# CGMS Baseline

## Sustained contributions to the Global Observing System

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# TABLE OF CONTENTS

# 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 primary goal of the coordination activities is to support operational weather monitoring and forecasting as well as climate monitoring. 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, measurements, and services. CGMS members plan to maintain the capabilities and services described below to support the WMO Global Observing System (GOS). This document will remain consistent with the principles of the WMO Integrated Global Observing System (WIGOS) 2040 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 | Link to current version |
|---|---|---|
| CGMS Baseline | Revised every four years | (this document) |
| CGMS Contingency Plan | Defines guidance and the process for identifying, mitigating, and coping with risks to the continuity of the CGMS Baseline. | CGMS-46-CGMS-WP-28 |
| 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. | CGMS HLPP 2018-2022 |
| WMO Gap Analysis | Contains the WMO gap analysis of CGMS Baseline against the WIGOS 2040 Vision. Document is provided to CGMS at least every 4 years. | CGMS-46-WMO-WP-14 |
| WIGOS Vision | Contains the overall vision for the complete observing system, based on WMO requirements. Document is updated by WMO every 4 years. | CGMS-46-WMO-WP-01 |

## 1.3 SCOPE OF THE BASELINE

The baseline enumerates the observations, measurements, 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 and measurements; services, including data collection and direct broadcast; as well as data sharing and distribution.

### 1.4 EVOLUTION OF THE BASELINE

The Baseline will be updated every four years to take into account the evolving programmatic plans of CGMS members and the WMO Gap Analysis of the CGMS Baseline against the WIGOS 2040 Vision. The process for updating the CGMS baseline is illustrated in Appendix A.

Following approval of the CGMS Baseline, WMO will include the revised CGMS Baseline in the new Manual on WIGOS.

### 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, MEASUREMENTS, AND ORBITS

### 2.1 OBSERVATIONS AND MEASUREMENTS

The orbits considered by CGMS for exploitation are: Low Earth Orbit (LEO), Geostationary orbit (GEO), Highly Elliptical Orbit (HEO), and stationarity in the L1 Lagrange libration point.

- LEO may be sun-synchronous or drifting. Sun-synchronous orbits may have 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 approximatively the same location of the Earth, including high latitudes, at approximatively the same time twice/day. For large-swath instruments, coverage at 4-hour intervals require three satellite at fairly-spaced ECT’s. Drifting orbit provide more frequent coverage with decreasing latitude (missing high 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 six fairly-spaced satellites, nominally stationary over 0°, 60°E, 120°E, 180°, 120°W and 60°W.

- 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 planned by some CGMS members but is 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 several minutes 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 either geostationary orbit (GEO) or Lagrange Point 1 (L1) when monitoring or observing the sun.

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

| Sensor Type | Orbit | Observation / Measurement | Attributes |
|---|---|---|---|
| Microwave Sounder | LEO | Atmospheric temperature, humidity, and precipitation | 3 sun-synchronous orbits, nominally early morning, mid-morning and afternoon |
| Infrared Sounder | LEO, GEO | Atmospheric temperature, and humidity | LEO - Hyperspectral on 3 sun-synchronous orbits, nominally early morning, mid-morning and afternoon<br><br>GEO - Hyperspectral at orbital positions 0° and 105° E. |
| Radio Occultation | LEO | Atmospheric temperature and humidity, Ionospheric Electron Density | 3 sun-synchronous orbits, early morning, mid-morning, and afternoon as well as other designated orbits such as equatorial – A minimum of 6,000 globally distributed occultations |

| Sensor Type | Orbit | Observation / Measurement | Attributes |
|---|---|---|---|
| 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.) | LEO - 3 sun-synchronous orbits, nominally early morning, mid-morning, and afternoon<br><br>GEO - Global coverage, nominally 6 evenly spaced satellites |
| Narrow Band Visible and Near Infrared Imager | LEO, GEO | Ocean colour | LEO - 2 orbits<br><br>GEO - 1 slot located 128.2°E |
| High Resolution Visible Infrared Imager | LEO | Land use, Vegetation type and status | LEO - 1 orbit |
| Microwave Imager | LEO | Sea surface temperature, Ocean surface winds, Precipitable water, Soil moisture, Snow and ice properties, Sea ice properties | LEO - 3 sun-synchronous orbits, nominally early morning, mid-morning and afternoon |
| Radar Altimetry | LEO | Ocean surface topography | LEO - 2 sun-synchronous orbits, early morning and mid-morning orbits as well as reference mission on a high-precision, inclined orbit |
| Scatterometer | LEO | Ocean surface winds | LEO - 3 sun-synchronous orbits, early morning, mid-morning and afternoon orbits |
| Lightning Mapper | GEO | Lightning mapper | GEO - In certain slots, 0°, 75.2°W, 137°W 86.5°E, and 105°E |

| Sensor Type | Orbit | Observation / Measurement | Attributes |
|---|---|---|---|
| Visible / IR Radiometer | LEO | Radiation balance | LEO - 2 sun-synchronous orbits, early morning and afternoon orbits |
| Visible/UV Spectrometer | LEO, GEO | Ozone | LEO - 2 sun-synchronous orbits mid-morning and afternoon<br>GEO - 2 slots at 0° and 128.2°E |
| Coronagraph | Sun-Earth line | Coronagraphy | GEO - 1 slot<br>L1 |
| EUV Imager | Sun-Earth line | EUV imagery | GEO - 2 slots |
| X-Ray Spectrograph | Sun-Earth line | X-Ray flux | GEO - 2 slots |
| Ion/Electron/Proton Spectrometer | LEO, GEO, and L1 | Energetic particles, solar wind | LEO - 2 sun-synchronous orbits, nominally early morning, mid-morning, and afternoon<br>GEO - Global coverage, nominally 6 evenly spaced satellites<br>L1 as in situ measure measurements |
| Magnetometer | LEO, GEO, L1 | Magnetic field, Solar wind | LEO - 3 sun-synchronous orbits, nominally early morning, mid-morning, and afternoon<br>GEO – 2 slots<br>L1 - as in situ measurement |
| Plasma Analyzer | L1 | Solar wind | L1 as in situ measure measurements |
| Precipitation Radar | LEO | Precipitation | LEO - equatorial orbit |
| Submillimeter Ice Cloud Imager | LEO | Cloud ice | LEO - sun synchronous mid-morning orbit |

| Sensor Type | Orbit | Observation / Measurement | Attributes |
|---|---|---|---|
| Synthetic Aperture Radar | LEO | Soil Moisture, Sea ice | LEO - 1 orbit |

# 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 191 WMO members and in particular provides critical global input data for the WMO members designated by 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 and measurement 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 near-real-time data dissemination of imagery, sounding, and other real-time data of interest to members by direct broadcast. 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 and measurements 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 comparability of satellite measurements taken at different times and locations by different instruments 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 and measurements.
- Providing a pathway for new sensors, observations, and measurements 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 Global Observing System (GOS), CGMS members shall work through Working Groups I, II, & IV to establish and adopt best practices for interoperability and compatibility of systems and services.

## APPENDIX A: CGMS BASELINE PROCESS