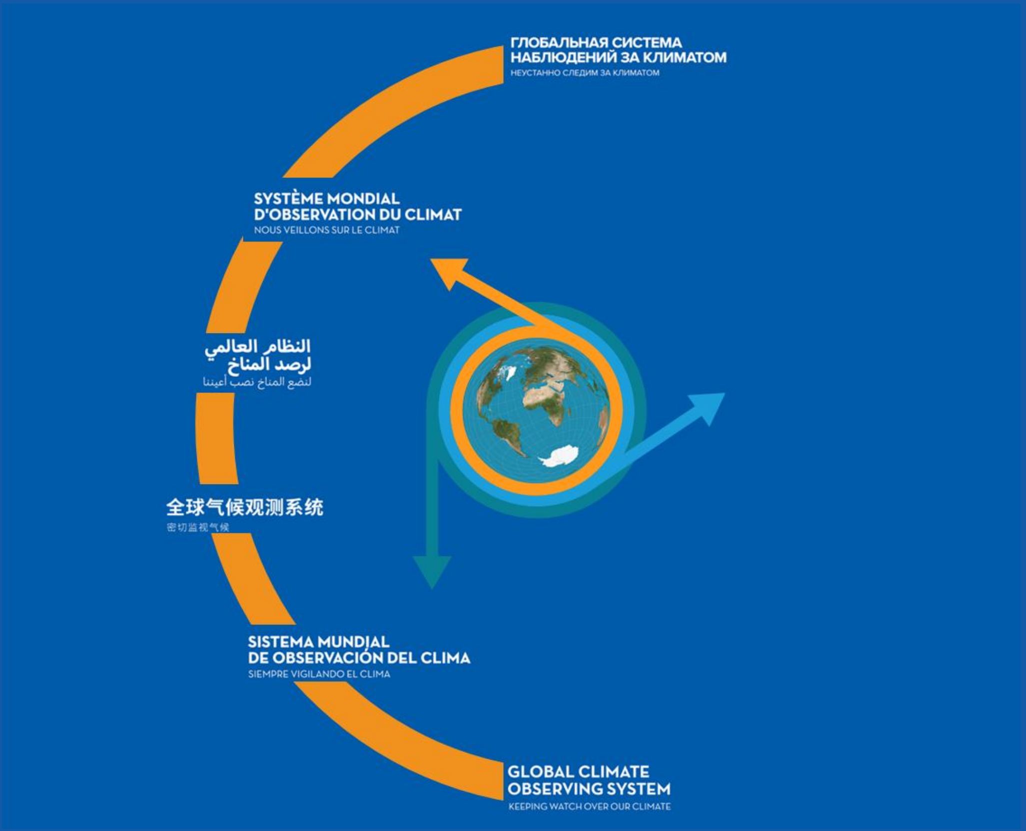


Keeping Watch Over Our Climate: New Recommendations From The Global Climate Observing System

Han Dolman

Chair GCOS Steering Committee

Royal Netherlands Institute for Sea Research and Free University Amsterdam

Thanks to the GCOS secretariat at WMO, Geneva

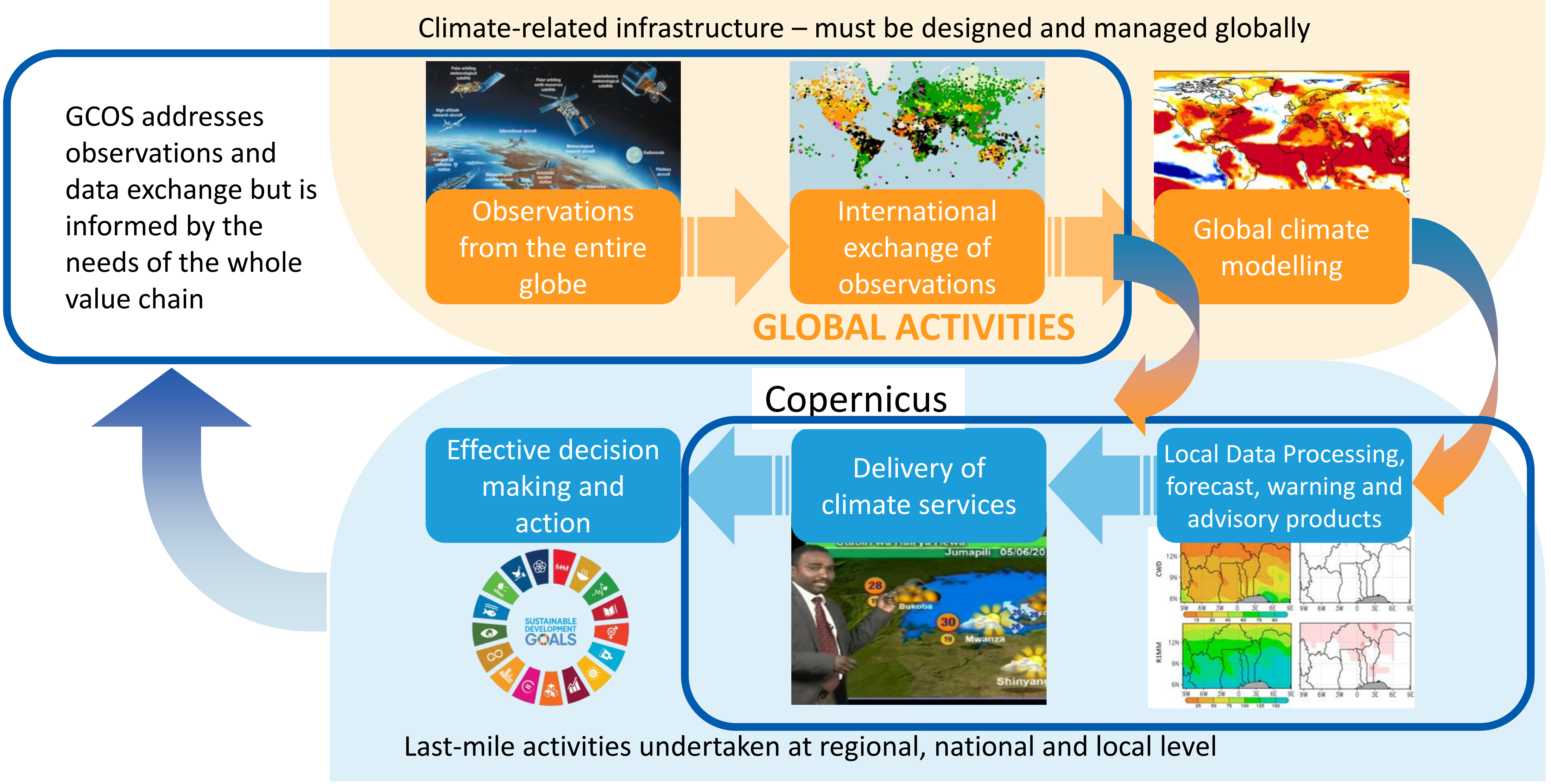
GLOBAL CLIMATE OBSERVING SYSTEM
KEEPING WATCH OVER OUR CLIMATE

WMO IOC International Science Council UN environment

Supported by the European Union

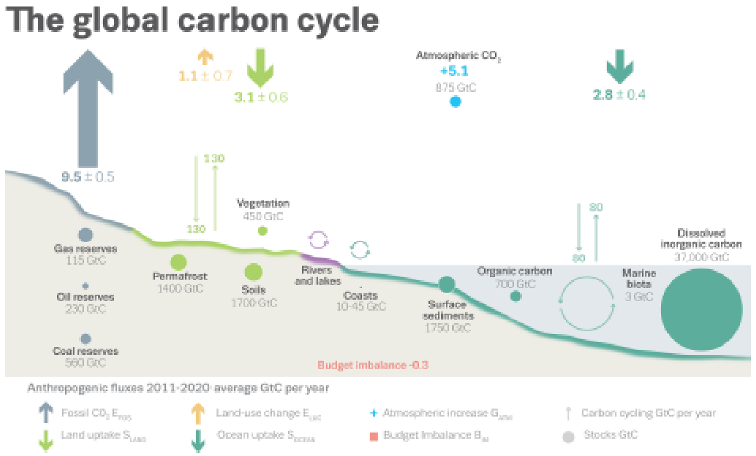
Copernicus Europe's eyes on Earth

Successful delivery and use of climate services depends on all elements in the value chain working properly



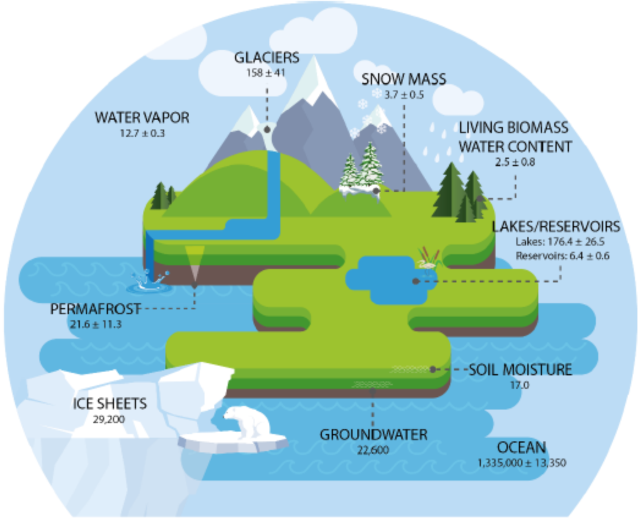
Demand for climate information and its impact is changing

Photograph: Rehan Khan/EPA, Guardian 9-9-22

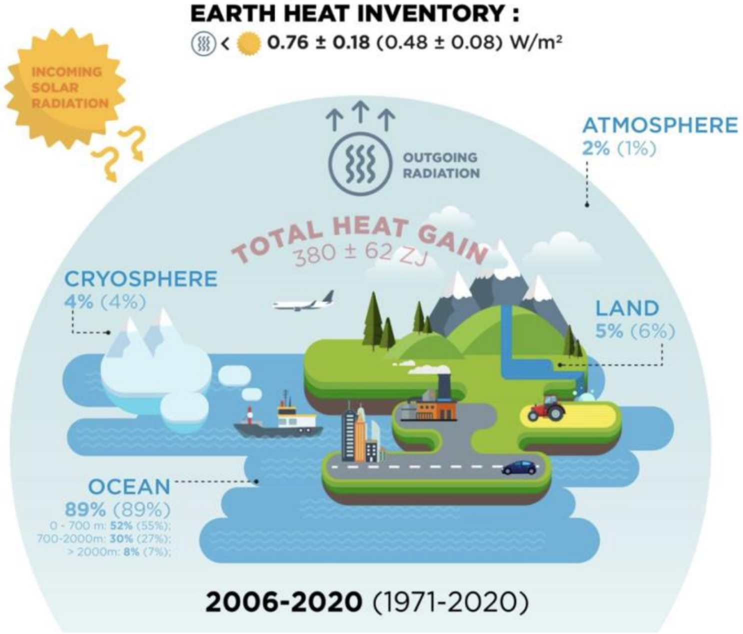


Earth Energy, Carbon and Water Cycles

Mitigation



GLOBAL WATER STORAGES

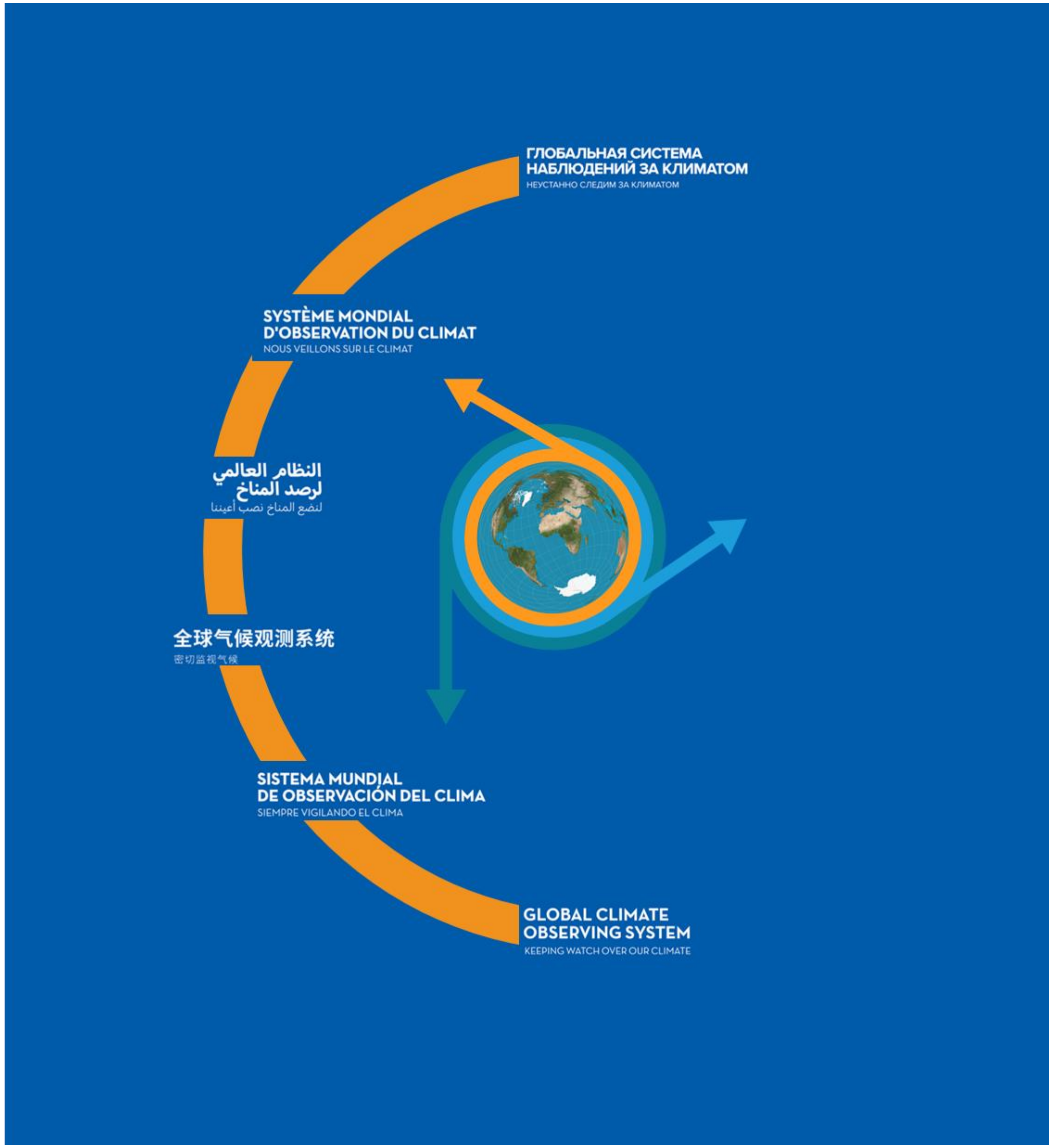


Adaptation

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

- The GCOS 2021 Status Report
- The UNFCCC Paris Agreement
- Implications of the IPCC 6th Assessment Report and Special Reports
- Scientific studies of the climate cycles of carbon, water and energy

Broad Engagement

- Consultations with observing community
- Drafting by GCOS
- Public Review

Themes for Action

- **Ensuring Sustainability**
  Addressing in situ and satellite observations that are currently at risk.
- **Filling Data Gaps**
  Observations are consistently deficient in parts of Africa, South America, Southeast Asia, the deep oceans and polar regions.
- **Improving data quality, availability and utility, including reprocessing**
  Improvements in transforming observations into user-relevant information
- **Managing Data**
  Ensuring data is well-curated, discoverable, open and freely available and permanently archived
- **Engaging with Countries**
  Coordinating national efforts with global systems and support, understanding national needs.
- **Other Emerging Needs**
  Some new needs can already be identified and adressed (e.g. for adaptation and mitigation)

Main Inputs → Broad Engagement → Themes for Action

Themes and issues in the IP2022

A: ENSURING SUSTAINABILITY

- Ensure long-term support for in situ networks
- Address gaps is satellite observations likely to occur in near future – prepare follow-on plans

B: FILLING DATA GAPS

- Development of reference networks: in situ and satellite
- Implement GBON
- Global reporting of hydrological observations,
- Implement trace gas and aerosol, ocean biological, biogeochemical, CO_2 and N_2O observations
- Improve estimates of latent and sensible heat fluxes and wind

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

- Develop standards and best practices
- Improvements to satellite and in situ products
- New and improved reanalysis products

D: MANAGING DATA

- Define governance and requirements of data centre
- Ensure in situ data centres exist for all ECV
- Improve discovery and access
- Data rescue

E: ENGAGING WITH COUNTRIES

- Improve regional and national engagement in GCOS
- Enhance support for national climate observations

F: OTHER EMERGING NEEDS

- Higher resolution real time data
- Improvements in urban, polar, coastal regions and EEZ
- Develop operational Global GHG Monitoring System

Key issues

- **Sustained, long-term funding.** The provision of many observations still supported through limited-term funding, and the climate observing system remains fragile, particularly in the ocean

- **Addressing the key gaps in observations**. Addressing areas where observations are consistently deficient, most notably parts of **Africa, South America, Southeast Asia, in the deep ocean and polar regions**

- **The improvement of data quality, availability, accessibility and utility**. Many climate observations are underexploited because of the lack of consistency, and clarity, in their processing, interoperability and usability. Increased effort is required to ensure that the data can be readily used in reanalysis and are fit for purpose..

- **The creation and maintenance of climate data repositories.** Climate data must be made available through global data repositories, and their access must be free and unrestricted.

Key issues

- **Addressing the emerging needs.** GHG observing system

- **The engagement with nations.**

- **The improvement of regional and national climate change information.** Improved understanding of the local decision-making context and associated observational requirements, will help address the gap between the “top-down”, global, production of observations and climate information, and the "bottom-up" local-scale decision making.

- **Integrated and collocated observations** of the physical, chemical, and biological components of the climate system

- The conference participants called for the establishment of **a global goal on observations under the UNFCCC.** This should guide the much needed **“action-oriented framework for observation"** **.**

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

WMO State of the Global Climate 2022

Earth Information Day, COP27
9 November 2022

WMO OMM
World Meteorological Organization
Organisation météorologique mondiale

WMO State of the Global Climate

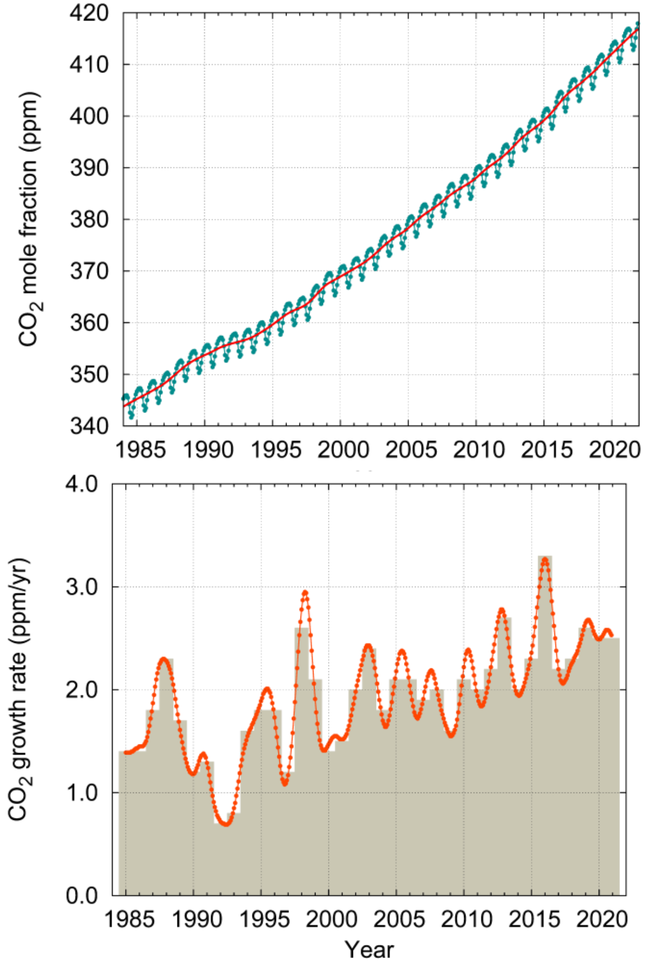
30th State of the Global Climate report

77 WMO Members contributed

50 Scientific experts From 38 institutions

20 experts from 7 UN agencies

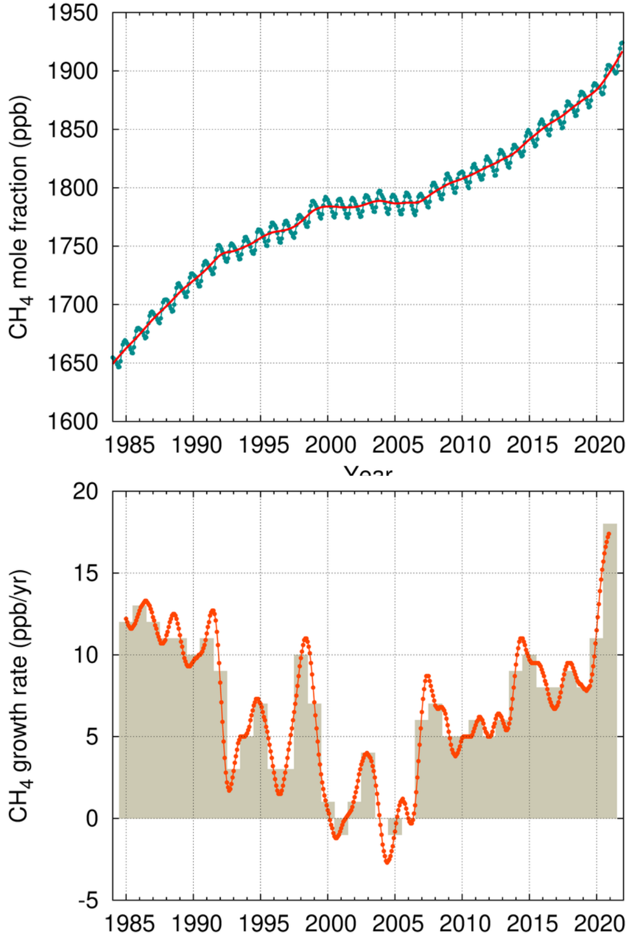
New record levels of greenhouse gases. Methane annual increase highest on record



Carbon Dioxide

415.7 ± 0.2 ppm

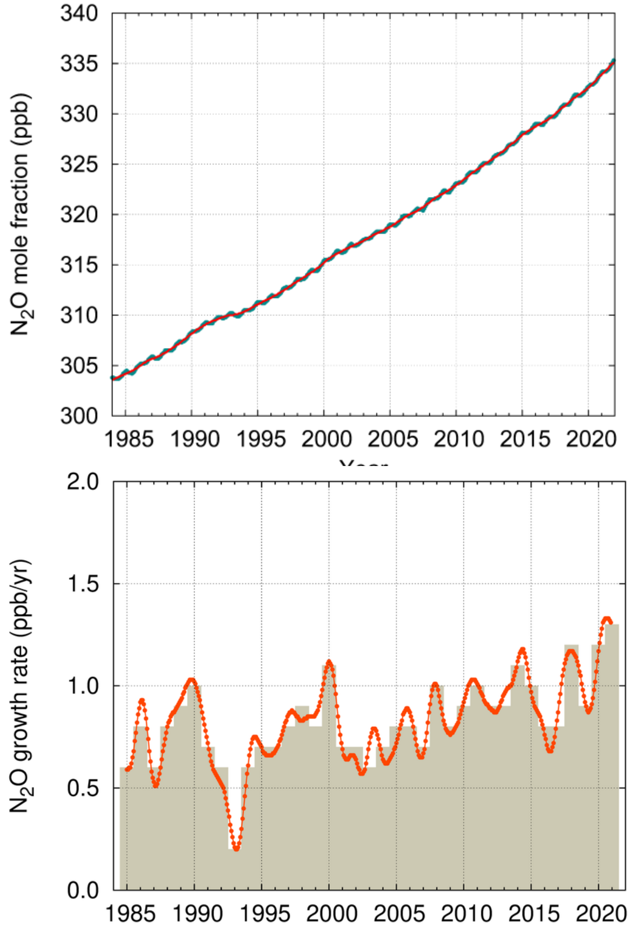
149% of preindustrial



Methane

1908 ± 2 ppb

262% of preindustrial



Nitrous Oxide

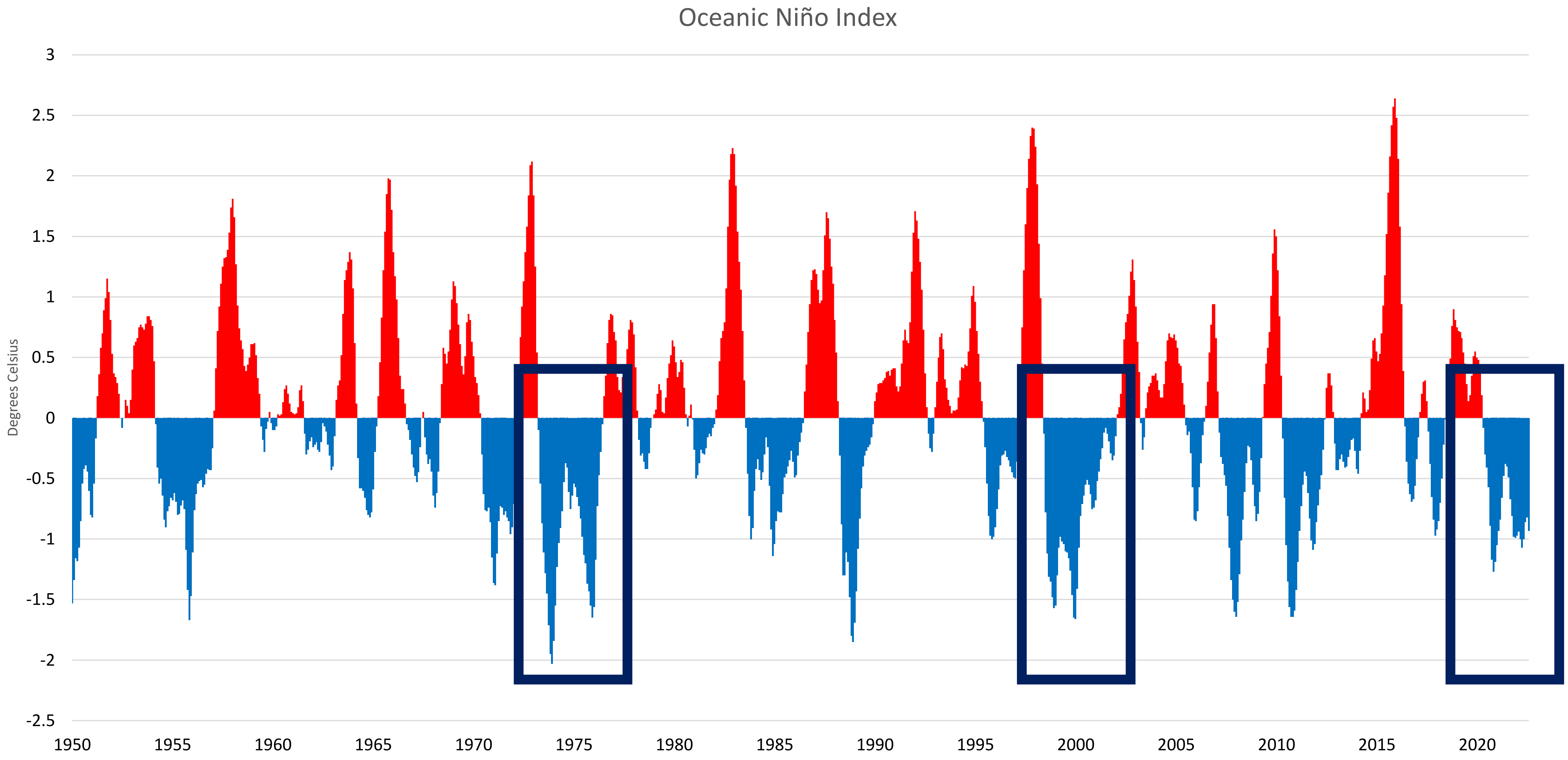
334.5 ± 0.1 ppb

124% of preindustrial

The year 1750 is used for pre-industrial concentrations

WMO GAW

Triple-dip La Niña – only 3rd time in 50 years



NOAA National Centers for Environmental Information

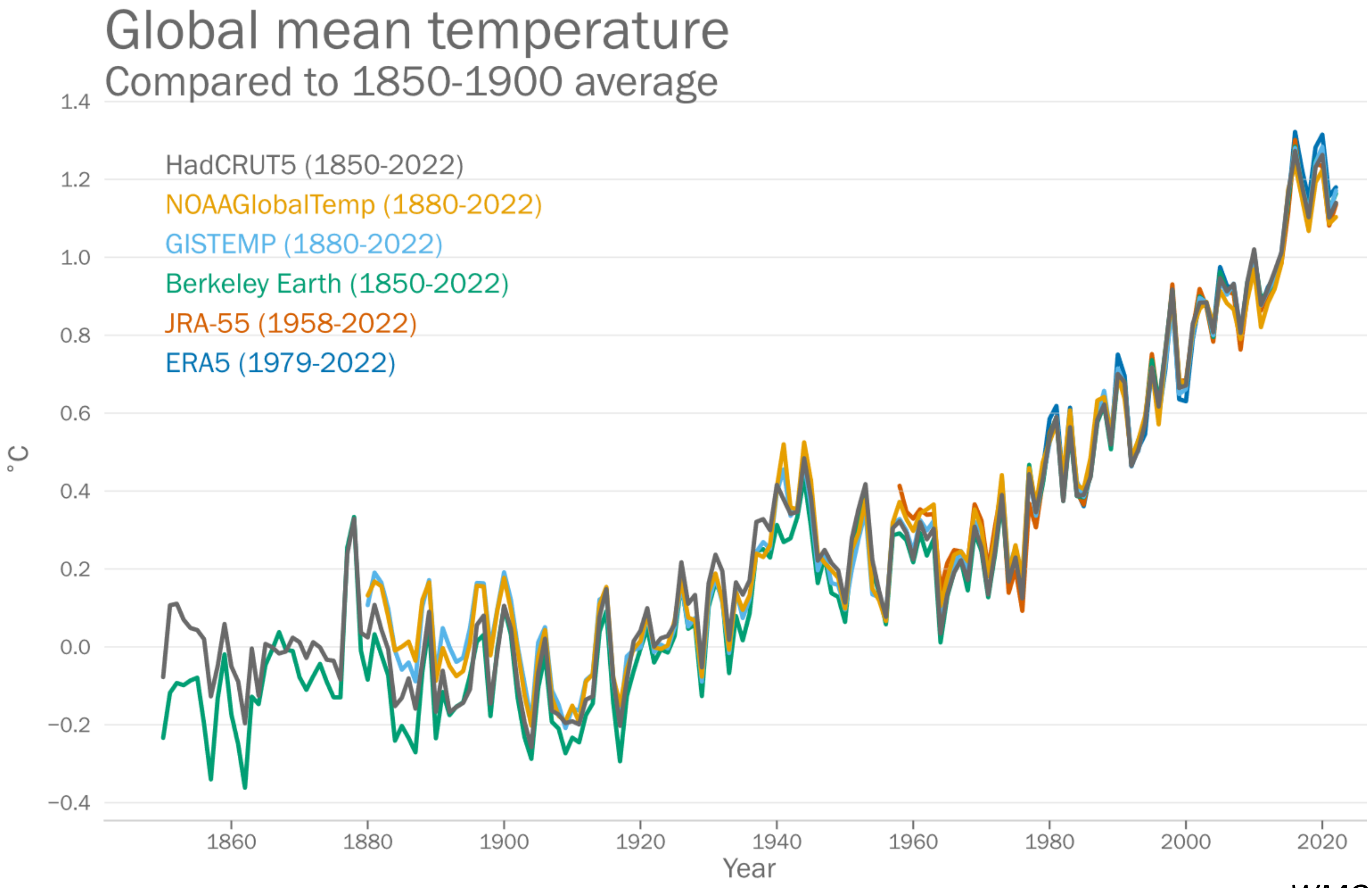
Past eight years (2015-2022) set to be eight warmest years on record

2022 based on data to September from 6 data sets

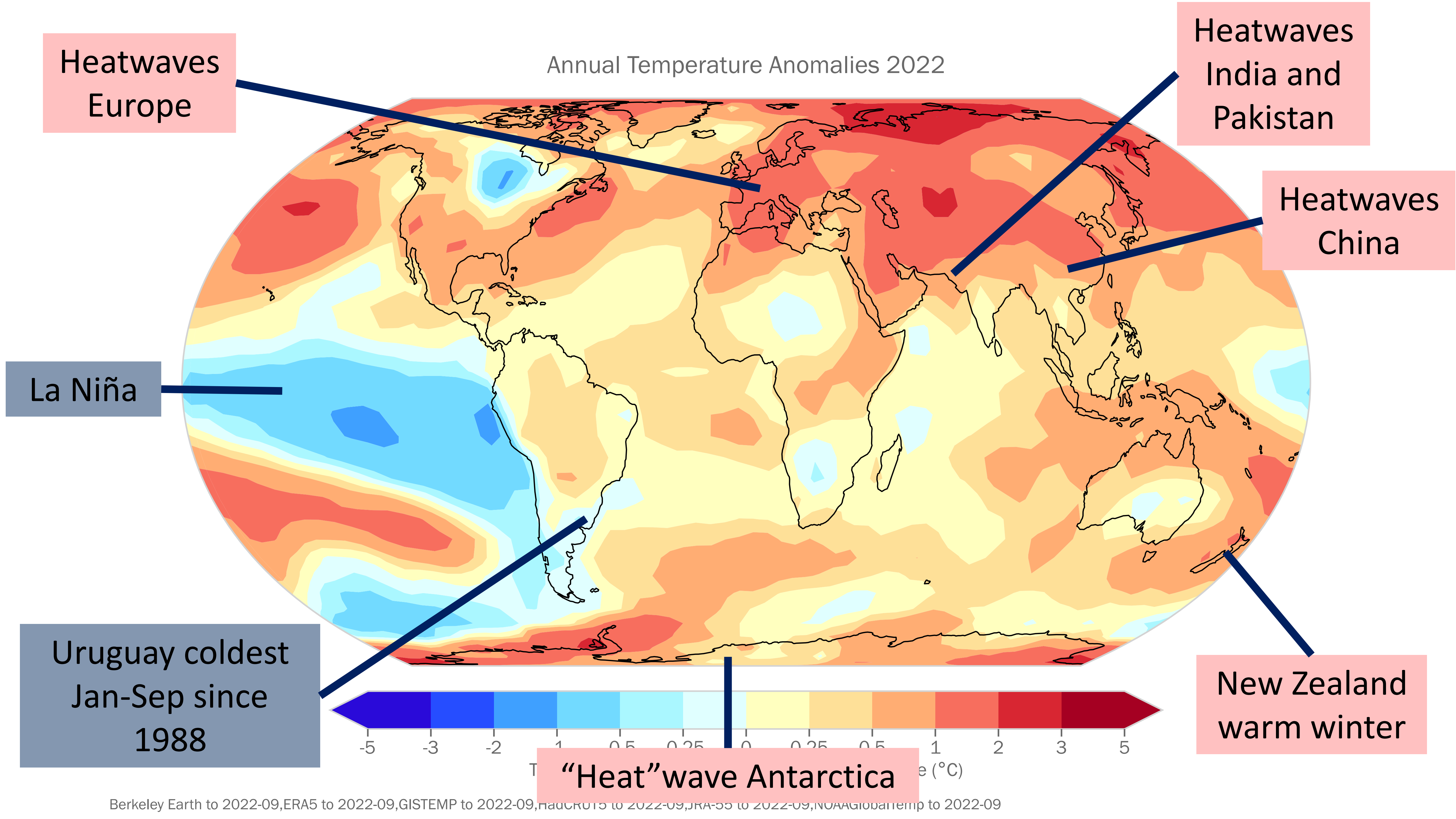
2022 most likely 5th or 6th warmest at this point despite ongoing La Niña

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

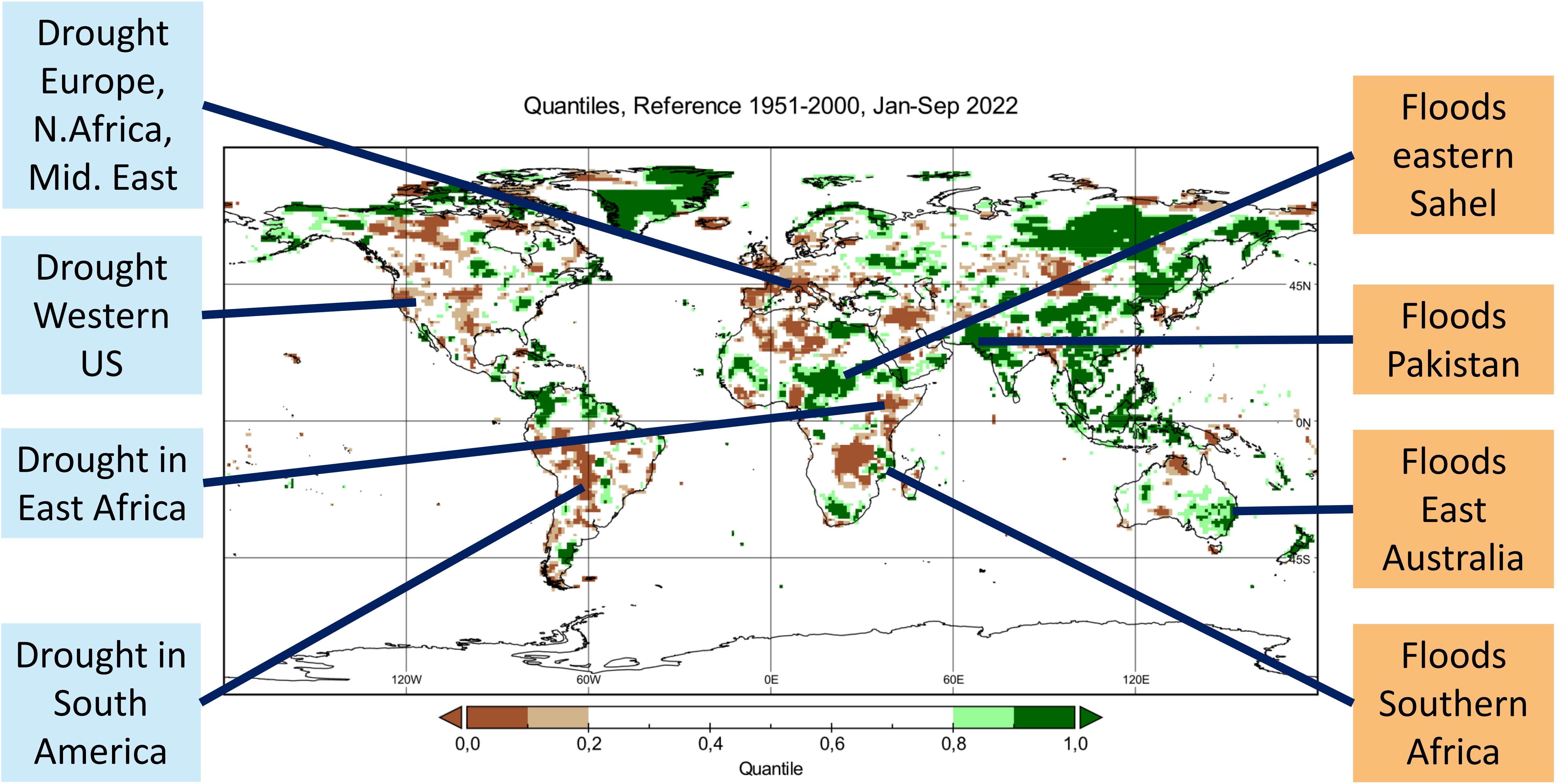
10-year average 2013-2022 1.14 [1.02 to 1.27] °C



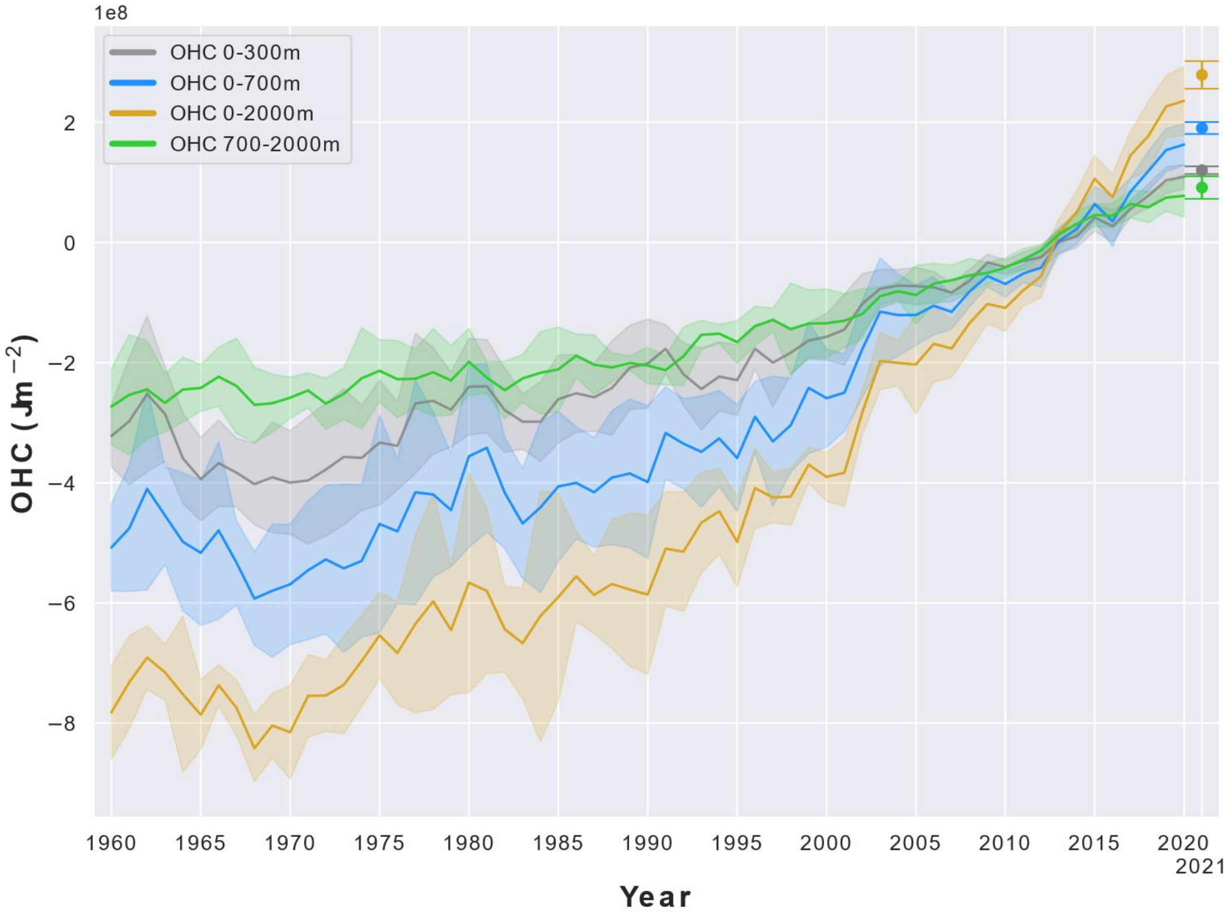
WMO

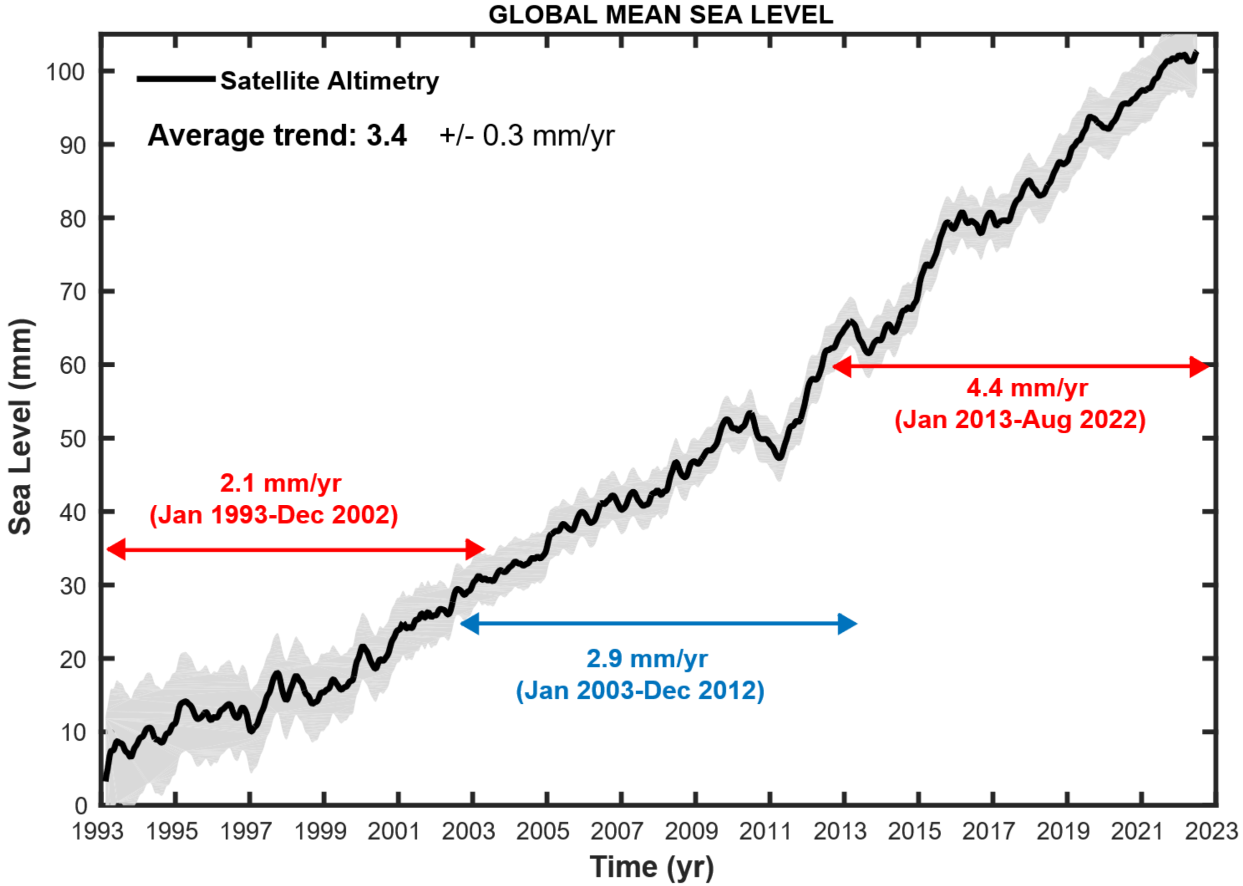


Annual Temperature Anomalies 2022
Heatwaves Europe
Heatwaves India and Pakistan
Heatwaves China
La Niña
Uruguay coldest Jan-Sep since 1988
“Heat”wave Antarctica
New Zealand warm winter
-5
-3
-2
0
1
2
3
5
Berkeley Earth to 2022-09,ERA5 to 2022-09,GISTEMP to 2022-09,



Global Precipitation Climatology Centre GPCC, DWD





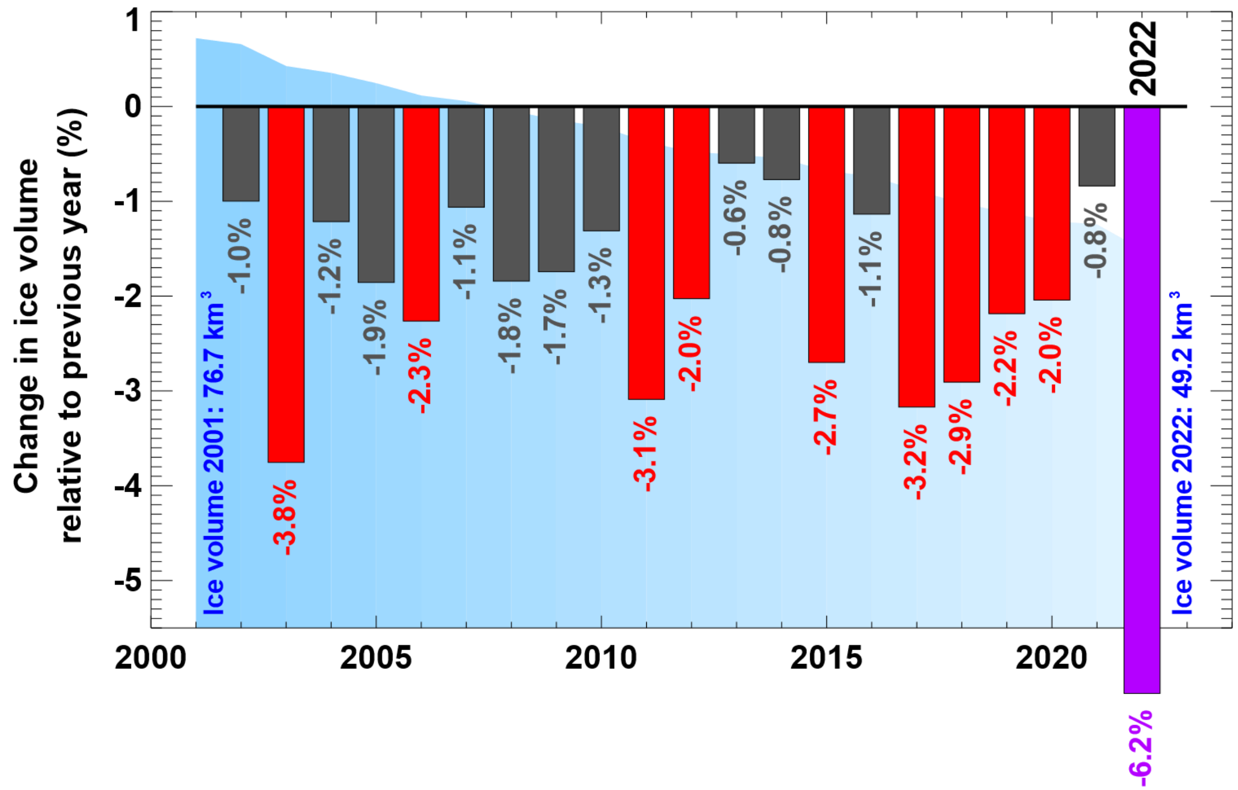
Around 90% of the energy trapped in the Earth system by greenhouse gases goes into the ocean, heating them and raising sea level

Ocean heat content reached record high in 2021 (no data for 2022 yet).
Sea level reached new record high in 2022

Mercator Ocean International

LEGOS CNES and OMP

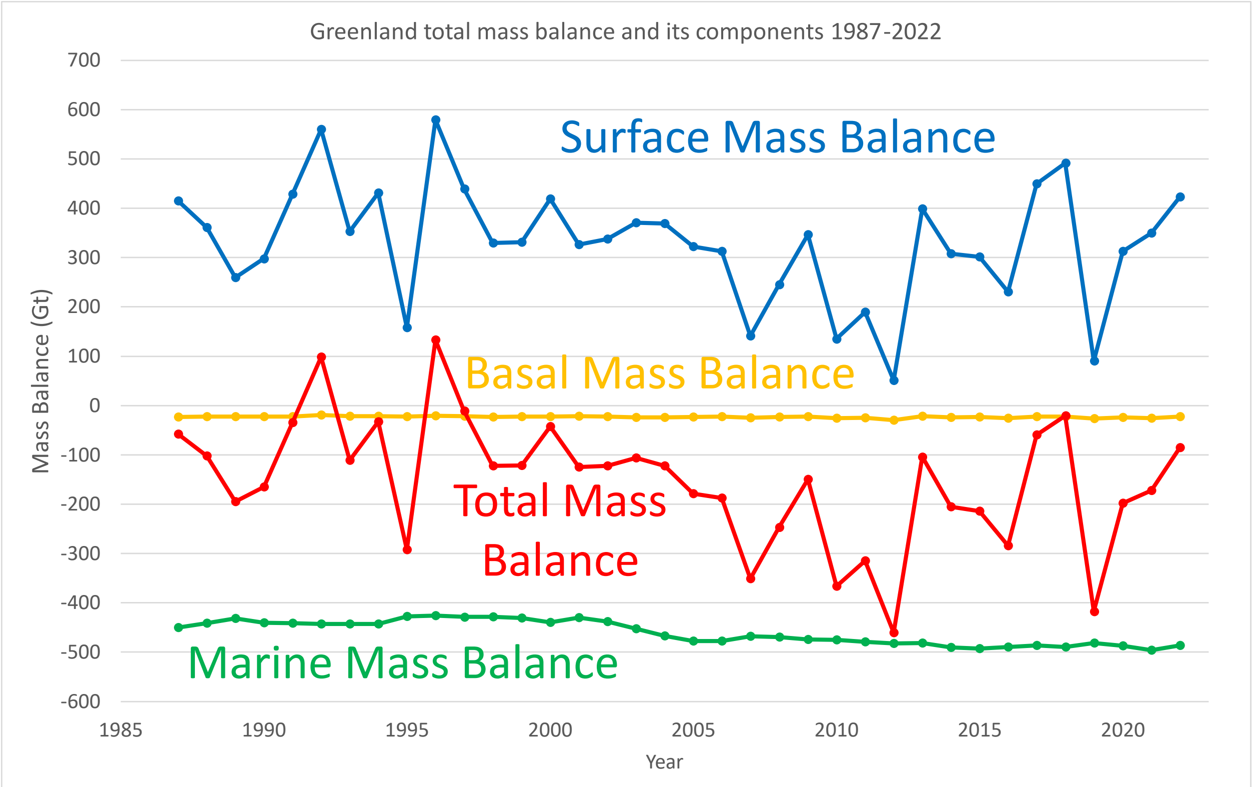
Percentage change in glacier ice volume in Switzerland



Between 2021 and 2022 around 6% of the ice was lost, the largest single year loss on record

Since 2001, in Switzerland over a third of glacier ice has been lost

ETH Zurich

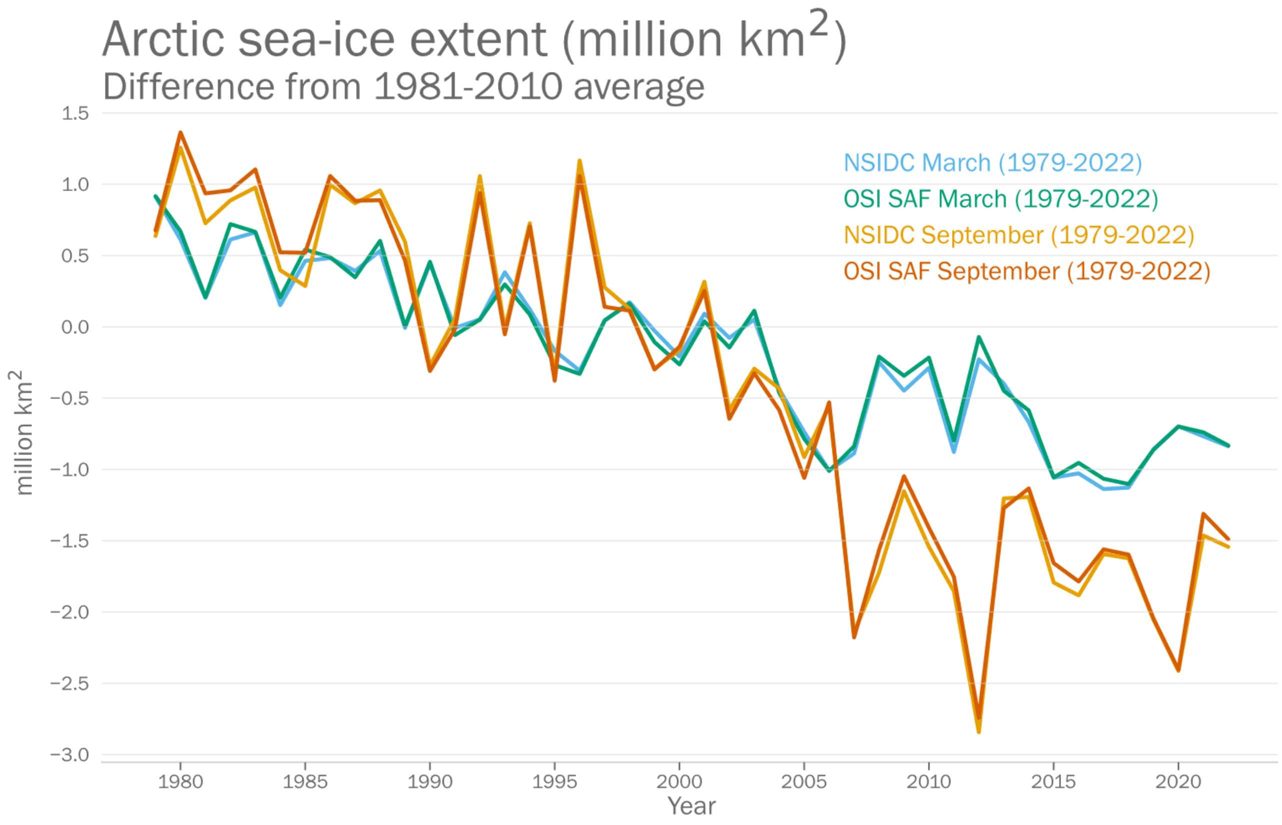


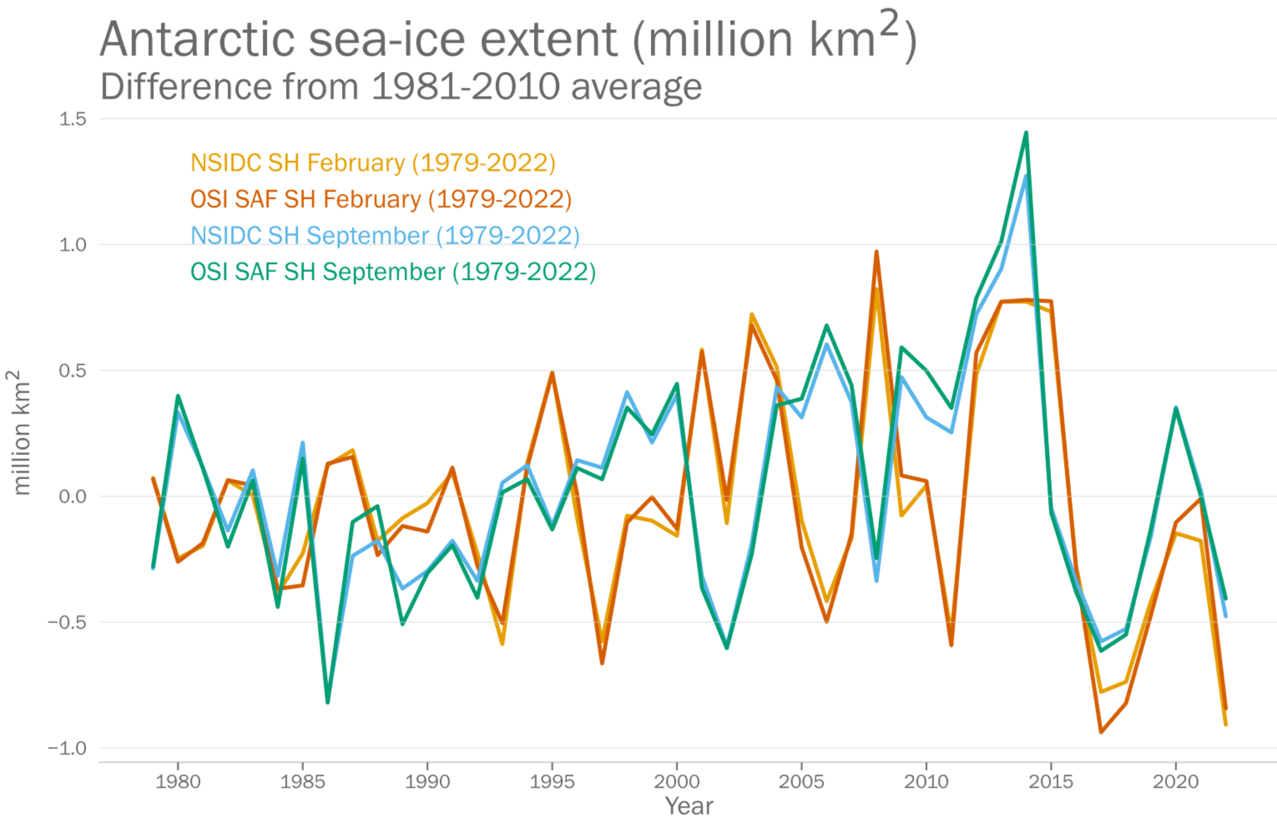
26th consecutive year of negative mass balance

Summer was relatively cool compared with recent years.

September was unusually warm. Warmest September on record at the Summit station

DMI





September sea-ice extent 11th lowest on record

September monthly minimum was above the average for the last decade

Past decade has seen record high extents and record low extents

Ice extent dropped to 1.92 million km^2 on February 25, 2022, the lowest extent on record

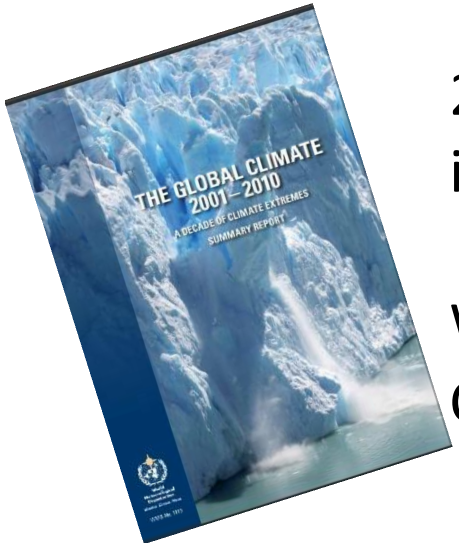
Norwegian Meteorological Institute, British Antarctic Survey, WMO

Annual global

Final report launch Mar-Apr 2023

Key indicators, high-impact events, and risks and impacts in partnership with other UN agencies.

Decadal global



2011-2020 report in preparation

Will be released at COP28 in 2023

Annual regional

Europe 2021 was released 2 Nov

Asia 2021 will be released 14 Nov

Southwest Pacific 2021 will be released 17 Nov

For information : https://public.wmo.int/en/our-mandate/climate/wmo-statement-state-of-global-climate

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

For more information on the WMO State of the Clima

https://public.wmo.int/en/our-mandate/climate/wmo
state-of-global-climate

Thank you
Merci

Greenhouse gases and the Paris Agreement

Problem Statement

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

Paris Agreement approved in 2015, aiming to hold increase in global mean temperature well below 2.0° C (preferably 1.5°), via reduction of GHG emissions;

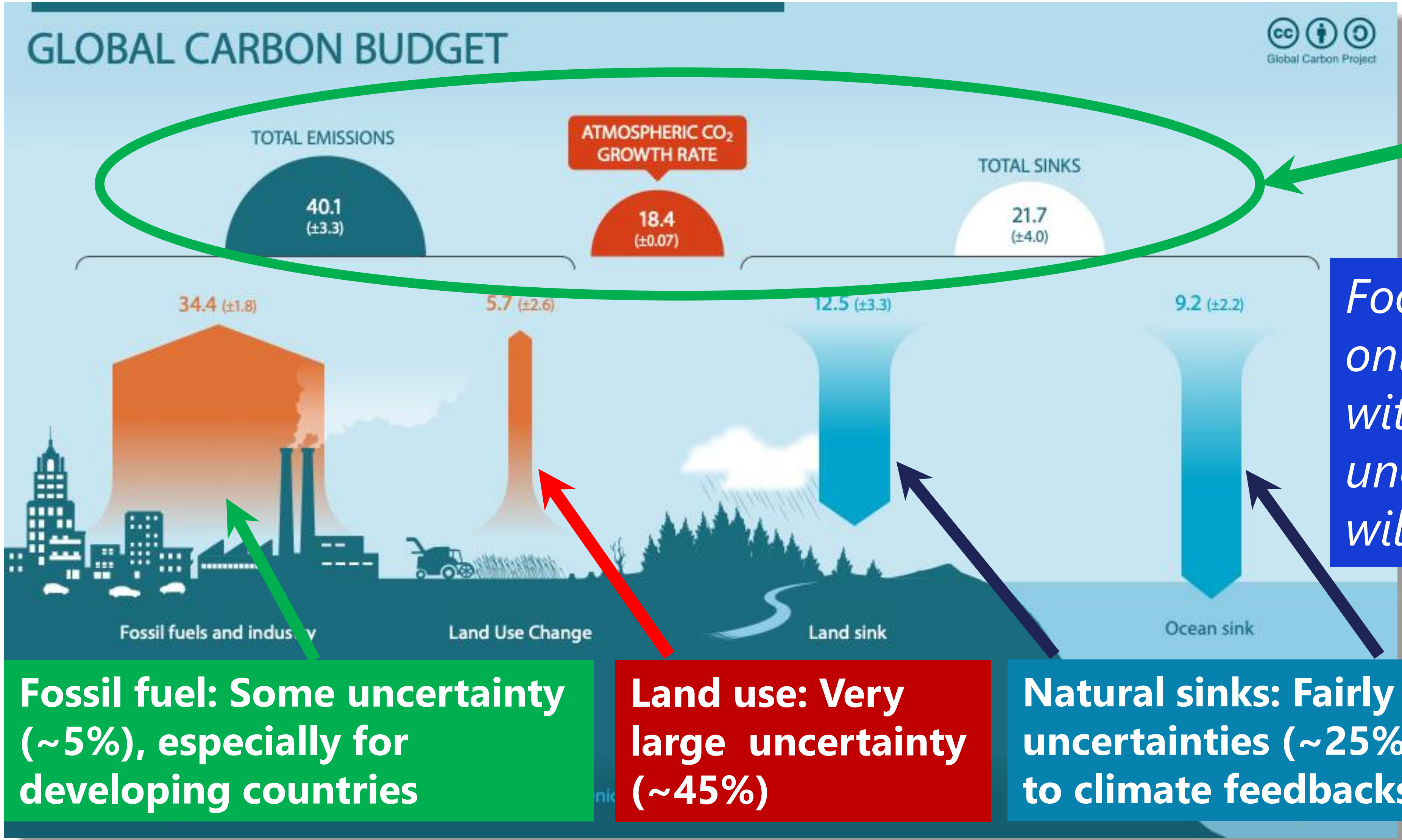
This is not a simple and straightforward proposition!

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.

How well do we understand the CO_2 budget ?

(Graphic from Canadell, WMO GHG Monitoring Workshop, May 2022);



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

In collaboration with a broad group of greenhouse gas monitoring stakeholders, WMO is developing a framework for a …

Multi-model, coordinated system providing time-continuous delivery of consolidated, top-down, monthly estimates of net GHG fluxes at a global 100 by 100 km resolution, resolution to provide authoritative and timely input to the

- Global Stocktake;
- Work programme for urgently scaling up mitigation ambition and implementation;
- IPCC Assessment Reports;
- National Inventories and NDCs;
- Other user applications, including sub-national mitigation services

WMO Side Event on coordinated Greenhouse Gas Monitoring in the Science Pavilion (P20)
Friday November 11 15_15-16:30

In order to deliver credible, authoritative and verifiable information to Parties, greenhouse gas monitoring must be open to all interested contributors and be based on open access to input and output data and published algorithms.

Further enhancing and understanding of the Earth climate cycles and observation gaps

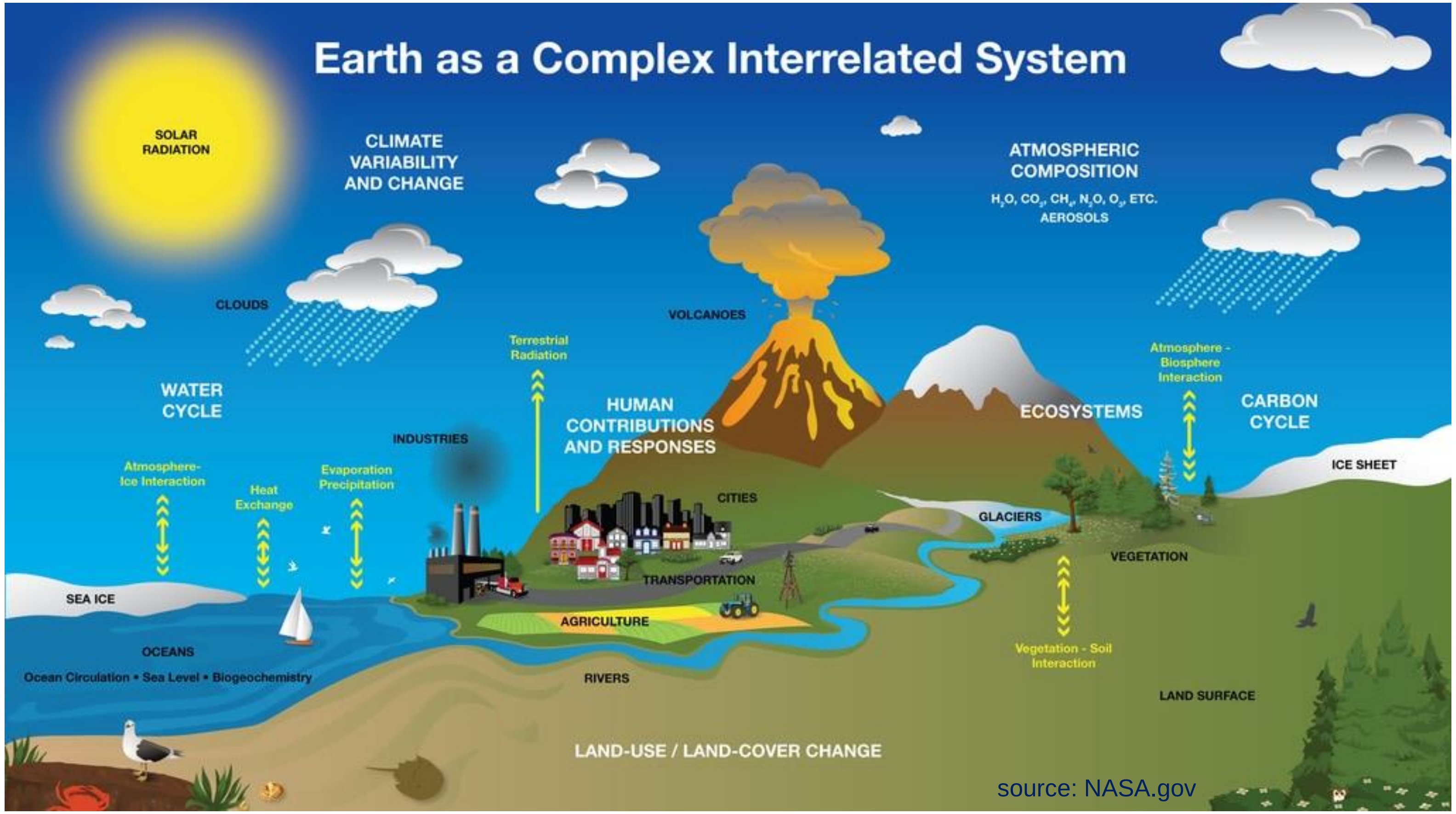
Karina von Schuckmann

Mercator Ocean international, France

COP27, UNFCCC Earth Information Day 2022

Understanding, monitoring and predicting Earth system cycles ultimately relies on observations

EXPLAINER

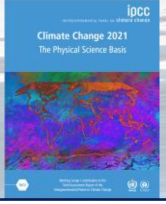


source: NASA.gov

Earth system cycles …

- **sustain life** on Earth through the transfer, exchange & storage of heat, water, carbon, … **across all domains** - the atmosphere, ocean, land, cryosphere and biosphere.
- interactions are triggered and altered by **natural variations** of the climate system to maintain and balance the **life-sustaining** natural **rhythm** of the Earth system cycles.

Systematic climate observations across all domains are the **foundation for monitoring, understanding and predicting** Earth cycles natural rhythm, their underlying processes, and future evolutions are needed to close knowledge gaps.

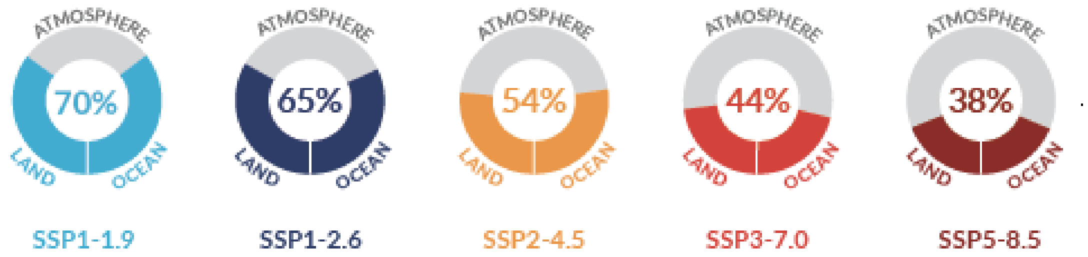


Long-term pressure from climate change affects the natural rhythm of all cycles across all domains.

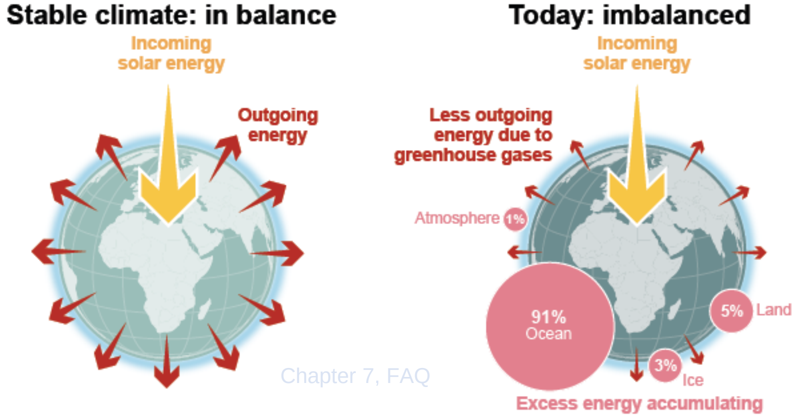
EXPLAINER

Carbon & nitrogen cycles: Human activity has caused an accumulation of well-mixed GHG (CO_2: 47%, CH_4: 156%, N_2O: 23 %)*, lowering land & ocean sink dynamics

* above pre-industrial (1750) levels



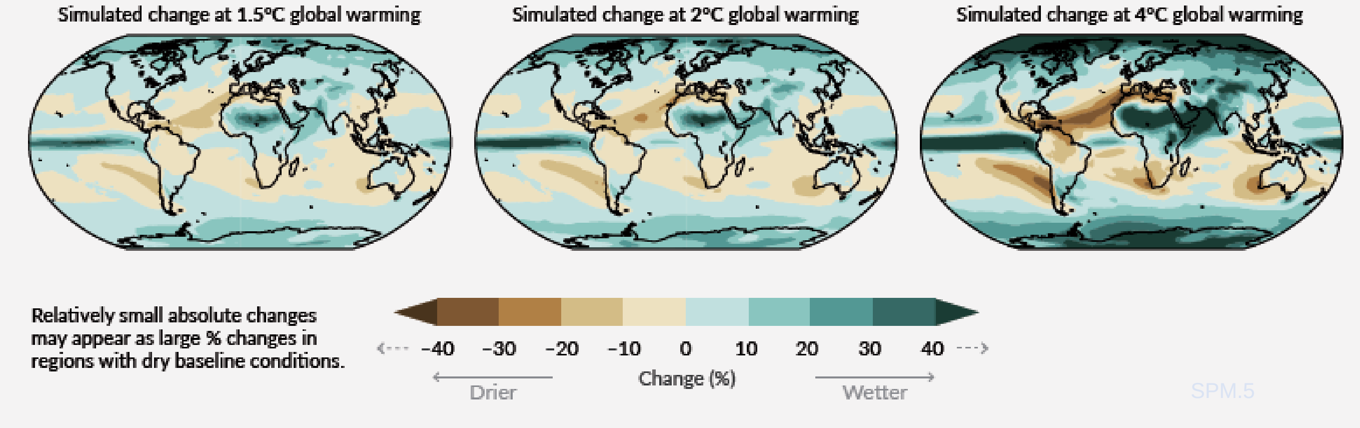
SPM.7



Chapter 7, FAQ

Energy Cycle: Human activity has caused an imbalance of the natural energy flows, leading to an accumulation of surplus heat warming all domains: Ocean, Atmosphere, Land, Cryosphere

Water Cycle: Human activity has caused an intensification of the water cycle & is projected to further intensify, including its variability, global monsoon precipitation and the severity of wet and dry events



SPM.5

With increasing warming, feedbacks between climate change & the cycles become larger, intensifying related impacts & their severity

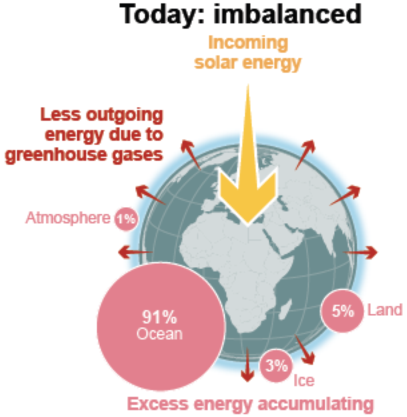
RECOMMENDATION

EXAMPLE: THE OCEAN HEAT-CARBON NEXUS

Carbon sinks set the airborne fraction, which **sets radiative forcing** that drives the additional heat in the atmosphere

The **ocean** sets the **thermal response** through ocean heat uptake

Feedback: ocean warming **weakens** the ocean **sink**, which **increases** the airborne fraction, and hence the **radiative forcing**

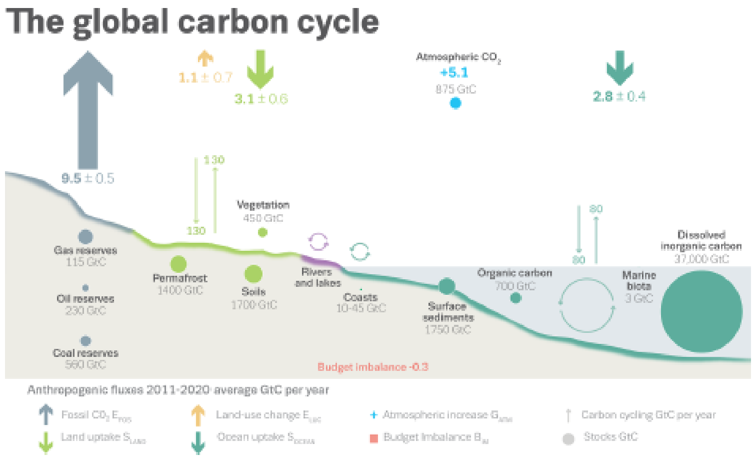


Precise **understanding, monitoring** and **predicting** Earth's climate can only be achieved through a **comprehensive view of the Earth system cycles** and underlying processes of transfer, exchange and storage **across all components**, and related **feedbacks** with climate change **across all time scales**. ➔ **GCOS IP**

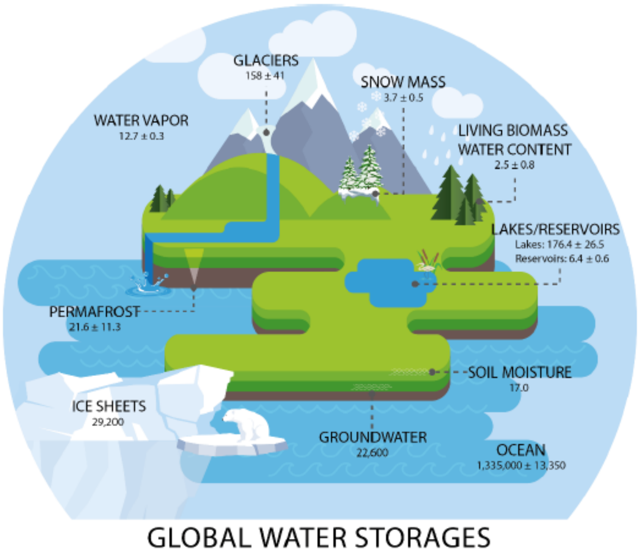
From science to policy: supporting the climate service value chain

OUTCOME

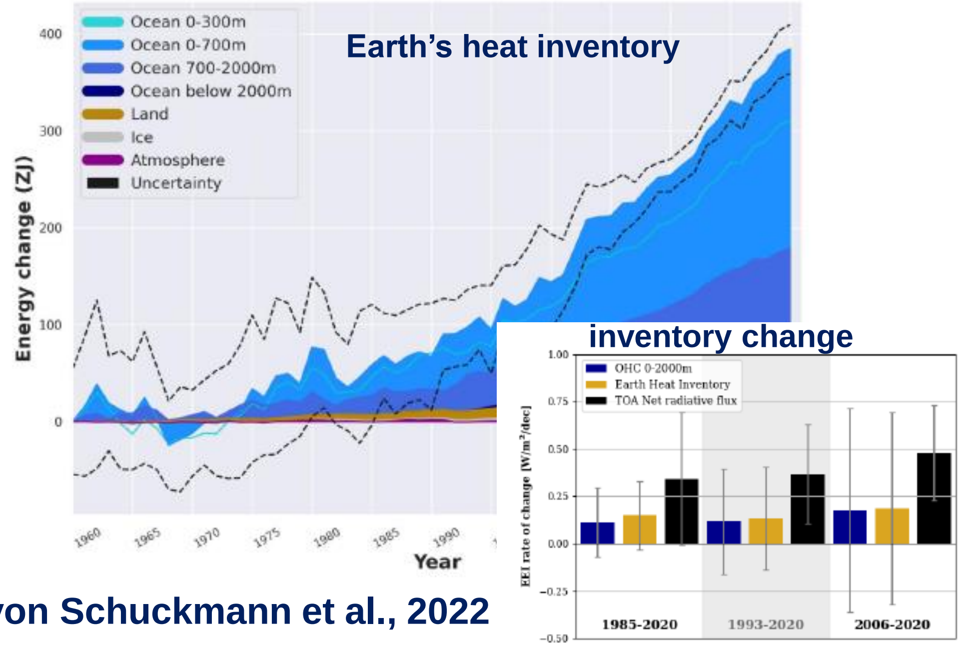
EXAMPLE: Regular knowledge updates of Earth’s cycles under GCOS & the global carbon project assessing today’s capacities



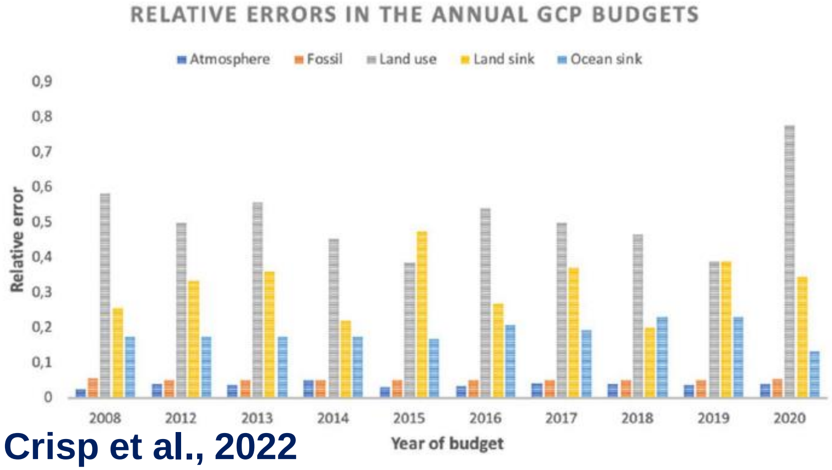
Friedlingstein et al., 2022



Dorigo et al., 2021



von Schuckmann et al., 2022



Crisp et al., 2022

To **monitor, understand and predict** the Earth system cycles & their feedbacks, **systematic** and **long-term measurements** are fundamental, and need to be **sustained** and **enhanced** in the future to support decisions on **climate change action** and **sustainable development**

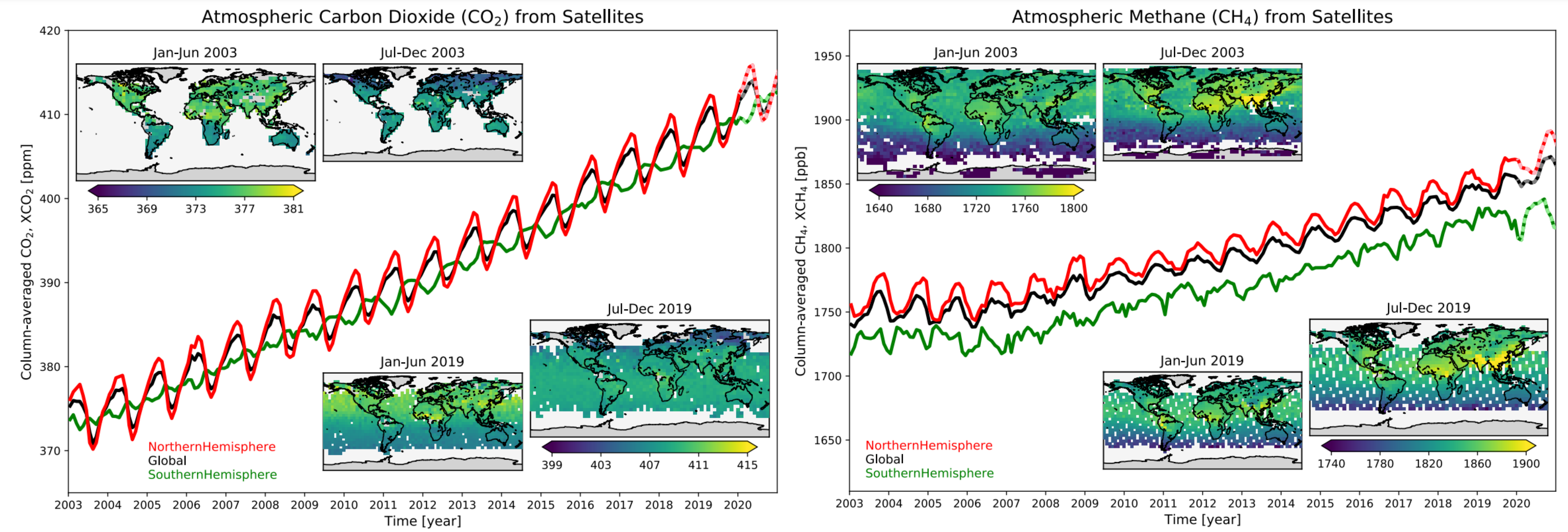
A critical element of setting out a robust climate policy regime and credible targets is ensuring the accuracy of the climate trajectory.

CONCLUSION

- The Earth's system **cycles are the most robust indicators** informing on the state and future evolution of **climate change.**
- **Recognition** that both the **natural cycle and the anthropogenic perturbation of the cycles** need to be considered together to accurately monitor, understand and predict **the climate trajectory**.
- Urgent need to **fill observational & knowledge gaps** for a better understanding of the Earth system cycles to achieve any UNFCCC & Paris Agreement **targets for net-zero**.
- Work directly with the **observing, prediction, and research communities** to maintain focus and regularly evaluate progress on responding to multilateral agreements (UNFCCC, Paris agreement) while **synthesizing** and **communicating** information about current capacities and gaps **to decision makers**
- Leverage and **improve** monitoring, understanding and prediction of related **regional change & impact** across all time scales in support of **adaptation strategies**

Climate Change

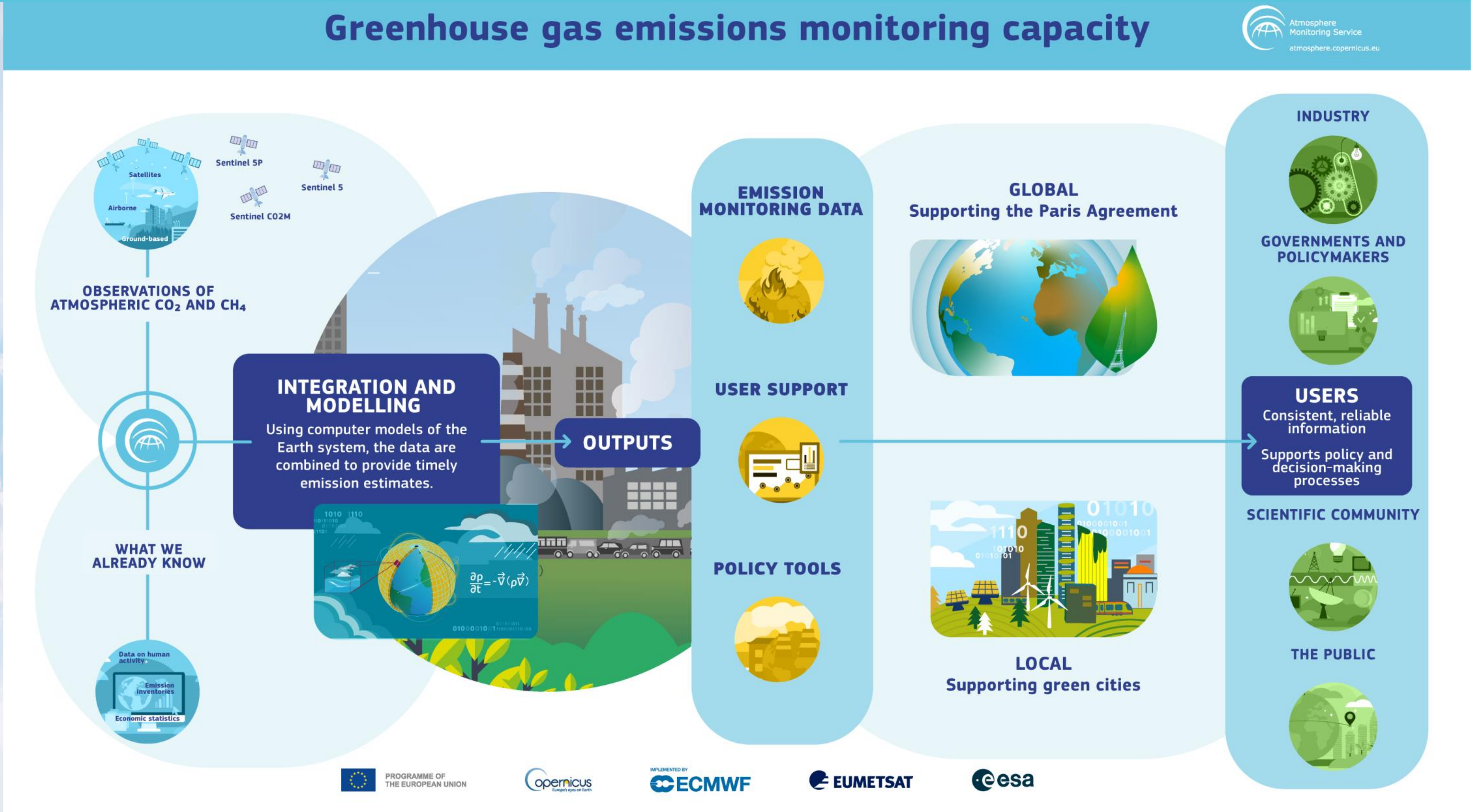
Explainer



Copernicus Europe's eyes on Earth
European Commission
ECMWF

Atmosphere Monitoring

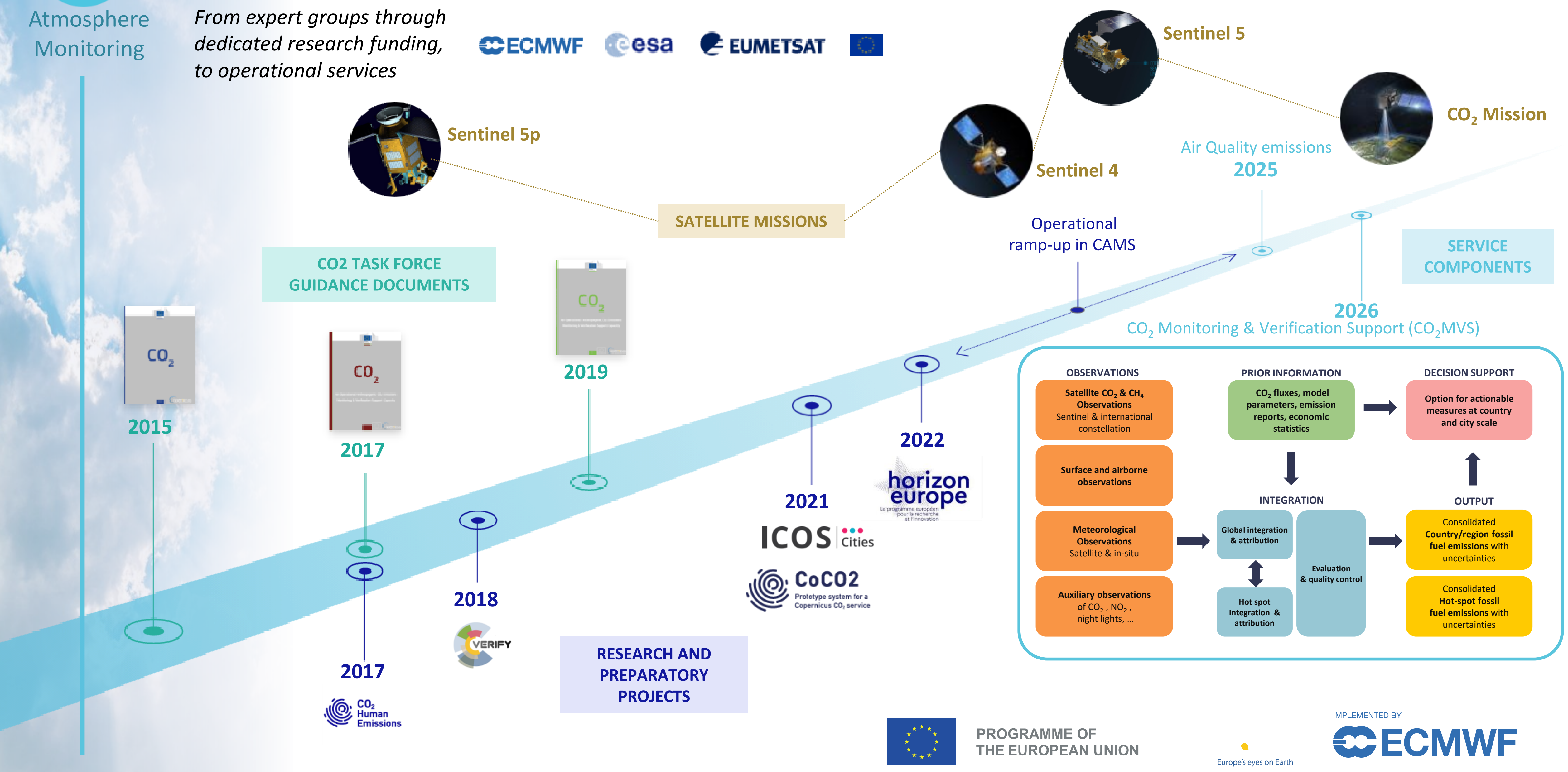
Recommendation



Timeline of CAMS Emission Services

Atmosphere Monitoring

From expert groups through dedicated research funding, to operational services



PROGRAMME OF THE EUROPEAN UNION

Europe's eyes on Earth

IMPLEMENTED BY ECMWF

Outcome

Climate Change

Climate observations are now crucial for managing the transition towards a low carbon economy with an energy mix characterised by a large fraction of renewable.

Copernicus Europe's eyes on Earth | European Commission | ECMWF

Conclusions

- Observations are key to understand the climate system and its variations; an operational deliveries of climate variables to society is now essential.
- But it is no longer simply a matter of climate monitoring, high quality climate data is now a key requirement for supporting the decarbonization of our energy mix.
- A great leap forward in our ability to monitor global carbon emissions is about to happen thanks to the combinations of models and observations.

Copernicus EU

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ECMWF

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Copernicus ECMWF

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www.copernicus.eu
climate.copernicus.eu

Climate Change

Thank you for your attention

Introduction

- National greenhouse gas inventory
  - ✓ Key component of transparency framework under the Paris Agreement
  - ✓ Emission estimates based on “activity data” and “emission factors”
    - Associated with levels of human activities, therefore useful in considering portfolios for achieving mitigation targets
  - ✓ Basis for NDC setting
  - ✓ Essential data to track progress made in implementing and achieving NDC
- Earth observations and national GHG inventory
  - ✓ National inventory compilers – close to end-users of climate services value chain (= policy makers)
  - ✓ Utilizing earth observations (particularly in the domain of atmosphere, land and biosphere) is expected to enhance inventory quality.
    - 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories
    - Expert meeting on use of atmospheric observation data in emission inventories

Atmospheric observation and GHG inventory

- Latest updates: Elaborated guidance on comparison of greenhouse gas emission estimates with atmospheric measurement in the 2019 Refinement
  - ✓ Successful examples of comparison already exist
  - ✓ However, difficulties still exist (depending on gases, sectors, regions...)
    - Issue of natural vs anthropogenic, uncertainty in inverse modelling, distribution of measurement locations, lack of skills and resources to use observed data, etc
- How can the utility of atmospheric measurements be enhanced
  - ✓ Planning future development taking account of different available techniques for different scales and purposes, and also of strengths and weaknesses of atmospheric measurements for different gases
  - ✓ Enhancing and continuing dialogue between atmospheric observation researchers and inventory compilers to e.g. improve inverse modelling
- Expected outcome
  - ✓ Better use of atmospheric measurements for verification of inventories helps more accurate quantification of effects of mitigation action, leading to better mitigation planning and implementation

TABLE 6.2 (NEW)
STRENGTHS, PROBLEMS AND PROSPECTS OF USING ATMOSPHERIC MEASUREMENTS FOR VERIFICATION OF GHG EMISSIONS

Gas	Strengths/Successes[13]	Problems/Weaknesses	Future Development/Possibilities
CO_2	Large number of observations, although historically focusing on natural fluxes.	With sparse observing networks, uncertainties of models may be significantly higher than those of national anthropogenic CO_2 emission inventories.	Need more CO_2 observations targeting anthropogenic emissions, complemented by APO and radiocarbon observations.
CO_2 city-scale	City-scale studies show some degree of success. Inventory uncertainties are relatively larger than at national scale.	Even with dense observation networks, errors in emission estimates are large, due to interference from strong vegetation fluxes. Not used in national reporting.	Large efforts are ongoing to develop observation networks, pilot projects for tracking urban emissions, trends. Radiocarbon, APO, satellite observations also expected to contribute.
CH_4	Large anthropogenic emission fraction. National reporting[14]: UK, Switzerland. National-scale emission estimates[15]: EU-28, USA, India, China and others.	Few countries have observations, transport and inverse models have uncertainties, interference from natural emissions (wetlands) cited.	Regional observation networks and satellite observations are expanding.
N_2O	National reporting: UK National-scale emission estimates: EU-28, US, and others.	Observation sites are few, gridded inventories are simplified, large contribution from natural sources.	Expansion of surface networks will contribute to better model estimates.
HFCs, SF_6	Dominant anthropogenic emission fraction. National reporting: UK, Switzerland, Australia. National-scale emission estimates: China, US, EU. Revised EFs: Australia, UK.	Measurements are sophisticated and expensive. Observation sites are few, gridded inventories are simplified.	Expanding the monitoring network depends on funding.

Land/biosphere observation and GHG inventory

- **Latest updates: Elaborated guidance on use of remote sensing data for estimation of emissions/removals in AFOLU in the 2019 Refinement**
  - ✓ Examples of global land cover datasets exist. Steps to construct biomass density map are elaborated. However, consistent time series to quantify AD and EF –land cover/use change, biomass changes– are not yet achieved.
  - ✓ Data gaps – e.g. some areas of land may not be covered with data in every period, due to persistent cloud or haze, errors in the satellite etc
  - ✓ Lack of skills and resources to access and use data, particularly for developing countries
- **How can the utility of land/biosphere observations be enhanced**
  - ✓ Promoting cooperation with remote sensing community to improve capacities of inventory compilers to access and use remotely sensed data
- **Expected outcome**
  - ✓ Enhanced use of land/biosphere observations improve estimates of emissions/removals from AFOLU, leading to better land management for mitigation, though other aspects need to be considered

Conclusion

How can the provision of climate information, based on Earth observations, better inform decision making under the UNFCCC and Paris Agreement now and in the future to support understanding and implementation of mitigation action and national reporting?

- **Use of information from atmospheric observations and inverse models has potential for verification of national GHG inventories, which will help better quantification of effects of mitigation efforts. It will inform decision making on NDC planning, and will facilitate tracking progress made in implementation and achievement of NDC.**
- **Land cover information and biomass density map obtained from land/biosphere observations will improve estimates of emissions/removals from AFOLU in national GHG inventories. It will inform decision making on land management for mitigation**
- **To this end, enhanced dialogue and cooperative interaction between Earth observation researchers and inventory compilers is critical.**


Atmosphere
Land & Atmosphere
Carbon Observations
the ocean
However, the ocean stores 80%

Earth observations for impacts, risks, and adaptation progress

Climate change 2022: Impacts, adaptation and vulnerability

H.O. Pörtner, Co-Chair IPCC WGII, and WGII Author Team



Characteristics of observations relevant for IPCC WGII:

… what need to be monitored for changes (declines and improvements) and action

Wanted:

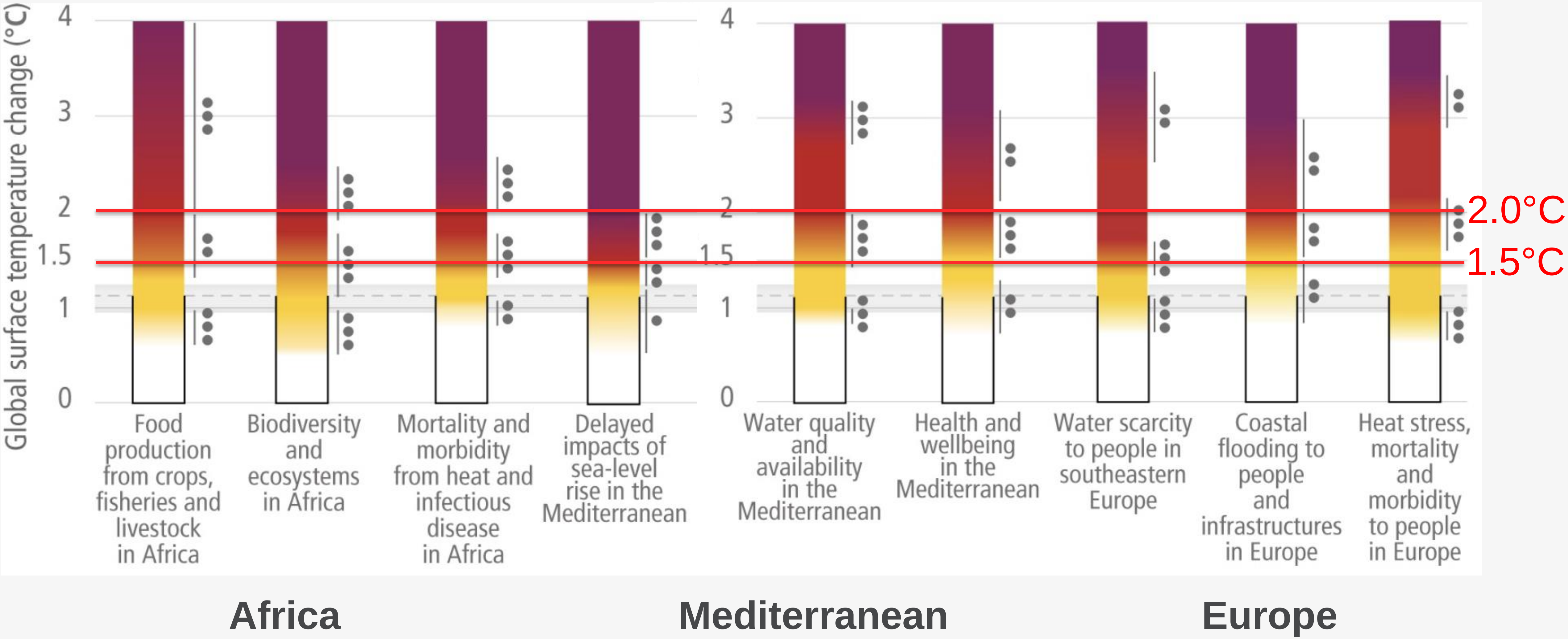
- Indicator (sets) for complex processes involving living “systems“
- To be integrated into higher level characters such as
- …vulnerability, … biodiversity, … risk levels … spatial patterns

Goal: Mobilizing action …

- Guidance of ambition in mitigation and adaptation
- Setting guardrails for climate action
- Pointing to criteria for alternative futures (… or their avoidance)
- Providing early warnings, e.g. for health: heat, disease vectors etc.
- Assessing liveability and Climate Resilient Development
- Evaluating Progress in Adaptation and Mitigation

Global and regional risk provide orientation for action (adaptation and mitigation)

… keeping risk at moderate levels by limiting global warming to 1.5°C



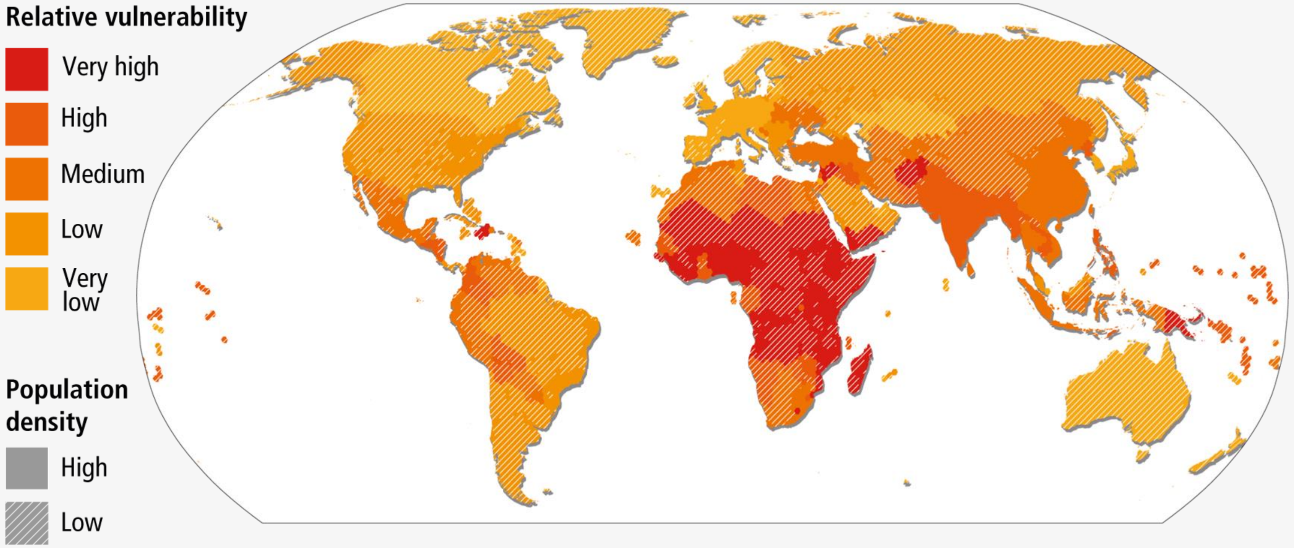
Tracking vulnerability at high spatial and societal resolution

Regional differentiation needed
Higher resolution needed

Indicators to be tracked and integrated:

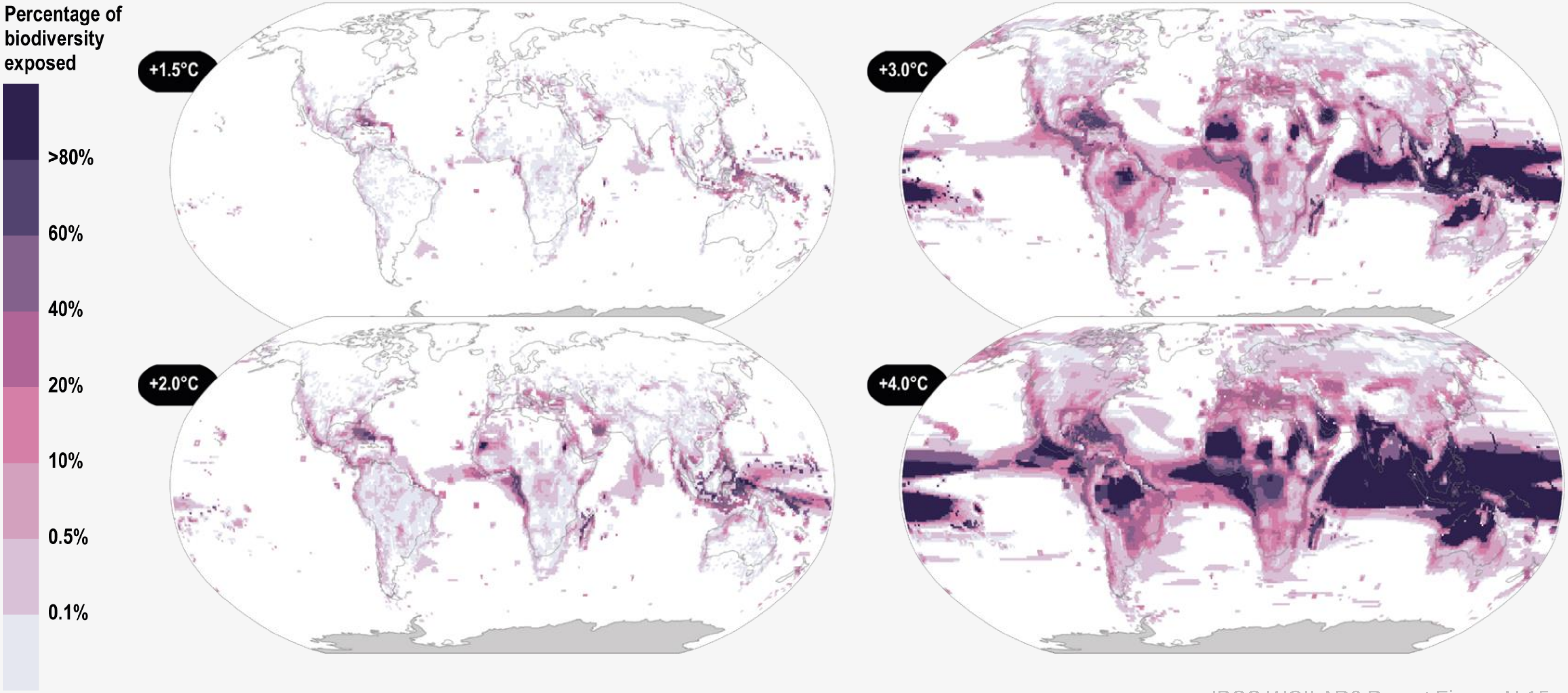
- Poverty, inequity, inclusivity
- Basic services availability (electricity, water, communication, health, education)
- Security
- Social, political, economic stability
- Transparency

A map with limited (within region) resolution:



J. Birkmann and colleagues,

The Future: e.g., Loss of Species (and Human) Habitat and Biodiversity



IPCC WGII AR6 Report Figure AI.15

What needs to be monitored for changes (declines, improvements) and action?

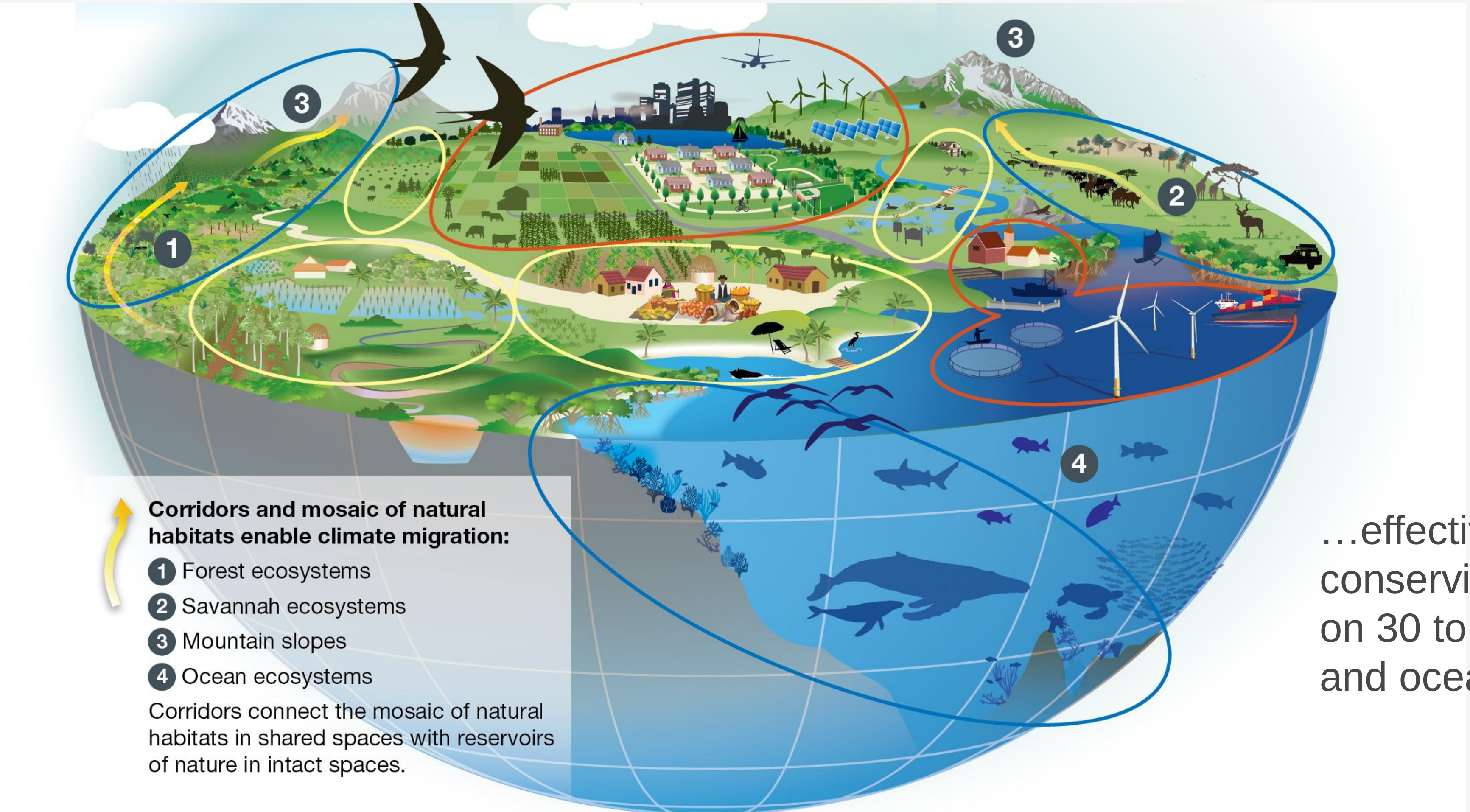
Indicators to be tracked and integrated:

- Background: non-climatic stressors enhancing vulnerability
- Species inventories
- Population Densities
- Geographical ranges
- Phenological indicators
- Metagenomics
- Resilience

Spatial planning guided by success implementation :

Treating climate, biodiversity, and human society as coupled systems is key to successful outcomes.

To be successful, conservation and climate actions would go hand in hand across landscapes, in cities and rural areas, taking people's needs into consideration, for maximized benefits for climate, biodiversity and humans.

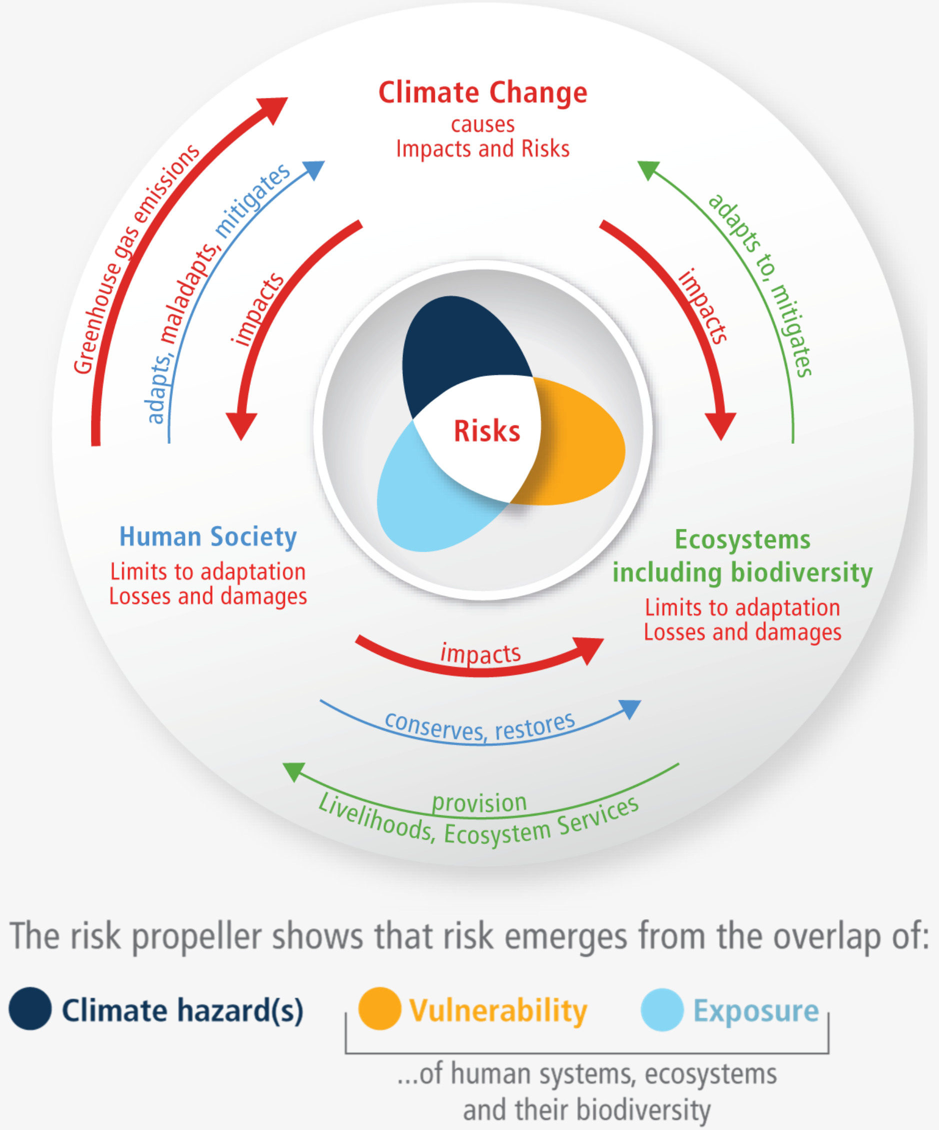


…effectively conserving ecosystems on 30 to 50% of land and ocean

Observations for risk assessment and adaptation

Systematic observation linking earth observation and statistical data, is key to better understand patterns of:

- **Rapid and slow-onset hazards** (droughts, floods, sea-level rise), including compound events
- **Exposure to different climatic hazards** over time (biodiversity, cities, settlements, people, critical infrastructures)
- **Vulnerability of humans** (e.g. low-income households and marginalized groups) **and ecosystems** (fragmentation, degradation)



Thank you!

IPCC Working Group II Author Team

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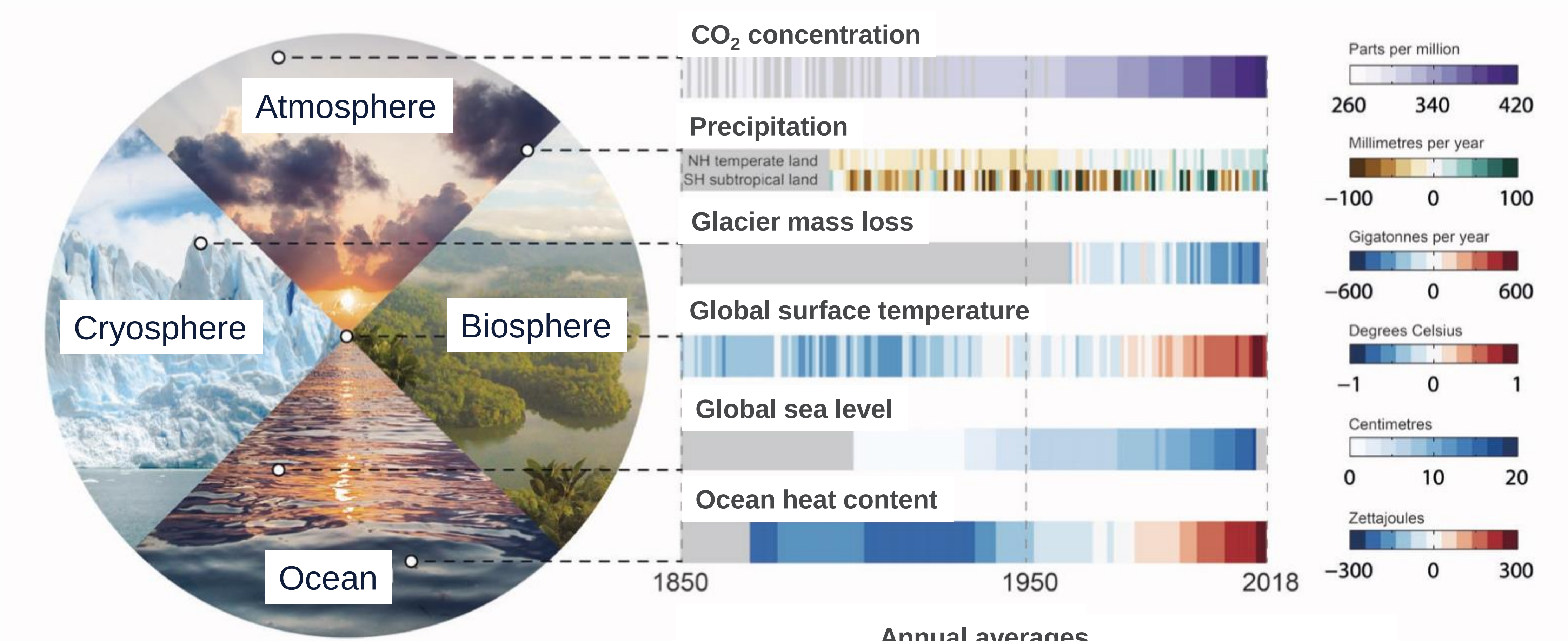
Earth Information Day 2022

Panel 3-
Earth observations for Adaptation and Early Warning Systems

Aïda Diongue-Niang
ANACIM
IPCC WGI Chapter 1 Lead Author
With inputs from Anna Pirani, IPCC WGI &Philippe Peyrillé, Météo-France

Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred



Annual averages
Grey indicates that data are not avalable

WGI Figure 1.4

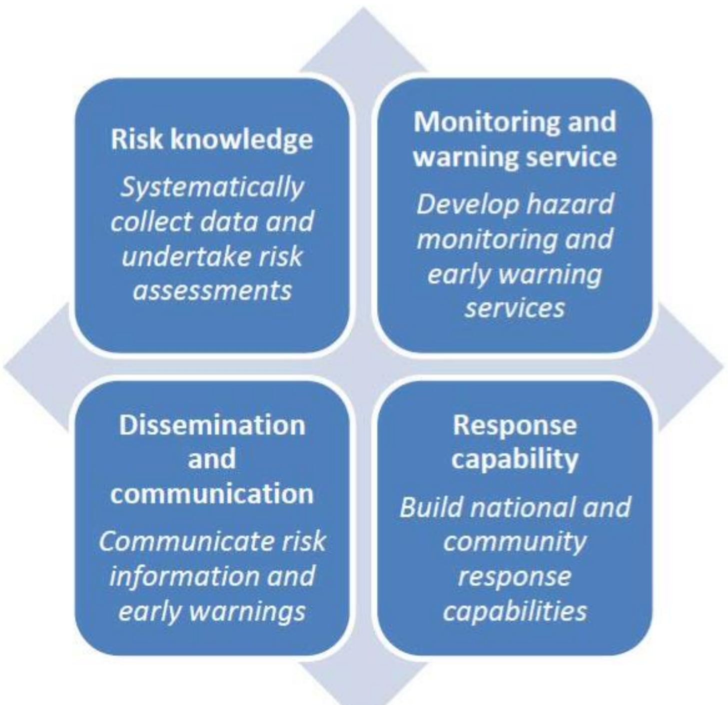
IPCC provides Warnings since FAR

Quote from AR6, IPCC WGI
« Human activities are causing climate change, making extreme climate events, including heat waves, heavy rainfall, and droughts, more frequent and severe »

Early Warning Systems

« The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss » - UNISDR

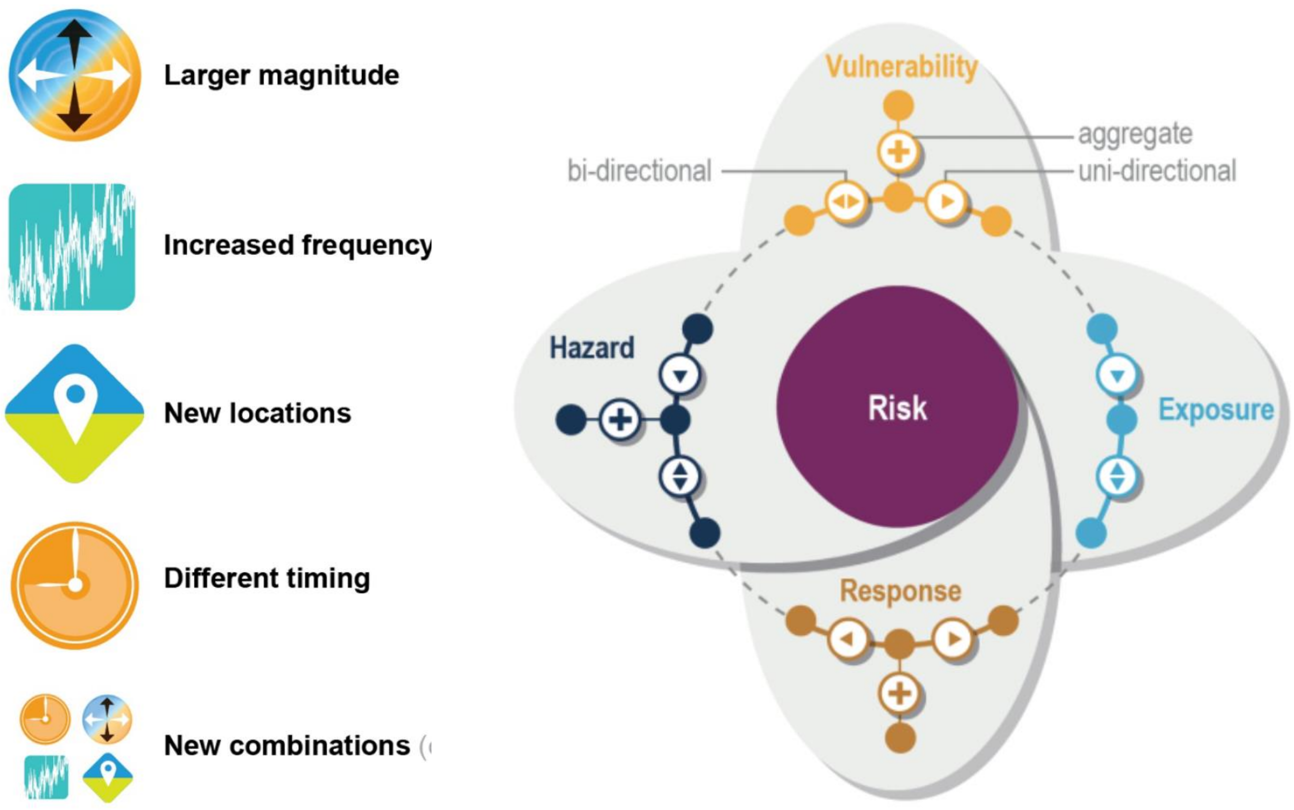
Climate and non-climate data needed for risk assessment



Earth observations for monitoring and prediction
Suden-onset e.g heavy precipitation
Slow-onset, e.g; Sea-level rise

A common risk framework has been adopted across the AR6

Linking climatic impact-drivers with societal and ecosystem vulnerabilities and exposure, and consequences of responses to climate change



3.3-3.6 billion people in highly vulnerable contexts

Ecosystems

1 billion people exposed to sea level rise by 2050

Responses

- *Maladaptation*
- *Pressures on land use*

WGII Figure 1.5

INTERGOVERNMENTAL PANEL ON climate change

Obseravtions for Past, Present changes and their attribution and future changes at global, regional and local levels

Advances, IPCC, WGI, chapter I

Chen etal, 2021 doi:10.1017/9781009157896.003.

A summary of advances and challenges of observations since AR5, for climate change assessments: for Monitoring and Trend analyses, Processus Understanding and Climate Modelling, e.g.

- More Availability of long series of historical data, e.g. data rescue program,
- Satellite measurement of microphysical properties of aerosol, cloud and precipitation, of the biosphere (e. g, leaf index area), the cryosphere (e.g. aerial phorgraphies), the ocean (e.g. altimetry),
- Expansion of in-situ observations of the ocean including tropical moored buoys, global network of tide gauges,
- Reanalyses, including paleo reanalyses and regional renalyses and ocean reanalyse

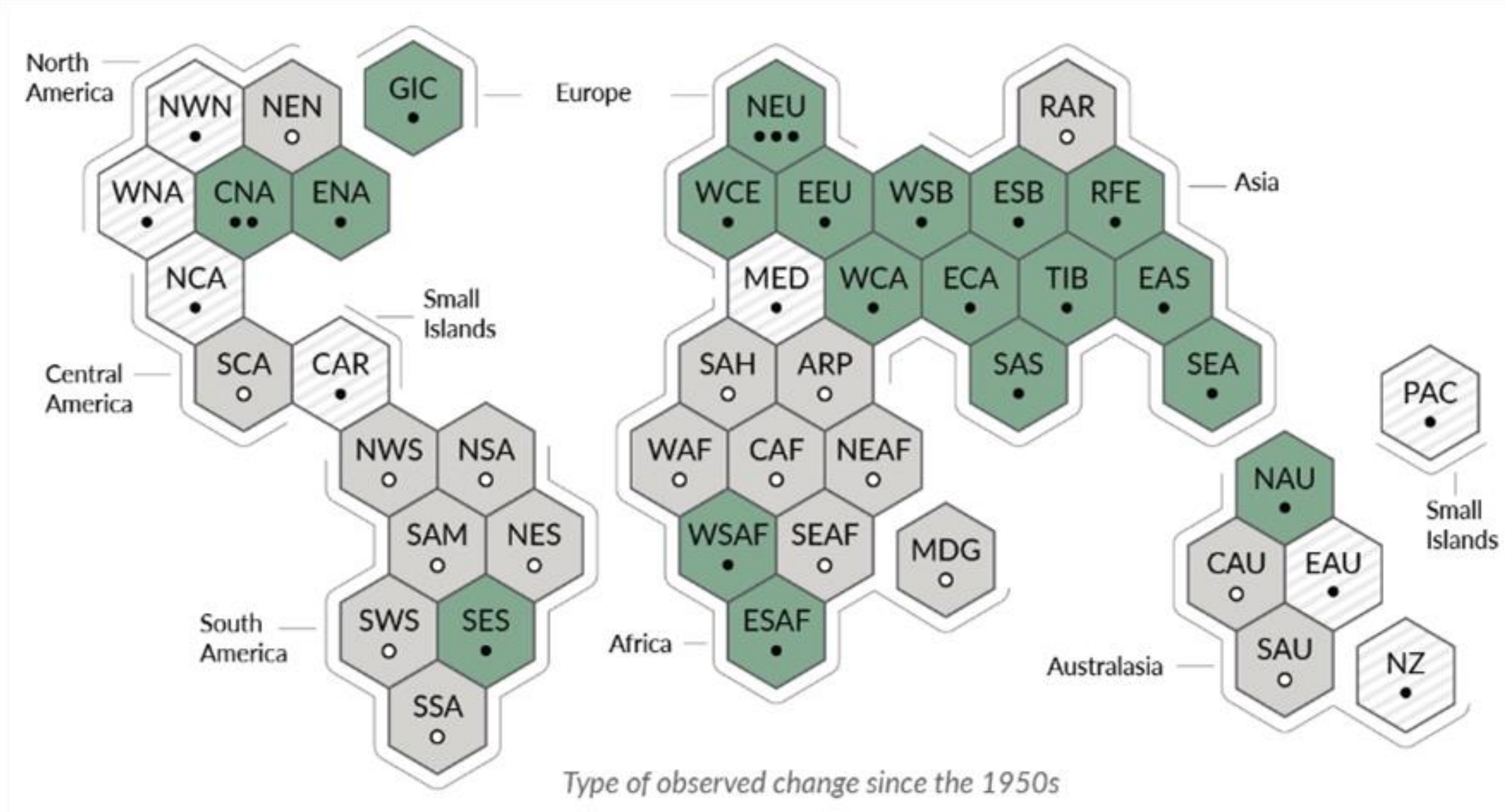
Challenges, Threats

- Disruption during COVID-19
- Loss of natural climate archives as a direct consequence of warming temperature (e.g; retreat of glaciers, coral bleaching, mortality of long lived trees)
- Loss of historical weather archives
- Regions with limited data or access to the data (Figure SPM 3)

Recommandations

- **Expand international data rescue programs**
- **Internationally coodinated efforts to rescue vulnerable paleoclimate archives**
- **Progam to expand the global network of tide gauges**

Heavy precipitation



Type of observed change

Colour = Increase/decrease

Low agreement in the type of change

Limited data and/or literature

Confidence in human contribution to the observed change

●●● High

●● Medium

● Low due to limited agreement

○ Low due to limited evidence

WGI Figure SPM.3

Monitoring and warning services

Observations for monitoring and for numerical prediction, from minutes to decadal timescales

Advances, challenges, gaps

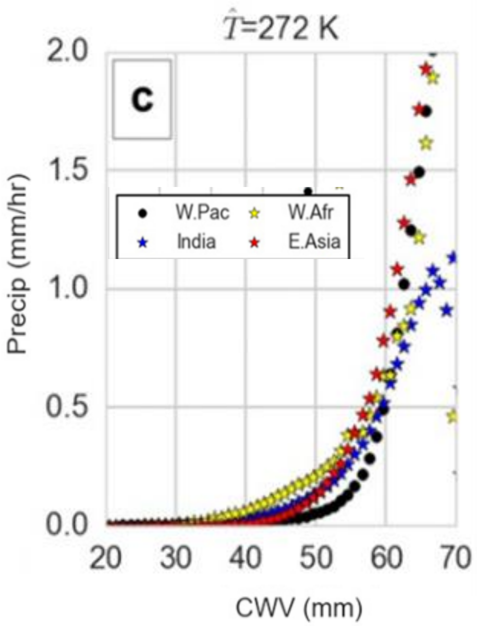
- Monitoring- Tremendous advances with satellite data and products.
  - Need of in-situ data for calibration and of capacity for data processing in some countries
- Global numerical weather prediction: needs a good initial state through *real-time* data assimilaton and relies on data exchange –
  - Advances in assimilation technique and use of satellite data
  - Gaps in surface and upper-network network coverage and data exchange, especially in Africa, the South-West Pacific, South America and Antarctica - WMO staticts
- Climate models – needs of observatons of the the components of the climate system other than the atmosphere
  - Concept of Seamless Earth system models, co benefits in the use of observations for different timescales
- (Sub) regional collaboration for EW services –advances particularly in Europe, Gaps mainly in developping regions, e.g; Africa

Recommandations

- **Support WMO Global Basic Observing Network (GBON)**
- **Support WMO Systematic Observation Financing Facility SOFF**
- **Support of (sub) regional early warning services to feed naional early warning systems**

Example of good practices and tools – use of Precipitable Water for monitoring and predicting active phases of the West African monsoon

MISVA collaborative project (https://misva.aeris-data.fr) between Meteo-France and CMRS Dakar and West African NMSs, supported by CREWS

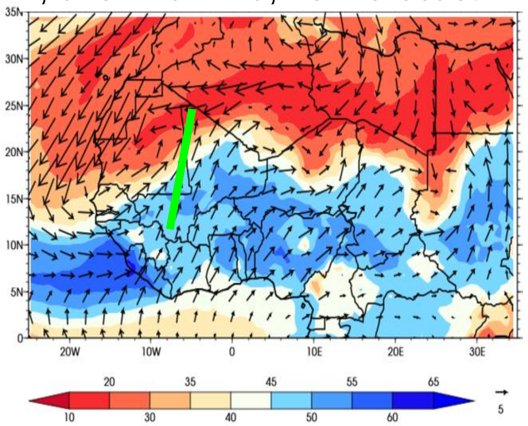


Ahmed and Neelin (2018)

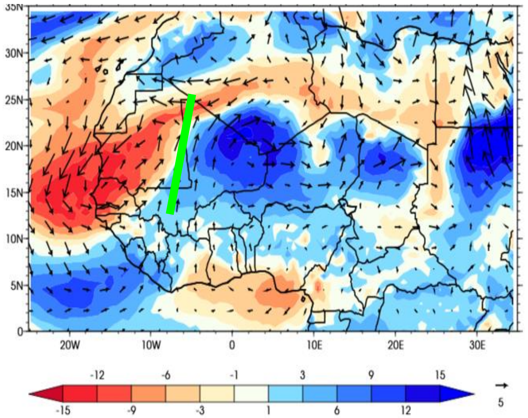
Precipitable Water

- Column of water vapor (integral) that can condensate
- Tigh link between precipitable water and precipitation
- Better preditability than precipitation ⇒ good reliability for a forecaster
- Challenges with declining RS

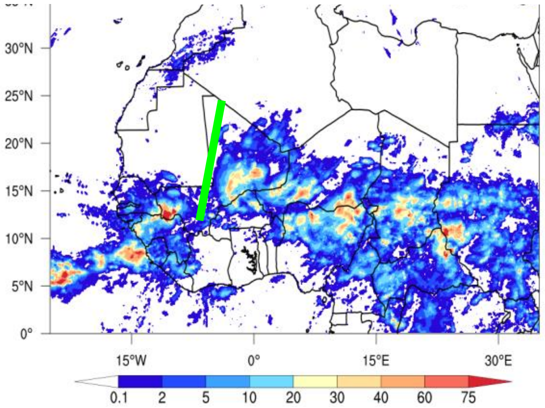
Precipitable Water (mm) ; 925 hPa wind, 18h forecast



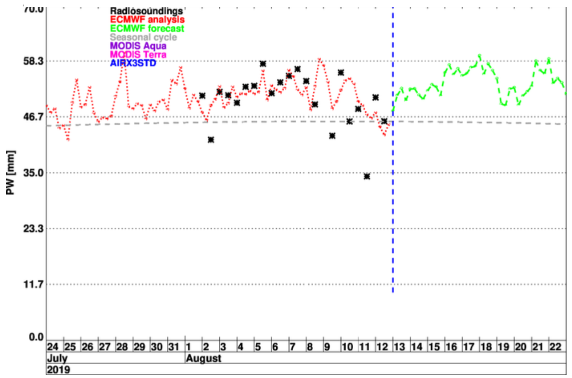
Anomaly : Precipitable Water (mm) , 925 hPa wind , 18h forecast



Observed Precipitation 14/08/2019 (mm) - IMERG



PWAT evolution at Niamey RS site 13/08/2019



Conclusion

Hazard knowledge in risk assessments in a changing climate require observations from the global coupled atmosphere–ocean–land–cryosphere system

Observations routinely recorded in general by National meteorological services and their exchnage underpin Early warning services of an Early warning system.

Observing network and/or observations management are not optimal for many regions

Efforts to improve observation coverage including in urban areas are needed

Early warning services need to be integrated into disaster risk reduction, climate servies, and adaptation to climate change strategies for effective early action and ccorditioned national action.

Earth observation capabilities to enhance early warning systems and climate services in Malawi

Lucy Mtilatila
Director of Climate Change and Meteorological Services
Ministry of Natural Resources and Climate Change, Malawi

Samuel Gama
Principal Mitigation Officer at Malawi’s
Department of Disaster Management Affairs

GEO GLOWS GLOBAL WATER SUSTAINABILITY

GEO GROUP ON EARTH OBSERVATIONS

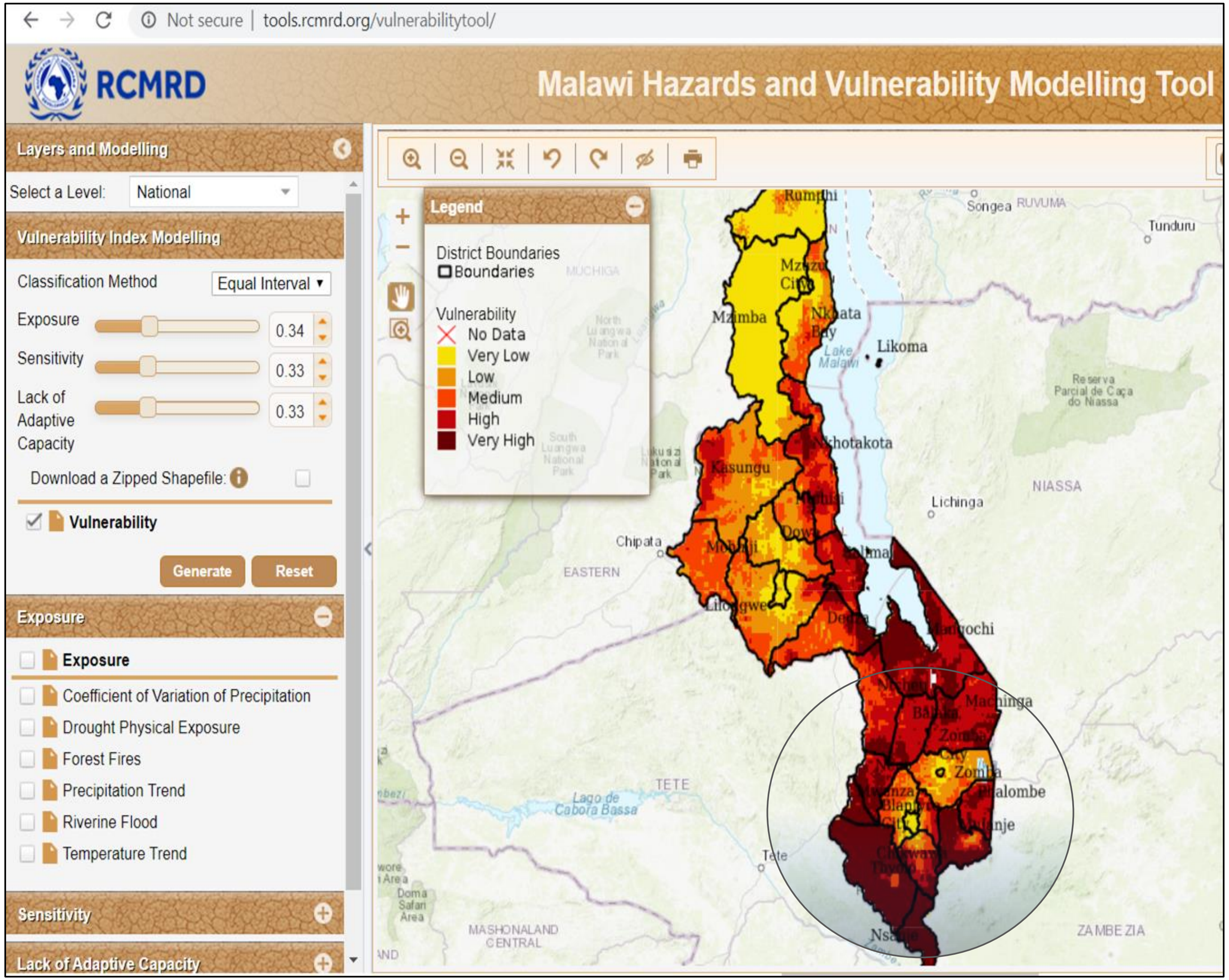
Malawi's Hazards and Vulnerability

Hazards:

- **Floods**
- Heavy storms
- **Drought**
- Landslides
- Pest Infestations
- **Disease epidemics / Waterborne diseases**

Vulnerability:

- **Agriculture-based economy** (over 85% of the population)
- Higher impact of climate change and variability in the South
- **Over-reliance on in-situ measurements for flood forecasting**
- Extensive deforestation and watershed degradation



The Integrated Community-Based Flood Early Warning System (CBFEWS)

Water level Sensor

Data Transmission

Data Server Upload

Manual Trigger

Remote Trigger

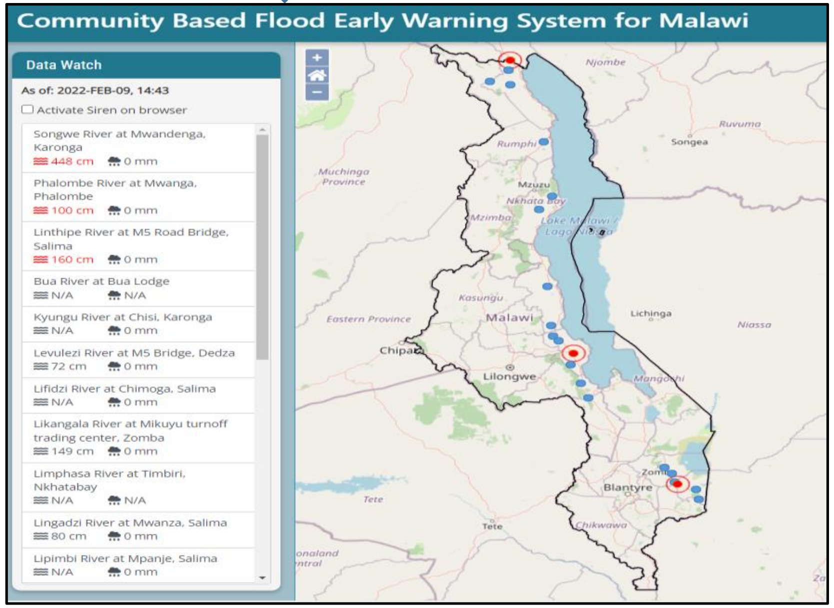
Alarm Unit

Upload

Alarm track

Trigger

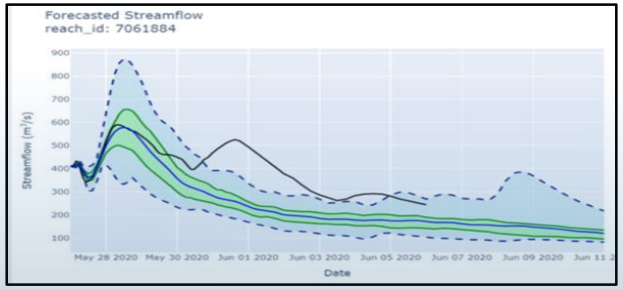
Manual River Staff Gauge



REST API

GLOBAL WATER SUSTAINABILITY

GEOGloWS ECMWF Streamflow forecast



RCMRD

The GEOGloWS-ECMWF Streamflow Forecasting Service

https://geoglows.apps.aquaveo.com/apps/geoglows-hydroviewer/
https://tethys.byu.edu/apps/geoglows-hydroviewer/

GEO GLOWS GLOBAL WATER SUSTAINABILITY

ECMWF

Malawi's annual flood impact

Rain Season November/April		Financial Impact (Million USD)		Population		
Period	Event	Losses and Damages	Recovery	Affected by economic loss	Displaced	Dead
2011/2012	Heavy rainfall	12	22	18,000	6,800	18
2014/2015	2 Cyclones	215	494	1,101,364	230,000	106
2018/2019	2 Cyclones	220	368	975,600 (277,089) ★	N/A	60
CBFEWS/**GEOGloWS** Implemented **2021/2022**	2 Cyclones	156	185	994,967 (156,197) ★	221,127	46

2015/2016 Drought

★ **Districts in which CBFEWS was implemented in 2021**

GEO GLOWS GLOBAL WATER SUSTAINABILITY

Next Steps

- *World Bank* to support the Government to scale-up to 10 flood prone districts in the Southern part of Malawi, targeting additional 40 river systems.

- *RCMRD and GEOGloWS partners* through the *USAID SERVIR Program* to replicate the integrated project and increase the institutional capacity in other countries.

- *GEOGloWS* to develop supplementary guidance to the UNFCCC NAP Technical Guidelines to include the GEOGloWS-ECMWF service in other countries.

GEO GLOWS
GLOBAL WATER SUSTAINABILITY