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SCAR report

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Contents

Implementation Plans of SCAR's Scientific Research Programmes:

SCIENTIFIC COMMITTEE ON ANTARCTIC RESEARCH

at the

Scott Polar Research Institute, Cambridge, United Kingdom

SCAR Report

SCAR Report is an irregular series of publications, started in 1986 to complement SCAR Bulletin. Its purpose is to provide SCAR National Committees and other directly involved in the work of SCAR with the full texts of reports of SCAR Standing Scientific Groups and Group of Experts meetings, that had become too extensive to be published in the Bulletin, and with more comprehensive material from Antarctic Treaty meetings.

SCAR Bulletin

SCAR Bulletin, a quarterly publication of the Scientific Committee on Antarctic Research, carries reports of SCAR meetings, short summaries of SCAR Standing Scientific Groups, Action Groups and Groups of Experts meetings, notes, reviews, and articles, and material from Antarctic Treaty Consultative Meetings, considered to be of interest to a wide readership.

Antarctic Climate Evolution (ACE)

Implementation Plan

Executive summary of ACE implementation plan

- A 11-person steering committee is proposed to include a range of expertise sufficient to lead the programme.
- Six sub-committees are being established to implement the science programme. Membership of these committees allows ACE to widen involvement in the programme in terms of expertise, gender and nationality.
- ACE steering committee officers have a 3-year term of office (co-Chairs will stand down in 2008). The sub-committee structure of ACE allows future involvement in the steering committee from a wide-range of scientists.
- A website has been constructed to inform the public, media, schools and colleges, and scientists about the progress of the project (www.ace.scar.org).
- ACE has already established a strong record of publishing scientific findings in peer-reviewed journals (e.g. papers in Nature and Geology, plus special issues of Global and Planetary Change, vol. 45, 2005, and Palaeogeography, Palaeoclimatology, Palaeoecology, vol. 198, in press). An edited book on ACE is being planned for publication in 2007.
- A timetable of activity has been defined, and dates/locations of forthcoming meetings have been coordinated with major international symposia.
- Plans for outreach, education and data management are in line with SCAR advice.

Approach to implementation

We propose that the ACE Scientific Research Programme be led by a steering committee of 10-12 persons. The committee would meet formally at least once a year, and conduct the rest of its business either remotely or when the majority of committee members are present at international symposia. Members will serve for a 3-year term, with the possibility of extension depending on contribution and performance. We propose that Martin Siegert and Robert Dunbar be identified as co-Chairs, to be replaced in 3 years time. The steering committee (membership of which is detailed below) has a wide knowledge of thematic issues and has appropriate regional (field), technical and logistical experience.

Committee

The following persons are nominated as the initial steering committee of ACE:

Martin J. Siegert – University of Bristol, UK	co-chair
Robert B. Dunbar – Stanford University, USA	co-chair
Robert M. DeConto – University of Massachusetts, USA	media and website
Fabio Florindo – Istituto Nazionale di Geofisica e Vulcanologia, Italy	secretary
Jane Francis – University of Leeds, UK	
Damian Gore – Macquarie University, Australia	
Carlota Escutia – University of Granada, Spain	
Robert Larter – British Antarctic Survey, UK	

Ross D. Powell – Northern Illinois University, USA
Sandra Passchier – Montclair State University, USA
Gary Wilson – University of Otago, New Zealand
Rob Bauer – US National Snow And Ice Data Centre, USA data management

Function of the programme and sub-committees

The central function of ACE is to coordinate the integration of improved geological data and Antarctic palaeoclimate modelling for a series of time periods from the onset of glaciation around the Eocene-Oligocene boundary 34 Ma ago, to the last glacial maximum (LGM) and the establishment of the present ice sheet configuration. Six subcommittees have been set up to coordinate scientific work within these timeframes. The sub-committee names, and their current chairs, are as follows:
LGM-Holocene Chair: Tony Payne (UK)
Pleistocene Chair: Tim Naish (NZ)
Middle Miocene-Pliocene Chair: Alan Haywood (UK)
Oligocene-Miocene Chair: Rob DeConto (USA)
Eocene/Oligocene Chair: Jane Francis (UK)
Radio-Echo Sounding Chair: Detlef Damaske (Germany)

Terms of reference for sub-committees

The sub-committees provide the overall leadership, direction and management for their respective topics. The main functions of the committees are to:

- Develop and implement an action plan.
- Encourage and facilitate communication and collaboration among research scientists working on any aspects of Antarctic climate evolution pertinent to the respective topic.
- Ensure that activities of the committee are communicated and wherever possible, integrated with those of other time-based themes, modelling themes and process-based themes of the ACE programme.
- Investigate, develop and exploit avenues for future funding in support of ACE objectives.
- Advise the research community on the types of geoscience data required for palaeoclimate modelling and effective model-data intercomparison, and the critical locations for which such data are needed for the time periods listed.
- Provide advice/assistance as needed on technical issues related to geoscience field and laboratory programmes and to palaeoclimate modelling studies pertinent to the time periods listed.
- Promote data access and data sharing (and data-contributions to the SDLS, Antarctic data centres, and World Data Centres [WDC]) to facilitate and expedite data syntheses needed for developing new field programmes and enhancing palaeoclimate models.
- Summarize and report the results of these efforts to the scientific and wider community on an ongoing basis at workshops and symposia.
- Contribute to formal reporting that will be presented to SCAR every two years.

LGM-Holocene ACE sub-committee

Rationale: The ice sheets of Antarctica were so much larger at the last glacial maximum (LGM, ~21,000 years) than today that global sea level dropped by around 20 m (around 1/6th the sea-level fall from all the world's ice sheets). The ice sheets at the LGM left a wealth of geological data, which can be used to constrain, validate and test numerical ice-sheet/climate models. Such work is critical to evaluating the evolution and stability of the present ice sheet. There are many questions to be answered with respect to the ice sheet configuration and flow at and after the LGM. The keys to answering the questions are (1) to enhance the sophistication of the models, and (2) to integrate geological data on past ice sheet and climate conditions with model output. The LGM-Holocene sub-committee will facilitate the co-ordination of research agendas in the following areas:

- Numerical modelling of the Antarctic ice sheet with special application to the causes of grounding-line evolution during deglaciation.
- The use of Earth-System models (in particular, coupled ocean-atmosphere GCMs) to understand climate change in the circum-Antarctic region from the LGM onwards, and the implications of these changes for the ice sheet.
- The integration of the on-shore and off-shore geomorphological records of ice thinning and grounding-line retreat.
- The integration of long-term sea-level records with inverse geophysical modelling to constrain mass loss from Antarctica.
- The development of high-resolution palaeo-climate records from ice cores and deep-sea cores from the Southern Ocean, and the development of a consistent chronology to link individual records.

The sub-committee will focus attention on the following open research questions: Has grounding-line retreat stopped? Can present-day changes be attributed to on-going retreat? How synchronous was deglaciation in the various sectors of the ice sheet? To what extent does the geomorphology reflect local rather than regional effects? What caused deglaciation? Can high-resolution chronologies be used to distinguish between the effects of sea-level rise and accumulation-rate change? What is the role of ice streams in controlling the rate of grounding-line retreat and volume loss? To what extent are ice streams transients features within the ice sheet and what are the controls on their long-term dynamics? What was the contribution of the ice sheet to eustatic sea-level rise and how was this contribution distributed spatially and temporally?

The sub-committee will convene dedicated sessions at relevant international scientific conferences such as the AGU, EGU, INQUA and IGS; making research grant proposals to the relevant national funding agencies with particular reference to the forthcoming IPY; and jointly co-writing a chapter reviewing modelling and observational literature for the LGM-Holocene as part of a dedicated ACE edited volume. The sub-committee will meet occasionally, primarily during larger international conferences and will seek funds from ACE itself to facilitate this.

The sub-committee as expertise in: the numerical modelling of ice sheets and palaeo-climate; ice and deep-sea sediment core records; on-shore and off-shore geomorphology; and sea-level records and modelling.

Committee membership: Tony Payne (Chair, UK); Philippe Huybrechts (Belgium); Catherine Ritz (France); David Pollard (US); Colm O'Cofaigh (UK); Mike Bentley (UK); Howard Conway (US); Eric Wolff (UK); Glenn Milne (UK); Rob Dunbar (US)

Pleistocene ACE sub-committee

Rationale: Studies of Antarctic ice cores show that Pleistocene climate variability between hemispheres has occurred out of phase. This variability raises questions about the response of the southern high latitudes to external climate drivers, such as orbital insolation, solar variability, and internal amplifiers such as thermohaline circulation and carbon-cycle changes that operate at both Milankovitch and millennial-decadal time scales. Answers to these questions will improve our understanding of the vulnerability of the ice sheet during Pleistocene climatic optima and its potential impact on (1) global thermohaline circulation as a southern source of melt water discharge, and (2) sea level rise well beyond the present sea level stand. The Pleistocene sub-committee will facilitate Antarctic and global environmental research investigating:

- The interval of Late-Pliocene global cooling co-incident with development of a bi-polar cryosphere (working jointly with the Mid-Miocene Pliocene sub-committee).
- The period of Mid-Pleistocene reorganisation of the climate system (1.0-0.4 Ma) – Mid-Pleistocene Climate Transition (MPCT).
- Major glacial terminations and super-interglacial periods (e.g. marine isotope stages 31, 11, 9 and 5) of extreme climatic warmth.

The primary focus of this sub-committee is to provide new knowledge of the role the Antarctic in the bi-polar cryosphere. It will take an integrated approach which combines atmospheric (ice core), proximal marine (SHALDRILL, ANDRILL, ODP), distal deep marine (ODP), and far-field seal-level (Wanganui Basin, Huon Peninsula etc.) records to provide boundary conditions and constraints for Earth system and climate modelling studies. In particular the committee is interested in the influence of Pleistocene Antarctic ice cover on global sea-level and ocean circulation. To achieve these scientific ambitions the committee will:

- Integrate existing datasets with new proximal datasets from EPICA, SHALDRILL, ANDRILL and ODP/IODP to determine ice sheet/shelf responses to climate forcing, including variability at a range of temporal scales (10^2-10^4 years), and possible collapses.
- Relate Antarctic ice variability to thermohaline circulation as expressed by variations in abyssal Pacific inflow along eastern New Zealand to the Pacific Ocean (ODP Leg 181 datasets).
- Synthesise global proxy data for key climatic transitions (Late Pliocene, Mid-Pleistocene, Late Pleistocene termination-interglacial).
- Undertake numerical modelling studies of ice sheet dynamics and global climate for these transitions.

Committee membership: Tim Naish (NZ Chair); Lionel Carter (NZ); Eric Wolff (UK); Andrew Mackintosh (NZ); Ross Powell (US); Rainer Gersonde (Germany); Gary Clarke (Canada); John Chappell (AUS); Stuart Henrys (NZ); Reed Scherer (US); David Pollard (US); Ian Hall (UK)

Middle Miocene-Pliocene ACE sub-committee

Rationale: The middle-to-late Miocene period represents a time of significant ice sheet expansion in Antarctica. The sea stable isotope record shows a mid-Miocene "climatic optimum" centred at about 15 Ma, followed by strong enrichment of oceanic _^{18}O over the next 6 Ma. It is during this interval that East Antarctic glacial ice is thought to have evolved into a major and permanent ice sheet. The Pliocene Epoch is a critical time for understanding the nature of the Antarctic ice sheet as IPCC projections of global temperature rise suggest that we will exceed Pliocene levels within the next hundred years. Of key importance in this time interval is the timing of the transition of the EAIS from a polythermal, dynamic condition to a predominantly cold stable state. Two opposing and vigorously defended views prevail. The long-standing view is that the EAIS became stable in mid-Miocene time, evidence of which is primarily from the longevity of the landscape and well-dated surfaces and ash deposits in the Dry Valleys region along the western border of the Ross Sea. Another controversial view is that terrestrial glacial deposits, known as the Sirius Group, scattered through the Transantarctic Mountains, indicate dynamic ice sheet conditions as recently as Pliocene time. The Mid Miocene and Pliocene ACE sub-committee will facilitate Antarctic and global environmental research investigating:

- The period of middle Miocene cooling.
- The period of late Miocene cooling.
- Pliocene warm periods.
- The Pliocene - Pleistocene transition (working jointly with the Pleistocene sub-committee).

In particular the committee will co-ordinate and input relevant research activities for the Neogene from the British Antarctic Survey core programme GEACEP (Greenhouse to Ice-house Evolution of the Antarctic Cryosphere & Palaeoenvironment). These efforts will include:

- New data acquisition from the Ross Sea region as well as the Antarctic Peninsula in general.
- Data synthesis of global proxy climate and environmental data for the Mid Miocene, Late Miocene, Pliocene and the Plio-Pleistocene transition.
- Earth System Modelling studies for the Mid and Late Miocene cooling, Pliocene warming and the Plio-Pleistocene transition.

Provisional committee: Alan Haywood (UK); John Smellie (UK); Allan Ashworth (USA); Paul Valdes (UK); Sandra Passchier (the Netherlands); Carrie Lear (UK); David Cantrill (Sweden)

Oligocene-Miocene ACE sub-committee

The Oligocene-Miocene boundary marks a significant transition in the development of the Antarctic cryosphere, where small dynamic ice sheets of the late Oligocene rapidly expanded to continental scale in the early Miocene. Sediment cores recovered in Western Ross Sea indicate orbital modulation of the ice sheet during the transition. It is argued that the transition occurred as a consequence of a unique set-up of orbital parameters during an interval of declining CO2 that led to a prolonged period of cold

summer orbits, during which time a large ice sheet established. The main functions of the committee are to develop and implement environmental research investigating:

- The Eocene-Oligocene climate transition and earliest Oligocene glaciation
- The nature and timing of Oligocene ice sheet variability.
- The response/role of Antarctica in possible Late Oligocene global warming.
- Transient cooling events including the Mi1 glaciation.
- The nature of early Miocene ice sheet variability.
- The Mid-Miocene Climate Optimum (MCO) and it's signature in Antarctica.
- Mid-Late Miocene cooling and stepped ice volume increase (working jointly with the Miocene-Pliocene sub-committee chaired by Dr Alan Haywood*).*

Emphasis will be placed on understanding Antarctica's role in (and response to) fundamental climate transitions and ephemeral events through the late Paleogene and early Neogene. This will be accomplished through the synthesis of newly acquired data from Antarctic field investigations with data from ongoing deep sea drilling expeditions and sequence stratigraphic reconstructions of eustasy. These synthesized data will be integrated into numerical modelling studies to 1) test data-driven hypotheses, 2) explore the envelope of climate-cryosphere behaviour in response to specific forcings, and 3) to explore possible mechanisms and feedbacks responsible for the dramatic Antarctic and global environmental changes recognized in Paleogene and Neogene proxy climate records.

Committee membership: Robert DeConto (chair) USA; David Pollard (proposed) Penn State University, USA; Matthew Huber (proposed), USA; Steve Pekar, USA; David Harwood (proposed), USA; Catherine Stickley (proposed), UK; Katarina Billups, USA. Members from other nations are TBA.

Eocene-Oligocene ACE sub-committee

Rationale: The Eocene-Oligocene interval was a critical time in Antarctica's geological history because it involved a fundamental climate change that saw the end of the Mesozoic greenhouse (ice-free) climate and the birth of our present icehouse world. The Eocene climate record in Antarctica is represented by sediments and fossils, including rich assemblages of fossil plants, that signal warm temperate climates to latitudes as high as ~65-70°S 50 million years ago. By the latest Eocene climates had cooled and ice formed at sea level in Antarctica, as shown by glacial sediments. The ice sheets expanded as the Oligocene climate cooled further. The programme of activity will include the following:

- Compilation of data on existing Eocene and Oligocene geological proxies for climate from Antarctica. Time intervals of interest include: (1) Early Eocene peak greenhouse warmth; (2) Latest Eocene-Oligocene onset of glaciation; (3) Oligocene climate cooling.
- Interpretation of palaeoclimate for this interval from proxy data.
- Analysis of global linkages, particularly from the marine isotope record.
- Publication on Eocene-Oligocene climates of Antarctica and global links.
- Comparison with climate-vegetation model outputs.

Provisional committee: Jane Francis (UK); Sergio Marenssi (Argentina); Vanessa Thorn (NZ); Mike Hambrey (UK); Jim Zachos (USA); Henk Brinkhuis (the Netherlands), Barbara Mohr (Germany)

Radio-echo sounding ACE sub-committee

Rationale: Radio-echo sounding is critical to the ACE programme in that it provides data on subglacial topography and conditions, which are essential to models of the ice sheet. RES data also provide information on internal ice sheet layering which can also be used to validate ice sheet models and investigate flow and accumulation conditions during the Pleistocene. RES can also offer information about ancient landscapes, which is relevant to ice sheet history over much longer timescales. Several significant regions of Antarctica have yet to be surveyed using RES. Such data gaps lead to fundamental problems in ice sheet model boundary conditions. These gaps lie predominantly in the Antarctic interior, where field logistics are difficult to coordinate. The IPY may be used to stimulate data acquisition in these areas. Existing proposals such as GigaGAP and ICECAP are in an advanced stage of development. The ACE-RES subcommittee will act to encourage the use of RES in Antarctica and bring together new RES projects to coordinate activities. The outcome of this sub-group will be to complete the RES coverage of the ice sheet, and supply information to the Antarctic ice sheet modelling community. The action plan, to be developed over the summer 2006, includes the following:

- Establish an up-to-date overview of RES surveys.
- Develop a simple questionnaire to be sent to all possible scientists holding RES data acquired after the last SCAR-BEDMAP update.
- Update BEDMAP if possible (renew the BEDMAP initiative within SCAR).
- Check all IPY proposals with regard to RES. Establish contact to these groups - keep track on these activities.
- Distribute information on RES surveys to the community to establish contacts between scientist acquiring RES data, and to make the data available to ice-sheet modellers.

Committee membership: Detlef Damaske, Germany; Ian Allison (Australia); Don Blankenship (USA); Robert Bindschadler (USA) (for IPY Mass Balance); Sun Bo (China); Heinz Miller (Germany)(for IPY Traverses); Ignazio Tabacco (Italy); David Vaughan (UK)

Data management

Successful development, testing and refinement of palaeoclimate models depend on the accessibility of relevant observational data. Therefore ACE will encourage responsible archiving of data and samples to established data centres and repositories. Furthermore, through its website, ACE will establish a directory of such data centres and repositories to help researchers locate the data they need. ACE will also foster continued development of the Antarctic Data Library System for Cooperative Research (SDLS), which was set up under the former SCAR-ANTOSTRAT project. The SDLS now contains most of the processed data from marine multichannel seismic surveys that have been carried out around Antarctica.

Rob Bauer, from the Joint Committee on Antarctic Data Management, will inform and guide the ACE programme on data management issues. Ron Bauer will ensure that ACE promotes data access and data sharing (and data-contributions to the Antarctic Master Directory (AMD), the Antarctic Data Library System for Cooperative Research (SDLS), the (national) Antarctic data centres (NADC), and World Data Centres [WDC]) to facilitate and expedite data syntheses needed for developing new field programmes and enhancing palaeoclimate models.

ACE and the International Polar Year (IPY)

The IPY provides a unique opportunity to plan, fund and undertake international collaborative research in the polar regions. By the time of IPY (2007-8), the ACE programme will be fully functioning. It is therefore highly appropriate that ACE, as an existing major international Antarctic research programme, seeks to become involved in IPY research in order to fulfil the ambition of this intense period of investigation. ACE has been acknowledged as a potential IPY core programme, following assessment of our 'expression of intent'. ACE is in the process of forming a full IPY proposal to be submitted on 30 June 2005.

Links to other SCAR programmes

ACE has formal links with three other SCAR SRP proposals. The first is Subglacial Antarctic Lake Environments (SALE), the second is Antarctica and the Global Climate System (AGCS) and the third is Evolution and Biodiversity in Antarctica (EBA).

ACE and SALE will interact in three ways. First, the palaeoclimatic record contained in subglacial lake sediments will provide important new information from the interior of the continent. ACE and SALE will collaborate on the acquisition of such records. Second, the ice sheet history quantified through numerical modelling as part of the ACE programme will offer important constraints on the formation and development of subglacial lake environments. ACE will provide SALE with model results in order for the history of subglacial lakes to be established in the context of ice sheet and climate evolution. Third, the radio-echo sounding exploration of Antarctica planned by ACE will uncover the locations of subglacial lakes and the basal ice sheet conditions that govern their existence. We will provide SALE with such information to assist the planning of subglacial lake exploration.

Investigating Antarctic history over glacial-interglacial periods is appropriate to the study of both modern and ancient environments. ACE and AGCS aim to investigate this history as a component of much broader and distinct science plans. Further, each SPPG has compatible yet discrete specialisms that are well suited to studying the glacial-interglacial history of Antarctica. ACE contains expertise in ice-sheet/climate modelling, marine and terrestrial geology, marine geophysics and radio-echo sounding. AGCS includes expertise in atmospheric modelling and ice coring. This combined expertise covers the full suite of knowledge required to build a sub-committee on the Pleistocene history of Antarctica.

ACE and EBA have mutual interests in understanding past environments. For ACE such work is central to its programme of work. For EBA it is critical to evaluate how and why the present distribution and form of biota exists in Antarctica. Palaeoclimate information,

collected and modelled through ACE will be made available to EBA. Members of EBA have been contacted; we are still waiting to hear from this SCAR programme. Members of EBA will be encouraged to attend ACE meetings to discuss results and inform the ACE community about the various inputs the EBA programme requires.

Links to other international programmes

ACE has relevance to several major international programmes. In particular, several members of the ACE programme are also involved in the Antarctic Drilling Programme, ANDRILL. ANDRILL aims to acquire sedimentary records of past climate change from a variety of locations around the Antarctic Continent. ACE is able to support ANDRILL by offering small funds to assist with meetings, and helping the integration of numerical modelling and geological data. In addition, ACE has good connections with the science programme of the European Project for Ice Coring in Antarctica (EPICA). ACE can assist EPICA by facilitating comparison, integration and modelling of EPICA (and other ice coring) results with palaeoclimatic data from other sources (e.g. marine and lake sediment cores and terrestrial geological records). In particular, ACE can serve as a means by which the ANDRILL, EPICA and ice sheet modelling communities may integrate.

Outreach and education

ACE will endeavour to support and encourage the next generation of Antarctic scientists in three ways. First, an online lecture series paralleling the findings and outcomes of the ACE programme will be made available to schools, colleges, universities, and natural history museums via the ACE website (www.ace.scar.org). These lecture materials will comprise downloadable power-point presentations, and will match ACE's scientific programme. Second, we will encourage young scientists to take part in ACE workshops by offering bursaries for travel and subsistence. Although the level and number of the bursaries will be dictated by funds available, it is hoped that at least two bursaries will be available for each workshop/meeting. The condition of each bursary will be a report by the holder about their research and workshop experiences, which will be posted on the ACE website. Third, we will facilitate an exchange scheme between our respective institutions to allow young scientists to take part in fieldwork and to sample the research culture of other nations. Similar schemes operate within, for example, the Worldwide University Network, and it is anticipated that external funds (from such schemes) will be used to support the exchanges arranged through ACE.

ACE will liaise with the SCAR office to ensure effective communication and outreach, as set out in the 'SCAR Communications Plan' and 'A Strategy for Capacity Building and Education'.

Symposia and workshops

Workshops and sessions to be organised by ACE include:

- Workshop on the use of ice sheet and climate modelling, Boston 2005-6.
- A session of Pliocene global warming will be convened at the Earth Systems Processes 2 meeting in Calgary, August 2005.

- Sessions on all the ACE sub-committee programmes will be convened at the International Symposium on Antarctic Earth Sciences (USA Santa Barbara, Sept. 2007).
- Paleogene-Neogene climate-ice sheet modelling workshop at the ANDRILL data integration meeting in New Zealand in 2007.
- An international research meeting on the Neogene and Antarctica at Cambridge, UK during the summer of 2008.
- Greenhouse-icehouse transition session at Fall AGU in 2008, focusing on the latest results from numerical climate, cryosphere, and ocean modelling studies.

Funding

Future applications for external funding of ACE activities will include:

- Work on the LGM will be funded initially through a UK-NERC application, organized by Tony Payne.
- Pleistocene work will be funded through applications to ANDRILL (both the McMurdo Ice Shelf Project in 2006-2007 and the Southern McMurdo Sound Project in late 2007), SHALDRILL, IODP, the NZ Marsden Fund and, possibly, IMAGES.
- Both Mid Miocene and Pliocene, and the Eocene-Oligocene work, will be the foci of a future proposal for ANDRILL drilling, aided by a proposed UK-NERC consortium grant.
- RES will be funded by a series of applications to national funding agencies, including the USA, UK and Germany. Much activity will be planned for the IPY period, 2007-9.

Timetable of activities

The tasks, deliverables and time-lines we envisage are outlined in Table 1. This should be viewed as a guide, as it is difficult to be prescriptive in charting future progress in research.

Themes	2005-6	2006-7	2007-8	2008-9	2009-10
Holocene/last glacial maximum/and Pleistocene	Internal layers, ice flow and accumulation reconstruction	Complete review of Antarctic ice sheet – ice shelf – Southern Ocean record	Review of data collected by IMAGES and ANDRILL projects	Assess reviews of Quaternary and Pliocene in light of new data from S Ocean and sub-Ross IS core International meeting on the Neogene and Antarctica, Cambridge, Summer 2008	Publish state-of-the art report on data and modelling AIS history and behaviour from a perspective of both long term (10^3-10^6 years and short-term(1 to 10^2 years)climate change over the last 5 million years
Pliocene	Continue review of sedimentary cores from Legs 178 and 188 (plus sediment cores from national programmes) Continue fostering IODP proposals for Wilkes Land and Ross Sea Earth Systems Processes 2 meeting in Calgary, August	Continue review of sedimentary cores from Legs 178 and188.	Complete review of on-land and offshore record. Revise IODP proposals for Wilkes Land and Ross Sea Develop proposals using SHALDRIL and ANDRILL technologies Convene session at ISAES, Santa Barbara USA		
Middle Miocene	Continue review of sedimentary cores from Leg 188 Continue fostering IODP proposals for Wilkes Land and Ross Sea	Complete review of offshore record – revise IODP proposals for Wilkes Land and Ross Sea Develop proposals using SHALDRIL and Cape Roberts (ANDRILL) technologies	Revise IODP proposals for Wilkes Land and Ross Sea Convene session at ISAES, Santa Barbara USA	International meeting on the Neogene and Antarctica, Cambridge, Summer 2008 Assess reviews in light of new ANDRILL, SHALDRIL and IODP data	Publish state-of-the-art report that includes new data from ANDRILL, SHALDRIL, IMAGES and IODP integrated with modelling AIS history and behaviour for the period from 50 to 10 Ma ago
Oligocene-Miocene boundary			Convene session at ISAES, Santa Barbara USA		
Eocene-Oligocene	Continue review of sedimentary cores from Leg 188 Continue fostering IODP proposals for Wilkes Land and Ross Sea	Paleogene-Neogene climate-ice sheet modelling workshop at the ANDRILL data integration meeting in New Zealand in 2007	Convene session at ISAES, Santa Barbara USA	Greenhouse-Icehouse trans. Session at AGU-Fall meeting, Dec 2008	
Radio Echo Sounding	Analyse existing data to reveal internal layer structure of both ice sheets	Plan future exploratory research	Begin new surveys of East and West Antarctica to fill data gaps Convene session at ISAES, Santa Barbara USA	Continue surveys, and provide data to numerical ice sheet modelling community	Continue surveys, and provide data to numerical ice sheet modelling community

Table 1. Outline of tasks, deliverables and timelines for work to be carried out under the aegis of the ACE programme from 2005 to 2010.

Timetable of steering committee meetings

ACE plans to undertake steering committee meetings at the following dates/locations (many of which will take place around existing conferences).

2005

- August 2005. Aberystwyth, UK. International conference on glacial sedimentary processes and products. Co-sponsored by ACE.
- December 2005. San Francisco, USA. Fall Meeting of the American Geophysical Union.

2006

- July 2006. Hobart, Australia. SCAR Open Science Meeting
- December 2006. San Francisco, USA. Fall Meeting of the American Geophysical Union.

2007

- March 2007. Steering committee meeting to coincide with the start of the IPY in order to coordinate activities during the IPY period. Location TBA.
- August 2007. University of California, Santa Barbara, USA. 10th International Symposium on Antarctic Earth Sciences (ISAES X)

2008

- July 2008. St Petersburg, Russia. SCAR Open Science Meeting.
- December 2008. San Francisco, USA. Fall Meeting of the American Geophysical Union.

Outputs to date

(a) Publications

Special issues of scientific journals:

Florindo, F., Cooper, A.K. and O'Brien, P.E. (Editors), 2003. Antarctic Cenozoic palaeoenvironments: geologic record and models. Palaeogeography, Palaeoclimatology, Palaeoecology, vol. 198, Issues 1-2, 1-278.

Florindo, F., Harwood, D.M., Wilson, G.S. (Editors), 2005. Long-term changes in Southern high-latitude ice sheets and climate: the Cenozoic history. Global and Planetary Change, vol. 45, 1264.

Individual papers in scientific journals:

Barrett, P.J. 2003. Cooling a continent. Nature, 421, 221-223. DeConto, R.M., Pollard, D. 2003a. Rapid Cenozoic glaciation of Antarctica triggered by declining atmospheric CO2. Nature, 421, 245-249.

Taylor, J., Siegert, M.J., Payne, A.J., Hambrey, M.J., O'Brien, P.E., Leitchenkov, G., Cooper, A.K. Late Miocene/early Pliocene changes in sedimentation paths, Prydz Bay, Antarctica: changes in ice-sheet dynamics? Geology, 32, 3, 197-200. doi: 10.1130/G20275.1; 2 figures. (2004).

(b) Other Publications

Florindo, F., Dunbar, R., Siegert, M., DeConto, R., Barrett, P., Cooper, A., Escutia, C., Janecek, T., Larter, R., Naish, T., Powell, R. Antarctic Climate Evolution (ACE) Research Initiative. Terra Antarctica, 9, 127-132. (2003).

Siegert, M.J. Antarctic Climate Evolution: a new research initiative. The EGGS. Newsletter of the European Geophysical Society, issue #6, p17-23. 10 December 2003. (2003).

Sessions of international symposia

Antarctic Climate Evolution, AGU Fall meeting, 2002.
Antarctic Climate, Neogene Proxies, and Climate Modeling. AGU Fall meeting, 2004.
Long-term changes in Southern high-latitude ice sheets and climate, EGU, 2003.
Antarctic cryosphere and Southern Ocean climate evolution (Cenozoic-Holocene), EGU, 2005.

Forthcoming

International Conference on Glacial Sedimentary Processes and Products. University of Wales, Aberystwyth, 22 - 27 August, 2005.

(c) Brochures, posters, press/media articles and similar PR material

(d) Creation of a website

Posters and brochures for ACE have been designed, as has a logo, and these have been disseminated at numerous international conferences over the past four years.
The ACE website is available at www.ace.scar.org

Subglacial Antarctic Lake Environments (SALE)

Implementation Plan

Introduction

The final revision of the Subglacial Antarctic Lake Environments (SALE) proposal was approved as a SCAR Scientific Research Programme at the XXVIII SCAR Delegates Meeting in Bremerhaven, Germany, October 2004.

The first meeting of SALE was convened from 22 -23 April, 2005 and a web site has been established (http://salepo.tamu.edu/scar_sale). Subject to SCAR Executive Committee approval of the membership roster, J Priscu and M Kennicutt II have agreed to continue as Convener and Secretary of SALE, respectively. The Secretary has also been assigned the duties of SALE Treasurer and maintainer of the SALE website.

A recommended membership list has been provided to the SCAR Executive for consideration. The proposed SALE membership has been expanded from the SALEGOS members to include F Pattyn (Belgium) and C Mayer (Germany). Consideration of membership, balance, and national representation will be a standing agenda item for each SALE programme meeting.

The SALE-Unified International Team for Exploration and Discovery (SALE-UNITED) Expression of Interest (EoI) has been identified as a potential “core program” by the ICSU/WMO joint Committee for the IPY 2007-2008. SALE-UNITED will work closely with SCAR SALE and assist in the coordination of SALE activities during the IPY 2007-2008.

Deliverables

SALE will:

- Maintain and make widely available an up-to-date inventory of subglacial lake features.
- Devise a standard identification scheme for subglacial lake environments.
- Maintain a current bibliography of relevant articles from peer reviewed journals, meeting reports and the lay press.
- Provide a website with links to all activities related to subglacial lake environments including national programmes, meetings, and reports acting as a portal to data held by others (http://salepo.tamu.edu/scar_sale).
- Convene methodology and technology workshops in response to community needs.
- Establish expert groups on clean sampling technologies and other environmental stewardship issues in response to community needs.
- Organize workshops, scientific sessions, and symposia.
- Review CEEs for SALE projects and field activities as requested.
- Advise SCAR on all aspects of SALE as requested including convening of expert groups when additional expertise is needed.
- Develop and distribute promotional materials, a website, an available speaker and topics list, interactive tools for educating the public, a bibliography (including press releases and articles in the print and visual media), meeting reports, contact information for the media, and

- Promote and advocate common protocols and standards for data management that ensure quality and comparability across programmes.

Administrative milestones

Workshops, symposia and special sessions at major conferences are important for fostering collaboration and communication. The exchange of ideas in the furtherance of planning and coordination will be a primary mission of SALE. The following administrative milestones are expected based on a calendar year:

2005: Programme Meeting I: review/revise terms of reference, metrics of performance, scientific objectives, etc.; elect programme officers; and report progress to SCAR – **1st SALE Meeting , April 22-23, 2005, Vienna, Austria – COMPLETE**

2006: Programme Meeting II: organize and hold a workshop in Grenoble France – April, 2006; promote and organize SALE sessions at appropriate scientific meetings; develop a session for the SCAR Science Conference in Hobart, Tasmania and report progress to SCAR.

2007: Programme Meeting III: promote and organize SALE sessions at appropriate scientific meetings; develop a popular science article on SALE, and report progress to SCAR.

2008: Programme Meeting IV: organize and hold a workshop; promote and organize SALE sessions at appropriate scientific meetings; develop a popular science article on SALE, develop a session for the SCAR Science Conference in St Petersburg, Russia; and report progress to SCAR. *Begin a staggered rotation of SALE membership.*

2009: Programme Meeting V: promote and organize SALE sessions at appropriate scientific meetings, organize a major SALE international symposium.

2010: Programme Meeting VI: promote and organize SALE sessions at appropriate scientific meetings; develop a popular science article on SALE, develop a session for the SCAR Science Conference; and report progress to SCAR.

2011: Programme Meeting VII: organize publication of a SALE book, promote and organize SALE sessions at appropriate scientific meetings; develop a popular science article on SALE; and report progress to SCAR.

2012: Programme Meeting VIII: publish the SALE book; develop a major keynote session for the SCAR Science Conference; and report progress to SCAR.

This timetable and the deliverables will be reviewed and revised as necessary at each SALE meeting.

Metrics of success

The measures of success of a programme that serves primarily in an advocacy role are difficult to quantitatively define. However, it is important to develop metrics of performance that provide SCAR with some indication of a programme's impact. The following are proposed to measure the performance of SALE:

- Workshops held, attendance, and reports produced.
- Sessions on exploration and research of subglacial environments (number and quality) at national and international meetings, attendance, and resulting proceedings publications.
- Peer-reviewed publications each year (number and quality) related to subglacial environment exploration and research.
- Articles in the popular press including numbers of interviews given by SALE members number of web site hits each year, and
- Procurement of funds from other sources.

The SALE leadership will regularly compile these statistics for annual performance reviews.

Data management and information systems

SALE will adhere to all SCAR data management policies and procedures. A data management strategy is being developed under the auspices of SALE–UNITED for the IPY which will coordinate among national data management programmes and provide a central portal to data sets across all SALE programmes. SALE promotes open access to all data and will assist in developing common data formats.

While SALE will not retain data, its website will serve as a portal to member nations that do, making data widely available. SALE will develop a set of data management protocols and standards that all participants can agree to adhere to, to ensure comparability of data across all projects and programs. The standards will be developed by a SALE Sub-committee for Data Management Protocols and Standards in consultation with JCADM and other relevant organisations.

Education, outreach and communication

SALE will adhere to the SCAR Communications Plan and coordinate with the centralized outreach and education activities of the ICSU/WMO IPY Programme Office at the British Antarctic Survey.

To provide a focus for SALE outreach, a Sub-committee on Communication, Education, and Outreach will be formed to explore outreach and education options and develop a comprehensive communication, education, and information dissemination plan for SALE based on the SCAR plan. SALE's outreach efforts will include, but not be limited to: the creation of promotional materials, developing an available speaker and topics list, creating interactive tools for educating the public, posting of meeting reports, and providing contact information for the media

Conclusion

A detailed table of meetings and scientific and technological milestones is provided for the first four years of SALE in Appendix A. A review, revision, and updating of these milestone will be a standing agenda item at each SALE programme meeting. The metrics of success will be summarized each year as a regular component of the SALE meeting report. All of these documents will be readily accessible on the SCAR SALE website at http://salepo.tamu.edu/scar

Appendix A - SCAR Scientific Research Programme Subglacial Antarctic Lake Environments

Implementation Plan – 2005

(Key - S- Scientific Milestone, T- Technological Milestone, M – Meeting, BOLD Completed)

Month	Type	Activity	Responsible Party	Comments
April	**M**	**1st SALE Meeting – Vienna, Austria.**	**SCAR - SALE**	**April 22-23, 2005**
April	**M**	**Representatives attend ACE meeting.**	**M Kennicutt**	**April 25, 2005**
July	M	Representatives attend EBA Meeting.	J Priscu, M Kennicutt	July 2005
July	M	French-Russian Lake Vostok Meeting (GDRE).	S Bulat	July 5-8, 2005, St Petersburg
Oct-Nov	M	International Lake Vostok Meeting – Science and Environmental Issues.	V Lukin (RosHydroMet)	Under development
Dec	M	AGU Fall Meeting, San Francisco – Oral and Poster Session.	R Bell	Under development
Jan-Dec	S	Study of the organic carbon content and its origins in Subglacial Lake Vostok (SLV) accreted ice, Define the possible sources of microbial communities in these environments and test the hypothesis of ultra-low DOC in SLV.	Russia, US, France	On-going studies
Jan-Dec	S	Study the solid mineral inclusions in the SLV accretion ice to decode the depositional conditions, geological ages, and to test the hypothesis of hydrotheramal contributions to SLV.	Russia	On-going studies
Jan-Dec		**Update the inventory of subglacial features.**	**UK**	**M Siegert - complete**

Sep-Dec	S	Complete available LV data and generate new modelling data sets.	Germany	C Mayer
Jan-Dec	**S**	**Retrieval of further SLV accretion ice for further study by deepening the hole 50 meters.**	**Russia**	**Postponed until 2005-2006 season**
Jan-Dec	S	Over snow radar profiling and reflection seismic experiments near SLV to study lake boundaries, shore bedrock topography, lake bathymetry, sub-ice environments, and to model ice sheet and water circulation and ice sheet/water interactions.	Russia	
Jan-Dec	S	Assess the origin and evolution of SLV and the underlying sediments (link with ACE).	France, Russia, US	
Jan-Dec	S	Numerical modelling of ice/water interface in subglacial water bodies and sensitivity to changes in slope.	Belgium, UK	F Pattyn, M Siegert
Jan-Dec	S	Assess the biological contents preserved in East Antarctica ice cores to record the biological emissions from the oceans and continents to estimate DNA survival in ice.	France, Russia, Denmark	On-going studies
Jan-Dec	S	Assess the microbial content linked to *in situ* biological activity within the ice sheet and the basal ice of deep cores.	France, Russia, US, Denmark	On-going studies
Jan-Dec	S	Assess the major chemical elements, organic carbon compounds, heavy metals and gases in SLV accretion ice.	France, Russia, US, Italy	On-going studies

Jan-Dec	S	Assess SLV heat and mass balance using geochemical tracers, constrain geothermal flux, the exchange of water and heat with the overlying glacier, and the water circulation.	France, Russia, US, UK	On-going studies
Jan-Dec	S	Assess the origin and evolution of SLV and the underlying sediments (link with ACE).	France, Russia, US	On-going studies
Aug-Dec	S	Numerical modelling of ice/water interface in subglacial water bodies and sensitivity to changes in surface slope.	Belgium, UK	F Pattyn, M Stegert
Jan-Dec	T	Development of a vibrating drill to sample 20m thick ice cover over Lake Vida.	US	J Priscu
Jan-Dec	T	Development of clean drilling technologies for entry into LV.	Russia	On-going projects – Reported on by V Lukin, April 2005
Jan-Dec	T	Design drill head for a fast drill system in ice.	France	JR Petit
Jan-Dec	T	Design clean technologies and procedures and drilling fluids compatible with SALE.	France	JR Petit
Jan-Dec	T	Contribute to the ice borne and ice-related DNA signatures in open gene databases.	All	All
Jan-Dec	**T**	**Development and construction of an ROV system, sediment coring system, and observatory.**	**USA**	**Funded and underway – R Powell, USA**
Jan-Dec	**T**	**Development of an AUV for use in the Dry Valleys.**	**USA**	**Not funded – J Priscu**
Jan-Dec	**S/T**	**Development of optical devices to characterize biotic and abiotic particles in ice cores.**		**Funded and underway**

Appendix A - SCAR Scientific Research Programme Subglacial Antarctic Lake Environments

Implementation Plan – 2006

(Key - S- Scientific Milestone, T- Technological Milestone, M – Meeting, BOLD Completed)

Month	Type	Activity	Responsible Party	Comments
April	M	2nd SALE Meeting/International Workshop – Grenoble, France.	SALE Kennicutt/Petit	Proposals to NSF and CNRS
April	M	EGU – Oral/Poster Session.	SALE	TBD
June	M	French-Russian Lake Vostok Meeting (GDRE).	S Bulat, JR Petit	TBD
July	M	SCAR Open Science Conference, Hobart, Tasmania - Poster and Oral sessions.	SALE	TBD
Oct-Nov	M	SALE International Workshop, Buenos Aires.	M Kennicutt	Proposal to Tinker Foundation
Dec	M	AGU Fall Meeting, San Francisco – Oral and Poster session.		R Bell to arrange
Jan-Dec	S	Characterize the origins of surface and basal ice recovered in the Vostok ice core and radar along the flow line.	US, France	
Jan-Dec	S	Assess the biological contents preserved in East Antarctica ice cores to record the biological emissions from ocean and continent, estimate DNA survival time in ice.	France, Russia, Denmark	
Jan-Dec	S	Retrieval of further SLV accretion of further study by deepening the hole 50 meters.	Russia	

Jan-Dec	S	Over snow radar profiling and reflection seismic experiments near SLV to study lake boundaries, shore bedrock topography, lake bathymetry, sub-ice environments, and to model ice sheet/water interactions.	Russia	
Jan-Dec	S	Assess the origin and evolution of SLV and the underlying sediments (link with ACE).	France, Russia, US	
Jan-Dec	S	Numerical Modelling of ice/water interface in subglacial water bodies and sensitivity to changes in slope.	Belgium	F Pattyn, M Siegert
Jan-Dec	S	Numerical modelling of lake water – ice sheet interaction.	Germany	C Mayer
Jan-Dec	T	Development of clean drilling technologies for entry into SLV including ecologically clean observatories and sampling devices.	Russia	
Jan-Dec	T	Develop a hot water drill capable of melting a borehole through 3.5km of ice in West Antarctica.	UK	M Siegert
		Design a mechanical fast drill with 4 KM capability for East Antarctica.	France	JR Petit
Jan-Dec	T	Develop equipment and sensors for an observatory deployment in a subglacial lake.	UK	M Siegert
Jan-Dec	T	Develop a subglacial lake exploration probe with tether and communications.	UK	M Siegert
Jan-Dec	T	Field operations and testing of an ROV system through the Ross Ice Shelf.	UK	R Powell

Appendix A - SCAR Scientific Research Programme Subglacial Antarctic Lake Environments

Implementation Plan – 2007

(Key - S- Scientific Milestone, T- Technological Milestone, M – Meeting, BOLD Completed)

Month	Type	Activity	Responsible Party	Comments
March	M	EGU – Oral and Poster Session.	SALE	TBD
July	M	3rd SALE Meeting.	SALE	TBD
July	M	French-Rusian Lake Vostok Meeting (GDRE).	S Bulat	TBD
Aug-Sept	M	ISAES Meeting – Keynote, oral and poster session.	SALE	Aug 27-Sept 1, Santa Barbara, CA
Dec	M	AGU Fall Meeting, San Francisco – Oral and Poster session.	SALE	TBD
Jan-Dec	S	Geophysical Surveys of Lake Ellsworth.	UK	M Siegert
Jan-Dec	S	Characterize ice flow and ice accumulation over Subglacial Lake Ellsworth.	UK	M Siegert
Jan-Dec	S	Determination of water circulation in Subglacial Lake Ellsworth using computational fluid dynamics modelling and data acquisition.	UK	M Siegert
Jan-Dec	S	Airborne geophysical surveys over Princess Elizabeth Land to study bedrock topography, sub-ice environments, and subglacial lake distributions.	Russia	V Lukin
Jan-Dec	S	Lake entry of Subglacial Lake Vostok.	Russia	V Lukin
Jan-Dec	S	Assess the biological contents of the water at the sea-ice interface in SLV.	France	
Jan-Dec	S	Modelling grounding line migration in subglacial lakes.	Belgium	F Pattyn
Jan-Dec	S	Modelling the relation between ice sheet development and lake dynamics.	Germany	C Mayer

Jan-Dec	T	Development of ecologically clean drilling techniques, lake sampling techniques and lake observations.	Russia	
Jan-Dec	T	Continue to develop fast drill with 4km capability for East Antarctica including compatible ice drilling fluids.	France	JR Petit

Appendix A - SCAR Scientific Research Programme Subglacial Antarctic Lake Environments

Implementation Plan – 2008

(Key - S- Scientific Milestone, T- Technological Milestone, M – Meeting, BOLD Completed)

Month	Type	Activity	Responsible Party	Comments
March	M	EGU – Oral and Poster Session.	SALE	TBD
July	M	4th SALE Meeting.	SALE	TBD
July	M	SCAR Open Science Conference – Keynote, oral and poster presentations.	SALE	Aug 27-Sept 1, Santa Barbara, CA
July	M	French-Russian Lake Vostok Meeting.	S Bulat	TBD
Dec	M	AGU Fall Meeting, San Francisco – Oral and Poster session.	SALE	TBD
Jan-Dec	S	Geophysical survey of Lake Ellsworth.	UK	M Siegert
Jan-Dec	S	Determination of geochemistry, microbiology, and sedimentary records in subglacial Lake.	UK, Russia	M Siegert
Jan-Dec	S	Ellsworth from direct sampling Continue Airborne geophysical surveys over Princess Elizabeth Land to study bedrock topography, sub-ice environments, and subglacial lake distributions.	Russia	V Lukin
Jan-Dec	S	Continue geophysical observations over SLV to study lake boundaries, shore bedrock topography, sub-ice environments.	Russia	V Lukin
Jan-Dec	S	Lake Concordia region survey including shallow ice drilling to 200m.	Italy, France linked with TASTE-IDEA)	JR Petit
Jan-Dec	S	Modelling of ice flow around and near Lake Ellsworth.	UK, Belgium	M Siegert, F Pattyn

Jan-Dec	T	Development of ecologically clean drilling techniques, lake sampling techniques and lake observatories.	Russia	V Lukin
Jan-Dec	T	Continue to develop a hot fast drill with 4 km capabilities in East Antarctica including compatible ice drilling fluids.	France	JR Petit
Jan-Dec	T	Refinement of existing higher order ice sheet models to cope with ice flow across small subglacial lakes (e.g. Lake Ellsworth).	Belgium, UK	F Pattyn, M Siegert

Evolution and Biodiversity in the Antarctic: the Response of Life to Change (EBA)

Implementation Plan

The structure of this programme will be based around a series of five major unifying key questions that are addressed across the realms of terrestrial, limnetic and marine environments. These will form the Work Packages of the programme, which will operate along the lines of a matrix of the key questions vs selected environments.

The EBA programme will bring together a wide range of disciplines to tackle a series of well-focused questions. These disciplines include plate tectonics, climatology, glaciology, geophysics, oceanography, paleontology, molecular biology, taxonomy, biogeography, autecology, cellular and organismal-level ecophysiology, and community ecology.

The programme will run a series of workshops. There will be three types: a) thematical, fostering cross-disciplinary interaction, including joint workshops with the other SCAR programmes, particularly ACE and AGCS; b) interaction with non-polar experts in evolutionary biology; c) integrative, for the Antarctic community. The workshop timetable will be defined at the EBA workshop during the SCAR Biology Symposium in Curitiba in 2005.

Additional to the workshops will be national and international field programmes. Such programmes will be wide ranging, including subantarctic islands, inland to the most remote nunataks as well as northward to the Magallanes, and stretching across the Southern Ocean down to the deep ocean as well as the shelves. This wide range will need significant support from COMNAP and national programmes.

Scope

- To understand the evolution and diversity of life in the Antarctic.
- To determine how these have influenced the properties and dynamics of present Antarctic ecosystems and the Southern Ocean system.
- To make predictions on how organisms and communities are responding and will respond to current and future environmental change.
- To identify EBA science outcomes that are relevant to conservation policy and to communicate this science to the SCAR Antarctic Treaty System via the SCAR ATS Committee.

Work packages

1. Evolutionary history of Antarctic organisms

Key scientific areas to be investigated will include:

1. Vicariance and Radiations: When did the key radiations of Antarctic taxa take place? (key groups will be focused upon)

2. Impact of glaciation: on land (habitat modification/loss and timing and extent of isolation); at sea (evolutionary links between continental shelf and slope or deep-sea species).
3. Phylogeography: geographical structure and relationships in the Antarctic biome.
4. Evolutionary history of Antarctic micro-organisms (both prokaryotic and eukaryotic).

2. Evolutionary adaptation to the Antarctic environment

Key scientific areas to be investigated will include:

1. Adaptations and their integration into life history pattern in Antarctic organisms. The life history pattern of an organism integrates the proximate adaptations (genomic, biochemical, cellular, physiological, structural and behavioural) in response to the biophysical environment. As such, life history patterns enable successful reproduction and survival in response to the variability or stability of both the biological (eg competition, predation) and physical (eg temperature, water availability pressure, etc) environments.

3. Patterns of gene flow within, into and out of the Antarctic, and consequences forpopulation dynamics: isolation as a driving force

Key scientific areas to be investigated will include:

1. Population structure and dynamics in the context of evolutionary biology.
2. Natural and anthropogenic dispersal processes: immigration and emigration of organisms; intra-Antarctic dispersal; the role of advective/transport processes in gene flow and population structure.
3. Genetic structure of populations: differences among and between Antarctic and non-Antarctic populations
4. The extent to which populations of Antarctic organisms exist as metapopulations.

4. Patterns and diversity of organisms, ecosystems and habitats in the Antarctic, and controlling processes.

Key scientific areas to be investigated will include:

1. Biodiversity: to what extent is the diversity of the Antarctic biota underestimated (both standard & cryptic species)?
2. Spatial and temporal variations in diversity: variation of diversity at different spatial scales within the Antarctic and within defined time frames.
3. Response to latitudinal and environmental gradients: local, regional and global.
4. Unknown areas: patterns of diversity and biotic composition of unexplored but important areas (e.g. deep sea, inland nunataks, isolated islands, subglacial lakes).

5. Impact of past, current and predicted future environmental change on biodiversity, and the consequences for Antarctic marine, terrestrial and limnetic ecosystem function

Key scientific areas to be investigated will include:

1. Interactions between introduced and indigenous species in selected environments under climate change.
2. Effect of abiotic change on biota.
3. Modelling interactions between environmental change and organism responses in order to predict biotic change.
4. Impact of biological feedback on climate.

Links

EBA will establish links with other international programmes concerned with global physical change and the biological response. Of particular importance are bipolar connections. Furthermore will we forge avenues to align EBA outcomes with conservation policy in particular and to advise policy makers in general.

Timeline

2005: Planning phase including:

a) Planning meeting in Cambridge in March to draft Implementation Plan.
b) SCAR Biology Symposium "Evolution and Biodiversity in the Antarctic", Curitiba, Brazil. International workshop on EBA where work package sub-committees will be appointed and specific milestones detailed.
c) IPY advanced planning, database construction and integration.
d) Circulation of questionnaire about planned and anticipated research activities that will contribute to the aims of EBA in order to collect feedback from potential participants.

2006: SCAR Open Science Meeting, Hobart. EBA begins. Workshops:

- Elephant seals in a changing environment.
- CAML: processes underlying colonisation and dispersal in Antarctic marine fauna. Includes systematics, molecular biology, endemism, bioevolution.
- CAML/SCAR-MarBIN: populating the Antarctic marine biodiversity database and
- visualisation of data products. Includes seafloor topography, sampling intensity, CTD
- data, predator tracks.

2007: Workshops: World View of Evolution. Miraflores, Spain.

2008: SCAR Open Science Meeting, St. Petersburg. Evolutionary Biology-Biodiversity Joint Session.

2009: SCAR Biology Symposium, possibly in Japan or Korea. Major EBA session and third workshop (integrative) one. Also mid-programme review.

2010: EBA-IPY activities: will be the SCAR Open Science Meeting where we will devote to IPY results.

2011: last field season 2.

2012: SCAR Open Science Meeting.

2013: SCAR Biology Symposium – wrapup of results and last year of programme.

Methodology

The EBA programme is wide-ranging and multidisciplinary. The RiSCC programme has developed a manual of methods and workshops will assist in standardising methods as appropriate. In many disciplines, methods are developing rapidly, so it is not feasible or

productive to list specific methodologies in detail. However, a few general points are worth emphasising:

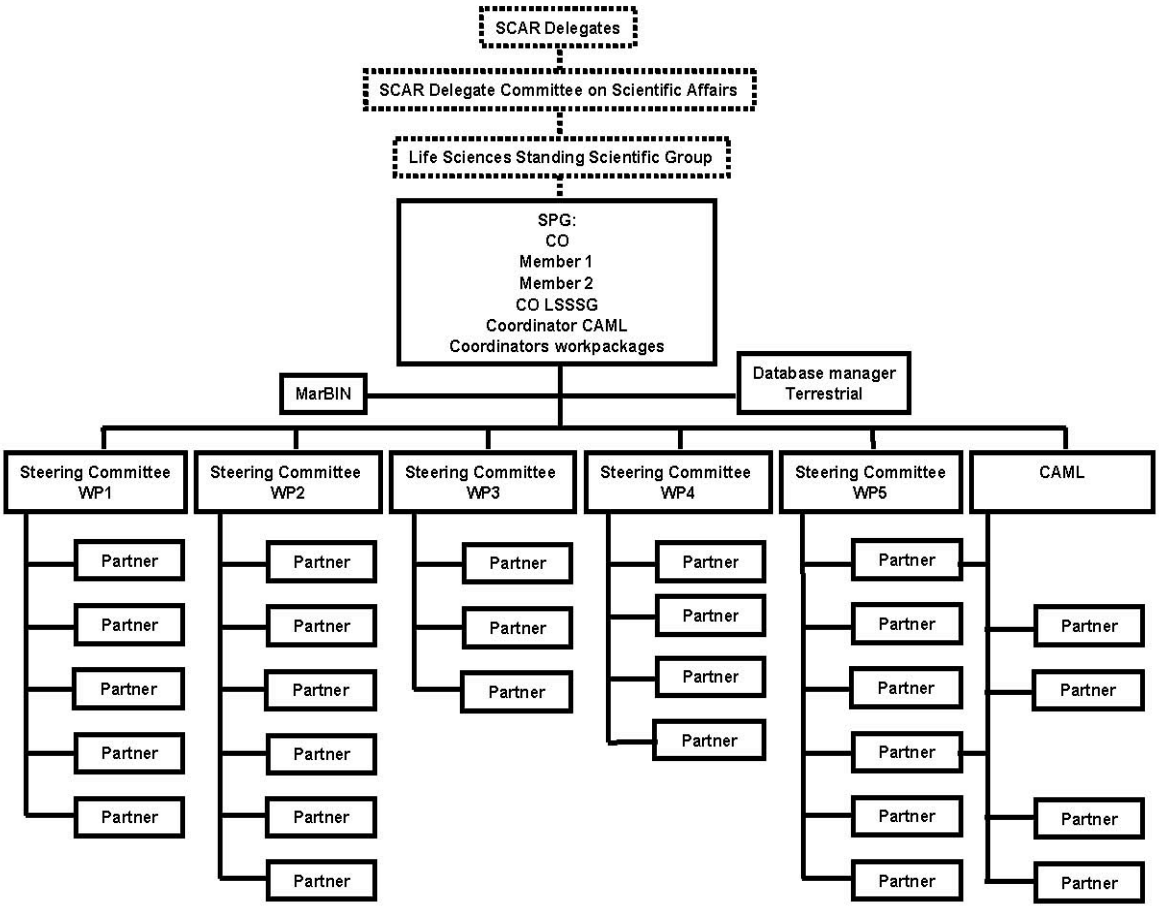
1. The programme will use state-of-the-art enabling technologies in molecular biology, genomics/proteomics, ecophysiology, microbiology, taxonomy and organismal biology, all of which are established and proven at the highest level in various national groups contributing to the EBA community.
2. The programme will liaise with the relevant physical, geological and historical disciplines to ensure regular interaction and use of the most recent data and insights in interpreting the biological results.
3. The programme will necessarily involve fieldwork and laboratory work, both in the Antarctic and in home institutions. In particular, the study of latitudinal gradients requires extensive international collaboration (as was achieved for the recent Victoria Land Transect study, which involved international collaboration, the IBMANT collaboration between European and Latin American countries on evolutionary connections between the Antarctic and South America, and ICEFISH 2004, a sub-Antarctic cruise with scientists from eight countries).
4. Exploration of some areas will require new technologies, for example, samplers for low densities of propagules in the atmosphere and sub-glacial lakes; benthic landers or remotely operated vehicles for the deep sea; autonomous underwater vehicles for work beneath ice shelves; and remote-controlled small aircraft for spectral sensing of terrestrial and limnetic environments.
5. Importance will be attached to spatial and temporal scales in studies of gene flow, population dynamics, disturbance ecology and biological diversity.

Relationship with IPY

The International Polar Year activities will fall within the timing of the EBA programme. EBA and IPY activities were conceived in parallel. The EBA Science Plan clearly shows that it will make a significant contribution to IPY activities by undertaking a focused initiative elucidating the evolutionary response of organisms, populations and communities to environmental change. EBA will leave a legacy of evolutionary and biodiversity information which is the hallmark of IPY.

Programme management and governance

The EBA programme will be managed by a Scientific Programme Group. This group will comprise coordinators of individual work packages and Census of Antarctic Marine Life (CAML). The SPG will work by electronic mail but will also meet once a year. An important aspect will be liaison with other scientific disciplines. This will be achieved by a series of multidisciplinary workshops focussed on specific topics. Six steering groups will be formed to support each of the objectives as well as CAML. EBA will construct a website to present the Science Plan and to communicate with its members and the general public. EBA will also schedule workshops to monitor the progress of the programme. EBA will work closely with JCADM with regard to data management, with marine data being integrated into MarBIN and terrestrial data into the RiSCC Biodiversity database, as well as into relevant data centres and databases.



Other planned workshops

- Dispersal.
- ICEFISH 2006.
- Phylogeography/ population genetics.
- The Molecular approach to Antarctic Biological Science: Strategies and techniques.
- Joint SALE/ EBA workshop.
- Connectivity between marine and terrestrial ecosytems

Milestones

2005: Implementation of EBA: International workshop where work package sub-committees will be appointed and specific milestones detailed: "Evolution and Biodiversity in the Antarctic", 9th SCAR Biology Symposium, Curitiba, Brazil.

2006: EBA begins. Workshop "Factors Driving Evolution in the Antarctic": 2nd SCAR Open Science Conference, Hobart.

2007: Workshop "World View of Evolution": Miraflores, Spain.

2008: Evolutionary Biology-Biodiversity Joint Session: 3rd SCAR Open Science Conference, St. Petersburg.

2009: Major EBA session, integrative workshop, mid-programme review and initiation of ideas for next LSSSG Programme: 10th SCAR Biology Symposium.

2010: EBA-IPY activities: 4th SCAR Open Science Meeting.

2012: 5th SCAR Open Science Meeting.

2013: Synthesis of results, completion of EBA programme and preparation for start of next LSSSG Programme: 11th SCAR Biology Symposium.

Deliverables

The main output from the EBA programme will be a significant step forward in our understanding of the Antarctic biota and its evolution. There will also be important contributions to fundamental understanding in a number of disciplines.

Specific output will include the following:

- Primary literature publications and books.
- Conference proceedings and publications from workshops.
- Programme reports.
- Website.
- Input to databases.
- Advisory reports to ATCM and others (e.g., CEP, CCAMLR, COMNAP).
- Input to, and feedback from, international programmes.
- Synergies with other SCAR programmes (e.g., ACE, AGCS, SALE).
- Trained PhD graduates and post-doctoral research fellows.
- Capacity development of students from developing Antarctic nations.
- Outreach via National Programmes and in coordination with proposed SCAR Outreach Committee.

National and International Involvement

It is anticipated that the majority of the SCAR nations will participate in this programme, that it will act as a major route for capacity building in new SCAR members and those with a comparatively reduced logistic and financial resource base, and that it will contribute to a wide variety of international programmes. Input from individual researchers and research groups will be solicited through a questionnaire. Researchers will be expected to register their anticipated contribution to the Programme through the EBA website.

Antarctica and the Global Climate System (AGCS)

Implementation Plan

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 behaviour prior to the instrumental period will be based on shallow ice core records; this will provide a long-term perspective for comparison with behaviour 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.

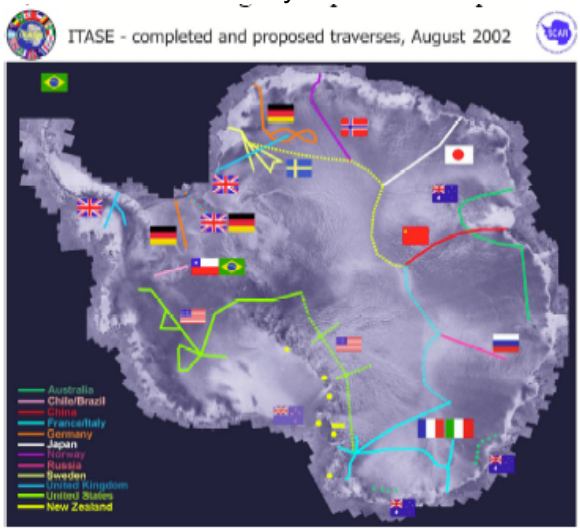
Components of the Antarctic climate system to be investigated in more detail by a variety of observations and models include aerosols, aerosol interactions with clouds, generation of precipitation, and katabatic wind regime. Surface melt and permafrost conditions on land will be explored. The uptake 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 paleolimate proxies such as lake and marine sediment records, and glacial deposits. Current and near future ice core activities include: programmes 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 database, 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 (ICEREADER). 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 variaibility 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 CO_2 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 datasets.
- Improvements to climate and limited area models.
- Greater visibility for SCAR through use of SCAR datasets.

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 datasets will be promulgated widely via international data centres and Antarctic research centres.

Interhemispheric Conjugacy Effects in Solar-Terrestrial and Aeronomy Research (ICESTAR)

Implementation Plan

Programme summary

A major challenge facing environmental science and policy is understanding the interactions between, and collective behaviour of, the many component parts of the Earth system, including the interaction between the natural environment and human society. This requires both the specification and prediction of the state of the system, involving the assimilation and integration of data from disparate sources (disparate instruments, sampling various locations, operated by different people and organisations). Near-Earth space (geospace) is an integral part of the Earth system, providing the material link between the Sun and Earth, primarily through the polar regions, and posing a potential hazard to space-borne and ground based technology on which Society is increasingly dependent. Understanding of the complex geospace environment has matured to the level of being able to describe many of its component parts and a major goal now is to seek a unified framework that can specify and predict its global state and, therefore, space weather. To enable this, this programme will establish a forum and working groups to provide a portal on the World Wide Web to all Antarctic geospace data and metadata, and tools for extracting and reducing these data into value-added products, similar to those available or being developed in other areas of SCAR science.

Antarctica is uniquely positioned to remotely sense the vast region of geospace (extending over millions kilometers from the planet) because the Earth's magnetic field focuses the effects of geospace into the polar regions and Antarctica has a land mass on which to base instruments at high latitudes, yet Antarctica has been under-exploited relative to the Arctic. Recently there has been substantial investment by a number of countries in sophisticated instrumentation providing a grid of instruments over much of the Southern Polar Region. Further instruments are to be installed in the near future that will provide coverage equal to and in some cases better than that in the Northern Polar Region. There is now the capability to investigate conjugate relationships at an unprecedented level of detail. ICESTAR is designed to exploit this and one of the main results of the programme will be the enhanced visibility, accessibility, and usability of the Antarctic geospace data to enable whole-system geospace research, including interhemispheric and ground-space studies, and new cross-disciplinary research such as teleconnections between the upper and lower levels of the atmosphere.

Programme rationale

The ICESTAR Programme will create an integrated, quantitative description of the upper atmosphere over Antarctica, and it's coupling to the global atmosphere and the geospace environment. The reasons to embark on the endeavor now are outlined below:

The emergence of new datasets. The volume of experimental data has been increasing significantly in recent years. In addition, many new datasets are expected to come on-line in the near future. At this time, there are new magnetometer chains, new polar orbiting satellites which allow the simultaneous view of the Southern and Northern polar regions, new ionospheric (SuperDARN, AMISR, and EISCAT) radars, new

mesospheric/thermospheric wind measurements (meteor radars, FPIs), new digisonde and TEC data. It is the right time to begin to create tools to examine the entire system as a whole.

Emergence of grid technology. The 'Grid' is just starting to be defined, and has yet to find a real niche. The seamless sharing of data is one possibility, and is one of the main goals of the ICESTAR programme. The creation of visualisation tools that can utilise globally distributed data sets will push the limits of the current technologies and will spark the creation of new Grid functions. In addition, enabling the convergence of data and models is another strong goal of the Grid technology, which is synergistic with the programme goals.

Enable easy access to distributed data. Many research groups are creating data assimilation tools that require the use of as many data sources as possible. The creation of the ICESTAR data portal and use of the Antarctic Data Master Directory will enable these developments to grow significantly.

Uniqueness of Antarctica. The Antarctic continent offers a unique vantage point for examining the near-Earth space environment, spanning from the top of the troposphere, through the stratosphere, mesosphere, thermosphere, and ionosphere, and into the magnetosphere. Here we underscore some of the similarities and differences between the Arctic and Antarctic:

- Very different underlying neutral atmosphere, e.g., planetary waves and gravity waves morphology is very different, and more intense jet stream exists in the Antarctic.
- Much larger displacement of the magnetic dip pole in the South than in the North, which means it is much easier to separate effects that are controlled by solar radiation.
- The geomagnetic field is weakest in the South Atlantic sector, thus the flux of energetic particles is higher than anywhere else allowing to studying the atmospheric consequences of energetic particle precipitation.

Focused science. The ICESTAR programme will enable focused upper atmosphere scientific research from Antarctica. One goal is to determine how this region of space fits within the global system. No other programme exists which is focused specifically on the quantitative understanding of the upper atmosphere above the Antarctic continent.

International cooperation. Studies of the polar upper atmosphere fundamentally require international collaboration. Consider first the deployment of instruments across Antarctica. These instruments are either located at manned bases or are remotely deployed and serviced from such bases. From a logistical and financial standpoint, it is not feasible to deploy a network of instrumentation in Antarctica without international collaboration. The problem is even more complex in the Arctic as individual countries there have control over portions of the region. With instruments being deployed and operated by different countries, international collaboration is essential so that data can be exchanged and integrated.

Programme organisation and management

Implementing the multi-national ICESTAR programme requires careful management. The Steering Committee, led by two Co-Chairs and guided by the SSG/PS leadership ex

officio, will provide the overall management and guidance of the programme.

- **Co-Chair:** Allan Weatherwax, Siena College (USA)
- **Co-Chair:** Kirsti Kauristi, Finnish Meteorological Institute (Finland)
- Brian Fraser, University of Newcastle (Australia)
- Martin Fullekrug, University of Bath (UK)
- Ruiyuan Liu, Polar Research Institute (China)
- Nikolai Østgaard, University of Bergen (Norway)
- Scott Palo, University of Colorado (USA.)
- Aaron Ridley, University of Michigan (USA)
- Natsuo Sato, National Institute of Polar Research (Japan)
- Eftyhia Zesta, University of California - Los Angeles (USA)
- Maurizio Candidi, SCAR SSG/PS (Italy), *ex officio*

The Steering Committee will meet every year to determine the programme progress and outline the venues for international collaboration. ICESTAR will hold scientific workshops either separately or in conjunction with the biennial SCAR Science Meetings. Specifically, ICESTAR will have four working groups that will focus on the following broad science objectives:

- Quantifying the atmospheric consequences of the global electric circuit and further understanding the electric circuit in the middle atmosphere as guided by the electric fields generated at the solar wind--magnetosphere interface.
- Quantifying the effects on the polar ionosphere and atmosphere of the magnetospheric electromagnetic fields and plasma populations, from the radiation belts to the tail plasma.
- Quantifying and understanding the similarities and differences between the Northern and Southern polar upper atmospheres, under the varying influence of the solar electromagnetic radiation and of the solar wind.
- Creating a data portal that will integrate all of the polar data sets and modeling results. This data portal will enable the research to be conducted by the other working groups.

The above-listed objectives will be the focus of four Thematic Action Groups (TAGs) established to coordinate research activities:

TAG-A: Quantification of the coupling between the polar ionosphere and neutral atmosphere from the bottom-to-top and the global electric circuit.
Leader: Martin Fullekrug, University of Bath (UK)

TAG-B: Quantification of the inner magnetospheric dynamics using remote sensing techniques.
Leader: Eftyhia Zesta, UCLA (USA)

TAG-C: Quantification of the state of the upper atmosphere, ionosphere, and magnetosphere over the Antarctic continent and how it differs from the Northern hemisphere during a wide range of geophysical conditions.
Co-Leader, Nikolai Østgaard, University of Bergen (Norway)
Co-Leader, Scott Palo, University of Colorado (USA)

TAG-D: Creation and management of the data portal.
Leader: Aaron Ridley, University of Michigan (USA)

Each TAG will establish and maintain liaison with the National Antarctic Programsmes

through SCAR and its relevant scientific groups and committees: ADD (Antarctic Digital Database), MAGMAP (Magnetic Anomaly Map), and READER (Reference Antarctic Data for Environmental Research). The programme goals and objectives will be detailed together with the SSG/PS Expert Group on Solar-Terrestrial Processes and Space weather (STEPS) and the relevant Action Groups APTIC (Antarctic Peninsula Troposphere - Ionosphere Coupling) and MADREP (Middle Atmospheric Dynamics and Relativistic Electron Precipitation). Similar collaboration will be established with relevant projects of the International Arctic Science Committee (IASC; http://www.iasc.no). The ICESTAR activities will also be coordinated with the Working Group on Polar Research of the International Association of Geomagnetism and Aeronomy (IAGA) and with the new international programmes Climate and Weather in the Sun-Earth System (CAWSES) sponsored by SCOSTEP and International Heliospheric Year (IHY) endorsed by COSPAR, IAU, and by UN Office for Outer Space Affairs. Finally, the proposed period for ICESTAR (2005-2009) overlaps the planned research activities in the framework of fourth International Polar Year (IPY, 2007-2008), during which ICESTAR and IHY together will coordinate the research of 29 multinational consortia to form a geospace focused core programme in the IPY network.

The following key solar-terrestrial physics and polar aeronomy questions provide a sound scientific background for the ICESTAR TAG team leaders to help address:

- How is Earth's magnetosphere different qualitatively and quantitatively under extreme, moderate, and quiet solar wind conditions?
- What is common and what is different in the solar-terrestrial and aeronomical phenomena observed over both the Arctic and Antarctic?
- Does auroral activity during substorms arise from instabilities in the ionosphere or does this aurora simply mirror plasma motions in the outer magnetosphere?
- How much do dark and sunlit ionospheres control polar substorm dynamics?
- To what extent are the ionized and neutral high-latitude upper atmospheric regions affected by mechanical and electrodynamic inputs from the lower atmosphere?
- How does the global electric circuit affect the ionosphere state?
- How is the global electric circuit closed between the low and high latitudes?

It is important and timely to act now to study the polar-regions in their interhemispheric context from observations in space and over the Arctic and Antarctic. The ICESTAR TAG team leaders will provide international guidance in addressing these, and other, important problems.

Overarching deliverables

The ICESTAR programme will deliver a wide variety of products ranging from a better scientific understanding of the polar atmosphere to a data portal that will enable scientists to create a systems-view of the polar region. Specifically, the ICESTAR programme will focus on delivering:

- A data portal linking together a large number of polar sites with diverse datasets. This data portal will have visualization and data translation modules that will allow users to examine the data and download it in formats that they can easily understand. The following data types will be provided to the portal by the associated groups: magnetometers, HF and MST radars, lidars, passive optical instrumentation, digisondes, riometers, VLF/ULF receivers, TEC measurements, and atmospheric electric field observations.

- Quantification of the role of seasonal differences in polar ionospheric conductance and the effects on magnetospheric, ionospheric, and thermospheric dynamics.
- Constraints on models based on conjugate remote sensing of inner magnetospheric dynamics.
- Characterization of the spatial and temporal properties of mesoscale convection in the ionosphere.
- Characterization of the basic state of the polar middle atmosphere.
- Quantification of the AC and DC global atmospheric circuit and its effects on the ionospheric state.

Milestones

2005–2006: Start of ICESTAR Programme – Collect information and coordinate observations at the existing instrumental arrays in the Arctic and Antarctic, aiming specifically at interhemispheric studies, including global development of the magnetic storms and substorms over the polar regions. Promote the deployment of new instruments where current gaps exist.

2007–2008: Main Phase (coincides with IPY) – Develop time-dependent geospace models controlled by external (i.e., solar wind) drivers; couple these models with the potential input from atmospheric processes including the global electric circuit and thunderstorms.

2009–future: Closure or Renewal Phase – Consider termination or extension of the ICESTAR Programme based on its progress and accomplishments.

Timetable of activities

As this is a revision of the original implementation plan submitted in April 2005, we list not only goals but also accomplishments when appropriate.

Summer 2005

Goals:

- Collect information and coordinate observations at the existing instrumental arrays in the Arctic and Antarctic aiming specifically at interhemispheric studies, including global development of the magnetic storms and substorms over the polar-regions. Promote the deployment of new instruments where current gaps exist.
- Conduct first technical workshop: First Specification for a reasonable VO overall structure. The VO could have e.g. the following elements: Distributed archives, adaptive metadata thesaurus, unified Graphics User Interface, possibilities to do context-based searching (e.g. searching SD-potential patterns with the criteria of certain cross polar cap potential drop) and distributed computing, procedures for monitoring usage statistics, and educator's interface for public outreach.
- Project meetings in EGU (Vienna) and IAGA (Toulouse): Specifications for the design reference models for each TAG. Specifications of the initial VO component archives (institutes, their data and software).

Accomplishments:

- ICESTAR Website: Established to facilitate international communication.
- CEDAR/GEM Meeting 2005: ICESTAR team member Allan Weatherwax helped organize the Coupled Geospace Workshop at the 2005 Santa Fe CEDAR/GEM Meeting.
- Polar Research Working Group II-G: ICESTAR coordinated activities with the IAGA Polar Research Working Group. Future collaborative endeavours are underway with this IAGA working group.
- ICESTAR Data Portal Workshop: The ICESTAR Data Portal and Virtual Observatory Workshop was held on 23 July 2005 in conjunction with the IAGA 2005 Scientific Assembly, Toulouse, France. There were more than 35 in attendance. A full report is given at: http://www.siena.edu/physics/icestar.
- Prototype Virtual Observatories and Data Portals:
  - A prototype of the VO for optical data (browser for quicklook data) was released: see http://gaia-vxo.org.
  - A prototype of the VO for magnetometer data, VGMO.NET, was released: see http://mist.engin.umich.edu/mist/vgmo/vgmo.html.
  - A prototype of the VO for the multi-instrument datasets at South Pole Station was released: see http://siena.isti.com/.
- ICESTAR and IPY: ICESTAR, under the direction of Kirsti Kauristie of the Finnish Meteorological Institute, submitted on 10 Jan 2005 an Expression of Interest to the Joint Committee of IPY. IPY JC selected the programme to the second round of core project candidates and encouraged collaboration with the IHY EoI in order to establish an umbrella organization for 24 geospace oriented projects. The ICESTAR/IHY programme was endorsed on Dec 1 2005 as one of the IPY core projects. After that five more EoIs has joined the initiative. IPY will publish the final list of the core projects in March 2006.
- Meeting on Atmospheric Studies by Optical Methods: Prof. Scott Palo presented an invited talk about the ICESTAR program at the 32nd Annual European Meeting on Atmospheric Studies by Optical Methods, 01 September 2005, London, Ontario.
- EGU General Assembly Special Session Announced: TAG Team leader Nikolai Ostgaard announces the session, Interhemispheric similarities and asymmetries in geospace phenomena. He will chair this session together with Janet Kozyra who is a work package leader in the CAWSES programme.
- Presentation: TAG Team Leader Nikolai Østgaard gave a talk on conjugate imaging of cusp aurora at the IHY meeting in Paris.

Autumn 2005

Goals:

- Establish project management:
  1. Core group (e.g. chairpersons and Aaron Ridley): Budget matters, Public outreach, contact towards SCAR, overall control on the VO development schedule.
  2. Scientific and Technical Board (e.g. ICESTAR steering committee + representatives from the distributed archives): Making specifications, finding resources for the actual development work, evaluating the outcome.
- First meeting of the Scientific and Technical board: What elements in the VO specification are necessary and what properties they should have to meet the

demands of the design reference models? Recommendations to the community to fill the most critical gaps in the measurement instrumentation. Output: the URD (User Requirements Definition).

Accomplishments:

- Fall AGU 2005 - ICESTAR Related Talks and Presentations:
  1. Deploying a Low Cost Virtual Observatory and Data Portal at a Small Liberal Arts College by H. Schechner and A. T. Weatherwax.
  2. Geospace Climatology: A Window to the Heliosphere Through Polar Regions by V. O. Papitashvili.
  3. The Future of Systems Aeronomy in Addressing New Science Frontiers by J. U. Kozyra, L. J. Paxton and A. Ridley.
  4. GAIA - A Virtual Auroral Observatory by E. Donovan.
  5. Polar Gateways to Exploration of Icy Worlds in the Solar System by J. Cooper.

Winter/Spring 2006

Goals:

- Second Technical workshop: Specification for the technical solutions to meet the needs of the URD. Search for the most suitable options for the programming languages, for data catalogue structures, for visualization tools and input and output data formats. The second updated version of the Optical VxO will be released.
- Build prototype of federated distributed archives and metadata collection routines.
- Convene “Coupling from the Sun to the Ground” - Special Session for 2006 Spring AGU. See the website hhtp://www.siena.edu/physics/ICESTAR/special_session_spring_agu_2006.htm for full details of this special sesion.
- Preparatory work for the IPY activities begins: ICESTAR research groups are invited to submit proposals for Coordinated Investigation Programmes (CIP) to the Discipline Planners of IHY. CIPs will facilitate especially the arrangement of coordinated multi-instrumental measurement campaigns but can also serve as an efficient procedure for collaboration in modeling and outreach activities. For more details, see http://www.ihy.rl.ac.uk/HowCIPsWork.shtm.

Accomplishments to Date

- Negotiations about ICESTAR-IHY collaborations: Kirsti Kauristie attended the first European General Assembly of IHY (Jan 10-13 2006), gave there an invited presentation about ICESTAR and discusses with the European IHY coordinators (Prof. R. A. Harrison, R. Stamper, and C. Briand) about the future ICESTAR-IHY activities.
- Activities in the EGU-meeting: TAG Team Leader Nikolai Østgaard will give an invited talk about the ICESTAR science and coordination activities in an EGU Union Symposium hosted by Dr J. C. Ellis-Evans.
- EGU General Assembly Special Session: ST5.5 Inter-hemispheric similarities and asymmetries in geospace phenomena', will be convened by TAG-C Team leader Nikolai Østgaard. He will chair this session together with Janet Kozyra who is a work package leader in the CAWSES programme. We will have an

invited talk by Aaron Ridley (given by Gombosi) and an ICESTAR/IHY paper by L. Alofnsi.
  - http://www.cosis.net/members/meetings/sessions/information.php?p_id=186&s_id=3523
- TAG Team Leader Nikolai Østgaard will give an invited talk at the International Conference on Substorms-8 on conjugate imaging of substorms.
- Co-director Allan Weatherwax presented an ICESTAR related seminar at South Pole Station during a visit to Antarctica to conduct fieldwork.

Summer 2006

Goals:

- Present ICESTAR papers at SCAR XXIX Open Science Conference:
  - Vertical Electrodynamic Coupling by Martin Fullekrug.
  - Auroral Conjugacy Studies - by Nikolai Østgaard et al.
  - Deploying Data Portals and Virtual Observatories - by Allan Weatherwax et al.
  - Pi1B Pulsations and their Association with Substorm Onset - by H. Kim et al.
  - ICESTAR: Interhemispheric Conjugacy Effects in Solar-Terrestrial and Aeronomy Research - by Vladimir Papitashvili and the ICESTAR Team.

Autumn 2006

Goals:

- Build the User Interface and other necessary elements.
- Test the prototype system with the design reference models. Test results presented e.g. in a CAWSES-ICESTAR workshop.
- Adjust the system according to the feedback from the first test runs.
- IHY Discipline Planners will categorize the submitted CIPs according to Universal Processes and present the implementation plans for coordinated campaigns during the IPY years (Reconnection and wave-particle interactions are examples of Universal Processes with common ICESTAR and IHY interests).
- Foster the first measurements of the NASA THEMIS mission (especially TAG-B and C).

Winter/Spring 2007

Goals:

- Second meeting of the Scientific and Technical Board: Mid-term review.
- Introduce the VO to the IPY community and expanding the system with new data archives and software.
- Establish reliable monitoring routines for user statistics (both for VO and for the individual data archives).
- Publish the results of the design reference models.

Autumn 2007- Spring 2009

Goals:

- Collaborate with the IPY community, presenting results in international meetings.
- Expand the VO according to the needs of the user community and upgrading its distributed computing capabilities.
- Publish results of IPY studies.
- Third meeting of the Scientific and Technical Board**:** Evaluation of the user statistics and decision about continuation or closure.