A UV NO_2 DOAS retrieval for satellite data from GOME-2/MetOp-A

A possibility to detect NO_2 vertical distribution

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1 Motivation

- NO_2 is one of the most important air pollutants
- catalyses ozone production, causes summer smog, acid rain, and adds local radiative forcing
- NO_x emission sources and their horizontal distribution are well known from satellite measurements
- knowledge of the vertical NO_2 distribution is only limited
  ⇒ satellite observations from GOME-2 on board of EUMETSAT's MetOp-A are used to develop a new NO_2 retrieval for the UV spectral range

2 BAMF - NO_2 vertical sensitivity

- calculation of BAMF with the radiative transfer model SCIATRAN
- to investigate the different vertical sensitivities in the two wavelength regions, UV and vis
- 352nm (UV) and 438nm (vis), with a solar zenith angle of 50°, surface spectral reflectance 0.04 (UV) and 0.06 (vis) and a US standard atmosphere profile

$$\sum_i SC_i = \sum_i BAMF_i \, x \, VC_i$$

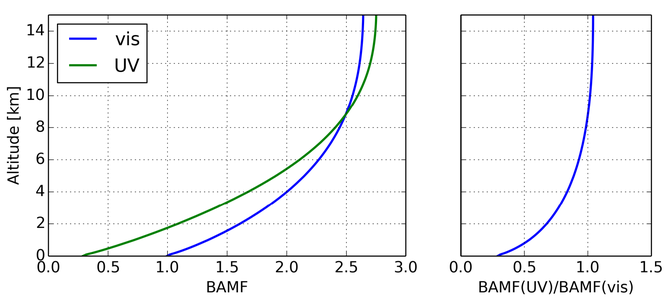

Figure 1: BAMF for UV and visible spectral range (left) and quotient of both BAMFs (right). BAMF diverge with altitude.

- the sensitivity for NO_2 above 9 km is higher in the UV compared to the visible spectral range
- below 9 km the sensitivity is clearly higher in the visible spectral range
  ⇒ vertical sensitivity from two NO_2 retrievals in different wavelength windows

3 UV NO_2 DOAS retrievals

- fit setting of NO_2 retrievals:

	UV NO_2 fit	vis NO_2 fit
fitting window	342 – 361.5nm	425 – 450nm
polynomial degree	5	3
cross sections	O_3, NO_2, O_4, BrO, HCHO, Ring	O_3, NO_2, O_4, H_2O, Ring
instrumental function	Zeta	–

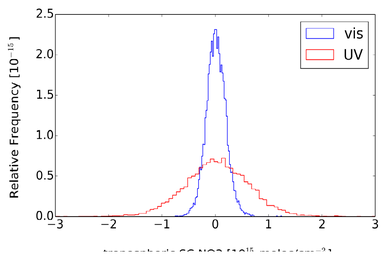

Figure 2: Scatter of retrieved NO_2 SCs over region of presumably no NO_2 indicates retrieved accuracy for January 2008.

- usage of data from 2007 to 2014 from GOME-2/MetOp-A
- usage of pixels with cloud fraction smaller than 0.2 (FRESCO+ version 6)
- stratospheric correction: reference sector (180 – 210°E)
- larger fitting errors for the UV NO_2 than for the vis NO_2 retrieval (calculated for 5°S – 5°N, 150 – 210°E)
- the scatter of retrieved NO_2 SC over polluted areas is much smaller compared to the scatter of retrieved NO_2 SC over the Pacific

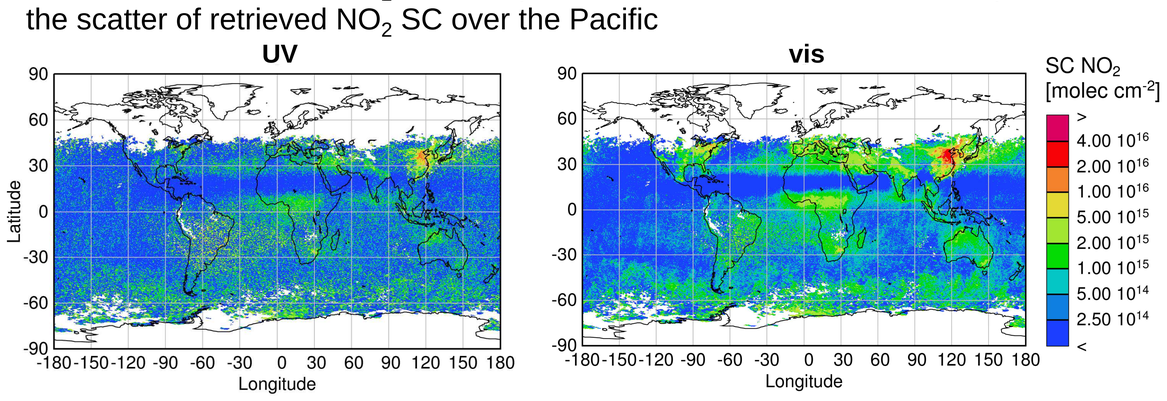

Figure 3: Tropospheric NO_2 SC for the UV spectral range (left) and for the visible spectral range (right) for January 2008. In some regions our new NO_2 retrieval agrees well with the common NO_2 retrieval from the visible spectral range. In the UV, well known NO_2 signals over highly polluted areas are observed (e.g., China), albeit at much lower levels than in the visible.

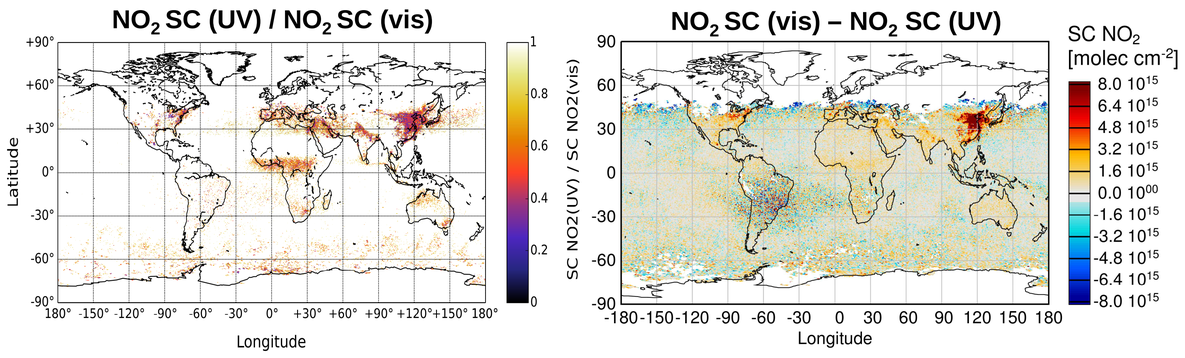

Figure 4: UV NO_2 SC divided by vis NO_2 SC (left) and vis NO_2 SC minus UV NO_2 SC (right) for January 2008. On the right hand side large differences can be observed in China as well as over further industrialised areas. Similar areas are found on the left hand side. Here only values larger 10^{15} molec cm^{-2} are plotted. From the quotient we could derive a vertical sensitivity. For lower values the NO_2 is probably located closer to the ground.

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4 Regional NO_2 SC timeseries

- anthropogenic air pollution:
  - e.g., China: NO_2 signals in highly polluted areas are visible in both spectral ranges
- biomass burning:
  - e.g., Africa south of the Equator (ASE) and Africa north of the Equator (ANE)
  - ASE: visible in both spectral ranges
  - ANE: NO_2 signals clearly visible in the visible spectral range cannot be detected in the UV spectral range

⇒ possible reasons: NO_2 values are to small to be detected or NO_2 is close to the ground (soil emission)

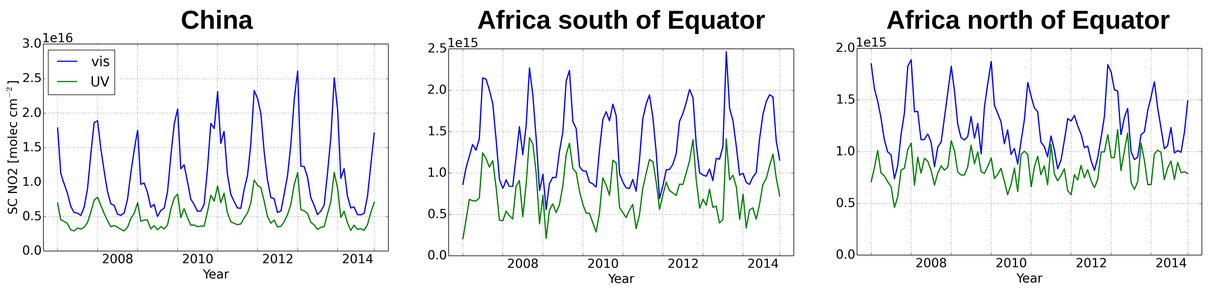

Figure 5: Time series for the UV and visible spectral range. Left: China (30 – 40°N, 110° – 125°E), middle: Africa south of the Equator (5 – 20°S, 10 – 40°E), and Africa north of the Equator (0 – 10°N, 15°W – 40°E).

5 Comparison of NO_2 VCs

- with AMF calculations, we should get similar VCs for both NO_2 retrievals:
  - NO_2 VC derived from the UV and visible spectral ranges as well as from model data show a good agreement
  - differences are partly due to stratospheric correction: e.g., lower values over North America in satellite observations
  - larger noise in UV NO_2 VC is due to the higher fitting error in the UV → Figure 2
  - large differences for example over China are due to errors in AMF calculation, possible reasons are:
  - vertical distribution of NO_2 in the model is not correct simulated
  - Aerosols are not considered in AMF calculation

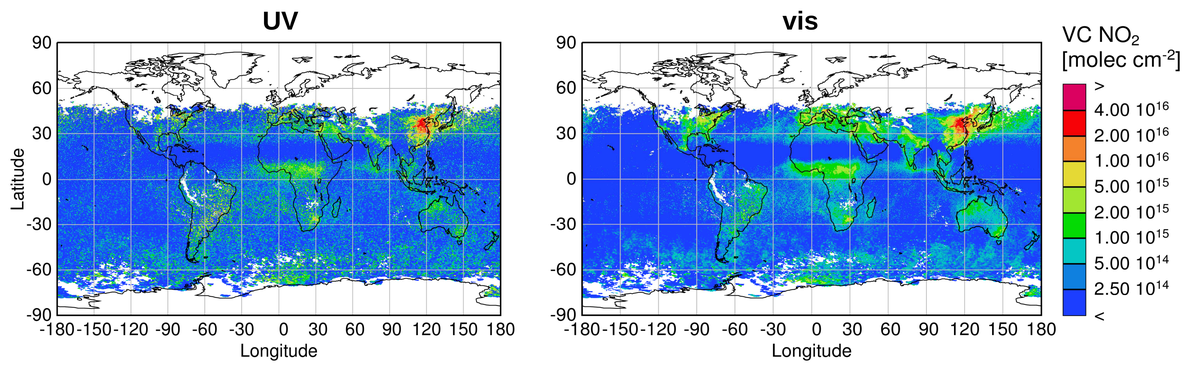

Figure 6: Tropospheric NO_2 VC for the UV spectral range (left) and for the vis spectral range (right) for January 2008.

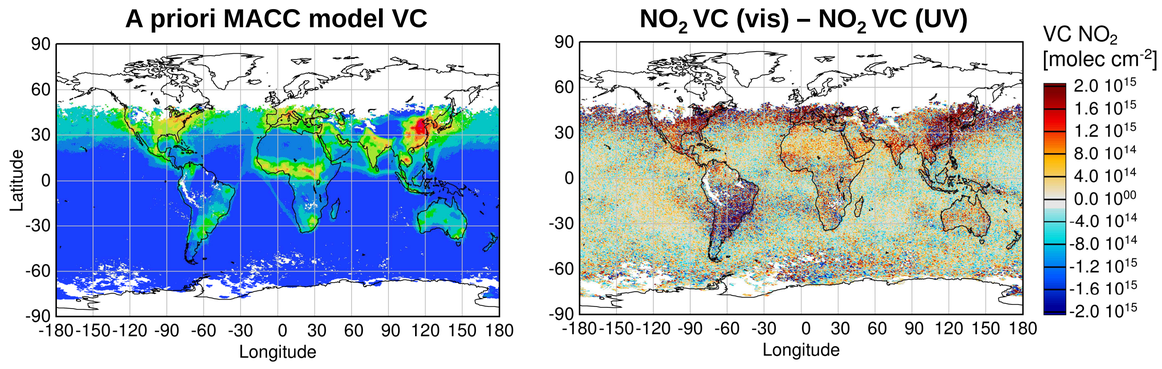

Figure 7: A priori tropospheric NO_2 MACC model VC for AMF calculations (left) and the difference of NO_2 VC for the visible minus the NO_2 VC for the UV spectral range.

6 Summary & Outlook

- we provide a NO_2 fit in the UV spectral range for GOME-2/MetOp-A satellite data
- pattern of SCs and VCs derived from the visible and UV spectral range agrees well
- NO_2 in the visible is more sensitive to the lower troposphere
  ⇒ possibility to derive vertical distribution of NO_2
- differences are mostly located in areas with high anthropogenic air pollution
- in future, we will try to improve the UV NO_2 retrieval and get further information on the NO_2 vertical distribution

References & Acknowledgement

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