Annual Report

2005-2006

British Antarctic Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Above and cover: *RRS* James Clark Ross *leaving Signy Research Station, South Orkney Islands.*

Our vision

British Antarctic Survey aspires to become, by 2012, the leading international centre for Global Science in the Antarctic Context.

Our mission

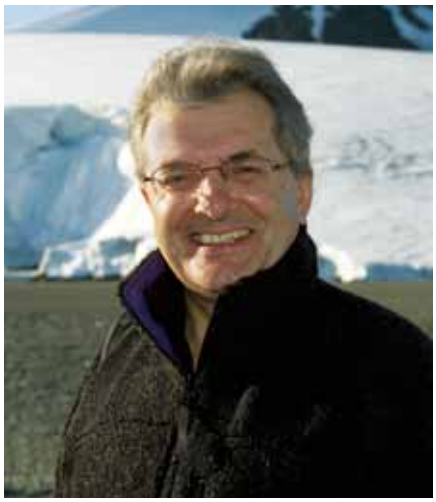
To undertake a world-class programme of scientific research and to sustain for the UK an active and influential regional presence and a leadership role in Antarctic affairs.

Director's Introduction

This was the first year of our new integrated science programme, Global Science in the Antarctic Context (GSAC). Our aim is to make major contributions both to fundamental scientific knowledge and to determining how the Earth functions and what its future may be. We will do this by exploiting information uniquely available from the Antarctic and Southern Ocean. The scientific questions addressed by GSAC, both directly by BAS staff and through our numerous national and international collaborations, are designed to provide the key means by which we progress along this path.

So how did it go? For once the Antarctic was kind to us, with minimal disruption due to adverse weather or ice conditions. A particular success was an airborne geophysical survey over the Wilkes subglacial basin in collaboration with the Italian Antarctic Programme – very remote from our normal theatre of operations. This was the largest survey ever conducted by BAS, comprising 71 flights which generated 65,000km of survey lines – equivalent to more than one-and-a-half times around the world!

The air operation was closely integrated with Italian ground-based and geological studies. The objective was to provide new insights into the current and (geologically) recent stability of the East Antarctic Ice Sheet, and into the nature and timing of the uplift of the Transantarctic Mountains. Despite very low temperatures and the magnitude of the challenge, the operation was a great success, thanks not least to the high degree of cooperation and support from our international colleagues.

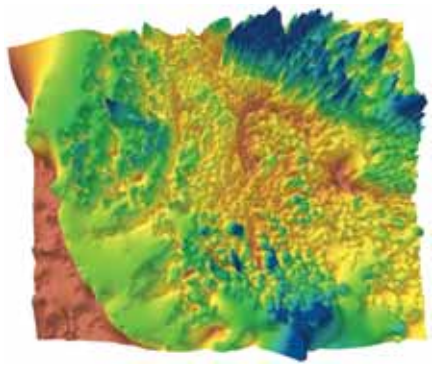


Prof Chris Rapley CBE
Director **British Antarctic Survey**

Science highlights this year include the discovery of a 'teleconnection' between the tropical Pacific and the ecosystem of the Scotia Sea. El Niño events affect the breeding success of fur seals and penguins at Bird Island, South Georgia. They do so through physical connections via the atmosphere and ocean, which affect winter sea-ice extent around the Antarctic Peninsula, reducing the breeding success of krill. Some two-and-a-half years later, this interruption in the flow of krill arrives at the ocean in the vicinity of Bird Island, resulting in a barren year for the region's higher predators. A prediction that 2005–2006 would be a poor year for seal pup production, based on this theory, proved correct.

The scientific focus of Bird Island has been innovative research into the role of birds and mammals in the marine ecosystem of Antarctica. This world-class science has been pioneered by Professor John Croxall CBE for over two decades. His contribution both to research and to conservation was recognised by his election to a Fellowship of the Royal Society – the highest scientific accolade in the UK.

Images: **Top Right:** *The fully redeveloped Bird Island Research Station, South Georgia.* **Centre Right:** *Subglacial topography of part of the West Antarctic Ice Sheet, revealed in unprecedented detail.* **Bottom Right:** *87% of glaciers on the Antarctic Peninsula are retreating.*



Another important science highlight was the production of a greatly-improved subglacial topographic map of the Amundsen Sea sector of the West Antarctic Ice Sheet, following the extremely successful joint BAS/University of Texas survey of the previous field season. This revealed significant differences between the subglacial constraints on ice loss from the Pine Island and Thwaites glaciers. It also cast new light on the most vulnerable parts of the ice sheet, and the means by which significant volumes of ice might flow into the ocean. The area susceptible to large-scale melting is estimated to be equivalent to a rise of global mean sea level of 1.5m.

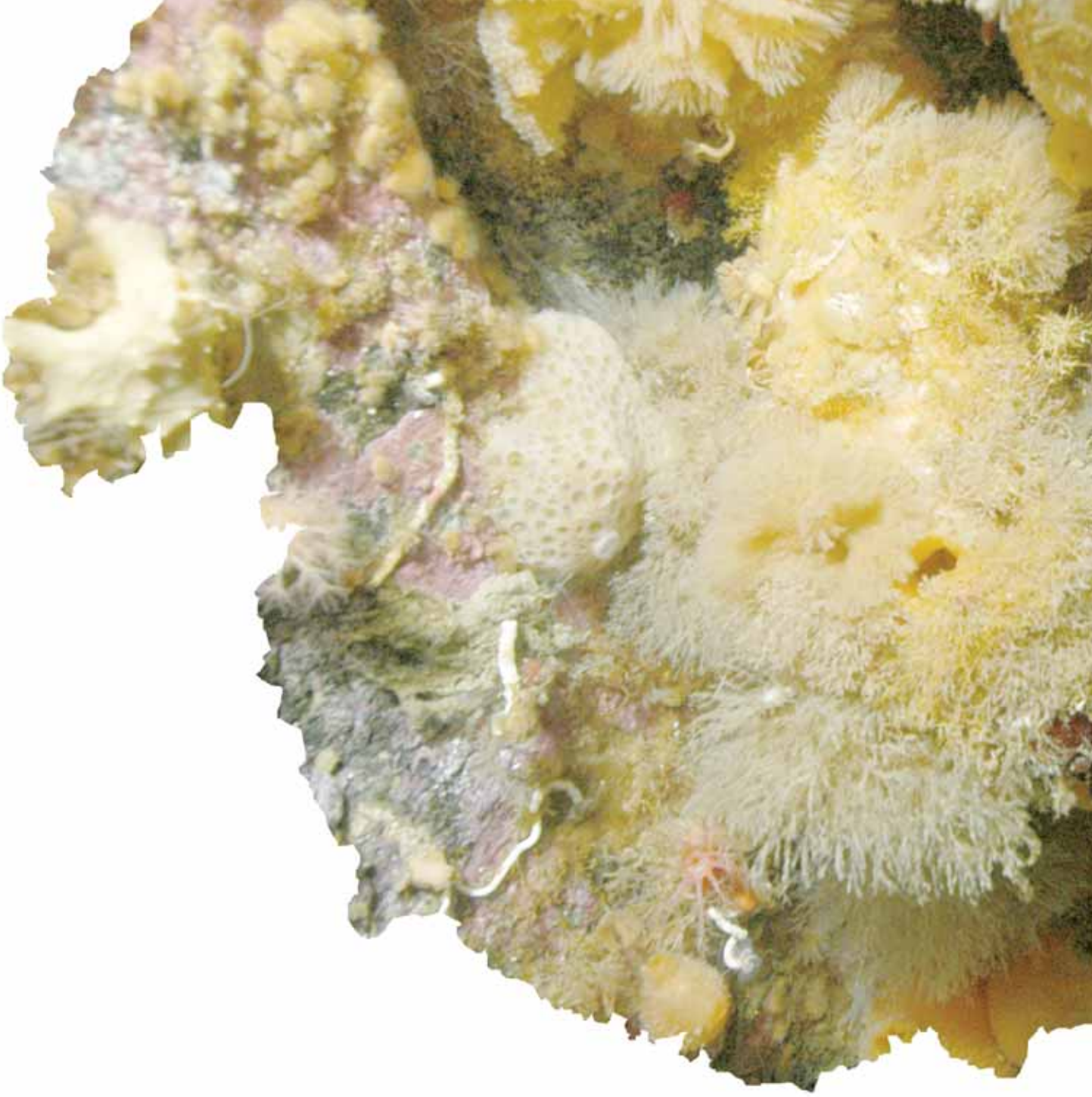
Intense media interest focused on the results of a joint project between the BAS Mapping and Geographic Information Centre and the US Geological Survey. Following the analysis of 2,000 aerial photographs extending back over 60 years and more than 100 satellite images, it was found that 87% of the 244 marine glacier fronts on the Antarctic Peninsula are retreating. Average retreat rates have accelerated in the last few decades, and the boundary between glaciers retreating and advancing has shifted progressively southwards. This provides further dramatic evidence of the physical impact of the strong warming taking place in the region.

The support of a world-class science operation in such a remote and challenging part of the planet requires world-class logistics and facilities. Consequently, in addition to the 70 or so science field projects BAS carries out each season, there is, on average, one major infrastructure project. This season saw the completion of the redevelopment of Bird Island Research Station, providing accommodation and facilities to a modern standard. This was a challenging project because of the short timescale from design to implementation, the notorious weather and sea-related difficulties of offloading large amounts of cargo to the island, and the removal of waste and the old buildings. So it was with justifiable satisfaction and pride that those occupying the station, and representatives of those involved in the project, attended the official opening of the new facilities on 26 February 2006 by His Excellency the Commissioner of South Georgia and the South Sandwich Islands. The first phase of the redevelopment of the Rothera facilities was also successfully completed, and major progress was made on the planning and design of our impressive new Halley VI station.

As evidence that the world is warming has continued to emerge, and as more and more observations show that polar ice is melting, media interest in our work has continued to grow. Our media team has responded to this, with a bumper year for media enquiries. BAS has been prominent as an authoritative source of information on polar issues and climate change.

Finally, BAS is hosting the International Programme Office (funded by the Natural Environment Research Council) for the International Polar Year 2007–2008. Scientists from over 60 nations are planning to work together to an unprecedented degree to characterise and understand the polar regions, and to engage public interest to a level similar to that of the moon landings! BAS will lead one of the major programmes and participate in many others.

In summary then, a year in which BAS has again fulfilled its role in carrying out world-class science, maintaining for the UK a high-level presence in the Antarctic and Southern Ocean and a leadership role in Antarctic affairs.

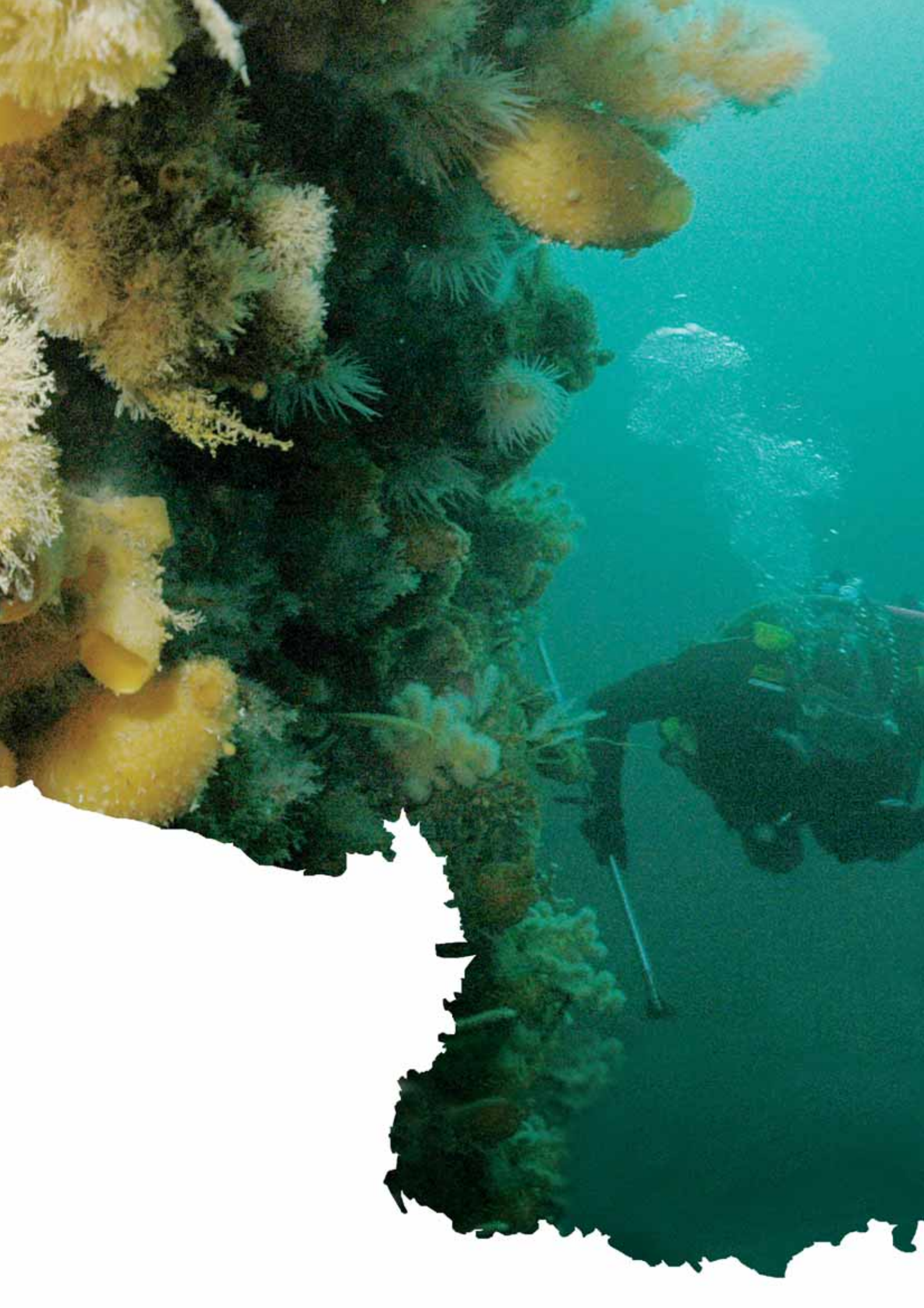


Global Science in the Antarctic Context

Global Science in the Antarctic Context (GSAC) comprises eight interconnected research programmes totalling 18 projects, plus long-term monitoring and survey. It addresses Antarctica as a pivotal component of the Earth system and a unique source of environmental knowledge. It covers the period from 30 million years in the past to 300 years in the future and focuses on issues of climate, sea level, and biological evolution and adaptation.

The aim is to increase humanity's skill in predicting the future behaviour of the planet and the effects of environmental change for the benefit of society, policy-makers and business. GSAC involves over 120 national and international collaborations.

Image: *BAS marine biologist surveys the benthos nearly 20m down near Anchorage Island, Antarctic Peninsula.*



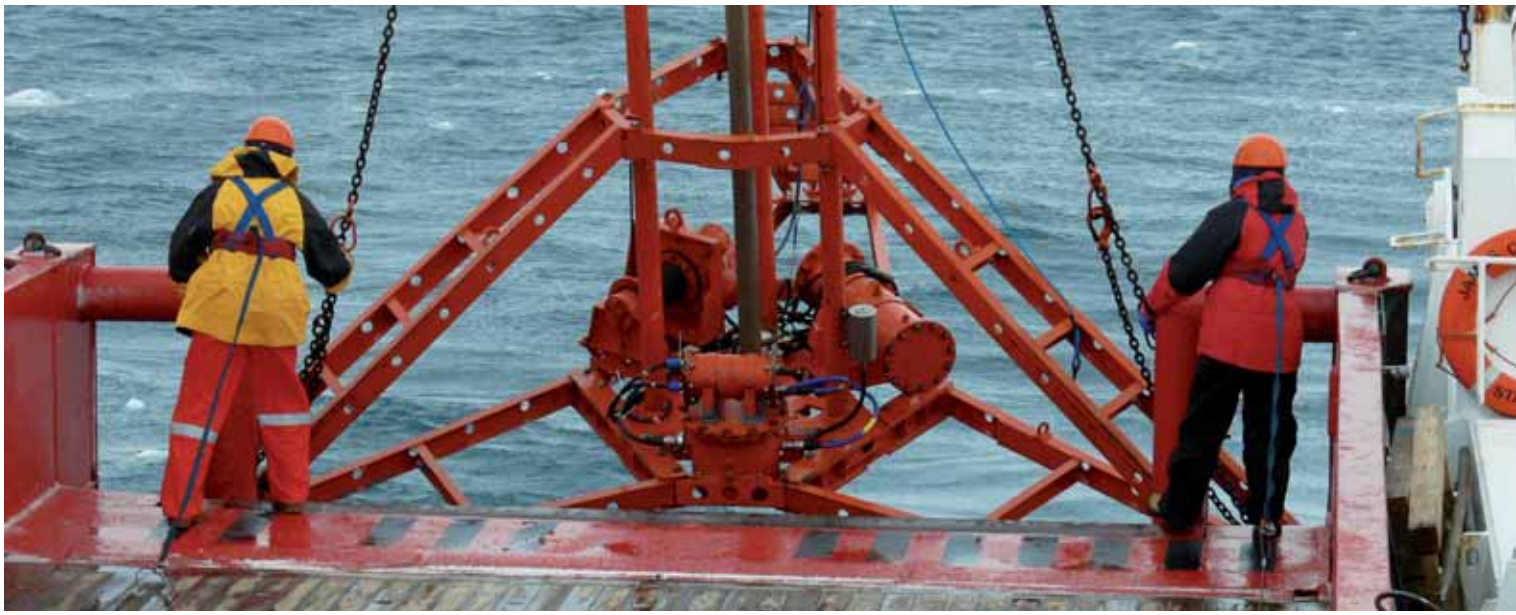
GRADES Glacial Retreat in Antarctica and Deglaciation of the Earth System

Principal Investigator: **Prof David Vaughan** dgv@bas.ac.uk

Introduction

The greatest uncertainty in predicting global sea-level rise for the coming centuries is the potential for current changes in the West Antarctic Ice Sheet to accelerate into a large-scale deglaciation event.

GRADES will increase understanding of global deglaciation events and reduce uncertainty in predictions of future change in the West Antarctic Ice Sheet and global sea level. This will be achieved by integrating palaeoenvironmental measurements affecting the history of past deglaciations. We will use geophysical surveys of the most vulnerable parts of the West Antarctic Ice Sheet, studies of the key processes promoting and limiting change in ice flow, and computer simulations of deglaciation events.



Quaternary deglaciation of the Amundsen Sea

In 2006, BAS completed a science cruise on RRS *James Clark Ross* to one of the least-visited sectors of the Southern Ocean, the Amundsen Sea. Although this was planned to coincide with the seasonal sea-ice minimum, the ice denied us access to our primary targets in Pine Island Bay. However, the conditions provided a rare opportunity to visit a previously uninvestigated region near Dotson and Getz ice shelves. Marine sediment cores, seismic reflection profiles, swath bathymetry and oceanographic data were all collected successfully.

This excellent body of data will help establish the timing and progress of the retreat of the West Antarctic Ice Sheet in this area after the last glacial period. Such data will provide the most critical test on the models used to predict the future of the West Antarctic Ice Sheet.

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Technical terms: **Basal reflections:** *Seismic waves sent down through the ice bounce back from the bed at the base of the ice. These basal reflections indicate ice depth and the bed conditions.* **Deglaciation event:** *The widespread reduction of glacial ice as a result of climate change, sea-level rise and ice sheet dynamics.* **Geophysical surveys:** *Mapping of the physical properties of an area of the Earth.* **Palaeoenvironmental measurements:** *Interpretations of ancient environments and climates.* **Quaternary:** *The geologic time period comprising the last two million years.* **Seismic reflection profiles:** *Data from seismic surveys of the sea bed, showing depth and geological structure.* **Subglacial topography:** *The shape of the bed beneath and ice sheet or glacier.* **Swath bathymetry:** *A technique for mapping the ocean floor (from a ship) in a continuous strip that can be up to several kilometres wide.*

Images: **Above:** *Deployment of vibrocorer from the aft deck of RRS* James Clark Ross. **Top Right:** *Strip of DELORES data, showing the base and internal layers of part of the West Antarctic Ice Sheet.* **Centre Right:** *Perspective view of the new subglacial topography of West Antarctica.* **Bottom Right:** *Distribution of annual positive degree days calculated for a. 1950, b. 2000 and c. 2050.*

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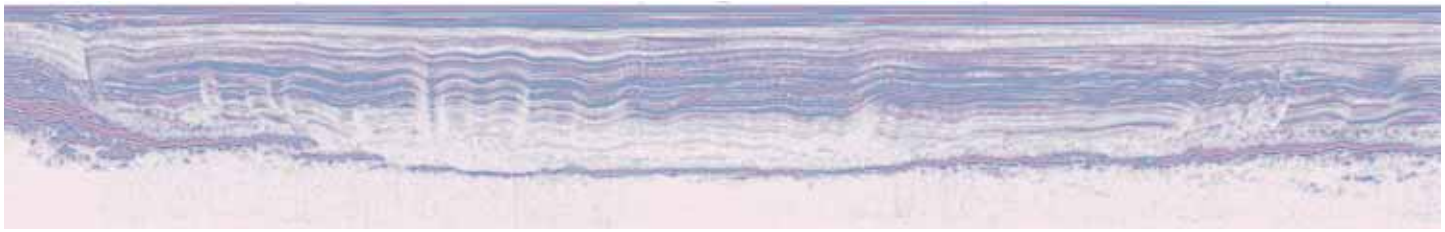

DELORES: A new tool for ice-sheet research

A new, lightweight, ice-penetrating radar system for investigating deep ice has been developed, tested, and proven by BAS. The DEep LOoking Radio-Echo Sounding (DELORES) system is a significant development of an existing system operated by the University of Washington and St Olaf's College, Minnesota. The new system offers major improvements in performance and reliability. DELORES was initially tested in Greenland in 2005, followed by the successful operation of two units in Antarctica. We collected excellent data, including basal reflections to a depth of 3.3km, and high-resolution images of internal layers.

The architecture of internal layers, imaged by DELORES beneath the crests of ice-rises, will allow us to determine how long it took the West Antarctic Ice Sheet to return to a near equilibrium after the last glacial period, around 12,000 years ago. This is an important piece of the jigsaw in understanding how the Earth system responds and adjusts to change.

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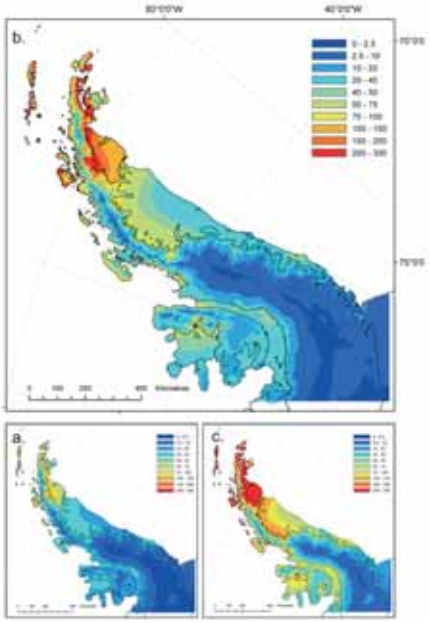

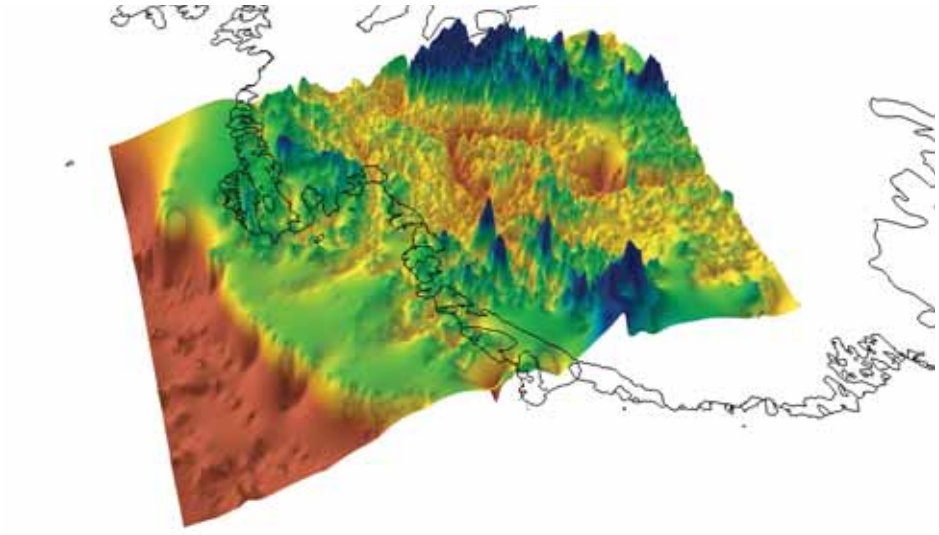

Subglacial topography of West Antarctica

The Amundsen Sea sector of the West Antarctic Ice Sheet is thinning rapidly. There are significant concerns about whether this thinning is an early indication that the ice sheet is beginning to collapse – an event that would cause much greater sea-level rise than is currently predicted. Glaciologists have been hampered in evaluating the risk of ice-sheet collapse because very little was known about the underlying topography and geology on which the ice sheet rests.

An extensive airborne survey in 2004–2005, completed by BAS in collaboration with University of Texas and the US National Science Foundation, has given us far better understanding of the subglacial topography for this entire sector of West Antarctica. This allows us to determine the most vulnerable parts of the ice sheet, and the route by which a collapse that would begin around the coast would be most likely to reach the central part of the ice sheet. The new subglacial topography derived from this project has been made freely available on the Web, and assessments of the likely future stability of the West Antarctic Ice Sheet are under way in BAS and by collaborators worldwide.

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Trends in melting on the Antarctic Peninsula and impact on sea-level rise

The rapid warming recorded over the Antarctic Peninsula during the last 50 years has been strongest on the west coast, and during the winter months. Summer warming has been much slower but a new analysis has shown rising trends in the duration of summer melting conditions. For example, between 1950 and 2000, the record from Faraday/Vernadsky Station showed a 74% increase in positive-degree days (i.e. days above 0˚C) – a proxy measure for snow and ice melt.

Although much of any extra melt is refrozen within the ice sheet, the fraction that runs off into the oceans has been estimated. This shows that, in 2000, as a direct and immediate response to climate warming, the contribution of the Antarctic Peninsula to global sea-level rise is 0.008–0.055mm per year. If summer warming continues at the present rate, this contribution could treble in the next 50 years.

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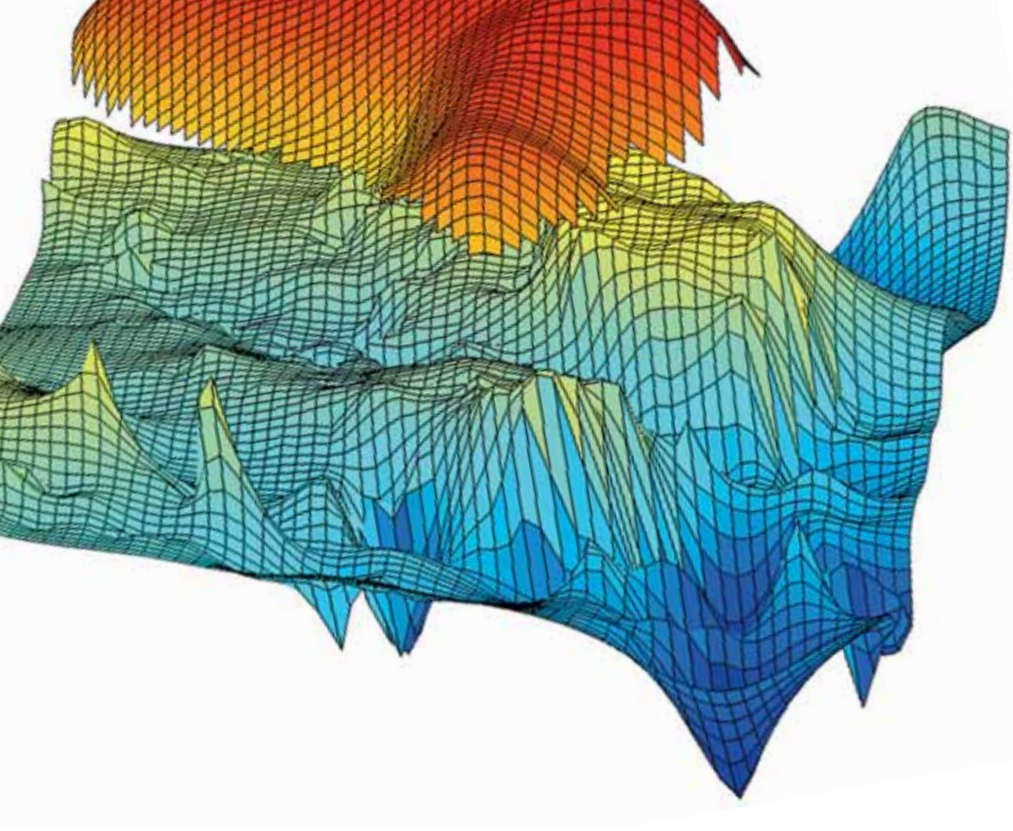

CACHE Climate and Chemistry: Forcings, Feedbacks and Phasings in the Earth System

Principal Investigator: **Dr Eric Wolff** ewwo@bas.ac.uk

Introduction

CACHE uses ice cores, along with marine and lake sediment records collected in Antarctica, to examine past climates. These reveal complex interactions between different parts of the Earth system, and very large natural swings in global climate.

Present-day atmospheric chemistry and models help us interpret past data, so that we can understand how climate and atmospheric composition were linked in the past.

Where was the ice at the last glacial maximum?

Initial results from a new Antarctic ice core show that the Antarctic ice sheet in the Weddell Sea region at the last glacial maximum (LGM) was smaller than ice-sheet models suggest. In 2005, BAS, with its French partners from Laboratoire du Glaciologie et de l'Environnement and the Institut Polaire Français, completed the 948m-deep ice core to bedrock at Berkner Island. Ice-sheet modelling had suggested that Berkner Island was overridden by the main Antarctic ice sheet during the LGM, around 21,000 years ago.

Radar profiles clearly show an ice-flow feature, known as a Raymond bump, close to the summit of the island. This indicates that the ice dome has been an independent ice rise for several thousand years and has not been overridden by the ice sheet. The volume of air in bubbles and shift in stable isotope data in the LGM ice confirm that inland ice did not cover Berkner Island. This implies that this sector of Antarctica contributed less than previously calculated to the change in sea level between the LGM and the present.

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Technical terms: **Antarctic Circumpolar Current:** *The eastward flowing ocean current that completely encircles Antarctica.* **Brine slush:** *Salty liquid on the surface of sea ice, often mixed with snowfall.* **Chemical proxy data:** *Data inferred from the analysis of certain chemicals.* **Diatoms:** *Single-celled organisms with a silica shell.* **EPICA:** *A consortium of laboratories from 10 European countries.* **Frost flowers:** *Delicate salty crystals that form on newly-grown sea ice.* **Halogens:** *Element such as chlorine, bromine and iodine.* **Last glacial maximum:** *The time of maximum extent of the ice sheets during the last glaciation, approximately 20,000 years ago.* **North Atlantic Deep Water:** *A water mass that forms in the high northern latitudes of the Atlantic from the cooling and sinking of very saline surface water.* **Open water lead:** *A channel of open water in an area covered by sea ice.* **Polar boundary layer:** *The well-mixed region of the lower atmosphere where surface/atmosphere interactions take place.* **Polar Front:** *The northerly extent of the cold waters circling Antarctica.* **Stable isotope data:** *Results of analysis showing changes in the ratio of different sorts of oxygen or other elements within the ice, related to air temperature at the time of snowfall.*

Images: **Above:** *Internal radar layers from Berkner Island showing the existence of a 'Raymond bump'.* **Top Right:** *Marine sediment cores are carefully stored and labelled after extraction.* **Centre Right:** *Deuterium (a proxy for temperature), sea salt sodium (representing salt), and non-sea-salt calcium (representing dust) flux over the last 740,000 years.* **Bottom Right:** *Surface ozone concentrations at Halley Research Station during spring 2003.*

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Ocean circulation: the south also plays a role

Sediments taken from the sea floor in the south-west Atlantic have provided new evidence of how ocean circulation and climate in Antarctica were linked to that of the North Atlantic around the end of the last glacial period (between 22,000 and 12,000 years ago). Many of the explanations for climate changes at this time include changes in ocean circulation and resulting heat transport.

Constraints, such as those provided by this work, help us to differentiate between various models. We carried out a detailed analysis of diatoms occurring in the sediments at different times to show that North Atlantic Deep Water (NADW) arrived in the south-west Atlantic sector of the Southern Ocean around 16,500 years ago, much earlier than previously thought. In this sector, the variability in the strength of NADW inflow appears to be controlled by the position of the Polar Front and the strength of the Antarctic Circumpolar Current. These records show that at times the Southern Ocean may exert control over NADW and thus influence the transport of heat around the globe.

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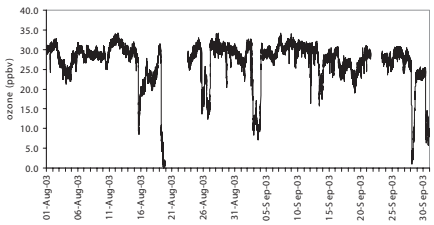

Southern Ocean sea ice and iron flux over eight glacial cycles

The amount of salt and dust in an Antarctic ice core has improved our understanding of how natural climate variations work. The deep ice core drilled by the European Project for Ice Coring in Antarctica (EPICA) at Dome C spans 800,000 years. BAS has led the analysis of chemical proxy data in the core. When Antarctica is at its coldest, we find high salt concentrations, indicating increased sea-ice extent in the Indian Ocean.

We also find high levels of terrestrial dust, indicating drier or windier conditions in Patagonia – the source of the dust. These results help us understand how climate and CO_2 may be linked in the natural climate system. Each time the Earth emerged from cold glacial conditions, CO_2 increased over several thousand years and clearly played a major role in amplifying the climate change. Dust also plays a role by providing nutrients to microbes in the Southern Ocean, while sea ice plays an important part in altering the way CO_2 is transported to the deep ocean. The measurements show that each time Earth warmed, the dust change preceded the sea-ice change. We now understand that different processes must be operating at different stages of the warming, together leading to the very large climate shifts.

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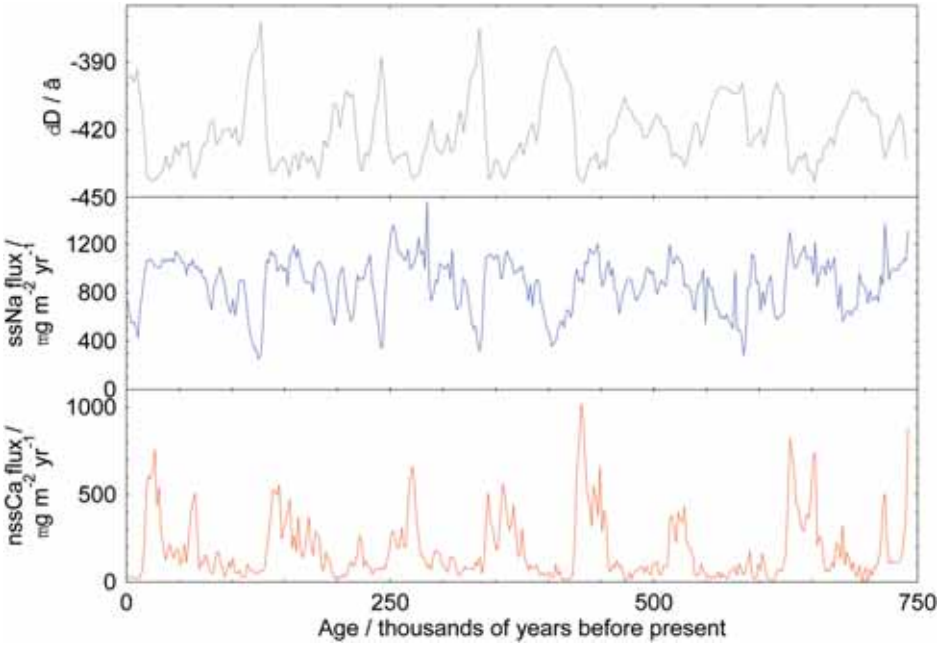

Ozone depletion at Halley

New measurements at Halley Research Station have allowed us to define the conditions leading to springtime ozone-depletion events (ODEs) in the polar boundary layer. In both polar regions, surface ozone concentrations in the spring have been observed to drop rapidly from normal background amounts to a level too low for instruments to detect, and this can last for days to weeks. This is associated with halogen compounds, whose source remains uncertain.

We combined measurements made at the Halley Clean Air Sector Laboratory of surface ozone with detailed boundary-layer measurements and standard meteorological parameters. The ODEs fell into two categories. Type I events were the result of different air masses passing over Halley. They displayed rapid ozone loss and were associated with regional-scale transport of air from the southern Weddell Sea – an area of vigorous sea-ice production. Ozone reduction during Type II events was much more gradual. It appears to have been driven by contact with a nearby open water lead where sea-ice production occurs. The analysis demonstrated the influence of air-mass transport on ODEs, and also suggested that halogens responsible for ozone loss are derived during new sea-ice formation, perhaps from brine slush or frost flowers.

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COMPLEXITY Natural Complexity Programme

Principal Investigator: **Dr Mervyn Freeman mpf@bas.ac.uk**

Introduction

The Earth system is complex. The physical and biological environments interact, and even the weakest of these interactions can play a surprisingly important role. Furthermore, similar behaviours and structures can occur in seemingly dissimilar phenomena.

COMPLEXITY explores the interfaces between the traditional compartments of the Earth system (air, land, water, ice, life) and of Earth system science. It looks at their tangible connections and, in particular, the transferability of concepts and tools for exploring them. In this first year of the programme, we have applied one such common concept – fractals – to understanding the ice and near-Earth space environments.

Modelling the aurora with the help of Joseph and Noah

In the 1960s, Benoit Mandelbrot introduced the idea of fractals to describe how the shape of many aspects of the natural world departed from the ideal geometrics of points, lines and planes. In particular, he proposed two kinds of fractal model to capture the way in which natural data are often persistent in time (his 'Joseph effect', common in meteorology) or prone to large jumps (the 'Noah effect', similar to stock market fluctuations). Both these effects are recognised in measures drawn from the Earth's aurora and also the solar wind, the aurora's primary energy source. Modelling them has tended to emphasise one or other of the Noah and Joseph descriptions. BAS scientists and the University of Warwick have applied a unifying framework to modelling the data. This has resolved some contradictory findings in earlier papers where, with hindsight, we can now see that purely Joseph or Noah descriptions were being considered.

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Technical terms: **Aurora:** *A display of coloured light in the night sky near the Earth's magnetic poles, caused by collisions between charged particles and atoms of atmospheric gases.* **Electrical resistance:** *A measure of the degree to which a material resists the flow of electric current.* **Fractal:** *A shape that appears similar at all scales of magnification.* **Magnetic reconnection:** *The process whereby magnetic lines of force (or magnetic field lines) break and reconnect to change the connectivity and configuration of the overall magnetic field.* **Magnetosphere:** *A region around a planet under the direct influence of its magnetic field.* **Plasma:** *A gas comprising electrically charged particles.* **Solar wind:** *The outward flow of plasma from the Sun.*

Images: **Above:** *A view of the aurora near Halley Research Station, Brunt Ice Shelf.* **Right:** *a. The Larsen Ice Shelf, Antarctic Peninsula, from a composite of two Landsat satellite images with the coastline shown in red. b. The length and roughness of the coastline are estimated using the 'box counting' algorithm. c. A plot of the logarithm of the number of occupied grid squares vs. the logarithm of grid-square size. The straight line shows that the coastline is a fractal and the gradient of the line is a measure of the roughness.* **Far Right:** *The electrical resistance of a plasma for 104 simulations of plasma-wave instability, showing the increase of the average and spread of the distribution of resistance as the instability develops. Image: Petkaki et al., JGR, 2006.*

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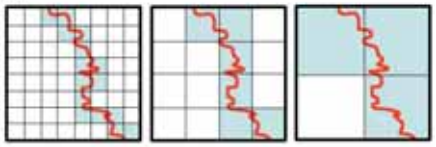

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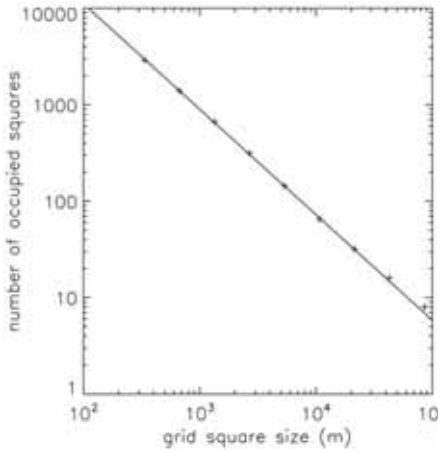

How long is the coastline of Antarctica?

The Antarctic coastline is continuously changing as icebergs break off into the sea. This is part of a natural balancing of ice mass, returning water to the oceans that previously fell as snow and became locked up in the Antarctic ice sheet. However, recent, sudden break-up and erosion of ice shelves and glaciers has led to concerns about an accelerating loss of polar ice, with a consequent rise in global sea level. To help understand this, we have developed a new method for analysing iceberg formation by measuring the roughness of the ice coastline that the icebergs leave behind.

We studied satellite images from different parts of the Antarctic Peninsula at varying times and discovered that the coastline is a fractal. The fractal dimension – a measure of the coastline's roughness – appears to depend on whether the ice shelf is in irreversible retreat or not. This could give us a new diagnostic of ice sheet health. We have developed a new model of iceberg formation which predicts the distribution of iceberg sizes and likelihood of massive iceberg loss. This will help us understand the overall Antarctic ice mass balance.

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Understanding plasma-wave instabilities and their role in magnetic reconnection

Magnetic reconnection is a universal process that is important for the transport of energy in many different space environments, including the Earth's magnetosphere. Here, plasma-wave instabilities may play a critical role in providing the unusual electrical conditions necessary for magnetic reconnection to occur.

BAS scientists have investigated the evolution of these instabilities and the resulting anomalous electrical resistance. By analysing over 100 computer simulations, we found that the resistance is very sensitive to the initial conditions from which the instability grows, that the average resistance is higher than previous estimates, and that the range of possible resistances increases with time. This could provide a natural source of enhanced resistance for magnetic reconnection to occur and improves our understanding of the role of plasma-wave instabilities in the magnetic reconnection process.

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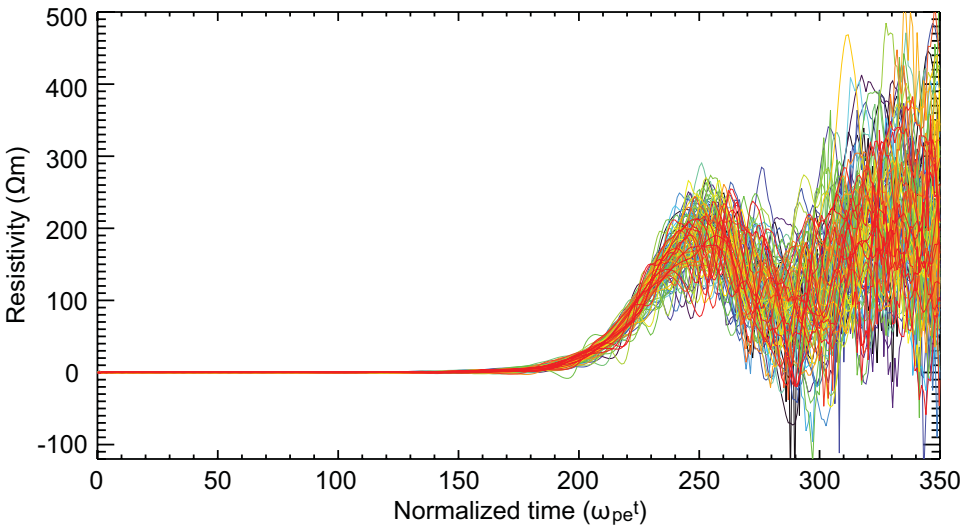

ACES Antarctic Climate and the Earth System

Principal Investigator: **Dr John King** jcki@bas.ac.uk

Introduction

Predicting how the Earth's climate may vary in response to natural or man-made changes is one of today's greatest scientific challenges. It requires an understanding of the workings of the climate system, both in its components and in the ways that these interact.

ACES integrates studies of the Antarctic atmosphere, ocean and sea ice to provide a new perspective on the Antarctic climate system and its coupling to the global atmosphere and ocean. By quantifying the role of polar processes in controlling global climate, the programme will reduce uncertainty in predictions of climate change.

A new platform for studying the Antarctic atmosphere

Over the last three years, specialised meteorological instruments have been installed on a BAS Twin Otter aircraft. These measure basic meteorological parameters such as temperature, humidity and pressure, as well as more complex turbulence and cloud parameters. During the 2005–2006 Antarctic season, the instruments were used for the first time to measure the transfer of heat from the ocean to the atmosphere in the Antarctic coastal region.

Eighty-five hours were flown over various surfaces, including open ocean and sea ice. The data are being analysed at BAS Cambridge and early results are very exciting, with the instrument performance exceeding expectations. Over the coming years, the aircraft will be used to study the structure of Antarctic clouds and to improve our understanding of how atmosphere, ocean and sea ice interact around Antarctica – one of the greatest unknowns in understanding Antarctic climate processes.

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Technical terms: **Antarctic continental shelf:** *The submerged border of the Antarctic continental land mass that gradually descends before sloping steeply down to the deep ocean floor.* **Circumpolar Deep Water:** *A warm deep-water current that flows around Antarctica below the cold Antarctic Circumpolar Current.* **El Niño/Southern Oscillation:** *A phenomenon, typically occurring every 2-7 years, associated with ocean and atmospheric changes across the equatorial Pacific that have global effects on weather and climate.* **Extra-tropical:** *Area outside the tropics (north of Tropic of Cancer, south of Tropic of Capricorn).*

Images: **Above Left and Right:** *BAS Twin Otter aircraft fitted with instruments for airborne meteorological observations.* **Bottom Right:** *Surface temperature and salinity trends in the Southern Ocean.* **Centre Right:** *Model results from the Amundsen Sea continental shelf showing southwards intrusion of a layer of Circumpolar Deep Water.* **Far Right:** *Variability of sea-level pressure.*

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Warming of the Southern Ocean

The west coast of the Antarctic Peninsula is one of the most rapidly warming regions on Earth. Annual mean air temperatures at land stations have risen by around 3°C in the past 50 years. Until recently, little was known about how conditions had changed in the adjacent ocean region. Analysis of a new compilation of ocean observations (compiled in collaboration with the DISCOVERY 2010 programme) has shown that ocean surface temperatures in this region have risen by more than 1°C between 1955 and 1998.

The warming has been accompanied by an increase in ocean salinity, consistent with a reduction in winter sea-ice production. The rate of warming decreases with increasing depth, suggesting it has been driven by atmospheric change rather than by upwelling of warmer waters. If the warming continues, there may be serious consequences for marine organisms in the region, many of which cannot tolerate increases in water temperature of more than 1–2°C.

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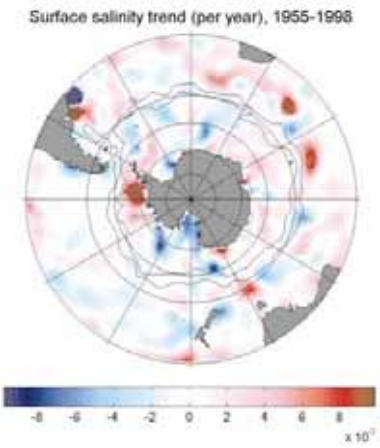

Modelling of Circumpolar Deep Water transport onto the Antarctic Continental Shelf

BAS scientists have used a high-resolution ocean model to study the processes that bring warm Circumpolar Deep Water (CDW) onto the Antarctic continental shelf and the impact of the water in two contrasting regions. Fimbulisen, an ice shelf in the north-eastern Weddell Sea, lies very close to the edge of the continental shelf. Beneath it, a sea-bed trough provides an access route for CDW to flow beneath the ice shelf and cause rapid melting.

However, strong easterly winds blow all along the coast, driving cold surface waters against the ice shelf, where the ice barrier causes them to descend. If the winds are strong enough, the cold surface layer reaches deep enough to block the inflow of CDW. In the Amundsen Sea, although the ice shelves are well south of the continental shelf edge, similar troughs can lead warm CDW to them. Winds here are often westerly, causing thinning of the cold surface layer, and CDW is drawn up and onto the ice shelf. Frequent inflows of CDW sustain rapid melt rates and the thinning of ice shelves.

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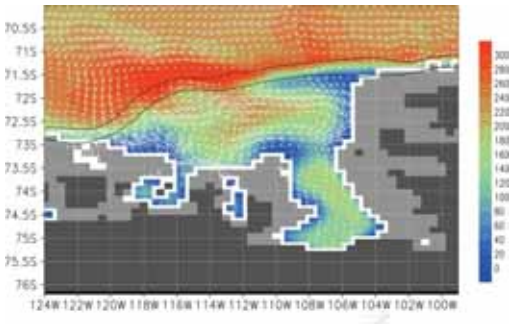

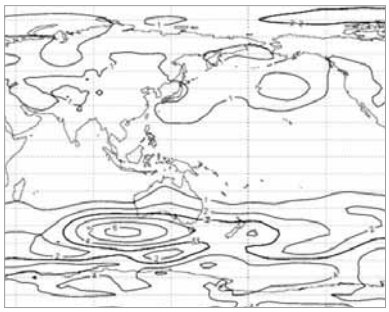

Limits to the predictability of tropical and high-latitude connections in the southern hemisphere

There is a connection between El Niño/Southern Oscillation (ENSO) and the atmospheric circulation over the Bellingshausen Sea, to the west of the Antarctic Peninsula. The two areas are joined by an atmospheric wave 'train' that is created in the tropics by the temperature anomalies associated with ENSO. Large variations are observed between the high-latitude response to ENSO events with apparently similar tropical conditions.

A series of predictions from an atmospheric global climate model with identical tropical conditions reveals that the mid-latitude westerly winds of the southern hemisphere are very changeable. In particular, the high variability of the winds over the Amundsen and Bellinghausen Seas has led the area to sometimes be called the 'Pole of Variability'. Changes of the westerlies over the southern Pacific means that the way large-scale atmospheric waves propagate through this region is also variable. This limits the predictability of the extra-tropical response of ENSO events in the southern hemisphere.

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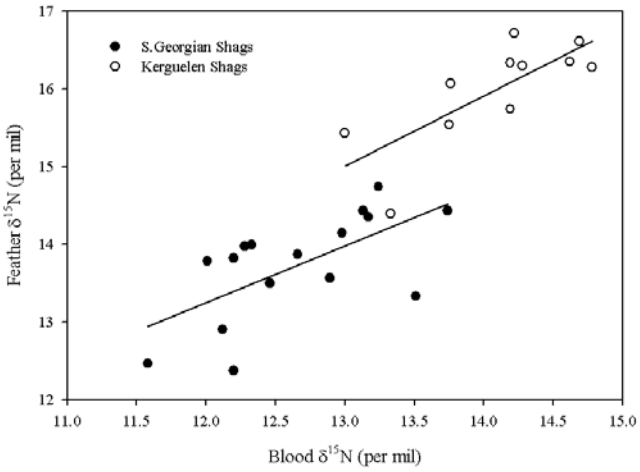
DISCOVERY 2010 Integrating Southern Ocean Ecosystems into the Earth System

Principal Investigator: **Prof Eugene Murphy** ejmu@bas.ac.uk

Introduction

Although cold and often ice covered, the Southern Ocean is biologically very rich and has a history of uncontrolled exploitation. The challenge for environmental scientists today is to predict how human activity and climate change will affect this marine environment and how biological communities will respond.

DISCOVERY 2010 undertakes integrated oceanographic and biological analyses to develop models of how ecological systems work and respond to variability and change in the Southern Ocean.



Stable isotopes reveal diverse foraging strategies in shags, penguins and petrels

To understand the complexity of the Southern Ocean food web, it is essential to know how species vary in what they eat, how they catch their prey and where they go to do so. It is possible to attach microtransmitters and loggers to large, wide-ranging animals, such as albatrosses and seals during the breeding season, but this is much harder in winter when they are far from their colonies. It is not an option for smaller birds such as petrels and prions.

We used the concentrations of the two natural isotopes of carbon and nitrogen in blood and feathers as a forensic technique to investigate differences in feeding ecology of various species. In diving species (penguins and shags), males are found to feed at a higher trophic level than females and dietary differences between individuals persisted for long periods, indicating specific and consistent foraging preferences. Comparison of moulting (wintering) habitat of subantarctic petrels breeding at two distant localities (South Georgia and Kerguelen) showed a striking degree of variation between species, sexes and individuals. This research may have important implications for likely population-level responses to environmental change.

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Technical terms: **Copepods:** *Minute, aquatic crustaceans.* **Ecosystem:** *An interacting community of organisms (e.g. plants and animals) and their physical and chemical environment.* **El Niño/ Southern Oscillation:** *A phenomenon, typically occurring every 2-7 years, associated with ocean and atmospheric changes across the equatorial Pacific that have global effects on weather and climate.* **Isotopes:** *Variations of same element with different numbers of neutrons but the same number of protons (i.e. same atomic number, different atomic mass).* **Krill:** *Shrimp-like crustaceans that form a key part of the Antarctic food web.* **Pelagic animals:** *Creatures that live in the open sea, away from the sea bottom.* **Phytoplankton:** *Microscopic, planktonic plants.* **Primary producers:** *Tiny organisms capable of producing their own food, which do not feed on other organisms and are therefore at the bottom of the food web.* **Trophic levels:** *The different levels within a food web.*

Images: **Above Left:** *Wintering strategies in the common diving petrel vary greatly.* **Above Right:** *Nitrogen isotope values of both South Georgian and Kerguelen shags indicate striking long-term consistency in individual prey and habitat preferences.* **Top Right:** *Antarctic fur seal pup production at Bird Island, South Georgia.* **Centre Right:** *Antarctic krill in upward swimming mode (upper) and parachuting mode (lower) captured by a free falling camera. Images: U. Kils.* **Far Right:** Cymatocyclis calciformis *(approx. 300 microns long) within the stomach of an Antarctic krill.*

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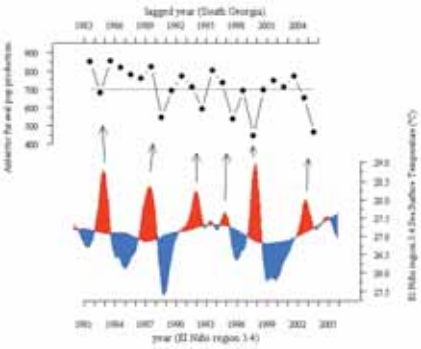

Earth system signals in top marine predators

The effects of climate variability on the physical and biological environment are evident in different regions of the Southern Ocean. Variability in the seasonal patterns of air temperature, sea-surface temperature and sea ice in the south-west Atlantic correlate with the El Niño/Southern Oscillation (ENSO) variation observed, on average, 2.5 years previously in the tropical Pacific. Models accounting for these lagged correlations can predict environmental responses of marine predators in the Scotia Sea.

At South Georgia, environmental effects translate into varied availability of prey, with consequences for the populations of Antarctic fur seals. Model predictions indicated that Antarctic fur seal pup production at Bird Island, South Georgia, would be very low in the 2005–2006 season as a result of high tropical Pacific Ocean temperatures in 2003. It was the second-worst pup production on record (over 23 years). At Signy Island, South Orkney Islands, environmental variability affected penguin populations, which respond to changes in sea ice, affecting their breeding habitat and food supply. This research indicates that the Earth system responds to change in ways that connect around the globe and across much of the marine food web.

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Parachuting allows krill to eat and run

Like many other small pelagic animals, krill perform day/night vertical migration (DVM) in which they occupy the upper ocean layers at night to feed, and the deeper layers by day to hide. This behaviour may be a rapid means of transporting carbon to the ocean's depths. Until recently, the amount of carbon transferred to deeper waters was not considered to be large because it was assumed that DVM happened just once every 24 hours. Researchers from BAS and the University of Hull have discovered that krill can make many migrations each night. What is more, the downward migration may be rapid – krill fan out their swimming legs and enter a controlled descent, similar to parachuting.

The behaviour is most apparent when their stomachs are full, so it may be an effective means of getting out of harm's way when they can eat no more. Antarctic krill could transfer up to 20 million tonnes of carbon per year from the surface to deeper waters through this behaviour, equivalent to the annual carbon emissions of 35 million cars.

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Coping with food shortage: novel adaptations of krill and copepods

Together, copepods and krill are the main links in the transfer of energy from primary producers to the large predators in the Southern Ocean food web. However, we do not know what happens to this energy flow when the phytoplankton do not bloom and there is little summer food available. We examined this by comparing summers of high and low food production in the Scotia Sea.

With abundant food, the copepods grew four times faster than krill – but this was reversed when food was scarce. Most copepods simply continued their winter hibernation at depth whereas the krill managed to keep growing. This was unexpected as previously krill were thought to starve when food is scarce in summer. By using isotopic analysis, BAS scientists have shown that the krill could switch to feeding on the microbial food web, the low-level background of tiny, single-celled animals and plants that persists in both summer and winter. Understanding such links is leading to a better appreciation of how the unique food web of Antarctica is fuelled and how it will respond to environmental change.

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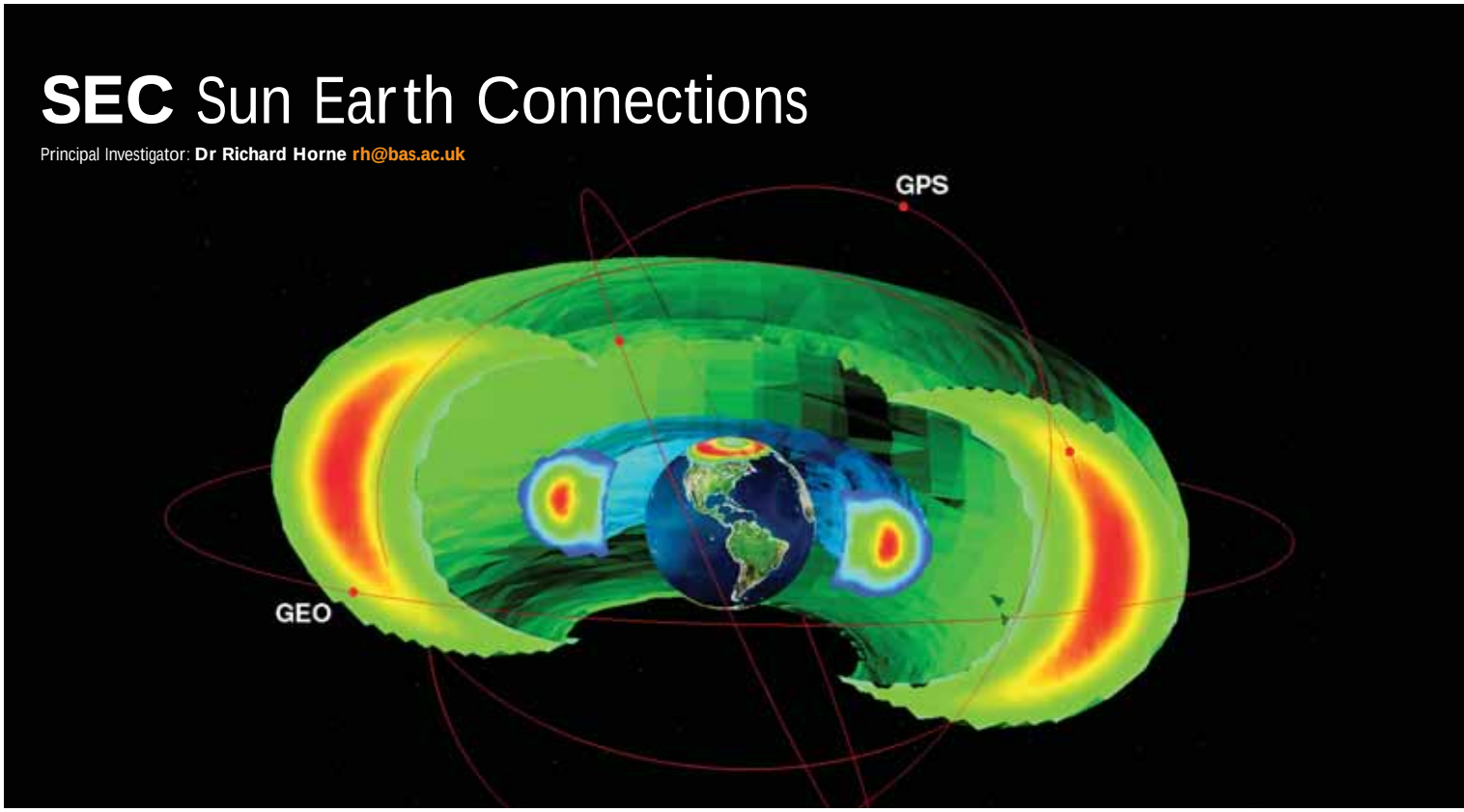
SEC Sun Earth Connections

Principal Investigator: **Dr Richard Horne** rh@bas.ac.uk



Introduction

Solar eruptions are a source of high-energy radiation that damages satellites, spacecraft and astronauts. They also disrupt communications, navigation and power supplies, and increase radiation doses to aircraft, passengers and aircrew.

This radiation also affects the composition and dynamics of the atmosphere and may affect the Earth's climate system. SEC studies how the Earth's atmosphere responds to solar variations so that we can assess the hazards and mitigate their effects, and distinguish between natural and human contributions to climate change.

Wave acceleration in space

The Van Allen radiation belts were the first major discovery of the space age. They consist of two regions of energetic charged particles trapped inside the Earth's magnetic field. Since their discovery, scientists have tried to understand how charged particles are accelerated to very high energies. A major breakthrough came when a BAS, American and French team observed two rare space storms that occurred almost back-to-back in October and November 2003. During the storms, part of the Van Allen radiation belt was drained of electrons and then re-formed much closer to the Earth.

By using scientific instruments in Antarctica, and on the CLUSTER mission satellites (European Space agency mission to map the magnetosphere), it was found that very low frequency radio waves caused the particle acceleration and intensified the radiation belts. This result is now included in models to help satellite operators and forecasters predict when satellites and astronauts are most at risk from radiation-belt events, so they can take protective measures.

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Technical terms: **Energetic particle precipitation:** *The deposition of energetic particles, normally trapped inside the Earth's magnetic field, into the atmosphere.* **Hale cycle:** *Sunspots reach their maximum every 11 years and, with the same frequency, the Sun reverses its magnetic polarity. It therefore returns to the same polarity every 22 years, which is the Hale cycle.* **Magnetometer:** *An instrument for measuring the strength of a magnetic field.* **Magnetosphere:** *A region around a planet under the direct influence of its magnetic field.* **Solar eruptions:** *Large bursts of energy emitted from the Sun's surface.* **Space storms:** *Blasts of disruptive radiation and charged particles from the Sun that travel out into space.* **Stratosphere:** *The layer of the atmosphere ranging, in polar regions, from approximately 8km up to 50km, where temperature increases with height. The ozone layer is situated in the stratosphere.* **Troposphere:** *The lowest layer of the atmosphere, where most weather occurs, from the surface to approximately 10km altitude.* **Van Allen radiation belts:** *A doughnut-shaped region around the Earth in which electrically charged particles are trapped by the planet's magnetic field.*

Images: **Above:** *Illustration of the Earth's Van Allen radiation belts.* **Top Right:** *The disruptive effects of atmospheric waves on high-altitude winds. The greatest effects occur during the Antarctic winter.* **Bottom Right:** *Graph showing the 11-year cycle of sunspot activity. Image: NASA.* **Far Right:** *AARDDVARK global receiver and transmitter locations.*

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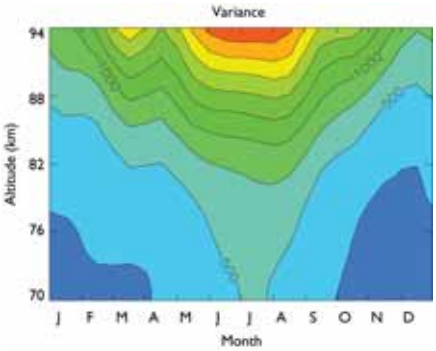

Is there a 22-year solar driver of planetary-scale atmospheric waves?

Sensitive magnetometers on the ground can detect small perturbations in the Earth's magnetic field caused by winds in the upper atmosphere. These magnetometers have operated at some sites since 1900 and their data contain a record of neutral air motion at an altitude of 120km going back for more than a century. Extracting this information is difficult because the signatures are masked by the effects of day-to-day variations in geomagnetic storm activity and extreme ultraviolet solar radiation.

Detailed analysis of the data reveals the long-term history of planetary-scale atmospheric waves in the upper atmosphere. The strength of these waves is modulated with the 22-year Hale cycle of solar activity. This suggests that long-term activity on the Sun may be influencing planetary wave activity here on Earth.

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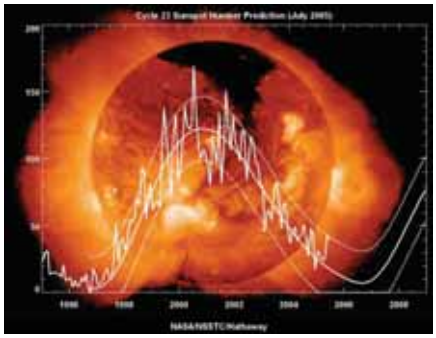

Sources of atmospheric waves

Atmospheric waves produced at low altitudes can travel upwards through the stratosphere and drive atmospheric circulation between 60 and 100km above the Earth. These waves, known as atmospheric gravity waves, reach high altitudes when they travel at an angle against the prevailing horizontal winds in the stratosphere (~25km), otherwise they lose energy.

Using radar data from Rothera Research Station, BAS scientists have determined how gravity-wave activity changes with season in the upper atmosphere. In summer, activity is much stronger over Rothera than at similar latitude sites elsewhere in the world. Surprisingly, gravity-wave activity is stronger in winter than summer, despite much stronger stratospheric winds being available to absorb wave energy. This suggests either that there is a low-altitude source of gravity waves in the troposphere that is very much stronger in winter, or that the waves are produced in or above the stratospheric winds. Understanding the origin and variability of atmospheric gravity waves is important to improve the accuracy of global climate models.

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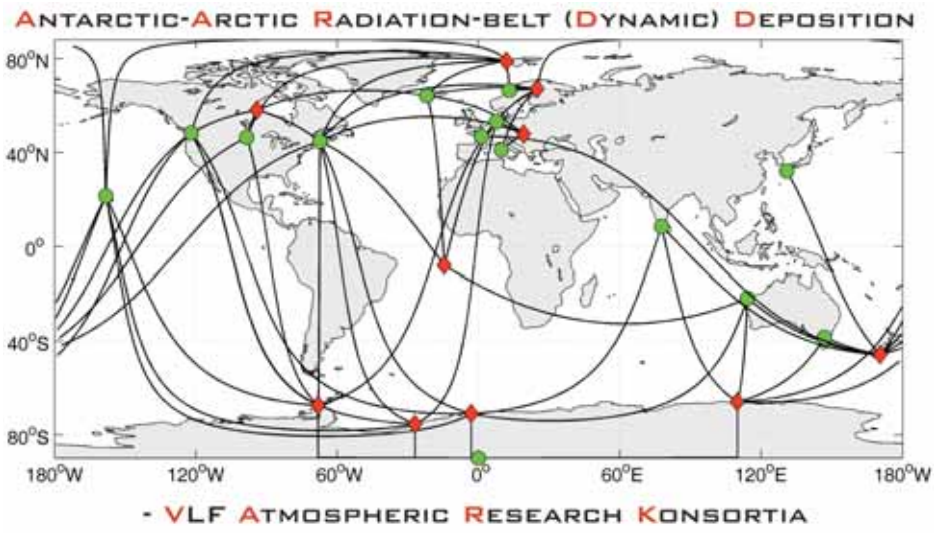

Ozone depletion via energetic particle precipitation

On 20 January 2005, the Sun produced a massive solar flare, ejecting large quantities of solar protons and electrons. Fast-moving solar protons arrived at the Earth after only an hour and hit the Earth's atmosphere, destroying polar ozone and affecting radio communications. The slower-moving mass of electrons arrived at the Earth about a day later, swamping the Earth's protective magnetic field like a solar tsunami. As the Earth's magnetic field compressed under the pressure, many geostationary satellites registered the abrupt disappearance of the outer Van Allen radiation belt.

We have used the newly-formed Antarctic–Arctic Radiation belt Dynamic Deposition VLF Atmospheric Research Konsortia (AARDDVARK) network of instruments to observe and understand these dynamic events. Working closely with collaborators from New Zealand, USA, and Finland, BAS has determined that the majority of the outer Van Allen belt was lost to space, but 10% was deposited into the Earth's atmosphere. Detailed modelling indicated that the effect of the deposition of these fluxes of energetic particles into the polar regions caused significant ozone depletion at an altitude of 50-70km.

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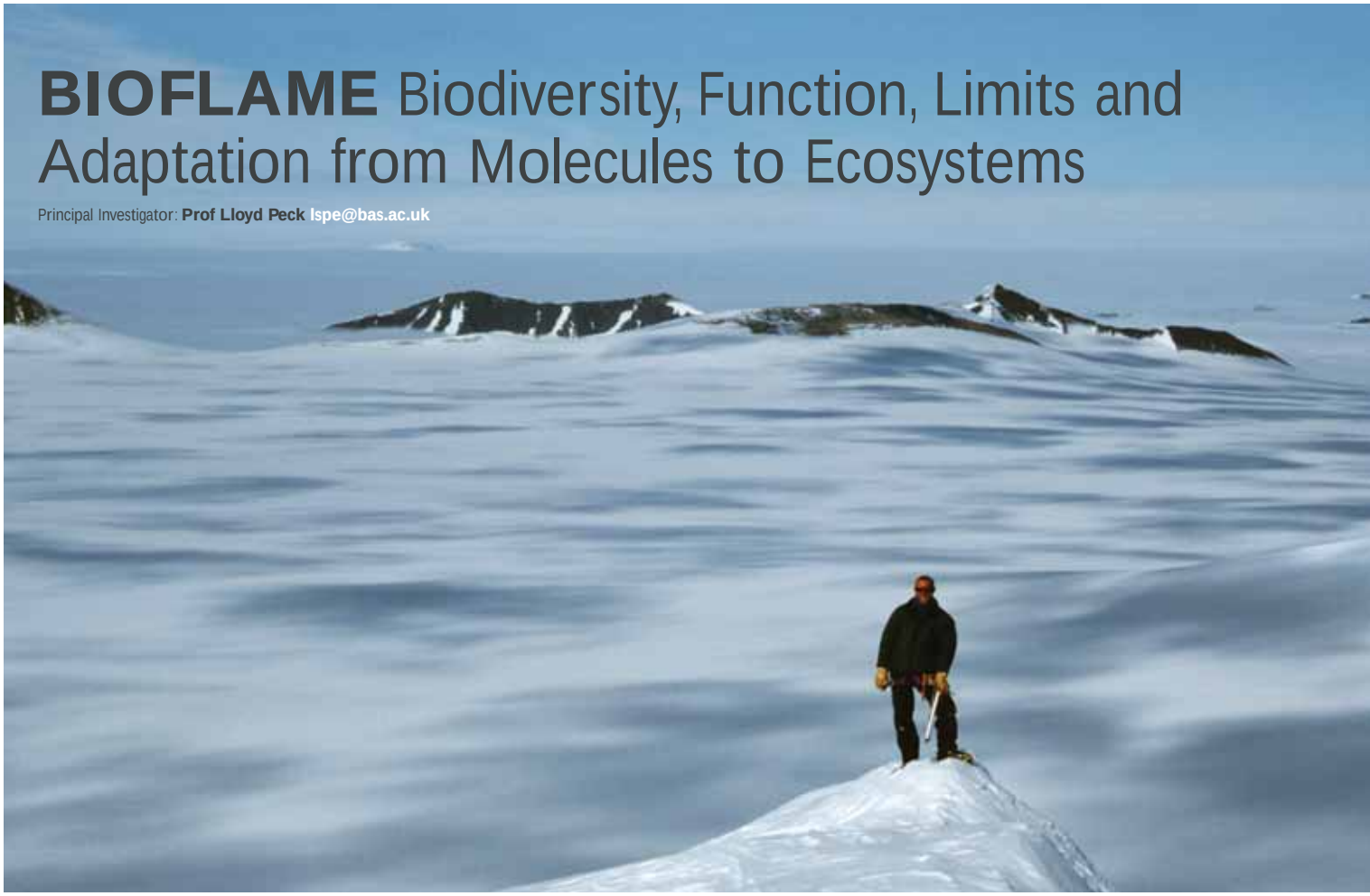
BIOFLAME Biodiversity, Function, Limits and Adaptation from Molecules to Ecosystems

Principal Investigator: **Prof Lloyd Peck lspe@bas.ac.uk**



Introduction

There are fundamental global questions that arise when evaluating the effects of changing environments on life on Earth, such as: "Why are there so many species and why are they distributed where they are?" and "What mechanisms do they have to cope with change?"

BIOFLAME melds traditional biodiversity, ecology and physiology with molecular biology methods to answer these questions for microbial and animal groups living in the extreme cold of Antarctica. We are identifying large-scale distribution patterns for terrestrial and marine species, matching them with historical and palaeo records where possible, and predicting potential range changes in the future. We are also evaluating in detail stress responses in cold-blooded animals, a group in which marine Antarctic species appear to be more limited and less capable than other species.

Technical terms: **Biodiversity:** *The variety and abundance of species.* **Biogeographical unit:** *A defined geographical area whose diversity of animals, plants and microbes are identifiably distinct from other areas elsewhere.* **Ecology:** *The study of the relationship between living things and their environment.* **Microarthropods:** *Minute invertebrates with an external skeleton and jointed legs, including insects, arachnids and crustaceans.* **Molecular biology:** *The study of the structure and function of biological molecules.* **Nematodes:** *Microscopic worms which have smooth, unsegmented, cylindrical bodies with pointed ends.* **Nunatak:** *The tip of a mountain that appears above a surrounding ice sheet.* **Palaeogeographic reconstructions:** *The analysis and understanding of ancient environments.* **Palaeo records:** *Records of the ancient past.* **Protein turnover:** *The manufacture and use of proteins in a living organism.* **Physiology:** *The study of the functions of living organisms at the whole animal, organ or cellular level.* **Rotifer:** *Minute, aquatic, multicellular organism.* **Tardigrade:** *Small, segmented animal that exists in extremely diverse environments wherever water is present, and can grow up to 1.2mm.* **Trophic levels:** *The different levels within a food web.*

Images: **Above:** *Area containing remote nunatak communities in the Behrendt Mountains, Ellsworth Land.* **Top Right:** *An Antarctic tardigrade.* **Centre Right:** *BAS geologist field-tests the new handheld digital-mapping system.* **Far Right:** *The energetic costs of making proteins in Antarctic sea cucumbers,* Holothurian, *has been established.*

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Exceptional tardigrade-dominated ecosystems in Ellsworth Land

Terrestrial faunal communities on inland nunataks of Ellsworth Land, Antarctica are exceptional in their simplicity. These communities comprise up to five species of tardigrade (three new to science) and at least two rotifer species, and include two trophic levels.

The tardigrade community shows similarity to the continental Antarctic fauna, with which it shares three species. The remaining two species are unique to Ellsworth Land and may suggest the region has had a prolonged existence as a separate biogeographical unit. The most striking finding is the absence of nematode worms, previously thought to be ubiquitous in faunal communities worldwide, and microarthropods. The isolated location has resulted in a unique community. Thus, our biogeographical understanding of Antarctica has changed, and these observations challenge current views of the complexity required for a community to function.

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Survival of the fittest

We have recently assessed the capacity of groups of simple multi-cellular organisms, including nematodes, tardigrades and rotifers, to survive temperatures close to the lowest experienced on Earth in nature.

Individuals of all three groups survived at -80°C for over six years. There were, however, significant differences within and between the groups, with nematodes and tardigrades surviving better than rotifers. These surprising abilities are leading us to revise our ideas on how well life can persist at very low temperatures.

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Development of digital mapping and data capture system

In preparation for the BIOFLAME field season on South Georgia, which aims to help refine palaeogeographic reconstructions of the Scotia Arc, BAS has developed and created a new digital-mapping system. It integrates with the industry standard mobile GIS system, ArcPad, and operates on a standard handheld computer (i.e. IPaq PDA or PC). Over 3,000 lines of computer code enable sophisticated geological observations and measurements to be captured directly into a geographical information system, automating many laborious tasks previously required to document a station locality.

The system possesses over 200 data fields in a complex relational database architecture, allowing data previously recorded in notebooks to be immediately accessible for all manner of data analysis. The first full use of the system was a great success, even in the worst possible weather conditions when traditional notebook and pencil recording would not have been feasible. As a result, much more comprehensive data sets were collected, improving work efficiency both in the field and with later data analysis.

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Assessing the costs of making and using proteins

Protein turnover is one of the major energy costs to all animals. The energetic costs of manufacturing proteins in Antarctic organisms living at very low ambient temperatures is essential in understanding the overall costs of growth in all organisms.

Recent work at BAS has accurately measured the cost of making proteins for the first time and shown that it is not temperature dependent. Hence, the costs in temperate and polar species are similar. Having an accurate assessment of the costs of making and using proteins at low temperatures is a major step forward in understanding polar adaptations in marine animals.

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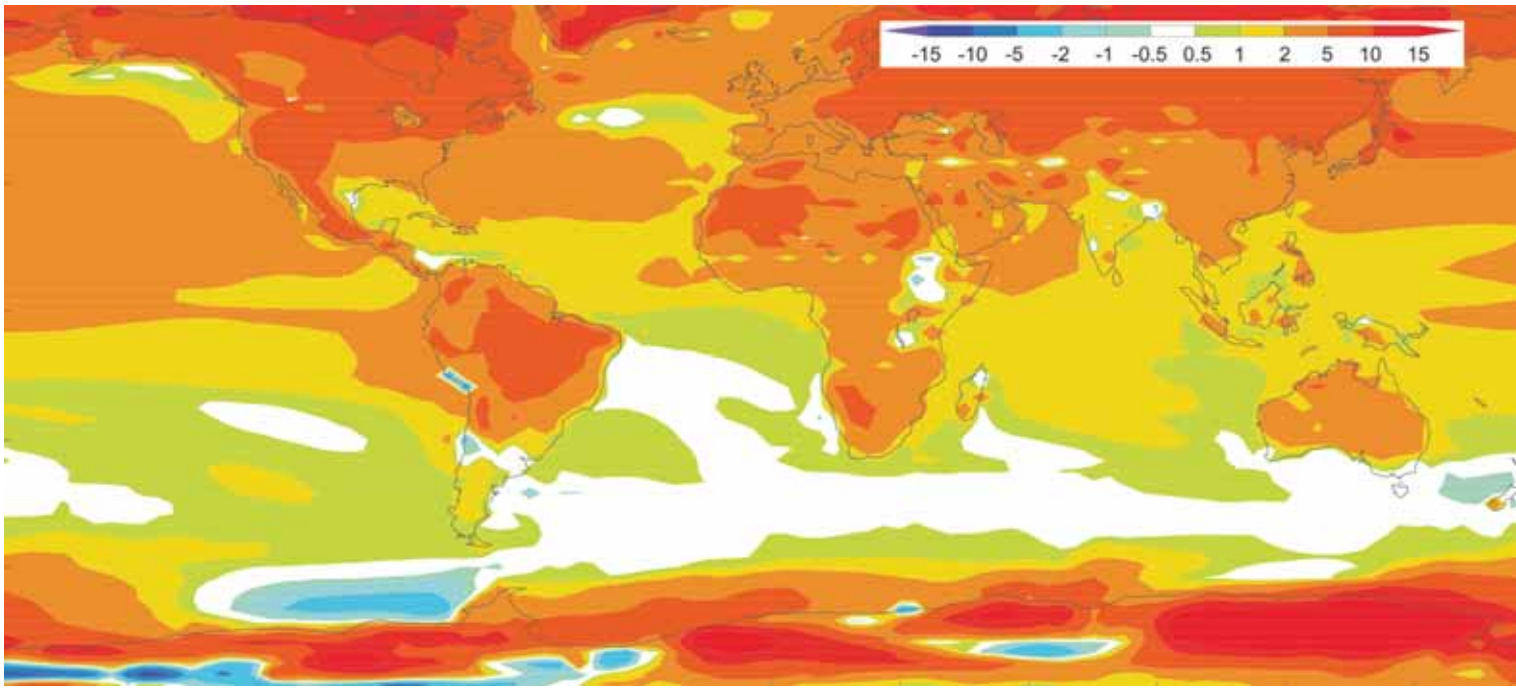
GEACEP Greenhouse to Ice-House Evolution of the Antarctic Cryosphere and Palaeoenvironment

Principal Investigator: **Dr Alan Haywood** ahay@bas.ac.uk

Introduction

By linking geological data with advanced computer models of Earth as an integrated system, GEACEP investigates the evolution of the Antarctic ice sheet and the changing global environment over the last ~30 million years.

We explore the nature of warm climates in Earth history, investigate the forcing and feedback mechanisms associated with the start of glaciation on Antarctica and examine the stability of the Antarctic ice sheet in the recent geological past. An integral part of the programme is an assessment of the ability of climate models to reproduce large-scale climate changes that have occurred in the past – a robust test of their ability to accurately predict future climate change.



Genesis of warm climates in Earth history – atmosphere vs. oceans

The genesis of warm climates much earlier in Earth's history has been hotly debated for many years. Scientists from BAS and the University of California reconstructed sea-surface temperatures (SSTs) from the tropics and high latitudes. These measurements were compared with predictions from a sophisticated ocean/atmosphere climate model for the Pliocene (~5.2 to 1.8 million years ago).

The new data and model results suggest that higher concentrations of the greenhouse gas carbon dioxide may have been the trigger for Earth's last great period of global warmth. Investigating the climatic conditions of the recent geological past is critical to understanding how climate will respond to emissions of greenhouse gases in the future.

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Technical terms: **Ecosystem:** *An interacting community of organisms (e.g. plants and animals) and their physical and chemical environment.* **Epoch:** *A division of geological time.* **Foraminifera:** *Single-celled, marine animals which usually secrete a carbonate shell.* **Forcing mechanism:** *A process that drives a system or causes it to change.* **Feedback mechanism:** *A change within a system as a result of a forcing mechanism that affects it (e.g. environmental changes).*

Images: **Above:** *Climate model prediction showing how different sea-surface temperatures were three million years ago (in degrees Celsius).* **Bottom Right:** *Tiny planktonic foraminifera are often used for sea-surface temperature reconstructions.* **Centre Right:** *Photograph of a fossil* Araucaria *branch from Seymour Island, Antarctica. Modern* Araucaria *branch shown for comparison.* **Far Right:** *Palaeontologist sorting and cataloguing fossil teeth in a tent on Seymour Island, Antarctic Peninsula.*

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Life and death of a tiny single-cell sea plankton

The reconstruction of past sea-surface temperatures (SSTs) provides important data that can be used to test climate models. The analysis of oxygen isotopes from surface dwelling foraminifera is a well-established technique for reconstructing SSTs. When foraminifera die they sink and become part of the sediments on the ocean floor, creating a record of past sea temperatures within the sediments.

However, BAS scientists have recently questioned the reliability of this technique for producing accurate SST estimates. We analysed published oxygen isotopic compositions of foraminifera from more than 30 Ocean Drilling Programme (ODP) sites for the Miocene (~23 to 5 million years before present) and Pliocene (~5 to 1.8 million years before present) epochs.

The results were compared to other independent SST estimates. SSTs predicted by the oxygen-isotope method differed significantly from estimates provided by other means. SSTs were predicted as almost always cooler than modern temperatures, this for periods in Earth history known to be warmer than the present day. The results suggest that the original oxygen-isotope composition of the foraminifer shells may have been altered after death, limiting the use of published ODP data for SST reconstruction.

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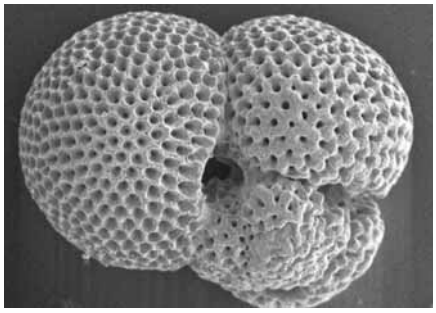

A sudden expansion of tropical grasses seven million years ago – fact or fiction?

By studying the fossilised teeth of mammals, scientists can build up a picture of the diet of ancient animals. This can indicate the type of vegetation present during various periods of geological time. Geological evidence suggests that seven million years ago, there was a relatively sudden expansion of tropical grasses of a type not seen before. These tropical grasses thrived in much warmer conditions and were also adapted to relatively low levels of atmospheric carbon dioxide, which steadily decreased over millions of years.

Vegetation modelling studies carried out by BAS and Bristol University have indicated that the tropical grasses may have been around much longer than anyone previously thought and the results have identified uncertainties in existing geological data. This research highlights a potential weakness in vegetation models that are currently being used to predict how present-day vegetation will react to current and future climate change.

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Insect traces provide a window on ancient Antarctic ecosystems

Fossil evidence of insect leaf eating (folivory) provides unique ecological information and an unprecedented opportunity to reconstruct past ecosystems. Researchers at BAS and Leeds University examined insect feeding traces in fossil Araucaria conifer leaves from Antarctica. The fossil leaves were derived from the Eocene (~55 to 34 million years before present) and found within the La Meseta Formation, Seymour Island, Antarctica. The fossil insect traces were compared to damage found in modern Araucaria conifers from South America.

The most likely trace-makers were identified as moth larvae (Lepidoptera), similar to that of a present-day moth (Araucarivora gentilli), which attacks leaves growing at mid-to-high altitudes in the Andes of Chile and Argentina today. The research shows how Antarctica in the Eocene was similar to South America today. This provides scientists with important clues about the environment and ecosystem of Antarctica during the Eocene and information with which to evaluate the output from climate models.

Contact: **Rosemary Stephens** (BAS & Leeds University) r.stephens@earth.leeds.ac.uk

LTMS Long-Term Monitoring and Survey

Biological sciences contact: **Prof Paul Rodhouse pgkr@bas.ac.uk** Geological sciences contact: **Dr Alistair Crame jacr@bas.ac.uk**
Physical sciences contact: **Mike Pinnock mpi@bas.ac.uk** Environmental information and mapping contact: **Dr John Shears jrs@bas.ac.uk**

Introduction

Long-term monitoring of the environment is essential to determine change and variability in the Earth system. Also, significant swathes of Antarctica remain unsurveyed.

To address this, BAS collects a wide range of environmental monitoring and survey information from Antarctica and the surrounding seas, such as meteorological and ozone data, mapping the ocean floor, and the population of albatrosses and petrels. Measurements are coordinated with international partners, and made available through the Antarctic Environment Data Centre.

Cooling the world's oceans – Antarctic Bottom Water

Oceanographers have long realised that the Southern Ocean plays an active role in the Global Thermohaline Circulation (GTC), via the formation and transport of Antarctic Bottom Water (AABW). This is the coldest, densest water in the global ocean and helps drive the GTC. It has been estimated that the Weddell Sea may contribute up to 60% of the AABW entering the global ocean, but determining the true contribution has been hampered by the scarcity of wintertime survey data and long-term oceanographic datasets.

To address this need, BAS and collaborators from the Bjerknes Centre for Climatic Research, Norway and the Lamont-Doherty Earth Observatory, USA have deployed moorings in the southern Weddell Sea and the Orkney Passage. These will monitor the formation of Antarctic Bottom Water (from ice-shelf water) and its subsequent outflow to the Scotia Sea.

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Technical terms: Ecosystem: *An interacting community of organisms (e.g. plants and animals) and their physical and chemical environment.* **Global Thermohaline Circulation:** *The global density and wind-driven circulation of the oceans.* **Isotopes:** *Variations of the same element with different numbers of neutrons but the same number of protons (i.e. same atomic number, different atomic mass).* **Meteoric water:** *Ground water that originated in the atmosphere, derived mainly from precipitation.*

Images: Above: *Deploying moorings off the aft deck of RRS* James Clark Ross. **Bottom Right:** *Extract from the newly-produced map of Anvers Island and Brabant Island in the Antarctic Peninsula.* **Centre Right:** *Silicified conifer wood from the Upper Cretaceous (100-65 million years ago) discovered on Livingston Island, South Shetland Islands.* **Far Right:** *Ocean salinity, temperature and density for the upper 200m of the water in Ryder Bay, Antarctic Peninsula.*

For more information please visit our website: **www.antarctica.ac.uk**

Mapping and Geographic Information Centre

The Mapping and Geographic Information Centre (MAGIC) maintains and develops the Antarctic Digital Database (ADD) on behalf of SCAR. The ADD is a seamless database of the best international topographic mapping for Antarctica. It is the accepted geographic framework for Antarctic science and logistics and is an important resource for international collaboration and the International Polar Year. The map data are freely available and can be downloaded from the Web. Recent activities include developing a more sophisticated Web interface to the data and adding detailed information about historic changes in the ice coast, as well as revision when improved geographic information becomes available. 2005–2006 publications, based on ADD data, included a double-sided map of the Antarctic Peninsula and Grahamland (sheet BAS Misc 13) and a satellite-image backdrop map of Anvers Island and Brabant Island (sheet BAS 250P SQ19-20/3 and 4).

BAS is collaborating with the USGS and NASA to compile a mosaic of Landsat satellite imagery for the whole of Antarctica, with MAGIC providing the segment covering the Antarctic Peninsula. The image mosaic will underpin new BAS map series for the Antarctic Peninsula region, be a valuable data source for science and logistics activities and provide a baseline for measuring change. Acquisition of more than 70 satellite images needed for the BAS segment was completed during the year. The completed mosaic of the whole continent will be available on the Web for free by August 2007.

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Antarctic Environment Data Centre

Scientists from the UK and elsewhere rely on timely access to data, both from current research activities and long-term data series. The Antarctic Environment Data Centre (AEDC), in partnership with the Archives Service, the Mapping and Geographic Information Centre and BAS's scientific data managers, have developed a suite of databases and applications to deliver these requirements. Data collected through UK-funded research in the Antarctic and Southern Ocean can now be accessed by scientists worldwide via a web-based catalogue.

Data collected from the 1970s onwards, relating to surveys of bird and seal colonies, have been re-organised and catalogued by the Archives Service as part of a recent initiative to improve access to historic components of long-term data series. Data collected through the Natural Environment Research Council's Antarctic Funding Initiative is now being catalogued and managed through the AEDC to ensure its long-term preservation and availability. Physical and biological oceanographic data have been compiled into a single, easily accessible database (the Lower Trophic Levels Database). The BAS fossil collection is being photographed to make this unique collection available internationally.

Direct and continuous communications between BAS Cambridge and Antarctica have enabled access to data from Antarctica in near real-time. Software automatically retrieves data and performs a variety of tasks, presenting the information in a directly usable form. This enables scientists to perform data analyses much sooner than previously possible. Working with other Natural Environment Research Council Data Centres, and the SCAR/COMNAP Joint Committee on Antarctic Data Management, the AEDC is ensuring that data collected through UK-funded research is integrated into international science activities, maximising the benefit for the international science community.

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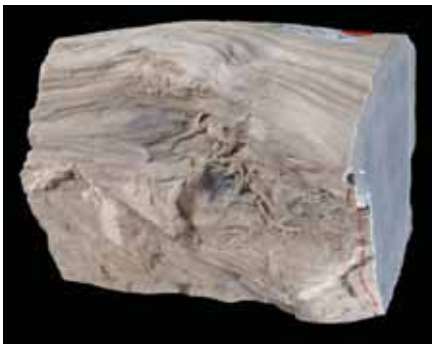

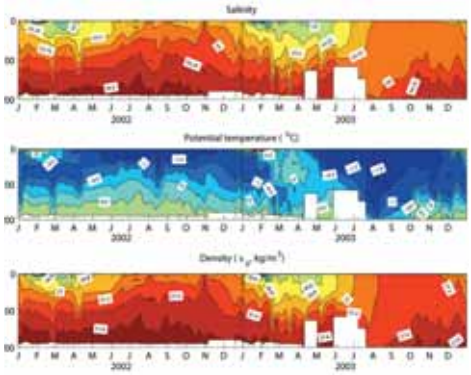

Freshwater inputs to the ocean west of the Antarctic Peninsula

Long-term monitoring of the oxygen isotopes in sea water near Rothera Research Station, on the western Antarctic Peninsula, has revealed that meteoric water (mostly in the form of glacial ice melt) is the dominant freshwater input to the ocean, accounting for up to 5% of the near-surface ocean during the Antarctic summer.

Sea-ice melt accounts for a much smaller percentage. This finding contradicts the assumption that sea-ice processes dominate the seasonal changes of the physical ocean environment close to the Antarctic continent. The predominance of glacial melt is significant, since it is known to be important in the operation of the ecosystem. If the rapid warming of the western Antarctic Peninsula continues, we expect meteoric water inputs to rise further, and a reduction in the input of sea-ice melt. Continued monitoring of oceanic fresh water will track these changes as they occur, and help to understand their ecological consequences.

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Delivering the Science

Image: *The BAS Dash-7 aircraft touches down on the blue-ice runway at Sky-Blu Field Station, Antarctic Peninsula.*

Infrastructure and Operations

Contact: **John Pye** ajpye@bas.ac.uk

Introduction

To deliver world class science 16,000km away, BAS needs modern technology for science and infrastructure, up-to-date facilities and effective operational management.

We have long-term planning horizons, a flexible and innovative approach, and an ongoing programme to introduce new facilities and technology. Success depends on excellent teamwork across many disciplines, a continuous search for better ways of working, and collaboration with other NERC programmes and national Antarctic operators.

Aircraft operations – 2005–2006 season

The BAS Antarctic flying programme in 2005–2006 was a great success, with 2,000 flight hours completed in the 138-day flying season. The air support of deep-field science depends on a network of fuel depots and logistic field camps. The season saw the increased integration of the Dash-7 (wheels only) and wheel/ski Twin Otter aircraft activity into a 'hub and spoke' operation. The 'hub' involves the Dash-7 flying in fuel from Rothera Research Station to the forward operating depot on blue-ice at Sky-Blu. All previous records were broken and the Dash-7 positioned 573 drums of fuel and 11,000kg of equipment. The Twin Otters provide the 'spoke' by ferrying fuel and equipment forward into field camps. The aircraft and their crews have to spend longer periods at Sky-Blu to make the system work, but the result is a marked increase in aircraft utilisation. These improvements enable BAS to support the core programme of scientific fieldwork within the available resources.

From early November to late January, one of the Twin Otters conducted BAS's largest-ever geophysical and ice radar airborne survey. Seventy-one flights, totalling 270 survey hours, were flown in Wilkes Land for the GEACEP science programme, in collaboration with the Italian National Antarctic Programme.

In addition to the diverse range of science support, there was an extensive air campaign to clean up and remove redundant science and logistics sites, including the removal of three deep-field geophysical observatories.

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Technical terms: **Geophysical and ice radar airborne survey:** *Ground/ice survey using sophisticated radar instruments mounted on the wing of, and inside, a Twin Otter aircraft.* **Magnetometer:** *An instrument for measuring the strength and direction of a magnetic field.* **Remote geophysical observatories:** *Automated field stations set up to record scientific measurements in remote areas.* **Transponder:** *Device used to receive and transmit signals.* **Ultra Short Baseline System:** *System to communicate with remotely operated undersea vehicles.*

Images: **Above:** *Installing magnetometer sensors on a BAS Twin Otter aircraft on the ski-way at Rothera Research Station.* **Top Right:** *Construction of the new facility at Bird Island Research Station.* **Centre Right:** *Diagram explaining the Ultra Short Baseline System.* **Bottom Right:** *The extendable pole on the bottom of RRS James Clark Ross housing the transponder unit.*

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Bird Island redevelopment

The new scientific research and accommodation facilities at Bird Island were opened on 26 February 2006 by His Excellency Howard Pearce, Commissioner of South Georgia and the South Sandwich Islands. The new station normally accommodates up to 10 people, with a maximum of 12 for short periods when required. The timescale for the project was tight, with BAS taking occupation of the new buildings within 12 months of the decision to go ahead with the project. One of the big challenges was the need to work around the seal population, causing the minimum disturbance to animal life. Construction and demolition could only take place late in the Antarctic summer, after the breeding season had finished.

Another major challenge was getting ashore 1,200m^3 of building materials (which needed over 100 cargo-tender loads between the ship and the station. This was achieved through the close teamwork of all parties at BAS, including the crew of RRS *Ernest Shackleton*, and our construction partner Morrison Construction (Falklands) Ltd. We used an additional cargo-tender on loan from RRS *James Clark Ross*, and extra crew helped with the long process of offloading. Over 800m^3 of building waste was also safely and successfully removed after the old facilities were demolished.

The redevelopment provides new scientific laboratories and domestic and living accommodation, ensuring world-class research facilities for BAS and visiting scientists for the next 20 years. The new facilities also significantly reduce the environmental impact of the station through improved energy efficiency and waste management.

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Underwater positioning system for RRS *James Clark Ross*

RRS *James Clark Ross* is one of the most sophisticated marine research vessels in the world. As part of our commitment to maintaining its capability, the ship was fitted with a state-of-the-art Ultra Short Baseline System (USBL) during last year's refit. This will enable BAS to deploy Remotely Operated Vehicles (ROVs) from the vessel.

The system uses a transponder fitted to a retractable pole, which can transmit and receive acoustic signals to communicate with transponders located on equipment in the water and accurately triangulate the position in relation to the ship. This can track vehicles up to 7km away. Using a network of satellite positioning systems (such as GPS), the ship can then locate the exact position of the ROV. The vehicle can be used to investigate interesting undersea anomalies or events by positioning monitoring equipment, taking video or still images, or collecting samples in regions that have previously been difficult to access.

Installing this technology is the first step toward being able to deploy the National Oceanography Centre's ROV 'ISIS' in Antarctic and Arctic regions that were previously inaccessible by conventional methods.

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UK and International Collaborations

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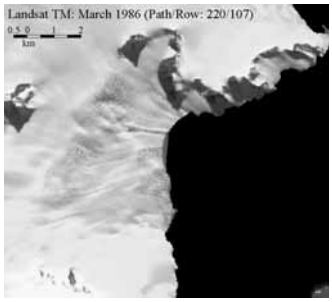
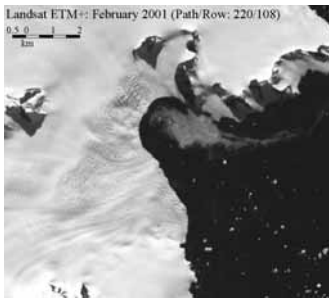
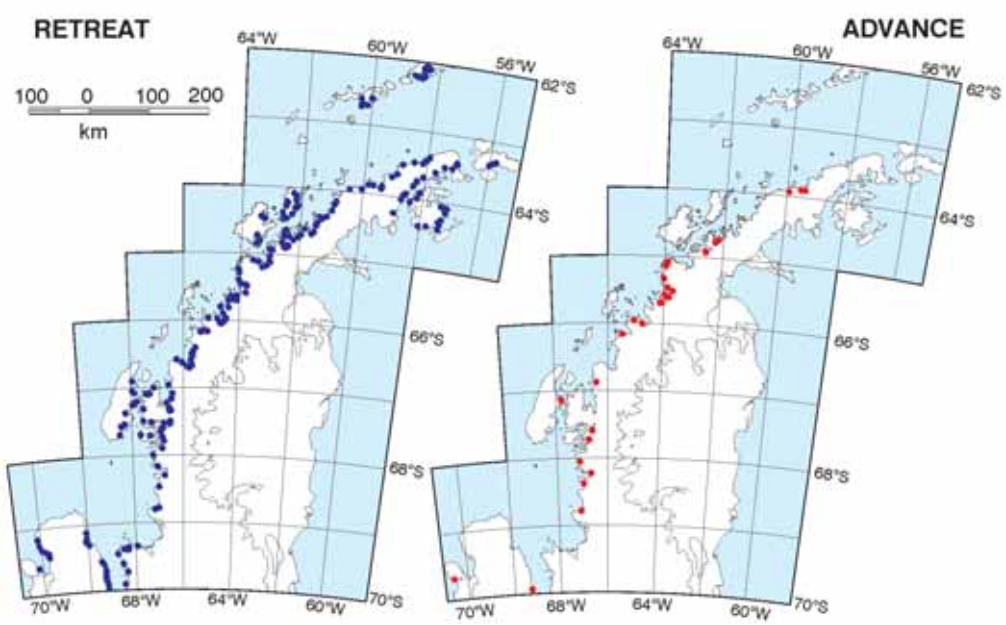
Introduction

BAS scientists alone cannot answer all the important questions that can be posed in Antarctica.

Collaboration with those in universities and research centres in the UK and overseas is essential to provide even wider perspectives and ranges of skills.







Changes in Antarctic Peninsula glaciers

In the last half century, the Antarctic Peninsula has been one of the fastest-warming regions on the planet. In a collaborative project with the United States Geological Survey, BAS has analysed more than 2,000 aerial photographs and 100 satellite images, spanning the last 60 years, to compile a time series of changes in the position of glacier and ice-shelf fronts around the coast of the peninsula. Measurements have shown that 87% of the 244 marine glacier fronts have retreated and that the average rate of retreat has increased with time. There is also clear evidence that the regions in retreat have moved progressively further south.

Contacts: **Prof David Vaughan** **dgv@bas.ac.uk** **Alison Cook** **acook@bas.ac.uk**

Technical terms: **Aerogeophysics survey:** *Ground/ice survey using sophisticated instruments mounted on the wings of, and inside, a Twin Otter aircraft.* **Ecosystem:** *An interacting community of organisms (e.g. plants and animals) and their physical and chemical environment.* **Feedbacks:** *Changes within a system as a result of a forcing mechanism that affects it (e.g. environmental changes).* **Forcings:** *Processes that drive a system or cause it to change.*

Images: **Above:** *Satellite photographs of the Sheldon Glacier, Adelaide Island, showing its marked retreat between 1986 and 2001. Maps of the Antarctic Peninsula showing which glaciers have advanced and which have retreated.* **Top Right:** *Logo of the International Polar Year.* **Centre Right:** *Satellite photograph of the Montagu Island volcano erupting. Image: Matt Patrick.* **Bottom Right:** *A BAS Twin Otter aircraft in action in Antarctica.*

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Spectacular volcanic eruption on a remote subantarctic island

A rare volcanic eruption is expanding the size of an island in a British overseas territory. Spectacular satellite images show that Montagu Island, an erupting volcano in the South Sandwich Islands, South Atlantic, has grown by 0.2km^2. Researchers from BAS and the Hawaii Institute of Geophysics and Planetology were alerted to satellite data showing a large volume of lava pouring into the sea like a huge waterfall. Red-hot lava has formed a molten river 90m wide that has extended to the shoreline on the north side of the island. This event is special because Montagu Island is mostly ice covered and it is rare to make direct observations of eruptions associated with ice sheets. This opportunity to monitor a live eruption and see how it affects ice cover may provide insights on how past eruptions interacted with ice sheets over the last 30 million years.

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International Polar Year

The polar regions have profound significance for the Earth's climate and ultimately its environments, ecosystems and human society. However, we still remain remarkably ignorant of many aspects of how this part of the Earth system operates. The International Polar Year (IPY) 2007–2009 will be an intense, internationally-coordinated campaign of research that will initiate a new era in polar science. It recognises the strong links that these regions have with the rest of the globe.

IPY will involve a wide range of research disciplines and be truly international in its participation. It aims to involve the public and to help train the next generation of engineers, scientists and leaders. The IPY International Programme Office is located at BAS and funded by the Natural Environment Research Council. It provides central planning, coordination, oversight and guidance of the IPY under the direction of a joint committee of the International Council for Science and the World Meteorological Organisation. Already there are over 200 scientific projects endorsed by IPY, involving over 50,000 scientists from 60 nations. BAS scientists are playing major roles in many of these projects.

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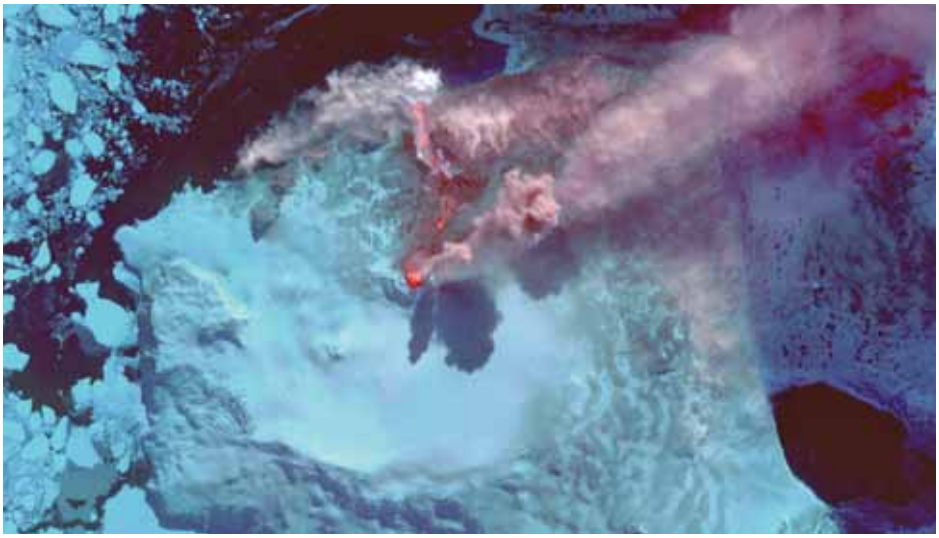

Aerogeophysics survey of the Wilkes Subglacial Basin

In collaboration with the Italian Antarctic Programme (PNRA), BAS has carried out a new aerogeophysical survey over the Wilkes Subglacial Basin. This is the largest and most remote air survey ever conducted by BAS. The work was carefully integrated with Italian ground-based geophysics and geological studies over the Transantarctic Mountains.

The main aim of the survey was to find out whether Cenozoic age (last 65 million years) sediments were present in the Wilkes Subglacial Basin. The answer to this question is central to the ongoing debate regarding the stability, or otherwise, of the East Antarctic Ice Sheet during the recent geological past, as well as for constraining the uplift of the Transantarctic Mountains.

This survey will help researchers determine whether the East Antarctic Ice Sheet reduced in size during the warm Pliocene (~5 to 1.8 million years ago). It will establish the extent of the relationship between Cenozoic uplift of the Transantarctic Mountains, the West Antarctic Rift System and the Wilkes Subglacial Basin, and help to quantify the forcings and feedbacks between uplift, subsidence, and glaciation/deglaciation.

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UK Influence in Global Affairs

Contact: **Dr John Shears** jrs@bas.ac.uk

Introduction

Sustaining a leadership role for the UK in global affairs, as well as in the Antarctic, is part of the BAS mission. We ensure that the UK Government and key decision-makers are scientifically well advised and address key areas of concern, such as protecting the Antarctic environment, global climate change and sustainable fisheries management.

Technical terms: Ecology: *The study of the relationship between living things and their environment.* **Ecosystem:** *An interacting community of organisms (e.g. plants and animals) and their physical and chemical environment.* **Krill:** *Shrimp-like crustaceans that form a key part of the Antarctic food web.*

Images: Above: *Joint UK/French field camp on Berkner Island.* **Top Right:** *A commercial fishing vessel operating near the subantarctic island of South Georgia.* **Bottom Right:** *Scientific Committee for Antarctic Research logo.*

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Scientific input to the Intergovernmental Panel on Climate Change (IPCC)

This year, BAS has made important contributions to the Intergovernmental Panel on Climate Change (IPCC), which coordinates international scientific advice to decision makers responding to global climate change. Professor David Vaughan is a coordinating lead author for the IPCC, and is writing the chapter to the next IPCC report on the effects of climate change in the Polar Regions (Arctic and Antarctic). His work is supported by funding from the Department of Environment, Food and Rural Affairs (Defra).

As a result of his work for the IPCC, Professor Vaughan was invited to address a conference discussing climate change and governance, in Wellington, New Zealand, with among others, Prime Minister Tony Blair and Lord Oxburgh. The conference was supported by the New Zealand and British governments, together with the Royal Society of New Zealand and the New Zealand Institute of International Affairs. In addition, BAS staff also contributed to other chapters of the IPCC report and acted as specialist reviewers.

Contact: **Prof David Vaughan** dgv@bas.ac.uk

Science for a sustainable future for Southern Ocean fisheries

The main focus of the Ocean Ecosystems and Management project is to deliver policy-relevant science for marine resource management by integrating oceanography, ecology and fisheries from across the DISCOVERY 2010 science programme. The primary use of this science is the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), the body that sets the catch levels for fisheries in the Southern Ocean. CCAMLR has adopted an ecosystem approach to fisheries. This takes into account the effects of fishing not only on the target species but also on the ecosystem as a whole.

The process for managing the fishery for Antarctic krill, the species at the centre of the Antarctic food web, focuses on distributing fishing effort to avoid large catches in sensitive areas, such as near penguin colonies during the summer. By bringing together a broad suite of scientific disciplines, new models have been developed to examine the potential consequences of different fishery-management options. This will help to avoid irreversible changes in this globally-important ecosystem. This work complements the applied fisheries research undertaken by BAS for the Government of South Georgia and the South Sandwich Islands.

Contact: **Dr Keith Reid** kre@bas.ac.uk

Coordination of international scientific advice from the Scientific Committee for Antarctic Research (SCAR)

In 2005, SCAR decided to institute three new medals to recognise exceptional contributions from within the Antarctic community. Professor David Walton (BAS) was awarded the international collaboration medal for his work over 14 years leading SCAR at the Antarctic Treaty Consultative Meetings (ATCM) and running the Group of Specialists on Environmental Affairs and Conservation. At ATCMs, Professor Walton has helped to provide the Antarctic Treaty nations with independent and high-quality scientific advice using SCAR's exceptional network of experienced Antarctic scientists around the world.

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Protecting the Environment

Contact: **Dr John Shears jrs@bas.ac.uk**

Introduction

BAS is committed to delivering the GSAC science programme and its associated logistics with the minimum of environmental impact.

We also maintain a leadership role in Antarctic environmental affairs. The Environmental Office delivers this through the use of Environmental Impact Assessment and monitoring, participating in Antarctic Treaty inspections, and cleaning up abandoned British bases.

Images: Above: *Inspecting the historic hut at Cape Evans.* **Top Right:** *Demolition waste awaiting removal from Bird Island, South Georgia. Image: Dewi Edwards.*
Bottom Right: *Low-temperature degradation of hydrocarbon fractions (C16-20) by Antarctic bacteria supplemented with nutrients.*

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Antarctic Treaty inspections

A fundamental requirement of the Antarctic Treaty is that all research stations, ships and aircraft operating in Antarctica are open to inspection at any time by any Treaty nation.

The Environmental Protocol to the Antarctic Treaty also allows for inspections of protected areas. An inspection of these in the Ross Sea region was conducted, in November 2005, by New Zealand, the UK and the USA. This was the first time that comprehensive inspections of protected areas had been conducted in Antarctica. Five Antarctic Specially Protected Areas, including the heroic-age huts built by Scott and Shackleton, were visited, as well as the McMurdo Dry Valleys Antarctic Specially Managed Area. The results of the inspection are being used to help improve the conservation and management of these areas.

Contact: **Dr John Shears jrs@bas.ac.uk**

Cleaning up the BAS legacy on South Georgia

In 2006, a BAS clean-up team safely removed more than 800m^3 of demolition waste from Bird Island Research Station, as well as abandoned BAS field huts, scientific exclosure fences and former work sites at nine locations on South Georgia. Many of the field sites were established by BAS during the 1970s and 1980s and had not been visited since. Before demolition could start, hazardous substances (including asbestos, laboratory chemicals, batteries and adhesives) were removed for safe disposal. A small group of technical experts from Morrison Construction (Falklands) Ltd. assisted with the clean-up.

RRS *Ernest Shackleton* served as the platform for the operation, and proved to be an excellent support vessel for environmental operations at remote coastal locations. By cleaning up South Georgia in this way, BAS has demonstrated its commitment to the long-term environmental protection of the island.

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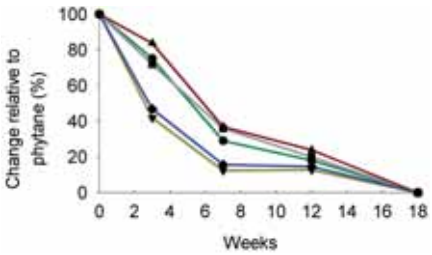

Antarctic bacteria help clean up oil spills

Occasionally, fuel oil spills occur in Antarctica and must be cleaned up. Research by BAS and the University of Wales at Bangor has shown that Antarctic soils already contain bacteria that can break down hydrocarbons.

Unlike bacteria from temperate climates, some Antarctic bacteria remain active at low temperatures. This makes them suitable for degrading spilled hydrocarbons in the cold Antarctic terrestrial environment. When the bacteria were given nutrients and water, the rate of oil breakdown rapidly increased. In future, Antarctic soil bacteria could be of use in oil-spill clean-up technologies in other cold regions of the world.

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Science in Society

Contact: **Linda Capper MBE** lmca@bas.ac.uk

Introduction

Explaining our science in accessible language is vital to enable informed public dialogue about global environmental issues.

Media relations, publications, events, exhibitions, educational resources, the World Wide Web and a public information service are the primary means of promoting public engagement and dialogue about BAS science.

Images: Above: *RRS James Clark Ross at the International Festival of the Sea in Portsmouth. Image: Tim Foord.* **Top Right:** *The route taken by visiting artist Layla Curtis, displayed as part of her online, multimedia map record of her trip to Antarctica.* **Bottom Right:** *BBC News correspondent David Shukman down a crevasse near Rothera Research Station, Antarctic Peninsula.*

For more information please visit our website: **www.antarctica.ac.uk**

Public engagement and enthusing young people

Over the weekend of 30 June to 3 July 2005, over 7,000 visitors came onboard RRS *James Clark Ross* and HMS *Endurance* during the spectacular International Festival of the Sea at Portsmouth Naval Dockyard. Families enjoyed talking to BAS scientists and support staff, who brought our science and operations to life. A manned route around the ships meant visitors could ask questions about mapping, ice-core science and living and working onboard ship and on Antarctic research stations. Biologists displayed specimens ranging from phytoplankton to deep-sea fish, giving the public an exciting introduction to Southern Ocean science.

Formal and informal learning initiatives continued throughout the year with a series of classroom talks and visits, as well as working with teachers on continued professional development. A partnership to create an online interactive geography teaching resource was formed with the Royal Geographical Society and Foreign & Commonwealth Office.

Contact: **Linda Capper MBE** lmca@bas.ac.uk

Artists and Writers Programme

The annual Artists and Writers Programme, sponsored jointly by BAS and the Arts Council for England, takes two people to Antarctica during the Antarctic summer. The 2005–2006 successful applicants were chosen from 43, all of whom had submitted interesting and challenging proposals.

Artist Layla Curtis provided a new perspective on how we understand geographical space by creating rich, multi-layered, multimedia maps linking times and places during her personal journey. Writer Jean McNeill used her background as a travel writer and training as an anthropologist and fiction writer to take on a new writing challenge. Her interest is focused on Antarctica's unique and specific culture.

Contact: **Dr John Shears** jrs@bas.ac.uk

Hitting the headlines

Many people source information about science and technology from newspapers, TV and radio. The BAS press team regularly manage media visits to Cambridge and, during 2005–2006, were in discussion with 13 television documentary producers to develop programmes featuring Antarctic research – principally on climate change.

In January 2006, BBC News science and environment correspondent David Shukman visited Rothera Research Station for a series of special reports. This included the first live TV broadcasts from a BAS research station. Glacialis TV visited Rothera and also Bird Island Research Station for a major Canadian Broadcasting TV documentary series to be screened in 2007.

Exciting scientific results published in peer-reviewed journals are written up as press releases and issued to international science and environment journalists. In April 2005, Alison Cook and Professor David Vaughan revealed that Antarctic glaciers have undergone a widespread retreat over the last 50 years. Worldwide media coverage was generated by this research. Professor Chris Rapley's presentation about 'Antarctica: the awakening giant' at the American Association for the Advancement of Science is another example that reached a global audience.

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Health and Safety

Contact: **Robert Culshaw MVO rocu@bas.ac.uk**

BAS remains fully committed to managing the health and safety (H&S) of its operations and to meeting its legal obligations and duty of care to all its employees both in the UK and the Antarctic.

In the last year we have continued to improve the Safety Management System introduced in 2004.

We have:

- Introduced a revised database to improve our management of risk assessments and procedures
- Revised the accident, incident, near-miss (AINM) reporting system to include environmental incidents and to allow anonymous reports
- Revised our alcohol and drugs policy to meet changed legislation
- Expanded our Safety Management Team in order to improve our liaison with, and management of, collaborative scientists
- Introduced a policy and guidelines for staff about bringing children to work at BAS Cambridge

Our H&S performance is monitored by the BAS Board every month. There is also a programme of unannounced H&S inspections at BAS and once every year an independent external assessor is commissioned for a detailed audit.

We continue to encourage the active involvement of all our staff in H&S, both informally and through the H&S committees convened on all our stations and ships. We held one open meeting during the year, when the Deputy Director introduced staff to the changes to the accident, incident and near-miss (AINM) and risk-management systems. BAS's open approach to H&S means minutes of meetings and summaries of AINM reports are available to all staff via the BAS Intranet.

Images: Above: *Crevasse training near Rothera Research Station, Antarctic Peninsula.* **Top Right:** *BAS personnel department.* **Far Right:** *BAS award-winning IT recruitment advertisement.*

For more information please visit our website: **www.antarctica.ac.uk**

Recruitment and Career Development

Contact: **Fiona Brazil** **fibra@bas.ac.uk**

Introduction

Recruitment for the 2005–2010 BAS science programme, 'Global Science in the Antarctic Context' (GSAC), presented a major challenge to achieve the quality and expertise of staff required, particularly in the physical sciences area.

Working with our advertising partners, Tribal, the Web- and print-based recruitment campaign went global. Visits to our employment Web pages increased from an average of 42,000 to 60,000 a month, and over 1,100 applications were received from around the world. A total of 39 new science and technology staff were recruited, of which nine came from overseas – from New Zealand, Australia, Canada, Germany and France. Excluding the UK, this brings the number of countries represented at BAS to 18, demonstrating the international appeal of our organisation and its science.

INVESTOR IN PEOPLE

BAS was recognised for the effectiveness of its GSAC recruitment campaign in the 2005–2006 Public Sector People Managers Association Recruitment Awards where it won 'Best Recruitment Advertisement in Sustainability/Regeneration/Environment' and 'Best Recruitment Advertisement in IT'. The BAS personnel team also won the award for 'Best HR Practice' in the 2005 Cambridgeshire Recruitment Awards, sponsored by the Recruitment and Employment Confederation. This recognised excellence in recruitment processes, but also highlighted the quality of BAS's staff induction, appraisal and training. In May 2005, we were pleased to receive further acknowledgement of this quality when BAS's Investor in People award was reconfirmed for another three-year period.

BAS Today

Contact: **Linda Capper MBE** lmca@bas.ac.uk

Antarctica is a remote and frozen wilderness, yet it offers a unique opportunity for science that addresses key global issues.

British Antarctic Survey (BAS), part of the Natural Environment Research Council, is a world leader in Antarctic research. Based in Cambridge, BAS is the UK's national Antarctic operator and maintains an active and influential role in Antarctic affairs.

BAS operates five research stations in and around Antarctica (four year-round and one summer-only), has five aircraft and two ice-strengthened ships, RRS *James Clark Ross* and RRS *Ernest Shackleton*. BAS ships and aircraft are equipped with sophisticated technology and a range of specialist equipment, enabling them to carry out scientific research as well as logistical operations.

Each year BAS sends more than 450 staff, collaborators, contractors and visitors to Antarctica to work on over 70 science projects; at sea, on research stations or in the field. The logistics of undertaking science in the Antarctic in a safe and cost-effective way is challenging and complex. Detailed operational planning for each science season starts two years before, and is managed from BAS Cambridge.

BAS science programmes are planned on a five-year timetable. Details of the current programme, Global Science in the Antarctic Context 2005–2010 (GSAC), can be downloaded from the BAS website and are available in hard copy. GSAC makes full use of the BAS Antarctic infrastructure and builds on the successes of previous BAS research, survey and monitoring, while shifting our focus to address key global issues such as climate change. The quality of the programme's content was assured through open competition and by independent, rigorous, international peer review. GSAC involves over 120 national and international collaborations.

To maintain and run self-contained research stations, ships and aircraft, as well as delivering world-class science and technology, our workforce needs an exceptionally wide range of skills. We apply national standards of best practice in selecting our people through open competition, and then in managing and supporting their performance and development. Above all, we aim to build on our skills and expertise in a culture that is open and encourages new ideas. Details of vacancies at BAS are listed on the BAS website.

Images: Above: *BAS field camp near Rothera Research Station, Antarctic Peninsula.* **Right Top:** *Slice of ice core from Dyer Plateau, Antarctic Peninsula.* **Right Bottom:** *BAS field station at Fossil Bluff, Antarctic Peninsula.* **Far Right Top:** *BAS Rigid Inflatable Boat (RIB) operating near Rothera Research Station, Antarctic Peninsula.* **Far Right Bottom:** *Black-browed albatross landing near South Georgia.*

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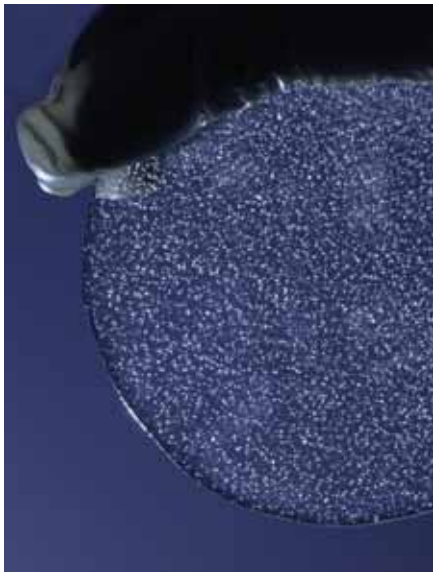


Facts and Figures

UK staff, based at BAS Cambridge

- 196 scientists contributing to the BAS science programme
- 49 scientific support staff including Directorate
- 214 staff in the Administration and Logistics Division, technical, aircrew and ships

Overwintering Antarctic staff

- 21 at Rothera Research Station
- 16 at Halley Research Station
- 9 at King Edward Point Research Station
- 4 at Bird Island Research Station

Ships

- Two complements of 27 crew on RRS *James Clark Ross*
- Two complements of 21 crew on RRS *Ernest Shackleton*
- 66 scientific and technical staff working on RRS *Ernest Shackleton* and RRS *James Clark Ross*
- 178 staff carried to Antarctic destinations on RRS *James Clark Ross* and RRS *Ernest Shackleton*

Summer participants in Antarctic operations

- 148 at Rothera, including those in transit to Halley
- 37 at Halley
- 15 at Signy
- 11 at Bird Island
- 12 at King Edward Point
- 19 contractors at Bird Island and 4 at King Edward Point/Grytviken
- 39 in the field on various projects off HMS *Endurance* and on South Georgia

Antarctic Funding Initiative

- 25 scientists supported

Publications

- 201 peer-reviewed research papers listed in the ISI database of high-quality journals

Education and Training

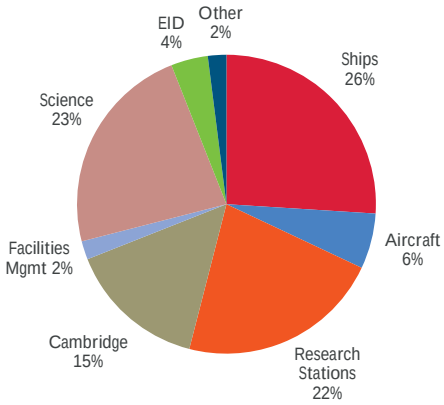
- 54 registered for higher degrees (co-supervised by BAS staff)

Expenditure

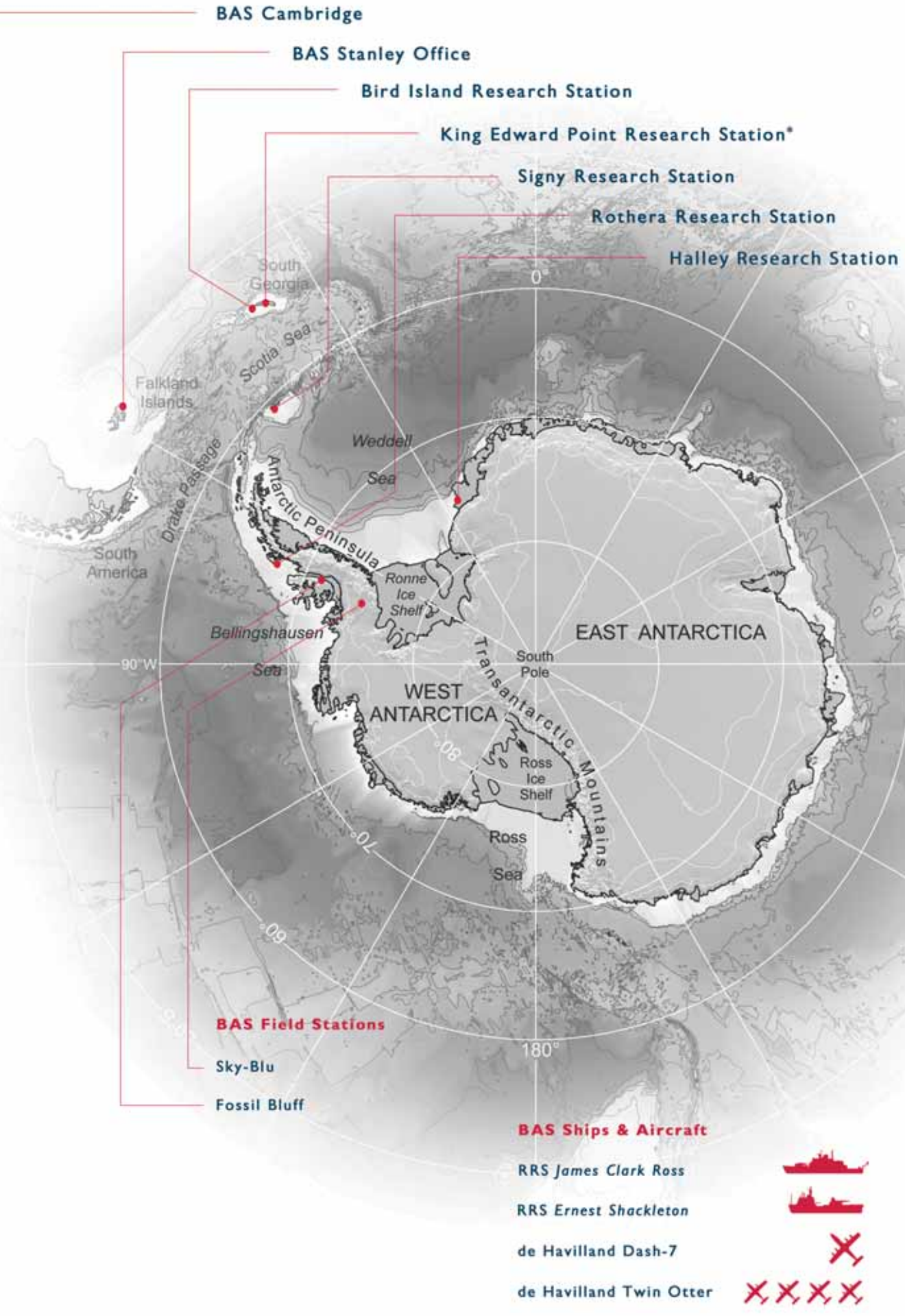
- Total budget 2005–2006: £49 million.

Expenditure

Analysis of Expenditure 2005–2006



BAS Offices and Research Stations



*Run on behalf of the Foreign and Commonwealth Office and the Government of South Georgia and South Sandwich Islands.

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Feedback and further information

We welcome your feedback and comments on this document. These should be addressed to:

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