WORLD METEOROLOGICAL ORGANIZATION
GLOBAL ATMOSPHERE WATCH

No. 151

REPORT of the CAS WORKING GROUP on ENVIRONMENTAL POLLUTION and ATMOSPHERIC CHEMISTRY

(GENEVA, SWITZERLAND, 18-19 MARCH 2003)

NOVEMBER 2003

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WMO TD No. 1181

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1. OPENING OF THE SESSION

1.1 The First Session of the Commission for Atmospheric Sciences (CAS) Working Group (referred to as WG) was opened by the chairman, Prof. Oystein Høv. He noted the establishment of the WG by CAS XIII and recognized a number of the new members. Prof. Høv then introduced the Deputy Sercretary-General, M. Jarraud, who welcomed the members of the Working Group to the WMO. He commented that the GAW Strategic Plan for 2001-2007, which was accepted by CAS-XIII and EC-LIV, is the guideline for the future development of the Global Atmosphere Watch (GAW). The plan provides long-term vision for the programme. He stated that such issues as climate change and urban air quality require coordinating global monitoring, organizing assessements and assisting developing countries. He mentioned further the need to harmonize satellite and ground-based measurements through the Integrated Global Observing Strategy (IGOS). He reminded the participants that their deliberations and recommendations would be considered by the upcoming WMO Congress XIV, to be held in May. He then wished the Working Group to have a successful meeting and to enjoy their stay in Geneva.

1.2 Dr E. Manaenkova, Director of the Atmospheric Research and Environment Department (AREP), welcomed the Working Group members to the department. She requested that the Working Group follow the terms of reference expressed in CAS XIII with its next CAS meeting in 2005. She pointed out that the immediate duty of the Working Group would consist of preparing a summary report for the CAS President for presentation at Congress XIV. She expressed her expection that the meeting would be a fruitful one.

2. APPROVAL OF THE AGENDA

2.1 The Chairman began the session by requesting all the particpants (Annex A) to introduce themselves and describe their scientific interests. Prof. Høv then reviewed the proposed agenda and requested any corrections or additions. Since there were none, the agenda was adopted and is given in Annex B.

2.2 Prof. Høv stated that the Working Group must review several critcal issues and give advice on what actions should be taken in the future; these deliberations would then be transmitted to WMO Members at the Congress in May. Issues raised at the CAS-XIII and EC-LIV would need to be addressed. He also reminded the Working Group members that they should take up their duties as rapporteurs as outlined in CAS-XIII.

3. WORKING GROUP MEMBER PRESENTATION OF THEIR SCIENTIFIC PROGRAMMES

3.1 The Working Group members were invited to make brief presentations on recent scientific advances in their areas of responsibility.

3.2 The presentations began with Mr B Hicks, Rapporteur on the Urban Atmospheric Environment, who informed the group that after a period of uncertainty the Quality Assurance/Science Activity Centre (QA/SAC) for the Americas, Albany, NY, USA, has been placed on a solid funding basis. Thus all GAW QA/SACs are in full operation. He also discussed the importance of both air quality and dispersion forecasting in urban areas. Further, he explained the difficulties of such forecasts during catastrophic events that require advising the public on what actions to be taken. Wind tunnels are now being used to model such events.

3.3 Dr H. Matsueda, Rapporteur on Greenhouse Gases including Their Effects on Climate Change, described the activities in Japan related to understanding the carbon cycle, especially the long-term measurement of carbon dioxide. Their unique programme of such measurements was a cooperative effort between JMA's Meteorological Institute and the Japan Airlines to measure CO_2 plus CH_4 and CO on commercial aircraft. Some 2400 samples were taken starting in 1993 on a route between Japan and Australia at the elevation of ten kilometers. The results showed that there was important carbon dioxide transport across the two hemispheres. Further, Dr Matsueda described the JMA's very active GAW programme that includes a number of Global and Regional

stations, the World Data Centre for Greenhouse Gases, a World Calibration Centre for Methane Calibration and the Quality Assurance/Science Activity Centre for Asia and the Pacific.

3.4 Prof. E. A. Piacentini, Rapporteur on Atmospheric Ozone and Ultraviolet Radiation, outlined the very active GAW programme in Argentina. One of its major contributions is the GAW Global Observatory at Ushuaia. The station is particularly important in making total ozone measurements during the ozone hole period. Argentina has a number of other Regional stations. Also noteworthy is the station in Buenos Aires (Villa Ortuzar), where a number of training courses and instrument calibrations take place on a regular basis. Prof. Piacentini also mentioned that other Argentinean organizations cooperate in the GAW programme such as the University of Buenas Ares, and the governments of the cities of Buenos Aires and Cordoba.

3.5 In his presentation, Dr M. Bittner, Rapporteur on Satellite Measurements of Atmospheric Consituents, first reviewed the GAW activities in Germany. These include supporting both Global and Regional stations. Also Germany hosts the QA/SAC for Europe and Africa and has sponsored GAW training courses at a number of locations in the country. He also explained the activities of the German Aerospace Centre (DLR) and strongly endorsed the importance of coordinating ground- and space-based atmospheric chemistry measurements. He then proposed that the new World Data Centre for the Remote Sensing of the Atmosphere, which his organization is hosting for ICSU, could also be designated a GAW World Data Centre.

3.6 Describing the very active Swiss programme, G. Müller outlined in detail the key contributions. They include the World Calibration Centre for Ozone, Carbon Monoxide and Methane, the QA/SAC Switzerland, and the World Optical Depth Research and Calibration Centre. Mr Müller, the Rapporteur on Strategic Planning and Implementation of GAW, has led the effort to produce the GAW Strategic Plan (GAW Report No. 142). He pointed out that Swiss scientists have been active in assisting with the establishment of the Nairobi ozonesonde measurements and the Mount Kenya Global station. Further, the DACH project that links the high Alpine monitoring stations of Germany, Switzerland and Austria is an important activity related to GAW. A World Infrared Radiation Calibration Centre is being developed at the World Radiation Centre in Davos. Switzerland with its six GAW stations (Bern, Payerne, Jungfraujock, Locano, Davos and Arosa) has focused its effort on three scientific areas: ozone, radiation, and aerosols. Mr Müller outlined the main strategic goals, foci, achievements and challenges of the GAW programme in 2001-2004. He strongly recommended that the tasks outlined in the GAW Strategic Plan for 2001-2004 be reviewed and their implications for 2005-2007 be considered.

3.7 Prof. O. Høv, Chairman of the Working Group and coordinator of the work of the individual rapporteurs, outlined all the problems which GAW must deal with, which range from urban to global. He discussed the approaches that have been made in monitoring, contrasting top-down to bottom-up. An example of top-down is the European Monitoring and Evaluation Programme (EMEP), which is closely linked to WMO and GAW. In contrast, GAW is a more bottom-up and volunteer type of organization where the rationale is spelled out in the GAW Terms of Reference and the GAW Strategic Plan, and is up-dated in the session of CAS-XIII. (Oslo, May 2002). He pointed out the interconnection of long-range transport and climate change and the direct impact of pollutants on the climate.

3.8 Representing Y. Tsaturov, Rapporteur on Atmospheric Transport and Deposition of Pollutants including Modelling, A. Konoplev described the GAW programme in the Russian Federation. He discussed activities related to EMEP and the Arctic Monitoring and Assessment Programme (AMAP). At present there is particular interest in Persistent Toxic Substances (PTS) which includes Mercury (Hg), Persistent Organic Pollutants (POPs) and other heavy metals. A site has been set up in the northern part of the country (Amderma) to measure PTSs. Additionally, a joint effort with the US is the development of coordinated measurements at the Barrow GAW Global station and Chukatka for POPs and heavy metals.

3.9 As the Working Group Rapporteur on Aerosols, J. Gras began by describing his personal scientific involvement in the Australian GAW aerosol programme at the Global station at Cape

Grim as a part of the CSIRO programme. Recently an Australian dioxin study has been put in place which is related to the GAW interest in POPs. He also discussed the importance of the GAW long-term objectives and their relationship to national activities in Australia. Dr Gras ended by numerating the combined effort of the CSIRO and the Bureau of Meteorology in GAW that included four Total Ozone stations, two ozone sonde locations, solar radiation/UV stations and regional precipitation chemistry stations. Common to many other countries, he noted that there was strong competition for funds to support the GAW programme.

3.10 Ms R. Simeva, Rapporteur on Reactive Gases, outlined some of the difficulties of making environmental measurements in the Balkan region. Needs in the region include stabilizing the operations of the present system, keeping up with recent information concerning GAW activities, improving the instrumentation, as well as the political problem of ensuring government support. Particularly now, urban pollution is of great interest in the region. This requires some form of twinning arrangements with a developed country, up-to-date guidelines and a continuous programme of intercalibration of instruments.

3.11 Representing Prof. X. Xu, Rapporteur on Urban Atmospheric Environment, Prof. G. Ding reviewed the Chinese GAW activities. Besides the well-known Mount Waliguan GAW Global Observatory, there are three GAW Regional stations in China. Three new Regional stations are planned in the next five years. He mentioned an acid rain network of 150 stations mostly in the eastern part of the country and a special network of 20 stations used to monitor sand storms. Of particular interest is the upcoming Olympics 2008 when a dense network of PM 2.5 measurement sites will be established around Beijing.

3.12 Mr J. Rotich, representing the Working Group member and Rapporteur on Changes in Atmospheric Composition on a Long-Term Basis, W. Kimani, described the GAW activities on the Global station on Mount Kenya. Measurements include surface ozone, black carbon, carbon monoxide and meteorological parameters. Data are not yet being submitted to the GAW World Data Centres.

4. CHALLENGES FACING THE GAW PROGRAMME

4.1 Addressing the Working Group's main task of evaluating GAW's present status and future plans, Prof. Høv pointed out three major goals. First, there is a need to implement or revise those tasks not completed within the time frame 2001-2004 as spelled out in the Strategic Plan. This must be accomplished by the different GAW components such as SAGs, QA/SACs etc. He went on to propose that based on this exercise, the tasks for 2005-2007 would be documented. It is obvious that though much has been done, there are still gaps that must be filled. Second, since the effort to implement GAW is based on the work of numerous volunteer organizations around the world, it is necessary that these groups be recognized for their important contributions. Appreciation must be expressed in some form to show to the governments and the public that important work is being done. Third, he stated that the programme should consider assessments of its various programmes following the example of the stratospheric ozone assessments. This would show GAW programme contribution to our understanding of our environment.

4.2 The chairman invited Dr L. Barrie, Chief of the Environment Division, to initiate the overview with a presentation on challenges to the Global Atmosphere Watch Programme. He began by stating the GAW Mission: the systematic monitoring of chemical composition globally, analysis and assessment, and the development of a predictive capability. He then outlined the major monitoring themes: stratospheric ozone, tropospheric ozone, greenhouse gases (CO_2, CH_4, N_2O and CFCs), UV radiation, reactive gases (CO, VOCs, NOy and SO_2), precipitation chemistry and aerosols (optical, chemical and physical). Because of the complex infrastructure of the GAW system, Dr Barrie explained the interactions of the different units with Figure 1. This figure demonstrates how the different parts of GAW all come together to monitor the chemical parameters of the atmosphere. More details will be given later in the report for each component. He made the point that from a network point of view there were the Global and Regional stations

but one could also map by component such as the ozonesonde network or the total column network. To support such measurements, GAW has developed World Calibration Centres, World Data Centres and Quality Assurance/Science Activity Centres.

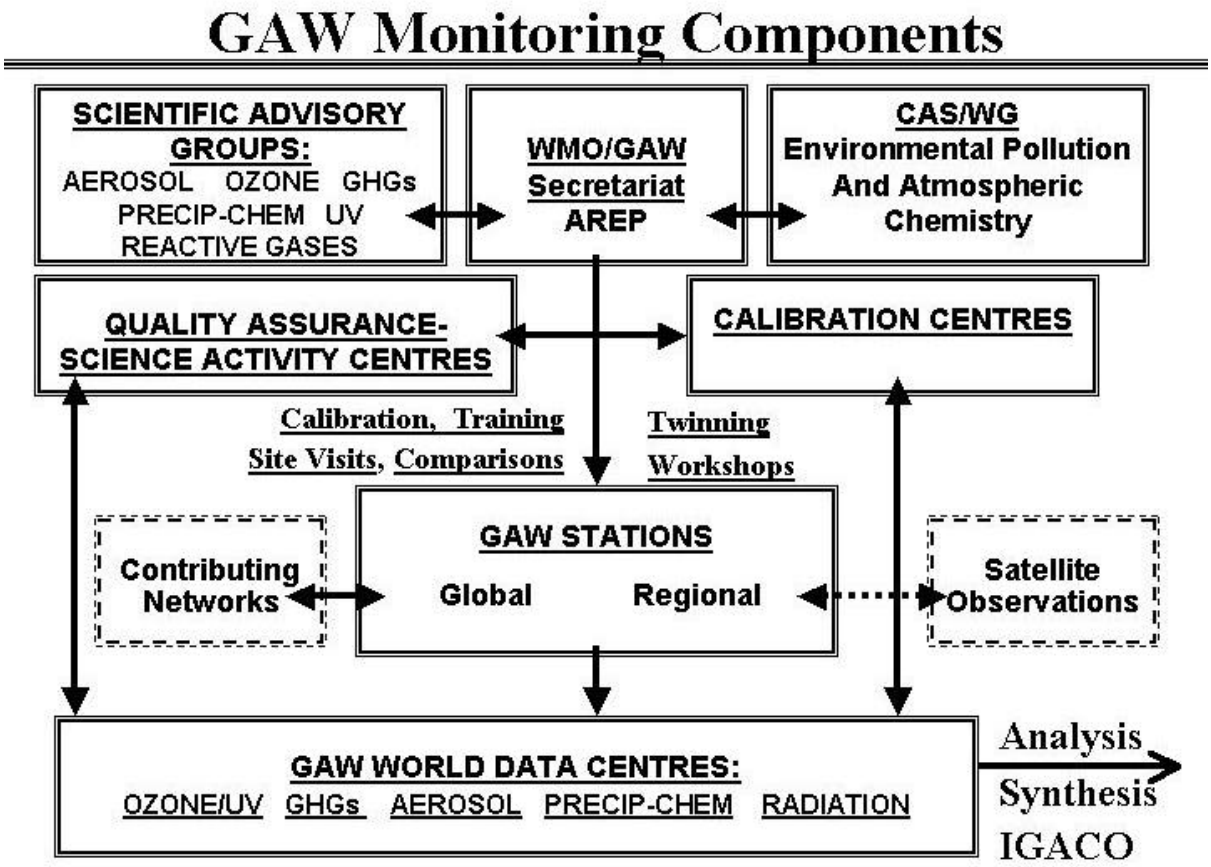

Figure 1: ***Components of GAW. The dashed lines represent partners that combine with GAW to constitute the global atmospheric composition monitoring system. IGACO is the Integrated Global Atmospheric Chemistry Observations system which GAW has a major role in developing.***

Dr Barrie also outlined the analysis and assessment aspect of GAW. A good example of this is the support of the WMO/UNEP Scientific Assessment of Ozone Depletion and the publication of the Antarctic Ozone Hole Bulletins. He suggested a Global Aerosol Watch based on the example of the ozone assessment. Associated with this, the Integrated Global Atmospheric Chemistry Observations (IGACO) was established under the Integrated Global Observing Strategy (IGOS) to coordinate ground-based atmospheric chemistry measurements under GAW with space-based measurements. IGACO certainly fits into the analysis and assessment aspect of the GAW programme.

As part of developing a predictive capability, he described briefly the GAW Urban Research Meteorology and Environment (GURME) project which assists developing countries in air quality forecasting. A more detailed description will be given later. Dr Barrie ended his presentation by outlining ten challenges to GAW shown in Table 1.

Table 1: **TEN CHALLENGES FOR GAW**

1.	Maintaining long-term measurements of quality in the current network.
2.	Establishing long-term measurements of quality to improve global coverage, particularly in countries that are developing or in transition.
3.	Developing collaboration between NHMSs and the chemical measurement community in some countries.
4.	Calibration, quality assurance and standard operating procedures: costly and not high profile but essential.
5.	Working with contributing partners that have networks as substantive as GAW to build a global network.
6.	Developing World Data Centres that are comprehensive global repositories for high quality global observations of targeted GAW species.
7.	Development of GAWSIS so that the GAW global network is accurately known.
8.	Building a global aerosol monitoring network and integrated data analysis system in partnership with other organizations including satellite agencies.
9.	Developing and implementing with IGOS a strategy for International Global Atmospheric Chemistry Observations (IGACO).
10.	Continuing to build air quality management capacity in countries with mega-city air pollution problems.

5. GAW ORGANIZATION COMPONENTS

5.1 As a part of the discussion on data management, the chairman asked J. Klausen from the Swiss Federal Laboratory for Materials Research and Testing (EMPA) to present the activities that take place at that organization concerning GAW. He outlined the duties of the World Calibration Centre for Surface Ozone, Carbon Monoxide and Methane where the scientists at EMPA calibrated instruments on site at a number of Global stations since 1996. He furthermore enumerated the accomplishments of the QA/SAC Switzerland such as supporting the QA system at individual sites, co-ordinating instrument calibrations and providing input to the SAGs and the Secretariat. Dr Klausen stated the Data Quality Objectives and Standard Operating Procedures would be written for CO and CH_4. The QA/SAC would assist in the establishment of the SAG for Reactive Gases. He stated in particular that the QA/SAC would take the initiative to begin the harmonization/integration of GAW with EMEP. It was also suggested that a meeting – GAW 2004 - take place to address data analysis and modelling.

5.2 Following the EMPA overview, Dr Klausen described the status and progress that had taken place with the GAW Station Information System (GAWSIS). The purpose of GAWSIS is to provide a web-based data information and mapping system of the GAW network, thereby facilitating management of the GAW network and guiding future development. Specifically, the goal is to establish a single meta-data archive for GAW and facilitate exchange of scientific and technical information between GAW stations and thereby enhancing awareness of the GAW system. At present, GAWSIS can be used on-line to search for station information and to produce overview lists and station reports. A number of steps must still be taken which include ensuring that countries submit information on their stations, integrate information with the GAW World Data Centres (WDCs), complete information on contributing networks, and provide map-oriented information. It is particularly important to continuously up-date and reach out to "silent" stations.

GAWSIS has the potential to become a one-stop data warehouse for the GAW networks. It can be a bridge between the WDCs. To succeed, the system needs support from various partners, including the WDC managers, station contacts and the scientific community. When completed, GAWSIS will act as a central coordination point of the GAW system.

5.3 Continuing on the data management theme, M. Proffitt from the Secretariat gave a more detailed account of the present status of the WDCs. He stated that a review of the active stations that had submitted data to the WDC revealed that over 800 stations had provided data. Dr Proffitt reported a new and useful development, i.e., that a single code had been proposed to be assigned to each GAW station. It was expected that this would be implemented shortly.

5.4 Dr Barrie then gave a brief report on communications which included GAW reports, presentations and the newsletter. The main suggestion from the Working Group was that the Information Sheet, which in the past has been issued every four months, should be continued in its present form until a better approach could be worked out.

5.5 M. Proffitt led the discussion of the GAW activities in capacity building. He began by reviewing the two Global Environment Facility (GEF) projects: (i) the establishment of six GAW Global Stations and (ii) the ozone/UV project for South America (Cone project). These projects still require considerable coordination. Furthermore, a number of capacity building projects by different countries have been active such as the GAW Technical and Education Centre (GAWTEC) at the Zugspitze - Hohenpeissenberg observatory and total ozone calibration and training in the Czech Republic and Germany.

A number of proposals have been submitted to donors with some success. The most prospective funding possibility is the new Trust Fund that has been set up by the Conference of Parties to the Vienna Convention to which donors can contribute to support the GAW total ozone and vertical ozone networks. Other proposals have been submitted.

Dr Proffitt described a particular problem related to the ozone programme especially in developing countries. Many Dobson spectrophotometers are being replaced with Brewer Spectrophotometers without proper overlap. This endangers the long-term records at many of the stations. To solve this problem, funds are needed to provide expert advice and guidance during this period of instrument change over.

6. STATUS OF OBSERVING SYSTEMS

6.1 ***Ultraviolet radiation:*** Completing the review of the various infrastructure aspects, the Working Group reviewed the programme parameter by parameter. The first presentation was by Prof. Paul Simon, chairman of the SAG for UV. He began by outlining the history of the group, which was formed in 1995 in order to address the need to coordinate the global monitoring and assessment of UV radiation. Since that time, the SAG has supported the GAW programme, as outlined in its web site. This includes producing recommendations/guidelines on instrument specifications, site quality control and data archiving. Furthermore, through the Secretariat, the SAG has helped organize workshops, contributed to the GAW strategic planning, and coordinated international intercomparisons. A number of technical reports have been produced under its guidance. The group has closely interacted with the World Ultraviolet Radiation Data Centre in Canada. Another task has been the integration of UV modelling to complement the ground-based measurement system.

To continue its strong support of the GAW UV programme, the SAG has the following future plans:

- Update the procedures for UV data archiving.
- Review the UV network status.
- Continue the definition of instrument specifications.
- Establish a UV World Calibration Centre along with Regional Calibration Centres.
- Define a set of Data Quality Objectives (DQOs) and Standard Operating Procedures (SOPs) for the UV measurements systems.
- Specify the needs and use of UV modelling in GAW.
- Encourage a relationship of satellite measurements with the ground-based GAW measurements.

6.2 ***Aerosols:*** Because of the impact of aerosols on both climate change and air quality, the GAW aerosol programme is crucial. The main challenge, however, is that the measurement of the many aerosols properties is very complex. The chairman of the SAG for Aerosols, U. Baltensperger, gave an overview of their activities in light of the specific tasks outlined in the GSP. Specifically, some of the tasks reviewed include:

- Complete a register of aerosol sites.
- Finish the deployment of the Swiss GAW Precision Filter Radiometer and a synthesis of the initial data.
- Begin a calibration and intercomparison programme as an interim step for the establishment of a World Calibration Centre for Aerosols Physical Properties
- Improve the submission of data from participating sites on a regular basis to the World Data Centre for Aerosols.
- Organize special sessions on GAW aerosol studies.
- Contribute actively to capacity building in developing countries.

One of the chief contributions of the SAG Aerosols has been the development of a standard aerosol measurement guideline for Regional and Global stations. This group has been one of the most active groups and is expected to continue its important work.

6.3 ***Precipitation Chemistry:*** Mr R. Artz, chairman of the SAG for Precipitation Chemistry, gave the overall view of the activities of the group which was to meet at the WMO headquarters immediately after the meeting. Precipitation Chemistry has been a WMO parameter of interest

dating back to the late sixties. The SAG has been active in advising the GAW programme. A significant effort coming to fruition is the "Guidance Document for the GAW Precipitation Chemistry Programme". This document has been long in coming and addresses siting, field protocols, laboratory operations, data management and QA/QC. One noteworthy aspect is that the group has defined the Data Quality Objectives (DQO) for GAW precipitation chemistry measurements. It was noted that over the last decade the number of samples qualifying under the DQOs has increased significantly.

Mr Artz also described the long-term laboratory intercomparison programme that began in 1978. Participation in the intercomparison is required of every laboratory serving a GAW precipitation chemistry station. The results of the intercomparisons are made public with the data.

Mr Artz summarized the work of the SAG by listing how well the programme has reached its goals as outlined in the GSP. Some of those goals include: improving measurements with new SOPs, encouraging timely submission and distribution of data, and establishing additional precipitation chemistry sites. Also, the goal of preparing a scientific assessment and providing data for the evaluation of ecosystems effects is important. He mentioned in addition that the group has links with other precipitation chemistry programmes.

6.4 ***Ozone:*** The next topic discussed was the activities of the ozone programme within GAW. Dr M. Proffitt reported on this aspect. He began by describing SAG for Ozone activities, especially the issues which the group had discussed and which included such questions as intercomparisions, Brewer/Dobson interactions, lidar measurements, and submission of data. Dr Proffitt then reviewed the different aspects of GAW ozone activities. Starting with total column ozone, he stated that the well-known long-term calibration system for the 120 Dobson Spectrophotometers world-wide has been in place for a long time and will continue to function. The main problem that arises is with the 160 Brewer Spectrophotometers, for which there is only a commercial method for calibration and intercomparison. Efforts are, however, being made to promote Dobson/Brewer intercomparisons and integrate the two systems. The ozone profile system of ozonesondes is also coordinated through GAW. After considerable intercomparisons under the JOSIE experiments and a multi-instrument comparison this summer (Balloon Experiment on Standards for Ozonesondes –BESOS), it is expected that a Standard Operating Procedure (SOP) can be completed for most of the sondes now used around the world.

Dr Proffitt also mentioned the surface ozone programme and referred to the important contribution made by the QA/SAC Switzerland. He described additionally the Antarctic Ozone Hole Bulletins, which are issued from August to December every year. Also since the last time the Working Group met, the WMO/UNEP Scientific Assessment of Ozone Depletion 2002 has been completed and the report will be issued shortly. Another important issue and now joint WMO-SPARC project has been the setting of a scientific criteria to judge the limits of the ozone recovery.

6.5 ***Greenhouse Gases:*** Continuing the review of the GAW programme, Dr L. Barrie discussed greenhouse gases. A reactivated SAG for Greenhouse Gases covering CO_2, CH_4, CFCs and N_2O is scheduled to meet in the near future. The latest interest for CO_2 is better spatial coverage and implementation of vertical measurements using tall towers. The SAG will focus on CH_4 and N_2O. Further, an important development is the possibility of up-coming intercalibrations of CFC laboratories that could lead to a World Calibration Centre for CFCs. Dr Barrie reviewed the infrastructure now in place for the greenhouse and reactive gases. Fluxnet, a network to measure the flux of greenhouse gases, and how this fits into the GAW programme was discussed.

6.6 ***Reactive Gases:*** Dr L. Barrie outlined the need for GAW to become more active with regard to the reactive gases (CO, VOC, NOy and SO_2). He stated that a SAG for Reactive Gases would soon be formed. There has been considerable interest in CO within GAW, and the SAG will focus on this gas in its first deliberations. It was stated that since selected reactive gases can be observed reasonably well from satellites, this would be a good connection with IGACO.

6.7 ***Natural Radioactivity:*** Dr Barrie brought up the subject of natural radioactive materials such as radon (Rn^{222}), Rn^{222} daughters, Be^{7}, Pb^{210} and Kr^{85}. He stated that the leadership in this field owing to the lack of a SAG would be directed to the Environmental Measurements Laboratory, Department of Home Security, USA. A meeting of experts will be co-sponsored with WCRP and IAEA in June on this topic in Saclay, France, to organize the GAW effort in natural radioactivity.

7. GAW URBAN RESEARCH METEOROLOGY AND ENVIRONMENT (GURME) PROJECT

The GURME project arose from the need of some WMO Members for assistance in developing urban programmes especially related to forecasting pollution transport. Dr L. Jalkanen outlined the short history of the project with the initial planning meeting in Beijing in 1999. At that point a SAG for GURME was established and has been very active under the leadership of Dr G. Carmichael. The main goals are to:

- Enhance the capabilities of the NMHSs in urban/environmental forecasting and air quality services
- Provide NMHSs easy access to information on measurement and modelling techniques
- Collaborate with other organizations, especially the WHO, to better define the measurements needed to support urban forecasting.
- Promote pilot projects. Two pilot projects have already been organized for the cities of Beijing and Moscow.

Dr Jalkanen further described that one way to achieve the above goals was through organizing workshops for urban forecasting (SE Asia 2000) and expert meetings (Mexico 2002) on current operational models. Other such meetings/workshops are planned for the future. In association with the project, a passive sampler network has been put in place in urban areas which measure SO_2, NO_2, O_3 etc.

The SAG has sponsored a GURME web page which outlines all the GAW activities related to the project. A special presentation on GURME will be made at WMO Congress XIV in May 2003.

8. COOPERATION WITH OTHER ORGANIZATIONS AND GAW RESOURCES

Dr L. Barrie gave a brief overview of GAW activities and individual staff member's responsibility within the Environment Division and is summarized in Figure 2. He also reviewed the GAW resources which included the regular WMO budget plus funds from the trust funds that could provide support.

9. WORKING GROUP OBSERVATIONS AND RECOMMENDATIONS

Using the GSP as a guide, the Working Group formulated the following observations and recommendations:

9.1 ***Overall status of the GAW Programme:*** The Working Group was generally quite pleased with the progress made by GAW over the last two years. The SAGs on aerosols, ozone, UV and deposition/precipitation chemistry and the GURME project function well; the SAGs for greenhouse gases and reactive gases are being activated. The World Data Centres, in particular on ozone and UV at the Meteorological Service of Canada, Toronto, and on greenhouse gases (as well as other gases) at the Japan Meteorological Agency, Tokyo, are receiving most of the representative data within their terms of reference. The QA/SAC for the Americas, USA, has been put on a firm financial basis after a period of uncertainty; while the other QA/SACs have sufficient funding to carry out their services. The support from MeteoSwiss has been particularly important to the programme, because it has provided strong strategic direction through the GAW Strategic Plan, the development of the GAW Station Information System (GAWSIS) and the setting of standards concerning the quality of the analytical programme. Since most GAW data (and GAW stations) have several "labels" (EMEP, NDSC), the promotion of the GAW programme to give it higher

visibility requires constant attention. More emphasis must be put on the referencing of GAW data when they are being applied. The involvement of GAW in GCOS (Global Climate Observing System) is an important step because it gives GAW access to funding lines under UNFCCC and the Kyoto Protocol.

Owing to the huge burden of work concerning GAW that has been placed on the Secretariat, the Working Group strongly urged that the Environment Division be staffed to its full complement of four scientific professionals as authorized by the WMO Congress.

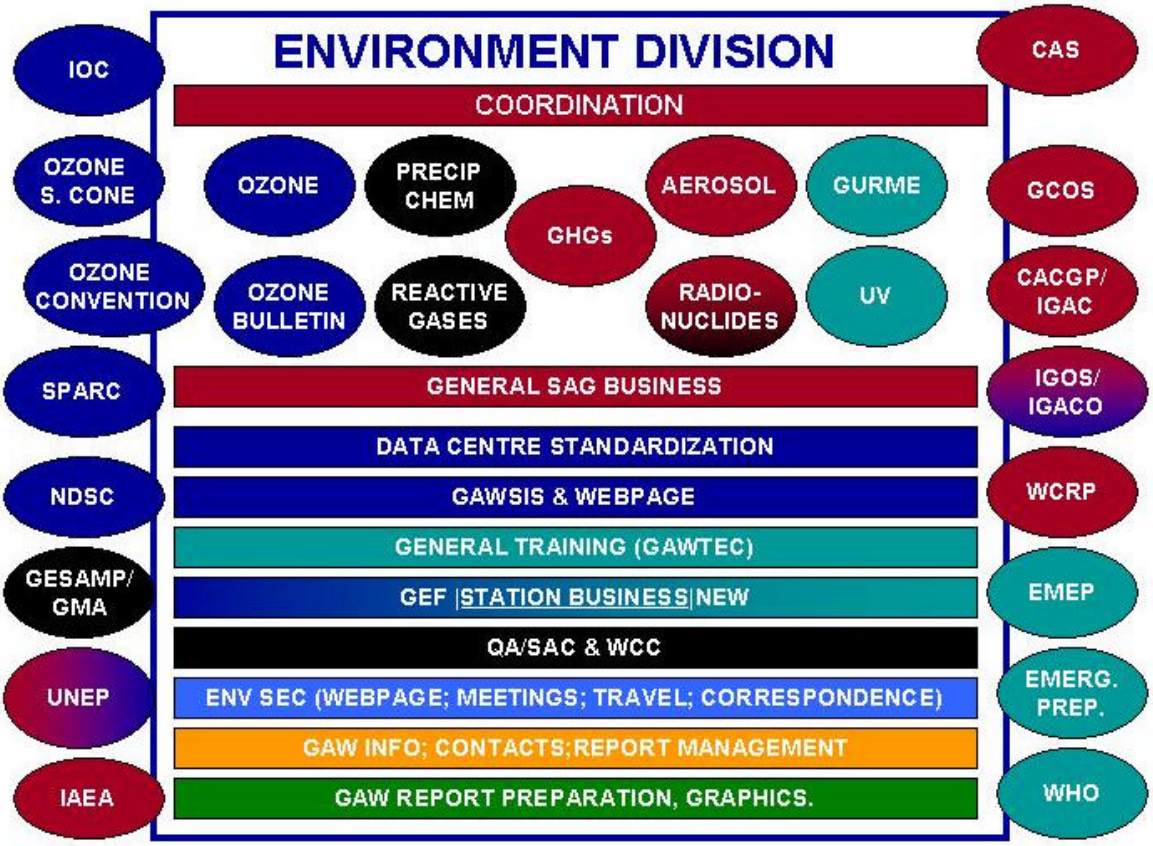

Figure 2: ***A schematic summary of the AREP/ENV divisional activities and staff responsibilities. GAW activities are within the large box and coordination with other environmental programmes is indicated with ellipses outside the box. The ellipses inside the box represent GAW global monitoring networks for specific variable groups with components detailed in Figure 1. The horizontal bars represent cross-cutting activities common to all networks. Colour represents different staff. Dashed lines indicate potential future activities.***

9.2 ***The GAW Strategic Plan:*** The main guidance for much of the discussion was the GAW Strategic Plan 2001- 2007 (GSP), published as GAW Report No. 142. The Working Group considered what successes had been achieved in completing the tasks outlined in the report for the period 2001 to 2004. The Working Group discussion leaders in each area listed above were asked to formulate their reviews in terms of the tasks assigned to their particular scientific or technical area. Through this review, it became apparent that though tasks in many areas had been completed, it was necessary to make a status check subject by subject. Responsible parties such as SAGs and QA/SACs will be asked in the coming months to review their sections in the GSP and

to (1) confirm what tasks have been completed, (2) document actions to be taken to complete or revise unfinished tasks and (3) prepare a new list of tasks for period 2005-2007. G. Müller, Working Group member and Rapporteur on Strategic Planning and Implementation of GAW, agreed to coordinate this task with a deadline of Spring of 2004.

9.3 ***Global Climate Observing System (GCOS):*** The Working Group stated that GAW must be recognized as the baseline network for atmospheric chemistry within the GCOS system reflecting its current international status. This would allow access for GAW to the UNFCCC and Kyoto Protocol funding lines. It is a significant development that GAW now is a part of the GCOS adequacy report.

9.4 ***Integrated Global Atmospheric Chemistry Observations (IGACO):*** Coordinating ground- and space-based observations has been one of the prominent themes within GAW as documented by GAW Report No. 140. Accepted as a project under the Integrated Global Observing Strategy (IGOS), IGACO has the goal to coordinate and enhance cooperation between GAW and satellite communities concerned with atmospheric chemistry measurements. An IGACO steering committee co-chaired by GAW/WMO and the European Space Agency is now active, and a final Theme Report plan is being prepared. The Working Group recognized that IGACO could be a mechanism to enhance support for ground-based measurements by the space community.

9.5 ***Proposed new World Data Centre:*** M. Bittner, Working Group member and Rapporteur on Satellite Measurements of Atmospheric Constituents, informally stated that the German Aerospace Centre, Oberpfaffenhofen, Germany, would be willing to designate the new World Data Centre for Remote Sensing of the Atmosphere they are hosting for ICSU as a GAW World Data Centre. This centre archives data from Schiamachy and MIPAS on board ENVISAT (http://wdc.dlr.de), and the Working Group strongly endorsed it and suggested as a first step to prepare a more detailed proposal outlining the centre activities and how it would fit into GAW. Initially this proposal should be reviewed by the Working Group, the Secretariat and the IGACO steering committee.

9.6 ***Outside funding possibilities to support GAW activities:*** To continue and strengthen the GAW System, support from outside sources continue to be critical for the programme. It was announced at the meeting that GCOS funds will be available to continue the work of the QA/SAC for the Americas. Furthermore the Secretariat reported on the new Trust Fund for Financing Activities on Research and Systematic Observations Relevant to the Vienna Convention which will be used to support the total and vertical ozone measurement network of GAW. The Working Group recognized this as a good approach and recommended that those countries active in the ozone programme should consider contributing to this fund.

9.7 ***Measurement of Total Ozone:*** The measurement of total ozone using the Dobson Spectrophotometer has been in place for over eighty years. Over many decades, the WMO has played a key role in coordinating the calibration of the some 120 instruments around the world. The Dobson system has been essential in monitoring the depletion of the stratospheric ozone layer and its possible recovery. A critical issue that is now emerging is the replacement of many of the Dobsons with the more sophisticated Brewer Spectrophotometer. To avoid interruption of the otherwise unbroken long-term total ozone record, the Working Group supported the Secretariat in arranging that this exchange be done in the proper manner. Furthermore, the number of observation files of total ozone submitted to the Toronto data centre has been declining in recent years, a worrying indication of reductions in the observing programmes at a time when the stratospheric ozone depletion globally does not show signs of a recovery.

9.8 ***Ultraviolet (UV) Radiation :*** Because of the high scientific and public interest concerning the impact of UV radiation on human health and the biosphere, the UV activities coordinated by GAW continue to require considerable attention. The Working Group felt that it would be wise to focus on one or two "signal parameters" measured by one type of recommended instrument in order to extend UV monitoring to more countries, in particular in the tropics. The SAG is asked to make a recommendation for a signal parameter and an instrument. It is noteworthy to state that the

SAG on UV has added an epidemiologist to its ranks; it is seen as important to develop this trend further so that scientists who deal with UV interactions in an Earth system framework (ecosystem on land and in the oceans and their interaction with changes in UV fluxes) participate and contribute to the SAGs activities.

9.9 ***Reactivation of the SAGs for Greenhouse Gases and Reactive Gases:*** Recognizing the important role that the SAGs play in providing scientific advice that underpins the GAW system, the Working Group strongly advised that the two SAGs dealing with Greenhouse Gases and Reactive Gases be activated as soon as possible, particularly in light of the need to revise the strategic tasks. The Working Group advised that the newly formed SAG for Reactive Gases develop its foci gradually in view of the resources, and perhaps start out with CO and its trends in time as well as its distribution in space.

9.10 ***Aerosols:*** Because of the major role aerosols play in both climate change and air quality, the Working Group recognized the importance of making progress through the Aerosol SAG in establishing a viable GAW measurement programme. This has been one of the most difficult problems because of the complex nature of aerosol measurements. A good starting point is the coordination of the optical measurements made by a number of groups around the world. In addition, the SAG has prepared a list of aerosol measurements that can be recommended for Global and Regional sites. The Working Group recognized that owing to the complicated nature of aerosol measurements it is necessary to have a well-established supporting infrastructure. Establishing a WCC for aerosol chemistry and QA/SACs would be a useful step.

9.11 ***GAW Urban Research Meteorology and Environment (GURME):*** This project focuses on establishing air quality diagnostic capability in developing countries as well as in more developed countries (Mexico City, Beijing, Moscow GURME projects). Further aims are to develop forecasting capabilities for major population centres throughout the world to protect the citizens against poor air quality. The passive sampler approach for screening is a useful and inexpensive method to complement GURME activities.

9.12 ***GAW Station Information System (GAWSIS):*** One of the noteworthy accomplishments of the GAW programme has been the further refinement of the web-based GAWSIS Station Information System. The Working Group encouraged all countries with GAW facilities to submit information and corrections to the system. It is expected that GAWSIS will be particularly useful in mapping different GAW parameters on a global basis and become a "one stop data warehouse" for GAW station network information and bridge the gaps between WDCs.

9.13 ***Appreciation to organizations and groups participating in GAW:*** The Working Group emphasized the importance of recognizing the numerous groups, institutions, organizations and individual researchers that have contributed to the success of GAW over the last decade. It was suggested that a specific list be formed showing these organizations.

10. CLOSING OF THE MEETING

Before closing the meeting, some miscellaneous business was discussed. Decisions were made on appointing or reappointing the chairs of the seven Scientific Advisory Groups, a prerogative of the Working Group Chairman. Further the next Working Group meeting will be in 2005. The Chairman thanked the participants and closed the meeting.

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ANNEX A

WMO/CAS WORKING GROUP ON ENVIRONMENTAL POLLUTION AND ATMOSPHERIC CHEMISTRY (Geneva, 18-19 March 2003)

List of participants

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ANNEX B

WMO/CAS WORKING GROUP ON
ENVIRONMENTAL POLLUTION AND ATMOSPHERIC CHEMISTRY
(Geneva, 18-19 March 2003)

Provisional Agenda

1. OPENING OF THE SESSION

2. ADOPTION OF THE AGENDA

3. CHALLENGES FACING THE GAW PROGRAMME

4. GAW ORGANIZATIONAL COMPONENTS
- 4.1. SAGs and QA/SACs
- 4.2. An Example QA/SAC: Swiss QA/SAC EMPA
- 4.3. Data Management (GAWSIS and the World Data Centres)
- 4.4. Communications (GAW reports, presentations, newsletter)
- 4.5. Capacity Building

5. STATUS OF OBSERVING SYSTEMS
- 5.1. Ozone
- 5.2. Greenhouse Gases
- 5.3. Reactive Gases
- 5.4. Atmospheric Deposition/ Precipitation Chemistry
- 5.5. UV
- 5.6. Aerosols
- 5.7. Natural Radioactivity

6. GURME PROJECT (URBAN ENVIRONMENT)

7. COOPERATION WITH OTHER ORGANIZATIONS

8. GAW RESOURCES

9. GROUP DISCUSSION OF ISSUES AND PROBLEMS: REVIEW ACTIONS FROM CAS XIII AND EC LIV

10. CLOSING REMARKS

11. ADOPTION OF THE REPORT

12. CLOSURE OF THE SESSION

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GLOBAL ATMOSPHERE WATCH REPORT SERIES

1. Final Report of the Expert Meeting on the Operation of Integrated Monitoring Programmes, Geneva, 2-5 September 1980

2. Report of the Third Session of the GESAMP Working Group on the Interchange of Pollutants Between the Atmosphere and the Oceans (INTERPOLL-III), Miami, USA, 27-31 October 1980

3. Report of the Expert Meeting on the Assessment of the Meteorological Aspects of the First Phase of EMEP, Shinfield Park, U.K., 30 March - 2 April 1981

4. Summary Report on the Status of the WMO Background Air Pollution Monitoring Network as at April 1981

5. Report of the WMO/UNEP/ICSU Meeting on Instruments, Standardization and Measurements Techniques for Atmospheric CO_2, Geneva, 8-11; September 1981

6. Report of the Meeting of Experts on BAPMoN Station Operation, Geneva, 23-26 November, 1981

7. Fourth Analysis on Reference Precipitation Samples by the Participating World Meteorological Organization Laboratories by Robert L. Lampe and John C. Puzak, December 1981*

8. Review of the Chemical Composition of Precipitation as Measured by the WMO BAPMoN by Prof. Dr. Hans-Walter Georgii, February 1982

9. An Assessment of BAPMoN Data Currently Available on the Concentration of CO_2 in the Atmosphere by M.R. Manning, February 1982

10. Report of the Meeting of Experts on Meteorological Aspects of Long-range Transport of Pollutants, Toronto, Canada, 30 November - 4 December 1981

11. Summary Report on the Status of the WMO Background Air Pollution Monitoring Network as at May 1982

12. Report on the Mount Kenya Baseline Station Feasibility Study edited by Dr. Russell C. Schnell

13. Report of the Executive Committee Panel of Experts on Environmental Pollution, Fourth Session, Geneva, 27 September - 1 October 1982

14. Effects of Sulphur Compounds and Other Pollutants on Visibility by Dr. R.F. Pueschel, April 1983

15. Provisional Daily Atmospheric Carbon Dioxide Concentrations as Measured at BAPMoN Sites for the Year 1981, May 1983

16. Report of the Expert Meeting on Quality Assurance in BAPMoN, Research Triangle Park, North Carolina, USA, 17-21 January 1983

17. General Consideration and Examples of Data Evaluation and Quality Assurance Procedures Applicable to BAPMoN Precipitation Chemistry Observations by Dr. Charles Hakkarinen, July 1983

18. Summary Report on the Status of the WMO Background Air Pollution Monitoring Network as at May 1983

19. Forecasting of Air Pollution with Emphasis on Research in the USSR by M.E. Berlyand, August 1983

20. Extended Abstracts of Papers to be Presented at the WMO Technical Conference on Observation and Measurement of Atmospheric Contaminants (TECOMAC), Vienna, 17-21 October 1983

21. Fifth Analysis on Reference Precipitation Samples by the Participating World Meteorological Organization Laboratories by Robert L. Lampe and William J. Mitchell, November 1983

22. Report of the Fifth Session of the WMO Executive Council Panel of Experts on Environmental Pollution, Garmisch-Partenkirchen, Federal Republic of Germany, 30 April - 4 May 1984 (WMO TD No. 10)

23. Provisional Daily Atmospheric Carbon Dioxide Concentrations as Measured at BAPMoN Sites for the Year 1982. November 1984 (WMO TD No. 12)

24. Final Report of the Expert Meeting on the Assessment of the Meteorological Aspects of the Second Phase of EMEP, Friedrichshafen, Federal Republic of Germany, 7-10 December 1983. October 1984 (WMO TD No. 11)

25. Summary Report on the Status of the WMO Background Air Pollution Monitoring Network as at May 1984. November 1984 (WMO TD No. 13)

26. Sulphur and Nitrogen in Precipitation: An Attempt to Use BAPMoN and Other Data to Show Regional and Global Distribution by Dr. C.C. Wallén. April 1986 (WMO TD No. 103)

27. Report on a Study of the Transport of Sahelian Particulate Matter Using Sunphotometer Observations by Dr. Guillaume A. d'Almeida. July 1985 (WMO TD No. 45)

28. Report of the Meeting of Experts on the Eastern Atlantic and Mediterranean Transport Experiment ("EAMTEX"), Madrid and Salamanca, Spain, 6-8 November 1984

29. Recommendations on Sunphotometer Measurements in BAPMoN Based on the Experience of a Dust Transport Study in Africa by Dr. Guillaume A. d'Almeida. September 1985 (WMO TD No. 67)

30. Report of the Ad-hoc Consultation on Quality Assurance Procedures for Inclusion in the BAPMoN Manual, Geneva, 29-31 May 1985

31. Implications of Visibility Reduction by Man-Made Aerosols (Annex to No. 14) by R.M. Hoff and L.A. Barrie. October 1985 (WMO TD No. 59)

32. Manual for BAPMoN Station Operators by E. Meszaros and D.M. Whelpdale. October 1985 (WMO TD No. 66)

33. Man and the Composition of the Atmosphere: BAPMoN - An international programme of national needs, responsibility and benefits by R.F. Pueschel. 1986

34. Practical Guide for Estimating Atmospheric Pollution Potential by Dr. L.E. Niemeyer. August 1986 (WMO TD No. 134)

35. Provisional Daily Atmospheric CO_2 Concentrations as Measured at BAPMoN Sites for the Year 1983. December 1985 (WMO TD No. 77)

36. Global Atmospheric Background Monitoring for Selected Environmental Parameters. BAPMoN Data for 1984. Volume I: Atmospheric Aerosol Optical Depth. October 1985 (WMO TD No. 96)

37. Air-Sea Interchange of Pollutants by R.A. Duce. September 1986 (WMO TD No. 126)

38. Summary Report on the Status of the WMO Background Air Pollution Monitoring Network as at 31 December 1985. September 1986 (WMO TD No. 136)

39. Report of the Third WMO Expert Meeting on Atmospheric Carbon Dioxide Measurement Techniques, Lake Arrowhead, California, USA, 4-8 November 1985. October 1986

40. Report of the Fourth Session of the CAS Working Group on Atmospheric Chemistry and Air Pollution, Helsinki, Finland, 18-22 November 1985. January 1987

41. Global Atmospheric Background Monitoring for Selected Environmental Parameters. BAPMoN Data for 1982, Volume II: Precipitation chemistry, continuous atmospheric carbon dioxide and suspended particulate matter. June 1986 (WMO TD No. 116)

42. Scripps reference gas calibration system for carbon dioxide-in-air standards: revision of 1985 by C.D. Keeling, P.R. Guenther and D.J. Moss. September 1986 (WMO TD No. 125)

43. Recent progress in sunphotometry (determination of the aerosol optical depth). November 1986

44. Report of the Sixth Session of the WMO Executive Council Panel of Experts on Environmental Pollution, Geneva, 5-9 May 1986. March 1987

45. Proceedings of the International Symposium on Integrated Global Monitoring of the State of the Biosphere (Volumes I-IV), Tashkent, USSR, 14-19 October 1985. December 1986 (WMO TD No. 151)

46. Provisional Daily Atmospheric Carbon Dioxide Concentrations as Measured at BAPMoN Sites for the Year 1984. December 1986 (WMO TD No. 158)

47. Procedures and Methods for Integrated Global Background Monitoring of Environmental Pollution by F.Ya. Rovinsky, USSR and G.B. Wiersma, USA. August 1987 (WMO TD No. 178)

48. Meeting on the Assessment of the Meteorological Aspects of the Third Phase of EMEP IIASA, Laxenburg, Austria, 30 March - 2 April 1987. February 1988

49. Proceedings of the WMO Conference on Air Pollution Modelling and its Application (Volumes I-III), Leningrad, USSR, 19-24 May 1986. November 1987 (WMO TD No. 187)

50. Provisional Daily Atmospheric Carbon Dioxide Concentrations as Measured at BAPMoN Sites for the Year 1985. December 1987 (WMO TD No. 198)

51. Report of the NBS/WMO Expert Meeting on Atmospheric CO_2 Measurement Techniques, Gaithersburg, USA, 15-17 June 1987. December 1987

52. Global Atmospheric Background Monitoring for Selected Environmental Parameters. BAPMoN Data for 1985. Volume I: Atmospheric Aerosol Optical Depth. September 1987

53. WMO Meeting of Experts on Strategy for the Monitoring of Suspended Particulate Matter in BAPMoN - Reports and papers presented at the meeting, Xiamen, China, 13-17 October 1986. October 1988

54. Global Atmospheric Background Monitoring for Selected Environmental Parameters. BAPMoN Data for 1983, Volume II: Precipitation chemistry, continuous atmospheric carbon dioxide and suspended particulate matter (WMO TD No. 283)

55. Summary Report on the Status of the WMO Background Air Pollution Monitoring Network as at 31 December 1987 (WMO TD No. 284)

56. Report of the First Session of the Executive Council Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry, Hilo, Hawaii, 27-31 March 1988. June 1988

57. Global Atmospheric Background Monitoring for Selected Environmental Parameters. BAPMoN Data for 1986, Volume I: Atmospheric Aerosol Optical Depth. July 1988

58. Provisional Daily Atmospheric Carbon Dioxide Concentrations as measured at BAPMoN sites for the years 1986 and 1987 (WMO TD No. 306)

59. Extended Abstracts of Papers Presented at the Third International Conference on Analysis and Evaluation of Atmospheric CO_2 Data - Present and Past, Hinterzarten, Federal Republic of Germany, 16-20 October 1989 (WMO TD No . 340)

60. Global Atmospheric Background Monitoring for Selected Environmental Parameters. BAPMoN Data for 1984 and 1985, Volume II: Precipitation chemistry, continuous atmospheric carbon dioxide and suspended particulate matter.

61. Global Atmospheric Background Monitoring for Selected Environmental Parameters. BAPMoN Data for 1987 and 1988, Volume I: Atmospheric Aerosol Optical Depth.

62. Provisional Daily Atmospheric Carbon Dioxide Concentrations as measured at BAPMoN sites for the year 1988 (WMO TD No. 355)

63. Report of the Informal Session of the Executive Council Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry, Sofia, Bulgaria, 26 and 28 October 1989

64. Report of the consultation to consider desirable locations and observational practices for BAPMoN stations of global importance, Bermuda Research Station, 27-30 November 1989

65. Report of the Meeting on the Assessment of the Meteorological Aspects of the Fourth Phase of EMEP, Sofia, Bulgaria, 27 and 31 October 1989

66. Summary Report on the Status of the WMO Global Atmosphere Watch Stations as at 31 December 1990 (WMO TD No. 419)

67. Report of the Meeting of Experts on Modelling of Continental, Hemispheric and Global Range Transport, Transformation and Exchange Processes, Geneva, 5-7 November 1990

68. Global Atmospheric Background Monitoring for Selected Environmental Parameters. BAPMoN Data For 1989, Volume I: Atmospheric Aerosol Optical Depth

69. Provisional Daily Atmospheric Carbon Dioxide Concentrations as measured at Global Atmosphere Watch (GAW)-BAPMoN sites for the year 1989 (WMO TD No. 400)

70. Report of the Second Session of EC Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry, Santiago, Chile, 9-15 January 1991 (WMO TD No. 633)

71. Report of the Consultation of Experts to Consider Desirable Observational Practices and Distribution of GAW Regional Stations, Halkidiki, Greece, 9-13 April 1991 (WMO TD No. 433)

72. Integrated Background Monitoring of Environmental Pollution in Mid-Latitude Eurasia by Yu.A. Izrael and F.Ya. Rovinsky, USSR (WMO TD No. 434)

73. Report of the Experts Meeting on Global Aerosol Data System (GADS), Hampton, Virginia, 11 to 12 September 1990 (WMO TD No. 438)

74. Report of the Experts Meeting on Aerosol Physics and Chemistry, Hampton, Virginia, 30 to 31 May 1991 (WMO TD No. 439)

75. Provisional Daily Atmospheric Carbon Dioxide Concentrations as measured at Global Atmosphere Watch (GAW)-BAPMoN sites for the year 1990 (WMO TD No. 447)

76. The International Global Aerosol Programme (IGAP) Plan: Overview (WMO TD No. 445)

77. Report of the WMO Meeting of Experts on Carbon Dioxide Concentration and Isotopic Measurement Techniques, Lake Arrowhead, California, 14-19 October 1990

78. Global Atmospheric Background Monitoring for Selected Environmental Parameters BAPMoN Data for 1990, Volume I: Atmospheric Aerosol Optical Depth (WMO TD No. 446)

79. Report of the Meeting of Experts to Consider the Aerosol Component of GAW, Boulder, 16 to 19 December 1991 (WMO TD No. 485)

80. Report of the WMO Meeting of Experts on the Quality Assurance Plan for the GAW, Garmisch-Partenkirchen, Germany, 26-30 March 1992 (WMO TD No. 513)

81. Report of the Second Meeting of Experts to Assess the Response to and Atmospheric Effects of the Kuwait Oil Fires, Geneva, Switzerland, 25-29 May 1992 (WMO TD No. 512)

82. Global Atmospheric Background Monitoring for Selected Environmental Parameters BAPMoN Data for 1991, Volume I: Atmospheric Aerosol Optical Depth (WMO TD No. 518)

83. Report on the Global Precipitation Chemistry Programme of BAPMoN (WMO TD No. 526)

84. Provisional Daily Atmospheric Carbon Dioxide Concentrations as measured at GAW-BAPMoN sites for the year 1991 (WMO TD No. 543)

85. Chemical Analysis of Precipitation for GAW: Laboratory Analytical Methods and Sample Collection Standards by Dr Jaroslav Santroch (WMO TD No. 550)

86. The Global Atmosphere Watch Guide, 1993 (WMO TD No. 553)

87. Report of the Third Session of EC Panel/CAS Working Group on Environmental Pollution and Atmospheric Chemistry, Geneva, 8-11 March 1993 (WMO TD No. 555)

88. Report of the Seventh WMO Meeting of Experts on Carbon Dioxide Concentration and Isotopic Measurement Techniques, Rome, Italy, 7 - 10 September 1993, (edited by Graeme I. Pearman and James T. Peterson) (WMO TD No. 669)

89. 4th International Conference on CO_2 (Carqueiranne, France, 13-17 September 1993) (WMO TD No. 61)

90. Global Atmospheric Background Monitoring for Selected Environmental Parameters GAW Data for 1992, Volume I: Atmospheric Aerosol Optical Depth (WMO TD No. 562)

91. Extended Abstracts of Papers Presented at the WMO Region VI Conference on the Measurement and Modelling of Atmospheric Composition Changes Including Pollution Transport, Sofia, 4 to 8 October 1993 (WMO TD No. 563)

92. Report of the Second WMO Meeting of Experts on the Quality Assurance/Science Activity Centres of the Global Atmosphere Watch, Garmisch-Partenkirchen, 7-11 December 1992 (WMO TD No. 580)

93. Report of the Third WMO Meeting of Experts on the Quality Assurance/Science Activity Centres of the Global Atmosphere Watch, Garmisch-Partenkirchen, 5-9 July 1993 (WMO TD No. 581)

94. Report on the Measurements of Atmospheric Turbidity in BAPMoN (WMO TD No. 603)

95. Report of the WMO Meeting of Experts on UV-B Measurements, Data Quality and Standardization of UV Indices, Les Diablerets, Switzerland, 25-28 July 1994 (WMO TD No. 625)

96. Global Atmospheric Background Monitoring for Selected Environmental Parameters WMO GAW Data for 1993, Volume I: Atmospheric Aerosol Optical Depth

97. Quality Assurance Project Plan (QAPjP) for Continuous Ground Based Ozone Measurements (WMO TD No. 634)

98. Report of the WMO Meeting of Experts on Global Carbon Monoxide Measurements, Boulder, USA, 7-11 February 1994 (WMO TD No. 645)

99. Status of the WMO Global Atmosphere Watch Programme as at 31 December 1993 (WMO TD No. 636)

100. Report of the Workshop on UV-B for the Americas, Buenos Aires, Argentina, 22-26 August 1994

101. Report of the WMO Workshop on the Measurement of Atmospheric Optical Depth and Turbidity, Silver Spring, USA, 6-10 December 1993, (edited by Bruce Hicks) (WMO TD No. 659)

102. Report of the Workshop on Precipitation Chemistry Laboratory Techniques, Hradec Kralove, Czech Republic, 17-21 October 1994 (WMO TD No. 658)

103. Report of the Meeting of Experts on the WMO World Data Centres, Toronto, Canada, 17-18 February 1995, (prepared by Edward Hare) (WMO TD No. 679)

104. Report of the Fourth WMO Meeting of Experts on the Quality Assurance/Science Activity Centres (QA/SACs) of the Global Atmosphere Watch, jointly held with the First Meeting of the Coordinating Committees of IGAC-GLONET and IGAC-ACE, Garmisch-Partenkirchen, Germany, 13 to 17 March 1995 (WMO TD No. 689)

105. Report of the Fourth Session of the EC Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry (Garmisch, Germany, 6-11 March 1995) (WMO TD No. 718)
106. Report of the Global Acid Deposition Assessment (edited by D.M. Whelpdale and M-S. Kaiser) (WMO TD No. 777)

107. Extended Abstracts of Papers Presented at the WMO-IGAC Conference on the Measurement and Assessment of Atmospheric Composition Change (Beijing, China, 9-14 October 1995) (WMO TD No. 710)

108. Report of the Tenth WMO International Comparison of Dobson Spectrophotometers (Arosa, Switzerland, 24 July - 4 August 1995)

109. Report of an Expert Consultation on 85Kr and 222Rn: Measurements, Effects and Applications (Freiburg, Germany, 28-31 March 1995) (WMO TD No. 733)

110. Report of the WMO-NOAA Expert Meeting on GAW Data Acquisition and Archiving (Asheville, NC, USA, 4-8 November 1995) (WMO TD No. 755)

111. Report of the WMO-BMBF Workshop on VOC Establishment of a "World Calibration/Instrument Intercomparison Facility for VOC" to Serve the WMO Global Atmosphere Watch (GAW) Programme (Garmisch-Partenkirchen, Germany, 17-21 December 1995) (WMO TD No. 756)

112. Report of the WMO/STUK Intercomparison of Erythemally-Weighted Solar UV Radiometers, Spring/Summer 1995, Helsinki, Finland (WMO TD No. 781)

113. The Strategic Plan of the Global Atmosphere Watch (GAW) (WMO TD No. 802)

114. Report of the Fifth WMO Meeting of Experts on the Quality Assurance/Science Activity Centres (QA/SACs) of the Global Atmosphere Watch, jointly held with the Second Meeting of the Coordinating Committees of IGAC-GLONET and IGAC-ACE[Ed], Garmisch-Partenkirchen, Germany, 15-19 July 1996 (WMO TD No. 787)

115. Report of the Meeting of Experts on Atmospheric Urban Pollution and the Role of NMSs (Geneva, 7-11 October 1996) (WMO TD No. 801)

116. Expert Meeting on Chemistry of Aerosols, Clouds and Atmospheric Precipitation in the Former USSR (Saint Petersburg, Russian Federation, 13-15 November 1995)

117. Report and Proceedings of the Workshop on the Assessment of EMEP Activities Concerning Heavy Metals and Persistent Organic Pollutants and their Further Development (Moscow, Russian Federation, 24-26 September 1996) (Volumes I and II) (WMO TD No. 806)

118. Report of the International Workshops on Ozone Observation in Asia and the Pacific Region (IWOAP, IWOAP-II), (IWOAP, 27 February-26 March 1996 and IWOAP-II, 20 August-18 September 1996) (WMO TD No. 827)

119. Report on BoM/NOAA/WMO International Comparison of the Dobson Spectrophotometers (Perth Airport, Perth, Australia, 3-14 February 1997), (prepared by Robert Evans and James Easson) (WMO TD No. 828)

120. WMO-UMAP Workshop on Broad-Band UV Radiometers (Garmisch-Partenkirchen, Germany, 22 to 23 April 1996) (WMO TD No. 894)

121. Report of the Eighth WMO Meeting of Experts on Carbon Dioxide Concentration and Isotopic Measurement Techniques (prepared by Thomas Conway) (Boulder, CO, 6-11 July 1995) (WMO TD No. 821)

122 Report of Passive Samplers for Atmospheric Chemistry Measurements and their Role in GAW (prepared by Greg Carmichael) (WMO TD No. 829)

123 Report of WMO Meeting of Experts on GAW Regional Network in RA VI, Budapest, Hungary, 5 to 9 May 1997

124 Fifth Session of the EC Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry, (Geneva, Switzerland, 7-10 April 1997) (WMO TD No. 898)

125. Instruments to Measure Solar Ultraviolet Radiation, Part 1: Spectral Instruments (lead author G. Seckmeyer) (WMO TD No. 1066)

126. Guidelines for Site Quality Control of UV Monitoring (lead author A.R. Webb) (WMO TD No. 884)

127. Report of the WMO-WHO Meeting of Experts on Standardization of UV Indices and their Dissemination to the Public (Les Diablerets, Switzerland, 21-25 July 1997) (WMO TD No. 921)

128. The Fourth Biennial WMO Consultation on Brewer Ozone and UV Spectrophotometer Operation, Calibration and Data Reporting, (Rome, Italy, 22-25 September 1996) (WMO TD No. 918)

129. Guidelines for Atmospheric Trace Gas Data Management (Ken Masarie and Pieter Tans), 1998 (WMO TD No. 907)

130. Jülich Ozone Sonde Intercomparison Experiment (JOSIE, 5 February to 8 March 1996), (H.G.J. Smit and D. Kley) (WMO TD No. 926)

131. WMO Workshop on Regional Transboundary Smoke and Haze in Southeast Asia (Singapore, 2 to 5 June 1998) (Gregory R. Carmichael). Two volumes

132. Report of the Ninth WMO Meeting of Experts on Carbon Dioxide Concentration and Related Tracer Measurement Techniques (Edited by Roger Francey), (Aspendale, Vic., Australia)

133. Workshop on Advanced Statistical Methods and their Application to Air Quality Data Sets (Helsinki, 14-18 September 1998) (WMO TD No.956)

134. Guide on Sampling and Analysis Techniques for Chemical Constituents and Physical Properties in Air and Precipitation as Applied at Stations of the Global Atmosphere Watch. Carbon Dioxide (WMO TD No. 980)

135. Sixth Session of the EC Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry (Zurich, Switzerland, 8-11 March 1999) (WMO TD No.1002)

136. WMO/EMEP/UNEP Workshop on Modelling of Atmospheric Transport and Deposition of Persistent Organic Pollutants and Heavy Metals (Geneva, Switzerland, 16-19 November 1999) (Volumes I and II) (WMO TD No. 1008)

137. Report and Proceedings of the WMO RA II/RA V GAW Workshop on Urban Environment (Beijing, China, 1-4 November 1999) (WMO-TD. 1014) (Prepared by Greg Carmichael)

138. Reports on WMO International Comparisons of Dobson Spectrophotometers, Parts I – Arosa, Switzerland, 19-31 July 1999, Part II – Buenos Aires, Argentina (29 Nov. – 12 Dec. 1999 and Part III – Pretoria, South Africa (18 March – 10 April 2000) (WMO TD No. 1016).

139. The Fifth Biennial WMO Consultation on Brewer Ozone and UV Spectrophotometer Operation, Calibration and Data Reporting (Halkidiki, Greece, September 1998)(WMO TD No. 1019).

140. WMO/CEOS Report on a Strategy for Integrating Satellite and Ground-based Observations of Ozone (WMO TD No. 1046).

141. Report of the LAP/COST/WMO Intercomparison of Erythemal Radiometers (Thessaloniki, Greece, 13-23 September 1999) (WMO TD No. 1051).

142. Strategy for the Implementation of the Global Atmosphere Watch Programme (2001-2007), A Contribution to the Implementation of the Long-Term Plan (WMO TD No.1077)

143. Global Atmosphere Watch Measurements Guide (WMO TD No. 1073).

144. Report of the Seventh Session of the EC Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry and the GAW 2001 Workshop (Geneva, Switzerland, 2 to 5 April 2001) (WMO TD No. 1104).

145. WMO GAW International Comparisons of Dobson Spectrophotometers at the Meteorological Observatory Hohenpeissenberg, Germany (21 May – 10 June 2000, MOHp2000-1), 23 July – 5 August 2000, MOHp2000-2), (10 – 23 June 2001, MOHp2001-1) and (8 to 21 July 2001, MOHp2001-2). Prepared by Ulf Köhler. (WMO TD No. 1114).

146. Quality Assurance in monitoring solar ultraviolet radiation: the state of the art. (WMO TD No. 1178)

147. Workshop on GAW in RA VI (Europe), Riga, Latvia, 27-30 May 2002.

148. Report of the Eleventh WMO/IAEA Meeting of Experts on Carbon Dioxide Concentration and Related Tracer Measurement Techniques (Tokyo, Japan, 25-28 September 2001). (WMO TD No. 1138).

149. Comparison of Total Ozone Measurements of Dobson and Brewer Spectrophotometers and Recommended Transfer Functions (prepared by J. Staehelin, J. Kerr, R. Evans and K. Vanicek). (WMO TD No. 1147).

150. Updated Guidelines for Atmospheric Trace Gas Data Management (Prepared by Ken Maserie and Pieter Tans. (WMO TD No. 1149).