Global Greenhouse Gas Watch (G3W)

Entering in the Implementation and Pre-Operational Phase 2024-27: A proposed framework for enhancing collaboration

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

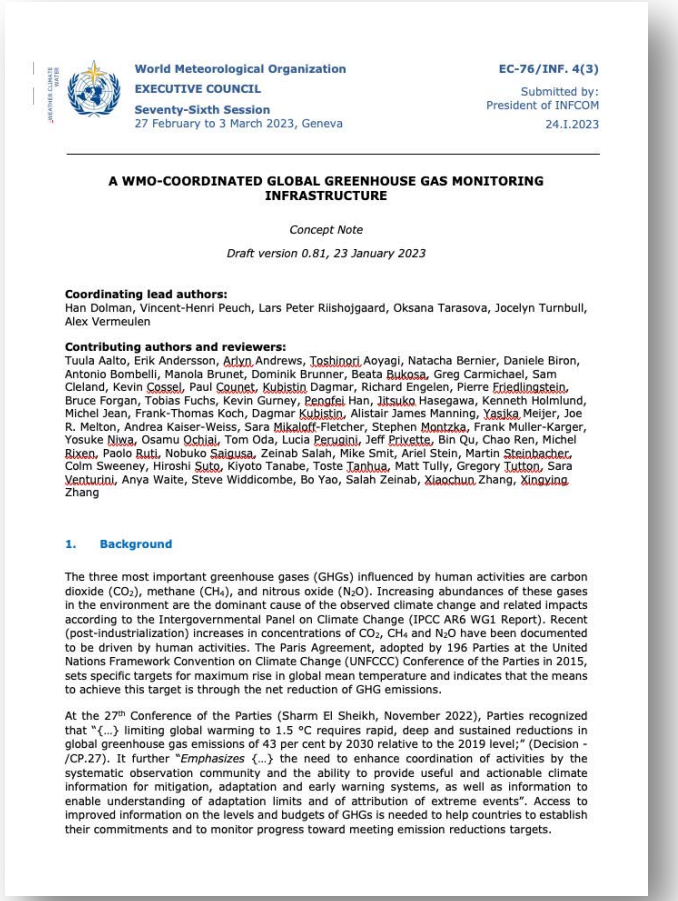
Presented to the Expert Meeting on Reconciling land use emissions
IPCC Task Force on National Greenhouse Gas Inventories,
9-11 July 2024, European Commission, Joint Research Centre, Ispra, Italy

WORLD METEOROLOGICAL ORGANIZATION

ipcc
INTERGOVERNMENTAL PANEL ON climate change

The vision and concept behind G3W

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



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EC-76/INF. 4(3)
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President of INFCOM
24.I.2023

A WMO-COORDINATED GLOBAL GREENHOUSE GAS MONITORING INFRASTRUCTURE

Concept Note

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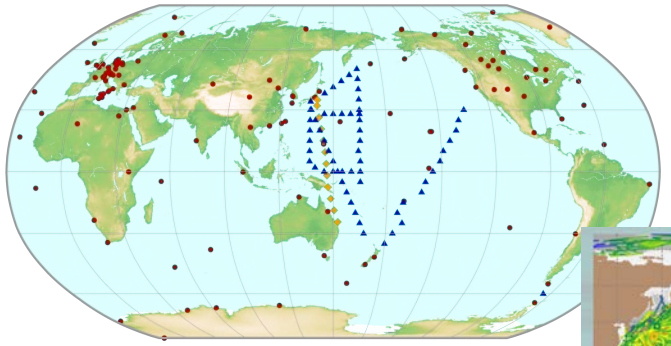
Coordinating lead authors:
Han Dolman, Vincent-Henri Peuch, Lars Peter Riishojgaard, Oksana Tarasova, Jocelyn Turnbull, Alex Vermeulen

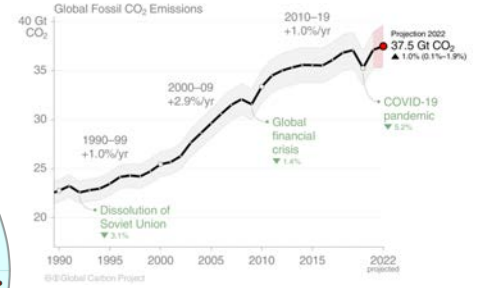
Contributing authors and reviewers:
Tuula Aalto, Erik Andersson, Arlyn Andrews, Toshinori Aoyagi, Natacha Bernier, Daniele Biron, Antonio Bombelli, Manola Brunet, Dominik Brunner, Beata Bukosa, Greg Carmichael, Sam Cleland, Kevin Cossel, Paul Counet, Kubistin Dagmar, Richard Engelen, Pierre Friedlingstein, Bruce Forgan, Tobias Fuchs, Kevin Gurney, Pengfei Han, Jitsuko Hasegawa, Kenneth Holmlund, Michel Jean, Frank-Thomas Koch, Dagmar Kubistin, Alistair James Manning, Yasjka Meijer, Joe R. Melton, Andrea Kaiser-Weiss, Sara Mikaloff-Fletcher, Stephen Montzka, Frank Muller-Karger, Yosuke Niwa, Osamu Ochiai, Tom Oda, Lucia Perugini, Jeff Privette, Bin Qu, Chao Ren, Michel Rixen, Paolo Ruti, Nobuko Saigusa, Zeinab Salah, Mike Smit, Ariel Stein, Martin Steinbacher, Colm Sweeney, Hiroshi Suto, Kiyoto Tanabe, Toste Tanhua, Matt Tully, Gregory Tutton, Sara Venturini, Anya Waite, Steve Widdicombe, Bo Yao, Salah Zeinab, Xiaochun Zhang, Xingying Zhang

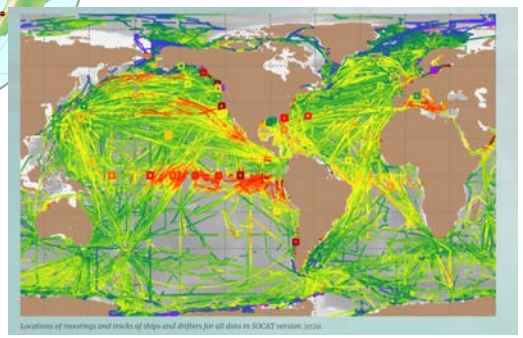
1. Background

The three most important greenhouse gases (GHGs) influenced by human activities are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). 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 CO_2, CH_4 and N_2O 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.

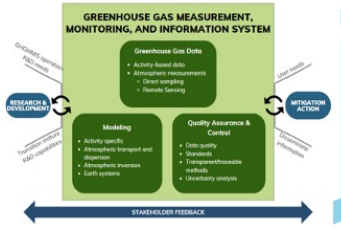




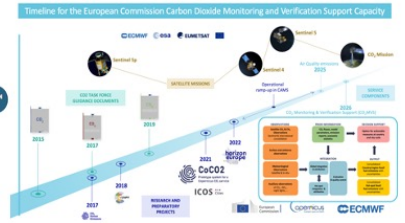


Substantial **research efforts** have been on-going and will remain **essential**, but **transition to sustained operations** is a necessity in the context of the climate crisis.

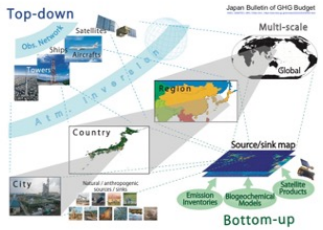
There is good alignment with **fast-track GHGs information efforts**, such as in EU, JAPAN, US… and **large investments in the space sector**.



US GGMMIS, 2023



EU COPERNICUS, 2023



JAPAN NIES, 2023

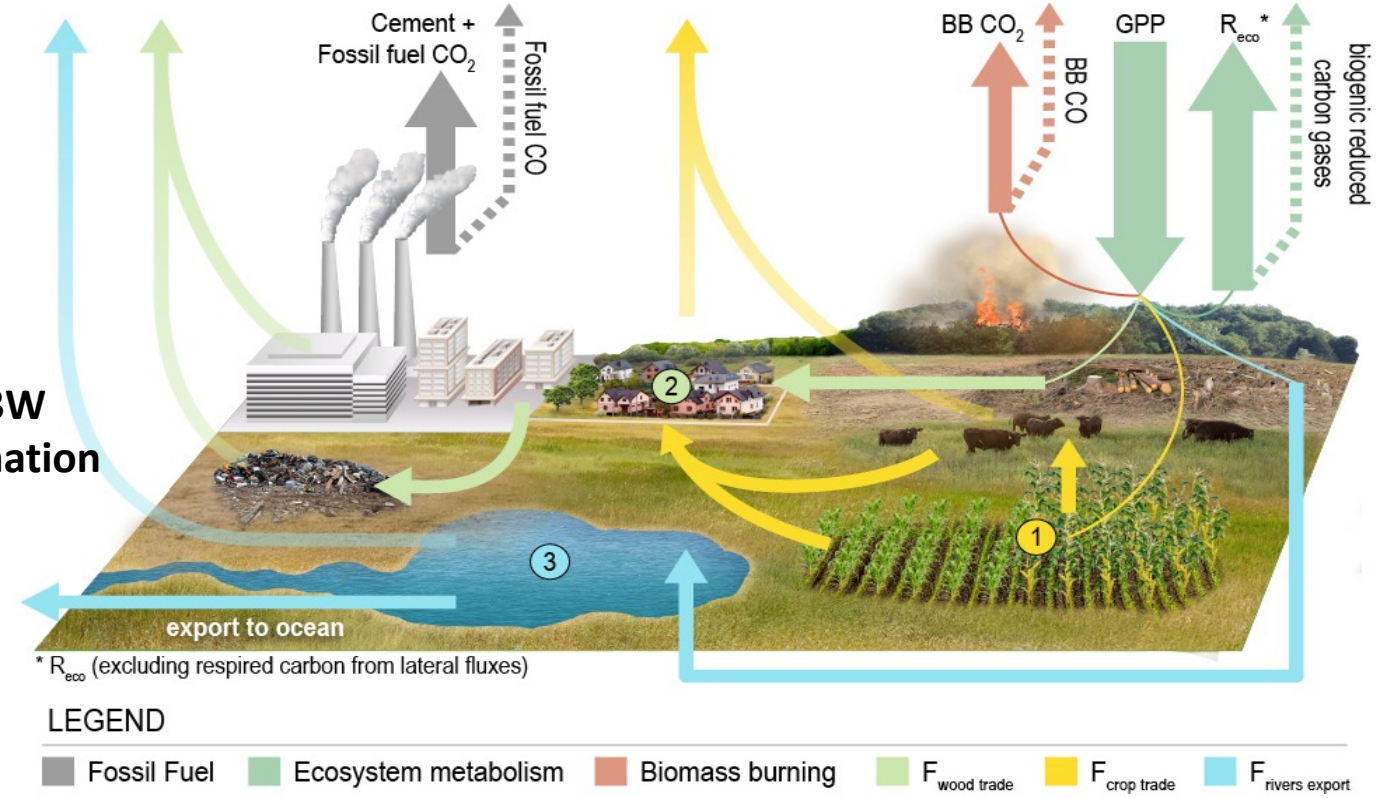
G3W – the Global Greenhouse Gas Watch Flagship in a

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**



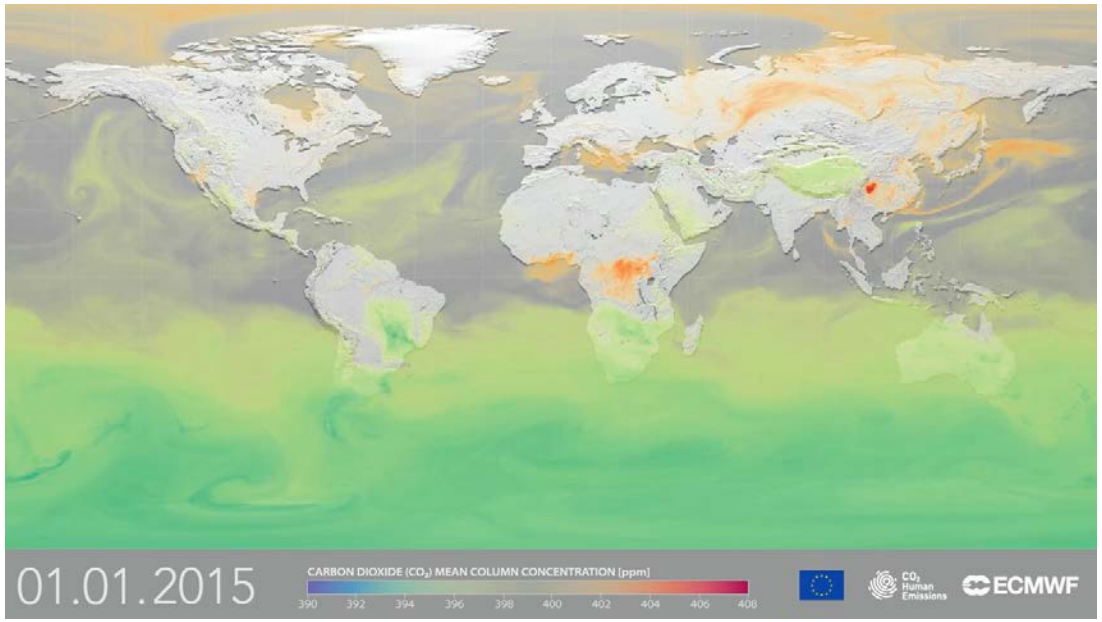
Byrne et al. 2022 ESSD

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

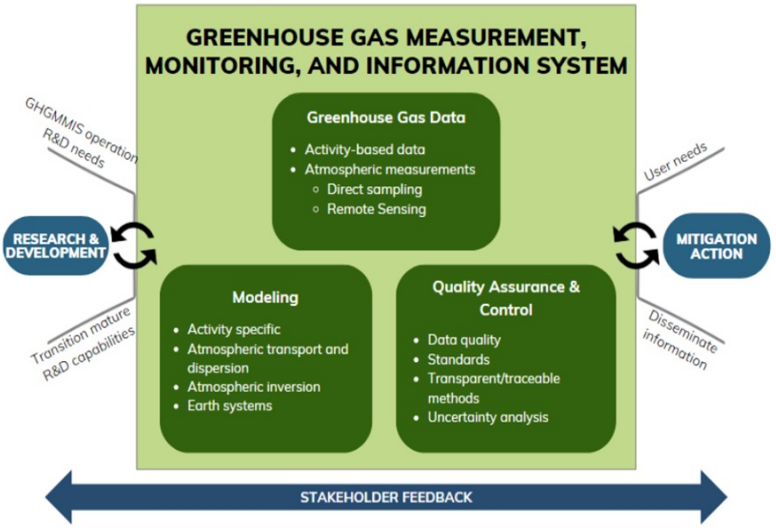
Why : an **Earth System Approach** is a must-have because **Earth's climate responds to the laws of Climate Physics** and depends Atmospheric GHGs, NOT on Claimed Offset of Carbon emissions or to Good-will of Pledges.



Animation source: Copernicus Earth Observation Programme / ECMWF CAMS

G3W is 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, …



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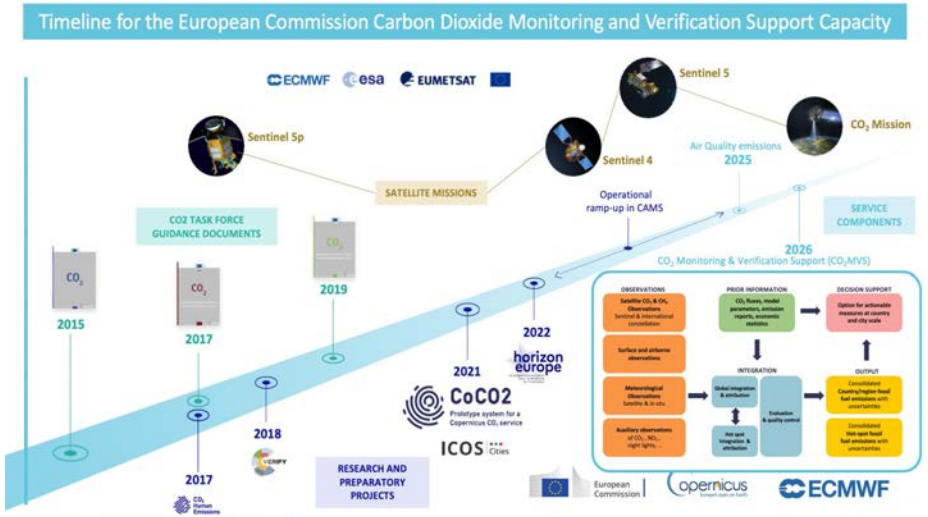
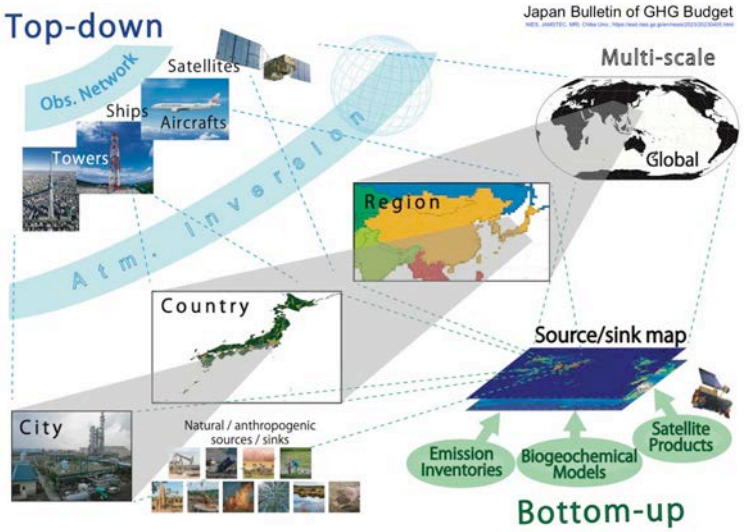


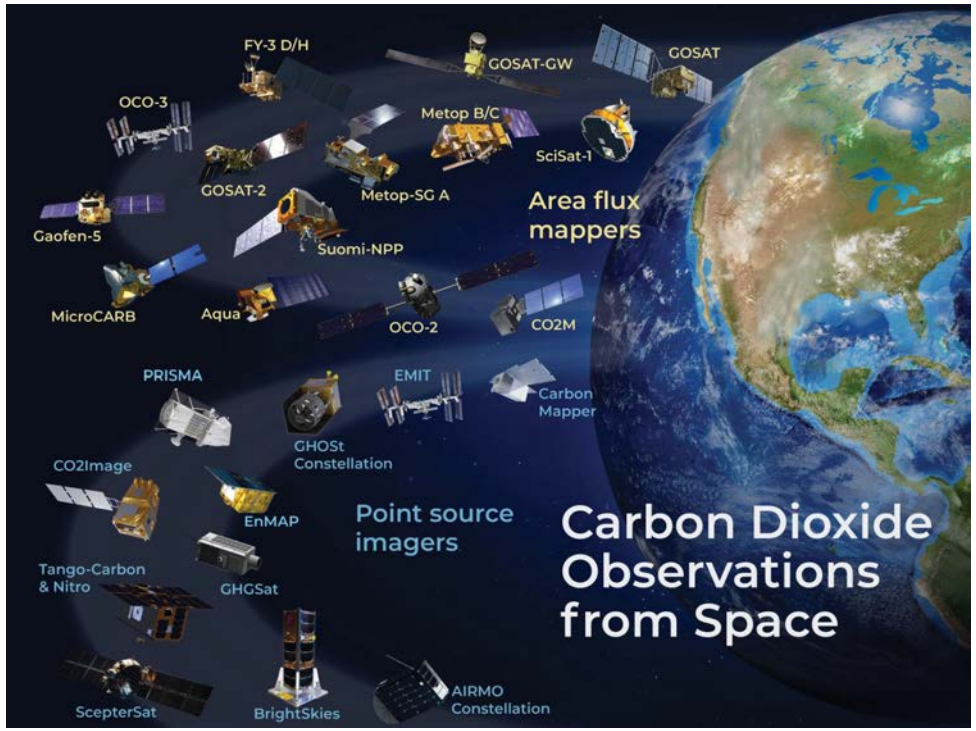
EU COPERNICUS, 2023

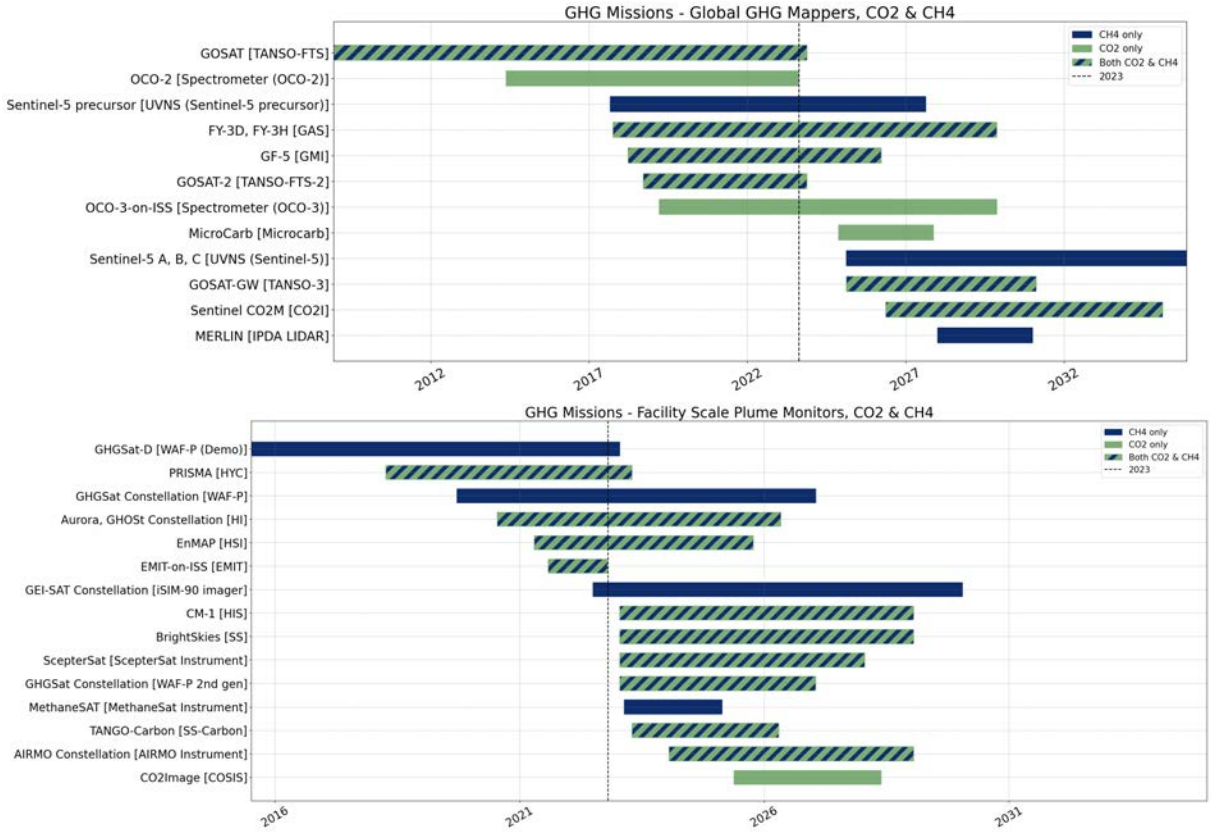


JAPAN NIES, 2023

G3W is synchronizing with Space Agencies

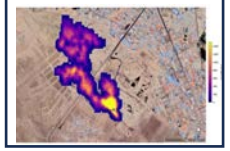
- In 2024-27 the **G3W IPP Implementation and Pre-operational Phase**, it is crucial for the global coverage of local relevance that **G3W Space Remote Sensing** components are well coordinated.
- This is thanks to **CEOS** and to **CGMS**





Mappers

Spotters



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CEOS – Committee on Earth Observations Satellites + **CGMS – Coordination Group on Meteorological Satellites**

G3W implementation steps

TT-G3W-networks under SC-ON (network design)

Covered under TT-G3W-Data

TT-G3W-Research under the Research Board (R2O strategy)

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_2 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_2
- P2 – Identify needs – CH_4
- P3 – Identify needs – N_2O
- P4 – Fluxes characterization

Section 7 R&D Needs – R (3)

- R1 – G3W R2O 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

TT-G3W-Modelling under SC-ESMP (products and centers requirements)

TT-G3W-Data under SC-IMT (design data architecture)

IG3IS steering committee proposed to take a lead on user engagement

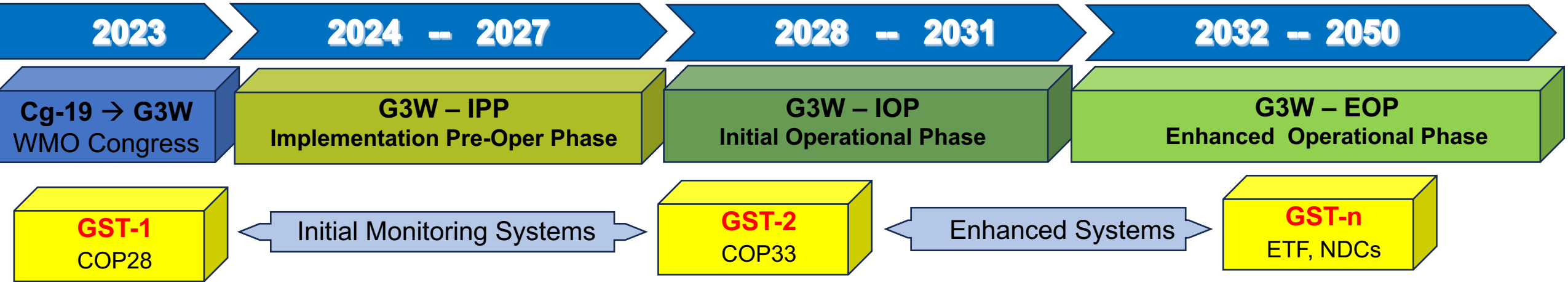
G3W @ IPCC TFI: Take Home Messages

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. IPCC/GCOS/CEOS/CGMS/IOC started)**

- **The IPCC contributions to G3W can be crucial in two main ways:**
  1. **greater and more timely access to interoperable inventories (priors), as INPUT in National systems**
  2. **greater impact of the Consensus Monitoring information OUTPUT to UNFCCC and other stakeholders**

- **The G3W efforts are integral part of a Climate Infrastructure to support Science & Services, and interact via WMO channels, with the 193 Members (NMHSs), UN, UNFCCC, IPCC, States/non-States actors**



Thank you

Take Home 🏠 message

- ***CLIMATE ACTION NEEDS***
- ***SCIENCE DRIVEN – CONSENSUS BASED***
- ***CLIMATE DATA – INFORMATION - KNOWLEDGE***

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g3w-gov@groups.wmo.int

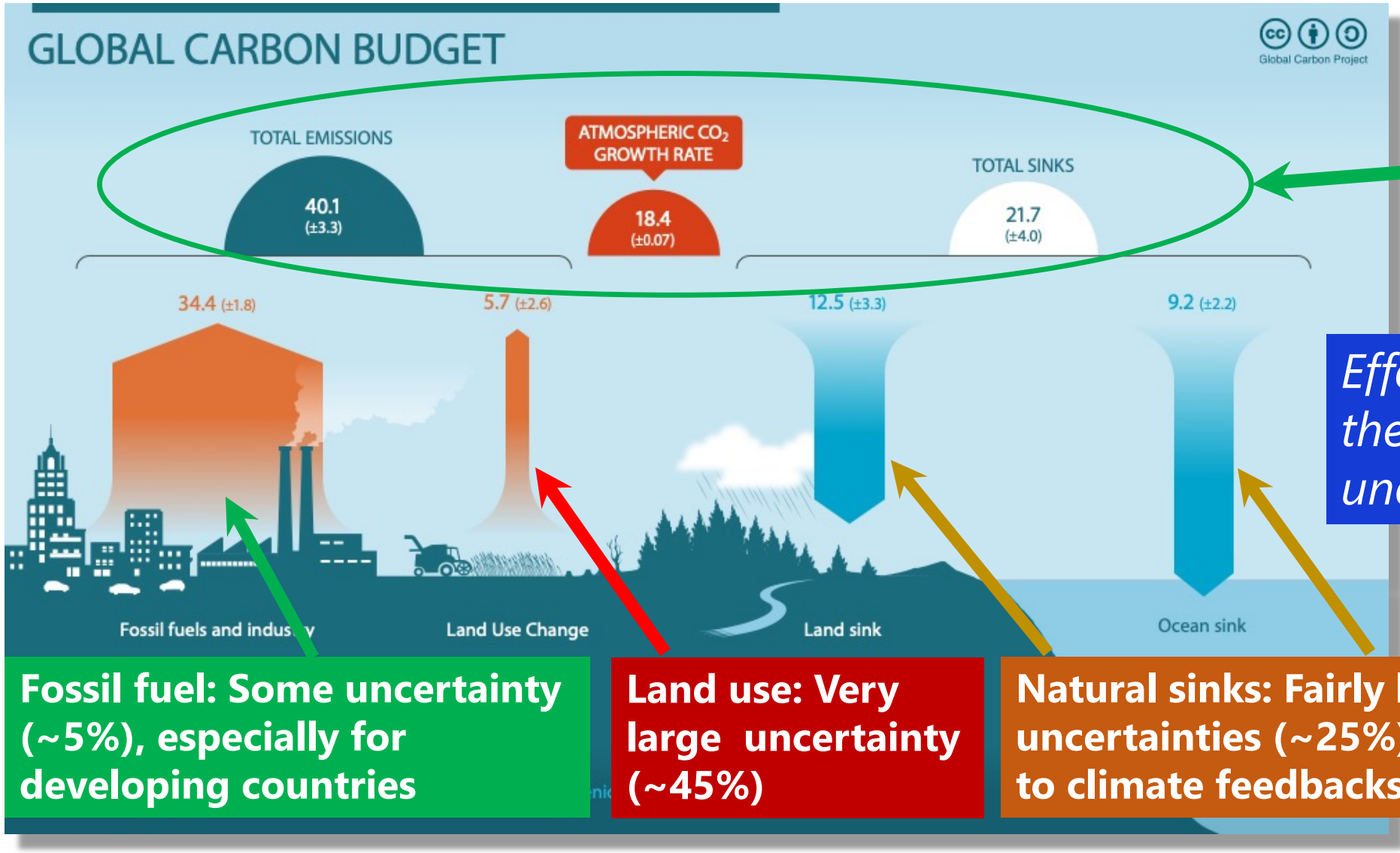
G3W – A co-design & co-development effort from the start

G3W Implementation Plan - Coordinating lead authors: Greg Carmichael, Vincent-Henri Peuch, Frederic Chevallier, Shanna Combley, Vanda Grubišić, Tom Kralidis, Alistair Manning, Yasjka Meijer, Lesley Ott, Yosuke Sawa, Adrienne Sutton, Jocelyn Turnbull, Alex Vermeulen, Oksana Tarasova, Gianpaolo Balsamo.

G3W IP - Contributing authors and reviewers (in alphabetic order):
Tuula Aalto, Anna Agusti-Panareda, Clement Mathieu Jacques, Mihai Alexe, Erik Andersson, Arlyn Andrews, Kyle Arndt, Nicola Arriga, Dorothee Bakker, Annett Bartsch, Ana Bastos, Daniele Biron, Antonio Bombelli, Kevin W. Bowman, Stephen.A. Briggs, Manola Brunet, Rui Cheng, Eric Choi, Steve Cohn, Shanna Combley, Kevin Cossel, Paul Counet, Chris Davis, Steven J Davis, Phil DeCola, Thomas Diehl, Richard Engelen, Onoriode Esegbue, Shuangxi Fang, Andreas Fix, Bruce Forgan, Pierre Friedlingstein, Tobias Fuchs, Thanos Gkritzalis, Lifeng Guo, Judith Hauck, Maria Hood, Sander Houweling, Ophery Ilomo, Tatiana Ilyina, Shutler Jamie, Michel Jean, Junli Jin, John Stephen Kayode, Joerg Klausen, Ernest Koffi , Thelma Krug, Dagmar Kubistin, Akihiko Kuze, Casper Labuschagne, Siv K Lauvset, Sung Ching Lee, Christian Lessig, Ian Lisk, Ingrid Luijkx, Marta Magnani, Salah Mahmoud Zeinab, Shamil Maksyutov, Giselle Lujan Marincovich, Amanda Maycock, Yasjka Meijer, Joe Melton, John Miller, Tillmann Mohr, Gary Morris, Jonas Mphepya, Frank Muller-Karger, John Mund, Ray Nassar, Yosuke Niwa, Ronnie Noonan-Birch, Kevin O'Brien, Osamu Ochiai, Tom Oda, Dario Papale, Lucia Perugini, Wouter Peters, Jan Polcher, Joanna Post, Benjamin Poulter, Ben Poulter, Bin Qu, John Remedios, Chao Ren, Markus Repnik, Marie-Helene Rio, Michel Rixen, Karen Rosenlof, Paolo Ruti, Zeinab Salah, Richard Sanders, Susanne Schödel, Marko Scholze, Frank Martin Seifert, Alexey Shiklomanov, Stephen Sitch, Ward Smith, Kieran Stanley, Martin Steinbacher, Tobias Steinhoff, Wenying Su, Hiroshi Suto, Colm Sweeney, Toste Tanhua, Maciej Telszewski, Rona Thompson, Bronte Tilbrook, Matt Tully, Jocelyn Turnbull, Peter van Oevelen, Anya Waite, Rik Wanninkhof, Brad Weir, Ray Weiss, Martin Wooster, John Worden, Irène Xueref-Remy, Melaku Yigiletu, Xiaochun Zhang, Xingying Zhang

Where are CO_2 fluxes uncertainties? How to reduce them?

(Graphic by the Global Carbon Project)



Top level global budget is understood

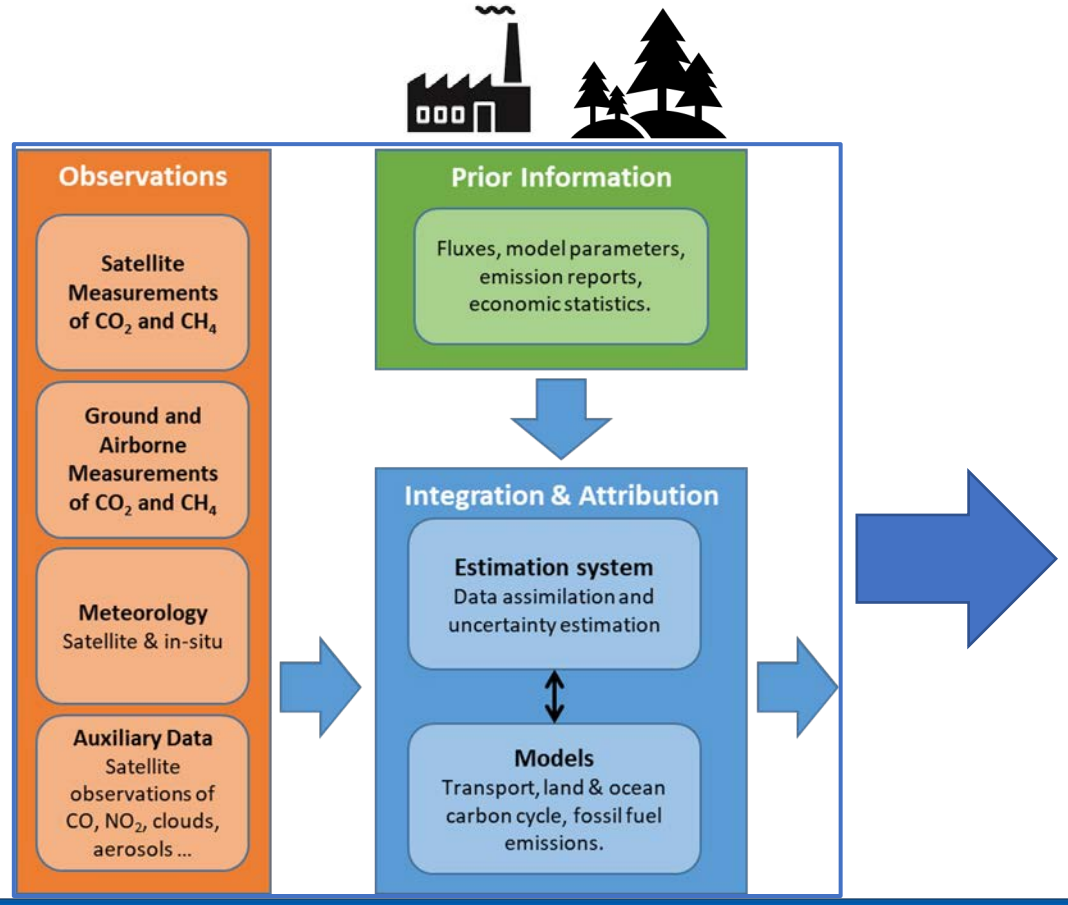
Efforts are needed on the areas with larges uncertainties!

Fossil fuel: Some uncertainty (~5%), especially for developing countries

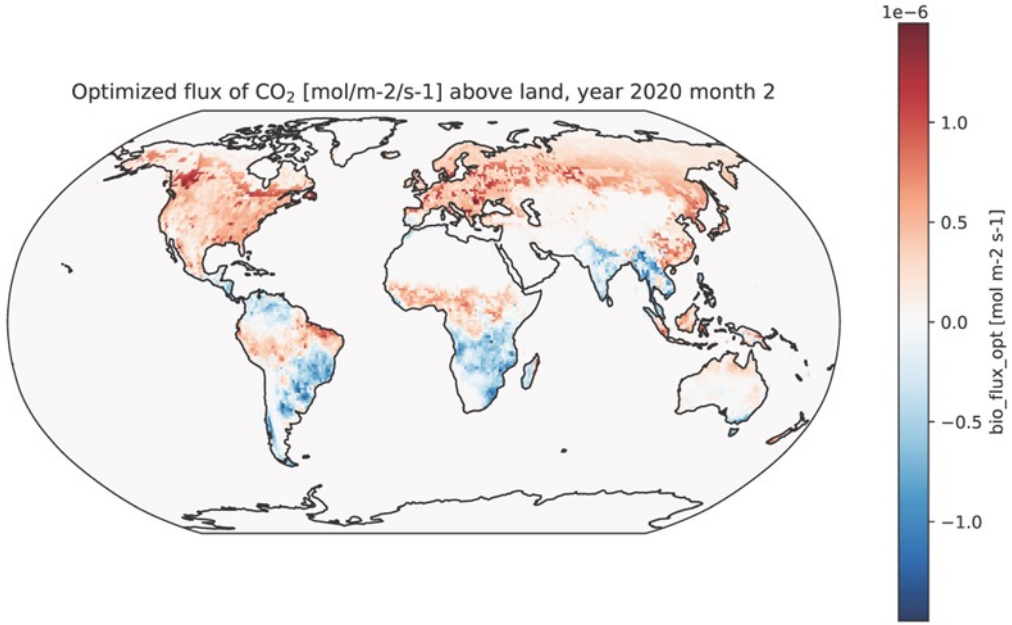
Land use: Very large uncertainty (~45%)

Natural sinks: Fairly large uncertainties (~25%); subject to climate feedbacks

G3W – the Global Greenhouse Gas Watch
An integrated Earth system operational approach



Outputs: Globally gridded monthly net fluxes of CO_2 and CH_4 (and N_2O)



G3W will be supported by several global modelling centers (similar to operational World NWP Centers)

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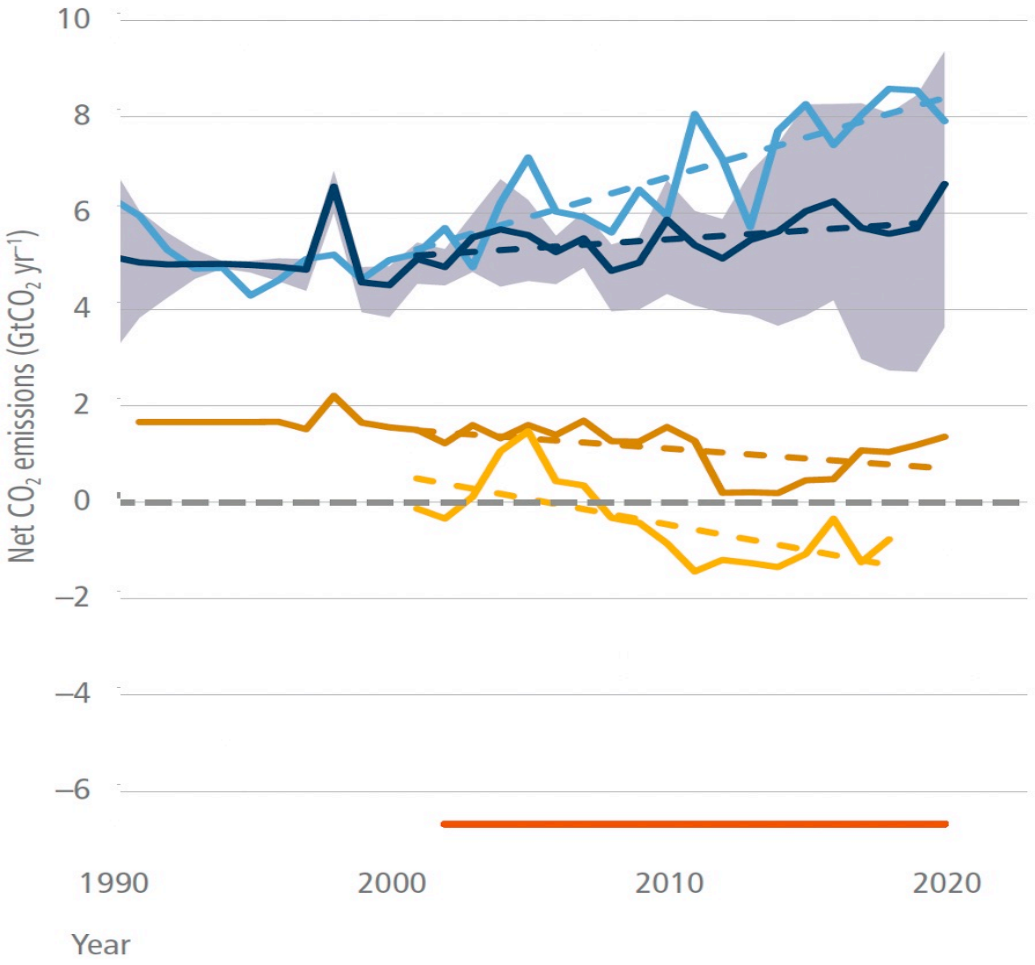
The gap in land use emissions affects EO-based GST uptake

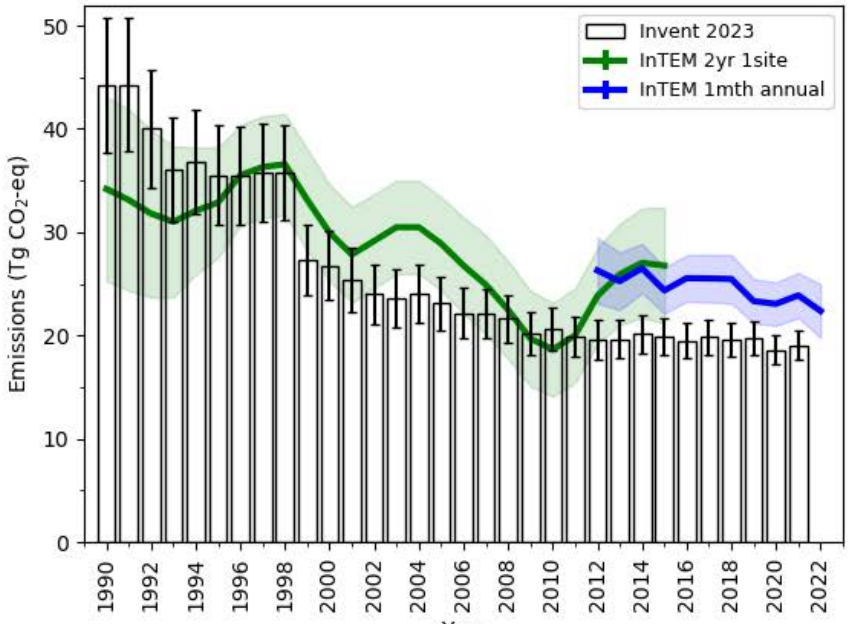


Estimated using different methods:
(i) Global models from the Global Carbon Budget (Friedlingstein et al. 2020): Dynamic Global Vegetation Models (DGVMs) and Bookkeeping models;
(ii) Earth Observation data (forest-related fluxes only, Harris et al. 2021);
and (iii) country-based data: National GHG Inventories (NGHGI, Grassi et al. 2021) and FAOSTAT (Tubiello et al. 2020).

- *Global net LULUCF CO2 flux in the WGIII contribution to the IPCC AR6 (Nabuurs et al. 2022)*

Lessons learned through the work with UNFCCC: National emission reporting

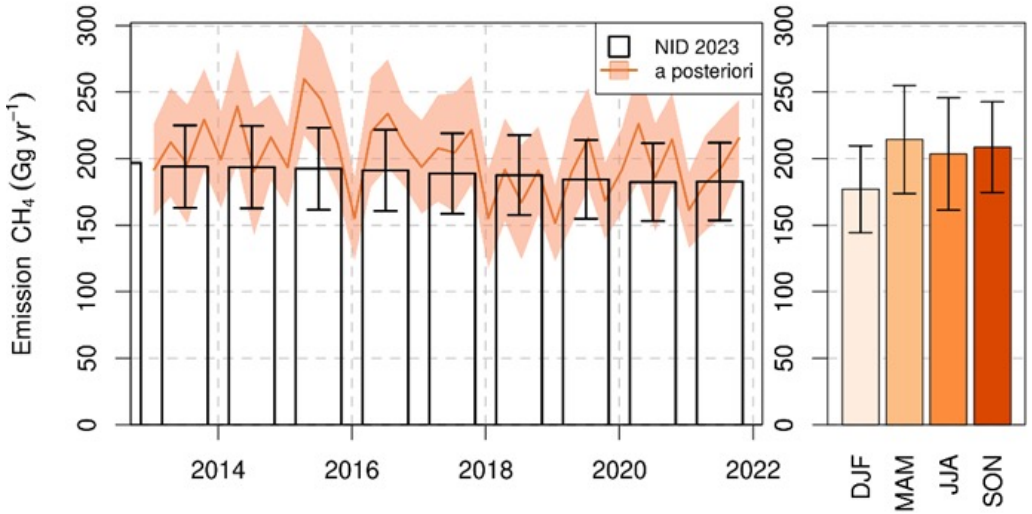
N_2O Emissions of the UK



Included in the National submission

Additional information

CH_4 emissions of Switzerland



- Additional information to inventory builders to improve emission reporting to UNFCCC
- Improved timeliness and availability of the information to support tracking of the impact of emission reduction actions and to help guide national GHG policy and regulations

Results by Alistair Manning and Stephan Henne

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

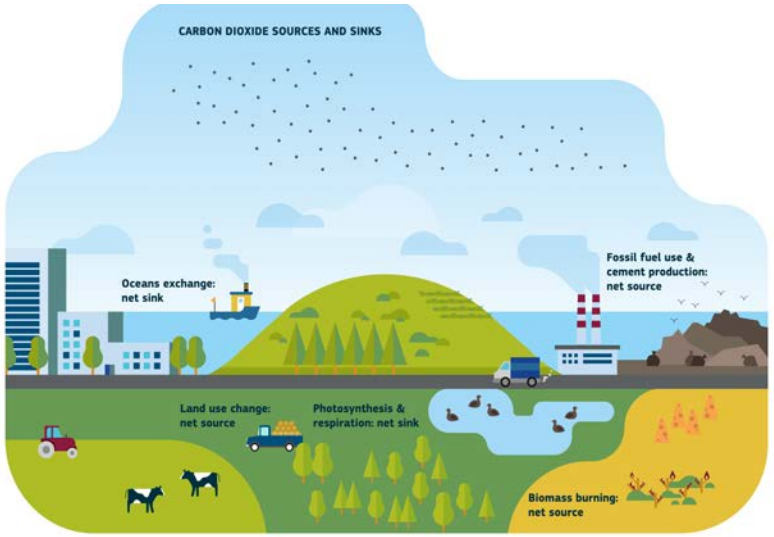
Initial Monitoring Systems

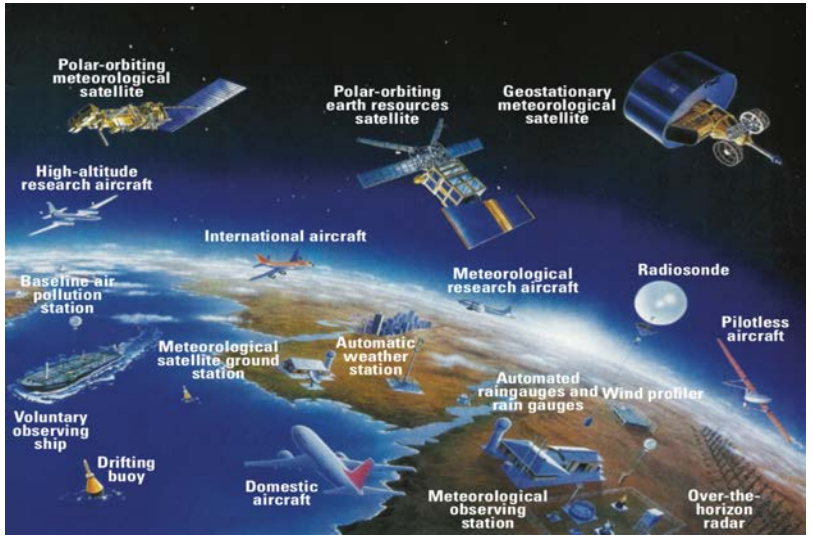
GST-2
COP33

Enhanced Systems

GST-n
ETF, NDCs

"for Measuring, Understanding, and Managing the Earth's Climate"





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

UNFCCC
COP-SBSTA

WMO
WIGOS-WIS-WIPPS

Public-Private Partnerships

CO_2, Carbon dioxide

GHGs Earth's Observing Systems is building on Weather experience

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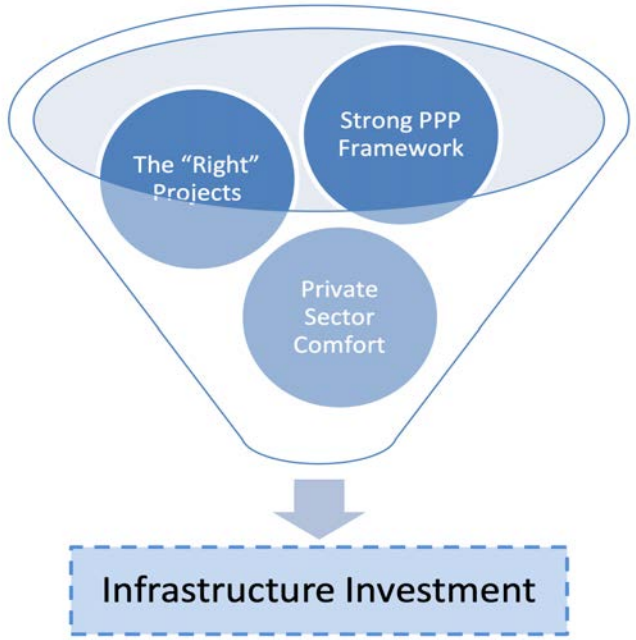
G3W longer-term plans & vision

Synchronizing Public & Private Funding Opportunities

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

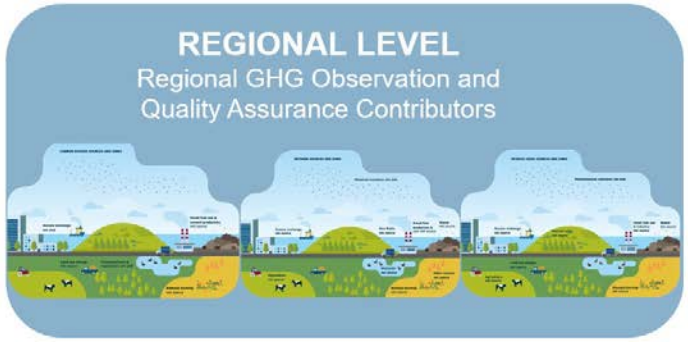
Funding mechanisms include 3 pathways:

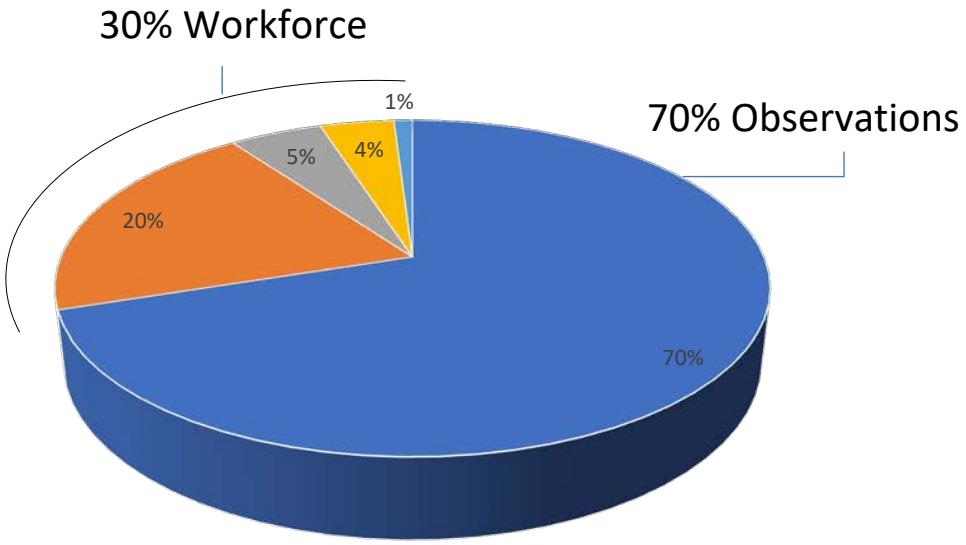
- **G3W initial WMO-funds**, approved by the 19th World Meteorological Congress (Cg-19) **Resolution 5** of in 2023.
- **G3W trust-fund**, managed by WMO, with two Champions Nations contributing in 2023 and more expected from Public & Private sources from 2024.
- **Specialized G3W financial vehicle** 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



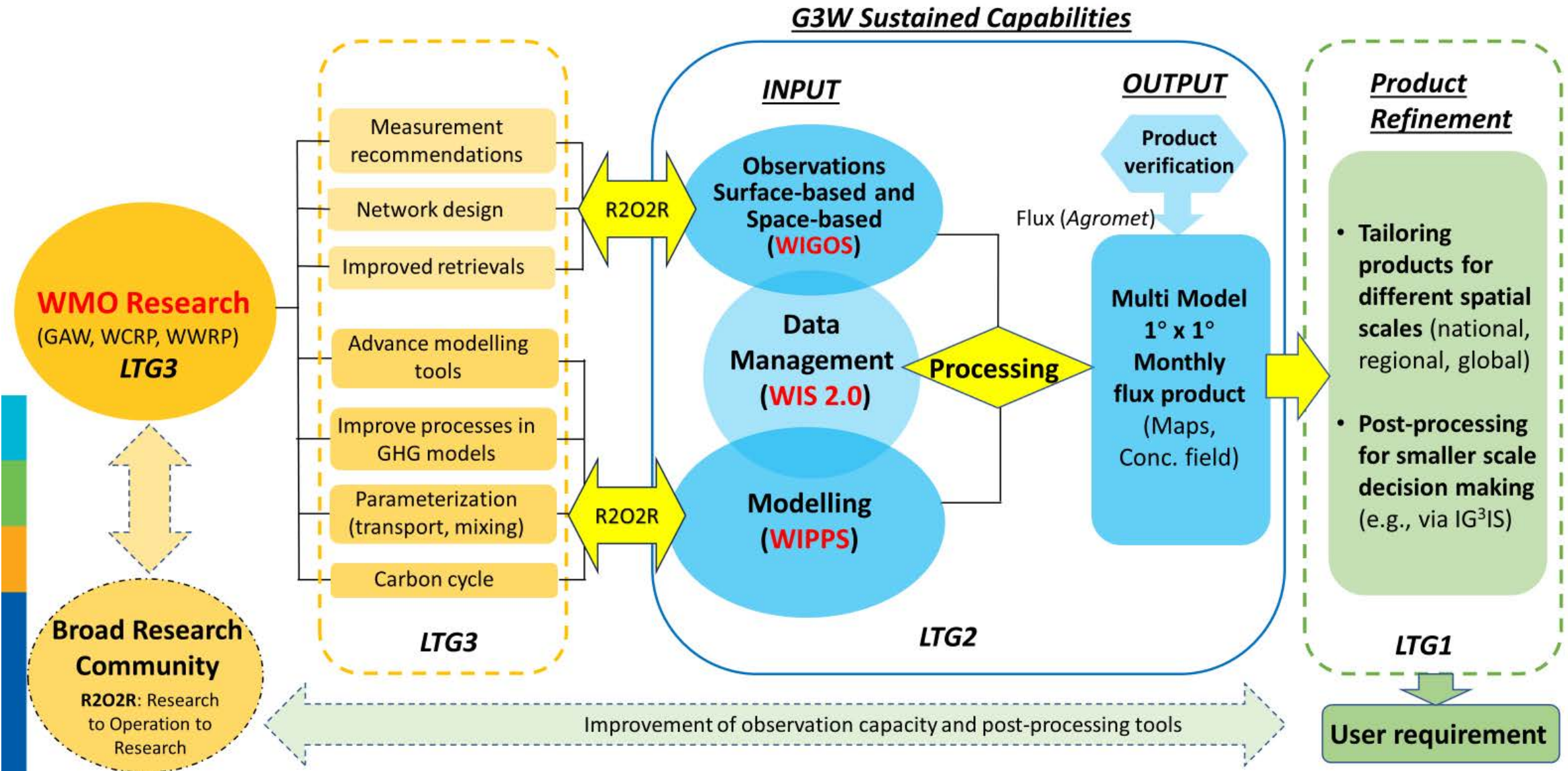


The G3W will develop strategic actions to fund systematically infrastructure + workforce, beyond opportunity-based and development-based funding mechanisms.

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

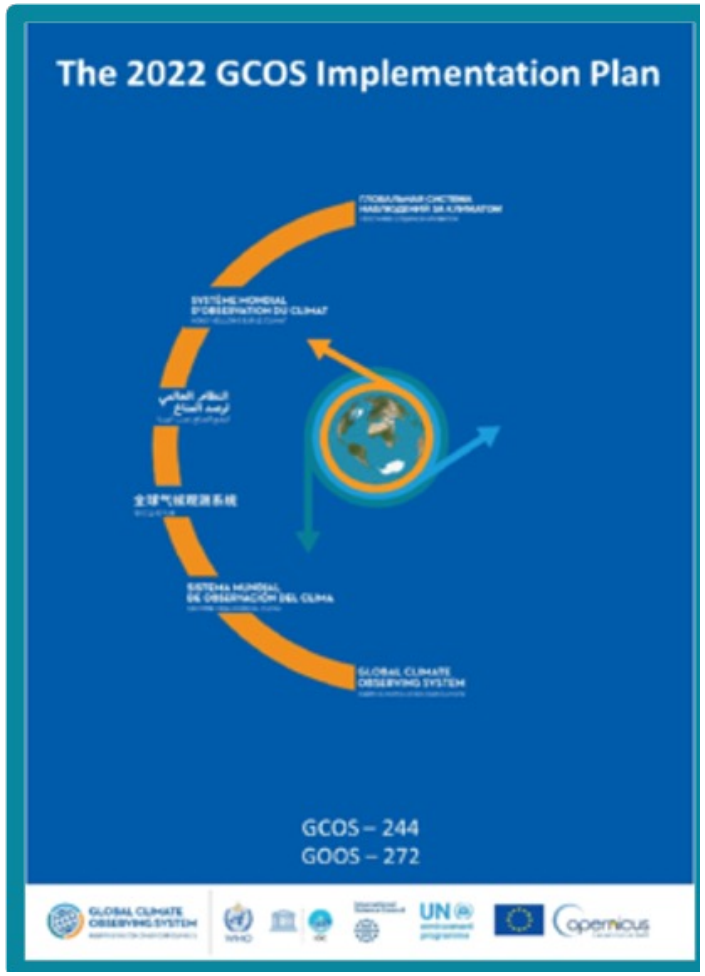
- Observing system surface-based infrastructure
- Observing systems integration, modelling and data management
- Capacity building and capacity development for G3W input and uptake
- Regional Pilot Projects and supporting research for G3W emerging priorities
- Central coordination by WMO secretariat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

Synchronizing within the WMO shared Governance & Goals



G3W GCOS GAW shared efforts

- 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	The overall aim here is to develop an integrated operational global greenhouse gas monitoring infrastructure. The first steps are: 1. Design and start to implement a comprehensive global set of surface-based observations of CO_2, CH_4 and N_2O 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 CO_2 and CH_4 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	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. Monitoring of hot-spots via dedicated observations to validate specific point-source emissions and identify missing sources form emission inventories. 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 (SO_2, 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).
Implementers	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.

How are GCOS and G3W related?

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!**

G3W Implementation Pilots in 2024-2027: A Methane case

COP28 Global Methane Pledge – 155 Countries

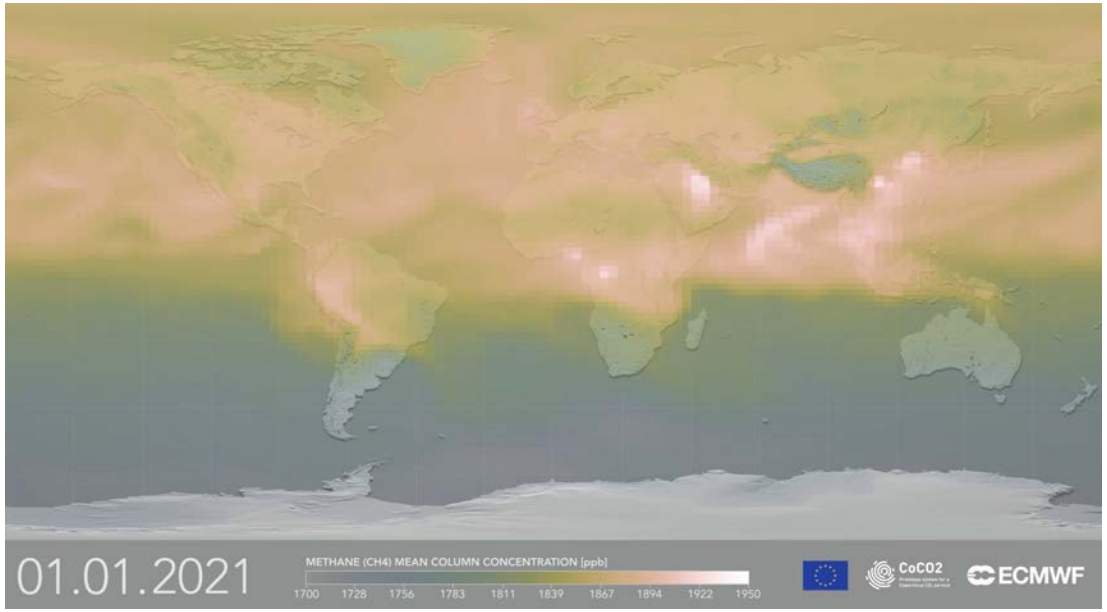
- https://www.globalmethanepledge.org

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 a IPCC 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 both **Agility** of Private Sector investment and **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 and GCOS ECVs)

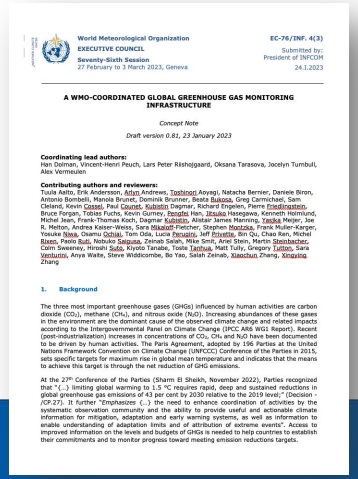


Animation source: Copernicus Earth Observation Programme / ECMWF CAMS

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**.



World Meteorological Organization
EXECUTIVE COUNCIL
Seventy-Sixth Session
27 February to 3 March 2023, Geneva

EC-76/INF. 4(3)
Submitted by:
President of INFCOM
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A WMO-COORDINATED GLOBAL GREENHOUSE GAS MONITORING INFRASTRUCTURE

Concept Note

Draft version 0.81, 23 January 2023

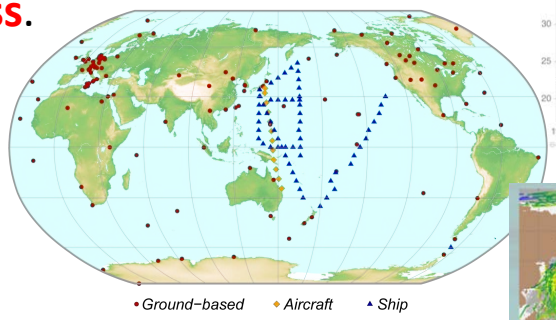
Coordinating lead authors:
Han Dolman, Vincent-Henri Peuch, Lars Peter Riishojgaard, Oksana Tarasova, Jocelyn Turnbull, Alex Vermeulen

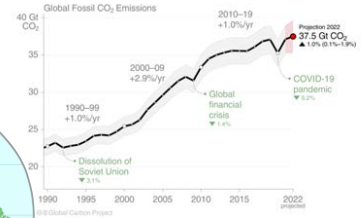
Contributing authors and reviewers:
Tuula Aalto, Erik Andersson, Arlyn Andrews, Toshinori Aoyagi, Natacha Bernier, Daniele Biron, Antonio Bombelli, Manola Brunet, Dominik Brunner, Beata Bukosa, Greg Carmichael, Sam Clelland, Kevin Cassel, Paul Courrel, Kubishin Dagmar, Richard Engelen, Pierre Friedlingstein, Bruce Forgan, Tobias Fuchs, Kevin Gurney, Pengfei Han, Jitsuko Hasegawa, Kenneth Holmlund, Michel Jean, Frank-Thomas Koch, Dagmar Kubistin, Alistair James Manning, Yasuko Meijer, Joe R. Melton, Andrea Kaiser-Weiss, Sara Mikaloff-Fletcher, Stephen Montzka, Frank Muller-Karger, Yosuke Niwa, Osamu Ochiai, Tom Oda, Lucia Perugini, Jeff Privette, Bin Qu, Chao Ren, Michel Ramonet, Paolo Ruti, Nobuko Saigusa, Zeinab Salah, Mike Smit, Ariel Stein, Martin Steinbacher, Colm Sweeney, Hitoshi Suda, Kiyoto Tanabe, Toste Tanhua, Matt Tully, Gregory Tyndon, Sara Venturini, Anya Waite, Steve Widdicombe, Bo Yao, Salah Zeinab, Xiaochun Zheng, Xinguing Zhang

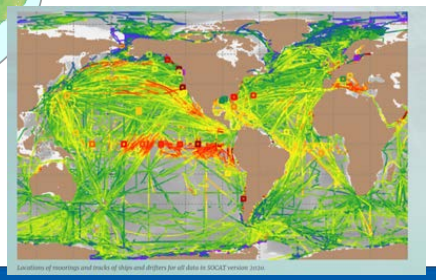
1. Background

The three most important greenhouse gases (GHGs) influenced by human activities are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). 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 CO_2, CH_4 and N_2O 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.







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

G3W Implementation & Pre-operational Phase 2024-2027

WORLD METEOROLOGICAL ORGANIZATION

G3W – Global Greenhouse Gas Watch