World Climate Research Programme
c/o World Meteorological Organization
7 bis, avenue de la Paix
Case postale N° 2300
CH-1211 Geneva 2 – Switzerland
wcrp@wmo.int

42nd Session of the WCRP Joint Scientific Committee – CliC Report

28th June – 2nd July, *James Renwick, Fiamma Straneo, Beatriz Balino, Tim Naish,*

It has been a productive period for the CliC community, even amidst the pandemic, and we are pleased to share in this report highlights some of our progress and a summary of future plans. CliC supported projects have made major contributions to the *Melting Ice and Global Consequences* Grand Challenge primarily through a series of modelling intercomparison projects. These include the Ice Sheet Modelling Intercomparison Poject (ISMIP6) which has produced some of the first community-wide projections of sea level rise from Greenland and Antarctica using stand-alone ice sheet models forced by Coupled Model Intercomparison Project (CMIP) models and projections of ice loss from glaciers (GlacierMIP; Model Intercomparison of Global Scale Glacier Models) – both of which provided estimates for the upcoming Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Additional important contributions to our ability to model ice loss were made by the new Marine Ice Sheet Ocean Model Intercomparison Project 2 (MISOMIP2), the Earth System Model-Snow Model Intercomparison Project (ESM-SnowMIP) and the Land Surface, Snow and Soil Moisture Model Intercomparison Model (LS3MIP). These projects reflect a strategy aimed at connecting cryosphere scientists with the modelling communities. Beyond the intercomparison modelling projects cited above, CliC supported activities focused on ice sheets, sea-ice variability, mid-latitude-polar region linkages and permafrost that spanned across multiple disciplines and Earth System Components. Finally, it engaged in joint activities with other WCRP Core projects aimed at the coordination of observations and modelling efforts.

The Co-Chairs would like to thank the cryosphere community for continuing their efforts even in the challenging circumstances posed by COVID-19. A special thanks goes to Gwen Hamon, Executive Officer of CliC International Project Office (IPO) from 2014 to 2020, for her essential and extensive contributions to CliC. We also heartily welcome Beatriz Balino (Executive Director) on board and very much look forward to working with her. We are also very grateful to the Bjerknes Center for Climate Research (BCCR), for hosting the CliC IPO, and the BCCR and the Research Council of Norway for their financial support to the IPO.

Selected Highlights

- **ISMIP6 & GlacierMIP**. 20 publications in 2020 *Nature*, *GRL*, and *The Cryosphere in 2021*. Underpins IPCC AR6 sea-level projections. **GrIS -** good agreement, spread due to models [*Goelzer et al. (2020), The Cryosphere*]. **AIS -** poor agreement due to EAIS SMB, ocean forcing, and basal melt rates & MISI matters. *[Seroussi et al. (2020) Cryosphere]*. **Glaciers -** will lose 18% (79mm) (RCP2.6) to 36% (159mm) (RCP8.5) of their mass by 2100. [*Marzeion et al (2020), Earths Future*], [*Hock et al., (2019) J. Glaciology*]. Emulator approach to explore uncertainties Large uncertainty remains, but nature of uncertainty better understood [*Edwards et al. (2021), Nature*]
- **SIMIP -** Overview on Antarctic Sea ice in CMIP6 models (Roach et al., 2020, GRL). CMIP6 sea ice output looking at biases in Arctic sea ice simulations (Smith et al.2020, The Cryosphere). The Community SIMIP paper on Arctic sea ice in CMIP6 models (SIMIP Community 2020, GRL)
- **ASIGW Arctic Sea Ice Working Group -** Participation in the MOSAiC field experiment. Many of the MOSAiC protocols for sea ice observations were developed by the ASIWG (e.g. measurements of albedo, snow depth, mass balance, melt ponds, ice core stratigraphy).
- **BEPSII - Biogeochemical Exchange Processes at Sea Ice Interfaces -** Collective study from the BEPSII community in *Nature Climate Change* (Lannuzel et al. 2020). Disruptive changes to the Arctic sea-ice

biogeochemical system and associated ecosystem are expected in the future. There is an urgent need for the establishment of long-term observing platforms in climate-sensitive sea-ice regions to collect benchmark data, record seasonal and decadal trends, and to anticipate thresholds and tipping points.

- **PCN – Polar Carbon Network -** An expert assessment provides the first circumarctic estimate of the quantity and climate sensitivity of organic carbon in Arctic Ocean subsea permafrost (Sayedi et al. 2020, ERL). Slow but substantial greenhouse gas release from submarine permafrost should be expected in the future.RCP8.5, the subsea permafrost domain could release 43 Gt by 2100, with approximately 30% fewer emissions under RCP2.6.
- **PCPI – Polar Climate Predictability Initiative -** PCPI lead Kyle Clem explore the recent warming over the South Pole in *Nature Climate Change* (Clem et al. 2020). The warming of 0.61 ± 0.34°C per decade is more than three times the global average. The warming resulted from a strong cyclonic anomaly in the Weddell Sea caused by increasing sea surface temperatures in the western tropical Pacific. The results show how closely linked the interior Antarctic climate is to tropical variability.

Primary Science Issues

- Driven by urgence to understand Human impacts & essential climate services
- Arctic warming and potential for permafrost degassing
- Changes in sea-ice extent
- Polar ice sheet contribution to sea-level rise *1 B people impacted - inundation*
- Loss of Mountain glaciers and ice caps *2 B people impacted – fresh water*
- Antarctic Ice Sheet dynamics and the uncertain contribution to sea-level rise

Challenges and Future Plans

To date, studies of the drivers and climate-impacts of change in the cryosphere have been largely decoupled from studies of the impact of the loss of cryosphere services for global societies. Furthermore, climate research on the cryosphere facilitated by CliC has largely focused on the physical climate with a limited integration of other natural sciences. Yet, projections needed for adaptation, mitigation and for sustainable development require a system approach that addresses problems across the natural sciences and social sciences and includes the engagement of stakeholders. This research and its communication, in turn, will benefit from input from scientists whose cumulative expertise ranges across disciplines, nations and contributes a diversity of perspectives.

To address these challenges, CliC will broaden its mission to include research that is co-designed and executed with relevant stakeholders groups, while continuing to support the research that advances understanding of processes within the cryosphere components of the climate system. Key to this broadened mission is the identification of services provided by the cryosphere to local and global communities and of how these are being impacted by current and projected changes. Examples of these services include supply of freshwater from glaciers, travel over sea-ice, solid building on frozen ground, a stable sea level, and support for leisure activities. Under this mission, CliC will seek to promote research and activities aimed at determining what a *'safe cryosphere'* may look like in a *'safe landing climate'* and in what way the cryosphere may continue to provide the same services to society. To do this, CliC will seek to broaden its reach to scientists and stakeholders from countries and regions that have traditionally not been involved in CliC activities and, in particular, from those who inhabit cryosphere regions. In this regard, CliC will link to WCRP´s new Core Project "Regional Information for Society (RifS)". CliC's new strategic plan aligns with the vision of the WCRP's Strategic Plan (2019-2029) "*using sound, relevant, and timely climate science to ensure a more resilient present and sustainable future for humankind",* and addresses directly the fourth strategic objective of *"bridging climate science and society*".
CLiC will also partner with SCAR's new strategic research program, INSTANT, which is focussed on improving knowledge of instabilities and thresholds in the Antarctic ice sheet to reduce uncertainties in sea-level rise projection