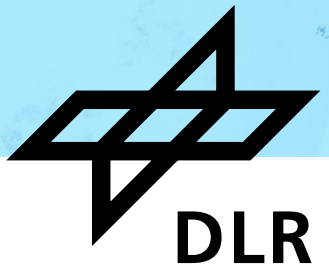
GSICS ANNUAL MEETING 2025

FDR4ATMOS: Current Status and First Results of Phase 2



Introduction

- The Fundamental Data Record for ATMOSpheric Composition (FDR4ATMOS) project is part of the ESA Long Term Data Preservation (LTDP) programme
- The FDR product contains *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 are based on Level 1, i.e. on irradiances and reflectances.
- Project phases:
  - Phase 1 2019-2024: Harmonisation GOME-1 and SCIAMACHY, data set available at ESA
  - Phase 2 2024-2026: Add GOME-2 to timeseries, in cooperation with EUMETSAT

General Method

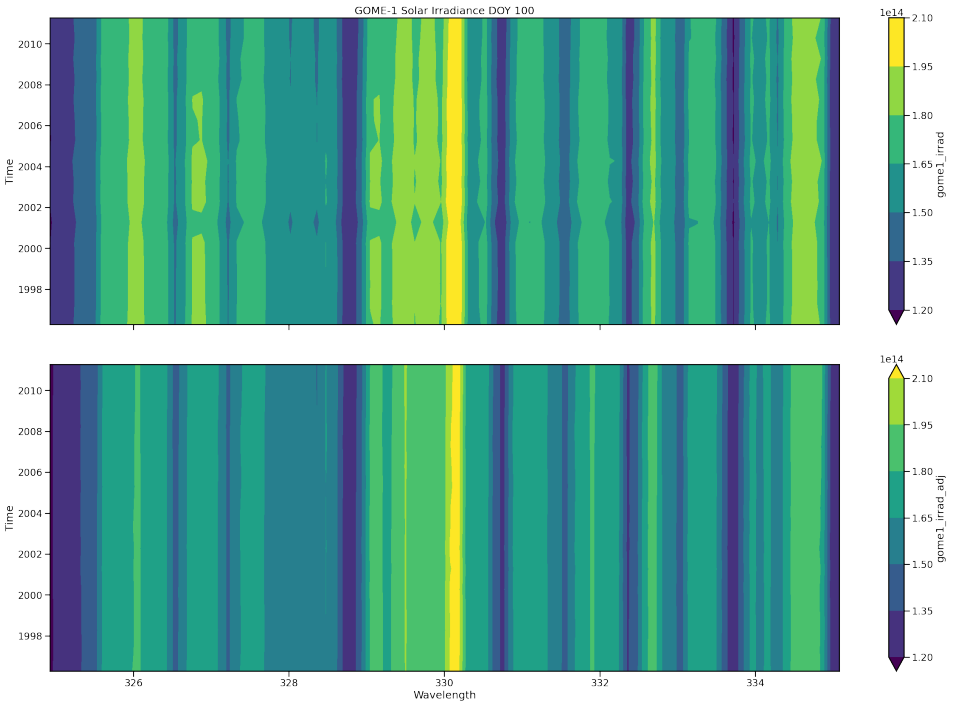
- Generic Formula:

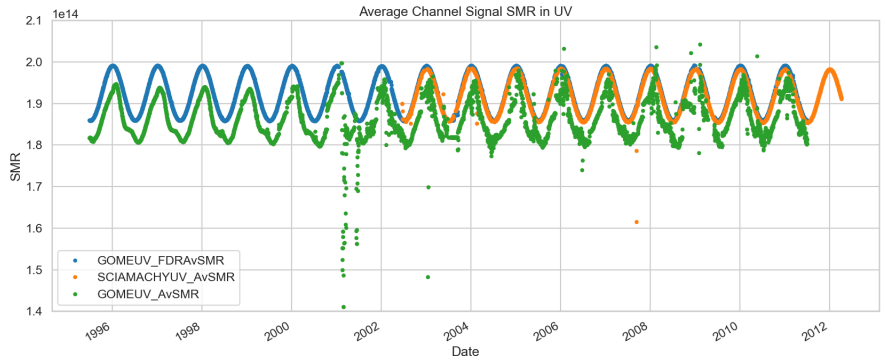
$$S_{inst1} = S_{inst2} \times C_{\Delta inst} \times C_{1,scene}(geometry, S_{inst1.2}, \ldots) + C_{2,scene}$$

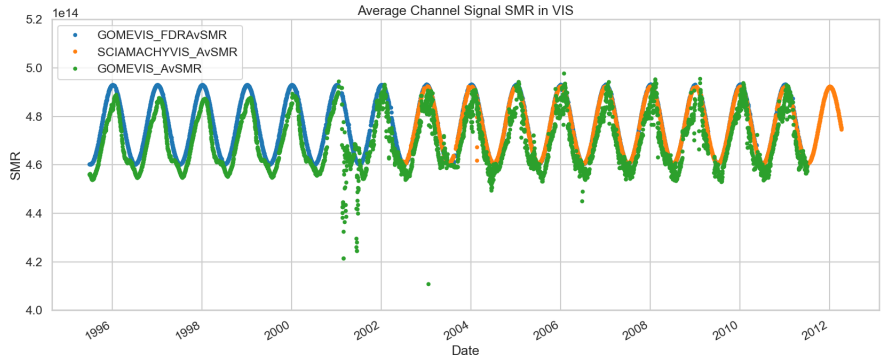
- Goal: Harmonise the broadband signal offset while keeping spectral structures
- Steps:
  - Align the spectral grids of both instruments
  - Ratio instrument spectra
  - Smooth ratio by polynomial (avoids Level 2 impact for DOAS like retrievals) $\Rightarrow$ Scaling factors
  - Investigate scene dependent effects
  - Apply to fully resolved spectra

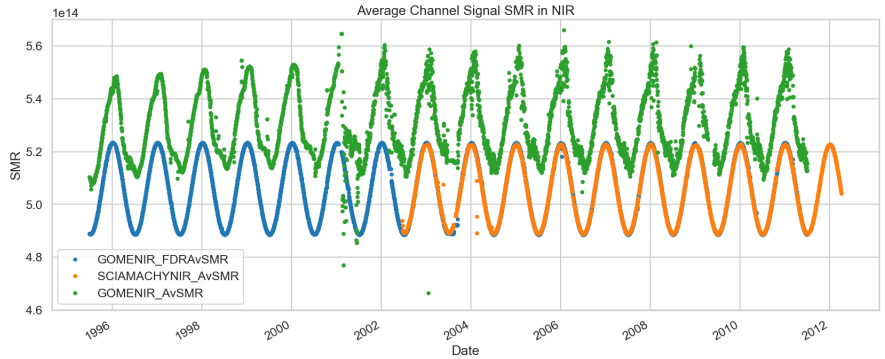
Harmonisation Solar Irradiances - version 1

- Etalon GOME-1 removed
- BSDF related pattern removed
- Below: Original and corrected (UV)
- Right: Channel Averages
- V1 data shown here, already available



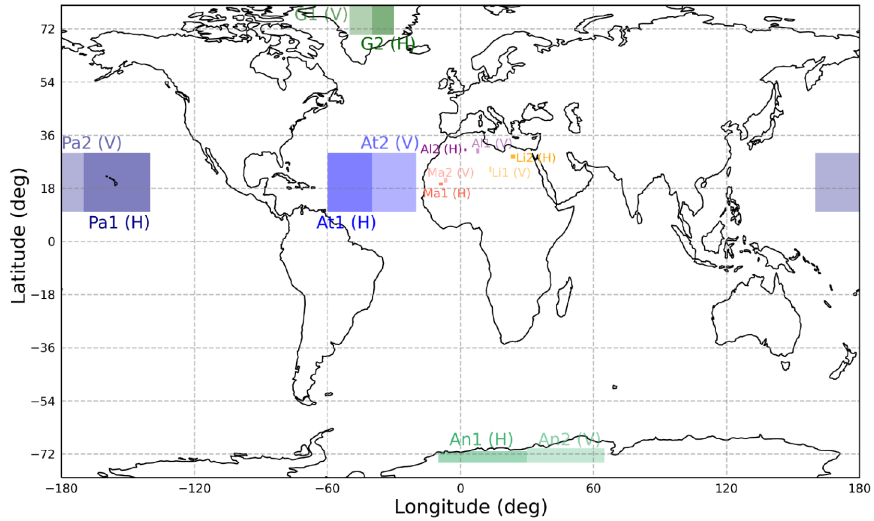


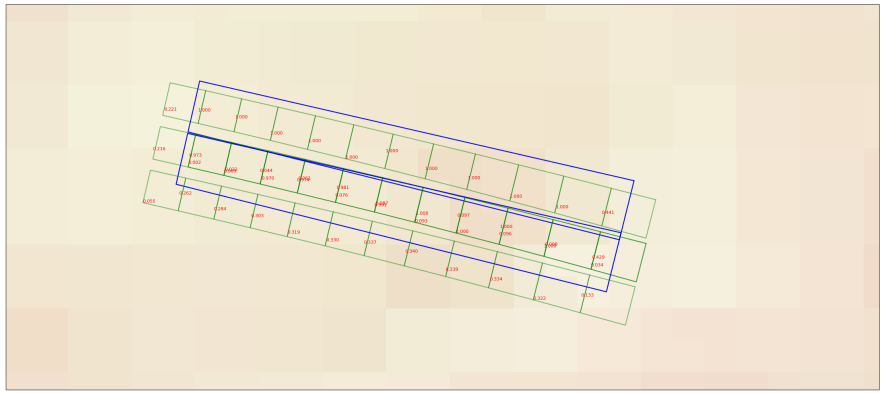




Harmonisation Reflectances - Method

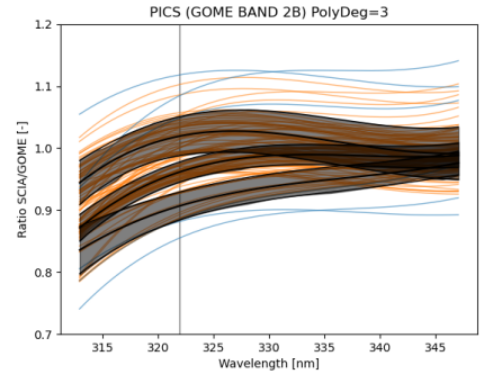
- Harmonisation was done on reflectances (cancels multiplicative instrument effects, e.g.GOME-1 etalon)
- Matching Scenes with homogeneous signal have been defined to
  - cover different signal levels to avoid instrumental biases due to e.g. non-linearity
  - cover different observation geometries
- Spatially higher resolved SCIAMACHY data were mapped onto GOME-1 footprints
- Harmonisation factors were calculated for all scenes (reference year 2003)

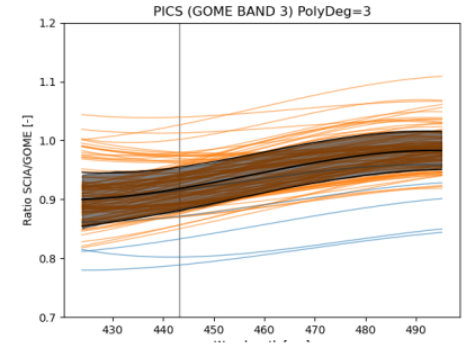


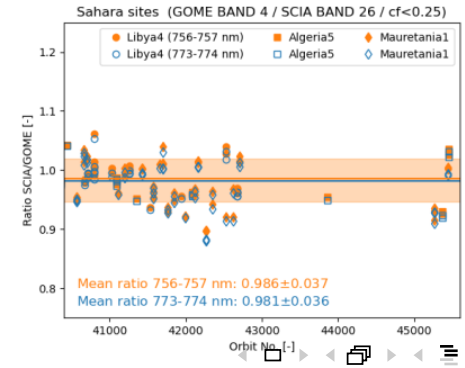


Harmonisation Reflectance - Transfer Factors

- Transfer curves for all PIC Sites
  - Blue thin line: Excluded curves
  - Black line: Average of all 2003 observations
  - Shaded Area: Standard deviation of Average
- Top: UV
  - 3 curves, one for each viewing angle (East - Nadir - West)
  - Polynomial 3rd degree
- Middle: VIS Polynomial 3rd Degree
- Bottom NIR:
  - Excluded O2A band Absorption
  - One factor for whole channel
- No scene dependencies found
- V1, data available at ESA

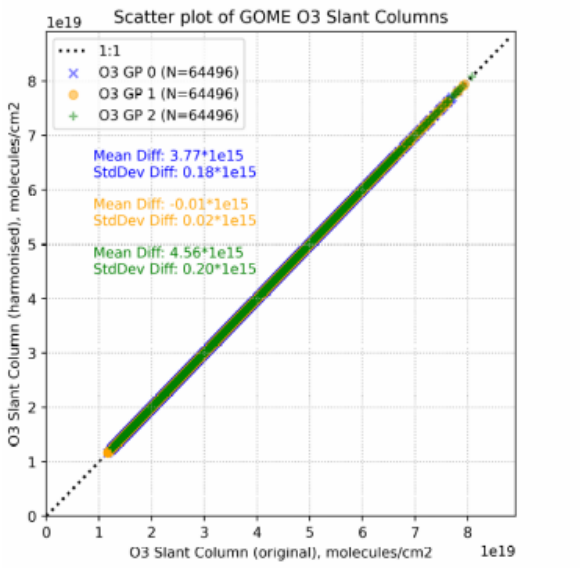


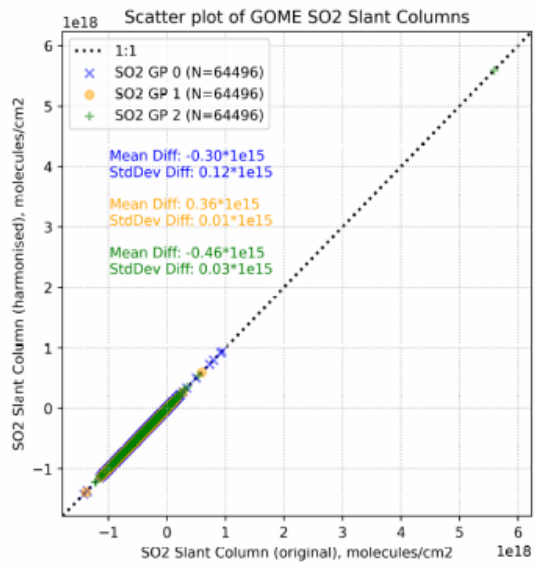


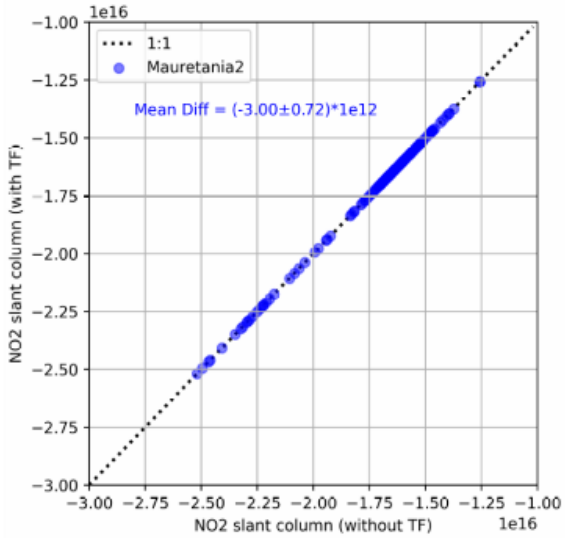


Harmonisation Reflectance - Level 2 Impact

- Limited Level 2 impact study was done
- No negative impact on Level 2 DOAS retrieval of O3, SO2, NO2
- This is expected because of the polynomial harmonisation function
- An extended check on Level 2 impact is planned for the current phase

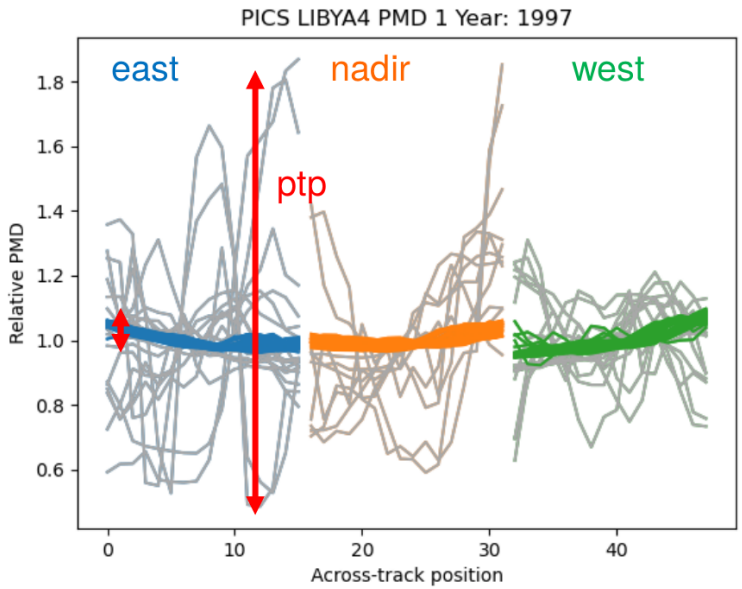


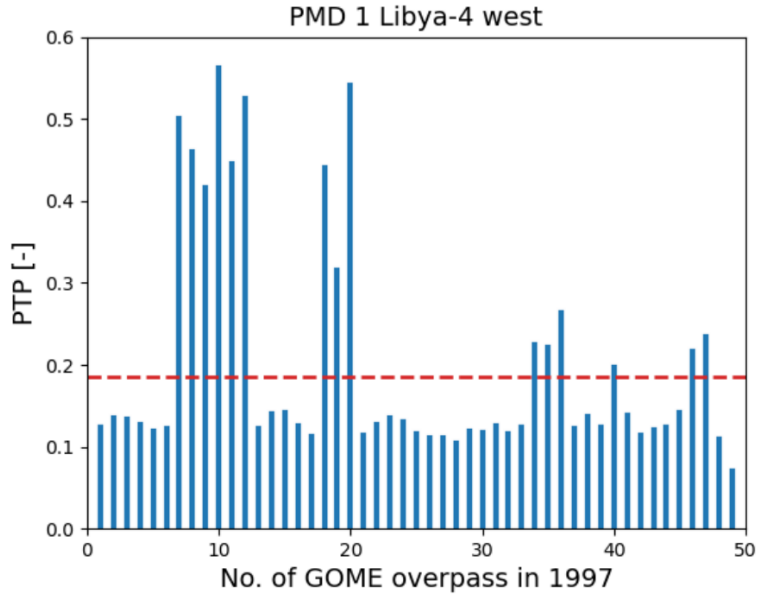




Phase 2: GOME-1 Degradation Correction

- The reflectance of GOME-1 shows a distinct degradation with time
- Using PIC sites we are developing a correction
- We filtered the data using broadband PMD measurements

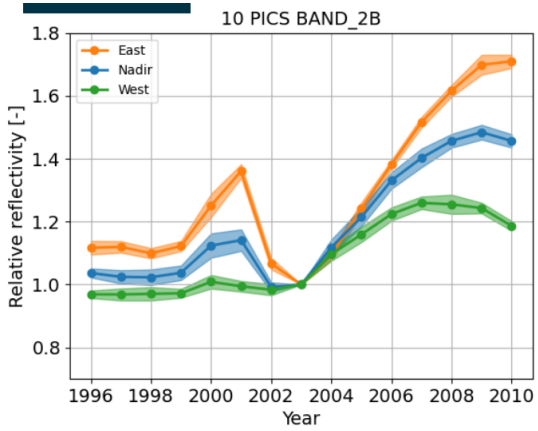


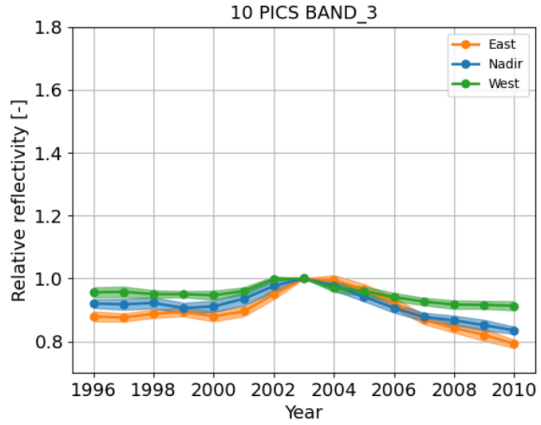


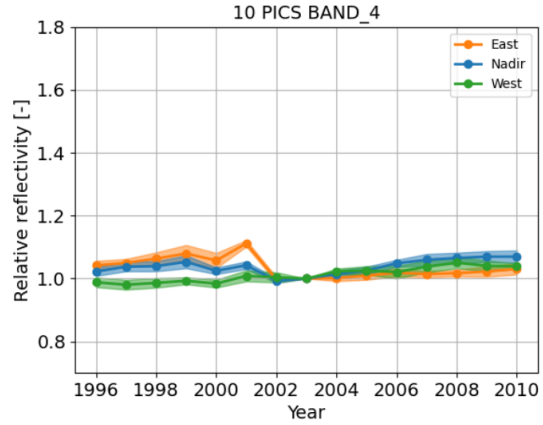
- 16 PMD measurements per GOME ground-pixel -> 40x20km2
- Cut-off the distribution of peak-to-peak values at 60% (grey lines & dashed red line)

Phase 2: GOME-1 Degradation Correction

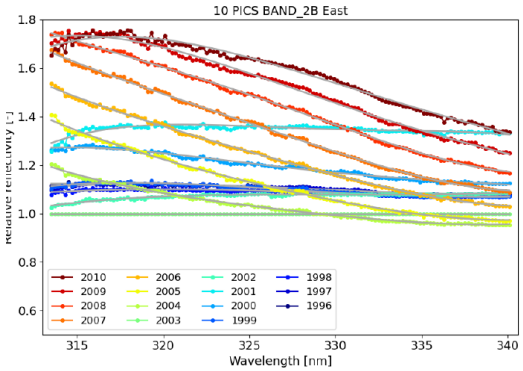
- Variability in time:

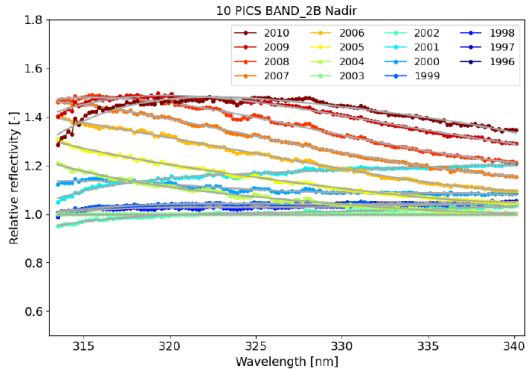


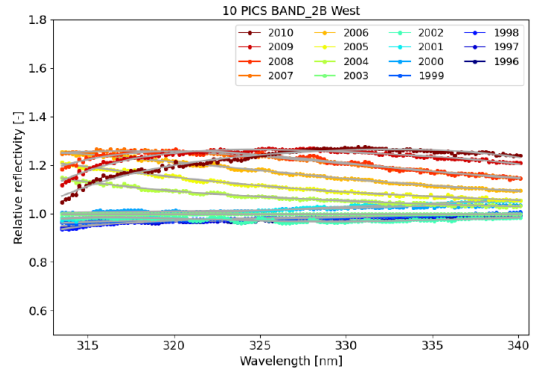




- Spectral Variability



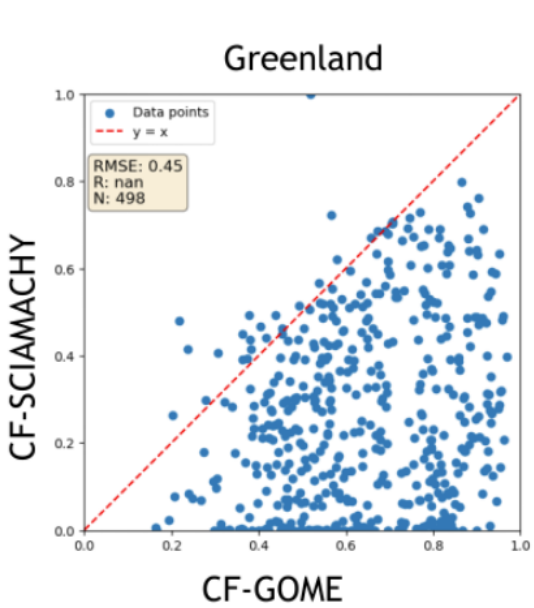


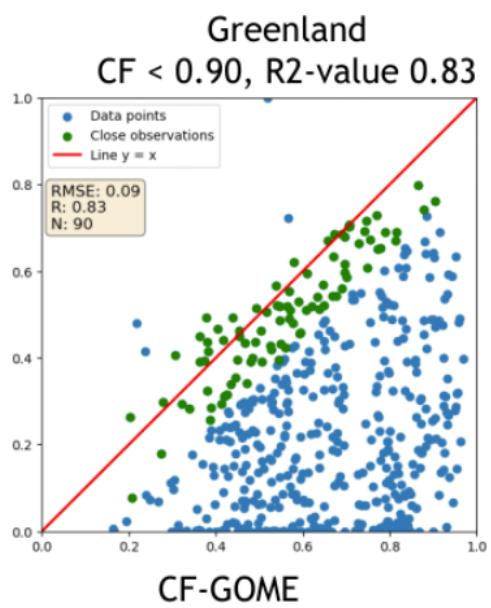


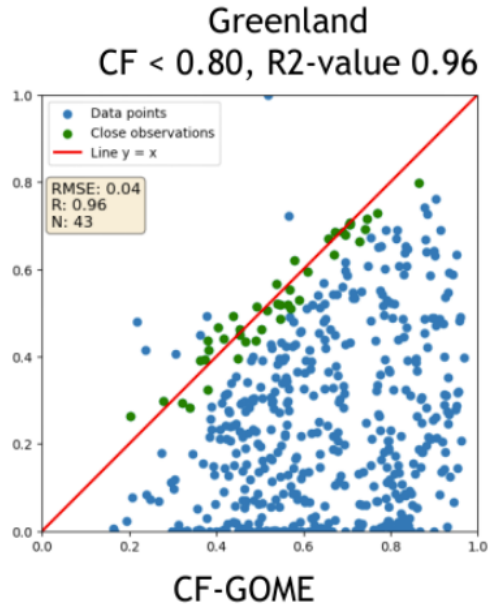
- smooth behaviour in time and wavelength

Phase 2: Improvement of TF and Uncertainty

- In phase 1 we saw, that non-PIC sites could not be used for harmonisation (to high variance of the individual transfer curves)
- We set up a study to extend the data base (more scenes) and find the reason for the unusable scenes
- Using PMD/cloud fraction data to judge the similarity of the GOME-1 and SCIMACHY scenes, we can improve the transfer curves and use more scenes (paper is in preparation)

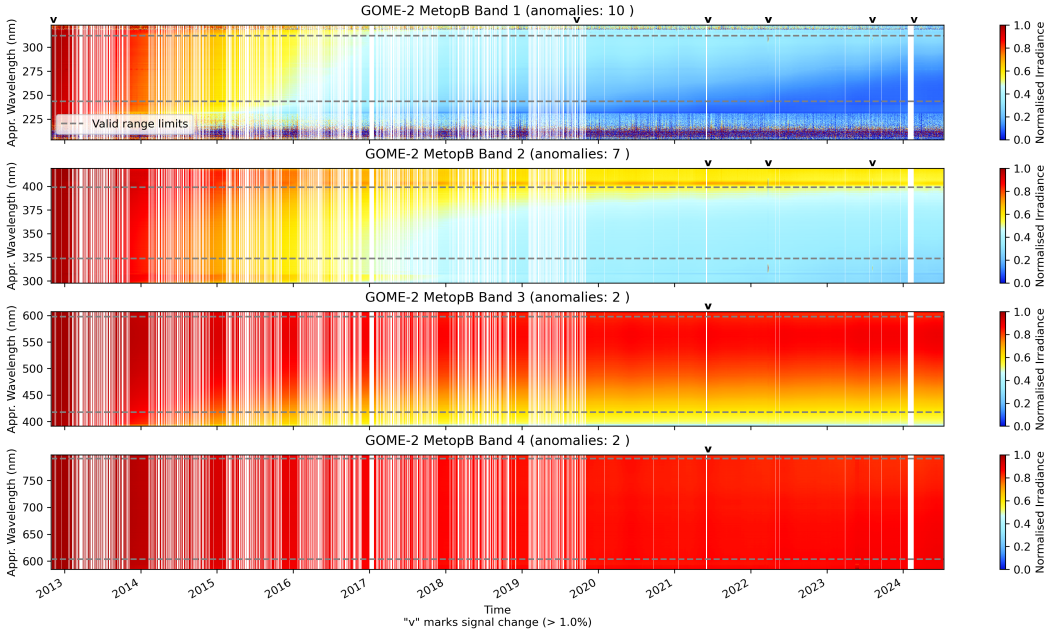






Assessment of GOME-2 Solar Irradiances

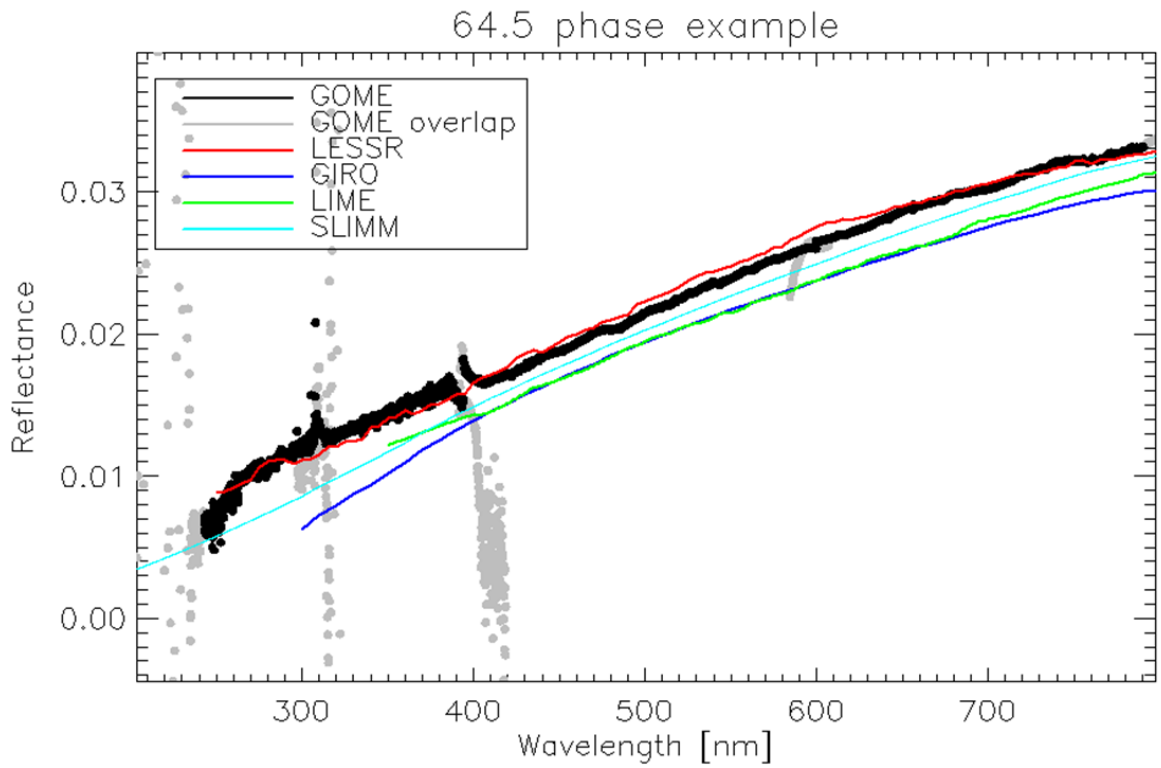
- We analysed GOME-2 to identify gaps or anomalies in the solar irradiance data



- Defining an anomaly as a >1% deviation between to data points (“v” mark above)
- We only found a few anomalies, most had already been filtered out by EUMETSAT QC
- We communicated the additional anomalies to EUMETSAT

GOME-2 Lunar Data

- We analysed lunar data of GOME-2 that were calibrated by EUMETSAT
- From the data the lunar irradiance and reflectance was calculated
- Additionally anomalies of the lunar data were analysed and mitigation measurements proposed
- A GOME-2 lunar data product will be released this year



Summary

- The FDR4ATMOS project delivers FDRs on Level 1 Basis
- Version 1 of the dataset was released in Q3 2024,
  - Link: DOI:10.5270/ESA-852456e
  - Note: we found an index issue with the SCIAMACHY wavelength variable. We are testing a fix and new data will be generated (release data to be announced)
- Phase 2 is done in cooperation with EUMETSAT
  - In the first year, we
    - improved the reflectance harmonisation curves of version 1
    - developed a GOME-1 degradation correction
    - generated lunar reflectance and irradiance from GOME-2 data
  - This year we
    - will harmonise the solar irradiances from GOME-1,2 and SCIAMACHY (using the TSIS Spectrum)
    - start the harmonisation of reflectances of GOME-1,2 and SCIAMACHY
    - improve the lunar model further

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