Retrieval of vertical columns of water vapour from SCIAMACHY/ENVISAT satellite data

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A contribution to ACCENT-TROPOSAT-2, Task Group 1

Stefan Noël and Sebastian Mieruch

Institute of Environmental Physics / Remote Sensing (iup/ife),
University of Bremen, FB 1, P.O. Box 330440, D-28334 Bremen, Germany

Summary

Within the last year the complete GOME spectral data from 1995 until end of 2004 have been processed using the AMC-DOAS water vapour retrieval algorithm. Comparisons of GOME and SCIAMACHY water vapour results for the year 2003 show a good agreement between the two data sets such that for the first time a combined GOME/SCIAMACHY global water vapour climatology could be generated covering already now more than 10 years. Based on this new data set a first analysis of climatologic water vapour trends has been performed. Preliminary results reveal a small increase in total water vapour over Europe.

Introduction

Water vapour is one of the most important atmospheric constituents as it significantly contributes to weather and climate. Its large spatial and temporal variability makes water vapour a tracer for atmospheric change. Water vapour is the most important natural greenhouse gas. Therefore the knowledge of the global distribution of water vapour is crucial for models which aim to predict weather or climate.
The University of Bremen has developed a method to derive water vapour total column amounts on the global scale from nadir measurements performed by the Global Ozone Monitoring Experiment (GOME, see e.g. [Burrows *et al.*, 1999]) and the SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY, see e.g. [Bovensmann *et al.*, 1999]) in the spectral region around 700 nm (see e.g. [Noël *et al.*, 1999, 2004]). The retrieval method, called Air Mass Corrected Differential Optical Absorption Spectroscopy (AMC-DOAS), does not rely on external information, e.g. calibration by radiosonde data as it is the case for microwave sounders like SSM/I. Therefore GOME and SCIAMACHY can provide a completely new and independent water vapour climatology useful for climatologic trend studies.

Scientific activities

Within 2004 to 2005 a first quasi-operational version of the AMC-DOAS algorithm for SCIAMACHY has been developed and optimised. The resulting water vapour total columns have been validated by comparisons with SSM/I and ECMWF data, showing in general a good agreement between the different data sets (see [Noël *et al.*, 2005] and previous annual report).

During the last year the AMC-DOAS algorithm has been applied to the whole GOME spectral data set until end of 2004 and a first intercomparison between GOME and SCIAMACHY water vapour data has been performed. Furthermore, as an example for an application of the combined GOME/SCIAMACHY data set, preliminary water vapour trends over Europe within the last decade have been estimated based on the combined GOME/SCIAMACHY water vapour data set.

Results of these activities have been presented at various national and international conferences and workshops (ACCENT Workshop 2005, AURA Science Meeting 2005, DPG 2005, DOAS Workshop Bremen 2006, EGU 2005 and 2006, ESA Atmospheric Science Conference 2006).

Scientific results and highlights

Comparisons between GOME and SCIAMACHY water vapour columns

The AMC-DOAS method has been originally developed for the analysis of GOME data. Because of the similarity of the GOME and SCIAMACHY instrument, the method could easily be adapted also to SCIAMACHY nadir measurements which provide a better spatial resolution than GOME (typically 30 km x 60 km instead of 40 km x 320 km, see Figure 1).

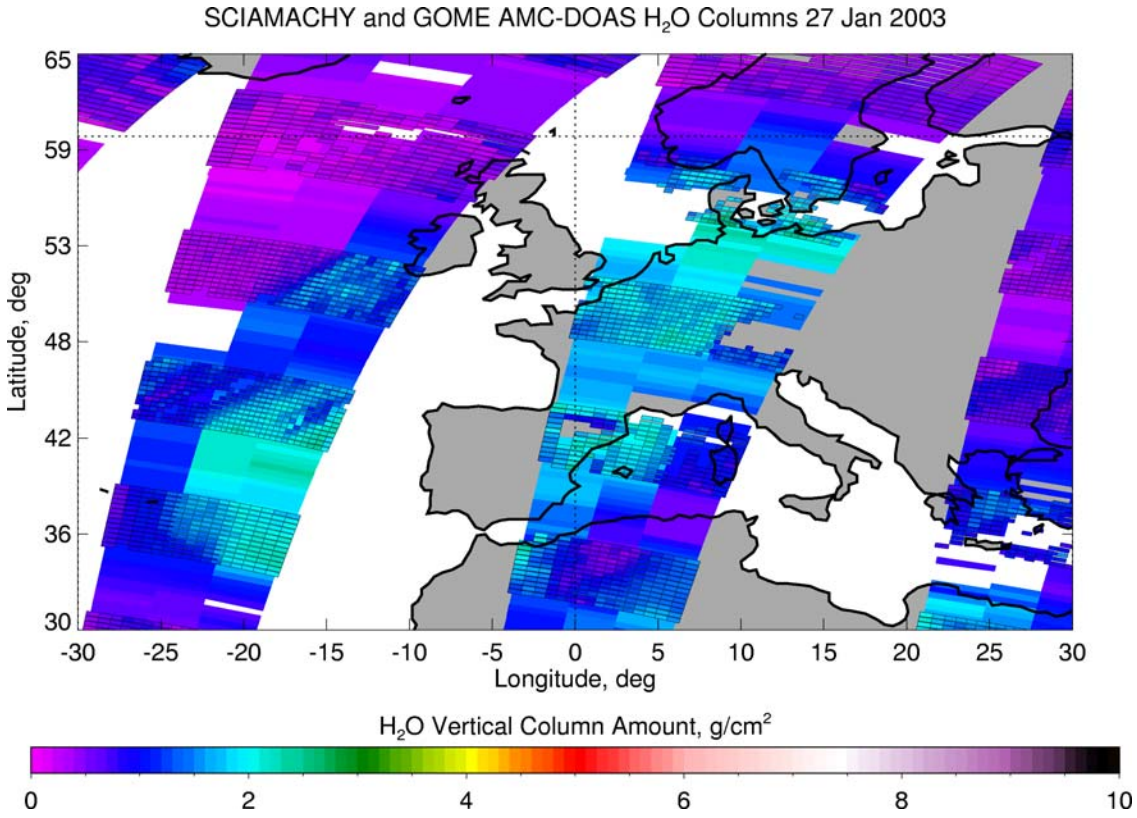

Figure 1: GOME and SCIAMACHY water vapour measurements over Europe. The smaller SCIAMACHY ground pixels are marked by boxes.

Intercomparisons between GOME and SCIAMACHY are facilitated by the fact that the orbits of ERS-2 and ENVISAT are almost identical. Both are sun-fixed polar orbits which only differ in the local time of the ascending note crossing (10:30 for ERS-2 and 10:00 for ENVISAT) such that the number of collocations (i.e. measurements at the same place on the same day) between GOME and SCIAMACHY is usually quite high.

The left part of Figure 2 shows as an example a comparison of GOME and SCIAMACHY water vapour columns for all collocated data on 27 January 2003. For this comparison all data have been gridded to 0.5°×0.5°. From the scatter plot it can be seen that GOME and SCIAMACHY data agree quite well. The correlation between the two data sets is about 0.98, but SCIAMACHY columns seem to be slightly higher than the GOME columns.

This tendency is also visible in the right part of Figure 2 where the (global) mean deviation between the GOME and SCIAMACHY water vapour results is plotted as a function of time

for the whole year 2003. The black dots denote the global mean deviation for one day, the blue vertical bars the corresponding standard deviation. The standard deviation is in the order of ±0.2 g/cm^2 which is – due to the similar instruments and orbits – smaller than the typical scatter of about 0.5 g/cm^2 when comparing to SSM/I or ECMWF data (see [Noël *et al.*, 2005]). The red line denotes monthly mean deviations derived from the daily means. There seems to be a small seasonal trend in the data which is not visible when comparing SCIAMACHY columns with SSM/I or ECMWF data. Therefore it is assumed that these seasonal variations are caused by the GOME data, probably by the varying coverage[1] or by missing actual solar reference spectra. An intercomparison of 2002 data which is planned in the near future may help to solve this issue.

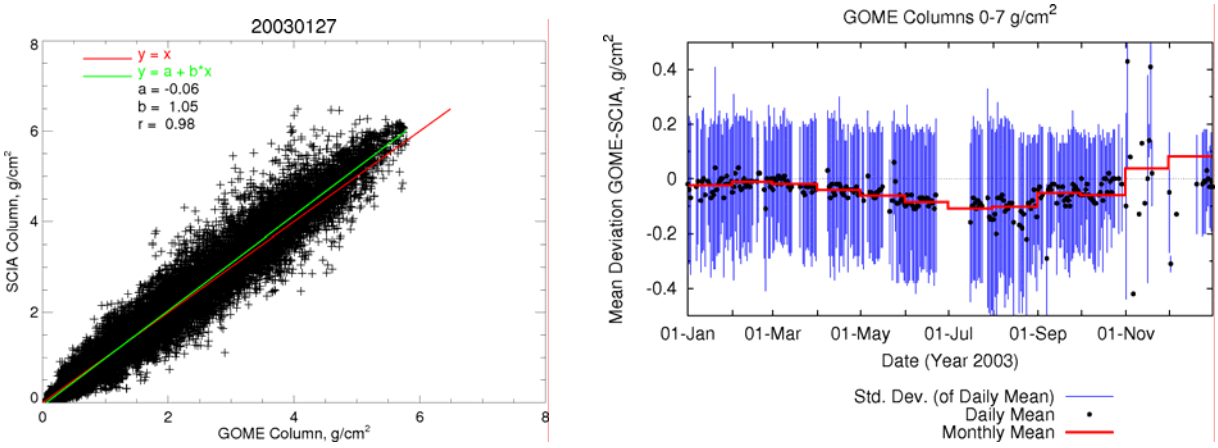

Figure 2: Comparison between GOME and SCIAMACHY water vapour columns for the year 2003. Left: Example scatter plot for 27 January 2003. Right: Mean deviations for the whole year.

Nevertheless, the results of the intercomparison show that the GOME and SCIAMACHY water vapour data fit well together such that now a combined data set of GOME and SCIAMACHY water vapour data is available covering more than 10 years. This data set will increase with further GOME and SCIAMACHY measurements and can most likely be extended by measurements from the GOME-2 series of instruments on the METOP satellites, the first one to be launched June 2006.

Trend estimates

As a first climatologic application the combined GOME and SCIAMACHY data set has been used to derive a water vapour trend over Europe.

For this purpose, monthly mean data have be determined from the gridded GOME and SCIAMACHY water vapour columns at a spatial resolution of 0.5°×0.5°. For this exercise we concentrated on the European region, defined by the longitudinal/latitudinal range 10°W to 20°E and 35°N to 60°N, respectively.

The (preliminary) result of this analysis (see Figure 3) is a slight positive increase of about 0.8%/year of the European water vapour content which is generally in line with surface temperature measurements over the same time interval. However, the significance of the observed water vapour trend requires further investigation.

More details on the trend analysis and results can be found in [Noël *et al.*, 2006].

[1] Due to an on-board tape recorder failure GOME can not provide any longer global measurements data after June 2003.

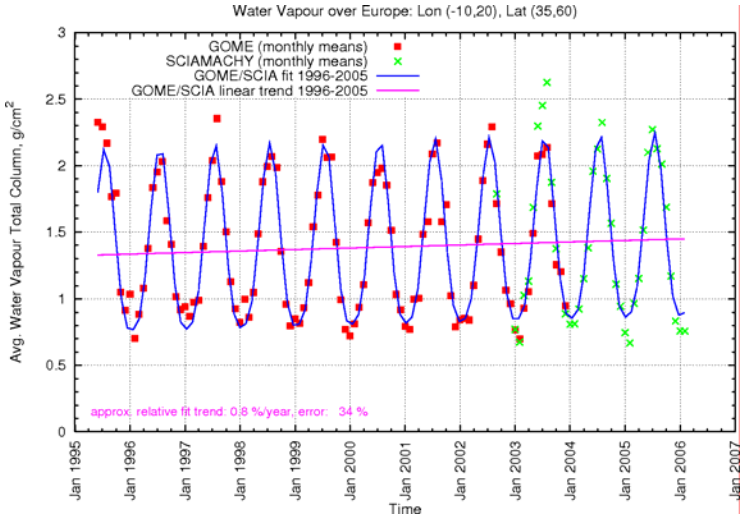

Figure 3: Preliminary water vapour trend over Europe derived from GOME and SCIAMACHY data.

Future outlook

Currently the SCIAMACHY data set suffers from large data gaps especially during 2002 and 2003. Therefore the next step in the area of water vapour retrieval and trend analysis will be the reprocessing of the SCIAMACHY water vapour data using the recently available new version of consolidated calibrated spectra which should be much more complete. Based on the resulting new combined GOME/SCIAMACHY water climatology the trend analysis studies will then be extended to further regions, including a significance analysis of the trend results. An adaptation of the AMC-DOAS retrieval algorithm to GOME-2 is also planned, depending of course on the availability of the spectral data.

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Recent Publications related to AT2 work

Noël, S., M. Buchwitz ,and J. P. Burrows, First retrieval of global water vapour column amounts from SCIAMACHY measurements, *Atmos. Chem. Phys.*, **4**, (2004) 111-125.

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