Evaluation of GOME2 tandem observations of NO_2

A. Richter, A. Hilboll, L. K. Behrens and J. P. Burrows
Institute of Environmental Physics/Remote Sensing, University of Bremen
FB 1, P.O. Box 330440, D-28334 Bremen, Germany
Email: Andreas.Richter@iup.physik.uni-bremen.de

Introduction

- Tropospheric NO_2 columns is one of the key products from nadir UV/visible satellites such as SCIAMACHY, OMI, or GOME2
- The series of GOME2 instruments on the MetOp platforms will provide 15 years of observations with three successive instruments of identical build
- The first GOME2 is operational since January 2007
- The second GOME2 is providing data since January 2013
- The two instruments follow each other with half an orbit (50 minutes) distance
- The instruments have been operated in different configurations during 2013 resulting in different degrees of overlap at different spatial resolutions
- for the overlap region, the same scene is observed under different relative azimuth angles

Can we extract useful information from the dual observation of the same scene but with different relative azimuth angles?

Comparison of GOME2-A and B

Spectral Analysis:

- IUP-UB product, fitting range 425 - 450 nm, GOME2 measured absorption cross-sections where available, all settings identical, no empirical calibration functions

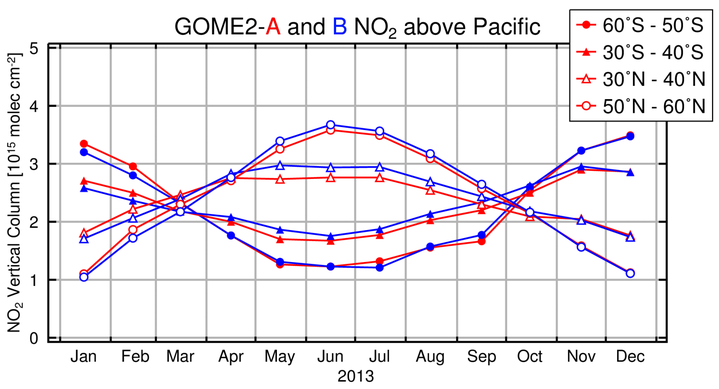

Fig. 1: Comparison of stratospheric GOME2-A and GOME2-B NO_2 columns over the Pacific (180 - 220°E). A stratospheric AMF has been applied without azimuth correction as tropospheric NO_2 amounts are expected to be low.

The agreement between columns from both instruments is good in all seasons, differences being smaller

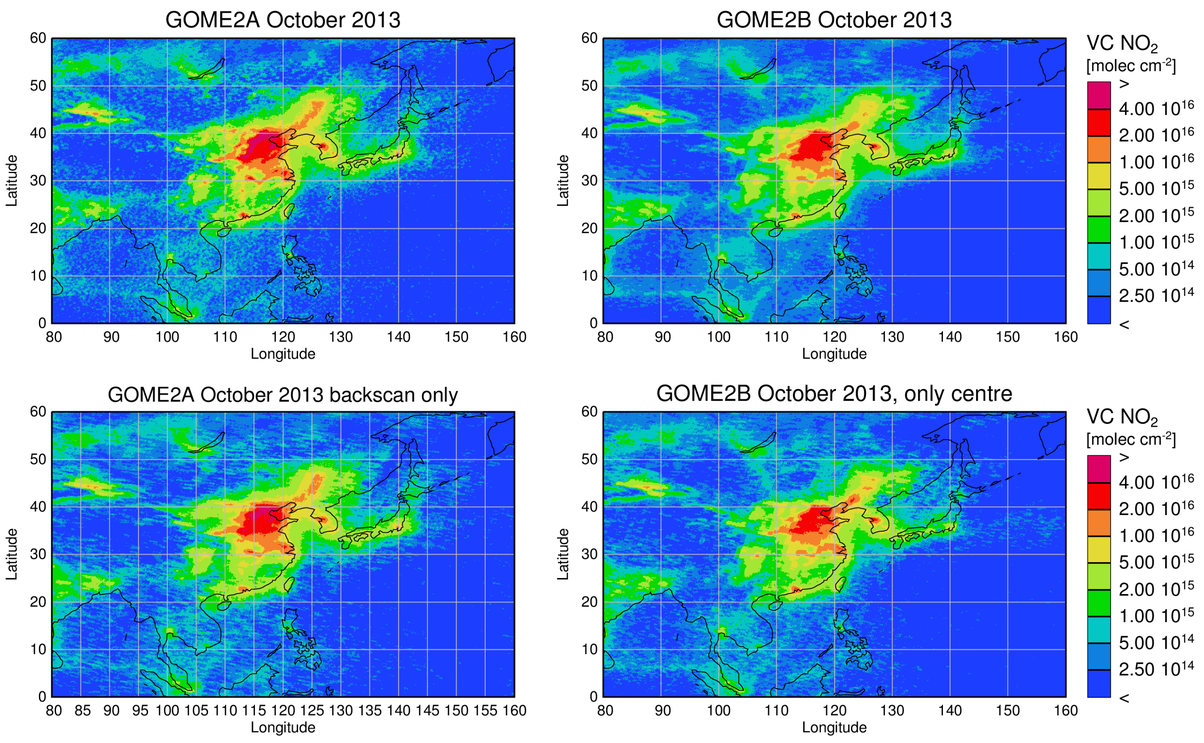

Fig. 2: Comparison of tropospheric NO_2 columns for October 2013 retrieved from GOME2-A data (left) and GOME2-B observations (right). At that point, GOME2-A had already been switched to higher spatial resolution (40 x 40 km^2). GOME2-A resolution is 40 x 80 km^2.

- More spatial detail is found for GOME2-A as expected, but also higher maximum values.
- Results from GOME2-A using backscan only which has about the spatial resolution of the GOME2-B forward scans (lower left) are not significantly lower, indicating that spatial resolution is not the explanation.
- Limitation of GOME2-B data to the centre of the swath corresponding to the GOME2-A coverage does not increase the values, showing that viewing zenith angle changes are not responsible for the differences

Main result of satellite data comparison:

- The agreement between NO_2 columns from both GOME2 instruments is good, but needs to be improved for combined use one data product

Acknowledgements

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Sensitivity Study

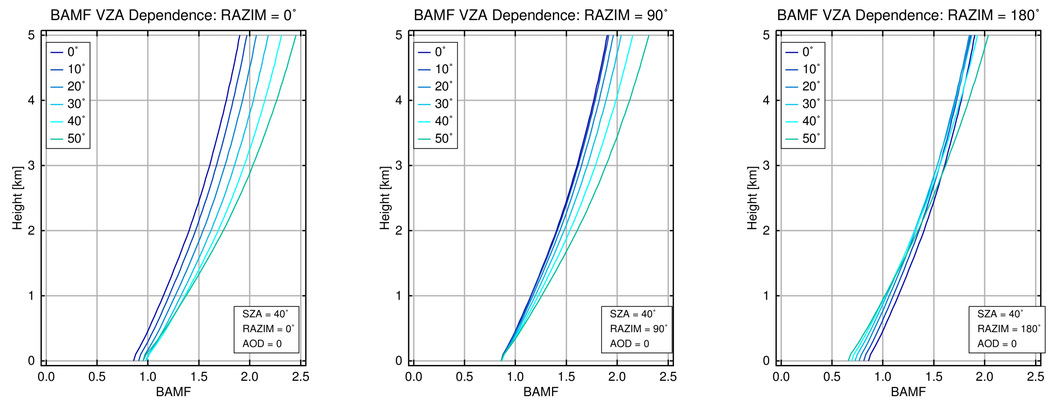

Fig. 3: Dependence of the measurement sensitivity (box air mass factor BAMF) on viewing zenith angle (VZA) of observation. An albedo of 0.05 has been assumed.

While in the stratosphere the dependence on VZA is large (1/sin(VZA)) and independent of relative azimuth angle (RAZIM, 0° = observations towards the sun), the VZA dependence close to the surface is small and depends on relative azimuth.

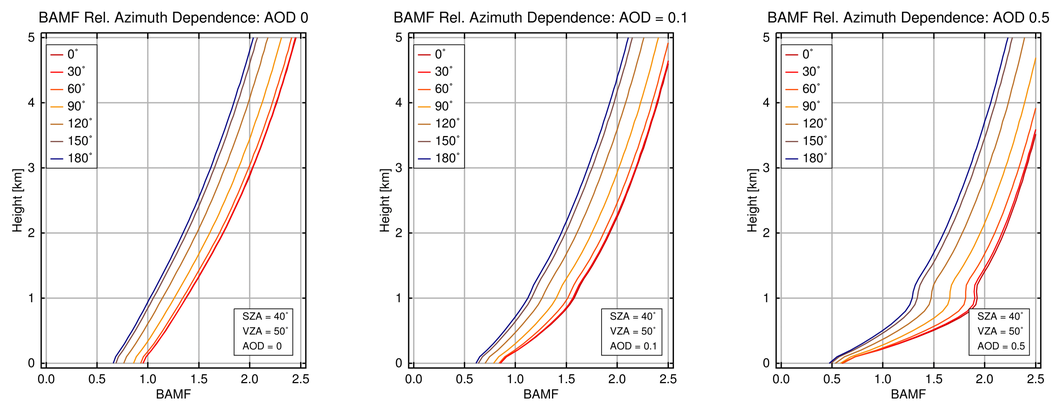

Fig. 4: Dependence of box AMF on relative azimuth for different aerosol optical depth. A well mixed aerosol in the lowest 1 km of the atmosphere was assumed with a single scattering albedo of 0.95 and an asymmetry factor of 0.7.

In the presence of aerosols, the BAMF for the lowest layers decreases while it increases above the aerosol layer. The clear dependence on relative azimuth decreases with aerosols but does not disappear.

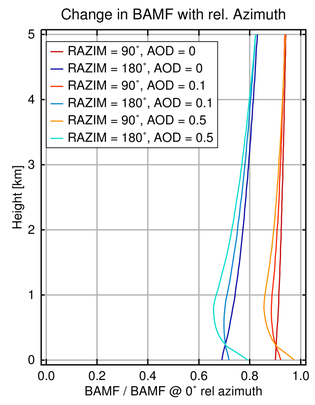

Fig. 5: Relative reduction of BAMF in the 90° and 180° relative azimuth directions as compared to the 0° view for different aerosol amounts. For 180°, the effect is of the order of 20 - 30%.

Main results of sensitivity study:

- the VZA dependence is small close to the ground
- the dependence on relative azimuth is systematic with 20 - 30% lower sensitivity at 180° RAZIM (looking away from the sun)
- aerosols have an impact on the effect but do not suppress it

In real data, many additional effects can result in differences, such as

- changes in NO_2 during the 50 minutes,
- BRDF effects,
- calibration problems

Conclusions

- In GOME2 tandem operation, some ground-pixels are measured twice within one hour with opposing relative azimuth angles
- while the impact of the viewing zenith angle on measurement sensitivity is small close to the ground, the relative azimuth has a systematic impact
- the size of the effect is 20 - 30%, in first approximation independently of aerosol loading
- while the current GOME2 products are in good agreement in background regions, there is a systematic difference over polluted regions which needs to be resolved before the relative azimuth effect can be detected in the data
- the effect is present in a statistical sense for all data products having large swaths

Selected References

Hilboll, A., Richter, A., and Burrows, J. P.: Long-term changes of tropospheric NO2 over megacities derived from multiple satellite instruments, *Atmos. Chem. Phys.*, **13**, 4145-4169, doi:10.5194/acp-13-4145-2013, 2013

Leitão, J., Richter, A., Vrekoussis, M., Kokhanovsky, A., Zhang, Q. J., Beekmann, M., and Burrows, J. P.: On the improvement of NO2 satellite retrievals – aerosol impact on the airmass factors, Atmos. Meas. Tech., 3, 475-493, 2010

Richter, A., Begoin, M., Hilboll, A., and Burrows, J. P.: An improved NO2 retrieval for the GOME-2 satellite instrument, *Atmos. Meas. Tech.*, **4**, 1147-1159, doi:10.5194/amt-4-1147-2011, 2011

see also: www.iup.uni-bremen.de/doas