Evaluating the dependence of OMI NO_2 slant columns on retrieval settings

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Introduction

- NO_2 is one of the most important satellite data products
- OMI has been providing a high resolution NO_2 data set since fall 2004
- combining OMI data with other data sets (GOME, SCIAMACHY, GOME-2) requires excellent consistency of the retrievals
- here, the consistency of NO_2 slant columns from the University of Bremen (IUP-UB) retrieval is evaluated and compared to the NASA operational product as well as to GOME-2 data
- three different "heritage" fitting windows are evaluated on OMI data: 425 - 450 nm (SCIAMACHY), 405 - 465 nm (OMI), and 425 - 497 nm (GOME-2)

Effect of different fitting windows

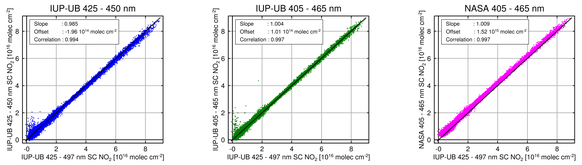

Figure 1: Comparison of one orbit of OMI NO_2 fits on 2007/02/01 over the Pacific. The fit in the large GOME-2 window is on the x-axis. No screening for poor fit quality was applied.

- comparison of the NO_2 slant columns retrieved in the three fitting windows shows excellent agreement
- correlation coefficients are all larger than 0.99
- slopes between retrievals including the NASA operational product are very close to 1, the 425 - 450 nm window yielding slightly lower values (-1.5%)
- there are small offsets between the IUP-UB retrievals but a systematic high offset of 1.5 10^{15} molec cm^2 in the NASA slant columns
- in the 425 - 450 nm and 405 - 465 nm fitting window there are spurious high values for a small number of fits at low latitudes (see lower left corner of figures) which are not seen in the 425 - 497 nm window and in the NASA retrievals
- these values are usually removed by fitting quality criteria

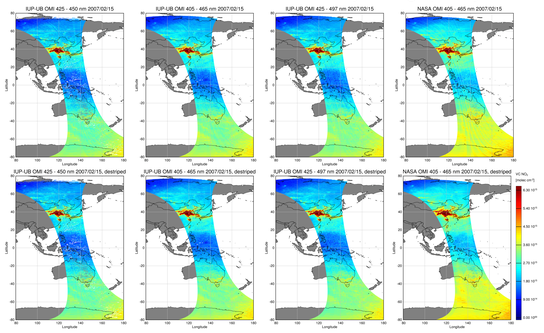

Figure 2: Comparison of one orbit of OMI vertical NO_2 columns. A simple stratospheric air mass factor has been applied everywhere.

- the higher values of the operational NASA product are apparent.
- in the small fitting window, NO_2 columns show larger scatter, in particular at low latitudes.
- there appears to be more striping in the operational NASA product than in the IUP-UB data. After de-striping (lower panel), all retrievals show nearly no stripes.

Acknowledgements

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- GOME-2 lv1 data were provided by EUMETSAT
- OMI lv1 and lv2 data were provided by NASA

Sensitivity to tropospheric NO_2

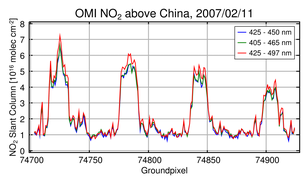

Figure 3: Small part of one orbit on February 2, 2007 passing over China on a clear day. While the background values agree very well between the three fitting windows, larger NO_2 columns are retrieved in the fitting window reaching up to 497 nm over polluted areas as result of the larger sensitivity to the lower atmosphere.

- The sensitivity of nadir observations of tropospheric absorptions depends on wavelength
- in the absence of clouds, sensitivity increases systematically towards longer wavelengths as result of reduced Rayleigh scattering
- wavelength dependence of surface reflectivity can enhance the effect
- the presence of aerosols can reduce the effect
- this needs to be taken into account in the analysis of tropospheric NO_2 columns
- at least in principle, it also can be used to infer information on the vertical NO_2 distribution

Sand signature

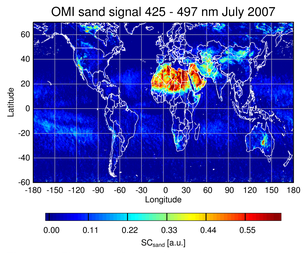

Figure 4: Fitting coefficient of empirical sand cross-section in the 425 - 497 nm fitting window for July 2007. Data have been cloud screened (< 20%) to better isolate the surface signature

- analysis of GOME-2 data in the large fitting window (425 - 497 nm) revealed large residuals over regions having sand on the surface
- an empirical cross-section was derived from GOME-2 data which is found in the fit over all bare soil regions
- the signal has been confirmed in airborne measurements during sand storms
- the same signal is found in OMI retrievals with the same spatial distribution and similar magnitude as in GOME-2 data
- some differences to be expected (different overpass time and viewing angles)

Comparison with GOME-2 data

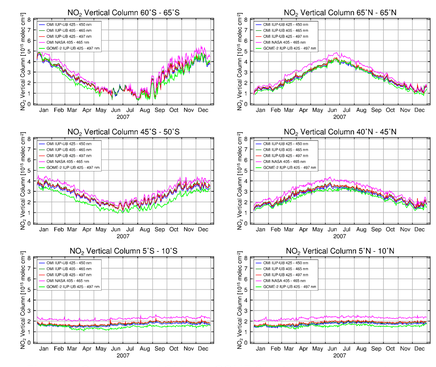

Figure 5: Comparison of OMI and GOME-2 vertical columns over the Pacific sector (180° - 220°E) for the year 2007. Results from the three IUP-UB fitting windows are shown together with NASA operational data and IUP-UB GOME-2 columns

- IUP-UB OMI NO_2 vertical columns over the clean Pacific sector are very consistent throughout 2007 at all latitudes with some offsets becoming apparent in particular in low latitudes
- there is a clear positive offset of NASA operational columns modulated by air mass factor
- GOME-2 vertical columns are lower by about 20% in lower and mid latitudes as expected from diurnal variation of stratospheric NO_2
- GOME-2 and OMI agree in high latitudes in summer when there is no diurnal variation expected

Data and analysis settings

University of Bremen (IUP-UB) data analysis:

- NASA operational lv1 V3 data
- 425 - 450 nm, 405 - 465 nm, 425 - 497 nm
- Vandaele low temperature NO_2 cross-section
- convolution of all cross-sections with parameterised OMI slit function
- liquid water and sand signal included in 425 - 497 nm fit
- averaged solar irradiance (OMI-Aura_L1-GLOBAL-OMTMIRRYA_2005m0101t0000-syear-rPDS01_v003-2007m0716t145802.he4)
- destriping (if any) using same orbit data over equatorial region
- two phase spike removal

NASA data:

- NASA operational lv2 V3
- 405 - 465 nm fitting window
- only NO_2 slant columns used
- original or de-striped data, see figure captions

Vertical columns:

- simple stratospheric air mass factor with geometric line of sight correction
- applied to original (not de-striped) slant columns

Conclusions

- OMI NO_2 slant column retrievals using different fitting windows show a very high degree of consistency
- comparison of IUP-UB retrievals with the operational NASA data set reveals an offset, NASA data being higher
- comparison with IUP-UB GOME-2 data shows qualitatively the expected behaviour (photochemical model needed for quantitative analysis)

- there seems to be slightly less striping in the IUP-UB retrievals but all data are good after de-striping
- there are some spurrious high values in IUP-UB data at low latitudes for the smaller fitting windows which are not present in the NASA data
- in cloud free situations, the larger NO_2 signal in the 425 - 497 nm window over polluted scenes is evident and can be used for improving NO_2 retrievals
- the sand signal reported for GOME-2 is also present in OMI data

- these tests are relevant for the decision on TROPOMI / Sentinel-5-Precursor NO_2 retrieval settings

Selected references

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