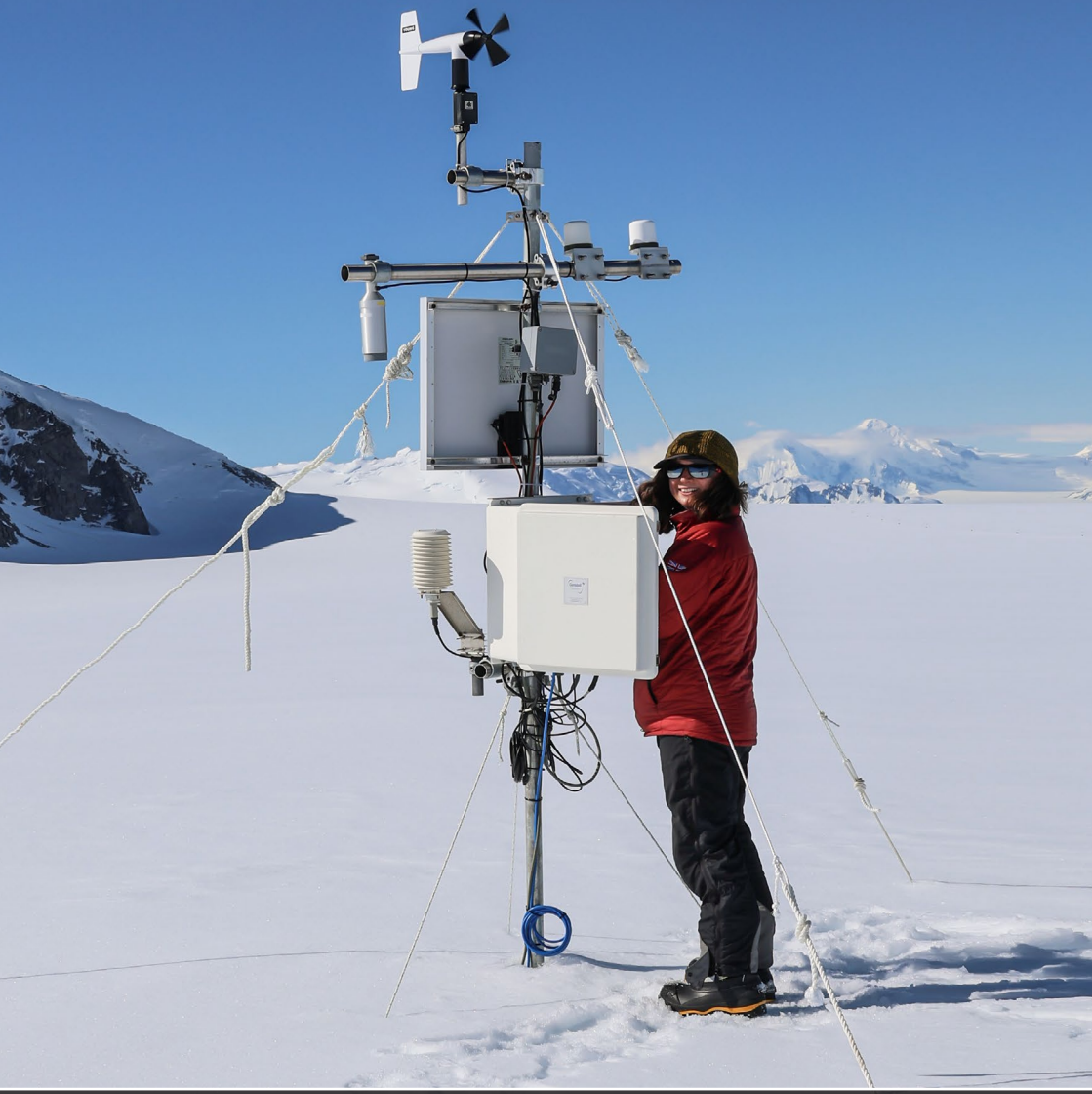
BAS Science Summaries

2024-2025 Antarctic field season



British Antarctic Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE

FOR A SUSTAINABLE PLANET

Contents

Cover: *Servicing an Automatic Weather Station near Rothera Research Station, Antarctic Peninsula*

BAS Science Summaries

2024-2025 Antarctic field season

Introduction

This booklet contains summaries of all the field, station, and ship-based science projects that the British Antarctic Survey (BAS) is supporting during the 2024-25 Antarctic field season. Once again, there is some ambitious and important science being done in Antarctica this season; a whole range of projects of different levels of scale and complexity. It's a key part of the new BAS science strategy *Polar Science for a Sustainable Planet*.

▲ *Professor Dominic Hodgson*
Interim Director of Science

BAS excels in delivering field support for big science projects that address the most urgent questions facing society. Many of these projects will ultimately provide information needed by policy-makers and are of the highest societal importance. These large projects are delivered through collaborations involving multiple partners, either UK-only or including international scientists. Here are some of the highlight projects that will be delivered this season.

BIOPOLE (Biogeochemical processes and ecosystem function in changing polar systems and their global impacts) is a major five-year project, involving five Natural Environment Research Council (NERC) research centres as well as UK and international partners, to research nutrient supply and ecosystem processes at both poles. Important nutrients in the global oceans are found at higher abundance in the Polar Regions than elsewhere, partly because there are sources that are unique to the poles (including glaciers and sea ice), but also because the way the polar ecosystems behave is different to that of other regions. But rapid climatic change at the poles is potentially changing the supply of nutrients and the processing capacity of its ecosystems. This threatens not only the marine food stocks on which humanity depends but biological drawdown of carbon into the oceans that helps regulate atmospheric carbon dioxide. Our ability to fully characterise and predict this threat is limited by inadequate representation of polar biogeochemical and ecosystem processes in Earth System Models (ESMs). BIOPOLE will make new measurements that will improve these critical models to help predict the future of this important system. In the 2024-25 season, important measurements will be made onboard RRS *Sir David Attenborough*, the UK's polar research vessel. You can read more about BIOPOLE on pages 11 and 12.

continued ▷

Introduction continued

The **Southern Ocean Clouds** project, or SOC, focusses on understanding high-latitude mixed-phase clouds and to improve the way that they are represented in climate models. Although it's known that clouds have a significant influence on global climate there remains considerable uncertainty in many cloud processes. For the Southern Hemisphere, this uncertainty means that models cannot simulate some fundamental climate features which hinders their ability to make predictions of the long-term climate. There is evidence that the problem lies in the way that mixed phase (water and ice) clouds are described in the models. The Southern Ocean Clouds project will operate over a number of seasons and from a number of platforms (land, ship, aircraft). It will gather important data to improve the representation of clouds in models, and hence the model's ability to carry out southern hemisphere climate studies. In 2024-25, long-term measurements will be collected from East Beach Hut at Rothera Research Station, from RRS *Sir David Attenborough* and by a flying campaign based out of Rothera. This will take place simultaneously and investigate the microphysical properties of the clouds in the airmasses that have passed close to the ship or to East Beach Hut. SOC is one of five projects that make up the NERC-funded strategic programme 'The Uncertainty in Climate Sensitivity due to Clouds' – more about SOC can be found on pages 13 and 14.

RIFT-TIP (Rates of Ice Fracture and Timing of Tabular Iceberg Production) builds on the many years of 'Lifetime of Halley' data and experience on the Brunt Ice Shelf. It seeks to explain what controls the propagation of cracks in ice shelves and in particular the timing of rift growth. The project combines field measurements and samples, satellite observations, and a new numerical model of ice fracture. In the 2024-25 field season, the project will conduct a detailed geophysical study of ice properties and fracture behaviour around the active crack tip at the eastern end of Halloween Crack (named after being detected on 31 October). This will involve ground-penetrating radar surveys, GPS and laser measurements of crack width, and deployment of surface seismometers. Fibre-optic seismic sensing (DAS) will be used to understand the location and magnitude of fracture events at high vertical resolution. Four ice cores will also be drilled near the crack and brought back to Cambridge to more closely investigate the impact of local stress concentration on ice-crystal fabric and toughness. The ultimate aim is to understand enough about the ice near Halley so that projections of other ice shelves should become possible. RIFT-TIP is funded through NERC Pushing the Frontiers scheme – you can read more about RIFT-TIP on page 15.

A team will head to King George Island to explore the **past, present and future of unique cold-water benthic ecosystems in the Southern Ocean**. We aim to understand how Southern Ocean seafloor communities have evolved, what maintains the biodiversity and stability of these communities today, and how human influences such as climate change will affect communities in the future. This project is novel as it includes data on southern hemisphere seafloor communities from a long timeframe, from about 54 million years ago to the present day. Biodiversity loss and extinction are key issues today, around one million animal and plant species are now threatened with extinction, many within decades. The Southern

continued ▷

Introduction continued

Ocean is the fourth biggest ocean on the planet, and the most pristine in relation to the rest of the world. Seafloor communities here are vulnerable and deemed to be at a high risk from modern environmental change. We need to understand the stability of these communities, and how they formed, to be able to protect them from increasing human influence such as tourism, fishing and climate change. We are interested in the interactions between seafloor animals, and between the animals and their environment. Specifically, this field season on King George Island will study rocks that were deposited under the earliest glacial conditions of the Cenozoic. We will be looking for links between environment and community composition. This will help inform us of what predator and prey interactions there are, and the environmental conditions that led to the evolution of Antarctica's unique seafloor community. You can read more about the project on page 16.

As well as the projects highlighted above, it's important to recognise some of the long-term measurements that are again being supported this season. Sustained observations are incredibly important. They provide the long-term context for short-term changes (for example, they can show whether short-term changes are unusual or not), and it is only with some long datasets that we can understand features of the environment that take decades to appear. There are long-term observations being carried out at Rothera, Halley, and at really remote sites such as the Amundsen Sea Embayment (West Antarctica). We are fortunate that BAS science activities can support the capture of these critically important data.

Plans for the 2024-25 season are, as always, challenging and ambitious. A fascinating suite of projects is planned, covering all sorts of different science. I hope you enjoy reading more about them in this booklet.

I wish everyone involved a successful and safe 2024-25 field season.

Professor Dominic Hodgson

Interim Director of Science, BAS
September 2024

List of science projects

Highlight projects

Field-based projects

continued ▷

List of science projects *continued*

Field-based projects continued

Sledge	Project title ***Location***	Page
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Rothera Research Station

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Halley VI Research Station

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List of science projects *continued*

Halley VI Research Station continued

Bird Island Research Station

King Edward Point Research Station

Signy Research Station

List of science projects *continued*

RRS Sir David Attenborough

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Multiple locations

Project title	Page
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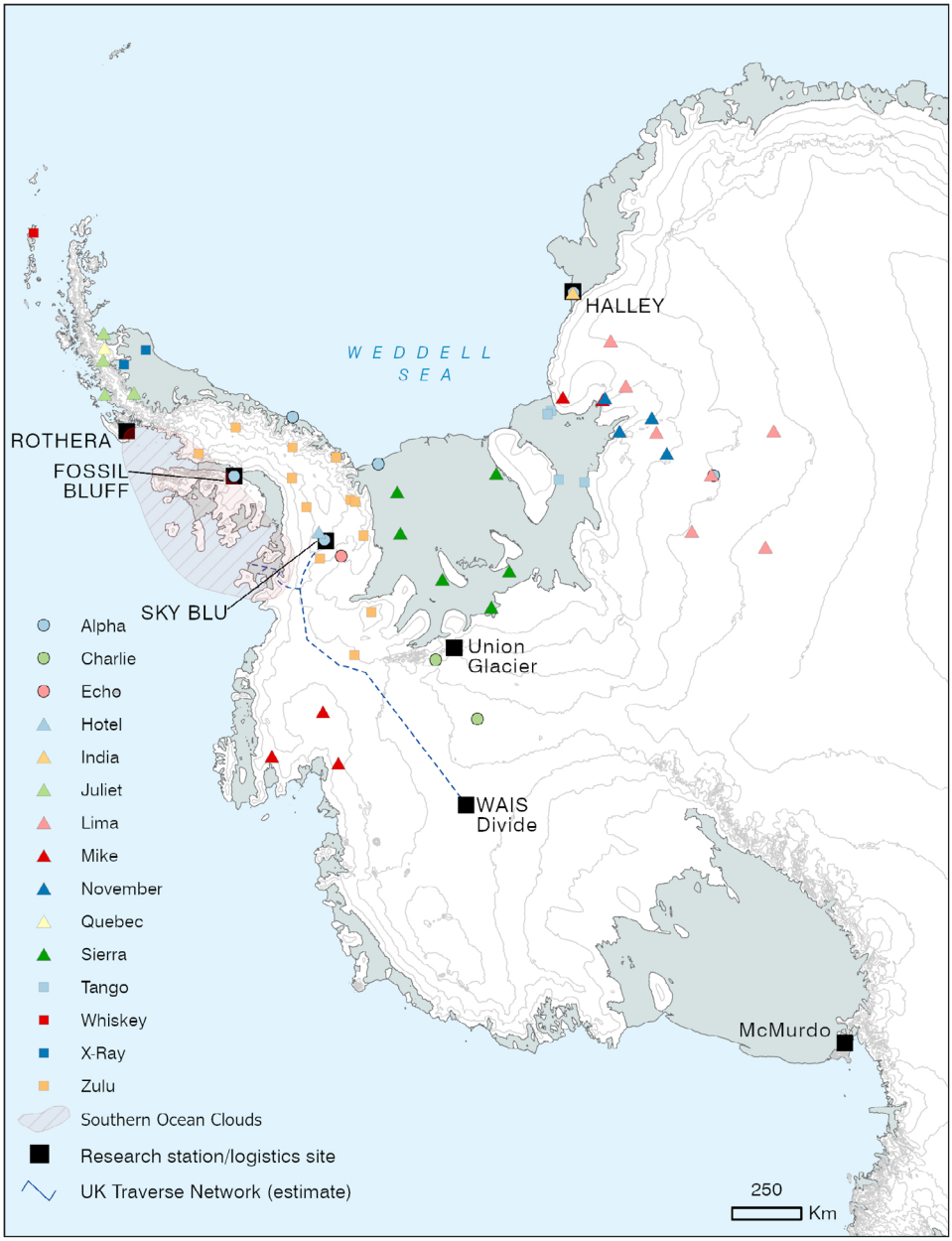
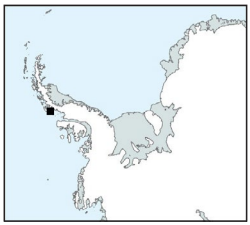
Map of field-based project locations

2024-2025 Antarctic field season



Highlight project

Biogeochemical processes and ecosystem function in changing polar systems and their global impacts (BIOPOLE) – Rothera



Location: Ryder Bay, Rothera

Timing: December 2024 to January 2025

More information: *https://biopole.ac.uk*

BIOPOLE will address a fundamental aspect of the Earth System – how nutrients in polar waters drive the global carbon cycle and primary productivity. The oceans play a vital role in absorbing atmospheric CO_2, mitigating large amounts of man-made carbon emissions. However, this part of the global carbon cycle relies on an adequate supply of nutrients to drive the carbon-absorbing marine biological processes. Much of these nutrients are exported from the Polar Regions. BIOPOLE will improve our ability to quantify this export and identify its sensitivity to climate change.

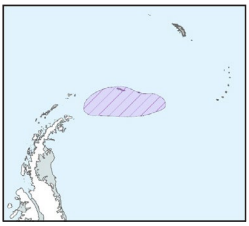
BIOPOLE will combine data collection, novel analyses and computer simulations to radically improve our ability to measure, understand and predict how nutrient supply and ecosystem processing in the Polar Regions will be affected by climate change. One of our key objectives is to assess the nutrient sources of major inputs from land, sea ice and oceans and provide information on the key transformation processes that determine their eventual inputs to open-ocean ecosystems. Field observations and laboratory analyses will be used alongside satellite data, historical data (both observational and modelled) and projected changes in inputs, to gain insight into future impacts on supply to marine ecosystems.

We will carry out work in Ryder Bay from Rothera Research Station in austral summer 2024-25, including two different types of sampling: firstly, we will sample from freshwater streams/inputs into Ryder Bay for dissolved and particulate constituents, and, secondly, we will work with the Rothera Oceanographic Time Series project to collect more oceanographic data and samples from sites within Ryder Bay.

▲ *Sampling in rivers as part of the BIOPOLE project*

Highlight project

BIOPOLE II – SDA



Location: Weddell-Scotia Confluence following Scotia Ridge

Timing: February to March 2024

BIOPOLE is undertaking an ambitious programme of research in both Polar Regions to understand the role that both poles play in determining the chemical balance of the oceans. It is this balance that facilitates the productivity of all marine life and their role in storing carbon and regulating climate. As part of BIOPOLE II, we will use RRS *Sir David Attenborough* to help us address three fundamental questions 1. What are the key sources and flows of nutrients (primarily nitrogen and phosphorous) from glaciers, rivers, sea ice, and ocean upwelling processes into the polar oceans? 2. How do polar marine ecosystems, including microorganisms and small zooplankton called copepods, process and store carbon and nutrients and 3. How are carbon and nutrients exported to the rest of the world's oceans and what are their impacts on marine primary productivity and fisheries in the mid latitudes?

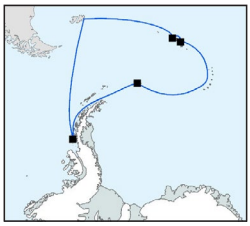
The cruise will cover large areas of the Scotia and Weddell Seas, and enter the marginal ice zone, to sample across a range of environments with different levels of biological productivity. We will have a multi-institute, multinational team studying the physical oceanography, biogeochemistry, nutrients and ecosystems biodiversity structure. There will also be sampling of phytoplankton, zooplankton and benthic organisms to consider their body condition, life-cycles, trophic interactions and distribution.

▲ *Sampling with a mammoth net*

▲ *Sorting a benthic catch*

Highlight project

Southern Ocean Clouds (SOC) – SDA



Location: Southern Ocean (Falkland Islands-Rothera-Weddell Sea-Signy-South Sandwich Islands-King Edward Point-Bird Island-Falkland Islands)

Timing: November to December 2024

The Southern Ocean is an area where biases in climate model representations of surface radiation and sea-surface temperature are larger than anywhere else on Earth.

These biases limit the ability of these models to simulate global climate, and therefore predict future changes correctly. There is evidence that they are caused by the models not simulating mixed-phase clouds (i.e. clouds formed of droplets and ice crystals) over the high latitudes of the Southern Ocean correctly. The processes leading to the formation of these clouds are the topic of the Southern Ocean Clouds (SOC) project. The cruise happens alongside long-term ground-based measurements at Rothera and an airborne campaign with the MASIN Twin Otter.

During the cruise we will measure aerosol numbers, composition and size and will identify how many particles act as ice nucleating or cloud condensation particles. We will look at such particles in precipitation, surface snow, and sea water. We will use a variety of techniques to identify the composition of the aerosols and the precursor gases that contribute to the formation of aerosol particles. Experiments with bubble chambers will investigate the transport of particles from the sea into the atmosphere. Finally, we will collect samples of soil, mosses, and lichen for later analysis for their ice nucleating potential.

▲ *Characterisation of ice nucleating particles by collaborators from the University of Leeds*

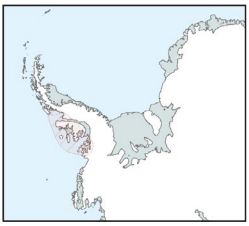
▲ *The inside of the BAS Aerosol Lab container*

Highlight project

Southern Ocean Clouds (SOC) – Rothera

Location: East Beach Hut, Rothera Research Station

Timing: December 2024 to January 2025

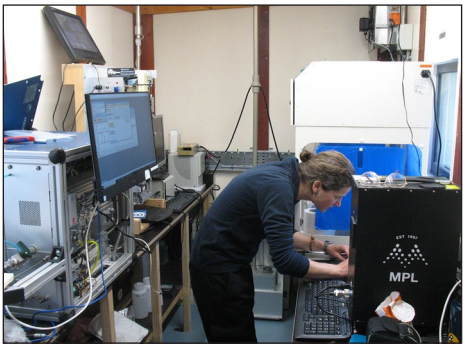


The overall objective of this project is to address the climate model cloud bias over the Southern Ocean and coastal Antarctic regions, thus evaluating the impact that clouds representative of the region may have on the surface radiation balance, surface mass balance, and the global climate.

From East Beach Hut we now have a three-year record of aerosol size and composition as well as measurements of aerosol precursor gases such as DMS and information on cloud type and habit from the micropulse lidar. These measurements will be a high priority during the period that SOC cruise is close to Rothera and when the associated flying campaign is taking place.

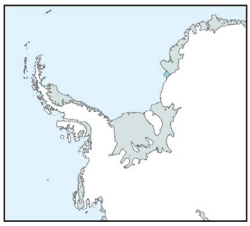
As well as the SOC cruise and the long-term measurements from East Beach Hut, we will have a flying campaign based out of Rothera this year. This will take place at the same time as the SOC cruise and will investigate the microphysical properties of the clouds in the airmasses that have passed close to the ship or to East Beach Hut. This will enable us to correlate the aerosol properties observed close to the ground with cloud microphysical properties.

▲ *The Rothera Clean Air facility at East Beach was built in the 2021-22 season and will be measuring cloud and aerosol properties for at least four years*



▲ *The inside of the hut is full of instruments to measure the physical and chemical properties of aerosol as well as their cloud-forming ability*

Highlight project



Rates of Ice Fracture and Timing of Tabular Iceberg Production (RIFT-TIP)

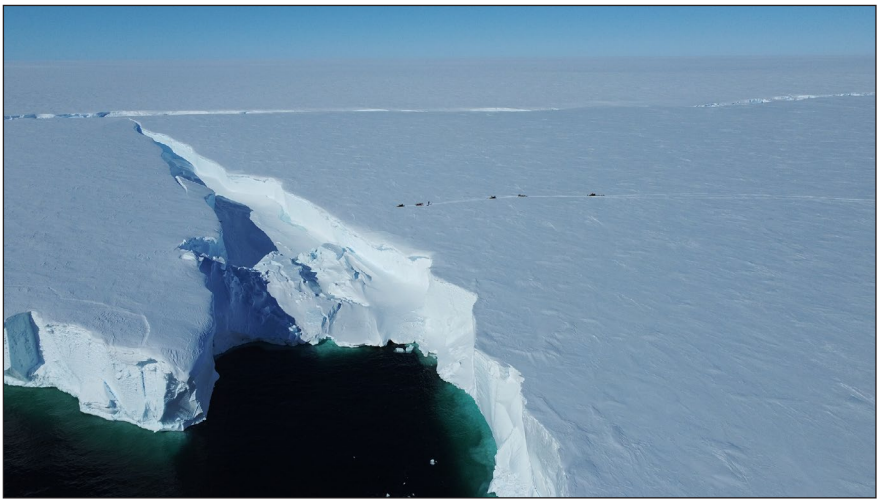
Location: Halley VI Research Station

Timing: December 2024 to February 2025

More information: *https://www.bas.ac.uk/project/rift-tip*

The RIFT-TIP project will investigate physical controls on crack propagation in ice shelves, in particular the timing of rift growth. Rifts lead to iceberg calving which can influence overall ice-shelf stability and the rate of sea-level rise. We will combine field and satellite observations of fracture on the Brunt Ice Shelf with laboratory failure tests using a new phase-field fracture model (KRAKEN). Alongside new observations, we will leverage data collected over the last decade within the Lifetime of Halley programme to tune the model, including from the calving of icebergs A-81 and A-83 in January 2023 and May 2024.

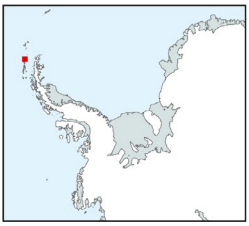
In the 2024-25 season, the project will conduct a detailed geophysical study of ice properties and fracture behaviour around the active crack tip at the eastern end of Halloween Crack. This will involve ground-penetrating radar surveys, GPS and laser measurements of crack width, and deployment of surface seismometers. Fibre-optic seismic sensing (DAS) will be used to understand the location and magnitude of fracture events at high vertical resolution. Four ice cores will also be drilled near the crack and brought back to Cambridge to more closely investigate the impact of local stress concentration on ice crystal fabric and toughness.



▲ *Intersecting rifts on the Brunt Ice Shelf*

Highlight project

The past, present and future of unique cold-water benthic ecosystems in the Southern Ocean



Location: Lion's Rump, King George Island

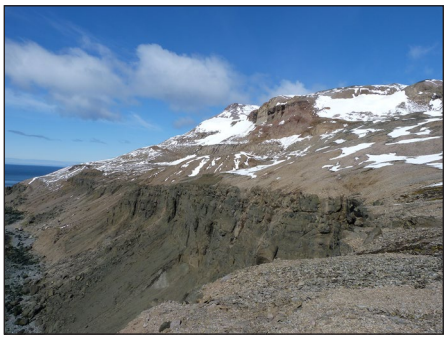
Timing: December 2024 to January 2025

We aim to understand how Southern Ocean seafloor communities have evolved, what maintains the biodiversity and stability of these communities today, and how human influences such as climate change will affect communities in the future.

This project is novel as it includes data on Southern Hemisphere seafloor communities from a long timeframe, from about 54 million years ago to the present day. Biodiversity loss and extinction are key issues today, around 1 million animal and plant species are now threatened with extinction, many within decades. We rely on these natural resources for survival (e.g. food) and leisure (e.g. tourism). Around 66% of marine environments have been significantly altered by human actions.

The Southern Ocean is the fourth biggest ocean on the planet, and the most pristine in relation to the rest of the world. Seafloor communities here are vulnerable, deemed to be at a high risk from modern environmental change. We need to understand the stability of these communities, and how they formed, to be able to protect them from increasing human influence such as tourism, fishing and climate change.

We are interested in the interactions between seafloor animals, and between the animals and their environment. Specifically, this field season on King George Island will study rocks that were deposited under the earliest glacial conditions of the Cenozoic. We will be looking for links between environment and community composition. This will help inform us of what predator and prey interactions there are, and the environmental conditions that led to the evolution of Antarctica's unique seafloor community. This research will give insights into how disturbances such as rapid climate change can alter biodiversity. For example: at what temperature in the past do we see the ecosystem structure change to what we find on modern Southern Ocean seafloors? If climate change causes temperatures to rise higher than this, it is likely to restructure the community?

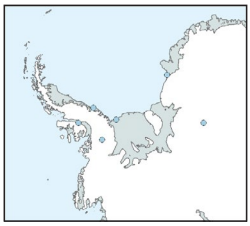


▲ *The Polonez Cove Formation – ~25 million-year-old glacial sea-floor sediments*

▲ *Camp on King George Island in 2019*

Field-based project (Sledge Alpha)

Annual Antarctic Automatic Weather Station servicing



Location: Various locations (Sky-Blu, Fossil Bluff, Butler Island, Ronne Ice Shelf, Halley, Baldrick)

Timing: Ongoing

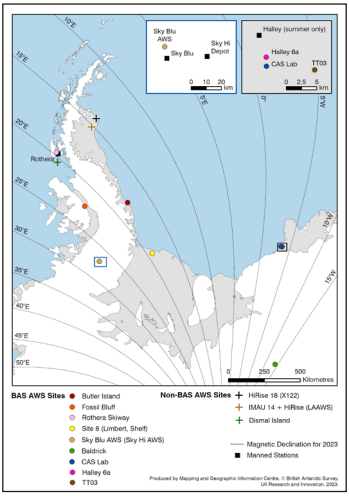
More information: *https://bas.ac.uk/project/meteorology-and-ozone-monitoring/#about*

BAS runs a network of eight Automatic Weather Stations (AWS) on the Antarctic Peninsula and in the Halley region. They are Fossil Bluff, Butler Island, Sky-Blu, Site 8, Baldrick, Halley VIa, CASLab and TT03. The BAS AWS are part of an international network of over 100 stations covering Antarctica.

The BAS Met Team collaborates with scientists from all over the world to ensure the best possible coverage of Antarctica to meet the needs of the scientific and forecasting communities. In addition, BAS services stations for the Universities of Utrecht and Wisconsin. Data is sent via satellite link to meteorological offices around the world so that it can be used immediately for weather forecasting. As well as being vital for forecasting, the data from these stations is the very data that has provided scientists with the incredible climate statistics of the last five decades. It is essential that we visit the stations as regularly as possible to ensure that this invaluable data continues to be recorded.

Every year the Rothera Met Team visits the Peninsula sites, while the Halley Met Team visit the Halley sites and Baldrick. A site visit involves collecting high resolution data from the last year, raising the instruments and power systems above the previous year's snow accumulation, and carrying out necessary repairs and updates. A station service can typically take up to six hours. This project will be supported out of Rothera and Halley.

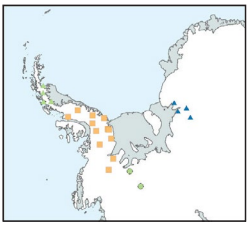
▲ *Servicing Butler Island Automatic Weather Station*



▲ *Map of BAS AWS network*

Field-based project (Sledges Charlie, Juliet, November and Zulu)

Quantifying West Antarctic mantle viscosity via precise GPS measurement of Earth's response to surface mass balance anomalies (UKANET project)



Location: Throughout West Antarctica

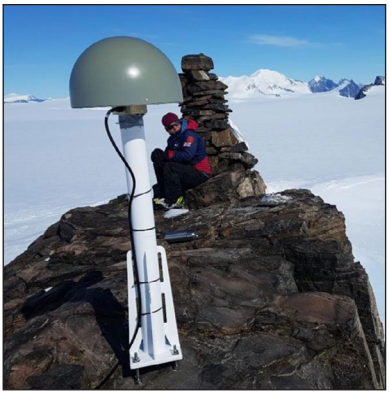
Timing: Opportunistic throughout the season (multi-seasonal)

More information: *https://ukanet.wixsite.com/ukanet*

Satellite measurements of ice-sheet change provide insight into current and future sea-level rise, but they are complicated by a phenomenon known as Glacial Isostatic Adjustment (GIA). GIA is the ongoing response of the solid Earth to past ice-sheet change such as melting of ice. This is the same phenomenon whereby many people are aware that Scotland, for example, is still rising slowly after the ice age.

GIA can be measured wherever we have access to bedrock, but due to the lack of outcrops across much of Antarctica, spatial variations in GIA are poorly known and we are forced to rely on mathematical models to interpret the satellite data. These models are calibrated and validated using precise measurements of Earth deformation made by continuous GPS receivers sited on bedrock. This project is concerned with installing and maintaining those receivers across West Antarctica in a network known as UKANET. These measurements also allow us to work out the rheology of the solid Earth (how it behaves when an ice load is applied). We are pioneering a new approach to determining spatially-variable rheology that involves analysing the GPS-measured response of the solid Earth to natural snowfall variations across Antarctica.

▲ *Preparing to upgrade the instruments and power supply at Welch Mountains, Antarctic Peninsula*



▲ *GPS monument and antenna at Traverse Mountains, Antarctic Peninsula*

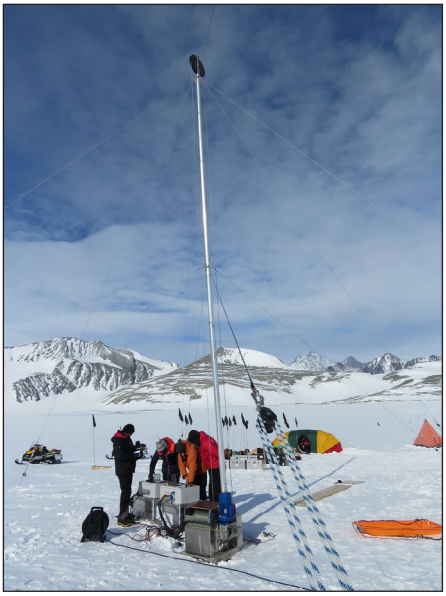
Field-based project (Sledge Echo)

Interglacial collapse of the West Antarctic Ice Sheet revealed by subglacial drilling (INCISED)

Location: Behrendt Mountains, near Sky-Blu

Timing: November 2024 to January 2025

This is year three of a multi-year drilling project. The aim is to test the hypothesis that the West Antarctic Ice Sheet (WAIS) has collapsed, perhaps multiple times, in past interglacial periods. This will be done by retrieving rock cores from bedrock located beneath the ice sheet and analysing this rock for cosmogenic isotopes that are only produced when the rock has been exposed to the atmosphere. Using a combination of innovative drilling technology, sophisticated chemical analysis and computer modelling we will show if, when, and how often the WAIS has collapsed during warmer periods in the past, and provide estimates of the sea-level contribution each time. The work in Behrendt Mountains will be to retrieve a first transect of drill cores that will tell us if and when the WAIS collapsed in the area between the Weddell Sea and Amundsen Sea.

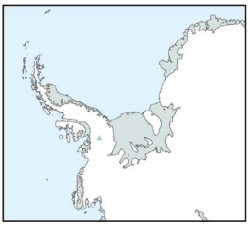


▲ *The BAS Rapid Access Isotope Drill (RAID) in action at a previous test site*

▲ *The new P-RAID rock drill with coring barrel extended. We will be testing the P-RAID in conjunction with use of the RAID*

Field-based project (Sledge Hotel)

Sea ice and westerly winds during the Holocene in coastal Antarctica, to better constrain oceanic CO_2 uptake (REWIND)



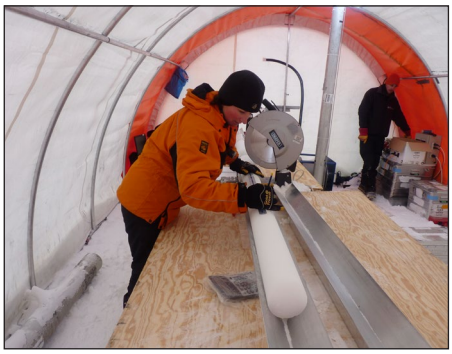
Location: Near Sky-Blu

Timing: November 2024 to February 2025

The Southern Ocean currently absorbs over 40% of the anthropogenic carbon dioxide (CO_2) from the atmosphere. However, the Southern Ocean can also release CO_2. The extent to which the ocean will act as a source or sink of anthropogenic CO_2 in the future constitutes a major uncertainty facing society today.

We will drill a deep ice core from the Antarctic Peninsula to explore how westerly winds and sea ice have influenced the uptake or release of CO_2 from the Southern Ocean during the Holocene (~11,000 years). We will measure a suite of chemicals and particulate material, including marine diatoms, to reconstruct winds and sea ice in the Pacific sector at annual resolution. This will be compared with a new high-resolution CO_2 record.

We have identified several suitable deep drilling sites, which are approximately 35km from Sky-Blu. In season one (2024-25) we will conduct geophysical surveys, using DELORIS radar, to confirm the ideal drilling location. Once selected, the drill team will be deployed to set-up the drilling camp and start the drilling. The deep drilling will be completed in season two (2025-26), when the team aim to reach bedrock at between 750-800m.

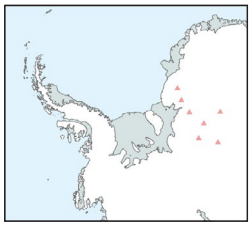


▲ *Ice core drill in the field*

▲ *Flying the ice cores from the field in a Twin Otter*

Field-based project (Sledge Lima)

Conjugate experiment to investigate the sources of high-latitude magnetic perturbations in the coupled solar wind-magnetosphere-ionosphere-ground system



Location: Various locations

Timing: December 2024 to February 2025

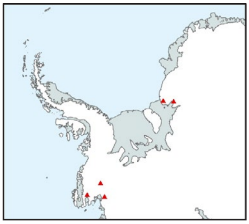
The Low Power Magnetometers (LPMs) operate unmanned all year round, including the long winter, when continuous periods of darkness and temperatures as low as -80°C prohibit human intervention. This has been made possible by new technology which allows the magnetometers to use very little power and survive the winter on solar power stored during the summer. The network measures magnetic fluctuations over a wide area. The data can be used to produce maps of space weather in the region around the Earth where satellites orbit. Information is recorded by the instrument and removed once a year during servicing. This project will be supported out of Halley and Rothera.

Space weather causes fluctuations in Earth's magnetic field that create unwanted geomagnetically induced currents (GICs) in power grids, which in extreme cases can cause blackouts. In this project we will improve our understanding and forecasting of space weather and GICs by comparing measurements of geomagnetic field fluctuations at magnetically conjugate locations in the Arctic and Antarctic. 'Magnetically conjugate' means that the Antarctic locations are at equivalent positions with respect to the South Magnetic Pole as the Greenland locations are with respect to the North Magnetic Pole. Magnetically conjugate measurements are scientifically valuable because space weather phenomena are mostly organised by the geomagnetic field and thus should be similar at magnetically conjugate locations. Departures from conjugacy help us understand what other factors influence space weather, and can be compared with model predictions to help improve model accuracy.

▲ *BAS scientist checking the solar power unit for one of the remote Low Power Magnetometers*

Field-based project (Sledge Mike)

Depot digging



Location: BAS Depot Network, primarily Ellsworth Land, Ronne Ice Shelf

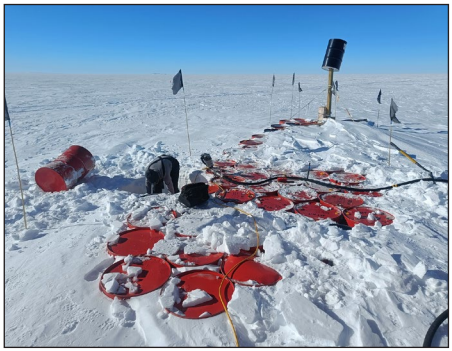
Timing: November to January 2025

BAS's area of operations on the Antarctic continent is vast, covering an area which is largely unoccupied and by comparison in excess of most of Europe. Across this area are a series of depots, primarily consisting of Avtur drums, acting as refuelling hubs to allow the Twin Otters to fly multiple legs across the continent more efficiently.

These drum depots, generally placed on the snow surface, are subject to drifting, snow accumulation and ablation as well as occasionally melting out, especially when in position across multiple seasons. The depot network therefore requires constant maintenance as well as restocking.

This season's priorities are to tidy up and amalgamate a series of depots that are a legacy of projects carried out on Pine Island Glacier and on the Abbot Ice Shelf and to raise two depots on the Ronne Ice Shelf.

A team made up of Field Guides and other station personnel will set up camp at the depot sites and raise the depot sites over several days.

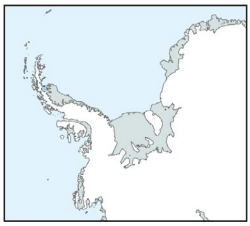


▲ *Depot raising... get the shovels!*

▲ *Newly raised depot with drum marker*

Field-based project (Sledge Quebec)

Direct influence of meltwater on Antarctic Ice Sheet Dynamics



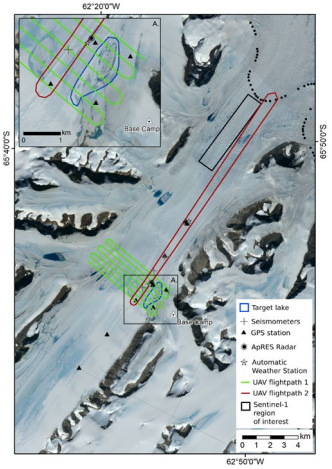
Location: Flask Glacier

Timing: November to December 2024

More information: *https://ldeo-glaciology.github.io/AntPen_NSF_NERC*

When ice sheets and glaciers lose ice faster than it accumulates via snowfall they shrink and contribute to sea-level rise. The Antarctic Ice Sheet is the largest potential contributor to sea-level rise and its future is highly uncertain. Ice flows viscously under gravity towards the ocean and the rate of ice flow controls how fast ice sheets and glaciers shrink. Ice flow rates vary in space and time. Recently, members of this project team published the first satellite observations suggesting that meltwater reaches the base of outlet glaciers in the Antarctic Peninsula and causes them to accelerate. This could become more common as air temperature increases around Antarctica this century. Therefore, confirming the team's recent satellite observations, establishing a baseline against which to compare future changes, and improving our understanding of the direct influence of meltwater on Antarctic Ice Sheet dynamics is important for improving predictions of sea-level rise.

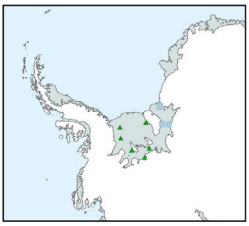
This is a two-year US-UK collaboration project, with two deep-field research campaigns on Flask Glacier in the Antarctic Peninsula. We will deploy instruments and complete UAV surveys over two field seasons to gain insights into both the drivers and implications of short-term changes in ice-flow velocity caused by surface melting.



▲ *Planned paths for UAV surveys and placements of ApRES, seismometers, GPS and automatic weather stations on Flask Glacier, Antarctic Peninsula*

Field-based project (Sledges Sierra and Tango)

Melt rates over Ronne Ice Shelf



Location: Filchner-Ronne Ice Shelf

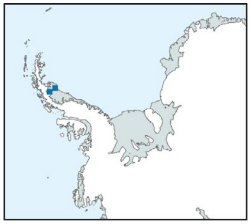
Timing: Opportunistic throughout the season

This is a continuation of an activity in support of Shelf Seas NC-SS. During the Filchner Ice Shelf System (FISS) project, 14 ApRES were sited at carefully selected locations over the Filchner-Ronne Ice Shelf in order to monitor time series of basal melt rates. These devices are downward-looking radars that are able to detect the basal melting of the ice shelf at time scales of oceanographic interest. This provides us with an indication of the oceanographic processes active beneath the ice shelf, without going to the time and expense of drilling an access hole and deploying expensive instrumentation. When the FISS project ended, five of the sites were selected for long-term monitoring, yielding information about the way the sub-ice-shelf cavity responds to external oceanographic forcing from the ice front. In addition, ApRES are being maintained at three sites where boreholes were made to deploy sub-ice-shelf ocean instrumentation: site 5a, and at two sites on the northern Filchner Ice Shelf, sites FNE1 and FNE3.

▲ *Measuring melt rates on the Ronne Ice Shelf*

Field-based project (Sledge X-ray)

Dutch polar climate and cryosphere change consortium



Location: Larsen C Ice Shelf

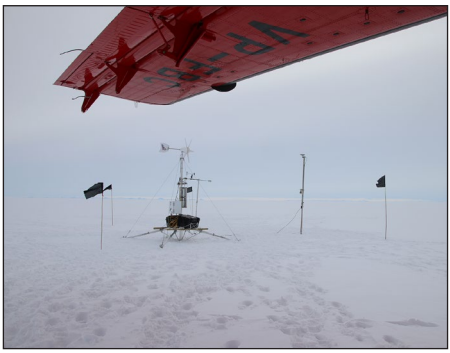
Timing: December 2024

More information: *https://www.projects.science.uu.nl/iceclimate/aws/antarctica.php*

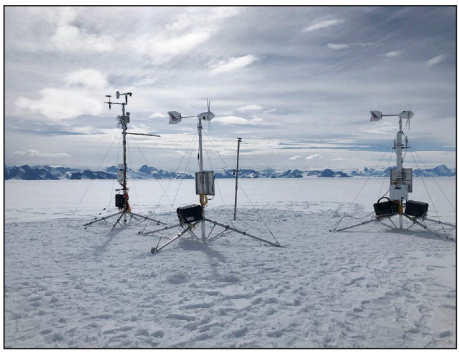
Climate change in the Polar Regions is amplified and leads to a reduction in sea ice, changes in ocean circulation and ice volume. Mass loss of the Greenland Ice Sheet doubled over the last decade compared to the decade before and for Antarctica it even tripled. As a result, coastal risks will increase strongly if no further adaptation measures are taken.

Against this background within the NPP project we will contribute to modelling efforts and participate in ice sheet modelling and climate modelling intercomparison projects. In addition, we plan to contribute to observing physical changes using field observations (automatic weather stations) and remote sensing data (gravimetry and elevation measurements). Finally, we will translate how observed and modelled changes in the cryosphere affect regional sea level and extreme sea level along the Dutch coast.

For the upcoming 2024-25 season we plan maintenance of our automatic weather station measurements at two locations on Larsen C Ice Shelf. This maintenance visit is a simultaneous effort with the HiRise project and is planned to be performed by BAS personnel. It will include raising instruments to the surface and performing instrumentation servicing and changes to some elements.



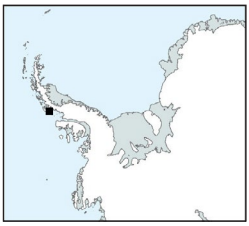
▲ *iWS and HiRise 14 on the Larsen C Ice Shelf*



▲ *HiRise 18 on the Larsen C Ice Shelf*

Field-based project

BEA LTMS maintenance and routine sampling



Location: Rothera Research Station (Anchorage Island), Alexander Island (Coal Nunatak, Mars Oasis), Signy Research Station

Timing: Ongoing

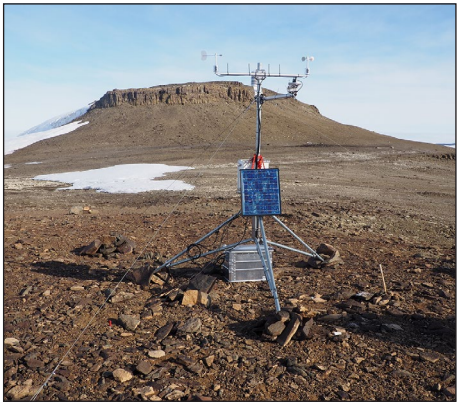
BAS has operated three terrestrial microclimate monitoring stations at sites accessed from Rothera since the mid to late-1990s and one at Signy since the early 1990s. The stations span almost the entire extent of the biological region known as the maritime Antarctic, which has been one of the fastest-warming regions of the planet over recent decades.

Routine site and equipment visits, downloading and maintenance work, and one-off sampling requests, originally the responsibility of the Rothera Terrestrial Assistant, have been carried out by management agreement by the Bonner Lab Manager since the creation of that post. Such visits are typically now carried out within a full 'away-day'.

All three Rothera-accessed stations have had substantial maintenance and upgrading in the last three-to-four seasons, and the Signy station has been replaced and relocated close to the station.

In addition to the maintenance, targeted soil/peat collections supporting an NSF-NERC grant will be carried out at Signy Island, targeting the invasive midge *Eretmoptera*, from standard introduction sites immediately adjacent to station buildings.

▲ *The AWS on Anchorage Island is easily accessible by boat from Rothera Research Station. Reptile Ridge can be seen here in the background*

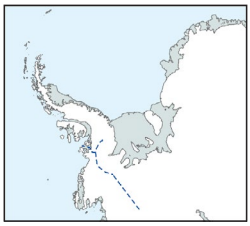


▲ *Coal Nunatak is on Alexander Island and only a short flight away from Fossil Bluff. The AWS overlooks King George VI Sound*

Field-based project

Ops tractor traverse

Location: SB9, SB9b, English Coast and Sky-Blu
Timing: November 2024 to February 2025



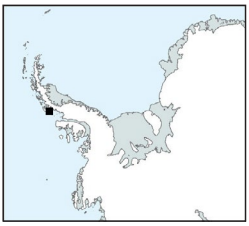
The BAS Ops tractor traverse team are planned to regroup this season – two PistenBullys will return from the Thwaites Glacier Program at WAIS Divide (a drive of over 1,000km) and join up with the rest of the fleet at SB9b. At SB9b and SB9 the team will raise the depots across two sites and transport all the cargo to the English Coast in preparation for the SDA ship's relief around new year. Once the cargo has been safely transferred to the SDA then the team will begin ferrying new fuel and cargo towards Sky-Blu in preparation for next season.

▲ *Tractor traverse crossing the Antarctic ice in 2023*

Rothera Research Station

ARIES upgrade

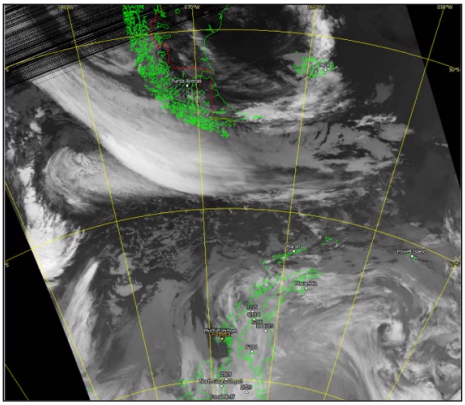
Timing: October to November 2024



The ARIES dome is the smaller white dome on Rothera Point which houses a satellite dish and receiver system called ARIES (Antarctic Reception of Images for Environmental Science). When a polar orbiting satellite passes nearby, ARIES captures image data and stores it for use in climate research and local weather forecasting. During the summer months these satellite images are analysed by the Rothera forecaster and used in the daily met brief to show areas of cloud and fog over areas in which BAS aircraft intend to fly. Very often the pilots and forecaster are waiting for that next satellite image over a certain area which will give them a better picture of what's going on and determine whether to go flying or not.

This season engineers from Dundee Satellite Station Ltd will visit Rothera to upgrade the current ARIES system to receive X-band transmission. The new upgrade will allow us to receive data and images from more satellite passes. This data is also used to support other science projects like WIPSY, that uses NOAA satellite passes to calculate upper-level winds.

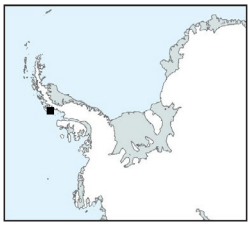
▲ *The ARIES Dome captures satellite image data to help with daily weather forecasting*



▲ *Example of satellite data received by the ARIES system*

Rothera Research Station

BRUV (Baited Remote Underwater Video)



Timing: Ongoing

More information: *https://www.gov.uk/government/publications/the-blue-belt-programme*

https://www.uwa.edu.au/news/article/2021/april/worlds-largest-ocean-monitoring-protects-marine-biodiversity

We are partnering with the UK Government Blue Belt program's Global Ocean Wildlife Analysis Network, deploying BRUVS in the British Antarctic Territory (BAT). We hope that BRUVS will add an additional capacity to our research, allowing us to monitor the animals living in the surface waters. We hope to add this missing information to the monitoring of the near-shore marine environment in Ryder Bay that has been conducted for more than 20 years.

The duration of winter sea-ice cover in Ryder Bay is extremely variable, with the overall warming trend recorded on the Western Antarctic Peninsula since the 1970s affecting winter sea-ice duration. Mid-ocean research cruises have been monitoring krill and fish populations further north in the Southern Ocean for many years and have shown marked reductions in krill numbers. The early life stages of krill rely heavily on algae living on the underside of the sea ice for food and so changes in the winter sea ice are expected to have a marked effect on krill populations. We want to use BRUVS to learn how the annual variation in oceanography and sea ice affects these species.

The value of life in the oceans is increasingly being recognised, not just for the intrinsic value of biodiversity, but for the key ecosystem services it provides to human society. One of the emerging questions is to better understand how healthy marine ecosystems capture carbon from the atmosphere and store it into the seafloor. Partnering with Blue Belt and the University of Western Australia will allow us to investigate specific questions about the pelagic marine system in Ryder Bay.

Being part of this global network gives us an excellent opportunity to compare different oceans and understand more about our changing oceans.

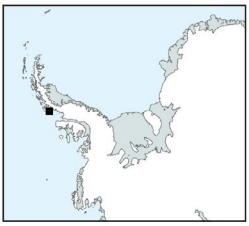
▲ *A BRUV (Baited Remote Underwater Video) system being assembled on the boat for deployment*

▲ *View of the bait box underwater. Notice the notothenioid fish in the right bottom corner*

Rothera Research Station

Discovery Building control tower communications installation

Timing: November 2024 to May 2025



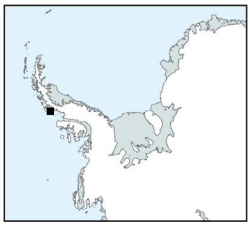
As BAS Operations transitions into the new Discovery Building, the communications engineering department is installing a cutting-edge tower control system from Rohde & Schwarz. This advanced system consolidates the existing capabilities of the current control tower into a unified network, enabling tower operators to access all flight-critical communication channels from a single screen. Supported by a new data control centre, it will monitor, maintain, and protect these essential communication links.

The new system will enhance BAS's operational capabilities, paving the way for future developments. It may enable dual antenna use at both Rothera and Halley, controlled from a single location at Rothera. Additionally, it could help facilitate and manage integrated VOIP (Voice Over Internet Protocol) communication across all stations, including connectivity back to Cambridge, and improve training on the new system via virtual machines connected to the network.

▲ *The Discovery Building control tower*

Rothera Research Station

Marine Biological Research at Rothera Research Station



Timing: Year-round

More information: *https://www. bas.ac.uk/team/science-teams/biodiversity*

The seafloor around Rothera Research Station is characterised by very high natural levels of disturbance but is one of the environments least disturbed by human activity. This high diversity assemblage provides important ecosystem services, including storing carbon from the atmosphere into skeletons and body structures. The dynamics of this ecosystem are changing as human effects on the atmosphere reach the Southern Ocean and impact marine ecosystems.

In their natural state assemblages living on the seafloor are structured by iceberg disturbance, with a depth gradient with higher iceberg scour frequency in the shallows than at depth. When icebergs impact the seafloor, they can kill over 90% of all the animals living there, re-setting the community to pioneering species and mobile species that are able to rapidly re-colonise these areas of seabed. The amount of iceberg scour is negatively correlated to the duration of seasonal sea ice, which is the major signal of climate change in the ocean around Rothera. The duration of winter sea ice is reducing and the amount of iceberg scour is increasing.

To monitor these changes the iceberg impact study has maintained a grid of markers on the seafloor that measures the number of iceberg impacts per square meter of seafloor, allowing communities of known age to be identified and the frequency of iceberg scours to be followed. This will provide us with important information on the trajectory of seafloor assemblages around Rothera.

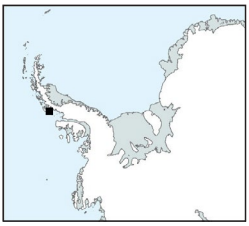
The marine biologist project for 2024-25 is to quantify the carbon in assemblages living on the rocky shores around Rothera, to build a profile of carbon stored within these assemblages, to compare with identical measurements taken 10 years ago, to look for signals of change. The reproduction of selected species has been monitored monthly for more than 25 years and has allowed the detection of environmental effects on the amount of energy these species allocate to reproduction.

Seaweed relies on remaining attached to the seafloor in shallow water and are therefore hugely impacted by iceberg scour. Changes in iceberg scour are therefore expected to lead to changes in the biomass and coverage by seaweed around Rothera, which will compete for space with the animals living on the seafloor. Studies will continue to measure seaweed species. Surveys will be continued to monitor ecological change in other species, including anemones.

▲ *Iceberg scour near Rothera Research Station*

▲ *Monitoring ecological change*

Rothera Research Station



Monitoring of skuas and shags at Rothera Point and Ryder Bay

Location: Rothera Point and Anchorage, Mucklescarf, Killingbeck and Skart Islands

Timing: December 2023 to March 2024

More information: *https://www.bas.ac.uk/project/skua-monitoring-at-rothera*

Rothera Point and the islands in Ryder Bay hold 10.3% and 3.5% of the global populations of south polar skuas and Antarctic shags, respectively. The small population of south polar skuas (<30 pairs) at Rothera Point has been studied since the late 1990s. Although the initial intention was to monitor possible impacts of the station, the long-term data are invaluable as indicators of local prey availability at sea and the effects of changes in sea-ice coverage, and for helping in the assessment of possible impacts of installation of wind turbines.

Up until 2005, the monitoring was of population size and breeding success (chicks fledged per pair). Subsequently, the breeding parameters that are collected include laying dates, clutch size, egg dimensions, hatching success, fledging success, chick condition and adult attendance (which provides an index of foraging effort) of each pair. In addition, since the 2007-08 season, monitoring has included resighting of colour-ringed adults, which can be used to estimate adult survival, breeding frequency and divorce rates, and to determine the breeding histories of individuals and the effects of mate change. There is also some monitoring of skuas on nearby Anchorage Island, which act as controls. As well as the skua monitoring, the project includes annual counts of Antarctic shags on Mucklescarf, Killingbeck and Skart Islands.

▲ *South polar skua and Antarctic shag on Mucklescarf Island*

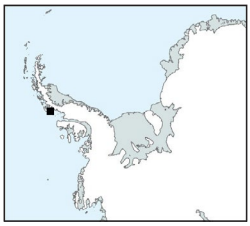
▲ *Antarctic shag fitted with GPS, time-depth and GLS-immersion loggers. These devices provide data on fine-scale movements, dive profiles and at-sea activity patterns (timing of flights and foraging bouts) during the breeding season*

Rothera Research Station

New VLF hut installation

Location: East Beach

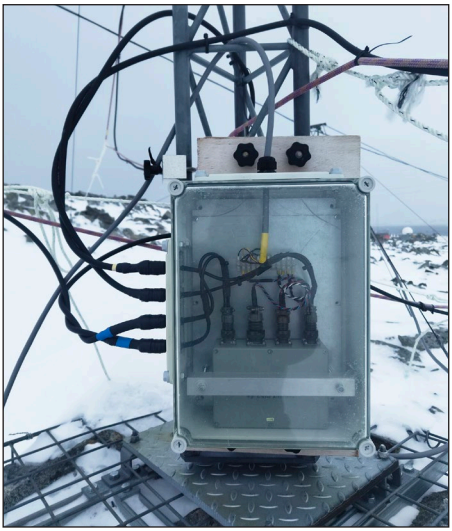
Timing: January to March 2025



The Very Low Frequency (VLF) antenna on Rothera Point listens to radio waves as part of a network of receivers located all over the Polar Regions. Data gathered by this network is used by more than 35 institutions around the world! We can use VLF to record and map, in real-time, lightning strikes around the world *(http://webflash.ess.washington.edu)*. We can also use the VLF receiver for finding out about interactions between our atmosphere and particles from the solar wind.

The hut is running on DC low voltage to minimise noise due to mains electricity. The experiments in it are very sensitive. We are moving the experiments because Rothera has become too electrically noisy around the station. This alongside the move to the Discovery Building and the replacement of Old Bransfield House means that the VLF laboratory that deals with the processing and data side of the antenna will be installed on East Beach. East Beach presents an electrically quieter area of station.

▲ *The VLF antenna*



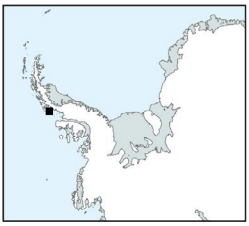
▲ *The VLF control box*

Rothera Research Station

North-south antenna replacement

Location: Rothera Point

Timing: January to March 2025

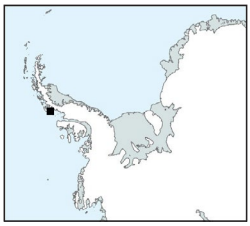


The North-South (N-S) Fan-Dipole Wideband Array is an antenna used with the HF (High Frequency) systems in the control tower. These antennas, along with the HF equipment, provide reliable medium to long-range communications with our aircraft and field teams across Antarctica. HF frequencies can bounce off the ionosphere (the upper atmosphere) to propagate over long distances, a method known as skywave propagation. This season, we will be replacing the N-S antenna as part of our ongoing efforts to maintain this vital communication link.

▲ *The north-south wideband array on Rothera Point*

Rothera Research Station

Repair and maintenance of the Rothera MF radar masts



Timing: September 2024 to March 2025

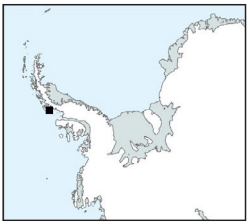
There has been a Medium Frequency (MF) radar operating at Rothera since 1997. It provides measurements of the horizontal winds blowing at altitudes from 60 to 95km, giving vital information on the middle-atmosphere above the Antarctic Peninsula. The winds are part of a pole-to-pole circulation and are perturbed by tides in the atmosphere, driven by heating from the Sun (6-24hr periods) and by large planetary waves (periods of days). Data from the radar are used to study the dynamics of the middle-atmosphere and how it couples upwards and downwards in response to changes in the lower atmosphere and variations in space weather coming from above. A secondary capability is the monitoring of the electron density in the lower ionosphere and the detection of energetic charged particle precipitation, which affects the chemistry and temperature of our atmosphere.

▲ *MF radar array at Rothera Research Station*

Rothera Research Station

Rothera biological long-term monitoring – IBIS (IceBerg Impact Study)

Timing: Ongoing

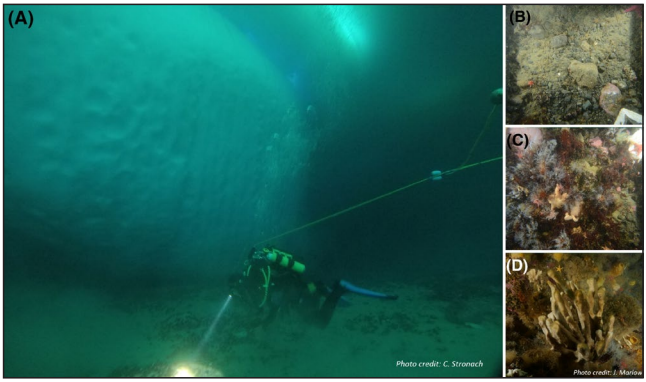


Since the austral summer of 2002-03 BAS has monitored the shallow seabed adjacent to Rothera Research Station. There are three grids of 25 concrete markers at each of 5, 10 and 25m on the seabed of South Cove, which are surveyed annually in December by the Rothera Marine Assistant. Each block that is hit is noted and replaced, so we have a detailed history of disturbance of the seabed for nearly 20 years. Linked to the Rothera oceanographic Time Series (RaTS) this is a powerful tool to investigate climate, ice and biology in the polar shallows.

It is one of the longest, continually-monitored areas for disturbance anywhere in the global ocean. Initially it allowed us to investigate how often the seabed was hit by icebergs and what impact this had on megabenthos. Crucially it was found that the duration of seasonal sea ice (fast ice) cover was related to how often the seabed was pummelled by icebergs. Sea ice is changing drastically in both Polar Regions and Rothera is in the hotspot of sea-ice losses in time and space – what does this mean for life on Antarctica's seabed?

Researchers at the Argentinian research station of Carlini (formerly Jubani) became interested and, collaboratively working with BAS, set up a series of similar iceberg scour monitoring grids at King George Island.

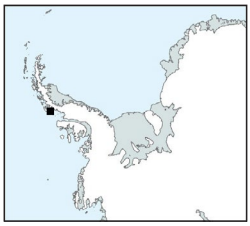
Life in the Polar Regions is thought to be vulnerable to even small changes, and the coastal shallows are the fastest-changing part. Onward monitoring of the Rothera iceberg grid (IBIS) together with that at Carlini should prove to be an important part of the toolset to enable us to understand the wider picture of how the many aspects of climate changes holistically influence life at the far ends of our planet.



▲ *Impact of icebergs and stages of recovery: Photos show (A) a grounded iceberg frozen immobile in the sea ice and the state of benthic communities (B) immediately after impact, (C) 11 years post-impact and (D) sheltered from ice-scouring impact*

Rothera Research Station

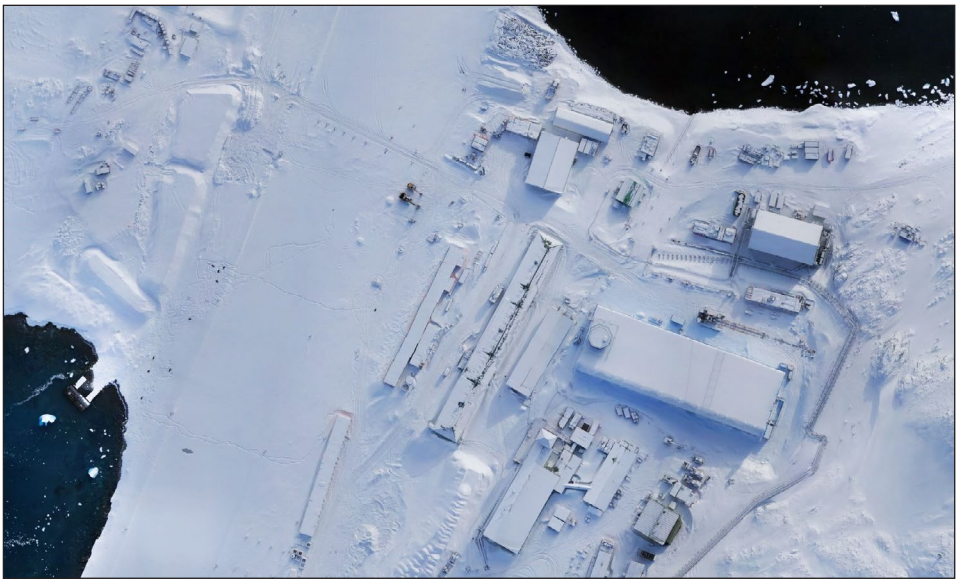
Rothera minimum snow cover aerial survey 2024-25



Timing: February to March 2025

With the rapid pace of development at Rothera there is a significant requirement to collect up-to-date high-resolution aerial imagery of the station. Due to environmental constraints (minimum snow cover) the data can only be collected between the beginning of February and the middle of March each year. The data will be used for a wide variety of outputs across the organisation including; science, operations, environment and infrastructure.

The survey will be conducted from a Twin Otter and using a medium format Phase One aerial camera. Along with the aerial survey, a ground survey will be undertaken to establish ground control points using existing features across Rothera Point with a pair of Trimble geodetic GNSS receivers.

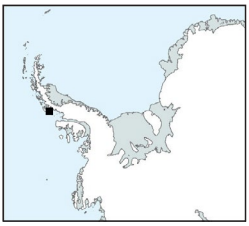


▲ *The most recent (2022-23 season) 'minimum snow cover' survey!*

Rothera Research Station

Rothera ramp survey

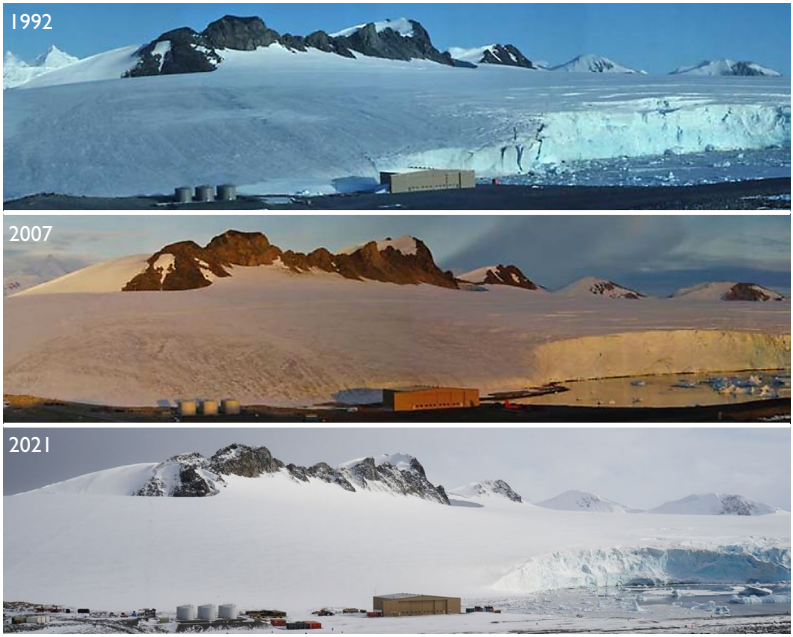
Timing: February to March 2025



The ice ramp at Rothera is disappearing before our eyes! At the end of every summer the surface profile of the ramp is surveyed to see how much it is changing. This survey is routinely conducted using GPS measurements along a single survey line. From 2025 onwards we plan to start using remotely-piloted aircraft to provide high-accuracy measurements of the ramp surface elevation.

This long-term co-location of ice measurements and Met records is unique and is a valuable data set for studying actual ice changes under a changing climate. Over the past 30 years the bottom has gone back well over 100m, and has lowered by almost 20m. The top hasn't changed much, which means that the ramp is slowly getting steeper.

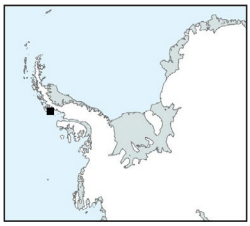
The ramp is affected by the Antarctic Peninsula's regional climate. We can compare the amount of ice that melts each year with the Rothera Met data and it correlates well with air temperature. More ice is lost in warmer years, but occasionally there'll be a cooler year and the ramp thickens slightly. The photographs taken between 1992 and 2021 below illustrate the changes. The survey line is located well to the left of the fuel farm, but the most striking change seen in the photographs is behind and right of the hangar; high ice cliffs in 1992 had become a nice gentle slope by 2021.



▲ *The changing face of The Ramp at Rothera from 1992 (top), to 2007 (middle) and 2021 (bottom). The bottom of the ice has retreated well over 100m*

Rothera Research Station

Rothera Time Series (RaTS)



Location: Ryder Bay

Timing: 1998 to present (ongoing)

More information: *https://bas.ac.uk/project/rats*

The glaciers, sea ice, ocean physics and biology along the Antarctic Peninsula are very closely linked, with strong feedbacks between ice and ocean through winter mixing and summer melting. These changes then strongly affect the growth of phytoplankton, which underpins both the food web and carbon uptake. There are also changes between years, from variable local weather patterns and wider scale processes such as El Niño and the ozone hole. It is therefore extremely important to monitor the system throughout the annual cycle and on decadal timescales. The sinking organic detritus from phytoplankton, and the zooplankton that graze on it, feeds the benthic ecosystem and leads to the sequestering of carbon in the sediments.

The Rothera Time Series is unique in covering winter sampling. The sample site is 4km from the station, accessed by small boat or a sled. There have been many interesting feedbacks found, with less sea ice leading to more heat and carbon loss in winter, followed in summer by more heat uptake (which, unexpectedly, exceeds the original loss) but reduced phytoplankton growth and so less carbon uptake. With a potential shift to less sea ice across a wider region, including a wide scale absence of sea ice in the winter of 2022, it is important to continue the sampling to assess the oceanographic processes driving these changes, and the consequences of the surface waters being exposed to wind-driven mixing and heat loss through the winter when there is no sea ice.

CTD casts are taken once or twice a week to monitor the temperature, salinity, chlorophyll and turbidity together with a variety of water samples to understand the ice melt and biological processes. In addition, an ocean glider is deployed for month-long missions to measure similar parameters, including close to the glacier front and further away from station, following the route warm water needs to follow to reach the glaciers to study how it mixes and cools en route to the melting ice.

▲ *Ocean glider ready to be deployed for a month*

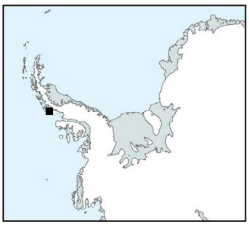
▲ *Deploying a CTD on the hand winch to 500m depth*

Rothera Research Station

Silicon cycling in glaciated environments (SiCLING)

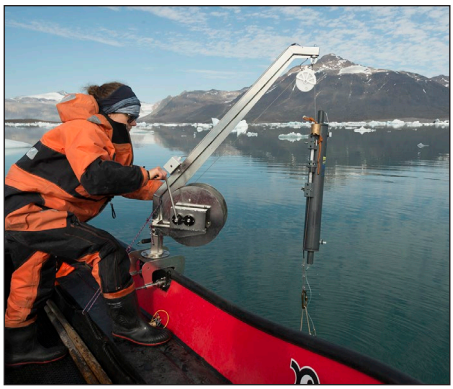
Timing: December 2024 to January 2025

More information: *https://www.bas.ac.uk/project/sicling*



The Polar Regions are experiencing the most rapid climate change observed on Earth. Marine ecosystems are already responding to – and amplifying – environmental change, with important implications for carbon burial and important natural resources such as fisheries. Diatoms are one important type of algae, which form the basis of these polar ecosystems and provide an important conduit for carbon flow from the surface to the seafloor. These algae build their microscopic shells from silica, and so dissolved silicon (DSi) is a critical nutrient for their growth.

Our recent work has shown that glaciers are a substantial source of both DSi and reactive particles of silica, termed ASi. However, the processes by which DSi and ASi escape glaciated fjords are not understood; these processes have profound implications for the supply of DSi to coastal and open ocean ecosystems in the Polar Regions, and ultimately how this system will respond and change in the future. SiCLING will investigate links between silicon and metal cycling within glacial sediments in Arctic and Antarctic fjords, and the impact of these processes on the flow of nutrients into the polar coastal ocean and beyond. As part of this, we will be making observations in Ryder Bay near Rothera Research Station, including water and particulate sampling from small boats.



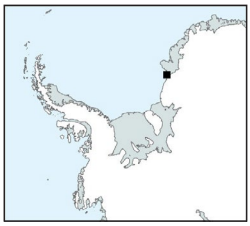
▲ *Collecting water samples from polar fjords for silica analysis*

▲ *Brash ice in Antarctic fjord*

Halley VI Research Station

Airglow spectrometer (Agspec)

Timing: 2024-ongoing

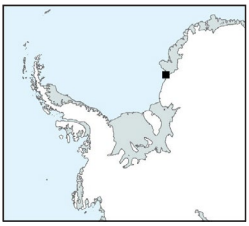


The airglow spectrometer measures the spectra of faint airglow emissions in the middle atmosphere. These spectra can be used to measure the temperature of the middle atmosphere but also can be used to measure atmospheric waves (e.g. tides and gravity waves). By combining long-term temperature records across Antarctica we can see the effect of climate change (increased temperatures at surface) on the middle atmosphere temperature.

▲ *Airglow spectrometer instrument*

Halley VI Research Station

All-sky camera

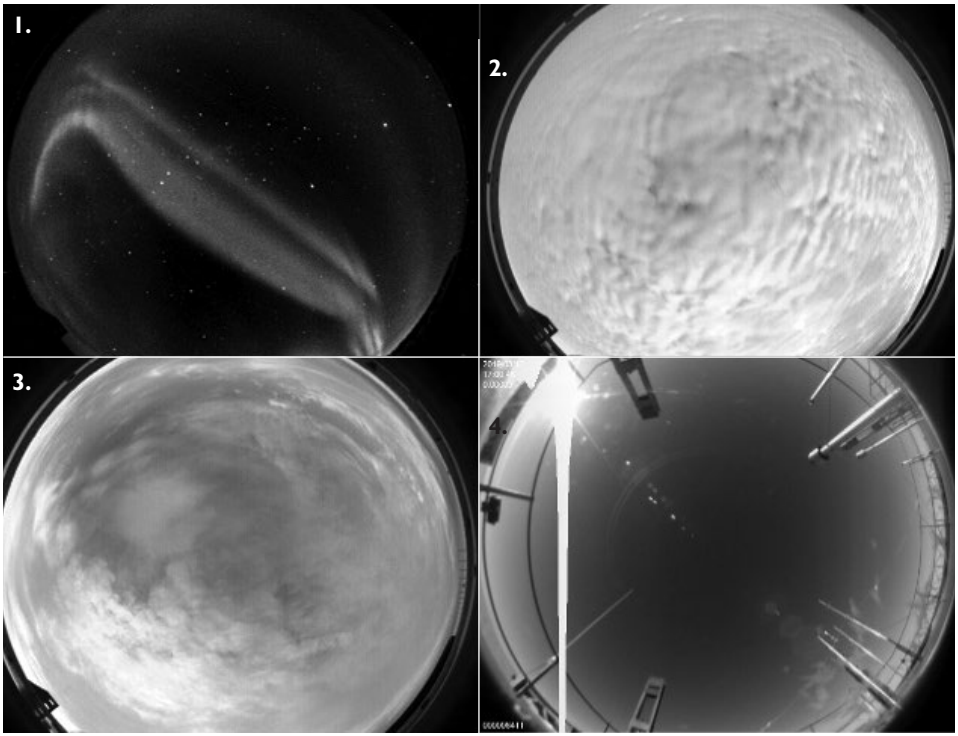


Timing: 2018-ongoing

More information: *https://bas.ac.uk/polar-operations/sites-and-facilities/facility/all-sky-camera-black-and-white*

This instrument takes regular, visible light images of the sky using a fisheye lens. This data is used to determine the cloud cover levels at a given site. It is normally used to aid the analysis of mesopause (upper middle atmosphere, 87km) airglow spectra measurements (cloud equals poor airglow spectra) which are used to calculate mesopause temperatures. It also can be used to observe aurora.

This instrument has been engineered to run autonomously over the unmanned Halley winter period.

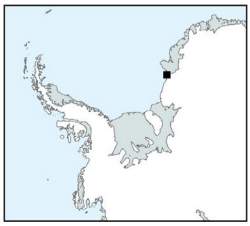


▲ *Figures (1-3) are from Halley in previous years, one of the aurora, two of cloud cover. Fig 4 is an image taken by the camera during its unmanned operation in March 2019*

Halley VI Research Station

Auroral cameras – conjugate measurements of isolated proton auroras, red aurora, and pulsating auroras at subauroral latitudes

Timing: 2020-ongoing



We have three small auroral cameras at the Halley Research station that have run autonomously. These cameras are used to observe:

Proton auroras

Energetic protons striking the upper atmosphere can cause isolated bursts of light from the upper atmosphere known as proton auroras. One curious aspect is that the bursts of light occur in the northern and southern hemisphere but not at the same time. One theory suggest that the bursts of light are due to an ultra-low frequency wave packet that travels along the geomagnetic field and bounces between the northern and southern hemisphere. Theory suggests that each time the wave packet crosses the equator it causes a burst of energetic protons that travel along the magnetic field into the atmosphere – so causing the burst of light. However, satellite observations provide inconclusive support for this idea. The optical instrument at Halley is designed to measure these bursts of light and compare the timing with signals at Nain in the northern hemisphere. The intention is to combine the optical measurements with measurements of the wave packets using the search coil magnetometer at Halley and Nain and hence test the theory more carefully.

Red aurora

Red aurora are sometimes observed at Halley after a large geomagnetic storm. They can last for hours but the chain of events leading to the red aurora is very complicated and not well understood. Satellite data suggest that ions trapped in the geomagnetic field are the ultimate source of energy for the red aurora. The ions are heated and then somehow transfer this heat to electrons which travel down into the atmosphere and collide with oxygen atoms which emit the light we see as the red aurora.

continued ▷

▲ *Red aurora (Image: Kazuo Shiokawa)*

Halley VI Research Station

Auroral cameras continued

The object of this project is to deploy a special type of camera that can measure the red aurora across the whole sky so we can understand this energy transfer process. The camera has been built by our Japanese colleagues at Kanazawa University in Japan as part of a new and longer-term collaboration with BAS.

This project is important since high-energy ions which power the red aurora also cause damage to satellites in orbit. By understanding the red aurora and measuring how long it lasts we can help determine how long satellites may be at risk of damage.

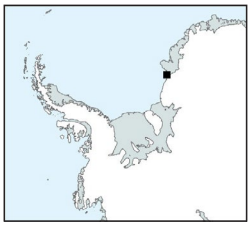
Pulsating auroras

Observations show that the intensity of the aurora can vary as if there is a switch turning it on and off every second or so. As energetic electrons striking the atmosphere cause the bright auroral patches, the suggestion is that wave-particle interactions modulate the flow electrons coming down the field line into the atmosphere. It is thought that the waves responsible are very low frequency plasma waves, which originate in space but which also travel along the geomagnetic field and can be detected at Halley. The intention is to combine the optical observations with measurements of very low frequency waves at Halley to test some of the theories.

▲ *The auroral camera system (left) on the roof of the CASLab, adjacent to the All-Sky Camera system (right)*

Halley VI Research Station

Clean Air Sector Laboratory (CASLab)



Timing: 2012-ongoing

More information: *https://bas.ac.uk/polar-operations/sites-and-facilities/facility/halley/clean-air-sector-laboratory-caslab/#about*

Tropospheric ozone

The laboratory-based TEi 49i ozone monitor currently runs continuously in the CASLab. These measurements not only help us to understand the mechanisms of reactive chemistry in the seasonal sea-ice zone, but also contribute to our commitments of being a background monitoring station for the WMO's Global Atmospheric Watch programme.

Aerosol loading

The Automated Condensation Particle Counter (CPC) instrument measures the concentration of particles (>0.01 µm) in the atmosphere. These particles are produced from a variety of processes relating to the production of reactive halogen oxides and sulphur compounds from the seasonal sea-ice zone and contribute to local aerosol loading. These measurements therefore make a complimentary addition to those made by the TEI 49i ozone monitor.

▲ *The Clean Air Sector Laboratory (CASLab) at Halley Research Station*

▲ *The CASLab is located away from the main station*

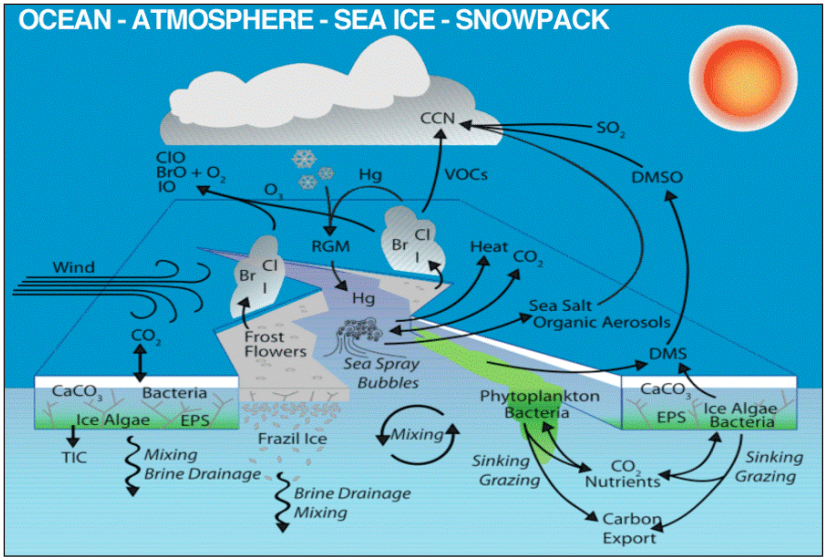
continued ▷

Halley VI Research Station

Clean Air Sector Laboratory (CASLab) continued

Greenhouse gas observations of CH_4 and CO_2

We have developed two autonomous systems centred on the Picarro instrument, which measure the atmospheric methane (CH_4) and carbon dioxide (CO_2) mole fraction. We are currently running one of these systems with our international colleagues at the Alfred Wegener Institute's (AWI) Neumayer Station III. Measurements of CH_4 and CO_2 contribute to a NERC-funded project; the Methane-DH project aimed at improving quantification the global budget of atmospheric methane.

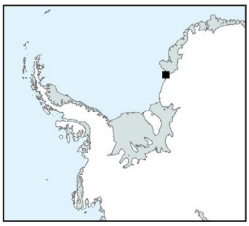


▲ *Schematic showing the physical, chemical and biological interactions in the sea-ice zone*

Halley VI Research Station

Discovering reasons for atmospheric methane growth using deuterium isotopes (MethaneDH)

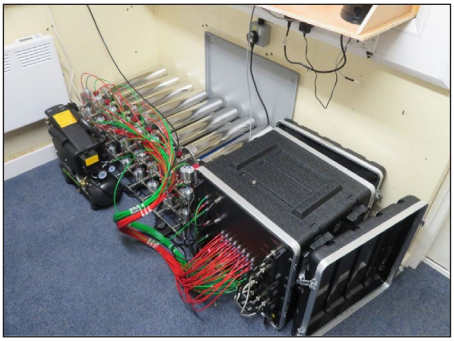
Timing: 2021-ongoing



Atmospheric methane levels are growing rapidly with a 70ppb (an extra ~4% of total atmospheric methane) rise in atmospheric methane mole fraction observed over the last decade. The reasons behind the growth since 2007 are not well known. The changing 13C/12C isotopic signature of atmospheric methane can give us some insight into the reasons for the change because, concurrent with the atmospheric methane rise, it has become depleted in 13C. There have been several proposed reasons for the increase and corresponding isotopic shift and we need additional tracers of the sources to explain it. This proposed work will use measurements of the deuterium/hydrogen (D/H) isotope ratio of methane to constrain the source distribution of methane globally.

New instrumentation for high-precision multiple-sample measurement of D/H isotopes in methane in ambient air has recently been developed and this will be used to analyse air samples collected close to sources. The isotopic signatures of the major sources will hence be characterised, including wetland, waste, biomass burning, fossil fuel, ruminants and rice agriculture. A focus of the field campaigns will be on tropical Africa and East Asia, parts of the world with high emissions of methane, but with very few measurements of methane isotopic signatures. Measurements at remote locations, such as Halley, will act as baseline information, and latitudinal transects will inform on global distributions. The results will then be used to identify regional source signatures for the main source categories. Understanding the causes of the current rise in methane is critical to driving policy for greenhouse gas reduction globally and the desire to remain within the 2°C temperature change outlined in the Paris Agreement.

The engineering teams at BAS have built an automated flask sampler that will run unattended through the Halley winter collecting air samples that will be shipped out for analysis the following season.

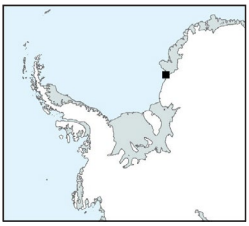


▲ *The automated methane flask sampler in the CASLab*

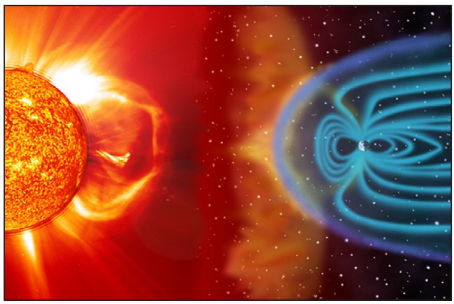
Halley VI Research Station

Electro-Magnetic Quiet Area

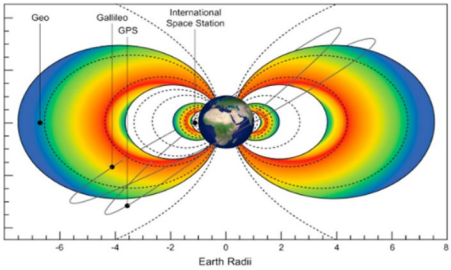
Timing: 2012-ongoing



The Electro-Magnetic Quiet Area (EMQA) at Halley is a region of the station that is packed with very sensitive instrumentation that detects very slight disturbances in the Earth's magnetic field and variations in one of the upper most layers of our atmosphere – the ionosphere. These instruments run automatically throughout the year without the need for human intervention. This season we will be carrying out some minor maintenance on some of the equipment.



▲ *The solar wind pushing on Earth's magnetic field (Image: NASA)*



▲ *Earth's Van Allen radiation belts*

Search coil magnetometer

This instrument is designed to measure ultra-low frequency waves. These waves are generated in space by natural processes during geomagnetic storms and other active periods driven by solar disturbances. Some of the waves are guided along the geomagnetic field and are able to penetrate the atmosphere and reach the ground. We want to find out more about these waves since we think they cause a depletion in the Earth's radiation belts – i.e., we think they remove high-energy charged particles that circulate around the Earth and which cause damage to satellites. The Halley and Rothera search coil magnetometers are part of an international network of magnetometers called MICA-S (Magnetic Induction Coil Array – South). By making measurements over a network of instruments at different locations we can get a better information on where the waves originate, where they propagate to, and thus gain a better understanding on the region in space where they deplete the Earth's radiation belts.

Fluxgate magnetometer

This instrument measures perturbations in the Earth's magnetic field caused by electrical currents in the ionosphere and beyond. Periods of particularly large and variable magnetic perturbations are known as magnetic storms during which electrical power distribution networks across the globe, such as the National Grid, can be disrupted or damaged.

continued ▷

Halley VI Research Station

Electro-Magnetic Quiet Area continued

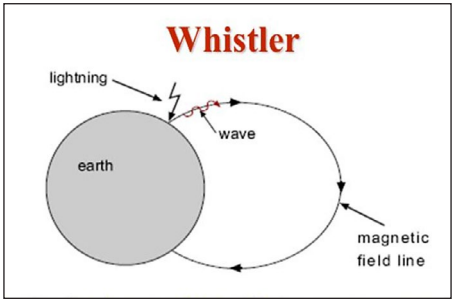
Very Low Frequency (VLF) receiver

The Halley VLF receiver listens to very low frequency radio waves as part of several networks of receivers located all over the Polar Regions. The data gathered by these networks are used by more than 35 institutions around the world to:

- Record and map, in real-time, lightning strikes around the world (WWLLN instrument – University of Washington, Seattle, USA)
- Listen to powerful VLF communication transmitters located in mainland USA, Hawaii, Europe (including the Lake District). This technique uses the upper atmosphere as a gigantic energetic particle detector to find out about interactions between our atmosphere and solar flares, solar eclipses, explosions on other stars, and particles effects from the solar wind – the aurora (AARDDVARK instrument – University of Otago, New Zealand)
- Record electromagnetic waves from space – these waves are responsible for the harsh conditions for satellites as they orbit through the Van Allen Belts (VELOX instrument – BAS, Space Weather Observatory)
- Record and analyse whistling tones originating from lightning in America – this inputs into space weather models used to protect satellites from the harsh radiation environment of space (AWDA instrument – University of Eotvos, Budapest, Hungary).

As part of the Halley Automation Project we also run one Low Power Very Low Frequency (VLF) wave receiver. These instruments provide back up to two of our higher power experiments, known as AARDDVARK and VELOX.

▲ *The Halley VLF receiver*



▲ *Schematic showing the generation and detection of a 'whistler' from a lightning strike at the WWLLN instrument*

MOSAIC

The Mesospheric Ozone Spectral Analysis Instrument Chain (MOSAIC) is a chain of spectrometers running from pole to pole at about the longitude of Europe/Africa. The chain is a joint collaboration between the Massachusetts Institute of Technology, Lancaster University, the South African National Space Agency, and the British Antarctic Survey. This experiment will map the concentration of high altitude ozone from pole to pole and identify the changes caused by space weather. The instrument

continued ▷

Halley VI Research Station

Electro-Magnetic Quiet Area continued

is a passive, low-cost spectrometer for detecting ozone at altitudes of ~100km (about the same height as the aurora). The instrument uses a satellite TV dish and a low noise block converter (LNB) to monitor the line radiation at 11.072GHz generated by ozone. By fitting the shape of the ozone line radiation very accurately we can determine the concentration of ozone with altitude, especially from 50-100km altitude. At these high altitudes the concentration of ozone is affected by chemistry reactions induced by energetic particle impacts on the atmosphere, such as those that cause the aurora.

Riometer

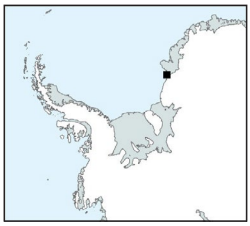
This instrument looks straight up and measures the noise coming from the galaxy at frequencies between 15-50MHz. The galactic noise is almost constant, with just small variations occurring as the stars rotate across the sky each day. Space weather events cause changes in the transmission of the galactic noise signal through the Earth's ionosphere around 50-100km up. We can measure these changes in radiowave opacity using the riometer, and calculate what is happening to the levels of ionization. This information tells us about the geophysical processes going on during solar storms, it indicates the presence of the aurora directly over Halley (even during daylight hours), and indicates the levels by which local radiowave propagation conditions could be affected – like polar radio blackouts. A new version of the instrument will be deployed in 2024, so while there is no photo of it at Halley yet, the pre-deployment version is pictured below.

▲ *The Halley MOSAIC spectrophotometer is located on top of a container*

▲ *A new riometer was deployed in 2024*

Halley VI Research Station

Glaciological monitoring of the Brunt Ice Shelf

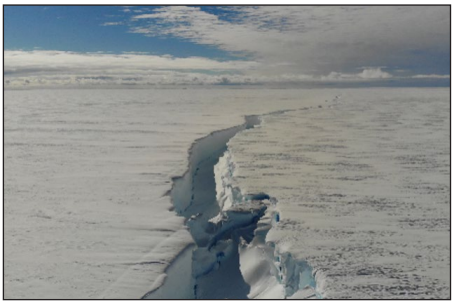


Timing: 2011-ongoing

More information: *https://bas.ac.uk/project/brunt-ice-shelf-movement*

The project uses data from a variety of in situ instruments on the ice shelf, satellite data, and numerical modelling to understand the changing risk to our operations and infrastructure on the Brunt Ice Shelf. In 2016-17, the Halley technical, vehicle, science and operational teams successfully moved the Halley VI station to a new, safer location on the ice shelf.

In February 2021, the first of several large icebergs (now called A74) calved from the northern part of the ice shelf. In January 2023, a second large iceberg (now called A81) calved from the western part of the ice shelf. In May 2024 a third large iceberg calved from north of Halloween Crack (now called A83). As a result of the project, the Brunt Ice Shelf is the most closely and thoroughly observed ice shelf on Earth. A network of 11 GPS instruments measures the deformation of the ice shelf around Halley VI while six additional GPS track the movement of icebergs, sending data to Cambridge every day. Satellite imagery from ESA, NASA and the German Aerospace Agency along with ground penetrating radar and on-site drone footage provide additional information on any growth of cracks to inform operations during the summer season.



▲ *Chasm 1 on the Brunt Ice Shelf*

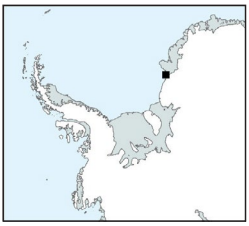
▲ *Maintaining a GPS station on the Brunt Ice Shelf*

Halley VI Research Station

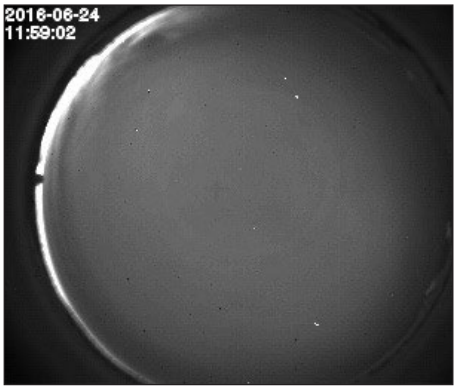
Infrared camera

Timing: 2021-ongoing

More information: *https://www.scar.org/science/angwin/angwin*



This all-sky imager observes infrared airglow emissions at ~87km during the night and operates on a high temporal cadence (an image every 10 seconds.) This enables short period atmospheric gravity waves (thought to carry most of the energy and momentum in the gravity wave spectrum) to be observed. It is operated jointly by BAS and Bath University and is part of ANGWIN (ANtarctic Gravity Wave Instrument Network). Understanding gravity waves in Antarctica is important because they are the main driver of upper atmospheric circulation in this region.



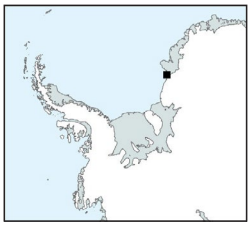
▲ *An image taken by the infrared camera in 2016 at Halley when the station was occupied throughout the winter*

▲ *Inside the experiment enclosure*

Halley VI Research Station

Meteorology and ozone monitoring

Timing: 2012-ongoing



Stratospheric ozone measurements

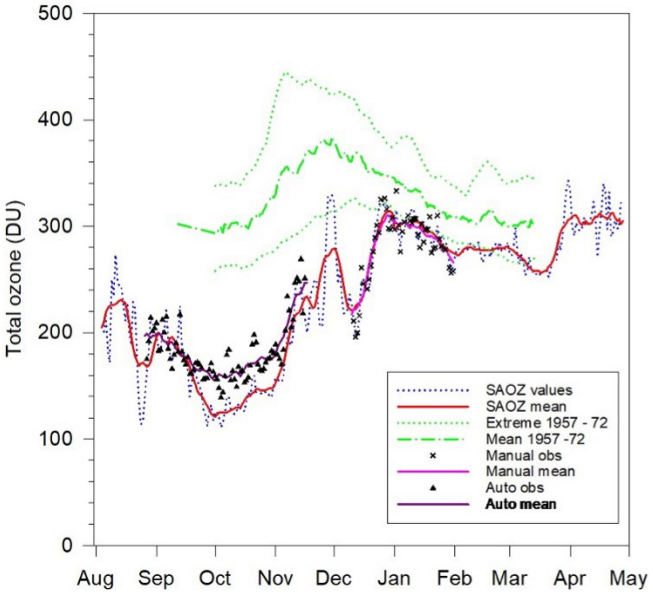
Stratospheric ozone shields the Earth's surface from more than 90% of harmful solar ultraviolet radiation. The 'Ozone Hole' was discovered in 1985 by BAS scientists using Halley's unique data set of Dobson spectrophotometer observations which now spans 60 years. Maintaining these observations, at Halley and elsewhere, is crucial to monitoring the slow recovery of stratospheric ozone following the banning of CFCs.

The destruction of ozone by CFCs in the stratosphere requires extremely cold temperatures, and energy from sunlight. Antarctic ozone therefore begins to decrease in the spring with the end of polar night and recovers during the dark winter months when ozone is replenished by atmospheric mixing.

The automated Dobson is being returned to the UK this summer season for repair and calibration; we still have the SAOZ instrument (Système D'Analyse par Observations Zénithales) running at Halley. This is another instrument that measures stratospheric ozone, as well as Nitrogen Dioxide, which plays a key role in the global ozone distribution.

The discovery of the Ozone Hole is a prime example of the importance of investing in long-term observational science.

continued ▷



▲ *Ozone measurements at Halley in 2023-2024 (AutoDobson, Manual Dobson and SAOZ data)*

For more information, please visit: **bas.ac.uk**

Halley VI Research Station

Meteorology and ozone monitoring continued

Radiosonde launches

This year, we will resume our launch of radiosonde balloons six days a week as soon as personnel return to Halley in late November. These radiosondes measure temperature, humidity, wind speed and wind direction from the Earth's surface, through the troposphere (10km) and high up into the stratosphere (~25km). Each set of measurements provide a snapshot of the state of the atmosphere above Halley at the time of the launch. This information is then fed into global weather forecasting models.

Automated air sampling

We have an automated system for collecting air samples throughout the unmanned winter months. These air samples are collected monthly and sent to the U.S. National Oceanic and Atmospheric Administration (NOAA) in the following summer. They will measure a range of greenhouse gases and atmospheric pollutant, thus maintaining these important global data sets that were first established at Halley in 1983.

Snow sampling campaign

Snow samples are collected that are then melted down for water samples. These are sent to the IAEA-WMO Global Network for Isotopes in Precipitation (GNIP) which has been in operation since the 1960's and is comprised of hundreds of observation stations located around the world.

SPN1 solar radiation sensor

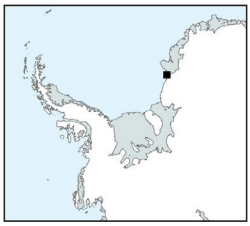
The SPN1 sunshine pyranometer provides measurements of total radiation, diffuse radiation, direct radiation and sunshine duration.

▲ *Automated air sampling system running in the CASLab*

▲ *Radiosonde launch at Halley*

Halley VI Research Station

Skiymet Meteor Radar

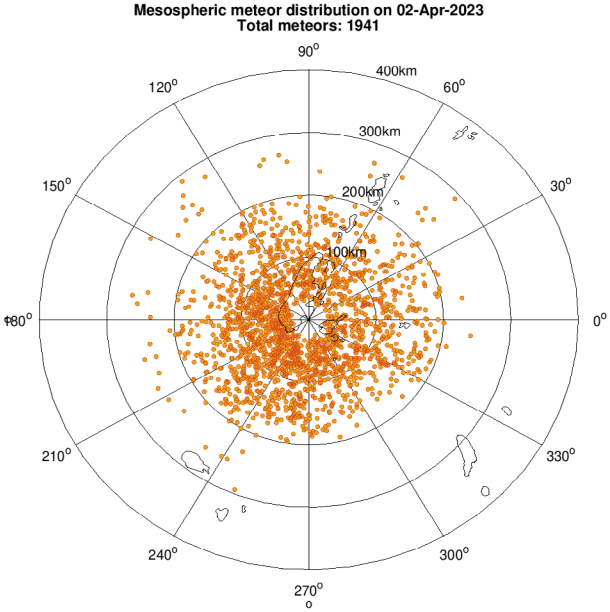


Timing: 2024-ongoing

More information: *https://www.bas.ac.uk/polar-operations/sites-and-facilities/facility/skiymet*

The meteor radar detects the ionised trails of meteors drifting with the winds of the upper mesosphere in a region ~300km in diameter centred over each radar. The radars use these drifts to determine zonal and meridional winds at heights of 80-100km with height and time resolutions of ~2km and 1 hour. Both the radars can make continuous measurements over periods of many years and so are ideally suited to studies of winds, tides and waves. Statistical techniques applied to the individual meteor drifts allow us to determine the parameters of atmospheric tides and the variances and momentum fluxes of gravity waves.

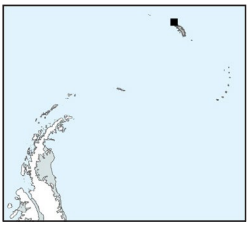
Work includes installing six antenna on telegraph poles and connecting antenna to electronics located in a caboose at Halley. A similar system already exists at Rothera.



▲ *Example output from the Skiymet already in place at Rothera Research Station showing a dot plot of the distribution of mesospheric meteors on 2 April 2023*

Bird Island Research Station

Bird Island marine predators long-term monitoring programme



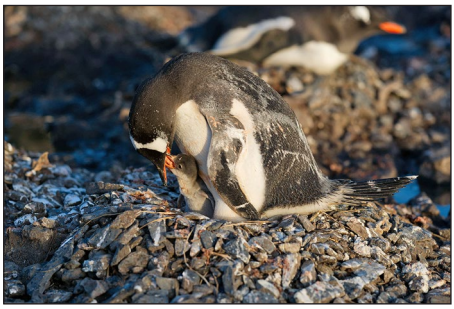
Timing: Ongoing

More information: *https://www.bas.ac.uk/project/higher-predators-long-term-science*

BAS carries out long-term science at Bird Island as part of the CONSEC (Research, Conservation and Leadership in Southern Ocean Ecosystems) programme funded by NC-ALI to understand changes in Antarctic ecosystems. Marine predators are sensitive to processes that are natural (such as climate variability), or brought about by humans (such as fishing). Resighting programmes for ringed or tagged individuals provide data on survival of juvenile, immature and adult animals, age at recruitment, breeding frequency, breeding success etc., which are used in diverse studies of ecology and life history. Species studied intensively at Bird Island include wandering, black-browed and greyheaded albatrosses, northern and southern giant petrels, white-chinned petrels, macaroni penguins, Antarctic fur and leopard seals.

BAS also monitors population size and breeding success of light-mantled albatrosses, gentoo penguins and leopard seals. Other parameters are also collected on chick or pup growth, trip duration, phenology and diet composition that reflect annual changes in food availability in the wider environment. These data help inform the regional conservation management authority for Southern Ocean fisheries, the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), and the Agreement on the Conservation of Albatrosses and Petrels (ACAP), which seeks to achieve a favourable conservation status for the listed species.

▲ *Male fur seals hold territories on the beaches at Bird Island. Fur seals are studied on the special study beach and around the Island*

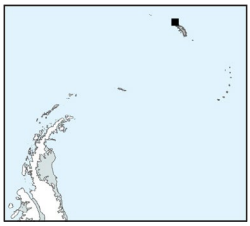


▲ *A gentoo penguin feeds its chick. Gentoo penguin populations are monitored at Bird Island*

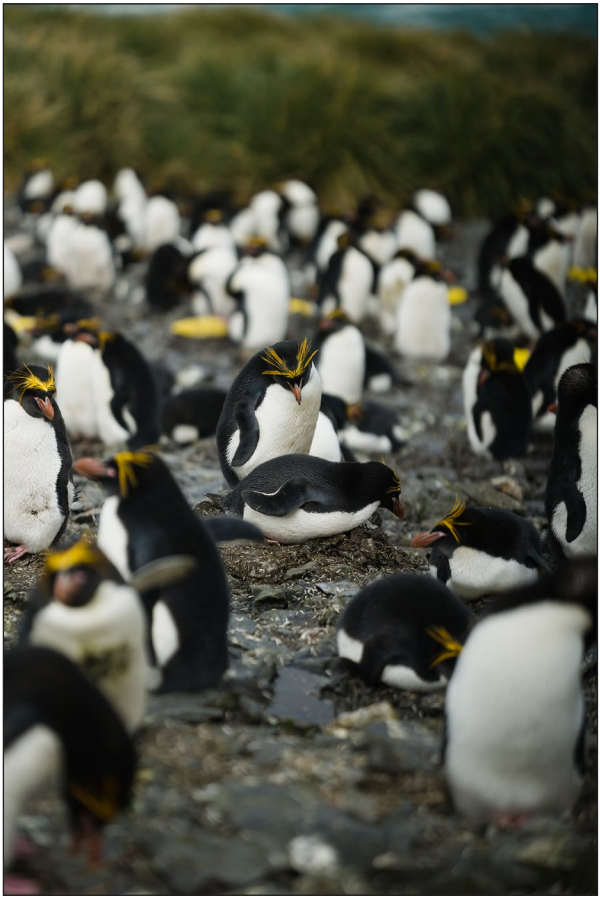
Bird Island Research Station

Penguin weighbridge

Timing: Ongoing



The penguin weighbridge on Bird Island is a long-running programme to automate the attendance and body condition of macaroni penguins during the breeding season. The penguin colony Little Mac supports approximately 420 pairs of macaroni penguins, and the penguin weighbridge is used to determine the attendance patterns (arriving and leaving the colony) and weight of individual birds. This project will install a new RFID system to the weighbridge to update the monitoring system, making it more reliable and with increased data resolution.

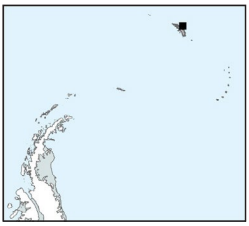


▲ *A macaroni penguin incubates a nest at Little Mac penguin colony*

King Edward Point Research Station

Degradation of kelp material at South Georgia

Timing: June to August 2024



Little is known about the fate of carbon from macroalgae (a.k.a seaweed) when material washes up in the intertidal. This project aims to calculate degradation rates of a dominant kelp species, *Macrocystis pyrifera*, at a sub-Antarctic research station, King Edward Point, on South Georgia via a targeted in situ manipulative experiment and empirical surveys.

Kelp individuals, consisting of *Macrocystis pyrifera*, are regularly cleared from the jetty by boat operators to avoid entanglement into the impeller. This project proposed to tag kelps, which have been cleared from the jetty, attach unique identifications to each kelp plant with numbered tags and deploy them on the beach in the intertidal zone, above the strandline.

We have observed a variety of macroalgae material, including kelp washed up on the strandline from whole plants to fragmented material. Kelp plants from the experiment would regularly be measured to provide a metric of *M. pyrifera* degradation rates across time. Furthermore, at each sampling interval, samples of degrading kelp material will be collected and frozen for subsequent microbial analysis at the Scripps Institution of Oceanography to test the hypothesis of microbial community succession over time.

To quantify the spatial extent of sub-Antarctic detritus at King Edward Point, transects and quadrats will be used to assess the percentage cover and depth of intertidal macroalgae accumulations. This project will complement recent work from Rothera Research Station where the experimental breakdown of macroalgae material has been measured in subtidal benthic habitats.

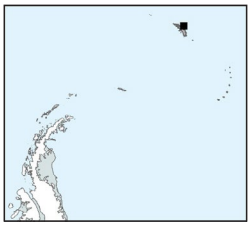
▲ *Accumulations of macroalgae material on the strandline around the intertidal of King Edward Point Research Station*

▲ *An In situ intertidal experiment to calculate the degradation rates of M. pyrifera*

King Edward Point Research Station

Higher predator monitoring at Cumberland Bay

Timing: September 2024 to April 2025



King Edward Point (KEP) Research Station conducts applied science, focused on the sustainable management of the three fisheries within the South Georgia Marine Protected Area; toothfish, krill and icefish. Since 2008 Antarctic fur seals and gentoo penguins, both krill-dependant species, have been monitored at Maiviken in Cumberland Bay as indicators of krill abundance in the ecosystem. Cumberland Bay is an important study site due to its proximity to the northern shelf and shelf-break of South Georgia, where the krill fishery operates.

Standard monitoring methods for krill-dependent predators, used across the Antarctic and sub-Antarctic regions, are implemented at South Georgia. Each summer, the populations of fur seals and gentoo penguins are surveyed on the beaches at Maiviken, and breeding success is assessed based on the number of successfully reared offspring and their average weights. Additionally, fur seal scats are collected year-round, allowing krill to be measured and the small earbones (otoliths) of fish in the diet to be identified.

Data from KEP is reported to CCAMLR (Convention for the Conservation of Antarctic Marine Living Resources) annually. CCAMLR are responsible for setting the annual krill fishery quota in the South Georgia region (sub-area 48.3). The Government of South Georgia and the South Sandwich Islands then apply additional measures to the fishery, such as seasonal closures and No Take Zones. Predator data from KEP also contributes to the understanding of long-term trends in predator populations across the sub-Antarctic region.

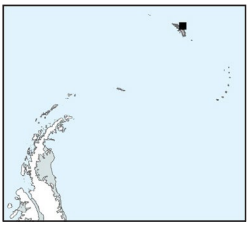
Long-term monitoring of additional species also occurs at KEP. Southern elephant seal numbers are monitored, with recent work suggesting juvenile seals are krill predators. Populations of both species of giant petrel are also monitored. In recent years, quadcopter drones have been introduced to the program, particularly for counting seals. A Darwin Plus funded project is also using a fixed-wing drone around South Georgia, with the long-term aim of integrating this technology into the KEP program.

▲ *Gentoo penguins at the Maiviken colony*

▲ *Drones are used for accurate counts of Southern elephant seals and Antarctic fur seals*

King Edward Point Research Station

Hungry humpbacks: measuring seasonal foraging intensity at South Georgia



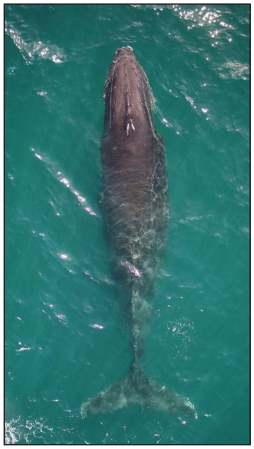
Timing: Mid-January to mid-April 2025

More information: *www.bas.ac.uk/project/hungry-humpbacks*

Whales are the largest krill-predators at South Georgia, yet their impacts on krill stocks are poorly understood. Recently, whale surveys revealed high summer abundance and extended use of South Georgia waters into winter, coincident with a krill fishery. This project measures how whale foraging intensity varies across the feeding season in South Georgia, using UAV-based (drone) measurements of body condition and satellite-tracking of whale diving rates to measure season-specific krill consumption, and inform krill quota-setting for the Subarea 48.3 CCAMLR Krill Risk Assessment (KRA).

The UAV pilots will collect calibrated UAV aerial images from humpback whales near Cumberland Bay. Small-boat surveys will also be conducted near Cumberland Bay, collecting whale sightings, photo-identifications and biopsy-samples. Humpback whales will be instrumented with depth-recording satellite tags, to identify spatial habitat-use and how foraging depth and intensity varies across the feeding season.

This project will provide seasonal krill consumption estimates for humpbacks and generate satellite tracking-based winter habitat use models to describe whale distribution. Both datasets will be integrated into the Area 48.3 KRA and will provide the first baseline measurements of krill consumption in SG waters by whales, across seasons.



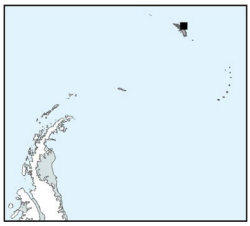
▲ *Drone image of a humpback whale near shore off Sappho Point, South Georgia*

▲ *Humpback fluke off South Georgia*

King Edward Point Research Station

South Georgia groundfish survey

Timing: January to February 2025



Groundfish surveys are conducted biennially to gather data on the abundance and biomass of mackerel icefish. These surveys also provide insights into toothfish recruitment and the abundance, distribution, and ecology of non-target species. Initiated in the 1987-88 season, the survey's extensive dataset enables the investigation of decadal changes in the abundance and distribution of key species. The most recent survey took place in January 2023, the next scheduled for early 2025.

Groundfish surveys play a crucial role in the biomass estimates for icefish stock assessments and provide valuable data on other demersal species, including pre-recruit Patagonian toothfish. This project involves the analysis of the historical survey dataset to investigate spatial and temporal patterns in these populations.

The upcoming survey data will be analysed and presented to the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). Samples collected during the survey, such as icefish and toothfish stomachs, will be analysed at King Edward Point Research Station. The data on icefish diet will enhance understanding of krill variability and the trophic ecology of icefish.

Over the last three surveys, stomach samples of marbled rockcod were collected during the groundfish surveys. Analyses of these samples focused on identifying temporal and spatial differences in diet composition and comparing these findings with mackerel icefish stomach data from the same periods. This information is vital for understanding the recovery of marbled rockcod, a species that is showing notable signs of recovery following heavy exploitation in the 1970s.

This comprehensive project, integrating long-term survey data and contemporary ecological analysis, aims to provide a deeper understanding of the dynamics of demersal fish populations in the South Georgia region. The outcomes will contribute to more effective management and conservation strategies, supporting the sustainability of these crucial marine resources.

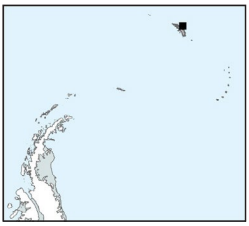
▲ *The fishing vessel, Robin M Lee, at South Georgia preparing to undertake the biennial Groundfish Survey*

▲ *Sorting and measuring of fish and benthic species following a research trawl*

King Edward Point Research Station

Southwest Atlantic Elephant Seal Population Assessment (SAESPA)

Timing: Late September to early November 2024



Southern elephant seal population data in the southwest Atlantic is limited, and at South Georgia is 30-years out-of-date. Consequently, our understanding of how these marine predators are faring, particularly given the impact of climate change, is lacking. Using satellite imagery, we plan to census breeding populations on South Georgia, the South Orkney and the South Shetland Islands and will supplement this census with Remotely Piloted Aerial Systems (RPAS) surveys on South Georgia. This will establish modern baseline and investigate possible southward shifts in populations since the 1990s. Paramount to the success of the wider satellite population census is the determination of when elephant seal breeding numbers peak as this will facilitate the correction of counts made before or after the peak. Identifying this peak will be the focus of the fieldwork for this project, which will involve multiple RPAS flights to collect overhead imagery of elephant seal colonies, primarily at St Andrews Bay.

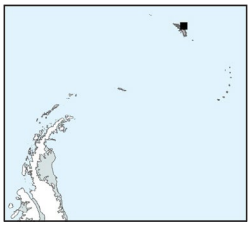
▲ *Sensefly eBee X in flight, Rothera 202*

▲ *Project logo*

King Edward Point Research Station

The ECHO Surveys: long-term monitoring of plankton communities in South Georgia waters

Timing: Year-round



The South Georgia marine ecosystem is subject to natural variability, regional climate change and commercial fisheries. Plankton communities are the foundation of this productive environment, with krill particularly important for many animals. Understanding the seasonal and annual variations in plankton communities provides key data to help interpret changes in marine mammal and seabird populations, as well as understand exploited fish populations.

Since 2001, regular plankton trawling has been conducted in Cumberland Bay, currently carried out every other month from the fisheries patrol vessel *Pharos SG*. These trawls provide data on the seasonal and inter-annual changes in the plankton communities, including krill. The presence of fish larvae, which are abundant in the bays, provides valuable data on the status of fish populations, including the commercially important mackerel icefish.

The ECHO surveys, named after the primary acoustic data collection device, the echosounder, are conducted year-round in the Eastern Core Box (ECB) off the north-east coast of South Georgia. The ECHO surveys follow on from the Darwin Plus funded Winter Krill Project. Every other month four 60km survey transects, running perpendicular to the shelf, are sailed during both day and night. Acoustic data is collected by an EK80 echosounder and whale observations recorded from the bridge. Plankton trawls are conducted each evening, targeted at krill swarms when they have been spotted on the echosounder and environmental data collected through CTD drops.

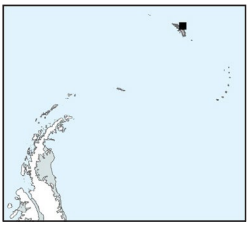
Comprehensive plankton surveys in the ECB will help us understand the variability in krill throughout the year at South Georgia. Data on krill size and abundance aids in interpreting variability in the breeding success of penguins and seals, as well as the presence of whales.

▲ *South Georgia fishery patrol vessel*

▲ *Antarctic krill*

King Edward Point Research Station

Transmission, spread, and population impacts of Avian Influenza on South Georgia wildlife



Location: King Edward Point and Bird Island

Timing: Summer 2024-25

Highly Pathogenic Avian Influenza (HPAI) was first detected in South Georgia in October 2023. The initial cases involved dead brown skuas on Bird Island, but the outbreak quickly spread across South Georgia, affecting a broader range of species, including mammals. Elephant seals, brown skuas and wandering albatrosses were among the most severely impacted. While the situation remains uncertain, there is a risk of a new outbreak during the summer of 2024-25.

This project aims to coordinate systematic sampling across South Georgia, developing on-site testing and sequencing capacities and capabilities to enable real-time monitoring of the outbreak and deeper understanding of the transmission mechanisms. Additionally, the project seeks to correlate patterns in pathogen spread with population-level impacts by combining information on pathogen sequences, host exposure and survival data inferred from immunological data, and long-term monitoring of marine predators around South Georgia.

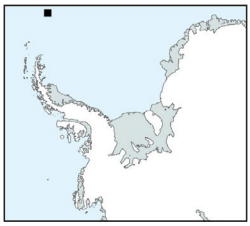
▲ *Elephant seal*

▲ *Brown skua*

Signy Research Station

Changing environmental conditions in Signy Island and their impacts on diatoms in lake microbial mats

Timing: December 2024 to February 2025



Antarctica is experiencing rapid climate and environmental change, and potentially impacting the functioning and productivity of lakes as found on Signy Island. A prominent feature of Antarctic lake ecosystems is the formation of extensive benthic microbial mats in the littoral zones and illuminated lake bottoms that dominate primary production in the lakes. Diatoms are microalgae that occur in diverse assemblages worldwide including Antarctica microbial mats and responsive to changes in environmental conditions through alterations in species composition. However, our understanding of the diversity and ecological function of the diatoms in more recent decades has been limited, further confounded by the taxonomic revisions taking place since the late 20th Century. More recently, some diatom species have also been shown to undergo phenotypic plasticity (changes in shape morphology) in response to a shift in environmental variables.

By monitoring changes in diatom communities, we can gain a better understanding of the degree and nature of ecosystem change on Signy Island, both in the short term and long term to determine the impact of climate change. Several lakes have experienced an increase in nutrients due to rising fur-seal populations since the mid-1970s which presents a natural laboratory to study how diatoms in microbial mats could respond to climatic driven eutrophication in Antarctica in the future.

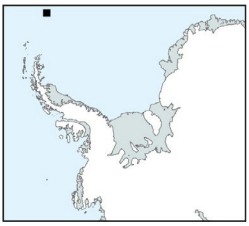
The main objectives of the research project are to characterise the richness and community composition of diatoms within microbial mats in lake ecosystems across Signy Island, and to determine the spatial and environmental drivers of community composition across short and long temporal scales using morphological identification and DNA metabarcoding analyses. Water chemistry will be determined to identify any changes in the lakes since the last measurements that were taken in 2005. Temporal comparisons will be based on modern microbial mat samples collected in different decades and study diatoms from lake sediments to understand how short-term and long-term variations in environmental factors impact diatom diversity and function as well as to better understand diatom evolutionary and ecological processes over recent decades We will also evaluate if phenotypic changes can be observed for selected species using AI-based morphometrics and investigate any links with environmental change.

▲ *Diatoms dominated by Pinnularia australomicrostauron from microbial mats collected from Sombre Lake, Signy Island, 2016*

▲ *Diatoms from Paternoster stream collected from Signy Island, 2016*

Signy Research Station

Signy Island marine predators long-term monitoring programme



Timing: December 2024 to April 2025

More information: *https://www.bas.ac.uk/project/higher-predators-long-term-science/higher-predators-signy-island-penguin-monitoring*

BAS carries out long-term science at Signy as part of the CONSEC (Research, Conservation and Leadership in Southern Ocean Ecosystems) programme funded by NC-ALI to understand changes in Antarctic ecosystems. Marine predators are sensitive to processes that are natural (such as climate variability), or brought about by humans (such as fishing). The data collected annually include population size, reproductive success, timing of breeding and diet composition of predators.

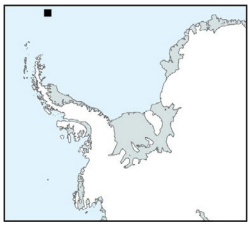
Analyses show that modes of climate variability, e.g. the Southern Annular Mode and the El Niño-Southern Oscillation, affect upper-trophic-level predators, including seals and penguins. The Antarctic is unusual in that scientists and policy-makers from many nations have adopted an ecosystem approach for managing fisheries. One of the programme objectives is to help inform the regional conservation and management authority for Southern Ocean fisheries, the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR). BAS data on southern giant petrels at Signy are also submitted to the Agreement on the Conservation of Albatrosses and Petrels (ACAP), which seeks to achieve a favourable conservation status for albatrosses and petrels, primarily by coordinating and undertaking international activity to mitigate known threats to their populations.

▲ *The South Georgia shag breeds at the South Orkney Islands, South Georgia and the South Sandwich Islands, and is now recognised by taxonomists as a separate species within the blue-eyed shag complex*

▲ *The gentoo penguin is one of three penguin species (Adélie, chinstrap and gentoo penguins) monitored annually at Signy for population trends and breeding success*

Signy Research Station

Spatial and temporal patterns of climate change impacts on vegetation and permafrost across the Antarctic Peninsula and Scotia Arc macroregion



Location: Signy and Rothera Research Stations

Timing: January to March 2025

Since 2000 the warming of the Antarctic Peninsula (AP) paused although it is predicted to resume, as suggested by the extreme events in early 2020. The AP macroregion includes different climatic and biogeographic regions with likely different responses to climate change (CC), highlighting the need for long-term and multidisciplinary studies. This multidisciplinary proposal aims achieve a better understanding of CC impacts on terrestrial ecosystems analysing cryosphere (permafrost, snow), biosphere (vegetation, soils), hydrosphere (permafrost hydrology). Since late 1990s, despite the recent pause in warming, both abiotic (permafrost) and biotic (vegetation) responses are not homogeneus across the AP. Since 2009 the two native vascular plants exhibited striking expansions on Signy Island, increasing >100%. Their success could be due to their capability competing for nutrients and the occurrence of fungal root symbionts. Soil fungi and microbiota have pivotal ecological roles and their potential alterations arising from CC could have substantial effects on ecosystems. Vascular plants expansion could also facilitate invasive plants establishment.

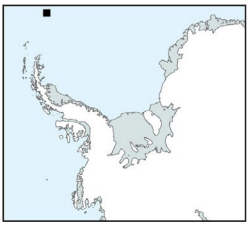
We aim assess whether the climatic and environmental changes occurred since the early 2000s are producing measurable impacts at different spatial and temporal scales on vegetation, permafrost, and soils across the AP macroregion from the South Orkney Islands to Marguerite Bay through a multidisciplinary and international consortium. We will assess the sensitivity of vegetation, soil chemistry and microbiota through long-term manipulative experiments on Signy Island; b) use *Deschampsia antarctica* as a target of major ecosystem changes involving vegetation and assess whether its expansion is associated with changes in its rhizosphere and associated root and soil microbiota; c) quantify permafrost degradation and Active Layer Thickening (ALT) through long-term monitoring and ALT impacts on the hydrology and hydrochemistry of surface freshwaters.

BAS staff will support this project by downloading the ongoing experiments and conduct maintenance of the long-term monitoring network.

▲ *Signy Research Station*

Signy Research Station

Summer-monthly collections of the intertidal bivalve Lissarca miliaris at Shallow Bay, Signy Island



Timing: November 2024 to March 2025

Lissarca miliaris is a small, up to 5mm-long, reddish-brown bivalve that lives on red and brown seaweed in the intertidal of Signy Island. Specimens previously collected between 1972 and 2011 were analysed for growth and reproduction and showed changes in growth performance correlating with a 40-year warming event of air temperatures, suggesting local adaptation to increasing temperatures. They also showed changes in reproductive efforts with more but smaller juveniles being brooded and released. Since 2011 we continued the summer-monthly bivalve collections to monitor further growth and reproductive changes and since 2014 we monitor the annual intertidal, subtidal and terrestrial temperatures, a key environmental factor, with TinyTag temperature loggers. In our annual dataset until 2021, we can see that times with broken winter sea-ice increase, intertidal bivalves are experiencing colder winter temperatures and variation growth rate is linked with variation in temperature.

For the bivalve collections a handful of seaweeds is picked at monthly intervals during the summer season from the stepping stones in 'Shallow Bay' and checked for the presence of the small bivalves. The bivalves (~50 individuals) will be removed either in the field or in the lab from the seaweed and fixed in ~70% ethanol.

The measurements from the TinyTag loggers, deployed at one intertidal, one subtidal and four terrestrial sites, will be downloaded once per year and at the same time have their batteries replaced.

▲ *Lissarca miliaris on seaweed*

RRS *Sir David Attenborough*

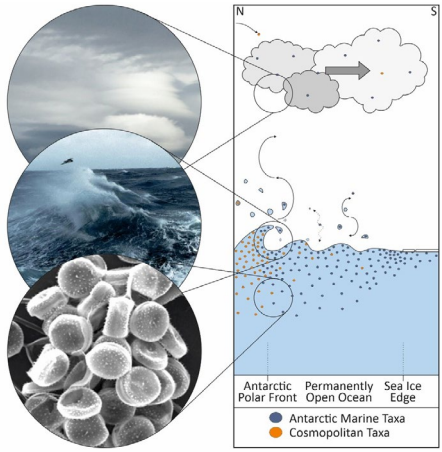
How do marine diatoms end up in ice cores?

Timing: March to August 2025

The presence of diatom microfossils in glacier ice and ice cores has been documented from numerous sites in Antarctica, Greenland, as well as from ice-covered mountain sites, and attributed to entrainment and transport by winds. Recent analysis of diatom microfossils preserved in Antarctic Peninsula ice cores have revealed their potential as a proxy for winds over the Southern Ocean (Allen et al. 2020, Tetzner et al. 2022a,b).

Although there is great potential to reconstruct winds from ice cores, very little is known about the entrainment of diatoms into the atmosphere. Sea spray is considered the main vector for ejecting diatoms from the surface ocean but how varying sea state, wind speeds and diatom productivity in the surface waters affect the entrainment are totally unconstrained.

This project will collect samples from the sea surface, sea spray and air samples to quantify the number and composition of diatoms entrained from the sea surface into low altitude air masses on a latitudinal transect across the Polar Front.



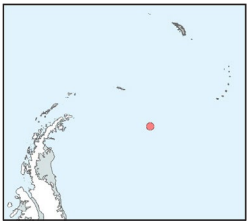
▲ *Diatoms are injected into the atmosphere from the surface ocean via sea spray and transported towards Antarctica in the air and clouds*

▲ *Sea spray over the ship's bow on a Drake Passage crossing*

RRS *Sir David Attenborough*

Polar Ocean Ecosystem Time-Series (POETS) Western Core Box (WCB)

Timing: February to March 2025

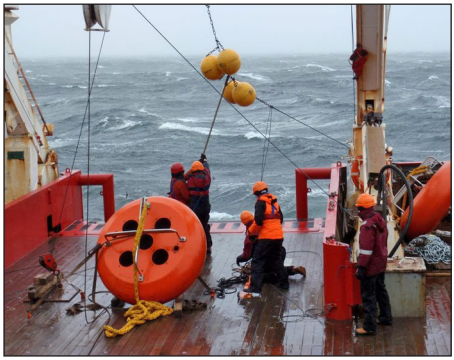


South Georgia is an isolated island in the Atlantic sector of the Southern Ocean. Located south of the Polar Front, the region is bisected by the Antarctic Circumpolar Current, which transports nutrients and organisms from the Antarctic Peninsula across the Scotia Sea to the region.

South Georgia has been identified as a key source of regional biodiversity, potentially supporting anomalously high levels of endemic and range-edge species. Its pelagic ecosystem is extremely productive and intense phytoplankton blooms support a rich food web that includes zooplankton, in particular Antarctic krill, and vertebrate predators (penguins, seals and whales).

Antarctic krill play a central role in the Southern Ocean food web as effective grazers on phytoplankton as well as a key prey item of a wide range of higher trophic predators. Inter-annual fluctuations in krill abundance at South Georgia are significant and have been linked to environmental forcing and reduced predator foraging and breeding performance.

The WCB undertakes an acoustic survey for krill, net and environmental (CTD) sampling and deploys and recovers several moorings for all-year round monitoring. These data are required to understand the long-term variability in krill biomass at South Georgia and the influences from climate variability, fishing pressure and predation.



▲ *Mooring deployment*

▲ *Adult female Antarctic krill (Euphausia superba)*

RRS *Sir David Attenborough*

Scientific UK: Icelandic collaboration aboard the SDA through early-career-researcher training and networking (SKILLSET)

Location: Harwich to Madeira (via Portsmouth)

Timing: October 2024

SKILLSET will make use of UK polar research infrastructure to foster scientific collaborations between UK and Icelandic polar scientists. During the Harwich to Madeira passage, 10 early-career researchers (ECRs) from the UK and Iceland will participate in a training and networking cruise aboard the SDA between Harwich and Madeira.

The interdisciplinary program, led by experienced BAS scientists, includes: ship instrumentation training, scientific talks, biogeochemical laboratory work, networking sessions, science communication, road mapping future collaborations, data management training, higher predator surveying, as well as generally experiencing life offshore. A full range of the SDA's capabilities and instrumentation will be explored: meteorological instruments, vessel mounted acoustic doppler current profiler (VMADCP), automatic underway instrumentation, uncontaminated water sampling system, the laboratory facilities, acoustic mapping and salinometers. Participants will apply what they've learnt about atmospheric, physical oceanographic and biogeochemical observation, through mini-projects around ocean-atmosphere interactions contributing to the cruise report.

This is the first time the SDA will be used for a bespoke training cruise, targeting ECRs for whom at-sea research vessel experience will have the greatest impact. Gaining such experience remains a barrier to careers in polar and often scientists find themselves 'in at the deep end', learning things as they go on cruises. We hope that lasting science partnership will result from this collaboration between the UK and Iceland national committees of 'Association of Polar Early-Career Scientists (APECS): UK Polar Network and APECS Iceland.

▲ *RRS Sir David Attenborough*

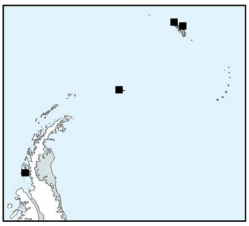
UK POLAR NETWORK

APECS
Association of Polar Early Career Scientists
Iceland

▲ *Logos of UK Polar Network and APECS Iceland, between whom SKILLSET is a collaboration*

Multiple locations

Highly infectious avian influenza (HPAI) monitoring around BAS stations

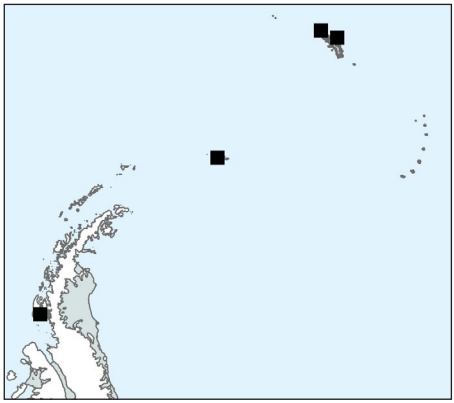


Location: Rothera, Bird Island, King Edward Point and Signy

Timing: October 2023 onwards

Highly Pathogenic Avian Influenza (HPAI; H5N1 strain) was first detected in South Georgia in October 2023 and subsequently at Rothera in March 2024, thus being the first confirmed cases of HPAI in the sub-Antarctic and Antarctic regions. The initial cases were limited to brown skuas on Bird Island, but the outbreak quickly spread across South Georgia, affecting a broader range of species, including marine mammals. Elephant seals, brown skuas and wandering albatross were among the most severely impacted. At Rothera, analogous to the outbreak in South Georgia, the initial cases were brown skuas on Lagoon Island, one of the nearby islands in Ryder Bay, and later spread towards Anchorage Island. No affected mammals were observed around Rothera to date.

While the situation for the upcoming season remains uncertain, there is anticipation of a new outbreak during the summer of 2024-25. The BAS HPAI strategy aims to closely monitor any potential outbreaks of HPAI around the BAS Antarctic stations, with follow-up accredited testing of the virus strain and full genome sequencing. Sampling of deceased birds and mammals enables us to study the pathogen spread across Antarctica, monitoring any genetic mutations in HPAI that may occur and helps us to understand the effect on local bird and mammal populations. Additionally, we will be taking occupational hygiene and environmental samples to monitor any potential risk of human exposure and determine how long the virus can survive in soil and water.

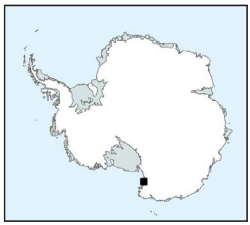


▲ *Map of the Antarctic Peninsula with KEP, Bird Island, Signy and Rothera*

▲ *Brown skua at Rothera point, April 2024*

Other collaborative projects

Nansen Ice Shelf drilling, oceanography and sampling



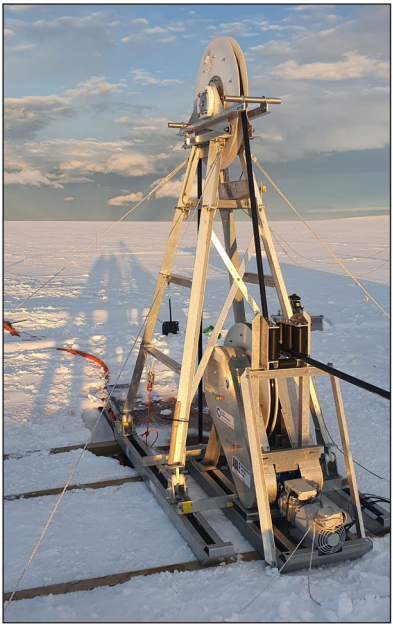
Location: Jang Bogo Station, RV *Araon*

Timing: November 2024 to February 2025

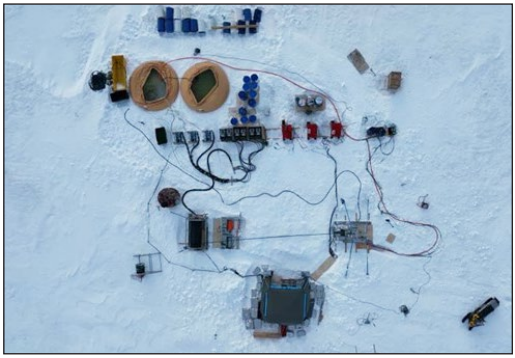
This project is in association with and supported by the Korea Polar Research Institute (KOPRI).

A hot water drill will be used to melt snow and ice at the field site and this water is used to melt a 30cm hole through the 1,200-1,300m-thick ice shelf. The hole will eventually freeze up again once the drilling is completed (only water is used to drill the holes, no other drilling fluids are used). An oceanographic Conductivity-Temperature-Depth (CTD) will be used to measure the ocean properties. Sea water samples of up to 12 litres will be collected. Sediment samples, 6cm in diameter and up to 3m long will be recovered from the seabed. Finally, a permanent oceanographic mooring will be deployed into the underlying ocean to monitor ocean properties, with data logged at the surface.

This work will enable ocean properties and ice/ocean interactions to be measured and monitored, with samples allowing additional measurements to be conducted. Using these data and samples, the ice history, ocean circulation, ice/ocean interactions and the impacts of influxes of subglacial melt water or surface melt water on ice-shelf melting can be assessed.



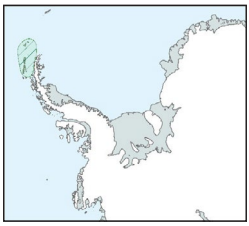
▲ *Drill tower on the Dotson Ice Shelf*



▲ *Drone view of hot water drill site layout during drilling*

Other collaborative projects

Safeguarding Antarctic krill stocks for baleen whales



Location: West Antarctic Peninsula and Elephant Island/Hans Hanson

Timing: April 2024 to March 2026 (fieldwork only is March 2025)

Antarctic krill *(Euphausia superba)* are food for a wide variety of animals, including other zooplankton, squid, fish, birds and marine mammals. Interactions between krill and its predators structure Antarctic marine ecosystems. However, krill are also the focus of a commercial fishery.

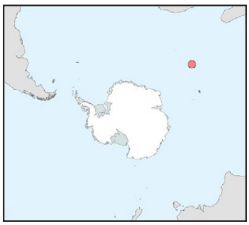
To conserve biodiversity and improve protection of natural environments, we urgently need to increase our understanding of how krill, whales and the fishery overlap in space and time, so that we can develop our capacity to forecast these interactions. This is particularly urgent given changes in krill abundance and distribution attributed to climate change, the requirement for a sustainable krill fishery, and the ongoing recovery of whales from historical exploitation.

Our team will be working from a small research vessel to deploy bio-logging tags on whales in a key fishing ground around the Antarctic Peninsula, enabling us to monitor individual whale movement and feeding behaviour. By tracking whales live, we plan to map krill distribution in 3D using acoustic systems fitted to a small research vessel and an autonomous surface vehicle. These small vessels will enable us to survey the krill at a much finer resolution than typical surveys. We aim to characterise the krill swarms preferred by foraging predators and identify the extent to which whale foraging and the krill fishery may overlap.

▲ *Fin whale*

Other collaborative projects

Westerly winds and the Southern Ocean CO_2 sink



Location: Île de la Possession, Crozet Island

Timing: October to December 2024

The capacity of the Southern Ocean to absorb anthropogenic CO_2 has been limited (according to some models) by an observed increase in the strength of the Southern Hemisphere Westerly Winds (SHW) which is drawing CO_2-saturated waters back to the surface. This proposed positive climate feedback between winds and CO_2 means that the ocean may no longer function as a net sink of CO_2, driving up atmospheric greenhouse gases and accelerating rates of global warming. Thus, reconstructing past changes (and the range of natural variability), in the strength and position of the SHW, and evaluating the performance of the conflicting models, is now a major priority for palaeoclimate science. We have instigated a series of projects studying the history of the SHW around the Southern Ocean to reconstruct past wind strength from peat and lake sediment records. In this project we are sampling peat cores from the west coast of Île de la Possession. These will be radiocarbon dated and analysed for proxies for past wind strength.

▲ *Field team collecting a peat core on a subantarctic island*

Feedback and further information

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

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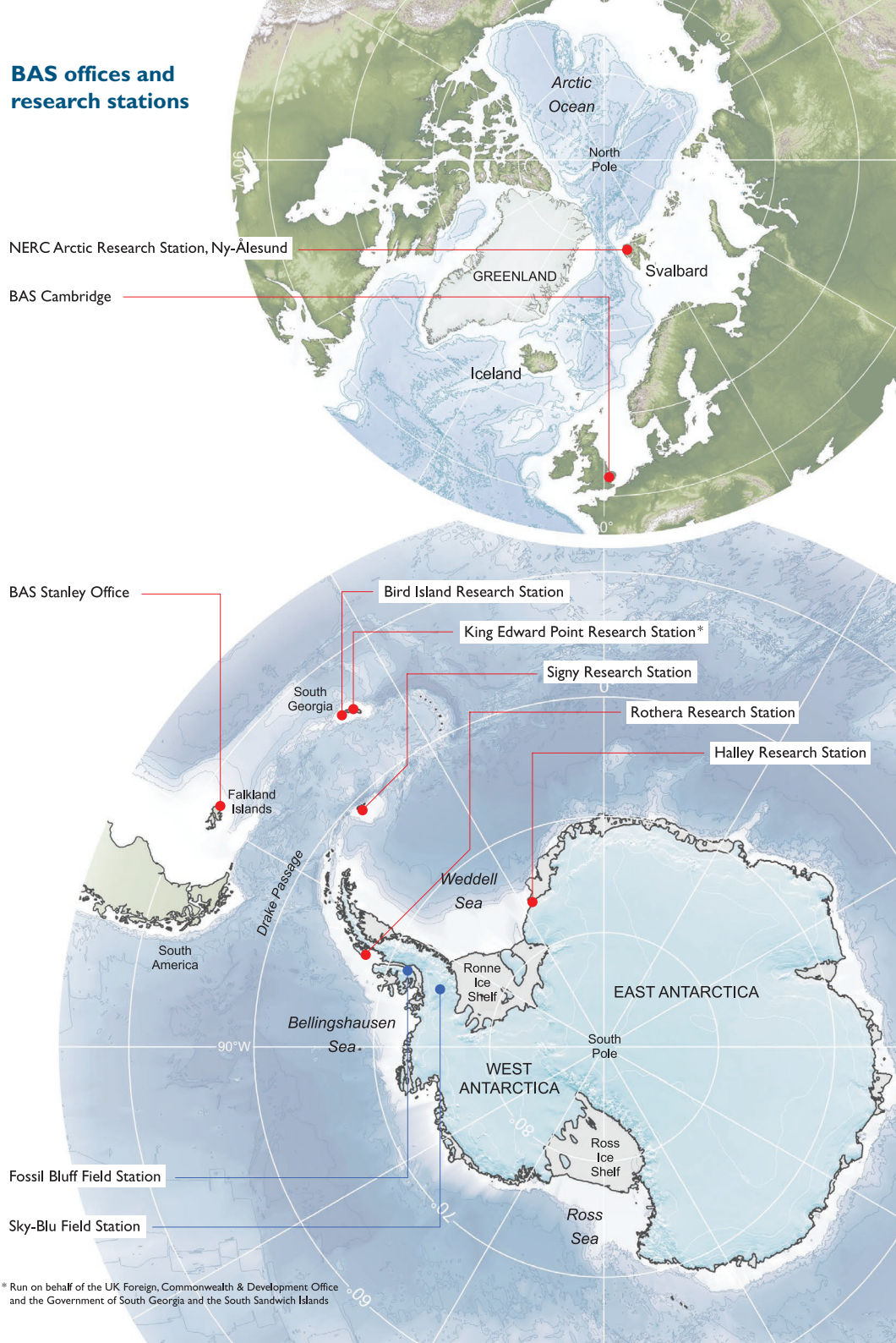
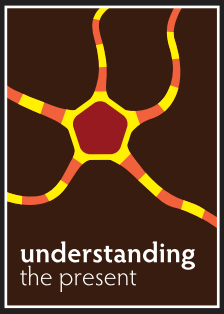


* Run on behalf of the UK Foreign, Commonwealth & Development Office and the Government of South Georgia and the South Sandwich Islands



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