Name of research institute or organization:

Belgian Institute for Space Aeronomy (BIRA-IASB)

Title of project:

Atmospheric physics and chemistry

Project leader and team:

Dr. M. Van Roozendael: project leader UV-Vis
Dr. Martine De Mazière: project leader FTIR

Bart Dils, Caroline Fayt, François Hendrick, Christian Hermans, Tobias Kerzenmacher, Jean-Christopher Lambert, Gaia Pinardi, C. Senten, Corinne Vigouroux, Gauthier Vanhaelewyn: team scientists
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Project description:

UV-Vis

The monitoring of stratospheric column amounts of ozone and nitrogen dioxide, started in 1990 with a SAOZ spectrometer, has been continued in 2010 with a 4 months interruption from August to early December due to an electronic card failure after a thunderstorm. The joint exploitation of the SAOZ and FTIR NO_2 measurements started in 2009 as part of the EU FP6 GEOMON project has been continued in view of a comprehensive trend analysis covering the period from 1983 until 2010. This study, which also takes into consideration the reference high quality MAXDOAS measurements started in July 2010 (see below), will be presented at the EGU General Assembly meeting of 2010. The NDACC data base has been updated with revised SAOZ data sets of NO_2 and ozone covering the full period from 1990 until 2010. This revision also includes the new ozone settings developed in 2009 and recently submitted to ACP (Hendrick et al., 2010).

In July 2010 a new high-quality MAXDOAS system has been installed at the Jungfraujoch station, next to the SAOZ instrument. This instrument is identical in design to the MAXDOAS system operated by BIRA during the CINDI intercomparison campaign in Cabauw, The Netherlands, June-July 2009 (Roscoe et al., 2010). The BIRA MAXDOAS is a dual-channel system. Both equipped with gratings of 1200 grooves/mm, the two channels respectively cover the UV region from 300 to 388 nm, and the visible range from 400 nm to 550 nm. The instrumental response function is close to a Gaussian with a full width at half maximum of 0.4 and 0.5 nm, respectively. The spectrometers are connected to two low-noise thermo-electrically cooled CCD detector systems with 2048×512 and 1340×100 pixels for the UV and VIS, respectively. The optical head, mounted on a sun-tracker, can collect direct-sun and scattered light at various elevation (0-90°) and azimuth angles (0-360°). Skylight is collected by an off-axis parabolic mirror within a 0.8° field of view and directed to the spectrometers through optical fibers. The optical head also includes a 6-position filter wheel equipped with transmission diffuser plates and neutral density filters. A full description of the instrument can be found in Clémer et al. (2010). Compared to the SAOZ instrument which only provides integrated stratospheric columns of O_3 and NO_2, the MAXDOAS can measure a number of additional parameters, including tropospheric columns and profiles of NO_2, O_3, formaldehyde (HCHO), bromine oxide (BrO), water vapor (H_2O) as well as aerosol

parameters (extinction profiles and AOD). With this new instrument, BIRA has been involved in the CLACE campaign organized by PSI at the Jungfraujoch in summer 2010.

FTIR solar absorption spectrometry

BIRA-IASB collaborates with the University of Liège for the exploitation of the Fourier transform infrared measurements carried out at the Jungfraujoch since several decades. (see report by ULg).

The concentration of CO at Jungfraujoch is measured on a continuous basis at the surface by in-situ observations, with a non-dispersive infrared detection method. It is also observed regularly by FTIR remote-sensing methods in the boundary layer. In 2010, we have finalized the work on comparisons between both data sets and associated long-term trends, and their interpretation, in collaboration with colleagues from the University of Liège and EMPA in Switzerland. While the in situ NDIR measurements detect local CO concentrations at the site, the FTIR technique provides integrated measurements along the line-of-sight. Nevertheless, the pressure broadening of the spectral absorption lines recorded at high resolution enables retrieving information on the vertical distribution of CO, mainly in the troposphere, including its concentration near the surface. To provide enough information content we derive from the FTIR profile data the averaged volume mixing ratio (vmr) between 3.58 and 7 km, and then we compare this average vmr with coincident in-situ surface concentration data from the NDIR observations. Both datasets show a significant negative trend over the investigated time period (1997-2007). However, the NDIR dataset's negative trend is much stronger. In 2009 and 2010, we looked further into possible causes for the different trends using backtrajectory modeling combined with studies of the emission trends at the various source regions. The results will be presented at the EGU Symposium in April 2011 and the publication is ready for submission.

We also developed a sophisticated code for the evaluation of the error budgets associated with FTIR observations. For various species (HCl, HF, CH_4), we compared the error budgets associated with the retrieved profiles between the Jungfraujoch station and the Ile de La Reunion station where BIRA-IASB is operating an FTIR solar absorption experiment similar to the one at the Jungfraujoch. The different characteristics of the sites in terms of altitude, relative humidity, local trace gas concentrations, …are clearly reflected in the error budgets. This work was presented in the form of poster contributions at various meetings. It will be published in 2011.

In 2009 and 2010, we contributed to the 2010 WMO Scientific Assessment of Ozone Depletion, with an updated analysis of the O_3 trends (total column trends and partial column trends in 4 atmospheric layers) over Europe for the period 1995-2009, based on FTIR data (C. Vigouroux in chapter 2 of the report). The trends (in %/decade including the 95% confidence limits) observed at the Jungfraujoch for this period are non-significant, for the total column (-0.1±1.1%/decade) as well as for the three stratospheric layers that can be distinguished (-1.9±3.6%/decade@10-18 km, 0.4±0.9%/decade@18-27 km and 0.8±0.9%/decade@27-42 km.

In 2010, we continued working on the coordinated validation of the IASI instrument on METOP-1, for the species CO, HNO_3 and CH_4, using ground-based FTIR data. These results have already been presented at international symposia and will be

published in 2011. In the publication on CO and HNO_3, we will include two successive versions of the IASI data products, to show the improvement based on the validation results.

In 2010, we also used Jungfraujoch for the validation of the most recent data processors of MIPAS CO, HNO_3, and CH_4 products and SCIAMACHY CO. These results are included in the latest Multi-TASTE report for ESA.

J. Hannigan and M. De Mazière, co-chairs of the NDACC IRWG (Network for the Detection of Atmospheric Composition Change, Infrared Working Group), have launched an effort to better homogenize the FTIR data retrievals at all NDACC IRWG stations, for the 10 atmospheric gases that are mandatory. The almost final conclusions of this effort have been discussed at the latest IRWG meeting in May 2010. A corresponding publication is in preparation.

Key words:

atmospheric composition, long-term monitoring, optical remote sensing, vertical inversion methods, satellite validation

Internet data bases:

The data are archived in the NDACC database (http://www.ndacc.org/), in the NADIR/NILU database (http://www.nilu.no/projects/nadir).

Data processed for ENVISAT validation purposes are also submitted to the ENVISAT CAL/VAL database (http://nadir.nilu.no/calval).

The new HDF format for FTIR vertical profile data has been implemented at the NDACC data base and FTIR data submission in the new HDF format has progressed significantly.

In the EU project GEOmon, Jungfraujoch FTIR and SAOZ data are delivered to a dedicated ftp site at NILU at latest 3 months after data acquisition: these are the so called Rapid Delivery data. The Jungfraujoch data can be visualized easily at http://www.geomon.eu/science/act4/SciAct4_O3_measurements.html, and they can be downloaded from ftp://ftp.nilu.no/pub/GEOmon/ activity4_StratosphericOzone/ Jungfraujoch/

Collaborating partners/networks:

Collaborations with University of Liège and NDACC partners

Collaboration with European FTIR and UV-Vis teams and modeling teams in the frame of the EU project GEOMon;

Collaboration with Royal Meteorological Institute of Belgium (KMI-IRM), Univ. Liège and Univ. Libre de Bruxelles in the frame of the national projects AGACC, and AGACC-II (Science for Sustainable Development Programme); see http://www.oma.be/AGACC/Home.html

Collaboration with Univ. Liège and Univ. Libre de Bruxelles in the frame of the PRODEX projects SECPEA (Space-based Exploration of the Chemistry and Physics of the Earth Atmosphere), and A3C (Atmospheric Composition, Chemistry and Climate)

Collaboration with M. Chipperfield of Univ. Leeds.

Both the UV-Vis and FTIR observations contribute to the international Network for the Detection of Atmospheric Composition Changes (NDACC, or the former NDSC).

Collaboration with B. Buchmann, D. Brunner, S. Henne and M. Steinbacher of EMPA

Collaboration with S. Reimann of EMPA in the frame of the EU project ACTRIS

Collaboration with P. Zieger and U. Baltensperger of PSI

Collaboration with F. Goutail and A. Pazmino of LATMOS, France

Collaboration with K. Kreher and P. Johnston of NIWA, New-Zeland

Collaboration with the GOME, ENVISAT, ACE and MetOp GOME-2 and IASI satellite communities.

Scientific publications and public outreach 2010:

Refereed journal articles and their internet access

Clémer, K., M. Van Roozendael, C. Fayt, F. Hendrick, C. Hermans, G. Pinardi, R. Spurr, P. Wang, and M. De Mazière, Multiple wavelength retrieval of tropospheric aerosol optical properties from MAXDOAS measurements in Beijing, Atmos. Meas. Tech., 3, 863–878, 2010.
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Irie, H., H. Takashima, Y. Kanaya, K. F. Boersma, L. Gast, F. Wittrock, D. Brunner, Y. Zhou, and M. Van Roozendael, Eight-component retrievals from ground-based MAX-DOAS observations, submitted to Atmos. Meas. Tech. (2010)

Loyola, D. G., M. E. Koukouli, P. Valks, D. S. Balis, N. Hao, M. Van Roozendael, R. J. D. Spurr, W. Zimmer, S. Kiemle, C. Lerot, J-C. Lambert, The GOME-2 Total Column Ozone Product: 1 Retrieval Algorithm and Ground-Based Validation, accepted for publication in J. Geophys. Res. (2010).

Roscoe, H.K., M. Van Roozendael, C. Fayt, A. du Piesanie, N. Abusallah, C. Adams, M. Akrami, I. Alonso Calvo, A. Cede, J. Chong, K. Clemer, U. Friess, M. Gil Ojeda, F. Goutail, R. Graves, A. Griesfeller, K. Grossmann, G. Hemerijckx, F. Hendrick, J. Herman, C. Hermans, H. Irie, Y. Kanaya, K. Kreher, P. Johnston, R. Leigh, A. Merlaud, G. H. Mount, M. Navarro, H. Oetjen, A. Pazmino, E. Peters, G. Pinardi, O. Puentedura, A. Richter, A. Schönhardt, R. Shaiganfar, E. Spinei, K. Strong, H. Takashima, T. Vlemmix, M. Vrekoussis, T. Wagner, F. Wittrock, M. Yela, S. Yilmaz, F. Boersma, J. Hains, M. Kroon, A. Piters, Intercomparison of slant column measurements of NO_2 and O_4 by MAX-D0AS and zenith-sky UV and visible spectrometers, Atmos. Meas. Tech., 3, 1629-1646, 2010.
http://www.atmos-meas-tech.net/3/1629/2010/amt-3-1629-2010.pdf

Theys, N., M. Van Roozendael, F. Hendrick, I. De Smedt, Q. Errera, A. Richter, M. Begoin, X. Yang and M. De Mazière, Global observations of BrO in the troposphere using GOME-2 satellite data, Atmos. Chem. Phys. Discuss., 10, 28635-28685, 2010.

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de Laat, A.T.J., A.M.S. Gloudemans, H. Schrijver, I. Aben, Y. Nagahama, K. Suzuki, E. Mahieu, N.B. Jones, C. Paton-Walsh, N.M. Deutscher, D.W.T. Griffith, M. De Mazière, R. Mittelmeier, H. Fast, J. Notholt, M Palm, T. Hawat, T. Blumenstock, C. Rinsland, A.V. Dzhola, E.I. Grechko, A.M., Poberovskii, M.V. Makarova, J. Mellqvist, A. Strandberg, R. Sussmann, T. Borsdorff, and M. Rettinger, Validation of five years (2003-2007) of SCIAMACHY CO total column measurements using ground-based spectrometer observations, Atmos. Meas. Tech., 3, 1457-1471, 2010; http://www.atmos-meas-tech.net/3/1457/2010/amt-3-1457-2010.pdf

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Dils, B., S. Henne, E. Mahieu, M. Steinbacher, M. De Mazière, How to compare NDIR surface in situ with FTIR remote sensing measurements of CO concentrations at the Jungfraujoch? ,to be submitted, Jan. 2011.

Senten, C., M. De Mazière, G. Vanhaelewyn, and C. Vigouroux, Information operator approach applied to ground-based high-resultion Fourier transform infrared measurements, to be submitted to Atmosph. Meas. Techniques, Feb. 2011.

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Pinardi, G., J.-C. Lambert, J. Granville, M. Van Roozendael, A. Delcloo, H. De Backer, P. Valks, N. Hao, Overview of The Validation of GOME-2 Total And Tropospheric NO_2 Columns, Proceedings of the 2010 EUMETSAT conference, Cordoba, Spain, 20-24 September 2010.

Pinardi, G., R. Campion, M. Van Roozendael, C. Fayt, J. van Geffen, B. Galle, S. Carn, P. Valks, M. Rix, S. Hildago, J. Bourquin, G. Garzon, S. Inguaggiato, Comparison of Volcanic SO_2 Flux Measurements From Satellite And From The NOVAC Network, Proceedings of the 2010 EUMETSAT conference, Cordoba, Spain, 20-24 September 2010.

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