CGMS

CGMS-36 WMO-WP-18
v1, 3 October 2008
Prepared by WMO
Agenda Item: E.2
Discussed in Plenary

CGMS RELATED RECOMMENDATIONS OF THE IMPLEMENTATION PLAN FOR EVOLUTION OF THE GOS

The paper presents a report on the actions within the Implementation Plan for Evolution of the GOS (IP-EGOS) that are relevant to CGMS. CGMS is invited to consider these actions and take them into account in future planning.

Actions proposed: CGMS consider and discuss the actions of the IP-EGOS relevant to CGMS.

CGMS RELATED RECOMMENDATIONS OF THE IMPLEMENTATION PLAN FOR EVOLUTION OF THE GOS

1 BACKGROUND

The "Implementation Plan for the Evolution of the Space and Surface-based Sub-systems of the GOS" (IP-EGOS) was developed following the adoption by CBS Ext.02 of a Vision for the GOS to 2015.

In 2005, CBS-XIII endorsed the IP-EGOS. It was subsequently published as WMO TD No. 1267.

The IP-EGOS currently contains a set of about 50 recommendations, each with corresponding comments on progress and accompanying actions. There is a set of recommendations for the surface-based sub-system of the GOS and a set for the space-based sub-system of the GOS.

There are 22 specific recommendations for the space based portion. Some of the surface based recommendations are relevant to satellite operators as they are complimentary to satellite based observing.

Maintaining and updating the Implementation Plan for Evolution of the GOS (EGOS-IP) is the responsibility of the CBS OPAG-IOS Expert Team on Evolution of the GOS (ET-EGOS).

At each ET-EGOS meeting, IP-EGOS is reviewed and updated, as a record of progress against the original plan distributed to Members. Updates have taken account of feedback from many sources including: CGMS, AMDAR Panel, JCOMM, GCOS, other IOS ETs, WMO Regional representatives, and WMO Members via the newly-created National Focal Points (NFPs).
The latest version of the EGOS-IP, updated at ET-EGOS-4, may be accessed over Internet at http://www.wmo.int/pages/prog/www/OSY/GOS-redesign.html

2 DISCUSSION

2.1 The current version of the Implementation Plan has been prepared by the WMO CBS OPAG-IOS Expert Team on the Evolution of the Global Observing System (ET-EGOS), formerly the Expert Team on Observational Data Requirements and Redesign of the Global Observing System (ET-ODRRGOS) with input from the WMO CBS OPAG-IOS Expert Teams on Satellite Systems and on Satellite Utilization and Products as concerns the space-related aspects.

The scope and assumptions of the IP are as follows:

It addresses both surface-based and space-based sub-systems of the GOS.
It responds to observational requirements of all WMO programmes to which the GOS might reasonably be expected to contribute.
It responds to a vision of the GOS in 2015 and beyond as set out in section 5 of the plan.

It envisages that the future GOS will build upon existing sub-systems, both surface- and space-based, and will capitalize on existing and new observing technologies not presently incorporated or fully exploited. Each incremental addition to the GOS will be reflected in better data, products and services from the National Meteorological and Hydrological Services (NMHSs).

It responds to those elements of the GCOS Implementation Plan which call for action by WMO Members (through CBS) or by the WMO Space Programme. (A cross-check between the GCOS Implementation Plan and this IP has been performed.)

It takes note of the GAW Strategic Implementation Plan but does not attempt to duplicate its actions.

It does not explicitly express the need for aspects of continuity of current observing systems – it is concerned primarily with evolution rather than continuity. However it is recognized that aspects of continuity of observing systems are of key importance for many applications, including operational weather forecasting and climate monitoring.

It recognizes the special challenges and issues concerning developing countries.

2.2 A new "Vision for the GOS to 2025" was presented in Plenary under Agenda Item D and should have been discussed and subsequently endorsed by CGMS at that time. The version proposed for adoption by CBS was presented as an annex to that paper.

2.2 Assuming that the new "Vision for the GOS to 2025" is adopted by CBS, a new version of the EGOS-IP will be required in response to the new "Vision".

2.3 Annex 1 provides satellite specific recommendations and actions from the current space-based part of IP-EGOS. Actions of direct interest to CGMS are in bold face type.

2.4 Annex 2 provides some items from the surface-based part of IP-EGOS of interest to CGMS. That section in the IP-EGOS is entitled "NEW ACTIONS TO BE ADDED BASED ON NEW REQUIREMENTS SPECIFIED IN SEVERAL APPLICATION AREAS".

3. ACTION

CGMS consider and discuss the actions of the IP-EGOS relevant to CGMS.

ANNEX 1

Extract from Section 3 of the implementation plan for evolution of the surface and space-based sub-system of GOS, items with CGMS action requested or implied.

A balanced GOS - Concern 1 - LEO/GEO balance

There has been commendable progress in planning for future operational geostationary satellites. In addition to the plans of China, EUMETSAT, India, Japan, Russian Federation and USA, WMO has been informed of the plans of the Republic of Korea to provide geostationary satellites. The Republic of Korea has made a formal declaration to WMO and is now considered part of the space-based component of the GOS. These developments increase the probability of good coverage of imagery and sounding data from this orbit, together with options for adequate back-up in case of failure. On the other hand, current plans for LEO missions are unlikely to fulfil all identified requirements. It would be timely for the WMO Space Programme and/or CGMS to study the balance between polar and geostationary systems and to advise if there is scope for optimizing this balance between the two systems in the long-term.

Progress Jul 08: The optimal use of the GEO-LEO complementarity is one aspect of the optimization and re-design of the space-based observing system initiated in 2006.

The first optimization workshop has reviewed the planned locations of geostationary satellites and proposed to take advantage of additional satellite capabilities to increase robustness of the geostationary constellation.

Next Actions Jul 08: To bear in mind the desirable balance between GEO and LEO components in future global planning activities.

A balanced GOS - Concern 2 - Achieving complementary polar satellite systems

While no single satellite operator can provide all the LEO satellite missions needed to fulfil WMO requirements, this would be achievable through sharing of responsibility, investment and expertise among the various WMO Members contributing to the GOS, provided that the individual programmes of agencies can contribute to a globally planned system in a complementary fashion. Through this process, the goals of GEOSS could be greatly advanced. WMO Space Programme Office is encouraged to facilitate this process in fostering the development of an agreed vision of the future GOS, addressing any obstacles to progress, and identifying opportunities for international partnerships, an example of which is the NOAA-EUMETSAT Joint Polar System.

Progress Jul 08: Following the two optimization workshops held in 2006 and 2007 the development of a new vision for the GOS to 2025 is well underway.

Next actions Jul 08: To refine and adopt a new vision for the GOS in 2025 that would provide guidance on how individual agencies' plans can best contribute to a globally optimized system in a complementary fashion.

Calibration

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

Comment: A major issue for effective use of satellite data, especially for climate applications, is calibration. GCOS Implementation Plan (GIP) Action C10 calls for continuity and overlap of key satellite sensors. The advent of high spectral resolution infrared sensors (AIRS, IASI, to be followed by CrIS) enhances the possibilities for accurate intercalibration. As regards visible channels, MODIS offers very comprehensive onboard shortwave solar diffuser, solar diffuser stability monitor, spectral radiometric calibration facility, that can be considered for inter-comparison with geosynchronous satellite data at visible wavelengths. MERIS appears to have merit in this area due to its programmable spectral capability, if implemented. GOES-R selected ABI channels have been selected to be compatible with VIIRS on NPOESS. This only deals with optical sensors, and other sensor types (e.g., active, passive, MW) should be considered. The Global Space-based Inter-Calibration System (GSICS) has been established to ensure comparability of satellite measurements provided through different instrum ents and satellite programmes and to tie these measurements to absolute references. GSICS activities will ultimately include: regular processing of VIS-IR-MW radiances from co-located scenes of GEO and LEO satellites, with common software tools as well as: pre-launch instrument characterization; on-orbit calibration against on-board, space or earth-based references; calibration sites and field campaigns; radiative transfer modelling.

Progress Jul 08: CMA, CNES, EUMETSAT, JMA, KMA, NASA, NIST and NOAA are joining their efforts in GSICS. LEO to LEO intercalibration is performed on a routine basis by NOAA. A common procedure has been developed in order to perform GEO to LEO IR intercalibration in a similar way for each geostationary satellite. Hyperspectral sensors such as MODIS and IASI are taken as references in order to account for differences
in Spectral Response Functions of the various broadband instrument channels.
Results are available on a routine basis through the GSICS website (http://www.wmo.int/pages/prog/sat/Calibration.html).

Next Action Jul 08: To pursue the implementation of GSICS with the expectation that GEO to LEO IR intercalibration becomes fully operational at global scale in 2009, and then extended to visible channels.

S2. GEO Imagers - Imagers of future geostationary satellites should have improved spatial and temporal resolution (appropriate to the phenomena being observed), in particular for those spectral bands relevant for depiction of rapidly developing small-scale events and retrieval of wind information.

Progress Jul 08: The following geostationary satellite operators have reported at CGMS that they will have at least SEVIRI-like capability before 2015: EUMETSAT (present), Russian Federation (2008). By 2015, future generation satellites should provide further improved imaging capabilities: GOES-R (NOAA), MTSAT-FO (JMA), FY-4-O (CMA) and MTG (EUMETSAT).

Next Actions Jul 08: WMO Space Programme will continue discussions with space agencies, via CGMS; IMD plans need clarification.

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

Comment: Infrared hyperspectral sensors should be required on all operational geostationary satellites as a high priority for meeting existing user requirements in numerical weather prediction (NWP), nowcasting, hydrology and other applications areas. Based on the experience gained from classical IR sounding from GEO satellites and from hyper-spectral Infrared sounding from LEO satellites, hyper-spectral sensors on GEO satellites are expected to enable a breakthrough, in particular for regional and convective-scale NWP; it would help to overcome current limitations of rapidly evolving severe weather forecasting.

In addition, in order to ensure a timely and optimal preparation of the user community, to optimize the positive impact of this new instrument type, and as a risk reduction measure to refine the specifications of the relevant operational ground segments, it would be very useful to proceed with a preparatory mission in advance of the operational flights.

Progress Jul 08:

- CMA has plans for its FY-4/Optical series by 2014; EUMETSAT has included IRS in the Phase A baseline for the MTG sounder series planned for launch around 2017; NOAA is re-considering options for a hyperspectral sounding instrument on GOES-R series; JMA is exploring the possibility of such development for MTSAT-Follow-on.

- The CEOS Strategic Implementation Team has agreed an action to WMO to seek confirmation of plans for geostationary hyperspectral sounders on MTG and FY-4-O, by end 2008, and GOES-S and MTSAT-FO, later (Action WE-06-02_4).

- The US prototype instrument GIFTS is available and could be used for a preparatory mission if funding could be identified to upgrade the current engineering unit to the status of pre-operational space qualified instrument.

- Opportunities for international cooperation on such a demonstration mission are being explored by CGMS in the context of the International Geostationary Laboratory (IGeoLab), noting a flight opportunity for GIFTS on board of the geostationary satellite Elektro-L 2 planned for launch in 2010.

Progress September 08:

JMA informed ET-SAT/SUP that an hyper-spectral sounder is no longer considered for MTSAT follow-on.

Next Actions Jul 08:

- **WMO to encourage geostationary satellite operators to confirm and implement their plans for GEO hyperspectral instruments.**

- **WMO to pursue in the meantime the initiatives towards flying a preoperational hyperspectral sounder in geostationary orbit in advance of 2015, as a preparatory mission, in order to allow risk reduction and optimal benefit of the planned operational missions.**

S4. GEO System Orbital Spacing - To maximize the information available from the geostationary satellite systems, they should be placed "nominally" at a 60-degree sub-point separation across the equatorial belt. This will provide global coverage without serious loss of spatial resolution (with the exception of Polar Regions). In addition, this provides for a more substantial backup capability should one satellite fail. In particular, continuity of coverage over the Indian Ocean region is of concern.

Comment: The nominal configuration of the operational geostationary constellation should guarantee both system reliability and product accuracy. The 5-satellite system that has been maintained through recent years is not sufficient to meet these needs in the long-term.

Progress Jul 08: WMO Space Programme office submitted a proposal to CGMS-35 in November 2007 for a geostationary locations scheme where inter-satellite separation would not exceed 60° longitude, and an action was agreed by satellite operators to review the constraints and flexibility of future geostationary locations.

Next Actions Jul 08: WMO and CGMS satellite operators to explore further the possibility to reduce the maximum longitude separation between future adjacent geostationary satellites.

LEO satellites

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

Comment: There are several avenues to improve timeliness of LEO satellite data. The use of both an Arctic and Antarctic data acquisition station allows the collection of global data with no blind orbit and with a limited on-board storage time. A network of ground stations distributed around the globe such as the NPOESS SafetyNet allows further reducing the latency of global data. A complementary approach is to collect and retransmit direct readout data following the concept of the Regional ATOVS Retransmission System (RARS). For the long-term, the use of Data Relay Satellites can also be considered.

Progress Jul 08: The current goal of the RARS project is to ensure that over 90% of the global ATOVS datasets can be acquired and retransmitted within 30 minutes. The RARS network includes the EUMETSAT EARS, the Asia-pacific RARS and the South-American RARS. Mid 2008, the coverage exceeds 75% of the globe and it is expected to reach 85% in 2009 thanks to planned extensions on Pacific islands, Africa and the Pacific coast of South-America. It is considered to extend the RARS approach to advanced sounders such as IASI, AIRS, and other time-critical data such as ASCAT.

The applicability to IASI data is subject to the reactivation of Metop HRPT, the capability of RARS receiving stations to receive Metop, and the reduction of data volume through eigenvector compression. The FY-3A satellite that was launched in May 2008 includes an IR and MW sounding capability (IRAS, MWTS, MWHS) and a direct readout capability in X-band and L-band (MPT, AHRPT) that could be considered for an extension of the RARS.

After complete implementation of the NPOESS SafetyNet, 80% of NPOESS global data should be acquired within 15 min, which would be consistent with the stated timeliness requirements for NWP, provided that provisions are made for the timely redistribution of these data towards international NWP centres. However the

SafetyNet will not be available for NPP and, by the launch of NPOESS-C1, it would only be partly implemented with McMurdo and Svalbard but not all its 14 stations. Acquiring and distributing sounding data (CrIS, ATMS) from NPP and NPOESS-C1 through a RARS-type arrangement would be a useful gap-filler until data timeliness can be ensured through the SafetyNet. It would enhance the benefit of the NPP and NPOESS missions and minimize the negative impact of phasing out the last ATOVS instruments.

The use of direct broadcast imagery received at high-latitude stations enables derivation of polar winds with optimal timeliness.

Additionally, ERS-2 GOME and scatterometer data are now available in near real time (within 30 minutes) in the coverage region of ESA (e.g., Europe and North Atlantic) and cooperating ground stations (e.g., Beijing and Perth).

Next Actions Jul 08: WMO and the RARS Implementation Group to complete the implementation of the RARS network; to encourage the implementation of similar plans for LEO imagery from high-latitude stations for the timely derivation of polar winds; to consider an extension of the RARS project to include FY-3 sounding data.

WMO and the RARS Implementation Group, in cooperation with the NPOESS Integrated Program Office, to prepare an extension of the RARS project to include NPP and NPOESS sounding data as a gap filling measure until timely availability of this data can be ensured worldwide through the SafetyNet; to consider a possible demonstration step with Aqua/AIRS data.

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

Comment: Coordinated orbital planning for both nominal and contingency situations is a permanent action of CGMS. On one hand, the orbital planes of sun-synchronous operational missions should be distributed to take advantage of the available spacecraft to improve the temporal coverage. On the other hand, Equatorial Crossing Times (ECT) should be stable to ensure homogeneity of long-term climate data records. Following the Re-design and Optimization Workshop in June 2007, a recommended scenario is to maintain the core operational LEO satellites in a 3-orbit configuration, with 4-hour nominal separation between ECT. If two or more satellites can perform comparable missions in the same orbital plan, they should preferably be synchronized and maintained with a phase difference allowing an optimal refresh cycle and ground track separation.

Progress Jul 08: A 3-orbit configuration (13:30, 17:30, 21:30 LST) for core LEO sun-synchronous missions has been proposed as part of the new vision for the GOS in 2025 and discussed with CGMS and CEOS. There are plans for populating these 3 orbits over the coming decades, however the planned missions currently do not include sounding on the early morning orbit. The CEOS Strategic Implementation Team agreed that WMO should propose a plan for operational IR and MW sounding from the early morning orbit.

Next Action Jul 08: To refine the new Vision of the GOS to 2025 with respect to orbital configuration of sun-synchronous operational missions, and discuss its implementation with CGMS and CEOS satellite operators.

S7. LEO Sea Surface Wind - Sea-surface wind data from R&D satellites should continue to be made available for operational use; 6-hourly coverage is required.

Comment: GCOS (GIP, Action A11) calls for continuous operation of AM and PM satellite scatterometers or equivalent. QuikScat scatterometer data have been available to the NWP community since 1999, and will continue through the life of QuikScat (NASA has no current plans for a successor SeaWinds scatterometer). Oceansat-2 has scatterometer capability that may be made available to the world community (this availability needs to be confirmed). The relative performance of the multi-polarisation passive MW radiometry versus scatterometry requires further assessment.

Progress Jul 08: For scatterometry, ERS-2 scatterometer has been followed by ASCAT on METOP, sea surface wind is thus being observed in an operational framework since 2007. There are plans for a scatterometer aboard the Indian Oceansat-2 and the Chinese HY-2 series, although data availability still needs confirmation.

Following the Windsat demonstration mission, early assessments of the microwave imagery polarimetric capabilities to provide information on sea surface wind direction suggest that, while this technology will not be competitive with scatterometry at low wind speed, good information is available at high wind speed.

The revised NPOESS baseline includes a microwave imager/sounder (MIS) expected to provide wind speed and direction information at sea surface starting with NPOESS-C2 in 2016.

A preliminary proposal for an Ocean Surface Wind constellation was presented by NOAA, EUMETSAT and ISRO at the CEOS Strategic Implementation Team and it was agreed to prepare a full proposal.

Next Actions Jul 08: Satellite operators should maintain at least 2 scatterometers and 2 full polarimetric microwave imaging missions in order to achieve both sufficient accuracy and coverage. WMO shall bring this recommendation to the attention of CGMS.

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

Comment: GCOS (GIP, Action O12) requires continuous coverage from one high-precision altimeter and two lower-precision but higher-resolution altimeters.

Progress Jul 08: Jason-1 continues to provide global ocean topography data to the NWP community. Jason-2 was successfully launched in June 2008. ESA has plans for a Sentinel-3 ocean mission that will include an altimeter. Cryosat-2 is planned for 2009, HY-2A in 2010. Jason-2 follow-on funding is still to be confirmed. China has not yet confirmed the availability of HY-2A data for WMO Members, noting that the HY-2A mission is not managed by CMA but by the State Oceanic Administration (SOA). Substantial agreement of the community was achieved on the concept of a constellation for Ocean Surface Topography including at least one reference altimetry mission plus 2 additional altimeter systems on higher inclination to ensure global coverage.

Next Actions Jul 08: WMO Space Programme to continue to work with CGMS Satellite operators and CEOS Constellation on Ocean Surface Topography in order to confirm the plans and ensure continuity of at least one reference altimetry mission plus 2 additional altimeter systems on higher inclination to ensure global coverage.

WMO Space Programme to request China to clarify intentions for sharing HY-2A data.

S9. LEO Earth Radiation Budget - Continuity of ERB type global measurements for climate records requires immediate planning to maintain broadband radiometers on at least one LEO satellite.

Comment: Plans for ERB-like measurements after Aqua remain uncertain. There are also concerns about the continuity of absolute measurements of incoming solar radiation. This is a high priority item for GCOS (GIP, Action A24).

Progress Jul 08: FY-3A and FY-3B will have a prototype Earth Radiation Budget Unit (ERBU) in 2008/2009. NPP in 2010 and possibly the first NPOESS satellite (likely launch in 2013) are expected to carry the CERES instrument. The observation strategy proposed by the GOS Re-design and Optimization workshop, and confirmed by GCOS AOPC, calls upon one LEO broad-band multi-angle viewing radiometer, complemented by collocated cloud properties, aerosol and water vapour measurements, complementary geostationary diurnal cycle information, as well as Total Solar Irradiance measurement. In particular, satellite-derived information on the absorption properties of aerosols are urgently required to better understand the ERB and evaluate the contribution of aerosol radiative forcing.

Next Actions Jul 08: To confirm or refine the recommended observation strategy with support of GCOS and the science community and to work with satellite operators towards its implementation.

R&D satellites

S10. LEO Doppler Winds - Wind profiles from Doppler lidar technology demonstration programmes (such as ADM-Aeolus) should be made available for initial operational testing; a follow-on long-standing technological programme is solicited to achieve improved coverage characteristics for operational implementation.

Progress Jul 08: Plans for ADM-Aeolus demonstration are proceeding with a launch now planned for May 2010; ESA and ECMWF are developing software for processing Doppler winds prior to their assimilation into NWP models; resulting winds will be available on the GTS. Scenarios for a preparatory mission and operational follow on are under consideration. EUMETSAT is considering the requirements for observations of the 3D wind field as part of their planning for post-EPS missions. NASA/GSFC has performed an accommodation study for a Doppler wind lidar on next generation NPOESS.

Next Actions Jul 08: WMO Space Programme will continue to discuss with space agencies, via CGMS and WMO Consultative Meetings on High-level Policy on Satellite Matters, to ensure that the demonstration with ADM-Aeolus can be followed by a transition to operational systems for wind profile measurement. Plans for continuity of a Doppler Winds capability following ADM-Aeolus should be further discussed by CGMS satellite operators in 2008.

S11. GPM - The concept of the Global Precipitation Measurement Missions (combining active precipitation measurements with a constellation of passive microwave imagers) should be supported and the data realized should be available for operational use, thereupon, arrangements should be sought to ensure long-term continuity to the system.

Comment: GCOS (GIP Action A7) requires stable operation of relevant operational satellite instruments for precipitation and associated products.

Progress Jul 08: TRMM continues to provide valuable data for operational use. Early termination of TRMM after 2004 was averted after user community appeals for its continuation. NASA has assured continued operation into 2009. In 2005, ESA's European GPM was not selected as the next Earth Explorer Mission. At the fifth International planning workshop WMO expressed it support and its readiness to facilitate partnerships to expand the GPM constellation. It was recognized that ISRO's Megha-tropiques has a passive microwave capability that is not yet part of the GOS but could be useful in the GPM constellation (availability needs to be confirmed). Other R&D and operational satellites in polar orbit may contribute to the constellation with their microwave radiometers. GPM was addressed at the 6th Consultative Meeting (Buenos Aires, January 2006) and its importance was stressed. The GPM core satellite is now planned for launch in July 2013. Timely implementation of the GPM mission was identified as an action in the GEO work plan. CEOS has created a "Global Precipitation Constellation" initiative in order to coordinate efforts to take advantage of existing instruments while preparing the GPM mission.

Next Actions Jul 08: WMO Space Programme to continue to support initiatives for the timely implementation of GPM.

S12. RO-Sounders - The opportunities for a constellation of radio occultation sounders should be explored and operational implementation planned. International sharing of ground support network systems (necessary for accurate positioning in real time) should be achieved to minimize development and running costs.

Comment: GCOS (GIP Action A20) requires sustained, operational, real-time availability of GPS RO measurements.

Progress Jul 08: SAC-C, CHAMP and COSMIC data have been successfully used in an operational context and the use of METOP/GRAS is starting. NWP OSEs have shown positive impact with small number of occultations. Climate applications are being explored. The GOS Re-design and Optimization Workshop clearly recommended constellations of small satellites with radio-occultation sensors. Upon proposal by WMO, CGMS-34 took an action to explore opportunities for cooperation on ground support network.

Next Actions Jul 08: Within the CEOS Strategic Implementation Team (Apr 08), NOAA agreed to complete by end September 2008 the assessment of requirements needed to perform an OSSE to compare the operational benefits of the various ROS constellation options identified by the WMO Re-design and Optimization Workshop in June 2007. OSSEs would then be undertaken in 2009. **Plan for a constellation providing operational follow-on to COSMIC should be discussed by CGMS.**

S13. GEO Sub-mm for precipitation and cloud observation - An early demonstration mission on the applicability of sub-mm radiometry for precipitation estimation and cloud property definition from geostationary orbit should be provided, with a view to possible operational follow-on.

Progress Jul 08: Geo sub-mm is one of two systems being considered for IGeoLab. A task team evaluated the IGeoLab possibilities for a Geostationary Observatory for Microwave Atmospheric Sounding (GOMAS) as well as other possible instruments. This type of instrument in geosynchronous orbit is high priority for meeting existing user requirements in numerical weather prediction (NWP), nowcasting, hydrology and other applications areas. GOMAS was not accepted by ESA as a core Explorer mission.

Studies on GEO MW have continued in the context of IGeoLab. A GEO MW IGeoLab Focus Group workshop was held in April 2007 in Beijing and made a proposal to CGMS-XXXV to investigate two scenarios, one based on filled aperture antenna and the other based on synthetic aperture antenna. Choice between the two technologies is also linked to the relative priority given to the detection of precipitation and rapid vertical sounding.

Next Actions Jul 08: WMO Space Programme will continue supporting this IGeoLab action and subsequent dialogue with space agencies, via CGMS.

New comment Jul 08: It is planned to convene the IGeoLab GEO MW focus Group in October 2008 in Beijing, during IPWG timeframe. Mission requirements for a Phase A study of a microwave sounder on FY-4M will be discussed.

S14. LEO soil moisture and ocean salinity - The capability to observe ocean salinity and soil moisture for weather and climate applications (possibly with limited horizontal resolution) should be demonstrated in a research mode (as with ESA's SMOS and NASA's Aqua, and NASA/CONAE Aquarius/SAC-D) 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 meso-scale.

Progress Jul 08: ERS scatterometer data sets have provided monthly global soil moisture maps since 1991 at 50 km resolution. EUMETSAT delivers an operational global NRT soil moisture product from Metop/ASCAT data. WindSat and AMSR-E are being studied for possible utility of 6 and 10 GHz measurements for soil moisture for sparsely vegetated surfaces. SMOS is scheduled for launch in April 2009. Aquarius is scheduled for launch in May 2010.

Next Actions Jul 08: WMO Space Programme will discuss at CGMS progress and options for provision of soil moisture and salinity products including real-time delivery of soil moisture products for NWP.

S15. LEO SAR - Data from SAR should be acquired from R&D satellite programmes and made available for operational observation of a range of geophysical parameters such as wave spectra, sea ice, and land surface cover.

Progress Jul 08: The wave spectra from ENVISAT are available in near real-time from an ESA ftp server. CSA's RADARSAT data are used in deriving ice products by the National Ice Center. Continuity of ESA SAR mission is considered as part of the Sentinel programme.

Next Actions Jul 08: WMO Space Programme to continue to discuss with space agencies, via CGMS, (1) broader access by WMO Members to ENVISAT SAR data, (2) availability of SAR data from other agencies, and (3) continuity of such missions.

S16. LEO Aerosol - Data from process study missions on clouds and radiation as well as from R&D multi-purpose satellites addressing aerosol distribution and properties should be made available for operational use.

Comment: Terra and Aqua carry the MODIS sensor that is providing global aerosol products over ocean and most land regions of the world at 10 km spatial resolution. Additional R&D satellites currently providing aerosol optical thickness and optical properties include Terra/MISR, PARASOL and Aura/OMI. CALIPSO carries an R&D lidar for monitoring the vertical distribution of aerosols along the orbital ground track

of the spacecraft, which is in the A-train orbit along with Aqua, PARASOL, CloudSat, and Aura. NASA's Glory mission (2008) has added APS, an aerosol polarimetry sensor. ESA and JAXA are preparing the Earthcare (cloud/aerosol mission) for launch in 2 013.

Next Actions Jul 08: WMO Space Programme will continue discussions with space agencies, via CGMS, CM, and via CEOS Constellation for Atmospheric Composition, regarding availability of these data for operational use.

S17. Cloud Lidar - Given the potential of cloud lidar systems to provide accurate measurements of cloud top height and to observe cloud base heigh t in some instances (stratocumulus, for example), data from R&D satellites should be made available for operational use.

Comment: GLAS data are currently able to determine vertical distribution of cloud top altitude along the nadir ground track of ICESat, but this spacecraft operates in ~100 day epochs and is not continuous. CALIOP on CALIPSO makes such data routinely available in the A-train orbit (with Aqua, PARASOL, CloudSat, and Aura). ADM-Aeolus is expected to contribute to cloud measurements.

Next Actions Jul 08: WMO Space Programme will discuss with space agencies, via CGMS and at CM, near real time operational use of these data and operational follow-on planning.

S18. (*Recommendation S18 is to be found in Section "Process studies" below)*

S19. Limb Sounders - Temperature profiles in the higher stratosphere from already planned missions oriented to atmospheric chemistry exploiting limb sounders should be made operationally available for environmental monitoring.

Progress Jul 08: MIPAS and SCIAMACHY data are available in near real time from the ESA ftp server.

Next Actions Jul 08: WMO Space Programme will discuss with space agencies, via CGMS, progress/plans for distribution of data from MIPAS and SCIAMACHY on ENVISAT, from MLS and HIRDLS on Aura, and from similar instruments.

S20. Active Water Vapour Sensing - There is need for a demonstration mission of the potential 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.

Next Actions Jul 08: WMO Space Programme will discuss with space agencies, via CGMS.

S21. Lightning Observation - There is a requirement for global observations of lightning. Several initiatives for operational space-based implementation exist. These should be encouraged to fruition.

Comment: NASA's observations of lightning from OrbView-1/OTD and TRMM/LIS have demonstrated that 90% of lightning occurs over land, and that it is heavily tied to deep convection. In addition to its importance in severe storms and warnings for safety, lightning is an importance source of NOx and thus contributes to elevated levels of tropospheric ozone.

Progress Jul 08: The dynamics of lightning occurrence and its importance for nowcasting has been recognized by NOAA that plans to include a lightning sensor on GOES-R and CMA that plans a lightning mapper on FY-4. It is under consideration by EUMETSAT for MTG.

Next Actions Jul 08: WMO Space Programme will continue to monitor the issue with space agencies, via CGMS.

S22. Formation Flying - Advantages of formation flying need to be investigated.

Comment: NASA has already demonstrated both a morning constellation (involving Landsat 7, EO-1, SAC-C, and Terra) and an afternoon constellation (Aqua, PARASOL, Aura, CloudSat and CALIPSO, soon to be joined by OCO (December 2008)). These multi-agency and multi-country constellations demonstrate the added value of coordination of Earth observations to make a polar orbiting system greater than the sum of the parts, but able to launch when sensors and spacecraft are ready and available.

Next Actions Jul 08: The utility of data from sensors flying in formation need to be assessed. WMO Space Programme will discuss with space agencies, via CGMS.

Process studies

In reviewing the Implementation Plan for the Evolution of the Global Observing System, and not withstanding other potential requirements, the need for following process study mission was identified:

S18. LEO Far IR - An exploratory mission should be implemented, to collect spectral information in the Far IR region, with a view to improve understanding of water vapour spectroscopy (and its effects on the radiation budget) and the radiative properties of ice clouds.

Next Actions Jul 08: WMO Space Programme to discuss with space agencies, via CGMS.

Additional recommendations for Climate Monitoring

Long-term continuity of observations shall be ensured for the following Essential Climate Variables, which are not addressed within the recommendations above:

Ocean colour (GIP, Action O18);
Sea ice (GIP, Action O23);
Cryosphere (GIP, Action T14); and,
Land cover (GIP, Action T24).

Detailed requirements for these observations are contained in the Satellite Supplement to the GCOS Implementation Plan (GIP) "GCOS Systematic Observations Requirements for Satellite-based Products for Climate" (GCOS-107, September 2006, WMO/TD N°1338).

ANNEX 2

Items from the surface-based part of IP-EGOS of interest to CGMS

NEW ACTIONS TO BE ADDED BASED ON NEW REQUIREMENTS SPECIFIED IN SEVERAL APPLICATION AREAS:

GN1. Develop in-situ wave observation capability. *In-situ* wave observations are needed to meet the requirements for maritime safety services, and in particular for (i) assimilation into offshore wave forecast models, (ii) validation of wave forecast models, (iii) calibration/validation of satellite wave sensors, (iv) description of the ocean wave climate and its variability on seasonal to decadal time scales. Some coastal buoys are presently making directional wave observations and some open ocean buoys are making significant wave height measurements. However, practically none are reporting directional or spectral wave data from the open ocean. Observations are needed at a minimum, significant wave height, peak period and 1-D spectra, hourly in real-time, for assimilation into coupled atmosphere-ocean wave models for real-time forecasting activities, and subsequent verification.

> **Action July 2007:** JCOMM to set up a Pilot Project with a view towards integrating the in-situ wave observation capability into WIGOS.
>
> **Update July 2008:** The idea of a sub pilot project under the WIGOS Pilot Project for JCOMM was abandoned. However, JCOMM is still pursuing the idea separately from the WIGOS, or at least not directly as part of it to address issues such as (1) assimilation into offshore wave forecast models; (2) validation of wave forecast models; (3) calibration and validation of satellite wave sensors; (4) ocean wave climate and variability; (5) role of waves in coupling. The DBCP and the JCOMM Expert Team on Storm Surges (ETWS) are jointly organizing a Technical Workshop on Wave Measurements from Buoys, tentatively in NE US in September 2008. The goal is (i) to provide a forum for the exchange of ideas and information related to wave measurement from moored and drifting buoys, taking into consideration the users requirements; (ii) to discuss priorities for the development of cost-effective wave observing technology; and (iii) to develop a technical work plan for implementation of enhanced global wave measurements, for consideration by the DBCP and its Action Groups.
>
> **New action July 2008:** JCOMM to continue efforts in developing cost-effective *in-situ* wave observing technology.

GN2. Increase time resolution of SST data (in-situ observations from drifters). Increased time resolution SST data, at least hourly, are needed in order to better resolve the diurnal cycle of the SST. In-situ SST data are being used by the GHRSST together with satellite data. Relatively minor technological developments should eventually permit these requirements to be met for all global drifters.

> **Update July 2008**: The PTT real-time clock on drifters can be used with sufficient accuracy to provide for the hourly SST. On the other hand, accurate real time clocks have been installed on some prototypes.
>
> **New action July 2008:** DBCP to continue efforts to distribute hourly SST data and report to ET-EGOS.

GN4. Develop operational procedures for the GRUAN. The proposal for the GCOS Reference Upper Air Network (GRUAN) has been endorsed by the AOPC. The Lead Centre for the GRUAN will develop operational procedures in consultation with appropriate CBS and CIMO expert team, GSICS and other relevant partners.

Update July 2008: The Richard Assmann Observatory in Lindenberg, Germany, was designated by WMO as the Lead centre for the GRUAN network for an initial pilot phase. The Implementation Meeting of the GRUAN, organized by the AOPC Working Group on Atmospheric Reference Observations (WG-ARO) (Lindenberg, Germany, 26-28 February 2008) decided on necessary actions required to refine the cooperation with all partners, resolve scientific and technical issues from the report of the AOPC WG-ARO and define a work plan for the implementation of the network. As part of the work plan:

- A set of twelve initial candidate sites shall be invited by WMO/GCOS to become GRUAN sites;

- Close linkages with the satellite community, mainly through GSICS, shall be sought and maintained, particularly in view of utilization of GRUAN data for satellite instrument calibration and validation, and of possible sponsoring of additional radiosondes launches at GRUAN sites;

- The GRUAN Lead Centre, in collaboration with initial GRUAN sites, CBS, CIMO and WG-ARO will develop a manual for operating practices at GRUAN sites; the manual will be included in the WMO regulatory material. At its 8th session in June 2008, the CBS Management Group agreed to recommend formal establishment of GRUAN to CBS-XIV in 2009.

New actions July 2008: (i) Radiosonde inter-comparison is planned for 2010 under the auspices of GCOS and CIMO, to determine the best set of instrumentation and practices for GRUAN sites; (ii) it is recommended that the working group on reference radiosonde observations be made aware of the WIGOS pilot projects, and the GRUAN development advance in the spirit of such projects.

GN5. Maintain and expand the Baseline Surface Radiation Network to obtain global coverage. Data are used for climate monitoring and to provide valuable observations for the validation of earth radiation budget satellite data.

Action July 2008: WMO Secretariat to seek commitment from Members to provide continuity for these measurements.

GN7. Improve the accuracy of precipitation estimates from remotely sensing systems. This applies in particular to rain estimates from satellites and weather radar.

Comment: ET-EGOS chair to bring this to the attention of ET-SAT and the developers working on the algorithms to exploit radar measurements**.**
Update July 2008: The IPWG, which will meet in Beijing next October, is the appropriate forum to address this recommendation, but ET-EGOS may consider whether additional input from ET-SAT is needed. The Chair of ET-SAT sent an email to the Co-Chairs of the IPWG to request them to respond to this recommendation at the next IPWG meeting.
New action July 2008: Add an agenda item for ET-SAT-4 to discuss this issue (see http://www.wmo.int/pages/prog/sat/meetings/ET-SAT-SUP-4.html).