# WORLD METEOROLOGICAL ORGANIZATION

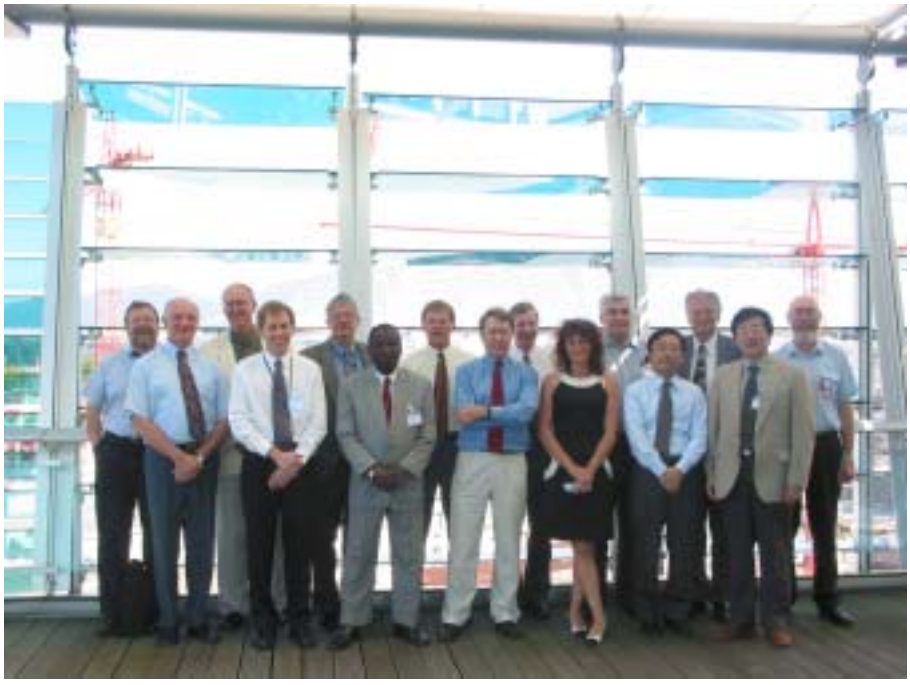
## COMMISSION FOR BASIC SYSTEMS

### OPAG ON INTEGRATED OBSERVING SYSTEMS

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

## SEVENTH SESSION

## FINAL REPORT



**GENEVA, SWITZERLAND, 12 – 16 JULY 2004**

# 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 12 – 16 July 2004 to proceed with the work assigned by CBS. Chairman Dr P. Menzel set an agenda that included (a) updating the data bases of user requirements and observing system capabilities, (b) hearing the outcomes from the Workshop on Impact of Various Observing Systems on NWP (held March 2004) and the implications for the redesign of the GOS, (c) getting an update on WMO participation in various meetings (the WMO consultative meetings on high level policy on satellite matters, Coordination Group for Meteorological Satellites, GEO), (d) reviewing the observing system capabilities and user requirements and the associated statements of guidance with applications area experts, (e) reviewing field campaign and data assimilation task for THORPEX, (f) finalizing a draft implementation plan for the Redesign of the Global Observing System that was started at the last ET-ODRRGOS meeting, and (g) preparing for the Implementation and Coordination Team meeting in September 2004 and the CBS meeting in February 2005.

Substantial progress was realized in all areas. The WMO/CEOS data base was discussed (assignments for insertion of several new R&D instrument capabilities were made) and Statements of Guidance were reviewed (agrometeorology, hydrology, atmospheric chemistry were significantly updated). Interaction with THORPEX was continued (the THORPEX Implementation Plan was reviewed and several suggestions were made). An implementation plan for the 42 recommendations for evolution of the GOS was prepared for presentation to the ICT. A workplan for the next two years of the ET was drafted.

# 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 seventh session of the Expert Team on Observational Data Requirements and Redesign of the Global Observing System (ET-ODRRGOS) 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 12 July 2004 in the WMO Secretariat, Geneva. The list of participants is attached as Annex I.

The Deputy Secretary-General of WMO, Prof Hong Yan, welcomed participants to Geneva and to the WMO Secretariat. He noted that the WMO Executive Council (Geneva, June 2004) was very satisfied with the continuing activities of CBS on the redesign and implementation of a future composite GOS. Prof Yan also noted the recent activities of the ad hoc Group on Earth Observations (GEO), an initiative set up by the Earth Observation Summit, and how the GOS is likely to be adopted as a role model for provision of Earth observations. He commented that staying informed of and being engaged in this activity is a challenge for the ET-ODRRGOS. Prof Yan advised that the final drafting of the ET-ODRRGOS Implementation Plan for the Evolution of the Surface and Space-based Components of the GOS would be a major outcome of the meeting; it is anticipated that it will be presented to CBS at its next meeting early in 2005. The Deputy Secretary-General 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 ET 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 ET CHAIRMAN AND OPAG IOS CHAIR *(Agenda Item 2*

2.1 The Chairman presented his report that included a review of the extensive work carried out by the Team during its previous six 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 (1) hearing the outcomes from the WMO NWP OSE Workshop held March 2004 and the associated implications for the redesign of the GOS, (2) getting an update on WMO participation in various meetings (the WMO consultative meetings on high level policy on satellite matters, CGMS, GEO), (3) reviewing the observing system capabilities and user requirements and the associated statements of guidance with applications area experts (agrometeorology, hydrology, atmospheric chemistry, JCOMM), (4) reviewing the THORPEX Implementation Plan, (5) finalizing a draft implementation plan for the Redesign of the Global Observing System that was started at the last ET-ODRRGOS meeting, and (6) preparing for the next ICT and CBS. The ET accepted these goals as the focus for the activities for the week.

2.2 The chair of the OPAG-IOS, Dr J. Purdom, expressed his thanks to the ET for their fine work over the past several years. The OPAG Chair updated the ET on the GOS related activities since their previous meeting. He noted that Cg-XIV elevated Satellite Activities to status of Major WMO Programme and accepted the GCOS Climate Monitoring Principles. The Chair pointed to the important findings at the Third WMO Workshop on the Impact of Various Observing Systems on NWP that was held in Alpbach, Austria during 9–11 March 2004 where scientists from lead centers across the globe addressed advances in NWP for both global and regional scale modeling.

Among the important topics still to be addressed were: (1) improved use of satellite data in cloudy areas and over land; (2) more effective thinning of data and products; and (3) improved model physics. The OPAG Chair noted that at CGMS XXXII (a) a relationship to THORPEX through observer status on the International Core Systems Committee was requested, (b) the role of R&D satellites in redesign of GOS was discussed, and (c) the success of the European ATOVS Retransmission System (EARS) had suggested exploring the possibility of extending such activity globally. On this last item, it was agreed that CGMS Members, with help from EUMETSAT, would form local consortiums to develop regional ATOVS Retransmission Services in conjunction with EARS and that this activity should be focused within the WMO Space Program.

2.3 The OPAG chair then discussed the importance of the relationship between IOS, ET-ODRRGOS, and THORPEX. CBS is working in close coordination with CAS on THORPEX and THORPEX will impact all CBS OPAGs activities. The THORPEX Implementation Plan is under development – a number of objectives and goals within that implementation plan deal directly with ET-ODRRGOS activities and responsibilities. The OPAG Chair is a member of the TIP planning group whose next meeting to be held in Beijing, China in early September, and requested input from the ET Members.

2.4 The OPAG Chair then summarized the findings from the International Winds Workshop (that convenes the International Winds Working Group) held in Helsinki, Finland, 14-16 June 2004. An important finding is that all major NWP centers are now experiencing positive impact from MODIS winds in Polar Regions (both hemispheres), but there will be a possible several year gap in those winds with NPOESS. It seems as though the NPOESS system and Environmental Data Records (EDRs), while developed with the best of intentions, were frozen in late 20$^{th}$ century mentality and did not allow for planned growth as science evolved. In retrospect, it seems that the scientific community was not utilized adequately in the NPOESS genesis process – this will have a negative impact on NWP at the beginning of the NPOESS era when the capability for deriving polar winds will be diminished.

2.5 The OPAG IOS chair brought forth important points discussed at EC-LVI, particularly the activities regarding the Global Earth Observation System of Systems (GEOSS) and the need for technical commissions to rapidly evaluate the draft Implementation Plan. He requested the ET members to review the plan when it becomes available and to provide input to the ET-ODRRGOS Chair within a month. Finally, the OPAG IOS Chair reviewed actions relevant to his activities from the Nov 2003 ET-ODRRGOS meeting and the importance of developing a future work plan for presentation to CBS 2005.

## 3. REPORT ON THE THIRD WMO WORKSHOP ON THE IMPACT OF VARIOUS OBSERVING SYSTEMS ON NWP *(Agenda item 3*)

3.1 The Third WMO Workshop on the Impact of Various Observing Systems on NWP was held in Alpbach, Austria from 9-12 March 2004. About sixty participants attended, mainly from the NWP community, but also data producers, operators, and managers of network and observing systems and the WMO Secretariat. The Workshop's agenda covered three major sections: Global Forecast Impact Studies, Regional Aspects of Impact Studies, Observation Targeting and Network Design Studies.

3.2 Dr H. Böttger summarized the Report from the NWP OSE Workshop. He noted that the Report will be published together with the Technical Proceedings (papers submitted by the speakers) on CD and possibly also on paper. Copies of the presentations at the workshop are available on CD.

3.3 The ET was invited to consider the NWP OSE Workshop conclusions and recommendations (given in Section 4 of the NWP OSE Workshop Report). The ET agreed that the workshop requirements for observational data will be reflected in the updates of the Implementation Plan for the evolution of the surface and space-based component of the GOS.

3.4 The Expert Team noted the NWP OSE Workshop request for guidelines for OSEs and forwarded their document on this subject to the conference attendees. The ET also discussed

several possible new OSEs in response to some of the issues raised at the workshop. This is reflected in the Actions in Annex IV.

3.5 Dr. Oleg Pokrovsky gave a presentation on his study on optimization of the RAOB network in RA I (Africa). Forty-six sites currently provide sonde data in RA I, but there remain several data gaps in various parts of Africa. Inadmissible high error magnitudes have been screened in the fields of the main meteorological parameters (T500, H500, U700, V700 and Q850). In order to optimise selection of additional sites in these areas, he used an optimization algorithm on the NCEP-NCAR re-analysis daily data for 1990-99. This produced a list of 59 stations (adding 13 new stations from the WMO list of RAOBs in RA I) that cover most of gap areas and provide a much more uniform distribution of objective analysis error. Average root mean square error is reduced by 20 percent. A similar study was carried out for the GUAN network where monthly data for 1958-1998 was used to select the sites with the most impact. The efficiency of this approach was also illustrated by comparison of error fields corresponding to existing and proposed GUAN networks in RA I. Dr Pokrovsky noted the opportunity for such an optimization of a regional network; the criteria would include maximization of information content with respect to a set of height, temperature and wind fields, minimization of measurement cost, and minimization of the number of observing sites. This could lead to an economic analysis of surface network management balanced against information content. The ET noted that the AMDAR Panel should take this report into consideration when they explore expansion of ascent / descent data in RA I.

## 4. RELEVANT ACTIVITIES FROM THE WMO CONSULTATIVE MEETINGS ON HIGH-LEVEL POLICY ON SATELLITE MATTERS, CGMS AND GEO *(Agenda item 4)*

4.1 The ET was reminded that the first Earth Observation Summit (EOS-I in July 2003) had launched an ad hoc Group on Earth Observations (GEO), with the goal of furthering the creation of a comprehensive, coordinated, and sustained Earth observing system or systems. In order to promote the development of the now named Global Earth Observing System of Systems (GEOSS), GEO started development of a GEOSS Framework Document and an associated 10-Year Implementation Plan. The GEO process is intended to:

- Cover the full spectrum of *in situ* and remotely sensed (space-based and aircraft) observations;
- Provide an opportunity for all nations and international organizations to work together for a common cause, under a commonly agreed approach, framework, and methodology;
- Actively involve developing countries in making improved observations within their national territories, and access and use observations made by others;
- Provide a means to build on the efforts of these international efforts to assess user requirements, identify gaps in global observations, improve communication among nations and organizations with common interests in similar observation capabilities;
- Provide high-level (ministerial) recognition of the universal need for improved Earth observation;
- Promote consensus-building among participants about the highest priority observation needs, which are unmet or require significant increase in resources to provide comprehensive solutions.

In the long-term, implementation of the 10-Year plan should result in:

- Commitment of nations to make more complete long-term collection of high-priority Earth observations;
- Filling of the gaps in observing capabilities;
- Capacity-building in both developing and developed countries;
- Greater interoperability and connectivity among individual component observing systems for improved exchange and appropriate sharing of data and information to commonly agreed standards.

4.2 The ET noted EC-LVI specifically requested the technical commissions, as well as the Consultative Meetings on High-level Policy on Satellite Matters, to rapidly evaluate the draft Implementation Plan, to provide advice as necessary to ensure that the existing World Weather Watch Global Observing System, Global Atmosphere Watch, World Hydrological Cycle Observing System, Global Climate Observing System, Global Ocean Observing System, Global Terrestrial

Observing System and other related observing systems are developed in a mode that is compatible with the Ten-year Implementation Plan; and, when the Plan is finalized, to provide advice as to how the WMO-coordinated systems should operate within the framework of the Plan. Thus, the ET agreed that it should take into consideration the task created by the resolution (see Annex IV for the relevant action items).

4.3 The ET agreed that its primary focus remains to redesign the Global Observing System and that in doing so it would also meet the goals to be established in the GEO 10-year Implementation Plan. Further, the ET appreciated the grand scope of activities now focused on creating a Global Earth Observing System of Systems, which would significantly enhance the WMO GOS.

## 5. REVIEW AND UPDATE OF STATEMENTS OF GUIDANCE FOR SELECTED APPLICATIONS *(Agenda item 5)*

The ET recalled earlier discussions where it had confirmed 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 as much as possible 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. The ET emphasized the importance of help from the secretariat in fostering this process for generating and updating SOGs in the multiple applications areas embraced by the ET.

### 5.1 Statement of Guidance for JCOMM

5.1.1 JCOMM advised the meeting that it was not yet ready to provide an update to the Statements of Guidance for JCOMM Program Areas that were prepared in January 2002. They noted that before the SOGs can be updated JCOMM would need to conduct a user requirement review. JCOMM also informed the meeting that JCOMM Observation Programme Area priorities include achieving global coverage with in-situ networks plus system-wide monitoring and performance reporting. Some details are available in Section 4.2 of the final report of the third session of the JCOMM Management Committee (Geneva, March 2004) that can be found at http://www.wmo.int/web/aom/marprog/Wordpdfs/Jcomm-MR/JCOMM%20MR31%20MAN-3/JCOMM%20MR31%20MAN-3.pdf.

5.1.2 The ET requested that the Secretariat request JCOMM to provide updates to their SOGs as a matter of urgency, before the ICT meeting in September 2004 (see status of previous actions in Annex III).

### 5.2 Statement of Guidance for Agricultural Meteorology

5.2.1 Dr M. Sivakumar of the Agricultural Meteorology Division provided an update to the Statement of Guidance for Agricultural Meteorology, last updated several years ago. The ET expressed its gratitude to Dr Sivakumar and noted that this version of the SOG now includes capabilities of and requirements for in-situ observations.

5.2.2 The ET felt that further elaboration was required on some components of these SOGs, and the Chairman advised that he would discuss and resolve these issues with AGMP directly. The final version of the SOG will be posted on the ET web site in September 2004.

### 5.3 Statement of Guidance for Hydrology and Water Resources

A Statement of Guidance for Hydrology and Water Resources, provided by Dr W. Grabs, was presented to the meeting. There was discussion as to whether all the variables required were defined in the WMO/CEOS database of user requirements. It was recommended that the IGOS Theme Report should be used to further update the SOGs for Hydrology and Water Resources. In

addition some merging of the old and new SOGs was deemed desirable. The Chairman advised that he would attempt such an editing and then have the resulting version posted on the ET web site in September 2004.

### 5.4 Statement of Guidance for Atmospheric Chemistry

5.4.1 A Statement of Guidance for Atmospheric Chemistry was presented by Dr L. Barrie. It is based on the recently approved Atmospheric Chemistry Theme Report of IGOS entitled Integrated Global Atmospheric Chemistry Observation (IGACO) strategy that was distributed in hardcopy. IGACO is the framework with which atmospheric composition observations will be integrated in the planned GEOSS. IGACO is a focused strategy for bringing together ground-based, aircraft and satellite observations of 13 chemical species in the atmosphere using atmospheric forecast models that assimilate not only meteorological observations but also chemical constituents. The list includes the Essential Chemical Climate Variables in Appendix 1 of the GCOS adequacy report as well as other variables important to issues of ozone depletion, air quality and long range transport/deposition of air pollution. The report critically assesses and reports on the status of current observing systems, the requirements for accuracy/precision and spatial/temporal resolution, and the current state of modeling chemical cycles in forecast and climate models. It recommends specific steps to be taken in a phased approach over the next 15 years led by the WMO's Global Atmosphere Watch (GAW) programme in cooperation with other key WMO programmes and the space agencies through CEOS.

5.4.2 Incorporation of IGACO measurement requirements and recommendations to fill major gaps into the Atmospheric Chemistry SOG is critical. The SOG reflects the recommendations of CEOS and IGOS with WMO/GAW to take the lead in updating it. This would involve WMO constituent bodies (CAS, CBS, and the WMO Executive Council) as well as the WMO Consultative Meetings on High-level Policy on Satellite Matters to promote the implementation of IGACO.

5.4.3 The ET expressed appreciation for this contribution and noted that a gap analysis between observing system capabilities and user requirements was at hand. Dr Barrie expressed a willingness to work with the ET Chair to accomplish this. The SOG for Atmospheric Chemistry will be posted on the ET web site by September 2004.

### 5.5 Statements of Guidance for Climate Applications

AOPC- X (19-23 April 2004) reviewed the Statements of Guidance for Climate Applications and proposed that these SOGs be forwarded to the CBS OPAG/DPFSS (Seasonal to Interannual Forecasting) and WMO/CCl (Climate Variability and Climate Change) for further review and ultimate 'ownership'. The ET agreed and asked the Secretariat and the OPAG IOS chair to pursue appropriate linkages.

### 5.6 Review of Observing System Capabilities and User Requirements

5.6.1 The ET recalled the steps in the Rolling Review of Requirements Process whereby observational requirements have been compared to user estimates of expected observational performances. It noted that the last full review of the user estimates of expected observational performances found in the CEOS/WMO database was performed in 2001. It was also pleased to note that since 2001 many new user estimates of expected performances have been added to the database especially for *in situ* systems including the GCOS Surface and Upper Air Networks.

5.6.2 The ET noted that some demonstrations of new capabilities were terminating and plans for new demonstrations were changing. In particular, the ET noted the important contributions of the Tropical Rainfall Measuring Mission (TRMM) satellite which had been a major crossover (research and application) success for NASA and JAXA and for the NWP centres around the world who continue to use the data in real-time to improve forecast models and support hurricane forecast operations. The ET noted with regret that financial considerations were forcing the termination of TRMM. The ET was also informed of the changes in plans for the R&D demonstration of the Geostationary Imaging Fourier Transform Spectrometer (a demonstration of hyperspectral infrared remote sensing instrument from geostationary orbit); again financial considerations were stalling

this important technology test and demonstration of a vital future component of the evolved GOS. The ET emphasized that new technology demonstrations are an essential part of its implementation plan for the evolved GOS in assuring smooth transitions from old to new capabilities.

5.6.3 Thus, the ET recognized the need for a fresh review of the present list of user estimates of expected observing system performances. The action list in Annex IV suggests that a work programme that would provide for review, update and/or validation all the expected performances. The ET noted the importance of keeping the data base as current as possible.

5.6.4 For satellite instruments only, the ET noted that the database contained two sets of expected performances that originated from the space agencies and those provided by the ET-ODRRGOS. While in the Rolling Review of Requirements process only WMO (user) provided estimates were utilized, there were several requirements for which no expected performances existed in the WMO (user) estimates, whereas estimates did exist from the space agency. The ET agreed to complete the list of user estimates of expected performances for all satellite missions and instruments operating within the space-based component of the GOS.

### 5.7 Report from AOPC

5.7.1 On behalf of Dr M. Manton, Chairman of the GCOS/WCRP Atmospheric Observations Panel for Climate (AOPC), Drs J. Schmetz and H. Teunissen presented a brief summary of recent activities of the AOPC relevant to the ET, including results from the Tenth Session of the Panel, held in Geneva from 19-23 April 2004. Items addressed included Statements of Guidance (SOGs) for Climate Applications, some proposals for high-quality upper-air reference networks, and issues related to satellite observations and climate product development, especially those related to CGMS activities. AOPC-X also reviewed the performance and status of the GCOS Surface Network (GSN) and the GCOS Upper-Air Network (GUAN) and the remedial actions being taken to revitalize underperforming stations; small but measurable improvement in overall performance of the networks, especially for GUAN, and activities were continuing, with the ongoing support of a number of WMO Members. The AOPC reiterated the importance of maintaining close links with the ET-ODRRGOS toward furthering AOPC objectives and requested the AOPC Chair to ensure that the AOPC was appropriately represented at future ET-ODRRGOS sessions.

5.7.2 Regarding Statements of Guidance for Climate Applications, AOPC-X discussed the three SOGs presented at the November 2003 ET session and made modifications in response to the comments received from that session. In recognition of the suggestions from the ET and the desire for additional input, the AOPC agreed that the latest draft of the SOG on Seasonal-to-Interannual Forecasting (SIA) should be provided to the CBS OPAG on Data Processing and Forecasting Systems (DPFS) for comment and subsequent ownership; the resulting SOG should be presented to the ET-ODRRGOS for consideration in their redesign of the GOS. Additionally, the AOPC suggested that the SOGs on Monitoring Climate Change and Monitoring Climate Variability be provided to CCl for further review by appropriate CCl Expert Teams and individuals, and subsequently be submitted through these ETs to the CBS ET-ODRRGOS. The AOPC noted that CCl was in the process of developing additional SOGs for climate applications and agreed that it should review these as appropriate as part of the process of submitting them to the ET-ODRRGOS. The Panel further recommended that formal ownership of these two SOGs reside within the CCl structure.

5.7.3 It was also reported that AOPC-X concluded that current operational radiosondes do not measure upper tropospheric and lower stratospheric water vapour with adequate accuracy whereas satellite radiances are in principle accurate enough but need an absolute reference. In this context, AOPC discussed some proposals for the establishment of high-quality upper-air reference networks, which could be related to, or indeed be subsets of, the GUAN. One of these involved the release of very-high-quality radiosondes at a limited number of stations at regular intervals, perhaps several days, with particular emphasis on water vapour measurements. Another involved the release of similarly high-quality radiosondes timed to match the overpass of relevant satellites for calibration and intercomparison purposes. AOPC-X endorsed the concept of selecting a subset of GUAN as a reference network for water vapour and stratospheric temperature and

requested that its newly-established ad-hoc Working Group on Reconciliation of Surface and Free Atmosphere Temperature Trends liaise with relevant scientists and agencies to assist in the implementation of this concept. It also suggested that such reference networks be co-located with existing GUAN stations to the extent feasible to take advantage of existing expertise, while emphasizing that any arrangements for additional soundings must not disturb the routine operation of those stations for GUAN purposes.

5.7.4. In response to development of the *Second Report on the Adequacy of the Global Observing Systems for Climate in Support of the UNFCCC*, ET-ODRRGOS had suggested in November 2003 that the existing GCOS observational data requirements be reviewed, taking into account the Essential Climate Variables that had been defined in the Adequacy Report. This review had been undertaken by members of the GCOS Science Panels and an updated version had been developed for inclusion in the CEOS/WMO database. It was planned that this version would be reviewed by relevant WCRP experts to ensure harmonization as needed with WCRP requirements.

5.7.5 The ET was reminded that GCOS was leading the development of a phased 5- to 10-year implementation plan to respond to the findings of the Second Report on the Adequacy of the Global Observing Systems for Climate in support of the UNFCCC, as had been requested by the Conference of the Parties to the UNFCCC at its Ninth Session in Milan in December 2003 (COP-9). The first draft of the plan had been completed and distributed for open review. A final version had been requested by COP for presentation to its Subsidiary Body for Scientific and Technological Advice at their twenty-first session in December 2004. COP-9 had also formally endorsed, through Decision 11/CP.9, the expanded GCOS Climate Monitoring Principles that had been adopted by WMO Congress in May 2003 through its Resolution 9 (Cg-XIV).

5.7.6 The ET expressed appreciation for the ongoing dialogue with the AOPC and their help in fostering SOG updates; ET-ODRRGOS will request that ownership of the climate SOGs be transferred to OPAG DPFS (Seasonal to Inter-annual Forecasting) and CCl (Monitoring Climate Change, Monitoring Climate Variability) as suggested. The ET noted the important input from AOPC that reference water vapour measurements in the upper troposphere (UT) and lower stratosphere (LS) were needed to anchor the gradients measured by satellites; the ET also noted that current in situ measurement capabilities for UT and LS water vapour were not meeting climate requirements and thus needed further development. The ET looked forward to hearing the suggestions formulated by the ad hoc working group. Finally the ET noted that their Implementation Plan for the Evolution of the GOS would reference complementary recommendations from the GCOS Implementation Plan when it becomes available.

## 6. IMPLEMENTATION PLAN FOR EVOLUTION OF SPACE AND GROUND-BASED COMPONENTS OF THE GOS

6.1 The group reviewed in plenary all 42 sections of the November 2003 draft ET GOS Implementation Plan. The team then split into two task teams to update the surface based and space-based systems. Considerable discussion and much rewriting produced the current version of the Implementation Plan (see Annex V). This version will be presented to the ICT and possibly amended there for final presentation to the CBS.

6.2 As part of the drafting on the ET GOS Implementation Plan cross references to the draft GCOS Implementation were drafted and forwarded to GCOS for their information.

## 7. ACTION ITEM REVIEW

The ET reviewed progress on past actions (see Annex III). Several Actions remain open and the secretariat was enlisted to pursue progress. Further the ET noted in the new actions what was expected when an action was submitted in an ET final report (see Annex IV).

### 7.1 Update on THORPEX

7.1.1 The ET was informed that Ms A. Simard, chair of CBS OPAG on DPFS, represented CBS at the 3rd ICSC meeting (December 2003, Montreal) and presented recommendations made by

ET-ODRRGOS from the November 2003 meeting. ICSC-3 discussed cooperation with CBS and requested that co-chairs of ISSC lead effort in examining CBS questions regarding which issues THORPEX should address in the course of its implementation. The ICSC-3 approved the THORPEX International Science Plan and established an ad hoc Expert Group for development of the THORPEX Implementation Plan (EG-TIP). The TIP will be composed of senior and well-recognized members of the THORPEX community.

7.1.2 The EC-LVI (June 2004, Geneva) noted with satisfaction the active collaborative efforts between CAS and CBS, which led to broadening and strengthening of cooperation between the two Commissions on the involvement of WWW in THORPEX. Recognizing that THORPEX was very relevant to the WWW research needs in all programme areas, the Council welcomed the CBS decision to take part in the development of the THORPEX International Implementation Plan. In that connection the Council appreciated that the president of CBS acted as a member of THORPEX ICSC. The Council requested the presidents of CAS and CBS to pursue further collaboration and to consider further practical steps to ensure effective implementation of the programme for the benefit of all Members.

7.1.3 The ET reviewed the THORPEX Implementation Plan (TIP), in particular with respect to the science questions forwarded at the November 2003 ET meeting. See Annex VI.

7.2 AMDAR Status

The ET welcomed the CBS rapporteur on the AMDAR activities, Dr J. Dibbern, and the ET reiterated the importance of AMDAR in the ET GOS Implementation Plan. The AMDAR Technical Coordinator presented a thorough status report of the current situation of AMDAR. An AMDAR Programme Implementation Table listing likely dates was also presented (see below).

| Programme Items | 2005-2006 | 2008 | 2010 |
|---|---|---|---|
| **Operational programmes** (Australia, E-AMDAR*, New Zealand, USA, South Africa) | expanding | stable | Stable |
| **Emerging programmes** (Hong Kong China, Saudi Arabia, Japan, Canada, Central-western Africa) | expanding | expanding/stable | Stable |
| **Developing programmes** (Chile, Argentina , UAE, Rep. of Korea, China) | first data | expanding | Stable |
| **Planned programmes** (Eastern-central Europe#, Russian Federation, Oman, Egypt, Morocco, Kenya, Pakistan, India, Iran, Israel, Libya)) | | first data | Expanding |
| **Development** software and technologies | work in progress | operational | Stable |
| **Humidity/water vapour sensors** | operational trials | expanding | Operational |
| **Targeted data** | partly operational | expanding | Expanding |
| **Optimisation systems** | partly operational | expanding | Expanding |
| **Data monitoring, QC and data exchange** | ongoing | ongoing | Ongoing |
| **Awareness and training** | ongoing | ongoing | Stable |
| **Development** of operational forecasting tools | in progress | operational | Operational |

* E-AMDAR current: UK, France, Netherlands, Germany, Sweden
E-AMDAR emerging: Finland
E-AMDAR planned: Portugal, Spain, Iceland, Italy, Switzerland, Austria, Ireland, Belgium
# Eastern-central Europe: Poland, Hungary, Rumania, Ukraine, Czech Republic

### 7.3 Adaptive Observing System

The secretariat presented a paper prepared for WMO by Mr C. Pastre of the topic of adaptive observation systems. The ET felt that the concepts presented in the paper were consistent with earlier ET discussions, felt the proposal of a workshop (as suggested in the paper) was worthy of further consideration, and suggested that the OPAG IOS Chair bring this document to the attention of the THORPEX Implementation Team and to CBS. It was emphasized that a tight connection was required between CBS and the THORPEX implementation process so that both groups remain aware of the others requirements.

7.3.2 In further discussion, it was noted that observation targeting to high impact weather events does not just mean events such as vigorous winter storms and other dynamic events, but that some high impact events can also be fairly static, such as stagnant weather linked to persistent high pressure which can have a devastating impacts both socially and economically.

### 7.4 Molniya Orbits

In a paper contributed by Dr L. Riishojgaard from NASA/GSFC, the ET was informed about Molniya orbits, a possible alternative for meteorological remote sensing of latitude bands that elude polar orbiting and geostationary observatories. A sensor in the highly elliptical Molniya orbit spends about two thirds of the time near apogee where it provides close to a stationary perspective centered over the high latitudes. This could provide an extension of time-continuous imagery all the way to the pole. One satellite in Molniya orbit would provide coverage of the middle and high latitudes during 16 hours per day. Two satellites would provide continuous coverage of one hemisphere, while a constellation of four satellites would provide constant coverage of the middle and high latitudes for both hemispheres, thereby extending the time-continuous imaging capabilities to the entire globe. The real-time downlinking and dissemination can be achieved with a single primary ground station, contrasting with polar orbiters that rely on an extensive net of stations supplemented by onboard data storage capabilities. The ET appreciated this input and suggested that the newly formed ET-SAT could provide some guidance on the possible role of sensors in Molniya orbit in the evolved GOS.

## 8. PREPARATIONS FOR THE UPCOMING ICT ON IOS

The ET noted that the ET Chair would be attending the upcoming ICT in September 2004. He will be presenting a summary of ET activities since the last ICT, noting the strong THORPEX engagement and the increased AMDAR Panel participation, and presenting the ET GOS Implementation Plan and assisting with any editing prompted by the ICT.

## 9. PREPARATION OF ET-ODRRGOS INPUT TO CBS-XIII

ET reviewed its work plan. Good progress in all areas was noted; an notable exception was securing a funded activity for the study of observing system design. The ET discussed a possible work plan for the next two years and a draft work plan is presented in Annex VII. The ET concluded with a review of its Terms of Reference; while much has been accomplished as evidenced by the final draft of the ET GOS Implementation Plan much remains to be done to initiate actions and assure progress on the Implementation Plan. Thus the ET offered some suggestions for revision of the Terms of Reference (see Annex VIII).

## 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 16 July 2004.

**ANNEX I**

**EXPERT TEAM ON**
**OBSERVATION DATA REQUIREMENTS AND**
**REDESIGN OF THE GLOBAL OBSERVING SYSTEM**
**SEVENTH SESSION**
**GENEVA, SWITZERLAND**
**12 – 16 JULY 2004**

**LIST OF PARTICIPANTS**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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

    2.1 Guidance from OPAG IOS chair

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

    3.1 Implications for Re-design of the GOS
    3.2 Implications for future OSEs

4. RELEVANT ACTIVITIES OCCURRING AT THE WMO CONSULTATIVE MEETINGS ONHIGH-LEVEL POLICY ON SATELLITE MATTERS, CGMS AND GEO

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

    5.1 JCOMM input on SOGs
    5.2 SOGs for Agrometeorology
    5.3 SOGs for Hydrology and Water Resources
    5.4 SOGs for Atmospheric Chemistry
    5.5 Review of observing system capabilities and user requirements

6. IMPLEMENTATION PLAN FOR EVOLUTION OF SURFACE AND SPACE-BASED COMPONENTS OF THE GOS

7. ACTION ITEM REVIEW

8. PREPARATION FOR THE UPCOMING ICT ON IOS

9. PREPARATION OF ET-ODRRGOS INPUT TO CBS-XIII

10. ANY OTHER BUSINESS

11. CLOSURE OF THE SESSION

**ANNEX III**

## STATUS OF ACTIONS FROM NOV 2003 MEETING

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

Open. Letter from secretariat requesting action is being posted.

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

Open. Letter from secretariat requesting action is being posted.

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 03).

Closed: Dialogue with THORPEX is continuing. ET reviewed THORPEX implementation plan with a focus on the science questions posed at November 2003 ET meeting. ET discussed possible suggestions for field programs, observing system trials, and data assimilation tests. Communication with THORPEX is facilitated by the fact that the OPAG IOS Chair is a member of the THORPEX Implementation Team.

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 (c) 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).

Closed: CGMS 31 and 32 addressed all issues. (a) Space operators recognize the desire for maximum lifetime utilization, but cautioned that safety issues with respect to de-orbiting sometimes conflict. (b) CGMS has taken this on as a permanent action. (c) Early access to research data sets still remains a challenge; ET suggests that the WMO Space Programme discuss this at the next Consultative Meeting on High Level Policy.

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).

Open. Secretariat is preparing letter from CBS to CCL. OPAG DPFS to be approached by OPAG IOS.

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).

Open. AMDAR Rapporteur is drafting possible field experiments useful for meaningful OSEs.

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

Closed. Updated SOGs are being posted on the ET-ODRRGOS web site.

8. Continue iterating the draft of the ET-ODRRGOS Implementation Plan for Evolving the GOS (ET, Aug 04).

Closed. ET has finalized the implementation plan for presentation to the ICT in September 2004.

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).

Closed. Three months of Windsat data has been made available to some NWP centres. The WMO Space Programme is asked to keep space agencies mindful that future demonstrations of new observing system technologies need to plan for early familiarization and testing of the data by NWP centres as a tool for evaluating consistency with and contribution to the GOS.

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

Open. Letter from secretariat requesting action is being posted.

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

Open. OPAG IOS Chair will be requesting a summary report from CGMS of plans for data flow and distribution of emerging sensors (NPP, NPOESS, METOP, Aura, GCOM, COSMIC, FY3, METEOR 3M, … )

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, update the user requirements as appropriate, and maintain the SoG for that application area (Secretariat, Dec 03).

Open. PoCs will be contacted by the secretariat. They are

| | |
|---|---|
| Global NWP | J. Eyre |
| Regional NWP | F. Rabier |
| Synoptic Met | E. Legrand |
| Nowcasting and VSRF | (PoC TBD via J. Schmetz) |
| Atmospheric Chem. | L. Barrie |
| Aeronautical Met | H. Puempel |
| SIA Forecast | OPAG DPFS |
| Climate Variability | CCl / R. Heino |
| Climate Change | CCl / R. Heino |
| Ocean | H. Kawamura |
| Hydrology | W. Grabs |
| Agro Met | M. Sivakumar |

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

Closed. See above.

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

Closed with nomination of Jochen Dibbern and AMDAR report given at Jul 2004 ET-ODRRGOS meeting.

**ANNEX IV**

## NEW ACTIONS FROM JUL 2004 MEETING

Implication of an Action: Secretariat will contact the responsible parties (requesting acknowledgement and acceptance) and then follow up to monitor progress until action is completed (with ET chair being alerted of problems and progress).

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1. Establish ET-ODRRGOS web page containing table of contents that includes connections to (a) a list of members, (b) all seven final reports from previous ET-ODRRGOS meetings, (c) updated SoGs, (d) connections to WMO TDs (913, 992, 1052, 1040) written by ET-ODRRGOS, and (e) Implementation Plan for Evolution of the GOS. (Secretariat, Aug 04)

2. Provide OSE guidance to Alpbach Workshop attendees. (ET chair to provide to Jean-Noel Thepaut and Lars-Peter Riishojgaard, Aug 04)

3. Obtain more information on OSSE progress at NCEP/EMC. (ET chair write letter to Steve Lord, Aug 04)

4. Obtain update from CIMO on in situ observation capabilities for characterizing UT and LS temperature and moisture for climate. (R. Stringer contact CIMO, Aug 04)

5. Present updated SoG for Hydrology to IPWG for comment. (OPAG IOS Chair, Oct 04)

6. Request report from regional rapporteurs on information regarding observations potentially available but not currently distributed for review at ICT. (Secretariat, Aug 04)

7. Review and update CEOS/WMO data base of observing system capabilities: (1) ground based component to assure consistency with recent CBS monitoring statistics (R. Stringer, Oct 04); (2) space based component to assure inclusion of new operational and R&D capabilities. (Secretariat to enlist ET-SAT members for space agency estimates and ET-ODRRGOS subsequently should review data base from user perspective, Apr 05)

8. Provide feedback on THORPEX Implementation Plan. (ET to OPAG IOS Chair, Aug 04)

9. Design an OSE 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. The study should last for a period of at least 3 months and should be completed by the end of 2006. AMDAR data suitable for such a study should become available by the end of 2005. 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. (NWP Rapporteurs with NWP experts and AMDAR Panel, Mid 2005)

10. Bring to the attention of RAs via CBS and AMDAR Panel the requirements for user awareness, training and operational forecasting tools in developing countries. Specifically:

- An increase in the awareness of the availability of existing and potentially additional AMDAR data on the GTS;
- Training in the use of AMDAR data in operational forecasting;
- Development of stand-alone PC-based interactive data displays and operational forecasting tools.

(OPAG IOS Chair, Feb 2005)

11. Bring document on Adaptive Observing Systems to the attention of the THORPEX Implementation Team and to CBS. (OPAG IOS Chair, Sep 2004 and Feb 2005)

12. Review the draft GEOSS Implementation Plan and provide input to the ET-ODRRGOS Chair. (ET to ET chair, August 04)

**ANNEX V**

**IMPLEMENTATION PLAN FOR EVOLUTION OF SPACE AND GROUND-BASED COMPONENTS OF THE GOS**
**(July 2004)**

## 1. Background

1.1 The OPAG Integrated Observing Systems Expert Team on Observational Data Requirements and Redesign of the Global Observing System (ET-ODRRGOS) has been given three main tasks by the Commission for Basic Systems (CBS): (a) to continue the Rolling Requirements Review (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) to suggest changes in the Global Observing System (GOS) filling gaps identified by the RRR; and (c) to draft an implementation plan for evolution of the GOS for consideration by CBS.

1.2 The significant findings of ET-ODRRGOS that have provided the basis for the plan are:

a. The RRR is readily applied to a diversity of applications areas, provided the data base of user requirements and observing system capabilities is accurate;
b. Working with the Rapporteurs of Regional and Global OSEs, it was found that hypothetical changes to the GOS can be explored in Observing System Experiments (OSEs) with NWP centre assistance, provided data assimilation procedures are well understood and impact studies are conducted in a statistically significant way. Further it was made apparent that Observing System Simulation Experiments (OSSEs) require huge human and computer resources and are beyond the resources available;
c. The future GOS should build upon existing components, both ground and space based, and capitalize on existing and new observing technologies not presently incorporated or fully exploited; each incremental addition to the GOS will be reflected in better data, products and services from the National Meteorological and Hydrological Services (NMHSs);
d. The scope of the next decades changes to the GOS will be so massive that new revolutionary approaches for science, data handling, product development, training, and utilization will be required. There is an urgent need to study comprehensive strategies for anticipating and evaluating changes to the GOS.

1.3 Several major accomplishments by the ET preceded the drafting of the Implementation Plan and influenced its content appreciably. They are:

a. Users Requirements and Observing System Capabilities were charted in ten application areas (after engaging ocean and climate communities). The Rolling Review of Requirements was pursued, and Statements of Guidance were issued in all ten areas (available in WMO/TD 913, 992, 1052 and summarized in the final report of the July 2002 ET-ODRRGOS meeting).
b. Several OSEs were pursued to test possible re-configurations of the GOS (these are summarized in section 5 of this Annex).
c. Candidate Observing Systems (space-based and ground-based) for the coming decade were studied (reported in WMO/TD 1040).
d. Special challenges and issues concerning developing countries were considered and addressed (see section 4 of this Annex).
e. Recommendations for the evolution of space-based and ground-based components of the GOS were drafted and endorsed by CBS (available in the final report of the October 2002 ICT meeting).
f. A vision for the GOS of 2015 and beyond was drafted (available in section 6 of this Annex).

1.4 The resulting Implementation Plan for the Evolution of the GOS (available in section 3 of Annex V) presents a coherent approach for implementing the necessary changes to the space based and ground based components of the GOS so that the vision for the GOS of 2015 can be realized.

## 2. Recommendations for the Evolution of the GOS from ET-ODRRGOS

2.1 The evolution of the GOS proposed by the ET-ODRRGOS is now framed in 46 recommendations detailed in Section 3. Those recommendations for evolution of the GOS reflect the Statements of Guidance produced in ten applications areas, results from regional programmes (such as COSNA, EUCOS and NAOS), conclusions from the Toulouse and Alpbach Workshops on Impact of Various Observing Systems on NWP (see WMO/TD No. 1034 and No. 1228 respectively), and OSEs prompted by suggested changes to the GOS.

2.2 The 20 recommendations for the space based component of the GOS (S1 – S20), with 9 for operational geostationary and polar orbiting and 11 for R&D satellites, build upon the known plans of the operational and R&D satellite operators and call for rigorous calibration of remotely sensed radiances as well as improved spatial, spectral, temporal, radiometric accuracies. The wind profiling and global precipitation measurement missions were singled out for their importance to the GOS.

2.3 The 22 recommendations for the ground-based component of the GOS (G1 – G22) include: more complete and timely data distribution; enhanced AMDAR especially over data sparse areas; optimized rawinsonde launches; targeted observations; inclusion of ground based GPS, radars, and wind profilers; increased oceanic coverage through expanded Automated Ship balloon observations, drifting buoys, and ARGO; and possible use of Unmanned Aeronautical Vehicles.

2.4 The original draft (with 42 recommendations) was endorsed by CBS in December 2002. At that time, CBS requested a draft implementation plan that is presented here.

2.5 The number of recommendations has been expanded to include 3 relevant to NWP interactions (N1 – N3) with data from the evolving GOS and one with regard to further study of observing system design (O1).

## 3. Implementation Plan for the Evolution of GOS

### 3.1 Implementing Recommendations for Evolution of Space-Based Component of GOS

*Calibration*

S1. Calibration - There should be more common spectral bands on GEO and LEO sensors to facilitate inter-comparison and calibration adjustments; globally distributed GEO sensors should be routinely inter-calibrated using a given LEO sensor and a succession of LEO sensors in a given orbit (even with out the benefit of overlap) should be routinely inter-calibrated with a given GEO sensor

Comment: A major issue for effective use of satellite data, especially for climate applications, is calibration. The advent of high spectral resolution infrared sensors will enhance accurate intercalibration.

Progress: CGMS-XXXI discussed GCOS Climate Monitoring Principles, inter-calibration of visible sensors, and inter-calibration of IR sensors on all GEOs with HIRS and AVHRR (reporting on the last item remains as a permanent action of CGMS). CGMS-XXXII considered improved infrared inter-calibration capabilities using AIRS data; the implications for GCOS Climate Monitoring Principles were discussed. CEOS is to host a calibration workshop in October 2004.

Next Action: WMO Space Programme to continue discussion with space agencies, via CGMS

Schedule: Continue activity with current sensors and expand to IASI by CGMS in 2006.

*GEO satellites*

S2. 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.

Progress: All operators reported plans at CGMS: NOAA, EUMETSAT and Russia reported plans for a SEVIRI-like capability by 2015.

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

Schedule: Firm plans to reach goal should be in place by CGMS in 2006.

S3. GEO Sounders - All meteorological geostationary satellites should be equipped with hyper-spectral infrared sensors for frequent temperature/humidity sounding as well as tracer wind profiling with adequately high resolution (horizontal, vertical and time).

Comment: This was to be demonstrated by GIFTS. However NASA has recently cancelled the mission for budgetary reasons.

Progress: All operators reported plans at CGMS: NOAA has firm plans including this capability for the GOES-R series; EUMETSAT has it under consideration for the MTG series; China and India have plans for capability similar to current GOES sounder before 2010.

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

Schedule: Firm plans to reach goal in place by CGMS 2006.

S4. 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.

Comment: In recent years, contingency planning has maintained a 5-satellite system, but this is not a desirable long-term solution.

Next Action: WMO Space Programme to discuss with space agencies, via CGMS and WMO consultative meetings on high-level policy on satellite matters, the strategy for implementation with attention to the problems of achieving required system reliability and product accuracy.

Schedule: Plan should be available by CGMS in 2006

*LEO satellites*

S5. LEO data timeliness - More timely data are needed. Improved communication and processing systems should be explored to meet the timeliness requirements in some applications areas (e.g. Regional NWP).

Progress: EARS data are now available with a delay of less than 30 min; the data are used operationally at some NWP centres and planned at others. NPOESS plans are for data delivery in less than 30 min and thus consistent with this requirement.

Next Actions: WMO Space Programme to plan, with Members and CGMS, the development of an Integrated Global Data Service, to include (1) the extension and enhancement of EARS, (2) the implementation of similar systems, with a goal of achieving timely retransmission of global data, (3) an equivalent system for NPP data, (4) expansion of EARS and equivalent systems to include IASI data, (5) establishment of equivalent systems for the LEO data from satellites of other agencies.

Schedule: Plan for IGDS, including above elements, prepared by mid-2005, with goal for completion of phased implementation of global ATOVS retransmission service by mid-2006.

S6. LEO temporal coverage - Coordination of orbits for LEO missions is necessary to optimize temporal coverage while maintaining some orbit redundancy.

Progress: This is now the subject of a permanent action of CGMS.

Next Action: WMO Space Programme to agree with space agencies, via CGMS, the target system to be implemented and steps towards achieving it.

Schedule: Target system agreed upon by CGMS in 2006.

S7. 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.

Progress: 3 months of data has been made available to Windsat science team.

Next Action: WMO Space Programme, via CGMS, to request assessment of Windsat performance and to consider the implications for the evolved GOS.

Schedule: Assess Windsat performance by 2005. Assess implications and provide feedback to NOAA by 2005.

S8. LEO Altimeter - Missions for ocean topography should become an integral part of the operational system.

Progress: Agreement has been reached to proceed with JASON-2.

Next Action: WMO Space Programme to discuss with space agencies, via CGMS and WMO consultative meetings on high-levelpolicy on satellite matters, the continuity of operational provision after JASON-2.

Schedule: Plans for operational follow-on should be reported at CGMS in 2006.

S9. 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 satellite.

Comment: There are no current plans for ERB-like measurements after Aqua.

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

Schedule: Plans for continuity of capability should be available by CGMS in 2006.

*R&D satellites*

S10. 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 for operational implementation.

Comment: Plans for Aeolus demonstration are proceeding on schedule, but there are no plans for operational follow on.

Next Action: WMO Space Programme to discuss with space agencies, via CGMS and WMO consultative meetings on high-level policy on satellite matters, to assure demonstration with Aeolus and initiation of operational systems for wind profile measurement.

Schedule: To confirm plans for near real time (NRT) data distribution by CGMS in 2005. Plans for continuity of a Doppler Winds capability following Aeolus should be formed by CGMS in 2006.

S11. 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.

Progress: TRMM continues to provide valuable data for operational use. Continuation of TRMM by NASA is under threat; termination would adversely affect WMO members. At CGMS-XXXII, NASA, ESA and JAXA reported plans for a GPM mission in 2008. ESA's EGPM launch will be decided if and when this mission is selected.

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

Schedule: Plans should be reported at CGMS in 2006.

S12. RO-Sounders - The opportunities for a constellation of radio occultation sounders should be explored and 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.

Progress: CHAMP and SAC-C data have available to some centres but not in NRT. NWP OSE has shown positive impact with small number of occultations. Good progress in planning for NRT distribution of METOP/GRAS and COSMIC data.

Next Actions: WMO Space Programme to discuss with space agencies, via CGMS, (1) the proposal to develop a shared ground network system and (2) operational constellations following COSMIC.

Schedule: Plan for shared ground network should be available by CGMS in 2006. Plan for operational follow-on should be drafted by CGMS in 2006.

S13. 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.

Progress: EUMETSAT, NESDIS and WMO prepared a paper for CGMS on the International Geostationary Laboratory (IGL) that would be a joint undertaking to provide a platform for demonstrations from geo orbit of new sensors and capabilities. Geo sub-mm is one of two systems being considered for IGL.

Next Action: WMO Space Programme to continue dialogue with space agencies, via CGMS

Schedule: Plan for IGL should be drafted by CGMS in 2005.

S14. 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.

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

Schedule: WMO Space Programme to report to ET following CGMS in 2006.

S15. 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.

Next Action: WMO Space Programme to discuss with space agencies, via CGMS, (1) access by WMO members to ENVISAT SAR data, and (2) continuity of such missions.

Schedule: Assessment of status and plans completed by CGMS in 2006.

S16. 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.

Progress: Cloudsat will carry a R&D aerosol instrument. NPOESS is adding an aerosol instrument. This issue has been referred to the CEOS SIT and CGMS.

Next Action: WMO Space Programme to continue discussion with space agencies, via CGMS and CEOS.

Schedule: Plans for data distribution should be drafted by CGMS in 2006. WMO SP to report to ET following CGMS in 2006.

S17. 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.

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

Schedule: WMO Space Programme to report to ET following CGMS in 2005.

S18. 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.

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

Schedule: WMO SP to report to ET following CGMS in 2005.

S19. 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.

Next Action: WMO Space Programme to discuss with space agencies, via CGMS, progress/plans for distribution of data from MIPAS and SCIAMACHY on ENVISAT, from MLS and HIRDLS on AURA, and from similar instruments.

Schedule: Plans for data distribution should be documented by CGMS in 2006.

S20. 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: WMO Space Programme to discuss with space agencies, via CGMS.

Schedule: WMO Space Programme to report to ET following CGMS in 2005.

### 3.2 Implementing Recommendations for Evolution of Ground-Based Component of GOS

*Data coverage, distribution and coding*

G1. Distribution - Some observations made routinely are not distributed in near real-time but are of interest for use in meteorological applications.

(a) Observations made with high temporal frequency should be distributed globally at least hourly.

Comment: Recent studies have shown that 4D-Var data assimilation systems or analysis systems with frequent update cycles can make excellent use of hourly data, e.g. from SYNOPs, buoys, profilers, and other automated systems, in particular AWS.

Next Actions: CBS to urge WMO Members to implement this recommendation at the earliest possible date, no later than November 2005.

(b) Observational data that are useful for meteorological applications at other NMSs should be exchanged internationally. Examples include high resolution radar measurements (i.e. products, both reflectivity and radial winds, where available) to provide information on precipitation and wind, surface observations, including those from local or regional mesonets, such as high spatial resolution precipitation networks, but also other observations, such as soil temperature and soil moisture, and observations from wave rider buoys. WMO Members in regions where these data are collected should make them available via WMO real time or near-real-time information systems, whenever feasible.

Next Actions: Regional Rapporteurs, via letter from Secretariat, are requested to provide information on data potentially available in this category. [The letter should request supply and

alert potential users to plans]. IOS ICT in September 2004 meeting and ET-ODRRGOS in 2005 should review input and consider which potentially available data merit further action.

G2. Documentation - All observational data sources should be accompanied by good documentation including metadata, careful QC, and monitoring.

Next Actions: (1) WMO Secretariat to draft a letter to Members (NWP centres) requesting report of specific problems inhibiting effective use of available data. [In their responses Members need to address problem areas for each data type. Reports should be specific and indicate what problems are preventing users from using data effectively.] (2) ET-ODRRGOS to review responses. (3) Based on the analysis of 1 and 2 above, such information should become accessible through a centralized WMO web portal (late 2005).

G3. Timeliness and Completeness - There should be a timely distribution of radiosonde observations with all observation points included in the message (together with the time and the position of each data point; information on instrument calibration prior to launch, and information on sensor type and sub-sensor type). Appropriate coding standards should be used to assure that the content (e.g. vertical resolution) of the original measurements, sufficient to meet the user requirements, is retained during transmission.

Comment: NWP OSEs have demonstrated the usefulness of full resolution data for NWP. The NWP OSE Workshop (Alpbach, 2004) reiterated the need for near real time distribution of full resolution RAOB data.

Next Actions: CBS to urge all Members with the existing capability of producing full vertical resolution sounding data to implement the transmission as soon as possible, starting in November 2005. Further CBS to ask all Members to generate, as soon as possible, sounding data in Table Driven Code Forms (BUFR or CREX), following the technical specifications defined by CBS in the Guidance for Migration (See http://www.wmo.ch/web/www/documents.html#CodeTables). In the interest of timely data delivery, the first BUFR message should be sent when level 100 hPa is reached and the second message should be sent when the whole sounding is completed (containing all observation points). The delivery of the profile data in several stages may be necessary to accommodate the interests of other application areas, such as Nowcasting and aeronautical meteorology.

G4. Baseline system - Provide comprehensive and uniform coverage with at least 12-hour frequency of temperature, wind, and moisture profiles over mid-latitude continental areas and coastal regions. In tropical regions the wind profile information is particularly import.

Comment: Regional forecasting systems continue to show benefit from a comprehensive and uniform coverage with at least 12-hour frequency of temperature, wind, and moisture profiles over mid-latitude continental areas and coastal regions. In tropical regions the wind profile information is considered to be of particular importance. At this stage the radiosonde and PILOT network still plays an important role in meeting these requirements (NWP OSE Workshop, Alpbach 2004). Profile data are now and will in future, to an increasing extent, be provided from a mix of observing system components and will be complemented by the utilization of satellite data over land. In polar regions, this need has not been addressed, however the linkage between CBS, CAS's THORPEX, and IPY should give guidance for that data sparse region.

Next Action: OPAG-IOS chair in consultation with the chairs of the Regional Working Group on Planning and Implementation of WWW to ensure that operators and managers of regional observing systems are made aware of these requirements (CBS in 2005).

G5. Stratospheric observations - Requirements for a stratospheric global observing system should be refined (document need for radiosondes, radiances, wind data, humidity data, noting the availability and required density of existing data sources, including GPS sounders, MODIS winds and other satellite data)

Comment: NWP OSE Workshop, Alpbach 2004, suggested that OSE results on the usefulness of stratospheric observations should be consolidated. It also noted that the COSMIC mission likely

will provide a substantial enhancement to the stratospheric observing system. Further, AOPC has noted that current in situ measurement capabilities for UT and LS water vapour are not meeting climate requirements and stressed need for further development.

Next Action: ET to initiate further OSEs to include the use of COSMIC data when available. Results of OSEs to be reviewed and consolidated at that stage (2008).

*Broader use of ground based and in situ observations*

G6. Ozone 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. [recommendation is supported by information from the Joint ECMWF / WMO expert team meeting on real time exchange of ground based ozone measurements, ECMWF, 17-18 October 1996, WMO NWP OSE Workshop, Alpbach 2004]

Next Action: CBS and CAS to request WMO Members making ozone profile measurements to place data on the GTS in near real time in BUFR/CREX format at the earliest possible date. Secretariat to inform Members of this requirement and request Members to inform WMO of their implementation plans (November 2005).

*Moving towards operational use of targeted observations*

G7. Targeted Observations - Observation targeting to improve the observation coverage in data sensitive areas for NWP should be transferred into operations once the methodology has matured. Non-linear methods in targeting have been studied and should also be considered. The operational framework for providing information on the sensitive areas and responding to such information needs to be developed.

Comment: The proof of the observation targeting concept was given by US Weather Service in the north-eastern Pacific for winter storms. THORPEX has declared observation targeting a core research activity in its implementation plan (2.3 ii), has successfully carried out jointly with EUCOS the NA-TreC campaign, and has benefited from the lessons learned from FASTEX.

Next Action: The OPAG-IOS Chair to maintain liaison and ensure targeting strategies developed by THORPEX are made available to the CBS.

*Optimization of rawinsonde distribution and launches*

G8. RAOBs - 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. [recommendation is supported by information from the EUCOS Studies]

Comment: Observation targeting requires a flexible observing practice. THORPEX has included this concept in their considerations.

Next Actions: ET to follow the THORPEX Implementation Plan and to learn from the THORPEX experience. When appropriate ET to request Secretariat to inform Regional Rapporteurs and managers of observing systems of the requirements for adapting to flexible observing practices including taking observations on demand, while safe-guarding the integrity of the baseline observing system.

*Development of the AMDAR Programme*

G9. AMDAR - AMDAR technology should provide more ascent/descent profiles, with improved vertical resolution, where vertical profile data from radiosondes and pilot balloons are sparse as well as into times that are currently not well observed such as 2300 to 0500

local times. [recommendation is supported by information from the Toulouse report, ECMWF northern hemisphere AMDAR impact study, OSEs 4, 5, 8]

Progress: The AMDAR Panel plans to coordinate homogeneous coverage of AMDAR data over 24 hours over as many regions as possible and to improve the value of upper air data through a combination of:

- Expanding the number of operational national and regional programmes;
- Development and use of new onboard software and alternative AMDAR technologies;
- Selective deployment of humidity/water vapour sensors;
- Provision of targeted observations into data sparse areas and special weather situations;
- Use of optimisation systems to improve cost effectiveness;
- Improvements in the monitoring, quality control;
- Efforts to encourage and pursue the free exchange of data; and
- Improvements in user awareness & training plus operational forecasting tools & systems.

The AMDAR Programme Implementation Table follows.

| Programme Items | 2005-2006 | 2008 | 2010 |
|---|---|---|---|
| **Operational programmes** (Australia, E-AMDAR*, New Zealand, USA, South Africa) | Expanding | stable | stable |
| **Emerging programmes** (Hong Kong China, Saudi Arabia, Japan, Canada, Central-western Africa) | Expanding | expanding/ stable | stable |
| **Developing programmes** (Chili, Argentina , UAE, Rep. of Korea, China) | first data | expanding | stable |
| **Planned programmes** (Eastern-central Europe#, Russian Federation, Oman, Egypt, Morocco, Kenya, Pakistan, India, Iran, Israel, Libya)) | | first data | expanding |
| **Development** software and technologies | work in progress | operational | stable |
| **Humidity/water vapour sensors** | operational trials | expanding | operational |
| **Targeted data** | partly operational | expanding | expanding |
| **Optimisation systems** | Partly operational | expanding | expanding |
| **Data monitoring, QC and data exchange** | Ongoing | ongoing | ongoing |
| **Awareness and training** | Ongoing | ongoing | stable |
| **Development** of operational forecasting tools | in progress | operational | operational |

* E-AMDAR currently : UK, France, Netherlands, Germany, Sweden
E-AMDAR emerging: Finland
E-AMDAR planned : Portugal, Spain, Iceland, Italy, Switzerland, Austria, Ireland, Belgium

# Eastern-central Europe : Poland, Hungary, Rumania, Ukraine, Czech Republic

Next Actions: ET-ODRRGOS to continue to monitor progress of the AMDAR Programme in the above activities.

G10. Transmission of AMDAR reports - 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. [recommendation is supported by information from the Toulouse and Alpbach NWP OSE Workshop reports, ECMWF northern hemisphere AMDAR impact study].

Comment: 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. More T, U/V, Q profiles, but especially winds, are needed in the tropics. Moreover,

the timing and location of reports, whose number is potentially very large, can be optimized while controlling communications costs.

Next Action: AMDAR Rapporteur to report progress to ET. Members in the Regions must assume responsibility of implementation.

G11. Humidity sensors on AMDAR - Further development and testing of water vapour sensing systems is strongly encouraged to supplement the temperature and wind reports from AMDAR. [recommendation is supported by information from the Toulouse and Alpbach NWP OSE Workshop reports]

Progress: Demonstration of WVSS-2 is expected in 2004-05. This system employs an absolute measurement of water vapour content that is expected to be accurate from the ground to flight altitudes.

Next Action: AMDAR Rapporteur to report progress of the AMDAR programme to ET.

*Alternative AMDAR systems*

G12. TAMDAR & AFIRS - To expand ascent/descent profile coverage to regional airports, the development of TAMDAR and use of AFIRS should be monitored with a view towards operational use.

Comment: A range of alternative AMDAR systems including TAMDAR, AFIRS and MDS could supplement conventional 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.

Next Action: ET-ODRRGOS to review progress under AMDAR and EUCOS Programmes. First data from TAMDAR and AFIRS are expected in late 2004.

*Atmospheric moisture measurements*

G13. Ground GPS - Develop further the capability of ground-based GPS systems for the inference of vertically integrated moisture with an eye toward operational implementation. Ground based GPS processing (ZTD and PW, priority for ZTD) should be standardized to provide more consistent data sets. Data should be exchanged globally. [recommendation is supported by information from the NWP OSE Workshop in Alpbach]

Comment: Such observations are currently made in Europe, North America and Asia. It is expected that the global coverage will expand over the coming years. The COSNA/SEG, NAOS, JMA reports provide useful background information.

Next Actions: CBS to urge Members to collect and exchange the ground-based GPS data. Members should take the appropriate action to ensure that the data processing be standardized by November 2005.

*Regarding improved observations in ocean areas*

G14. More profiles over oceans - Increase the availability of high vertical resolution temperature, humidity, and wind profiles over the oceans. Consider as options ASAP and dropsondes by designated aircraft.

Next Action: ET-ODRRGOS request a review from JCOMM on the current status and plans of ASAP by end of 2004.

G15. Telecommunications - Considering the expected increase in spatial and temporal resolution of *in situ* marine observing platforms (from include drifting buoys, profiling floats, XBTs for example) and the need for network management, the bandwidth of existing telecommunication systems should be increased (in both directions) or new relevant satellite telecommunications facilities should be established for timely collection and distribution.

Comment: 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.

G16. Tropical moorings - For both NWP (wind) and climate variability/climate change (sub-surface temperature profiles), the tropical mooring array should be extended into the tropical Indian Ocean at resolution consistent with that presently achieved in the tropical Pacific and Atlantic Oceans. [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.

G17. Drifting buoys - Adequate coverage of wind and surface pressure observations from drifting buoys in the Southern Ocean in areas between 40S and the Antarctic circle should be assured using an 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. [recommendation is supported by information in the Toulouse NWP OSE Workshop Report and the ET-ODRRGOS OSE studies].

Comment: 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)

G18. XBT and Argo - 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.

G19. Ice buoys - For NWP purposes, coverage of ice buoys should be increased (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*

G20. More profiles in Tropics - Temperature, wind and if possible the humidity profile measurements (from radiosondes, PILOTs, and aircraft) should be enhanced in the tropical belt, in particular over Africa and tropical America.

Comment: 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.

Action: AMDAR Rapporteur to report to ET. CBS to urge Members to consider activation of silent stations through a shared funding programme.

*New Observing Technologies*

G21. AWS - Noting the widespread adoption of AWS, (a) there should be coordinated planning that includes

- appropriate codes and reporting standards,
- global standard for quality management and the collection / sharing of metadata, and

- expanded range of measured parameters;

Next action: ET-AWS to be asked to review advances in technology and to summarize for ET-ODRRGOS.

(b) exact time of observation, as distinct from a notional time or time period, should be reported.

Next action: Reporting formats should be reviewed to include the details of observation times, OPAG_IOS Chair to bring this to the attention of the OPAG ISS ET on Data representation and codes (at CBS in 2005).

G22. New systems - In the context of THORPEX, the feasibility of new systems should be demonstrated as much as possible. These possible operational sub-systems include but are not limited to
- ground based interferometers and radiometers (e.g. microwave) that could provide continuous vertical profiles of temperature and humidity in selected areas;
- Unmanned Aeronautical Vehicles (UAVs);
- high altitude balloons.

Action: OPAG IOS Chair to liaise with the THORPEX ICSC and keep the relevant ETs informed.

### 3.3 Implementing Additional High Priority Recommendations for Evolution of the GOS

*Interaction between NWP centres, data providers and users*

N1. New data types - NWP centres should receive early (advance) information about and experience with new data types; this includes (a) early access to test data and observations during the cal/val phase to prepare for the operational use of the data and (b) information on the characteristics of the data and products (e.g. AMVs which may be representative of atmospheric layers rather than just one level over layers). [recommendation is supported by information contained in the report from the Alpbach NWP OSE Workshop].

Comment: Data assimilation and modeling capabilities have grown and are under constant development to make optimal use of current and future observing systems.

Action: ET-ODRRGOS through OPAG-IOS chair and CBS/CGMS to encourage data producers to provide metadata on observations and observing systems as early as possible.

N2. Data from research satellites – R&D systems provide valuable data for NWP, which should be made available in a timely fashion. Research satellite data provide NWP centres with an excellent opportunity to prepare for new satellite data streams, which will become part of the operational global observing system. Effective learning of how to make use of new data types can best be achieved through operational use of any experimental data streams. [recommendation is supported by information contained in the report from the Alpbach NWP OSE Workshop].

Action: ET-ODRRGOS through OPAG-IOS chair and CBS/CGMS to encourage operators of R&D satellites to provide early access to observations.

N3. Timely data delivery – Data processing and delivery systems should strive to meet NWP requirements of 30 minutes as much as possible.

Comment: The requirements for early delivery and frequent updates of forecast guidance have evolved over recent years. NWP centres have significantly reduced their data cut-off times at the expense of available observations in their data assimilation processes. Timeliness requirements for observational data are becoming more stringent for NWP centres. HH + 20 to 90 minute data cut-off times are currently applied for many NWP short-range runs. Late data can only be assimilated in update runs with long data collection times (several hours). Within the next few years, a data processing and delivery time of approximately 20 to 30 minutes is expected to be the

operational requirement used in medium and short-range forecasts. Any minute gained is useful because observation arrival drives the rest of the forecast production chain.

Action: ET-ODRRGOS through OPAG-IOS chair and CBS/CGMS to bring to the attention of data producers the more stringent timeliness requirements for observational data at NWP centres, (NWP OSE workshop, Alpbach 2004).

O1. Observing System Study - Support well-resourced studies of re-designed observing systems. This is an ongoing process.

Next Actions: ET to monitor and learn from EUCOS and THORPEX demonstration studies of observing system capabilities. Further EUCOS studies evaluating the relative importance and the impact of the ground-based and space-based components of the observing system will soon be commissioned (2005). This will result in an information exchange through documentation and workshops as appropriate.

## 4. Considerations for Evolution of the GOS in Developing Countries

4.1 In drafting this implementation plan, it was noted that redesign of the GOS included several special considerations and issues that involve developing countries. In many areas of Africa, Asia, and Latin America (Regions I, II, and III and some tropical areas between 25N and 25S), the current GOS provides no observations, whereas in other areas observations should be improved. When looking at candidate observing systems, consideration must be given not only to NWP but also to many other applications, including human forecasting. The evolution of the GOS in developing countries must address some of the issues that fall in three categories: (a) lack of public infrastructure such as electricity, telecommunication, transport facilities, etc., (b) lack of expertise from people to do the job, training, etc., and (c) funding for equipment, consumables, spare parts, manpower, etc. The lack of infrastructure and expertise may be the result of a lack of funding.

4.2 The evolution must take into account upgrading, restoring, substitution and capacity building (especially in the use of new technologies). Two aspects need to be considered: the data production and the data use. It is possible that some countries do not and will not be able to produce data and will therefore only be users of data. To help developing countries produce data for international exchange, due consideration must be given to the three issues previously identified i.e. public infrastructure, expertise and funding.

4.3 Possible approaches towards the redesign have been discussed. A first step should be to identify observing systems that are less dependent on infrastructure, expertise, and funding. In some circumstances, these are satellite, AMDAR, dropsondes, and AWS. However a minimum set of reliable RAOBs would be required as a backbone to the upper air network but also to validate the satellite observations with enough height and accuracy. Migration toward the table-driven codes (BUFR or CREX) as a reliable representation of the data is expected.

4.4 However, obtaining vertical profiles by AMDAR in many data sparse areas is worth testing. It must be recognised that AMDAR ascent/descent and enroute data will provide little stratospheric information and currently no humidity data (although humidity sensors are being tested). It is imperative that useful approaches be drafted 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. More generally the role of developing countries in the THORPEX through the regional associations should be explored.

4.5 It was felt that capacity building in some countries needed further attention. Some countries have satellite receiving stations or receive satellite data through the GTS, but lack the expertise to utilise the information to their benefit. Some countries are acquiring Doppler radar but need training on how to retrieve the information. For example, Region I has benefited with expanded access to conventional data and satellite imagery through the PUMA project. This type of project should be expanded to include other data types for routine application (synoptic, aviation, nowcasting).

4.6 If resources are available, the highest priority should go to (a) maintaining the RBSN and RBCN, noting that GSN and GUAN stations are part of the RBSN, and (b) to rehabilitate observing sites in critical locations.

4.7 Finally, the following recommendations should be taken into account when addressing the evolution of the GOS in developing countries:

- Define geographical areas using advanced techniques to help identify where priority should be if additional funding was available;
- Encourage regional associations in concert with CBS to define trial field experiments over data sparse areas, for a limited time, to evaluate how additional data would contribute to improve performance at the regional and global scale. A clearly demonstrated impact might make it easier to agree on some coordinated funding mechanism for areas concerned including funding from GEF (Global Environmental Facilities) for climate stations;
- Examine whether automated stations could become a viable, cost effective alternative to manned stations for the surface network in the future;
- In data-sparse areas of the world, it may be more cost-effective to make full use of AMDAR ascent/descent data at major airports; however the RAOB network still plays an important role in human forecasting;
- When changes are made to the climate observing systems, the GCOS Climate Monitoring Principles should be followed;
- The telecommunication problems should be referred to the OPAG on ISS and looked at as a priority;
- Prioritise where the needs are most pressing for VCP or other funding.
- High priority should be given by the region and secretariat to maintain a minimum RAOB network with acceptable performance within data challenged regions.

## 5. OSEs supporting the implementation plan recommendations and actions

In course of the development a global approach to redesign of the GOS, the ET-ODRRGOS kept under permanent review the impact assessments studies being conducted by NWP centres under regional programmes such as COSNA, EUCOS and NAOS. The ET-ODRRGOS found that findings of COSNA, EUCOS and NAOS as well as conclusions and recommendations of The Toulouse and Alpbach Workshops on Impact of Various Observing Systems on NWP provided essential input to the redesign process of the GOS. However, the ET-ODRRGOS strongly supported the workshop recommendation that impact studies should be carried out for a sufficiently long period, preferably in each of four seasons and that the statistical significance of the results should be established. In addition, the ET ODRRGOS suggested nine OSEs for consideration by NWP centres and asked the OSE/OSSE rapporteurs (Jean Pailleux and Nobuo Sato) to engage as many as possible in this work. Good response was received and results are coming in. The OSEs and the initial results from the contributing NWP centres are listed below:

5.1. Impact of hourly versus 6-hourly surface pressures. Using 4DVAR assimilation ECMWF found positive impact especially over the north Atlantic and southern oceans.

5.2. Impact of denial of radiosonde data globally above the tropopause. The Canadian AES report found positive impact from RAOB data above the tropopause.

5.3. Information content of the Siberian radiosonde network and its changes during last decades. The Main Geophysical Observatory in St Petersburg found that information content was ascending until 1985, descending thereafter. NCEP related a decrease in performance of 500 hPa height analysis over NA to a decrease in Siberian RAOBs.

5.4. Impact of AMDAR data over Africa through data denial in a 4D-Var analysis and forecasting system. ECMWF showed that denial over NH of observations below 350 hPa has large significant impact in summer and winter. Investigation of African AMDAR impact is pending at MeteoFrance.

5.5. Impact of tropical radiosonde data. Met Office varied the density of SE Asia RAOBs used in assimilation and produced high impact on winds at all levels with occasional propagation of impact to mid-latitudes. Temperature and wind information is the most important potential measurements from AMDAR in less well observed tropical areas (e.g. Africa, Central America).

5.6. Impact of three LEO AMSU-like sounders (NOAA –15, - 16, and -17 plus AQUA). ECMWF showed large positive impact from two AMSUs over one MSU. Met Office showed positive impact of three over two AMSU when NOAA-17 was added to the GOS.

5.7. Impact of AIRS data. ECMWF found that addition of one AIRS to a baseline observing system without satellites showed more impact than addition of one AMSU. Further, AIRS impact on the full GOS was positive (but initially small).

5.8. Impact of better than 3 hourly ascent descent AMDAR data. Preliminary NH AMDAR ascent/descent impact suggests positive effect of higher frequency data. EUCOS arranged higher frequency observations in 2003 to enable this study by Met Office and ECMWF.

5.9. Impact of polar winds from MODIS water vapor imagery. Initial 30-day impact study at ECMWF and NASA DAO showed that forecasts of the geopotential height for the Arctic, Northern Hemisphere extratropics, and Antarctica are improved significantly. Subsequent usage at more than ten NWP centres has confirmed positive impact of MODIS polar WV winds.

## 6. Vision for the GOS in 2015

In drafting the recommendations for the evolved GOS and then the implementation plan, the ET was guided by the following vision for the evolved GOS of 2015 and beyond.

*For the Space based component, there will be*

6 operational GEOs
- all with multispectral imager (IR/VIS)
- some with hyperspectral sounder (IR)

4 operational LEOs
- optimally spaced in time
- all with multispectral imager (MW/IR/VIS/UV)
- all with sounder (MW)
- three with hyperspectral sounder (IR)
- all with radio occultation (RO)
- two with altimeter
- three with conical scan MW or scatterometer

Several R&D satellites serving WMO members
- Constellation small satellites for radio occultation (RO)
- LEO with wind lidar
- LEO with active and passive microwave precipitation instruments
- LEO and GEO with advanced hyperspectral capabilities
- GEO lightning
- Possibly GEO microwave

All with improved intercalibration and operational continuity.

*For the Ground based component, there will be*

Automation to enable
- targeting of observations in data sensitive areas
- optimal operation of
    - radiosondes
    - ASAP systems
    - aircraft in flight

Rawinsondes

- optimized utilization
- stable GUAN
- supplemented by
    - AMDAR ascent/descent
    - ground based GPS water vapor information
    - wind profilers
    - satellite soundings
- rawinsondes automatically launched
- computerized data processing
- real-time data transmission
- high vertical resolution

Commercial aircraft observations

- of temperature & wind plus humidity on some aircraft
- in-flight and ascent/descent data
- high temporal resolution
- available from most airports including currently data void airports in Asia, Africa and South America.
- possibly supplemented with UAVs

Surface observations

- automated systems
- land sensors at high spatial resolution, supporting local applications such as road weather
- ocean platforms (ship, buoys, profiling floats, moorings) in adequate number to complement satellite measurements

Radar observing systems measuring

- radial winds
- hydrometeor distribution and size
- precipitation phase, rate, and accumulation
- multiple cloud layers, including base and top height.

Data collection and transmission

- digital in a highly compressed form
- entirely computerized data processing
- role of humans in observing chain reduced to minimum
- information technology in all areas of life will provide new opportunities for obtaining and communicating observations
- for satellite data in particular
- use of ADM including regional/special DCPC in the context of FWIS
- DB for special local applications in need on minimal time delay and as backup

## ANNEX VI

## COMMENTS ON THE THORPEX IMPLEMENTATION PLAN

1. With regard to the science questions posed to THORPEX by the ET (listed below), the ET had the following comments.

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?

*Questions 1 and 2* are indeed part of the THORPEX plan and are covered in various places in the TIP.

*Question 3* relative to AWS observation network was not highlighted by the THORPEX ISSC (International Science Steering Committee) as part of THORPEX, and the ET agrees that this indeed relates to short-range forecasting issues that are not part of the THORPEX goals.

*Question 4* regarding AMDAR, together with questions 6 to 9 are implicitly part of the TIP and should be inserted as relevant examples in section 6.2.1 ("expected outcomes of the targeting techniques"). It is proposed to add the following text to the last paragraph in section 6.2.1:

In particular, issues of major interest which should be addressed are the following:

- What are the geographic areas where AMDAR has most input/value?
- What is the optimal vertical resolution of AMDAR profiles?
- What is the contribution of the Siberian Rawinsonde network to NWP and what alternative network configurations should be considered?
- What are the key observation system configurations that would help to identify the sources of cyclogenesis in tropics?
- What is the contribution of stratospheric data (in particular from in situ observation systems) on tropospheric forecasting skill?

*Question 5* was debated. It was agreed that THORPEX would certainly need the appropriate tools for validating high-impact weather which are often declined in terms of mesoscale parameters such as precipitation. Work independent from THORPEX will most certainly take place in NWP centres,

and THORPEX has to develop strong links with this activity. It is also believed that such elaborate validation tools will be a pre-requisite to more advanced forecast verification measures such as those described in section 7.1.c of the TIP.

*Question 10* about the contribution of surface soil moisture data on tropospheric forecasting skill is already included in section 6.1.1.

*Question 11* about the forecasting capabilities in relation to high intensity rainfall is covered in the core research objectives (section 2)

*Question 12* about the downstream effects of targeting is actually covering two issues (additional targeted data and redeployment of observations) and should be added in the first paragraph of section 6.2.1:

> The evaluation of the impact of adaptive observations, including both the additional targeted data and the redeployment of various observation systems, should take into consideration both the targeted area and broader downstream effects occurring throughout the forecast ranges of interest to THORPEX (3 to 14 days). This will give input to the general question of how to go from regional experiments to the global impact of adaptive observations.

*Question 13* about the impact of cloud information is already mentioned in 6.1.c (IR sounders in cloudy areas) and 6.1.d (cloud information)

*Question 14* related to the input from THORPEX to CBS should be reflected in section 6.2.4.

> Sentence "To do this…" should be replaced by "To do this, after the demonstration made by THORPEX of the introduction of observation targeting into operations and appropriate interaction with the CBS, there will need to be a set of requirements…."

2. In addition, the ET had a few comments.

2.1 P.8, 4.1.1, introduces the concepts of "predictability and forecastability" but does not define them. In non-technical English they are synonyms, but this is probably not the intention here. Is one intended to mean the theoretical limit and the other what is practically achieved?

2.2 P.14, line 4. "Precision" means accuracy here? [Precision is usually used in technical work on observations to mean the precision to which a value is reported (e.g. the bits or significant figures with which it is recorded), which is not its accuracy.

2.3 P.17-19, 5.1. This section could usefully be enhanced by including the new aircraft technologies that have to be demonstrated and their impact explored. These include extensions of the AMDAR system to other parts of the world (many of which are very sparse in conventional observations), the introduction of the TAMDAR system, etc.

2.4 P.19-2, 5.2. Here (or elsewhere) there should be something about radio occultation (RO), particularly constellations of receivers such as COSMIC, which is scheduled for launch in 2006. These systems offer temperature measurements of high vertical resolution and accuracy in the upper troposphere and lower stratosphere. Their presence will raise questions such as: if there is, from satellites, AMSU-like data, advanced IR sounder data and RO data, and there is a baseline radiosonde network, is there a need for any other stratospheric data for NWP?

2.5 P.21, 6.1 c. Delete "geostationary" from title. The first two sentences address issues principally affecting geo data but, with recent advanced in winds from MODIS, also affecting image sequences from polar satellites. The third sentence in principle affects all satellite data, but in the short/medium term the focus will be on IR sounder data from polar satellites.

2.6 P.22, 6.2. There should be more attention in the Implementation Plan on the non-targeting aspects of adaptive observing systems, i.e. “negative targeting” - saving resources by not making observations where they are not needed. This is potentially important, because it would release resources that may be need to fund targeted observations. If some of the potentially adverse consequences of negative targeting are not studied carefully and shown to be acceptable, then operational agencies are unlikely to have the confidence to go down this road.

2.7 P.23, 6.2.1, 1st bullet. Add “in the region of interest and downstream “ to the end of the first sentence. In the last sentence “…the term targeting is being used in the widest possible way.” Does this include “adaptive observing” as discussed above?

2.8 P.25, 1st para, “the observations are poor quality”. This is true for some observations but not all; there are some very high quality humidity observations. The problem is that the horizontal sampling does not capture the spatial structures in the field, leading to aliasing problems (representativeness error).

## ANNEX VII

## ET-ODRRGOS SUGGESTED WORK PLAN FOR 2005-2006

1. Post on ET web page (a) members, (b) final reports from meetings, (c) RRR process description, (d) updated SoGs, (d) WMO TDs written by ET, (e) Implementation Plan for GOS Evolution, and (f) six monthly progress reports on action list and work plan.

2. Continue updating data bases of user requirements and observing system capabilities and include user reviewed R&D expected performances.

3. Continue RRR for ten application areas and expand to new areas as advised by CBS.

4. Work with application area PoCs to update SoGs.

5. Review with Rapporteurs and NWP experts the progress concerning OSE guidance for evolution of GOS (attention to EUCOS, African AMDAR, … studies).

6 Initiate actions and assure progress on Implementation Plan

7. Continue interactions with THORPEX (participate in developing TIP)

8. Follow up on CBS approved recommendations for the evolution to the GOS (with particular attention to the developing countries).

9. Suggest new name, Expert Team on Evolution of the GOS, to CBS

## ANNEX VIII

## SUGGESTED TERMS OF REFERENCE FOR EXPERT TEAM ON EVOLUTION OF THE GOS

a. Update and report on observational data requirements of the WWW as well as other WMO and international programmes supported by WMO;

b. Review and report on the capability of both surface-based and space-based systems that are candidate components of the evolving composite Global Observing System;

c. Carry out the Rolling Requirements Review of several application areas using subject area experts (including atmospheric chemistry through liaison with CAS, marine meteorology and oceanography through liaison with JCOMM, aeronautical meteorology through liaison with CAeM, agrometeorology through liaison with CAgM, hydrology through liaison with CHy, and climate variability and change detection through liaison with CCl and GCOS);

d. Review the implications of the Statements of Guidance concerning the strengths and deficiencies in the existing GOS and evalubate the capabilities of new observing systems and possibilities for improvements of existing observing systems to reduce deficiencies in the existing GOS; taking particular care to examine the implications of changes in observing technology, in particular changes to automated techniques (such as Automated Surface Observing Stations), on the effectiveness of all WMO Programmes, and report on major consequences in a timely fashion;

e. Carry out studies of hypothetical changes to the GOS with the assistance of NWP centres;

f. Maintain and update the Implementation Plan for Evolution of the GOS; monitor progress against the Plan, report progress and updated Plan to CBS

g. Prepare a document to assist Members, summarising the results from the above activities.

## ANNEX IX

## ACRONYM LIST

| | |
|---|---|
| **AMDAR** | Aircraft Meteorological Data Relay |
| **AOPC** | Atmospheric Observations Panel for Climate |
| **AREP** | Atmospheric Research and Environment Programme |
| **ATOVS** | Advanced TIROS Operational Vertical Sounder |
| **CAS** | Commission for Atmospheric Sciences |
| **CBS** | Commission for Basic Systems |
| **CCl** | Commission for Climatology |
| **CEOS** | Committee on Earth Observation Satellites |
| **Cg** | Congress (WMO) |
| **CGMS** | Coordination Group for Meteorological Satellites |
| **CM** | Consultative Meetings on High-level Policy on Satellite Matters (WMO) |
| **COP** | Conference of the Parties (UN Framework Convention on Climate Change) |
| **EARS** | European ATOVS Retransmission Service |
| **EC** | Executive Council |
| **ET** | Expert Team |
| **GAW** | Global Atmosphere Watch |
| **GEO** | d hoc Group on Earth Observations |
| **GEOSS** | Global Earth Observing System of Systems |
| **GCOS** | Global Climate Observing System |
| **GOS** | Global Observing System |
| **GUAN** | GCOS Upper-Air Network |
| **ICSC** | International Core Steering Committee (THORPEX) |
| **ICT** | Implementation/Coordination Team |
| **IGACO** | Integrated Global Atmospheric Chemistry Observations |
| **IGOS** | International Global Observing Strategy |
| **IOS** | Integrated Observing System |
| **ISSC** | International Science Steering Committee (THORPEX) |
| **JCOMM** | Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology |
| **NPOESS** | National Polar-orbiting Operational Environmental Satellite System |
| **NWP** | Numerical Weather Prediction |
| **OPAG** | Open Program Area Group |
| **OSE** | Observing System Experiment |
| **RA** | Regional Associations |
| **SOG** | Statement of Guidance |
| **THORPEX** | THe Observing system Research and Predictability EXperiment |
| **TIP** | THOPEX Implementation Plan |
| **UNFCCC** | United Nations Framework Convention on Climate Change |
| **WCRP** | World Climate Research Programme |