The World Climate Research Programme (WCRP)

The Kigali Outcome: Climate Science for a Sustainable Future for all

Detlef Stammer (WCRP JSC Chair)

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WCRP 2023 Open Science Conference

- **Transformative conference**, with many contributions from the impact and social sciences underpinning WCRPs vision of climate science to ensure a more resilient present and sustainable future for humankind.

- **Conference was held in Africa** in recognition of the **disparities in the drivers and consequences** of climate change around the world; persistent **inequities in the global scientific community** that undermines and disadvantages the knowledge contribution from communities in resource poor nations; and a **collective commitment to address both.**

- Almost **1500 delegates participated in the hybrid event** (around 50% onsite). 32% of the delegates were from Africa and 26% from other regions of the Global South.

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Conference was organized along three overarching themes, each convening about 13 sessions:

Theme 1: Advances in Climate Research

Theme 2: Human Interactions with Climate

Theme 3: Co-produced Climate Services and Solutions

Overarching topics were discussed in daily "Plenaries"

- Climate Change and Society
- Climate Change and the Earth System
- Climate Change Solutions

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WCRP OSC Delegates Acknowledged

- **The world is in a state of polycrises leading to cascading systemic risk and increasing inequality**, with unabated climate change being one of the greatest threats to humanity.
- **Probability is rising for complex and compound extremes,** leading to cascading hazards, severe weather events, prolonged droughts, heatwaves, devastating floods and landslides, and wild/forest fires.
- **Human-induced changes have led to profound and widespread changes**; global surface temperatures soon surpassing 1.5°C.
- **Any further delays to climate change mitigation and societal transformations (adaptation) will exacerbate the impacts** and demand enhanced adaptation and mitigation responses.
- **Requires urgent unprecedented societal and technological transformation on a global scale**, for immediately attaining net zero carbon emissions.

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Global community to urgently act to address climate change by

- **Committing to significantly increased ambition for climate mitigation and adaptation, upholding fair principles** and accelerated process of phasing out fossil fuel energy systems; improving climate knowledge and developing climate decision support systems at global and regional levels.
- **Implementing transformative, ethical and equitable solutions that are feasible, scalable and fit for purpose to manage complex risks** of inevitable climate impacts. This includes effective nature-based and technological solutions and behavior change.
- **Pledging to develop inclusive, diverse and equitable global knowledge partnerships between science and all sectors of society** (incl. indigenous knowledge) for accelerated and transformative action over a 10 to 20-years with emphasis on context-specific and demand-driven needs, and collaborative leadership from around the world.
- **COP28 needs to inject new urgency into climate action and societal transformation, especially in light of the current global stocktake and NDC assessment.**

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Climate science community to enabling transformative actions by

- **Committing** to give **equal visibility, voice and opportunity** to early career scientists, marginalized scientists, and historically disadvantaged scientific communities, and access to resources.
- **Expanding the scope of climate research and collaborations, to bring integrated knowledge to the understanding** of human systems, ecosystems, biodiversity.
- **Advance trans-disciplinarity engagement with policymakers and the broader public in the co-design and co-creation of actionable knowledge.**
- **Prioritizing pathways for translating observations and model data into actionable climate information for informed decision-making and resilience building**; addressing critical data gaps in cities and informal settlements, the oceans, and data sparse regions.
- **Advocating the practices of open science and open education**, and work with the global science funding communities to support their **effective adoption in the Global South**, raising value of regional knowledge.

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Agencies, governments, private sector to work with climate science

- **Mobilizing resources to sustain fundamental and solution-oriented climate science** needed to develop actionable climate information, implement climate adaptation options.
- **Providing improved climate change projections with context-relevant information down to cities scale**; tools and data infrastructure to make these data usable by all to support climate relevant decision-making.
- **Enhancing long-term, sustained and accessible observations and paleoclimate reconstructions**, both remotely sensed and *in situ,* to increase space/time coverage; to monitor behavior impact, to improve climate assessments and projections.
- **Establishing improved climate information and early warning services, at local and regional scales** - to provide information for adaptation, disaster risk and reduction strategies.

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- Detailed conference outcomes will be made public in the
  - “Kigali Declaration: Climate science for a sustainable future for all"
  - as well as around 20 concept papers.

- They will be summarised in the following contributions focussing on a selected set of topics.

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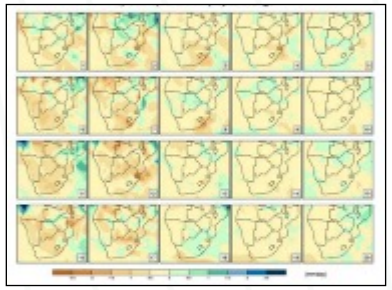
Bruce Hewitson

“Reginal information [for policy and decision]
The “global south”, equity and climate justice”

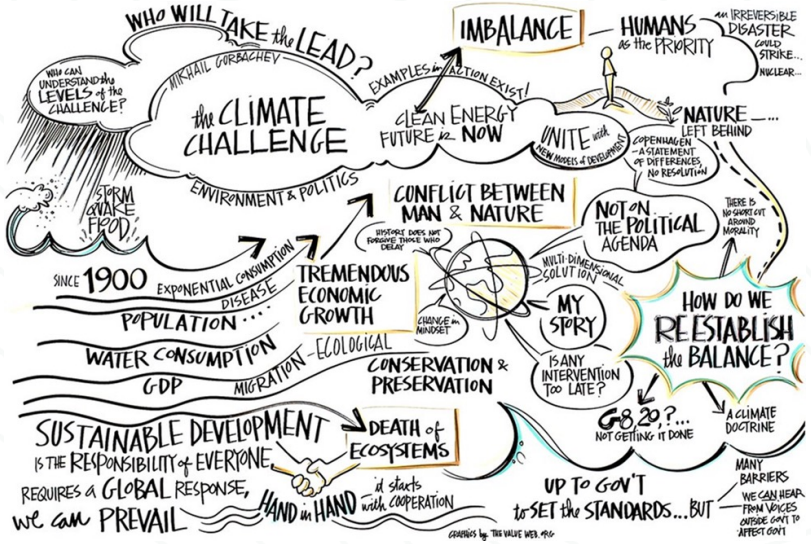
Regional Climate Information in Context

Knowledge = information + context

Scientific information vs application information



- A **rapidly expanding production of climate projection data** through multiple and complementary efforts promises significant advances for actionable information. *(CORDEX, CMIP, convection permitting and kilometer-scale models, and exploration of AI)*
- **The stakeholder context is a complicated space** where information is often constructed with simplified assumptions resulting in poor transparency, limited guidance, unexplained uncertainty, presumed authority, and creates a challenge for translating data into defensible and actionable information.



- **Policy and decision makers are accountable for socio-economic consequences** and thus require (mostly missing) measures of robustness of the regional information from a multiplicity of non-congruent data sources.
- A **supply chain of data via climate services organizations** is often weakly aligned to context, while **co-production of information** (can) distills information incorporating context yet is resource intensive and difficult to scale.
- **Climate services is a heterogeneous community** of widely different modalities leading to competing messages, and includes national, institutional, trans-border, and commercial activities.

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Regional climate information

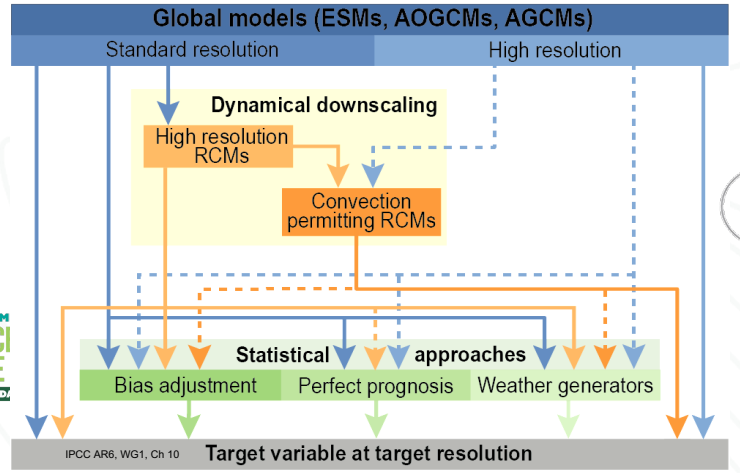
The dilemma:

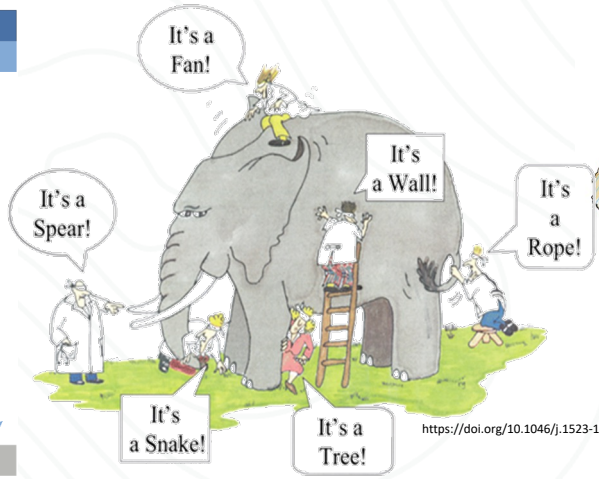
a) There is **more data than we can readily handle**, creating challenges to access and distill, and the data continue to grow rapidly.

b) The policy and decision makers **choice of data leads to contrasting messages and outcomes** that are difficult to assess as adequate-for-purpose.

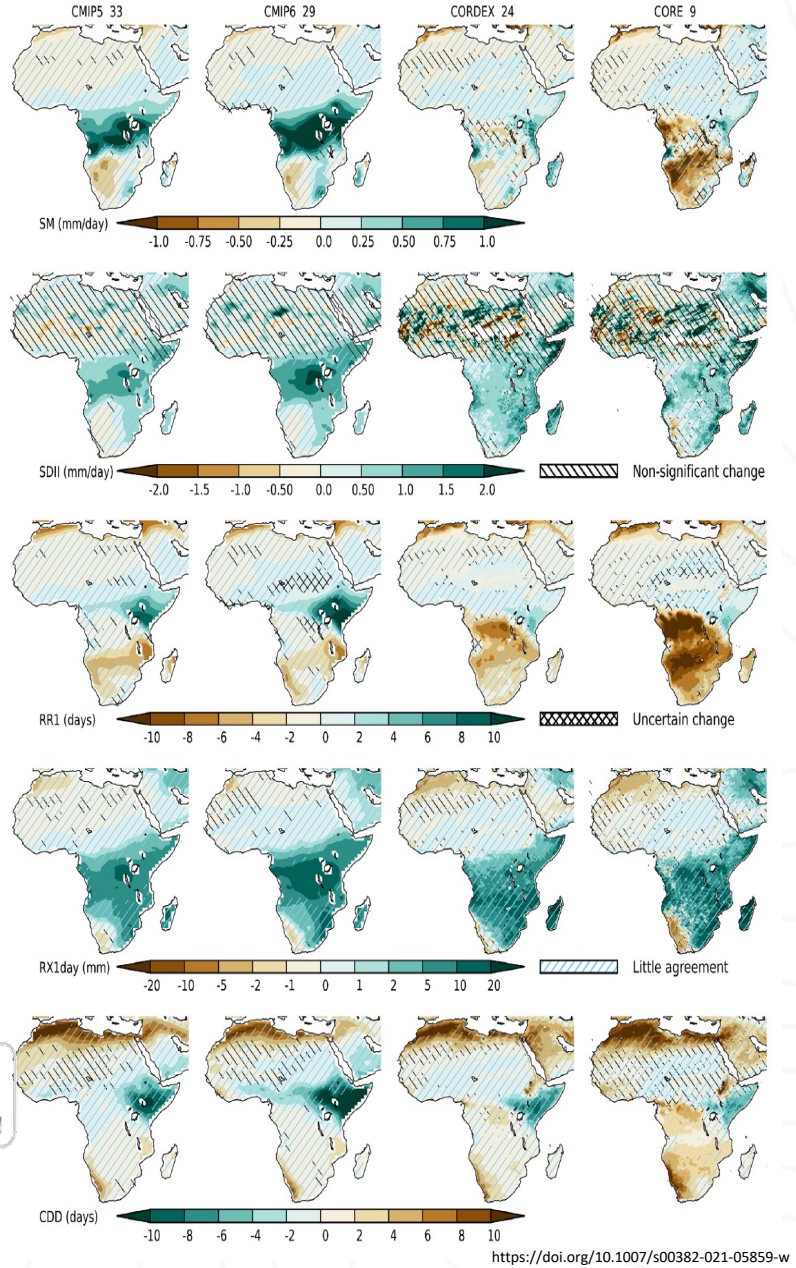
The challenge:

To resource the scientific community to develop and coordinate community-wide, accepted, and systematic approaches to *assess the robustness of the non-congruent data for actionable information.*





https://doi.org/10.1046/j.1523-1755.2002.00600.x



https://doi.org/10.1007/s00382-021-05859-w

Regional climate information: additional scientific challenges

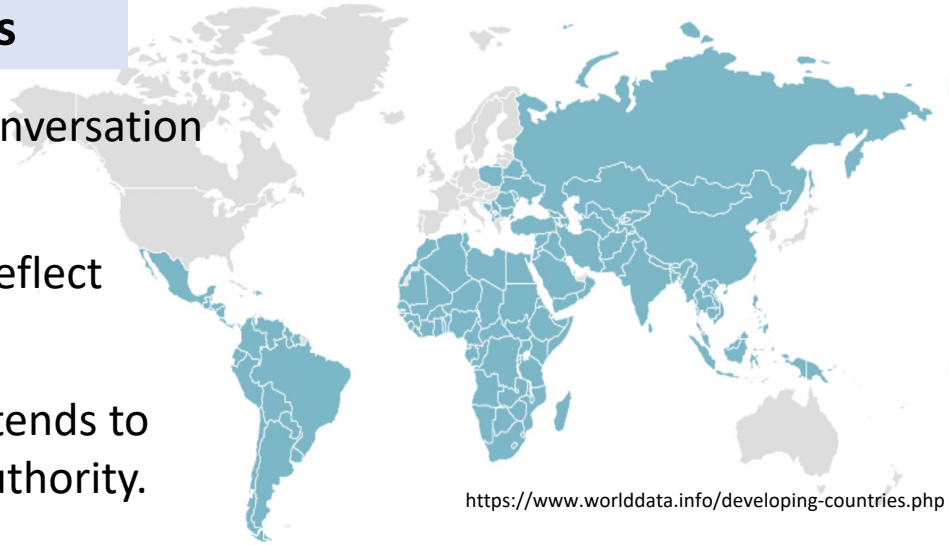
- **Regional tipping points are a matter of concern.** While much is being done on global tipping points there is a paucity of such science at regional scales, and there is arguably a need for a regional tipping point model intercomparison project.

- **Open data sources that are accessible by the full global community are fundamental** to provide traceable, reproducible and verifiable climate predictions, including open sharing of observational data.

- **There are significant technological and data storage challenges** from the evolving modeling efforts, yet these data have the potential to improve understanding of critical regional processes and local scale forcings crate (e.g. convection permitting, and km-scale resolution, urban modeling, etc.).

- **A rapid escalation of effort is needed to support communities in extracting the relevant information** to inform decision-making processes.

The global south and (in)equity in climate science: the ratio of voices



https://www.worlddata.info/developing-countries.php

- **The OSC2023 participant majority was from the global south** and the conversation on disparity and inequity threaded through all conversations
- **The terminology of "global south" and "global north" is inadequate** to reflect resource differentials and power relationships that occur at all scales.
- **The language of the "north" conveys a power relationship:** the "north" tends to speak of "including the south" which indicates a position of convening authority.
- **The south articulates an exclusion from co-convening the science agenda** and leads to a sense of disempowerment, extractive partnerships, and a sentiment that the north inadequately understands the lived experience of the south.
- **The South brings exceptional skills, context insight, and an innate capacity for transdisciplinary research** which may often be more developed than some of the north.
- **Climate literacy and context literacy are equally important.** Stakeholders are often poorly equipped to comprehend nuances and caveats of the science, while climate scientists are poor at comprehending the imperatives of local context
- **Lessons from failures have profound value** to align science with applications, yet these are poorly documented.
- **Engagement between north and south should begin from the design phase of any action** predicated on developing a comprehension of the lived realities .
- **A tension between cost-benefit and rights-based approaches** to science resource allocation and the modalities of collaboration, requiring the resource rich to relinquish some degree of authority.

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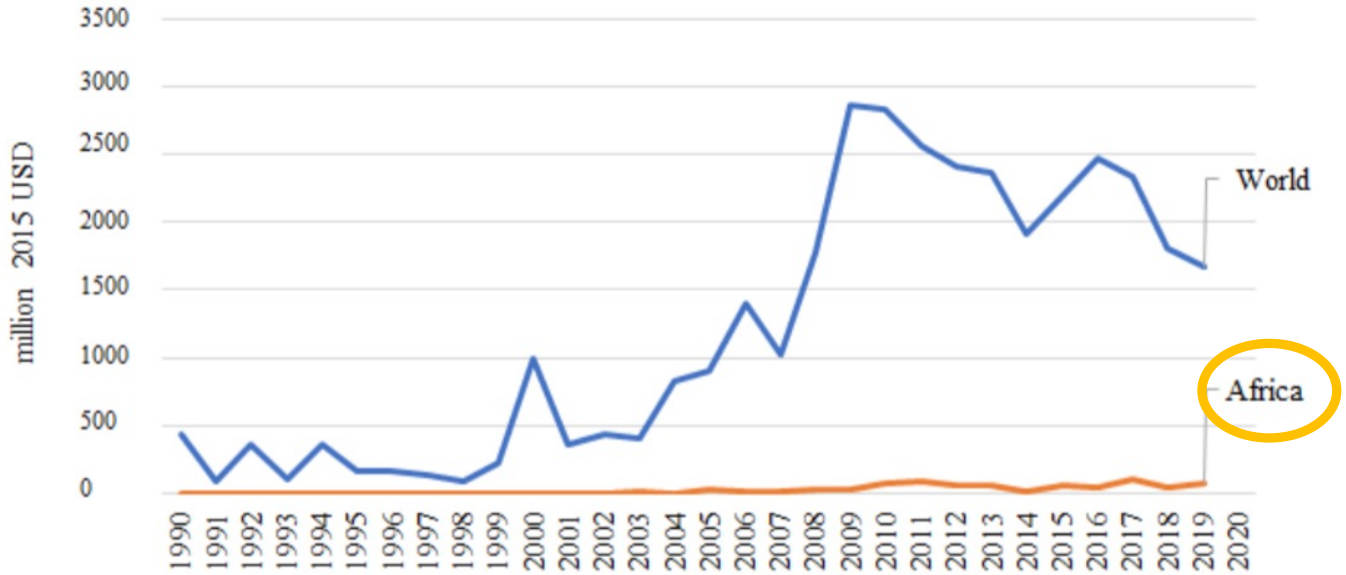
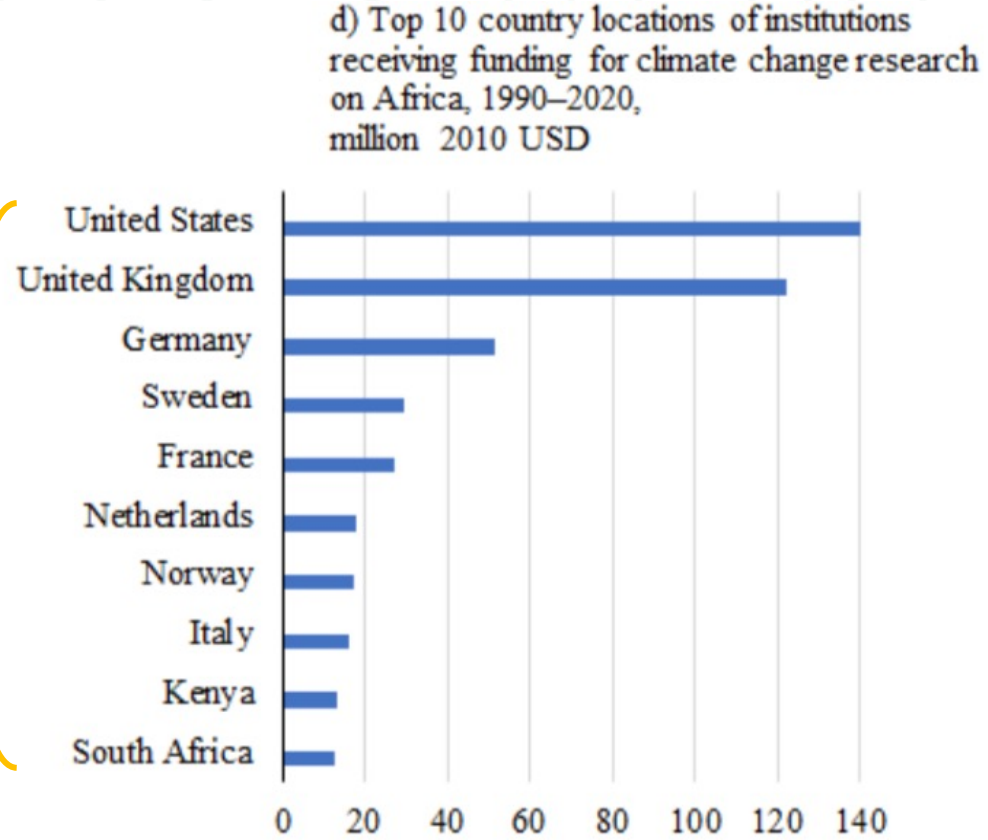
The most vulnerable of the world (~80% of the worlds population) is poorly resourced for undertaking research and for developing information that is context-aligned to stakeholder actions.

The Africa example:

Very little finance for research on climate change in Africa: **Only 3.8% of global climate change research funding was spent on Africa since 1990.**

Most funding for climate research that does address Africa goes to EU & US institutions with less than 1% received by African Institutions





IPCC AR6 WG2 Africa Chapter

Climate justice as it relates to the activities of climate science

For the practices of the climate science community, key issues include what does justice look like, who defines justice, and what are the optimum modalities of redress?

- **Communities with elevated vulnerability have legitimate needs to be part of convening the solutions**, and scientific inequalities must be addressed as fundamental rights. Enhanced collaboration, data sharing, and a holistic approach to developing understanding of climate change impacts is imperative.
- **A wider discourse on ethics within climate science is urgently needed.** It is commendable that IPCC now has some initial comments on inequity and climate justice. Future climate actions requires explicit ethical considerations of equity and justice, especially when predicated on regional climate information.
- **Inequities in climate science sit alongside gender, economic, and cultural inequities**, and exist internationally, regionally, and within country requiring a holistic perspective.
- **Capacity development is often inadequately context aware, and commonly reduced to "skills transfer".** Holistic capacity development for research, climate services, climate literacy, and assessing actionable information is critical to foster informed decision-making ensuring effective adaptation strategies.
    - **There is need to build capacity of the north to comprehend the lived experience of the south**. This includes scientists, institutions and funding agencies.
    - **Local customs and practices should frame risk communication methods and materials**, engaging the discourse of social, political and economic justice, human rights.

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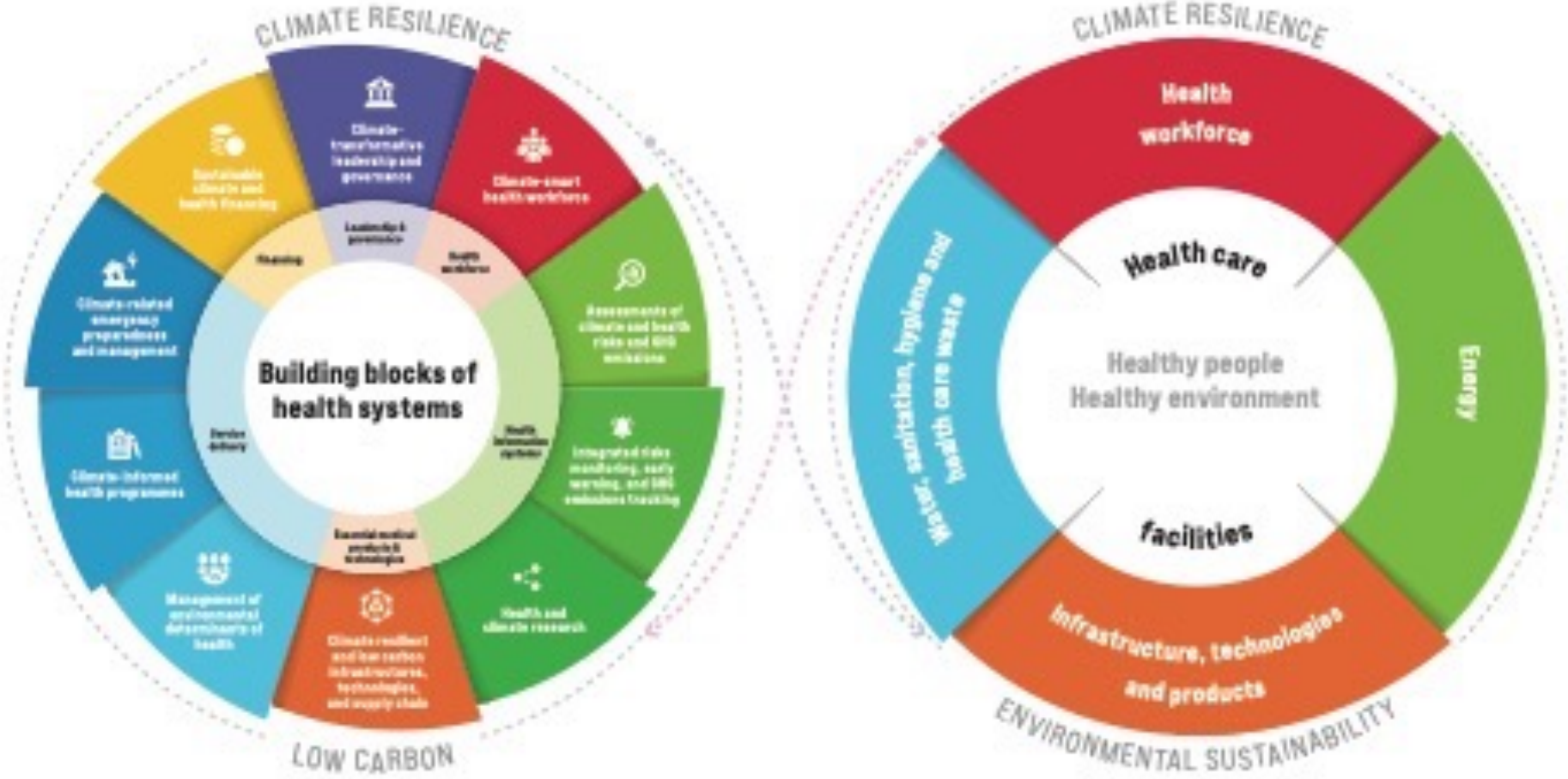
Kristie Ebi

"Human health and urban systems"

Health: priority is to build climate-resilient and environmentally sustainable health systems



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WHO 2023

Health: climate services

- New methods and tools are being developed
  - Integrated surveillance
  - Remote sensing
  - Seasonal to sub-seasonal forecasts
- Access to high quality data remains a challenge
- Sustained funding is needed to embed tools within disease control programs

Urban

- Need urban-resolved climate modeling across scales
  - Accurately represent urban characteristics and processes that can capture the feedback from urban areas to larger weather and climate processes
- Include human behavior in models, for example, energy use in buildings
- Urban climate modelling is essential to help plan cities
  - Increases in heavy rainfall in urban areas is becoming an increasing risk and better tools are needed for prediction and to manage this risk to health and wellbeing, to infrastructure and communities
- Research is need to better understand the role of aerosols on extreme rainfall events

Cross-cutting issues

- Communication is essential for the development of climate services
  - Develop a standard lexicon. WMO provides guidance on how to convey information on risks, including the uncertainties
- Development of climate services needs to consider the value of qualitative research (lived experience) and knowledge about behavior
  - Understanding behaviors (in terms of climate risks and coping strategies) is essential to ensure that climate services benefit all members of a community
  - There is evidence of differential access to climate information between women and men, so a gender perspective should be included in climate services research

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Francisco (Paco) Doblas-Reyes

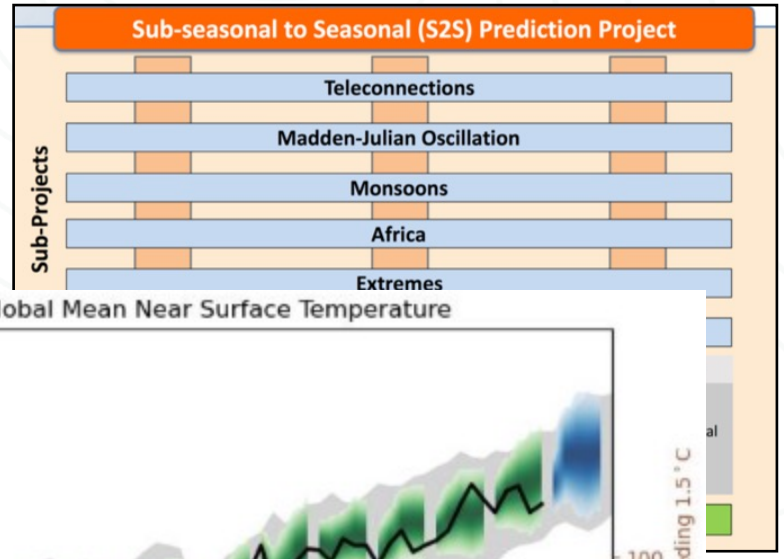
"Climate Prediction, Early Warning and Climate Services"

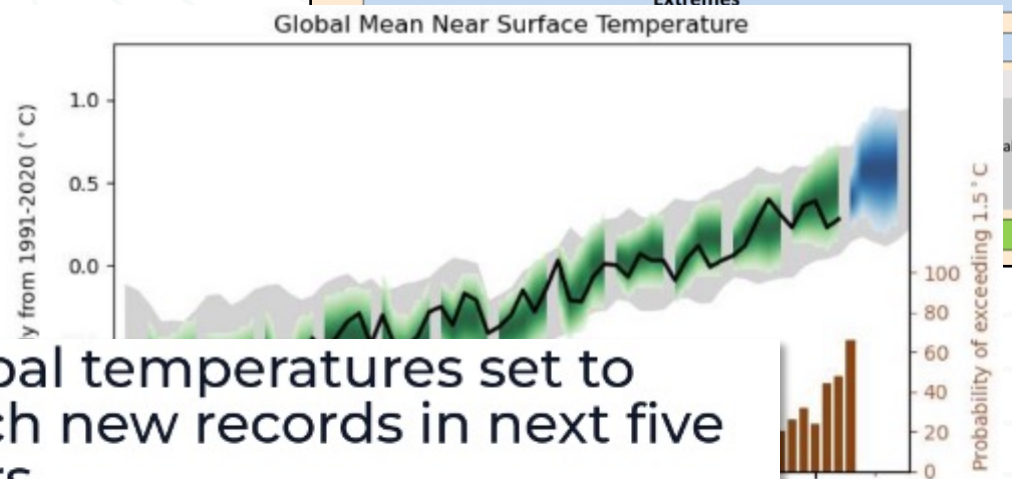
Climate prediction

Advance research in subseasonal to interdecadal prediction in collaboration with operational activities and societal applications

It relies on WGSIP and DCPP, as well as some lighthouse activities:

- Developing ***numerical experimentation, machine learning and analysis*** for climate prediction (of both physical and chemical states) over a range of time scales, ***assessing and improving predictions*** *and fostering uptake by operations*
- Addressing the needs for ***data assimilation and ensemble generation***
- Making climate prediction information ***societally relevant*** and entering ***the communication challenge***





Global temperatures set to reach new records in next five years

NEWS

17 May 2023

Global temperatures are likely to surge to record levels in the next five years, fuelled by heat-trapping greenhouse gases and a naturally occurring El Niño event, according to a new update issued by the World Meteorological Organization (WMO).

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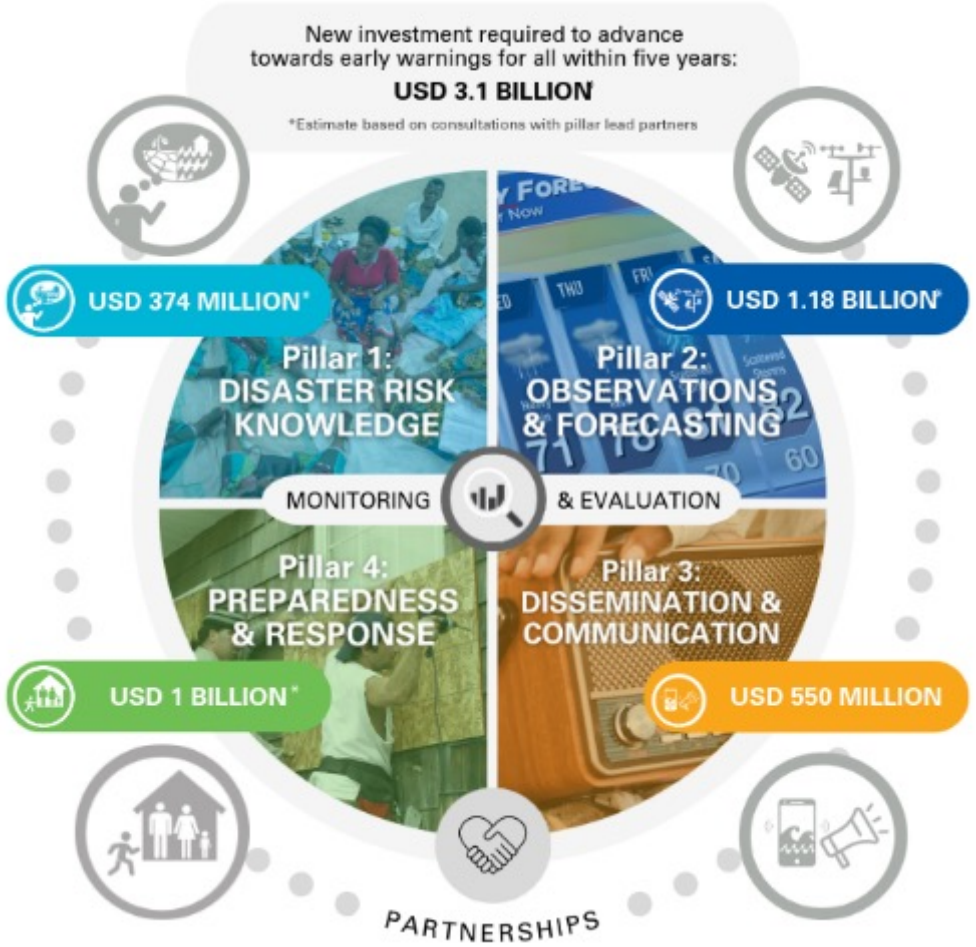
Early warnings

Contribute to the global assessment of observation, monitoring and forecasting of hazards

The whole Programme, and in particular climate prediction and attribution efforts, play a role:

- Contributing to how the ***observing gaps for monitoring hazards*** can be closed
- Enhancing capacity to ***detect, predict and attribute hazards***
- Identifying research priorities to ***optimize international efforts on observation and forecasting***
- Illustrating how to ***upscale regional initiatives*** to share data products



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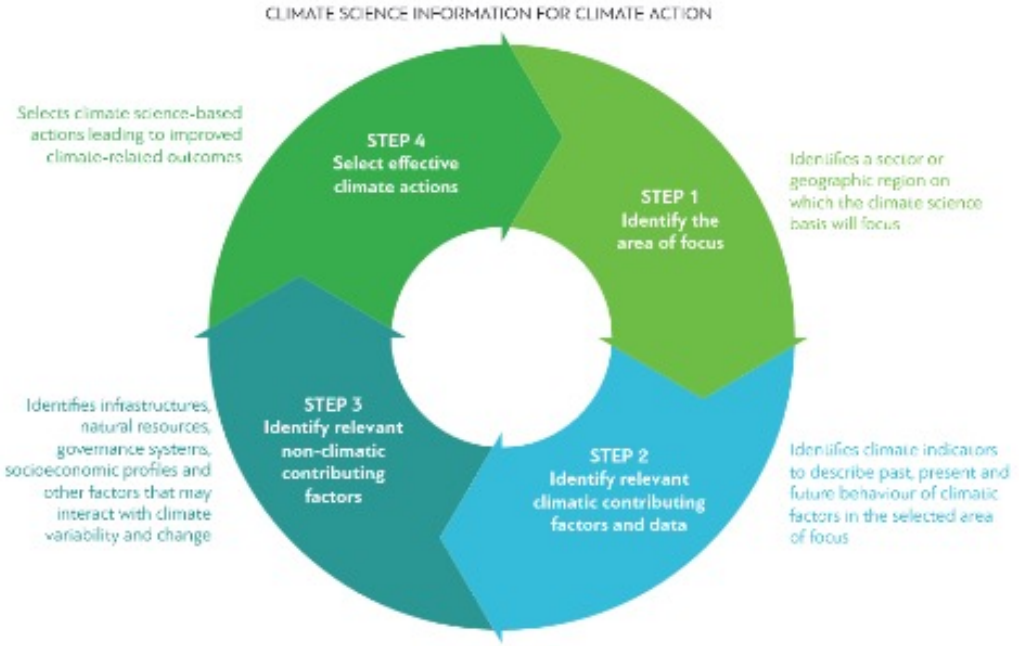
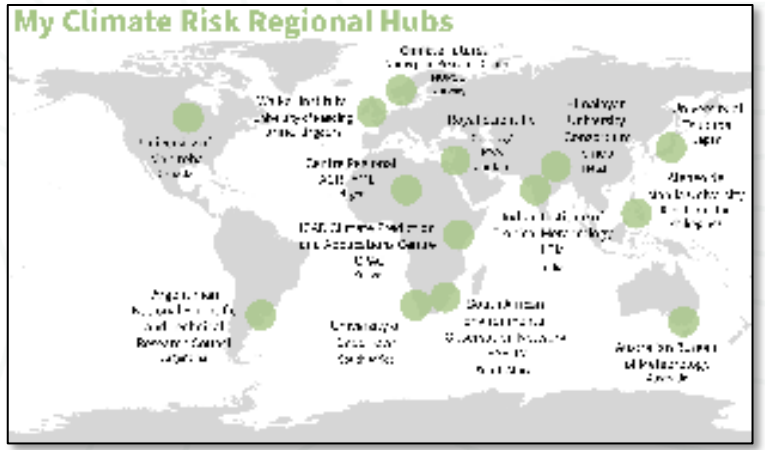
Climate services

Underpin the development of sources of climate information for climate-related decision making at both global and local scales

RIfS, ESMO and My Climate Risk are key elements for the research on and the implementation of climate services:

- Providing ***essential datasets*** like CMIP and CORDEX that are a key source of future climate information for adaptation and mitigation
- ***Understanding climatic drivers and forcings*** that are relevant for decision making
- ***Bridging climate information and society***, with the complexity of local contexts and the challenge of accessing non-climatic data
- Formulating ***minimum requirements*** for climate services standardisation and scalability





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Operations, research and service

- Many (operational) climate products provided by research
- Open data availability leads to the (false) assumption “climate research=job done”
- Despite the impact, still limited support to fundamental research, especially in countries with economies in transition
- Efficient transfer of research to operations in a continuous dialogue needed:
  - transition research outcomes to cover user needs
  - address challenges posed by product shortfalls

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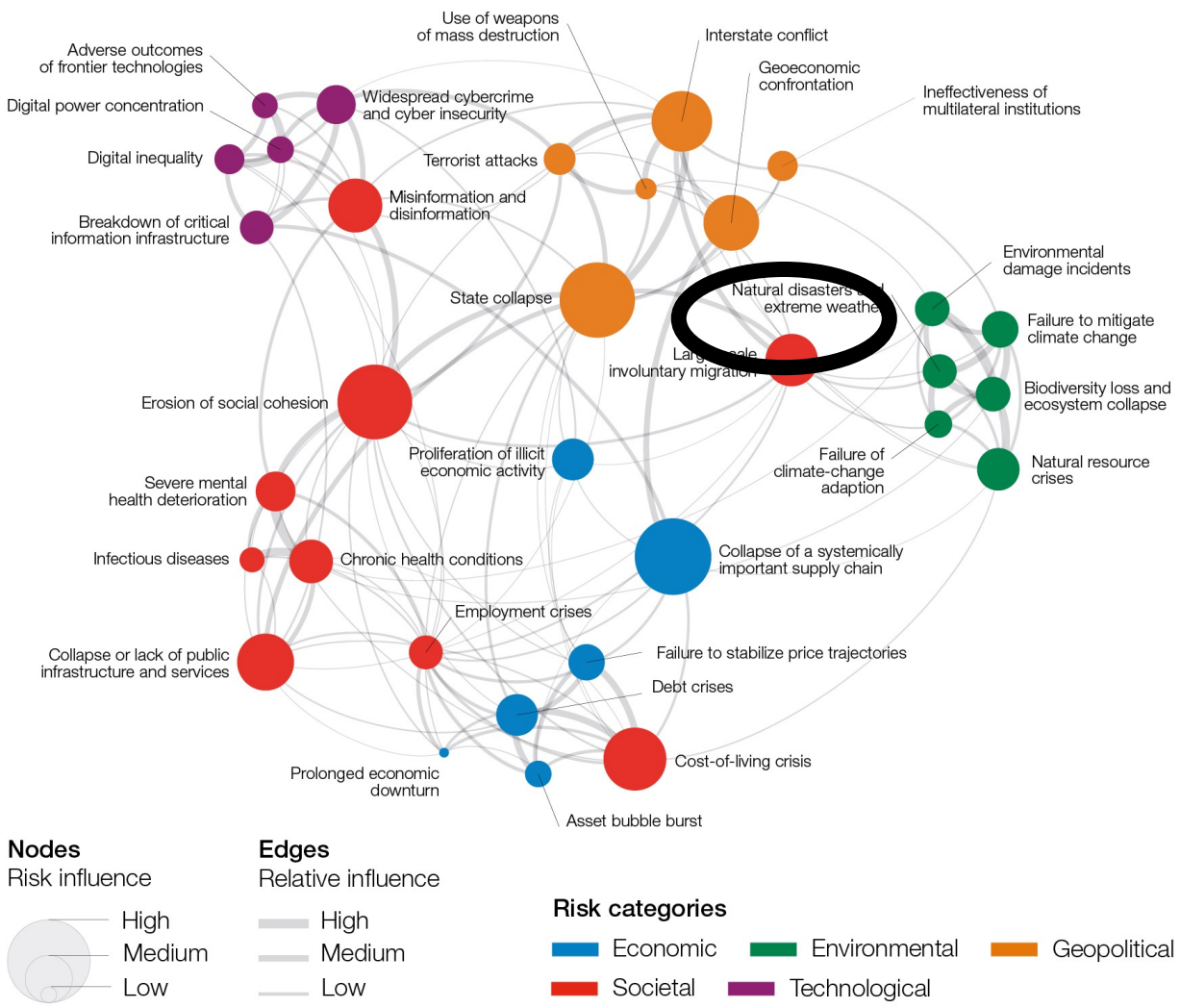
Jana Sillmann

"Extremes, Attribution and Adaptation"

Climate Change and Systemic Risk

- Climate change in the context of other crises and risks in a highly interconnected world.
- Climate change leads to disproportionate risks and harms to those who have done the least to cause the climate crisis – especially those living in the Global South.
- Climate change mitigation and adaptation as a matter of equity and justice.



Source: World Economic Forum, Global Risks Perception Survey 2022-2023

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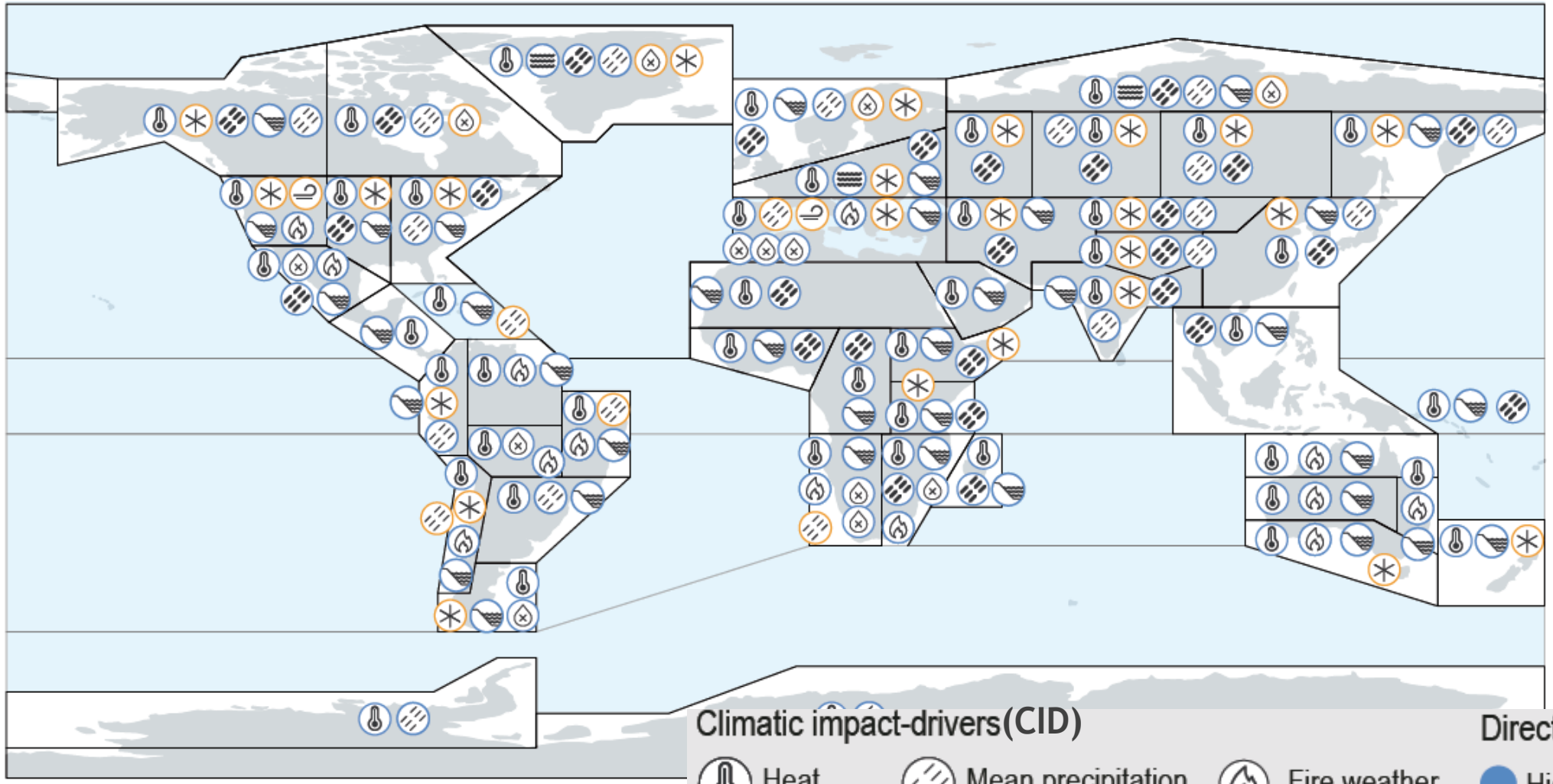
Multiple climatic impact-drivers are projected to change in all regions of the world



IPCC AR6 WGI, Fig 12.11

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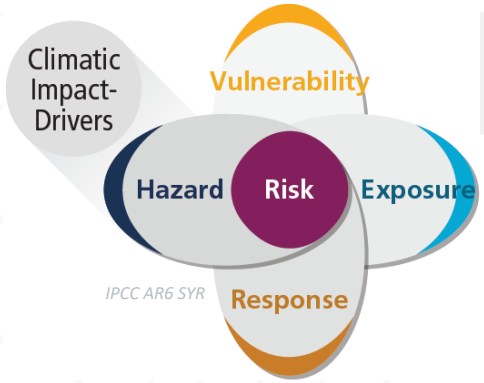
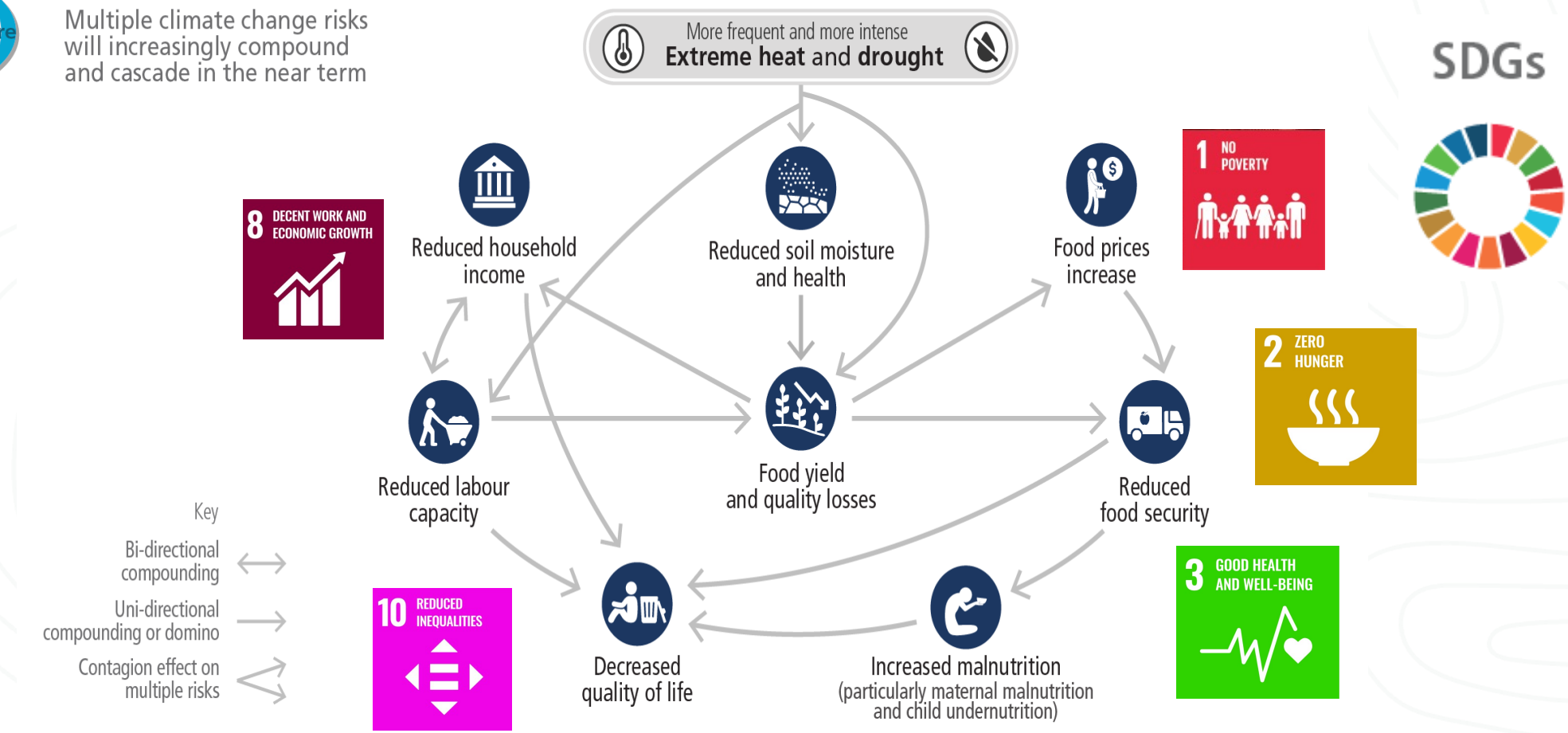
Every region faces more severe and/or frequent compound and cascading risks



c) Example of complex risk, where impacts from climate extreme events have cascading effects on food, nutrition, livelihoods and well-being of smallholder farmers



IPCC AR6 SYR, Fig 4.3

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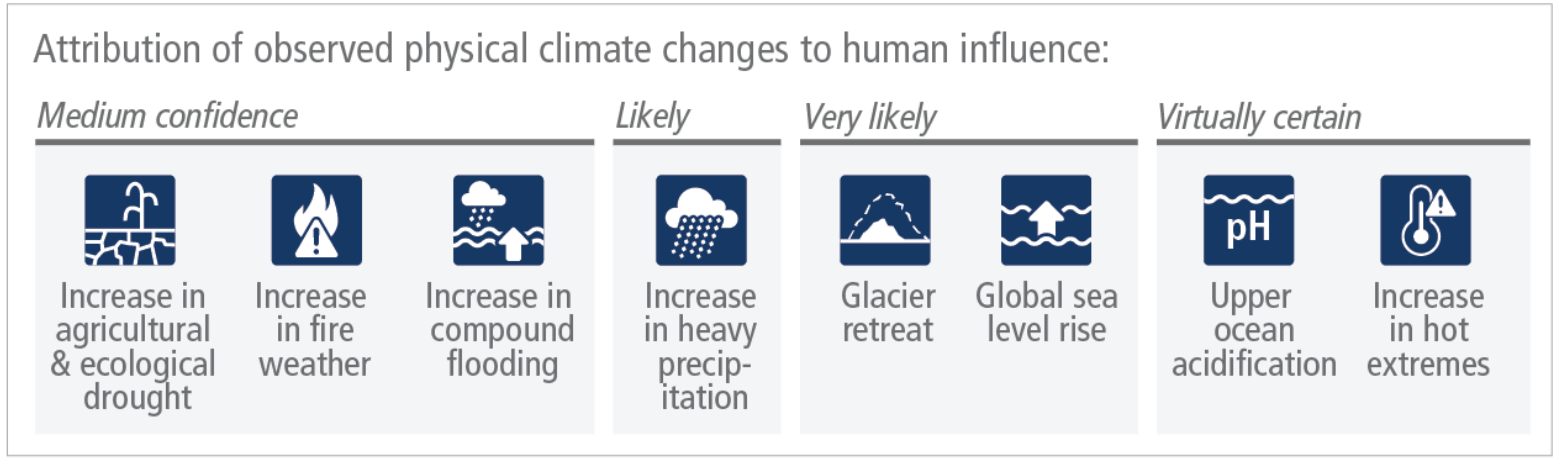
Advances in weather event and climate attribution

b) **Impacts are driven by changes in multiple physical climate conditions, which are increasingly attributed to human influence**



IPCC AR6 SYR, SPM Fig 1

- Huge advances in attributing hot extremes to climate change
- Also advances in attribution of agricultural and ecological drought
- Data gaps hindering attribution of precipitation extremes in many regions

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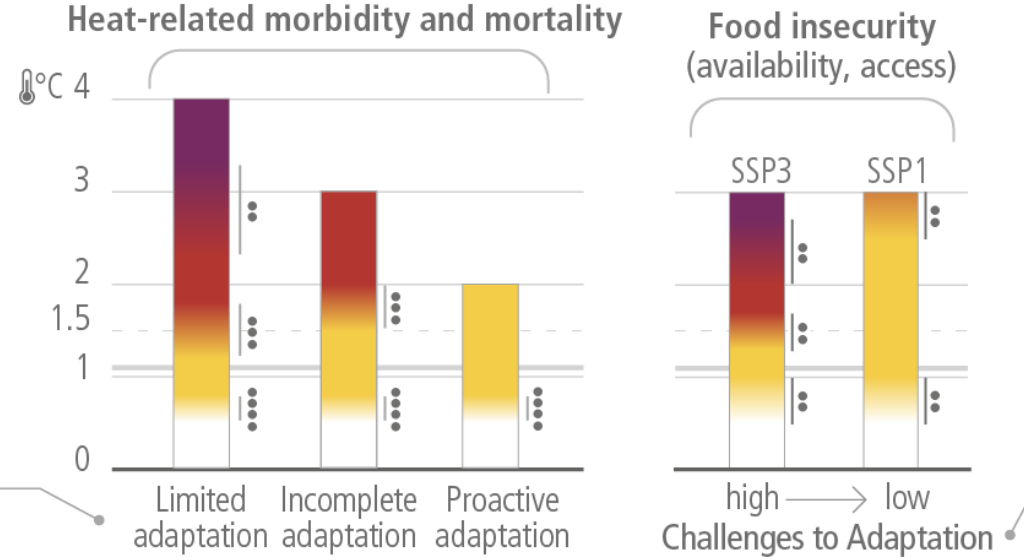
Extremes and adaptation

- **Compounding events and compounding drivers** are key areas of research focus.
- Advances in **higher resolution modelling (km-scale)** to simulate convection and scale interactions with implications for both global-regional scales, feedbacks and local extremes.
- Moving from weather event attribution to **impact attribution** requires recognizing **non-climatic factors** that determine exposure and vulnerability of affected systems.
- **Impact-based forecasts** are a useful tool to increase the relevance of **early warnings for decision makers**, but also face challenges around responsibility and liability.

Adaptation and sustainable development reduce risks

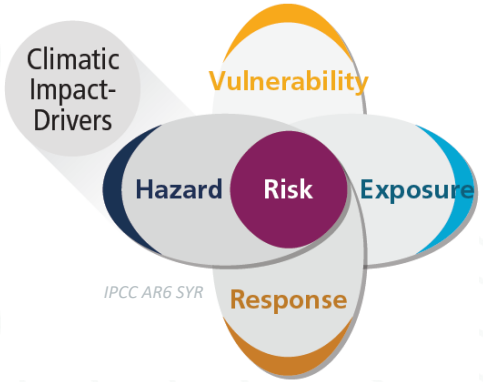
d) Adaptation and socio-economic pathways affect levels of climate related risks

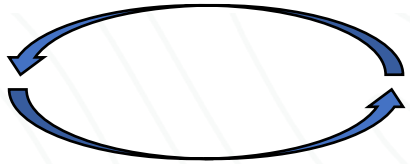
Limited adaptation (failure to proactively adapt; low investment in health systems); incomplete adaptation (incomplete adaptation planning; moderate investment in health systems); proactive adaptation (proactive adaptation management; higher investment in health systems)



The SSP1 pathway illustrates a world with low population growth, high income, and reduced inequalities, food produced in low GHG emission systems, effective land use regulation and high adaptive capacity (i.e., low challenges to adaptation). The SSP3 pathway has the opposite trends.

IPCC AR6 SYR, Fig 3.3.1





Research is needed on how emerging information on multi-hazards and compounding risks can be included in/support adaptation decision-making.

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L. Ruby Leung

"The Future of Climate Modeling"

Climate Modelling for Advancing Understanding

A model hierarchy better connects modeling with theories and observations to support climate research

Advances in computer and AI/ML

A model hierarchy

Advances in observations

The climate modelling community need to learn how to make the most of technological advances such as AI and advanced computing

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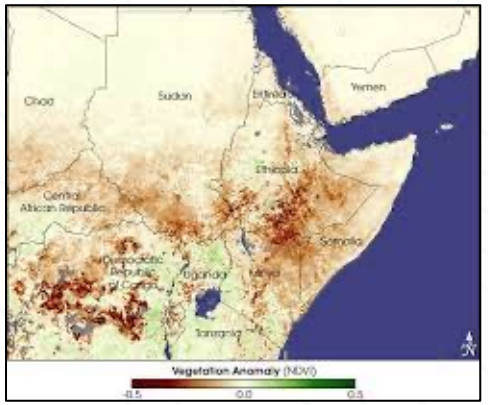
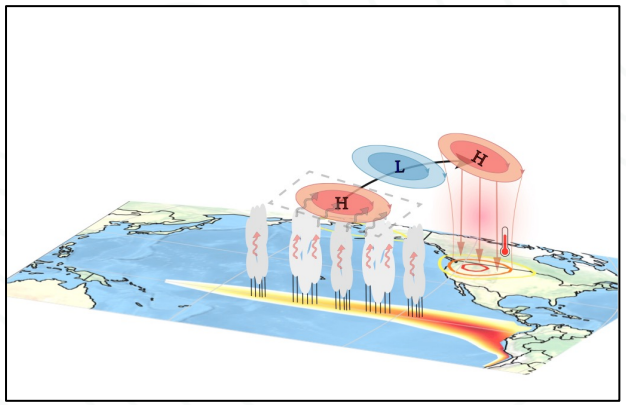
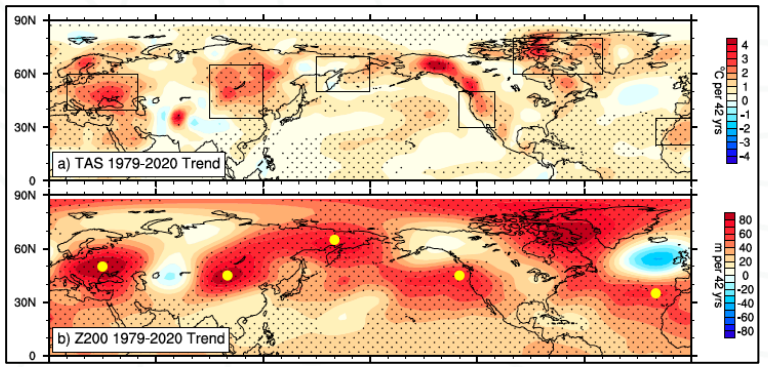
Understanding emerging patterns of change

- Although the global picture of climate change is consistent, and well explained, thanks in part to the modelling, the emerging observational record is increasingly showing patterns of change that we can't explain.
- More concerted effort that targets specific questions will be needed to understand this record and the processes underpinning emerging changes. These efforts will require a hierarchy of models and engagement of the full breadth of the research community.







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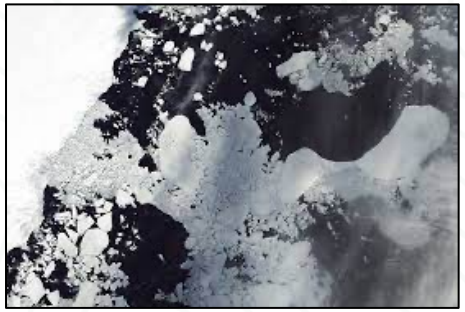
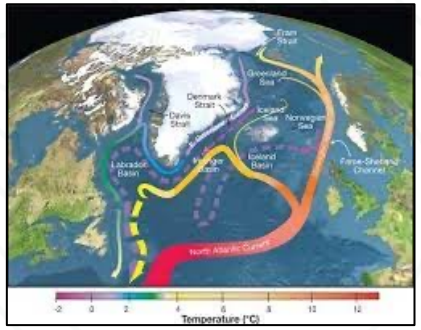
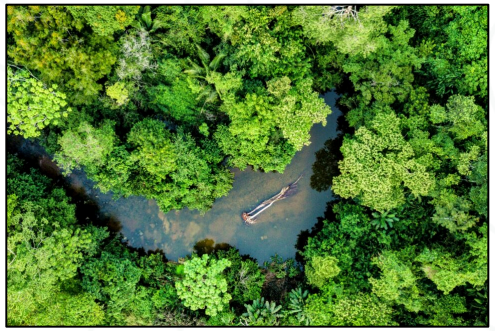
Assessing the risk of novel future climate states

- Societal discourse is increasingly dominated by speculation as to the role of processes that the models don't include, or the effects of processes that models do include, but produce diverging emergent behaviors.
- There is an urgent need to focus research efforts on these processes which might lead to novel future climate states, to begin building story lines that would allow us to better assess the risk associated with them.







Understanding high-impact weather-related events

- Modeling high-impact weather events is challenging with existing global climate models. This impedes our ability to understand their controlling factors.
- Future efforts aiming at understanding and modeling the physics underpinning different types of high-impact weather-related events will be needed to provide confidence in our ability to assess how such events may change with warming.

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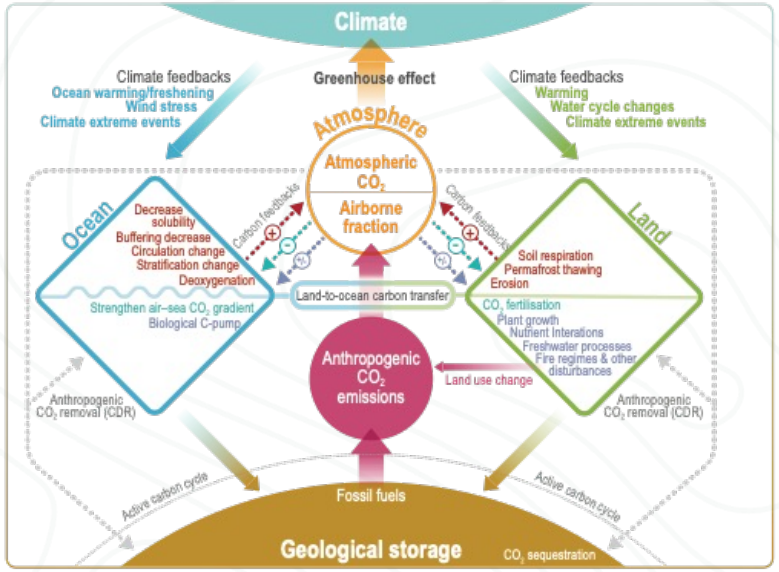
Pierre Friedlingstein

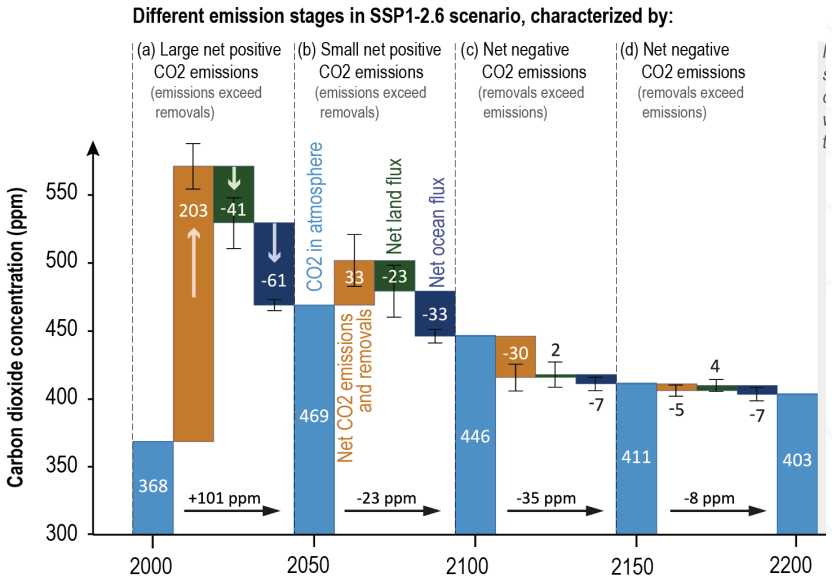
"Future climate projections, global cycles CMIP7 scenarios"

Climate projections

Main outcomes from OSC, key remaining uncertainties

- Global carbon cycle
  - Quantification of carbon cycle feedbacks under a changing climate
  - Response of the carbon cycle to climate overshoot, Carbon dioxide Removal





IPCC AR6 WG1, Chapter 5, 2021

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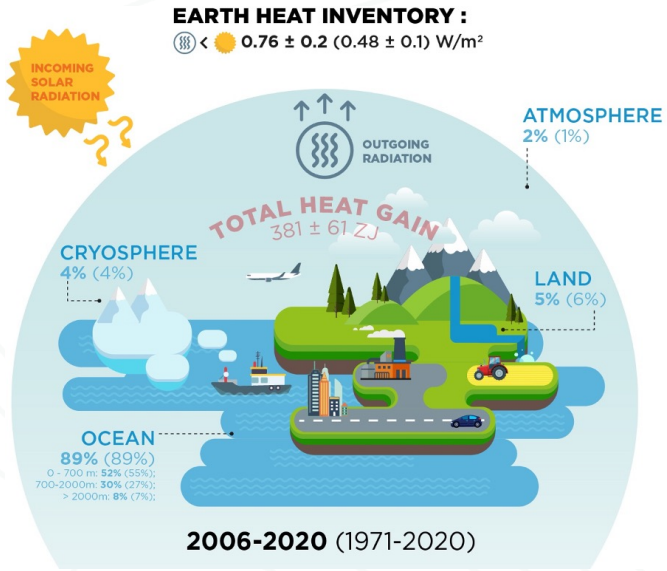
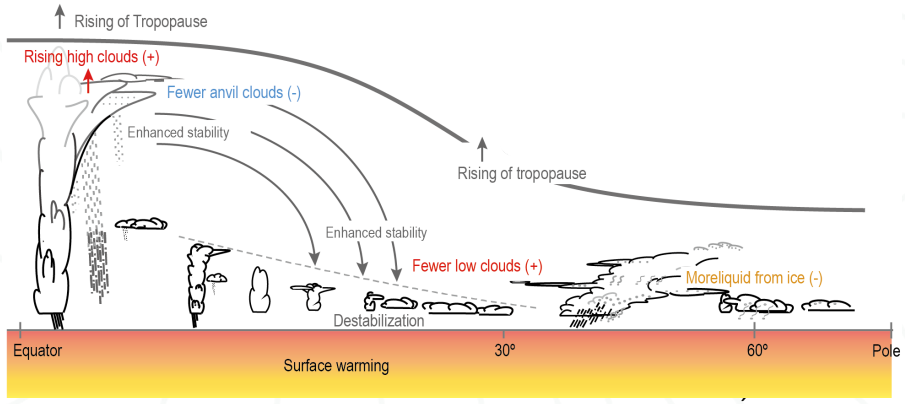
Climate projections

Main outcomes from OSC, key remaining uncertainties

- Global energy cycle
  - Understanding the increase in the Earth Energy Imbalance, role of forcings (GHGs, aerosols) and response (clouds)
  - Impact on climate sensitivity estimates



Von Schuckmann et al. ESSD., 2023



IPCC AR6 WG1, Chapter 7, 2021

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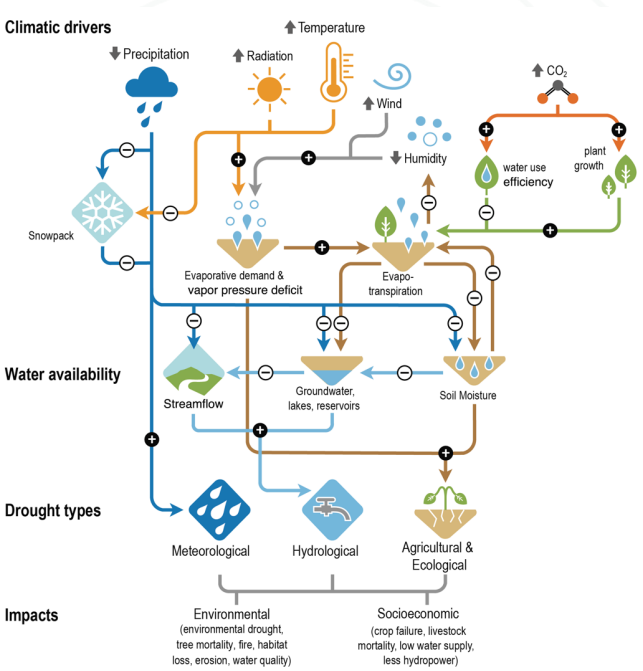
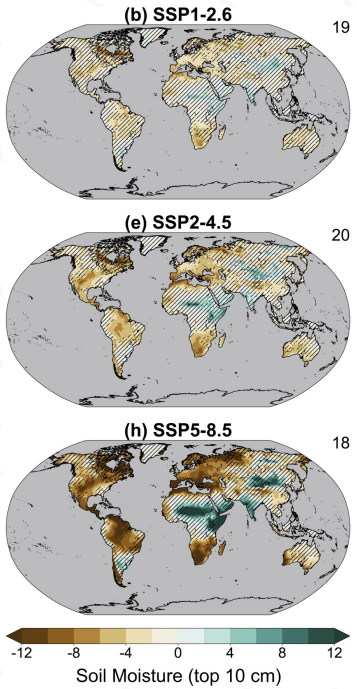
Climate projections

Main outcomes from OSC, key remaining uncertainties

- Global water cycle
  - Climate change and changes in the global water cycle and impact on human water resources
  - Understanding future changes in extremes (length, intensity of rain event) and associated impacts (floods, droughts)





IPCC AR6 WG1, Chapter 8, 2021

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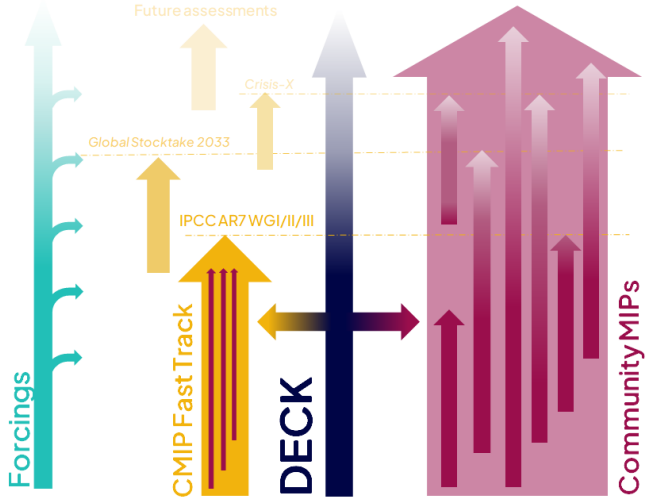
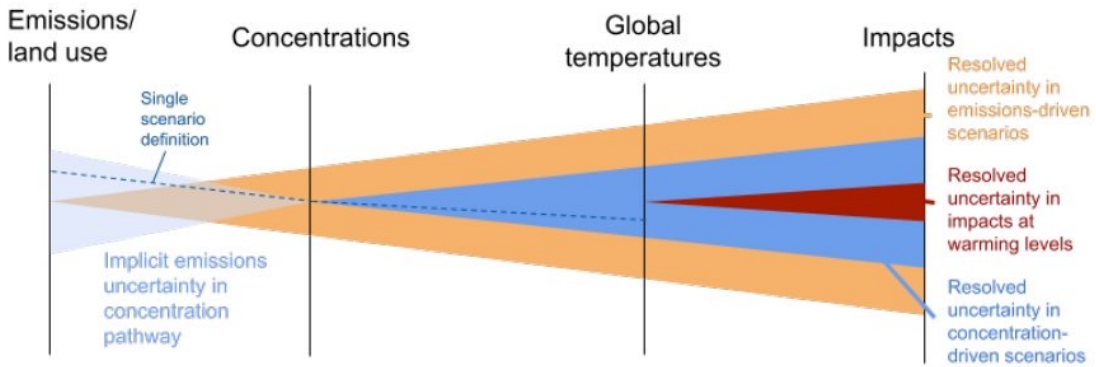
CMIP7

CMIP7 overall philosophy

- Fast track route vs. Community MIPs, to *feed in IPCC AR7 and beyond (GST, future assessments,…)*
- *Move from Concentration-driven scenarios to Emission-driven scenarios (i.e. Earth System Models)*
- *Community engagement (Task team, ECR Fresh Eyes team)*





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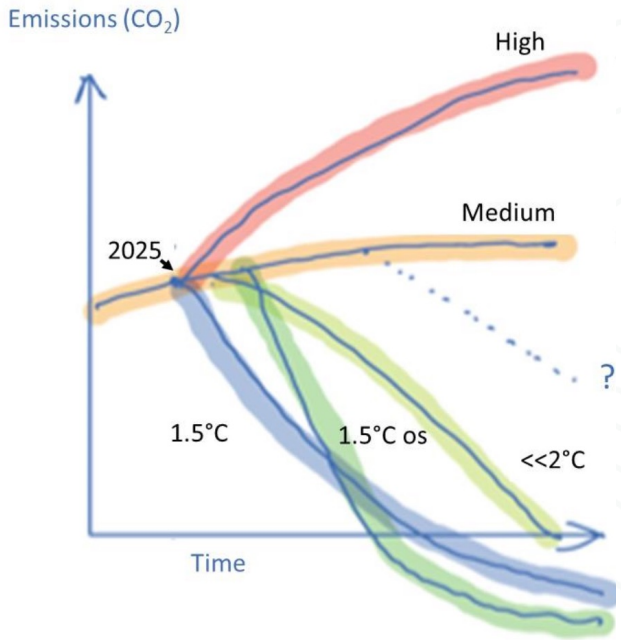
CMIP7 Scenarios

ScenarioMIP overall design

- Small sets of « representative » scenarios. 1.5°C, 1.5°C-overshoot, 2°C, Medium emissions, High emissions scenarios.
- Some will have extensions beyond 21st century (ex. to 2300).
- *Scenarios and associated climate simulations need to be available for IPCC AR7*
- *Community engagement (Task Forces, advisory group, community consultation)*



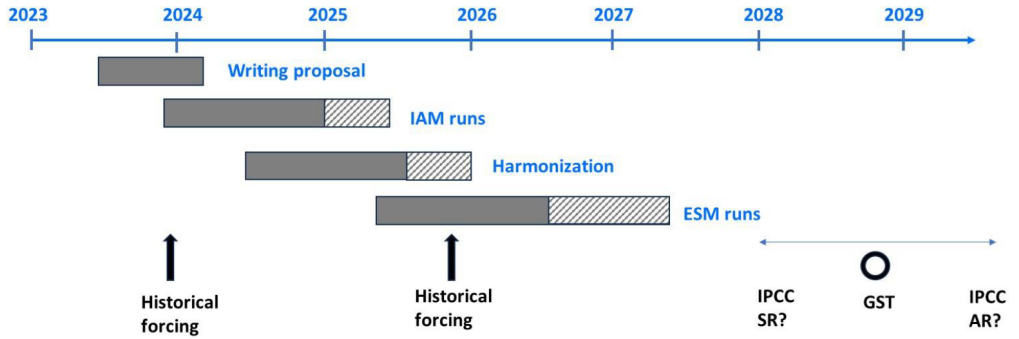


Figure 3: Outline ScenarioMIP protocol implementation timeline (ambitious). Timing of IPCC reports is particularly uncertain given the current transition phase between AR6 and AR7; no decisions have been taken yet on special reports, the assessment reports, literature cut-off dates and their timing.