

GAW Report No. 210

Report of the Third Session of the CAS JSC OPAG-EPAC

(Geneva, Switzerland, 27-29 April 2011)

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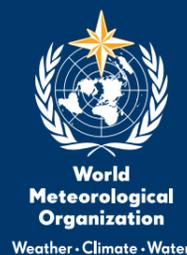
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WORLD METEOROLOGICAL ORGANIZATION GLOBAL ATMOSPHERE WATCH

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

(Geneva, Switzerland, 27-29 April 2011)



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TABLE OF CONTENTS

1.	OPENING OF THE MEETING	1
1.1	Welcome	1
1.2	Adoption of Agenda and approval of the report of the previous meeting	1
1.3	Overview of CAS-XV, Executive Council Research Task Team (EC RTT) and other important initiatives in light of GAW	1
2.	GAW STRATEGIC PLAN	2
2.1	Review of the status and future direction of the work of SAGs and ETs	2
2.2	QA/QC in GAW	8
2.3	GAW station classification and the procedures for acceptance of stations	10
2.4	Products and Services	11
2.5	Review of the Addendum of the GAW Strategic Plan	11
3.	CONGRESS PREPARATIONS	11
4.	DISCUSSION ITEMS	12
4.1	Black carbon and ozone as short-lived climate forcers	12
4.2	Technical chemicals that replace halocarbons, relationship to GAW	12
4.3	Water vapour (GRUAN)	13
4.4	Sand and dust storm warning advisory and assessment system (SDS-WAS)	13
4.5	Volcanic ash forecasting	14
4.6	Satellite Task Team	14
4.7	Data Flow and WIS	15
4.8	Contribution to environmental conventions and intergovernmental assessments	16
4.9	Relationship with other programmes, especially GCOS, GMES and GEOSS	16
5.	MATTERS ARISING	16
5.1	Network for the Detection of Mesopause Change (NDMC)	16
6.	REVIEW OF ACTION ITEMS AND RECOMMENDATIONS	17
7.	CLOSURE OF THE MEETING	19
	ANNEX A - List of Participants	21
	ANNEX B - Meeting Agenda	23
	ANNEX C - JSSC Terms of Reference	24
	ANNEX D - Recommendation letter to be circulated to major space agencies	25

1. OPENING OF THE SESSION

1.1 Welcome

The meeting of the CAS Joint Scientific Committee of the Open Programme Area Group on Environmental Pollution and Atmospheric Chemistry (JSC OPAG-EPAC) was opened at the WMO Secretariat at 11.00 on 27 April by the Co-Director of the Research Department, Dr Ghassem Asrar, and the JSC Chair, Prof. Øystein Hov, who welcomed the participants to the meeting. Dr Asrar announced the arrival on 2 May of Dr Deon Terblanche as the new director of the Atmospheric Research and Environment Branch. Dr Asrar spoke about the upcoming WMO Congress and he also mentioned that the SPARC Office will be hosted by ETH in Zurich. He asked the JSC to identify areas where resources are needed. He mentioned the following areas or issues as particularly interesting: sand and dust storms, climate change and mitigation and the role of GAW, and the relationship between GAW and WIS/WIGOS. Hiroshi Koide asked whether funding for the Global Framework for Climate Change (GFCS) will come from voluntary funds. Ghassem Asrar confirmed this and added that there are also Green Funds and that WMO will assist countries who wish to apply for such funding.

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 had been received from the following JSC members: Araneda, Artz, Carmichael, Langen and Peuch. Richard Artz participated via Telecon. Invited experts taking part in the meeting were Karen Woudsma (GAWTEC), Wolfgang Fricke (Hohenpeißenberg Observatory) and John Burrows (Institute of Environmental Physics, University of Bremen).

1.2 Adoption of Agenda and approval of the report of the previous meeting

The Agenda was approved without modifications. The approved Agenda can be found in Annex B. The main items were the GAW Strategic Plan, preparations for the WMO Congress and a number of discussion items as shown in the agenda. The following report does not consistently follow the order of business but items are grouped according to the theme.

Action item 1: Each contributor to the Session is to write a one paragraph summary of their presentation(s). Due date is 6 May.

There was then some discussion around the report from the previous OPAG-EPAC JSC meeting in May 2009. Liisa Jalkanen informed that the report has been posted on the web prior to the present JSC meeting and that it is still possible to send editorial comments. A deadline of 6 May was given for comments.

Action item 2: JSC members are to send in their comments on the report from the previous OPAG-EPAC JSC meeting by 6 May.

Stuart Penkett mentioned that at the last JSC meeting there was discussion about IGACO and he would like to know if there would be discussion on that topic also at the present meeting. Øystein Hov explained that IGACO is now implemented in GAW and that IGACO belongs to the past. Already at the CAS meeting in Cape Town (Feb. 2006) it was decided that IGACO be implemented in GAW. Gerhard Müller proposed that one should terminate the discussion about IGACO and rather focus on the future. The report from the last meeting was adopted, but with the possibility to comment on it until 6 May.

1.3 Overview of CAS-XV, Executive Council Research Task Team (EC RTT) and other important initiatives in light of GAW

1.3.1 CAS-XV

Øystein Hov gave an overview of decisions and recommendations from the fifteenth session of the Commission for Atmospheric Sciences, which was held in Incheon, Republic of Korea in November 2009. He reminded that CAS had highlighted that:

- Changes in air pollution, climate and the biogeochemical cycles of trace chemicals in the atmosphere such as carbon and reactive nitrogen give rise to environmental problems. Meteorological processes often strongly influence their severity and rate of change.
- The analysis and abatement of these problems requires an interdisciplinary approach both nationally and internationally.

Thus the Commission:

- Urges WMO and its partners to intensify efforts to develop appropriate partnerships across disciplines nationally and internationally to address these challenges.
- Agrees that it is important to develop a common understanding of air pollution, its health impacts, its long range transmission and the interaction with weather and climate change.
- Agrees that many international conventions and initiatives would benefit greatly from a common approach developed with the help of WMO and its partners nationally and internationally.

Øystein Hov then cited from the recommendation in Chapter 8.3.4 in the report from CAS-XV (WMO-No. 1050), which speaks to a strengthening of observations, near-real time delivery of data and capacity building.

1.3.2 EC-RTT

Øystein Hov gave an overview of the report from the Executive Council Task Team on Research Aspects of an Enhanced Climate, Weather, Water and Environmental Prediction Framework (EC-RTT). General recommendations from the EC-RTT are:

- Coordinating and Accelerating Prediction Research: Develop a unified approach to multidisciplinary weather, climate, water and environmental prediction research and step up high-performance computing investments for coordinating and accelerating weather, climate, coupled chemical and hydrology model development, validation and use.
- Linking Research, Operation and Service Delivery: Develop closer linkages between research, operations and users through Forecast Demonstration Projects (FDPs) that accelerate technology transfer.
- The Role of WMO Commissions: Implement a process to review and rationalise the roles and mandates of the commissions, and to improve their effectiveness in enhancing WMO Member capabilities in research, observations, prediction and services.

Summing up the EC-RTT recommendations and what they imply for GAW, Øystein Hov listed the following points:

- GAW is mature but resource strapped.
- WMO should ensure that the capabilities related to meteorological observations, research models, and operations are used for:
 - Linking regional air pollution issues together in a global perspective
 - Air quality forecasting
 - NRT AMDAR like observations of chemical composition including H₂O
 - Air pollution and climate change interactions, both ways
 - The water cycle issue – water as a resource and a carrier of pollutants/nutrients
 - The reactive nitrogen issue
- NMHS's are under financial pressure. WMO member countries anyhow face these problematic issues and need to address them through the institutions they have.
- NMHS's and WMO are very well positioned through the capacity to observe and to do research including develop and apply models, operationalise, verify/validate, disseminate and reach out.

2. GAW STRATEGIC PLAN

2.1 Review of the status and future direction of the work of SAGs and ETs (Each SAG and ET chair reported)

Presentations had been given already at the GAW 2009 meeting. These reviews at JSC highlighted the important points for the Session.

Report from SAG-Aerosol

John Ogren, the Chair of SAG Aerosols, reported on recent progress of the aerosol programme. Updates to the recommended list of aerosol measurements for GAW stations were included in the 2011 Addendum to the GAW Strategic Plan. The SAG's recommendation to GCOS for elaboration of the "Aerosol Properties" Essential Climate Variable has been noted by GCOS. The World Calibration Centre for Aerosol Physics has been very active in conducting station audits, holding training sessions, and organizing workshops for characterizing aerosol instruments used at GAW stations, and the World Optical Depth Research and Calibration Centre is supporting aerosol optical depth measurements at GAW stations. Unfortunately, a central calibration facility for aerosol chemistry still does not exist. The GAW Aerosol Lidar Observation Network held its second workshop in September 2010, and its European component made valuable observations in near-real time of the plume from the Eyjafjallajökull volcanic ash cloud in April and May 2010. The World Data Centre for Aerosols currently offers near-real-time collection and dissemination of GAW aerosol data from 39 instruments at 23 stations, distributed nearly from pole to pole.

Report from SAG-Ozone

Johannes Staehelin reported on the work of the SAG-ozone. The global network of Dobson spectrophotometers provides reliable long-term ground based total ozone measurements, which are also crucial for validation of satellite records including merged series. Regular Langley plot calibrations of the primary Dobson instrument (maintained by the Dobson World Calibration Centre, ESRL, Boulder, Co, USA) performed at the Mauna Loa Observatory in Hawaii provide evidence for the excellent long-term calibration stability of the network. In the "WMO/UNEP Dobson Data Quality Workshop" held in Hradec Kralove (Czech Republic, February 14-18, 2011) it was recommended to archive level 0 (i.e. original instrumental readings) Dobson data and to use a template which contains the important information of the calibration of the individual instruments. Archiving this information in a central archive will allow to (i) document data quality of the Dobson network in a modern central way; (ii) reprocess suspicious historical Dobson measurements; (iii) reprocess Dobson measurements if required e.g. when new ozone absorption cross sections need to be adopted. In the Brewer network absolute calibrations by the Langley plot method (performed in Hawaii) are not only regularly performed with the instruments of the Brewer triad (operated in Toronto, maintained by Brewer World Calibration Centre, EC, Toronto, Canada) but also with Brewer spectrophotometers operated at the Regional (European) Brewer calibration centre (Izaña, Tenerife, Spain). For the Brewer network formulation of SOPs of Brewer intercomparisons has highest priority. Data quality of ozone sonde measurements and the respective documentation is gradually improving (assisted by the Central Calibration Laboratory for ozone sondes, Jülich, Germany); presently data archiving (including harmonization with NDACC and SHADOZ network) and homogenization of ozone sonde records have highest priority. Umkehr algorithms for Brewer and Dobson instruments are presently critically analysed and improved. IGACO-O3/UV was implemented and this organization has been used to organize fruitful collaborations among scientists involved in ozone measurements performed from ground and space. IGACO-O3/UV was particularly valuable in the context of ACSO ("Absorption Cross Sections of Ozone") a joint ad hoc group of GAW (SAG-ozone, IGACO-O3/UV) and the International Ozone Commission (IO3C, IAMAS) established in spring 2009 and the SPARC/IGACO-O3/IO3C Initiative on "Understanding Past Changes in the Vertical Distribution of Ozone", a project started by a workshop which took place in Geneva January 25th-27th 2011.

Report from SAG-GHG

Ed Dlugokencky reported on activities in the Greenhouse Gas SAG. The last SAG meeting had taken place in Jena on 11 September 2009. Upcoming meeting was the 16th meeting of CO₂ experts to be held 25-28 October 2011 in Wellington, NZ. The next SAG meeting would be arranged right after that on 29 October, also in Wellington. One important issue discussed in the GHG SAG is the one on global averages of greenhouse gas mole fractions. If these mole fractions are going to be used by the IPCC they will have to demonstrate traceability to the WMO scale, which is not the case for all measurement programmes as of now. Since IPCC is subject to close scrutiny one needs a defensible approach. Dlugokencky then discussed the issue of GHG requirements for IGACO. He commented that the IGACO Statement of Guidance (SoG) has heavy emphasis on remote sensing, especially from satellites. The requirements are poorly defined, not scientifically useful and there is little evidence that such GHG observations are useful so far. Increased mole fractions of methane in 2007 and 2008, as observed by SCIAMACHY are consistent with in situ observations. However, there is insufficient spatial information to identify the cause of the recent methane increase.

There was discussion on the inclusion of GAW data in the IPCC reports. Øystein Hov stressed that GAW stations have to assure that GAW data are traceable to international standards and that traceability is a more serious issue than the filtering techniques used to make global averages. **Recommendation 1:** GAW stations are requested to publish traceability of their measurements.

Regarding the new World Calibration Centre for SF₆ a proposal has been submitted by KMA/KRISS. The SAG is generally supportive of the proposal. The question was raised how to assess the capabilities of an institute if a GAW Central Facility is offered. The SAG asks that the proposal be resubmitted using GAW terminology. Moreover, representatives of KMA/KRISS will be present at the next expert meeting, which will facilitate the dialogue. Then Dlugokencky described the work on the Guidelines for the Measurement and Quality Assurance of CO₂. Andrew Crotwell (NOAA) and Andrew Manning (Univ. of East Anglia) are leading the work, and the guidelines will be published in Atmos. Meas. Tech. Dlugokencky then spoke about new directions for GHG global standards intercomparisons, the goal of which is to improve the usability of GHG round robin results and which will have as a benefit better merging of GHG data. Finally, the plans for the future include a discussion on short-lived halocarbons and whether they belong in the GHG SAG, in the RG SAG or even in a new SAG. The 2011 GHG Bulletin is also on the agenda for future plans.

The discussion after Ed Dlugokencky's presentation led to **Recommendation 2:** The GAW Secretariat should encourage the initiation of a process aiming at the establishment of an SF₆ calibration centre.

Report from SAG-RG

Stuart Penkett gave a report for the Scientific Advisory Group on Reactive Gases. He reminded that the reactive gases measured by GAW include carbon monoxide, surface ozone, oxides of nitrogen, volatile organics and sulphur dioxide. The scientific advisory group, with a new composition, met in Malta at the end of March 2011.

Several reports on individual reactive gases have been produced between 2008 and 2011, namely GAW Report No. 171 - A WMO/GAW Expert Workshop on Global Long-Term Measurements of Volatile Organic Compounds (VOCs), February 2007, GAW Report No. 189 – Report of the MACC/GAW Session on the Near-Real-Time Delivery of the GAW Observations of Reactive Gases, August 2010, GAW Report No. 192 – Guidelines for the Measurement of Atmospheric Carbon Monoxide, July 2010, and GAW Report No. 195 – WMO/GAW Expert Workshop on Global Long-Term Measurements of Nitrogen Oxides and Recommendations for GAW Nitrogen Oxides Network, February 2011. An overview report describing the status of the GAW Programme for individual reactive gases is planned for publication in 2012 with the object of raising the visibility of Reactive Gases in GAW. The various tasks specified for reactive gases in the GAW Strategic Plan are being addressed systematically. Several difficulties have been

encountered with the setting up of essential GAW facilities and new measurement programmes mainly due to lack of funds. Progress within the area of reactive gases within GAW has been considerably assisted by the appointment of Oksana Tarasova to WMO. Stuart Penkett listed among the planned activities for 2011 and 2012:

- Participate in ACTRIS, a new EU project to support high quality measurements of NO_x and VOCs at surface-based sites.
- Workshop on SO₂ measurements within GAW planned for spring 2012 led by Stefan Gilge.
- Workshop to update GAW Report 97 (Quality Assurance Project Plan (QAPjP) for continuous ground-based ozone measurements) led by Ian Galbally with Christoph Zellweger, Hans-Eckhart Scheel and Sam Oltmans co-opted on to Surface Ozone Sub-SAG RG.
- Expert group to be set up within GAW at the request of members of the Ozone Measurement Community to examine surface ozone trends in detail will involve both Ozone and Reactive Gases SAGs.
- Production of overview report by 2012 showing the status of the measurement programmes across all GAW Reactive Gases including long-running data records.

Finally, Prof. Penkett presented a list of potential problems facing the RG SAG:

- It was hoped that a World Calibration Centre for NO_x would be funded at Jülich.
- It was hoped to establish a continuous measurement site for hydrocarbons at the Summit Observatory in Greenland. The proposal was not funded, however.
- Only a very small number of GAW sites are providing near-real-time data for modelling purposes.
- No agency has been identified to support an SO₂ network within GAW.
- The cost of standards for individual measurement programmes is rather large.

Report from SAG-GURME

Liisa Jalkanen presented the report from the GURME SAG on behalf of Greg Carmichael, the SAG chair, who was unable to attend the meeting. The focus of GURME has been on capacity building and training course development in relation to air quality forecasting (AQF) and modelling. Workshops to this effect were held in Lima, Peru, in July 2006, in Pune, India, in December 2009, in Mexico City in August 2009, in Niigata, Japan, in January 2011 and in Hangzhou, China, in March 2011. A workshop for AQF is planned in Panama later in 2011. GURME cosponsored the IWAQFR in Quebec in November 2010. As examples, the GURME projects for Latin American Cities (Sao Paulo, Mexico City and Santiago) and Shanghai were shown. Two of the most recent GURME projects are:

- AFQ for the Commonwealth Games (CWG) that took place in New Delhi in 2010 (SAFAR project).
- NRT Application to AFQ, coordinated by CMA and to be launched in 2011.

The SAFAR project involved four components to facilitate the current and 24h to 48h advance forecasting:

- The development of high resolution emission inventory of air pollutants for NCR and defining an air quality index for India.
- Network of eleven Air Quality Monitoring Stations (AQMS) equipped with instruments to provide near real time air quality information. (CO, CO₂, O₃, NO, NO_x, NO₂, BTX, O₃, PM_{2.5}, PM₁₀, BC).
- A 3-D atmospheric chemistry transport forecasting model coupled with weather forecasting model to provide forecast of air pollutant levels.
- Display the information on LED and LCD screens located at 20 different locations in Delhi in a public friendly format.
- Displaying the online detailed information through the Web portal developed for CWG as: <http://safar.tropmet.res.in/>.

The project on NRT Data Application to Air Quality Forecasts has the following objectives:

- Develop and establish a NRT chemical data transfer system to collect and process both ground based and satellite observations, based on the WMO data transfer protocols for conventional weather data;
- Develop an AQ forecasting system and integrate it with the NRT system to illustrate the capacity of NRT data to enhance the accuracy of AQ forecasts in China;
- Develop an emission estimating system using the NRT data and inverse modelling methodology;
- Exchange and transfer research results with other national and international agencies.

GURME has also collaborated with several COST actions and EU projects, such as COST-728: Mesoscale for AP and Dispersion Applications, COST-0602: Chemical weather, COST-0603: Allergenic Pollen, COST-1004: European framework for online integrated air quality and meteorology modelling (EuMetChem) and the research project MEGAPOLI. WMO and IGAC are jointly working on the report: "The Impacts of Megacities on Air Pollution and Climate". During the discussion on the GURME Programme there was a lot of emphasis on pollen allergy. It was pointed out by Geri Müller that Task 9.17 in the GAW Strategic Plan Addendum is the only one that mentions the pollen problem and that more could be done. In Switzerland, for example, 20% of the population are affected by pollen. The discussion led to **Recommendation 3**: The GURME SAG should look into the pollen problem and make a recommendation on how to put more emphasis on this in the next GAW Strategic Plan (2016 onwards). The following Action Item was also agreed upon: **Action item 3**: It was agreed to change the text in the Addendum to the current GAW SP in order to put more emphasis on pollen.

Report from SAG-UV

Ann Webb reported on activities in the SAG for UV Solar Radiation. The last meeting of the SAG took place in Bangkok in February of 2010 and the next meeting is planned for July 2011 in Melbourne. The UV programme has matured and there has been substantial improvement of the accuracy of measurements. However, there is a very concrete threat of possibly losing the GAW regional calibration facility at NOAA in Boulder. Unfortunately the network of measurement stations is declining both in developed and developing countries. This can be said to be due to the Montreal protocol working and less interest being placed in the loss of ozone and its consequences. Nevertheless UV data are flowing into the WOUDC and data is being used. The focus is moving toward positive effects of UV (to vitamin D and immune system, from cancer and cataract effects), research is still going on in the health and environment sector as there is the need to enhance the understanding of these effects. The meeting recommended that the SAG UV summarize the needs of the UV community and formulate objectives for future measurement needs. The UV community should advertise these activities. There is a lot of emphasis on data quality and DQOs for UV measurements are now available. Guidelines for broadband instruments are available (GAW Report No. 198) and SOP (Guidelines) for spectral instruments are coming soon.

A complete set of Instrument documents detailing all four instrument types are now available as GAW reports. In the GAW system there are two Regional Calibration Centres (Boulder and Davos, respectively). An application is currently in progress for a World Calibration Centre. The WOUDC contains data from 7 Broadband (Belgrade started 2009), 43 Multiband and 57 Spectral (Uccle and Princess Elisabeth started in 2011) stations. Not all listed stations are currently submitting data Other UV data does exist e.g. at the EUVDB. The will to link the data bases exists, but not the manpower. At the last SAG meeting, Craig Sinclair from the Cancer Council of Victoria gave an update on user needs with respect to health. There is a need to update the UVI guide. This is WHO led and is still at the planning stage. Craig Sinclair will keep the SAG informed. The WOUDC is trying to calculate UVI in a uniform way for all stations represented in the database. There is a debate about definition, and this will be finalised after the UVI update. With respect to measurement needs it was reported that satellite measurements remain topical, but for UV they are not of GAW quality. Improved aerosol data would improve UV retrievals.

There is a need for a UV product of a single measurement unit from WOUDC (but detailed data must be retained too). A candidate is UVI. WOUDC is trialling practicalities of calculation at the database. There has also been discussion on the possibility of weighting spectral data with other action spectra (e.g. Vitamin D). Finally, Dr Webb reported that several SAG members were heavily involved in the writing of the 2010 issue of the WMO/UNEP Scientific Assessment of Ozone Depletion.

Report from ET-WDC

Jörg Klausen reported on the work of the ET-WDC. ET-WDC maintains a webpage at <https://sites.google.com/site/wmoetwdc>, where meeting minutes and other information are available. The terms of reference remain unchanged for the time being and relate to coordination among the WDCs and liaison with the WMO Information System. The members of ET-WDC comprise of the managers of the WDCs and GAWSIS, with Geir Braathen representing the WMO Secretariat. Experts such as Chair ET NRT CDT, Julian Wilson, Steve Wilcox, or Ken Masarie may also be invited to attend. ET-WDC has focused on data management questions relating to QA procedures, traceability of data, documentation of uncertainties and archiving of level 0 (“raw”) data. The implementation of operational metadata exchange between several WDCs / other data centres and GAWSIS has progressed, and is still being developed. WDCPC is being re-established at ISWS in the USA after a longer dormant period, and WDCA was moved from JSC in Ispra to NILU in Norway. WRDC is improving its internet connectivity and is working on a metadata base. The MoU between WMO and DLR for the WDC-RSAT has been renewed. WDC-RSAT also acts as a “data publication agent” for DOIs. Several more contributing networks have been included in GAWSIS, and a preliminary global overview for AOD observations has been established. All WDCs continue to meet the challenges of satisfying increasing user demands in the face of constant or diminishing resources. A WIGOS/WIS pilot project has focused on improving interoperability of WDCs and GAWSIS and on becoming WIS-compatible. Several WDCs are already candidates or have been designated as DCPC in WIS. In future, ET-WDC will continue to provide a forum for exchange of information and aligning the operations of the WDCs and GAWSIS, as well as data archives of contributing networks, among each other and with WIS. There was a discussion on data exchange, data formats, flagging of data and provision of meta-data. The development is possibly going in the direction of the data itself becoming more and more distributed and that only meta-data will be centralised. The discussion led to **Recommendation 4**: We should be more conscientious about meta-data, data versions, and data storage. We should raise the level of awareness and take advantage of the technical development. One needs a system for recognition of data providers in publications. ET-WDC should follow up the development in the area of data publications. There are journals that allow for peer-reviewed publication of data. This would give data originators credit and there would be more stringent quality control and version control. This could be promoted in GAW.

Report from ET-NRT-CDT

In the absence of the Chair, Vincent-Henri Peuch, Liisa Jalkanen commented shortly on the activities of the ET-NRT-CDT. The most recent, short, meeting took place in Hangzhou, China, in connection with the Workshop on Near-Real-Time Data Delivery. This workshop also launched the Chinese GURME project on NRT Chemical Data Delivery and provided a good platform to intensify the interactions between Chinese and European experts. Geir Braathen reported on information from Christoph Wehrli on AOD data delivery in NRT. This system, as part of a WIGOS/WIS pilot project, for 24 h delivery of data has been operational since 2010. It will be very difficult to provide real NRT data. It was noted that NRT data is being used in MACC air quality forecasts. Regarding the membership of the ET, the JSC welcomed the addition of Tim Haig from EEA into the group, as EEA has a very important role in NRT data delivery in Europe, for land, ocean, and air and for emergency issues.

2.2 QA/QC in GAW

2.2.1 *Activities of Central Facilities (Representatives from Japan, Germany, Switzerland, and USA and the Secretariat reviewed activities)*

Oksana Tarasova presented a general overview of the Quality Assurance framework in the GAW Programme. Central Facilities play an important role in this system. Five types of Central Facilities support QA in GAW. A table with Central Facilities in the GAW Strategic Plan 2008-2015 was updated to include new assigned Central Facilities. Progress was made on CO₂ isotopes, molecular hydrogen, SF₆ and VOCs. Funding of an NO_x WCC is uncertain. Still some gaps exist in the QA system. Prior to the JSC OPAC EPAG meeting a request was sent to all Central Facilities. The majority of the organizations provided the requested report (the summary report was circulated among JSC members). Some difficulties were encountered in reaching a number of Central Facilities due to different reasons. For the future assignment of Central Facilities the procedures are laid out in Annex 3 of the GSP Addendum.

Hiroshi Koide from Japan Meteorological Agency (JMA) reported on the tsunami damage at the GAW regional station at Ryori with his sincere appreciation for sympathies from the participants. He presented the recent activities and future perspectives the GAW central facilities hosted by JMA, e.g., WDCGG, WCC for methane and QA/SAC for Asia and the South-West Pacific, and Regional Dobson Calibration Centre (RDCC) for Asia, as well as the introduction of JMA's newly started aircraft observations of carbon dioxide, methane, carbon monoxide and nitrous oxide. He indicated that WDCGG is being appointed as WIS data collection or production centre (DCPC) in Cg-XVI following the CAS-XV recommendations, and the metadata from the DCPC will be delivered together with all other WMO data catalogues to facilitate the data exchange across WMO Programmes.

Jörg Klausen reported on the Swiss contribution to GAW, which consists of a broad national observation programme and international services to the Programme. MeteoSwiss coordinates the work of a number of academic and government institutions and acts as the focal point for all GAW activities in Switzerland. Swiss GAW Central Facilities provide essential services to the GAW Programme. MeteoSwiss is entrusted with permanent funds by the Swiss government to co-fund these activities. The international GAW-CH programme comprises of strategic contributions (GAW Strategic Plan, GAWSIS), a QA/SAC, and a number of World Calibration Centres (surface ozone, carbon monoxide, methane, carbon dioxide – audits, AOD, infrared and UV radiation), as well as twinning activities mainly in Kenya, Indonesia, and Algeria. In these countries, several instruments were renewed and new measurements started thanks to Swiss engagement. A glossary of QA/QC-related terminology is available at <http://gaw.empa.ch/glossary.html> and promotes the use of internationally standardized terminology. Swiss researchers contributed to a number of SAG reports. The scope of WCC-Empa was expanded to include audits of continuous CO₂ measurements at global GAW stations. Together with the RCC in Buenos Aires, an intercomparison and training on surface ozone in WMO RA III was organized in 2010. WORCC manages quasi-real-time data of the GAW PFR network and has calibrated ~30 instruments during 2009/2010. The network is still expanding and comprises of twice as many stations (24) as originally planned. WORCC was also host to the 3rd international Filter Radiometer Comparison in 2010. The EUVC was designated as RCC for UV in 2008. EUVC operates with an ISO17025 QMS for its calibration services and has been invited to become the WCC by WMO. The WRC-IRS (infrared radiation) has conducted the first pyrgeometer intercomparison during IPC-XI. WRC-IRS has also successfully developed the IRIS radiometer to serve as reference instrument for longwave irradiance.

Wolfgang Fricke reported on German contributions to GAW. German GAW stations include the global stations Neumayer (Antarctica) and Zugspitze/Hohenpeißenberg and the regional stations Schauinsland and Neuglobsow. Central facilities include WCC-O₃-sondes hosted by FZJ, WCCs for N₂O and VOC hosted by KIT, WCC Aerosol Physics hosted by IfT, Regional Dobson Calibration Centre for Europe, hosted by DWD (Hohenpeißeberg). MPI-BGC hosts the Central Calibration Laboratory for H₂. DLR (Oberpfaffenhofen) hosts the World Data Centre for

Remote Sensing of the Atmosphere. The GAW Training and Education Centre (GAWTEC) is hosted by UBA and the Bavarian Government. UBA also hosts the Quality Assurance/Science Activity Centre (QA/SAC) for VOC and N₂O. Among relevant projects where German institutions either coordinate or play an important role are: MOZAIC, CARIBIC, GEMS, MACC, EUCAARI, EUSAAR, ACCENT, ACTRIS, IAGOS. A new station building has been constructed at the Antarctic Global Station Neumayer (AWI, Bremerhaven). The new station (Neumayer III) has been in operation since 2009 and has an expected lifetime of 25 to 30 years.

Ed Dlugokencky reported on the NOAA activities. He mentioned the usefulness of “Calibrations Manager” software tool for ordering standards.

There was a discussion on the distinction between a regional station and a contributing station. It was agreed to keep the definition of Global and Regional stations as they appear in the 2008-15 GAW Strategic Plan. The following action item was assigned: **Action item 4:** A sentence should be added to the Addendum to explain what a contributing network is. Jörg Klausen was asked to provide this text.

The discussion also led to the following Recommendation and Action Items: **Recommendation 5:** Any agreement with contributing networks should contain a list of stations and their characteristics.

Action item 5: JSC members are asked to review Table 1 of the GAW Strategic Plan Addendum by 6 May. Input should be sent to Jörg Klausen as editor of the GSP Addendum.

Action item 6: Editorial changes to Addendum sent to Jörg by May 2 10:00 CET DST.

Action Item 7/Advice: GAW Secretariat should review the minutes of SAG meetings before sending out the reporting template to the central facilities. In that way one may not need to ask the Central Facilities for a separate report.

2.2.2 Rolling Review of Requirements (O. Tarasova)

Oksana Tarasova presented an overview of the Rolling Review of Requirement (RRR) process. This process consists of four stages:

- (i) A review of users' requirements for observations, within an area of application covered by WMO programmes (supposed to be technology free).
- (ii) A review of the observing capabilities of existing and planned observing systems (all platforms).
- (iii) A “Critical Review” of the extent to which the capabilities (ii) meet the requirements (i); and
- (iv) A “Statement of Guidance” based on (iii).

GAW implements the IGACO strategy and is considered as a framework to address the atmospheric chemistry application area. Four basic challenges are identified in this area: air quality, climate change, oxidation capacity and stratospheric ozone depletion. The idea and the benefit of the establishment of a proper RRR process is a possibility a) to inform WMO Members on the extent to which their requirements are met by present systems, will be met by planned systems, or would be met by proposed systems as well as b) to provide resource materials useful to WMO Members for dialogue with observing system agencies regarding observing systems.

The only GAW document following all four steps is the GAW Report 140, published in 2004, which served as a basis for the IGACO strategy and the “Statement of Guidance” document for atmospheric chemistry. Use of this basic document (GAW report 140 dates back to 2001) also led to a substantial bias to ozone related species. A review of the current “Statement of Guidance” is urgently needed. The JSC agreed to adopt **Recommendation 6:** GAW should begin to build up a capacity to contribute to the Rolling Review of Requirements. This should go as tasks in the Addendum to the GAW Strategic Plan for each SAG.

Yuri Tsaturov raised the problem of volcanic ash, and he informed that Roshydromet proposed the establishment of a volcanic ash warning centre to ICAO already in 1997. In addition to monitoring, Roshydromet also has numerical models for volcanic ash dispersion. Forecasts can be made up to 18h. In Russia there are 46 offices linked to this warning centre. The Russian warning centre is connected to Toulouse, Tokyo and Anchorage. Tsaturov informed that the ash from Iceland reached all the way to Siberia. The Russian centre can cover a territory that is not covered by other centres. In addition, the Central Upper Air Observatory can do aircraft measurements of volcanic ash. The specialised centre within Roshydromet focuses on volcanic ash and tsunami warnings. The centre already has experience dealing with disasters and is now working on the Fukushima nuclear accident. Tsaturov concluded by explaining that he gave this presentation in order to solicit support from WMO to establish an ICAO VAAC in Moscow. Hiroshi Koide mentioned that for nuclear disasters there is the IAEA, and he wanted to know if there is another centre in Moscow that also deals with nuclear disasters. Tsaturov explained that there is only one centre, but that it has been given new tasks to include volcanic ash in addition to the existing responsibilities. Øystein Hov opined that such a centre can only be good. Being informed scientists we should endorse this, although this is not a central GAW activity. There was agreement that the JSC supports the establishment of the VAAC in Moscow. This constitutes **Recommendation 7**.

2.2.3 Training activities

Karin Woudsma presented an overview of recent activities at the GAW Training and Education Centre (GAWTEC). As a part of WMO's capacity building strategy, the German Quality Assurance/Science Activity Centre (QA/SAC Germany), funded by the Federal Environment Agency (Umweltbundesamt, UBA) has established the GAW Training & Education Centre (GAWTEC) in 2001. In addition there is funding from the Bavarian State Ministry of the Environment and Public health, WMO, DWD and Empa. GAWTEC courses are offered twice a year and cover measurement techniques, data handling and theoretical background of atmospheric physics and chemistry. The training activities are mainly focused on station operators and scientists from GAW stations located in developing countries as well as from stations which do not meet the high measurement quality criteria. The objectives of GAWTEC are:

- To improve personal skills in chemical and meteorological measurement techniques and data handling.
- To provide a platform for GAW station personnel for the exchange of measurement related experiences and the discussion of problems.
- To broaden the understanding of atmospheric processes and to increase the ability for data interpretation.
- To enhance the ability to identify measurement errors to increase data quality within the GAW station network.

Since 2001, twenty GAWTEC courses have been held for 227 trainees from 56 countries. It is rather difficult to quantify the success of the GAWTEC courses. One question one should try to answer is whether we get better data from stations that send their personnel to GAWTEC. This could be answered by looking at the results of audits, by contacting the World Data Centres and twinning partners. General information and news on upcoming courses will be posted on the homepage: www.gawtec.de.

Recommendation 8: SAGs should provide feedback to GAWTEC about needs for training and guidance on focus areas.

2.3 GAW station classification and the procedures for acceptance of stations

Oksana Tarasova presented current station classification in GAW. Due to numerous requests from WMO Members a clarification of the difference between contributing and regional stations was required. Network attribution as "GAW contributing" was not clear in current GAW documentation. A number of clarifications was proposed which were included in Annex 2 of the

GAW Strategic Plan Addendum. The procedures include better indication of working status of stations in GAW SIS.

2.4 Products and Services

Liisa Jalkanen pointed out that there is an increasing demand for end products and services, these have already been included in the GAW Strategic Plan and are revised for the Addendum. We need to identify users of our data and products. The SAGs ought to have representatives for the end users to guide the SAGs. The discussion on this topic led to **Recommendation 9**: The SAGs are asked to propose new members that represent end users.

2.5 Review of the Addendum of the GAW Strategic Plan

Jörg Klausen reported on the progress on the preparation of the GAW Strategic Plan Addendum: 2012-2015. This addendum specifies the implementation of the GAW Programme for the second half of the GAW Strategic Plan: 2008-2015. In 2009, JSC OPAG EPAC requested the JSC Subgroup on Strategic Planning (chair: Gerhard Müller) to develop the Addendum. The process consisted of assessing progress made during 2008-2011, defining strategic implementation tasks for the targeted period, and highlighting products and services offered by GAW. In 2010, SAG and ET chairs, as well as Central Facilities were approached with a request for input. This was then reviewed and several drafts of the Addendum were written. Later in 2010, the Writing Team met to gauge progress and to identify open issues. The complete draft was circulated at the end of 2010. In 2011, feed-back was incorporated, and remaining open issues discussed and decided during the JSC OPAG EPAC meeting (this meeting). Important achievements of the GAW Programme during 2008-2011 include the establishment of several new Central Facilities and the designation of four new global stations; a closer association of the Programme with the WIGOS/WIS process; acceptance of the GAW networks for CO₂, CH₄, N₂O, and ozone as GCOS networks; and the development of more formal procedures for the acceptance of new stations and Central Facilities to the Programme.

3. CONGRESS PREPARATIONS

Liisa Jalkanen reminded the Session that the WMO Congress would take place from 14 May to 6 June gathering together every 4 years the WMO Members, currently 189. Among the topics to be raised at Congress and of relevance to the GAW Programme are:

- CAS has recommended that AREP cease to exist. GAW and WWR Programmes will continue.
- There will be a new Expected Result on research.

The GAW Programme will be discussed on 24 May. We have 3000 words at disposal for our document. Translation and interpretation are very costly so the number of words is strictly limited. It is also important that we look closely at what is decided for WIGOS and how that can affect GAW.

Gerhard Müller asked where there still would be a possibility to include results from this JSC meeting into the Cg document. Liisa Jalkanen gave an explanation of how the reporting will work at Cg-XVI. The report part from GAW will be in the report of the Secretary General and the WMO President.

Ghassem Asrar added that it is not too late to provide input for these reports and he reminded that also the CAS President will give a report and presentation. In addition, one can also intervene from the floor during the Congress session. Gerhard Müller would like to know whether the report from the CAS President was available? Liisa Jalkanen explained that there are no documents from the Presidents of the Technical Commissions. The Presidents will just give a report at the relevant Congress sessions. Each President will have 12 minutes to speak.

Øystein Hov rounded off the discussion by informing that input for Congress should be sent to Liisa Jalkanen, but that it would also be possible to intervene at Congress.

4. DISCUSSION ITEMS

4.1 Black carbon and ozone as short-lived climate forcers

Liisa Jalkanen informed about the WMO/UNEP Black Carbon and Ozone Assessment. Greg Carmichael and Luisa Molina took part in the writing of the report. The group of authors have looked at two thousand emission processes. The final version was to be published in June 2011. One conclusion from the report is that there is a need for observations for model validation. A discussion around this topic followed.

Jörg Klausen informed that Greg Carmichael had asked if we have BC data in GAW. Ogren told that he had not been asked by Greg for such data. The Aerosol SAG has made recommendations on how to measure BC. But Ogren was not sure if those responsible for the observations follow these recommendations. Very few stations measure BC or elemental C in a reliable fashion.

Ogren asked what is the question is for the SAG and what the SAG should do.

Øystein Hov replied that the goal is to verify model results using sound observations.

Then Jörg Klausen asked what we should do about deposited BC. Hov replied that BC on the ground changes the albedo (esp. on snow) and might be as important as BC in the atmosphere. We should limit ourselves to atmospheric BC, but leave it to the PC SAG to look into deposited BC.

Hov added that collaboration with the Atmospheric Brown Clouds (ABC) is important. The discussion led to **Recommendation 10**: SAG aerosol is requested to discuss and review the observations of what is called BC in order to contribute to the classification of their quality and their value in model validation. SAG Precipitation Chemistry is asked to discuss what it can contribute to the observational evidence of deposition of BC in precipitation, particularly in snow. The determination of the magnitude and trend of ozone as a Short-Lived Climate Forcer (SLCF) is dependent on good measurements of ozone in the upper troposphere and around the tropopause. Limb-scanning instruments on satellite platforms are important in this context to establish the observational basis for UT ozone distribution and change; see 4.6 below.

4.2 Technical chemicals that replace halocarbons, relationship to GAW

Stuart Penkett gave a presentation on halogenated compounds. Halogen-containing species still have an important impact on global warming. Especially molecules with a CF_3 group are powerful greenhouse gases. The atmospheric concentrations of chlorofluorocarbons have leveled off and are slowly on the way down thanks to the Montreal Protocol. However, compounds that replace the chlorofluorocarbons show rapidly increasing concentrations. Two prime examples of such compounds are HFC-134a, which is used for air conditioning systems in cars and HCFC-141b, which is used for insulation purposes. These replacement compounds have much shorter lifetimes (often 10 times less) in the atmosphere than the original chlorofluorocarbons. Penkett also discussed about other halogenated compounds with long atmospheric lifetimes. Three examples that were shown were perfluoroethane (C_2F_6), sulphur hexafluoride (SF_6) and perfluorocyclobutane (C_4F_8). If one integrates the global warming effect of the HFCs, PFCs and SF_6 one arrives at the equivalent of 500 million tons of CO_2 per year. This is equivalent to the total annual CO_2 emissions from the United Kingdom. The discussion following the presentation led to Recommendation 11.

Recommendation 11: SAG Greenhouse Gases is asked to discuss the issue of observing the global distribution and trend in halocarbon replacement gases, in order to assess their contribution to the greenhouse effect and to quantify their role as SLCFs.

4.3 Water vapour (GRUAN)

Øystein Hov gave a presentation on the GCOS Reference Upper Air Network (GRUAN). GRUAN is an international reference observing network, designed to meet climate requirements and to fill a major void in the current global observing system. It will provide long-term, high-quality climate records from the surface, through the troposphere, and into the stratosphere. Data from GRUAN will be used to determine trends, constrain and validate data from space-based remote sensors and to provide accurate data for the study of atmospheric processes. It is envisaged as a global network of 30-40 stations, and, where possible, one will build on existing observational networks and capabilities.

The key scientific questions of GRUAN are:

- Characterization of changes in temperature, humidity, and wind.
- Understanding the climatology and variability of water vapour, particularly in the Upper Troposphere/Lower Stratosphere region as it is of crucial importance for ascertaining climate sensitivity.
- Understanding changes in the hydrological cycle
- Understanding and monitoring tropopause characteristics.
- Understanding the vertical profile of temperature trends.
- Bringing closure to the Earth's radiation budget and balance.
- Understanding climate processes and improving climate models.

After the presentation there were questions and comments. Stuart Penkett pointed out that water vapour is important for OH production, so it is hence important for atmospheric chemistry, not only dynamics. Johannes Staehelin informed that water vapour is included in the Swiss GAW programme. Øystein Hov reminded that water vapour traditionally has been in the domain of dynamic meteorology. Stuart Penkett suggested we should find out what GAW can do about water vapour. Jörg Klausen proposed that we in GAW should take note of its importance, but recognize that other networks, such as GRUAN and NDACC, deal with it. John Ogren gave the reference of a recent paper that has been published in Science where the importance of water vapour is discussed (Lacis et al., Atmospheric CO₂: Principal Control Knob Governing Earth's Temperature, Science 15 October 2010: Vol. 330 no. 6002 pp. 356-359 DOI: 10.1126/science.1190653).

The discussion led to agreement that water vapour is an important parameter for atmospheric lifetime of gases and particles through its influence on OH and wet removal processes. It is considered an essential response to temperature change in the context of climate. The following Recommendation was adopted: **Recommendation 12:** More emphasis should be put on the quantification of the life cycle of water vapour in the atmosphere. Supporting interaction between GAW and the GCOS Reference Upper Atmosphere Network (GRUAN) is encouraged.

4.4 Sand and dust storm warning advisory and assessment system (SDS-WAS)

Xiao-Ye Zhang gave a presentation, prepared by himself and Slobodan Nickovic, on the WMO SDS Warning Advisory and Assessment System. The history of the SDS-WAS dates back to 2004 when CMA hosted an international symposium on SDS as well as a WMO Experts Workshop on SDS. A questionnaire that was disseminated in 2005 indicated that 40 countries were interested in building an SDS warning system. In May 2007, the 14th WMO Congress endorsed the launch of the SDS-WAS. The first SDS-WAS hands-on training workshop was held in Barcelona in 2010. Regional meetings for the Asian and African nodes were held in 2008 and 2009. Twelve operational research dust forecast centres in Europe, North America, Middle East and Far East participate in SDS-WAS. After the presentation there were a few questions and it was informed that although the community is close to operations, SDS-WAS is not operational in the same way as the Volcanic Ash Advisory Centres. The discussion resulted in *Recommendation 13*.

The JSC notes that the sand and dust storm forecasts issued through the SDS-WAS on an experimental operational basis are becoming mature and of high quality.

Recommendation 13: The JSC recommends that when SDS-WAS enters a permanent operational phase, it should be made sure that there is interoperability of observations of atmospheric aerosols, including exchange of data, between GAW and SDS-WAS. In this way the information value in all observations for model validation and process understanding is maximised, and a good return from investments in observations is ensured.

4.5 Volcanic ash forecasting

Herbert Puempel, Chief of WMO's Aeronautical Meteorology Division, gave a presentation entitled: "Recent progress and issues of Volcanic Ash affecting Aviation". The importance of volcanic ash measurements in near-real time became a very actual topic during the Eyjafjallajökull eruption in April/May 2010. There is a need for composite observing systems with calibration through in-situ measurements. Iceland is a "special case", with excellent monitoring of volcanoes, but there are still large uncertainty initially about Eruption Source Parameters. Many volcanoes around the world are poorly monitored or un-monitored, but there are laudable efforts by many Members to improve the situation of observatories such as in Indonesia, Russian Federation, Chile etc. The best detection of volcanic ash can only be obtained by an integration of systems:

- Space-based remote sensing for early detection and areal coverage.
- LIDAR for layer thickness and position.
- Reverse modelling for improved Eruption Source Parameters.
- Aircraft sensors for low concentration on research aircraft, or on commercial airliners (e.g. IAGOS).

The lidar network in Europe (Earlinet and some other lidars) was essential in the observations of the vertical structure of ash emitted in the Eyafjällajökull eruption.

Recommendation 14: GAW should be prepared to contribute further to the on-going work in the framework of WMO and the GAW Aerosol Lidar Observation Network (GALION) to improve the predictive capability of volcanic ash, including validation of model forecasts.

4.6 Satellite Task Team

The background for this item is the IGACO report that dates back to 2004, so there is a need to revisit the satellite needs.

John Burrows gave a presentation entitled: "Passive satellite remote sensing of methane and carbon dioxide: From SCIAMACHY towards CarbonSat and CarbonSat Constellation". In his presentation Burrows showed the capabilities of SCIAMACHY on Envisat with focus on methane and CO₂, which are only two of several species measured by this instrument. He then described the capabilities of CarbonSat, a planned mission which has been selected by ESA to be one of two candidate Earth Explorer Opportunity Missions (EE-8) to be launched in 2018. More information about this mission can be found here: <http://www.iup.uni-bremen.de/carbonsat/>

There were two issues discussed under item 4.6:

- 1) A recommendation letter to be sent from WMO/GAW to space agencies concerning the continuation of limb, occultation and greenhouse gas measurements from space.
- 2) The establishment of a task team that will update satellite requirements in GAW.

The discussion under point 1) led to two recommendations:

Recommendation 15: The recommendation letter given in Annex D should be brought to the attention of the Director Generals of CSA, ESA and NASA etc.

Recommendation 16: New missions for limb scanning are urgently needed in order to continue the analysis of the evolution in time and space of the distribution with height of trace species that influence climate, in particular ozone and water vapour.

Then followed a discussion on the synergies of space based and ground based observations of atmospheric composition. Stuart Penkett pointed out the capability of satellites to reveal environmental problems and mentioned formaldehyde as an example. John Burrows followed up by mentioning the capability to measure glyoxal (OHC-CHO, 1,2-ethanedione) from space and with MAX-DOAS from the ground. It has a short chemical lifetime of a few hours in the boundary layer and lower troposphere and therefore serves as an indicator and a marker of photochemical hotspots and their response to changing atmospheric conditions around the globe. Burrows suggested that more GAW stations should have MAX-DOAS instruments in order to measure glyoxal from the ground.

Øystein Hov reminded the meeting participants that CAS President Michel Béland had asked for the establishment of a task team on satellite requirements. Burrows opined that this task team will have to go through all the various parameters that need to be measured and that ground based satellite validation also has to be considered. Johannes Staehelin mentioned that the task team will have to take the IGACO-Ozone/UV Implementation Plan into consideration. John Ogren informed that the ESA-CCI (European Space Agency Climate Change Initiative) also have formulated needs and that this initiative seem to deal with the same topics as the planned GAW Task Team. John Burrows reminded that the IGACO report was reviewed by a number of recognised experts. This gave the report credibility. The same procedure should be followed for the new report. Øystein Hov suggested a 18-24 month time frame for the work followed by a review process. He also indicated that we need to find experts from China, Japan and the Republic of Korea. Hov further suggested that experts in the MACC community be consulted as well as experts who contribute to the SDS-WAS. The discussion resulted in the following recommendation: **Recommendation 17:** A task team should be established to review the requirements for satellite observations and concurrent surface observations (remote sensing and in-situ), to support the advancement of the main issues in GAW. Each SAG and Expert Team are asked to suggest 1-2 members of the task team, and sound out with the people they propose if they are willing to contribute. It should be made sure to include the operational needs of volcanic ash and sand and dust storm (experimental) services, and also of other (experimental) operational expertise related to GAW. The Secretariat together with the SAG and ET chairs and the JSC chair will propose a task team and its term of reference, with the help of the nominations from the SAGs etc. The task team needs to have a reasonable number of members (ca. 10) covering the appropriate areas of expertise while ensuring a reasonable geographical as well as gender representation. WMO should provide secretarial support. The task team ought to have its first meeting in 2011 to be put in motion. An 18-24 month activity period is foreseen, followed by a peer review process to ensure that the team's report has high credibility.

4.7 Data flow and WIS

Geir Braathen gave a presentation on data exchange in atmospheric sciences and discussed about the following topics of concern to free exchange of data:

- Real time data delivery vs. long-term archiving
- Intellectual property rights vs. public interest
- Free access vs. commercial interests
- Multitude and proliferation of data bases
- Data formats
- Tools for analysis and visualisation
- Tools for combining data from various sources
- How to find data (data mining)?
- One-stop facilities

He then explained how data exchange will function in the WMO Information System (WIS), where in particular there are well defined standards for metadata. The discussion that followed resulted in the following statement and recommendation:

GAW recognises the strengthened opportunities for data quality control, search and retrieval that is offered through WIS. **Recommendation 18:** GAW should ensure full participation in WIS for distribution of GAW metadata and physical data.

4.8 Contribution to environmental conventions and intergovernmental assessments

Convention support and contribution to international environmental assessments are major goals for GAW. The discussion led to **Recommendation 19:** The OPAG-EPAC JSC should put high priority on well targeted and high quality contributions to relevant international conventions and assessments. This forms an important part of the justification of the GAW Programme.

4.9 Relationship with other programmes, especially GCOS, GMES and GEOSS

GAW is the atmospheric chemistry component of GCOS, providing networks for measurements of surface CO₂, CH₄, SF₆, N₂O; column O₃; and profile O₃. An effort is underway, led by SAG-Aerosol, to propose an Aerosol Optical Depth network as a component of GCOS. Future meetings of JSC OPAG EPAC should consider the question "What are the barriers to contributing to GAW, and how can we reduce them?" Examples of other UN-affiliated networks where enhanced collaboration with GAW might benefit both programs include the WCRP-sponsored Baseline Surface Radiation Network (BSRN) and the UNEP-sponsored Atmospheric Brown Clouds project.

Recommendation 20: Efforts should be made by the entities of GAW (SAGs, ETs etc) to make sure that GAW activities with high relevance also for other programmes are communicated with these in order to maximise the scientific return from investments.

5. MATTERS ARISING

5.1 Network for the Detection of Mesopause Change (NDMC)

DLR-DFD hosts and operates the WMO-GAW World Data Center for Remote Sensing of the Atmosphere (WDC-RSAT). Less known in the GAW community is DLR's engagement within the Network for the Detection of Mesopause Change (NDMC), which it founded some three years ago. It is a global program with the initial mission to promote international cooperation among research groups investigating the mesopause region (80-100 km) with the goal of early identification of changing climate signals. Like NDACC, this program involves the coordinated study of atmospheric variability at all time scales, the exchange of existing know-how, and the coordinated development of improved observation, analysis techniques and modelling. The initial emphasis is on mesopause region airglow techniques utilizing the existing ground-based and satellite measurement capabilities. Scientists investigating the mesosphere are invited to join the NDMC irrespective of their research goals and/or measurement techniques (spectrometer, lidar, radar, ground-based or satellite borne remote sensing devices). NDMC seeks "affiliated status" with the Global Atmosphere Watch (GAW) Programme of the World Meteorological Organization (WMO) and has established communication ties with Dr. Geir Braathen (GAW and NDACC). No formal agreement with either WMO-GAW or NDACC exists so far, and DLR requests an affiliated status in GAW of NDMC. The discussion resulted in the following recommendation:

Recommendation 21: JSC asks the Secretariat to evaluate whether GAW is the most appropriate affiliation for NDMC in WMO, as the focus of NDMC is on observing mesopause temperatures. The Secretariat is asked to recommend for the JSC how to proceed in this matter.

6. REVIEW OF ACTION ITEMS AND RECOMMENDATIONS

The action items and recommendations that were agreed upon during the meeting are summarized below.

Action items

Action item 1: Each contributor to the Session is to write a one-paragraph summary of their presentation(s). Due date is 6 May.

Action item 2: JSC Members are to send their comments on the report from the previous OPAG-EPAC JSC meeting (2009) by May 6.

Action item 3: It was agreed to change the text in the Addendum to the current GAW SP in order to put more emphasis on pollen.

Action item 4: A sentence should be added to the Addendum to explain what a contributing network is. Jörg Klausen was asked to provide this text.

Action item 5: JSC members are asked to review Table 1 of the GAW Strategic Plan Addendum by 6 May. Input should be sent to Jörg Klausen as editor of the GSP Addendum.

Action item 6: Editorial changes to Addendum sent to Jörg by May 2 10:00 CET DST.

Action Item 7:/Advice: GAW Secretariat should review the minutes of SAG meetings before sending out the reporting template to the central facilities. In that way one may not need to ask the Central Facilities for a separate report.

Recommendations

Recommendation 1: GAW stations are requested to publish traceability of their measurements.

Recommendation 2: The GAW Secretariat should encourage the initiation of a process aiming at the establishment of an SF₆ calibration centre.

Recommendation 3: The GURME SAG should look into the pollen problem and make a recommendation on how to put more emphasis on this in the next GAW Strategic Plan (2016 onwards).

Recommendation 4: We should be more conscientious about meta-data, data versions, and data storage. We should raise the level of awareness and take advantage of the technical development. One needs a system for recognition of data providers in publications. ET-WDC should follow up the development in the area of data publications. There are journals that allow for peer-reviewed publication of data. This would give data originators credit and there would be more stringent quality control and version control. This could be promoted in GAW.

Recommendation 5: Any agreement with contributing networks should contain a list of stations and their characteristics.

Recommendation 6: GAW should begin to build up a capacity to contribute to the Rolling Review of Requirements. This should go as tasks in the Addendum to the GAW Strategic Plan for each SAG.

Recommendation 7: The OPAG-EPAC JSC supports the establishment of the VAAC in Moscow.

Recommendation 8: SAGs should provide feedback to GAWTEC about needs for training and guidance on focus areas.

Recommendation 9: The SAGs are asked to propose new members that represent end users.

Recommendation 10: SAG aerosol is requested to discuss and review the observations of what is called BC in order to contribute to the classification of their quality and their value in model validation. SAG Precipitation Chemistry is asked to discuss what it can contribute to the observational evidence of deposition of BC in precipitation, particularly in snow. The determination of the magnitude and trend of ozone as a Short-Lived Climate Forcer (SLCF) is dependent on good measurements of ozone in the upper troposphere and around the tropopause. Limb-scanning instruments on satellite platforms are important in this context to establish the observational basis for UT ozone distribution and change.

Recommendation 11: SAG Greenhouse Gases is asked to discuss the issue of observing the global distribution and trend in halocarbon replacement gases, in order to assess their contribution to the greenhouse effect and to quantify their role as SLCFs.

Recommendation 12: More emphasis should be put on the quantification of the life cycle of water vapour in the atmosphere. Supporting interaction between GAW and the GCOS Reference Upper Atmosphere Network (GRUAN) is encouraged.

Recommendation 13: The JSC recommends that when SDS-WAS enters a permanent operational phase, it should be made sure that there is interoperability of observations of atmospheric aerosols, including exchange of data, between GAW and SDS-WAS. In this way the information value in all observations for model validation and process understanding is maximised, and a good return from investments in observations is ensured.

Recommendation 14: GAW should be prepared to contribute further to the on-going work in the framework of WMO and the GAW Aerosol Lidar Observation Network (GALION) to improve the predictive capability of volcanic ash, including validation of model forecasts.

Recommendation 15: The recommendation letter in Annex D should be brought to the attention of the Director Generals of CSA, ESA and NASA etc.

Recommendation 16: New missions for limb scanning are urgently needed in order to continue the analysis of the evolution in time and space of the distribution with height of trace species that influence climate, in particular ozone and water vapour.

Recommendation 17: A task team should be established to review the requirements for satellite observations and concurrent surface observations (remote sensing and in-situ), to support the advancement of the main issues in GAW. Each SAG and Expert Team are asked to suggest 1-2 members of the task team, and sound out with the people they propose if they are willing to contribute. It should be made sure to include the operational needs of volcanic ash and sand and dust storm (experimental) services, and also of other (experimental) operational expertise related to GAW. The Secretariat together with the SAG and ET chairs and the JSC chair will propose a task team and its term of reference, with the help of the nominations from the SAGs etc. The task team needs to have a reasonable number of members (ca. 10) covering the appropriate areas of expertise while ensuring a reasonable geographical as well as gender representation. WMO should provide secretarial support. The task team ought to have its first meeting in 2011 to be put in motion. An 18-24 month activity period is foreseen, followed by a peer review process to ensure that the team's report has high credibility.

Recommendation 18: GAW should ensure full participation in WIS for distribution of GAW metadata and physical data.

Recommendation 19: The OPAG-EPAC JSC should put high priority on well targeted and high quality contributions to relevant international conventions and assessments. This forms an important part of the justification of the GAW Programme.

Recommendation 20: Efforts should be made by the entities of GAW (SAGs, ETs etc.) to make sure that GAW activities with high relevance also for other programmes are communicated with these in order to maximise the scientific return from investments.

Recommendation 21: JSC asks the Secretariat to evaluate whether GAW is the most appropriate affiliation for NDMC in WMO, as the focus of NDMC is on observing mesopause temperatures. The Secretariat is asked to recommend for the JSC how to proceed in this matter.

7. CLOSURE OF THE MEETING

The chair closed the meeting at 14:55 on Friday 29 April. Both he and the Chief of AER thanked the participants for their contributions.

Presentations from the meeting are available at:
<http://www.wmo.int/pages/prog/arep/gaw/OPAG-EPAC2011.html>

**Meeting of the CAS JSC OPAG-EPAC
(27-29 April 2011, Geneva, Switzerland)**

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Meeting of the CAS JSC OPAG-EPAC
(27-29 April 2011, Geneva, Switzerland)

AGENDA

Start at 11.00 Wednesday, 27 April
End at 15.00 Friday 29 April

1. Opening of the session

- 1.1 Welcome
- 1.2 Adoption of agenda and approval of the report of previous OPAG/EPAC meeting
- 1.3 Overview of CAS-XV, Executive Council Research Task Team (EC RTT) and other important initiatives in light of GAW (Øystein Hov)

2. GAW Strategic Plan (for guidance the length of reports and reviews should be 10-15 min, followed by discussion)

- 2.1 Review the status of the work of SAGs and ETs and the future direction of their work (Each SAG and ET chair to report)
- 2.2 QA/QC in GAW
 - 2.2.1 Activities of Central Facilities (Representatives from Japan, Germany, Switzerland, and USA will give a review of activities)
 - 2.2.2 Rolling Review of Requirements (O. Tarasova)
 - 2.2.3 Training activities (Karin Woudsma, GAWTEC)
- 2.3 GAW station classification and the procedures for acceptance of stations (O. Tarasova)
- 2.4 Products and Services (L. Jalkanen)
- 2.5 Review of the Addendum of the GAW Strategic Plan (G. Muller/J. Klausen to present the items not covered above)

3. Congress preparations (L. Jalkanen)

4. Discussion items: (Introductory 5-10min presentations to be made for each item followed by discussion)

- 4.1 Black carbon and ozone as short lived climate forcers (with consideration of other components such as OC, SO₄)
- 4.2 Technical chemicals that replace halocarbons, relationship to GAW
- 4.3 Water vapour (GRUAN)
- 4.4 Sand and dust storm warning advisory and assessment system
- 4.5 Volcanic ash forecasting
- 4.6 Setting up the Satellite Task Team (limited in time, for the task of updating satellite requirements in GAW)
- 4.7 Data flow and WIS
- 4.8 Contribution to environmental conventions and intergovernmental assessments
- 4.9 Relationship with other programmes, especially GCOS. GMES and GEOSS are other examples

5. Matters arising

6. Review of recommendations and action items

7. Closure of meeting

**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)**

(CAS XIV, Annex II, Annex to paragraph 12.3 of the General Summary)

- (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 timescales;
 - (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.

Recommendation letter to be circulated to the DGs of ESA, NASA etc. by WMO GAW

**Statement by WMO CAS JSC OPAG EPAC, 29th April 2011
concerning the continuation of the existing limb and occultation
and GHG measurements from space**

Introduction

In order to assess accurately the climate and chemistry interactions in a changing atmosphere and climate, long-term knowledge of atmospheric composition is required in the UT/LS, stratosphere and mesosphere (e.g. ozone, ozone depleting species, water vapour, aerosol, polar stratospheric clouds, polar mesospheric clouds, greenhouse gases). As reported and foreseen by WMO Report 140 and IGOS-IGACO, measurements of atmospheric composition from space are an essential component of the global observing system of systems, GEOSS.

The space agencies are to be commended on their development over the past 25 years of nadir sounding of the vertical columns of trace gas composition and noting the successes of

- a) The SCIAMACHY project and its spin off GOME and GOME-2, by the European national space agencies, ESA and EUMETSAT in the early morning orbit
- b) The development of instruments by NASA and European national agencies in the early afternoon orbit

and the plans for geostationary measurements of air quality parameters by ESA/EUMETSAT, the South Korean Space Agency, JAXA and NASA. Similarly the selection of NPP or NPOESS, which focuses on Ozone in UT/LS and stratosphere.

However, since the selection of the instrumentation for NASA AURA, ESA ENVISAT, and the CSA SCISAT-1, no new limb or occultation vertical profile sounding measurements of atmospheric composition, which are key for reporting, monitoring, and verification of the Montreal Protocol and any post Kyoto agreement, are firmly planned and committed.

Based on the demonstrations by SCIAMACHY and GOSAT, there is now a recognised need for measurements, having high spatial resolution and temporal sampling, of carbon dioxide and methane from space to complement and enhance the ground based measurements of these gases.

GAW Recommendation

In order:

- a) To avoid significant data gaps in the longterm measurement of the composition of key atmospheric species and essential climate variables (ozone and key ozone depleting species, aerosols, water vapour, polar stratospheric clouds), in the upper troposphere, the stratosphere, and the mesosphere.
- b) To provide the maximum time for the preparation of new and improved measurements to continue and consolidate the long term data record.
- c) To maximise the scientific return from ENVISAT, AURA and SCISAT-1.

It is therefore essential to maintain the atmospheric limb sounding and occultation instruments aboard ESA ENVISAT (SCIAMACHY, MIPAS and GOMOS), NASA AURA (MLS) and the CSA SCISAT-1 delivering data for the maximum possible period. In particular GAW recommends the prolongation of ENVISAT limb and occultation measurements significantly beyond the current planned termination of measurements in 2014, foreseen by ESA.

LIST OF RECENT GLOBAL ATMOSPHERE WATCH REPORTS*

100. Report of the Workshop on UV-B for the Americas, Buenos Aires, Argentina, 22-26 August 1994.
101. Report of the WMO Workshop on the Measurement of Atmospheric Optical Depth and Turbidity, Silver Spring, USA, 6-10 December 1993, (edited by Bruce Hicks) (WMO TD No. 659).
102. Report of the Workshop on Precipitation Chemistry Laboratory Techniques, Hradec Kralove, Czech Republic, 17-21 October 1994 (WMO TD No. 658).
103. Report of the Meeting of Experts on the WMO World Data Centres, Toronto, Canada, 17 - 18 February 1995, (prepared by Edward Hare) (WMO TD No. 679).
104. Report of the Fourth WMO Meeting of Experts on the Quality Assurance/Science Activity Centres (QA/SACs) of the Global Atmosphere Watch, jointly held with the First Meeting of the Coordinating Committees of IGAC-GLONET and IGAC-ACE, Garmisch-Partenkirchen, Germany, 13 to 17 March 1995 (WMO TD No. 689).
105. Report of the Fourth Session of the EC Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry (Garmisch, Germany, 6-11 March 1995) (WMO TD No. 718).
106. Report of the Global Acid Deposition Assessment (edited by D.M. Whelpdale and M-S. Kaiser) (WMO TD No. 777).
107. Extended Abstracts of Papers Presented at the WMO-IGAC Conference on the Measurement and Assessment of Atmospheric Composition Change (Beijing, China, 9-14 October 1995) (WMO TD No. 710).
108. Report of the Tenth WMO International Comparison of Dobson Spectrophotometers (Arosa, Switzerland, 24 July - 4 August 1995).
109. Report of an Expert Consultation on 85Kr and 222Rn: Measurements, Effects and Applications (Freiburg, Germany, 28-31 March 1995) (WMO TD No. 733).
110. Report of the WMO-NOAA Expert Meeting on GAW Data Acquisition and Archiving (Asheville, NC, USA, 4-8 November 1995) (WMO TD No. 755).
111. Report of the WMO-BMBF Workshop on VOC Establishment of a "World Calibration/Instrument Intercomparison Facility for VOC" to Serve the WMO Global Atmosphere Watch (GAW) Programme (Garmisch-Partenkirchen, Germany, 17-21 December 1995) (WMO TD No. 756).
112. Report of the WMO/STUK Intercomparison of Erythemally-Weighted Solar UV Radiometers, Spring/Summer 1995, Helsinki, Finland (WMO TD No. 781).
- 112A. Report of the WMO/STUK '95 Intercomparison of broadband UV radiometers: a small-scale follow-up study in 1999, Helsinki, 2001, Addendum to GAW Report No. 112.
113. The Strategic Plan of the Global Atmosphere Watch (GAW) (WMO TD No. 802).
114. Report of the Fifth WMO Meeting of Experts on the Quality Assurance/Science Activity Centres (QA/SACs) of the Global Atmosphere Watch, jointly held with the Second Meeting of the Coordinating Committees of IGAC-GLONET and IGAC-ACE^{Ed}, Garmisch-Partenkirchen, Germany, 15-19 July 1996 (WMO TD No. 787).
115. Report of the Meeting of Experts on Atmospheric Urban Pollution and the Role of NMSs (Geneva, 7-11 October 1996) (WMO TD No. 801).
116. Expert Meeting on Chemistry of Aerosols, Clouds and Atmospheric Precipitation in the Former USSR (Saint Petersburg, Russian Federation, 13-15 November 1995).

* (A full list is available at <http://www.wmo.int/pages/prog/arep/gaw/gaw-reports.html>)

117. Report and Proceedings of the Workshop on the Assessment of EMEP Activities Concerning Heavy Metals and Persistent Organic Pollutants and their Further Development (Moscow, Russian Federation, 24-26 September 1996) (Volumes I and II) (WMO TD No. 806).
118. Report of the International Workshops on Ozone Observation in Asia and the Pacific Region (IWOAP, IWOAP-II), (IWOAP, 27 February-26 March 1996 and IWOAP-II, 20 August-18 September 1996) (WMO TD No. 827).
119. Report on BoM/NOAA/WMO International Comparison of the Dobson Spectrophotometers (Perth Airport, Perth, Australia, 3-14 February 1997), (prepared by Robert Evans and James Easson) (WMO TD No. 828).
120. WMO-UMAP Workshop on Broad-Band UV Radiometers (Garmisch-Partenkirchen, Germany, 22 to 23 April 1996) (WMO TD No. 894).
121. Report of the Eighth WMO Meeting of Experts on Carbon Dioxide Concentration and Isotopic Measurement Techniques (prepared by Thomas Conway) (Boulder, CO, 6-11 July 1995) (WMO TD No. 821).
122. Report of Passive Samplers for Atmospheric Chemistry Measurements and their Role in GAW (prepared by Greg Carmichael) (WMO TD No. 829).
123. Report of WMO Meeting of Experts on GAW Regional Network in RA VI, Budapest, Hungary, 5 to 9 May 1997.
124. Fifth Session of the EC Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry, (Geneva, Switzerland, 7-10 April 1997) (WMO TD No. 898).
125. Instruments to Measure Solar Ultraviolet Radiation, Part 1: Spectral Instruments (lead author G. Seckmeyer) (WMO TD No. 1066), 2001.
126. Guidelines for Site Quality Control of UV Monitoring (lead author A.R. Webb) (WMO TD No. 884), 1998.
127. Report of the WMO-WHO Meeting of Experts on Standardization of UV Indices and their Dissemination to the Public (Les Diablerets, Switzerland, 21-25 July 1997) (WMO TD No. 921).
128. The Fourth Biennial WMO Consultation on Brewer Ozone and UV Spectrophotometer Operation, Calibration and Data Reporting, (Rome, Italy, 22-25 September 1996) (WMO TD No. 918).
129. Guidelines for Atmospheric Trace Gas Data Management (Ken Masarie and Pieter Tans), 1998 (WMO TD No. 907).
130. Jülich Ozone Sonde Intercomparison Experiment (JOSIE, 5 February to 8 March 1996), (H.G.J. Smit and D. Kley) (WMO TD No. 926).
131. WMO Workshop on Regional Transboundary Smoke and Haze in Southeast Asia (Singapore, 2 to 5 June 1998) (Gregory R. Carmichael). Two volumes.
132. Report of the Ninth WMO Meeting of Experts on Carbon Dioxide Concentration and Related Tracer Measurement Techniques (Edited by Roger Francey), (Aspendale, Vic., Australia).
133. Workshop on Advanced Statistical Methods and their Application to Air Quality Data Sets (Helsinki, 14-18 September 1998) (WMO TD No. 956).
134. Guide on Sampling and Analysis Techniques for Chemical Constituents and Physical Properties in Air and Precipitation as Applied at Stations of the Global Atmosphere Watch. Carbon Dioxide (WMO TD No. 980).
135. Sixth Session of the EC Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry (Zurich, Switzerland, 8-11 March 1999) (WMO TD No.1002).
136. WMO/EMEP/UNEP Workshop on Modelling of Atmospheric Transport and Deposition of Persistent Organic Pollutants and Heavy Metals (Geneva, Switzerland, 16-19 November 1999) (Volumes I and II) (WMO TD No. 1008).
137. Report and Proceedings of the WMO RA II/RA V GAW Workshop on Urban Environment (Beijing, China, 1-4 November 1999) (WMO-TD. 1014) (Prepared by Greg Carmichael).

138. Reports on WMO International Comparisons of Dobson Spectrophotometers, Parts I – Arosa, Switzerland, 19-31 July 1999, Part II – Buenos Aires, Argentina (29 Nov. – 12 Dec. 1999 and Part III – Pretoria, South Africa (18 March – 10 April 2000) (WMO TD No. 1016).
139. The Fifth Biennial WMO Consultation on Brewer Ozone and UV Spectrophotometer Operation, Calibration and Data Reporting (Halkidiki, Greece, September 1998)(WMO TD No. 1019).
140. WMO/CEOS Report on a Strategy for Integrating Satellite and Ground-based Observations of Ozone (WMO TD No. 1046).
141. Report of the LAP/COST/WMO Intercomparison of Erythral Radiometers Thessaloniki, Greece, 13-23 September 1999) (WMO TD No. 1051).
142. Strategy for the Implementation of the Global Atmosphere Watch Programme (2001-2007), A Contribution to the Implementation of the Long-Term Plan (WMO TD No.1077).
143. Global Atmosphere Watch Measurements Guide (WMO TD No. 1073).
144. Report of the Seventh Session of the EC Panel of Experts/CAS Working Group on Environmental Pollution and Atmospheric Chemistry and the GAW 2001 Workshop (Geneva, Switzerland, 2 to 5 April 2001) (WMO TD No. 1104).
145. WMO GAW International Comparisons of Dobson Spectrophotometers at the Meteorological Observatory Hohenpeissenberg, Germany (21 May – 10 June 2000, MOHp2000-1), 23 July – 5 August 2000, MOHp2000-2), (10 – 23 June 2001, MOHp2001-1) and (8 to 21 July 2001, MOHp2001-2). Prepared by Ulf Köhler (WMO TD No. 1114).
146. Quality Assurance in monitoring solar ultraviolet radiation: the state of the art. (WMO TD No. 1180), 2003.
147. Workshop on GAW in RA VI (Europe), Riga, Latvia, 27-30 May 2002. (WMO TD No. 1206).
148. Report of the Eleventh WMO/IAEA Meeting of Experts on Carbon Dioxide Concentration and Related Tracer Measurement Techniques (Tokyo, Japan, 25-28 September 2001) (WMO TD No 1138).
149. Comparison of Total Ozone Measurements of Dobson and Brewer Spectrophotometers and Recommended Transfer Functions (prepared by J. Staehelin, J. Kerr, R. Evans and K. Vanicek) (WMO TD No. 1147).
150. Updated Guidelines for Atmospheric Trace Gas Data Management (Prepared by Ken Maserie and Pieter Tans (WMO TD No. 1149).
151. Report of the First CAS Working Group on Environmental Pollution and Atmospheric Chemistry (Geneva, Switzerland, 18-19 March 2003) (WMO TD No. 1181).
152. Current Activities of the Global Atmosphere Watch Programme (as presented at the 14th World Meteorological Congress, May 2003). (WMO TD No. 1168).
153. WMO/GAW Aerosol Measurement Procedures: Guidelines and Recommendations. (WMO TD No. 1178).
154. WMO/IMEP-15 Trace Elements in Water Laboratory Intercomparison. (WMO TD No. 1195).
155. 1st International Expert Meeting on Sources and Measurements of Natural Radionuclides Applied to Climate and Air Quality Studies (Gif sur Yvette, France, 3-5 June 2003) (WMO TD No. 1201).
156. Addendum for the Period 2005-2007 to the Strategy for the Implementation of the Global Atmosphere Watch Programme (2001-2007), GAW Report No. 142 (WMO TD No. 1209).
157. JOSIE-1998 Performance of EEC Ozone Sondes of SPC-6A and ENSCI-Z Type (Prepared by Herman G.J. Smit and Wolfgang Straeter) (WMO TD No. 1218).
158. JOSIE-2000 Jülich Ozone Sonde Intercomparison Experiment 2000. The 2000 WMO international intercomparison of operating procedures for ECC-ozone sondes at the environmental simulation facility at Jülich (Prepared by Herman G.J. Smit and Wolfgang Straeter) (WMO TD No. 1225).
159. IGOS-IGACO Report - September 2004 (WMO TD No. 1235), 68 pp, September 2004.

160. Manual for the GAW Precipitation Chemistry Programme (Guidelines, Data Quality Objectives and Standard Operating Procedures) (WMO TD No. 1251), 186 pp, November 2004.
161. 12th WMO/IAEA Meeting of Experts on Carbon Dioxide Concentration and Related Tracers Measurement Techniques (Toronto, Canada, 15-18 September 2003), 274 pp, May 2005.
162. WMO/GAW Experts Workshop on a Global Surface-Based Network for Long Term Observations of Column Aerosol Optical Properties, Davos, Switzerland, 8-10 March 2004 (edited by U. Baltensperger, L. Barrie and C. Wehrl) (WMO TD No. 1287), 153 pp, November 2005.
163. World Meteorological Organization Activities in Support of the Vienna Convention on Protection of the Ozone Layer (WMO No. 974), 4 pp, September 2005.
164. Instruments to Measure Solar Ultraviolet Radiation: Part 2: Broadband Instruments Measuring Erythemally Weighted Solar Irradiance (WMO TD No. 1289), 55 pp, July 2008, electronic version 2006.
165. Report of the CAS Working Group on Environmental Pollution and Atmospheric Chemistry and the GAW 2005 Workshop, 14-18 March 2005, Geneva, Switzerland (WMO TD No. 1302), 189 pp, March 2005.
166. Joint WMO-GAW/ACCENT Workshop on The Global Tropospheric Carbon Monoxide Observations System, Quality Assurance and Applications (EMPA, Dübendorf, Switzerland, 24 – 26 October 2005) (edited by J. Klausen) (WMO TD No. 1335), 36 pp, September 2006.
167. The German Contribution to the WMO Global Atmosphere Watch Programme upon the 225th Anniversary of GAW Hohenpeissenberg Observatory (edited by L.A. Barrie, W. Fricke and R. Schleyer) (WMO TD No. 1336), 124 pp, December 2006.
168. 13th WMO/IAEA Meeting of Experts on Carbon Dioxide Concentration and Related Tracers Measurement Techniques (Boulder, Colorado, USA, 19-22 September 2005) (edited by J.B. Miller) (WMO TD No. 1359), 40 pp, December 2006.
169. Chemical Data Assimilation for the Observation of the Earth's Atmosphere – ACCENT/WMO Expert Workshop in support of IGACO (edited by L.A. Barrie, J.P. Burrows, P. Monks and P. Borrell) (WMO TD No. 1360), 196 pp, December 2006.
170. WMO/GAW Expert Workshop on the Quality and Applications of European GAW Measurements (Tutzing, Germany, 2-5 November 2004) (WMO TD No. 1367).
171. A WMO/GAW Expert Workshop on Global Long-Term Measurements of Volatile Organic Compounds (VOCs) (Geneva, Switzerland, 30 January – 1 February 2006) (WMO TD No. 1373), 36 pp, February 2007.
172. WMO Global Atmosphere Watch (GAW) Strategic Plan: 2008 – 2015 (WMO TD No. 1384), 108 pp, August 2008.
173. Report of the CAS Joint Scientific Steering Committee on Environmental Pollution and Atmospheric Chemistry (Geneva, Switzerland, 11-12 April 2007) (WMO TD No.1410), 33 pp, June 2008.
174. World Data Centre for Greenhouse Gases Data Submission and Dissemination Guide (WMO TD No. 1416), 50 pp, January 2008.
175. The Ninth Biennial WMO Consultation on Brewer Ozone and UV Spectrophotometer Operation, Calibration and Data Reporting (Delft, Netherlands, 31-May – 3 June 2005) (WMO TD No. 1419), 69 pp, March 2008.
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), 61 pp, March 2008.
177. Joint Report of COST Action 728 and GURME – Overview of Existing Integrated (off-line and on-line) Mesoscale Meteorological and Chemical Transport Modelling in Europe (ISBN 978-1-905313-56-3) (WMO TD No. 1427), 106 pp, May 2008.
178. Plan for the implementation of the GAW Aerosol Lidar Observation Network GALION, (Hamburg, Germany, 27 - 29 March 2007) (WMO TD No. 1443), 52 pp, November 2008.
179. Intercomparison of Global UV Index from Multiband Radiometers: Harmonization of Global UVI and Spectral Irradiance (WMO TD No. 1454), 61 pp, March 2009.

180. Towards a Better Knowledge of Umkehr Measurements: A Detailed Study of Data from Thirteen Dobson Intercomparisons (WMO TD No. 1456), 50 pp, December 2008.
181. Joint Report of COST Action 728 and GURME – Overview of Tools and Methods for Meteorological and Air Pollution Mesoscale Model Evaluation and User Training (WMO TD No. 1457), 121 pp, November 2008.
182. IGACO-Ozone and UV Radiation Implementation Plan (WMO TD No. 1465), 49 pp, April 2009.
183. Operations Handbook – Ozone Observations with a Dobson Spectrophotometer (WMO TD No. 1469), 91 pp, March 2009.
184. Technical Report of Global Analysis Method for Major Greenhouse Gases by the World Data Center for Greenhouse Gases (WMO TD No. 1473), 29 pp, June 2009.
185. Guidelines for the Measurement of Methane and Nitrous Oxide and their Quality Assurance (WMO TD No. 1478), 49 pp, September 2009.
186. 14th WMO/IAEA Meeting of Experts on Carbon Dioxide, Other Greenhouse Gases and Related Tracers Measurement Techniques (Helsinki, Finland, 10-13 September 2007) (WMO TD No. 1487), 31 pp, April 2009.
187. Joint Report of COST Action 728 and GURME – Review of the Capabilities of Meteorological and Chemistry-Transport Models for Describing and Predicting Air Pollution Episodes (ISBN 978-1-905313-77-8) (WMO TD No. 1502), 69 pp, December 2009, electronic version -July 2009.
188. Revision of the World Data Centre for Greenhouse Gases Data Submission and Dissemination Guide (WMO TD No.1507), 55 pp, November 2009.
189. Report of the MACC/GAW Session on the Near-Real-Time Delivery of the GAW Observations of Reactive Gases, Garmisch-Partenkirchen, Germany, 6-8 October 2009, (WMO TD No. 1527), 31 pp. August 2010.
190. Instruments to Measure Solar Ultraviolet Radiation Part 3: Multi-channel filter instruments (lead author: G. Seckmeyer) (WMO TD No. 1537), 55 pp. November 2010.
191. Instruments to Measure Solar Ultraviolet Radiation Part 4: Array Spectroradiometers (lead author: G. Seckmeyer) (WMO TD No. 1538), 43 pp. November 2010.
192. Guidelines for the Measurement of Atmospheric Carbon Monoxide (WMO TD No. 1551), 49 pp, July 2010.
193. Guidelines for Reporting Total Ozone Data in Near Real Time (WMO TD No. 1552), 19 pp, April 2011 (*electronic version only*).
194. 15th WMO/IAEA Meeting of Experts on Carbon Dioxide, Other Greenhouse Gases and Related Tracers Measurement Techniques (Jena, Germany, 7-10 September 2009) (WMO TD No. 1553). 330 pp, April 2011.
195. WMO/GAW Expert Workshop on Global Long-term Measurements of Nitrogen Oxides and Recommendations for GAW Nitrogen Oxides Network (Hohenpeissenberg, Germany, 8-9 October 2009) (WMO TD No. 1570), 45 pp, February 2011.
196. Report of the First Session of the CAS JSC OPAG-EPAC and GAW 2009 Workshop (Geneva, Switzerland, 5-8 May 2009) (WMO TD No. 1577)
197. Addendum for the Period 2012 – 2015 to the WMO Global Atmosphere Watch (GAW) Strategic Plan 2008 – 2015, 57 pp, May 2011.
198. Data Quality Objectives (DQO) for Solar Ultraviolet Radiation Measurements (Part I). Addendum to WMO/GAW Report No. 146 - Quality Assurance in Monitoring Solar Ultraviolet Radiation: State of the Art
199. Second Tropospheric Ozone Workshop. Tropospheric Ozone Changes: observations, state of understanding and model performances (Météo France, Toulouse, France, 11-14 April 2011), 226 pp, September 2011
200. WMO/GAW Standard Operating Procedures for In-Situ Measurements of Aerosol Mass Concentration, Light Scattering and Light Absorption (Edited by John A. Ogren), 134 pp, October 2011
201. Quality Assurance and Quality Control for Ozonesonde Measurements in GAW (Prepared by Herman Smit and ASOPOS Panel), 95 pp. January 2013

202. Workshop on Modelling and Observing the Impacts of Dust Transport/Deposition on Marine Productivity (Sliema, Malta, 7-9 March 2011), 50 pp, November 2011.
203. The Atmospheric Input of Chemicals to the Ocean. Rep. Stud. GESAMP No. 84/GAW Report No. 203. 69 pp.
204. Standard Operating Procedures (SOPs) for Air Sampling in Stainless Steel Canisters for Non-Methane Hydrocarbons Analysis (Prepared by Rainer Steinbrecher and Elisabeth Weiß), 25 pp. September 2012
205. WMO/IGAC Impacts of Megacities on Air Pollution and Climate, 309 pp. September 2012 (ISBN: 978-0-9882867-0-2)
206. 16th WMO/IAEA Meeting of Experts on Carbon Dioxide, Other Greenhouse Gases and Related Tracers Measurement Techniques (GGMT-2011), Wellington, New Zealand, 25-28 October 2011, 67pp, October 2012.
207. Recommendations for a Composite Surface-Based Aerosol Network, Emmetten, Switzerland, 28-29 April 2009.
208. WMO GURME Workshop on Urban Meteorological Observation Design, (Shanghai, China, 11-14 December 2011)
209. Guidelines for Continuous Measurements of Ozone in the Troposphere (Prepared by Ian E. Galbally and Martin G. Schultz)