

FDR4ATMOS: A LEVEL 1 FDR PRODUCT COMBINING GOME, SCIAMACHY AND GOME-2 DATA

EUMETSAT Meteorological Satellite Conference 2026



Definition (FDR)

A 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 and **provides (metrological) uncertainties**

- $\Rightarrow$ Cross-calibration/harmonisation of instrument data is needed
 - Is often done for imagers, but was not done before for spectrally resolved imagers
- Challenges:
 - No collocated measurements (e.g. GOME-1 and SCIAMACHY are 30 Minutes apart)
 - Different spatial resolutions
 - Spectral structures must not be changed in the harmonisation
- The FDR4ATMOS projects aims to build a FDR data record spanning different instruments
- 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

- Generic Formula:

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

- with $C_{\Delta inst}$, $C_{1,scene}(geometry, S_{inst1.2}, \dots)$, $C_{2,scene}$ as harmonisation factors
- 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

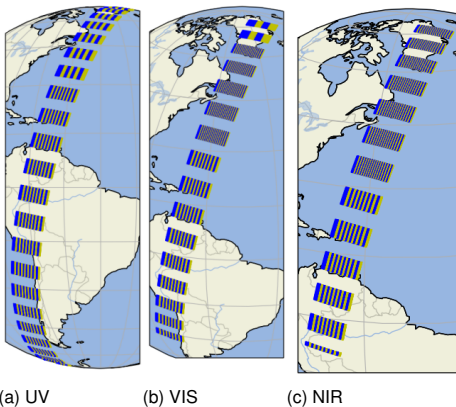
- Spectral bands harmonised Earthshine (GOME-1)

UV (O3, SO2)	VIS (NO2)	NIR (O2A Band)
313-347nm	424-495nm	754-774nm

- Span the combined mission time of GOME-1, SCIAMACHY and GOME-2 1995-2025
- Reference Instrument: SCIAMACHY (reflectances), TSIS (solar irradiances)
- Each product contains reflectances from one day for GOME-1, SCIAMACHY, GOME-2 (depending on availability)
- Spectral bands solar irradiances: Full channel range (2-4)
- **Separate Lunar Products from SCIAMACHY and GOME-2 will be provided**
- SCIAMACHY re-scaled to the minimum integration time in the band
- **Version 1.1 of the dataset was released in Q2 2026**
 - Link: DOI:10.5270/ESA-852456e

Pre-processing: SCIAMACHY Rescaling

- Original SCIAMACHY integration time varies with orbit phase and spectral band



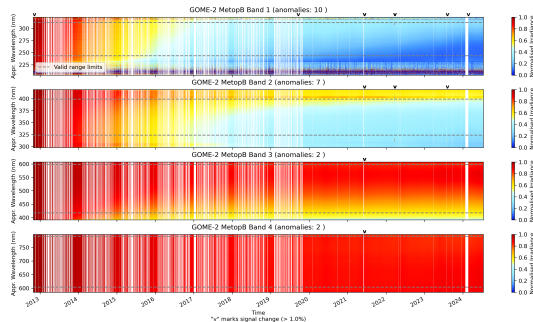
- We rescaled all data to the minimum IT in each band, so the data are uniform over the orbit
- This is done using 32Hz PMD measurements

Preparation: Assessment of L1 Data & Calibration



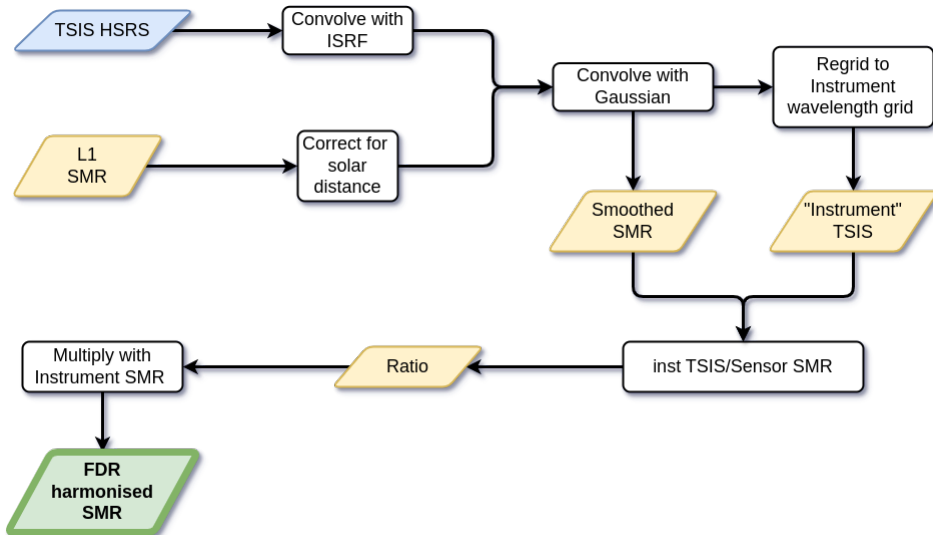
- For GOME-1 & SCIAMACHY: Done within the project team
- For GOME-2: In cooperation with EUMETSAT:
 - Review of on-ground/in-flight calibration for uncertainties
 - Checking L1 data for gaps and anomalies
 - EUMETSAT and FDR4ATMOS are in constant contact
 - ⇒ improvements for L1 data esp. degradation correction were found
 - ⇒ Lunar Data: A mis-pointing in the lunar measurements GOME-2C was identified and reported to EUMETSAT flight dynamics team
 - ⇒ the cooperation is beneficial for GOME-2 products and FDRs

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

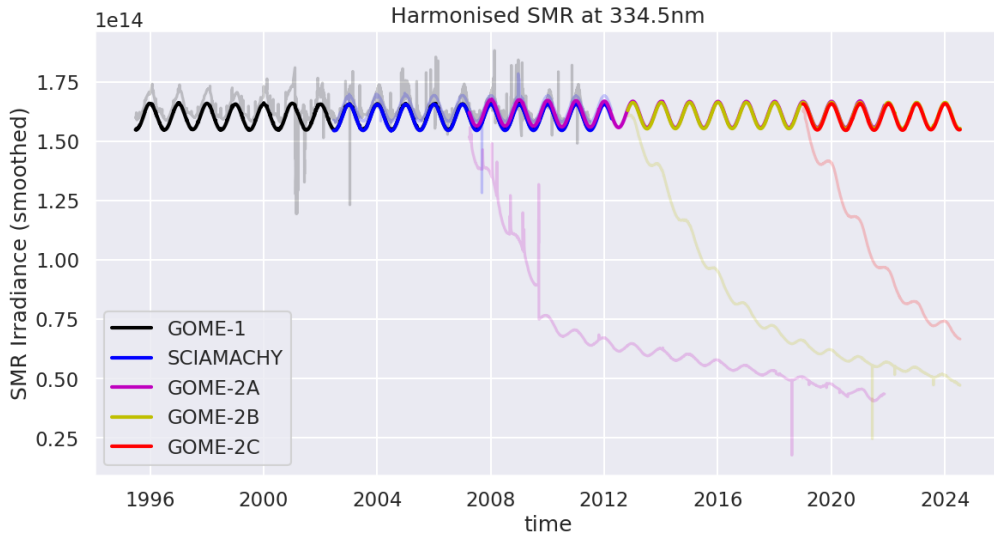


- Defining an anomaly as a >1% deviation between two data points ("v" mark above)
- We only found a few anomalies, most had already been filtered out by EUMETSAT QC
- We communicated the additional anomalies to EUMETSAT

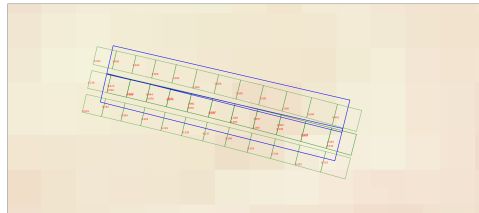
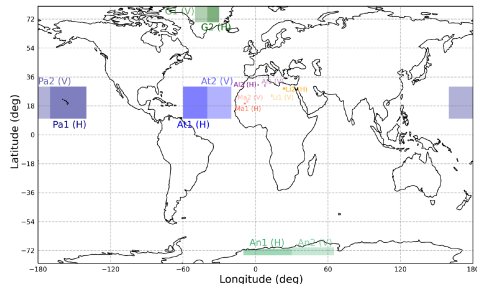
Harmonisation Solar Irradiances - Method



Harmonisation Solar Irradiances



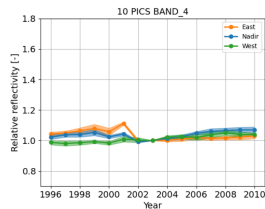
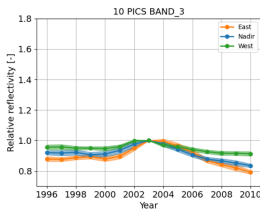
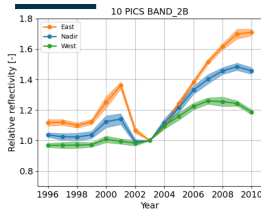
- Harmonisation was done on reflectances (cancels multiplicative instrument effects, e.g. GOME-1 etalon)
- For V1 and V2 we use PICS for harmonisation
- SCIAMACHY were mapped onto GOME-1/2 footprints
- Harmonisation factors were calculated for all scenes
 - Reference year GOME-1: 2003
 - Reference years GOME-2 A-C: First stable operational data



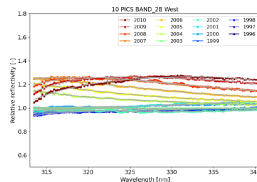
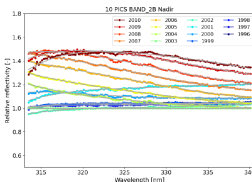
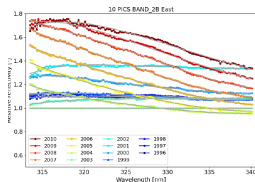
V.2: GOME-1 Degradation Correction



■ Variability in time:

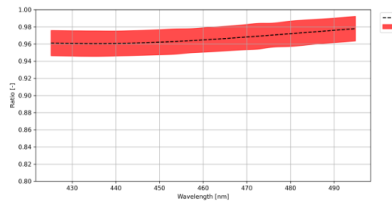
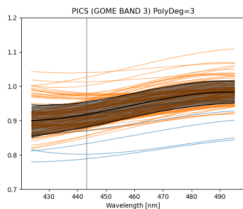
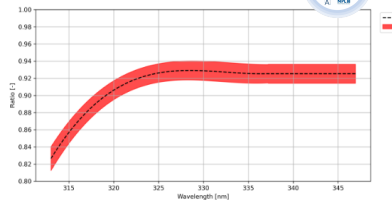
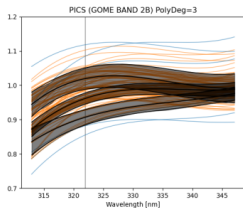


■ Spectral Variability



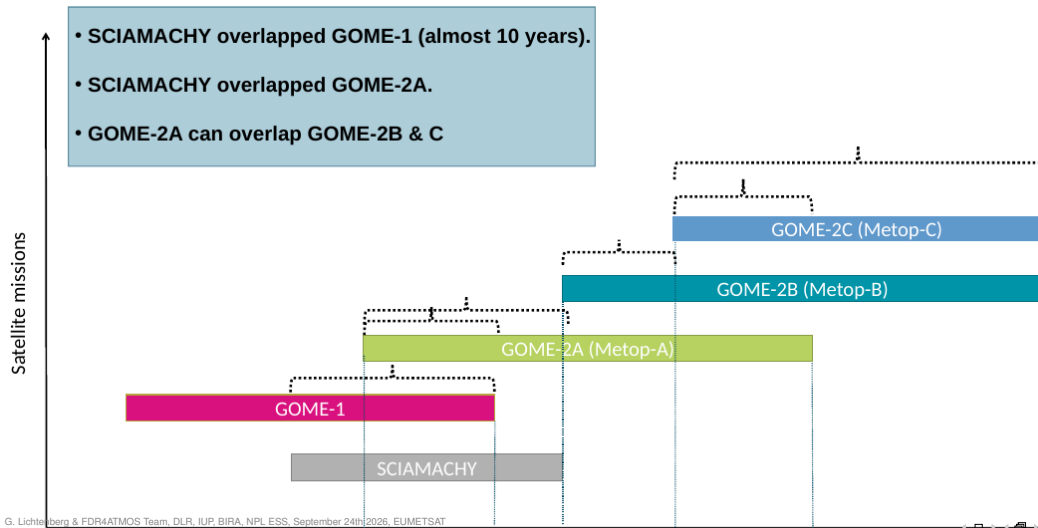
■ smooth behaviour in time and wavelength

V.2: GOME-1 SCIAMACHY Transfer V1.1 → V2



- Left: version 1.1, right: version 2, Top: UV, Bottom: VIS
- UV: No more split between viewing directions
- **Uncertainties cut by $\approx$ half to $\pm 1\%$**

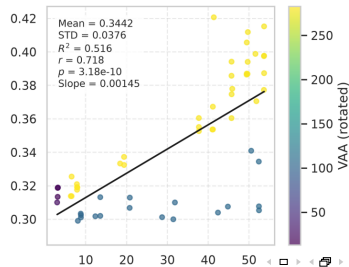
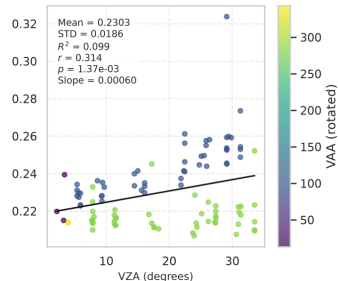
V.2: FDR Updates for GOME-2 - no overlap for 2B/C



V.2: FDR Updates for GOME-2 - BRDF impact

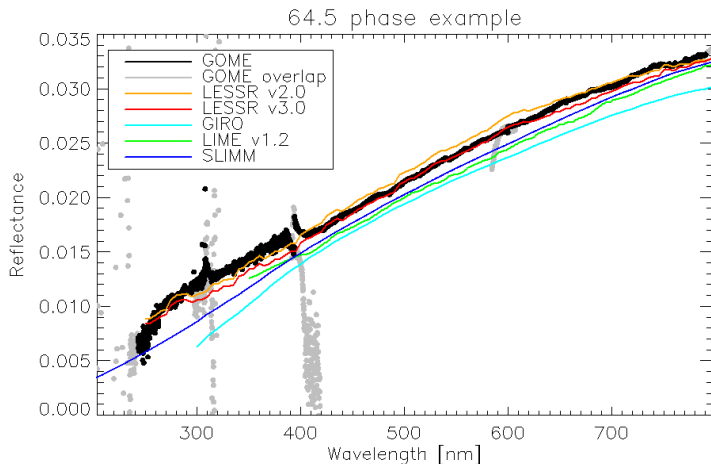


- For GOME-1 assumption of Lambertian BRDF was valid (large swath of GOME-1)
- For GOME-2 the effects become visible
- For V2 we are working on a first order correction
 - by building pairs with similar VZA for SCIAMACHY and GOME-2 instead of time pairs
 - by excluding PICS with larger VZA dependence
- Right:
 - Reflectance (average) as function of VZA for Sudan1
 - Top: SCIAMACHY, Bottom: GOME-2
 - Note: Wider range of VZA for GOME-2



- All products in netCDF format (including GOME-2 data)
- FDR follow CF conventions
- One product per day
- Data of known bad quality (e.g. SCIAMACHY decontaminations) are *removed*.
- V1: All instruments and bands in one file
- V2: Under discussion if products must be split
- **Main Content L1b:**
 - Harmonised GOME-1, SCIAMACHY and GOME-2 reflectances & irradiances
 - Uncertainties
 - “synthetic” radiance that is calculated from harmonised data for convenience of L2 algorithms calculating their own reflectance
- L1a data: Available on request with additional intermediate data and PMD/polarisation copied from original 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 measures proposed
- GOME-2 and SCIAMACHY lunar data products will be released next year



- The FDR4ATMOS project delivers FDRs on [Level 1 Basis](#)
- [Improvements V2 vs V1.1:](#)
 - GOME-2 data will be added $\Rightarrow$ [FDR spanning 1995 - 2025](#)
 - Adding random uncertainties for all measurements [based on metrological principles](#)
 - [GOME-1 degradation correction](#)
 - Solar irradiance harmonisation based on GSICS recommended TSIS-HSRS spectrum
 - Planned release V2: 2027 (using not yet released GOME-2 L1b V. R4)
- **Lunar Products:**
 - SCIAMACHY and GOME-2 stand-alone Lunar Data Product will be released next year
 - Lunar model LESSR update based on SCIAMACHY and GOME-2 data
- **Future:**
 - ESA has signaled for a possible 2 year continuation of FDR4ATMOS, details under discussion
- [Questions or suggestions? Contact me: \[guenter.lichtenberg@dlr.de\]\(mailto:guenter.lichtenberg@dlr.de\)](#)



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