Cryosphere Grand Challenge:

"Melting Ice – Global Consequences"

A draft initial workplan was developed last year.

Following further discussion with WCRP and CliC leadership, a revised workplan was prepared (February, 2016).

It is available here: http://www.wcrp-climate.org/GRANDCHALLENGES/Melting%20Ice/documents/Melting_Ice_Global_Consequences_Feb_2016.pdf

Motivation for narrower focus

(recall this was briefly covered at last JSC)

As the climate warms, the response of the cryosphere is inevitably enhanced melt. This has had, and will continue to have, profound, societally relevant global consequences. The most pressing of these involve:

- thawing permafrost and the potential for enhanced natural emissions of carbon dioxide and methane to the atmosphere;
- shrinking of mountain glaciers and large ice sheets with consequent sea-level rise and impacts on water resources;
- declining coverage of sea ice and snow, which will affect marine and ground transportation across the Arctic

In order to make scientifically credible, quantitative projections of these critical changes, we need to better understand the underlying processes and improve our capability to represent them in global earth system models.

The overarching question: ***How will melting ice respond to, and feedback on, the climate response to increasing greenhouse gases, and what will the impacts be?***

So, our initial focus will be in the following three areas …

1. Quantifying the amount of carbon available in permafrost areas, evaluating the potential for release of this carbon, and improving our capability to simulate the response of permafrost, and its connection to the global carbon cycle, under a warming climate.

This is a pressing and timely issue given the potential for significant, positive feedback in the climate system, in addition to the direct ramifications of permafrost thaw on human activities throughout the high latitudes.

2. Evaluating glacier and ice sheet models for use in projecting melt rates and corresponding sea-level rise – in both cases these represent scientific communities that have not been strongly engaged in climate projection activities. WCRP leadership is fundamental in developing such links.

In addition to sea-level rise, shrinking glaciers will have profound and direct impacts on millions of people whose water resources depend on the summertime storage provided by mountain glaciers.

3. Assembling the most reliable observational data on sea-ice and snow and using these data to evaluate and improve climate model simulations of the remarkable changes that have already been observed and to enhance confidence in future projections.

Many activities in the Arctic, from marine transportation to seasonal roads and traditional hunting are profoundly affected by the amount and timing of sea-ice and snow cover. In addition, changes in snow and ice have direct consequences for fragile high-latitude ecosystems (terrestrial and marine), and, some have suggested, impacts on hemispheric circulation and weather patterns.

The workplan lays out specific activities to make rapid progress in these areas, namely:

•establishing a Permafrost Modelling Forum to foster engagement amongst the permafrost observation/process and large-scale modelling communities so as to improve confidence in carbon stock estimates and the potential release rates under warming climate; build upon Permafrost Carbon Network;

•focusing analysis efforts on large-scale ice sheet models and global glacier mass balance models, and applying them in the CMIP6 context to provide quantitative estimates of future sea-level contributions (this may also be relevant to water availability grand challenge);

•enhancing the involvement of sea-ice and snow obs/process specialists in analysis of CMIP6 simulations.

The goal is to have community-led papers summarizing these results in time to make a visible contribution to the next IPCC and similar assessments.

NOTE: two weeks ago, the IPCC agreed to prepare three Special Reports, in addition to the regular three Working Group contributions.

- Impacts of 1.5oC temperature increase and related GHG emission pathways

- Climate change, oceans and cryosphere

- Climate change, desertification, land degradation, sustainable land management, food security, and GHG fluxes in terrestrial ecosystems

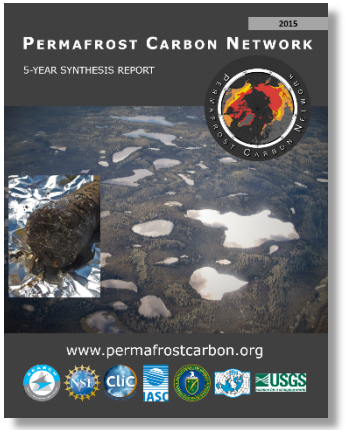
Progress to date:

- Initial workshops/activities have brought in people not traditionally engaged in WCRP activities.
- Detailed CMIP6 proposals submitted and accepted by CMIP panel (sea-ice, snow, ice sheets); data requests prepared. GMD papers in progress.
- Workplan and leaders in place for global glacier mass balance initiative.
- Leadership in place for permafrost modelling forum, and international participation is building.
- We also have a core contribution to the sea-level grand challenge.

Permafrost Carbon Network

What is the magnitude, timing, and form of the permafrost carbon release to the atmosphere in a warmer world?

www.permafrostcarbon.org



Schädel, McGuire & Schuur 2015

Recently (since December 2015) published or accepted products/syntheses:

Abbott BW, Jones JB, Schuur EAG et al. (2016) Biomass offsets little or none of permafrost carbon release from soils, streams, and wildfire: an expert assessment. *Environmental Research Letters,* 11, 034014 http://dx.doi.org/10.1088/1748-9326/11/3/034014

Grosse G, Goetz S, McGuire AD, Romanovsky VE, Schuur EAG (submitted) Review and Synthesis: Permafrost in a Warming World and Feedbacks to the Earth System. *Environmental Research Letters,* 11, 040201

Schädel C, Bader MFK, Schuur EAG et al. (accepted) Potential carbon emissions dominated by carbon dioxide from thawed permafrost soils. *Nature Climate Change*

Vonk JE, Tank SE, Bowden WB et al. (2015) Reviews and syntheses: Effects of permafrost thaw on Arctic aquatic ecosystems. *Biogeosciences,* 12, 7129-7167. doi: 10.5194/bg-12-7129-2015

Wik M, Varner RK, Anthony KW, MacIntyre S, Bastviken D (2016) Climate-sensitive northern lakes and ponds are critical components of methane release. *Nature Geoscience,* doi:10.1038/ngeo2578

Products in revision:

McGuire AD, Koven CD, Lawrence, DM et al. (submitted): A model-based analysis of the vulnerability of carbon in the permafrost region between 1960 and 2009. *Global Biogeochemical Cycles*

Olefeldt D, Goswami S, Grosse G, et al. (in revision) Thermokarst terrain: circumpolar distribution and soil carbon vulnerability. *Nature Communications*

New syntheses in progress:

- **Reconciling Permafrost Region Methane Budgets**: *Lead: D. McGuire, J. Frederick, R. McDonald*
- **Quantifying relationships between vegetation structure and permafrost thermal dynamics;** *Lead: M. Loranty, H. Kropp, S. Natali*
- **Where and when will the Arctic become wetter or drier?** *Lead: C. Andresen, C. Wilson*
- **Carbon emissions from the Arctic during the non-growing season.** *Lead: S. Natali*
- **Strategizing a laboratory protocol to determine the decomposability of soil organic matter in permafrost.** *Lead: C. Schädel*

Upcoming meetings:

- **Synthesis Lead meeting:** June 18-19, 2016; Potsdam, Germany (CliC support for early career scientists)
- **6th Annual Meeting of the Permafrost Carbon Network:** December 11, 2016, San Francisco, CA

Ice Sheet Model Intercomparison Project for CMIP6

Leads: S. Nowicki, T. Payne and E. Larour

Community building via:

- workshops (PreAGU, Dec 2015),
- meetings (IGS, Aug 2015; EGU, Apr 2016)
- presentations (AGU 2016; EGU 2016; WCRP SL GC 2016; CliC SSG 2016;…)

Current modeling activity: initMIP

- Targets standalone ice sheet models
- Goal 1: Understand impact of initialization method on ice sheet evolution and sea level projection.
- Goal 2: Get ISM community ready for ISMIP6 projections (ie: file format, variable request, output grid…)
- 15 different groups, 20 different initializations

GMD ISMIP6 paper near completion

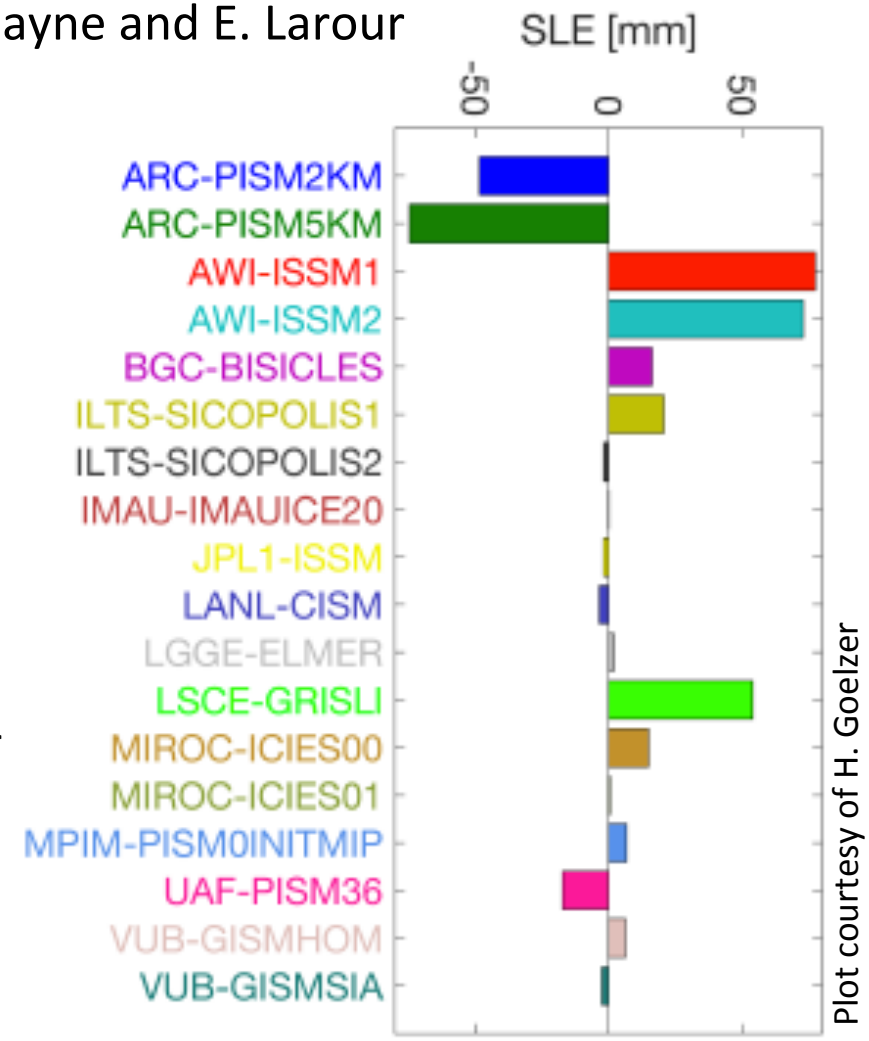
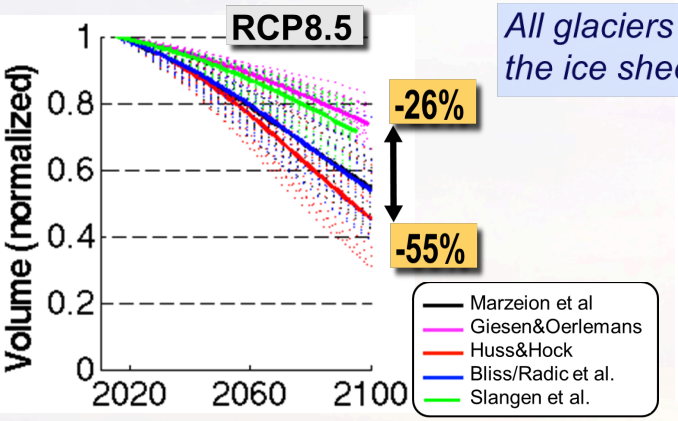


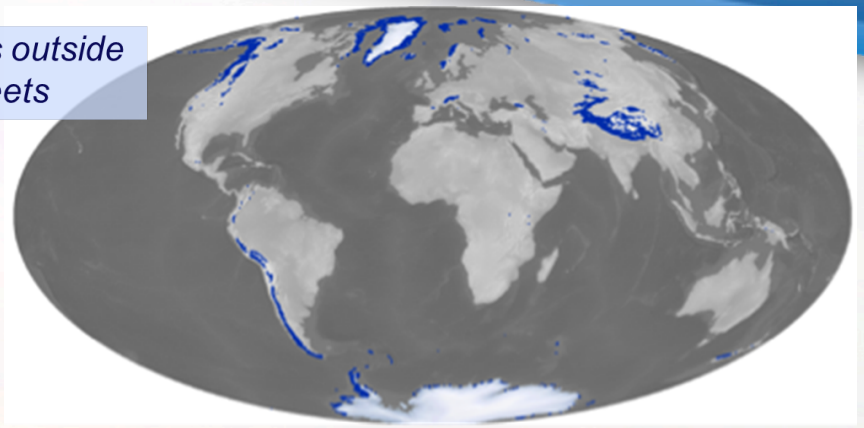
Fig: Centennial sea level background trend in control experiment due to model drift or transient initialization

Website: http://www.climate-cryosphere.org/activities/targeted/ismip6
Wiki: http://www.climate-cryosphere.org/wiki/index.php?title=InitMIP

GlacierMIP



All glaciers outside the ice sheets



Objective:

- to compare the existing global-scale projections for each of the major glacierized regions.

Progress:

- Several groups engaged, initially using CMIP5 model forcing; preparing for CMIP6.

Next steps:

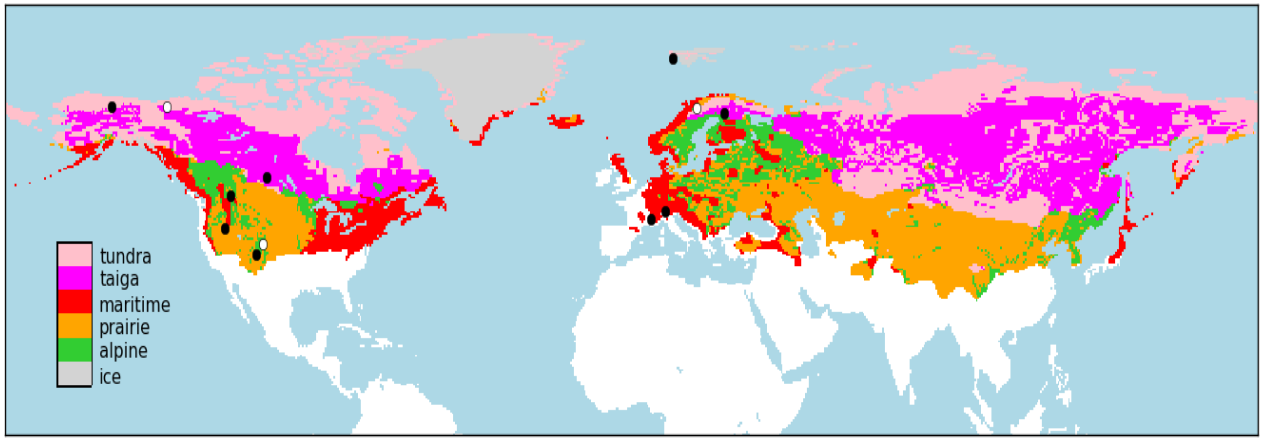
- Submission of publication on model intercomparison by the end of 2016

ESM-SnowMIP: Snow model evaluation and snow feedback analysis

Strategy

- Contributing to LS3MIP: Coupled & forced global land surface model runs
- Strong link to GEWEX community
- Snow feedback analysis: Prescribed land surface state and shortwave radiative effect analysis
- Start with site-specific runs including dedicated snow models
- Additional global experiments after CMIP6

Meeting to launch site experiments at AGU 2016



Data provided by NCAR/EOL under sponsorship of the National Science Foundation. http://data.eol.ucar.edu/

CMIP6 SIMIP

Recent progress:

- Compiled a list of sea-ice state variables that allows researchers to analyze the heat budget, the mass budget and the momentum budget of sea ice.
- This list is now in the CMIP6 data request: (www.climate-cryosphere.org/simip).
- Description of data request published in CMIP6 GMD special issue (currently in GMD Discussion).

Next steps:

- Coordinate efforts to analyze CMIP6 sea ice model simulations.
- Focus on improved model evaluation through joint workshop(s) with providers of observational data.

Next steps:

•Short paper outlining/publicizing Grand Challenge (to be done shortly).

•Continue organization and implementation of MIP activities.

•Promote early organization of group papers summarizing results, particularly in light of the IPCC AR6 schedule and planned Special Reports.

•Think about an overall synthesis paper on 'global consequences of melting ice' – a kind of wrap-up of the first phase of this Grand Challenge.

•At WCRP level:

- discuss how best to identify these activities with WCRP – noting reliance on core project infrastructure, but wanting to illustrate clear outcomes of Grand Challenge.
- Discuss ways to attract additional financial support for meetings/workshops/synthesis.
- Discuss longer-term future of GC.