Grand Challenge: *The Cryosphere in a Changing Climate*

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Overview

- White paper drafted by V. Kattsov, G. Flato, S. Bony, S. Gille, B. Kirtman, V. Ryabinin, A. Scaife and K. Trenberth.

- WP notes the importance of the Cryosphere in the climate system, the important feedbacks, and the need for improved representation of cryospheric processes in global and regional models used to make quantitative predictions and projections of future climate.

- A dedicated workshop was held in Tromso, Norway in October, 2013 to discuss the white paper, engage the cryosphere research community, and identify specific next steps.

- Because of the substantial overlap with CliC 'core' activities, many of the specific Grand Challenge activities are being integrated with overall CliC planning.

Proposed Science Foci

- The white paper identified the following topics as being tractable, ready for enhanced attention, and likely to yield visible progress with rather modest organization/ coordination:
  - Seasonal, interannual and longer term predictions of polar climate and the role of the cryosphere in climate predictability. (note that this anticipated the emergence of PCPI as a mechanism to pursue this topic – second half of presentation).
  - Enhanced analysis of model intercomparison results (CMIP, CORDEX) aimed at understanding and attributing model biases to cryosphere components. (note: this has been taken up in CliC targeted activities – later presentation).

Proposed Science Foci, cont'd

- Improved representation of permafrost and high-latitude land surface (including wetlands) in climate models, with a specific emphasis on their role in the global carbon cycle.

- Focused effort on developing ice sheet models, with specific emphasis on the role of ice sheet dynamics on the rate of sea-level rise. (note: there is a clear connection here to the grand challenge on sea-level rise).

Cryosphere Grand Challenge Workshop

- ~30 invitees, chosen to represent a broad cross-section of cryosphere science, with an emphasis on engaging researchers who have not previously been involved in CliC or WCRP activities.
  - Wanted to use as an outreach opportunity, and to generate new/alternative ideas.
  - Some invitees chosen to make connections to other WCRP projects or to relevant international bodies.
  - Several people attended 'remotely', and presentations were all video-recorded and are available on the CliC web site.

- Started with overview talks to set the stage, then discipline-focused breakout groups (glaciology, snow, sea-ice, permafrost).

- Direction was to identify 'actionable items', along with motivation, timeframe, and suggested leaders/participants.

The Research Council of Norway

Tromso, Norway
16-18 Oct 2013

CliC

www.climate-cryosphere.org

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MEETINGS

The Cryosphere in a Changing Climate

World Climate Research Programme and Climate and Cryosphere Project Workshop; Tromsø, Norway, 16–18 October 2013

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The World Climate Research Programme (WCRP) Joint Science Committee has announced a series of "Grand Challenges," calls to scientists to focus their research on areas that are important in understanding the climate system. One such area is the cryosphere in a changing climate. A 2012 draft white paper on this topic (http://www.climate-cryosphere.org/media-gallery/618-gc-cryo) served as the basis for a WCRP workshop held in mid-October 2013 in Tromsø, Norway. The workshop centered on four themes: predictions and projections of polar climate; cryosphere model biases and shortcomings; ice sheet models, dynamics, and sea level rise; and permafrost and carbon for Earth system models.

Participants heard presentations on the WCRP Grand Challenges and the cryosphere in a changing climate (Greg Flato, Environment Canada), the Polar Climate Predictability Initiative (Marilyn Raphael, University of California, Los Angeles), ice sheets and glaciers in a changing climate (Andy Shepherd, University of Leeds), sea ice in a changing climate (Dirk Notz, Max Planck Institute for Meteorology), permafrost and carbon in a changing climate (Ted Schuur, University of Florida), and cryosphere biases and shortcomings in Earth system models (Gerhard Krinner, Université Joseph Fourier). Interdisciplinary breakout groups then brainstormed on priority research issues and discussed action plans for moving forward.

Workshop attendees then broke into four topic groups—glaciology, snow, sea ice, and permafrost—to develop plans for advancing research, including specific questions to address, the time frame, and a list of potential participants.

The permafrost breakout group put forward plans to assess the magnitude, timing, and form of carbon-based greenhouse gas release into the atmosphere from thawing permafrost and how to better incorporate this information into Earth system and global climate models.

The glaciology breakout group proposed plans for assessing current and future melt of global glaciers and ice caps; addressing the shortcomings in the quantification of freshwater volume and availability from the cryosphere; and building better models that capture ice sheet snowpack melt, storage, and runoff.

The sea ice breakout group proposed projects on understanding the effects of changing sea ice on high-latitude and midlatitude climate systems, as well as the internal variability of sea ice up to multidecadal time scales, and assuring their better representation in climate models.

Finally, the snow group began plans for an initiative to better understand the role of snow in the Earth system, as well as plans to enhance understanding of the effects of snow changes on freshwater availability.

All of these goals were specifically framed in terms of tasks to accomplish in the near future (3–5 years). As working groups move forward on these goals, inclusion of interdisciplinary aspects (atmosphere, biosphere, etc.) will be encouraged to better produce meaningful research outputs.

The full meeting report, as well as presentation videos and PDFs, is available at http://www.climate-cryosphere.org/meetings/past-meetings/wcrp-cryo-gc-2013. Also available are "Frostbytes," short videos about current research being conducted by the early-career workshop participants. In addition, a separate and evolving strategy document is also being produced as a follow-up to the original white paper.

Funding for the workshop was provided by the Research Council of Norway, the WCRP, the Climate and Cryosphere (CliC) Project Office, and the Norwegian Polar Institute.

—Allen Pope, National Snow and Ice Data Center, University of Colorado, Boulder; email: allen.pope@nsidc.org; and Jenny Baeseman, Climate and Cryosphere Project, Norwegian Polar Institute, Norway

Topics that emerged

- Current state of the permafrost carbon reservoir and greenhouse gas balance of the circumpolar region
- Magnitude, timing and form of greenhouse gas release from permafrost carbon reservoir to the atmosphere in a warming world
- Current and future mass loss of global glaciers and ice caps
- Freshwater volume and availability from the cryosphere
- Ice sheet snowpack melt, storage, and runoff
- Impact of changing sea ice on high-latitude climate systems
- Internal variability of sea ice up to multi-decadal time scale
- Impact of snow changes on water resources
- The role of snow as an active component of the global climate system

- Note that one of the introductory talks was on PCPI, and the various proposed activities within it were described. So, we did not pursue any topics that were already covered by PCPI.

- The specific topics that were identified generally fit well under the overarching science foci that were outlined in the White Paper.
  - In many cases, the feeling was that the community was ready, and that progress could be made with only some impetus provided by meeting support or coordinating a review/assessment paper.
  - In some cases (e.g. permafrost carbon network), there was already an organized activity that could be built upon.

- Some of the proposed topics were closely related to (or overlap with) new targetted activities already discussed by the CliC SSG, so some rationalization was needed.

- Subsequent discussions, leading up to and at the CliC SSG meeting in February, resulted in some refinement of specific activities, and some consolidation within CliC's evolving structure.

- There was a feeling that we should not take on too much all at once, but focus on those topics where we could best mobilize effort and add value.

- We also invited leads from all the other GC's to attend the CliC SSG to ensure that CliC's role in the other GC's and the connections between the Cryo GC and other GC's were identified.
  - Connection to sea-level grand challenge is most obvious and there have been subsequent discussions and an agreed division of responsibility between CliC and CliVar.

- The CliC SSG generally felt that much of the Cryosphere Grand Challenge mapped naturally onto CliC ‘core’ activities and fit well into the CliC structure.
  - More on this in the CliC presentation, but briefly …

Topics that emerged

- Current state of the permafrost carbon reservoir and greenhou
balance of the circumpolar region
- Magnitude, timing and form of greenhouse gas release from
carbon reservoir to the atmosphere in a warming world

Part of Permafrost Carbon Network activities

ISMASS and potential activity on glacier volume

- ss loss of global glaciers and ice caps
- Freshwater volume and availability from the cryosphere

Arctic Freshwater Synthesis

- Ice sheet snowpack melt, storage, and runoff

Sea-ice and climate modeling forum

- hanging sea ice on high-latitude climate systems
- variability of sea ice up to multi-decadal time sc

Arctic Snow workshop (with IASC, AMAP and InterAct)

- Impact of snow changes on water resources
- The role of snow as an active component of the global clima

ESMSnowMIP

- Also, PCPI has a well-developed plan, a set of specific actions, and leaders identified, so that aspect of the Cryosphere Grand Challenge is well in hand.
  - Over to Ted …