REPORT ON ANTARCTIC CLIMATE EVOLUTION (ACE)

INTRODUCTION

ACE is an international research initiative to study the climate and glacial history of Antarctica through palaeoclimate and ice-sheet modelling integrated with the geological record.

ACE promotes the exchange of data and ideas between research groups focussing on the evolution of Antarctica's climate system and ice sheet. Although it has only been running officially since the beginning of 2005, its two-year planning phase and its origins from the former SCAR programme ANTOSTRAT, which ended in 2001, have allowed ACE to develop several advances in our understanding of Antarctic history. ACE's role is to facilitate cooperation between earth scientists through meetings and symposia, to assemble the results of these collaborations in the scientific literature, and to promote the development and funding of international research collaborations. Full details of the ACE programme can be found on its website, launched in January 2005 (www.ace.scar.org).

SUMMARY OF FIVE MAIN ACHIEVEMENTS

ACE's five main achievements to date include:

1. Publication of two papers in *Nature*, which demonstrate that the onset of the Antarctic Ice Sheet at 34 million years was an inevitable consequence of CO_2 lowering, triggered but not solely caused by the opening of the Drake Passage.
   DeConto, R.M., Pollard, D. 2003a. Rapid Cenozoic glaciation of Antarctica triggered by declining atmospheric CO_2. *Nature*, 421, 245-249.
   Barrett, P.J. 2003. Cooling a continent. *Nature*, 421, 221-223
2. Publication of an ACE paper in *Geology*, showing that the formation of the trough mouth sedimentary fan in Prydz Bay was due to a feedback between the ice sheet and the base that it erodes. The trough carved out by the glacier resulted in faster flow within it and, consequently, a point source for fan development at the shelf break.
   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. (2004).
3. Publication of three special issues on the glacial and climate history of Antarctica:
   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, 1-264. This issue featured a mix of modelling and data papers with a focus on the Eocene–Oligocene boundary and the initiation of ice sheet growth, together with papers on seismic stratigraphy and reports from drilling around the margin.
   Barrett, P., Florindo, F. and Cooper, A. (Editors) (2006). "Antarctic Climate Evolution - view from the margin". *Palaeogeography, Palaeoclimatology, Palaeoecology*, v. 231, p 1-252. The papers within this issue cover a wide range of techniques and timeframes concerning the evolution of the Antarctic continental margin, ranging from detailed sedimentary analyses of the Cape Roberts Project core to numerical modelling investigations of ice sheet growth and decay.
4. Since 2004, ACE has organised seven dedicated sessions at international workshops (details below).
   - August 2004; A full session of the International Geological Congress, organised by Fabio Florindo and Peter Barrett, entitled 'Cenozoic Antarctic Glacial History'.

- December 2004; A full session at the Fall AGU, organised by Alan Haywood and Paul Valdes, entitled “Antarctic Climate, Neogene Proxies, and Climate Modeling”. The session addressed Antarctic and global proxy records of Neogene climate and environmental change. The aim was to synthesise results from marine and terrestrial proxy data for the Miocene and Pliocene and to combine them with outputs derived from numerical climate and ice-sheet models.
- August 2005; An international symposium, co-sponsored by ACE (with International Association of Sedimentologists (IAS), the main sponsor, plus the International Commission of Snow and Ice, the International Glaciological Society, the International Quaternary Association, the Quaternary Research Association and the British Geological Survey) entitled "Glacial Sedimentary Processes and Products". The meeting was held at the University of Wales Aberystwyth. It promoted dialogue between researchers in the fields of contemporary glacial processes, glacial sedimentology and ice sheet modellers in order to advance these fields in an integrated way. Contributions were given from researchers working on all aspects of glacial sedimentary processes and products in glaciomarine, glaciolacustrine and terrestrial settings, from Archaean times to the present day.
- August 2005; A full session of the Earth Systems Science symposium, held in Calgary, Canada, and organised by Alan Haywood, entitled “The Last Great Global Warming: Proxy Reconstructions and Modelling the Pliocene Climate”. The Pliocene was the most recent period in Earth history in which temperatures were as warm as they are likely to be within the next century. The session addressed fundamental questions concerning our knowledge of the Pliocene world, including what the biota, climate and environments of the Pliocene where really like, why was the climate warmer than today, what was the nature of Pliocene climate variability and what relevance does the period have to the future climate change debate?
- September 2005; An international workshop, co-sponsored by ACE, entitled “Cenozoic onshore and offshore stratigraphic record from the East Antarctic margin: recent results and future directions”. The meeting was organised by Laura De Santis and Carlota Escutia Dotti. Its aim was to discuss the state of knowledge of Cenozoic East Antarctic ice sheet evolution and to define future research activities in the east Antarctic margin, including activities related to proposed IODP Wilkes Land drilling.
- December 2005; Fall AGU special session organised by Tony Payne, Colm O'Cofaigh and Glenn Milne (all member of the LGM-Holocene Committee) on "Antarctic Ice Sheet Evolution from the Last Glacial Maximum to the Holocene: Recent Advances From Modeling and Field Investigations". The aim of the session was to bring together modellers and field-based researchers working on the evolution of the Antarctic Ice Sheet (AIS) from the time of the Last Glacial Maximum (LGM) and extending into the Holocene. The main theme of the session was to discuss new results that advance our understanding of the development of the AIS during this period and the consequent implications for regional and global climate change, as well as future AIS retreat. The session was very well attended and attracted contributions from the following communities: terrestrial glacial geology and geomorphology; marine geology and geophysics; studies of high-resolution ice core and sediment core records; glaciological modelling; climate modelling; and modelling of glacial isostatic adjustment.

5. ACE has established links with ongoing research activities concerning geological and geophysical data acquisition, and modelling as follows:
    - ANDRILL (a deep sediment core drilling project in Antarctica): ACE co-sponsored the last steering group meeting of ANDRILL, in Leeds, July 2005. The results of ANDRILL are of direct relevance to ACE as they address the evolution of the Antarctic ice sheet in response to climate change in the Ross Sea region. Consequently, many of the ACE team are also members of the ANDRILL community, and thus the two groups have

strong synergies and connections. The ANDRILL community met jointly with the ACE steering committee at the San Francisco AGU meeting in December 2005.

- Radio Echo-Sounding: ACE has assembled a committee to promote the acquisition of radio-echo sounding data in Antarctica, from which subglacial topography, which make up a critical yet currently incomplete boundary condition of numerical models, can be established.
- Modelling: Following its workshop on modelling, held in 2002, ACE has overseen the development of new models of the ice-ocean-climate-lithosphere system in Antarctica, which are currently being used to investigate earth system processes. For example, DeConto and Pollard have recently built a model that predicts sediment transport beneath the ice sheet. When included in time-dependent runs of ice sheet development the model reveals how sediments are eroded and deposited. Such output can be compared against the geological record to help understand ice sheet histories.

PROGRAMME DISSEMINATION

Posters and brochures for ACE have been designed, as has a logo, and these have been distributed at numerous international conferences over the past four years. The ACE website is available at www.ace.scar.org, and has received over 2000 hits since May 2005. These items provide a means by which future scientific results may be provided to a broad audience.

PROGRESS AGAINST PRIOR WORK PLANS

What is the overall rationale and goal for each activity?

As stated in the ACE proposal (2004), "the main function of the programme lies in the acquisition and compilation of "ground truth" geoscience data, and the use of these data in developing a suite of palaeoclimate models (both continent-wide, Southern Ocean-based, and sectorial) for the Antarctic region for significant periods of climate change through Cenozoic times". To meet this aim, the project has established an implementation plan, approved by the SCAR executive committee in 2005.

What were the planned milestones and deliverables?

The first year of ACE involved executing the first stage of the implementation plan. Specifically, this meant establishing a series of sub-committees to deal with each of the time and process-led themes of ACE. In addition, ACE committed to analysing geophysical data of the Antarctic ice sheet glacial structure, in order to ascertain information related to ice flow and accumulation changes.

What milestones were met, and what deliverables provided?

The ACE implementation plan has been undertaken as agreed. All the subcommittees proposed have been established and work has begun within them. The scientific commitment to analysis ice sheet geophysical data has been met fully.

What were the main achievements during the 2-year cycle?

The main achievements of ACE over the last two years have been:

- to activate its implementation plan,
- to undertake seven special sessions at international conferences,
- to publish three special volumes dedicated to papers presented at ACE meetings

What are the links to other national and/or international activities?

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.

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.

ACE is in the process of establishing links with PAGES (the 'past global changes' programme of the IGBP http://www.pages.unibe.ch). Julie Brigham-Grette was present at the ACE steering committee meeting (December 2005) to discuss ACE participation within PAGES. One possible way forward is for ACE to tale responsibility for the full production of a PAGES sponsored publication on past changes in Antarctica.

ACE is developing links with the JCADM (Joint Committee on Antarctic Data Management) and, to assist with this link, Rob Bauer has been recruited to the ACE steering committee.

What deviations were made from the work plan, and why?
None

What SCAR funds were allocated to the activity?
ACE received $21,000 from SCAR in 2005. In addition, ACE received $5000 in 2005 from an anonymous donor, and $8000 was carried forward from the previous year: total $34,000.

How were the SCAR funds spent?
SCAR funds have been used sparingly over the last two years. This low spending has, with the agreement of Colin Summerhayes, been possible by arranging ACE meetings at international symposia where funds for travel and accommodation are available from other sources. SCAR has not, thus far, paid for the bulk of ACE meeting expenses. ACE funds are consequently being built up to a level in which a large international ACE meeting is possible (possibly in 2008). Some ACE funds have been spent, as follows:

	Funding (2005)	**Expenditure**	**Funds**
	34,000.00	**12,742.45**	**21,257.55**
ACE web (University of Massachusetts, R Dunbar)	2,000.00	2,000.00	
IACT (ACE) Workshop Escutia 05 (US$ 5,000)	5,000.00	5,000.00	
ACE mtg, Vienna		2,352.15	
ACE data entry (Darren Atkinson, Aberystwyth)		363.64	
ANDRILL (Jane Francis)		776.95	
East Ant. Margin Wshp., Spoleto, Italy, Sept 05		1,020.45	
ACE SSG Mtng., San Francisco, Dec 05		1,229.26	

A further $21,000 has been awarded in 2006.

PROPOSED WORK PLAN FOR THE NEXT 2 YEARS

What new activities are planned?

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

<table>
<tr><th>Themes</th><th>2005-6</th><th>2006-7</th><th>2007-8</th><th>2008-9</th><th>2009-10</th></tr>
<tr><td>Holocene/last glacial maximum/ and Pleistocene</td><td>Internal layers, ice flow and accumulation reconstruction.</td><td>Complete review of Antarctic ice sheet – ice shelf – Southern Ocean record</td><td>Review of data collected by IMAGES and ANDRILL projects.</td><td rowspan="2">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.</td><td rowspan="3">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.</td></tr>
<tr><td>Pliocene</td><td>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</td><td>Continue review of sedimentary cores from Legs 178 and 188.</td><td>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</td></tr>
<tr><td>Middle Miocene</td><td>Continue review of sedimentary cores from Leg 188.

Continue fostering IODP proposals for Wilkes Land and Ross Sea</td><td rowspan="2">Complete review of offshore record – revise IODP proposals for Wilkes Land and Ross Sea.

Develop proposals using SHALDRIL and Cape Roberts (ANDRILL)</td><td>Revise IODP proposals for Wilkes Land and Ross Sea.

Convene session at ISAES, Santa Barbara USA</td><td rowspan="2">International meeting on the Neogene and Antarctica, Cambridge, summer 2008.

Assess reviews in light of new ANDRILL, SHALDRIL and IODP data.</td><td rowspan="2">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</td></tr>
<tr><td>Oligocene-Miocene boundary</td><td>Continue review of Cape Roberts cores.</td><td>Convene session at ISAES, Santa Barbara USA</td></tr>
</table>

Eocene-Oligocene	Continue review of sedimentary cores from Leg 188. Continue fostering IODP proposals for Wilkes Land and Ross Sea.	technologies. 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	ago.
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.

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

Further plans for ACE in 2006-7 include:

1. A special session of the 2006 EGU entitled "Deep Time Perspectives on Climate Change: Marrying the Signal from Computer Models & Biological Proxies" - Session CL16,
2. A field campaign in 2006, led by the British Antarctic Survey on James Ross Island. The aim of the fieldwork is to map, describe, sample and photograph glacial sedimentary sequences and associated fossils on James Ross Island. The rock and fossil samples will be analysed to create realistic environmental reconstructions and new data on environmental change, particularly Antarctic ice sheet history, over the past 7-10 million years. Particular foci of the work are to identify the source region(s) and thermal regime(s) of former ice sheet(s), to document any significant impact caused by the so-called “warm Pliocene” interval (the period between 3 and 5 million years ago), and to identify and date periods of significantly reduced ice cover (so-called “interglacials”). The warm Pliocene period is the closest analogue for Earth conditions that we are likely to experience in the next 100 years. The new information obtained from this project will be used as critical input to climate models identifying how global change will occur throughout the next 300 yrs.
3. Fostering the IODP Wilkes Land drilling plan, now in the preliminary IODP drilling schedule for Austral summer 2008-2009.
4. Developing the IODP Ancillary Programme for obtaining a Holocene ultra-high resolution record of climate variability from the Adelie Drift (Wilkes Land)
5. Supporting and encouraging involvement with the ANDRILL programme.
6. Developing an international plan for the collection of airborne and ground based geophysical data relating to the Antarctic ice sheet (i.e. ice thickness and bed elevation data in current ‘data free’ zones and in regions of glaciological change).

What are the new planned milestones and deliverables for each (new or continuing) activity?
None

What SCAR funds are required to support the activities and how will they be used?
SCAR funds are requested to assist with workshops and symposia. It is essential to note that ACE has resisted spending money solely on ACE steering committees, but cannot rule out such expenditure in the future. The funds unspent in the last year should be viewed as a tremendous effort on the part of ACE. These saved funds must be made available for ACE in the next two years.

Why is SCAR support needed for these activities (what is the value added)?
There is a great deal of value-added to ACE activities. Most of these are underpinned by funding from national research councils. The part that ACE plays is to pull together in international partners in a way not possible without SCAR support. The result is that ACE, and therefore SCAR, excels in supporting international research on issues related to Antarctic Climate Evolution.

To what extent will these activities complement other national and international activities?
ACE's role is to bring together the scientific efforts of the international community, which are likely to be funded by individual research councils. For example, ACE has assisted with a recent steering committee of ANDRILL, and has initiated an international committee to oversee the development of geophysical data acquisition in Antarctica.

IPY CONTRIBUTIONS
What IPY projects are SSG members contributing to and which are they leading?
ACE has been accepted as a fully endorsed project of IPY. It has strong links with BIPOMAC, a project aiming to understand the glacial history of both polar regions.

What progress has been made against past recommendations?
No scientific recommendations have been made to date.

SUPPORTING INFORMATION
ACE's steering committee and subcommittee members include scientists from Argentina, Australia, Belgium, China, France, Germany, the Netherlands, New Zealand, Sweden, UK and the USA.

Names and affiliations of co-Chairs
Martin J. Siegert – School of GeoSciences, University of Edinburgh, Grant Institute, West Mains Road, Edinburgh EH9 3JW, UK, m.j.siegert@ed.ac.uk
Robert B. Dunbar – Department of Geological and Environmental Sciences Stanford University, Stanford, CA 94305-2115, USA, dunbar@stanford.edu

Steering committee members (and their e-mail addresses)
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Robert M. DeConto – University of Massachusetts, USA, deconto@geo.umass.edu
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Members of the subcommittees: Catherine Ritz (France); David Pollard (USA); Colm O'Cofaigh (UK); Mike Bentley (UK); Dominique Raynaud (France); Philippe Huybrechts (Belgium); Howard Conway (USA); Glenn Milne (UK); Rob Dunbar (USA); Lionel Carter (NZ); Andrew Mackintosh (NZ); Rainer Gersonde (Germany); Gary Clarke (Canada); John Chappell (AUS); Stuart Henrys (NZ); Reed Scherer (USA); David Pollard (USA); Roderick Van Der Wal (Netherlands); Ian Hall (UK); John Smellie (UK); Allan Ashworth (USA); Paul Valdes (UK); Carrie Lear (UK); David Cantrill (Sweden); Steve Pekar, (USA); Katarina Billups (USA); Sergio Marenssi (Argentina); Vanessa Thorn (NZ); Mike Hambrey (UK); Jim Zachos (USA); Henk Brinkhuis (the Netherlands), Barbara Mohr (Germany); Detlef Damaske (Germany); Ian Allison (AUS); Don Blankenship (USA); Sun Bo (China); David Vaughan (UK).

REPORT ON SUBGLACIAL ANTARCTIC LAKE ENVIRONMENTS (SALE)

INTRODUCTION

SCAR's SALE programme continues to promote, facilitate, and champion international cooperation and collaboration to explore and study subglacial lakes and streams in Antarctica, following appropriate standards of environmental protection.

This report is a summary of SALE activities for each performance criterion established by SCAR to judge whether the programme is achieving its objectives and goals and whether the programme supports SCAR's mission.

SUMMARY OF FIVE MAIN ACHIEVEMENTS

Major advances in SALE science have been reported in a series of publications over the last year and include:

- Subglacial lakes are common features of ice sheets, there are more than 145 identified subglacial lakes.
- There is a spectrum of subglacial environments and the beginnings of a classification system.
- Subglacial hydrologic systems exist and there is evidence of rapid water movement beneath ice sheets.
- Subglacial lakes and ice streams appear to be linked inferring that subglacial lakes influence ice sheet movement.
- Paleo-outbursts of subglacial waters have influenced land forms, and may be linked to past global climate change.

OUTPUTS AND DELIVERABLES

Publications in peer reviewed literature

See the SALE publications page - http://salepo.tamu.edu/literature.

Year	Number of Publications
2001	12
2002	9
2003	8
2004	25
2005	16
2006 thru (5/06)	2
In Press	11
Total 2002-2006+	83

Other Publications

- See the SCAR SALE reports page http://salepo.tamu.edu/workshops http://salepo.tamu.edu/scar_sale/meetingreports.
- SALE 1st Meeting Report - April 22-23, Vienna, Austria - http://vpr-zope.tamu.edu/scar_sale/meetingreports/salemtg1
- SALE 2nd Meeting Report – April 27-28, 2006, Grenoble, France http://salepo.tamu.edu/scar_sale/meetingreports/scarsale2/index_html

- SALE information items are regularly posted to the ANSWER email notification system that automatically generates weekly digests of posted items to a mailing list. There are currently over 700 subscribers to ANSWER http://csd.tamu.edu/digests.
- SALE has created an eBulletin Board to send information specifically to scientists, researchers, and technologists with SALE interests. There are about 150 subscribers to the SALE eBulletin.

Brochures, posters, press/media articles and similar PR material

- See the SALE Press Page - http://salepo.tamu.edu/press
- SALE is in the process of creating a poster and brochure for wide distribution.
- All Power Point Presentations produced by SCAR SALE are posted to the website. http://salepo.tamu.edu/literature
- Power Point Presentations delivered during the SALE Workshop 2006 are available on-line.

Creation of a website, and number of hits per website

- See the SCAR SALE webpage - http://salepo.tamu.edu/scar_sale
- See the SALE Programme Office webpage - http://salepo.tamu.edu/
- From its inception in 2005, hits on the SALE website have grown to about 70,000 to 80,000 hits a month.
- The SALE PO website also provides links to all member programme websites. http://salepo.tamu.edu/sale%20members

Creation of database(s), and amount of use of database(s)

- See the SALE data access and management webpage - http://salepo.tamu.edu/saledata
- The SALE Programme Office website serves as a portal to SALE data repositories but does not serve as a primary archive or server of data.
- SCAR SALE does not have a mechanism to directly monitor access to databases since they reside at other locations.
- A JCADM liaison will be named specifically for SALE.

Number and type of education/training and other capacity building activities

- SCAR SALE has established a Subcommittee for Education, Outreach, and Communication (EOC). It is currently Chaired by F Pattyn (Belgium). The subcommittee is establishing its Terms of Reference.
- SCAR SALE will closely coordinate all of its EOC activities with the IICSU/WMO IPY Programme Office.

New technology/model developments

- SCAR SALE has established a Subcommittee for Technology. It is Chaired by R Powell(US). The Committee is establishing its Terms of Reference.
- Models of all types are extensively used by many SALE researchers. Reports on model developments are contained within the National SALE report at the SALE website.

Contributions to IPY

- SALE is a "core" programme for the IPY2007-2008 - "Exploring New Frontiers".
- See the SALE-UNITED webpage - http://salepo.tamu.edu/sale_united
- A major workshop was held in April 2006 to initiate SALE IPY activities (see below).

Key achievements

- Each SCAR SALE Meeting includes reports of recent accomplishments by countries and programmes.
- See the attached Milestone Table for 2005-2008.

INPUTS

Number, gender and country of participating scientists

- SALE includes 12 members from 7 countries - Belgium, France, Germany, Italy, Russia, United Kingdom, and United States.
- SALE includes 11 male and 1 female members.
- Recently (Meeting #2 – April, 2006) SALE recommended an expansion of its membership to 14 which would increase the number of countries participating to 9 and improve disciplinary balance.

Number and type of meetings/workshops, and numbers, genders and countries represented in their attendees

- SCAR SALE co-sponsored a major international workshop in Arpil, 2006 in Grenoble, France, entitled: "SALE in the IPY: Advanced Science and Technology Planning", There were 84 attendees from 11 countries. Fourteen (14) women attended the workshop. For details go to the workshop website http://salepo.tamu.edu/saleworkshop2006

Links to other SCAR SRPs or Action or Expert Groups

- SALE is closely linked with ACE and EBA and has formal liaisons with these SCAR SRPS.
- Two SALE members are active ACE members (M Seigert and R Powell).
- One SALE member is an active EBA member (J Priscu).
- SALE representatives attended ACE (M Kennicutt) and EBA (J Priscu) planning meetings in 2005.
- SALE will liaise with the Expert Group on drilling when it is established.

Links to other ICSU bodies or to other scientific groups

- SALE is considering establishing a liaison with COSPAR for consultation on environmental protection methods.

Development and staffing of a project office or other administrative support

- A SALE Programme Office (PO) has been established at Texas A&M University and M Kennicutt serves as the PO Director. See - http://salepo.tamu.edu/salepo.tamu.edu
- Administrative and computer support is provided by the Office of the Vice President for Research at Texas A&M University for the SALE PO.
- A SCAR SALE website has been created at Texas A&M University. See - http://salepo.tamu.edu/scar_sale

Sources and amounts of income for project activities

- A workshop proposal for $75,000 was funded by the US NSF Office of Polar Programme - 7/19/05. Additional funds were provided to the workshop by CNRS.
- Hosts of SALE annual meeting provide local facilities at no cost to the programme.
- The office of the Vice President for Research at Texas A&M University provides in-kind support for the SALE Programme Office.

Expenditures on project activities

- SCAR provides $21,000/year most of which is spent on travel expenses for SALE members to attend the yearly SALE meetings.

EVALUATION CRITERIA

SCAR SRP performance is judged on a set of agreed evaluation criteria. These were the same criteria used in the SRP selection process:

Science quality

- SALE science is highly interdisciplinary and of high international quality as witnessed by the number and quality of publications and funded programmes.

Science importance/relevance/timeliness

- SALE science addresses basic scientific questions across a range of disciplines including tectonics, glaciology, hydrology, biology, limnology, genomics and biogeochemistry.
- SALE is tackling difficult technological challenges including the design of drilling and coring equipment, sensor development, sampling techniques, improved laboratory methodologies, miniaturization of equipment, and "clean technologies" for all aspects of SALE.
- SALE science includes the study of climate change; life in extreme environments; and the interactions of subglacial geology, ice dynamics, tectonics, climate and evolution.

"Fit" to current SCAR Strategic Plan

- SALE assists in initiating, developing, and coordinating high quality international scientific research in the Antarctic region adding knowledge about the role of Antarctica in the Earth system.
- SALE provides scientific advice to SCAR on all issues related SALE science and technology.
- SALE facilitates free and unrestricted access to scientific data and information produced by its members.
- SALE is committed to developing scientific capacity in all SCAR Members with interest in SALE science with special efforts to attract younger scientists.
- SALE promotes the incorporation of SALE science in education at all levels.
- SALE has effective procedures to communicate scientific information about the Antarctic region to the public.
- SALE is committed to an effective, efficient and flexible organisational structure, working mechanisms and practices.
- SALE actively works to increase funding for SALE activities.

Operational and technical feasibility

- There are now major SALE programmes in a number of countries – see the national report in the SCAR SALE Meeting Reports.
- Remote sensing, aerogeophysical surveys, and modeling are currently funded projects – 2005-2006.
- More challenging efforts such as lake entry, sample return, and observatory emplacement will occur as technologies are developed and resources identified.

Degree of international involvement/commitments

- SALE now includes programmes from 7 nations with a proposal to add two more countries.
- SALE-UNITED has links with over 30 IPY EoIs that include participants from many countries including programmes in the Arctic. The EoI links will be replaced with links to programmes websites as they are created http://salepo.tamu.edu/sale_united/coopipy

Data archival and access

- SALE has adopted an open data policy. See - http://salepo.tamu.edu/saledata
- SALE-UNITED (SALE in the IPY) adheres to the IPY Data Policy which also stresses an open data policy.
- SALE's approach to data accessibility and archive is a two pronged approach utilizing international data repositories and national data centers including JCADM.

Public/policy profile

- SALE has garnered great scientific and public interest as witnessed by the high level of coverage in the press. See - http://salepo.tamu.edu/press

Value added by SCAR involvement

- SALE, by its nature and complexity, is interdisciplinary and international in scope. SCAR is the only mechanism available to bring together the kind of alliance needed to accomplish the ambitious goals and objectives of SALE.

Education and outreach

- SALE is pursuing education and outreach programmes. In the US a proposal has been submitted to the NSF IPY solicitation to create a more interactive outreach and education programmes and to improve diversity in the programme See - http://salepo.tamu.edu/anteoc
- SALE adheres to SCAR EOC and capacity building plans and procedures.
- SALE participates in all EOC opportunities for the IPY organized by the IPY International Programme Office.

International Polar Year 2007-2008

- SALE-UNITED submitted an EoI to the ICSU/WMO Joint Committee first call for submissions and was selected as a lead programme for final proposal submission (SALE-UNITED).
- SALE-UNITED submitted a final full proposal to ICSU/WMO JC on June 29, 2005.
- SALE-UNITED has been named a Full Coordinated Project in the final ICSU/WMO IPY programme and is expected to be a major component of the "Exploring New Frontiers" IPY theme. See SALE -UNITED webpage - http://salepo.tamu.edu/sale_united
- SALE-UNITED has formed collaborative relationships with over 30 other initial IPY EoIs and provides direct links to these programmes at the SALE website. http://salepo.tamu.edu/sale_united/coopipy

REPORT ON EVOLUTION AND BIODIVERSITY IN THE ANTARCTIC (EBA)

INTRODUCTION

Evolution and Biodiversity in the Antarctic (EBA) is a new and ambitious programme of research under the SCAR umbrella that sets out to:

- Understand the evolution and diversity of life in the Antarctic.
- Determine how these have influenced the properties and dynamics of present Antarctic ecosystems and the Southern Ocean system.
- Make predictions on how organisms and communities are responding and will respond to current and future environmental change.
- Identify EBA science outcomes that are relevant to conservation policy and to communicate this science to the SCAR Antarctic Treat System and other stakeholders by appropriate routes.

The structure of the programme is based around five major unifying key questions, drawn together as work packages, that are addressed across the realms of terrestrial, limnetic and marine environments. In order to encourage integration of studies and findings across these realms and across the geographic spread of the Antarctic activities of contributing nations, the overall programme and work packages have been intentionally structured so as to be jointly led by representatives widely recognized within the Antarctic marine, terrestrial and limnetic biological research communities. In doing so, the programme brings 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 organism-level ecophysiology, and community ecology.

Highlights include some continuance with the past, e.g. in the SCAR MarBIN marine and RiSCC terrestrial biodiversity databases; the plans for the Census of Antarctic Marine Life (CAML); and the synthesis volumes from the Ecology of the Antarctic Sea Ice Zone (EASIZ) and the Regional Sensitivity to Climate Change in Antarctic Terrestrial and Limnetic Ecosystems (RiSCC) programmes .

MarBIN is a network for marine biodiversity information. It is the Antarctic node of the Ocean Biogeographical Information System (OBIS) and links to the Global Biodiversity Information Facility (GBIF). It helps to establish a census of Antarctic marine biodiversity and to look at patterns of biodiversity, and to identify gaps.

CAML has been accepted as an IPY project, and may have 8-10 or so ships. It is part of a larger, global, Census of Marine Life (COML) programme. Ship plans are now being developed. Data will go into MarBIN. It will undertake a species inventory for the Southern Ocean.

RiSCC established trends in Antarctic terrestrial and limnetic ecosystems, and was wound up as EBA started. RiSCC is one foundation of EBA. EASIZ is another, and its results have also just been published in a synthesis volume as a special issue of Deep Sea Research. The third foundation element is derived from the previous Evolanta programme, itself also responsible for earlier special issues of Antarctic Science.

A major new finding is that the biota of the Antarctic Peninsula is very different from that of the rest of the continent, i.e. there is a striking biogeographical ‘divide’ between the two. This is one of several lines of evidence that suggests that the biota does not have a ‘recent’ origin. Within these two areas there are also local centres of endemism and diversity, suggesting that future research will identify further biogeographical regions within the continent.

Molecular biology has demonstrated that it has a significant role to play. For instance, molecular clocks can be used to quantify evolutionary patterns. In one study they suggest a 40 million year

separation between two endemic fly species (occurring on the Peninsula and South Georgia respectively).

AGREED WORK PACKAGES

1. Evolutionary history of Antarctic organisms

Key scientific areas to be investigated will include:

- Vicariance and Radiations: When did the key radiations of Antarctic taxa take place? (key groups will be focused upon).
- 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).
- Phylogeography: geographical structure and relationships in the Antarctic biome.
- Evolutionary history of Antarctic micro-organisms (both prokaryotic and eukaryotic).

2. Evolutionary adaption to the Antarctic environment

Key scientific areas to be investigated will include:

- 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 environments. As such, life history patterns enable successful reproduction and survival in response to the variability or stability of both the biological (e.g. competition, predation) and physical (e.g. temperature, water availability, pressure, etc) environments.

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

Key scientific areas to be investigated will include:

- Population structure and dynamics in the context of evolutionary biology.
- 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.
- Genetic structure of populations: differences among and between Antarctic and non-Antarctic populations.
- 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:

- Biodiversity: to what extent is the diversity of the Antarctic biota underestimated (both standard & cryptic species)?
- Spatial and temporal variations in diversity: variation of diversity at different spatial scales within the Antarctic and within defined time frames.
- Response to latitudinal and environmental gradients: local, regional and global.
- 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*:*

- Interactions between introduced and indigenous species in selected environments under climate change.
- Effect of abiotic change on biota.

- Modelling interactions between environmental change and organism responses in order to predict biotic change.
- Impact of biological feedback on climate.

STEERING COMMITTEE
Co-chair: Guido di Prisco (Italy, marine, also representing ICEFISH)
Co-chair: Pete Convey (UK, terrestrial)
Secretary: Dana Bergstrom (AUS, terrestrial)
Member: Angelika Brandt (Germany, marine)
Member: Marc Lebouvier (France, conservation matters)
Ex officio: Ad Huiskes (NL, terrestrial, Chief Officer Life Sciences Standing Scientific Group of SCAR)
Census of Antarctic Marine Life (CAML): Michael Stoddart (AUS, marine)

WORKPACKAGE LEADERS
WP1: Brigitte Hilbig (Germany, marine, also representing ANDEEP-SYSTCO), Dominic Hodgson (UK, terrestrial)
WP2: Dan Costa (USA, marine), Takeshi Naganuma (Japan, terrestrial, also representing MERGE)
WP3: Antonio Mateo Sole-Cava (Brazil, marine), Ian Hogg (NZ, terrestrial)
WP4: Julian Gutt (Germany, marine), Satoshi Imura (Japan, freshwater)
WP5: Edith Fanta (Brazil, marine), Tad Day (USA, terrestrial)

MILESTONES
EBA came into existence when its science implementation plan and proposed Steering Committee were formally approved by the SCAR Executive in November 2005. The finalisation and agreement by participating scientists of these two items, for submission to the SCAR Executive, was therefore a main focus of the 2005 SCAR Biology Meeting (Curitiba, Brazil). The nominated work package leaders for each package (two for each, drawn from the international marine and terrestrial biology communities within SCAR) were then circulated widely amongst the EBA community after the meeting, before being formally approached.

While not formally part of EBA itself, it is important to highlight the role played by the predecessor SCAR programmes Evolanta and RiSCC (which were formally wound up at SCAR Curitiba) and EASIZ, formally completed in 2004, in the development of the EBA science programme, and in contributing to its member scientific community.

The SCAR Hobart Open Science Conference therefore provides the first opportunity since the programme's formal adoption for its members to meet. EBA scientists will use this opportunity to give high profile keynote presentations on EBA itself (Fanta, Brazil) and its predecessor biological programmes (Convey, UK & Bergstrom, AUS; Prisco, IT & Rodhouse, UK), as well as keynotes at the pre-meeting International Forum on the Sub-Antarctic (Bergstrom & Selkirk, AUS; Convey, UK). Many Open Science Meeting presentations will be given by EBA members, who will also contribute further to specific workshops arranged throughout the conference, in particular those of CAML and LGP, and the Inter-Programme Workshop.

OUTPUTS
At this early stage of the programme's life, outputs take the form of:

- EBA personnel have taken over and continued the production of the major RiSCC product, the volume " *Trends in Antarctic Terrestrial and Limnetic Ecosystems*, eds. Bergstrom, D.M**,** Convey, P. & Huiskes, A.H.L. Springer, Dordrecht"; the volume is due for publication in late summer 2006, and includes 16 chapters prepared by 39 authors.

- EBA personnel are now responsible for the main products of EVOLANTA, i.e. research on evolutionary biology of Antarctic organisms.
- EBA personnel are now responsible for completing the coordination of the output of the EASIZ programme closing meeting (special issue of *Deep Sea Research*)
- An EBA special journal issue (*Antarctic Science*, eds. Fanta, Arntz, Detrich, Kawal, and Walton) arising from Curitiba.
- EBA starting to appear in the acknowledgements to new scientific papers of involved scientists, bringing it and SCAR to the notice of the wider scientific community (examples listed in Appendix).
- Formalised EBA contribution to IPY, in the form of the endorsed programmes EBA, Tarantella, MERGE, Aliens in Antarctica, CAML, ICEFISH, CCAMLR, ANDEEP-SYSTCO, MarBIN, CLICOPEN, HABIPOL, HERMES, IAI, SVALBASE, TUNU, ARCTOS, Pole-to-Pole.
- Formalised EBA contribution to CAML.
- Participation in ICEFISH Symposium (organised by HW Detrich at the Darling Marine Center, Univ of Maine; August 21st-25th, 2005), illustrating links between the IPY-endorsed EBA and ICEFISH.
- Participation in SCAR inter-programme workshop (Amsterdam, Nov 2005), when links were established with the other SCAR programmes SALE, ACE, AGCS; this to be developed further at the Inter-Programme workshop in Hobart.
- Contribution (Frenot, FRA; Convey, UK) to the "Non-Native species in the Antarctic" workshop (Christchurch, April 2006; organised by Gateway Antarctica and Antarctica New Zealand), and subsequent development of proposals to CEP meeting, Edinburgh, June 2005.

FINANCES

2005 expenditure

- Terrestrial database $3000
- MarbIN Workshop $3000.01
- EBA SSC Workshop Cambridge $6099.59
- Carried forward $8900.40

2006 expenditure

- Publication costs of *Antarctic Science* EBA Symposium Special Issue, $10,000
- Future workshop schedule and costs to be defined at Hobart Open Science Meeting.

Appendix – example publications citing EBA support

Brinkmann, M., Pearce, D.A., Convey, P. & Ott, S. The cyanobacterial community of polygon soils at an Antarctic terrestrial inland site – Coal Nunatak, Alexander Island. *Polar Biology* (in press).

Chown, S.L. & Convey, P. Spatial and temporal variability across life's hierarchies in the terrestrial Antarctic. *Phil Trans Roy Soc Lond B* (in press).

Convey, P. (2007) Antarctic terrestrial biodiversity – patterns and problems. *Proceedings of Malaysian International Antarctic Science Congress* (in press).

Convey, P. (2007) Antarctic Ecosystems. *Encyclopedia of Biodiversity*, 2nd Edition, ed. S.A. Levin. Elsevier, San Diego (in press).

Convey, P., Barnes, D.K.A., Clark, M.S. Dominic A. Hodgson, D.A. & Peck, L.S. (2007) An holistic approach to understanding the biological impacts of climate change: Antarctica as a planetary warning system. *Inside Agriculture* (in press).

Convey, P. & Smith, R.I.L. (2006) Thermal relationships of bryophytes from geothermal habitats in the South Sandwich Islands, maritime Antarctic. *Journal of Vegetation Science*. 17.529-538.

Giordano D, Grassi L, Parisi E, Bargelloni L, di Prisco G, Verde C (2006) Embryonic b-globin in the non-Antarctic notothenioid fish *Cottoperca gobio* (Bovichtidae). *Polar Biology* (in press).

Maslen, N.R. & Convey, P. (2006) Nematode diversity and distribution in the southern maritime Antarctic – clues to history? *Soil Biology and Biochemistry.* 38. 3035-3040.

Mazzarella L, Bonomi G, Lubrano MC, Merlino A, Riccio A, Vergara A, Vitagliano L, Verde C, di Prisco G (2006) Minimal structural requirements for Root effect: crystal structure of the cathodic hemoglobin isolated from the antarctic fish *Trematomus newnesi*. *Proteins* **62**: 316-321

Peat, H.J., Clarke, A. & Convey, P. (2007) Diversity and biogeography of the Antarctic flora. *Journal of Biogeography.* 34. 132-146.

Verde C, De Rosa MC, Giordano D, Mosca D, de Pascale D, Raiola L, Cocca E, Carratore V, Giardina B, di Prisco G (2005) Structure, function and molecular adaptations of haemoglobins of the polar cartilaginous fish *Bathyraja eatonii* and *Raja hyperborea*. *Biochem J* **389**: 297-306

Verde C, di Prisco G (2006) The adaptive evolution of polar fishes: structure, function and molecular phylogeny of hemoglobin. *Memoirs of National Institute of Polar Research, Special Issue* No. **59** (in press).

Verde C, Parisi E, di Prisco G (2006) Tracking adaptive evolution in the structure, function and molecular phylogeny of haemoglobin in non-Antarctic notothenioid fish species. *Deep Sea Research II.* 53. 1105-1114.

Verde C, Parisi E, di Prisco G (2006) The evolution of thermal adaptation in polar fish. *Gene* (in press).

Verde C, Balestrieri M, de Pascale D, Pagnozzi D, Lecointre G, di Prisco G (2006) The oxygen-transport system in three species of the boreal fish family Gadidae. Molecular phylogeny of hemoglobin *J Biol Chem* (in press).

Waller C.L., Worland M.R., Convey P. & Barnes D.K.A. (2006). Ecophysiological strategies of Antarctic intertidal invertebrates faced with freezing stress. *Polar Biology*. 29. 1077-1083.

Waller, C., Barnes, D.K.A. & Convey, P. Ecological contrasts across an Antarctic land-sea interface. *Austral Ecology.* 31.656-666.

REPORT ON ANTARCTICA AND THE GLOBAL CLIMATE SYSTEM (AGCS)

INTRODUCTION

AGCS uses meteorological, oceanographic and glaciological data, including records from deep and shallow ice cores covering the past 10,000 years, plus the output of global and regional coupled atmosphere-ocean-ice climate models, to understand Antarctica's role in the Earth's climate system, and how the climate of the Antarctic and the high southern latitudes will evolve over the next 100 years in response to natural and human forcing. Outputs will include an improved understanding of the complex interactions between the atmospheric, oceanic and cryospheric elements of the climate system in the polar regions, of natural climate variability as opposed to human influence in the polar regions, and of how signals of tropical and mid-latitude climate variability reach the Antarctic, and high latitude climate signals are exported northwards. This work on the "modern" climate system complements that on the past climate system by SCAR's ACE programme (section 2.1.1). AGCS and its various sub-programmes (http://www.antarctica.ac.uk/met/SCAR_ssg_ps/AGCS.htm.) are co-sponsored by SCAR and the World Climate Research programme (WCRP).

This document reports on progress with the implementation of the SCAR AGCS SRP since it was established at SCAR XXVIII in Bremerhaven, Germany in October 2004. It provides details of progress with the science, lists outputs and identifies targets for the next two years. AGCS consists of four science themes concerned 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
4. The export of Antarctic Climate Signals

FIVE SCIENTIFIC HIGHLIGHTS

1. An undocumented major warming of the Antarctic winter troposphere was discovered that is larger than any previously identified regional tropospheric warming on Earth. The warming was identified by a careful analysis of the balloon-launched radiosonde data for the Antarctic extending back into the 1950s that forms part of the SCAR READER database. The warming is largest close to 5 km above sea level where temperatures have increased at a rate of 0.5 – 0.7 deg C over the last 30 years. The results were published in Science in March 2006 (Turner et al., 2006).
2. An analysis of recent trends in Antarctic snow accumulation from ice core and model data showed that over the continent as a whole the annual trends are small and not statistically different from zero, suggesting that recent Antarctic snowfall changes do not mitigate current sea level rise. The work was carried out with the Polar MM5 climate model (Monaghan et al., In Press).
3. The climate of the Western Antarctic Peninsula (WAP) is the most rapidly changing in the Southern Hemisphere, with a rise in atmospheric temperature of nearly 3 deg C since 1951 and associated cryospheric impacts. It has been demonstrated for the first time, that the adjacent ocean showed profound coincident changes, with surface summer temperatures rising more than 1 deg C and a strong upper-layer salinification. Initially driven by atmospheric warming and reduced rates of sea ice production, these changes constitute positive feedbacks that will contribute significantly to the continued climate change. Marine species in this region have extreme sensitivities to their environment, with population and species removal predicted in response to very small increases in ocean temperature. The WAP region is an important breeding and nursery ground for Antarctic krill, a key species in the Southern Ocean foodweb with a known dependence on the physical environment. The changes observed thus have significant ecological implications (Meredith and King, 2005).
4. Modelling studies have shown for the first time that the major, near-surface increase in temperature on the eastern side of the Antarctic Peninsula has been caused, at least in part, by increases in greenhouse gases. Over the last few decades the Southern

Hemisphere Annular Mode (SAM) has shifted into its positive phase during the summer, resulting in a drop (increase) in atmospheric pressure over the Antarctic (mid-latitudes). This has results in a strengthening of the westerly winds around the Antarctic and more mild, maritime air masses crossing the Antarctic Peninsula. The warming has been instrumental in the disintegration of the ice shelves in this area (Marshall et al., In Press).

5. Ice core reconstructions of past atmospheric circulation suggest that modern atmospheric circulation intensity is within the range of variability of the last ~1000 years (Mayewski and Maasch, 2006). Ice core records also reveal increased penetration of marine air masses into the western coastal regions of West Antarctica as of the 1940s (Dixon et al., 2006).

PROGRESS AGAINST PRIOR WORK PLAN

What were the planned milestones and deliverables? What were the achievements against these during the 2-year cycle?

All the AGCS milestones and deliverables are listed in the AGCS Implementation Plan available at http://www.scar.org/researchgroups/physicalscience/agcs/. Because of space restrictions only selected achievements are listed below, but an expanded version is available on the web at http://www.antarctica.ac.uk/met/SCAR_ssg_ps/AGCS Progress.htm

- Theme 1. Insight has been gaining into changes in the Southern Hemisphere Annular Mode (SAM) over recent decades and especially its influence on Antarctic Peninsula temperatures.
- Theme 1. Model studies have shown that the horizontal precipitation variability across Dronning Maud land reflects the synoptic and topographic forcing. On the plateau, where these forcings become weak, a monotonous inland decrease in precipitation was not found. (U. Wacker, AWI).
- Theme 2. See item 5 under Scientific Highlights.
- Theme 3. The planned airborne campaign AGAMES “Antarctic Trace Gas and Aerosol Airborne Measurement Study” in 2005/06 had to be postponed because of an accident with the POLAR 4 aircraft.
- Theme 3. In preparation for the IPY activity POLAR AOD (aerosol optical depth) Network in which ground-based measuring activities will take place in Antarctica, a special intercomparison campaign was held in Ny-Aalesund, Arctic.
- Theme 4. The AWI undertook a major cruise in the Weddell Sea over 20 Nov 2005 -12 Jan 2006 in which valuable oceanographic data were collected.
- Theme 4. Insight was gained into the maintenance of perennial sea ice cover from the Ice Station POLarstern drift experiment. During this cruise Helium isotope and neon measurements were made.
- Theme 4. Oceanographic measurements in the Weddell Sea have indicated that the bottom water temperature increased steadily during the last decades. E. Fahrbach (AWI).
- Theme 4. During FS Polarstern cruise ANT-XXII/3 in 2005, CO_2 system parameters were measured on two repeat sections through the Weddell Sea.
- Theme 4. In the framework of the Southern Ocean Observation System, 29 ice compatible floats have been deployed within the southern part of the Antarctic Circumpolar Current and the Weddell Gyre.
- Further understanding was obtained of how signals of the El Nino-Southern Oscillation are transferred into the Antarctic and the limits on how robust the ENSO can be in an area of high natural climate variability.
- A workshop was held (jointly with CliC and ICPM) to assess the quality of the reanalysis fields at high latitudes.
- AGCS was instrumental in organising a workshop (jointly with POGO and CoML) on the design of a Southern Ocean Observing System, which will be held at the end of the SCAR OSC.

What deviations were made from the work plan, and why?

There were no major deviations from the work plan. The problems with the POLAR 4 aircraft are noted above.

What SCAR funds were allocated to the activity and how were the SCAR funds spent?
AGCS had a budget of $21K in 2005, of which $8.2K was spent and $12.7K carried forward to 2006. The 2005 spend was as follows:

AGCS Steering Committee meeting	$4.2K
Ice READER data base development	$4K
Total	$8.2K

Planned spend for 2006:

Development of the Ocean READER data base	$4K
Development of the Ice READER data base	$4K
ASPECT Workshop, Hobart, July 2006	$6K
Last 2,000 year workshop Hobart, July 2006	$6K
Reanalysis workshop, Cambridge, UK, April 2006	$10K
Publication of ITASE paper in Annals of Glaciology	$3K
Total	$33K

What are the new planned milestones and deliverables?
The targets for the next two years will be decided at the AGCS Steering Committee meeting in Hobart during July 2006. However, some possible targets will be:

- Assessment of the Antarctic element of the IPCC Assessment Round 4 model predictions for the next century.
- Investigation of the mechanisms responsible for changes in the SAM.
- Research into mechanisms behind the mid-tropospheric warming above the Antarctic that occurred over the last 50 years.
- Investigation of the current state of the Antarctic climate in the context of the last several hundred years for purposes of assessing natural vs anthropogenic impact.

What SCAR funds are required to support the activity and how will they be used?
We anticipate requiring level funding over the next two years of about $21K per year. The exact usage of the funds will be decided in Hobart, but possibilities are:

- Further data recovery of early Antarctic climate records
- Development of the READER data bases
- Workshops on climate variability
- Further cross-SRP/SSG workshops

OUTPUTS/DELIVERABLES
(a) Publications in peer reviewed literature (including articles "in press") – selected papers
Bertler,N. & et al (2005) Snow chemistry across Antarctica. Annals of Glaciology, 41, 167-179.
Blaker A. T., B. Sinha, V. O. Ivchenko, N. C. Wells, V. B. Zalesny (2006), Identifying the roles of the ocean and atmosphere in creating a rapid equatorial response to a Southern Ocean anomaly, Geophys. Res. Lett., 33, L06720, doi:10.1029/2005GL025474.
Dixon, D., Mayewski, P.A., Kaspari, S., Sneed, S., and Handley, M., 2004, A 200 year sub annual record of the primary sources of sulfate in West Antarctica, Annals of Glaciology 39, 545-556.
Fahrbach, E., Hoppema, M., Rohardt, G., Schröder, M., Wisotzki, A. (2006). Causes of deep-water variation: Comment on the paper by L.H. Smedsrud "Warming of the deep water in the Weddell Sea along the Greenwich meridian: 1977-2001", Deep-Sea Research I, 53(3), 574-577.
DOI: 10.1016/j.dsr.2005.12.003

Fogt, R.L., and D.H. Bromwich, 2005:Decadal variability of the ENSO teleconnection to the high latitude South Pacific governed by coupling with the Southern Annular Mode. J. Climate, accepted for publication.

Hellmer, H. H., Dieckmann, G. S., Haas, C., Schröder, M. (2006). Sea ice feedbacks observed in western Weddell Sea, EOS, Transactions, American Geophysical Union, 87(18), 173, 179.

Hoppema, M., Anderson, L. G. (2006). Biogeochemistry of polynyas and their role in sequestration of anthropogenic constituents, In: "Polynyas: Windows into Polar Oceans", W.O. Smith Jr., D. Barber (Eds.). Elsevier Oceanography Series, Amsterdam, in press.

Klatt, O., Fahrbach, E., Hoppema, M., Rohardt, G. (2005). The transport of the Weddell Gyre across the Prime Meridian, Deep-Sea Research II, 52, 513-528. DOI: 10.1016/j.dsr2.2004.12.015

Legeais, J.-F., Speich, S., Arhan, M., Ansorge, I., Fahrbach, E. , Garzoli, S., Klepikov, A. (2005). The baroclinic transport of the Antarctic Circumpolar Current south of Africa, Geophysical Research Letters, 32, L24602. DOI: 10.1029/2005GL023271

Makinson, K., Schröder, M., Osterhus, S. (2006). The effect of critical latitude and seasonal stratification on tidal current profiles along Ronne Ice Front, Antarctica, Journal of Geophysical Research, in press.

Marshall, G. J., Orr, A., van Lipzig, N. P. M. and King, J. C. (In Press) The impact of a changing Southern Hemisphere Annular Mode on Antarctic Peninsula summer temperatures. Journal of Climate.

Mayewski, P.A. and Maasch, K., in press 2006, Recent warming inconsistent with natural association between temperature and atmospheric circulation over the last 2000 years, Climate of the Past (Discussions).

Mayewski,P.A. & et al (2005) The International Trans-Antarctic Science Expedition (ITASE): An Overview. Annals of Glaciology, 41, 180-185.

Meredith, M.P. and A.McC. Hogg, “Circumpolar response of Southern Ocean eddy activity to changes in the Southern Annular Mode”. Submitted to Geophysical Research Letters, 2006.

Meredith, M.P., M.A. Brandon, M.I. Wallace, A. Clarke, M.J. Leng, I.A. Renfrew, N. van Lipzig and J.C. King. “Variability in the freshwater balance of northern Marguerite Bay, Antarctic Peninsula: results from _18O”. Submitted to Deep-Sea Research, 2006.

Meredith,M.P. & King,J.C. (2005) Climate change in the ocean to the west of the Antarctic Peninsula during the second half of the 20th century. Geophysics Research Letters, 32, L19606 doi:10.1029/2005GL024042.

Monaghan, A.J., D.H. Bromwich, and S-H. Wang, 2006: Recent trends in Antarctic snow accumulation from Polar MM5. *Philosophical Trans. Royal. Soc.,* conditionally accepted, October 2005.

Piel, C., Weller, R., Huke, M., Wagenbach, D. (2006). Atmospheric methane sulfonate and non-sea salt sulfate records at the EPICA deep-drilling site in Dronning Maud Land, Antarctica, Journal of Geophysical Research-Atmospheres, 111, D03304 DOI: 10.1029/2005JD006213

Spikes, V.B., Hamilton, G.H., Arcone, S.A., Kaspari, S. and Mayewski, P.A., 2005, Primary causes of variability in Antarctic accumulation rates, Annals of Glaciology 39, 238-244.

Turner,J., Lachlan-Cope,T.A., Colwell,S.R., Marshall,G.J. & Connolley,W.M. (2006) Significant warming of the Antarctic winter troposphere. Science, 311, 1914-7.

Wacker, U. (2006). Nonlinear effects in a conceptual multilayer cloud model, Nonlinear Processes in Geophysics, 13, 99-107.

(b) Other Publications (e.g. institution reports, articles in the grey literature, maps, atlases, CDs, Newsletters or contributions to newsletters)

Several articles on AGCS science appeared in conference proceedings.

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

- A great deal of press coverage was generated by the discovery of the Antarctic mid-tropospheric warming. TV and radio interviews were carried out and many articles appeared in newspapers around the world.

- The Meredith and King West Antarctic Peninsula warming paper was the subject of a full-page article in the UK Guardian newspaper, and also featured on a large number of news websites (including BBC news).

(d) Creation of a website, and number of hits per website
An AGCS website (http://www.antarctica.ac.uk/met/SCAR_ssg_ps/AGCS.htm) has been created that describes the research programme and our goals. At present we don't have any information on the number of hits.

(e) Creation of database(s), and amount of use of database(s) (e.g. as measured by hits on a web version)
- The frequently used MET-READER data base of monthly mean Antarctic climate data (http://www.antarctica.ac.uk/met/READER/) has continued to be developed and kept up to date with recent data. A new database, known as ICE-READER (http://www2.umaine.edu/itase/content/icereader/), indicating the locations where Antarctic ice cores have been collected has been created. It is planned to add information on the data analysed in these cores and the papers that resulted.
- During 2006 a summer student will be employed to start work on the OCEAN-READER data base that will point to the key data sets on Southern Ocean oceanographic data.
- Important data sets have been created from the air chemistry (Neumayer Station) and aerosol (Konen station) observing programmes. The data are accessible under PANGAEA (http://www.pangaea.de/PangaVista); search for "Neumayer Air Chemistry") and are also submitted to GAW (http://www.empa.ch/gaw/gawsis/default.asp ; submitted: surface ozone, condensation particle number concentration, aerosol scattering by integrating nephelometer).
- Data from Polarstern cruise ANT XXII/3 were processed and are in the AWI data base. It will also be released to the CLIVAR data centre.

(f) Number and type of education/training and other capacity building activities:
- Numerous public outreach talks were given by AGCS scientists.
- Various UK labs/universities are spinning up a proposal to NERC to directly address some of the key questions under AGCS Theme 4.

(g) New technology/model developments
- While making extensive use of climate models, our main involvement in model development has been through trying to improve the representation of Antarctic sea ice.
- AGCS scientists have worked closely with the Physical Sciences SSG Expert Group on Ice Drilling in developing and exploiting the latest technology for drilling ice cores.

(h) Contributions to IPY
AGCS is involved in the following full IPY proposals:

- Antarctic Climate and Atmospheric Circulation (ID 180).
- Antarctic Regional Interactions Meteorology Experiment (RIME) (ID 15).
- Comprehensive Meteorological dataset of active IPY Antarctic measurement phase for Scientific and applied Studies (ID 267).
- Climate of Antarctica and the Southern Ocean – Ocean Circulation Cluster (ID 132).
- Trans-Antarctic Scientific Traverses Expeditions – Ice Divide of East Antarctica (ID152).
- Dome A Observations and Multidisciplinary Exploring—Actions during IPY (ID 297).
- International Polar Year GEOTRACES: An international study of the biogeochemical cycles of Trace Elements and Isotopes in the Arctic and Southern Oceans (ID 35).

(i) key achievements (short paragraphs on each)
- Publications in the peer reviewed literature (see above).
- Development of the READER databases.
- Preparation of IPY proposals.

(j) number, gender and country of participating scientists
The AGCS Steering Committee consists of:

- Dr. John Turner, British Antarctic Survey, UK (Chair) (J.Turner@bas.ac.uk) M.
- Prof. David Bromwich, Byrd Polar Research Center, Ohio State University, USA (bromwich.1@osu.edu) M.
- Dr. Mike Meredith, British Antarctic Survey, UK (M.Meredith@bas.ac.uk) M.
- Prof. Paul Mayewski, University of Maine, USA (paul.mayewski@maine.edu) M.
- Dr. Alberto C. Naveira Garabato, National Oceanography Centre, UK (acng@noc.soton.ac.uk) M.
- Dr. Tony Worby, University of Tasmania, Australia (a.worby@utas.edu.au) M.
- Dr. Nancy Bertler, Victoria University of Wellington, New Zealand (nancy.bertler@vuw.ac.nz) F.
- Dr. Cunde Xiao, Chinese Meteorological Administration, Beijing (cdxiao@cams.cma.gov.cn) M.
- Dr. Gino Casassa, Centro de Estudios Cientificos, Chile (GC@cecs.cl) M.
- Dr. Shigeru Aoki, Low Temperature Institute, Hokkaido University, Japan (shigeru@lowtem.hokudai.ac.jp) M.
- Ms Helen Campbell, British Antarctic Survey, UK (HCAMP@bas.ac.uk) (JCADM rep) F.

The Implementation Plan explicitly names 64 scientists (52 male and 12 female) working on AGCS activities, but there are many other people involved in the project, including co-workers and students.

(k) number and type of meetings/workshops, and numbers, genders and countries represented in their attendees.
Workshop on High Latitude Reanalyses, British Antarctic Survey, 10-12 April 2006. Twenty participants from the UK (13), USA (6), France (1). Nineteen male and one female.

(l) links to other SCAR SRPs or Action or Expert Groups
A very valuable cross-SSG/cross-SRP workshop was held in Amsterdam in November 2005. Amongst other things, this meeting decided on the climate prediction variables covering the next century that would be provided to the EBA programme.

(m) links to other ICSU bodies or to other scientific groups
Close links have been established with the World Climate Research Programme Climate and Cryosphere (CliC) project and especially the CliC Project Area 4 on Linkages between the cryosphere and global climate.

(n) development and staffing of a project office or other administrative support
AGCS does not have a formal project office.

(o) sources and amounts of income for project activities
Besides the funds provides by SCAR, the activities of AGCS have been funded by national Antarctic programmes, research grants and university funds.

(g) expenditure on project activities
See the breakdown of the usage of SCAR funds.

REPORT ON INTERHEMISPHERIC CONJUGACY EFFECTS IN SOLAR-TERRESTRIAL AND AERONOMY RESEARCH (ICESTAR)

INTRODUCTION

ICESTAR will create an integrated, quantitative description of the upper atmosphere over Antarctica, and of its coupling to the global atmosphere and the geospace environment.

ICESTAR like the other SRPs carries out its work through a number (4) of subgroups, on the global electrical circuit, the magnetosphere-ionosphere coupling, on inter-hemispheric comparisons of solar effects, and on data portal development.

SUMMARY OF FIVE MAIN ACHIEVEMENTS

Highlights are represented by 5 papers:

(i) effects of solar energetic particles (protons) on middle atmospheric chemistry. These cause chemical reactions producing NO2, above about 40km, which can be measured by GOMOS satellite measurements. NO2 is associated with ozone destruction inside the polar vortex.
(ii) control of equatorial ionosphere plasma density anomalies near the equator. The westward neutral wind drags positive ions westward creating a low density area in which the plasma can drift upwards. The control is by atmospheric tides and it appears as longitudinal modulation in the plasma density.
(iii) sprites, streamers and beads have been studied for their characteristics. These are transient luminous events that appear above thunderstorms. Observations of a recently developed advanced imaging system have been used for statistical analysis of streamer and bead lifetimes and scale sizes.
(iv) solar wind energy gets into the magnetosphere and drives global plasma circulation there, which maps along the geomagnetic field lines to a convection pattern in the polar ionospheres. This pattern is associated with the cross-polar cap potential (CPCP), which can be used as a proxy for the coupling efficiency between the solar wind and magnetosphere. The CPCP drives large-scale currents that couple the magnetosphere and ionosphere by flowing along the geomagnetic field lines. Asymmetries are observed between the two polar regions, but are smaller than suggested by model simulations. This appears to be due to the different solar illumination and particle precipitation conditions affecting the background ionospheric conductances in the polar regions.
(v) The topology of the geomagnetic field defines the morphology and dynamics of large-scale auroral displays (like substorms). These are linked by the same magnetic field lines, so should be conjugate in both hemispheres, and should be analysed together. A study of substorm onset locations observed by the IMAGE (Imager for Magnetopause-to-Aurora Global Exploration) satellite shows that asymmetries in the substorm onset locations are 5-10 times larger than statistical models anticipate. Consequently, better models are needed to describe more accurately the solar wind magnetic field penetration into the magnetotail.

OTHER SELECTED ACHIEVEMENTS IN 2005 - 2006

- ICESTAR hosts a *Data Portal and Virtual Observatory Workshop* in Toulouse, France, July 2005
- ICESTAR leads *Heliosphere Impact on Geospace*, a core project of the fourth International Polar Year programme
- ICESTAR leads an IPY-ICESTAR proposal effort submitted to the Norwegian Research Council

- ICESTAR scientists will present 38 papers at the Open Science Conference of the 2006 SCAR meeting in Hobart, Australia
- ICESTAR co-sponsored scientific sessions at both the European and American Geophysical Union Meetings in 2006

ICESTAR PROGRESS IN 2005 - 2006

The ICESTAR Programme will create an integrated, quantitative description of the upper atmosphere over Antarctica, and its coupling to the global atmosphere and the geospace environment. The reasons to embark on the endeavour 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 extensive statistical studies 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 visualization tools that can utilize 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.

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.

ACCOMPLISHMENTS IN 2005 - 2006

- *ICESTAR Website:* Established to facilitate international communication.
- *CEDAR/GEM Meeting 2005:* ICESTAR team member Allan Weatherwax helped organise 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 data sets 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 organisation 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. *See* IPY contributions section below.
- *Meeting on Atmospheric Studies by Optical Methods:* Prof. Scott Palo presented an invited talk about the ICESTAR programme 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.
  - *Fall 2005 AGU - ICESTAR Related Talks and Presentations:*
    - Deploying a Low Cost Virtual Observatory and Data Portal at a Small Liberal Arts College by H. Schechner and A. T. Weatherwax
    - Geospace Climatology: A Window to the Heliosphere Through Polar Regions by V. O. Papitashvili.

  - The Future of Systems Aeronomy in Addressing New Science Frontiers by J. U. Kozyra, L. J. Paxton and A. Ridley.
  - GAIA - A Virtual Auroral Observatory by E. Donovan.
  - Polar Gateways to Exploration of Icy Worlds in the Solar System by J. Cooper.
- *ICESTAR-IHY Collaboration:* 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 gave 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.
- *ICS-8:* TAG Team Leader Nikolai Østgaard will give an invited talk at the International Conference on Substorms-8 on conjugate imaging of substorms.
- *ICS-8:* Krsti Kauristi, Nikolai Østgaard, and Allan Weatherwax present ICESTAR related papers at the Eighth International Conference on Substorms, March 27-31, 2006.
- Co-director Allan Weatherwax presented an ICESTAR related seminar at South Pole Station during a visit to Antarctica to conduct fieldwork.

PROPOSED WORK PLAN FOR THE NEXT 2 YEARS

- 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).
- 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.
- Launch of the ICESTAR-IHY-IPY project (Kick –off meeting in Helsinki Feb 5-9, 2007).

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.

IPY CONTRIBUTIONS

The ICESTAR community submitted an Expression of Intent to the call of IPY Core projects in January 2005. As response the IPY Joint Committee suggested ICESTAR to join with the IHY community (IHY= International Heliophysical Year) and to form an umbrella for 22 other projects which will address geospace and polar area aeronomy research topics. ICESTAR and IHY submitted the second round proposal with the title "ICESTAR/IHY – Interhemispheric Conjugacy in Geospace Phenomena and their Heliospheric Drivers" in June 2005 for IPY JC reconsideration. At the beginning of December the proposal received IPY's final endorsement after which the programme has still been expanded with seven additional sub-projects according to the suggestions of IPY JC. Consequently, today the programme includes 29 multinational consortia and appears as the project number 63 ("Heliosphere Impact on Geospace") in the official IPY Planning Chart.

SCIENCE OF THE ICESTAR-IHY-IPY PROGRAMME

The scientific goals of the ICESTAR-IHY-IPY programme can be categorised under the following three main themes:

- *Coupling processes between the different atmospheric layers and their connection with the solar activity*: E.g. effects of mid-atmospheric circulation and extreme solar activity on the content of stratospheric ozone and minor constituents, variations of the cosmic ray fluxes above the polar areas and South Atlantic Anomaly, energy transfer from powerful weather fronts to geospace heights and using novel technology for stratospheric magnetic field measurements.
- *Energy and mass exchange between the ionosphere and the magnetosphere:* E.g. multiscale and tomographic studies of ionospheric phenomena (auroral precipitation, convection, turbulence and electron content) as driven by magnetospheric and solar activity, remote-sensing of the radiation belts, and balloon-borne radio soundings of the ionosphere in conjunction with ground stations and satellites as pilot studies for future NASA missions.
- *Inter-hemispheric similarities and asymmetries in geospace phenomena*: Science goals as above but under this theme special emphasis will be put on using both Arctic and Antarctic observations. In addition to several magnetometer and optical instrument networks bipolar data will be available also from HF-radars, riometers, digital ionosondes, dynasondes, dual-frequency GPS receivers and LEO satellite beacon receivers.

Each project in the combined proposal has a set of project-specific scientific objectives, but the interrelationships between the studied processes mean there is significant synergy between the projects. The result is that the overall proposal will be able to address topics with far-reaching scientific impact and of importance to society at large. For example, a practical benefit will be improved prediction of space weather phenomena which adversely affect spacecraft operations, humans in space, and satellite-based positioning systems; on the scientific side, global scale coordination of observing networks will allow us to study conjugate and multi-scale geospace phenomena in fundamentally new ways.

INSTRUMENTATION AND MEASUREMENT CAMPAIGNS

The groups of the programme already run a large body of instrumentation in both the Arctic and the Antarctic polar regions to support their research projects. Several consortia are also proposing to install new instruments to significantly improve the spatial coverage and resolution and to provide pairs of geomagnetically conjugate observations from both the hemispheres. A wide range of instrumentation with anticipated lifetimes beyond 2007 is proposed for installation in both polar regions including: HF radars, magnetometers, riometers, auroral imagers, GPS scintillation and dual frequency receivers, a VLF beacon transmitter, MST radars, radiometers, autonomous meteo-magnetic stations and balloon-borne radio sounders. Below we list some examples of institutes and/or research groups who have expressed their intentions to arrange measurement campaigns or to build permanent instrumentation in the polar regions:

Institute	Instrument/Campaign	Comments
British Antarctic Survey, UK	Radiometers, mesospheric imagers, Lidars	Collaboration with ALOMAR and EISCAT facilities
IFSI/INAF, Italy	Antarctic SuperDARN radar	
University of Calgary, Canada	THEMIS optical instrumenta-tion	Data sharing will take place via the GAIA Virtual Observatory
University of La Sapienza, Italy	Balloon campaigns measuring the cosmic microwave back-ground and magnetic field in the Arctic stratosphere	Collaboration with the Andoya Rocket range.
The EISCAT Association, Sweden	Continuous measurements with the EISCAT Svalbard radar	
National Institute of Polar Research, Japan	Antarctic MST/IS radar (PANSY)	The radar will start operation during the IPY years
National Institute of Geophy-sics and Volcanology, Italy	GPS scintillation and dual frequency receivers both per-manent stations and cam-paigns (Antarctic research vessel)	
GLORIA-team, several countries	New Arctic and Antarctic Imaging riometers	
Stanford University, USA	VLF transmitter and receivers in Antarctica	
University of Saskatchewan, Canada	Artic SuperDARN radars	The PolarDARN extension of SuperDARN

National Academy of Science, Ukraine	Antarctic automatic meteo-magnetic stations	
Polar Research Institute of China	Magnetometers, Antarctic SuperDARN radar	Conjugacy region for the Svalbard measurement stations

The IHY community will coordinate an overarching synoptic observation programme and will provide systems and assessment processes for coordinating and facilitating dedicated campaigns in order to reap the advantages of interdisciplinary observations. The sub-projects within the ICESTAR-IHY-IPY programme projects have been encouraged to register their activities formally with the IHY either as Coordinated Investigation Programmes (CIPs) or as Synoptic Programmes. Seven of the sub-projects have made their CIP proposal already. The proposals will be reviewed by IHY Science Working Groups (SWGs) , organised by discipline and consisting of experts in the field. For the projects coming together for IPY there is typically already a commitment of resources. The role of the SWGs will therefore, in this case, largely be confined to identifying synergies between proposals; in general, they will also liaise with observatory representatives and IHY national coordinators to assess the feasibility of proposals and negotiate the use of observatory facilities.

DATA PORTALS

In the first ICESTAR workshop in July 2005 Toulouse the data sharing issues were discussed for the first time among a wider community including representatives of some of the most widely used existing geospace data servers (e.g. SPIDR and CDAWeb, for more details see the notes of this meeting in http://www.siena.edu/physics/ICESTAR/portal_workshop.htm). It was decided in the workshop that special attention in the first phase will be paid to three data servers: VGMO (magnetometer data), GAIA (auroral precipitation data), and Madrigal (Incoherent scatter radar data). The aim is to build or upgrade these systems so that they have easily adoptable interfaces both to the direction of the users and the data providers. A more ambitious goal will be to make the systems to communicate with each other electronically.

The VGMO system has been designed in the University of Michigan (http://mist.engin.umich.edu). The user interface can appear either as a web-based portal (for a passive user) or as set Java-scripts to be installed to a computer which aims to be a standalone data node. VGMO has been built to adapt fluently new data sets and data analysis tools and it can easily be upgraded for automatic communication with other VOs. However, before this system or any other data broker interface can be used efficiently the wide community of magnetometer data providers should agree on the standard data query and metadata elements and acknowledgement practices. The ICESTAR community (more specifically research groups in the University of Michigan, University of Alberta and British Antarctic Survey) has taken the responsibility to arrange splinter meetings in the context of scientific conferences to maintain such discussion until a consensus about the standards has been reached at least among the most important data providers. The goal is to find a practice which enables the data providers to contribute to multiple portals with minimum effort. The first splinter meeting was arranged in Banff (Canada) in March 2006 where the coordinators started to collect the principal contacts and their agreements to participate the discussions.

The first version of the GAIA-portal is available in http://gaia-vxo.org. It has been built by the Institute of Space Research at the University of Calgary in collaboration with the University of Lancaster. The service is a browsing and indexing tool for optical and riometer quicklook data. The system fetches the data quality charts (e.g. keograms for allsky camera data) from distributed data sources and combines them “in fly” to a composite chart showing the global data availability. Although the current version of the portal does not provide full resolution data it will facilitate the usage of optical and riometer instruments significantly: the data providers are requested to provide only the periods of optimum

performance of their instruments. GAIA has received some positive attention in the NASA Virtual Observatory (VO) Programme. This programme will expand the existing NASA VO system with six new VO's and has invited GAIA to serve as a "working VO" in their outreach and education material. This collaboration will give GAIA the opportunity to participate to the decision making of future practices allowing interoperability of VOs from different disciplines.

The Madrigal data portal is a well-established and widely appreciated tool for professional incoherent scatter (IS) radar users. IS radars can provide interesting observations for a multitude of geospace and aeronomy research areas. Thus the IPY years will provide the IS radars a valuable opportunity to increase their user community. However, the current version of Madrigal may be a too heavy tool for beginners to use for the browsing of raw data or to extract any data products. This may appear as a harmful obstacle for starting a deeper collaboration with the IS radar community. To avoid such complication the EISCAT community has started to investigate the possibilities to use the functionalities developed in the UK AstroGrid programme in order to build a beginner-interface for Madrigal and to upgrade it with inter-VO communication capabilities.

MANAGEMENT

The ICESTAR-IHY-IPY programme will be organised as a federation of subsidiary projects, each with a large degree of autonomy but with coordinating oversight from a steering committee. The constituent projects will have their own management bodies typically consisting of the instrument PIs and representatives from the funding parties, so that the best available expertise is close to the everyday activities. The umbrella steering committee will consist of representatives from the subprojects, with the lead being taken by IHY and ICESTAR, and including experts for the scientific issues, for the data-sharing procedures and for public and educational outreach. This committee will identify where the constituent projects have the potential to collaborate on observations or logistics. In this context it is important to note that some of the projects are already consortia with well-established procedures for coordination (e.g. the EISCAT and SuperDARN communities). The detailed networking and collaboration plan will be finalized in the ICESTAR-IHY-IPY kick-off meeting which will be arranged in Helsinki (Finland) at the beginning of year 2007.

EDUCATION AND PUBLIC OUTREACH

For direct communication with the general public ICESTAR-IHY-IPY will establish an outreach programme which aims to coordinate parallel semi-annual media events in all participant countries during the IPY years. These events will be realized as press releases and popular lectures summarizing the recent scientific findings of the project. For the audience keen on observing the environment several research groups will put up web-interfaces to show real-time data from their instrumentation. The public understanding of geospace science will be expanded also in collaboration with national research councils. The IPY 2007 Space Science Symposium and the "Life on Icy Worlds" conference, respectively, planned to be arranged in Greenland and in Alaska will be important forums for educating national science administrators and teachers about historical and forth coming research activities with the perspectives from Arctic natives, Antarctic scientists, and solar system explorers.

To educate next generation of geospace scientists ICESTAR-IHY-IPY will together with space science centres provide plenty of material for interesting and challenging exercises and thesis works. Students will participate in the measurement campaigns and in the development of the modern data-sharing systems. The easily accessible data-archives will provide important reference material for observational and theoretical investigations.

SUPPORTING INFORMATION

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.), aweatherwax@siena.edu
Co-Chair: Kirsti Kauristie, Finnish Meteorological Institute (Finland), kirsti.kauristie@fmi.fi
Prof. Brian Fraser, University of Newcastle (Australia), brian.fraser@newcastle.edu.au
Dr. Martin Fullekrug, University of Bath (UK), M.Fullekrug@bath.ac.uk
Dr. Ruiyuan Liu, Polar Research Institute (China), ryliu@vip.sina.com
Prof. Nikolai Østgaard, University of Bergen (Norway), nikost@rapid.fi.uib.no
Prof. Scott Palo, University of Colorado (U.S.A.), scott.palo@colorado.edu
Dr. Natsuo Sato, National Institute of Polar Research (Japan), nsato@nipr.ac.jp
Dr. Eftyhia Zesta, University of California - Los Angeles (U.S.A.) ezesta@atmos.ucla.edu
Dr. Maurizio Candidi, SCAR SSG/PS (Italy), *ex officio,* Maurizio.Candidi@ifsi.rm.cnr.it

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 modelling 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 Programmes 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.

BUDGET REQUEST FO THE NEXT BIENNIUM

Estimated SCAR funding required for the next two years is approximately $30,000 USD, as budgeted in the original proposal. The SCAR funds will enable ICESTAR to run the following three meeting:

Dates	ICESTAR Sponsored Meeting	Amount
Summer 2006	ICESTAR participation at the SCAR meeting in Hobart.	$8,000
Winter 2007	ICESTAR-IHY-IPY coordination meeting in Helsinki, Finland.	$10,000
Summer 2008	ICESTAR Data Portal Meeting II	$7,000

ICESTAR will further continue to provide travel to support for researchers worldwide to participate and present ICESTAR related papers at scientific meeting and workshops. Approximately $5,000 is budgeted for such expenses.

OUTPUTS/DELIVERABLES

ICESTAR Website: Established to facilitate international communication.
http://www.siena.edu/physics/ICESTAR/default.htm

ICESTAR-IHY-IPY Website: Heliosphere Impact on Geospace
http://www.space.fmi.fi/ipyid63/