



Research Projects 2007

Polar Research



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Polar Research

Polar research is important for an understanding of the world we live in. Changes in the global climate are noted first and are greatest in the polar regions.

Both polar regions have undergone changes in the last few years. In the Arctic, these are temperature rises in eastern Siberia and north-west North America, melting of ice from Greenland, reduced summer ice cover in the Arctic, and some thawing of permafrost. In the Antarctic, it is mainly the Antarctic Peninsula that has been affected by higher temperatures and the melting of ice.

According to most researchers today, the Arctic is one of the areas on earth where the climate change will be most evident. This change will have direct effects on the population in the Arctic and will at the same time have an impact on the entire global climate system. But there are great uncertainties about the way it will evolve, and research is of great importance.

Swedish research in the Arctic has a long tradition. It stretches back to the middle of the 19th century when Swedish geologists, geographers and biologists carried out seasons of field observations on Greenland and Svalbard.

Since then, Swedish researchers have taken part in both large and small ice core drilling projects on the ice sheet in Greenland. The construction of the Swedish ice breaker Oden in 1989 gave Swedish Arctic research a unique platform which is used by researchers from Sweden and other countries in all disciplines, ranging from oceanography and geology to atmospheric research.

In Swedish and foreign expeditions, Swedish researchers have also studied the ecology of the Arctic tundra in Russia and Canada. They have also been active in research projects in Sweden which can be characterised as subarctic research. This research has been mainly conducted around the field stations at Tarfala and Abisko in the very north of Lapland but also in other places, for example in the Bothnia Bay.

Swedish research in Antarctica began later, first at the turn of the 20th Century, but now there are Swedish research stations, Wasa and Svea, in Antarctica. They conduct research mainly in glaciology, meteorology, geology and botany.

The Polar Research Secretariat is a Swedish authority that organises and leads major expeditions to the Arctic and Antarctic. Parallel with this, the Swedish Research Council also has the mandate to plan Swedish polar research. Since 2007 there is a cooperation agreement on Polar research between the Swedish Research Council, The Polar Research Secretariat and the National Science Foundation in the US. The Polar Research Secretariat, The Swedish Research Council and Formas are the most important fund providers for Swedish polar research.

This year, 2007, is the start of the International Polar Year IPY for which the Swedish Research Council has been given a special responsibility in coordinating the polar research inputs. In order to enhance the opportunities for Swedish participation in research consortia under the umbrella of IPY, the Swedish Committee for the International Polar Year has called for grant applications by Swedish researchers for projects that form part of international consortia endorsed by the IPY International Programme Office.

During 2007, the Swedish Research Council and Formas, together with the Swedish Space Board, have also called for grant applications for projects concerning sustainable development, the aim being to support interdisciplinary research with the focus on the climate, including research concerning ongoing changes and adaptations in the northerly polar regions.

Formas, together with The Swedish Research Council, has compiled this catalogue of their research projects relating to the polar regions (inclusive of subarctic research in Sweden).

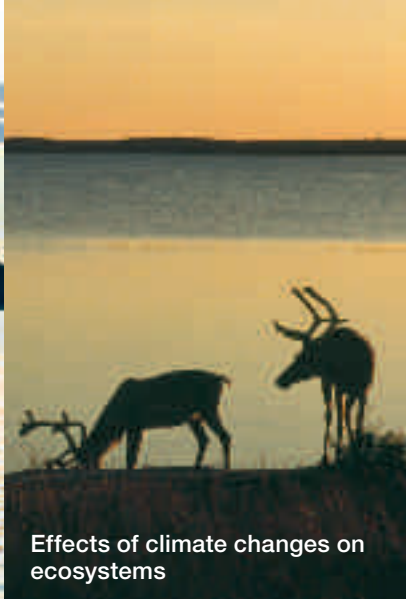
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Effects of climate changes on the community



Effects of climate changes on ecosystems



Sea, snow, ice, atmosphere



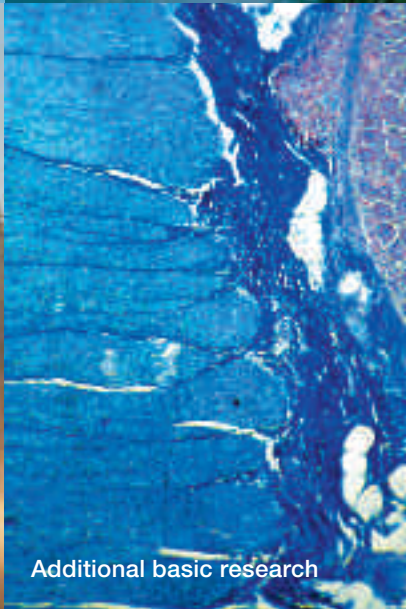
Systematic monitoring



The circulation and effects of pollutants



Greenhouse gas balances



Additional basic research



Paleoclimatology

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Sea, snow, ice, atmosphere



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Formas

Research grant 2004–2006

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Exchange of carbon dioxide between the Baltic Sea and the overlying atmosphere

Is the Baltic Sea a source or sink for carbon dioxide? There are still large gaps in our knowledge of the significance of the ocean for the carbon cycle, and especially the factors that govern exchanges between the ocean and the atmosphere. An inland sea such as the Baltic has great significance at relatively high latitudes. Within the project, concentrations of carbon dioxide in the surface water are measured to the east of Gotland. Measurements are made using a buoy. On the basis of these measurements it will be possible to discern how the atmosphere affects the cycling of carbon dioxide and to describe these processes in a model. The descriptions will then be used in an oceanographic model to determine the significance of the Baltic Sea in the carbon cycle.

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Formas

Employment as Research assistant and research grant 2006–2007

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Estimating aerosol optical thickness over ocean areas

Aerosol particles in the atmosphere affect the incoming solar radiation and climate on Earth. At higher particle concentrations, more of the incoming solar radiation is reflected back into space. The latter also holds when the particles grow larger because of increased relative humidity. Estimation of the degree to which anthropogenic aerosol particles affect the radiation balance of the Earth requires better knowledge of the natural state. Preliminary results show that there is a relationship between the dispersion parameter aerosol optical thickness (AOT) and wind force in the lower part of the marine troposphere. The objective of the project is to develop a parametrisation of AOT as a function of wind force. The researchers are also investigating what individual influence ocean salinity and relative humidity have on elevated AOT. Through better understanding of the natural processes, the effect of continental aerosols on the marine troposphere can be estimated with greater accuracy.

Research agency:

Formas

Research grant (PhD) 2004–2007

Modelling of future sea level changes caused by contracting glaciers

Global sea levels have risen by 10–20 cm over the past century. New studies show that “small” glaciers outside Antarctica and Greenland make a significant contribution to the present rise in sea level. The objective of this project is to model future

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changes in these “small” glaciers and their contribution to global sea level changes over the coming decades. The project uses the most recent climate projections to estimate future glacial melting. A new method is developed to simulate volumetric changes in glaciers with the help of available climate projections for temperature and precipitation. The results will have both scientific significance (for e.g. glaciological and climate related modelling) and practical significance, and will serve as the basis for political decisions, since sea level changes have societal, economic and ecological consequences.

Research agency:

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Research grant 2005–2007

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Ice conditions, heat fluxes and circulation in the Arctic Ocean

The Arctic ice cap is dependent on the existence of a surface layer with fresher water that maintains a low temperature and prevents heat from underlying water masses reaching the ice. The extent of this fresh water layer varies, and the project will quantify how these variations affect the ice. Another part of the project is to study the relatively warm water from the Atlantic that flows into the Arctic Ocean. The changes will be analysed using a simplified model for the way in which the large scale wind field brings in warmer water from the Norwegian Sea. Another aim is to try to find the passage in the Lomonosov Range below the Arctic Ocean where water flows between the two largest basins of the Arctic Ocean.

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Research grant 2005–2008

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The significance of biogeochemical processes for the carbon dioxide systems of surface waters

The marine climate in the Arctic is changing, with increased surface water temperature and reduced ice cover. Part of a greater understanding of the complex system is to investigate how large the carbon dioxide contribution is to/from the surface waters in the shallow shelf and coastal seas and lakes in the Arctic. The project is contributing with the first high resolution measurements of carbon dioxide concentration and dissolved oxygen in the surface waters of the Arctic Ocean and Bering Sea. Biological production in the shallow shelf and coastal seas in these polar regions is dependent on seasonal freezing and thawing of the sea ice, and the inflow of river water. These processes vary greatly with atmospheric and marine conditions, which make them sensitive to climate changes.

Waves and aerosol particles in the mesosphere in the Arctic and Antarctic

Noctilucent clouds appear in the summer over the Arctic at a very great height. The occurrence of these clouds varies greatly from year to year. Atmospheric waves control the temperature where noctilucent clouds are formed, and the project intends to study how these waves are affected by changes in atmospheric wind systems from year to year. The project will also investigate how waves and other natural atmospheric variations influence the recently discovered particle layers at great height above North Sweden, to find how they are formed and what they probably consist of. These particles are believed to facilitate chemical reactions in the atmosphere, and also to influence remote sensing and analysis by satellite. Comparisons will also be made with atmospheric variations above the Antarctic.

Climatic processes in the Arctic atmospheric boundary layer

Models of the effect of climate in the Arctic are unreliable because we do not fully understand the energy balance above the sea. In winter, snow and ice isolate the atmosphere from the relatively warm sea water. In the summer, meltwater lakes are formed which control temperature and keep it around freezing point. Large scale local evaporation also gives rise to low clouds which may become “whiter” and reflect more sunlight if the quantity of aerosol particles in the atmosphere from biological activity increases. The project will increase understanding of these and other processes in the lower Arctic atmosphere by using observations from Arctic expeditions in order to improve current climate models.

ASCOS – the significance of aerosol particles for the occurrence of clouds north of the Arctic ice margin

The biologically very active ice margin and the open crevasses inside the pack ice play an important role in cloud formation in the Arctic. At the ice margin, dimethyl sulphide is emitted which can be converted into material for the growth of airborne particles into condensation nuclei for water vapour in the air. Open crevasses inside the pack ice, which emit particles in the form of algal fragments, bacteria and viruses, have been found to be another surprising source of condensa-

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tion nuclei. The project will give detailed information on the sources of particles and their capacity to form cloud and fog droplets. These results are essential for the understanding of the Arctic climate, responses to climate changes, and possible feedbacks where the melting of ice may result in increased cloud formation that prevents heating by sunlight.

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Research grant 2006–2008

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Global climate models: Processes in snow and forest

One weak point in global climate models is the description of what happens to snow in the vast coniferous forest belt. Of the snow that falls in dense coniferous forests, a large proportion sticks to the crowns and evaporates. Evaporation from snow on open fields is much lower. The aim of this project is to study and develop algorithms for processes in existing models in this field, partly by testing climatic data from several climatic zones. The increased knowledge will be used to improve global climate models, calculate runoff and predict weather.

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Research grant 2006–2008

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The Arctic Project: The life cycle of aerosols in the Arctic boundary layer and its significance for aerosol-cloud-climate interactions

Both aerosols and clouds are important components of the climate system, but, in contrast to greenhouse gases, they have almost exclusively a cooling effect. Aerosols can contribute to cloud microphysics so that they are whiter and reflect more sunlight. At the same time, the cloud is the most important mechanism for removing aerosols from the atmosphere. The aim of the project is to understand this fascinating interplay and the processes which govern the life cycle of aerosols in the Arctic. One of the tools used will be aircraft to observe how aerosols and cloud properties vary with altitude.

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Research grant 2006–2008

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Meltwater variations of Vatnajökull – an uninvestigated Holocene climatic sensor in the North Sea region

Europe's largest glacier, Vatnajökull, consists of several active glacier tongues which can act as "climatic feelers", since their size and meltwater quantity are governed by precipitation and temperature. The objective of this Swedish-Icelandic project is to drill and analyse sediment cores from the lake

Lögurinn that drains one of the most active glacier tongues. The climatic conditions which the sediments reveal will reconstruct the glacial/climatic history of the Vatnajökull area. Examples of the questions to which answers are sought are whether Vatnajökull is a relict from the Ice Age or relatively young, and in such a case what type of climate change has created this mighty glacier complex.

The Arctic Basin – origin and development

The bedrock in the northern ice-covered polar regions is largely uninvestigated. Two basins, the Eurasian and the Amerasian, dominate the polar regions and are separated by the long submarine Lomonosov Ridge. The project is studying the old eroded Palaeozoic and Precambrian mountain chains in the northern hemisphere (e.g. the Caledonids in Scandinavia) which extend towards the north. Do they cross the Lomonosov Ridge and return along the margin of the Amerasian Basin? One dimension of this research is the wish by countries to stake a claim to large areas of the High Arctic, on the basis of geological knowledge, for future energy extraction. The project may therefore acquire significance in the UN Commission on the Law of the Sea.

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Research grant 2006

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Development of the climatic history of the Arctic Ocean: an Ice Age puzzle

The accumulated sediments on the floor of the Arctic Ocean are a unique climatic and environmental archive. The project will collect and study data from two ice breaker expeditions, among them that with Oden to the so far uninvestigated areas of the Lomonosov Ridge to the north of Greenland. A submarine vessel will be used there for the first time in the central Arctic to obtain detailed information on the sea floor. With geophysical measurements and geological core sampling, sediment archives from the Amerasian and Eurasian Basins will be linked and will contribute to the “Ice Age puzzle” in understanding the development of the climatic history of the Arctic Ocean.

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Research agency:
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Research grant 2007

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Circulation and transformation of Atlantic water and deep water in the western part of the Arctic Ocean

In the global thermohaline circulation, warm surface water in the Atlantic is transported towards the north where it is cooled and transformed into heavier deep water that flows towards the south along the sea floor. In the area just to the north of Greenland, there is presumably a deep connecting channel between the two large Arctic deep water basins. The project will map the sea floor and, on the basis of this new “map”, oceanographic observations will identify and determine the flows of various water masses. One interesting question is whether there is an outflow of deep water from the Amerasiatic Basin in this area.

Research agency:
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Research grant 2007

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Climatically controlled changes to glaciers on Vestfonna, Svalbard – processes and modelling

The glaciers on Svalbard and the rest of the world have retreated over the past one hundred years. Increasing flows of water inside and out of the glaciers affect the global sea level, but also sediment transport and the availability of fresh water. The project is studying Vestfonna, an 8,000 km² ice cap on Svalbard, in order to model and estimate future changes of the glacier’s mass balance on the basis of predictions from global climate models. The objective is to offer modern modelling tools for assessing the effect of climate changes on Arctic glacier systems.

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Research grant 2007–2009

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Modelling of variations in the climate of the Arctic Ocean, with the focus on changes in the sea ice

In the project we will investigate climatic variations in the North Sea and Arctic Ocean during the 19th and 20th centuries with the aid of a high resolution coupled ice-sea model. The aim is to acquire a better understanding of the physical processes that govern ice-ocean interactions in the Arctic. We will make a special investigation of how the inflow of warm water from the Atlantic and Pacific affects the reduction in ice which has been observed over the past 20 years, and how this inflow will change in a future climate.

Primary emissions of aerosol particles

The project will measure emissions of primary aerosol particles in three environments; the marine environment in the Arctic, an urban environment, and the environment above the Amazon region. To do this, we use micro-meteorological methods that give a direct estimate of the aerosol flux. Our intention is to improve and develop new detailed parametrizations, especially in the size ranges where the aerosol has the greatest relevance for climate. In this way, we are hoping to help improve predictions of climate and air quality.

The significance of particulate organic matter for cloud formation in the Arctic from a molecular perspective

The overarching aim of the project is to reduce the uncertainty of climate models in the Arctic. An interdisciplinary approach at molecular level will study the coupling between microbiological life at the sea surface and clouds and fogs north of 80° Latitude. With a set of laboratory experiments on material collected during previous ice breaker expeditions to the North Pole, the project will be able to provide detailed information on the origin of condensation nuclei and on the fundamental processes for their capacity to form cloud and fog droplets.

ASCOS – boundary layers and boundary layer clouds in central Arctic

With the aid of instruments on ice and the ice breaker, we are planning detailed observations of a vertical column, extending from a few hundred metres below sea level, through the ice and the sea surface, up to several kilometres in the atmosphere. The aim is to understand the interplay among various processes that are of key importance for climate: atmospheric turbulence, radiation, aerosol particles and cloud microphysics. The fundamental objective of the project is to improve modelling of the Arctic climate, so that better projections may be made of future climate changes.

Denitrification, dehydration and stratospheric cloud formation over the Arctic and Antarctic

Stratospheric clouds are formed at an altitude of 16–27 kilometres above the winter pole. Ice particles from these clouds

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Research agency:
The Swedish Research Council
Employment as Research

**assistant incl. research grant
2007–2010**

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may bring with them nitrogen that normally binds to reactive compounds and prevents these from participating in ozone degradation. The result of this process is therefore that more ozone can be destroyed in catalytic reactions. The project intends to study the formation of ice particles and their significance for denitrification and the removal of water, both with the aid of satellite measurements and by means of theoretical modelling.

Research agency:

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**Employment as Research
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2007–2010**

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**Glacial-interglacial variability in the deep sea
circulation of the Arctic Ocean and its influence
on quaternary ice age cycles**

Increased inflow of fresh water to the Arctic may give rise to a collapse of the thermohaline circulation in the North Atlantic – with dramatic climatic changes as a consequence. Geochemical changes in the composition of sediment can reveal variations in the oxygenation and origin of bottom water. In this project, sediment cores taken by the ice breakers Healy and Oden will be analysed with the x-ray fluorescence scanner. In this way, the project may give a picture of how the circulation has changed during the ice age cycles.

Research agency:

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Council**
Research grant 2007–2009

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**The effect of climate change on the surface
layer of polythermal glaciers**

The project will study the processes and mechanisms that govern temperature distribution in a polythermal glacier and its response to changes in the climate. The project will investigate the cold surface layer of two glaciers in Lapland under different local climatic conditions. Data from the field investigation will be used in developing and verifying a physical model of temperature distribution in a glacier. The model will enable estimates to be made of the response of the glacier to future climate changes.

Research agency:

**The Swedish Research
Council**
**Post-doctoral scholarship
2007–2009**

**Inflows of fresh water to the Arctic Ocean –
wind effects on the climate**

It has recently been discovered that the exchange of heat and fresh water between sea and atmosphere has a great influence on wind-driven water transport, the Ekman transport. This study will make use of large quantities of data from the North Sea in estimating how large is the effect of this new discovery. How large will be the Ekman transport of fresh

water from the Norwegian coastal current to the Atlantic water when the new mechanism is included in the calculation? How is transport affected by various wind climates? And how sensitive is the system to a higher fresh water content in the coastal current?

The ozone layer and UV radiation in a changing climate – ORACLE-03

It is well known today that the ozone layer in the stratosphere has been partly destroyed by the chlorinated compounds (Freons) which humanity has released into the atmosphere. Emission of Freons is today prohibited in most countries, but the chlorinated compounds that can destroy ozone will persist in the atmosphere for several decades. The key factor that governs the amount of ozone that is destroyed is the quantity and composition of stratospheric cloud in the polar regions (PSC). So far, PSC have occurred to a lesser extent in the Arctic than in the Antarctic, and there has been less ozone depletion there. But the increasing amounts of greenhouse gases in the atmosphere are expected to cause more extensive cloud formation in the stratosphere and more ozone degradation. In this project the ozone layer above the Arctic and Antarctic will be investigated. The project is part of the International Polar Year IPY.

The future and status of the High Arctic cryosphere

The way the global heat regulating system functions is that excess energy is transported to the polar regions in the endeavour to balance temperature differences between the poles and tropics, and it is probable that the greatest warming will occur in the polar regions. In this project the status of the Arctic ice systems will be investigated. The aim is to make a long term prediction of how ice volumes will change and how this may influence sea levels and indirectly the climate systems in the Arctic, with relevance to the delicate conditions for flora and fauna and the harsh living conditions of Arctic people. The project is part of a major project KINNVIKA which is part of the International Polar Year IPY, which will coordinate research and logistics on Nordostlandet in Svalbard.

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Microphysics and chemistry for atmospheric ice particles and water droplets

In this research project, a study is made of the way in which ice particles are formed, and the way in which ice particles and water droplets influence the chemical composition of the atmosphere. Particles in the atmosphere have a strong influence on the earth's climate. These particles disperse light from the sun and infrared radiation from the earth. They also influence cloud formation in the atmosphere. Ice particles and water droplets also have an effect on chemical processes. One important component in the formation of an ozone hole is the presence of polar stratospheric clouds. In this research project, experimental studies are made to increase understanding of a) reactions that occur on the surfaces of ice particles and water droplets, b) the processes which result in the formation of ice particles in the atmosphere. Special emphasis is placed on surface processes that occur in the stratosphere and the upper layers of the troposphere.

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Research grant 2007–2009

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Cores from the Holocene from the north Labrador Sea and south Baffin Bay to the west of Greenland

This research project is studying core samples from the present warm epoch, Holocene. A number of cores from navigable waters to the west of Greenland will be studied to see how short term variations in the geomagnetic field have affected production of cosmogenic nuclides. This area is particularly suitable because it is situated near the Greenland ice sheet where reconstructions of cosmogenic nuclides have previously been made. The ambition is to differentiate between solar and geomagnetic modulation of cosmogenic nuclides in the short geological perspective (hundreds – thousands of years) which will have great significance for the way we interpret changes in the earth's climate.

Research agency:
**The Swedish Research
Council**
Research grant 2006–2008

Ice and credibility: Fieldcraft, research stations and the growth of a culture of precision in glaciological research, 1870 – 1970

Today, climate is a political issue that has been the subject of controversy for a long time. Political and economic interests are opposed, but how can it be explained that researchers also are in disagreement? This is the question which this research project intends to answer. The point of departure is

a discussion that did not begin in earnest until the 1930s, namely whether humanity may have modified the climate by its use of fossil fuels. This research project will study if there is a relationship between the "research style" that was developed in Scandinavian glaciology and the need to uphold fixed opinions in the debate on climate change. The project will examine the historic origin of what has become one of the great contentious scientific and political issues of our times, which is of great importance for all humanity and the earth we live on.

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Greenhouse gas balances



Greenhouse gases from boreal soils at low temperatures

The project aims to generate new knowledge which will result in more reliable calculations of the greenhouse gas balance in boreal ecosystems. Studies have shown that soils in boreal regions may be significant sources of greenhouse gases, even during the winter months. The emission of nitrous oxide in particular appears to be high. This is often disregarded in calculations of greenhouse balances. The objective of the project is to identify and quantify the biogeochemical processes that regulate the cycling of greenhouse gases from forest soil in winter. The project is investigating how this cycling will be affected by a change in winter climate. Laboratory experiments are combined with field tests to identify and quantify the factors that regulate the formation of nitrous oxide in soil at low temperatures, and also to find how variations in frost depth and soil temperature affect the cycling of greenhouse gases from boreal forest soils.

Scaling up of carbon dioxide exchange in northerly spruce forests from shoot level to tree and ecosystem level

Forest ecosystems have a key role in the biogeochemical carbon cycle – as source, sink and reservoir. To employ forests as carbon sinks, it is necessary to be able to predict, inter alia, how climate, nutrients and management will affect the flow and storage of carbon today and in the future. Today, there are no models suitable for the simulation of carbon dioxide exchange over entire ecosystems, while at the same time existing models have not been evaluated with long term tests. Simultaneous measurements of carbon dioxide exchange made at shoot, tree and ecosystem level over eight years in the spruce forest at Flakaliden provide a unique opportunity. The focus of the project is on the modification and evaluation of models for scaling up from shoots to trees and ecosystems, and investigation of whether it is possible to scale up using single parameters, for instance nitrogen and specific leaf area

Greenhouse gas emissions from drained forest ground of high fertility

Draining of wet areas in order to increase forest production has been performed since the nineteenth century. Draining increases carbon dioxide emission from the soil, and some of

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the nitrogen present in organic matter is emitted in the form of nitrous oxide which has a greenhouse effect 296 times that of carbon dioxide. Forest soils can also act as sources or sinks for methane, another important greenhouse gas. The objective of this project is to measure the total greenhouse gas emissions from a drained high-fertility spruce forest in such a way that the component pools and flows can be used in testing and developing simulation models. The project includes measurements of emissions of methane, nitrous oxide and carbon dioxide, and the way they are regulated in the system.

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The significance of ground frost for the exchange of methane and carbon dioxide between boreal mires and the atmosphere

A changed climate can be expected to have a very great effect on northerly ecosystems. Mires are one of the dominant ecosystem types in northerly climatic regions. They have special significance because they have accumulated carbon in the form of peat, and because they emit methane in conjunction with the anaerobic decomposition of organic matter. The project focuses on the significance of ground frost in the winter for peat accumulation and methane emission. The researchers are performing experiments in the field and in the laboratory.

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Effects of nitrogen deposition and fertilisation on the carbon balance of a northern pine forest

Terrestrial ecosystems, particularly forest ecosystems, have a major influence on the global carbon balance, but it is extremely uncertain how great this influence is. To be able to supply the knowledge required to predict the effects of present and future climate changes and land use on national and global carbon balances, interdisciplinary cooperation is necessary concerning the factors and processes that regulate carbon flow in the soil-plant-atmosphere system. The objective of the project is to quantify 1) the annual carbon balance at system and component levels, 2) the influence of nitrogen deposition, and 3) the influence of conventional forest fertilisation. The study is carried out in a normally managed 70 year old pine forest in Västerbotten in the north of Sweden.

A climate change and carbon cycle laboratory

Northerly wetland ecosystems produce the greenhouse gases carbon dioxide and methane, but the mechanisms for this are largely unknown. Plants are believed both to emit gas that is produced in the soil through air ducts in the stem, and, via exudations from the roots, to supply nutrients to greenhouse gas-producing microorganisms in the soil. The project will build up a laboratory with instrumentation for the study of intact systems with permafrost and peat/plants/microorganisms. This will make it possible to determine many of the carbon compounds that are usually found in the root zone, and will in this way give us better opportunities to study how carbon cycles through the ecosystem.

Physical and biogeochemical factors which govern trace gas exchange in northerly peat bogs

Carbon bound in northerly peat bogs can potentially be emitted into the atmosphere and contribute to the greenhouse effect. The project is measuring the flux of trace gases for such a process at Stordalen, a bog complex in north-west Sweden. Measurements of carbon dioxide, Hydrogen, Total Hydrocarbons and Methane for plant communities with variable soil hydrology will provide information on the long term response of regional and global ecosystems to climate changes. The weather is believed to be an important factor. For instance, drier and warmer weather can reduce the capacity of certain wetland plants to bind carbon, which is instead emitted in the form of Carbon dioxide. Colder and wetter weather can increase the flux of Methane.

C14 dating of terrestrial biomarkers in the discharges from the large Russian Arctic rivers

It is estimated that one third of the soil-bound carbon in the world is in Siberia; this is as much as all the carbon in the atmosphere in the form of carbon dioxide. There are also even larger carbon reserves deeper down in the permafrost. The project will study whether thawing of the frost in Siberia and increased coastal erosion will initiate entry of the bound carbon into the modern carbon cycle. Liberated carbon will be traced in the large Russian-Siberian rivers by determining, with the C14 method, the age of chemical carbon compounds from land plants in the river water. Possible variations over different climatic and vegetation zones will also be studied.

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Support for expensive equipment

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Fluxes, transformation and fixation of terrestrial organic carbon in the Swedish boreal coastal zone

Boreal/subarctic coastal sediments, together with peat bogs and mires, are important carbon sinks. Considerable quantities of organic carbon are simultaneously formed in these areas. The project is studying the various competing processes by monitoring carbon, using isotope analyses, along its entire passage from sources on land, to the river estuaries and on into the sea. The Bothnian Bay acts as the area of field study, the aim being to create a modern and comprehensive carbon budget, inclusive of sources in the drainage basins and influences from neighbouring basins. Data is collected using the recently built German research ship Merian.

Research agency:
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Research grant 2005–2007

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Iron isotope dynamics in boreal river systems

Iron in sea water often limits the growth of phytoplankton in the sea, and it therefore has a coupling to the global carbon balance. The project is studying iron transport to the sea via rivers. The proportions of the four stable isotopes of iron are altered by chemical and biological processes, which provides information on the history connected with the iron found in various materials and environments. The Kalix River and its drainage basin will be studied in detail in order to understand the origin of the iron exported to the sea. The objective is to create a model for isotope composition in the northern Russian rivers which discharge into the Arctic Ocean.

Research agency:
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Research grant 2006–2008

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Landscape patterns, the quantities and degrees of stability of soil organic matter in areas with permafrost

Widespread thawing in taiga and tundra ecosystems may result in large quantities of carbon being released into the atmosphere, resulting in increased global warming. The aim of the project is to evaluate the quantity of SOM (soil organic matter) and its resistance to degradation in remote areas of North Central Canada and Northern European Russia. Better estimates of SOM will be valuable for modelling the climate and ecosystems, and will provide improved knowledge of the role of northerly soils and peatlands in the global carbon cycle.

The carbon cycle in the Arctic Ocean at a time of climate changes

The project is studying chemical markers for currents of water masses and for the transformation of carbon in Arctic coastal seas and its flux out into the Arctic deep central basins. The overarching question is what the situation is today and how this is affected by a climate change. The focus is not only on quantifying the fluxes, but also on understanding the underlying processes. One important part of this is to quantify how much anthropogenic carbon there is in the Arctic Ocean at present. Another question is what proportion of the surface water on its way to the north flows to the east and west around Greenland. This is significant for the strength of deep water formation and for the amount of heat that is transported northwards along the Scandinavian west coast.

Research agency:
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Research grant 2007–2009

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The circulation and effects of pollutants



The effect of climate on the emission of naturally produced halides from sea, ice and snow

A dramatic reduction in the ozone content of the lower troposphere has been observed in polar regions. This is related to the high concentrations of naturally produced halogenated hydrocarbons. Marine macro and micro algae are the most important producers. The atmospheric chemical reactions of the greatest significance are those which involve chlorine, but bromine also catalyses the breakdown of ozone. It has been shown that the synergistic effect between chlorine and bromine accounts for 20% of the decrease in stratospheric ozone in the polar regions. The project is investigating the biological and chemical production and decomposition of volatile halogenated organic compounds in order to calculate the global budget for halogens. What are the factors that regulate the production and flow of these compounds from the ocean to the atmosphere? Results will be incorporated in models. Mechanisms are investigated by observing enzymatic processes with Raman spectroscopy.

Old and new environmental pollutants in the Arctic

It has been known for a long time that environmental pollutants such as persistent chemical control agents have been spread through the atmosphere to the Arctic regions. The concentrations of these chlorinated hydrocarbons in certain parts of the Arctic oceans are now higher than in the oceans outside the areas in which these pollutants had most recently been used. In the project, a study is made of the circulation and degradation of these and new groups of pollutants in Arctic environments. The new pollutants had been considered easily degradable, but there are a lot of indications that they are now present in Arctic environments in concentrations that can give rise to negative ecological effects. The material is based on measurements made and samples taken during the large polar expedition Beringia 2005.

Changes in vegetation persist when nitrogen supply decreases

The supply of nitrogen to forest soil has increased through the spreading of fertilisers by humans and the burning of fossil fuels. At northerly latitudes, this may have serious consequences for the composition of vegetation. Bilberry and

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lingonberry are driven out and replaced by grass and tall herbaceous plants. According to an earlier conjecture, this process is reversible, i.e. vegetation recovers its original composition when the supply of nitrogen ceases. Studies in northern Sweden show, however, that the changes have persisted, even for several decades after the use of nitrogenous fertilisers had ceased. The investigations suggest that the effects of nitrogen that had been supplied interact with attacks by parasites and insects, which appears to hit berry bushes harder. The attacks may modify the nitrogen cycle in berry bushes and their essential symbiosis with certain fungi. The mechanisms of this are studied in the project, as well as the differences between the nitrogen compounds that are utilised by grass and by berry bushes. The research can supply valuable knowledge concerning the effect of nitrogen deposition and lay down directives regarding acceptable levels.

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The biogeochemical circulation of organic halogenated compounds and its significance for the degradation of atmospheric ozone

Ozone in the atmosphere is degraded by a group of volatile halogenated organic compounds, halocarbons, which also act as greenhouse gases. One of the largest sources is the ocean where they are formed by wracks, phytoplankton and bacteria. The project will answer the question of how important the ocean is as a source of hydrocarbons and the significance it has for atmospheric chemistry. This will be done by studying formation mechanisms and degradation, the ocean-air, ice-air and snow-air fluxes of hydrocarbons, and the way these processes are affected by climate changes such as the reduction in the area covered by snow and ice.

Effects of climate changes on ecosystems



The effect of reindeer grazing on alpine vegetation when the climate changes

In the increasingly warmer climate, alpine vegetation has changed. Several plant species have increased their distribution area, and it is expected that, in the long term, the characteristic alpine heaths will become overgrown. The project is investigating how this development is affected by reindeer grazing. Alpine birch, spruce, pine and larch have been planted in around 50 enclosures in both forest and heath areas. Some enclosures keep out reindeer, while others also exclude voles and lemmings. In the project, both the change in vegetation and the carbon/ nitrogen dynamics, inside and outside the enclosure, are compared. The results are compared with predictions by mathematical and statistical models. The project is significant in elucidating the sustainability of reindeer husbandry in a changeable climate. It can also throw a light on whether grazing by reindeer can counteract overgrowth.

The significance of vegetation for the climate

Organic compounds from e.g. the burning of fossil fuels are dispersed in the atmosphere and affect the climate. What is much less well known is how much is spread from natural sources such as plants. This is important knowledge, since plants are by far the greatest contributors. Globally, it may be a matter of a billion tonnes a year, or more than 90% of all organic compounds released into the atmosphere, including combustion of fossil fuels. In the project, a study is made of the emission of organic hydrocarbons by plants in some of the types of environment that have had the least study – northerly and subarctic forests and wetlands. Key species will be identified, as well as the environmental factors and physiological processes which govern the emission and its chemical composition. It will then be possible to construct large scale models which provide a picture of the significance of environmental types for air quality and their effect on the concentration of greenhouse gases in the atmosphere.

Plants and animals in the alpine region and the impacts of climate change

The Arctic regions have experienced the most rapid warming, with evident impacts on, primarily, plant communities. As far as the Scandinavian alpine chain is concerned, this may

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mean that entire biotopes will disappear. What characterises the alpine region is not the mountain peaks, nor the tundra, but the combination of great height and latitude. This combination provides the special alpine heathland with its distinct ecosystem. The aim of the project is to include the most important links in the alpine ecosystem and to study this at a comprehensive geographical scale over an extended time perspective. The project is conducted in close collaboration with other international projects within the International Polar Year IPY.

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Milder winter climate as a possible cause of reductions in vole populations in the north of Sweden

Snow depth and winter temperatures are assumed to be important factors for regulating the population dynamics of small mammals which are the key organisms of the boreal ecosystem. The project MILDVOLE is investigating whether a milder winter climate and the related changes in seed production by pine and spruce underlie the reduction in vole populations in the north of Sweden. The project makes use of 58 time series with different relevant data which are input into a GIS system. The aim is to contribute with important results concerning the effects of climate change on forest ecosystems.

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Research grant 2005–2007

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The influence of climate on production and biostructure in northerly freshwater ecosystems

How can production and biodiversity in northerly lakes be influenced by climate changes? The project intends to establish knowledge of how the production and composition of organisms in low-productive northerly freshwater ecosystems is directly and indirectly regulated by the climate. The research comprises all the organismal communities of the ecosystems. On the whole, there is little knowledge of this kind available at present. The results can be used in making predictions of how an increase in air temperature can in the long term affect northerly freshwater ecosystems.

Climate changes, biodiversity and the carbon cycle – studies under controlled conditions

The presence of specific soil types and plants influences the exchange of greenhouse gases in northern ecosystems. For instance, microorganisms in the soil emit carbon dioxide in the presence of oxygen, while under anoxic conditions methane is instead emitted. Even small environmental changes which modify these processes may have far reaching consequences for carbon circulation. The project is making use of a laboratory in order to study, with the help of isotope analyses, how carbon is cycled in intact peat/plant/microorganism. The analyses will monitor the carbon dioxide that is assimilated in the plants in photosynthesis, passes into the soil via the plant, and finally returns into the atmosphere in the form of greenhouse gases.

Changes in the structures and functions of terrestrial ecosystems

Ecosystems have an important function through the emission and absorption of greenhouse gases, and it is of great importance to find how our natural Swedish ecosystems change over time. This project is studying what has happened to the natural ecosystems in the Arctic regions over the past 30-50 years. The project also comprises analyses of what the situation may be like in the future. The International Biological Programme (IBP) which was carried out in the 70s is a key foundation for this research project. The project is part of the International Polar Year IPY.

Geobiology in Subantarctic ecosystems: interactions and response to climate change

Climate changes in the Subantarctic region may have a large impact on terrestrial ecosystems. The project is studying the interplay between climate (macro and micro), the freezing and thawing processes of the earth, and the plant *Azorella selago*. This is the first interdisciplinary study in the area which draws together understanding of the interplay between climate, biota and geomorphological processes. The results will provide new insights into the interplay between geomorphology and ecosystems in the Subantarctic region, and will predict how climate changes will affect terrestrial ecosystems.

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Effects of climate changes on the community



Adaptation of society to climate change and extreme weather effects

The storm ‘Gudrun’ and several floods have shown that society is very vulnerable to natural disasters. The scenarios which the Intergovernmental Panel on Climate Change IPCC has presented also show that this vulnerability must be taken into consideration in community planning. The project focuses on capacity, driving forces and challenges for climatic modification on national authority level and among Swedish municipalities, coupled with risk management and physical planning. The case studies made in the project relate to both floods and coastal erosion, and to municipalities which have modified their physical planning processes to take climate changes into consideration.

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Risk factors for population diseases among the population in the Arctic climate

Population diseases such as heart attacks, diabetes, asthma, arthritis, hypertension, multiple sclerosis and cancer have become increasingly common and cause great individual suffering, premature death and a steady increase in health care costs. In this project, genetic and environmental factors which contribute to the development of these diseases will be studied in Swedish populations living in an Arctic climate (the counties of Västerbotten and Norrbotten). This study is part of a major EU project (EUROSPAN) in which five countries are represented. The comparison between different European populations provides a unique opportunity to elucidate the interplay between the significance of genetic and environmental factors for the incidence of population diseases. The project is part of the International Polar Year IPY.

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Research grant 2007 (IPY)

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Paleoclimatology



Dendroclimatological reconstruction of regional climatic variations in Fennoscandia since AD 500

Variations in the annual rings of a tree provide information on earlier natural fluctuations in the climate. Dendroclimatology can also reveal events that influenced the growth of a tree, such as drought and flooding. The project will make regional climatic reconstructions of high resolution for Fennoscandia (Sweden, Norway and Finland), on the basis of new and existing 300–500 year long tree ring chronologies. These data can be used in calibrating climate models so that they give more reliable predictions. The project also provides an opportunity to study the frequency of floods and extremely cold or warm summers, and in this way decide whether the occurrence of such extreme events has increased, and to reconstruct atmospheric circulation back in time.

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Research grant 2005–2008

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Cenozoic palaeo-oceanography in the central Arctic Ocean

The Arctic Ocean contributes to the distribution of heat over the earth and plays a large role in the global ocean/climate system. The project analyses the sediment archive from the Lomonosov Ridge, with information on environmental change in the central Arctic over 50 million years. Material from the Arctic Coring Expedition (ACEX) will provide answers to questions such as: How long has there been permanent sea ice in the central Arctic? Was initial formation of sea ice due to global climate changes or the increased inflow of fresh water from rivers? The project will also study the deep Fram Strait between Svalbard and Greenland which opened the deep water connection to the other oceans 6–20 million years ago.

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Research grant 2005–2007

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Tectonic development of Arctic land masses

The Arctic region is surrounded by exotic land masses which moved to their present positions from other places where they had at one time been formed. The project is investigating the development of one of these large exotic land masses called the Arctic Alaska-Chukotka microplate (AACM). Analyses of the chemical composition of rocks will reveal whether AACM is one single large land mass or several smaller ones, and whether it comes from northern Canada or from some other exotic land mass in the Arctic region. The fragmenta-

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tion and movement of AACM is believed to have coincided with the formation of the Amerasiatic basin, one of the deep basins that are important for the global circulation of sea water.

Research agency:
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Research grant 2006–2008

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Quantitative and high resolution climate reconstruction based on proxy data from Swedish alpine lakes for the last millennium

Analysis of various natural climate archives (ice cores, tree rings, peat bogs, sea and lake sediments) shows how the climate has changed, in general terms, since the last Ice Age. The aim of the project is to find what climate changes have taken place during the past thousand years by using stratified sea sediments as the archive. In contrast to earlier studies, a much more detailed and quantitative picture will be reconstructed. The tools used will be diatoms which are an important group of primary producers and biological climatic indicators.

Research agency:
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Research grant 2007–2009

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Solar activity, cosmic radiation and climate: unique Beryllium-10 archive from stratified sea sediment

The isotope Beryllium-10 is produced through nuclear reactions between cosmic radiation and atmospheric molecules. Traces of the isotope in the sediment function as unique chronological markers for the intensity of cosmic radiation, solar activity and the terrestrial magnetic field, which, in turn, are related to climatic fluctuations. The project intends to study stratified sea sediments in Sweden and Finland as a new source in reconstructing the concentration of Beryllium-10 during the past 10,000 years. Previous results show that the atmospheric flux of Beryllium-10 has varied in correlation with the climate, and it should for this reason also be included in the evaluation and modelling of both past and future climate.

Research agency:
The Swedish Research Council
Research grant 2007–2009

The Holocene sediment archive of Bothnian Bay – a tool for predicting climate related environmental changes in the Baltic Sea

One possible scenario is that, in step with climate changes, salinity in the Baltic Proper will drop to present levels in Bothnian Bay. Salinity indirectly affects a number of biogeo-

chemical parameters which, in turn, control the number and kinds of plankton that are formed. The project will study, by investigating sediment archives from earlier stages of the sea with variable salinity, what the environmental consequences a decrease in salinity may have. In the archive, a study will also be made of the age and rate of growth of bound phosphorus, 'concretions', in order to understand its turnover rate and availability for plankton.

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Changes in the ecosystems of subarctic lakes over 10,000 years

There are many indications that a marked global temperature rise will take place during the coming century. Land areas at high northerly latitudes may then be exposed to the greatest changes. Increased knowledge of natural changes in the ecosystems in these areas is therefore of the highest importance for the prediction of future changes. The aim of this project is to elucidate how algal composition, nutritional status and other ecological parameters in subarctic lakes in the north of Sweden have been modified by natural changes in climate and vegetation dynamics in the drainage basins over the past 10,000 years.

Research agency:
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Post doctoral grant 2006–2007

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Archaeological field studies of whaling stations

The aim of the project is to elucidate the development of this industry in the Arctic (and Antarctic) from the 17th century to the present. Parameters such as whaling, mining, oil and gas, and their consequences for local environment and geopolitical conditions in the polar regions, will be studied. The overarching issues are why, how and under what economic and political conditions the natural resources of the polar regions have been developed. One aspect will be to take a closer look at how developers in the polar regions proceed to strengthen their territorial claims and simultaneously strengthen the influence of their own country. The project is part of the LASHIPA project within the International Polar Year IPY.

Research agency:
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Research grant 2007–2008 (IPY)

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The deep drilling project NEEM on Greenland – Retrieval of ice core for unique climatic studies

Information on how climate changes are stored in the ice sheet, and much of the knowledge we have today, is derived

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Research grant 2007 (IPY)

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from investigations of ice cores drilled in Greenland and the Antarctic. The objective of this project is to drill, in Greenland, an ice core that extends over more than one glacial cycle (ca 140,000 years) and in which the entire previous warm period Eem is represented. Eem is a key period to study in order to refine today's climate models for future climatic development, since it represents an interglacial period with only the effect of natural climate, when the temperature was also higher than in the present interglacial. The NEEM project, which is part of the International Polar Year IPY, has 14 participating countries and is planned to extend over five years.

Research agency:

The Swedish Research Council

Research grant 2007–2008 (IPY)

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The palaeoclimate in the Arctic and its extremes (APEX) – subproject Greenland

North Greenland is in a strategic location for increasing our understanding of the climate system, the interaction between the terrestrial cryosphere and marine systems, and their relationship with the extent of the sea ice cover in the Arctic basin. In the project, series of geological strata will be investigated to obtain a long term perspective over climatic and environmental development and to enable a perspective to be provided on possible changes in the Arctic basin during the current global warming. The project is part of the umbrella programme APEX which is part of the International Polar Year IPY.

Research agency:

The Swedish Research Council

Support for expensive equipment

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Installation of a multibeam echo sounder and a sediment echo sounder on the ice breaker Oden

By upgrading the ice breaker Oden with a multibeam echo sounder and an integrated sediment echo sounder, we will have one of the most capable research ships in the world for polar regions. A multibeam echo sounder measures the sea floor over a large area extending from both sides of the ship. This provides a three-dimensional image of the sea floor. Knowledge of the appearance and topography of the sea floor is of critical importance for the solution of fundamental problems in oceanography, marine geology and marine geophysics. The project thus lays the foundations for the continued strong international status of Swedish polar research.

Rituals and symbols in the struggle for the Polar regions

Over the past 400 years, the polar regions have been the subject of an international struggle for natural resources and political influence. In this research project, a study is made of the relationship between industrial activity in the polar regions and the development of geopolitical conditions, from an international and comparative perspective. The focus is placed on symbolic and ritual activities in the landscape of the polar regions, in order to answer the question of how exploiters in the polar regions proceeded to strengthen their territorial claims and at the same time strengthen their own country. The study focuses on two areas which, in the eye of international law, were no man's land right into the 20th Century and where there was considerable competition about natural resources and influence: Svalbard in the Arctic and South Shetland/ Antarctic Peninsula in the Antarctic.

Research agency:
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Post-doctoral grant 2007–2009

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To sharpen the tools – improvement of tephro-chronological datings around the Atlantic

Today there is a great need for exact dating methods in palaeoclimatology, i.e. the branch of geological science that studies climatic variations back in time. Tephrochronology is one method for dating and correlating different types of geological archives such as lake sediments, glacier ice and ocean sediments. By using dated tephra layers, datings can be obtained that are more exact than those by e.g. the carbon-14 method. In this research project, tephra from deep sea cores from the Atlantic and ice cores from the Greenland ice sheet will be analysed. The core that will be primarily studied is the NGRIP core which has the best chronological resolution and age determination of all the cores drilled on Greenland and the Antarctic. Tephra from lake sediments and peat from the central parts of Sweden, and from a deep lake in Patagonia, will also be analysed.

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Research grant 2007–2009

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Systematic monitoring



The diversity of Swedish mires – regionality, conservation and environmental changes

Mires cover 11 per cent of the area of Sweden, and global peat deposits amount to one third of the amount of carbon in the atmosphere. New research shows that mire vegetation in the south of Sweden may have been affected by high levels of nitrogen deposition. In the project, mires are investigated along a deposition gradient from southern Sweden towards the north in order to quantify the coupling between nitrogen deposition, the proportion of sphagnum (which is sensitive to nitrogen) and peat accumulation. Peat formation is determined by counting the annual rings of pine and measuring the distance between the mire surface and germination point. The Swedish wetland survey is a database of over 30,000 objects. The database is used in the project to model the distribution of mire types in relation to climatic data. The model can then be used to predict future mire vegetation. Data from the wetland survey is also needed to improve future Swedish mire protection strategies.

Research agency:

Formas

Employment as Research assistant and research grant 2004–2009

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Additional basic research



Cardiovascular control mechanisms

Today there are more than 30,000 fish species; they are poikilothermic animals, which means that their body temperature varies with the ambient water temperature. It is possible to find species that have adapted to all conceivable environments, from hot (43°C) springs and lakes, to those that live in Arctic and Antarctic waters where the water temperature goes down to 1–8°C. In this research project, a study is made of cardiovascular regulation in a small group of Antarctic fishes. These species have been genetically isolated over the past 10–15 million years, which is not the case with those fish species that live in Arctic regions where there are no similar geographical and hydrological barriers to migration. The research project studies cardiovascular control to see which mechanisms are common and which have developed as an adaptation to the extreme environment in which these fishes live at present. A large part of the study will focus on studying the effects of various internal and external stimuli on the cardiovascular system, as well as combinations of these such as stress/feed intake or work/feed intake.

Research agency:
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Research grant 2006–2008

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Life, competitiveness, functions and cooperation opportunities among marine bacteria

In recent years, development of molecular working methods has made it possible to study microbial communities in detail. This has resulted in a practically explosive accumulation of information in the form of DNA sequences. These sequences are stored in databases that are available for use and analysis. In this research project, a study is made of bacterial populations with the aim of gaining an insight into the life, functions, competitiveness and cooperation opportunities of marine bacteria at species level. In order to understand the distribution of marine bacteria, samples from the polar regions will provide unique opportunities to study the processes which contribute to the formation and maintenance of marine species diversity.

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Research grant 2006–2008

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Astroparticle physics with the neutrino telescope AMANDA and IceCube at the South Pole

The secrets of the Universe can be revealed by studying the radiation of particles from cosmic sources. In recent years, the value of making a special investigation of the flux of neutrinos from the Universe, as a complement to studies of electro-

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magnetic radiation and the radiation of energetic particles, has been increasingly emphasised. Neutrinos have weak interactions and pass through matter without being absorbed. At the same time, the great penetration capacity of neutrinos means that they are difficult to detect. The detector material must therefore be readily available in large quantities and must also be transparent to the blue Cherenkov light which signals the passage of an energetic particle produced by a neutrino. In practice, this means water or ice. Construction of a telescope in stable ice is the idea underlying the AMANDA telescope (Antarctic Muon and Neutrino Detector Array) which has been constructed in the Antarctic ice at the South Pole. In this research project, AMANDA will be expanded into a unique telescope with an instrumented volume of approximately 1 km³, IceCube, which contains almost 5,000 light detectors. The project is a world-wide research project in which several countries are taking part.

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