CGMS

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PROGRESS ON THE IMPLEMENTATION PLAN FOR EVOLUTION OF THE GOS

WMO-WP-07 reports on the progress made with respect to the practical implementation of the Implementation Plan for the Evolution of the Surface and Space-based Subsystems of the Global Observing System (IP-EGOS).

The Annex includes the latest update of the space-related part of the IP-EGOS, as reviewed by the Expert Team on Evolution of the GOS in July 2007, and the Expert Team on Satellite Systems in September 2007.

CGMS Satellite Operators are invited to take note and comment as appropriate.

PROGRESS ON THE IMPLEMENTATION PLAN FOR EVOLUTION OF THE GOS

1 INTRODUCTION

The Implementation Plan for the Evolution of the Surface and Space-based Subsystems of the GOS (IP-EGOS) was adopted by the WMO Commission for Basic systems (CBS) in 2002. Its section 3 is related to space-based observations and includes 22 recommendations as well as “Progress” and “Next Actions” for the implementation of these recommendations. The information contained under “Progress” and “Next Actions” is updated on a yearly basis by the WMO Secretariat and reviewed by ET-EGOS, taking into account the comments from ET-SAT. It may be noted that the IP-EGOS is related to the implementation of the “Vision for the GOS to 2015”, which is the current baseline. It is anticipated that, when a “Vision for the GOS in 2025” will be adopted (See WMO-WP-06) a new Implementation Plan will be developed to provide a roadmap towards implementation of this new vision.

2 SUMMARY OF PROGRESS

The Annex includes the latest update of Section 3 of the IP-EGOS, as reviewed by the Expert Team on Evolution of the GOS (ET-EGOS) and the Expert Team on Satellite Systems (ET-SAT).

One may note in particular the successful ongoing implementation of recommendations S1 on Calibration through the GSICS project, and S5 on LEO data timeliness through the RARS.

Substantial steps have been taken through the optimization workshops that addressed Concern 2 on complementary polar systems, S6 on LEO temporal coverage, S7 on LEO Sea Surface Wind and S8 on LEO Altimetry, but all these topics still need to be actively pursued. A lot of attention and further efforts are also required on S3 on GEO Sounders, S4 on GEO Orbital Spacing, S9 on LEO Earth Radiation Budget, S11 on GPM , S12 on Radio-occultation, and S13 on GEO sub-mm. These subjects are addressed in WMO-WP-03, -04, -05, -06, -22 and -23.

3 CONCLUSION

CGMS Satellite Operators are invited to take note and comment as appropriate.

ANNEX

IMPLEMENTATION PLAN FOR EVOLUTION OF THE SPACE AND SURFACE BASED SUBSYSTEMS OF THE GLOBAL OBSERVING SYSTEM

Section 3

(Updated by ET-EGOS-3, 12 July 2007 and ET-SAT-3, 7 September 2007)

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 fulfill 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**: The issue of GEO-LEO optimization was raised by WMO at the "CGMS-WMO optimization workshop" held with CGMS satellite operators on 28-29 August 2006. The 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:** 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

EUMETSAT has recently initiated planning for the post-EPS era (i.e., first element in orbit in ~2019) through a thorough assessment of the user requirements for all observations that might usefully be made from low earth orbit. This is to be complemented with a remote sensing assessment of the missions needed to meet these requirements. It is expected that some of these missions will be implemented through satellite missions/systems provided by EUMETSAT, whilst other "missions" may be achieved by cooperation with other partners (e.g., NOAA/EUMETSAT Joint Polar System, complementarity with GMES missions, or acquisition of data in partnership with other space agencies). Through this process, the goals of GEOSS could be greatly advanced. WMO Space Programme Office is encouraged to consider how this process might best be facilitated, to discuss any obstacles to progress, and to identify short-term opportunities for engagement with this process. In addition, noting the polar plans of China and the Russian Federation, WMO Space Programme should also extend coordination efforts to include these agencies.

> **Progress**: Global optimization of the satellite mission plans was recognized as an important objective and has led to convene the first WMO/CGMS Optimization workshop mentioned above. It was central to the scope of the Re-design and Optimization workshop convened by WMO on 21-22 June 2007.

Next actions: 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, e.g. in defining thematic constellations as is currently considered for altimetry.

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, CrIS) will enhance accurate intercalibration. Also regarding visible intercalibration, 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.

Progress: The Global Space-based Inter-Calibration System (GSICS) has been established to ensure comparability of satellite measurements provided through different instruments 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. The GSICS Implementation Plan was adopted at the GSICS Implementation Meeting on 23 June 2006 and endorsed by CGMS 34 in November 2006. A GSICS Executive Panel was nominated, led by Dr Mitch Goldberg from NOAA, as well as a GSICS Research Working Group and a GSICS Data Working Group. All groups had at least one meeting already. The Executive Panel has agreed on a first Operation Plan for 2007. LEO to LEO intercalibration is performed on a routine basis by NOAA. A common procedure is being developed and will be implemented by the end of 2007 by each operator of geostationary satellite in order to perform GEO to LEO IR intercalibration in a similar way. Hyperspectral sensors such as MODIS and IASI will be taken as the references in order to account for differences in Spectral Response Functions of the various broadband instrument channels. A GSICS website was established (http://www.wmo.int/pages/prog/sat/Calibration.html)

Next Action: To pursue the implementation of GSICS with the expectation that GEO to LEO IR intercalibration becomes operational early 2008, and then extended to visible channels.

GEO satellites

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: 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: WMO Space Programme will continue discussions with space agencies, via CGMS, especially with IMD and JMA.

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: Instruments of this type in geosynchronous orbit are high priority enhancements to the Global Observing System (GOS) 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, the impact of hyper-spectral sensors on GEO satellites is expected to be very positive. In addition, in order to optimize this impact, it would be useful to proceed with a direct demonstration mission based e.g. on the USA's GIFTS development in advance of the planned operational series.

Progress: EUMETSAT has included IRS in the Phase A baseline for the MTG sounder series planned for launch around 2017; CMA has plans for its FY-4/Optical series by 2014; NOAA is re-considering options for a hyperspectral sounding instrument on the GOES-R series; JMA is exploring the possibility of such development for MTSAT-Follow-on. For the meantime, opportunities for international cooperation on 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, but there remains a funding issue to manufacture a space qualified instrument on the basis of the current engineering model.

Next Actions: To encourage geostationary satellite operators to confirm and implement their plans for GEO hyperspectral instruments; to pursue in the meantime the IGeoLab proposal for a demonstration or pre-operational hyperspectral sounding mission from the GEO orbit.

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: In recent years, contingency planning has maintained a 5-satellite system, but this is not a desirable long-term solution.

Progress: WMO Space Programme continues to discuss with space agencies, via CGMS and WMO Consultative Meetings on High-level Policy on Satellite Matters, the strategy for implementation towards a nominal configuration with attention to the problems of achieving required system reliability and product accuracy. This issue was addressed as part of the gap analysis at the GOS re-design and optimization workshop, although no precise recommendation was formulated at that stage.

Next Actions: WMO Space Programme to develop and propose to CGMS a geostationary coverage scheme where inter-satellite separation would not exceed 60° longitude.

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).

Progress: The successful EUMETSAT ATOVS Retransmission Service (EARS) has been renamed the EUMETSAT Advanced Retransmission Service and will carry AVHRR and ASCAT products in addition to ATOVS. EARS ATOVS data are now available with a delay of less than 30 minutes; the data are used operationally at some NWP centres and planned at others. A RARS has started operations in Asia-Pacific area, and testing has begun for a RARS in South-America. Following the global RARS workshops held in Darmstadt in December 2004, in Geneva in December 2005 and in September 2006, a RARS Implementation Group was set up and held its first meeting on 3-4 July 2007. The primary goal is to achieve quasi-global coverage for timely retransmission of ATOVS datasets. Preliminary contacts with the South African Weather Service indicate a potential for extending the coverage towards South Africa and surrounding seas. The RARS approach is expected to be expanded to IASI and other time-critical data, including an equivalent system for NPP data.

NPOESS initial plans are for 80% of global data acquisition in less than 15 min and would thus be consistent with the stated timeliness requirements for NWP, provided that provisions are made for the timely redistribution of these data towards NWP centres.

As regards polar winds, plans are being developed to improve the timeliness through the use of direct broadcast imagery received at high-latitude stations.

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, Perth,..).

Next Actions: WMO Space Programme to pursue further actions to implement RARS at a global scale and to encourage the implementation of similar plans to allow the derivation of polar winds with improved timeliness

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

Progress: This is now the subject of a permanent action of CGMS. WMO Space Programme collaborates with space agencies, via CGMS, towards a target system defining both nominal and contingency planning in the AM and PM polar-orbits. This was addressed by the GOS Re-design and Optimization workshop on 21-22 June 2007, where a recommendation was made for a 3-orbit configuration, with 4-hour nominal separation between ECT, and back-up.

Next Actions: To formulate a 3-orbit configuration for core LEO sun-synchronous missions , as part of the new vision for the GOS in 2025.

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: 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.
As concerns MWI, Windsat data have been distributed to several NWP centres in 2005. Early assessments of its 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.
The GOS Re-design and Optimization workshop recommended maintaining at least 2 scatterrometers and 2 full polarimetric microwave imaging missions in order to achieve both sufficient accuracy and coverage.

Next Actions: The recommended configuration should be included into the new vision for the GOS in 2025, and brought to the attention of CGMS 35.

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: Agreement has been reached to proceed with Jason-2 (2008). Jason-1 continues to provide global ocean topography data to the NWP community. ESA has plans for a Sentinel-3 ocean mission that will include an altimeter. Observation strategy for altimetry was addressed at the GOS Re-design and Optimization workshop mentioned above. Large agreement of the community was achieved around 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: 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.

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: FY-3A and FY-3B will have a prototype Earth Radiation Budget Unit (ERBU) in 2008/2009. Either NPP or the first NPOESS satellite (likely launch in 2013) are expected to carry the CERES instrument. An observation strategy was proposed by the GOS Re-design and Optimization workshop, based on one LEO broad-band multi-angle viewing radiometer, collocated cloud/aerosol/water vapour measurements, complementary geostationary diurnal cycle information, as well as Total Solar Irradiance measurement.

Next Actions: 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: Plans for ADM-Aeolus demonstration are proceeding with a launch now planned for June 2009, and ESA and ECMWF are developing software for the assimilation of Doppler winds into NWP models. There are currently no plan for either a preparatory mission or an operational follow on. EUMETSAT is considering the requirements for observations of the 3D wind field as part of their planning for post-EPS missions. Preliminary considerations for a preparatory mission based on ADM-Aeolus were mentioned at the ESA/ESTEC ADM-Aeolus workshop on 25-27 September 2006.

Next Actions: 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 2007.

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: 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-tropique 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 December 2012. Timely implementation of the GPM mission was identified as an action in the GEO workplan. CEOS has launched a "Global Precipitation Constellation" initiative in order to coordinate efforts to take advantage of existing instruments while preparing the GPM mission.

Next Actions: 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: SAC-C, CHAMP and COSMIC data have ben successfully used in an operational context and the use of METOP/GRAS is being prepared. 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 planning 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: Plan for a constellation providing operational follow-on to COSMIC should be discussed by CGMS in 2007.

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: 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. Alternative projects may be discussed at CGMS XXXIV.

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 proposed to investigate two scenarios for consideration by CGMS 35, one based on filled aperture antenna and the other based on synthetic aperture antenna. Choice between the two technology is also linked to the relative priority given to the detection of precipitation and rapid vertical sounding.

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

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 mesoscale.

Progress: ERS scatterometer data sets have provided monthly global soil moisture maps since 1991 at 50 km resolution. EUMETSAT plan 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 late 2007. Aquarius is scheduled for launch in 2009.

Next Actions: 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, land surface cover.

Progress: 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: 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 2012.

Next Actions 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 height 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: 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: MIPAS and SCIAMACHY data are available in near real time from the ESA ftp server.

Next Actions: 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: 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 NO_X and thus contributes to elevated levels of tropospheric ozone.
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> **Progress:** 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 however EUMETSAT are reviewing requirements and implementation options for lightning observations and the potential role of ground-based observations to meet requirements is being re-assessed.
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> **Next Actions:** 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 (2006) and CALIPSO (2006), soon to by joined by OCO (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:** 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:** 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)
- 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).