NDACC Capacity report

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LEAD AUTHOR	Project Coordinator	Martine De Mazière	22/10/2014	

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1. Introduction

The NORS project has been aiming at demonstrating the suitability of ground-based remote sensing data for the quality assessment of the Copernicus Atmospheric Monitoring service (CAMS, formerly GMES Atmospheric Service or GAS). NORS has focused on ground-based remote sensing data from the Network for the Detection of Atmospheric Composition Change or NDACC.
For this demonstration, the NORS project has worked with the data from 4 operational NDACC pilot stations.
In addition, it has shown the feasibility of using the whole NDACC network (see D10.2 'NDACC Status Report') as well as the feasibility of adding capacity to the Network, by exporting the NORS achievements to new, potential NDACC stations outside Western Europe.
This deliverable 'NDACC Capacity Report' reports about the latter activities.

2. Building capacity: summary of the achievements

Several NORS partners have committed themselves to collaborate with research institutions in Russia and in continents outside Europe to implement or advance additional potential NDACC stations, and to export the expertise acquired in NORS to these stations to enable them to contribute to the quality assessment of CAMS, now or in the near-future.

To reach the objectives, in most cases, there have been visits from the NORS partners to these stations and vice versa, to share expertise and to implement at these stations the algorithms, data archiving tools, etc. that were developed in NORS. Some of these stations have already submitted a request for NDACC affiliation or are preparing themselves to do so in the near-future. Some (e.g., Xianghe) are already submitting Rapid Delivery data to the NORS/NDACC database and as such provide data for the validation of the MACC products. In general, common publications in peer-reviewed papers or presentations at international workshops and symposia have resulted from the collaboration.
These stations are a valuable addition to the network of atmospheric ground-based monitoring stations, in order to enhance the global coverage of the network. The strong involvement of the local research institutions and their links and potential affiliation to NDACC are important for the long-term sustainability of these stations.

The Table below provides an overview of the status of the new/advanced stations and Section 3 reports in more detail the activities that have been conducted at these stations, to reach the final goal.

Station Name	Country	Lat (°N)	Lon (°E)	Local organisation	Cooperating NORS partner	Instrument(s)	Available Data	Data submitted to NDACC RD ?	NDACC candidate ? [1]
Xianghe Integrated Observatory	China	39.75°	116.96°	Institute for Atmospheric Physics / Chinese Academy of Sciences	BIRA-IASB	MAXDOAS	March 2010 till now	Yes	No
Beijing	China	39.95°	116.32°	Chinese Academy of Meteorological Sciences	MPIC	Mini-MAXDOAS	August 2008 to present	No	No
Kourovka	Russia	57.0°	59.55°	University of Yekaterinburg	UniBremen	FTIR	Since July 2012	No	Not yet
Tomsk	Russia	56.50°	84.97°	Zuev Institute of Atmospheric Optics	KIT	FTIR	No	No	No
Paramaribo	Suriname	5.81°	- 55.21°	Anton de Kom University	UniBremen	FTIR	Since 2004 on campaign basis	No	Yes
Paramaribo	Suriname	5.81°	- 55.21°	Meteorological Service of Suriname	UniHeidelberg	MAXDOAS	Since 2001	No	Not yet
Altzomoni	Mexico	19.12°	-98.65°	UNAM	KIT	FTIR	Since October 2012	No	Yes
Rio Gallegos	Argentina	-51.92°	69.23°	CEILAP-CONICET	CNRS	O3 Lidar SAOZ	March 2008 till now	Yes, since July 2014	Already NDACC

[1] 'Candidate' means that an application for becoming NDACC station has been submitted

Bujumbura	Burundi	-3.38°	29.38°	University of Bujumbura	BIRA-IASB	MAXDOAS	December 2013 till now	No	No
Addis Ababa	Ethiopia	9.0°	39.0°	Addis Ababa University	KIT	FTIR	No	No	No
Belgrano	Antarctica	-77.87°	-34.62°	Instituto Antártico Argentino (IAA)	INTA	MAXDOAS	Stratospheric BrO, NO2 and O3	Not yet	Yes
Seoul	South Korea	37.58°	127.00°	Sookmyung Women's University, Department of Chemistry	IAP/UniBern	O3, H2O MW	Since 2006	Not yet	Yes

3. Building capacity: reports per station

3.1. Xianghe Integrated Observatory, China

MAX-DOAS measurements of NO_2, H_2CO and aerosols are performed by IASB-BIRA at the Xianghe Observatory (China) since March 2010, in collaboration with the Institute of Atmospheric Physics (IAP)/Chinese Academy of Sciences (CAS). Tropospheric profiles of both trace gases and aerosols have been retrieved by using the bePRO profiling tool developed at BIRA-IASB (Clémer et al., 2010; Hendrick et al., 2014). After a research phase where retrieval settings were optimised and data quality investigated, GEOMS HDF data files have been submitted on a daily (NO_2, aerosols) and monthly (CH_2O) basis to the NDACC/NORS RD validation server. The automatic submission started in June 2013 while data files covering the March 2010-May 2013 were submitted off-line, so that the complete time-series is available on the validation server. It should be noted that Xianghe was the key MAX-DOAS station for the implementation of the MAX-DOAS profiles and column in the NORS validation server. An example of CH_2O validation plot extracted from the NORS validation server is shown in Figure 1.

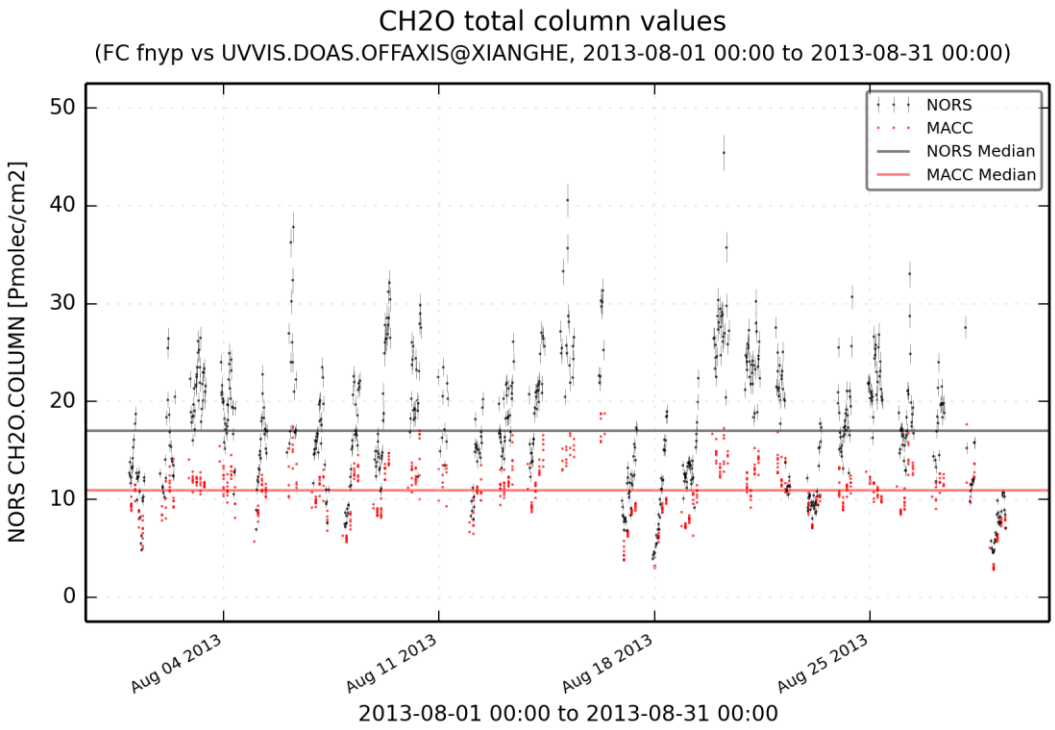

Figure 1: Example of MACC CH2O validation using MAX-DOAS measurements at Xianghe. It corresponds to August 2013 and the MACC model is fnyp. The full report can be downloaded at https://nors.stcorp.nl/report/CH2O-fnyp-UVVIS.DOAS.OFFAXIS-20130801T0000-20130831T0000-XIANGHE-BIRA.IASB/.

Investigations were also done about the retrieval of SO_2 (Wang et al., 2014) from MAX-DOAS measurements at Xianghe. This trace gas is an important air-quality-related species and if there is a demand by modellers, SO_2 profiles could also be delivered to the NDACC/NORS validation server in the future.

FTIR and CIMEL instruments are also available at the site.

Ting Wang (IAP/CAS) spent one year (October 2012-October 2013) at BIRA-IASB in the framework of her PhD thesis and Michel Van Roozendael (Lead of the DOAS Research Group at BIRA-IASB) was a member of her PhD jury.

Papers using Xianghe data:

Gielen, C., M. Van Roozendael, F. Hendrick, G. Pinardi, T. Vlemmix, V. De Bock, H. De Backer, C. Fayt, C. Hermans, D. Gillotay, and P. Wang, A simple and versatile cloud-screening method for MAX-DOAS retrievals, Atmos. Meas. Tech., 7, 3509-3527, 2014.

Hendrick, F., J.-F. Müller, K. Clémer, M. De Mazière, C. Fayt, C. Gielen, C. Hermans, J. Z. Ma, G. Pinardi, T. Stavrakou, T. Vlemmix, P. Wang, and M. Van Roozendael, Four Years of Ground-based MAX-DOAS Observations of HONO and NO_2 in the Beijing Area, Atmos. Chem. Phys, 14, 765-781, 2014.

Vlemmix, T., F. Hendrick, G. Pinardi, I. De Smedt, C. Fayt, C. Hermans, A. Piters, P. Levelt, and M. Van Roozendael, MAX-DOAS observations of aerosols, formaldehyde and nitrogen dioxide in the Beijing area: comparison of two profile retrieval approaches, Atmos. Meas. Tech. Discuss., 7, 9673-9731, 2014.

Wang, T., F. Hendrick, P. Wang, G. Tang, K. Clémer, H. Yu, C. Fayt, C. Hermans, C. Gielen, G. Pinardi, N. Theys, H. Brenot, and M. Van Roozendael, Evaluation of tropospheric SO_2 retrieved from MAX-DOAS measurements in Xianghe, China, Atmos. Chem. Phys. Discuss., 14, 6501-6536, 2014.

3.2. Beijing, China

With our partners Jianzhong Ma and Ji Junli from CAS, Beijing, we performed joint MAX-DOAS measurements at Beijing, Gucheng and Tibet. We also worked jointly on the data analysis and interpretation. The knowledge transfer includes the following aspects:

- spectral analyses of NO_2, O_4, HCHO, SO_2, CHOCHO
- cloud screening based on MAX-DOAS cloud classifcation schemes
- application of the geometrical approximation to retrieve tropospheric trace gas VCDs
- application of inversion algorithms for the retrieval of aerosol extinction and trace gas profiles

The data have also been used for satellite validation, which is of great importance over polluted regions like north-east China. Most MAX-DOAS measurements had a focus on air pollution. But some measurements addressed also fundamental research questions in atmospheric chemistry, e.g. the analysis of free tropospheric BrO concentrations from MAX-DOAS measurements in Tibet. Our partners visited us several times in recent years.
Our joint activities resulted in the following peer revied publication:

Ma, J. Z., Beirle, S., Jin, J. L., Shaiganfar, R., Yan, P., and Wagner, T.: Corrigendum to "Tropospheric NO_2 vertical column densities over Beijing: results of the first three years of ground-based MAX-DOAS measurements (2008–2011) and satellite validation" published in Atmos. Chem. Phys., 13, 1547–1567, 2013, Atmos. Chem. Phys., 13, 5629-5629, doi:10.5194/acp-13-5629-2013, 2013.

Our measurements also contributed to the following publication:

Hendrick, F., Müller, J.-F., Clémer, K., Wang, P., De Mazière, M., Fayt, C., Gielen, C., Hermans, C., Ma, J. Z., Pinardi, G., Stavrakou, T., Vlemmix, T., and Van Roozendael, M.:

Four years of ground-based MAX-DOAS observations of HONO and NO_2 in the Beijing area, Atmos. Chem. Phys., 14, 765-781, doi:10.5194/acp-14-765-2014, 2014.

Another publication publication about the measurements at the Gucheng site is in preparation.

3.3. Kourovka, Russia

Prof. V.I.Zakharov and his remote sensing group at the Ural Federal University in Ekaterinburg, Russia operate a Bruker 125M FTIR instrument. The instrument was procured in 2009 and installed at the Observatory in Kourovka (57.038N, 59.545E), which is ~80km outside of Ekaterinburg and reachable by car or by train. Konstantin Gribanov and Nikita Rokotyan from the group visited Bremen in November 2011, Christof Petri from UBremen visited the Ekaterinburg group from 25.06.12 till 07.07.12 and from 24.08.13 till 05.09.13. They worked together on FTIR data analysis as well as on the alignment of the interferometer. The interferometer has been updated electronically. During the second stay the solar tracker has been aligned to enable a semi automated tracking of the sun. Measurements can be performed remotely from Ekaterinburg via internet connection. Measurements are regularly performed in the near-infrared spectral region and the instrument is ready to perform NDACC measurements in the mid-infrared region. The issue limiting regularly performed NDACC measurements is the requirement for liquid nitrogen: it has to be filled into the detectors manually - while the site with the instrument is outside the city. A possible solution is a system for automated filling of the liquid nitrogen, but the financial situation didn't allow the acquisition of such a system till now. This problem could not be solved within the NORS project.

3.4. Tomsk, Russia

Prof. Leonid Sinitsa and his group operate a high resolution FTIR spectrometer at Zuev Institute of Atmospheric Optics. It is located in Tomsk, Siberia (56° 30′ N , 84° 58′ O). It is a Bruker 125M, originally dedicated for lab spectroscopy. A solar tracker has been added and the spectrometer is operated parttime for lab and parttime for atmospheric measurements. A sub-set of NDACC optical filters is available at the site.

Boris Veronin and Semen Vasilchenko, both co-workers of Prof. Leonid Sinitsa, University Tomsk, visited KIT in 2012 and 2013, respectively. Frank Hase (KIT) provided the latest version of PROFFIT to analyse Tomsk's spectra and trained the use of PROFFIT and LINEFIT software.

3.5. Paramaribo, Suriname

FTIR experiment:

The UBremen has been operating a Bruker 120M high resolution FTS at Paramaribo, Surimame since 2004. It is located at the Meteorological Service of Suriname in the city of Paramaribo (5.8°N, 55.2°W). The Paramaribo site has been run on campaign basis: the UBremen performed usually two measurement campaigns during the two dry seasons in Suriname, funded by different projects and the University of Bremen. During the NORS project the instrument has been exchanged with an upgraded FTS 120/5M. This instrument is able to perform DC measurements and could be run semi-automated. During one of the campaigns comparison measurements between the old and the upgraded instrument have been performed. Local personnel have been instructed to perform measurements and the site is now

operational on sunny days all over the year. The limiting factor for NDACC measurements is the availability of liquid nitrogen in Suriname, which still has to be imported from the US.

MAXDOAS experiment:
UHeidelberg is operating a long-term MAX-DOAS experiment at the Meteorological Service of Suriname in Paramaribo since 2001. During a visit in November 2011, UHeidelberg has maintained and updated the long-term MAX-DOAS instrument. During this visit, the local operators at the Meteorological Service of Suriname received additional training for the operation and maintenance of the instrument
The long-term MAX-DOAS measurements at Paramaribo, Suriname, were performed continuously until January 2014, when the instrument unfortunately broke down. Depending on the funding situation, the UHeidelberg team plans a travel to Suriname in order to repair the instrument in early 2015.

3.6. Altzomoni, Mexico

The observing site Altzomoni (19.1187 N, 98.6552 W) is located in central Mexico within the Izta-Popo National Park, 60 km southeast of Mexico City. It is a high altitude observatory at 3,985 m a.s.l. A container equipped with a Bruker HR 125 and a camtracker based solar tracker has been prepared by KIT Karlsruhe and shipped to Mexico in 2012. The NDACC optical filter set and HBr cell are available to ensure high quality of the measurements. Observation and data analysis started in 2012.

The PI of this site is Michel Grutter from UNAM Mexico City. There is a strong collaboration between his group and the ground-based remote sensing team at KIT Karlsruhe, including several visits of scientists at both institutes. PhD student Alexandro Bezanillo and Post-doc Eddy Medina Plaza visited KIT for 1 month each.

Michel Grutter and Wolfgang Stremme (UNAM) applied for NDACC affiliation. members of this groupattended the annual meeting of the NDACC IRWG (Infrared Working Group) each year since 2011. NDACC certification is in progress.

3.7. Rio Gallegos, Argentina

Since spring 2005 the Lidar Division of CEILAP, joined with French and Japanese researchers has been monitoring atmospheric parameters using lidar technologies in the southernmost continental part of South America. The Río Gallegos experimental site is located in South Patagonia (51º55’S, 69º14’W), in the subpolar region. It is one of the few lidar stations in the southern hemisphere. CEILAP operates a differential absorption lidar instrument (DIAL) for the measurement of ozone vertical distribution. This instrument is part of the Network for Detection of Atmospheric Composition Change (NDACC). The lidar measurements aim at evaluating the influence of the ozone hole on stratospheric ozone fields in the southern hemisphere and on UV radiation at the surface. Since 2006, other products such as aerosol content and temperature profiles in the stratosphere are retrieved from the lidar measurements. In addition, SAOZ measurements of ozone and nitrogen dioxide total columns are performed at Rio Gallegos since 2008.

In the frame of the NORS project, the coordinator of the station, Dr. Jacobo Salvador, has travelled to Europe in order to be trained on the Rapid Delivery procedure and on the latest version of the DIAL ozone retrieval algorithm. This version has now been implemented in

Rio Gallegos. In addition, Dr Jacobo Salvador has updated the SAOZ procedure level 1 (slant columns retrieval) at the station. The automatic delivery of SAOZ real time data of Rio Gallegos in the new UV-Vis HDF format (template v006) has been implemented since July 2014. SAOZ consolidated V3 data since 2008 should be submitted to NDACC before the end of the project.

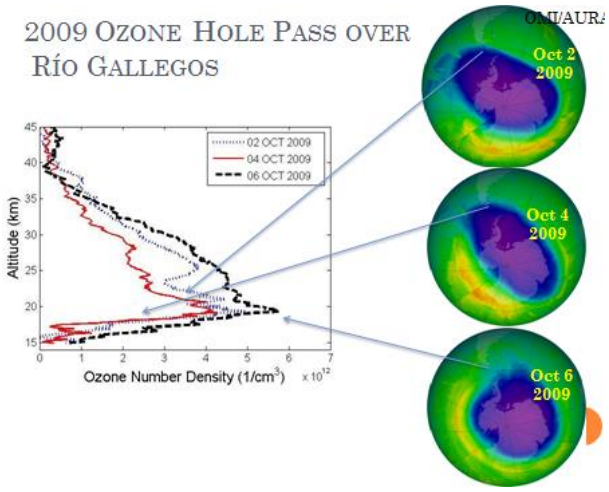

Figure 2: Example of ozone hole overpass above the Rio Gallegos station and its effect on ozone profile measurements in 2009. Total ozone amounts of 353, 271 and 375DU have been measured by SAOZ in October 2, 4 and 6, respectively.

3.8. Bujumbura, Burundi

The BIRA-IASB MAX-DOAS instrument installed at the University of Burundi in Bujumbura is operational since end of November 2013. Operation and maintenance of the UVVIS DOAS spectrometer are done in close collaboration with the University of Burundi (Prof. Pierre Nzohabonayo, Rachel Akimana, and Eugène Ndenzako). Eugène Ndenzako spent four months (November 2012-February 2013) at BIRA-IASB to learn about the DOAS technique.

The optimisation of the settings for the retrieval of NO_2, HCHO, and aerosols vertical profiles is under progress, and so data files have not yet been submitted to the NORS validation server. Figure 3 shows the current time series of tropospheric NO_2 and HCHO vertical column densities and aerosol vertical optical depth from November 2013 till 2014.
A CIMEL instrument is also operated by BIRA-IASB at the site.

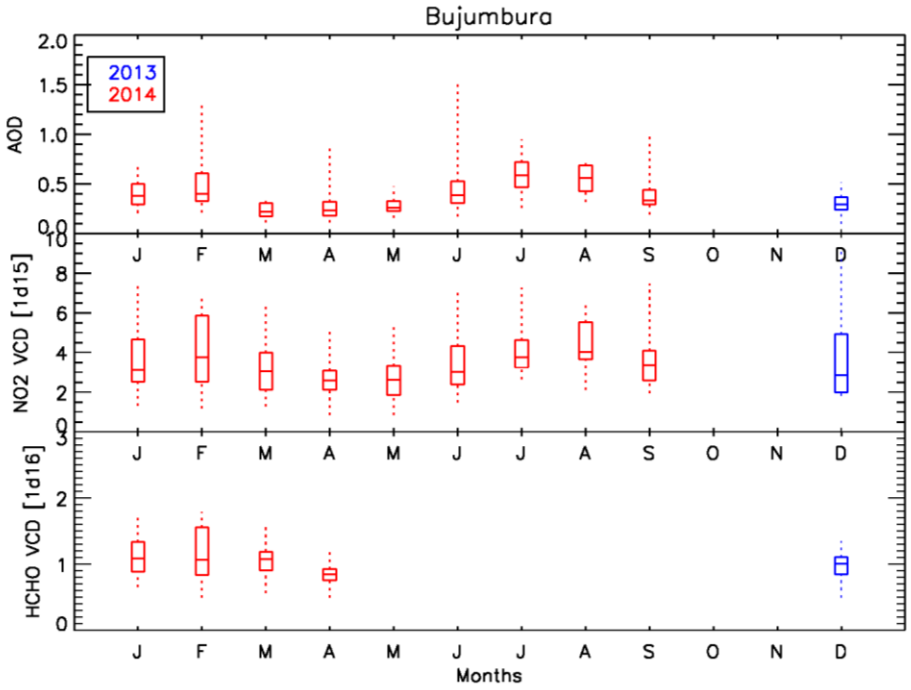

Figure 3: Time-series of AOD, NO2 and HCHO vertical column densities (VCD; in molec/cm2) retrieved from MAX-DOAS measurements at Bujumbura. Minimum, maximum, 25 and 75% percentiles, and median values are plotted. HCHO data are missing from May 2014 due to a failure of the UV CCD detector. A new detector will be reinstalled soon.

Investigations are also currently performed on how to compare MACC and MAX-DOAS profiles: since Bujumbura is surrounded by mountains and the horizontal resolution of the model does not allow to capture the height of the instrument (surrounding model grid points are all at an altitude larger than 1200m while the altitude of the instrument is about 800m), the default vertical inter- and extrapolation algorithms provide erroneous results in the intercomparisons.

3.9. Addis Ababa, Ethiopia

Dr. Gizaw Mengistu Tsidu (Physics Dept of Addis Ababa Univ.) and his group operate a Bruker 125M on the campus of Addis Ababa University, Ethiopia, (9.0 N, 39.0 E, 2443 m a.s.l.). The spectrometer is mounted in a container and was prepared by KIT Karlsruhe. It was shipped to Addis Ababa in 2009. Measurements and data analysis is made by Addis Ababa group.

Dr. Gizaw Mengistu Tsidu had got a Georg Forster stipendium from Humboldt-Foundation. Until recently he visited KIT for 1 year. During his stay spectra recorded in Addis were analysed and a paper on H_2O retrievals has been submitted to AMT:
Mengistu Tsidu, G., T. Blumenstock, and F. Hase: Observations of precipitable water vapour over complex topography of Ethiopia from ground-based GPS, FTIR, radiosonde and ERA-Interim reanalysis, Atmos. Meas. Tech. Discuss., 7, 9869-9915, 2014.

3.10. Belgrano, Antarctica

The long-term monitoring program of INTA for NO_2 and O_3 column by visible spectroscopy in the Antarctic region was initiated in February 1994 by an Agreement between INTA (Spain) and DNA (Argentina).

At that time two unattended scanning spectrometers operating in short spectral ranges for NO_2 (430 - 450 nm) and O_3 (470 - 490 nm) observations were deployed at Marambio station (Antarctic Peninsula, 64ºS, 56ºW) and Ushuaia (Tierra del Fuego, 55ºS, 68ºW). A third one was installed in the Belgrano station (Continental Antarctica, 78ºS, 35ºW) in January 1995. The stations are separated by 10º in latitude providing a good information inside, outside and at the edge of the vortex, and very close in longitude providing meridional cross-sections across the vortex.
Within WP10, INTA is exporting the NORS expertise to Belgrano II station (see Figure 4) in Antarctica (77º52'S, 34º37'W).

Figure 4: View of Belgrano II station

Belgrano II station is located on the coast of the Antarctic continent in the Weddell Sea area. The station is built on the rocks and at an elevation of 256 m asl next to the Filchner Ice Shelf. Climatologically speaking, the station is within the easterly flow regime that is found around much of the continent. However, offshore flow is common on many occasions, as can be seen via the coastal polynya that is often present over the southern Weddell Sea. Deep lows in the Weddell Sea can enhance the easterly flow giving gale or occasionally storm force winds. Belgrano is representative of an in-polar vortex station during the winter-spring season until the vortex breakdown.
In 2011 in the framework of a project funded by Spanish system of Science and Technology, (VIOLIN "Extended Vertical Investigation of the Ozone Layer In ANtarctica"), a MAX-DOAS UV-Vis instrument (NEVAII) was installed in Belgrano II station. Regular measurements of NO_2 and O_3 were extended to BrO and OClO MAXDOAS measurements.

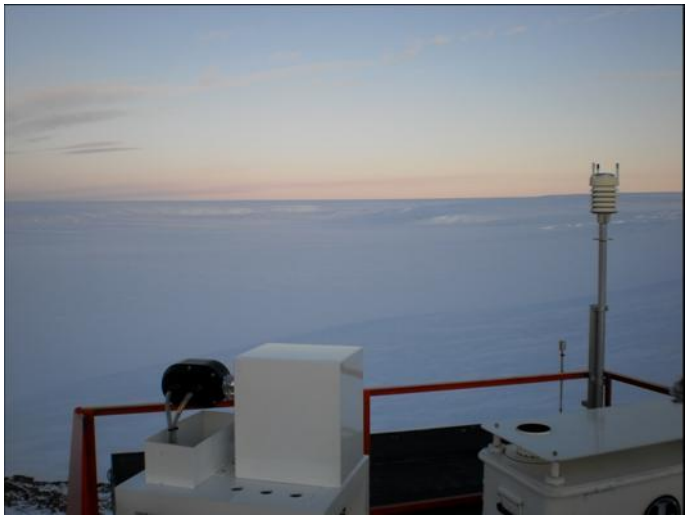

Figure 5: View of light collector of MAXDOAS instrument at Belgrano II station.

An application for including Belgrano station as part of NDACC was submitted in September 2013.
In early January 2013, after several mechanical problems, a second MAXDOAS spectrometer allowing to measure in the visible range, started measuring as well. Both spectrometers share the pointing system although the entrance optics is independent. Both instruments are synchronized to measure simultaneously at the same elevation at the same time. The instrument is pointing to NE, looking at the Filchner Ice Shelf and operational elevation angles are: 2º, 3º,5º,10º,15º, 30º, 60º and 90º. A view of the light entrance and positioning system of both instruments is shown in
Figure 5.

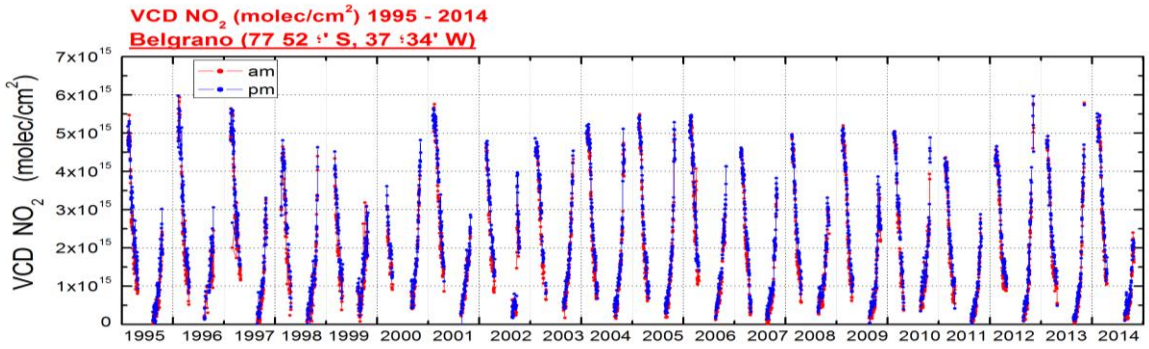

Figure 6: Homogenized data series of stratospheric NO_2 since 1995.

2.5 years of continuous measurements of BrO and OClO and more than half a year of O_3, NO_2 and IO data are currently available.
Since the start of the NORS project INTA has maintained and updated the long-term MAX-DOAS measurements at Belgrano and instrumental performance has been significantly improved, especially with respect to the pointing system. Operators at the DNA receive annual training for the operation and maintenance of the instrument that ensures the proper operation in Antarctica during the whole year.
NO_2 and O_3 analysis settings compliant with the NDACC recommendations have been applied to the data analysis, except for O_3 where the recommended spectral interval is not

completetely covered. MAXDOAS algorithm development and sensitivity analysis are ongoing for BrO, O_3 and NO_2 profiles and columns as well as for aerosol extinction profiles.

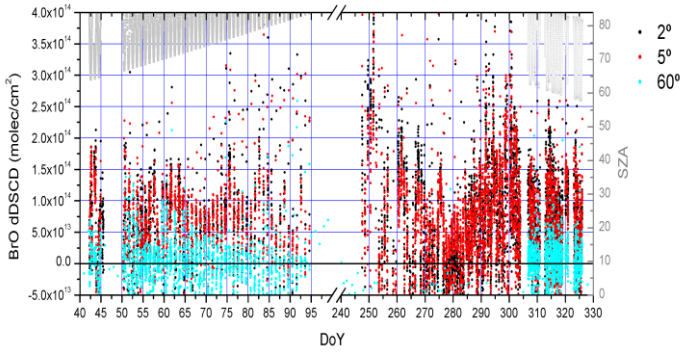

Figure 7: dSCD of BrO during 2013 at 2º, 5º and 60º elevation angles.

Work has been focused initially on the inversion of aerosol and BrO profiles (BrO enhancement events); later it will also be extended to NO_2 and O_3.
Data series of stratospheric NO_2 vertical column is shown in Figure 6. Data homogenization has been performed using data series of previous scanning spectrometer and the MAXDOAS data starting measuring in 2013. Both instruments will keep measuring simultaneously during at least year 2015, to ensure the correct overlapping of the series.
dDSCD of BrO for year 2013 is shown in Figure 7**Error! Reference source not found.** for elevations 2º, 5º and 60º (black, red and green dots, respectively). The columns seem to be consistent with a tropospheric distribution close to the ground, but proper calculation of vertical profiles is still ongoing. During September 2013 some episodes of tropospheric BrO enhancement were observed.
In Figure 8, days 250-256 have been displayed, where two episodes of surface ozone depletion were observed; one at day 252, not clearly related to a bromine enhancement, and another one at days 253-254.

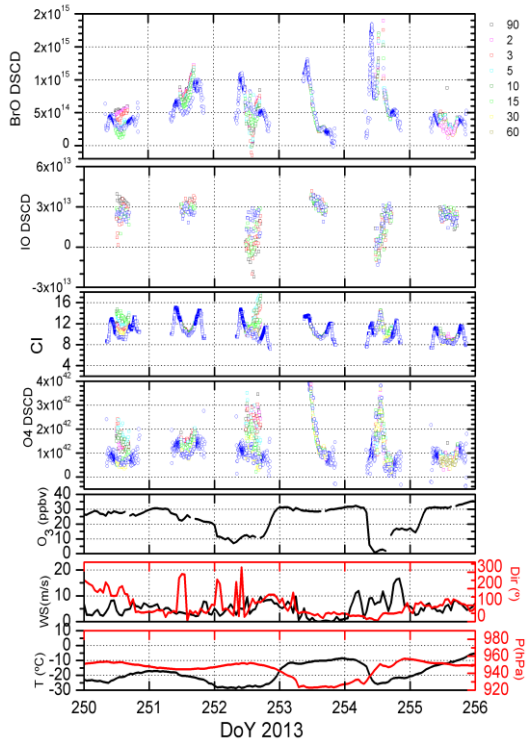

Figure 8: Tropospheric bromine enhancements and surface O3 depletion events observed in the beginning of September 2013 at Begrano II station.

Surface ozone depletion episode of day 254 is associated to an enhancement of tropospheric bromine during days 253 and 254. It is a quick event characterized by an increase of wind speed the previous night, associated to blowing snow. Then, wind speed close to the station remains below 5m/s whereas meteorological data report storm and blowing snow around the station. The bromine enhancement is possibly produced by heterogeneous reaction over the surface of the rising ice by wind as suggested by Yang et al., 2010 and Friess et al., 2011. During days 253-254, visibility decreases due to blowing snow and due to cloudiness as shown by O_4 retrievals and the evolution of colour index. Under these conditions vertical resolution of MAXDOAS measurements is severely affected.
Some tests have been performed using OEM to calculate BrO vertical profiles during the events of BrO enhancements during 2011 and for day 253 of 2013 (see Figure 9). Results are very promising but are still preliminary.

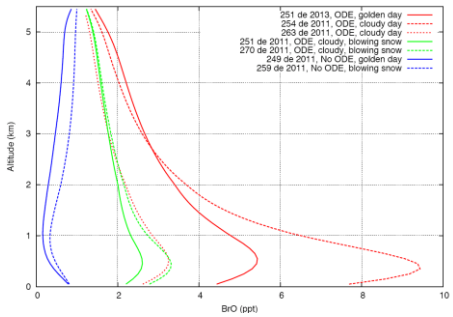

Figure 9: BrO profiles calculated using MAX-DOAS measurements.

These results are part of the work presented y Puentedura et al. at EGU 2014.

References:
Puentedura O., Yela M., Gil M., Pérez M., Navarro-Comas M., Iglesias J. and Ochoa H. "Halogen oxides from MAXDOAS observations at Belgrano station (Antarctica, 78ºS) in 2013". Ref: Geophysical Research Abstracts, Vol. 16, EGU2014-14635.

3.11. Seoul, South-Korea

Prof. Jung Jin Oh and Dr. Soohyun Ka (Sookmyung Women's University, Seoul) visited the Institute of Applied Physics (Bern) in January 2013. Prof. Oh would be glad to contribute to the NORS network as an active member. Prof. Niklaus Kämpfer and Dr. Axel Murk visited Prof. J. J. Oh at Seoul in May 2013. The purpose of the visit: technical improvements of the microwave radiometer at Seoul. Since then, in the frame of the collaboration with the Sookmyung Women University in Seoul, South Korea, the capacities of the microwave radiometry of water vapor and ozone have been expanded. UBern helped upgrading the existing radiometer for ozone monitoring. The microwave radiometer called SORAS is capable of retrieving stratospheric and mesospheric ozone profiles on a regular basis (Ka, 2012). The aim is to operate the system in the frame of NDACC in the near future. In addition to the ozone microwave radiometer, USeoul operates the microwave radiometer SWARA for continuous profiling of middle atmospheric water vapour (De Wachter et al., 2011). SWARA is already member of NDACC and provided monthly data files since 2006. The rapid delivery of SWARA and SORAS data files to RDDS is planned for the near future.

Compact and tranportable microwave radiometers

During the last decade, UBern developed and operated compact microwave radiometers which are invaluable for measurement campaigns at different geographic locations and as a traveling reference for the NDACC stations network. The activity increased during the NORS project and three transportable microwave radiometers were transported to La Réunion. The 22 GHz microwave radiometer MIAWARA-C profiles the middle atmospheric water vapour above the Maïdo observatory on La Réunion since August 2013. Before, MIAWARA-C was used for a validation campaigns at Sodankylä and Zimmerwald (Tschanz et al., 2013). The microwave radiometer WIRA of IAP-Bern (Rüfenacht et al., 2012) measures zonal and meridional wind above La Réunion since 2014 by precise determination of the Doppler shift of the 142 GHz ozone line. Before, WIRA carried out measurement campaigns at OHP and Sodankylä (Rüfenacht et al., 2012 and Rüfenacht et al. 2014). Further, the transportable ozone microwave radiometer GROMOS-C was developed at IAP-Bern using technical innovations (Fernandez et al., 2014). After a measurement campaign at Jungfraujoch in 2013, GROMOS-C changed to the new location La Réunion. It is not planned to deliver the data of the transportable microwave radiometers to the NORS Rapid Data Delivery System (RDDS) or to NDACC. However, the coincident measurements of the transportable microwave radiometers play a crucial role for optimisation and validation of the NDACC network. In addition, basic atmospheric research and testing of new locations of future NDACC sites are strongly fostered by the transportable microwave radiometers. A travel of GROMOS-C from La Réunion to the next NORS site Ny Alesund is planned for middle of 2015.

Capacity building in atmospheric research

In cooperation with NORS, the observation and simulation of the diurnal variation in stratospheric ozone were investigated by an international team of NDACC scientists organized by ISSI at Bern. Ground-based microwave radiometers of NDACC were used to quantify the diurnal ozone variations at Ny Alesund, Bern and Mauna Loa (Studer et al.,

2014; Parrish et al., 2014). Cross-validations with models, reanalysis data (e.g., MACC) and spaceborne instruments (SBUV, SMILES) were performed. It was found that diurnal ozone variations can be as strong as 15% in the polar stratosphere (Schanz et al., 2014). Since the daily ozone cycle may effect satellite-based ozone trend estimates, the team in Bern actively works on a correction for diurnal sampling biases.

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