

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

Corinne Vigouroux, Caroline Fayt, Clio Gielen, François Hendrick, Christian Hermans, Gaia Pinardi, Frederik Tack: team scientists

Project description:

UV-Vis (main results, significance of results, progress in 2013):

Since 1991, BIRA-IASB has been monitoring the long-term evolution of stratospheric NO₂ and ozone columns as part of its contribution to the Network for the Detection of Atmospheric Composition Change (NDACC). These activities have been continued in 2013 despite several instrumental problems. First the operation of the SAOZ zenith-sky UV-Vis instrument had to be interrupted in August 2012 due to a severe electronic breakdown which could only be fixed one year later in September 2013. During this period, the BIRA-IASB MAXDOAS instrument was operated, providing stratospheric ozone, NO₂ and BrO column measurements in addition to tropospheric ozone, NO₂ and HCHO. Unfortunately, the MAXDOAS itself had to be degraded to a zenith-sky measuring system in January 2013 due to a failure of the suntracker which could not be fixed until October 2013. Despite these issues, the continuity of the stratospheric ozone and NO₂ time-series could be maintained. The monitoring of tropospheric NO₂, HCHO and ozone had however to be stopped for about 9 months.

Nevertheless, the data exploitation of the 3-years long (2010-2012) time-series of tropospheric NO₂ and HCHO has been further developed as part of the EU FP7 NORS and ACTRIS projects, as well as within the national AGACC-II project. These activities have been conducted in collaboration with the University of Liège and EMPA colleagues. On the one hand, MAXDOAS remote-sensing free-tropospheric NO₂ concentration measurements have been linked to in-situ observation by EMPA, considering the impact of the different spatial representativeness of these measurements. Secondly, as part of the NORS project, a fully automated Rapid-Delivery processing chain has been developed and demonstrated for the stratospheric NO₂ and ozone column products, which are now delivery to the NDACC data base on a daily basis.

Concerning free-tropospheric HCHO measurements, the existing time-series of MAXDOAS and FTIR observations have been intercompared and further evaluated against independent satellite and three-dimensional chemical transport data sets. Major progress has been achieved as regards the difficult spectral evaluation of both UV-Vis and FTIR HCHO data, leading to significant improvement of the consistency of the observations by both techniques and to a better understanding of the error sources. Although this study is still ongoing, a publication will follow in the next months.

FTIR solar absorption spectrometry (main results, significance of results, progress in 2013):

BIRA-IASB collaborates with the University of Liège (ULg) for the exploitation of the Fourier transform infrared measurements at the Jungfraujoch and it coordinates a number of national (Belgian) and European projects in which the Jungfraujoch measurements play an important role.

In 2013, the analysis of O₃ trends (total column trends and partial column trends in 4 atmospheric layers based on FTIR data) already started in 2012 has been continued and extended to the period 1995-2013 and to non-European stations. A multivariate regression analysis method has been applied to the data, highlighting the various processes that impact the observed O₃ variability and trends. This study has been completed as a contribution to the international SI²N initiative¹ which coordinates the input of the international scientific community on the assessment of the variability and long-term changes in the vertical distribution of ozone. FTIR ozone trends are being published in the SI²N ACP/AMT/ESSD special issue (Hassler et al., 2013, Vigouroux et al., to be submitted).

BIRA-IASB coordinates the EU FP7 NORS project where the Jungfraujoch is one of the 4 demonstration stations used as an input to the automated NORS Copernicus Atmospheric Service validation system (<http://nors-server.aeronomie.be>). In this framework, the Jungfraujoch FTIR data are submitted to the database within 1 month after acquisition.

BIRA-IASB is also partner in the EU FP7 ACTRIS Research Infrastructure project. It is responsible for investigating how VOC remote sensing measurements can be linked to in-situ measurements. It also contributes to a similar activity on NO_x. To this end, it uses FTIR and UV-Vis MAXDOAS data at the Jungfraujoch, for CO and C₂H₆ and NO₂. This work is performed in collaboration with EMPA.

Key words:

Atmospheric composition, long-term monitoring, optical remote sensing, vertical inversion methods, satellite and model 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>).
- Revised HDF GEOMS formats for UV-Vis DOAS and FTIR data products have been implemented at the NDACC data base, as a contribution to the NORS project
- In the framework of NORS, a Rapid-Delivery submission system has been implemented for several NDACC sites (among them Jungfraujoch), by which measurements are provided to the data base within 1 day to 1 month after data acquisition.

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 project NORS
- 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)
- Collaboration with B. Buchmann, D. Brunner, S. Henne, S. Reimann and M. Steinbacher of EMPA (NORS and ACTRIS projects)
- Collaboration with F. Goutail, J.-P. Pommerau and A. Pazmino of LATMOS, France (SAOZ)
- Collaboration with the OMI, ACE and MetOp GOME-2 and IASI satellite communities
- Collaboration with Université Libre de Bruxelles for IASI FORLI data validation

¹ **SPARC/IO₃C/IGACO-O₃/NDACC Activity on Past changes in the Vertical Distribution of Ozone**

Scientific publications and public outreach 2013:

Refereed journal articles and their internet access

Hassler, B., I. Petropavlovskikh, J. Staehelin, T. August, P.K. Bhartia, C. Clerbaux, D. Degenstein, M. De Mazière, B.M. Dinelli, A. Dudhia, G. Dufour, S.M. Frith, L. Froidevaux, S. Godin-Beekmann, J. Granville, N.R.P. Harris, K. Hoppel, D. Hubert, Y. Kasai, M.J. Kurylo, E. Kyrölä, J.-C. Lambert, P.F. Levelt, C.T. McElroy, R.D. McPeters, R. Munro, H. Nakajima, A. Parrish, P. Raspollini, E.E. Remsberg, K.H. Rosenlof, A. Rozanov, T. Sano, Y. Sasano, M. Shiotani, H.G.J. Smit, G. Stiller, J. Tamminen, D.W. Tarasick, J. Urban, R.J. van der A, J.P. Veefkind, C. Vigouroux, T. von Clarmann, C. von Savigny, K.A. Walker, M. Weber, J. Wild and J. Zawodny, SI2N overview paper: ozone profile measurements: techniques, uncertainties and availability, *Atmos. Meas. Tech. Discuss.*, **6**, 9857-9938, doi:10.5194/amtd-6-9857-2013, 2013.

<http://www.atmos-meas-tech-discuss.net/6/9857/2013/amtd-6-9857-2013.html>

Koukouli, M., D. Balis, I. Zyrididou, C. Lerot, M. Van Roozendaal, J.-C. Lambert, J. Granville, J.-P. Pommereau, F. Goutail, G. Labow, S. Frith, D. Loyola, R. Spurr and C. Zehner, Validating the new GOME/ERS-2, SCIAMACHY/Envisat and GOME-2/MetOp-A homogeneous total ozone climate data records developed as part of the ESA Climate Change Initiative, submitted to *J. Geophys. Res.* (2014).

Pinardi, G., M. Van Roozendaal, N. Abuhassan, C. Adams, A. Cede, K. Clémer, C. Fayt, U. Frieß, M. Gil, J. Herman, C. Hermans, F. Hendrick, H. Irie, A. Merlaud, M. Navarro Comas, E. Peters, A.J.M. PETERS, O. Puentedura, A. Richter, A. Schönhardt, R. Shaiganfar, E. Spinei, K. Strong, H. Takashima, M. Vrekoussis, T. Wagner, F. Wittrock and S. Yilmaz, MAX-DOAS formaldehyde slant column measurements during CINDI: intercomparison and analysis improvement, *Atmos. Meas. Tech.*, **6**, 167-185, doi:10.5194/amt-6-167-2013, 2013.

<http://www.atmos-meas-tech.net/6/167/2013/amt-6-167-2013.html>

Pommereau, J.-P., F. Goutail, F. Lefèvre, A. Pazmino, C. Adams, V. Dorokhov, P. Eriksen, R. Kivi, K. Stebel, X. Zhao, M. Van Roozendaal, Why unprecedented ozone loss in the Arctic in 2011? Is it related to climatic change?, *Atmos. Chem. Phys.*, **13**, 5299-5308, doi:10.5194/acp-13-5299-2013, 2013.

<http://www.atmos-chem-phys.net/13/5299/2013/acp-13-5299-2013.html>

Sofieva, V. F., N. Rahpoe, J. Tamminen, E. Kyrölä, N. Kalakoski, M. Weber, A. Rozanov, C. von Savigny, A. Laeng, T. von Clarmann, G. Stiller, S. Lossow, D. Degenstein, A. Bourassa, C. Adams, C. Roth, N. Lloyd, P. Bernath, R.J. Hargreaves, J. Urban, D. Murtagh, A. Hauchecorne, F. Dalaudier, M. Van Roozendaal, N. Kalb and C. Zehner, Harmonized dataset of ozone profiles from satellite limb and occultation measurements, *Earth Syst. Sci. Data*, **5**, 349-363, doi:10.5194/essd-5-349-2013, 2013.

<http://www.earth-syst-sci-data.net/5/349/2013/essd-5-349-2013.html>

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<http://nors.aeronomie.be/>

<http://agacc.aeronomie.be>