Extremes and Risks at WCRP2023

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(and many others….)

UNSW CANBERRA

climate extremes
ARC centre of excellence

21st Century Weather
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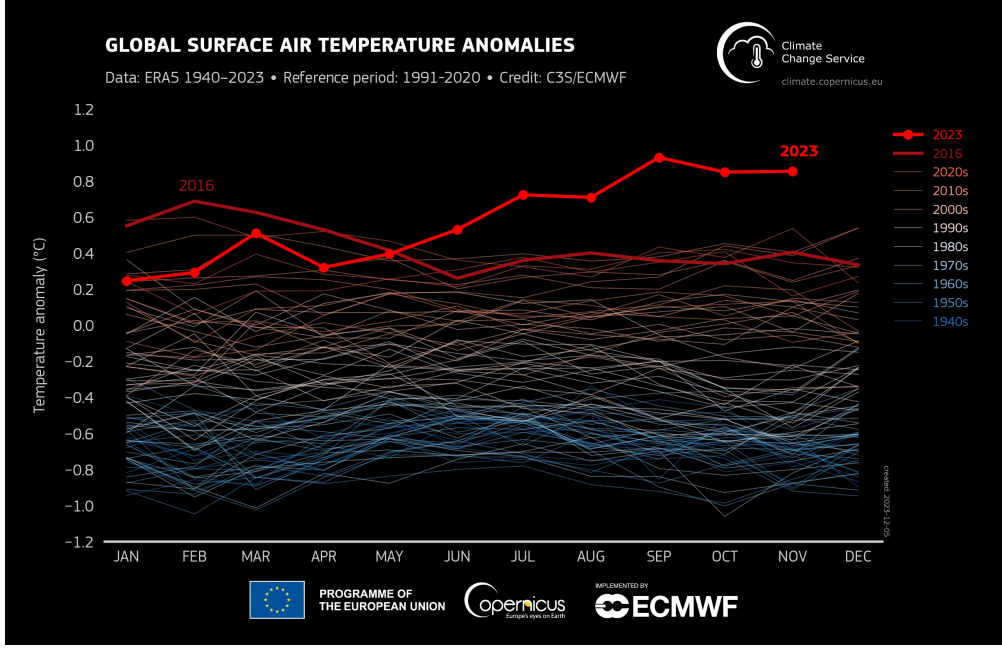
Day 1 Plenary Highlights

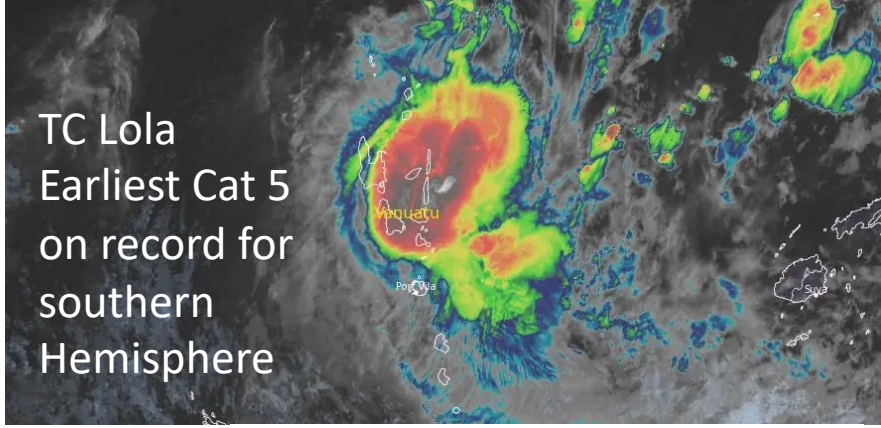
- Africa is experiencing higher temperatures, heatwaves, heavy rains, floods, prolonged droughts desertification, and stronger cyclones.
- Society must cope with ongoing changes and their impacts: the emergence of complex risks including drought, heavy rain and flooding, heatwaves, extreme fire weather, and other extremes occurring at the same time.
- The reasons for this year's unprecedented temperature spikes in the atmosphere and the ocean are still being investigated and is likely not solely due to known forcing factors. This year highlights the complexity and connectivity of the climate system.
- Impacts of climate change are mainly felt in the extremes. But decisions around impacts are mainly made in corporate and government circles. there is a need for "data impact models". collaborative work between social, economic, and physical sciences.
- Climate litigation trends: 55% of outcomes are related to climate change. This is relevant to ocean protection from further climate impacts due to extreme events

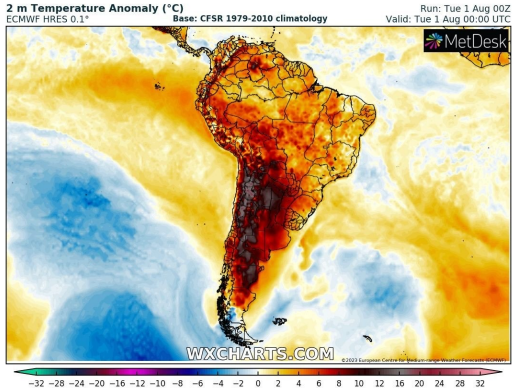


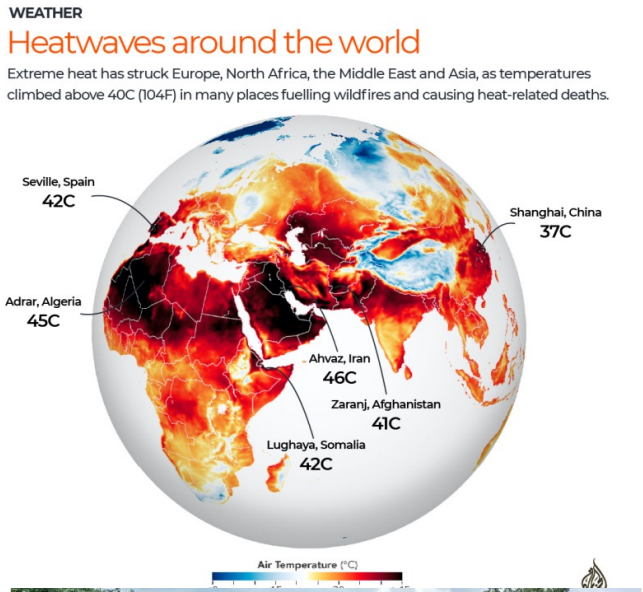
"Maybe soon we can stop talking of the global north, and the global south because for climate, there is no north and south. There's one world…" (Macharia Kamau of the International Science Council)

Day 2 Plenary Highlights

- Increased extreme weather events are happening at the same time as extreme political conflicts around the world.
- We are not living in a time of peace, safety or security. It is demonstrative of what it means to deal with climate extremes in the context of climate inequity and justice
- We cannot have climate justice without social, political and economic justice and especially without human rights.
- The climate emergency 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.
- Communicating risks requires evaluating risk perception, as people exposed to risks have different profiles and cultural contexts.
- Vulnerable populations and countries have legitimate development demands and want to be part of the solution.
- Addressing climate change to pursue ambitious development goals has real value, and inequalities must be addressed as fundamental rights

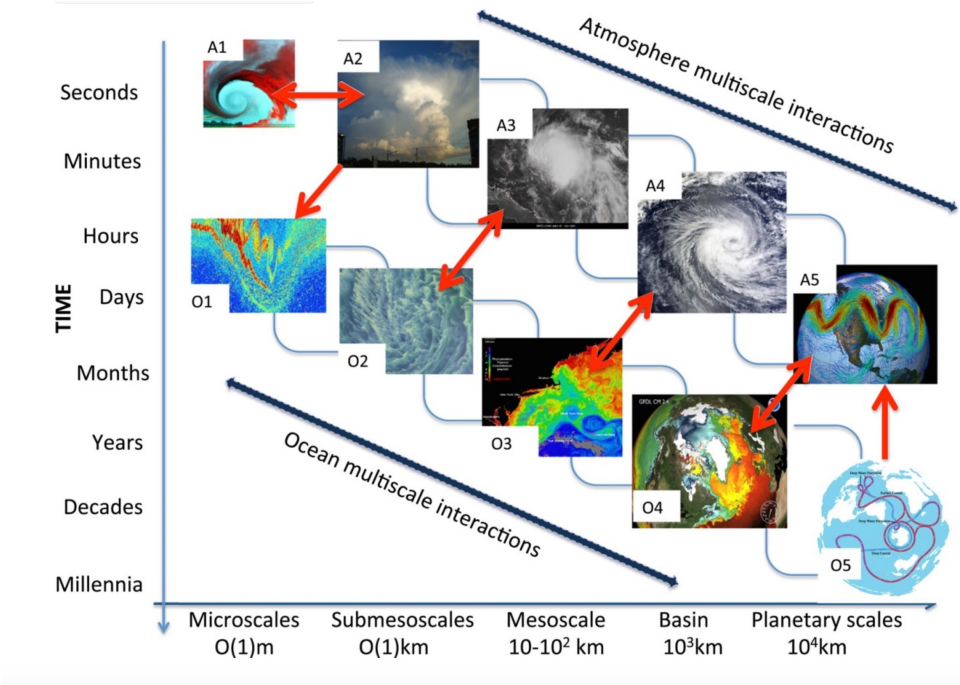






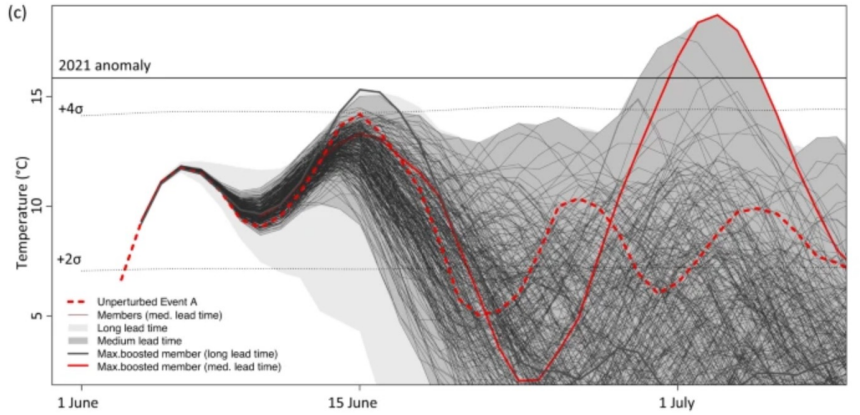
Day 3 Plenary Highlights

- We are increasingly passing 1.5°C on a monthly basis and will do so more often on an annual basis. By the 2030s we expect this to occur every second year.
- But we must be careful about over interpretation of annual events and avoid exaggerating findings of one particular study which is confusing for the public and policymakers
- Depending on sector, users have different needs for information on weather and climate in terms of timescale and variables. The common factor is the need for local information on a scale that users can relate to.
- We need to integrate model output with the real-world changes. Climate modelling for society requires local information for applications. Here, AI can fill gaps in information

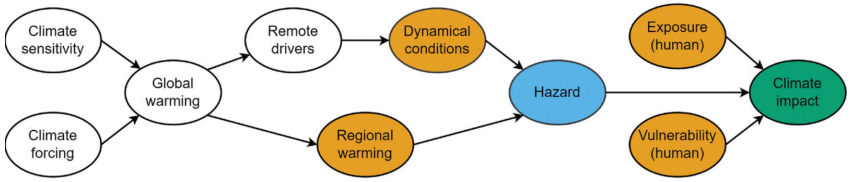


possibility and probability: likelihood, and uncertainty (s30, Day 4)

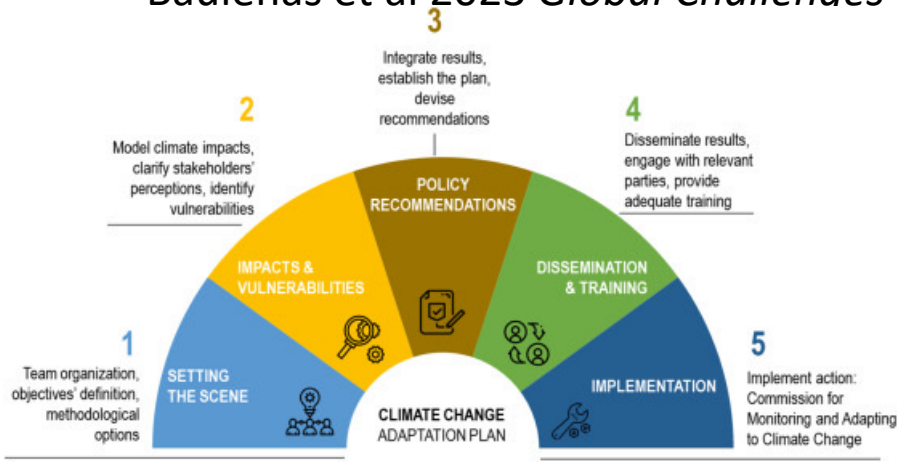
- Climate and climate risk projections are uncertain. Future probabilistic treatment of climate risks are uncertain and often not possible or misleading.
- One needs to anticipate the unexpected - events that have previously been considered impossible/implausible.
- Approaches that go beyond statistical hazard assessments and standard climate model ensemble projections to enable stress testing of the affected systems are required.
- These may include climate storylines, UNSEEN approach, or brainstorming by involved parties of their experience in other regions and imagining possible outcomes.
- Unexpected outcomes may reveal serious limitations of current practice regarding governance, early warning systems, emergency responses and spatial planning.
- Complex risks require resources simultaneously and thus overstrain the response capacities.
- Stakeholder-driven work and co-production ensure that the obtained information is actionable and can be directly used in adaptation planning.
- Stakeholders often want single numbers but might accept working with uncertain outcomes if they have a clear understanding of their sources and relevance.



Fischer et al 2023 *Nature Climate Change*



Baulenas et al 2023 *Global Challenges*



Goncalves et al 2022 *Science of the Total Environment*

Showcasing progress and future challenges in understanding Earth's climate system, and advances in capacity around the world.

Analyze key drivers and impacts of climate change (past, current and future), identifying risks to human and ecosystem health.

Connecting scientific knowledge, planning, decision-making and policy processes.

Theme 1: Advances in Climate Research

- **S01** Climate variability on timescales from weeks to centuries and millennia
- **S02** Climate predictability and prediction
- **S03** Global and regional monsoons
- **S04** Storms, eddies and jets in the atmosphere and ocean
- **S05** Polar processes and change
- **S06** Rapid and/or irreversible changes in the climate system
- **S07** Atmosphere-land interactions: energy, water & carbon
- **S08** Ocean-atmosphere interactions: energy, water & carbon
- **S09** Interactions between atmospheric composition and climate, including aerosol processes
- **S10** Lessons from paleoclimate for recent and future climate change
- **S11** Advances in global and regional climate modelling
- **S12** Advances in climate observations and model-data fusion

Theme 2: Human Interactions with Climate

- **S13** Carbon cycle
- **S14** Global energy budget
- **S15** Water cycle
- **S16** Ice sheets and sea level change
- **S17** Climate feedbacks and climate sensitivity
- **S18** Current and future forcing, including aerosols and scenarios
- **S19** Land use and land cover change
- **S20** Impacts on land and marine ecosystems
- **S21** Impacts on food security and water availability
- **S22** Impacts on human health and urban systems
- **S23** Circulation change in the climate system (atmosphere and ocean)
- **S24** Attribution of changes
- **S25** Regional climate change
- **S26** Mitigation scenarios including overshoot and climate intervention

Theme 3: Co-produced Climate Services and Solutions

- **S27** Hazards and extreme events
- **S28** Regional information – Data and methods
- **S29** Regional information – Constructed for climate services
- **S30** Plausibility, probability, likelihood, and uncertainty
- **S31** Climate knowledge co-production in a decision and policy context
- **S32** Capacity development for climate services
- **S33** Linking policy and climate information
- **S34** Climate services: effectiveness and evaluation
- **S35** Regional information and scales in time and space
- **S36** Observations for decisions
- **S37** Regional attribution
- **S38** Connecting regional impacts and climate information
- **S39** Institutions and frameworks
- **S40** Lessons from failures

Theme 1 – Advances in Climate Research

Progress

- Advances in research-based climate forecasting, prediction and the development of early warning systems for climate extremes and hazards.
- Advances in higher resolution modelling to simulate convection and scale interactions with implications for both global-regional scales and local extremes.

Challenges

- Improvements in the understanding of internal variability, tropical-extratropical interactions, ocean-land-atmosphere interactions, eddies, jets, etc., that lead to more accurate location of extremes, storms, etc.,
- Still very much a need for long-term climate research in extremes, as there are still large gaps in understanding

Opportunities

- Advances in higher resolution modelling with the use of ML for improved parameterisations and other applications (e.g. model tuning, prediction) to simulate scale interactions and implications for both global-regional scales and local extremes, as well as new large ensembles.
- Realising the full potential of s2s and s2d predictions, including for extreme events (e.g. Pakistan floods) impacts and decision support.
- Rectifying the mismatch between data gathered in the global north can be achieved through establishing and supporting strong relationships across the Global South and North especially at the graduate level where student exchanges can be an effective way of surmounting some of these issues.

Theme 2: human interactions with climate

Climate feedbacks and climate sensitivity

- The **sudden warming of 2023 is concerning and probably not all explainable by forcing changes**.
- **Land use and land degradation is important** because of its impact on climate through water and energy fluxes, and the significant socioeconomic consequences.
- There is a **growing need for more advanced and accurate models** for land use and land cover change

Water cycle

- Observed trends in the water cycle can, in some regions of the world, be attributed to climate drivers, but **in most cases these changes are attributed to other anthropogenic factors**, such as urbanization or water abstraction.
- Methods are urgently needed to **separate climate and anthropogenic signals in the observed indicators of the continental water cycle**, including extremes

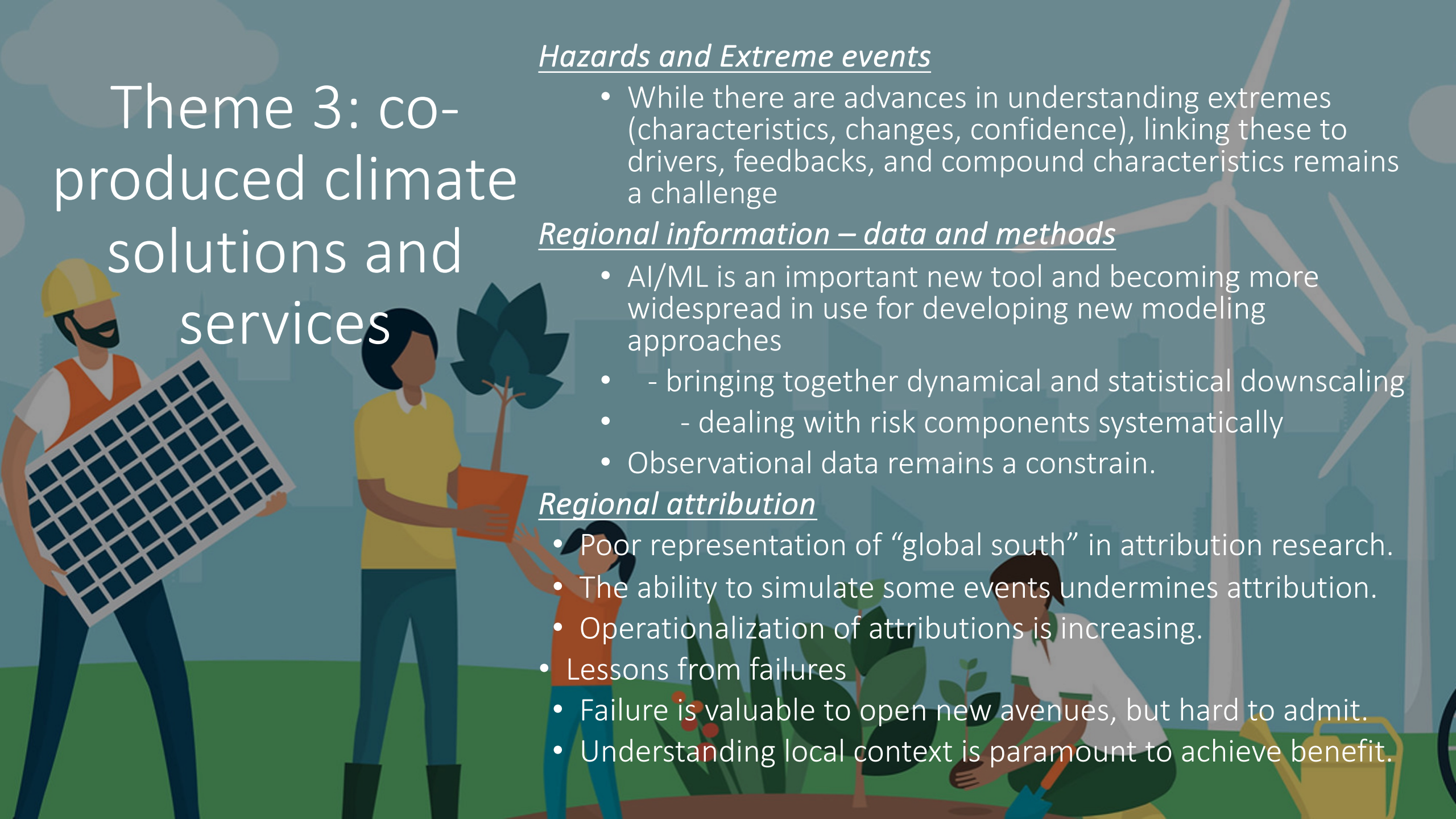
Impacts on human health and urban systems

- need for **urban-resolving climate modeling** approaches across scales, that accurately represents urban characteristics and processes that can capture the feedback from urban areas to larger weather and climate processes.
- Research is needed to better understand the **role of aerosols on extreme rainfall events**.

Attribution of changes

- Small island states need **tools and protocols** to do their own attribution studies.
- There is a place for **rapid extreme event attribution**, noting the trade-off between fast and comprehensive studies. **Rapid extreme attribution** allows the **communication of the role of climate change** behind an extreme event at the time when people are actually interested in it, however there is an under representation of the Global South
- Impact attribution is much harder and more complex, it is very much needed but is a work in progress

Theme 3: co-produced climate solutions and services



Hazards and Extreme events

- While there are advances in understanding extremes (characteristics, changes, confidence), linking these to drivers, feedbacks, and compound characteristics remains a challenge

Regional information – data and methods

- AI/ML is an important new tool and becoming more widespread in use for developing new modeling approaches
- - bringing together dynamical and statistical downscaling
- - dealing with risk components systematically
- Observational data remains a constrain.

Regional attribution

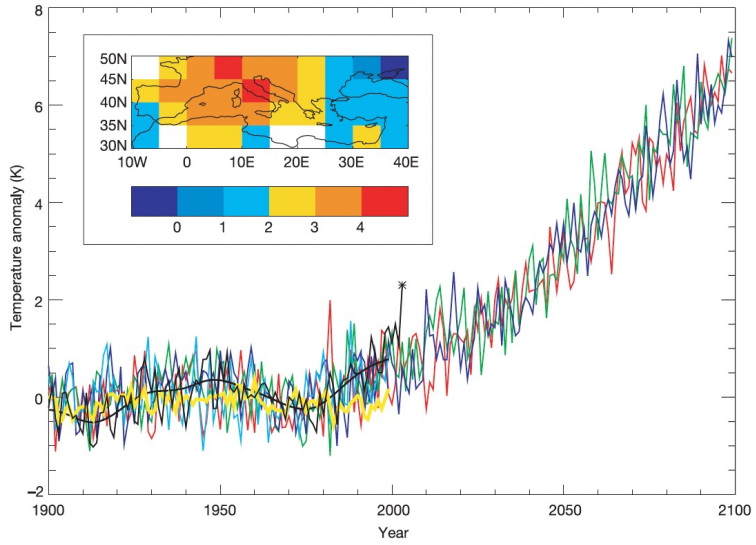
- Poor representation of “global south” in attribution research.
- The ability to simulate some events undermines attribution.
- Operationalization of attributions is increasing.

- Lessons from failures
- Failure is valuable to open new avenues, but hard to admit.
- Understanding local context is paramount to achieve benefit.

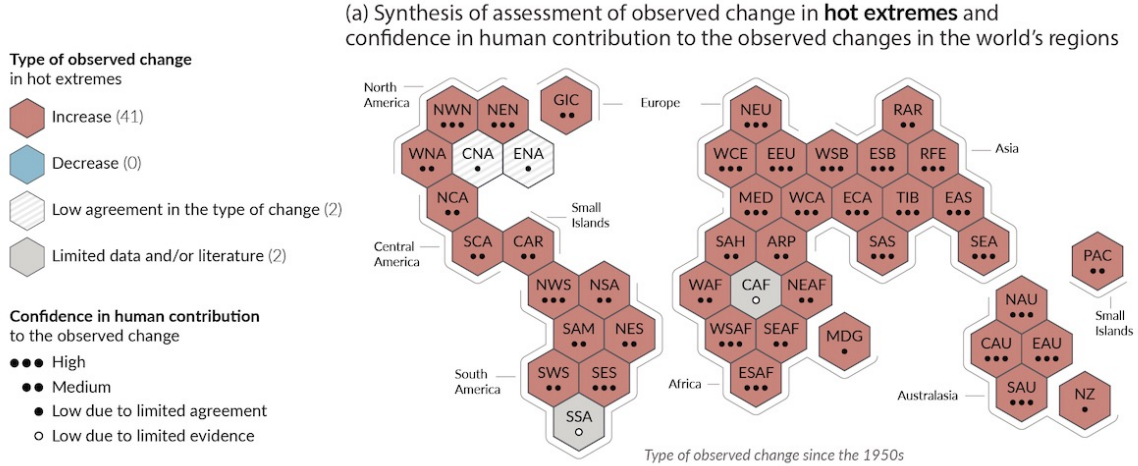
Frontiers in Attributing Climate Extremes and their associated impacts concept paper

One of 20+ concept papers that are outcomes of the conference

1. The role and current limitations of observations;
2. How events are defined for EEA and why this is important for interpretation;
3. Statistical methods commonly employed including developments in compound and record-shattering events;
4. How physical climate models are used for EEA;
5. The emergence of impacts attribution; and
6. Communication of the results of EEA to non-scientist audiences.



Stott et al. 2004, *Nature*



IPCC SPM, 2021

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