

An Overview of the Global Greenhouse Gas Watch (G3W)

As an integrated part of the Climate Infrastructure

Presented to **Global Climate Observing System (GCOS)**
31st Steering Committee (GCOS-SC-31)
WMO Geneva, July, 4th, 2024

by Dr. Gianpaolo BALSAMO, G3W Director,
World Meteorological Organization (**WMO**)



WORLD
METEOROLOGICAL
ORGANIZATION

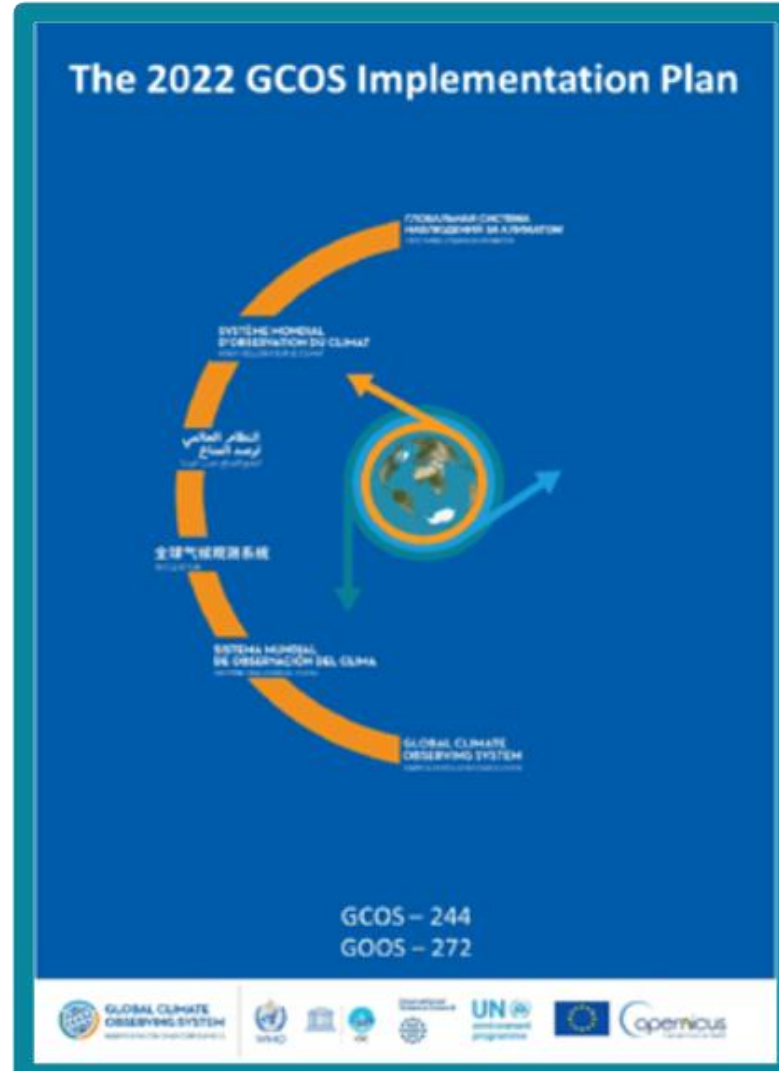


GLOBAL CLIMATE
OBSERVING SYSTEM



G3W as a Vision of GCOS

- G3W follow-on to **Action F5** in the **2022 GCOS Implementation Plan**
- **G3W** concept follows **GCOS**: Developing an
 - Integrated
 - Operational
 - Global
 - GHGs
 - Monitoring System
- **GAW** Programme & **IG3IS** Research are key
- G3W will aim at R2O – O2R

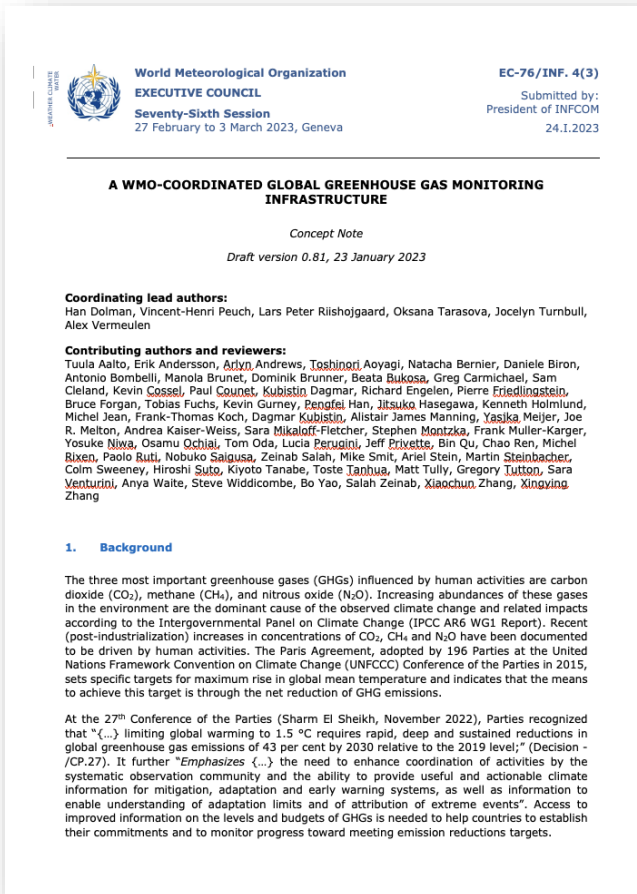


Action F5: Develop an Integrated Operational Global GHG Monitoring System	
Activities	<p>The overall aim here is to develop an integrated operational global greenhouse gas monitoring infrastructure. The first steps are:</p> <ol style="list-style-type: none"> 1. Design and start to implement a comprehensive global set of surface-based observations of CO₂, CH₄ and N₂O concentrations routinely exchanged in near-real time suitable for monitoring GHG fluxes. 2. Design a constellation of operational satellites to provide near-real time global coverage of CO₂ and CH₄ column observations (and profiles to the extent possible). 3. Identify a set of global modelling centres that could assimilate surface and satellite-based observations to generate flux estimates. 4. Improve and coordinate measurements of relevant ECVs at anthropogenic emissions hotspots (large cities, powerplants) to support emission monitoring and the validation of tropospheric measurements by satellites.
Issue/Benefits	<p>The Paris Agreement requests Parties to regularly provide estimates of anthropogenic emissions by sources and removals by sinks of greenhouse gases, and information necessary to track progress made in implementing and achieving their nationally determined contribution under Article 4. The proposed global greenhouse gas monitoring infrastructure would support the development of these estimates (i.e. emission inventories); validate national and regional achievement of Parties' commitments in their National Adaptation Plans (NAPs); and monitor changes to the cycles of GHG that may impact the achievement of the temperature goal of the Paris Agreement.</p> <p>Monitoring of hot-spots via dedicated observations to validate specific point-source emissions and identify missing sources from emission inventories.</p> <p>Remote monitoring of atmospheric composition can quantify and identify major emission sources. Anthropogenic emission hotspots like cities and industrial facilities and power plants contribute strongly to the global GHG emissions and to emission of key ozone and aerosol precursors (SO₂, VOCs). Reliable remote observations of these emission hotspots in synergy with source detection models can contribute to verifying emission estimates and monitor and guide mitigation efforts (link to Flux ECV).</p>
Implementers	<ol style="list-style-type: none"> 1. WMO (INFCOM, GAW and IG3IS). 2. Space agencies, National agencies, Research organizations, Academia. 3. WMO (INFCOM, GAW and IG3IS), National agencies. 4. GCOS, Space agencies, National agencies.



The vision and concept behind G3W

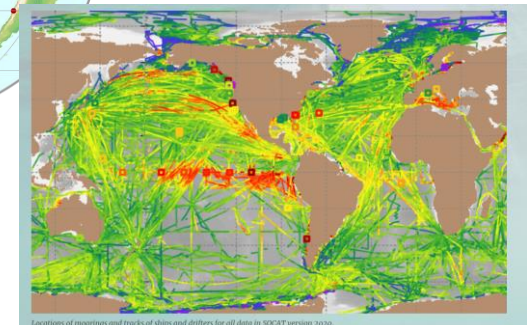
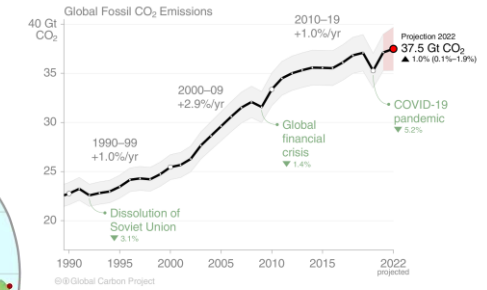
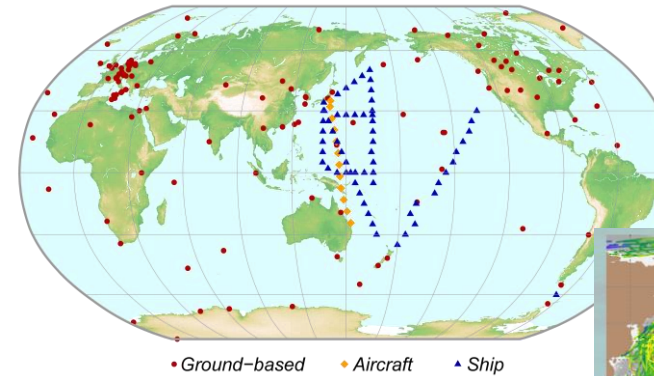
Global Greenhouse Gas Watch presented to EC-76, adopted by Cg-19 Congress and **endorsed by EC-78**.



1. Background

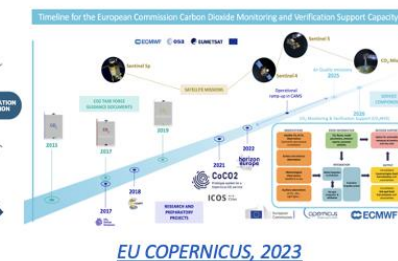
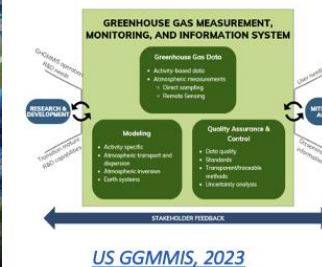
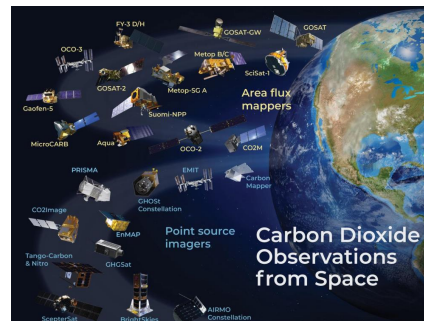
The three most important greenhouse gases (GHGs) influenced by human activities are carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). Increasing abundances of these gases in the environment are the dominant cause of the observed climate change and related impacts according to the Intergovernmental Panel on Climate Change (IPCC AR6 WG1 Report). Recent (post-industrialization) increases in concentrations of CO₂, CH₄ and N₂O have been documented to be driven by human activities. The Paris Agreement, adopted by 196 Parties at the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties in 2015, sets specific targets for maximum rise in global mean temperature and indicates that the means to achieve this target is through the net reduction of GHG emissions.

At the 27th Conference of the Parties (Sharm El Sheikh, November 2022), Parties recognized that "... limiting global warming to 1.5 °C requires rapid, deep and sustained reductions in global greenhouse gas emissions of 43 per cent by 2030 relative to the 2019 level;" (Decision -/CP.27). It further "Emphasizes (...)" the need to enhance coordination of activities by the systematic observation community and the ability to provide useful and actionable climate information for mitigation, adaptation and early warning systems, as well as information to enable understanding of adaptation limits and of attribution of extreme events". Access to improved information on the levels and budgets of GHGs is needed to help countries to establish their commitments and to monitor progress toward meeting emission reductions targets.



Substantial research efforts have been on-going and will remain essential, but **transition to sustained operations** is a necessity in the context of the climate crisis.

There is good alignment with **fast-track GHGs information efforts**, such as in EU, JAPAN, US... and **large investments in the space sector**.



G3W – the Global Greenhouse Gas Watch Flagship in a

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

- **G3W Master-Plan**

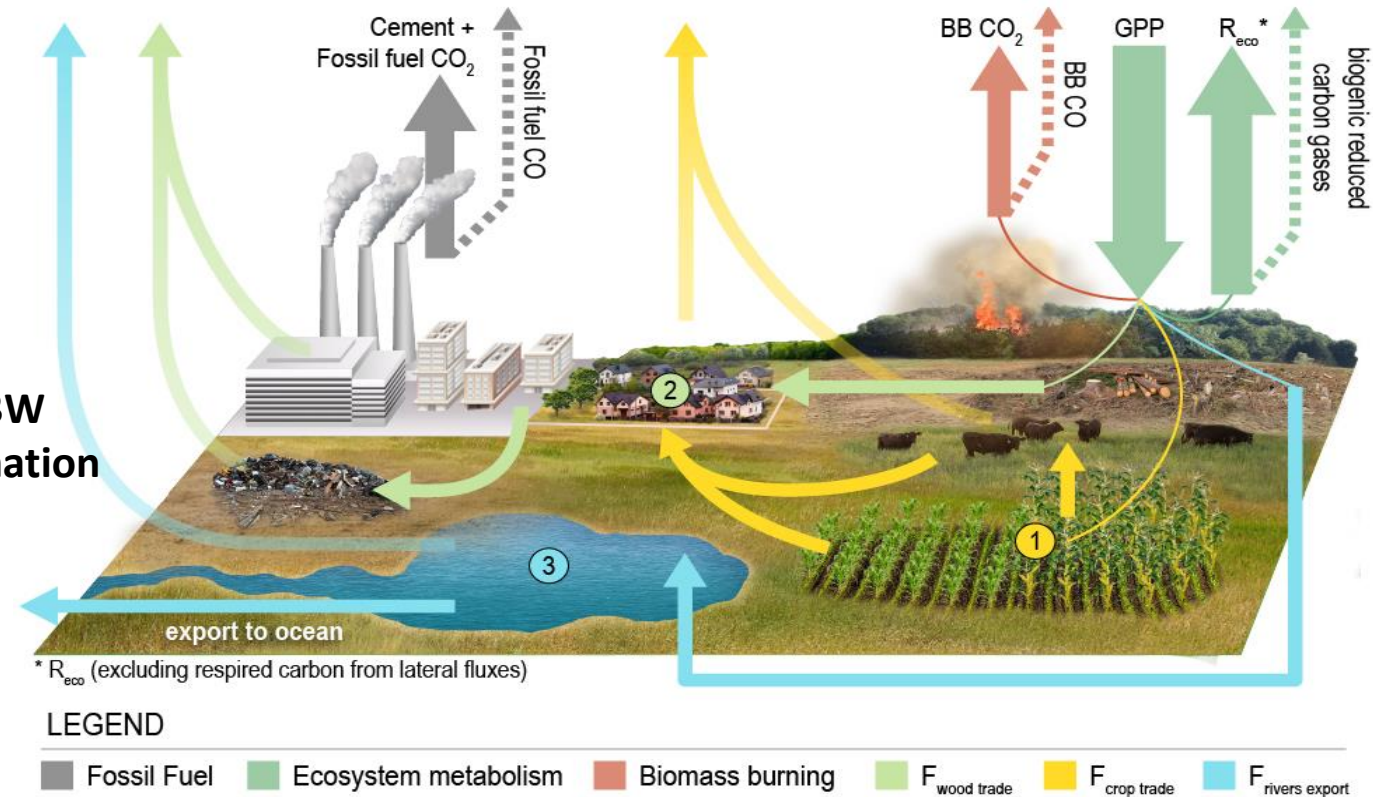
G3W-IPP Implementation & Pre-Oper Phase **2024-27**
 G3W-IOP Initial Operational Phase **2028-31 (GST-2)**
 G3W-EOP Enhanced Operational Phases **2032-50**

- **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
- AG-G3W joint INF / RB / SER
- WIGOS / WIPPS / WIS synergy



Byrne et al. 2022 ESSD

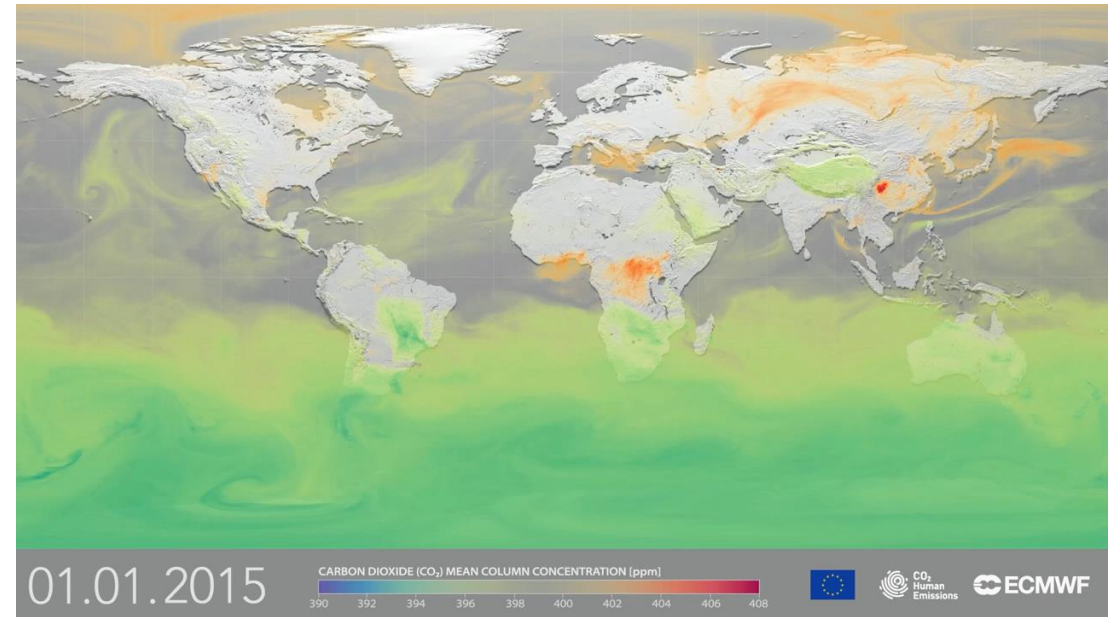


The “What, How & Why” for the G3W Flagship

What: The Global Greenhouse Gas Watch - **G3W** fills critical information gaps on greenhouse gases (GHGs), via an integrated **operational 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.



Animation source: Copernicus Earth Observation Programme / ECMWF CAMS



G3W Implementation Plan: priority deliverables from Q3/2024

- 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



- Definition of the output products and system requirements

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

- Identify product requirement
- Provide recommendations on the use of G3W outputs



How G3W + GCOS synergy can support Climate Action?

Climate Action is composed of **adaptation** and **mitigation** and WMO responded to the **United Nations** call

Monitoring the Climate system and the atmospheric constituents that most directly influence it is a priority.

Sustainability if the **Space-based** and **Surface-based infrastructure** is paramount and WMO will support **GCOS evolution**

Science for Services: Besides human activities influencing the Climate system there are complex mechanisms at work. **Permafrost melting**, Tropical/Boreal forests burning/*scorching*, Antarctica/Greenland **ice melting**, Ocean circulations, ...

Are all identified mechanisms that may bring the systems crossing planetary boundaries and into new equilibria. Research is fundamental to support the Service evolution via the **Research Programmes (WCRP, WWRP, GAW, National)**.

The **synergy between GCOS & G3W & GCW** foreseen as a key strength in 2024-2027 implementation framework & beyond. The **gaps** identified by the **GCOS SC** are also crucial gaps of **G3W** (e.g. Ocean Observing system, Biosphere & Cities/Soils).



Global Cryosphere Watch - active contributions to GCOS IP-2022

2022 GCOS ECVs REQUIREMENTS

- **Sea Ice ECV** – paper - A New Structure for the Sea Ice ECV of the GCOS, (Lavergne, Kern et al, 2022)
- **Snow ECV:**
 - GCW – GCOS/TOPC: Snow ECV Requirements Review 2024: Community Survey - currently open
 - Remote sensing of mountain snow from space: status and recommendations, Gascoin et al, 2024

Theme: IMPROVING DATA QUALITY, AVAILABILITY AND UTILITY, INCLUDING REPROCESSING

- **Measurement best practices** for Snow, Glacier, and Permafrost variables (ECVs) – WMO -No 8
- **Intercomparisons** concept development (ESA funded SnowPex - Satellite Snow Products and SIN'XS – Sea Ice-thickness products)

Theme: FILLING DATA GAPS

- **GCW publications** – in preparation:
 - *State of Cryosphere Monitoring in Central Asia*
 - *Snow Cover Observation, Data and Data Utilization - South America*
 - *Survey - cryosphere observations and data availability – High Mountain Asia*
- [Global Cryosphere Watch – Data Portal](#) – interoperable interfaces with existing data centres
- **WIGOS** and **WIS** metadata (snow, glaciers, permafrost) and Cryosphere Observing Stations in **OSCAR/Surface**

Guide to Instruments and Methods of Observation

Volume II – Measurement of cryospheric variables

2023 edition

WEATHER CLIMATE WATER

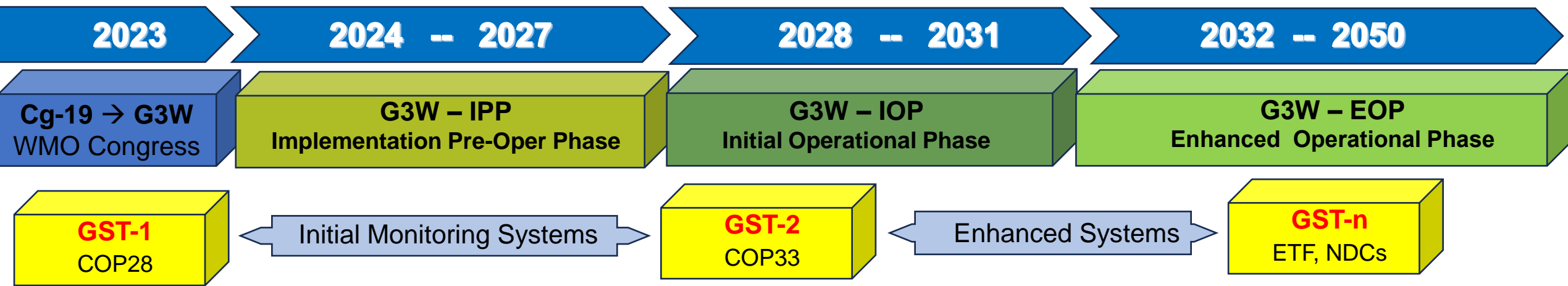


Thanks to Rodica Nitu

G3W @ GCOS SC: Take Home Messages

The G3W Implementation Plan (approved + endorsed) provides a vision for GHGs monitoring. What next?

- Timed Prioritised Activities to implement the plan from Q3/2024 (eg. GCOS/CEOS/CGMS/IOC started)
- The GCOS contributions to G3W has been & will be crucial benefit from G3W in two main ways:
 - 1 greater and more timely access to interoperable observations for ECVs, as INPUT in National systems
 - 2 greater impact of the Monitoring information OUTPUT (Climate-Change Indicators) for stakeholders
- The G3W (and GCW) efforts are integral part of a Climate Infrastructure to support Science & Services, and interact via WMO channels, the 193 Members (NMHSs), UN, UNFCCC, IPCC, States/non-States actors





Thank you



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Take Home  message

CLIMATE ACTION NEEDS

SCIENCE DRIVEN – CONSENSUS BASED

CLIMATE DATA – INFORMATION - KNOWLEDGE

g3w-gov@groups.wmo.int

2023

2024 -- 2027

2028 -- 2031

2032 -- 2050

Cg-19 → G3W
WMO Congress

G3W – IPP
Implementation Pre-Oper Phase

G3W – IOP
Initial Operational Phase

G3W – EOP
Enhanced Operational Phase

GST-1
COP28

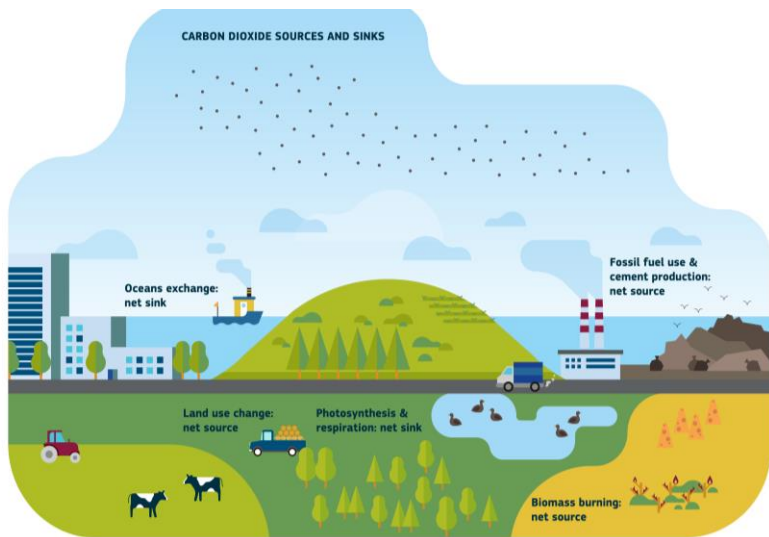
Initial Monitoring Systems

GST-2
COP33

Enhanced Systems

GST-n
ETF, NDCs

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



CO₂, Carbon dioxide



GHGs Earth's Observing Systems is building on Weather experience

UN family
IPCC-IOC-
UNEP-UNFCCC-
WHO-WMO-WTO

UNFCCC
COP-SBSTA

WMO
WIGOS-WIS-WIPPS

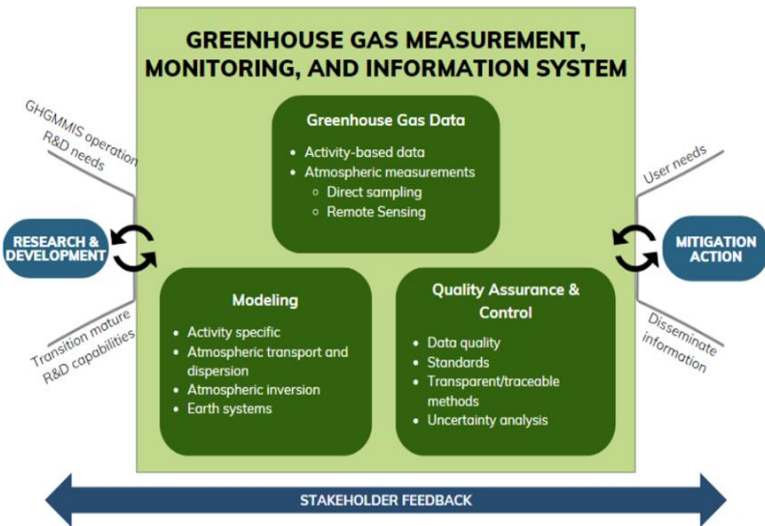
Public-Private Partnerships



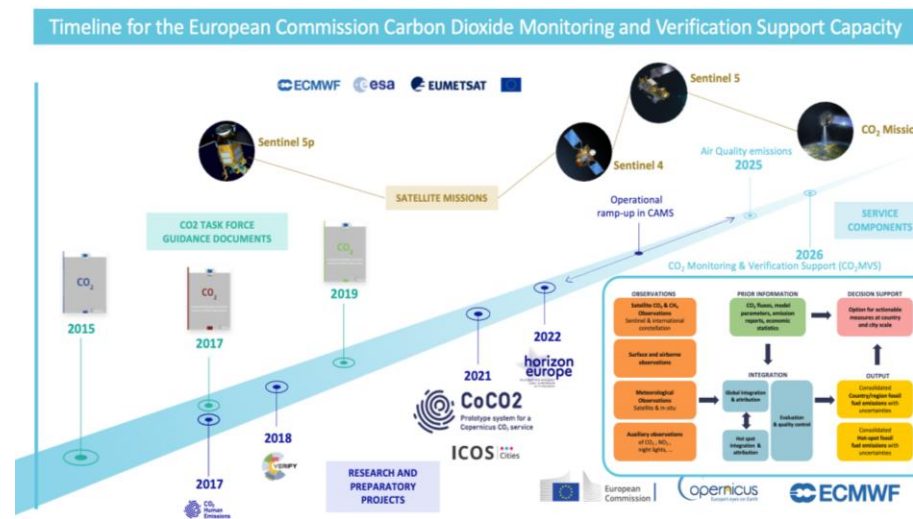
G3W longer-term plans & vision

Synchronizing with National & Regional efforts

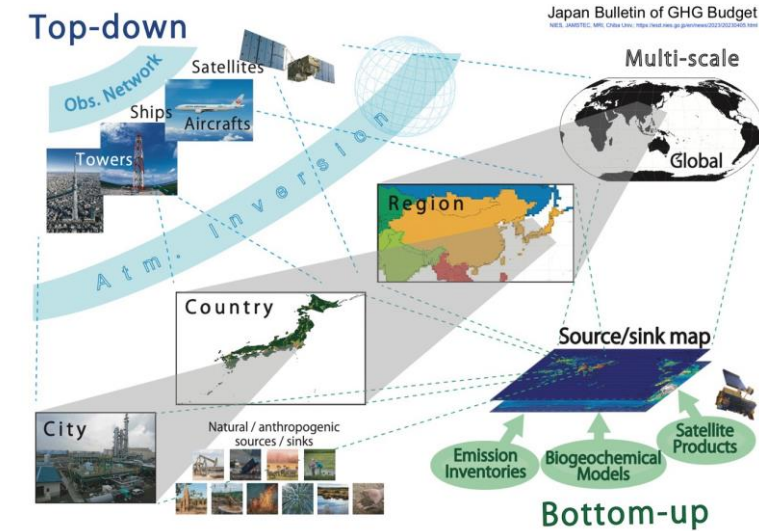
- In 2024 the **G3W Implementation Plan**, the **G3W Sustainability Strategy** documents.
- In 2025 & 2026 the **Ramp up Operations** with sustained funding sources (WMO + External).
- This is in good alignment with fast-track GHGs information efforts, such as in EU, JAPAN, US, ...



US GHGMMIS, 2023



EU COPERNICUS, 2023



JAPAN NIES, 2023



G3W Implementation Pilots in 2024-2027: A Methane case

COP28 Global Methane Pledge with 155 Countries

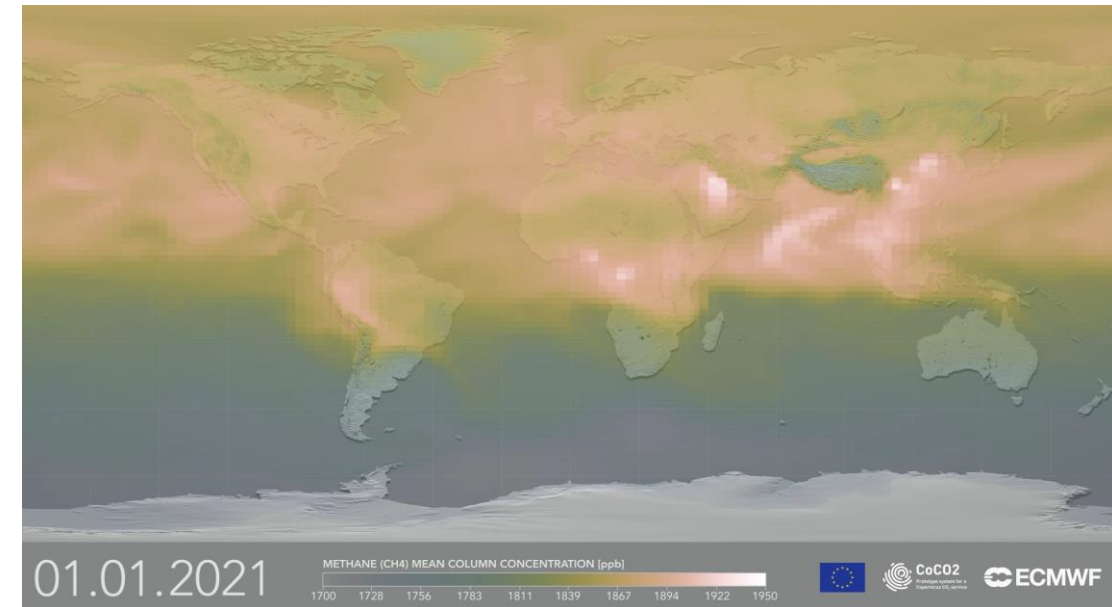
- <https://www.globalmethanepledge.org>

What: The Global Greenhouse Gas Watch – Surface-based and Satellite-based observation infrastructure can benefit from the COP28-COP29-COP30 momentum.

How: a **Public-Private Partnership** on GHGs concentrations and fluxes can tackle Methane as IPCC identified priority to preserve the remaining Carbon budget for Paris Agreement goals. A collaboration UNEP-IMEO, Global Methane Hub, CCAC, GMI and G3W.

Why : a Win-Win-Win approach in which Science-Economy-Society benefit from rapidly curbing emissions with the Agility of Private Sector investment and the Sustainability of Public Long-Term Goals and UN SDGs framework.

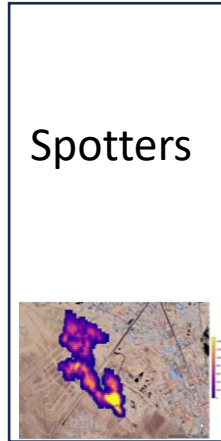
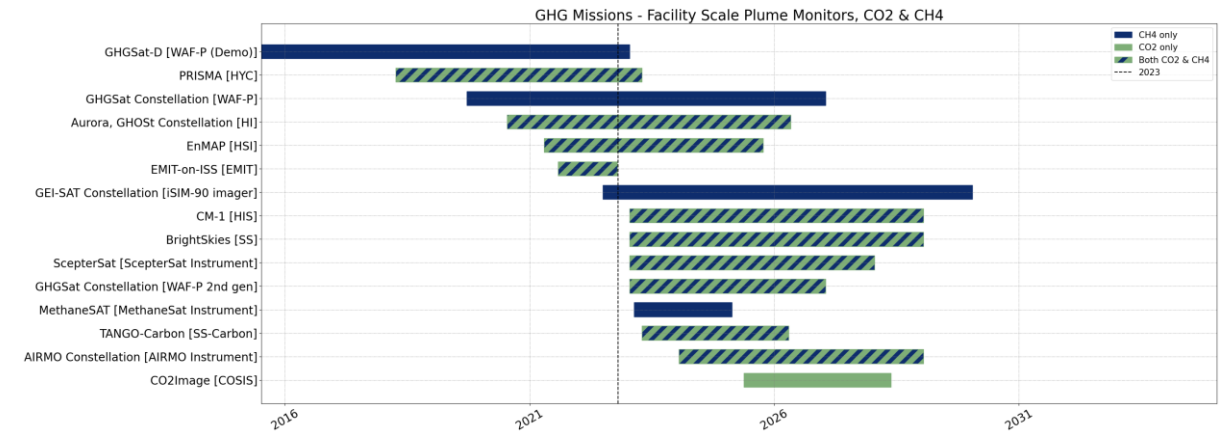
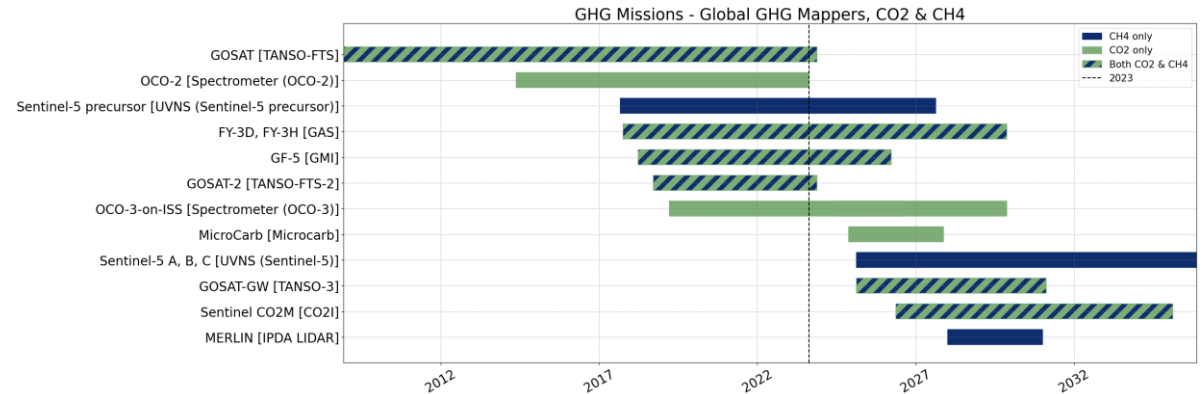
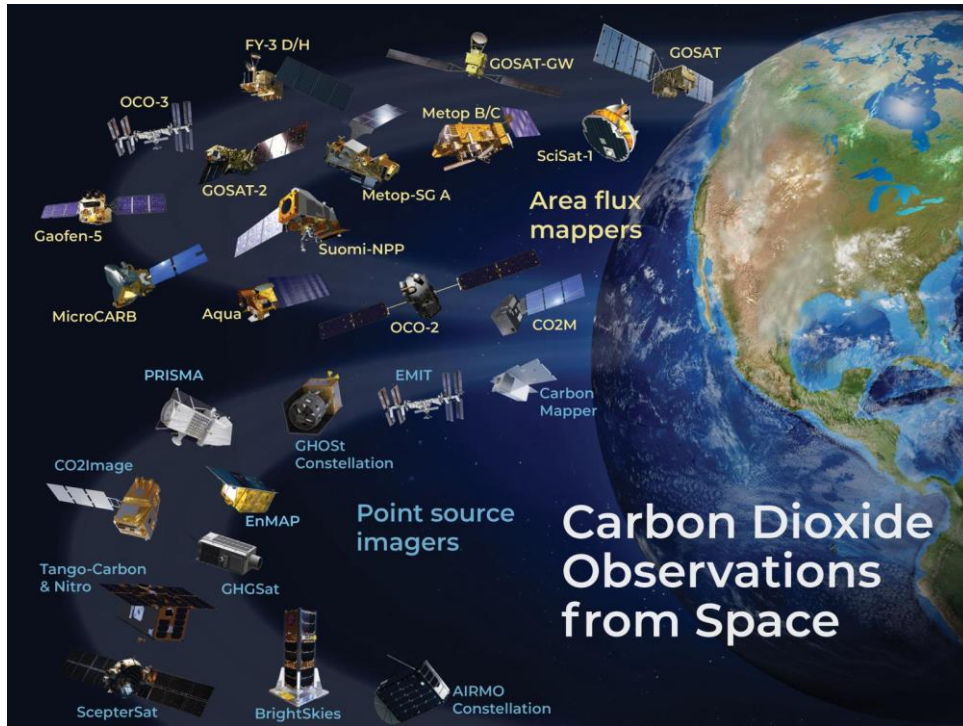
Methane is crucially connected to Climate-Change via the Cryosphere (eg. **Permafrost melting** linking G3W with GCW)



Animation source: Copernicus Earth Observation Programme / ECMWF CAMS

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**



WORLD METEOROLOGICAL ORGANIZATION

CEOS – Committee on Earth Observations Satellites



CGMS – Coordination Group on Meteorological Satellites

G3W progress discussed at CEOS-SIT-39 CGMS-52 in Q2/2024

- G3W presented to WG-Climate, CEOS-SIT-39 in April 2024 and to CGMS-52 in June 2024.
- A WMO delegation in Tokyo and Washington DC, and Online ensured G3W presence.



G3W presented at the
CEOS – Committee on
Earth Observations Satellites



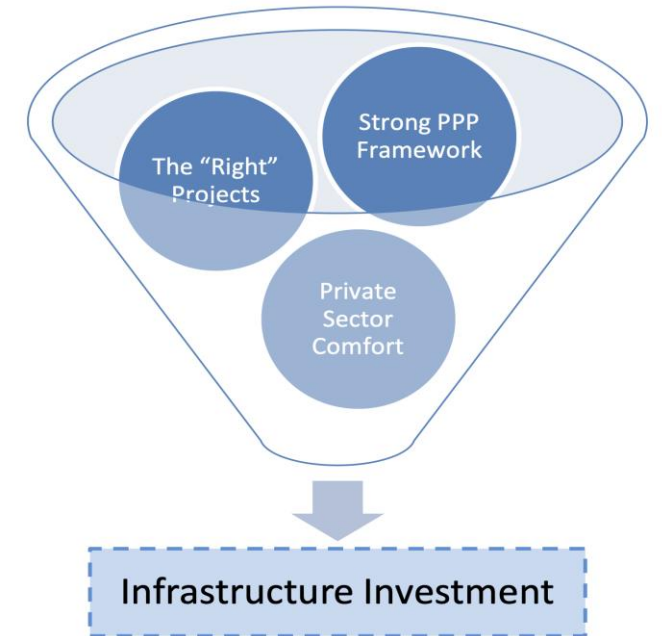
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Synchronizing Public & Private Funding Opportunities

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

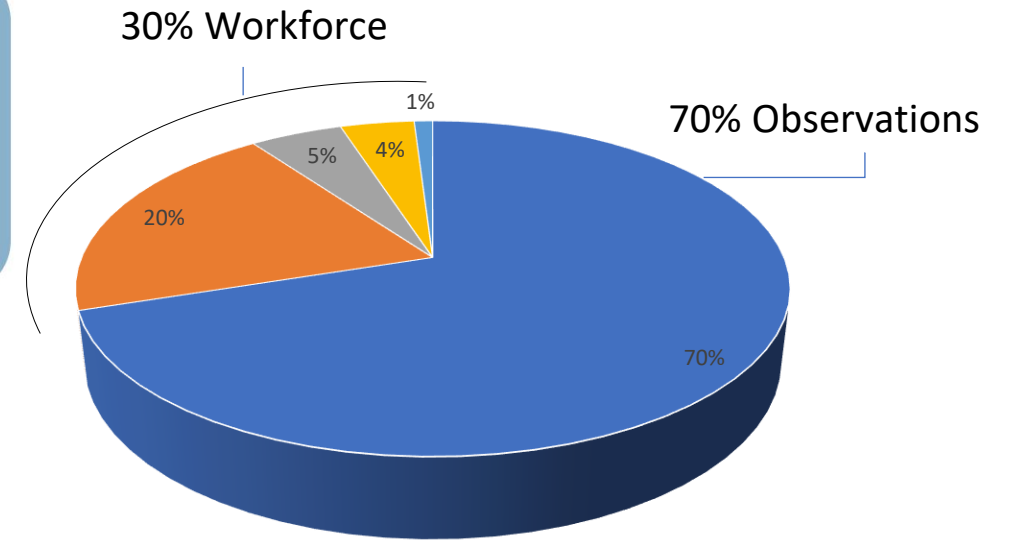
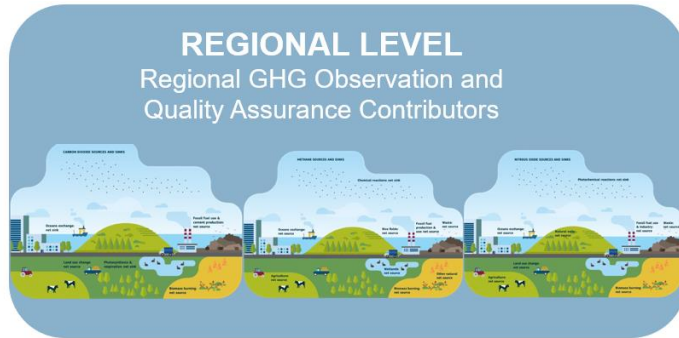
Funding mechanisms include 3 pathways:

- **G3W initial WMO-funds**, approved by the 19th 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](#)

G3W Sustainability and Focus : A Region First Approach

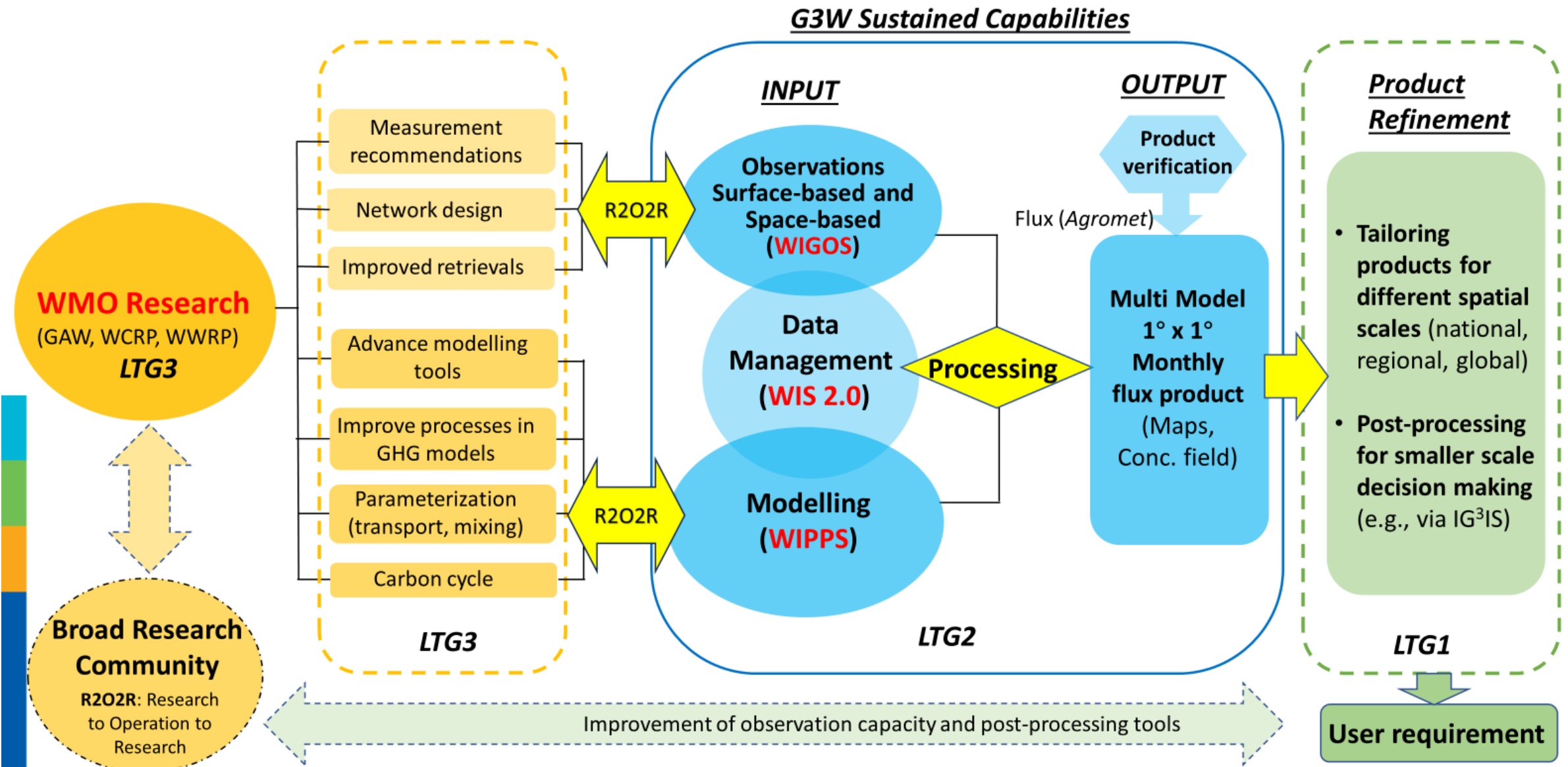


The G3W will develop strategic actions to fund systematically infrastructure + workforce, beyond opportunity-based and development-based funding mechanisms.

The estimated costs in 3 scenarios (1 B\$, 500 M\$, 300 M\$)

- Observing system surface-based infrastructure
- Observing systems integration, modelling and data management
- Capacity building and capacity development for G3W input and uptake
- Regional Pilot Projects and supporting research for G3W emerging priorities
- Central coordination by WMO secretariat including public-private-partnerships (PPP) development

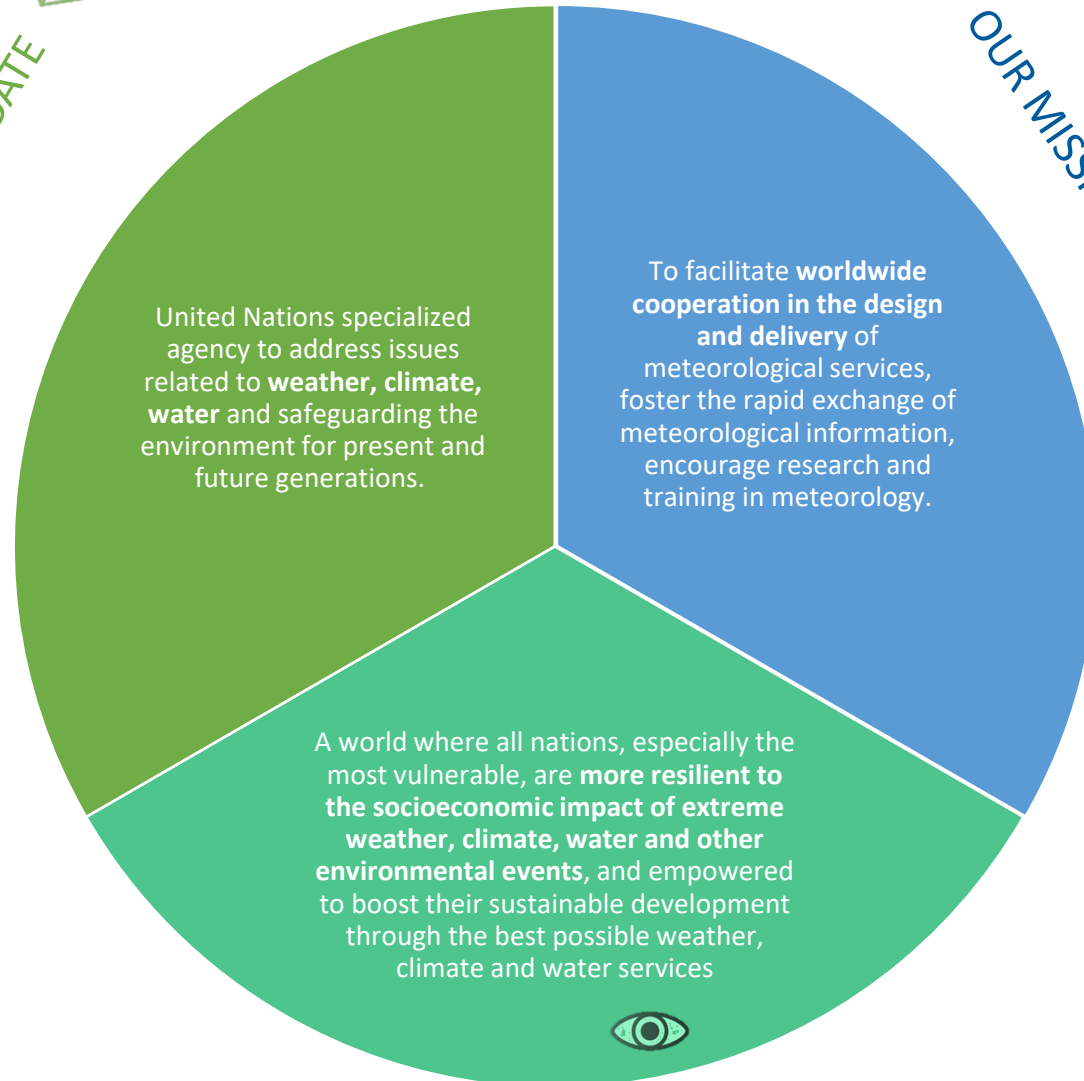
Synchronizing within the WMO shared Governance & Goals



WMO – the World Meteorological Organization in a



OUR MANDATE 



United Nations specialized agency to address issues related to **weather, climate, water** and safeguarding the environment for present and future generations.

To facilitate **worldwide cooperation in the design and delivery** of meteorological services, foster the rapid exchange of meteorological information, encourage research and training in meteorology.

A world where all nations, especially the most vulnerable, are **more resilient to the socioeconomic impact of extreme weather, climate, water and other environmental events**, and empowered to boost their sustainable development through the best possible weather, climate and water services

OUR MISSION 

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

WMO convention

EW4All –the Early Warning for All Flagship in a




The EW4All Flagship will ensure every person on Earth is protected by lifesaving early warning systems by 2027

How?





Disaster risk knowledge
Systematically collect data and undertake risk assessments

- Are the hazards and the vulnerabilities well known by the communities?
- What are the patterns and trends in these factors?
- Are risk maps and data widely available?



Detection, observations, monitoring, analysis and forecasting of hazards
Develop hazard monitoring and early warning services

- Are the right parameters being monitored?
- Is there a sound scientific basis for making forecasts?
- Can accurate and timely warnings be generated?



Preparedness and response capabilities
Build national and community response capabilities

- Are response plans up to date and tested?
- Are local capacities and knowledge made use of?
- Are people prepared and ready to react to warnings?



Warning dissemination and communication
Communicate risk information and early warnings

- Do warnings reach all of those at risk?
- Are the risks and warnings understood?
- Is the warning information clear and usable?



Early Warnings for All



Pillar 2 is focused on delivering 5 outcomes:

- Increased availability of quality observation data to assess and monitor priority hazards.
- Enhanced data exchange and access for forecasting and warning systems.
- Increased capabilities to forecast all priority hydrometeorological hazards.
- Impact-based forecasts and warnings are produced for all priority hazards.
- Strengthened relevant policy, institutional mechanisms, and stakeholder engagement processes in place to support MHEWSs

The delivery of Early Warnings for All requires scale up and coordinated investments and action across the four essential pillars of end to end, people-centred Multi-Hazard Early Warning Systems



Global Status of Multi-Hazard Early Warning Systems 2023



G3W Plan in Action

In 2023 three key events

- 1st **WMO GHGs Monitoring Symposium**
G3W reaches broad science support
- 19th **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**



In 2024 two key event

- **INFCOM3 endorse G3W** plan & governance to be presented to **WMO Executive Council**
- **EC-78 endorsed G3W**. Implementation begins!



Cross-cutting Theme: Address Capacity & Technology gaps

Collaboration on implementation is required with:

- NMHSs
- Training Centers
- Research community
- Capacity development panel
- Partner organizations

The highest **priority** activities:

- Establish a competence framework for participation in G3W
- Cataloguing of the existing capacity development resources on GHG.

Section 9 Capacity Building – C (5) (Overarching)

C1 – Technical participation framework
C2 – Continuously capacities evaluate

C3 – Members' capacities in data use
C4 – Capacity development programs for Member
C5 – National capacities development

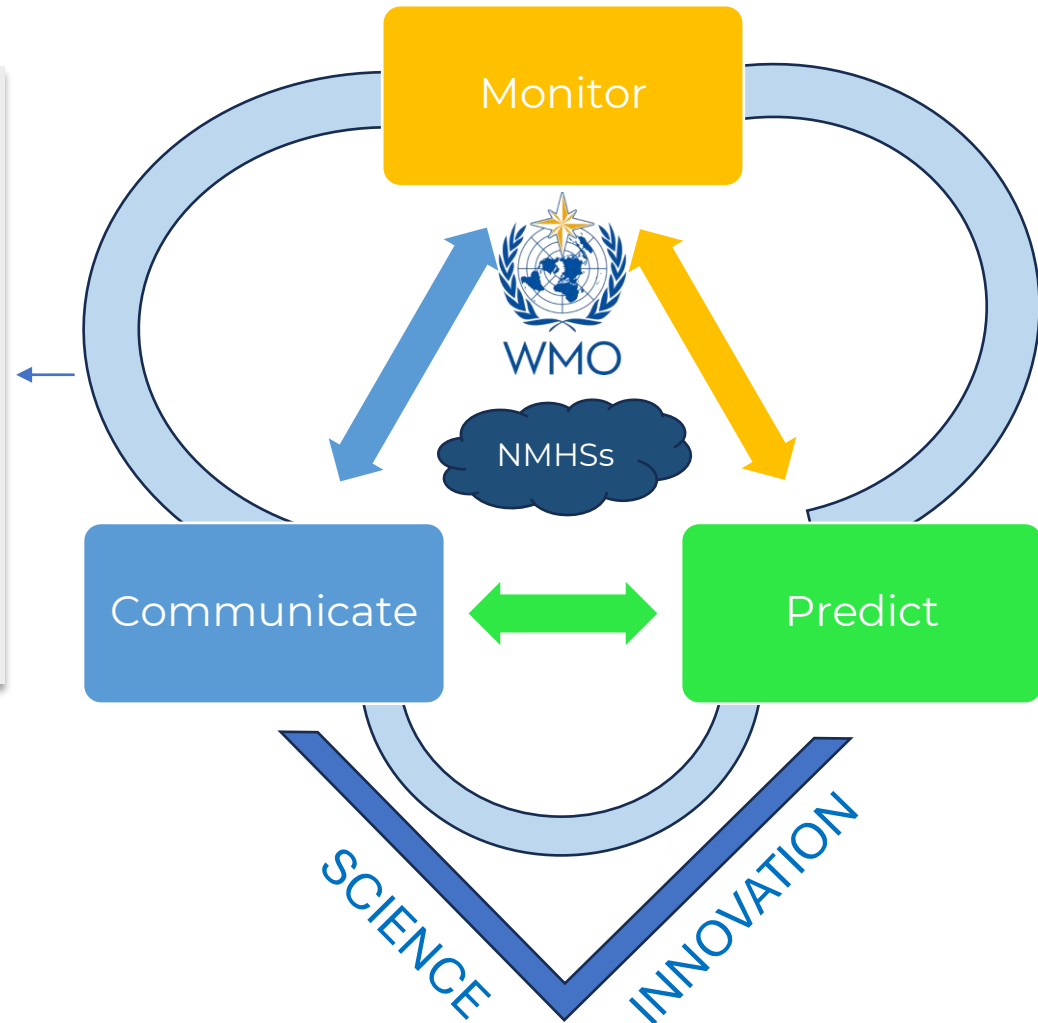


Aligning with WMO Capacity Development Resolution 36 (Cg-19)



WWW – Lesson Learnt from National Hydro-Met. Services

- Interact and engage with public, private and academic sectors.
- Engage with economic sectors
- Provide evidence to support decision-makers in developing and implementing policies



- Perform regular earth-system observations, according to established standards
- Establish, improve and maintain hydrometeorological networks.
- Collect and share data

- Provide forecasts at different time scales, from early warnings to climate outlooks
- Co-develop sectoral services (risk management, transport, energy , agriculture, health, tourism, etc.)



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- **G3W Master-Plan**

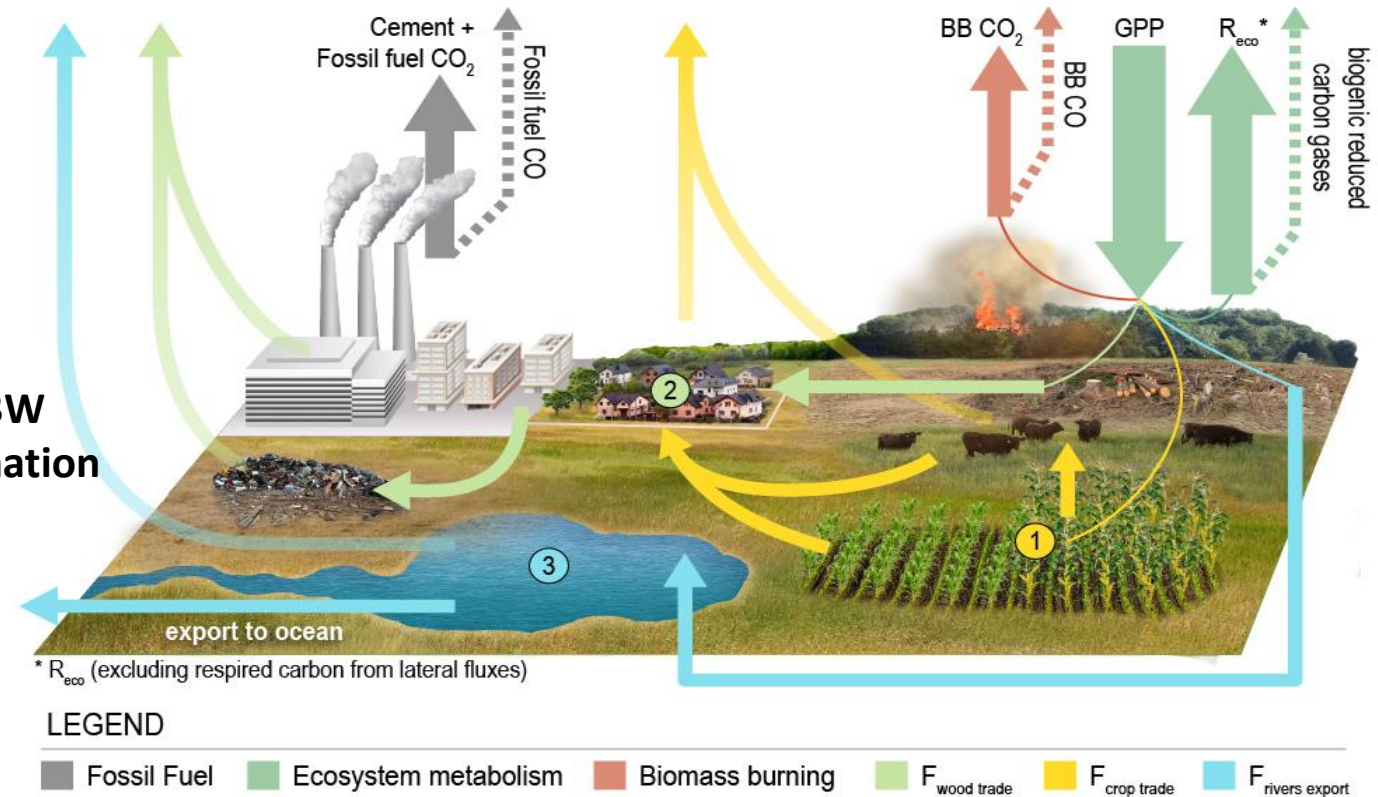
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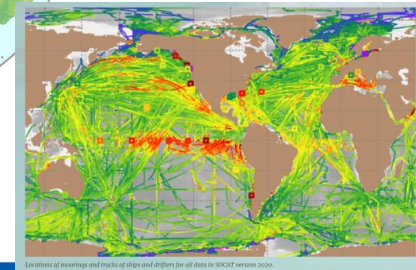
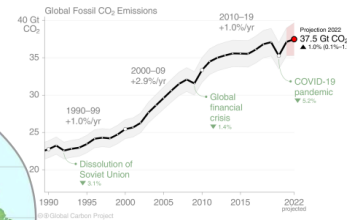
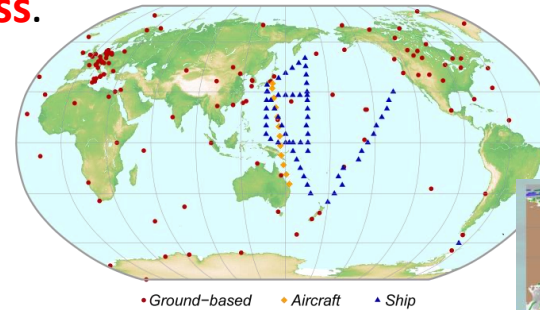
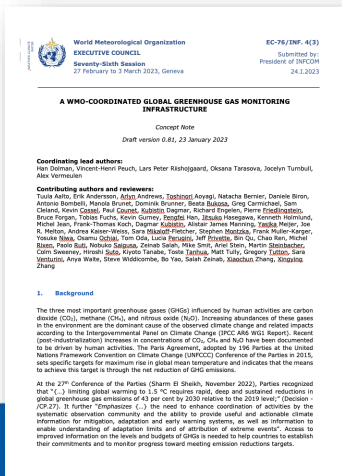
Byrne et al. 2022 ESSD



G3W Implementation Plan: Progress up to Q2/2024

- A 1st complete draft of G3W IP with WMO RMS contribution on the 18th of January 2024.
- G3W-SG & G3W-Team worked to consolidate the G3W IP up to the 22nd of January 2024
- G3W IP v1.0 published on the web, for an Open-Community-Review on the 23rd of January 2024
- G3W IP v2.0 presented to INFCOM-Management on the 7th of February 2024
- G3W presented to WMO INFCOM-3 and approved in the week of the 15th of April 2024.
- G3W presented to WMO EC-78 and endorsed on the 10th of June 2024.

A successful WMO journey from the concept note presented to EC-76 **adopted by the 19th Meteorological Congress.**



To a WMO flagship **endorsed by the 78th WMO Executive Council.**

G3W Implementation & Pre-operational Phase 2024-2027

