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UPDATE ON THE IMPLEMENTATION PLAN

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Summary and Purpose of Document

This document updates the draft implementation plan for an evolved Global Observing System that was drafted at the last ET-ODRRGOS meeting in November 2003.

ACTION PROPOSED

The meeting is invited to take the information contained in this document, into account during its discussion about drafting an implementation plan for redesign of the Global Observing System.

Evolution of the GOS: Implementation Plan

Implementing the Recommendations for Evolution of GOS in general

This section for Evolution of the GOS in general has been added to the text of the draft Implementation Plan (Annex IV, Report of ET-ODRRGOS 6th session, Nov 2003).

High-Priority General Recommendations

Interaction between NWP centres, data providers and users

1. *Data assimilation and modeling capabilities have grown and are under constant development to make optimal use of current and future observing systems. NWP centres require*

· *early (advance) information about new data types ;*

· *early access to test data and observations during the cal/val phase to prepare for the operational use of the data*

· *information on the characteristics of the data and products (e.g. AMVs which may be representative of atmospheric layers rather than just one levelover layers).*

Action: ET-ODRRGOS through OPAG-IOS chair and CBS/CGMS to encourage data producers to provide metadata on observations and observing systems. (NWP OSE workshop, Alpbach 2004)

2. *Research satellites provide valuable data for NWP, which should be made available in a timely fashion. Research satellite data provide NWP centres with an excellent opportunity to prepare for new satellite data streams, which will become part of the operational global observing system. Effective learning of how to make use of new data types can best be achieved through operational use of any experimental data streams.*

Action: ET-ODRRGOS through OPAG-IOS chair and CBS/CGMS to encourage operators of RD satellites to provide early acces to observations. (NWP OSE workshop, Alpbach 2004)

3. *The requirements for early delivery and frequent updates of forecast guidance have evolved over recent years. NWP centres have significantly reduced their data cut-off times at the expense of available observations in their data assimilation processes. Timeliness requirements for observational data are becoming more stringent for NWP centres. HH + 20 to 90 minute data cut-off times are currently applied for many NWP short-range runs. Late data can only be assimilated in update runs with long data collection times (several hours). Within the next few years, a data processing and delivery time of approx 20 to 30 minutes is expected to be the operational requirement used in medium and short-range forecasts. Any minute gained is useful because observation arrival drives the rest of the forecast production chain.*

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

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

Starting from the text of the space-based section of the draft Implementation Plan (Annex IV, Report of ET-ODRRGOS 6th session, Nov 2003), comments have been added, in italics, concerning progress against the "Next Action". In most cases, the Next Action was to refer the issue to CGMS and/or to the WMO Consultative Meeting on High Level Policy on Space Matters (CMHLPSM). The Report of CGMS-XXXI states, in general (p.28), "with regard to

the recommendations for the space-based component of the GOS, many of the next actions for implementation will rely on the WMO Space Programme to take them up with space agencies, via CGMS and WMO CMHLPSM". Some of the Next Actions were addressed explicitly by CGMS, and these are recorded below. [Further input needed from ET-ODRRGOS participants who attended either of these meetings.]

The GCOS Implementation Plan has also been studied. The actions in it referring specifically to the space-based component of the GOS have been identified and are listed in the GCOS Annex after the space-based section. Cross-references between actions in the GCOS Implementation Plan and actions in the draft GOS Implementation Plan are noted below against relevant items.

Calibration

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

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

CGMS-XXXI discussed both GCOS Climate Monitoring Principles and inter-calibration of visible sensors. Status re link between the two and re GEO IR sensors is not clear. Update requested from those present at CGMS. Calibration workshop to be held 2nd half of 2004(?). Note link to GCOS IP Action C7

GEO satellites

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

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

CGMS Action 31.36 requests satellite operators to report on plans to achieve the goal that all geo imagers should be upgraded to at least the level of SEVIRI by 2015. Discussed also at WMO CMHLFSM?

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

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

CGMS Action 31.36 requests satellite operators to report on plans to achieve the goal that frequent IR sounding should be made by high resolution spectrometers by 2015. Discussed also at WMO CMHLFSM?

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

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

Check status of this action: was it discussed at CGMS or WMO CMHLFSM?

LEO satellites

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

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

Status: EARS data now available with delay of <30 min; used operationally at some NWP centres and planned at others. NPOESS plans consistent with this (tbc). Plans for NPP to be checked. Plans for other programmes? Discussed at CGMS and/or WMO CMHLFSM?

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

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

This is now the subject of a permanent action of CGMS. Suggest next actions are: to define what a satisfactory outcome would be, and to report progress towards achieving it.

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

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

CGMS Action 31.35. CGMS to request that the Windsat Coriolis evaluation be performed in a manner similar to AIRS as a matter of urgency. Discussed also at WMO CMHLFSM? Windsat data starting to be made available for assessment. Note link to GCOS IP Action A13.

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

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

Check status of this action: was it discussed at CGMS or WMO CMHLFSM? Note link to GCOS IP Action O14.

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

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

Check status of this action: was it discussed at CGMS or WMO CMHLFSM? Note link to GCOS IP Action A26

R&D satellites

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

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

Check status of this action: was it discussed at CGMS or WMO CMHLFSM?

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

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

Check status of this action: was it discussed at CGMS or WMO CMHLFSM? Note link to GCOS IP Action A8.

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

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

Check status of this action: was it discussed at CGMS or WMO CMHLFSM? Developments: CHAMP data available to some centres but not in NRT. Good progress in planning for NRT distribution of METOP/GRAS and COSMIC data. GPSOS cut from NPOESS.

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

CGMS Action 31.37: EUMETSAT, NESDIS and WMO to prepare a paper on the International Geostationary Laboratory (IGL) that would be a joint undertaking to provide a platform for demonstrations from geo orbit of new sensors and capabilities.

CGMS Action 31:38: ESA to report on activities related MW sounder from geo orbit.

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

instruments is unlikely to be adequate for salinity in coastal zones and soil moisture on the mesoscale.

Note link to GCOS IP Action O18

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

Note link to GCOS IP Action O24

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

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

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

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

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

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

Check status of this action: was it discussed at CGMS or WMO CMHLFSM?

GCOS Annex. From GCOS Implementation Plan

Actions specifically relevant to evolution of the space-based component of the GOS are noted below.

Cross-cutting

C7 Develop plans for operations to contribute to climate monitoring through adherence to GCOS Climate Monitoring Principles as extended specifically to satellite operations.

C8 Ensure continuity and overlap of key satellite sensors; recording and archiving of all satellite meta-data; maintaining currently adopted data formats for all archived data; providing data service systems that ensure accessibility; undertaking reprocessing of all data relevant to climate for inclusion in integrated climate analyses and re-analyses.

Atmosphere

A8 (Concerning precipitation observations) Ensure stable operation of relevant operational satellite instruments (SSM/I, AMSU, geostationary infra-red) and support transfer to operations of critical research instruments (AMSR, TRMM/GPM instruments).

A13 Ensure continuous operation of satellite scatterometer observations. [Note: It is not clear from the GCOS IP report that they have recognised the planned contribution of ASCAT on METOP]

A22 Continuing system of satellites providing specific microwave radiance data following the GCOS Climate Monitoring Principles.

A23 Develop an agreed plan for a network of ground-based GPS receivers and associated data processing, standards and protocols, and data management. [Note: This appears under “upper-air water vapour”. There is no equivalent statement under “upper air temperature” concerning GPS radio occultation data.]

A24 (Concerning cloud properties) Ensure continuation of ISCCP record of visible and infra-red radiances and include additional data streams as they become available.

A25 Research to improve cloud property observations in three dimensions.

A26 Ensure continuation of Earth Radiation Budget Observations.

Ocean

O8 IGOS-P Ocean Theme Team to publish update of the Ocean Theme and, as appropriate, restating the satellite requirements and explicitly noting requirements for climate.

O11 (Concerning SST) Ensure a continuous mix of polar orbiting and geostationary IR measurements combined with passive microwave coverage and the comprehensive in-situ networks.

O14 (Concerning sea level) Ensure continuous coverage of one high-precision and two lower-precision but high-resolution altimeters.

O18 (Concerning sea surface salinity) Research programmes to demonstrate feasibility of utilizing satellite data to help resolve global fields of SSS.

O20 (Concerning ocean colour) Implement plans for a sustained and continuous deployment of satellite sensors and research and analysis.

O24 (Concerning sea ice) Ensure sustained satellite (SAR, microwave, visible and IR) operations; …

Terrestrial

T13 Obtain integrated analyses of snow cover in both hemispheres.

T16 (Concerning glaciers and ice sheets) Ensure continuity of current space-borne cryosphere missions.

T20 (Concerning albedo) Test prototype algorithms to retrieve the directional hemispherical reflectance factor (or black sky albedo) from geo satellites on a daily and global basis.

T21 Obtain in situ cal/val measurements and co-located albedo products from all satellite operators generating such products.

T22 Identify most appropriate satellite-derived albedo for specific climate models.

T23 Implement processing chains to retrieve the directional hemispherical reflectance factor (or black sky albedo) from geo satellites on a daily and global basis from archived and current satellite data.

T27 (Concerning land cover) Commitment to continuous 10-30 metre resolution optical satellite systems with data acquisition strategies at least the equal of the Landsat 7 mission.

T31 fAPAR and LAI products to be made available as gridded products at 250m–1km resolution.

T32 (Concerning fAPAR) Establishment of a cal/val network of in situ observing sites (reference sites).

T33 Evaluate the various LAI satellite products and benchmark against ground truth to arrive at an agreed operational product.

T36 (Concerning fire disturbance) Re-analysis of historical satellite data, 1982-present.

T37 Continued generation of active fire and burnt area products.

T38 (Concerning fire disturbance) Apply CEOS<WGVCV and GOFC-GOLD validation protocol.

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

Starting from the text of the surface-based section of the draft Implementation Plan (Annex IV, Report of ET-ODRRGOS 6th session, Nov 2003), comments have been added, in italics, concerning progress against the "Next Action". Two new recommendations (5 and 6) have been added.

Data coverage, distribution and coding

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

Note: OSE-1 provided justification for this recommendation.

Next Actions: (for SYNOPs (land and marine), buoys, profilers): WMO Members to implement this recommendation at the earliest possible date, no later than Nov 2005. (for AMDAR): See 10-12 below. The benefit of this implementation will be more rapid development.

2. Observational data not yet centrally collected but potentially useful in NWP should be exchanged internationally. These observations include high-resolution radar measurements (both reflectivity and radial winds, where available) to provide information on precipitation and wind, surface observations, including those from local or regional mesonets, wave buoys. WMO Members in regions where these data are collected should make them available via WMO real time information systems.

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

Note: Despite the overwhelming volume of satellite data, surface data (in particular surface pressure) over sea remain a requirement to anchor the pressure field. Surface data are

important not only in global NWP, but also for regional NWP. The impact of surface pressure and wind data was addressed in several OSEs presented at the NWP OSE Workshop, Alpbach, 2004. A large negative impact was found when surface pressure data were removed. There is no alternative equivalent source of observations available. Good quality surface pressure observations are of particular importance over the oceans. Surface pressure observations from ships only, in the presence of surface wind data, manage to recover much of the forecast skill lost when surface pressure observations are removed. It was concluded from high-resolution (T511) experiments that surface observations over sea and land are still a very important component of the GOS. Their impact can be seen at all forecast ranges (very systematic during the first 72 hours) and in all seasons, with the largest impact in summer. Data from buoys and ships are of crucial importance synoptically.

3. All data sources should be accompanied by good documentation including metadata, careful QC, and monitoring.

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

4. Appropriate coding standards should be used to assure that the content (e.g. vertical resolution) of the original measurements, sufficient to meet the user requirements, is retained during transmission. Some current coding/formatting standards in the character codes degrade potentially useful information in meteorological reports. (Example (1) lost information at various levels in a rawinsonde sounding in the TEMP code could be retained in the BUFR code. Example (2) the vertical sounding taken over some 90 minutes and displaced from the starting position could be complemented by position and time information for each data point). The NWP OSE workshop (Alpbach, 2004) reiterated the need for a timely distribution of radiosonde observations in BUFR with all observation points included in the message together with the time and the position of each data point; information on instrument calibration prior to launch and information on sensor type and sub-sensor type is also required.

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

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

5new. Regional forecasting systems require a comprehensive and uniform coverage with at least 12-hour frequency of temperature, wind, and moisture profiles over continental areas and coastal regions. The radiosonde network still plays an important role in meeting this requirement. *(NWP OSE workshop, Alpbach, 2004)*

Action: ET-ODRRGOS through OPAG-IOS chair and CBS to ensure that operators and managers of regional observing systems are made aware of these requirements.

6new. OSE results on the usefulness of stratospheric observations should be consolidated and requirements for a stratospheric global observing system should be refined (need for radiosondes, radiances, wind data, humidity data, noting the availability and required density of existing data sources, including GPS sounders, MODIS winds and other satellite data). *(NWP OSE Workshop, Alpbach, 2004)*

Action: ET-ODRRGOS to initiate a study for the design of a consolidated and integrated stratospheric observing system

Broader use of ground based and in situ observations

7. Calibration of measurements from satellites depends on using ground-based and *in situ* observations, such as ozone profiles from sondes. Near real-time distribution of ozone sonde data is required for calibration and validation of newly launched instruments and for potential use in NWP. [Joint ECMWF / WMO expert team meeting on real time exchange of ground based ozone measurements, ECMWF, 17-18 October 1996, *NWP OSE Workshop, Alpbach, 2004*]

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

Moving towards operational use of targeted observations

8. Transfer into operations the proven methodology of observation targeting to improve the observation coverage in data sensitive areas. This concept is in operational use at the US Weather Service in the northeastern Pacific during the winter storm period. EUCOS conducted a field experiment in the Atlantic October-December 2003, in the context of a THORPEX study. Further EUCOS experiments are planned. Designated major operational centres should share the responsibility for determining the target areas. [FASTEX results and Toulouse report, *NWP OSE workshop, Alpbach, 2004*]

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

High Priority System Specific Recommendations

Optimization of rawinsonde launches

9. Optimize the distribution and the launch times of the rawinsonde sub-system (allowing flexible operation while preserving the GUAN network and taking into consideration regional climate requirements). Examples include avoiding duplication of Automated Ship-borne Aerological Program (ASAP) soundings whenever ships are near a fixed rawinsonde site (freeing resources for observations at critical times) and optimizing rawinsonde launches to meet the local forecasting requirements. [EUCOS Studies, OPAG IOS Chairman]

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

Development of the AMDAR programme

10. AMDAR technology should provide more ascent/descent profiles, with improved vertical resolution. A good way to accomplish this is to extend the AMDAR

programme to short-haul commuter flights, business aviation, and airfreight. Emphasis should be to expand into areas where vertical profile data from radiosondes and pilot balloons are sparse a well as into times that are currently not well observed such as 11 pm to 5 am local times. [Toulouse report, ECMWF northern hemisphere AMDAR impact study, OSEs 4, 5, 8]

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

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

11. AMDAR coverage is both possible and sorely needed in several currently data-sparse regions, especially Africa and South America, Canadian arctic, northern Asia and most of the world's oceans. More T, U/V, Q profiles, but especially winds, are needed in the tropics Moreover, the timing and location of reports, whose number is potentially very large, can be optimized while controlling communications costs. The recommendation is to optimize the transmission of AMDAR reports taking into account, en route coverage in data-sparse regions, vertical resolution of ascent/descent reports, and targeting related to the weather situation. [Toulouse report, ECMWF northern hemisphere AMDAR impact study, *NWP OSE Workshop, Alpbach, 2004*].

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

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

12. Lower-tropospheric water vapour measurements are vital in many forecast applications. To supplement the temperature and wind reports from AMDAR, the further development and testing of water vapour sensing systems is strongly encouraged. Example: WVSS-2 employs a laser diode to measure the absorption by

water vapour of energy in the laser beam over a short path length. This is an absolute measurement of water vapour content that is expected to be accurate from the ground to flight altitudes. [Toulouse report, NWP OSE workshop, Alpbach, 2004]

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

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

Tropospheric Aircraft Meteorological Data Reporting (TAMDAR)

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

Note: EUCOS Programme Plans are very relevant here, NWP OSE workshop, Alpbach, 2004.

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

14. *Ground based GPS*12. Develop further the capability of ground-based GPS systems for the inference of vertically integrated moisture with an eye toward operational implementation. Ground based GPS processing (ZTD and PW, priority for ZTD) should be standardized to provide more consistent data sets. Data should be exchanged globally. The coordination of geodetic data between the GPS processing centres is required. Such observations are currently made in Europe, North America and Asia. It is expected that the global coverage will expand over the coming years.

Note: The COSNA/SEG, NAOS, JMA reports provide useful background information, NWP OSE workshop, Alpbach, 2004.

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

Regarding improved observations in ocean areas

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Improved observations over tropical land areas

21. Enhance the temperature, wind and if possible the humidity profile measurements (from radiosondes, pilots and aircraft) in the tropical belt, in particular over Africa and

tropical America. There is evidence from recent impact studies with the radiosonde/pilot balloon network over the Indonesian/Australian region that such data give a better depiction of winds in the tropics and occasionally strongly influence the adjacent mid-latitude regions. [OSE-5]

Action: (see AMDAR plans)

New Observing Technologies

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

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

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

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

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

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

Additional Recommendation for Evolution of the GOS

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

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

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