WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

CGPM-2022

Metrology for Climate Action: agreed outcomes and next steps from the BIPM-WMO Workshop

Dr Anthony Rea
Director, WMO Infrastructure Department

WMO OMM
World Meteorological Organization
Organisation météorologique mondiale

World Meteorological Organization

- UN Specialized Agency on weather, climate & water
- 193 Members, HQ in Geneva
- 2nd oldest UN Agency, 1950- (IMO 1873)
- Coordinates work of 1000s of national experts from meteorological & hydrological services, academia & private sector
- Co-Founder and host agency of IPCC (1st World Climate Conference)

WMO Convention

PART II

ARTICLE 2

Purposes

The purposes of the Organization shall be:

(a) To facilitate worldwide cooperation in the establishment of networks of stations for the making of meteorological observations as well as hydrological and other geophysical observations related to meteorology, and to promote the establishment and maintenance of centres charged with the provision of meteorological and related services;

(b) To promote the establishment and maintenance of systems for the rapid exchange of meteorological and related information;

(c) To promote standardization of meteorological and related observations and to ensure the uniform publication of observations and statistics;

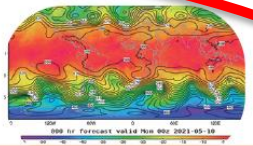
WMO OMM

Successful application of weather and climate services depend on a functioning meteorological value chain

Global meteorological infrastructure

Observations from the entire globe

International exchange of observations



Global Numerical Weather Prediction

Weather and climate-related infrastructure - **must be designed and managed globally**

Last-mile activities undertaken **primarily at regional, national and local level**

Local data processing, forecast, warning and advisory products

Delivery of weather and climate services

Effective decision-making and action

WMO OMM

WMO Vision, Mission, Objectives and Strategy

VISION 2030

By 2030, we see a world where all nations, especially the most vulnerable, are more resilient to the socioeconomic consequences of extreme weather, climate, water and other environmental events; and underpin their sustainable development through the best possible services, whether over land, at sea or in the air *(and in space)*

OVERARCHING PRIORITIES

Preparedness for, and reducing losses from hydrometeorological extremes	Climate-smart decision-making to build resilience and adaptation to climate risk	Socioeconomic value of weather, climate, hydrological and related environmental services

CORE VALUES

Accountability for Results and **Transparency**	**Collaboration** and **Partnership**	**Inclusiveness** and **Diversity**

LONG-TERM GOALS

1 Services	2 Infrastructure	3 Science & Innovations	4 Member Services	5 Smart Organization
Better serve societal needs	**Enhance Earth system observations and predictions**	**Advance targeted research**	**Close the capacity gap**	**Strategic realignment of structure and programmes**

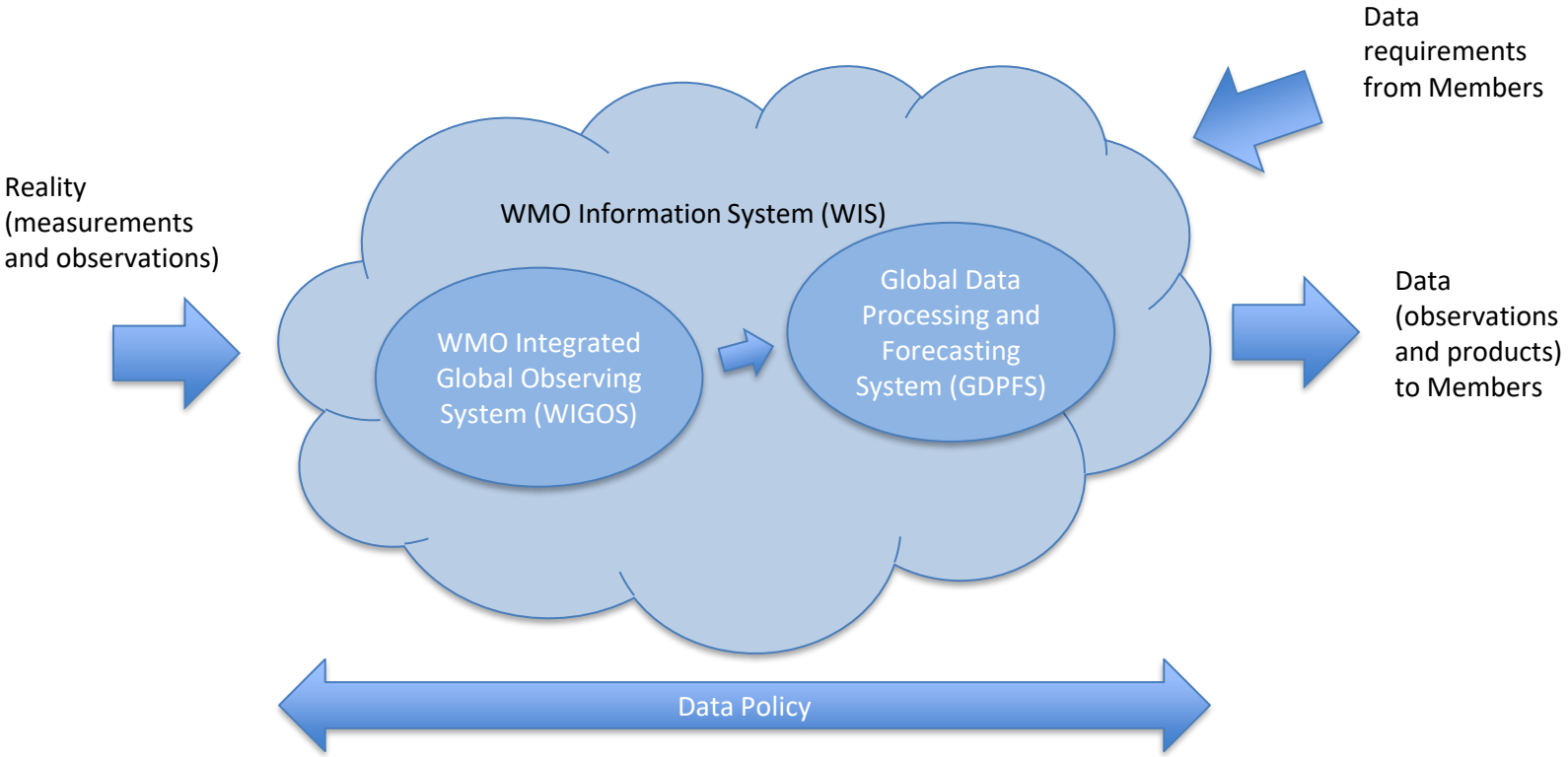
STRATEGIC OBJECTIVES

FOCUSED ON 2020-23

• Strengthen **national multi-hazard early warning/alert systems** • Broaden provision of **policy- and decision-supporting climate, water** and **weather services**	• Optimize **observation data acquisition** • Improve access to, exchange and management of **Earth system observation data and products** • Enable access and use of **numerical analysis and prediction**	• Advance **scientific knowledge of the Earth system** • Enhance **science-for-service value chain** to improve predictive capabilities • Advance **policy-relevant science**	• Enable developing countries to **provide** and **utilize essential weather, climate, hydrological** and related **environmental services** • Develop and sustain **core competencies** and **expertise**	• Optimize WMO **constituent body structure** • Streamline WMO **programmes** • Advance **equal, effective** and **inclusive participation**

See https://library.wmo.int/index.php?lvl=notice_display&id=21525

WMO OMM


Data requirements from Members
Reality (measurements and observations)
WMO Information System (WIS)
WMO Integrated Global Observing System (WIGOS)
Global Data Processing and Forecasting System (GDPFS)
Data (observations and products) to Members
Data Policy

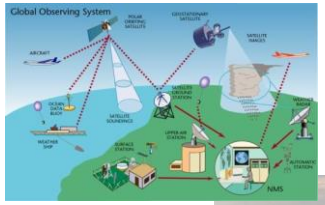
WMO OMM

Observing Components of WIGOS

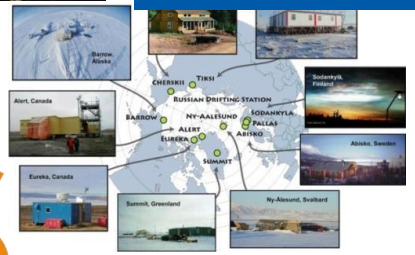
- Global Observing System (WWW/**GOS**)
- Global Atmospheric Watch (**GAW**)
- WMO Hydrological Observations System (**WHOS**)
- Global Cryosphere Watch (**GCW**)

Contributing Networks

- Global Climate Observing System (**GCOS**)
- Global Ocean Observing System (**GOOS**)



GCOS



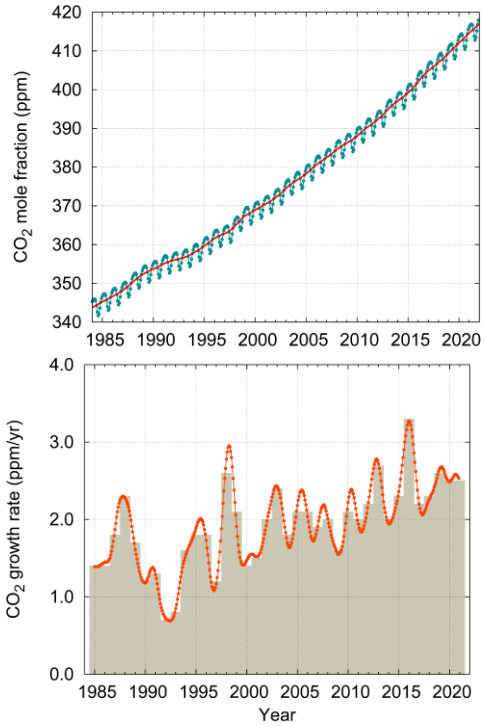
GOOS

WMO OMM

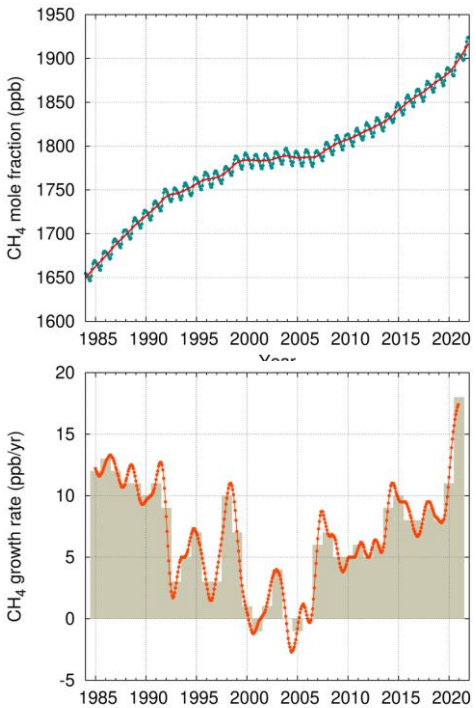
WMO at COP27:

- State of Climate
- Early Warning Systems for all
- GHG Monitoring Infrastructure
- GCOS Implementation Plan
- Numerous side events

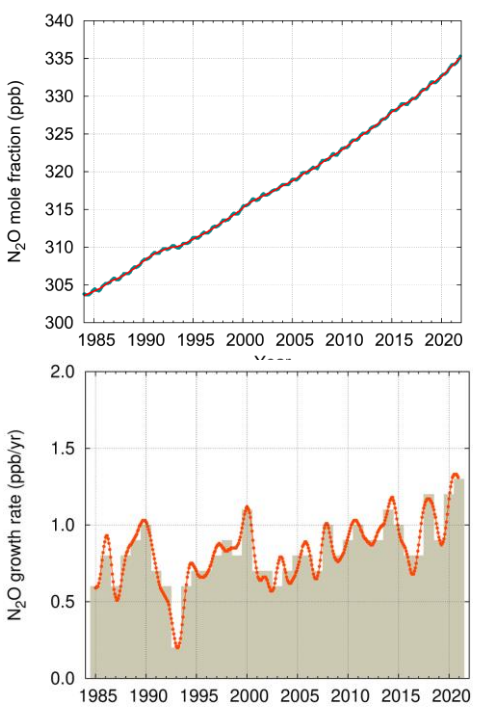
New record levels of greenhouse gases. Methane annual increase highest on record



Carbon Dioxide
415.7 ± 0.2 ppm
149% of preindustrial



Methane
1908 ± 2 ppb
262% of preindustrial



Nitrous Oxide
334.5 ± 0.1 ppb
124% of preindustrial

WMO OMM

The year 1750 is used for pre-industrial concentrations

WMO GAW

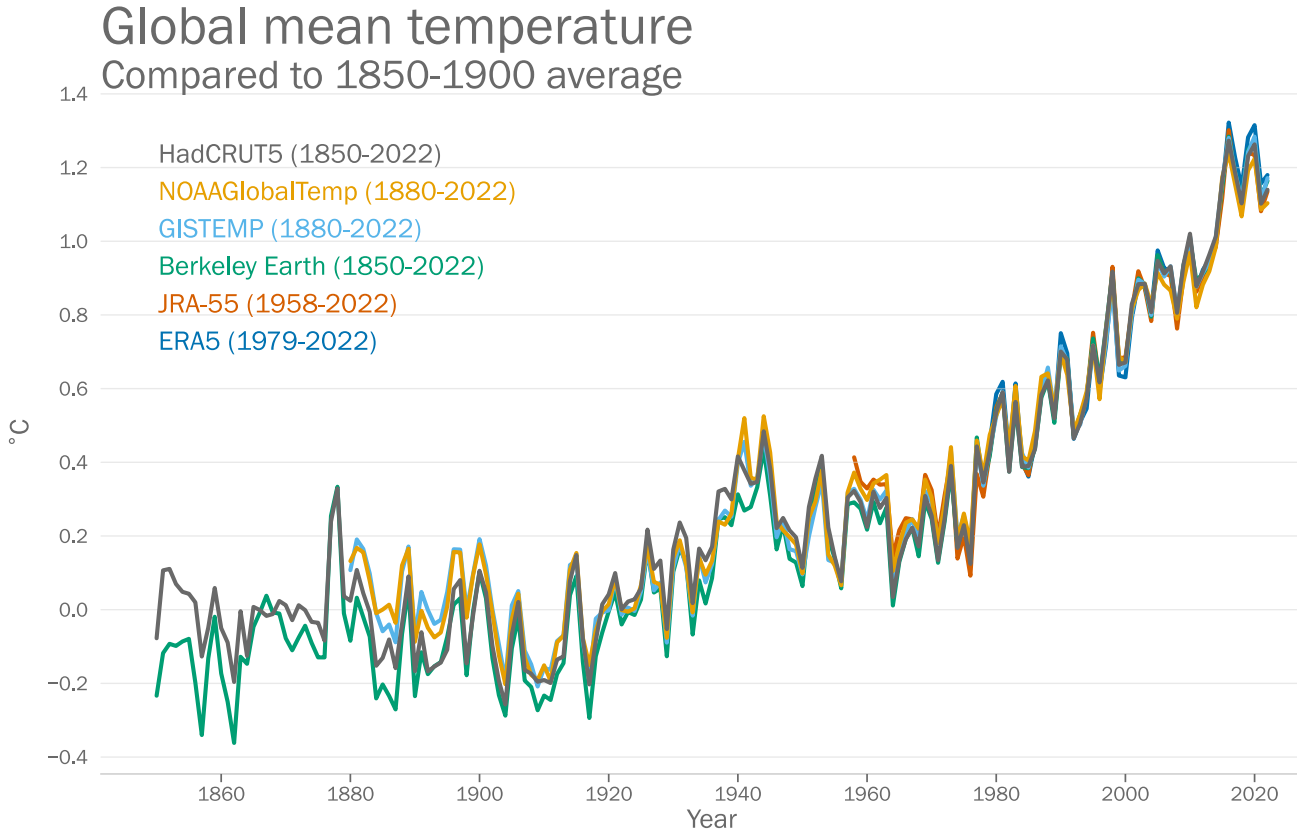
Past eight years (2015-2022) set to be eight warmest years on record

2022 based on data to September from 6 data sets

2022 most likely 5th or 6th warmest at this point despite ongoing La Niña

2022 1.15 [1.02 to 1.28] °C above 1850-1900 average

10-year average 2013-2022 1.14 [1.02 to 1.27] °C



WMO OMM

WMO

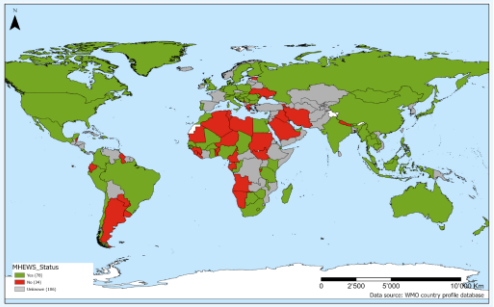
Early warning/climate adaptation initiative for COP-27

"Today I announce the United Nations will spearhead new action to ensure every person on Earth is protected by early warning systems within five years.

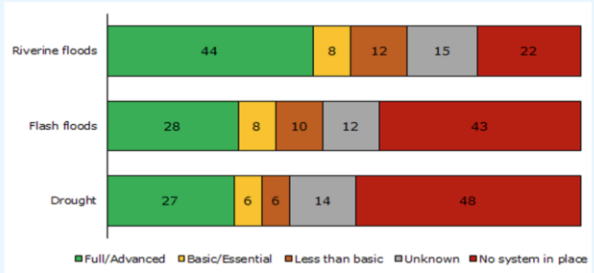
I have asked the World Meteorological Organization to lead this effort and to present an action plan to achieve this goal at the next UN climate conference, later this year in Egypt."

António Guterres, Secretary-General of the United Nations, 23rd March 2022

Global Status of Early Warning System Coverage



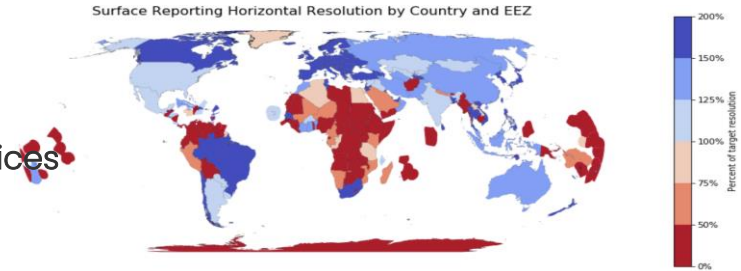
Capacities are particularly lacking for the creation of drought and flash flood warnings, despite these hazards being the deadliest and most costly events, respectively, after storms (1970-2019).



53% of Members have no basic flash flood warning system

54% of Members have no basic drought warning system

- Systematic Observation Financing Facility
- Investments in hydrological infrastructures
- Multi-Hazard, Impact-based early warning services
- Partnerships with WB, GCF, UNDP etc.

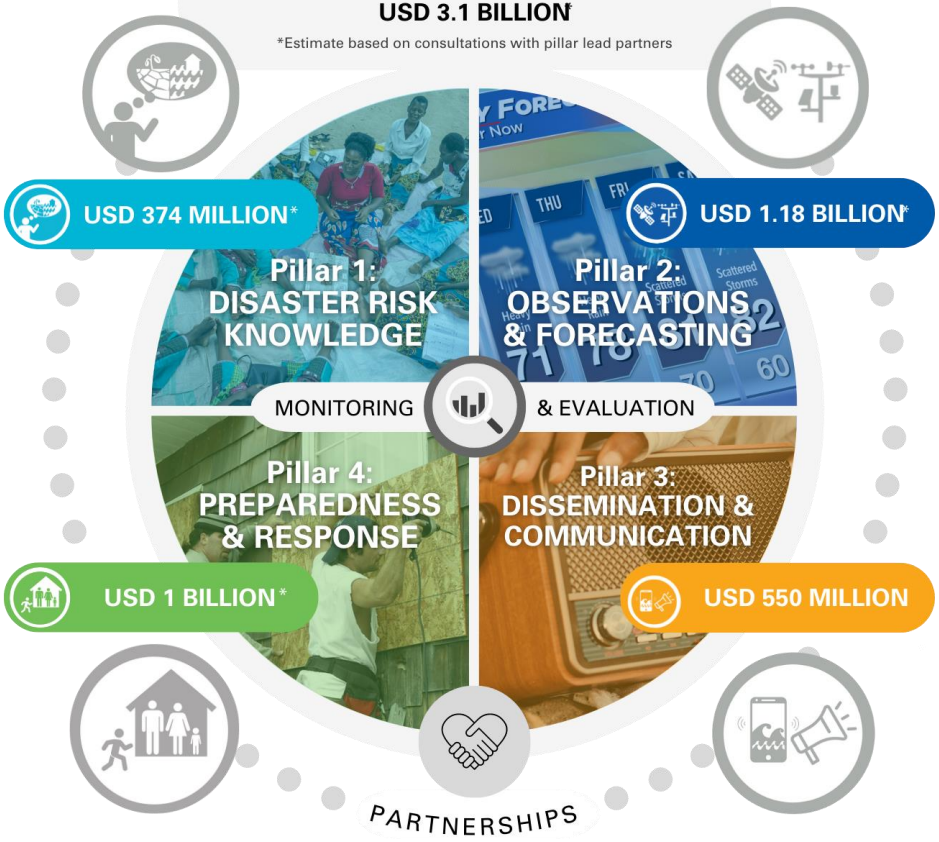


WMO OMM

New investment required to advance towards early warnings for all within five years:

USD 3.1 BILLION*

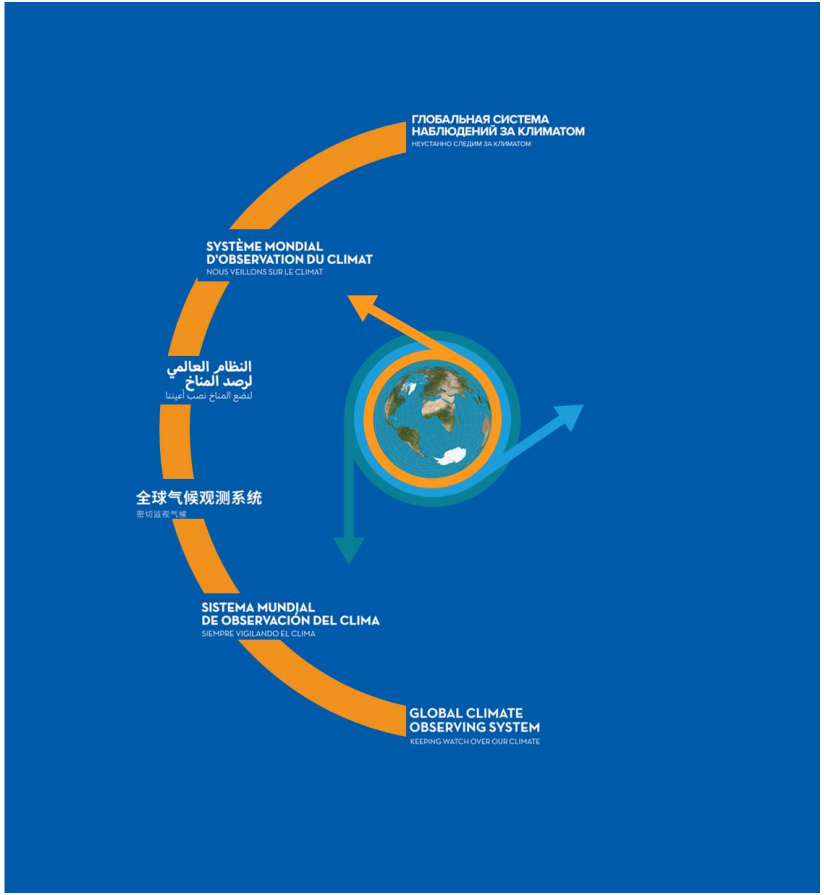
*Estimate based on consultations with pillar lead partners



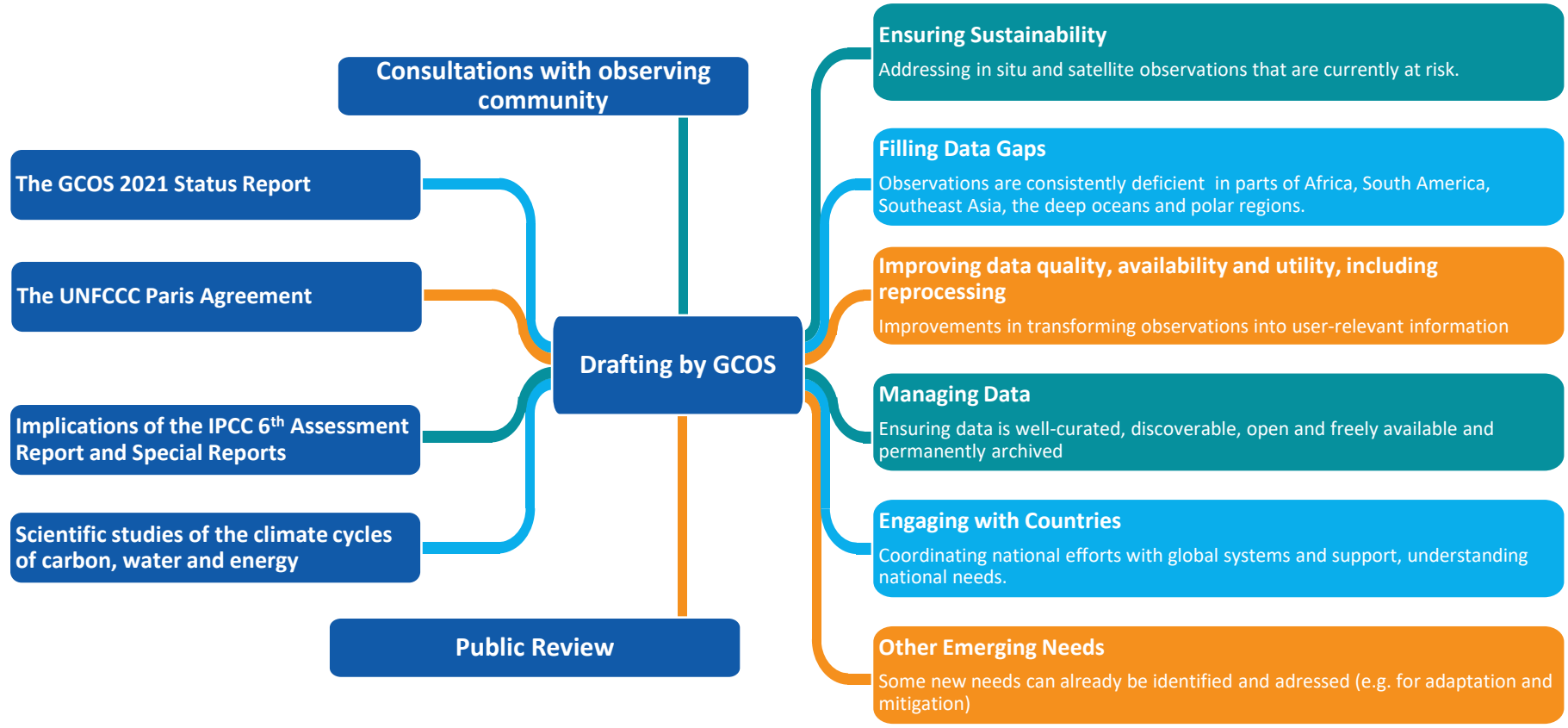
WMO OMM

GCOS Implementation Plan

- Produced every 5-6 years, GCOS Implementation Plans:
  - Are submitted to UNFCCC and the GCOS sponsors.
  - Provide recommendations for a sustained and fit for purpose Global Climate Observing System.
  - Cover climate monitoring needs over the entire Earth system from the atmosphere to the oceans, from the cryosphere to the biosphere.
  - Encompass the water, energy and carbon cycles.
- This 2022 GCOS Implementation Plan has a different form to earlier plans, it has:
  - Fewer, more focused, and integrated actions.
  - Clearer means of assessment.
  - Clearer identification of the stakeholders who need to respond to the actions.
  - The updated ECVs requirements are presented in a separate document - *The 2022 GCOS ECVs Requirements* (GCOS 245).



Wide range of views and inputs condensed into 6 themes



Main Inputs → **Broad Engagement** → **Themes for Action**

Greenhouse Gas Monitoring Infrastructure – Problem Statement

Anthropogenic emissions of greenhouse gases (primarily CO2, CH4 and N2O) are the primary drivers of climate change;

In response, the was Paris Agreement approved in 2015, aiming to hold the increase in global mean temperature well below 2.0^{o} C (preferably 1.5^{o}), via reduction of GHG emissions;

This is not a simple and straightforward proposition!

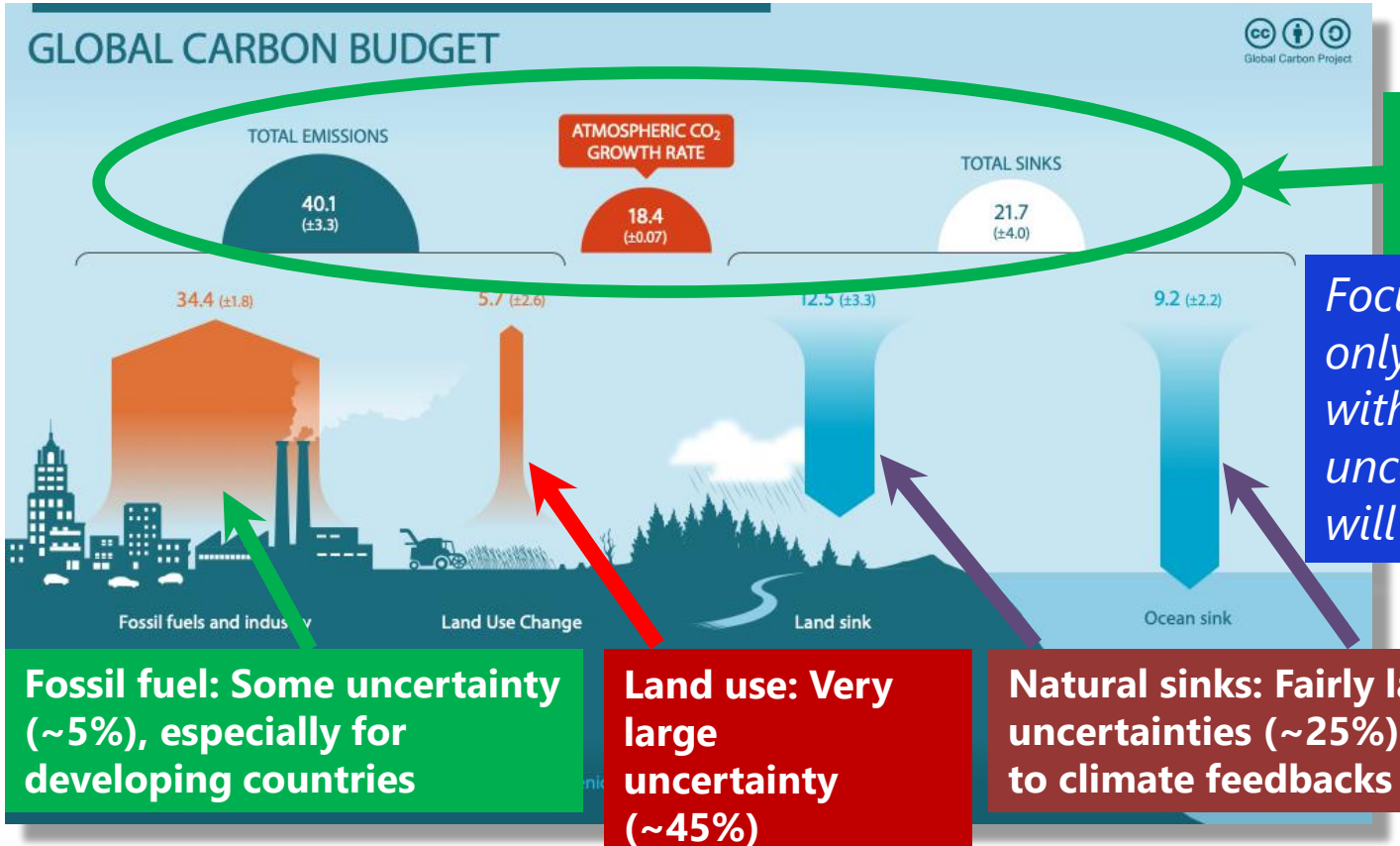
HE Amb. Carlos Fuller, former SBSTA Chair (WMO Climate Policy Advisors Meeting, 2022): **"What matters for climate is not how much carbon humans pump into the atmosphere; what matters is how much of it remains there at any given time!"**

This means that successful mitigation requires monitoring and understanding of all GHG fluxes, natural as well as anthropogenic.

WMO OMM

How well do we understand the CO_2 budget ?

(Graphic by the Global Carbon Project)



Top level global budget is well understood

Focusing our efforts only on the areas with low uncertainties (green) will not work!

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

How can we improve our understanding of GHG cycles?

By using the approach that has proven immensely successful for weather prediction and climate monitoring:

- **Integrated global GHG observing system** as a WIGOS component;
- **Timely international exchange of all GHG observations**, both from satellite and surface;
- **Routine GHG modeling and assimilation**, converting observations into *coherent, global estimates of greenhouse gas concentrations and fluxes;*
- Framework for **direct comparison** and independent verification **of model output.**

Collaboration between WMO and BIPM

- WMO signed the CIPM Mutual Recognition Arrangement in 2010 and designated 3 laboratories.
- Three conferences were co-organized between WMO and BIPM in 2010, 2015 and 2022
- WMO taking part in CCPR and CCQM
- Several NMI experts are members of WMO Expert Teams, and chairing some of them.
- Stronger collaboration is welcomed.

WMO OMM

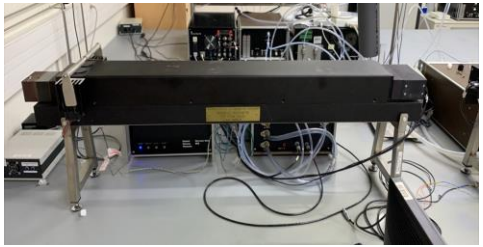
WMO participation in the CIPM MRA

WMO designated laboratories (since 2010): NOAA/ESRL, EMPA and PMOD/WRC

Comparison	Description	Measurement	Pilot institute	WMO Laboratory
BIPM.QM-K1	Ozone at ambient level	2007 -	BIPM	EMPA
CCQM-K68.2019	Nitrous oxide in air	2019 - 2020	BIPM	NOAA/ESRL
CCQM-K82	Methane in air	2012	BIPM	NOAA/ESRL
CCQM-K120	Carbon dioxide in air	2017	BIPM	NOAA/ESRL
EURAMET.PR-S6	Total solar irradiance	2015	PMOD/WRC(CH)	PMOD/WRC(CH)

Participation in currently active/planned comparisons:

Surface Ozone Standards

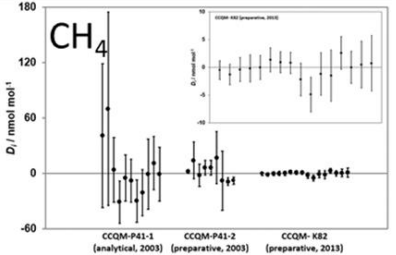


BIPM.QM-K1

CO_2 in Air Standards

CCQM-P225 BIPM.QM-K2,5

Methane in Air Standards



CCQM-K82.2023

WMO OMM

METROLOGY FOR CLIMATE ACTION

Bureau International des Poids et Mesures

WORLD METEOROLOGICAL ORGANIZATION

26–30 SEPTEMBER 2022

Theme 1: Metrology in support of the physical science basis of climate change and climate observations

- ❒ Atmospheric chemistry and physics
- ❒ Oceans and hydrology
- ❒ Earth Energy Balance
- ❒ Biosphere monitoring
- ❒ Cryosphere Monitoring

Theme 2: Metrology as an integral component of operational systems to estimate greenhouse gas emissions based on accurate measurements and analyses

- ❒ Accuracy requirements for atmospheric composition measurements across economic sectors, and temporal and spatial scales
- ❒ State of play in integrated approaches for advanced GHG emission estimates and the way forward to operational services
- ❒ Novel GHG concentration and flux methods and sensors
- ❒ Strengthening the linkage of remote sensing GHG concentration measurements to emission fluxes

- 1078 registered participants
- 145 draft recommendations
  - 99 for Theme 1
  - 46 for Theme 2

→ Many opportunities for future WMO-BIPM collaboration

- Participants' comments on draft recommendations finished on 4. Nov.
- Additional work will be required by the Steering Committee to harmonize the style of the recommendations
- Some topics are recurring across the various sub-themes
  - Vocabulary
  - …

Some areas for future work/collaboration

based on draft recommendations of Workshop on Metrology for Climate Action

- Vocabulary related to metrology
  - Critical for increased collaboration
  - This topic was already identified at time of 2010 BIPM-WMO workshop, and now reiterated by most topic areas.
  - WMO INFCOM-2 (Oct. 2022) agreed on the need to develop a WMO standard vocabulary
    - Respecting other internationally recognized vocabularies (such as the VIM)
  - Strong collaboration between experts of BIPM/NMIs and WMO will be needed
- Training material on metrological principles
  - WMO INFCOM has a team working on this, contribution from more metrology experts would be welcome.
- Development of guidance material for traceability of new Essential Climate Variables (ECVs) products
- Update of WMO guidance material reflecting new and innovative measurement methods

Some areas for future work/collaboration

based on draft recommendations of Workshop on Metrology for Climate Action

- Developing uncertainty methods relating in-situ and space measurements.
  - Disagreement between satellite and in-situ measurements are frequently not understood (even for well metrologically characterized measurements)
- Characterization of impact of siting on measurement uncertainty budget
  - Significant, if not major, part of the uncertainty budget comes from the siting rather than measurement method and
- Implementation of tiered network concept (GSRN, BSRN, GAW,…)
- Traceability of water vapor measurements (radiosonde intercomparisons)
- Traceability of ozone concentration

WMO OMM

Some areas for future work/collaboration

based on draft recommendations of Workshop on Metrology for Climate Action

- Greenhouse Gas Initiative
  - Expansion of network (including for lower tiers)
  - Continue collaboration between WMO and BIPM/NMIs on GAW
  - IG3IS
  - Advance understanding of bias and uncertainties in GHG observations and data
- Replacement of radiation scales (WRR, WISG) by SI-traceable reference (Tentatively around 2027)
- Replacement of total column ozone and aerosol optical depth relative measurements to SI-traceable measurements
- Improve traceability of Earth Observation data used by WMO
  - While a significant fraction of in-situ and ground-based measurement networks could provide fully traceable data (e.g. datum, U95, coverage factor), uncertainty information in generally not shared with the measurements.
- WMO expresses strong support to SI-Traceable Satellites, such as TRUTHS and CLARREO

Final remarks

- How to engage in WMO Expert Teams (ETs):
  - WMO expert teams are usually established for a 4-year duration.
  - Call for experts usually takes place before ETs are established.
  - BIPM Secretariat can nominate experts to take part in / contribute to work of ETs.
  - Nominations are reviewed by ET Chairs and relevant higher body leadership.

WMO OMM


World Meteorological Organization
7bis, avenue de la Paix
CH-1211 Geneva 2
Switzerland
Thank you !
Merci !

WMO OMM