WORLD METEOROLOGICAL ORGANIZATION
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COMMISSION FOR BASIC SYSTEMS
OPEN PROGRAMME AREA GROUP ON INTEGRATED OBSERVING SYSTEMS
EXPERT TEAM
ON OBSERVATIONAL DATA REQUIREMENTS AND REDESIGN OF THE GLOBAL OBSERVING SYSTEM

FOURTH SESSION

GENEVA, SWITZERLAND

28 JANUARY - 1 FEBRUARY 2002

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

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) met 28 January through 1 February 2002 at the World Meteorological Organization (WMO) Headquarters building in Geneva, Switzerland.

The ET-ODRRGOS pursued their agenda (a) to discuss potential near term contributions of non-operational (research and development) satellites to the GOS, (b) to hear about progress on non-satellite components of the GOS (esp. *in-situ* ocean observations), (c) to review satellite and *in-situ* observing system Statements of Guidance (SOGs) and their implications for redesign of GOS, (d) to review progress on Observing System Experiments and their implications for the GOS, and (e) to develop a draft proposal for the redesign of the GOS.

Discussion of R&D satellite contributions focused on areas where gaps between user requirements and space capabilities could be identified. These gaps were categorised by geophysical parameters and thematic areas (e.g., atmospheric thermodynamics, atmospheric dynamics, atmospheric chemistry, clouds and precipitation, clouds and radiation, ocean surface and sea-ice, land surface and vegetation). ET made twelve high priority recommendations to evolve the space based GOS (using geostationary, polar orbiting, operational, R&D, small, and constellations of mini satellites). The ET also noted that the description of the space-based part of GOS (as defined in the GOS regulatory material) needed updating and took the action to complete this well before the next CBS.

Similarly review of non space-based observing systems such as rawindsondes, AMDAR, Argo and others lead to 16 recommendations for the ground based component of the GOS. Another OSE was suggested (in addition to the seven OSEs previously suggested in April 2001) to justify more frequent distribution of AMDAR profiles.

An important overall recommendation is to expand data delivery systems so that relevant observing system assets (both satellite and *in-situ*) can be used operationally (this is a major problem in the current GOS).

Three new applications areas were introduced: atmospheric chemistry, coastal marine weather forecasting, and seasonal to interannual forecasting. In each a Statement of Guidance regarding the capabilities to meet requirements was drafted. The CEOS/WMO data base was adjusted to accommodate new entries.

The ET-ODRRGOS planned the next meeting for 1 – 5 July 2002.

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 fourth session of the Expert Team on Observational Data Requirements and Redesign of the Global Observing System of the CBS Open Programme Area Group (OPAG) on Integrated Observing Systems (IOS) was opened by its Chairman, Dr P. Menzel, at 10 am on Monday 28 January 2002 in the WMO Secretariat, Geneva. The list of participants is attached as Annex I.

The Assistant Secretary-General of WMO, Mr Hong Yan, welcomed the participants to Geneva and to the WMO Secretariat. He noted that while it was difficult to overstate the importance of any of the CBS Expert Teams, it was clear that the outcome of this Team would have far reaching effects on the development of meteorology for many decades to come. As we moved into the twenty-first century, WMO Members would continue the excellent cooperation, of already nearly one century and a half, building a network of observing and forecasting technologies. As this effort moved forward there needed to be a homogeneous combination of space-based and surface-based systems for global environmental observation of the atmosphere, land, and oceans. This would be ensured through an international partnership to be known as the Integrated Global Observing Strategy (IGOS). The OPAG-IOS and its Expert Teams have critical roles to play in providing input to this partnership. The Assistant Secretary-General noted that the Chairman’s report to the session fully summarised the previous work of the Expert Team and highlighted matters that would require the attention of the present meeting. In wishing the session every success in its deliberations, the Assistant Secretary-General looked forward to reading the Team's draft proposal for a redesign of the GOS to be submitted to the next session of CBS at the end of the current year.

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

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

1.3 Working arrangements *(Agenda item 1.3)*

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

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

The Chairman presented his report that included a review of the extensive work carried out by the Team during its previous three sessions as well as a sub-group Expert Team meeting at a Coordination Group for Meteorological Satellites (CGMS) Workshop in April 2001. He detailed the ET progress on their work programme drafted at the last CBS and outlined the goals for the current meeting. These include to (1) discuss the addition of research and development (R&D) satellites to the GOS and their potential for near term contributions, (2) review developments in the non-satellite components of the GOS (esp. *in situ* ocean observations), (3) explore the implications of the existing Statements of Guidance (SoGs) for redesign of the GOS, (4) introduce new applications areas to the SoG (e.g. atmospheric chemistry, coastal marine services), (5) review the planned Observing System Experiments (OSEs), and importantly, (6) develop a draft proposal for the redesign of the GOS. The ET accepted these goals as the focus for the activities for the week.

3. PERSPECTIVES ON USE OF R&D SATELLITES IN GOS OPERATIONS *(Agenda item 3)*

3.1 Dr D. Hinsman provided background information regarding recent developments that have prompted R&D satellites to be considered for possible contributions to the GOS. The first and most important was the fifty-third session of the WMO Executive Council where CBS was requested to expand the description of the space-based GOS to include R&D satellite missions. The second related activity was the twenty-ninth session of the Coordination Group on Meteorological Satellites (CGMS-XXIX) that discussed a paper prepared by Dr B. Bizzarri for EUMETSAT “towards an updated/upgraded GOS”. The third relevant activity was a meeting of the CBS OPAG IOS Task Team on Regulatory Material held in Geneva 26-30 November 2001 where ET-ODRRGOS was asked to undertake this task.

3.2 The ET-ODRRGOS reviewed the paper from Dr Bizzarri that addressed areas where gaps between user requirements and space capabilities could be identified. These gaps were categorised by geophysical parameters and thematic areas (e.g., atmospheric thermodynamics, atmospheric dynamics, atmospheric chemistry, clouds and precipitation, clouds and radiation, ocean surface and sea-ice, land surface and vegetation). As a result of this analysis, Dr Bizzarri had drafted 42 recommendations on how to fill or reduce the gaps by the 2015 time frame (using geostationary, polar orbiting, operational, R&D, small, and constellations of mini satellites). ET-ODRRGOS adapted some of the 42 into their recommendations for the new GOS (see Annex III). As a general recommendation for R&D satellites, ET-ODRRGOS suggested that relevant data be made available in a timely fashion for use in operational activities (via GTS or other systems).

3.3 The ET also noted that the description of the space based component of the GOS (as defined in the GOS regulatory material) needed updating and took the action to complete this well before the next CBS (see Action 1 in Annex V).

3.4 Dr W Zhang reported on plans within the Peoples Republic of China (PRC) for evolving their satellite remote sensing assets, with a goal of contributing to the GOS. China is evolving to their second series of polar orbiting meteorological satellites, starting with FY-3A in 2004. The FY-3 series will include (a) Visible and Infrared Radiometer (VIRR) with ten visible and infrared channels; (b) Moderate Resolution Visible and Infrared Imager (MODI) with 20 channels located mainly at VIS and NIR region that are complementary to the VIRR; (c) Infrared Atmospheric Sounder (IRAS) that will have 26 channels where the first 20 channels are almost the same as HIRS/3 and remaining six channels designed to measure aerosols, stratosphere temperature, carbon dioxide content and cirrus; (d) Microwave Atmospheric Sounder (MWAS) with 8 channels for temperature sounding in cloudy areas; (e) Microwave Radiation Imager (MWRI) with 12 channels conically scanning for land and ocean surfaces characterization as well as various states of water in the atmosphere, clouds and surfaces; and (f) Total Ozone Mapper and Ozone Profiler (TOM/OP), consisting of two instruments to measure ozone in the earth’s atmosphere - TOM is a 6 channel spectrometer with 50km resolution at the nadir and OP is a 12-channel spectrograph with 200 km resolution at nadir. The FY-3 series will provide forecasters with an all weather measurement capability and will broadcast the data in S-band with AHRPT format and X-band with Mission Picture Transmission (MPT) for the high data rate instruments. On the geostationary side, China has the FY 2 series of imagers that will be adding several spectral channels to their current visible and infrared window measurements.

3.5 ET-ODRRGOS welcomed this information and noted that international coordination of the equator crossings would represent a significant increase in temporal coverage offered by the low earth orbiting (LEO) satellites.

4. CURRENT STATUS OF SURFACE-BASED COMPONENTS OF GOS *(Agenda item 4)*

EUCOS

4.1 An update of the European Composite Observing System (EUCOS), a programme of the 18 member countries of EUMETNET, was given by Dr J. Caughey. During the three years up until the end of 2001 the programme was in a planning and early implementation phase. This resulted in a detailed design describing the evolution and optimisation of the system from 2002 until 2006. The current total system is known as EUCOS-O and contains the relevant in-situ observational infrastructure of the 18 members as well as the E-ASAP and E-AMDAR programmes.

4.2 It is envisaged that the system in 2006 (EUCOS-I) will significantly improve data capture in sensitive data sparse areas through greatly enhanced E-AMDAR and E-ASAP programmes. During the period of evolution it is expected the EUCOS Studies Programme will guide further detailed development especially the greater use of targeted data acquisition e.g. from unpiloted aeronautical vehicles (UAVs). As the system evolves and a more effective range of observations is captured, it is expected that the quality of regional NWP will improve, especially the ability to accurately predict the occurrence of high impact weather events.

NAOS

4.3 Dr T Schlatter summarized recent activities of the North American Observing System (NAOS) programme. NAOS is trying to plan a North American mesoscale composite observing system. The chosen strategy is to conduct a pilot project in a small region, demonstrate success, and then move to another region until eventually major portions of North America are covered. The requirements for instrumenting a small region for a pilot project are to (1) estimate regional model resolution five to ten years hence, (2) identify critical weather phenomena resolvable by the model, and (3) choose the instruments and the siting apt for the region and the weather phenomena. The new observing systems remain in the region long enough (ideally several years) to demonstrate improvement in weather services there. The final step is to determine the minimum set of new observations required to sustain the improvements indefinitely. All other observations can be removed from the region and deployed in a new region, where the pilot project is repeated.

4.4 Near the end of 2001, the U.S. Congress appropriated funds for improved prediction of air quality and high-resolution temperature in New England. The principal beneficiary of this project is to be the power-generation / energy sector. The appropriation is initially for one year. If extended, this would provide an opportunity to conduct a pilot experiment such as described above. Other regions of the country considered desirable for pilot experiments are the West Coast and the Southern Plains.

AMDAR

4.5 Mr J Stickland reviewed the status of the Aircraft Meteorological Data Relay (AMDAR) observing system. AMDAR programme are operated currently by Australia, New Zealand, the United States, South Africa, Namibia, and by five European countries - the Netherlands, the United Kingdom, France, Sweden and Germany. The European programme is supported by a group of fourteen EUMETNET member countries. A total of 16 participating airlines are providing observations. AMDAR aircraft produce over-flight data at cruise levels and vertical profiles of wind and temperature observations at many remote airports. Up to 120,000 observations per day are now produced globally, most of which are distributed on the WMO Global Telecommunications System (GTS). The AMDAR temperatures are within 1.1 C rms and the wind vectors within 5.4 m/s in the monitoring statistics with other observations (e.g. raobs). AMDAR has proved to be a cost-effective data source (the typical cost of an AMDAR profile is $1.20 US) and is considered as one of the key candidates for the future composite observing system.

4.6 The projections over the next few years are as follows. (1) The availability of a much broader range of AMDAR equipped aircraft will be meeting the same performance standards. (2) More readily available and affordable AMDAR systems with flexible onboard software will be meeting operational needs of individual NMSs. (3) There will be increased support for AMDAR to airlines from avionics providers. (4) The increasing number of lower flying regional aircraft will result in more profiles at smaller airports (and hence coverage in more data void regions) and an increase in the number of en-route observations in the 15,000 to 20,000 ft altitude range. (5) The introduction of humidity sensors is expected to commence in the next few years but implementation is likely to be slow. (6) Likewise, the implementation of turbulence reporting using an aircraft independent element will become more extensive. (7) The choice of a suitable system to measure and report icing conditions will also be made in the next few years with implementation to follow. (8) Lastly, while there has been some discussion about establishing an appropriate fund of voluntary contributions to support activities like this, to date there has been nothing formalized; if no funding assistance is found, there will be very few observations from these areas.

In Situ Marine Observing Systems

4.7 Mr. E. Charpentier reported on the current status of *in situ* marine observing systems that are being made under the Observations Programme Area of the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM). They include:

- Ship based observing platforms managed by the JCOMM Ship Observations Team which include (i) ASAPP radiosondes (over 5300 soundings annually), (ii) VOS meteorological observing platforms (over 160000 reports monthly from more than 6500 ships), (iii) VOSClim high quality meteorological observing platforms (target of 200 ships), and SOOP oceanographic platforms (over 12000 XBTs dropped in the first 6 months of 2001),
- Data buoys managed by the DBCP (800 data buoys reporting in BUOY format in November 2001 plus over 200 moorings reporting in SHIP format),
- Sub-surface profiling floats managed by the Argo programme (310 opertational floats at the time of the meeting, 3000 planned for 2005),

4.8 JCOMM has established an *in situ* observing platform support centre (JCOMMOPS, http://www.jcommops.org/) at its first session in June 2001 to provide *inter alia* information on the operational status of observing systems coordinated by the DBCP, SOOP, and Argo. This site has maps, a list of platforms, monitoring information (including regarding the data quality as made available by relevant monitoring centres).

4.9 He reported that JCOMM is fully supportive of the work of the CBS ET-ODRRGOS and the rolling review of requirements process; however some of the requirements in the WMO/CEOS database for JCOMM related activities must be updated according to latest recommendations (e.g. by GODAE and OceanObs99 conference). Finally, he summarized specific network deficiencies based upon analysis of some of the critical review charts (e.g. for buoy data), on future developments of these programmes, and on new technology or methods for network management which might be used by them in the future GOS. These included for example:

(i) the newly established Worldwide Recurring ASAP Project (WRAP) with a route passing both the Cape of Good Hope and Cape Horn, calling at ports in Australia, New Zealand, Brazil and Western Europe and therefore permitting soundings from the Indian and Southern Oceans and the Tasman Sea, approximately every 3 months,

(ii) development of the Argo profiling float programme (water temperature and salinity profiles at 3°x3° horizontal resolution, specific information regarding the development of Argo can be obtained from the Argo Information Centre at http://argo.jcommops.org/),

(iii) new sampling strategy in high density and frequently repeated line mode for the SOOP XBT programme as recommended by the GODAE & CLIVAR Upper Ocean Thermal Review in 1999 as a complement to Argo data during its gradual implementation,

(iv) use of Wind Observation Through Ambient Noise (WOTAN) technique with Lagrangian drifters, as well as similar technology for measuring precipitation at the sea surface,

(v) maintaining a network of about 80 SVP Barometer drifters (SVPB) in the region 40S to the Antarctic Circle,

(vi) possible extension of the Tropical Moored Buoy array in the Indian Ocean to provide surface meteorological data, including wind, and sub-surface water temperature profiles,

(vii) data buoy network management capability to extend the operational life-time of the buoys and save costs (e.g. temporarily shut a buoy down when the data are not needed) when satellite downlink capability will be available, and

(viii) Development of the VOSClim programme which will provide high quality surface meteorological data and metadata and serve as a reference data set for air-sea flux computations used in support of global climate studies.

5. UPDATING THE REVIEW OF OBSERVING SYSTEM TECHNOLOGIES AVAILABLE IN NEXT DECADE. (*Agenda Item 5*)

To address a task previously assigned, ET-ODRRGOS had explored observing system technologies that will be available in the next decade with the goal to develop a strategy for a composite upper-air observing system that best utilizes the strengths of *in situ* and satellite observing systems. WWW Technical Report No.20 (WMO/TD No.1040) was the first outcome of these efforts. The Secretariat noted that this document has proven to be very useful with many requests for copies. The ET felt that updates were necessary which should be achieved with broader community input; thus the ET took an action to solicit CIMO and JCOMM review within an agreed structure. (see Annex V, Action 2).

6. IMPLICATIONS OF STATEMENTS OF GUIDANCE FOR REDESIGN OF GOS (*Agenda Item 6*)

6.1 Drs J. Eyre and T. Schlatter presented the implications for the re-design of the GOS emerging from an analysis of gaps between user requirements and present/planned observing system capabilities as set out in the SoGs on global and regional NWP. Dr F. Rabier presented a similar analysis (prepared by Dr E. Legrand) for user requirements in synoptic meteorology, focussing on those aspects not covered in the analysis for NWP applications.

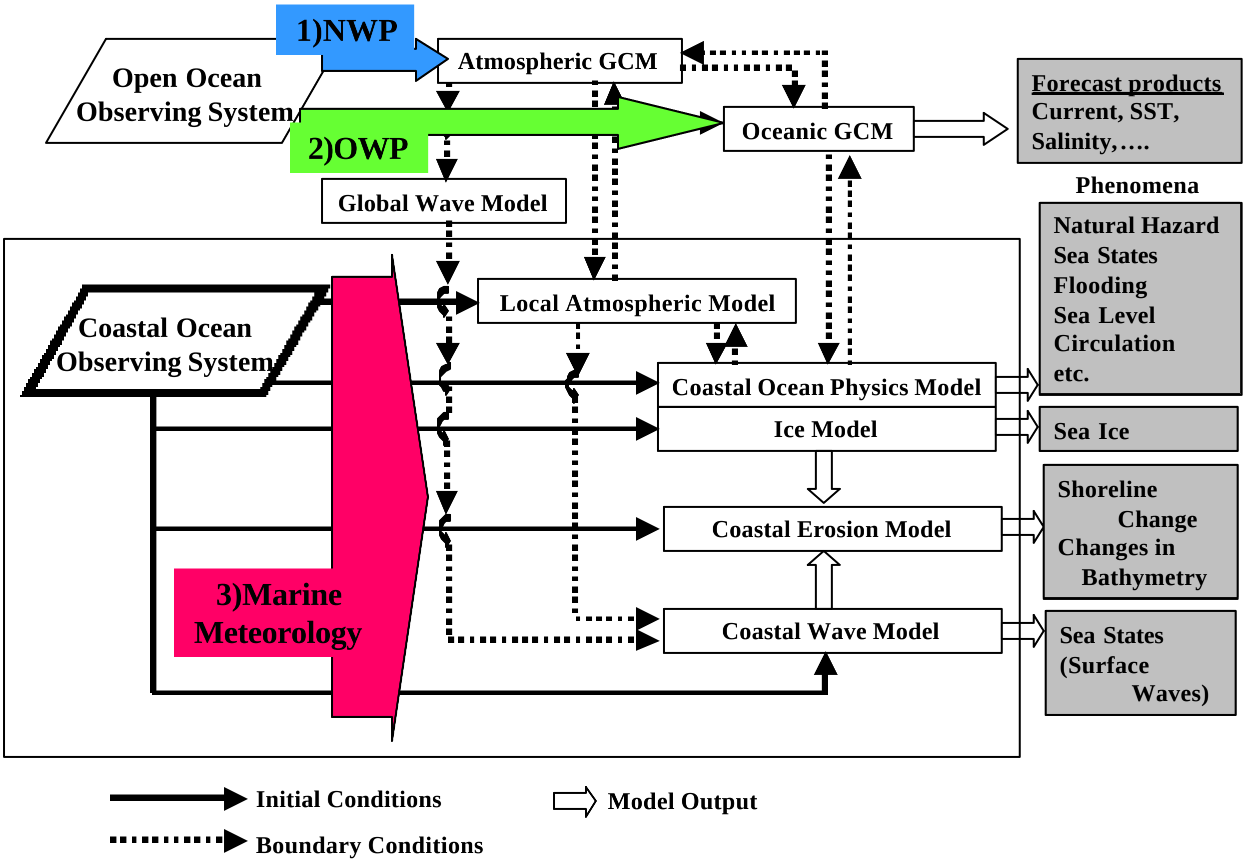
6.2 ET discussion of these papers as well as consideration of ocean applications led to development of draft of recommendations for the *in situ* component of new GOS as set out in Annex III. The ET spent the better part of two days refining and summarizing the space (from agenda item 3) and *in situ* recommendations for an evolved GOS. The ET also took an action to review these with a broader expert community in the applications areas (see Annex V, Actions 3 and 4).

6.3 Another OSE was also suggested (as an addition to the seven OSEs previously suggested by ET-ODRRGOS in April 2001); to justify higher frequency of AMDAR profiles, ET-ODRRGOS felt that it would be beneficial to perform an OSE comparing forecasts in which the frequency of ascent/descent profiles at a given airport is the maximum available versus forecasts in which the frequency is limited to one every 3 hours (see Annex V, Action 5). Four-dimensional variational (4DVAR) assimilation systems are expected to show the greatest impact of the high-frequency profiles.

7. INTRODUCING OTHER APPLICATIONS AREAS *(Agenda Item 7)*

7.1 Dr J. Gille (via teleconference) introduced his revised SoG for atmospheric chemistry (in Annex IV) that updated a previous effort that considered only the space based component of the GOS. He stressed the following major points. (a) To meet the measurement requirements, it will be necessary to exploit the synergy between satellite measurements and ground based and *in situ* data. (b) To date there have been many more space-based chemistry observations of the stratosphere and higher than in the troposphere. In the future more tropospheric measurements are planned, but their numbers will still be lower than those planned for the stratosphere and higher. (c) In the troposphere, space-based observations of O3, water vapour, and CO are being made at acceptable levels, but measurements of aerosols, CO2, long-lived source gases, radicals and reservoirs and sinks do not meet the requirements. (d) In the stratosphere and mesosphere, many planned missions give promise for acceptable measurements, but adequate temporal resolution within 24 hours appears to be a problem. He felt that *in situ* observing system resources must be retained to maintain ozone-sondes in the tropics; for the space based observing system the potential for frequent CO observations should be explored. Discussion then prompted Action 6 (see Annex V).

7.2 Dr H. Kawamura presented thoughts on several applications areas relating to the JCOMM programme (together with E. Charpentier). Four application areas were deemed appropriate within ocean considerations (a) NWP; (b) Seasonal and Inter-annual Forecasts, (c) Ocean Weather Forecast (OWF), and (d) Coastal Marine Services. Increasing ocean information from the remote sensing methods enables prediction of high-frequency components of ocean variability, i.e., ocean weather forecasts. On the basis of traditional ocean observation components for NWP and monitoring of the low frequency variability relevant for seasonal to interannual changes, new *in situ* and satellite observations will be integrated to realize operational ocean nowcasting and forecasting in the near future. Some definitions were offered. (a) Marine Meteorology - Nowcasts and forecasts of sea state (wave environment), ocean topography, fog, sea ice and coastal circulation patterns are of critical importance to safe and efficient marine operations including shipping, port operations, search and rescue operations, fishing, recreational boating and swimming, and the extraction of natural resources. (b) Coastline Changes - Coastlines are constantly eroding and accreting from routine and episodic events associated with tides, winds, waves, storm surges, sediment re-suspension and transport by rivers, tectonic processes and human modifications of the coastal zone. (c) Pollution - Polluted sea areas (i.e., oil spill, red tide, high sediment concentration, etc.) are drifted by surface and wind-driven currents. Detections of the polluted area and current/wind fields are required for mitigation of their influence on the coastal environment. The following figure suggests some of the inter-relationships between these areas and the associated functions.



A preliminary SoG for OWF and Coastal Marine Services was drafted (see Annex IV). An action was taken to review these with the broader ocean community and to update as necessary (See Annex V, Action 7).

7.3 Dr M. Manton presented a SoG for Seasonal to Interannual (SIA) Forecast that had been reviewed by many of the climate experts in GCOS (see Annex IV). This iteration of the initial first draft from members of CCl represented a convergence of opinion within multiple climate groups (CCl, GCOS and WCRP). The ET-ODRRGOS welcomed this broader review of the initial SoG and requested that the climate representatives draft a short list of climate application areas that could be addressed by the RRR process (see Annex V, Action 8).

7.4 Dr H. Puempel updated the ET on issues concerning Aviation (Aeronautical) Meteorology. He noted that the increase in air traffic seen over the last decades has averaged 7 to 8% per year, and both airways and major hub airports are reaching capacity. Hence new ways of optimizing air traffic have been sought and are being phased in from now to 2010. These changes have a significant impact on the way aeronautical meteorology is required to operate. A few examples include changes en-route, during approach sectors, and at airport landings. The increased density of air-traffic is raising the need for detection and prediction of evolving low stratus/fog areas for the VFR/IFR-category discrimination power (with split-window /multi-spectral LEO imagery of 1km horizontal resolution or better at shorter intervals during morning and evening hours) as well as forecasting deep convection which requires information on static stability, boundary layer moisture and convergence, vertical wind profiles / helicity, CAPE / DCAPE, synoptic-scale forcing, and capping inversions. Such information is required at high vertical and temporal resolution and with accurate humidity information. In populated areas, AMDAR profiles hold most promise for a high vertical and temporal resolution of temperature and wind, but the addition of moisture information is seen as crucial. Until these data come on stream in significant numbers, AMSU-like data and conventional radiosoundings are the only operational sources of such information.

7.5 ET-ODRRGOS ended the discussion of SoGs by taking an action to review the data-base of user requirements and observing system capabilities in all SoGs to assure that current data are correct. (see Annex V, Action 9)

8. STATUS OF IMPLEMENTATION AND PRELIMINARY RESULTS OF OSEs (*Agenda Item 8*)

8.1 Dr H. Boettger reported on the results from the OSEs carried out by ECMWF in 2001 in response to the proposals made by the Expert Team in April 2001. (1) The impact of hourly surface pressure and also wind observations (SYNOP, SHIP and DRIBU) has been evaluated in the context of ECMWF's operational 4D-Var data assimilation system. The study period was 1-31 May 2001. The globally available observations from the main synoptic hours at 00, 06, 12 and 18 UTC were used in the experiments. Only the data from the intermediate hours were excluded. The hourly surface observations are found to have a positive impact in the short-range forecast in those areas where such data are available (i.e. the North Atlantic and the southern oceans where other data are relatively sparse). The global exchange of all hourly surface observations for use in a 4D-Var system appears to be beneficial for NWP. (2) Vertical profile data from aircraft were denied over North America and Europe for the period 1-31 January 2001. All aircraft data (T, u, v) between the ground and 350 hPa were excluded from 25-60N, 120-75W and 35-75N, 12.5W-42.5E. The impact of the wind and temperature profiles from the aircraft observations taken during ascent and descent can be detected in the increment field of geopotential height in the free atmosphere. Forecast errors are reduced over North America, the North Atlantic and Europe. The signal propagates eastward with forecast time and is clearly visible out to Day 5 of the forecast and beyond. The atmospheric profiles from aircraft appear to have a significant impact on the 4D-Var data assimilation resulting in improvements of the short and medium range forecast over North America, the North Atlantic and Europe. The results support the expansion of the coverage of aircraft observations including the observations taken during ascent and descent from other parts of the globe.

8.2 Dr P. Menzel presented the results of a GOES / POES data denial experiment over the North American region using the EDAS with 32 km resolution and 60 levels. For this mid fall case study, the hourly GOES data is far more important than six hourly POES data. The water vapor detected by GOES was large in most areas during this moist autumn case; results in a drier winter case study will possibly show closer impact from POES and GOES. These results are contrary to the common opinion that POES data is more important than GOES data. He also reported on recent work has demonstrated the feasibility of deriving tropospheric wind information at high latitudes from polar-orbiting satellites (such as MODerate Resolution Imaging Spectro-radiometer (MODIS) on-board the NASA polar orbiting Terra satellite). The methodology employed is based on the algorithms currently used with geostationary satellites, modified for use with the polar-orbiting MODIS instrument. The unique challenges have been largely overcome, including the irregularity of temporal sampling, different viewing geometries from one image to the next, large uncertainties in the model forecast profiles used in height assignment and quality control, and the complexity of surface features, including their motion. Model impact studies are underway with the Data Assimilation Office of NASA and the ECMWF.

8.3 Dr F. Rabier presented a paper from the Global NWP rapporteur, Dr J. Pailleux, reporting on NWP Centre commitments to contribute to the study of the seven OSEs suggested by the ET-ODRRGOS in April 01. The paper suggested that the priorities for evolving the GOS include studies of the appropriate balance of RAOBS and AMDAR and observation targeting strategies as well as preparation for assimilating hyper-spectral infrared, radio occultation, and wind lidar data. Efficient and timely communication of NWP impact studies is imperative for the evolution of the GOS. Therefore, the rapporteur recommended that exchange of information be facilitated by a regular workshop (every 3 years) and that a small ad-hoc committee with NWP and GOS expertise begin organizing the next workshop as soon as possible (with CAS and CBS involvement). The ET-ODRRGOS strongly agreed and suggested an ad hoc committee (J. Pailleux, N. Sato, H. Boettger, J. Eyre, and T. Schlatter) begin at once (see Annex V, Action 10). Further the ET felt that a summary table of past OSEs and their implications for the GOS should be assembled for ET information (Action 11).

8.4 Dr J. Eyre gave a brief update on the The Hemispheric Observing-system Research and predictability experiments (THORpex) planned for early 2006. The World Weather Research Program and the Working Group on Numerical Experiment have approved further development of THORpex, a management structure has been worked out, and the first International THORpex Workshop will be held three days in March or April 2002. More details will be available on the web site http://www.nrlmry.navy.mil/~langland/THORPEX_document/Thorpex_plan.htm. Dr P. Menzel also noted that International H2O Project (IHOP_2002), a field experiment scheduled to take place over the Southern Great Plains (SGP) of the United States from 13 May to 30 June 2002, has the chief aim of improved characterization of the four-dimensional (4-D) distribution of water vapor and its application to understanding and prediction of convection. The web site http://www.atd.ucar.edu/dir_off/projects/2002/IHOP.html provides more information. The ET noted that both of these field experiments will provide opportunities for future OSEs and planned to stay informed of their progress.

9. FUTURE WORK PROGRAMME AND PREPARATION OF ET INPUT TO CBS-EXT *(Agenda Item 9)*

The ET discussed a preliminary agenda for a sub-group meeting in Jul 2002. It was suggested that activities and outcomes of that meeting should include a report on the SEG meeting, an OSE update, and final draft of the evolved GOS recommendations.

10. ANY OTHER BUSINESS *(Agenda Item 10)*

10.1 Mr M. Saloum presented a document containing some aspects of the issues regarding the state of performance of the stations listed in the RBSN and the GCOS network. Also he presented the Kisumu Resolution summarising the outcome of the second GCOS regional workshop held in October 2001 in Kisumu, Kenya. There is a critical need to develop and or improve the African climate observing system to better understand the role of Africa in the global climate system and the African climate variability and change. This will also enable a better climate monitoring in the continent and thus a better mitigation of the effects of extreme climate events.

10.2 The redesign of observing systems in Africa is essentially important because in many areas the system simply does not exist, whereas in other areas it is satisfactory or could be improved. The issues to be addressed have been identified; they essentially fall into three categories:

- Lack of public infrastructure (electricity, telecommunication, transport facilities, etc.);
- Lack of expertise (lack of staff, lack of training, etc.); and
- Lack of funding (equipment, consumables, spare parts, manpower, etc.).

10.3 To enable Africa's full participation in the Observing Programmes, due consideration must be given to these three issues. Attention must specially be given to improving current telecommunication facilities in those countries with poor telecommunication infrastructure. The needs for improvement may call for upgrading, restoring, substitution and capacity building, and therefore the following actions should be considered.

10.4 The development and implementation of a regional strategy in the framework of the redesign of the GOS, taking into account the following: (1) identification of observing systems that are less dependent on classical infrastructures that require expertise and cost: satellites, AMDAR, automatic stations; (2) reorganising observation networks by application fields; (3) restructuring the management of observation networks into sub-regional groupings and application field (e.g. ASECNA in synoptic and aeronautical meteorology.

10.5 The ET welcomed this comprehensive summary and noted that during its second meeting (Geneva, 29 November-3 December 1999) it had drafted several considerations for evolving the GOS in challenged regions of the world.

11. CLOSURE OF THE SESSION *(Agenda Item 11)*

The chairman thanked the Expert Team members and the other participants for their excellent contributions to the meeting. He also noted the valuable support from the WMO secretariat in facilitating the meeting. The session closed in the usual manner at 1 pm on Friday 1 February 2002.

ANNEX I

EXPERT TEAM MEETING ON OBSERVATION DATA REQUIREMENTS AND REDESIGN OF THE GLOBAL OBSERVING SYSTEM, FOURTH SESSION, GENEVA, SWITZERLAND, 28 January - 01 February 2001

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ANNEX II

AGENDA

1. ORGANIZATION OF THE SESSION
    - 1.1 Opening of the meeting
    - 1.2 Adoption of the agenda
    - 1.3 Working arrangements

2 REPORT OF THE CHAIRMAN

3 PERSPECTIVES ON USE OF R&D SATELLITES IN GOS OPERATIONS

4 CURRENT STATUS OF SURFACE-BASED COMPONENTS OF GOS

5 PLANS FOR UPDATING DCUMENTATION OF OBSERVING SYSTEM TECHNOLOGIES AVAILABLE IN NEXT DECADE

6 IMPLICATIONS OF STATEMENTS OF GUIDANCE FOR REDESIGN OF GOS

7 INTRODUCING OTHER APPLICATIONS AREAS

8 STATUS OF IMPLEMENTATION AND PRELIMINARY RESULTS OF OSEs

9 FUTURE WORK PROGRAMME AND PREPARATION OF ET INPUT TO CBS-EXT.

10 ANY OTHER BUSINESS

11 CLOSURE OF THE SESSION

ANNEX III

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

Based on the Rolling Review of Requirements (RRR) for Applications Areas GNWP, RNWP, Synoptic Meteorology, Nowcasting and VSRF, Aeronautical Meteorology, SIA, Atmospheric Chemistry:

Comments on planned improvements to Space Based Component of GOS

LEO satellites

1 LEO Imagers - Until the advent of NPOESS, high-quality sea-surface temperature data from R&D satellites (e.g. ATSR, AATSR, MODIS) will be made available for operational use, specifically for climate monitoring. Future geostationary satellites will have improved capability of observing sea surface temperatures and their diurnal variation.

2 LEO Imagers - In the near and mid term future, vegetation data from R&D and operational satellites will be available for operational use. In the NPOESS era, continued access will improve small-scale applications. Data from commercial satellites may also provide complementary information.

3 LEO Imagers - Imagers on future polar satellites will enable trace motion wind determination in overlapping areas at high latitudes, similar to those from geostationary satellites.

4 LEO Sounders – The advent of hyper-spectral IR sounder on AQUA, METOP, NPP, and NPOESS will improve temperature and moisture profiling; plans for making early hyper-spectral IR data available for operational evaluation are being realized.

5 LEO Ocean Colour - In the near and mid term future, ocean colour data from R&D satellites will be available for operational use. In the NPOESS era, continued access will be useful, especially in coastal zones.

GEO satellites

6 GEO Imagers -The GEO imagers will evolve in a synergistic way with the GEO Sounders. Depending on the characteristics of the evolved temperature/humidity sounder, the imager can focus on different channels with an emphasis on monitoring rapidly developing small scale events.

7 GEO Imagers - Future geostationary satellites will have improved capability for observing land surface temperatures and characterizing fire size and temperature.

8 GEO Sounders - IR sounding spectrometers from geostationary orbit are unlikely to be able to follow diurnal variations in boundary layer ozone important in air quality and hazard warnings. [This implies that observing systems primarily for atmospheric chemistry will need additional capabilities not detailed here.]

High Priority System Specific Recommendations

GEO satellites

9 GEO Imagers - Imagers of future geostationary satellites should have improved spatial resolution and improved observing cycle, in particular for those channels relevant for depiction of rapid developments and retrieval of wind information. There must be global coverage with useful viewing geometry (with the exception of polar regions) to assure improved synoptic meteorology applications.

10 GEO-Sounders - In the 2015 timeframe, all meteorological geostationary satellites in GOS 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).

11 GEO-MW - An early demonstration mission on the applicability of MW/Sub-mm radiometry for precipitation estimation and cloud property definition from geostationary orbit should be provided, in view of possible operational follow-on in the 2015 timeframe.

LEO satellites for Atmosphere and Land Observations

12 GPM - Data from the Global Precipitation Mission must be made available for operational use, and arrangements should be sought to ensure long-term continuity to the system.

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

14 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.

15 RO-Sounders – Following the METOP and NPOESS radio-occultation sounders, there should be plans for long term operational implementation of a larger constellation. International collaboration is encouraged to minimise development and running costs (e.g. through sharing of ground positioning systems).

16 LEO ERB – Continuity of ERB type measurements for climate records requires planning to maintain broad-band radiometers on at least one of the LEOs through the near future. GERB will provide observations of the diurnal aspects of broad–band radiation.

LEO satellites for Ocean Observations

17 LEO Sea Surface Wind - In the near and mid term future, sea-surface wind data from R&D satellites must be made available for operational use, and relevant satellite programmes should be coordinated so that a two-satellite coverage is achieved. In the 2010 time frame, sea surface wind must be observed in a fully operational framework (i.e. by NPOESS and METOP/post-METOP). It is urgent to assess whether the multi-polarisation passive MW radiometry is competitive with scatterometry.

18 LEO ALT - Missions for ocean topography should gradually in the next decade become an integral part of the operational system.

19 LEO MW - A mission to observe ocean salinity and soil moisture for weather and climate applications, based on a SmallSat to provide limited horizontal resolution and great accuracy, should be demonstrated for possible operational follow-on. Note that the horizontal resolution from this instrument will be inadequate for salinity in coastal zones and soil moisture in mesoscale.

20 LEO SAR - Data from SAR for wave spectra and other observations of ocean and ice should be acquired from R&D satellite programmes for operational use. SAR observation data of land snow and ice from R&D satellites should be made available for operational use. Data from commercial satellites may also provide complementary information.

Lower Priority System Specific Recommendations

21 Active WV Sensing - A demonstration of 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.

22 Cloud Lidar - Given the promise of cloud lidar systems to provide accurate measurements of cloud top height and potential observation of cloud base height (in stratocumulus, for example) performed by research satellites, these data should be made available for operational use.

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

24 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.

Summary Table for Evolving Space Based Component of GOS

System	Improved parameters	Instrumentation
GEOs upgraded (> 2015)	Temperature, humidity, ozone profiles, winds at tracer heights, Atmospheric instability index, Earth surface long-wave emissivity. Cloud pattern, cover, type, top temp and height, Sea-surface temp, land surface temp, fires.	Frequent-sounding and imaging IR spectrometer exploiting Large Focal Plane Array detectors. Fast VIS/IR imager.
GEO MW (> 2008)	Cloud water / ice, precipitation.	MW/Sub-mm radiometer.
LEOs upgraded (post-METOP) (> 2015)	Temp, humidity, & ozone profiles; total columns of key trace gases. Sea/land/ice surface temperatures, sea-ice cover, NDVI, fires, Aerosol size, Cloud pattern, cover, type, top height, cloud optical thickness, drop size, low stratus/fog, High lat winds at tracer heights. Short- and long-wave outgoing radiation at TOA.	IR/MW sounder. Improved VIS/NIR/IR imager. Broadband imager.
	Sea-surface wind and temp, sea-ice cover and surface temp. snow cover, precipitation.	MW radiometer with multi-polarisation/viewing
	Water and ice radiative transfer, aerosol properties. Ozone. LAI, PAR, FPAR (large scale). Ocean colour.	Imagers covering parts of UV, VIS, NIR, IR, FIR, & Sub-mm, with multi-polarisation.
MiniSat for ocean topography(> 2008)	Significant wave height, sea level, ocean topography, geoid. Polar ice thickness and sheet topography.	Medium-class altimeter (follow-on Jason).
SmallSat for wind Profile (> 2015)	Wind profile in clear air. Aerosol profile (large scale), cloud top and base height.	Doppler lidar (follow-on Aeolus).
SmallSat for land & ocean ice (>2015)	Wave spectra, ocean ice. Land snow & ice	SAR
SmallSat for salinity & moisture (> 2008)	Ocean salinity (large scale). Soil moisture (large scale).	Low-frequency MW radiometer.
Constellation of mini-sats (> 2008)	UT/LS temperature profile, height of tropopause.	Radio-occultation sounders.

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

Based on the RRR for Applications Areas GNWP, RNWP, Synoptic Meteorology, Nowcasting and VSRF, Aeronautical Meteorology, SIA, Atmospheric Chemistry:

High-Priority General Recommendations

Data distribution and coding

1. Exchange international observational data not yet centrally collected or used in NWP, e.g., wind profiling radars, local or regional mesonets, scanning weather radars, hourly METARs, wave

buoys. All sources must be accompanied by good metadata, careful QC, and monitoring once source is identified.

2. Revise coding standards so that full content of raw report is retained during transmission. Current coding/formatting standards in the character codes degrade potentially useful information in meteorological reports. (Example: lost information at various levels in a rawinsonde sounding in the TEMP code could be retained in the BUFR code.)

Broader use of ground based and in situ observations

3. Use ground-based and *in situ* observations for calibration of satellite measurements and validation of NWP models. For model: high-resolution precipitation this includes soil moisture and soil temperature. For satellite calibration use ozone profiles. Studies are needed to define the *in situ* networks for these purposes.

Coordination of targeted observations

4. Investigate the possibility of charging one or more meteorological centers with the responsibility for providing guidance for targeting of *in situ* observations based on the requirements of nominated application areas. Observing systems should include, at least, AMDAR, unpiloted aeronautical vehicles (UAVs), and ship-based systems.

High Priority System Specific Recommendations

Optimization of rawindsonde launches

5. Optimize the spatial resolution and the launch times of the rawinsonde sub-system (allowing flexible operation while preserving the GUAN network and taking into consideration regional climate requirements). Example: Launch Automated Ship-borne Aerological Program (ASAP) soundings at 06 and 18 UTC whenever ships are near a fixed rawinsonde site. Example: Optimise rawindsonde launch to local time of day.

Development of the AMDAR program

6. AMDAR technology should provide more ascent/descent profiles, with improved vertical resolution. A good way to accomplish this is to extend the AMDAR program to short-haul commuter flights, business aviation, and air freight. Emphasis should be in challenged GOS areas (e.g. Africa)

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

8. AMDAR coverage is both possible and sorely needed in several currently data-sparse regions, especially Africa and South America. Moreover, the timing and location of reports, whose number is potentially very large, can be optimized while controlling communications costs. The recommendation is to optimize the transmission of AMDAR reports taking into account, coverage in data-sparse regions, vertical resolution of reports, and targeting related to the weather situation.

Ground based GPS

9. Develop the capability of ground-based GPS systems for the inference of vertically integrated (or conceivably path-integrated) moisture with an eye toward operational implementation.

Improved observations in ocean areas

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

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

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

13. For NWP purposes, extend coverage of drifting buoys in the Southern Ocean in area between 40S and Antarctic circle based upon adequate mix of SVPB (surface pressure) and WOTAN technology (surface wind).

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

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

Lower Priority Suggestions

Development of new technologies

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

17. Demonstrate the feasibility of UAVs to be a operational sub-system.

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

Summary Table for Evolving Non-Space Based Component of GOS

System	Parameter	Action/Development
AMDAR	Vertical profiles of temperature and wind at airports	Increase coverage, increase vertical resolution Extend programme to short-haul, commuter and freight flights
	Flight level data	Study feasibility of adaptive use, demonstrate the need for high frequency data, in particular over Africa, South America
	Vertical profiles of humidity	Develop capability
Radiosondes	Vertical profiles of temperature wind and humidity	Optimize spatial resolution and operation of sub-system (launch times, adaptive operation) Increase the availability over the oceans (ASAP, dropsondes, etc.)
Ozone soundings	Vertical profile of ozone	Integrate into GOS

UAVs	Spatial coverage and vertical profile of wind, temperature and humidity	Demonstrate feasibility of an operational sub-system; target areas for operation are the ocean storm tracks
High-altitude balloons	Vertical profile of temperature, wind and humidity	Demonstrate feasibility of an operational sub-system
Wind profiling radar	Vertical profile of wind	Distribute data
Drifting buoys	Surface measurements of temperature, wind and pressure, SST	Extend coverage especially in SH based on SVPB and WOTAN technology
Moored buoys	Surface wind, pressure sub-surface temperature profiles Wave height	Improve timely availability for NWP (monthly & seasonal forecasting) extend coverage into Indian Ocean Provide data
Ships of opportunity (SOOP)	Sub-surface temperature profiles (XBT)	Improve timely delivery and distribute high resolution data
VOS	Surface pressure, SST, wind	Maintain their availability to provide complementary mix of observations
Subsurface profiling floats Argo programme	Sub-surface temperature and salinity	Improve timely delivery and distribute high resolution data
Tide gauges (GLOSS)	Sea level observations	Establish timely delivery
Ice buoys	Ice temperature, air pressure, temperature and wind	Increase coverage
SYNOP and METAR data	Surface observations of pressure, wind temperature, clouds and ‘weather’ Visibility Precipitation Snow cover and depth Soil moisture	Exchange globally for regional and global NWP at high temporal frequency (hourly), develop further automation Ditto Ditto Distribute daily Distribute daily
Scanning weather radar	Precipitation amount and intensity Radial winds	Provide data, demonstrate use in hydrological applications (regional and global NWP) Demonstrate use in regional NWP Ensure compatibility in calibration and data extraction methods
Ground Based GPS	Vertical profile of humidity	Demonstrate capability
Ground Based Interferometers and other radiometers (e.g. MW)	Time continuous vertical profile of temp/humidity	Demonstrate capability

ANNEX IV

1. Draft Statement of Guidance for JCOMM Program Areas

Background

1.1. The WMO and the Intergovernmental Oceanographic Commission and have established a new Joint Technical Commission on Oceanography and Marine Meteorology (JCOMM). At its first session at Akureiry, Iceland in June 2001, the commission noted with interest that the CBS ET-ODRRGOS had considered some proposals for the redesign of the marine part of the GOS on the basis of input provided by the first session of JCOMM (see WMO-No.931, para 12.2.7). This document describes application areas relating to the JCOMM activities. Observation variables used for the application areas are listed as well as their observing systems.

Introduction

1.2. One of the important roles of JCOMM is to be an efficient mechanism for coordinating and integrating marine observation systems. JCOMM will provide a consistent framework for the collection, archival, distribution, and utilization of data collected at sea for oceanographic and meteorological applications. There are four major application areas relevant to JCOMM: (a) Numerical Weather Prediction, NWP, (b) Ocean Weather Forecast, OWF, (c) Seasonal to Inter-annual Forecast, SIA, and (d) Coastal Marine Services. NWP uses the marine meteorological parameters to initialise the numerical models, and the SST distribution becomes one of the most important boundary condition. OWF and SIA predict future ocean statues using numerical models, but the former target is higher frequency component (a week to a month) of ocean variability and the latter the lower frequency components (seasonal and inter-annual).

1.3. Two of the four application areas are described in the other documents (ODRRGOS-ET) and specific JCOMM requirement in this regard were taken into account. NWP has been discussed in the previous Statement of Guidance (STA-26). In contrast, Seasonal and Inter-annual Forecasts is a newly raised application area as well as JCOMM applications. It considers both the atmospheric and oceanic lower-frequency variation using coupled numerical models, which is described in the SIA SoG found in paras 3.1-3.19 of this Annex.

1.4. Therefore, the statement of guidance presented below refers to the following application areas, Ocean Weather Forecast and Coastal Marine Services. OWF is now designed and implemented by a GOOS/GCOS OOPC pilot project, Global Ocean Data Assimilation Experiment (GODAE). Integrating existing and near future ocean observation systems, near-operational ocean weather forecast is or will be conducted in the GODAE project. Demonstration phase of GODAE is set for 2003-2005. Coastal Marine Services include the traditional tasks of the JCOMM community. However, the social needs have increased and become diversified, which forces JCOMM community to redesign the observing systems including backbone GOSs (e.g., GOOS/Coastal Ocean Observing Panel).

Ocean Weather Forecasts

1.5. Increasing ocean information from the remote sensing methods enables us to predict high-frequency components of ocean variability, i.e., ocean weather forecasts. On the basis of traditional ocean observation components for NWP and monitoring of the low frequency variability (e.g., *in situ* platform based observing system), new *in situ* and satellite observations will be integrated to realize operational ocean nowcasting and forecasting in the near future. The ocean observation data will be assimilated into the numerical forecast models.

1.6. Important observation variables and their present global ocean observing systems are listed in the table below.

Observation variables	Observing System
Temperature/salinity profiles	Tropical mooring buoy (TIP) XBTs (SOOP) Profiling floats (Argo)
Sea Surface Height	Satellite Altimeter Tide Gauges (GLOSS)
High-resolution SST	Infrared, Microwave radiometers

1.7. In order to generate the forecasting products, the observed data must be delivered to forecasting centres in timely manner.

1.8. The boundary conditions for deriving the ocean forecast model are provided by the NWP products, which is generated by the atmospheric numerical model using the marine meteorological observation data as mentioned in the above Paragraph 1.3.

Coastal Marine Services

1.9. With respect to Marine Meteorology, nowcasts and forecasts of sea state (wave environment), ocean surface topography, fog, sea ice and coastal circulation are of critical importance to safe and efficient marine operations including shipping, port operations, search and rescue operations, fishing, recreational boating, swimming, and the extraction of natural resources, etc.

1.10. Coastline Changes are constantly occurring due to eroding and accreting from routine and episodic events associated with tides, winds, waves, storm surges, sediment re-suspension and transport by rivers, tectonic processes and human modifications of the coastal zone.

1.11. Marine Pollution involves monitoring polluted sea areas (i.e., oil spill, red tide, high sediment concentration etc.) that are drifted by surface and wind-driven currents. Detections of the polluted area and current/wind fields are required for mitigation of their influence on the coastal environment.

1.12. In order to provide useful information (products) for the society living in/relating to the coastal region, we need various observational data not only the marine meteorological (physical) variables but also geological/biological variables. The following lists some (but not all) of the important marine meteorological parameters: SST, air temperature, air pressure, surface wind, air humidity, surface wave, temperature/salinity profiles, currents, sea ice, river discharge, coast lines, bathymetry, etc.

1.13. The coastal variables are traditionally observed by the *in situ* observing systems. The variables and their observing systems are described in the table below.

Observation variables	Observing System
Wind, Wave height/direction/spectrum	Wind/Wave Moored Buoy
Surface meteorological data	Ships and/or marine platforms
Subsurface oceanographic data (Temperature, salinity currents)	Small moored buoy, Ships (Thermistor strings), ADCP
(need consultation with JCOMM service expert)	

1.14. Satellite observations are also useful for MS as well as the other ocean application area. Satellite observations with higher temporal and spatial resolutions are required for MS because its major activities are carried out in the coastal seas. Concerning the requirements for the coastal phenomena, potential satellite products for MS are high-resolution coastal wind, high-resolution

SST, and high-resolution ocean. Potential of very high-spatial resolution sensors for JCOMM programme area is pointed out.

1.15. High-resolution coastal wind: The surface wind is a key parameter to nowcast and forecast of the coastal marine meteorological and oceanic conditions. It is strongly influenced by the coastal topography and land-sea surface conditions. Traditional global/regional NWP products do not have enough spatial resolution for MS. The microwave scatterometer has limited spatial resolution (25km), and the wide swath SAR measurement has limited temporal resolution (one measurement every few days) and provides no wind direction.

1.16. High-resolution sea surface temperature: SST in the coastal region has a large variability due to the diurnal cycle of solar radiation, which enhances surface characteristics of the land and sea and forces land-air-sea interactions, i.e., land-sea breezes. High-resolution SSTs (1 km) can be retrieved by the LEO infrared radiometer and rather degraded resolution SSTs (5 km) from the GEO IR radiometer. However, quantitative detection of the SST diurnal cycle is still challenging subject. In contrast, microwave radiometers cannot be used for the coastal applications because of 1) rather coarse spatial resolution and 2) contamination of land signals in the measurement in the coastal sea.

1.17. High-resolution ocean colour : The ocean colour remote sensing provides images of biological/non-biological parameters with high-spatial resolution of 1 km. The ocean colour can detect several types of marine pollutions and harmful biological activities. Parameter retrieval algorithm in turbid waters is not established yet, but developments of an observation system based on the OC remote sensing have presented promising results for a future operational observing system.

1.18. Very high-resolution visible/infrared imagers (i.e., Landsat) and synthetic aperture radar: These provide information on the coastline, which gradually changes through erosion and accretion processes relating to coastal meteorological/oceanic phenomena. However, their images are rather expensive and not freely available to the community. In order to design efficient observing system for MS in the near-coast sea region, a mechanism to incorporate these high-resolution images needs to be discussed.

2. Draft Statement of Guidance for Atmospheric Chemistry

2.1. The requirements for measurements of atmospheric trace species necessary in Atmospheric Chemistry are complex, involving as they do many different gases, whose concentrations and measurement needs vary with altitude. These gases play different roles, generally based on their radiative or chemical effects, or their use as tracers of atmospheric motion. Their importance and roles differ between the troposphere and the upper atmosphere. To date many space-borne instruments have obtained large sets of observations related to the chemistry and distribution of ozone in the stratosphere and mesosphere; results and prospects for the troposphere are much more limited. The stratosphere is more data rich because the absence of clouds and the low density and humidity permit limb-viewing techniques to be used; these facilitate the detection of small amounts of absorbing gases with good vertical resolution. To date only passive techniques have been used for the measurement of trace gases, (although lidar measurements of particulates have been made from the U.S. space shuttle).

2.2. The troposphere is more difficult because measurements are hampered by the presence of clouds, aerosols, and large gaseous absorption, especially by water vapour. These preclude the use of limb techniques below the upper troposphere, and require the use of nadir techniques which are characterized by coarse vertical resolution. In addition, techniques based on both UV-VIS scattering and IR emission techniques tend to have lowest sensitivity near the surface. Numerous reactive gases with short lifetimes are emitted at the surface and have their largest concentrations at the lowest levels, but even these concentrations may be very small.

2.3. Clearly, satellite observations are not able to determine the concentrations of all species at all levels, and there is a strong synergy with ground based measurements such as those provided by the Global Atmospheric Watch (GAW), the Network for the Detection of Stratospheric Change (NDSC), and others. In the ideal situation, surface and lower tropospheric measurements would join with satellite-based observations to provide measurements throughout the troposphere, with some ability to depict vertical variations. This synergy is also operating when surface data are used to validate low altitude satellite data, as can occur for ozone, carbon monoxide and aerosol measurements.

2.4. The requirements indicate that data with a horizontal resolution of 500 km (in both latitude and longitude) within 24 hours are necessary. The longitudinal requirement is difficult to meet in the stratosphere (only HIRDLS on the EOS Aura spacecraft is designed to meet this requirement). As indicated above, the vertical requirement is difficult to meet in the troposphere. The applications of satellite data to atmospheric chemistry at this time are for research purposes, rather than for operational needs, so that the temporal requirements are generally not stringent. Data availability within 72 hours suffices for most applications. The requirements are given for the Higher stratosphere/mesosphere (here denoted Upper Stratosphere, US), Lower Stratosphere (LS), Higher Troposphere (UT), and Lower Troposphere (LT). The situation for the stratosphere and mesosphere is described first.

Chemistry in the Stratosphere and Mesosphere

Ozone

2.5. Ozone deserves special discussion because of its importance in screening the surface from harmful ultraviolet radiation, in maintaining the temperature structure of the stratosphere, and in stratospheric chemistry. This importance has resulted in the development of observing techniques in the UV, IR and microwave. The capabilities of current sensors and the planned research sensors on ENVISAT (GOMOS, MIPAS), on EOS Aura (HIRDLS, MLS, TES occasionally), and on ADEOS II (ILAS II) suggest that acceptable data will be obtained through about 2008. Beyond that, the operational NPOESS instrument is being designed to obtain profile data from the scattering of UV-Visible radiation at the limb. This technique has not often been tried, and the initial results did not meet the requirements, so the longer term availability of adequate data remains to be demonstrated. Space-based observations are enhanced by ground-based ozone lidars and ozone sondes (LS only) at a limited number of sites. These are extremely useful in confirming the continuing accuracy of the satellite results.

Water vapour

2.6. Water vapour is important because of its radiative and chemical properties, as well as its potential use as a tracer. With a required 3-day observing period, current sensors and the planned research sensors on ENVISAT (GOMOS, MIPAS), on EOS Aura (HIRDLS, MLS, TES), and on ADEOS II (ILAS II) suggest that acceptable data will be obtained through about 2008. Sensors beyond that date are not completely defined.

Aerosols

2.7. The research sensor HIRDLS appears capable of meeting the minimum requirements for aerosol measurements. GOMOS, MIPAS and SAGE III can make the measurements, but not within a 24-hour period. There may be larger percentage errors than the required value in low background conditions.

Long-lived source gases (CH4, N2O, F11, F12)

2.8. These source gases are important greenhouse gases; they also generate chemical radicals in the stratosphere. They have been used as tracers of atmospheric motion. GOMOS, MIPAS, and HIRDLS appear capable of meeting the requirements for vertical resolution and horizontal coverage, but only HIRDLS can provide the coverage in 24 hours.

Radical Species (NO, NO2, ClO, BrO)

2.9. These chemically active species play the major roles in ozone depletion, and in other parts of the ozone chemistry. NO2 should be measured by GOMOS, HIRDLS, and MIPAS and TES. ClO and BrO should be measured by MLS, SCIAMACHY and GOMOS (only under ozone hole conditions), although with less than the required longitudinal resolution within 24 hours. NO is expected to be measured by MIPAS, SCIAMACHY and TES. The comments on coverage over 24 hours apply here as well.

Reservoirs and Sinks (ClONO2, HNO3, HCl)

2.10. These species are the intermediate or end-products of chlorine and nitrogen chemical cycles; they are relatively inactive. ClONO2 and HNO3 primarily occur in layers in the stratosphere, and will be measured by HIRDLS, MIPAS, and MLS. HCl will be measured by MLS, although the longitudinal resolution will not meet the requirements.

2.11. Data from the NDSC add significantly to the space-based data by providing on-going measurements with which to validate space-based observations. In addition they provide significant additional information by their ability to make closely spaced measurements in time, and to extend observations over periods longer than a single space-borne instrument.

Chemistry in the Troposphere

2.12. To date there have been far fewer space-based observations of trace species in the troposphere chemistry than in the stratosphere and higher. Although more measurements of tropospheric gases are planned in the future, they will still be fewer than future measurements of stratospheric gases.

Ozone

2.13. Tropospheric ozone near the surface is important for its effects on animals and plants, for its role as an oxidant, and as a source of OH radical. There has been considerable work on the measurement of tropospheric ozone from space, especially in the near UV with the advent of GOME and in the infrared with IMG. SCIAMACHY and OMI (UV) as well as TES (IR) should obtain similar results. However, the 5 km vertical resolution requirement may be difficult for these instruments, or for passive UV or IR techniques in general. The horizontal resolution should be achievable in the one week coverage period.

2.14. Data from the GAW network and other surface observations can augment these data to a considerable extent, as will balloon-sonde measurements and tropospheric lidars from a large number of stations. Unfortunately, many of these, especially in the tropics, do not have stable funding. As in most other cases, these data do not meet the 500 km requirement.

2.15. In the UT, HIRDLS and MIPAS (above clouds only) and MLS will provide observations.

Water vapour

2.16. For atmospheric chemistry, water is important for its radiative properties and as a source of OH. In the LT, future research and operational sounders (including AIRS on EOS PM-1, IASI on METOP, and CrIS on NPOESS) should be able to provide data meeting the requirements. In the UT, MLS (as well as GOMOS, HIRDLS, ILAS, MIPAS, SAGE, and SCIAMACHY in clear conditions) will augment the operational sounder observations. This suggests that acceptable data will be obtained through about 2008, and probably beyond. These data will be augmented by radiosondes in the UT.

Aerosols

2.17. To date remote-sensing measurements indicate only total tropospheric amounts, rather than profiles. Future active experiments (e.g. PARASOL) may provide the requisite information (but only in sufficiently clear conditions.) Ground-based lidar measurements can provide vertical profiles (under conditions of limited cloudiness), but they are relatively few in number. Ground-based photometer measurements (e.g. from AERONET) can provide measurements of total optical depth, and particle size.

CO2

2.18. Space-based measurement of CO2 in the lower troposphere with the requisite RMS accuracy remains a daunting challenge. There is some hope that IASI, AIRS or CrIS might provide useful information, but that remains to be demonstrated. Numerous space-based techniques are being studied at this time. Surface measurements provide good results, but not with the required horizontal resolution.

CO

2.19. CO is the only tropospheric gas (other than water vapour and ozone) that has been measured from a space-borne platform. The MOPITT instrument on the EOS Terra platform has made measurements of vertical profiles for 14 months, and thereafter is making measurements of mid-tropospheric values. Global coverage requires ~ 3 days. Subsequently SCIAMACHY will provide vertical column amounts, and TES will obtain profiles similar to MOPITT, but will not achieve the minimum horizontal resolution within its 4-day observing cycle.

2.20. Determining CO amounts near the surface from space is a problem. Surface measurements need to be used to improve these results.

Long-lived source gases (CH4, N2O, F11, F12)

2.21. Because of their long lives in the troposphere, these source gases are expected to have small mixing ratio gradients, except for differences between the Northern and Southern hemispheres. Present space-based techniques can not profile these in the LT. Stratospheric instruments can obtain information down into the UT, often only under clear conditions. In this case, it is likely that the requirements for global coverage at 500 km resolution in 24 hours cannot be met consistently. Here surface measurements from networks such as GAW, ALE-GAGE, and other high-quality networks will be needed.

Formaldehyde (HCHO)

2.22. Formaldehyde is an oxidation product of CH4, CH3OH, and isoprene, among other species. Column amounts have been determined from GOME-measured spectra, and similar determinations are expected from SCIAMACHY and OMI. Part of its importance derives from its role as an ozone precursor. Space-based measurements should be supplemented by ground-based measurements.

Radical Species (NO, NO2, ClO, BrO)

2.23. The halogen oxides are generally present in very low concentrations (except near the surface during polar winter), and thus are probably not measurable from space. GOME, SCIAMACHI and OMI are able to determine columns of NO2, from which tropospheric columns may be estimated. There do not now appear to be capabilities to measure NO or NO2 profiles in the LT from space. MIPAS, SCIAMACHY and TES may be able to make acceptable measurements of NO (and perhaps NO2) in the UT.

Reservoirs and Sinks (ClONO2, HNO3, HCl)

2.24. The amount of ClONO2 in the troposphere is extremely low. HNO3 and HCl are very soluble, so their concentrations are low and quite variable. There are no space-based techniques for measuring these in the LT. Instruments mentioned for the stratosphere may be able to make measurements in the UT under cloud-free conditions. Instruments are available to make *in situ* measurements of HNO3 from aircraft.

Sulfur containing gases (SO2 and OCS)

2.25. SO2 can be measured from space after large volcanic eruptions by backscattered UV techniques (e.g. TOMS), but measurements under background conditions have not been reported. No space-based measurements of OCS have been reported, although measurements with high spectral resolution may be possible. Both gases can be measured with *in situ* techniques, so ground-based and aircraft measurements are possible.

Summary of Atmospheric Chemistry SOG

2.26 The major points regarding atmospheric chemistry are:

- To meet the measurement requirements, it will be necessary to exploit the synergy between satellite measurements and ground based and *in situ* data;
- To date there have been many more space-based chemistry observations of the stratosphere and higher than in the troposphere. In the future more tropospheric measurements are planned, but their numbers will still be lower than those planned for the stratosphere and higher;
- In the troposphere, space-based observations of O3, water vapour, and CO are being made at acceptable levels, but measurements of aerosols, CO2, long-lived source gases, radicals and reservoirs and sinks do not meet the requirements;
- In the stratosphere and mesosphere, many planned missions (GOMOS, HIRDLS, ILAS, MIPAS, MLS, SCIAMACHY and TES), followed by NPOESS, give promise for acceptable measurements, but adequate resolution within 24 hours appears to be a problem (except for HIRDLS).

3. Draft Statement of Guidance for Seasonal to Inter-annual Forecasts

Background

3.1. This statement has been developed through a process of consultation to document the data requirements to support seasonal to interannual prediction. The initial draft was prepared jointly by CCl and CBS. At the ET-ODRR-GOS meeting in April 2001, AOPC was invited to liaise with the broad climate community to develop an update to the draft statement. The present draft statement has been prepared through consultation with the GCOS Panels (AOPC, OOPC and TOPC), WCRP (particularly the CLIVAR program) and WCP. It is expected that the statement will be reviewed routinely to ensure that it remains consistent with the current state of the relevant science and technology.

Introduction

3.2. Coupled atmosphere-ocean models are used to produce seasonal to inter-annual forecasts of climate. Whilst such forecasting is still subject to much research and development, many seasonal forecast products are now widely available. The complexity of the component models range from single baroclinic models to full general circulation model representations of both the ocean and atmosphere. There is also a large variation in the approach to assimilation, with some of the simpler models just assimilating wind information while the more complex models usually assimilate subsurface temperature information and satellite surface topography and temperature data. Indeed, major challenges remain in the development of assimilation techniques that optimise the use of observations in initialising models. At present, useful forecast skill (as measured against ocean and atmosphere indices) is restricted to around 6-8 months lead-time and is largely confined to the tropical Pacific and those regions directly impacted by El Niño.

3.3. The time and space scales associated with seasonal-to-interannual variability (large scale, low frequency) suggest the key information for forecasts will mostly derive from the slow parts of the climate system, in particular the ocean. The initial conditions for the atmospheric model component are not so significant. However, when considering impacts such as rainfall deficiencies or increased temperatures over land, there are often very good reasons for considering variables associated with the land surface conditions.

3.4. Empirical and statistical methods are also used to predict climate conditions a season ahead. However in this document, the assessment of how well observational requirements are met is related to the coupled model inputs only. Historical data sets play an important role in SIA prediction by supporting calibration and verification activities, but this SOG does not address the requirements for historical data sets.

3.5. Comprehensive statements on requirements of AOPC, OOPC, TOPC, WCP, WCRP and CCl have appeared in several places, most recently in the proceedings of *First International Conference on Ocean Observing Systems for Climate*, and published separately in *Observing the Oceans in the 21st Century* (published by the GODAE Office and the Bureau of Meteorology). In terms of key variables, the priorities have changed little since the Tropical Oceans-Global Atmosphere Experiment of 1985-1994. These requirements are being entered into the CEOS/WMO data base. The above references also provide details of ocean-based and space-based platforms capable of meeting these requirements. Further, the report of the IGOS Ocean Theme Team provides a consolidated and integrated perspective for the oceans that embraces SIA forecasts explicitly.

3.6. In this SOG, the requirements for SIA forecasts are based on a consensus of the coupled atmosphere-ocean modelling community, and they represent only those variables that are known to be important for initialising models or for testing and validating models. For the most part, aspects that remain purely experimental are not included. There is some attempt to capture the impacts aspects; that is, those variables that are needed for downscaling and/or regional interpretation.

3.7. The data requirements for each major function (model development, initialisation, and validation) can be somewhat different. For example, integrated data sets, such as blended SST products or atmospheric reanalysis products, are generally more important for validation than for initialisation.

Sea surface temperature

3.8. Accurate SST determinations, especially in the tropics, are important for SIA forecast models. Ships and moored and drifting buoys provide observations of good temporal frequency and acceptable accuracy, but coverage is marginal or worse over large areas of the Earth. Instruments on polar satellites provide information with global coverage in principle, good horizontal and temporal resolution and acceptable accuracies, except in areas that are persistently cloud-covered (which includes significant areas in the tropics). Geostationary imagers with split window measurements are helping to expand the temporal coverage by making measurements hourly and thus creating more opportunities for finding cloud-free areas and characterising any diurnal variations (known to be to up 4 C in cloud free regions with relatively calm seas). Microwave measurements provide acceptable resolution and accuracy and have the added value of being able to "see through" clouds. Blended products from the different satellites and *in-situ* data can be expected to be good for SIA forecasts.

Ocean wind stress

3.9. Ocean wind stress is a key variable. Current models use winds derived from NWP, from specialist wind analyses or, in some cases, winds inferred from atmospheric models constrained by current SST fields. The tropical moored buoy network has been the mainstay for surface winds over the last decade, particularly for monitoring and verification, providing both good coverage and accuracy in the equatorial Pacific. Fixed and drifting buoys and ships outside the tropical Pacific provide observations of marginal coverage and frequency; accuracy is acceptable.

3.10. Satellite surface wind speed and vector measurements are potentially an important source. Currently their data reaches SIA models mostly through the assimilated surface wind products of NWP, where their positive impact is acknowledged. Overall, a two-satellite scatterometer system, or its equivalent, would provide good coverage and acceptable frequency, and it would complement the ocean-based systems. At this time, continuity and long-term commitment are a concern. Irrespective of these issues, improved integration of the data streams and operational wind stress products from NWP and other sources will be needed to achieve acceptable or better coverage, frequency and accuracy.

Subsurface temperature and salinity profiles

3.11. Many, but not all, SIA forecast models assimilate subsurface temperature data, at least in the upper ocean (down to ~500 m depth). No current model assimilates salinity data (subsurface or surface), principally because of the paucity of data and inadequate knowledge of the variability. The Tropical Atmosphere Ocean (TAO) moored buoy network provides data of good frequency and accuracy and acceptable spatial resolution for the tropical Pacific, at least for the current modelling capability. The tropical moored network in the Atlantic (PIRATA) is better than marginal but does not yet have the long-term resource commitments to be classified as acceptable. There is no array in the Indian Ocean. The Ships-of-Opportunity Programme (SOOP) provides data of acceptable spatial resolution over some regions of the globe but the temporal resolution is marginal. It is noted that SOOP is evolving to provide enhanced temporal resolution along some specific lines. The *Argo* Pilot Project offers the potential for global coverage of temperature and salinity profiles to ~1500 m, mostly with acceptable to good spatial resolution, but only marginal temporal resolution in the tropics. In all cases the accuracy is acceptable for SIA purposes. The complementarity between surface wind and surface topography measurements is important.

Ocean altimetry

3.12. Ocean altimetry provides a measure of the sea surface topography relative to some (largely unknown) geoid (or mean sea surface position) that in turn is a reflection of thermodynamic changes over the full-depth ocean column. In principle, the combination of altimetry, tropical mooring and *Argo* will provide a good system for initialising the thermodynamic state of SIA models. There are currently no operational altimeters. Experimental satellites are providing a mix of data with acceptable accuracy and resolution and data with good spatial resolution (along the satellite tracks) but marginal accuracy and frequency. The "synoptic" global coverage, particularly the tropical beyond the Pacific, is an important attribute.

Surface heat and freshwater flux

3.13. There are a few sites in the tropical ocean where the data on surface heat flux are of some value. At a selected number of sites the accuracy and temporal resolution will be good. NWP products, in principle, have good resolution but the accuracy is marginal. Satellite data provide prospects for several of the components of heat flux, particularly shortwave radiation, but at present none is used on a routine basis for SIA forecasts. Precipitation estimates are important for validation because of the fundamental role of the hydrological cycle in SIA impacts. They also have potential importance in initialisation because of the links to salinity. Experimental satellite data are acceptable for the tropics.

Ocean current data

3.14. No model currently assimilates ocean current data. However, because of the central importance of dynamics and advection, current data are important for testing and validation. For example, experimental fields of surface current for the tropical Pacific and Atlantic are now being produced routinely by blending geostrophic estimates from altimetry with Ekman estimates from remotely-sensed wind observations. Drifting buoys are acceptable in terms of accuracy and temporal resolution but marginal in spatial coverage (only the surface). Moored buoys are good in temporal coverage and accuracy, but marginal otherwise.

Sea level

3.15. *In-situ* sea level measurements provide an additional time-series approach (good temporal resolution and accuracy; marginal spatial coverage), particularly for testing models.

Atmospheric data

3.16. Since several SIA systems are driven by operational winds and, in several cases, operational surface heat flux products, the global (atmospheric) observing system is important for SIA forecasts.

Other data

3.17. There are many other data sets that potentially may play a role in future-generation SIA forecasts models. Because these roles are largely unknown, it is premature to discuss the adequacy of observing systems to meet these needs. In no case are they expected to rank near the above data in terms of priority. These include:

- Surface salinity (particularly from new space-based approaches). No present model uses surface salinity.
- Snow cover. Research suggests snow cover may be important, particularly at short lead times (intraseasonal-to-seasonal). No current model ingests snow cover data or uses it for impacts or applications.
- Ice cover. Ice cover is important for the global properties of the global atmospheric climate model. It is implicitly included in most SST products.
- Soil moisture and terrestrial properties. Research suggests proper initialisation of soil moisture can be important. There are also some indications that terrestrial properties may be important, particularly in downscaling and impacts/applications.
- Ocean colour. Ocean transparency is already included in several ocean models and is thought to be a factor in SIA models. Ocean colour measurements provide a means to estimate transparency.

- Clouds. Poor representation of clouds remains a key weakness of most SIA models. Better data are needed to improve parameterisations but these needs are adequately specified under NWP and elsewhere.

Summary

3.18. The following key points summarise the SOG for Seasonal to Interannual forecasts:

- The requirements for seasonal-to-interannual modelling and forecasts are now entered in the CEOS/WMO data base (as well as available in several GCOS and WCRP documents; see paragraph 5);
- The WCRP has concluded that models show useful skill in predicting variability of the El Niño-Southern Oscillation but there is less useful predictability beyond the Pacific. The exploitation of skill is dominated by the signal of El Niño;
- Integrated and complementary approaches to the atmospheric and oceanic observing systems is required, exploiting synergies with other areas;
- The continuation of the TOGA Observing System (SST and winds; subsurface temperature; sea level and currents) provides the backbone of the system in place today;
- Enhancements from satellite wind vector and surface topography estimates, from new autonomous instruments such as *Argo*, and from enhanced surface flux reference sites will be a substantial contribution.

3.19. The key observational problems affecting improvements in seasonal to inter-annual forecasting are:

- The transition of research networks and outputs to operational status;
- The timely operational acquisition of data from research and non-governmental systems/sources;
- The lack of long-term commitment to
    - a two-satellite scatterometer system,
    - tropical moored arrays in the Atlantic and Indian Oceans,
    - operational satellite altimetry,
    - a network of surface flux reference sites.

ANNEX V

Actions

(1) Update description of satellite part of GOS (as defined in the GOS regulatory material) well before the next CBS (J. Eyre, April 02).

(2) Update WMO/TD 1040 (by Jul 02) through CIMO input (D. Lockett), JCOMM (E. Charpentier), and broader community (P. Menzel) within an agreed structure. Structural points to be considered include

- for each technology, use a standard structure that presents (a) what is measured and how, (b) performance: space and time resolution, accuracy, etc., (c) development status and future prospects, (d) costs, if known;
- present in a logical order (e.g. radiosondes before ASAPs);
- avoid technology names (and websites) which are too mission-specific, although these could be added as examples;
- avoid comments on user requirements (out of place here);
- avoid nation-specific points where possible;
- try to be reasonably comprehensive – check for consistency with technologies represented in the database;
- where possible, indicate an expert point of contact on each technology;
- update regularly.

(3) Review Annex III recommendations and summary for an evolved GOS with a broader expert community (All, Jul 02).

(4) Identify challenged regions for different components of the GOS, especially the *in situ* component (H. Boettger, Jul 02).

(5) Request that the NWP centres consider an OSE to justify higher frequency of AMDAR profiles.

This would involve comparison of two types of forecasts, one in which the frequency of ascent/descent profiles at a given airport is the maximum available and the other in which the frequency is limited to one every 3 h (J. Pailleux and H. Boettger, Jul 02). EUCOS would arrange a special observing period (J. Caughey).

(6) Review data base to assure that capabilities of Aura and other new developments for making measurements useful to atmospheric chemistry are present; thereupon iterate the Atmospheric Chemistry SoG (J. Gille; Jul 02).

(7) Update Ocean user requirements and the associated SoG after discussion with ocean community (E. Charpentier, H. Kurawara, Jul 02)

(8) Climate representatives draft a short list of application areas within climate that could be addressed by the RRR process (V. Vent-Schmidt, Jul 02).

(9) Review data base of user requirements and observing system capabilities in all SoGs to assure that current data are correct (All, Jul 02).

(10) An ad hoc committee (J.Pailleux, N Sato, H Boettger, J Eyre, and T. Schlatter) begin to plan the next NWP OSE and Implications for GOS Workshop (Feb 02).

(11) Begin assembling a draft of a summary table of past OSEs and their main results (J Pailleux, Jul 02).