CGMS Baseline

Sustained contributions to the observing of the Earth system, space environment and the Sun

Endorsed by CGMS-50 Plenary on 16 June 2022
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Presented to CGMS-51 plenary for endorsement

(CGMS-51-WGIII-WP-07)

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1. INTRODUCTION

The Coordination Group for Meteorological Satellites (CGMS) provides a forum for the exchange of technical information on meteorological and environmental satellite systems as well as research and development missions in support of the World Meteorological Organization's (WMO) Rolling Review of Requirements (RRR), the IOC-UNESCO, and other users. The primary goal of the coordination activities is to support operational monitoring and forecasting of weather, space weather and the climate. CGMS coordinates satellite systems of its members in an end-to-end perspective including, but not limited to protection of on-orbit assets, support to users, and facilitation of shared access to satellite data and products.

1.1 DOCUMENT PURPOSE

The 'Baseline' constitutes the commitments and plans of CGMS members to provide particular observations and services. CGMS members plan to maintain the capabilities and services described below to support the global observing system. This document will remain consistent with the principles of the WMO Integrated Global Observing System (WIGOS) Vision and the WIGOS Vision serves as important input in the development of CGMS members' plans.

1.2 REFERENCE DOCUMENTS

Title	Purpose and Revision cycle (incl. links)
CGMS Baseline	(This document) Revised on an annual basis~~at least every four years~~
CGMS Contingency Plan	Defines guidance and the process for identifying, mitigating, and coping with risks to the continuity of the CGMS Baseline. https://cgms-info.org/wp-content/uploads/2022/05/CGMS-contingency-plan_v1_2018.pdf (Ref. CGMS/PLN/19/1110023, v.2~~1~~, CGMS-51~~0-CGMS~~WGIII-WP-04~~25~~)
CGMS High-Level Priority Plan (HLPP)	4-year rolling plan containing high-level priorities for CGMS activities. Aspirational targets for enhancing the CGMS response to the WIGOS Vision are included in the HLPP. Revised annually. ~~https://www.cgms-info.org/documents/CGMS_High_Level_Priority_Plan.pdf~~
WMO Gap Analysis	Contains the WMO gap analysis of CGMS Baseline against the WIGOS 2040 Vision. Document provided to CGMS on an annual basis~~at least every 4 years~~. CGMS-51~~0~~-WMO-WP-13~~08~~
WIGOS Vision	Contains the overall vision for the complete observing system, based on WMO requirements. WMO document No. 1243 https://community.wmo.int/vision2040

Commented [AT1]: To be updated following CGMS-51 plenary endorsement

1.3 SCOPE OF THE BASELINE

The baseline enumerates the observations and their supporting missions that provide meteorological and environmental data required to support the WMO application areas. Support of this goal requires coordination and cooperation among all CGMS members. In order to ensure efficient allocation of resources and timely cooperation, the capabilities contained herein are considered the aggregate baseline capabilities of all CGMS members.

In the development of the scope of the Baseline, the following principles determined which missions were included:

- Commitment by CGMS members to provide a capability;
- Long-term sustained provision of the capability by CGMS members;
- Data from missions are available on a free and unrestricted basis;
- Data can be utilised in operational applications.

This document takes a holistic approach and therefore includes space-based observations; services, including data collection and direct broadcast; as well as data sharing and distribution.

1.4 EVOLUTION OF THE BASELINE

The Baseline will be reviewed annually to take into account the evolving programmatic plans of CGMS members and the WMO Gap Analysis of the CGMS Baseline against the WIGOS Vision. The process for updating the CGMS baseline is illustrated in Appendix A.

Following approval of the CGMS Baseline, the WMO Manual on WIGOS is updated with the revised CGMS Baseline.

1.5 ADDITIONAL RESPONSE TO THE WIGOS VISION

The Baseline constitutes the most comprehensive CGMS response to the WIGOS Vision possible under the current programmatic constraints and specific national priorities. CGMS will continue to strive for a full implementation of the WIGOS Vision and CGMS Working Group III will propose targets for extending the response to the WIGOS Vision. These targets will (after approval by the CGMS plenary) be reflected in the 4-year rolling CGMS High-Level Priority Plan, and will be reflected in the CGMS Baseline when realised as fully committed contribution by CGMS members.

2. OBSERVATIONS AND ORBITS

The orbits considered by CGMS for exploitation include Low Earth Orbit (LEO), Geostationary Orbit (GEO), Highly Elliptical Orbit (HEO), and at the L1 Lagrange point.

- LEO may be sun-synchronous or drifting. The sun-synchronous orbits considered have an Equatorial Crossing Time (ECT) in the “early morning” (typically, 5:30 and 17:30), the “mid-morning” (typically, 9:30 and 21:30) or the “afternoon” (typically, 13:30 and 1:30). They overfly approximately the same location of the Earth, including high latitudes, at approximately the same time twice/day. For large-swath instruments, coverage at 4-hour intervals require three satellite at fairly spaced ECT’s. Drifting orbits with different inclination provide more frequent coverage of lower latitudes and ensure the viewing of the Earth at changing times of the diurnal cycle.

- GEO provides continuous view of about 1/3 of the Earth's surface centred on the stationary sub-point. Full coverage of all longitudes, excluding polar regions, requires a number of evenly spaced satellites.

- HEO can be used for frequent Earth observation of high latitudes, or to fly through the magnetosphere at various distance from the Earth, for the purpose of space weather. [Note that HEO missions are being flown or planned by some CGMS members but are not yet considered part of the CGMS Baseline].

- L1 provides continuous view of the Sun, and *in-situ* detection of particles of the solar wind minutes to hour(s) before they reach the magnetosphere and the Earth.

- The term Sun-Earth line used below should be understood as covering observations that may be obtained from any suitable orbital position on the line connecting the Sun and the Earth when monitoring or observing the sun. Typical orbital positions include GEO and the 1st Lagrangian Point (L1). Requirement for continuous observations needs to be taken into account for orbits around the Earth because of potential satellite eclipses.

- Other orbits away from the Sun-Earth line (e.g. L5 or L4) can be used for solar and heliospheric imaging and in-situ measurements for space weather to improve the coverage and enhance space weather forecasting.

- CGMS members may elect to host their sensors on platforms not owned by the member (hosted payloads). Hosted payloads will be reflected in the CGMS baseline and risk assessment when the CGMS member commits to provide the sensor data consistent with the Baseline principles.

- CGMS members may provide commercially sourced data to meet commitments to the CGMS Baseline [under licenses]. The CGMS members commit to the provision of such data consistent with the Baseline principles.

The observations are a combination of active and passive remotely sensed observations, and in-situ measurements.

Sensor Type	Orbit	Observations	Attributes
Microwave Sounder	LEO	Atmospheric temperature, humidity, and precipitation	3 sun-synchronous orbits, nominally early morning, mid-morning and afternoon
Hyperspectral Infrared Sounder	LEO, GEO	Atmospheric temperature, humidity, and winds Atmospheric composition: CO, CO2, SO2 , depending on spectral band also CH4 and NH3	LEO – 3 sun-synchronous orbits, nominally early morning, mid-morning and afternoon GEO – 2 slots: 86.5°-105°E range and 0°

Sensor Type	Orbit	Observations	Attributes
Radio Occultation	LEO	Atmospheric temperature and humidity, Ionospheric Electron Density	Minimum 6000 occultations from low inclination orbits (<30°) distributed geographically and temporally in local time, 1000 occultation from other drifting orbits, and 7600 occultations from sun-synchronous orbits. Electron density profiles up to 500 km.
Multi-purpose meteorological imagers (multispectral, visible, and IR)	LEO, GEO	Sea Surface Temperature, Aerosols, Land surface temperature, Cloud properties, Feature tracking winds (AMV), Flood mapping, Fires, Cryosphere applications (sea ice, snow cover, etc.), ocean colour	LEO – 3 sun-synchronous orbits, nominally early morning, mid-morning, and afternoon IR dual-angle view imagery for high-accuracy SST (at least one am spacecraft) GEO – 137°W, 75.2°W, 0°, 74°E, 76°E, 82°E, 86.5°E-105°E, 128.2°E, 140°E
Multi-viewing, multi-channel, multi-polarisation imager	LEO	Aerosol, cloud microphysics, BRDF (Bidirectional Reflectance Distribution Function)	LEO – 1 sun-synchronous orbit
Lightning Mapper	GEO	Lightning mapping	GEO – 137°W, 75.2°W, 0°, 86.5°E-105°E,
Broadband short/long wave radiometer	LEO	Radiation balance	LEO – 2 sun-synchronous orbits, early morning and afternoon orbit
Visible/UV Spectrometer	LEO, GEO	Aerosol, Atmospheric Composition: O3, CO2, NO2, SO2, BrO. Cl	LEO – 2 sun-synchronous orbits mid-morning and afternoon GEO – 2 slots at 0° and 128.2°E
UV limb spectrometer	LEO	Aerosol, Atmospheric Composition: O3	LEO – 2 sun-synchronous orbits, mid-morning, afternoon

Sensor Type	Orbit	Observations	Attributes
SWIR imaging spectrometer	LEO	Atmospheric Composition: CO_2, CH_4	LEO – 2 orbit sun-synchronous late morning and afternoon
Precipitation Radar	LEO	Precipitation	LEO – drifting orbit
Microwave Imager	LEO	Sea surface temperature, ocean surface winds, precipitable water, soil moisture, snow and ice properties, sea ice properties, precipitation, cloud liquid water	LEO – 2 sun-synchronous orbits, nominally mid-morning and afternoon
Narrow Band Imager	LEO, GEO	Ocean colour, aerosol	LEO – 2 sun-synchronous orbits GEO – 1 slot, 128.2°E
Radar Altimetry	LEO	Ocean surface topography	LEO – 1 orbit mid-morning as well as reference mission on a high-precision, drifting orbit
Scatterometer	LEO	Ocean surface winds	LEO – 3 sun-synchronous orbits, early morning, mid-morning and afternoon orbits
Submillimetre Ice Cloud Imager	LEO	Cloud Ice	LEO – 1 sun synchronous mid-morning orbit
Synthetic Aperture Radar	LEO	Soil Moisture, Sea ice	LEO – 1 orbit
High Resolution Optical Imager	LEO	Land use, vegetation type and status, aerosol	LEO – 1 orbit
Coronagraph	Sun-Earth line	Coronagraphy	GEO – 1 slot, 75.2°- 137°W range L1
EUV Imager	Sun-Earth line	EUV imagery	GEO – 2 slots, 137°W 75.2°W LEO – 1 orbit

Sensor Type	Orbit	Observations	Attributes
X-Ray Spectrograph	Sun-Earth line	X-Ray flux	GEO – ~~2~~5 slots, 165.8° E, 86.5 °E, 76° E, 14.5° W, 75.2°W, 137°W L1
Low energy electrons & protons	GEO	Magnetospheric particles	86.5°-123°E range 75.2°- 137°W range, in-situ measurement~~Longitudes?!~~ ~~[GEO 2 sectors]~~
High energy electrons & protons	GEO	Magnetospheric and solar energetic particles	0° 86.5°-123°E range 75.2°- 137°W range, in-situ measurement~~TBD~~ ~~[GEO 3 sectors]~~
Very high energy protons	GEO	Magnetospheric and solar energetic particles	0° 86.5°-123°E range 75.2°- 137°W range, in-situ measurement~~TBD~~ ~~[GEO 3 sectors]~~
Energetic heavy ions	GEO	Solar energetic particles	0° 75.2°- 137°W range, in-situ measurement~~TBD~~ ~~[GEO 2 sectors]~~
~~Energetic~~ Precipitating particle sensor	LEO~~, L1~~	Magnetospheric energetic ~~and solar energetic~~ particles	LEO – 3 orbits as in-situ measurement ~~L1 as in-situ measurement~~
Solar wind particle sensor	L1	Solar energetic particles	L1 as in-situ measurement
Terrestrial Magnetometer	GEO~~, L1~~	Earth's magnetic field~~, interplanetary magnetic field~~	GEO – 4 slots: 137°W, 75.2°W, 86.5°E-105°E, 128.2°E, in-situ measurement ~~L1 as in-situ measurement~~
Interplanetary Magnetometer	L1	Interplanetary magnetic field	L1 as in-situ measurement
Plasma Analyser	L1	Solar wind	L1 as in-situ measurement

3. SERVICES

3.1 DATA SHARING SERVICES

Meteorological applications in general are critically dependant on global exchange of observation data. The international exchange of satellite data obtained by the CGMS Baseline system is a vital element of the WMO Integrated Global Observing System, which underpins the operational weather, climate, hydrological and other environmental services of all 193 WMO members and territories. In particular, it provides critical global input data for the WMO members designated as Global Producing Centres for long- and medium-range weather forecasts, Tropical Cyclone Forecasting Centres and Centres for Transport Modelling for Environmental Emergency Response. CGMS members will establish and operate terrestrial and space-based dissemination services in order to exchange observations directly among members, and to make them available to National Hydrological and Meteorological Services and to the broader international user community in a timely and cost-effective manner. This data exchange should follow CGMS best practices.

3.1.1. Direct broadcast services

The core meteorological satellite systems in LEO orbits, and other operational satellite systems where applicable, should ensure low latency data access of imagery, sounding, and other real-time data of interest to users by means of direct broadcast or other mechanisms. Application areas where low latency and availability is suitable include Severe Weather Monitoring, Nowcasting and Short- and Medium-Range Numerical Weather Prediction. Other application areas could also benefit from very low latency products, e.g. ionospheric monitoring. CGMS members should follow the best practices for direct broadcast services developed by CGMS Working Group I.

3.2 In-situ data relay

CGMS members will provide for the relay of *in-situ* meteorological and environmental information from fixed and mobile platforms (e.g. ocean buoys, tide gauges, tsunami platforms, and river gauges). *In-situ* data relay services should be provided on both LEO and GEO satellites when relevant.

4. ENSURING DATA AND SERVICES

To ensure quality and continuity of observations CGMS members will take the following steps in the provision of their data and services.

4.1 CALIBRATION AND VALIDATION

CGMS members are responsible for ensuring the quality and compatibility of satellite observations taken at different times and locations, by different instruments, and by various satellite operators. CGMS members will characterise instruments prior to launch, follow the common methodologies, and implement operational procedures outlined by Global Space-based Inter-Calibration System (GSICS). Instruments should be inter-calibrated on a routine basis against reference instruments or calibration sites.

CGMS will strive to achieve global compatibility of satellite products, by establishing commonality in the derivation of satellite products for global users where appropriate and by fostering product validation and inter-satellite comparison through International Science Working Groups and Sustained, Coordinated Processing of Environmental Satellite Data (SCOPE)-type mechanisms.

4.2 CONTINGENCY PLANNING TO ENSURE CONTINUITY

CGMS members will take steps to ensure continuity of this CGMS Baseline by following the guidelines outlined in the CGMS contingency plan.

4.3 MONITORING IMPLEMENTATION OF THE BASELINE

CGMS will monitor members' implementation of the CGMS Baseline through an annual risk assessment. CGMS members will provide the information necessary to compare current observing capabilities against the CGMS Baseline. This assessment is outlined in the CGMS global contingency plan.

4.4 RESEARCH TO OPERATIONS AND EMPLOYING RESEARCH MISSIONS

The CGMS Baseline focuses on satellite missions that are provided on an operational and sustained basis. This does not preclude the use by CGMS members of other missions undertaken on a research or experimental basis (e.g. to demonstrate a specific capability). Research and experimental missions support the CGMS Baseline by:

- Supplementing the CGMS Baseline observations.
- Providing a pathway for new sensors and observations to be added to the CGMS Baseline as future operational missions.
- Supporting contingency operations in the case of a gap in the CGMS Baseline.

4.5 SYSTEM COMPATIBILITY AND INTEROPERABILITY

In order to help maintain a robust WMO Integrated Global Observing System (WIGOS), CGMS members shall work through CGMS Working Groups I, II and IV to establish and adopt best practices for interoperability and compatibility of systems and services.

ANNEX: CGMS baseline process

APPENDIX A: CGMS BASELINE PROCESS