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

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

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Summary

Within the last year large progress in the context of water vapour retrieval from SCIAMACHY data could be made. An extended validation of the AMC-DOAS water vapour columns has been performed showing good agreement with both SSM/I and ECMWF data. Especially, first global monthly means of SCIAMACHY water vapour total columns could be derived.

Introduction

Within the framework of the ACCENT/TROPOSAT-2 programme it is envisaged to further improve the University of Bremen AMC-DOAS algorithm (see e.g. [Noël *et al.*, 1999,2004]) for the retrieval of total columns of water vapour from SCIAMACHY nadir measurements in the spectral region around 700 nm. The work includes (i) processing of a large (statistically significant) set of SCIAMACHY spectra, (ii) analysis of the accuracy and precision of this data set using independent measurements and models, and (iii) algorithm improvements. Intermediate (column) data products will be made available for ACCENT and feedbacks will be used to further improve the algorithm.

Scientific activities

Measurements of the SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY) [Bovensmann *et al.*, 1999] on-board the European environmental satellite ENVISAT have been used to derive water vapour total column amounts on the global scale.

For this purpose, the Air Mass Corrected Differential Absorption Spectroscopy (AMC-DOAS) approach, originally developed for GOME data [Noël *et al.*, 1999], has been applied to SCIAMACHY's nadir measurements in the spectral region around 700 nm. The AMC-DOAS method does not rely on external calibration data sources (like radio sonde measurements). The derived water vapour columns therefore provide a completely independent data set.

Previous investigations [Noël *et al.*, 2004] already showed a good agreement of the water vapour columns derived from SCIAMACHY with correlative data from e. g. the Special Sensor Microwave Imager (SSM/I) and from the European Centre for Medium-Range Weather Forecasts (ECMWF).

However, these investigations were based on a limited set of SCIAMACHY data. Meanwhile, the AMC-DOAS retrieval method has been applied to a larger amount of data (namely the whole year 2003), and a first validation could be performed.
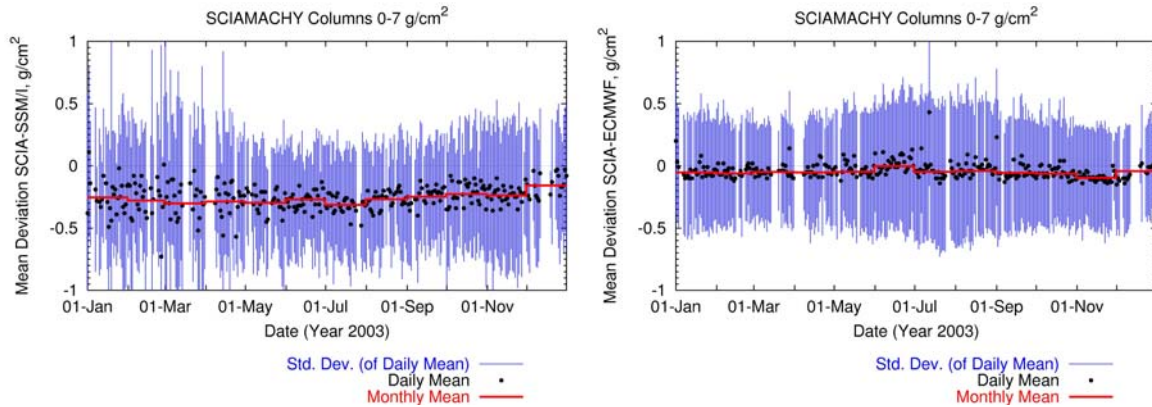
Figure 1. Comparison of globally averaged water vapour total columns. Left: Comparison with SSM/I data. Right: Comparison with ECMWF data.

For this purpose, all currently available SCIAMACHY Level 1 data for the year 2003 have been processed using the AMC-DOAS retrieval algorithm. The resulting swath water vapour data have then been spatially gridded to 0.5° x 0.5°. From the gridded data first daily means and from these monthly means have been computed. Then, these data have been compared with SSM/I and ECMWF results brought to the same spatial grid.

The results of these activities have been presented not only at AT-2 workshops but also at various national and international conferences (DPG, EGU, COSPAR 2004, ESA ACVE-2 Workshop, SCIAMACHY Validation Workshop 2004, Envisat Symposium 2004).

Scientific results and highlights

Two types of comparisons have been performed to validate the SCIAMACHY water vapour data set:

1. Time series of globally averaged deviations between SCIAMACHY total water vapour columns and corresponding SSM/I and ECMWF data have been generated.

2. Global maps of monthly mean water vapour results from SCIAMACHY and ECMWF are compared.

A more detailed description of these activities and the related results can be found in [Noël *et al.*, 2005]. Only a short summary will be given here.

Time series

The results for the time series are shown in Figure 1.

As can be seen from this figure, comparisons of SCIAMACHY water vapour total columns with SSM/I and ECMWF data for the year 2003 show in general a good agreement, although a high scatter of about 0.5 g/cm^2 is visible throughout the year. This scatter has been observed before (see e.g. [Noël *et al.,* 2004]). It can be mainly attributed to the large variability of water vapour and the different spatial and temporal scales of the data sets.

On the global average, SCIAMACHY data tend to be lower than both SSM/I and ECMWF data. The reason for this systematic offset – which seems to be rather independent of time and/or season – is currently unclear. However, since these offsets are small compared to the large scatter of the data (especially w.r.t. the ECMWF data), a further analysis of this issue will be in general very difficult.
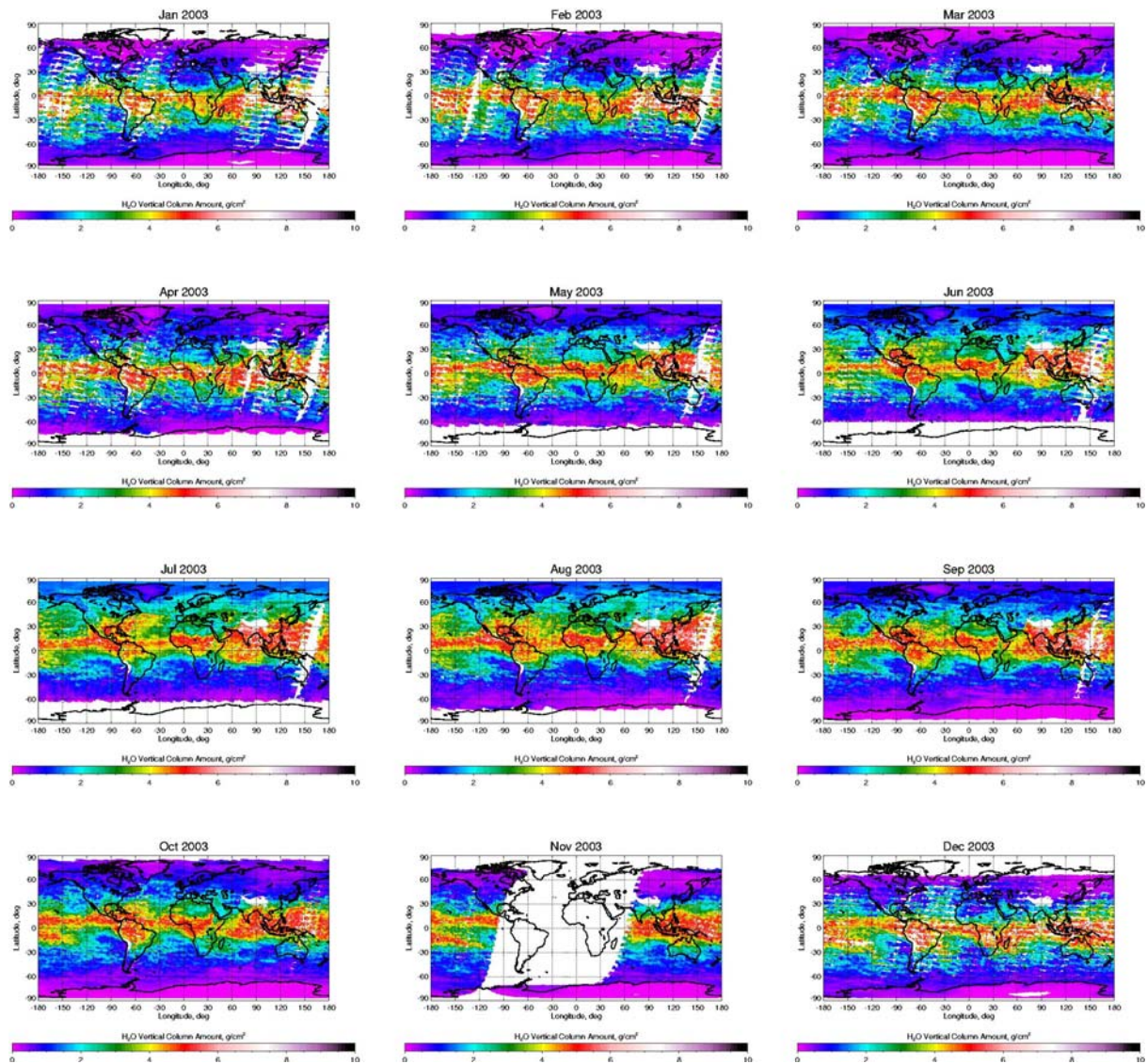
Figure 2.SCIAMACHY water vapour monthly means for the year 2003. White areas denote regions of missing SCIAMACHY data.

Monthly means

For the first time, monthly means of SCIAMACHY water vapour total columns could be generated. The results for the year 2003 are shown in Figure 2. These results are of somewhat preliminary nature, because they are a based on a combination of consolidated and unconsolidated (near-realtime) Level 1 data. This was necessary because there is still no complete consolidated SCIAMACHY Level 1b data set available. Even when using all available SCIAMACHY data large gaps occur in the monthly average (see e.g. November 2003).

Nevertheless, compared with the corresponding ECMWF water vapour data (Figure 3), the SCIAMACHY monthly means look quite reasonable. They show the expected high humidity in the tropics and low humidity at higher latitudes. Moreover, the seasonal shift of the Inner Tropical Convergence Zone (ITCZ) can be clearly identified.

However, the difference plots between the SCIAMACHY and ECMWF results shown in Figure 4 reveal that the quality of the agreement depends on the geographical region.
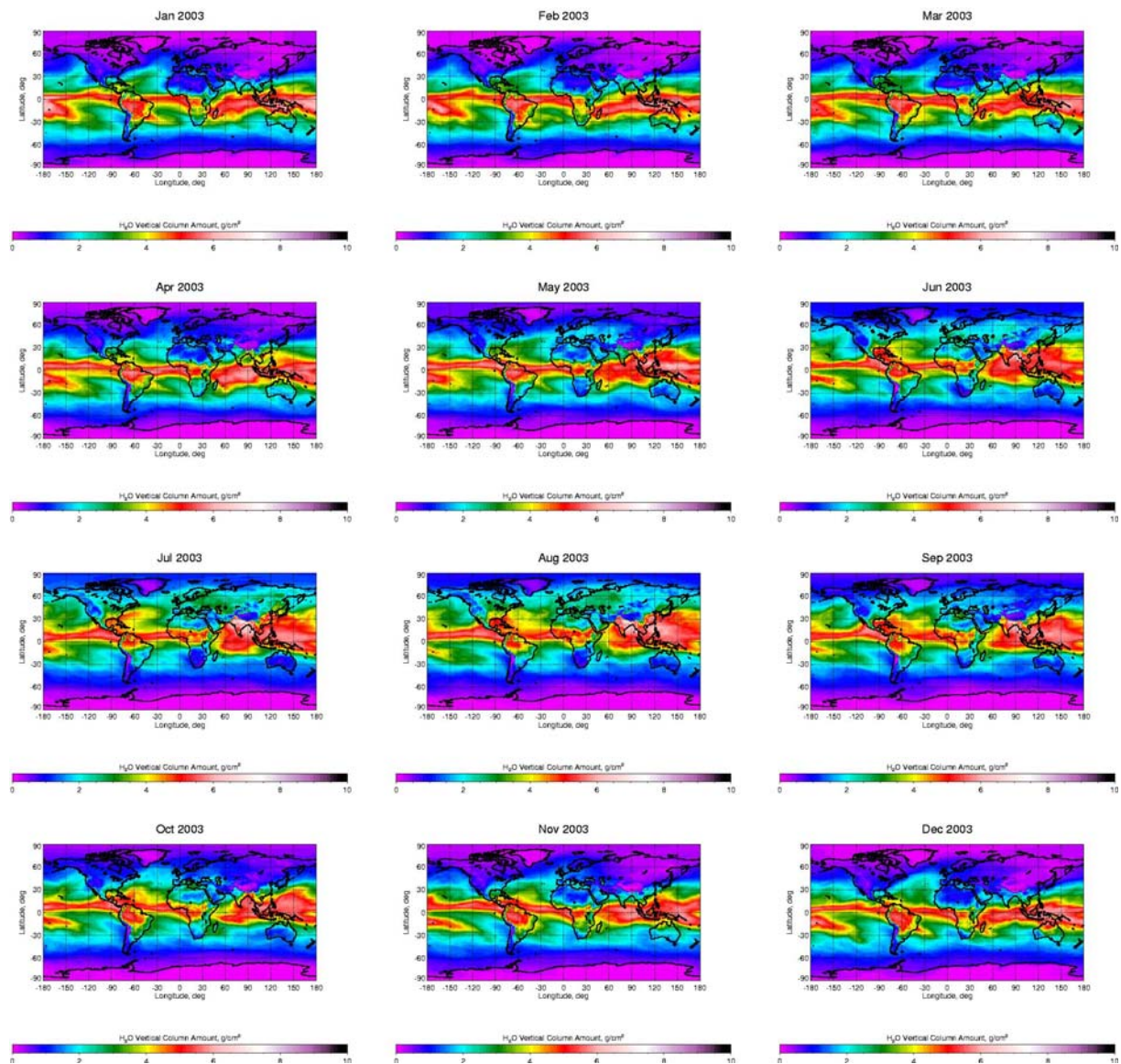
Figure 3. ECMWF water vapour monthly means for the year 2003.

Over ocean, SCIAMACHY water vapour data are noisier than the ECMWF model results. Depending on season, larger discrepancies occur over desert areas, like the Sahara. These deviations over land could be caused by albedo effects or by influences of surface elevation. However, because of the typically spare radio sonde data in these regions problems of ECMWF data may also not be excluded.

Future outlook

In the future, the observed discrepancies between SCIAMACHY and ECMWF data need to be investigated in more detail. Furthermore, it is planned to extend the comparison to GOME water vapour data generated with the same (AMC-DOAS) retrieval method. For this purpose a larger amount of GOME data will be processed. From the combination of GOME and SCIAMACHY water data it will – finally – be possible to generate a new, completely independent long-term global water vapour data set which can be used for trend analysis. This data set may then even be extended by further missions, like GOME-2 on METOP.
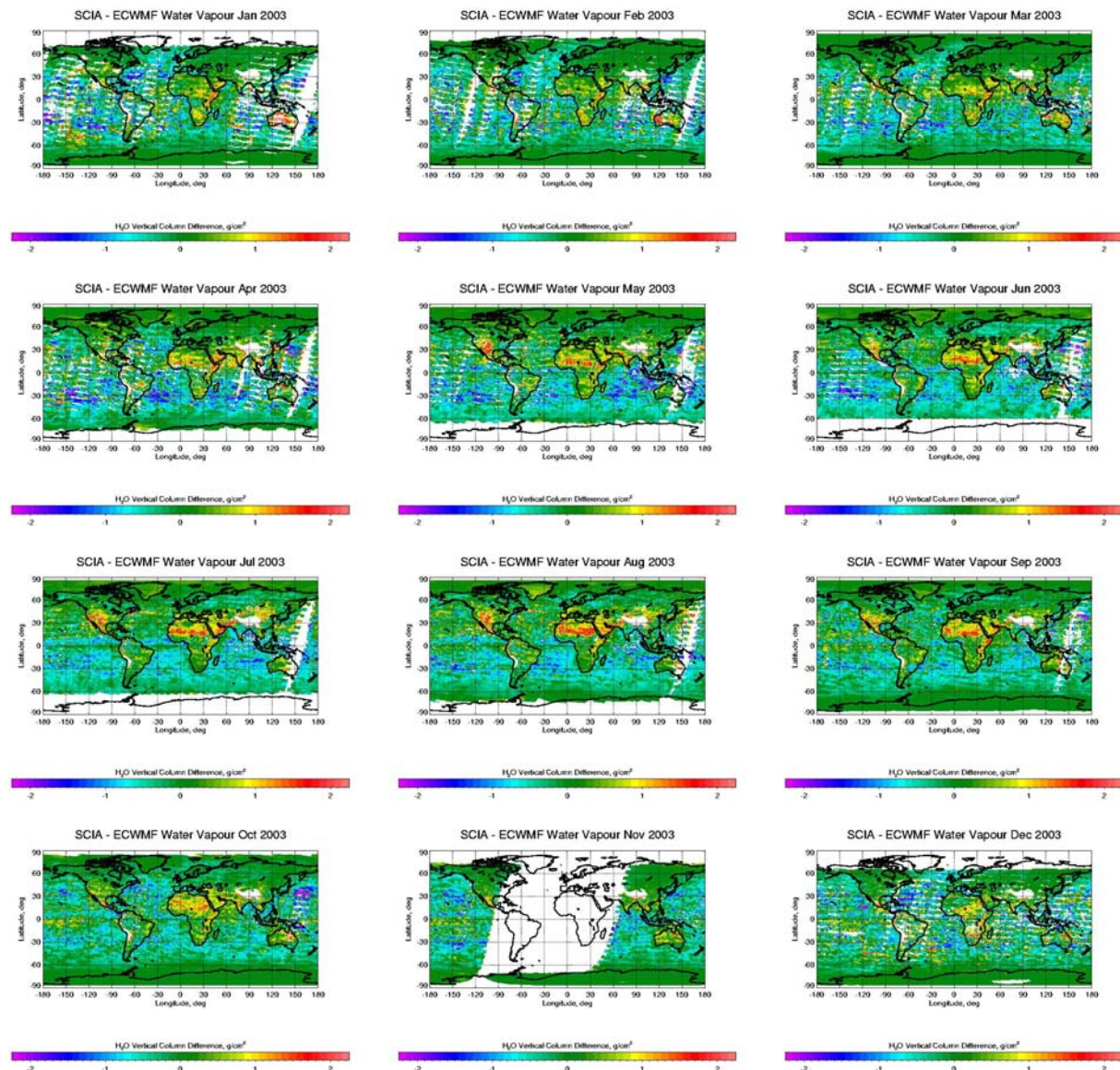
Figure 4. Difference between SCIAMACHY and ECMWF monthly means of water vapour total columns

In general, the interpretation of the results is currently limited by the availability of SCIAMACHY calibrated spectra. Therefore it is foreseen to repeat the analysis as soon as a completely reprocessed Level 1 data set is available.

References

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Noël, S., M. Buchwitz, H. Bovensmann, and J. P. Burrows, 1999, Atmospheric water vapor amounts retrieved from GOME satellite data, *Geophys. Res. Lett.*, **26**(13), 1841-1844.

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

Recent Publications related to AT2 work

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