THREE YEARS OF GLOBAL SIMULTANEOUS MEASUREMENTS OF TROPOSPHERIC METHANE, CARBON DIOXIDE AND CARBON MONOXIDE RETRIEVED FROM SCIAMACHY USING WFM-DOAS

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

Michael Buchwitz, Oliver Schneising, Iryna Khlystova, Heinrich Bovensmann, and John. P. Burrows

University of Bremen, FB1
Institute of Environmental Physics / Remote Sensing (iup/ife)
Otto Hahn Allee 1, 28334 Bremen, Germany
Phone.: +49-(0)421-218-4475, Fax: +49-(0)421-218-4555
e-mail: Michael.Buchwitz@iup.physik.uni-bremen.de

Summary

The three carbon atom containing gases methane (CH_4), carbon dioxide (CO_2), and carbon monoxide (CO) are important atmospheric constituents affecting climate and air quality. Here we present new data sets of global, simultaneous measurements of all three gases covering the time period 2003-2005. The data sets have been generated by inverting the spectral near-infrared nadir observations of the SCIAMACHY spectrometer onboard the European environmental satellite ENVISAT using the latest versions of the scientific retrieval algorithm WFM-DOAS (CO version 0.6, methane and CO_2 version 1.0). We give a short overview about these data sets referring to other publications where more details are given. The assessment of the quality of these data sets is an ongoing activity, especially for methane and CO_2 but also for carbon monoxide.

Introduction

The main objective of this ACCENT sub-project is to generated a number of high-quality atmospheric trace gas data products. This comprises the improvements of the retrieval algorithm but also includes verification and validation of the generated data sets by comparison with independent (primarily ground-based FTS) measurements, global models, and satellite data (e.g., MOPITT). These activities require co-operation with a large number of other institutions within, e.g., ACCENT/AT-2. Our goal is to achieve a high enough data quality such that the data sets can be used to improve our knowledge of regional (net) surface fluxes of CO, CH_4, and CO_2. SCIAMACHY (Bovensmann et al., (1999)) has the potential to significantly contribute to this important research area, as the SCIAMACHY NIR/SWIR nadir measurements have nearly equal measurement sensitivity at all altitudes, including the boundary layer, where the source/sink signals are largest.

Trace gas results

We have processed all SCIAMACHY nadir spectra (Level 1 version 5) of the years 2003-2005 made available by ESA/DLR to retrieve CO columns and dry air column-averaged mole fractions (or mixing ratios) of methane (denoted XCH_4, unit: ppb) and carbon dioxide (denoted XCO_2, unit: ppm). These data sets are shortly discussed in the following.

Carbon monoxide (CO)

Carbon monoxide columns are retrieved from a small spectral fitting window (2324.4-2335.0 nm) located in SCIAMACHY channel 8 covering several absorption lines of CO. The latest version of the retrieval algorithm is WFM-DOAS version 0.6. Figure 1 gives an overview

about this data set showing yearly averages for the years 2003, 2004, and 2005 and regional details for Europe and South-East Asia for 2004. As can be seen, major CO source regions such as China, central Africa and the northern part of South America, can be clearly identified. The WFM-DOAS version 0.6 CO retrieval algorithm and corresponding years 2003-2005 data set is described in Buchwitz et al. (2007a). Details concerning a first validation are given in Dils et al., (2006).

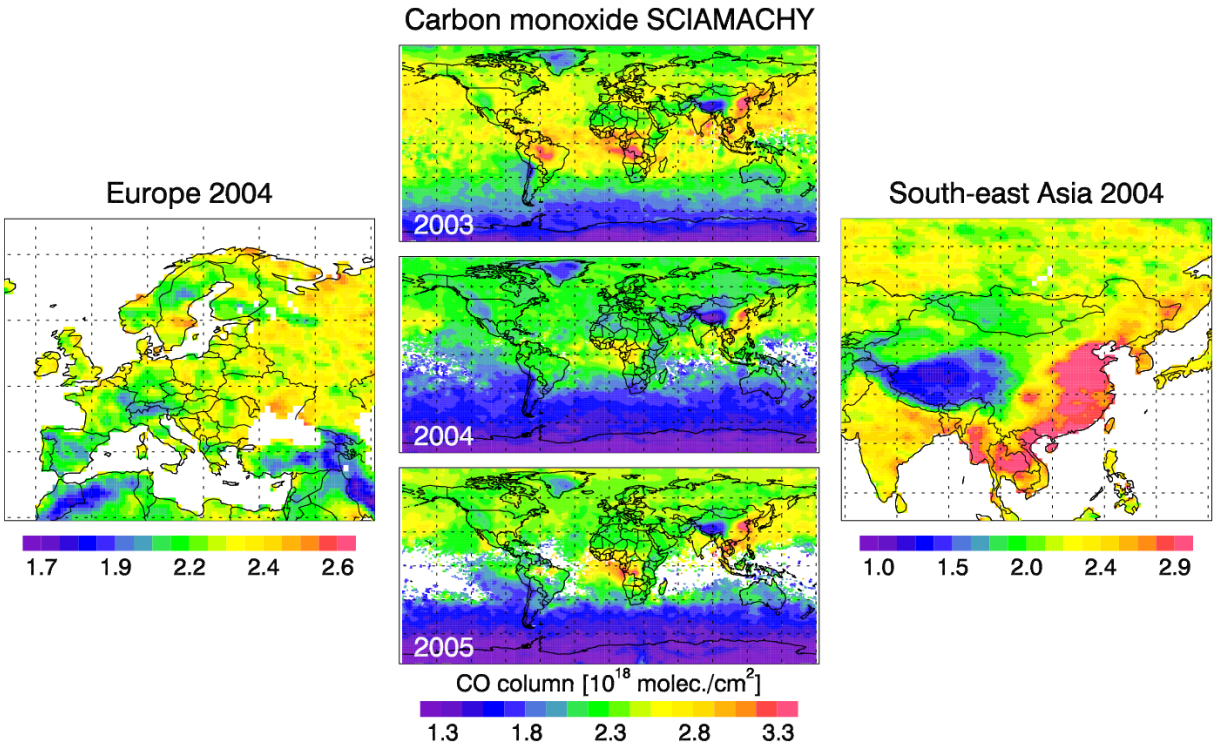

Figure 1: Vertical columns of carbon monoxide (CO) retrieved from SCIAMACHY nadir observations using the WFM-DOAS version 0.6 retrieval algorithm. Middle: yearly averages for the years 2003, 2004, and 2005 (from top to bottom). Left: Year 2004 average over Europe. Right: Year 2004 average over South-East Asia.

Methane (CH_4)

Methane vertical columns are retrieved from a small spectral fitting window located in SCIAMACHY channel 6. Following the method first proposed by Frankenberg et al. (2005), CO_2 from channel 6 is used as a proxy for the light path and the CO_2 column is used to estimate the air column needed to compute XCH_4. The latest version of the retrieval algorithm is WFM-DOAS version 1.0. Figure 2 shows seasonal averages for the year 2003 compared to model simulations using the TM5 model using scenario S1 from Bergamaschi et al. (2007). As can be seen, the two independent data sets agree quite well, except for the tropics, where SCIAMACHY sees significantly higher methane compared to the model. This shows that the WFM-DOAS version 1.0 XCH_4 data set confirms the findings of Frankenberg et al. (2005) (see also a discussion of the previous WFM-DOAS version 0.5 XCH_4 data set given in Buchwitz et al. (2006)). More information concerning this new data set are given in Schneising et al. (2007). A detailed publication is in preparation. First validation results are given in Dils et al. (2006).

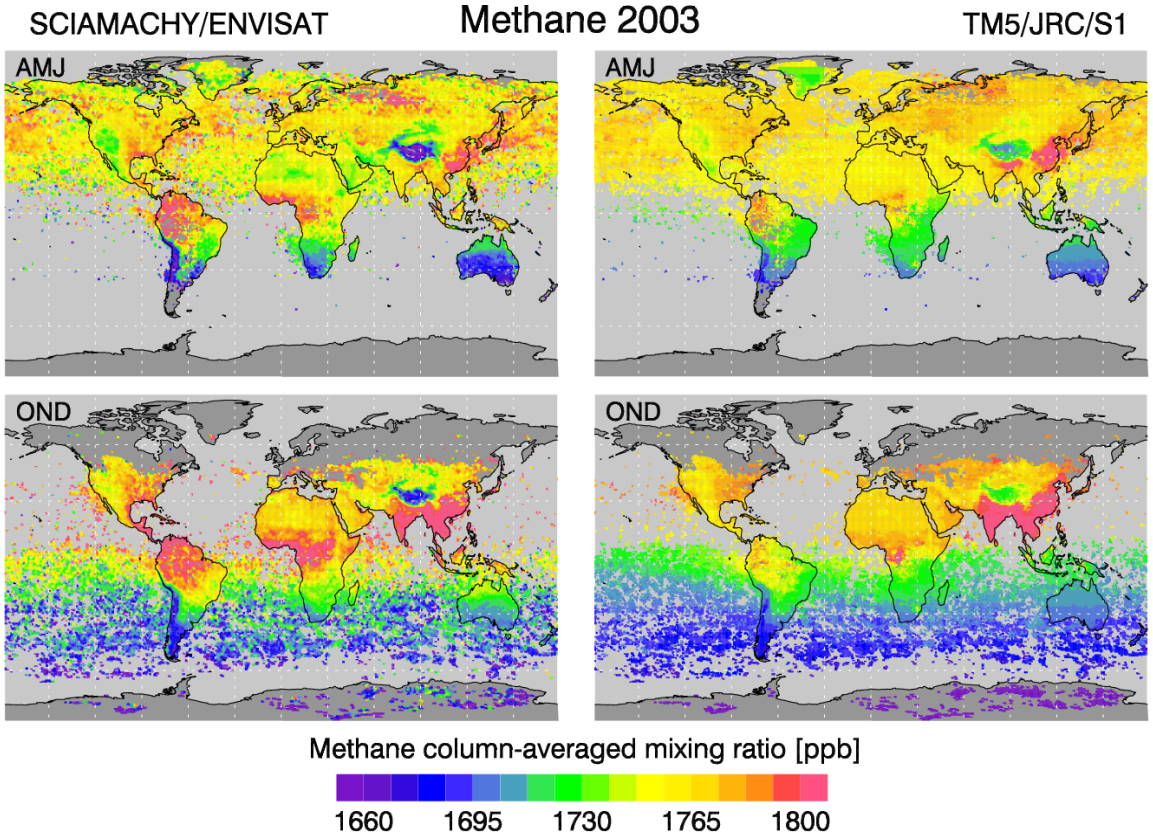

Figure 2: Seasonal averages of dry air column-averaged mixing ratios of methane. Top: April-June 2003 average, bottom: October-December 2003 average. Left: SCIAMACHY WFM-DOAS XCH_4 version 1.0 data set, right: TM5 model simulations.

Carbon dioxide (CO_2)

Carbon dioxide vertical columns are retrieved from a small spectral fitting window located in SCIAMACHY channel 6. Oxygen (O_2) from channel 4 is used as a proxy for the light path and the O_2 column is used to estimate the air column needed to compute XCO_2. The latest version of the retrieval algorithm is WFM-DOAS version 1.0. Figure 3 shows northern hemispheric maps of the retrieved XCO_2 and corresponding seasonal averages (thick blue line) indicating that SCIAMACHY can observe the CO_2 seasonal cycle as well as the annual CO_2 increase primarily resulting from the burning of fossil fuels. For comparison CO_2 surface measurements based on weekly flask sampling are also shown. For a more quantitative discussion see Buchwitz et al. (2007b).

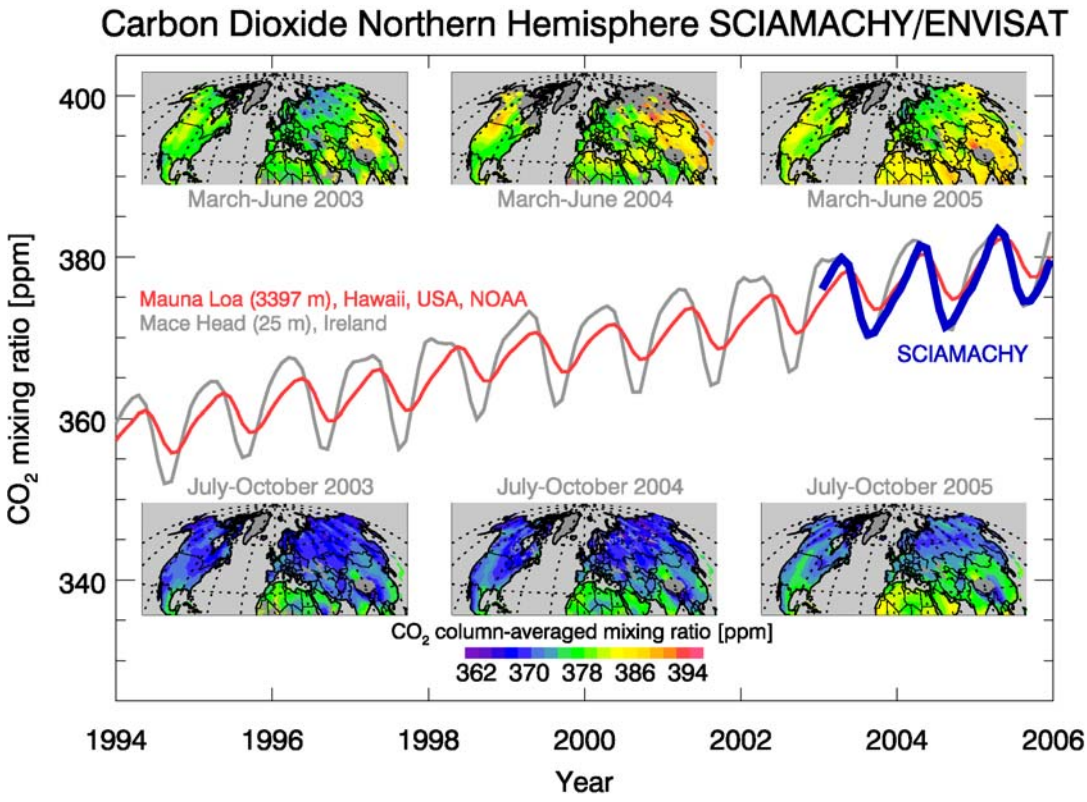

Figure 3: Overview about three years of SCIAMACHY CO_2 dry air column-averaged mole fraction (or mixing ratio) retrievals focusing on northern hemispheric large scale CO_2 variability. Shown are northern hemispheric maps corresponding to time periods where the CO_2 seasonal cycle has it maximum (March-June) and minimum (July-October) and seasonal averages (thick blue line). For comparison CO_2 surface measurements performed at Mauna Loa (red) and Mace Head (grey) are also shown (courtesy: NOAA/ESRL/GMD).

Conclusions

We have presented a short overview about the status of the retrieval of CO, methane and carbon dioxide columns from SCIAMACHY near-infrared nadir spectra using the WFM-DOAS scientific retrieval algorithm. The discussed data sets are available from the authors on request. Details are given on the SCIAMACHY/WFM-DOAS web page:
http://www.iup.uni-bremen.de/sciamachy/NIR_NADIR_WFM_DOAS/index.html .

Acknowledgements

We thank ESA and DLR for providing us with the SCIAMACHY spectra (operational Level 1 data products). Funding for this study came from DLR-Bonn (grants 50EE0027 and 50EE0507), from ESA (GMES-PROMOTE, see http://www.gse-promote.org) and from the University and the State of Bremen. We acknowledged exchange of information within the EU 6th FP Network of Excellence ACCENT (http://www.accent-network.org).

References

Bergamaschi, P., C. Frankenberg, J. F. Meirink, M. Krol, F. Dentener, T. Wagner, U. Platt, J. O. Kaplan, S. Körner, M. Heimann, E. J. Dlugokencky, A. and Goede, Satellite chartography of atmospheric methane from SCIAMACHY onboard ENVISAT: 2. Evaluation based on inverse model simulations, *J. Geophys. Res*. 112, D02304, doi:10.1029/2006JD007268, 2007.

Bovensmann, H., J. P. Burrows, M. Buchwitz, J. Frerick, S. Noël, V. V. Rozanov, K. V. Chance, and A. H. P. Goede, SCIAMACHY - Mission objectives and measurement modes, J. Atmos. Sci., 56, (2), 127-150, 1999.

Buchwitz, M., R. de Beek, S. Noël, J. P. Burrows, H. Bovensmann, O. Schneising, I. Khlystova, M. Bruns, H. Bremer, P. Bergamaschi, S. Körner, M. Heimann, Atmospheric carbon gases retrieved from SCIAMACHY by WFM-DOAS: version 0.5 CO and CH_4 and impact of calibration improvements on CO_2 retrieval, Atmos. Chem. Phys., 6, 2727-2751, 2006.

Buchwitz, M., I. Khlystova, H. Bovensmann, J. P. Burrows, Three years of global carbon monoxide from SCIAMACHY: Comparison with MOPITT and first results related to the detection of enhanced CO over cities, Atmos. Chem. Phys., 7, 2399-2411, 2007a.

Buchwitz, M., O. Schneising, J. P. Burrows, H. Bovensmann, M. Reuter, J. Notholt, First direct observation of the atmospheric CO_2 year-to-year increase from space, Atmos. Chem. Phys., 7, 4249-4256, 2007b.

Dils, B., De Maziere, M., Blumenstock, T., Hase, F., Kramer, I., Mahieu, E., Demoulin, P., Duchatelet, P., Mellqvist, J., Strandberg, A., Buchwitz, M., Khlystova, I., Schneising, O., Velazco, V., Notholt, J., Sussmann, R., and Stremme, W., Validation of WFM-DOAS v0.6 CO and v1.0 CH4 scientific products using European ground-based FTIR measurements, proceedings of the Third Workshop on the Atmospheric Chemistry Validation of ENVISAT (ACVE-3), 4-7 Dec. 2006, ESA/ESRIN, Frascati, Italy, ESA Publications Division Special Publication SP-642 (CD), 2006.

Frankenberg, C., J. F. Meirink, M. van Weele, U. Platt, and T. Wagner, Assessing methane emissions from global spaceborne observations, *Science*, 308: 1010-1014, 2005.

Schneising, O., M. Buchwitz, H. Bovensmann, and J. P. Burrows, Three years of SCIAMACHY carbon dioxide and methane column-averaged dry air mole fraction measurements, Proceedings ENVISAT Symposium 2007, Montreux, Switzerland, 23-27 April 2007, ESA publications division SP-636 (CD), p. 4, 2007.