GLOBAL ATMOSPHERIC CARBON DIOXIDE FROM SCIAMACHY ON ENVISAT

M. Buchwitz, O. Schneising, M. Reuter, H. Bovensmann, and J. P. Burrows

Institute of Environmental Physics (iup), University of Bremen FB1,
Otto Hahn Allee 1, 28334 Bremen, Germany,
Michael.Buchwitz@iup.physik.uni-bremen.de

ABSTRACT

Global satellite observations of the column-averaged dry-air mole fraction of CO_2, denoted XCO_2, can provide important missing information to better constrain regional CO_2 surface fluxes. This requires high accuracy and sensitivity to near-surface CO_2 concentrations. The only satellite instrument with high surface CO_2 sensitivity prior to the launch of GOSAT (2009) is SCIAMACHY on the European environmental satellite ENVISAT. At the University of Bremen the Weighting Function Modified Differential Optical Absorption Spectroscopy (WFM-DOAS or WFMD) retrieval algorithm has been developed and is continuously being improved to retrieve information about CO_2 and other important gases such as methane from the SCIAMACHY nadir spectra. It has been shown that CO_2 spatio-temporal variations on the order of a few ppm can be detected with SCIAMACHY using WFM-DOAS. It has also been shown that scattering related errors e.g. due to thin cirrus clouds may result in XCO_2 biases exceeding 1%. Detailed comparisons with global models such as NOAA's CarbonTracker show clearly correlated spatio-temporal pattern but also large (several ppm) differences, which are not well understood. A promising approach to assess to what extent biases of the satellite retrievals contribute to the observed differences is to apply different retrieval approaches to the satellite data. For this purpose, and in order to generate an improved SCIAMACHY XCO_2 data product in the future, we are developing a new algorithm called BESD (Bremen optimal EStimation DOAS). BESD aims at combining the advantages of DOAS and Optimal Estimation (OE) primarily to reduce scattering related errors. Preliminary WFM-DOAS XCO_2 retrievals covering the time period 2003-2009 show that SCIAMACHY is very stable. This is an important prerequisite for the generation of a long-term high quality global XCO_2 data set from SCIAMACHY covering the entire lifetime of ENVISAT (2003 to about 2013).

GOAL, ACHIEVEMENTS AND FUTURE WORK

It has been shown that SCIAMACHY (*Bovensmann et al., 1999*) has the potential to significantly reduce currently quite larger uncertainties of regional CO_2 surface fluxes (*Houweling et al., 2004*). This however requires nearly bias free satellite retrievals. At the University of Bremen the WFM-DOAS algorithm has been developed and is continuously being improved to retrieve XCO_2 and other important gases such as methane from the SCIAMACHY nadir spectra (*Buchwitz et al., 2000, 2005, 2007; Schneising et al., 2008, 2009*). Previous publications focused on the first three years of ENVISAT, 2003-2005 (*Buchwitz et al., 2007; Schneising et al., 2008*). Recently WFM-DOAS has also been applied to generate a longer time series. Fig. 1 shows a first preliminary result that indicates that SCIAMACHY is very stable. As the ENVISAT mission has recently been extended, we are confident that a long time series covering 2003 to possibly 2013 can finally be generated.

In *Schneising et al., 2008*, the latest version of WFM-DOAS (version 1.0) is described in detail including error analysis and comparisons of the retrieved XCO_2 data set with reference data covering the years 2003-2005. For comparison (sparse) ground-based Fourier Transform Spectroscopy (FTS) XCO_2 retrievals and global CarbonTracker XCO_2 (*Peters et al., 2007*) has been used. Despite significant spatio-temporal correlations with CarbonTracker also significant differences have been identified, which are not well understood. A major focus of our future activities will be to better understand the observed differences with respect to global models such as CarbonTracker. The differences are likely due to problems with both data sets, i.e. with CarbonTracker and with the satellite retrievals. One approach to determine to what extent the differences are due to biases of the satellite retrievals is to apply different retrieval methods to the SCIAMACHY data. For this purpose we are developing a more flexible and advanced algorithm called BESD (*Buchwitz et al., 2009*). A major goal of this activity is also to generate an improved SCIAMACHY XCO_2 data product in the future.

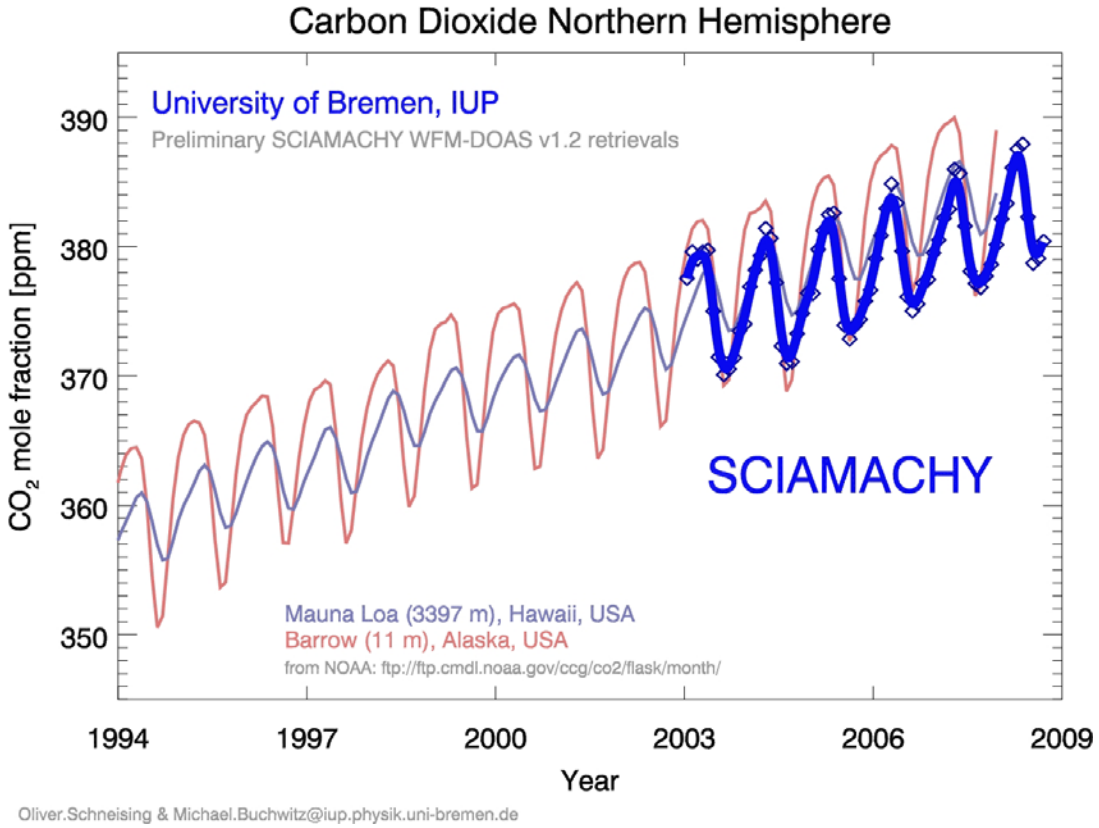

Fig. 1: Preliminary WFM-DOAS version 1.2 retrieval results showing northern hemispheric SCIAMACHY XCO_2 during 2003-2008 (blue symbols and thick blue line; each symbol represents a northern hemispheric monthly average). Also shown for qualitative comparisons are NOAA CO_2 surface observations at Mauna Loa, Hawaii, and Barrow, Alaska (obtained from ftp://ftp.cmdl.noaa.gov/ccg/co2/flask/month/).

REFERENCES

Bovensmann, H., J. P. Burrows, M. Buchwitz et al., SCIAMACHY - Mission objectives and measurement modes, *J. Atmos. Sci.*, 56, (2), 127-150, 1999.

Buchwitz, M., V. V. Rozanov, J. P. Burrows, A near-infrared optimized DOAS method for the fast global retrieval of atmospheric CH_4, CO, CO_2, H_2O, and N_2O total column amounts from SCIAMACHY Envisat-1 nadir radiances, *J. Geophys. Res.*, *105*, 15,231-15,245, 2000.

Buchwitz, M., R. de Beek, J. P. Burrows, et al., Atmospheric methane and carbon dioxide from SCIAMACHY satellite data: initial comparison with chemistry and transport models, *Atmos. Chem. Phys.*, 5, 941-962, 2005.

Buchwitz, M., O. Schneising, J. P. Burrows et al., First direct observation of the atmospheric CO_2 year-to-year increase from space, *Atmos. Chem. Phys.*, 7, 4249-4256, 2007.

Buchwitz, M., M. Reuter, O. Schneising, Towards an improved CO_2 retrieval algorithm for SCIAMACHY on ENVISAT, *Proceedings Atmospheric Science Conference*, Barcelona, Spain, 7-11 Sept 2009, ESA Special Publication SP-676 (CD-ROM), 2009.

Houweling, S., F.-M. Breon, I. Aben, et al.: Inverse modeling of CO_2 sources and sinks using satellite data: A synthetic inter-comparison of measurement techniques and their performance as a function of space and time, *Atmos. Chem. Phys.*, 4, 523-538, 2004.

Peters, W., A. R. Jacobson, C. Sweeney, et al.: An atmospheric perspective on North American carbon dioxide exchange: CarbonTracker, *Proceedings of the National Academy of Sciences (PNAS) of the United States of America*, 27 Nov. 2007, 104(48), 18925-18930, 2007.

Schneising, O., M. Buchwitz, J. P. Burrows, et al., Three years of greenhouse gas column-averaged dry air mole fractions retrieved from satellite - Part 1: Carbon dioxide, *Atmos. Chem. Phys.*, 8, 3827-3853, 2008.

Schneising, O., M. Buchwitz, J. P. Burrows, et al., Three years of greenhouse gas column-averaged dry air mole fractions retrieved from satellite - Part 2: Methane, *Atmos. Chem. Phys.*, 9, 443-465, 2009.