Study on the possible correction of the GOME/ERS-2 reflectance degradation as part of FDR4ATMOS

M. Coldewey-Egbers[1], G. Lichtenberg[1], S. Slijkhuis[1], B. Aberle[1], A. Owda[1], O. Pego J.[1], A. Dehn[2], G. Brizzi[3]

[1]Deutsches Zentrum für Luft- und Raumfahrt (DLR), Wessling, Germany, [2]European Space Agency (ESA-ESRIN), Frascati, Italy, and [3]SERCO, Frascati, Italy

Introduction

The Fundamental Data Record for ATMOSpheric Composition (FDR4ATMOS) project is part of the European Space Agency (ESA) Long Term Data Preservation (LTDP) programme. The aim is to generate multi-decadal records of selected Earth observation level-1 parameters, i.e. irradiance and reflectance, from the heritage missions GOME/ERS-2 (1995-2011), SCIAMACHY/ENVISAT (2002-2012), and the GOME-2/MetOp-A/-B/-C sensors (2007-today). The focus is on the compilation of harmonised multi-instrument time series, which then provide an improved performance compared to the single sensor data records.

From previous studies it is known that GOME/ERS-2 suffered from substantial differential degradation of radiance and irradiance spectra and, thus, to significant degradation of the reflectance due to the different light paths for radiance and irradiance (Coldewey-Egbers et al., 2018). In this paper we present results of a study related to a method for a possible soft-correction of the degradation of the reflectance as a prerequisite for the harmonisation with SCIAMACHY and GOME-2 data as part of FDR4ATMOS.

The study is limited to three selected spectral regions in the ultra-violet (UV), the visible (VIS), and the near-infrared (NIR) wavelength range. These regions are relevant for the retrieval of level-2 data products such as atmospheric amounts of ozone, sulphur dioxide, and nitrogen dioxide or cloud parameters.

Pseudo-Invariant Calibration Sites

- Extract GOME L1 radiance and irradiance data for all overpasses 1995-2011 over Saharan Pseudo-Invariant Calibration Sites (PICS, https://calval.cr.usgs.gov/apps/test_sites_catalog)
- 10 sites: Algeria-3 and -5, Egypt-1, Libya-1, -2, -3, and -4, Mali, and Mauritania-1 and -2, see Fig. 1
- PICS are characterized by stable spectral properties and atmospheric conditions (little or no vegetation, minimal rainfall), generally high reflectance (sand dunes, desert), and distinct spatial homogeneity
- Search area: ±0.5° in latitude and ±0.75° around center of site

Fig. 1: Location of 10 selected Saharan PICS. Sites in Niger and Sudan were not used.

Analysis of intra-pixel PMD variability

- Selection of GOME measurements was further optimized based on a detailed analysis of the corresponding PMD (Polarization Measurement Device) measurements
- PMDs have a much higher spatial resolution (20x40km^2)
- Only GOME pixels with homogeneous behaviour of the PMD values are used (see Fig. 2)
- Use distribution of peak-to-peak (PTP) values of PMD to define a threshold (see Fig. 3)

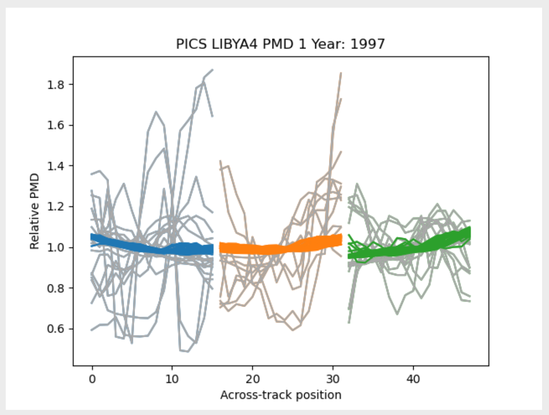


Fig. 2: Analysis of intra-pixel PMD variability for GOME measurements over Libya-4 in 1997. We show the PMD relative to the mean PMD value in the respective ground-pixel as a function of the across-track position for east (blue), nadir (orange), and west (green) pixels. Grey curves denote the pixels whose peak-to-peak value is larger than the defined threshold (see Fig. 3).

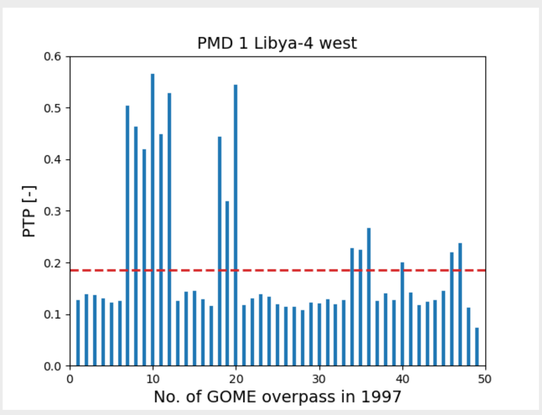


Fig. 3: Distribution of intra-pixel peak-to-peak PMD value for all GOME overpasses at Libya-4 in 1997. Dashed red line denotes the threshold. All values above the threshold are not used for the analysis. The threshold is set to the 60th percentile of the PTP distribution.

Analysis of reflectance degradation and calculation of soft-correction

- Calculate annual mean reflectance 1995 through 2011 for all 10 individual PICS
- Fig. 4 shows the reflectance relative to the reflectance in 1995 as a function of time for selected wavelengths in the UV (left), VIS (middle), and NIR (right) spectral range separately for east (orange), nadir (blue), and west (green) pixels.
- The change in the behavior in 2001 is related to the reduced pointing accuracy
- Significant degradation occurred in the UV spectral range (left); in the visible spectral range, reflectance started to degrade in 2001 (middle); in the near-infrared degradation is small (right)

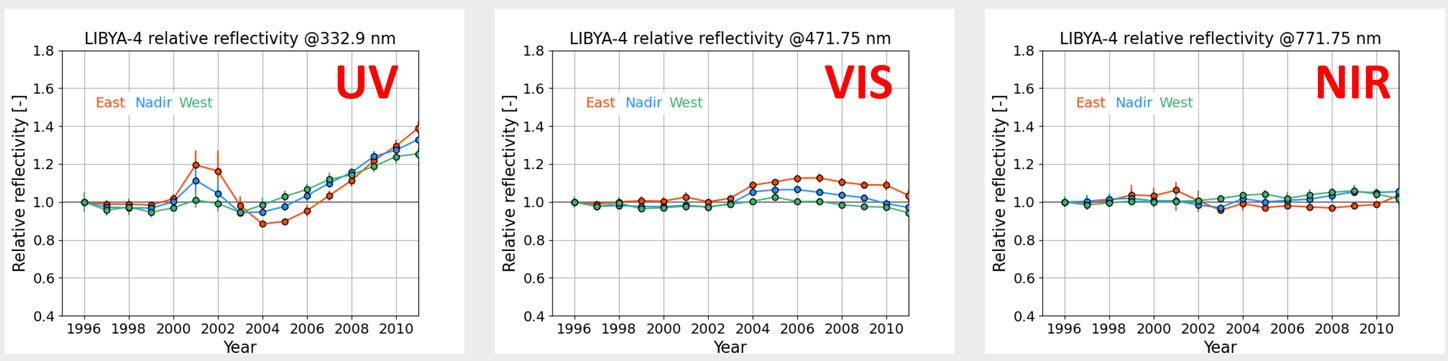


Fig. 4: GOME reflectance 1995-2011 relative to the reflectance in 1995 for PICS Libya-4 and three selected wavelengths in UV (left), VIS (middle), and NIR (right).

- The next step is to average the relative reflectance over all 10 PICS (see Fig. 5 for UV spectral range)

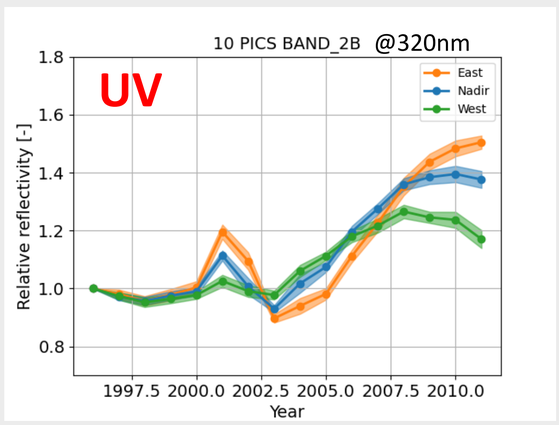
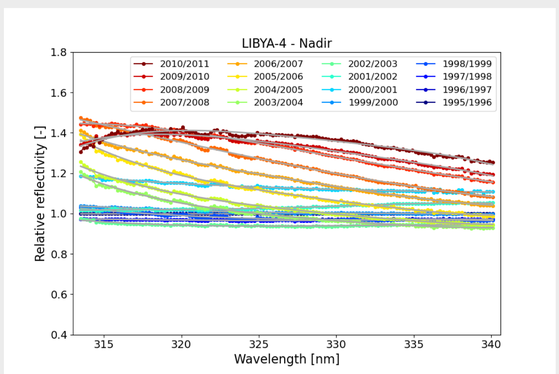


Fig. 5: GOME reflectance 1995-2011 relative to the reflectance in 1995 averaged over all 10 Saharan PICS for one selected wavelength (320nm) in the UV spectral range.

- Analysis described above is performed for all individual wavelengths in the selected spectral region
- The final step is a polynomial fit over wavelength for all individual years (see Fig. 6 for UV spectral range 313-340nm)

Fig. 6: GOME relative reflectance 1995-2011 as a function of wavelength (313-340nm). Grey curves denote a 4th order polynomial fit.



Application of correction factors

- Assuming that the atmospheric conditions and the spectral behavior at the Saharan PICS did not change over the entire mission period of GOME, we use the analysis of the relative reflectance as a soft-correction for the GOME measurements
- Fig. 6 shows the GOME reflectance as a function of time over July 1995 through June 2011 for selected wavelengths in the UV spectral range (top), the VIS spectral range (middle), and the NIR spectral range (bottom). Orange dots denote the original GOME reflectance and green dots denote the corrected reflectance
- As part of the FDR4ATMOS project the soft-correction for the GOME reflectance will be implemented in the Generic Calibration And Processing System (GCAPS)

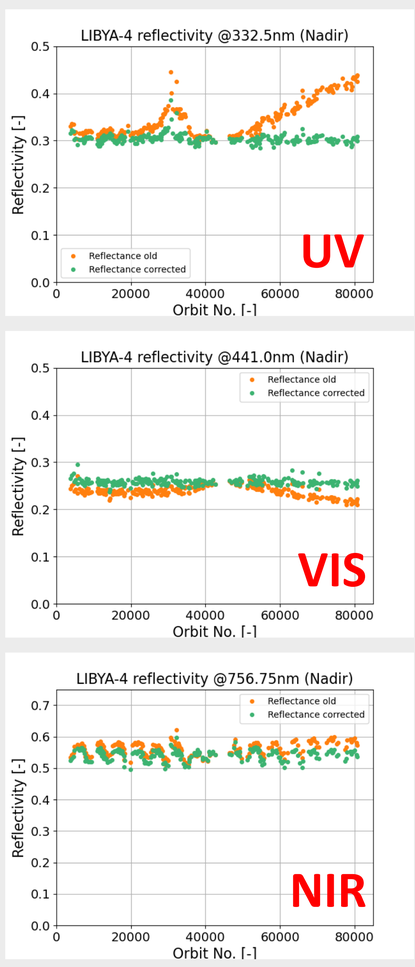


Fig. 6: see text for details

See also

- Oral presentation by Lichtenberg et al.: FDR4ATMOS: Adding GOME-2 data to the GOME-1/SCIAMACHY harmonized FDR product.
- Poster by Owda et al.: Scenes investigation for enhancing cross-calibration performance: GOME and SCIAMACHY case study.

References

- Coldewey-Egbers et al.: The Global Ozone Monitoring Experiment: review of in-flight performance and new reprocessed 1995–2011 level 1 product, Atmos. Meas. Tech., 11, 5237–5259, https://doi.org/10.5194/amt-11-5237-2018, 2018.

Acknowledgements

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- More details available on https://atmos.eoc.dlr.de/FDR4ATMOS