Report of the CAS Joint Scientific Steering Committee of the Open Area Programme Group on Environmental Pollution and Atmospheric Chemistry (JSSC OPAG-EPAC)

(Geneva, Switzerland, 11-12 April 2007)
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WORLD METEOROLOGICAL ORGANIZATION
GLOBAL ATMOSPHERE WATCH

REPORT of the CAS JOINT SCIENTIFIC STEERING COMMITTEE of the OPEN AREA PROGRAMME GROUP on ENVIRONMENTAL POLLUTION and ATMOSPHERIC CHEMISTRY (JSSC OPAG-EPAC)

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1. OPENING OF THE MEETING

Prof. Hong Yan, the Deputy Secretary-General (DSG) of WMO, opened on behalf of the Secretary-General the first session of the Joint Scientific Steering Committee (JSSC) of the Open Programme Area Group (OPAG) on Environmental Pollution and Atmospheric Chemistry (EPAC) on Wednesday 11 April 2007 at the Geneva Headquarters of WMO. He noted that the Global Atmosphere Watch (GAW) programme is unique in coordinating long-term atmospheric measurements globally for use as critical information on the state of the atmosphere, contributing to the scientific conclusions of assessments such as IPCC. He also stressed the importance of having quality controlled data, an essential part of GAW, available for analysis. He noted that the NMHSs throughout the world are broadening their traditional role to include prediction of other environmental phenomena, than weather, that could substantively affect the health and welfare of their citizens. He also touched upon the importance of the development of the third GAW Strategic Plan (GSP) covering the years 2008-2015 and wished the participants a successful meeting and fruitful deliberations for the GSP.

The Director of the Atmospheric Research and Environment Programme (AREP) Department, Dr Leonard Barrie, and the JSSC Chair, Prof. Øystein Hov, welcomed the participants to the meeting. The list of participants to the session can be found in Annex A. A Tour de Table was carried out so that all the participants became acquainted. Apologies were forwarded from Peter Manins (Australia) replaced by Paul Fraser, and M. Araneda (Chile) and X.-Y. Zhang (China), who were not able to attend the meeting.

2. APPROVAL OF AGENDA

The approved Agenda can be found in Annex B. The main item was the GAW Strategic Plan, which was discussed also under the Status of GAW observing systems and GURME. There were also presentations on national and regional GAW activities, on data and quality management in WMO and on other major observational strategies and programmes.

3. PRESENTATIONS ON ENCLOSED CD-ROM

The presentations given during the two days of the meeting are provided on the CD-ROM included with this report. A detailed account of each presentation is therefore not given here.

4. ASSIGNMENTS

Several assignments were decided upon: Hennie Kelder of KNMI as rapporteur for atmospheric chemistry satellite observations related to IGACO/GAW for GEO/GEOSS; Slobodan Nickovic, with Geir Braathen as back-up, of the WMO Secretariat as rapporteur for the WMO Information System (WIS) and Vincent-Henri Peuch as chair of the Expert Team on Near-real-time Chemical Data Transfer (ET-NRTC DT).

5. OVERVIEW OF CAS XIV

Øystein Hov opened by pointing out that the main topic on the agenda for the JSSC meeting was the GAW Strategic Plan. He then gave an overview of the Commission for Atmospheric Sciences (CAS) XIV meeting held in Cape Town in February 2006 and presented the terms of reference for the JSSC OPAG-EPAC (Appendix C) as decided at CAS XIV. The chair also showed the CAS structure with the two OPAGs, their Scientific Advisory Groups (SAGs) and Expert Teams (ETs) and regional rapporteurs, and the corresponding tasks. He further presented the structure of products, services and delivery system flow of information within National weather services, which can be seen as a blueprint for GMES and GEOSS and GAW. He noted that a substantial research and knowledge base is needed to make this work. The nine societal benefit areas of GEOSS were presented as potential user sectors. Ø. Hov showed the IGACO conceptual framework for GAW including the flow of data from observations to end users.
Ø. Hov further presented what he as the Chair perceives as challenges to GAW, these include product/indicator/signal parameter oriented analysis and forecasting of hazards beyond accepted bounds. He also touched upon issues which are likely to change environmental policy direction. He also noted the importance of climate change feedback on air pollution in the future. He thanked the national and individual contributions to GAW noting their importance in making GAW function.

In the ensuing discussion on IGACO, it was noted that IGACO is a strategy to be implemented in GAW and that tangible results will be needed. It was noted that many parts of GAW are stronger than just GAW as there are also for instance national responsibilities in the same areas that are nationally funded.

6. GAW STRATEGIC PLAN 2008-2015

Gerhard Müller gave an overview on the GAW Strategic Plan for 2008-2015 highlighting changes and development from the previous Strategic Plan especially in the light of IGACO. He went through the schedule of the development of the plan. The tendency towards nested systems was seen as a challenge. G. Müller stressed the importance of the spirit of cooperation.

A short discussion followed on the contents of the GSP. Stuart Penkett pointed out that earlier strategic plans have made clear links for instance to UNEP and the Vienna Convention for the Protection of the Ozone Layer. Now, in the new plan, he suggested to make clear the links between GAW and IPCC type of activities, an importance also pointed by the DSG. Ø. Hov commented that GAW ought to be better publicized and advertised. L. Barrie replied that IPCC is an assessment based on published work and that GAW activities generate data and publications upon which IPCC is founded.

7. STATUS OF THE GAW PROGRAMME AND GURME

The SAG chairs presented the status of their respective sectors of the GAW programme. Please see presentations in attached CD for details.

7.1 Aerosols

7.1.1 Activities of the aerosol SAG

Urs Baltensperger, the Chair of the Aerosol SAG, presented the work carried out in the last year. A very positive element is the Aerosol SAG web site at http://gaw.tropos.de. He noted that when it comes to aerosols, IGACO does not include all the variables identified in GAW Report # 153 as core aerosol variables focussing mainly on optical properties. Optical Depth (Vis + IR), extinction coefficient (Vis), and AOD (Vis) measurements are requested in IGACO. In addition, other variables, namely aerosol chemistry in two size fractions and many size distribution characteristics need to be measured in GAW. The SAG is currently working on four Standard Operating Procedures (SOPs).

During discussion U. Baltensperger noted he was happy with the representation of aerosols in the GSP but that the capacity building section would need some editing.

The Chair of the Reactive Gas SAG, S. Penkett, mentioned that there are some reactive gases that are important for aerosol formation, such as SO2. Thus there is a need for better links between these SAGs. He further noted that SO2 aerosol has a large impact on climate and that there is a scarcity of observations of SO2 globally. Satellites are not sensitive enough and regional acid rain type networks in Europe and North America are limited in area. Most environmental agency observations are too insensitive in areas downwind of source regions. Text was requested to be added to the GSP on this matter. Johannes Staehelin suggested that the aerosol SAG concerns could be taken on board through an IGACO-aerosol initiative. It was further noted that a global calibration facility for aerosol chemistry is not being pursued currently but that this situation could change.
7.1.2 WMO’s sand and dust storm warning system and the GALION project

Slobodan Nickovic presented the progress on the establishment of a WMO Sand and Dust Storm Warning System (SDS WS). The SDS Scientific Steering Committee met in November 2006 in Shanghai, China. It was decided to set up a WMO portal website for regional SDS warnings. Three SDS WS centres are established /being established in following regions: North African/European region (hosting country – Spain), East Asian/Pacific region (hosting country – China), and North American region (hosting country – to be determined). Special emphasis will be given to provision of SDS forecasting data that are tailored to the needs of the ‘community of practice’.

S. Nickovic then reported on the WMO Experts Meeting on the Implementation of a GAW Aerosol Lidar Observation Network, GALION. The meeting took place 27 - 29 March, 2007 at the Max-Planck Institute in Hamburg, Germany. The meeting agreed to establish a WMO global network of lidar ground measurements. The work will start with a web portal server for collecting/displaying voluntarily uploaded lidar profile data from different networks. There will also be work on the scientific assessment – climatology of vertical aerosol features, to be combined with modelling results (from 2008 onward). The implementation of near-real time data delivery is a long-term task.

Discussion followed on a more general nature. There was discussion whether one should adopt the IGACO recommendations verbatim, it was agreed not to do so. It was noted that the implications of climate change are important for GAW, for instance as regards the emission of gases, intensification of photochemical smog, and increase of dust due to changes in precipitation patterns and temperature rise. It was noted that it is important to mention climate change in the GSP appropriately.

7.2 Precipitation chemistry

Wenche Aas, representing the Chair of the Precipitation Chemistry (PC) SAG, Richard Artz, presented the work of the SAG. There are about 200 precipitation chemistry sites world wide, however the information in GAWSIS needs to be updated as only a few of the stations are registered. She informed the session on the laboratory intercomparison programme, the Manual for the GAW Precipitation Chemistry Programme (GAW Rep No 160), and challenges to the GAW PC Programme. She then gave a summary of the WMO Expert Meeting on Precipitation Chemistry Data Syntheses and Community Product, which was held in Geneva on 23 January 2007, and of the preparation of the next global data precipitation chemistry assessment.

Discussion on the World Data Centre for Precipitation Chemistry (WDCPC) followed. It was pointed out that there are problems with the functioning of this data centre and it was noted that it is necessary to find out officially the current situation. There was discussion on the future of the data centre. L. Barrie pointed out that a valuable part of the WDCPC is the World Calibration Centre (WCC) and its activities, distributing standards twice annually to all major world laboratories engaged in precipitation chemistry observations.

A more general discussion on data centres followed. Ø. Hov made a comparison between classical meteorological data and environmental data: meteorological data always have a home, for example nationally or within ECMWF. The environmental field is not organized in the same manner globally. Ø. Hov pointed out that such a discussion as on WDCPC was required for all the GAW WDCs, there is a clear need for more solid structure. He further suggested that WMO should look at the possibility of recommending establishment of data centres for environmental data. More collaboration with EMEP on this is a possibility. He noted that IPY provides a good example with a strict data protocol that states clearly that data has to be open.

Recommendation: The JSSC endorsed the need for an assessment of global precipitation chemistry and deposition using all data globally and global atmospheric chemistry/deposition models.

Recommendation: Maintain the WCC for Precipitation Chemistry and its valuable activities to date.
Recommendation: Seek a solution for the functioning of the World Data Centre for Precipitation Chemistry.

7.3 Reactive gases

Stuart Penkett, Chair of the SAG on Reactive Gases, presented the work of the SAG. He pointed out that reactive gases as a group are very diverse and include surface ozone (O₃), carbon monoxide (CO), volatile organic compounds (VOCs), oxidised nitrogen compounds (NOₓ, NOᵧ), and sulphur dioxide (SO₂). All of these compounds play a major role in the chemistry of the atmosphere and as such are heavily involved in inter relations between atmospheric chemistry and climate, either through control of ozone and the oxidising capacity of the atmosphere, or through the formation of aerosols. The global measurement base for most of them is entirely unsatisfactory, the only exceptions being surface ozone and carbon monoxide. S. Penkett reported on the WMO/GAW Expert Workshop on Global Long-Term Measurements of Volatine Organic Compounds (VOCs), which was held in Geneva, from 30 January to 1 February 2006.

S. Penkett presented a map of a prospective GAW VOC network, which will be a combination of several networks, such as NOAA/GMD and EMEP. He further showed the potential structure of such a network including station configuration, a central calibration laboratory and world/regional calibration centres. He also presented some maps of formaldehyde and NO₂ from satellite data and he talked about the CARIBIC flying laboratory and the MOZAIC European airbus programme. He noted that there is a need to set up more formally an activity to facilitate the ground-truthing of satellite data.

There was discussion on CO and hydrogen. S. Penkett pointed out that there has been no meeting arranged so far on the topic of hydrogen. L. Barrie mentioned that a joint WMO-GAW/ACCENT workshop on tropospheric CO was arranged at EMPA in October 2005 (GAW Report No. 166).

7.4 Greenhouse gases

Ed Dlugokencky presented the work of the Greenhouse Gas (GHG) SAG, which he chairs. He stressed the importance of quality assurance and linking observations to the WMO world reference standards and which he summarised: “It is better to have no data than bad data”. He also mentioned the need for more data in polar and tropical regions. There is a big potential source of CH₄ in Arctic methane hydrates, which might be released as temperatures rise. He presented the Carbon Tracker, a system that calculates carbon dioxide uptake and release at the Earth's surface over time and that estimates the carbon dioxide exchange from an 'atmospheric point of view'. The Carbon Tracker can be found at: http://carbontracker.noaa.gov

There are plans to also make a Methane Tracker and it is expected to be available next year.

E. Dlugokencky mentioned that the WMO Global CO₂ and CH₄ Network was adopted by GCOS in November 2005 as part of the comprehensive climate network of GCOS. The plan is to add the GAW N₂O network to this as well. He also noted that satellite retrievals are key to quantifying tropical CH₄ emissions, these need validation by in situ measurements.

Ø. Hov pointed out that there is better integration in the GHG SAG than in the other SAGs considering research and policy. Discussion followed on data which have not been submitted to WDCGG.

Recommendation: The JSC endorsed the registration of GAW GHG network as a comprehensive network within GCOS.

Recommendation: Organizations are asked to submit N₂O flask data to WDCGG in a timely manner.
7.5 Ultraviolet radiation
Ann Webb presented the work carried out in the UV SAG, which she chairs. She noted that UV measurements are made with spectral (< 1 nm), multifilter (~ 10 nm) and broadband (usually erythemally weighted) instruments. Within each instrument class there are different makes and models with differing characteristics. She mentioned that the World Ozone and UV Data Centre (WOUDC) contains mainly spectral UV data and that UV index has been adopted as the common parameter to be reported to WOUDC. She went on to list some challenges for UV measurements, such as the lack of calibration centres. She noted that WMO, through the SAG, has helped support a number of joint-effort intercomparisons over the years, which have been important for the furthering of the quality of UV data.

After the presentation the discussion centred around data availability and access. A. Webb would like to see a one-stop portal that can give access to all UV data, through links or at the site. On the question whether the UV SAG has considered near-real time data delivery she replied that for the time being the emphasis is on improving data delivery to WOUDC. There was a question on obtaining key photolysis rates at sites. A. Webb replied that the tools are there for converting from irradiance data, but that currently there is a lack of resources to do this for the massive amount of data.

7.6 Ozone
Johannes Staehelin presented the work of the Ozone SAG, which he chairs. He described various aspects of the instrumental measurements. Two important current activities are the work on the IGACO-Ozone implementation plan and the proposal to adopt the GAW ozone observing system as a network in GCOS.

After the presentation there was a discussion on whether surface ozone belongs to the Ozone SAG or the Reactive Gases SAG. Later during the meeting it was agreed that surface ozone continues to belong to the latter.

There were also questions on the IGACO offices. It was noted by the JSSC Chair that IGACO offices will be incorporated into the SAGs.

Geir Braathen gave a report on the activities taking place in IGACO-Ozone/UV. The IGACO-Ozone/UV office is hosted at the FMI. The IGACO-Ozone implementation plan is scheduled to be completed by end of 2007. The various activities planned within IGACO-Ozone/UV are both scientifically and technically oriented. It was noted that data format issues are stumbling blocks that hinder the development of products. There was a comment that the IGACO-Ozone/UV work is largely operational and GAW should focus more on products, application of research, and service development.

The proposal to adopt the GAW ozone network (excluding surface ozone) as part of GCOS is to be submitted to the GCOS secretariat. The final decision on this matter will be taken at the GCOS Steering Committee meeting 16-19 October 2007. There was a comment that this needs to be reflected in the GSP.

Recommendation: The JSSC endorsed the registration of GAW Ozone network as a comprehensive network within GCOS.

7.7 GURME

7.7.1 GURME activities
Greg Carmichael reported on the activities within the GAW Urban Research Meteorology and Environment (GURME) project. He started by noting that air quality prediction is a challenge of scales and integration. He presented the tasks for the strategic planning period 2008-2015. Observational and modelling needs, capacity building, air quality and related products, and users are linked through assimilation, demonstration, education, coordination, and dissemination. He informed the session of the development of an air quality (AQ) forecasting course that was put
together by the GURME Training Team and delivered for the first time in Lima, Peru in July 2006 for South American countries. This course is to be delivered in other WMO regions as well. The Latin American Cities project has also included training on the role of satellites in air quality.

G. Carmichael described some of the GURME projects, such as Latin American Cities and Shanghai, and the GURME Helsinki Test Bed Partnership. He noted that in GURME projects there is collaboration between NMHSs, environmental agencies, municipal authorities and academia. The Shanghai GURME project is part of a larger demonstration project Multi-Hazard Early Warning System (MHEWS) for Shanghai, which will be ready by 2010 and demonstrated at the World EXPO. The GURME part contains subprojects on a testbed, urban heat island, assessment of the influence of side-to-side cities in the Yangtze River Delta Region, understanding the physical and chemical mechanism during the formation, transportation and transformation processes of the main air pollutants, establishment of the air pollution numerical prediction model for Shanghai and its Delta region, and improvement of the assessment technique of air quality.

7.7.2 WMO Conference on Secure and Sustainable Living

Liisa Jalkanen reported on the International Conference on Secure and Sustainable Living: Social and economic benefits of weather, climate and water services, which took place in Madrid in March 2007 with 500 participants from 115 countries under the patronage of Her Majesty Queen Sofia. The purpose of this large WMO conference was to increase awareness of users to opportunities provided by NMHSs and for the NMHSs to understand more fully user requirements. A focus event on air quality, organized by GURME, was held at the conference. The Madrid Conference Statement and Action Plan includes the following steps to be taken:

- Strengthen observational programmes and associated research and development,
- Improve delivery and distribution systems (incl. EWS),
- Urban environment critical ecosystem requiring targeted analysis, research and NMHS services,
- New economic assessment techniques to be developed.

Discussion followed the two above presentations. There was a question on calculating individual exposure budgets. G. Carmichael replied that this might come in the future, but for now GURME has not looked further down in scale than street canyon level. AQ forecasting has been the focus in GURME. There was a question if AQ management should be introduced into GURME activities. G. Carmichael replied that information such as “if 50 % of people do not use cars, the air quality will be…” can be included but due to the split between responsibilities normally between NMHSs and environmental agencies, not much on AQ management (such as plant siting) will be included. It was noted that GURME activities would fit well into GEO. There was also discussion on the potential of satellite data integration into modelling.

A question was raised on the criteria for selecting GURME pilot projects. G. Carmichael replied that there is a procedure for establishing pilot projects and a task was agreed to be added on this to the GSP.

Action: Add a task on criteria for GURME projects into GSP.

8. Remaining Chapters of the Strategic Plan and General Discussion

The SAG presentations covered a large part of the GSP. Discussion of general nature and on the remaining chapters followed. It was noted that some chapters/parameters were lacking products and services. It was agreed that S. Penkett would provide some text for the mission of GAW, that S. Nickovic would provide something on GALION, and that U. Baltensperger text on aerosol chemistry.

In discussion on Chapters 4, Quality Assurance, and 5, Data Management, there were questions regarding the ISO rules. It was pointed out that these are difficult to understand, as it is a new type of language, and that help is needed. In UV work have changed to ISO terminology with
the help of V. Mohnen, but the real meaning can be difficult to grasp. It is not clear to the SAG chairs how much work will be required to comply with the ISO rules. This issue came up later in the discussion of WMO Quality Management Framework (QMF).

During the discussion on Chapter 11, Resources, there were concerns raised over the funding situation. Ø. Hov pointed out one positive aspect, namely that the European Union is more and more supporting the goals of IGOS and IGACO. However, for GAW operation more stable funding than offered through 3-4 year projects is needed.

Finally, the executive summary was discussed. It was agreed that some text on GURME should be added.

Kelder wanted to include a mentioning that the lower troposphere becomes more and more accessible from satellites and that data access is also easier now than earlier. ESA and Eumetsat do a lot now to involve users. Müller responded that many people still have difficulties to access satellite data and this should be made visible. Peuch added that we should not give the impression that we can measure air quality from space. This is still for the future.

Hov rounded off the discussion promising that he would make a last check of the document and verify that agreed changes are carried out.


9. DATA AND QUALITY MANAGEMENT IN WMO
Please see presentations in attached CD for details.

9.1 WMO Information System (WIS)
David Thomas gave a presentation on the WMO Information System (WIS), which is going to be the successor and expansion of WMO Global Telecommunication System (GTS). The Global Information System Centres (GISC) will provide for global exchange of data and products, collect and provide metadata for all data and products, and support data and information discovery and pull. The WIS vision: Integrated approach for all WMO Programmes to provide the right information to the right place at the right time through:

- Routine collection and dissemination of time-critical and operations-critical data and products.
- Data Discovery, Access and Retrieval service.
- Timely delivery of data and products.
- Unified procedures.
- Coordinated and standardized metadata.
- External access (especially for metadata).

It was mentioned that the October WMO Bulletin (2006) has excellent articles on WIS. There was discussion on the addressing of GAW needs in WIS. V. Mohnen had represented GAW in the expert group on WIS and S. Nickovic has been named as the GAW representative. The GAW WDCs can become Data Collection and Production Centres (DCPCs) and they can be considered ideal for illustrating the DCPCs. It was noted that the GAW community is not just NMHSs, thus the question is that will WIS improve data accessibility for the GAW community? D. Thomas replied that metadata will certainly be publicly available, and that non-members (non-NMHSs) may become additional national centres, EPAs can be nominated, but this needs to be done through the Permanent Representative (PR) of the country. It was felt that this needed more discussion, but that was decided to take place after Joerg Klausen’s presentation.
9.2 WMO GAW World Data Centres and GAWSIS

Jörg Klausen gave a presentation on the WMO-GAW World Data Centres and the GAW Station Information System (GAWSIS). GAWSIS will have links to all (surface) data centres, there are plans to include also centres outside of GAW. J. Klausen is a member in the WMO metadata group, this work is very technical.

After the presentation discussion continued on how WIS can serve the needs of GAW. There is data on one hand and users on the other, can WIS help us get a path through this jungle? Is it necessary to change the data format? D. Thomas replied that there are benefits to using WMO formats, but that it would not be necessary. GAWSIS would synchronize with GISC, it would be the NC/DCPC between GAW centres as portrayed in the WIS vision.

Action: It was decided that a group consisting of the Expert Team on World Data Centres (ET-WDC) together with Vincent-Henri Peuch and Slobodan Nickovic, and in his absence Geir Braathen, liaise with those who are responsible for WIS to obtain the most appropriate interface between GAW and WIS.

9.3 WMO Quality Management Framework

Isabelle Rudi gave a presentation on the WMO Quality Management Framework (QMF). V. Mohnen represented CAS in the Inter-Commission Task Team on Quality Management Framework (ICTT QMF). Some participants felt a bit of confusion on links to QMF and to ISO, but it was noted by the Chair that QMF is there to help us. I. Ruedi explained that the Technical Commissions (TCs) can recommend standards for ISO for instance by developing a standard and then submitting it to ISO for publishing. In case there is concern for instance for costs, the option no 2 presented here is applicable, namely that the publications of joint ISO-WMO technical standards will be:

- Published independently by ISO and WMO, each referring to the standard of the other organization.
- ISO sells ISO Publication.
- WMO sells WMO publication (same as now).
- WMO free to choose its distribution policy.

ICTT-QMF recommended to allow free internet access to the electronic versions of WMO publications, issue Technical Regulations and their annexes in all languages simultaneously, and to avoid issuance of supplements - instead issue new versions. It was noted that the Strategic Plan lacked a link to ISO.

Action: It was agreed that links between GAW and ICTT QMF and ISO should be added to the GSP as well as appropriate task(s).

10. REGIONAL AND NATIONAL GAW ACTIVITIES

Yukitomo Tsutsumi, Japan, Gerrie Coetzee, South Africa, Paul Fraser, Australia, Yuri Tsaturov, Russian Federation and Yrjö Viisanen, Finland gave presentations on GAW activities in their respective regions. Here follows a short summary of their presentations. More detailed information is found on the CD-ROM attached to this report.

Y. Tsutsumi, Japanese Meteorological Agency (JMA), gave an overview of GAW activities in Japan. His talk was organized in three sections: 1) GAW observations in JMA, 2) GAW facility activities in JMA and 3) JMA services that provide information on environmental issues.

Observations: Greenhouse gases, reactive gases and aerosols are measured at three sites: Ryori (since 1987), Minamitorishima (since 1993) and at Yonagunijima (since 1996). Common to all three sites is that they measure CO₂, CH₄, CO, O₃ and aerosol optical depth. At Ryori one also measures N₂O, CFCs and aerosol vertical profiles. Tsutsumi gave references to several scientific papers where these data have been used. Ozone and UV radiation are measured at four sites: Sapporo, Tsukuba, Naha and Syowa (Antarctica). Also for ozone and UV there were several
examples of scientific papers with data from Japanese ozone and UV stations. Next Tsutsumi described **activities at Japanese GAW facilities**. These facilities include: WMO World Data Centre for Greenhouse Gases (WDCGG), mobile data submitters to WDCGG, such as passenger aircraft and ships, and the WDCGG web site. Tsutsumi described the problems with the WDCGG data reporting manual, which is now out of date because of the technological development since 1991 and the increased number of species that are reported. Tsutsumi then highlighted the WMO Greenhouse Gas Bulletin, which is made in collaboration between WDCGG, NOAA/ESRL/GMD and the WMO Secretariat. Then he described QA/SAC activities in JMA, CO₂ observations in Danum Valley, Malaysia, support to total ozone observations in South Korea, and World Calibration Centre activities (Asia and Oceania) for methane. JMA hosts the Regional Dobson Calibration Centre for Asia and Tsutsumi reported on the RA II Dobson intercomparison which was held in Tsukuba in 2006. In the third section of the talk, Tsutsumi reported on **information services**. These include: A sand and dust-storm analysis and prediction system, UV index forecasting and carbon circulation analysis.

G. Coetzee, South African Weather Service, gave a presentation on 1) GAW activities and 2) GURME activities in South Africa. 1) **GAW activities** include trace gases and aerosol measurements at the global GAW station at the Cape Point; total ozone measurements at Irene and Springbok; ozonesonde observations at Irene; UV-B radiation measurements at Cape Town, Cape Point, Port Elizabeth, De Aar, Durban and Pretoria; and BSRN measurements at De Ar. Coetzee mentioned the upcoming Dobson intercomparison for RA I, which is planned to take place in 2008 in Irene. The ozonesonde activities at Irene have been part of the SHADOZ (Southern Hemisphere ADditional OZonesondes) network since 1997. At the Antarctic station SANAE, there are measurements carried out on surface ozone, total ozone (SAOZ) and other trace gases. 2) In the second part of the presentation, Coetzee described GURME activities. This is a new activity for SAWS. The drive behind is a new government act that states the right of every human to live in a clean environment. An air quality network with data information in real time has been set up for Cape Town. Among regional initiatives Coetzee mentioned the CAPIA project, involving the southernmost states of Africa and the APINA network, the main role of which is to form a strong link between the air pollution scientific community and policy makers at national and regional levels in Africa.

P. Fraser, CSIRO Marine & Atmospheric Research, presented the Australian GAW activities, which are carried out as a co-operation between CSIRO and the Bureau of Meteorology (BoM). The activities encompass observations of solar and terrestrial radiation, total column ozone, profile ozone with electrochemical sondes and precipitation chemistry. The most complete suite of observations are done at the Cape Grim station, which is a global GAW station and one of the least polluted sites in the world. Here a number of trace gases and other parameters are measured. Radiation is measured at a dozen sites scattered all over the country. Total column ozone is measured from five sites (including Macquarie Island) and ozonesondes are launched from two sites (Melbourne and Macquarie Island). Analysis of total ozone and UV data indicate that the first phase of ozone recovery has set in, namely that the ozone decline has slowed down and maybe even leveled out. Annual mean ozone profiles from 1999 and 2000 show still substantially less ozone than a mean profile from 1970 (Macquarie Island). The BoM runs a regional instrument centre that maintains physical standards and look after the quality assurance of the data from the networks. CSIRO runs a global network for greenhouse gases, which is the second largest in the world after the NOAA network. CSIRO also contributes to the operation of the GAW station in Danum Valley in Malaysia. Another project is the analysis of CO₂ and CH₄ in air bubbles from ice cores drilled at Law Dome and South Pole and that give time series of these two gases 2000 years back in time.

Y. Tsaturov, Roshydromet, presented GAW activities in the Russian Federation. The Russian **precipitation chemistry** network consists of 170 stations measuring chemical composition and/or pH. During the last few years the precipitation chemistry data from the Russian stations were not submitted to the GAW World Data Centre for Precipitation Chemistry (WDCPC), USA, but the submission is in process now. Monitoring of two major **greenhouse gases** (CO₂ and CH₄) is carried out at three stations (Teriberka - Kolsky peninsula; New Port – Yamal peninsular; Voeikovo
- suburbs of Saint-Petersburg). The observations of total column ozone are carried out over the territories of Russia, Ukraine, Kazakhstan. In the framework of this task Roshydromet provides stable functioning of the system for monitoring anomalies and the distribution of the column ozone based on the analysis of data from the ground ozonometric network which in Russia includes 29 stations. In 2006 regular observations of UV-B radiation were fulfilled at 14 stations of the National ozonometric network (Total Ozone) under Roshydromet. Measurement data are sent to the Voeikov Main Geophysical Observatory. In 2006 regular automated measurements of total ozone and spectral UV were started at Tsimlyansk. The activities of the World Radiation Data Centre (WRDC) during 2006 were directed at the extension of the GAW network of stations which observe the radiation balance components. All data are published on the WRDC site. The number of users of this site grows rapidly. During 2005 - 2006 years the Roshydromet Hydrometeorological Bureau of Moscow and Moscow Region has continued implementation of the GURME Pilot Project. The Pilot Project is carried out in cooperation with the different organizations of Roshydromet with assistance of the Moscow Government and the Government of the Moscow Region. It is a pleasure to note, that the project is implemented satisfactorily.

Y. Viisanen, Finnish Meteorological Institute (FMI), spoke about the atmospheric observatory at Pallas-Sodankylä and the collaboration with Tiksi in the IASOA project. FMI takes part in the IASOA project, proposed by NOAA, for IPY. This project was chosen to lead the coordination of 19 related Atmospheric proposals into an IPY activity. The aims of IASOA are to develop intensive Arctic atmospheric/interdisciplinary observatories with International partnerships; Enhance atmospheric networks (e.g. BSRN, GAW, CRN, Aeronet, UVnet, MPLNet); Coordinate ongoing monitoring activities with field campaigns; and Integrate with AON, GEWEX, SEARCH, WCRP. Partner countries are: Canada, Finland, Norway, Russia, Denmark, China, Germany, Japan, Sweden, United States, Italy. The Pallas-Sodankylä station is a member of the group of Circumpolar Atmospheric Observatories, which in addition comprises Barrow, Eureka/Alert, Summit, Ny-Ålesund, Abisko and Tiksi. CO₂ is measured at Pallas and the growth rate between 1997 and 2006 has been oscillating between 1 and 3 ppm/year. Micro-meteorological CO₂ flux measurements are carried out at various sites of the FMI, representing different vegetation types. Viisanen pointed out that more than half of the world’s 12 million km² of boreal forests are situated in Fenno-Scandinavia and the Russian Federation. Viisanen showed results from a scientific paper that has been published in Science and which shows that there is a high natural aerosol loading (1000-2000 particles/cm³) over Boreal Forests. The observed loading can be explained by the conversion of 5-10% of the emitted terpenes into particulate matter. The question is how this affect cloud droplet number concentrations and climate, and if there are any climatic feedback mechanisms involved. The Tiksi Observatory in Eastern Siberia was rebuilt in 2006 with funds from the US National Science Foundation. The station will have a clean air facility to support IPY/IASOA, ACIA and AMAP programmes and to help Russians to start atmospheric composition monitoring of CO₂ and CH₄ concentrations and their trends; CO₂ and CH₄ balances of a typical tundra landscape; Aerosol physics including cloud formation; Airborne mercury, lead, cadmium, and PAH compounds.

11. INFORMATION FROM AND COLLABORATION WITH OTHER MAJOR OBSERVATIONAL STRATEGIES AND PROGRAMMES

All presentations can be found in the enclosed CD.

11.1 GEO and GEOSS

Brendan Kelly from the GEO secretariat gave a presentation on GEO and GEOSS. He noted that they have a 10 year workplan which will most likely be extended. The focus is on benefits to society. The Committees that are important to GAW are the ones on user interface and on architecture and data. He stressed the fact that the success of GEO depends on guidance and contributions from all of us. GEO is a framework where contact can be facilitated. There is a need to foster ownership in groups such as GAW and a need to make things more useful and rational. The workplan includes monitoring and forecasting air quality systems globally and there is an “Air and Health Community of Practice (AHCP)”.

10
During the following discussion it was noted that as GEO is you/us, it will take off and not remain a plan if we want it to work. And do not continue business as usual. It was noted that there is a lot of discussion that is taking place in GEO but not elsewhere, which is important. It was also noted that it is good to have governmental support in these activities on ministerial level. B. Kelly noted that they are not able to reach to Asia and Africa at the moment and that would be a good role for GAW. The Chair summarized by noting that GEO is somewhat of a top down system. We need to open up for this, something can happen. We need to show more societal benefits.

11.2 International Polar Year (IPY)

Eduard Sarukhanian, special advisor to the Secretary-General on IPY, and Øystein Hov presented overviews of the work going on within the International Polar Year. IPY 2007-2008 is an intensive and internationally coordinated campaign of high quality research activities and observations in the polar regions. It is intended to lay the foundation for major scientific advances in knowledge and understanding of the nature and behaviour of the polar regions and their role in the functioning of the planet. Some IPY project proposals related to GAW:

- Atmospheric Monitoring Network for Anthropogenic Pollution in Polar Regions (ATMOPOL, ID 76, Institute for Air Research, Norway).
- Polar Study using aircraft, remote sensing, surface measurements and modelling of climate, chemistry, aerosols and transport (POLARCAT, ID 32, Institute for Air Research, Norway).
- Ozone layer and UV radiation in changing climate evaluated during IPY (ORACLE-O3, ID 99, Alfred Wegener Institute for Polar and Marine Research, Germany).
- Ocean-Atmosphere-Sea Ice-Snowpack Interactions (OASIS, ID 38, C.N.R.-IIA, Italy).
- Air-Ice Chemical Interactions (AIIC-IPY, ID 20, BUS, UK).
- International Arctic Systems for Observing the Atmosphere (IASOA, ID 196, NOAA, USA).

The session was invited to provide guidance for IPY implementation to facilitate the efficient services of IPY operations, the sustainable exchange of IPY data in real- and non-real time modes, and on security of a legacy of the IPY, including atmospheric chemistry measurements and observational data sets.

E. Sarukhanian noted that another important task is to establish through IPY Joint Committee a dialog with CBS, CAS, CHy, JCOMM, GEO, CGOS, GOOS, WCRP as well with the Arctic Council and ATCM to secure provision for the legacy of observing systems established or rehabilitated during the IPY. It is highly desirable to establish a mechanism for early assessment of benefits acquired from new observations, in order to prepare for supporting the long-term reinforcement of networks in Polar Regions. He further noted that this mechanism should consist of representatives from the main partners involved in IPY, including WMO technical commissions.

11.3 CEOS

Joerg Langen gave a presentation on behalf of Ernest Hilsenrath and himself on the Committee on Earth Observation Satellites (CEOS). The Atmospheric Composition (AC) Constellation is one of four pilot projects to bring about technical/scientific cooperation and collaboration among space agencies and provide coordinated input to GEOSS. The themes of the four constellations are Atmospheric Composition, Precipitation, Ocean surface topography, and Land surface imaging. The AC Constellation study will identify mission(s) or data delivery that serves the science and application community. The AC Constellation considers only the space component of atmospheric composition observations, but recognizes the need for complementary ground based measurements and modelling to fully address science priorities. He further discussed the AC Constellation plan, benefits, objectives for 2007, participants and interaction with GAW. He presented a view of the GSP from the ‘space perspective’ and noted that the establishment of requirements for space measurements depends on expertise regarding space capabilities. He felt this should be led by CEOS.
Discussion followed during which it was noted that the newly established World Data Centre for Remote Sensing of the Atmosphere (WDC-RSAT) is a step in the direction of including the space community in the GAW organisational structure. It was also noted that NDACC takes care of several of the molecules mentioned, such as ClO and BrO. The view was expressed that GAW should have a say on which molecules to measure. It was not agreed that CEOS should decide on this. The molecules mentioned are mainly of interest to stratospheric scientists. The Chair suggested that we should change the wording in the GSP and state that WMO-GAW is the lead in implementing the IGACO strategy including setting measurement requirements for all types of measurements. He further invited the satellite community to read the GSP with their IGACO glasses on and get back with comments. This will be a long process that should be started now.

11.4 European initiatives towards a GMES atmospheric service and near real time chemical data exchange

Vincent-Henri Peuch gave a presentation on European initiatives towards a GMES atmospheric service and near real time chemical data exchange. He started by noting that there is a significant overlap between the GEMS and PROMOTE consortia, but while aiming at the joint objective of a GMES atmosphere core service, they approach different sides. GEMS is very much oriented on the development of new operational systems, supporting research and validation, while PROMOTE is specially focused on demonstration of existing services and organising links with users. He went on to present some results for GEMS.

He noted that NRT (1-24h delay) access to observational data is needed for assimilation or verification of « Chemical Weather » / Air Quality forecasts. The advantages are: « automatic » streams are set up and make actual use of the data; « automatic » monitoring and feedback to data producer is possible; experience gathered in operations is far superior to what can be gained on the basis of past episodes. Whereas the disadvantages are: data is most likely unvalidated; accommodate for a range of formats; air quality data has a political weight (vs annual declaration of exceedances by countries); acknowledgement of data owner and funding. He ended by discussing the ToRs for the ET-NRT CDT.

11.5 Plans for future satellite missions for air quality in Europe

Hennie Kelder gave a comprehensive presentation on plans for future satellite missions for air quality in Europe. He started by listing the air quality science objectives:

- How fast is air quality changing on a global and regional scale?
- What is the strength and distribution of the sources and sinks of trace gases and aerosols influencing air quality?
- What is the role of transport?
- What is the role of tropospheric composition in global change?

H. Kelder summarized by saying that for 2007 - 2011 atmospheric chemistry community is well served by SCIAMACHY, OMI, GOME-2 and IASI. There will be continuity through Metop, GOME-2 and IASI till 2020, but not optimal for air quality due to restricted temporal and spatial resolution. He noted as chances and opportunities: ESA/EU/EUMETSAT GMES Atmospheric Services, sentinels 4 and 5; Eumetsat Post-EPS sentinel 5: Possible launch 2018 - ; Earth Explorer missions, 2016 - and national initiatives: Gapfiller.

Recommendation: GAW should take a lead in including the atmospheric chemistry community in setting requirements for future space-based atmospheric chemistry observations

12. CLOSING OF THE MEETING

The chair closed the meeting at 16.00 on 12 April 2007. Both he and the Director of AREP thanked the participants for their contributions.
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Group Photo of Participants at the CAS Joint Scientific Steering Committee of the Open Area Programme Group on Environmental Pollution and Atmospheric Chemistry (JSSC OPAG-EPAC) Geneva, Switzerland, 11-12 April 2007.
MEETING of the CAS JOINT SCIENTIFIC STEERING COMMITTEE of the OPEN AREA PROGRAMME GROUP on ENVIRONMENTAL POLLUTION and ATMOSPHERIC CHEMISTRY (JSSC OPAG-EPAC)

(Geneva, Switzerland, 11-12 April 2007)

AGENDA

Wednesday, 11 April 2007

9.00 Opening of the Session
   Welcome by the Deputy Secretary-General, Prof. Hong Yan
   Welcome by Director AREP, Len Barrie

9.20 Overview of CAS XIV and review of terms of reference
   Oystein Hov, Chair JSSC

9.45 Status of GAW observing systems and GURME
   Each SAG chair or representative will give a 15 min overview of activities, discussion to follow. Overview and discussion will include the relevant chapter of the WMO Global Atmosphere Watch (GAW) Strategic Plan: 2008-2015.

   Overview of the GAW Strategic Plan, Geri Müller

10.15 Group photograph and Coffee Break

10.45 Status of GAW observing systems and GURME (cont)
   Aerosols, Urs Baltensperger
   Sand and Dust Storm forecasting, Slobodan Nickovic
   Galion, Slobodan Nickovic

   Precipitation Chemistry, Wenche Aas
   Including discussion on WDCPC

   Reactive gases, Stuart Penkett

12.15 Lunch

13.30 Status of GAW observing systems and GURME (cont)
   Greenhouse gases, Ed Dlugokencky

   Ultraviolet radiation, Ann Webb

   Ozone, Johannes Stähelin
   IGACO O₃/UV, Geir Braathen and Yrjö Viisanen
   GCOS proposal, Geir Braathen and Johannes Stähelin
15.00 Coffee break

15.30 GURME, Greg Carmichael
    WMO Conference on Secure and Sustainable Living (Madrid March 2007),
    Liisa Jalkanen

16.00 Data Management
    WMO GAW World Data Centres and GAWSIS, Joerg Klausen
    WMO WDC for remote sensing, Oystein Hov

16.45 GAW Strategic Plan, Geri Muller
    The parts of the GAW Strategic Plan 2008-2015 that have not been covered above, will be
discussed.

18.30 Fondue hosted by WMO, Buvette Bains de Paquis, Quai du Mont-Blanc 30

Thursday 12 April 2007

9.00 Data and quality management in WMO
    WMO WIS, David Thomas (WMO/WWW)
    WMO Quality Management Framework, Isabelle Ruedi (WMO/WWW)

10.00 Regional/national GAW activities (20 min presentations including discussion)
    Yukitomo Tsutsumi, Japan
    Gerrie Coetzee, South Africa

10.40 Coffee break

11.10 Regional/national GAW activities (cont)
    Paul Fraser, Australia
    Yuri Tsaturov, Russian Federation
    Yrjö Viisanen, Finland

12.10 Lunch

13.15 Information/collaboration with other major observational strategies/programmes
    GEOSS, Brendan Kelly
    IPY, Eduard Sarukhanian and Oystein Hov
    European initiatives towards a GMES atmospheric service and NRT chemical data
    exchange, Vincent-Henri Peuch
Plans for future satellite missions for air quality in Europe, Hennie Kelder

Other initiatives (as per participants input)

15.00 Coffee break

15.15 GAW Strategic Plan adaptation, Geri Muller

16.00 Closure

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TERMS OF REFERENCE FOR THE JOINT SCIENTIFIC STEERING COMMITTEE FOR THE OPEN PROGRAMME AREA GROUP FOR ENVIRONMENTAL POLLUTION AND ATMOSPHERIC CHEMISTRY (JSSC FOR OPAG-EPAC)

(a) To keep informed of, and review scientific developments in, the fields of environmental pollution and atmospheric chemistry, including the interrelationships between changes in atmospheric composition, global and regional climate and other aspects of the Earth system, and perturbations to the natural cycles of chemical species in the atmosphere/ocean/biosphere system;

(b) To advise CAS and recommend actions that WMO should take to promote, initiate, facilitate or set priorities for:
   (i) Long-term globally integrated observations of atmospheric composition and air pollution, including greenhouse gases, ozone, UV radiation, reactive gases, aerosols and precipitation chemistry;
   (ii) The high quality, timeliness and continuity of data from the monitoring network including aircraft and satellite and the development of a functional system for real-time or quasi-real-time measurements;
   (iii) The transport, transformation and deposition of air pollutants on all space and time-scales;
   (iv) User-friendly access to the data and application of data for analysis, assimilation and assessments on the existing and emerging environmental issues both of global and regional importance;
   (v) Development of air pollution, weather and climate predictive capability including inverse modelling for source estimation;
   (vi) Management of urban air quality;

(c) To maintain a Strategic Implementation Plan for the GAW programme taking into account the IGACO strategy;

(d) To oversee the operation of the GAW programme;

(e) To cooperate with other relevant programmes and organizations inside and outside WMO:
   (i) Liaise and communicate with GEOSS, CEOS and IGOS.
   (ii) Collaborate with the CAS WWRP, particularly with the Expert Team for Weather Modification, working groups of CBS and other technical commissions of WMO.
   (iii) Review and assess the Societal and Economic Application (SEA) Component of EPAC and contribute to other WMO SEA related activities.

(f) To support international conventions;

(g) The members of the OPAG-EPAC Joint Scientific Steering Committee (JSSC) are the chairs of the Scientific Advisory Groups and other selected experts to fill gaps in geographical and thematic representation. The members are appointed by the management group upon recommendation by the OPAG-EPAC chair.
GLOBAL ATMOSPHERE WATCH REPORT SERIES


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


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


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


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


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


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


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


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


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


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


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


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


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

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


89. 4th International Conference on CO₂ (Carqueiranne, France, 13-17 September 1993) (WMO TD No. 561).


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


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


104. Report of the Fourth WMO Meeting of Experts on the Quality Assurance/Science Activity Centres (QA/SACs) of the Global Atmosphere Watch, jointly held with the First Meeting of the Coordinating Committees of IGAC-GLONET and IGAC-ACE, Garmisch-Partenkirchen, Germany, 13 to 17 March 1995 (WMO TD No. 689).
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<th>No.</th>
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<tr>
<td>105</td>
<td>Report of the Fourth Session of the EC Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry (Garmisch, Germany, 6-11 March 1995) (WMO TD No. 718).</td>
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<tr>
<td>107</td>
<td>Extended Abstracts of Papers Presented at the WMO-IGAC Conference on the Measurement and Assessment of Atmospheric Composition Change (Beijing, China, 9-14 October 1995) (WMO TD No. 710).</td>
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<td>113</td>
<td>The Strategic Plan of the Global Atmosphere Watch (GAW) (WMO TD No. 802).</td>
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<td>120</td>
<td>WMO-UMAP Workshop on Broad-Band UV Radiometers (Garmisch-Partenkirchen, Germany, 22 to 23 April 1996) (WMO TD No. 894).</td>
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124. Fifth Session of the EC Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry, (Geneva, Switzerland, 7-10 April 1997) (WMO TD No. 898)

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

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


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


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


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


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


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


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<tr>
<td>146.</td>
<td>Quality Assurance in monitoring solar ultraviolet radiation: the state of the art. (WMO TD No. 1180).</td>
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<td>149.</td>
<td>Comparison of Total Ozone Measurements of Dobson and Brewer Spectrophotometers and Recommended Transfer Functions (prepared by J. Staehelin, J. Kerr, R. Evans and K. Vanicek) (WMO TD No. 1147).</td>
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<tr>
<td>150.</td>
<td>Updated Guidelines for Atmospheric Trace Gas Data Management (Prepared by Ken Maserie and Pieter Tans (WMO TD No. 1149).</td>
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<td>154.</td>
<td>WMO/IMEP-15 Trace Elements in Water Laboratory Intercomparison. (WMO TD No. 1195).</td>
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<td>159.</td>
<td>IGOS-IGACO Report - September 2004 (WMO TD No. 1235)</td>
</tr>
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170. WMO/GAW Expert Workshop on the Quality and Applications of European GAW Measurements (Tutzing, Germany, 2-5 November 2004) (WMO TD No. 1367).


172. WMO Global Atmosphere Watch (GAW) Strategic Plan: 2008 – 2015 (WMO TD No. 1384)


174. World Data Centre for Greenhouse Gases Data Submission and Dissemination Guide (WMO TD No. 1416).


176. The Tenth Biennial WMO Consultation on Brewer Ozone and UV Spectrophotometer Operation, Calibration and Data Reporting (Northwich, United Kingdom, 4-8 June 2007) (WMO TD No. 1420).