

Report of the GC on Melting Ice, Global Consequences

1. Highlights for JSC

- Three key intercomparison efforts that arose from this Grand Challenge are the Sea Ice Model Intercomparison Project (SIMIP), the Ice Sheet Model Intercomparison Project for CMIP6 (ISMIP6), and the ESMSnowMIP component of the Land Surface, Snow and Soil Moisture Model Intercomparison Project (LS3MIP). All of these are endorsed participants in CMIP6 and have active, autonomous scientific communities and leadership.
- Details can be found here:
 - <https://www.wcrp-climate.org/modelling-wgcm-mip-catalogue/cmip6-endorsed-mips-article/1056-modelling-cmip6-simip>
 - <https://www.wcrp-climate.org/modelling-wgcm-mip-catalogue/cmip6-endorsed-mips-article/1049-modelling-cmip6-ismip>
 - <https://www.wcrp-climate.org/modelling-wgcm-mip-catalogue/cmip6-endorsed-mips-article/1069-modelling-cmip6-ls3mip>
- As for all CMIP6 components, each of these has a paper describing the project in detail (these are available from the links provided above). These papers are part of a large special issue of the journal Geoscientific Model Development.
- The large author teams on each of these papers reflects the enthusiastic community engagement that has developed, and is something the WCRP should be very proud of.
- A large European consortium has developed a mission proposal focused on remote sensing of the cryosphere in both the Arctic and Antarctic, and I was invited to participate as they felt it responded directly to scientific needs articulated by this Grand Challenge. Although the mission was not approved, a paper describing it is in press and the concept will be pursued..

GNSS Transpolar Earth Reflectometry exploriNg system (G-TERN): Mission concept

Estel Cardellach, *Member, IEEE*, Jens Wickert, Rens Baggen, Javier Benito, Adriano Camps, *Fellow, IEEE*, Nuno Catarino, Bertrand Chapron, Andreas Dielacher, Fran Fabra, Greg Flato, Heinrich Fragner, Carolina Gabarró, Christine Gommenginger, Christian Haas, Sean Healy, Manuel Hernandez-Pajares, Per Høeg, Adrian Jäggi, Juha Kainulainen, Shfaqat Abbas Khan, Norbert M.K. Lemke, Weiqiang Li, Son V. Nghiem, Nazzareno Pierdicca, Marcos Portabella, Kimmo Rautiainen, Antonio Rius, *Member, IEEE*, Ingo Sasgen, Maximilian Semmling, C.K. Shum, François Soulat, Andrea K. Steiner, Sébastien Tailhades, Maik Thomas, Roger Vilaseca, and Cinzia Zuffada, *Member, IEEE*

II. SCIENTIFIC OBJECTIVES

Advancing the understanding of the cryosphere in a changing climate has been identified as a 'Grand Challenge' by the World Climate Research Programme (WCRP). Components of the cryosphere play a central role in several processes that remain an important source of uncertainty in projections of future climate change. Examples of such processes are the prospect of an ice-free Arctic Ocean in contradistinction to Antarctic sea ice increase; the role of ice-sheet dynamics in amplification of Greenland and Antarctica's contribution to the global sea-level rise; the fate of mountain glaciers providing fresh water to hundreds of millions of people worldwide; and the strength of positive feedbacks between the warming climate and natural emissions of greenhouse gases from the thawing permafrost [35]. Furthermore, a particular issue has emerged in past Intergovernmental Panel on Climate Change (IPCC) Assessments [36] as topic of considerable uncertainty: the ability of models to simulate recent declines and future changes in sea ice. Recent studies have linked changes in snow and ice to circulation changes, weather extremes, and the obvious impacts on terrestrial and marine ecosystems, which create a great sense of urgency [37]. For the reasons discussed below, G-TERN primarily aims to contribute to understanding

This is an example of the influence WCRP is having more broadly in motivating new research activities.

2. Early success and/or planned activities in 2018/2019



Has been very successful in maintaining momentum, and has had three workshops, including one this past December.



SIMIP had a workshop in March of 2017

- To discuss and define best practices for the evaluation of sea-ice simulations against observations
- To identify and define new remote sensing and in situ sea ice observations that will allow for improved model evaluation and initialization
- To discuss and coordinate the analysis of CMIP6 sea ice simulations for improved understanding of sea ice processes and improved sea ice projections.



had a kickoff meeting in September, 2017, and is planning a much larger meeting, in conjunction with the coordination teams of C4MIP and LUMIP and the European project CRESCENDO, to be held in Toulouse in October, 2018.

3. Partners for GC implementation (within and outside WCRP community)

Many organizations are providing direct and in-kind support, primarily through the scientific leads of these three projects

4.Overall GC timeline (include any milestones)

In all cases, the projects must await simulations performed by modelling groups around the world as part of CMIP6. Historical runs are now underway, and future scenario runs will be done in the coming year (see WGCM report). In order to be cited in upcoming IPCC main assessment, papers resulting from these projects will have to be submitted by 31 January, 2020 and accepted by 15 October 2020.

5. Issues and challenges

- This GC operates with very limited resources and depends on the generous contributions from the scientists leading the various intercomparison activities.
 - As has been the case from the start, it has been difficult to clearly distinguish between the activities of the cryosphere GC and the CliC core project. In some sense this doesn't matter, but in the future we should avoid such ambiguities to the extent possible.
 - I have been leading this GC since its inception (in my capacity as CliC co-chair), but since I am no longer co-chair, I feel it would be better to pass this responsibility on, ideally to someone who can put more time and energy into it.
-