WMO Gap Analysis for Space-based Component of the WMO Integrated Global Observing System (WIGOS) Using WMO OSCAR/Space Tools

ITSC-25

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Contents

- WIGOS as a part of WMO’s global infrastructure
- WIGOS Vision 2040 and its evolution
- OSCAR database and WMO Gap Analysis
- Results of WMO 2025 Gap Analysis

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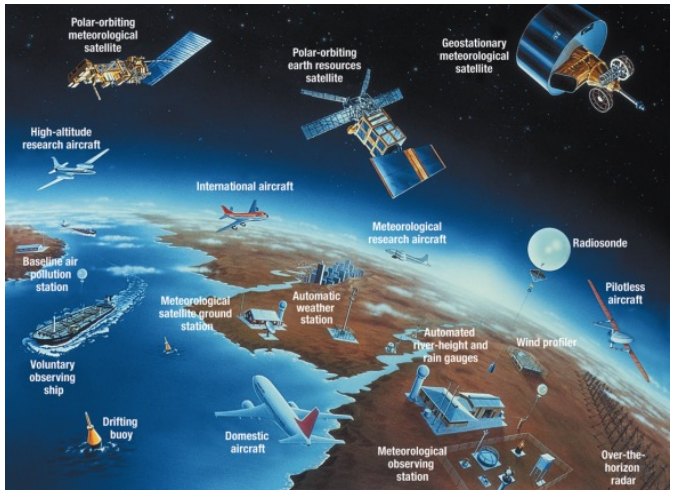
WIGOS as a part of WMO's global infrastructure

- Combines surface, upper air & Space based observations for the measurements of various Earth System domains
  - Atmosphere, hydrology, cryosphere, ocean, terrestrial, space weather

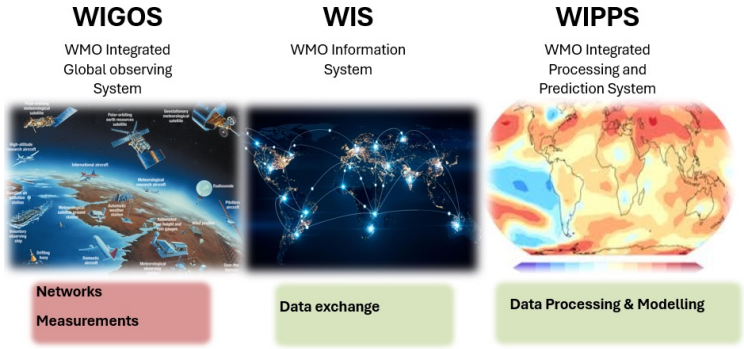


- WMO coordinated effort within expert teams and standing committees
  - Network design and Rolling Review of Requirements
  - Collaboration with partners like CGMS and CEOS

- WIGOS Tools: OSCAR/Surface, OSCAR/Space, OSCAR/Requirements, WDQMS (WIGOS Data Quality Monitoring System)

- WMO Unified Data Policy and data exchange
  - See poster 1p.01 WMO Core and Recommended Satellite Data

- Radio frequency coordination



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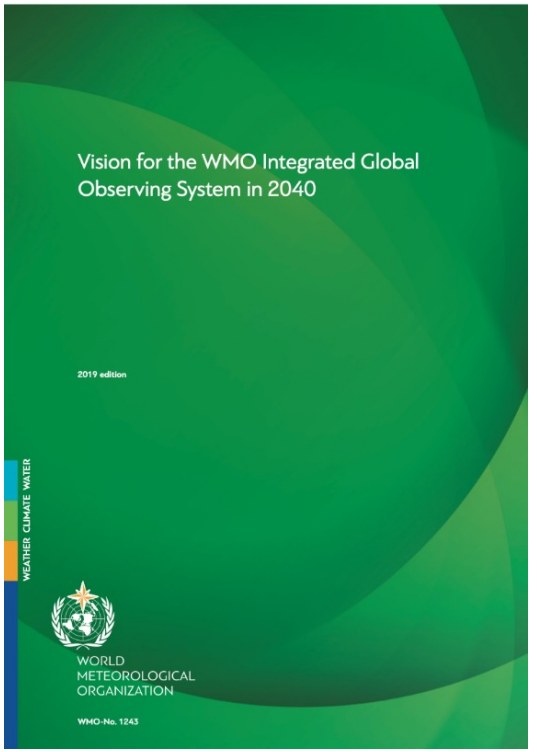
Vision for WIGOS 2040

The “Vision for WIGOS in 2040” describes:

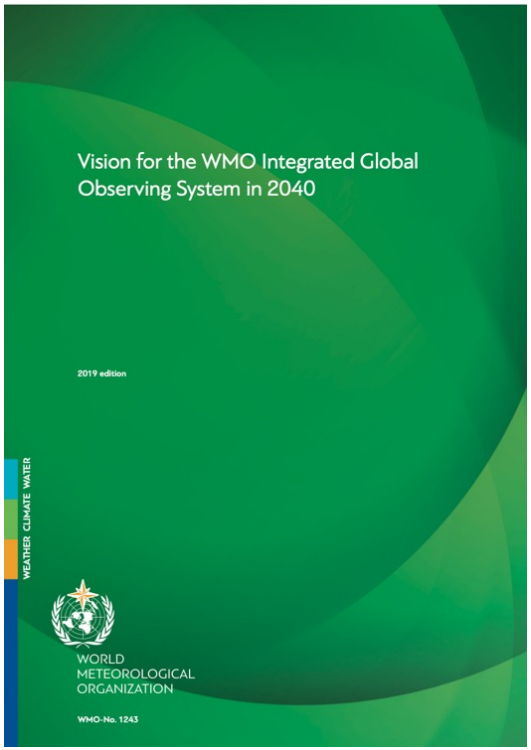
- High-level targets to guide the evolution of WIGOS
- A desired, future state of the space- and in-situ based observing system by 2040 within the areas of weather, climate and water and related environmental services.
- Adopted by Congress in 2019
  - Before WIGOS Vision 2025
- WIGOS Vision update ongoing: WIGOS Vision 2050
  - Topic to be presented in International Issues and Future Systems (IIFS) WG



Vision for WIGOS 2040 - Space Component

- The space-based component consists of four subcomponents:

1. Backbone system with specified orbital configuration and measurement approaches
2. Backbone system with open orbit configuration and flexibility to optimize the implementation
3. Operational pathfinders, and technology and science demonstrators
4. Additional capabilities (e.g. contributions by commercial operators)



Observing System Capability Analysis and Review Tool

OSCAR

Observing Systems Capability Analysis and Review Tool

Login

Home | Observation Requirements | Space-based Capabilities | Surface-based Capabilities | Analysis

Welcome to OSCAR

OSCAR is a resource developed by WMO in support of Earth Observation applications, studies and global coordination.

It contains quantitative user-defined requirements for observation of physical variables in application areas of WMO (i.e. related to weather, water and climate). OSCAR also provides detailed information on all earth observation satellites and instruments, and expert analyses of space-based capabilities.

The tool constitutes a building block of WIGOS and more specifically, the so-called Rolling Requirements Review process. OSCAR targets all users interested in the status and the planning of global observing systems as well as data users looking for instrument specifications at platform level. To continue, please select one of the following modules:

- Observation Requirements
- Satellite Capabilties
- Surface based Capabilties

Each of the modules can be consulted individually, however, the tool is also designed with the goal to integrate user requirements with actual capabilities. This facilitates the Rolling Requirements Review process, comparing "what is required" with "what is, or will be available", in order to identify gaps and support the planning of integrated global observing systems.

OSCAR overview - click to enlarge

The tool is being further developed, and additional functionality and information will be added as appropriate. Recently several new features were developed for the Gap Analyses functionality. In addtion, a restful API to retrieve observation records in OSCAR/Space and return them as JSON records was developed. This allows users to query the database and retrieve its records in the JSON format. Please see the details in the API documentation.

For support and feedback please use the helpdesk form.

Getting started with OSCAR/Space and OSCAR/Requirements

- Watch the 10 minute OSCAR screen-cast to get an overview of the application and learn how to use its functionalities
- Documents available for download
  - OSCAR/Space and OSCAR/Requirements User manual (413 kbyte)

Getting started with OSCAR/Surface

- Read the OSCAR/Surface User manual

See http://space.oscar.wmo.int

version 2.7.0α

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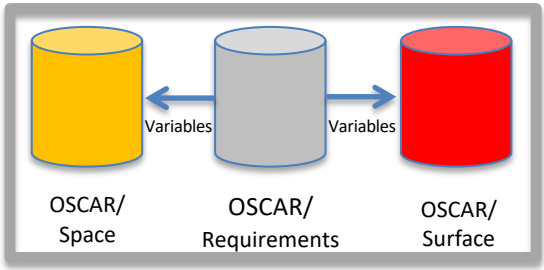
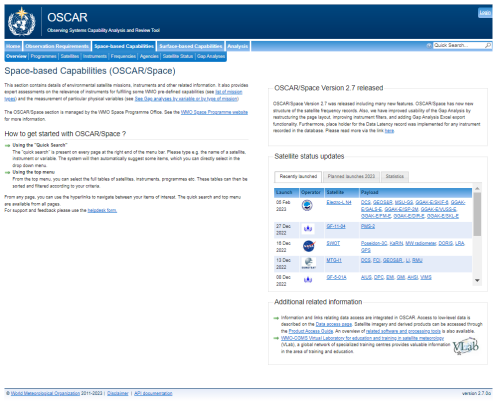
OSCAR combines three databases

- OSCAR is WMO-maintained online resource, which combines three components
- OSCAR/Space:
  - Current and planned satellite programmes, satellites and their instruments since TIROS-I (1st April 1960) until around 2040
  - Over 1000 satellites and around 1200 instruments (800 for Earth Observation and 400 for Space Weather)
- OSCAR/Surface:
  - Surface-based stations/platforms under WIGOS
- OSCAR/Requirements:
  - Observation requirements for WMO application areas and for all relevant variables

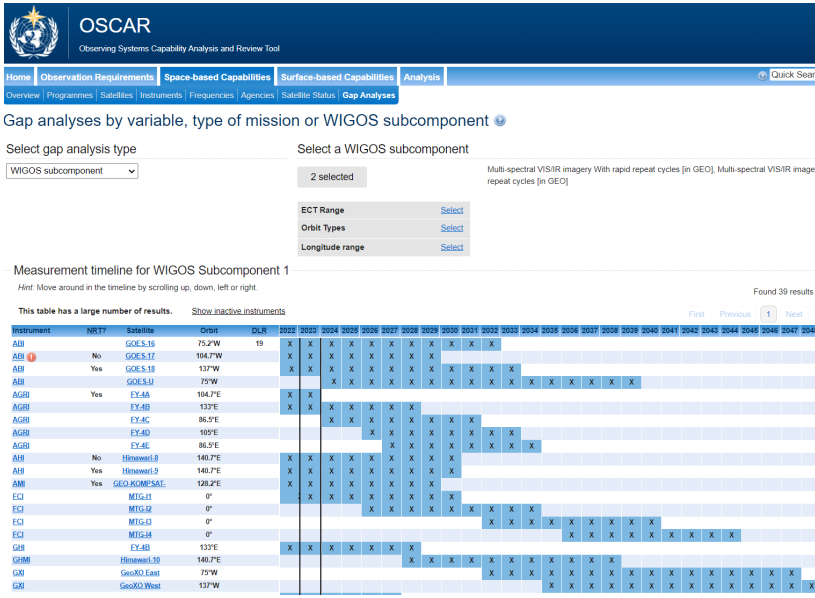




See http://space.oscar.wmo.int

OSCAR/Space provides WMO Gap Analysis

- Compares the satellite information recorded in OSCAR/Space to the user requirements in the space-based component of WIGOS Vision 2040
- Updated annual to cover next decade to support the CGMS Risk Assessment
- Presented under CGMS WGIII
  - Operational Continuity and Contingency Planning



WIGOS Vision - Geostationary core constellation

Earth Observation	Orbit	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Orbits or Satellites	WIGOS Vis.	Notes
Backbone system with specified orbital configuration and measurement approaches (Subcomponent 1)															
Geostationary core constellation with a minimum of five satellites providing complete Earth coverage															
VIS/IR Imagery	GEO	6	6	6	6	6	6	6	6	6	6	6	Orbits	≥5 satellites	No anticipated gaps in imagery out to 2033
IR Sounding	GEO	3	3	3	3	3	3	3	3	3	3	4	Orbits	≥5 satellites	No hyperspectral sounder over W.Atlantic/Indian Oceans
Lightning	GEO	4	5	5	5	5	5	5	5	5	5	4	Orbits	≥5 satellites	ELECTRO-M N3 covers Pacific from 2029
UV/VIS/NIR Sounder	GEO	3	2	2	2	2	2	2	1	1	1	2	Orbits	≥5 satellites	Lose TEMPO by 2026, Gain GEO-XO in 2035

Definition of colours for orbital coverage
5/6 GEO
3/4 GEO
1/2 GEO
No GEO

Gap =

Rows in pink = CGMS baseline instrument

WIGOS Vision 2040 Subcomponent 1:

- Backbone system with specified orbital configuration and measurement approaches:
  - Geostationary core constellation with **a minimum of five satellites** providing complete Earth coverage

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WIGOS Vision - LEO core constellation

Earth Observation	Orbit	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Orbits or Satellites	WIGOS Vis.	Notes
Backbone system with specified orbital configuration and measurement approaches (Subcomponent 1)															
Sun-synchronous core constellation satellites in three orbital planes (morning, afternoon, early morning)															
IR Sounding	LEO	3	3	3	3	3	3	3	3	3	3	3	Orbits	3 SSO	Good coverage from all 3 orbits
MW Sounding	LEO	3	3	3	3	3	3	3	3	3	3	3	Orbits	3 SSO	Good coverage from all 3 orbits
VIS/IR Imagery	LEO	3	3	3	3	3	3	3	3	3	3	3	Orbits	3 SSO	Good coverage from all 3 orbits
Day/Night VIS Imagery	LEO	3	2	2	2	2	2	2	2	2	2	2	Orbits	3 SSO	FY-3E/J for early AM and NOAA for PM orbit
MW Imager	LEO	3	3	3	3	3	3	2	2	2	2	2	Orbits	3 SSO	Assumes access to WSF-M
Scatterometers	LEO	4	4	4	4	4	4	3	3	3	3	3	Orbits	3 SSO	Lose drifters (HY-n) after 2031

Definition of colours for orbital coverage
3 LEO orbits covered
2 LEO orbits covered
1 LEO orbit covered
No LEO coverage

Gap =

Rows in pink = CGMS baseline instrument

WIGOS Vision 2040 Subcomponent 1:

- Backbone system with specified orbital configuration and measurement approaches:
  - Sun-synchronous core constellation satellites in **three orbital planes** (morning, afternoon, early morning)
  - Additional scatterometers on drifting orbit

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WIGOS Vision - Instruments on other satellites in low-Earth orbit (Subcomponent 1)

Earth Observation	Orbit	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Orbits or Satellites	WIGOS Vis.	Notes
Backbone system with specified orbital configuration and measurement approaches (Subcomponent 1)															
Instruments on other satellites in low-Earth orbit															
Radar Altimeters	LEO/DRIFT	3	3	3	3	3	3	3	3	3	3	3	Orbits	LEO	Note potential loss of >80N obs
Dual-view IR SST/LST	LEO	1	1	1	1	2	2	2	2	2	2	2	Orbits	LEO	Only 10:00 with Sentinel 3. LSTM (13:30) later this decade.
MW SST/LST	LEO	2	2	2	2	2	2	2	1	1	1	1	Orbits	LEO	Assumes CIMR flies in 2029
Strato/Meso Sounder	LEO	3	3	3	3	3	3	3	3	3	3	3	Orbits	LEO	Sterna assures good coverage
UV/VIS/NIR Sounder	LEO	3	3	3	3	2	2	2	2	2	2	2	Orbits	LEO	05:30 orbit not covered and drifters (OCO-3, NACHOS) cease in 2026
Greenhouse Gas measurements	LEO	19	17	16	16	16	14	9	9	10	6	5	Satellites	LEO	Only METOP-SG-A2 and Meteor after 2033
Limb sounder (UV/VIS)	LEO/DRIFT	4	3	2	2	2	2	2	2	1	1	1	Orbits	LEO	Lose drifters in 2026. AOS HAWKSat may help after 2031
Low frequency MW	LEO	1	1	0	0	1	1	1	1	1	1	1	Orbits	LEO	Potential gap between SMOS/SMAP and CIMR
Precipitation radar	DRIFT	2	3	5	5	6	2	2	2	1	1	0	Satellites	LEO	INCUS provides good coverage 2027-30. Potential gap after 2034.
Cloud radar	LEO	1	1	1	0	0	0	0	0	0	0	0	Satellites	LEO	EarthCARE only mission in place. None planned
Earth Radiation Budget	LEO	15	13	11	8	7	6	5	5	5	4	3	Satellites	LEO	CERES + Libera + 2X Meteor-M N2
Total solar irradiance	LEO/DRIFT	4	4	5	5	5	4	4	4	3	2	1	Satellites	LEO	Relies on FY-3 satellites at end of period
Spectral solar irradiance	LEO/DRIFT	3	3	3	3	2	1	2	2	2	2	2	Satellites	LEO	Degrade after lose TSIS-2 in 2028. FY-3E/J provides continuity.
Core GNSS constellation	LEO/DRIFT	4	4	4	4	4	4	4	3	4	4	4	Orbits	LEO	Loss of COSMIC-2 reduces coverage over tropics.
Ocean Colour	LEO	2	2	2	2	2	2	2	2	2	2	2	Orbits	LEO	No 05:30 measurements
HS imager for vegetation	LEO	2	1	1	1	1	1	2	2	2	2	2	Orbits	LEO	No drifters until TRUTHS 2031. CHIME after 2029. All in morning orbits.
High Resolution land imagery	LEO	2	2	2	2	2	2	2	2	2	2	2	Orbits	LEO	Many commercial satellites not included here. Lose drifters in 2027
SAR imagery	LEO	52	35	34	30	27	20	15	11	8	7	6	Satellites	LEO	C band only committed to 2032 but many commercial systems
Gravitometry (Drift orbits)	DRIFT	20	18	12	12	12	13	13	11	11	10	10	Satellites	LEO	Mainly for laser ranging.

Definition of colours for orbital coverage
3 LEO orbits covered
2 LEO orbits covered
1 LEO orbit covered
No LEO coverage

Rows in pink = CGMS baseline instrument

Gap =

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Earth Observation	Orbit	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Orbits or Satellites	WIGOS Vis.	Notes
Backbone system with specified orbital configuration and measurement approaches (Subcomponent 1)															
Geostationary core constellation with a minimum of five satellites providing complete Earth coverage															
VIS/IR Imagery	GEO	6	6	6	6	6	6	6	6	6	4	5	Orbits	≥5 satellites	No anticipated gaps in imagery out to 2033
IR Sounding	GEO	3	3	3	3	3	3	3	3	3	3	4	Orbits	≥5 satellites	No hyperspectral sounder over W.Atlantic/Indian Oceans
Lightning	GEO	4	5	5	5	5	5	5	5	5	5	4	Orbits	≥5 satellites	ELECTRO-M N3 covers Pacific from 2029
UV/VIS/NIR Sounder	GEO	3	2	2	2	2	2	2	1	1	1	2	Orbits	≥5 satellites	Lose TEMPO by 2026, Gain GEO-XO in 2035
Earth Observation	Orbit	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Orbits or Satellites	WIGOS Vis.	Notes
Backbone system with specified orbital configuration and measurement approaches (Subcomponent 1)															
Sun-synchronous core constellation satellites in three orbital planes (morning, afternoon, early morning)															
IR Sounding	LEO	3	3	3	3	3	3	3	3	3	3	3	Orbits	3 SSO	Good coverage from all 3 orbits
MW Sounding	LEO	3	3	3	3	3	3	3	3	3	3	3	Orbits	3 SSO	Good coverage from all 3 orbits
VIS/IR Imagery	LEO	3	3	3	3	3	3	3	3	3	3	3	Orbits	3 SSO	Good coverage from all 3 orbits
Day/Night VIS Imagery	LEO	3	2	2	2	2	2	2	2	2	2	2	Orbits	2 SSO	FY-3E/J for early AM and NOAA for PM orbit
MW Imager	LEO	3	3	3	3	3	3	2	2	2	2	2	Orbits	3 SSO	Assumes access to WSF-M
Scatterometers	LEO	4	4	4	4	4	4	3	3	3	3	3	Orbits	3 SSO	Lose drifters (HY-n) after 2031
Earth Observation	Orbit	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Orbits or Satellites	WIGOS Vis.	Notes
Backbone system with specified orbital configuration and measurement approaches (Subcomponent 1)															
Instruments on other satellites in low-Earth orbit															
Radar Altimeters	LEO/DRIFT	3	3	3	3	3	3	3	3	3	3	3	Orbits	LEO	Note potential loss of >80N obs
Dual-view IR SST/LST	LEO	1	1	1	1	2	2	2	2	2	2	2	Orbits	LEO	Only 10:00 with Sentinel 3. LSTM (13:30) later this decade.
MW SST/LST	LEO	2	2	2	2	2	2	2	1	1	1	1	Orbits	LEO	Assumes CIMR flies in 2029
Strato/Meso Sounder	LEO	3	3	3	3	3	3	3	3	3	3	3	Orbits	LEO	Sterna assures good coverage
UV/VIS/NIR Sounder	LEO	3	3	3	3	2	2	2	2	2	2	2	Orbits	LEO	05:30 orbit not covered and drifters (OCO-3, NACHOS) cease in 2026
Greenhouse Gas measurements	LEO	19	17	16	16	16	14	9	9	10	6	5	Satellites	LEO	Only METOP-SG-A2 and Meteor after 2033
Limb sounder (UV/VIS)	LEO/DRIFT	3	2	2	2	2	2	2	2	1	1	1	Orbits	LEO	Lose drifters in 2026. AOS HAWKSat may help after 2031
Low frequency MW	LEO	1	1	0	0	1	1	1	1	1	1	1	Orbits	LEO	Potential gap between SMOS/SMAP and CIMR
Precipitation radar	DRIFT	2	3	5	5	6	2	2	2	1	1	0	Satellites	LEO	INCUS provides good coverage 2027-30. Potential gap after 2034.
Cloud radar	LEO	1	1	1	0	0	0	0	0	0	0	0	Satellites	LEO	EarthCARE only mission in place. None planned
Earth Radiation Budget	LEO	15	13	11	8	7	6	5	5	5	4	3	Satellites	LEO	CERES + Libera + 2X Meteor-M N2
Total solar irradiance	LEO/DRIFT	2	2	3	3	3	2	2	2	1	1	1	Satellites	LEO	Relies on FY-3 satellites at end of period
Spectral solar irradiance	LEO/DRIFT	3	3	3	3	2	1	2	2	2	2	2	Satellites	LEO	Degrade after lose TSIS-2 in 2028. FY-3E/J provides continuity.
Core GNSS constellation	LEO/DRIFT	4	4	4	4	4	4	4	3	4	4	4	Orbits	LEO	Loss of COSMIC-2 reduces coverage over tropics.
Ocean Colour	LEO	2	2	2	2	2	2	2	2	2	2	2	Orbits	2 SSO	No 05:30 measurements
HS imager for vegetation	LEO	2	1	1	1	1	1	2	2	2	2	2	Orbits	LEO	No drifters until TRUTHS 2031. CHIME after 2029. All in morning orbi
High Resolution land imagery	LEO	3	3	2	2	2	2	2	2	2	2	2	Orbits	LEO	Many commercial satellites not included here. Lose drifters in 2027
SAR imagery	LEO	52	35	34	30	27	20	15	11	8	7	6	Satellites	LEO	C band only committed to 2032 but many commercial systems
Gravitometry (Drift orbits)	DRIFT	20	18	12	12	12	13	13	11	11	10	10	Satellites	LEO	Mainly for laser ranging.
Earth Observation	Orbit	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Orbits or Satellites	WIGOS Vis.	Notes
Backbone system with open orbit configuration and flexibility to optimize the implementation (Subcomponent 2)															
GNSS Reflectometry	LEO/DRIFT	4	4	4	4	4	3	3	3	1	1	1	Orbits	LEO	Relies on FY-3 satellites in next decade
Doppler wind lidar	LEO	0	0	0	0	0	0	0	0	0	1	1	Satellites	LEO	Assumes EPS-Aeolus in 2034
Backscatter lidar	LEO	1	1	1	0	0	0	0	0	0	0	0	Orbits	LEO	Only EarthCARE
DIAL lidar	LEO	1	2	2	2	2	2	2	1	1	0	0	Orbits	LEO	MERLIN+DQ
Altimeter lidar	DRIFT	3	3	2	2	1	1	0	0	0	0	0	Orbits	LEO/DRIFT	Nothing planned after ISS-MOLI/GEDI 2024-2030
Wide swath radar altimeter	DRIFT	3	3	2	2	2	2	2	2	2	2	2	Bands	DRIFT	Green=Ku/Ka/X-band Yell=Only 2 bands/Orange=1 band
Sub-mm imager	LEO	2	1	1	1	3	3	3	1	2	2	1	Orbits	LEO	Relies on ICI/Metop-SG for continuity, boosted by POLSIR 2029-31
Limb sounder IR/MW	LEO	2	0	0	0	0	0	0	0	0	0	0	Satellites	LEO	MW relies on ODIN and Aura/MLS both close to EoL
UV/VIS/NIR Imaging	LEO	3	4	4	4	4	4	3	2	2	2	2	Orbits	LEO/DRIFT	Relies on Sentinel-5/5P, CO2M, OCO-2 and GHGSat
Multi-angle/pol. radiometer	LEO	3	3	3	3	3	2	2	2	2	1	1	Orbits	LEO	3MI+PACE+DQ
High temporal MW sounders	LEO	2	2	1	0	3	3	3	3	3	3	3	Orbits	DRIFT	TROPICS, Tomorrow-IO and EPS-Sterna
SW scanning limb sounder	LEO/DRIFT	6	3	4	4	3	3	3	3	3	3	3	Satellites	LEO/DRIFT	OMPS-Limb, ACS-Limb
SW occultation limb sounder	LEO/DRIFT	6	4	3	3	1	1	0	0	0	0	0	Satellites	LEO/DRIFT	ACS, SAGE-III, OSIRIS
Continuous polar coverage	MOL	2	3	3	3	3	3	2	2	2	2	2	Satellites	MOL	Arctica, Green=2 satellites
MW Sounding	GEO	1	1	1	1	2	1	1	1	1	0	0	Orbits	GEO	Currently only FY-4M

Indicates a CGMS baseline measurement

Definition of colours for orbital coverage

5/6 GEO or 3 LEO orbits covered	
3/4 GEO or 2 LEO orbits covered	
1/2 GEO or 1 LEO orbit covered	
No GEO or LEO coverage	

Gaps against WIGOS Vision for Earth Observation

01	Hyperspectral IR sounders (GEO)	10	GNSS Reflectometry (LEO/Drift)
02	UV/VIS/NIR sounders (GEO)	11	Doppler Wind Lidar (LEO/Drift)
03	Day-night visible imagers (LEO)	12	Backscatter Dial Lidar (LEO/Drift)
04	Microwave Imagers (LEO)	13	Lidar and wide swath radar for Altimetry (LEO/Drift)
05	Low frequency microwave imager (LEO)	14	Limb sounder in IR and MW (LEO/Drift)
06	UV/VIS Nadir and Limb Sounders (LEO)	15	UV/VIS/NIR spectrometer (LEO/Drift)
07	Precipitation radar and cloud radar	16	High Temporal MW Sounders (LEO/Drift)
08	Total and spectral solar irradiance (LEO)	17	Multi-angle polarised radiometer (LEO)
09	Altimeter lidar (Drift)	18	SW Occultation limb sounder

Definition of colours for orbital coverage	
5/6 GEO or 3 LEO orbits covered	
3/4 GEO or 2 LEO orbits covered	
1/2 GEO or 1 LEO orbit covered	
No GEO or LEO coverage	

Summary

- WIGOS combines surface, upper air & Space based observations for the measurements of various Earth System domains
- It is a WMO coordinated effort within WMO expert teams and standing committees
- WIGOS Vision describes the high-level targets to guide the evolution of WIGOS including space-based component
- WMO provides annually a Gap Analysis for space-based component of WIGOS based on the OSCAR/Space database
- The latest analysis shows gaps in 18 instrument categories

Thank you.

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Hyperspectral IR sounders on GEO

- FY-4 series is the only GEO satellite with hyperspectral sounder until MTG series will be operational from 2026
- Himawari-10 is planned to include a hyperspectral sounder from 2029
- NOAA has plans with GEO-XO to cover the US from 2035
- Anyway, there are gaps over the West Atlantic, Indian and East Pacific oceans without confirmed plans in the next decade

Earth Observation	Orbit	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Orbits or Satellites	WIGOS Vis.	Notes
Backbone system with specified orbital configuration and measurement approaches (Subcomponent 1)															
Geostationary core constellation with a minimum of five satellites providing complete Earth coverage															
VIS/IR Imagery	GEO	6	6	6	6	6	6	6	6	6	6	6	Orbits	≥5 satellites	No anticipated gaps in imagery out to 2033
IR Sounding	GEO	3	3	3	3	3	3	3	3	3	3	4	Orbits	≥5 satellites	No hyperspectral sounder over W.Atlantic/Indian Oceans
Lightning	GEO	4	5	5	5	5	5	5	5	5	5	4	Orbits	≥5 satellites	ELECTRO-M N3 covers Pacific from 2029
UV/VIS/NIR Sounder	GEO	3	2	2	2	2	2	2	1	1	1	2	Orbits	≥5 satellites	Lose TEMPO by 2026, Gain GEO-XO in 2035

UV/VIS/NIR sounders on GEO

- Sounding of the atmosphere using reflected solar radiation at UV and VIS wavelengths is very limited at present
- GEO-KOMPSAT-2B and TEMPO have such an instrument launched in 2023
- Sentinel will enhance the coverage over Europe from 2025 and NOAA GEO-XO over US from 2035
- This leaves gaps over the mid-Atlantic, Asia and the Pacific in the next decade, which is a significant gap in the planned observing system

Earth Observation	Orbit	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Orbits or Satellites	WIGOS Vis.	Notes
Backbone system with specified orbital configuration and measurement approaches (Subcomponent 1)															
Geostationary core constellation with a minimum of five satellites providing complete Earth coverage															
VIS/IR Imagery	GEO	6	6	6	6	6	6	6	6	6	6	6	Orbits	≥5 satellites	No anticipated gaps in imagery out to 2033
IR Sounding	GEO	3	3	3	3	3	3	3	3	3	3	4	Orbits	≥5 satellites	No hyperspectral sounder over W.Atlantic/Indian Oceans
Lightning	GEO	4	5	5	5	5	5	5	5	5	5	4	Orbits	≥5 satellites	ELECTRO-M N3 covers Pacific from 2029
UV/VIS/NIR Sounder	GEO	3	2	2	2	2	2	2	1	1	1	2	Orbits	≥5 satellites	Lose TEMPO by 2026, Gain GEO-XO in 2035

Microwave Imagers on LEO

- The retirement of the SSMIS instruments on the DMSP satellites will reduce the number of MW imagers within next few years
- WSF-M1 is now in the early morning orbit (~05:00 LT) to potentially replace SSMIS
- Both the early morning (05:00 LT) and early afternoon (13:30 LT) orbits are at risk in the next decade and plans need to be put in place to provide continuity.

Earth Observation	Orbit	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Orbits or Satellites	WIGOS Vis.	Notes
Backbone system with specified orbital configuration and measurement approaches (Subcomponent 1)															
Sun-synchronous core constellation satellites in three orbital planes (morning, afternoon, early morning)															
IR Sounding	LEO	3	3	3	3	3	3	3	3	3	3	3	Orbits	3 SSO	Good coverage from all 3 orbits
MW Sounding	LEO	3	3	3	3	3	3	3	3	3	3	3	Orbits	3 SSO	Good coverage from all 3 orbits
VIS/IR Imagery	LEO	3	3	3	3	3	3	3	3	3	3	3	Orbits	3 SSO	Good coverage from all 3 orbits
Day/Night VIS Imagery	LEO	3	2	2	2	2	2	2	2	2	2	2	Orbits	3 SSO	FY-3E/J for early AM and NOAA for PM orbit
MW Imager	LEO	3	3	3	3	3	3	2	2	2	2	2	Orbits	3 SSO	Assumes access to WSF-M
Scatterometers	LEO	4	4	4	4	4	4	3	3	3	3	3	Orbits	3 SSO	Lose drifters (HY-n) after 2031

The most critical gaps for the next decade

- Doppler Wind Lidar on LEO/Drift
- High Temporal MW Sounders on LEO/Drift
- Greenhouse gas measurements

- Limb sounder in IR and MW on LEO/Drift

Day-night visible imagery

- Satellites with a day-night visible channel capability are only in the early morning (FY-3) and early afternoon (NOAA) orbits

- There are no plans for day-night imagery in the late morning orbit

Earth Observation	Orbit	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Orbits or Satellites	WIGOS Vis.	Notes
Backbone system with specified orbital configuration and measurement approaches (Subcomponent 1)															
Sun-synchronous core constellation satellites in three orbital planes (morning, afternoon, early morning)															
IR Sounding	LEO	3	3	3	3	3	3	3	3	3	3	3	Orbits	3 SSO	Good coverage from all 3 orbits
MW Sounding	LEO	3	3	3	3	3	3	3	3	3	3	3	Orbits	3 SSO	Good coverage from all 3 orbits
VIS/IR Imagery	LEO	3	3	3	3	3	3	3	3	3	3	3	Orbits	3 SSO	Good coverage from all 3 orbits
Day/Night VIS Imagery	LEO	3	2	2	2	2	2	2	2	2	2	2	Orbits	3 SSO	FY-3E/J for early AM and NOAA for PM orbit
MW Imager	LEO	3	3	3	3	3	3	2	2	2	2	2	Orbits	3 SSO	Assumes access to WSF-M
Scatterometers	LEO	4	4	4	4	4	4	3	3	3	3	3	Orbits	3 SSO	Lose drifters (HY-n) after 2031

Back-up

Backbone system with open orbit configuration and flexibility to optimize the implementation (Subcomponent 2)

Earth Observation	Orbit	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Orbits or Satellites	WIGOS Vis.	Notes
Backbone system with open orbit configuration and flexibility to optimize the implementation (Subcomponent 2)															
GNSS Reflectometry	LEO/DRIFT	4	4	4	4	4	3	3	3	1	1	1	Orbits	LEO	Relies on FY-3 satellites in next decade
Doppler wind lidar	LEO	0	0	0	0	0	0	0	0	0	1	1	Satellites	LEO	Assumes EPS-Aeolus in 2034
Backscatter lidar	LEO	1	1	1	0	0	0	0	0	0	0	0	Orbits	LEO	Only EarthCARE
DIAL lidar	LEO	1	2	2	2	2	2	2	1	1	0	0	Orbits	LEO	MERLIN+DQ
Altimeter lidar	DRIFT	3	3	2	2	1	1	0	0	0	0	0	Orbits	LEO/DRIFT	Nothing planned after ISS-MOLI/GEDI 2024-2030
Wide swath radar altimeter	DRIFT	3	3	2	2	2	2	2	2	2	2	2	Bands	DRIFT	Green=Ku/Ka/X-band Yell=Only 2 bands/Orange=1 band
Sub-mm imager	LEO	2	1	1	1	3	3	3	1	2	2	1	Orbits	LEO	Relies on ICI/Metop-SG for continuity, boosted by POLSIR 2029-31
Limb sounder IR/MW	LEO	2	0	0	0	0	0	0	0	0	0	0	Satellites	LEO	MW relies on ODIN and Aura/MLS both close to EoL
UV/VIS/NIR Imaging	LEO	4	5	5	5	5	5	4	2	2	2	2	Orbits	LEO/DRIFT	Relies on Sentinel-5/5P, CO2M, OCO-2 and GHGSat
Multi-angle/pol. radiometer	LEO	3	3	3	3	3	2	2	2	2	1	1	Orbits	LEO	3MI+PACE+DQ
High temporal MW sounders	LEO	2	2	1	0	3	3	3	3	3	3	3	Orbits	DRIFT	TROPICS, Tomorrow-IO and EPS-Sterna
SW scanning limb sounder	LEO/DRIFT	6	3	4	4	3	3	3	3	3	3	3	Satellites	LEO/DRIFT	OMPS-Limb, ACS-Limb
SW occultation limb sounder	LEO/DRIFT	6	4	3	3	1	1	0	0	0	0	0	Satellites	LEO/DRIFT	ACS, SAGE-III, OSIRIS
Continuous polar coverage	MOL	2	3	3	3	3	3	2	2	2	2	2	Satellites	MOL	Arctica, Green=2 satellites
MW Sounding	GEO	1	1	1	1	2	1	1	1	1	0	0	Orbits	GEO	Currently only FY-4M

Definition of colours for orbital coverage
3 LEO orbits covered
2 LEO orbits covered
1 LEO orbit covered
No LEO coverage

Gap =

WMO OMM

UV/VIS Nadir and Limb Sounders for atmospheric chemistry

- For limb sounders (scanning or occultation views) the afternoon orbit is covered by NOAA OMPS (up to 2041) and morning orbit by OMS-Limb (FY-3F) out to 2032
- Most of the requirements for stratospheric chemistry are for 6 hr or longer sampling times so a 2 polar orbiter system should be maintained

CGMS Baseline

- LEO – 2 sun-synchronous orbits, mid-morning, afternoon
- Need to ensure continuity beyond 2032

HLPP

- *Work towards establishing optimum constellations for new observations introduced in CGMS Baseline: UV limb sounding spectrometry for profiles of Ozone and trace gases.*

Earth Observation	Orbit	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Orbits or Satellites	WIGOS Vis.	Notes
Backbone system with specified orbital configuration and measurement approaches (Subcomponent 1)															
Instruments on other satellites in low-Earth orbit															
Radar Altimeters	LEO/DRIFT	3	3	3	3	3	3	3	3	3	3	3	Orbits	LEO	Note potential loss of >80N obs
Dual-view IR SST/LST	LEO	1	1	1	1	2	2	2	2	2	2	2	Orbits	LEO	Only 10:00 with Sentinel 3. LSTM (13:30) later this decade.
MW SST/LST	LEO	2	2	2	2	2	2	2	1	1	1	1	Orbits	LEO	Assumes CIMR flies in 2029
Strato/Meso Sounder	LEO	3	3	3	3	3	3	3	3	3	3	3	Orbits	LEO	Sterna assures good coverage
UV/VIS/NIR Sounder	LEO	3	3	3	3	2	2	2	2	2	2	2	Orbits	LEO	05:30 orbit not covered and drifters (OCO-3, NACHOS) cease in 2026
Greenhouse Gas measurements	LEO	19	17	16	16	16	14	9	9	10	6	5	Satellites	LEO	Only METOP-SG-A2 and Meteor after 2033
Limb sounder (UV/VIS)	LEO/DRIFT	4	3	2	2	2	2	2	2	1	1	1	Orbits	LEO	Lose drifters in 2026. AOS HAWKSat may help after 2031
Low frequency MW	LEO	1	1	0	0	1	1	1	1	1	1	1	Orbits	LEO	Potential gap between SMOS/SMAP and CIMR

Low frequency microwave imager on LEO

- Measuring the surface at the lower microwave frequencies (<10 GHz) is important for SST, soil moisture and salinity
- The ESA proposal for CIMR (and Japanese AMSR-3 instruments) should ensure good coverage for the next decade, and HY-2 series provide coverage in the early morning orbit prior to CIMR.
- Potential gap of < 5GHz in 2027-28 after SMOS/SMAP retired which impacts soil moisture/salinity
- Plans for long term continuity of these measurements should be put in place

CGMS Baseline

- *Covered by general baseline for microwave imagers, no specific attributes for low-frequency instruments*

HLPP

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

Earth Observation	Orbit	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Orbits or Satellites	WIGOS Vis.	Notes
Backbone system with specified orbital configuration and measurement approaches (Subcomponent 1)															
Instruments on other satellites in low-Earth orbit															
Radar Altimeters	LEO/DRIFT	3	3	3	3	3	3	3	3	3	3	3	Orbits	LEO	Note potential loss of >80N obs
Dual-view IR SST/LST	LEO	1	1	1	1	2	2	2	2	2	2	2	Orbits	LEO	Only 10:00 with Sentinel 3. LSTM (13:30) later this decade.
MW SST/LST	LEO	2	2	2	2	2	2	2	1	1	1	1	Orbits	LEO	Assumes CIMR flies in 2029
Strato/Meso Sounder	LEO	3	3	3	3	3	3	3	3	3	3	3	Orbits	LEO	Sterna assures good coverage
UV/VIS/NIR Sounder	LEO	3	3	3	3	2	2	2	2	2	2	2	Orbits	LEO	05:30 orbit not covered and drifters (OCO-3, NACHOS) cease in 2026
Greenhouse Gas measurements	LEO	19	17	16	16	16	14	9	9	10	6	5	Satellites	LEO	Only METOP-SG-A2 and Meteor after 2033
Limb sounder (UV/VIS)	LEO/DRIFT	4	3	2	2	2	2	2	2	1	1	1	Orbits	LEO	Lose drifters in 2026. AOS HAWKSat may help after 2031
Low frequency MW	LEO	1	1	0	0	1	1	1	1	1	1	1	Orbits	LEO	Potential gap between SMOS/SMAP and CIMR

Precipitation radar and cloud radar on LEO

- Precipitation radar:
  - The GPM-DPR will provide coverage for this decade
  - FY-3 satellites (FY-3G/I) have a precipitation radar providing measurements into the next decade in a drifting orbit without redundancy.

- Cloud radar:
  - EarthCARE is the only cloud radar planned for this decade
  - When EarthCARE retires there are no planned cloud radars to continue the measurements. The user requirement for sampling is for 3 hourly or better.

CGMS Baseline

- *Precipitation radar: LEO – drifting orbit, nothing for cloud radar*

HLPP

- *1.1.3 Ensure continuity of Precipitation Radar measurements*

Earth Observation	Orbit	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Orbits or Satellites	WIGOS Vis.	Notes
Backbone system with specified orbital configuration and measurement approaches (Subcomponent 1)															
Instruments on other satellites in low-Earth orbit															
Precipitation radar	DRIFT	2	3	5	5	6	2	2	2	1	1	0	Satellites	LEO	INCUS provides good coverage 2027-30. Potential gap after 2034.
Cloud radar	LEO	1	1	1	0	0	0	0	0	0	0	0	Satellites	LEO	EarthCARE only mission in place. None planned

WMO OMM

Total and spectral solar irradiance on LEO

- Continuity of total solar irradiance measurements in polar orbits are planned from FY-3E/J and the ESA TRUTHS mission on drifting orbit for the next decade

- The spectral solar irradiance observations will be reduced after 2028 when ISS-TSIS-2 is retired and after that FY-3E/F/J will provide continuity in the early morning orbit

CGMS Baseline:

- *Not included*

Earth Observation	Orbit	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	Orbits or Satellites	WIGOS Vis.	Notes
Backbone system with specified orbital configuration and measurement approaches (Subcomponent 1)															
Instruments on other satellites in low-Earth orbit															
Total solar irradiance	LEO/DRIFT	4	4	5	5	5	4	4	4	3	2	1	Satellites	LEO	Relies on FY-3 satellites at end of period
Spectral solar irradiance	LEO/DRIFT	3	3	3	3	2	1	2	2	2	2	2	Satellites	LEO	Degrade after lose TSIS-2 in 2028. FY-3E/J provides continuity.