

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. Martine De Mazière: project leader FTIR

Dr. M. Van Roozendael: project leader UV-Vis

Bart Dils, Caroline Fayt, François Hendrick, Christian Hermans, Jean-Christopher Lambert, Gaia Pinaridi, C. Senten, Corinne Vigouroux: team scientists

Pierre Gérard, José Granville: team support engineers

Project description:

UV-Vis (main results, significance of results, progress in 2008)

BIRA-IASB operates a SAOZ (Système d'Analyse par Observations Zénithales) UV-visible spectrometer installed on the Sphinx platform since June 1990. Measurements of the ozone and nitrogen dioxide total columns are performed twice a day at twilight and used for trend analysis as well as for satellite validation as part of the Network for the Detection of Atmospheric Composition Change (NDACC). SAOZ total ozone and NO₂ data are regularly submitted to the NDACC, ENVISAT Cal/Val and GeoMON databases and used for the geophysical validation of a number of satellite missions. The SAOZ instrument was seriously damaged in June 2007 after a thunderstorm, which resulted in a data gap of 14 months until the instrument was repaired and re-installed in September 2008. In the course of 2008, the NO₂ measurements from both SAOZ and FTIR instruments have been used to investigate long-term trends at Northern mid-latitude, in comparison with similar analyses performed at other stations of the NDACC. Trend results are found to show large hemispheric differences which are currently not understood. Also trend evaluations obtained from UV-Vis and FTIR techniques are currently inconsistent. Work is ongoing to try and resolve these apparent inconsistencies, in collaboration with NDACC colleagues from NIWA and ULg. Regarding satellite validation, main activities in 2008 have focused on the assessment of the latest upgrade of the GOME and SCIAMACHY processors (in the latter case, for both nadir column and limb profile data products), as well as on a first validation of the GOME-2 operational product covering a complete yearly cycle. Finally preparation work has been engaged in view of the next major UV-Vis intercomparison exercise which will take place in summer 2009 at Cabauw (The Netherlands) in the combined framework of NDACC, CEOS and GeoMON.

FTIR solar absorption spectrometry (main results, significance of results, progress in 2008)

BIRA-IASB participates in the measurement of the atmospheric composition by Fourier transform infrared spectrometry coordinated by the University of Liège (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 2008, we have continued 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. Pettitt change point tests reveal that the NDIR minus FTIR bias changes substantially from 1997 till 2004 after which the bias stabilizes. Possible causes for the observed differences are still under investigation. We hope to publish the study in 2009.

BIRA-IASB also coordinates the Belgian AGACC project that aims – among others - at an advanced exploitation of the ground-based FTIR and MAXDOAS measurements at the Jungfrauoch. University of Liège is responsible for the FTIR measurements, BIRA-IASB for the MAXDOAS measurements. BIRA-IASB has performed a preparatory campaign at Uccle in the second half of 2006 for the measurement of H₂CO by (simultaneous) FTIR and MAXDOAS observations. The data have been analysed in 2007: a good agreement between the MAXDOAS and FTIR data has been demonstrated. The strategy developed for the FTIR and MAXDOAS data analysis of H₂CO at Uccle has been adjusted to the measurement conditions at Saint Denis at the Ile de La Reunion (21°S, 55°E). H₂CO data have been retrieved successfully from the campaign observations in 2004-2005 and 2007; MAXDOAS and FTIR data have been found to be in good agreement. This study of H₂CO has been extended to comparisons with SCIAMACHY data and with IMAGES model results. A publication in this respect is in preparation and will be submitted in the first trimester of 2009.

In 2009 we hope to start MAXDOAS measurements of H₂CO at the Jungfrauoch and to compare these with the FTIR data acquired by the University of Liège.

Key words:

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

Internet data bases:

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- 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>).
 - Revised FTIR vertical profile data have been submitted to NADIR/NILU in a dedicated database for UFTIR (see <http://www.nilu.no/uftir>). They will be copied to the NDACC database as soon as this one is upgraded to accept FTIR profile data.
 - The SAOZ data are also submitted to the Rapid Delivery ftp site at the GEOmon Data Center (<http://www.geomon.eu/data.html>)

Collaborating partners/networks:

- Collaborations with University of Liège and NDACC partners
- Collaboration with European FTIR and UV-Vis teams and modelling teams in the frame of the EU projects GEOMon and HYMN;
- 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 the GOME, ENVISAT, ACE and MetOp GOME-2 and IASI satellite communities.

Scientific publications and public outreach 2008:

Refereed journal articles and their internet access

De Mazière, M., C. Vigouroux, P. Bernath, T. Blumenstock, C. Boone, V. Catoire, M. Coffey, P. Duchatelet, J. Hannigan, L. Harvey, N. Jones, E. Mahieu, G. Manney, C. Piccolo, C. Randall, C. Senten, K. Strong, J. Taylor, K. Walker, S. Wood, Validation of ACE v2.2 methane profiles from the upper troposphere to lower mesosphere, *Atmos. Chem. Phys.*, Special Issue 'Validation Results for the Atmospheric Chemistry Experiment (ACE)', 8, 2421-2435, 2008. (www.atmos-chem-phys.net/8/2421/2008/)

Vigouroux, C., M. De Mazière, P. Demoulin, C. Servais, F. Hase, T. Blumenstock, I. Kramer, M. Schneider, J. Mellqvist, A. Strandberg, V. Velazco, J. Notholt, R. Sussmann, W. Stremme, A. Rockmann, T. Gardiner, M. Coleman, and P. Woods, Evaluation of tropospheric and stratospheric ozone trends over Western Europe from ground-based FTIR network observations, *Atmos. Chem. Phys.*, Special Issue 'Results from the European project UFTIR, Time series of Upper Free Troposphere observations from a European ground-based FTIR network', 8, 6865–6886, 2008. (www.atmos-chem-phys.net/8/6865/2008/)

Zander, R., E. Mahieu, P. Demoulin, P. Duchatelet, G. Roland, C. Servais, M. De Mazière, S. Reimann and C.P. Rinsland, Our changing atmosphere: Evidence based on long-term infrared solar observations at the Jungfraujoch since 1950, *Sci. Total Environ.*, 391, 184-195, 2008.

Lerot, C., M. Van Roozendael, J. van Geffen, J. van Gent, C. Fayt, R. Spurr, G. Lichtenberg, and A. von Bargaen, Six years of total ozone column retrieval from SCIAMACHY nadir measurements, submitted to *Atmos. Meas. Techn.* (2008).

Hendrick, F., P.V. Johnston, K. Kreher, C. Hermans, M. De Mazière, and M. Van Roozendael, One decade trend analysis of stratospheric BrO over Harestua (60°N) and Lauder (44°S) reveals a decline, *Geophys. Res. Lett.*, 35, L14801, doi:10.1029/2008GL034154.

Theys, N., M. Van Roozendael, Q. Errera, F. Hendrick, F. Daerden, S. Chabrillat, M. Dorf, K. Pfeilsticker, A. Rozanov, W. Lotz, J.P. Burrows, J.-C. Lambert, F. Goutail, H.K. Roscoe, and M. De Mazière, A global stratospheric bromine monoxide climatology based on the BASCOE chemical transport model, accepted for publication in *Atmos. Chem. Phys.* (2008).

Gunn, L.N., W. Feng, M.P. Chipperfield, M. Van Roozendael, M. Gil, M. Yela, P.V. Johnston, K. Kreher, S.W. Wood, Long-Term Changes in Stratospheric NO₂: Studies

with a 3-D CTM Forced by ERA-40 Analyses and Chemical Data Assimilation, submitted to *Atmos. Chem. Phys.* (2008).

Hendrick, F., A. Rozanov, P. V. Johnston, H. Bovensmann, M. De Mazière, C. Fayt, C. Hermans, K. Kreher, W. Lotz, N. Theys, A. Thomas, J. P. Burrows, and M. Van Roozendael, Multi-year comparison of stratospheric BrO vertical profiles retrieved from SCIAMACHY limb and ground-based UV-visible measurements, submitted to *Atmos. Meas. Techn.* (2008).

Loyola, D. G., R. M. Coldewey-Egbers, M. Dameris, H. Garny, A. Stenke, M. Van Roozendael, C. Lerot, D. Balis, and M. Koukouli, Global long-term monitoring of the ozone layer - a prerequisite for predictions, accepted for publication in *International Journal of Remote Sensing* (2008).

Lerot, C., M. Van Roozendael, J.-C. Lambert, J. Granville, J. Van Gent, D. Loyola, and R. Spurr, The GODFIT algorithm: a direct fitting approach to improve the accuracy of total ozone measurements from GOME, accepted for publication in *International Journal of Remote Sensing* (2008).

Farahani, E., K. Strong, R. L. Mittermeier, H. Fast, M. Van Roozendael, and C. Fayt, Ground-based UV-visible spectroscopy of O₃, NO₂, and OCIO at Eureka, Canada: Part I - Evaluation of the analysis method and comparison with infrared measurements, submitted to *Atmos. Meas. Techn.* (2008).

Conference papers

Duchatelet, P., E. Mahieu, P. Demoulin, C. Frankenberg, F. Hase, J. Notholt, K. Petersen, P. Spietz, M. De Mazière and C. Vigouroux, Impact of different spectroscopic datasets on CH₄ retrievals from Jungfraujoch FTIR spectra, submitted to the Proceedings of the 8th Atmospheric Spectroscopy Applications (ASA) meeting, (Reims, France, August 27-30, 2008).

Mahieu, E., P. Duchatelet, P. Bernath, C.D. Boone, M. De Mazière, P. Demoulin, C.P. Rinsland, C. Servais and K.A. Walker, Retrievals of C₂H₂ from high-resolution FTIR solar spectra recorded at the Jungfraujoch station and comparison with ACE-FTS observations, Poster presentation at the EGU General Assembly (Vienna, April 13-18, 2008), 2008 ([EGU2008-A-08188](#))

Dils, B., E. Mahieu, P. Demoulin, M. Steinbacher, B. Buchmann and M. De Mazière, Ground-based CO observations at the Jungfraujoch: Comparison between FTIR and NDIR measurements, Poster presentation at the EGU General Assembly (Vienna, April 13-18, 2008), 2008 ([EGU2008-A-08687](#)).

Ciais, P., C. Textor, M. Logan, P. Keckhut, B. Buchmann, S. Godin-Beekmann, G. de Leeuw, M. De Mazière, E. G. Nisbet, P. Rayner, M. Schulz, K. Torseth and the GEOMon team, Monitoring the atmospheric composition using satellite-ground-based synergies, Poster presentation at the EGU General Assembly (Vienna, April 13-18, 2008), 2008.

De Mazière, M., Lambert, J.-C., Roscoe, H. K., Cook, P., Keckhut, P., Textor, C., Ciais, P., and NDACC partners involved for observations, modelling and outreach, Monitoring of the evolution of stratospheric ozone and its relation to climate, in the GEOMon project, poster presentation at the Quadrennial Ozone Symposium 2008, Tromsø, Norway, June 29 - July 5, 2008.

Vigouroux, C., and UFTIR partners, Ozone tropospheric and stratospheric trends (1995-2004) over Western-Europe from ground-based FTIR observations, oral

presentation (by C. Vigouroux) at the Quadrennial Ozone Symposium 2008, Tromso, Norway, June 29 - July 5, 2008.

Ciais, P., C. Textor, M. Logan, P. Keckhut, B. Buchmann, S. Godin-Beekmann, G. de Leeuw, M. De Mazière, E. G. Nisbet, P. Rayner, M. Schulz, K. Torseth and the GEOMON team, Monitoring the atmospheric composition using satellite-ground-based synergies, poster presentation at the IGAC 10th International Conference Symposium, Annecy, France, September 7-12, 2008

Dils, B., M. De Mazière, C. Vigouroux, C. Frankenberg, M. Buchwitz, A. Gloudemans, T. Blumenstock, F. Hase, I. Kramer, E. Mahieu, P. Demoulin, P. Duchatelet, J. Mellqvist, A. Strandberg, K. Petersen, J. Notholt, R. Sussmann and T. Borsdorff, Validation of SCIAMACHY CH₄ scientific products using ground-based FTIR measurements, poster presentation at the IGAC 10th International Conference Symposium, (Annecy, France, September 7-12, 2008).

Sussmann, R., F. Forster, T. Borsdorff, M. De Mazière, B. Dils, C. Vigouroux, T. Blumenstock, M. Buchwitz, J.P. Burrows, P. Demoulin, P. Duchatelet, C. Frankenberg, J. Hannigan, F. Hase, N. Jones, J. Klyft, I. Kramer, E. Mahieu, J. Mellqvist, J. Notholt, K. Petersen, O. Schneising, A. Strandberg, K. Strong, J. Taylor, S. Wood, Satellite validation of column-averaged methane on global scale: ground-based data from 15 FTIR stations versus last generation ENVISAT/SCIAMACHY retrievals, poster presentation at the IGAC 10th International Conference Symposium, (Annecy, France, September 7-12, 2008).

Dils, B., M. De Mazière, C. Vigouroux, R. Sussmann, F. Forster, T. Borsdorff, T. Blumenstock, M. Buchwitz, P. Demoulin, P. Duchatelet, C. Frankenberg, A. Gloudemans, J. Hannigan, F. Hase, N. Jones, J. Klyft, I. Kramer, E. Mahieu, J. Mellqvist, J. Notholt, K. Petersen, A. Strandberg, K. Strong, J. Taylor, S. Wood, evolution of SCIAMACHY CH₄ scientific product quality & initial look at the 'HYMN FTIR dataset', presentation at HYMN second annual meeting, Garmisch-P., Oct. 13-15, 2008.

De Mazière, M., B. Dils, C. Vigouroux, C. Senten, E. Mahieu, P. Demoulin, C. Servais, M. Steinbacher, B. Buchmann, Contributions to the exploitation of Fourier transform infrared observations at Jungfraujoch: recent work on ozone and CO, presentation at Workshop 'Spawning the atmosphere measurements at Jungfraujoch', Bern, Oct. 25-27, 2008.

Data books and reports

Dils, B., M. De Mazière, T. Blumenstock, F. Hase, I. Kramer, E. Mahieu, P. Demoulin, P. Duchatelet, J. Mellqvist, A. Strandberg, M. Buchwitz, I. Khlystova, O. Schneising, V. Velasco, J. Notholt, R. Sussmann and W. Stremme, Validation of WFM-DOAS CO and CH₄ Scientific Products using Ground-based FTIR Measurements, in *Observing Tropospheric Trace Constituents from Space, ACCENT-TROPOSAT-2 in 2006-7*, J. Burrows and P. Borrell, Eds., 2008.

Kruglanski, M., A.-C. Vandaele, M. De Mazière, Atmospheric Constituent Retrieval from Thermal Infrared Nadir Sounding, in *Observing Tropospheric Trace Constituents from Space, ACCENT-TROPOSAT-2 in 2006-7* (Urbino, December 2007), J. Burrows and P. Borrell, Eds., p. 189-191, 2008.

Mahieu, E., C. Servais, P. Duchatelet, P. Demoulin, M. De Mazière, K.A. Walker, C.D. Boone, P.F. Bernath, C.P. Rinsland and R. Zander, Optimised approaches to invert Jungfraujoch high-resolution FTIR observations for long-term monitoring and

satellite validation of tropospheric species, to appear in the ACCENT-TROPOSAT final report, 2008.

Radio and television

Belgian Press release «Top of Europe» prend le pouls du climat (“Top of Europe” neemt de pols van het klimaat), Dec. 2, 2008

Address:

Belgian Institute for Space Aeronomy
Ringlaan 3
B-1180 Brussels
Belgium

Contacts:

Martine De Mazière
Tel. +32 2 373 03 63
Fax: +32-2-374 84 23
e-mail: martine@oma.be

Michel Van Roozendael
Tel. +32 2 373 04 16
Fax: +32-2-374 84 23
e-mail: michelv@oma.be

URL:

<http://www.oma.be/BIRA-IASB/>
<http://www.oma.be/AGACC/Home.html>
<http://www.nilu.no/uftir>
<http://www.geomon.eu>