PROJECT FINAL REPORT

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Project acronym: NORS

Project title: Demonstration Network Of ground-based Remote Sensing Observations in support of the Copernicus Atmosphere Monitoring Service

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Final publishable summary report

1. Executive summary

The project has succeeded in achieving all its objectives, as demonstrated by the final results:

- A Rapid Data Delivery System that is fully operational for the NORS stations and target products, and that is also adopted by other existing and new NDACC stations and for more target products (e.g., H_2O and FTIR NO_2). This system enhances the visibility and the use of the ground-based remote sensing data (NDACC) in general. It can be considered an important progress in the ground-based remote sensing community. We also see that some teams submit the data at a faster pace (daily, weekly, ..) than the monthly pace: we can expect that more NDACC partners will shorten the delay of data submission in the near future.
- Optimized GEOMS HDF templates for the submission of the NORS/NDACC data. One advantage of the standardisation of the format is that erroneous data submission is easily detected. This serves the homogeneity and better usability of the NDACC database.
- Improved maturity and quality assurance of the NORS target MAXDOAS products at the NORS stations, and integration of these products in the NDACC database and the Rapid Data Delivery System. This is the case today, e.g., for the MAXDOAS aerosol data at Xianghe.
- Significant progress in cloud detection and classification, and distinction from aerosol, in MAXDOAS data.
- Better characterisation of the information content and uncertainties of the NORS target products – including user documentation. This will be very valuable for all uses of NORS-type data: modelling, satellite validation, process and trend studies. These documents have been published on the NDACC database and on the NORS Validation Server.
- Better understanding and documentation of the differences between products from different remote-sensing techniques for the same geophysical parameter. In particular, for HCHO and NO_2 from FTIR and UV-Vis spectrometry, and for CO from mid- and near-infrared Fourier-transform spectrometry.
- A compilation of evaluations of satellite data used in the MACC-II assimilation analyses, versus NORS products. This will help understanding the quality of the MACC-II products.
- Homogeneous and harmonised re-analysed time series of NORS products since 2003, compliant with the progress made in the project as to the data products. These time series support the quality assessment of the reanalysis in MACC.
- Tropospheric column data at demonstration sites, derived from the integration of surface in-situ data with representativeness information and model profiles. The methodology to derive these data is also a result of this project. Integrated in-situ profiles (and intermediate results) are available for FTIR CO, O_3 and CH_4 data at Jungfraujoch and Izaña and for MAXDOAS lower tropospheric columns of NO_2 at Jungfraujoch, from http://lagrange.empa.ch/NORS_browser/ .
- Integrated ozone profiles and tropo- and stratospheric column data at NORS sites. The methodology and S/W to derive these datais also a result of this project and is available.
- A Web-based server for the validation of the target MACC (CAMS) products, that is fully operational and that has already been extended to additional target products (like H_2O and FTIR NO_2) and several more NDACC sites.

- The demonstration of quality assessment of the MACC-II products, including the reanalysis, using ground-based remote sensing data. The use of the NORS/NDACC data in the MACC reports for the validation of the NRT global atmospheric composition service is increasing with every issue of the report. In the latest report of September 2014, 5 chapters use NORS/NDACC data from several instruments for the validation of the MACC-III products for CO, formaldehyde, ozone, NO2 and aerosol.
- A spin-off of the NORS project is that the comparison algorithms and the interface developed for the NORS Validation Server will be largely re-usable for validation purposes of atmospheric composition satellite data. This means that an Atmospheric Satellite Validation Server can easily be 'derived' from the NORS Validation Server, with a minimal effort. This should also be very beneficial for supporting the Copernicus Sentinel missions. ESA has shown interest in re-using the NORS experience for this purpose.
- The atmospheric communities (ground-based, satellite and model communities) are much better aware of NDACC, and of its value.
- Additional NDACC stations in other continents are under development; they adopt from the start the expertise gained in NORS. Some are already submitting data, even in Rapid Delivery mode, to the NDACC database. Several operartional NDACC stations have joined the rapid delivery to the database .

Information about NORS and results are published on the NORS Webpages: nors.aeronomie.be.

2. Summary description of project context and objectives

The NORS project is a research and development project, for improving and supporting the Copernicus Atmosphere Monitoring Service (CAMS), called GMES Atmospheric Service (GAS) at the time of project start. At that time, CAMS (GAS) did use almost no ground-based remote-sensing data for the validation of its model outputs, but merely sonde data and in-situ surface data.
So NORS would fill this gap. The ultimate goal of NORS was therefore to demonstrate the suitability of data from ground-based remote sensing networks for the quality assessment of the CAMS products.
As such, in first instance, the project focused on a selection of data from the Network for the Detection of Atmospheric Composition Change (NDACC), the so-called target data. NORS has improved the availability and timeliness of the target data, their characterisation and usability, and their integration with in-situ and other data sources. It has also delivered integrated ozone data products. The quality assessment of the CAMS products is being performed on a daily automatic basis by the so-called NORS Validation Server that is fully operational since end of 2013, i.e., well before the end of the NORS project. Customer-driven validation processes are also possible via this Server, for the so-called VIP users.

A lot of effort has been made to reach the ultimate aim of NORS which was to (1) involve the larger NDACC community and new observatories outside Western-Europe in the effort, for enabling validation of the CAMS products on the global scale, and (2) to guarantee long-term data availability and sustainability of the NORS Validation Server.
As to (1), NORS has been very successful: many more NDACC (or candidate NDACC) stations than the initial four are providing data that are compliant with the requirements of the NORS data and Validation Server and several more are contributing data on a rapid delivery basis to the Server.
Regarding (2): we have succeeded in embedding the NORS Validation Server and validation reports in the MACC-III project and there is good hope that NORS-like activities will be sustained

in CAMS. A sustained support for the ground-based remote-sensing data acquisition and analysis is not guaranteed yet.

3. Potential impact

Societal implications of NORS

The NORS project has several societal implications: (i) direct socio-economic impact, (ii) indirect socio-economic impact, and (iii) societal implications for the future.

Direct socio-economic impact

The effective project duration has been 37 months (33 months planned initially plus a project extension of 4 months). During these 37 months, several partners involved in NORS could hire new researchers to work on the project or could extend the work contracts of one of their researchers. In other words, the project created jobs for researchers. Also the SME involved in the project benefitted from the project for job preservation.

Indirect socio-economic impact

Especially at the S&T offices and at the coordinator's location, IT support had to be reinforced (allocation of storage space, implementation of new S/W, …) thereby 'feeding' the IT business.

Societal implications for the future

The project NORS has led to a follow-up in the MACC-III project. As such, (1) at least one job has been preserved, for the person operating the NORS Validation Server in MACC-III, and (2) the MACC-III products that are provided as a service to society (scientists, policy makers, public at large) will benefit from the quality assessment that is provided via the NORS expertise.

It is also planned that the expertise and tools developed in NORS will be further enhanced and improved in the Copernicus Atmospheric Monitoring Service (CAMS), thereby providing information about the quality of the CAMS products, for the benefit of society, and providing job(s) for researchers.

Another implication of NORS is that many partners in the Network for the Detection of Atmospheric Composition Change have achieved a system to provide Rapid Delivery of their data: this experience will make them more 'competitive' in the acquisition of future projects, and enables them to create job perspectives for their collaborators.

The Rapid Delivery of data will make the NDACC data more accessible and usable for Earth Observation applications, potentially for the benefit of society.

The new data products that have been developed in the NORS project, e.g., aerosol extinction profiles in the lowermost troposphere, are also attractive for future applications.

Main dissemination activities

Dissemination activities have been manifold:

- Publications in scientific journals, mostly peer-reviewed journals

- Presentations, oral and poster, at scientific meetings, international symposia and workshops; in particular at NDACC Steering Committee and Working Groups meetings, and at MACC meetings.
- A brochure for the wider public
- A dedicated public web site
- Information about the NORS project in UK stakeholder-oriented journals (The Parliament Magazine 17 December 2012, Adjacent Government Company (http://www.adjacentgovernment.co.uk/wp-content/uploads/2014/01/Belgian-Institute-ebook-web.pdf))
- Link on MACC-II/-IIII website
- Information and links on NDACC Website and in NDACC Hot News and Newsletter
- The successful organisation of a dedicated NORS/NDACC/GAW Workshop in Brussels (Nov. 5-7, 2014), following the NDACC Steering Committee meeting at the same location (Brussels, Nov. 3-5, 2014)
- Participation to MACC monthly teleconferences, to report occasionally about NORS

Exploitation of results of the NORS project

The results of the NORS project will be exploited in MACC-III and the Copernicus Atmospheric Monitoring Service, thereby achieving a major goal of the project.

The NORS Validation Server provides building blocks for other validation activities, e.g., of satellite data.

The data formatting efforts in NORS and the use of the NDACC data files in an automated way in the NORS Validation Server has already resulted in an improved consistency of the NDACC database. This effort will be continued.

The new data products (e.g., aerosol extinction profiles) and methodologies (e.g., cloud filtering, integration of ozone data) that were developed in NORS can be further exploited for more advanced scientific research purposes.

NORS has also improved the characterization of the data: this will be beneficial for future exploitation of the NDACC (and NORS-type) data, e.g., the horizontal extent of the information content will be used to better support satellite and model validation, e.g., for the Sentinel (precursor) missions.

This characterisation has also helped identifying pollution patterns around cities like Athens.
A side-effect of NORS is a more advanced automation of data acquisition, analysis and archiving: this increases the cost-efficiency of the generation of this kind of data, which is a major advantage for enhancing the exploitation of the data. It will be exploited in the in-situ component of the Copernicus Services.

4. Work progress and achievements during the project

4.1 WP1: Project coordination

All objectives of this work package have been met. All partners have smoothly and adequately collaborated. The Project Manager and Project Coordinator have regularly communicated with REA and the EU and have timely addressed all open questions or issues.

The final scientific report of the first reporting period has been delivered on 24 December 2012 to REA and had been very well received.

The following delays have been requested and accepted for the following deliverables:

- D4.4 Data representativeness: M21 > M24
- D5.1 Description of methodology for data integration M24 > M25
- D6.2 Integrated Ozone profile data: M30 > M36
- D6.3 Integrated Ozone tropo- and stratospheric column data: M30 > M36
- D7.1 Re-analysed time series: M27 > M28
- D8.3 Validation server in test-phase: M18 > M21
- D8.4 Ready-to-use Validation Server: M21 > M25
- D9.1 Feedback report regarding validation server: M20 > M24

The lists of deliverables and milestones are given in Table 5. Deliverables and Table 6. Milestones of Section 5.

The Data User Guide, the Uncertainty Budgets and the Data Representativeness deliverables documents have also been posted on the NDACC Web pages.

Next to the Kick-Off Meeting and two Progress Meetings, fourteen Project Management Team (PMT) teleconferences have been organized, among which three with participation of the Steering Committee (SC). The meetings and teleconferences have been scheduled well in advance and the agendas have been distributed in advance as well. Minutes have been written by the Project Manager and, after approval by all participants to the teleconference, distributed to the consortium and the Steering Committee and posted on the project's website.

The Final Project Review/Meeting has been organised in the form of an international NORS/NDACC/GAW workshop on 5-7 November 2014, at the Belgian Science Policy Offices in Brussels. More than a hundred participants attended this Workshop. The Workshop has been aligned with an NDACC Steering Committee meeting (3-5 Nov. 2014, same location).

4.2 WP2: Project outreach

<u>NORS Webpages:</u>

The NORS webpages (http://nors.aeronomie.be), that are hosted by the coordinator, BIRA-IASB, and managed by the Project Manager, have been regularly updated with new information and documents throughout the entire project. They follow the template of the Copernicus website.

The NORS Website has a public and a private section. The purpose of the public part of the website is to advertise NORS to the broad public and the scientific community and to highlight NORS achievements. It is also used to link to the websites of partners.

The private part of the website is a password protected area that is used to exchange information with and between partners and in general with people who are related to the project (REA, Steering Committee, etc.). It is used to make all documents available to all project's partners (reports, deliverables, presentations during progress meetings, minutes of meetings etc.).

New users can easily request an account through the Login Form on the Documents page.

The homepage displays the emblem of the European Community and of the Seventh Framework Programme. It mentions that this project has received research funding from the European Community's Seventh Framework Programme ([FP7/2007-2013]) under grant agreement n°284421.

NORS on partners' webpages:

NORS on INTA's webpage:
http://www.inta.es/atmosfera/29/670/359/contenidos.aspx

NORS on EMPA's webpage:

- Brief project description on the group website, focus on Empa's contribution: http://www.empa.ch/plugin/template/empa/*/127021
- Browser for tropospheric products inter-comparison (result of WP5) is available under: http://lagrange.empa.ch/NORS
  The browser enables the selection of individual FTIR and MAXDOAS scans, displays the according surface sensitivities of individual partial columns and provides comparison plots of in-situ and model/in-situ profiles with ground based remote sensing profiles.

NORS on the NDACC Webpages

NORS and rapid data delivery to the NDACC database, M. De Mazière, at http://www.ndacc.org/ Hot News.

An article about NORS has been published in the NDACC Newsletter 2012 (author: M. De Mazière); a second one about the final achievements of NORS will be published in the 2014 NDACC Newsletter.

NORS Flyer

The NORS flyer is a colourful leaflet for advertising the project to the broad public and scientific community. It has been distributed at EGU 2012 and other occasions.

REA has received one hundred copies of the flyer for internal distribution within the European Commission.

The flyer displays the emblem of the European Community and of the Seventh Framework Programme. It mentions, as required, that this project has received research funding from the European Community's Seventh Framework Programme ([FP7/2007-2013]) under grant agreement n°284421, that it reflects only the project consortium's views and that the European Community is not liable for any use that may be made of the information contained therein.

A digital version of this flyer is available on the NORS website.

Promotional FP7 Space brochure

NORS has contributed to the "Eye on Space" brochure about the Space Research projects under the 7th EC Framework Programme for Research.

A digital version of this brochure is available on the NORS website.

Membership of MACC-II Management Board

At the MACC-II KO meeting, M. De Mazière has been elected as the Chairwoman of the MACC-II Beneficiaries Committee, making her also member of the MACC-II Management Board. As such, she reports about the NORS progress at the Management Board meetings of MACC-II and takes care of a good connection between NORS and MACC-II and -III.

Other

An e-book has been published in Adjacent Government Company (http://www.adjacentgovernment.co.uk/wp-content/uploads/2014/01/Belgian-Institute-ebook-web.pdf) to make publicity to the European Commission. This e-book is also available on the NORS webpages under Outreach/Brochures.

The coordinator has also written articles about NORS in The Parliament Magazine, (17 December 2012), in the 6th March 2013 issue of Pan European Networks and an editorial page in the September 2014 issue (issue 12) of Pan European Networks, entitled: 'Validation: the key to reliability'.

Several partners have published peer-reviewed papers in international journals and/or have given presentations at international workshops and Symposia about results obtained in NORS. Achievements of NORS have also been reported at NDACC Steering Committee and Working Group meetings. The list is available on the NORS Webpages and is provided here below in the section 'Use and dissemination of foreground'.

4.3 WP3: Rapid data delivery at 4 NDACC stations

The Rapid Data Delivery System (RDDS) is at the heart of the NORS project since it is aiming at providing the ground-based remote sensing data of the selected ground stations to the NORS partners, and to all potential users, in particular to the MACC consortium and to MACC users. The ground-based remote sensing data are also provided for inter-comparison, calibrations, and cross-validations with coincident MACC model data and satellite data, in particular the ESA Sentinel satellites. The data files must be all in the same data format (HDF GEOMS format). The data files within RDDS should be quality controlled. Two levels of quality are implemented in RDSS: the so-called Rapid Delivery (RD) data which are well-suited for validation and quick-look purposes but are possibly of somewhat lesser data quality, are missing some ancillary information or possibly have less information content than the usual qualified data of the Network for the Detection of Atmospheric Composition Change (NDACC). They are delivered within one month after data acquisition and are stored in the RD directory of the NDACC database. Figure 1gives an overview of the submission of HDF GEOMS files to the RDDS and NDACC archives. When the remote sensing data are consolidated and within a time limit of 4 weeks, the data provider can directly submit the HDF GEOMS files to the NDACC archive (without a previous submission to RDDS).

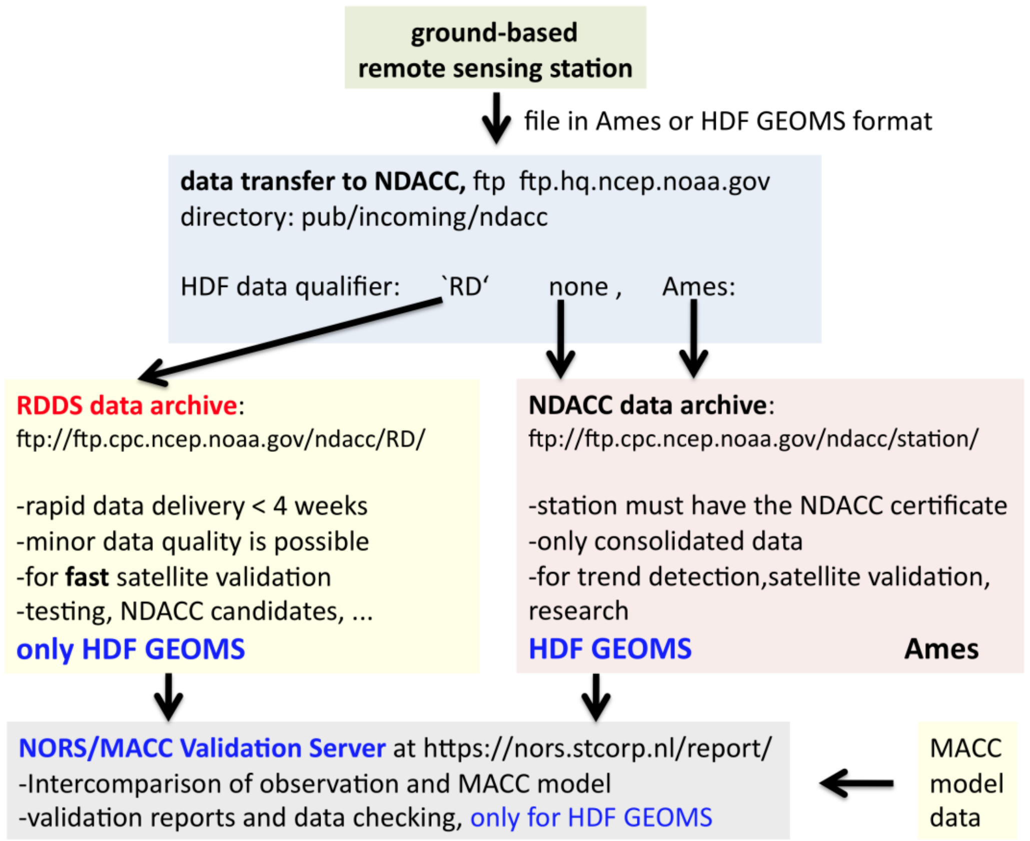

Figure 1: Flow chart of data files from the station to the data archives of NDACC and RDDS. The NORS Validation Server automatically looks for the submitted HDF GEOMS files and builds time series of gas species using the latest and most reliable data versions (consolidated data are preferred against the rapid data). At present (November 2014), 15 stations are submitting HDF GEOMS files.

In the other case, the data provider firstly submits the HDF GEOMS files to RDDS within four weeks. Then the data provider has the opportunity to consolidate and re-process the data files before a final submission of the HDF GEOMS files to the NDACC data archive. Submission to the NDACC data archive is only supported for approved measurement instruments which fulfill the NDACC requirements for a high data quality. NDACC aims at the detection of long-term trends in atmospheric composition. The detection of long-term trends requires a higher data quality in terms of long-term stability of the instrument and the retrieval technique. On the other hand, RDDS aims at a fast validation of the satellite and the MACC model data. Complementary to NDACC, RDDS is open to new stations, for example, the test of a NDACC candidate station can be performed within RDDS.

Compared to the NASA Ames data format, the new HDF GEOMS format contains more metadata and conveys retrieval information such as an averaging kernel matrix for each trace gas concentration profile which is mandatory for accurate cross-validation with satellite measurements and model data.
In the beginning of the project, all NORS partners learnt about the characteristics of the new HDF GEOMS format. Reading and writing programs of measurement data files had to be adjusted to the new HDF GEOMS format. Particularly the generation of the HDF GEOMS files was a considerable effort since it required software updates or installations (e.g., Image Data Language Virtual Machine, IDL VM). Generally all NORS partners are convinced that the HDF GEOMS format is a good investment into the future and that it is a progress compared to the old NASA Ames format of

the NDACC data centre. Here it should be stated that the development and usage of HDF GEOMS format were strongly supported by the colleagues of the NDACC data centre (Roger Lin and Jeannette Wild), of the NASA Aura Validation Data Centre that was the first to adopt the new HDF GEOMS format (e.g., Ian Boyd), and by ESA.
Considerable efforts were also spent in optimization of the HDF GEOMS files which are of course depending on the measurement technique. A consensus had to be reached as to an optimal and standardized format by all NORS partners. For example, no changes were necessary for the HDF GEOMS template of microwave radiometers while there were discussions in case of the HDF GEOMS template of the FTIR instruments (e.g., air mass variable). Most important is that all NORS partners agree that the data files from one ground-based remote sensing technique must be standardized (e.g., same variable names, definitions, units) and that this standard is defined in a technique-specific template (see also WP4).
M. De Mazière and colleagues from BIRA negotiated with the NDACC database managers Jeannette Wild, Roger Lin, and others about the implementation of RDDS within the NDACC data centre. The advantage of the close cooperation between the NORS RDDS and NDACC is on both sides: NORS can use the existing and reliable NDACC infrastructure for file submission, distribution, and archiving, while NDACC is interested in the practical experiences gained with the new HDF GEOMS format and the Rapid Delivery data submission. Of course RDDS has a larger potential for sustainability, public outreach, user acceptance and support from researchers if the RDDS is set up in cooperation with NDACC. The main objective of RDDS is the improvement of the timeliness of data availability and of data access of ground-based remote sensing data in support of MACC and future CAMS quality assurance, of satellite teams and the upcoming ESA Sentinel missions and of any other user. Significant efforts were also necessary for planning and changing of the NDACC data directory tree for RDDS. By September 2012 the final structure was agreed and implemented. Roger Lin of NDACC provided support in testing the RDDS data submission. The RD directories can be accessed via ftp://ftp.cpc.ncep.noaa.gov/ndacc/RD where the screen image of RDDS in Figure 2 was obtained with the German version of the Firefox web browser.

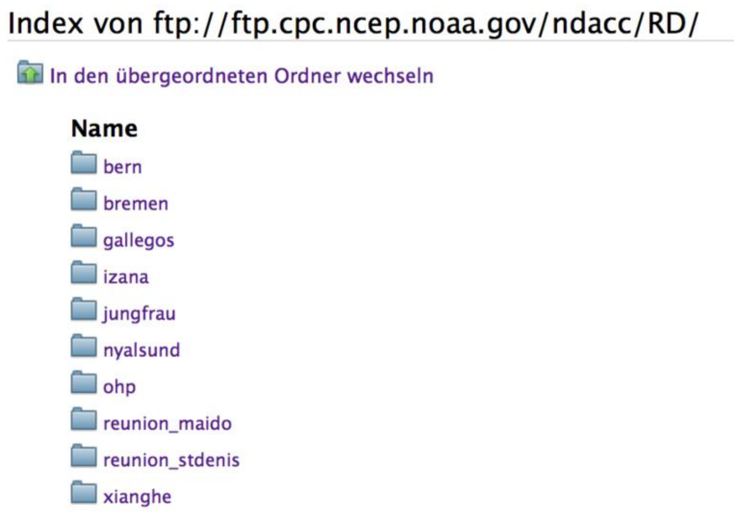

Figure 2: HDF directories for HDF GEOMS files of Rapid Delivery (RD) data of RDDS in October 2014. The figure shows the path to those NORS stations of the Rapid Data Delivery System (RDDS) which submit RD data (ftp://ftp.cpc.ncep.noaa.gov/ndacc/RD/).

The RD data are catalogued in the RD directory on the public server ftp://ftp.cpc.ncep.noaa.gov/ndacc/RD/, and carry the substring RD as the initial characters of the string entry in the DATA_QUALITY attribute of the (GEOMS HDF) data file

(DATA_QUALITY=RD). A ‘RD_readme’ file on the NDACC database (ftp-server ftp://ftp.cpc.ncep.noaa.gov/ndacc/) and an explanatory paragraph on the NDACC Webpages (www.ndacc.org) explain the contents and usage of this ‘RD’ directory to the data users. The consolidated data are submitted, as usual, to the station directories.

The RDDS set-up received a lot of attention and positive comments during the NDACC Steering Committee meeting in October 2012. Several NDACC partners showed a lot of interest in participating to the rapid data delivery effort

Generally, major efforts, patience and a lot of time of the NORS partners were needed for the progress from the old file formats to the HDF GEOMS format, to optimize the new format, to make negotiations with the NDACC database managers and to establish the RDDS.

The development and implementation of the NORS Validation Server has highlighted the need for some changes in the GEOMS HDF templates in the course of the NORS project.Even in the beginning of the third year of NORS, small changes of the data format were still discussed and implemented for the sake of optimization.

From Figure 2 above, it is obvious that not only the 4 NORS pilot stations are now submitting data to the RD directory! The RDDS attracted data submission from instruments which were not included in the original NORS proposal. The H_2O microwave radiometer MIAWARA of University of Bern at Zimmerwald (Switzerland) operationally delivers its vertical profiles of middle atmospheric water vapour to RDDS. The station Xianghe (China) provides UV/VIS DOAS measurements of aerosols and NO_2 to RDDS. The DOAS instrument is operated by BIRA. In addition, a significant number (14) of NDACC stations are now submitting their consolidated data in the GEOMS HDF format to the station directories, which makes these data ingested and analysed by the NORS Validation Server. Table 1 gives an overview about the gas species and aerosols measured at the current RDDS station with various remote sensing techniques. Table 1 does not include the stations which directly submit HDF GEOMS files to the NDACC station directory.

Table 1: Trace gas and aerosol measurements obtained by different remote sensing techniques at the RDDS stations. The data products are column densities and/or vertical profiles of concentration or volume mixing ratio.

	DOAS	MAX DOAS	Lidar	MWR	FTIR
Ny Alesund	**(O_3, NO_2)**			**O_3**	**(CH_4, CO)**
Bremen					**O_3, CO, CH_4**
Bern (Alps 1)				**O_3, H_2O**	
Jungfraujoch (Alps 2)	**O_3 , NO_2**				**CH_4, CO, NO_2, O_3**
OHP (Alps 3)	**O_3 , NO_2**		**O_3**		
Izana	**O_3 , NO_2**				**CH_4, CO, NO_2, O_3**
Xianghe		**aerosol, NO_2, HCHO**			
Maido, La Réunion			**(O_3)**		**CH_4, CO, NO_2, O_3, HCl, HF, HNO_3**

St. Denis, La Réunion	**O_3 NO_2**				
Rio Gallegos	**O_3 , NO_2**				

The NORS document D3.3 "Final Documentation of the Data Delivery System" describes in detail the processing and the delivery of the remote sensing data. Most stations succeeded in the automatic processing of the GEOMS HDF files by using the software tools provided by NDACC and AVDC. In summary, the infra-structure and functions of RDDS are working without a problem. The NORS partners take care of the evaluation of their data and the operational data delivery. The data providers already benefit from the HDF GEOMS format and the NORS validation server which allow a fast and convenient quality check of the observational data sets.

4.4 WP4: Advanced characterisation of NORS data products

Task 4.1: Data formats

A first important step in WP4 was to define the format, templates and content of the NORS archives. These formats are for data exchange within the project and for making data available to the end users. This effort led to the production of the data format definitions document issued in May 2012 (D4.1). The existing GEOMS templates were adopted, for reasons given in the document available on the NORS website. Further tuning/harmonization of the formats was performed throughout the project, for example by adding cloud and AOD flags and a field for spatial displacement of the measurement volume. Additional needs for changes in the file formats resulted from tests with the NORS validation server, and the respective amendments to the format were implemented. Further optimisation has to be expected also in the future depending on application of the data.
Software tools have been developed by all partners for conversion of proprietary formats to the per-technique GEOMS format. The new format was then adopted for delivery of both, RD and reanalysis data for all involved NORS/NDACC stations by the UV/Vis groups. Data formats in the FTIR community had already been unified and very little adaptations were necessary. Data from microwave instruments have successfully been converted to an appropriate GEOMS format.
The LIDAR Working Group of NDACC has almost finalised an ISSI (International Space Science Institute, Bern) project about the homogenisation of the characterisation of the LIDAR uncertainties, and the HDF templates are being updated in agreement with this project's results and with the discussion with the GEOMS Metadata Board. For all techniques, data templates are available from the AVDC and NORS Websites.
In order to make the use of the data as simple as possible, data user guides for users of NORS products were created including information on measurement principle, data products, data formats, and uncertainties. These user guides are available from the NORS and NDACC webpages.

Task 4.2: Information content and harmonization of networks/techniques

The homogenization of retrieval settings and parameters is currently under progress within the NDACC UV-VIS Working Group. Regarding total O_3 columns, recommendations for DOAS settings and AMF look-up tables were provided in 2010. They have been successfully applied to CNRS, INTA, BIRA-IASB, IUP-Bremen stations with a significant improvement of the data quality and consistency leading to a better agreement with satellite data (Hendrick et al., 2011). Similar recommendations and AMF climatology for stratospheric NO_2 column retrieval have been released in spring 2012. They have been already applied to BIRA-IASB,INTA, and IUP-Bremen stations and they are currently being tested on SAOZ data sets. These recommendations and AMF tools have been made publicly available on the NDACC UV-VIS Working Group website (http://www.ndacc.org/). Regarding the homogenization of DOAS retrievals, it should be also noted that a set of updated recommendations for the retrieval of HCHO slant columns has been recently formulated as a result of the intercomparison exercise of HCHO MAX-DOAS observations performed during the CINDI campaign held in Cabauw in summer 2009 under the auspices of the NDACC (Pinardi et al., 2012).

INTA has implemented a new method for NO_2 and O_3 surface concentrations estimation from MAXDOAS measurements on mountain sites (Gomez et al., 2014). Validation with in-situ instrumentation has been performed and good agreement was found (see Figure 3);

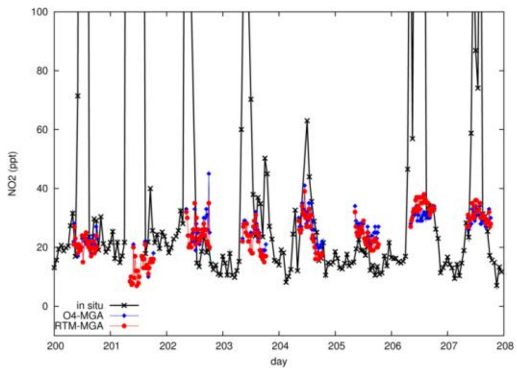

Figure 3: Surface NO2 mixing ratios at the Izaña observatory for days 200 to 207 in 2011. The black crosses correspond to the in situ measurements. The blue diamonds correspond to the NO2 mixing ratios obtained with the O4-MGA (Modified Geometric Approach) . The red solid circles correspond to the NO2 mixing ratios obtained with the geometrical approach modified by using RTM modelled light path lenghts Taken from Gomez et al., 2014.

Algorithms were created at IASB and MPI Mainz to identify and classify clouds in UV-VIS observations under different observation geometries (zenith-sky, horizon observations at high altitudes, MAX-DOAS observations). Under some conditions, these algorithms also retrieve aerosol optical properties, in particular Aerosol Optical Depth (AOD). Results were published in Wagner et al., 2014 and Gielen et al., 2014. As shown in Figure 4 and Figure 5, both methods are able to differentiate between different types of clouds and also aerosol situations. Such data are needed for flagging of MAX-DOAS measurements and are also useful for cloud studies.

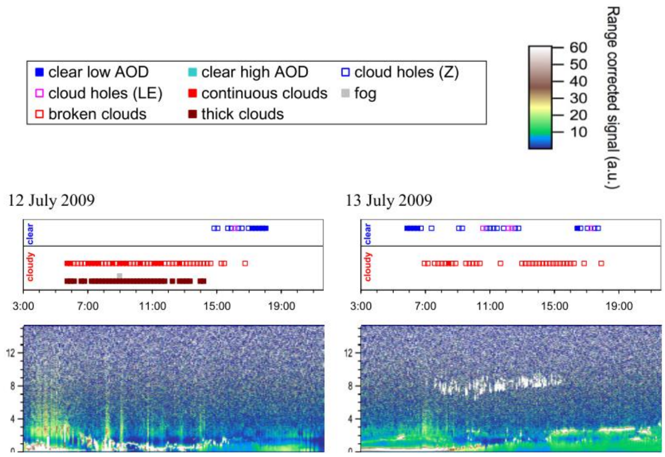

Figure 4: Results of the cloud classification (top) for two days of the CINDI campaign together with the backscatter signal measured by the backscatter lidar between 0 and 15 km (bottom). Figure taken from Wagner et al., 2014.

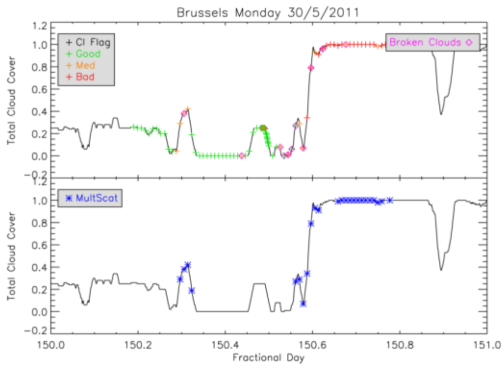

Figure 5: Total cloud-cover values from thermal infrared measurements in Brussels are given in black points. Top: overplotted in coloured crosses are the respective CI-flag values as derived from the IASB cloud-screening method (green/orange/red=good/med/bad). Data with a broken-cloud flag are marked with a magenta diamond. Bottom: blue asterisks are data points with a multiple-scattering flag.

BIRA-IASB and ULg, have performed a comparison of ground-based FTIR and UV-VIS (SAOZ) stratospheric NO_2 vertical columns measured in parallel at the Jungfraujoch station over the 1990-2009 period. FTIR and SAOZ data sets are in good agreement, with FTIR measurements lower than SAOZ by 7.8 ± 8.2% on average (Figure 6). The information content associated with FTIR and SAOZ profile retrievals has also been compared. Both techniques show similar column averaging kernels and degrees of freedom for signal (DOFS) values indicating that they have similar vertical resolution and sensitivity to the vertical distribution of NO_2. Therefore, retrieved FTIR and SAOZ NO_2 columns can be directly compared. More details on this study can be found in Hendrick et al. (2012).

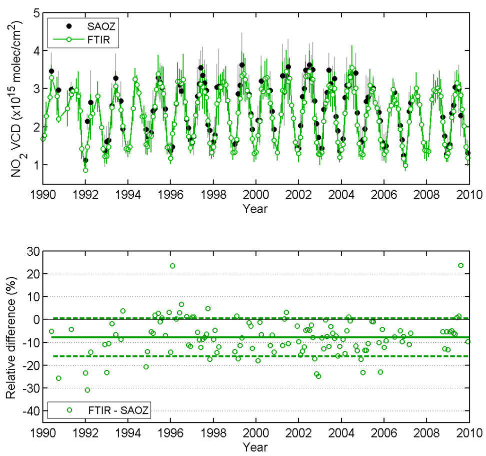

Figure 6: Comparison between FTIR and SAOZ monthly mean stratospheric NO2 columns at Jungfraujoch (46.5°N, 8°E) for the 1990-2009 period. To ensure photochemical matching, i.e. comparison in the same photochemical conditions, the SAOZ columns, representative of twilight conditions, are converted on a daily basis to the mean FTIR measurement SZA using the BIRA-IASB stacked box photochemical model PSCBOX. The error bars correspond to the 1-sigma standard deviation (natural variability). The relative differences appear on the lower plot with solid and dashed green lines corresponding to the mean FTIR – SAOZ difference and its 1-sigma standard deviation, respectively, which is -7.8 ± 8.2%.

A similar comparison between MAX-DOAS and FTIR observations at Jungfraujoch has been performed for HCHO by ULg and BIRA-IASB. As the vertical sensitivity of the two measurements is very different, the total columns cannot be directly compared. However, combination of the two datasets allows for a more detailed characterisation of the HCHO vertical profile and comparison with atmospheric models showed that the results from the two instruments are consistent but that the models have some biases (see Figure 7). More details can be found in Franco et al., 2014.

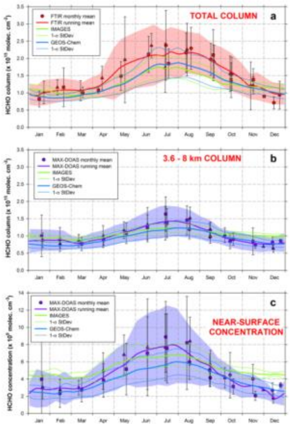

Figure 7: Monthly-mean column abundances of HCHO and associated 1−σ SD bars displayed on a one-year time base, according to the FTIR and MAX-DOAS retrievals (a and b, respectively) above Jungfraujoch from July 2010 to December 2012. The circle, triangle and square symbols correspond to the monthly means from 2010, 2011 and 2012, respectively while the thick curves show a running mean fit to the daily measurements, using a 15 day step and a two-month wide integration interval. The HCHO amounts calculated from the smoothed CTMs profiles are displayed in each frame as thick blue (GEOS-Chem) and green (IMAGES) lines. The same figure, but for the HCHO concentration derived from MAX-DOAS and the CTMs within the 3.6–8km near-surface layer, is drawn in (c). Figure taken from Franco et al., 2014.

Since NO_2 displays a strong diurnal cycle in the stratosphere, the comparison between MACC-II model data with NORS measurements performed by the NORS validation server (WP8) requires a photochemical correction tool in order to convert MACC-II data points to the times of the NORS data points. For these purposes, BIRA-IASB has developed such an NO_2 photochemical correction tool. In collaboration with M. P. Chipperfield (University of Leeds), look-up tables of stratospheric NO_2 vertical profile and column diurnal variations have been calculated ‘off-line’ using the BIRA-IASB stacked box photochemical model PSCBOX daily initialized with SLIMCAT 3D-CTM chemical and meteorological fields. Modelled NO_2 vertical profile and column diurnal variations are then averaged over a period of 10 years (2000-2009) for each {latitude, day number} pair. An interpolation routine written in Fortran has been created in order to extract the appropriate photochemical correction factors and their corresponding uncertainties. The look-up tables and extraction tool have been released to the NORS and NDACC communities.

Using such modelled stratospheric NO_2 columns, an algorithm was developed at IASB to retrieve tropospheric NO_2 columns from UV-VIS zenith-sky observations. While the approach has been applied successfully, some differences to tropospheric NO_2 retrievals using MAX-DOAS observations remain and need to be fully understood. The potential of this technique is to make use of the large existing data set of zenith-sky NO_2 observations at many stations.

Some MAX-DOAS stations are now equipped with instruments facilitating measurements in many azimuthal directions. As shown in Figure 8, such observations reveal large spatial gradients in NO_2 as well as temporal shifts in pollution episodes linked to horizontal transport. Such information is useful for comparisons with models and satellite data but also for analysis of pollution events and their impact on atmospheric composition.

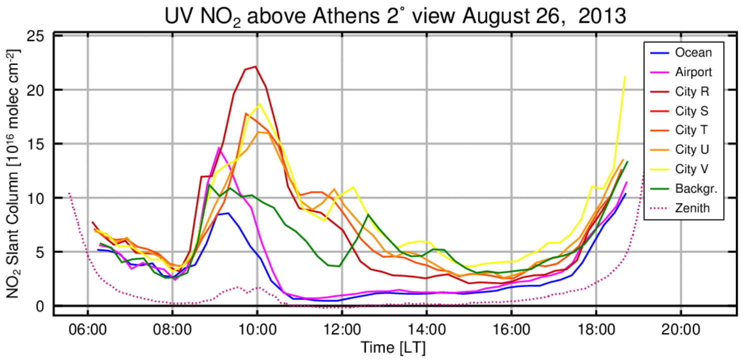

Figure 8: IUP Bremen MAX-DOAS observations taken from Penteli Hill in Athens, Greece in different azimuthal viewing directions. Large differences can be seen as result of the horizontal inhomogeneity in combination with emission changes and transport.

A standardization of the vertical resolution and accuracy determination is currently under progress within the NDACC LIDAR Working Group. This work will also contribute to the determination of error and vertical resolution values implemented in GEOMS/LIDAR HDF files.

A comparison between NDACC and TCCON retrieval strategies for CO was made, first based on IUP Bremen data and then extended to other NORS/TCCON FTIR stations.
An updated strategy to retrieve CH_4 from FTIR observations using Hitran08 line parameters has been evaluated.
FTIR retrievals for NO_2 and HCHO were harmonized with respect to choice of fitting regions and a priori profiles.

In summer 2013 an extensive MAX-DOAS intercomparison campaign (MADCAT), organized by MPIC, was held in Mainz (June to September 2013), see http://joseba.mpch-mainz.mpg.de/mad_cat.htm. During the intensive phase (early June to early July), more than 10 groups operating 14 instruments participated in this exercise. These include all NORS MAX-DOAS teams, but also many scientists who had just recently started MAX-DOAS measurements and data analysis. Many of them come from countries (e.g. Belarus, China, India, Pakistan – see WP 10, Task 10.1) with severe air pollution and a strong need for reliable MAX-DOAS results.
During the extensive phase of the campaign, regular meetings were held, where important topics, (e.g. instrument calibration and adjustment, spectral analyses, profile inversion) were discussed. In post-campaign meetings during the DOAS workshop in Boulder, USA, and the EGU General Assembly in Vienna, 2014, future activities and joint publications were discussed. Besides intercomparison of the results of the spectral retrievals, also profile inversion schemes will be compared. Here one specific focus is on the retrieval and interpretation of the horizontal gradients of trace gases and aerosols. Such gradients are analysed from multi-azimuth MAX-DOAS measurements and car-MAX-DOAS measurements.

UH has harmonised the retrieval settings for stratospheric trace gas measurements at the two Antarctic stations Neumayer and Arrival Heights. The analysis settings are based on the latest NDACC recommendations. The conversion of NO_2 and ozone SCDs to VCDs has been performed using the NDACC airmass factor database. The agreement of ozone VCDs for both stations with multiple satellite datasets is better than 4% (see Figure 9). NO_2 and ozone data for the period from 1999 – 2013 have been uploaded to the NDACC database. The Arrival Heights dataset will be made available to the public via the NDACC database after it has been accepted as NDACC instrument, for which a certification is foreseen for the near future.

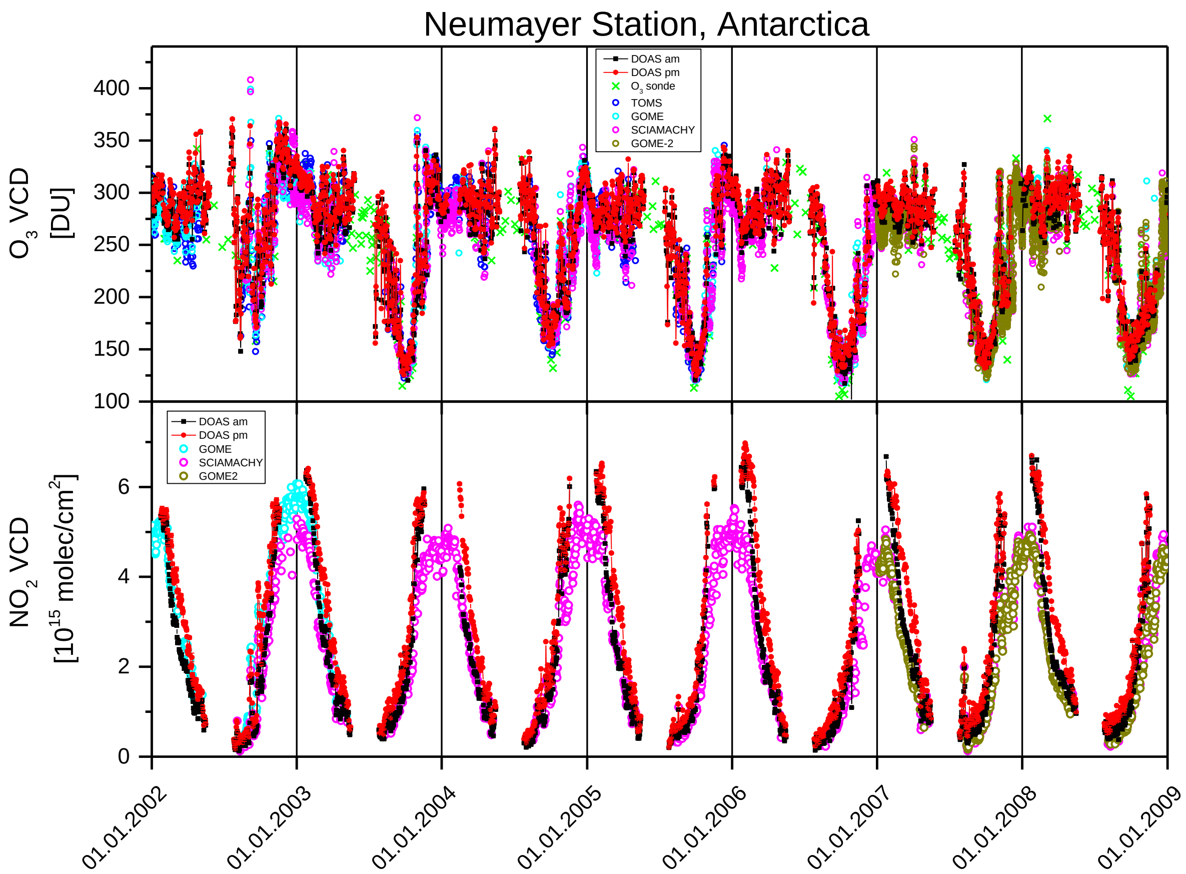

Figure 9: Stratospheric ozone (top) and NO_2 (bottom) VCDs from 2002-2009 and comparison with multiple satellite measurements (TOMS, GOME, SCIAMACHY, and GOME-2) as well as ozone soundings. The differences between ground-based and satellite based NO_2 VCDs is due to the differences in measurement times as ground-based measurements are shown for a solar zenith angle of 90°.

UH and the German Weather Service (DWD) jointly operate a long-term MAX-DOAS instrument at the meteorological station Hoheinpeißenberg. Data from this instrument has been systematically processed and vertical profiles of trace gases and aerosols were retrieved using the HeiPro optimal estimation algorithm. A particular emphasis was on the standardisation and automatisation of both spectral analysis and vertical profile retrieval. The data has been validated using co-located in situ trace gas and aerosol measurements as well as sun photometer and Lidar observations, see Figure 10 and Figure 11. A particular advantage of the measurements at Hohenpeißenberg is the fact that the observatory is located at a mountain approximately 250 m above the surrounding terrain. Additional downward looking viewing directions of the MAX-DOAS instrument therefore allow for an accurate retrieval of trace gas and aerosol amounts not only above, but also below the altitude of the instrument.

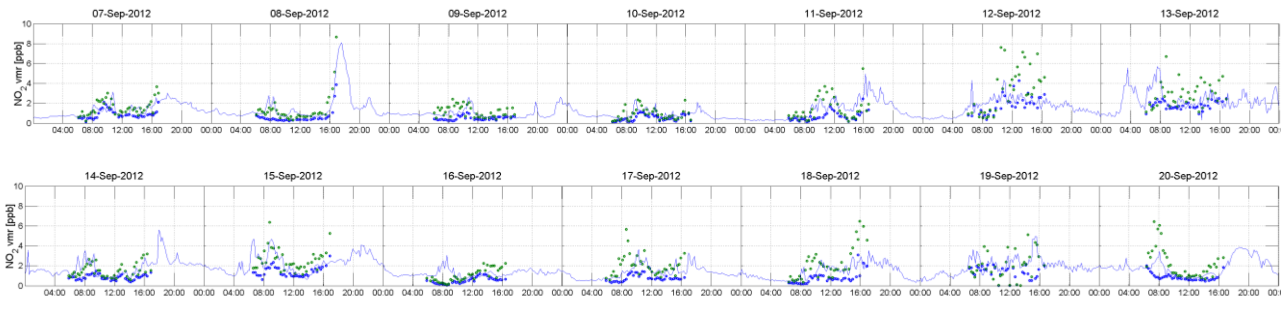

Figure 10: Comparison of NO_2 VMR at Hohenpeißenberg observed in situ (blue line) with MAX-DOAS retrievals in the layer below (green circles, 0 – 200 m) and above (blue circles, 200 – 300 m) the instrument.

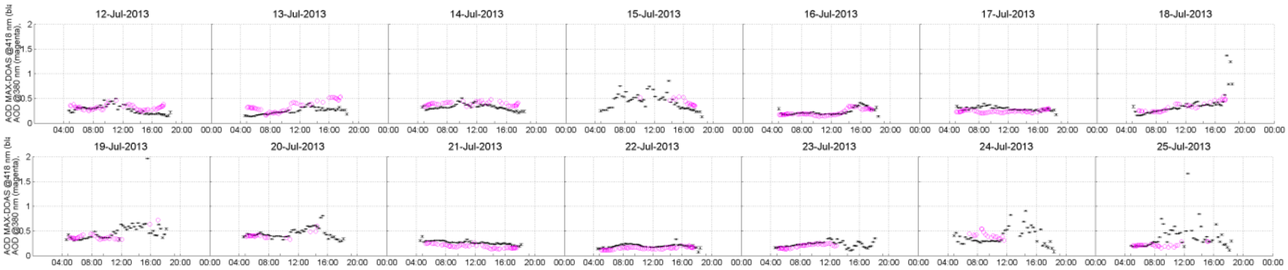

Figure 11: Comparison of the aerosol optical thickness at Hohenpeißenberg observed by sun photometer (magenta dots) and retrieved by MAX-DOAS (black dots).

The SO_2 plume emitted by the eruption of the Icelandic volcano Bardabunga in September 2014 offered the opportunity for a case study on the ability of MAX-DOAS to detect uplifted trace gas layers. The observations at Hohenpeißenberg on 22. September, after the plume of Bardabunga was transported over southern Germany, are shown in Figure 12. The fact that both the total column density and the surface concentration of SO_2 from MAX-DOAS are in good agreement with Brewer and in situ measurements, respectively, provides a high level of confidence that the SO_2 plume is observed correctly by MAX-DOAS at altitudes between 700 and 2000 m.

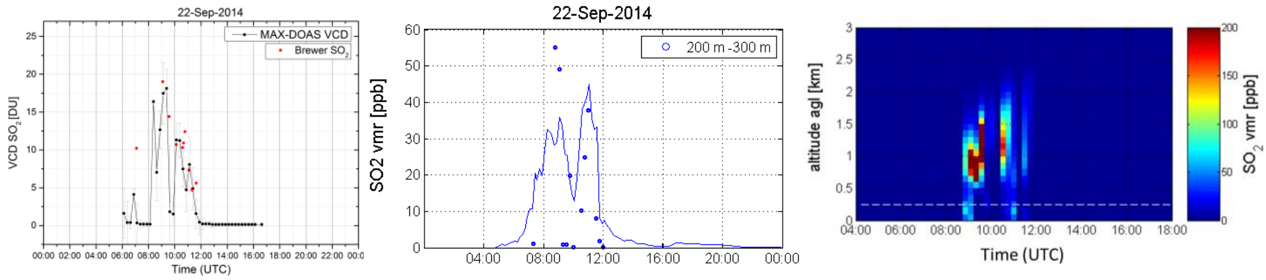

Figure 12: Observations of SO_2 at Hohenpeißenberg after the eruption of Mt. Bardabunga. Left: SO_2 vertical column density from MAX-DOAS and from Brewer spectrometer; Middle: SO_2 surface concentration from MAX-DOAS and in situ; Right: SO_2 vertical profile from MAX-DOAS on 22. September, clearly showing an uplifted layer at altitudes between 700 and 2000 m.

The ability of MAX-DOAS to detect clouds has been systematically investigated using measurements performed onboard the Polarstern research vessel during a cruise from Punta Arenas (Chile) through the marginal sea ice zone of Antarctica to Cape Town (South Africa) during Austral spring 2013. The meteorological conditions in this area are favourable for cloud observations by MAX-DOAS as the cloud cover is characterised by a high degree of homogeneity.

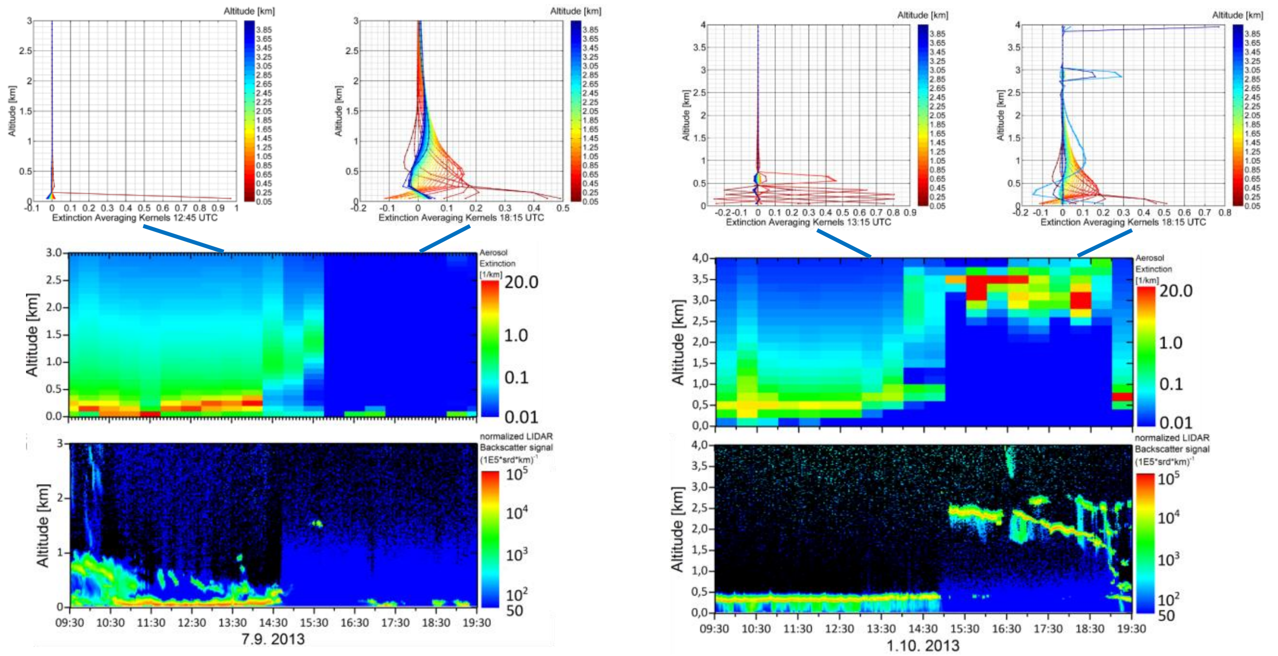

Figure 13: Examples for aerosol extinction profiles from MAX-DOAS (middle panel) and backscatter profiles from ceilometer (bottom panel), together with examples for averaging kernels during different cloud conditions (top panel) observed during two days (7. September and 1. October) of the Polarstern cruise in Austral spring 2013.

Figure 13 shows cloud observations during two days of the Polarstern cruise. MAX-DOAS extinction profiles were obtained using the HeiPro aerosol retrieval algorithm without any explicit treatment of clouds, i.e. clouds showed up in the retrieved profiles as dense aerosols. A good agreement between MAX-DOAS and ceilometer measurements is achieved, demonstrating that the cloud bottom altitude can be retrieved realistically by MAX-DOAS. In particular, both low-lying and high altitude clouds can be retrieved. The averaging kernels shown in Figure 13 indicate that the vertical sensitivity of MAX-DOAS is strongly affected by clouds. The measurements are only sensitive below the clouds, where the sensitivity is even enhanced for low-lying clouds in comparison to the clear-sky case. As a result of the non-linear nature of MAX-DOAS measurements, a significant increase in sensitivity occurs at the cloud bottom, enabling a detection of clouds at altitudes above 2 km where MAX-DOAS is not sensitive during clear-sky conditions, as the measurements on 1. October 2013 show exemplarily.

Task 4.3: Uncertainties

Work on uncertainties and their description has been performed in all different instrument communities. Discussion evolved during the definition of the GEOMS data format templates. An attempt has been made to come to a unified description of uncertainties with a document summarising different aspects of the uncertainties with the aim to serve as a guideline for data users. The document includes a very general description of the measurement process, a characterisation of errors, a mathematical description of sensitivity and smoothing errors, and a discussion of collocation choice. The document is available from the NORS webpage.

Task 4.4: Comparison to satellite observations (INTA)

Work has been done at Izaña station by studying the effective location of zenith DOAS measurements and their impact on direct comparison with satellites in terms of effective solar zenith angle, photochemistry, pollution impact, etc. The same study has been performed for other DOAS stations operated by INTA at polar/subpolar austral regions (Ushuaia (56ºS), Marambio (64ºS) and Belgrano (78ºS). Applications for NDACC certification of these stations are on the way.

A selection of BIRA-IASB and SAOZ stratospheric O_3 and NO_2 data sets have been compared to satellite nadir observations. For ozone, EP-TOMS and OMI-TOMS data showed the best results while for NO_2, best results are obtained by combining GOME version GDP5 (1996–2003) and SCIAMACHY – IUP (2003–2011). A special emphasis was on comparison of two stations having similar latitude but different seasonalities and absolute values, Bauru (22°S, 49°W) in S-E Brazil and Reunion Island (21°S, 55°E) in the S-W Indian Ocean. Both O_3 and NO_2 merged satellite data sets are fully consistent with the larger columns of the two species above South America and the seasonality of the differences between the two stations, reported by SAOZ, providing reliable time series for further trend analyses and identification of sources of interannual variability. Details can be found in Pastel et al., 2014.

A small validation study using data from a ship-borne cruise has been performed by IUP Bremen in the Pacific between Japan and Australia (Peters et al., 2012). GOME-2 and SCIAMACHY stratospheric NO_2 columns showed excellent agreement with zenith-sky observations after correction for the diurnal variation (Figure 14). Comparisons for tropospheric constituents (NO_2, HCHO) showed more qualitative agreement only, as result of the low values found and the localised nature of sources (from ships and biogenic sources on islands).

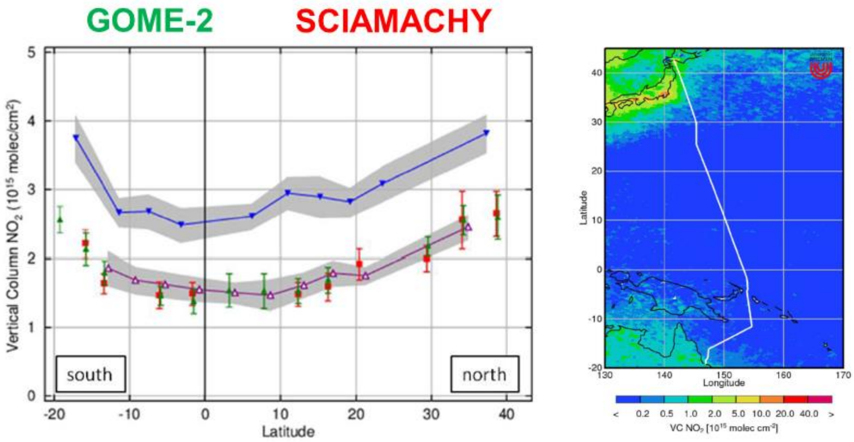

Figure 14: Validation of GOME-2 and SCIAMACHY stratospheric NO_2 columns using ship-based MAX-DOAS observations during the TRANSBROM cruise. Right: ship track on a GOME-2 NO_2 map, left: comparison of MAX-DOAS AM (purple) and PM (blue) columns with satellite data at overpass time (green = GOME-2, red = SCIAMACHY). Excellent agreement is found in absolute values and latitudinal variation between AM ground-based observations and satellite data as expected from the diurnal variation of stratospheric NO_2.

Direct validation of satellite NO_2 observations from different sensors over Beijing using ground-based MAX-DOAS has been performed by MPIC (Ma et al., 2012). While overall good correlation was found, satellite retrievals provide too low columns, probably from a combined effect of aerosol shielding and spatial smoothing.

A comparison between ozone profiles from HALOE, SAGE II, GOMOS, Aura MLS and Lidar at OHP has been made from 1985 until now, in order to identify relative drifts and stability of satellite and ground-based stratospheric ozone profile measurements. The results are published in Nair et al., 2012.

Deliverable 4.7, contains a literature study on the consistency of all NORS products obtained by different instrumentation with satellite data used for assimilation by MACC II.

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4.5 WP5: Integration of tropospheric products

The objective of WP5 was the integration/inter-comparison of surface in-situ observations with NORS products at the two demonstrations sites Jungfraujoch and Izana. Since surface in-situ observations are very precise and can be traced back to international standards, this WP serves as a demonstration of the quality of the NORS products in the troposphere. However, in order to facilitate a meaningful comparison, the representativeness of the surface in-situ and ground based remote sensing observations needs to be taken into account. In the main activity of the WP a novel method was developed that used backward Lagrangian Particle Dispersion Modelling (LPDM). The LPDM simulations were tailored towards each remotely sensed tropospheric profile. They helped to 1) characterise the air mass history of each sampling volume and the in-situ observation, and in turn their representativeness, and 2) to generate high-resolution model profiles specific for the remote sensing volumes. The latter were then merged with the surface in-situ observations and yielded the aspired reference profiles against which the remote sensing data can be validated. Furthermore, MAXDOAS observations from Izaña were evaluated using the modified geometric approach (MGA) to observe free tropospheric concentrations of NO_2 and O_3 along a horizontal line of sight.

In-situ profile comparison

The analysis was carried out for FTIR observations of CO, CH_4, and O_3 from both demonstrations sites and as well for MAXDOAS NO_2 retrievals from Jungfraujoch. FLEXPART backward simulations for individual partial columns in the troposphere were performed by EMPA for the years 2009-2011 for the FTIR and 2011 and 2012 for MAXDOAS. For Izaña FLEXPART simulations were performed for O_3 and NO_2 from MGA retrievals and the years 2011 and 2012. FLEXPART was driven by high resolution (2 km x 2 km) input wind fields from the operational weather prediction model COSMO, run by MeteoSwiss. The model results were used to obtain model profiles of the mentioned species by combining recent emissions picked up by the dispersion model with global baseline concentrations from global scale models. Input from global scale models were taken from 3 different inputs: 1) MACC reanalysis (CO, O_3, CH_4, NOx), 2) TM5 (CH4) and 3) FLEXPART-CTM (CO, CH4). The model profiles were fused with surface in-situ observations using the newly developed method described in **D5.1**. The method uses the information obtained from the backward dispersion simulation to identify profile regions for which the surface observation is representative and adjusts simulated concentrations according to the surface observations. The resulting profiles are referred to as in-situ profiles. For a final validation of the remote sensing profiles, the in-situ profiles were folded with the remote sensing averaging kernels and averaged over the tropospheric column. Different depths for the tropospheric column were analysed. The resulting in-situ profiles were made available **(D5.2)** to the project partners and provide invaluable input for further tuning/testing of the retrieval strategies and algorithms.

The cross comparison results, obtained with the above method, were compiled in deliverable **D5.3**. These results can be summarised as follows (see Figure 15): Correlations of all remotely sensed tropospheric columns correlated reasonably well with surface in-situ data that was observed at the same time as the remote sensing data. Correlations were generally better for CO than for any other trace gas. For Izaña correlations were slightly improved against night-time in-situ observations. Night-time observations were used because they should be less influenced by local disturbances that only affect the surface in-situ observations but not the remote sensing techniques. When comparing against in-situ and model-only columns the correlations of the remote sensing columns largely improved for all species and both sites. At the same time the bias corrected RMSE largely decreased. Improvements were largest for O_3 for which surface observations were expected to have a rather limited representativeness for the vertical column. Bias corrected RMSE for hourly data were in the order of 10 ppb for CO, O_3 and CH_4 and around 50 ppt for NO_2. Regression slopes for CO and O_3 retrieved by FTIR versus in-situ columns were not significantly different from 1, while they were around 1.4 for CH_4 columns and 1.2 for NO_2 columns. In case of CO and O_3 this presents an improvement over the pure surface in-situ comparison for which either slopes were significantly different from 1 or uncertainties of the slopes were large. While the other comparison statistics improved when using in-situ columns instead of surface in-situ data, the overall absolute bias increased for CO and CH_4 (only Izaña). Biases were about 5 ppb for O_3 (at Jungfraujoch) and CH_4 (at Jungfraujoch) and 10 ppb for CO (both sites) and O_3 (at Izaña). For CH_4 a bias between 40 and 70 ppb was determined at Izaña depending on the baseline model used for the generation of the in-situ profile. Virtually no bias (<20 ppt) was determined for the MAXDOAS NO_2 observations at Jungfraujoch.
Comparisons versus model-only and in-situ columns were very similar for most species and both sites. This does not necessarily imply that the whole comparison method and surface in-situ integration deteriorates to a model validation exercise as is the main goal of NORS. The model profiles used here differ from those used in the CAMS in the sense that 1) they are dedicated transport simulation for specific remote sensing volumes, 2) we used different baseline models in the study and carefully selected those that exhibited no systematic bias compared to the surface in-situ observations at the comparison sites. The comparison of the remote sensing tropospheric columns with the baseline models themselves was usually worse than for our dedicated FLEXPART model profiles. Furthermore, the influence of incorporating the surface data was larger when tropospheric columns were calculated up to lower altitudes (not shown). In that case comparison statistics improved from model-only to in-situ columns, but the overall agreement was usually worse due to the limited information the remote sensing could obtain from a less deep column. In one case, profile retrievals of a MAXDOAS were compared, which had a much finer vertical resolution than the FTIR retrievals. Hence, the targeted lower tropospheric column was not very deep and the influence of the surface in-situ data was comparatively large while also the model performance was relatively weak. In this case a clear improvement in the comparison statistics was visible when using the in-situ data.
Another important aspect of the cross comparison was the analysis of the resolved temporal scales of variability. When comparing with in-situ surface data correlations for hourly de-trended and de-seasonalised data were usually small and the overall correlation resulted from a common seasonal cycle. The integration of in-situ and model data especially improved the correlations on the hourly time scale (example given in Figure 16: Scatter plots of CO signal decomposed into different temporal scales of variability (Δ): (red squares) inter-annual, (blue diamonds) seasonal, (gray

circles) hourly residuals. The tropospheric column of CO as obtained by FTIR at Izaña were analysed versus (left) surface in-situ observations at the same time as FTIR observations, (center) tropospheric mean columns of the in-situ profiles folded with the FTIR AVKs, (right) tropospheric mean columns of the in-situ profiles. The tropospheric column ranged from the surface to 7.2 km asl. The black line represents the one-to-one line.

). This leads to the conclusion that the remote sensing techniques are well able to resolve hourly variability. The same conclusion could not have been drawn to the same extent from the comparison of surface in-situ data alone.

In summary, the cross comparison of the remotely sensed tropospheric columns with model assisted in-situ proves the high quality of the FTIR derived tropospheric columns of CO and O_3 and MAXDOAS retrievals of NO_2 at Jungfraujoch. For FTIR CH_4 tropospheric columns larger uncertainties remain that may partly be related

to the quality and consistency of the CH_4 line parameters. Further improvements of the CH_4 retrieval strategy are ongoing.

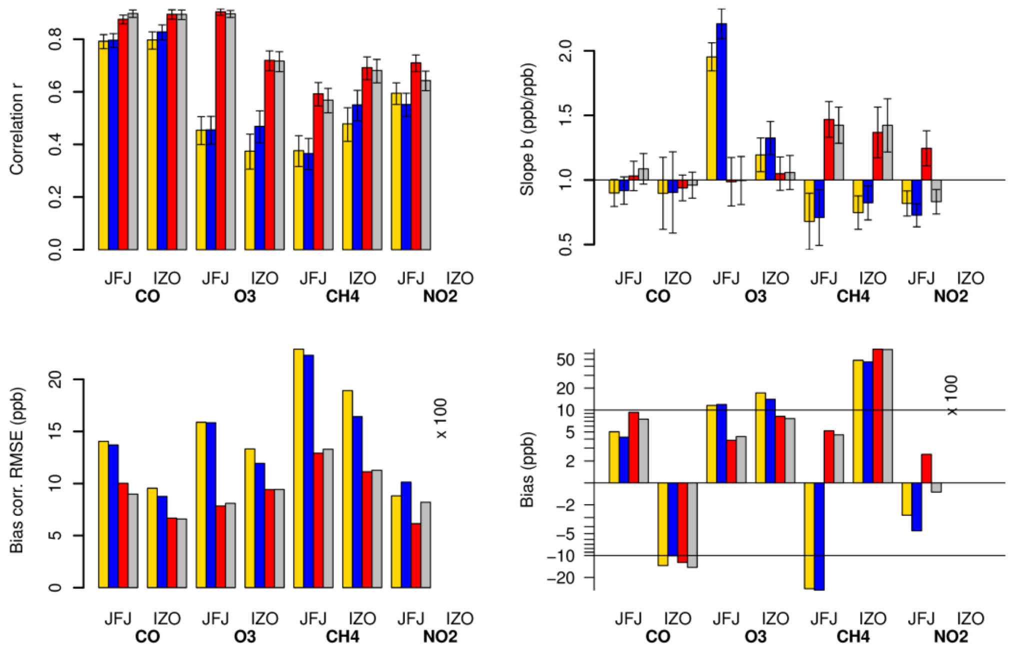

Figure 15: Comparison statistics for FTIR retrieved tropospheric columns of CO, O_3 and CH_4 at Jungfraujoch (JFJ) and Izaña (IZO) and MAXDOAS lower tropospheric columns of NO_2 at Jungfraujoch. (top, left) correlation coefficient, r, (top right) slope of linear regression, (bottom left) bias corrected root mean square error, (bottom right) remote sensing bias. Error bars on correlation and slope represent 95% confidence estimates. Results for four different reference data sets are shown: (yellow) day-time surface in-situ observations, (blue) night-time surface in-situ observations, (red) in-situ columns, and (gray) model-only columns. In-situ columns were obtained from the model-only profiles after merging with surface in-situ observations. Both model profiles and in-situ profiles were folded with the respective averaging kernel before the comparison. The analysis was performed on hourly aggregates. Note that the values for bias and bias corrected RMSE were multiplied by 100 in the case of NO_2 observations.

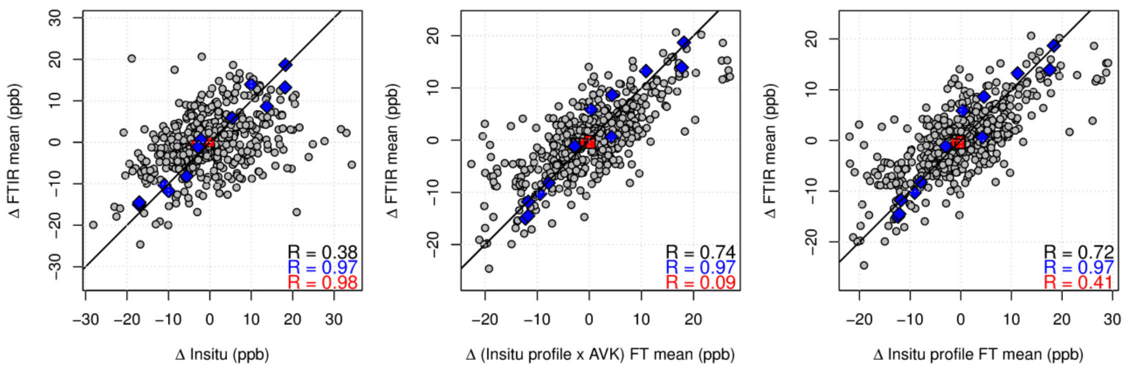

Figure 16: Scatter plots of CO signal decomposed into different temporal scales of variability (Δ): (red squares) inter-annual, (blue diamonds) seasonal, (gray circles) hourly residuals. The tropospheric column of CO as obtained by FTIR at Izaña were analysed versus (left) surface in-situ observations at the same time as FTIR observations, (center) tropospheric mean columns of the in-situ profiles folded with the FTIR AVKs, (right) tropospheric mean columns of the in-situ profiles. The tropospheric column ranged from the surface to 7.2 km asl. The black line represents the one-to-one line.

Izaña MAXDOAS comparison

INTA has been working on the retrieval of lower tropospheric concentrations of NO_2 and O_3 using MAXDOAS observations at Izaña by applying the approximation developed by Gomez et al. (2014). In this approximation (modified geometric approach: MGA) MAX-DOAS SCDs of O_3 and NO_2 measured at Izaña observatory have been used to estimate O_3 and NO_2 mixing ratios. MGA relies on the assumption that the scattering altitude is the same and is close to the station level for SCD at elevation angles 0º and 90º. The horizontal path in the layer corresponding to the level of the observatory is calculated by using libradtran or MAXDOAS measurements of O_4. Once known, the horizontal path is thus used to convert the difference of the SCD at both elevation angles to the concentration in the layer of the observatory. The lower tropospheric MAXDOAS concentration is then obtained by using a monthly mean profile of air density for Izaña. The method was applied to all observations for the years 2011 to 2013. An example period in spring 2013 (Figure 17) reveals the difficulties in comparing the MAXDOAS retrieved lower tropospheric concentration of NO2 with that sampled by the surface in-situ analyser. In general, the agreement between both methods is good when no up-slope winds are present (days 139-145). When up-slope flow is present usually only the in-situ measurement is affected by increased NO_2 during day-time (days 130-138). In addition, there is a situation when also the MAXDOAS is affected by the up-slope flow. This is when the wind is from the south and a layer of elevated NO_2 forms in the wake of the island towards the north, which is the viewing direction of the MAXDOAS (days 126-128). A more detailed comparison is currently in preparation for peer reviewed publication.

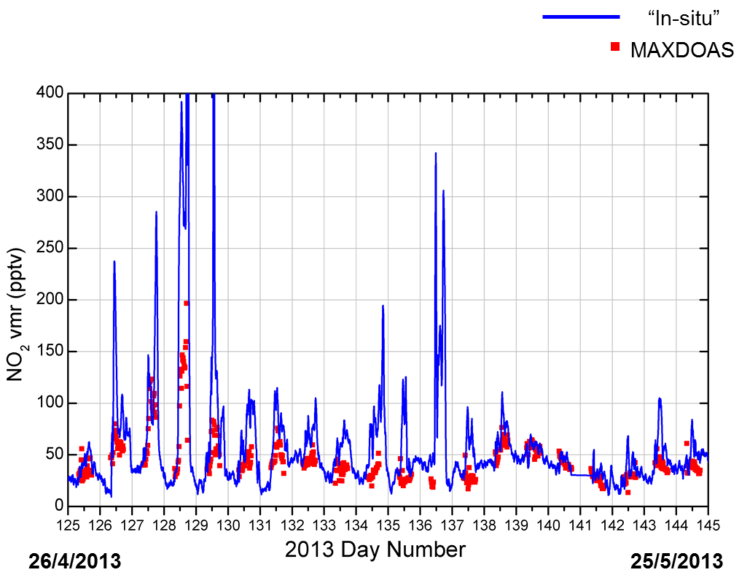

Figure 17: Example time series of NO2 observations at Izaña: (blue) values obtained by surface in-situ observations and (red) observed by MAXDOAS MGA method.

Milestones/Deliverables

D5.3 Cross comparison report (month 36)
The results of the WP's main activity as summarised above are outlined in detail in this final deliverable. Furthermore, these results are planned to be published in a peer-reviewed manuscript after the end of the project.

References

Gomez, L., Navarro-Comas, M., Puentedura, O., Gonzalez, Y., Cuevas, E., and Gil-Ojeda, M.: Long-path averaged mixing ratios of O3 and NO2 in the free troposphere from mountain MAX-DOAS, Atmos. Meas. Tech., 7, 3373-3386, doi: 10.5194/amt-7-3373-2014, 2014.

4.6 WP6: Integration of ozone products

The main objectives of WP6 are to develop a methodology for integrating ground-based ozone profile data from different types of measurements, in order to provide consistent and homogeneous ozone vertical distribution time series as well as tropospheric and stratospheric ozone partial columns at the 4 NDACC stations included in the NORS project.

The data considered in the work package are listed in Table 2.

Table 2: Data used for WP6

Ny Alesund **79°N, 12°E**	**Alpine station**	**Izana** **28°N, 16°W**	**La Réunion** **22°S, 56°E**
FTIR 2003-2013 **Lidar** 2003-2013 **Microwave**	**FTIR (Jungfraujoch 47°N, 8°E)** 2003-2013 **Lidar (OHP (44°N, 6°E)** 2003-2013 **Microwave (Bern, 47°N, 7°E)**	**FTIR** 2000-2012 **Ozone sondes** 2000-2012	**FTIR** 2004-2011 **Lidar** 2004-2013 **Ozone sondes**

2006-2013 **Ozone sondes** 2003-2013	2003-2013 **Ozone sondes (OHP, 44°N, 6°E)** 2003-2013 **Ozone sondes (Payerne, 47°N, 7°E)** 2003-2013		2003-2013

Description of the methodology for ozone profile integration

Due to the different characteristics of the ozone profiles in terms of vertical resolution and validity domain, a compromise has to be made in order to integrate the data. For instance the vertical resolution of higher resolved measurements, e.g. from ozone sondes and lidar, has to be degraded using the averaging kernels of the passive remote sensing techniques (FTIR and microwave). Also the difference between FTIR and microwave measurements can be due to the use of different a priori profiles in the retrieval and this difference has to be corrected. After correction of these potential sources of bias, systematic differences can still persist. Satellite measurements can then be used in order to investigate the remaining biases and eventually correct them.

The various steps of the integration methodology can be summarized as follows:

- Evaluation of the validity domain and vertical resolution of the various data sets.
- Adjustment of vertical resolutions: smoothing of high resolved data.
- Check of bias due to a priori profile (for FTIR and microwave data) and correction.
- Check of remaining bias using satellite data and correction
- Check of geophysical bias (Alpine stations case)
- Data integration
- Calculation of stratospheric and tropospheric partial columns

1. <u>Smoothing of high resolved data</u>

Lidar and ozone sondes measurements are characterized by a higher vertical resolution compared to that of FTIR and microwave. In order to evaluate their systematic differences with respect to microwave and FTIR measurements, the profiles have to be smoothed using the following formula: $x_s = x_a + A(x_h - x_a)$ where x_s is the smoothed lidar or ozone sonde profile, x_h is the initial lidar or ozone sonde profile and x_a and A are the FTIR or microwave a priori profile averaging kernel matrix, respectively.

2. <u>Bias due to a priori profile</u>

A first source of systematic difference between measurements types can be due to different a priori profiles. Indeed in the case of Alpine stations, Bern MW and Jungfraujoch FTIR measurements use different a priori profiles. Bern uses monthly climatological profile, while Jungfraujoch uses an annual ozone mean profile. In order to improve the comparison, a priori profiles have to be adjusted and FTIR measurements have been corrected using the MW a priori profiles.

3. <u>Instrumental bias</u>

In order to evaluate the validity of the various data sets, their respective systematic differences for coincident data (± 12 h difference) have been investigated and compared to similar systematic difference with measurements performed by the AURA-MLS satellite instrument. The AURA-MLS measurements were selected within a domain of 4° in longitude and 3° in latitude around each station.

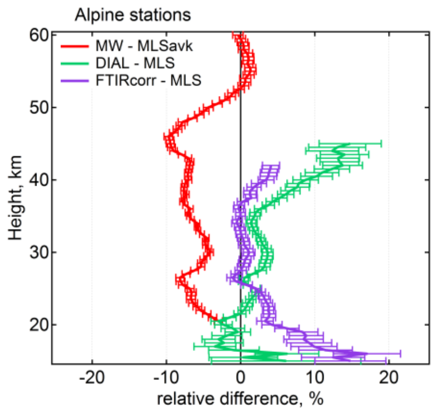

Figure 18: Bias between FTIR corrected for a priori and MLS coincident measurements (purple), lidar and MLS (green) and microwave and MLS (red) measurements in the case of the alpine stations.

Since lidar measurements present a lower bias with respect to MLS data and very small bias with respect to ozone sonde data, MW data have been corrected from their bias with MLS.

4. <u>Geophysical bias</u>

In the case of the Alpine stations, because of the distance between OHP and the other sites, possible geophysical bias can exist between the data sets due to the systematic sampling of different air masses. The geophysical bias is evaluated using coincident measurements from AURA-MLS in the vicinity of the various sites. Results show that the difference between MLS measurements obtained at OHP and both other Alpine stations is generally very small above 20 km. In order to better understand the measurement difference below 20 km, the systematic difference between OHP and Payerne ozone sondes measurements on coincident days was analysed. Results of the climatological difference shows very small biases not exceeding 5 to 10 %. The small values of the differences indicate that the geophysical bias between OHP and other Alpine stations is very small and similar to the uncertainty of the various measurements. As a consequence, no geophysical bias correction was applied to the individual data before the merging.

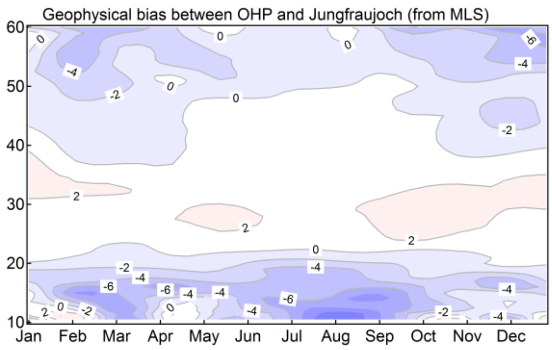

Figure 19: Difference between coincident MLS ozone measurements obtained at OHP and Jungfraujoch.

5. <u>Data integration</u>

After the corrections and/or smoothing of the different individual profiles, e.g. a priori profile correction in the case of FTIR and MLS bias correction in the case of MW, the various data sets show systematic differences in the range of ± 10 %, which makes them suitable for merging. Merged ozone profile data are computed from the error weighted average of the individual coincident daily ozone profiles corrected from eventual instrumental and geophysical bias. A general formula for the computation of merged ozone data is thus the following:

$$O_3(z) = \sum_{i=1}^{n} w_i(z) B_i(z) G_i(z) O_{3i}(z) \qquad (2)$$

where O_3 (z) is the merged ozone profile, $w_i(z)$ is the weight linked to the error of the measurements, $B_i(z)$ corresponds to the correction for eventual instrumental bias, $G_i(z)$ is the correction for geophysical bias and O_{3i} (z) are the invidual eventually smoothed ozone profile sources. The weight related to the error of the measurements is computed as follows:

$w_i(z) = \frac{\varepsilon_i^{-1}(z)}{\sum_{i=1}^{n} \varepsilon_i^{-1}(z)}$ where $\varepsilon_i(z)$ is the error profile of the individual ozone measurements.

An example of ozone profile integration for the Alpine stations is given in Figure 20:

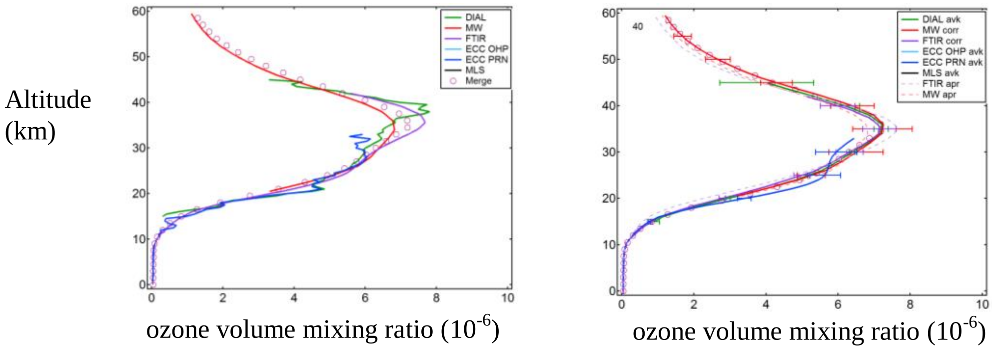

Figure 20: example of integrated ozone profile at Alpine station

4.7 WP7: Reanalysis of ground-based time series back to 2003

The purpose of this milestone is to achieve a harmonized data set of NORS products. The data set includes data from 4 different observation techniques. In total 4 sites are included in NORS:

- Ny-Ålesund (Spitzbergen),
- Alpine site (Bern, Jungfraujoch, OHP),
- Izaña (Tenerife I.),
- La Réunion (Maido and St Denis).

Table 3 lists the available technique at each site. Please note that continuous MWR measurements at Ny-Ålesund started in 2006, and FTIR measurements at La Réunion (St Denis) in 2009, Maido Observatory in 2013.

Table 3: Instrumentation at each NORS observation site

	DOAS (UV-VIS)	FTIR	LIDAR	MWR
Ny-Ålesund	X	X		X (since 2006)
Alpine sites	X (Jungfraujoch)	X (Jungfraujoch)	X (OHP)	X (Bern)
Izaña	X	X		
La Réunion		X (since 2009)		

This re-analysed data set includes

- Stratospheric O_3 columns and NO_2 columns from DOAS UV-Vis measurements
- Tropospheric and stratospheric columns of O_3, CO and CH_4 from FTIR observations
- O_3 vertical profiles of O_3 in the stratosphere between 10 and 50 km from LIDAR-DIAL measurements

- O_3 vertical profiles in the stratosphere between 20 and 70 km from millimetre wave radiometers (MWR)

For the re-analysis retrieval guidelines for each technique were defined. MS 12 lists these guidelines for each technique. Please refer to this document for details on the retrieval procedure and settings.

The re-analysis has been conducted and the resulting data are archived in the NDACC data base. The data is available at ftp://ftp.cpc.ncep.noaa.gov/ndacc/.

4.8 WP8: Web-based server for validation of CAMS products using NORS data products

The objective of this work package was to build a system that generates in an operational and consistent way validation reports of CAMS products based on independent NORS data products.

This work package has progressed in accordance with the objectives and description stated in the Work Package Description in Annex I. All requested deliverables and milestones were met, and all effort was expended as expected in terms of resources and planning (albeit with some delays in the actual delivery dates).

The work package consisted of the following three tasks:

Task 8.1 (*Definition of the validation server*) has concluded, resulting in the following deliverable:

- **Deliverable D8.1**, the *Validation server User Requirements Document* (URD) was released on May 14, 2012.

  The delivery of the URD was delayed by two weeks with respect to the schedule mentioned in Annex I, due to high participation of all partners in the reviewing process. It was decided to have a second round of review iterations, to ensure a high-quality, consensus document. The URD was developed in consultation with the MACC-II VAL subproject (in particular with H. Eskes, KNMI).

Task 8.2 (*Development of the validation server system*) has concluded, resulting in the following deliverables:

- **Deliverable D8.2**, *the Validation server Design Document* (DD) was released on July 9, 2012.

  The delivery of the DD was delayed by one week with respect to the schedule mentioned in Annex I as a knock-on effect from the delay in the delivery of the D8.1 (URD).

  As a companion text to D8.2 (and input for D8.3 and D8.4), the internal report *Description of algorithms for the NORS Validation server* has been iteratively developed by BIRA. This document included a detailed description of the validation chain algorithms for each target product and was used to supporting the implementation of the validation server by S&T.

- **Deliverable D8.3**, *the Validation server in test-phase* was released on August 26, 2013.

  The NORS validation test server is a web application running in a client's browser window.

The server was hosted at Science and Technology (S&T), and required secure authenticated access.

The delivery of D8.3 was delayed by 3 months because of staffing issues at S&T.

Task 8.3 (*Validation server system tests*) has been concluded, resulting in the following deliverables:

- **Deliverable D8.4**, *the Ready-to-use Validation server* was released on December 20, 2013.

  All partners involved in the WP Partners performed tests on the Validation test server (D8.3), and reported test results to S&T and BIRA-IASB. S&T then updated the system to correct / improve for reported problems, until satisfaction of the partners. Details on these augmentations can be found in deliverable D9.1 (*Feedback regarding the validation server*) and internal project memo ST-FP7-NORS-MEM-001 (*The NORS validation server: response to feedback report*).

  The delivery of D8.4 was delayed by 3 months because of the earlier delay in D8.3.

  As with the test sever, NORS intercomparison reports are generated for all the NORS data stations currently uploading rapid delivery data, and for all the intercomparisons for which the algorithms are fully implemented. In addition, intercomparisons will automatically be generated and included for any non-NORS NDACC station that uploads data products (either rapid delivery or consolidated) in a HDF format conform to the GEOMS standard, for the instruments and parameters supported by NORS.

  The Validation server can be reached from the main NORS Webpage and from the MACC Validation Webpages at the URL: `<http://nors-server.aeronomie.be/>`

The algorithms used in the server are published in GMDD and publically available, Langerock et al., 2014.

Langerock, B., M. De Mazière, F. Hendrick, C. Vigouroux, F. Desmet, B. Dils, and S. Niemeijer, Description of algorithms for co-locating and comparing gridded model data with remote-sensing observations, Geosci. Model Dev. Discuss., 7, 8151–8178, 2014, doi:10.5194/gmdd-7-8151-2014

4.9 WP9: Validation of CAMS products for O_3, NO_2, CO, CH_4, H_2CO, aerosol

This work package started at Month 18 (April 2013). A first important task was to evaluate the NORS Validation Server (NVS) and the validation reports. As a result, the D9.1 document ("The NORS validation server: feedback report") was finalized and issued in early November 2013. D9.1 outlined the usefulness of the validation reports and their clear presentations. The test users also identified at that time features needing improvement and provided suggestions for addition of elements. Interactions and collaboration between WP8 and WP9 members still allowed improvement of NVS before its entry into operation.
Already during the testing and development phase of NVS, many intercomparisons of NORS data with MACC-II products have been made offline, and results for the validation of MACC-II Ozone products have been reported in the September issue of the MACC-II Deliverable D_82.9 'Validation report of the MACC near-real time global atmospheric composition service. System

evolution and performance statistics - Status up to May 2013' which is available on the MACC-II Webpages at
http://www.gmes-atmosphere.eu/services/aqac/global_verification/validation_reports/.
Additional comparisons are available offline, and some results were communicated to the MACC-II consortium, like the observed disagreements between NORS and MACC-II products for CH_4.
Figure 21 shows a nice example of a comparison between NORS MAXDOAS aerosol optical depths at Xianghe and collocated MACC-II forecast (fnyp) data.

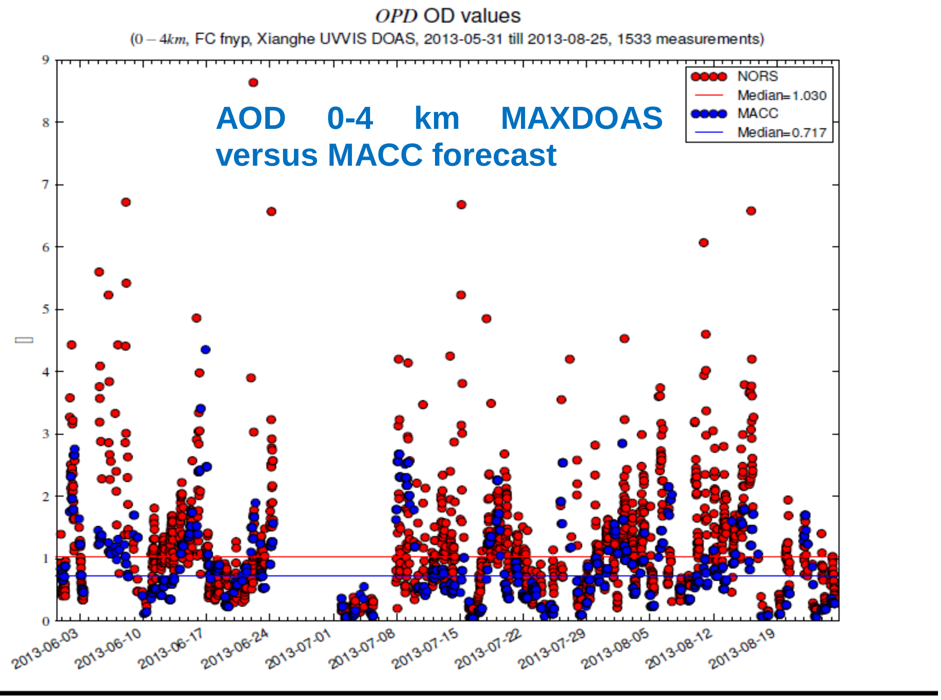

Figure 21: Comparison between data from MAXDOAS and MACC fnyp model for aerosol optical depth between the surface and 4 km altitude at Xianghe (China).

More recently, some additional specific investigations have been conducted for insertion in the MACC validation reports. They involved several targets, techniques, sites and forecast model versions. In addition to the ozone and aerosol intercomparisons reported here above, measurements of tropospheric CO derived from FTIR observations at Reunion Maido and Jungfraujoch have been compared with operational MACC products while HCHO partial columns (up to 3.5 km) from MAXDOAS observations above Xianghe (China) were also the subject of intercomparison with MACC forecasts. We direct the reader to the D9.2 deliverable document (Assessment of CAMS products) for more information.

In parallel, exploitation of NVS validation reports has been performed for the suite of CAMS products (O_3, NO_2, CO, CH_4, HCHO, aerosol). It should be pointed out here that given the many techniques and sites involved, a huge number of combinations for comparison is available from the validation server. Implementation of Taylor diagrams in the standard reports was a key element easing or even allowing evaluating the relative performance of the MACC forecast in operation until October 2014 (i.e, MACC_osuite, MACC_fcnrt_MOZ, MACC_CIFS_TM5). The models were evaluated using the available NORS data, generally covering a time period extending until the end of September 2014. For obvious reasons, the new "g" model versions which started in early October 2014 have not been evaluated yet in WP9, although they were already handled by NVS. The D9.2 document provides per-species and per-technique comparisons between NORS and CAMS products.

As to possible new target species, Sulphur dioxide (SO_2) is an interesting possibility since it is one of the main indicators for air quality. Recent developments have allowed the determination of vertical profiles from MAX-DOAS observations. Surface concentrations and vertical columns can be derived, as demonstrated from the Xianghe site. It should be noted however that the MAX-DOAS method is not applicable in background conditions because of a too low signal-to-noise ratio..

HCHO is another likely candidate. As indicated above, low tropospheric columns derived from MAXDOAS have already been compared with MACC forecasts, showing a good agreement for background conditions. Addition of FTIR products which have been shown to be very complementary (with FTIR instruments sensitive up to the tropopause, see Franco et al. (2014) for the Jungfraujoch, Vigouroux et al. (2009) for Reunion) might be very relevant.

4.10 WP10: Capacity building and sustainability

<u>Task 10.1: export NORS expertise to candidate NDACC stations outside western Europe.</u>

- **Xianghe (China)**

Operation and maintenance of the UVVIS MAXDOAS spectrometer at Xianghe are done by BIRA-IASB in close collaboration with the Institute of Atmospheric Physics (IAP)/Chinese Academy of Sciences (CAS). A rapid data delivery system has been developed for the MAX-DOAS measurements of tropospheric NO_2 and aerosols. Daily (with 24h delay) and monthly HDF data files are automatically submitted to the NORS/NDACC database since beginning of June 2013. 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.

The BIRA-IASB/CAS collaboration has resulted in the publication of four peer-reviewed papers in 2014:

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.

- **Beijing (China), Greater Noida and Mohali (India), Islamabad (Pakistan)**

In the frame of NORS WP10 several intensive co-operations were established by MPIC with the following scientists and research groups:
-Jianzhong Ma, Chinese academy of science, Beijing, China
-Ramesh P. Singh, Sharda University, Greater Noida, India
-Vinayak Sinha, ISER, Mohali, India
-Fahim Khokhar, NUST, Islamabad, Pakistan

With all these groups MPIC performed joint MAX-DOAS measurements and data analysis and interpretation. Knowledge (including the recent NORS improvements) was transferred to the involved scientists. This knowledge transfer includes the following aspects:
- spectral analyses of NO_2, O_4, HCHO, SO_2, CHOCHO
- cloud screening based on MAX-DOAS cloud classification schemes
- application of the geometrical approximation to retrieve tropospheric trace gas Vertical Column Densities
- application of inversion algorithms for the retrieval of aerosol extinction and trace gas profiles

In addition to measurements at fixed locations, also car-MAX-DOAS measurements have been performed. The results at different locations have been applied to satellite validation. 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.

Researchers from all mentioned institutions have visited the MPIC research group several times in recent years. Also scientists from MPIC travelled to the different partner institutes. Most intense collaboration was established with Jienazhong Ma and Jin Junli from CAS, Beijing, China.

The following publications resulted from the joint activities:

Shaiganfar, R., Beirle, S., Sharma, M., Chauhan, A., Singh, R. P., and Wagner, T.: Estimation of NO_x emissions from Delhi using Car MAX-DOAS observations and comparison with OMI satellite data, Atmos. Chem. Phys., 11, 10871-10887, doi:10.5194/acp-11-10871-2011, 2011.

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.

- **Seoul (Korea)**

The IAP-Bern cooperates with Prof. J.J. Oh from Sookmyung Women's University in all topics related to atmospheric microwave remote sensing. A new ground-based microwave radiometer has been developed for measurement of stratospheric ozone profiles. The radiometer is called SORAS (Seoul Ozone RAdiometer System) and is using the 110.836 GHz ozone line.
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 capacity of the microwave radiometry of water vapor and ozone have been expanded in three ways:

- 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. The aim is to operate the system in the frame of NDACC in the near future.
- Further UBern started operation of a new ozone radiometer for campaigns in Bern. The instrument is called GROMOS-C in contrast to the NDACC instrument that is used in NORS and that is called GROMOS. The C stand for campaigns.
- Since end of August 2013, two microwave radiometers are operated at the Maïdo observatory at La Réunion, for a one-year campaign. One instrument is for strato-mesospheric water vapor, the other one for the determination of the horizontal wind profiles in the stratosphere and mesosphere.

- **Kourovka (Russia, 57°N, 59° O)**

Christof Petri from University Bremen B visited the Yekaterinburg group in Russia 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 (Bruker 125M). 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 are regularly performed in the near infrared spectral region and the instrument is ready to perform NDACC measurements in the mid infrared region. The limiting issue for regularly performed NDACC measurements is the liquid nitrogen which has to be filled in the detectors while the site with the instrument is ~80km outside the city. This problem could not be solved within the NORS project.

- **Paramaribo (Suriname)**

University of Bremen continued FTIR measurements at the Meteorological Service in Paramaribo, Suriname and realized three measurement campaigns partly payed out of NORS. The existing Bruker 120M FTIR interferometer has been exchanged with an upgraded 120-5M (new electronics) which is able to perform DC-coupled measurements. 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.

University Heidelberg is operating a long-term MAX-DOAS instrument at the Meteorological Service of Suriname in Paramaribo since 2001. During a visit in November 2011, UH 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 MAXDOAS measurements were performed continuously until January 2014, when the instrument unfortunately broke down. Depending on the funding situation, a visit to Suriname in order to repair the instrument is planned in early 2015.
The long-term MAX-DOAS measurements at Paramaribo, Suriname, operated by partner UH in collaboration with the Meteorological Service of Suriname, have been continued as planned. The

development of new retrieval algorithms for the analysis of the data from Paramaribo according to the current NDACC recommendations is in progress.

- **Altzomoni (Mexico)**

This FTIR site is operated in collaboration between Karlsruhe Institute of technology (KIT) and the local University (UNAM). The site made a site presentation at the NDACC/IRWG meeting in June 2014: therein, Wolfgang Stremme and Michel Grutter asked for NDACC affiliation. NDACC certification process will start soon. After certification, they will start submitting data to NDACC.

- **Rio Gallegos (51.62° S, 69.22° W, South Argentina)**

CNRS has performed measurements of the total content of ozone and nitrogen dioxide at the NDACC station of Rio Gallegos located in South Argentina (51.62° S, 69.22° W) since 2008. CNRS also collaborates with CONICET-CEILAP for the LIDAR observations of ozone and temperature vertical distribution at this station. A scientist from Argentina has been trained to work on the data retrieval for the SAOZ and the LIDAR at Rio Gallegos NDACC station. They have now the new version of the LIDAR Near Real Time retrieval programme and an update of the SAOZ procedure level 1 (slant column version 2). Recommendations and advices on the use of the new LIDAR NRT retrieval were made during the visit of S. Godin-Beekmann in Argentina in February 25-28, 2013. The CNRS has imported the new automated lidar data retrieval and the HDF conversion software at Rio Gallegos. CNRS is now working with them to get the real time data.

- **Addis Abeba (Ethiopia)**

The FTIR site at Addis Abeba is operational. It is a collaboration between KIT and Dr. Gizaw Mengistu Tsidu, PI. Dr. Mengistu Tsidu had got a Georg-Forster stipendium from Humboldt foundation. Until recently he visited us for 1 year. During his stay spectra recorded in Addis were analysed. They have not applied yet to obtain the NDACC affiliation.

- **Bujumbura (Burundi)**

The BIRA-IASB MAX-DOAS instrument installed at the University of Burundi in Bujumbura is operational since end of November 2013. The optimisation of the settings for the retrieval of NO2, HCHO, and aerosols vertical profiles is under progress, and so data files have not yet been submitted to the NORS validation server. 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). It should be noted that 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).

- **Belgrano (Antarctica)**

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 masl next to the Filchner Ice. Climatologically, 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.Temperature in the lower stratosphere starts to decrease in February and reaches values low enough for possible PSC (I and II types) formation and to initiate the process of chlorine activation in late May or early June. During winter, the Weddell sea is heavily iced and considerable ice coverage is retained into the spring and early summer months.
Measurement data series started in 1994 within a collaboration research agreement between INTA and the DNA (Dirección Nacional del Antártico) from Argentina, with the installation of a scanning spectrometer to measure stratospheric NO_2 and O_3.
In February 2011, with the financial support of the Spanish Science and Technology System, a Multiaxis Differential Optical Absorption Spectroscopy (MAX- DOAS) UV instrument was installed at Belgrano II to extent the knowledge of BrO and OClO distribution in this site and to improve the Antarctic program INTA has been performing since 1994. In February 2013, a second MAXDOAS spectrometer started to measure in the visible range. Both instruments have been entirely developed at INTA including the detector read-out electronics and have been robustly designed for continuous operation in rough environment like Antarctica. Belgrano station is a candidate to be a NDACC site for continuous monitoring of atmospheric composition.
According to NDACC recommendation, NO_2 and O_3 analysis settings have been applied to data analysis, except for O_3 where the recommended spectral interval is not reached. MAX-DOAS algorithm development and sensitivity analysis are ongoing for BrO, O_3 and NO_2 profiles and columns as well aerosols extinction profiles. Work is currently focused on the inversion of aerosol and BrO profiles (BrO enhancement events) and it will be extent to NO_2 and O_3 later on.
Operators at the IAA (Instituto Antártico Argentino) receive annually training for the operation and maintenance of the instrument that guarantees the proper operation. Daily protocol for proper maintenance of instrument in order to assure the quality of measurements according to requirement of NDACC is currently applied.
Within the framework of NORS project, NDACC expertise has been exported to MAXDOAS observations carried out in this station. Now 4 years of continuous measurements of BrO and OClO and more than one and half a year of O_3, NO_2 and IO data are available.
Other instrument available:

TEI 49C - Surface ozone measurements
Ozonesoundings
MPL LIDAR (PSC)

Task 10.2: Promote the achievements of NORS in NDACC and CEOS WGCV

NORS activities and requirements have been reported and discussed at every annual meeting of the NDACC Steering Committee (SC) and at the NDACC Working Groups annual meetings. NORS has also been presented at the Sentinel-5 Precursor Mission Advisory Group meetings (ESTEC, 8–9 March 2012, and 15-16 October 2012), and at the CEOS WGCV-37 (2013) and -38 meetings (2014).

In particular, at the 2013 meeting of the NDACC SC, the presentation about NORS provoked great enthusiasm. It has been agreed to post the data-use and interpretation related NORS deliverables (D4.2, D4.3 and D4.4) on the NDACC Webpages, and to link the NORS Validation Server to the NDACC webpages as soon as it is validated and operational. M. De Mazière was elected as the European co-chair of the NDACC, for a 3-year term starting Oct. 4, 2013.

B. Bojkov and J.C. Lambert, the chair and co-chair, resp., of the Atmospheric Composition sub-group of the CEOS WGCV, also attended the NDACC SC meeting, and B. Bojkov, who is also head of ‘Sensor Performance, Products and Algorithms’ in the Directorate of Earth Observation Programmes at ESA, welcomed the NORS progress leading to possible applications for the upcoming Sentinel and Sentinel precursor missions.

Task 10.3: Meetings with EEA

M. De Mazière attended the GISC Workshop ‘Monitoring Matters’ with EEA in Copenhagen in April 2013, demonstrating the NORS progress. NORS is advertised in the Workshop report.

NORS metadata have been discussed during the Workshop “Metadata for Air Quality and Atmospheric Composition” in Dublin in March 2012. EEA was also represented at that meeting. The compliance with INSPIRE and ISO standards has been discussed.
The GEOMS Metadata Board has been resurrected and discussions about GEOMS metadata, compliance with INSPIRE and ISO, and the connection to other standards in atmospheric data formatting will be further investigated by this Board. Regular teleconferences have been scheduled.

In addition

S&T represented NORS at the MACC-II/GMES-Pure Atmospheric Services User Workshop on 11 and 12 June. We provided input on what NORS, as a 'user' of the MACC data, would need/prefer in order to evolve into an operational validation service for MACC.

M. De Mazière (MDM) regularly reports about NORS during the monthly teleconferences of the MACC-II Project Management Team and regular interactions with the MACC-II Val-team take place. MDM hosted the project management meeting of MACC-II on June 7 at BIRA, where it was discussed that at least the operational part of NORS should be included in the operational Copernicus Atmospheric Service. This objective will be pursued in the coming months.

4.11 WP11: Project management

The administrative, legal and financial management of the project has been adequately ensured throughout the entire period of the project.

Two modifications of ‘Annex I – Description of Work’ have been requested by the NORS consortium and approved by REA for the following items:

Grant Agreement Amendment 1:

- Replacing deliverable D4.6 “Methane data assessment” by “Assessment of consistency between carbon monoxide from NDACC and TCCON measurements”.
- Extending the exportation of the NORS expertise to the Astronomical Observatory of Seoul (South Korea) in collaboration with IAP/UBern.
- Including AEMET (AGENCIA ESTATAL DE METEOROLOGÍA) as a third party making their resources available to a beneficiary free of charge.

Grant Agreement Amendment 2:

- A four month extension of the NORS project (37 months in stead of 33 months) to cover partially the gap between the initial end of the project (planned July 2014) and the beginning of the Copernicus Atmospheric Services (presumably April 2015).
- Electronic-only signature and transmission of the financial statements (Form C) and the electronic-only transmission of the certificates on financial statements and certificates on the methodology (forms D and E), abolishing thus the parallel submission of paper forms.

The list of the project meetings is provided in Table 4. All meetings have been scheduled well in advance. The agenda has been distributed prior to the meeting. Minutes have been written and distributed by the Project Manager. All meetings were considered fruitful.

Table 4: List of project meetings

Month	Meeting Name	Venue	Date
M2	Kick Off Meeting	BIRA-IASB	Wednesday, 14 December 2011
M4	PMT Teleconference 1		Thursday, 9 February 2012
M6	PMT Teleconference with SC 1		Thursday, 12 April 2012
M8	PMT Teleconference 2		Tuesday, 26 June 2012
M11	PMT Teleconference 3		Thursday, 13 September 2012
M13	First Progress Review/Meeting	BIRA-IASB	Tuesday 20 & Wednesday 21 November 2012
M14	PMT Teleconference 4		Thursday, 13 December 2012
M16	PMT Teleconference 5		Thursday, 26 February 2013
M18	PMT Teleconference with SC 2		Thursday, 18 April 2013
M20	PMT Teleconference 6		Thursday, 20 June 2013
M22	PMT Teleconference 7		Thursday, 20 August 2013
M24	Second Progress Review/Meeting	BIRA-IASB	Thursday 17 & Friday 18 October 2013
M26	PMT Teleconference 8		Thursday, 12 December 2013
M28	PMT Teleconference 9		Thursday, 13 February 2014
M30	PMT Teleconference with SC 3		Monday, 14 April 2014
M32	PMT Teleconference 10		Thursday, 26 June 2014
M34	PMT Teleconference 11		Wednesday, 8 October 2014
M37	Final Project Review/Meeting/Workshop	Belspo	5-7 November 2014

Figure 22 shows the project planning. The inscriptions in red (+”x”M) show the requested delays and extension.

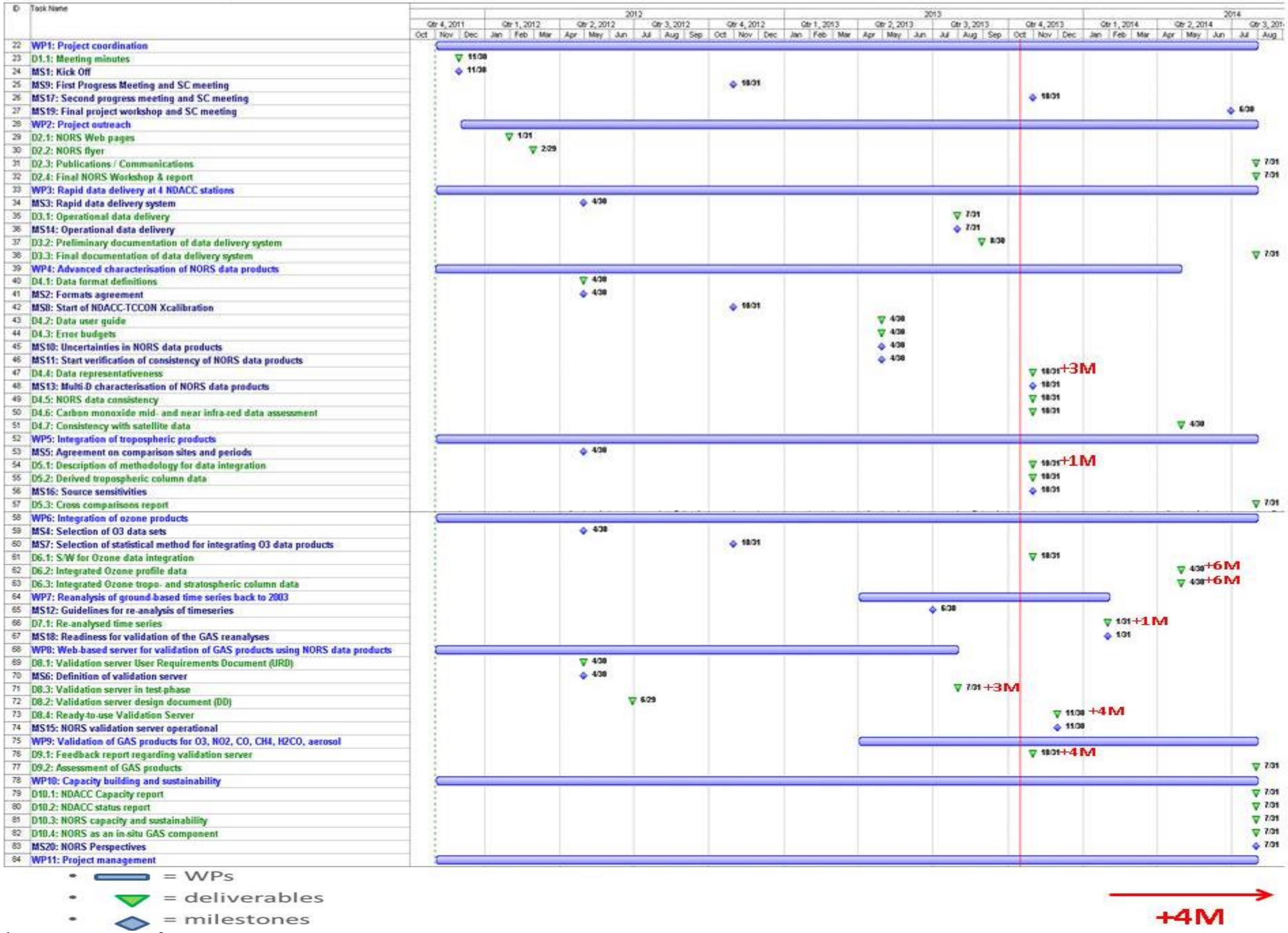

Figure 22. Project planning

5. Deliverables and milestones tables

Deliverables

Table 5. Deliverables. The deliverables colored in blue are first year deliverables. The deliverables colored in green are second year deliverables. The deliverables colored in red are third year deliverables.

DELIVERABLES											
Del. no.	**Deliverable name**	**Version**	**WP no.**	**Lead beneficiary**	**Nature**	**Dissemi-nation level[2]**	**Delivery date from Annex I (proj month)**	**Actual / Forecast delivery date Dd/mm/yyyy**	**Status No submitted/ Submitted**	**Contrac-tual Yes/No**	**Comments**
D1.1	Meeting minutes		WP1	BIRA-IASB	R	RE	M1	M3	Submitted	Yes	The Kick-Off Meeting took place in M2.
D2.1	NORS Web pages		WP2	BIRA-IASB	O	PU	M3	31/01/2012	Submitted	Yes	The website contains a public and private part. To access the private part, one has to create an account (at the bottom of the Login Form).
D2.2	NORS flyer		WP2	BIRA-IASB	O	PU	M4	29/02/2012	Submitted	Yes	REA has received 100 copies of the flyer.
D2.3	Publications / Communications		WP2	BIRA-IASB	O	PU	M37	30/11/2014	Submitted	Yes	
D2.4	Final NORS		WP2	BIRA-IASB	R	PU	M37	30/11/2014	Submitted	Yes	

[2] **PU** = Public
PP = Restricted to other programme participants (including the Commission Services).
RE = Restricted to a group specified by the consortium (including the Commission Services).
CO = Confidential, only for members of the consortium (including the Commission Services).
Make sure that you are using the correct following label when your project has classified deliverables.
EU restricted = Classified with the mention of the classification level restricted "EU Restricted"
EU confidential = Classified with the mention of the classification level confidential " EU Confidential "
EU secret = Classified with the mention of the classification level secret "EU Secret "

	Workshop & report										
D3.1	Operational data delivery		WP3	Ubern	O	PU	M21	12/09/2013	Submitted	Yes	The operational rapid data delivery has been established.
D3.2	Preliminary documentation of data delivery system		WP3	Ubern	R	PU	M22	12/09/2013	Submitted	Yes	The preliminary report describes RDDS, data processing and delivery.
D3.3	Final documentation of data delivery system		WP3	Ubern	R	PU	M37	30/11/2014	Submitted	Yes	
D4.1	Data format definitions		WP4	ULg	R	PU	M6	11/5/2012	Submitted	Yes	We will adopt the GEOMS-compliant templates, for all techniques involved in NORS. They are similar to those used by the NDACC network. To be compatible with the NDACC DHF, we will stick to the hdf v4 format.
D4.2	Data user guide		WP4	BIRA-IASB	R	PU	M18	8/05/2013	Submitted	Yes	The Data user guide is a useful document describing the different measurement techniques, the retrieval methodology and includes concept/examples of horizontal and/or vertical averaging.
D4.3	Uncertainty budgets		WP4	KIT	R	PU	M18	2/05/2013	Submitted	Yes	Error budget of NORS data products has been decribed in detail and reported on time.
D4.4	Data representativeness		WP4	Ubremen	R	PU	M24	31/10/2013	Submitted	Yes	
D4.5	NORS data consistenc		WP4	Ubremen	R	PU	M24	31/10/2013	Submitted	Yes	

	y										
D4.6	Carbon monoxide mid- and near infra-red data assessment		WP4	Ubremen	R	PU	M24	31/10/2013	Submitted	Yes	
D4.7	Consistenc y with satellite data		WP4	INTA	R	PU	M30	30/04/2014	Submitted	Yes	
D5.1	Descriptio n of methodolo gy for data integration		WP5	EMPA	R	RE	M25	01/12/2013	Submitted	Yes	Methodology for surface in-situ data integration has been reported in detail. Report was uploaded in time.
D5.2	Derived tropospheri c column data		WP5	EMPA	O	PU	M24	01/12/2013	Submitted	Yes	In-situ profile data as obtained from merging surface in-situ and model data were made available on website. Report describing data format and use was uploaded in time.
D5.3	Cross compariso ns report		WP5	EMPA	R	PU	M37	30/11/2014	Submitted	Yes	Validation/cross comparison report of selected NORS remote sensing products will be uploaded by the end of the project.
D6.1	S/W for Ozone data integration		WP6	CNRS	O	PP	M24	08/11/2013	Submitted	Yes	
D6.2	Integrated Ozone profile data		WP6	CNRS	O	PU	M36	31/10/2014	Submitted	Yes	
D6.3	Integrated Ozone tropo- and stratospher ic column data		WP6	CNRS	O	PU	M36	31/10/2014	Submitted	Yes	

D7.1	Re-analysed time series		WP7	KIT	O	PU	M28	07/04/2014	Submitted	Yes	
D8.1	Validation server User Requirements Document (URD)		WP8	BIRA-IASB	R	PU	M6	14/05/2012	Submitted	Yes	The delivery of the URD has been delayed by 2 weeks due to high participation of all partners in the reviewing process. A second round of iteration has been decided, to insure a qualitative document.
D8.2	Validation server design document (DD)		WP8	S&T	R	PU	M8	09/07/2012	Submitted	Yes	Several evolutions of the document were circulated internally during the development phase, capturing new information and insights.
D8.3	Validation server in test-phase		WP8	S&T	O	PU	M21	30/8/2013	Submitted	Yes	The delivery of the server was delayed by 3 months because of staffing issues. A first version of the validation server was made available in August for internal review. An updated version was demonstrated at the progress meeting in October.
D8.4	Ready-to-use Validation Server		WP8	S&T	O	RE	M25	30/12/2013	Submitted	Yes	Several updates and extensions to the validation server were released during the deployment phase, based on new test reports and product changes.
D9.1	Feedback report regarding validation server		WP9	ULg	R	CO	M24	08/11/2013	Submitted	Yes	Revision_03. Including two illustrative validation reports.
D9.2	Assessment of CAS products		WP9	ULg	R	PU	M37	01/12/2014	Submitted	Yes	Final version corresponds to “Revision 06”.
D10.1	NDACC Capacity		WP10	BIRA-IASB	R	PU	M37	30/11/2014	Submitted	Yes	

	report										
D10. 2	NDACC status report		WP10	BIRA-IASB	R	PU	M37	30/11/2014	Submitted	Yes	
D10. 3	NORS capacity and sustainability		WP10	BIRA-IASB	R	PU	M37	30/11/2014	Submitted	Yes	
D10. 4	NORS as an in-situ GAS component		WP10	BIRA-IASB	R	PU	M37	30/11/2014	Submitted	Yes	

Milestones

Table 6. Milestones. The milestones colored in blue are first year milestones. The milestones colored in green are second year milestones. The milestones colored in red are third year milestones.

MILESTONES							
Mile-stone no.	**Milestone name**	**WP nº**	**Lead bene-ficiary**	**Delivery date from Annex I dd/mm/yyyy**	**Achieved Yes/No**	**Actual / Forecast achieve-ment date dd/mm/yyyy**	**Comments**
MS1	Kick Off	WP1	BIRA-IASB	M1	Yes	14/12/2011	The Kick-Off Meeting took place on 14/12/2011 at BIRA-IASB. The minutes and presentations have been distributed to REA and the NORS consortium.
MS2	Formats agreement	WP4	ULg	M6	Yes	09/05/2012	The data format definitions document has been issued. It provides the necessary information on the adopted formats and templates, per NORS technique.
MS3	Rapid data delivery system	WP3	UBern	M6	Yes	October 2012	Submission, distribution and archiving of HDF GEOMS data files for RDDS were successfully tested. The system works and RDDS is already in use by the NORS partners.

MS4	Selection of O_3 data sets	WP6	CNRS	M6	Yes	23/04/2012	
MS5	Agreement on comparison sites and periods	WP5	EMPA	M6	Yes	01/05/2012	Within the WP it was agreed on Jungfraujoch and Izana as comparison sites. Short report available.
MS6	Definition of validation server	WP8	BIRA-IASB	M6	Yes	14/05/2012	A detailed definition of the validation server is described throughout the User Requirements Document in D8.1
MS7	Selection of statistical method for integrating O_3 data products	WP6	CNRS	M12	Yes	31/01/2013	The selection of a statistical method for integrating O3 data product have been chosen. Tests are running on the method to provide new profiles.
MS8	Start of NDACC-TCCON Xcalibration	WP4	UBremen	M12	Yes	26/10/2012	The comparison of CO total column retrievals within the TCCON and NDACC network was set up for the station at St-Denis, La Reunion Island.
MS9	First Progress Meeting and SC meeting	WP1	BIRA-IASB	M12	No	20-21/11/2012	The First Progress Meeting and Steering Committee meeting took place on 20 and 21 November 2012 at BIRA-IASB. The minutes and presentations have been distributed to REA and the NORS consortium.
MS10	Uncertainties in NORS data products	WP4	KIT	M18	Yes	3//05/2013	Report on uncertainties in NORS data products was submitted on time.
MS11	Start verification of consistency of NORS data products	WP4	Ubremen	M18	Yes	3//05/2013	For different products (O3, NO2) comparisons of retrievals from different instruments were initiated. The Transbrom ship cruise was identified as an opportunity to also compare HCHO observations.
MS12	Guidelines for re-analysis of timeseries	WP7	KIT	M20	Yes	2/07/2013	Guidelines for the re-analysis have been submitted with a delay of 2 months. Reanalysis is on-going.
MS14	Operational data delivery	WP3	Ubremen	M21	Yes	12/09/2013	Operational data delivery has started for most of the instruments and stations.
MS13	Multi-D characterisation of NORS data products	WP4	Ubern	M24	Yes	06/11/2013	
MS16	Source sensitivities	WP5	EMPA	M24	Yes		

MS17	Second progress meeting and SC meeting	WP1	BIRA-IASB	M24	Yes	17-18/10/2013	
MS15	NORS validation server operational	WP8	S&T	M25	Yes	31/01/2014	
MS18	Readiness for validation of the GAS reanalyses	WP7	KIT	M28	Yes	07/07/2014	
MS19	Final project workshop and SC meeting	WP1	BIRA-IASB	M37	Yes	07/11/2014	
MS20	NORS Perspectives	WP10	BIRA-IASB	M37	Yes	07/11/2014	

Use and dissemination of foreground

Section A (public)

TEMPLATE A1: LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, IN CHRONOLOGICAL ORDER										
NO.	Title	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Year of publication	Relevant pages	Permanent identifiers[3] (if available)	Is/Will open access[4] provided to this publication?
1	Tropospheric BrO column densities in the Arctic derived from satellite: retrieval and comparison to ground-based measurements	H. Sihler, U. Platt, S. Beirle, T. Marbach, S. Kühl, S. Dörner, J. Verschaeve, U. Frieß, D. Pöhler, L. Vogel, R. Sander, and T. Wagner	Atmos. Meas. Tech	5			2012	2779-2807	10.5194/amt-5-2779-2012	yes
2	Trend analysis of stratospheric NO2 at Jungfraujoch (46.5°N, 8.0°E) using ground-based UV-visible, FTIR, and satellite nadir observations	Hendrick, F., E. Mahieu, G. Bodeker, K. F. Boersma, M. P. Chipperfield, M. De Mazière, P.	Atmos. Chem. Phys.	12			2012	8851–8864	10.5194/acp-12-8851-2012	yes

[3] A permanent identifier should be a persistent link to the published version full text if open access or abstract if article is pay per view) or to the final manuscript accepted for publication (link to article in repository).

[4] Open Access is defined as free of charge access for anyone via Internet. Please answer "yes" if the open access to the publication is already established and also if the embargo period for open access is not yet over but you intend to establish open access afterwards.

		Demoulin, I. De Smedt, C. Fayt, C. Hermans, K. Kreher, B. Lejeune, G. Pinardi, C. Servais, J.-P. Vernier, and M. Van Roozendael								
3	Formaldehyde and nitrogen dioxide over the remote Western Pacific Ocean: SCIAMACHY and GOME-2 validation	Peters, E.; Wittrock, F.; Großmann, K.; Frieß, U.; Richter, A. & Burrows, J. P.	Atmos. Chem. Phys. Discuss.	12			2012	15977-16024	10.5194/acpd-12-15977-2012	yes
4	Measurements of tropospheric NO2 in Romania using a zenith-sky mobile DOAS system and comparisons with satellite observations	Constantin, D.-E., A. Merlaud, M. Van Roozendael, M. Voiculescu, C. Fayt, F. Hendrick, G. Pinardi, and L. Georgescu	Sensors	13			2013	3922-3940	10.3390/s130303922	yes
5	Long-path averaged mixing ratios of O3 and NO2 in the free troposphere from mountain MAX-DOAS	Gomez, L., Navarro-Comas, M., Puentedura, O., Gonzalez, Y., Cuevas, E., and Gil-Ojeda, M.	Atmos. Meas. Tech. Discuss.	6			2013	8235-8267	10.5194/amtd-6-8235-2013	yes
6	MAXDOAS formaldehyde slant column measurements during CINDI: intercomparison and analysis improvement	Pinardi, G., M. Van Roozendael , N. Abuhassan, C. Adams, A. Cede, K. Clémer, C. Fayt, U. Frieß, M. Gil, J. Herman,	Atmos. Meas. Tech.	6			2013	167-185	10.5194/amt-6-167-2013	yes

		C. Hermans, F. Hendrick, H. Irie, A. Merlaud, M. Navarro Comas, E. Peters, A. J. M. Piters, O. Puentedura, A. Richter, A. Schönhardt, R. Shaiganfar, E. Spinei, K. Strong, H. Takashima, M. Vrekoussis, T. Wagner, F. Wittrock, and S. Yilmaz								
7	Intercomparison of stratospheric ozone profiles for the assessment of the upgraded GROMOS radiometer at Bern	Studer, S., Hocke, K., Pastel, M., Godin-Beekmann, S., and Kämpfer, N.	Atmos. Meas. Tech. Discuss.	6			2013	6097-6146	10.5194/amtd-6-6097-2013	yes
8	Iodine monoxide in the Western Pacific marine boundary layer	K. Großmann, U. Frieß, E. Peters, F. Wittrock, J. Lampel, S. Yilmaz, J. Tschritter, R. Sommariva, R. von Glasow, B. Quack, K. Krüger, K. Pfeilsticker,	Atmos. Chem. Phys.	13			2013	3363-3378	10.5194/acp-13-3363-2013	yes

		and U. Platt								
9	A 20-day period standing oscillation in the northern winter stratosphere	Hocke, K., Studer, S., Martius, O., Scheiben, D., and Kämpfer, N.	Ann. Geophys.	31			2013	755-764	10.5194/angeo-31-755-2013	yes
10	Tropospheric NO2 vertical column densities over Beijing: results of the first three years of ground-based MAX-DOAS measurements (2008–2011) and satellite validation	Ma, J. Z., Beirle, S., Jin, J. L., Shaiganfar, R., Yan, P., and Wagner, T.	Atmos. Chem. Phys.	13			2013	1547-1567	10.5194/acp-13-1547-2013	yes
11	Improved retrieval of nitrogen dioxide (NO2) column densities by means of MKIV Brewer spectrophotometers	Diémoz, H., Siani, A. M., Redondas, A., Savastiouk, V., McElroy, C. T., Navarro-Comas, M., and Hase, F.	Atmos. Meas. Tech.	7			2014	4009-4022	10.5194/amt-7-4009-2014	yes
12	Retrievals of formaldehyde from ground-based FTIR and MAX-DOAS observations at the Jungfraujoch station and comparisons with GEOS-Chem and IMAGES model simulations	B. Franco, F. Hendrick, M. Van Roozendael, J.-F. Müller, T. Stavrakou, E. A. Marais, B. Bovy, W. Bader, C. Fayt, C. Hermans, B. Lejeune, G. Pinardi, C. Servais, and E. Mahieu	Atmos. Meas. Tech. Discuss	7			2014	10715-10770	10.5194/amtd-7-10715-2014	yes
13	A simple and versatile cloud-screening method for MAX-	Gielen, C., M. Van Roozendael	Atmos. Meas.	7			2014	3509-3527	10.5194/amtd-7-5883-2014	yes

	DOAS retrievals	, F. Hendrick, G. Pinardi, T. Vlemmix, V. De Bock, H. De Backer, C. Fayt, C. Hermans, D. Gillotay, and P. Wang	Tech.							
14	Vertical distribution of BrO in the boundary layer at the Dead Sea	Holla, R.; Schmitt, S.; Zingler, J.; Frieß, U.; Corsmeier, U.; Kottmeier, C. & Platt, U.	submitted to Environmental Chemistry				2014			yes
15	Description of algorithms for co-locating and comparing gridded model data with remote-sensing observations	Langerock, B., M. De Mazière, F. Hendrick, C. Vigouroux, F. Desmet, B. Dils, and S. Niemeijer	Geosci. Model Dev. Discuss.	7			2014	8151–8178	10.5194/gmdd-7-8151-2014	yes
16	MAX-DOAS observations of aerosols, formaldehyde and nitrogen dioxide in the Beijing area: comparison of two profile retrieval approaches	Vlemmix, T., F. Hendrick, G. Pinardi, I. De Smedt, C. Fayt, C. Hermans, A. Piters, P. Levelt, and M. Van Roozendael	Atmos. Meas. Tech. Discuss.	7			2014	9673-9731	10.5194/amtd-7-9673-2014	yes
17	Four Years of Ground-based MAX-DOAS Observations of HONO and NO2 in the Beijing Area	Hendrick, F., J.-F. Müller, K. Clémer, M. De Mazière, C. Fayt, C. Gielen, C.	Atmos. Chem. Phys.	14			2014	765-781	10.5194/acp-14-765-2014	yes

		Hermans, J. Z. Ma, G. Pinardi, T. Stavrakou, T. Vlemmix, P. Wang, and M. Van Roozendael								
18	Improved spectral fitting of nitrogen dioxide from OMI in the 405–465nm window	van Geffen, J. H. G. M., K. F. Boersma, M. Van Roozendael, F. Hendrick, E. Mahieu, I. De Smedt, M. Sneep, and J. P. Veefkind	Atmos. Meas. Tech. Discuss.	7			2014	10619–10671	10.5194/amtd-7-10619-2014	yes
19	Evaluation of tropospheric SO2 retrieved from MAX-DOAS measurements in Xianghe, China	Wang, T., F. Hendrick, P. Wang, G. Tang, K. Clémer, H. Yu, C. Fayt, C. Hermans, C. Gielen, J.-F. Müller, G. Pinardi, N. Theys, H. Brenot, and M. Van Roozendael	Atmos. Chem. Phys.	14			2014	11149-11164	10.5194/acp-14-11149-2014	yes
20	Tropospheric nitrogen dioxide column retrieval from ground-based zenith-sky DOAS observations	Tack, F., Hendrick, F., Goutail, F., Fayt, C., Merlaud, A., Pinardi, G., Hermans, C., Pommereau, J.-P., and Van Roozendael, M.	Atmos. Meas. Tech. Discuss.	8			2015	935-985	10.5194/amtd-8-935-2015	yes

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[5]	Main leader	Title	Date	Place	Type of audience[6]	Size of audience	Countries addressed
1	conference	Blechschmidt, A.-M.	Using MAX-DOAS measurements of tropospheric NO_2 columns for MACC-II validation, oral presentation at the NORS/NDACC/GAW workshop	5-7 November 2014	Brussels, Belgium	Scientific Community		
2	conference	Buchmann, B.	Treibhausgase und Reaktive Gase auf dem Jungfraujoch, 192. Annual Congress of the Swiss Academies of Sciences SCNAT 2012	24-25 October 2012	Interlaken, Switzerland	Scientific Community		
3	conference	De Mazière, M.	NORS, Demonstration Network Of ground-based Remote Sensing observations in support of the GMES Atmospheric Service, oral presentation at the NDACC Steering Committee Meeting	11 Nov., 2011	Salines les Bains, La Réunion	Scientific Community		
4	web	De Mazière, M., Kalb, N.	NORS website (http://nors.aeronomie.be/)	November 2011		Scientific Community, Industry, Civil Society, Policy makers, Medias		
5	flyer	De Mazière, M. & NORS	NORS brochure	February 2012		Scientific		

[5] A drop down list allows choosing the dissemination activity: publications, conferences, workshops, web, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters, Other.

[6] A drop down list allows choosing the type of public: Scientific Community (higher education, Research), Industry, Civil Society, Policy makers, Medias ('multiple choices' is possible.

		consortium				Community, Industry, Civil Society, Policy makers, Medias		
6	conference	De Mazière, M.	NORS, oral presentation at the MACC-II KO meeting	1 March 2012	Reading, United Kingdom	Scientific Community		
7	other	De Mazière, M.	Demonstration Network Of ground-based Remote Sensing observations in support of the CAMS Atmospheric Service (NORS) in “Eye on Space" brochure about the Space Research projects under the 7th EC Framework Programme for Research	9 July 2012		Scientific Community, Industry, Civil Society, Policy makers, Medias		
8	conference	De Mazière, Martine	NORS: overview and project status, oral presentation at the NDACC UVVIS WG meeting at BIRA-IASB	3-4 July 2012	Brussels, Belgium	Scientific Community		
9	conference	De Mazière, M.	Need for metadata in NORS - adoption of GEOMS, oral presentation at the Workshop “Metadata for Air Quality and Atmospheric Composition“, Morrison hotel, Lower Ormond Quay	5-7 September 2012	Dublin, Ireland	Scientific Community		
10	poster	De Mazière Martine, Hocke Klemens, Richter Andreas, Godin-Beekmann Sophie, Henne Stephan, Blumenstock Thomas, Niemeijer Sander, Mahieu Emmanuel	NORS: Demonstration Network Of ground-based Remote Sensing Observations in support of the GMES Atmospheric Servic e, poster presentation at the IGAC International Science Conference 2012 ‘Atmospheric chemistry in the Anthropocene’	17-21 September 2012	Beijing, China	Scientific Community		
11	conference	De Mazière, Martine	Transition to HDF status, discussion about the format homogenization in the	15-18 Oct., 2012	Garmisch-Partenkirchen	Scientific Community		

			NDACC DHF at the 2012 NDACC SC meeting					
12	conference	De Mazière, Martine, Hocke Klemens, Richter Andreas, Godin-Beekmann Sophie, Henne Stephan, Blumenstock Thomas, Niemeijer Sander, Mahieu Emmanuel, and participating teams and SC members	Progress in the first year of NORS, oral presentation at the NDACC Steering Committee Meeting	15-18 Oct., 2012	Garmisch-Partenkirchen, Germany	Scientific Community		
13	other	De Mazière, M.	NORS: Ensuring the quality of the GMES Atmosphere Service, The Parliament Magazine, 360, p. 101	17 December 2012		Scientific Community		
14	other	De Mazière, M.	NORS project: Dr M De Mazière from BIRA-IASB highlights how NORS contributes to ensuring the quality of the Copernicus Atmosphere Service, Pan European Networks: Science & Technology, 06, p. 96	March 2013		Scientific Community		
15	conference	De Mazière, M. and B. Langerock	Demonstration Network Of ground-based Remote Sensing Observations in support of the Copernicus Atmospheric Service, demonstration at the 'Monitoring Matters' GISC Workshop, EEA	10-11 April 2013	Copenhagen, Denmark	Scientific Community		
16	poster	De Mazière, Martine, François Hendrick, Christof Petri, Andreas Richter, Thomas Blumenstock, Udo Frieß, Thomas Wagner, Maud Pastel, Sophie Godin-Beekmann, Manuel Gil	NORS-NDACC new sites, Poster presentation at the GISC Workshop « Monitoring matters », (EEA)	10-11 April 2013	Copenhagen, Denmark	Scientific Community		

		Ojeda and Olga Puentedura Rodriguez and Emmanuel Mahieu							
17	conference	De Mazière, M., I. Boyd, A.F. Vik, A.M. Fjaeraa, T. Krognes, G. Taha, J. Wild, C. Retscher, B. Bojkov, A. Burini, S. Niemeijer	GEOMS templates, oral presentation at the NDACC Infrared Working Group annual meeting	10-14 June 2013	Abashiri, Japan	Scientific Community			
18	other	De Mazière, M.	NORS: a contribution to the quality assessment and improvement of the Copernicus Atmosphere Service, NDACC Newsletter, Vol. 5	Sept. 2013		Scientific Community			
19	conference	De Mazière, M. and the NORS consortium	How NORS is enhancing the value of NDACC, especially for validation purposes, oral presentation at the NDACC Steering Committee meeting	30 Sept.-3 Oct. 2013	Frascati, Italy	Scientific Community			
20	other	De Mazière, M.	NORS White Paper	3 November 2013		Scientific Community, Policy makers			
21	other	De Mazière, M.	Demonstration Network Of ground-based Remote Sensing observations in support of the CAMS Atmospheric Service (NORS) in "Climate, Air Quality, Ozone and UV" brochure in Adjacent Digital Politics	January 2014		Scientific Community, Industry, Civil Society, Policy makers, Medias			
22	conference	De Mazière, M., B. Langerock and the NORS consortium	Remote sensing network observations of atmospheric composition for assessing and improving the MACC-II products: status of the NORS project, oral presentation at the MACC-II Open Science Conference	27-30 Jan. 2014	Brussels, Belgium	Scientific Community			

23	workshop	De Mazière, M. & NORS consortium	NORS/NDACC/GAW Workshop	5-7 November 2014		Scientific Community, Policy makers		
24	poster	Demoulin, P. , E. Mahieu , C. Servais , B. Lejeune , W. Bader , G. Roland , R. Zander, K. Walker , P. Bernath , M. Van Roozendael , F. Hendrick	Long-term trends of NOy above Northern mid-latitudes as inferred from Jungfraujoch, HALOE and ACE-FTS solar observations, poster presentation at the Quadrennial Ozone Symposium 2012	27-31 August 2012	Toronto, Canada	Scientific Community		
25	conference	De Smedt, I., M. Van Roozendael, T. Stavrakou, J.-F. Müller, G. Pinardi, and F. Hendrick	Satellite observations of tropospheric formaldehyde combining GOME-2 and OMI measurements, Oral presentation at the General Assembly of the European Geosciences Union	27 April-2 May 2014	Vienna, Austria	Scientific Community		
26	conference	Eskes, H.	Validation of the MACC atmospheric composition global forecasting service, oral presentation at the NORS/NDACC/GAW workshop	5-7 November 2014	Brussels, Belgium	Scientific Community		
27	conference	Franco, B., F. Hendrick, M. Van Roozendael, J.-F. Müller, T. Stavrakou, E. Marais, B. Bovy, W. Bader, C. Fayt, C. Hermans, B. Lejeune, G. Pinardi, C. Servais, and E. Mahieu	Retrievals of formaldehyde from ground-based FTIR and MAX-DOAS observations at the Jungfraujoch station and comparisons with GEOS-Chem and IMAGES model simulations, oral presentation at the NORS/NDACC/GAW workshop	5-7 November, 2014	Brussels, Belgium	Scientific Community		
28	poster	Frieß, U., U. Corsmeier, C. Kottmeier, and U. Platt, Holla, R.; Schmitt, S.; Zingler, J.	Vertical distribution of BrO and aersols at the Dead Sea Valley, Geophysical Research Abstracts, EGU General Assembly 2013	7-12 April 2013	Vienna, Austria	Scientific Community		
29	conference	Frieß, U.	Lectures on the topic of Remote Sensing of Atmospheric Trace Gase,	July 2013	Toronto, Canada	Scientific Community		

			NSERC/CREATE Summer School (http://www.candac.ca/create)						
30	conference	Frieß, U., S. Yilmaz, and U. Platt	Retrieval of Vertical Profiles of Trace Gases and Aerosols using the HEIPRO Algorithm: An Overview. Oral Presentation at the EGU General Assembly, 2014.	27 April – 02 May 2014	Vienna, Austria	Scientific Community			
31	conference	Frieß, U.	On the ability of MAX-DOAS to detect clouds, oral presentation at the NORS/NDACC/GAW workshop	5-7 November 2014	Brussels, Belgium	Scientific Community			
32	poster	Gielen, C., M. Van Roozendael, F. Hendrick, C. Fayt, C. Hermans, G. Pinardi, and T. Vlemmix	Development of a cloud-screening method for MAX-DOAS observations, Poster presentation at the General Assembly of the European Geosciences Union	07-12 April 2013	Vienna, Austria	Scientific Community			
33	conference	Gielen, C., M. Van Roozendael, F. Hendrick, C. Fayt, C. Hermans, G. Pinardi, and T. Vlemmix	Development of a cloudscreening method for MAX-DOAS observations, Oral presentation at the 6th International DOAS Workshop	12-14 August 2013	Boulder, USA	Scientific Community			
34	poster	Gielen, C., M. Van Roozendael, F. Hendrick, C. Fayt, C. Hermans, G. Pinardi, H. De Backer, V. De Bock, Q. Laffineur, and T. Vlemmix	The effect of cloud screening on MAX-DOAS aerosol retrievals, Poster presentation at the EGU	27 April-2 May 2014	Vienna, Austria	Scientific Community			
35	conference	Gielen, C.	A first look at African aerosol and trace-gas emissions from the Bujumbura station, oral presentation at the NORS/NDACC/GAW workshop	5-7 November 2014	Brussels, Belgium	Scientific Community			
36	poster	Gil-Ojeda, M., M. Navarro-Comas, A. Redondas, O.	Total ozone measurements from the NDACC Izaña Subtropical Station: Visible spectroscopy versus Brewer and	August 27-31, 2012	Toronto, Canada	Scientific Community			

		Puentedura, F. Hendrick, M. Van Roozendael, J. Iglesias and E. Cuevas	satellite instruments, poster presentation at the Quadrennial Ozone Symposium 2012					
37	conference	Gil-Ojeda, M.	NO_2 seasonal evolution in the background free troposphere from MAXDOAS measurements, oral presentation at the NORS/NDACC/GAW workshop	5-7 November 2014	Brussels, Belgium	Scientific Community		
38	conference	Godin-Beekmann, S.	Contribution of lidar ozone measurements to the SI2N initiative on the past changes on the vertical distribution, oral presentation at SI2N (SPARC/IO3C/IGACO-O3/NDACC) workshop	16-18 April 2012	Columbia, Maryland, USA	Scientific Community		
39	conference	Godin-Beekmann S., Prijitha Nair, Maud Pastel, Andrea Pazmino, Florence Goutail, Gérard Ancellet, Irina Petropavloskikh, Lucien Froidevaux, Joseph Zawodny, Alain Hauchecorne,	Evaluation of ozone total column and vertical distribution recovering trends at NDACC Northern mid-latitude station, oral presentation at Quadrennial Ozone Symposium	August 27-31, 2012	Toronto, Canada	Scientific Community		
40	conference	Godin-Beekmann, S.	Comparison and merging of ozone profile data from various measurement techniques at 4 NDACC stations, oral presentation at the NORS/NDACC/GAW workshop	5-7 November 2014	Brussels, Belgium	Scientific Community		
41	conference	Gomez-Martin, L.	Surface O3 from MAX DOAS measurements, oral presentation during the NDACC UV-VIS Working Group meeting	July 3-4, 2012	Brussels, Belgium	Scientific Community		
42	conference	Gomez-Martin, L.	NORS WP10: Status of the MAX-DOAS instruments operated by INTA in	1-2 July 2013	Mainz, Germany	Scientific Community		

			Antarctica (Marambio, Belgrano, Ushuaia), oral presentation at the NDACC UVVIS WG meeting at MPI					
43	conference	Goutail, F., A Bazureau, and the SAOZ team	Status of the rapid data delivery to the NORS/NDACC database, oral presentation at the NDACC UVVIS WG meeting at MPI	1-2 July 2013	Mainz, Germany	Scientific Community		
44	conference	Gribanov, K.	The possibility of NDACC infrared FTIR observations at Kourovka, oral presentation at the NORS/NDACC/GAW workshop	5-7 November 2014	Brussels, Belgium	Scientific Community		
45	poster	Gu, M., C.-F. Enell, J. Pukite, S. Kühl, F. Hendrick, M. Van Roozendael, U. Platt, U. Raffalski	Long-term variation of stratospheric NO2 from ground-based zenith-sky DOAS observations at Kiruna, Sweden, Poster presentation at the 6th International DOAS Workshop	12-14 August 2013	Boulder, USA	Scientific Community		
46	conference	Hao, N., M. Van Roozendael, A. Ding, B. Zhou, F. Hendrick, Y. Shen, T. Wang, and P. Valks	Retrieval of tropospheric NO2 vertical column densities and aerosol optical properties form MAX-DOAS measurements in Yangtze River Delta, China, Oral presentation at the General Assembly of the European Geosciences Union	27 April-2 May 2014	Vienna, Austria	Scientific Community		
47	poster	Hendrick, F., D. Ionov, F. Goutail, A. Pazmino, U. Friess, M. Gil, J.-C. Lambert, M. Pastel, J.-P. Pommereau, A. Richter, T. Wagner, and M. Van Roozendael	New NDACC recommendations for the retrieval of stratospheric NO2 columns from ground-based zenith-sky UV-visible observations, poster presentation at the European Geophysical Union General Assembly 2012	22 – 27 April 2012.	Vienna, Austria	Scientific Community		
48	poster	Hendrick, F., E. Mahieu, A. Rozanov, K. F. Boersma, M. De Mazière, P. Demoulin, C.	Trend analysis of stratospheric NO2 above Jungfraujoch (46.5°E, 8°E) and Harestua (60°N, 11°E) using long-term ground-based UV-visible, FTIR, and	18-22 June 2012	Bruges, Belgium	Scientific Community		

		Fayt, C. Hermans, G. Pinardi, and M. Van Roozendael	satellite observations, poster presentation at the ESA ATMOS 2012, Advances in Atmospheric Science and Applications					
49	conference	Hendrick, F., C. Fayt, B. Franco, C. Gielen, C. Hermans, E. Mahieu, J.-F. Müller, G. Pinardi, T. Stavrakou, and M. Van Roozendael	NORS WP3 status: GEOMS data formatting-Rapid delivery service, QA/QC procedures, oral presentation at the NDACC UVVIS WG meeting at BIRA-IASB	3-4 July 2012	Brussels, Belgium	Scientific Community		
50	poster	Hendrick, F., J.-F. Müller, K. Clémer, M. De Mazière, C. Fayt, C. Hermans, T. Stavrakou, T. Vlemmix, P. Wang, and M. Van Roozendael	Four years of ground-based MAX-DOAS observations of HONO and NO2 in the Beijing area, Poster presentation at the American Geophysical Union Fall Meeting	3-7 December 2012	San Francisco, USA	Scientific Community		
51	conference	Hendrick, F., J.-F. Müller, M. De Mazière, C. Fayt, C. Hermans, T. Stavrakou, P. Wang, and M. Van Roozendael	Four Years of Ground-based MAX-DOAS Observations of HONO and NO2 in the Beijing Area, Oral presentation at the General Assembly of the European Geosciences Union	07-12 April 2013	Vienna, Austria	Scientific Community		
52	conference	Hendrick, F., and M. Van Roozendael	Harmonisation of MAX-DOAS retrievals within NORS, oral presentation at the NDACC UVVIS WG meeting at MPI	1-2 July 2013	Mainz, Germany	Scientific Community		
53	conference	Hendrick, F., C. Fayt, M. Van Roozendael, and I. Boyd	NORS WP3: rapid data delivery at 4 NDACC stations, oral presentation at the NDACC UVVIS WG meeting at MPI	1-2 July 2013	Mainz, Germany	Scientific Community		
54	conference	Hendrick, F., J.-F. Müller, M. De Mazière, C. Fayt, C. Gielen, C. Hermans, G. pinardi, T. Stavrakou, P. Wang, and M. Van Roozendael	Four Years of Ground-based MAX-DOAS Observations of HONO and NO2 in the Beijing Area, Oral presentation at the 6th International DOAS Workshop	12-14 August 2013	Boulder, USA	Scientific Community		
55	conference	Hendrick, F., C. Fayt, B.	Retrieval of HCHO from MAX-DOAS	27 April - 2	Vienna, Austria	Scientific		

		Franco, C. Gielen, C. Hermans, E. Mahieu, J.-F. Müller, G. Pinardi, T. Stavrakou, and M. Van Roozendael	measurements at the high-altitude station of Jungfraujoch (46.5°N, 8.0°E), oral presentation at the "EGU 2014 General Assembly"	May 2014		Community		
56	conference	Hendrick, F.	Overview of the progress achieved by the NDACC UV-vis Working Group during the NORS project, oral presentation at the NORS/NDACC/GAW workshop	5-7 November 2014	Brussels, Belgium	Scientific Community		
57	conference	Henne, S., M. Steinbacher, E. Mahieu, W. Bader, T. Blumenstock, E. Cuevas-Agulló, D. Brunner, and B. Buchmann	Comparison of ground-based remote sensing and in-situ observations of CO, CH4 and O3, accounting for representativeness uncertainty, oral presentation at the "EGU 2013 General Assembly"	7-12 April 2013	Vienna, Austria	Scientific Community		
58	poster	Henne, S.	Accounting for spatial representativeness in comparisons of tropospheric ground-based remote sensing and surface in-situ observations – Application to FTIR and MAXDOAS observations of CO, CH_4, O_3, and NO_2, poster at the NDACC/NORS/GAW workshop	5-7 November 2014	Brussels, Belgium	Scientific Community		
59	poster	Hocke K., S. Studer, A. Schanz, N. Kämpfer	Diurnal Variation of Stratospheric and Mesospheric Ozone Observed by Ground-based Microwave Radiometry, EGU General Assembly	7-12 April 2013	Vienna, Austria	Scientific Community		
60	conference	Hocke, K.	NORS, MW-Freitagseminar, seminar of IAP-UniBern	22 Nov 2013	Bern, Switzerland	Scientific Community		
61	conference	Hocke, K.	The Three Roles of the Rapid Data Delivery System of NORS, oral presentation at the NORS/NDACC/GAW workshop	5-7 November 2014	Brussels, Belgium	Scientific Community		

62	poster	Holla, R.; Schmitt, S.; Zingler, J.; Frieß, U.; Corsmeier, U.; Kottmeier, C. & Platt, U.	Vertical distribution of BrO and aersols at the Dead Sea Valley, Geophysical Research Abstracts, EGU General Assembly 2013	7-12 April 2013	Vienna, Austria	Scientific Community		
63	conference	Kiel, M.	MIR and NIR comparisons of trace gas retrievals based on FTIR operation in Karlsruhe, oral presentation at the NORS/NDACC/GAW workshop	5-7 November 2014	Brussels, Belgium	Scientific Community		
64	conference	Lambert, J.-C.	Smoothing and Sampling Issues Affecting Data Comparisons, oral presentation at the 8th Atmospheric Composition Constellation Meeting (ACC-8)	18-19 April 2012	Columbia, USA	Scientific Community		
65	conference	Langerock, B. and M. De Mazière	Objectives and status of the NORS project, oral presentation at the NDACC Infrared Working Group annual meeting	June 11-13, 2012	Wengen, Switzerland	Scientific Community		
66	conference	Langerock, B. and M. De Mazière	Demonstration Network Of ground-based Remote Sensing observations in support of the GMES Atmospheric Service, oral presentation at the NDACC Infrared Working Group annual meeting	June 11-13, 2012	Wengen, Switzerland	Scientific Community		
67	conference	Langerock, B.	SFIT uncertainty computations at BIRA-IASB, oral presentation at the IRWG/NORS Workshop on uncertainties	Jan. 28-Feb. 1, 2013	Boulder, USA	Scientific Community		
68	conference	Langerock, B. and M. De Mazière	Outline of the use of FTIR measurements in the NORS validation server, oral presentation at the NDACC Infrared Working Group annual meeting	June 10-14, 2013	Abashiri, Japan	Scientific Community		
69	conference	Langerock B., De Mazière M.	Developments in the NORS project, oral presentation at the IRWG-TCCON workshop.	12 May -16 May 2014	Jena, Germany	Scientific Community		
70	conference	Langerock, B.	NORS validation server: achievements and ongoing discussions, oral presentation at the NORS/NDACC/GAW	5-7 November 2014	Brussels, Belgium	Scientific Community		

			workshop					
71	conference	Mahieu, E.	Recent results from long-term FTIR monitoring activities at Jungfraujoch: some unexpected trends and new target species, oral presentation at the meeting "Spawning the atmosphere measurements of Jungfraujoch, Schneefernerhaus and Sonnblick"	22-23 January 2014	Bern, Switzerland	Scientific Community		
72	conference	Moreira, L.	Harmonization and trend analysis of the 20 years time series of stratospheric ozone profiles observed by the GROMOS microwave radiometer at Bern, oral presentation at the NORS/NDACC/GAW workshop	5-7 November 2014	Brussels, Belgium	Scientific Community		
73	conference	Nasse, J.-M., J. Zielcke, J. Buxmann, U. Frieß, and U. Platt	Retrieval of vertical aerosol- and trace gas profiles in the Antarctic troposphere using helicopter-borne MAX-DOAS measurements, Oral presentation at the EGU General Assembly, 2014.	27 April – 02 May 2014	Vienna, Austria	Scientific Community		
74	conference	Pastel M., Pazmino A., Goutail F., Pommereau J.-P.	oral presentation at the NORS/NDACC UV-VIS Working Group Meeting (BIRA-IASB)	3-4 July 2012	Brussels, Belgium	Scientific Community		
75	poster	Pastel M., Godin-Beekmann S., Mahieu E., Demoulin P., Hocke K.	First steps of a new methodology for integrating ground-based ozone profile data, poster presentation at the Quadrennial Ozone Symposium 2012	August 27-31, 2012	Toronto, Canada	Scientific Community		
76	conference	Pastel M., Godin-Beekmann S.	NORS project, Contribution of the CNRS LIDAR team, NDACC Lidar Working Group	4-8 November 2013	California, USA	Scientific Community		
77	conference	Pastel M., Godin-Beekmann S.	Preliminary results of the seasonal ozone vertical trends at OHP France, NDACC Lidar Working Group	4-8 November 2013	California, USA	Scientific Community		
78	conference	Petri, C., T. Blumenstock, F. Hase,	Carbon monoxide retrieved from ground-based FTIR remote-sensing in the mid-	12-16 May 2014	Bad Sulza, Germany	Scientific Community		

		M. De Mazière, B. Langerock, E. Mahieu, B. Franco, and J. Notholt	and near infrared spectral region, oral presentation at the joint NDACC-IRWG and TCCON meeting					
79	conference	Petri, C.	Carbon Monoxide retrieved from Ground Based FTIR Remote Sensing in the Mid- and Near Infra-Red Spectral Region, oral presentation at the NORS/NDACC/GAW workshop	5-7 November 2014	Brussels, Belgium	Scientific Community		
80	conference	Pinardi G., M. Van Roozendael, J.C. Lambert, K. Clemer, I. De Smedt, F. Hendrick, C. Lerot, N. Theys, J. van Gent, T. Vlemmix, M. De Maziere, H. Yu, H. De Backer, A. Delcloo	Integrated trace gas validation and quality assessment system for the EUMETSAT polar system, oral presentation at the 2012 EUMETSAT Meteorological Satellite Conference, Sopot	3-7 September 2012	Poland	Scientific Community		
81	poster	Pinardi, G., Huan Yu, F. Hendrick, F. Tack, J. Granville, J.-C. Lambert, and M. Van Roozendael	End-to-end validation of total and tropospheric NO2 columns from atmospheric composition satellite sensors, Poster presentation at the ESA ACVE conference	13-15 March 2013	Frascati, Italy	Scientific Community		
82	poster	Pinardi, G., M. Van Roozendael, J.-C. Lambert, J. Granville, M. De Mazière, H. De Backer, A. Delcloo, I. De Smedt, F. Hendrick, H. Yu, T. Wang, C. Lerot, N. Theys, J. van Gent, F. Tack, C. Gielen	Trace gas validation and quality assessment system for atmospheric sensors on METOP, Poster presentation at the 2013 ESA Living Planet Symposium	9-13 September 2013	Edinburgh, United Kingdom	Scientific Community		
83	poster	Pinardi, G. , M. Van Roozendael, J.-C. Lambert , J. Granville, M. De Mazière, H. De	Trace gas validation and quality assessment system for atmospheric sensors on METOP, Poster presentation at the 2013 EUMETSAT Meteorological	16-20 September 2013	Vienna, Austria	Scientific Community		

		Backer, A. Delcloo , I. De Smedt, F. Hendrick , H. Yu , T. Wang, C. Lerot, N. Theys , J. van Gent , F. Tack, and C. Gielen	Satellite Conference					
84	conference	Pinardi, G., M. Van Roozendael, J.C. Lambert, J. Granville, F. Hendrick, F. Tack, H. Yu, A. Cede, Y. Kanaya, H. Irie, F. Goutail, J.-P. Pommereau, F. Wittrock, T. Wagner, U. Friess, T. Vlemmix, A. Piters, N. Hao, M. Tiefengraber, J. Herman, N. Abuhassan	GOME-2 total and tropospheric NO2 validation based on ZenithSky, DirectSun and MAXDOAS network observations, Oral presentation at the EUMETSAT conference	22-26 September 2014	Geneva, Switzerland	Scientific Community		
85	conference	Pinardi, G.	On the use of zenith-sky, MAXDOAS and direct-sun network observations to validate GOME-2 total and tropospheric NO2 columns, oral presentation at the NORS/NDACC/GAW workshop	5-7 November 2014	Brussels, Belgium	Scientific Community		
86	conference	Pommereau, J.-P., F. Goutail, A. Pazmino, D. Ionov, F. Hendrick, and M. Van Roozendael	Evaluation of Satellites NO2 Columns using the SAOZ UV-Vis Network, Oral presentation at the ESA ACVE conference	13-15 March 2013	Frascati, Italy	Scientific Community		
87	conference	Puentedura, O.	El reto de medir componentes atmosféricos en el rango de las ppt mediante DOAS, 23th RNE	September 19, 2012	Cordoba, Spain	Scientific Community		
88	poster	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, Geophysical Research Abstracts, Vol. 16, EGU2014-14635.	27 April-2 May 2014	Vienna, Austria	Scientific Community		

89	poster	Puentedura O.	MAXDOAS observations at Belgrano II station (Antarctica, 78ºS), poster at the NDACC/NORS/GAW workshop	5-7 November 2014	Brussels, Belgium	Scientific Community		
90	conference	Remmers, J.	Azimuthal variability of trace gases and aerosols measured during MADCAT in summer 2013 in Mainz, Germany, oral presentation at the NORS/NDACC/GAW workshop	5-7 November 2014	Brussels, Belgium	Scientific Community		
91	conference	Richter, A., F. Wittrock, E. Peters, and J. P. Burrows	NORS WP4: uncertainties, oral presentation at the NDACC UVVIS WG meeting at MPI	1-2 July 2013	Mainz, Germany	Scientific Community		
92	conference	Richter, A.	Spatial and temporal variability of NO_2 in Athens observed by MAX-DOAS, oral presentation at the NORS/NDACC/GAW workshop	5-7 November 2014	Brussels, Belgium	Scientific Community		
93	poster	Schanz A., K. Hocke and N. Kämpfer	A Global View on Diurnal Ozone Variation in the Stratosphere with WACCM, 14th Swiss Global Change Day	April 16, 2013	Bern, Switzerland	Scientific Community		
94	poster	Tack, F., F. Hendrick, F. Goutail, C. Fayt, A. Merlaud, G. Pinardi, J.-P. Pommereau, and M. Van Roozendael	Tropospheric nitrogen dioxide column retrieval based on ground-based zenith-sky DOAS observations, Poster presentation at the EGU	27 April-2 May 2014	Vienna, Austria	Scientific Community		
95	conference	Vlemmix, T., F. Hendrick, I. De Smedt, G. Pinardi, A. Piters, and M. Van Roozendael	MAX-DOAS observations of formaldehyde, nitrogen dioxide, and aerosols in the Beijing area: Comparison of two profile retrieval approaches, Oral presentation at the ESA ACVE conference	13-15 March 2013	Frascati, Italy	Scientific Community		
96	conference	Vlemmix, T., F. Hendrick, G. Pinardi, I. De Smedt, C. Fayt, C. Hermans, C. Gielen, A. Piters, P. Levelt, and M.	Comparison of two profile retrieval algorithms for MAX-DOAS: tropospheric profiles of NO2, HCHO and aerosols obtained from four years of observations in China, Oral presentation at the EGU	27 April-2 May 2014	Vienna, Austria	Scientific Community		

		Van Roozendael						
97	conference	Wagner, T.	NORS WP4: data reporting of parameterized profile inversions, oral presentation at the NDACC UVVIS WG meeting at MPI	1-2 July 2013	Mainz, Germany	Scientific Community		
98	conference	Wagner, T.	Absolute calibration of sky radiances, colour indices and O_4 DSCDs obtained from MAX-DOAS measurements, oral presentation at the NORS/NDACC/GAW workshop	5-7 November 2014	Brussels, Belgium	Scientific Community		
99	poster	Wang, Y.; Xie, P.; Wagner, T.; Li, A.; Luo, Y.; Remmers, J.; Horbanski, M. & Frieß, U.	Retrieval of vertical profiles of multiple trace gases from MAX-DOAS observations during the MADCAT Campaign in Mainz, Germany, EGU General Assembly	27 April-2 May 2014	Vienna, Austria	Scientific Community		
100	poster	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 SO2 retrieved from MAX-DOAS measurements in Xianghe, China, Poster presentation at the EGU	27 April-2 May 2014	Vienna, Austria	Scientific Community		
101	conference	Wittrock, F. with contributions from BIRA-IASB, UBremen, INTA, MPI-Mainz	NORS WP4 status, oral presentation at the NDACC UVVIS WG meeting at BIRA-IASB	3-4 July 2012	Brussels, Belgium	Scientific Community		
102	poster	Yela M., Puentedura O., Navarro-Comas M., Gómez-Martín L., Iglesias J., Ochoa H. and Adame J.A.	MAXDOAS observations at Belgrano II station (Antarctica, 78ºS). NORS/NDACC/GAW workshop	5 - 7 November 2014	Brussels, Belgium	Scientific Community		

Section B (Confidential[7] or public: confidential information to be marked clearly)

Part B1

TEMPLATE B1: LIST OF APPLICATIONS FOR PATENTS, TRADEMARKS, REGISTERED DESIGNS, ETC.					
Type of IP Rights[8]:	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Application reference(s) (e.g. EP123456)	Subject or title of application	Applicant (s) (as on the application)

Part B2

Type of Exploitable Foreground[9]	Description of exploitable foreground	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application[10]	Timetable, commercial or any other use	Patents or other IPR exploitation (licences)	Owner & Other Beneficiary(s) involved
	Ex: New supercond uctive Nb-Ti alloy			*MRI equipment*	*1. Medical* *2. Industrial inspection*	*2008* *2010*	*A materials patent is planned for 2006*	*Beneficiary X (owner)* *Beneficiary Y, Beneficiary Z, Poss. licensing to equipment manuf. ABC*

[7] Note to be confused with the "EU CONFIDENTIAL" classification for some security research projects.

[8] A drop down list allows choosing the type of IP rights: Patents, Trademarks, Registered designs, Utility models, Others.

[19] A drop down list allows choosing the type of foreground: General advancement of knowledge, Commercial exploitation of R&D results, Exploitation of R&D results via standards, exploitation of results through EU policies, exploitation of results through (social) innovation.

[10] A drop down list allows choosing the type sector (NACE nomenclature) : http://ec.europa.eu/competition/mergers/cases/index/nace_all.html

Report on societal implications

A General Information *(completed automatically when **Grant Agreement number** is entered.*	
Grant Agreement Number:	284421
Title of Project:	Demonstration Network Of ground-based Remote Sensing Observations in support of the Copernicus Atmosphere Monitoring Service (NORS)
Name and Title of Coordinator:	De Mazière Martine, Director general a.i.

B Ethics	
1. Did your project undergo an Ethics Review (and/or Screening)? • If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports? Special Reminder: the progress of compliance with the Ethics Review/Screening Requirements should be described in the Period/Final Project Reports under the Section 3.2.2 *'Work Progress and Achievements'*	***No***
2. Please indicate whether your project involved any of the following issues (tick box) :	
RESEARCH ON HUMANS	
• Did the project involve children?	NO
• Did the project involve patients?	NO
• Did the project involve persons not able to give consent?	NO
• Did the project involve adult healthy volunteers?	NO
• Did the project involve Human genetic material?	NO
• Did the project involve Human biological samples?	NO
• Did the project involve Human data collection?	NO
RESEARCH ON HUMAN EMBRYO/FOETUS	
• Did the project involve Human Embryos?	NO
• Did the project involve Human Foetal Tissue / Cells?	NO
• Did the project involve Human Embryonic Stem Cells (hESCs)?	NO
• Did the project on human Embryonic Stem Cells involve cells in culture?	NO
• Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?	NO
PRIVACY	
• Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	NO
• Did the project involve tracking the location or observation of people?	NO
RESEARCH ON ANIMALS	
• Did the project involve research on animals?	NO
• Were those animals transgenic small laboratory animals?	NO
• Were those animals transgenic farm animals?	NO
• Were those animals cloned farm animals?	NO
• Were those animals non-human primates?	NO
RESEARCH INVOLVING DEVELOPING COUNTRIES	
• Did the project involve the use of local resources (genetic, animal, plant etc)?	NO

• Was the project of benefit to local community (capacity building, access to healthcare, education etc)?	YES
DUAL USE	
• Research having direct military use	NO
• Research having the potential for terrorist abuse	NO

C Workforce Statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

Type of Position	Number of Women	Number of Men
Scientific Coordinator	1	
Work package leaders	5	6
Experienced researchers (i.e. PhD holders)	3	9
PhD Students	1	1
Other: project manager	1	

4. How many additional researchers (in companies and universities) were recruited specifically for this project?	**3**
Of which, indicate the number of men:	1

D Gender Aspects

5.	**Did you carry out specific Gender Equality Actions under the project?**	○ X	Yes No

6. Which of the following actions did you carry out and how effective were they?

		Not at all effective … **Very effective**
❑	Design and implement an equal opportunity policy	○ ○ ○ X ○
❑	Set targets to achieve a gender balance in the workforce	○ ○ ○ ○ ○
❑	Organise conferences and workshops on gender	○ ○ ○ ○ ○
❑	Actions to improve work-life balance	○ ○ ○ ○ ○
○	Other:	

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?

○ Yes- please specify

X No

E Synergies with Science Education

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?

○ Yes- please specify

X No

9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?

○ Yes- please specify

X No

F Interdisciplinarity

10. Which disciplines (see list below) are involved in your project?

X Main discipline[11]: 1

○ Associated discipline[11]:2 | ○ Associated discipline[11]:

G Engaging with Civil society and policy makers

11a	**Did your project engage with societal actors beyond the research community?** *(if 'No', go to Question 14)*	○ X	Yes No

11b If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?

○ No

○ Yes- in determining what research should be performed

○ Yes - in implementing the research

○ Yes, in communicating /disseminating / using the results of the project

[11] Insert number from list below (Frascati Manual).

11c In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?	○ ○	Yes No

12. Did you engage with government / public bodies or policy makers (including international organisations)

- ○ No
- ○ Yes- in framing the research agenda
- ○ Yes - in implementing the research agenda
- ○ Yes, in communicating /disseminating / using the results of the project

13a Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?

- ○ Yes – as a **primary** objective (please indicate areas below- multiple answers possible)
- ○ Yes – as a **secondary** objective (please indicate areas below - multiple answer possible)
- ○ No

13b If Yes, in which fields?

Agriculture Audiovisual and Media Budget Competition Consumers Culture Customs Development Economic and Monetary Affairs Education, Training, Youth Employment and Social Affairs		Energy Enlargement Enterprise Environment External Relations External Trade Fisheries and Maritime Affairs Food Safety Foreign and Security Policy Fraud Humanitarian aid		Human rights Information Society Institutional affairs Internal Market Justice, freedom and security Public Health Regional Policy Research and Innovation Space Taxation Transport	

13c If Yes, at which level? ○ Local / regional levels ○ National level ○ European level ○ International level	
H Use and dissemination	
14. How many Articles were published/accepted for publication in peer-reviewed journals?	**20**
To how many of these is open access[12] provided?	
How many of these are published in open access journals?	**20**
How many of these are published in open repositories?	
To how many of these is open access not provided?	**0**
Please check all applicable reasons for not providing open access:	**NA**
❑ publisher's licensing agreement would not permit publishing in a repository ❑ no suitable repository available ❑ no suitable open access journal available ❑ no funds available to publish in an open access journal ❑ lack of time and resources ❑ lack of information on open access ❑ other[13]: ……………	

15. How many new patent applications ('priority filings') have been made? *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).*	**0**

16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	Trademark	
	Registered design	
	Other	

17. How many spin-off companies were created / are planned as a direct result of the project?	**0**
Indicate the approximate number of additional jobs in these companies:	

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:

❑	Increase in employment, or	❑	In small & medium-sized enterprises
X	Safeguard employment, or	❑	In large companies
❑	Decrease in employment,	❑	None of the above / not relevant to the project
❑	Difficult to estimate / not possible to quantify		

[12] Open Access is defined as free of charge access for anyone via Internet.
[13] For instance: classification for security project.

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (*FTE = one person working fulltime for a year*) jobs:	*Indicate figure:*
Difficult to estimate / not possible to quantify	X

I Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations?

○ Yes X No

21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?

○ Yes X No

22 Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?

❑	Press Release	X	Coverage in specialist press
❑	Media briefing	❑	Coverage in general (non-specialist) press
❑	TV coverage / report	❑	Coverage in national press
❑	Radio coverage / report	X	Coverage in international press
X	Brochures /posters / flyers	X	Website for the general public / internet
❑	DVD /Film /Multimedia	X	Event targeting general public (festival, conference, exhibition, science café)

23 In which languages are the information products for the general public produced?

❑	Language of the coordinator	X	English
❑	Other language(s)		

***Question F-10*:** Classification of Scientific Disciplines according to the Frascati Manual 2002 (Proposed Standard Practice for Surveys on Research and Experimental Development, OECD 2002):

FIELDS OF SCIENCE AND TECHNOLOGY

1. NATURAL SCIENCES
1.1 Mathematics and computer sciences [mathematics and other allied fields: computer sciences and other allied subjects (software development only; hardware development should be classified in the engineering fields)]
1.2 Physical sciences (astronomy and space sciences, physics and other allied subjects)
1.3 Chemical sciences (chemistry, other allied subjects)
1.4 Earth and related environmental sciences (geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, vulcanology, palaeoecology, other allied sciences)
1.5 Biological sciences (biology, botany, bacteriology, microbiology, zoology, entomology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences)

2 ENGINEERING AND TECHNOLOGY
2.1 Civil engineering (architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and other allied subjects)

2.2 Electrical engineering, electronics [electrical engineering, electronics, communication engineering and systems, computer engineering (hardware only) and other allied subjects]

2.3. Other engineering sciences (such as chemical, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialised subdivisions; forest products; applied sciences such as geodesy, industrial chemistry, etc.; the science and technology of food production; specialised technologies of interdisciplinary fields, e.g. systems analysis, metallurgy, mining, textile technology and other applied subjects)

3. MEDICAL SCIENCES

3.1 Basic medicine (anatomy, cytology, physiology, genetics, pharmacy, pharmacology, toxicology, immunology and immunohaematology, clinical chemistry, clinical microbiology, pathology)

3.2 Clinical medicine (anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, otorhinolaryngology, ophthalmology)

3.3 Health sciences (public health services, social medicine, hygiene, nursing, epidemiology)

4. AGRICULTURAL SCIENCES

4.1 Agriculture, forestry, fisheries and allied sciences (agronomy, animal husbandry, fisheries, forestry, horticulture, other allied subjects)

4.2 Veterinary medicine

5. SOCIAL SCIENCES

5.1 Psychology

5.2 Economics

5.3 Educational sciences (education and training and other allied subjects)

5.4 Other social sciences [anthropology (social and cultural) and ethnology, demography, geography (human, economic and social), town and country planning, management, law, linguistics, political sciences, sociology, organisation and methods, miscellaneous social sciences and interdisciplinary , methodological and historical S1T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences].

6. HUMANITIES

6.1 History (history, prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, genealogy, etc.)

6.2 Languages and literature (ancient and modern)

6.3 Other humanities [philosophy (including the history of science and technology) arts, history of art, art criticism, painting, sculpture, musicology, dramatic art excluding artistic "research" of any kind, religion, theology, other fields and subjects pertaining to the humanities, methodological, historical and other S1T activities relating to the subjects in this group]