Report to CLIVAR SSG-20

Panel or Working Group: **Southern Ocean Panel**

1. Contributions to developing CLIVAR science and fit, where appropriate, to the CLIVAR imperatives

8th Session of the CLIVAR/CliC/SCAR Southern Ocean Panel

Presentations and discussions relevant to the following CLIVAR research opportunities:
Decadal variability and predictability of ocean and climate variability and;
Dynamics of regional sea level variability
(Presentations included ocean-atmosphere observations in the Southern Ocean, under ice observations, highlights of the Antarctica Ocean 2K working group activities, SOOS update, upper and lower limbs of the meridional overturning circulation, eddy physics, the nexus between Southern Ocean and WGOMD activities, CORE intercomparisons and CMIP5 model analyses with regard to the Southern Ocean)

WGOMD/SOP Workshop on Sea Level Rise, Ocean/Ice Shelf Interactions and Ice Sheets

Presentations and discussions relevant to the following CLIVAR research opportunities:
Decadal variability and predictability of ocean and climate variability and;
Dynamics of regional sea level variability
(Sessions included coverage of observations of sea level and land ice change, land ice dynamics and modelling; ocean – ice-shelf interactions and ocean model and coupled model simulations. Presentations included global and regional thermostatic sea level change, sea level change in the geological record, satellite estimation of Antarctic sea level, global ocean change in historical records and ocean-ice interaction: observations and modelling in Greenland and Antarctica).

Publications

Bourassa, Mark A., and Coauthors, 2013: High-Latitude Ocean and Sea Ice Surface Fluxes: Challenges for Climate Research. Bull. Amer. Meteor. Soc., 94, 403–423.
doi: http://dx.doi.org/10.1175/BAMS-D-11-00244.1
This paper was written by the US CLIVAR High Latitude Surface Flux Working Group. Mark A. Bourassa, Sarah T. Gille, Cecilia Bitz, David Carlson, Ivana Cerovecki, Carol Anne Clayson, Meghan F. Cronin, Will M. Drennan, Chris W. Fairall, Ross N. Hoffman, Gudrun Magnusdottir, Rachel T. Pinker, Ian A. Renfrew, Mark Serreze, Kevin Speer, Lynne D. Talley, Gary A. Wick

Briefly list any specific areas of your panel's activities that you think would contribute to the WCRP Grand Challenges as identified by the JSC at its most recent meeting[1]

- *Provision of skillful future climate information on regional scales*
  - *Close engagement with WGOMD on SO modeling activities. There is a need for some new experiments using a similar framework as CORE II, e.g., wind and freshwater perturbations*
  - *There has been a detailed evaluation and synthesis of CMIP5 model projections spanning atmosphere, oceans (hydrography, circulation, etc, and sea-ice)*
- *Regional sea level rise*
  - *Ongoing input on the role of the southern hemisphere cryosphere on sea level*
  - *2013 workshop co-organized with WGOMD on sea level rise, amongst other topics*
- *Cryospheric response to climate change*
  - *Activities towards the development of SOOS*
  - *2013 workshop focused on ocean/ice-shelf interaction, and ice sheets*
  - *SOP7 addressed Southern Ocean physics (and ice)*
- *Improved understanding of the interactions of clouds, aerosols, precipitation, and radiation and their contributions to climate sensitivity*
  - *Atmospheric processes over the Southern Ocean was one of the key topics of SOP7*
  - *SOP8 included a dedicated session on Southern Ocean clouds: recent advances and future imperatives*
- *Past and future changes in water availability (with connections to water security and hydrological cycle) and Science underpinning the prediction and attribution of extreme events*
  - *Focus on atmospheric processes over the Southern Ocean during SOP7, which highlighted e.g. SAM influence on precipitation/drought events in Southern Hemisphere regions*
  - *Support extending the observing under ice, for better cryosphere predictions, glacial ice melt processes*

2. Key new science findings in the context of the new ocean-atmosphere CLIVAR (1-3 suggestions)

- IPCC models show large variation in sea-ice representation and sea-ice response to climate change
- Estimates of ice volume from animals: SEaOS

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1. Provision of skillful future climate information on regional scales (includes decadal and polar predictability)
2. Regional sea-level rise
3. Cryosphere response to climate change (including ice sheets, water resources, permafrost and carbon)
4. Improved understanding of the interactions of clouds, aerosols, precipitation, and radiation and their contributions to climate sensitivity

- Estimates of CO2 fluxes in response to SAM changes (ocean still a sink, for now)
- Distinct SAM and ENSO control of ACC frontal position
- SOSE: high resolution Southern Ocean reanalysis
- Eddy fluxes important for mode waters, maybe deep warming
- Spatial structure of lateral diffusion linked to overturning
- May be in eddy-saturation regime such that wind increase does not translate into stronger ACC
- Accurate surface fluxes and waves (surface boundary layer meteorology) impacts prediction of winds and storms
- CASO and SASSI observations of stratification trends and CO2 system
- Increased ice shelf basal melting does not need a warmer ocean, just a re-routing of warm open ocean waters. Such rerouting can be driven jointly by changes in wind direction and shelf water freshening.

3. Key science questions that you anticipate your community would want to tackle in the next 5-10 years within the context of the new ocean-atmosphere CLIVAR (1-3 suggestions)

- **Sea-level rise:** What are the main contributions to sea-level rise? What are the relative contributions of, for example, steric changes in the ocean versus addition of mass to the ocean from land-ice sources?
  The freshwater input simulation
- **Ocean modelling:** Which of the identified processes contributing to sea-level rise are well represented by current ocean models? What is the relative importance of steric contributions to sea-level rise compared to the mass induced contributions from ice-sheet melting? How well are ocean and coupled climate models able to predict changes in ocean warming at the ice-sheet margins? What role might sea-ice or polynyas play in moderating or amplifying ocean changes at the ice-sheet margins? How can the use of observations enlighten our understanding of ocean and sea-ice processes adjacent to Greenland and Antarctica? How can we reduce long-term drift in ocean climate models?
- **Ocean/ice-shelf interactions:** What is the state-of-science in both the observation and modelling of sub-ice shelf processes? How might these processes change in a changing climate? What are the relative roles of basal melt, basal accretion, and calving, in determining the current and future evolution of ice-shelves? How might changes in mean or extreme winds affect ice-shelves? What role might be played by sea-ice in buffering ice-shelves from tides and surface waves? What are the effects of increased ice-shelf meltwater injection on local ocean/sea-ice interactions?
- **Ice-sheet observation and modeling:** How well do we understand the current mass balance, including its spatial variability, of the Antarctic and Greenland ice-sheets? What is the state-of-science in ice-sheet modeling? What are the relative roles of ice dynamics and of surface mass balance in determining current and future changes?
- **Ocean/ice-shelf interactions:** How will possible increased melting

break-up of ice-shelves affect ice-sheets? What is the role of ice-shelves on adjoining ice stream dynamics? How well are dynamical ice-sheet models able to simulate ice flow? Are these models capable of predicting the response to changes in the system?

4. Cooperation with other WCRP projects, other global change bodies (e,g. IGBP) and links to applications

The CLIVAR/CliC/SCAR Southern Ocean Region Panel acts as an intersection between WCRP CLIVAR, WCRP CliC and the Scientific Committee on Antarctic Research (SCAR), which is an interdisciplinary committee of the International Council for Science. The link with SCAR is particularly prevalent with the development of the Southern Ocean Observing System.

The panel is building on links with the WGOMD community; the 8th meeting of the Southern Ocean panel had three 'themes', one of which was a joint session with the WGOMD. During this session the panel heard about a variety of modelling comparison projects from invited speakers with expertise in this field. A series of papers are in press intercomparing Southern Ocean physics and Southern Ocean circulation/hydrography metrics in the CMIP5 simulation set.

The panel is also developing links with SPARC/DynVar. Ed Gerber (an invited speaker at SOP7) attended the WCRP Polar Climate Predictability Initiative as a representative of SOP, to communicate current activities in the Southern Ocean.

5. Activities in the context of scientific capacity building and career support?

The SOBOM program is currently in its infancy howver, once fully running it will include an education, diversity and outreach (EDO) theme. The EDO team of the C-SOBOM collaboration will work to foster a strong pipeline of ocean scientists, bring new talent and technology into the field of oceanography, and better equip the public and policymakers to address the challenges of climate change. An undergraduate education and diversity program will be coordinated by Theme 2 Lead Oscar Schofield at Rutgers University, which has an innovative series of educational programs reaching out to K-12 and undergraduate students. Graduate student and postdoc training will be carried out jointly by all the participating institutions under the leadership of Princeton University. Co-Lead Heidi Cullen of Climate Central, an independent, non-profit journalism and research organization that promotes understanding of climate science, will coordinate outreach. Programs to increase diversity in the pipeline of ocean scientists will be carried out in partnership with the Institute for Broadening Participation.

There are substantial activities across all participating nations but they are not SOP-driven per se. In Australia for example, there are:
- student at sea programs
- ECR workshops
- career training for ECRs (grants, projects, advising PhDs...)
- winter schools

- travel support
- graduate courses
- internships

Ed Gerber attended the WCRP Polar Climate Predictability Initiative in Toronto, Canada in April 2012. The purpose of this meeting was to develop a draft implementation plan for an initiative, to be considered by the WCRP Joint Scientific Committee (JSC) at its meeting in July 2012, as well as at the IASC Atmosphere WG meeting in April 2012. As a result of this meeting the JSC decided SPARC would taking the lead in planning for the WCRP Polar Climate Predictability Initiative.

6. Activities in the context of knowledge exchange with societal actors?

SOP has an involvement with the SOBOM programme. SOBOM theme 3 concerns education diversity and outreach activities. Activities will include undergraduate education and outreach, graduate and postdoctoral training as well as independent non-profit journalism to promote the understanding of climate science.

7. New activities being planned, including timeline, request for endorsements, potential for new funding opportunities

- Southern Ocean Biogeochemical Observations and Modelling (SOBOM)
- Develop a review paper on the state of southern climate system and recent trends (underway with panel co-authors)
- Work closely with CliC to develop a freshwater flux estimate and evaluation for the Southern Ocean, particularly in regard to ice shelf and land-ice melt.

8. Workshops / meetings planned

- SOP9 (to be held at Princeton (dates??)
- SOOS Asian Workshop, 23 – 25th May 2013

9. Issues for the SSG

Annex A

Proforma for CLIVAR Panel and Working Group requests for SSG approval for meetings

Requests should be made through D/ICPO (rogbar@noc.ac.uk), against the following headings:

1. **Panel or Working Group:**
2. **Title of meeting or workshop:**
3. **Proposed venue:**
4. **Proposed dates:**
5. **Proposed attendees, including likely number:**
6. **Rationale, motivation and justification, including: relevance to CLIVAR themes & JSC cross cutting topics and any cross-panel/working group links and interactions involved:**
7. **Specific objectives and key agenda items:**
8. **Anticipated outcomes (deliverables):**
9. **Format:**
10. **Science Organising Committee (if relevant)**
11. **Local Organising Committee (if relevant)**
12. **Proposed funding sources and anticipated funding requested from WCRP:**