WORLD CLIMATE RESEARCH PROGRAMME
OPEN SCIENCE CONFERENCE

Day 4, 26 October 2023

1. Morning Dome Plenary: Climate Change Solutions

Detlef Stammer (WCRP Chair) chaired a session in which Aditi Mukherji (Director, Climate Adaptation and Mitigation Impact Area Platform, CGIAR), Peter Dueben (Head of Earth System Modelling, ECMWF), and Minal Pathak (Associate Professor, Global Centre for Environment and Energy, Ahmedabad) discussed food security, the digital revolution for climate information, and progress on climate change mitigation and sustainable development.

Feeding the future global society - challenges for food security

Agriculture is at the frontline of the impacts of climate change, but it is also a source of climate change. We need to mitigate but we need to do it with care so as not to penalize the poorest of the poor who have not contributed to climate change, said Aditi Mukherji.

- Unless there are immediate and deep reductions across all sectors, including agri-food systems, 1.5°C is beyond our reach. But stringent mitigation to keep within 1.5°C to 2°C may lead to severe food insecurity in sub-Saharan Africa and South Asia. We have a catch-22. We must mitigate but without affecting the lives and livelihoods of poor farmers. A just transition should apply to the agri-food sector.
- There is a need to invest in real solutions that work, are proven, and benefit people including the most vulnerable and the planet.
- Four principles of an agricultural breakthrough:
    1. Sustainable increases in agricultural productivity in low- and middle-income countries;
    2. Reduced greenhouse gas emissions from the agri-food sector;
    3. Improved soil, water resources and natural ecosystems. Our food system is not fit for purpose;
    4. Improved adaptation and resilience to climate change particularly for vulnerable smallholder producers; There is no one silver bullet.
- Five pathways for a breakthrough:
    1. Reduce unsustainable consumption, including reducing high fertilizer application. Promote alternative proteins to replace excessive consumption of animal source protein. Reduce food waste.
    2. Increase production of sustainable, healthy, and nutritious food in low-income countries without area expansion. Appropriate use of fertilizers in areas of under-use.
    3. Reduce damage to natural resources such as water, soil, biodiversity.
    4. Reduce emissions, absolute or relative, using low emission fertilizers.
    5. Prioritize interests and needs of smallholder producers and promote digital services like advisories.

Digital revolution - Climate information for all

The quiet revolution of numerical weather prediction is giving way to the era of global kilometer-scale models and machine learning tools, says Peter Dueben.

- Kilometer-scale models will improve the realism of simulations significantly and now also become available for wider applications. This will make a difference for the generation of large and unified training datasets.
- Machine learning models (Google/DeepMind and NVIDIA) are already beating conventional weather forecast model in deterministic scores and are much faster, by several orders of magnitudes. Conventional models will not be replaced by machine learning tools. These are still extremely important and will continue to be extremely important. However, within the next

couple of years most weather predictions will come from machine learning, which will be the glue between models and observations.

- Change of gear. The work mode of 2010 is very different from that of 2020 and 2030.
  - The quiet revolution (1980-2020): Steady investment into Earth System modelling and observations made a difference.
  - The digital revolution (2015-today): Conventional models need to be made future-proof via new software and hardware standards.
  - The machine-learning revolution (2022-today): A PhD student can write a machine learning tool that can beat the best weather predictions. To make progress, data needs to be open and easy to use.
  - The next step: Models will be better, tools will be easier, and data/HCP will be federated. Achieving this needs programmes such as Destination Earth, Earth-2 and EVE. We need to find new public/private balance and make sure that tech giants help with groundwork development.

There is progress on climate change mitigation and sustainable development, says Minal Pathak:

- Technology costs have fallen. Solar pricing has dropped by 85% and electric batteries are also cheaper. But we continue to invest in fossil fuels. Emissions have grown in most regions but are unevenly distributed.
- There are options now available in every sector to halve emissions by 2030. We need to understand which options work in which region and which sector. The challenge is to scale these up in the energy and industry sectors, cities, transport and buildings, consumption patterns.
- Many options have synergies with the SDGs. But ambitious mitigation pathways imply large and sometimes disruptive changes, for instance the transition away from coal affects the poorest people in India.
- There should be capacity building for inter-disciplinary research and action in Global South.
- We need to rethink our role as scientists and publishers, funders, individuals, and avoid helicopter research.

2. Parallel Sessions

- **Polar processes and change -** The significant influence of sea ice geometry on air-sea interactions in polar regions was clearly demonstrated. The profound impact of atmospheric circulation patterns on Antarctic sea ice reveals the connection between these dynamics and sea ice behavior, and thence the role of atmospheric circulation modulated by processes such as ENSO and SAM. Mesoscale eddies in the Southern Ocean also play a key role in affecting the dynamics of heat transport and sea ice conditions.

  The seasonal recovery of Arctic sea ice can be slowed by frequent atmospheric rivers, accounting for much of the decline in sea ice area in recent decades. The stark reality of rapid Arctic warming is clear, with significant implications for the biogeochemistry of Arctic fjords and illustrating the intricate interdependence of processes in polar climate systems, from sea ice geometry to atmospheric circulation, atmospheric rivers, mesoscale eddies, and biogeochemical changes. This complex web of interactions shapes polar environments. Modelling systems are needed that represent these interactions, along with improved observation (especially remote sensing) capabilities, to predict and mitigate the impacts of climate change in polar regions.

  Interdisciplinary approaches may provide a more comprehensive understanding of the interplay between physical and ecological processes in polar environments.

- **Atmosphere-land interactions -** Examples from West Africa, the Tibetan Plateau, North and South America show that spatial patterns of soil moisture modify important weather systems via the thermodynamic structure of the atmosphere, cloud formation and rainfall. Soil moisture – atmospheric feedback mechanisms operate at scales ranging from 1km / daily to 100km / monthly. For longer time scales, ground water plays an important role in the water cycle.

  Wildfire is a critical and natural process in ecosystems while posing an increasingly severe hazard to humans. Links between CO_2 fertilization, above-ground biomass and fuel load, affecting fire risk, demonstrate that including interactive wildfires in land models is a priority in Earth system models.

  Model improvement requires that these soil moisture effects, groundwater and evaporation processes are captured – over at the appropriate space and time scales. A lack of aquifer data limits our understanding of groundwater – new information for groundwater stores of Africa is ready for use to improve the land-atmosphere interactions of this region.

- **Interactions between atmospheric composition and climate, including aerosol processes -** Large ensembles in fully coupled Earth system models are important in advancing our understanding of tropospheric ozone trends, especially in addressing the problem of signal-to-noise in observed trends from satellite data.

  Forests play a complex role in climate mitigation; their effects on Short Lived Climate Forcers and natural aerosol climate feedbacks are similar in magnitude to other climate feedbacks. Models must include full climate-emission-chemistry-aerosol processes.

  High-quality, long-term observations are needed to advance knowledge and understanding; there is a shortage of in situ measurements with regions in the Global South being severely under-observed. In tropical regions, aerosols are important to ice nucleation in cold clouds – more data are needed to improve the parameterizations used in models.

  Emerging priorities and opportunities included: building capacity in skills and sharing resources and equipment between the Global North and South; leveraging satellite and air quality observations to constrain climate relevant processes; and updating data on Short Lived Climate Forcers for regular updates.

- **Lessons from paleoclimate for recent and future climate change -** New findings showed how paleoclimate records can enlighten potential relationships between climate and human societies (e.g., over Central America). Paleoclimate information has value in model development and tuning - not only at the model evaluation stage.

  More use of model simulations to prepare for and guide field work in remote locations (e.g., Antarctica), or to interpret seemingly contradictory records (e.g., surface hydrological changes) is encouraged. New scenarios and processes can now be tested for the abrupt events of the last deglaciation and the Holocene, thanks to new records of ocean circulation (e.g., Indonesian throughflow).

- **Circulation change in the climate system (atmosphere and ocean) -** Northern Hemisphere summer jet streams and storm tracks have substantially weakened due to both aerosol and CO_2 forcing with apparently little influence from sea ice loss.

  In the North Atlantic, the AMOC is expected to decline in the future, with potential roles for sea ice loss, salinity and temperature feedbacks, and impacts on heat storage in the tropical South Atlantic that may have global implications e.g., potential links with the Asian monsoon.

  In the Southern Hemisphere, cooling trends in the Southern Ocean along with Antarctic sea ice expansion and subsequent decline are important with tropical-extra-tropical interactions playing a role in driving these observed trends.

  Global scale teleconnections involving the atmosphere, ocean, and cryosphere, and the coupling between them, have implications for projected regional climate change. With climate models failing to capture some recent historical trends and/or variability, there is a critical need to improve models and their representation of the large-scale circulation if we are to simulate impacts of climate change correctly.

- **Regional climate change -** Initiatives such as CORDEX have enabled strong representation of Africa with respect to available high resolution model datasets; similar systematic programmes for other Global South regions would be useful. The continued inclusion of capacity development/training in the CORDEX programme is essential.

  The formation of an Africa research hub that undertakes coordinated projects, answering questions important to the Africa context; that continues the interdisciplinary approach implemented for CORDEX Africa; and that can pursue funding opportunities is essential, given the enhanced capacities from previous efforts like CORDEX Africa. A WCRP Framework that supports this (and similar efforts in the Global South) would be useful.

  Next steps planned by CORDEX for convection permitting simulations at ~1km resolution holds potential for improved understanding of tropical convection processes and improving climate services; while plans to include urban, vegetation, hydrology, sea ice (and other) model components hold potential for improved representation of processes at higher resolution.

  There is potential for improving model representation of extreme events through the application of Machine Learning.

  Obtaining “buy-in” from more nations, governments and organizations about the importance of, and potential for, Global South-North partnerships is critically important.

- **Uncertainties in climate projections: plausibility, possibility and probability -** Climate and climate risk projections are uncertain. A probabilistic treatment of climate risks in a future climate is therefore often not possible or misleading. One needs to anticipate the unexpected, i.e., events that have previously been considered impossible or at least implausible.

  Approaches that go beyond statistical hazard assessments and standard climate model ensemble projections to enable stress testing of the affected systems are required. Such

approaches may include the use of physical climate storylines, the UNSEEN approach, or brainstorming by the involved parties of their experience in other regions and imagining possible outcomes.

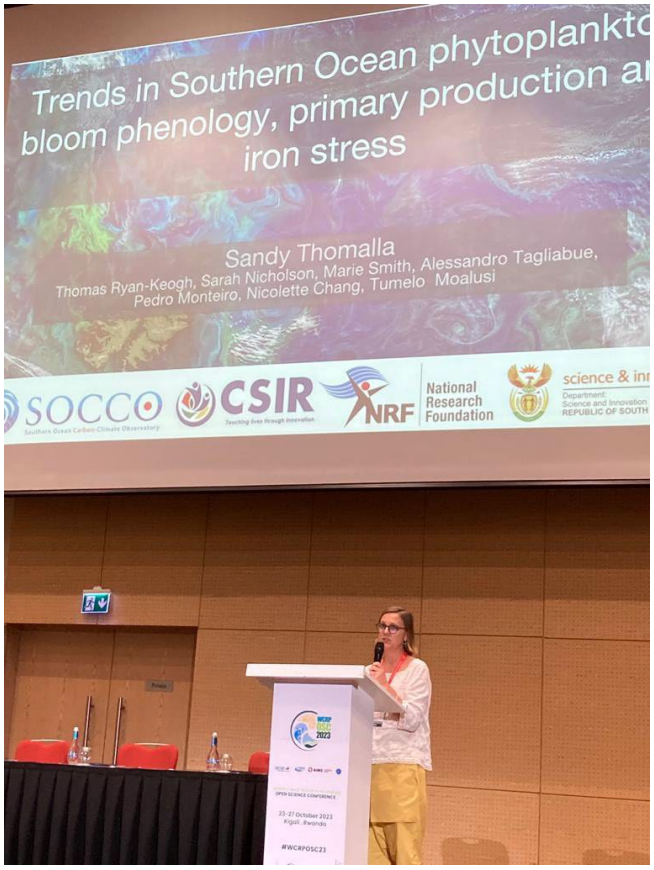
Unexpected outcomes may reveal serious limitations of current practice regarding governance, early warning systems, emergency responses and spatial planning. Complex risks may require resources simultaneously and thus overstrain the response capacities. Dynamic adaptation pathways help to adapt based on early warning signals of emerging climate trends.

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.

In the Global South resources are often missing for climate risk assessments, e.g., for observational data and research in general.

- **Capacity Development for Climate Services** - Capacity development for climate services is key for fostering informed decision-making, empowering local institutions and communities, and thereby ensuring effective adaptation strategies. There is a growing acknowledgment of the importance of understanding the needs and expectations of the target group and their decision contexts in the design of the training activities. Other important aspects include: adoption of gender responsive people-centric approaches, proactive engagement with policymakers, coordination of activities, communication of training opportunities (e.g., through a training catalog), establishment of strategic partnerships (e.g., with boundary organizations), the need for assessing the benefits of trainings, and a commitment to ensuring the sustainability of training programs.

Group photo after the **Capacity Development for Climate Services** session on Day 4 of the Open Science Conference 2023. (Credit: Amanda Sue Grossi/Twitter)



Dr Sandy Thomalla speaking on "Widespread changes in Southern Ocean phytoplankton blooms linked to climate drivers" at the session on Polar processes and change. (Credit: SOCCO Science/Twitter).