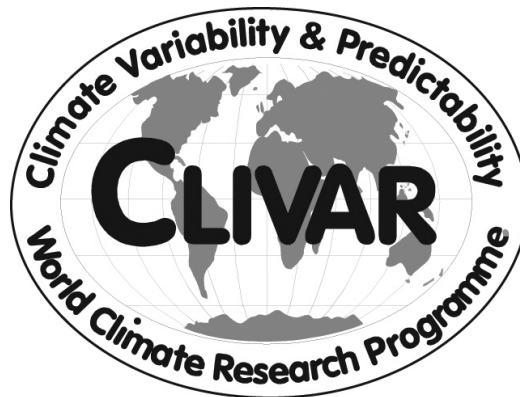


INTERNATIONAL  
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OCEANOGRAPHIC  
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METEOROLOGIC  
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## WORLD CLIMATE RESEARCH PROGRAMME



### Report of the 4<sup>th</sup> Meeting of the CLIVAR/CIIC/SCAR Southern Ocean Region Panel

14 and 17 November 2006  
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## 1. Summary of Action Items

1. All observing system maps (SO panel, CASO, Expert Group, SASSI) should be kept updated (ICPO, Alex Orsi [for SASSI])
2. Panel to continue to update the IPY modelling plan. (Karen Assmann, Steve Rintoul, Sabrina Speich and rest of panel)
3. Recommend an initial CASO/SASSI session/workshop at SCAR 2008 (Alberto Naveirra)
4. Panel to input physical climate requirements of the Southern Ocean Observing System (SOOS) being coordinated by the SCAR/SCOR Oceanography Expert Group (all panel, lead Kevin Speer)
5. Work to build support for a focussed effort to produce a global ocean synthesis that incorporates IPY period data (all panel, lead Kevin Speer)
6. Panel to provide justification for potential process studies for discussion before the next meeting (all)
7. With help from SCAR compose a letter to the relevant institutes outlining our concerns of possible future gaps in satellite data (Sabrina Speich, Kevin Speer, Ian Renfrew)
8. The panel should get an update on the status of the SEAFLEX (<http://www.gfdl.fsu.edu/SEAFLEX>) project. The SEAFLEX Project has been initiated to investigate producing a high-resolution satellite-based data set of surface turbulent fluxes over the global oceans (Ian Renfrew, ICPO)
9. The panel felt it should encourage the use of AMDARS (Aircraft Meteorological Data Reporting) on Antarctic aircraft. Firstly Ian Renfrew will contact Vladimir Ryabin at WMO, since this was something he was taking forward and if necessary COMNAP (the Council of Managers of National Antarctic Programmes) (Ian Renfrew, ICPO)
10. Panel to write to Dave Bromwich and check northern boundaries of proposed atmospheric reanalysis. The reanalysis should pay attention to the boundary layer and in particular the sea-ice zone. (Ian Renfrew)
11. Panel to provide feedback on the IGOS cryosphere document, particularly on Ch 11.6 (Southern Ocean observing system) and sea-ice systems. Any other gaps? E.g. changes on ice-shelves...(Doug Martinson, Eberhard Fahrbach, Alex Orsi, Steve Rintoul, ICPO, all panel)
12. Panel to continue work to identify SO region indices. Add page on SO panel website to include explanation of chosen indices and links to the relevant data. Panel should also consider indices for use in validating GCMs/IPCC models. (All panel)
13. The role of ice shelves in climate and sea level rise is not well understood. A coordinated effort and observational program is required. Panel to produce recommendations and feed into the CliC SSG. Also encourage national centres to work on this, e.g. National Snow and Ice Centre. (Dave Holland, all panel)
14. Panel to provide feedback to the relevant people involved with SOIMIP/ SOPHOCLES and to look into the possibility of a member of the panel attending the Bergen meeting (Kevin Speer and all panel)

## 2. Introduction

The main aims of the CLIVAR/CliC/SCAR Southern Ocean region panel are:

1. To design a strategy to assess climate variability and predictability of the coupled ocean-atmosphere-ice system in the Southern Ocean region.
2. To oversee and coordinate Southern Ocean region process studies, sustained observations, and model experiments needed to meet the objectives of CLIVAR, CliC and SCAR.

Further details can be found at: <http://www.clivar.org/organization/southern/southern.ph>

The 4th meeting of the Southern Ocean region panel was held from the 14<sup>th</sup> to 17<sup>th</sup> of November 2006 in the Palacio San Martín in Buenos Aires, Argentina. The first half of the third day was given over to a “Science Morning” consisting of a series of talks and discussions led by local scientists. The subjects of the talks ranged from the influence of the Southern Ocean on climate variability of South America to Glacio-climatic investigations in southern Patagonia and the Antarctic Peninsula. This provided an excellent opportunity for the panel and invited experts to interact with local scientists and students and for everyone to see some of the excellent work being done by scientists in Argentina (see Appendix A for agenda).

Except for the “Science Morning” (when attendance was much higher), eighteen panel members and invited experts attended the meeting (see Appendix B). This included local scientific experts who were invited to relevant panel sessions. An important aspect of the panel meeting was to engage more with Latin American, and in particular Argentinean, scientists.

Since the last meeting there had been several changes in membership to reflect a more climate rather than ocean focus to the panel (see <http://www.clivar.org/organization/southern/members.php>). Thus the panel aimed to build on its past activities and strengths such as involvement with the International Polar Year (IPY) through e.g. the Climate of Antarctica and the Southern Ocean (CASO) project, but also to have a stronger emphasis on cross-cutting climate questions such as climate indices, IPCC model runs and focussing on the whole (ocean-atmosphere-cryosphere) observing system (particularly post-IPY).

The meeting started with short speeches from the local sponsors of the meeting: Captain Raúl E. Benmuyal, Director of the Argentinean Naval Hydrographic Office, Commander Miguel Angel Rabiolo, Director General of the Argentinean Meteorological Service, Dr Jorge Aliaga, Dean of the School of Physical and Natural Sciences of the University of Buenos Aires and Dr Mariano A. Memolli, Director of the Argentinean Antarctic Institute. Mike Sparrow and Carlos Ereño from the ICPO and Kevin Speer and Ian Renfrew (co-chairs of the panel) thanked the sponsors and gave a short overview of the following days’ proceedings. The main actions and outcomes from the meeting are summarised here. When appropriate, relevant updates that have occurred since the meeting have been highlighted.

We would like to thank Carlos Ereño and Paula Richter for organising the local logistics so well, Sergio Marensi of the Antarctic Institute for providing us with such a beautiful setting for the meeting and Raúl Benmuyal of the Argentinean Naval Hydrographic Institute for providing refreshments.

### 3. Meeting Outcomes and Agreed Actions

#### i) IPY and the Southern Ocean Observing System

The International Polar Year ([www.ipy.org](http://www.ipy.org)) is an unprecedented opportunity to improve the observational capacity and our knowledge of Antarctica and the surrounding oceans (as well as the equivalent northern high latitude system). IPY will see several enhancements to the sustained observing system, including:

- Synoptic multi-disciplinary transects
- Sea ice thickness measurements
- Measurements of ocean circulation under sea ice
- Ice cores
- Ice cavity observations

The panel's involvement in IPY has been mainly through the CASO umbrella project (the lead project in the IPY Ocean Circulation cluster in the south), which is being coordinated by Steve Rintoul. See: <http://www.clivar.org/organization/southern/CASO/index.htm>. CASO has several aims:

- To obtain the first circumpolar snapshot of the Southern Ocean, including physical, ecological and biogeochemical properties
- To measure the circumpolar extent and thickness of Antarctic sea ice through an annual cycle for the first time
- To observe the sub-ice ocean circulation, water mass properties and biological distributions

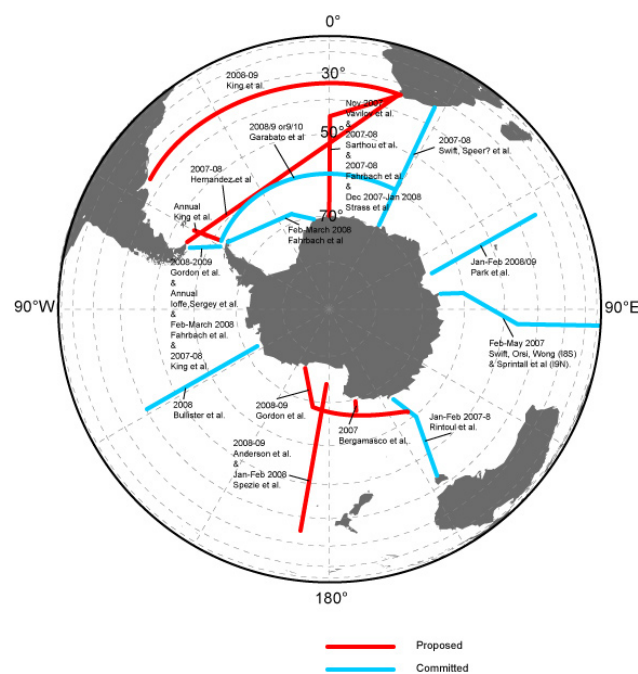


Figure 1: The CASO hydrographic sections (as of May 2007)

Although it will be possible to achieve many of the original aims of CASO, the panel did have some concerns, for example with respect to the lack of zonal lines and moorings in the subtropical Indian and Pacific and that some of the sections that really require ice-breakers may not be carried out in such ships. Such problems will need to be dealt with as they arise and by best use of available resources.

Several new measurement techniques are being utilised during IPY. -The use of animal-borne CTDs (e.g. the SEaOS [Southern Elephant seal as Oceanographic Samplers] project: <http://biology.st-andrews.ac.uk/seaos>) is a promising method of helping to fill a potential gap with observations in the sea-ice zone. Such relatively new observational techniques should be a strong legacy of IPY.

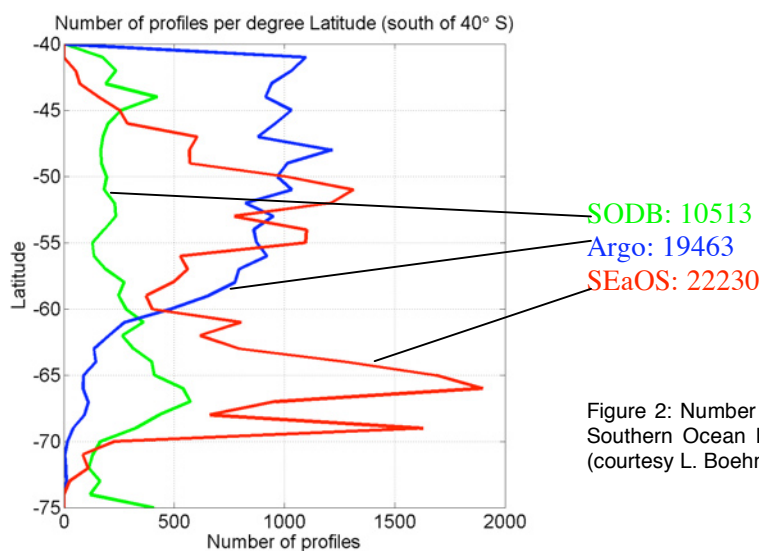


Figure 2: Number of SEaOS profiles compared to Argo and the Southern Ocean Data Base (SODB), as of beginning of 2007 (courtesy L. Boehme)

The panel felt that drafting strategy recommendations for an integrated modelling effort in the Southern Ocean and Antarctic Marginal Seas during IPY should be a priority. A first draft of such a strategy, prepared by Karen Assmann, with input from Sabrina Speich, Alberto Naveirra, Alex Orsi, Karen Heywood, Kevin Speer and others is given below:

*Integrated IPY modeling effort for the Southern Ocean and Antarctic Marginal Seas*

The IPY effort needs to ensure that the global ocean/climate modelling community is aware of the importance of Southern Ocean processes in correctly representing global ocean circulation and its variability.

Ideally IPY projects should incorporate modelling components ranging from regional scale and processes to circumpolar or global models. Within the projects it should be made a priority to improve the communication and information flux between these components and levels. Parametrizations specific to Southern Ocean and high latitude processes that were devised from observations and idealised process studies should be tested in larger scale applications to assess their large-scale importance and advise the global modelling community on how to incorporate them into their models.

An important IPY legacy will be the creation of much improved channels for the exchange of information amongst the Southern Ocean modelling community. Coordination of observational programmes in the Southern Ocean is underway to help scientists and program managers leverage resources ([http://www.clivar.org/organization/southern/CLIVAR\\_CliC\\_Obs.htm](http://www.clivar.org/organization/southern/CLIVAR_CliC_Obs.htm))

The panel will establish a similar website for Southern Ocean modelling efforts, whether they are connected to IPY or not. This will improve communications during IPY and form the basis for a coordinated modelling effort after IPY. In this context the panel endorses the establishment of a Southern Ice Ocean Modelling Intercomparison Project (formally SIOMIP, now known as SOPHOCLES which stands for Southern Ocean Physical Oceanography and Cryospheric LinkagES – see Section 2 ix).

Assimilation of extensive data sets from IPY cluster projects like CASO (<http://www.clivar.org/organization/southern/CASO/index.htm>) and its sister project SASSI (<http://woceatlas.tamu.edu/sassi>) into either regional/circumpolar or global models is strongly encouraged. Ocean data assimilation (ODA) is developing fast, and, despite the fact that results are not yet completely satisfactory, progress is rapid and the outcome very promising. With ODA we encourage the analysis effort of the ocean state and variability more than the forecast framework. Indeed, ODA can provide the ocean four-dimensional multivariate fields that cannot be adequately resolved through observations. The effort of the oceanographic community to provide data in real or quasi-real



time should be implemented during the IPY CASO/SASSI projects. This will allow a better enhancement of the unique observational effort that will take place during IPY. This effort should also include biogeochemical data.

Open scientific questions on which more significant progress should be made during IPY include a better constrained Southern Ocean fresh water budget and its variability. These challenges require a well coordinated modelling effort covering a wide range of processes. For sea ice these include the factors determining sea ice extent, particularly in summer, the use of the newly available database to constrain sea ice thickness and volume and thus northward fresh water export in the form of sea ice, as well as an improvement of the representation of dynamic deformation processes. A related issue is an improved estimate of precipitation over the ocean in the region due to the substantial volume of flooding and snow ice formation in the Southern Ocean.

A desirable goal for IPY is a collaborative modelling effort between the ocean and ice sheet modelling communities. A first step towards this has been the modelling of the interaction between ice shelf base and ocean and its inclusion in regional and circumpolar ocean models over recent years. Observational IPY efforts like that at Fimbulisen will help to constrain ice shelf basal mass fluxes and improve the existing database whose sparsity has prohibited rigorous model evaluation so far. Regional high-resolution models will allow investigations of the sensitivity of the smaller fringing ice shelf cavities to changes in inflow. Their results should be used to improve the representation of the smaller cavities in coarser circumpolar or global models.

The fresh water input by melting icebergs is one example of an active component in the Southern Ocean fresh water budget that is still poorly known. The panel encourages efforts to combine existing iceberg drift models and satellite data to a parameterization or climatology of iceberg fresh water input for use in sea ice-ocean models.

Global models should be used in combination with assimilation products of existing and IPY-planned data sets to investigate the net fresh water transport in the Southern Ocean and its variability. These complementary efforts will enable the modelling community to address standing questions posed through analysis of modern observations, e.g. to determine if the observed warming of the Circumpolar Deep Water is associated with the reported dramatic changes in the salinity of surface and bottom waters.

To understand ongoing changes in the characteristics of outflowing Southern Ocean water masses it is important to improve model representation of cross-shelf exchanges and down slope flows, particularly in models that are too coarse to represent the underlying processes explicitly. Important progress in this area has been made by the AnSlope study which focussed on the Ross Sea in recent years. Results from this programme have also been used by the Climate Process Team on Gravity Current Entrainment (CPT-GCE) which links US observational and modelling efforts in this area.

The Southern Ocean continues to be the area with the largest uncertainty within estimates of the oceanic carbon dioxide sink. The synoptic circumpolar snapshot of hydrographic and biogeochemical observations that will be obtained by CASO and related IPY programmes will help to reduce this uncertainty. It will also provide a comprehensive dataset for use in the evaluation of global ocean and coupled climate carbon cycle models in order to improve climate predictions.

The International Polar Year will provide a data-intensive period during 2007-2009. Regional analyses are planned but a synthesis of global scope is needed to address heat and freshwater transports at the largest scales. Support for a focused effort to produce a global ocean synthesis that incorporates IPY period data is needed. In order to achieve this the support of IPY related groups such as SCAR to create data archives and access will be essential.

The panel felt that a plan for a post-IPY sustained observing system was a priority. This would link strongly with the Southern Ocean Observing System (SOOS) being coordinated by the SCAR/SCOR Oceanography Expert Group (<http://www.clivar.org/organization/southern/expertgroup/index.htm>) and is a direct recommendation of the XXX Antarctic Treaty Convention Meeting (Resolution G (2007): Long-term Scientific Monitoring and Sustained Environmental Observation in Antarctica). The current state of the observing system is summarised



on the Southern Ocean region panel's website at: [http://www.clivar.org/organization/southern/CLIVAR\\_CliC\\_Obs.htm](http://www.clivar.org/organization/southern/CLIVAR_CliC_Obs.htm). Whereas IPY will give the first true snapshot of the Southern Ocean a future sustained observing system is needed to give a measure of the variability in the system. The role of the SO panel will be to advise on the optimal physical climate requirements of such a system. Some initial ideas include:

- ⊙ Repeats of at least six of the shorter CASO hydrographic section every 2-5 years
- ⊙ Moorings/stations on select sections, mainly for chemical properties
- ⊙ Maintaining the Argo array in the Southern Ocean and expansion under ice (currently only in the Weddell Sea)
- ⊙ Improved sea-ice zone observations
- ⊙ Maintaining and hopefully improving the number of meteorological buoys/stations

*Action: All observing system maps (SO panel, CASO, Expert Group, SASSI) should be kept updated (ICPO, Alex Orsi [for SASSI])*

*Action: Panel to continue to update and post the IPY modelling plan, and build a modelling coordination site similar to the observational one in liaison with other panels and groups. (Karen Assmann, Steve Rintoul, Sabrina Speich and rest of panel)*

*Action: Recommend an initial CASO/SASSI session/workshop at SCAR 2008 (Alberto Naveirra)*

*Action: Panel to input physical climate requirements of the Southern Ocean Observing System (SOOS) being coordinated by the SCAR/SCOR Oceanography Expert Group (all panel, lead Kevin Speer)*

*Action: Work to build support for a focussed effort to produce a global ocean synthesis that incorporates IPY period data (all panel, lead Kevin Speer, Naveira, Rintoul)*

## **ii) Future Process Studies**

As well as the sustained observing system, a discussion was held on possible future process studies in the region. Such process studies are required to parameterize key effects in models. Kevin Speer initiated the discussion by giving some examples of important processes, including atmospheric and ocean eddy transports, sea-ice albedo, and ice-ocean-shelf interaction.

Several suggestions were made, for example process studies to look at the grounding line and shelf slope exchange. It was felt that this should be discussed further between now and the next meeting. Possible starting points for discussion are:

- ⊙ Eddy transports in the ocean and atmosphere (e.g. topographic effects)
- ⊙ Sea-ice thickness and albedo
- ⊙ Ice shelf melting and calving (land-ice-ocean interaction)
- ⊙ Coastal polynyas and the surface boundary layer
- ⊙ Atmospheric transport of moisture, dust, etc onto AA continent
- ⊙ The carbon cycle

*Action: Panel to come up with a list of potential process studies for discussion before the next meeting...(all)*

## **iii) Satellite Observations**

Sabrina Speich gave an update on satellite observations in the Southern Ocean region. The panel was concerned that there could be gaps in certain satellite data in the future unless the scientific community made their needs better known.

*Action: With help from SCAR compose a letter to the relevant institutes outlining our concerns of possible future gaps in satellite data (Sabrina Speich, Kevin Speer, Ian Renfrew)*

*Action: The panel should get an update on the status of the SEAFLEX (<http://www.gfdl.fsu.edu/SEAFLEX>) project. The SEAFLEX Project has been initiated to investigate producing a high-resolution satellite-based data set of surface turbulent fluxes over the global oceans (Ian Renfrew, ICPO)*

#### **iv) Meteorology**

Ian Renfrew gave a summary of the state of the meteorological observing system in the Southern Ocean region. The ever increasing amount and quality of satellite-derived observations is helping to improve atmospheric observations even in remote regions like the Southern Ocean. Several recent data sets were mentioned: for example, QuikSCAT winds, and radio occultations soundings from GPS satellites (currently being used as validation for the AMPS – Antarctic Mesoscale Prediction System) both of which have great potential. A short talk on AMPS highlighted the various model domains being run operationally, which cover (i) much of the Southern Ocean, (ii) the Antarctic continent and (iii) various areas of interest such as the Peninsula and McMurdo area (see <http://www.mmm.ucar.edu/rt/mm5/amps/>). The AMPS data are being archived by NCAR and there are a number of validation studies mainly by Bromwich's group at the Byrd Polar Center (see <http://polarmet.mps.ohio-state.edu/PolarMet/abstracts.html>). There are regular workshops on meteorological forecasting for Antarctica and it is worth the panel being involved in some way with these.

There are relatively few studies of the quality of air-sea fluxes or meteorological representation over the Southern Ocean and at present it is difficult to clearly define gaps in the observing system, since the covariations between different parts of the system are not well known and because there are relatively few data in the first place. Gaps are, on the other hand, very clear in the sea-ice zone, where it is known that there are great difficulties in accurately representing air temperature, humidity and winds for example. However it is clear that the Southern Ocean is a data sparse region and so any additional observations are almost certain to be of benefit.

There are plans or possibilities for the following:

- ⊙ Increased met buoys and/or met moorings (off Australia as part of an Australian project; in the south Pacific sector as part of the ORION project)
- ⊙ Automatic Weather Stations on islands (to be encouraged)
- ⊙ New IMET (Improved Meteorology System) on ships (to be encouraged)
- ⊙ Aircraft observations (summer case studies) from BAS's newly instrumented aircraft
- ⊙ Use of Autonomous Unmanned Vehicles (AUVs) on a local scale as part of a BAS project
- ⊙ Use of AMDARS (Aircraft Meteorological Data Reporting) on aircraft operated on behalf of the national Antarctic operators

It was also noted that David Bromwich and others are planning a funding bid to NSF for an Antarctic regional reanalysis project, based on the AMPS framework.

*Action: The panel felt it should encourage the use of AMDARS (Aircraft Meteorological Data Reporting) on Antarctic aircraft. Firstly Ian Renfrew will contact Vladimir Ryabin at WMO, since this was something he was taking forward and if necessary COMNAP (the Council of Managers of National Antarctic Programmes) (Ian Renfrew, ICPO)*

*Action: Panel to write to Dave Bromwich and check northern boundaries of atmospheric reanalysis. Reanalysis should pay attention to the boundary layer and in particular the sea-ice zone. (Ian Renfrew)*

#### **v) Review of the Integrated Global Observing Strategy (IGOS) Cryosphere document**

The principal objectives of IGOS are to address how well user requirements are being met by the existing mix of observations, including those of the global observing systems, and how they could be met in the future through better integration and optimization of remote sensing (especially space-based) and *in-situ* systems (for further details see: <http://stratus.ssec.wisc.edu/igos-cryo>). The panel was asked to comment on the draft cryosphere document plan, in particular on the Southern Ocean observing system and sea-ice systems. An initial comment was that the document was rather Arctic focussed and so the importance of Antarctica should be made more explicit.

*Action: Panel to provide feedback on the IGOS cryosphere document, particularly on Ch 11.6 (Southern Ocean observing system) and sea-ice systems. Any other gaps? E.g. changes on ice-shelves... (Doug Martinson, Eberhard Fahrback, Alex Orsi, Steve Rintoul, ICPO, all panel)*

Since the meeting the panel have provided such feedback.

#### **vi) Indices in the Southern Ocean Region**

The use of indices to describe the state of the climate system by examining the connections between the ocean, cryosphere and atmosphere is well known (e.g. ENSO, SAM etc.). Many groups such as the Ocean Observations Panel for Climate (OOPC) and the CCI/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices (ETTCIDI) are interested in such indices, especially those that could be used to help give an idea of model skill. One goal of this meeting was to suggest and develop ideas for new indices in the Southern Ocean region, e.g. a scalar index of the state of a feature of the climate system that is known to vary over daily to decadal timescales.

The following list is a first “straw man” effort based on discussions during the panel meeting:

##### *Stratification indices:*

- ⊙ Monitor changes in stratification at nominal 35°S locations in the South Atlantic, South Pacific, and Indian Ocean, together with Antarctic peninsula and time-series stations in polar basins but significantly distant from the source areas (Weddell and Ross Gyres)

##### *Ice indices:*

- ⊙ Monitor sea-ice extent using satellites
- ⊙ Monitor ice thickness along repeat satellite tracks
- ⊙ Monitor the grounding line (using e.g. proposed InSAR mission – see Section 2 vii).

##### *Upper Ocean:*

- ⊙ Monitor salinity of shelf waters in the Ross Sea
- ⊙ Monitor the mixed layer depth and salinity

##### *Transport:*

- ⊙ Monitor the transport along the Antarctic continental slope at a few (perhaps three) locations and Drake Passage

*Action: Panel to continue work to identify SO region indices. Add page on SO panel website to include explanation of chosen indices and links to the relevant data. Panel should also consider indices for use in validating GCMs/IPCC models. (All panel)*

#### **vii) Ice Shelves and Climate Change**

The Panel recognised that one of the largest uncertainties regarding sea level changes in the future come from possible ice shelf movement. Progress could be made in reducing uncertainties of sea-level rise with a concerted effort to monitor the grounding line, representing the boundary between the ice sheet and the ocean. Measuring and modelling the characteristics of convection in ice-shelf cavities, calving, and the intersection of ice streams with the ocean are necessary parts of this effort. As a step in this direction the panel recommended establishing a remotely-sensed “grounding line index” based, for example, on Rignot et al (1998). Eventually an operational system for monitoring the circumpolar location of the grounding line could be put into place and maintained. Another step is to create ocean and ice-sheet models capable of exchanging mass with one another, i.e., possessing a migrating grounding line capability.

*Action: The role of ice shelves in climate and sea level rise is not well understood. A coordinated effort is required. Panel to produce recommendations and feed into the CliC SSG. Also encourage national centres to work on this, e.g. National Snow and Ice Centre. (Dave Holland, all panel)*

Since the meeting the panel have presented this to the CliC SSG and OOPC.

### *viii) IPCC Models in the Southern Ocean Region*

The Southern Ocean is one of the regions where the scatter between the results of the different IPCC models is the largest, both for the last 30 years, for which we have relatively good observational data to compare models with, and for future projections. The panel therefore devoted much of an afternoon to discussing how the IPCC models fare in the Southern Ocean region, the discussion being led by Hugues Goosse and Claudio Menendez (with input from David Thompson).

The large degree of variability in this region on interannual to interdecadal time scales poses problems in the assessment of the quality of model simulations and in the finding of robust signals in the Antarctic periphery. Longer times series of surface temperature and sea ice extent, for instance, would be particularly helpful in this framework to have a better estimate of the observed interdecadal variability and trend over the 20<sup>th</sup> century and to check if models are able, or not, to simulate the observed characteristics.

The climate simulation of the southern extratropics has improved since the IPCC Third Assessment Report despite the fact that most coupled models no longer employ flux adjustments. However, large biases in many aspects of the Southern Ocean system in the individual models still persist. In particular, the ensemble of AR4 models has systematic low pressure bias near 50°S and consequently the meridional gradient of atmospheric circulation is relatively weak (Carril et al., 2005). This bias adversely impacts the westerly wind stress maximum and the location of the Antarctic Circumpolar Current (ACC), which are usually placed too far north in most models (Russell et al., 2006). In general, models with sufficient resolution show considerable skill in reproducing extratropical storm tracks (Bengtsson et al., 2006). However, simulated storm tracks are often too zonally oriented and many models show deficiencies in the distribution, intensity and number of cyclones (PCMDI, 2004; Lambert and Fyfe, 2006).

Both observations and simulations show a trend in the Southern Annular Mode (SAM) towards its positive phase with decreasing sea level pressure over Antarctica and a compensating increase in midlatitudes. The SAM simulated by AR4 models exhibits a high spatial correlation with the observed patterns during the late 20<sup>th</sup> century, though this mode represents too large a percentage of the total temporal variability (Miller et al., 2006).

The AR4 multimodel average evidences a positive annular trend in response to increasing concentrations of greenhouse gases and tropospheric sulphate aerosols. The associated poleward shift of the storm tracks is accompanied by a similar shift in the midlatitude jets and surface zonal wind stress (Yin, 2005; Russell et al., 2006), which in turn is important for driving upwelling in the Southern Ocean and the ACC flow through the Drake Passage (Meredith and King, 2005).

Despite the large scatter between the various models, the multimodel average sea ice extent is in good agreement with the observations, meaning that there is apparently no systematic bias in the models (e.g. Arzel et al. 2006). On the other hand, the models generally tend to overestimate the variability of the ice extent compared to the observations during the period 1979-2004. At the end of the 21<sup>st</sup> century, all the models simulate a clear decrease of the annual mean sea-ice extent, ranging from less than  $2 \times 10^6$  km<sup>2</sup> to more than  $4 \times 10^6$  km<sup>2</sup> for scenario A1B. In the projections for the 21<sup>st</sup> century, the amplitude of the seasonal cycle of the sea-ice extent tends to increase in the Southern Ocean, although this increase is less strong than in the Arctic (e.g. Arzel et al. 2006).

Over the 20<sup>th</sup> century, the multimodel average simulates a stronger warming around the peninsula compared to other regions, which is in qualitative agreement with observations. This is probably related to the positive trend in the SAM index over the 20<sup>th</sup> century, in both observations and in the multimodel average (Carril et al., 2005). Despite the simulated positive future trend in SAM, such a regional feature is absent in the projected temperature change for the end of the 21<sup>st</sup> century. The maximum warming is located over the continent and over the Weddell Sea where it is associated with a large reduction of the ice cover in the multimodel average (Figure 3).

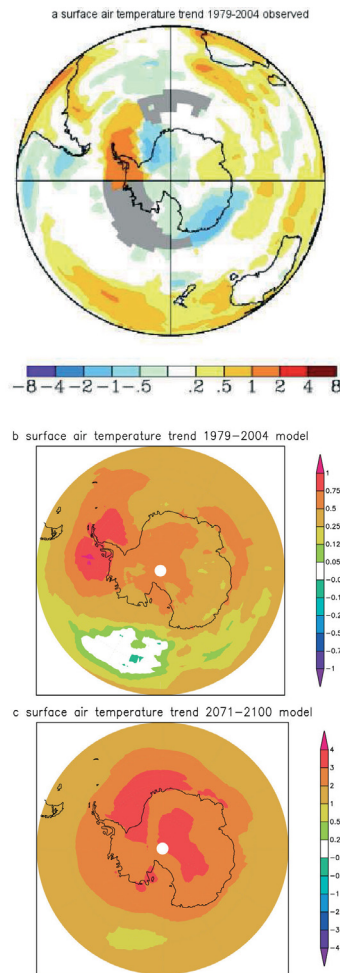


Figure 3: (a) The observed annual surface air temperature trend (in °C integrated over the period 1979-2004. Source: NASA/GISS. Gistemp <http://data.giss.nasa.gov/gistemp>) (b) Multimodel average (over 16 IPCC models) of the annual mean surface air temperature trend (in °C) integrated over the period 1979-2004 (c) The difference in annual mean surface air temperature between 2071-2100 in SRES A1B scenarios runs and the 1979-2004 period averaged over 16 IPCC models (in °C). (Figure from Lefebvre et al., in preparation)

The simulated strength of the ACC also varies a lot between the different models, ranging from less than 50 Sv to more than 200 Sv. Various factors could explain those large intermodel differences. In particular, the strength of the westerly wind over Drake Passage and the salinity gradient across the ACC seem to play a dominant role (Russel et al. 2006). On the other hand, the models which include a representation of the climatic influence of volcanic eruptions in addition to anthropogenic forcings are generally able to reproduce well the observed mid-depth ocean warming since the 1950s in the latitude band 35°S-65°S (Fyfe, 2006).

Based on the above analysis Hugues Goosse and Alex Orsi have submitted a paper to the CLIVAR/WCRP 2<sup>nd</sup> International Conference on Earth System Modelling.

***ix) A Southern Ocean Ice Model Intercomparison Project***

The Panel was asked to consider the matter of a Southern Ocean Ice Model Intercomparison Project (formally SIOMIP, now known as SOPHOCLES), led by Siobhan O’Farrell. The Panel reviewed various modelling intercomparison projects and discussed this proposal, making the following recommendations:

*The proposed SOIMIP brings together different modelling groups involved the cryospheric component of the climate system and could, like other MIPs before it, exert a positive organising force on the community. Building up a community of users that exchange information on techniques and results is a useful contribution to the CLIVAR/CliC/SCAR programs and one that we would support. The Panel felt, however, that the focus of the project was not yet clearly defined. If the focus of the activity were clearer then the aims could be somewhat*



*better defined, and the membership made more representative. Also, the Panel wonders if this initiative might not be more efficiently organized as a working group or team associated with the Coordinated Ocean-sea ice Reference Experiments (COREs) of CLIVAR's Working Group on Ocean Model Development (WGOMD). Then the question of direct relevance to climate models would be more explicit. If a goal is to improve the parameterization of sea-ice in climate models perhaps the group wants to consider the Climate Process Team approach as in US CLIVAR, which brings together observationalists and modellers in a specific subject area to address this goal. The Panel hopes that these suggestions can be taken constructively and that the initiative does not lose momentum but rather carries forward the effort to improve models.*

Note that since the meeting this activity has moved forward. As of March 2007, Siobhan O'Farrell informs us that a meeting is to be held in Bergen 25th-26th of August 2007 the weekend before the Polar Dynamics meeting (<http://web.gfi.uib.no/conference2007/program.html>). This will be in association with the WGOMD meeting.

The project has also changed its name to SOPHOCLES which stands for Southern Ocean Physical Oceanography and Cryospheric LinkagES. The name change reflects that the emphasis in the project is now on model processes: How well do models currently represent the key Southern Ocean processes? What is missing? How best can we use new observational data sets from IPY, SOOS, satellite observations of ice etc. to constrain models? Can we develop and test new parameterizations that can be used in future generation models that will be used for a range of model applications on all time scales from ice-ocean forecasting through to climate change?

This approach will likely include a broader number of people from the modelling community with a range of interests and a focus on producing a more realistic representation of the cryosphere and Southern Ocean in future models.

*Action: Panel to provide feedback to the relevant people involved with SOIMIP/ SOPHOCLES and to look into the possibility of a member of the panel attending the Bergen meeting (Kevin Speer and all panel)*

#### ***x) Date of next Meeting***

The panel will look at options for the next meeting in Spring 2008. Geneva and the US were raised as possible venues.

#### **4. References**

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## **Appendix A: Agenda**

### ***Day 1. Tuesday the 14<sup>th</sup>***

8.45-9.15 Welcome (*Servicio de Hidrografía Naval, the Dirección Nacional del Antártico and the Servicio Meteorológico Nacional* plus Mike Sparrow & Carlos Ereño on behalf of CLIVAR).

9.15-9.30 Introduction (Kevin Speer) - Aims of meeting, main issues panel needs to address etc.

9.30-9.55 Report from CLIVAR SSG (Doug Martinson)

9.55-10.10 Report from CliC SSG (Ian Renfrew)

10.10-10.30 ICPO issues (Mike Sparrow) - New CLIVAR FOCUS e-zine, meeting report, website, actions from last meeting etc.

10.30-11.00 Tea/Coffee

11.00-11.30 Relationship with SCAR/SCOR Oceanography Expert Group including SOOS (Eberhard Fahrback)

11.30-11.55 OOPC updates and links to panel (Yasu Fukumachi)

11.55-12.30 Links between ACC fronts and atmospheric variability (Kevin Speer)

12.30-13.00 Summary and Discussion of Indices in the Southern Ocean Region - revisited on Wednesday (Kevin Speer to lead)

13.00-14.30 Lunch

14.30-16.00 IPCC models in Southern Ocean region (Hugues Goosse, Claudio Menendez, input from Dave Thompson)

- Are the key underlying physical mechanisms plausibly represented in the models?

- Role of SO panel, other modeling projects (ocean, atmosphere, coupled?)

16.00-16.30 Tea/Coffee

16.30-17.10 Southern ocean - ice-shelf interaction from an observations and modeling viewpoint (Dave Holland)

17.10-17.30 Discussion

### ***Day 2. Wednesday the 15<sup>th</sup>***

8.45-8.55 Quick overview of IGOS (Vladimir Ryabinin)

8.55-9.35 Regional ocean modeling and/or regional coupled modeling (Karen Assmann, Dave Holland)

9.35-9.50 Discussion

9.50-10.30 Sea-ice and glacial melt freshwater and heat flux (Doug Martinson)

10.30-11.00 Tea/Coffee

11.00-12.00 Update on CASO and IPY (Steve Rintoul, Alex Orsi) - general update & panel's continuing role in CASO. SASSI/iAnZone and other IPY issues

12.00-13.00 Met. Observations (Ian Renfrew) - Radiosones, balloons, AWS, buoys, other sustained Met obs?  
What is missing, where are gaps, how to improve network...

13.00-14.30 Lunch

14.30-15.15 Sustained hydro Obs (Sabrina Speich)

15.15-16.00 Transport monitoring (Weddell, Ross, ...) (Steve Rintoul, Alberto Naveira, Alex Orsi)

16.00-16.30 Tea/Coffee

16.30-17.30 Panel's role in producing or assessing indices, from data and models (continued from Tuesday).

### ***Day 3. Thursday the 16th***

*Science morning - panel interaction with 'local' scientists*

8.45-9.00 Introduction & Welcome (Kevin Speer, Ian Renfrew)

9.00-9.30 "The role of the Weddell Sea in the global CO<sub>2</sub> sink" (Alejandro Bianchi)

9.30-10.00 "SMN Scientific Activities in Antarctic and Subantarctic regions" (Osvaldo Barturen)

10.00-10.30 "Climate variability in South America: Influence of the Southern Oceans" (Carolina Vera)

10.30-11.00 Coffee/Tea

11.00-11.30 "Antarctic sea ice and climate variability over South America" (Rosa Hilda Compagnucci & Sandra Barreira)

11.30-12.00 "The role of different phytoplankton groups on the CO<sub>2</sub> dynamics in the South-Western Atlantic Ocean" (Irene Schloss, Gustavo Ferreyra)

12.00-12.30 "Glacio-climatic investigations carried out by IAA in southern Patagonia and Antarctic Peninsula" (Pedro Skvarca)

12.30-13.00 "The biological contribution to the atmosphere-ocean-bottom CO<sub>2</sub> fluxes: Myth or reality" (Gustavo Ferreyra & Serge Demers)

13.15-14.30 Lunch

*SO region Panel Meeting continued...*

14.30-15.15 Future CLIVAR-related process studies (Kevin Speer)

15.15-16.00 Model/data assimilation and GSOP (Alberto Naveira)

16.00-16.30 Tea/Coffee

16.30-17.00 Update on satellite Observations (Sabrina Speich)

17.00-18.00 Regional atmospheric reanalysis (Ian Renfrew)

- Update from Bromwich?

- Validation and assessment of the quality of air-sea flux products in the SO region?

- Does this serve a climate process study goal? Are there key processes resolved only by reanalysis?

***Day 4. Friday the 17<sup>th</sup>***

8.45-8.55 Day's aims etc. (Kevin Speer, Ian Renfrew, Mike Sparrow)

8.55-9.30 Final discussion on panel's role. Final comments etc.

9.30-10.30 End of meeting actions, document options, book concept, indices article, IPCC relevant statement, for role of SO in climate etc.

10.30-11.00 Tea/Coffee

Meeting end.

## Appendix B: Attendees

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(Note that the list of attendees on the Science day was much higher as it included the speakers as well as other local scientists and students)

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