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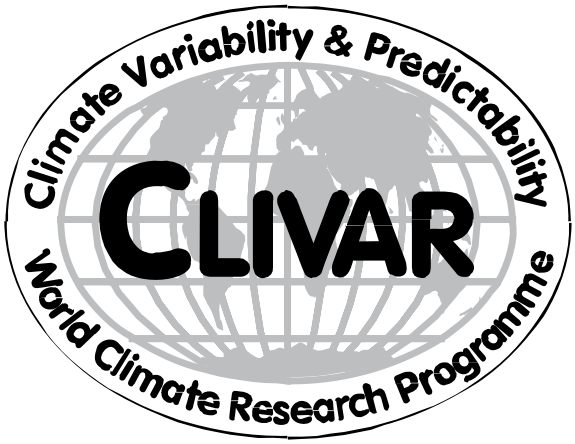

Reports of
The Modes of Southern Hemisphere Climate Variability Workshop
(27-28th June 2005)

and

The Third Session of the Clivar/CliC/SCAR Southern Ocean Region Panel Meeting
(29-30th June 2005)

Scott Polar Research Institute, Cambridge, UK

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Part 1: Report of the Modes of Southern Hemisphere Climate Variability Workshop

June 27-28th, 2005
Scott Polar Research Institute, Cambridge, UK

1. Introduction

Our understanding of the southern hemisphere ocean-ice-atmosphere system is still in its infancy compared to its northern counterpart. Several studies have hypothesized various modes of variability of the system such as the Southern Annular Mode, the Antarctic Circumpolar Wave, and the Semi-Annual oscillation, but only very recently has there been a focused effort to understand these modes and how they influence climate. The CLIVAR/CliC/SCAR Southern Ocean region panel felt that the time was ripe to bring together experts from various fields to try to answer some of the more pressing questions such as: What are the dominant modes of variability of the southern hemisphere ocean-ice-atmosphere system, how do they influence regional and global climate, are they predictable and how will they be affected by climate change?

The goals of the workshop were to review the present understanding of the major modes of variability in southern hemisphere climate, the potential for predictability of the climate at mid- to high-latitudes of the southern hemisphere, to identify gaps in our understanding and to discuss the field and modelling efforts required to fill these gaps.

2. Workshop format

The workshop was organized around invited talks by scientists spanning meteorology, oceanography, sea ice, remote sensing and paleoclimate, including both modelers and observationalists.

The workshop began with introductions from Colin Summerhayes, welcoming the delegates to Scott Polar, and Steve Rintoul who outlined the aims of the workshop.

The main programme was based on 30 minute talks, plus 10 minutes questions/discussion after each talk. A copy of the workshop agenda, including brief summaries of each talk, is included in Appendix 1. At the end of each session there was a more general discussion covering the topics presented in each set of talks. The final discussion focused on the observations and model studies needed to address gaps in our understanding of southern hemisphere climate variability. While no formal poster session was scheduled, several posters were displayed around the main lecture theatre.

Many of the invited speakers produced articles for a special issue of Exchanges, which is available online at: http://www.clivar.org/publications/exchanges/ex35/pdf/Exchanges35_web.pdf
The meeting program, list of speakers and copies of the talks are also available online at: http://www.clivar.org/organization/southern/Modes_meet.html

3. Workshop Summary

(i) The southern annular mode and southern hemisphere climate
The Southern Annular Mode (SAM) is the primary mode of southern hemisphere climate variability. The SAM owes its existence to eddy-mean flow interaction in the southern hemisphere storm track. The impact of the SAM on land and ocean temperatures was discussed, and its role in recent southern hemisphere climate change was reviewed. Measures of the SAM were also discussed, with no overall consensus on a preferred index. Instead it became clear that there are

pros and cons of using an EOF-type analysis (likely most appropriate when reanalyses data are believable) or a zonal-index type analysis (simpler and perhaps more robust but unable to capture details of the large scale structure of the SAM).

There is clear evidence of a positive trend in the SAM in recent decades, with the largest trends in summer (Dec-Jan-Feb). A number of recent studies have attributed the trend to human influences, either changes in stratospheric ozone or greenhouse warming, although others have suggested the trend is within the range of natural variability. New analyses of climate model runs conducted for the IPCC 4th Assessment Report show that all of the models show a positive trend in the SAM when forced with the full suite of natural and anthropogenic forcings; that the SAM trend is outside the range of internal variability in the models; and that, while both greenhouse and ozone forcing tend to drive the SAM to its positive index state, ozone appears to be the stronger driver (at least in DJF). The dynamics of the SAM response to greenhouse forcing remain obscure.

The extent to which the SAM is linked to climate variability in the southern hemisphere continents north of Antarctica is not yet clear. Studies have suggested correlations between variations in the SAM and variations in rainfall in South America, South Africa and southwestern Australia, presumably because changes in the SAM are associated with shifts in the location of the southern hemisphere storms. However, model studies suggest that translating this into predictable effects over land will be difficult.

The semi-annual oscillation (SAO) refers to a twice-yearly maximum in the magnitude of the sea level pressure gradient between mid- and high-latitudes (e.g. between 50°S and 65°S). The SAM and the SAO in a sense describe different aspects of the same phenomenon: both describe variations in the circumpolar flow, but the SAO describes variations in the amplitude of the annual cycle whereas the SAM describes variability about the annual cycle.

(ii) ENSO and southern hemisphere teleconnections

The Rossby wave teleconnection pattern in the southern hemisphere atmosphere, known as the Pacific South America (PSA) pattern, transfers climate signals from the tropics to high southern latitudes. Many fields have largest variance in the southeast Pacific, where Rossby wave trains generated in both the Indian and Pacific basins reach high latitudes. The PSA pattern is strongest in winter. Atmospheric model experiments with a circular continent displaced from the South Pole reproduce a "pole of variability" in the southeast Pacific, suggesting that orography plays a role in the asymmetric distribution of variability in high southern latitudes. While there is evidence for ENSO-related variability in many high latitude ocean and atmosphere fields, the nature of the connection between low and high latitudes varies with time. For example, during the 1980s, snowfall on the West Antarctic Peninsula was strongly positively correlated with the Southern Oscillation Index; during the 1990s the correlation was strong and negative. The response of the peninsula to the PSA depends strongly on the location of the PSA centre, as east-west shifts of the SLP anomaly can shift the flow over the peninsula from northerly to southerly. The existence of strong teleconnections between the tropics and high southern latitudes means that simulations of Antarctic climate are very sensitive to errors in tropical SSTs.

(iii) Ocean/ice responses to modes of variability

Sea ice extent and drift velocities are sensitive to the main modes of southern hemisphere variability, including the PSA, SAM, SAO and the wave number 3 pattern. One example is the Antarctic Dipole, a pattern of anomalies of opposite sign in the southeast Pacific and southwest Atlantic in sea ice and sea-level pressure. The dipole pattern is largely driven by the PSA pattern, although the persistence of the anomalies may indicate a role for ocean-ice dynamics. On a circumpolar scale, the SAO has a particularly strong correlation with sea ice extent, on a range of

time-scales. Lag/lead relationships suggest that there is a feedback from the sea-ice distribution on sea-level pressure.

Satellite-derived sea ice drift products are now available that provide new insights into coupled dynamics in the sea ice zone (e.g. the Atlas of Antarctic Sea Ice Drift, http://www.imk.uni-karlsruhe.de/seaiceatlas). The combination of radar and laser altimeters and geodetic satellites, carefully validated with *in situ* observations, promises to deliver the first circumpolar estimates of sea ice thickness (and other properties) in the Southern Ocean. These remote sensing products will enable a substantial step forward in understanding the coupled dynamics in the sea ice zone and their influence on climate.

It was suggested that changes in the transport of the Antarctic Circumpolar Current were correlated with changes in the SAM, on time-scales from intra-seasonal to interannual (and perhaps longer). However, the magnitude of the transport response is relatively modest (e.g. a few Sverdrups for a one standard deviation change in the SAM index). This ocean-atmosphere interaction and variability was proposed to constitute a climate mode, though the coupling mechanism between the ocean and atmosphere for this mode is not yet evident.

Evidence from numerical simulations of the ocean/ice system suggests that modes of variability trapped to the Antarctic continent exist on decadal time scales and are of circumpolar extent. Mechanisms invoked include ice advection and the melt/freeze cycle, together with wind-driven effects. Antarctic ice cores provide a unique long-term perspective on the nature of the major modes of southern hemisphere climate variability, including proxies for ENSO, temperature, sea ice extent and circulation patterns such as the strength of the westerlies, the Amundsen Sea Low and the East Antarctic High. This resource has so far been under-utilised by oceanographers and meteorologists.

Several talks discussed the evidence for water mass variability in observations and models. There is clear evidence of changes in each of the major Southern Ocean water masses, but the short and discontinuous observational records make it difficult to describe and determine the causes of the variability. Models have an important role to play, but most models still have significant problems in reproducing the observed water mass structure in the Southern Ocean, so the interpretation of changes in model simulations requires some care.

There was a discussion on the utility of additional meteorological observations in the open ocean and sea-ice zone of the Southern Ocean. Recent work by King (King, J. C., 2003: Validation of ECMWF Sea Level Pressure Analyses over the Bellingshausen Sea, Antarctica, *Weather and Forecasting*, Vol18, No. 3, pp536-540) provided some evidence that the current generation of meteorological analyses are very good in a statistical sense over the Southern Ocean, especially in terms of mean sea level pressure (and hence geostrophic wind speed), due to the use of modern satellite sounder data. However it is likely they are less accurate for near-surface temperature and humidity, hence fluxes, especially over or close to the sea-ice zone.

4. Open questions and challenges

A number of modes of variability in the atmosphere-ocean-ice system have been identified in the southern hemisphere. Some of the modes are inherent aspects of the high latitude southern hemisphere climate and others are forced by teleconnections from lower latitudes. While many of the modes have analogs in the northern hemisphere, the different continental geometry results in significant differences in the mean state and variability of the southern hemisphere atmosphere, ocean and sea ice. The modes of southern hemisphere variability described in the literature are not all independent and in some cases describe different aspects of the same physical phenomenon. Both models and observations reveal variability of the modes on a range of time-scales, but our

understanding of the variability is increasingly primitive as the time-scales increase, reflecting the short length of observational records and weaknesses in the models that are more severe at longer time-scales.

The workshop provided an excellent summary of the present state of our understanding of southern hemisphere climate variability and identified a number of open questions: What is the dynamical explanation for the response of the SAM to enhanced greenhouse warming in climate models? Is there evidence for coupled modes of variability in the mid- to high-latitude southern hemisphere, or are the ocean and sea ice primarily responding to atmospheric variability? There is evidence for quasi-decadal variability in a number of climate parameters and relationships in high southern latitudes: does this reflect "reddening" of the stochastic forcing by the atmosphere, or do coupled dynamics play a role?

In order to answer many of the above questions relevant high quality data are needed. With regards to the observational network, the following points came out of the meeting discussions:

- It is important to keep the radiosonde network running for satellite validation purposes. For example, the Russian radiosondes are now not working in many places due to lack of money. There is also a lack of radiosonde data in west Antarctica. Would this be a good investment? Studies need to be carried out to investigate this
- Improved meteorology measurements (IMET) on ships would be an important addition
- Where relevant data are collected we need to ensure these get to the GTS
- Need subsurface timeseries in areas identified by atmospheric analysis
- Require continued availability of satellite-derived ice concentration
- Need oceanic meridional sections across the Southern Ocean
- Long-term monitoring of deep-ocean variables along deep-western boundary need to be done
- Importance of flux estimates, e.g. SEAFLUX project must be emphasised

The International Polar Year (IPY) provides a unique opportunity to tackle many of these questions. The workshop was followed by a discussion of a number of IPY programs studying the role of the ocean, atmosphere and sea ice in past, present and future climate. More information on the developing plans for the IPY can be found on the panel's website (http://www.clivar.org/organization/southern/).

Appendix 1: Agenda and abstracts

Summaries of the talks given at the workshop are included below. Full versions of the talks can be obtained via the Southern Ocean CLIVAR/CliC/SCAR panel's website or directly from http://www.clivar.org/organization/southern/Modes_meet.html

Monday 27th of June

8:00 8:40 Registration
8:40 9:00 Steve Rintoul, Ian Renfrew, Colin Summerhayes: Introduction and welcome

Session One: The southern annular mode and southern hemisphere climate
Chair: Ian Renfrew; rapporteur: Kevin Speer

9:00 9:40 The mean state of the southern hemisphere atmosphere
Dave Thompson (davet@atmos.colostate.edu)
In order to understand Modes of Variability an understanding of the mean state of the system is required. The mean state of the atmosphere was summarised with reference to perturbations about the mean giving rise to modes such as SAM.

9:40 10:20 Human influences on the southern annular mode
Nathan Gillet (n.gillett@uea.ac.uk)
The Southern Annular Mode has exhibited an upward trend over recent decades, which is largest in the boreal summer. An analysis of the control simulations of eight coupled climate models indicated that this trend is unlikely to be due to internal climate variability alone. Simulations, which incorporated greenhouse gas, stratospheric ozone, sulphate aerosol, solar and volcanic forcing changes exhibited a significant positive trend in the Southern Annular Mode over the past fifty years consistent with that observed. A comparison of the response to individual forcings in two coupled models indicated that stratospheric ozone depletion has been the dominant contributor to the summer SAM trend, with greenhouse gas and natural forcings also playing a role. Simulations with a high vertical resolution model indicate that ozone-induced stratospheric cooling is enhanced by a dynamical feedback, and that ozone depletion induces a dipole in tropospheric eddy forcing in the upper troposphere, which results in a poleward shift of the eddy driven jet, and hence a positive trend in the SAM.

10:20 10:40 tea

10:40 11:20 Southern hemisphere annular mode indices
Gareth Marshall (GJMA@bas.ac.uk)
In this presentation we review the main definitions of the SAM and investigate the relative merits and disadvantages of these. We show data from the first quantitative analysis of the effect that different definitions of the SAM can have on derived trends. We also note that altering the definition can actually lead to changes in the attribution of SAM trends. It is shown that current reanalysis products have difficulty accurately portraying the pressure fields over the Southern Ocean prior to the assimilation of satellite sounder data in 1979, with an important detrimental effect on the accuracy of derived long-term SAM trends. An alternative is to use a matrix of station observations instead to produce temporally stable trends: however, these are temporally limited because most Antarctic stations did not commence operation until the IGY of 1957/58. Longer time-series of the SAM can be produced using principal component regression techniques, which are discussed briefly, as is the use of paleo-data from Antarctic ice cores to provide us with even longer-term SAM proxies. Finally, we outline the two current on-line SAM indices for those in the audience who may wish to utilise such data.

11:20 12:00 Southern Ocean Modes of Climate Variability - Representation in models and their Impact on Regional Climate

Illana Wainer (wainer@usp.br)

In this study we analyze the Southern Ocean modes of variability by applying the Empirical Orthogonal Functions (EOF) method to the Sea Level Pressure field simulated by 9 of the IPCC AR4 coupled general circulation models for "Climate of the 20th Century experiment (20c3m)". These simulations have included a more realistic scenario of climate forcing, running from the late nineteenth century through the end of the twenty-first century. The SAM pattern (EOF1 mode) is a very robust feature of the climate system and is well represented in all investigated models (consistent with Miller et al., 2005). Wave # 2 and # 3 patterns are a common feature for most of the models in the non-annular component, suggesting the influence of ACW on both atmospheric and oceanic variability. However, this structure is more defined on SLP rather than SST, which could suggest that the ACW is primarily driven by the atmosphere in the general coupled models. The models differ considerably with respect to the positive trend of the SAM, ranging from -0.77 to 6.67 in these 20th century simulations. There is also a wide variation between models with respect to the variability of the SAM phase. Since each phase is marked by specific mechanisms (e.g. strengthening of the westerlies, enhanced Ekman drift, stronger ACC in the positive phase), this may be a drawback when using multi-model analyses for climate prediction. Interannual variability of the SAO, also investigated, has been subject of growing interest. Before 1979, the SAO explained more than 50% of the total variance - after that period, the SAO decreased significantly. It is shown that the SAO has a significant Interannual component and that it is weakening over the Pacific and Indian ocean basin but is still strong in the Atlantic.

The impact of the above modes in South American and South African precipitation patterns was also shown to be strong. The analysis of the influence of the SAM onto bi-monthly precipitation anomalies over southeastern South America (SESA) performed by Silvestri and Vera (2003) shows that the SAM signal is significantly strong during both winter and late spring associated with distinctive circulation changes in the southern hemisphere. The fact that AAO variability is related with precipitation changes over SESA is of importance because it contributes to explain the precipitation variance fraction not related with ENSO. Although the latter means a predictability decrease considering that the mechanism of the AAO limits its own predictability and that of related fields. Furthermore, time series of smoothed AAO index and western South African rainfall for 1950-2000 - correlation coefficient 0.6. Wet winter composite 500 hPa height anomalies display a SAM-like pattern plus wave #3 shift indicating that for the negative phase of the SAM there is a shift in storm-track leading to more rain.

12:00 13:00 Discussion

13:00 14:00 Lunch

Session Two: ENSO and other southern hemisphere teleconnections

Chair: Dave Thompson; rapporteur: Mike Sparrow

14:00 14:40 Decadal variability of the Antarctic-Enso teleconnection and its association with the Southern Annular Mode

D. Bromwich (Bromwich@polarmet1.mps.ohio-state.edu)

Decadal variability of the El Niño-Southern Oscillation (ENSO) teleconnection to the high latitude South Pacific is examined by correlating the European Centre for Medium-Range Weather Forecasts (ECMWF) 40-year Reanalysis (ERA-40) and observations with the Southern Oscillation index (SOI) over the last two decades. There is a distinct annual contrast between the 1980s and the 1990s, with the teleconnection in the 1990s being significantly amplified due to an enhanced response during austral spring. Geopotential height anomaly composites constructed during the peak ENSO seasons also capture the decadal variability.

Empirical orthogonal function (EOF) analysis reveals that the 1980s SON teleconnection is weak due to the interference between the Pacific South American pattern (PSA) associated with ENSO and the Southern Annular Mode (SAM). An in-phase relationship between these two modes during SON in the 1990s amplifies the height and pressure anomalies in the South Pacific, producing the strong teleconnections seen in the correlation and composite analyses. The in-phase relationship between the tropical and high latitude forcing also exists in DJF during the 1980s and 1990s.

These results suggest natural climate variability plays an important role in the variability of the SAM, in agreement with a growing body of literature. Additionally, the significantly positive correlation between ENSO and the SAM only during times of strong teleconnection suggests that both the tropics and the high latitudes need to work together in order for ENSO to strongly influence Antarctic climate.

14:40 15:20 The impact of high latitude climate modes on Antarctic sea ice
Xiaojun Yuan (xyuan@ldeo.columbia.edu)
This study investigates the influence of high latitude climate variability on the Antarctic sea ice distribution. The climate variability examined here includes distinct climate modes, such as the Southern Annular Mode, quasi-stationary wave-3 pattern, Pacific South American pattern and Semi-annual Oscillation. The singular value decomposition analysis is applied to examine the coupled relationships between sea ice and atmospheric pressure, temperature and wind fields. The results reveal that the sea ice field is highly coupled with the atmosphere in the forms of these known climate patterns. The leading coupled mode is accountable for 50% to 60% of total squared covariance between sea ice and sea level pressure for all seasons. The leading coupled mode between sea ice and surface air temperature is also accountable for more than 50% of total squared covariance of these fields. The influences from the Pacific South American pattern and wave-3 pattern on sea ice are stronger than that from other patterns, particularly in the western hemisphere. The Southern Annular Mode has relatively less influence on sea ice than other patterns. The impacts from the atmosphere are much stronger in winter than in summer. Sea ice usually responds to the atmospheric forcing with a two month delay.

15:20 15:40 tea

15:40 16:20 Links between the Antarctic and the rest of the climate system
John Turner (jtu@bas.ac.uk)
This talk will concentrate on the links between atmospheric and oceanic variability in the tropical Pacific and the climate of the Antarctic Peninsula. The emphasis will be on how signals of ENSO reach the Peninsula and why seemingly very similar El Nino events have such very different signals at high latitudes. It has been known for some time that a Rossby wave train can become established over the South Pacific during El Nino events, but recent work has shown that positive SST anomalies alone are not enough to generate a wave train, but that there must be broadscale atmospheric support in terms of ascent. The strength of the westerlies over the Southern Ocean and the presence of the Pole of Variability to the west of the Antarctic Peninsula mean that the Pacific South American Association pattern is more variable than the Pacific North American Association.

16:20 17:00 Calibrated ice core derived climate proxies
Paul Mayewski (Paul.Mayewski@maine.edu)
The presentation will include a brief introduction to the International Trans Antarctic Scientific Expedition (ITASE) – a 20-nation SCAR-IGBP initiative that is focused on recovery of ice core records that describe past climate of the last 200-1000 years over Antarctica and the Southern Ocean. The ice core records utilised in the discussion are all annually dated and calibrated with

instrumented climate series. The calibrations offer proxies for past snow accumulation, temperature, and atmospheric pressure allowing interpretation of past climate

17:00 18:00 Discussion: ENSO and other southern hemisphere teleconnections

(Evening: Workshop dinner)

Tuesday 28th June

Session Three: Ocean/ice response to modes of variability
Chair: Doug Martinson; rapporteur: Rosemary Morrow

8:40 9:20 Circumpolar ocean transport response to forcing by the Southern Annular Mode
Mike Meredith (mmm@bas.ac.uk)
The SAM is the dominant mode of atmospheric climate variability in the Southern Hemisphere outside the tropics. It is largely zonally-symmetric, and shows variability on all timescales longer than a few weeks. The SAM plays a dominant role in controlling
fluctuations in the circumpolar westerly winds over the Southern Ocean on these timescales. This talk will address the impact of the SAM on oceanic circumpolar transport fluctuations around Antarctica on a range of timescales, specifically subseasonal, seasonal, interannual and secular. An observed connection with atmospheric variability at lower latitudes on subseasonal timescales will be discussed. The requirements for a measurement system capable of reliably monitoring interannual timescales in transport variability will be outlined.

9:20 10:00 Ice-ocean modes in the Antarctic marginal seas
Aike Beckmann (aike.beckmann@helsinki.fi)
The hydrosphere and marine cryosphere of the Antarctic Marginal Seas are characterized by a number of unique processes: interactions between sea ice, ice shelves, ocean and atmosphere, causing complex water mass transformations and exchanges between the surface and deep ocean, which are strongly affected by tides and freshwater input through drifting and melting icebergs.

This presentation focuses on model representations of the ocean-ice response to various modes of variability, starting with the notion that the circumpolar water ring may support a variety of circumpolar modes, including dynamically driven modes in the upper ocean (wave number 2 or 3) but also thermohaline driven modes in the near-bottom layers (like an interdecadal dipole anomaly detected in a model by Beckmann and Timmermann, 2001).The consequences of interannual to interdecadal variability are illustrated by looking at modelled Weddell Sea bottom water volume, and the exchange of water with the Filchner-Ronne ice shelf cavity.

In the second part of the talk, the lessons learned from a regional sea ice-ocean-ice shelf model of the Antarctic Marginal Seas (BRIOS) are summarized and the need to transfer the state-of-the-art methods to today's global coupled ice-ocean models is stressed.

10:00 10:40 Modes of Antarctic Sea Ice Drift Variability, and their connection to atmosphere-ocean modes
Mark Drinkwater (Mark.Drinkwater@esa.int)
Recent studies have identified modes of variability in the lower atmosphere in conjunction with variability expressed in ice concentration and SST. In contrast, this study highlights the interrelationship between variations in sea-level pressure, ice drift, and ice concentration. The presentation recaps the primary modes of atmospheric variability, and identifies weaknesses of using satellite-derived ice concentration as the only index of sea-ice response. The primary advantage of using satellite tracked ice drift is in resolving ambiguities in the relative contribution

of dynamics and thermodynamics to anomalies in sea ice concentration - and in understanding their respective impact on atmosphere-ice-ocean fluxes. Statistics of covarying ice drift, ice concentration and sea-level pressure over the period 1978-1998 reveal the dominant quasi-quadrennial mode (3-5 year period) of variability in the South Pacific and South Atlantic sectors of the Southern Ocean. This dominant mode is shown to be strongly correlated with the Southern Oscillation Index. Illustrations of the interannual variations in the resulting patterns of ice drift, and the impact on Weddell freshwater transport are provided. Finally, to date no significant relationship has been observed between the primary mode of Atmospheric variability (SAM) and sea ice concentration. An analysis of long-term ice drift statistics reveals a significant Southern Ocean wide reduction in ice drift velocity variance. It is speculated is related to the combined influence of increasing positive index of SAM, the ACC and reduced cyclonicity.

Future studies will benefit from the Antarctic Ice Drift Atlas
http://imkhp7.physik.uni-karlsruhe.de/~eisatlas) and downloadable databases, and from new Global ice tracking techniques using spaceborne radar data.

10:40 11:00 tea

11:00 11:40 The semi-annual oscillation in the southern hemisphere and its influence on temperature and sea ice

Michiel Van den Broeke (m.r.vandenbroeke@phys.uu.nl)

The semi-annual oscillation (SAO) is the phase-locked, twice-yearly expansion and contraction of the circumpolar pressure trough (CPT). In this talk, the impact of the SAO on near surface climate and sea ice in the southern hemisphere and specifically high latitudes are discussed. The expansion of the CPT in mid-winter (June) causes enhanced meridional air exchange, but owing to longitudinal intensity gradients in the CPT, with its three climatological pressure minima, there is a strong longitudinal dependency in the response. This results in clearly detectable minima and maxima in the sensitivity to the SAO along a latitude circle. Decadal variability in the strength of the SAO and specifically its weakening since the mid-1970s has led to pronounced seasonality in temperature, wind speed and cloudiness trends at selected Antarctic stations. We furthermore highlight the important role of the atmospheric boundary layer, with its surface-based temperature inversion and katabatic winds over the ice sheet, in transferring large-scale circulation variability and change to the surface.

11:40 13:00 Discussion

13:00 14:00 Lunch

Session Four: What are the major gaps in our understanding of southern hemisphere modes of variability, and how can we address them*?*

Chair: Eberhard Fahrbach; *rapporteur: John King*

14:00 14:40 The role of Southern Ocean sea ice and convection on the mean state and variability of the global deep ocean

Achim Stoessel (achim@ocean.tamu.edu)

This talk addresses three issues: 1) The long-term response of the global thermohaline circulation in global ocean GCMs to changes in the Southern Ocean high-latitudes, 2) Model variability of the northward spreading of AABW along the deep-western boundary, and its linkage to variability in Southern Ocean sea ice and convection, and 3) The verification of Southern Ocean sea ice in global ocean GCMs including the seasonal and higher-frequency variability of the ice edge and coastal polynyas. All three issues reveal "major gaps" in our understanding of the interactions between high-latitude processes in the Southern Ocean and the global ocean in terms of its long-term

equilibrium response as well as its variability. Recommendations for items in ocean GCMs to be improved include the parameterization of convection and downslope bottom plumes, the slopes of the bathymetry, mixing due to tidal energy dissipation at bathymetry, and, notoriously, the coupling to the atmosphere. Recommendations for observational programs include continued availability of satellite-derived ice concentration, monitoring of oceanic meridional sections across the Southern Ocean, and long-term monitoring of deep-ocean variables along the deep-western boundary. Finally, the quality of atmospheric variables (reanalyses) over the Southern Ocean, in particular winds and precipitation, will also be decisive for a realistic simulation of the global thermohaline circulation.

14:40 15:20 Antarctic Bottom Water variability and sensitivity to change
This talk was split into two parts, with Alex Orsi speaking first followed by Svein Osterhus.

Alex Orsi (aorsi@tamu.edu)
The ocean's thermohaline circulation is driven by buoyancy changes affecting the surface waters of polar regions, e.g. forcing from atmospheric cooling and fresh water sinks like sea-ice formation (Wunsch, 2002). Newly formed dense waters sinking at high latitudes then flow equatorward along narrow but strong deep western boundary currents (Schmitz, 1995). While the deep layers of all interconnected ocean basins reveal the saline influence from the northern North Atlantic (Reid and Lynn, 1971), cooling and freshening of the abyssal ocean has repeatedly being attributed to the Southern Ocean (Wust, 1935; Mantyla and Reid, 1983; Orsi et al., 1999).
Direct connections exist between the thermohaline properties of the world ocean bottom waters and the observed changes in the characteristics of upper layer waters over the Antarctic continental margins. Seasonal to decadal variability have been detected at locations close to Antarctic Bottom Water sources in the Weddell Sea (Foster et al., 1979, 1987; Fahrbach et al., 2001; Visbeck et al., 2001), off the George V Coast (Jacobs, 2004) and the Ross Sea (Bergamasco et al., 2002). Signals with annual to decadal scales in the Antarctic Bottom Water properties north of the Antarctic Circumpolar Current have also been reported in the Atlantic (Coles et al., 1996) and Pacific sectors (Johnson and Orsi, 1997).
Ross Sea shelf waters are experienced a dramatic freshening (0.12 salinity decrease) over the past four decades (Jacobs et al., 2002), comparable to the Great Salinity Anomaly (Dickson et al., 2002) in the North Atlantic. A similar trend is inferred in the Ross Sea Bottom Waters exported westward into the Australian-Pacific Basin, where "fresh-mode" in bottom water colder than -04 C has been reported since 1994 (Whitworth, 2002). Among the causes for the ongoing freshening observed in Southern Ocean water masses are possible changes in the wind fields, precipitation rates, sea ice production and spatial extent, and melting rate of the Antarctic Ice Sheet (Jacobs, 2004).
Sustained collection of in situ and remote measurements at key locations of the Antarctic continental margins will provide a more complete understanding of the observed temporal changes in Southern Ocean climate. Monitoring along the Ross and Weddell corridors will tentatively start during the International Polar Year (2007-2008), to jumpstart the systematic and circumpolar view of Antarctic climate change.

Svein Osterhus (Svein.Osterhus@gfi.uib.no)
The coldest and densest water in the southern ocean can be traced back to the southern Weddell Sea. There cold shelf water make a significant contribution to the production of Weddell Sea Bottom Water (WSBW), a precursor to Antarctic Bottom Water (AABW) (Orsi et al., 1999). Using 20 current meter moorings deployed over a period of 30 years, Foldvik et al. (2004) argued that the overflow of Ice Shelf Water (ISW) from the Filchner Depression alone may produce 4-5 Sv of WSBW by mixing with overlying waters when cascading down the southern Weddell continental slope. High-Salinity Shelf Water (HSSW) forms by cooling and freezing on the continental shelf during the winter months (Foldvik et al., 2001, Nicholls et al., 2003). Under the floating ice shelf the Ice Shelf Water (ISW) is formed when High Salinity Shelf Water (HSSW) comes in contact

with the shelf ice at great depths. The ISW has been observed to exit the sub-ice shelf cavity in the southern Weddell Sea in the Filchner Depression (Gammelsrød et al., 1994). By drilling holes through the ice shelf up to 1 km deep, and deploying moored instruments in the underlying water column, our understanding of the circulation pattern and variability of the ISW in the sub-ice cavity is continuously being improved (Nicholls et al., 2001 & 2004). Large interannual variability in the sub-ice ISW circulation and production has been revealed (Nicholls & Østerhus, 2004). This is believed to stem from variations in the production of HSSW due to changes in the sea ice conditions. Grounded Icebergs is also can also change the hydrographic conditions and may have an impact on the deep water productions (Nøst and Østerhus, 1998).

15:20 15:40 tea

15:40 16:20 Southern Ocean variability and climate change in HadCM3
Sheila Stark (sheila.stark@metoffice.gov.uk)
The Southern Ocean is data sparse compared to much of the global ocean so models offer the potential to interpret observed changes, understand mechanisms and predict future climate change. In this talk I present an overview of the work that has been done at the Hadley Centre on the Southern Ocean. I start with an overview of the Southern Ocean simulation of HadCM3 focusing primarily on the ACC and water masses. The remainder of the talk focuses on Subantarctic Mode Water (SAMW) and Antarctic Intermediate Water (AAIW). I compare model simulations to observations and show what the model predicts will happen over the coming century under the IPCC B2 forcing scenario. The variability of these two water masses is discussed and I show that more observations are needed to allow us both to assess model performance and detect climate change signals.

16:20 17:40 Discussion

17:40 18:10 Plans for review article on workshop outcomes (speakers, chairs, rapporteurs and others interested)

Wednesday 29th-Thursday 30th June: CLIVAR/CliC/SCAR Southern Ocean region panel meeting –
See Part 2 of this joint report

Appendix 2: Modes of variability workshop participants

Aoki	Shigeru	<shigeru@hassaku.lowtem.hokudai.ac.jp>	National Institute for Polar Research, Japan
Beckmann	Aike	<aike.beckmann@helsinki.fi>	University of Helsinki, Finland
Bellerby	Richard	< richard.bellerby@bjerknes.uib.no>	University of Bergen, Norway
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Bromwich	David	<Bromwich@polarmet1.mps.ohio-state.edu>	Ohio State University, USA
Budillon	Giorgio	<giorgio.budillon@uniparthenope.it>	università degli studi di napoli "parthenope", Italy
Caltabiano	Antonio	<caetano@noc.soton.ac.uk>	ICPO, NOCs, Southampon UK
Diggs	Steve	<sdiggs@ucsd.edu>	Scripps Institution of Oceanography, La Jolla, USA
Drinkwater	Mark	<Mark.Drinkwater@esa.int>	ESTEC Earth Sciences Div. The Netherlands
Fahrbach	Eberhard	<efahrbach@awi-bremerhaven.de>	Alfred-Wegener-Institut, Germany
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Gillett	Nathan	<N.Gillett@uea.ac.uk>	University of East Anglia, UK
Gomis	Damià	<damia.gomis@uib.es>	IMEDEA, Spain
Harangozo	Steve	<sah@bas.ac.uk>	British Antarctic Survey, Cambridge
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Meredith	Mike	<mmm@bas.ac.uk>	British Antarctic Survey, Cambridge
Miles	Georgina	<GMIL@bas.ac.uk>	British Antarctic Survey, Cambridge
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Sparrow	Mike	<m.sparrow@noc.soton.ac.uk>	ICPO, NOCS, Southampton UK
Speer	Kevin	<kspeer@ocean.fsu.edu>	Florida State University, USA
Stark	Sheila	<sheila.stark@metoffice.gov.uk>	Met Office, UK
Stoessel	Achim	<achim@ocean.tamu.edu>	Texas A&M University, USA
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Thompson	David	<davet@atmos.colostate.edu>	Colorado State University, USA
Turner	John	<jtu@bas.ac.uk>	British Antarctic Survey, Cambridge
Van den Broeke	Michiel	<m.r.vandenbroeke@phys.uu.nl>	Utrecht University, The Netherlands
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Part 2: Report Of The Third Session Of The Clivar/CliC/SCAR Southern Ocean Region Panel Meeting

June 29-30th, 2005
Scott Polar Research Institute, Cambridge, UK

1. Action Items
Since the meeting progress has been made in several of the action items below. Comments in italics give an update as of the end of November 2005.

International Polar Year:
1. There is a lack of modelling work in the CASO proposal (c.f. with SASSI). This seems to be because the modelling community were under the impression that IPY was mainly an observational programme. The panel need to encourage modelling proposals (Aike Beckmann, Steve Rintoul, all panel)

No modelling proposals have been received as of 22/11/05. Steve Rintoul raised this issue at the WGOMD-6 meeting (Hobart Australia, 8-11 November 2005).

2. Steve Rintoul to send out email to all CASO Expressions of Interests (EOIs) to obtain details of their plans etc. before final submission to the IPY committee (Steve Rintoul, rest of panel)

Done. CASO has been submitted.

3. The need was identified to have a page like the Southern Ocean Observations page showing CASO IPY activities. Details of thee activities should be forwarded to Mike Sparrow (Mike Sparrow, plus SO community)

Page is up and running, see: http://www.clivar.org/organization/southern/CASO/index.htm

General panel meeting:

4. It would be useful to the panel to have an update on the status of the IPAB buoys (Mike Sparrow)

Christian Hass is now looking after IPAB and is also a new member of the panel. There is a new website at http://www.awi-bremerhaven.de/IPAB.

5. The panel recommends a focused effort to produce an Antarctic reanalysis, encompassing the SO – write to SCAR/AGCS/ David Bromwich (Ian Renfrew, Kevin Speer)

This is being worked on. See article in Exchanges (http://www.clivar.org/publications/exchanges/ex35/pdf/Exchanges35_web.pdf) by Bromwich.

6. The panel should review the white paper for proposed time series sites etc – perhaps after new membership has been drafted in (panel, for future)

Action required.

7. Panel to produce a list of climate indices based on Southern Ocean phenomena for the OOPC. Of particular interest are indices that rely on in situ observations, to help demonstrate their value. (Various, coordinated by Kevin Speer). (Carried over from previous meeting)

This has been done. Draft recommendations can be downloaded from: http://www.clivar.org/organization/southern/documents/SOP2GSOP.pdf.

8. Panel to follow up on Modes of Variability Workshop, e.g. produce meeting report, special exchanges issue etc. (All panel coordinated by Ian Renfrew, Steve Rintoul, Mike Sparrow)

The special CLIVAR Exchanges issue is available from:

http://www.clivar.org/publications/exchanges/ex35/pdf/Exchanges35_web.pdf
The workshop report is joint with this panel meeting report.

2. Introduction

In 2004 the Scientific Committee on Antarctic Research (SCAR) became the third co-sponsor of the Southern Ocean (SO) region panel. Thus the SO CLIVAR/CliC/SCAR panel is charged with refining and implementing the science plans of CLIVAR, CliC and SCAR in the SO Sector.

The terms of references (TORs) of the panel are:

- To design a strategy to assess climate variability and predictability of the coupled ocean-atmosphere-ice system in the Southern Ocean region.
- To develop and refine an implementation plan for the Southern Ocean region that defines the process studies, sustained observations, and model experiments needed to meet the objectives of CLIVAR, CliC and SCAR.
- To work in concert with relevant CLIVAR panels (e.g. regional panels, numerical experimentation groups), ACSYS/CliC Panels (DMIP, OPP, NEG) and other groups (e.g. Ocean Observation Panel for Climate, Argo Science Team) to integrate SO observations with those in neighbouring regions to ensure the objectives of CLIVAR/CliC/SCAR are met and resources are used efficiently.
- To enhance interaction between the meteorology, oceanography, cryosphere, biogeochemistry and paleoclimate communities with an interest in the climate variability of the SO region.
- To serve as a forum for the discussion and communication of scientific advances in the understanding of climate variability and change in the SO region
- To work with the CLIVAR, CliC and SCAR data systems on issues related to distribution and archiving of SO observations.
- To advise the CLIVAR, SCAR and ACSYS/CliC SSGs on progress achieved towards implementation.

For further details see: http://www.clivar.org/organization/southern/

The current members of the SO panel at the time of the meeting (see Section 10 for new membership) were:

S. Rintoul - co-chair	CSIRO, Hobart, Australia
I. Renfrew - co-chair	University of East Anglia, Norwich, UK
S. Aoki	National Institute for Polar Research, Tokyo, Japan
I. Allison	Antarctic CRC, Hobart, Australia
A. Beckmann	University of Helsinki, Helsinki, Finland
S. Cunningham	National Oceanography Centre, Southampton, UK
E. Fahrbach	Alfred-Wegener Institut für Polar und Meeresforschung, Bremerhaven, Germany
P. Froelich	Florida State University, Talahassee, USA
A. Gordon	Lamont Doherty Earth Observatory, Palisades, USA
D. Martinson	Lamont Doherty Earth Observatory, Palisades, USA
R. Morrow	LEGOS, Toulouse, France
C. Sabine	NOAA/PMEL, Seattle, USA
K. Speer	Florida State University, Talahassee, USA
K. Heywood (ex-officio)	University of East Anglia, Norwich, UK
M. Sparrow	International CLIVAR Project Office (ICPO), National Oceanography Centre, Southampton, UK

C. Ereño	ICPO South American representative, University of Buenos Aires, Buenos Aires, Argentina

There are also several national representatives (see Appendix 4) who keep the panel – and SO community as a whole – up to date with their country's work in the SO region and act as a contact point in their country.

3. Purpose of the meeting

The third meeting of the CLIVAR/CliC/SCAR Southern Ocean region Panel was held at the Scott Polar Research Institute (SPRI) following a workshop on Modes of Southern Hemisphere Climate Variability, also organised by the panel (see Part 1 of this report).

Unfortunately Arnold Gordon, Stuart Cunningham and Chris Sabine were unable to attend. However, attendance was good as many people stayed on from the climate variability workshop and several of the national representatives (see Appendix 4) such as Damia Gomis from Spain, Svein Osterhus from Norway and Mauricio Mata from Brazil attended. Mario Hoppema also kindly stood in for Chris Sabine as the Carbon representative. A full list of the attendees is given in Appendix 1.

The first day was devoted to a discussion of the International Polar Year (IPY). The IPY has potential to deliver significant advances in Antarctic and Southern Ocean science of relevance to CLIVAR, CliC and SCAR. The Panel had prepared an umbrella proposal for climate work in the IPY (Climate of Antarctica and the Southern Ocean, CASO), which has since been approved by the IPY Steering Committee. The meeting provided a good opportunity to make further steps towards coordination and implementation of IPY plans, taking advantage of the attendance of many of the main players at the Modes of Variability Workshop and the SCAR AGCS (Antarctica and the Global Climate System) meeting being held in Cambridge.

Copies of presentations given at the panel meeting can be downloaded from: http://www.clivar.org/organization/southern/Panelmeet3.html

4. IPY: Welcome and introduction

Colin Summerhayes started by welcoming the attendees to the meeting and gave an introduction to the International Polar Year (IPY). There was quite a lot of discussion about funding issues (projects that get the IPY seal of approval still have to request funding from their own national sources) and ship time (people being concerned that there won't be enough ship time to go around).

4.1 IPY: Antarctic ocean circulation

The CASO proposal was originally proposed as an IPY activity by Steve Rintoul and the SO panel. Its original aims were far reaching and involved:

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

In order to achieve this an enhanced IPY observing system would be necessary which would include:

- Synoptic multi-disciplinary transects (See Figure 1)
- Sea ice volume measurements

- An enhanced sea ice drifter array
- Measurements of ocean circulation under sea ice
- Enhanced Southern Ocean Argo
- Enhanced meteorological measurements
- Ice cores from high accumulation rate coastal sites
- Process studies

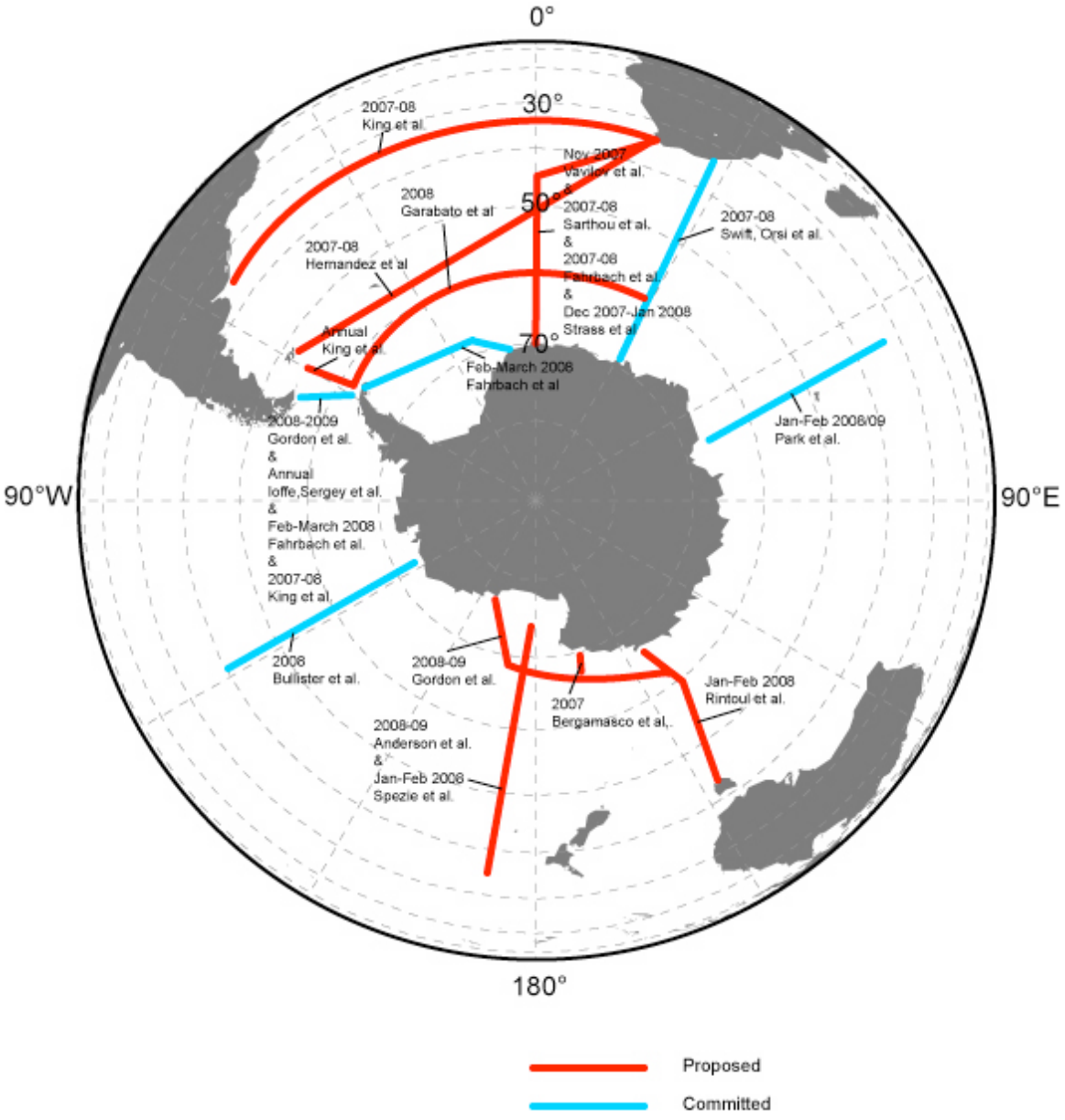

Figure 1: Schematic of proposed multi-disciplinary transects during IPY

However, the CASO "vision" was too large to provide a practical vehicle for implementation. The IPY committee decided to cluster projects along discipline or regional lines and thus CASO was given responsibility for "Antarctic Ocean Circulation".

Looking at the Expressions of Interest (EOI) so far under the CASO umbrella, there are several potential gaps:

- Modelling
- Argo, open ocean and under ice
- Zonal lines in subtropics

- Gaps in section coverage
- ACC transport monitoring

All of these are being worked on, but the gap in the modelling work seems to be because the modelling community were under the impression that IPY was mainly an observational programme. This needs to be addressed.

ACTION: There is a lack of modelling work in the CASO proposal (compared with e.g. SASSI). The panel needs to encourage modelling proposals (Aike Beckmann, Steve Rintoul, all panel)

Several challenges exist. The main challenge is getting IPY proposals funded in their home countries; the panel is supporting these efforts by writing letters of support where work is clearly relevant to CASO goals, although ultimately the funding decisions are made by others. The organization of the IPY into clusters, while necessary, will make the coordination between related activities more difficult to manage. The Panel will have an important role to play here in the time leading up to and following the IPY.

ACTION: Steve Rintoul to send out email to all CASO Expressions of Interests (EOIs) to obtain details of their plans etc. before final submission to the IPY committee (Steve Rintoul, rest of panel)

ACTION: The need was identified to have a page like the Southern Ocean Observations page showing IPY activities. Details of these activities should be forwarded to Mike Sparrow (Mike Sparrow, plus SO community)

The point was also made that some EOIs should be in several clusters, e.g. could be in both SASSI and CASO. This should also encourage communication between the clusters.

Post-meeting note: With respect to this action item, the new CASO website can bee seen at: http://www.clivar.org/organization/southern/CASO/index.htm

4.2 IPY: Antarctic coasts and margins
Karen Heywood gave a presentation on SASSI (Synoptic Antarctic Shelf-Slope Interactions Study), which was chosen as the lead IPY project for Antarctic coasts and margins.

The SASSI areas of interest include:

- Antarctic continental shelf and slope to the abyss
- Circumpolar locations, as many as possible logistically
- Coastal polynyas
- Both narrow and wide shelves and slopes
- Under ice shelves and sea ice

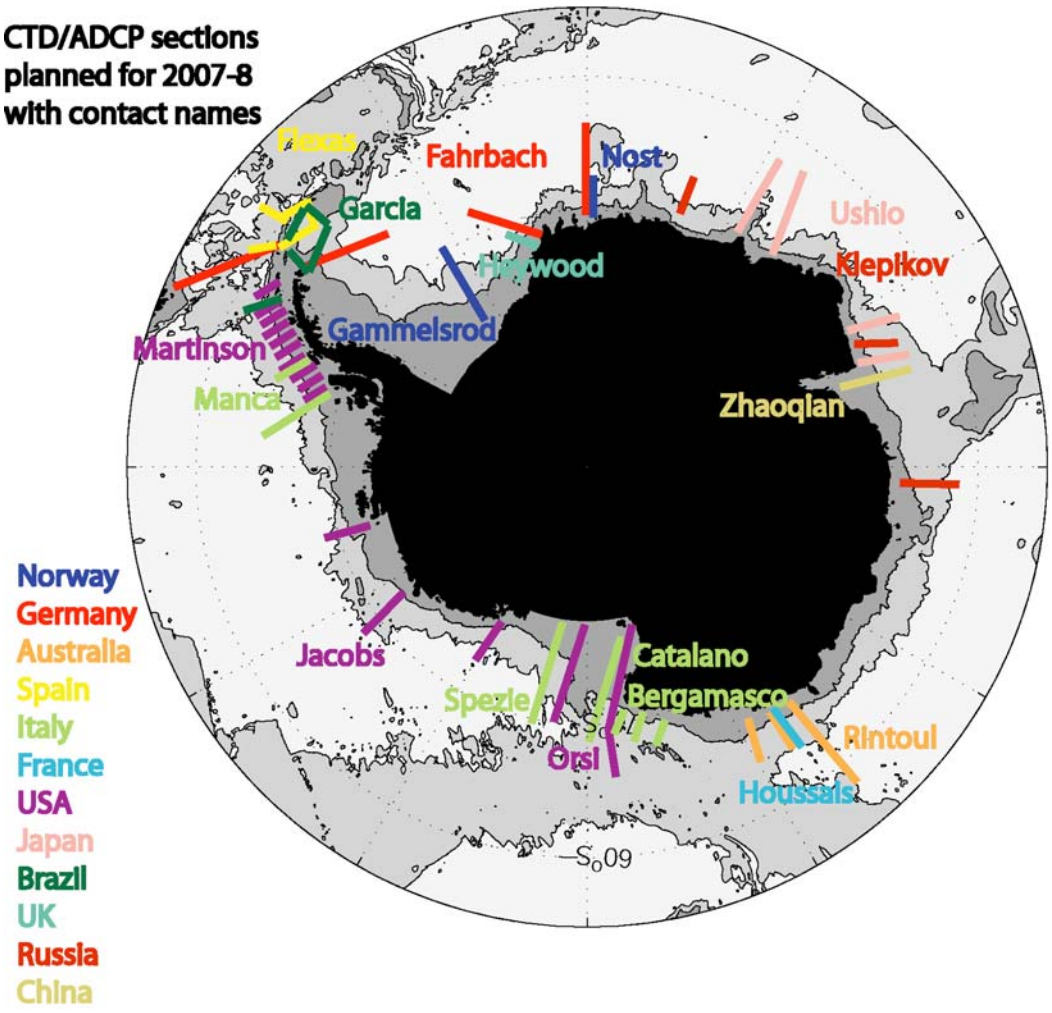

Figure 2 SASSI synoptic transects (planned as of 22/11/05). See http://www.uea.ac.uk/~e280/sassi.html for updates

SASSI will consist of short synoptic transects radiating outwards across the Antarctic continental shelf and slope (see Figure 2) and a number of mooring arrays. There will also be remote sensing and modelling studies and deployment of floats. There are obvious areas of overlap with CASO and so the two umbrella projects will be working closely together. A SASSI planning workshop and iAnZone biennial meeting was held on Sunday 9th October 2005, in Venice. For further details see http://www.uea.ac.uk/~e280/sassi.html

4.3 IPY: Meteorology and air-sea interaction

John Turner gave a presentation on Antarctica and the Global Climate System (AGCS) and IPY. AGCS is split in to several themes:

Theme 1 – Decadal Time Scale Variability e.g. ENSO links with West Antarctic mass balance

Theme 2 – Global and regional signals in ice cores. Extensive use will be made of meteorological re-analysis fields and the output of climate model runs

Theme 3 – Natural and anthropogenic forcing on the Antarctic climate system e.g. using models to predict temperature changes into the next century based on various greenhouse gas scenarios

Theme 4 - The Export of Antarctic Climate Signals. Strong focus on Antarctic Bottom Water, plus other water masses such as intermediate and mode water

AGCS will use IPY as a Special Observing Period to investigate:

- Low-high latitude teleconnections

- The routes by which extra-polar climate signals reach the ice core sites
- The quality of analyses
- Future data requirements
- The quality of satellite-derived products e.g. sea ice concentrations
- Model simulations of high latitude processes

4.4. IPY: Sea ice, shelf ice and icebergs

Eberhard Fahrbach discussed the processes that must be addressed to better understand the interaction of the cryosphere and the Southern Ocean:

- Shelf ice: Near "shore" fresh water input and water mass transformation
- Icebergs: Distant fresh water input and event-like fresh water input
- Sea ice: Differential freshwater removal or input; modification of exchanges with the atmosphere of heat, momentum and gases; and modification of radiation budget (albedo)

He then went through the different EOIs and concluded that for:

Shelf ice studies –

- The fresh water import from the land is relatively well covered
- Ice-ocean interaction studies are focussed on the Antarctic Peninsula and Fimbul Ice Shelf. Both locations are areas where ice shelves are subject to rather warm ocean temperatures. Do we know enough, about the 'normal' ice shelves from past studies?

Icebergs-

- Studies are focussed on formation processes and drift pattern. Modelling is progressing well

Sea ice-

- Extensive *in-situ* sea ice programmes are planned. However it is not certain to what extent they will be realized. Remote sensing programmes are in much better shape, but sea ice thickness is still a problem (see below)

Seymour Laxon then gave a presentation on Southern Ocean ice thickness from space. He concluded that:

- Satellite radar altimetry has the potential to provide data on Antarctic ice thickness
- Combining Radar and Laser data has the potential to significantly reduce uncertainties in snow loading
- There remains a critical need for timely and well understood calibration data
- IPY may provide a valuable opportunity to gather both in-situ and airborne data

5. Sustained observations, Antarctic/Southern Ocean reanalysis and interaction with OOPC/GSOP

Kevin Speer talked both on sustained observations and interaction with OOPC/GSOP and on Antarctic/Southern Ocean reanalysis.

The Southern Ocean climate system includes ocean and ice-covered regions, with both free and fast sea-ice as well as ice shelves extending into the ocean. Important processes overlap with the interests of other scientific organizations and for this reason the CLIVAR Southern Ocean panel is joint with CliC and SCAR, and advises all three SSGs. A further consideration is the approaching International Polar Year. Numerous parties are preparing plans to supplement the observing system or install new elements.

Key climate research questions that will be investigated by sustained observations in the Southern Ocean include:

- ACC transport variation, relation to the Antarctic Oscillation (AAO)/Southern Annular Mode (SAM) and other patterns, and the transmission of anomalies between oceans
- Vertical structure of heat and fresh-water anomalies and transport processes in the ocean
- Dense water formation and the transmission of climate signals by boundary currents
- Ice shelf stability and the heat and fresh-water balance of the ocean-ice system
- The role of the Southern Ocean and ice system in setting the ocean's background state and mean ocean-atmosphere-ice seasonal cycle
- Intrinsic variability and teleconnections of the Antarctic Oscillation, Pacific-South-American Anomaly (PSA 1&2), the Antarctic Dipole, and Antarctic Circumpolar Wave
- Coupled response of atmosphere, ocean, and ice to low-latitude ENSO and other variability
- Carbon uptake, biogeochemistry, and the CO_2 feedback
- Support of process studies and model development

Summary of the Adequacy and Evolution of the Observing System

Required enhancements:

i) Sea-ice

- Extension of profiling floats to sea-ice zone, with positioning
- Sea-ice thickness (echo sounders) and meteorological buoys in the sea-ice zone for sea-ice dynamics

ii) Surface Meteorology

- Enhance IMET coverage. *In situ* sampling of the diurnal cycle of SST and wind will help with interpretation of sun synchronous satellite observations
- Meteorological buoys in the seasonal sea-ice zone (Tair, wind…)
- AWS on subantarctic islands
- Surface Time-series stations in SE Indian (high mean wind conditions) and Pacific (synoptic variability) sectors. Some technological buoy development required
- Air-sea fluxes, such as SEAFLUX project

iii) Drifters

- ARGO spatial coverage in areas opening up from initial deployment
- Surface drifters – enhance coverage following Reynolds scheme

iv) Transport Arrays

- Coherent circumpolar array in Weddell outflow/Ross outflow/Princess Elizabeth Trough/Adelie

v) XBTs

- Retain high sampling rates or improve sampling rates

ACTION: It would be useful to the panel to have an update on the status of the IPAB buoys (Mike Sparrow)

Special opportunities – International Polar Year 07/08

An overarching theme is freshwater fluxes between air-sea-ice components. The implementation of the following observing systems is recommended as the highest priority, and agrees with IPY guiding themes.

- Observations in the sea-ice zone: profiling floats and Met buoys
- Air-sea flux improvements via IMET, time-series stations
- Simultaneous transport arrays to reveal internal modes of ocean variability, synoptic sections

Data management

Data management is an area in which CLIVAR still needs to focus its efforts. As far as ocean data goes, CLIVAR has a number of Data Assembly Centres (the previous WOCE DACS plus a few new ones) to manage specific data streams. Links to these DACs and details of their responsibilities can be found at: http://www.clivar.org/data/. There are no specifically Southern Ocean data centres

or archives under CLIVAR, although the CLIVAR IPO keeps track of hydrographic cruises at: http://www.clivar.org/carbon_hydro/hydro_table.php, and of other elements of the Southern Ocean observing system at:
http://www.clivar.org/organization/southern/CLIVAR_CliC_Obs.html.

A number of data management items are being worked on:

- The IPY considers data management to be a high priority. Although the DACS are good for storing data it might well be that some sort of Data Information Centres are needed, especially for the amalgamation of contributions to the sustained system from various programs, e.g. iAnZone, and to a certain extent IPY

- The data from the Japanese Antarctic Research Expeditions (till March 2001) were submitted to J-DOSS, and are freely available online at http://www.jodc.go.jp/service.htm. Other countries have made similar steps to data availability

Antarctic/Southern Ocean reanalysis
A recurring question for CLIVAR researchers is the quality of the atmospheric reanalysis fields, especially the surface fluxes, over the Southern Ocean, and the means to improve them. It is important to ensure that additional data are assimilated. Some steps have been made by the reanalysis centres but systematic comparisons between the products and the data are still few, and their impact is unclear given the centres' focus.

We recommend that a focused effort be undertaken to produce an Antarctic reanalysis, encompassing the Southern Ocean. A high-resolution regional atmospheric model might be the basis to initiate such an effort, including, for example, the ability to represent katabatic winds. High-resolution forward atmospheric and oceanic models are in use, and are starting to be coupled. Progress in assessing climate models will require close comparisons and links with Southern Ocean observations, and these are not satisfactory for the present reanalysis programs.

Ongoing analysis work includes the Antarctic Mesoscale prediction System program at NCAR, based on the Byrd Polar Research Institute's implementation of MM5. The reanalysis matter will probably be a key component of the SCAR AGCS.

ACTION: The panel recommends a focused effort to produce an Antarctic reanalysis, encompassing the SO. Chairs should write to SCAR/AGCS/David Bromwich (Ian Renfrew, Kevin Speer)

ACTION (carried over from previous meeting): The panel should review the white paper for proposed time series sites etc – perhaps after new membership has been drafted in (panel, for future)

6. CLIVAR/CCHDO hydrographic and carbon data management
Steve Diggs gave a presentation on the CLIVAR/Carbon Hydrographic Data Office (CCHDO).

The CCHDO locates, collects, inspects, modifies to improve adherence to standards, organizes, and makes available the CTD, hydrographic, tracer, and ocean carbon data and associated documentation relevant to studies of the large-scale circulation and water masses of the World Ocean.

After WOCE ended, the WOCE Hydrographic Program Office (WHPO) became the CLIVAR and Carbon Hydrographic Data Office (CCHDO). More than just a name change, the office has broadened its focus to include all high quality hydrographic data and metadata relevant to climate

variability. In addition, the CCHDO is in the process of reworking its entire system to include a "cruise-centric" view of hydrography and fast data access in easy-to-use formats. New strategic alliances with organizations such as the Carbon Dioxide Information Analysis Centre (CDIAC) will increase the quality control of the datasets while preventing duplication of effort in the analysis and dissemination processes.

Although the CCHDO's basic functions are an essential component of CLIVAR, it is also recognised that now is the time to take a closer look at the status of data flow and management within the CLIVAR system. The amount of program-related data coming through the system does not seem be increasing, despite advancements in computer science, networks and hardware. The conclusion is that the most important aspect of data management is close cooperation of all of the institutions and individuals participating in the program. Only through such coordinated efforts will we be able to produce a high-quality data system so essential for researching global climate variability.

7. Southern Ocean Argo data system

Unfortunately Rebecca McCreadie was unable to attend the meeting, but Brian King stepped in at the last moment to give her presentation. The panel has reiterated the importance of Argo in the data sparse Southern Ocean region in all it's meetings, therefore it was felt that it would be useful to learn about the new Southern Ocean Argo data system during the discussion on CLIVAR data.

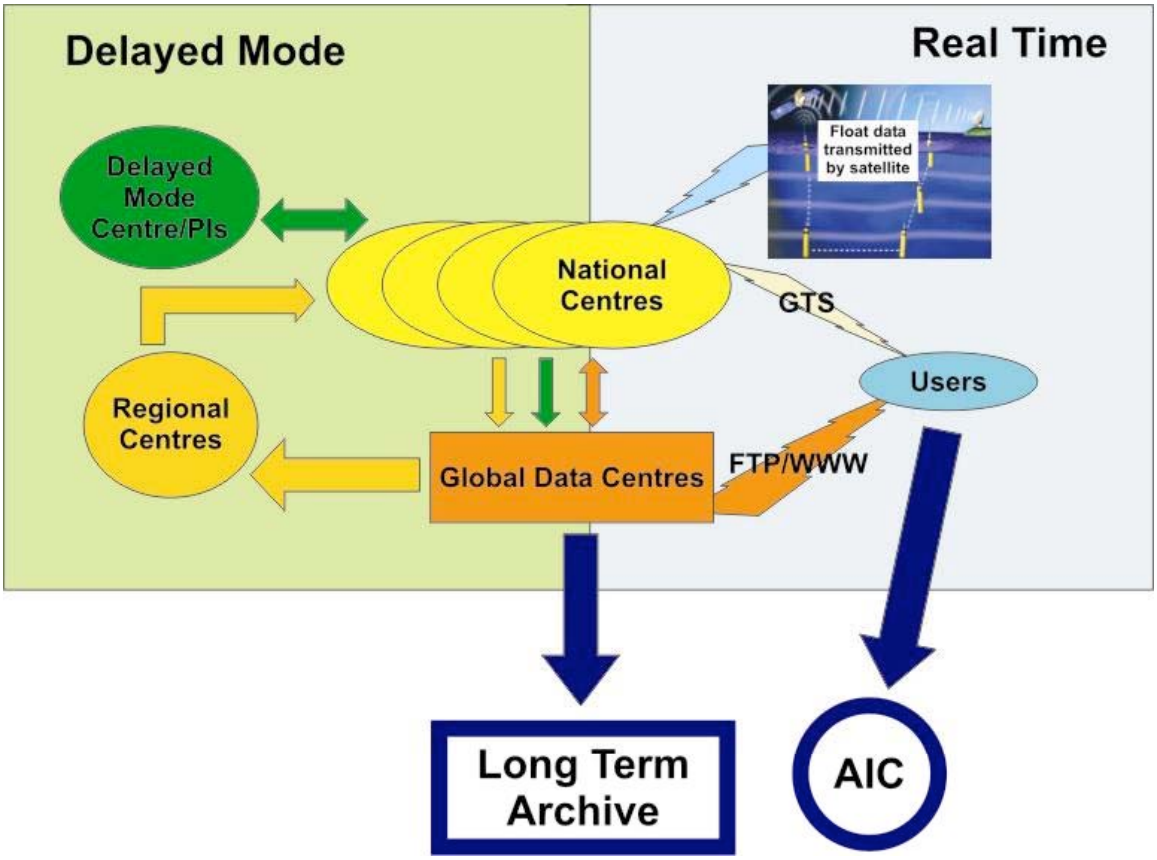

Figure 3: Argo data flow

In the Southern Ocean the regional data assembly centres (RDACs) operate in the Atlantic Ocean Sector (BODC 70°W – 90°E) and the Indian Ocean Sector (CSIRO 90°E – 180°E; BODC remainder). As yet there is no RDAC for the Pacific Ocean Sector.

The RDACs:
- Perform regional analysis of all Argo data in the region
- Provide feedback via national DACs to PIs
- Develop a regional historical data set
- Prepare and distribute Argo data products
- Prepare and distribute documentation on the RDAC activities

The RDACS provide products such as output from the Argo assimilating UK Met Office FOAM model (monthly at 5m and 995.5 m giving potential temperature, salinity and velocity - http://www.metoffice.com/research/ncof/foam/index.html) and the current status of the array. They are working on future products such as maps of all historical data available with age indication, temperature and salinity contour plots at set depths etc.

In order to perform quality control on the float data it is essential that the RDACs have access to CTD data as soon as they are collected (i.e. even before final quality control etc. has been done). The panel strongly encourages PIs to submit their data to the RDACs when contacted (they will not be made publicly available).

8. Interaction with the paleoclimate community

Flip Froelich presented progress on the Geotraces Project. The International Geotraces Project began as an outgrowth of marine geochemists' desire to extend the legacy of the GEOSECS program of the 1970's - to expand our knowledge of the biogeochemistry and chemical cycles of trace elements and isotopes (TEI's) that were impossible to measure in the ocean thirty years ago. Geosecs (Geochemical Ocean Sections) led directly to important breakthroughs in understanding ocean circulation using geochemical tracers, plus the broader cycles of carbon, nutrients and a few trace elements. By demonstrating the power of ocean tracers, GEOSECS was the grandfather of projects such as TTO, WOCE, and JGOFS.

The advent of new analytical technologies to measure vanishingly small concentrations of trace elements and their isotopic signatures, plus clean ocean sampling techniques to provide faithful samples for measurement, provides a timely opportunity to describe the global distributions of the biologically-important trace elements, their isotopic signatures, and the processes controlling their distributions. The importance of many TEI's as tracers of oceanic processes, as co-factors for critical biological processes, and also as monitors for operation of the carbon cycle, is now well accepted. Yet for many TEI's our knowledge of their first-order oceanic distributions and the processes controlling these distributions is virtually non-existent. To develop the full power to utilize these new generation biogeochemical TEI distributions to infer past and future changes in ocean biogeochemical processes and oceanic health requires a global assessment of the current patterns.

The primary motivations for Geotraces are thus to:
- determine the role of micronutrients in ocean biogeochemistry (N, P, Si, Fe, Zn, Mo, Cd….)
- establish the impact of these trace elements on the carbon cycle and on rates of carbon cycle processes
- develop new tracers of ocean processes – vertical and horizontal mixing, benthic boundaries, submarine groundwater inputs, mineral dust infalls, etc.

- establish the transport and fate of both trace micronutrients (iron) and toxic agents (lead, mercury) to the ocean, especially via the atmosphere
- establish ground-truth proxies of past ocean environments and the ocean's response to global change in order to correctly assess its future health

Preparations are currently in the planning stages, with the program expected to participate in the International Polar Year during 2007-2009. Core activities during 2008-2013 will involve 12-15 ocean sections chosen to address the maximum number of processes run by various countries but with international representation, plus preparations for initiation of several process studies. Final ocean sections plus parallel and follow-up process studies through 2018 will focus on estuaries, shelf processes, the distal northern and southern limbs of the meridional overturning circulations, submarine groundwater fluxes, etc., generally tied to the ends of ocean sections. The program is designed to rely on and coordinate with important global scale programs such as SOLAS, CLIVAR, IMBER, IPY, LOICZ, ORION/GOOS and IMAGES/PAGES.

Geotraces is currently sponsored by SCOR and various national funding agencies. The members of the international planning group, the July 2005 science plan draft, and additional information is available on the Geotraces website: http://www.ldeo.columbia.edu/res/pi/geotraces/ (also accessible via www.geotraces.org). Co-chairs of the planning group are Bob Anderson (US - Lamont) and Gideon Henderson (UK - Oxford).

9. Status of carbon and biogeochemistry programmes and implications for the panel

Mario Hoppema attended the panel meeting to update the panel on Carbon related activities. The International Ocean Carbon Coordination Project (IOCCP), which is the main coordination body for the international carbon community, now has a broader mandate, i.e. for the whole ocean carbon cycle, instead of just for CO_2. A scientific Steering Group with chair Chris Sabine, has been installed. At the 2nd IOCCP Workshop in Tsukuba, Japan international agreement was reached on the format of pCO_2 metadata, data file reporting and recommended practices for data exchange/integration. In May 2004 and December 2004 stakeholders' meetings took place where the group recognized two types of needed coordination activities: 1) meeting research program goals, 2) development of global ocean observing system. At 14-17 November 2005 the IOCCP-CLIVAR International Repeat Hydrography Workshop will be organized in Mutsu, Japan.

SOLAS and IMBER, the two international research programs in charge of ocean carbon, installed a working group (-> SOBER), which is working on a joint implementation plan. It will comprise issues like carbon transformation in the surface ocean and in the mesopelagic layer, as well as spatial and temporal variability in CO_2 fluxes. Envisaged tools are to develop automated instruments and use of manipulative meso-scale experiments, and assimilation models. Next autumn the first meeting will take place, coordinated by IOCCP.

There is a new US carbon program (Ocean Carbon and Climate Change; OCCC), which will handle all US ocean carbon work. Also work underway in the US, such as the CLIVAR CO_2 repeat hydrography, now falls under OCCC. The SSC is chaired by Scott Doney, while Chris Sabine is one of the members. Although the implementation is first focused on the North Atlantic and North Pacific, there will be new Southern Ocean studies in the near future. An air-sea gas exchange experiment is planned possibly in the Southern Ocean and there will be Southern Ocean pilot studies. US CLIVAR CO_2 repeat hydrography completed two Southern Ocean studies in 2005 (P16S and A16S). S4P is scheduled for 2007, but it is apparently hard to find a convenient ship.

CarboOcean is an integrated Project of the EU, which consists of 47 participating groups, including associated collaborators from the USA. It started this year and is funded with € 14.5 M for 5 years. Its goal is to accurately assess the marine carbon sources and sinks, where the focus is on the

Atlantic and Southern Oceans. Both observational and modelling work will be done. Key European experts and scientific resources are part of the project. The consortium management is based in Bergen, Norway, with Christoph Heinze being coordinator. The first CarboOcean cruises have been completed in 2005.

10. Membership

Table 1 shows the membership at the time of the meeting. Three new members (including a new co-chair) had been appointed between meetings. Seven other members were rotating off. Table 2 gives the new membership as of the end of November 2005.

Name	**Affiliation**
S. Rintoul - co-chair	CSIRO, Hobart, Australia
I. Renfrew - co-chair	University of East Anglia, Norwich, UK
S. Aoki	National Institute for Polar Research, Tokyo, Japan
I. Allison	Antarctic CRC, Hobart, Australia
A. Beckmann	University of Helsinki, Helsinki, Finland
S. Cunningham	Southampton Oceanography Centre, Southampton, UK
E. Fahrbach	Alfred-Wegener Institut für Polar und Meeresforschung, Bremerhaven, Germany
P. Froelich	Florida State University, Talahassee, USA
A. Gordon	Lamont Doherty Earth Observatory, Palisades, USA
D. Martinson	Lamont Doherty Earth Observatory, Palisades, USA
R. Morrow	LEGOS, Toulouse, France
C. Sabine	NOAA/PMEL, Seattle, USA
K. Speer	Florida State University, Talahassee, USA
K. Heywood (ex-officio)	University of East Anglia, Norwich, UK

Table 1: Membership as of end June 2005

Name	**Affiliation**
Ian Renfrew - co-chair	University of East Anglia, Norwich, UK
Kevin Speer - co-chair	Florida State University, Talahassee, USA
Aike Beckmann	University of Helsinki, Helsinki, Finland
Yasushi Fukumachi	Hokkaido University, Sapporo, Japan
Hugues Goosse	Université catholique de Louvain, Louvain-la-Neuve, Belgium
Niki Gruber	University of California, Los Angeles, USA
Christian Hass	Alfred-Wegener Institute, Bremerhaven, Germany
Doug Martinson	Lamont Doherty Earth Observatory, Palisades, USA
Alberto Naveira Garabato	National Oceanography Centre, Southampton, UK
Steve Rintoul	CSIRO, Hobart, Australia
Sabrina Speich	University of Bretagne Occidentale, Brest, France
Dave Thompson	Colorado State University, Fort Collins, USA
Michiel van den Broeke	Utrecht University, Utrecht, Netherlands
Ex-Officio members:	
Eberhard Fahrbach	Alfred-Wegener Institute, Bremerhaven, Germany
Alex Orsi	Texas A&M University, College Station, USA

Table 2: New membership as of November 2005

11. Discussion: How can the panel become more effective and relevant?
It is often difficult to measure how successful a panel is being, especially when the panel's remit is (necessarily) so wide. Many activities might have occurred without the panel's input, but in some cases the Panel has clearly taken the lead (e.g. with CASO and the IPY).

To date the Panel has been quite ocean-focussed. While this was appropriate at the start of CLIVAR, when much of the implementation work involved oceanographic fieldwork, it is now clear that the important open questions require a more complete synthesis of ocean, atmosphere and cryosphere science. The Modes of Variability workshop organized by the Panel as part of this meeting was a first step in this direction. It was also decided to take advantage of a number of vacancies created by people rotating off the Panel to include a broader mix of expertise.

During discussion, a suggestion was made that the panel could become more active in actually carrying out scientific analyses, rather than simply advise that they be done. The issue will be discussed further with the new panel membership (see Section 10).

12. Next Meeting
The venue for the next meeting was left open. South America was again suggested, particularly Buenos Aires, with autumn 2006 being the likely date.

Appendix 1. Southern Ocean panel meeting attendees

Aoki	Shigeru	<shigeru@hassaku.lowtem.hokudai.ac.jp>	National Institute for Polar Research, Japan
Beckmann	Aike	<aike.beckmann@helsinki.fi>	University of Helsinki, Finland
Bellerby	Richard	< richard.bellerby@bjerknes.uib.no>	University of Bergen, Norway
Bergamasco	Andrea	< andrea.bergamasco@ismar.cnr.it>	CNR_Istituto di Scienze Marine, Venice Italy
Bromwich	David	<Bromwich@polarmet1.mps.ohio-state.edu>	Ohio State University, USA
Budillon	Giorgio	<giorgio.budillon@uniparthenope.it>	università degli studi di napoli "parthenope", Italy
Caltabiano	Antonio	<caetano@noc.soton.ac.uk>	ICPO, NOCs, Southampon UK
Diggs	Steve	<sdiggs@ucsd.edu>	Scripps Institution of Oceanography, La Jolla, USA
Drinkwater	Mark	<Mark.Drinkwater@esa.int>	ESTEC Earth Sciences Div. The Netherlands
Fahrbach	Eberhard	<efahrbach@awi-bremerhaven.de>	Alfred-Wegener-Institut, Germany
Froelich	Flip	<froelich@magnet.fsu.edu>	Florida State University, USA
Garcia	Carlos	<dfsgar@furg.br>	Fundagco Universidade Federal do Rio Grande, Brazil
Gomis	Damià	<damia.gomis@uib.es>	IMEDEA, Spain
Harangozo	Steve	<sah@bas.ac.uk>	British Antarctic Survey, Cambridge
Heywood	Karen	<K.Heywood@uea.ac.uk>	University of East Anglia, UK
Hoppema	Mario	<mhoppema@awi-bremerhaven.de>	Alfred-Wegener-Institut, Germany
King	John	<JCKI@bas.ac.uk>	British Antarctic Survey, Cambridge
King	Brian	<bak@noc.soton.ac.uk>	NOCS, Southampton UK
Laxon	Seymour	< swl@cpom.ucl.ac.uk>	University College London, UK
Leach	Harry	<leach@liverpool.ac.uk>	University of Liverpool, UK
Lefebvre	Wouter	<lefebvre@astr.ucl.ac.be>	Université catholique de Louvain, Belgium
Lettmann	Karsten	<klettmann@awi-bremerhaven.de>	Alfred-Wegener-Institut, Germany
Lovenduski	Nicole	<nikki@atmos.ucla.edu>	University of California, Los Angeles, USA
Martinson	Doug	<dgm@ldeo.columbia.edu>	University of Columbia, USA
Mata	Mauricio	<mauricio.mata@furg.br>	FURG, Brazil
Mayewski	Paul	<Paul.Mayewski@maine.edu>	University of Maine, USA

Meredith	Mike	<mmm@bas.ac.uk>	British Antarctic Survey, Cambridge
Miles	Georgina	<GMIL@bas.ac.uk>	British Antarctic Survey, Cambridge
Morrow	Rosemary	<rosemary.morrow@cnes.fr>	CNES, Toulouse, France
Naveira	Alberto	<a.naveira-garabato@uea.ac.uk>	University of East Anglia, UK
O Farrell	Siobhan	<Siobhan.O'Farrell@csiro.au>	CSIRO, Australia
Olbers	Dirk	<dolbers@awi-bremerhaven.de>	Alfred-Wegener-Institut, Germany
Orsi	Alex	<aorsi@tamu.edu>	Texas A&M University, USA
Osterhus	Svein	<Svein.Osterhus@gfi.uib.no>	University of Bergen, Norway
Renfrew	Ian	< i.renfrew@uea.ac.uk>	University of East Anglia, UK
Rintoul	Steve	<Steve.Rintoul@csiro.au>	CSIRO, Australia
Sparrow	Mike	<m.sparrow@noc.soton.ac.uk>	ICPO, NOCS, Southampton UK
Speer	Kevin	<kspeer@ocean.fsu.edu>	Florida State University, USA
Stoessel	Achim	<achim@ocean.tamu.edu>	Texas A&M University, USA
Summerhayes	Colin	<cps32@cam.ac.uk>	Scott Polar Research Institute, Cambridge, UK
Turner	John	<jtu@bas.ac.uk>	British Antarctic Survey, Cambridge
Van den Broeke	Michiel	<m.r.vandenbroeke@phys.uu.nl>	Utrecht University, The Netherlands
Wainer	Ilana	<wainer@usp.br>	Universidade de Sao Paulo, Brazil
Wallace	Mags	<miwa@bas.ac.uk>	British Antarctic Survey, Cambridge
Yuan	Xiaojun	<xyuan@ldeo.columbia.edu>	University of Columbia, USA

Appendix 2. Initial meeting agenda

Monday 27th- Tuesday 28th June: Modes of Southern Hemisphere Climate Variability Workshop
See part 1 of this joint report.

Wednesday 29th June: IPY implementation
Open session from morning to mid-afternoon, joint with SCAR-AGCS and SCAR/SCOR Expert group and others interested

Status of IPY planning

9:00 9:30	Introduction/Aims : *S. Rintoul, E. Fahrbach, C. Summerhayes*
9:30 10.05	Antarctic ocean circulation: *S. Rintoul*
10:05 10:40	Antarctic coasts and margins: *K. Heywood*
10:40 11:00	tea
11:00 11:35	Meteorology and air-sea interaction: *J. Turner, D. Bromwich*
11:35 12:00	Sea ice, shelf ice, icebergs: *E. Fahrbach, S. Lexon*
12:00 13:00	Discussion: What is missing? Strategy to fill gaps?
13:00 14:00	Lunch
14:00 15:20	IPY implementation: - Role of Southern Ocean implementation panel, and relationship to other panels - Action items to facilitate implementation; identify individuals to take responsibility for particular topics - Future of CASO and known projects under this umbrella.
15:20 15:40	tea
15:40 1700	Follow-up to modes of variability workshop: what are the implications for plans for the IPY (will proposed IPY activities address modes of variability?) and more generally for the panel's work (will CLIVAR/CliC/SCAR plans address modes of variability and southern hemisphere predictability?).

Thursday 30th June: Panel Business

9:00 9:10	Introduction *S. Rintoul, I. Renfrew*
9:10 9:40	Sustained observations and interaction with OOPC/GSOP *K. Speer*
9:40 10:10	CLIVAR/CCHDC hydrographic and carbon data management *S. Diggs*
10:10 10:40	Southern Ocean Argo data system *R. McCreadie*
10:40 11:00	Tea/Coffee
11:00 11:30	Interaction with paleoclimate community *P. Froelich*
11:30 12:00	Status of carbon and biogeochemistry programs and implications for panel *M. Hoppema*

12:00 12:30	Antarctic/Southern Ocean reanalysis *K.Speer*
12:30 13:00	Agreement on work plan and assignment of lead contacts for IPY activities *S. Rintoul to lead*
13:00 14:00	Lunch

Panel members only

14:00 14:30	Review of action items
14:30 14:50	Membership
14:50 15:20	Discussion: How can the panel become more effective and relevant?
15:20 15:30	Next meeting
15:30 15:40	Close

Appendix 3. Action items from previous meeting

Action items were grouped into the following categories:

1. Progress in implementation
2. Cross panel and project cooperation
3. Regional integration
4. Carbon issues
5. Data issues
6. International Polar Year
7. Other relevant issues

1. Progress in implementation

1:1. A white paper on sustained observations and process studies needed in the Sea Ice Zone to be completed. Arnold Gordon to coordinate contributions *(Arnold Gordon and others).*

This has been superceded to a large extend by CASO/ SASSI and the other Southern Ocean IPY projects.

1:2. Several countries are now carrying out sections across the Drake Passage. It would be useful to have this work summarised *(Stuart Cunningham)*

Done. The document can be downloaded from the panel's website: http://www.clivar.org/organization/southern/index.htm

2. Cross panel and project cooperation

2:1. Panel to produce a list of climate indices based on Southern Ocean phenomena for the OOPC. Of particular interest are indices that rely on *in situ* observations, to help demonstrate their value. *(Various, coordinated by Kevin Speer).*

This has been carried across to this meeting's action items (and, in fact, has now been done)

2:2. At the request of the OOPC, the Panel is to produce a white paper for time series sites in the Southern Ocean, including science justification, summary of funded and proposed work, and rationale for oceanographic use of observatories deployed by other programs (e.g. DEOS sites). *(Initial draft from Steve Rintoul, subtropical; Rosemary Morrow, Kerguelen; Kevin Speer, SE Pacific; comments and input from panel)*

Panel gave input to e.g. Uta Neumann about the OCEANSites time series sites. In many ways this is an ongoing action item as there are still time series sites that require champions.

3. Regional integration

3:1. There was concern from the panel that the newly formed Indian Ocean panel should be able to cover circulation issues in mid latitudes, CO_2 issues etc. The panel recommend appointing someone to the panel who has an interest in these matters *(Chairs to write to SSG and Gary Meyers)*

This action item is no longer relevant. The IOP has been formed and has oceanographic representation (in fact Mike Sparrow attended part of their last meeting and they had a lot of oceanographic representation in the form of invited experts). Mike will be looking after this panel from October 2005.

4. Carbon issues

4:1. No standards or protocols have been specified for carbon measurements conducted on CLIVAR cruises. The panel suggests that the International Ocean Carbon Coordination Project (IOCCP) prepare recommendations to be circulated among the CLIVAR basin panels and SSG and distributed to PI's. *(Chris Sabine)*

Chris has been working on this & Mario gave an update at his meeting (see Section 9)

4:2. The panel identified a need for more international coordination of carbon measurements (e.g. carbon groups were not always aware of cruise opportunities where collaboration might fill gaps in the global array of carbon measurements). The panel recommends that individual PIs and national reps let Katy Hill (who is the CLIVAR Carbon staffer) (klh@soc.soton.ac.uk) and Maria Hood (m.hood@unesco.org) know of their plans. (*Mike Sparrow, Katy Hill)*

Continuous action required. Note Nico (nico@noc.soton.ac.uk) has now taken on Katy's responsibilities.

4:3. Chris Sabine to contact Nicolas Metzl about the possibility of including deep carbon stations on some OISO cruises. *(Chris Sabine)*

Chris Sabine sent off an email to Nicolas. His reply is as followed:

Dear Chris,

After some weeks (months ?) I reply to your question concerning the reoccupation of a CLIVAR section in the south western Indian Ocean. Unfortunately, such project is clearly not manageable in France for a near future. I understand this should be a high priority (and it is) but other french projects are also High Priority since years in our domain as part of Clivar and now Solas. Some of these projects, although very attractive, are still not in the line (I can't list these projects here, but as I am involved in Clivar-France committee I know very well the status of the priorities). Since 1998, I am mostly interested with interannual variability and decadal trends (and how these changes are connected to external and internal forcing terms). So I am trying to push on performing regular transects in the south-western (OISO project); in addition of continuous surface and discrete measurements we are conducting hydrocast, attempting to reoccupy the stations at different season and years. This project is feasible because it does not cost ship-time (during logistics around islands) and we are few persons onboard. So the ratio quality/money is performant. At present I can only offer to the international community low resolution stations (mostly 0-1000m; sometime 0-2000 when ARGO floats are launched; three full depth stations one in the SBT, two in the S.O.). For full-depth high resolution, we have to wait better years. Note that in our project, sampling is limited to pCO2,DIC,TA, C13, O18, and other classical properties plus some bio. We don't measure CFCs neither C14. Sorry for not being positive.

4:4. Chairs to write to US funding agencies iterating the importance of Carbon measurements in the Southern Ocean *(chairs and Chris Sabine)*

Done.

5. Data issues

5:1. Check that Southern Ocean XBT data collected regularly by several nations (e.g. China, Japan) is being submitted to data centres. *(Shigeru Aoki)*

The data from the Japanese Antarctic Research Expeditions (till March 2001) were submitted to J-DOSS (the online data management system of the JODC) on 2004/01/13. It is freely available online at http://www.jodc.go.jp/service.htm.

5:2. Panel to enquire how much of the SO TSG data is being submitted to the Coriolis data centre *(national reps headed by Rosemary Morrow).*

Rosemary has contacted Coriolis data centre.

5:3. Need to ensure integration of CLIVAR and CliC data systems, in particular to ensure easy access to integrated data sets by users. Stuart Cunningham to coordinate with CLIVAR

and CliC data management efforts. Stuart and Shigeru Aoki to draft recommendations for the CLIVAR data management system and contribute to the planned workshop. *(Stuart Cunningham and Shigeru Aoki)*

Note that the workshop has now taken place. Continuous action required.

6. International Polar Year

6:1. The International Polar Year. The panel will submit a statement of intent with suggestions for a focus for the IPY. *(coordinated by Steve Rintoul).*

Done – CASO-oceans, see Section 4.1

7. Other relevant issues

7:1. Add relevant links and text to SO panel web site to underscore importance of carbon, paleo-oceanography, atmospheric circulation and modelling (areas with insufficient attention in original implementation plan). *(Chris Sabine, Philip Froelich, Ian Simmonds, Gurvan Madec, coordinated by Mike Sparrow)*

[Chris Sabine] I am not sure where links should go, but it would be useful to add a link to the IOCCP web site (<http://ioc.unesco.org/ioccp/>http://ioc.unesco.org/ioccp/) under news. It is indirectly there with the CLIVAR/Carbon hydrographic link, but the IOCCP also deals with underway and mooring measurements that visitors might like to know about. It also might be interesting to add information to the observing system tables on whether carbon and transient tracers are a part of the various programs listed or whether there are possibilities of adding such measurements.

Another point I should bring up is that the IOCCP has decided to work with regional groups to encourage the synthesis and interpretation of large-scale data sets. We are currently working with PICES in the Pacific and CARINA (or Carbo-ocean or some melding of both) in the Atlantic. We have talked about the need to have a Southern Ocean regional group and would like to hear if the panel has any good suggestions on how to best accomplish that.

[Mike Sparrow] This can be done, but probably I need to streamline the panel's website. I will work on this.

7:2. Stuart Cunningham to circulate the South Atlantic (SACOS) meeting report to the panel when available. *(Stuart Cunningham)*

The report is now available on the panel's website.

7:3 Mike Sparrow to chase up national reports for e.g. Spain, other Latin American countries and ensure that the present reports are kept updated. *(Mike Sparrow)*

We now have additional national representatives from Spain, Finland, Chile, Brazil and Argentina, see Appendix 4.

7:4 Chairs to write a letter to SCOR endorsing iAnzone's contribution to Southern Ocean research *(chairs)*

SCAR now co-sponsor of iAnZone.

7:5. The importance of IPAB to SLP, SST measurements in the Southern Ocean should be made clear. Chairs to write to SCAR. (*Steve Rintoul, Eberhard Fahrbach and Enrico Zambianchi)*

SCAR now co-sponsor IPAB.

Appendix 4. List of SO panel national representatives

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Australia	Steve Rintoul	Steve.Rintoul@csiro.au
Belgium	Hugues Goosse	hgs@astr.ucl.ac.be
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Chile	Dante Figueroa	dfiguero@udec.cl
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Finland	Aike Beckmann	aike.beckmann@helsinki.fi
France	Sabrina Speich	speich@univ-brest.fr
Germany	Eberhard Fahrbach	efahrbach@awi-bremerhaven.de
Italy	Enrico Zambianchi	enrico.zambianchi@uninav.it
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Netherlands	Michiel van den Broeke	m.r.vandenbroeke@phys.uu.nl
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Russia	Alexander Klepikov	klep@aari.nw.ru
South Africa	Chris Reason	cjr@egs.uct.ac.za
Spain	Damià Gomis	damia.gomis@uib.es
United Kingdom	Alberto Naveira	acng@noc.soton.ac.uk
USA	Kevin Speer	kspeer@ocean.fsu.edu

Other national reps are required to act as contact points and where necessary keep the panel and community as a whole abreast of SO work in their countries. Please email m.sparrow@noc.soton.ac.uk if you are interested.

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