REPORT of the FOURTH WMO MEETING of EXPERTS on the QUALITY ASSURANCE/SCIENCE ACTIVITY CENTERS (QA/SACs) of the GLOBAL ATMOSPHERE WATCH

Jointly held with the

FIRST MEETING of the COORDINATING COMMITTEES of IGAC-GLONET and IGAC-ACE$^{ED}$

Garmisch-Partenkirchen, Germany, 13-17 March 1995
業務参考資料について温熱化情報センターに配布します

（添付物あり）
事務連絡
平成7年9月11日

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「第4回QA/SAC専門家会議」及び「全球対流圈オゾンネットワーク調整委員会第1回会合」報告書について

このことについて、WMO事務局から気象庁宛て、標記会議（1995年3月13〜17日、於：ドイツ・ガルミシュパルテンキルヘン、当庁からは観測部高層課伊藤朋之（オゾン層解析室長が出席）の報告書が配布されましたので、参考資料としてこれを交付します。

本送付先：観測部管理課補佐官
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1. OPENING OF THE MEETING, ELECTION OF CHAIRMAN AND INTRODUCTION

The Fourth World Meteorological Organization (WMO) Meeting of Experts on the Quality Assurance/Science Activity Centres (QA/SACs) of the Global Atmosphere Watch was opened by Dr John M. Miller, Chief, Environment Division.

On behalf of the Secretary-General, Professor G.O.P. Obasi, Dr Miller welcomed the participants (see Annex B for list of participants). In his opening address, Dr Miller noted that the scientific input to the debate on global environmental issues must derive from an adequate knowledge base. This can only be achieved through high quality, strategically oriented observations, and coordinated research related to the particular issue. This complex task must be tackled jointly by international organizations and the scientific community. Therefore, WMO-GAW has established a close cooperation with the International Global Atmospheric Chemistry (IGAC) Programme, a core project of the International Geosphere-Biosphere Programme (IGBP). Of direct and immediate benefit to WMO are such IGAC projects as GLONET (Global Tropospheric Ozone Network), and ACEED (Atmospheric Chemistry Education), which complement similar ongoing WMO-GAW activities. To promote cooperative planning efforts, it was agreed between the Environment Division of WMO and the International Project Office of IGAC to organize a joint meeting of the QA/SAC Advisory Committee, and the Coordinating Committees of GLONET and ACEED, respectively. Dr Miller noted that this is the first such joint planning meeting among these scientific communities, with additional ones to follow as the need for global interaction increases.

On behalf of the Scientific Steering Committee of IGAC, Dr Alex Pszenny restated the need for global cooperation in order to document and to understand changes in the chemistry of the atmosphere. The chemistry of the atmosphere is changing: a global warming is expected due to increasing concentrations of greenhouse gases (CH₄, CO₂, N₂O, CFCs and ozone) and altered amounts of clouds and particles in the atmosphere; the stratospheric ozone layer, and consequently the surface solar flux of ultraviolet radiation, is being modified; the integrated oxidation rate, loosely referred to as the oxidation efficiency or oxidation capacity of the atmosphere, is changing and the abundance of trace gases including those with significant greenhouse warming potential is perturbed. Assessment of the problems, their impacts and the responses to them occupy a prominent position on the international agenda today. By working together, a scientifically effective and economically efficient solution to these problems—confronting all countries of the world—will eventually emerge.

In welcoming the workshop participants to the Fraunhofer Institute for Atmospheric Environmental Research (IFU) and to the resort town of Garmisch-Partenkirchen, Professor W. Seiler stressed the importance of vigorous quality assurance in a global monitoring network and emphasized the significant progress achieved by the QA/SAC for Europe and Africa since its implementation in January of 1993. It now is an integral part of IFU and—supported by IFU—has built global alliances with internationally recognized institutes/organizations for the purpose of sharing quality assurance responsibilities and exchanging scientific know-how. This alliance will strengthen in the future as investigators become increasingly aware of the added credibility that QA/QC related efforts will bring to their scientific research projects. Professor Seiler also acknowledged the increased involvement of IFU in IGAC-projects reflecting IFU's interest in global change research.

Professor V.A. Mohnen was elected Chairman of the joint WMO-IGAC meeting. In his opening remarks he thanked the Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie (BMBF) for supporting the German QA/SAC Office (responsible for Europe/Africa) at IFU since January of 1993 and the National Oceanic and Atmospheric Administration (NOAA) for implementing in January of 1995 the United States QA/SAC office (responsible for the Americas).

Professor Mohnen, in following up on the earlier comments, characterized the establishment of QA/SACs as an important prerequisite for creating a credible and reliable global data set for the GCOS-GAW programme (the third and final Center, responsible for Asia and Oceania, will become operational on April 1, 1995, under the direction of the Japan Meteorological Agency). Another prerequisite for the success of GAW is a close interaction with the scientific...
research community as represented in IGAC. The Executive Council Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry (The Panel) recommended that high priority be given initially to the implementation of quality assurance/quality control for tropospheric ozone (GAW Report No. 93). The Global Tropospheric Ozone Project (GLONET) of IGAC is the ideal scientific partner for GAW to jointly plan and oversee the expansion of current measurement sites in order to achieve representative global coverage and a quality-assured global data set. A final prerequisite for maintaining a high-quality global research/monitoring network is the adequate supply and proper training of atmospheric chemists including all station personnel so that they can conduct the demanding and complex measurement programme. Here again, IGAC shares with GAW similar concerns and has responded with the formation of the Atmospheric Chemistry Education Project (ACE\textsuperscript{ED}).

On the basis of recent developments and progress within the QA/SACs, IGAC-GLONET and IGAC-ACE\textsuperscript{ED}, and on advice from The Panel, Professor Mohnen defined the overall objectives of this joint WMO/IGAC workshop as follows:

(a) To explore joint activities of GAW, GLONET and ACE\textsuperscript{ED} and identify projects for immediate and, where appropriate, joint implementation;

(b) To provide guidance for the conduct of and coordination between Quality Assurance/Science Activity Centres (QA/SACs) and World Calibration Facilities (WCFs);

(c) To establish the oversight responsibilities for the three QA/SACs.

Professor Mohnen outlined the workshop structure and suggested that the experts split into three subworking groups (see Annex C for agenda and Annex B for group assignment), namely Subworking Group I (SWGI) dealing with GLONET issues under the chairmanship of Dr Jake Hales, Subworking II (SWGII) focusing on QA/SAC specific tasks under the chairmanship of Mr. Gerhard Müller and Subworking Group III (SWGIII) discussing educational aspects under the chairmanship of Professor Kenneth Demerjian, who also is the Convener of the IGAC-ACE\textsuperscript{ED} project.

Professor Mohnen agreed to serve as overall workshop rapporteur, to produce a draft report for review by reviewers designated by WMO and IGAC, to circulate the reviewed document to all participants and to prepare a final report for publication by WMO.

2. ADOPTION OF THE AGENDA

The Chairman introduced the agenda, which was adopted unanimously and is reproduced in Annex C.

3. OVERVIEW OF GAW, IGAC-GLONET AND IGAC-ACE\textsuperscript{ED}

3.1 Introduction

The main driving force of global atmospheric observations and atmospheric chemistry research is the need to develop sound environmental policy related to the following questions:

- What is the effect of human activity on stratospheric and tropospheric ozone? How is the UV flux at the surface of the Earth changing in response to changes in the ozone column density?

- How is surface climate sensitive to the atmospheric concentrations of greenhouse gases and aerosols, and what factors control these concentrations?

- How is the oxidizing power of the atmosphere changing with time, and what is the influence of human activity?
How is regional air quality degraded by industrial and other anthropogenic emissions in populated areas of the world?

The answers to these questions are provided--in part--by GCOS-GAW and IGAC-GLONET, and the resulting data sets are used by policy makers to resolve major scientific issues. It is therefore imperative that all data be obtained by strict adherence to comprehensive quality assurance programmes. The Quality Assurance/Science Activity Centers (QA/SACs) design and execute these quality assurance programmes. An integral part of the quality assurance is education and training, and ACEED supports these activities within IGAC and GAW.

3.2 WMO Global Atmosphere Watch (GAW) Programme -- Dr John M. Miller

The Global Atmosphere Watch (GAW) programme is a coordinated network of observing stations, associated facilities and infrastructure encompassing measurement and related scientific assessment activities. The overall role of GAW is to supply basic information of known quality indicative of the atmospheric environment that transcends specific issues (GAW Report No. 86).

The overall GAW measurement responsibilities include:

- greenhouse gases;
- ozone (surface, total and profile);
- radiation (including UV-B) and optical depth;
- precipitation chemistry;
- chemical and physical properties of aerosols;
- reactive gases;
- radionuclides;
- related meteorological parameters.

The data obtained by GAW provide information for:

- scientific assessments and early warnings/advisories.

The GAW-structure calls for (1) up to 30 GLOBAL STATIONS located at remote pristine locations; (2) over 300 REGIONAL STATIONS for characterizing the regional environmental quality away from direct pollution sources; and (3) a mechanism/system of activities for producing measurements of known quality and of value for making environmental policy decisions (quality assurance/quality control). WMO’s strategy for implementing total quality assurance is built around Quality Assurance/Science Activity Centres (QA/SACs) (GAW Report Nos. 80, 92 and 93).

Calibration centres have been established as follows:

- Carbon dioxide: NOAA/CMDL; Scripps
- Tans: USA
- Column ozone: NOAA/MDL-Dobson
- Evens: USA
- Column ozone: AES-Brewer
- Kerr: Canada
- Solar radiation: WRC
- Fröhlich: Switzerland
- Precipitation Chemistry: EPA/SUNY
- Hunike/Galvin: USA

Newly formed World Calibration Facilities are now being established for surface ozone, aerosol optical depth (AOD), carbon monoxide (CO), and radioactivity and more are planned for UV-B, methane (CH₄) and nitrous oxide (N₂O), chlorofluorocarbons (CFCs), volatile organic compounds (VOCs) and reactive gases (NOₓ, SO₂, etc.). World Data Centres currently identified are as follows:

Ozone and UV Radiation: Canada
Greenhouse and other Trace Gases: Japan
Aerosols: EU (CEC)
Radiation: Russia
Turbidity: USA
Precipitation Chemistry: USA
GAW is widely seen as a top priority activity of WMO. It is also slowly becoming appreciated that the days of simple monitoring using standardized instruments are coming to an end. There seems to be acceptance of the view that we are entering a new generation of more complex environmental problems, for which many considerations need to be taken into account before appropriate regulatory or control actions can be contemplated. In this regard, it would seem that GAW should be structured, as much as is possible, to provide a flexible infrastructure on which to build new monitoring programmes to address new environmental problems as they arise.

3.3 Global Tropospheric Ozone Network (GLONET) -- Professor Volker A. Mohnen

3.3.1 Ozone plays a central role in most of the key physical, chemical and radiative processes in the troposphere. It has become apparent that: (1) O$_3$ vertical distribution significantly influences the radiative forcing of the troposphere/surface climate system; and (2) the photodissociation of O$_3$ defines the "oxidation efficiency" of the free troposphere. Because of these roles, it is imperative that we gain a much more detailed knowledge of its global horizontal and vertical distribution and long-term concentration trends in the troposphere than current O$_3$ measurement programmes will permit. Attainment of the following goals is an essential prerequisite for defining a global climatology and trends of O$_3$ in the troposphere with known uncertainty.

Goals
- Promote high-quality measurements of tropospheric O$_3$;
- Facilitate the expansion of existing stations capable of profiling tropospheric O$_3$.

3.3.2 Implementation

Recent WMO assessment reports and articles in the reviewed literature characterize the state of knowledge regarding tropospheric O$_3$ trends as very sketchy. The majority of stations are located in northern mid-latitudes. There are less than 15 stations with long-term records (> 15 years), and most of these are located in Canada, Europe and Japan, with only one in the US and one in Australia. Among these stations the data quality and sampling frequency are uneven. There is only one station in the tropics with a record from 1979, but the sampling frequency has been low. An increase in measurement frequency is needed at many of the existing stations, and new stations are required in regions where there are none. The assurance of continuity is required at several of the stations established in recent years. By far the greatest need is for improved data quality, for both present and future measurement stations. This is the focus of two of the three initial tasks of GLONET.

From considerations of the causes of O$_3$ variability, the size of the region of the atmosphere effectively sampled above a fixed observation station, and trend prediction analysis, it has been concluded that an increase in measurement frequency and a major expansion of the current number of O$_3$ measurement stations would be necessary to detect regional and global trends of tropospheric O$_3$ with an accuracy of ± 1% per year.

To address the stated problems, GLONET is organized initially into three tasks. The first emphasizes improvements in the quality of O$_3$ profile measurements. The second identifies geographic regions where new stations are critically needed for achieving representative global coverage and develops a strategy for needed network expansion. A third encompasses initial planning for a worldwide O$_3$ and related species intensive measurement programme in the 1998-1999 time frame to establish a global data base for validation of chemistry/transport models: The International Tropospheric Ozone Year (ITOY).

3.3.2.1 World Calibration Facility for Ozonesondes

Several national and international efforts are underway towards building a representative global network of ozonesonde stations, and GLONET is committed to support such efforts. However, prior to any expansion, and in order to optimize the use of existing networks for
accurate measurements of tropospheric $O_3$ profiles, it is absolutely essential that certain tasks be accomplished:

- Intercalibration and intercomparison of existing ozonesonde types;
- Agreement on measurement frequency and timing;
- Agreement on procedures for data processing and analysis.

The short-term objectives of this task are: (1) to bring together from around the world scientists from the current ozonesonde measurement programmes, and (2) to compare instrument performance in a controlled environment and, thus, determine the accuracy and other characteristics influencing data comparability of the field instruments. The long-term objective is to establish a permanent facility for ozonesonde intercomparison and calibration.

3.3.2.2 Network Expansion for Measuring Tropospheric $O_3$ Profiles and Representative Tropospheric $O_3$ Concentrations

This task is strategically designed to coordinate with and build upon existing multinational research/monitoring programmes aimed at measuring and assessing long-term tropospheric $O_3$ concentrations. In particular, the GLONET approach will complement ongoing efforts in WMO’s Global Atmosphere Watch (GAW) programme, IAMAS’s International Ozone Commission (IOC) and other major programmes concerned with surface $O_3$ measurements.

In addition, GLONET will participate in the planning of IGACT Activity 5.1 (MILOX) to encourage and promote: (1) the accurate and representative measurement of tropospheric $O_3$ profiles using ozonesondes, differential absorption lidars or other profiling techniques; and (2) the establishment of long-term surface $O_3$ stations that representatively measure free tropospheric $O_3$ concentrations. This effort will also include theoretical work on the modelling of atmospheric $O_3$. A close interaction between the modelling and the development of measurement strategy is essential.

3.3.2.3 International Tropospheric Ozone Year (ITOY)

The aim of this task (which is still in a very early planning state) is to carry out a global scale measurement campaign of $O_3$ and its most important precursors, including hydrocarbons, CO and NO$_x$, during a period of at least one year. The main purpose of such a campaign is to establish a global data base for validation of chemistry/transport models to be used for assessing the current and potential future anthropogenic impact on the chemical composition of the troposphere. A key component of ITOY will be an expanded network of ozonesonde (and perhaps lidar) stations, with additional sites particularly in tropical and subtropical areas. Measurements from aircraft, ships and satellites will also be a fundamental part of ITOY.

3.4 Atmospheric Chemistry and Environmental Education in Global Change (ACE$^E$D) -- Professor Kenneth L. Demerjian

3.4.1 The growing need to understand the composition of the Earth’s atmosphere and how and why it changes has become increasingly apparent in the last decade. Issues of stratospheric ozone depletion, global climate change and regional pollution are problems of great interest to today’s society and require substantial scientific insight to address in a meaningful and cost-effective manner.

Scientists trained and educated in atmospheric chemistry and the environment are in limited supply and the need in developing and developed countries is critical. The IGACT programme recognizes the importance of a strong emphasis on education and training and the need to create the appropriate infrastructure within developing countries to enhance their scientific capacity to realize the full benefits of participation in IGAC as well as deal with the scientific and environmental policy challenges facing the global community.
Goal

- To coordinate education activities aimed at promoting understanding of global change in the chemistry of the atmosphere, and its relationship to the biosphere, geosphere and to anthropogenic activities, internationally, both in the developing and developed countries and countries in all climate regions.

3.4.2 Implementation

To promote education and training in this field, scientists in IGBP/IGAC, and GCOS/GAW have agreed to join forces with those in START and pool their expertise to design and execute an integrated approach to "academic capacity building" in developing countries. The mechanism involves the establishment of a pool of voluntary lecturers recruited from the international scientific community to carry out the educational mission. This highly interactive and interrelated education/training programme will:

- Establish atmospheric chemistry programmes at the undergraduate level at universities in developing countries;

- Provide graduate research assistantships at cooperating universities with PhD programmes in atmospheric chemistry for qualified students from developing countries;

- Initiate and expedite employment opportunities at all levels (BS, MS, PhD) in support of IGBP/IGAC, GCOS/GAW and START activities in developing countries (open to students who successfully participated in (1) and/or (2) above);

- Develop and offer short courses/training workshops on topics of interest to IGBP/IGAC, GCOS/GAW (participants include professionals from universities, research projects and monitoring programmes).

The "academic capacity building" process is an extremely challenging opportunity and one that is long term in nature. The intent of ACEED will be to develop a strategic plan which outlines a methodical approach for identifying the incremental steps to be taken in pursuit of basic goals of the programme. In this context the establishment of the "volunteer teaching/training cadre" is an important first step in the ACEED strategic plan and an essential component of the capacity-building activity.

3.4.3 Capacity Building in Developing Countries

Through the coordination of IGAC, START, IAI and GAW and a series of workshops under the auspices of the WMO a plan to design and implement jointly a capacity-building programme in developing countries for atmospheric chemistry has been prepared. An initial first step in the implementation of this plan requires seed funds for the establishment of the international cadre of volunteer scientists.

Goal

- To develop an integrated approach to academic capacity building in atmospheric and environmental chemistry in cooperation with multinational research/monitoring/assessment programmes with the participation of an international cadre of volunteer scientists.

3.4.4 Short-Term Objectives

- Initiate implementation of a "volunteer teaching corps of scientists" through a recruitment under the auspices of the American Geophysical Union (AGU) and the International Union of Pure and Applied Chemistry (IUPAC);
The American Geophysical Union (AGU) coordinates the international recruitment efforts and publishes the "Announcement for Atmospheric Chemists" in EOS;

Establish a steering committee responsible for the development of curricula and courses designed for:

- Training professionals/researchers/teachers from the physical sciences in atmospheric chemistry as it relates to global change processes, environmental quality and related research monitoring and assessment activities;
- Training science faculty interested in introducing atmospheric chemistry and its related areas into the undergraduate programme.

Convene workshops made up of selected members from the "volunteer teaching/training cadre" to define course offerings for designated programmes and develop detailed outlines of course content;

Prepare a proposal for submission to an international funding agency to establish a global education and training programme in atmospheric chemistry;

Implement the first "academic capacity building" pilot project in South America.

3.4.5 Long-Term Objectives

Establish atmospheric chemistry programmes at the undergraduate level at universities in developing countries;

Develop career opportunities at all professional levels within the multinational research/monitoring/assessment programmes that are operational in developing countries;

Design and conduct training workshops for the WMO Global Atmosphere Watch (GAW) programme responsive to the research and operational support needs for professional and technical personnel in developing countries;

Develop and offer short courses/training workshops on topics of interest to IGBP/IGAC, GCOS/GAW (participants include professionals from universities, research projects and monitoring programmes);

Prepare a proposal for submission to an international funding agency to establish an education and training programme in environment/air pollution chemistry for developing countries.

4. WORKSHOP REPORT

4.1 Subworking Group I (Dr J.M. Hales, Chairman)

4.1.1 Overview

The primary objective of Working Group 1 was to examine specific proposed and ongoing projects related to global tropospheric ozone research, and to report group suggestions regarding the organization and conduct of these efforts. The relationships and interactions of the Global Atmosphere Watch (GAW), the Global Ozone Network (GLONET) and the International Tropospheric Ozone Year (ITOY) are of primary interest in this regard, since these organizations coordinate much of the research that is either occurring or proposed within this general scientific area.

GAW, GLONET and ITOY were discussed in some detail during the workshop, along with several of the more specific ozone-related efforts that exist within these coordination groups.
as well as elsewhere, and as an introduction to this report the Working Group emphasizes three of its most important points of agreement. These are itemized as follows:

- The ITOY programme, if conducted in a carefully designed and expedient manner, will result in a major and needed advancement of our understanding of the behaviour and current state of global tropospheric ozone. The Working Group gives its strong endorsement to the ITOY concept, and encourages further development of its scientific design and, ultimately, its successful execution;

- The Working Group was particularly impressed with the new ozonesonde calibration facility built and operated by the Research Center KFA at Jülich, Germany, and its proposed Jülich Ozone Sensor Intercomparison Experiment (JOSIE). The Working Group feels that successful operation of this project will measurably advance the quantitative validity of balloon-borne ozone measurements, and strongly encourages and endorses this activity;

- The Working Group was also highly impressed with the ongoing MOSAIC project, which deploys ozone-monitoring equipment on commercial Airbus flights to provide widespread and routine measurements along aircraft flight routes. The Working Group encourages the prompt release of existing MOSAIC data for analysis to the extended research community, and continued operation of the project during future years;

Working Group comments substantiating these three general endorsements appear in the sections immediately below.

4.1.2 GAW/GLONET/ITOY Relationships and Interactions

Although the GAW, GLONET and ITOY functional elements share major areas of scientific interest, each has its individual organizational basis and historical background. GAW is an organizational component of the World Meteorological Organization (WMO), while GLONET is a functional element of the International Global Atmospheric Chemistry (IGAC) programme. ITOY is also an IGAC initiative; but it has arisen more recently and somewhat spontaneously, and its exact organizational relationship within IGAC is currently unclear. Although substantial commonality exists between these programmes, each tends to have its own scientific emphasis. GAW’s primary interest is in long-term monitoring of ozone concentrations in both the troposphere and the stratosphere. GLONET shares this interest, but addresses process-oriented research as well. ITOY’s primary interest is in providing comprehensive global ozone measurements over a relatively short (1 to 2 year) period, and indeed expects to complete its measurements during 1998 and 1999. GLONET and ITOY focus primarily on tropospheric, as opposed to stratospheric ozone; but the obvious interrelationships between the two atmospheric layers necessitate cognizance of some elements of stratospheric behaviour as well. Individual features of the GAW/GLONET/ITOY interrelationship are discussed sequentially below.

4.1.2.1 GLONET and Its Relationship to GAW

As noted above, the GAW and GLONET programmes share a large number of interests pertaining to atmospheric ozone, from the standpoints of both scientific understanding and general assessment. In view of this commonality, GLONET and GAW have recently established a formal "seamless" linkage, which sets a firm basis for resource pooling and other cooperative operations. This arrangement will economize and streamline global tropospheric ozone research appreciably, and is strongly endorsed by the Working Group.

4.1.2.2 ITOY and Its Relationship to GLONET within the IGAC Structure

As noted in Section 4.1.1 above, the Working Group strongly endorses the overall objectives and the scientific and educational merits of the ITOY endeavour. Furthermore, we feel strongly that the functional relationship of ITOY within IGAC must be defined in a precise manner to ensure efficient and smooth development of the ITOY programme. Recognizing that there is
extensive overlap in the motivation and objectives for GLONET and ITOY, the Working Group urges the IGAC Scientific Steering Committee to clarify, at the earliest opportunity, just how the ITOY activity is to fit in the organizational structure of IGAC.

Although it is not the Working Group’s purview to determine the precise nature of this administrative structure, we foresee two viable possibilities; either the ITOY activity could be elevated to comprise a new IGAC activity in itself, or ITOY and GLONET could be merged. Under either circumstance the committee wishes to stress the importance of encouraging and maintaining the ITOY initiative.

4.1.2.3 GAW and Its Future Relationship to ITOY

The Working Group suggests that, at the successful conclusion of ITOY, it will be appropriate and very desirable for WMO GAW to encourage and coordinate the continued (long term) operation of a selected subset of the ITOY-established ozonesonde stations.

4.1.2.4 The ITOY Scientific Design

In considering the draft ITOY proposal the Working Group noted several concerns, particularly with regard to the ITOY’s Global Environment Facility (GEF) component, which are itemized in the following subsections.

4.1.2.4.1 The need for a more comprehensive scientific design: Currently available documentation does not reflect a high level of scientific rationale or planning in ITOY’s design, particularly regarding criteria to be used for siting of the proposed new ozonesonde stations. Information should be presented regarding how station selection criteria will meet basic data requirements needed to satisfy the scientific aims of ITOY. For example, is this the optimal network size and observation frequency to provide the short-term climatology that is a primary aim of ITOY? Will more observations be needed or can it be done with fewer?

4.1.2.4.2 The need for stronger ties with existing and anticipated tropospheric measurement systems, and reflection of these in ITOY’s scientific design. Additional emphasis within ITOY should be placed on the continuation and enhancement of the existing programmes where ozonesonde measurements are already being made. Along with the enhancement of the ozonesonde measurements programme planned for ITOY, it is important to integrate information from the existing ozone profiling systems, surface ozone observations (including high-altitude sites), aircraft measurements (for example MOSAIC and special campaigns), and satellite platforms (particularly the upcoming GOME mission) into a comprehensive observational data set.

4.1.2.4.3 The need for stronger ties with the stratospheric ozone measurement community. The Working Group strongly recommends that the ozonesonde observations to be made as part of ITOY cover the full altitude range from the surface to 35 km. While it may be more economical to terminate balloon flights at or just above the tropopause, numerous advantages would be obtained by continuing flights into the middle stratosphere. As well as enabling evaluation of the total ozone column, useful, by comparison with satellite total ozone, as a sonde data validation and QA measure, full profiles would also greatly enhance the volume of sonde-derived stratospheric ozone data, hence contributing to WMO GAW objectives, and provide a valuable source of validation data for satellite-derived ozone measurements, such as those from GOME. This information is also important for studying stratosphere/troposphere exchange processes.

Within this context, we note that this suggestion applies not only to ITOY, but to GAW and GLONET as well. The Working Group perceives something of an artificial disconnect between tropospheric and stratospheric ozone research in this regard; because of commonality of many of the measurement methods as well as the obvious process coupling between the two spheres, this disconnect is scientifically undesirable and should be minimized as much as is possible within the administrative constraints imposed on the two research areas.
4.1.3 Ozoneonide Calibrations and Intercomparisons

4.1.3.1 Jülich Ozone Sensor Intercomparison Experiment

4.1.3.1.1 Background

Past field intercomparisons between different ozone sondes sensor types have shown that there have been relative differences of the response to ozone between different sensor types and that these relative differences may have been changing with time. The accuracy of the sensor types were generally not assessed during the intercomparisons because there was usually no reference standard to which the ozone sondes could be compared.

To address the question of the accuracy of different ozone sensors, the Institut für Chemie der Belasteten Atmosphäre at Jülich, Germany, developed an environmental simulation chamber (ESC) capable of simulating ozone sondes flight conditions. The chamber controls pressure between 10 and 1000 hpa, temperature between 200 and 300 K and ozone mixing ratio between 5 and 10000 ppbv. The ozone concentration is measured by a UV photometer standard which is calibrated to an estimated accuracy of ± 2%. The Working Group discussed this facility and its application at some length, and recommends proceeding along the general lines of the experimental approach outlined in the sections immediately following.

4.1.3.1.2 Jülich Environmental Simulation Chamber Experiment (JOSIE): Objectives and expected products

It is proposed that an experiment be conducted at the Jülich ESC in February 1996 to assess the performance of different ozone sensor types. Goals of the Jülich Ozone Sensor Experiment (JOSIE) are to:

- Characterize different ozone sensor types used in GAW under controlled laboratory conditions, and thus provide a statistically robust data base to determine precision and accuracy of ozone sondes measurements as a function of sensor type, altitude, and ozone level;

- Develop and update standard operating procedures (SOPs) for both pre-flight operations and post-flight data reduction, to ensure homogeneous data quality for the ozone sondes stations operating in GAW/GLONET.

The experiment is designed to evaluate the sensitivity, precision and accuracy of each sensor type at different pressure altitudes and ozone levels. Questions addressed by the experiment include:

1. How do pre-launch procedures influence post-launch sondes performances?
2. What is the time response of the different sensors?
3. How is the data analysis affected by such procedures as
   - background signal correction
   - total ozone column normalization?

4.1.3.1.3 Preparation for the JOSIE

The chamber experiment should include participants representing all types of ozone sensor types currently operating in GAW. These sensor types include:

(1) Brewer-Mast

   -- standard pump
   -- Teflon pump
(2) ECC -- science pump
        -- EN-SCI

(3) Japanese KC79 sensor

(4) Indian sensor

Nine months prior to the experiment the hosts at Jülich will provide to WMO detailed technical information and description of the ESC facility for distribution to the participants. Also a questionnaire is to be distributed to the participants requesting technical information regarding their operation. All participants will also submit their normal operating procedures to the intercomparison organizers prior to the experiment.

4.1.3.1.4 Experiment, Test and SOP in Use by WMO Member Countries

4.1.3.1.4.1 Setup of the Environmental Simulation Chamber (ESC)

An environmental simulation chamber for comparison of the different balloon-borne electrochemical ozonesondes (ECC and Brewer-Mast) that are used in the GAW network is operated. The chamber has a test room volume of 500 liters (80 x 80 x 80 cm), and pressure as well as temperature can be dynamically regulated between 10 and 100 hpa and between 200 and 300 K (rate = ± 2 K/min), respectively. The volume mixing ratio of ozone can be simultaneously regulated between 5 and 10000 ppb. The chamber is computer controlled such that vertical profiles of pressure, temperature and ozone concentration under realistic atmospheric flight conditions of ozone soundings up to an altitude of about 28 km can be simulated. As reference instrument for the measurement of ozone a dual-beam UV photometer with a time resolution of 1-2 seconds and an accuracy of better than 1-2 percent is used.

4.1.3.1.4.2 Experimental Design

The experimental setup for the simulation of the vertical ozone soundings in the chamber is shown in Figure 1. In several simulation experiments, four different types of ozonesondes can be "flown" simultaneously and compared to the UV photometer. Two different types of vertical profiles of pressure, temperature and ozone concentrations can be simulated. The first type of profile will be a typical mid-latitude profile taken from the US Standard Atmosphere (1976) for 40-50°N with a tropopause height of 12 km. The second type of profile relates to typical tropical conditions of high convective activity, high tropopause at 18 km and low tropopause temperature which means extremely low ozone values in the middle and upper troposphere (1).

The pressure and temperature in the ESC will change according to ascent velocities of 5 m/s up to a burst altitude corresponding to 35 km. During the ascent profiling, several tests will be performed to characterize the response time of the different ozone sensors. Special attention will be given to the "background current" signal in the troposphere as well as the stratosphere.

4.1.3.1.4.3 Time Schedule

The ozone intercomparison will take place in February 1996 at the Ozone Sonde Calibration Facility at the research Center KFA-Jülich, Germany. Participation will be split into two groups each of three participants (WMO Members) operating the different ozone sensors listed above. Each of these groups will participate in a two-week period doing intercomparisons in the ESC.

A total of five simulation experiments of vertical ozone soundings can be performed during this period, and the whole intercomparison campaign will take four weeks of operation at the ESC facility.
4.1.3.2 In-Flight Intercomparison of Ozone sondes and Airborne UV-Photometer

The Working Group also discussed the idea of additional confirmatory checks of ozonesonde performance using coincident aircraft measurements of ozone (and perhaps other trace gas species) during specific ozonesonde ascents. In so doing it was recognized that simultaneous aircraft measurements are not considered redundant with the chamber studies, but instead provide the unique capability to investigate statistical aspects of sampling representativeness and effects of co-varying fields of potentially interfering pollutants such as \( \text{SO}_2 \) and \( \text{NO}_x \). As such, the Working Group suggested that key objectives of a proposed aircraft comparison should include the following:

1. Obtain near-coincident ozone measurements using ozonesondes and airborne UV-photometer for intercomparison;

2. Obtain high temporal resolution aircraft measurements of free tropospheric ozone to enable subsequent investigation of the spatial representativeness of individual ozonesonde profiles;

3. Investigate the covariability on different spatial scales of ozone and pollutants such as \( \text{SO}_2 \) and \( \text{NO}_x \) using aircraft data.

General features of aircraft measurements to accomplish these objectives involve deployment of the DLR Falcon aircraft, equipped with an onboard UV ozone photometer suitable for ozone measurement in the low-pressure environment of the tropopause region. The aircraft will be used to make correlative ozone measurements for intercomparison with ozone data obtained by balloon sondes at Hohenpeissenberg, Payerne and possibly Uccle.

The ozonesonde flights and aircraft flight plan will be coordinated to enable near-coincident measurements of ozone by each instrument for subsequent intercomparison. The fast-response aircraft instruments will also continuously monitor ozone, \( \text{NO}_x \), and \( \text{SO}_2 \) as the aircraft proceeds from one balloon location to the next, and during ascent and descent, hence enabling the desired analysis of the spatial variability, both horizontal and vertical, and covariability of these trace gases.

4.2 Subworking Group II (Mr. G. Müller, Chairman)

4.2.1 Overview

The spread of QA/SAC activities is broad, steps in their implementation need to follow therefore a strategy with clearly defined priorities. This operational strategy is based on the principal elements of scientific quality assurance and involves (GAW, 80, 92, 93 and 97):

- Development of data quality objectives (DQOs) for each GAW measurement parameter. The DQOs are defined by accuracy, precision, completeness, comparability and representativeness and derived after consultations with the appropriate international scientific community(ies) (workshops, position papers, etc.);

- Development, distribution and maintenance of reference standards for all GAW parameters in cooperation with the QA/SAC-World Calibration/Instrument Intercomparison Facilities;

- Development of quality control procedures for all GAW sites which include all measures that influence data quality. Of particular importance are (1) adherence to standard operation procedures (SOPs) for each measurement parameter; (2) twinning arrangements between a well-established and a newly formed station; (3) organization of focused training/education workshops for station personnel; and (4) capacity building in those countries where scientists trained and educated in atmospheric chemistry and
related physical sciences are in such limited supply that the GAW activities could not be sustained over an extended period of time;

- Development of quality assessment capabilities to ensure continued maintenance of DQOs. This assessment is provided through data reviews (flagging) and expert consultations (system and performance checks).

The QA/SAC has built global alliances with internationally recognized research institutes/organizations for the purpose of sharing quality assurance responsibilities and exchanging scientific know-how particularly in the area of calibration standards. In addition to the existing calibration centres for carbon dioxide, Dobson and Brewer column ozone, a total of eight new World Calibration Facilities have been established to date and assigned as follows:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface ozone</td>
<td>EMPA/SMI</td>
</tr>
<tr>
<td>CO</td>
<td>NOAA-CMDL/IFU</td>
</tr>
<tr>
<td>Radioactivity</td>
<td>DOE-EML</td>
</tr>
<tr>
<td>Aerosol physics/chemistry</td>
<td>IFT</td>
</tr>
<tr>
<td>Aerosol optical depth</td>
<td>WORCC/SMI</td>
</tr>
<tr>
<td>Greenhouse gases</td>
<td>JMA/NOAA-CMDL</td>
</tr>
<tr>
<td>Radiation</td>
<td>WRC</td>
</tr>
<tr>
<td>Precipitation chemistry</td>
<td>EPA/SUNYA-ASRC</td>
</tr>
</tbody>
</table>

The QA/SAC for Europe and Africa has now been operational since January 1, 1993, and has already made significant progress in quality assuring the WMO Global Atmosphere Watch (GAW) programme as stated by a group of experts assembled by WMO. During the week of 6 March 1995, the WMO Executive Council Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry met in Garmisch-Partenkirchen to review the WMO Global Atmosphere Watch programme. As a major contribution to GAW, the Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie (BMBF) has supported the activities of the Quality Assurance/Science Activity Centre (QA/SAC) for Europe and Africa. At the request of the Panel/Working Group, the first two years of operation of the QA/SAC were reviewed by a committee of outside experts, based on a report prepared by Professor Mohnen (Annex D). The experts presented the Panel with a report showing that the QA/SAC has done an outstanding job in providing GAW with its first coordinated quality assurance programme and that the continued operation of the QA/SAC is essential to the success of the GAW programme.

The QA/SAC responsible for the Americas has been in operation since January 1, 1995, and is located at the State University of New York at Albany (SUNYA/ASRC). NOAA, DOE, and EPA are responsible for the QA/SAC Americas, each with their own policies and interests. The QA/SAC responsible for Asia/Oceania will begin operation on April 1, 1995, under the sponsorship and direction of the Japan Meteorological Agency (JMA).

With all three QA/SACs becoming operational during 1995 and with additional World Calibration Facilities (WCFs) being established in support of GAW QA activities, the primary objective of Working Group II was to provide guidance regarding the conduct of and coordination between QA/SACs and WCFs.

4.2.2 Establishment of World Calibration Facilities (WCFs)

Table 4.1 identifies the institutions responsible for the activities of the World Calibration Facilities, GAW QA/SACs and World Data Centres (WDCs).
<table>
<thead>
<tr>
<th>Species</th>
<th>Region</th>
<th>World Calibration Centres</th>
<th>World QA/SACs</th>
<th>World Data Centres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface O₃</td>
<td>Am</td>
<td></td>
<td>SUNY</td>
<td></td>
</tr>
<tr>
<td></td>
<td>E/A</td>
<td>EMPA</td>
<td>SUNY-IFU</td>
<td>IFU</td>
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<tr>
<td></td>
<td>A/O</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Ozone sondes</td>
<td>Am</td>
<td>KFA</td>
<td>SUNY</td>
<td>AES</td>
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<td></td>
<td>E/A</td>
<td></td>
<td>IFU</td>
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<tr>
<td></td>
<td>A/O</td>
<td></td>
<td>JMA</td>
<td></td>
</tr>
<tr>
<td>Total Ozone</td>
<td>Am</td>
<td>CMDL/AES</td>
<td>SUNY</td>
<td>AES</td>
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<td></td>
<td>E/A</td>
<td></td>
<td>IFU</td>
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<td></td>
<td>A/O</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>Am</td>
<td>CMDL/IFU</td>
<td>IFU</td>
<td>JMA</td>
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<tr>
<td></td>
<td>E/A</td>
<td></td>
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<td></td>
<td>A/O</td>
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<td></td>
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<tr>
<td>CO₂</td>
<td>Am</td>
<td>CMDL</td>
<td>JMA</td>
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<td></td>
<td>E/A</td>
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<td></td>
<td>A/O</td>
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<tr>
<td>N₂O</td>
<td>Am</td>
<td></td>
<td>*</td>
<td>JMA</td>
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<td></td>
<td>E/A</td>
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<td>A/O</td>
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<tr>
<td>CH₄</td>
<td>Am</td>
<td></td>
<td>*</td>
<td>JMA</td>
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<td></td>
<td>E/A</td>
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<td></td>
<td>A/O</td>
<td>*</td>
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<tr>
<td>VOCs</td>
<td>Am</td>
<td>IFU/NILU</td>
<td>IFU</td>
<td>JMA</td>
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<td></td>
<td>E/A</td>
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<tr>
<td></td>
<td>A/O</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>SOₓ, NOₓ</td>
<td>Am</td>
<td></td>
<td>*</td>
<td>JMA</td>
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<td></td>
<td>E/A</td>
<td>*</td>
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<tr>
<td></td>
<td>A/O</td>
<td>*</td>
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<tr>
<td>CFCs</td>
<td>Am</td>
<td></td>
<td>*</td>
<td>JMA</td>
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<td></td>
<td>E/A</td>
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<td></td>
<td>A/O</td>
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<tr>
<td>³⁶Kr</td>
<td>Am</td>
<td></td>
<td>*</td>
<td>JMA</td>
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<td></td>
<td>E/A</td>
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<tr>
<td></td>
<td>A/O</td>
<td>*</td>
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<td></td>
</tr>
<tr>
<td>Rn, ⁷Be, ²¹⁰Pb</td>
<td>Am</td>
<td>EML</td>
<td>SUNY</td>
<td>JMA</td>
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<tr>
<td></td>
<td>E/A</td>
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<tr>
<td></td>
<td>A/O</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Precipitation</td>
<td>Am</td>
<td>QA/SAC Am &amp; E/A and US EPA</td>
<td>SUNY</td>
<td>NCDC</td>
</tr>
<tr>
<td>Chemistry</td>
<td>E/A</td>
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<td></td>
<td>A/O</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Optical Depth</td>
<td>Am</td>
<td>PMOD</td>
<td>SUNY</td>
<td>NCDC</td>
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<td></td>
<td>E/A</td>
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<td></td>
<td>A/O</td>
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<tr>
<td>UV</td>
<td>Am</td>
<td></td>
<td>*</td>
<td>AES</td>
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<td></td>
<td>E/A</td>
<td>*</td>
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<tr>
<td></td>
<td>A/O</td>
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<tr>
<td>Aerosols</td>
<td>Am</td>
<td>IFT</td>
<td>*</td>
<td>ISPRA</td>
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<tr>
<td></td>
<td>E/A</td>
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<tr>
<td></td>
<td>A/O</td>
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</table>

*To be determined*
ensure and quantify the quality of the empirical data relevant to that facility. The procedures, techniques and infrastructure required to provide quality assurance to precipitation chemistry, carbon dioxide, and ozone column density obtained from Dobson and Brewer instruments are already in place and will be the responsibility of QA/SAC Japan (CO$_2$) and Americas, respectively.

For the greenhouse gases CH$_4$ and N$_2$O, volatile organic compounds (VOCs), nitrogen and sulfur compounds, and UV-B no recommendation was made by the subgroup. The QA/SACs will work out proposals for the establishment of corresponding calibration facilities.

For some calibration centers (e.g. CO, aerosol optical depth) dedicated advisory groups are recommended. The composition of these advisory groups will be determined by the responsible WCF and submitted for approval to the chairman of the EC Panel/CAS Working Group.

Currently Quality Assurance Project Plans (QAP)Ps are only available for surface ozone. For the other parameters they have to be developed by the QA/SACs with the help of the established WCFs and their associated advisory groups.

4.2.2.1 The Surface Ozone World Calibration Center

EMPA was designated as the calibration center for surface ozone measurements. The QAP)Ps for surface O$_3$ measurements are available in GAW Report No. 97, including the audit procedures. The major costs for operating the facility are covered. An SOP draft is also available and will be revised in the course of the work according to the acquired experience.

The question of how audits are to be planned and funded was discussed. QA/SAC Europe and Africa will fund audits when costs exceed the calibration facility's budget on a case by case basis. It was also recognized that negotiations between QA/SAC Europe-Africa and QA/SAC Asia-Oceania must occur in order that the quality assurance of surface ozone measurements will be available to the Asia and Oceania region.

QA/SAC Europe-Africa will inform the GAW stations of the establishment of the world calibration facility for surface O$_3$ measurements, and will provide a list of the stations to be audited to EMPA. The subgroup approved and accepted the proposed activities of the world calibration centre presented in Table 4.2.

4.2.2.2 Carbon Monoxide World Calibration Facility

The World Calibration Facility for carbon monoxide has been established at CMDL in Boulder, Colorado, and IFU Garmisch-Partenkirchen to provide the research community with CO reference gases at atmospheric concentrations. All standards prepared in the laboratory are referenced to the calibration scale developed at CMDL. Some funds have been provided by the WMO to equip this facility, but additional support for personnel is needed. CO standards will be provided to the GEF-GAW sites at the cost of preparation.

CMDL is responsible for the maintenance of the calibration scale, for the preparation of the standards and, jointly with the QA/SACs, for preparing the Quality Assurance Project Plan (QAP) and for organizing global CO intercomparisons. IFU will provide independent evaluation of the standards, perform audits at GEF/GAW stations, provide test gas samples to the stations and help coordinate intercomparisons (see Table 4.3).

CMDL and IFU recommended that at the stations test gases should be analyzed daily to aid in the quality control of station measurements. A global intercomparison network should be established to define systematical differences in measurements between laboratories around the world. Performance audits are envisioned on a yearly basis. The procedure to perform the audits will be part of the SOP to be developed. The QAP must be defined by a group of experts under the auspices of the WMO.
4.2.2.3 World Optical Depth Research and Calibration Centre (WORCC)

The Center is funded for several years by SMI. QAP should be defined by a group of experts under the auspices of WMO. The implementation of the QA/QC plan can start immediately. The development of calibration techniques will depend on the defined data quality objectives. The specific tasks of the centre are defined in Table 4.4.

Table 4.2. WMO World Calibration Center for Surface Ozone

RESPONSIBILITIES OF THE CALIBRATION CENTER

The Air Pollution and Environmental Technology section of the Swiss Federal Laboratories for Materials Testing and Research (EMPA) operates the surface ozone calibration center for Europe and Africa.

General Goals

- Quality assurance of surface ozone measuring, in particular the traceability of ozone measurements of the national networks in Europe and Africa to the GAW ozone standard (NIST UV-photometer).

- Providing training and education in the field of surface ozone measuring, in particular for countries starting the measurements of air pollutants.

Specific Tasks

1. To maintain a NIST UV-photometer as a primary calibration standard for surface ozone measurements within GAW as the QA/SAC designated calibration center. To maintain a transfer standard instrument traceable to the NIST UV-photometer. To trace the GAW-standard back to the reference instrument of NIST in Gaithersburg.

2. To develop relevant quality control procedures (e.g. SOPs) in cooperation with the QA/SAC.

3. To perform regular system and performance audits at the GAW sites using the transfer standard. These system and performance audits follow the QA activity schedule as determined by the QA/SAC. The audit-reports are submitted to the QA/SAC.

4. To organize and perform instrument inter-calibrations of surface ozone.

5. To instruct operators and hold trainings in the field of measuring atmospheric surface compounds (ozone, reactive gases, wet deposition). To assist national network authorities in establishing new stations or instruments.

6. To cooperate with the group of experts established by the QA/SAC supervision, auditing and assisting the activities of the calibration centers.

7. To report annually to the Swiss Meteorological Institute (Swiss representative of WMO) on the work done during the year and submit a programme for the coming year for approval.
Table 4.3. Activities for the Coordination of CO Measurements: Collaborations between CMDL and IFU

<table>
<thead>
<tr>
<th>1. CMDL</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Maintenance of the CMDL/WMO calibration scale</td>
</tr>
<tr>
<td>(B) Provide CO standards to the community</td>
</tr>
<tr>
<td>(C) Help coordinate global intercomparisons of CO measurements</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. IFU</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Provide independent evaluation of the CMDL standards</td>
</tr>
<tr>
<td>(B) Participate in QA/QC of GEF/GAW sites</td>
</tr>
<tr>
<td>- review measurement results</td>
</tr>
<tr>
<td>- provide “test gases” for daily operations</td>
</tr>
<tr>
<td>- provide external audits of site operations</td>
</tr>
<tr>
<td>(C) Help coordinate global intercomparisons of CO measurements</td>
</tr>
</tbody>
</table>

4.2.2.4 World Calibration Centre for Radioactivity

The proposed activities and responsibilities for the Centre are outlined in Table 4.5. Data quality objectives (DQOs) are not yet defined, so that QAPjP, associated SOPs and audit procedures have not been formulated. WMO will organize a workshop of the international scientific community in cooperation with QA/SAC America to define the DQOs.

The radionuclides of interest include 7Be, 210Pb and 222Rn. EML can provide filters spiked with nuclide standards traceable to NIST twice a year for assessment of analytical performance. The quality assurance protocols for 222Rn measurements have yet to be determined because they will depend upon the characteristics and expected levels at individual sites.

There is presently no data centre for radioactivity in GAW and little radioactivity monitoring at the GAW global stations. This provides a unique opportunity to build a monitoring network from scratch, unobstructed by the ballast of historical developments.

4.2.2.5 World Calibration Centre for Radiation

The World Radiation Centre (WRC) at Davos is involved in the calibration of instruments within the WWW-Programme of WMO. The spectrum covers shortwave and longwave radiation. SOPs already exist for many of the radiation instruments.

With regard to UV-B measurements the EC Panel/WG CAS has established a steering committee whose responsibilities are to develop a plan for UV-B measurements and QA aspects for GAW.

Longwave measurements are an integral part of the BSRN-Programme within WRCP. BSRN has its own central world facilities. The subgroup recommended to rely on the existing organization structures for UV-B and longwave radiation and not to develop separate calibration centres under GAW.

4.2.2.6 World Calibration Centre for Precipitation Chemistry

The data quality objectives (DQOs) for the GAW precipitation chemistry network are given in WMO Report No. 80. The centre is now being installed at the QA/SAC-Americas in Albany, NY, and relies on EPA for calibration standards. The centre will accept data from the whole world and assesses the data quality using a Canadian (AES, Toronto) computer-based programme that has been modified and tailored to accept WMO data. A direct computer link
between the Albany data centre and AES will be established. The GAW data will subsequently flow from SUNY, Albany, to the World Precipitation Data Center in Asheville, NC.

Table 4.4. Specification of the World Optical Depth Research and Calibration Centre

<table>
<thead>
<tr>
<th>The World Optical Depth Research and Calibration Centre (WORCC), operated by the Physikalisch-Meteorologisches Observatorium Davos, Switzerland, provides the following tasks:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• develop accurate radiometric references for spectral solar radiometry used to determine optical depth (as in the case of the World Radiometric Reference for total solar irradiance radiometry);</td>
</tr>
<tr>
<td>• develop procedures to ensure worldwide homogeneity of optical depth measurements by e.g. providing transfer standards for solar precision filter radiometry (formerly called sunphotometry);</td>
</tr>
<tr>
<td>• develop and test new instrumentation and methods for the determination of optical depth;</td>
</tr>
<tr>
<td>• implement a trial phase at the GAW GLOBAL OBSERVATORIES with Solar Precision Filter Radiometers (SPFR) to test methods for optical depth determination and calibration transfer;</td>
</tr>
<tr>
<td>• develop relevant quality control procedures in cooperation with the GAW Quality Assurance/Science Activity Centres;</td>
</tr>
<tr>
<td>• train operators of Solar Precision Filter Radiometers (SPFR).</td>
</tr>
</tbody>
</table>


The implementation of the World Optical Depth Research and Calibration Centre (WORCC), operated by the Physikalisch-Meteorologisches Observatorium Davos, Switzerland, shall follow the following plan:

- March 1995 (EC Panel): Establishment of a group of experts (WORCC/GAW-WG) with the following charter:
  - assist the WORCC in defining its tasks;
  - establish in cooperation with the WORCC the specifications for new Solar Precision Filter Radiometers (SPFR) and standard references;
  - define the objectives of the comparison experiments and the implementation of the trial phase;

- July 1995: First session of the WORCC/GAW-WG: Resolutions about Solar Precision Filter Radiometer (SPFR) specifications (wavelength, bandwidth, field of view, stability, etc.) and calibration strategy;

- August 1995: start of detailed design and construction of trial phase SPFR;

- January 1996: adaptation of the spectral radiometric calibration facility at PMOD/WRC for the SPFR (based on the absolute measurement of a cryogenic radiometer with an accuracy of 0.01% at specific laser wavelengths and on the transfer and interpolation by silicon trap detectors with an accuracy of < 0.1% for 450 nm < \( \lambda \) < 850 nm; < 0.3% for 350 nm < \( \lambda \) < 450 nm);

- July 1996: testing and verification of the specifications of the new SPFR at Davos and Jungfraujoch; development of operational and quality control procedures including calibration strategies;

- January 1997: start to supply GAW GLOBAL OBSERVATORIES with SPFR and training of observers at Davos; test of calibration transfer procedures.
Table 4.5. World Calibration Centre for Environmental Radioactivity

Responsibilities of the Calibration Center

The Environmental Measurement Laboratory (DOE-EML, New York, NY) will operate the radioactivity calibration centre.

General Goals

Under the auspices of QA/SAC Americas:

EML implements a GAW-approved quality assurance plan for the determination of natural and anthropogenic radioactivity in surface air.

EML provides training and education in the techniques of monitoring radioactivity in surface air for operators of designated GAW sites.

Specific Tasks

1. In collaboration with QA/SAC Americas, EML will specify the Data Quality Objectives for the measurement of radioactivity in surface air.

2. EML will develop a quality assurance plan and standard operating procedures for QA/SAC Americas approval that will outline the steps required to meet the data quality objectives (DQOs), and the steps required to assess the degree to which these DQOs are met.

3. EML will instruct candidate site operators at its laboratory in New York on the techniques, instrumentation and quality assurance issues involved in radioactivity monitoring.

4. EML will analyze the filter samples collected at the new GAW sites for radioactive particulates during the first year of site operation. Subsequently, the site assumes responsibility for the measurements, and will be subject to the quality assurance plan approved by the QA/SAC.

5. EML will provide filter samples spiked with known quantities of radionuclides, which are traceable to NIST, twice a year as external quality control samples.

6. EML will implement the appropriate quality control protocols to assess the performance of radon measurement systems in concert with the DQOs.

7. EML will conduct performance audits at GAW sites on a schedule that is determined by QA/SAC Americas, and will submit audit reports to the QA/SAC and the site operators. The travel costs for these audits will be borne by QA/SAC Americas.

The subgroup advised the Centre and QA/SAC-Americas to implement the following tasks:

- Develop a Quality Assurance Project Plan (QAPjP) for GAW Precipitation Chemistry measurements;
- Provide training to field and laboratory staff as required;
- Upgrade the field and laboratory SOPs in GAW Publication 85;
- Include the measurement of organic acids at GAW sites;
- Provide standard reference materials to needy GAW laboratories;
- Continue to carry out field audits and field intercomparison studies on a systematic basis including, but not limited to, the annual laboratory intercomparison studies;
Establish data management and quality control procedures for:
(a) routine data quality control of all GAW data;
(b) evaluating laboratory intercomparison results with special emphasis on improving
the capabilities of low performing laboratories.

Establish the new World Precipitation Chemistry Data Center in Asheville, NC. Notify
all GAW contributing countries of the new procedures for submitting data. Establish
a data publication/dissemination schedule.

4.2.2.7 World Calibration Centre for Aerosol Physics/Chemistry

The World Calibration Facility for aerosol physics/chemistry is now being established
at the Institute for Tropospheric Research, IfT, Leipzig, Germany.

The GAW aerosol programme is aimed at understanding changes in the atmospheric
aerosol in general and, more specifically, (1) at assessing the direct and indirect effect of the
aerosol on climate through aerosol data representative of different regions, and (2) at determining
the relative contribution of natural and man-made sources to the physical and chemical properties
of the aerosol at locations representative of different regions (GAW Report No. 79). Because of
the significant difficulties in representatively measuring the required physical and chemical
parameters that characterize the atmospheric aerosol system, GAW has proceeded with great
care and restraint in implementing the aerosol component of GAW. With the help and advice
of the World Calibration Centre for Aerosol Physics/Chemistry and its associated advisory
committee, the QA/SACs can now aggressively move ahead in completing the Quality Assurance
Project Plan (QAP) and building up a viable aerosol programme within GAW.

4.2.2.8 World Calibration Centre for Ozonesondes

The GAW-QA/SACs will closely cooperate with the GLONET Coordinating Committee
in implementing the initial ozonesonde calibration/instrument characterization activities outlined
in Section 4.1.3 of this report.

4.2.3 Relationship between QA/SACs

Originally the distribution of activities among the three QA/SACs was planned on a
regional basis (GAW Report Nos. 92, 93). With the aim to augment the effectiveness of
cooperation, the subgroup recommended a change to a distribution of QA functions on the basis
of parameters. This distribution is shown in Table 4.6. Education/training and science activities
will remain regional issues. The QA/SACs are responsible for assessing the quality of the data
from all GAW sites. These operational QA functions represent a heavy load for the centres. The
subgroup therefore advises the QA/SACs to attempt to delegate some of the operational QA
activities to the associated world calibration facilities.

4.3 Subworking Group III

4.3.1 Overview

The status of the Volunteer Teaching corps project and the initial meeting of the
AGU/ACE\textsuperscript{ED} WMO Steering Committee in Washington, DC, with South American representatives
were presented. Two pilot courses have been requested: (1) Photochemical Air Quality Modelling,
and (2) Instrumentation, Measurement Techniques and Sampling Methodologies in Atmospheric
Chemistry. The WMO proposal jointly prepared by QA/SAC, IGAC-ACE\textsuperscript{ED}, AGU IGBP-START and
IAI entitled "Capacity Building in Atmospheric Chemistry for Developing Countries" is complete
and ready for submission to GEF. To be successful it now requires support letters from Ministries
of participating countries which WMO is currently soliciting. The specific role that the ACE\textsuperscript{ED}
Committee will play in support of scientific capacity building associated with WMO/GAW and
QA/SAC related needs was discussed and specific guidelines were recommended.
The World Calibration/Intercomparison Centre for Aerosol Physics and Chemistry will be operated by the Institute for Tropospheric Research (IfT, Leipzig)

- AEROSOL PHYSICS

Generation of Monodisperse Calibration Aerosols
Particles of known composition in the size range 3-10,000 nm, pure or mixed substances are available. Above 1000 nm clean and contaminated water droplets are available.

Particle Measurements
In the size range 5-50,000 nm all manufactured primary standards for particle measurements are available (TSI-UCPC, PMS-PCASP-X, TSI-APS)

Optical Aerosol Properties
A high sensitivity reference integrating nephelometer with sealed chamber can be operated at different pressure and temperature levels down to scattering coefficients of $\sigma_N(\lambda = 550 \text{ nm}) \sim 5 \times 10^8 \text{ m}^{-1}$. With an integrating plate photometer, the absorption coefficient of aerosol samples can be measured for intercomparisons with aethalometers.

- AEROSOL CHEMISTRY

Chemical Reference Samples
Samples of particulate matter (soot, sulfates, crustal components) can be generated for analytical intercomparisons.

Chemical Analysis
For the chemical analyses of aerosol samples ion chromatography, capillary electrophoresis and atomic absorption spectrometers are available.

4.3.2 Atmospheric Chemistry Education

ACE\textsuperscript{ED} has joined with START, the World Meteorological Organization’s (WMO) Global Atmosphere Watch (GAW), the InterAmerican Institute (IAI), the European Experiment on the Transport and Transformations of Environmentally Relevant Trace Constituents in the Troposphere over Europe (EUROTRAC), and several other national and international organizations to design and execute an integrated approach to academic capacity building in atmospheric-biospheric chemistry in developing countries. The initial emphasis will be linked closely to the enhancement of the GAW global observatory network that is under way.

Within the GAW framework most of the impetus for education and training is centered around atmospheric chemistry, a relatively young but technically demanding discipline whose vitality is essential to our ability to respond to society’s need to understand the future of planet Earth. The source of this vitality is, and always will be, the continued entrance of an adequate number of young scientists into the field. Thus, the education/training component of the QA/SACs must attract high-calibre individuals, nurture their creativity and effectively prepare them for professional careers.

To address this need a partnership has been formed with nongovernmental, international research, multinational, and governmental organizations to develop and implement an academic/research capacity building programme. The American Geophysical Union (AGU) with its international membership and in cooperation with the International Union of Pure and Applied Chemistry (IUPAC) has begun to recruit and establish an international Volunteer Teaching Corps. This will enable the establishment of atmospheric chemistry curricula and undergraduate level programmes at universities in developing countries. Stipends will be available through the GAW
for a select number of successful students in the programme to pursue graduate education at cooperating universities around the world. After graduation, students will be able to gain initial experience through IGAC and EUROTRAC research before returning to their home countries with the challenge of contributing to START, GAW, and/or research activities of IGAC. In addition, atmospheric chemistry education programmes will be developed for professionals in national meteorological services who are increasingly challenged with complex assessment tasks outside their traditional areas of expertise and training.

This programme will establish long-term cooperative arrangements with academia, global research and monitoring programmes, and professional societies, all brought together under the framework of the Volunteer Teaching Corps.

Initial funding for a pilot project has been awarded by the US National Science Foundation’s Atmospheric Chemistry Programme to demonstrate the feasibility of this approach. This "proof of concept" grant has enabled the atmospheric chemistry community to convene a workshop in Washington, DC, at the AGU Headquarters during which an atmospheric chemistry curriculum was defined. This initial concept was refined at this meeting and plans for the first two courses were prepared.

4.3.2.1 Short Course in Instrumentation and Measurement Methodologies in Atmospheric Chemistry Research

IGAC’s Atmospheric Chemistry and Environmental Education in Global Change (ACE<sup>ED</sup>) Activity, the InterAmerican Institute for Global Change Research (IAI), Global Change System for Analysis, Research and Training (START), the American Geophysical Union (AGU), and the World Meteorological Organization’s Global Atmosphere Watch (GAW) will sponsor a two-week Advanced Study Short Course for Latin American scientists on "Instrumentation and Measurement Methodologies in Atmospheric Chemistry research" at the University of Buenos Aires/INQUIMAE from 30 October - 10 November 1995. Topics to be covered by members of ACE<sup>ED</sup>'s Volunteer Teaching Corps include:

- Fundamental concepts and measurement principles;
- Overview of instruments used in air pollution and atmospheric chemistry;
- Instrument methodologies;
- Data management;
- Elements of quality assurance/quality control.

There will be space for up to 30 participants. Preference will be given to applicants with a knowledge of fundamental aspects of analytical chemistry or physics. The course will be conducted in Spanish.

Main focus will be on trace substances of atmospheric relevance.

I. Overview: The Measurement System
   - Sampling
   - Measurement
     - Lower Detection Limit
       - Signal-to-noise
       - Signal-to-background
     - Sampling statistics
   - Data Assessment
   - Data Management

II. Fundamentals of QA/QC
   - Calibration Principles
   - Reference Methods
III. Spectroscopic Measurement Techniques
   - Emission Spectroscopy
     Chemiluminescence
     Fluorescence
     Flame Photometry
   - Infrared Absorption Spectrometry
     Beer Lambert Absorption
     Fourier Transform Infrared Spectrometry
     Gas Filter Correlation Techniques
   - Tunable Diode Laser Spectrometry

IV. Ultraviolet/Visible Absorption Spectrometry
   - Differential Optical Absorption Spectrometry

V. Gas Chromatography
   - Combination with Various Detectors
     Flame Ionization (FID)
     Mass Spectrometer (MS)
     Electron Capture (ECD)

VI. Conductometry

VII. Colorimetry

VIII. Coulometry

IX. Enzymatic Techniques

X. Bibliography

4.3.2.2 Short Course in Photochemical Air Quality Modelling

University of Chile, Santiago
20-31 May 1996

I. Photochemical Aspects of Air Quality Modelling
   A. Photochemistry of Atmospheric Species
   B. Theoretical and Experimental Determination of Solar Actinic Flux and of Photolytic
     Rate Constants
   C. Principals of Chemical Kinetics and Laboratory Studies of Atmospheric Reactions
   D. Smog Chamber Experimentation and its Role in Chemical Mechanism Development
   E. Chemistry of Nitrogen Oxides
   F. Chemistry of Volatile Organic Compounds and Natural Hydrocarbons
   G. Reactivity Scales and Characterization Ozone Production Capacity in the
     Atmosphere
   H. Explicit and Condensed Mechanisms of the Chemistry of Polluted Atmospheres

II. Emission Inventories and Air Quality Modelling
   A. Overview of the Distribution of Precursor Emissions
   B. Basic Principles in Emission Inventory Development
      i. Point Source Inventories
      ii. Mobile Source Inventories
      iii. Area Source Inventories
      iv. Biogenic Inventories

III. Air Quality Observations and their Role in Urban AQ Modelling
   A. Initial and Boundary Conditions
   B. Performance Testing and Evaluation
IV. Meteorological Observations and their Role in Urban AQ Modelling
   A. Meteorological Observations: Surface and Upper Air
   B. Objective Wind Field Analysis Approaches
   C. Mixed Layer Heights

V. Fundamental Process Components of Air Quality Simulation Models
   A. Carbon Bond IV vs RADM2 Chemical Modules
   B. Photolytic and Temperature Dependent Rate Constants
   C. Dry Deposition
   D. PBL Dynamics

VI. An Overview of Operational Approaches Used in Ozone Air Quality Management
   A. EKMA
   B. Urban Airshed Model
   C. Regional Oxidant Models

VII. Description and Application of a Photochemical Box Model (PBM)
    A. PBM Formulation and Process Modules
    B. Preparation of Meteorological and Air Quality/Emissions Data Files
       for the PBM
    C. Example Applications of the PBM
       i. Generic Urban Scenario
       ii. Generic Regional Scenario
    D. Analysis of Results/Performance Evaluation Techniques

VIII. PBM Applications Laboratory
      A. Hands on Application of the PBM
      B. Sample Applications Developed from Data Sets Provided by
         Participants
      C. Analysis of Results

IX. Fundamentals of Observational Based Modelling Approaches
    A. Blanchard and Roth Approach
    B. Chang and Suzio Approach
    C. Correlation Analysis Techniques

X. Description and Application of an Observational Based Modelling Approach with
   Laboratory
   A. Techniques to be decided ...

XI. Bibliography

4.3.2.3 The Role of ACEED in Scientific Capacity Building and Training Aspects of GAW and
   Related QA/SAC Activities

The ACEED committee recommends the establishment of Bi-Annual WMO Capacity Building
Regional Training Workshops in addition to the QA/SAC topic-specific workshops which
are in direct support of GAW network activities. The typical bi-annual capacity building regional
workshops will be one week in duration, while the operational/scientific training workshops will
be one to two weeks in duration.

Proposed mechanism:

- QA/SAC initiates and defines workshop topics in cooperation with WMO;
- WMO provides organization and funding;
ACE\textsuperscript{ED} through the Volunteer Teaching Corps will advise on lecturers and provide access to and implementation of the Volunteer Teaching Corps.

The initiation of an ACE\textsuperscript{ED} related WMO-QA/SAC-GAW Workshop Activity will follow the following protocol:

(a) QA/SAC designates specific needs and topics;
(b) WMO with the help of the QA/SAC identifies local host (negotiates and receives WMO funds);
(c) Local host and QA/SAC contact ACE\textsuperscript{ED}/Bierly regarding access to Volunteer Teaching Corps;
(d) Local host contacts volunteers and arranges scheduling;
(e) Local host-QA/SAC -- identifies participants;
(f) Execute workshop;
(g) Local host prepares and submits report;
(h) QA/SAC performs audit to check effectiveness of workshop.

The first test of an ACE\textsuperscript{ED}-GAW Cooperative Workshop will be in early 1996 in Africa. This workshop will consider broad-based scientific topics which support GAW capacity building in the region. A second workshop is envisioned for South America focusing on tropospheric ozone. The data for this workshop will depend on the completion of the installation sites under the GEF-CONE project in South America (anticipated in 4\textsuperscript{th} quarter of 1996).

4.3.3 Discussion Regarding Guideline for Education and Scientific Capacity Building for IGAC Research Projects

The IGAC-ACE\textsuperscript{ED} committee, in pursuit of its goals to extend education and build scientific capacity in developing countries, proposes that the IGAC-SSC endorse and communicate to all Conveners the following guidelines: IGAC research activities should in so far as possible identify and provide opportunities for scientific capacity building in developing countries. Specifically:

- invite and provide opportunities for scientist and students from developing countries to participate in IGAC research projects;
- establish fellowships/traineeships for students from developing countries at institutions in developed countries and provide opportunities for academic exchange programmes.

and in the case of research projects to be conducted within developing countries:

- contact and involve local scientists in the experiment/project planning and execution from the project’s inception;
- provide for prior academic and technical training for local scientists to enhance participation opportunities in research projects;
- establish long-term partnerships with research scientists and universities in the developing countries;
- identify within proposals the option for leaving research equipment in the developing countries upon completion of the experiments/projects.

5. CLOSING OF THE MEETING

The outline of the report and the recommendations were presented and accepted.

On behalf of WMO and IGAC, Dr Miller thanked the local organizer for making all arrangements and for use of the excellent conference facilities at IFU. Professor Mohnen thanked again all the scientists for their participation and their outstanding contributions to this report and to the international programmes GAW, GLONET and ACE\textsuperscript{ED}.

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ANNEX A

List of Acronyms

ACE\textsuperscript{ED} Atmospheric Chemistry Education
AES Atmospheric Environment Service, Toronto, Canada
AGU American Geophysical Union
ASRC Atmospheric Sciences Research Center, State University of New York at Albany
BMBF Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie
BSRN Baseline Surface Radiation Network
CMDL Climate Monitoring and Diagnostics Laboratory, Boulder, CO, USA
CONE Southern Cone Ozone Project
DOE US Department of Energy
DQO Data quality objective
EC/CAS Committee on Atmospheric Sciences, WMO
ECD Electron capture
EML Environmental Measurements Laboratory, New York, NY, USA
EMPA Federal Laboratories of Materials Testing and Research, Dübendorf, Switzerland
EPA Environmental Protection Agency
ESC Environmental simulation chamber
EUROTRAC European Experiment on the Transport and Transformations of Environmentally Relevant Trace Constituents in the Troposphere over Europe
FID Flame ionization
GAW Global Atmosphere Watch Programme
GCOS Global Climate Observing System, WMO
GEF Global Environment Facility
GLONET Global Tropospheric Ozone Network
GOME Global Ozone Monitoring Experiment--A European Satellite Programme
IAI InterAmerican Institute
IFU Fraunhofer Institute of Atmospheric Environmental Research, Garmisch-Partenkirchen, Germany
IfT Institut für Troposphärenforschung, Leipzig, Germany
IGAC International Global Atmospheric Chemistry Programme
IGGBP International Geosphere-Biosphere Programme
ISPRA  Centro Euratom di Ispra, Ispra (VA), Italy
ITYO  International Tropospheric Ozone Year
IUPAC  International Union of Pure and Applied Chemistry
JMA  Japan Meteorological Agency, Tokyo, Japan
JOSIE  Jülich Ozone Sensor Intercomparison Experiment
KFA  Kernforschungsanlage Jülich, Jülich, Germany
MOSAIC  Ozone and Moisture Detectors Flown on Commercially Operated Aircraft (A-340)
MS  Mass spectrometer
NCDC  National Climatic Data Center, Asheville, NC, USA
NOAA  National Oceanic and Atmospheric Administration
PBM  Photochemical box model
PMOD  Physikalisch-Meteorologisches Observatorium Davos, Davos, Switzerland
QAPjP  Quality assurance project plan
QA/QC  Quality assurance/quality control
QA/SAC  Quality Assurance/Science Activity Centre
RADM2  Regional Acid Deposition Model--Version 2
SMI  Swiss Meteorological Institute
SOP  Standard operating procedure
SSC  Scientific steering committee
START  System for Analysis, Research and Training--an IGBP Core Project
SUNYA  State University of New York, Atmospheric Sciences Research Center, Albany, NY, USA
WCF  World Calibration Facility
WMO  World Meteorological Organization
WRC  World Calibration Centre
WRCP  World Research Climate Programme
WORCC  World Optical Depth Research and Calibration Centre
ANNEX B

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ANNEX C

Agenda

Joint IGAC-GLONET and WMO QA/SAC Workshop

Each Day: 8:30 AM Transport from Hotel to IFU

Monday, 13 March (Jointly with GLONET/ITOY and ACEED)

9:00 Welcome address -- John Miller (WMO), Alex Pszenny (IGAC), and Wolfgang Seiler (IFU)
9:30 QA/SAC Overview -- Volker Mohnen
10:15 Coffee break
10:30 ACEED -- Ken Demerjian
11:15 GLONET -- John Miller
12:00 Discussion
12:30 Lunch
1:30 Interaction between QA/SAC, ACEED, GLONET
3:00 Coffee break (End of Joint Workshop)
3:15 QA/SAC Advisory - Division of tasks, Priority of activities:
   • The QA/SAC Americas -- Hicks, Hales
   • The QA/SAC Japan -- Ito
   IGAC-GLONET: Inaugural Meeting, Agenda for Discussion Group
5:30 End of Session

Tuesday, 14 March -- QA/SAC (Jointly with GLONET/ITOY)

9:00 World Calibration/Intercomparison Facilities:
   • Aerosol Optical Depth (Prof. Fröhlich)
   • Aerosol Chemistry (Prof. Heintzenberg)
   • Surface Ozone (Dr Hofer)
10:15 Coffee break
10:30
   • Ozone Sonde (Prof. Kley)
   • Airborne Ozone Sonde Calibration (Prof. Schumann)
   • Carbon Monoxide (Dr Novelli, Dr Scheel)
12:30 Lunch
1:30
   • Radioactivity (Dr Krey)
   • Discussion on Ozone Satellite Data & World Data Center
     (Prof. Burrows, Prof. Seiler)
   • Progress Report on MOZAIC (Prof. Kley)
   • Ozone Lidars (Dr Ancellet)
3:00 Coffee break
3:15
   • Sub-Working Group I (IGAC-GLONET/ITOY)
   • Progress Report on ITOY
   • Progress Report on ITOY-GEF Proposal
Sub-Working Group II
   • Operational Protocol for GAW World Calibration/
     Instrument Intercomparison Facilities
5:30 End of Session
6:30 Social Mixer -- QA/SAC, GLONET, ACEED
7:00 Conference Dinner -- Queens Hotel Residence
Wednesday, 15 March*

Excursion (Zugspitze) -- High Altitude Observatory (and opportunity for great skiing!)
*Weather permitting -- if necessary, switch programme with Thursday

Thursday, 16 March

9:00    Sub-Working Group I (IGAC-GLONET):
        • Ozonesonde Intercomparison/Calibration Experiment
          (Laboratory & In-Flight, Nov 1995 & mid-1996)
        Sub-Working Group II (QA/SAC Advisory):
          • Interactions Between QA/SACs (Definition & Scheduling of Activities)

10:15   Coffee break
10:30   Sub-Working Groups (Continued)
12:30   Lunch
1:30    Sub-Working Groups (Continued)
3:15    Coffee break
3:30    Sub-Working Groups (Continued)
5:30    End of Session
7:00    Joint Dinner at Bavarian Restaurant

Friday, 9 December

9:00    Sub-Working Group I:
        • Integration of tropospheric ozone measurement systems
        • Advocacy efforts to ensure overall funding base for GLONET & ITOY and KFA-Jülich Facility
        Sub-Working Group II:
          • Educational/training workshops for 1995/96 for GAW
          • Continuation of German QA/SAC beyond December 31, 1995

10:15   Coffee break
10:30   Sub-Working Groups (Continued)
12:30   Lunch
1:30    Joint Session -- Report from Sub-Working Groups
3:30    Closing of Workshop
ANNEX C

IGAC-ACE\textsuperscript{ED} Meeting
Garmisch-Partenkirchen, Germany
15-17 March 1995

Agenda

\textit{Wednesday, March 15 -- Morning}

Introductory Remarks, Adoption/Revision of Agenda -- K. Demerjian
Review Operational Plan and Proposed Revisions -- K. Demerjian
Status Reports on IGAC-ACE\textsuperscript{ED} Initiatives:
- AGU/NSF Volunteer Teaching Corps Project -- E. Bierly
- WMO/GEF Education Capacity Building Proposal -- V. Mohnen
- IT\textsuperscript{O}Y Education Component -- A. Pszenny

\textit{Wednesday, March 15 -- Afternoon}

Discussion of Proposed AGU/NSF Pilot Teaching Corps Projects
South American Training and Academic Capacity Building:
- Short Course in Instrumentation and Measurement Methodologies in Atmospheric Chemistry -- V. Mohnen
- Short Course in Urban Air Quality Modelling and its Application -- K. Demerjian/E. Sanhueza

\textit{Thursday, March 16 -- Morning}

Preparation and Review of Proposed Course Outlines and Recommendations of Teaching Volunteers for the Short Courses in Instrumentation and Modelling -- ACE\textsuperscript{ED} Committee

\textit{Thursday, March 16 -- Afternoon}

Discussion of IGAC-ACE\textsuperscript{ED} Future Initiatives -- ACE\textsuperscript{ED} Committee:
- Costa Rica: Proposal for Education Capacity Building in Environmental Monitoring and its Analysis and Interpretation -- J. Miller
- ALFA Project: Opportunities in Education Capacity Building through European Community Funding -- H. Rodhe
- IGAC Research Related ACE\textsuperscript{ED} Opportunities -- A. Pszenny

\textit{Friday, March 17 -- Morning}

Discussion and recommendations regarding the development of guidelines for educational requirements and opportunities within IGAC Research Projects -- ACE\textsuperscript{ED} Committee

Discussion and recommendations regarding the role IGAC-ACE\textsuperscript{ED} might play as a clearing house for information on educational capacity building programmes -- ACE\textsuperscript{ED} Committee
ANNEX D

Summary of Activities of QA/SAC-Europe & Africa
January 1, 1993 - December 31, 1994

Professor Volker A. Mohnen

The establishment and operation of a QA/SAC is an important prerequisite for creating a credible and reliable global data set for the GCOS-GAW programme. Upon appeal of the Secretary General of WMO, Professor G.O.P. Obasi, to all membership countries, Germany has offered to establish the QA/SAC for Europe and Africa. Subsequently, a proposal was submitted (Prof. V.A. Mohnen, Principal Investigator) to the German Bundesministerium für Forschung und Technologie, BMFT, to establish this QA/SAC at the Fraunhofer Institute for Atmospheric Environmental Research, FhG-IFU (Garmisch-Partenkirchen) in recognition of the considerable expertise and existing infrastructure available at IFU. The operation of this first centre began in January of 1993 with an initial duration of three years, and under the leadership of Prof. Mohnen. The Deutsche Wetterdienst, in a letter from Dr T. Mohr, President, has officially informed the Secretary-General of WMO of this event (August 2, 1994).

IFU provides the necessary scientific, technical and administrative infrastructure to support the basic functions of the QA/SAC including access to calibration laboratories and transfer calibration standards, making available expert consultants for system and performance audits, organizing workshops and training courses, and twinning with a global station (Kenya).

The QA/SAC is now an integral part of IFU and linked directly to the IFU directorate. The QA/SAC interacts most closely with the division "Chemistry of the Troposphere" headed by Dr F. Slmer where most of the facilities and expertise of interest to GAW reside. In return, the QA/SAC has contributed significantly to the quality assurance activities within IFU. In addition, pilot projects for quality assuring major European projects such as SANA (BMFT-funded) and EUROTRAC-TRACT (mostly EU-funded) have been designed and executed by IFU for the first time in Europe. These mutually beneficial interactions enabled the QA/SAC to operate at a highly efficient and productive level in spite of its rather limited budget. Nevertheless, the responsibilities of the QA/SAC are so broad and complex that they exceed the resources of a single research institute such as IFU. There is another reason, however, why all QA activities can and should not be centralized. The concept of integrated quality management is relatively new in European scientific research and must have broad support to succeed. This can be accomplished most effectively by building global alliances with internationally recognized research institutes/organizations and sharing with them the responsibility for quality assuring specific measurement parameters of interest to GAW.

In the sections that follow, a brief summary of some QA/SAC activities over the past two years of operation are highlighted together with a brief scientific rationale for measuring the particular parameter in GCOS-GAW.

Tropospheric ozone

Surface ozone is a criterion pollutant which has been routinely measured in North America and Europe. Based on this long monitoring history and experience, detailed quality assurance procedures have been developed and tested that have been incorporated in a Quality Assurance Project Plan (QAPjP) for GAW and--after extensive reviews--published as GAW Report No. 97. This QAPjP has been implemented at all global GAW stations. It is based on the assumption that UV-photometry is the preferred method for surface ozone and that the NIST UV-photometer will be the World Reference Standard to which all calibrations must be traceable. Standard operating procedures (SOPs) for monitoring surface ozone, calibrating ozone instruments and conducting system/performance audits have been included in this QAPjP.
The QA/SAC relies on the Eidgenössische Materialprüfungsanstalt (EMPA, Dübendorf, Switzerland; Dr P. Hofer, Head of the Section Air Pollution) to act as "Surface Ozone Calibration Facility" for GAW. This is one of several Swiss contributions to GAW arranged through QA/SAC by the Schweizer Meteorologische Anstalt (SMA, Zürich; Dr G. Müller).

The first system and performance audit (expert consultation) was conducted on September 17, 1994, at the Mt. Walliguan (China) global station. The second expert consultation by QA/SAC scientists took place at the global station Ushuaia (Argentina) from November 21-28, 1994. It must be emphasized here that the surface ozone intercomparison between the QA/SAC transfer standard and the station instrument was excellent and by far exceeded the DQO for this GAW parameter. The other global stations funded through GEF will be visited as soon as they become fully operational.

The QA/SAC is currently working with WMO on implementing additional surface ozone stations in South America made possible through funds from GEF ("Cone" project). This will greatly improve representative data coverage in the southern cone area of South America (three sites in Argentina, three sites in Chile, one site in Brazil, one site in Paraguay and one site in Uruguay). The newly formed (January 1, 1995) QA/SAC Americas will now continue the QA support for these upcoming stations.

Tropospheric ozone profiles data are very limited. From recent WMO assessment reports and articles in the reviewed literature the QA/SAC assessed the state of knowledge to be very sketchy. The data quality and sampling frequency are uneven. By far the greatest need is for improved data quality for both, present and future measurement stations. The QA/SAC was therefore faced with two formidable tasks. First, to develop DQOs and harmonized quality assurance procedures and second, to expand the existing network of ozonesonde stations for achieving global coverage ("regional representativeness" and "comparability"). For obtaining tropospheric ozone profile measurements of KNOWN quality, it is essential that certain QA tasks be accomplished:

- Intercalibration and intercomparison of existing ozonesonde types;
- Agreement on measurement frequency and timing;
- Agreement on procedures for data processing and analysis.

Previous intercomparisons, carried out by launching several different kinds of ozone sondes simultaneously, have left many questions unanswered about differences in instrument performance because there was no reference standard to which the ozonesondes could be compared.

To resolve these current problems, the QA/SAC has established cooperation with the Kernforschungsanlage Jülich (KFA-ICG-2, Prof. D. Kley). A "World Calibration/Instrument Intercomparison Center for Ozone Sondes" has now been formed at Jülich and the first international workshop will take place in February of 1996.

The QA/SAC initiated the necessary steps for preparing a draft QAP inP for tropospheric ozone soundings and a work schedule for the November 1995 workshop. These activity plans have been further refined at the QA/SAC Advisory Meeting, March 13-18, 1995, Garmisch-Partenkirchen, and will be finalized after the February 1996 workshop, when the results of the intercomparison have been assessed. In addition to these ground-based quality assurance experiments, the QA/SAC also recognized a need for in-flight intercomparison/calibration of ozone sondes and was successful in establishing an Instrument/Intercomparison Facility for In-Flight Ozone Soundings" through cooperation with the Deutsche Forschungsanstalt für Luft-und Raumfahrt, DLR (Institut für Physik der Atmosphäre, Prof. U. Schumann). The DLR will make available their Falcon aircraft equipped with a UV-photometer as transfer standard and other trace gas instruments to quality assure ozonesondes during their ascent. Detailed plans have been worked out at the QA/SAC Advisory Meeting (March 13-18, 1995) and will be finalized at the November 1995 workshop in Jülich. Current plans call for a Spring 1996 in-flight calibration mission.
Tropospheric ozone now occupies a leading position on the international research agenda not only because of its role in atmospheric chemistry but also because it is an important climate gas (see IGBP Newsletter No. 19). There is a strong overlap of GAW and IGAC activities, in particular with IGAC-GLONET (Global Tropospheric Ozone Network) and with the new ITOY (International Tropospheric Ozone Years) initiative. The QA/SAC has early on discussed with the IGAC Core Project Office (Prof. R. Prinn and Dr A. Pszenny, MIT) the problem of obtaining a representative climatology for tropospheric ozone with the limited and uneven distribution of current observations. It was agreed that GAW and IGAC/GLONET should jointly proceed with these efforts. Dr John Miller and Prof. Mohnen further agreed to be co-conveners for IGAC-GLONET and to develop a strategy for promoting high-quality measurements of tropospheric ozone and facilitating the expansion of existing stations capable of profiling tropospheric ozone (Global Change Report No. 32, The Operational Plan, Activity 6.1).

The GLONET operational plan was accepted by the IGAC Steering Committee and is now implemented jointly with GAW. Accordingly, the QA/SAC has organized a joint workshop (QA/SAC Advisory and GLONET Coordinating Committee, March 13-18, 1995, Garmisch-Partenkirchen) to combine the quality assurance activities for both projects. Furthermore, the QA/SAC was asked by the ad hoc Working Group of ITOY co-chaired by Prof. P. Crutzen and Prof. H. Rodhe to develop and eventually implement all required QA/QC procedures for ITOY patterns after GAW to assure compatibility between GAW and ITOY data sets. To further strengthen the ties between GAW QA/SAC and ITOY, Prof. Mohnen agreed to serve as a member of the ad hoc Working Group. ITOY plans call for a total of 25 new ozonesonde stations in developing countries and/or on remote islands in addition to about 20 stations in developed countries. Since ITOY will be operational for only two years, there is a challenge as well as an opportunity for GAW QA/SAC to select a subset of optimally located stations for continued monitoring of tropospheric ozone changes and thus achieve its goal of obtaining globally representative tropospheric ozone data. The contribution of the Schweizer Meteorologische Anstalt (SMA, Dr G. Müller) towards improving the global coverage for ozone soundings deserves special mention here. Upon consultation with the QA/SAC the SMA has provided SF 300,000 to GAW for the installation in 1995 of a complete ozonesonde station at the global GAW site in Kenya, for whom IFU acts as twinning partner.

**Ultraviolet-B radiation**

Currently, GAW does not "operationally" monitor UV-B radiation, although individual investigators use some GAW facilities for conducting such measurements. It is envisioned, however, that global GAW stations might eventually use narrowband spectral radiometers, while regional GAW stations might deploy multi-wavelength broadband instruments for monitoring UV-B radiation.

WMO organized in July of 1994 an international meeting of experts on UV-B radiation (Les Diablerets, Switzerland) in order to assess the current state of science and technology. Prof. Mohnen presented an overview of the necessary steps leading to a Quality Assurance Project Plan for this measurement parameter and required for producing globally harmonized data sets. The experts present at this conference unanimously agreed to establish a science steering committee for UV-B radiation within WMO and under the EC/CAS Panel for the purpose of harmonizing emerging global UV-B data sets. These efforts would include the development of and adherence to a world UV-B calibration standard (reference instrument and/or calibration "lamp" source) which is one of the necessary precursors for initiating a GAW monitoring activity. NOAA-ARL is currently setting up a national UV-B calibration/instrument intercomparison facility in Boulder, CO, duplicating a similar facility located at NIST. The QA/SAC is seeking guidance from both, the SSC for UV-B and the national UV-B calibration facility, on how to proceed and is prepared to develop the QAPjP for UV-B measurements in GAW.

**Precipitation**

There are currently about 150 "potential" GAW precipitation chemistry measurement sites, of which approximately 75% are located in Europe and North America. Canadian and United States monitoring programmes follow mandatory and strictly enforced QA protocols which cover all aspects of the measurement system. However, there is a need for more harmonization of the QA protocols as well as standardization of the analysis methods used. The QA/SAC has discussed this issue at the last plenary meeting and has agreed to work on the development of a quality assurance program for the precipitation composition measurements.
all aspects of site selection, sample treatment and shipment, laboratory analysis (central analytical facility), data quality checks and data management. Most European GAW sites are part of the UNECE European Monitoring and Evaluation Programme (EMEP) network, which also has implemented thorough and well-documented quality assurance and quality control procedures. However, these protocols are *not* mandatory but rely on the participating countries for enforcement. With the exception of Japan and Hong Kong, station coverage in Asia is poor and almost nonexistent in Africa and South/Central America. With the breakup of the former Soviet Union, the continuation of precipitation networks is in great jeopardy in this region. Rebuilding these GAW stations and significantly expanding stations in Asia, Africa, South and Central America is a formidable challenge for WMO and the QA/SAC.

WMO-GAW (formerly BAPMoN) has in place procedures for precipitation chemistry sampling and analysis (e.g., WMO, 1978: International Operations Handbook for Measurement of Background Atmospheric Pollution, WMO Report No. 491--provisional revision, 1988; and Meszaros, E. and D.M. Whelpdale, 1985: Manual for BAPMoN Station Operators, Technical Document WMO/TD 66). One central feature of the GAW precipitation chemistry programme is the *annual* laboratory intercomparison conducted since 1975 by the US EPA Atmospheric Research and Exposure Assessment Laboratory, Quality Assurance and Technical Support Division. Three artificial precipitation samples and two heavy metals samples (all NIST traceable) are shipped to chemical laboratories worldwide who participate in the analysis of precipitation samples collected at GAW sites. There are currently about 93 such laboratories on the WMO list (June 1994) but past experience has shown that less than half report back their results.

However, the above described GAW interlaboratory check is *not* yet mandatory and procedures have not been strictly enforced in the past. As a result, different collectors, different sampling periods and different laboratory procedures are in use within the global network, since the responsibility for obtaining quality assured data resides within the individual country and even within different national agencies/institutions.

The QA/SAC faced the task of producing globally harmonized precipitation data from this "fragmented" network (the data quality varies significantly from country to country) and proceeded as follows:

1. A set of uniform data quality objectives (DQOs) was developed by an international expert group depending on the monitoring objectives.

   - Assessment of the effects of anthropogenic emission changes in such a way that rapid answers (within five years) can be obtained regarding the efficacy of abatement measures will necessitate the implementation and operation of "high-accuracy measurement" stations. These stations must be able to detect *small* trends (about 5% per year over less than five years);

   - The changes in precipitation chemistry and fluxes, due to changing anthropogenic emissions in many parts of the earth, can be monitored by "trend networks" of moderate precision. Here the longer-term developments are important, and high time resolution (and hence ultrahigh precision and accuracy) is of less importance. The quality of the data must be sufficient that any trends over a time period of more than five years can be detected;

   - Characterizations of regional fluxes require the operation of networks, which provide good quality data, but they do not have to meet the stringent data quality objectives compared to the "trend networks".

The QA/SAC has extensively reviewed the result of the GAW EPA Laboratory Intercomparison and contributed the main results to the review team established by the EC Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry and charged with the review of the Global Precipitation Chemistry Programme (Annex VI, Excerpts from GAW Report No. 83, WMO/TD 526). Based on this assessment, the QA/SAC identified chemical laboratories in urgent need of improvements requiring immediate attention as well as those of consistent excellent performance. QA/SAC recommended to WMO to immediately proceed with training workshops, production and distribution of an updated manual covering laboratory analytical methods and collection standards and expert consultations (system and performance audits).

Based on consistent high performance documented by the QA/SAC assessment, WMO asked the Czech Hydrometeorological Institute in Prague (Dr J. Šantroch) to produce a manual which was subsequently distributed as GAW Report No. 85 to all stations and laboratories.

QA/SAC worked closely with WMO in organizing several training workshops targeted for regions in need of help and/or improvements.

- Sofia, Bulgaria, 4-8 October 1993, in conjunction with the WMO Region VI "Conference on the Measurement and Modelling of Atmospheric Composition Changes Including Pollution Transport", and covering all GAW measurement parameters including precipitation chemistry (GAW Report No. 91);

- Halkidiki, Greece, 11-15 October 1993 covering all GAW measurement parameters;

- Boulder, Colorado USA, 8-12 March 1994 involving Algeria, Argentina, Brazil, China, Indonesia and Kenya covering status of the six GEF funded sites and quality assurance requirements for all GAW measurement parameters;

- Buenos Aires, Argentina, 9-13 May 1994. WMO Training Workshop on Atmospheric Pollutants and Monitoring covering all GAW measurement parameters;

- Beijing, China, 12-16 September 1994 covering all GAW measurement parameters;

- Hradec Kralove, Czech Republic, 18-22 October 1994. "First WMO-GAW Workshop on Precipitation Chemistry". This workshop was a joint activity of the Czech Hydrometeorological Institute (Dr J. Šantroch) and the QA/SAC and specifically addressed all aspects of chemical analysis. The participants were carefully selected and had to be directly involved in or in charge of the analytical laboratory that analyzed GAW precipitation samples (newly independent countries, Russia, Ukraine, etc.). QA/SAC designed this workshop as a model for future training activities with actual hands-on demonstration of pH; conductivity - ion chromatography measurements following the GAW protocol. WMO and QA/SAC also identified during this workshop equipment needs for immediately improving data quality. WMO is now seeking funds for providing such equipment to the chemical laboratories.

QA/SAC initiated steps to increase station coverage and to search for analytical facilities that could serve as training centers and/or twinning partners.

- QA/SAC identified the Government Laboratory, Kowloon, Hong Kong as a center of excellence with consistent high performance based on the US EPA laboratory intercomparison. Professor Mohnen visited on 1-4 September 1994 the Royal Observatory, Ms. Elaine Hui Koo, and the Government Laboratory, Dr T.T. Kam and Mr. C.Y. Au Yeung, to discuss training/twinning possibilities. The QA/SAC proposal is now
Upon invitation of WMO, Prof. Mohnen addressed the delegates from 53 African countries (WMO Region Association I) at their 11th session in Garborone, Botswana, 14-19 November 1994. He presented the GAW concept, stressed the need for quality assurance and appealed to the delegates for more station coverage within WMO Region I. During the conference Prof. Mohnen met with many delegates who unanimously asked for training/education support to improve the indigenous capacity within their respective countries. Without such ongoing support and expert consultations, the monitoring activities will be of short duration. A GAW training workshop is now planned for January 1996;

A workshop on "Development of a Coordinated Air Deposition Monitoring Network in Central and Eastern Europe", Garmisch-Partenkirchen, 5-9 December 1994 was organized by the QA/SAC jointly with and funded by NOAA-ARL (Dr Bruce Hicks). One central feature of this workshop was implementing harmonized QA/QC procedures patterned after WMO-GAW and EMEP (Annex VIII). The participants endorsed this concept and funds are now sought by NOAA to proceed with the implementation.

The QA/SAC conducted two system and performance audits for precipitation chemistry, namely at the Chinese global station Waliguan (and its associated analytical laboratory in Beijing) and at the Argentinean global station Ushuaia (and its associated analytical laboratory in Buenos Aires).

Chemical and physical properties of aerosols

Aerosol Optical Depth (Turbidity) has been measured at GAW sites for over a decade. An intensive examination of these data revealed serious flaws in both the internal consistency of data from any single station and the comparability among any specific set of station records (WMO Report No. 94: Report on the Measurements of Atmospheric Turbidity in BAPMoN). Consequently, turbidity measurements were terminated at all GAW sites in 1993 and the QA/SAC faced the task of designing and implementing a comprehensive QA/QC programme prior to the initiation of new turbidity measurements. A WMO "Meeting of Experts to Assess the GAW Measurements and Climate-Related Data of Aerosol Optical Depth/Turbidity" convened on 7-11 December 1993 at the Air Resources Laboratory (ARL) of the US NOAA in Silver Spring, Maryland. The specific purposes of this meeting related to the demand for aerosol optical depth data of greater quality than had been derived from the long-running, but now terminated BAPMoN measurements (the predecessor of GAW), and to draw up some plans for the future, considering:

- what aerosol-related radiative measurements are required;
- how the QA/SACs will interact with the new aerosol optical depth programme (including interactions with data acquisition and archiving functions) and;
- how to arrange implementation of the new programme.

Professor Mohnen chaired the subworking group on quality assurance and developed, jointly with the participating experts, a concept for quality assuring future sun-photometry observations that is now being implemented in GAW together with other recommendations of the full panel. The QA/SAC has approached the Schweizer Meteorologische Anstalt, SMA (Dr G. Müller) to form a "World Calibration Facility for Sun-photometry" at the PMOD/WRC, Davos, under the scientific leadership of Dr C. Fröhlich. The SMA has accepted this challenge and is now pursuing this activity as one of the Swiss contributions to GAW (CHARM). Under the Swiss plan, (1) a total of 16 newly developed sunphotometers will be deployed to global GAW stations, (2) a reference standard will be maintained, (3) regular instrument calibrations will be performed, (4) an international expert group will review the data, and (5) standard operating procedures (SOPs) will be developed jointly with the QA/SAC.

This activity can be viewed as the first step towards rebuilding a global network for atmosphere optical depth (AOD), an important parameter in the "aerosol-climate puzzle".
Aerosol Chemistry and other aerosol properties ("carbon black", condensation nuclei, cloud and ice nuclei, etc.) are implemented at specific GAW sites and serve as preliminary QA-experiment. The "Report of the WMO Meeting of Experts to Consider the Aerosol Component of GAW", GAW Report No. 79, served as guide for the QA/SAC in its initial effort to design a Quality Assurance Project Plan (QAPjP). Since that time and under Prof. G. Jenning’s (University of Galway) leadership, a set of technical manuals have been prepared for GAW by a team of scientists. Because of the differing opinions within the aerosol community, QA/SAC was unable to define at this time data quality objectives (DQOs) and therefore needed to proceed first with the identification of an internationally recognized center for aerosol research that could serve as "World Calibration/Instrument Intercomparison Facility for Aerosols". QA/SAC could then work jointly with this center on implementing an aerosol programme in GAW that produces measurements of known quality. The Institut für Troposphärenforschung (IfT) Leipzig, Germany, under the leadership of Prof. J. Heintzenberg has agreed to provide these services to GAW QA/SAC (QA/SAC Advisory Meeting, March 13-18, 1995, in Garmisch-Partenkirchen).

QA/SAC has also sought advice from the International Global Aerosol Programme (IGAP) and Prof. Mohnen was invited to serve as member on its Science Steering Committee representing the GAW community. However, the IGAP has now merged with IGAC (International Global Atmospheric Chemistry) and the various IGAP activities have been incorporated in IGAC core projects.

Reactive gases

Carbon monoxide (CO) is often the primary sink for hydroxyl radical (OH) and therefore is an intimate component in the series of photochemical reactions which ultimately oxidize reduced carbon, nitrogen, and sulfur trace gases. Although CO itself is not a significant contributor to the greenhouse effect, its effect on the concentrations of other greenhouse gases can be considerable due to its influence on the OH radical.

The QA/SAC again relied on the advice of experts for designing the Quality Assurance Project Plan (QAPjP). The "Preliminary Report of the WMO-Sponsored Meeting of Carbon Monoxide (CO) Experts" provided this guidance and QA/SAC currently is proceeding with the establishment of a "World Calibration Facility for Carbon Monoxide". There are two centers with international recognition for CO calibration, namely NOAA-CMDL (Dr P. Novelli) and FhG-IFU (Dr H.C. Scheel). Both have accepted the QA/SAC request to operate jointly the WCF for CO. QA/SAC has worked closely with scientists at these centers in defining DQOs, SOPs and audit procedures. A "test" audit for carbon monoxide was already successfully performed by the QA/SAC team at the global GAW station Ushuaia, Argentina.

Summary

The QA/SAC for Europe and Africa has designed and implemented a quality assurance programme for GCOS-GAW, based on the recommendations of the EC/CAS Panel of Experts and the QA/SAC Advisory Committee. The QA/SAC has maintained close communication links with the WMO Environment Division (Dr J. Miller) and provided assistance on all matters related to GAW. The QA/SAC has sought advice from, and cooperation with, the scientific community and considers this activity as an essential and integral element of quality assurance. As a result, a mutually beneficial cooperation has been established whereby QA/SAC obtains access to scientific facilities and expertise and—in return—transfers the concept of quality assurance to scientific research projects. Implementing a comprehensive quality assurance programme for GAW will require many years and will demand increased research and educational commitments from the community at large. Failure to commit sufficient resources to the QA/SACs will endanger the integrity of the global data set and thus reduce its value to decision makers.
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


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