

Division for Strategic Priorities

**NORKLIMA —**  
*Climate change and impacts in Norway*

*Programme period*  
2004-2013

*Project Catalogue*  
2005

<http://program.forskingsradet.no/norklima/>

# NORKLIMA

## Climate Change Vulnerability in Norway: Socio-economic Perspectives on Policies and Impacts

Prosjektansvarlig:

**CICERO Senter for klimaforskning**

Prosjektleder:

**O'Brien, Karen Linda Seniorforsker**

Prosjektnr: 145715/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.4.2001-30.9.2008**

2001: **894,000** 2002: **1,081,474** 2003:

**1,153,125** 2004: **416,250** 2005: **430,500**

2006: **35,870**

Main objective: To gain a deeper understanding of the socio-economic impacts of the climate change issue in Norway.

Sub-goals:

- 1) To identify the sectors and regions that are most vulnerable to potential changes in temperature, precipitation, and the frequency and magnitude of extreme events.
- 2) To distinguish the socio-economic vulnerability of different sectors and regions to climate change mitigation policies, identifying "winners and losers" in terms of climate in terms of climate policies and climate impacts.
- 3) To enhance understanding of the implications of differential impacts of climate policies for social and political conflicts and for developing climate policies

Climate change will have differential impacts across sectors and regions of Norway. This is true if temperatures, precipitation, and wind patterns change as a result of an enhanced levels of climate gases and particles in the atmosphere. It is also true if Norway and other countries take actions to mitigate these changes through international agreements and national policies.

The purpose of the project is to gain a deeper understanding of the climate change issue in Norway from the perspective of both emissions reduction policies and climate change impacts. In other words, both sides of the climate change issue will be examined in terms of impacts and socio-economic vulnerability. The project will be carried out through formal collaboration with NIBR and DNMI, and through informal collaboration with the

broader national and international impacts community.

## Parameterisation of snow and ice albedo in the ECHAM5 General Circulation Model (GCM)

Prosjektansvarlig:

**Norsk Polarinstitutt**

Prosjektleder:

**Winther, Jan-Gunnar Direktør**

Prosjektnr: 148642/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.9.2002-31.8.2005**

2002: **229,000** 2003: **739,000** 2004: **759,000**

2005: **518,600**

The main goal is to improve today's parameterisation of snow and ice albedo in the ECHAM5 GCM and thereby provide more realistic climate modelling predictions.

To achieve this goal we propose to develop a quantitative understanding of the processes that collectively make up the snow/ice-albedo feedback. We will determine how shortwave radiation is distributed within the sea ice-ocean and snow/glacier-land systems, and then assess the effects of this distribution on the regional and global heat balance.

The project plans to improve today's parameterisation of snow and ice albedo in the ECHAM5 General Circulation Model (GCM). The project makes use of albedo data collected in the past, e.g., from Russian North Pole drifting stations, Alaska, Antarctica, Greenland, the Barents Sea, and Svalbard to develop robust (empirical) decay functions and algorithms describing the variability of snow and ice albedo, spectrally as well as in time and space. These decay functions and algorithms will be used to revise the present parameterisation of albedo in ECHAM5. Additionally, the project wishes to test the potential of using satellite-derived albedo as model input data. Finally, the ECHAM5 model and also a coupled atmosphere-ocean GCM (ECHAM/HOPE) will be used to perform sensitivity analysis using various combinations of parameterisation.

## **Model estimations of the present and future N<sub>2</sub>O emissions from soil plant systems in the north - feedbacks in climate change**

Prosjektansvarlig:

**Universitetet for miljø- og biovitenskap, Institutt for plante- og miljøvitenskap**

Prosjektleder:

**Bakken, Lars Professor**

Prosjektnr: 148758/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**15.4.2002-14.10.2005**

2002: **371,000** 2003: **597,200** 2004: **597,200**  
2005: **6,600**

The general aim is to explore the possibility of reducing uncertainties in the estimates of terrestrial climate gas sources by modelling.

- By implementing N<sub>2</sub>O emission models in our existing soil plant ecosystem models, emissions as function of agronomic practice will be explored. - Possible feedbacks in global warming by altered N<sub>2</sub>O emissions will be investigated, by running the models with alternative weather scenarios. - State of the art N<sub>2</sub>O models are unlikely to capture the peaks in N<sub>2</sub>O emissions observed during winter. Alternative algorithms will be developed to simulate such events, which are important for the total emission from northern terrestrial ecosystems.

Terrestrial sources and sinks for climate gases are uncertain, and so are the impacts of human activities and global warming on these fluxes. The soil microbial N-transformations are known to be an important source of atmospheric N<sub>2</sub>O, and the human impact on this emission is massive, due to agriculture and nitrogen emissions. The predicted global warming will affect the N<sub>2</sub>O emissions, particularly in northern latitude soils, due to a dominance of winter emissions which are likely to be extremely sensitive to small temperature changes. To reduce uncertainties, we need adequate simulation models which can be integrated in larger contextual models. This is not a trivial task. Simulation models for N<sub>2</sub>O emissions will be used for predictive as well as analytic purposes. Analytic modelling will focus on the physical and biological events evoked by freezing/thawing cycles in soil, which lead to subsequent peaks in N<sub>2</sub>O emissions. Predictive modelling will be done by implementing N<sub>2</sub>O emission models into an existing ecosystem model which simulates C- and N-transformations as driven by weather (daily) and agronomic practice.

## **Effects of climate change on ecosystems in Svalbard: Past and future immigration of thermophilous key species**

Prosjektansvarlig:

**Naturhistorisk museum, Universitetet i Oslo**

Prosjektleder:

**Brochmann, Christian Professor**

Prosjektnr: 150322/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2002-31.12.2006**

2002: **893,000** 2003: **1,575,500** 2004:  
2005: **1,249,490** 2006: **598,000**

Principal objective: To estimate the likelihood and speed of immigration to Svalbard of plant species that dominate in more southern ecosystems and therefore are expected to give ecological cascade effects.

Subgoals: - To determine the frequency of past immigrations of thermophilous species to Svalbard and identify the source area(s) - To estimate the dispersal potential of species that have not yet arrived in Svalbard but are dominating in more southern ecosystems - To estimate the effect of the mode of dispersal (bird-dispersed, wind-dispersed, and without particular adaptations) on the likelihood of immigration to Svalbard

The archipelago of Svalbard was almost completely ice-covered during the last glaciation. The most thermophilous plants occurring there today must therefore have arrived postglacially by long-distance dispersal. Such species (e.g. dwarf birch, arctic blueberry) are probably relics from the hypsitherma, which was 1-2° C warmer than today. Climate models predict an increase of the average temperature by 3-3,5° C from 1990 to 2070 in Svalbard. Thus, even more thermophilous species may establish, given that they are able to cross the oceans. Species such as mountain birch, grey willows, and blueberry dominate more southern ecosystems and will cause ecological cascade effects if they succeed to establish in Svalbard. The project will use molecular markers (AFLPs, DArTs, transposon displays, cpDNA markers), genotype assignment tests, and phylogenetic analyses to identify source areas and frequency of previous immigrations of plant species to Svalbard, to estimate dispersal abilities of putative immigrant species that have not yet arrived, and to compare the likelihood for successful immigrations of species that are bird-dispersed, and without particular adaptations. The research team combines molecular, phylogeographic, and

paleoclimatological expertise and will train one post-doc, one PhD, and several MAs.

## **Climate impacts on the population ecology of ringed seals (*Phoca hispida*) and polar bears (*Ursus maritimus*) at Svalbard**

Prosjektansvarlig:

**Norsk Polarinstitutt**

Prosjektleder:

**Lydersen, Christian Forsker**

Prosjektnr: 150323/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2002-31.12.2005**

2002: **1,659,000** 2003: **2,229,000** 2004: **794,000** 2005: **295,000**

The principle objective of this programme is to assess past and present impacts of climatic conditions on the population ecology of polar bears and ringed seals, and to develop predictive tools to assess the potential impacts of future climate change on these animals and the ecosystem they occupy. The sub-goals of the programme include assessment of the effects of climate on:

1. Spatial patterns 2. Predator-prey dynamics 3. Growth and survivorship (using tooth growth layers-specimens collected 1950-2002 and DNMI meteorological and ice records and archived sea-ice-satellite images) and 4. Modelling potential impacts of future climate change.

Climate change scenarios predict that Arctic regions will experience the most profound changes anywhere on the globe due to global warming in the coming decades. This is of great concern from a conservation and biodiversity perspective because this biome is dominated by specialists that have through evolutionary time adapted to extreme conditions, including cold temperatures and long winters -specialists that are found nowhere else on earth.

Polar bears (*Ursus maritimus*) and ringed seals (*Phoca hispida*) are two such species. Both are long-lived, sea-ice-dependent, circumpolar high Arctic marine mammals. Foraging and reproductive success of these animals is directly affected by the dynamics of sea ice - which is a climate driven system. Ringed seals are the most abundant Arctic seal and are a keystone species in the Arctic marine ecosystem. Polar bears are the apex predator in this system.

Both of these high trophic level animals are ideal indicators of climate- (or anthropogenic-) induced change in the Arctic system. The project will

explore the impact of climate variability on the movement patterns, growth patterns and interactions of these two species, identify critical habitat features and develop a predictive model to assess the impact of future climate change on these animals and the ecosystem they occupy.

## **Effect of ultraviolet radiation on lipids, fatty acids and nutritional quality of Arctic marine algae and zooplankton**

Prosjektansvarlig:

**Biologisk institutt, Universitetet i Oslo**

Prosjektleder:

**Hessen, Dag O. Professor**

Prosjektnr: 150331/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.7.2002-31.1.2006**

2002: **1,432,000** 2003: **1,843,000** 2004: **1,868,000** 2005: **970,470**

Objective(s):

Main aim: To assess the role of UV-radiation on synthesis and oxidation on essential fatty acids at the base of the arctic, marine food web.

Sub-goals: • Determine variability in lipid classes and fatty acids in samples of Arctic phytoplankton along gradients of UV-exposure, depth and water transparency. • Determine corresponding variability among major zooplankton species, *Calanus finmarchicus* and *calanus glacialis*. • Study diurnal in situ dynamics in lipids and PUFAs in phyto- and zooplankton as related to doses and dose-rates of UV-R. • Perform experimental UV-R exposure to mixed (natural) phytoplankton communities as well as cultures of phytoplankton

UV-R is a key determinant of oxidation of poly-unsaturated fatty acids (PUFAs) in phytoplankton. These PUFAs cannot be synthesized de novo in zooplankton, but are key molecules for marine pelagic food web via zooplankton to fish, particularly in the Arctic. Enhanced UV-R (ozone depletion) could thus be a key determinant of structure and energy transfer in these food webs. The project is planned as a combination of field and lab experiments at Ny-Ålesund (70°N), at Svalbard, with supplementary lab exposure experiments at Austevoll Aquaculture station and University of Oslo. The major efforts will be devoted to intensive field campaigns. The experiments will study how UV-climate will affect PUFAs in phytoplankton along light gradients in Kongsfjorden, and how these changes will be transferred to key copepod species.

The project will contribute to our basic understanding of solar ultraviolet radiation as an environmental stressor. It will also add to our knowledge of how the flow of essential macromolecules through the food chain is affected by environmental stressors. On a more applied level, the project will allow a preliminary assessment of the potential impact of solar ultraviolet radiation on Arctic ecosystems, including the productivity of commercially important fisheries in the Arctic.

## **The role of climatic variation in the dynamics and persistence of an Arctic predator - prey/host - parasite system**

Prosjektansvarlig:

**NINA, Avd. for arktisk økologi**

Prosjektleder:

**Yoccoz, Nigel Forsker**

Prosjektnr: 150340/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2002-31.12.2006**

2002: **1,082,500** 2003: **1,058,500** 2004: **1,058,500** 2005: **1,053,500** 2006: **1,053,500**

Main Objective: To elucidate how a climatically driven spatial and temporal environmental variability shapes the dynamics of an Arctic predator - prey/host - parasite system based on field studies on an empirical model system at Svalbard. Sub-objectives: - To study how temporal variability in winter climate, directly (through temperature) or indirectly (through spatial and temporal variation in properties of snow), drives the spatio-temporal population dynamics and demography of *Microtus* voles. - To estimate how prevalence rates of the tape-worm parasite *Echinococcus multilocularis* change in its intermediate (i.e. the vole) and determinate hosts (i.e. the arctic fox) as function of: 1. snow-cover - and density-dependent fox predation rate on voles, and 2. climatically driven spatio-temporal variation in vole population density and demography. - Based on parameter estimated from field studies at Svalbard, to build an empirical model predicting the dynamics of this predator-prey/host-parasite system, including the conditions for the persistence of further spatial expansion of the vole host and the parasite in the Arctic.

*Microtus* voles and lemmings are functionally important species in most terrestrial Arctic ecosystems; they are both prey and predators (herbivores), and are the hosts of many parasites. The key role of these small mammals is primarily due to their population dynamics with recurrent

years with high numbers/biomass. The project aims to predict how climate change may affect the ecosystem functions of arctic small mammals through the properties of ice and snow. For this purpose the project will study a metapopulation of the sibling vole *Microtus rossiameridionalis* at Svalbard and its interaction with a predator, the arctic fox, and a parasite, the tape-worm *Echinococcus multilocularis*. The parasite has both the vole (intermediate) and the fox (final) as host species. This predator-prey/host-parasite system has many favourable model system characteristics that should enable us to establish:

1. How the variability of winter climate determines qualitative/quantitative properties of the snow cover in space and time
2. How properties of the snow cover in turn shape the spatio-temporal density dynamics in the vole populations
3. How the spatio-temporal variation in vole dynamics and the snow cover in turn shapes the functional response of the arctic fox to their vole prey
4. Finally, how this chain of processes (1-3) determines spatially and temporally varying prevalence of *Echinococcus multilocularis* both in its intermediate (i.e. the vole) and final host (i.e. the arctic fox)

The project aims to use field data to estimate the parameters necessary for building an empirical (statistical) model that will allow one to investigate how the dynamics of the system, including the likelihood of persistence of the parasite, may change under different scenarios of winter climate variability. The data/analysis can also be used to predict under which climatic circumstances whether *Microtus* vole and their associated parasites may spread further on Svalbard and other high Arctic terrestrial ecosystems.

## **On Thin Ice? Climatic influence on Energy Flow and Trophic Structure in Arctic Marine Ecosystems**

Prosjektansvarlig:

**Akvaplan Niva AS**

Prosjektleder:

**Carroll, Michael L.**

Prosjektnr: 150356/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.7.2002-31.12.2005**

2002: **530,600** 2003: **2,131,000** 2004: **2,077,000** 2005: **1,258,810**

Objective(s): The principal objective of this project is to determine the sensitivity of the Arctic marine ecosystem of northeast Spitsbergen to changing

climate via sea ice cover in this region. This will be accomplished through the following subgoals:

- Quantify the timing and magnitude of primary production and its dominant sources for the northern Svalbard shelf
- Trace the trophic fate of the primary production in areas of different zooplankton population distributions
- Measure benthic biomass and community characteristics in the areas
- Relate the changes of carbon available both in quantity and origin to variations in ice conditions
- Determine food web trophic structure and response to climate variability using stable isotope and fatty acid profiles

The project aims to test the hypothesis that changing ice conditions associated with different climatic regimes drives primary production on the northern Svalbard shelf through different carbon sources (ice algae vs. phytoplankton). The project proposes that such variation in the dominant source pathways of primary production has concomitant effects to both the pelagic and benthic systems, as well as the trophic pathways by which they are coupled. The project will carry out an extensive field campaign, combined with laboratory analyses to test a series of working hypotheses related to the primary producers, zooplankton, and benthic components. The test region is the northern Barents Sea near northeast Spitsbergen where sea ice varies on small spatial and temporal scales. The project will compare systems influenced predominantly by different water masses, i.e. Atlantic water (warm scenario) vs. Arctic water (cold scenario) and the project will assess temporal aspects by sampling in different seasons (i.e. spring vs. autumn) and in different years.

Ultimately, the project aims to provide insight into the energetic pathways and trophic structure of this ecosystem and its stability versus sensitivity in the face of predicted future climate changes. Such an ecosystem-based approach is the most effective means to understand the possible consequences of climate change to biotic systems.

## **FARIN - Factors controlling UV radiation in Norway**

Prosjektansvarlig:

**Norsk institutt for luftforskning**

Prosjektleder:

**Engelsen, Ola Forsker**

Prosjektnr: 155810/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2003-31.12.2006**

2003: **814,000** 2004: **1,057,000** 2005:

**1,076,000** 2006: **739,150**

The principal objective is to quantify the various factors controlling UV radiation in Norway. The following sub-goals are identified:

1. To quantify how UV radiation is affected by clouds, snow and ozone as a function of latitude and season, and identify and quantify any possible longterm changes.
2. To quantify how aerosols affect surface UV radiation.
3. To measure and analyse the distribution of diffuse sky radiation.
- 4.

5. To measure and analyse the UV radiation on horizontal and vertical surfaces.
5. To perform a comprehensive instrument comparison.

The amount of stratospheric ozone has declined during the last decades. A decrease in the ozone column will eventually give an increase in the UV irradiance at the Earth's surface assuming all other parameters affecting UV irradiance are unchanged. Besides ozone, the UV radiation is controlled by clouds, aerosols and surface albedo. Furthermore, the orientation on the surface receiving the UV radiation, is of importance. Norway, including Svalbard, covers more than 20° of latitude. The climate is quite diverse with little snow throughout the year in the far south and often snow cover well into the summer in the far north. Furthermore, the northern location makes Norway exposed to low ozone levels during the Arctic spring. Thus, it is a unique laboratory for studying various factors that control the UV radiation levels.

The aim of the FARIN project is to quantify the various factors controlling UV radiation in Norway, including clouds, ozone, surface albedo, aerosols, latitude, and geometry of exposed surface. The project group operates a variety of instruments and models applicable to study the UV controlling factors. These include both scanning spectroradiometers, a network of moderate bandwidth filter instruments and state-of-the-art radiative transfer models.

## **Improved Parameterisation of Microphysical and Optical Properties of Clouds in Global Climate Model**

Prosjektansvarlig:

**UNIFOB AS - Bjerknes-**

**senteret, Universitetsforskning Bergen**

Prosjektleder:

**Stamnes, Jakob J. Professor**

Prosjektnr: 155811/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2003-31.12.2006**

2003: **624,000** 2004: **1,012,000** 2005:

**1,034,000** 2006: **822,640**

The principal objective is to enhance our understanding of physical processes associated with

mixed-phase cloud/radiation interactions by combining expertise in cloud microphysics with expertise in scattering and radiative transfer modelling. Sub-goals: - Use observational data to derive parameterisations of microphysical processes in mixed-phase clouds. - Use a variety of numerical codes for scattering and radiative transfer by non-spherical particles to model and parameterise optical properties of mixed-phase clouds. - Test derived parameterisations against SHEBA and ARM data by using the MM5 mesoscale model.

Information about cloud microphysical properties including phase as well as particle size and shape distribution obtained from cloud radar and lidar instruments deployed during the SHEBA experiment and at the ARM sites will be used to test and improve the treatment of cloud/radiation interactions in the MM5 mesoscale model. These data will also be used to develop cloud microphysics parameterisations and radiative transfer models suitable for use in mixed-phase clouds. Specific scientific questions include whether the modelled radiative fluxes are realistic in the presence of ice and mixed-phase clouds. The findings will be used to carry out a critical evaluation of the treatment of cloud parameterisations and radiative transfer in the presence of mixed-phase clouds in Global Climate Models.

## **Economic Impact of Climate Change on Norway's Fisheries**

Prosjektansvarlig:

**Samfunns- og næringslivsforskning AS, Senter for fiskeriøkonomi**

Prosjektleder:

**Hannesson, Rognvaldur Professor**

Prosjektnr: 155823/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.7.2003-31.12.2005**

2003: **730,000** 2004: **1,000,000** 2005:

**1,270,000**

Assess the economic impact of climate change on the net value of fish exports from Norway. The main steps of the analysis are as follows:

- review structural changes in the fishing industry after the collapse of the herring stocks around 1970
- establish changes in fish catches under plausible climate scenarios - assess likely changes in fish farming due to climate change - establish plausible scenarios for changes in composition of exports - assess changes in gross value of exports, based on market prices and relationships in the past 10 – 15

years - assess likely new investment (accelerated investment) in boats and processing plants induced by climate change - assess change in net economic benefit by subtracting catching and processing costs - compare these structural changes with changes that have occurred in past (e.g., after the collapse of the herring stocks in the 1960s and 70s).

Changes in ocean climate in Norwegian waters are expected to lead to changes in the distribution and migrations of fish in this area. These changes can be expected to lead to changes in fish catches, and location of fish processing and fishing operations. This will produce a change in net economic benefit from Norway's fishing industry, positive or negative.

The project will assess the likely change in net economic benefit for climate change scenarios considered plausible by oceanographers. One will seek contact and cooperation with researchers at the Institute of Marine Research, Bergen, who have been and plan to be engaged in research on fish migrations and climate change, in order to establish plausible scenarios. The changes expected to occur will be compared to the structural changes that have occurred in the past due to long term fluctuations in fish stocks and changes induced by markets and technology. The project will also evaluate possible changes in fish farming due to changes in the ocean environment resulting from climate change.

## **Effect of climate change on flux of N and C: air-land-freshwater-marine links**

Prosjektansvarlig:

**Universitetet for miljø- og biovitenskap, Institutt for plante- og miljøvitenskap**

Prosjektleder:

**Stuanes, Arne O. Professor**

Prosjektnr: 155826/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2003-31.12.2007**

2003: **2,314,600** 2004: **2,657,250** 2005:

**2,491,500** 2006: **2,326,500** 2007: **2,175,250**

1. Quantify the effect of climate change on deposition and flux of N and C from semi-natural terrestrial ecosystems to water.
2. Assess effects of climate change on N and C fluxes and concentrations at the river basin scale.
3. Assess the consequences of changes in fluxes of N and C on freshwater and marine water quality and biology.
4. Assess the implications for environmental policy and management of land and water resources (LTRAP, OSPAR, WFD).

The project is an integrated, interdisciplinary project to quantify the effects of climate change on flux and deposition of nitrogen (N) and carbon (C) from terrestrial semi-natural ecosystems to aquatic ecosystems in Norway. The interaction of changed land-use and climate will also be studied. A 3-pronged approach will be applied involving analysis of existing data from monitoring programmes and previous experiments, new ecosystem-scale experiments with climate change, and development and application of processor-oriented models to extrapolate and scale up the results in time and space to the river basin scale and to marine coastal ecosystems. Both the experimental and the monitoring parts of the project will be focused on mountains, heathlands and other semi-natural ecosystems. Climatic change can be expected to impose more marked changes in these systems compared to forests and cultivated land. The project will take an interdisciplinary approach and build upon previous strong collaboration between the scientists and institutes involved. The results will be relevant to several important sectors in Norwegian society, including forestry, nature protection, fisheries, drinking water quality and water resources, and will supply important new information for development of adaptation strategies for effects of climate change.

## **EnviTools - New Spaceborne Radar Methods for Glacier Characterisation as Tools for Arctic Environment and Resource Monitoring**

Prosjektansvarlig:

**NORUT Informasjonsteknologi AS**

Prosjektleder:

**Høgda, Kjell Arild**

Prosjektnr: 155834/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2002-31.12.2006**

2003: **1,614,000** 2004: **2,112,000** 2005:

**2,092,000** 2006: **1,682,000**

The overall goal is to:-The goal is to develop new methods for retrieval of cryospheric variable from EO data in order to increase the usefulness of EO data in for environmental authorities and research. Scientific sub-goals are as follows: - Improve the understanding of scattering mechanism and effective scattering centre location from snow and glaciers - Adapt and extend the techniques of InSAR and GPR and demonstrate its capabilities for measuring glacier parameters. - Develop scattering models, methodology, and techniques for processing and analysis of multi-frequency and

polarisation SAR with respect to feature interpretation and extraction. - Develop retrieval schemes utilizing multi-temporal radar data sets

Global climate change is likely to cause dramatic changes in arctic environment and the effects of glacier changes can be monitored using glaciological, meteorological and remote sensing data.

Several simultaneously SAR, GPR and *in situ* data acquisitions will perform from different "test sites" during varying environmental/glaciological conditions. The project will acquire data from multiparameter SAR instruments such as EnviSAT and Radarsat-II. Subsurface characterization will be obtained using a flexible configurable GPR equipment covering the frequency range from 100 MHz to 5.3 GHz. The high frequencies allow direct comparison between the SAR and GPR signature. Scattering model will be adapted in order to interpret the data. Advanced signal processing techniques will be applied to the SAR data in order to retrieve snow glacier properties. The algorithms will be used on recent past SAR images in Svalbard to test if any glacier facies changes are detectable over this time period of available SAR-data. The algorithms will be developed to fully utilize the future multiparameter spaceborne SAR instruments for glacier parameter retrieval.

## **OCTAS - Ocean Circulation and Transport Between the North Atlantic and the Arctic Sea**

Prosjektansvarlig:

**Statens kartverk**

Prosjektleder:

**Solheim, Dag**

Prosjektnr: 155835/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2002-30.6.2007**

2003: **2,891,000** 2004: **3,415,000** 2005:

**3,415,000** 2006: **2,779,000**

The overall aim of this proposal is to enhance Norwegian capacity in Earth observation technologies in a coordinated way by promoting and developing methods for the joint exploitation of current space missions and associated climate modelling.

It is the goal to determine - in an integrated approach using space born and *in situ* data - the mean dynamic sea surface topography (MDT) in the Fram Strait and adjacent seas as a crucial input for ocean circulation and transport studies in the polar region and to assess the impact of the MDT through assimilation in ocean circulation models.

The anticipate global warming is likely to affect the polar climate early and significantly. A possible weakening of the mean ocean circulation and the associate northward heat transport between Europe and Greenland would significantly affect the climate in Northern Europe and also change ocean upwelling and transports of larvae, both relevant for fish populations.

Considering the large European investment in Earth observing satellites, it is of great importance that the space borne data are fully exploited in the context of ocean monitoring.

The project aims to enhance Norwegian capacity in Earth observation technologies by developing methods for the joint exploitation of current missions like CHAMP, GRACE, and JASON-1 and the approved ESA Envisat (Radar Altimeter) and GOCE missions for ocean circulation studies and associated climate modelling.

The project study region is the Fram Strait and the adjacent seas and this region complements that of the EU-funded GOCINA project. An accurate geoid and the mean sea surface height will be determined and used to get a highly accurate dynamic sea surface topography. The latter is used for improved analysis of the ocean circulation and transport facilitating a major part of the exchange between the Arctic Sea and the North Atlantic.

## **Mechanisms of climatic adaptation in forest trees**

Prosjektansvarlig:

**Institutt for biologi, Universitetet i Tromsø**

Prosjektleder:

**Junttila, Olavi Professor**

Prosjektnr: 155873/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2003-31.5.2007**

2003: **1,481,250** 2004: **2,312,250** 2005: **1,345,250** 2006: **2,217,300** 2007: **239,150**

Aiming at understanding responses of forest trees to a changing climate, the main objective of the project is to increase the knowledge of the significance of temperature and the interaction between the temperature and light climate in the rhythmicity of growth and dormancy in trees, and to increase the knowledge about the physiological and molecular background of these climatic responses

Subgoals are

- 1) Studies of effects of temperature and interaction between temperature and light climate on the rhythmicity of growth and dormancy in forest trees
- 2) Identification and studies of expression of genes involved in climatic adaptation in Norway spruce, using microarray and real-time PCR technology as well as transgenic plants as tools.
- 3) To educate a Ph.D and a Post-doctor candidate.

Rapid climatic changes may significantly affect the regulation of the rhythmicity of growth and winter dormancy in forest trees and other perennial species of the temperate zone. The growth potential and winter survival of such species are directly related to proper adaptation to the prevailing climatic conditions. This is primarily based on a close co-ordination of growth and dormancy with the temperature climate. The light climate is known to play an important role in regulating bud set before the winter and temperature is known to be an important determinant of dormancy release and bud break. The temperature appears also to affect the induction and depth of dormancy, but little data on this is available. Knowledge of the significance of the interaction between the temperature and the light climate in climatic adaptation is scarce, although such interactions may explain some of the annual variation in dormancy-related processes in nature. The physiological and molecular mechanisms underlying climatic adaptation are also largely unknown. Such knowledge is of prime importance in understanding the responses of trees and other plants to a changing climate and will contribute to an understanding of the evolution of climatic adaptation.

The project aims at studying the effects of temperature and the interaction between temperature and photoperiod in regulation of dormancy and growth rhythms in forest trees. The project also aims at identifying physiological and molecular mechanisms involved in the climatic adaptation by identifying and studying specific genes involved in this in Norway spruce by the use of microarray and real-time PCR technology, as well as by the use of transgenic plants as tools.

## **Climate effects on dynamic biodiversity - compositional and functional changes in diversity in time and space**

Prosjektansvarlig:

**Institutt for biologi, Universitetet i Bergen**

Prosjektleder:

**Heegaard, Einar Forsker**

Prosjektnr: 155875/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.4.2003-31.3.2006**

2003: **668,000** 2004: **671,000** 2005: **671,000** 2006: **277,000**

1. Quantify the rate-of-change in species-composition both in time and space for several groups of organisms, including vascular plants, chironomids, diatoms, ferns, etc. Do different

organisms have similar ecotones and inter-ecotone rates of change?

2. Evaluate species-turnover rates for different organisms in relation to known past climatic changes, and present-day climatic gradients in space.

3. Identify spatial ecotones as indicators of geographical regions with a particularly high economic and natural vulnerability.

4. Generalise the statistical ecotone-detection procedure for analyses of multiple-predictor space.

Predicted climate changes will affect nature as a whole. For a better understanding of species-distribution and species-composition as a response to climate change it is important to consider comparable information on dynamic biodiversity across groups of organisms in time and space. It is known that climate changes will have a strong effect on species-distribution and species-composition in areas where numerous species occur at or near their distributional border.

These biological transition zones can be detected as regions with unusually high species-turnover, i.e. ecotones. The project focuses on the rate-of-change in species-composition for different organisms (vascular plants, ferns, chironomids, diatoms, mites, etc.) and a combination of palaeorecords and spatial data allows the spatio-temporal history of species-turnover to be addressed. With a new statistical procedure for ecotone detection the ecotone and inter-ecotone species-turnover will be quantified in both time and space.

The combined use of spatial and temporal biological and climatological data provide the opportunity of testing the effect of climate conditions and change on dynamic biodiversity, and testing if the groups of organisms differ in their response to climate change. This enables an identification of areas with a particularly high economic and natural vulnerability.

## **CLIMAR - Climate And Production Of Marine Resources**

Prosjektansvarlig:

**Havforskningsinstituttet**

Prosjektleder:

**Melle, Webjørn Seniorforsker**

Prosjektnr: 155889/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.4.2003-31.12.2006**

2003: **1,800,000** 2004: **3,221,000** 2005: **3,078,500** 2006: **2,643,000**

Our principal objectives are to establish the processes which constitute the coupling between climate fluctuations and the growth and migration

patterns of the Norwegian spring spawning herring in the Nordic Seas, and to develop models of the oceanography, plankton food web, and fish growth and migration that will allow a quantitative analysis of the climatic factors involved, and prognoses of the consequences of future climate scenarios.

From a stock size of >12MT in the mid-20th century, the Norwegian spring spawning herring was driven almost to extinction in the early 1970s, with significant social, economic and ecological consequences. The stock began to recover in the 1990s, but with radically different seasonal migration patterns from those prior to the collapse. There is provisional evidence for a link between the stock collapse and an abrupt change in North Atlantic climate that occurred in the mid-1960s. The project will analyse available long term time series of herring growth and abundance in relation to climate, hydrography and biological production at lower trophic levels. The project will seek a process orientated oceanographic and ecological justification for the statistical relationship between herring and climate, and develop state-of-the-art mathematical models to aid prediction of the consequences of climate changes in the future.

## **Effects of climatic change on an economically important pest insect in Norwegian forest ecosystems**

Prosjektansvarlig:

**Norsk institutt for skogforskning**

Prosjektleder:

**Økland, Bjørn Forsker**

Prosjektnr: 155893/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2003-31.12.2006**

2003: **743,000** 2004: **743,000** 2005: **743,000** 2006: **743,000**

Principal objective: To explore the effects of climate change on the population dynamics of the spruce bark beetle, as a basis for reducing the risk of beetle outbreaks through forest management

Sub-goals:

1. To explore the role of climate in outbreaks of the spruce bark beetle in space and time
2. To estimate the distribution of bivoltinism in the spruce bark beetle in Norway under different scenarios of climate change
3. To estimate the risk of forest damage by the spruce bark beetle in different regions of Norway under different scenarios of climate change
4. Describe forest management practices to be considered in various regions of Norway to reduce

the impact of beetle outbreaks triggered by climate change

Climate change may have profound effects on insects that cause widespread tree mortality and have significant impacts on forest ecosystems. The spruce bark beetle (*Ips typographus*) is by far the most aggressive and serious insect pest on mature trees in Eurasia, including Norway. The exact factors triggering outbreaks of the spruce bark beetle are not fully understood, but climatic variables significantly influence population levels. A general temperature increase may, for example, lead to a northward expansion of the areas experiencing two beetle generations per year (bivoltism).

The project aims at increasing our understanding of how climatic factors influence the risk of bark beetle outbreaks through tempo-spatial analyses of a data set from a 23-year monitoring programme in southern Norway. The distribution of bivoltism and the risk of damages by the spruce bark beetle will be estimated under various scenarios of climate change. The results will be made available for economical modelling and forest management adaptations in various districts of Norway.

## **EACC - Ecology and economy of agriculture in a changing climate**

Prosjektansvarlig:

**Universitetet for miljø- og biovitenskap, Institutt for plante- og miljøvitenskap**

Prosjektleder:

**Bakken, Lars Professor**

Prosjektnr: 155896/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2003-31.12.2007**

2003: **1,300,000** 2004: **2,000,000** 2005: **1,800,000** 2006: **1,600,000** 2007: **1,300,000**

The ultimate aims are to explore

- The consequences of an expected climate change for the economical and environmental performance of Norwegian agriculture. The environmental factors included are: soil erosion, N-losses, and fluxes of greenhouse gases. - The

management options to sustain or improve the economic and environmental performance of agroecosystems in a new climate. - The policy options to ensure implementation of such management options

To achieve these goals, experiments and models refinements will be conducted, resulting in improved understanding and prediction of processes within the soil-plant ecosystems which are crucial for the environment

Climate change (CC) will affect a multitude of interlinked processes within agroecosystems, including economic consequences. The project will use an established cluster of economic and natural scientific models (ECECMOD) to explore the CC effects on agriculture in Norway. ECECMOD is well suited for such purposes, since weather data are used as driving variables for its models of soil physics and biology, plant growth and soil erosion. A dedicated and experienced interdisciplinary team of researchers behind ECECMOD allows us to be operative from day one. The models have been parameterized for four regions, covering 10% of the farmed area in Norway. Refinements, validation efforts and new model developments will be performed, regarding simulations of plant growth, tillage effects, soil erosion, greenhouse gas emissions and pesticide use.

In cooperation with meteorologists, global change driven weather scenarios (dynamic downscaling) will be used as input data for the models.

Uncertainty will be addressed throughout such simulations. Coupled atmospheric chemistry and transport models will be used to simulate ozone damage on crops. The resulting crop production functions are used in the economic models to simulate farmers choices and the economic performance. Alternative economic scenarios will be constructed, to explore the effects of expected structural changes in agriculture in the coming decades.

## **CATRINE - Climate change and associated trade patterns - Impacts for the Norwegian economy**

Prosjektansvarlig:

**CICERO Senter for klimaforskning**

Prosjektleder:

**Aaheim, Asbjørn Forsker**

Prosjektnr: 155898/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.7.2003-31.12.2005**

2003: **988,000** 2004: **1,024,000** 2005: **988,000**

Principal objective: To assess the impacts of climate change to the Norwegian economy, when both direct responses to climate change in Norway and effects of climate change on the terms of trade is taken into account

Sub goals: - Develop an integrated macroeconomic model for the world with Norway as a separate region. - Estimate the impacts of climate change in terms of shifts in supply and demand within each region. - Carry out separate sector studies of the forestry sectors and establish relationships in the

macroeconomic model that refers to directly to the results of these studies.

The purpose of the project is to assess the impacts of climate change on the Norwegian economy related both to changes in economic activities as a direct response to climatic changes and to possible changes in the terms of trade for Norwegian goods and services. A computable general equilibrium model for the world economy will be developed, where Norway will be included as a separate region, and the rest of the world will be represented in 4 or 5 regions as to include adequate relations for world trade patterns.

Impacts of climate change will be estimated for each region, and implemented in the model by means of shifts in supply and demand, or by productivity gains and losses from the utilization of natural resources. One challenge will be integrating results from non-integrated studies of impacts in different sectors into macroeconomic models. To illustrate these relationships, one will focus particularly on the forestry sector: Forestry has been subject to detailed economic analyses, the sector is important to Norway and is at the same time subject to foreign competition. Forestry is also sensitive to climate change and represents a means to mitigate it.

## **The effects of climate variation on vertebrate population dynamics: A comparative approach**

Prosjektansvarlig:

**Institutt for biologi, Norges teknisk-naturvitenskapelige universitet**

Prosjektleder:

**Sæther, Bernt-Erik Professor**

Prosjektnr: 155903/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2003-31.12.2007**

2003: **2,266,500** 2004: **3,037,600** 2005: **2,749,000** 2006: **1,899,332** 2007: **1,708,000**

The aim with the present project is based on a general theoretical framework in stochastic population ecology

- to identify under which conditions climate will most strongly affect spatio-temporal variation in the population dynamics of vertebrates.

By this approach we will - examine quantitatively how an expected change in climate will affect population processes in space and time, using both terrestrial and marine examples.

Such information will be crucial when - designing monitor-schemes or relating trends in population fluctuations to expected changes in climate.

The purpose with the project is to identify under which conditions an expected climate change will most strongly affect vertebrate population dynamics. Based on a newly developed theoretical foundation in stochastic population ecology and data from birds, mammals and marine fishes the project will study this by posing three questions:

1. Can intra-specific variation in the effects of climate on vertebrate population dynamics be predicted from knowledge of basic population dynamical parameters (e.g. specific growth rate, form of density regulation)?
2. What are the life history characteristics of species that are likely to be most strongly influenced by variation in climate?
3. How does climate affect the spatial scale of synchrony in population fluctuations?

The project can examine whether the effects of climate are stronger on the population dynamics in highly productive than in poor environments, whether a stronger climate influence are found in species with a large clutch size and high specific growth rate than in low reproductive species and whether the effects of climate on the spatial scaling of the synchrony in population fluctuations are dependent on interspecific differences in migration

## **Phenology as an indicator of climate change effects**

Prosjektansvarlig:

**NORUT Informasjonsteknologi AS**

Prosjektleder:

**Høgda, Kjell Arild**

Prosjektnr: 155904/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2003-31.12.2007**

2003: **1,725,000** 2004: **2,273,500** 2005: **2,303,500** 2006: **2,303,500** 2007: **2,264,500**

The objective of the project is to establish knowledge about ongoing large-scale changes in the phenological cycle and-primary production of vegetation in order to investigate biological, economical, and social consequences of observed and predicted changes.

Sub-goals:

- Co-ordinate and share in an open web interface the collected time-series of data. - Identify the important climatic variables to model and predict the future trends on phenological events and primary production. - Investigate consequences of climatic change for the biomass in the northern birch forest and in the reindeer pastures. - Analyse the social and economic consequences.

An immediate and observable effect of global warming in Norway is a transition in the seasonal

vegetation cycles. Changes in the phenological phases are often the first indication of transition in ecosystem. A lengthening of the growing season, as observed in central and southern Norway, is likely to increase biomass production and accelerated tree growth across the region. Changed winter and spring conditions, due to more snow from increased winter precipitation as observed in the northern continental regions, will have an impact on the grazing resources for reindeer, and thereby a socio-economic impact on the Sámi people and culture. The project will combine satellite with ground registrations in order to identify the important climatic variables, this to model and predict changes in future phenological timing and primary production along the north-south, coastal-inland and altitude gradients. The project will analyse the consequences for the agro-forestry sector. main emphasis will be on the northern birch forest. The project will study the role of climate variability as a driving factor for the reindeer management, and its implications for the Sámi culture. Other effects the project will study are the increase in pollen allergies in Norway, and changes in goose migration patterns.

## **ProClim - Polar Ocean Climate Processes**

Prosjektansvarlig:

**UNIFOB AS - Bjerknes-senteret, Universitetsforskning Bergen**

Prosjektleder:

**Haugan, Peter M. Instituttleder**

Prosjektnr: 155923/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2002-30.9.2007**

2003: **7,375,000** 2004: **6,433,000** 2005: **6,388,000** 2006: **5,804,000**

The principal objective of the project is to quantify and understand climate processes in polar marginal seas, with emphasis on the western Barents Sea, Svalbard region and Greenland Sea in order to improve our understanding of future regional and global climate and its predictability. Sub-goals: -

To identify the parameters setting the mode of Greenland Sea convection. - To understand dense water formation on polar shelves, and develop high resolution atmosphere, ice and ocean model tools which properly describe the processes. - To measure major cold outflows from the shelf region and understand the mixing processes determining their fate. - To assess the variable contributions to deep mixing and sinking from shelves and in the deep ocean and understand the regional interaction between the processes.

The project will address climate processes in the geographical region of the Polar Climate Research

Programme by means of observations, process modelling, parameterisation, analyses of observations/model fields and synthesis. It will be organised in four work packages:

1. Deep mixing and sinking.
2. Water mass formation on shelves.
3. Slope convection and overflows off shelves.
4. Integration by (basin scale) models, observations and theory.

Work packages 1 to 3 will provide in-depth understanding of those regional components of global thermohaline ocean circulation which are believed to be especially important for ocean heat transport and sea ice extent in the northern seas. The fourth work package will use large scale models and observations to quantify the variability and understand the interaction between processes. The project team will use their unique field experience and facilities in Svalbard waters, the Greenland and Barents Seas, in combination with theoretical and modelling expertise and an already established strong international network.

## **ECOBE - Effects of North Atlantic Variability on the Barents Sea Ecosystem**

Prosjektansvarlig:

**Havforskningsinstituttet, Senter for marint miljø**

Prosjektleder:

**Sundby, Svein Forsker**

Prosjektnr: 155930/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2002-31.12.2006**

2003: **5,435,000** 2004: **4,963,000** 2005: **5,881,000** 2006: **5,721,000**

The over-all goal:

Understand and quantify the impacts of Arctic climate variability on trophic transfer and ecosystem structure of the Barents Sea in order to improve the prediction of growth and recruitment on key fish species.

Objectives: - Explore the linkages between large-scale weather patterns, such as the NAO, and the regional and local climate, and investigate how such patterns cascades into spatio-temporal changes in the ocean climate parameters that are of importance for biomass production.

- Explore the effects of ocean climate and circulation on the production and advection of *Calanus finmarchicus* onto the northern Norwegian Shelf and the Barents Sea.

- Develop an integrated model system based on first-principles physics and biology to simulate distribution, transport, growth and survival of fish

larvae from the spawning areas in spring to 0-group distribution in autumn when year-class strengths are largely determined.

- Develop egg production models for the key fish species, with special focus on Arcto-Norwegian cod, Arcto-Norwegian haddock and Norwegian spring-spawning herring, based on the combined effects of food abundance and temperature on gonad production and maturation.
- Develop a trophodynamic model system that integrates the models described above to simulate growth and recruitment of Barents Sea fish stocks.

The project addresses how Arctic climate variability and change influence biomass production and trophic transfer in Barents Sea ecosystem. The population of copepods in the Norwegian Sea, particularly the *Calanus finmarchicus*, plays a key role in the transformation of biomass from lower to higher trophic levels in the Arctic. The advection of copepod-rich water from the Norwegian Sea into the Barents Sea is hypothesized to be of great importance to the Barents Sea biomass production. The first emphasis will be on analyses of a large variety of time series from hydrography, currents, zooplankton, to 0-group fish, in addition to paleo data on water mass properties. The second emphasis will be on development of a model system that integrates and quantifies the effects of climate variability on biomass production and trophic transfer from copepods to fish recruitment, including the modifying effect from sea bird predation. The model results will be evaluated against time series on abundance and distribution of 0-group fish. The project is an interdisciplinary approach with 9 partner institutions.

## **ENDOCLIMA - Interacting Effects of Climate Change and Endocrine Disrupters, additional support to the ENDOCLIMA Marie Curie.**

Prosjektansvarlig:  
**Institutt for biologi, Norges teknisk-naturvitenskapelige universitet**  
Prosjektleder:  
**Jensen, Bjørn Munro Professor**  
Prosjektnr: 155933/S30  
Bevilgningsperiode og finansiering fra Norges forskningsråd:  
**1.1.2003-31.12.2006**  
2003: **335,000** 2004: **335,000** 2005: **335,000**  
2006: **335,000**

The ENDOCLIMA MCTS will focus on combined and interacting effects of climate change and endocrine disrupters on organisms and populations in order to forecast possible effects of these anthropogenic factors on Arctic biodiversity and ecosystem functioning. With respect to training, the aim is to educate future scientists who can generate and provide knowledge about the interacting effects of climate change and endocrine disrupters to ensure sustainable management of natural resources and ecosystems. Fellows will be given an integrative biological education in organismal and population biology in relation to climate change issues and endocrine disruption. This will be achieved by hosting and educating between 10 and 20 visiting PhD fellows (equivalent to 78 months of support from EU).

To strengthen the capacity to understand how climate change and endocrine disrupters, and in particular their interacting effects, affects the northern environment, 8 professors and 2 post-docs at the Department of Biology, NTNU, have formed a research group (acronymed ENDOCLIMA) that aim at applying an integrated biological approach to enhance the Norwegian research effort in Global Change research issues. ENDOCLIMA has been given support by the European Commission to establish a Marie Curie Training Site (MCTS) for a periode of 4 years to host foreign PhD fellows for a total of 78 month.

The candidates that receive scholarships (3-12 months) will study interacting effects of climate change and endocrine disrupters. To increase the scientific outcome of the ENDOCLIMA MCTS, we apply for additional support from the Norwegian Research Council. This is motivated by our focus on effects of the global change issue in the Arctic region. Due to the high cost of conducting research in the Arctic, additional support will significantly increase the scientific output of the ENDOCLIMA MCTS with respect to climate change research issues in the Arctic.

Participating scientists in the ENDOCLIMA MCTS have submitted other applications for specific research projects that are linked to the ENDOCLIMA MCTS.

## **CABANERA - Carbon flux and ecosystem feed back in the northern Barents Sea in an era of climate change**

Prosjektansvarlig:  
**Norges Fiskerihøgskole**  
Prosjektleder:  
**Wassmann, Paul Forsker**

Prosjektnr: 155936/S30  
Bevilgningsperiode og finansiering fra Norges forskningsråd:  
**1.1.2002-31.12.2006**  
2003: **4,321,500** 2004: **5,974,500** 2005:  
**5,757,000** 2006: **4,234,000**

Principle objective: Determine the climatic sensitivity of the dominant energetic and carbon pathways in the MIZ of the northern Barents Sea and Svalbard shelf.

Sub-goals: -Sensitivity test an existing physically-biologically coupled 3D model -Conduct fully integrated, seasonal process studies across the MIZ -Use field investigations and data to improve model algorithms -Improve the model by adding CO<sub>2</sub> and benthos module -Validate simulation with field results -Investigate the impact of climate variability on C flux and ecosystem feed back -Forecast consequences of climate change for MIZ ecosystem

Sea ice is a dominant feature of the shelf seas fringing the Polar Ocean, and a strong indicator of climate change. Ice conditions and low-pressure pathways influence stratification and vertical mixing, and drive primary production through different dominant carbon sources and processes. Changing climatic conditions is therefore expected to alter the dominant energetic and carbon pathways, with ramifications for atmospheric CO<sub>2</sub> - exchange, fisheries and wild life. The synergetic effect of combining the expertise of different scientific fields and institutions with strong arctic experience is crucial to investigate tightly entangled processes and pathways.

The project proposes a multi-disiplinary approach with focus on the northern marginal ice zone (MIZ) of the Barents Sea and the northern Svalbard Archipelago. At different seasons, physical and biological process studies will be conducted at five stations from the southern to the northern MIZ. The project will apply and combine a wide range of methods and tools to investigate how primary production, the biological and chemical carbon pump, and pelagic-benthic coupling are regulated by climate change (variable ice cover, PAR, vertical mixing and stratification).

In order to predict how climate change modulates the role of the MIZ in the future, a 3D physical-biological coupled model will be applied.

## **MACESIZ - Marine Climate and Ecosystems in the Seasonal Ice Zone**

Prosjektansvarlig:  
**Nansen Senter for Miljø og Fjernmåling**  
Prosjektleder:  
**Johannessen, Ola M. Professor**  
Prosjektnr: 155945/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:  
**1.1.2002-31.12.2006**  
2003: **4,648,000** 2004: **5,192,000** 2005:  
**5,159,000** 2006: **5,001,000**

Explore, quantify and simulate past, present and future natural and anthropogenic climate variability and changes, and the response of the marine ecosystem, in the seasonal ice zone of the Greenland Sea, the Fram Strait, and the Barents Sea:

- Identify the marine climate processes determining the SIZ variability and changes - Identify the responses of the marine ecosystem - Assess the quality of their representation and simulations in climate and ecosystem models - Identify the seasonal ice cover respond to past climate changes and the origin of the recent climate changes - Assess the possibility of ice cover retreat in this century, and ecosystem impacts.

The seasonal ice zone is the area between the summer minimum and the winter maximum extent of the polar ice pack, a crucial region in which the polar atmosphere, sea ice cover and ocean interact with the bordering atmospheres and oceans. The northern hemisphere climate of the 20th century has undergone major fluctuations, e.g. an ongoing warming trend which started around 1980 with a pronounced enhancement in the Arctic region and a decrease of the ice extent and a widening of the SIZ. These observations are in accordance with climate model predictions. The pertinent questions in this regard include:

1. To what degree can the changes in the SIZ and the Arctic climate system be ascribed to natural and anthropogenic forcing?
2. To what degree may anthropogenic forcing reduce, or even remove, the Arctic sea-ice cover in this century?
3. How will a widened SIZ and a shrinking ice cover impact on the marine ecosystems?

A joint effort of nine partner institutions within the marine geophysical, geological and biological disciplines aims at answering the questions by analysing comprehensive data sets and integrating climate and ecosystem models of the past, present and future.

## **CITS - Climate Impact of Transport Systems**

Prosjektansvarlig:  
**CICERO Senter for klimaforskning**  
Prosjektleder:  
**Berntsen, Terje Koren Forsker**  
Prosjektnr: 155949/S30  
Bevilgningsperiode og finansiering fra Norges forskningsråd:  
**1.1.2003-31.12.2005**

2003: **385,000** 2004: **385,000** 2005: **435,000**

The overall objective is: To quantify the climate impact in terms of radiative forcing of the most important transport sectors given present and near-future emissions paths with particular emphasis on the roles tropospheric ozone and aerosols.

Partial objectives: A. Assess the reported emissions from transport and compile emissions relative to traffic performance. B. Calculate changes in the atmospheric distribution of climate forcing agents due to transportation. C. Calculate the radiative forcing from the well-mixed GHG form emissions from the various main transport modes (ships, aviation, cars, railway, etc.). D. Calculate the radiative forcing due to indirect effects of emissions from transport (through ozone, methane, aerosols, etc.) due to emissions from transport; for on the various main transport modes (ships, aviation, cars, etc.). E. Compare the climate effects in terms of radiative forcing and metrics based on radiative forcing of the different transport modes in a common framework.

The impact of various sectors of traffic (road traffic, trains, ships, aviation) on the global climate will be assessed in terms of radiative forcing.

Particular emphasis will be given to the effects of short-lived species, such as ozone (through emissions of precursors from traffic) and primary and secondary particles, in addition to long-lived greenhouse gases like CO<sub>2</sub> and N<sub>2</sub>O. The time and location of the emissions of short-lived species will be taken into account in determining their impact. A global 3-D chemical transport model (Oslo CTM2), which includes a comprehensive photochemical scheme and modules for sulphate, soot and organic carbon aerosols, will be applied to study the effects of short-lived species for each transport sector. As part of the project a module simulating the secondary formation of organic aerosols will be developed and included in the model. The climate impact of various sectors will be calculated per transport unit (passenger km or tonne km) in order to enable policymakers to fairly compare the contributions of different sectors to climate change as a basis for mitigation measures.

## **UTLS-AIR - Chemistry of the upper troposphere and lower stratosphere - impact of aircraft emissions**

Prosjektansvarlig:

**Institutt for geofag, Universitetet i Oslo**

Prosjektleder:

**Isaksen, Ivar Sigmund Angell Professor**

Prosjektnr: 155955/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2003-28.2.2006**

2003: **560,000** 2004: **595,000** 2005: **614,000**

The overall scientific aim is to improve our understanding of the processes, which control the chemistry of the upper troposphere and lower stratosphere, with a special focus on aircraft impact. Existing measurement data and instruments will aid model improvement and validation. Process studies will follow addressing chemistry and transport patterns in the UTLS region. The present and future impact of aircraft will be studied through a series of model experiments. Sensitivity studies will consider different flight altitudes, different aircraft routing, and the dependence of such sensitivities on season. Options to reduce aircraft impact will be identified following the achievements of the TRADEOFF project.

Our understanding of the impact of aircraft on the atmosphere has been growing rapidly during the last decade. Aircraft emissions occur in the upper troposphere and the lower stratosphere (UTLS), an important region for both chemistry and climate. The Department of Geophysics, University of Oslo has played an active role in numerous international projects in this field, and UTLS-AIR will continue this work applying a new chemical transport model (OSLO CTM-2) containing comprehensive modules for both tropospheric and stratospheric chemistry.

First, the resolution and the parameterisations of heterogeneous chemistry and lightning emissions will be improved. Existing measurement data will be exploited for analysis of transport and chemical processes important for the UTLS region and for model validation. Detailed process studies will follow addressing the budget and interannual variability of key components in the UTLS region. The impact of aircraft on the chemical composition of the UTLS region will be calculated in detail, both for present and future scenarios, providing information to policymakers. Sensitivity runs will be performed addressing cruising altitude and flight routing. Options to reduce aircraft impact will be investigated. Crucial to this work is the use of ECMWF ERA-40 reanalysis data, allowing consistent runs for different years including the entire stratosphere.

## **External and internal forced variability of the Atlantic-European climate system over the last millennium - a model approach**

Prosjektansvarlig:

**UNIFOB AS - Bjerknes-senteret, Universitetsforskning Bergen**

Prosjektleder:

**Drange, Helge Direktør**

Prosjektnr: 155957/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.7.2003-30.6.2006**

2003: **486,500** 2004: **794,000** 2005: **802,000**  
2006: **428,000**

The overall objective is to examine, quantify and synthesise by numerical modelling the natural variability modes of the Atlantic-European climate system, and the relative role of external and internal forcing factors, over the last millennium. The following sub-tasks are defined: - Set up a version of the Bergen Climate Model for a millennium-long control integration - Perform and analyse the control integration (Exp. 1) - Perform and analyse a 500 years integration with prescribed, external forcings for the period 1500-2000 (Exp. 2) - Synthesise key time series for NAO, winter precipitation, land and ocean temperatures, deep ocean variability for the last 1000 in the North Atlantic-Arctic region. - Perform a series of data - model intercomparisons.

The project aims to bridge activities and knowledge in numerical climate modelling and paleoclimate reconstructions in Norway. The activities will be based on running a state-of-the-art atmosphere-sea ice-ocean model for 1000 years with constant external forcing (i.e., constant solar irradiance, and constant atmospheric greenhouse gas and aerosol concentrations) to assess the natural variability modes in the model. In addition, the model will be integrated for 500 years, representing the period 1500-2000, with prescribed variations in the solar irradiance, and by incorporating the effect of volcanic eruptions and increasing concentrations of the greenhouse gasses. The obtained climate fluctuations from these integrations will be compared with available high-quality, high-resolution proxy records. Finally, the robustness of the simulated variability modes will be examined by adding the human-induced change to the atmospheric concentration of greenhouse gasses and aerosols to the first 250 years of the second experiment. This will address the possibility of climate surprises in the climate system of the 21st

## **Atmospheric Chemistry and Transport from Isotopic Analysis**

Prosjektansvarlig:

**Kjemisk institutt, Universitetet i Oslo**

Prosjektleder:

**Nielsen, Claus J. Professor**

Prosjektnr: 155959/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2003-31.12.2006**

2003: **100,000** 2004: **100,000** 2005: **100,000**  
2006: **100,000**

The overall objective is to contribute to the understanding of Global Change. The specific objectives are: - To provide quality controlled reaction rate coefficients and kinetic isotope effects for selected molecule-radical reactions. - To provide UV absorption cross-sections for selected isotopomers. - To provide the best available theoretical insight concerning isotopic enrichment in atmospheric chemical reaction and photolysis.

Global change depends critically on the concentrations of gases present in the atmosphere at trace levels. The balance between the production and the loss terms governs the concentration of these gases. The stable isotope abundance can be used to provide insight as to the sources and regional and global transformations of greenhouse gases. In particular, the additional information obtained from the construction of an isotopomer budget reduces the uncertainties in the grand budget. To obtain such isotopomer budgets, the isotopic signature of the trace gas's sources and its atmospheric sinks must be quantified. The necessary information is not available today. The project aims at quantifying the isotopic signatures of relevant chemical and photolytic reactions of important atmospheric trace gases and includes both laboratory and theoretical studies. In addition, comparative photolysis experiments will be carried out at the EUPHORE facility in Valencia, Spain.

## **COMBINE**

Prosjektansvarlig:

**Institutt for geofag, Universitetet i Oslo**

Prosjektleder:

**Kristjansson, Jon Egill Professor**

Prosjektnr: 155968/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2003-15.9.2006**

2003: **840,000** 2004: **890,000** 2005: **909,000**  
2006: **31,500**

Principal Objective: To evolve the description and understanding of the aerosol indirect effect through

a combination of model simulations and satellite retrievals. Sub-goals: 1) Identify possible anthropogenic aerosol influence on cloud microphysics based on satellite data. 2) Develop source and sink terms for cloud droplet number. Collaboration with PNNL and AerOzClim. 3) Conduct AGCM experiments with new continuity equation in place. 4) Investigate ways to parameterize the indirect effect of ice clouds. 5) Synthesis of model and observationally based findings.

The indirect effect of aerosols is considered to be a major modulator of earth's climate, only surpassed in magnitude by greenhouse gas forcing, but with opposite sign. However, there is great uncertainty concerning the indirect effect. This is due to a combination of poorly understood physics, insufficient measurements and oversimplified model treatments. The modeling aspect has been addressed within the RegClim project, and will be worked on to some extent in RegClim III and AerOzClim.

To strengthen the research in this area, the project will carry out an integrated effort combining climate modeling and the use of satellite observations. The project will be carried out in collaboration between the Department of Geosciences at the University of Oslo and the Norwegian Institute for Air Research. The modeling approach will be strengthened, e.g., by introducing prognostic equations for cloud droplet number and ice crystal number. The satellite observations will serve to identify and evaluate the magnitude of the indirect effect, as well as to validate crucial model parameters, such as aerosol optical depth, cloud optical depth, liquid water path and cloud condensation nuclei concentrations. These quantities will be obtained from the MODIS (Moderate Resolution Imaging Spectroradiometer) instrument onboard the Terra and Aqua satellites.

## **NORPAST-2 - Past Climate of the Norwegian Region-2**

Prosjektansvarlig:

**Institutt for Geologi, Universitetet i Tromsø**

Prosjektleder:

**Hald, Morten Professor**

Prosjektnr: 155971/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2003-31.12.2006**

2003: **3,175,000** 2004: **3,884,000** 2005:

**4,261,000** 2006: **2,680,000**

Principal objective:

Advance the knowledge of patterns and variability of past climate in the Norwegian region and to contribute to the Understanding of climate forcing factors.

Sub-goals:

- Identify patterns and frequencies of natural climate variability on decadal to seasonal time scales during the last millennium. - Identify long term trends and geographical distribution of gradual changes in natural climate during the Holocene and late glacial. - Elucidate the role of ice-ocean interaction in forcing and shaping abrupt climatic change. - Study the relative importance of the various forcing factors. - Investigate the origin of the climate change during the Recent Past (natural/anthropogenic origin). - Develop, improve and test proxy methods for climatic reconstructions

The project aims to advance the knowledge of patterns and variability of past climate in the Norwegian Region (Norway and adjoining continental margin and fjords) and to contribute to the understanding of climate forcing factors. The studies will focus on quantitative climate reconstructions during the last deglaciation, the Holocene and the Recent Past, by investigating a limited number of highresolution sites from terrestrial and marine archives; by improving paleoclimatic proxies; and by synthesising existing and new data. The project will be divided into five related modules:

1. Patterns and frequencies of natural climate variability on decadal to seasonal time scales during the last millennium.
2. Patterns and frequencies of natural climate variability on decadal to millennial time scales during the late glacial and Holocene.
3. Ice sheet/ocean interactions during abrupt climate changes.
4. Development, improvement and testing of proxy methods for climate reconstructions.
5. Correlation and synthesis of results.

## **NoClim - Norwegian Ocean and Climate Project - Phase II**

Prosjektansvarlig:

**UNIFOB AS - Bjerknes-**

**senteret, Universitetsforskning Bergen**

Prosjektleder:

**Haugan, Peter M. Instituttleder**

Prosjektnr: 155972/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2003-31.12.2006**

2003: **3,866,000** 2004: **4,373,000** 2005:

**4,474,000** 2006: **3,287,000**

The principal objective of the project is to significantly improve our understanding of

processes which govern oceanic heat transport towards the Nordic Seas, and which provide the basis for atmospheric heat transport from the Atlantic sector towards northern Europe. .

Subgoals:

-To elucidate how stable the Atlantic Meridional Overturning Circulation (AMOC) is to human induced greenhouse warming. -To identify whether rapid climate transitions in the past were associated with changes in the overturning rate in the Nordic Seas. -To investigate whether the balance of evidence (from observations, process understanding and models) indicates that abrupt changes are underway or likely to happen in the near future.

The project is a continuation of the NOClim Phase I project, but focussing all available resources on the fundamental and overarching issue of Atlantic Water flow towards and into the Nordic Seas. The project will be executed by combining theory and numerical modelling with analyses of recent instrumental data and reconstructions from proxy data. The project work will be organised in three modules:

- Module A: Theory and modelling of meridional oceanic heat transport.
- Module B: Analysis of abrupt changes in the past.
- Module C: Analysis of modern variability and detection of significant changes.

The project intends to serve as an authoritative source of information and advice to the Research Council and the public concerning the difficult issues of possible rapid climate change related to ocean circulation. The project will actively exploit international links and contacts both in scientific syntheses and public outreach, and also integrate other relevant national research.

## **AerOzClim - Aerosols, Ozone and Climate - main application**

Prosjektansvarlig:

**Institutt for geofag, Universitetet i Oslo**

Prosjektleder:

**Isaksen, Ivar Sigmund Angell Professor**

Prosjektnr: 155974/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2003-31.12.2006**

2003: **3,250,000** 2004: **3,250,000** 2005:

**3,250,000** 2006: **3,250,000**

The main objective of AerOzClim is to improve our understanding of aerosol-climate and ozone-climate interactions, by continue to develop and apply global models in combination with analysis of observations, to study processes involved, and to

provide improved parameterisations of climate models.

The studies will include:

- Process studies of poorly described processes in models, in order to reduce large uncertainties connected with estimates of the direct aerosol effect  
- Methods to calculate process-allocated aerosol life cycles, with parameterized radiative properties, water-activity and cloud-droplet impacts, implemented in an atmospheric GCM; - Collection of additional data and analysis of processes affecting ozone loss and climate change in the stratosphere, and in the UTLS region. - Develop model tool for ozone chemistry/climate interactions. Implement the parameterised processes in GCMs and perform coupled climate/chemistry model studies.

Ozone and aerosols show large spatial and temporal variations in the atmosphere. In the troposphere, man made emissions have increased their concentrations significantly, particularly in regions of emissions of pollutants. In the stratosphere, ozone is reduced due to man made emissions. In order to improve our understanding of aerosol-climate and ozone-climate interactions AerOzClim will perform processes studies and parameterisation of processes in climate models. The studies will include interactive model runs to estimate the interaction of aerosols and ozone with climate. The studies will include the use of CTMs and GCMs combined with data analysis. Ozone modelling and analysis will include processes in the troposphere as well as in the stratosphere. Studies of aerosols will include different types of anthropogenic and natural aerosols.

The activities are divided into 4 moduls:

1. Understanding the direct aerosol effect.
2. Aerosol-climate interactions in climate models.
3. Observations and analysis of stratospheric ozone, water vapour and other trace gases, and
4. Ozone-climate interactions.

There will be significant interactions in modelling and analysis between the modules and with other national and international projects. Results from the AerOzClim project will be published in international journals and presentation at meetings, and for the public through articles in popular journals like CICERONE.

## **RegClim Phase III - Regional Climate Development Under Global Warming - Main application**

Prosjektansvarlig:

**Meteorologisk institutt - Oslo**

Prosjektleder:

**Iversen, Trond Professor**

Prosjektnr: 155976/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2003-31.12.2006**

2003: **5,250,000** 2004: **5,250,000** 2005: **5,300,000** 2006: **5,250,000**

Overall Aim (Principal Objective):

To estimate scenarios for regional climate change suitable for impact assessments in Northern Europe, bordering sea areas and major parts of the Arctic (our region) given a global climate change; and to quantify their uncertainties due to choice of methods, global scenarios, and to uncertain processes influencing our region's climate, in particular those causing the warm and ice-free Nordic Seas, and the effects of aerosols.

Sub-goals are detailed in project description for the Main Application, and for the Module Applications. In summary:

(a) Major Result-producing Sub-goals related to the Principal Modules (M). 1) ECHAM GSDIO scenario downscaled in the atmosphere with finer resolution than before; 2) Uncertainty and risk: multi-model and multi-scenario atmospheric empirical and dynamical downscaling, mel. common SRES; 3) Pure ocean, and coupled atmosphere-ocean downscaling of the common SRES-scenario; 4) Global projections for processes important for northern North Atlantic climate for common SRES; 5) Global projections with improved aerosols for common SRES; 6) Downscaling global RegClim-scenarios for process-specific uncertainty and risk estimates (atmosphere, ocean, coupled); 7) Feasibility of using Forcing Singular Vectors for generating ensembles for dynamica downscaling; 8) Relate flow-regime Forcing Sensitivities to results from PM3 and PM4.

(b) For Project Administration and Management (PAM): 1) Establish relations to climate centres; 2) Agree on a common SRES-scenario for at least one set of experiments in all PMs; 3) Annual seminar, progress evaluation and adjustments of plans; 4) General Technical Report, popular summary, major update of web-site, and press release; 5) Evaluate the need for new Brochure and Press Conference.

RegClim Phase III continues and adjusts earlier RegClim phases. It will produce projections of regional climate change for impact assessments in Northern Europe, bordering sea areas and major parts of the Arctic (our region), given global climate change; and to quantify uncertainties due to methods, scenarios, and poorly understood processes influencing our region. Changed risks for extreme events will receive attention.

Four principal modules are defined. Downscaling future projections of global climate will be done in PM1 and PM2. Empirical (statistical) downscaling and dynamical (numerical model) downscaling will be used in the atmospheric and upper ocean.

Changed risks for extreme events and quantification of uncertainty will be quantified. Uncertainties in the Arctic and the Nordic Seas receive specific attention by coupled limited-area downscaling (PM2) and coupled global modelling with grid focus (PM3). The description of aerosol-radiation-cloud processes will be developed in AerOzClim and the global climate response estimated in PM4. The uncertainty in a regional climatic response of unresolved regional processes will be quantified through downscaling global scenarios from PM3 and PM4. The understanding of uncertainties associated with natural variability and emission scenario will benefit from Nordic co-operation. RegClim provides input data to climate impact studies in our region, and contributes to international climate research and to IPCC.

The modules are:

1. RegClim PM1: Atmospheric interpretation for regional climate.
2. RegClim PM2: Regional interpretation for oceanic and Arctic climate.
3. RegClim PM3.
4. RegClim PM4: Climate responses of regional contaminants.
5. RegClim Phase III - Regional climate development under global warming. Principal Module 5: Optimal forcing structures for atmospheric flows and regional climate predictability.

## **A study of the Arctic Upper Troposphere/Lower Stratosphere (UTLS) Region**

Prosjektansvarlig:

**Norsk institutt for luftforskning**

Prosjektleder:

**Hansen, Georg Avdelingsdirektør**

Prosjektnr: 155978/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2003-30.4.2006**

2003: **500,000** 2004: **500,000** 2005: **374,000** 2006: **126,000**

Main objective:

To investigate the characteristics and the role in global change of the Arctic tropopause, with special emphasis on Arctic tropopause property trends and stratosphere-troposphere coupling processes.

Sub-goals:

- Re-analyse data sets from meteorological services and radiosonde and ozonsonde stations in

Scandinavia and Svalbard from 1990 to present w.r.t. tropopause characteristics (seasonal and inter-annual variation): - Build up data set of time-resolved observations of vertical distribution of temperature, ozone, and backscatter intensity/SNR in the UTLS region using lidar and radar. - Study Arctic UTLS thermal structure and coupling processes (inter-annual, intra-seasonal variability) and dependence on atmospheric circulation and planetary waves.

The project will study of the Arctic tropopause and stratosphere coupling. This will be done on the basis of a meteorological (ECMWF) data set from 1990 until now and a set of radar and lidar high resolution measurements from several stations in Scandinavia (ALOMAR, Kiruna, Sodankylä) and on Svalbard (Ny-Ålesund).

Characteristics of the Arctic and subarctic tropopause (altitude, temperature, structure) will be derived, as well as the relation between the thermal, dynamical and ozone tropopause. From simultaneous measurements at the relatively near stations in Northern Scandinavia, information on horizontal scales of tropopause structures will be deduced.

The project will also investigate coupling processes in the Arctic UTLS region, with an emphasis on the winter spring season, when the Arctic polar stratospheric vortex is present. Focus will be on year-to-year and seasonal variability of cold events in the UTLS region and their coupling to the circulation state, dynamical large-scale fluxes due to planetary waves, and the signature of leading atmospheric patterns in addition to the arctic Oscillation in the UTLS region.

## **Geohazards, Climatic Change, and Extreme Weather Events**

Prosjektansvarlig:

**Norges geologiske undersøkelser**

Prosjektleder:

**Blikra, Lars H. Forsker**

Prosjektnr: 164885/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2005-31.12.2008**

2005: **2,757,000** 2006: **2,787,000** 2007:

**2,331,000** 2008: **2,125,000**

An assessment of geohazards and their consequences in Norway under a predicted future climate regime. Hereunder:

- To establish relationships between meteorological conditions (triggering factors) and geohazards in

the form of avalanches and slides based on past (mainly historical) records for Norway.

- To produce high-resolution climatic scenarios for the next 5 decades, as input to assessments of the frequency and dimensions of future geohazard events.

- To establish geohazard scenarios for the next decades in selected regions of Norway based on the above historical records and climate scenarios.

- To assess the socioeconomic consequences of geohazards for the Norwegian society with reference to past experience and develop risk-based predictions for the socioeconomic consequences of future climate- and geohazard scenarios.

- To derive policy implications with a focus on the society's ability learn by experience and increase its preparedness.

Geohazards are events related to geological features and processes that cause loss of life and severe damage to property and the natural and built environment. The most common in Norway are snow avalanches, clay-, debris- and rock slides, which together caused more than 2000 deaths during the last 150 years. Statistically, about 10 large slides and avalanches are expected to occur in Norway the next 50-100 years, each with possibly 20-100 deaths and a large impact on infrastructure unless preventive planning and actions are made. A possible increase of extreme weather events in the next 50 years may lead to an increased slide frequency.

The project involves five different institutions, which also includes two of the Norwegian Centres of Excellence in Research, covering a wide range of natural and social sciences. The proposed research will define the relationships between meteorological conditions and geohazards based on historical records and numeric simulations. We will produce h

igh resolution climate and weather scenarios for the next 50 years, and use these in assessing the frequency and character of future geohazards events. This will be done partly in selected case regions, covering a range of geohazards types, geographic setting and degree of societal preparedness, but results will also be extrapolated for Norway as a whole. The project involves assessment of the socioeconomic consequences of geohazards in Norway, both in the past, and under the predicted future climate. Important parameters are cost related to damage as well as to mitigation measures, learning by experience, preparedness, and impact on policy makers.

Bridging gaps between natural and social sciences is an important aspect of the project. As geohazards

are an important part of Norwegian daily life and receive significant public interest, we aim at reporting project results in frequent newspaper articles and popular science magazines, in addition to scientific journals.

## **Quality of soil organic matter in forest and heathland soils, co-operation between Italy and Norway**

Prosjektansvarlig:

**Universitetet for miljø- og biovitenskap, Institutt for plante- og miljøvitenskap**

Prosjektleder:

**Strand, Line Tau Førsteamanuensis**

Prosjektnr: 164903/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.8.2005-31.10.2005**

2005: **120,000**

Dr Certini's work during his visit will be conducted in close cooperation with the ongoing Clue project. During the visit by Dr Certini we propose to:

1) Establish methods for characterization of the quality of soil organic matter in semi-natural forest and heathland ecosystems.

2) Pave way for future projects through the co-operation between the Agricultural University of Norway, Department of Plant and Environmental Sciences, the Norwegian Forest Research Institute, Skogforsk and the University of Florence, Department of Soil Science and Plant Nutrition.

3) Publish a paper based on the work done during the guest stay.

The Clue project, "Effect of climate change on flux of N and C: air – land – freshwater – marine links", financed by the Norwegian research council started in 2003 (project No155826/S30). Quantification and characterization of dissolved organic matter (DOM) from soils subjected to different manipulations simulating future climate changes and expected land use changes, is one of the main tasks in this 5-year project. The dissolved organic matter is naturally related to the quantity and quality of the soil organic matter (SOM). In order to strengthen our competence within the Clue project on methods for characterizing SOM we have established contact with the Department of Soil Science and Plant Nutrition, University of Florence, Italy. We wish to benefit from the experience this department has in determining the quality of SOM in relation to different soil types and soil forming processes. Through a visit by senior scientist Dr

Certini we wish to establish methods for characterizing SOM

relevant also to the characterization of the DOM in the Clue project. We intend to use a combination of extraction methods and non-destructive methods to characterize the SOM. The techniques we wish to use in studying the complex structure of soil organic matter will be: near-infra-red spectroscopy (NIR) and solid-state <sup>13</sup>C nuclear magnetic resonance (NMR). The soils will be taken from experimental sites used in the Clue-project. During the guest visit we also hope to develop a lasting cooperation with the Department of Soil Science and Plant Nutrition, University of Florence, through future research proposals, staff and student exchange programs. Results from experiments done during Dr Certini's stay will be published in an international refereed journal with cooperating researchers as co-authors.

## **Pollution risks and water management at airports and roads in a changing climate**

Prosjektansvarlig:

**Jordforsk**

Prosjektleder:

**French, Helen K. Forsker**

Prosjektnr: 164946/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2005-31.12.2008**

2005: **546,000** 2006: **598,000** 2007: **625,000**

2008: **377,000**

Main Objective: Quantify possible consequences of climate change for the risk of polluting groundwater and surface water caused by hydrological changes at airports and roads. Sub-goals: 1) Determine the relationship between weather and winter operations (mechanical removal of snow and use of de-icing chemicals) 2) Quantify spatial and temporal melt water infiltration through a partly frozen soil during snowmelt 3) Relate infiltration pattern to the distribution of soil and snow physical parameters and micro-topography. 4) Quantify transport parameters during various snowmelting scenarios. 5) Examine the significance of a temporal and spatially variable infiltration on flow and transport in the unsaturated zone at different scales for risk assessment purposes. 6) Build a model concept, which enables transfer of knowledge from the particular sites examined to other locations and weather scenarios. 7) Determine key parameters and processes for predicting infiltration process during snowmelt.

Management of surface runoff formed during snowmelt is a challenge in many urban areas. Even

in areas with normally high infiltration capacity, the ground surface can become impermeable during snowmelt. Climate change is expected to increase precipitation during autumn and give more frequent temperature fluctuations around 0°C in Norway. This is likely to affect the infiltration regime throughout the winter and during snowmelt. It is hypothesised that these changes will reduce infiltration capacity and hence have important implications for surface runoff management. Increased use of de-icing chemicals and reduced infiltration capacity will increase the risk of polluting groundwater and surface waters. Oslo airport, the main northern bound motorway (E6) and railway are all situated on the largest unconfined sandy aquifer in Norway, Gardermoen. The flow and transport pattern as well as the structural architecture have been widely characterised at the site. Because it also hosts the extensively equipped research site, Moreppen, it is an appropriate location for studies related to climate change risk assessment purposes. Joint efforts with Oslo airport and the Norwegian Road Authorities to perform statistical analysis of historical data of climatic conditions and associated winter weather operations will provide information about likely consequences for management practices in a changing climate. State-of-the-art non-destructive tomographic and surface imaging tools based on electrical measurements will quantify the infiltration process in the field at different scales; at a reference site, Moreppen, along the runway, and below temporarily formed surface ponds. The infiltration pattern will be related to physical conditions at the site. To identify the need for adaptation strategies, a 3D unsaturated flow and transport model will be calibrated on the field data at different scales and used to examine possible pollution effects of different climate change scenarios.

## **Norwegian Component of the Ecosystem Studies of Sub-Arctic Seas (NESSAS)**

Prosjektansvarlig:

**Havforskningsinstituttet**

Prosjektleder:

**Drinkwater, Kenneth Dr.**

Prosjektnr: 165000/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2005-31.12.2008**

2005: **1,092,000** 2006: **2,913,000** 2007:

**3,260,000** 2008: **2,735,000**

The overall goal of NESSAS is quantify the impact of climate variability on the structure and function of the Barents Sea marine ecosystem in order to

predict the ecosystem response to possible future climate change and its possible economic impact.

Subgoals include:

1. What are the processes linking global and regional climate variability to the physical oceanography of the Barents Sea?
2. How does the variability in the ocean climate affect ecosystem processes and structure within the Barents Sea?
3. Forecasting how changes in climate will affect the structure of the marine ecosystems in the Barents Sea.
4. What is the economic impact of the expected changes in the fish stocks?
5. How does the climate forcing of the structure and function of the marine ecosystem in the Barents Sea compare to other Sub-Arctic Seas?

The overall goal of NESSAS is to quantify the impact of climate variability on the structure and function of the Barents Sea marine ecosystem in order to predict the ecosystem response to possible future climate change and its possible economic impact. The program will use past and ongoing projects as well as undertake new research to address some of the gaps in our knowledge regarding the climate forcing of the physical oceanography of the Barents Sea and their impacts on the ecosystem. This will include a combination of retrospective analyses and modelling.

The information on processes and mechanisms linking climate and ecosystem responses will be used to extend and improve the existing models before making quantitative predictions on the ecosystem response to future climate scenarios. This will include changes to the fish and invertebrate stocks.

Many of the models that will be used have been developed under previous projects and will be modified, where needed, to address the specific issues within NESSAS. The economic impact of the expected changes in the fish stocks under various climate change scenarios on the value of the fisheries, fleet structure and plant processing capabilities will also be addressed. In addition, comparisons with other Sub-Arctic Seas such as the Bering Sea, the Labrador Shelf, the shelves off West Greenland and Iceland, the Sea of Okhotsk and the Oyashio region will be made in order to gain insight into the functioning of Sub-Arctic Seas in general and the Barents Sea in particular. This project will form the major contribution of Norway

to the new international GLOBEC regional program entitled Ecosystem Studies of Sub-Arctic Seas (ESSAS).

## **Climatic responses in boreal ecosystems: a spatiotemporal analysis spanning 70 years of vegetation dynamics in a north-boreal alpine ecotone**

Prosjektansvarlig:

**Norsk institutt for skogforskning**

Prosjektleder:

**Nilsen, Petter Forsker**

Prosjektnr: 165035/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2005-31.12.2008**

2005: **1,700,000** 2006: **1,430,000** 2007:

**1,270,000** 2008: **1,600,000**

Determine changes in forest productivity, vegetation and vegetation gradients, and timberline position in the northern boreal zone, and predict future climate change effects in this ecotone. Evaluate the accuracy of the LiDAR scanning method for rapid and cheap biomass and C storage and increment estimations.

- Analyse changes through the past 70 years in vegetation and soil properties in relation to climatic data.

- Detect and analyse changes in tree- and timberline position throughout the same period.

- Use LiDAR airborne scanning technology in order to estimate above ground biomass and carbon storage and annual carbon sequestration along a gradient from forests in the middle boreal zone to the alpine zone.

- Make future predictions on changes in the timberline, plant dynamics, diversity, and productivity based on regional RegClim results.

- Provide the audience with information regarding the results from the study.

The north boreal forests and the low alpine areas cover a large proportion of the Norwegian land surface. The predicted anthropogenic climate changes are supposed to have large influences in these areas due to potential immigration of tree species above the existing treeline. Steep

temperature gradients influence the survival of many plant species and their internal competition.

The changes are supposed to be slow, and the efforts to quantify the changes will be large with existing survey methods. We therefore look for the use of more easy accessible methods as LiDAR airborne scanning for present and future determination of resources.

We will also use past vegetation and soil registrations for analysing the development of the vegetation and the tree stands in a selected research area (Hirkjølen). This is an outstanding study area, due to a detailed mapping of vegetation, soil properties and timberline position in 1932-1936. The field registrations were done in permanently marked plots

positioned in a regular grid which covers an area of appr. 1400 ha and ranges from 740 to 1160 m a.s.l. The plots will be reanalysed with respect to vegetation and soil, and the information will be included in a digital terrain model along. The old and the new vegetation data will be analysed with respect to changes which can be related to climatic fluctuations. Changes in timberline position will be analysed.

These results together with other relevant information on plant species composition and competition will be used combined with RegClim regional climate scenarios in order to predict the effects of future climate change in this ecotone. We plan to provide information from the project in co-operation with professional information workers.

## **Climate effects of reducing black carbon emissions**

Prosjektansvarlig:

**CICERO Senter for klimaforskning**

Prosjektleder:

**Berntsen, Terje Koren Forsker**

Prosjektnr: 165064/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2005-31.12.2008**

2005: **716,000** 2006: **2,550,000** 2007:

**2,982,000** 2008: **1,752,000**

To quantify the net effect on climate of reducing black carbon aerosols: Scientific, economical and political perspectives.

Sub-goals:

A1. Quantify the impact of BC in snow on surface reflectance

A2. Quantify the radiative forcing and temperature change of the direct and semi-direct effect of BC

A3. Quantify the forcing and temperature change due to change in surface reflectance

B1. Identify important sources of BC and possible reduction potentials, including associated emissions of other components.

B2. Quantify changes in atmospheric distribution and deposition of BC due to these emission changes.

B3. Quantify the radiative forcing due to changes in atmospheric distribution caused by the reduced emissions.

C1. Identify other key environmental issues affected by BC emission reductions

C2. Quantify costs of alternative emission reduction options

C3. Identify political obstacles and possibilities for emission reductions

Processes leading to emissions of black carbon (BC) aerosols from incomplete combustion affect the Earth's climate through several forcing mechanisms: Direct absorption of sunlight, a semi-direct effect on clouds, by deposition on snow and ice thus changing the surface albedo, and through associated emissions of other climate agents. The proposed project will study the net effect of reducing emissions of BC aerosols, taking into account scientific, economic and political perspectives. This will be done first by measuring the spectral reflectance of snow and sea ice surfaces, and by measuring and analyzing BC content in the snow and sea ice in Svalbard and the Greenland Sea. This information will then be used along with other observations and chemical transport model (CTM) calculations of BC deposition in other regions to drive a general circulation model (GCM) to quantify the global climate impact. In collaboration with two leading European research groups, GCM calculations of the direct and semi-direct effect will be carried out with the aerosol optical properties and distribution from the CTM included. To investigate the climate effects of BC emission reductions, three emission scenarios (including associated emission changes of other climate relevant species) will be constructed: 1) A pure natural science perspective, 2) Scenario 1 with an added economy perspective by choosing the most cost-effective emission reduction, and 3) A focus on political feasibility, but building on scenarios 1 and 2. The climate effects (including long-term effects of changes in long-lived greenhouse gases) will be estimated by combining the CTM and a simple climate model (SCM) and analyzed with the perspectives of economics and political feasibility.

## Norwegian Service Centre for Climate Modelling

Prosjektansvarlig:

**Meteorologisk institutt - Oslo**

Prosjektleder:

**Skålin, Roar Direktør**

Prosjektnr: 165100/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2005-31.12.2006**

2005: **250,000** 2006: **250,000**

To facilitate efficient climate research and climate effect studies in Norway by providing technical assistance in IT related areas, such as

- Archiving of climate modelling data;
- Data access, handling and format conversion;
- Programming, computational efficiency and porting of climate models;

The Norwegian Service Centre for Climate Modelling (NoSerC) was established late 2000. The centre is located at the Norwegian Meteorological Institute (met.no) and financed by the Research Council of Norway and met.no. The overall aim of the centre is to facilitate efficient climate research and effect studies in Norway by providing technical assistance in the areas of data handling and analysis and computational efficiency of climate models.

Main tasks proposed for the period 2005-2006:

1. Operate the facility for archiving of climate modelling data;
2. Provide assistance and data for effect studies;
3. Programming, porting and computational efficiency of climate models;
4. Provide access to international climate datasets.

In addition to provide technical assistance, NoSerC has so far financed a national facility for archiving of climate modelling data. In order to meet the increasing storage requirements for climate data, such a facility must grow by a factor of 2-4 every year. Based on signals received in 2002, NoSerC propose no funding for new infrastructure in this application, but we encourage NORKLIMA to discuss the responsibility for such funding and evaluate the possibilities of meeting the storage requirements.

## Marine ecosystem consequences of climate induced changes in water masses off West-Spitsbergen

Prosjektansvarlig:

## **Norsk Polarinstitutt**

Prosjektleder:

**Gabrielsen, Geir Wing Forsker**

Prosjektnr: 165112/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.7.2005-30.6.2008**

2005: **1,827,000** 2006: **4,412,000** 2007:

**4,362,000** 2008: **1,399,000**

Climate change will affect the distribution of warm Atlantic water (AW) and cold Arctic water (ArW) masses of shelf and fjord regimes in West-Spitsbergen. This will alter the zooplankton composition and subsequently change the energy transfer within the pelagic food web with consequences for upper trophic levels.

H1: Climate change will alter the volume transport and characteristics of AW, the recirculating deep ArW and Arctic surface water. Subsequently the exchange of water masses in the gradient shelf slope - West-Spitsbergen fjords will be affected, and by that also the fast ice condition in Kongsfjorden.

H2: Variability in water circulation patterns is the main mechanism regulating the distribution and size structure of zooplankton and pelagic fish.

H3: Changes in size and energy content of key zooplankton prey will influence the energy transfer in the pelagic food web with consequences for growth and survival of Little auk and Black-legged kittiwake chicks.

The overall goal of the MariClim proposal is to determine the influence of climate variability and change on the energy transfer in the marine pelagic ecosystem in different water masses on the west coast of Spitsbergen. The project will compare the pelagic food webs in fronts involving ArW and AW masses in this high Arctic region. Climate change effects can be studied in Kongsfjorden because of high variability in the influx and dynamics of AW and ArW. A cold climate scenario would result from less influx of AW to the shelf and fjord regimes in West-Spitsbergen, whereas a warm climate scenario would occur because of an increased influx of AW.

The main hypothesis is that variability in water circulation patterns is the main mechanism regulating the distribution and size structure of the zooplankton community, and that changes in size and energy content of key zooplankton prey will influence the energy transfer in the pelagic food web with consequences for growth and survival of Little auks and Kittiwake chicks. The seabirds require access to abundant and energy-rich zooplankton and pelagic fish in order to raise their chicks successfully. Climate related changes in water masses would be expected to indirectly affect

these seabirds through changes in their prey base and associated energy flow. Cruises and field work will be conducted in Kongsfjorden. Scientific historical data from different disciplines (oceanography, sea-ice, marine ecology and seabirds) will be used for climate variability analysis and model validation.

The new Arctic Marine Laboratory in Ny-Ålesund will be extensively used by the proposed project. The work will involve a strong international collaboration, including 11 institutes actively participating in the project, and recruitment of young scientists through 2PhD -, engaged researcher (2.5 years)/ guest researcher positions (1 year) and several Master students.

## **Biogeochemistry in Northern Watersheds, a Reactor in Global Change**

Prosjektansvarlig:

**Biologisk institutt, Universitetet i Oslo**

Prosjektleder:

**Hessen, Dag O. Professor**

Prosjektnr: 165139/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.3.2005-31.12.2008**

2005: **1,893,000** 2006: **2,955,000** 2007:

**1,743,000** 2008: **1,409,000**

Main goal: To build an empirical model for predicting mass balance of carbon, the flux associated elements from and greenhouse gases from watersheds related to climate and vegetation. We hypothesize that increased precipitation and warming in concert will cause increased runoff of TOC and associated elements.

Sub-goals:

1. To make predictions of TOC export and GHG emissions) under future scenarios of temperature, precipitation and forest cover.
2. To study the biogeochemical linkage between carbon (C), nitrogen (N), phosphorus (P) and silica (Si) in catchments.
3. To study the fate of the major flux of organic C that enters freshwaters and coastal areas. Photo-oxidation and oxidization by heterotrophic bacteria, contribution to food web, sedimentation
4. To study the relationship between fluxes of organic C, N and P and the emission of greenhouse gases methane (CH<sub>4</sub>) and dinitrogenoxide (N<sub>2</sub>O) from different strata of the watershed as delineated by remote sensing.

Land and freshwater ecosystems are important reactors in Global Change; pollution and climate

change affect biogeochemical functions, which feeds back on climate forcing and eutrophication through emissions to water and atmosphere. An interdisciplinary watershed project is proposed, focusing the release and ecological roles dissolved organic carbon (DOC) on its way from soil to the coast, and the release of greenhouse gases (GHG) to the atmosphere. The rationale for combining these phenomena in one project is the common spatial and temporal regulators in the landscape (geomorphology, hydrology, forest biomass and productivity), hence a common interest in tackling scaling issues by stratifying the landscape into homogenous response units (HRU).

In a reference watershed, novel high resolution remote sensing techniques will be used in combination with hydrological modeling, to delineate HRUs. The terrestrial "ground truth" will be investigated by field campaigns (hydrology, soil- and vegetation, gas fluxes, their isotope signatures, etc). The ultimate aim is to explore the options for adequate landscape stratification based on remote sensing, as a basis for upscaling estimates of DOC release and GHG flux/isotope-signatures. Ongoing measurements of DOC and chemistry in the reference watershed will be continued and refined. The project is divided into 5 work packages. WP1 will analyse databases for Nordic lakes to explore concentrations and mass transport of DOC, N, P and Si related to hydrology and watershed properties. WP2 and 3 involves all partners in process-oriented studies of the reference watershed. WP4 will study loss rates and transformations of DOC in water (photo-oxidation and microbial) while WP5 will build on WP1-4 to construct an empirical model for a mass balance of C and flux of greenhouse gases from northern catchments in relation to catchment characteristics and climate, linking also the dependency of other key elements to the flux and fate of C.

## **Stable isotope signatures in N<sub>2</sub>O and CH<sub>4</sub>: linking microbial processes to atmospheric chemistry**

Prosjektansvarlig:

**Universitetet for miljø- og biovitenskap**

Prosjektleder:

**Bakken, Lars Professor**

Prosjektnr: 165145/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.5.2005-31.12.2008**

2005: **425,000** 2006: **638,000** 2007: **518,000**

2008: **419,000**

Principal objective and sub-goals To study biogenic isotope signatures of the radiatively active atmospheric trace gases N<sub>2</sub>O and CH<sub>4</sub> in the framework of the microbial ecology of C- and N-transformations in terrestrial ecosystems with the ultimate goal to improve source estimates of flux-weighted isotope signatures used in atmospheric chemistry models. To this end, strain-specific kinetic fractionation constants for the heavy isotopes in N<sub>2</sub>O will be determined for denitrification under controlled laboratory conditions. The kinetic variability of isotope fractionation will be compared to the isotopic signals in N<sub>2</sub>O from naturally denitrifying soil microbial communities to evaluate the potential of stable isotope signatures for source apportionment and up-scaling. <sup>13</sup>C and D/H measurements in CH<sub>4</sub> will be used to apportion in situ CH<sub>4</sub> oxidation in selected wetland sites run by NECC. The project shall build national competence in biosphere-atmosphere research and make isotope techniques available for greenhouse gas studies across Scandinavia.

The stable isotope content (<sup>15</sup>N, <sup>18</sup>O, <sup>13</sup>C, D/H) of atmospheric nitrous oxide (N<sub>2</sub>O) and methane (CH<sub>4</sub>) reflects the overall balance of isotopic fractionation associated with its formation, transport and destruction. Knowledge of process-specific isotope effects has become a powerful tool in clarifying source-sink relationships for these important greenhouse gases and helps to constrain the global budgets for N<sub>2</sub>O and CH<sub>4</sub>. Recent analytical developments in continuous flow isotope ratio mass spectrometry (CF-IRMS) now also allow determination of the site-specific <sup>15</sup>N abundance within the linear N<sub>2</sub>O molecule. This opens for an additional, independent signal to further confine N<sub>2</sub>O sources and sinks. Substantial knowledge exists to date about the kinetic isotope effects (KIE) of the major atmospheric sink processes, UV-photolysis, O(<sup>1</sup>D)-oxidation and hydroxyl-reaction. The isotopic imprints of the dominant biogenic source processes, nitrification, denitrification and methanogenesis, in contra

Norway and at the Institute for Energy Technology Kjeller, to perform in-depth studies on the kinetic fractionations associated with the production, consumption and emission of N<sub>2</sub>O and CH<sub>4</sub>, including the site-preference of <sup>15</sup>N in N<sub>2</sub>O. This work draws heavily on in-house expertise in the ecophysiology of microbial C- and N-transformation and on instrumentation to measure and control the kinetics of such transformations. The project, and its strong international dimension, will enable us to participate in modern studies of biosphere-atmosphere interactions and to make

theses rapidly developing techniques available for other groups within Norwegian climate research.

## Winter school in atmospheric chemistry in Ny-Ålesund and at the University Centre in Svalbard - Trace gases and aerosols in the Arctic

Prosjektansvarlig:  
**Universitetssenteret på Svalbard AS**  
Prosjektleder:  
**Holmén, Kim**  
Prosjektnr: 165300/S30  
Bevilgningsperiode og finansiering fra Norges forskningsråd:  
**1.11.2005-1.3.2006**  
2006: **100,000**

Title: Trace gases and aerosols in the Arctic  
Responsible: Kim Holmén (NILU), Frode Stordal (UiO/NILU) og Lars R. Hole (UNIS/NILU).  
Guest Teachers: Christoph Heinze (Geophysical institute/University of Bergen), Juha-Pekka Tuovinen (Finnish meteorological institute). Others from the research community in Ny-Ålesund and universities in Oslo and Bergen.  
ECTS: 10  
Duration: 5 weeks / 10-15 lectures per week.  
Material: ACIA-report, articles  
Teaching: Lectures at UNIS, two week visit in Ny-Ålesund (Zeppelin-station and other stations such as Institut Polaire Francais and Japan Station for glaciology and climatic research ), exercises and model applications.

### Contents

The course will describe chemical composition of the Arctic atmosphere, with focus on tropospheric conditions. Anthropogeneous and natural sources will be treated in the biogeochemical cycles for different compounds. Sources and sinks for gases and aerosols and their chemical transformation under transport to and from the Arctic will be discussed in a global setting. Main focus will be given to climate gases, oxidants (tropospheric ozone) and their precursors, acid rain, stratospheric ozone and aerosols with and their role in the climate system. Our course will be based on observations of gases and aerosols in the Arctic, with emphasis on data from Ny-Ålesund. Theoretical models for the interpretation of data will be introduced. We will also describe how to plan and carry out experiments in atmospheric chemistry through team work and we will have critical evaluation of previous experiments.

Measurement data from FLUXNET and ILEAPS will also be applied.

## Utenlandsstipend application for Kari Sire Berner

Prosjektansvarlig:  
**Norsk Polarinstitut**  
Prosjektleder:  
**Koc, Nalan Seniorforsker**  
Prosjektnr: 165354/S30  
Bevilgningsperiode og finansiering fra Norges forskningsråd:  
**1.3.2005-31.12.2005**  
2005: **51,000**

This is an application for a 4 months utenlandsstipend for PhD fellow Kari Sire Berner to be spendt at Woods Hole Oceanographic Institute (WHOI), U.S.A during 2005. Berner's PhD fellowship, which is financed through NFRs NORKLIMA projects NORPAST2 (Project **155971/720**) and **NoClim2 (Project 155972/720)** and the EU-financed PACLIVA project, has the objective of assessing the Holocene climate development and the natural variability of the North Atlantic Drift and the Norwegian Atlantic Current by utilizing quantitative methods.

The purpose of the stay at WHOI for Berner is:

1. to discuss the sedimentology and chronology of core LO14
  2. to present her diatom based Holocene SST results from LO14 and MD952011 to colleagues at WHOI
- to put her own results in context of the benthic and planktonic foraminifera assemblage and isotope based results from Reykjanes Ridge which the colleagues at WHOI are generating
  - start a collaborative multi-proxy manuscript with colleagues from WHOI

Berner is invited by Dr. J. McManus to Woods Hole Oceanographic Institute (WHOI) to collaborate with them on their ongoing research on changes in the strength of Holocene ocean circulation. Berner's project aims at reconstructing both short and long term trends in the natural climate during the Holocene that can not be monitored by instrumental data. Main task of the project is to reconstruct Holocene SSTs utilizing diatoms by help of quantitative statistical methods from a number of selected sites. The study focuses on assessment of the Holocene climate development and the natural variability of the North Atlantic Drift and the Norwegian Atlantic Current which play a key-role in the climate of Norway. Therefore, we have chosen 3 sites that lie under these current systems; LO14 from the Reykjanes Ridge, MD952011 from the Voring Plateau and a

site north of the Faeroys. Holocene records, focussing on the time intervals of the last 1000 years and the Holocene Climate Optimum (HCO) with decadal resolution, will be generated. This is to assess whether climate displays a different character in variability during a warm HCO period versus the cooler last 1000 years, as contribution to the NORPAST2 and PACLIVA projects. We will also provide quantitative SST reconstructions for the Younger Dryas/Holocene transition, Neoglaciation transition and the transition from the Medieval Warm Period to the Little Ice Age for estimation of changes in the Meridional Ocean Circulation during these abrupt transitions within NoClim2 Module B.

The purpose of the stay at WHOI for Berner is: to discuss the sedimentology and chronology of core LO14, to present her results from LO14 and MD952011 to colleagues at WHOI, to put her own results in context of the benthic and planktonic foraminifera assemblage and isotope based results from Reykjanes Ridge which the colleagues at WHOI are generating and to start a collaborative multi-proxy manuscript with colleagues from WHOI.

## **COMPAS**

Prosjektansvarlig:

**UNIFOB AS - Bjerknes-senteret, Universitetsforskning Bergen**

Prosjektleder:

**Kvamstø, Nils Gunnar Førsteamanuensis**

Prosjektnr: 165424/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2005-31.12.2009**

2006: **1,554,000** 2007: **1,482,000** 2008:

**1,482,000** 2009: **1,482,000**

(i) To fill the gap in the understanding, and improve the quantitative assessment, of the Atlantic Ocean's impact on the climate of Northern Europe and Norway (hereafter NEN).

(ii) To evaluate how Atlantic ocean / NEN climate interactions are represented in the current generation of coupled climate models, through the analysis of present and past climate records and a representative set of coupled climate models.

(iii) To promote an innovative and multidisciplinary approach to climate research, connecting researchers working in the fields of modern climate, past climate and climate dynamics, thereby building Norwegian leadership in the joint observational and theoretical understanding of climate fluctuations.

Based on relocation of the Principal Investigator from the USA to Norway, a group for interdisciplinary studies of climate dynamics will be established. COMPAS will fill the gap in the current understanding, and assess the impact, of the Atlantic Ocean on the climate of Northern Europe and Norway. COMPAS will develop an innovative and multidisciplinary approach in which theoretical models and the most comprehensive climate records (i.e., paleo and modern records) strongly interact.

COMPAS will improve the ability to predict the evolution of climate in Norway, and will build Norwegian leadership in a new and exciting area of climate research. Specifically, COMPAS will put bounds on the strength, and elucidate the mechanisms, of the Atlantic Ocean forcing through a joint analysis of theoretical models, modern instrumental (last hundred year) and paleo (last ten thousand years) climate records.

In a second step, COMPAS will evaluate, based on the previous analyses, the representation of the Atlantic Ocean forcing in the current generation of climate models.

The COMPAS project will be based at the Bjerknes Centre for Climate Research (BCCR, Bergen), which complements perfectly the expertise of the Principal Investigator. The BCCR will offer, through its on-going EU projects PACLIVA and DYNAMITE, the best paleo archives and a set of European coupled climate model outputs to be used by COMPAS.

## **Ad hoc group for the modelling and assessment of contributions to climate change (MATCH): support for travel**

Prosjektansvarlig:

**CICERO Senter for klimaforskning**

Prosjektleder:

**Fuglestad, Jan Forskningsdirektør**

Prosjektnr: 165428/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2005-31.12.2006**

2005: **66,400** 2006: **33,200**

Assess methods for calculating the contribution of different emission sources (e.g. regional, national or sectoral) to climate change and its impacts, taking into account uncertainties, and the sensitivity of the calculations to the use of different methods, models and methodological choices.

Sub-goals:

- 1) Collecting and improving knowledge and data on the climate system: latest scientific information on the climate system will be addressed and synthesised for application in simplified climate models.
- 2) Calculating contributions to climate change based on simple models and input from 1.
- 3) Travel and participation at workshops and meetings in the Scientific Coordination Committee
- 4) Collaboration with other groups involved in the MATCH process
- 5) Publication of results

As part of the negotiations under the United Nations Framework Convention on Climate Change (UNFCCC) on the Kyoto Protocol, the delegation of Brazil made a proposal, in May 1997, to set differentiated emissions reduction targets for Parties according to the impact of their historic emissions on temperature rise (document FCCC/AGBM/1997/MISC.1/Add.3). The scientific and methodological aspects of the proposal were referred to the Subsidiary Body for Scientific and Technological Advice (SBSTA) for further consideration. Two expert meetings on the subject have been organized by the UNFCCC secretariat and the governments of Brazil and the United Kingdom of Great Britain and Northern Ireland supported a third expert meeting. At the third meeting, the experts agreed to continue the work on the modelling and assessment of contributions to climate change (MATCH) to respond to the mandate of the SBSTA in a process up to 2005. The aim of this ad-hoc group is to improve the robustness of the preliminary results concerning contributions to climate change based on a proposal by Brazil for the calculation of contributions of GHG to climate change and to explore the uncertainty and sensitivity of the results to different assumptions. A Scientific Coordination Committee for the MATCH process was established to coordinate the modelling efforts and assessment of the Brazilian Proposal. CICERO has been strongly involved in this process and apply for support for travel in order to continue this participation.

## **Utenlandsstipend application for Aurelie Nowinski**

Prosjektansvarlig:

**Norsk Polarinstitutt**

Prosjektleder:

**Koc, Nalan Seniorforsker**

Prosjektnr: 165460/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.3.2005-31.12.2005**

2005: **52,000**

This is an application for a 4 months utenlandsstipend for PhD fellow Aurélie Nowinski to be spent at Institute for Arctic and Alpine Research (INSTAAR), Boulder, U.S.A during 2005. Nowinski's PhD fellowship, which is financed through NFRs NORKLIMA project MACESIZ (Project 155945/700) and the EU-financed PACLIVA project, has the objective of establishing a sea ice transfer function and utilizing it together with sea surface temperature transfer function for assessing the Holocene climate development and variability of the Irminger and the East Greenland Currents by these quantitative methods. The purpose of the stay at INSTAAR for Nowinski is:

- to discuss the sedimentology and chronology of the cores MD992269 and MD99232
- to present her SST and sea ice results to colleagues at INSTAAR
- to put her own diatom based results in context of the benthic and planktonic foraminifera and coccolith based results
- start a collaborative multi-proxy manuscript with colleagues from INSTAAR

Nowinski is invited by Dr. Anne Jennings to Institute for Arctic and Alpine Research (INSTAAR), Boulder, U.S.A. to collaborate on multiproxy study of cores from the Irminger and East Greenland Currents. Nowinski's project has two main components:

1. Developing a set of transfer functions to quantify past changes in the seasonal ice zone and applying the transfer functions to produce a reconstruction of sea ice variability at decadal resolution for the past 1000 years, and for the Neoglaciacion period 5000 to 4000 years BP at multidecadal resolution. This part contributes to MACESIZ project WP 4.
2. Assessing the sea surface temperature (SST) variability of the Irminger and East Greenland Currents during the last 1000 years and during the Holocene Climate Optimum (HCO). This part contributes to PACLIVA project.

## **Radiative forcing of climate change**

Prosjektansvarlig:

**Institutt for geofag, Universitetet i Oslo**

Prosjektleder:

**Myhre, Gunnar**

Prosjektnr: 165533/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2005-31.12.2007**

2005: **1,000,000** 2006: **1,000,000** 2007: **860,000**

Main objective

- Contribute to increase knowledge about the radiative forcing of climate change useful for the IPCC process

Sub objectives

- Give estimates for radiative forcing mechanisms which are poorly or not quantified
- Reduce uncertainties in estimates of land use changes and its impact on the radiative forcing and the hydrological cycle
- Participate in an aerosol and climate field campaign
- Continue and expand established international collaboration

Scientifically this proposal focuses on one selected topic within the research field of climate change, namely on the processes causing climate change. Gaps in the knowledge of this topic are significant and quantitative estimates of climate forcing are uncertain in many cases. This proposal is related to changes in the stratosphere, tropospheric aerosols, and processes caused by land use changes. Most of the research on stratospheric changes will be on the anthropogenic change in water vapour and the impact of variation in the solar irradiance on ozone. Over the last few years there has been a substantial improvement in the understanding of aerosols and their radiative properties. This has resulted in improved global aerosol models and better calculations of radiative forcing estimates. However large uncertainties are still present and the main aim of the work on tropospheric aerosols is to further reduce the uncertainties in the radiative effect of aerosols. In the context of radiative forcing land use changes have received relatively weak attention, although this is a central point in the understanding of future climate change. In this proposal work on the land use change and the hydrological cycle is linked; and specifically the work will focus on surface albedo changes and water vapour changes. Most of the work will be oriented towards producing results that are of importance for the IPCC Fourth Assessment Report (AR4). The proposal is for a 3 year research position including

funds for the applicant to act as lead author in the IPCC AR4 process. The proposal also provides an opportunity for Norwegian involvement in a large aerosol and climate field campaign. Several studies in the project will be made in collaboration with international experts, building upon common work over several years. Methods to be used are in the forefront in this part of the science, mainly a group of atmospheric numerical models.

## **Exchange visit at Institute of Ocean Sciences, Canada and University of Alaska Fairbanks, USA, for PhD student Arild Sundfjord**

Prosjektansvarlig:

**Geofysisk institutt, Universitetet i Bergen**

Prosjektleder:

**Svendsen, Harald Professor**

Prosjektnr: 165587/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**15.1.2005-20.4.2005**

2005: **44,000**

PhD student Arild Sundfjord wishes to have exchange stays at the Institute of Ocean Sciences (IOS), Sidney, BC, Canada, and University of Alaska Fairbanks (UAF), Fairbanks, AK, USA, for cooperation with renowned scientists working with similar projects.

Sub-goals: 1) work on analysis and publication of integrated turbulence measurements from the Barents Sea MIZ in conjunction with experts at IOS, 2) improve numerical model algorithms, based on results from above and expertise on tidal modelling over complex topography at UAF, 3) perform model simulations and interpretation of results of these, work on publication, 4) contribute to increased scientific disciplinary integration of the CABANERA project by learning from interaction between groups of physical oceanography, chemical oceanography and marine biologists in the projects SBE, CASES and JWACS, located at IOS and UAF.

The NORKLIMA funded project CABANERA is a multi-disciplinary project investigating the uptake and cycling of Carbon in the Marginal Ice Zone (MIZ) of the Barents Sea. Similar investigations are being made on the opposite side of the Arctic Ocean, through the projects SBE, CASES and JWACS. PhD candidate Arild Sundfjord therefore wishes to cooperate with core groups in physical oceanography of these projects. This is most efficiently performed through exchange stays at the

respective institutions, the Institute of Ocean Sciences (IOS), Sidney, BC, Canada, and University of Alaska Fairbanks (UAF), Fairbanks, AK, USA.

During the CABANERA cruise in summer 2004, measurements ranging from microscale turbulent phenomena to larger scale current fields will give a detailed picture of processes from generation of turbulence extracting energy from the mean flow field via the turbulent energy cascade, down to the scales of dissipation. The analysis of these results will benefit from interaction

with expertise located at IOS. The results will furthermore be used to improve the numerical model SINMOD, particularly the vertical diffusion algorithm and the connection between tides, current shear and vertical turbulence. This work will be performed in cooperation with experts on Arctic Ocean modelling at UAF.

Both institutions are involved in interdisciplinary shelf-basin projects and it is expected that PhD candidate Sundfjord will benefit from working at IOS and UAF when it comes to integrating results of field measurements and numerical modelling of physical oceanographic features with those of the biological and chemical oceanography compartments of the CABANERA project.

## **Modelling larval cod on Georges Bank**

Prosjektansvarlig:

**Institutt for biologi, Universitetet i Bergen**

Prosjektleder:

**Fiksen, Øyvind Forsker**

Prosjektnr: 166070/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.2.2005-1.7.2005**

2005: **75,000**

Main objectives:

We will test and improve an individual-based model of larval cod developed in Bergen with the extensive set of data available from the US GLOBEC program, and improve our understanding of how physical variables and prey abundance and distribution affect larval growth and recruitment success.

Sub-objectives:

1. To use data on prey densities, distribution and type, in addition to environmental information such as light, temperature and turbulence, to predict food intake, diet, prey selectivity and growth of larval cod and haddock over Georges Bank.
2. To give Trond Kristiansen scientific experience from a strong scientific environment abroad.

3. To strengthen the connections between GLOBEC activities in Norway and the US.

Here we apply for Trond Kristiansen to visit Woods Hole for a period of 5 months during 2005. There he will collaborate with members of the US GLOBEC team on applications and testing of a model of larval cod feeding and growth processes. This model has now reached a stage where he is using the model with data from ponds and land-locked fjords. The best data available to use is from Georges Bank, gathered by the extensive US GLOBEC field program. Greg Lough and Cisco Werner have invited Kristiansen to come to Woods Hole and apply his model of larval cod on these data. This opens a wide range of opportunities for exploring the interplay between larval distribution, foraging abilities, prey characteristics and physical variables on the feeding success of both cod and haddock larvae. We believe that such collaboration with US GLOBEC will benefit the ongoing Norwegian GLOBEC activities, particularly the ECOBE project.

## **Mass balance and freshwater contribution of the Greenland ice sheet: a combined modelling and observational approach**

Prosjektansvarlig:

**Nansen Senter for Miljø og Fjernmåling**

Prosjektleder:

**Johannessen, Ola M. Professor**

Prosjektnr: 169930/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.3.2005-28.2.2007**

2005: **383,000** 2006: **540,000** 2007: **171,000**

The overall aim of this project is to produce a 45+ year (1957-2003) dataset of Greenland climate, mass

balance and freshwater fluxes. To achieve this, we define the following, specific objectives:

- Prepare a dataset of freshwater fluxes from the Greenland ice sheet entering the Arctic Ocean, Greenland/Iceland/Norwegian and Labrador seas over the last five decades, including solid ice fluxes;
- Disseminate this dataset to the oceanographical community as a boundary condition for ocean models to study the sensitivity of the north Atlantic thermohaline circulation to variability of freshwater fluxes from the Greenland ice sheet;

- Capture the Greenland climate, mass balance and runoff at a much higher horizontal resolution (11 km) than has been done so far, to represent in a realistic fashion the narrow ablation zone of the GrIS;
- Do so for a longer period (45+ years) than has been done so far, to represent interannual and decadal variability;
- Quantify the mean and variability of solid ice fluxes crossing the grounding line (in collaboration with E. Rignot);
- Use the results to place the decadal altimeter-derived mass balance observations into a longer-term context;

The thermohaline circulation is a global ocean circulation, driven by differences in the density of the sea water that is controlled by temperature (thermal) and salinity (haline). In the north Atlantic, the thermohaline circulation transports warm and salty water to the north, where it, together with the North Atlantic Drift (the north-eastern most extension of the Gulfstream), contributes to the warm sea surface along the coast of western Europe and to the relatively mild European winters.

From ice cores drilled in Greenland, there is evidence that rapid climate changes took place during the last glacial (the period roughly from 100,000 to 20,000 years before present): over a period of just several decades, northern European winter temperature dropped by as much as 10 degrees for periods typically lasting 1000 years. The present explanation is that large, pulse-like freshwater fluxes (probably from icebergs that originated from the continental ice sheets) were released into the north Atlantic where they weakened or shut down the thermohaline circulation.

In a warmer greenhouse climate, it is also likely that the freshwater flux into the north Atlantic will increase; using a scenario of doubling CO<sub>2</sub> within the next 70 years, most atmospheric models predict an increase in precipitation in high latitudes. One of the great uncertainties in these projections is the role of the Greenland ice sheet, which is situated in the middle of the area of interest. We know so little about the variability in its meltwater production and its sensitivity to regional warming that its contribution to the problem of the north Atlantic thermohaline circulation is

often ignored, in spite of the fact that the Greenland ice sheet contains enough water to rise global sea level by 6 m!

In this proposed research we will quantify in detail how, where and when the Greenland ice sheet has fed fresh water through iceberg calving, subglacial melting and meltwater runoff into the surrounding ocean during the last half century. The melting and runoff is calculated using a coupled snow - atmosphere model that is run over Greenland at very high resolution (11 km in the horizontal), which will take about 1 year on a supercomputer to run! The resulting data will be used by the oceanographical community as a boundary condition for their models of the north-Atlantic thermohaline circulation.

## Variations of the Atlantic Meridional Overturning Circulation during rapid climate changes: calibration, modelling and palaeoceanographic ob

Prosjektansvarlig:

**UNIFOB AS - Bjerknes-senteret, Universitetsforskning Bergen**

Prosjektleder:

**Dokken, Trond Martin Seniorforsker**

Prosjektnr: 169931/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.1.2005-31.12.2008**

2005: **469,700** 2006: **671,000** 2007: **671,000**

2008: **200,300**

to test the hypothesis that rapid climate transitions are always associated with changes in overturning rate in the Nordic Seas.

- to investigate whether changes in dense overflow water flux and properties are associated with changes in the northward extension and strength of the Atlantic Meridional Overturning Circulation (AMOC).
- to investigate the possible coupling between variations in the northward flow of warm water and variations in the deep water flow.
- to combine climate model results, in situ process studies, and palaeoceanographic proxy data to provide quantitative assessments of the rate and magnitude of hydrographic changes during rapid climate shifts, focussing on: (i) the "so called" Little Ice age/Medieval Warm period, the sharp warming

periods (ii) at about 14,600 (H1-Bølling transition) and (iii) 11,600 years ago (Younger Dryas-Holocene

transition), and (iv) the rapid cooling into Younger Dryas 13,300 years ago.

- to develop new calibrated methods for characterising the heat and salinity content of the surface layer of Northeast Atlantic/Nordic Seas, and implement the methodology in the investigations of the above objectives.
- to utilise a new kinematic method for characterising the strength of the AMOC.
- to implement the methodology developed in Norway and the UK within the NOClim and Rapid programmes, by integrating current work, establishing the robustness of proxies through calibration and modelling, adding new key proxy measurements, establishing a data base and placing data within a modelling framework.

Our ability to understand the potential for future abrupt changes in climate is limited by our lack of understanding of the processes that control them. The climate system appears to operate in quasi-stable modes, and may switch from one mode to another within a few decades. Recent evidence suggest that abrupt climate changes often occur when gradual causes push the earth system across a threshold. Studies, using paleo data, of past climate suggest that large and rapid (as fast as 10-20 years) changes have occurred and that changes in the Atlantic Meridional Overturning Circulation (AMOC) are a major contributing factor. A better understanding of the processes that “drive” the AMOC is of key importance.

Examination of proxy data for the hydrography of the N. Atlantic has suggested 3 modes of operation of the MOC, modern, peak glacial and meltwater pulse modes. The meltwater event mode is the most severe in terms of regional atmospheric temperature drop and cessation of deep meridional overturning. In the project we propose to test the hypothesis that rapid climate transitions are always associated with changes in overturning rate in the Nordic Seas. This will make a major contribution to understanding what might happen with increased greenhouse gas levels and global warming.

## **Impact of changing freshwater flows on the thermohaline circulation and European climate – analysis and modelling of the last deglaciation**

Prosjektansvarlig:

**UNIFOB AS - Bjerknes-senteret, Universitetsforskning Bergen**

Prosjektleder:

**Dokken, Trond Martin Seniorforsker**

Prosjektnr: 169932/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.4.2005-31.3.2008**

2005: **523,600** 2006: **748,000** 2007: **748,000**

2008: **224,400**

1) Understanding the sensitivity of climate models to changes in forcing, most importantly changes in the source, magnitude and location of freshwater fluxes to the ocean. Additional sensitivity analyses, examining modelled response to ice sheet extent and albedo, changes in land-sea distribution, and specification of initial conditions will quantify the importance of freshwater fluxes in comparison with other changes in forcing that are generally better constrained. 2) Documentation of the deglaciation history of the Eurasian ice sheet. The main focus will be on the reconstruction of changes in the extent of the ice sheet and associated proglacial lakes. Estimates of the 3-D structure of the ice and of ice drainage patterns will be made wherever possible and will guide the design of freshwater-discharge sensitivity experiments. 3) Documentation of changing environmental conditions in the northern hemisphere extratropics through the deglaciation, encompassing the beginning and end of Heinrich event 1 and the Younger Dryas, based on a new 4-D synthesis of marine data from the Arctic and North Atlantic Oceans and comparison of these reconstructions with terrestrial data from North America, Europe and Russia. The ocean reconstructions will be made at an effective time-resolution of 250 years based on multiple biological and physical proxies (forams, diatoms, dinoflagellates, and isotopes) and will include uncertainty estimates. Access to the terrestrial data will be through collaboration in ongoing international palaeodata synthesis initiatives, but this project will contribute to these efforts through standardisation of chronologies between the marine and terrestrial realm and through database management. 4) Determining what conditions triggered abrupt changes in the THC under glacial and interglacial conditions. 5) Assessing the possibility for abrupt THC changes in the 21st century, using selected greenhouse-gas

scenarios based on the IPCC Special Report on Emissions Scenarios (SRES) and the WRE stabilisation scenarios.

Changes in the amount and location of river and meltwater discharge to the North Atlantic and Arctic Oceans could profoundly affect the thermohaline circulation and thus the climate of Europe. Abrupt changes in ocean circulation, and the location of North Atlantic Deep Water (NADW) formation, have been recorded during the last 21,000 years. Palaeodata and modelling suggest these changes may have been caused by ice-sheet dynamics (changing meltwater inputs, blocking/unblocking of river channels) and by climate change affecting continental runoff and river discharge. A concerted effort is planned to understand past changes in NADW formation and to explore the risk of comparable changes taking place in the future. Our approach involves using two efficient coupled ocean-atmosphere-vegetation models to explore the impacts of a range of possible freshwater-flux scenarios representing different intervals during the last deglaciation. New reconstructions of Eurasian ice-sheet deglaciation history will be used to inform the choice of scenarios. The plausibility of the simulations will be evaluated using a 4D reconstruction of the ocean during the deglaciation and palaeoenvironmental records of regional climates over the northern continents, prior to using the models to examine the consequences of potential future changes in freshwater fluxes on ocean circulation and climate.

## **Punctuated disintegration of the NW European Ice Sheet and rapid climate change**

Prosjektansvarlig:

**UNIFOB AS - Bjerknes-senteret, Universitetsforskning Bergen**

Prosjektleder:

**Sejrup, Hans Petter Professor**

Prosjektnr: 169933/S30

Bevilgningsperiode og finansiering fra Norges forskningsråd:

**1.4.2005-31.3.2008**

2005: **570,000** 2006: **814,000** 2007: **814,000**

2008: **244,000**

1. Constrain the timing of Norwegian Channel Ice Stream (NCIS) events during the last glacial period
2. Ascertain North Atlantic footprint of ice-rafted debris from the NCIS and assess correlations between NCIS events and known ocean and climate excursions
3. Reconstruct dimensions of the NCIS and compute range of ice flux
4. Review evidence

- for all hypothesised ice streams of Hiberno-British and southern Fennoscandian ice sheets. Augment with new mapping to find other examples. Provide seeding locations and estimate potential ice fluxes for input to modelling.
5. Review evidence for major ice-dammed lakes, and compute their water volume and likely drainage routes. Given known ice margin retreat configurations predict location and volume of other potential ice dammed lakes. Provide locations and volumes of melt for input to modelling
6. Compile geophysical and bathymetric data for the North Sea to develop the hypothesis of a grounded-ice break-up event and constrain its timing. Estimate the ice volume involved and likely melt water pathways to the North Atlantic
7. Simulate iceberg trajectories for the above events to determine the location, volume and timing of melt input into the ocean
8. 'Seed' the trajectory model with other locations (e.g. Irish Sea Ice Stream) to assess whether inputs from these could be significant for the thermohaline circulation (THC) of the North Atlantic
9. Assess the impact of such freshening on the THC, and consequent climatic consequences, with reference to the evolution of the European ice sheets during the last glacial period (please note that these are NOT listed in order of priority but, because of the interdisciplinary nature of the proposal, so as to show how the elements of the project interact)

Despite the large amount of study dedicated to understanding the development of the last glaciation in Europe over the last two hundred years, the firm existence of extensive glaciation over the North Sea, as well as the existence of an ice stream issuing through the Norwegian Channel has only recently been established. These two major parts of the Fennoscandian Ice Sheet, joining the continental ice to that of the British Isles, provide a potentially important source for meltwater and icebergs to have entered the North Atlantic in the past. There is previous evidence that at least some of the Heinrich events – sustained periods of significant iceberg calving to the North Atlantic – originated from the eastern Atlantic, or at least contained a contribution from these eastern ice masses, as opposed to the original view of Heinrich events as emanating from the Laurentide Ice Sheet. In this proposal we aim to establish the area, volume and history of the ice sheet over the North Sea, and the Norwegian Channel Ice Stream during the last, Weichselian, glaciation. This will provide the basis for modelling experiments, employing a state-of-the-art iceberg trajectory model, to examine the likely path of icebergs from this region of the Europe, and their potential impact on North Atlantic convection processes, and hence the global thermohaline circulation