CGMS HIGH LEVEL PRIORITY PLAN (HLPP) - 2023 TO 2027

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INTRODUCTION

The main goals of the coordination activities of the Coordination Group for Meteorological Satellites are to support operational weather monitoring and forecasting as well as climate monitoring, in response to requirements formulated by WMO, its programmes and other programmes jointly supported by WMO and other international agencies.

It is the policy of CGMS to coordinate satellite systems of its members in an end-to-end perspective, including protection of in orbit assets and support to users - e.g. through appropriate training - as required to facilitate and develop shared access to and use of satellite data and products in various applications. This policy is reflected in the structure of this 4-year High Level Priority Plan, covering:

1. Operational continuity and contingency planning
2. Coordination of satellite systems and operations
3. Coordination of data access and end user support
4. Enhancement of the quality of satellite-derived data and products
5. Monitoring of climate including greenhouse gases
6. Space weather monitoring
7. Outreach and training activities

CGMS reviews the HLPP on an annual basis, considering in particular new requirements and perspectives arising from interactions with the user and scientific communities, the development of applications, e.g. numerical weather prediction (NWP), and relevant research activities. It ensures proper interaction with other space agencies and their relevant constituencies (e.g. CEOS including its working groups and virtual constellations).

Following CGMS-50 in 2022, CGMS conducted a strategic review of its response to several new challenges. The outcome of the review included a number of new or revised medium- and long-term targets, all of which are reflected in this version of the HLPP.

HIGH LEVEL PRIORITY TASKS

The high level priority tasks are presented according to the logic of the CGMS end-to-end systems.

1 ENSURE OPERATIONAL CONTINUITY AND PERFORM CONTINGENCY PLANNING

1.1 Mitigate the impact of identified degradation or loss of capabilities of the CGMS baseline and ensure appropriate contingency measures are in place

The 2021 CGMS Risk Assessment concluded that the overall CGMS constellation is very robust, but that for a few observation areas risks have been identified to the provision of operational services in the next decade. Based on this analysis, CGMS will take actions to:

1.1.1 Ensure continuity of passive microwave imager observations;

1.1.2 Ensure continuity of precipitation radar observations;

1.1.3 Ensure continuity of scatterometer observations;

1.1.4 Ensure continuity of Radio Occultation observations with required quantity, geographical coverage and temporal sampling for numerical weather prediction and for ionospheric monitoring;

1.1.5 Ensure continuity of coronagraph, plasma analyser and magnetometer observations from L-1 through exploitation of scientific space weather missions for operational gap-filling.

1.2 Advance the response to the Vision for WIGOS in 2040 for space, by the implementation of new capabilities beyond the CGMS baseline

The 2021 review of the CGMS baseline concluded that the baseline is still a comprehensive response to the WIGOS vision, addressing the key application areas. However, in the coming years CGMS members will be launching several satellites with new capabilities expanding the response to the vision and CGMS therefore agreed to revise the CGMS baseline, and will:

1.2.1 Work towards establishing optimum constellations for new observations introduced in the CGMS baseline:

- Short-wave IR spectrometers for monitoring of greenhouse gases (CO2 and CH4);
- Multi-viewing, multi-channel, multi-polarisation imaging for aerosols;
- UV limb sounding spectrometry for profiles of Ozone and trace gases.

In addition, a number of new satellite programmes are under consideration by CGMS members, that offer the potential to expand the response to the WIGOS vision either through application of new technologies or through extending the coverage of existing capabilities. In this respect CGMS will strive to:

1.2.2 Advance the new generation of GEO satellites, including advanced imaging, lightning mapping and hyperspectral IR sounding for the whole geostationary ring;

1.2.3 Work towards operational hourly daytime UV/VIS mapping of air quality from geostationary orbit;

1.2.4 Work towards ensuring optimised hyperspectral IR measurements from LEO and GEO orbits to improve time sampling, spatial and spectral resolution and timeliness of observations, including the deployment of HSIR instruments across the GEO ring as per WIGOS vision 2040;

1.2.5 Work towards optimising the distribution of planned scatterometer missions across different polar and inclined non-synchronous orbits to achieve the 6-hour sampling requirement of the WIGOS and resolve diurnal variations;

1.2.6 Work towards ensuring low frequency microwave imagery for all-weather SST and ice monitoring from at least 2 sun-synchronous orbits;

1.2.7 Establish observational requirements for microwave observations (sounder and imager) for NWP and precipitation and perform gap analysis against CGMS baseline. For precipitation, develop a benchmark to conduct comprehensive assessments of current and future scenarios for the CGMS baseline;

1.2.8 Work towards increasing geographical resolution and coverage for altimetry measurements, including very high latitudes;

1.2.9 Advance the atmospheric radio occultation constellation, with the long-term goal of providing 20000 occultations per day on a sustained basis;

1.2.10 Work towards operational 3D wind profile observations from space-based lidar;

1.2.11 Work towards operational infrared/µwave limb sounding for climate monitoring and NWP applications;

1.2.12 Move towards an operational space weather monitoring capability from the Lagrangian Point L-5;

1.2.13 Establish the operational framework for the provision of magnetometer data from LEO orbit;

1.2.13 Investigate continuous space weather observations from lunar orbit for terrestrial and future lunar space weather services as well as for heliophysics research, complementing the geostationary and L1 measurements.

1.2.14 Work towards auroral monitoring capabilities;

1.3 Ensure long-term continuity of OSCAR/Space as a primary tool to support the CGMS Risk assessment and the WMO Rolling Review of Requirements including gap analysis against observing system requirements for satellite data and make OSCAR/Space the primary repository for WIGOS satellite metadata records generated by CGMS operators

1.4 Assess impact and benefits of CGMS satellite missions

1.4.1 Support satellite impact studies, including in particular impact of data latency and the impact of the early morning orbit.

1.4.2 Develop capacity to assess socio-economic benefits of CGMS satellite missions.

1.4.3 Collect and make available to CGMS members SEB case studies of relevant satellite systems for the purpose of identifying common practices in the next phase.

1.4.4 Explore with WMO and other agencies the possibility to develop a study on the SEB value of the space-based observing system responding to WIGOS 2040 in cooperation with CGMS, and to trigger collaboration with CGMS members;

1.5 Identify partnership opportunities on space and ground segments and establish CGMS coordinated mechanisms

1.6 Relationship with the Private Sector

1.6.1 Identify/evaluate potential or future commercial Earth observation technologies – and share information on pilots/testbeds etc. to evaluate new commercial Earth observation technologies.

1.6.2 Assess the operational maturity of commercial observation technology.

1.6.3 Develop best practices/templates for end user license agreements/procurements, for considering the value of public access and the additional costs of data sharing rights, including quality control considerations**;**

2 COORDINATION OF SATELLITE SYSTEMS AND OPERATIONS

2.1 Coordination/Optimisation of Data Collection Systems (DCS)

2.1.1 Build on the work of the SWOT analysis on the DCS from geostationary meteorological satellites, and particularly progress on the five proposals for further work (covering RFI mitigation including creation of an RFI DCS register, joint DCS PR materials, DCS introduction video, manufacturer workshop, discoverable information);

2.1.2 Establish an enhanced DCP standard, taking into account requirements of tsunami alert systems and in-situ ocean observations (e.g. buoys) and lessons learned from the development of high-rate DCP. This would give agencies a common standard and would once again allow international use of DCPs. It is foreseen that this would be covered under a project with engineering work spanning 2024-2027, which would include the production and testing of a prototype transmitter;

2.2 Radio Frequency (RF) protection

2.2.1 Facilitate an effective preparation of national and ITU-R regional groups' positions for the World Radiocommunication Conference (WRC) 2023 favourable for CGMS-related issues, in particular but not exclusively with regard to the:

- Establishment of a new frequency allocation to EESS (passive) in the bands 239.2-242.2 GHz and 244.2-247.2 GHz under agenda item 1.14 to cover and protect the band 231.5-252 GHz for planned and future passive microwave sensors for ice cloud measurements;

- Recognition to the extent possible of the need for protection of the band 6425-7125 MHz or to find, if possible, complementary frequency resources for SST observations to compensate for the increased interference potential due to the identification of the band for IMT 5G mobile (agenda item 1.2);

- Protection of the band 1695-1710 MHz (used for LEO direct broadcast to user stations) from planned new frequency usage by commercial satellite systems (agenda item 1.18) or from possible high-altitude platform stations as IMT base stations (HIBS) in the neighbouring band (agenda item 1.4);

- Establishment of recognition and protection of sensing frequencies for space-based space weather observations (agenda item 9.1 Topic A).

2.2.2 Within the general ITU framework, triggered by ITU-R Resolution 731, regarding the establishment of sharing conditions between active and passive services in bands

above 71 GHz, to ensure protection of passive sensing bands, in particular in bands in which all emissions are prohibited (Radio Regulations Footnote 5.340).

2.2.3 Pursue the establishment of a set of best practices for the RFI detection, monitoring, and mapping based on the common aspects of the approaches already adopted by CGMS members;

2.3 Data acquisition and data processing, including low latency data access

2.3.1 Ensure the ease of use of satellite-derived data and products, disseminate in one of the standard formats, as specified in the CGMS LRIT/HRIT Global Specification and the WMO Manual on Codes. Once the use of netCDF with the CF convention for satellite-derived data is captured in the WMO Manual on Codes, ensure compliance with this for these data disseminated in netCDF.

2.3.2 To address technical and operational aspects of direct low latency data access (present and future) of mutual or global interest for the CGMS agencies, including facilitating transition to new LEO systems.

2.3.3 Merge the LEO (global) and DB (regional) best practices into a consolidated “Low latency best practices” containing common best practices for both regional and global missions, as well as specific best practices for direct broadcast and global missions.

2.3.5 Develop efficient standardised data handling for high-resolution imaging and hyperspectral instruments;

2.4 Coordination with WMO Information Systems (WIS)

2.4.1 Actively ensure the WIS 2.0 usage for satellite data provision and discovery.

2.4.2 Support WIS and WIGOS in the definition of harmonised product metadata for satellite data and implement these for CGMS missions.

2.4.4 Provide coordinated CGMS inputs to WMO on satellite and instrument identifiers for data representation and metadata within the WIS;

2.5 Operational issues related to space weather

2.5.1 Evaluate existing operational space weather products and services in support of CGMS members’ spacecraft operations and recommend additional services as appropriate.

2.6 Space traffic coordination

2.6.1 Review of CGMS member agencies' satellite operations for collision avoidance and re-entry prediction.

2.6.2 Perform a gap analysis between the needs and the available/used space traffic coordination (STC) services, carry out an assessment of service development prospects and prepare a proposal for best practises to support improvement.

2.6.3 Engage with UN-COPUOS to achieve a global standardised approach for STC based on a CGMS proposal;

2.7 Space sustainability

2.7.1 Share space sustainability rating methodologies and carry out a pilot project where some operational mission plannings are evaluated.

2.7.2 Follow efforts to establish an international agency policy on "zero debris" and based on the outcome, carry out an assessment of impacts of such policy on operational missions of CGMS members and the private sector.

2.7.3 Prepare a CGMS best practises document for long term space sustainability;

2.8 CGMS satellite missions in hybrid space infrastructures

2.8.1 Taking passive µwave sensing as an initial case, identify all current constellations, and those planned for the next few years (CGMS baseline, complementary systems, and potential data buys) and demonstrate the impact of CGMS contributions, as part of the integrated system.

2.8.2 Address such aspects as orbit coordination and harmonised data access to ensure the different components of the hybrid space infrastructures provide a seamless operational service to the users.

2.8.3 Conduct a critical review of WIGOS 2040 with respect to hybrid systems;

2.9 New technologies for satellite systems

2.9.1 Assess the internet-of-things (IOT) technology for inter- and intra-connections between satellite and ground network.

2.9.2 Explore improvements to LEO satellite systems low latency data access from both a global and regional perspective, harnessing common emerging technologies and taking account of the evolution of the commercial and agency space systems;

3 COORDINATION OF DATA ACCESS AND END-USER SUPPORT

3.1 Support the user-provider dialogue on regional/continental scales through regional coordination groups maintaining requirements for dissemination of satellite data and products through the various broadcast services

3.1.1 Establish a sustained interaction with the operational nowcasting communities with a view to fully utilise the commonality of the future geostationary imagers and sounders;

3.2 Prepare operational users for new generation of meteorological satellites through user readiness programmes, with coordinated contributions from CGMS members

3.2.1 Consider the full range of user capabilities (ranging from advanced short-range NWP to more conventional nowcasting) when planning data utilisation, products generation and dissemination strategies, in particular for the new geostationary satellites.

3.2.2 Improve the provision to users of characterisation data (including apodization) for geostationary and low Earth orbit hyperspectral infrared instruments.

3.2.3 Develop best practices for operational user notifications;

3.3 Coordinated global data exchange

3.3.1 Develop best practices for global data exchange.

3.3.2 Explore options for optimal data exchange of advanced data from new generation GEO missions, in consultation with the global NWP centres through GODEX-NWP.

3.3.3 Support the coordination of the operational digital video broadcast (DVB) satellite services for the Americas, Africa, Europe and the Asia Pacific regions;

3.4 Increase access to, and use of, data from R&D and pre-operational missions

3.5 Investigate the feasibility of utilising existing dissemination infrastructure for meteorological information in helping to mitigate disasters

3.6 Increase operational access to data and products in support to the ocean user community

3.6.1 Ensure the timely access to and exchange of near-real-time scatterometer data, share access to calibration and validation information across CGMS agencies.

3.6.2 Promote the product metadata standards within ocean communities, such as on SST, ocean colour, ocean vector surface wind and ocean surface topography, to facilitate common data representation and near-real time exchange. This must be done in dialogue with the relevant CEOS Virtual Constellations;

3.7 Application of cloud technologies

3.7.1 Develop best practices for cloud services interoperability.

3.7.2 One or more CGMS members to prepare demonstration of collaboration with private sector regarding satellite data distribution;

3.8 Research to operations

3.8.1 Collect the experience of each agency by carrying out a research-to-operations method survey with each agency including identification of research missions with a potential transfer to operations.

3.8.2 Based on the results of the method survey, propose a consistent CGMS research-to-operations baseline process that includes flexibility and adaptability and facilitates the participation of R&D agencies;

4 ENHANCE THE QUALITY OF SATELLITE-DERIVED DATA AND PRODUCTS

4.1 Establish a fully consistent calibration of relevant satellite instruments across CGMS agencies, recognising the importance of collaboration between operational and research CGMS agencies

4.1.1 Maintain within GSICS a framework for inter-calibration of hyper-spectral sounders.

4.1.2 Establish within GSICS a consistent inter-calibration for thermal IR channels using hyper-spectral sounders as reference. The implementation will be done successively by the individual satellite operators.

4.1.3 Establish within GSICS a consistent inter-calibration for solar channels using instruments with adequate in-orbit calibration and vicarious methods as reference. The implementation will be done successively by the individual satellite operators.

4.1.4 Establish within GSICS a common reference solar spectrum with appropriate spectral coverage and spectral resolution and develop common methods and tools for on-ground calibration and characterisation and inter-calibration of UV-VIS-NIR SWIR spectrometers.

4.1.5 Establish a methodology to characterise microwave instruments for O2 absorption channels through the SNO and RTM modelling. The implementation will be done successively by the individual satellite operators.

4.1.6 Establish mechanisms for cross-calibrating scatterometers across the constellation;

4.2 Establish commonality in the derivation of satellite products for global users where appropriate (e.g., through sharing of prototype algorithms)

4.2.1 Establish commonality in the derivation of AMV products for global users where appropriate (e.g., through sharing of prototype algorithms) and consider backwards compatibility when designing AMV algorithms for the 16-channel imagers, so that present state-of-the-art algorithms can be applied to old imagery.

4.2.2 Investigate the best configurations to be used by the AMV producers for use in global and regional NWP models respectively, and clearly define the appropriate requirements for each of them.

4.2.3 Assess value of derivation of winds from GEO Hyperspectral IR.

4.2.4 Establish a coherent development of volcanic ash products and applications with close user community coordination.

4.2.5 Assess the cloud properties generated from the geostationary and polar orbiting imagers and pursue best practices that lead to improved consistency and accuracy across the globe and the Geostationary ring.

4.2.6 Establish together with the user community a commonly agreed approach for retrieval of Principal Component scores and associated parameters from hyperspectral infrared data, minimising information loss including the mutually acceptable update strategy for the principal component basis and to implement such an approach in a coordinated manner;

4.3 Foster the continuous improvement of products through validation and inter-comparison through international working groups and SCOPE-type mechanisms

4.3.1 Apply the IPWG validation protocol (as defined on its web page) to precipitation combination datasets generated using multiple satellite and in-situ data sources, and expand the number of participating agencies to broaden the validation domain. The IPWG website is currently being transitioned, and will be updated to reflect the status of previous, current and newly added operating validation regions.

4.3.2 Provide SCOPE-CM Implementation Plan following the agreed new concept.

4.3.3 Conduct an intercomparison study between the different methods to derive level 2 data from infrared hyperspectral sounders, recognising that there are several software packages available that utilize AIRS/IASI/CrIS data.

4.3.4 Coordinate and improve the use of cloud properties in the high impact applications, in particular Atmospheric Motion Vectors and All-Sky Radiance Products.

4.3.5 Support the continued analysis and growth of the cloud climatology assessment data archive initiated by GEWEX and the coordinate the development and assessment of cloud climate products for the next generation of the International Cloud Climatology Project (ISCCP-NG);

4.4 Maintain, enhance and improve the methods to describe the error characteristics of satellite data and products

4.4.1 Establish a common vocabulary and methodology with appropriate error propagation to include the errors associated with validation data (e.g. radiosonde temperature, water vapour, precipitation and winds).

4.4.2 Agree on standardised procedures to derive NedT estimates for microwave sounders, and include such estimates in the disseminated BUFR data;

4.5 Strengthen interaction with users in selected thematic areas by establishing a close relation with them as beta-testers and foster optimum use of satellite data

4.5.1 Report on the progress within the nowcasting community toward the use of hyperspectral sounders and work toward common products to serve the requirements of the global community.

4.5.2 Enhance the use of satellite precipitation datasets through an IPWG-led user workshop where training on visualisation and analysis tools will be one of the topics;

4.6 Foster and support research regarding enhanced radiative transfer capabilities, recognising the paramount importance of radiative transfer developments for satellite products

4.6.1 Continue support for line-by-line (LBL) reference model development and enhanced characterization of spectroscopy to ensure that product development teams and users of level 1 data have access to the latest updates in LBL forward modelling and the uncertainties involved.

4.6.2 Perform validation and intercomparison of LBL models/spectroscopy to assess the impact of spectroscopic uncertainties and the differences between line-by-line and fast radiative transfer models.

4.6.3 Through coordination between IPWG, ITWG and ICWG, continue to improve microwave radiative transfer models to include complex surfaces (e.g. snow, desert, etc.) and scattering atmospheres (e.g. frozen hydrometeors) to support improved algorithm development for current and future sensors;

4.7 Stimulate trade-off analyses for the development of future passive sounding instruments

4.7.1 Conduct studies to investigate the technical feasibility to reduce the field of view sizes for future microwave sounders to keep in line with the spatial resolution expected for future global NWP models.

4.7.2 Conduct trade-off studies regarding the benefits of spectral, radiometric, and spatial resolution of infrared sounders, taking into account aspects such as scene inhomogeneity and uncertainties in spectroscopy;

4.8 Support to emerging application areas

4.8.1 Foster the coordinated development of novel products and applications of the new generation of imagers, initially for the areas of fire, aerosols, flood-mapping and river ice break-up.

4.8.2 Provide support to users in the WMO application areas, including for agricultural, hydrology, cryosphere, marine/ocean and other applications, with a focus on the WMO co-led UN Early Warnings for All (EW4ALL) identified priority hazards (heat, drought, flood, and tropical cyclones); and, where appropriate, identify and follow-up on opportunities by other entities (e.g. CEOS led activities).

4.8.3 Review capabilities of and identify critical gaps in the CGMS constellation for the provision of physical snow and ice products in support of operational cryosphere, polar and high-mountain monitoring, and reflecting WMO priorities to address global and regional impacts of changes in the cryosphere (2024-2027).

4.8.4 Establish product development priorities including synergistic products for operational monitoring of cryosphere, polar and high-mountain regions;

4.9 Identify AI/ML technologies for applying to the product processing and data management infrastructure and develop best practices

5 ADVANCE THE ARCHITECTURE FOR SPACE-BASED MONITORING OF CLIMATE, INCLUDING GREENHOUSE GAS MONITORING (THROUGH THE JOINT CEOS-CGMS WORKING GROUP ON CLIMATE)

5.1.1 Update the ECV Inventory of Climate Data Records, Gap Analysis and Coordinated Action Plan (CAP) of CEOS and CGMS and report on status of the implementation of the CAP. (This target is cyclic and all three parts are covered every year including endorsement by CEOS and CGMS).

5.1.2 Report to and interact with the UNFCCC Subsidiary Body for Scientific and Technological Advice – Research and Systematic Observation (SBSTA-RSO) to foster usage of satellite data in the context of the Paris Agreement, in particular results from the operational GHG monitoring system. (This target is also part of the cyclic regular annual reporting).

5.1.3 Respond to the GCOS IP after new versions of it issued by GCOS (every 5 years). Provide support to GCOS for the GCOS status report (one year prior to the new GCOS IP).

5.1.4 JWGClimate Task Team on GHG monitoring to coordinate the specific CGMS contributions to the operational GHG constellation, covering activities on mission coordination, inter-calibration, product prototyping, data distribution, exchange, formatting, and on training and outreach.

5.1.5 Foster the implementation of the architecture for climate monitoring from space by strengthening the analysis of use cases for climate data records to increase usage in climate services and science.

5.1.6 JWGClimate to publish updated definitions for the fundamental, thematic, and interim Climate Data Record.

5.1.7 Engage in the development of requirements for an integrated global greenhouse gas observing system (i.e. both space-based and surface-based assets).

5.1.8 Support the WMO joint study group on greenhouse gas (GHG) monitoring for the development of requirements for data latency of GHG observations;

6 ADVANCE OPERATIONAL SPACE WEATHER MONITORING FROM SPACE

6.1 Coordinate CGMS activities and align priorities with the operational space weather user community, in particular the ICAO Space Weather Centres, ISES, WMO ET-SWx and the UNCOPUOS STSC.

6.2 Establish a consistent inter-calibration framework in GSICS for energetic particle measurements using instruments with adequate in-orbit calibration and vicarious methods.

6.3 Advance the integration of Space Weather coordination activities into the relevant CGMS working groups.

6.4 In coordination with IROWG establish requirements for and recommend an implementation of an optimised system for radio occultation observations for ionosphere monitoring.

6.5 Ensure the timely access to and global exchange of space weather data of CGMS Members, including instruments hosted on third-party satellites.

6.6 Document current data formats for space weather observations.

6.7 Produce a report of space weather (SWx) observation requirements for improved STC services and space sustainability and consider the impact on future SWx observations due to increased demand on SWx services;

7 OUTREACH AND TRAINING

7.1 Engage in communication and outreach activities to promote EO and Space Weather observations benefits

7.2 Training

7.2.1 Continue to foster optimum use of satellite data for weather forecasting, climate applications, and environmental assessments including hazardous events such as volcanic ash and flooding.

7.2.2 Update and develop new training material through the WMO-CGMS Virtual Laboratory for Education and Training in Satellite Meteorology (VLab) and in partnership with the WMO Training and Education Programme and the Community for the Advancement of Learning in Meteorology and related disciplines (CALMet). This will be done in cooperation with the Committee on Space Research (COSPAR), the CEOS Working Group on Capacity Building and Data Democracy (WGCapD), CEOS-CGMS Joint Working Group on Climate, and other programmes in areas of common or complementary interest.

7.2.3 Provide shared, regular support to funding the VLab technical support officer function through the WMO VLab Trust Fund, and to the VLab Centres of Excellence as per agreed expectations;

7.3 User conferences

Conduct regional satellite users' conferences to:

i) share experience and foster the exchange of ideas;
ii) promote better access, and improve the utilisation of, existing satellite data and products;
iii) prepare the user community on new satellite systems' data products and services;
iv) engage with the user community on the application of new Climate Data Records, supported by the CEOS-CGMS Joint Working Group on Climate;
v) gain user feedback on data, product and system real-world application;
vi) engage young people entering the field; and
vii) other items as appropriate.