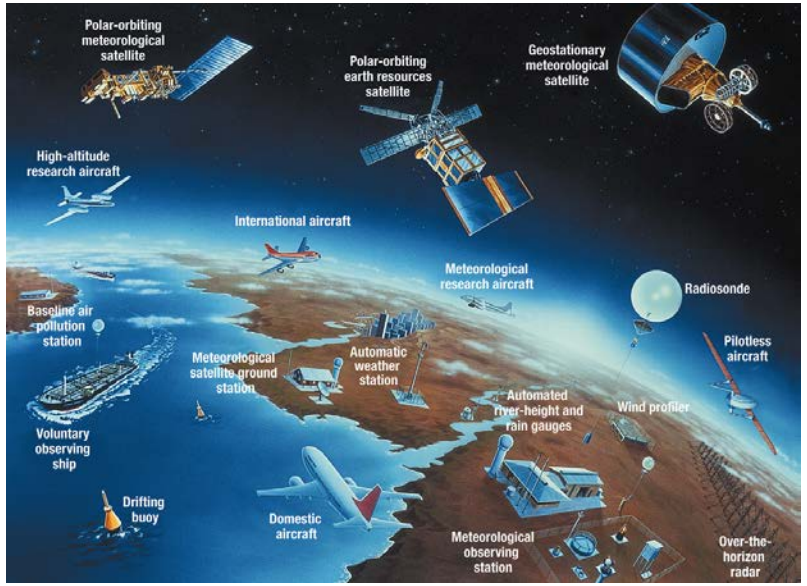
Need for km-scale climate modelling

Prof. Petteri Taalas
Secretary-General

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

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, 1873-
- Coordinates work of > 300 000 national experts from meteorological & hydrological services, academia & private sector
- Co-Founder and host agency of IPCC (1st World Climate Conference)
- WMO SG UNSG Guterres' Climate Core Group Member (1/4)

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Succesful WMO reforms

1. Constituent body reform, 8 => 2 Technical Commissions, Scientific Advisory Panel, hydrology panel, new data policy

2. Secretariat alignment & reform: new management, resources from admin => young experts, private sector engagement, high position in the UN, global visibility, Early Warning Services for All, Climate Risk and EWS, Systematic Observation Financing Facility

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Biggest risks for global economy 2023-2033

World Economic Forum 2023

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Early Warnings for All

The UN Global Early Warning Initiative for the Implementation of Climate Adaptation

> 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 at the next UN climate conference, later this year in Egypt.
>
> UN Secretary-General Antonio Guterres on World Meteorological Day 23 March 2022

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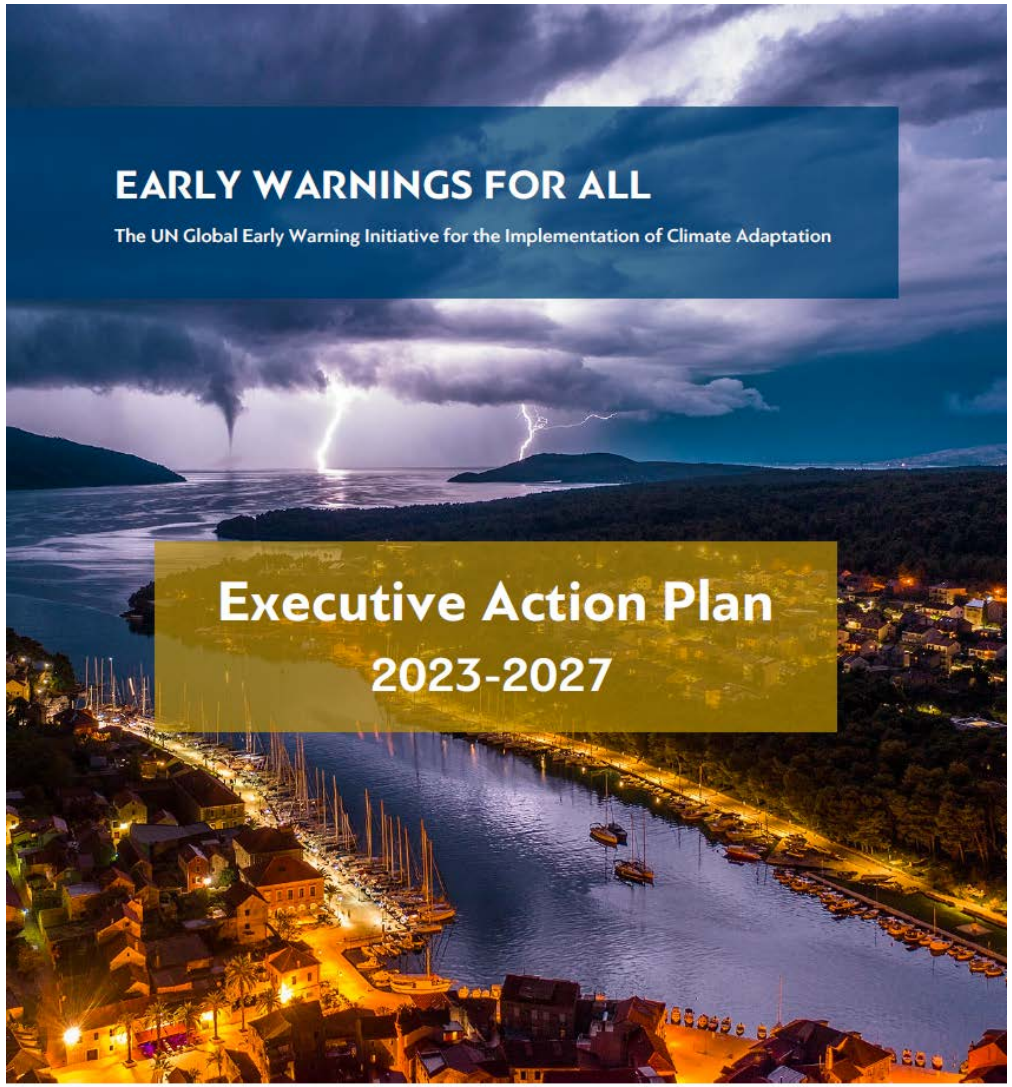


Available at WMO [online library]

Launched on Monday 7 November at COP 27, received huge support

[Early Warnings for All Action Plan gets overwhelming backing at COP27]

WORLD METEOROLOGICAL ORGANIZATION

COP27 SHARM EL-SHEIKH EGYPT 2022

WMO

WEATHER CLIMATE WATER

The state of MHEWS globally

- An enhanced data collection campaign (the ***WMO Performance Monitoring System***) conducted since March 2022 shows that significant MHEWS gaps remain globally
- A **composite Early Warning Index** will be developed with Members and key partners in the months ahead. This index will better demonstrate changes in the global status of early warnings and early action going forward and highlight areas where urgent action is required.

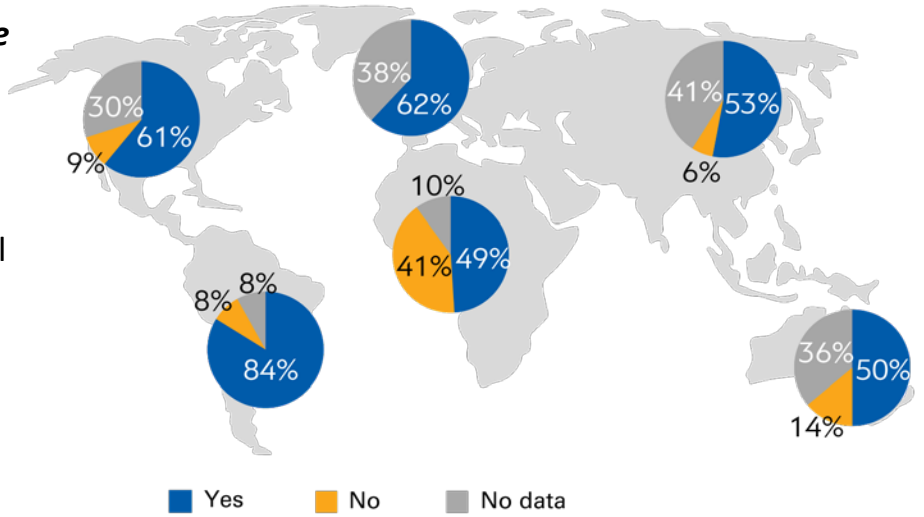
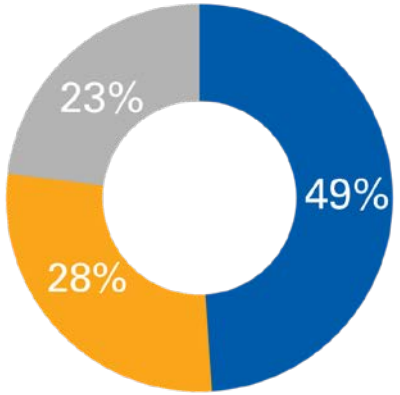
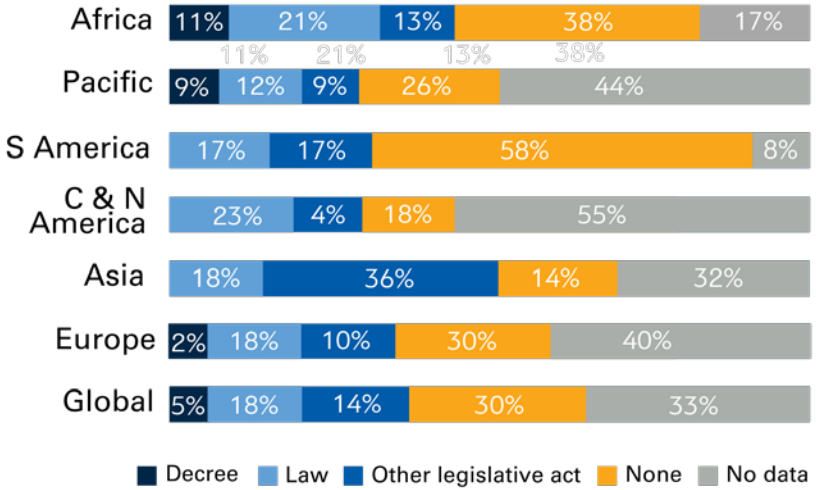


Figure 4: Percentage of countries reporting to have Standard Alerting Procedures (SAPs)



Percentage of WMO Members reporting to have MHEWS



Percentage of Members reporting to have legislation on MHEWS

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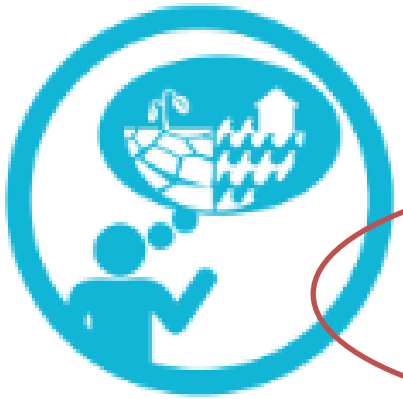
Four pillars of Early Warnings for All: 3.1 b$ 2023-27



Disaster risk knowledge

Systematically collect data and undertake risk assessments

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

Detection, observations, monitoring, analysis and forecasting of hazards

Develop hazard monitoring and early warning services

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

Preparedness and response capabilities

Build national and community response capabilities

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

Warning dissemination and communication

Communicate risk information and early warnings

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

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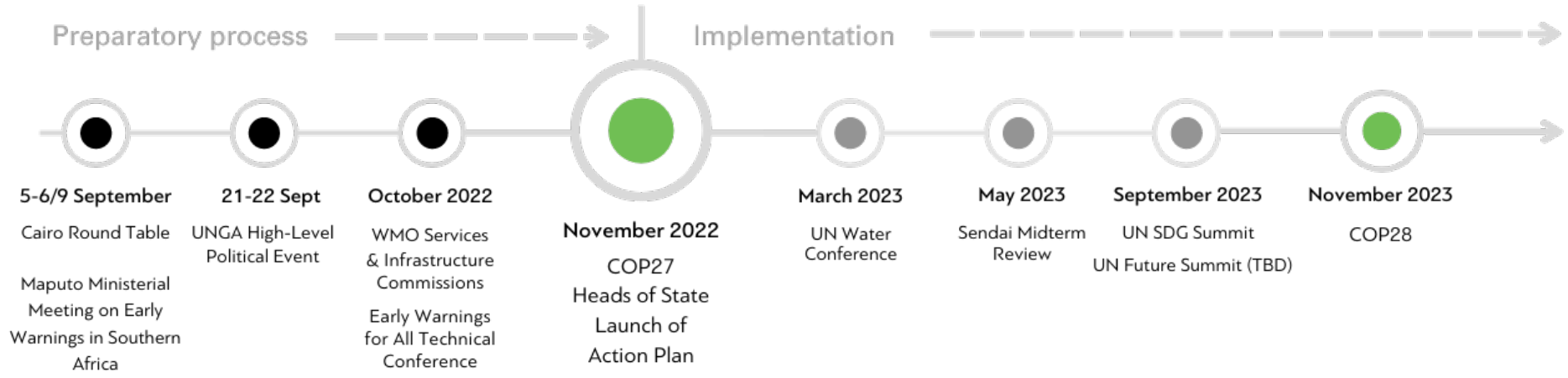
Milestones to COP27 and beyond



COP27
SHARM EL-SHEIKH
EGYPT 2022

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Launch at COP 27 of the Early Warning for all Plan with more than 10 Heads of State and CEOs

Sharm el Sheikh COP 27

Microsoft President Brad Smith

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Engagement of UNSG's office, COP-28 president, UNDRR and IFRC in the EWA planning

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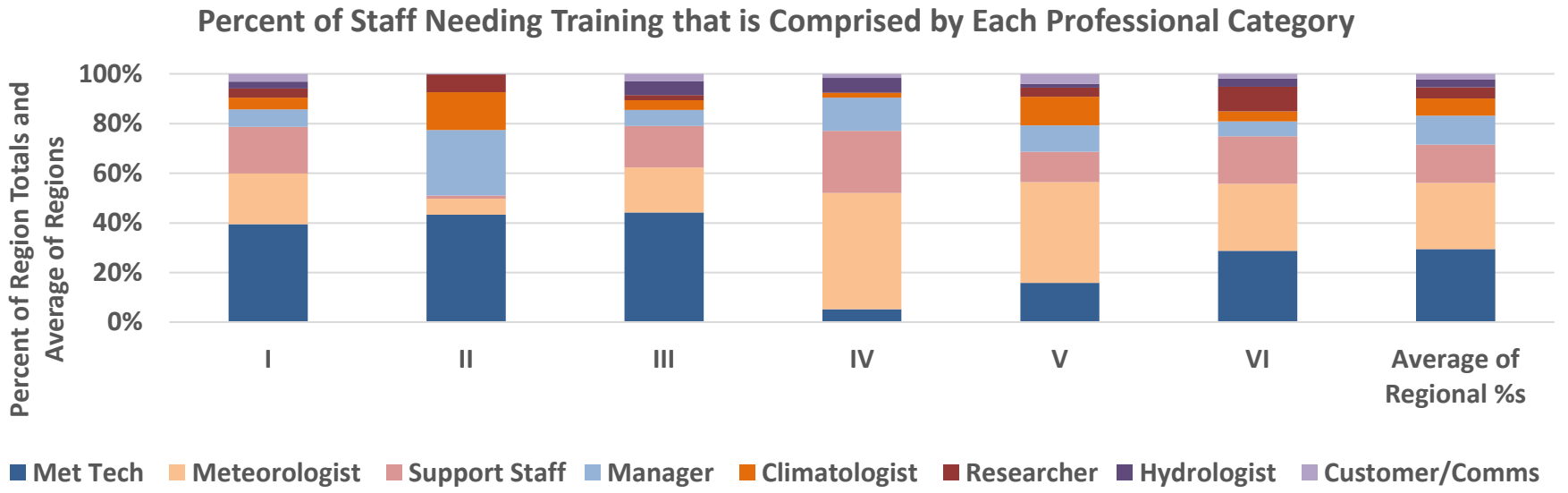
Number of staff in need of training

- Worldwide, 90,000 people need training in various professional areas.
- The most numerous group of people needing training is Meteorological Technicians (36,085 people). The next largest group are Managers (20,769 people), followed by Climatologists (11,819 people) and Meteorologists (9,911 people).
- Large numbers of Researchers and Support Staff also need trained, as well as moderate numbers of Hydrologists and Customer Interactions and Communications Staff.



Professional Categories	I	II	III	IV	V	VI	Global
Met Tech	2.505	31.584	726	262	195	813	**36.085**
Manager	444	19.248	106	674	132	165	**20.769**
Climatologist	297	11.112	66	93	141	110	**11.819**
Meteorologist	1.295	4.706	299	2.363	502	746	**9.911**
Researcher	240	5.186	33	13	46	276	**5.794**
Support Staff	1.192	963	273	1.259	150	528	**4.365**
Hydrologist	170	58	94	292	18	90	**722**
Customer/Comms	198	96	46	81	50	97	**568**
Regional Totals	**6.341**	**72.953**	**1.643**	**5.037**	**1.234**	**2.825**	**90.033**

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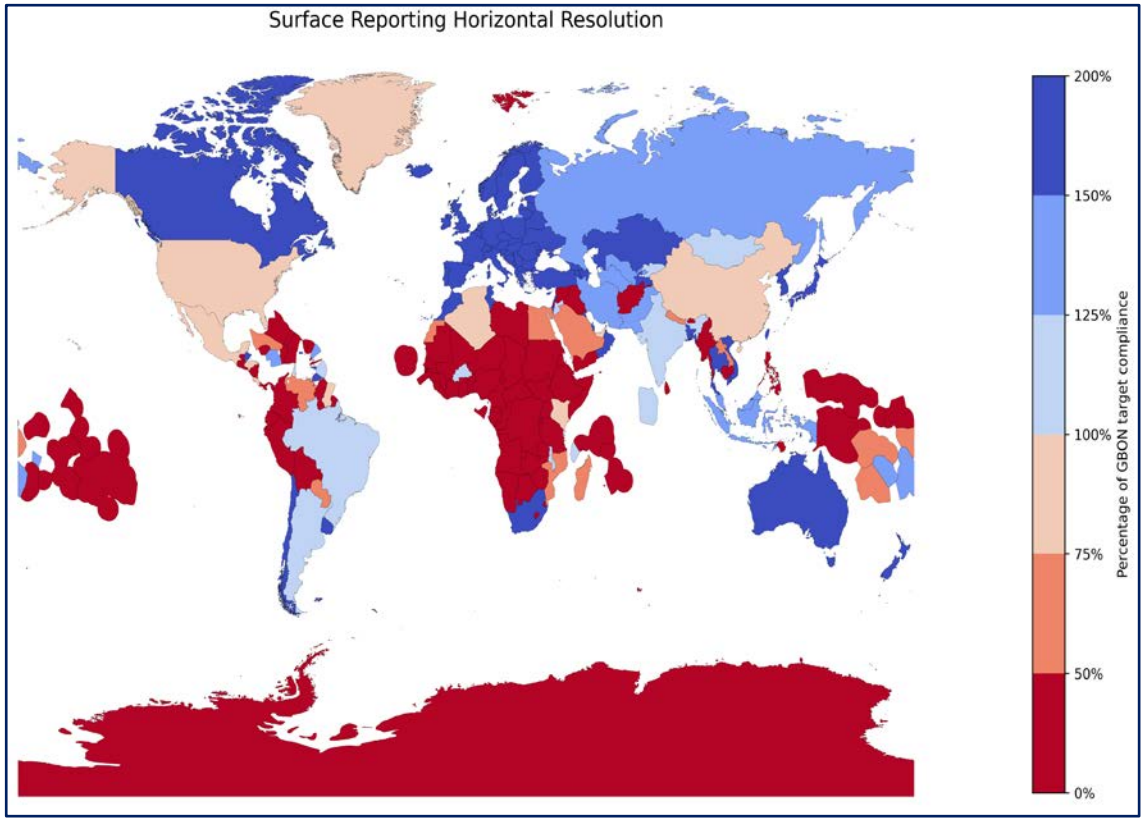
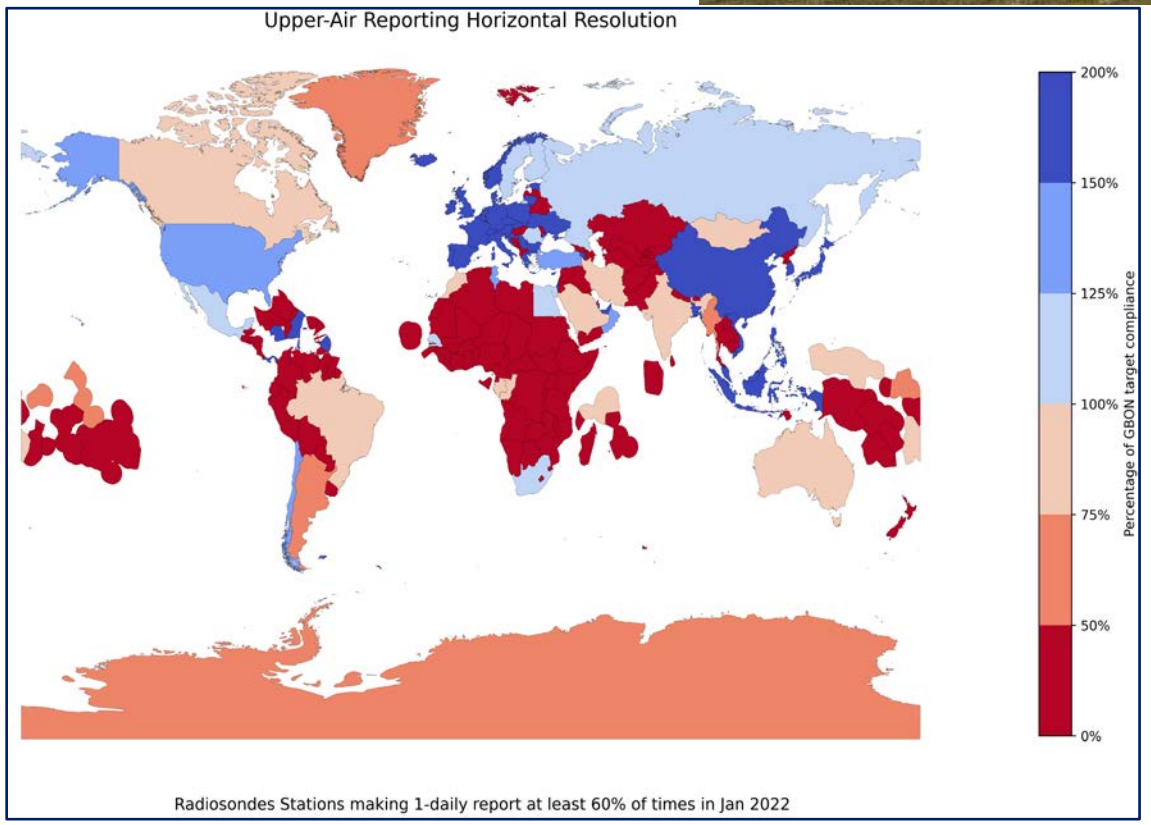
Global Basic Observation Gaps, January 2022

Surface observations



Gap in SIDS and LDCs (standard density): **596 surface stations**; existing network delivers roughly **9% of required number of observations**;

Upper air observations



Gap in SIDS and LDCs (standard density): **139 upper air stations**; existing existing network delivers roughly **8% of required number of observations**;

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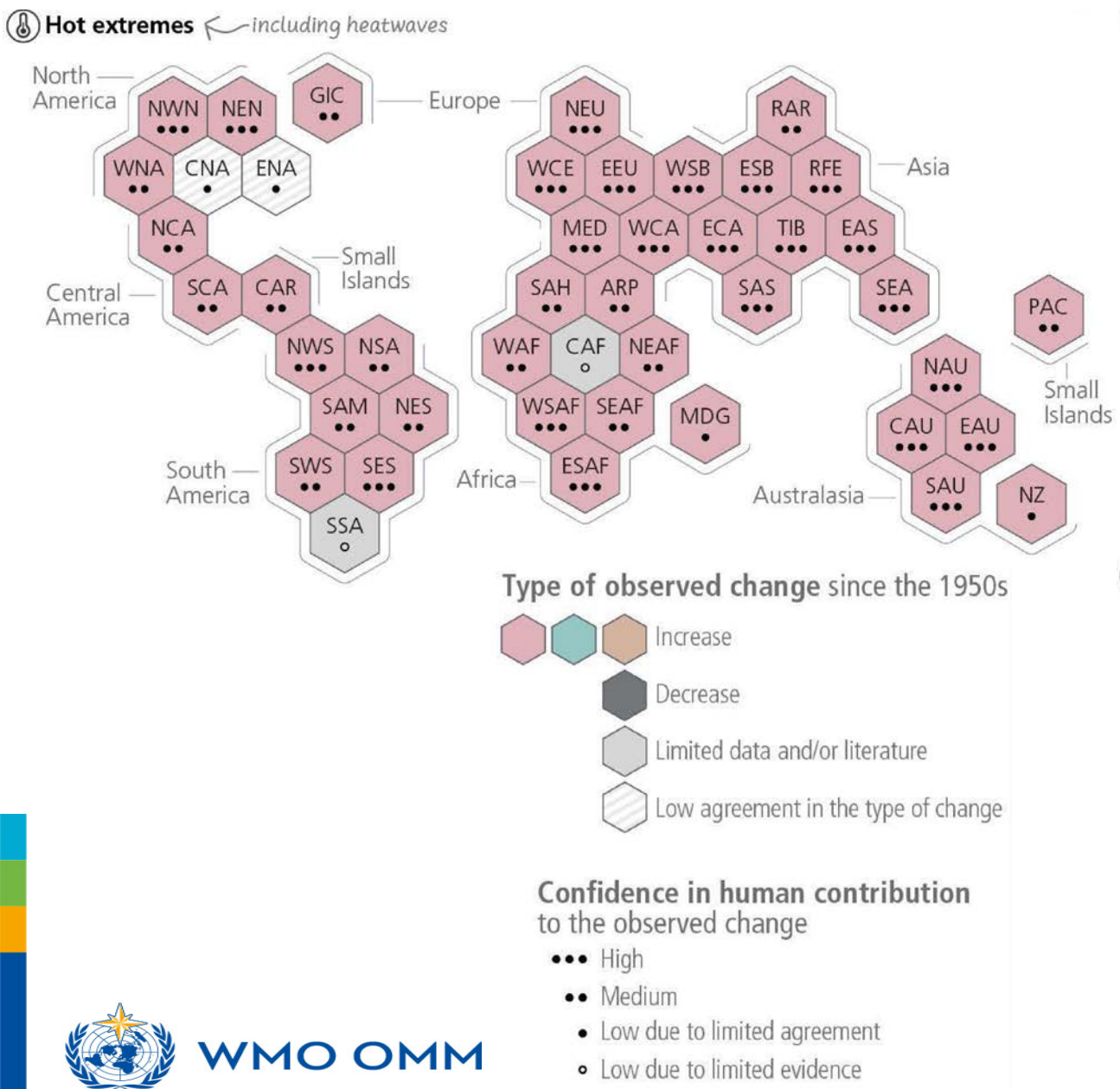
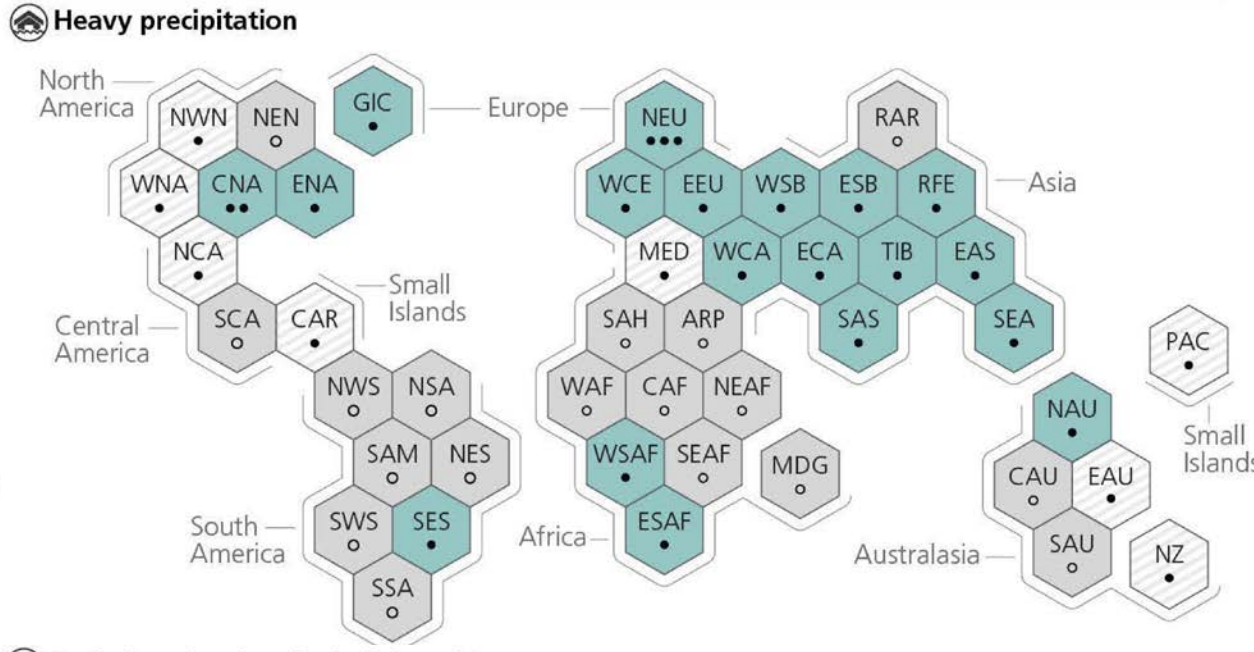
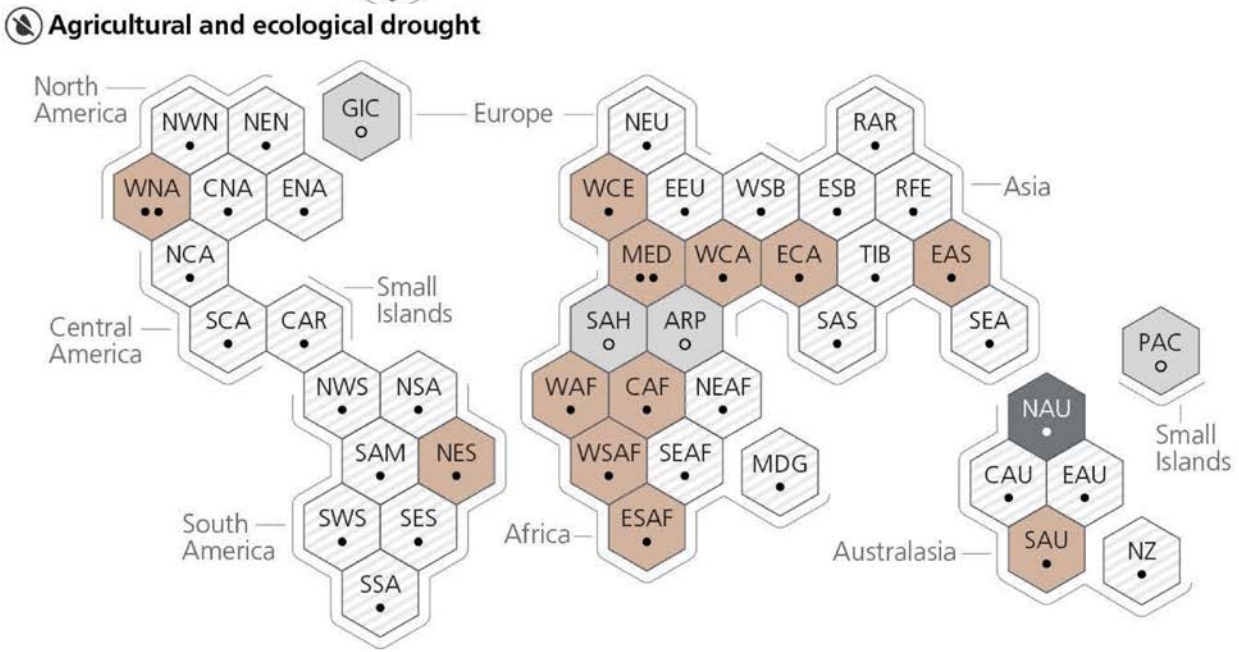
Observed heat waves, flooding and drought







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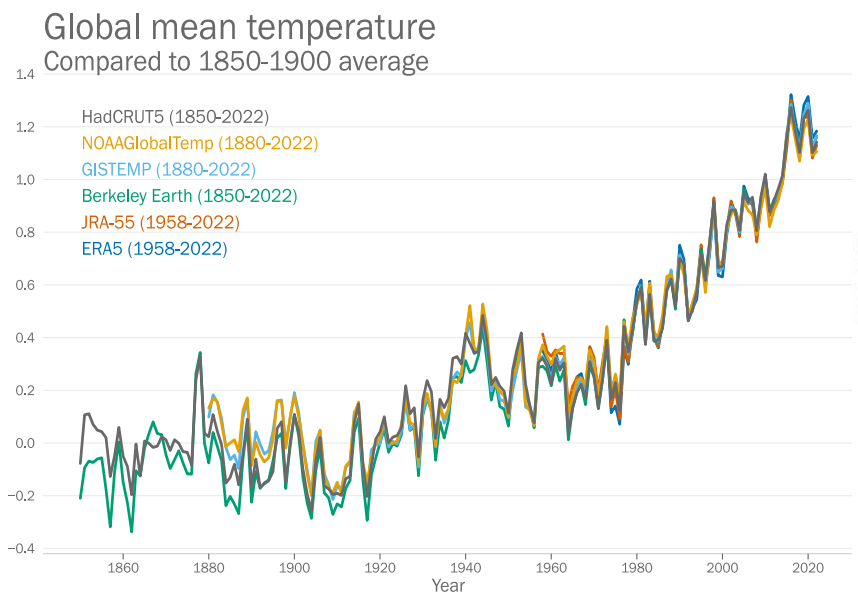
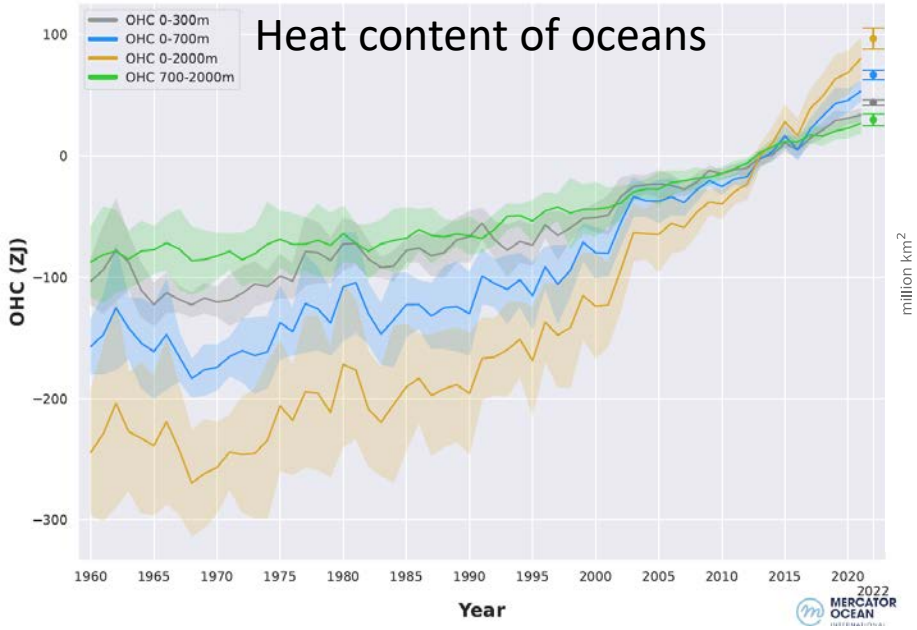
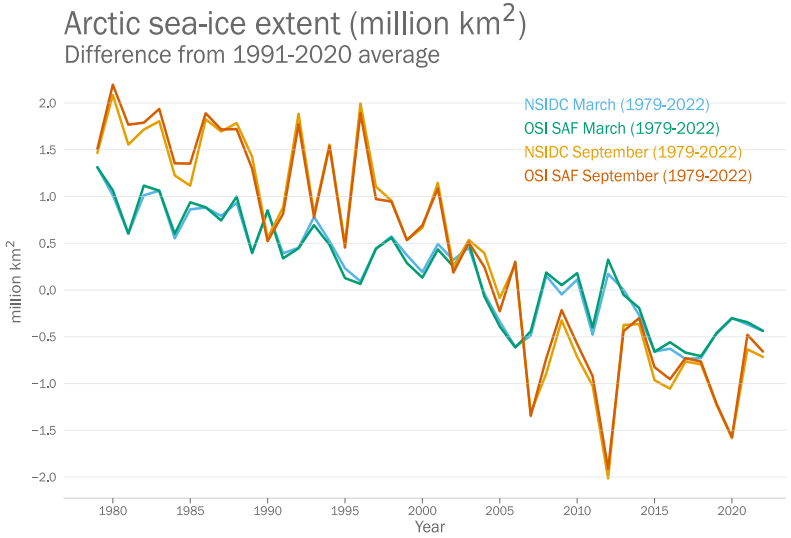
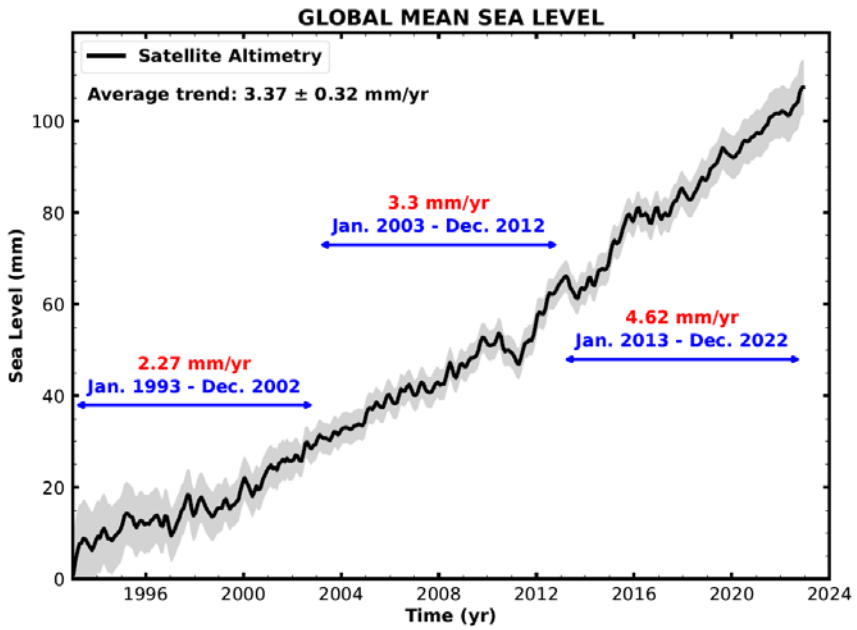
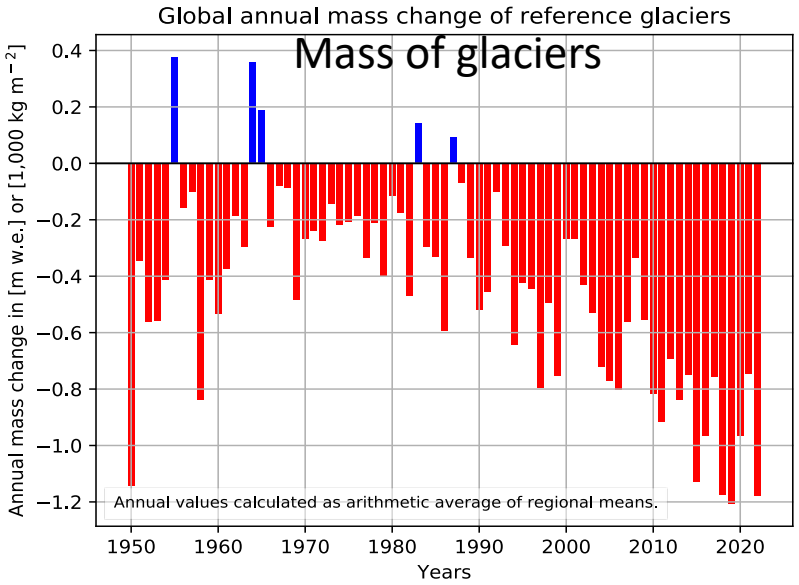
Climate change is visible

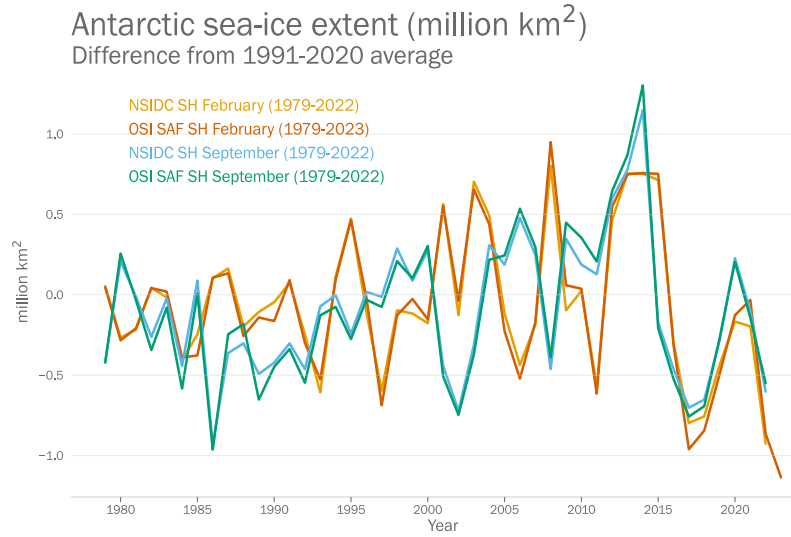








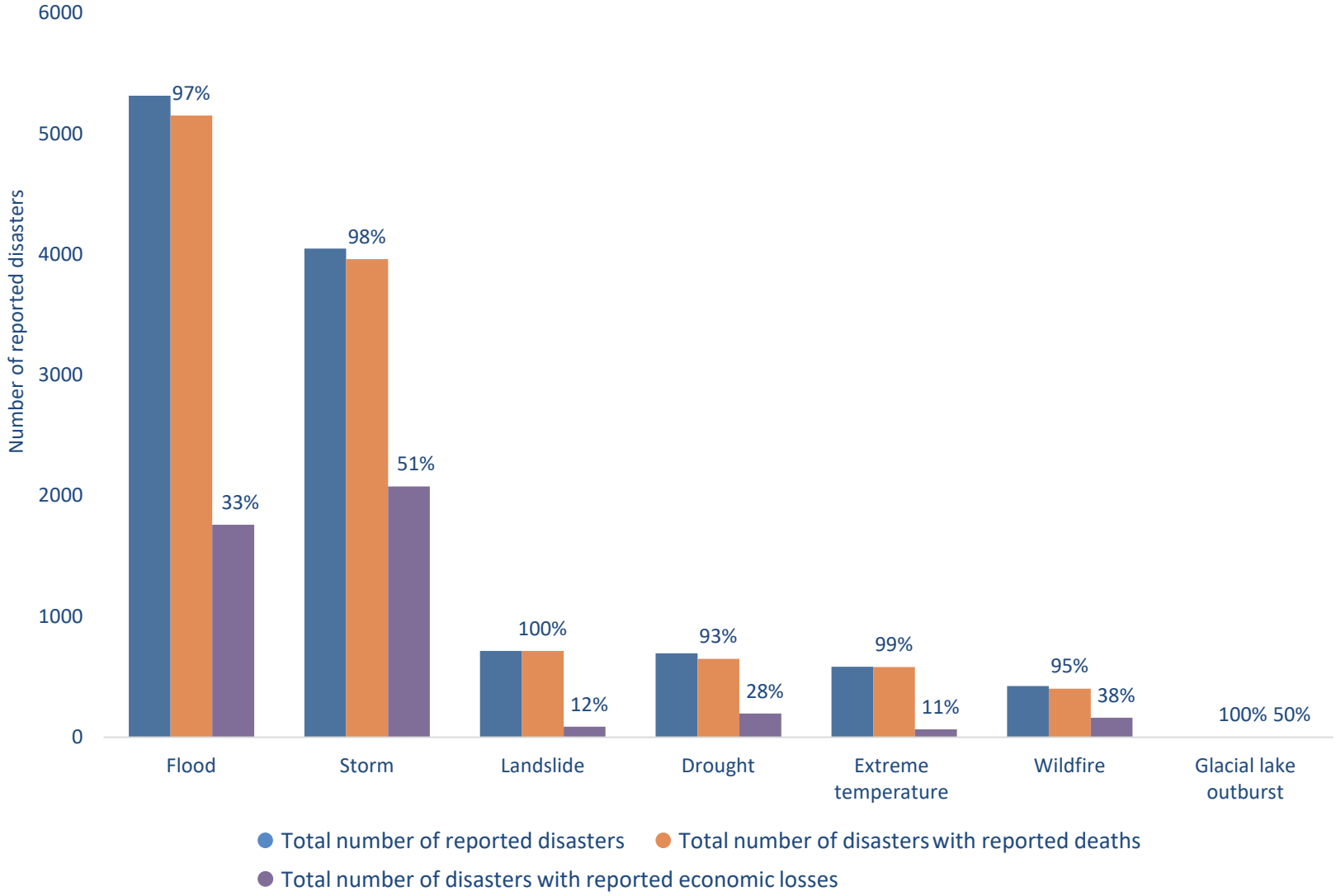




Reported deaths and economic losses by hazard type* (1970-2021)

Globally, economic losses are reported for every third flood and every second storm.

The **lowest** ratios of reported economic losses to overall number of events are for extreme temperature- and landslide-related events.



Source: Centre for Research on the Epidemiology of Disasters, 2023: EM-DAT: The International Disaster Database, https://emdat.be.

*Note: * refers to the EM-DAT classification; disasters refers to weather-, climate-, and water-related disasters.*

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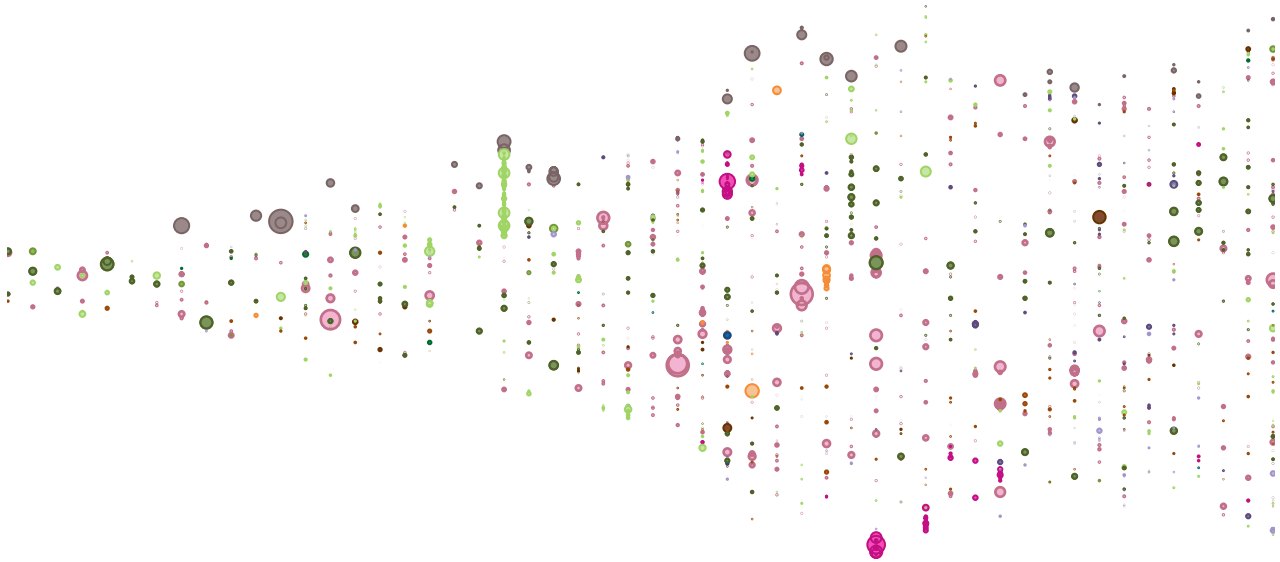
Reported economic losses as a % of developed economies' Gross Domestic Products (1970-2021)

2 824 disasters were reported in developed economies, yet economic losses were reported for **51%** (1438 disasters) only.

In developed economies, 84% of disasters with reported economic losses had an impact equivalent to less than 0.1% of the gross domestic product (GDP) of respective economies.

No disasters were reported with economic losses greater than 3.5% of GDP.



Sources:

Centre for Research on the Epidemiology of Disasters, 2023: EM-DAT: The International Disaster Database, https://emdat.be.

The World Bank, 2023: Data, GDP (current US$), https://data.worldbank.org/indicator/NY.GDP.MKTP.CD.

Note: the hazard classification is based on EM-DAT hazard type; the bubbles are event-specific; the size of a bubble relates reported economic losses from weather-, climate- and water-related extremes to countries' annual Gross Domestic Products.

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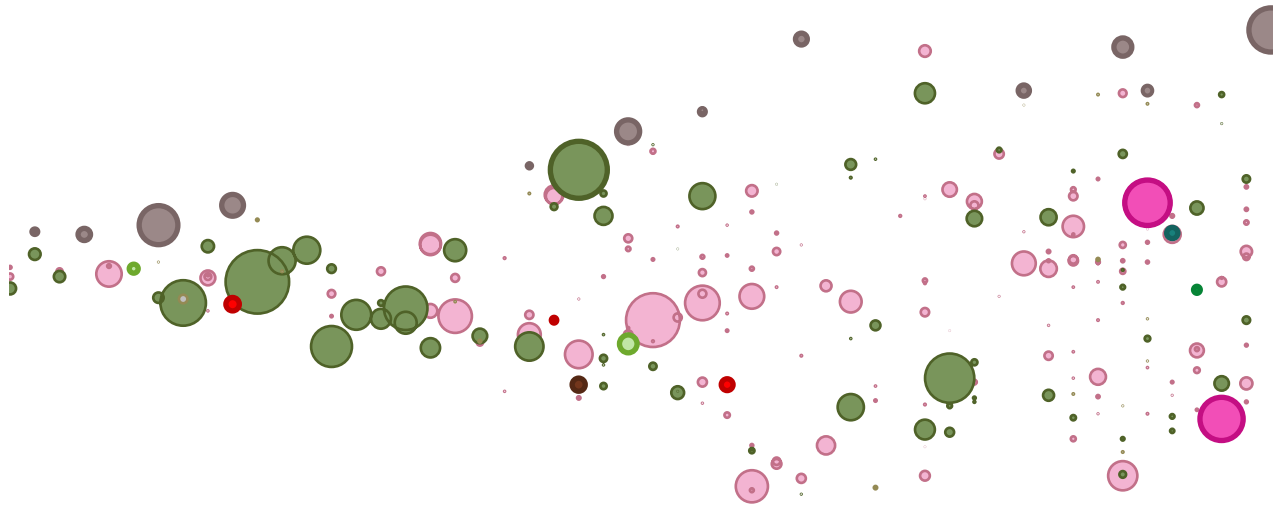
Reported economic losses as a % of Least Developed Countries' Gross Domestic Products (1970-2021)

2 086 disasters were reported in Least Developed Countries, yet economic losses were reported for **13%** (280 disasters) only.

In LDCs, 38% of disasters with reported economic losses had an impact equivalent to less than 0.1% of the respective GDPs.

7% of disasters for which economic losses were reported had an impact equivalent to more than 5% of the respective GDPs, with several disasters causing economic losses up to nearly **30%**.



Sources:

Centre for Research on the Epidemiology of Disasters, 2023: EM-DAT: The International Disaster Database, https://emdat.be.

The World Bank, 2023: Data, GDP (current US$), https://data.worldbank.org/indicator/NY.GDP.MKTP.CD.

Note: the hazard classification is based on EM-DAT hazard type; the bubbles are event-specific; the size of a bubble relates reported economic losses from weather-, climate- and water-related extremes to countries' annual Gross Domestic Products.

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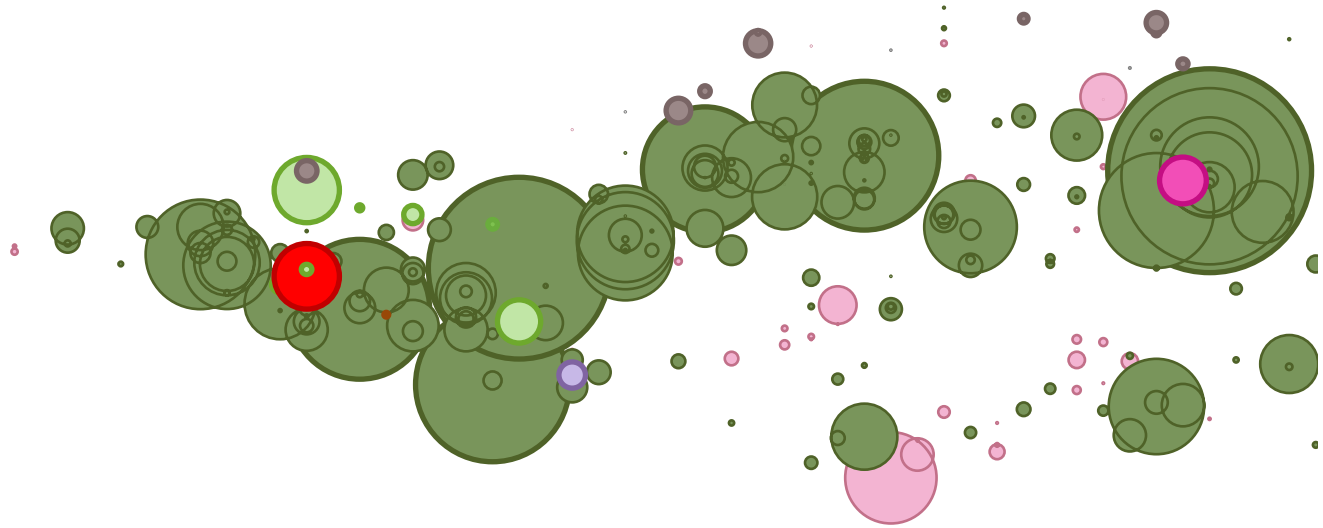
Reported economic losses as a % of Small Island Developing States' Gross Domestic Products (1970-2021)

840 disasters were reported in Small Island Developing States between 1970 and 2021, yet economic losses were reported for **38%** (319 disasters) only.

20% of disasters with reported economic losses led to an impact equivalent to more than 5% of the respective GDPs, with some disasters causing economic losses above 100%.



1970 1980 1990 2000 2010 2020

Avalanche, Cold wave, Drought, Extra-tropical storm, Flood (general flood, flash flood, riverine flood, coastal flood), Forest fire, General storm, Hail, Heat wave, Land fire (Brush, Bush, Pasture), Landslide, Lightning/Thunderstorms, Mudslide, Severe winter conditions, Tornado, Tropical cyclone, Winter storm/Blizzard

Sources:

Centre for Research on the Epidemiology of Disasters, 2023: EM-DAT: The International Disaster Database, https://emdat.be.

The World Bank, 2023: Data, GDP (current US$), https://data.worldbank.org/indicator/NY.GDP.MKTP.CD.

Note: the hazard classification is based on EM-DAT hazard type; the bubbles are event-specific; the size of a bubble relates reported economic losses from weather-, climate- and water-related extremes to countries' annual Gross Domestic Products.

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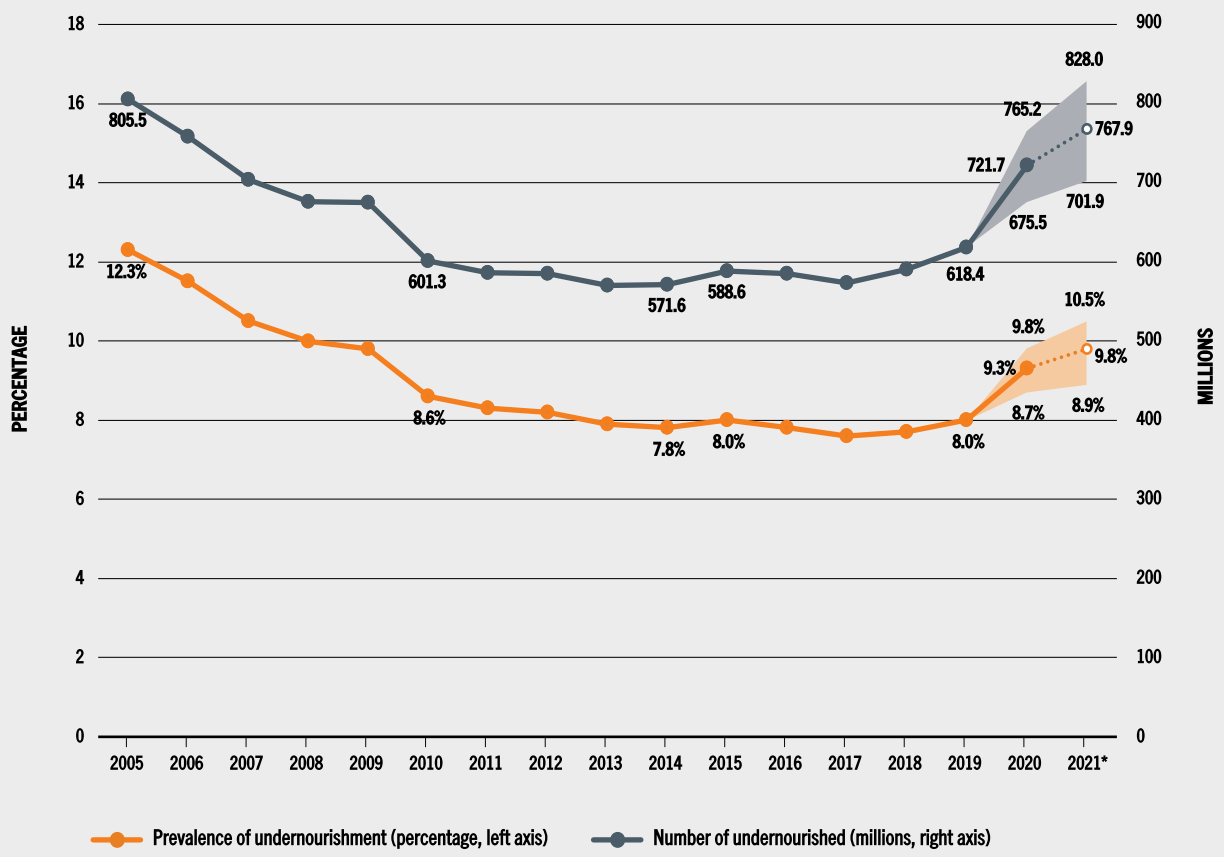
Socio-economic Impacts



NOTES: * Projected values for 2021 are illustrated by dotted lines. Shaded areas show lower and upper bounds of the estimated range.
SOURCE: FAO.

Populations facing acute food insecurity

exacerbated by hydrometeorological hazards

- 22.5-23.4 M (million) in Ethiopia, Kenya & Somalia
- 28 M in Latin America & Caribbean
- 18.9 M in Afghanistan (45% of the population)
- 7 M in South Sudan

Internal displacements

associated with hydrometeorological hazards

Floods & Storms

- 8 M in Pakistan
- 1.1 M in Bangladesh
- 665,000 in Brazil

Drought

- 1.2 M in Somalia
- 512 000 in Ethiopia

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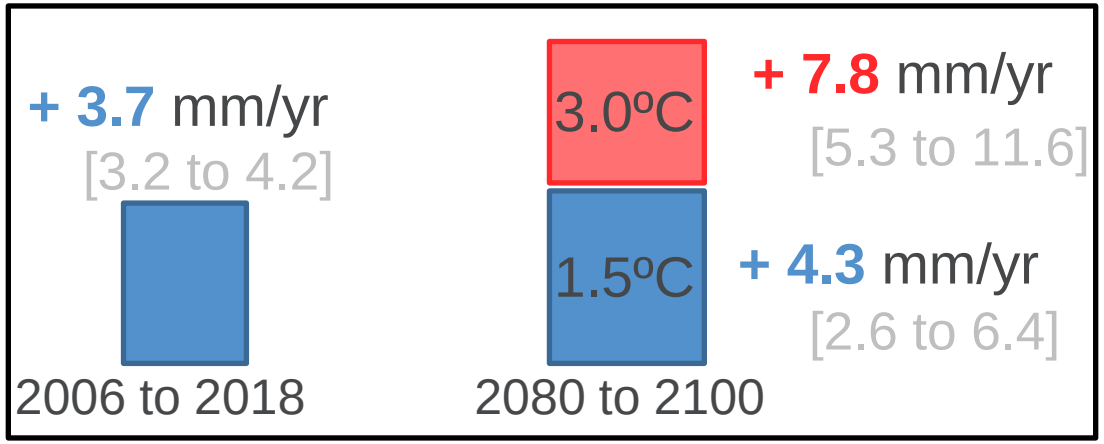
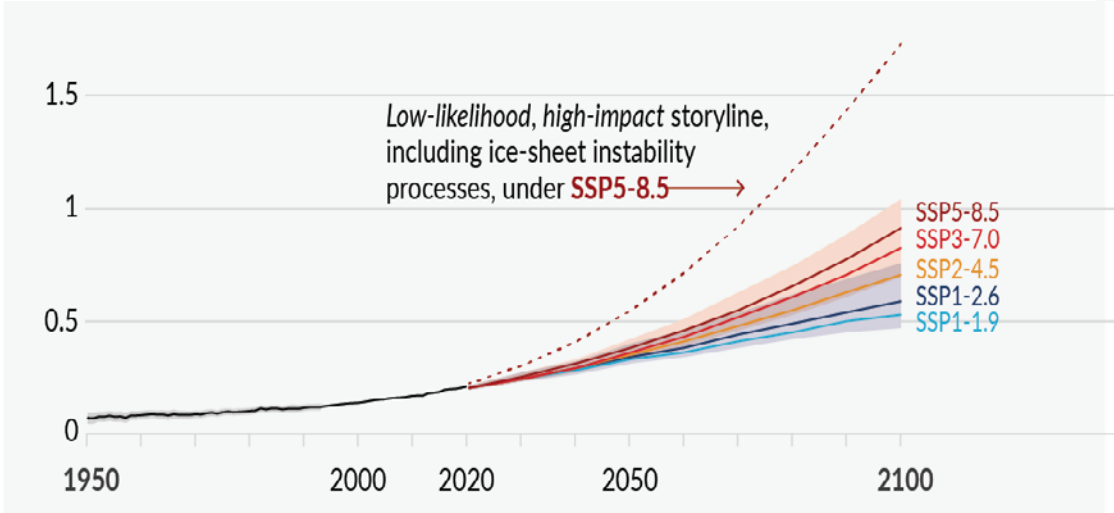
WMO IMO-WMO 1873 2023 150

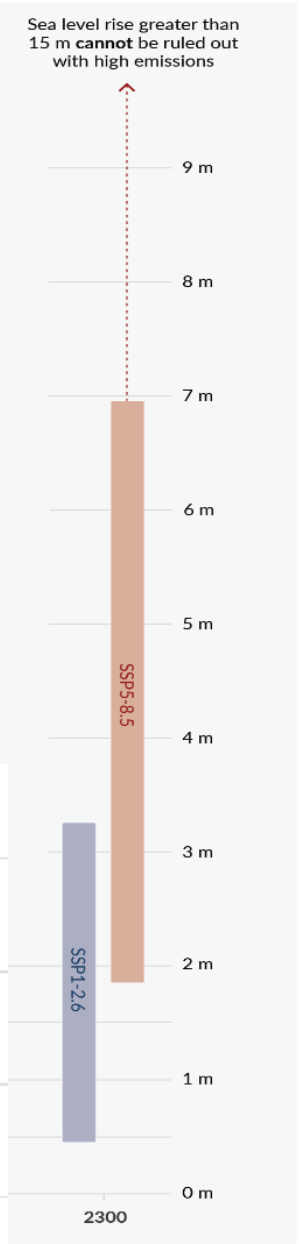
Future sea level rise

- By 2100 projected global mean sea level rise:
  - 0.32-0.62 m under the low GHG emissions scenario (SSP1-2.6)
  - 0.55-0.90 m under the high GHG emissions scenario (SSP3-7.0)
- Up to an additional metre of sea level rise by 2100 under a low likelihood, high impact (LLHI) storyline.
- Sea level rise will continue for centuries.
- Rate of sea level rise can only be slowed by limiting warming.



IPCC AR6 WG1 Table 9.10
LLHI storyline: 15.8 [8.6–30.1] mm/yr





IPCC AR6 WG1 SPM.8

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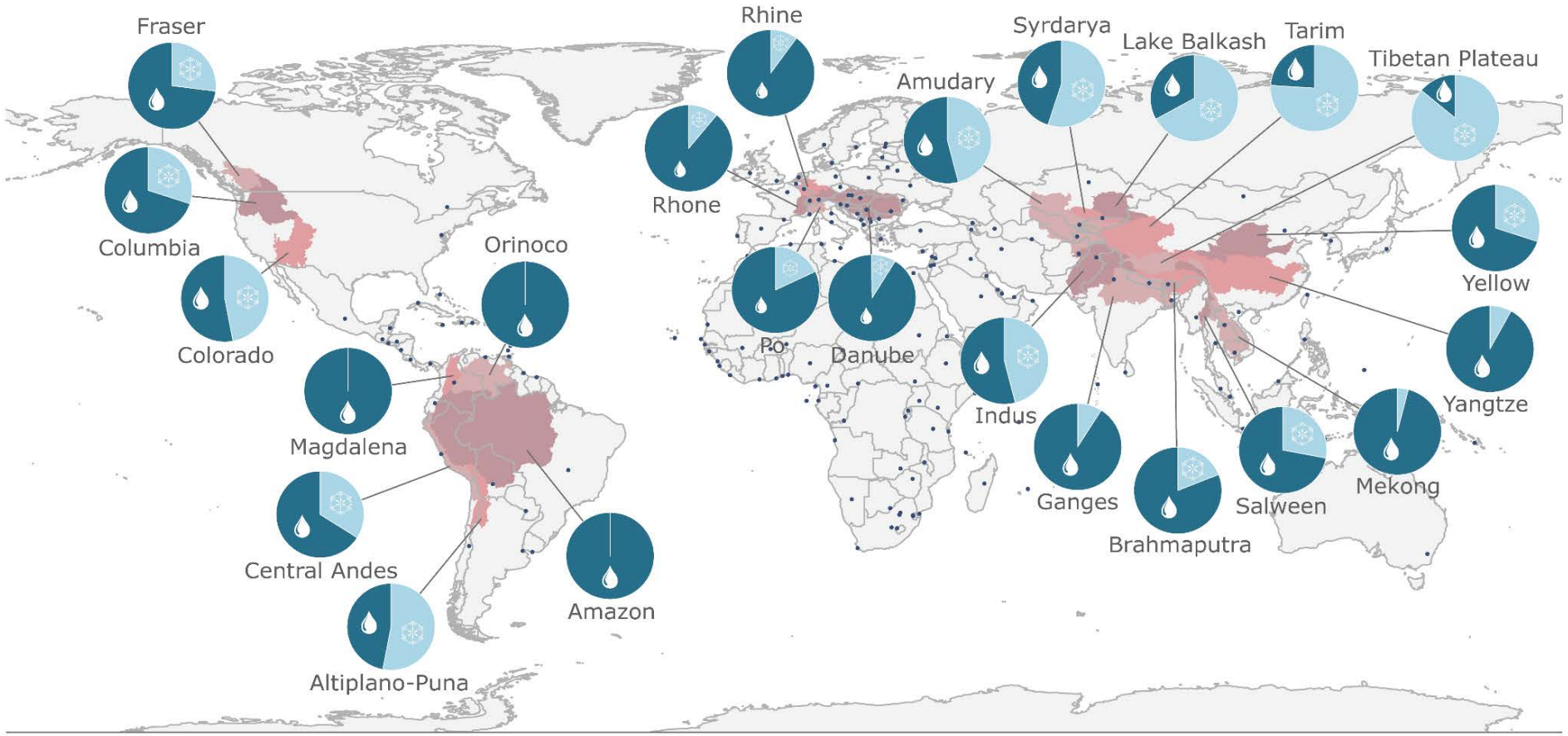
Water from glaciers/rainfall

Contribution of the cryosphere to water availability (in selected river basins of Asia, America and Europe)



Data in "Towards mountains without permanent snow and ice" by Huss et al., 2017 (Table 2 - period: from 1998 to 2012).

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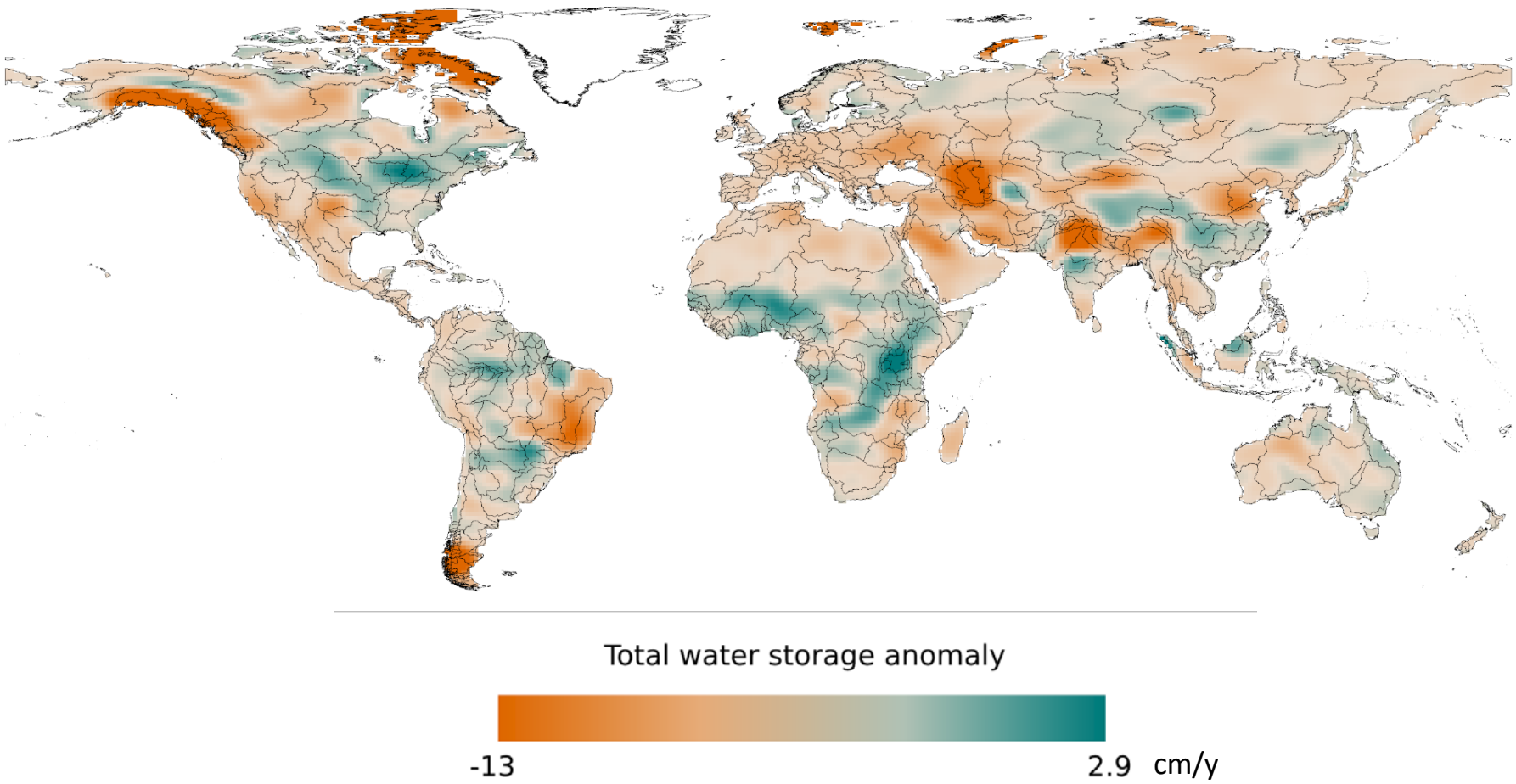
Total Water Storage Trends 2002-2021



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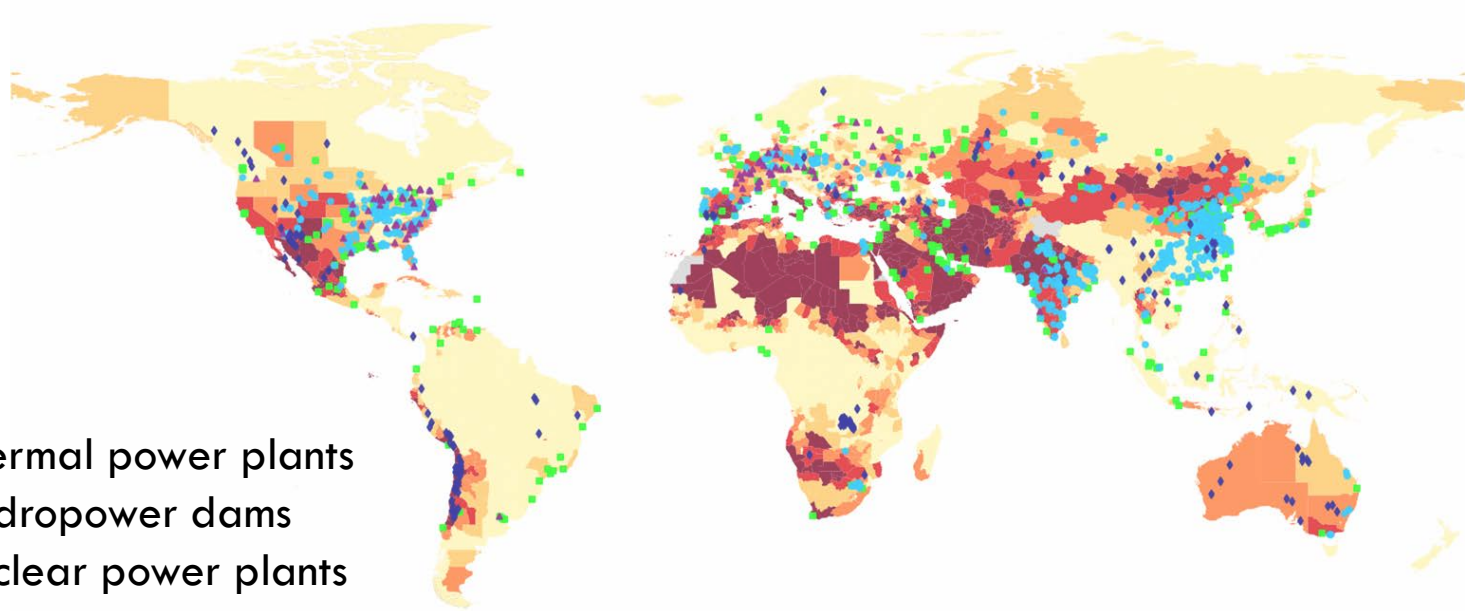
Climate change is a challenge for energy



33% of thermal power plants
26% of hydropower dams
15% of nuclear power plants

located in **high water stress areas**

Low (< 10%) Low-medium (10-20%) Medium-high (20-40%) High (40-80%) Extremely high (> 80%)
Thermal power plants Nuclear power plants Refineries Copper mines

(IEA, IAEA)

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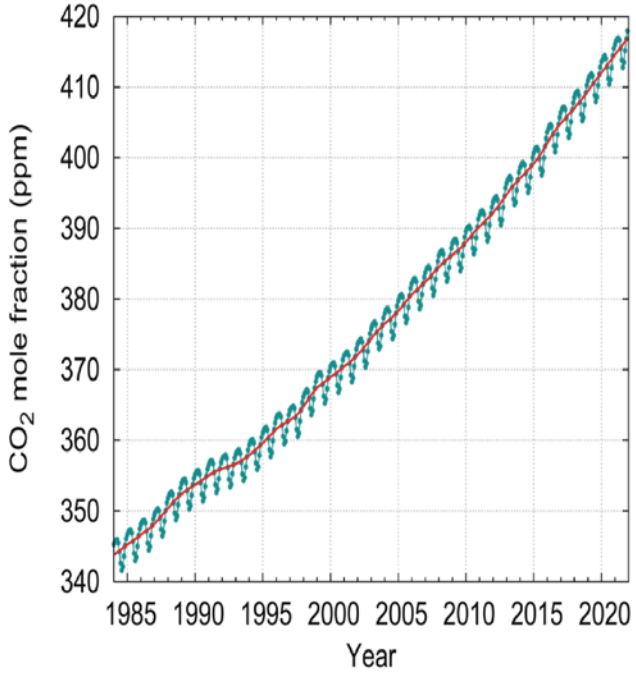
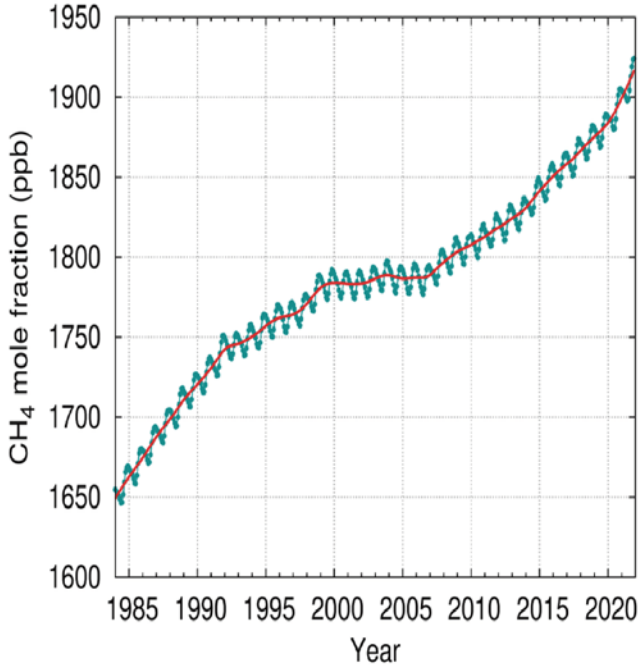
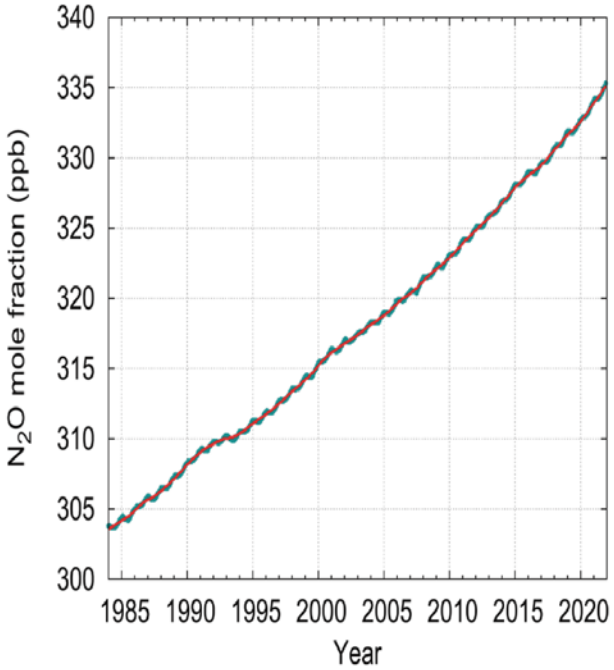
Greenhouse gas concentrations (CO_2, CH_4 and N_2O) continue to rise to new record highs



Carbon dioxide levels **+149%**



Methane levels **+262%**



Nitrous oxide levels **+124%**

of pre-industrial levels (before 1750)

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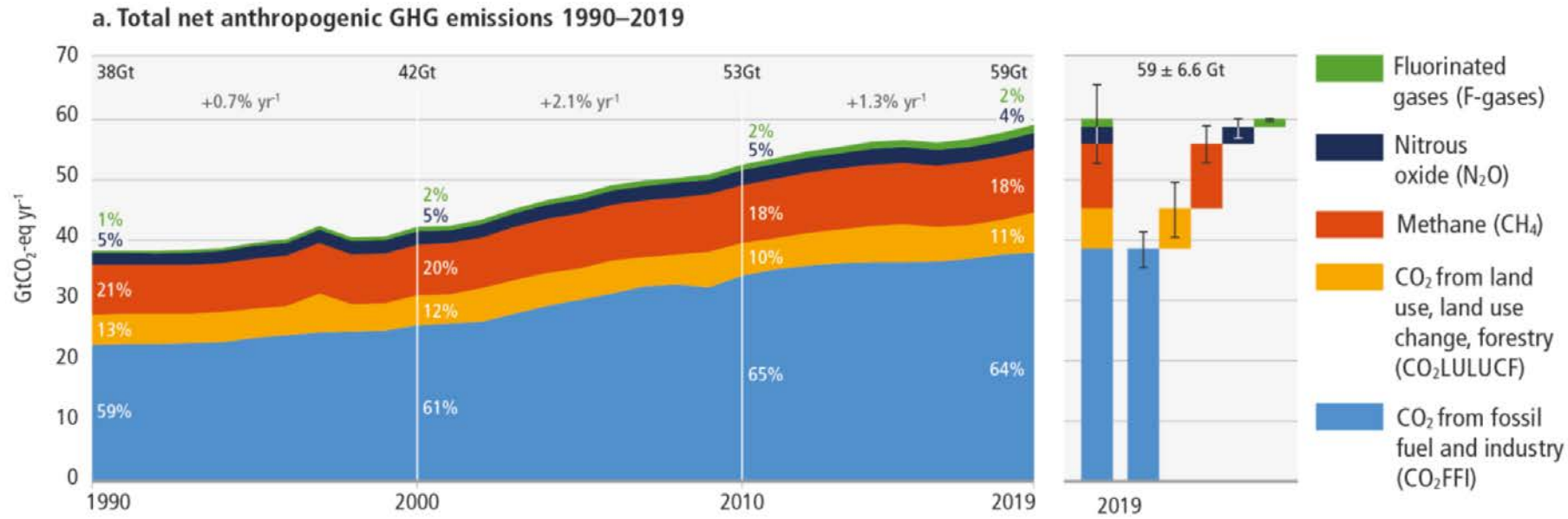
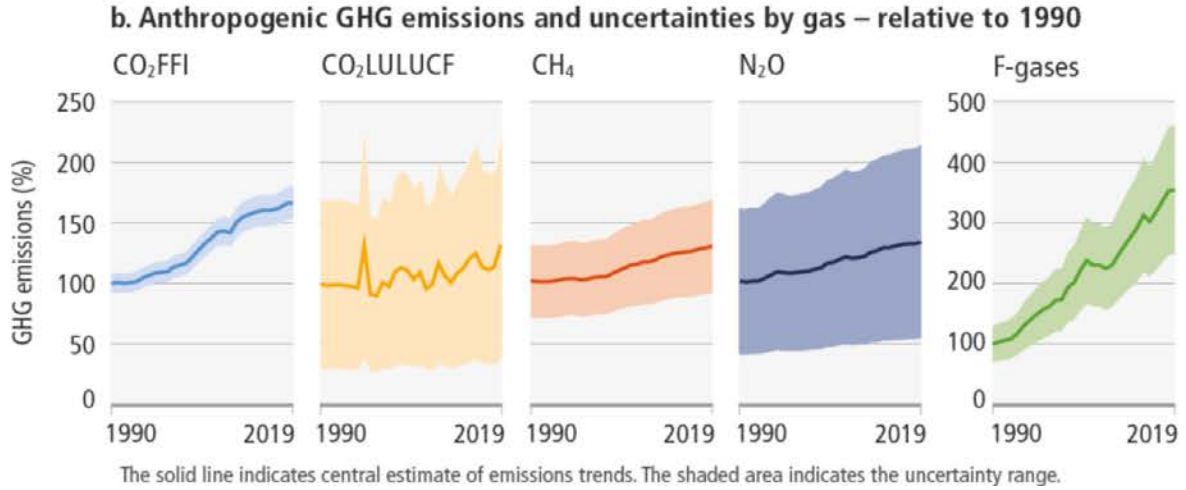
Greenhouse gas emissions 1990-2019





The solid line indicates central estimate of emissions trends. The shaded area indicates the uncertainty range.

	2019 emissions ($GtCO_2$-eq)	1990–2019 increase ($GtCO_2$-eq)	Emissions in 2019, relative to 1990 (%)
CO_2 FFI	38±3	15	167
CO_2 LULUCF	6.6±4.6	1.6	133
CH_4	11±3.2	2.4	129
N_2O	2.7±1.6	0.65	133
F-gases	1.4±0.41	0.97	354
Total	59±6.6	21	154

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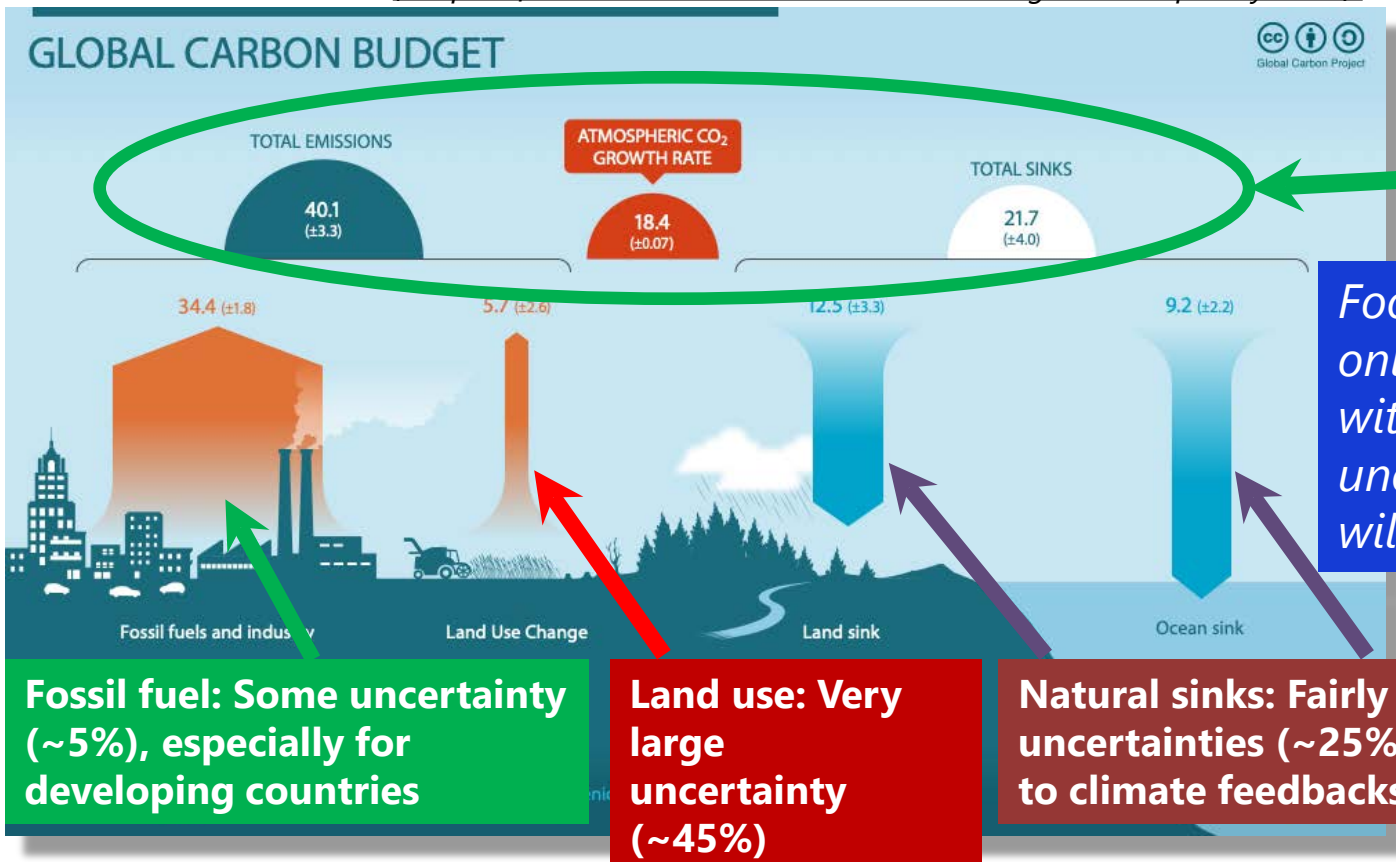
How well do we understand the CO_2 budget ?

(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

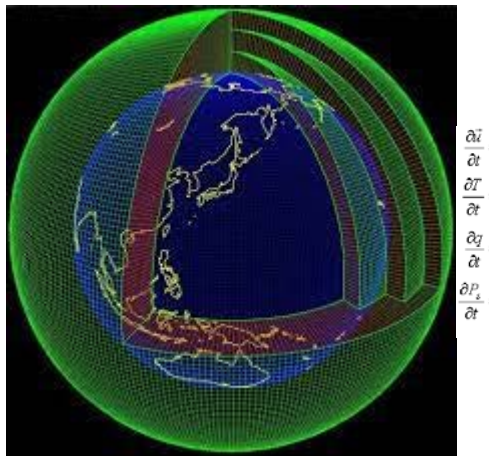
Land use: Very large uncertainty (~45%)

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

GAW+Satellites+models => Global Greenhouse Gas Watch

NASA OCO, JAXA Ibuki, CHINA Tansat already exist

+



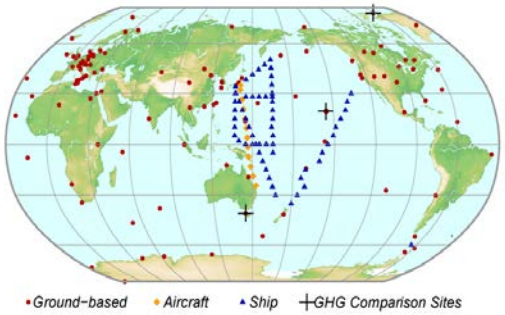
$$\frac{\partial \vec{u}}{\partial t} = -\vec{u}\cdot\vec{\nabla}\vec{u} - \dot{\eta}\frac{\partial \vec{u}}{\partial \eta} + 2\vec{\Omega}\times\vec{u} - RT\vec{\nabla}(\ln(P)) - \vec{\nabla}\phi$$

$$\frac{\partial T}{\partial t} = -\vec{u}\cdot\vec{\nabla}T - \dot{\eta}\frac{\partial T}{\partial \eta} + \frac{R}{C_p}T\frac{\omega}{P}$$

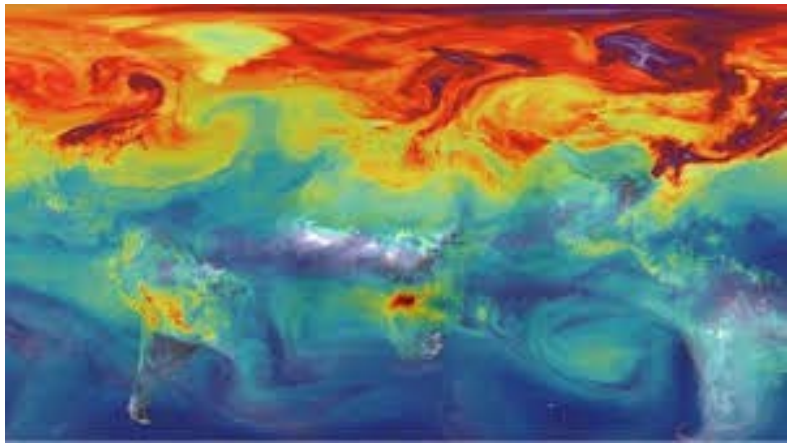
$$\frac{\partial q}{\partial t} = -\vec{u}\cdot\vec{\nabla}q - \dot{\eta}\frac{\partial q}{\partial \eta}$$

$$\frac{\partial P_s}{\partial t} = -\vec{\nabla}\cdot\int_0^1 \frac{\partial P}{\partial \eta}\vec{u}\,d\eta$$

Atmospheric modeling & assimilation



European Copernicus 2025-



Real-time monitoring of CO_2, CH_4 and N_2O

- **Integrated, internationally coordinated global greenhouse gas monitoring system**
- **Better understanding if sources and sinks**
- **Support Paris Agreement implementation**
- **Strong support by UNFCCC & UN Climate Core Group**

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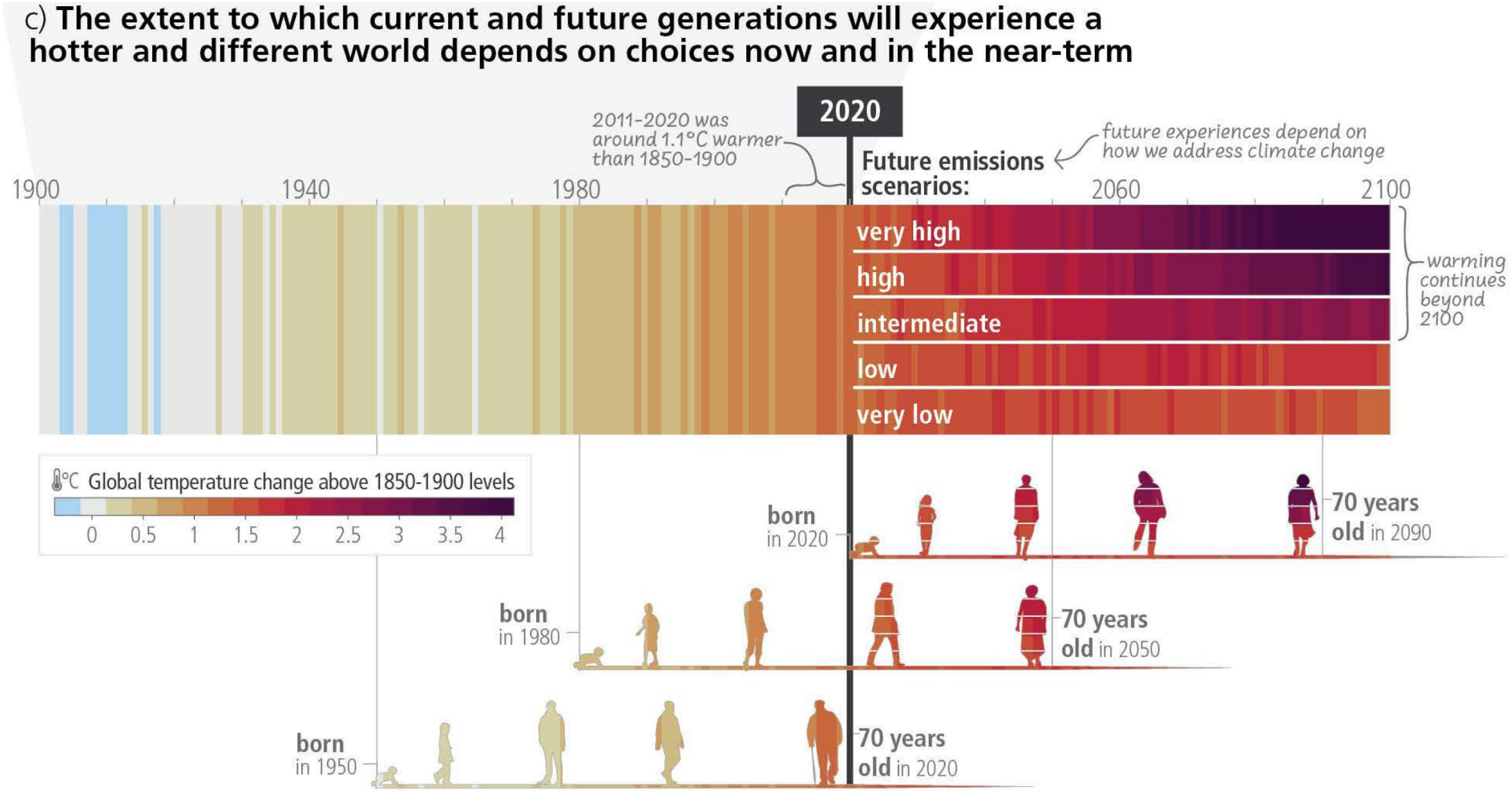
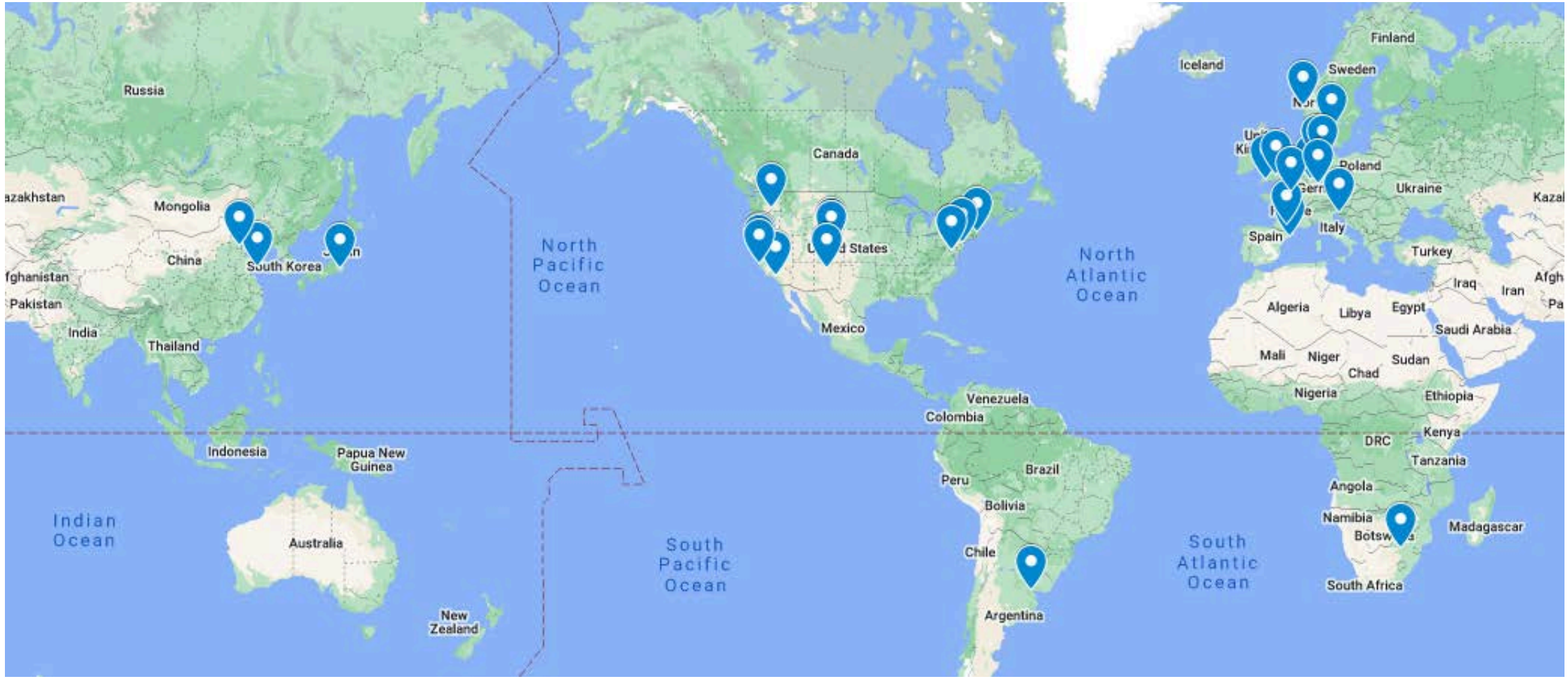
Possible climate scenarios 1900-2100



Map of km Scale Model Efforts: Regional & Global



21 different efforts identified. 12 global, 9 regional.
About ⅔ of these groups attended meetings in person or virtually.

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WMO's Open Consultative Platform (OCP)

"PARTNERSHIP AND INNOVATION FOR THE NEXT GENERATION OF WEATHER AND CLIMATE INTELLIGENCE"

OCP-HL-1 (High-Level Round Table), June 2019

OCP-HL-3 on Evolving Roles and Responsibilities – Future of NMSs, June 2022

- The **Open Consultative Platform (OCP)**, established on the occasions of the 18th World Meteorological Congress in 2019, **serves as an open, constructive and participatory framework** for addressing the grand challenges of the global weather enterprise.
- In the spirit of collaboration, mutual respect, and trust, **the Platform enables all stakeholders to stay abreast of issues and opportunities**, both institutional and technological, **to motivate collaborative, win-win approaches and to nurture innovation**.
- **WMO plays a central global role** in facilitating the cooperation of Member States and Territories and their weather enterprise stakeholders.

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Needs/concluding remarks

@ Future of weather extremes

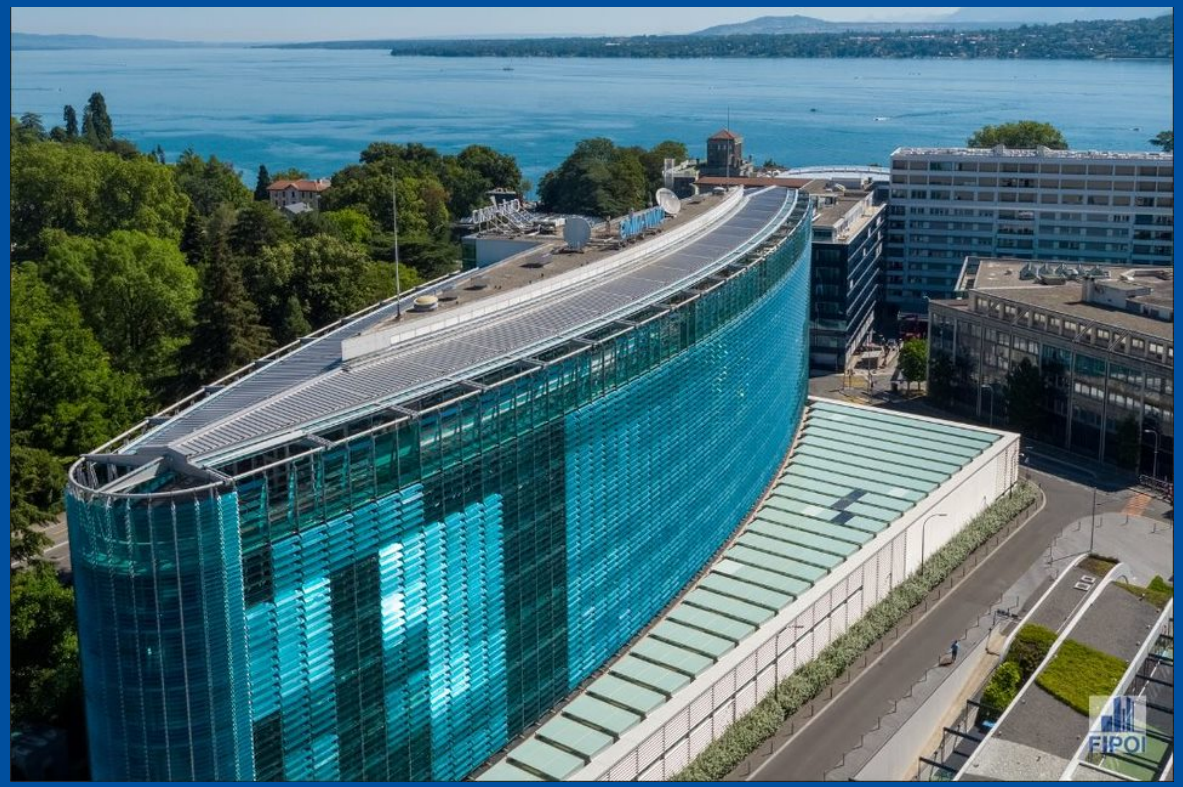
@ Hydrological cycle including cryosphere

@ Risks of Solar Radiation Modification

@ Sea level rise, especially contribution of Antarctica

@ WMO is interacting with COP-28 presidency to promote support for EW4ALL, GGGW & km-scale climate modelling

@ The issues will also be handled at UN Climate Action Summit September in NY and Science Conference October in Kigali



شكرا لكم
Thank you
Gracias
Merci
Спасибо
谢谢

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

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World Meteorological Organization
Organisation météorologique mondiale