WORLD METEOROLOGICAL ORGANIZATION

COMMISSION FOR BASIC SYSTEMS

OPAG ON INTEGRATED OBSERVING SYSTEMS

EXPERT TEAM ON
OBSERVATIONAL DATA REQUIREMENTS AND
REDESIGN OF THE GLOBAL OBSERVING SYSTEM

SIXTH SESSION

FINAL REPORT

GENEVA, SWITZERLAND, 3 - 7 NOVEMBER 2003

WMO General Regulations 42 and 43

Regulation 42

Recommendations of working groups shall have no status within the Organization until they have been approved by the responsible constituent body. In the case of joint working groups the recommendations must be concurred with by the presidents of the constituent bodies concerned before being submitted to the designated constituent body.

Regulation 43

In the case of a recommendation made by a working group between sessions of the responsible constituent body, either in a session of a working group or by correspondence, the president of the body may, as an exceptional measure, approve the recommendation on behalf of the constituent body when the matter is, in his opinion, urgent, and does not appear to imply new obligations for Members. He may then submit this recommendation for adoption by the Executive Council or to the President of the Organization for action in accordance with Regulation 9(5).

EXECUTIVE SUMMARY

The WMO/CBS/OPAG IOS Expert Team on Observational Data Requirements and Redesign of the Global Observing System (ET-ODRRGOS) met in Geneva, Switzerland on 3 – 7 November 2003 to proceed with the work assigned by CBS. This includes (a) continuing the Rolling Review of Requirements (RRR), under which requirements for observations to meet the needs of all WMO programmes are compared with the capabilities of present and planned observing systems to provide them, (b) refining the recommendations to the Commission for Basic Systems (CBS) of WMO on the "re-design" of the Global Observing System (GOS), (c) drafting an implementation plan that evolves the GOS and assures full WMO utilization, and (d) considering strategies that would lead to comprehensive studies of observing system design.

Good progress was realized in all four areas. The WMO/CEOS data base was updated and Statements of Guidance were reviewed. Plans were finalized for a Third WMO Workshop on the Impact of Various Observing Systems on Numerical Weather Prediction to be held in Alpbach, Austria from 9 – 12 March 2004. The 42 recommendations for evolution of the GOS were revisited in attempts to make suggestions for implementation. An initial draft of an implementation plan was started and plans to work it to maturity were agreed upon. The ET also made progress in their consideration of strategies that would lead to a comprehensive study of observing system design.

GENERAL SUMMARY OF THE WORK OF THE SESSION

1. ORGANIZATION OF THE MEETING *(Agenda item 1)*

1.1 Opening of the meeting *(Agenda item 1.1*)

The sixth session of the Expert Team on Observational Data Requirements and Redesign of the Global Observing System of the CBS Open Programme Area Group (OPAG) on Integrated Observing Systems (IOS) was opened by its Chairman, Dr P. Menzel, at 10 am on Monday 3 November 2003 in the WMO Secretariat, Geneva. The list of participants is attached as Annex I.

The Assistant Secretary-General of WMO, Mr Hong Yan, welcomed participants to Geneva and to the WMO Secretariat. He noted that Fourteenth Congress (Geneva, May 2003) was very satisfied with the work being continued by CBS on the redesign of the GOS. Congress also provided guidance for the further work on the redesign, which this Expert Team should heed in its deliberations. He also advised that Congress approved the establishment of the WMO Space Programme, which was seen as a fundamental step to further enhance the space-based subsystem of the GOS. Finally the Assistant Secretary-General drew attention to the deliberations of the Congress, which requested that the redesign of the GOS be vigorously continued as part of the overall modernization of the WWW systems; this is the challenge to which the Expert Team must rise – to make this redesign a reality. He wished the Team every success in its deliberations during the week.

1.2 Adoption of the agenda *(Agenda item 1.2*)

The agenda as adopted by the session is given in Annex II.

1.3 Working arrangements *(Agenda item 1.3)*

The meeting agreed on working arrangements and adopted a tentative work plan for consideration of the various agenda items.

2. REPORT OF THE CHAIRMAN *(Agenda Item 2)*

The Chairman presented his report that included a review of the extensive work carried out by the Team during its previous five meetings. He detailed the ET progress on their work programme drafted at the last CBS and outlined the goals for the current meeting. These include to (1) update the WMO/CEOS data bases, (2) hear from the climate and ocean communities on their evaluations of the GOS capabilities relevant to their user requirements, (3) update several Statements of Guidance (especially in application areas not recently reviewed such as agro-meteorology and hydrology), (4) review presentations on recent Observing System Experiments, (5) continue planning the upcoming Third WMO Workshop on the Impact of Various Observing Systems on Numerical Weather Prediction (scheduled for Alpbach, Austria, 9 – 12 March 2004), (6) further development of the Implementation plan that assures full WMO utilization of the evolving GOS, and (7) consider strategies that would lead to a comprehensive study of observing system design. The ET accepted these goals as the focus for the activities for the week.

3. REVIEW OF Cg-XIV, CBS-EXT.(02) AND CBS-MG RECOMMENDATIONS FOR EVOLUTION OF SURFACE AND SPACE-BASED COMPONENTS OF THE GOS *(Agenda item 3)*

Summary of recommendations made by CBS Ext.(02) and CBS-MG

3.1 The Chair OPAG IOS informed the Expert Team of the decisions by CBS-Ext.(02) and the CBS Management Group Meeting (October 2003) with regard to the GOS issues and appropriate

follow-up actions. He thanked the ET for their excellent work and progress and looked forward to their meeting the challenges of their future work plan. Foremost among those challenges are: (1) to develop as soon as possible an infrastructure and implementation plan including a detailed time schedule within WMO to assure full utilization of the evolving GOS; (2) to develop the framework for supporting a focused funded activity for the study of observing system design; (3) to bring to fruition the Workshop on Impact of Various Observing Systems on NWP; and (4) with regard to item (1) above, to pursue early implementation (with particular attention to the developing countries). He pointed out that the redesign of the GOS would be impacted by evolution in observing system technologies as well as advances in science; thus the redesign of the GOS is an evolving activity that must possess a certain amount of flexibility. He further noted the importance of Observing System Experiments in helping to determine the optimum mix of that evolving observing system. To aid in that activity, while taking advantage of targeted experiments that are regional in nature, he indicated that his preference for COSNA SEG to be absorbed into the ET ODRRGOS as a sub-group that deals with those activities. He noted that WMO had a new major cross-cutting programme, the WMO Space Programme, that would have a major impact on redesign. He also brought forward other relevant issues including the recently adopted GCOS Climate monitoring principals and potential implications of the Earth Observation Summit (EOS). With regard to the EOS, he pointed to the strong relationship between the summits purpose and the ET's activity. The EOS related matters are discussed in more detail in Agenda item 3.4.

Cg-XIV recommendations on the GOS issues

3.2 Recommendations of the Fourteenth Congress (Geneva, May 2003) relevant to the GOS issues were brought to the attention of the Expert Team. It was noted with appreciation that the Congress confirmed that the World Weather Watch has the highest priority as the basic WMO Programme on which nearly all other programmes of the Organization depend. With regard to the GOS, Congress expressed its satisfaction that progress has been made in the further improvement of the operation of the WWW during the period 2000-2003. In particular, Congress noted that in the past four years, the overall implementation of surface and upper-air observational programme in the RBSNs had shown increasing stability and that the most recent monitoring results confirmed those encouraging trends compared to those of the years 1995 to 1999. While varied from region to region, the globally averaged availability in 2002 of surface and upper-air reports on the MTN was 75 and 63 per cent, respectively, of the reports expected from RBSN stations. Congress, however, noted with concern that deficiencies in surface and upper-air data coverage over certain areas in Regions I, II, III and V continued to be caused to a large degree by inadequate funds to rehabilitate and operate both observational and telecommunication equipment, especially at remote stations.

3.3 Congress noted with appreciation the improvements in the availability of data produced by other observing systems. In particular, it noted with satisfaction that marine networks had recovered from the loss of reporting stations and were at the level achieved in 1996. Congress reaffirmed the importance of the AMDAR Programme including the work carried out by the AMDAR Panel, and the significant contribution AMDAR continued to provide to the GOS. It agreed with the recommendation of CBS that AMDAR should be more fully integrated into the WWW Programme, and requested the Executive Council to consider the appropriate measures including the desirability of funding AMDAR activities in developing and coordinating the AMDAR Programme.

3.4 It was of particular interest to the Expert Team that Congress noted with satisfaction the challenging work being continued by CBS on the redesign of the GOS, which so far had resulted in updated observational requirements of all WMO Programmes and a first assessment of the evolution of the surface- and space-based components of the GOS. Furthermore, Congress supported the following views and conclusions of CBS on redesign issues:

(a) The rolling review of requirements was readily applied to a diversity of application areas, provided the database of user requirements and observing system capabilities was accurate;

(b) Hypothetical changes to the GOS could be explored in OSEs with NWP centre assistance, provided data assimilation procedures were well understood and impact studies were conducted in a statistically-significant way. Present weaknesses and possible future improvement of data assimilation systems and NWP should also be taken into account when assessing the results of OSEs. Furthermore it was made apparent that the OSSEs required huge human and computer resources and were beyond the available resources;

(c) The future GOS should build upon existing components, both surface and space based, and capitalize on existing and new observing technologies not presently incorporated or fully exploited; each incremental addition to the GOS would be reflected in better data, products and services from the NMHSs;

(d) The impact of the changes to the GOS in the next decades was anticipated to be so massive that new revolutionary approaches for science, data handling, product development, training and utilization would be required. There was an urgent need to study comprehensive strategies for anticipating and evaluating changes to the GOS. These should take into account the possibility of adapting the observing programmes to prevailing atmospheric conditions.

3.5 The Expert Team noted that Congress encouraged improved links between surface-based and space-based components in RA VI established by EUCOS and EUMETSAT. Furthermore, Congress also noted with appreciation the activities to optimize data coverage over Europe carried out by EUMETNET's EUCOS programme and recommended use of experience gained in cooperation and joint funding schemes in other regions. Congress reiterated the view of the Executive Council that the structure of the future GOS and the implementation of new technologies should be driven by Members' requirements rather than by technological opportunities. It reaffirmed that new technologies should be implemented as soon as practical to replace older, more costly observing systems with a view to reducing the expenditures. Congress noted the importance for the future GOS of the organization and implementation of observing systems envisaged by THORPEX. It stressed that CAS and CBS should coordinate their efforts in this experiment especially in carrying out the associated data management and data dissemination functions. It noted the comprehensive revisions developed to the GOS regulatory material. Congress requested CBS to continue vigorously its efforts in the redesign of the GOS, as a part of overall modernization of WWW systems. In the light of the above guidance given by Cg-XIV, the Expert Team considered appropriate follow-up actions including development of strategies and implementation plan for the redesign of the GOS.

WMO Space Programme

3.6 The Expert Team was informed of decisions by the Fourteenth WMO Congress with regard to satellites. In particular, it was briefed on the establishment of the new cross-cutting major WMO Space Programme and the associated portions contained in the WMO Sixth Long Term Plan. The Expert Team also noted that CBS now has lead responsibility for two major programmes, the World Weather Watch Programme and the WMO Space Programme. The approved WMO Space Programme Long-term Strategy is:

> "To make an increasing contribution to the development of the WWW GOS, as well as to the other WMO-supported Programmes and associated observing systems (such as AREP's GAW, GCOS, WCRP, HWR's WHYCOS and JCOMM's implementation of GOOS) through the provision of continuously improved data, products and services, from both operational and R&D satellites, and to facilitate and promote their wider availability and meaningful utilization around the globe."

3.7 The main elements of the WMO Space Programme Long-term Strategy include: increased involvement of space agencies; promotion of a wider awareness of the availability and utilization of data and products; considerably more attention to be paid to the crucial problems connected with

the assimilation of R&D and new operational data streams in nowcasting, numerical weather prediction systems, reanalysis projects, monitoring climate change, chemical composition of the atmosphere, as well as the dominance of satellite data in some cases; closer and more effective cooperation with relevant international bodies; additional and continuing emphasis on education and training; facilitation of the transition from research to operational systems; improved integration of the space component of the various observing systems throughout WMO Programmes and WMO-supported Programmes; and increased cooperation amongst WMO Members to develop common basic tools for utilization of research, development and operational remote sensing systems.

3.8 The Expert Team was also informed that the Fourteenth WMO Congress had established by resolution, sessions at WMO Consultative Meetings on High-level Policy on Satellite Matters, in order to establish more formally the dialogue and participation of environmental satellite agencies in WMO matters. The Consultative Meetings will continue to provide advice and guidance on policy-related matters and will also maintain a high level overview of the WMO Space Programme.

3.9 The Expert Team was briefed on the results of the CBS Management Group Meeting held in Langen, Germany in October 2003. The Chair OPAG IOS highlighted an action item resulting from the Management Group Meeting to review the present terms of reference for all Expert Teams with the goal of identifying any necessary changes, taking into consideration the increased responsibilities resulting from the WMO Space Programme's objectives, as well as the need for appropriate representation on the Expert Teams by Research and Development space agencies.

Earth Observation Summit

3.10 The Expert Team was briefed on the recent Earth Observation Summit (EOS) held in Washington DC, 31 July 2003, and the subsequent establishment of the ad hoc Group on Earth Observations (GEO). The EOS adopted a declaration that affirmed the need for timely, quality, long-term, global information as a basis for sound decision making. In order to monitor continuously the state of the Earth, to increase understanding of dynamic Earth processes, to enhance prediction of the Earth system, and to further implement our environmental treaty obligations, the Summit recognized the need to support: improved coordination of strategies and systems for observations of the Earth and identification of measures to minimize data gaps, with a view to moving towards a comprehensive, coordinated, and sustained Earth observation system or systems; a coordinated effort to involve and assist developing countries in improving and sustaining their contributions to observing systems, as well as their access to and effective utilization of observations, data and products, and the related technologies by addressing capacity-building needs related to Earth observations; the exchange of observations, recorded from *in-situ*, aircraft, and satellite networks, dedicated to the purposes of the Declaration, in a full and open manner with minimum time delay and minimum cost, recognizing relevant international instruments and national policies and legislation; and the preparation of a 10-year Implementation Plan, building on existing systems and initiatives, with the Framework being available by the Tokyo ministerial conference on Earth observations to be held during the second quarter of 2004, and the Implementation Plan being available by the ministerial conference to be hosted by the European Union during the fourth quarter of 2004. To achieve these objectives, the Summit established an *ad hoc* Group on Earth Observations taking into account the existing activities aimed at developing a global observing strategy. The Expert Team was further informed of the five GEO Sub Groups (Architecture, International Cooperation, Capacity Building, Data Utilization and Data Requirements), their Terms of Reference and a status of ongoing activities. The Expert Team was pleased to note the strong participation of the WMO Secretariat in all of the Sub Groups and GEO Secretariat and that the valuable work performed in the past by the Expert Team for the Redesign of the GOS had been made available into the GEO Process including the observational data requirements for all WMO and supported Programmes, a description of the Rolling Review of Requirements and the latest Statements of Guidance. The Expert Team indicated a strong desire that its work continue to be provided for consideration in the GEO deliberations.

4. REPORT FROM THE AOPC (*Agenda Item 4*)

Ninth Atmospheric Observations Panel for Climate (AOPC) Meeting

4.1 On behalf of Dr. M. Manton, Chairman of the GCOS/WCRP Atmospheric Observations Panel for Climate (AOPC), Dr. H. Teunissen presented an overview of the most recent activities of the AOPC and related GCOS activities. The Ninth Session of the GCOS/WCRP Atmospheric Observations Panel for Climate, held in Asheville, USA from 23-27 June 2003, focused discussion around (i) the status and latest developments regarding the GCOS atmospheric networks, especially the GSN and GUAN; (ii) consideration of new or enhanced networks for measurement of additional parameters of importance to AOPC (surface radiation, CO2); (iii) further development and review of Statements of Guidance for three climate applications areas; (iv) establishment of an AOPC Working Group on Reconciling Vertical Temperature Trends; (v) consideration of a proposal for network of very-high-quality upper-air reference stations, possibly as a subset of GUAN; and (vi) review of the latest status of the GCOS Second Adequacy Report to the United Nations Framework Convention on Climate Change (UNFCCC).

4.2 The performance of the GSN and GUAN networks remains well below ideal, with about 65% of expected reports being received at the GCOS Monitoring Centres for GSN and 75% for GUAN. GCOS is working closely with WMO/WWW and TCO of WMO to take specific actions to revitalize a number of GUAN stations, under the guidance of AOPC for station selection and with funding support provided recently by several members, including the USA/NOAA through its Climate Change Research Initiative. A contractor has been engaged by GCOS to carry out these activities, which are expected to continue for some time and include underperforming GSN as well as GUAN stations.

Climate SOGs

4.3 The latest drafts of three Statements of Guidance (SOGs) for climate applications were presented for consideration by the ET. These are Seasonal to Interannual Forecasts (SIA), which was developed in cooperation with the ET and had already appeared in its documentation; Monitoring Climate Change; and Monitoring Climate Variability. The latter two were developed by the AOPC, with input from a number of expert members of the climate community following the AOPC-IX session. Additional input was being sought, in particular from the CCl community, and would be incorporated as it became available. As with the SOGs for other application areas, these SOGs would continue to be updated as appropriate, with this presentation to the ET being part of that process. The ET provided feedback to AOPC on these SOGs (see section 5) and noted with appreciation AOPC efforts to provide rigour to the climate statements of guidance.

Second Report on the Adequacy of the Global Observing Systems for Climate Change in Support of the UNFCCC

4.4 The ET was briefed on the *Second Report on the Adequacy of the Global Observing Systems for Climate Change in Support of the UNFCCC,* developed under GCOS guidance in response to a decision of the UNFCCC Conference of the Parties (COP-5) and endorsment by its Subsidiary Body for Scientific and Technological Advice (SBSTA-15) as well as the Executive Council of WMO (EC-LIV). Cg-XIV had strongly endorsed the conclusions of the report and urged all Members to support the implementation of its recommendations as a matter of urgency. SBSTA-18 (June 2003) had welcomed the report and developed a draft decision for consideration by COP-9 (December 2003) which, *inter alia*, would request the development of a phased five to ten year implementation plan for the integrated global observing systems for climate. Work was underway to develop such a plan, with strong support from the AOPC and the other GCOS science panels as well as IPCC scientists, with a view to presenting a final document to COP-10 in December 2004. The ET noted this report and suggested that the existing GCOS observational data requirements be reviewed taking into consideration this *Second Report on the Adequacy of the Global Observing Systems for Climate Change in Support of the UNFCCC.*

4.5 An expanded version of the GCOS Climate Monitoring Principles had been developed by AOPC in consultation with the Coordination Group on Meteorological Satellites. This updated

version included principles focused specifically on satellite observations and had been adopted by the WMO Congress in May 2003 through its Resolution 9 (Cg-XIV). The Principles had been extensively referenced in both the Second Adequacy Report and the SOGs referred to above.

5. REVIEW AND UPDATE OF STATEMENTS OF GUIDANCE *(Agenda item 5)*

5.1 The ET discussed the creation of SOGs and their role in updating them. The ET noted that the user requirements for an application area must be maintained by a responsible entity (that assumes responsibility and ownership of these requirements), that the analysis of observing system capabilities and user requirements must be performed with a data base that accurately reflects both, that the RRR process should be engaged for experts to generate the SOG for that application area that summarizes a gap analysis between capabilities and requirements, and that the process used to generate that SOG should be reviewed by the ET, and that upon ET acceptance of the SOG it would be factored into the GOS redesign considerations.

SOG for Seasonal to Interannual Forecasts

5.2 The ET felt that the SOG for SIA Forecasts needed convergence between the earlier version (drafted with CBS and CCl input) and this version (iterated by AOPC). In particular the first version of the SIA SOG noted that the requirements for SIA Forecasts built upon those for Global NWP; the current version should also reflect this. Also it was felt that the increasing capability of satellite programs to determine ocean wind stress, ocean currents, and sea level needed to be reflected. Finally it was noted that data requirements for some of the new variables were needed for the RRR process to be fully engaged. It was suggested that OPAG DFPS be approached to assume ownership of the SIA requirements and that CCl, OPAG DFPS and AOPC engage in a further discussion to reach agreement on one SOG for SIA.

SOGs for Monitoring Climate Change and Monitoring Climate Variability

5.3 The ET noted that the SOGs for Monitoring Climate Change and Monitoring Climate Variability provided ample science discussion on the key observations but did not offer an adequate analysis of the adequacy of the GOS for meeting the user requirements in these applications areas. The ET felt that they were not SOGs in their current form and encouraged AOPC to continue their efforts to apply the RRR process in these applications areas. In particular, observational data requirements for the two new applications areas should be developed and included in the WMO/CEOS data base. The ET remains available to assist.

5.3.1 With regard to the SoG on Monitoring Climate Change, a few specific suggestions were made. (1) Reprocessing the available data should be considered as a regular activity that enables better understanding of the required data and meta-data and generates better algorithms and improved products. (2) The Earth radiation budget at the top of the atmosphere should be added to the list if significant climate forcing measurements.

SOG for Aviation Meteorology

5.4 Dr H. Pümpel presented information from a WMO Workshop/Seminar on the Use of Radar, Satellite and NWP Data in Aviation Meteorology, held in Toronto, 27–31 October 2003. Aviation meteorology is facing the need to supply the aviation industry, currently in an economically difficult situation, products to help economical and safe operations at minimum cost. Studies have shown that meso-scale and high impact weather phenomena are mostly responsible for costly delays and incidents. The methodologies currently applicable to the prediction of deep convection in nowcasting (typically kinematic extrapolation methods) and in high resolution modelling are at their limits to cover the forecast range between 2 and 6-9 hours considered essential for Air Traffic Management and Flight Planning. Insufficient vertical resolution in lower tropospheric humidity and winds over land as well as difficulties in assimilating these data are seen as critical shortcomings. For aviation impact variables such as high level turbulence and icing, risk areas can be predicted with some success, but intensities varying on a very small scale are proving elusive. AMDAR

winds and turbulence as well as icing reports are seen as crucial input for algorithm development. For subjective forecasting in the very short range, radar reflectivities and satellite derived cloud-top temperatures at high temporal resolution and cloud physics data available from new geostationary satellites could give good guidance for nowcasting. AMDAR profiles are considered essential for subjective very short range forecasting in data sparse areas in developing countries. Scatterometer data and AIRS temperature profiles from cloud-free retrievals hold significant promise for local and regional aeronautical forecasting. SOG for Aviation Meteorology will be updated within the calendar year and posted on the ET web site.

SOG for Atmospheric Chemistry

5.5 Dr L. Barrie presented information on the Global Atmosphere Watch (GAW) Programme of WMO. As mandated by WMO Congress, the mission of the WMO Global Atmosphere Watch (GAW) Programme in the Atmospheric Research and Environment Programme (AREP) is threefold: (i) systematic monitoring of chemical composition globally (ii) analysis and assessment and (iii) development of a predictive capability for future atmospheric states. It is responsible for the chemical components and UV radiation in the list of essential climate variables of the atmosphere reported in the 2nd Adequacy Report on Climate Monitoring submitted to the UNFCC by GCOS as well as other chemicals related to air quality, stratospheric ozone depletion and the oxidizing power of the atmosphere.

5.6 GAW currently oversees global monitoring of greenhouse gases, ozone and related UV radiation, aerosols, reactive gases and precipitation chemistry. It does this through a network of Global and Regional stations operated by WMO members and partners as well as through coordination with contributing networks that complete the global picture. For each chemical group listed above, it includes a Scientific Advisory Group (SAG) of reputable scientists, Quality Assurance/Science Activity Centres, facilities hosting reference standard gases or instruments, world calibration centers, world data centers, instrument calibration and training workshops and World Data Centres. The SAGs establish measurement guidelines, data quality objectives and where appropriate, write standard operating procedures for particular measurements. For chemical variables of the atmosphere, GAW is the counterpart in WMO of the World Weather Watch for meteorological variables. The main difference is that because the disciplinary and technological nature of atmospheric composition measurements is such that the monitoring activities are generally conducted under research departments in the National Hydrological and Meteorological Services that WMO represents.

5.7 To date GAW has focused mainly on surface-based networks of in situ, total column and balloon vertical profiling. However, now that chemical composition measurements from aircraft and satellites are showing promise of becoming at least pre-operational, GAW has taken a lead role in designing a system for Integrated Global Atmospheric Chemistry Observations (IGACO). A Theme Report on Atmospheric Chemistry has been submitted November 2003 to IGOS, to CEOS and this Expert Group. It was developed under the joint leadership of WMO/GAW and the European Space Agency (ESA) by a panel of international atmospheric measurement, analysis and modeling researchers. It contains a recommended target list of observables, an assessment of the measurement requirements for satellites that updates those in WMO/CEOS Report WMO/GAW No. 140 and recommendations for implementation of an Integrated Observing System for atmospheric chemistry in the short term (0 to 10 years) and in the long term (>10 years). The IGACO Theme Report is submitted to this WMO Experts Group with the suggestion that it form the basis of a Statement of Guidance for Atmospheric Chemistry. The ET recommended that the SOG for Atmospheric Chemistry be updated to reflect this new information.

Review of Observing System Capabilities and User Requirements

5.8 Dr D. Hinsman gave a brief review of the status of the WMO/CEOS database. The last full review occurred in 2001. New user-estimates of expected performances have been added to the data base, especially for in situ systems. The existing list of user-estimates of observing system performances was presented and an ET review was requested. During the ET meeting, this was

started with special attention being paid to adding the increased space based capabilities from the Chinese satellites.

5.9 It was agreed that the WMO/CEOS database used in the Rolling Review of Requirements (RRR) process will be updated by December 2003 with tasking as follows: (a) In-situ (including reassessment of vertical resolution as requested by Dr Pümpel) to be done by Dean Lockett; (b) In-situ GOOS by Etienne Charpentier; and (c) Satellites by Dr Wenjian Zhang.

6. STATUS AND RESULTS OF OSEs *(Agenda item 6)*

Mr J. Pailleux reported on the status of the OSEs. Eight specific OSEs, in addition to standard OSEs (testing the contribution of one particular observing system), were suggested in previous sessions of the Expert Team. Of these eight experiments, only one could not be carried out, namely the OSE on the impact of AMDAR data over Africa. The meeting was advised that this experiment would not be conducted. Due to the large volume of OSE results, a comprehensive summary of OSEs was not made during the meeting. The compilation of the results of the conducted OSEs will be presented at the Alpbach workshop in March 2004. There are currently two natural trends in the OSE work which should be encouraged in relation with the GOS optimization: (1) to further test the complementarities between different data sets; and (2) to develop and conduct more mesoscale OSEs.

6.1 Dr J. Eyre reported on the results from OSEs carried out by ECMWF and the Met Office (UK). Both centres have run impact trials demonstrating significantly improved forecast performance when assimilating ATOVS data from 3 satellites (NOAA-15, -16 and -17) compared with 2 satellites. With three satellites, a more complete global data coverage is obtained in any 6-hour period. ECMWF have also shown additional positive impact when data from a 4th AMSU-A instrument (from the Aqua satellite) is added to the system. The ET noted with appreciation the continuing processing and distribution of NOAA 15 data through NESDIS and beneficial impact on NWP that was demonstrated through these OSEs. The ET also asked the OPAG IOS chair to encourage CGMS to undertake international coordination of equator crossing times that would maximize the temporal coverage of the polar orbiting global observing systems.

6.2 Dr H. Böttger presented results of the use of radiance observations from AIRS on AQUA that have been received at ECMWF in near real-time since October 2002. As a result of a significant amount of preparation (both technical and scientific) carried out prior to launch using simulated observations, monitoring of the real AIRS radiances started almost immediately after the arrival of the data. The monitoring quickly indicated that the AIRS instrument was very stable, well calibrated and consistent with the expected spectral characteristics. Furthermore, the cloud detection scheme and radiative transfer model (developed before launch) were found to work very well applied to the real AIRS data. The early validation of these two key elements allowed an initial set of 4D-Var assimilation experiments with AIRS to begin. These were performed at lower (T159) resolution and were aimed at establishing the best configuration of the AIRS data usage that could then be tested rigorously at full (T511) resolution. The result was a fairly conservative usage of the AIRS data avoiding parts of the spectrum susceptible to solar contamination and channels sensitive to ozone and surface emission over land. A very simple bias-correction scheme and observation error model were also derived and the data thinned to a horizontal separation of 120 km. This configuration was then tested at full resolution over the period December 2002 to March 2003 (a total of 100 cases) to gauge the meteorological impact of the AIRS radiances. It was found that the assimilation of AIRS caused a small but consistent reduction in the size of analysis increments near radiosonde locations, and modestly improved the quality of forecasts. These results were sufficiently encouraging that the assimilation of AIRS was included in the operational implementation of the forecasting system upgrade 7 October 2003. The ET noted that the preparation phase for AIRS utilization had been very effective, complimented the ITOVS Working Group for their coordination efforts, and thanked NASA and NESDIS for their implementation of a successful near real time data distribution system. It was agreed that the full benefit of AIRS would be realized as more assimilation experience is gained.

6.3 Mr J. Pailleux advised the meeting that two OSE papers will be presented by Canada at the Alpbach workshop in March 2004. The first reports on a set of global OSEs testing the impact of various observing systems against the Canadian 3D-Var model of December 2001. This OSE assisted in testing the 3D-Var model before it was implemented. Other interesting results obtained during the running of this OSE, such as the relative impacts of radiosonde data versus satellite data, and comparison of these impacts with similar results from other NWP centres, will also be presented at the Alpbach workshop. A second Canadian paper to be presented at Alpbach will deal with more specific OSEs, including the impact of stratospheric data from radiosondes.

6.4 Dr O. Pokrovsky presented an outline of his approach to optimization of the observing system. This approach is based on quantitative information content assessment related to variability characteristics of various temporal and spatial scales. Results pertaining to the Siberian radiosonde network were obtained and an optimization scenario was developed. It was shown that the current Siberia RAOB network is not optimal. It provides internal continental areas of Russian Asia with regular temporal data and measures the height in Central Siberia. But the Arctic and Pacific coasts are not well represented. However these domains are of importance because they exhibit atmospheric low frequency oscillation poles. These are West, North and East Pacific oscillations which impact weather forecasting for Western coast of North America. The optimization procedure provides a step by step selection of the most informative sonde stations. A minimal sonde network of eleven stations located along Arctic and Pacific coasts as well as in internal continental areas was developed. This configuration requires less sonde launches, but provides higher RMS (root mean square) accuracy in the geopotential field grid representation over Siberia. Most improvements are achieved in coastal regions. The ET was appreciative of this work, noted that redistribution of sondes based on NWP forecast background error characteristics might be somewhat different, and encouraged that such a study of South African vertical profile distribution be considered.

6.5 The Forecast Systems Laboratory submitted a paper on recent progress in developing and testing an advanced version of the Rapid Update Cycle (RUC) cloud-top pressure assimilation technique intended to improve short-range forecasts of cloud/hydrometeors, icing, and precipitation. The new version of the RUC (RUC20) has modified the cloud/hydrometeor analysis technique using GOES sounder hourly cloud-top data. FSL routinely computes statistics of differences between GOES cloud-top pressure and RUC20 forecasts (1, 3, 6, 9, 12 hour) every 3 hours. The predicted cloud-top from RUC shows dramatic improvement in the correlation with subsequent GOES cloud observations (up by 20% even out to 12 hours) when the GOES sounder cloud top information is assimilated. The ET noted that assimilation of measurements affected by clouds remained an important challenge and was encouraged by the significant positive impact of these hourly determination of cloud properties.

6.6 The ET was informed that the Met Office (UK) has run a 16-day impact trial of CHAMP occultation data in the form of retrieved vertical profiles of refractivity. Although relatively few profiles were available for assimilation (only ~40 per 6-hour assimilation cycle), the impacts on analysis accuracy were consistently positive in the upper troposphere and lower stratosphere. There were also significant positive impacts on forecasts of lower stratospheric temperature (all latitudes), upper tropospheric temperature (Southern Hemisphere) and surface pressure (Tropics). The ET noted that the radio occultation measurements of the tropopause region nicely complement infrared and microwave radiometric measurements and that work toward realizing NWP benefit from the combined systems should continued to be encouraged.

6.7 Dr Böttger reported on a new series of NWP global impact studies conducted by ECMWF to assess the relative value and contribution of the various components of the Global Observing System. The experiments were run for two months in winter 2002/03 and two months in summer 2003 using the operational system as the baseline (control). The impact of the major components of the GOS was tested through data denial, i.e. by eliminating all satellite data, all aircraft data and all radiosonde data (TEMP and PILOT and profilers). The main findings from the experiments were summarized as follows:

i) Satellite data have a larger impact in northern hemisphere than seen in previous global OSEs;
ii) In the short-range radiosonde data still have a significant impact, comparable to satellite data;
ii) In the medium-range the impact from satellite data is larger than the one from radiosondes;
iv) Conventional radiosondes still have large impact in the short range and remain an important independent source of in-situ information; and
v) Forecasts in northern and southern hemisphere are now of comparable quality

The ET was appreciative of this brief summary of these global OSEs and looked forward to the more detailed presentation at NWP OSE Workshop in March 2004.

6.8 Dr J. Caughey, the EUCOS Programme Manager, described recent progress in the gathering of data for three proposed OSEs: (a) targeted observations were taken in February / March 2003 (as a European component of THORPEX); (b) higher frequency AMDAR data were collected in 2003; and (c) higher density surface marine observations were taken to help identify the requirement for surface pressure/wind measurements in support of satellite observations. EUCOS is conducting these OSEs in collaboration with several European NWP centres. The ET noted that many aspects of the EUCOS programme were of interest to CBS as examples of regional activities that improve the effectiveness of observing systems. In particular, the various EUCOS data gathering experiments enable unique investigations of the best mix of observations that could guide the evolution of the GOS.

6.9 Dr E. Manaenkova (D/AREP) and Dr J. Eyre presented the current state of the THORPEX Programme, its ongoing and planned activities and scientific research objectives, and requested ET feedback on the THORPEX plans. It was noted that Cg-XIV established THORPEX as a ten-year long international Global Atmospheric Research Programme under the CAS as a part of the WWRP. THORPEX aims to accelerate improvements in the accuracy of 1 to 14-day weather forecasts for the benefit of society and the economy. The Programme builds upon ongoing advances within the basic-research and operational-forecasting communities. It will make progress by enhancing international collaboration between these communities and with users of forecast products. In response to this briefing and the relevant decisions of CBS Management Group (Langen, October 2003), the ET agreed:

i) to encourage members to review the 2nd version of the THORPEX Science Plan (available on www.wmo.int/web/arep/wwrp/THORPEX/THORPEX.htm) (preferably by December 15 2003);

ii) to take part in developing the THORPEX International Research Implementation Plan (2004);

Iii) to assist in connecting the THORPEX science opportunities as defined in the International Science Plan with future operational requirements and to provide specific NWP requirements from the operational NWP communities; and

iv) to consider THORPEX results in GOS redesign activities.

6.10 The ET strongly supported THORPEX activities. It was felt that THORPEX could make important contributions toward answering questions posed by CBS that are relevant to the redesign of a cost-effective GOS. The ET drafted an initial list of questions that THORPEX could help to answer (available in Annex V) and took an action to forward these to THORPEX. Furthermore, the ET encouraged THORPEX to make its experimental data sets available to all NMHSs (through GTS and other means) and to allow NWP centers access to the full set of experimental data for post experiment analysis. These efforts will be supported by WWW.

7. THIRD WMO WORKSHOP ON THE IMPACT OF VARIOUS OBSERVING SYSTEMS ON NWP (Alpbach, Austria, 9 – 11 March 2004) *(Agenda item 7)*

7.1. Dr P. Menzel reported that the Third WMO Workshop on the Impact of Various Observing Systems on Numerical Weather Prediction will be held in Alpbach, Austria from 9 – 12 March 2004. The Coordination Group for COSNA (CGC) organized the first two workshops on impact studies that took place in Geneva (April 1997) and in Toulouse (March 2000) respectively. Results from Observing System Experiments (OSEs) both with global and regional aspects were presented and conclusions were drawn concerning the contributions of the various components of the observing system to the large scale forecast skill at short and medium range (Workshop Proceedings published as WMO World Weather Watch Technical Report No. 18 and 19 respectively). At the Alpbach workshop, the key NWP centres will present recent results studying some significant changes and developments in the Global Observing System. The results will then be reviewed in plenary discussions. Conclusions helping with the design of an optimized Global Observing System for NWP will be drawn.

7.2 Arrangements for the conference were discussed. The ET approved the agenda of the workshop. A final list of invited speakers from key NWP centers and global network operators was drawn. The ET noted that the local organizer is providing information on hotel accommodation and conference facilities; he will be asked to officially assume responsibilities for local arrangements and to confirm conference center booking and other related costs. The co-chairs Jean Pailleux and Horst Böttger are being assisted by the Organizing Committee that includes: John Eyre, Met Office; Ko Koizumi, JMA; Tom Schlatter, NOAA/FSL; Paul Menzel, NOAA/ORA; Helmut Rott, University of Innsbruck; Alexander Karpov, WMO.

8. ET ACTION ITEM REVIEW AND IMPLEMENTATION PLAN FOR EVOLUTION OF THE GOS *(Agenda item 8)*

Action item review

8.1 An action item review from the fifth ET meeting revealed that all but two of the actions had been completed. The ocean related actions remained open. The climate actions had been closed. The inputs to the Manual of the GOS had been submitted and adopted.

8.2 There was some discussion regarding whether WMO/TD 1040 and its utility within the terms of reference of ET-ODRRGOS warranted the work and effort necessary to review, extend and maintain the document as an official WMO publication. The point was made that the document does have utility in providing a reference for and maintaining an updated progress status of the technologies that have to be considered in restructuring and redesigning the global observing system. The document has also been published and distributed to a large number of WMO Members. Some effort has already been made by members of the ET to commence the review and extension process and it was decided that Dr P. Menzel, Etienne Charpentier and Dean Lockett would consolidate this process and attempt to produce an updated version for review by the ET. The terms of reference for the content of the document were reviewed at the ET meeting and some guidelines were produced.

8.3 The Focal Points for each application area were updated and it was resolved that the secretariat will enlist them to coordinate review and revision of the SOGs from appropriate experts. The following is the updated list:

Application	Owner of user requirements	Focal Points
global NWP	CBS/OPAG-DPFS	J. Eyre
regional NWP	CBS/OPAG-DPFS	T. Schlatter
synoptic meteorology	CBS/OPAG-DPFS	E. Legrand
nowcasting and VSRF	CBS/OPAG-PWS	TBD
atmospheric chemistry	GAW	L. Barrie
aeronautical meteorology	CAeM	H. Pümpel
SIA forecasts	CBS/OPAG-DPFS	M. Manton / A. Simard

other climate	CCl and GCOS	R Heino / V. Vent-Schmidt / M. Manton
ocean	JCOMM	H. Kawamura
hydrology	CHg	TBD
agro meteorology	CAgM	TBD

8.4 Based on the results of discussions under various agenda items, a new action list was drafted (see Annex III)

Implementation Plan for Evolution of the GOS

8.5 The ET started the draft of an implementation plan (see Annex IV). Each of the 42 recommendations for the evolution of the GOS was addressed. With regard to the recommendations for the space based part of the GOS, many of the next actions for implementation will rely on the WMO Space Programme to take them up with space agencies, via CGMS and WMO consultative meetings on high-level policy on satellite matters. For the surface based subsystem of the GOS, different strategies of implementation were suggested for the different components. The implementation plan will be iterated monthly, with the goal that a final version can be drafted at the next ET meeting (prior to the OPAG IOS ICT meeting in 2004).

9. ANY OTHER BUSINESS *(Agenda item 9)*

Current Status of AMDAR

9.1 Mr J. Stickland, the AMDAR Panel Technical Coordinator, reported on the status of implementation of the Aircraft Meteorological Data Relay (AMDAR) observing system. He pointed out the world-wide growing interest in AMDAR as well the increasing membership of the AMDAR Panel that involved 20 Members countries. In addition to the 9 Member countries with mature operational AMDAR programmes, there had been an increased number of countries that were either developing or testing new national AMDAR programmes including Canada, Saudi Arabia, Japan, China, the Republic of Korea, Hong Kong China and Chile. Furthermore, a number of countries continue to express interest in developing national AMDAR programmes including Morocco, the Russian Federation, United Arab Emirates, Oman, Argentina, India, Finland and a group of Central and Eastern European countries. Significant effort is therefore being deployed in developing AMDAR to provide upper air data into those well recognized data sparse areas of the world. Specifically, the ET noted with interest plans to enhance AMDAR coverage over the Southern African region. This would be achieved through the expansion of AMDAR onto more than 50 domestic aircraft operating into smaller airports in the region. Attempts will also be made to involve additional smaller regional aircraft through the implementation of new AMDAR technologies.

9.2 Member countries with established AMDAR programmes were continuing to extend AMDAR and develop sophisticated data optimization systems to form well managed integrated upper-air observing systems. A major step forward had been taken with the establishment of the first formal agreement between a major regional AMDAR data provider (EUMETNET AMDAR) and an organization (ASECNA) representing 15 countries in the data sparse regions of Central and West Africa plus Madagascar to provide a funded programme of targeted AMDAR data. Data targeting and optimization system technologies now permit programmes of this type to be established almost anywhere in the world.

9.3 The ET noted the recent directives from Congress and Executive Council to CaeM, CBS and the AMDAR panel to more fully integrate AMDAR into the WWW global observing system. Consequently, the AMDAR Panel was increasingly focusing attention on this activity. The ET further noted that financial assistance from extra budgetary resources would be required in order to achieve this goal. A number of major steps had been taken with the completion of AMDAR guidance material and the development of new regional AMDAR bulletin headers and extended code forms to improve the distribution and exchange of AMDAR data. The Panel continued to be more involved in the various relevant OPAGs and Expert Teams of CBS, CAeM and CIMO and

other related groups. The Panel was addressing the need for AMDAR familiarization and training. In this regard, a successful technical training workshop was conducted in Dakar, Senegal in 2002 for ASECNA and four more such workshops were being planned for South America, Eastern Europe China and Morocco. Interest for such training was also expressed by the Russian Federation, Saudi Arabia and Oman. The ET noted however that while more training workshops would be worthwhile, the high costs involved with such workshops and the need to find additional resources remain to be addressed.

9.4 The ET noted with interest activities being carried out for the development of a reliable humidity sensor in the US, Germany and the UK. Several trials were being planned over the next 18 months with sensor installations being scheduled on research aircraft. In addition, operational trials were planned on commercial aircraft in the US.

9.5 Work continued on the development of alternative AMDAR systems in the US, Canada and Australia. Of particular interest was the Tropospheric Airborne Meteorological Data Relay (TAMDAR) system that would undergo an operational trial on more than 60 aircraft in the US and separate trials were being planned in Canada and France.

9.6 The ET agreed that integration of AMDAR into WWW should encompass specific activities including training to facilitate reception and use of AMDAR data in operational work of NMHSs concerned. The ET also recognized that regionalized case studies should be carried out with AMDAR data aiming at the optimization (not reduction) of the existing network over local areas concerned. Based on these studies, appropriate recommendations on new composition of local observing system should be developed and submitted to CBS for consideration and approval.

9.7 After some discussion the ET recommended that, if possible, several OSEs should be undertaken. One OSE, spanning at least 3 months, should be completed by the end of 2006 and assess:

(a) the potential impact on NWP predictions of a substantial increase in AMDAR data in a data sparse region; and
(b) the relative impact with respect to a single conventional upper station given the availability of these AMDAR data.

The South African region, as representative of a data sparse area, should be the focus of one OSE. Assistance could be provided by the AMDAR Panel and the South African Weather Service in providing guidance on enhancing AMDAR coverage through a data coverage and frequency analysis over the next 2 to 3 years.

9.8 Regarding AMDAR Awareness Training, it was recognized that there is a global need to promote the availability and use of AMDAR data both for NWP and operational meteorological forecasting. In this regard, the ET strongly recommended that the AMDAR rapporteur work with the OPAG Chair to bring it to the attention of the Secretariat.

9.9 The AMDAR Panel informed the ET that it could undertake technical training for the development of an AMDAR operational programme. In this regard, the ET was informed of a recent example of such training undertaken in Dakar, Senegal, for the ASECNA group of countries in Central and Western Africa and Madagascar in November 2002.

9.10 The AMDAR Panel also indicated that it did not have the relevant expertise and therefore could not conduct AMDAR user training. However, it emphasized the need for such training that could be carried out in combination with other training activities such as NWP applications for aeronautical meteorology. The ET recognized this requirement and recommended that user training could be undertaken by the Secretariat in consultation with the AMDAR Panel.

Future activities of SEG/COSNA within CBS

9.11 The meeting was informed on recommendations of the CBS-MG to incorporate activities of Scientific Evaluation Group (SEG) of COSNA into the working structure of CBS. The ET confirmed that the COSNA SEG activities were providing extremely important input toward the redesign of the GOS. Furthermore, the ET underlined that the evaluation and assessment of global and regional impact studies of the various components of the observing system and the observing practices are foreseen in terms of reference of CBS ICT/IOS and ET-ODRRGOS. The ET also recognized that some SEG activities related to the OPAG on DPFS. In this connection the ET noted the recommendation of the CBS-MG to decide upon working arrangements for SEG within the OPAGs structure at a later stage, taking into account the outcome of the upcoming NWP OSE Workshop (March 2004).

9.12 Following the recommendation of the CBS-MG to develop relevant TORs for SEG within the CBS structure, the ET drafted a list of relevant activities and issues that should be addressed within the domain of the OPAG on IOS. They are:

i) Scientific evaluation of the various components of the global and regional observing system on NWP to be undertaken by NWP centres.
ii) Results to be presented and reviewed at regular workshops (every three years).
iii) Progress to be followed and reported to ET on ODRRGOS by rapporteurs.
iv) ET on ODRRGOS to create a subgroup of NWP centre representatives to meet once (or as required) between workshops.
v) Issues to be addressed by rapporteurs and subgroup:
    - Evaluate through global impact studies the relative value and contributions of the various components of the global observing system;
    - Evaluate through global and regional impact studies the value of emerging observing systems;
    - Evaluate through global and regional impact studies the benefit from selective and targeted observing techniques;
    - Examine the opportunities created by technology change and the development of concepts for incorporating new procedures, techniques and systems in the GOS.
    - Formulate recommendations concerning the evolution of the observing system, the deployment of new observing platforms, and of the optimization of the observing schedule and observation targeting;

10. CLOSURE OF THE SESSION *(Agenda Item 10)*

The chairman thanked the Expert Team members and the other participants for their excellent contributions to the session. He also noted the valuable support from the WMO Secretariat in facilitating the meeting. The session was closed at 1.30 pm on Friday 7 November 2003.

ANNEX I

EXPERT TEAM ON
OBSERVATION DATA REQUIREMENTS AND
REDESIGN OF THE GLOBAL OBSERVING SYSTEM
SIXTH SESSION
GENEVA, SWITZERLAND
3-7 November 2003

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ANNEX II

AGENDA

1. ORGANIZATION OF THE SESSION

    1.1 Opening of the meeting
    1.2 Adoption of the agenda
    1.3 Working arrangements

2. REPORT OF THE CHAIRMAN

3. REVIEW OF Cg-XIV, CBS-EXT.(02) AND CBS-MG RECOMMENDATIONS FOR EVOLUTION OF SURFACE AND SPACE-BASED COMPONENTS OF THE GOS

4. REPORT FROM THE AOPC

5. REVIEW AND UPDATE OF STATEMENTS OF GUIDANCE FOR VARIOUS APPLICATIONS

6. STATUS AND RESULTS OF OSEs

7. THIRD WMO WORKSHOP ON THE IMPACT OF VARIOUS OBSERVING SYSTEMS ON NWP (Alpbach, Austria, 9 to 11 March 2004)

8. ET ACTION ITEM REVIEW AND IMPLEMENTATION PLAN FOR EVOLUTION OF THE GOS

9. ANY OTHER BUSINESS

10. CLOSURE OF THE SESSION

ANNEX III

ACTIONS

Actions carried over from the last meeting

1 Update Ocean user requirements and the associated SOG after discussion with ocean community (E. Charpentier, H. Kawamura, Mar 04).

2. Request review of CRs and associated SOGs in ocean application areas from selected experts (Secretariat, Mar 04).

Actions generated at this meeting

3. Review the THORPEX Science Plan and provide feedback to E. Manaenkova (with a copy to ET chair) (ET, Dec 03). Forward draft of ET-ODRRGOS science questions (where THORPEX can assist the ET in their consideration for the evolution of the GOS) to CBS representative to THORPEX ICSC meeting (OPAG IOS Chair, Dec 04).

4. Recommend to CGMS (a) that processing of functioning satellite instruments be maintained as long as possible, (b) that international coordination of equator crossing times maximizing the temporal coverage of the polar orbiting global observing systems be undertaken, and (b) that R&D satellite operators be encouraged to make their data available for routine near real time use as much as possible (Secretariat, Nov 03).

5. Approach OPAG-DPFS regarding ownership of the SIA and other requirements and engage CCl, OPAG-DPFS, and AOPC in a further discussion to reach agreement on one SOG for SIA (OPAG IOS Chair, Mar 04).

6. Draft useful approaches for studying the impact of additional observations (e.g. AMDAR) in regions of scarce conventional observations (e.g. RAOBS) and discuss possible observing system experiments to explore enhancing the observations on these areas (ET, Aug 04).

7. Maintain the latest version of each SOG on the OPAG IOS ET-ODRRGOS web site (Secretariat, Dec 03).

8. Continue iterating the draft of the implementation plan for evolving the GOS (ET, Aug 04).

9. Request at CGMS that Windsat evaluation be performed in the manner similar to AIRS (with distribution of data sets for outside evaluation as soon as possible via CGMS) as a matter of urgency (OPAG IOS Chair, Nov 03).

10. Request a review from JCOMM on the current status and plans for the ocean observing system at next ET meeting (Secretariat, Dec 03).

11. Request emerging WMO Space Programme to report on space operator plans for data flow and distribution of emerging sensors (Secretariat, Aug 04).

12. Provide a draft letter to Chair OPAQ IOS that will contact the appropriate entity (that owns the user requirements) for each application area to request that they assume responsibility for the RRR process and creation of that application area SOG (Secretariat, Dec 03).

13. Complete table listing application area, user requirement owner entity, and focal point in 8.3 (Secretariat, Nov 03).

14. Approach AMDAR Panel to nominate a rapporteur to address broad AMDAR issues and specifically address 9.1.2 (Secretariat, Dec 03).

ANNEX IV

Evolution of the GOS: towards an implementation plan

Implementing the Recommendations for Evolution of Space-Based Component of GOS

Calibration

1 Recommendation: "A major issue for effective use of satellite data, especially for climate applications, is calibration. There should be more common spectral bands on GEO and LEO sensors to facilitate intercomparison and calibration adjustments; globally distributed GEO sensors can be intercalibrated using a given LEO sensor and a succession of LEO sensors in a given orbit (even with out the benefit of overlap) can be intercalibrated with a given GEO sensor. The advent of high spectral resolution infrared sensors will enhance accurate intercalibration."

Next Action: OPAG IOS ask CGMS to recognize this activity as the heart of the GCOS monitoring principles and request initiation of routine intercalibration of all GEO infrared sensors (both operational and R&D) as well as evolved microwave sensors (MSU transitioned to AMSU).

GEO satellites

2 GEO Imagers - Imagers of future geostationary satellites should have improved spatial and temporal resolution (appropriate to the phenomena being observed), in particular for those spectral bands relevant for depiction of rapidly developing small scale events and retrieval of wind information.

Next Action: WMO Space Programme to discuss with space agencies, via CGMS and WMO consultative meetings on high-level policy on satellite matters.

3 GEO Sounders - All meteorological geostationary satellites should be equipped with hyper-spectral infrared sensors (to be demonstrated by GIFTS) for frequent temperature/humidity sounding as well as tracer wind profiling with adequately high resolution (horizontal, vertical and time).

Next Action: WMO Space Programme to discuss with space agencies, via CGMS and WMO consultative meetings on high-level policy on satellite matters.

4 GEO Imagers and Sounders - To maximize the information available from the geostationary satellite systems, they should be placed "nominally" at a 60-degree sub-point separation across the equatorial belt. This will provide global coverage without serious loss of spatial resolution (with the exception of Polar Regions). In addition this provides for a more substantial backup capability should one satellite fail. In particular, continuity of coverage over the Indian Ocean region is of concern.

Next Action: WMO Space Programme to discuss with space agencies, via CGMS and WMO consultative meetings on high-level policy on satellite matters

LEO satellites

5 LEO data timeliness - More timely data are needed. Improved communication and processing systems are required to meet the timeliness requirements in some applications areas (e.g. Regional NWP).

Next Actions: (1) WMO Space Programme to request space agencies, via CGMS, to improve current processing and data systems in line with updated user requirements; (2) ET-SSUP, in consultation with ET-ODRRGOS, to review progress and plans for EUMETSAT ATOVS Retransmission System, and to consider whether it should be extended to other parts of world and to other satellite instruments/systems and to alternative data transmission systems.

6 LEO temporal coverage - Coordination of orbits for LEO missions is necessary to optimize temporal coverage while maintaining some orbit redundancy.

Next Action: WMO Space Programme to discuss with space agencies, via CGMS.

7 LEO Sea Surface Wind - Sea-surface wind data from R&D satellites should continue to be made available for operational use; 6-hourly coverage is required. In the NPOESS and METOP era, sea surface wind should be observed in a fully operational framework. Therefore it is urgent to assess whether the multi-polarisation passive MW radiometry is competitive with scatterometry.

Next Action: WMO Space Programme, via CGMS and the WMO consultative meetings on high-level policy on satellite matters, to request assessment of Windsat performance

8 LEO Altimeter - Missions for ocean topography should become an integral part of the operational system.

Next Action: WMO Space Programme to discuss with space agencies, via CGMS and WMO consultative meetings on high-level policy on satellite matters

9 LEO Earth Radiation Budget - Continuity of ERB type global measurements for climate records requires immediate planning to maintain broad-band radiometers on at least one LEO.

Next Action: WMO Space Programme to discuss with space agencies, via CGMS and WMO consultative meetings on high-level policy on satellite matter.

R&D satellites

10 LEO Doppler Winds - Wind profiles from Doppler lidar technology demonstration programme (such as Aeolus) should be made available for initial operational testing; a follow-on long-standing technological programme is solicited to achieve improved coverage characteristics and reduced instrument size necessary for operational implementation.

Next Action: WMO Space Programme to discuss with space agencies, via CGMS and WMO consultative meetings on high-level policy on satellite matters

11 GPM - The concept of the Global Precipitation Measurement Missions (combining active precipitation measurements with a constellation of passive microwave imagers) should be supported and the data realized should be available for operational use, thereupon, arrangements should be sought to ensure long-term continuity to the system.

Next Action: WMO Space Programme discuss with space agencies, via CGMS and WMO consultative meetings on high-level policy on satellite matters

12 RO-Sounders - To complement the METOP and NPOESS radio-occultation sounders, the opportunities for a larger constellation should be explored and expanded operational implementation planned. International sharing of ground network systems (necessary for accurate positioning in real time) should be achieved to minimize development and running costs.

Next Action: WMO Space Programme to discuss with space agencies, via CGMS and WMO consultative meetings on high-level policy on satellite matters

13 GEO Sub-mm - An early demonstration mission on the applicability of sub-mm radiometry for precipitation estimation and cloud property definition from geostationary orbit should be provided, with a view to possible operational follow-on.

14 LEO MW - The capability to observe ocean salinity and soil moisture for weather and climate applications (possibly with only limited horizontal resolution) should be demonstrated in a research mode (as with ESA's SMOS and NASA's OCE) for possible operational follow-on. Note that the horizontal resolution from these instruments is unlikely to be adequate for salinity in coastal zones and soil moisture on the mesoscale.

15 LEO SAR - Data from SAR should be acquired from R&D satellite programmes and made available for operational observation of a range of geophysical parameters such as wave spectra, sea ice, land surface cover.

16 LEO Aerosol - Data from process study missions on clouds and radiation as well as from R&D multi-purpose satellites addressing aerosol distribution and properties should be made available for operational use.

17 Cloud Lidar - Given the potential of cloud lidar systems to provide accurate measurements of cloud top height and to observe cloud base height in some instances (stratocumulus, for example), data from R&D satellites should be made available for operational use.

18 LEO Far IR - An exploratory mission should be implemented, to collect spectral information in the Far IR region, with a view to improve understanding of water vapour spectroscopy (and its effects on the radiation budget) and the radiative properties of ice clouds.

19 Limb Sounders - Temperature profiles in the higher stratosphere from already planned missions oriented to atmospheric chemistry exploiting limb sounders should be made operationally available for environmental monitoring.

20 Active Water Vapor Sensing - There is need for an exploratory mission demonstrating high-vertical resolution water vapour profiles by active remote sensing (for example by DIAL) for climate monitoring and, in combination with hyper-spectral passive sensing, for operational NWP.

Next Action: (Recommendations 13-20): WMO Space Programme to discuss with space agencies, via CGMS and WMO consultative meetings on high-level policy on satellite matters

Implementing the Recommendations for Evolution of Surface-Based Component of GOS

High-Priority General Recommendations

Data distribution and coding

1. Exchange internationally observational data not yet centrally collected but potentially useful in NWP, e.g., radar measurements to provide information on precipitation and wind, surface observations, including those from local or regional mesonets, wave buoys. Encourage WMO Members in regions where these data are collected to make them available via WMO real time information systems.

Next Actions: Request Members, via letter from WWW Secretariat to Regional Rapporteurs to IOS ICT, to provide information on data potentially available in this category. [The letter should request supply; alert potential users to plans; arrange training material]. ET-ODRRGOS to review input and consider which potentially available data merit further action.

2. Observations made routinely but not distributed should be made available (for example data with high temporal frequency should be distributed at least hourly). Recent studies have shown that 4D-Var data assimilation system or analysis system with frequent update cycles can make excellent use of hourly data, e.g. from SYNOPs, buoys, profilers, aircraft (AMDAR).

Note: OSE-1 provided justification for this recommendation.

Next Actions: (for SYNOPs (land and marine), buoys, profilers): WMO Members to implement this recommendation at the earliest possible date, no later than Nov 2005. (for AMDAR): See 8-11 below. The benefit of this implementation will be more rapid development.

3. Assure that all sources are accompanied by good documentation including metadata, careful QC, and monitoring.

Next Actions: [Actions are needed addressing problem areas for each data types. Actions should be specific and driven by user problems. What problems are preventing users from using data effectively?] (1) WMO (OPAG DPFS?) draft a letter to Members (NWP centres) requesting report of specific problems inhibiting effective use of available data. (2) ET-ODRRGOS to review responses.

4. Use coding standards that assure that the content (e.g. vertical resolution) of the original measurements, sufficient to meet the user requirements, is retained during transmission. Some current coding/formatting standards in the character codes degrade potentially useful information in meteorological reports. (Example (1) lost information at various levels in a rawinsonde sounding in the TEMP code could be retained in the BUFR code. Example (2) the vertical sounding taken over some 90 minutes and displaced from the starting position could be complemented by position and time information for each data point).

Note: The CBS decision to migrate to table driven and binary codes is relevant to this issue.

Next Actions: (1) WMO Members with the existing capability to implement this recommendation with respect to the vertical information in radiosonde measurements at the earliest possible date, but no later than Nov 2005. Other Members to develop plans to implement on an appropriate timescale. All Members to report to WMO on their plans in this area. (2) Revise appropriate Manuals to update reporting standards consistent with the above action. (3) ET-ODRRGOS to consider need for similar changes for other observation types (e.g. profilers) plans.

Broader use of ground based and in situ observations

5. Calibration of measurements from satellites depends on using ground-based and *in situ* observations, such as ozone profiles from sondes. Near real-time distribution of ozone sonde data is required for calibration and validation of newly launched instruments and for potential use in NWP. [Joint ECMWF / WMO expert team meeting on real time exchange of ground based ozone measurements, ECMWF, 17-18 October 1996]

Next Action: WMO Members making ozone profile measurements to place data on the GTS as near to real time as is feasible (but no later than 24 hours) in CREX format at the earliest possible date. Members to inform WMO of their implementation plans.

Moving towards operational use of targeted observations

6. Transfer into operations the proven methodology of observation targeting to improve the observation coverage in data sensitive areas. This concept is in operational use at the US Weather Service in the north-eastern Pacific during the winter storm period. EUCOS is planning field experiments in the Atlantic, in the context of a THORPEX study. Designated major operational centres should share the responsibility for determining the target areas. [FASTEX results and Toulouse report]

Next Actions: (1) With a strategy to learn from THORPEX, CBS representatives to request THORPEX to provide CBS with a strategy for an operational targeted observing system. CBS representative to THORPEX ICSC meeting (Dec 2003) to bring this forward [including meteorological situations in which targeting could be useful, observing systems to be activated]. (2) ET-ODRRGOS to request a study to survey and compile information on activities and results associated with use of in situ observation systems for targeting purposes that have taken place in the past.

High Priority System Specific Recommendations

Optimization of rawinsonde launches

7. Optimize the distribution and the launch times of the rawinsonde sub-system (allowing flexible operation while preserving the GUAN network and taking into consideration regional climate requirements). Examples include avoiding duplication of Automated

Ship-borne Aerological Program (ASAP) soundings whenever ships are near a fixed rawinsonde site (freeing resources for observations at critical times) and optimizing rawinsonde launches to meet the local forecasting requirements. [EUCOS Studies, OPAG IOS Chairman]

Next Actions: ET suggestion to WMO to request a WMO funded-study, to develop guidelines of issues to be considered (e.g. local weather phenomena, local times of 0000 and 1200 UTC observations, other observations available, costs) when optimizing local/regional launch schedules for radiosondes. This should consider initiating a local study

Development of the AMDAR programme

8. AMDAR technology should provide more ascent/descent profiles, with improved vertical resolution. A good way to accomplish this is to extend the AMDAR programme to short-haul commuter flights, business aviation, and air freight. Emphasis should be to expand into areas where vertical profile data from radiosondes and pilot balloons are sparse a well as into times that are currently not well observed such as 11 pm to 5 am local times. [Toulouse report, ECMWF northern hemisphere AMDAR impact study, OSEs 4, 5, 8]

Note: The AMDAR Panel plans to (1a) continue to support the South African Weather Service to extend the Southern Africa Pilot Project to a regional programme under SADC; (1b) monitor and provide technical support to the ASECNA programme in collaboration with the EUMETNET AMDAR; (1c) coordinate and/or implement targeted AMDAR observations programmes as opportunities arise; (1d) provide information, guidance and monitor progress on alternative AMDAR systems (e.g. TAMDAR, MDS, AFIRS, Cell phone technology). (AMDAR TC and Panel Members).

Next Actions: ET-ODRRGOS to (2a) continue to monitor progress of the AMDAR Programme in above activities; and (2b) ET-ODRRGOS recommend that several OSEs be undertaken, if possible. One OSE is required to assess (i) the potential impact on NWP predictions of a substantial increase in AMDAR data in a data sparse region; (ii) the relative impact with respect to a single conventional upper station given the availability of these AMDAR data; (iii) the study should last for a period of at least 3 months; (iv) the study should be completed by the end of 2006. Specifically, the first OSE to be undertaken should be over the South Africa region as representative of a data sparse area. Assistance could be provided by the AMDAR Panel and the South African Weather Service in providing guidance on enhancing AMDAR coverage through a data coverage and frequency analysis over the next 2 to 3 years.

9. AMDAR coverage is both possible and sorely needed in several currently data-sparse regions, especially Africa and South America, Canadian arctic, northern Asia and most of the world's oceans. Moreover, the timing and location of reports, whose number is potentially very large, can be optimized while controlling communications costs. The recommendation is to optimize the transmission of AMDAR reports taking into account, en route coverage in data-sparse regions, vertical resolution of ascent/descent reports, and targeting related to the weather situation. [Toulouse report, ECMWF northern hemisphere AMDAR impact study]

Note: The AMDAR panel is planning to assist more countries to become involved in AMDAR programmes by (1a) initiating new developing programmes in Saudi Arabia, Canada, Chile, China, Hong Kong China, Japan, and the Republic of Korea, and (1b) planning programmes in Argentina, Finland, Morocco, Russian Federation, United Arab Emirates and a group of Central and Eastern European countries. Further the AMDAR panel is planning to improve the effectiveness of existing programmes by assisting in (2a) development of data optimization systems to improve cost effectiveness and coverage; (2b) data targeting in data sparse areas, (2c) further developments in quality monitoring and control of data exchanged on the GTS; (2d) development of new AMDAR systems based on alternative technologies including TAMDAR; (2e) improvements to onboard software and the development of new international standard software specifications.

Next Action: ET-ODRRGOS to review progress of the AMDAR programme.

10. Lower-tropospheric water vapour measurements are vital in many forecast applications. To supplement the temperature and wind reports from AMDAR, the further development and testing of water vapour sensing systems is strongly encouraged. Example: WVSS-2 employs a laser diode to measure the absorption by water vapour of energy in the laser beam over a short path length. This is an absolute measurement of water vapour content that is expected to be accurate from the ground to flight altitudes. [Toulouse report]

Note: AMDAR Panel is planning to continue to monitor and support development of new measurements and sensors including humidity. Examples include providing assistance to: (i) evaluation of the most recent US WVSSII sensor by NCAR and NWS; (ii) operational evaluation trials of the TAMDAR humidity sensor in the US, France and Canada; (iii) evaluation trials of the UK humidity sensor in collaboration between Cambridge University and the Met Office; (iv) evaluation trials of the MOZAIC humidity sensor in collaboration between DWD and DLR]

Next Action: ET-ODRRGOS to monitor progress associated with development of new sensors and technology particularly in relation to water vapour measurement.

Tropospheric Aircraft Meteorological Data Reporting (TAMDAR)

11. TAMDAR could potentially supplement AMDAR and radiosonde data by providing lower level en route observations and profiles over additional, regional airports not served by larger AMDAR compatible aircraft. Instrumentation would not necessarily be designed to function in the high troposphere and would therefore be less expensive. The development of the TAMDAR system should be monitored with a view towards operational use.

Note: EUCOS Programme Plans are very relevant here.

Next Action: ET-ODRRGOS to review progress under AMDAR and EUCOS Programmes.

Ground based GPS

12. Develop further the capability of ground-based GPS systems for the inference of vertically integrated moisture with an eye toward operational implementation. Distribute globally the measurements of total column water vapour from available and emerging ground based GPS systems for use in NWP. Such observations are currently made in Europe, North America and Asia. It is expected that the global coverage will expand over the coming years.

Note: The COSNA/SEG, NAOS, JMA reports provide useful background information.

Next Actions: (1) WMO Members with the existing capability to implement this recommendation with respect to the vertical information in measurements at the earliest possible date, but no later than Nov 2005. Other Members to develop plans to implement on an appropriate timescale. All Members to report to WMO on their plans in this area. (2) Revise appropriate Manuals to update reporting standards consistent with the above action. (3) ET-ODRRGOS to consider need for similar changes for other observation types (e.g. profilers)

Regarding improved observations in ocean areas

13. Increase the availability of high vertical resolution temperature, humidity, and wind profiles over the oceans. Consider as options ASAP and dropsondes by designated aircraft.

Note: The EUCOS programme plan provides background for actions in this area.

Next Action: ET-ODRRGOS request a review from JCOMM on the current status and plans of ASAP in next 6 months. Follow AMDAR philosophy in making these sort of data available.

14. Considering the envisaged increase in spatial and temporal resolution of *in situ* marine observing platforms and the need for network management, either increase the bandwidth of existing telecommunication systems (in both directions) or establish new relevant satellite telecommunications facilities for timely collection and distribution. Examples include drifting buoys, profiling floats, XBTs.

Note: The JCOMM Operations Plan provides background for actions in this area.

Next Action: ET-ODRRGOS request information on progress regarding distribution of increased temporal and spatial resolution in situ marine observations from JCOMM.

15. For both NWP (wind) and climate variability/climate change (sub-surface temperature profiles), it is recommended to extend the tropical mooring array into the tropical Indian Ocean at resolution consistent with what is presently achieved in the tropical Pacific and Atlantic Oceans.

Note: The JCOMM Operations Plan provides background for actions in this area.

Next Action: ET-ODRRGOS request information on progress in extending the tropical mooring array from JCOMM

16. Ensure adequate coverage of wind and surface pressure observations from drifting buoys in the Southern Ocean in areas between 40S and the Antarctic circle based upon adequate mix of SVPB (surface pressure) and WOTAN technology (surface wind). The pressure observations are a valuable complement to the high density surface winds provided by satellite.

Note: The Toulouse report and the ET-ODRRGOS OSE study provide background for actions in this area. Plans from agencies other than JCOMM need to be considered.

Next Actions: (1) ET-ODRRGOS to request information from JCOMM on plans for preserving/enhancing the network. (2) ET-ODRRGOS to review requirement for surface pressure observations in ocean areas based in results of OSE studies (EUCOS)

17. For Ocean Weather Forecasting purposes, improve timely delivery and distribute high vertical resolution data for sub-surface temperature/salinity profile data from XBTs and Argo floats.

Note: The JCOMM Operations Plan provides background for actions in this area.

Next Actions: (1) ET-ODDRGOS to request information on progress from JCOMM for the next ET-ODRRGOS meeting. (2) ET-ODRRGOS to review adequacy for WMO requirements.

18. For NWP purposes, increase coverage of ice buoys (500 km horizontal resolution recommended) to provide surface air pressure and surface wind data.

Note: The JCOMM Operations Plan provides background for actions in this area.

Action: ET-ODRRGOS to request information on progress regarding ice buoys from JCOMM.

Improved observations over tropical land areas

19. Enhance the temperature, wind and if possible the humidity profile measurements (from radiosondes, pilots and aircraft) in the tropical belt, in particular over Africa and tropical America. There is evidence from recent impact studies with the radiosonde/pilot balloon network over the Indonesian/Australian region that such data give a better depiction of winds in the tropics and occasionally strongly influence the adjacent mid-latitude regions. [OSE-5]

Action: (see AMDAR plans)

New Observing Technologies

20. Demonstrate the feasibility of ground based interferometers and radiometers (e.g. microwave) to be an operational sub-system providing continuous vertical profiles of temperature and humidity in selected areas.

Action: ET-ODRRGOS to review advances in technology and user requirements. [Update of TD 1040]

21. Demonstrate the feasibility of Unmanned Aeronautical Vehicles (UAVs) to be an operational sub-system.

Action: ET-ODRRGOS to review advances in technology and user requirements. [Update of TD 1040]

22. Demonstrate the feasibility of high altitude balloons to be an operational sub-system

Action: ET-ODRRGOS to review advances in technology and user requirements. [Update of TD 1040]

Additional Recommendation for Evolution of the GOS

1. Support well-resourced studies of re-designed observing systems.

Next Actions: ET-ODRRGOS indicate support EUCOS plans (how?) and monitor similar activities elsewhere.

ANNEX V

Science questions where THORPEX can help the ET-ODRRGOS find answers

The ET-ODRRGOS put forward for consideration the following questions or suggestions for investigation or research in relation to THORPEX:

1. What are the specific observing requirements for high-impact weather?
2. How should we specify the adaptive ("on the day") component of the GOS?
3. What are the optimal spatial and temporal resolutions of AWS observation networks (e.g. value of 1-minute resolution data)?
4. Regarding AMDAR:
    - What are the geographic areas where AMDAR has most input/value?
    - What is the optimal vertical resolution of AMDAR profiles?
5. What constitutes validation of a "good" forecast for mesoscale NWP?
6. What is the contribution of the Siberian Rawinsonde network to NWP and what alternative network configurations should be considered?
7. What are the key observation system configurations that would help to identify the sources of cyclogenesis in tropics?
8. What is the contribution of stratospheric data on tropospheric forecasting skill?
9. What is the contribution of stratospheric in situ observation systems on tropospheric forecasting skill?
10. What is the contribution of surface soil moisture data on tropospheric forecasting skill?
11. What are the forecasting capabilities in relation to high intensity rainfall (e.g. flooding of Yangtze River)?
12. What are the global downstream effects of observation targeting?
13. What is the impact in improved assimilation in numerical models of improved cloud characterization.
14. What strategies can CBS learn from THORPEX on how to introduce observation targeting in to operations, in particular if more than one WMO member is to be involved in the decision making process about the deployment of the special observations.