

Name of research institute or organization:

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**Royal Belgian Institute for Space Aeronomy (BIRA-IASB)**

Title of project:

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Atmospheric physics and chemistry

Part of this programme:

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NDACC, ACTRIS, GAIA-CLIM, QA4ECV, Sentinel-5 Precursor Mission Performance Center, CAMS, C3S, FRM4DOAS

Project leader and team:

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Dr. Michel Van Roozendaal: project leader UV-Vis

Dr. Martine De Mazière: project leader FTIR

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Project description:

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**UV-Vis observations (main results, significance of results, progress in 2017)**

BIRA-IASB has conducted UV-Vis zenith-sky DOAS measurements of total stratospheric NO<sub>2</sub> and ozone at the Jungfraujoch station since 1990, complemented by MAX-DOAS observations of tropospheric gases (NO<sub>2</sub>, O<sub>3</sub>, HCHO, aerosol) since 2010. Although the long-term data series acquired with the SAOZ instrument had to be stopped in late 2014 due to a major instrument failure, the stratospheric monitoring could nevertheless be continued with the MAX-DOAS instrument. This monitoring was continued in 2017 despite instrumental issues which limited the data acquisition during a few months (see below). In order to restore an independent zenith-sky monitoring capability, a new mini-SAOZ system has been developed in the course of 2017 and it was planned to install it before the winter period. Unfortunately, this installation schedule had to be delayed by a few months. The instrument is however up and running and currently tested at BIRA-IASB. It will be installed at the Jungfraujoch in early spring 2018. At the same time, we hope to be able to fix the visible channel of the MAX-DOAS system which is out of order due to a detector breakdown.

Despite all these issues, UV-Vis measurements acquired at the Jungfraujoch have been submitted to the NDACC data base. The operational rapid delivery processing chain developed during the EU FP7 NORS project has also been maintained in 2017 and used to provide NO<sub>2</sub> and O<sub>3</sub> measurement in support of the Copernicus Atmospheric Monitoring Service (CAMS). These data will also feed the Sentinel-5 Precursor operational validation service currently developed at BIRA as part of the S5P Mission Performance Center.

In addition to these activities, a new PhD study has been started in late 2017 which will concentrate on the scientific exploitation of the MAX-DOAS data. In particular observations performed during several years in the direction of the valley will be exploited to infer information on the vertical distribution of the anthropogenic pollutants emitted in the Swiss plateau or transported from Northern Italy. The aim will be to investigate the processes leading to the uplifting of pollutants from lower altitudes up to the station and tracing back their origin.

### **International coordination activities (main results, significance of results, progress in 2017)**

BIRA-IASB (C. Vigouroux) has coordinated the contribution of the NDACC FTIR ozone data, including the Jungfraujoch data delivered by University of Liège, to the Tropospheric Ozone Assessment Report (TOAR). This work has been documented in two TOAR publications, one submitted for peer-review in November 2017 to Elementa (“Tropospheric Ozone Assessment Report: Present-day distribution and trends of tropospheric ozone relevant to climate and global atmospheric chemistry model evaluation”, lead author: A. Gaudel) and the other one to be submitted in January 2018 to Elementa (“Tropospheric Ozone Assessment Report: Tropospheric ozone observations – How well do we know tropospheric ozone changes?”, lead author: D. Tarasick). C. Vigouroux is also responsible for the NDACC FTIR ozone data, including Jungfraujoch, in the SPARC initiative LOTUS (Long-term Ozone Trends and Uncertainties in the Stratosphere), aiming at a better understanding of several key open issues identified by previous ozone trends assessments, most notably on the understanding of uncertainties in the trend analysis chain. The LOTUS report is under review at SPARC. This work has also been used in the study of Steinbrecht et al. (2017).

Starting in March 2015, BIRA-IASB has been involved in the EU H2020 GAIA-CLIM (Gap Analysis for Integrated Atmospheric ECV CLimate Monitoring) project which aims at improving our ability to use ground-based and sub-orbital observations to characterise satellite observations for a number of atmospheric Essential Climate Variables (ECVs). In particular traceable reference-quality measurements have been established for total ozone using ground-based UV-visible spectroscopy, and for O<sub>3</sub> and H<sub>2</sub>O profile measurements using ground-based FTIR solar absorption spectrometry. These will have an impact on measurements being performed at the Jungfraujoch. A traceability chain for the data acquisition and processing models has been established and common procedures for uncertainty budget evaluations have been agreed and implemented by the NDACC FTIR and UV-VIS communities.

As part of the EU QA4ECV project (Quality Assurance for ECV products), BIRA-IASB has led a task for characterizing and establishing MAXDOAS tropospheric NO<sub>2</sub> and H<sub>2</sub>CO column measurements as well as NDACC and TCCON FTIR CO profile measurements as traceable reference data sets for satellite validation. The Institute is in contact with the University of Liège and the Jungfraujoch NDACC FTIR CO data is included in this reference data set after the data was processed with the updated sfit4 retrieval software. The updated retrieval software package allows the determination of a harmonized uncertainty budget.

BIRA-IASB is also responsible for the use of NDACC data, including the Jungfraujoch SAOZ, MAXDOAS and FTIR data for the validation of various products of the Copernicus Atmospheric Monitoring Service (CAMS), led by ECMWF. The results are reported on quarterly basis in the validation reports that are available at [https://atmosphere.copernicus.eu/quarterly\\_validation\\_reports](https://atmosphere.copernicus.eu/quarterly_validation_reports). Jungfraujoch NDACC data are included as soon as they are submitted to the NDACC database. In addition, BIRA-IASB is in charge of the CAMS-27 contract which aims at guaranteeing a continuous rapid-delivery and quality-controlled NDACC data stream to CAMS. In 2017, it collaborated with the University of Liège to ensure that the Jungfraujoch FTIR data matches the quality requirements for CAMS model validation: uncertainty harmonization and retrieval settings for CO, CH<sub>4</sub> and O<sub>3</sub>. Similarly, BIRA-IASB is in charge of the Sentinel-5 Precursor (S5P) operational validation service (VDAF) within the ESA S5P Mission Performance Center (MPC). In this context, BIRA-IASB coordinates the validation of the S5P products using NDACC data, including the Jungfraujoch FTIR data.

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 validation purposes are also submitted to the ESA CAL/VAL EVDC database at NILU (<http://nadir.nilu.no/calval>).

All the data sets submitted in these data bases are generated using HDF GEOMS formats, as defined for UV-Vis DOAS and FTIR data products in the NORS and QA4ECV 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.

The NDACC database is 'read' by the CAMS validation server on a daily basis, for using the data for the validation of the CAMS NRT and re-analysis products. A similar facility is currently implemented for the S5P-MPC VDAF system.

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 GAIA-CLIM and QA4ECV

Collaboration with M. Chipperfield of the University of Leeds

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

Collaboration with F. Goutail, J.-P. Pommereau and A. Pazmino of LATMOS, France (SAOZ)

Collaboration with the OMI, TROPOMI (S5P), and MetOp GOME-2 and IASI satellite communities

Collaboration with Université Libre de Bruxelles for IASI FORLI data validation

Collaboration with S&T for the CAMS, QA4ECV and S5P Validation Server

Scientific publications and public outreach 2017:

**Refereed journal articles and their internet access**

Blechschmidt, A.-M., J. Arteta, A. Coman, L. Curier, H. Eskes, G. Foret, C. Gielen, F. Hendrick, V. Marécal, F. Meleux, J. Parmentier, E. Peters, G. Pinardi, A.J.M. Piters, M. Plu, A. Richter, M. Sofiev, Á.M. Valdebenito, M. Van Roozendael, J. Vira, T. Vlemmix and J.P. Burrows, Comparison of tropospheric NO<sub>2</sub> columns from MAX-DOAS retrievals and regional air quality model simulations, *Atmos. Chem. Phys. Discuss.*, in review, 2017. <https://doi.org/10.5194/acp-2016-1003>

De Mazière, M., A.M. Thompson, M.J. Kurylo, J. Wild, G. Bernhard, T. Blumenstock, J. Hannigan, J.-C. Lambert, T. Leblanc, T.J. McGee, G. Nedoluha, I. Petropavlovskikh, G. Seckmeyer, P.C. Simon, W. Steinbrecht, S. Strahan and J.T. Sullivan, The Network for the Detection of Atmospheric Composition Change (NDACC): History, status and perspectives, *Atmos. Chem. Phys. Discuss.*, in review, 2017. <https://doi.org/10.5194/acp-2017-402>

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Garane, K., C. Lerot, M. Coldewey-Egbers, T. Verhoelst, I. Zyrichidou, D.S. Balis, T. Danckaert, F. Goutail, J. Granville, D. Hubert, M.E. Koukouli, A. Keppens, J.-C. Lambert, D. Loyola, J.-P. Pommereau, M. Van Roozendael and C. Zehner, Quality assessment of the Ozone\_cci Climate Research Data Package (release 2017): 1. Ground-based validation of total ozone column data products, *Atmos. Meas. Tech. Discuss.*, in review, 2017. <https://doi.org/10.5194/amt-2017-378>

Keppens, A., J.-C. Lambert, J. Granville, D. Hubert, T. Verhoelst, S. Compernelle, B. Latter, B. Kerridge, R. Siddans, A. Boynard, J. Hadji-Lazaro, C. Clerbaux, C. Wespes, D. Hurtmans, P.-F. Coheur, J. van Peet, R. van der A, K. Garane, M. Koukouli, D. Balis, A. Delcloo, R. Kivi, R. Stübi, S. Godin-Beekmann, M. Van Roozendael and C. Zehner, Quality assessment of the Ozone\_cci Climate Research Data Package (release 2017): 2. Ground-based validation of nadir ozone profile data products, submitted to AMT, 2017.

Peters, E., G. Pinardi, A. Seyler, A. Richter, F. Wittrock, T. Bösch, M. Van Roozendael, F. Hendrick, T. Drosoglou, A.F. Bais, Y. Kanaya, X. Zhao, K. Strong, J. Lampel, R. Volkamer, T. Koenig, I. Ortega, O. Puentedura, M. Navarro-Comas, L. Gómez, M. Yela González, A. Piter, J. Remmers, Y. Wang, T. Wagner, S. Wang, A. Saiz-Lopez, D. García-Nieto, C.A. Cuevas, N. Benavent, R. Querel, P. Johnston, O. Postlyakov, A. Borovski, A. Elokhov, I. Bruchkouski, J. Liu, C. Liu, Q. Hong, C. Rivera, M. Grutter, W. Stremme, M.F. Khokhar, J. Khayyam and J.P. Burrows, Investigating differences in DOAS retrieval codes using MAD-CAT campaign data, *Atmos. Meas. Tech.*, **10**, 955-978, doi:10.5194/amt-10-955-2017, 2017.  
<https://www.atmos-meas-tech.net/10/955/2017/>

Steinbrecht, W., L. Froidevaux, R. Fuller, R. Wang, J. Anderson, C. Roth, A. Bourassa, D. Degenstein, R. Damadeo, J. Zawodny, S. Frith, R. McPeters, P. Bhartia, J. Wild, C. Long, S. Davis, K. Rosenlof, V. Sofieva, K. Walker, N. Rähpö, A. Rozanov, M. Weber, A. Laeng, T. von Clarmann, G. Stiller, N. Kramarova, S. Godin-Beekmann, T. Leblanc, R. Querel, D. Swart, I. Boyd, K. Hocke, N. Kämpfer, E. Maillard Barras, L. Moreira, G. Nedoluha, C. Vigouroux, T. Blumenstock, M. Schneider, O. García, N. Jones, E. Mahieu, D. Smale, M. Kotkamp, J. Robinson, I. Petropavlovskikh, N. Harris, B. Hassler, D. Hubert and F. Tummon, An update on ozone profile trends for the period 2000 to 2016, *Atmos. Chem. Phys.*, **17**, 10675-10690, <https://doi.org/10.5194/acp-17-10675-2017>, 2017.

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<http://uv-vis.aeronomie.be/>  
<http://infrared.aeronomie.be>  
<http://nors.aeronomie.be/>  
<http://agacc.aeronomie.be>