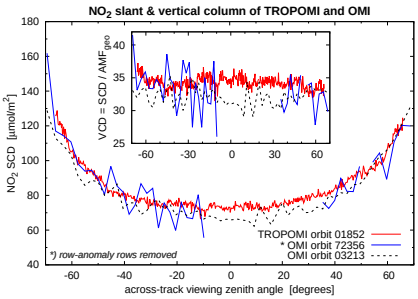
Royal Netherlands
Meteorological Institute
*Ministry of Infrastructure
and Water Management*

TROPOMI NO_2 slant column retrieval: uncertainties and comparisons with other satellite based NO_2 data

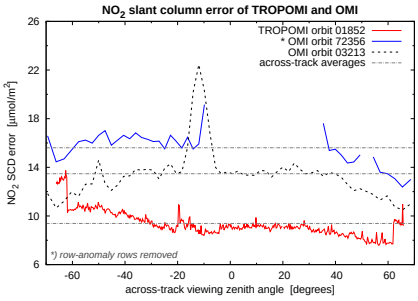
Jos van Geffen [1]*, Henk Eskes [1], Maarten Sneep [1], Mark ter Linden [2], Marina Zara [1], Isabelle De Smedt [3], Michel Van Roozendael [3], Folkert Boersma [1,4], Pepijn Veefkind [1]

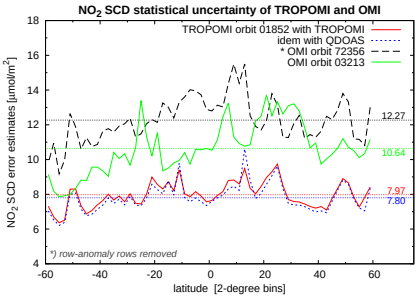
The NO_2 slant column (SCD) retrieval for TROPOMI is based on improvements [5,6] of the DOAS approach operationally used for the NO_2 SCD retrievals of OMI (the OMNO2A processor). Below some first TROPOMI NO_2 SCD retrieval results are compared to results using QDOAS [7] as well as to NO_2 SCDs from OMI (from QA4ECV [8] processing). Also shown are NO_2 SCD error estimates in comparison with results using an independent statistical uncertainty estimate based on spatial variability [9].



Comparing TROPOMI and OMI

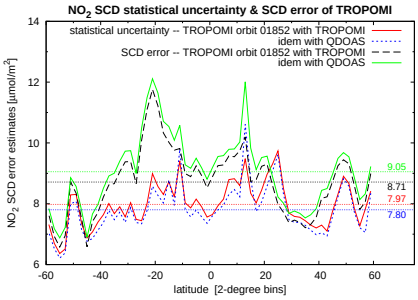
Slant column retrieval results for the Pacific Ocean orbit on 20 Feb. 2018 of TROPOMI are compared to those for the (almost) overlapping OMI orbit and to those of a similar OMI orbit from 20 Feb. 2005.
The NO_2 slant column (SCD) and vertical column (VCD = SCD / AMF_{geo}) [*left*] and the SCD error [*right*] of TROPOMI show much less across-track variation than OMI's, and the SCD error of TROPOMI is some 30% lower than OMI's.
Data of scanlines with nadir latitude in the range $[-20°:+20°]$ is averaged along-track; orbits are over the Pacific Ocean.
OMI data is processed within the QA4ECV framework [8].

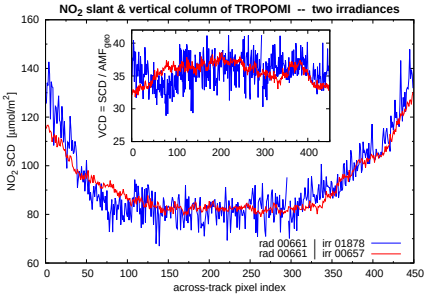




SCD uncertainty & error estimate

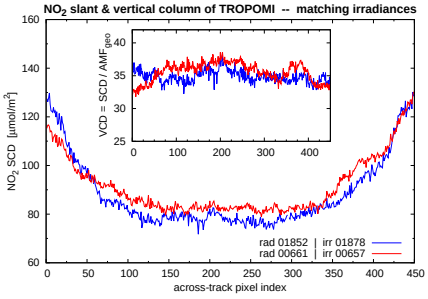
A statistical estimate using the spatial variability over a remote Pacific Ocean sector can be used to compare SCD uncertainties of different retrieval methods [9].
Statistical uncertainty of TROPOMI [*left*] is clearly much lower than OMI's, and TROPOMI data processed with QDOAS [7] gives results very similar to the TROPOMI processor. Like for other instruments [9], the SCD error estimates for TROPOMI [*right*] are on average larger than the statistical uncertainties.
Data of scanlines with nadir latitude in the range $[-60°:+60°]$ is used, without cloud filtering; orbits are over the Pacific Ocean.





Effect of irradiance choice

The NO_2 slant column (SCD) and vertical column (VCD = SCD / AMF_{geo}) for radiance orbit 00661 of 28 Nov. 2017 using the irradiance of the same day (orbit 00657) are compared to results using the irradiance of 20 Feb. 2018 (orbit 01878) [*left*] and results for radiance orbit 01852 of 20 Feb. 2018 using the corresponding irradiance [*right*]. Clearly it is best to use the irradiance measured nearest in time to the radiance for the NO_2 retrieval.
Data of scanlines with nadir latitude in the range $[-20°:+20°]$ is averaged along-track; orbits are over the Pacific Ocean.



TROPOMI NO_2 SCD processor — Intensity Fit DOAS using Optimal Extimation ("IFDOE")

– DOAS equation is solved in intensity fit formulation in wavelength window $[405:465]$ nm
– Included are: NO_2, O_3, O_2-O_2, H_2O-vapour, H_2O-liquid, Ring effect (all sampled @ 0.01 nm and pre-convolved with the ISRF)
– χ^2 minimisation using an Optimal Estimation (OE) routine with a-priori errors set very large, so that these do not limit the solution; a pre-whitening of the data is performed to improve numerical stability
– Reflectance: $R(\lambda) = \pi/\mu_0 \cdot I(\lambda)/E_0(\lambda)$

– Wavelength calibration of irradiance and radiance is performed prior to the DOAS fit in the full fit window
– The irradiance is interpolated to the radiance wavelength grid with a high-sampling interpolation which uses a high-resolution solar spectrum (pre-convolved with the ISRF)
– Cross sections are interpolated to the reflectance grid with a cubic spline
– If more than 1% of the wavelength pixels in the fit window are flagged as "saturated", the ground pixel is discarded

– SCD error estimates are scaled with the normalised χ^2, where χ^2 is normalised by (N-D), with N the number of wavelength pixels (≈ 305) and D the degrees of freedom, which is almost equal to the number of fit parameters (12)
– Model reflectance at 440 nm is used to derive the cloud fraction and from that the cloud radiance fraction in the NO_2 window; FRESCO provides the cloud pressure & scene albedo and scene pressure

Note: $10\,\mu\text{mol/m}^2 = 6\times10^{14}\,\text{molec/cm}^2$

[1] KNMI – Royal Netherlands Meteorological Institute, De Bilt, NL
[2] S[&]T – Science and Technology, Delft, NL
[3] BIRA-IASB – Belgian Institute for Space Aeronomy, Brussels, BE
[4] WUR – Wageningen University, Wageningen, NL
[5] Van Geffen et al., AMT **8**, 1686–1699, 2015.
[6] Van Geffen et al., TROPOMI NO_2 ATBD v2.0, in preparation, 2018.
[7] Danckaert et al., 2017: `http://uv-vis.aeronomie.be/software/QDOAS/`
[8] Boersma et al., 2018: `http://www.qa4ecv.eu/`
[9] Zara et al., AMT, in review, 2018.

Disclaimer The presented work has been performed in the frame of the Sentinel-5 Precursor Validation Team (S5PVT) or Level 1/Level 2 Product Working Group activities. Results are based on preliminary (not fully calibrated/validated) Sentinel-5 Precursor data that will still change.
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*** Contact:** jos.van.geffen@knmi.nl