

GERMANY

In accordance with Decision VCV/3: Recommendations of the fourth meeting of the Ozone Research Managers to the Parties of the Vienna Convention at Geneva in 1999, the following significant research and monitoring activities have been carried out since 1999 in Germany.

Ozone-monitoring and related research in Germany is distributed over numerous institutions. Usually, there is no distinct separation between research and development, monitoring and quality control. In general, research is carried out at university institutes or at research centres (MPI, DLR, FZ-Jülich). Regular long-term monitoring of ozone outside the planetary boundary layer is provided by DWD and AWI, UV-monitoring by BfS, UBA and DWD. Surface ozone is monitored by authorities at the national (UBA), state and local level. Surface ozone will not be discussed further in the report.

Table 1. Overview of institutes involved in ozone/UV research (R), development (D), modelling (MD), monitoring (MT), quality assessment /quality control (QA/QC)

Institute	Location	Field	Keywords
Deutscher Wetterdienst, www.dwd.de/research/	Hohenpeissenberg, Lindenberg	MT, R, QA/QC	Regional Ozone Centre, DCC, NDSC, GAW
Alfred Wegener Institut für Polar u. Meeresforschung, www.awi-potsdam.de/ www.awi-bremerhaven.de/	Potsdam, Bremerhaven	R, MT, D	Neumayer, Ny Ålesund, MATCH
Forschungszentrum Jülich, www.fz-juelich.de/	Jülich	R, QA/QC, MD	Calibration C. O ₃ - Sonde, JOSIE CLAMS
MPI f. Meteorologie (DKRZ), www.dkrz.de/ DLR, DLR/DFD, www.dlr.de/	Hamburg Oberpfaffenhofen	R, MD R, MD, MT	ECHAM GOME, ECHAM, Air-Traffic
IAP Kühlungsborn, www.iap-kborn.de/	Kühlungsborn	R, D, MT	Middle Atmosphere, Alomar,
Bundesamt f. Strahlenschutz (BfS) www.bfs.de/	Salzgitter	MT	UV
Umweltbundesamt, www.umweltbundesamt.de/	Berlin	MT,	Air quality
Uni Bremen, IUP, IFE, www-iup.physik.uni-bremen.de/index.html	Bremen	R, D	GOME, SCIAMACHY, MICROWAVE
Uni Köln, Inst f. Meteorologie, www.uni-koeln.de/math-nat-fak/geomet/	Köln	R, MD	EURAD,
FU Berlin, Inst. f. Meteorologie , strat-www.met.fu-berlin.de/	Berlin	R, MT	Stratosphere
Uni Frankfurt, Inst. f. Meteorologie, www.rz.uni- frankfurt.de/IMGF/meteor/klima/	Frankfurt	R, MT	CFC's
Uni Mainz, MPI f. Chemie , www.mpch-mainz.mpg.de/	Mainz	R, MD	ECHAM/CHEM
Uni Heidelberg, www.ophys.uni-heidelberg.de/	Heidelberg	R, QA/QC	DOAS
Uni Karlsruhe, IMK www-imk.physik.uni-karlsruhe.de/	Karlsruhe, Garmisch (IFU)	R, MD	MIPAS, FTIR, KASIMA
Uni München (LMU), www.forst.tu- muenchen.de/EXT/LST/METEO/	München Freising-Weihenstephan	R, MD R	UV, STAR
Uni Hannover, Inst. f. Meteorologie www.muk.uni-hannover.de	Hannover	R	UV

Monitoring

Germany's Meteorological Service (DWD) is running a very intense measurement program at the Observatories Hohenpeissenberg and Lindenberg, monitoring the ozone vertical distribution and total ozone columns on a regular and long-term basis (Table 2). Special efforts are put into high quality and long-term consistency. The time series cover 35 years for ozone measurements up to 30 km altitude (balloon-sonde and Dobson-spectrometers) and 15 years for upper stratospheric LIDAR observations. Data are regularly submitted to the data centers at Toronto, Thessaloniki, NILU, and NDSC. In addition to the observational UV-network of the BfS (Table 2), DWD continues to measure UV-B radiation for research and development purposes (see below). Both institutes provide the public with UV-information including daily forecasts of the UV-index.

The Alfred Wegener Institute for Polar and Marine Research (AWI) is very active in atmospheric research. It operates two fully equipped polar stations in the Arctic (Ny-Ålesund/Koldewey - NDSC primary station), and Antarctic (Neumayer). The Neumayer meteorological observatory is designed as a radiation and climate monitoring station and an air chemistry observatory as well. Measurements of radiation are carried out on a large scale as part of a global observation network to detect long-term changes in the Earth's radiation budget and their impacts on climate. Since 1992 vertical ozone balloon soundings belong to the regular observations.

At Koldewey station, routine ozone and UV measurements are taken by ECC-sondes, Lidar, microwave, DOAS, FTIR and UV-spectrometers. Many of these measurements are run in close cooperation with IUP/Uni Bremen.

DLR/DFD is routinely retrieving and processing the data from a number of satellites to investigate the atmosphere and surface of the earth. Especially the processing, distribution and archiving of the GOME and in future the SCIAMACHY data is a substantial task of DLR/DFD. A variety of GOME ozone and UV products is made available via the Atmospheric User Centre (AUC) on the Internet (<http://auc.dfd.dlr.de/GOME/index.html>).

Type of observation	Location	Org.	Instrument	Type	Start
Total Ozone Column	Hohenpeissenberg	DWD	Dobson	No. 104, No. 064	1967
	Hohenpeissenberg	DWD	Brewer	No. 010	1983
	Hohenpeissenberg	DWD	Microtops	No. 3128, No. 3785	1996
	Lindenberg	DWD	Brewer	No. 078	1992
	Potsdam	DWD	Dobson	No. 071	1964
	Potsdam	DWD	Brewer	No. 030	1987
	Potsdam	DWD	Brewer	No. 118	1996
Calibration	Hohenpeissenberg	DWD	Dobson	No. 064	1999
Ozone Vertical Profile	Hohenpeissenberg	DWD	Ozonesonde	Brewer-Mast	1967
	Hohenpeissenberg	DWD	LIDAR (Stratosphere)	DIAL	1987
	Lindenberg	DWD	Ozonesonde	ECC (since 1992)	1974
	Ny Ålesund (Spitzbergen)	AWI	Ozonesonde	ECC	1990
	Ny Ålesund (Spitzbergen)	AWI	LIDAR	DIAL	1991
	Neumayer (Antarctica)	AWI	Ozonesonde	ECC	1992
	Garmisch	FZK	LIDAR (Troposphere)	DIAL	1988
Calibration	Jülich	FZ	Ozonesonde		
UV	Garmisch	FZK	Bentham DTM 300		1994
	Hohenpeissenberg	DWD	Brewer MK II	No. 010	1991
	Lindenberg	DWD	Brewer MK IV	No. 078	1991
	Potsdam	DWD	Brewer MK II	No. 030	1993
	Potsdam	DWD	Brewer MK III	No. 118	1996
	Potsdam	DWD	Bentham DM 150		2000
	Potsdam	DWD	Spectro 320D		2002
	Dortmund	BAuA	Bentham DM150		
	Kulmbach	LfU	Bentham DM150		
	München	BfS	Bentham DM150		1993
	Langen	BfS	Bentham DM150		1993
	Schauinsland	BfS	Bentham DM150		1993
	Sylt	CAU	Bentham DM 300		1995
	Zingst	BfS	Bentham DM150		1993
	Zugspitze	FZK	Bentham DTM 300		1995

Table 2. Operational network for long-term measurements of ozone and UV

Research and Development

129 research projects were funded in the German Ozone Research Programme by the German Ministry of Education and Science (BMBF). This programme started in 1989 and has ended in 1999. Many field campaigns, e.g. POLECAT, POLSTAR, CHORUS, laboratory studies, modelling and the evaluation of existing data, were conducted in close cooperation with partners from Europe and abroad. This very successful programme substantially improved the understanding of the ozone layer, especially at northern high and mid-latitudes. Some continuation of that programme is being funded by the BMBF in the more widespread AFO 2000 Programme. In particular the KODYACS project is investigating the links between long-term ozone depletion and climate change. KODYACS combines substantial modelling efforts (ECHAM/CHEM) with analysis of existing long-term measurements.

IUP-Uni Bremen is one of the leading institutes in the scientific design of the GOME and the SCIAMACHY instruments. Algorithms for retrieving trace gas amounts from the instruments' raw data are developed in cooperation with German Remote Sensing Data Center (DFD), the Smithsonian Astrophysical Observatory (Harvard, Cambridge/MD, USA), the University of Heidelberg (Germany), the Koninklijk Nederlands Meteorologisch Instituut (KNMI, The Netherlands), and other institutes from the GOME Science Advisory Group.

IUP-Uni Bremen substantially contributes to the NDSC. They operate the KOLDEWEY Arctic station in cooperation with AWI. They are building a new tropical station (Merida, Venezuela, 4700 m asl) in cooperation with FZ Karlsruhe. They are also contributing to another arctic station on the Greenland ice-shelf (at 3200 m asl) in cooperation with DPC, Copenhagen, Uni Bordeaux, Uni Leeds and NSF USA (EU-Project).

At Forschungszentrum Karlsruhe/IMK measurements of ozone and ozone relevant species have been performed for many years by ground-based and airborne observations. The measurements are combined with process studies and 3D chemical transport modelling. These efforts led to the detection of severe denitrification over the Arctic and the specification of chlorine and nitrogen species in Arctic winters over the last decade. In cooperation with MPI Mainz they identified a critical sensitivity of the arctic vortex and the ozone loss to greenhouse gas forcing, which leads to delayed recovery of the ozone layer arising from enlarged PSC and denitrification probability.

Long-term measurements of stratospheric CFC12 have been conducted by the University of Frankfurt and FZ Jülich. Since 1978 they have studied the evolution of this important source gas by regular balloon soundings.

By the winter 2000/01 the MATCH campaign, coordinated by AWI and funded by the EU and national institutes ended after ten successful years. One of the main findings of MATCH is that under certain conditions the ozone loss rates measured in-situ inside the Arctic polar vortex are up to a factor of two larger than we can currently explain. Follow up studies have raised significant concerns about the completeness of our current understanding of the chemical ozone loss in the Arctic (see Future Activities).

QA/QC/Validation

Activities towards improving the quality of balloon-ozone-soundings were continued at the World Calibration Center for Ozone Sondes (WCCOS) at FZ Jülich. JOSIE 1996 showed the critical importance of sonde preparation procedures. Since, WCCOS has been instrumental in the international effort to achieve Standard Operating Procedures (SOPs), that would guarantee a uniformly high standard of ozone soundings world-wide. The second international ozone sonde intercomparison experiment (JOSIE-2000) conducted in September 2000 is an important milestone on this path towards SOPs. Pre-experiments sponsored by the WMO, prior to JOSIE-2000, were performed in 1998 and 1999. A meeting of experts in Geneva from May, 1-3, 2001 critically examined JOSIE 2000 and evaluated the entire series of JOSIE experiments.

The Regional Dobson Calibration Center (RDCC) for WMO RA VI at the Meteorological Observatory Hohenpeissenberg (MOHp) became operational in 1999. The first intercomparison was carried out with two regional standards, D064 (Germany) and D074 (Czech Republic), and the world standard D065 (Boulder, USA). RDCC is responsible for calibration and second level maintenance of more than 30 Dobson spectrometers operational in Europe and the Middle East. The close cooperation between MOHp and the Solar and Ozone Observatory at Hradec Kralove (SOO-HK, Czech Republic) guarantees excellent calibrations. 4 intercomparisons were performed in 2000 and 2001 with altogether 13 spectrometers from 10 countries. One of these instruments (D044, formerly University of Cologne) was completely refurbished and given to the Armenian Hydrometeorological Service as a loan.

In June 2002 a calibration of the regional standard instrument Dobson No. 064 by the primary ("World") standards D 065/D 083 is planned at the World Dobson Laboratory at NOAA in Boulder (USA). A regular calibration with three operational Dobsons and the second regional standard D 074 (from Czech Republic), will be held at MOHp afterwards.

Since July 2001 GAWTEC, the GAW Training and Education Centre of the GAW Programme has been established with funds from the Bavarian State and support from WMO. It is a cooperating partner of the German Quality Assurance/Scientific Activity Centre and organizes training courses twice a year for personnel from GAW stations worldwide. GAWTEC is based at the UFS Schneefernerhaus at the Zugspitze mountain. Experts from UBA, DWD and IFU at Garmisch and additional invited experts are giving training courses in measurement techniques of GAW-relevant parameters including ozone. Special emphasis is put on quality control, data handling and interpretation.

Within the EU-Projects STREAMER (cooperation with DLR/DFD) and EUMETSAT Ozone-SAF Hohenpeissenberg did a very thorough validation of (pre-operational) ozone profiles derived from GOME data. Validation will be continued in the Ozone-SAF. A SCIAMACHY validation group was set up at University of Heidelberg.

Future Activities

A novel Fourier transform infrared spectrometer (MIPAS=Michelson Interferometer for Passive Atmospheric Sounding) has been developed at Forschungszentrum Karlsruhe/IMK for the measurement of atmospheric trace constituents. One of these instruments will supplement the SCIAMACHY instrument onboard ESA's ENVISAT satellite. The atmosphere at the Earth's limb will be observed over an altitude range of 5 to 150 km with a vertical resolution of 3 km. By means of horizontal (limb) sounding of infrared emissions MIPAS can measure profiles of over 20 trace gases globally day and night. Global coverage will be obtained in 3 days. After ENVISAT's launch in spring 2002, there will be data sets available at the ATMOS User Center (DLR/DFD/AUC, see above).

DWD is intensively preparing to take over the assigned task of European Centre for UV-forecasting. Within the EU-Project "Small Scale Structure Early Warning and Monitoring in Atmospheric Ozone and Related Exposure to UV-B Radiation (STREAMER)" DWD has developed an operational system for dynamical forecasts of 3D ozone fields, driven by DWD's global GME numerical weather forecast model. Feeding the predicted ozone, cloud, moisture, etc. fields into the "STAR" radiative transfer model from LMU Munich, DWD is producing highly resolved UV forecasts on a daily basis. Following the recommendations of COST action 713, DWD has offered this service to WMO.

12 new EU projects have recently been approved to investigate emerging issues on ozone, UV radiation and aviation impacts during the next 2-3 years. In 10 of these 12 projects a large number of german research institutes are active partners or coordinate the project. The MATCH Campaign will be continued in Antarctica from 2003 onward, coordinating ozone-soundings from 8 stations on the continent.

Since spring 2002 DLR/DFD hosts the World Data Center for Remote Sensing of the Atmosphere for the International Council of Scientific Unions (ICSU).
