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COMMISSION FOR BASIC SYSTEMS

OPEN PROGRAMME AREA GROUP ON INTEGRATED OBSERVING SYSTEMS

EXPERT TEAM MEETING

ON OBSERVATIONAL DATA REQUIREMENTS AND REDESIGN OF THE GLOBAL OBSERVING SYSTEM

(Reduced Group)

GENEVA, SWITZERLAND

23-27 APRIL 2001

FINAL REPORT

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

On 23 – 27 April, 2001, the CBS OPAG on IOS Expert Team on Observational Data Requirements and Redesign of the GOS (ET-ODRRGOS) held its special reduced session in the WMO Headquarters in Geneva. The major goal of the session was to discuss issues related to the planning and implementation of Operational System Experiments (OSEs) and Observing System Simulation Experiments (OSSEs) within the framework of redesign of the GOS. On the first two days, the Coordination Group for Meteorological Satellites (CGMS) held a workshop to discuss the evolution of remote sensing in various specialised areas over the next 10 – 15 years and its potential contribution to the GOS.

CGMS Workshop

The CGMS workshop presentations included concepts for evolving geostationary (GEOs) satellites with high spectral resolution Infra-Red for improved soundings and winds and microwave for precipitation and cloud studies. They discussed enhancing the low earth-orbit (LEOs) satellites with active microwave for ocean surface determinations and high spatial resolution multi-spectral capabilities for sea/land/ice surface feature discrimination. The proposals provided for supplementing both with mini- and small-satellites for Lidar winds and tropospause and stratospheric definition. One goal suggested for the GOS of 2020 is for all citizens of the planet to have “weather in the palm of their hands.” This vision utilises LEOs and GEOs as well as *in situ* sensors, advanced computers, twenty-first century communications to provide timely and detailed weather information and forecasts to individuals in a “Palm Pilot” sized instrument. LEO observations would provide global coverage, high spatial resolution, microwave sounding, Global Positioning System (GPS) density profiles, Doppler LIDAR winds, and water vapor while GEO observations would provide high temporal resolution (weather dynamics), tracer wind velocities, synergism with ground-based observations, lightning measurements, and microwave precipitation determinations. It was pointed out that there will be considerable economic benefits for extending forecasts (by 2020 a 7-day forecast that is as accurate as today’s one day forecast will change the way the world functions). The above presentations provided by eight speakers had been posted on the WMO Web.

Expert Team Meeting

ET-ODRRGOS discussed studies carried out by NWP Centres on changes in the GOS that have occurred during the past decade and their impact on the skills of NWP both regionally and globally. ECMWF reported on NWP impact studies using satellite sounding data (both infra-red and microwave instruments), cloud-drift winds from geo-satellites, and wind scatterometer data from ERS, NSCAT and QuikSCAT research satellites. In all cases, the impact was studied using variational data assimilation systems (3DVAR and 4DVAR). Notable was the positive impact of two Advanced Microwave Sounder Units over that achieved by just one; as well as the positive impact of scatterometer data. Met Office (UK) reported on systematic “data denial” experiments testing the impact of satellite atmospheric motion vectors (AMVs), ERS-2 scatterometer data, and ATOVS data. The ATOVS results showed an impact of two AMSUs consistent with the ECMWF results. The use of tropospheric ATOVS data over land is also showing positive impact. Météo France showed examples of degradation of forecasts for Europe from satellite derived AMVs in the region of 50° N and 35° W; additionally, it was noted that errors in winter-time forecasts for the European area have often been traced back to a lack of observations in the polar areas. NOAA National Centers for Environmental Prediction (NCEP) provided information on impact tests with targeted observations in the North Pacific Ocean (overall 70% of the additional observations showed clear improvement with rms error reduction of 10 to 25% in the 24 to 96 hr forecast). The NOAA Cooperative Institute for Meteorological Satellite Studies presented 24-hour forecast results for North America indicating that removal of satellite data (NoSAT) has a bigger impact on the model forecasts of temperature and moisture than removal of conventional RAOB data (NoRAOB). Isolating the impact of the GOES Sounder revealed that summer GOES moisture information has up to five times more impact than RAOBs. The South African Weather Bureau submitted ‘with-AMDAR’ and ‘without-AMDAR’ tests for some 50 cases. Early subjective evaluations are indicating positive impact in a majority of the cases, although not uniformly so. The WMO presented a “Statistical Analysis of Forecast Verification Scores from Six Forecast Centres, 1991-2000.” Significant improvement in skill was evident at all NWP centres and anomalous poor performance was evident in 1999, but it could not be traced with certainty to the reduction in radiosonde launches over the northern and central Asian parts of RA II.

ET-ODRRGOS also discussed a coordinated development and utilisation of a comprehensive software tool for carrying out Observing System Simulation Experiments (OSSEs) as well as preparation, maintenance, and evolution of a realistic OSSE database with user-friendly access. It was noted that undertaking an OSSE is often abandoned because of the huge human and computer resources required. The major task, therefore, would be aimed at leveraging and coordinating individual investments to facilitate more and better OSSEs. After some debate, the ET-ODRRGOS felt that the required resources for OSSEs are still so large that the limited resources for evaluating changes to the GOS would probably be better focussed on well-defined Operational System Experiments (OSEs).

ET-ODRRGOS then suggested seven OSEs for consideration by NWP centres and asked the OPAG/IOS rapporteurs on Scientific Evaluation of OSEs and OSSEs to engage as many as possible in this work. They include studying the

- Impact of hourly SYNOPs
- Impact of denial of radiosonde data globally above the tropopause
- Information content of the Siberian radiosonde network and its changes during last decades.
- Impact of AMDAR data over Africa through data denial in a 4D-Var analysis and forecasting system
- Impact of tropical radiosonde data
- Impact of three LEO AMSU-like sounders
- Impact of AIRS data

The status / results of the experiments will be presented and discussed at the next ET-ODRRGOS meeting.

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 special session of a reduced group of the CBS/OPAG/IOS Expert Team on Observational Data Requirements and Redesign of the Global Observing System (ET-ODRRGOS) was held in the WMO Headquarters from 23 – 27 April 2001. The chairman of the Expert Team, Dr. Menzel, opened the session, at 9:00 a.m. on Monday 23 April 2001. The session was attended by 5 members of the Expert Team, a representative of the Commission for Atmospheric Sciences, and representatives of GCOS. In addition, the first two days (23-24 April) consisted of a workshop conducted jointly with the Coordination Group for Meteorological Satellites (CGMS) on the capabilities that are under consideration for future generations (roughly 2015) of operational polar and geostationary satellites. During this portion of the meeting, a number of experts on remote sensing gave presentations. The full list of participants is given in ANNEX II.

- On behalf of the Secretary-General, the Assistant Secretary-General, Mr A.S. Zaitsev, welcomed the participants to Geneva and to the Secretariat. Mr Zaitsev noted that the Global Observing System (GOS), which had evolved over the past four decades, was eroding for numerous reasons, not the least of which was financial. It had now become necessary to replace those elements that had fallen into disrepair or disuse. And, he stated, "how better than to build this new GOS upon a solid foundation of durable, higher performance, technology." He challenged the ET-ODRRGOS to play a significant role in the Redesign of the Global Observing System by devising practical Observing System Experiments and Observing System Simulation Experiments. These experiments, in turn, could be used to evaluate the impact of new technologies on NWP globally.

- Speaking to the Expert Team on Wednesday morning, the chairman of the OPAG-IOS Dr. Purdom recalled the goals of the Expert Team. He stated that from his perspective the commonly used phrase "redesign of the GOS" was somewhat misleading. He believed that it was obvious to all that the complete redesign of the GOS was impractical and instead felt that guiding and promoting evolution of the system was the task of ET-ODRRGOS, as well as promoting full utilisation of existing subsystems until they can be replaced in a systematic and cost effective way. The OPAG-IOS chairman recalled that data from both the upper air network and the surface network continue to show data voids over land that tend to be located in developing countries. While he held out hope that these data voids could begin to be filled by remote sensing methods in the near future, he suggested that satellite operators will always need sources of *in situ* data as references for the space-borne instruments. He suggested (as an example of the innovative thinking he had been urging) that the satellite operators might choose to "adopt" some of the stations in these data void areas, supporting the surface and upper air stations needed to establish ground truth for their observations as a part of their operational programmes, while at the same time solidifying the support to the GOS, the GSN, and the GUAN. He stated that the hardest hypotheses for the ET-ODRRGOS were associated with Observing System Experiments (OSEs) and Observing System Simulation Experiments (OSSEs) because the ET has no resources of its own and must rely on others, such as the numerical weather prediction (NWP) centres, to carry out their suggestions. But he lauded both the NWP centres and the ET for their efforts thus far and encouraged them to keep up the effort and press onward toward the goals.

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

The agenda shown in ANNEX I was adopted after the chairman agreed that related items could be covered under discussion points of the agenda.

1.3. Working *arrangements* *(Agenda item 1.3.)*

Working hours and a tentative timetable for the meeting were agreed upon. The meeting agreed to take as a goal to complete the agenda and close the meeting by close of business on Friday, April 27.

2. PRESENTATIONS BY EXPERTS ON THE FUTURE *IN SITU* AND SPACE-BASED OBSERVING SYSTEM *(Agenda Item 2)*

During the first two days, a workshop was conducted jointly with the Coordination Group for Meteorological Satellites (CGMS). The chairman, Dr. Menzel, in coordination with the CGMS Secretariat, had arranged for eight experts from various services and disciplines, including the chairman of OPAG-IOS, to brief the Expert Team on evolving technologies which could be available for the future Global Observing System (GOS). These experts spoke on subjects ranging from future microwave remote sensing (both passive and active) to contributions of the Global Positioning System to methods for supplementing the future space-based system. The potential synergy between active systems on low-earth orbiting (LEO) satellites and passive systems on satellites in high orbits, notably geosynchronous orbits, was a common theme. The presentations from that workshop were made available to participants in the form of a CD-ROM prepared by the Secretariat. The report of this WMO/CGMS joint workshop will be published separately. Discussion of issues raised at the workshop within the ET-ODRRGOS led to actions to pursue making more R&D satellite data available in real time for operational use, to stress that early evaluation of WindSat is necessary to prepare for NPOESS passive techniques of surface wind vector determination, and to initiate discussions for international sharing of a ground network to distribute precise orbit determination data needed to support near real time processing of radio occultation data (see ANNEX IV).

3. CHAIRMAN'S REPORT (Agenda item 3)

3.1. Past Activities

Dr. Menzel reviewed past activities of the Expert Team on Observational Systems and Redesign of the Global Observing System (ET-ODRRGOS). He summarised the activities at its three sessions. The previous three meetings have been extremely productive, drawing congratulations from the WMO administrative and technical bodies. Reports from each meeting have been made available on the WMO/CBS web site (http://www.wmo.ch/web/www/reports/ET-OBS-GOS-06-00.doc contains the most recent report). Notable accomplishments included:

- The third iteration of the Rolling Review of Requirements and its corresponding Statement of Guidance on how well the combined satellite and *in situ* observing systems meet user requirements in six applications areas (global NWP, regional NWP, synoptic meteorology, nowcasting and very short-range forecasting, seasonal to inter-annual forecasting, and aeronautical meteorology). *Statement Of Guidance Regarding How Well Satellite And In Situ Sensor Capabilities Meet WMO User Requirements In Several Application Areas, 2001, Sat-26, Technical Document WMO/TD No. 1052* was released in January 2001.
- A report on Observing *Systems Technologies and Their Use in the Next Decade, 2001, WWW-20, Technical Document WMO/TD No. 1040,* that details satellite and *in situ* observing system technologies planned for the next decade.
- A report (through the OPAG-IOS chair) to the twelfth session of CBS.

CBS expressed its appreciation for the work carried out by ET-ODRRGOS in a number or areas. In addition, CBS compiled a task list for ET-ODRRGOS for the coming two years that agreed quite well with the work-plan ET-ODRRGOS had suggested at its last meeting. It includes:

- Updating and reporting on observational data requirements of the WWW as well as other WMO and international programmes supported by WMO;
- Reviewing and reporting candidate components of the evolving composite Global Observing System;

- Carrying out the Rolling Requirements Review of several application areas using subject area experts;
- Reviewing the implications of the Statements of Guidance concerning the strengths and deficiencies in the existing GOS, evaluating the capabilities of new observing systems and possibilities for improvements of existing observing systems to reduce deficiencies in the existing GOS, with attention to changes in automated techniques (such as Automated Surface Observing Stations) on the effectiveness of all WMO Programmes;
- Carrying out studies of hypothetical changes to the GOS with the assistance of NWP centres;
- Preparing a prioritised list of proposals for modification to the GOS for CBS consideration;
- Developing criteria for dealing with design issues of the composite GOS, paying particular attention to developing countries and the Southern Hemisphere.
- Preparing a document to assist Members, summarising the results from the above activities.

CBS expects that ET-ODRRGOS will provide preliminary guidance on the future GOS at the Extraordinary Session of CBS in December 2002; the assigned tasks listed above focused on that goal.

3.2. Development and Implementation of OSEs and OSSEs

The chairman stressed that it is essential for a realistic system to evolve from ET-ODRRGOS GOS redesign efforts. To this end, there must be practical criteria for OSEs and OSSEs that should include:

- Credibility of the system should be established through the proper calibration;
- Specifications for ranges of performance provided by manufacturers should be used rather than discrete values;
- Validation should include the use of analyses and observations;
- In global impact studies, validation should take into account regional aspects, stratification by weather events, severe weather, etc.;
- Consideration should be given to the use of ensemble forecasts;
- Forecasters/users should be involved in the evaluation of the experiments.

The CBS Management Group (CBS-MG), meeting in January 2001, nominated Drs Jean Pailleux (France) and Nobuo Sato (Japan) as Rapporteurs on Scientific Evaluation of OSEs and OSSEs for global and mesoscale experiments, respectively. Dr. Jean Pailleux was welcomed in that capacity (Sato-san was unable to attend).

3.3. Plans for this meeting

Dr. Menzel reiterated that the presentations by experts at the CGMS workshop of 23-24 April 2001 should provide excellent background information on the capabilities that are under consideration for future generations (after 2015) of operational polar and geostationary satellites. He noted that the agenda for the week called for discussion of studies carried out by NWP Centres and others on changes in the GOS that have occurred during the past decade and their impact on the skills of NWP both regionally and globally. He also requested that the ET-ODRRGOS suggest several OSEs that would provide information relevant to redesign and evolution of the GOS.

4. UPDATES ON IMPACT ASSESSMENTS CONDUCTED BY NWP CENTRES SINCE THE THIRD SESSION. (*Agenda Item 4*)

4.1. Dr. Böttger reported on recent OSEs conducted at the European Centre for Medium-range Weather Forecasts. These included impact studies using satellite sounding data, cloud-drift winds from geo-satellites, and wind scatterometer data from ERS, NSCAT and QuikSCAT. In all cases, the impact was studied using variational data assimilation systems (3DVAR and 4DVAR). In addition, Dr. Böttger's report covered results of tests of US and European wind profiler data and three EUCOS scenarios for the European ground-based observing system. Notable was the positive impact of two AMSUs over that achieved by just one as well as the positive impact of scatterometer data.

4.2. Dr. Eyre reported on experiments carried out over the last year at the Met Office (Bracknell, UK). One set of "data denial" experiments has been performed to study systematically the current impact of different components of the Global Observing System (GOS) on the performance of the Met Office's operational global numerical weather prediction (NWP) system. Other OSEs have been conducted in the course of research and development to improve the use of satellite data within the global NWP system. These have included experiments to test the impact of satellite atmospheric motion vectors (AMVs), ERS-2 scatterometer data, and ATOVS data. The ATOVS results showed an impact of two AMSUs consistent with the ECMWF results.

4.3. Dr. Pailleux reported on recent impact studies that had been carried out at Météo France and on studies that are imminent in countries using HIRLAM (high resolution limited area model). Although the Météo France studies had in general confirmed those presented at the Toulouse Workshop, there were some notable discrepancies. In particular, in one case, the 60-hour Météo France forecast for Europe had been shown to be degraded by the use of satellite derived cloud motion vectors in the region of 50° N. latitude and 35° W. longitude. In the tropics, Dr. Pailleux said that his service had confirmed that SATOBS did not uniformly improve upper air forecasts and that the impact was more consistently positive at higher levels (*e.g.*, above 500 hPa).

There was discussion on the need for wider distribution of radar data (precipitation and wind) and that these data should be recognized as an accepted part of the GOS. The ET agreed to take this up in a full meeting.

In discussion of an impact study of NOAA-15 AMSU data, it was noted that errors in wintertime forecasts for the European area have often been traced back to a lack of observations in the polar areas. Dr. Hinsman pointed out that within the last three months at least two airline companies have commenced true polar flights from New York to Hong Kong and perhaps another oriental destination. He wondered whether these flights carried AMDAR equipment and, if so, whether these observations could prove to be valuable to forecasts needing upper air data from the Polar Regions.

4.4. Dr. Pokrovsky discussed optimisation of the GOS using sophisticated statistical techniques such as information content measures (e.g. Shannon sampling), Empirical Orthogonal Fields (EOFs), *etc.* His premise was that the GOS could be optimised to produce the most cost-effective system with high performance and low cost using this method. He reported on his analysis of the impact of the absence of some Russian rawinsondes on NWP both globally and regionally; this analysis offered an original approach and new results. It was suggested, and is reflected in an action item, that his approach be applied to the reanalysis data sets to gauge long term changes in the information content of the Siberian radiosonde network.

4.5. Dr. Schlatter provided information on a study performed by the National Centers for Environmental Prediction (NCEP-US) to test the provision of adequate initial field data for numerical forecasts for the western coast of North America, using specifically targeted observations in the North Pacific Ocean. Details were provided regarding case selection, targeting (of adaptive dropsonde observations), and the resulting changes in forecast accuracy. Overall, it was found that 70% of the additional observations showed clear improvement (rms error reduction of 10 to 25%) in to the 24 to 96 hr forecast. He also presented a status report on the OSEs conducted by NOAA that included: (a) replacing radiosonde reports at selected sites with AMDAR: impact was very small for numerical weather prediction but is apparently large for climate monitoring and local forecast efforts, and (b) using the reanalysis data sets for investigating the impact of the reduction in the Russian radiosonde launches: negative impact was seen in 1-3 day forecasts for Japan, China, Alaska, and Canada, but virtually no impact beyond 3 days.

4.6. Dr. Menzel presented a satellite data impact study conducted by CIMSS/NESDIS using the Eta Data Assimilation System (EDAS) to test the impact of including satellite products versus conventional RAOB information in a forecast model. Ten-day periods each in summer winter and spring seasons were evaluated. The 24-hour forecast results for temperature and moisture at various pressure levels indicate that overall, removing the satellite data (NoSAT) has a bigger impact on the model forecasts of temperature and moisture than removing conventional RAOB data (NoRAOB). Isolating the impact of the GOES Sounder revealed that in the summer season, the GOES moisture information has up to five times more impact than RAOB.

4.7. Early results from an AMDAR impact study by the South African Weather Bureau were presented (these were conducted by the SAWB and shared by Hillarie Riphagen). Since August 2000, aircraft data have been provided over southern Africa by South African Airlines (SAA), British Airways (BA), KLM Royal Dutch Airlines, Qantas, Air Mauritius and Air Namibia. Versions of the Eta data assimilation and prediction system 'with-AMDAR' and 'without-AMDAR' have been run for some 50 cases at the SAWB. Early subjective evaluations are indicating the positive impact in a majority of the cases, although not uniformly so.

5. CONSIDERATION OF LESSONS LEARNED BY PREVIOUS ASSESSMENTS AND THE IMPACT UPON PLANS FOR FUTURE OSEs AND OSSEs. *(Agenda Item* 5)

An independent "Statistical Analysis of Forecast Verification Scores from Six Forecast Centres, 1991-2000" was presented by Ms. Marjorie McGuirk, one of the authors. Significant improvement skill was evident at all NWP centres. Additionally, anomalous poor performance was evident in 1999, but it could not be traced with certainty to the reduction in the Russian Federation radiosondes.

6. USE OF OSEs and OSSEs TO EXAMINE IMPACT ON THE GLOBAL OBSERVING SYSTEM AND NWP OF IMPROVED PRODUCTS AND DATA. (Agenda Item 6)

6.1. An analysis performed by Dr. Hinsman showed a sample redesign of the GOS, using only *in situ* sensors. The sample computed steps that would be necessary to achieve a minimum level of performance in global NWP. The radiosonde network in each of the land based homogeneous areas would require draconian adjustment; 233 radiosondes would need to be moved from one area to another and, in addition, 87 new ones would be required. Such a drastic reallocation — which would violate data continuity for the GUAN — is not a realistic approach. However, he showed that the addition of AMDAR profile observations to existing radiosondes has the potential of meeting requirements in many regions. This is, in fact, already the case in RA IV Central and RA VI West Europe.

An analysis of benefit versus performance demonstrated that observing systems need not be designed to the meet the maximum levels of benefit; in fact optimal benefit to performance ratio is achieved at less than maximum levels of performance.

6.2. The ET noted that the general considerations for OSE and OSSE guidelines (see ANNEX III) was strongly endorsed by the Toulouse NWP workshop. They concurred with the recommendations from that workshop and the WGNE, namely that studies should be carried out for a sufficiently long period, preferably separate periods in all four seasons, and that the statistical significance of the results should be established. These criteria have not been fulfilled for most of the results reviewed at this meeting.

Dr. Manton, chair of AOPC, stimulated discussion of the OSE / OSSE guidelines that resulted in addition of two new requirements and one comment. He suggested, and the ET-ODRRGOS agreed, that an OSE must:

- Recognize that the future global observing system (GOS) should also be designed to capture extreme events. Without careful consideration of this requirement, OSEs could be used to reduce the scope of the GOS and hence to reduce the effectiveness of the GOS in resolving the most important cases that justify its overall cost.
- Recognize that for global climate purposes, the GOS is required to resolve the spatial and temporal variability in a consistent manner across the whole globe. Thus OSEs need to be applied to the analysis of the effectiveness of the network in all regions, not just population centres.

In addition there should be the appreciation that:

- OSEs and OSSEs provide one type of information that can influence the future GOS. Additional information can be derived from studies of model capability to represent variance on relevant time and space scales.

The ET-ODRRGOS also discussed a coordinated development and utilisation of a comprehensive software tool for carrying out OSSEs as well as preparation, maintenance, and evolution of a realistic OSSE database with user-friendly access. Scientists often abandon undertaking an OSSE because of the huge human and computer resources required; this suggestion is aimed at leveraging and coordinating individual investments to facilitate more and better OSSEs. After some debate, the ET-ODRRGOS noted that the required resources for OSSEs are still so large that the limited resources for evaluating changes to the GOS would probably be better focussed on well-defined OSEs.

7. PLAN FOR REVIEW OF CANDIDATE EXPERIMENTS BY THE FULL EXPERT TEAM (*Agenda Item 7*)

7.1. The ET-ODRRGOS suggested seven OSEs (ANNEX V) for consideration by NWP centres and asked the OSE/OSSE rapporteurs to engage as many as possible in this work. They include studying the:

- Impact of hourly SYNOPs,
- Impact of denial of radiosonde data globally above the tropopause,
- Information content of the Siberian radiosonde network and its changes during last decades,
- Impact of AMDAR data over Africa through data denial in a 4D-Var analysis and forecasting system,
- Impact of tropical radiosonde data,
- Impact of three LEO AMSU-like sounders, and
- Impact of AIRS data.

The status / results will be presented and discussed at the next (full) ET-ODRRGOS meeting. The ET also agreed to bring these suggestions to the attention of the Working Group on Numerical Experimentation (WGNE) and to encourage their participation.

8. ANY OTHER BUSINESS (*Agenda Item 8*)

8.1. The ET-ODRRGOS reviewed the progress on past action items and assigned some new action items (ANNEX IV). Alternatives for holding the next full meeting in 4Q01 or 1Q02 were discussed.

9. CLOSURE OF THE SESSION

The session closed at 1500 hours on Friday 27 April 2001.

ANNEX I

AGENDA

1. ORGANIZATION OF THE SESSION

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

2 PRESENTATIONS BY EXPERTS ON THE FUTURE *IN SITU* AND SPACE-BASED OBSERVING SYSTEM

3 CHAIRMAN'S REPORT

4 UPDATES ON IMPACT ASSESSMENTS CONDUCTED BY NWP CENTRES SINCE THE THIRD SESSION

5 CONSIDERATION OF LESSONS LEARNED BY PREVIOUS ASSESSMENTS AND THE IMPACT UPON PLANS FOR FUTURE OSEs AND OSSEs

6 USE OF OSEs and OSSEs TO EXAMINE IMPACT ON THE GLOBAL OBSERVING SYSTEM AND NWP OF IMPROVED PRODUCTS AND DATA

7 PLAN FOR REVIEW OF CANDIDATE EXPERIMENTS BY THE FULL EXPERT TEAM

8 ANY OTHER BUSINESS

9 CLOSURE OF THE SESSION

ANNEX II
LIST OF PARTICIPANTS

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Geneva, 23-28 April 2001
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ANNEX III

GUIDELINES FOR OSEs / OSSEs

III.1. Observing System Experiments (OSEs)

- They are relatively cheap at centres already equipped to do them.
- They are limited to currently available observations (i.e. to operational observations or, at higher cost, to “special observations” which are available with some effort, but not operationally).
- They can be used to test the impact of current observing systems, in isolation or combination.
- They can be made using a random ensemble of cases, or a contiguous set of cases from randomly-selected period(s), or cases chosen because the impact of observations known to be higher than normal (e.g. through study of changes in consecutive forecasts).
- Sample size is important; there is a danger of drawing too general conclusions from a small ensemble of experiments. Ideally experiments should include different seasons, and even different years, as results may depend on a particular weather type. If this is not possible, then at least some statistics of the frequency of weather types, and sensitive areas, in the region of the observations, should be considered. The statistical significance of results should be calculated.
- Recognize that the future global observing system (GOS) should be designed also to capture extreme events. Without careful consideration of this requirement, OSEs could be used to reduce the scope of the GOS and hence to reduce the effectiveness of the GOS in resolving the most important cases that justify its overall cost.
- Recognize that for global climate purposes, the GOS is required to resolve the spatial and temporal variability in a consistent manner across the whole globe. Thus OSEs need to be applied to the analysis of the effectiveness of the network in all regions, not just population centres.
- Experiments can measure the impact of withdrawing an observation type. This demonstrates the current benefit of that observation type. It provides a basis for testing scenarios of withdrawing the system, either to reduce cost or to re-deploy the resource elsewhere.
- Experiments with “special observations” can test certain types of scenarios, e.g. 4 sondes per day but from limited sites, versus 2 sondes per day from all sites.

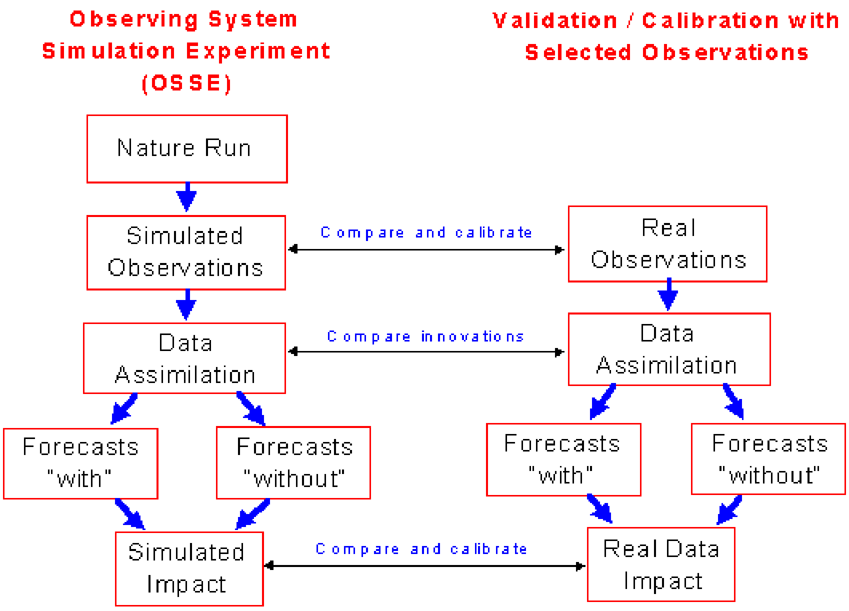
III.2. Observing System Simulation Experiments (OSSEs)

- They are expensive!
- However, they can be the most convincing way to test impact of planned observing systems for which realistic observations (with realistic coverage) are not available.
- They can also be a “clean” way to test impact (of current or future observations) because you know the “truth”; it is the "nature run" from which observations are simulated.
- However, they are prone to over/under-optimistic specification of observation errors and coverage. Great care is needed in their realism.
- Particular problems arise if the assimilating model is the same as the model used to simulate the observations (identical twin experiment) usually, but not always, leading to over-optimistic results. It is recommended to use different models for the two stages of the process.
- Similarly, if the simulated observation error characteristics are the same as those used in the assimilation, results will tend to be over-optimistic.

- For these reasons it is recommended to calibrate an OSSE against a comparable OSE, if possible. Because OSSEs are based upon a long-term “free” forecast, day by day agreement between the parallel OSE and OSSE should not be expected but the statistical behaviour of the impact of denying specific data sources should be similar in both. The figure below illustrates this idea.
- For realistic results, it is necessary to simulate not only the observing system of interest but also all other components of the composite observing system expected to be in place at the time of interest. For these future systems, a desirable but impracticable requirement would be to simulate expected improvements in the NWP and data assimilation technology. Because of these unavoidable limitations, OSSEs may not always give an accurate measure of future capabilities. Detecting and allowing for this requires expert judgement.

III.3. Common sense

- For very costly decisions, for instance for future satellite systems, OSSEs play an important role in the decision process, along with OSEs of prototype and surrogate instruments, and stated requirements for observations.
- However, because of their complexity and cost, it is not possible to run experiments for all questions related to observing system design.
- It is often more appropriate to use judgement and experience to extrapolate and adapt results from an existing study. For this to happen efficiently, results of all studies need to be available to all experts concerned.
- OSEs and OSSEs provide one type of information that can influence the future GOS. Additional information can be derived from studies of model capability to represent variance on relevant time and space scales.



Principal components of an Observing System Simulation Experiment (left) and their relationship with a Real Observation Sensitivity Experiment (right). From Steve Lord.

ANNEX IV

ACTIONS FOR THE EXPERT TEAM

Actions outstanding from the Third Expert Team Meeting:

1. Edit and publish an updated “Candidate Observing Systems” (Chairman ETM, Aug 2000) *done,*
2. Develop expected performances for oceanographic observing systems (E. Charpentier, Jul 2000) *done,*
3. Observational SIA requirements to be reviewed by CCI and CAS (Chairman OPAG IOS and Pres CBS, Aug 2000) *done*,
4. Observational Aeronautical requirements to be reviewed by CAeM (Chairman OPAG IOS and Pres CBS, Aug 2000) *done,*
5. Complete Statement of Guidances for Global NWP, Regional NWP, Nowcasting, Seasonal and Inter-Annual Forecasting and Aeronautical Meteorology and publish as a WMO Satellite Activities Technical Document (Chairman Expert Team, Aug 2000) *done,*
6. Prepare draft Statement of Guidance for ocean applications (I. Robinson, Aug 2000) *pending first meeting of JCOMM,*
7. Update database manual to include new parameters (WMO Secretariat, Nov 2000) *done,*
8. OPAG IOS Chair to recommend to CBS formation of scientific evaluation group for OSEs and OSSEs to include WMO co-sponsorship of workshops (Chairman OPAG IOS, Nov 2000) *done except WMO co-sponsorship,*
9. Review implications for redesign of the GOS in light of SOGs (Applications area leaders, Mar 2001) *started in some applications areas:*

   Global NWP – Eyre

   Regional NWP- Schlatter

   Synoptic Met - Legrand

   Nowcasting &VSRF – Decker

   Seasonal Inter-Annual – Simard and Nicholls

   Aero Met – Puempel

   Hydrology – Engman

   Atmos Chem – Gille
10. Suggest OSE / OSSEs relevant to exploring redesign options (Applications area leaders, Mar 2001)) *suggested some OSEs at sub-group meeting,* IV, 2001,
11. Search for information on past ideas for GOS redesign and their status (Secretariat and ICT chair, Dec 2000) *continuing,*
12. Request the Chairman of OPAG/IOS to submit proposal to the CBS with a view to rectify the loss of vertical information (resolution) from RAOBS resulting from the TEMP encoding. (Nov 2000) *open,*
13. OPAG IOS Chair to inform CBS of impact of loss of pressure sensors on southern hemisphere buoys (Chairman OPAG IOS, Nov 2000) *influenced resolution,*

Actions resulting from the meeting of the sub-group of the Expert Team in April 2001:

1. Continue review of implications for redesign of the GOS in light of SOGs in applications areas and present papers at next meeting (applications area leaders),
2. Thank South African Weather Bureau for AMDAR OSE input and invite the Bureau to participate in future WMO NWP Workshops (ET chair),
3. Pursue resourcing of OSEs suggested at April 2001 meeting and engage NWP centres not participating in ET directly (OSE/OSSE rapporteurs and ET chair),
4. Convey OSE suggestions to CAS/WGNE and encourage participation (CAS rep on ET),
5. Explore wider distribution of radar data (precipitation and wind) data (ET),
6. Identify representatives and terms of engagement from various commissions and programmes to ET-ODRRGOS (secretariat),
7. Develop further techniques that identify observing systems that meet and fail to meet minimum performance requirements in selected applications areas (secretariat),
8. Invite OPAG IOS Chair to reiterate to CBS the need to make more R&D satellite data available in real time for operational use (ET chair),
9. Communicate to US that early evaluation of WindSat is necessary to prepare for NPOESS passive techniques of surface wind vector determination. To facilitate this, early access to WindSat data at operational NWP centres is encouraged. (ET chair),
10. Invite OPAG IOS Chair to initiate discussions for international sharing of ground network to distribute precise orbit determination data needed to support near real time processing of radio occultation data (ET chair).

ANNEX V

SUGGESTED OPERATIONAL SYSTEM EXPERIMENTS (OSEs)

V.1. *Impact of hourly SYNOPs*

This OSE will study the impact of reducing observations from surface stations (observations of surface pressure and any other variables normally assimilated) to a frequency of 6 hours using 4D-var in a global NWP system. Results will be compared with a control experiment in which such data are assimilated at the highest available frequency, which in some areas will be hourly.

The purpose of this experiment is to measure the impact on short- and medium-range forecasts of hourly surface observations from those areas where they are currently exchanged internationally. The benefits to be expected from more widespread international exchange of other hourly surface observations will be inferred, potentially leading to changes in practices concerning the exchange of these data. In addition to the potential for direct impact of forecast accuracy, increased exchange and archiving of hourly surface observations may benefit the verification of NWP products (particularly for precipitation) and climate monitoring (particularly for precipitation and temperature).

V.2. *Impact of denial of radiosonde data globally above the tropopause*

This OSE will investigate the NWP impact from exclusion of radiosonde measurements above the tropopause in any part of the world. Radiosonde reports will be truncated (in height) above 70 hPa, which is near the upper limit of the tropical tropopause. Satellite observations will be used exclusively in the stratosphere.

The radiosonde is the only in situ instrument platform capable of routine measurements in the stratosphere. Aircraft usually fly below the tropopause except at middle and high latitudes in winter. (Very few aircraft fly above 70 hPa.)

The OSE will lead to discussion of the following questions:

- Can satellite observations of various types compensate for the loss of stratospheric radiosonde observations? For numerical weather prediction? For climate monitoring? (Many in the climate community consider the radiosonde indispensable for providing a stable, long-term record for climate monitoring.)
- What is the effect on tropospheric forecast accuracy of the loss of stratospheric radiosonde observations? How immediate is the effect?
- How important are the stratospheric radiosonde observations for calibration and validation of satellite observations in the stratosphere? (Implies comparisons of radiosonde and satellite observations, in some cases, made possible by forward models.)

This OSE should be undertaken with a model of suitable vertical resolution in the stratosphere. Possible outcomes and suggested actions from this OSE on the impact of no stratospheric radiosonde data include:

- Strong or clear impact – Encourage tracking of all radiosondes to maximum altitude, where balloon bursts. Encourage use of larger balloons to sample greater altitudes.
- No impact – Rely more on satellite observations (e.g. AMSU) of the stratosphere for NWP. Possible future help would come from radio occultation measurements, whose vertical resolution in the stratosphere is expected to be between 1 and 1.5 km with an expected accuracy of 1K.

V.3. *Information content of the Siberian radiosonde network and its changes during last decades*

This study will quantify the information content of the Siberian radiosonde network in full and reduced form, investigating trends over the past decade. The decrease in the number of radiosonde launches from the Asian part of the Russian Federation is believed to have had an impacted on NWP. This study will help understand the impact and will involve the following tasks:

- Evaluation of changes in impact areas from the ten year retrospective,
- Determination of homogeneous zones and optimal network configuration, and
- Exploration of proposed network variants responding to different weather regimes.

The results expected from this OSE include:

- Recommendations for redesign of the network, in terms of number of stations and their locations, and
- Estimation of expected improvement of geopotential and wind velocity field analysis due to restoration of Siberian network in optimal mode.

V.4. *Impact of AMDAR data over Africa*

The impact of the AMDAR data over the African continent with an appropriate NWP forecasting system will be studied through denial of the AMDAR data in several experiments. The operational analyses produced with the identical forecasting system will serve as the control. The data impact will be evaluated with respect to improvements in the accuracy of the analysis and background fields and the ensuing forecasts. The study will analyse the impact of AMDAR data on regional and global upper-air wind, temperature and height fields in the short and medium range. Forecasts of near-surface weather parameters, including precipitation over Africa, will be considered if feasible.

AMDAR data are mainly available at asynoptic times. A 4D variational data assimilation system (4D-Var) is considered to be the most suitable test bed for such a study, although a 3D-Var system with background fields at the appropriate times may also be a candidate. The study will be pursued during an active period in the Atlantic hurricane season with easterly waves moving out of Africa and the subsequent development of tropical cyclones in the Atlantic, as well as dynamically active periods in either hemisphere’s winter.

Motivation for this OSE lies in the fact that data monitoring statistics of the Global Observing System (GOS) have in the past indicated that the African continent is a notoriously data sparse area, in particular with respect to in situ observations in the free atmosphere. In recent years some of the airlines with long haul routes across Africa have to an increasing extent contributed to the AMDAR component of the GOS. Initially all the wind vector and temperature data were provided as in-flight observations taken automatically through onboard sensors at flight level only. More recently the in-flight measurements have been complemented by ascent and descent data taken during take-off and landing of the aircraft. In any 24 hour period the coverage of the African continent with AMDAR data is suitably uniform and is considered to be a valuable contribution to the GOS over Africa.

V.5. *Impact of tropical radiosonde data*

The impact of removing all in situ profile data (e.g. radiosonde and AMDAR) in the tropical belt (20S-20N) will be studied, checking how the analyses and forecasts are be affected, not only in the tropics, but also in mid-latitudes. A second experiment will consist in removing the same data in a latitude-longitude box corresponding to the current highest density in radiosondes. Although the impact of radiosonde data has been evaluated through several OSEs (either global OSEs, or limited to some specific areas), little attention has been given to the tropics in these studies. Therefore, these two tropical OSEs should be carried out as first priority.

However, many other impact studies could also be carried out in order to understand the role and needs of profile type observations more, in the tropics:

- Repetition of these two experiments with and without satellite winds, as it is known that these winds considerably affect the tropical circulation. It is also known that there are problems in assimilating these observations in an optimal way;

- Separation of the overall radiosonde impact into wind impact and temperature/humidity impact;
- Varying the latitude/longitude box of the second experiment (e.g. one Indonesian box, one South American box).

The main expected outcome will be a better understanding of the requirements in the tropical areas for wind, temperature and humidity profile observations. Investigating the impact of the radiosonde data in a tropical area relatively well covered by radiosondes will also give a quantitative indication of the expected improvement, which will be obtained in current data - poor areas by deploying new observations (satellite or in-situ). This technique has already been used in mid-latitudes, by testing (e.g.) the impact of removing North American radiosondes.

V.6. *Impact of three LEO AMSU-like sounders*

This OSE will investigate the premise that 3 low earth orbiting microwave instruments of AMSU quality will provide additional significant benefit to global NWP beyond that evidenced with two AMSU-like microwave sounders. When the SSMI/S and Aqua/AMSU achieve polar orbit in late 2001, there might be the opportunity to evaluate global NWP from microwave sounder instruments spaced every four (or so) hours.

Many NWP centres now depend upon the temperature information provided by the microwave sounding instruments on board the NOAA polar orbiting spacecraft. Experiments have been carried out to measure the impact of these systems in a number of only recently available configurations. The positive impact of one AMSU every twelve hours versus two every twelve hours (930 AM LST and 130 PM LST) has encouraged the premise that an AMSU-like measurement every four hours (or three times every twelve hours) will still provide significant improvement to global short and medium range forecasts. It is estimated that the presently observed impact of one AMSU on NWP is about 8-12 hrs of forecast skill in the NH (about one to one and one-half days in the SH); for two AMSUs improvement continues to be large and significant. These results suggest the importance of the microwave sounding data in NWP and the need to maintain the best possible operational configuration (i.e. two and maybe three AMSU-like instruments). Therefore such observations in 3 LEO slots should be tested.

V.7. Impact of AIRS data

Data from the AIRS instrument on NASA's Aqua satellite will be assimilated and impact measured using a global NWP system. Results will be compared with a control experiment in which AIRS data are denied. Both experiments will assimilate all other observations in normal operational use.

The purpose of this experiment is to provide an early indication of the impact on short- and medium-range NWP performance to be expected from advanced infra-red sounder data. This will benefit preparations for forthcoming operational sounders (IASI on METOP and CrIS on NPOESS and MAIRS on FY3) and provide experience and feedback to improve the real-time processing of the AIRS data themselves. Although forecast impacts from AIRS are expected to be significant and of benefit to operational NWP, early experiments are not expected to exploit the full potential of these data.