

# WMO Global Greenhouse Gas Watch (G3W)

initiative and potential implications for the CGMS space agencies, including definition of reference support by CGMS

Presented to CGMS-52 plenary session, Item 4

Gianpaolo BALSAMO, G3W Director



## Executive summary for G3W



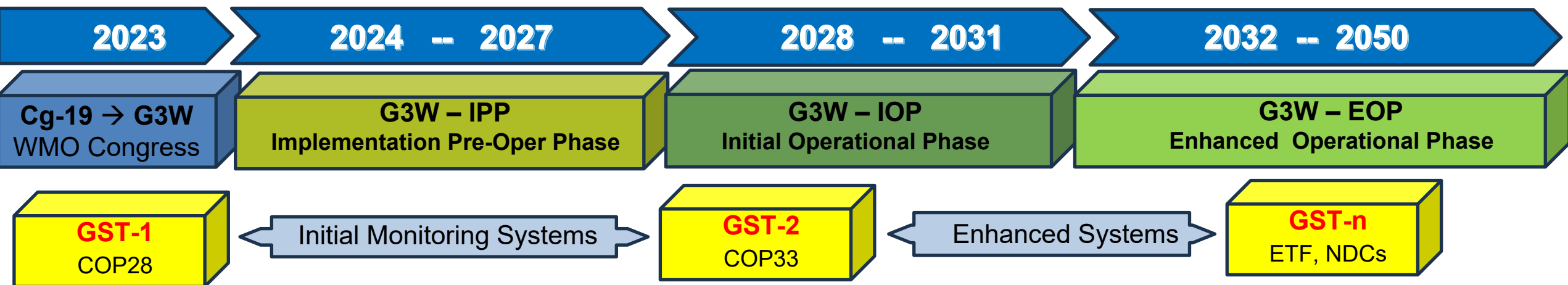
G3W the Global Greenhouse Gas Watch is approved by INFCOM-3 on 19<sup>th</sup> of April 2024

G3W will be presented to WMO Executive Council EC-78 on the 10<sup>th</sup> of June 2024

G3W is a WMO flagship with a costed implementation plan (1 B\$)

G3W calls to GHG-supporting Community for Roadmap activities

G3W involves both a "Sprint-run" & "Marathon" global efforts



G3W – the Global Greenhouse Gas Watch Flagship in a



The G3W Flagship responds to UN sustainability call, via **Climate Action** (mitigation) for **Climate Neutrality Goal**

• **G3W Master-Plan**

G3W-IPP Implementation & Pre-Oper Phase **2024-27**

G3W-IOP Initial Operational Phase **2028-31 (GST-2)**

G3W-EOP Enhanced Operational Phases **2032-50**

• **G3W Financial Sustainability**

WMO-RMS the Resources Mobilisation Strategy for **G3W**

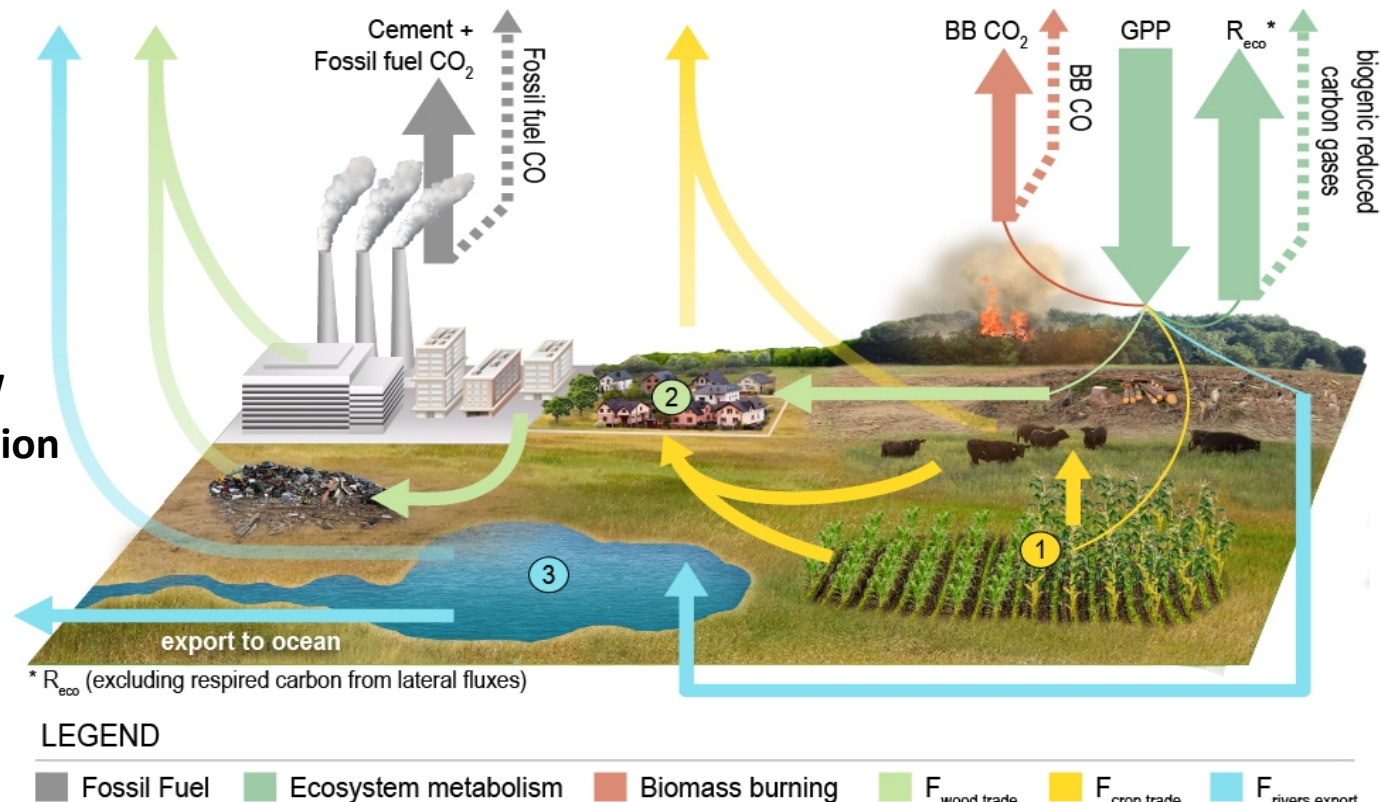
1 B\$ : 70% Observations, 29% Integration, 1% Coordination

• **G3W Working Structure**

• INFCOM-SC-ET Expert Teams

• EC-Joint-AG from the **WMO-G3W-SG**

• WIGOS / WIPPS / WIS synergy

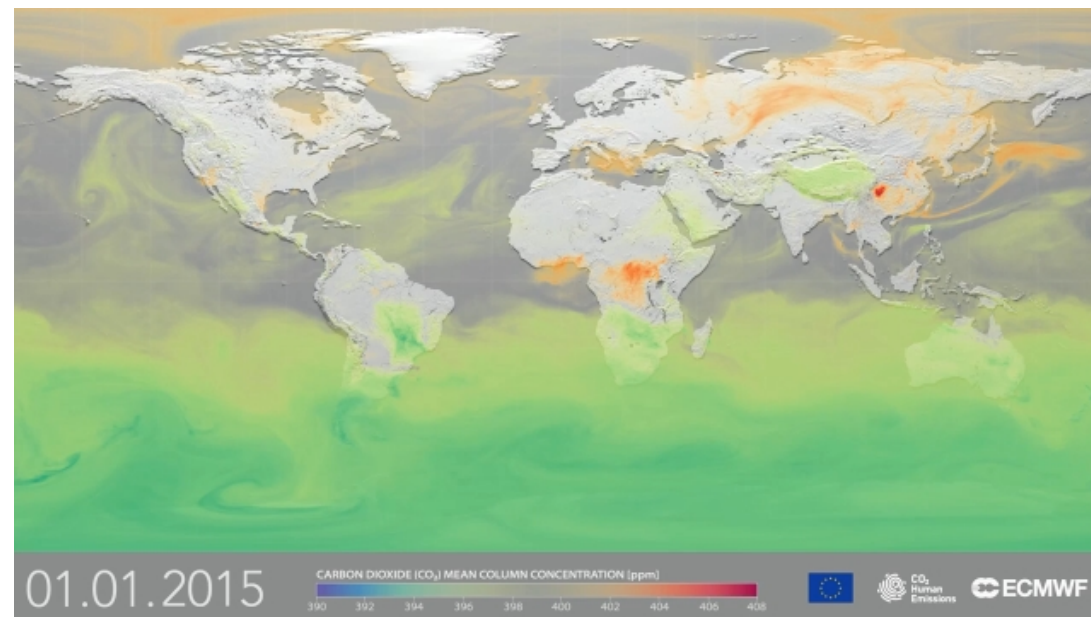


## The “What, How, Why” for G3W Flagship

**What:** The Global Greenhouse Gas Watch - **G3W** fills **critical information gaps** on greenhouse gases (GHGs), via an integrated **operational framework** that optimally combine **Earth Observations** with **Earth System Models** using **Data Assimilation & Artificial Intelligence** techniques to **reduce uncertainty** in assessing the efficacy of **Climate Action**.

**How:** a **Timely Policy-relevant information** on GHGs concentrations and fluxes allowing to assess both the **Natural & Human** influence on climate change <https://wmo.int/activities/global-greenhouse-gas-watch-g3w>

**Why :** an **Earth System Approach** is a must-have because **Earth’s climate responds to the laws of Climate Physics** and depends Atmospheric GHGs, NOT on Claimed Offset of Carbon emissions or to Good-will of Pledges.



## G3W Implementation Plan: priority deliverables

- Create inventory of observations
- Carry out observational network design

- Create inventory of prior data products

- Develop the supporting R&D strategy
- Identify the highest priority research needs for the operational systems

### Section 3 Observing System – O (12)

- O1 – Observation inventory
- O2 – Obs. standards & requirement
- O3 – Longer term Obs.
- O4 – Surface-based Obs. Design
- O5 – Reference Network Development
- O6 – Basic (“fit-for-purpose”) network
- O7 – RS & vertically-resolved Obs.
- O8 – Ocean network design
- O9 – Gridded Air-Sea CO<sub>2</sub> flux
- O10 – Space-based Obs. with CEOS-CGMS, direct
- O11 – Space-based Obs. with CEOS-CGMS, indirect
- O12 – Space-based Obs. with CEOS-CGMS, future

### Section 5 Prior Information – P (4)

- P1 – Identify needs – CO<sub>2</sub>
- P2 – Identify needs – CH<sub>4</sub>
- P3 – Identify needs – N<sub>2</sub>O
- P4 – Fluxes characterization

### Section 7 R&D Needs – R (3)

- R1 – G3W R20 Task Team establishment
- R2 – Advance Obs. & data exchange capabilities
- R3 – Advance modelling and flux inversion capabilities

### Section 4 Modelling System– M (7)

- M1 – Modelling center & data
- M2 – Modelling center-documentation
- M3 – Continuous Operations (RRR)
- M4 – Obs. acquisition and pre-processing
- M5 – Prior Implementation
- M6 – Production centers common approaches
- M7 – Modelling products evaluation

### Section 6 Data Management – D (7)

- D1 – Data from Raw to Exchange
- D2 – Data from providers to assimilation
- D3 – Data for model intercomparisons
- D4 – Data discovery and distribution
- D5 – Data repository for prior and fluxes
- D6 – Definition of prior data providers
- D7 – Data policy for the repository of prior fluxes

### Section 8 User Engagement & Uptake – U (4)

- U1 – Support the GST
- U2 – Guidance on regional products
- U3 – Establish relationship & pathway
- U4 – Develop user interface guidelines

- Definition of the output products and system requirements

- Evaluate applicability of WIS2.0 for G3W required data exchange
- Connect existing observations to WIS

- Identify requirement for the products
- Provide recommendations on the use of G3W outputs

## To be considered by CGMS:

- **EO Satellite-based** and **Surface-based** requirements for (eg. timeliness) need to satisfy **G3W Operating Centres**
- **Regular updates** communicating existing and upcoming **GHGs satellites capabilities** (public & private) is a necessity
- **Cal/Val activities** aim at co-development in collaboration with Satellite Agencies and **National and Regional efforts**
- Linking with **Private Sector** reaching Data Management Agreements that may preserve **WMO Resolution 1 – Unified Data Policy**



## Key issues of relevance to CGMS:

- The **G3W Implementation Plan** debated and approved by INFCOM-3, published as **EC-78 document** (web-link) in May 2024
- The **GBON requirements for GHGs** measurement is a Top-priority for the Surface-based Observing Network to support the Space-segment. WMO Secretariat to support Standing Commissions is insufficiently resourced.
- The **G3W Value Proposition** needs to be developed further to support the WMO/UN Resource Mobilisation. Coordination CEOS/CGMS/WMO welcome
- The **G3W Roadmap** (living document) to uptake CEOS/CGMS Roadmaps efforts as well as dedicated efforts (e.g. IOC-Ocean, Copernicus-Terrestrial).



## GCOS-GAW-G3W synergies with relevance to CGMS-52

The G3W Implementation Plan - approved by INFCOM-3 to be presented at EC-78

<https://wmo.int/media/update/global-greenhouse-gas-watch-implementation-plan-be-presented-executive-council-ec-78>

G3W fits a Climate Action strategy and there are 3 identified areas of synergies GCOS-GAW-G3W:

- 1. Observation Requirements differences within GAW and G3W with reference to GHGs observations entering in GCOS information products, and in G3W (e.g. NRT capability, see CGMS).**
  - 2. An analysis of the common gaps in GCOS and G3W (e.g. Deep-Oceans Carbon storage role, Cryosphere melting role with respect to GHGs)**
  - 3. Emerging Climate Indicators for Critical Tipping Points (e.g. Amazon CO2 absorption loss, Permafrost collapse CH4 release, others...) codesigned by GCOS & G3W to setup an early TP detection.**
- Optimal Network Design Workshop in Q3/Q4 2024 if possible. (WG-Climate)
  - COP30 Thematic programme of common interest to GCOS & G3W activity.
  - G3W communication via website and outreach activities. G3W both user-driven & science-driven.
  - GCOS & G3W in 2025-2027 will be further developed via common projects (CLIMACTION).





## G3W and WG-Climate identified synergies of interest for CGMS

### G3W and WG-Climate synergies

- ❖ WG-Climate-G3W trusted partners for space-based observations up to L2
- ❖ G3W interest to gradually operationalize L2+ aspects in collaboration with Regional/National Efforts
- ❖ In the section 3.5 of G3W implementation (Space-based observations of GHGs and related variables), three specific **actions** were included:
  - O10: Liaise and prioritise with CEOS-CGMS for direct GHG observations from space
  - O11: Liaise and prioritise with CEOS-CGMS for indirect GHG observations from space (required to infer GHG fluxes)
  - O12: Liaise and prioritise with CEOS-CGMS for required space-based observations to monitor changes in the carbon cycle in a (future) changing climate
- ❖ Some of the activities listed in GHG Roadmap will be (gradually) taken over by G3W
- ❖ In implementation phase, there is a need to work on **WG-Climate** ← → **G3W R202R**

## G3W and Private Sector consideration for CGMS

- CGMS feedback on **private sector engagement** welcome
- G3W reflections on **private sector interest (Carbon Markets)**
- **G3W costed plan** presented to **INFCOM-3**
- **G3W value proposition** refinement & **ROI study**
- Public-Private-Partnership & **Carbon Market**
- **Paris Agreement – Article 6**





# Thank you

Take Home  message

*CLIMATE ACTION NEEDS*

*SCIENCE DRIVEN – CONSENSUS BASED*

*CLIMATE DATA – INFORMATION - KNOWLEDGE*

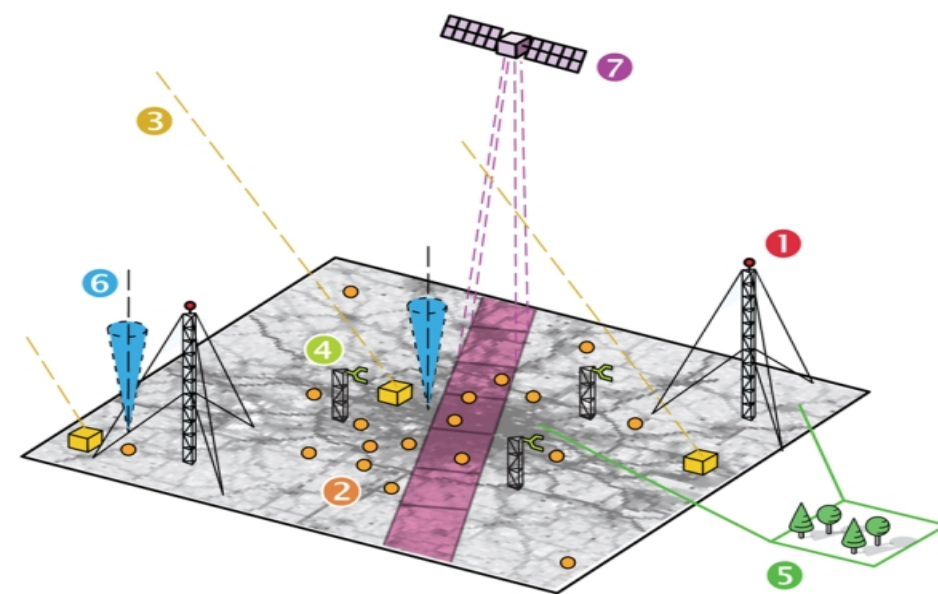
## Role of Earth Observations in G3W

The list of observable parameters required for the realization of the G3W is extensive, but clear priorities can be identified. Here the priorities are listed within five categories, from A (highest) to E (lowest):

- A. Ground-based measurements of GHGs
- B. *Remote-sensing and vertically resolved observations of GHGs*
- C. Ocean carbon cycle observations
- D. Direct GHG flux observations
- E. Higher tier observations

The minimum G3W system should have adequate observations from at least categories A, B and C. An adequate number of stations should provide observations of the lowest tier (category E), based on the overall network design

Tall towers (1), street level mid-cost sensors (2), roof level stations (3), eddy covariance flux stations (4), ecosystem parameters (5), total column GHG and meteorology (6) satellite (7) observations, in many parts including co-emitted species (from: ICOS Cities)



## Workshop recommendations: Status of observations and gaps

**Spatiotemporal data gaps:** over the Tropics, in Africa, over the open oceans, Arctic ecosystems, lack of vertically resolved measurements

**Validation gap:** Ground-based remote sensing even more sparse than in situ, satellite cross-validation

**Operational concerns:** No exhaustive inventory of available measurements, not timely for satellite validation, lack of definition of “good enough” measurements, planning of missions

**Financial gap:** lack of funds for maintenance, research-based funding

**Workforce gap:** not enough trained staff to support measurements

**Communication gap:** unclear how to make use of the observations

### Satellite agencies can help in:

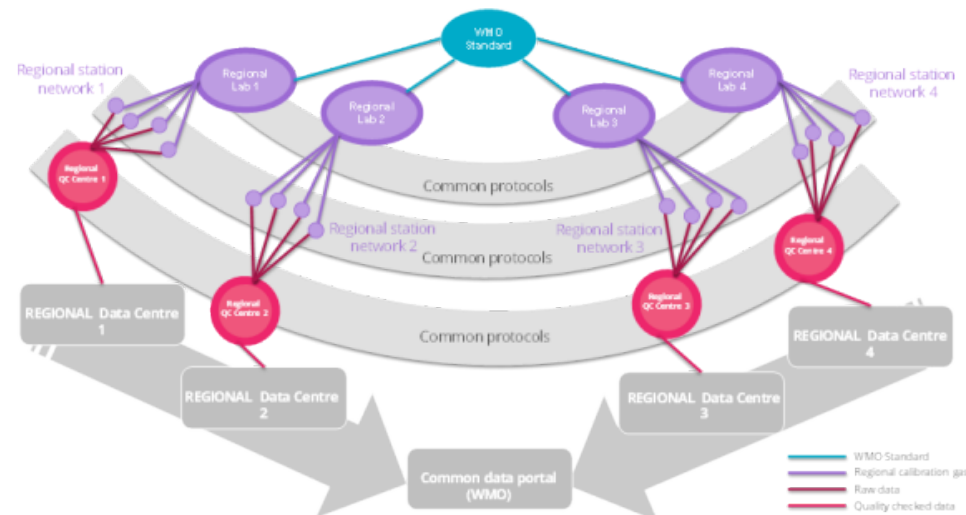
- addressing spatial and temporal gaps
- ensuring sustainability of the satellite observations
- assisting with the training of personnel
- communication regarding use of integrated observing system in support of the decision-making products generation



## Workshop recommendations: Integration and standardization

- Key aspect of integration is the integration of remote-sensing **and** in situ information for the **same** variables
- Integrated system needs an “all domains approach” which somehow retains the specific requirements of each individual domain (land, ocean, atmosphere).
- Multi-purpose measurements programme: inclusion of additional variables to constrain better priors (inundation datasets, higher frequency burned area, anything that improves the temporal profile of priors, vegetation type)
- Calibration is important, needs to be globally available (distributed calibration facilities)
- Existing standards need to be used as much as possible
- Metadata standards and metadata reporting needs to be consisted across and within domains

A tiered observing network, that includes a ‘reference’ quality component throughout the world can help provide a framework for integrated observing systems



## Workshop recommendations: Data systems & Data utilization

- **Data exchange** is important for GGGW implementation;
- **Data management** needs to be funded as an integral part of GGGW;
- **Guiding principle: FAIR and Open:** leverage the existing WMO standards(WIS2 and WIGOS); maintenance of standards, sensitive to user communities, cloud friendly
- Metadata/data reporting practice **for uncertainty reporting** and provenance are needed
- **Data access** can be federated, but sufficiently centralized
- **Timeliness can be improved;** will be easier if different data streams can be accommodated: (i) quick turn-around “NRT” data, as is, within days of measurement time; (ii) Final, quality-controlled data within months of measurement time;
- Sustainability (also of data management systems) is important

Satellite agencies can provide free and unrestricted access to as much relevant data as possible with the latency of 3 days or better

Communication of the value of integrated system (both in situ and satellite) is critical for user support

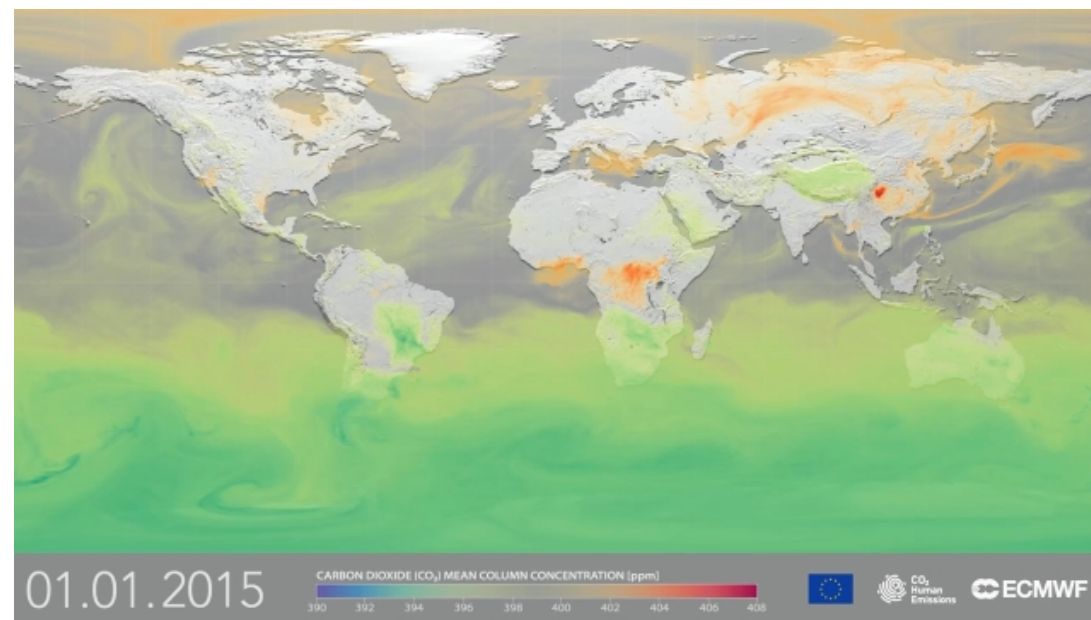


## The “What, How & Why” for the G3W Flagship

**What:** The Global Greenhouse Gas Watch - **G3W** fills critical information gaps on greenhouse gases (GHGs), via an integrated **operational global framework** that optimally combine **Earth Observations** with **Earth System Models** using **Data Assimilation & Artificial Intelligence** techniques to **reduce uncertainty** in assessing the efficacy of **Climate Action**.

**How:** a **Timely Policy-relevant information** on GHGs concentrations and fluxes allowing to assess both the **Natural & Human** influence on climate change <https://wmo.int/activities/global-greenhouse-gas-watch-g3w>

**Why :** an **Earth System Approach** is a must-have because **Earth’s climate responds to the laws of Climate Physics** and depends Atmospheric GHGs, NOT on Claimed Offset of Carbon emissions or to Good-will of Pledges.






## G3W Plan in Action

In 2023 two WMO key events

- 1<sup>st</sup> WMO GHGs Monitoring Symposium  
**G3W reaches broad science support**
- 19<sup>th</sup> World Meteorological Congress  
intergovernmental agreement approved  
**G3W proceeds with development**



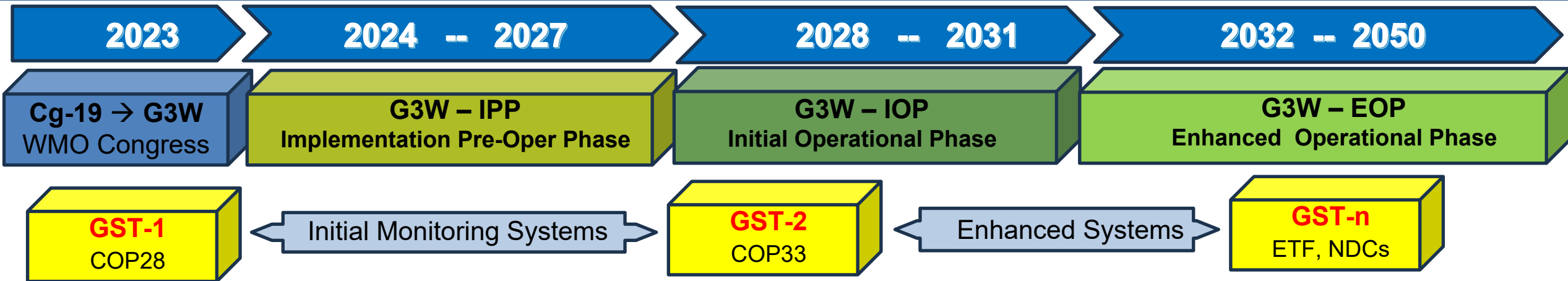
 COP28 raised the profile of the  
Global Greenhouse Gas Watch – G3W

- WMO prominent exposure at COP28 in particular at the Earth Information Day
- **G3W is noted by 196 Nations** in the [SBSTA-59](#), providing a successful closure of COP28 for G3W

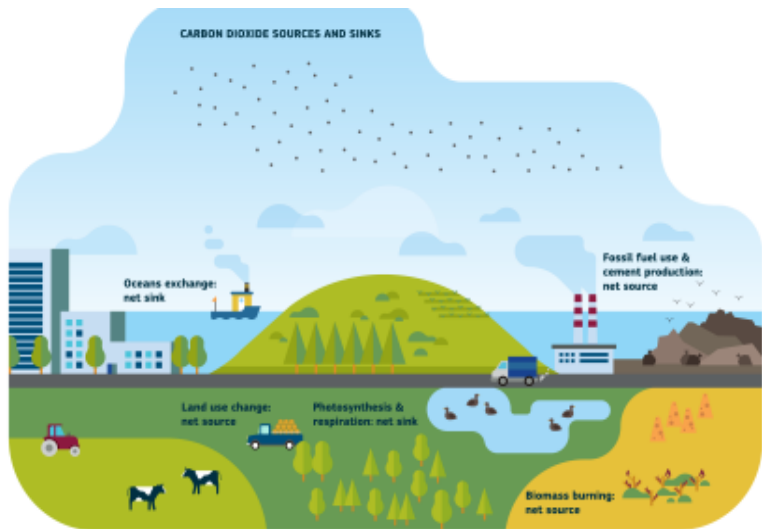
**Coordination Group for  
Meteorological Satellites**




# Coordination Group for Meteorological Satellites - CGMS



*“for Measuring, Understanding, and Managing the Earth’s Climate”*

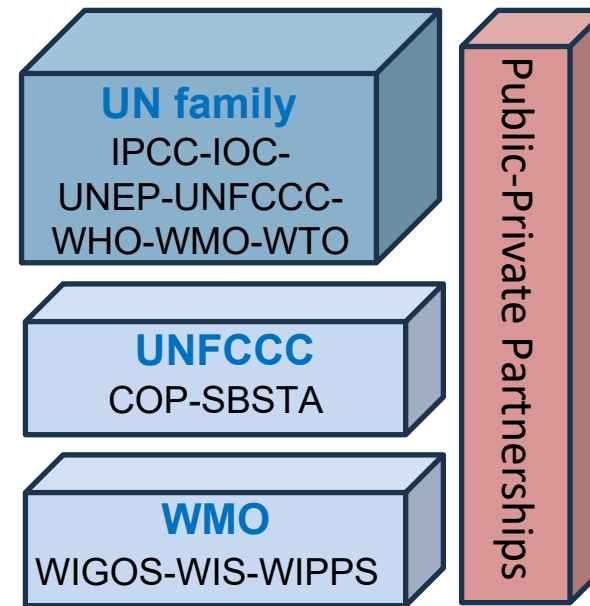
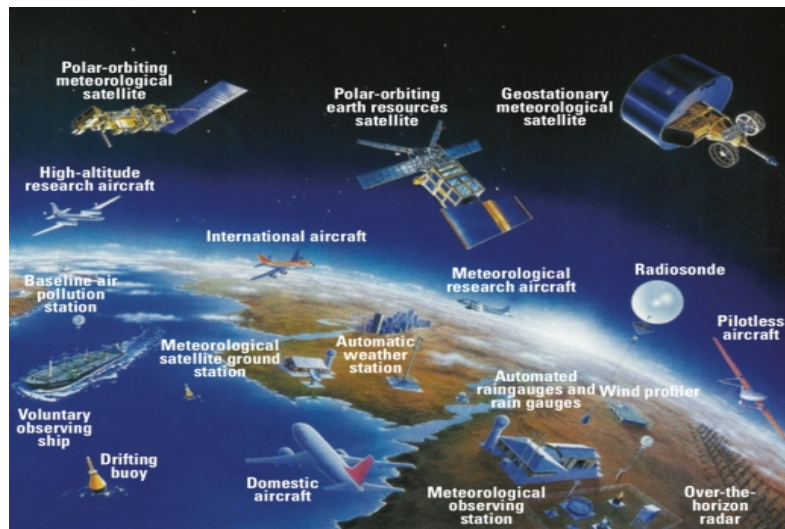


 CO<sub>2</sub>, Carbon dioxide

**Coordination Group for Meteorological Satellites**

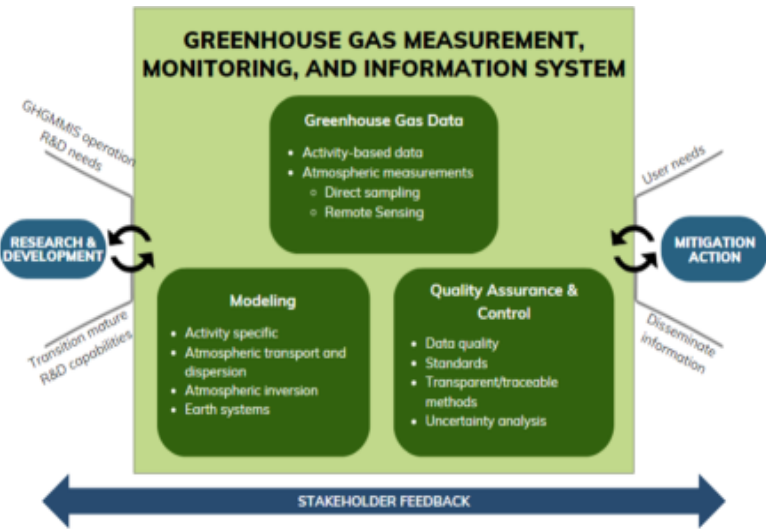


GHGs Earth’s Observing Systems is building on Weather experience

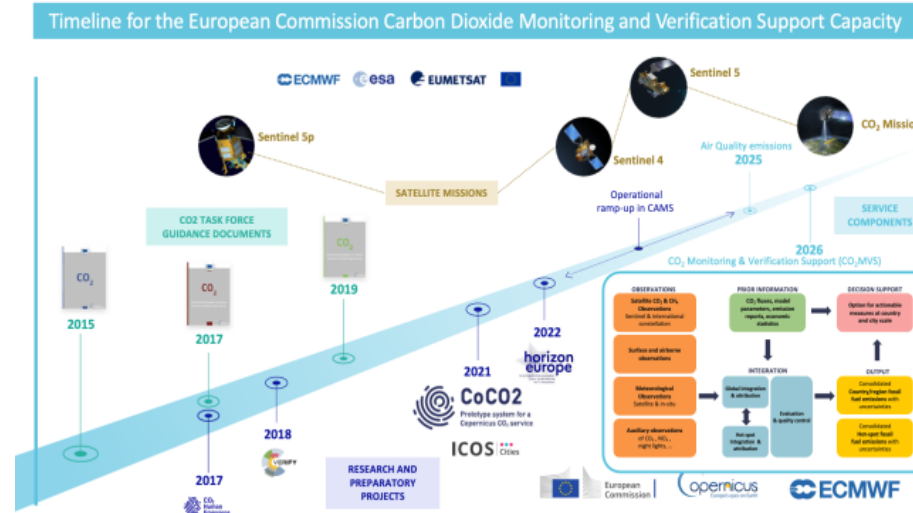


## Synchronizing with National & Regional efforts

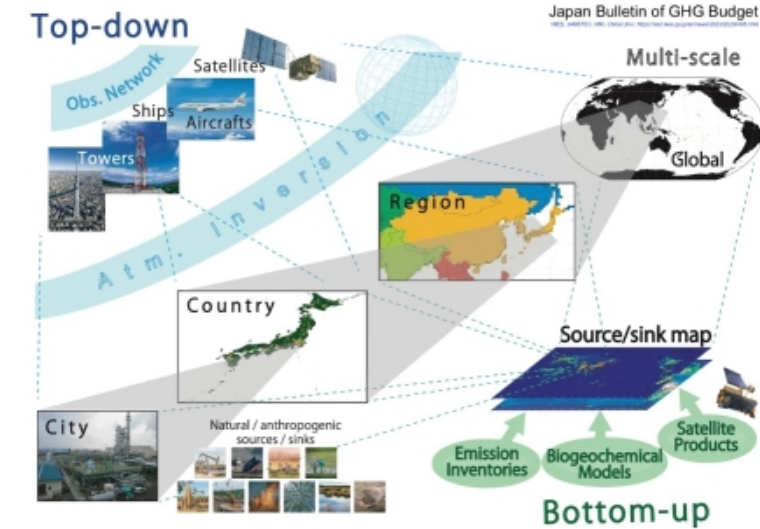
- In 2024 the **G3W Implementation Plan**, the **G3W Sustainability Strategy** documents.
- In 2025 & 2026 the **Ramp up Operations** with sustained funding sources (WMO + External).
- This is in good alignment with fast-track GHGs information efforts, such as in EU, JAPAN, US, ...



US GHGMMIS, 2023



EU COPERNICUS, 2023

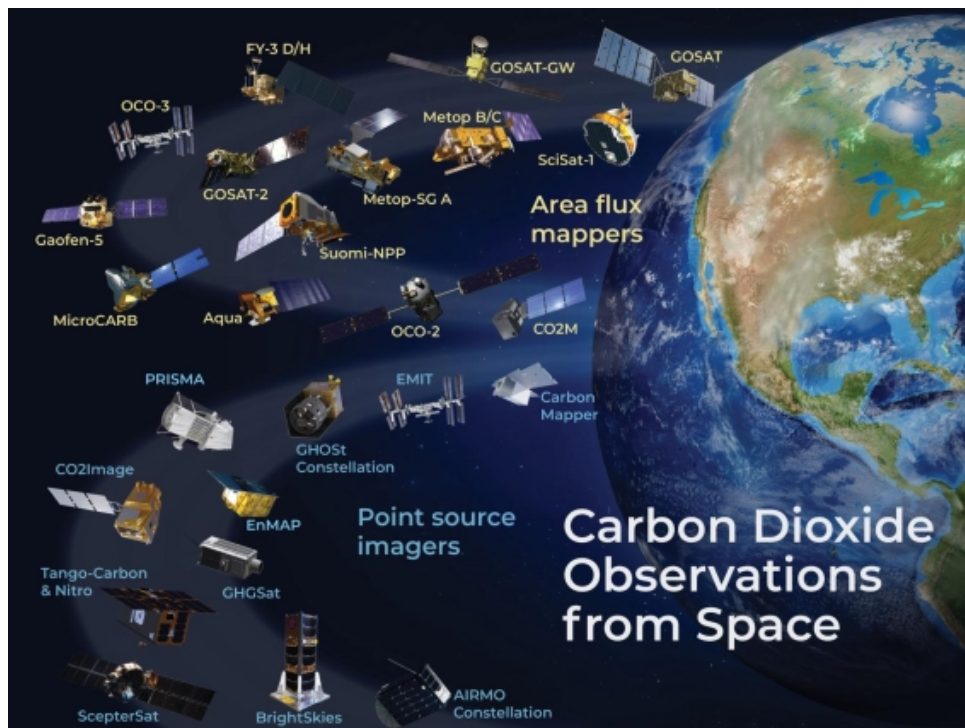


JAPAN NIES, 2023

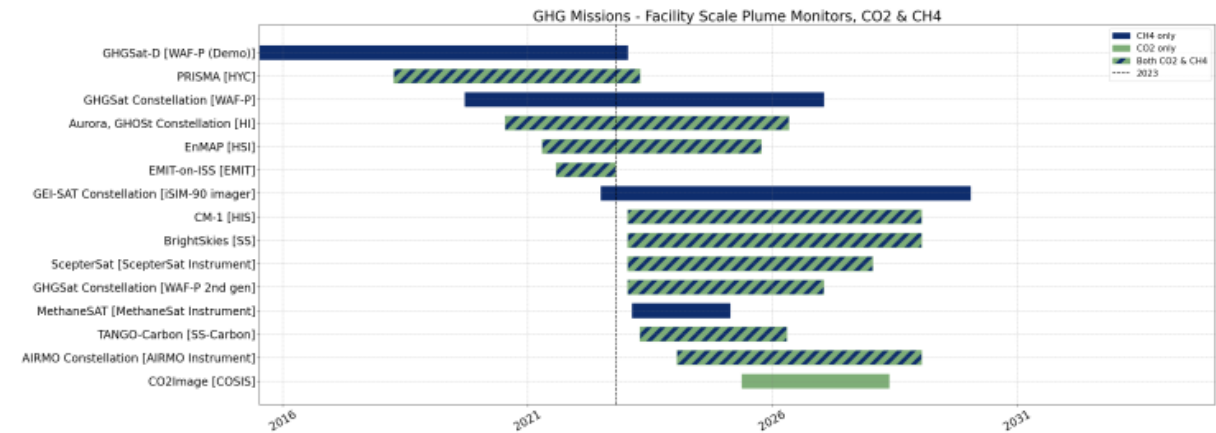
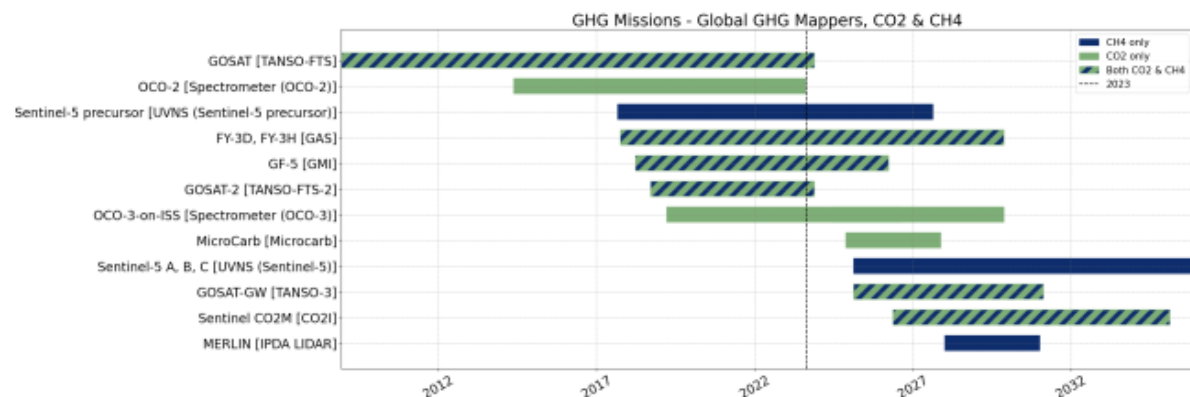


## Synchronizing with Space Agencies

- In 2024-27 the **G3W IPP Implementation and Pre-operational Phase**, it is crucial for the global coverage of local relevance that **G3W Space Remote Sensing** components are well coordinated.
- This is thanks to **CEOS** and to **CGMS**

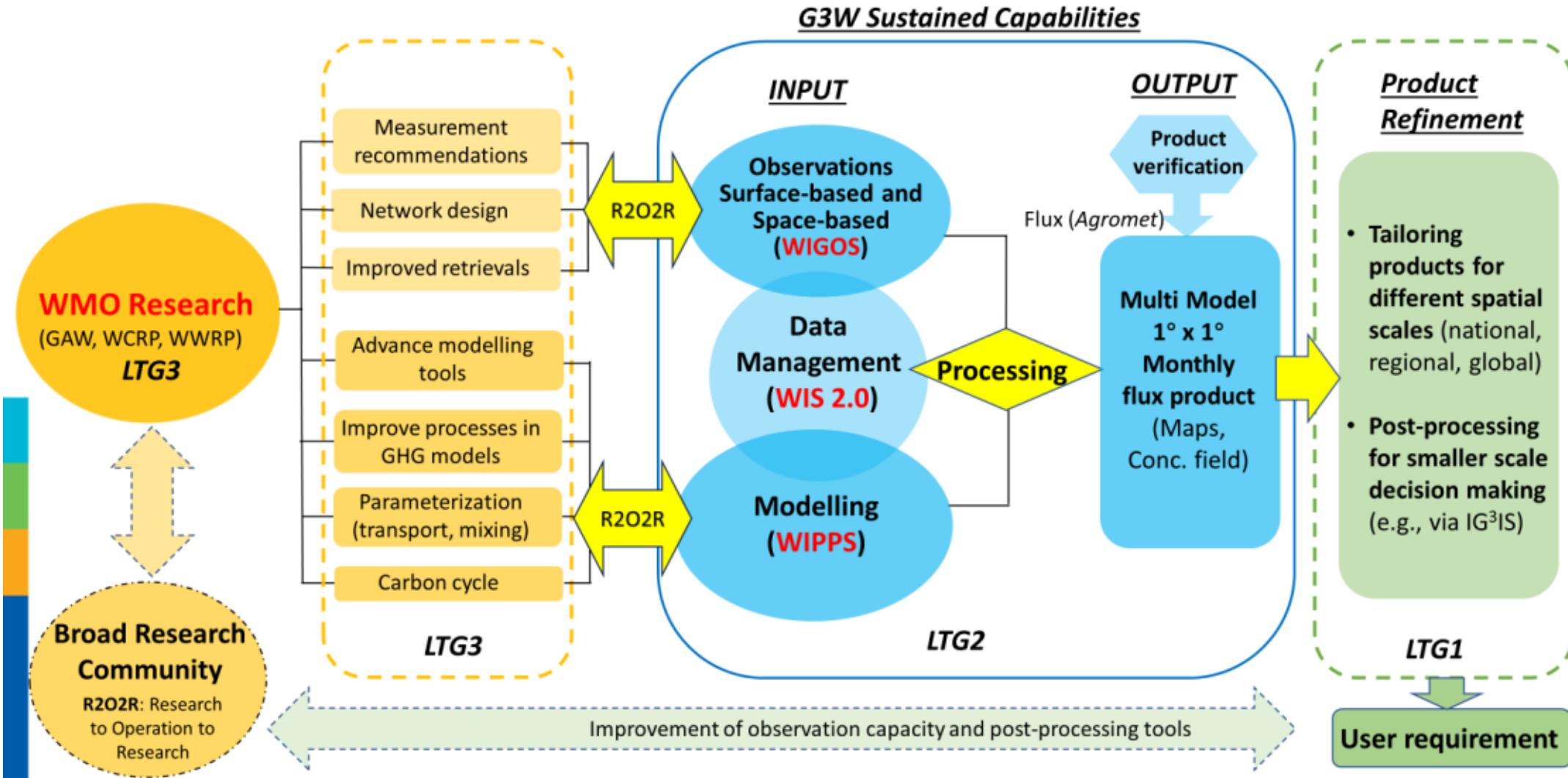


**CEOS – Committee on Earth Observations Satellites**



**CGMS – Coordination Group on Meteorological Satellites**

## Synchronizing within WMO Infrastructure, Services, Research, mirroring a shared Governance

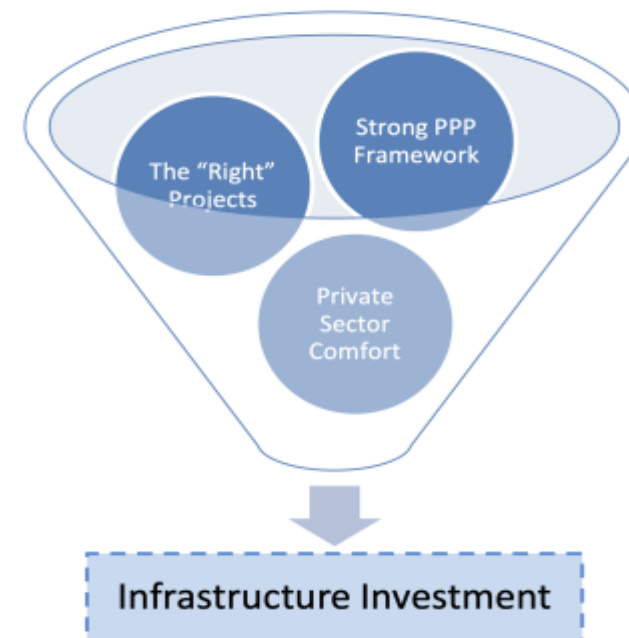


## Synchronizing with Private Funding Opportunities

To address infrastructure / service needs G3W aims at Mobilising **significant resources increase in 2024-2027**.

**Funding mechanisms** include 3 pathways:

- **G3W initial WMO-funds**, approved by the 19<sup>th</sup> World Meteorological Congress (Cg-19) [Resolution 5](#) of in 2023.
- **G3W trust-fund**, managed by WMO, with two Champions Nations contributing in 2023 and more expected from Public & Private sources from 2024.
- **Specialized G3W financial vehicle** to facilitate wider private sector contributions and activities, such as impact investing, that can be hosted outside of the UN system.



[World Bank, 2016a, #3553](#)



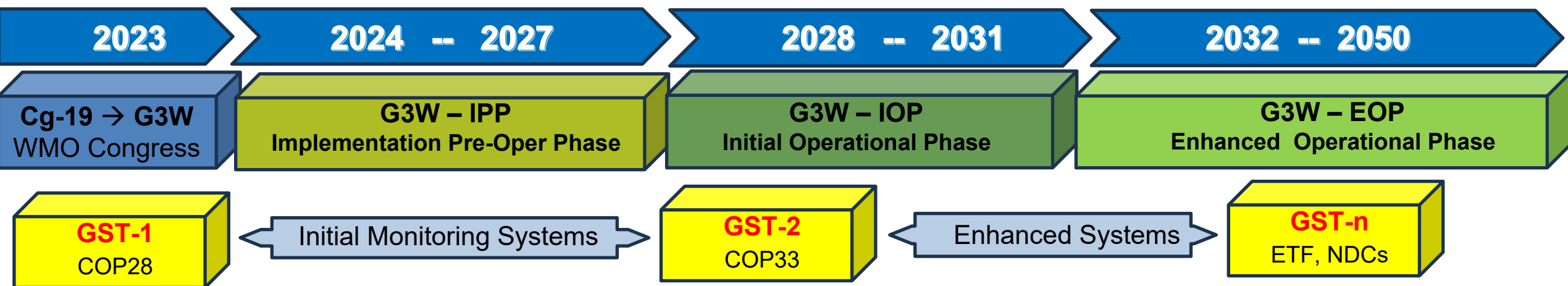
## WMO support to Global-Coordination: Space Agencies in Geneva 2024

- **G3W** presented at 15th Session of Consultative Meetings on **High-Level Policy on Satellite Matters**
- **G3W** to be presented to **CEOS** and to **CGMS** and to **INFCOM-3** Intergovernmental session in **April 2024**



## G3W Implementation Plan: Progress in 2024

- A 1<sup>st</sup> complete draft of G3W IP with WMO RMS contribution on the 18<sup>th</sup> of January 2024.
- G3W-SG & G3W-Team worked to consolidate the G3W IP up to the 22<sup>nd</sup> of January 2024
- G3W IP v1.0 published on the web, for an **Open-Community-Review** on the 23<sup>rd</sup> of January 2024
- G3W IP v2.0 presented to INFCOM-Management on the 7<sup>th</sup> of February 2024
- G3W IP presented to WMO INFCOM-3 and approved on the 19<sup>th</sup> of April 2024.
- G3W to be presented to WMO EC-78 in the week of the **10<sup>th</sup> of June 2024**.





## G3W Acknowledgements

### THE G3W STUDY GROUP

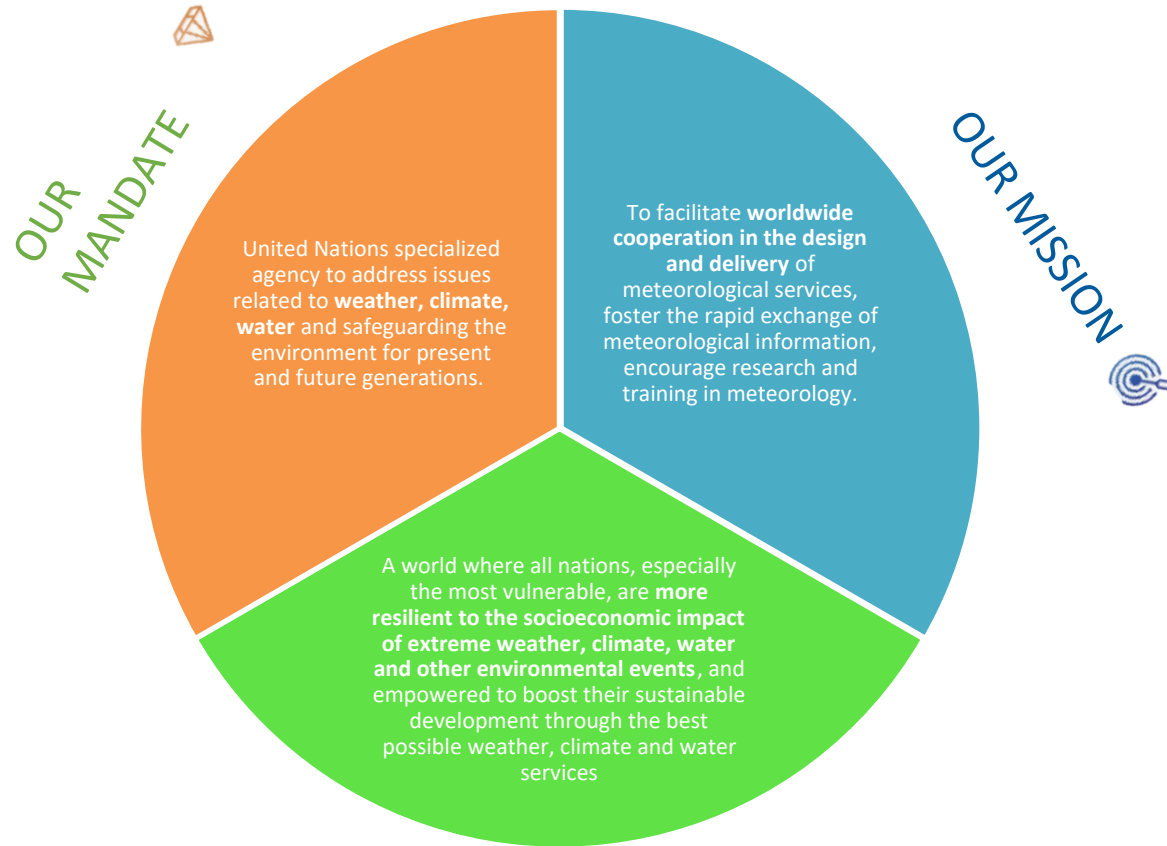
- The Executive Council (EC-75, June 2022) decided to form a joint Study Group between INFCOM, SERCOM and the Research Board.
- INFCOM Executive meeting (Sept 2023) approved the [updated ToR](#) of the SG-GHG.
- **35 GHGs experts** engaged for **8-month**
- Several writing teams have contributed
- Expertise across all planetary spheres (biosphere, atmosphere, hydrosphere, cryosphere, anthroposphere)
- Diversity of competencies & background with complementarity allowed to form a Balanced Team

### THE G3W STUDY GROUP MEMBERS

[Assoc. Prof. Ren, Chao](#) - Member- ( [Hong Kong, China](#) )  
[Daniele Biron](#) - Member- ( [Italy](#) )  
[Dr Anya Waite](#) - Member- ( [Canada](#) )  
[Dr Bruce Ward FORGAN](#) - Member- ( [Australia](#) )  
[Dr Dagmar Kubistin](#) - Member- ( [Germany](#) )  
[Dr Erik ANDERSSON](#) - Member- ( [ECMWF](#) )  
[Dr Frank E Muller-Karger](#) - Member- ( [United States of America](#) )  
[Dr Gary Morris](#) - Member- ( [United States of America](#) )  
[Dr Jocelyn Christine TURNBULL](#) - Member- ( [New Zealand](#) )  
[Dr Joe Melton](#) - Member- ( [Canada](#) )  
[Dr Kevin Cossel](#) - Member- ( [United States of America](#) )  
[Dr Lucia Perugini](#) - Member- ( [Italy](#) )  
[Dr Paolo Ruti](#) - Member- ( [EUMETSAT](#) )  
[Dr Salah Mahmoud, Zeinab](#) - Member- ( [Egypt](#) )  
[Dr Tobias FUCHS](#) - Member- ( [Germany](#) )  
[Dr Toste Tanhua](#) - Member- ( [Germany](#) )  
[Dr Tuula Aalto](#) - Member- ( [Finland](#) )  
[Dr Vanda Grubišić](#) - Member- ( [United States of America](#) )  
[Dr Vincent-Henri PEUCH](#) - Chair/Co-chair- ( [ECMWF](#) )  
[Dr Ward Nolan SMITH](#) - Member- ( [Canada](#) )  
[Dr Xingying ZHANG](#) - Member- ( [China](#) )  
[Matthew Tully](#) - Member- ( [Australia](#) )  
[Mr Alex Vermeulen](#) - Member- ( [Sweden](#) )  
[Mr Dolman, Albertus Johannes \(Han\)](#) - Member- ( [Netherlands](#) )  
[Mr Michel JEAN](#) - Member- ( [Canada](#) )  
[Mr Paul Counet](#) - Member- ( [EUMETSAT](#) )  
[Mr Xiaochun Zhang](#) - Member- ( [China](#) )  
[Mr Yasika MEIJER](#) - Member- ( [European Space Agency \(ESA\)](#) )  
[Ms Shanna T.L. COMBLEY](#) - Member- ( [United States of America](#) )  
[Prof. Alistair James Manning](#) - Member- ( [United Kingdom of Great Britain and Northern Ireland](#) )  
[Prof. Greg CARMICHAEL](#) - Chair/Co-chair- ( [United States of America](#) )  
[Prof. Manola BRUNET INDIA](#) - Member- ( [Spain](#) )  
[Prof. Pierre FRIEDLINGSTEIN](#) - Member- ( [United Kingdom of Great Britain and Northern Ireland](#) )  
[Prof. Thelma KRUG](#) - Member- ( [Global Climate Observing System \(GCOS\)](#) )  
[Yousuke Sawa](#) - Member- ( [Japan](#) )



## WMO – the World Meteorological Organization in a



WMO plays a role as a **global coordinator** for Member countries, harmonizing and supporting the work done across National Meteorological and Hydrological Services around:

**Protection of Life and Property**  
**Safeguarding the Environment**

Contributing to **Sustainable Development**

Monitoring the earth system (collecting and sharing **Data & Information**)

Defining **Best Practices**

Promoting targeted **Science** to improve **Infrastructure, Service delivery** and supporting **Policymaking**

Contributing to **Capacity development**, seeking to reduce the development gaps

**Coordination Group for Meteorological Satellites**



## WMO convention