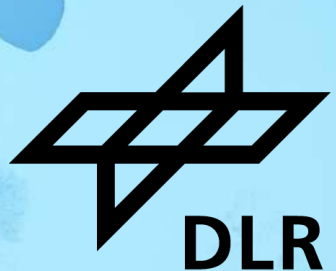


EVALUATION OF S5P/TROPOMI L1B DATA

M. Coldewey-Egbers, D. Loyola & KNMI L1 Team
CEOS AC-VC #22 / WGCV ACSG, Leiden, NL



Outline



- Motivation
- TROPOMI L1B data
 - Long-term stability of reflectance using PICS
 - Preparing investigations at Railroad Valley Playa
 - Comparison of irradiance with OMPS/SNPP
- ESA FDR4ATMOS project
- Summary

- Evaluation of Level-1B radiance and irradiance data from the Sentinel-5 Precursor Tropospheric Monitoring Instrument (S5P/TROPOMI) as part of the ESA Copernicus Atmospheric Mission Performance Center service (ATM-MPC)

L1B	V02.01.00	30/04/2018 - 22/11/2025	Orbit 2818 - 42022
	V03.00.00	From 22/11/2025 onward	From orbit 42023 onward

- Evaluation based on
 - Analysis of the long-term stability of the reflectance over PICS
 - Comparison with other satellite data -> OMPS/SNPP

Pseudo-Invariant Calibration Sites (PICS)



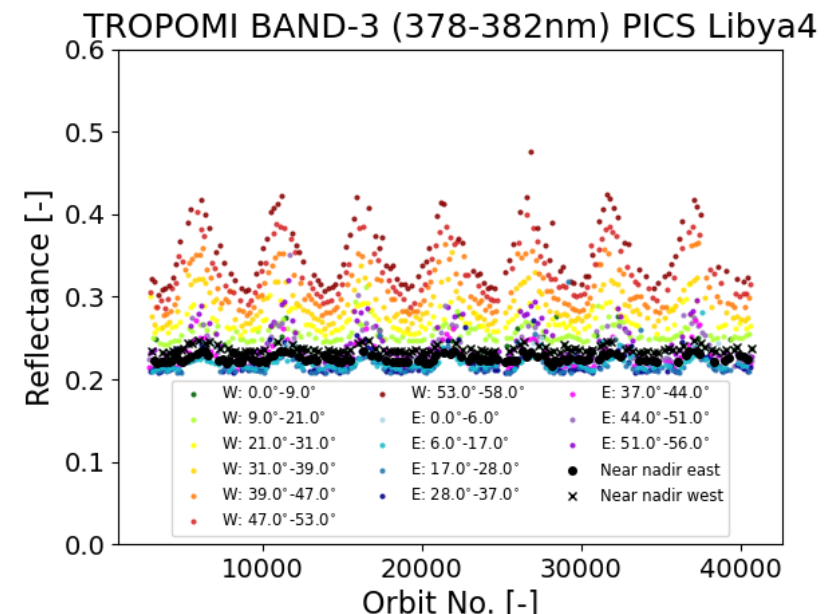
- About 20 sites located in Saharan Desert and Arabian Peninsula
- Spatially uniform and temporally invariant
- Low atmospheric impact: clear skies, minimal aerosol and water vapor content
- High reflectivity
- Lat: 18° - 31° N
- Lon: 9° W- 51° E
- Usable area:
 $10 \times 10 \text{ km}^2$ (Sudan1)
– $100 \times 100 \text{ km}^2$



Surface
Niger-2

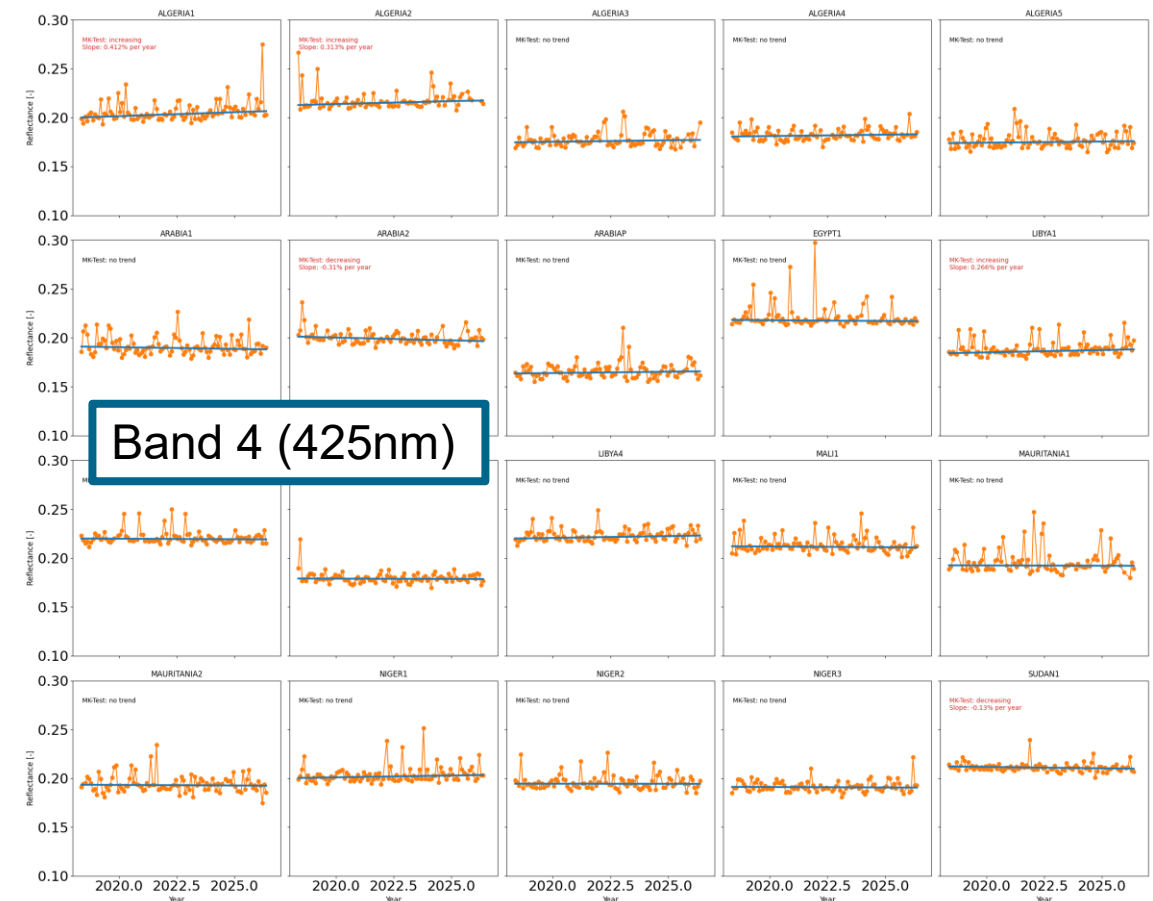
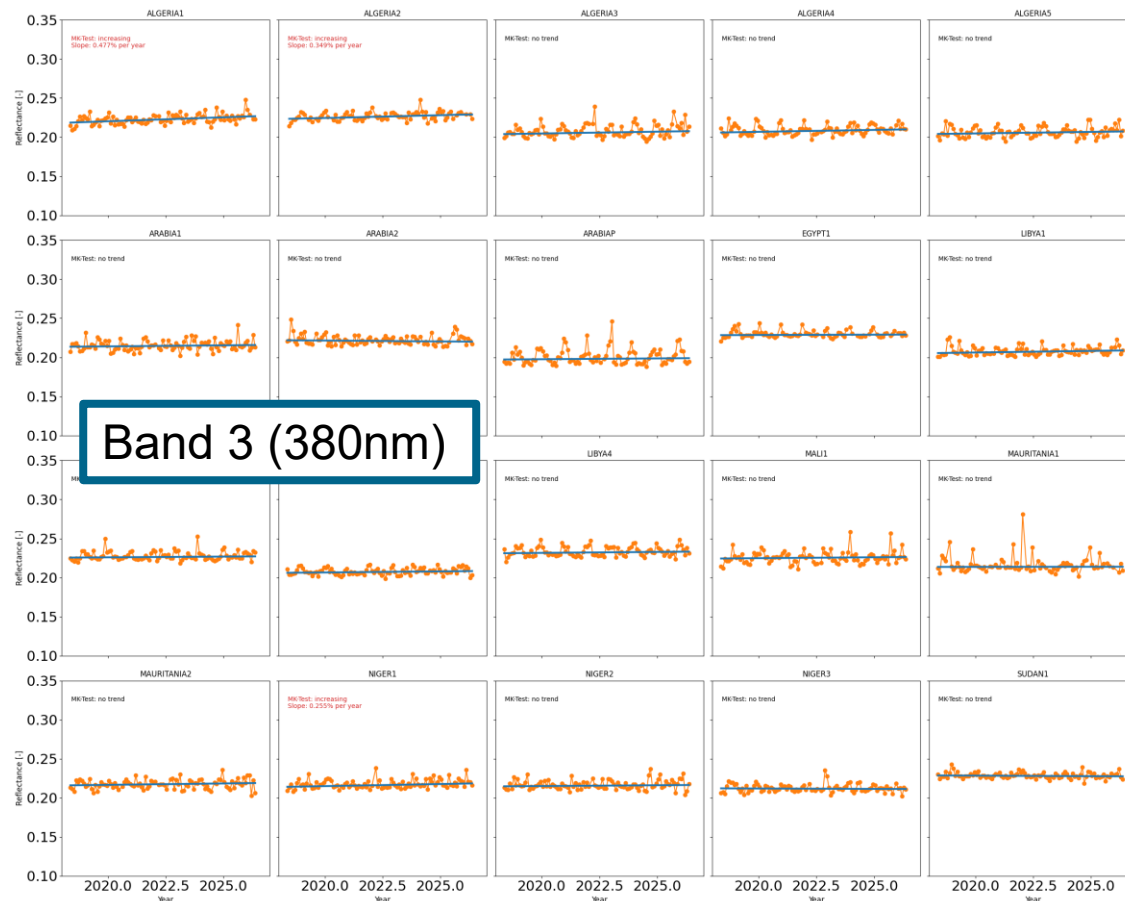
TROPOMI reflectance

- Extract TROPOMI radiance and irradiance (daily) from **May 2018 through May 2026**
- **Cloud fraction < 0.1**
- Maximum distance to center of site: **8km** (ground pixel size: 5.5x3.5km²)
- All viewing zenith angles
Here: **only near-nadir** pixels investigated
- **L1B v02.01.00** (until 22/11/2025)
v03.00.00 from 22 November 2025 onward



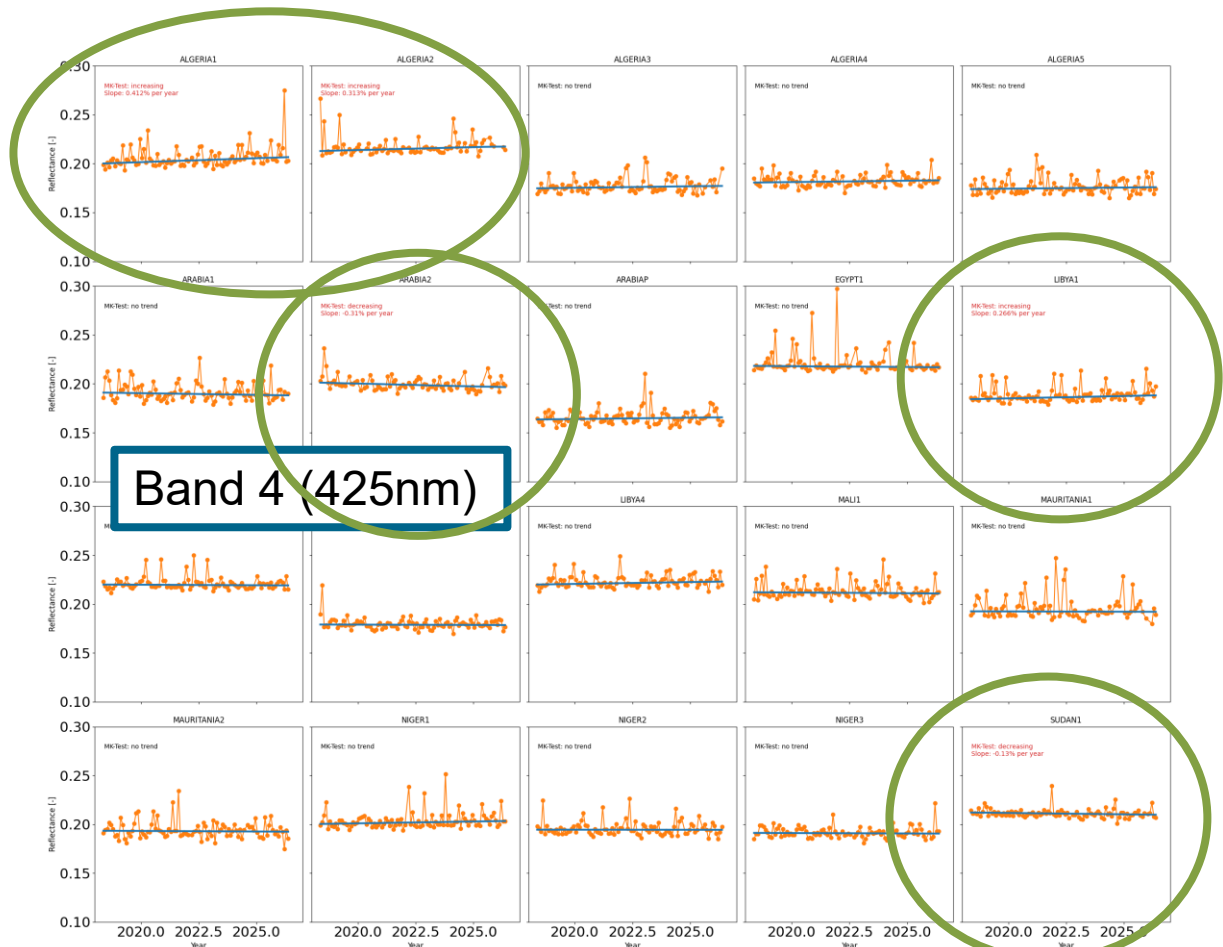
TROPOMI reflectance vs. time

- Near-nadir, cloud-free monthly mean reflectance (May 2018 – May 2026)
- Trend: Mann-Kendall-Test (significant for 3 sites (band 3) and 5 sites (band 4))



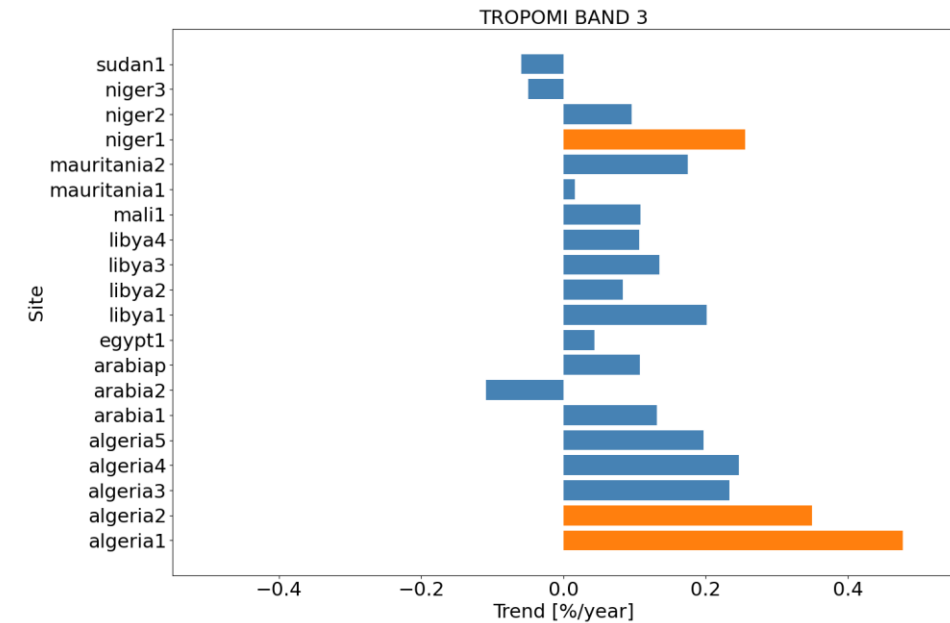
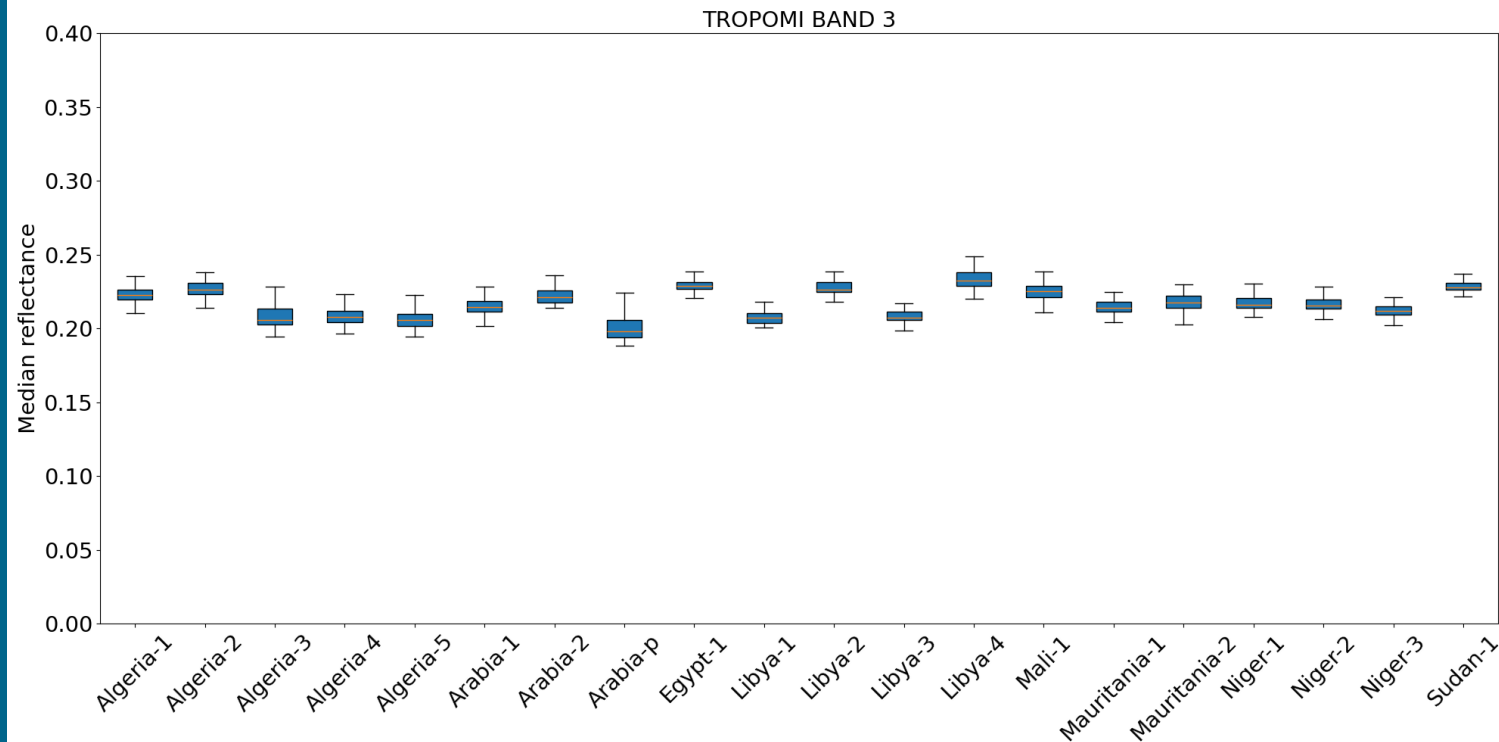
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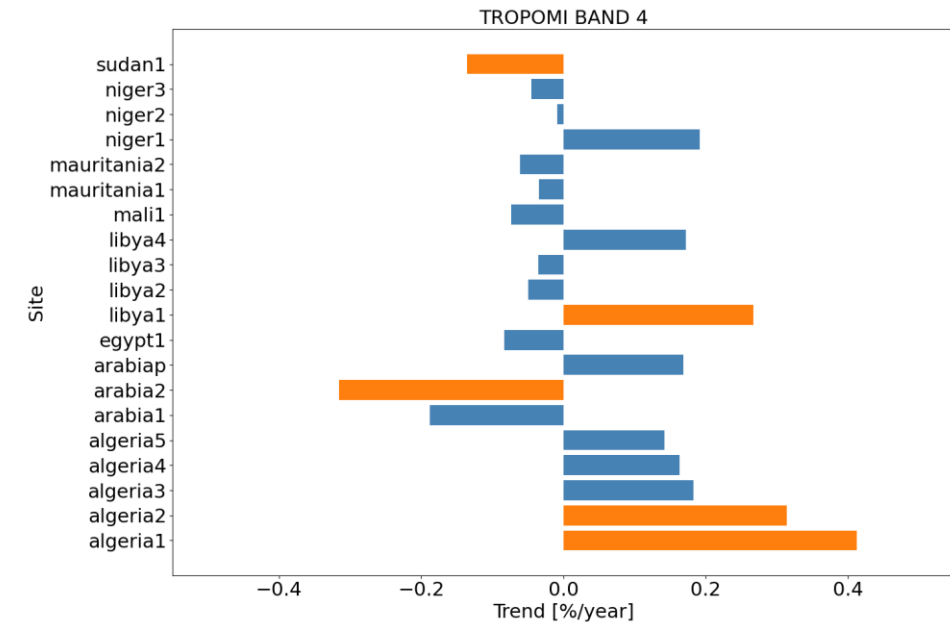
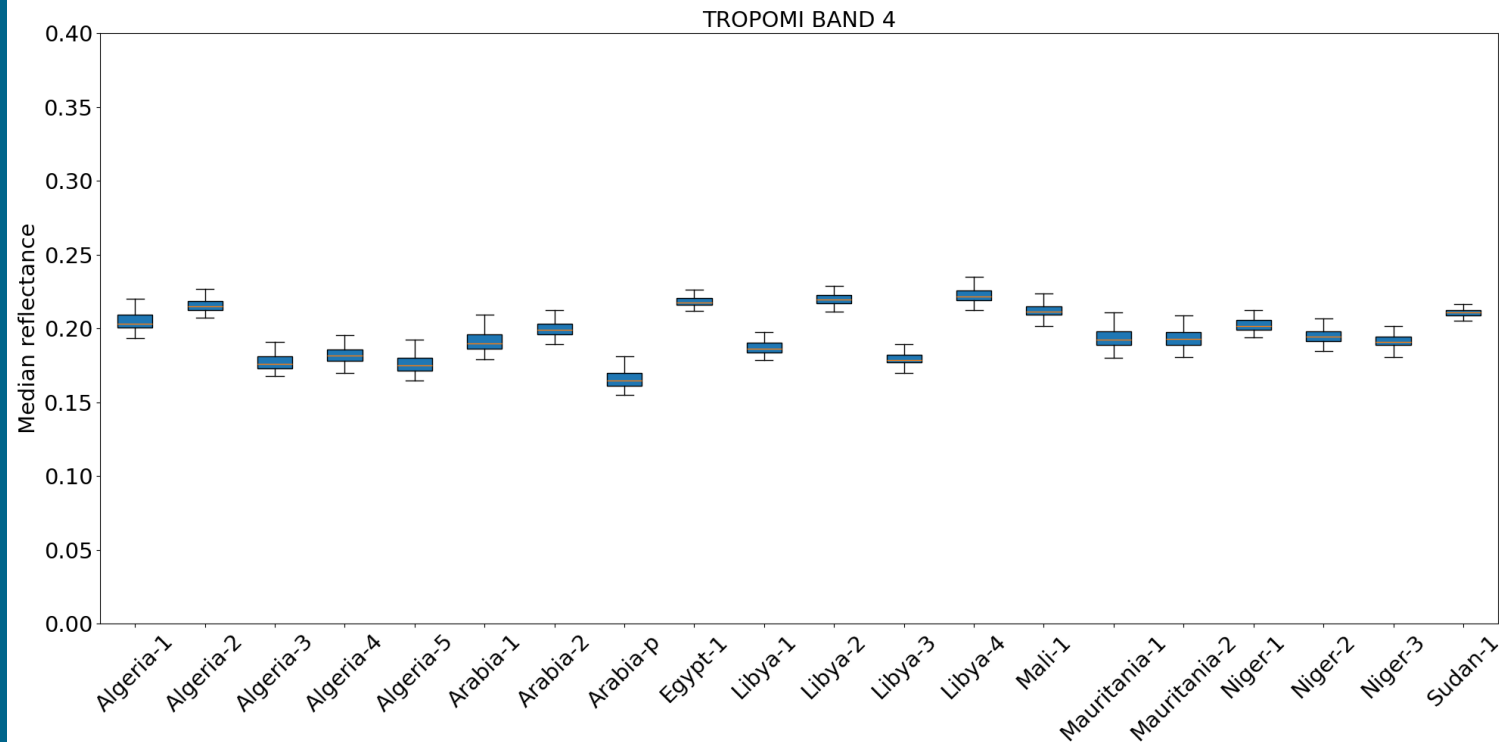
TROPOMI L1B Band 3 @380nm

- Mean reflectance all sites: 0.22 ± 0.01
- Mean temporal variation: 1.8%
- Trend: slightly positive, but not significant (except for Algeria1&2 and Niger2)



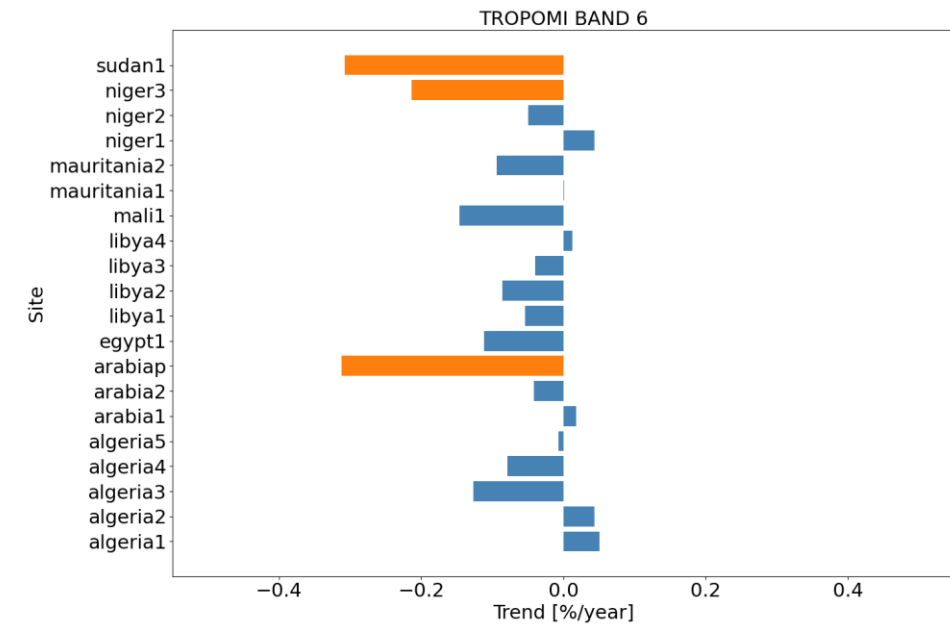
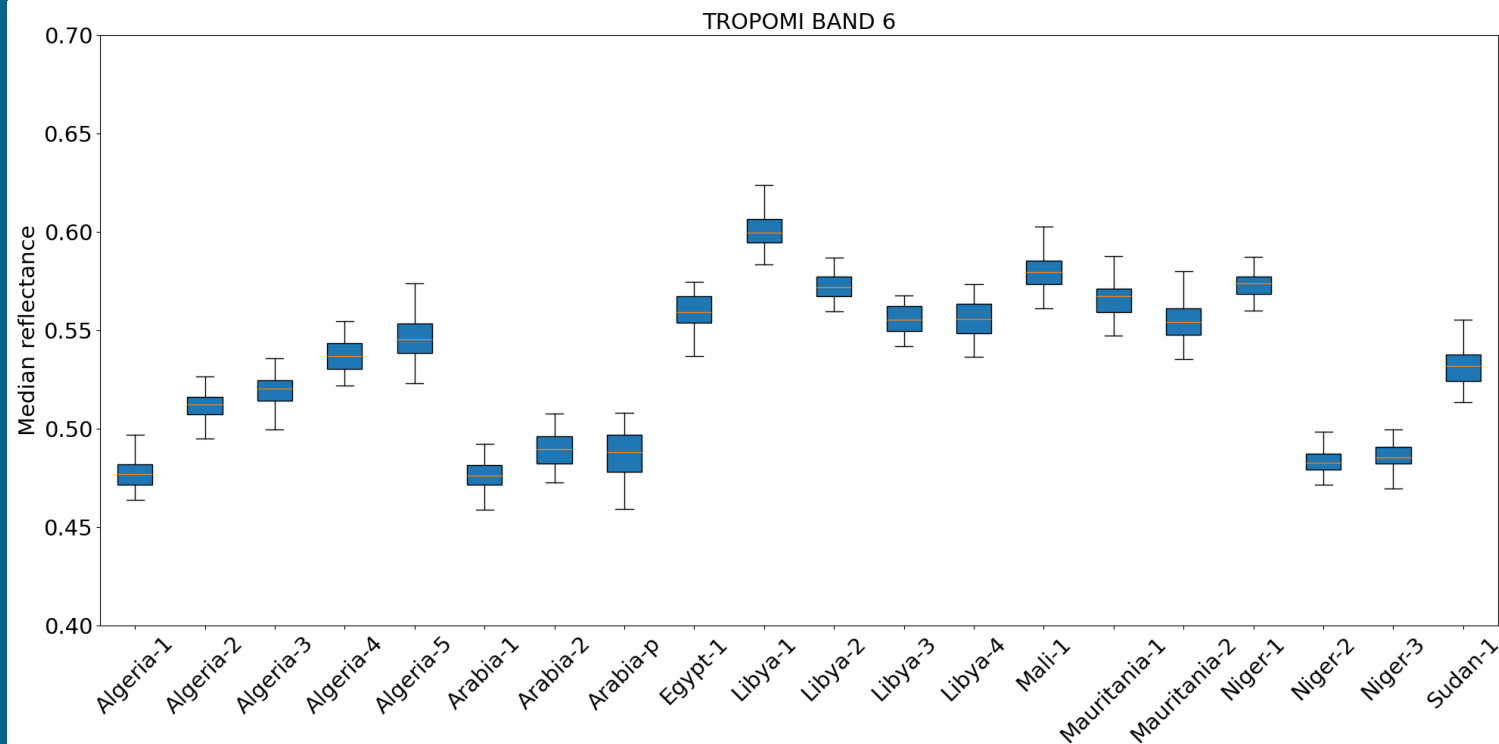
TROPOMI L1B Band 4 @425nm

- Mean reflectance all sites: 0.20 ± 0.02
- Mean temporal variation: 2.5%
- Trend: slightly positive & negative, significant for 5 sites, incl. Algeria 1&2



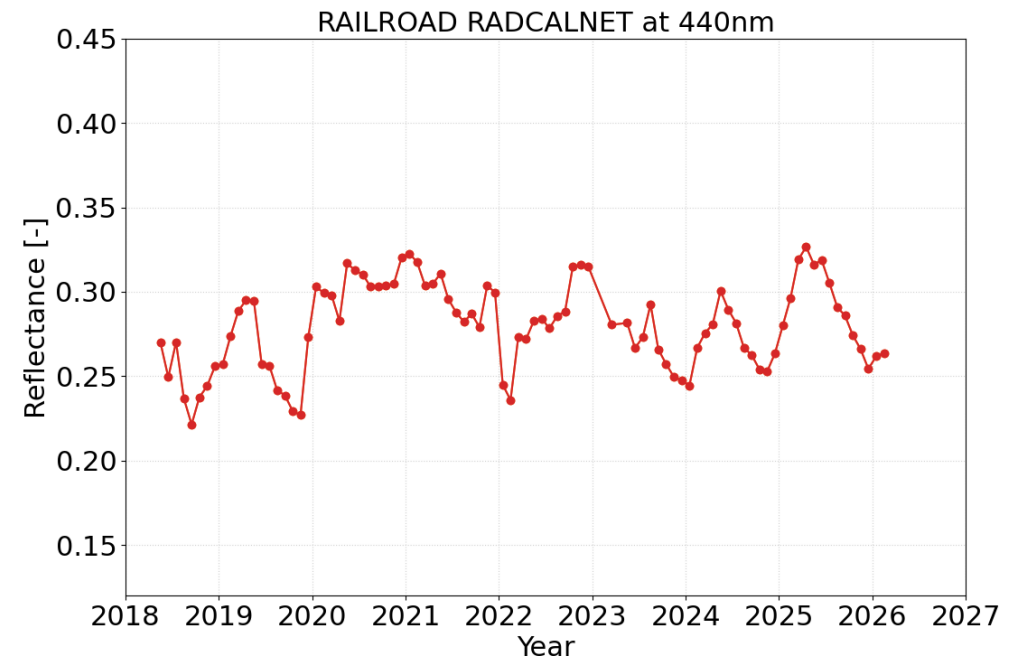
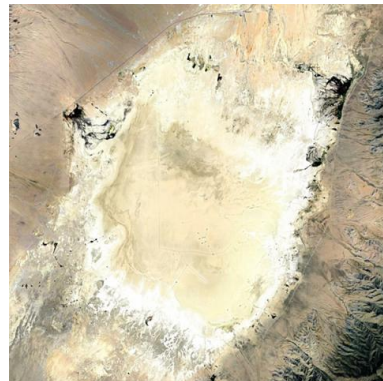
TROPOMI L1B Band 6 @750nm

- Mean reflectance all sites: 0.54 ± 0.04
- Mean temporal variation: 1.0%
- Trend: mostly negative, significant for 3 sites



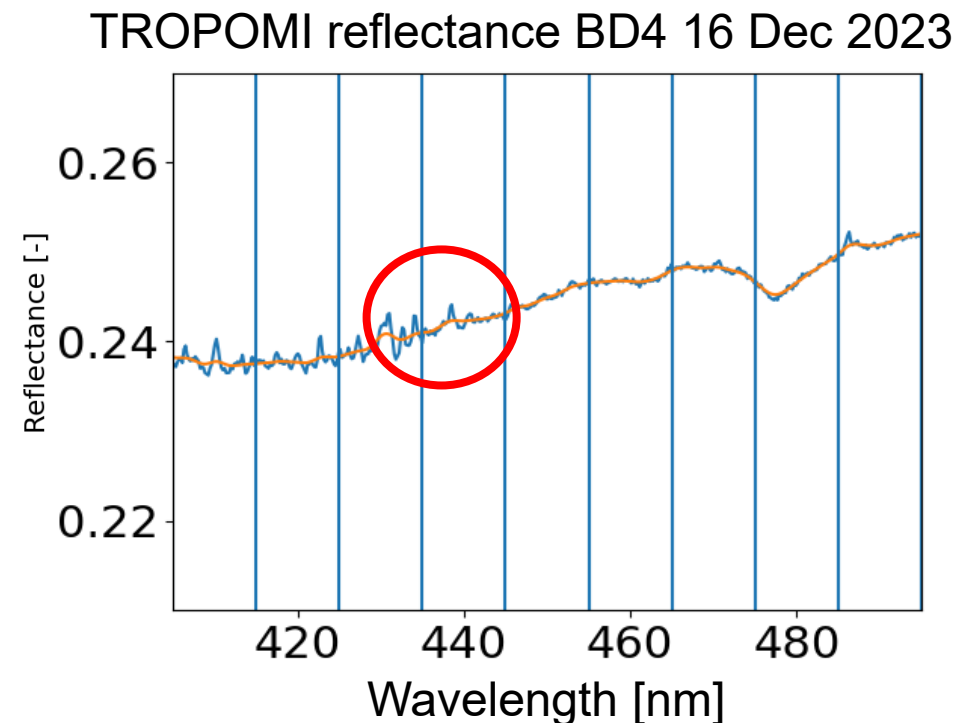
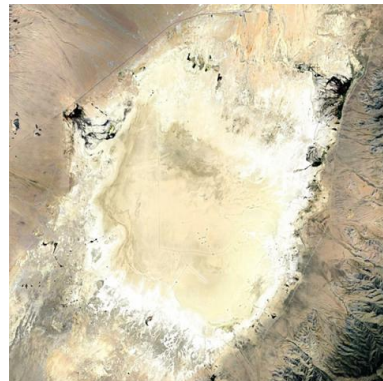
TROPOMI reflectance at Railroad Valley Playa

- USA in east-central Nevada (38.5°N, 115.7°W, 1435m a.s.l.)
- Dry lakebed, low aerosol loading, 15x15km²
- Instrumented reference test site as part of RadCalNet (Bouvet et al., 2019)
 - Provides nadir-view TOA reflectance from 400-2500nm (10nm intervals)
 - Measurements at 30min intervals from 09 a.m. to 03 p.m. LT



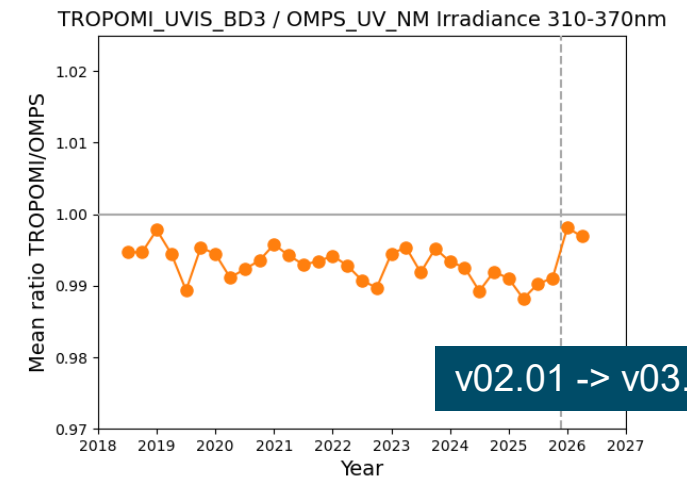
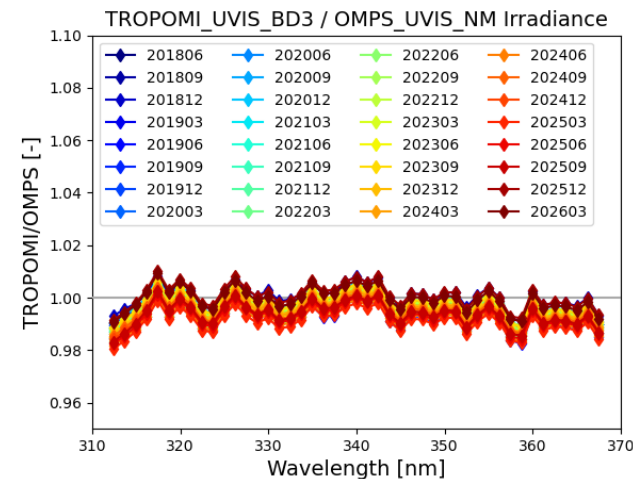
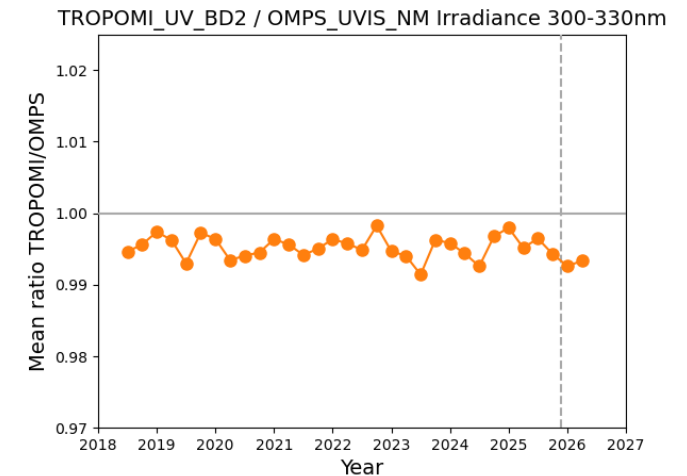
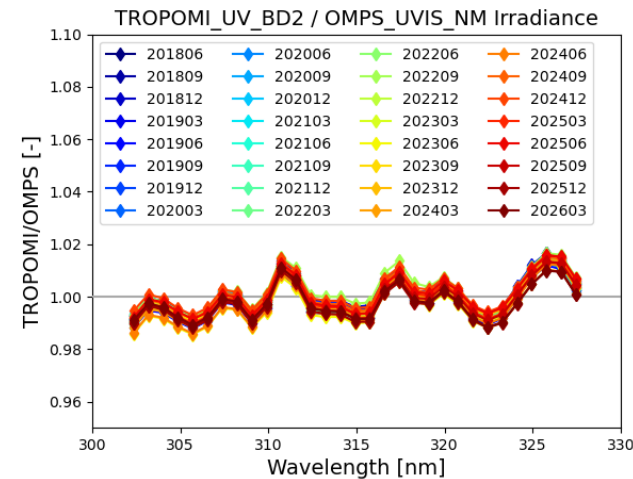
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Irradiance: TROPOMI vs. OMPS

- Ozone Mapping and Profiler Suite onboard Suomi National Polar-orbiting Partnership (OMPS/SNPP)
- Time difference between S5P and SNPP is ~5min
- OMPS Nadir Mapper: 300-380nm
- TROPOMI band 2 (300-330nm) and band 3 (305-400nm)
- 4 spectra/year (1st of Mar, Jun, Sep, and Dec from June 2018 through March 2026
 - Ratio and spectral structure of ratio stable over time
 - Band 3: small jump in 11/2025



v02.01 -> v03.00

ESA FDR4ATMOS project - overview



- **Fundamental Data Record for Atmospheric Composition** (FDR4ATMOS) project as part of the ESA Long Term Data Preservation (LTDP) programme
- Generate FDR products of **harmonized L1 irradiances and reflectances** in the UV (O3, SO2), VIS (NO2), and NIR (cloud properties) spectral ranges as well as lunar data products
- Consortium: DLR-IMF, IUP-HB, BIRA-IASB, NPL, ESS, SERCO, and ESA
- Phase-I: 2019 – 2024: **GOME/ERS-2** and **SCIAMACHY/ENVISAT** & Phase-II: 2024 – 2026: add **GOME-2/MetOp-A/-B/-C** (cooperation with EUMETSAT)

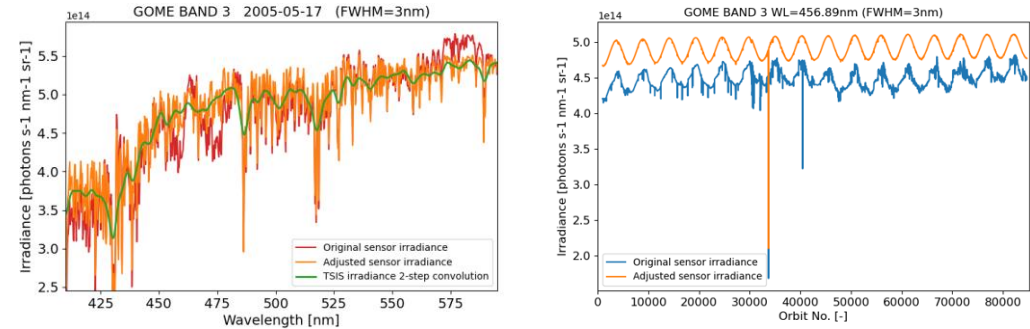
2 Papers

- Owda & Lichtenberg, Comparative analysis of GOME and SCIAMACHY reflectance over Pseudo-Invariant Calibration Sites: implications for spectrometers cross-calibration, AMT, 2026.
- Owda et al., Reflectance-based cross-calibration of GOME and SCIAMACHY spectrometers enhanced by polarization monitoring devices data, AMT, 2026.

ESA FDR4ATMOS project - results

■ Harmonization of irradiances

- Use v2 TSIS-1 as reference spectrum
- Convolution with ISRF



■ Harmonization of reflectances

- Based on measurements over PICS
- SCIAMACHY as reference sensor

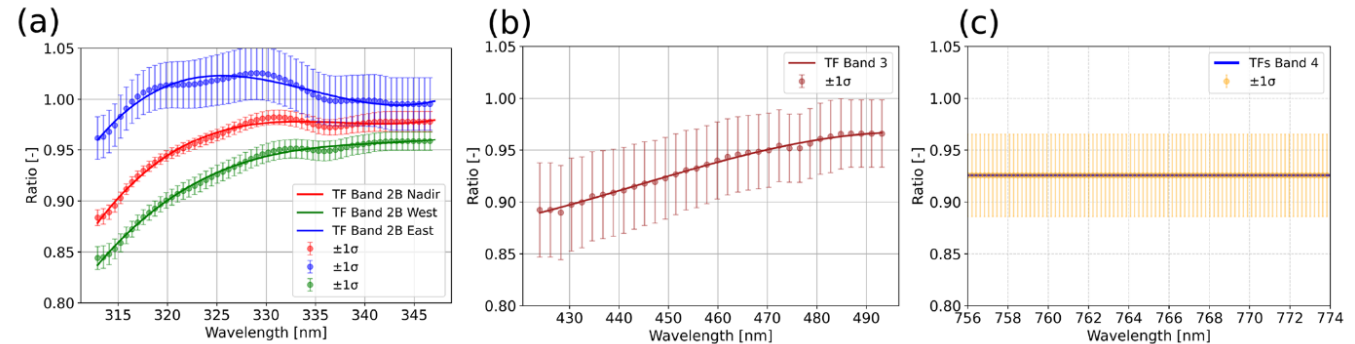
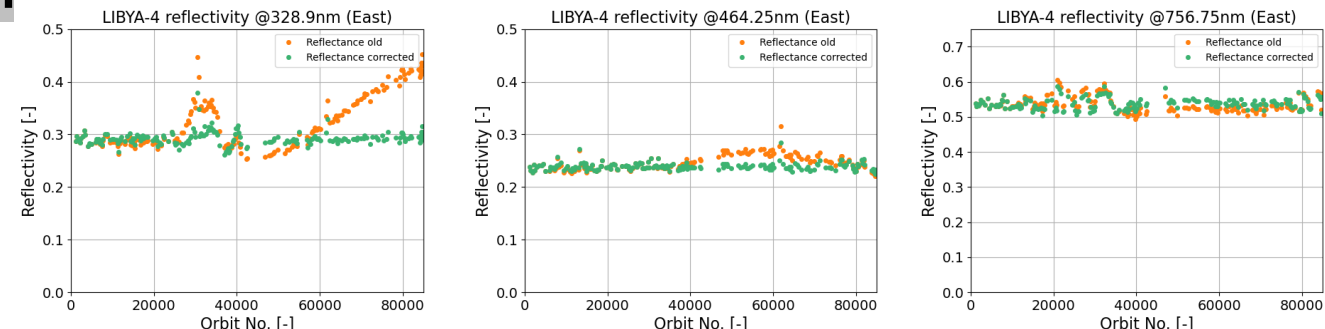


Fig.7, Owda et al., 2026

■ GOME reflectance degradation correction

- Based on measurements over 10 PICS
- Reference: measurements from the beginning of the mission 1995/1996



Summary



- Evaluation of TROPOMI L1B data
 - Reflectance vs. time at PICS (desert sites)
 - very good stability for bands 3, 4, and 6 (tbd: band 5)
 - Prepare investigations at Railroad Valley Playa
 - comparison with RadCalNet ground-based data
 - Comparison of irradiance with OMPS/SNPP
 - very good long-term stability & similar results for OMPS/N20 & OMI
- ESA FDR4ATMOS
 - Harmonized long-term L1 irradiance and reflectance data
 - V1.0 (GOME and SCIAMACHY) available: <https://doi.org/10.5270/ESA-852456e>
 - L1B (standard product) and L1A (for expert users) available

Future work



- Evaluation of Sentinel-4/MTG-S1 L1B ...
 - Launched on 04 July 2025
 - Geostationary (30°-65°N, 30°W-45°E, Europe, North Africa and eastern Atlantic)

- ... and Sentinel-5/Metop-SG A L1B data
 - Launched on 13 August 2025
 - Low-Earth orbit (832km)

- FDR4ATMOS
 - Include TROPOMI in harmonization