

Polar Science for Planet Earth

British Antarctic Survey Science Programme



**British
Antarctic Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

**POLAR SCIENCE
FOR PLANET EARTH**

Director's introduction

The polar regions may be at the ends of the Earth but what happens there affects us all.

They are places of compelling beauty, home to some of the world's most charismatic wildlife, and a critical part of the Earth System. Their icy landscapes have fascinated scientists for at least 100 years and buried in their snow, ice, rocks and oceans are secrets that can be unlocked only by scientific investigation.

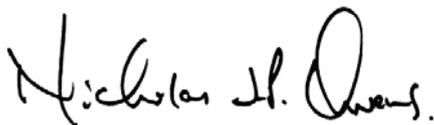
Scientific advances made by the British Antarctic Survey (BAS) have already changed humankind's understanding of planet Earth. Our discovery of the ozone hole drew world attention to the damage caused by chemicals in our atmosphere; we linked the rapid warming on the Antarctic Peninsula to human activity; and revealed the amazing survival story of organisms living in the extreme cold.

There is now overwhelming scientific consensus that human activity is driving climate change. The impact, extent and timescales of change, including sea-level rise and the sustainability of marine resources, are some of the big issues facing society today. Understanding the role that the polar regions play in these issues is a huge scientific challenge, and an urgent priority for society.

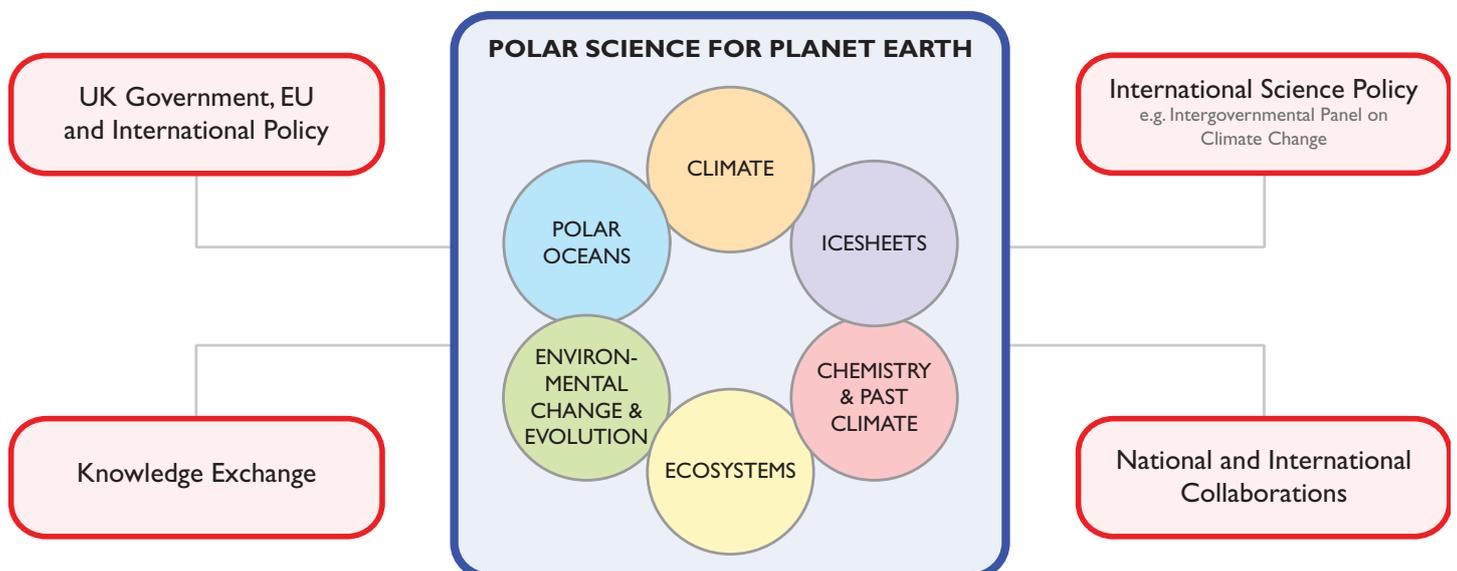
It is this challenge that has defined BAS's new science programme, Polar Science for Planet Earth (PSPE), which is a component of the Natural Environment Research Council strategy, Next Generation Science for Planet Earth. PSPE has restructured BAS science around six themed programmes, which are introduced in the following pages. As well as continuing our world-class research in Antarctica, PSPE expands our science in the Arctic, broadening our understanding of both of the world's polar regions.

The answers we seek are to be found by unlocking the past, understanding the present, predicting the future and exploring the unknown.

This is Polar Science for Planet Earth.



Professor Nicholas Owens
Director, BAS



Chemistry and Past Climate

Science Leader: **Dr Eric Wolff** ewwo@bas.ac.uk

To understand how the Earth and its climate will react to, mitigate, and amplify external changes, we can observe the past and study the present – only then can we predict the future. Important processes in regulating the Earth System take place in or near the polar regions, and the best records for understanding the way the Earth has worked in the past (ice cores) are found there.

The *Chemistry and Past Climate* programme concentrates on the Quaternary period (the last 2.6 million years). Ice-core and other palaeorecords can be analysed for that period. Although many aspects of the Earth were similar to the present, large climate changes, as well as periods warmer than today, can be observed. BAS scientists investigate how different parts of the Earth System interacted to produce the large climate changes that occurred naturally in the past, and complement this with investigations on how changing sea-ice and ocean conditions affect the present chemistry of the polar atmosphere.

Selected programme goals

- To understand what controlled the timing and strengths of the major climate shifts of the last million years and beyond, particularly the shifts from glacials (ice ages) to interglacial warm periods
- To use the warmest periods of the last million years to tell us about the likely response of the polar regions to future climate change
- To determine how sea ice responded to past climate change and assess how this fed back into atmospheric chemistry and ocean circulation
- To produce detailed records of climate change in the Antarctic Peninsula region over the last 2,000 years

Climate

Science Leader: **Dr John King** jcki@bas.ac.uk

The polar regions exert controls on global sea level, the carbon cycle, and atmospheric and ocean circulation. The climate of the polar regions is controlled by complex interactions between the Sun, the atmosphere, ocean and sea ice, making accurate prediction of regional climate a formidable challenge. Predicting how polar climate may change is therefore an essential part of understanding the global climate system.

The *Climate* programme uses observations from both polar regions to improve our understanding of how natural and human-induced factors contribute to climate change.

Selected programme goals

- To explain changes in atmospheric circulation, temperatures and sea-ice extent in both polar regions over the past 50 years and to determine how much of this change is due to human activity and how much is a result of natural factors (including solar variability)
- To improve the representation of polar climate processes in large-scale models, using targeted observations
- To improve climate predictions in the polar regions on the space and timescales needed by the international scientific community (including glaciologists, oceanographers and biologists)
- To maintain a programme of high-quality, long-term observations in the Antarctic using instruments at BAS research stations and remote field sites



Images: **Top:** A slice of ice core from Berkner Island, depth 120m. Trapped air bubbles – an archive of the past atmosphere – are visible in the ice. **Bottom:** The launch of a radiosonde weather balloon at Halley Research Station.



Ecosystems

Science Leader: **Prof Eugene Murphy** ejmu@bas.ac.uk

Polar ecosystems have global ecological and economic importance. They have unique biodiversity, play a major role in climate processes, and support indigenous communities and commercial fisheries. Polar ecosystems have adapted to cold and highly seasonal conditions, making them sensitive to climate and human impacts. Recent global, climate-driven changes, combined with expanding commercial fishing, threaten the balance of these unique marine and terrestrial ecosystems. By understanding their response, we can use them as a warning system for climate change across the planet.

The *Ecosystems* programme undertakes integrated analyses of Antarctic ecosystems and develops understanding of the large-scale operation of Arctic ecosystems and the role of polar ecosystems in the Earth System.

Selected programme goals

- To understand what determines the ability of species to adapt to change through genetic, physiological and ecological processes across a range of marine and terrestrial ecosystems
- To develop quantitative descriptions of the life-cycles of species to determine their likely response to environmental change
- To determine the resilience of polar ecosystems to past and current climate change to predict how they may respond in the future
- To provide data and policy advice on key species and whole ecosystems to underpin further development of sustainable fisheries management in the Antarctic and beyond – fulfilling UK obligations under the Antarctic Treaty

Environmental Change and Evolution

Science Leader: **Dr Alistair Crame** jacr@bas.ac.uk

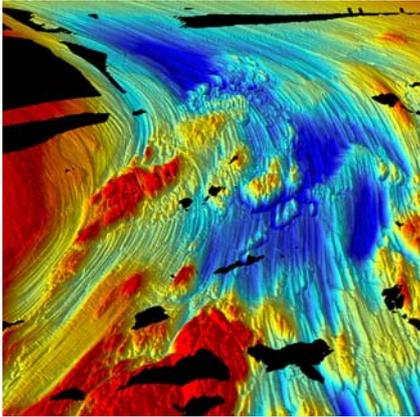
Earth's environment and life are an integrated system of many parts. These interactions show complex behaviour on all scales from minutes to millennia, rocks to continents and genomes to communities. We need to understand this behaviour in order to make better predictions of future environmental changes.

The *Environmental Change and Evolution* programme addresses key aspects in the polar regions of geological and ice-sheet structure, marine and terrestrial biodiversity, and natural complexity, that influence the unique role of the polar regions in environmental change and evolution.

Selected programme goals

- To apply and develop appropriate mathematical methods and models for analysing complex natural systems
- To explain how evolutionary and past processes formed present polar biogeography and biodiversity
- To determine continental structure beneath ice sheets and assess how it controls ice-sheet evolution and behaviour
- To survey poorly-known areas underneath the polar ice sheets, in the deep sea, and at the edge of the atmosphere, and compile geological, geophysical and satellite-derived data to generate digital maps of key areas of British Antarctic Territory





Images: Top: Swath bathymetric image of the seafloor in the western Amundsen Sea, showing landforms generated beneath former ice streams. **Bottom:** A CTD (conductivity-temperature-depth) device is retrieved from the Southern Ocean onboard RRS James Clark Ross.

IceSheets

Science Leader: **Prof David Vaughan** dgv@bas.ac.uk

The loss of ice from ice sheets in Antarctica and Greenland is a major source of current sea-level rise, and one that is accelerating rapidly. A report from the Intergovernmental Panel on Climate Change (2007) highlighted that the greatest uncertainty in projections of future sea-level rise is due to a lack of knowledge about ice sheets. Improved understanding of key ice-sheet processes is urgently required to allow reliable predictions of future sea-level change.

The *IceSheets* programme examines the role of ice sheets in the Earth System, and the processes that control ice-sheet change. It monitors current change and sets this in context with the past. BAS scientists produce tools to predict how ice sheets will change over time, allowing more accurate projections for increases in global sea level.

Selected programme goals

- To improve understanding of the ocean-atmosphere and bed interactions controlling ice-sheet flow and ice-sheet evolution
- To build and apply a robust mathematical and numerical framework for computer simulation of ice-sheet change and sea-level rise
- To determine current glacial change in the critical areas of the polar ice sheets
- To establish improved histories of ice-sheet change to provide context and constraint for future projections

Polar Oceans

Science Leader: **Dr Mike Meredith** mmm@bas.ac.uk

Global ocean circulation is one of the few mechanisms by which polar processes can directly influence the whole Earth System, including the UK, and possibly on timescales as short as decades. Its importance results from the enormous capacity of the ocean to store and redistribute heat, fresh water, carbon dioxide and other climatically-important substances. The polar regions are disproportionately important in determining the strength and shape of global ocean circulation.

The *Polar Oceans* programme investigates the role of processes and changes both in the shelf sea and in open-ocean environments, and will further our understanding of polar control of the Earth System.

Selected programme goals

- To explain the processes that drive and close the overturning circulation in the Southern Ocean
- To determine the impact of, and the feedback between, the ocean and ice shelves
- To understand the physical drivers of changes in the marine environment, and the likely implications for climate
- To determine the impacts that changes in the polar regions have on the Earth System via ocean circulation

BAS VISION

By 2020 the British Antarctic Survey will be recognised as a world-leading centre for polar research and expertise, addressing issues of global importance.

DELIVERING PSPE

Science delivery

To address questions of global scientific importance, PSPE will collect new data from land, ice, sea and air using state-of-the-art drilling, satellite, surveying, monitoring, fieldwork and laboratory technology. These will be used to develop new, and enhance existing, computer models. New technologies will be pioneered.

Long-term monitoring and survey

Long-term, quality-controlled and uninterrupted data records are essential to determine both long-term trends and variability in the Earth System. PSPE will maintain existing long-term datasets and build on BAS's strong tradition of making such observations.

Data collection and curation

Data are collected from our research stations, aircraft, ships and field parties, and from autonomous vehicles and instrument platforms. Satellite data is increasingly important for polar science, providing a broad context for more detailed measurements. BAS makes its data available to national and international scientists, as well as operational organisations (e.g. the UK Met Office) in near-real time, together with archiving data and samples.

National capability

BAS, part of the UK Natural Environment Research Council (NERC), 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 specialist equipment, enabling them to carry out scientific research as well as logistical operations.

Each year BAS sends more than 350 staff, collaborators, contractors and visitors to Antarctica to work on science projects at sea, on research stations or in the field.

PARTNERSHIPS

BAS scientists alone cannot answer all of the important polar science questions. Collaborations with other NERC research centres, the wider UK environmental science community and international centres of excellence give us a wider perspective. Co-ordination of field activities with international partners helps maximise the scientific return.



INVESTOR IN PEOPLE

Image: RRS Ernest Shackleton steams north through a freezing sea after resupplying Halley Research Station on the Brunt Ice Shelf, Antarctica.

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



KNOWLEDGE

BAS supports fully the sharing and flow of knowledge, people, skills and expertise both nationally and internationally. PSPE exploits commercialisation opportunities for the wider benefit of the economy and provides evidence to support Government policy-making.

Science in society

BAS is committed to explaining its science and operations to as wide an audience as possible. Media relations, publications, events, exhibitions, educational resources, the Internet and a public information service are BAS's main means of achieving engagement with people of all ages and from all sectors of society.

PEOPLE

The success of PSPE depends on the skills, quality, commitment and attitude of everyone who works for BAS. BAS aspires to develop its staff continuously and promote adaptability, flexibility and inter-disciplinary teamwork. BAS has been accredited with the industry-standard *Investors in People* (IIP) award. Despite working in some of the world's most challenging areas, BAS delivers its science using the best health and safety practice.

PROTECTING THE ENVIRONMENT

BAS operates in the world's last great wilderness areas. To preserve such an exceptional environment it is crucial to measure, understand and minimise the effects of our presence. BAS is committed to delivering PSPE with the minimum environmental impact through the use of an Environmental Management System (certified to ISO 14001 standard). All of our activities continue to comply with the requirements of the Protocol on Environmental Protection to the Antarctic Treaty.

Feedback and further information

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

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BAS OFFICES AND STATIONS

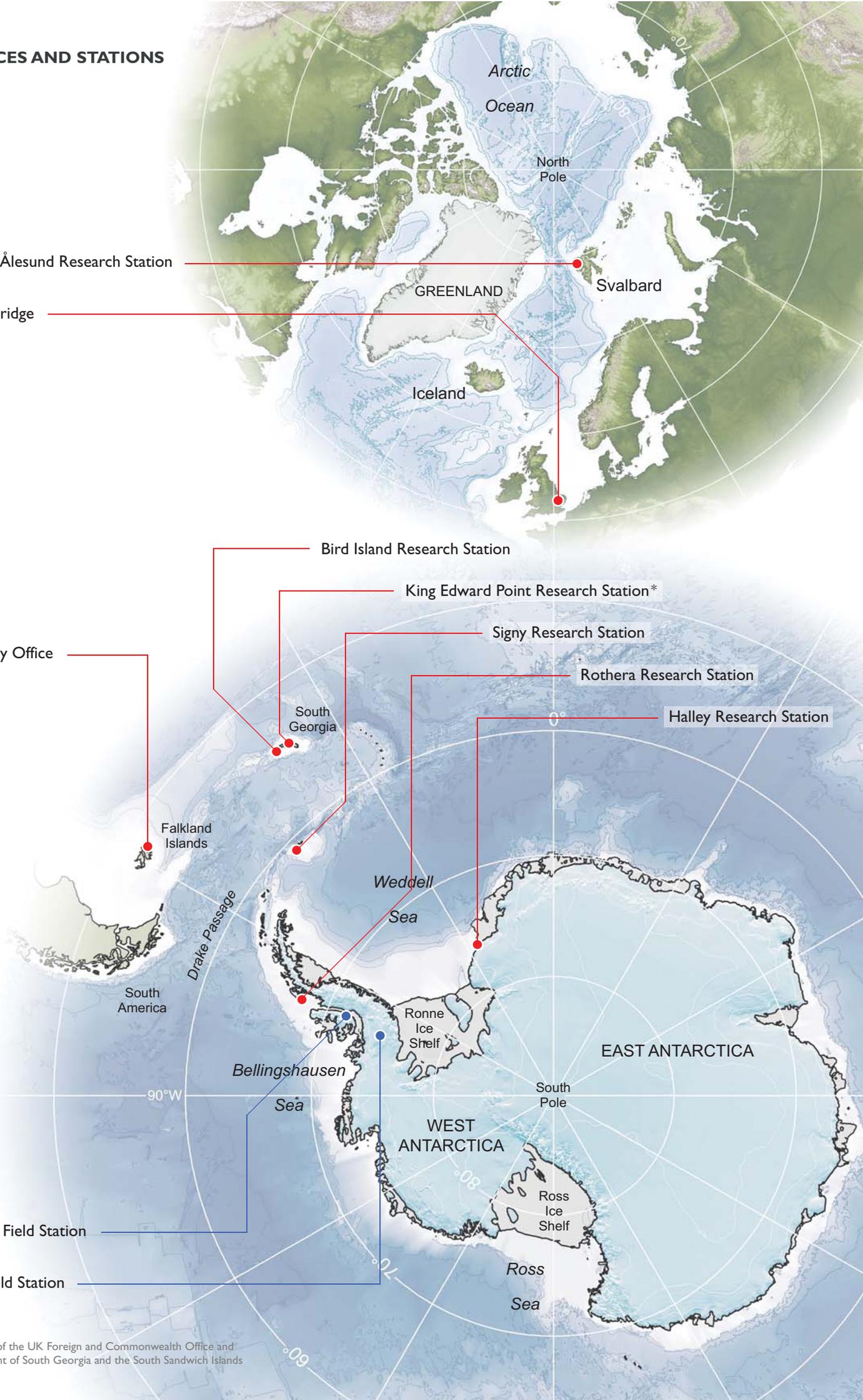
NERC Ny Ålesund Research Station

BAS Cambridge

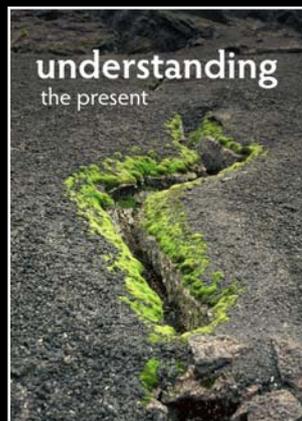
BAS Stanley Office

Fossil Bluff Field Station

Sky-Blu Field Station



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



British Antarctic Survey (BAS), a component of the Natural Environment Research Council, delivers world-leading, interdisciplinary research in the polar regions. Its skilled science and support staff based in Cambridge, Antarctica and the Arctic, work together to deliver research that underpins a productive economy and contributes to a sustainable world. Its numerous national and international collaborations, leadership role in Antarctic affairs and excellent infrastructure help ensure that the UK maintains a world-leading position. BAS has over 450 staff and operates five research stations, two Royal Research Ships and five aircraft in and around Antarctica.

www.antarctica.ac.uk



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