Meeting report

The 12th Session of the CLIVAR/CliC/SCAR Southern Ocean Region Panel

29 – 30 June, 2017 Boulder, CO, USA

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CLIVAR REPORT

Climate and Ocean: Variability, Predictability, and Change

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ACTION ITEMS

ACTION: SOOS plans to have meetings of task teams and working groups at the Polar 2018 symposium. Inga Smith and John Fyfe to seek SCAR's support for funds, through report and budget request to SCAR, to support SORP members interaction with SOOS at this meeting, as well as for SORP-13.

ACTION: Lynne Talley offered to lead an implementation plan for YOPP-SH, in order to formalize and determine what can be actually implemented, and the best strategy to get maximum return for investment. It could appear as a succinct statement that could be publicized onto the website. We need a Southern Hemisphere subset for Southern Ocean. What we could do is to mirror what they did for Arctic YOPP with YOPP-SH. Online discussions will be done for the drafting of the implementation plan. SORP members were invited to contribute to the drafting of the YOPP-SH implementation plan. [Lynne Talley and SORP volunteers]

ACTION: It was agreed that a strong statement of SORP and SOOS to articulate the Southern Ocean importance is necessary, and Joellen Russell will revise the SOOS's partnership statement. [Joellen Russell]

ACTION: A NORP panel meeting will be organized at the end of 2017. John Fyfe will check out whether the manager in Canada can host a meeting. Regarding the nominees of NORP members, Patrick Heimbach will send a Denmark name, Francois Massonet will send a Finland name to Amy soon after. [John Fyfe, François Massonnet, Patrick Heimbach]

ACTION: David Bromwich suggested sending the SORP-12 report to SCAR with the national reports as attachments of it. [Inga Smith]

ACTION: Inga to coordinate the drafting of a white paper or position statement related to observational needs for climate predictability in the Southern Ocean. [Inga Smith]

1. Introduction

The 12th session of CLIVAR/CliC/SCAR Southern Ocean Region Panel (SORP) was held on 29-30 June 2017 at National Centre for Atmospheric Research (NCAR) Foothills campus in Boulder, Colorado, USA. SORP-12 took place alongside with the 12th Workshop on Antarctic Meteorology and Climate (26-28 June) and the 2nd planning meeting of Year of Polar Prediction in the Southern Hemisphere (YOPP-SH, http://www.polarprediction.net/yopp.html) (28-29 June). A joint YOPP-SH/SORP session was scheduled in the morning session of 29 June, discussing the collaborations of both groups. The rest of the one and half days focused on the SORP business and interactions with Southern Ocean Observing System (SOOS, www.soos.aq).

2. Joint session of YOPP-SH/SORP

Welcome and Introduction:

YOPP-SH and SORP had a joint half-day session in the morning of 29 June. Inga Smith, one of the co-chairs of SORP, first welcomed the participants to the joint session and then gave an introduction on SORP's terms of references: to serve as a forum for the discussion and communication of scientific advances in the understanding of climate variability and change in the Southern Ocean; to advise CLIVAR, CliC, and SCAR on progress, achievements, new opportunities and impediments in internationally-coordinated Southern Ocean research, with specific activities:

Specific Activities:

1. Facilitate progress in the development of tools and methods required to assess climate variability, climate change and climate predictability of the ocean-atmosphere-ice system in the Southern Ocean.

2. Identify opportunities and coordinated strategies to implement these methods, spanning observations, models, experiments, and process studies.

3. Provide scientific and technical input into international research coordination, collaborating as required with other relevant programs, including SOOS.

4. Monitor and evaluate progress in Southern Ocean research, and identify gaps.

5. Enhance interaction between the meteorology, oceanography, cryosphere, geology, biogeochemistry and paleoclimate communities with an interest in the climate of the Southern Ocean.

6. Work with relevant agencies on the standardization, distribution and archiving of Southern Ocean observations.

Inga also expressed the intention of SORP to coordinate with YOPP-SH, and pointed out that SORP members were mainly climate modellers, but not familiar with NWP (Numerical Weather Prediction), thus it is a good opportunity to learn for them via the cooperation with YOPP-SH.

The YOPP-SH task team leader, also a new member of SORP from this year, David Bromwich, introduced the 10 years' project of YOPP since 2013: a preparation phase (2013-2017), YOPP Special Observing Periods (SOPs) (mid-2017 - mid-2019), and a consolidation phase (2019-2022). Unlike SORP which belongs to World Climate Research Programme (WCRP), YOPP is one of the key elements of the Polar Prediction Project (PPP), which is under the auspices of World Weather Research Programme (WWRP). For YOPP's mission of achieving a significant improvement in environmental

prediction capabilities for the polar regions and beyond, David deemed the link with ocean was critical because ocean predictability is vital for two-month atmospheric prediction. Thus SORP is central to YOPP goals. Joellen Russell supported David's point by mentioning that the ice prediction around Alaska cannot be done with only atmosphere, but has to better include the sea ice. John Fyfe also pointed out that the subsurface observations need to be assimilated for sea ice prediction over six months. David suggested that the fully coupled reanalysis is central to all applications but the current ones include atmosphere only.

Wintertime observations in Southern Ocean and Antarctic were discussed. Lynne Talley mentioned the wintertime observations have never been obtained before and would be better to be included in the YOPP-SH's field campaign. Joellen Russell added that the wintertime storm track observations are crucial but still quite unknown. But David Bromwich thought the storm track regions are far offshore, how to make the observation still remains a question.

Regarding the efforts YOPP-SH would focus, David Bromwich preferred that it should be towards scientific questions, such as the downstream impacts. While Inga Smith thought that it had better entrain the existing projects instead of creating new ones since it is driven by research funding. David Bromwich expressed that YOPP-SH will do the best on the upcoming observation phase, and will have more on oceanography in future.

The ENSO's impacts on the Antarctic and Southern Ocean were brought up by John Fyfe. David Bromwich agreed that ENSO has impacts on the blocking high in the higher latitudes of Southern Hemisphere, and believed that the different impacts of 97/98 and 15/16 ENSO events on the Antarctic are related with SAM (Southern Annular Mode). ENSO's impacts will be considered in YOPP-SH project.

Regarding the biological aspects and how they can be embraced in YOPP-SH, Joellen Russell reminded everyone that SOOS has great biological groups that focus on those aspects in the Southern Ocean.

SOOS field and modelling capabilities of relevance to YOPP:

Matthew Mazloff reported on behalf of SOOS its goals, working groups, achievements, and plans. SOOS coordinates and facilitates incorporating ocean observations and data management in the Southern Ocean. The predictive skill for two-month atmospheric prediction lies in the ocean preconditioning. One major outcome of SOOS is DueSouth (Database of Upcoming Expeditions in the Southern Ocean) which compiles and indexes user-provided information on voyages, leadership, and onboard projects in the Southern Ocean, and is proposed to connect with YOPP Explorer. Another outcome to be launched by the end of 2017 is SOOS Map, which is collaborated with EMODnet (European Marine Observations and Data Network). SOOS map tries to incorporate in layers all the major observation endeavours in the Southern Ocean, such as Argo, SOCCOM, GO-SHIP, DueSouth, tide gauges, AWS, XCTD/XBTs, OceanSITES, moorings, gliders and so on. SOOS has 5 regional working groups surrounding the Antarctic continent and 4 capability working groups covering animals, ecosystem, observation under sea ice, and air-sea fluxes. Matthew also briefly introduced the Southern Ocean State Estimation (SOSE) that is a biogeochemical-sea ice-ocean model using 4D-Var with multi-year assimilation windows to solve for the atmospheric fluxes necessary to bring the solution into consistency with observations. A targeted YOPP-SH ocean reanalysis was proposed to be produced out of SOSE.

Regarding the moorings, OceanSITES only covers half of the Southern Ocean moorings, while SOOS will include all. David Bromwich suggested to get SOFLUX (SOOS's Working Group on Southern Ocean Air-Sea Fluxes) moorings onto GTS (Global Telecommunication System) of WMO for bigger impacts of SOOS.

For the question of the criteria of defining the 5 regional working groups of SOOS, Inga Smith pointed out that it is more logistical instead of scientific. And Joellen Russell also thought that the 5 regional working groups are quite set thus hard to redefine them.

Designing an Antarctic sea ice prediction coordinated experiment:

François Massonnet introduced a sea ice prediction project in the Southern Ocean, SIPN-South. SIPN (Sea Ice Predication Network, https://www.arcus.org/sipn) was launched in 2013 aiming at developing a collaborative network of scientists and stakeholders to advance research on sea ice prediction and communicate sea ice knowledge and tools. Talking about the two polar regions, the studies on Arctic sea ice prediction are overwhelmingly more than those on Antarctic sea ice. And both the sources of sea ice predictability and skills of sub-seasonal to seasonal predictions between the two polar regions have significant distinctions. The Antarctic sea ice prediction remains as an opening area of research. The SIPN-South was thus formed with a first attempt to address the sea ice prediction. François also demonstrated the roadmap of SIPN-South during the period 2017-2019 with one of the objectives of coordinating a realistic prediction exercise in conjunction with YOPP-SH SOP in February 2019.

During the discussion, Alvaro Scardili from the Argentine Navy Hydrographic Service was interested to engaging in SIPN-South with its sea ice model. François will include him into the mailing list of contributors. John Fyfe mentioned there is a large spread among different products on the Antarctic sea ice extent of February. David Bromwich replied the sea ice extent would be one part of the campaign of YOPP-SH. Joellen Russell found the processes driving and changing melting play important roles in prediction of seasonality. François deemed that probability forecast is the only feasible way for seasonal time scales. The participation to SIPN-South is voluntary.

People proposed that support is needed from users like modellers to prove usefulness of the WMO buoys in the Antarctic. It was replied that it should be two-way communications. As for the needs for the Antarctic than the Arctic, Inga Smith thought fishing, tourism, and vessels are all practical needs for the Antarctic region aside from many scientific questions useful for climate predictability. Scott Carpenter pointed out the primary clients in the Antarctic are with resupply of national Antarctic programme bases. He also mentioned that WMO begun to make the global seasonal forecasts by designating some national climate centres as WMO Global Producing Centres for Long-Range Forecasts.

Discussion:

As a reply to the question what it is needed from ocean to optimize the atmospheric predictability, David Bromwich thought it inappropriate to separate ocean and atmosphere predictability because they are a coupled problem.

Icebergs also needed to be modelled. The Canadian model developed for the Arctic will do a test for the Antarctic next summer. Mixing layer and mixing estimates were suggested necessary to examine, but the models are unable to produce mixing estimates to compare with the observations.

Big push for YOPP is to move predictions into the weather timescales, to do the coupled assimilations so it will be a balanced atmosphere-ocean-sea ice system. The variables to be assimilated include temperature, salinity, height, and passive microwave.

There are increasing gaps of float coverage due to decreases in funding. Maintaining floats like Argo needs to be considered. Maintaining Argo floats in south of 60ºS is no longer a priority for US. We need floats that are closer into the Antarctic and can sample areas with polynyas. WMO doesn't see Argo as valuable data points because they are not permanent.

There is a shift towards temporary measurements because technology is becoming cheaper. Ships or planes of opportunity, buoys that can be frozen in and then out, AWS buoys, ice mass balance buoys are all critical and needed for forecast modelling community as discussed at COMNAP. The region to focus on is the South Pacific, which has big changes and climate sensitivity. It would be good idea to leverage other projects targeting those regions, such as Ross Sea, and Antarctic Peninsula. Lynne has just put some sea ice surface buoys into the Southern Ocean, so there is already a contribution. The YOPP-SH SOP is in summer, but for sea ice predictability, the crucial season is winter. One option is to deploy the buoy in summer in the open water and then they'll freeze in winter. Anything is helpful because we really lack validation data from satellites. According to David Bromwich, there is pending proposal for Thwaites studies. It is worth coordinating with what they are planning to put in drifting buoys once the proposal is granted.

For sea ice, one needs to focus on various regions and regional analysis rather than circumpolar analysis, SIPN will focus on Ross Sea, Weddell Sea which are highly variable and Amundsen Sea which suffers from sharp decline in sea ice extent.

Regarding the numerical modelling parts, ECMWF will have all the global predictions for 2 years of YOPP SOP (mid-2017~mid-2019), which are 3-hours output frequency, 0.125 degrees or 12 km resolution, 14 days' atmosphere only forecast and are already online and easily accessible. Scott Carpenter pointed out that manual charting provides 40-70% enhancement of delineation of sea ice edge relative to satellites. Also, there are some operational sea ice forecasting models. The Canadian model will be tested and made operational if it works. In terms of modelling efforts of YOPP, Matthew Mazloff suggested it should focus on improving bulk formula and coupling. A lot of tasks need to be done before getting into a full coupled system that will really help us understand where the problems lie and we can use the observations to improve. For example, if the bulk formula are terrible, we aren't going to improve the atmospheric modelling. We need to decide who can focus on the modelling and who can do ocean observations and do what. The atmospheric modelling part has been challenging in YOPP. Regarding model improvement, there is an issue that making improvement in one model doesn't improvement on the others, for example, WRF improvements have no bearing on ECMWF. There are various problems in the wide range of models with evolving appreciation of physical parameterization strengths and weaknesses, including that clouds have too much short wave radiation, which could be big part of sea ice prediction and fluctuation problems; Water/ice, how it interacts with short and long wave radiations; Mixed phase clouds not well enough understood (motivation for SOCRATES and MARCOS – study CCN and IN that seed liquid and ice clouds). That stretches across all time scales.

As for the who-cares question on the Antarctic atmosphere and ocean studies, more articulation of motivation reasons are needed to convince taxpayers. Sea level, carbon budget, ocean heat uptake, ozone assessment, and melting west Antarctic are all motivations.

Regarding the data archiving, YOPP data portal has metadata and links to actual data. For contributed data like radiosondes, CTDs, Steve Collwell could host that at BAS (British Antarctic

Survey) or people can use PANGAEA (https://www.pangaea.de/), which is hosted by AWI (Alfred Wegener Institute) in Germany. Further discussion with AWI on hosting the YOPP datasets in PANGAEA will be conducted.

Lynne proposed the idea of an implementation plan for YOPP-SH, in order to formalize and determine what can be actually implemented, and the best strategy to get maximum return for investment. It could appear as a succinct statement that could be publicized onto the website. We need a Southern Hemisphere subset for Southern Ocean. What we could do is to mirror what they did for Arctic YOPP with YOPP-SH. Online discussions will be done for the drafting of the implementation plan. SORP members were invited to contribute to the drafting of the YOPP-SH implementation plan.

3. Reports from other projects/programs in the region

SIMIP:

Alexandra Jahn gave an introduction on Sea Ice Model Intercomparison project (SIMIP) (www.climate-cryosphere.org/simip). 18 models have committed to participate in SIMIP, which is a diagnostic MIP with no experiments proposed, but only output requested. SIMIP was initiated in 2014 and aims to reduce the differences among models, and between models and observation to obtain a better understanding of sea ice in the climate system and eventually to achieve more realistic projections of the sea-ice evolution in both hemispheres. SIMIP sees itself not only as a pure model-intercomparison exercise, but also as a forum for identifying the best possible use of observations for the evaluation and improvement of model simulations. The 2nd SIMIP workshop was held in Bremerhaven in March 2017, coordinating the analysis of CMIP6 sea ice simulations.

SOSE (Southern Ocean State Estimation)

Matthew Mazloff reported the ocean reanalysis product, ECCO (Estimating the Circulation and Climate of the Ocean) and the Southern Ocean State Estimation (SOSE) which is part of the ECCO consortium. The comparison of ECCO against WOA on GMST trend in different depths showed better agreement over other reanalysis products. The Biogeochemical SOSE (B-SOSE) solution is available at http://sose.ucsd.edu/BSOSE_iter105_solution.html. B-SOSE is a version of SOSE that incorporates biogeochemistry, at 1/3 degree resolution for the period 2008-2012. B-SOSE includes the BLING biogeochemical model which represents carbon, nitrogen and oxygen cycles, and constrains this output with biogeochemical data from Argo floats, hydrographic cruises, and satellites. The B-SOSE data were verified by the monthly-averaged pCO_2 in Drake Passage (75W to 55W, south of 50S) from SOCATv4 observations. Through comparison with BGC-Argo data, the skill of B-SOSE at fitting observations is comparable to the skill of the climatology product (WOA), with added benefits of high spatial and temporal resolution, consistent ocean dynamics, and closed budgets for biogeochemical tracers.

PIPERS:

Sharon Stammerjohn was invited to give a talk introducing the field campaign of the sea ice observation project, "Polynyas, ice production, and seasonal evolution in the Ross Sea" (PIPERS).

The sea ice trend in the Ross Sea is most prominent among the sectors around Antarctic. While CMIP5 models are not capable of reproducing the sea ice trend in the Ross Sea.

The overarching goal of PIPERS is to improve estimates of sea ice production (SIP) and water mass transformation in the Ross Sea, provide first time measurements of the local and large-scale controls on SIP using an multidisciplinary/multiplatform approach consisting of measurements conducted during a 65-day cruise on the RVIB Nathaniel B. Palmer (10 April to 14 June 2017), data acquired from three autonomous buoy arrays providing space/time observations from May onward, and data acquired from two airborne surveys conducted by the NSF LC-130 using the IcePod system acquired in November, both pre- and post- field campaign. Its objectives include quantifying the full 3-D suite of air-sea-ice interactions during rapid sea ice growth, including heat, salinity, momentum, and water mass modification, both in polynyas and ice-covered areas, develop model parameterizations for air-ice-ocean fluxes for both polynyas and ice-covered areas, measuring sea ice growth, deformation, thickness evolution and export from polynyas to the pack ice to the ice edge, and measuring/validating remote sensing of ice mass balance/volume export by combining autonomous buoy observations with satellite-based area ice export and NSF aircraft-based estimates of ice thickness.

Comprehensive measurement methods and various equipment have been adopted in the field campaign to measure the radiative energy fluxes, surface and air temperatures, relative humidity, cloud height above the ocean, measure the ocean with Argo floats, wave and SWIFT buoy and full-depth CTD, and sample atmospheric CO_2, CH_4, N_2O, $^{14}CO_2$ and $^{14}CH_4$ in the atmosphere, and pCO_2, CH_4, N_2, O_2, Ar in the ocean. The sea ice has been measured in a 3D mapping way by virtue of multiple observing platforms. The time series of the daily high and low sea ice extent anomaly in the Antarctic have been well observed from 2012 to 2014. The patterns of the sea ice extent variability in each year exhibit differences, and no one mechanism could explain these.

Sharon also mentioned the Amundsen Sea Polynya International Research Expedition (ASPIRE) which ran from December 2010 to January 2011, and INSPIRE, a project that unites state-of-the-art modelling and ASPIRE data synthesis to address questions about controls on meltwater distributions, carbon fluxes, iron supply and climate sensitivity in the Amundsen Sea region.

NORP:

Amy Solomon briefed on the progress of the new panel under planning, NORP (the counterpart of SORP in the Northern Hemisphere) which was jointly proposed to CLIVAR and CliC and will focus on the Arctic region. NORP has been approved by the CliC and CLIVAR steering committees and by the WCRP JSC. A list of suggested members has been distributed to the CLIVAR steering committee. Amy Solomon and John Fyfe (who is rotating off SORP this year) will be the NORP co-chairs. When the co-chairs get a response from the CLIVAR steering committee the potential members will be contacted and the panel will be finalized. There are currently 6 task teams planned for the initial panel, which are

1) Development of a state-of-the-art Arctic Ocean analysis,

2) The role of the Arctic Ocean in Arctic amplification,

3) Advancing the understanding of climate variability due to Arctic-midlatitude linkages,

4) Quantifying the response to natural external forcing and internal variability in the Arctic Ocean,

5) Promoting studies to assess model errors in Arctic projections through initialized forecasts,

6) Greenland ice sheet - ocean interactions.

Two team leads have been identified for each task. A panel meeting will be organized at the end of 2017. John Fyfe will check out whether the manager in Canada can host a meeting. Regarding the nominees of NORP members, Patrick Heimbach will send a Denmark name, Francois Massonet will send a Finland name to Amy soon after.

SOOS:

Matthew gave a talk as the representative of SOOS. SOOS was established in 2011 to overcome important challenges for science and management in the region. SOOS's 2016-2020 implementation plan has identified 4 key goals and 4 core objectives. Sustained and multi-disciplinary observations and integrated data management including data discovery and delivery are the key words for the near future direction of SOOS. DueSouth, Southern Ocean Mooring Sites, and SOOS Map which is in development are all meaningful outcomes of SOOS in data integration and management.

SOOS sees SORP as one of its crucial partners. SORP was centrally involved in the development of SOOS objectives and scope. SOOS and SORP objectives are complimentary; with SORP focusing on articulation of observational data requirements required for understanding climate variability and predictability in the Southern Ocean, and SOOS focused on the design and implementation of an observing system to deliver said observations. Where possible, SOOS and SORP work together on issues of mutual interest, and SORP will be important in providing feedback and review of the observing system to ensure the required outcomes are being achieved. Connection is maintained through regular communication between SORP and SOOS members.

SOOS is establishing an observing system design task team, and would like SORP to advise pressing quantities of interest to observe.

During the discussion, Matt brought up the current problem of SOOS budget in covering staff salary of SOOS IPO. China can provide human resources rather than funding. For US, it is not possible to transfer funds to Australia to pay for salary. It was agreed that a strong statement of SORP and SOOS to articulate the Southern Ocean importance is necessary, and Joellen Russell will revise SOOS's partnership statement. Joellen Russell pointed out the difference of SORP and SOOS, which is SORP works on climate variability and predictability, while climate is only a tiny portion in SOOS. The observation themes of SOOS spans from animal census and ecosystem EOVs to surface fluxes and ocean under ice. Regarding future plan for meetings, Inga Smith said a joint SOOS/SORP meeting had been discussed for Wellington, New Zealand in 2019, but was not confirmed. SOOS plans to have meetings of task teams and working groups at the Polar 2018 symposium. David Bromwich suggested that it might be an option to seek SCAR's support for funds because SCAR has money for meetings.

GCOS and GOOS, OOPC

Kats Katsumata reported the recent activities of his involvement in GCOS (Global Climate Observing System) and GOOS (Global Ocean Observing System) as the ex-officio of SORP. GCOS sees itself a long term, user-driven operational system to meet the needs of users for global climate observations. GOOS is targeted as the permanent global system for observations, modelling and analysis of marine and ocean variables. From the view of SORP, the gaps/uncertainties in observations lie in sea ice, air-sea flux, ice-ocean flux, and under-ice observation in the ice shelf cavity. Current research priorities include the carbon/heat uptake which SOCCOM and ORCHESTRA are two projects focusing on, the climate/weather prediction (YOPP-SH), and the ocean-ice interaction.

Reports on meeting attended by SORP members:

PA-MIP

John Fyfe reported on the Polar Amplification Model Intercomparison Project (PA – MIP). PA-MIP is a modelling protocol to be used by numerous modelling centres to investigate the causes and consequences of polar amplification. Experiments will be conducted using models contributing to the CMIP6 Coupled Model Intercomparison Project and will explore Arctic and Antarctic change. Contact: Doug Smith (UK Met Office).

Detection and attribution of separate GHG, ozone and aerosol signals in observations of Southern Ocean temperature and salinity

John Fyfe reported on results using Canadian Earth System Model Version 2 (CanESM2) simulations showing for the first time the human fingerprints associated with both greenhouse gas forcing and stratospheric ozone depletion on observed changes in subsurface temperature and salinity in the Southern Ocean. Contact: John Fyfe (Environment and Climate Change Canada).

Bremerhaven 4th Polar Prediction Workshop and 2nd Sea Ice MIP Meeting

François Massonnet reported on the Bremerhaven workshop 27-30 March, 2017. Since 2014, the Sea Ice Prediction Network (SIPN, https://www.arcus.org/SIPN) runs an annual workshop covering themes as diverse as polar climate prediction, environmental forecasting, observations, modelling and model evaluation, data assimilation, predictability and polar climate variability from days to decades.

This year's workshop, hosted by the Alfred Wegener Institute (AWI), was followed by the second Sea Ice MIP (SIMIP) workshop. SIMIP is one of the numerous Model Intercomparison Projects (MIPs) of CMIP6. Unlike most MIPs, SIMIP is "passive": no dedicated experiments are going to be conducted. Rather, SIMIP has proposed a set of standard outputs for CMIP6 (Notz et al., Geosci. Mod. Dev., 2016) and intends to coordinate future studies of sea ice using CMIP6 data. CMIP6 simulations are currently being prepared or already ongoing, with different timings depending on the team. The first outputs are expected to be available over Fall 2017. During the first half of the SIMIP meeting, various speakers set the scene by presenting themes that will be important when conducting sea ice analyses. The idea for CMIP6 is that the work is coordinated so that everyone knows what everyone else is doing, which is probably the smartest way to avoid a "race" to publication. The following overarching themes would be addressed:

1. Snow on sea ice (lead Alek Petty)

2. Sea ice dynamics (lead Bruno Tremblay)

3. Surface energy and mass balance (lead Ed Blockley)

4. Process-oriented metrics (lead François Massonnet)

5. Observation-model comparison.

SOOS SSC and SOOS OASIIS (the Observing and Understanding the Ocean beneath Antarctic Sea Ice and Ice Shelves) workshop

Inga Smith reported on the SOOS SSC Meeting (11-13 June 2017, Bremerhaven, Germany) and the SOOS Observing Under Antarctic Sea Ice and Ice Shelf Workshop (14-16 June 2017, Bremerhaven, Germany).

Inga Smith and Jiuxin Shi presented a talk about SORP to the SOOS SSC and answered questions about SORP's role and how it links in with SOOS. Inga reminded the SOOS SSC that SORP now has an Ex-Officio position for a SOOS representative still to be filled. Anna Wahlin and Oscar Schofield are rotating off SOOS as Physical Sciences and Biological Sciences co-chairs. Vice-chairs then become chairs, so Seb Swart and Andrew Constable take on those roles.Mike Williams is the new vice-chair for physical sciences, and the biological one is unfilled, so Oscar will temporarily fill that role for a year. The SOOS SSC will meet in China in 2018. Mike Williams offered to host the SOOS SSC meeting in 2019 in New Zealand, with some kind of SOOS OSC alongside it. When Inga was asked by Mike if a joint meeting with SORP was possible at the same time, she agreed that it should be possible, depending on timing.

The OASIIS and FRISP workshops were science focussed. Summary of key points relevant to SORP are given below.

Critical issues:

- Ocean beneath sea ice and ice shelves is a blind spot in the observing system
- Sea ice: extent can be observed in a sustained fashion but not thickness and not environment below the ice.
- Satellites need ground truthing for sea ice thickness (scanning from below is only way to do this sustainably, and this is not being done)
- Satellites need to keep flying and currently in danger of losing AMSR.

There is a risk a gap because AMSR2 at end of life. Proposal needs to be made for AMSR3.

Japanese sensors so need encouragement from the international community to get this through.

- Rapid changes in Antarctic sea ice extent 2016/2017.
- Sea level rise: lack of observations is hampering understanding.
- Southern Ocean heat content and temperature trends: reanalysis products do not agree at all (Armour et al. (2016, SupplMat)), lack of deep obs and obs under ice.
- Is marine ice sheet instability already underway in West Antarctica?
- TEOS-10 vs EOS-80: how to compare new observations with old ones when new papers give results only in TEOS-10?
- Holes through ice shelves: the most expensive thing is making the hole so getting extra instruments is better use of resources than multiple holes, suggestion that need a canonical set of instruments that should always go through holes when they are drilled. Also suggested that for long-term observing system, should be saying where we want bore holes rather than waiting for them to happen. Ship-like analogy and get consortium together for bore holes to determine what projects are on that.
- Argo Southern Ocean array is declining; several major contributors (USA, Australia, Japan) see decreased deployments because of decreases in funding, and Europe and China will not fill this gap at current rates. USD 800k-1 million per year to fill the 40-50 float deployments per year gap.

Observational needs for ice-ocean models:

- Better bathymetry (sea floor): ice shelves are a barrier, but so is sea ice in many areas.
- Better under ice shelf topography
- Better information on under ice shelf roughness
- Better knowledge of how ocean currents flow under ice shelves.
- More and better measurements of turbulence and heat transfer under ice shelves. Using sea ice as a proxy for ice shelves was mentioned to be an issue because buoyancy under sea ice supresses turbulence, but under ice shelves (unless it is a flat bottomed part) because of slope also get along-

slope flow that do not get under sea ice.
- Observations of all three modes of ice shelf melting needed, and also seasonality of melting.
- Amounts and timing of ice shelf basal melt.

Emerging research areas:

- Coupled polynya and ice shelf basal melt processes (and grounded icebergs and ice shelf basal melt processes)
- Iron release through ice shelf basal melt and biological implications
- Teleconnections
- Grounding line measurements, including meltwater outflows.
- Emerging technologies:
- Under ice navigation for gliders
- Winter "parking" of Autosub, gliders, floats
- Ice avoiding floats, and under-ice positioning being worked on.
- Animal (not just mammal/seal) CTD tags (although Mike Williams raised serious concerns about the accuracy of seal tags, and Lars Boehme warned of ethical issues that seals need to benefit (health and well-being) in some way from having tags attached).
- He and Ne isotopes for tracing glacial meltwater (can distinguish glacial meltwater from precipitation/snow, which oxygen and deuterium isotopes cannot).
- EM detection of sub-ice platelet layers under sea ice.
- ApRES
- T-Pops/Lotus disposable T floats (~USD3000-5000, 40-50% success rates)

Things that were not mentioned much/at all:

- Paleoclimate data
- Ice sheets (other than the grounding lines)
- Snow
- ESM/GCM needs and results
- Biology/ecosystems
- Biogeochemistry

Opportunities:

- Swedish AUV - Wallenberg to be delivered March 2018: Test missions (mainly for Swedish scientists, in open water and some in sea ice in Baltic Sea). Missions will start in 2019 on Araon to Amundsen Sea 2019/2020. Have room for payload of other sensors (60 cm long, 6 RS232 connectors plus ethernet/LAN), Seabird CTD and O_2, CO_2, Nitrate. It can go to 3000 m depth, 200-300 km range.
- German ship: 30 Sept 2017 deadline for ancillary proposal for Dec 2018-Feb 2019 Polarstern cruise.
- Norway: New icebreaker Kronpris Haakon (2018): Southern Ocean 2018-2019. Weddell Sea/Dronning Maud Land every 3rd/4th year depending on funding.

Southern Ocean Model Intercomparison Project (SOMIP)

Joellen Russell (collaborators: Ron Stouffer, Michael Winton, Stephen Griffies, Gokhan Danabasoglu and Matthew England)

Southern Ocean Carbon and Climate Observations and Modeling project (SOCCOM, http://soccom.princeton.edu) is funding this.

What is the role of the Southern Ocean (SO) in the global climate system?

- Roemmich et al. (2015): SO accounts for 67-98% of excess heat that is transfered from the atmosphere to ocean.

- Gruber et al. (2009), Landschutzer et al. (2015): Up to half of uptake of atmospheric Anthropogenic CO_2 by the ocean occurs south of 30°S in the Southern Ocean.

- Sarmiento et al. (2004): 3/4 of global biological production in the ocean is fertilized from nutrients brought to the surface in SO south of 30 deg S and then exported northward.

SOMIP Specific interests:

- Coupled climate and earth system models differ widely in simulations of the SO – all of the model simulations submitted to the CMIP3 and CMIP5 efforts have their mean annual SH wind position northwards (equatorwards) of the observations.

- Winds are too far north and generally too weak – this is a bias not an error/uncertainty.

- The southern hemisphere westerly winds shift poleward (to the south) as the atmosphere warms due to increased atmospheric CO_2: the baseline circulation of the SO affects how the heat and carbon uptake in each model responds to increased wind forcing and/or stratification.

SOMIP Overall goal:

How does the global Earth System, specifically the uptake of heat and carbon by the ocean, respond to forcing over the Southern Ocean?

SOMIP Objective:

- Understand the causes of difference in the models' responses to a standard wind stress perturbation over the Southern Ocean

- Understand the causes of difference in the models' responses to a standard fresh water perturbation over the Southern Ocean

- Compare models to observations

- Increase our understanding of the important processes influencing model response.

SOMIP will compare the responses of coupled climate and earth systems model simulations to a specified forcing perturbation imposed on the ocean (south of 30°S) along with the internally calculated atmospheric flux of momentum from the wind stress and/or the flux of fresh water. SOMIP will consist of three separate experiments for wind, freshwater, and one combined experiment.

SOMIP will branch off the FAFMIP set of experiments, which impose global forcing perturbations. FAFMIP experiments include water flux perturbations, heat flux perturbations, and momentum flux perturbations.

SOMIP Plan:

- Idealized experiments

- 3 experiments: 300-900 years.

(1) An experiment that increases winds over the Southern Ocean and shifts them poleward. Implications 1 run (100-300 years).

(2) An experiment that imposes a fresh water anomaly (sometimes referred to as a "hosing experiment") of a set magnitude – 0.1 Sv. Each group may choose whether to impose the freshwater

anomaly as a uniform perturbation, as an additional iceberg flux or at 1 or more point sources along the Antarctic coast.

(3)   Combination.

SOMIP Previous studies:

Delworth and Zeng (2008) carried out a nearly identical wind experiment in an earlier version of the GFDL coupled climate model with a coarser ocean resolution. They reported that the Atlantic Meridional Overturning Circulation increased with a positive (poleward) Southern Ocean perturbation and decreased with a negative (equatorward) perturbation.

Stouffer et al. (2007) imposed a much larger freshwater perturbation (1.0 Sv) over either the Southern Ocean or in the North Atlantic. They reported that the extra fresh water in SH spreads out, while in the NH it remains concentrated. As soon as the perturbation is no longer imposed, the Southern Ocean overturning quickly returns to its "normal" mode, while the North Atlantic overturning takes many decades to return to its previous state.

Other Info:

Variables required are the standard ones required as part of the CMIP6 DECK.

4 groups set up to do runs and will share protocol as refereed paper.

Analysis metrics will be shared using ESM ValTool (www.esmvaltool.org).

ANTCLIM21: Antarctic Climate of the 21st Century (AntClim[21])

Joellen Russell

Scientific Committee for Antarctic Research (SCAR) funded project to look at Antarctic climate change in 21st century (https://www.scar.org/science/antclim21/).

AntClim[21] Goals:

The goals of AntClim[21] are to deliver improved regional predictions of key elements of the Antarctic and Southern Ocean atmosphere, ocean and cryosphere for the next 20 to 200 years and to understand the responses of the physical and biological systems to natural and anthropogenic forcing factors. A primary form of data that Joellen said they see as being used by AntClim[21] are the global coupled atmosphere-ocean model runs that form the basis of the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC). Paleo-reconstructions of selected time periods, recognized as past analogues for future climate predictions, will be used to validate model performances for the Antarctic region.

#GreatAntarcticClimateHack Goals:

Grow community using observations to evaluate climate similations.

Antarctic and SO metrics for ESMValTool.

9-12 Oct 2017: Scripps

#GreatAntarcticClimateHack (#GACH) was held October 9-12, 2017 at the Scripps Institution of Oceanography Forum, La Jolla, CA. There were 50 scientists on site and another 50 virtual attendees. The first-ever Climate Hack focused on bringing Antarctic and Southern Ocean observations to bear on evaluating the latest generation of climate and earth system models, and on producing new climate model metrics for the 21st Century.

#GACH was a workshop to train non-modeling experts to use observational datasets to interrogate CMIP model results, thereby creating new model metrics and validation tools. The aim of the workshop was to facilitate preparation for the next IPCC report for a much broader science community, increase non-traditional climate modeling publications, and learn to apply/utilize data sets that help develop model validation skills.

#GACH Deliverables:

A series of metrics gleaned from our #GreatAntarcticClimateHack will be documented in a peer-reviewed publication and submitted as the standard Southern Ocean and Antarctic analysis package of metrics for the CMIP6 effort to ESMValTool (www.esmvaltool.org), a community-based model assessment framework.

4. Panel business

SORP has welcomed two new members from this year, David Bromwich and Robin Robertson. Both of them gave a talk on their research topics. Ben Galton-Fenzi has not attended a panel meeting before and is due to rotate off at the end of 2017, so was allocated a talk made remotely.

Science talks from new members: David Bromwich

David Bromwich from Byrd Polar and Climate Research Center, Ohio State University, US talked about the reliability of the recent global atmospheric reanalyses over the Southern Ocean and Antarctica. He mentioned due to the data scarcity in high southern latitudes, the reanalysis data are regarded as very valuable datasets, however, with less reliability. He showed the intercomparison results of several well-known reanalysis products for the trend and time series of sea level pressure, temperature at 2m, total precipitation, and sea ice. The differences among the reanalysis products were truly marked, which greatly impedes the assessment of climate change across 20th century in high southern latitudes with those products. The 1979 transition into the modern observing system is still clearly detectable in recent reanalyses and remains an obstacle to long-term investigation. The long-term pressure drift in reanalysis over the Southern Ocean were quite likely relevant to the large positive pressure biases in some reanalysis during the first half of 20th century. However, the pressure drift issue did not demonstrate itself in the AMIP simulation, which reflected a more fundamental problem with data assimilation systems in extremely data-sparse regions like Antarctica/Southern Ocean. In the discussion, one intercomparison project on ocean reanalysis data was mentioned, the ORA-IP (Ocean Reanalysis Intercomparison Project) which evaluated ocean reanalysis products by estimating the noise from the ensemble spread and to gain insight into ocean variability by considering ensemble means. It was pointed out that the reanalysis data in Arctic was less spread than Southern Ocean.

Science talks from new members: Robin Robertson

Robin Robertson from University of New South Wales Canberra, Australia introduced her research on internal tides and mixing in the Antarctic region. Modelling of tides, internal tides, tidal mixing and their impacts in the marginal seas of the Antarctic and observational work in Heard Island and

Amundsen Sea are her primary work. She found tides can influence the melting of Amundsen Sea ice shelves dependent on topography. With the measurements of dissipation and hydrological data in Western Pacific and Baltic Sea, Robin evaluated the performance of 4 vertical mixing parameterizations widely adopted in the ocean circulation models. Ten sub-grid parameterization schemes were compared in a model for tidal mixing but it is difficult to compare with observations due to inconsistency in time scales. Challenges in mixing research for both observation and modelling were also addressed.

Robin also reported an Australian program (COSIMA) and a joint Australia-China centre (CSHOR) on Southern Ocean. COSIMA (Consortium for Ocean-Sea Ice Modelling in Australia) is a collaborative consortium within Australia's ocean and sea ice modelling community that integrates capability from different groups aiming to develop a high-resolution (0.1°) eddy-resolving global modelling framework that will be adopted nationwide for ocean and wave forecasting, sea ice forecasting, ocean reanalysis, ocean process studies, and ultimately coupled climate simulations. The budget of COSIMA is $800k in 4 year. CSHOR is a newly formed Joint Australian-Chinese Centre for Southern Hemisphere Ocean Research involving Qingdao National Laboratory for Marine Science (QNLM), China, University of Tasmania (contact: Steve Rintoul) and University of New South Wales, Australia. The budget for the centre is $20 Million AUD over 5 years.

Science talks from members: Ben Galton-Fenzi (remote)

Ben Galton-Fenzi from the Australian Antarctic Division reported remotely on research on predicting future mass loss from the East Antarctic Ice Sheet. The key science questions include: Melting from below: how will the Antarctic ice sheet respond to a warming ocean? What are the key regions of the ice sheet that are at risk of potential increase in ice discharge? How do ice sheet/ice shelf/ocean models represent current change and what is their reliability of informing future change? What are the limits on estimates of change and impacts on global sea level and climate? He introduced an international effort to measure basal melting of ice shelves with radar (ApRES), which project is called "NECKLACE" (Network for the Collection of Knowledge on meLt of Antarctic iCe shElves). The simulation of melting rate shows large dependence on the vertical resolution of models. He stated that parameterisation and model uncertainties limit ability to constrain ocean properties via observations of ice sheet processes (e.g. basal melting). Regarding the modelling efforts, Ben mentioned several multi-model multi-institutional comparison projects, the first is the MISOMIP (Marine Ice Sheet-Ocean Model Intercomparison Project), which is a CliC targeted activity, with three sets of idealised experiments so far, ISOMIP+ (Ice-shelf/Ocean Model IntercomParison), MISMIP+ (Marine Ice Sheet Model IntercomParison), and MISOMIP (coupled Marine Ice Sheet/Ocean Model IntercomParison). The second one is ISMIP6 (Ice Sheet Model Intercomparison for CMIP6), aiming at bringing ice sheet model intercomparisons in line with CMIP community. The third one is the Ocean and Ice sheet Ensembles (OIE) project, which focuses on comparison of ice-shelf ocean models, before comparing ice sheet models and then coupled models. Its first phase is named Realistic Ice Shelf Ocean Model IntercomParison (R-ISOMIP), which will evaluate model ensembles estimates of basal melting with observations and develop appropriate parameterisations for ice sheet models. In concluding, Ben emphasized that large multi-institute multi-model comparisons allow models and parameterisations to be improved, but need coordinated observations for evaluation and the necessity of the regional coupled Ice-sheet/ocean/atmosphere/sea-ice model.

National representatives and national reports

David Bromwich suggested sending the SORP-12 report to SCAR with the national reports as attachments of it.

SORP membership rotation

There will be 6 people with SORP membership due by the end of 2017, including one co-chair, John Fyfe. The panel hopes to invite members who come from South American countries and other under-represented regions, disciplines and groups as well as accommodate a SOOS ex-officio.

SORP task teams

Background: The newly formed Northern Oceans Region Panel (NORP) is establishing "task teams" within the panel. This seems to be helping with focus and with deciding appropriate members for the panel. It also makes it clearer what the roles of members of the panel are. SORP has not traditionally had task teams, so this proposal is to formalise some of the actions that SORP members are already taking.

Proposed task teams:

1. Sea ice-ice shelf-ocean-atmosphere interactions: This combined modelling and observational task team is particularly focussed on the timely issue of Antarctic sea ice extent. [An addition focus could be the role of Southern Ocean circulation (and climate) changes in observed Antarctic ice sheet mass loss (suggested by Patrick Heimbach) – should this be split off as another task team?] Members: Inga Smith, John Fyfe, François Massonnet, Alexander Klepikov, Joellen Russell, Jiuxin Shi, Ben Galton-Fenzi, Kenny Matsuoka, Riccardo Farneti

2. Ocean climate variables for the Southern Ocean: This task team has a well-defined role in working with OOPC (Ocean Observations Panel for Climate: http://goosocean.org/index.php?option=com_content&view=article&id=124&Itemid=281). SORP has an ex-offico member on the panel (currently Kats Katsumata, but he would like to rotate off and train up the next person). [In addition, liasing with SOOS on thinking about what has changed since the relevant whitepapers that were contributed to OceanObs'09 in advance of OceanObs'19 was suggested by Patrick Heimbach]. Members: Kats Katsumata, Robin Robertson, Alexander Klepikov, Isabelle Ansorge, Jiuxin Shi

3. Ocean state estimates: This task team looks in particular at ocean state estimates for the Southern Ocean. Members: Riccardo Farneti, Patrick Heimbach

4. Ocean carbon: This task teams looks at the measurement and modelling of carbon in relation to climate. Members: Joellen Russell

5. Year of Polar Prediction liason: This task team looks at issues of ocean and climate as they related to the upcoming Year of Polar Prediction in the Southern Hemisphere (YOPP-SH). Members: David Bromwich, François Massonnet

Planning for SORP-13

SORP-13 is scheduled on 14-15, June 2018 in Davos, Switzerland in conjunction with Polar 2018. There will be no SORP labelled session in the symposium. Room bookings for SORP-13 are in place for Thursday 14 June 2018 and Friday 15 June 2018, with afternoon of Friday 15 June set aside for a joint meeting with NORP.

David Bromwich reminded those present that SCAR can support ECS and people from developing country to attend meetings.

Next teleconference of SORP will be in September to October this year.

Appendix A: SORP-12 Agenda

NCAR Foothills, Boulder, US. June 29-30, 2017.

Thursday 29 June

YOPP-SH 2017 Session II/SORP-12 – Joint session of YOPP-SH and the CLIVAR/CliC/SCAR Southern Ocean Regional Panel   (chair: Lynne Talley)

08:30-08:45   Welcome and Introduction [Bromwich/Fyfe/Smith/Han/Werner]

08:45-09:00   Meeting goals [Bromwich/Fyfe/Smith/Han/Werner]

09:00-09:15   SOOS field and modelling capabilities of relevance to YOPP [Matthew Mazloff]

09:15-09:30   Designing an Antarctic sea ice prediction coordinated experiment [François Massonnet]

09:30-09:35   Group photo

09:35-10:05   Coffee break & posters

10:30-12:00   Discussion   [chairs: L. Talley/D. Bromwich]

        1. Define the Southern Ocean oceanographic observations needed during the YOPP-SH special observing period, 16 November 2018 – 15 February 2019. (SOOS representative expected to be present for this).

        2. Make progress on the issue of how the predictable ocean behaviour out to 2 months projects onto the behaviour of the atmosphere, i.e., how coupled numerical weather prediction over the Southern Ocean would be enhanced over that using specified ocean conditions.

12:00-13:00– SORP working lunch (seating in task teams)

29 June 2017 (afternoon)

13:00– Climate predictability of the ocean-atmosphere-ice system in the Southern Ocean: presentations and discussions on SOMIP (Southern Ocean Model Intercomparison Project) and AntClim21: SORP input and further building of collaborations [Joellen Russell]

13:30 – Sea Ice MIP: Invited presentation [Alexandra Jahn]

14:00– Science talk [David Bromwich] [30 minute talk, 30 minutes for discussion]

15:00 – Break

15:30-16:00 Meeting reports (5 minutes each) on recent meetings and initiatives:

(1)SOOS SSC and SOOS OASIIS (the Observing and Understanding the Ocean beneath Antarctic Sea Ice and Ice Shelves) workshop [Inga Smith];

(2) Polar Amplification Model Intercomparison Project (PA-MIP) [John Fyfe];

(3) Detection and attribution of separate GHG, ozone and aerosol signals in observations of Southern Ocean temperature and salinity [John Fyfe];

(4) Bremerhaven sea ice workshop [Alexandra Jahn and François Massonnet]

16:00-17:30 Drafting of a white paper or position statement related to needs for climate predictability in the Southern Ocean

19:00 Working dinner in the evening.

30 June 2017

9:00 − Ocean State Estimations [Matt Mazloff and Patrick Heimbach] (overview of what these are, and international activities related to this).

10:00 − Sea Ice Prediction Network Southern Ocean [François Massonnet]

10:30 – Break

11:00 − Science talk [Robin Robertson] [30 minute talk, 30 minutes for discussion]

12:00-13:00 –Working lunch (seating with SOOS, SeaMIP, and NORP liasons)

13:00 −Southern Ocean Observing System [Matt Mazloff]

13:30 - Discussion on SOOS planning and structure; data management; coordination of SORP and SOOS [Fyfe/Smith/Mazloff]

14:30−GCOS and GOOS, OOPC [Kats Katsumata]

15:00 − Science talk [Ben Galton-Fenzi] (by Gotomeeting) [30 minute talk, 30 minutes for discussion]

16:00 – Break

16:30 – National representatives and national reports [Inga Smith]

16:45 – SORP-13 and SORP rotations: In conjunction with Polar 2018. Room bookings are in place for Thursday 14 June 2018 and Friday 15 June 2018, with afternoon of Friday 15 June set aside for a joint meeting with the Northern Oceans Region Panel [Smith]

17:00 – Northern Oceans Region Panel (NORP) [Amy Solomon]

17:15 – Other business (close 17:30)

Appendix B: List of invited participants

Name	Affiliation, Country	Role
John Fyfe	Environment Canada, Canada	Co-chair
Inga Smith	University of Otago, New Zealand	Co-chair
François Massonnet	Université Catholique de Louvain	member
Joellen Russell	University of Arizona, USA	member
Kats Katsumata	JAMSTEC, Japan	member
Robin Robertson	University of New South Wales Canberra, Australia	member
David Bromwich	Byrd Polar and Climate Research Center, Ohio State University	member
Alexander Klepikov	Arctic and Antarctic Research Institute, Russia	member
Amy Solomon	NOAA, USA	guest
Alexandra Jahn	University of Colorado, Boulder, USA	guest
Matt Mazloff	UCSD, USA	guest
Sharon Stammerjohn	University of Colorado, Boulder, USA	guest
Lei Han	International CLIVR Global Project Office	SORP liaison

[Note: Some additional participants from the YOPP-SH workshop also sat in on all or parts of SORP-12]

Group Photo

Front row (left to right): Joellen Russell, David Bromwich, Patrick Heimbach, Matt Mazloff, Robin Robertson, Alexandra Jahn

Back row (left to right): Kats Katsumata, Alexander Klepikov, Inga Smith, John Fyfe, Lei Han, François Massonnet, Sharon Stammerjohn