REPORT OF THE FIFTH SESSION OF THE
EC PANEL OF EXPERTS/CAS WORKING GROUP
ON
ENVIRONMENTAL POLLUTION AND
ATMOSPHERIC CHEMISTRY

(Geneva, Switzerland, 7-10 April 1997)
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Table 1
1. OPENING OF THE SESSION

1.1 The Fifth Session of the WMO Executive Council Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry (henceforth referred to as the Panel) was opened by Mr J.P. Jarraud, Deputy Secretary General of the WMO on Monday, 7 April 1997.

1.1.2 After presenting the best wishes of Prof. G.O.P. Obasi, the Secretary-General, Mr Jarraud indicated that the Panel has an extremely important function as the scientific advisor for the Global Atmosphere Watch (GAW), a major component of the WMO Atmospheric Research and Environment Programme, and for other related programmes. The accomplishments of GAW were acknowledged by the Twelfth World Meteorological Congress (Geneva, May/June 1995) which "expressed its satisfaction with the many achievements realized in the implementation of GAW and conveyed its sincere appreciation to those specifically involved". Mr Jarraud noted that there is now broad recognition, both by Governments and within the scientific community at large, that GAW is an essential tool for monitoring the evolution of atmospheric composition for improving our understanding of its interaction with all aspects of the environment and, for the validation of satellite sounders.

1.1.3 Further, it has been recognized that the international coordination role of WMO through your Panel in environmental issues is likely to become more complex because of the need to encompass a broader range of scientific disciplines including meteorology, hydrology, oceanography, biological sciences, and atmospheric chemistry in the resolution of sustainable environmental issues.

1.1.4 Mr Jarraud reported that Twelfth Congress recognized that the environmental issues which have been foremost societal concerns over the past several years would continue through the turn of the century. Many issues - acid deposition, stratospheric ozone depletion and increases in UV-B radiation, climate change, tropospheric oxidant increases, and urban pollution - are those for which WMO has accepted responsibility. More than ever before, high quality observations of the physical and chemical elements of all these phenomena are required in order to enhance understanding and lead to their resolution. It is through the Panel's scientific leadership Mr Jarraud added, that GAW can fulfill its environmental responsibilities. He wished the Panel great success in their work.

2. APPROVAL OF THE AGENDA

2.1 The chairman, Dr Douglas Whelpdale, reviewed the agenda and invited participants to propose additions or other revisions. See Annexes A and B for the agenda adopted and the list of participants, respectively.

3. REVIEW OF RECOMMENDATIONS FROM THE TWELFTH WORLD METEOROLOGICAL ORGANIZATION CONGRESS AND THE FORTY SEVENTH SESSION OF THE EXECUTIVE COUNCIL

3.1 Dr Miller, Chief Environment Division, described the relationship of the Panel to other WMO bodies, in particular the World Meteorological Organization Congress, the Executive Council and the Commission for Atmospheric Sciences. He reviewed guidance provided to the Panel from recent sessions of these bodies as indicated in the following paragraphs.
3.2 High priority should be given to the design and implementation of improvements required to enhance data quality, data availability and global coverage in the GAW. Specific aspects for the WMO GAW to focus on during the next inter-sessional period included:

- To expand further the GAW global and regional network in Asia and the southern hemisphere;
- To complete the establishment and necessary maintenance aspects of the six new GAW stations supported by the GEF (Algeria, Argentina, China, Brazil, Indonesia and Kenya);
- To implement the “cone” project in South America supported by the GEF;
- To co-ordinate development of the QASACs (Germany for Regions I and VI, Japan for Regions II and V, United States for Regions III and IV);
- To co-ordinate the implementation of the World Calibration Centres (WCCs) and World Data Centres (WDCs);
- To promote training and education activities;
- To improve and assess measurement programmes.

*Global issues*

- To ensure appropriate contributions of GAW to the GCOS;
- To improve vertical ozone profile measurements and provide better global coverage of tropospheric ozone measurements; contribute to the design and planning of the intensive study, the International Tropospheric Ozone Years;
- To assess the state and evolution of atmospheric ozone both in the troposphere and stratosphere and its impact on UV-B;
- To ensure that satellite measurements of atmospheric chemistry parameters, such as ozone, were part of GAW.

*Regional issues*

- To develop acid deposition activities;
- To improve tropospheric oxidants (photochemical pollution) monitoring;
- To continue participation in EMEP;
- To participate in ETEX;
- To encourage the study of, atmosphere-surface exchange.

*National issues*

- NMHSs should take a leadership role and promote sustainable development through the further development of national monitoring capabilities, scientific knowledge, and operational services (including in particular environmental forecasting).
Strategic plan

- Congress also endorsed the proposal of the Panel to prepare a GAW basic strategy document to guide the evolution of GAW into the next millennium.

The Forty-seventh session of the Executive Council (June 1995)

- That the various components of the WMO GAW be appropriately referred to in future as WMO/GAW/ozone, WMO/GAW/precipitation chemistry, WMO/GAW/carbon dioxide, etc. and that the previous acronyms used be discontinued;
- That a new series of GAW training meetings be undertaken on a regional basis designed to foster a feeling of ownership and responsibility at the national and regional levels;
- That the non-continuous measurements by hand-held sunphotometers be discontinued, in view of the inconsistency of the measurements.

3.3 The chairman reminded Panel members that the Panel is the focal point for all environmental issues within WMO. It has the responsibility to provide advice to the Executive Council and the president of CAS concerning recommendations and development of relevant scientific programmes within WMO/CAS. Both bodies have been highly supportive of activities and accomplishments of the Panel over the past several years.

4. SCIENTIFIC DEVELOPMENTS IN ATMOSPHERIC CHEMISTRY

4.1 As is the customary procedure at sessions of the Panel, members were invited to make brief presentations on recent scientific advances in their areas of responsibility.

4.2 In view of the availability of reliable techniques for the measurement of the OH radical, Dr D. Ehhalt recommended that selected GAW stations be used for field measurements of this important species. GAW global stations would be particularly suitable because of the extensive suite of auxiliary measurements being made to aid in the interpretation of OH measurements. This is based on the following:

- New measurement techniques for measuring OH: Laser induced Fluorescence, Long Path UV Absorption, ION assisted Mass spectrometry;
- Techniques are now robust (could be moved to GAW stations) and the optical techniques are intercalibrated;
- Would complement GAW stations which are capable of measuring such photochemically active species as non-Methane Hydrocarbons, NO, O₃, and allow measurement of local oxidation capacity and determine with high-accuracy the O₃ production rate;
- Moving such an instrument from one GAW station to another would allow measurement of OH in many different atmospheric chemical environments;
- The Institute of Atmospheric Chemistry at the Research Centre in Jülich, Germany is in the process of building a large outdoor SMOG chamber. This chamber is expected to be able to operate at ambient trace gas concentrations. It would allow simulation of the chemical mixes, as determined at the various GAW stations, and allow measurement of the resulting OH concentration and O₃ production rate.

4.3 Dr John Gille presented preliminary results from two studies using satellite data to illustrate points relevant to GAW. Analysis of LIMS data shows that ozone (and water vapour) in the lower tropical stratosphere vary in response to the propagation of Kelvin waves, reminding us that even subtle dynamical effects can alter the distribution of chemically active gases on appropriate time scales. Analysis of UARS data shows the diurnal variation of ClONO₂ and ClO are in reasonable agreement with theory. This is possible because the UARS orbit processes. Future observations of
trace gases will be obtained from sun-synchronous orbits, and thus will not permit studies of diurnal variations in the troposphere or low stratosphere.

4.4 At the present time, and for the foreseeable future, atmospheric chemistry measurements from satellites cannot be made for all species of interest. Satellite measurements extending to the lower stratosphere generally are made by downward looking instruments. They have horizontal resolutions of a few 10's of kilometres and vertical resolutions typically of 4-8 km, and only a few species can be measured at this time. Many other techniques- occultation or limb climbing-measurements in the upper troposphere and lower stratosphere can be obtained and yield vertical resolutions of 1-4 km, but horizontal resolution of approximately 200 km, and permits the measurement of many species.

4.5 Currently more stratospheric than tropospheric data are available and, except for ozone, most of the data are applicable mainly for research rather than operational purposes.

4.6 Dr Bruce Hicks briefly touched on a number of points. These were: (i) coastal issues are of great importance; (ii) wet deposition of ammonium is underestimated by standard weekly sampling methods; (iii) dry deposition of S has likely been underestimated; (iv) the UV-S calibration facility is in place; (v) the broad band devices seem to have about 2% per year drift. Life monitoring spectral devices have wavelength uncertainties that are difficult to deal with; (vi) atmospheric turbidity has been advanced through actions of the Swiss for the observatories; (vii) for regional sites, the use of rotating shadow band devices appears also more promising; (viii) +/− 0.02 in AOD appears likely.

4.7 Prof. O. Hov, using measurements from the GAW station Ny Alesund on Spitzbergen (79°N) of surface ozone, demonstrated how O₃ is depleted at the surface in spring episodes, causing on average, an annual ozone minimum in May. Compared to background continental Europe O₃, O₂ in the Arctic boundary layer has a smaller annual variation with lower concentrations in summer and higher in winter than in rural Europe.

4.8 Ozone sonde measurements in the Arctic stratospheric polar vortex showed a much lower ozone layer maximum in March 1995 than in March 1992. The difference between 1995 and 1992 is due to chemical depletion.

4.9 Prof. Hov showed coupled NWP + chemistry calculations of the chemical development in a continental European plume over the eastern North Atlantic. These calculations will be assessed by field measurements (from the UK MRF C-130, EU-project coordinated by Hov) in August-September 1997.

4.10 Dr Nazarov pointed out the importance of flux measurements in GAW, which would contribute to a better understanding of the biogeochemical cycling of greenhouse gases, and thus aid in the determination of global sources, sinks and budgets. A fairly extensive network of CO₂ flux measurements does exist in parts of the world, which are beginning to address the above-noted requirement. Further, there would be merit in bringing together GAW concentration and flux data with national and international greenhouse gas emissions data.

4.11 Dr Nazarov also stressed the importance of linking GAW to the requirements of the FCCC. GAW measurements will provide the basis for determining what constitutes "...dangerous interference in the climate system...", and it is necessary to ensure that the international policy community is aware of the GAW and its capabilities.

4.12 Dr E. Sanhueza indicated that, at present, there is concern that the global anthropogenic nitrogen fixation (about 140 TgN yr⁻¹) is larger than natural fixation (90-130 TgN yr⁻¹); it is likely that fixed nitrogen is accumulating in ground water, soils and vegetation, causing several environmental problems. However, an analysis of the available data in the Orinoco savannahs indicates that these ecosystems are losing large amounts of fixed-N (mainly due to biomass burning; pyrodenitrification), and that it is difficult to find the sources of fixed-N that compensate the outputs.

4.13 This is a good example of why results obtained from one region of the world should not be automatically extrapolated to other regions. The characteristics (or situation) of "clean" regions are sometimes very different (even contrasting) to those found in polluted ones. Complete characterizations (integrated monitoring/studies) are needed for the various ecosystems of the world.
4.14 Dr D. Whelpdale briefly described some of the interconnections between atmospheric chemistry measurements of GAW and climate modelling and process studies. The high priority measurement needs of the climate community are vertical profile information on water vapour, greenhouse gases, ozone and aerosols. The ensuing discussion led to the suggestion that there is once more a need to explore the use of GAW data by the modelling community, in particular for climate modelling, biogeochemical cycle modelling, the optimization of station location within networks, and inverse modelling for determination of sources.

4.15 Dr Yoshikawa described the Japanese aircraft sampling programme which uses JAL commercial passenger jets. Measurements of CO₂, CO, NOₓ and CH₄ are made at 10-14 km between Tokyo and Sydney. He also described temporal variations in CO₂ outflux from the central/western Equatorial Pacific, which is known as a strong oceanic source for atmospheric CO₂. He explained that the CO₂ outflux in these regions during the 1990s decreased significantly compared to the 1980s mainly due to ENSO events.

4.16 Prof. C. Zerefos presented his report in section 5.4.

4.17 One important factor that emerged from these presentations, and from subsequent discussions during the session, was the broad "client" community that is developing for GAW. This includes users of the ozone mapping products from Greece, the UV-B "effects" community, IGAC scientists, SPARC, GCOS, MEDPOL, GESAMP, and the NWP modelling community.

5. GLOBAL ATMOSPHERE WATCH

5.1 Overview

5.1.1 Dr John Miller, in reviewing the GAW programme, began by stating that an objective of the programme was to coordinate the monitoring and related research for the changing composition of the atmosphere. The two aspects of this activity are the impacts of atmospheric chemistry on climate change and on the environment. His presentation touched on the following topics

- GAW Measurements
- GAW Modelling
- Other GAW Activities
- Infrastructure
- Training and Education
- Meetings, Workshops and Conferences
- Technical Publications
- Resources
- Cooperation with Other Organizations
- Challenges

5.1.2 A more detailed listing of this presentation is given in Annex C.

Recommendation

The Panel recommended that there was a need for the preparation of additional GAW Fact Sheets. Panel members were requested to propose additional topics for the fact sheets, and to identify potential authors and contributors.

5.2 Status of GAW Network/Central Facilities from Recent Survey

5.2.1 WMO Technical Regulations governing the GAW Programme [Res. 3 (EC-XLIV)] require that the status of GAW stations be published periodically in the relevant report series.

5.2.2 The most recent status report (GAW Report No. 99) gave the GAW status as at 31 December 1993. An updated edition, currently in preparation, will cover the period 1 January 1994 through 31 December 1996, and will also contain information on the operational status of GAW world data centres, quality assurance/science activity centres and instrument calibration centres. The information to appear in the report is being provided by the participating countries, through the GAW contact persons designated by the Permanent Representatives with WMO.
Recommendation

The Panel recognized the importance of these activities and encouraged the rapid publication of this information.

5.3 GAW Infrastructure - QA/SACs, Calibration and Data Centres

5.3.1 The three Quality Assurance/Science Activity Centres in Germany, Japan and the United States have made considerable progress developing their programmes since the last Panel meeting. The longest operating QA/SAC (Germany), in January 1994, is now in danger of not being supported. At the beginning of 1997, the German Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie (BMBF) decided not to renew QA/SAC support. Alternate solutions to this problem are being sought in Germany. The QA/SACs in Japan and the USA have been building a solid programme as they become operational.

5.3.2 Prof. Mohnen gave an overview of the activities of the three QA/SACs and the World Calibration Centres. An updated list of calibration centres is given in Table 1 at the end of this report. A couple of specific activities were mentioned. For example, because of the importance of tropospheric ozone as an issue for both climate change and air quality, major emphasis has been placed on its measurement at the surface and its vertical profile. Though there have been many intercomparisons of ozonesondes, no standardized procedure has been established. Annual intercalibrations among commercial vendors/sondes are required. In a related activity, surface ozone measurement standardization is handled by the Swiss EMPA. A sub-QA/SAC is planned for South America.

5.3.3 In reviewing QA/SACs' progress, Prof Mohnen said that for the reactive gases, carbon monoxide and nitrogen oxides are now in reasonable shape. In the area of precipitation chemistry, a new QA system for data quality review has been established at QA/SAC for the Americas and the intercomparisons of laboratories has now been revitalized. The results of the 19th intercomparison has now been received with over 90 samples distributed, and 70 responses received. There has been no response from many parts of Africa and Russia. Fifty-four results were returned by the analytical laboratories which responded and the overall performance has greatly improved over the last three years.

5.3.4 In concluding his review, Prof Mohnen stated that the main issue was the future of the QA/SAC in Germany.

Recommendation

The Panel requested that CAS and EC urge Members who host GAW Quality Assurance Science Activity Centres, the World Calibration Centres, the WMO World Data Centres and the WMO Ozone Mapping Centre, to continue their support for these essential parts of the GAW infrastructure.

5.4 Ozone Mapping Centre

5.4.1 The WMO Ozone Mapping Centre at the Laboratory of Atmospheric Physics-Aristotle University of Thessaloniki, Greece makes an important contribution to the GAW programme with its preparation of daily total ozone maps for the winter/spring period of the Northern Hemisphere when ozone depletion is the strongest. Stations from North America, Europe and Asia form the network. It is expected to begin preparation of the WMO Antarctic Ozone Bulletins at the end of 1997. Information on the ozone centre is available on the world wide web (http://www.athena.auth.gr/ozonemaps).

5.4.2 A notable feature evident during recent years has been the greatly accelerated development of Arctic ozone depletion. The worst years were 1992, 1993 and 1995, partly because of the dynamics. In 1995, a 15% decrease was shown over a 4-month average for Siberia. The Panel congratulated the University of Thessaloniki group on its important contribution to GAW.
5.5 Training and Education

5.5.1 Training and education is an essential part of the GAW programme. It is recognized that scientists trained and educated in atmospheric chemistry and the environment are in limited supply and the need in both developing and developed countries is critical. Cooperation with ACEed programme of IGAC is a particularly used means to alleviate this. IGBP/IGAC and GCOS/GAW have agreed to join forces with those of START and pool their expertise to design and execute an integrated approach to "academic capacity building" in developing countries.

5.5.2 Dr Miller presented a short overview of the training and education activities of GAW. They are conducted in four different categories; training workshops, individual training at active GAW stations, expert visits for training, and education in atmospheric chemistry. Specific activities were:

- Training workshops
  SCO\textsubscript{2}P workshops in Argentina (May 1995 and November 1996);
  UV workshop in Greece (October 1995);
  Ozone measurements training in Argentina (April 1996);
  WMO GAW training workshop for Africa in Kenya (October 1996).

- Individual training at active GAW stations or laboratories in Canada, Czech Republic, France, Germany, Spain, Switzerland.

- Expert visits for training purposes to Argentina, Brazil, China, Costa Rica, Indonesia, Iran, Kenya, Malaysia, Nigeria, Pakistan, Paraguay, Vietnam, Uruguay and others.

- Education in atmospheric chemistry for long-term capacity building in cooperation with IGAC, ACExcld: Atmospheric Chemistry in Argentina (October 1995); Air Quality Modelling in Chile (October 1996); Atmospheric Chemistry in Brazil (November 1996).

Recommendation

The Panel strongly supported the training activities in GAW and recommended that this activity continues in cooperation with other international organizations.

5.6 Strategic Plan

5.6.1 The final draft of the GAW Strategic Plan was presented to the Panel for discussion by Mr Gerhard Muller, principal author of the document. The Panel had received several earlier versions of the draft over the period of a year for their review. A number of general points were made during the discussion. These included:

The GAW is a voluntary system. It needs the support of its clients if it is to succeed. To obtain this support, GAW must publish its goals in an identifiable and recognizable way. The Strategic Plan is an excellent start in that direction;

The Strategic Plan must motivate GAW participants, both in terms of scientific work and search for funding. GAW must see a visible role for its atmospheric work. Accordingly the GAW Strategic Plan must now be used to motivate the programme. The Strategic Plan serves the above purpose except that the description of the organizational structure is complex and a simplified version should be provided.

5.6.2 The Panel endorsed the Strategic Plan and recommended that it be published pending minor revisions and distributed at the WMO Executive Council in June 1997. Further it would be discussed at the Commission on Atmospheric Sciences in February/March 1998. They congratulated Mr. Muller for the effort that he put into preparing the Plan and for the strong financial support from the Swiss Meteorological Institute which made it possible. The important next step is the implementation of the plan.
Recommendation

The Panel supported the implementation of the GAW Strategic Plan, including the establishment of the Operational Support Group and the Scientific Advisory Groups.

5.7 GCOS Progress Report on Atmospheric Composition

5.7.1 The Global Climate Observing System (GCOS) was established in 1992 to provide the observations needed to meet the requirements for monitoring the climate, detecting climate change, and for predicting climate variations and change. It was initiated via a MOU among WMO, IOC of UNESCO, UNEP, and ICSU which led to the setting up of a Joint Scientific and Technical Committee (JSTC) to provide scientific oversight and a Joint Planning Office (JPO), which together developed the plans and strategy for implementation of the system.

5.7.2 GCOS is working closely with other global observing systems: the climate modules of the Global Ocean Observing System (GOOS) and the Global Terrestrial Observing System (GTOS), and with international research programmes.

5.7.3 Of interest to the Panel, a Task Group on Atmospheric Composition was established in 1992 which stressed the need for close co-operation with ongoing research activities. The Group emphasized the need to enhance GAW station monitoring programmes and to include aerosols in its programme. The Task Group supported the Baseline Surface Radiation Network (BSRN) and recognised the value of space-based observations.

5.7.4 In 1994 the JSTC established an Atmospheric Observation Panel for Climate (AOPC) with the responsibility to design a long-term observing system for the atmosphere. This system will be included in the Initial Operational System (IOS) by GCOS. Building on the Task Group work, the AOPC, at its first session in 1994 gave priority to quality assurance issues future networks and to cooperate in the implementation of the GAW global station network. The AOPC was concerned about the integration of atmospheric chemistry data into dynamical models and noted the need for sophisticated sampling strategies and techniques. The AOPC set out the need for a composite sampling system including surface stations, profiling techniques and space-based observations. It designed an outline for chemical atmospheric composition. The data should describe the role of the atmosphere in the radiative balance of the earth, the processes leading to ozone depletion and the atmospheric chemistry relevant to these points. Data should therefore be available from GAW to monitor the concentration of all greenhouse gases, precursors, aerosols and stratospheric clouds.

5.7.5 The second session of the AOPC in 1995 was influenced by the International Meeting of Experts on Long-term Climate Monitoring of the GCOS, held in Asheville in January 1995. The AOPC assigned high priority to ozone and aerosol measurements, noting that the enhancement and development of such monitoring are a responsibility of CAS. In this regard, participants were concerned on the lack of adequate tropospheric measurements, profiles, satellite observations, tracers. Furthermore, only limited user access to data was noted. The AOPC recommended the establishment of procedures to monitor operational aspects, a key role for World Data Centres and Quality Assurance/Science Activity Centres.

5.7.6 Of special interest to GAW the GCOS Space Plan, Version 1.0, published in 1995, identified radiation and atmospheric composition components. The GCOS document "GCOS Observation Programme for Atmospheric Constituents: Background, Status and Action Plan" by Robert Vet, summarised the GCOS actions with regard to atmospheric compositions since 1992 as a result of all workshops and AOPC sessions. The report identified those parameters of interest to GCOS.

5.7.7 The Panel strongly recommended a review of these parameters. As a consequence, at a GCOS workshop to be held in May 1997, a short-list of GCOS requirements for atmospheric constituents measurements will be considered. There was agreement that (selected) GAW data sets should be posted on GCOS Net as one means of linking the two programmes more closely. GCOS was urged to review the list of parameters that had been originally proposed for inclusion in GAW.
Recommendation

The Panel recommended that the GAW network and the Network for Detection of Stratospheric Change (NDSC) be the nucleus for an atmospheric composition reference network. The corresponding requirements should be met by GAW activities, e.g., quality control and data archiving (World Data Centres).

5.8 Cooperation With Other Organizations

*International Global Atmospheric Chemistry Project/IGBP*

5.8.1 In August 1998 a large scientific symposium co-sponsored by IGAC and the CACGP will be held in Seattle, Washington (USA). The Programme Chair is Dr Anne Thompson of NASA/Goddard. Information on the Symposium is available at the web site: http://saga.pmel.noaa.gov/cacgp98/. It was recommended that the GAW programme be strongly represented at this conference.

5.8.2 The Global Integration and Modelling (GIM) activity is one of several activities that currently exist under the IGAC Global Focus. The principal goal of GIM is to facilitate the development and improvement of global chemistry/transport models for chemically, radiatively, and biologically important atmospheric species. It is important to note that several mature research efforts focused on global-scale atmospheric chemistry and transport modelling already exist. Thus, the activities that will be undertaken as part of GIM will be directed towards facilitating these existing efforts, rather than developing independent modelling capabilities. With this in mind, four distinct sub-tasks are currently underway or are planned for the near future. These are:

- **Tropospheric Ozone Global Model Intercomparison Exercise**: The objective of this exercise is to systematically evaluate the capabilities of the current generation of global tropospheric O$_3$ models, and to identify key areas of uncertainty in our understanding of the tropospheric O$_3$ budget.

- **Aerosol Dynamics Model Intercomparison Exercise**: At the November 1996 IGAC/GIM Meeting there was a consensus that the organization of an aerosol modelling intercomparison exercise would be of considerable value to the atmospheric sciences community. However, no closure was achieved on the scope and definition of this exercise, and discussions would be continued with the goal of initiating this exercise during the spring of 1997.

- **Tropospheric Global Aerosol Modelling Workshop and Intercomparison Exercise**: The goal of this exercise is to perform a detailed evaluation of the capabilities of the current generation of global aerosol models that are used to characterize the distribution of sulfates, soil dust and black carbon.

- **Workshop on Inverse Methods in Global Biogeochemical Cycles**: The main objective of this workshop will be to teach students entering the field about the mathematics of inverse problems and the issues of a priori constraints.

5.8.3 All the above modelling activities require a strong input from the GAW measurement programme.

5.8.4 Past and current IGAC-connections with GAW range from formal joint co-sponsorship of IGAC's GLONET activity to a WMO GAW member on the IGAC Scientific Committee (SSC). Informal linkages exist through two activities within IGAC's new Focus on Atmospheric Aerosols (ACAPS, DARP) as well as through the Atmospheric Chemistry and Environmental Education in Global Change (ACE-ED) Activity within IGAC's Fundamental Focus. IGAC and GAW have also co-sponsored two large international scientific meetings: the WMO-IGAC Conference on the Measurement and Assessment of Atmospheric Composition Change (Beijing, China, October 1995) and the IGAC-SPARC-GAW Conference on Global Measurement Systems for Atmospheric Composition (Toronto, Canada, May 1997).
5.8.5 Possible future joint IGAC-GAW meetings are hindered by the fact that the IGAC SSC has not discussed possible IGAC scientific conferences beyond 1998. However, there have been informal discussions with representatives of the European IGAC Project Office (EIPO) of the possibility of EIPO organizing an IGAC scientific conference somewhere in Europe in 1999. This and conferences further in the future will be discussed at the upcoming IGAC SSC meeting in Toronto (17-19 May 1997).

**Stratospheric Processes and their Role in Climate (SPARC)**

5.8.6 SPARC, which is a project within the World Climate Research Programme (WCRP), has projects which are closely related to GAW. SPARC fosters research and identifies gaps in climate-related research. SPARC has an active community of scientists that sponsor numerous workshops and conferences, the forthcoming IGAC-SPARC-GAW Conference on Global Measurement Systems for Atmospheric Composition in Toronto, Canada (May 1997). SPARC activities include:

- Stratospheric Temperature Trends
- Stratospheric Water Vapour Climatology
- Intercomparison of Tropospheric Stratospheric Circulation Models
- Stratospheric Reference Climatology
- Stratosphere-troposphere exchange
- Upper tropospheric and Lower stratospheric Ozone, Aerosols and Climate
- Understanding Ozone Trends with IOC
- Gravity wave processes and their parameterization
- UV-B - covered by GAW

5.8.7 Areas of common interest between GAW and SPARC include UV-B, greenhouse gases, total O₃, and O₃ vertical profiles.

**GESAMP/MEDPOL**

5.8.8 The Panel was informed about the ongoing GAW activities related to the air-sea exchange of trace substances and pollution of the marine environment through the atmosphere. This activity is carried out within the UN inter-agency Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) and the UNEP Programme for the Assessment and Control of Pollution in the Mediterranean Region (MED POL-Phase III).

5.8.9 With regard to GESAMP, the Panel noted with interest the report on "The Sea-Surface Microlayer and its Role in Global Change" prepared by a WMO-led GESAMP working group which discusses, inter-alia, the effects of UV radiation on the marine biota. At the present time GESAMP has started the preparation of two important reports on the Land-based Sources and Activities Affecting the Marine and Associated Freshwater Environment (to be completed in 1998-1999) and the State of the Marine Environment Report 2002. Furthermore, the GEF initiated preparation of a comprehensive report on the Global International Waters Assessment (GIWA) in which GESAMP will also be involved. All these reports will contain sections dealing with airborne pollution of the seas, air-sea exchange, effects of UV radiation and climate change, which WMO will be responsible.

5.8.10 Concerning MED POL, the Panel was informed about preliminary assessments of airborne pollution of the Mediterranean by nitrogen compounds, heavy metals and some persistent organic pollutants, and about preparation of an analytical review document "Transboundary Diagnostic Analysis for the Mediterranean Sea" financed by GEF which deals with the assessment of sources and extent of pollution together with possible pollution control actions. The report will be used for seeking major financial resources to reduce pollution in this region. WMO was requested to prepare a part of this report on pollution through the atmosphere.

**European Monitoring and Evaluation Programme (EMEP)**

5.8.11 Since its inception, EMEP has worked closely with the WMO on all aspects of the programme. The WMO was requested by the EMEP Steering Body to review the EMEP Chemical Coordination Centre. Close coordination on quality assurance in measurement techniques through
QA/SAC was accomplished. Further, in 1997, there will be a number of co-sponsored meetings concerning EMEP-GAW Regional monitoring in Europe. These are:

- Data analysis workshop - Czech Republic - April
- GAW Regional monitoring - Hungary - May
- Monitoring Strategy - Sweden - June

**European Tracer Experiment (ETEX)**

5.8.12 The ETEX tracer experiment consisted of two releases of perfluorocarbons from Monterfil, Bretagne, France in October and November 1994. The concentrations of these tracer compounds were observed at 168 ground measuring stations in 17 countries of Europe. The capability of 24 institutes to produce rapid forecasts of atmospheric dispersion in real-time with 28 long-range atmospheric models was tested. From the analysis of the first release, it was concluded that the modellers were able to provide results in a reasonable time after the notification of the release. Differences of 3 to 6 hours in arrival time and a factor of 3 in surface maximum concentrations should be viewed as the current achievable limit of accuracy in real time long range modelling. In complicated meteorological conditions, such as were predominant during the second release, it is more difficult to forecast tracer cloud evolution.

5.8.13 WMO provides a system to co-ordinate emergency response activities through two programmes - the World Weather Watch (WWW) and GAW. As regards radiological environmental emergencies, arrangements have been developed and implemented on a global scale under the WWW Programme in co-ordination and collaboration with the IAEA and other international organizations concerned, to provide governments with specialized meteorological support. To this end five Regional Specialized Meteorological Centres share the responsibility of providing on request transport model forecast charts on the predicted transport and deposition of radioactive matter.

5.8.14 In the case of an emergency, GAW would respond by assisting in evaluating the potential impact of the emergency situation on the environment. Depending on the nature of future events, GAW can play the role of organizing such evaluations of impacts on the atmosphere and deposition of hazardous materials to the earth's surface.

6. SPECIAL TOPICS AND ISSUES

6.1 Global Environment Facility Projects

6.1.1 Six additional GAW stations have been set up in specific locations representing major climatic or ecological regions of the world. These stations are located in:

- Algeria
- Argentina
- Brazil
- China
- Indonesia
- Kenya

6.1.2 WMO, UNDP and the host countries have cooperated to ensure coverage where none existed previously.

WMO provides:

- the international framework;
- expertise and training.

UNDP facilitates:

- host country involvement;
- project review.
Host countries provide:

- facilities;
- national infrastructure;
- scientific and technical personnel.

6.1.3 Financial support was provided by the World Bank, through the GEF, which agreed in 1991 to the establishment of the stations.

6.1.4 Key to the development of these six stations is the concept of "twinning," where expertise from a developing country is twinned or partnered with that of a developed country. This has proved to be extremely effective and shows the cooperative effort which has extended worldwide station coverage. These twinning partners included experts from: Australia, Canada, the Czech Republic, France, Germany, Japan, South Africa, Spain, Switzerland and the USA.

6.1.5 The establishment of the six stations has been very timely in providing, in the case of the new station in Argentina, essential data concerning ozone depletion and, at the station in Indonesia, critical data concerning the haze and smoke affecting the region.

6.1.6 The Panel congratulated all the individuals involved in the establishment of these stations which greatly improves world coverage of GAW.

Southern Cone Ozone Project

6.1.7 The Southern Cone Ozone Project (SCO3P) was implemented in the southernmost regions of South America to improve ozone and UV-B radiation monitoring. Funding for instrumentation was provided through GEF and the host countries provided the facilities, the national infrastructure and the scientific and technical personnel necessary to operate and maintain the stations. These countries are Argentina, Brazil, Chile, Paraguay and Uruguay. Training of the station personnel was organized by WMO. In addition to the 9 sites for monitoring total ozone, 8 for surface ozone and 15 for UV-B, 8 other sites were instrumented for automated solar radiation and meteorological parameter monitoring.

6.1.8 The Panel congratulated those involved in the successful implementation of this project, a major accomplishment in South America.

Recommendation

Panel requested that letters of appreciation be sent to (i) countries mounting new GAW station programmes; (ii) countries hosting central facilities voluntarily (Secretariat to draft, chair to sign). The Panel also requested that the WMO Executive Council and/or Congress thank countries who participated in the establishment of new GAW stations (i.e., both partners in case of twinning) and that continuing efforts be urged, now that progress was evident.

6.2 Urban/Regional Pollution Project to Include Relations with NMHSs, Modelling and Passive Sampling

6.2.1 Prof. Greg Carmichael reported on urban and regional initiatives and on the possible roles of passive samplers in GAW. The urban environment is an area where WMO anticipates enhanced activities. This is due to the fact that a growing portion of the world's population lives in urban environments, they are the centres for economic and thus energy consumption and pollution emissions, and NMHSs (especially in developing countries) are being asked to play larger roles in the management of urban environmental issues. As a first step in planning future WMO activities in urban environments, a Meeting of Experts on Atmospheric Urban Pollution and the Role of the NMHSs was held in Geneva in October 1996 (GAW Report No. 115). Some of the conclusions and recommendations from the meeting are: many NMHSs have important roles to play in management of urban environments; meteorological infrastructure to support air quality measurements needs to be reviewed and improved; urban air quality measurements in many countries need to be enhanced
which can be done with guidance from WMO, WHO and others; and air quality modelling capabilities need to be strengthened.

6.2.2 The possible roles for GAW on the urban issue include:

- definition of a list of priority pollutant measurements for urban environments;
- articulation of important elements of an urban measurement programme;
- compilation of information on available techniques (including the use of passive samplers);
- develop plans to integrate urban considerations into existing objectives within GAW which could take the form of measuring ozone, sulphur dioxide, carbon monoxide, and aerosol size and composition (because of its role in health and radiative forcing) at a few sites in urban environments;
- measurements could be justified in part on the need to establish information on gradients and trends of key anthropogenic atmospheric chemistry components in and around urban centres, since cities are the major emission areas;
- give careful deliberation to their role and scope in measurements in urban areas to avoid duplication with other programmes, and to avoid taking on monitoring of additional species if it jeopardises present monitoring activities.

6.2.3 Prof. Carmichael also reported on a WMO activity with the NMHSs in ASEAN countries to address the issue of regional smoke and haze. A site visit to each of the ASEAN countries was conducted in August 1996, and recommendations for actions directed towards improving air pollution monitoring, modelling, and emergency response capabilities in the region are being developed. Smoke and haze from biomass burning, and local and regional fossil fuel combustion activities is an important transboundary environmental issue in the region, and in the past severe smoke and haze episodes have caused disruption in aviation and shipping activities and has lead to high levels of air pollution. This issue, like the urban environment, represents a problem of regional concern, one where the NMHSs are playing an important role, and one where GAW activities are already making an important contribution. The study found that the ASEAN Meteorological Services are actively involved in regional smoke and haze activities, and through their traditional activities related to meteorological monitoring and forecasting, the NMHSs are contributing in significant ways to the study and management of smoke and haze pollution.

6.2.4 The issue of smoke and haze within South East Asia fits well with the objectives of the GAW programme (cf, the Fourth Long Term Plan for AREP/GAW, and the Strategic Plan Report No. 113). Biomass burning is a significant source of trace gases emitted into the atmosphere which can alter the chemistry of the atmosphere, both globally and regionally; it is an issue in which monitoring of chemical components plays an essential role; and is an area where substantial GAW activities are already on-going (as exemplified by the establishment of the new global station at Bukit Koto Tabang, Indonesia).

6.2.5 Possible roles for the GAW programme on this issue include:

- Provide important guidance on the standardization of measurement protocols and techniques and on the harmonisation of air quality indices, which would greatly facilitate the exchange and quality of data in the region.
- Develop a plan to integrate smoke and haze concerns into present GAW activities in the region. This could take the form of adding measurements, or increasing frequency of measurements, at selected sites during high haze periods.
- Play an important role through capacity building efforts in the areas of air pollution meteorology and air pollution modelling.
6.2.6 Prof. Carmichael also reported on the preparation of a background paper on the possible role(s) of passive samplers in GAW (see GAW Report No. 122).

Recommendations

The Panel wished to advise concerned NMHSs that the Panel and the Secretariat would be pleased to provide technical guidance and advice on monitoring and modelling techniques.

The Secretariat requested the Panel to investigate whether an update and review of urban modelling would be appropriate at this time. The favoured approach would be to provide technical transfer of modelling by experts at a workshop in the particular region where assistance was required.

The Panel agreed that preparation of a Fact Sheet on urban pollution, and monitoring and modelling approaches would be timely.

The Panel requested that the Secretariat, in consultation with the QA/SAC (Europe or Asia), develop a pilot project involving regional stations in South East Asia which would investigate the sampling of particulate material, and possible selected gaseous constituents using passive samplers.

6.3 Global Acid Deposition Assessment

6.3.1 Dr Whelpdale reported that the Acid Deposition Assessment had been completed and was published as GAW Report No. 106. Copies are available from the Secretariat. He noted that a peer-reviewed publication based on the Assessment was in press.

6.4 Satellite/aircraft measurements and GAW

6.4.1 Recognizing the importance of satellite measurements to the study of atmospheric chemistry, the Panel agreed to take steps to increase the collaboration between GAW and the satellite community.

6.4.2 In this regard, GAW should play a major and increasing role in the long-term validation of satellite determinations of trace gas concentrations; such ongoing validation is critical for the reliable determination of trends. GAW is already fulfilling this function for total column ozone and ozone profiles. In the near future there will be a need for column CH₄ and N₂O data, and profiles of CO + water vapour. Later there will be a need for the validation of profiles of a number of species in the upper troposphere and lower stratosphere. It should be noted that this will require that GAW implement new capabilities to measure the vertical distributions of several species, in addition to its surface observations.

6.4.3 Dr Gille felt that the prospects for obtaining tropospheric composition measurements by satellite looks considerable brighter that a few years ago, and it is an appropriate time to attempt to engage the satellite community in a collaborative effort of atmospheric monitoring.

6.4.4 To establish a GAW-satellite data relationship, validation of instrument sensors is a necessary process. The GAW community has substantial potential to contribute to such continuous validation although this may require some redirection of observing priorities in GAW.

6.4.5 Some Panel members cautioned that a more balanced approach is needed here. The need to convince the satellite community of the benefits to both sides, and the need we have for their assistance in building the infrastructure and quality assurance.

Recommendations

The Panel requested the satellite community be made aware that support for the GAW infrastructure, including quality assurance activities necessary to help WMO sustain the integrity of the GAW measurement programme relevant to the validation of space-based geophysical products, is urgently needed.
The Panel agreed that contact should be made with space agency committees to try to engage their interest. The Secretariat, with the assistance of Volker Mohnen, was requested to pursue this. It should be stressed that GAW is a partner for long term validation of satellite sensors (accurate trends, determination needs long term calibration).

6.5 Report of Scientific Steering Committee (SSC) on UV Measurements

6.5.1 Following the recommendations by EC XLVI and the WMO Meeting of Experts on UV-B Measurements, Data Quality and Standardisation of UV Indices (Les Diablerets, Switzerland, July 1994), the Panel at its last meeting approved the establishment of the WMO ad hoc Scientific Steering Committee on UV Monitoring (SSC) with the following terms of reference:

- To act as a focal point for UV Measurements and monitoring programmes;
- To coordinate UV calibrations and intercomparisons;
- To develop requirements for data analysis and archiving;
- To implement a QA/QC programme;
- To promote UV modelling activities;
- To encourage communication with the diverse UV community.

6.5.2 As chairman of the SSC, Dr. Paul Simon, Director of the Institut d'Aéronomie Spatiale, Belgium, gave an overview of the activities of the SSC which have been supported by both the WMO and the UV Monitoring and Assessment Programme, an organization sponsored by an international group of chemical companies. There have been three meetings of the SSC since the last Panel meeting. Besides the SSC meetings, there have been a number of sub-committee meetings which have handled special topics - instrument categorization, network status, QA/QC, data analysis, and data archiving. A number of GAW reports on these issues are now in preparation.

Recommendation

The Panel strongly urged that the group finalize their reporting especially on QC and instruments because of the many urgent requests for guidance in these areas from many WMO Members.

6.6 Real Time Exchange of Ozone Data

6.6.1 In October 1996, a group of experts met to discuss the real-time exchange of ground-based ozone measurements. This was a joint ECMWF/WMO meeting held in Reading, UK. ECMWF has plans to use the ozone data in future four-dimensional assimilation systems and meteorological models which are expected to become operational in the near future. The ground-based measurements such as total and vertical ozone will be used to cross validate data from satellite instruments and model calculations. Numerical weather prediction will benefit from the additional wind information that can be obtained from remotely sensed ozone data. In addition, further users will obtain model-predicted fields of atmospheric dynamics and ozone distribution which are internally consistent. The discussions of the group has been published in an ECMWF report.

6.6.2 Mr. F. Delsol, Director of the Atmospheric Research and Environment Programme Department, in his presentation of the above, noted that at present there is no real-time system for total ozone or vertical ozone soundings on a global basis. However, the GAW will be working with the numerical weather prediction centres to achieve this in the near future. The Panel noted that this was a unique link between the measurement of the chemistry of the atmosphere under GAW and the use of such data for operational weather prediction.

7. GAW EVENTS IN THE NEXT TWO YEARS

7.1 The Panel considered the events that would take place in the next two years under its auspices. These include:

- Series of meetings on Regional monitoring in Europe (April-June 1997)
• Numerous meetings on UV in 1997 (including UV indices, instrument intercomparisons), Europe and North America
• IGAC-SPARC-GAW Conference in Toronto (May 1997)
• Carbon Dioxide workshop and conference in Australia (September 1997)
• 1998 Ozone assessment - numerous meetings in 1997-1998 (June 1998 meeting of authors in Switzerland)
• Completion of the two GEF projects in 1997
• Implementation of the Strategic Plan
• EC meets in June 1997/98, ČAS meets in February 1998
• Ozone Antarctic Bulletins (August - December 1998)
• CACGP-IGAC Symposium Seattle (August 1998)
• Panel meeting (April 1999)

8. REPORT AND CLOSURE OF THE MEETING

8.1 The session entrusted the Secretariat to prepare the final report after consultation with the participants as necessary.

8.2 The meeting closed at 4:30 p.m. on Thursday 10 April 1997.
AGENDA

1. Opening of the Session

2. Approval of the Agenda

3. Review of the Recommendations from the Twelfth World Meteorological Organization Congress and the Forty Seventh Session of the Executive Council

4. Scientific Developments in Atmospheric Chemistry

5. Global Atmosphere Watch
   5.1 Overview
   5.2 Status of GAW Network/Central Facilities from Recent Survey
   5.3 GAW Infrastructure - QA/SACs, Calibration/Data Centres
   5.4 Ozone Mapping Centre
   5.5 Training and Education
   5.6 Strategic Plan

   Operation Support Group
   Observations Group
   Scientific Advisory Groups

   5.7 GCOS Progress Report on Atmospheric Composition
   5.8 Cooperation with other Organizations
       International Global Atmospheric Chemistry Project/IGBP
       Stratospheric Processes and their Role in Climate (SPARC)
       GESAMP/MEDPOL
       European Monitoring and Evaluation Programme (EMEP)
       European Tracer Experiment (ETEX)

6. Special Topics and Issues
   6.1 Global Environment Facility Projects
   6.2 Urban/Regional Pollution Project to Include Relations with NMHSs, Modelling and Passive Sampling
   6.3 Global Acid Deposition Assessment
   6.4 Satellite/Aircraft Measurements and GAW
   6.5 Report on Scientific Steering Committee on UV Measurements
   6.6 Real Time Exchange of Ozone Data

7. GAW Events in the Next Two Years

8. Report and Closure of the Meeting
ANNEX B

EC PANEL OF EXPERTS/CAS WORKING GROUP ON
ENVIRONMENTAL POLLUTION AND ATMOSPHERIC CHEMISTRY

(GENEVA, 7-11 APRIL 1997)

LIST OF PARTICIPANTS

Panel members

Prof. Dieter H. Ehhalt
Institut fur Atmospharische Chemie
Forschungszentrum Julich
P.O. Box 1913
5170 JULICH
Germany
Tel: 49.246161 4692
Fax: 49.246161 5346
email: k.welinhofer@kfajuelich.de

Prof. Igor M. Nazarov
Institute of Global Climate and Ecology
208 Glebovskaya Street
MOSCOW 107258
Russian Federation
Tel: 007.0951.692.410
Fax: 007.0951.800.831
email: nazarov@di.igce.msk.ru

Dr John C. Gille
NCAR
P.O. BOX 3000
BOULDER, CO 80307-3000
USA
Tel: 303.497.1412/8062
Fax: 303.497.1492/8080
email: gille@ucar.edu

Dr. Eugenio Sanhueza
I.V.I.C.
Apartado 21827
CARACAS 1020 A
Venezuela
Tel: 58.2.504.1414/1417
Fax: 58.2.504.1350 and 1115
email: esanhuez@quimica.ivic.ve

Dr Bruce Hicks
NOAA - Air Resources Laboratory
Room 3152, SSMC3
1315 East West Highway
SILVER SPRING, MD 20910
USA
Tel: 301.713.0684, ext. 136
Fax: 301.713.0119
email: bruce.hicks@noaa.gov

Dr D.M. Whelpdale
Atmospheric Environment Service
CCRD
4905 Dufferin Street
NORTH YORK, Ontario M3H 5T4
Canada
Tel: 416.739.4869
Fax: 416.739.5700
email: douglas.whelpdale@ec.gc.ca

Prof. Oystein Hov
Norwegian Institute for Air Research (NILU)
Postboks 100
N-2007 KJELLER
Norway
Tel: 47 63 89 80 00
Fax: 47 63 89 80 50
email: oystein.hov@nilu.no

Dr H. Yoshikawa
Japan Meteorological Agency
Meteorological Research Institute
Nagamine 1-1, Tsukuba
IBARAKI 305
Japan
Tel: 81.298 53 8721
Fax: 81.298 53 8728
email: hyoshika@mri-jma.go.jp
Prof. Ch. S. Zerefos
Aristotle University of Thessaloniki
Laboratory of Atmospheric Physics
Campus Box 149
THESSALONIKI 54006
Greece
Tel: 30.31.998041
Fax: 30.31.248602
email: zerefos@ccf.auth.gr

Dr Alex Pszenny
IGAC Core Project Office
Massachusetts Inst. of Technology
Building 24-409
CAMBRIDGE, MA 02139-4307
USA
Tel: 617 253 9887
Fax: 617 253 9886
email: pszenny@mit.edu

Prof. Anton Eliassen
Vice-President of CAS
Norwegian Meteorological Institute
P.O. Box 43, Blindern 0313 OSLO'3
Norway
Tel: 47 22 963 000/152
Fax: 47 22 963 050
email: anton.eliassen@dnmi.no

Dr Paul C. Simon
Institut d'Aéronomie Spatiale
3 avenue Circulaire
1180 BRUSSELS
Belgium
Tel: 322 373 0400
Fax: 322 375 9336
email: pauls@oma.be

Invited experts

Dr Jeremy Hales
ENVAIR
4811 W 18th Avenue
KENNEWICK, WA 99337
USA
Tel: 509.735.1753
Fax: 509 783 7352
email: jake@odysseus.owt.com

WMO Secretariat
F. Delsol
J. Miller
A. Soudine
S. Mbele-Mbong
L. Jalkanen
T. Spence (GCOS)
C. Richter (GCOS)
C. Wallén (UNEP)

Prof. Volker Mohnen
Atmospheric Science Research Centre
State University of New York
100 Fuller Road
ALBANY, NY 12205
USA
Tel: 518 442.3819
Fax: 518 442 3867
email: vam@atmos.albany.edu

Consultants
R.D. Bojkov
G. Carmichael
B. Mendonca

Dr Gerhard Müller
Swiss Meteorological Institute
P.O. Box 514
Kräihühlstrasse 58
8044 ZURICH
Switzerland
Tel: 411 256 9403
Fax: 411 256 9278
email: gmu@sma.ch
OVERVIEW OF GAW

GAW Measurements
- Greenhouse gases-carbon dioxide, CFCs, methane, nitrous oxide, tropospheric ozone;
- Ozone - surface, total column, vertical profile;
- Solar radiation including UV;
- Precipitation chemistry;
- Aerosols including optical depth;
- Reactive gases - carbon dioxide, sulfur dioxide, nitrogen oxides, VOCs;
- Radionuclides - krypton 85, radon, beryllium 7, lead 210;
- Meteorological parameters;
- Need to establish Scientific Advisory Groups (SAGs) for each measurement.

GAW Modelling
- EMEP modelling activities;
- UV modelling;
- Regional and urban modelling;
- Climate change modelling related to atmospheric chemistry.

Other GAW Activities
- MedPol/GESAMP;
- IAEA-WMO networks.

Infrastructure
- WMO Secretariat;
- National GAW global and regional networks;
- Quality Assurance Science Activity Centres - Germany, Japan, USA:
  - Define QA standards for all GAW measurements;
  - Programme of QA assessments;
  - Provide QA for data submitted to GAW;
  - Training;
  - Overview World Calibration Centres.
- World Data Centres - Total/Vertical Ozone, UV, Solar Radiation, Greenhouse and Other Gases, Aerosols, Turbidity (not active), Precipitation Chemistry, and Surface Ozone (new):
  - Archive GAW data;
  - Provide data to users;
  - Perform basic analysis.
- Ozone Mapping Centre.

Training and Education
- Training through workshops such as through the GEF projects;
- Individual training at active stations/laboratories – twinning;
- Expert visits for training purposes;
- Education courses in atmospheric chemistry in connection with IGAC.
Meetings, Workshops and Conferences
- Technical meetings to discuss a specific topic;
- Coordination meeting for GAW and related organizations;
- Intercalibration workshops;
- Scientific conferences.

Technical Publications and Assessments
- GAW/GO3OS series;
- Assessments - ozone, precipitation chemistry etc.;
- Peer-reviewed publications;
- Ozone Antarctic Bulletins;
- Popular brochures;
- Fact sheets.

Resources
- WMO/GAW base funding of about 325,000 SF per year;
- Contributions to the WMO Trust Fund;
- In kind contributions.

Cooperation with Other Organizations
- WCRP - SPARC, BSRN;
- IGAC - GLONET/ITOY;
- WHO;
- IAEA;
- UNEP;
- AMAP;
- NARSTO;
- IOC;
- GESAMP;
- NDSC;
- Other international monitoring programmes;
- Numerous national organizations.

General Challenges
- The changing composition of the atmosphere in respect to climate change and air quality;
- Needs of developed versus developing countries;
- The GAW Global network versus the GAW Regional network;
- Ground-based, aircraft and satellite measurements;
- Defining the GAW aerosol programme - climate versus deposition;
- GAW’s role in the urban environment;
- Promoting twinning/partners;
- GAW Strategic Plan;
- Contribution to GCOS;
- Recognize the WMO/GAW programme as the lead UN programme in atmospheric chemistry and the environment;
- Political realities;
- The overall operation of the GAW system;
- Build strong relationship with the scientific community, policy makers and other clients.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Operating Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropospheric Ozone (surface measurements and ozone sondes)</td>
<td>Swiss Federal Laboratory for Metals Testing and Research (EMPA), Dubendorf, Switzerland - surface ozone for Europe and Africa</td>
</tr>
<tr>
<td></td>
<td>National Institute for Science and Technology (NIST), Maryland, USA - surface ozone for the Americas</td>
</tr>
<tr>
<td></td>
<td>World Calibration Instrument Intercomparison Facility, Julich, Germany - ozone sondes for the world</td>
</tr>
<tr>
<td>Stratospheric Ozone (total ozone measurements)</td>
<td>NOAA-Boulder, USA maintains the WMO World Reference Standard (Dobson No. 83), absolute calibrations are carried out annually at Mauna Loa. Also maintains WMO World Secondary Standard (Dobson No. 65) most frequently used in intercomparisons.</td>
</tr>
<tr>
<td></td>
<td>AES-Toronto, Canada maintains a triad of Brewer instruments under continuous scrutiny. Travelling Brewer No. 34 is used for transfer or calibrations.</td>
</tr>
<tr>
<td></td>
<td>Main Geophysical Observatory, St Petersburg, Russia calibrates filter instruments against a well-maintained Dobson.</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>NOAA, Climate Monitoring and Diagnostics Laboratory (CMDL), Boulder, USA, for the world.</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>EMPA, Switzerland performs audits and provides test gas samples to stations in Europe and Africa.</td>
</tr>
<tr>
<td></td>
<td>NOAA-CMDL, Boulder, USA maintains calibration scale, standards and intercomparisons.</td>
</tr>
<tr>
<td>Volatile Organic Compounds</td>
<td>Japan Meteorological Agency, Tokyo, Japan for all regions of the world.</td>
</tr>
<tr>
<td>Precipitation Chemistry and Deposition</td>
<td>(Artificial precipitation samples - NIST traceable - distributed to all laboratories by QA/SAC Americas.)</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Radiation (ultraviolet and other)</td>
<td>World Radiation Centre, Davos, Switzerland. Not yet defined for UV</td>
</tr>
<tr>
<td>Optical Depth</td>
<td>World Optical Depth Research and Calibration Centre, Davos, Switzerland.</td>
</tr>
<tr>
<td>Aerosols</td>
<td>Institut fur Tropospharenforschung (IfT), Leipzig, Germany for all regions of the world. (To be confirmed)</td>
</tr>
<tr>
<td>Radioactivity</td>
<td>Environmental Measurements Laboratory, DOE, New York, USA for all regions of the world.</td>
</tr>
</tbody>
</table>
ENVIRONMENTAL POLLUTION MONITORING AND RESEARCH PROGRAMME REPORT SERIES


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


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


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


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

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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


23. Provisional Daily Atmospheric Carbon Dioxide Concentrations as Measured at BAPMoN Sites for the Year 1982. November 1984


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


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


35. Provisional Daily Atmospheric CO₂ Concentrations as Measured at BAPMoN Sites for the Year 1983. December 1985


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


46. Provisional Daily Atmospheric Carbon Dioxide Concentrations as Measured at BAPMoN Sites for the Year 1984. December 1986


50. Provisional Daily Atmospheric Carbon Dioxide Concentrations as Measured at BAPMoN Sites for the Year 1985. December 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

55. Summary Report on the Status of the WMO Background Air Pollution Monitoring Network as at 31 December 1987


58. Provisional Daily Atmospheric Carbon Dioxide Concentrations as measured at BAPMoN sites for the years 1986 and 1987


62. Provisional Daily Atmospheric Carbon Dioxide Concentrations as measured at BAPMoN sites for the year 1988


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


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


72. Integrated Background Monitoring of Environmental Pollution in Mid-Latitude Eurasia by Yu.A. Izrael and F.Ya. Rovinsky, USSR

73. Report of the Experts Meeting on Global Aerosol Data System (GADS), Hampton, Virginia, 11-12 September 1990


75. Provisional Daily Atmospheric Carbon Dioxide Concentrations as measured at Global Atmosphere Watch (GAW)-BAPMoN sites for the year 1990

76. The International Global Aerosol Programme (IGAP) Plan: Overview

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


83. Report on the Global Precipitation Chemistry Programme of BAPMoN

84. Provisional Daily Atmospheric Carbon Dioxide Concentrations as measured at GAW-BAPMoN sites for the year 1991

85. Chemical Analysis of Precipitation for GAW: Laboratory Analytical Methods and Sample Collection Standards by Dr. Jaroslav Santroch


89. 4th International Conference on CO₂ (Carqueiranne, France, 13-17 September 1993)

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, 4-8 October 1993


94. Report on the Measurements of Atmospheric Turbidity in BAPMoN


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 (QAPP) for Continuous Ground Based Ozone Measurements


99. Status of the WMO Global Atmosphere Watch Programme as at 31 December 1993


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)


103. Report of the Meeting of Experts on the WMO World Data Centres, Toronto, Canada, 17-18 February 1995, (prepared by Edward Hare)

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, 13-17 March 1995

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)


110. Report of the WMO-NOAA Expert Meeting on GAW Data Acquisition and Archiving (Asheville, NC, USA, 4-8 November 1995)


113. The Strategic Plan of the Global Atmosphere Watch (GAW)

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-ACE5d, Garmisch-Partenkirchen, Germany, 15-19 July 1996


116. GAW Guide


120. WMO-UMAP Workshop on Broad-Band UV Radiometers (Garmisch-Partenkirchen, Germany, 22-23 April 1996)


124. Fifth Session of the EC Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry, (Geneva, Switzerland, 7-10 April 1997)