

5 July 2005

Implementation Plan for the SCAR Scientific Research Programme

Antarctica and the Global Climate System**Introduction**

Antarctica and the Global Climate System (AGCS) is one of the five Scientific Research Programmes (SRPs) of SCAR. These are the flagship scientific activities of the organisation and it is anticipated that they will make major advances in their areas of Antarctic science. It is intended that they will have a duration of 5-10 years and be subject to periodic review.

The Science Plan for AGCS described the scientific goals of the programme – this is available online at <http://www.scar.org/researchgroups/>. AGCS is concerned with the nature of the atmospheric and oceanic linkages between the climate of the Antarctic and the rest of the Earth system, and the mechanisms involved therein. It will make use of data extracted from ice cores, satellite observations, the output of global and regional coupled atmosphere-ocean climate models and *in-situ* meteorological, atmospheric and oceanic data.

The research will be organised into four major, closely linked themes dealing with (1) Decadal time scale variability in the Antarctic climate system, (2) Global and regional climate signals in ice cores, (3) Natural and anthropogenic forcing on the Antarctic climate system and (4) The export of Antarctic climate signals.

In this present document we provide details of how we intend to achieve the targets outlined in the Science Plan. The actual scientific activities of AGCS will be carried out by the various SCAR National Programmes, and the implementation plan has been prepared based on their input. Inevitably, because of funding issues, it is difficult to be specific about activities more than two or three years in the future, so the goals are more details in the early years of the project. The actual input from the various nations amounts to over 90 pages of text, and this provides a very comprehensive description of what will be undertaken. In this main part of the document a broad outline is presented in summary form split into the four themes of the programme. The final section provides more general material that spans the programme.

This document is based on information received from Australia, Brazil, Canada, Chile, Finland, France, Germany, Italy, New Zealand, The Netherlands, Norway, Spain, the UK, Ukraine and the USA. We encourage the other SCAR nations to submit material on how they will contribute to AGCS.

Theme 1 – Decadal time scale variability in the Antarctic climate system

This theme focuses on explaining the mechanisms responsible for variability in the Antarctic climate system on the scale of several years to a century. This is the timescale on which much of the ocean variability takes place and the changes observed in the atmospheric conditions and sea ice environment reflect the close coupling between the atmosphere and ocean in the high southern latitudes. Key targets are to understand the expression of the low frequency variability of ENSO and the Southern Annual Mode (SAM) in the Antarctic and the variability of Southern Ocean water masses, including the warming of circumpolar deep water. Sea ice extent and concentration will also be examined. The relative importance of the radiative processes in modulating the climate system will also be investigated.

The implementation description is divided into two parts, those aspects dealing with the large-scale climate modes and their impacts, and the more process oriented investigations. The Southern Annual (SAM) and the El Niño–Southern Oscillation (ENSO) are generally recognized to be the leading modes of variability affecting the Antarctic climate system. They represent forcings originating in high latitudes and the tropics, respectively. A broad-based attack will be mounted by AGCS to study the variability of these modes, their changes over time, and their linear and nonlinear interactions. Approaches include observational descriptions based on atmospheric reanalyses and targeted case studies. Reconstruction of mode behavior prior to the instrumental period will be based on shallow ice core records; this will provide a long-term perspective for comparison with behavior observed over recent decades. A wide variety of numerical models will be exploited to understand the causes of mode variability. These include global coupled atmosphere-ocean-sea ice models, regional climate models, and atmosphere-only models. Observations and models will be applied to understand the impacts of SAM and ENSO on sea ice, ocean circulation, and water mass properties. Other impacts to be explored include ozone concentrations, atmospheric chemistry more generally, and ice sheet mass balance.

Components of the Antarctic climate system to be investigated in more detail by a variety of observations and models include aerosols, aerosol interactions with clouds, generation of precipitation, and katabatic wind regime. Surface melt and permafrost conditions on land will be explored. The uptake of carbon dioxide by the Southern Ocean will be investigated. The forcing of the Antarctic circumpolar current, the role of coastal polynyas, and variability of sea ice

One outcome will be a much better understanding of the functioning of the Antarctic climate system and its links with the Earth system. It is anticipated that the changes currently being observed may be separable into those arising from longer-term natural variability and from climate change. Targeted studies include an intercomparison of the Antarctic and Southern Ocean performance of Earth system models, and an evaluation of the utility of atmospheric reanalyses for Antarctic climate studies. Improved models are likely to result from this AGCS theme. Extensive publications as well as special issues in the refereed literature are expected. The SCAR Met-READER database will be expanded to become the primary tool for study of Antarctic climate by the global climate community.

Theme 2 - Global and regional climate signals in ice cores

Ice cores provide robust records of past climate over the Antarctic and Southern Ocean at scales potentially as low as storms up to millennial scales. They capture a complex mix of local, regional, hemispheric and global signals that provide a measure of the physical (temperature, precipitation, atmospheric circulation) and chemical (major and trace chemistry, isotopes, radionuclides) components of the atmosphere. Ice core records offer a framework for investigating controls on modern climate, understanding past climate, and a past climate perspective for evaluating change in the atmosphere, biosphere, and cryosphere. In this theme several activities are envisioned.

Theme 2 is heavily dependant on the production of an array of past climate records focusing primarily on ice cores, but also including other paleoclimate proxies such as lake and marine sediment records, and glacial deposits. Current and near future ice core activities include: programs related to ITASE (International Trans Antarctic Scientific Expedition – see Fig. XX) in West Antarctica (US), and East Antarctica (Australia, Brazil, Chile, China, France, Germany, Italy, Japan, New Zealand, Norway, Russia, Sweden, UK, USA), and deep drilling activities at: Law Dome (Australia), James Ross Island (UK), Berkner Island (France), Dronning Maud Land (NL), Talos Dome (France, Italy), the southwestern Antarctic Peninsula (UK), EPICA sites (France), the Wilkes Land region (Australia), and Siple Dome and the inland WAIS site (US). These will cover a range of periods, some extending back to the Last Glacial Maximum and beyond.



The current array of ice cores will be enhanced during the IPY through additional traverse programs such as TASTE-IDEA and ITASE and deep drilling. However, there is considerable need to expand ice coring activities covering the last ~2000 years into coastal Antarctica, the Antarctic Peninsula, the sub-Antarctic islands, and southern South America. Furthermore, to provide records of past climate that can be integrated into modern climate records will require enhanced research concerning the calibration of ice cores through comparison with meteorological station data, climate reanalysis series, and historic records.

AGCS plans to examine a temporal and spatial range of paleoclimate records for purposes of understanding:

- The presence or lack of phasing of major abrupt climate change at global to hemispheric to regional scales with special emphasis on the Holocene.
- The causes of millennial to centennial to decadal scale climate variability over Antarctica and the Southern Ocean during the Holocene.
- The response of mass balance over the Antarctic ice sheet to recent and near past climate change to assess impact on sea level.
- The response of sea ice to recent and near past change in climate.
- The response of climate to changes in forcing by solar and volcanic activity and radiative gases.
- The teleconnections between Antarctica, the Southern Ocean, Southern Hemisphere continents, and the Northern Hemisphere from the lower troposphere to the stratosphere, for purposes of investigating signals related to, for example: sea ice, ENSO, SAM, PSA, ACC, and the Antarctic Dipole.
- The changes in atmospheric composition and aerosol content on Antarctic climate including impact due to human activities.

Near-term (by early 2007) products resulting from Theme 2 will include:

- Ice READER – a listing of meta-data, contact information, publications, and data series for existing ice cores as a companion to Met READER and Ocean READER.
- A workshop (10-11 July 2006 during the SCAR Hobart meeting) to investigate “Climate of the Antarctic and Southern Ocean Over the Past 2000 Years – A Perspective for Assessing Future Climate Change” resulting in a white paper or review paper addressing behaviour of temperature, precipitation, atmospheric circulation, and sea ice over the past 2000 years.
- Involvement in a workshop sponsored by AGCS dedicated to examining the quality of climate reanalyses data for purposes of better understanding the quality of climate series necessary to develop calibrated ice core proxies of past climate.
- Peer reviewed publications following on the significant number already generated through ITASE and deep drilling projects.
- Generation of new ice coring activities resulting from IPICs meetings.

Theme 3 - Natural and anthropogenic forcing on the Antarctic climate system

Theme 3 will attempt to determine if the observed climate changes that have taken place over the last 50 years in certain sectors of the Antarctic were a result of natural climate variability or because of anthropogenic factors. Predictions will also be made of how the climate of the Antarctic will evolve over the next 100 years under various greenhouse gas scenarios. We will specifically use the predictions from the new generation of high resolution regional climate models that are becoming available. The main goals will be:

- To understand past climate change in the Antarctic using models and observational data. The main focus will be on the Twentieth Century, but some studies will extend back through the Holocene, which covers approximately the last 10k years. A particular focus will be to understand the rapid changes that have taken place on the Antarctic Peninsula during the last 50 years.
- Provide the best estimate possible, and the uncertainties, on climate evolution over the continent and Southern Ocean during the next century. We will work closely with Theme 4 on determining how the oceanic environment will change over this period.
- Estimate how changes in the Antarctic ice sheet will contribute to sea level rise.
- Understand the effects of past and possible future changes in stratospheric ozone on the surface and upper atmospheric conditions across the Antarctic.

To achieve these targets it will be necessary to have high quality observational data from the stations, satellites, ocean sensors and ice cores. The-situ meteorological observational data will be held within the READER data base, with this element being known as MET-READER. New data bases and web-based interfaces will be developed to hold the oceanic data (OCEAN-READER) and ice core data (ICE-READER). Past and present greenhouse gas levels will also be measured to aid prediction of future values, taking into account feedbacks. We will also document changing nature of aerosols and gases in the Antarctic, both in the free atmosphere and via lake sediments.

There will also need to be improvements to global and regional climate models to improve the representation of high latitude climate processes, such as air-sea-ice interactions and ice shelf-ocean interactions. We will work closely with the climate modelling centres on assessing and improving the state of the art climate models used in initiatives such as IPCC. The model output to be used will come from the climate modelling centres and from models run specifically for this programme.

Outcomes will consist of predictions of near-surface temperature, Antarctic mass balance, surface mass balance, sea ice extent and thickness, and storm tracks. Estimates of the stability of the ocean thermohaline circulation, along with expected changes in water masses will also be produced.

Theme 4 – The Export of Antarctic Climate Signals.

This theme will examine the means by which climate changes in the Antarctic can influence conditions at more northerly latitudes. Since much of this influence is believed to be exerted through oceanographic processes, this theme will have a specific focus on ocean variability and change. The broad goals of this theme are:-

- To document variability in Southern Ocean water mass properties and fluxes and assess how such variability is represented in ocean and climate models. The role of changing ocean circulation will be examined, with particular emphasis on understanding the mechanisms that control the northward export of water masses into the global overturning circulation.
- To determine the role of atmospheric and cryospheric forcing and variability on water mass production, with special focus on processes close to the Antarctic continent.
- To generate understanding of the mechanisms by which oceanic climate changes at high southern latitudes can be transmitted to the global system, and the impact they can have.
- The role of sea ice processes in controlling water mass formation and variability will be investigated

There are two fundamental scientific approaches underpinning this theme. The first uses primarily observational techniques to derive and document the evolving climate in the Southern Ocean, using historical hydrographic data, cruise-based data, profiling float data and other techniques as appropriate. This is needed to establish the magnitude and spatial extent of ocean climate variability around Antarctica, so that its ultimate impact on global conditions can be ascertained. The second involves the use of oceanographic and coupled climate models to ascertain how climate variability in Antarctica and the Southern Ocean is transmitted northward, and the magnitude of the impacts that result.

Contributions from the first approach will include direct measurements of ocean ventilation processes, repeat deep hydrographic sections across the Southern Ocean, and quantification of the magnitude of the Southern Ocean meridional overturning circulation and heat fluxes. It will also include quantification and long-term monitoring of the export of deep and bottom water in the South Atlantic sector of the Southern Ocean, and an investigation of the use of ocean proxies measured on the Antarctic continental shelf as indicators of large-scale Southern Ocean variability. The processes and dynamics involved in water mass formation (including sea ice and coastal processes) will be investigated, and the role of this water mass formation in sequestering CO₂ from the atmosphere will be assessed.

The second approach will include model-based investigations of the role of different sectors of the Southern Ocean in the global thermohaline circulation on a

range of timescales. There will be modelling studies of the variability of export of specific water masses from the Southern Ocean into the different ocean basins. Coupled models will also be run to assess the impact of freshwater and saline anomalies on water mass formation around Antarctica, and the subsequent impacts on more northerly regions.

Outcomes of this theme will include better understanding of key interactions and processes occurring in the Southern Ocean of global relevance. These will be disseminated primarily through peer-reviewed literature, conference presentations and other conventional scientific means, but there will also be significant efforts to place important scientific results in the general public domain. Results will be summarised on the AGCS website, and materials made available for educational purposes. It is anticipated that some of this work could generate media interest, and information needed for balanced reporting will be provided. Underpinning the enhanced scientific understanding of this theme will be improved oceanographic datasets that will be made available to the scientific community. This theme will also generate improvements to oceanographic and coupled models needed for better skill in climate prediction.

IPY activities of AGCS

A number of the studies forming AGCS will be undertaken as contributions to IPY. These will include:

- The collection of ultra-high resolution sampling from Law Dome (Australia)
- The IPY traverse activity (TASTE) carried out as part of ITASE will result in cores from the interior East Antarctic plateau.
- The IPICs IPY activity will result in more coastal cores from the continent in general. These activities interface closely and overlap with ITASE.
- The use of IPY as a Special Observing Period to carry out an intensive investigation of the transfer of atmospheric and oceanic signals between the tropics/mid-latitude areas and Antarctica.

Overall outcomes

- Better understanding of the linkages between the Antarctic environment and the rest of the climate system
- Predictions of how the climate of the Antarctic will evolve over the next century
- Greater understanding of the reasons for past climate change
- Improvements to climate models and ice core analysis techniques

Measures of progress

- Papers in peer reviewed journals
- The creation of unique observational and model data sets
- Improvements to climate and limited area models
- Greater visibility for SCAR through use of SCAR data sets

Timescale

Major activities are planned throughout the five years of the programmes. Details are provided in the national contributions in the annex.

Outreach

- The AGCS web site will be developed to provide accessible information for scientists and the general public

- Presentations on AGCS will be made at scientific meetings. Where possible the goals and results of AGCS will be communicated to the general public
- Close liaison will be maintained with other organisations, such as SCOR, WMO, CliC, GEWEX
- AGCS data sets will be promulgated widely via international data centres and Antarctic research centres

Dr John Turner, Chief Officer, Physical Sciences SSG
5 June 2005

Appendix – Contributions from the SCAR nations**Australia**

The following contributions are expected to arise from projected Australian Antarctic Science activities over the AGCS life-span (2005-2010), however changes in national facilities, scientific organization and logistical capability may result in variations. Significant changes may be expected to accompany the Australian Government's recently announced intercontinental air-link. While this may alter some details in the shape of the science plan, it is reasonable to expect an overall contribution as described here. Note that much of the work is already firmly specified in the research plans of the Antarctic Climate and Ecosystems Cooperative Research Centre.

Form completed by (name, institute) –

Dr Tas van Ommen (Australian Antarctic Division and Antarctic Climate and Ecosystems Cooperative Research Centre)

Dr Siobhan O'Farrell (CSIRO Marine and Atmospheric Research and Antarctic Climate and Ecosystems CRC)

Theme 1 - Decadal time scale variability in the Antarctic climate system**Scientific Activities**

1. Examine underlying patterns and mechanisms for variability on timescales of several years to a century, as revealed in climate model runs. These include runs with varied resolutions and lengths, and models with different physics and forcings to explore, e.g. role of sea-ice. Variability of water masses will be a key feature of studies. The model studies will look at stability and variability of overturning circulation and use high resolution studies to explore the role of mesoscale eddies. Model runs will use local models as well as IPCC AR4 data sets.
1. Examine (from theme 2) decadal time scale variability in proxy data and compare model performance against these records.
1. Investigate secular change and shifts, notably the post 1970's climate shift seen in the Indian Ocean sector. This investigation will explore connections with shifts in other sectors and whether mechanisms are related to ENSO, or propagating anomalies of the ACW kind.
1. Detect trends and variability in Southern Ocean uptake in CO₂ due to biogeochemical processes from a combination of CO₂ and other trace gas measurements in the atmosphere, ocean pCO₂ and biochemistry, and modelling.

Implementation/methodology i.e. planned field work, modelling studies

1. Runs with CSIRO climate models (Mk3 and Mk 3.5 models for 500+ years; Mk 2 model for multimillennial) and analysis to explore decadal variability – in particular ENSO, Southern Annular Mode, and also secular shifts such as the apparent changes since the 1970s.

1. Runs with the Australian Community Ocean Model (AusCOM) with forced atmosphere to explore in particular role of sea-ice and coastal process on water mass formation.
1. Collaborative analyses of IPCC AR4 model runs.
1. Intercomparison of variability and trends from models with ice core records (links to theme 2).

Who will undertake these activities?

ACE CRC, CSIRO Marine and Atmospheric Research (with Bureau of Meteorology and AAD logistical support), AAD, University of New South Wales (Dr. Matt England), TPAC

Expected scientific outcomes/deliverables

Data sets for intercomparison and analysis; quantification of variability and trends; improved understanding of mechanisms and couplings on timescales of several years to a century.

Timescale

2005-08	Investigate mechanisms of decadal variability in CSIRO and IPCC-AR4 modelling experiments.
2006-08	Link variability to ice core records and observational data sets
2007-10	Examine variability in AusCOM ocean only runs forced by NCEP/ERA and WGOMD-CORE atmospheric data sets.

Milestones

2006-07	Paper on climate variability in CSIRO Mk2+Mk3 models in Antarctic
2007-09	Subsequent papers on analysis of variability in CSIRO models compared with other IPCC models. Also papers on variability in ocean water masses.

Theme 2 - Global and regional climate signals in ice cores

Scientific Activities

1. Reconstruct climate proxies from East Antarctic ice cores, in particular Law Dome and Wilkes Land regions. Records will cover periods from before the Last Glacial Maximum to present. Records of recent millennia will have seasonal resolution. Studies will focus on sea-ice reconstructions, ENSO and short-timescale processes, Southern Ocean and mid-latitude teleconnections and decadal to centennial scale variability.
1. Calibration studies involving intercomparison between ice core time-series and instrumental data, as well as synthesis studies using other proxy data. This includes proposed activity to retrieve ultra-high resolution sampling from Law Dome in conjunction with the IPY special observing period for tracking air masses to ice core locations.

1. Retrieval of ice cores from other regions in East Antarctica, including an Eastern Wilkes Land site and a potential lower accumulation site inland of Casey.

Implementation/methodology i.e. planned field work, modelling studies

1. Analyses of recently drilled cores from Law Dome (“W19k”) and Eastern Wilkes Land (“GD17”).
1. Extension of high-resolution studies and calibration of Law Dome deep core.
1. Calibration studies using reanalysis products (NCEP/ERA-40) and meteorological data, especially against high-resolution core data.
1. Recovery of ultra-high resolution record from Law Dome covering the IPY special observing period (SOP) for tracking airmasses.
1. Proxy derivation and validation studies: intercomparisons with other proxy and climate forcing series on timescales up to glacial-interglacial.

Who will undertake these activities?

ACE-CRC, Australian Antarctic Division, University of Newcastle (Dr. Ian Goodwin)

Expected scientific outcomes/deliverables

Data sets of ice core proxies; calibration and verification that connect the data to past climate; improved understanding of mechanisms and forcing operating on timescales from individual snowfall events to glacial/interglacial climate shifts.

Timescale

2005-06	Law Dome W19k core analysis
2005-08	Analysis of Law Dome DSS record
2006-07	East Wilkes GD17 core analysis
2006-10	Synthesis and calibration of climate records
2007-10	East Wilkes Land new core analysis

Milestones

2006	Paper(s) on Law Dome DSS water isotopes: calibration, forcings, teleconnections
2007-08	East Wilkes Land new core recovered
2006	Paper on Law Dome W19k climate record
2008-09	High resolution snow recovery at Law Dome Summit for IPY/SOP

Theme 3 - Natural and anthropogenic forcing on the Antarctic climate system

Scientific Activities

1. Atmospheric and oceanic measurements will be incorporated with model simulations to better constrain past anthropogenic forcing and predict impacts on the Antarctic.
1. Observations from Amery Ice Shelf drilling and improved models of ice shelf-ocean interaction will improve estimates of future responses.
1. Better estimates of accumulation distribution and ice sheet modelling will be used to improve the estimate of 20th Century Antarctic ice sheet contribution to sea-level rise.

1. Measure past and present atmospheric greenhouse gas changes from atmospheric measurements and ice core studies respectively, with aim of predicting changes in future concentrations due to feedbacks of source and sink processes.

Implementation/methodology i.e. planned field work, modelling studies

1. Documentation of observed climate change will be spatially and temporally strengthened by new and longer ice core data sets: accumulation rates and variability and proxy changes e.g. proxy sea-ice extent
1. Atmospheric monitoring and ice core trapped-air measurements will be used to explore mechanisms and impacts of observed atmospheric composition changes.
1. Improved models of ice-shelf ocean interaction and ice-stream/ice-shelf boundaries to explore ice shelf stability and impact of collapse on discharge rates of grounded ice.
1. Detailed analyses of 20th Century climate change simulations in the region – to examine model versus observed changes.
1. Use AR4 models to develop scenarios of future climate change in Antarctic region under a range of greenhouse scenarios out to 2100 and beyond.
1. Investigate stability of ocean thermohaline circulation to climate change.
1. Extend CSIRO Mk3.5 model results out to millennial time scales
1. Model hindcasts using a data-assimilating model to characterise variability of ocean currents and water mass properties.
1. Detection and attribution studies from long (17-year) time-series of Australian observations along the SR3 transect.
1. Use of regional models for downscaling details at particular epochs, past and future.

Who will undertake these activities?

ACE-CRC, CSIRO-Marine and Atmospheric Research (including BoM and AAD support), AAD, UNSW

Expected scientific outcomes/deliverables

This work will provide clearer understanding of the impacts/role of anthropogenic forcing in changes over the past 50 years, and better predictions for climate, particularly in the Antarctic. Improved estimates will be obtained for sea-level and changes to the configuration of the ice-shelves and continental ice sheet.

Timescale

2005-06	AMISOR (Amery drilling) project
2006-07	Investigation of 20 th Century portions of IPCC AR4 climate models
2007-08	Complete millennial climate simulations/regional time-slice simulations

Milestones

2006-07	Paper on outcome of 20 th Century model/data intercomparisons
2007	Results from AMISOR borehole measurements available for model validation

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| 2009 | Estimates of the response of ice shelves to warming, and prediction, from improved models, of the impacts on discharge of grounded ice |
| 2010 | Climate change and detection studies from combined 17-year time series of ACE and Antarctic Cooperative Research Centre's SR3 oceanographic measurements |

Theme 4 - The export of Antarctic climate signals

Scientific Activities

1. Climate model runs to examine, in particular, the role of sea-ice and coastal processes and freshwater fluxes on water mass formation.
1. Oceanographic measurements, physical water mass properties.

Implementation/methodology i.e. planned field work, modelling studies

1. Runs with the Australian Community Ocean Model (AusCOM) forced with atmospheric data to explore in particular role of sea-ice and coastal process on water mass formation.
1. Runs with CSIRO Mk 3 coupled model with idealised freshwater anomalies to explore water mass formation and the impact on local climate of these anomalies and wider teleconnections in the SH (particularly in the Australian region).
1. Oceanographic measurements of ventilation processes and model experiments using tracers in present conditions, and in projections with climate change scenarios.
1. Repeat deep hydrographic sections: WOCE I9S (line at 115°E completed, but analysis to follow); Kerguelen Plateau (WOCE I8S and Princess Elizabeth Trough, completed but analysis to follow); Broke/Marginex West along Antarctic margin 30°-80°E; WOCE SR3
1. Use of new Australian ACCESS climate model to investigate changes related to Antarctic stratospheric ozone

Who will undertake these activities?

ACE-CRC, University of New South Wales (Dr. Matt England), CSIRO-Marine and Atmospheric Research and TPAC

Expected scientific outcomes/deliverables

The activities will provide numerous data sets of deep ocean circulation and water mass properties. These, and climate model runs will provide better knowledge of the stability of overturning, and of variability in overturning and water mass formation. This will feed into better understanding of coupled ocean-atmospheric modes that have been linked to lower latitude climate variability.

Timescale

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| 2005.6 | Modelling experiments with AusCOM |
| 2005-07 | Argo float deployment |
| 2005-08 | Repeat deep hydrographic sections |
| 2006-08 | CSIRO model experiments with anomalous freshwater fluxes and passive tracers in present and future |

2008-10 Inverse modelling

Milestones

2006	Complete oceanographic survey of shelf/slope waters 30°-80°E (Broke/Marginex – West)
2008	Census of water mass changes derived from recent and historical observations, including repeat sections, trace measurements and profiling float data
2008	Paper on CSIRO model freshwater and tracer studies
2010	Publish estimates of water mass transformation rates and overturning circulation from inverse models.

Brazil

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Theme 1 - Decadal time scale variability in the Antarctic climate systemScientific Activities

Investigate the mechanisms of the Antarctic Oscillation (AAO) on intraseasonal and interannual time scales;

Characterize the relationships between tropical-extratropical modes of variability and interannual variations of the Antarctic ozone and trends.

Explore mechanisms relating the variability of AAO and climate variations in the Southern Hemisphere.

Examine the possible role of intraseasonal and interannual variations in the AAO modulating sea ice extensions in Antarctica

Investigate the relationships between AAO variability and occurrences of weather extremes (i.e. winds, temperature and surface pressure) in Antarctica. Explore the influence of the ozone and radiation with respect to observed extremes.

Investigate the role of linear and non-linear interactions in the development of high latitude anomalies and the potential role of tropical/extratropical interactions. conceptual barotropic and baroclinic models

Use coupled oceanic/atmospheric models to investigate the influence of variations in the AAO and low-level circulations and surface heat fluxes in the southern oceans.

Explore the signal of climate change between the mid-Holocene simulations (6kBP) and present time based on the changes of the radiative forcing with a coupled atmosphere/ocean/biosphere model.

Implementation/methodology i.e. planned field work, modelling studies

Observational analyses will be performed on several data sets: 1) reanalyses from the National Center for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR). Air-sea interaction processes will be studied with a

combination of reanalyses and satellite estimates. Sea ice variability will be examined with daily time series from SSM/I data.

Weather extremes will be studied with observations from synoptic stations available from the National Sea Ice Data Center (NSIDC) as well as from Automatic Weather Stations (AWS)

Stratospheric ozone variability will be studied satellite (TOMS) data.

4. Mechanisms will be investigated by using several models, such as: (a) a dry spectral primitive equation model with basis functions provided by the vertical modes and horizontal modes of the linearized version of the model and the non-linear interaction coefficients explicitly computed. (b) long term simulations of the 6kBP climate and present climate provided by the Institut Pierre et Simon Laplace (IPSL), (c) influence functions of the linearized version of the shallow water equations about a climatological basic state⁵. The POM oceanic model, already implemented for the South Atlantic, will be initially used considering a single coupled system with large scale atmospheric models. Alternative models are MOM and/or OPA coupled models. Their basic limitation is the sea-ice coupling, a research subject that has been demanding a great effort from the scientific community.

Who will undertake these activities?

IAG members (names listed above), master and PhD students. This study is part of a joint collaboration with the Institute for Computational Earth System Sciences (ICESS) University of California Santa Barbara (USA) and the Brazilian Center for Weather Forecast and Climate Studies (CPTEC).

Expected scientific outcomes/deliverables

The results of this project will provide important elements to recognize the main mechanisms of interaction between tropics and extratropics in the southern hemisphere and in Antarctica. The understanding of these mechanisms will help to unveil important aspects of the intraseasonal-to-interannual variations of the AAO and implications for climate variations and weather in the southern Hemisphere, particularly over Antarctica and South America. Moreover, the knowledge of the relationships between the AAO, the Antarctic ozone, extreme weather events in the southern oceans and Antarctica, the sea ice extension and variations in the oceanic

Timescale

2005-2008 Perform observational ;

Milestones

2005-2006 Papers on observational studies relating tropical/extratropical modes of variability and the Ozone

2006-2008 Papers integrating observational and modelling studies

2006-2007 Establishment of an operational homepage with the monitoring of the AAO and sea ice extent on different time scales.

**Expected National Scientific Contributions to the
SCAR Scientific Research Programme**

Antarctica and the Global Climate System (AGCS)

Nation – Canada

Form completed by (name, institute) –

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The activities described below depend on funding from a variety of agencies. The scope of the activities may change in response to proposal outcomes and other factors. Other activities, not listed here, may also develop during the lifetime of the AGCS SRP.

Theme 1 - Decadal time scale variability in the Antarctic climate system

Scientific Activities

1. Study and predict decadal time-scale changes in the frequency and intensity of Southern Hemisphere extratropical cyclones
2. Real-time monitoring of southern ocean climate; analysis and interpretation of ocean climate data

Implementation/methodology i.e. planned field work, modelling studies

1. GCM computer modelling with forced CO₂ changes.
2. Real-time acquisition and dissemination of data from 6 Argo floats (temperature/salinity profiling floats) located in the southern ocean, number to be increased to at least 8 in late 2005 or early 2006 through collaborations with other countries; model ocean climate data to understand variability, especially formation of Antarctic intermediate water.

Who will undertake these activities?

1. Dr. John Fyfe, as member of team led by P.I. Dr. Ian Simmonds, Univ. Melbourne, Australia, also with colleagues from Germany.
2. Howard Freeland, Fisheries and Oceans Canada; Prof. Richard Karsten, Acadia University

Expected scientific outcomes/deliverables

1. (Depends on successful proposal to Australian Research Council) Increased understanding of the role of atmospheric fronts in climate change; 4 scientific publications, 2 Ph.D. theses.

2. Contribute to global effort to monitor and understand ocean climate; 3 papers by Canadian authors in the short term, many more in the long term as Argo has a long-term horizon. Currently supporting 1 post-doctoral fellow.

Timescale

1. 2006-2008
2. Argo is likely to be continued indefinitely as an operational ocean-observing system.

Milestones

1. Dependant on funding levels, to be determined.
2. Continued tracking of the existing 6 Canadian Antarctic floats to expected demise in 2007. New floats to be deployed in June 2005, with further deployments likely in 2006 and continuing each year.

Theme 2 - Global and regional climate signals in ice cores

Scientific Activities

No responses as of June, 2005

Theme 3 - Natural and anthropogenic forcing on the Antarctic climate system

Scientific Activities

1. Explore the role of the stratosphere in the atmospheric response to anthropogenic climate change.
2. Study the effect of a poleward shift in the Antarctic Circumpolar Current on the global CO₂ inventory.
3. Study role of sea ice carbon dioxide fluxes and biogeochemistry in the global carbon cycle, particularly with regard to potential climate change feedback mechanisms.

Implementation/methodology i.e. planned field work, modelling studies

1. GCM computer modelling.
2. GCM computer modelling
3. Laboratory studies of carbon system thermodynamics in ice brines; time series studies of carbon biogeochemistry in first-year sea ice in association with the IPY programs ICCED (#417) and Antarctic Sea Ice Biogeochemistry (#862).

Who will undertake these activities?

1. Dr. Paul Kushner, University of Toronto; John Scinnoca, Canadian Centre for Climate Modelling and Analysis; John Fyfe, Canadian Centre for Climate Modelling and Analysis
2. John Fyfe and Oleg Saenko, Canadian Centre for Climate Modelling and Analysis
3. The Canadian participants in this program (L. Miller; R. Macdonald, Institute of Ocean Sciences; A. Mucci, McGill University; A.-L. Norman, University of Calgary; T. Papakyriakou, University of Manitoba; and N. Steiner, University of Victoria), are conducting our research primarily in the Arctic. However, we are expecting to also conduct some work in the Antarctic with our collaborators: J.-L. Tison, Université Libre de Bruxelles, Belgium; G. Dieckmann and T. Mock, Alfred-Wegener-Institute für Polar- und Meeresforschung, Germany; D. Thomas, University of Wales-Bangor, United Kingdom; and H. Zemmellink, University of East Anglia, United Kingdom.

Expected scientific outcomes/deliverables

1. (Depends on success of Canadian NSERC proposal); Improved understanding of SH climate response to CO₂ change; 2 publications, 2 Ph.D thesis.
2. (Depends on success of proposal "Canadian Anthropogenic Climate Change Network" submitted to the CFCAS, P.I. Dr. Andrew Weaver, University of Victoria). Improved understanding of response of climate system to CO₂ change; 4 papers, 2 Ph.D. theses; Output of this effort will contribute to IPCC diagnostic subproject led by Drs. Fyfe and Saenko dealing with human-induced changes in the Southern Ocean.
3. Progress in understanding the role of sea ice in the global carbon cycle; 4 or more Canadian-led papers, 2 Master's theses, 1 Ph.D. thesis

Timescale

1. 2006-2008
2. 2006-2010
 1. Mainly in association with IPY: 2006-2009.

Milestones

1. Dependant on funding levels, to be determined.
2. Dependant on funding levels, to be determined.
3. Instrumentation development and intercalibration: completed in 2007; Field work and laboratory thermodynamic studies: completed in 2009

Theme 4 - The export of Antarctic climate signals

Scientific Activities

No responses as of June, 2005

Chile

Form completed by (name, institute) – Dr. Jorge Carrasco (Dirección Meteorológica de Chile)

Theme 1 - Decadal time scale variability in the Antarctic climate systemScientific Activities

- 1.- Study of the decadal climate behavior around the Antarctic Peninsula that can be associated with natural changes in the atmospheric circulation like ENSO, PDO and AAO.
- 2.- Determine the connection and interaction between lower (tropical and midlatitude) and polar southern latitudes in decadal time scale.
- 3.- Modeling future atmospheric scenarios in the Antarctic Peninsula using PRECIS regional model (Providing Regional Climate for Impact Studies) develop by the Hadley Centre.

Implementation/methodology i.e. planned field work, modelling studies

- 1.- Collect meteorological data from weather stations that have at least 30 years of information in the Antarctic Peninsula and southern South America. Air temperature, precipitation, atmospheric pressure, wind speed and wind direction, cloud cover and type will be analyzed on a different temporal scale from daily to annual in order to examine their variability and correlate them with different atmospheric indices (ENSO, PDO, AAO and other).
- 2.- Statistic analysis like principal components, montecarlo test, t-student and others will be applied to the series in order to determine the degree of association between the behavior of atmospheric variables and the atmospheric mechanisms linked to the different indices.
- 3.- NCAR/NCEP Reanalysis will be used to study the atmospheric pattern associated with different scenarios like, for example, composite of ENSO winter months or Positive PDO years, etc. Also, the atmospheric changes revealed by the weather stations will be analyzed through its series and using the reanalysis.
- 4.- Run PRECIS model with future IPCC scenarios for the Antarctic Peninsula.

Who will undertake these activities?

The National Weather Service, Centro de Estudios Científicos and the University of Chile

Expected scientific outcomes/deliverables

- 1.- Better understanding of the mechanisms and relationships between lower and polar latitudes circulation.
- 2.- A regional index that can better explain the behavior and changes of meteorological variables will be constructed and they will be associated with atmospheric circulation patterns. For example, regional AAO index.
- 3.- Model results of future scenarios in the Antarctic Peninsula

Timescale

2005-2007- Natural climate variability studies

2006-2008 - Model runs

Milestones

2007 - Paper on climate variability around the Antarctic Peninsula and mechanisms behind.

2008 - Paper on expected atmospheric changes in future climate scenarios

Finland (aerosols)

Form completed by (name, institute) – General Director, Prof. Mikko Alestalo, Finnish Meteorological Institute

Theme 1 - Decadal time scale variability in the Antarctic climate systemScientific Activities

1. Aerosol and weather parameter measurements at the Finnish Antarctic research station Aboa. The former have been conducted during summer seasons since 1997, the latter continuously since 1989.
2. Aerosol measurements at the international Dome Concordia (Dome C) research station

Implementation/methodology i.e. planned field work, modelling studies

1. At Aboa the aerosol measurements are being automatized so that continuous aerosol data will be obtained even though the station is a seasonal one. Also the weather station will be operated continuously.
2. At Dome C the aerosol measurements are part of a joint European project for the quantification of tropospheric aerosol and thin clouds variability over the East Antarctic plateau, including radiation budget (TAVERN). The project is planned to be a continuous one for monitoring aerosol physical and chemical properties.

Who will undertake these activities?

1. At Aboa the measurements are taken care of by the Finnish Meteorological Institute and the University of Helsinki.
2. In the TAVERN project the Finnish Meteorological Institute and the University of Helsinki are responsible for the instruments that measure aerosol physical properties *in-situ*. At Dome C the instruments may, however, be run by the international overwintering team.

Expected scientific outcomes/deliverables

1. At Aboa it is expected to see whether aerosol concentrations and especially the number of aerosol nucleation episodes will change with changing climate. The planned automatic filter measurements will yield data on whether the aerosol chemical composition will change. The weather parameters that have been measured since 1989 are as such important climatic signals. It is expected to see whether there will be changes in the measured parameters (wind, temperature, humidity, global radiation, UV-B radiation).
2. At Dome C year-round measurements will make it possible to study in detail the inter-annual and seasonal variation of aerosols over the high, interior Plateau.

Timescale

2005 - 2006

- improvement of the automatic aerosol measurements at Aboa
- preparations for the measurements to be started at Dome C

2007 - 2008

- automatic measurement data evaluation and interpretation
- start of the monitoring activities at Dome C

Milestones

2007 paper on the automatic aerosol measurements at Aboa

2008 paper on the first aerosol data from Dome C

Theme 2 - Global and regional climate signals in ice cores

Not applicable

Theme 3 - Natural and anthropogenic forcing on the Antarctic climate systemScientific Activities

1. Intensive measurement campaigns at Aboa and its surroundings.
2. At Dome C continuous aerosol measurements and intensive campaigns.

Implementation/methodology i.e. planned field work, modelling studies

1. At Aboa and its surroundings aerosol measurements will be conducted during summer seasons. In these campaigns the aerosol physical properties and chemical composition will be measured in detail.
2. At Dome C the measurements will be run year-round. In summer seasons also more detailed intensive campaigns will be conducted.

Who will undertake these activities?

1. At Aboa the Finnish Meteorological Institute and the University of Helsinki
2. At Dome C the Finnish Meteorological Institute and the University of Helsinki in cooperation with the international consortium.

Expected scientific outcomes/deliverables

Both at Aboa and at Dome C the physical measurements of scattering and absorption coefficient and aerosol optical thickness will yield data on aerosol forcing of climate. The measurements both at Aboa and Dome C are designed so that a closure of aerosol radiative forcing and chemical properties can be reached.

The aerosol chemical composition will yield information on the contribution of the various aerosol chemical species on the aerosol forcing. In the Antarctica practically all aerosol is natural. The major natural aerosol species are sulphur compounds nss sulphate and MSA. Both of them are oxidation products of DMS, emitted by phytoplankton in the oceans. The production of DMS depends on ocean temperature. Therefore data on MSA and sulphate concentrations show whether the natural aerosol forcing of climate is changing either due to natural changes or human activities.

Timescale

2006-2008, summer seasons

- Intensive aerosol field campaigns at Aboa and surroundings and at Dome C.

2007 - Automatic filter sample measurements started at Aboa, the samples will be analyzed for major ionic compounds

Milestones

2006 - Paper on summertime aerosol climate forcing at Aboa

- paper on particle formation at Aboa

2008 - paper on summertime aerosol climate forcing at Dome C.

Theme 4 - The export of Antarctic climate signals

N o t a p p l i c a b l e

Finland (ozone)

Form completed by (name, institute) – General Director, Prof. Mikko Alestalo, Finnish Meteorological Institute

Theme 1 - Decadal time scale variability in the Antarctic climate systemScientific Activities

1. Investigation of the variability and trends of the vertical ozone.
2. Investigation of the variability and trends of the sea ice albedo, sea ice concentration, sea ice extent and surface temperature.
3. Investigation of the surface UV radiation climate variability applying the analysis on the sea ice albedo trends.
4. Investigation of the aerosol optical depth.
5. Study of stratospheric composition and dynamics by combining remote sensing data, soundings, chemistry transport modelling (FinRose-CTM) and chemical data assimilation.

Implementation/methodology i.e. planned field work, modelling studies

1. Continuation of the joint ozone sounding programme at Marambio by National Meteorological Service of Argentina and Finnish Meteorological Institute.
2. Using calibrated AVHRR data of surface albedo and temperatures.
3. Linking radiation transfer modelling activities with the AVHRR albedo analysis and FMI co-operative AOD measurements at Marambio.
4. Participation in analysis of the results from the IPY ozone sounding Match campaigns using model studies.
5. Model studies of the vortex build-up, interaction between composition (ozone and water vapour) and dynamics using satellite and sonde data.

Who will undertake these activities?

Finnish Meteorological Institute as part of their Finnish Antarctic Research Programme on Polar Climate Change (FARPOCC) which is funded until 2008. Farpocc-project leader: professor Esko Kyrö, FMI.

Expected scientific outcomes/deliverables

1. To ensure the continuation of the valuable and internationally recognized long-term Antarctic ozone sounding and UV data series.
2. To improve the understanding of the future impact of the climate change on polar regions.

Timescale

1. 2005 -2008 studies on the stratospheric ozone
2. 2005-2007 studies related to the sea ice albedo
3. 2005-2010 studies on the UV radiation climate
4. 2005-2010 studies on the aerosols

5. 2005-2009 Atmospheric composition and dynamics; Modelling, data analysis and assimilation.

Milestones

1. 2006 paper on ozone laminae trends and variability at Southern Hemisphere
2. 2007 paper on ozone trends and variability at Marambio
3. 2007 paper on time series sea ice albedo in the Southern Hemisphere
4. 2008 paper on the variability of the UV radiation climate
5. 2010 paper on the aerosol optical depth
6. 2007 CTM validated using sonde and satellite data
7. 2008 Improved CTM performance (e.g. climate sensitivity) through validation and mathematical analysis
8. 2008 Papers on atmospheric composition and dynamics

Theme 2 - Global and regional climate signals in ice cores

Not applicable

Theme 3 - Natural and anthropogenic forcing on the Antarctic climate system

The same input as described in Theme1 can also be included within Theme3 (text copied).

Scientific Activities

1. Investigation of the variability and trends of the vertical ozone.
2. Investigation of the variability and trends of the sea ice albedo, sea ice concentration, sea ice extent and surface temperature.
3. Investigation of the surface UV radiation climate variability applying the analysis on the sea ice albedo trends.
4. Investigation of the aerosol optical depth.
5. Study of stratospheric composition and dynamics by combining remote sensing data, soundings, chemistry transport modelling (FinRose-CTM) and chemical data assimilation.

Implementation/methodology i.e. planned field work, modelling studies

1. Continuation of the joint ozone sounding programme at Marambio by National Meteorological Service of Argentina and Finnish Meteorological Institute.
2. Using calibrated AVHRR data of surface albedo and temperatures.
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1. To ensure the continuation of the valuable and internationally recognized long-term Antarctic ozone sounding and UV data series.
2. To improve the understanding of the future impact of the climate change on polar regions.

Timescale

1. 2005 -2008 studies on the stratospheric ozone
2. 2005-2007 studies related to the sea ice albedo
3. 2005-2010 studies on the UV radiation climate
4. 2005-2010 studies on aerosols
5. 2005-2009 Atmospheric composition and dynamics; Modelling, data analysis and assimilation.

Milestones

1. 2006 paper on ozone laminae trends and variability at Southern Hemisphere
2. 2007 paper on ozone trends and variability at Marambio
3. 2007 paper on time series sea ice albedo in the Southern Hemisphere
4. 2008 paper on the variability of the UV radiation climate
5. 2010 paper on aerosol optical depth
6. 2007 CTM validated using sonde and satellite data
7. 2008 Improved CTM performance (e.g. climate sensitivity) through validation and mathematical analysis
8. 2008 Papers on atmospheric composition and dynamics

Theme 4 - The export of Antarctic climate signals

Not applicable

France

Form completed by (name, institute) – Laboratoire de Glaciologie et Géophysique de l'Environnement (LGGE), mainly C. Genthon and J.R. Petit

Theme 1 - Decadal time scale variability in the Antarctic climate system**Scientific Activities**

Investigate interannual to interdecadal time-scale variability in the Antarctic system to:

- Assess natural variability and extract climate change signatures
- Identify modes of variability which relate the Antarctic with lower latitudes, either the mid-latitudes (SAM) or tropics (ENSO)
- Identified how these modes and other types of variability impact on the Antarctic climate and environment, e.g. mass balance, chemicals, etc.

Implementation/methodology i.e. planned field work, modelling studies

- Long climate model simulations, including IPCC-type control simulation will be used, models intercompared.
- Specific simulations (e.g. atmosphere with and without ocean forcing) will be made.
- High resolution multidecadal simulation will be carried out to access the small scale characteristics
- Surface Antarctic climate indicators of variability will be searched in the longest satellite series, in particular the passive microwaves, e.g. marginal/shelves melt statistics and surface temperature, and the altimeters too.
- Shallow ice cores, pits studies for ice chemistry, dust and stable isotopes, transfer functions and perennial observations of the surface mass balance will be carried out.

Who will undertake these activities?

The Laboratoire de Glaciologie et Géophysique de l'Environnement (LGGE), in collaboration with national partners (Laboratoire de Météorologie Dynamique LMD, Laboratoire des Sciences du Climat et de l'Environnement LSCE, Laboratoire d'Etudes en Géophysique et en Océanographie Spatiales LEGOS), as part of the Action Concertée Incitative Changement Climatique et Cryosphère (C3, to 2006), the GLACIOCLIM observatory (annual support), and other programs as new calls for projects are issued.

Expected scientific outcomes/deliverables

- Better characterisation and better understanding of Antarctic climate variability
- Including new satellite 1970s-today time series of melt and other climate indices (e.g; temperature)

- Improved climate models validations for the Antarctic region, in view of themes 3 and 4

Timescale

- Every year: Field mass balance observatory campaign
- Other activity: depends on funding continuity

Milestones

- Publication of results as appropriate.
- Distribution of observatory data: each year
- 2007-2009: IPY traverses from Talos Dome to Dome A via Dome C and Vostok

Theme 2 - Global and regional climate signals in ice cores

Scientific Activities

1. Production of Holocene climate records from ice cores in the context of palaeoclimate transects through East Antarctica.
2. Construction of ice core climate records over the Holocene period using a common chronology constrained by stratigraphic markers (e.g. Volcanoes, chemicals, Gas ...)
3. Construction of climate forcing proxies (volcanoes, solar activity, radiative gas) and climate records for the Holocene and beyond from the collaborative Berkner Island, Talos Dome, EPICA, Vostok ice cores and planned collaborative activities over the East Antarctic plateau region (Dome C-Dome A-Lake Vostok area).

Implementation/methodology i.e. planned field work, modelling studies

1. New Holocene ice cores record by drilling at Talos Dome and by new 180m deep drillings in 3 to 5 new ice cores in the region of Dome C-Dome A-Lake Vostok area.
2. Collaborative analysis of already-collected Vostok, Berkner Island and EPICA ice cores.
3. Process and statistical studies to extract new climate and climate forcing proxies from ice core : e.g. stable isotope, gas, cosmogenic products, dust and chemical data

Who will undertake these activities?

A French Italian Russian consortium of operators (IPEV, ENEA, RAE) for the necessary logistic support and a consortium of laboratories * for the ice core analysis. This activity will be performed in the frame of IPY proposed task of TASTE IDEA, Concordia station and Sale-United

*For France : LGGE Grenoble, LSCE Saclay, CEREGE Aix en Provence; For Italy : ENEA Roma, Univ.Milano, Univ. Venise, Univ. Firenze; For Russia: AARI, Univ. Kasan,...

Expected scientific outcomes/deliverables

1. Understanding, based on well-dated and synthesised records, of the Holocene climate of the East Antarctic plateau and from more coastal regions
2. Understanding how the Holocene variability is expressed in ice cores proxies.
3. Deciphering the regional variability from the general trends at decadal and secular periodicities,
4. Understanding the modes of variability and documenting the dynamic of the SAM and AAO over the Holocene
5. Test how Holocene climate variability is related to forcing proxy recorded in ice (e.g: volcanic activity, solar activity, radiative gas ...).
6. Comparing and linking the mode of variability of SAM and AAO at decadal and secular time scales to other records.

Timescale

2005/2007 Drilling at Talos Dome cores
 2007/2009 180m deep drillings along the route of TASTE-IDEA traverse; Lake Vostok traverse survey, and lake Concordia region studies
 2008/2010 Synthesis of climate records

Milestones

2007: Completion of Talos Dome ice core
 2007/2009: retrieval of 3 to 5 -180m deep ice cores in East Antarctic plateau
 2008-2010 :Publication as appropriate of high quality well dated records from East Antarctic plateau as key of climate records

Theme 3 - Natural and anthropogenic forcing on the Antarctic climate system

Scientific Activities

Predictions of Antarctic climate evolution at the 100+ years time-scales, with particular interest for mass balance and fresh water fluxes (**in relation with theme 4**)
 Estimation of the beginning of the “anthropocene”Implementation/methodology i.e. planned field work, modelling studies

- Analysis and regionalization of climate model simulations, e.g. IPCC
 - Dedicated climate change simulations with IPSL (global, stretched grid over Antarctica) and MAR (regional meso-scale) models
 - Work on ocean – sea-ice – atmosphere coupling at the regional scale
 - Work on ice-sheet – ice shelves -ocean coupling (**in relation with theme 4**)
- Synthesis of radiative trace gas (CO₂, CH₄) evolution during the Holocene

Who will undertake these activities?

The Laboratoire de Glaciologie et Géophysique de l'Environnement (LGGE), in collaboration with national partners (Institut Pierre-Simon Laplace), as part of the Action Concertée Incitative Changement Climatique et Cryosphère (C3, to 2006), the ENSEMBLES European Project (to 2009), and other programs as new calls for projects are issued.

Expected scientific outcomes/deliverables

- Identification and understanding of recent and current climate trends in models
- Better / more detailed (spatial resolution) predictions of climate change, of the roles and feedbacks of fresh water exchanges (in relation with theme 4)

Timescale

- A coupled atmosphere-ocean-ice sheet model, including ice-shelf ocean coupling (based on IPSL-CM4 GCM and LGGE ice-sheet model). 2005-2006
- A coupled ocean – sea-ice – atmosphere mesoscale model (based on MAR regional model + ORCALIM sea-ice – ocean model). 2005-2008
- Climate change simulations from the above. 2005-2009.

Milestones

- Publications as appropriate

Theme 4 - The export of Antarctic climate signalsScientific Activities

See Theme 2 for data production, interpretation for inland (and coastal) Antarctic climate and in terms of the dynamic of the exchange of air masses with the southern climate system (and sea ice-atmosphere-ocean dynamic).

Should sensitivity of Antarctic signals at decadal and secular periodicity to the solar activity and/or to volcanic forcing be significant, one would expect their interest for future modelling effort.

See Theme 3 for modelling

Implementation/methodology i.e. planned field work, modelling studiesWho will undertake these activities?

Expected scientific outcomes/deliverables

Timescale

Milestones

**Expected National Scientific Contributions to the
SCAR Scientific Research Programme**

Antarctica and the Global Climate System (AGCS)

Nation: Germany

Form completed by (name, institute) – Dr. Rüdiger Gerdes (Alfred Wegener Institute for Polar and Marine Research, Bremerhaven)

Theme 1 - Decadal time scale variability in the Antarctic climate system

(this also contributes to themes 3 and 4)

Scientific Activities

Investigate the role of wind forcing, sea ice and ice-shelf processes, and surface fresh water fluxes for the ACC transport.

Establish the relationship between atmospheric forcing and water mass distribution over the last 50 years.

Asses the variability of the export of specific water masses from the Southern Ocean into the different ocean basins.

Asses the effects of climate change over the next 100 years on sea ice, ocean circulation, and water mass properties in the Southern Ocean.

Implementation/methodology i.e. planned field work, modelling studies

The scientific objectives will be address through a combination of

- hindcast simulations with global and regional ocean-sea ice models using NCEP/NCAR and CORE forcing data sets.
- hindcast simulations using atmospheric forcing data from IPCC greenhouse gas scenario simulations.
- validation of the variability simulated in the model with available observations.
- analysis of hindcast simulations with respect to large scale oceanic teleconnections and the exchanges between the Southern Ocean and the subtropical gyres of the Southern Hemisphere.
- comparison of decadal variability in hindcast and scenario calculations.
- response experiments to investigate sensitivities.

Who will undertake these activities?

The Alfred Wegener Institute in collaboration with the DRAKKAR network.

Expected scientific outcomes/deliverables

- Improved understanding of processes governing the exchanges between the SO and the global ocean.
- Quantification of decadal variability in the SO circulation and water mass properties and their relation to atmospheric variability

Timescale

2005-2007: hindcast experiments for the last 50 years and their analysis; response experiments

2006-2008: response experiments and hindcast experiments for future atmospheric forcing

2008-2010: experiments at higher horizontal resolution and with improved models (based on results of previous calculations); experiments using improved forcing data sets and additional GHG scenario runs forcing.

Milestones

2007: Hindcast experiments 1950-2005 completed

2008: Experiments with future forcing completed

2010: Synthesis of model results published

Form completed by (name, institute) – Dr. Hans Oerter (Alfred Wegener Institute for Polar and Marine Research, Bremerhaven)

Theme 1 - Decadal time scale variability in the Antarctic climate system

Scientific Activities

Investigation of decadal variability of chemical species and isotopes in ice cores from Droning Maud Land

Implementation/methodology i.e. planned field work, modelling studies

Continuation of analysis of chemical species and isotopes on firn and ice cores from Dronning Maud Land.

Shallow coring during the proposed IPY-project IDEA (Ice divide of East Antarctica)

Who will undertake these activities?

AWI

Expected scientific outcomes/deliverables

Insight into the decadal climate variability and teleconnection mechanisms

Timescale

2005-2009

Milestones

2005-2006 analysis of existing firn/ice cores

2007-2009 collecting of IDEA firn/ice core

Theme 2 - Global and regional climate signals in ice cores

Scientific Activities

Comparison between stable-isotope signals in Greenland and Antarctic ice cores

Implementation/methodology i.e. planned field work, modelling studies

Analysis of EPICA ice core EDML from Droning Maud Land

Who will undertake these activities?

AWI

Expected scientific outcomes/deliverables

Understanding of the correlation of climate variability in the North and South

Timescale

2005-2007

Milestones

paper on Antarctic ice cores in comparison with Greenland ice cores

Form completed by (name, institute) Rolf Weller
 Alfred-Wegener-Institute
 Am Handelshafen 12
 27570 Bremerhaven, Germany

Theme 1 - Decadal time scale variability in the Antarctic climate system

Implementation/methodology i.e. planned field work, modelling studies &
 Who will undertake these activities? &
 Timescale

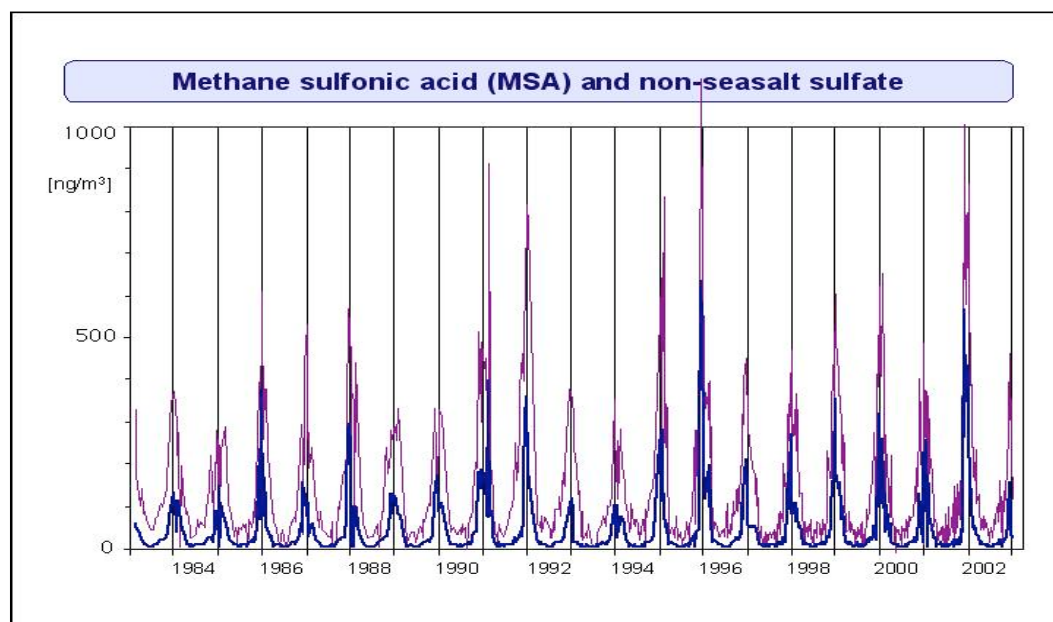
Scientific activity	Measured parameters	Measuring site	Duration	P.I.
Air Chemistry	Surface ozone	Neumayer Station 70°39'S/08°15'W	Started 1983, ongoing	R.Weller, AWI *)
	aerosols including analysis of their constituents; ionic compounds in aerosol and snow	Neumayer Station 70°39'S/08°15'W	Started 1983, ongoing	R.Weller, AWI, D. Wagenbach, IUP-HD **)
	Condensation nuclei	Neumayer Station 70°39'S/08°15'W	Started 1992, ongoing	R.Weller, AWI
	aerosol scattering (Nephelometer)	Neumayer Station 70°39'S/08°15'W	Started 2001, ongoing	R.Weller, AWI
	CO ₂ , δ ¹³ CO ₂ , ¹⁴ CO ₂ , CH ₄ , ⁸⁵ Kr, ⁷ Be, ²¹⁰ Pb, ²²² Rn, SF ₆	Neumayer Station 70°39'S/08°15'W	Partly started 1983, ongoing	D. Wagenbach, I. Levin, IUP-HD
Aerosol sampling	ionic compounds in aerosol and snow	Kohnen Station 75°S/00°E	During summer campaigns, started in 2000, ongoing	R.Weller, AWI, D. Wagenbach, IUP-HD
	ionic compounds in aerosol	Kohnen Station 75°S/00°E	year-round with an automatic aerosol sampler started in Jan. 2003, ongoing	R.Weller, AWI, D. Wagenbach, IUP-HD

*) AWI = Alfred Wegener Institute for Polar and Marine Research, Am Handelshafen 12, D-27570 Bremerhaven, Germany

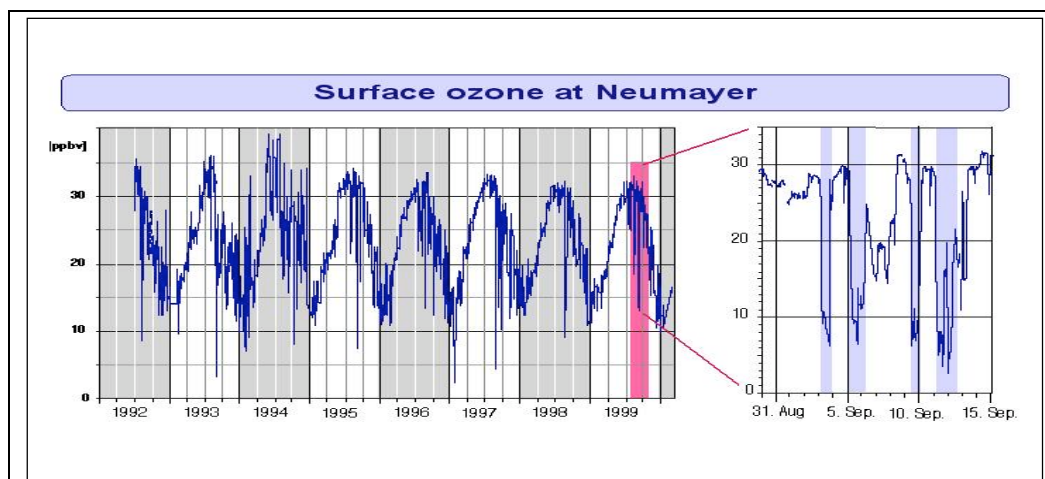
**) IUP-HD = Institute for Environmental Physics, University of Heidelberg INF 229, D-69120 Heidelberg, Germany

Expected scientific outcomes/deliverables & Milestones

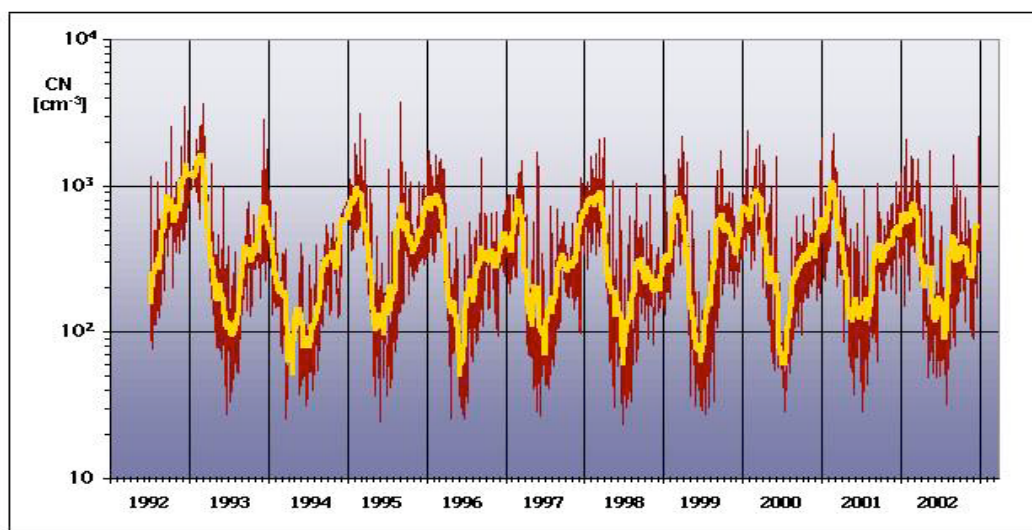
Our objective is to initiate a basic year-round measuring program and intensive summer campaigns focussing on aerosol and trace gas measurements at the EPICA drilling site in Dronning Maud Land (Kohnen Station, 75°S, 0°W) in order to complement and expand the research program already established at the coastal Neumayer Station. The results should help to interpret ionic profiles measured in the EPICA ice core. Up to now results from 4 summer campaigns conducted at Kohnen Station data about the chemical (ionic) composition of the aerosol, fresh and surface snow are available. In addition we installed an automated aerosol sampler for remote year-round aerosol sampling at the EPICA drilling site in DML. It is planned that our research activities will be continued at least for the next 3 years. The project is a close cooperation with the Institute for Environmental Physics, University of Heidelberg.

Some results from Neumayer Station...**Biogenic sulfur:**

Atmospheric methane sulfonic acid (MSA, blue line) and non-seasalt sulfate (nss-sulfate, red line) concentrations measured with the high volume sampling system (sampling period: one week). Note the distinct seasonality with maximum concentrations in January for both compounds. It is evident that the marine biogenic source, i.e. emission of dimethylsulfide (DMS) by phytoplankton dominates the sulfur budget at coastal sites in Antarctica.

Tropospheric ozone:

Surface ozone mixing ratios (daily means in parts per 10^9 by volume) at Neumayer. Maximum ozone values of about 32 ppbv can be observed in August while during polar summer (December) they decrease to a minimum of 13 ppbv. From August to September characteristic ozone depletion events can frequently be detected. Comparable to stratospheric ozone depletion, reactive halogen compounds are responsible for this peculiarity. However, in contrast to processes in the stratosphere, tropospheric ozone depletion is a natural phenomenon caused by release of reactive bromine compounds from sea-salt aerosol over the sea-ice covered ocean.

Condensation nuclei:

Condensation nuclei concentrations (daily means) concentrations at Neumayer. Note the stepwise increase of CN concentrations from polar winter (below 100 cm^{-3}) to the maximum in late austral summer (around 1000 cm^{-3}). Like MSA, CN are formed in the marine troposphere by photooxidation of DMS emitted by algae. Due to the relatively short atmospheric lifetime of CN, regional sources (Atka bay) dominate the signal.

...some relevant publications

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**Expected National Scientific Contributions to the
SCAR Scientific Research Programme**

Antarctica and the Global Climate System (AGCS)

Nation – Germany

Form completed by (name, institute) – Dr. Eberhard Fahrback (Alfred Wegener
Institute for Polar and Marine Research, Bremerhaven)

Theme 1 - Decadal time scale variability in the Antarctic climate system

Scientific Activities

Investigation of decadal variability in watermass properties and circulation in the
Atlantic sector of the Southern Ocean.

Implementation/methodology i.e. planned field work, modelling studies

Repeat cruises with POLARSTERN with hydrographic surveys in the Atlantic sector
of the Southern Ocean with a focus on the Weddell Sea.

Deployment of vertically profiling floats with under ice capacities

Maintenance of moored stations along the Greenwich Meridian and in the Weddell
Sea proper.

Regional modelling to relate local or remote atmospheric forcing to the observed
features.

Who will undertake these activities?

AWI: Dr. Eberhard Fahrback and coworkers

Expected scientific outcomes/deliverables

Identification of the structure and time scale of the observed variability

Identification of regional or remote forcing mechanisms

Guidelines to establish a long term observation system

Timescale

2005-2009

Milestones

2005: POLARSTERN cruise ANTXXII/3: Deployment of moorings and floats, hydrographic survey
 2006: Obtained data set evaluated and combined with historical data
 2007/2008: POLARSTERN cruise proposed for repeat section and exchange of moorings
 2009: 20 Years of data available in the Weddell Sea and 25 years on the Greenwich Meridian. 5 Years of float data.

Theme 3 - Natural and anthropogenic forcing on the Antarctic climate system

Scientific Activities

Repeat measurements of components of the CO₂-System to determine the role of the Atlantic sector of the Southern Ocean in the uptake of anthropogenic CO₂

Implementation/methodology i.e. planned field work, modelling studies

Repeat cruises with POLARSTERN with hydrographic surveys in the Atlantic sector of the Southern Ocean with a focus on the Weddell Sea.

Who will undertake these activities?

AWI: Dr. Mario Hoppema

Expected scientific outcomes/deliverables

Identification of the structure and time scale of the observed variability

Timescale

2005-2009

Milestones

2005: POLARSTERN cruise ANTXXII/3: Sampling of CO₂ relevant parameters
 2006: Obtained data set evaluated and combined with historical data
 2007/2008: POLARSTERN cruise proposed for repeat section
 2009: complete data set evaluated

Theme 4 - The export of Antarctic climate signals

Scientific Activities

Investigation of the role of the Atlantic sector of the Southern Ocean in the global thermohaline circulation system in order to establish an early warning system for the North Atlantic on decadal to centennial time scales.

Implementation/methodology i.e. planned field work, modelling studies

Modelling with a large scale finite element model (FESOM) with high resolution in the Southern Ocean on decadal time scales.

Who will undertake these activities?

AWI: Dr. Hartmut Hellmer and coworkers

Expected scientific outcomes/deliverables

Identification of key regions and quantification of key processes in the Atlantic sector of the Southern Ocean which affect the global thermohaline circulation

Provide model results suitable to assess to representative power of the long term observations in the Atlantic sector of the Southern Ocean for variations in the North Atlantic

Timescale

2005-2008

Milestones

2006: Availability of global model runs to identify key areas

2007: Sensitivity studies of key areas and key processes with a fine resolution coupled ice-ocean model in the Southern Ocean

2008: Availability of adjoint solutions to quantify interhemispheric connections.

**Expected National Scientific Contributions to the
SCAR Scientific Research Programme**

Antarctica and the Global Climate System (AGCS)

Nation – Germany

Form completed by (name, institute) –
Dr Mario Hoppema (Alfred-Wegener-Institut für Polar- und Meeresforschung,
Bremerhaven)

Theme 1 - Decadal time scale variability in the Antarctic climate system

Scientific Activities

Implementation/methodology i.e. planned field work, modelling studies

Who will undertake these activities?

Expected scientific outcomes/deliverables

Timescale

Milestones

Theme 2 - Global and regional climate signals in ice cores

Scientific Activities

Implementation/methodology i.e. planned field work, modelling studies

Who will undertake these activities?

Expected scientific outcomes/deliverables

Timescale

Milestones

Theme 3 - Natural and anthropogenic forcing on the Antarctic climate system

Scientific Activities

Implementation/methodology i.e. planned field work, modelling studies

Who will undertake these activities?

Expected scientific outcomes/deliverables

Timescale

Milestones

Theme 4 - The export of Antarctic climate signals

Scientific Activities

- Investigation of the role of Central Intermediate Water of the Weddell Sea in the sequestration of natural and anthropogenic carbon dioxide (CO₂) in the abyssal world oceans
- Monitoring the properties of the water masses at the prime meridian with respect to CO₂, oxygen and nutrients, as an indicator for natural and anthropogenic water mass changes in the Atlantic sector of the Southern Ocean
- Determination of the inventory of anthropogenic CO₂, its uptake and mechanisms in the Weddell Sea and the Antarctic Circumpolar Current using repeat sections

Implementation/methodology i.e. planned field work, modelling studies

- Hydrographic sections at the prime meridian and in the Weddell Sea with measurements of CO₂ species and auxiliary parameters, expanding the series of repeat sections as of 1984

- Analysis of new data in the light of previously collected data, in combination with modelling
- Data analysis and modelling effort to assess the path, loads and alteration of the Central Intermediate Water

Who will undertake these activities?

Alfred-Wegener-Institut (Bremerhaven). The work is partly funded by the EU Integrated Project CarboOcean 2005-2009. Collaboration with the Netherlands Institute for Sea Research (NIOZ, Texel, the Netherlands) and other CarboOcean partners)

Expected scientific outcomes/deliverables

- I. Understanding the role of unventilated or hardly ventilated water masses of the Antarctic, like the Central Intermediate Water, in the global carbon cycle, in particular its abyssal branch. Glacial-interglacial changes of the hydrographic conditions may have significant implications for the CO₂ sequestration by the Central Intermediate Water
- II. Expanding the data base of repeat sections of CO₂ and auxiliary parameters at the prime meridian and within the Weddell Sea for future reference to less anthropogenically perturbed conditions and as a basis for numerical modelling
- III. Inventory and inventory changes of CO₂ and anthropogenic CO₂ in the Weddell Sea and the Antarctic Circumpolar Current
- IV. Region-specific methodology for the determination of anthropogenic CO₂ and quantification of the CO₂ uptake

Timescale

2005 and 2007/2008	Polarstern cruise along the prime meridian and across the Weddell Sea
2005-2008	Data analysis for inventories and methodology of anthropogenic CO ₂ Modelling efforts for Central Intermediate Water

Milestones

2005 and 2008	Polarstern cruise and new data set
2006/2007	Paper expected on influence of Central Intermediate Water
2007/2008	Paper expected on inventory of anthropogenic CO ₂

Expected National Scientific Contributions to the SCAR Scientific Research Programme

Antarctica and the Global Climate System (AGCS)

Nation – Germany

Alfred-Wegener-Institute
Am Handelshafen 12
27570 Bremerhaven, Germany

Form completed by (name, institute) –
Dr. Andreas Herber (Alfred Wegener Institute)
Dr. Rolf Weller (Alfred Wegener Institute)
Dr. Lars Kaleschke (University of Bremen)

Theme 3 - Natural and anthropogenic forcing on the Antarctic climate system

Scientific Activities

Quantification of the horizontal and vertical aerosol distribution of the Antarctic aerosol concentration in the Atlantic sector of Antarctica, including aerosol – cloud interactions and assessment of their climate impact as part of AGAMES “Antarctic Trace Gas and Aerosol Airborne Measurement Study”. Additional will be performed ground-based aerosol measurements (optical, microphysical and chemical) at Neumayer station and temporary at Kohnen as part of POLAR-AOD network, an lead project of the IPY.

Scientific activity	Measured parameters	Measuring site	Duration	P.I.
Air Chemistry	Surface ozone	Neumayer Station 70°39'S/08°15'W	Started 1983, ongoing	R.Weller, AWI *)
	aerosols including analysis of their constituents; ionic compounds in aerosol and snow	Neumayer Station 70°39'S/08°15'W	Started 1983, ongoing	R.Weller, AWI, D. Wagenbach, IUP-HD **)
	Condensation nuclei	Neumayer Station 70°39'S/08°15'W	Started 1992, ongoing	R.Weller, AWI
	aerosol scattering (Nephelometer)	Neumayer Station 70°39'S/08°15'W	Started 2001, ongoing	R.Weller, AWI
	CO ₂ , δ ¹³ CO ₂ , ¹⁴ CO ₂ , CH ₄ , ⁸⁵ Kr, ⁷ Be, ²¹⁰ Pb, ²²² Rn, SF ₆	Neumayer Station 70°39'S/08°15'W	Partly started 1983, ongoing	D. Wagenbach, I. Levin, IUP-HD
Aerosol sampling	ionic compounds in aerosol and snow	Kohnen Station 75°S/00°E	During summer campaigns, started in 2000, ongoing	R.Weller, AWI, D. Wagenbach, IUP-HD
	ionic compounds in aerosol	Kohnen Station 75°S/00°E	year-round with an automatic aerosol sampler started in Jan. 2003, ongoing	R.Weller, AWI, D. Wagenbach, IUP-HD

*) AWI = Alfred Wegener Institute for Polar and Marine Research, Am Handelshafen 12, D-27570 Bremerhaven, Germany

**) IUP-HD = Institute for Environmental Physics, University of Heidelberg INF 229, D-69120 Heidelberg, Germany

Expected scientific outcomes/deliverables

- Initiate a basic year-round measuring program and intensive summer campaigns focussing on aerosol and trace gas measurements at the EPICA drilling site in Dronning Maud Land (Kohnen Station, 75°S, 0°W).
- Complement and expand the research program already established at the coastal Neumayer Station.
- The results should help to interpret ionic profiles measured in the EPICA ice core. Up to now results from 4 summer campaigns conducted at Kohnen Station data about the chemical (ionic) composition of the aerosol, fresh and surface snow are available.

Implementation/methodology i.e. planned field work, modelling studies

1. Provide first ever comprehensive information about the aerosol vertical distribution over the Antarctica based on in-situ observations.
2. Provide information on the inter-annual and seasonal variability of the aerosol concentration in the coastal area and the relation to the situation at the Antarctic plateau.
3. Coupling of airborne, ground-based and satellite measurements to quantify the temporal and spatial aerosol variability in Antarctica.
4. Model activities will be used to assess the climate impact due to Antarctic aerosol by using of aerosol assimilation tools and regional climate models.

Who will undertake these activities?

Continue the ground-based activities at Neumayer and temporary at Kohnen.

The first campaign called AGAMES is funded by AWI and NIPR Tokyo in cooperation with Stockholm University and DLR Oberpfaffenhofen – AGAMES project

The second campaign, operated from Halley, is funded by AWI and BAS in cooperation with Stockholm University.

Expected scientific outcomes/deliverables

1. Characterize physical, chemical and optical properties of the Antarctic tropospheric aerosol including closure calculations between measured and observed optical properties to address the direct aerosol radiative effect.
2. Investigate the aerosol spatial and temporal distribution and properties along horizontal gradient from the coastal Southern Ocean towards Antarctic interior.
3. Investigate the source area of biogenic sulphur and sea salt by airborne measurements over the open ocean and over pack ice, which are measured at Kohnen.
4. Estimate the relative importance of different aerosol and aerosol precursor sources (e.g., Southern Ocean versus long-range transported aerosols or troposphere-stratosphere exchange).
5. Investigate the aerosol transformation processes in the Antarctic troposphere and the origin of aerosols deposited on the Antarctic plateau as well as estimate the potential available aerosol mass for deposition.

6. Analyse the source of sea salt aerosol from different sea ice types and frost flowers by means of satellite remote sensing and atmospheric transport modeling

Timescale

2006-07 – Carry out of Airborne Operation in the vicinity of Neumayer, Kohnen and Syowa (Atlantic sector of Antarctica)

2007 – Analysis of the measurements, including the ground-based activities

2008-09 – Carry out of Airborne Operation in the vicinity of Halley to extend the region (Weddell sea) and the scientific focus (aerosol and cloud studies)

2009 – Analysis of the measurements, , including the ground-based activities and model runs

Milestones

2007-08 – Statement on the aerosol variability in the Atlantic sector

2009-10 – Quantification of aerosol in Antarctica and the assesment of climate impact, including the aspects of cloud formation and interaction

Italy (glaciology)

Form completed by (name, institute) –
Dr. Massimo Frezzotti (ENEA)

Theme 1 - Decadal time scale variability in the Antarctic climate systemScientific Activities

1. Investigate the interannual variability of atmospheric circulation over the East Antarctic and circum-Antarctic regions.
2. Study the signal of regional and global climate locked into snow.

Implementation/methodology i.e. planned fieldwork, modelling studies

1. Integration of meteo-climate and glaciological data to study the time/source variability of precipitation and air masses and their influence on ice locked in ice core
2. Study of post-depositional processes resulting from interaction between the surface snow layer and atmosphere at meter scale (AWS, snow gauge, drift sensor, stakes farm) and km scale (snow radar).
3. Study the snow accumulation temporal variability during the last three-century at decadal scale in Dome C drainage area, using firn core network.
4. Monitoring the recent climatic and environmental changes from the snow composition studies, refining the relationships (transfer functions) between the atmosphere, the firn and the ice geochemical compositions (water isotopes, chemical compounds, heavy metals...) and assessing post depositional effects.

Who will undertake these activities?

The Italian University and Research Institutes (in collaboration with others nation) as part of Talos Dome Ice Core and Concordia Station projects, which are funded over 2004-6.

Expected scientific outcomes/deliverables

1. Understanding of mechanisms that time/source variability of precipitation and of redistribution/sublimation process.
2. Investigation on the source area and travel path of precipitation and their isotopical and chemical composition.

Timescale

2005 –Field experiments with direct observations of precipitation and the sublimation/redistribution process at select sites

2004-06 – Analysis of climate variability in the firn core

2004-6 – Analysis of meteo-climate and glaciological data

Milestones

2005-6 – paper on snow accumulation variability during the last three century

2007 – paper on the role of sublimation in ice core interpretation

2007 – paper on climate variability in East Antarctica during the last three century at decadal scale

Theme 2 - Global and regional climate signals in ice cores

Scientific Activities

1. Investigations of global and regional signals in Talos Dome Ice cores
2. Response of the near-coastal sites Talos Dome to climate changes and Holocene history of accumulation rates in the Ross Sea region.
3. Understanding of the last glacial-interglacial transition when different climatic features and trends are observed between East Antarctica, Taylor Dome, Siple Dome and DSS.

Implementation/methodology i.e. planned field work, modelling studies

1. New glacial/interglacial cycle record by drilling ice core at Talos Dome.
2. Analysis of Talos Dome and EPICA DC ice cores.
3. Evaluation of the site spatial variability at Dome C e Talos Dome and of the atmosphere/snow transfer functions
4. Synchronise the signatures of other Antarctic ice cores (Byrd, Vostok, Dome Fuji, EPICA Dome C- DML, Taylor Dome Siple Dome), by using the same temporal markers (volcanic signatures).

Who will undertake these activities?

The Italian University and Research Institutes (in collaboration with others nation) as part of Talos Dome Ice Core and Concordia Station projects, which are funded over 2004-6.

Expected scientific outcomes/deliverables

- 1 Understanding, based on well-dated and synchronise records, of the Holocene climate and last glacial-interglacial transition of the Ross Sea area, and how it relates to Holocene climate and forcing elsewhere.
- 2 Determination of climatic variability in Ross Sea area and relationships with East and West Antarctica and circum-Antarctic regions.

Timescale

2005/2007	Drilling of Talos Dome ice core
2005/2007	Analysis of Talos Dome and EPICA Dc cores
2006/2007	Synchronise the signatures of Antarctic ice cores

Milestones

2006-7 – paper on Talos Dome Ice core

2007 – paper on synchronisation of Antarctic ice cores

ITALY (atmosphere)

Form completed by (name, institute) –
Vito Vitale (ISAC-CNR)
Andrea Pellegrini (PNRA SCrl)
Stefano Dietrich (ISAC-CNR)

Theme 1 - Decadal time scale variability in the Antarctic climate system**Scientific Activities**

1. Investigation on the dynamical structure of the Antarctic stratospheric vortex in the period 1993-2003 and its connections with the *ozone hole* phenomena.
2. Understanding of the processes observed in the PBL over the Antarctic Plateau along the year and their connections with the katabatic wind regime; developement of advanced models of the long-lived stable PBL and new parameterisations for climate models.
3. Contribution to the assessment of mass balance of the Antarctic ice cap through the monitoring of the atmospheric component and specific measurements.
4. Contribution to the study of the permafrost dynamics through the monitoring of the atmospheric component and specific measurements.
5. Experimentation and validation of novel instrumentation and new methodologies to measure meteorological parameters (in particular water vapour content and precipitation).
6. Investigation on the Antarctic precipitating clouds by means of satellite remote sensing and modeling.
7. Assessment of the role of coastal polynyas in the processes related to climatic impacts on sea ice extent and to ice shelf mass balance.

Implementation/methodology i.e. planned field work, modelling studies

1. A climatology of the polar stratospheric vortex characteristics and variability will be realized, using both observations and model evaluations. The mechanisms driving de-nitrification and de-hydration will be investigate, making use primarily of observations over McMurdo station.
2. A statistical study of ECMWF and NCEP re-analysis will be performed in order to investigate the southern stratosphere and troposphere coupling and their relationships with the stratospheric polar vortex characteristics.
3. Detailed year-round observations of the long-lived stable PBL at the extreme Antarctic Dome C site will be carried out to obtain information on turbulent fluxes of momentum, heat, humidity, energy and radiative fluxes, PBL temperature and wind profiles. This large data-set will help us to gain more understanding on the structure of the PBL, and the implications of its behaviour on the secondary meridional circulation through the mechanism of the katabatic winds.
4. An advanced model of the long-lived stable PBL will be developed, including a refined surface layer formulation, resistance and heat/mass transfer laws,

- diagnostic and prognostic PBL depth equations - with due regard to non-local effects of the free-flow stability and baroclinicity.
5. Time series of meteorological data will be acquired through 12 AWS distributed over Victoria Land and the Est Antarctic Plateau and radiosoundings performed at MZS (summer season) and Concordia station (year-round).
 6. 4 AWS's installed on the plateau plus one to be installed on Inexpressible Island (Victoria Land coast) will be upgraded with snow drift gauges, as a contribution to the estimate of the ice cap mass balance. A micro-lidar developed by ISAC-CNR and a commercial optical precipitation meter will be tested in order to try an assessment of snow-drift/precipitation. IPWV will be estimated from GPS data, based on the radio signal's delay: the reliability of results obtained from measured and estimated surface parameters (e.g. from atmospheric numerical models) will be evaluated and results will be compared against radiosounding's measurements and numerical modelling.
 7. Higher MW window frequencies (150 GHz able to observe the principle phenomena of scattering by ice hydrometeors) and Oxygen (118 GHz) and Water Vapor (183 GHz) sounding channels will be used for observing clouds at high latitudes enhancing the discrimination between snow cover and precipitation.
 8. Wind products from polar orbiting IR radiometer will be used to derive the cloud-drift motion and winds at different levels in the troposphere. Knowledge about wind will largely improve the retrieval of precipitating clouds. Strong katabatic winds influence the snow distribution over the plateau and the possibility to detect the intensity and the direction help to distinguish from falling snow and blowing snow.
 9. High-resolution cloud resolving mesoscale models will be used together remotely sensed measurements to better understand the Antarctic atmospheric circulation and the precipitation processes.
 10. An X-band satellite receiving station will be installed at Mario Zucchelli Station during summer 2006-'07. Regular acquisition of imagery from NOAA and DMSP satellites will be continued.
 11. Specific methodologies will be developed for: i) frazil and pancake ice thickness assessment from ocean wave dispersion detected by SAR; ii) the classification of different sea-ice types in SAR.

Who will undertake these activities?

The ENEA-Rome as part of their Special Project "Clima", in cooperation with the PNRA SCrl Consortium;

The CNR- Institute of Atmospheric Science and Climate (ISAC), the Istituto di Oceanografia e Geofisica Sperimentale (INOGS - Trieste), and the ENEA-Global Environment Division,

as part of the Italian National Antarctic Research Programme (PNRA) through several specific Research Projects.

Expected scientific outcomes/deliverables

1. Decadal climatology of stratospheric temperature and aerosol stratospheric load; quantification of the contributions of natural and anthropogenic forcing to the polar vortex strength and permeability; evaluation of the feedback

between polar ozone depletion and global change, and between polar stratosphere and troposphere.

2. A set of detailed year-round measurements over the Antarctic Plateau for a full study of the PBL processes, including phenomena occurring in the transition period between different seasons.
3. An advanced model of the long-lived stable PBL and new PBL parameterisations for climate models.
4. Acquisition of reliable data for the monitoring of different climate components concerning several scientific issues: meteorology and climatology, mass balance of the ice cap, IPWV estimates from GPS signal, precipitation, air-sea interactions, coastal polynyas and sea-ice.
5. Improve the discrimination between falling and blowing snow in the satellite-based precipitation algorithm by using the simulated wind fields jointly with satellite measurements.
6. Build up and validate a system for monitoring cloud microphysics and precipitation over Antarctica to be used during the IPY

Timescale

2005-2010 - Continuous long-term meteorological measurements through AWS and radiosounding systems. Lidar stratospheric measurements at McMurdo and DDU.

2005.2006 - Year-round field campaign at Concordia of PBL characteristics.

2005.2007 - Analysis of lidar stratospheric measurements and model evaluations.

2005-2006 - Snow drift gauges installed on 4-5 AWS's.

2006-2007 - Installation of micro-lidar and precipitation meter. Installation of an X-band satellite receiving station.

Milestones

2008 - Climatology of the polar stratospheric polar vortex.

2008 - Data set on the high Plateau characteristics.

2008 - PBL model and parametrizations.

2006-2008 Scientific publications

Monitored data and derived products will be published regularly on <http://www.climantartide.it>.

Theme 2 - Global and regional climate signals in ice cores

Scientific Activities

Implementation/methodology i.e. planned field work, modelling studies

Who will undertake these activities?

Expected scientific outcomes/deliverables

Timescale

Milestones

Theme 3 - Natural and anthropogenic forcing on the Antarctic climate system

Scientific Activities

1. Obtaining an improved understanding of polar aerosols on a regional scale and their radiative effects on the Antarctic climate through an international networking action to assure that consistent, high quality data be assimilated and analysed.
2. Characterization of the atmospheric aerosol particle and thin clouds in the lower troposphere over the East Antarctic Plateau, collecting information on their multi-layered as well as the micro-physical structure at the PBL.
3. Investigation of the radiative regime at the ground through year round measurements of shortwave and longwave fluxes; monitoring of long-term changes in irradiances at the earth's surface, in particular infrared radiation, as a consequence of climate change.
4. Evaluation of the role of clouds in modulating the radiation budget of the continent, in the Ross Sea coastal region and on the East Antarctic Plateau.
5. Monitoring surface O₃ and CO₂ concentrations at coastal as well as interior sites (MZS and Concordia stations); determination of seasonal variations of ozone and CO₂ concentration values and variations associated to phenomena with different space-time scales (i.e.: stratospheric intrusions, regional and long range transport episodes).
6. Investigation on the meridional and latitudinal variation of tropospheric aerosol along the the route New Zealand-Ross Sea.

Implementation/methodology i.e. planned field work, modelling studies

1. Calibration procedures between the various sun-radiometers operating in Antarctica and Arctic will be defined, in order to achieve homogeneous AOD evaluations, also establishing a network traceability. Intercomparison campaigns will be also organized.
2. A data bank for the spectrophotometric measurements (AOD archive) will be realized. The AOD archive will be designed to hold not only AOD data but also data-sets of other parameters required in studies of aerosol radiative effects, first of all the radiance measurements at the surface and at the top of the atmosphere (TOA) and those of surface reflectance. Historical data-sets, mainly from Russian Arctic and Antarctic stations, will be recovered and stored in the archive.
3. Long-term columnar and in-situ (micro-physical) measurements will be performed at Concordia station thanks to an international cooperation, providing an observational over determined data-set to investigate aerosols

and thin clouds. Year-round measurements based on LIDAR, Sun and Star photometer and in-situ aerosol measurements will be made possible to study in detail inter-annual and seasonal variation of aerosols over the high, interior Plateau.

4. Thanks to the different activities based on common calculation procedures and calibration methods, it will be possible to achieve a better characterization of aerosols in the high-latitude regions, both on spatial and temporal scales. Taking into account the relatively volcanic quietness during the recent years, data collected in the last 8-9 years should allow the definition of AOD background values in both polar regions: such threshold values being suitable for evaluating the width of the future changes, due to both natural and anthropogenic causes. The determination of the natural variations on both seasonal and spatial scales will lead us to assess the direct forcing induced by polar aerosols with a better confidence.
5. Direct and diffuse solar irradiances as well as longwave downward irradiances measurements will be continued/implemented at MZS and Concordia stations, following BSRN protocols. These measurements will enable us to investigate differences between coastal and internal radiative regimes at the same latitude. Concordia measurements will provide accurate and representative information on the radiation regime at the surface in the East-Antarctic Plateau region, supplying essential input parameters to both mass balance and climatic models for a crucial area.
6. The short-wave and long-wave radiation flux measurements performed in Antarctica (75°S) will be analyzed, with procedures similar to those defined in the BSRN network, in order to estimate cloud coverage and cloud type characteristics during the summer season and identify features that can be considered as typical of the Antarctic Plateau and of the Ross Sea coastal region. Information on the thin clouds optical thickness, one of the essential parameters for expressing their radiative properties, will be derived from sun-photometric measurements following developed methodologies. The possibility to extend this analysis to the polar region making use of the infrared radiation measurements will be investigated.
7. One structure for the *in-continuous* measurements of surface O₃ and CO₂, able to provide for Concordia Antarctic station data all along the year will be realized. These measurements will supply useful information on the seasonal trends of ozone and CO₂ concentration values, able to characterise (i) Dome C air masses circulation, tracing episodes of transport of air masses coming from the sea or from the Antarctic plateau, (ii) stratospheric air mass intrusion episodes and estimation of their contribution to the surface ozone and (iii) long term transport episodes affected by natural and/or anthropogenic origin (Erebus, New Zealand, ...). During summer period these measurements will be compared with those performed at MZS at the same latitude.
8. Automatic, ship-borne measurements for marine-aerosol studies during the ITALICA cruise from Italy to New Zealand and Ross Sea will be continued using a station that includes a two-wavelength, depolarisation LIDAR and in-situ instrumentation (Differential Mobility Analyser, Optical Particle Sizer, meteorological sensors). The continuous monitoring of the size-distribution, vertical profile, and time evolution of the marine aerosols will supply information on the latitudinal variation of the aerosol in the marine PBL. Aerosol optical depths will be compared with satellite data. Efforts will be devoted to enlarge

the station instrumentation and to develop an international cooperation on this issue.

Who will undertake these activities?

The CNR- Institute of Atmospheric Sciences and Climate (ISAC), the CNR Institute of Applied Physics "Nello Carrara" (IFAC), the CNR Institute of Information Science and Technologies (ISTI), the CNR Institute of Bioclimatology (IBIMET), The University of Florence- Department of Chemistry, the Università Politecnica delle Marche - Ancona, Dipartimento di Scienze del Mare, as part of the Italian National Antarctic Research Programme (PNRA) through several specific Research Projects.

Expected scientific outcomes/deliverables

1. Calibration procedures between the various sun-radiometers operating in Antarctica and Arctic, a network traceability including a set of instruments for round robin operations, intercomparison campaigns.
2. A data bank for the spectrophotometric measurements (AOD archive), holding not only AOD data but also data-sets of other parameters required in studies of aerosol radiative effects, and including historical data.
3. Detailed columnar and in-situ (micro-physical) year-round data-sets at Concordia to investigate aerosols climatic effects over the high interior Plateau as well as physical processes at the surface and the atmosphere/snow two-ways transfer functions, necessary to realistically analyse the EPICA ice core.
4. Improve understanding and characterization of polar aerosols and their radiative effects on climate through scientific cooperation with international Institutions.
5. Definition of AOD background values in both polar regions: such threshold values being suitable for evaluating the width of the future changes, due to both natural and anthropogenic causes.
6. Improve our knowledge on the radiation balance at the surface in Antarctica, and on the differences between the coast and the interior of the continent, through measurements at the same latitude.
7. Improve our knowledge on cloud coverage and cloud type characteristics over the Antarctic Plateau as well as in the Ross Sea coastal region. Estimate the effects produced by clouds on the radiative balance, by realistically separating them from those induced by the cryosphere.
8. Measurements of surface O₃ and CO₂ concentrations in coastal and interior stations at the same latitude in the Ross Sea and Victoria Land area, and information on their seasonal trends, stratospheric air mass intrusion episodes, and long term transport episodes.
9. Information of the latitudinal variation of the aerosol in the marine PBL along the route from New Zealand and Antarctica.

Timescale

2005-2010 - Measurements of O₃ and CO₂ concentrations at MZS during summer.
Implementation of the year-round station at Concordia (full

- operating in 2007). Measurements of short-wave and long-wave fluxes at the surface at MZS and Concordia.
- 2005-2007 - Implementation of the AOD archive, including recover of the historical data. Definition and realization of a network traceability and measurements hierarchy.
- 2005-2006 - Ship-borne marine aerosol campaign.
- 2007-2010 - Continuous long-term remote sensing and in-situ aerosol measurements at Concordia.
- 2006 - First intercomparison campaign between sun radiometers operating in polar areas.

Milestones

- 2007 - 2008 - Full implementation of the measurements at Concordia (radiation, aerosol, ozone and CO₂)
- 2007 - 2008 - Full implementation of the AOD archive and of the network reference station to assure traceability.
- 2008 - 2010 - Assessment of the role of aerosols radiative effects on a regional scale. Definition of a background value. Estimates of clouds effects on the radiation balance at the surface in the Ross Sea area.
- 2006 - 2010 - Scientific publications

Theme 4 - The export of Antarctic climate signals

Scientific Activities

Implementation/methodology i.e. planned field work, modelling studies

Who will undertake these activities?

Expected scientific outcomes/deliverables

Timescale

Milestones

New Zealand

Form completed by (name, institute) –

Dr. Nancy Bertler (Antarctic Research Centre at Victoria University of Wellington)
Dr. Tim Naish (Institute for Geological and Nuclear Sciences and Antarctic Research Centre at Victoria University of Wellington)
Prof. Peter Barrett (Antarctic Research Centre at Victoria University of Wellington)

Theme 1 - Decadal time scale variability in the Antarctic climate system**Scientific Activities**

1. Investigation on the influence of ENSO on interannual to centennial climate variability in the Pacific sector of Antarctica during the Holocene
2. Quantification of the effect of solar variability on the Ross Sea climate system with particular emphasis on the sensitivity of atmospheric circulation
3. Reconstruction of the variability of the Southern Annular Mode, Antarctic Circumpolar Wave, and ENSO beyond the instrumental record.

Implementation/methodology i.e. planned fieldwork, modelling studies

1. Deployment of weather stations at two of the study sites (Evans Piedmont and Whitehall Glaciers)
2. Recovery and analysis of six intermediate length (100-300m) ice cores along the Trans-Antarctic Mountains from low elevation, coastal sites. Three cores of the six cores have already been recovered.
3. High resolution analyses of water chemistry, isotopic composition, dust content and mineralogy.
4. Establishment of transfer functions between ice core parameters and existing meteorological and sea-ice (re-analysis) data

Who will undertake these activities?

Victoria University of Wellington (NZ) and the Institute of Geological and Nuclear Sciences (NZ) in conjunction with University of Maine (USA) and the Alfred Wegner Institute (Germany) as part of the NZ ITASE programme

Expected scientific outcomes/deliverables

1. Development of proxy record for ENSO influence in Antarctica beyond the instrumental record

2. Development of proxy record for Southern Annular Mode and Antarctic Circumpolar Wave beyond the instrumental record
3. Improved understanding of variability of the relative importance of these oscillating climate phenomena through time
4. Reconstruction of sea-ice variability in the Ross Sea through time
5. Improved understanding of regional impacts of global climate change in the Pacific Antarctic – New Zealand Sector
6. Providing baseline climate information for the Latitudinal Gradient Programme, such as temperature, precipitation, atmospheric circulation, storminess, and seasonality

Timescale

- | | |
|---------|---|
| 2005/06 | Recovery of ice core from Mt Prior / Malta Plateau |
| 2006/07 | Analyses of ice core from Mt Prior / Malta Plateau |
| 2006/07 | Analyses of ice cores from Evans Piedmont Glacier and Mt Erebus |
| 2006/07 | Recovery of ice cores from Byrd and Darwin Glaciers |
| 2007/08 | Analyses of ice cores from Byrd and Darwin Glacier |

Milestones

- | | |
|---------|--|
| 2005/08 | Recovery of three ice cores listed above |
| 2006 | Paper on sea ice variability in the McMurdo Sound |
| 2007 | Paper on the effect of solar activity on atmospheric circulation |
| 2008 | Paper on the influence of ENSO on katabatic winds |
| 2009 | Paper on feedbacks between ENSO, Antarctic Oscillation, and Antarctic Circumpolar Wave through the last two millennia. |

Theme 2 - Global and regional climate signals in ice cores

Scientific Activities

1. Investigation of the spatial and temporal climate variability along the Trans-Antarctic Mountains from six, low elevation, coastal sites and their polar plateau counterparts (the latter are recovered and analysed by the US-ITASE programme)
2. Provision of high resolution greenhouse gas record with narrow ice-age/gas-age difference (potentially < 40 yrs)
3. Linking with theme 4 - Holocene retreat history of Ross Ice Shelf
4. Linking with theme 4 - Integration of marine (ANDRILL) and terrestrial (ice core) records

Implementation/methodology i.e. planned fieldwork, modelling studies

1. Recovery and analysis of eight intermediate length (100-300m) ice cores along the Trans-Antarctic Mountains from low elevation, coastal sites. Three cores of the six have already been recovered.
2. High resolution analyses of water chemistry, isotopic composition, dust content and mineralogy
3. High resolution analyses of greenhouse gas concentration and isotopic composition in ice core gas bubbles from Mt Erebus ice core
4. Correlation between coastal ice core records and polar plateau records
5. Integration of marine data (ANDRILL) and Mt Erebus and Evans Piedmont Glacier ice core proxies

Who will undertake these activities?

Victoria University of Wellington (NZ) and the Institute of Geological and Nuclear Sciences (NZ) in conjunction with the Institute for Water and Atmospheric Research (NZ) University of Maine (USA) and the Alfred Wegner Institute (Germany) as part of the NZ ITASE programme

Expected scientific outcomes/deliverables

1. Coastal greenhouse gas record with small dating error and narrow air diffusion time window
2. Identification of carbon reservoirs contributions to past greenhouse gas variability
3. Improved understanding of temperature – greenhouse gas causality and feedback mechanisms
4. Linking with theme 4 - Integration of marine and terrestrial (ice core) records
5. Linking with theme 4 - Investigation of ocean-atmosphere interaction in the Ross Sea Region
6. Quantification of continentality gradients across the Trans Antarctic Mountains

Timescale

2005/06	Recovery of ice core from Mt Prior / Malta Plateau
2006/07	Analyses of ice cores from Evans Piedmont Glacier and Mt Erebus
2006/07	Analyses of ice core from Mt Prior / Malta Plateau
2006/07	Recovery of ice cores from Byrd and Darwin Glaciers
2007/08	Analyses of ice cores from Byrd and Darwin Glacier

Milestones

2005/08	Recovery of five ice cores listed above
2006	Paper on high resolution greenhouse gas record over last few millennia
2007	Paper on relative contribution of various greenhouse gas reservoirs over the last few millennia
2007	Paper on late Holocene retreat history of Ross Ice Shelf
2008	Paper on latitudinal, elevation, and continentality climate gradients

Theme 4 - The export of Antarctic climate signalsScientific Activities

1. Reconstruction of the Ross Ice Shelf and West Antarctic Ice Sheet response during superinterglacial warm periods, such as MIS 5e
2. Ross Ice Shelf behaviour and subsequent collapse during the post LGM deglaciation phase
3. Linking with theme 2 - Comparison between high resolution onshore records (Vostok, EPICA, Law Dome, Taylor Dome and local ice cores listed in theme 2) and the marine record (MIS - ANDRILL)
4. Linking with theme 2 - Investigation of relative timing and feedback mechanisms between atmospheric and oceanic climate forcings

Implementation/methodology i.e. planned fieldwork, modelling studies

1. Recovery of the MIS (McMurdo Ice Shelf) ANDRILL core at Windless Bight
2. Recovery of ice cores listed under theme 1 and 2
3. Integration of on- and off-shore climate proxies

Who will undertake these activities?

The ANDRILL programme is closely aligned with the ACE (Antarctic Climate Evolution) SCAR Programme. While the MIS ANDRILL core is expected to provide a climate record for the last 5Ma, the uppermost meters (~100,000 years) of the MIS core are relevant to science effort and time scale of AGCS. This aspect of our AGCS contribution will be undertaken by the NZ ANDRILL science group as part of ANDRILL effort at Windless Bight.

Expected scientific outcomes/deliverables

1. Improved understanding of Ross Ice Shelf and WAIS behaviour under superinterglacial warm periods condition, such as MIS 5e
2. Improved understanding of the oceanic / atmospheric feedback mechanisms and their relative timing
3. Reconstruction of the Ross Ice Shelf retreat velocity and its sensitivity to ambient air and ocean temperature
4. Insights into the forcings leading to the Ross Ice Shelf collapse during the last deglaciation.

Timescale

- 2006/07 Recovery of the MIS (McMurdo Ice Shelf) ANDRILL core at Windless Bight
- 2007 – 09 Analyses of the MIS core
- 2008 – 09 Integration of marine and terrestrial climate signal for the last 100,000 years as contained in the MIS and ice cores (local and regional).

Milestones

- 2006/07 Recovery of the MIS ANDRILL core at Windless Bight
- 2005/09 Recovery of five ice cores listed under theme 1 and 2
- 2008 Paper on Ross Ice Shelf behaviour and retreat velocity during last deglaciation
- 2008 Paper on Ross Ice Shelf and WAIS behaviour under superinterglacial warm periods condition as occurred during MIS 5e
- 2009 Paper on relative timing of atmospheric and oceanic forcings during the last 100,000 years

The Netherlands

Form completed by (name, institute) – Dr Michiel van den Broeke, Institute for Marine and Atmospheric Research, Utrecht University

Theme 1 - Decadal time scale variability in the Antarctic climate system

Scientific Activities

- Analysis of regional climate model simulation (1957-2002)
- Validation observations using automatic weather stations
- Validation observations using detailed meteorological experiments

Implementation/methodology i.e. planned field work, modelling studies

- RACMO2/ANT regional climate model forced at lateral boundaries by ERA40, hosted and run at Royal Netherlands Meteorological Institute (KNMI)
- AWS designed and built at IMAU, operated in Dronning Maud Land and Berkner Island
- Detailed meteorological experiment in Dronning Maud Land

Who will undertake these activities?

- IMAU, Utrecht University, Dr Michiel R van den Broeke and co-workers
- KNMI, Dr Erik van Meijgaard

Expected scientific outcomes/deliverables

- A validated 45 year climatology of Antarctica, including surface mass balance
- Observations of basic climate variables and radiation fluxes and validated energy balance from AWS
- Detailed insight in the structure of the Antarctic atmospheric boundary layer and its interaction with the large scale circulation

Timescale

- days to decades

Milestones

- Funding confirmation for additional 10 years of AWS operation in Dronning Maud Land (April 2005)
- Funding confirmation for detailed meteorological experiment in Dronning Maud Land (April 2005)
- Detailed meteorological experiment in Dronning Maud Land (Dec 2006-Feb 2007)
- Publications of RACMO2/ANT run
- Publications on AWS work
- Publications on detailed meteorological experiment

Theme 2 - Global and regional climate signals in ice cores

Scientific Activities

- Analysis of medium-deep firn cores for oxygen isotopes and variations in electrical properties (DEP) to be drilled in DML
- Controlled enrichment of water isotopes in snow and following migration in snow
- Development of laser device capable of on-line determination of d18O content of air

Implementation/methodology i.e. planned field work, modelling studies

- Medium deep firn cores drilled in coastal and interior Antarctica, using IMAU drill
- Controlled enrichment experiment in Dec 2006 and following seasons
- Testing in airplane of laser device capable of on-line determination of d18O content of air (collaboration with British Antarctic Survey, Dr Tom Lachlan-Cope)

Who will undertake these activities?

- IMAU, Utrecht University, Dr Roderik S W van de Wal
- Centre for Isotope Research, Prof dr Harro Meijer, dr Erik Kerstel

Expected scientific outcomes/deliverables

- Decadal to centennial climate variability in DML
- Diffusion of oxygen isotopes in snow
- Oxygen isotopes in air and transfer function into snow

Timescale

- Days to decades

Milestones

- Funding confirmation for laser device and fieldwork (April 2005)
- Publications on controlled snow enrichment experiment
- Publications on medium deep firn cores

Theme 3 - Natural and anthropogenic forcing on the Antarctic climate system

Scientific Activities

See description under Themes 1 and 2

Implementation/methodology i.e. planned field work, modelling studies

Who will undertake these activities?

Expected scientific outcomes/deliverables

Timescale

Milestones

Theme 4 - The export of Antarctic climate signals

Scientific Activities

No activities planned at present (April 2005)

Implementation/methodology i.e. planned field work, modelling studies

Who will undertake these activities?

Expected scientific outcomes/deliverables

Timescale

Milestones

**Expected National Scientific Contributions to the
SCAR Scientific Research Programme**

Antarctica and the Global Climate System (AGCS)

Nation – Norway

Form completed by (name, institute) – Jan-Gunnar Winther, Norwegian Polar Institute

Theme 1 - Decadal time scale variability in the Antarctic climate system

Scientific Activities

Implementation/methodology i.e. planned field work, modelling studies

Who will undertake these activities?

Expected scientific outcomes/deliverables

Timescale

Milestones

Theme 2 - Global and regional climate signals in ice cores

Scientific Activities

- 1) Third (and planned to be the last) drilling season at Kohnen station in Dronning Maud Land (DML) under the European Project for Ice Coring in Antarctica. Marine core off the coast of DML in 2006/07.
- 2) Norwegian-US IPY Traverse from Troll Station to South Pole and back again, over two field seasons. A number of shallow and a few intermediate ice cores will be retrieved.

Implementation/methodology i.e. planned field work, modelling studies

- 1) Drilling to bedrock. Retrieving a marine sediment core.
- 2) Three 100-m ice cores and about twenty 40 m cores

Who will undertake these activities?

- 1) The Norwegian Polar Institute and the University of Tromsø
- 2) The Norwegian Polar Institute, Norwegian Institute for Air Research, NORUT IT and University of Oslo

Expected scientific outcomes/deliverables

Improved understanding of temporal and spatial climate variability in DML, including temperature and accumulation, on decadal to millennium time scales.

Timescale

- 1) 2005-2006
- 2) 2006-2009

Milestones

- 1) Reaching bedrock at Kohnen Station, probably in 2006
- 2) Performing the traverse from Troll to SP in 2007/08 and from SP to Troll in 2008/09.

Theme 3 - Natural and anthropogenic forcing on the Antarctic climate system

Scientific Activities

Establishing a permanent atmospheric monitoring station at Troll Station.

Implementation/methodology i.e. planned field work, modelling studies

Measurements of greenhouse gases, UV-radiation, POPs, aerosols, heavy metals etc

Who will undertake these activities?

Norwegian Institute for Air Research

Expected scientific outcomes/deliverables

Timescale

2005-2008

Milestones

2005/06 season – establishing station infrastructure

Theme 4 - The export of Antarctic climate signals

Scientific Activities

Implementation/methodology i.e. planned field work, modelling studies

Who will undertake these activities?

Expected scientific outcomes/deliverables

Timescale

Milestones

**Expected National Scientific Contributions to the
SCAR Scientific Research Programme**

Antarctica and the Global Climate System (AGCS)

Spain

Form completed by:

- Dr. Damià Gomis, Institut Mediterrani d'estudis Avançats (IMEDEA), Univ. de les Illes Balears - CSIC. National delegate of the SSG of Physical Sciences.
- Dr. Maria del Mar Flexas, Institut Mediterrani d'estudis Avançats (IMEDEA), Univ. de les Illes Balears - CSIC.

From the contributions of:

- Dr. Margarita Yela, Instituto Nacional Técnica Aeroespacial (INTA).
- Dr. Carmen Domínguez, Dep. of Applied Mathematics, Univ. of Salamanca
- Dr. Rainer Zahn, Institució Catalana de Recerca i Estudis Avançats (ICREA), Univ. Autònoma de Barcelona.
- Dr. Carlos Duarte, Institut Mediterrani d'estudis Avançats (IMEDEA), Univ. de les Illes Balears - CSIC.

Theme 1 - Decadal time scale variability in the Antarctic climate system

Scientific Activities

1. Investigate the variability and trends of the ozone profiles inside the Antarctic polar vortex.
2. Investigate variability and trends of the O₃ total column and other related components like NO₂, OClO and BrO
3. Study of stratospheric composition and dynamics by combining remote sensing data, soundings, chemistry transport modelling and chemical data assimilation.
4. Investigation on the dynamical structure of the Antarctic Polar Vortex and its connections with the ozone hole episodes and its recovery
5. Study of UV spectral and integrated UV irradiances in Argentinean Antarctic sub-Antarctic stations
6. Modelling of polar ozone depletion and ozone hole excursions over southern high latitude regions.
7. Derivation of ozone loss from ozone soundings.
8. Validation of satellite instruments (OMI, SCIAMACHY and GOME- II)
9. Study of mid-winter lower stratosphere temperatures in the Antarctic vortex by comparison between observations and operational models

Implementation/methodology i.e. planned field work, modelling studies

- Long term monitoring program to measure NO₂, O₃ vertical column using DOAS technique at Ushuaia, Marambio and Belgrano station
- Long term monitoring program to measure O₃ profiles at Belgrano station by ozonesounder
- Long term monitoring program to measure OCIO and BrO vertical column using DOAS technique at Marambio station
- Long term monitoring program to measure biological UV doses and cloud optical depth over Belgrano, Marambio and Ushuaia.
- Long term monitoring program to measure surface O₃ at Belgrano station
- Ground-based validation will rely on correlative studies of OMI, SCIAMACHY and GOME-II data with UV and UV-visible measurements associated with the NDSC. Total O₃ and NO₂ will be validated with Ushuaia, Marambio and Belgrano stations.
- Lower stratosphere temperatures comparison between observations (radiosondes) and operational models

Who will undertake these activities?

Instituto Nacional de Técnica Aeroespacial (INTA) and Instituto Nacional de Meteorología (INM) as part of the joint program by INTA (Spain) INM (Spain), Dirección Nacional del Antártico (Argentina) and CADIC (Ushuaia).

Expected scientific outcomes/deliverables

- Climatology of vertical profiles of O₃ and temperature at Belgrano station
- NO₂ and O₃ year round measurements over Belgrano, Marambio and Ushuaia stations
- Validation of satellite instruments
- Differences between temperature observations (radiosondeos) and operational models
- Ozone loss over Belgrano

Timescale

2005-2010 Continuous long term NO₂ and O₃ measurements at Belgrano, Marambio and Ushuaia stations

2005-2010 Continuous long term OCIO and BrO measurements at Marambio stations

2005-2010 Continuous long term O₃ profiles measurements at Belgrano station

2005-2010 Continuous long term tropospheric NO₂, BrO and HCHO

2006-2009 Installation of ozonesounder at Ushuaia. Continuous long term O₃ profiles measurements at Belgrano station

2006-2007 Installation of two DOAS instruments at Belgrano, one to measure NO₂ and O₃ vertical columns and another one to measure OCIO, BrO (total column and tropospheric column)

Milestones

- 2005-2006 Paper on NO₂ distribution at Antarctic and Sub-Antarctic places
- 2006 Paper on study of mid-winter lower stratosphere temperatures in the Antarctic vortex by comparison between observations and operational models
- 2007 Paper on the variability of the UV radiation

Theme 2 - Global and regional climate signals in ice cores

Not applicable.

Theme 3 - Natural and anthropogenic forcing on the Antarctic climate systemScientific Activities

1. The ATOS project aims at resolving the increasing role of air-sea exchanges of materials in the polar seas by (1) quantifying the atmospheric inputs of organic carbon and key organic pollutants both in aerosol and gaseous phases; (2) elucidating the role of sea ice cover in controlling these rates and the inputs associated to sea ice melting; (3) evaluating the fate of the materials, by assessing their use by biota and transference up the food webs, and (4) evaluating the effects on microplankton as the entry points of the materials in the food web, through evaluations of cell mortality in relation to pollutant inputs and parallel increases in ultraviolet radiation dosage, and the evaluation of the effect of the materials on planktonic primary production and community respiration. The ATOS program represents the Spanish component of the OASIS and GEOTRACES programs. The OASIS program has, in turn, been endorsed by the IGBP programs IGAC (AICI) and SOLAS programs.
2. Monitoring subpolar glaciers as natural sensors of global warming: Implementation of experimental pilot catchment areas for measuring continuously glacier discharge (output time series) and relation with meteorological parameters (input time series). GLACE Project, Spanish branch of RANS (Russian Academy of Natural Sciences).

These activities are closely linked with Theme 4.

Implementation/methodology i.e. planned field work, modelling studies

1. Field activities will be conducted in the Southern Ocean (Antarctic Peninsula, Weddel and Belinghausen Seas) and the Arctic Seas. For the Southern Ocean, 45 days of ocean sampling (+ transits to land) will be necessary in January-February 2008, encompassing a triangular track between the Polar Front to the Bellinghausen Sea, from this to the Weddel Sea, tracking the edge of the sea ice, to return to the Polar Front. Ship time will be sought on board the Spanish R/V Hesperides. Activities during the cruise will include (1) along-way estimates of aerosol and gaseous

deposition of organic matter and pollutants, along with subsurface temperature-salinity-chlorophyll a-pCO₂ (air and sea), meteorology and total and ultraviolet solar radiation ; (2) vertical profiles of organic matter and pollutants using a Rosette sampler system and a CTD; (3) estimates of pollutant contents in biota sampled using a Rosette sampler system, a CTD and ; Estimates of organic matter and pollutant loads in sea ice; (4) experimental assessments, using large on deck incubators, of the effects of organic matter and pollutant inputs on planktonic communities. The cruise in the Arctic is also tentatively planned on board the R/V Hespérides, requiring 35 days of sampling in the Arctic during the summer (July and August) of 2007. Activities during the cruise will include the same as planned for the Southern Ocean, as well as the full array of standard analyses included in the OASIS program (see URL above). The exact location of the Arctic cruise will be coordinated with OASIS, in order to achieve the large-scale coverage the program seeks.

2. Maintain operating continuously, recording data every hour (8760 data by parameter measured) all 4 experimental catchment areas (CPE) which have been implemented during those last years of developing of the GLACE project:

- Hydraulic and hydrochemical parameters (time series -TS- with 1 hour cycletime).
- Meteorological parameters -TS-.
- Maintenance and checking CPE.

3. Establish a new CPE (the third one in the southern hemisphere) in Eastern Antarctica: 71°S, near the Russian Antarctic Base Novolazarevskaya, where glacier discharge takes place in summer time; Search and establish a new CPE (the third one CPE in the northern hemisphere) at latitude 70°/71°N.

Who will undertake these activities?

- IMEDEA (CSIC)
- IIAQB (CSIC).
- Spanish branch of RANS (Russian Academy of Natural Sciences)
- Uruguayan Antarctic Institute
- Moscow Geographical Institute, RAN (Russian Academy of Sciences)
- IPEV, Institut Polar Française.
- King Sejong KARP (Korea Antarctic Research Program)
- Water Division of XII Region of Chile.
- NPI, Norsk Polar Institutt, Ny-Alesund. Trond
- Hellarannsóknafélag Iceland.
- Laboratoire Souterraine Moulis, -CNRS-, France.

Expected scientific outcomes/deliverables

1. Advance current knowledge on the relevance of air-sea interactions for the metabolism, and flow of pollutants, of pelagic polar ecosystems, as well as provide a basis to forecast the effects of future reductions of sea ice in polar seas and oceans on the functioning of the pelagic ecosystems. Moreover, as the atmospheric materials that enter the sea in polar regions are likely to be introduced elsewhere, primarily on land, this research will provide novel insights onto the role of the atmosphere as a

vector linking loading of organic carbon and pollutants in temperate and tropical latitudes and the inputs of these materials to polar seas and oceans. Moreover, the process-based examination of the response of microplankton to these inputs will allow formulation of models to forecast responses to future scenarios.

2. Leave a data base of air-sea fluxes of organic carbon and pollutants in polar seas which could be used as a base line for future studies. This data base will be embedded within that of the OASIS program and, therefore, available.

3. According the spatial distribution of air temperature around polar circles, estimate the spatial distribution of subpolar glacier discharge.

Timescale

Milestones

Theme 4 - The export of Antarctic climate signals

Scientific Activities

Coupled ocean-climate system within the wider Antarctic-subantarctic zone from the perspective of past global changes. Concentrate on glacial-interglacial climatic cycles of the past 340,000 years at a temporal resolution of 200 years and finer i.e., comparable to the temporal resolution in the long climatic records from Antarctic Vostok and Epica-Dome C ice cores. A particular focus is on millennial to centennial scale changes in Southern Ocean thermohaline circulation, notably periods of sudden changes in the water mass production. The data profiles will be integrated into a hemisphere-wide network of palaeoceanographic records to gain a fuller picture of the linking between Antarctic climate variability and southern hemisphere ocean THC during periods of accelerated climate changes. The objective is to link the observations from the southern hemisphere with documented periods of past abrupt ocean and climate changes in the northern hemisphere so as to map signal propagation pathways along the ocean MOC surface and deep branches and to better understand the coupling of ocean and climate change across the hemispheres.

These activities are closely linked with Themes 2 and 3.

Implementation/methodology i.e. planned field work, modelling studies

A collection of sediment cores has been obtained during the last 3 years during three coring cruises onboard RVs Meteor (De), Marion Dufresne (France), Charles Darwin (UK) around southernmost South Africa with the intention to reconstruct variability within the Agulhas Current and leakage of Indian Ocean water to the Atlantic. An important aspect in this work is the reconstruction of ocean front movements

(Subtropical Convergence Zone, SCZ; Subantarctic Front, SAF; Polar Front, PF) in the area that is closely linked with the variability of Antarctic climates and their influence on the Antarctic Circumpolar Current (ACC). The data base to be generated will be complemented by similar data that have been assembled from the high-latitude South Pacific. Future coring activities are planned along a meridional transect from the Agulhas Corridor off South Africa across the ACC to link the dynamics of the ACC with the past mobility of the SCZ, SAF, and PF. Particular attention will be placed on the SCZ-SAF couple that merges in the Agulhas Plateau area and defines the width of the Agulhas Corridor through which the Indian-Atlantic water exchange occurs.

Analytical methodologies involved are: stable isotope (d18O, d13C), trace elements (Mg, Cd), biomarkers (Uk-37) that all are linked with ocean temperature, water mass production and mixing, ocean carbon cycling. Collaboration with the modelling community is in place and will be further expanded as time evolves.

Who will undertake these activities?

The work will be carried out within the palaeoclimatic research group in the Institut de Ciència i Tecnologia Ambientals at Universitat Autònoma de Barcelona. The various shipboard coring and shorebased analytical studies will be part of an international collaboration with partner groups in the UK (Cardiff University), Germany (Alfred-Wegener-Institute for Polar Research) and US (LDEO). It is woven into the larger research scheme of the IMAGES programme (International Marine Global Changes; parent organizations IGBP, PAGES).

Expected scientific outcomes/deliverables

The immediate outcome will allude to the global climatic framework within which Antarctic climate variation and variability proceeds. Notably the linking of Antarctic variability with changes in southern hemisphere ocean and climate change will be assessed, and its far-field influence on ocean circulation and climate change in the northern hemisphere.

Deliverables are: (i) high-quality palaeoceanographic data streams that are related to THC-relevant surface and deep ocean parameters; (ii) robust chronological framework that enables tight core-to-core parameter correlation and synoptic mapping of ocean palaeo-parameter fields across the southern hemisphere and (iii) across the hemispheres so as to gain a fuller insight into interhemispheric signal propagation pathways of ocean and climate change.

Timescale

The work is planned for a minimum of five years, with the option for onward studies based on the insights gained in the course of the work.

Milestones

The work is in progress and will evolve along several parallel lines

- 1) screening of existing cores with low-resolution stratigraphic analyses (planktonic foraminiferal oxygen isotopes) to assess the quality of sediment cores
- 2) select most promising cores for further, fine-scale analysis
- 3) establish key priority sites that are of best use to record a set of surface and deep ocean parameters
- 4) run full set of analytical procedures across the cores so as to provide for regional gradients
- 5) implement palaeo-data into existing global and eddy resolving numerical models to test (i) interpretation of palaeo-data, (ii) sensitivity of the models, (iii) linking between regional oceanographic changes in the south with ocean-climate changes in the northern hemisphere

UK

Form completed by (name, institute) –

Dr John Turner (British Antarctic Survey)

Dr Eric Wolff (British Antarctic Survey)

Dr Mike Meredith (British Antarctic Survey)

Theme 1 - Decadal time scale variability in the Antarctic climate systemScientific Activities

1. Investigation of the reasons for decadal time scale variability in the Antarctic climate system
2. Determination of the role of tropical forcing in dictating decadal time scale variability.
3. Quantification of the atmospheric and oceanic links between the Antarctic climate and extra-polar conditions, and determination of the mechanisms that control the high-low latitude teleconnections.

Implementation/methodology i.e. planned field work, modelling studies

1. Natural variability of the Antarctic climate system will be investigated via long (≈ 1000 years) control runs of the Hadley Centre climate model with pre-industrial levels of greenhouse gases.
2. Modelling studies with the Hadley Centre climate models to examine the high latitude impact of tropical forcing, such as sea surface temperature anomalies
3. Case studies of the impact on the Antarctic of individual ENSO events using the re-analysis data sets.
4. Collection of an ice core in the southwestern Antarctic Peninsula. This would cover the last 150 years.
5. Linking with Theme 4 to investigate the role of the ocean.
6. Linking our modelling activities with the ice core record via Theme 2.

Who will undertake these activities?

The British Antarctic Survey as part of their Antarctic Climate Change and Non-linear Teleconnections (ACCENT) project, which is funded over 2005-9.

Expected scientific outcomes/deliverables

1. Insight into the mechanisms that are responsible for varying the Antarctic climate on a range of time scales.
2. Understanding of whether t

Timescale

2005-07 – Modelling experiments with forced tropical conditions

2005-07 – Natural climate variability studies

2007-09 – Analysis of climate variability in the ice core

Milestones

2007 – paper on natural climate variability

2007 – paper on the role of tropical forcing

2006/7 season - Collection of the ice core

2009 – paper on climate variability in SW Antarctic Peninsula from the ice core and model data

Theme 2 - Global and regional climate signals in ice cores

Scientific Activities

1. Synthesis of Holocene climate records from the Antarctic Peninsula, in the context of palaeoclimate transects through the Americas.
2. Construction of forcings and climate for the Holocene and beyond from the collaborative Berkner Island and EPICA ice cores.

Implementation/methodology i.e. planned field work, modelling studies

1. New Holocene ice core record by drilling to bedrock at James Ross Island.
2. New associated lake and marine sediment cores from the Antarctic Peninsula, South Georgia region and Scotia Sea.
3. Analysis (in collaboration with others) of already-collected Berkner Island and EPICA ice cores.
4. Process and statistical studies to extract new proxies from ice core chemical data

Who will undertake these activities?

The British Antarctic Survey as part of its Holocene project CACHE-PEP, which is funded from 2005-2010.

Expected scientific outcomes/deliverables

1. Understanding, based on well-dated and synthesised records, of the Holocene climate of the Antarctic Peninsula, and how it relates to Holocene climate and forcing elsewhere.
2. A determination of where, on a transect from the Antarctic Peninsula through the Americas, an Antarctic pattern of climate gives way to a more northern pattern.

Timescale

2005/2007	Drilling of lake and marine cores
2006/2008	Drilling of James Ross Island ice core
2005 onwards	Analysis of Berkner Island core
2008/2010	Synthesis of climate records

Milestones

2008: Completion of James Ross Island core as key for linking other climate records

Theme 3 - Natural and anthropogenic forcing on the Antarctic climate system

Scientific Activities

Predictions of how the Antarctic climate system will evolve on a regional and continent-wide basis over the next 100 years using the latest version of the Hadley Centre climate model and a regional climate model.

Implementation/methodology i.e. planned field work, modelling studies

1. Future projections of the main climate variables across the Antarctic and the Southern Ocean will be produced using HadCM3 and HadGEM. Projections will be generated for different levels of greenhouse gases.
2. A coupled atmosphere-ocean-ice shelf regional climate model is being developed and will be used to produce regional projections later in the programme.
3. The READER data base will be maintained and updates to provide a reference source for in-situ climate data covering the last 50 years.

Who will undertake these activities?

The British Antarctic Survey as part of their Antarctic Climate Change and Non-linear Teleconnections (ACCENT) project, which is funded over 2005-9.

Expected scientific outcomes/deliverables

1. Fields and point values of the main atmospheric (air temperature, surface pressure, storm track, winds and precipitation-evaporation), cryospheric (sea ice extent and concentration) and oceanic (temperature, salinity, currents) variables for the next century with different levels of greenhouse gases.
2. Understanding of whether the Southern Hemisphere Annular Mode (SAM) has changed in recent decades because of natural variability or anthropogenic factors.

Timescale

2005-07 - Development of the regional climate model

2005-06 – Assessment of HadCM3 runs for next 100 years

2006-07 – Assessment of HadGEM runs

2006-07 Intercomparison of HadCM3/HadGEM predictions with those from other climate centres

2007-09 – Produce regional predictions for 2100 using the regional climate model

2005-09 – continued development of the READER data base

Milestones

2006 – Paper on HadCM3 Antarctic predictions for 2100

2007 – paper on HadGEM predictions

2007 – Regional climate model working.

2009 – paper on regional climate model predictions for 2100

Theme 4 - The export of Antarctic climate signals

Scientific Activities

- Investigation of the global climate impact of freshwater and saline anomalies around Antarctica
- Exploration of the use of measured ocean properties on the Antarctic continental shelf as a proxy for large scale Southern Ocean variability
- Monitoring of properties and variability in export of deep and bottom waters (including Antarctic Bottom Water, AABW) in the South Atlantic sector of the Southern Ocean.
- Large-scale determination of the rate of production and export of Antarctic-sourced waters (Antarctic Intermediate Water, AAIW; AABW);
- Investigation of the mechanisms, as well as the present rate and future trend of uptake, of anthropogenic carbon in the South Atlantic sector of the Southern Ocean;
- Determination the size of the Southern Ocean Meridional Overturning Circulation and oceanic heat fluxes.

Implementation/methodology i.e. planned field work, modelling studies

- Ensembles of perturbation experiments using HadCM3, imposing fresh or saline anomalies around Antarctica.
- Observations around Antarctic shelf, deployment of moored sensors.
- Moorings deployed near Filchner Sill (near source) and near South Georgia (“downstream”) to document changes in AABW properties. Analysis of extant moorings data from North Scotia Ridge, to document variability in northward export of deep waters across this ridge system. Repeat CTD

activities in Scotia Sea, Drake Passage and environs. Writing of proposal(s) for enhanced monitoring of deep gaps around Scotia Sea.

A hydrographic box survey enclosing the South Atlantic sector of the Southern Ocean will be conducted, as near-synoptically as possible. The box will consist of choke-point sections at Africa and South America, and a closure of the Atlantic at 30° or 45°S. Measurements will include a full suite of physical and biogeochemical parameters. The circulation will be analysed using inverse methods, and the volume transports will be combined with chemical measurements to provide biogeochemical budgets for the enclosed region. Seasonal variations in the upper layers mean that the survey should be split across two ships so that it is completed in the shortest possible elapsed time. One ship, for the African chokepoint, will need to be ice-capable. The likely sections would be a repeat of the WOCE A21 line in western Drake Passage, the WOCE A10 line at 30°S in the Atlantic, and the WOCE I6 line at 30°E (requiring RRS *James Clark Ross* or equivalent). The first two lines could be completed on the new RRS *James Cook*. Temporal variability/representativeness will be assessed with reference to the ongoing monitoring at Drake Passage.

See 4.

See 4.

Who will undertake these activities?

1,2. University of East Anglia (UEA) as part of their COAPEC funded work and through various PhD student projects and NERC/AFI projects. Collaboration with iAnZone partners.

3. BAS, as part of Long-Term Monitoring and Survey (LTMS). SOC, as part of core strategic work at Drake Passage (annual repeat hydrographic sections) and ongoing collaborations. UEA/BAS as part of funded North Scotia Ridge Overflow Project and ongoing collaborations.

4,5,6: Southampton Oceanographic Centre (SOC) (hydro), UEA (carbon) as part of new SOC Core Strategic Research Programme.

Expected scientific outcomes/deliverables

Documentation of the likely impact of freshwater shutting off the formation and sinking of Antarctic Bottom Water.

Development of proxies for Southern Ocean climate variability and a design for future measurement strategies.

Time series of AABW properties, for comparison with model predictions and climate indices. Documentation of export of deep Southern Ocean water masses through narrow gaps into global ocean.

Quantified rates of production and export of Antarctic-sourced waters, for inclusion in global analyses of circulation and climate.

Understanding of the mechanisms responsible for anthropogenic carbon uptake in the South Atlantic sector of the Southern Ocean, and its (time dependent) export.

Quantification of the size of the Southern Ocean Meridional Overturning Circulation, and its global relevance.

Timescale

- 1, 2: 2005-2007 Perturbation experiments with HadCM3
- 1, 2: 2007-2009 Analysis of processes on the Antarctic continental shelf and deployment of moored sensors.
3. Deployment of moorings in 2006; no planned end. Hydrographic sections annually. Analysis of extant moorings data ongoing from present.
- 4, 5, 6: Anticipation is for a field season in 2008/09 or 2009/10, to allow planning time for a 2-ship operation.

Milestones

- 1, 2:
- a) 2005 - paper on impact of slowing down formation of Antarctic Bottom Water
 - b) 2007 - paper on mechanisms for polar-tropical interactions, such as waves in ocean and atmosphere
 - c) 2009 - paper on any links between parameters on the continental shelf with large scale climate indices.
- 3:
- a) Moorings data recovered annually from 2007 onwards.
 - b) Hydrographic work conducted annually.
 - c) Proposal for enhanced moorings/monitoring work in 2005/6
 - d) Paper on variability in export of water masses by 2007.
- 4, 5, 6:
- a) calibrated dataset 6 months after field operations
 - b) report 12 months after field operations
 - c) first results of inverse analysis ca. 24 months after field operations

Ukraine

Form completed by (name, institute)

Dr Gennadi Milinevsky (Ukrainian Antarctic Center)

Dr Vladislav Timofeyev (Ukrainian Research Institute of Hydro Meteorology)

Theme 1 - Decadal time scale variability in the Antarctic climate system**Scientific Activities**

1. Investigation of the changeability in the Southern tropospheric circulation on time scales from seasonal to decadal and related changes in Antarctic climate.
2. Registration the hydro meteorological and environmental anomalies in the Western Antarctic Peninsula region, the simulation of the anomalous conditions.
3. Study the small ice cap dynamics as possible indicators of regional climate changes.
4. The search of the ozone layer changes response on regional climate warming in Antarctic Peninsula and Southern tropospheric circulation variations.
5. Specific and climatically important patterns of tropospheric circulation, searching the influence of ENSO to the Antarctic Peninsula weather.
6. Review and re-analysis: a) Faraday/Vernadsky meteo data set and sea water temperature; b) currently used indices of climate change.

Implementation/methodology i.e. planned field work, modelling studies

1. Natural variability of the Antarctic climate system will be investigated via different gridded data sets and the Antarctic stations measurements. Searching the teleconnections and other important indicators of large-scale circulation patterns, and their changes.
2. Continuous photogrammetry and GPS ice cap and small glaciers survey.
3. Development and upgrade hydrology- and meteo- equipment for measurements at Vernadsky Station.
4. Identifying and comparison the synoptic patterns between cold/warm years at Antarctic Peninsula.
5. Analysis of the climatology, and the cyclones and anticyclones main characteristics.

Who will undertake these activities?

Ukrainian Antarctic Centre in collaboration with Ukrainian Research Institute of Hydro Meteorology and National University "Lvivska Politechnica" in the framework of the State Research Program in Antarctica for 2002/10.

Expected scientific outcomes/deliverables

1. The patterns of large-scale circulation changes that is responsible for oscillations of the Antarctic climate on different time scales.
2. GIS for Argentina Island and nearby Antarctic Peninsula area.

3. The results of the comparison of the most important regional climate changes at Antarctic Peninsula with current global changes.

Timescale

2005-07 – Natural circulation variability studies, field GPS, photogrammetry work

2005-07 – Modelling experiments with anomalous conditions in circulation

2007-09 – Synoptic analysis and comparison against gridded data.

Milestones

2007 – Data set on natural climate/circulation variability in the region

2008 – Modelling experiments

2009 – Paper on the role of different hydrometeorological anomalies as sequence of current warming, GIS creation

Theme 2 - Global and regional climate signals in ice cores

Scientific Activities

No scientific activity expected in this theme

Implementation/methodology i.e. planned field work, modelling studies

Who will undertake these activities?

Expected scientific outcomes/deliverables

Timescale

Milestones

Theme 3 - Natural and anthropogenic forcing on the Antarctic climate system

Scientific Activities

1. The search of anthropogenic impact on Antarctic Peninsula regional climate on the base of mud, and botanical samples analysis, and of population dynamics.

Implementation/methodology i.e. planned field work, modelling studies

1. Study the aerosols sedimentation in the freshwater lake mud. RXF-analysis of the botanical samples. Observation of animal's population dynamics in the area using field work and historical data.
2. Supply the READER data base providing by the data from Vernadsky.
3. Establishing the network (4-5) of the automatic "meteo-magnetic" stations in vicinity of Antarctic Peninsula to study the peculiarities of tropospheric circulation pattern in vicinity of Vernadsky area..

Who will undertake these activities?

Ukrainian Antarctic Centre in collaboration with National Taras Shevchenko University of Kyiv and Radio Astronomy Institute in the framework of the State Research Program in Antarctica for 2002/10.

Expected scientific outcomes/deliverables

1. e tropospheric circulation pattern in vicinity of Vernadsky area.
2. The pattern of botanical and population changeability due to natural and anthropogenic influence on regional climate.

Timescale

2005-07 - Sampling and analysis

2006-07 – Field work on animal's population study, automatic "meteo-magnetic" stations network establishing.

2007-09 – Produce the tropospheric circulation pattern in vicinity of Vernadsky area.

Milestones

2007 – Paper on animal's population dynamics

2009 – Paper on tropospheric circulation pattern

Theme 4 - The export of Antarctic climate signals

Scientific Activities

No scientific activity expected in this theme

Implementation/methodology i.e. planned field work, modelling studies

Who will undertake these activities?

Expected scientific outcomes/deliverables

Timescale

Milestones

Contact: Gennadi Milinevsky, E-mail: science@uac.gov.ua

USA (Univ Cal Santa Barbara contribution)

Form completed by (name, institute) –

Dr. Charles Jones
Dr. Leila M. V. Carvalho
Institute for Computational Earth System Science (ICESS)
University of California
Santa Barbara, CA 93106-3060
USA

Theme 1 - Decadal time scale variability in the Antarctic climate system**Scientific Activities**

Investigate the mechanisms of the Antarctic Oscillation (AAO) on intraseasonal and interannual time scales
Characterize the coupling between the AAO and air–sea interaction processes in the southern oceans
Examine how intraseasonal and interannual variations in the AAO are related to changes in sea ice extensions in Antarctica
Investigate the relationships between AAO variability and occurrences of weather extremes (i.e. winds, temperature and surface pressure) in Antarctica

Implementation/methodology i.e. planned field work, modelling studies

Observational analyses will be performed on several data sets: 1) reanalyses from the National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) and European Centre for Medium Range Weather Forecasts ERA–40. Air–sea interaction processes will be studied with a combination of reanalyses and satellite estimates. Sea ice variability will be examined with daily time series from SSM/I data.
Weather extremes will be studied with observations from synoptic stations available from the National Sea Ice Data Center (NSIDC) as well as from Automatic Weather Stations (AWS)
Mechanisms will be investigated with outputs from several different simulations with the NASA/Goddard Laboratory of Atmospheres (NASA/GLA) general circulation model.

Who will undertake these activities?

Dr. Jones and Dr. Carvalho (UCSB) – project currently unfunded; proposal pending with the U.S. National Science Foundation (NSF)

Expected scientific outcomes/deliverables

The results of this project will provide a cohesive understanding of intraseasonal–to–interannual variations in the AAO, their associations with tropical–extratropical interaction, provide an enhanced characterization of the coupling with air_sea interaction processes (e.g. surface radiation and heat fluxes) and augment our

comprehension of the relationships between AAO, sea ice extension and extreme weather events in the southern oceans and Antarctica.

Timescale

2005-2008 Perform observational and modelling analyses

Milestones

Theme 2 - Global and regional climate signals in ice cores

Scientific Activities

Implementation/methodology i.e. planned field work, modelling studies

Who will undertake these activities?

Expected scientific outcomes/deliverables

Timescale

Milestones

Theme 3 - Natural and anthropogenic forcing on the Antarctic climate system

Scientific Activities

Implementation/methodology i.e. planned field work, modelling studies

Who will undertake these activities?

Expected scientific outcomes/deliverables

Timescale

Milestones

Theme 4 - The export of Antarctic climate signals

Scientific Activities

Implementation/methodology i.e. planned field work, modelling studies

Who will undertake these activities?

Expected scientific outcomes/deliverables

Timescale

Milestones

USA (Ice core contribution)

Form completed by (name, institute) –

Dr. Paul Andrew Mayewski (Climate Change Institute, University of Maine)

Dr. Eric Steig (University of Washington)

Dr. Kendrick Taylor (Desert Research Institute, University of Nevada)

Theme 1 - Decadal time scale variability in the Antarctic climate system**Scientific Activities**

1. Investigation of the reasons for decadal time scale variability in the Antarctic climate system
2. Determination of the role of tropical forcing in dictating decadal time scale variability.
3. Quantification of the atmospheric and oceanic links between the Antarctic climate and extra-polar conditions, and determination of the mechanisms that control the high-low latitude teleconnections.

Implementation/methodology i.e. planned field work, modelling studies

1. Collection of 200-2000 year long ice cores in West and East Antarctica as part of on-going ITASE and plenary IPICs activities in addition to ~100,000 year long record from inland West Antarctic deep drilling site.
2. Development of instrumentally calibrated ice core climate proxies using NCEP/NCAR reanalysis and in cooperation with British Antarctic Survey (ERA-40 reanalyses).
3. Case studies of the impact of ENSO, Amundsen Sea Low, and volcanic events over West Antarctica.

Who will undertake these activities?

Several US institutions under the auspices of the Office of Polar Programs, US National Science Foundation.

Expected scientific outcomes/deliverables

1. Insight into annual to multi-decadal scale responses to climate change.
2. Insight into the mechanisms that are responsible for varying the Antarctic climate on a range of time scales.

Timescale

2005-10 – Shallow to deep ice coring collection and analyses.

Milestones

2005 – 10 – papers on natural climate variability – response and forcing (several in press in dedicated Annals of Glaciology)

Theme 2 - Global and regional climate signals in ice cores

Scientific Activities

1. Synthesis of global scale Holocene climate records (including papers in press 2004-2005).
2. Construction of forcings and climate for the Holocene and beyond from the collaborative ITASE – inland West Antarctic deep drilling.

Implementation/methodology i.e. planned field work, modelling studies

1. New Holocene-glacial ice core record by drilling to bedrock at inland West Antarctic site.
2. New associated lake, ice core, and marine sediment cores from East-West Antarctica through the Americas to the Arctic.
3. Analysis (in collaboration with others) of already-collected ITASE cores
4. Process and statistical studies to extract new proxies from ice core chemical data

Who will undertake these activities?

Several US institutions as part of its IPICs, ITASE, ICARA activities, which is funded from 2005-2010.

Expected scientific outcomes/deliverables

1. Understanding, based on well-dated and synthesised records, of the Holocene climate of the Antarctic, and how it relates to Holocene climate and forcing elsewhere.
2. A determination of where, on a transect from West Antarctica through the Americas, an Antarctic pattern of climate gives way to a more northern pattern.

Timescale

2005/2010	Drilling of ice and lake cores
2006/2010	Synthesis of climate records

Milestones

2005: Completion of West Antarctic ITASE ice cores

2010: Completion of East Antarctic ITASE cores and inland WAIS deep core

Theme 3 - Natural and anthropogenic forcing on the Antarctic climate system***Scientific Activities***

Assimilation of ice core and other climate proxy data into global-scale climate analyses, ranging from statistical models to fully coupled ocean-atmosphere general circulation models, and use of these products in investigating past Antarctic climate on long timescales, and in projecting future Antarctic climate.

Implementation/methodology i.e. planned field work, modelling studies

1. Incorporation of Antarctic ice core and other climate proxy data into global statistical reconstructions of past climate.
2. Implementation of relevant tracer transports schemes in state-of-the-art climate models (NASA/GISS, NCAR-CCSM3), and validation against the proxy data and proxy-based reconstructions.
3. Investigation of Antarctic climate sensitivity to various model scenarios, on both short (interannual) and long (>millennial) timescales, and comparison with results from ice cores.
4. Use of these models to project future climate in the Antarctic.

Who will undertake these activities?

Various US investigators!

Expected scientific outcomes/deliverables

1. Improved understanding of annual to millennial-scale climate variability.

Input from the ASPECT Project

Theme 1 - Decadal time scale variability in the Antarctic climate system

Scientific Activities

1. Evaluate sea ice thickness and physical properties in order to characterize mechanisms of growth and decay and the roles of both the ocean and atmosphere in the sea ice annual cycle.
2. Determine ice and snow thickness responses, as well as ice extent and concentration, related to decadal scale variability in the Antarctic climate system, both atmospheric and oceanic.

Implementation/methodology i.e. planned field work, modelling studies

- **Winter**-(pre-IPY) Sept-Oct 2006 POLARSTERN CryoWedd, Sea Ice and Oceanography in the Weddell Sea (0 to 60W) helicopter borne EM measurements of ice thickness, and drilling and coring, snow thickness and ice elevation surveys to validate Cryosat
- **Winter**-July-August 2007 Aurora Australis-Use of Autosub AUV for uplooking sonar measurements of sea ice draft and detection of krill under sea ice in the 90-120E sector (S.Indian Ocean),ship-based programs of ice observations and surface measurements
- **Winter**-Aug-Sept 2008 NB Palmer-Autosub transects for sea ice draft and oceanography into Ross Sea and Terra Nova Bay Polynyas (PolyAnna project under SASSI)
- **Spring and Summer** 2007-2009 Ice Observations using ASPeCt protocols to determine ice thickness on logistic and research ships, during operations along the ice edge (China) and into coastal stations by various countries during spring and summer (AU, GER,CH,JP,US,IT,etc)
- **Year-round** 2007-2009 Upward looking Sonar (ULS) from moorings in the Weddell Sea to measure sea ice draft (0 to 60W longitude)

Who will undertake these activities?

Participation with vessels for winter operations are Germany, Australia and USA. Vessels for summer operations additionally from China, Japan, Italy, and Russia.

Expected scientific outcomes/deliverables

Knowledge of the response of the sea ice thickness distribution, as well as the extent and concentration, to atmospheric and oceanic driving. Establishment of a quantitative base for circumpolar ice thickness for comparison to the ASPeCt ice thickness distribution derived from ship observations in the past and for future determinations of the thickness distribution that will be available from validated satellite altimetric observations. Comparisons of altimetric derived ice thicknesses with prior ship observations will provide ice thickness variability for a thirty year record in selected areas providing some possibility of interdecadal variability determination in sea ice thickness.

Timescale

2006-2009, various cruises for determination of regional ice thickness distributions and satellite validation

Milestones

Use of Autosub AUV for regional determination of the ice thickness distribution-2007
Validation of satellite altimetry for mean ice thickness with AUV draft measurements-2007-2008

Establishment of a circumpolar ice thickness distribution based on composites of ice observations, AUV profiles, validated satellite imagery-2009

Intercomparisons with past transects from ship observations for interannual differences in ice thickness-2009

Theme 2 - Global and regional climate signals in ice cores

Scientific Activities

Determine the relationship of present day sea ice formation and evolution processes to sea ice biology and biogeochemistry for CO₂ fluxes and interpretation of DMSP signals in continental ice cores as a measure of sea ice conditions in past climates.

Determine regional variability in the biogenic gas production, as a function of ice age, type and formation and decay conditions. Assess frostflower formation on new ice in coastal polynyas for interpretation of sea salts in ice cores.

Implementation/methodology i.e. planned field work, modelling studies

Participate in cruises in Antarctic sea ice regions for ice sampling studies. These are:

- **Winter**-July-August 2007 Aurora Australis- Sample sea ice in the 90-120E sector (S.Indian Ocean) from a ship-based programs of ice observations and surface measurements
- **Winter**-Sept-Oct 2007 NB Palmer-SIMBA Drift Station and Buoy Array- (~70-80W) at the eastern edge of the Amundsen Sea Sample sea ice along with a ship-based programs of ice observations and surface measurements
- **Winter**-Aug-Sept 2008 NB Palmer-Autosub Sea ice sampling and open water sampling in the Ross Sea and Terra Nova Bay Polynyas (PolyAnna project) for new ice formation and frostflower estimation and production of phytoplankton in polynyas
- **Year-round** Participate in ice coring and sampling activities based at stations in the Antarctic Fast Ice Network for measurement of sea ice biology and biogeochemistry. Determine CO₂ fluxes and production of biogenic gases to determine whether fast ice productivity contributes to DMSP signal in ice cores.

Who will undertake these activities?

Biogeochemistry of Antarctic Sea Ice in the Climate System (BASICS) project is a subprogram of the overarching program, Antarctic Sea Ice in IPY. It is headed by J.L. Tison (Belgium) with initial participation from Germany, USA, Australia, UK, and Netherlands. These nations will participate in the drifting pack ice cruises. Other nations involved in maintaining coastal stations in the fast ice network are additionally Japan, China, France, and Russia.

Expected scientific outcomes/deliverables

Determination of regional and seasonal contribution of CO₂ exchange in ice-covered regions and any differences between drifting pack and fast ice. Determination of regional and seasonal biogenic gas production and, together with any seasonal distributions seen in ice cores, partitioning of the DMSP contribution between pack ice biology, outer ice edge biology and production in coastal polynyas.

Timescale

Field experiments are proposed for Sept-Oct 2006, July-Oct 2007 and August-Sept 2008

MilestonesDrifting Pack Ice

Cruises in austral winters of 2006, 2007, 2008

Data Analysis completed for circumpolar work 2009

Antarctic Fast Ice Network

Recruitment of coastal station participants-Dec 2005 workshop

Establishment of coastal station sites Jan-Feb 2007

Workshop on coastal station data sets –March 2009

Workshop on sea ice biology and biogeochemistry in fast ice 2009

Joint Activities- Drifting Pack and Fast Ice

Joint workshop on pack ice and fast ice sea ice biology and biogeochemistry early 2010

Development of partition functions for contributions of ice edge, polynyas and sea ice biology to ice cores late 2010

Theme 3 - Natural and anthropogenic forcing on the Antarctic climate systemScientific Activities

Measure sea ice deformation and kinematics to examine seasonal and annual variability in the Antarctic sea ice deformation field in the region.

Determine the full role of high frequency driving (tidal and inertial oscillations) in the sea ice drift and deformation fields on a seasonal basis, first, during freezing and then, during melting conditions and regional variability in high frequency deformation.

Combine buoy and satellite deformation measurements, together with in situ mass balance measurements, to provide an annual data set on sea ice thermodynamics and dynamics for comparison with coupled atmosphere-ice-ocean models.

Implementation/methodology i.e. planned field work, modelling studies

- **Summer**-Feb-March 2007- NB Palmer-Sea Ice Buoy Emplacement on Amundsen Sea pack ice during Pine Island oceanography cruise (~70W)
- **Winter**-Sept-Oct 2007 NB Palmer-SIMBA Drift Station and Buoy Array- Time series measurements of sea ice using repeated surveys during 30 day drift station and mass balance and drift buoys for sea ice thermodynamics, kinematics and deformation for up to one year. Initial emplacement (~70-80W) at the eastern edge of the Amundsen Sea
- **Modelling**-Use of data for development and validation of the coupled air-ice-ocean model (BRIOS model at Alfred Wegener Institute) and development/validation of finite element code for modeling sea ice interactions at high-resolution temporal and spatial scales.

Who will undertake these activities?

Oceanography and sea ice programs will be undertaken on US vessel NB Palmer with Stan Jacobs (Feb-March 2007) and Stephen Ackley (Sept-Oct 2007) as Chief Scientists. Modelling efforts will be led by Hartmut Hellmer (Alfred Wegener Institute). Other international participants includes Peter Wadhams (UK) , Matti Lepparanta (Finland) and Christian Haas (Ger).

Expected scientific outcomes/deliverables

Comparison of buoy-derived and satellite-derived ice motion and deformation parameters will determine the effects of higher scale phenomena such as tidal and inertial driving, and mesoscale ice dynamics on these fields.

Validation of high and lower resolution modeling will extend these measurements to computation of seasonal, interannual and decadal scale fluctuations in driving and response of sea ice fields.

Timescale

Experimental periods are 2007 for ship-based work and 2007-08 for buoy arrays. Data analysis and model development and validation will occur in 2008 and 2009.

Milestones

Submission of proposal for SIMBA Drift Station to NSF-June, 2005
 Approval of NSF proposal for SIMBA Drift Station-Jan 2006
 First Buoy Deployment Cruise-Feb-March 2007
 Ship-based Drift Station and final buoy deployment-Sept-Oct 2007
 Completion of expected buoy array lifetime- Sept 2008
 Data Analysis of Ship-Based Measurements-Jan-Dec 2008
 Data Analysis of Buoy and Satellite Data-June 2009
 Model Development and Validation-Completed June 2009

Theme 4 - The export of Antarctic climate signals

Scientific Activities

Combine sea ice thermodynamic and dynamic measurements to assess the thermal and deformation contributions to the ice thickness distribution and the sea ice mass balance. Ice growth and decay determines the salt flux/ freshwater budget for the southern sea ice region. These signals are then propagated into the deep ocean as bottom water signals or as contributions to the freshwater flux and cooling of surface waters in sea ice melt regions.

Implementation/methodology i.e. planned field work, modelling studies

Measurements of mass balance will be made using repeated profile methods at a fixed ice floe location and temporary installations of thermister strings for ice growth, conversion of flooded snow into sea ice and ice decay from ocean heat flux.

Automatic measurements of mass balance, ocean heat flux, snow depth and surface heat flux will be made from an array of mass balance buoys, extending over a 1 year time frame in the drifting pack.

Measurements will be taken for fast ice contributions at locations at or near coastal stations for heat fluxes, ice growth and decay. These will be taken year-round at a circumpolar set of manned stations.

Who will undertake these activities?

The ship-based drift station and buoy array, oceanography and sea ice programs will be undertaken on US vessel NB Palmer with Stan Jacobs (Feb-March 2007) and Stephen Ackley (Sept-Oct 2007) as Chief Scientists.

The coastal station work will be part of a developing IPY project under Antarctic Sea Ice in IPY and called the Antarctic Fast Ice Network. This effort is led by Petra Heil (Australia) with participation proposed for stations from Australia, USA, New Zealand, Japan, Russia, China and Germany.

Expected scientific outcomes/deliverables

Intercomparison of buoy-derived and satellite-derived fields for surface fluxes in ice-covered areas will contribute to understanding of sea ice mass balance and consequent effects on air-sea interaction in these regions.

Knowledge of the sea ice mass balance determines the salt flux/ freshwater budget for the southern sea ice region. These signals are then propagated into the deep ocean as bottom water signals or as contributions to the freshwater flux in surface waters in sea ice melt regions.

Contribution of coastal regions with fast ice to the ice mass balance, including accumulation of platelet ice associated with interaction with ice shelves. These transformations of upwelled water from ice shelves and development of platelet ice

are contributors to Ice Shelf Water characteristics. This water mass is also a contributor to Antarctic Bottom Water and is exported from the polar regions throughout the world ocean.

Timescale

Field season of 2007-2008 for ship-based work. Installation of mass balance buoys in late 2007, expected lifetime through 2008.

Continuous effort at manned stations through the period 2007-2009 resulting in over two years of coordinated measurements.

Milestones

Antarctic Fast Ice Network

Recruitment of coastal station participants-Dec 2005 workshop

Establishment of coastal station sites Jan-Feb 2007

Workshop on coastal station data sets –March 2009

Drift Station

First Buoy Deployment Cruise-Feb-March 2007

Ship-based Drift Station and final buoy deployment-Sept-Oct 2007

Completion of expected buoy array lifetime- Sept 2008

Data Analysis of Ship-Based Measurements-Jan-Dec 2008

Data Analysis of Buoy and Satellite Data-June 2009