

CLIVAR/CliC/SCAR Southern Ocean Region Panel SORP-11: Sept. 17-18, 2016

National activities report

Country CANADA
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Receipt of material prior to Sept. 5, 2016 will ensure inclusion in meeting discussion. Receipt of material prior to Oct. 10, 2016 will ensure inclusion in meeting report and contribute to future SORP discussions, as well as input to the SOOS and other CLIVAR/CliC/SCAR activities.

Purpose of material gathered for the SORP: To build an overview of
- observational, modeling, state estimation initiatives relevant to the SORP

(This can include a list of activities, maps showing where work has been done, major international project involvement, etc.)

A. Recent and ongoing activities

Does your country have a national committee tasked with oversight of Southern Ocean climate science?

Polar Knowledge Canada (POLAR) is Canada's lead federal agency to strengthen Canadian leadership in science and technology in the polar regions. POLAR is Canada's adhering body to the Scientific Committee on Antarctic Research (SCAR) and the International Arctic Science Committee (IASC), and serves as a primary point of contact for the international research community interested in doing research in Canada's Arctic or collaborating with Canadians on research in the Antarctic. For further information, please visit POLAR's website at <https://www.canada.ca/en/polar-knowledge.html> or contact POLAR at info@polar.gc.ca.

Canada does not currently have a national committee specifically tasked with oversight of Southern Ocean climate science. However, POLAR's Canadian Committee on Antarctic Research (CCAR) provides advice and guidance to POLAR on Antarctic matters more broadly, and serves as Canada's National Committee under SCAR.

What major activities have been carried out in the **last several years or are in progress** now? Contact information for the projects would be useful.

POLAR is working to develop a Canadian Antarctic Research Program to provide a more comprehensive understanding of the Antarctic region, global systems, and polar linkages. However, with the current absence of a national program, Canadian researchers pursue Antarctic research largely in partnership with the national Antarctic programs of other countries. Some examples of recent and current Canadian work related to Southern Ocean observational, modeling, and state estimation are provided below.

Philippe Tortell, Professor, Biological/Chemical Oceanography, University of British Columbia (ptortell@eos.ubc.ca) participated in a US National Science Foundation project in the Antarctic Peninsula region to collect a suite of chemical/biological measurements, with the outputs documented in the following publications:

- E.C. Asher, J.W.H. Dacey, and P.D. Tortell. The seasonal cycle of DMS, DMSP and DMSO concentrations and turnover rates in surface waters of the West Antarctic Peninsula. *Limnology and Oceanography*. In press*
- M.R. Stukel, E.C. Asher, N. Couto, O. Schofield, S. Strebel, P.D. Tortell and H.W. Ducklow. 2015. The imbalance of new and export production in the Western Antarctic Peninsula, a potentially “leaky” ecosystem. *Global Biogeochemical Cycles*, doi: 10.1002/2015GB005211*
- J.N. Young, S.A. Kranz, J.A.L. Goldman, P.D. Tortell, F.M.M. Morel. 2015. Antarctic phytoplankton down-regulate their carbon concentrating mechanisms under high CO₂ with no change in growth rates. *Marine Ecology Progress Series*. 532: pp 13-28, doi 10.3354/meps11336*
- Tortell, P.D., E.C. Asher, H. Ducklow, J. Goldman, J.D. Dacey, J. Grzymalski, J. Young, S. Kranz, K. Bernard, and F.M.M. Morel. 2014. Metabolic balance of coastal Antarctic waters revealed by autonomous pCO₂ and ΔO₂/Ar measurements. *Geophysical Research Letters*, doi 10.1002/2014GL061266*

The Canadian Centre for Climate Modelling and Analysis (CCCMA) at Environment and Climate Change Canada (ECCC) (cccma_info@ec.gc.ca) focuses on global Earth system modeling, which contributes increased knowledge of the Southern Ocean, as detailed in the following publications (2014-present):

- Hogg, A. McC., P. Spence, O. A. Saenko and S. M. Downes. (2016). The energetics of Southern Ocean upwelling, *Journal of Physical Oceanography*, Submitted.*
- Swart, N.C., J.C. Fyfe, N.P. Gillett and G.J. Marshall. (2015). Comparing Trends in the Southern Annular Mode and Surface Westerly Jet, *J. Clim*, 28, doi: 10.1175/JCLI-D-15-0334.1.*
- M.-È. Gagné, N. P. Gillett, J. C. Fyfe. (2015). Observed and simulated changes in Antarctic sea ice extent over the past 50 years, *Geophys. Res. Letters*, 42, 90-95.*

- *Swart, N.C., J.C. Fyfe, O.A. Saenko and M. Eby. (2014). Wind driven changes in the ocean carbon sink, Biogeosciences Discuss., 11, 8023-8048, doi:10.5194/bgd-11-8023-2014.*
- *Sigmond, M. and J.C. Fyfe. (2014). The Antarctic sea ice response to the ozone hole in climate models, J. Clim, 27, 1336-42, doi 10.1175/JCLI-D-13-00590.1*
- *Spence, P., S. M. Griffies, M. H. England, A. M. C. Hogg, O. A. Saenko, and N. C. Jourdain. (2014). Rapid subsurface warming and circulation changes of Antarctic coastal waters by poleward shifting winds, Geophys. Res. Lett., 41, 4601-4610, doi:10.1002/2014GL060613.*

CCCMA recently produced the CanESM2 “Super Ensemble,” for detection and attribution of observed changes in Southern Ocean temperature, salinity and sea-ice. It consists of the following four experiments spanning 1950 to 2100, each comprising large ensembles of 50 members: (1) all forcing; (2) natural forcing only; (3) anthropogenic aerosols forcing only; and (4) stratospheric ozone depletion only.

From 2006-13, Karen Kohfeld, Associate Professor and Canada Research Chair (II) in Climate, Resource and Global Change, Simon Fraser University (kohfeld@sfu.ca) was involved in an assessment of past changes of the state of Southern Hemisphere westerly winds and oceanic fronts using paleo-data, HiGEM model simulations, and satellite reconstructions of ocean fronts with researchers from the UK, Germany and Sweden.

Karen Kohfeld, Associate Professor and Canada Research Chair (II) in Climate, Resource and Global Change, Simon Fraser University (SFU) is also involved in the following current initiatives:

- *Understanding iron and nutrient (silica) cycling of the Southern Ocean using modern and ice model simulations, and compiling modern and past observations of nutrient and silica distributions with researchers from Australia, the US and Sweden. This has also involved the use of modern measurements of physical oceanographic characteristics and satellite measurements of chlorophyll activity and net primary productivity to determine physical and chemical (iron) controls on Southern Ocean nutrient cycling (2010 – ongoing)*
- *Understanding physical oceanographic conditions during the initiation of glaciations through the compilation of past observations of sea surface temperature and sea ice patterns in the Southern Ocean, working in collaboration with an Australian researcher (2015 – ongoing)*

Karen Kohfeld and Kirsten Zickfeld, Associate Professor, SFU have also been working with researchers from the UK and Sweden to assess the importance of vertical mixing parameters in model simulations of modern and

ice age climates, to understand the influence of these mixing parameters on circulation, nutrient, and carbon distributions in the ocean (2015 – ongoing).

Christian Haas, York University (haasc@yorku.ca), who is now based at the Alfred Wegener Institute and the University of Bremen, has worked with New Zealand researchers on remote sensing of fast ice thickness and snow cover in McMurdo Sound, with field measurements in 2009, 2011, and 2013 and was part of the first team worldwide to be able to map the thickness and distribution of fast ice under the sea ice from the air (using a helicopter). Plans are underway to map larger regions of fast ice up to Terra Nova Bay in November 2016, and also observe ice export from polynyas into the Ross Sea using a Kenn Borek Air aircraft, which will be the first fixed-wing electromagnetic sea ice thickness survey in Antarctica.

B. Planned activities

What major activities are **planned or likely to occur during the next several years?**
Contact information for the projects would be useful.

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POLAR is working to develop a Canadian Antarctic Research Program based primarily on the in-kind use of infrastructure and logistics in Canada's Arctic for international polar researchers in exchange for the in-kind use of similar resources in the Antarctic by Canadian researchers. POLAR's Canadian High Arctic Research Station (CHARS) and pan-northern science and technology program are attracting significant interest from the international polar research community. As a result, there is an unprecedented opportunity to leverage resources to better coordinate, increase and expand opportunities for Canadian expertise to contribute to strengthened knowledge of the Antarctic, global systems, and polar linkages.

POLAR will host a workshop in October 2016 in Ottawa to bring the Canadian Antarctic research community together to explore opportunities to strengthen Canadian Antarctic research activities and next steps towards the development of a Canadian Antarctic Research Program. POLAR will also continue to explore further partnership and collaboration opportunities with

domestic and international polar research institutions to support the delivery of a Canadian Antarctic Research Program. POLAR is interested in opportunities for Canadian researchers to collaborate with international researchers to participate in current or planned Southern Ocean related initiatives. For further information, please contact POLAR at: info@polar.gc.ca.

Some examples of upcoming Canadian work related to Southern Ocean observational, modeling, and state estimation are provided below.

Using its new Earth System Model (CanESM5), CCCMA will participate in the Coupled Model Intercomparison Project Phase 6 (CMIP6), which will comprise many thousands of years of global simulation of past and future climate.

As part of the upcoming Swiss Polar Institute-initiated Antarctic Circumnavigation Expedition, Guillaume Massé, Université Laval (Guillaume.Masse@takuvik.ulaval.ca) will lead a project to survey biological communities, sediments and oceanic conditions within the former Mertz area of East Antarctica using a combination of state-of-the-art autonomous or remotely operated airborne and under-water vehicles as well as ship borne instruments. The research team is also hoping to deploy the ROV in an area close to rarely visited islands (Balleny Islands, Scott Seamount, Peter 1st) to collect benchmark data for future ecosystem studies in the area. Canada's ArcticNet will also provide several of the ROSETTE probes and other equipment that will be used during the 140 days of the expedition, and all parties will contribute to the marine-based observations that will take place during the expedition.