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ON INTEGRATED OBSERVING SYSTEMS

ITEM: 5

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

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REVIEW OF RECOMMENDATIONS FOR EVOLUTION OF SURFACE AND SPACE-BASED COMPONENTS OF THE GOS

(Submitted by the Chairman)

Summary and Purpose of the Document

The January 2002 session of the Expert Team drafted specific recommendations regarding the evolution of surface-based and space-based components of the GOS. The document consists of a reproduction of Annex III from the Final Report of that meeting

ACTION PROPOSED

The Expert Team is invited to review and edit the recommendations for evolution of the GOS as necessary

(ANNEX III from ET ODRRGOS-4 (Jan 02) Final Report)

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 characterising 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 co-ordinated 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 centres 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

Optimisation of rawinsonde launches

5. Optimise 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 rawinsonde 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 optimised while controlling communications costs. The recommendation is to optimise 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 Flight level data Vertical profiles of humidity	Increase coverage, increase vertical resolution Extend programme to short-haul, commuter and freight flights Study feasibility of adaptive use, demonstrate the need for high frequency data, in particular over Africa, South America 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