BELGIUM[1]

OBSERVATIONAL ACTIVITIES

The main research institutes that are currently involved in ozone/UV and ozone related observations include: the Royal Meteorological Institute (KMI-IRM), the Belgian Institute for Space Aeronomy (BIRA-IASB) and the Université de Liège (ULg) - Institute of Astrophysics and Geophysics. The Université Libre de Bruxelles (ULB, Laboratoire de Chimie Physique Moléculaire) is providing the laboratory support for analysing spectra.

Column measurements of ozone and other gases/variables relevant to ozone loss

The Royal Meteorological Institute (KMI-IRM)

Continuation of regular ozone column measurements with two automated Brewer spectrophotometers (Nrs 16, 178) and one Dobson instrument (Nr 40) is a single monochromator, in use since 1983 and the other one (Nr 178) is a double monochromator installed in 2001. All these instruments are operated at Uccle (50.8°N, 43.5°E, 100 m asl), a complementary NDSC station and station 053 in the WOUDC list.

Profile measurements of ozone and other gases/variables relevant to ozone loss

University of Liège (ULg)

Continuation of infrared solar observations at the International Scientific Station of the Jungfraujoch (ISSJ - Primary Alpine NDSC Station in the Swiss Alps 46.5ºN, 8.0ºE, 3580 m asl)[2] using wide-band pass, very high spectral resolution Fourier transform Infra-Red (FTIR) instruments, which allow measuring multiple species, simultaneously. Geophysical parameters consist in total- and more recently- in distinct partial tropospheric and stratospheric column abundances above the site. Table 1 lists the atmospheric gases which have been studied routinely at the Jungfraujoch.

Table 1: Molecules currently studied in FTIR solar spectra recorded at the Jungfraujoch [3]

Reference gas:	N_2
Minor constituents:	CO_2, N_2O, CH_4, CO, *O_3*
Trace constituents:	
Halogenated species:	*HCl*, *$ClONO_2$*, *HF*, *COF_2*, CCl_2F_2, $CHClF_2$, CCl_3F, CCl_4, SF_6
Nitrogenated species:	*NO*, *NO_2*, *HNO_3*)
Others:	C_2H_6, C_2H_2, HCN, OCS, H_2CO_2, H_2CO (multi-month avg.,)

The Royal Meteorological Institute (KMI-IRM)

The vertical distribution of ozone continues to be measured three times per week by means of balloon soundings with ECC ozone sensors, since 1997; Brewer-Mast sensors were used during the 1969-1997 period.

[1] *no input was received from the Université Libre de Bruxelles (Dr M. Carleer) nor from the University of Antwerp (Dr Deckmyn)*
[2] *http://www.ndsc.ws)*
[3] *Species typed in italic are primarily present in the stratosphere, while the others are tropospheric source gases.*

The Belgian Institute for Space Aeronomy (BIRA-IASB)

Monitoring of O_3 and interacting species (halogens, NO_y, BrO, HCFC, CFC…) for budget and long-term trend studies, continues to be performed at:

- the International Scientific Station of the Jungfraujoch, Switzerland: FTIR and SAOZ instruments. SAOZ measures O_3 and NO_2 columns in the UV-Vis spectral range, since 1990. They complement the FTIR time series produced by ULg summarised in *1.2.1.*An additional MAXDOAS Instrument will be installed at the Jungfraujoch in late 2005.
- Harestua, Norway, 60°N, 11°E: UV-VIS DOAS instruments, since 1994 (O_3, NO_2, OClO, BrO)
- the Observatoire de Haute Provence (OHP), France, 44°N, 8°E: UV-VIS DOAS instrument (O_3, NO_2, BrO columns), since summer 1998. The UV-VIS DOAS instrument has been upgraded
- with an off-axis capability (MAXDOAS) in 2000 and since then provides also tropospheric abundances of O_3, NO_2, BrO, and H_2CO.
- at Ile de la Réunion (22°S, 55°E): UV-Vis MAXDOAS instrument (O_3, NO_2, BrO, H_2CO columns and tropospheric abundances), starting in summer 2002. Campaigns with a mobile Fourier-transform infrared (FTIR) instrument have been conducted in Sept-Oct. 2002, and August to November 2004. Permanent FTIR measurements at Ile de la Réunion are planned, starting in 2008. During the first FTIR campaign at the Ile de La Réunion, simultaneous measurements at sea level and at high altitude (2200 m asl) were performed, allowing to infer columns in the boundary layer/low troposphere, via a differential approach.

UV measurements - s*pectroradiometers*

The Royal Meteorological Institute (KMI-IRM) -The Belgian Institute for Space Aeronomy (BIRA-IASB)

- UV spectral irradiance measurements at Uccle: both Brewer spectrophotometers are also used to monitor the UV-B radiation intensities. They perform several scans per day (number depending on the time the sun is above the horizon)

Calibration activities

The Royal Meteorological Institute (KMI-IRM)

- The Dobson instrument was last calibrated at the Regional Calibration Centre of WMO in Hohenpeißenberg in 2000. Since then the monthly calibration tests with standard and mercury lamps showed that the instrument remains stable.

- The Brewer instruments were compared with the travelling reference instrument in 2003. The results of this calibration were taken into account for the new ozone observations and also the older data were recalculated.

- The ozone sondes are carefully prepared and a correction procedure is applied to minimise the inhomogeneity that could have been introduced at the change of the sonde type in 1997.

- The UV-B calibration level was checked with 1000W lamps in 2003 during the calibration visit. In 2004 the special comparative observations were performed with a travelling reference UV instrument of the Joint Research Centre (JRC in Ispra) in the frame of the Qasume project (Gröbner et al, 2004). This showed that the calibration based on the monthly tests with 50W lamps was within the expected errors.

The Belgian Institute for Space Aeronomy (BIRA-IASB)

The observations are all contributing to the NDSC and are being certified in this framework. Only for the measurements at the Ile de La Réunion, the NDSC qualification has not yet been solicited. But the quality of the spectral data has been verified by performing daily HBr cell measurements for controlling the instrument's alignment, as recommended by the NDSC IRWG (Infrared Working Group).

The MAXDOAS instruments have participated to several calibration campaigns, e.g., in Andoya in winter 2003, in the EC project FORMAT, and recently (summer 2005) in the Dandelions campaign in Cabauw (NI).

University of Liège (ULg)

Calibration of the Jungfraujoch FTIRs is performed according to recommendations in related NDSC protocols. This is done regularly by using sealed cells containing known amounts of either HBr or N_2O gases, which allow characterising the instrumental line shape. In addition, atmospheric gases whose vertical distributions and concentrations are well known (i.e., N_2 and CO_2) are used to check the overall instrumental performances and their long-term stability

RESULTS FROM OBSERVATIONS AND ANALYSIS

The Royal Meteorological Institute (KMI-IRM)

Research evolution of total atmospheric ozone and its distribution versus altitude at northern mid-latitudes, in particular above Belgium revealed a mean temporal decrease in 'good' ozone in the stratosphere and an increase in 'bad' ozone in the troposphere. With the help of model calculations it was shown that both changes are primarily of anthropogenic origin. Further observations in Uccle (Brussels) showed that observed levels of harmful UV-B irradiance at ground level anti-correlate with levels of stratospheric ozone. Initiatives have been taken to warn the general public about health risks resulting from excessive exposure to the sun in summertime.

The figure below shows the time evolution of the ozone column over Uccle based on the combined data from Dobson and Brewer instruments (1990-now). The ozone column decreased by 3% per decade in the period 1980-1997, with a likely sign of recovery afterwards, although the period is too short to draw firm conclusions. According to the Uccle soundings, the decrease occurred in the lower stratosphere, especially during winter and early spring. In the troposphere, on the contrary, the ozone concentrations tend to increase due to photochemical reactions in polluted air.

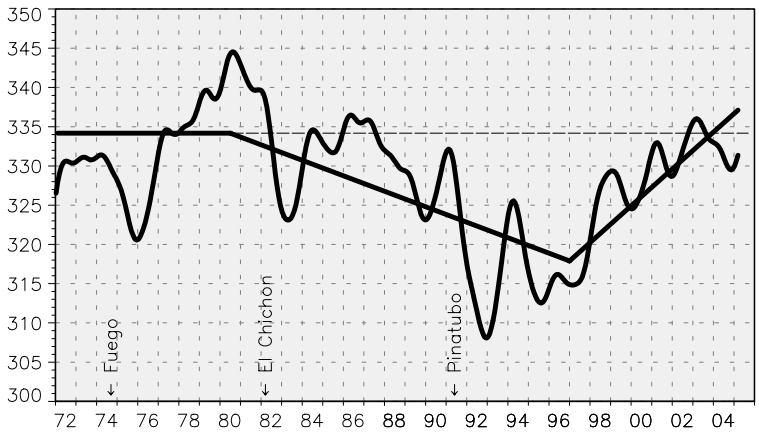

Figure 1: running annual mean of total ozone from Dobson and Brewer spectrophotometers at Uccle, together with a stepwise regression. The times of major volcanic eruptions, affecting the ozone layer are also indicated.

The Belgian Institute for Space Aeronomy (BIRA-IASB)

Based on monitoring, from aboard satellites, of stratospheric aerosol loading on a quasi-global scale. the spatio-temporal distribution between 12- and 35-km altitude has shown that aerosols are among the most varying constituents in the lower stratosphere, capable of exerting negligible to acute regional-scale effects on climate. In particular, major volcanic eruptions, like that of Mount Pinatubo (Philippines) in June 1991, enhance aerosol abundance significantly, worldwide. Belgian scientists were able to show that the aerosol increase following this event caused temporary depletion of stratospheric ozone above Uccle and of nitrogen dioxide over the Jungfraujoch. This is one example demonstrating the importance of simultaneous long-term monitoring of the particulate and gaseous composition of the stratosphere. Other important results are:

- Updated trends of stratospheric bromine
- Time series of O_3, NO_2 and BrO at the NDSC stations operated by BIRA-IASB (at Jungfraujoch since 1990; at Harestua since 1994; at OHP since 1998)
- Time series of OClO abundances in Harestua, including model simulations.
- Global maps of BrO, SO_2, NO_2 from GOME and SCIAMACHY
- BASCOE 4D Var assimilation analyses
- Climatology of stratospheric aerosol; time series of vertical distributions of aerosol optical properties based on SAGE II data
- campaign data at Ile de La Réunion : vertical distributions of a large number of species measured by FTIR: O_3, HCl, HF, CO, N_2O, HNO_3, …; O_3, NO_2, SO_2, BrO distributions in the troposphere from MAXDOAS
- NO_2 vertical profile climatology

University of Liège (ULg)

- Consistent monitoring, since the mid-1980s, of the vertical column abundances above the Jungfraujoch, of HCl and $ClONO_2$, which are the main inorganic Cl_y reservoirs in the stratosphere. Their sum shows that the rate of increase of Cl_y has progressively slowed down during the early-1990s, and stabilised in 1996-1997, in response to the amended production regulations on O_3-depleting substances by the Montreal Protocol. Since, the Cl_y loading has shown a slow but statistically significant decrease (-0.7 ± 0.2 %) over the 1998-2004 period, which is commensurate with the organic chlorine decrease in the troposphere.
- Monitoring of the evolution of anthropogenic chlorine-bearing source gases such as CFC-11, CFC-12, HCFC-22 and CCl_4 demonstrates the efficiency of the amended Montreal Protocol upon regulated versus unregulated ozone-depleting compounds.
- The O_3 column monitored from 1984 to 2004 shows that it has decreased by (4.5 ± 0.5) % during that 20-year period, with significant temporary perturbations that resulted from inter-annual variability and from the strong Mt. Pinatubo volcanic eruption in 1991.
- The most abundant NO_y compounds (HNO_3, NO_2, NO, $ClONO_2$) show no statistically significant change in their total stratospheric loading. However, NO_2 reveals a rate of increase of (0.5 ± 0.2) %/yr which is consistent with similar investigations performed at the NDSC southern mid-latitude station of Lauder (N-Z).
- The continued rise, although having slightly slowed down during the past years, of the inorganic fluorine concentration in the stratosphere, contrary to the decrease of chlorine.
- Measured rates of increase of the major radiatively active gases that are to be controlled under the Kyoto Protocol;[4]

[4] *http://sunset.astro.ulg.ac.be/girpas/.*

THEORY, MODELLING, AND OTHER RESEARCH

The Royal Meteorological Institute (KMI-IRM)

The Brewer data have been analysed for aerosol information in the UV. These data are available now (Cheymol and De Backer, 2003).

The Belgian Institute for Space Aeronomy (BIRA-IASB)

Modelling

- Complete 3D modelling of the stratosphere, including transport, chemistry, aerosol micro-physics and a heterogeneous chemistry module
- Chemical 4D variational data assimilation, in particular of O_3
- 1D box model for process studies, and for interpretation of UV-Vis DOAS observations
- Studies based on 3D model IMAGES for the troposphere and UT/LS boundary region
- Development of inverse tropospheric modelling methods, to improve emissions estimates (e.g., for CO)

Laboratory experiments

- Spectroscopic studies in support of remote sensing experiments (optical spectroscopy, ion chemistry for mass spectrometry applications…)
- Spectroscopic studies in support of investigations concerning global warming issues
- Radiometric calibration for UV monitoring instruments
- Studies of reaction pathways and kinetics of atmospheric species, using mass spectrometry.

Instrument developments

- MAXDOAS instruments and associated data analysis algorithms; The MAXDOAS technique has the capability of determining vertical distributions in the troposphere and low stratosphere.
- BARCOS: a system for remote-control and automatic operation of a Bruker FTIR spectrometer for monitoring the atmospheric composition

Retrieval algorithm developments

- Recently developed algorithms have implemented the Optimal Estimation Method, and therefore allow the retrieval of vertical profile information from the ground-based DOAS and FTIR spectra, at low vertical resolution (worse than 5 km), for e.g., NO_2, O_3, HNO_3, HCl, ... For the FTIR data this approach has been optimised for some target species (incl. $O_{3)}$ in the EC project UFTIR coordinated by BIRA-IASB.

Satellite data retrievals

- Development, validation and implementation of satellite data retrieval algorithms (e.g., for GOME and SCIAMACHY total O_3, NO_2, BrO, SO_2….;e.g. for aerosol and trace gases from GOMOS); data processing and dissemination
- Development of retrieval algorithms for IASI/Metop for aerosol and gases.

Satellite data validation and characterisation

- Continued contributions to the validation of ESA satellite data for O_3, NO_y, CH_4, CO, N_2O… (GOME, SCIAMACHY, GOMOS, MIPAS, ACE/SciSat …) using independent

ground-based data, mostly NDSC affiliated. This activity will be continued for OMI, GOME-2, IASI, …

- Characterisation of the 4D information content of various satellite data, on the purpose of (1) integrating time series form successive satellite sensors (e.g., for O_3 total column and profile), remote sensing and in situ data from various platforms (ground, balloon, aircraft, satellite,..) and, (2), developing observation operators for correct integration/comparison of satellite data with models.
- Development of climatologies of some stratospheric species like NO_2.

University of Liège (ULg)

Most of the research activities reported in the previous Ozone Research Managers Report (2002) are continuing [5]

Satellite data validation and characterisation

- Further exploitation of the ATMOS data (Atmospheric Trace MOlecule Spectroscopy, spanning the 1985-1994 period) as references for subsequent trend studies (e.g., the SciSat-ACE project (see below)) of over two dozen constituents present in the free troposphere and the stratosphere.[6]

DISSEMINATION OF RESULTS

Data reporting

The Royal Meteorological Institute (KMI-IRM)

The ozone data (columns and profiles) are regularly deposited in the WOUDC of WMO. Uccle is also a complementary station for ozone in the NDSC. Therefore the data are also made available in that network. In near real time the data are also distributed via NILU, where the data can be used for campaigns (e.g. Match campaigns to determine ozone losses in the polar and sub polar winter atmosphere, see Streibel et al, 2005). The data are also stored and used in databases for the validation of satellite data (ENVISAT and EUMETSAT). Total ozone values are exchanged daily with the WMO ozone mapping centres in Canada and Greece for the production of daily ozone maps.

The Belgian Institute for Space Aeronomy (BIRA-IASB)

- Data concerning the chemical species are submitted to NADIR/NILU and NDSC/NOAA databases, as well as to the Envisat Cal/val database at NILU. UV-B data are in the SUVDAMA (EC) database.
- Satellite data are disseminated via dedicated services and Web pages, e.g., http://www.temis.nl; http://www.oma.be/GOME/index.html; http://www.oma.be/DAEDALUS, http://www.gse-promote.org/
- Spectroscopic laboratory data are submitted to international databases like HITRAN, GEISA, and via the institute Web page http://www.oma.be/BIRA-IASB/Scientific/Data/CrossSections/ CrossSections.html)
- Project Web pages (see 'Projects and collaboration')

University of Liège (ULg)

- Series of NDSC-relevant molecules (e.g., HCl, $ClONO_2$, HF, COF_2, HNO_3, NO_2, NO, O_3, CFC-12, HCFC-22) measured from 1989 to present, are being archived routinely at the NOAA Data Host Facility (Washington, DC, USA), with the ozone data mirrored to the WOUDC archive in

[5] *http://sunset.astro.ulg.ac.be/girpas/).*
[6] *http://remus.jpl.nasa.gov/atmosversion3/atmosversion3.html.*

Toronto. Pre-1989 data are available upon requests sent to the ULg scientists listed at the end of this report. Specific databases produced in support of European campaigns or for the validation of space-based sensors of the atmosphere are generally archived at NILU [7] (Norway).

Information to the public

The Royal Meteorological Institute (KMI-IRM)

- Daily UV forecasts are produced and disseminated with the weather forecasts. They are also available at the internet (www.meteo.be).
- Ozone and UV data of Uccle were also used in yearly reports on the environment (MIRA-T-2003, 2004, Polders et al, 2003, 2004).

The Belgian Institute for Space Aeronomy (BIRA-IASB)

- via participations to expositions, via Web pages [8]
- BASCOE provides daily global O_3 forecasts via the Web[9] .

Belgian Federal Public Planning Service Science Policy (BELSPO)

The Belgian Public Planning Service Science Policy recently published an Assessment and Integration Report on Belgian Global Change research 1990 – 2002. It just one of the initiatives taken towards improved integration of research results into information relevant to policymaking[10].

Final Reports of relevant research projects within the Scientific Support Plan for a Sustainable Development Policy can be ordered or downloaded from the BELSPO website[11]*.*

Relevant scientific papers

The Royal Meteorological Institute (KMI-IRM)

Peer reviewed:

Coheur, Pierre-François, C. Clerbaux , M. Carleer, S. Fally, D. Hurtmans, R. Colin, C. Hermans, A.C. Vandaele, B. Barret, M. De Mazière and ***H. De Backer****, Retrieval of atmospheric water vapor columns from FT visible solar absorption spectra, Evaluation of spectroscopic databases, Journal of Quantitative Spectroscopy & Radiative Transfer, 82, 133-150, 2003.*

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[7] *http://www.nilu.no/*
[8] *http://www.aeronomie.be; http://www.oma.be/ESACII/Home.html; http://www.temis.nl/, etc.*
[9] *http://www.bascoe.oma.be*
[10] *http://www.belspo.be/belspo/home/publ/index*
[11] *http://www.belspo.be/belspo/fedra/prog.asp?l=nl&COD=EV*

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Other RMI publications related to the ozone reseach are available from:
http://www.meteo.be/ozon/miscellaneous/publications.php

The Belgian Institute for Space Aeronomy (BIRA-IASB)

peer-reviewed

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Other BIRA-IASB publications related to the ozone reseach are available from: http://www.aeronomie.be/nl.

University of Liège (ULg)

Montzka, S. A., P. J. Fraser, J. H. Butler, D. Cunnold, J. Daniel, D. Derwent, P. S. Connell, S. Lal, A. McCulloch, D. E. Oram, C. E. Reeves, E. Sanhueza, P. Steele, G. J. M. Velders, and R. Zander, Controlled substances and other source gases, Chapter 1 of WMO Scientific Assessment of Ozone Depletion: 2002, WMO Report No. 47, ISBN 92-807-2261-1, pp. I-1 to I-83, World Meteorological Organization, P.O. Box 2300, Geneva 2, CH 1211, Switzerland, March 2003, 2003.

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Other ULg publications related to the ozone reseach are available from:
http://sunset.astro.ulg.ac.be/girpas/

PROJECTS AND COLLABORATION

Participation in other national and international collaborations projects

The Royal Meteorological Institute (KMI-IRM)

- Belgian programme Scientific Support for Sustainable Development: ESAC-II: Experimental Studies of Atmospheric Changes II (2001-2005)
- COST action 726 on Long term changes and climatology of UV radiation over Europe (2004-2009).
- Action 1 of Science policy (2005-2006): 'Aerosol optical thickness deduced from ground solar radiation measurements'.
- 6th Framework Programme of the European Commission: GEMS- Aerosol subproject (2005-2009)
- satellite validation projects of ESA and Eumetsat.

The Belgian Institute for Space Aeronomy (BIRA-IASB)

- Belgian programme Scientific Support for Sustainable Development: ESAC-II: Experimental Studies of Atmospheric Changes II (2001-2005) (as coordinator)[12]
- IPCC Climate and WMO Stratospheric Ozone assessments

[12] *http://www.oma.be/ESACII/Home.html*

- 6th Framework Programme of the European Commission: GMES-GATO (finished Jan 31, 2005) GEMS, Evergreen[13], NOVAC, UFTIR [14], STAR[15] SCOUT-O3, ACCENT (and its subproject AT2)…
- 'Chemistry and climate related studies using the IASI remote sensor' for preparing the scientific research aspects of the IASI mission onboard METOP-1 (launch nominally 2005).
- ESA GSE project PROMOTE
- ESA study 'Capacity' [16]
- Envisat Atmospheric Chemistry Validation Team, and SCIAVALIG

University of Liège (ULg)

- IPCC Climate and WMO Stratospheric Ozone assessments

Representation in international organisations

The Royal Meteorological Institute (KMI-IRM)

- COST 726
- Brewer and Dobson scientific advisory groups of WMO
- Advisory group for the Regional Brewer Calibration Centre for region VI (Europe)
- EUMETSAT
- Ozone-SAF
- NDSC

The Belgian Institute for Space Aeronomy (BIRA-IASB)

- WMO: UV-SAG (GAW)
- SPARC/WCRP
- NDSC (GAW/WMO) (co-chairmanship of UV-VIs, IR and Satellite Working Groups)
- CEOS
- SAG of GOME and GOME-2, GOMOS, SCIAMACHY, OMI
- Atmospheric Science Panel (European Commission)
- ESA council
- Member of the Science Team of the Canadian ACE/SciSAT mission
- Member of EOS-Aura OMI International Science Team

University of Liège (ULg)

- Atmospheric Science Panel (European Commission)
- NDSC-Steering Committee,
- IOC
- GMES-GATO coordinating group.
- Science Team of the Canadian SciSat-ACE project.
- International Foundation of the 'Hochalpine Forschungsstationen Jungfraujoch und Gornergrat, Switzerland.

[13] *(http://www.knmi.nl/evergreen*
[14] *http://www.nilu.no/uftir*
[15] *http://www.knmi.nl/samenw/star*
[16] *http://www.knmi.nl/capacity/)*

Other collaborations

The Royal Meteorological Institute (KMI-IRM)

- with the Alfred Wegner Institute in Bremen for the Match Campaigns since the beginning of the 1990's.
- with the Forschung Zentrum Jülich in Germany, and other National institutes performing ozone soundings for the setting up standard operating procedure for ozone soundings for WMO.

FUTURE PLANS

The Royal Meteorological Institute (KMI-IRM)

It is envisaged to stop the Dobson measurements and make an agreement with the University of Ile de La Réunion to loan the instrument to use it there to complete the NDSC capacities of that station

The Belgian Institute for Space Aeronomy (BIRA-IASB)

- Continuation of long-term NDSC observations at abovementioned stations
- Permanent FTIR and MAXDOAS measurements at Ile de La Réunion from 2008 onwards (nominally)
- Acquisition of a mini-MAXDOAS instrument for mobile measurements
- Acquisition of a CIMEL sun photometer, to be integrated in the Photons-Aeronet network
- Volcano monitoring with MAXDOAS instruments (EC project NOVAC)
- Participation in satellite experiments with ESA, Canada, EUMETSAT

Belgian Federal Public Planning Service Science Policy (BELSPO)

Within the programme 'Science for a sustainable development (SSD)' a first call for proposals was launched. One of the priorities relates to the interaction between atmospheric composition and climate change. The evaluation procedure is ongoing; projects are to start in December 2005.

Recurrent measurements at NDSC stations are mainly funded with multi-annual research budget. BELSPO is considering a more sustainable solution in cooperation with the federal scientific research institutes.

Belgium will open in 2007 a new scientific station in Antarctica

NEEDS AND RECOMMENDATIONS

- Needs to secure the financial support to continue long-term monitoring activities (including calibration of instruments, necessary equipment for ozone soundings) instruments and associated software upgrades,...) and data archiving and dissemination services.

CO-ORDINATES OF BELGIAN INSTITUTES AND LEADING SCIENTISTS INVOLVED IN O_3 RELATED RESEARCH AND OBSERVATIONS

University of Liège
Institute of Astrophysics and Geophysics
Dr E. MAHIEU (Data analysis, interpretation and archiving)
Prof. (Emeritus) R. ZANDER (Data analysis and interpretation)
Ph. DEMOULIN (Data analysis and observations)
Dr C. SERVAIS (Observations, and Instrumentation maintenance/development)
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Belgian Institute for Space Aeronomy
Dr M. DE MAZIÈRE (Satellite and ground-based remote sensing measurements of the composition of the atmosphere, implementation and testing of retrieval algorithms to invert observations into geophysical data, remote-sensing instrument developments, data validation)
Dr M. VAN ROOZENDAEL (Satellite and ground-based remote sensing measurements of the composition of the atmosphere, implementation and testing of retrieval algorithms to invert observations into geophysical data, remote-sensing instrument developments, data validation)
Dr D. FONTEYN (Stratospheric modelling, 4D VAR data assimilation)
Dr J.-F. MULLER (Global tropospheric ozone modelling, inverse source/sink modelling)
Dr D. GILLOTAY Y (Ground- and space-based measurements of solar radiation: UV-B)
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