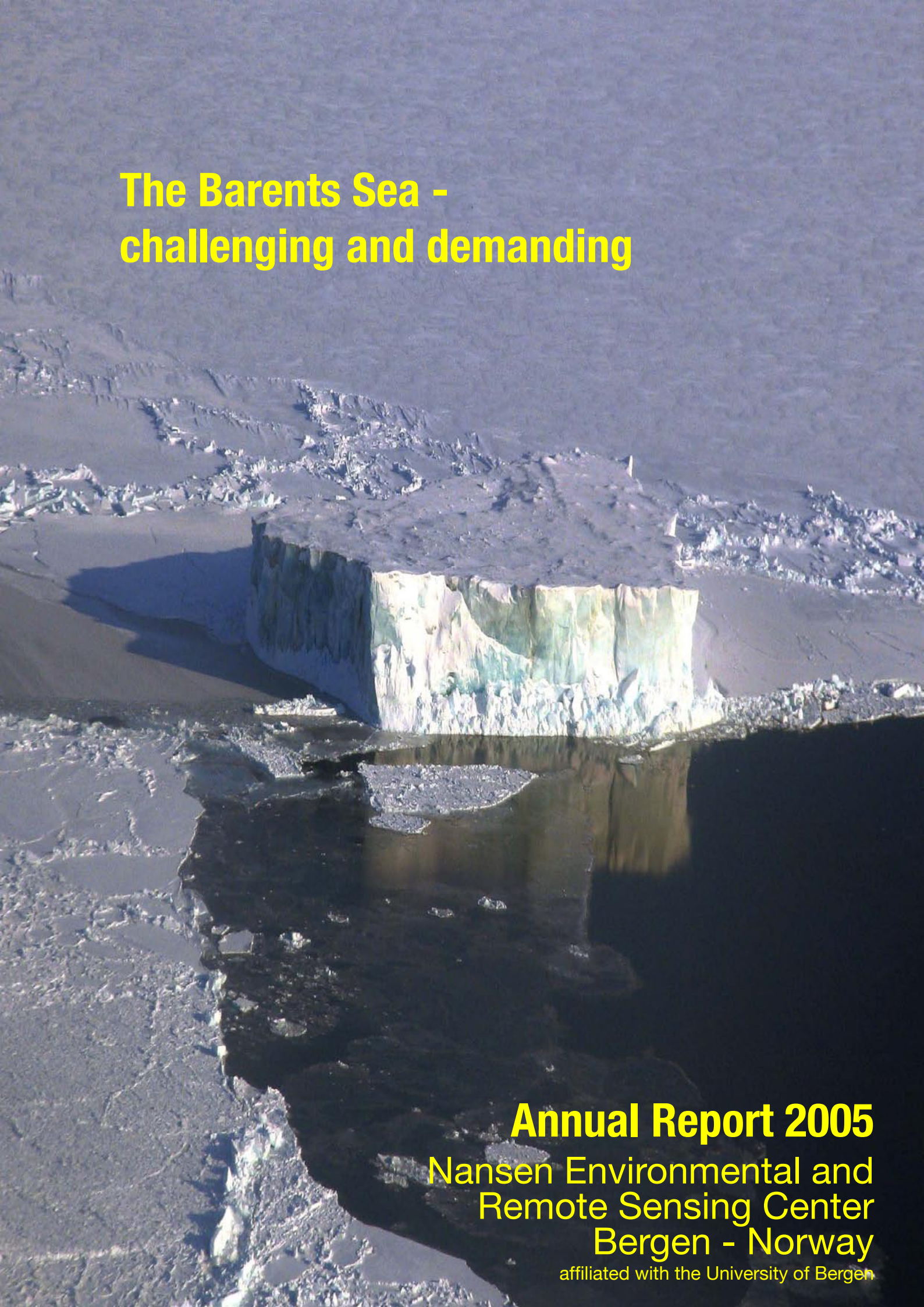


The Barents Sea - challenging and demanding

Annual Report 2005

Nansen Environmental and Remote Sensing Center
Bergen - Norway
affiliated with the University of Bergen

report from the board

VISION

The Nansen Center´s vision is to make a significant contribution to the understanding, monitoring and forecasting of the world's environment and climate on regional and global scales.

Main research focus areas are:

- Climate understanding - its variability and change
- Global ocean studies and ocean forecasting
- Development and use of satellite based methods for marine studies
- Satellite monitoring of global environment and climate
- Wind energy mapping in coastal areas
- Socio-economic impact of global change

ORGANIZATION

The Nansen Center is an independent non-profit research foundation affiliated with the University of Bergen, Norway. The Nansen Center conducts basic and applied research funded by research councils, space agencies, national and international governmental agencies and industry. The Nansen Center receives no basic funding.

STAFF

At the end of 2005 the Nansen Center employed a staff of 62 persons from 11 nations, including seven scientists in adjunct positions. The staff includes 16 Ph.D. candidates, seven Post Doc candidates and four Master students. Several foreign students and visiting scientists from especially Russia, China, France, Germany and India have visited the Nansen Center for periods from weeks to several months during 2005.

The Nansen Center's goal is to be an equal opportunity employer. 35% of the employees were females in 2005.

OFFICES AND ENVIRONMENT

The office conditions are very satisfactory – both in Bergen and at our newly established office in Svalbard Research Park, Longyearbyen, which will formally be opened on April 26th 2006. The Board concludes that the activities of the Center does not cause any damage to the environment.

PRODUCTION

During the year 2005, 26 papers were published in international referee journals - of which two in Science - two books, 11 technical and four special reports, six conference proceedings, one doctoral dissertation and six popular science articles – totally 56 publications and reports.

Public outreach has been done through newspaper interviews at national and international level - including TV and radio. Popular scientific lectures for school children, students and the public have been given in the Nansen Center´s adventure centre "Arctica".

DOCTORAL THESIS

Nina G. Winther at the Mohn-Sverdrup Center/Nansen Center, completed her Doctoral dissertation "Towards a North Sea prediction system" on November 4th 2005 at the Geophysical Institute, University of Bergen. Her doctoral work focused on the development and validation of an operational oceanographic system. The studies were conducted under the MONCOZE project funded by the Research Council of Norway and a Mohn-Sverdrup fellowship. Johnny A. Johannessen, Geir Evensen and Einar Svendsen were her supervisors.

AWARDS

The project "Climate and Environmental Change in the Arctic - CECA" (see also page 3), with Ola M. Johannessen as project leader, Lasse H. Pettersson as deputy leader, Lennart Bengtsson, Max-Planck Institute for Meteorology in Hamburg, and Leonid Bobylev, Nansen International Environmental and Remote Sensing Centre in St. Petersburg, as partners were the winners of EU Descartes research prize, Laureate, in Earth Science for 2005. The prize award of 200,000 € will be used to further support of young Russian scientists and Ph.D. candidates in Arctic climate research at the Nansen Center in St. Petersburg and other Russian collaborative institutes.

Furthermore, Ola M. Johannessen was elected as member of the Norwegian Academy of Science and Letters in 2005 – his fifth Academy election.

INTERNATIONAL ACTIVITIES

By the end of 2005, the Nansen Center participated in 13 EU funded projects and co-ordinated four of these projects. The Nansen Center also coordinates one INTAS (International Association for the promotion of co-operation with scientists from the New Independent State of the former Soviet Union) project with participation from Russia and Ukraine. Furthermore, the Nansen Center participates in the preparations for "The International Polar year 2007-2008 (IPY)" through the EU project "IPY-CARE - Climate of the Arctic and its role for Europe". IPY-CARE is coordinated by Ola M. Johannessen.

The collaboration with The Nansen-Zhu Centre at the Institute of Atmospheric Physics (IAP) of the Chinese Academy of Science in Beijing has expanded through mutual exchange of scientists and Ph.D. candidates. The Nansen-Zhu Centre now employs 36 persons and Prof. Hui-Jun Wang, the Director of IAP, is the co-director together with Helge Drange. Ola M. Johannessen is co-chairman of the Board. Ola M. Johannessen and Helge Drange were also formally appointed as "Visiting Professors" at the Institute of Atmospheric Physics (IAP) for the period June 2005 to May 2009.

Several Announcement of Opportunity (AO) projects from the European Space Agency (ESA) for the ENVISAT satellite mission are now being implemented for coastal, oceanic and Arctic regions. Johnny A. Johannessen is a member of ESA Science Advisory Committee - ESAC.

The Nansen Center is a major partner in EuroGOOS, which is an international organization with members from the major European meteorological and oceanographic institutions. The aim of EuroGOOS is to develop and coordinate ocean monitoring and forecasting in European and Arctic waters, as a part of the "Global Ocean Observing System (GOOS)" program. Ola M. Johannessen is a member of the EuroGOOS Board, and Stein Sandven is the chairman of the Arctic Task Team. He also leads the ArcticGOOS Secretariat at the Mohn-Sverdrup Center/Nansen Center established under the auspices of EuroGOOS.

Ola M. Johannessen is also a member of the WMO Steering Committee for "Global Climate Observing System (GCOS)" and Johnny A. Johannessen is a member of the GCOS panel; "Ocean Observing Panel for Climate (OOPC)".

The Nansen Center is one of the founding members of the European Climate Forum (ECF) and Ola M. Johannessen is a member of the Board. ECF is a multi-disciplinary forum gathering research, industry, administration and NGOs to meetings and projects dealing with climate change issues.

The cooperation with the Nansen Center in St. Petersburg, where Ola M. Johannessen and Jean-Pierre Contzen are the co-Presidents, Dr. Leonid Bobylev the Director and Lasse H. Pettersson the Secretary General, is expanding with new project activities. In 2004 the Nansen Center in Bergen bought new office premises (300m^2) in St. Petersburg for the Nansen International Center to rent. These new premises were officially opened on the 9th of December 2005. The Center employs now 30 Russian staff members.

Based on an application to the Norwegian

Cover page: **A drifting iceberg in the eastern part of the Barents Sea. Courtesy: Andrey Glazovsky, Inst. of Geography, RAS, Moscow.**

Ministry of Education and Research (Kunnskapsdepartementet) a grant of NOK 1.5 mill. for the period 2006-2008 was approved by Minister Mr. Øystein Djupedal. The grant was given directly to the Nansen International Center in St. Petersburg and will be used for education and research at the Center, in order to increase the bilateral scientific cooperation between Russia and Norway within climate and environmental research at high latitudes. The Board are very grateful for this grant to our Russian colleagues.

G.C. RIEBER CLIMATE INSTITUTE

The G.C. Rieber Climate Institute is a part of the Nansen Center, and is led by Professor Helge Drange. His Professorship II at the Geophysical Institute, University of Bergen is funded by the G.C. Rieber Foundation. The Institute has a staff of 21 persons. The main activities of the Institute are devoted to studies of the stability and variability of the North Atlantic and Arctic climate systems. The Institute is a major partner in the Bjerknes Cooperation in Climate Research established in Bergen, between the University of Bergen, the Institute of Marine Research and the Nansen Center. Helge Drange is a member of "CLIVAR; Working group for Ocean Model Development" under the World Climate Research Program, and "Vestnordisk Oceanklima" under Nordic Council of Ministers. The G.C. Rieber Foundation supports the Institute annually with NOK 0,4 mill. for recruitment of Master students to climate research in Norway. The Board thanks the G.C. Rieber Foundation for their important support during many years.

Helge Drange is also the head of the leader team for the Norwegian Climate Centre. The Norwegian Climate Center for Arctic and the Atlantic Ocean region is a new cooperation framework for coordination of all Norwegian research activities on the physical climate system currently performed at the Nansen Center, the Bjerknes Centre at the University of Bergen, the Institute of Marine Research, the Meteorological Institute, the University of Oslo, CICERO and the Norwegian Polar Institute.

MOHN-SVERDRUP CENTER

The Mohn-Sverdrup Center for Global Ocean Studies and Operational Oceanography (MSC) is part of the Nansen Center. By the end of 2005 the Center employed 20 persons. The Center is led by Ola M. Johannesen with Dr. Laurent Bertino as the deputy director. Its main research focus is to develop ocean and marine ecosystem models and data assimilation techniques for the Norwegian Sea, the Barents Sea and the Arctic Ocean region. Furthermore, also an ocean prediction model is implemented for the Indian Ocean in cooperation with the Nansen Center in Cochin, India. The Center in India has currently four employees – of which two are conducting their Ph.D. studies in Bergen. The Mohn-Sverdup Center was established in 2004 after an initial donation from Trond Mohn of NOK 25 mill. distributed over 5 years. The Board thanks Trond Mohn for his generous donation.

POLAR AND MARINE REMOTE SENSING

The Remote Sensing activities are led by Stein Sandven and Johnny A. Johannessen, who is also a Professor II at the Geophysical Institute, University of Bergen, where he is responsible for teaching in marine remote sensing. The Group employs 13 persons. Its main research focus is development and validation of algorithms for retrieval of ocean-coastal and ice parameters, including detection of icebergs and their drift – from satellite Earth observation data. The information from the satellites are further used in oceanographic process and climate studies. Furthermore, satellite ocean color data are used in real time to monitor algae blooms and water quality conditions for the North Sea and Norwegian coastal waters. This activity is led by Research Leader Lasse H. Pettersson.

Sea ice information from satellite Earth observation data sources is also used in real time in support of navigation in ice covered waters. Particularly, for the Northern Sea Route monitoring is done in cooperation with Russian scientists from the Nansen International Center and the Arctic and Antarctic Research Institute, both in St. Petersburg, and the Murmansk Shipping Company.

The research focus of the Group is currently on the development of an integrated ocean and ice monitoring and forecasting system for the Barents Sea by using satellite and in situ data, models and assimilation techniques. This will become an important activity under ArcticGOOS, and will be to the benefit and use for fisheries, gas- and oil exploration and production, as well as management of the Arctic and sub-Arctic regions.

ARCTICA

"Arctica" is a small public adventure centre at the Nansen Center. Among the attractions is a wide screen film "Svalbard – Arctic seasons", a slide exhibition about the life of Fridtjof Nansen and an Arctic exhibition in the "Science Room". Several school classes and other groups have visited "Arctica" during 2005, and it has become a very popular meeting place.

TERRA ORBIT AS and OCEAN NUMERICS LTD.

The Nansen Center is the owner of the company Terra Orbit AS as well as a shareholder in Ocean Numerics Ltd., UK. The goals for these companies are to offer services within respect to the environment, ocean monitoring and forecasting. The revenue of these activities will in turn contribute to the scientific development in the areas which the Nansen Center concentrates its applied research activities.

THE NANSEN SCIENTIFIC SOCIETY

The Nansen Scientific Society will be "the parent organization" for all the Nansen Centers in Norway, Russia, China and India - and possible additional Centers in other parts of the world. Its main goal is to expand the existing "Nansen Fellowship Program", supporting young Ph.D. Candidates and furthermore to contribute to the scientific coordination and funding of activities at the Nansen Centers. The vision is that research and education of young people from different countries and cultures will help to build a foundation for better understanding and co-existence between people – in the Spirit of Fridtjof Nansen. The Nansen Center in Bergen contributes with the initial NOK 4 mill. as its first founder and efforts are being made to increase the membership of the founders. On November 24th 2006 the Nansen Center will celebrate its 20th anniversary and the Nansen Scientific Society will then be inaugurated.

FINANCIAL SITUATION

The Nansen Center is an independent non-profit research foundation without any basic governmental funding. The income in 2005 amounted to NOK 36,474,295. The 2005 project income originated mainly from the Research Council of Norway, the European Commission, the European Space Agency, oil companies, the Norwegian Space Centre and INTAS. Substantial financial support has been received from G.C. Rieber Foundation and Frank Mohn ASA by Trond Mohn.

The annual surplus for 2005 amounts to NOK 3,184,069 - including financial loss of NOK 50,450. NOK 1,184,069 of the annual income will be transferred to the equity capital and NOK 2 mill. to the foundation of the "Nansen Scientific Society" – which also in 2004 received NOK 2 mill. from the Nansen Center. The equity capital amounts to NOK 26,950,722.

PROSPECTS FOR 2006

We are expecting a moderate expansion of our research activities in 2006 primarily due to increased activities in the Northern areas, where the Nansen Center has a lot of experience and expertise, developed through the past 20 years.

Bergen, March 29th 2006

Dag L. Aksnes (Chairman)
Bjart Nygaard (co-Chairman)
Hans Petter Sejrup
Anton Kjelaas
Lasse H. Pettersson (Repr. of employees)
Ola M. Johannessen (Director)

Leader Team

Founding Director

Professor Ola M. Johannessen, also chair in Remote Sensing/Oceanography at Geophysical Institute, University of Bergen

Mohn-Sverdrup Center for Global Ocean Studies and Operational Oceanography

Director Ola M. Johannessen and Deputy director Dr. Laurent Bertino

G.C. Rieber Climate Institute

Director Dr. Helge Drange, also Professor II at Geophysical Institute, University of Bergen

Polar & Environmental Remote Sensing

Research Director Stein Sandven, also Vice-Director and Professor II at UNIS, Svalbard (from April 2006)

Coastal & Ocean Remote Sensing

Research Director Dr. Johnny A. Johannessen, also Professor II at Geophysical Institute, University of Bergen

International Relations & Marketing

Director Lasse H. Pettersson

Administration

Director Bente E. Johannessen

Economy

Director Lars Gunnar Veland

The Board

Professor Dag L. Aksnes, University of Bergen, Chairman

Bjart Nygaard, Director, Rieber Eiendom AS, Vice Chairman

Professor Hans Petter Sejrup, Dean, Faculty of Mathematics and Natural Sciences, University of Bergen

Dr. Anton Kjelaas, representative for UNIFOB

Lasse H. Pettersson, Representative of the employees

Professor Ola M. Johannessen, Director

The Scientific Council

Professor Eirik Sundvor, University of Bergen, Chairman

Arild Blixrud, Director of London Office, Innovasjon Norge, UK

Harald Dovland, Assistant Director General, Norwegian Ministry of the Environment

Professor Anton Eliassen, Director, met.no

Lars Ingolf Eide, Chief Engineer, Norsk Hydro AS

John Erik Hagen, District Director, Norwegian National Coastal Directorate

Professor Hartmut Graßl, Max Planck Institute for Meteorology, Hamburg, Germany

Professor Einar Hope, Norwegian School of Economics and Business Administration

Jacqueline McGlade, Executive Director, European Environmental Agency, Denmark

Jan Petter Myklebust, Director International Division, University of Bergen

Sven Rong, Managing Director, Rieber Shipping ASA

Dr. Robert A. Shuchman, Senior Vice President, ALTARUM, Ann Arbor, U.S.A.

Rolf Skår, Director General, Norwegian Space Centre

Professor Ola M. Johannessen, Director

science report

More than two decades of scientific expertise achieved at the Nansen Center within Arctic and sea ice research are timely relevant in relation to climate change and the increased activities in the Barents Sea and Russian Arctic shelf seas.

Climate and Environmental Changes in Arctic

Director Ola M. Johannessen and Research leader Lasse H. Pettersson

The project "*Climate and Environmental Changes in Arctic – CECA*" were the Laureate winner of the "EU Descartes Research Prize for excellence in scientific collaborative research in Earth science" in 2005. The project was lead by Ola M. Johannessen with Lasse H. Pettersson as deputy leader. Partners were the Max Planck Institute for Meteorology with Professor Lennart Bengtsson and Nansen International Center in St. Petersburg with Dr. Leonid P. Bobylev. CECA involved studies of both natural and human-induced climate variability. Among the key findings are (see also http://www.nersc.no/ceca):

The large warming observed in Arctic regions from 1920 to 1940 and the subsequent cooling from 1940 to 1960 was natural climate variability – while the present warming, also largest in Arctic, primarily is caused by human activity through increasing release of greenhouse gases to the atmosphere.

The sea-ice cover in Arctic regions has decreased by 3% per decade since 1978. The thicker multi-year ice has been reduced by 7% per decade, which indicates that the Arctic sea ice cover may be in major transformation.

Simulation by climate models shows that the sea ice could disappear during summer with a doubling of atmospheric CO_2 – which is expected to happen by the end of this century. During winter, the reduction may be about 20%, with the Barents Sea expected to be open during winter.

Furthermore, CECA has shown that the increasing release of greenhouse gases will influence the low-pressure systems between Greenland and Iceland, in a way that they increase in strength, leading to a warmer, wetter and wilder (w-w-w) climate in Northern Europe in this century.

The interior regions, above 1500 meter, of the Greenland Ice Sheet has been determined to grow 5.6 cm per year over the past decade, while a decrease was observed below 1500 m (O.M. Johannessen et al, 2005). The results suggests that natural variability in the low-pressure systems in the Greenland/Iceland region dominated and caused growth in high-altitude areas – due to increased precipitation, while

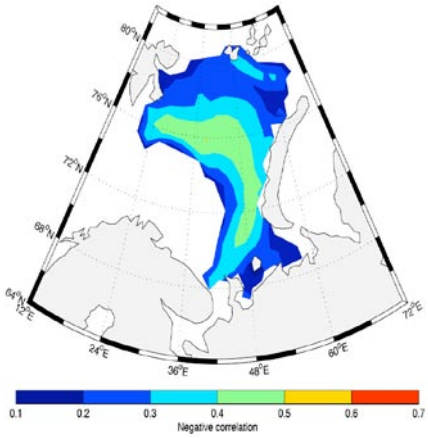


Fig. 1. Correlation between oceanic winter heat transport through the Barents Sea Opening and sea ice concentration in March. The blue and green colours illustrate that stronger than normal inflow of heat leads to less than normal sea ice in the Barents sea. Figure based on analyses of a 300 years long control integration with the Bergen Climate Model (BCM). Analyses of observed sea ice extent for the last 20 years show a corresponding relationship. Courtesy: Olivier Laurantin, NERSC.

melting due to warming is dominating in the rim areas.

The findings from the award-winning CECA project indicate large potential climate-change consequences – of both positive and negative character – for fisheries, oil and gas exploration and production, transport through the Northern Sea Route and for the ocean circulation, including the North Atlantic Current and on the climate in Europe.

What determines the sea-ice variability in the Barents Sea?

PhD student Ingo Bethke and Post Doc Jan Even Øie Nilsen

The Barents Sea is a unique Arctic shelf sea since it is only partially covered by sea ice in winter. Available observations show that the position of the maximum ice covered area strongly varies from winter to winter. This variability is of importance for the climate system since the ice cover operates as a lid between the warm ocean waters and the cold Arctic air, and therefore controls the ocean's surface heat loss. In fact, it is possible that the sea-ice variability in the Barents Sea may explain climate variations on hemispheric scales like the warm 1930s and ´40s north of 60°N, which was comparable to the global warming observed today.

Analyses based on observations and climate models show that the regional wind system is a key player for the variability of the Barents Sea ice cover. However, this is primarily due to the effect of the wind on the ocean currents, and only secondarily due to the direct influence of the wind forcing on ice drift and formation. Specifically, the local wind between the northern tip of Norway and Svalbard regulates the variations of the warm inflow of Atlantic water to the Barents Sea. The effect of this relationship is illustrated in Fig. 1, which shows that strong oceanic heat transport

into the Barents Sea leads to a reduced sea ice extent in the region.

A strong Atlantic inflow has the potential to trigger a feedback loop: Stronger than normal inflow leads to increased heat loss to the atmosphere. The atmospheric heat uptake weakens the atmospheric stability and thus favours stronger winds, which is likely to enhance the Atlantic inflow to the Barents Sea. Variability in the transport of heat into the Barents Sea is also dependent on ocean temperature anomalies that enter the Nordic Seas near the Faeroe Islands. Model sensitivity experiments with vanishing, half, normal and doubled strength of the wind forcing indicate that the large-scale wind systems in the North Atlantic and the Nordic Seas are responsible for about 30% of the inflow of Atlantic water, the rest being a result of the thermohaline circulation in the Nordic Seas and Arctic Ocean.

What about the future of sea-ice in the Barents Sea? For the next couple of decades and beyond, most model simulations show warmer and stronger Atlantic inflow to the Nordic Seas and the Barents Sea, stronger storm activity, warmer surface air temperatures and a strong reduction in sea-ice. This is also supported by studies of observed multidecadal trends in atmospheric forcing and oceanic response. However, climate predictions still face considerable challenges. The monitoring of ocean volume and heat fluxes through passages as e.g. the western entrance to the Barents Sea requires improvement to be fully applicable for evaluation of ocean models. Similar challenges apply to meteorological observations, which are generally sparse in the Arctic. Thus, even though climate models provide consistent products it is still open whether all phenomena and processes are represented sufficiently well to provide reliable estimates for the future climate. This question is at the core of the research at the G.C. Rieber Climate Institute.

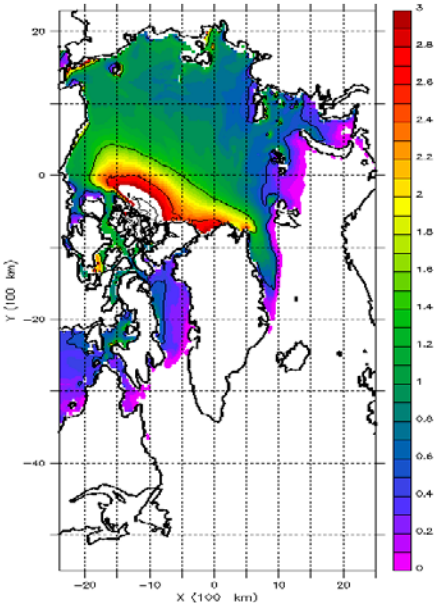


Fig. 2: TOPAZ sea-ice thickness (m) for the Arctic on 1st January 2006, extracted from the Live Access Server.

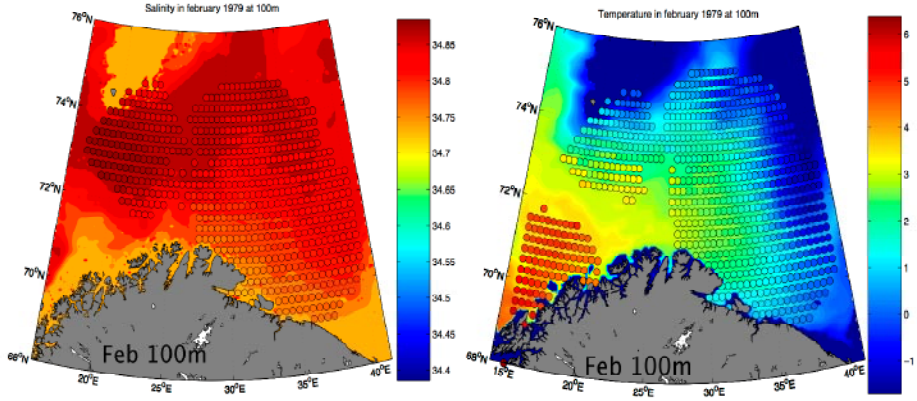


Fig. 3: Salinity (left) and temperature (right) at 100 m depths in the Barents Sea for February 1979. Background image shows the model monthly mean values. Circles: kriged field observations from the AARI-Nansen database, using the same colour scale as for the model data.

Monitoring and predicting the Atlantic and Arctic Oceans

Deputy director Laurent Bertino and PhD student Knut A. Lisæter

The TOPAZ ocean modelling and forecasting system in operation at the Mohn-Sverdrup Center is based on an Atlantic and Arctic Ocean implementation of the HYCOM model and uses the Ensemble Kalman Filter (EnKF) to assimilate satellite ocean and sea-ice variables. TOPAZ is to date the only real-time ocean forecasting system in the world based on advanced ensemble data assimilation techniques. TOPAZ produces 10 days forecasts and since October 2005 users can access the forecast and analyses in digital format via an OpenDAP data server and customize graphics on the Live Access Server (LAS), see http://topaz.nersc.no. Additionally validation results, against independent Argo data, are available online. An example of graphic as obtained from the LAS (Figure 2) shows the ice thickness on the 1st January 2006: It shows realistic thickening North of Greenland and North of the Canadian Archipelago but the quantitative validation is still practically difficult after the loss of ESA's Cryosat mission, which was intended to provide sea ice thickness observations.

The model forecast server constitutes the Arctic Thematic Portal (TEP) of the Marine Environment and Security for European Area (MERSEA) system. TEP is designed to receive forecasts from several Arctic systems operated by the Global Ocean Data Assimilation Experiment (GODAE) participants and to perform joint model validation studies for which we expect great benefit from the forthcoming International Polar Year research campaigns and studies. The TOPAZ system provides boundary conditions to three high-resolution (4-5 km) nested models in the Gulf of Mexico, in the Norwegian Sea and in the Barents Sea (see next section), where the user needs for forecasting information have been clearly identified. By 2007 the TOPAZ system will have an increased horizontal resolution (11-16 km instead of 18-36 km) and will thus provide boundary conditions of higher quality for the regional models.

The Barents and Kara Seas ocean and sea ice model

PhD student Intissar Keghouche

Regional and detailed sea ice information, including ice drift, ice concentration, ice thickness and iceberg identification and drift are essential for safe navigation and operations in the Barents and Kara Seas. To support these needs, a regional high-resolution (5 km grid cells) coupled ice-ocean model has been implemented for the Barents and Kara Seas. The model system consists of an improved version of the HYCOM model (same as TOPAZ), integrated with the Nansen Center ice dynamics model based on the Elastic Visco Plastic rheology. The models are forced with atmospheric data from the European Center for Medium range Weather Forecasting. The boundary conditions are given by the TOPAZ forecasting system for the Atlantic and the Arctic Oceans (see above). The model is tested with the perspective of use for development of an iceberg drift model and for operational ice-ocean forecasts.

Preliminary results are validated (Fig. 3) against a new comprehensive hydrographic data base developed by Dr. Alexander Korablev at Arctic and Antarctic Research Institute under the INTAS-project "*The Nordic Seas in the Global Climate System*", coordinated by Ola M. Johannessen. Furthermore, the results are compared favourably with remotely sensed sea ice concentration data for winter 1979, when the Barents Sea was exposed to extreme sea ice conditions. Further work is going on to evaluate the quality of the model to reproduce the general circulation and water masses.

Polar and Environmental Remote Sensing

Research director Stein Sandven

Sea ice classification of satellite radar (SAR) images in the Kara Sea has been investigated using a multisensor data fusion and neural network algorithm (Bogdanov et al., 2005). This method, which has been validated by *in situ* observations from field expeditions, gives improved results compared to single sensor methods. The ice classification can distinguish between various stages of

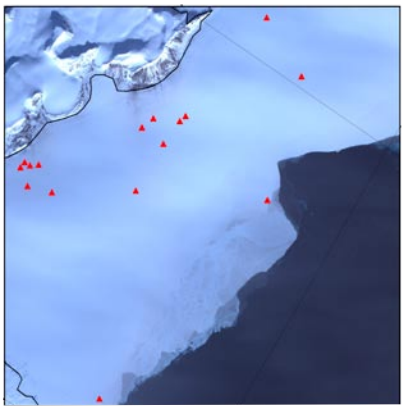


Fig. 4: Mapping of icebergs (red triangles) near Franz Josef Land, May 2005, using a sub-image of high-resolution optical ASTER satellite data.

new, young and first year ice as well as between level and deformed ice.

Wideswath SAR data from ENVISAT are regularly used to monitor ice drift in the Fram Strait, through the year. Ice drift is also retrieved from other satellite data, but SAR data gives more accurate and higher resolution of the ice drift, which is used to estimate the area flux of ice. The sea ice export through the Fram Strait is a key parameter in the Arctic sea ice budget.

An extensive selection of SAR images from ERS and ENVISAT covering the period from 1991 to 2005 have been analyzed for sea ice classification and process studies in support of ice navigation in the Northern Sea Route. The results of 15 years of SAR ice studies in this region will be published by Springer-Praxis in the book "*Remote Sensing of Sea ice in the Northern Sea Route: Studies and Applications*", O.M. Johannessen et al..

In the Franz Josef Land area, high resolution optical satellite images have been used for iceberg detection. In a single ASTER image more than 100 icebergs were identified embedded in the fast ice surrounding the archipelago in May 2005. The size of the observed icebergs was in the range 50 – 200 m (Fig. 4). To monitor iceberg positions and drift, both optical and SAR images with sufficient high resolution are required, supported by in situ observations. Icebergs in the Barents Sea are a particular risk for offshore operators and a system to monitor and forecast iceberg drift is under development.

Operational satellite ocean products

Post Doc Knut Frode Dagestad, Research director Johnny A. Johannessen and Research leader Lasse H. Pettersson

This year it has been demonstrated that the satellite synthetic aperture radar (SAR) data can be combined with an advanced radar imaging model, developed at Nansen International Centre in St. Petersurg, to produce quantitative estimates of surface current changes in frontal zones and eddies (Kudryavtsev et al., 2005; Johannessen et al., 2005). The method needs to be adequately refined and validated. However, this ability to quantify surface current features imaged by SAR is very promising and opens up more process oriented research with a wide range of downstream applications.

A new satellite data and information server has also been implemented at the Nansen Center with automatic downloading and processing of data from satellite ground receiving stations. In particular the ESA Envisat ASAR (radar) and MERIS (spectrometer) data are downloaded on a routine basis for selected ocean and coastal regions, both around Norway and abroad. At high latitudes, including the Barents Sea, the coverage of the polar orbiting satellites are more dense and most data are received at near daily repeat intervals, providing observations of temporal and spatial variability of physical and biogeochemical quantities.

The ASAR image (Figure 5 - 426 km wide at 150 m resolution) of the coastal regions of Finnmark, centered to Melkøya, shows distinct north-eastward elongated offshore bands of brighter-darker radar signals. Downwind and between some of the outer islands one also see expressions of wind-sheltered dark regions, giving almost no radar return. Using the orientation of these elongated bands a wind direction from southeast is prescribed to convert the radar image intensity to a wind speed map (upper figure). The artificial colours related to the wind speed magnitude clearly shows rapid and intense shifts connected with the distinct bands in the radar signals. The wind speed variability across these bands are up to 15 m/s, occurring over distances of less than 500 m. Such wind speed maps are very good documentation of the complex wind field patterns that is known to exist along the coasts of Norway. No other surface based observation system is able to provide such detailed quantitative information of the spatial variability in the coastal wind field.

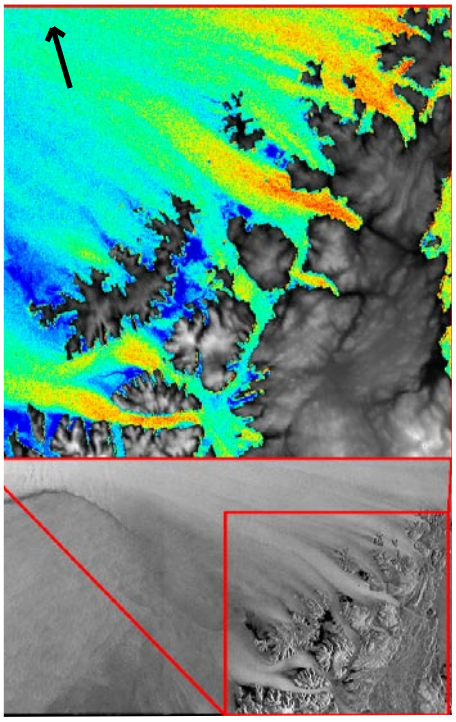


Fig. 5: Envisat Synthetic Aperture Radar (SAR) image from Melkøya in Finmark (lower image). The surfcae wind speed is estimated from the radar image (upper image). Red: high winds.

Our satellite data server offers a powerful tool for rapid access to and use of various data and products, either individually, combined or in synergy with other relevant observations and model fields. For scientific research, mesoscale ocean and atmosphere-ocean boundary layer processes are studied. In addition, the data also opens up for applications such as for wind farm siting and high-resolution ocean current and wind field monitoring and modelling.

The Nansen Center has since 1998 made ocean colour satellite data products available for monitoring of alga blooms in the North Sea and Skagerak region. Based on research conducted in cooperation with the Nansen International Center in St. Petersburg various data products and regional processing algorithms have been developed (e.g. Pozdnyakov et al, 2005). The Norwegian Research Council project "Integrated Modelling and remote Sensing of Algal Bloom monitoring in Norwegian waters - MORAN", including the Ph.D. work of Dr. Are Folkestad, has produced regional algorithms for Norwegian waters. The developed algorithms have been implemented and are now used operationally for generation of daily data products of chlorophyll, total suspended sediments and dissolved organic matter. Daily, rolling 7-days- and monthly-average composites are generated and the data products are disseminated through http://HAB.nersc.no as well as directly to users such as the Directorate of Fisheries, NIVA, met.no and the aquaculture industry. This algae bloom and water quality monitoring service is operated under the ESA MarCoast project supporting one of the GMES services to be fully operational by 2008.

publications

Referee papers in international journals

Climate Research

Drange, H., T. Dokken, T. Furevik, R. Gerdes, W. Berger, A. Nesje, A. A. Orvik, Ø. Skagseth, I. Skjelvan, S. Østerhus, (2005): An intronduction, in The Nordic Seas: An Integrated Perspective (Drange, H., T. Dokken, T. Furevik, R. Gerdes, W. Berger, Eds.), AGU Monograph 158, American Geophysical Union, Washington DC, pp.1-10.

Drange, H., R. Gerdes, **Y. Gao**, M. Karcher, F. Kauker, **M. Bentsen**, (2005): Ocean general circulation modelling of the Nordic Seas, The Nordic Seas: An Integrated Perspective, (Drange, H., T. Dokken, T. Furevik, R. Gerdes, W. Berger, Eds.), AGU Monograph 158, American Geophysical Union, Washington DC, pp.199-220.

Eldevik, T., F. Straneo, **A.B. Sandø**, T. Furevik, (2005): Pathways and export of Greenland Sea Water. The Nordic Seas: An integrated perspective, (Drange, H., T. Dokken, T. Furevik, R. Gerdes, W. Berger, Eds.), AGU Monograph 158, American Geophysical Union, Washington DC, pp.89-103.

Furevik, T., **J.E.Ø. Nilsen**, (2005): Large-Scale Atmospheric Circulation Variability and its Impacts on the Nordic Seas Ocean Climate - a Review. The Nordic Seas: An integrated perspective, (Drange, H., T.M. Dokken, T. Furevik, R. Gerdes, W. Berger, Eds.), AGU Monograph 158, American Geophysical Union, Washington DC, pp.105-136.

Gao, Y., H. Drange, M. Bentsen, O.M. Johannessen, (2005): Tracer-derived transit time of the waters in the

eastern Nordic Seas. Tellus. Vol. 57B, pp. 332-340.

Gong, D., **H. Drange**, (2005): A preliminary study on the relationship between Arctic Oscillation and daily SLP variance in the Northern hemisphere during wintertime, Adv. Atm. Sci., 22, pp.313-327.

Hátún, H., **A.B. Sandø**, **H. Drange**, B. Hansen, H. Valdimarsson, (2005): Influence of the Atlantic Subpolar Gyre on the Thermohaline Circulation, Science, Vol. 309, pp.1841-1844.

Hátún, H., **A.B. Sandø, H. Drange, M. Bentsen**, (2005): Seasonal to decadal temperature variations in the Faroe-Shetland inflow waters. The Nordic Seas: An integrated perspective, (Drange, H., T.M. Dokken, T. Furevik, R. Gerdes, W. Berger, Eds.), AGU Monograph 158, American Geophysical Union, Washington DC, pp.239-250.

Jiang, D., H-J. Wang, Z. Ding, X. Lang, **H. Drange** (2005): Modeling the middle Pliocene climate with a global AGCM, J. Geophys. Res., 110, doi:10.1029/2004JD005639

Johannessen, O.M., K. Lygre, T. Eldevik, (2005): Convective chimneys and plumes in the northern Greenland Sea. The Nordic Seas: An integrated perspective, (Drange, H., T.M. Dokken, T. Furevik, R. Gerdes, W. Berger, Eds.), AGU Monograph 158, American Geophysical Union, Washington DC, pp.251-272.

Johannessen, O.M., K. Khvorostovsky, M.W. Miles, **L.P. Bobylev**, (2005): Recent Ice-Sheet Growth in the Interior of Greenland. Science, Vol. 310, pp.1013-1016.

Kuzmina, S.I., L. Bengtsson, **O.M. Johannessen, H. Drange, L. Bobylev,** M.W. Miles, (2005): The North Atlantic Oscillation and greenhouse-gas forcing. Geophysical Research Letters, Vol. 32, L04703, doi:10.1029/2004GL021064.

Sorteberg, A., T. Furevik, **H. Drange**, N. G. Kvamstø, (2005): Effects of simulated natural variability on Arctic temperature projections, Geophys. Res. Lett., 32, L18708, doi:10.1029/2005GL023404.

Zou, H., L. Zhou, **Y. Gao**, X. Chen, P. Li, C. Ji, S. Ma and D. Gao (2005): Total ozone variation between 50 and 60 N. Geophysical Research Letters, 32, L23812, doi:10.1029/2005GL024012

Atmosphere - Ocean – Ice processes

Bogdanov, A.V., **S. Sandven, O.M. Johannessen**, V.Yu. Alexandrov, **L.P. Bobylev**, (2005): Multisensor Approach to Automated Classification of Sea Ice Image Data. IEEE Transactions on Geoscience and Remote Sensing. Vol. 43, No.7, pp. 1648-1664.

Johannessen, J.A., **V. Kudryavtsev**, D. Akimov, **T. Eldevik, N. Winther**, B. Chapron, (2005): On radar imaging of current features: 2. Mesoscale eddy and current front detection. J. Geophys. Res, 110 (C7), doi:10.1029/2004JC002802.

Kudryavtsev, V., D. Akimov, **J.A. Johannessen**, B. Chapron, (2005): On radar imaging of current features: 1. Model and comparison with observations. Journal of Geophysical Research, vol. 110, C07016, doi:10.1029/2004JC002505.

LeTraon, P., L. Phalippou, D. Cotton, **J.A. Johannessen**, G. Ruffini, P. Bahurel, M. Bell, B. Chapron, N. Pinardi, I. Robinson, L. Santoleri, D. Stammer, M.R. Drinkwater, H. Rebhan, (2005): Roadmap for a GMES Operational Oceanography Mission, ESA Bulletin, vol. 124, November 2005.

Marzeion, B., A. Timmermann, R. Murtugudde, F.-F. Jin, (2005): Bio-Physical Feedbacks in the Tropical Pacific, Journal of Climate, 18, pp.58-70.

Melentyev, V.V., **O.M. Johannessen,** and **L.P. Bobylev**, (2005): Siberian Permafrost and Seasonally Frozen Grounds: Parameters Retrieval Using Microwave Satellite Data. Earth Observation and Remote Sensing, Russian Academy of Sciences. No. 5, pp. 3-9, 2005.

Olsson, K.A., E. Jeansson, L.G. Anderson, B. Hansen, **T. Eldevik**, R. Kristiansen, M.-J. Messias, T. Johannessen, and A.J. Watson, (2005): Intermediate water from the Greenland Sea in the Faroe Bank Channel: spreading of released sulphur hexafluoride. Deep Sea Res. I, 52, pp.279-294.

Zilitinkevich, S.S., and **I. Esau**, (2005): Resistance and Heat Transfer Laws for Stable and Neutral Planetary Boundary Layers: Old Theory, Advanced and Re-evaluated, Quarterly J. Royal Meteorol. Soc., 131, 1863-1892, doi: 10.1256/qj.04.143.

Zilitinkevich, S.S., J. C. R. Hunt, A. A. Grachev, **I. N. Esau**, D. P. Lalas, E. Akylas, M. Tombrou, C. W. Fairall, H. J. S. Fernando, A. Baklanov, S. M. Joffre, (2005): The effect of large eddies on the convective heat/mass transfer over complex terrain: Advanced theory and its validation against experimental and LES data, Croatian Meteorological Journal , 40, pp.20-26.

Zilitinkevich, S.S., I.N. Esau, and A. Baklanov, (2005): Atmospheric boundary layers in storms: advanced theory and modelling applications. Advances in Geosciences, 2 (47), pp.47-49.

Optical Oceanography

Pozdnyakov D.V, A.A. Korosov, H. Grassl and **L.H. Pettersson**, (2005): An advanced algorithm for operational retrieval of water quality parameters from satellite data in the visible. Int. J. Remote Sensing, Vol 26, no 12, pp. 2669-2687, DOI:10.1080/01431160500044697.

Pozdnyakov, D., A.A. Korosov, **L.H. Pettersson,** and **O.M. Johannessen**, (2005): MODIS evidences the river run-off impact on the Kara Sea trophy. International Journal of Remote Sensing. Vol. 26, No. 17, pp.3641-3648.

Books

Drange, H., T. Dokken, **T. Furevik**, R. Gerdes, W. Berger (Eds.) (2005): The Nordic Seas: An Integrated Perspective. AGU Monograph 158, American Geophysical Union, Washington DC, pp. 366.

Filatov, N.N., D. Pozdnyakov, **O.M. Johannessen, L.H. Pettersson,** and **L.P. Bobylev**, (2005): White Sea – its marine environment and ecosystem dynamics influenced by global change. Nansen Center´s Polar series no. 3. Springer-Praxis Publishing, Heidelberg, Germany, ISBN: 3-540-20541-1, pp. 472.

Technical reports

Pettersson, L.H., D. Pozdnyakov, A. Korosov: Satellite Earth Observation Atlas for the Kara Sea 1998-2004. Annual report 2004 under the project MAREAS. NERSC Technical report no. 256, 2005.

Sandven, S, K. Kloster, H. Sagen, V. Alexandrov, S. Gerland, R. Hall, R. Forsberg, S. M. Hvidegard, C. Haas: Cryosat pre-launch cal-val studies of sea ice thickness. NERSC Technical report no. 257, 2005.

Pettersson, L.H., A. Korablev, A. Pnyushkov, A. Smirnov: *Confidential*. NERSC Technical report no. 258, 2005.

Pettersson, L. H., J. I. Allan, P. Andersen, F. G. Figueras, S. Groom, S. Kaitala, B. Karlson, T. Lorentzen, P. Miller, L. J. Naustvoll, A. Neumann, M. Skogen, T. Stipa, E. Svendsen and R. Torres, 2005: Harmful Algal Bloom Initiation and Prediction in Large European Marine Ecosystems – HABILE, Final Scientific Report, NERSC Technical Report no. 259, May 2005.

Pettersson, L.H., A. Folkestad, K. Sørensen, **J.A. Johannessen**: MERIS Validation Cruises in the Norwegian Coastal Current during spring 2002. NERSC Technical report no. 260, 2005.

Counillon, F.: Analysis of TOPAZ circulation around the Gulf of Mexico. NERSC Technical report no. 261, 2005.

Sandven. S., A. Seina, R. Berglund, C. Haas, R. Jalonen: ARCOP WP1: Ice information system. Review of ice services in the Northern Hemisphere. NERSC Technical report no. 263, 2005.

Parouty, S.: Comparison of operational ocean forecasting systems. NERSC Technical report no. 264, 2005.

Pettersson, L.H., A. Folkestad, A. Korosov, **K-F. Dagestad**: An Autonomous System for Near Real-Time MERIS Processing. NERSC Technical report no. 265, 2005.

Sandven, S., T. Hamre, B. Hackett, K. Sørensen, N. Robbe, F. Ziemer, A. Bogdanov, G. Gemelli, F. Nirchio, F. Cauneau, E.O. Tuama, S. Groom, F. Parthiot, P. Trivero, J. Populus, **A. Folkestad, L.H. Pettersson**, M. Cysewski, K. Lewis, J-F. Le Roux, J. Høkedal, J. Karud, W. Biamino: Data Integration System for Marine Pollution and Water Quality. DISMAR final report, NERSC Technical report no. 266, 2005.

Sandven, S., O. M. Johannessen, E. Fahrbach, E. Buch, H. Cattle, L. Toudal Pedersen and T. Vihma. The Arctic Ocean and the Need for an Arctic GOOS. EuroGOOS Publication # 22, March 2005, 50 pp.

Special reports

Furevik, B., T. Hamre, M. Babiker, K. Kloster, R. Elisassen: Operators Manual for Slick Analysis in SAR images. NERSC Special report no. 75, 2005.

Johannessen, O.M., L. Bengtsson, L. Bobylev: EU Descartes Laureate 2005 brochure, CECA – Climate and Environmental Change in the Arctic. NERSC special report no. 76, 2005.

Pettersson, L.H., S. Milutinovic, and A.G. Strøm-Erichsen, 2005: The role of Local Authorities in responding to Major oil spills. Technical report CPL/DEV (11) 1 Committee On Sustainable Development of the Chamber of Local Authorities under Council of Europe, Strasbourg, France. NERSC special report no. 77, 2005.

Lorentzen, Torbjørn and **Lasse H. Pettersson** (2005): How to estimate costs from harmful algal blooms – economic impacts on wild fisheries, aquaculture and commercial tourism. Institute for research in economics and Business Administration, Bergen, SNF report no. 25/05, November.

Conference proceedings

Cox, A., V.J. Cardone, **F. Counillon**, D. Szabo: Hindcast Study of Winds, Waves and Currents in Northern Gulf of Mexico in Hurricane Ivan. Offshore Technology Conference, Houston, Texas 2-5 May 2005.

Folkestad, A., A. Korosov, K. Sørensen, **L. H. Pettersson** and D. V. Pozdnyakov: An analytical Case 2 water algorithm for the North Sea. 31st International Symposium on Remote Sensing of Environment. St. Petersburg, Russia, June 20-24, 2005.

Hamre, T., S. Sandven, É. Ó Tuama: DISMAR: Data Integration System for Marine Pollution and Water Quality. 31st International Symposium on Remote Sensing of Environment. St. Petersburg, Russia, June 20-24, 2005.

Hamre, T., S. Sandven, É. Ó. Tuama: DISMAR: Data Integration System for Marine Pollution and Water Quality. MERIS (A)ATSR Workshop 2005. Frascati, Italy, 26 - 30 September 2005. ESA SP-597, December 2005.

Johannessen, J.A., F. Siegismund, H. Drange, L. Bertino, P. Knudsen, R. Fosberg, O.B. Andersen, A. L. Vest, R. Hipkin, A. Hunegnaw, D. Solheim, O. Omang, M.-H. Rio, F. Hernandez, K. Haines, J.-P. Drecourt, R. Bingham, GOCINA products of relevance for GOCE validation and calibration. Workshop GOCINA: Improved modelling of the ocean transport and climate prediction in the North Atlantic region using GOCE gravimetry, April 13-15 2005, Cahiers du Centre Europeen de Geodynmaique et de Seismologie, Volume 25.

Pettersson, L. H., A. Folkestad, E. Svendsen, M. Skogen, H. Søiland, L.J. Naustvoll, 2005: Monitoring and prediction of harmful algae blooms in Norwegian waters – the concept and experience from Chattonella spp. events. Aquaculture Europe 2005, Trondheim, Norway, August 5-9, 2005.

Stiansen, J.E., S. Sundby, A. Jenkins, **J.E.Ø. Nilsen** (2005). Swell as a turbulence source in shallow water. ICES CM 2005/O:26.

Doctoral disseratation

Winther, N.: Towards a North Sea prediction system. 4. november 2005. Supervisors: Prof. J.A. Johannessen, G. Evensen, E. Svendsen.

Popular science articles

Drange, H.: Om tjue år er det for seint. Syn og Segn, 4, 2005.

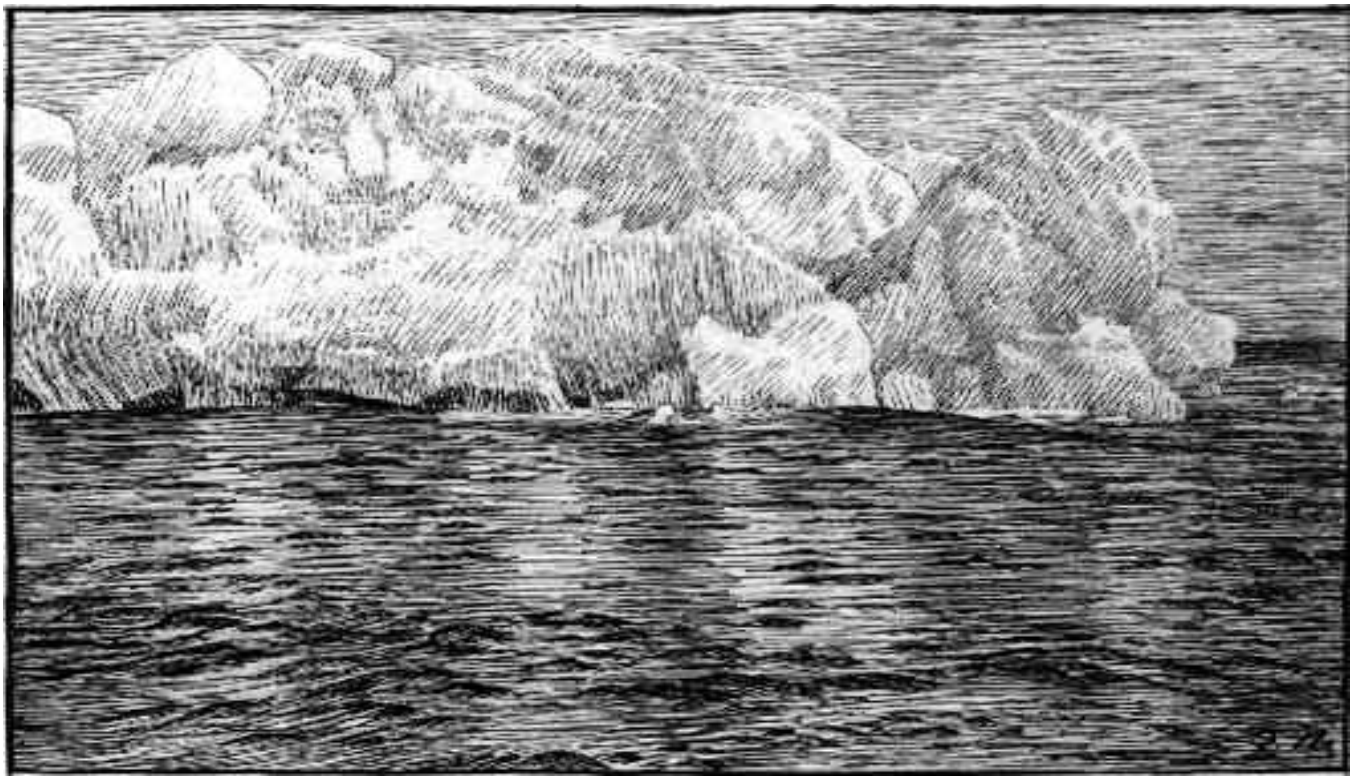
Eldevik, T.: Klimatiske veivalg i Norskehavet. Cicerone, 3, s.22-24, 2005.

Johannessen O.M., and **H. Ring**: Hva skjer ved klimaendring? Kronikk i Aftenposten, febr. 2005.

Johannessen O.M., Varmere, våtere og villere. Kronikk i Forskning.no, mars 2005.

Johannessen, O.M., Arctic climate – will the ice disappear in this century? RTTC Responding to climate change 2005, pp. 34-37.

Sandven, S. New satellites for monitoring the polar environment. Nordic Space Activities, Vol. 13, No. 1, 2005, pp 8 – 11.



The icebergs fascinated Fridjof Nansen.
Here his drawing (1912) of a grounded iceberg near Cape Mitra at Albert I Land, Svalbard.

The Nansen Group
Leader: Prof. Ola M. Johannessen

Nansen Environmental and Remote Sensing Center
Thormøhlensgate 47
N-5006 Bergen, Norway
Phone: +47 55205800
Fax: +47 55205801
e-mail: admin@nersc.no
http://www.nersc.no

Mohn-Sverdrup Center for Global Ocean Studies and Operational Oceanography
c/o NERSC
Thormøhlensgate 47
N-5006 Bergen, Norway
Phone: +47 55205821
Fax: +47 55205801
e-mail: ola.johannessen@nersc.no
http://msc.nersc.no

G.C. Rieber Climate Institute
c/o NERSC
Thormøhlensgate 47
N-5006 Bergen, Norway
Phone: +47 55205871
Fax: +47 55205801
e-mail:helge.drange@nersc.no
http://gcr.nersc.no

Nansen International Environmental and Remote Sensing Centre
14th. Line V.O. 7A, office 34-35
199034 Saint Petersburg, Russia
Phone: +7 812 324 5103/01
Fax: +7 812 324 5102
E-mail: adm@niersc.spb.ru
http://www.niersc.spb.ru

Nansen-Zhu International Research Centre
c/o Institute of Atmospheric Physics,
Chinese Academy of Sciences,
PO Box 9804, Beijing 100029, China
Phone: ++86-10-62063256
E-mail: nzc@mail.iap.ac.cn
http://nzc.iap.ac.cn

Nansen Environmental Research Centre India
Priya Square, Karshaka Rd.,
Kochi 682 016 Kerala - India
Phone: +91 4842 322 351
Fax: +91 4842 323 694
E-mail: nerci@ipath.net.in
http://www.nerci.in

Terra Orbit AS
Thormøhlensgate 47
N-5006 Bergen, Norway
Phone: +47 55205800
Fax: +47 55205801
e-mail: terraorbit@terraorbit.com
http://www.terraorbit.com

Ocean Numerics UK
Fugro House
Hithercroft Road, Wallingford
Oxfordshire, OX10 9RB, UK
Phone +44 1793 723014
Fax +44 1793 728302
e-mail: info@oceannumerics.com
http://www.oceannumerics.com