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INTEGRATED OBSERVING SYSTEMS

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CURRENT ACTIVITIES OF THE WMO GLOBAL ATMOSPHERE WATCH PROGRAMME

(*Submitted by the Secretariat)*

Summary and Purpose of Document

This document summarises major activities carried out within WMO Global Atmosphere Watch (GAW) Programme which was established in 1989.

ACTION PROPOSED

The meeting is invited to take into account information presented in this document when discussing interrelation of the GOS with other observing programmes.

ANNEX

The WMO/GAW Programme

(AREP & CAS)

Current Activities

Current Activities of the WMO Global Atmosphere Watch Programme

Environment Division, AREP, World Meteorological Organization

1. INTRODUCTION

The Global Atmosphere Watch (GAW) Programme of the World Meteorological Organization (WMO) was established in 1989. It focuses upon the role of atmospheric chemistry in global change (Strategic Plan, 2001). Consisting of a partnership of managers, scientists and technical expertise from 80 countries, GAW is coordinated by the WMO secretariat in Geneva and the Working Group on Environmental Pollution and Atmospheric Chemistry of the Commission for Atmospheric Science (CAS). Recognizing the need to bring scientific data and information to bear in the formulation of national and international policy, the GAW mission is threefold:

1. **Systematic monitoring** of atmospheric chemical composition and related physical parameters on a global to regional scale
2. **Analysis and Assessment** in support of environmental conventions and future policy development
3. **Development of a predictive capability** for future atmospheric states

In this paper, ongoing activities of GAW related to these missions are briefly described. A subset of the comprehensive networks of GAW forms the baseline network for atmospheric composition measurements in the Global Climate Observing System (GCOS) that is currently under development.

2. MONITORING

The development of information for science assessments and the associated agreements/conventions rely heavily on the information derived from GAW's monitoring. Figure 1 shows the major activities and facilities in this part of the GAW programme. Support for these is provided, in large part, by WMO member countries that participate in the GAW programme, augmented by outside international funding, and the WMO Secretariat's budget. A network of measurement stations is the backbone of GAW monitoring. It consists of GAW G*lobal* and R*egional* stations with additional observations made at *Contributing* stations. Approximately 80 countries host GAW Global and Regional stations through either their National Hydrological and Meteorological Services (NHMSs) or through collaboration with other national scientific organizations. The present network of 22 GAW Global stations is shown in Figure 2. They are situated near an upper air synoptic station in remote locations, representative of large geographic areas and routinely measure a variety of atmospheric chemicals over decades. Data are typically applied to global issues such as climate change and stratospheric ozone depletion, regional issues and satellite calibration/validation. An often under-stated function of the global GAW network is that its core measurements and facilities in remote regions enable shorter-term process-oriented multi-disciplinary studies to take place that otherwise could not have happened. GAW Regional stations are usually representative

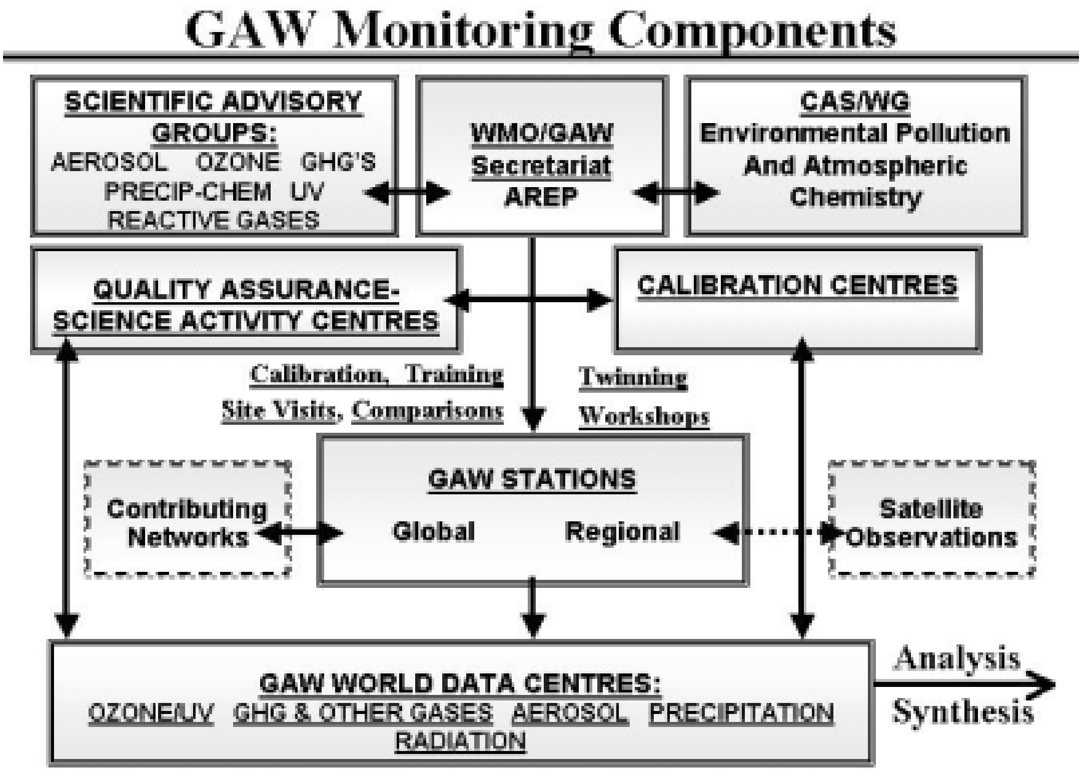

Figure 1 Components of GAW Monitoring. The dashed lines represent partners that combine with GAW to constitute the global atmospheric composition monitoring system.

of smaller geographic regions. A data base of network station information is maintained in the GAW Station Information System (GAWSIS) (see GAW website: http://www.wmo.ch/web/arep/gaw/gaw_home.html).

The GAW secretariat has established Scientific Advisory Groups (SAGs) to organize and co-ordinate monitoring activities for six parameter types (Fig.1). The SAGs advise on matters related to the science issue they represent.

Figure 2 The network of GAW Global atmospheric chemistry observatories. It is augmented by a large number of Regional GAW stations. The comprehensive global network configuration depends on the parameter measured (see Figures 3 to 5).

SAGs are responsible for assigning variables to be measured, preparing measurement quidelines, defining data quality objectives, developing standard operating procedures and overseeing the implementation of data quality criteria and standard operating procedures. To this end, they are assisted by GAW World Calibration Centres (WCC) and Quality Assurance/Scientific Activity Centres (QA/SAC). These centres and partners perform the vital function of helping to ensure that the data submitted to the GAW World Data Centres (WDC) is of high quality. The WCC activities include (a) maintenance of world standards for selected chemicals (b) calibration of instruments through station visits, (c) instrument comparisons and calibration campaigns, (d) laboratory measurement comparisons of circulated standard gases or reference samples, and (e) systematic and frequent calibration checks of the world standards (see detailed summary in Annex). In addition, there are GAW training activities particularly for developing countries (e.g. the Dobson ozone measurement training centre in the Czech Republic and the GAWTEC training courses conducted in Germany).

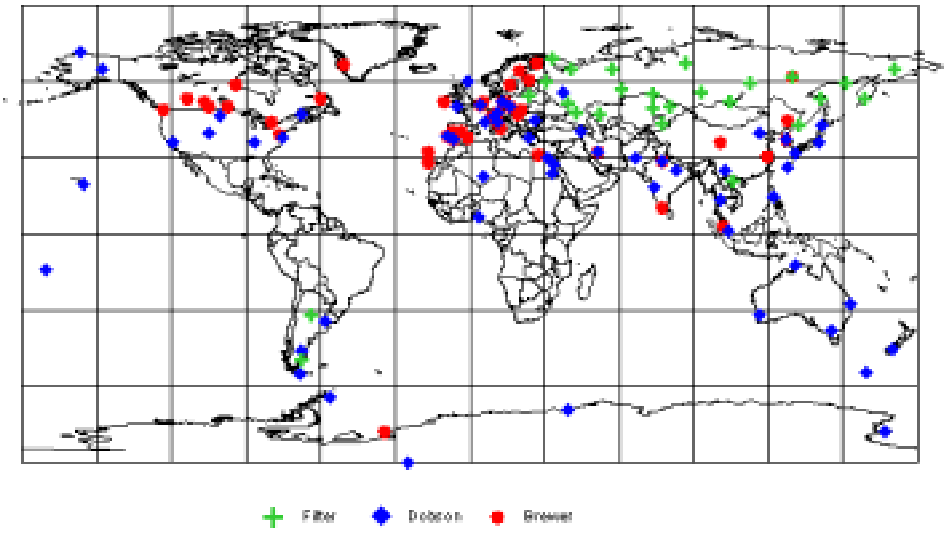

Figure 3 **A map of currently operating stations in the GAW global network for total column ozone for which regular observations since at least 1999 have been submitted to the World Ozone and UV Data Centre (WOUDC). Three types of instrument networks comprise this network as indicated by the symbols (Courtesy of Ed Hare of WOUDC, Canada).**

It is very important to emphasize that the network of GAW Global stations shown in Figure 2 is but one aspect of the GAW global monitoring programme. Depending on the variable measured, the world network of GAW Global, Regional and Contributing stations has a very different configuration. The GAW total column ozone network is shown in Figure 3. The task of ensuring that the data sets can be merged falls to GAW and requires substantial international collaboration and resources (e.g. routinely conducted instrument intercomparisons). It is comprised of data from three different instruments.

The GAW global network of currently operating ozone vertical profiles with balloon sondes is shown in Figure 4. It is a good example of a global network in which contributing partners, namely the NASA SHADOZ network combine with the GAW network utilizing similar measurement protocols and the GAW World Ozone and UV Data Center (WOUDC) to yield more comprehensive global observations of ozone in the troposphere

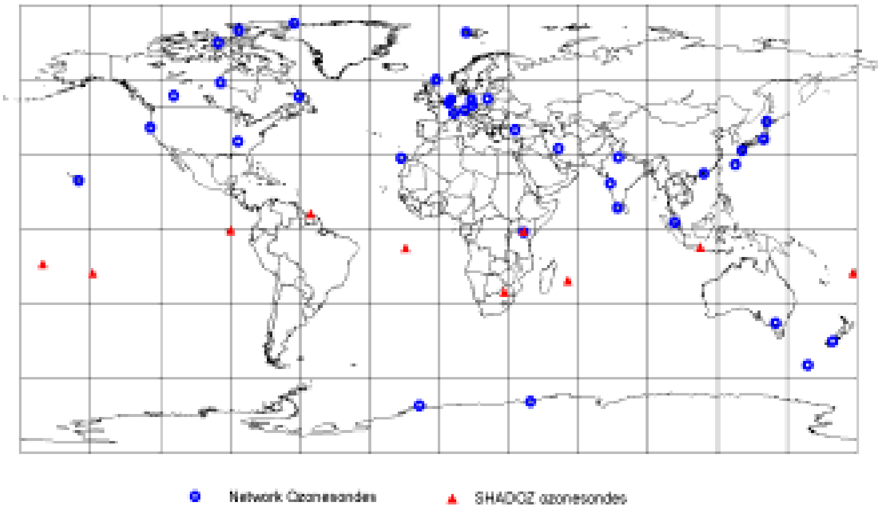

Figure 4 Currently operating stations in the GAW global network for ozone vertical profiles made with balloon sondes for which regular observations since at least 1999 have been submitted to the World Ozone and UV Data Centre (WOUDC). Blue dots are GAW stations and red triangles are stations of the NASA SHADOZ network, a Contributing network of GAW. (Courtesy of Ed Hare of WOUDC, Canada).

and stratosphere. The total column and vertical profile ozone networks are essential in the calibration and validation of satellite ozone measurements as well as in detecting trends.

The GAW global network of surface measurement stations for the greenhouse gas CO_2 is shown in Figure 5. This network is a composite of a world-wide flask sampling network operated by a number of laboratories at GAW global and regional stations as well as continuous measurements made at many of the global stations in Figure 2. A routine vertical profiling network based on small aircraft will soon be in place. The global

Figure 5 The GAW global network of stations contributing carbon dioxide surface observations to the World Data Centre for Greenhouse Gases (WDCGG) in Japan.

measurement networks for CH_4, N_2O and CFCs are comprehensive but not as well organized as those for CO_2. Assisting the global community to do this will be a priority of GAW.

The WDCs are operated and maintained by their individual host institutions and focus on selected atmospheric chemical constitutents. They collect, document and archive atmospheric measurements, the associated metadata from measurement stations world-wide and quality assurance information. They make the data freely available to the scientific community. In some cases, WDCs also provide additional products including data analyses, maps of data distributions, and data summaries:

1. The World Ozone and Ultraviolet Radiation Data Centre WOUDC (Toronto, Canada)

WOUDC, operated by the Meteorological Service of Canada (MSC), began as the World Ozone Data Centre (WODC) in 1960 and in June 1993 began receiving data on ultraviolet radiation. At present, there are over 400 registered stations represented in the WOUDC archive (website http://www.msc-smc.ec.gc.ca/woudc).

2. The World Data Centre for Greenhouse Gases WDCGG (Tokyo, Japan)

WDCGG was established at the Japan Meteorological Agency (JMA) in October 1990. It collects and distributes data on the mixing ratios of greenhouse (CO_2, CH_4, CFCs, N_2O, O_3 etc.), other related reactive gases (CO, NOx, SO_2, VOC, etc.) and associated meteorological parameters. As of February 2000, 182 stations in 42 countries submitted observational data for 13 species of greenhouse and related gases to the WDCGG. (http://gaw.kishou.go.jp/wdcgg.html).

3. The World Data Centre for Precipitation Chemistry WDCPC (Albany, USA)

This centre is operated by the Atmospheric Sciences Research Center (ASRC) of the State University of New York at Albany, and is supported by US and Canadian government agencies. Data includes precipitation acidity or alkalinity, the major cations ammonium, calcium, potassium, magnesium, sodium and the major anions: sulphate, nitrate, chloride. The website is http://qasac-americas.org

4. The World Data Centre for Aerosols WDCA (Ispra, Italy)

The WDCA is operated by the European Union's Joint Research Centre (JRC), Ispra, Italy, and was set up to archive aerosol related observations made under GAW. Its website is http://www.ei.jrc.it/wdca/.

5. The World Radiation Data Centre WRDC (St. Petersburg, Russian Federation)

WRDC was established in 1964 at the Main Geophysical Observatory of the Russian Federal Service for Hydrometeorology and Environmental Monitoring. It is the central repository of global, diffuse and direct solar radiation, downward atmospheric radiation, net total and terrestrial surface radiation (upward), spectral radiation components (instantaneous fluxes), and sunshine duration, on hourly, daily or monthly basis. The WRDC web site is http://wrdc.mgo.rssi.ru.

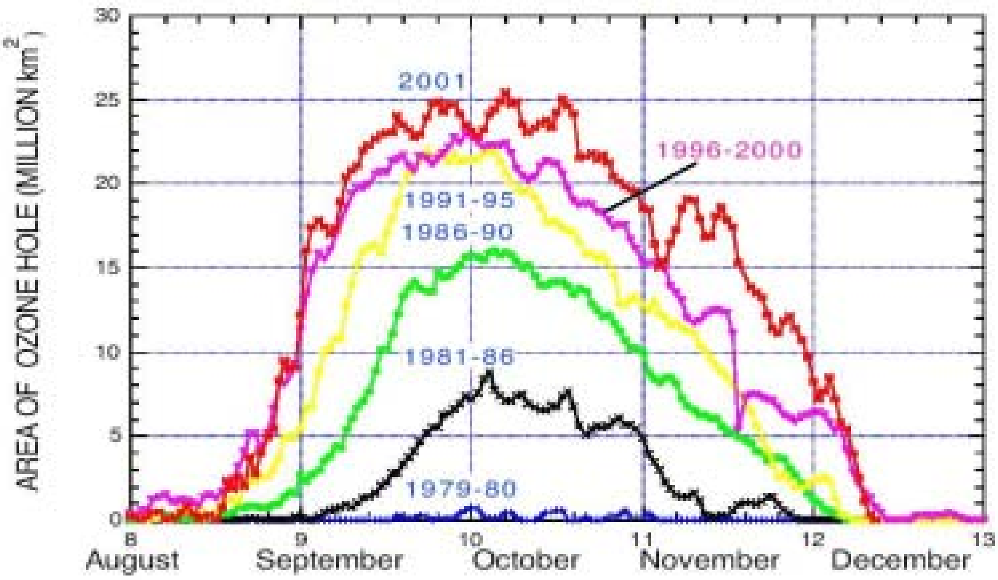

Figure 6 **Trends in the area (i.e within 220 DU contour) of the Antarctic ozone hole.**

3. ASSESSMENT AND SYNTHESIS

Stratospheric Ozone

The GAW programme includes active support for the Vienna Convention for the Protection of the Ozone Layer and its Montreal Protocol on Substances that Deplete the Ozone Layer through established partnerships with the Ozone Secretariat of UNEP headquarters in Nairobi. One of these important activities is support of the WMO/UNEP Scientific Assessment of Ozone Depletion. A second major joint WMO /UNEP responsibility is to organize and support the triennial meeting of the Ozone Research Managers of the Parties to the Vienna Convention for the Protection of the Ozone Layer. An important product provided by the GAW programme is a series of biweekly Antarctic Ozone Hole bulletins issued annually from August to November. The bulletins are assembled, written and published by the GAW secretariat with the assistance of the Norwegian Institute for Air Research (NILU) and the WOUDC data centre in Toronto. Figure 6 is an example of one product of these analyses.

Integrated Global Atmospheric Chemistry Observations (IGACO): GAW and the Satellite Community

Space-based observations offer a partial solution to the problem of obtaining a global measurement of gas, aerosols and associated meteorological parameters important to the atmospheric issues of GAW. Integration of satellite observations with non-satellite observations from the GAW programme is highly desirable. In addition, satellite systems can best meet their established requirements if they are checked against highly accurate ground based or airborne measurements of known quality. For instance for the past few decades, the GAW network of stations has provided to space agencies both total column ozone and vertical profile ozone data to be used for satellite validation. In future, surface-based measurements of aerosol optical depth and other constituents by GAW and partners will play a similar role for other satellite observations.

In June 1998, a partnership of 13 organizations including WMO and the Committee on Earth Observation Satellites (CEOS) initiated the Integrated Global Observing Strategy (IGOS; http://www.igospartners.org). Two of the goals were to identify gaps in existing observation systems and to encourage specific activities to develop and enhance components that will demonstrate the value of the strategy. In June 2001, WMO/GAW was instrumental in adding the "Integrated Global Atmospheric Chemistry Observation (IGACO)" theme to the three other established IGOS themes: the "Global Water Cycle", the "Ocean" and the "Global Carbon Cycle" (see Integration Strategy, 2001). IGOS has established an IGACO theme team co-convened by WMO/GAW and the European Space Agency (ESA) which met January 2003 and began the process of developing a Theme Report on IGACO for IGOS. Figure 7 summarizes the system of data generation, analysis and product generation supported by the IGACO strategy for integrating global atmospheric chemistry observations by satellite and non-satellite communities. A comprehensive set of integrated global observations of atmospheric ozone (troposphere as well as stratosphere) and of aerosol optical properties (e.g. optical depth, single scattering albedo etc.) are examples of products that may result from such activities. These would be invaluable in evaluating global climate and chemical transport models. A major challenge is how best to integrate routine air quality observations from commercial aircraft into this activity.

4. DEVELOPMENT OF PREDICTIVE CAPABILITY

An overall objective of GAW is to assist in the advancement of the prediction of future atmospheric states. Climate models and air quality predictions based on weather forecast techniques are under development in many National Meteorological and Hydrological Services. Because of the recognized importance of gases and

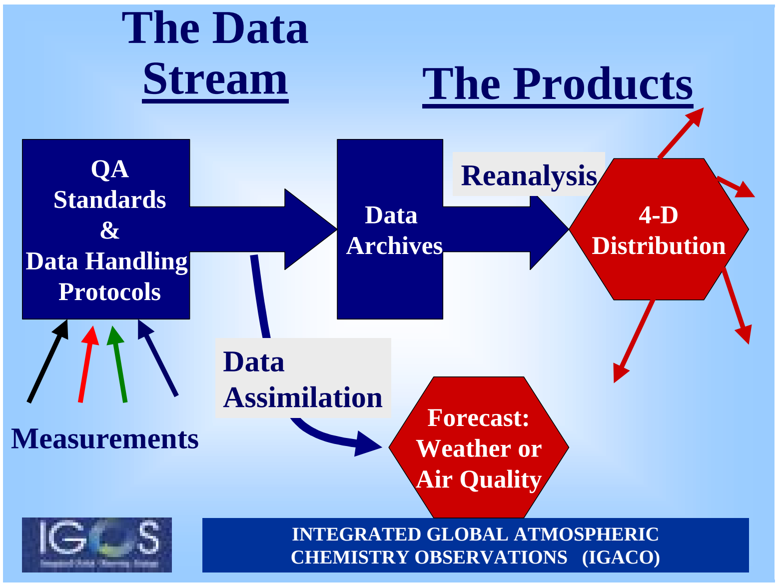

Figure 7 **A system diagram of the components and products of an Integrated Global Atmospheric Chemistry Observation (IGACO) system involving satellite and non-satellite atmospheric composition observations.**

aerosols in the climate system, global observations provided by GAW monitoring have and will play an important role in this development. An example of this is the use of global aerosol data assembled by the WDCA (see Section 2) in a Comparison of Large Scale Sulphate Aerosol Models (COSAM) sponsored by the World Climate Research Programme (WCRP) and the International Global Atmospheric Chemistry programme (Barrie et al, 2001). An integrated atmospheric ozone and related chemistry data set or an aerosol optical property data set such as that made possible through future IGACO efforts of GAW will prove useful to global modellers.

GURME

The need for a quite different capability on the urban to regional scale has been flagged by the NHMSs. In 1999, the GAW Urban Research Meteorology and Environment (GURME) project was added to GAW by the thirteenth WMO Congress in response to the requests of the NMHSs many of which have an important role to play in the study and management of urban environments. WMO established GURME as a means to help NMHSs enhance their capabilities in dealing with the air chemistry and meteorology of urban pollution. This will be done by the coordination and focussing of present activities, as well as initiation of new ones. The lead responsibility for GURME rests with the Scientific Advisory Group (SAG GURME). A detailed description of GURME is at the website http://www.wmo.ch/web/arep/gaw/urban.html.

Through a series of workshops, the GURME SAG and the GAW secretariat has developed a set of guidelines to help NMHSs in effectively dealing with urban pollution matters. The main points *or* recommendations are to:

1. identify the urban environmental problem to be solved
2. consider all components of the environmental system in addressing urban air quality issues.
3. develop an air quality forecast capability for the urban environment
4. implement measurements that support the development and evaluation of the air quality forecast. Air quality measurements implemented for the evaluation of air quality forecasts also provide a long term data base for the assessment of health and other environmental effects.
5. develop local expertise and facilities essential to steps 3 and 4 above. In order to succeed, it is important to face the need for considerable local resources. The mechanisms of achieving this include partnership, access to tools and information that encourage self-help, training and information exchange through workshops.
6. conduct pilot projects that demonstrate how NMHSs can successfully expand their activities into urban environment issues, showcase new technologies and develop illustrative examples. Presently, pilot projects have been initiated under GURME for in Beijing, Moscow and Latin American cities (see website). In addition, a pilot project on the use of passive samplers for urban measurements has been conducted involving several cities.

GURME will assist NMHSs to implement these guidelines. To this end, "The First WMO/GAW GURME Air Quality Forecasting Workshop" was organized in Kuching, Malaysia, August 2002. This regional workshop served to introduce world experts to regional scientists involved in applications of air quality forecast models. The first "GURME Expert Workshop on Air Quality Forecasting" was held in Mexico in October 2002. The current status of operational models and their expected short-term improvements was reviewed, documented and used to update existing information on air quality modelling on the GURME website.

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TABLE 1. A summary of the facilities responsible for components of the GAW calibration and quality assurance system as of May 2003. The facilities have assumed global responsibilities, unless indicated (Am: Americas; E/Af: Europe and Africa; As/O: Asia and the South-West Pacific). It should be emphasized that several major network operators contribute substantially to quality assurance of global atmospheric composition measurements in addition to those facilities listed below. {! mark represents missing components that the WMO/GAW secretariat with members and partners are close to filling}

SPECIES	QA/SAC	WORLD CALIBRATION CENTRE	REFERENCE STANDARD HOST	WORLD DATA CENTRE
CO_2	JMA (As/O)	CMDL	CMDL	JMA
CH_4	EMPA(Am, E/Af), JMA(A/O)	EMPA(Am, E/Af), JMA(As/O)	!	JMA
N_2O	UBA	IMK-IFU	!	JMA
CFCs	!			JMA
Total Ozone	JMA (As/O)	CMDL[1], MSC[2], MGO[3]	CMDL[1], MSC[2]	MSC
Ozone Sondes	FZ-Jülich	FZ-Jülich	FZ-Jülich	MSC
Surface Ozone	EMPA	EMPA	NIST	JMA
Precipitation Chemistry	ASRC	ASRC	ISWS	ASRC
CO	EMPA	EMPA	CMDL	JMA
VOC	UBA	IMK-IFU	NCAR	JMA
SO_2				JMA
NO_x				JMA
Aerosol Phys. Characteristics	UBA	WCCAP		JRC
Optical Depth		WORCC	WORCC	JRC
UV Radiation	ASRC-SUNY (Am)	SRRB (Am)		MSC
Solar Radiation		PMOD/WRC	PMOD/WRC	MGO
85Kr, 222Rn		EML		JMA
7Be, 210Pb		EML		EML

- ASRC- Atmospheric Science Research Centre Albany, NY (US NOAA GCOS;
- CMDL, Climate and Monitoring Diagnostics Laboratory, NOAA, USA;
- EML, Environmental Measurements Laboratory, DHS, USA.
- EMPA, Zurich, Swiss GAW;
- FZ-Juelich, Forschungs Zentrum Juelich, Germany;
- IMK-IFU, Institute fur Umwelt Forschung, Garmisch-Partenkirchen, Germany (UBA supported);
- ISWS, Illinois State Water Survey, USA
- JRC European Joint Research Centre, Ispra, Italy;
- JMA Japan Meteorological Agency GAW,
- MSC Meteorological Service, Research Directorate, Canada;
- MGO Main Geophysical Observatory, St. Petersburg, Russia;
- NIST, US National Institute for Standards and Technology;
- NCAR National Centre for Atmospheric Research USA;
- SRRB Surface Radiation Research Branch of NOAA ARL, USA;
- UBA Federal Environmental Agency, Germany;
- WCCAP: World Calibration Centre for Physical Aerosol Properties, Leibniz Institute for Tropospheric Research, Leipzig, Germany (UBA supported)
- WORCC: World Optical Depth Research and Calibration Centre and WRC World Radiation Centre,,Swiss GAW, Physikalisch-Meteorologisches Observatorium, Davos, Switzerland.

1. Dobson instrument
2. Brewer Instrument
3. Russian filter instrument