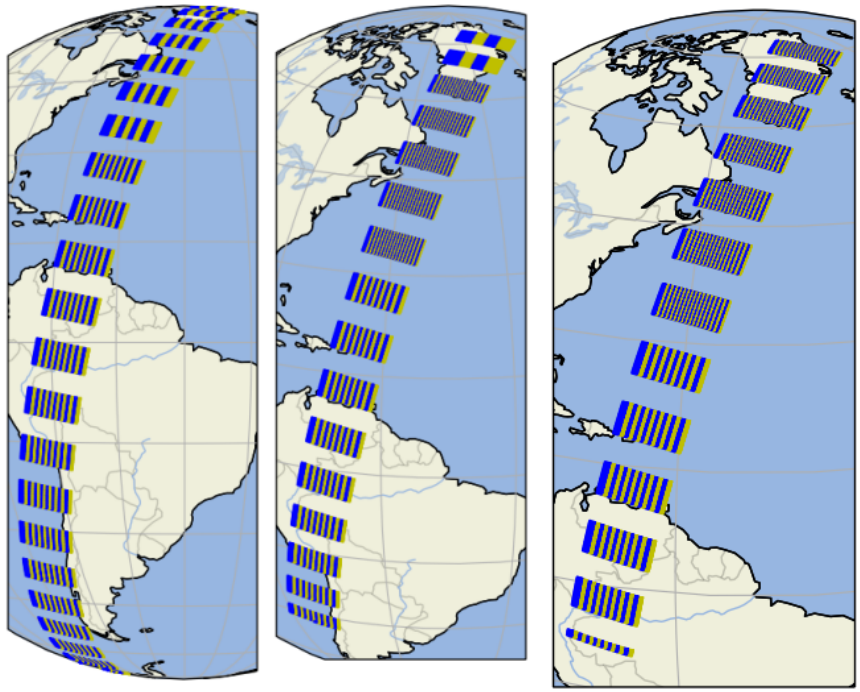
Level 1b shall at least contain:

- 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*.

SCIAMACHY clusters

- SCIAMACHY data have different spatial resolutions over orbit and spectral regions
- It is planned to harmonise by conversion to the smallest integration time,
- The impact will be checked
- Scaled data will be flagged



(a) UV (b) VIS (c) NIR

Summary & Conclusions

- The FDR4ATMOS project aims to
  - Deliver high quality SCIAMACHY data by improving the degradation correction
  - Add calibreted lunar data that cover the whole SCIAMACHY mission
  - Deliver FDRs on Level 1 Basis
- The FDR requirements and research needs were established
- We want to develop methodologies and algorithms for the harmonisation of spectrally resolved data that can also be used for current and future instruments
- FDR4ATMOS is a pathfinder project to explore how and how far spectrally resolved data can be harmonised and be used for Level 2 retrievals
- We welcome any feedback or recommendations from GSICS, contact me at DLR

FDR4ATMOS Team

DLR-IMF (prime)	G. Lichtenberg, S. Slijkhuis, M. Hamidouche, M. Coldewey-Egbers, B. Aberle
IUP Bremen	S. Noël, K. Bramstedt, T. Hilbig, T. Bösch
BIRA-IASB	J.-C. Lambert, J. van Gent, D. Hubert
NPL UK	P. Green, S. Hunt
ESS	M. Krijger
ESA	A. Dehn
SERCO	G. Brizzi

Additional Slides

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.

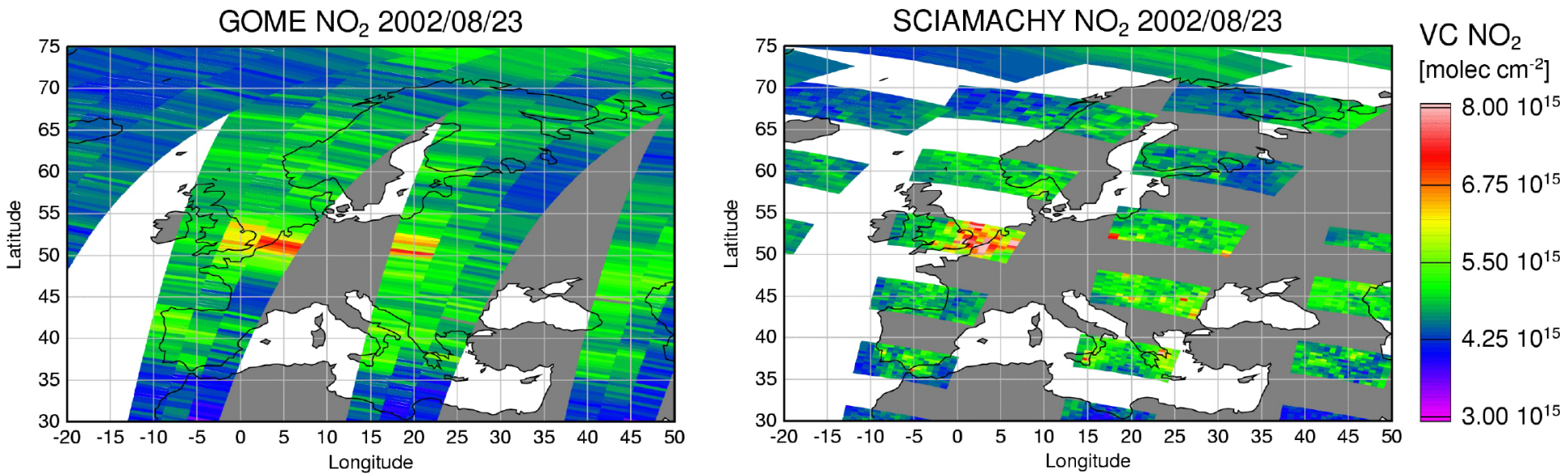
Definition (Proposed by C. Merchant at CEOS and CGMS WGC Meeting)

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.

Challenges and open points - spatial resolution

Coarser GOME resolution consequences

- less cloud free pixels
- hampers detection of sources
- makes ground based validation less representative

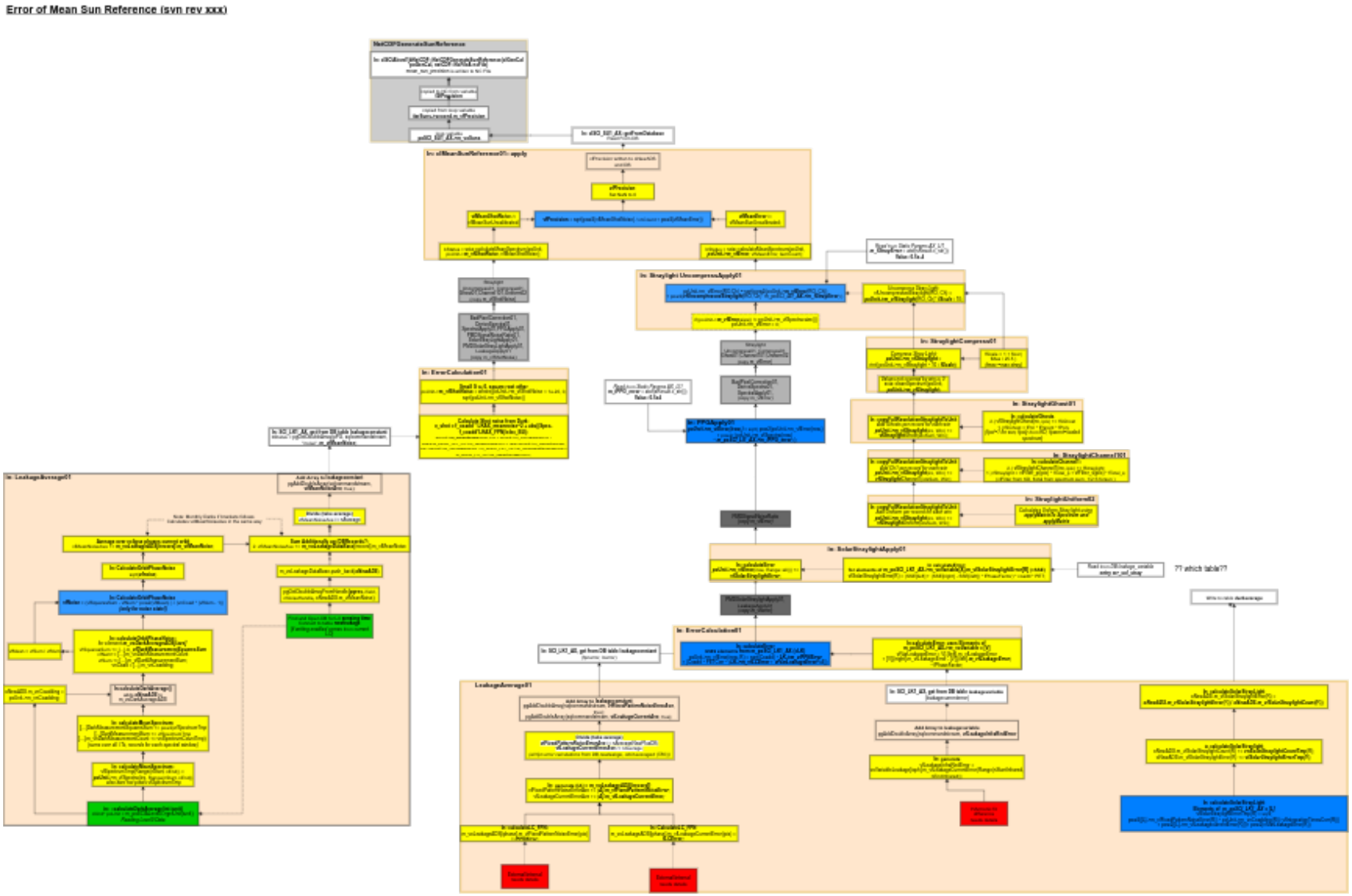


Reminder GOME-1 and SCIAMACHY

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

Illustration: Error Calculation SMR SCIA



Matching Scene Table

Location	Latitude (Min, Max)	Longitude (Min, Max)	Use
The Pacific1	(10.00 °N, 30.00 °N)	(200.00 °W, 170.00 °W)	H
The Pacific2	(10.00 °N, 30.00 °N)	(170.00 °W, 140.00 °W)	V
The Atlantic1	(10.00 °N, 30.00 °N)	(60.00 °W, 40.00 °W)	H
The Atlantic2	(10.00 °N, 30.00 °N)	(40.00 °W, 20.00 °W)	V
Greenland1	(70.00 °N, 80.00 °N)	(50.00 °W, 40.00 °W)	V
Greenland2	(70.00 °N, 80.00 °N)	(40.00 °W, 30.00 °W)	H
Antarctica1	(71.00 °S, 75.00 °S)	(10.00 °W, 30.00 °E)	H
Antarctica2	(70.00 °S, 75.00 °S)	(30.00 °E, 65.00 °E)	V
Mauretania1	(18.95 °N, 20.00 °N)	(9.75 °W, 8.00 °W)	H
Mauretania2	(20.00 °N, 21.50 °N)	(9.50 °W, 7.50 °W)	V
Libya1	(23.50 °N, 24.87 °N)	(12.90 °E, 14.00 °E)	V
Libya4	(28.05 °N, 29.50 °N)	(22.59 °E, 24.76 °E)	H
Algeria3	(29.87 °N, 31.50 °N)	(7.21 °E, 8.50 °E)	V
Algeria5	(30.57 °N, 31.47 °N)	(1.78 °E, 2.68 °E)	H

H: Harmonisation, V: Validation

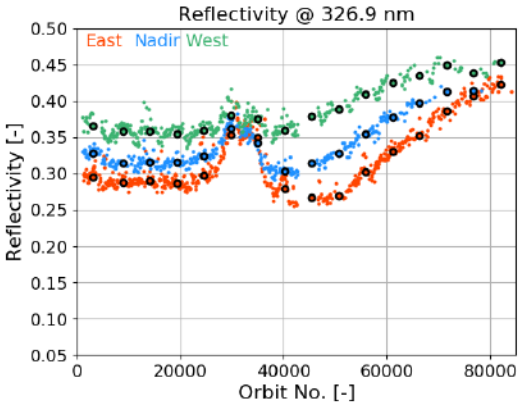
GOME reflectance at PICS Libya-4 (Sahara desert)

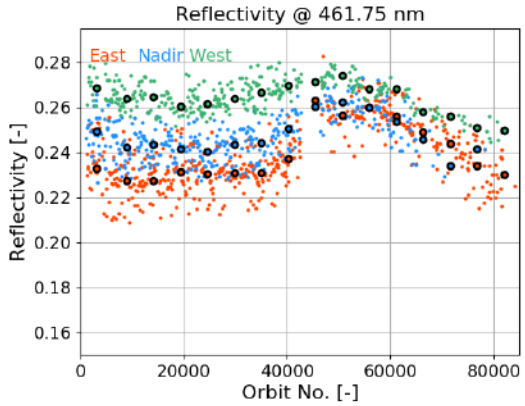
UV (326.9nm)

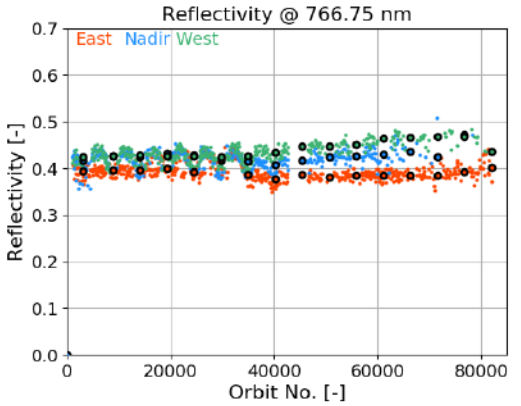
VIS (461.75nm)

NIR (766.75nm)

Reflectivity







Relative reflectivity w.r.t 1995