Annual Report 2010

Nansen International Environmental and Remote Sensing Centre

St. Petersburg, Russia

a non-profit international research institute for environmental and climate research

Founded in 1992
REPORT FROM THE GENERAL MEETING OF FOUNDERS

Vision
The Scientific Foundation “Nansen International Environmental and Remote Sensing Centre” (Nansen Centre, NIERSC) vision is to understand, monitor and predict climate and environmental changes in the high northern latitudes for serving the Society.

Major Research Areas
• Climate Variability and Change in High Northern Latitudes
• Atmosphere-Ocean Interaction
• Aquatic Ecosystems in Response to Global Change
• Applied Meteorological and Oceanographic Research for Industrial Activities
• Socioeconomic Impact of Climate Change

Organization
NIERSC is an independent non-profit international research foundation established by Russian, Norwegian and German research organizations. NIERSC conducts basic and applied environmental and climate research funded by the national and international governmental agencies, research councils, space agencies and industry. Additionally, the Nansen Centre receives basic funding from its Founders and the Nansen Scientific Society.

NIERSC was founded in 1992 and re-registered at the St. Petersburg Administration Registration Chamber into a non-profit scientific foundation in 2001. The Centre got accreditation at the Ministry of Industry, Science and Technology of the Russian Federation as a scientific institution in 2002 and was re-registered in 2006 according to a new legislation on Non-Commercial Organizations of the Russian Federation. NIERSC got a license for conducting meteorological and oceanographic observations from Roshydromet in 2006. In 2008 Nansen Centre received also a license from Roscosmos for conducting the space-related research activities.

Staff
At the end of 2010 the NIERSC staff incorporated 31 employees comprising core scientists, including three full Doctors of Science and five with a PhD degree, part-time researchers, and administrative personnel. 12 Nansen Fellowship PhD-students are supervised and supported financially, 7 of them holding also part-time positions of Junior Researchers at NIERSC.

Production
During the year 2010, totally 73 publications were published including one book, two chapters in books, 7 papers in peer reviewed journals, 12 papers in other journals and 51 conference proceedings (see the Reference list).

Doctor of Sciences Dissertation at NIERSC
On 30 September 2010 Dr. Vitaly Yu. Alexandrov successfully defended his Doctor of Sciences (Dr. Sci.) thesis in Oceanography. The title of his thesis is “Satellite Radar Monitoring of the Sea Ice Cover”.

The defense was carried out at the Scientific Council of Arctic and Antarctic Research Institute (AARI). The Higher Certifying Commission of the Russian Ministry of Science and Education gave Dr. Vitaly Yu. Alexandrov a qualification of Doctor of Physical and Mathematical Sciences (see a summary of the Dr. Sci. thesis in the Scientific Report).

Awards
Dr. Natalia Yu. Zakhvatkina received in 2010 the Academician Kupfer Award from Roshydromet Service for her research work “Arctic Sea Ice Identification using Satellite SAR Data”.

Socioeconomic Workshop
On 2 November 2010 a Workshop “Ecological and Economic Issues in the Context of Climate Change” was held at NIERSC. The primary focus of the Workshop was on the economics of climate change, with special emphasis on economic modelling. The presentations were delivered by key experts from St. Petersburg and Moscow.

Meetings and Workshops on Remote Sensing
Dr. Elizaveta V. Zabolotskikh took part in Algorithm comparison for atmospheric water vapor and cloud liquid water retrievals to be used for AMSR-2/GCOM-W satellite (Japan 2011) data processing (Japan, Tokyo, JAXA, 10-17 January 2010)
Dr. Leonid P. Bobylev and Dr. Elisaveta V. Zabolotskikh represented NIERSC at the Taiwan-Russia Workshop “Remote sensing of physical and biological processes: Application for waters around Taiwan” (National Taiwan Ocean University, Keelung, Taiwan, 15-16 October 2010).

National and International Activities

NIERSC has a long-lasting cooperation with Russian organisations such as St. Petersburg State University, institutions of the Russian Academy of Science, Federal Space Agency, Federal Service for Hydrometeorology and Environmental Monitoring including the Northern Water Problems Institute, Scientific Research Centre for Ecological Safety, Arctic and Antarctic Research Institute, Russian State Hydrometeorological University, Voeikov Main Geophysical Observatory, Murmansk Marine Biological Institute, Research Centre of Operational Earth Monitoring and other, totally about 40 institutions.

Fruitful relations are established also with a number of foreign and international organizations, universities and institutions including Max-Planck Institute for Meteorology, GKSS Research Centre, Friedrich-Schiller-University in Jena, Germany, Finnish Institute of Marine Research, Institut Français de recherche pour l’exploitation de la mer (IFREMER) in Brest, France, European Climate Forum, and especially with the NIERSC founders. Close cooperation is established with the Nansen Centre in Bergen. Most of scientific results described below are achieved within the joint research activities of both Nansen Centres, in St. Petersburg and Bergen, and cooperating partners.

Nansen Fellowship Programme

The main objective of the Nansen Fellowship Program (NFP) at NIERSC is to support PhD-students at Russian educational and research institutions, including Russian State Hydrometeorological University, St. Petersburg State University, Arctic and Antarctic Research Institute, and others.

The research areas are climate and environmental change and satellite remote sensing, including integrated use of satellite Earth observation techniques in combination with supporting in situ observations and numerical modeling for studies of the Earth system.

NFP provides the PhD-students with:
- Russian and international scientific supervision
- financial fellowship
- efficient working conditions at NIERSC
- training and research visits to international research institutions within the Nansen Group and beyond
- involvement into international research projects.

The postgraduate student activity is supervised by at least one Russian and one international senior scientist. All NFP PhD-students have since 1997 got their doctoral degree under the NFP.

NIERSC is sponsored by core funding from the Nansen Center in Bergen, Norway (NERSC) and the Nansen Scientific Society.

Research Projects

Below is the list of the research projects implemented at NIERSC in 2010. Most of them were implemented in close cooperation with other national and international scientific institutions.

Completed projects

- Developing Arctic Modeling and Observing Capabilities for Long-term Environment Studies (DAMOCLES, EU FP6, 2006-2010, Project Leader: Jean-Claude Gascard, UPMC)
- Maritime resources of the Barents Sea: satellite data driven monitoring in the context of increase of commercial efficiency of the fishery (MAREBASE, Research Council of Norway, 2008-2010, Principal Investigators: Prof. Stein Sandven, NERSC / Prof. Vladimir N. Kudryavtsev, NIERSC / Dr. Sci. Oleg V. Titov, PINRO / Dr. Alexandr S. Averkiev, RSHU)
- Software development for satellite sun glitter image processing (Contract with IFREMER, 2010, Principal Investigator: Prof. Vladimir N. Kudryavtsev, NIERSC)
- Meteor-3 (Contract with NTsOMZ, 2010, Principal Investigator: Prof. Dmitry V. Pozdnyakov, NIERSC)
- Federal Program “World Ocean” (Sub-contract with RSHU, 2010, Principal Investigator: Prof. Vladimir N. Kudryavtsev, NIERSC)
- CPA Algorithm (Contract with Michigan Technical University, 2010, Principal Investigator: Prof. Dmitry V. Pozdnyakov, NIERSC)

On-going projects

- Arctic and sub-Arctic climate system and ecological response to the early 20th century warming (ARCWARM, Research Council of Norway, 2007-2011, Project Leader: Prof. Ola M. Johannessen, NERSC)
- Descartes Program (EU Descartes Award fund, 2007-2011, Project Leader: Prof. Ola M. Johannessen, NERSC)

Assessing the sensitivity of Arctic coastal dynamics to change (RFBR – Helmholtz-Gemeinschaft, 2009-2012, Project Leaders: Dr. Pier Paul Overduin, AWI / Dr. Stanislav A. Ogagrood, MSU)

New projects

Agent-based modeling of climate-socioeconomic system with applications to the sustainability of Russian economy (ECF/NERSC, incl. donation by Prof. Hasselmann, 2010-2011, Principal Investigator: Dr. Dmitry V. Kovalyevsky, NIERSC)

Deterministic and stochastic models of economic dynamics (RFBR, 2010-2011, Project Leader: Dr. Dmitry V. Kovalyevsky, NIERSC)

Economics of climate change in a multiregional integrated assessment model for the Russian Federation (RFBR, 2010-2012, Project Leader: Dr. Dmitry V. Kovalyevsky, NIERSC)

Monitoring and Assessing Regional Climate Change in High Latitudes and the Arctic (MONARCH–A, EU FP7, 2010-2013, Project Coordinator: Prof. Johnny A. Johannessen, NERSC)

New Research Areas

In 2010 new research areas and topics were established at NIERSC:
- Natural and anthropogenic variability and change of the Arctic glaciers (Research funded through MAIRES project, EU FP7, Project Leader: Prof. Stein Sandven, NERSC)
- Permafrost remote sensing from satellites: tundra lake monitoring using ENVISAT ASAR WS data (Research funded through NFP, conducted in cooperation with Prof. Christiane Schmullius, FSU-Jena)

Prospects for 2011

The interdisciplinary studies of the High North will remain the main focus of NIERSC research in 2011. NIERSC staff is encouraged to further increase the number of publications in peer reviewed journals in 2011.

St. Petersburg, 19th May 2011

Jean-Pierre Contzen, UNIFOB, President
Valentin Meleshko, VMGO, Co-President
Hartmut Grassl, Max-Plank Society, Co-Vice President
Lasse H. Pettersson, NERSC, Co-Vice President
Valery Astakhov, SPbSU
Vladislav Donchenko, SRCES RAS
Nickolay Filatov, NWPI RAS
Leonid P. Bobylev, Director
Climate Variability and Change

Surface air temperature variability and trends in the Arctic
Dr. Svetlana I. Kuzmina
Prof. Ola M. Johannessen (NERSC, Norway)
Dr. Leonid P. Bobylev
Dr. Olga G. Aniskina

In the framework of ARCWARM project we examined the Arctic surface air temperature (SAT) variability and trends using unique long-term records of NansenSAT dataset. Arctic regions were determined by statistically justified manner using hierarchical Cluster Analysis. The magnitude of Arctic amplification was estimated and the role of different Arctic regions in this amplification was analysed. It was shown that the annual Northern Hemisphere (NH) and Arctic SAT had increased since 1900 with the warming rate of ~0.7°C/100yr. The greatest SAT changes in the annual course occurred in winter for the polar region (~1.3°C/100yr). Absolute SAT maxima for all seasons occurred in 1990s and 2005-2007. However, recent winter polar SAT anomaly did not exceed one occurred in 1944. Over the past 100 years the Arctic amplification was observed during all seasons, except summer. It was the most pronounced during early warming and cooling periods. Ongoing warming is characterized, till now, by significantly less magnitudes of the Arctic amplification than previous warming and cooling. But there is a clear tendency for the Arctic amplification strengthening during the latest period for all seasons, especially for winter (Fig. 1).

Analysis of climate changes in Saint-Petersburg using observational and modelling data
Dr. Svetlana I. Kuzmina
Dr. Olga G. Aniskina
Dr. Leonid P. Bobylev

An assessment of past and current state of the climate of St. Petersburg has shown that the rate of change of surface air temperature and precipitation in the late 20th and early 21st century significantly exceeds the trends noted earlier. The analysis of future changes in heat and water balance according to a new generation of climate models CMIP3 was performed. The probability of future extreme events was estimated. The long-term risk of Neva flooding to 2090 was analysed. Climate model results indicate a significant increase of SAT and precipitation, especially during the winter. Increasing proportion of rainfall at the end of 21st century is 20% in summer and 50% in winter. SAT growth by the end of the 21st century is about three degrees in summer and about 9 degrees in winter (Fig. 2). Recommendations for the environmental policies of the city were developed. The obtained results permit to get new insights about the peculiarities of manifestation of global warming and assess the trends of climate change and anthropogenic influence on climatic characteristics of the metropolis. This study is summarized in a paper submitted to Meteorology and Hydrology.

Polar low study using multi-sensor approach
Dr. Elizaveta V. Zabolotskikh
Dr. Leonid P. Bobylev
PhD-student Julia Ye. Smirnova
Prof. Vladimir N. Kudryavtsev
Prof. Johnny A. Johannessen (NERSC, Norway)

In the frame of DAMOCLES Project the enhanced techniques for polar low monitoring, developed at NIERSC during 2008-2009, were applied for further research associated with these adverse weather events. In 2010 the main efforts in the area of polar low studies were aimed at the involvement of the data from new sensors from different satellites. As in the previous years, the general research methodology was based on the usage of satellite passive microwave measurements of SSM/I and AMSR-E onboard DMSP and Aqua satellites correspondingly. The high potential of these data had repeatedly been confirmed by numerous case studies. The availability of high accuracy Neural Network Arctic polar algorithms allowed the detection of those polar lows that could not be identified by any of the other instruments. Besides, multi-sensor approach was further developed providing the most complete knowledge about the polar lows: the highest temporal resolution and all available parameter estimation. This approach now uses data from the following instruments: Envisat ASAR for high resolution wind speed retrieval; QuikSCAT/SeaWinds (before November 2009) and Metop ASCAT for low resolution additional wind speed data; Terra and Aqua MODIS, NOAA AVHRR data for the study of the polar low cloud structure; DMSP SSM/I, Aqua AMSR-E, NOAA AMSU-B for various geophysical parameter estimation; radiosonde reports and surface analysis maps as supplementary data; NCEP/NCAR reanalysis data for construction of pressure fields and searching for correlation between mesoscale lows found using satellite remote sensing data and low pressure areas in re-analysis data. The results of the study are summarized in a number of publications, including:


Permafrost reference map
Dr. Elena V. Shalina
Dr. Leonid P. Bobylev
Ms. Lyudmila S. Lebedeva
Mr. Kirill E. Zemesziks

The work has been carried out in the frame of the MONARCH-A FP7 Project. NERSC work is concentrated within two main tasks: 1) to create and deliver a digital ‘reference permafrost map from historical sources’ which could be used as a point of reference in the evaluation of permafrost changes, and 2) to assess changes occurred in the permafrost over the last 30 years. Permafrost is a critical element of land surface processes at high latitudes, affecting land cover, hydrology and snow dynamics. Its melting under climate warming will cause (and to some extent is causing now) potentially dangerous releases of greenhouse gases, as well as changing high-latitude hydrology and affecting human activities.

In order to collect data that could be the base for a reference permafrost map, NERSC team has produced an inventory of existing permafrost data sets and maps, including Russian historical maps and data from local sampling worldwide. Available and relevant for MONARCH-A Russian historical paper maps (totally 317 maps) have been collected and archived, data from local measurements of permafrost available on the Web has been downloaded. All maps of the archive are accompanied by metadata/commentary.

About 50% of the collected maps had been created in 1980s. Most of maps are for limited areas of Russian Federation, however a part of them are for the territory of the former Soviet Union or Russia. Comparison of collected maps demonstrates some differences in permafrost description that have to be analyzed. The paper map created by I. Baranov in 1977, a scale 1:5 000 000, was chosen as a base map for digitizing parameters of permafrost.

Atmosphere-Ocean Interaction Studies
Impact of ocean spray on the dynamics of the marine-atmospheric boundary layer
Prof. Vladimir N. Kudryavtsev

The impact of ocean spray on the dynamics of the marine-atmospheric surface boundary layer (MABL) in conditions of very high (hurricane) wind speeds is investigated. To that end a model of the MABL in the presence of sea-spume droplets is developed. The model is based on the classical theory of the motion of suspended particles in a turbulent flow, where the mass concentration of droplets is not necessarily small. The description of the spume droplets generation assumes that they, being turn off from breaking waves, are injected in the form of a jet of spray into the airflow at the altitude of breaking wave crests.

The droplets affect the boundary layer dynamics in two ways: via the direct impact of droplets on the airflow momentum forming the so-called “spray force”, and via the impact of droplets on the turbulent mixing through stratification. The latter is parameterized applying the Monin–Obukhov similarity theory. It is found that the dominant impact of droplets on the MABL dynamics appears through the action of the “spray force” originating from the interaction of the “rain of spray” with the wind velocity shear, while the efficiency of the stratification mechanism is weaker. The effect of spray leads to an increase in the wind velocity and suppression of the turbulent wind stress in the MABL.

Joint sun-glitter and radar imagery of surface slicks
Prof. Vladimir N. Kudryavtsev
PhD-student Alexander G. Myasoedov (NERSC, Norway)

This activity, carried out in the framework of IFREMER contract, is targeted on development of an advanced synergistic approach for analysis of SAR and optical scanner data focusing on study of oil spills surface signatures (Fig. 3).

In general, the main oceanographic applications of satellite optical data (e.g. from MODIS and MERIS instruments) are associated with ocean color studies. In such cases the sunlight reflected from the sea surface is a major part of upward radiation which creates significant difficulties for ocean color retrieval algorithms. On the other hand, sun glitter contains valuable information on statistical properties of the sea surface roughness, its mean square slope (MSS), skewness and kurtosis. A method is proposed to retrieve and interpret fine spatial variations of the sea surface roughness in sun glitter imagery. Observed sun glitter brightness anomalies are converted using a transfer function determined from the smoothed shape of sun glitter brightness. The method is applied to MODIS and MERIS sun glitter imagery of natural oil seeps and the catastrophic Deepwater Horizon oil spill in the Gulf of Mexico (Fig. 4).

The short-scale roughness variations in the presence of mineral oil slicks are consistently retrieved and compared to variations associated with the biogenic slicks. In doing so, the wind speed
dependency on the roughness anomalies is also taken into account. A comparison to normalized radar cross section (NRCS) anomalies taken from the corresponding high resolution ASAR images is performed, and similarities as well as differences are investigated. The results document significant benefit from the synergistic use of sun glitter and radar imagery for detection and monitoring of surface slicks. Results of this study are presented in: Kudryavtsev V., A. Myasoedov, B. Chapron, J. Johannessen, F. Collard. Joint sun-glitter and radar imagery of surface slicks. Remote Sensing of Environment (accepted for publication); Myasoedov A., V. Kudryavtsev. Sun glitter imagery of ocean phenomena. Scientific Transactions of the Russian State Hydrometeorological University, Vol. 16, pp. 94-114, 2010 (in Russian).

Envisat ASAR imaging of coastal upwelling in the Baltic Sea: case study with modeling
Prof. Vladimir N. Kudryavtsev
PhD-student Igor Ye. Kozlov
PhD-student Alexander G. Myasoedov

An analysis of Envisat Advanced Synthetic Aperture Radar (ASAR) and Aqua/Terra Moderate Imaging Spectrometer (MODIS) infrared (IR) imagery of coastal upwelling in the southeastern Baltic Sea is presented (Fig. 5). It is found that upwelling signatures are well distinct in SAR images, and the leading mechanism is the change of the marine-atmospheric boundary layer (MABL) stratification over the sea surface temperature (SST) front. This finding is supported by model calculations of the MABL transformation supplemented with the SAR calculations based on CMOD4 model. An empirical dependency of the SAR contrasts over upwelling on the wind speed and the SST drop is suggested. Surface slicks accumulated in the sea surface current convergence zones generate additional upwelling features in SAR imagery. This effect is interpreted within the frame of the coastal current circulation model based on analysis of the SST snapshot. Results of the study are summarized in: Kozlov L., V. Kudryavtsev, J. Johannessen, B. Chapron, I. Dailidiene, A. Myasoedov. ASAR imaging for coastal upwelling in the Baltic Sea. Advances in Space Research, 2011. DOI:10.1016/j.asr.2011.08.017 (published online).

Aquatic Ecosystems in Response to Global Change

Seasonal and multi-year phytoplankton dynamics in the Bay of Biscay as established from space
PhD-student Evgeny A. Morozov
Prof. Dmitry V. Pozdnyakov
Mr. Lasse H. Pettersson (NERSC, Norway)
Prof. Hartmut Grassl (MPI-M, Germany)

The Bay of Biscay plays a significant economic role for France and Spain: the bay’s coastal and pelagic zones accommodate highly productive ecosystems providing habitat for various fish, and mollusks important on industrial scales. Based on the major assets of satellite remote sensing, we investigated in detail (i) seasonal and spatial variations in phytoplankton community (including *L. chlorophorum*, which was identified only recently and subsumed under the category of harmful algae) and total suspended matter in the coastal zone as well as (ii) spatio-temporal regularities in blooms of the *E. huxleyi* (also assumed harmful) in the off-coastal zone. Through the bridging approach, several (past and still operating) ocean colour sensors were used to trace down decadal patterns in temporal variations of the above constituents of bays’ water. Via a synergistic use of satellite data from some non-ocean-colour sensors (providing information on sea surface temperature and on direction and speed of near surface winds), *in situ* and modeling data reported in the literature, as well as NCEP (National Centre for...
Environmental Predictions) reanalysis data, we established the main forcing factors that conditioned the investigated water constituents temporal variations observed from space throughout decades. In particular, bridged four decades data from ocean colour sensors CZCS, AVHRR, SeaWiFS and MODIS explicitly indicate that climate warming has indeed resulted in increasingly frequent and extensive blooms of E. huxleyi (Fig. 6). Climatic impact is also detected in the spatio-temporal variations of phytoplankton and suspended matter within the shelf zone. These are absolutely new findings never established before.

The research results are summarized in the paper submitted to the journal Continental and Shelf Research.

Spaceborne assessment of primary productivity and its decadal trends in the Arctic Basin

PhD-student Dmitry A. Petrenko
Prof. Dmitry V. Pozdnyakov
Dr. Svetlana Milutinovic (NERSC, Norway)
Dr. Francois Counillon (NERSC, Norway)

The research was undertaken under MONARCH-A FP7 project. The Arctic Ocean is experiencing alterations of its ecosystem due to undergoing climate change. This also regards the fundamental level of the inherent biological community – phytoplankton.

Due to various and not yet completely understood mechanisms of external forcing-biota interactions, the primary production inevitably responds to climatic signals. Determination of the ecosystem’s response and assessment of its trend are vitally important from many points of view, possibly, first and foremost, elucidation of forward and feedback interactions in the atmosphere-ocean system. An unprecedented size of in situ and modeling data related to phytoplankton primary production (PP) and satellite ocean colour data were used for quantification of PP via application of a number of algorithms/models, comparison of PP retrieval results with the available in situ measurements, selection of a most adequate tool of PP quantitative assessment, and finally, establishment of the PP interannual variation trends (see Fig. 7). Importantly, the trend is differentiated between thepelagic and shelf zones in order to assess separately for each type of zone the annual PP rates and their responsiveness to climate change. The availability of extensive and unique in their size in situ data permitted an unprecedented thorough validation of the PP retrievals imparting high credibility to the established trend.

A paper on the results of this research is being prepared for a refereed international journal.

Assessing the sensitivity of Arctic Coastal Dynamics to Change

PhD-student Evgeny A. Morozov
Prof. Dmitry V. Pozdnyakov
Dr. Anton A. Korosov (NERSC, Norway)

Pursued under the Helmholtz-RFBR project, our work was focused on processing ocean colour data with the NERSC/NERSC BOREALI algorithm for eventual generation of monthly and annual maps of terrigenous suspended mineral (sm) matter distribution in the coastal zone of the Kara Sea and dissolved organic matter (dom) across the entire sea as well as sea surface temperature and wind (NASA algorithms). The maps are drawn for the period 1998-2009, and intended for the establishment of the multi-year trend of transport of the terrigenous matter into the sea, as a reflection of coast and riverbank erosion due to climate warming in the Arctic Basin.

With verification purposes, the results of sm and dom retrievals are compared with the available statistically reliable historical data on sm and dom concentrations in the Kara Sea; and the comparisons proved to be very good. Fig. 8 illustrates the time series of sm for
Development of a methodology for retrieval of cloudiness parameters

**Prof. Dmitry V. Pozdnyakov**

The research was performed under the 2010 bilateral contract between the Michigan Technological University (USA) and NIERSC. The developed methodology is based on the equations of light propagation through the water column. The new algorithm retrieves simultaneously not only cloudiness parameters (i.e. concentrations of \( \text{chl}, \text{sm} \) and \( \text{dom} \)) but also the bottom depth provided the bottom type (e.g. silt/grass/mud/sand) is known.

In 2011 this methodology is to be exploited for Lake Michigan, and the results are to be summarized in a paper for a refereed international journal.

Development of a software package for producing specialized information products restored from the KMSS KA “Meteor-M” No. 1 monitoring data on ice cover and marine environment ecological state

**Dr. Anton A. Korosov (NIERS, Norway)**

This Design and Development Work (DDW) was accomplished under the 2010 contract between the Russian Space Agency (RSA) (via Research Center for Earth Operative Monitoring, Corporation “Russian Space Systems”) and NIERSC. A special methodology has been elaborated: Neural Network (NN) emulators were developed as operational algorithms for automated retrieval of cloudiness parameters, normalized spectral radiance emerging from the water body and water quality parameters inherent in the Caspian Sea. NNs were trained using the relevant MODIS data. Fig. 9 illustrates that the KMSS KA data thus processed is in a good compliance with the respective data from MODIS. Thus, due to the elaborated approach, KMSS KA “Meteor-M” No. 1 data can be used not only for qualitative but also quantitative assessment of water quality and in water optical parameters for a wealth of practical applications.

**MetOcean Group**

Development of methodology for sea ice drift variability analysis and modeling results validation

**Dr. Vladimir A. Volkov**

PhD-student Denis V. Demchev

**Prof. Stein Sandven (NIERS, Norway)**

In 2010 MetOcean Group continued activity on development of methods for sea ice cover monitoring in the Arctic, processing and interpretation of sea ice satellite images. At the same time, developing a modern statistical methodology of the sea ice drift variability analysis and modeling results validation was the main task of the MetOcean Group activities. The work was carried out under MyOcean FP7 project. In particular, the task on estimation of quality of a modeling results of TOPAZ forecasting system (Norway) was solved.

Data of operating drifting buoys, including located on the “North Pole” stations, and 2-daily gridded ice drift data from IFREMER with 32,5 km steps for winter periods from 2002, as well as data of the global climate set of the ice drift fields–Pathfinder with a step of 25 km from 1998 for winter and summer time, were used for comparison with TOPAZ modeling results. Gridded data were prepared using satellite images in the visible, IR and microwave ranges (AVHRR, SMMR, SSMI) and buoy data (IAPB).

All drift data were consolidated by NIERSC under special MyOcean oceanographic information system, and special software for operating with the archived data was developed.

The vectorial-algebraic approach developed with the assistance of Prof. V. Rozhkov was chosen as a fundamental method for analysis of the ice drift series and for the first time was adopted for validation of the modeling results. The vectorial-algebraic approach allows significantly compress the initial information and most adequately describe the vector time series of full-scale and model data restricted by a set of statistical characteristics in the invariant form.

Results of such statistical analysis describe in detail a variability of drift fields and identify some zones characterized by different dynamics and intensity of carryover ice transport, and some sea ice circulation systems for
different time intervals. In Fig. 10 a map of $I_1$ invariant is shown as an example describing a total variability of ice drift fields for two winter seasons. It is possible to see that a dispersion of ice drift in area of the Transarctic Current is increased essentially from 2004-2005 to 2006-2007 winter season when a minimum of old ice in the Arctic was recorded.

For comparison of calculated and observed drift fields a system of simplified correlation indexes (Nikolay Eu. Ivanov, AARI) was used. Analysis of fields of this correlation indexes demonstrates that the TOPAZ forecasting system describes very well the drift fields in central regions of the Arctic Ocean and a little bit worse in a coastal zones. It might be caused by a quality of wind reanalysis fields or desired boundary conditions.

The developed methodology could be applied for identification of some areas where modeling results are less accurate and for correction of parameters of existing models.

The results of the study are summarized in a paper by Volkov V.A., N.Ye. Ivanov, D.M. Demchev (submitted to Journal of Operational Oceanography).

**Satellite radar monitoring of the sea ice cover**

*(summary of Dr. Sci. Thesis)*

*Vitaly Yu. Alexandrov, Dr. Sci.*

The major objective of the study consists of elaborating the concept of sea ice monitoring on the base of satellite Synthetic Aperture Radar (SAR) data and developing techniques of processing and interpretation of sea ice satellite radar images, as well as synthesis of remote sensing data in different bands of electromagnetic waves.

The thesis consists of seven chapters. Chapter 1 “Theoretical basis of radar sea ice remote sensing” deals with analysis of methods of sea ice radar remote sensing, theoretical estimates of hydrometeorological object influence on signal reflected from the sea ice. The ranges of the backscatter for the major ice types at C-band are determined.

Chapter 2 “Interpretation of sea ice satellite radar images” is devoted to analysis of the possibilities to derive major sea ice parameters from satellite radar images at X-, C-, and S-bands. SAR signatures of the principal sea ice types and features have been specified and verified. During winter, several stages of ice development and ice forms, areas of level, slightly deformed, moderate deformed and heavily deformed ice, fast ice boundary, shore and flaw polynyas, leads and large icebergs can be detected. During summer ice edge position and ice concentration can be derived, single ice floes and ice stripes are identified.

Chapter 3 is “Automatic thematic processing of satellite radar images of the sea ice”. Our approach consists of developing algorithms for derivation of major sea ice parameters – ice type, total ice concentration and partial concentration of multiyear ice, characteristics of leads, and ice drift. After their verification these algorithms will be included into technology of SAR image interactive processing. Algorithms of sea ice classification in SAR images are based on neural network approach, linear discriminant analysis and Bayesian method.

Chapter 4 “Combined analysis of sea ice satellite images in different spectral bands” deals with developing technique of joint analysis of different remote sensing data - SAR, optical and passive microwave data, as well as SAR images acquired at different frequencies and polarizations. It is found that X-band is optimal for ice type discrimination. Icebergs and ice morphology features are better identified at L- and meter bands. Identification of water surface, young and first-year ice is improved by analyzing SAR C-band images at HH- and VV-polarizations. Leads in multiyear ice and icebergs among wind-roughened open water are reliably detected from co-polarization ratio. Combined interpretation of SAR and optical images allows unambiguous identification of ice type in leads and polynyas, as well as icebergs.

Chapter 5 “Application of satellite radar data for studies of the ice cover” deals with studies of climate and ice conditions in the Arctic on the base of satellite radar information. The seasonal and interannual variability of sea ice exchange between the Laptev Sea and the Arctic Ocean in the period 1979-1995 have been investigated based on joint analysis of satellite radar images, passive microwave radiometer data and the large-scale dynamic-thermodynamic sea ice model. Verification of multiyear ice parameters, calculated from SSM/I data using NORSEX algorithm, was done by means of comparison with the estimates derived from “Okean” and RADARSAT radar images.

Chapter 6 “Practical applications of satellite radar images for supporting navigation in the ice” is devoted to demonstration of SAR images for selecting optimal ship route in the ice and analysis of their efficiency for solving this problem.

In Chapter 7 “Development of system and methods of sea ice monitoring” methods of processing and fusion of data, acquired by various satellite, airborne and in situ remote sensing systems are described.

**Economic Modelling**

*Dr. Dmitry V. Kovalevsky*

*Prof. Klaus Hasselmann (MPI-M, Germany/ ECF)*

*Prof. Carlo Jaeger (PIK, Germany/ ECF)*

Research in microeconomics and economic growth theory was conducted in 2010 in the frame of two projects funded by RFBR. A modification of the seminal Sclar’s model (a counter-example of a globally unstable general equilibrium model of an exchange economy) with an arbitrary number of economic agents and the proportional-integral price adjustment mechanism was studied analytically and numerically with a special focus on stability properties. The Structural Dynamic Economic Model SDEM proposed by Hasselmann et al. was upgraded to a model SDEM-2 which takes proper account of impact of human capital accumulation and learning-by-doing effect (see the DEGIT-XVI Conference paper by D.V. Kovalevsky (2011) at http://www.degit.ifw-kiel.de/papers/folder.2011-09-12.2623700498/c016_043.pdf).

In close cooperation with Klaus Hasselmann an actor-based system-dynamic Integrated Assessment model MADIAM was updated to include business cycles and boom-and-bust cycles. Impact of key imbalances introduced in socioeconomic module of MADIAM on model dynamics was studied numerically.

A comparative study of price (carbon taxes) and quantity (emission trading schemes) economic instruments of state mitigation policy was conducted, in line with an overview of practices of imposing the national carbon taxes in different countries. New trends in Russian climate policy were continuously monitored in 2009-2010 with an ultimate goal to update and extend the ECF-NIERSC Working Paper on the subject (2009, a follow-up is in preparation).
PUBLICATIONS

Refereed Papers


Books


Other Papers


Kozlov I.E., V.N. Kudryavtsev, S. Sandven. Some results of studying the internal waves in the Barents Sea by means of radar remote sensing from space. Problems of the Arctic and the Antarctic, No. 3(86), pp. 60-69, 2010 (in Russian)

Khveletskaia M.A., A.V. Poberovskiy. The system of archiving of solar high-resolution IR spectra for remote sensing problems of atmosphere. Herald of St. Petersburg State University, Ser. 4, Iss. 3, pp. 100-104, 2010 (in Russian)


Mysyoeod A., V. Kudryavtsev. Sun glitter imagery of ocean phenomena. Scientific Transactions of the Russian State Hydrometeorological University, Vol. 16, pp. 94-114, 2010 (in Russian)


Proceedings


Glazovsky A. Arctic glaciers in changing climate: Results of recent studies. Abstracts of International Science Seminar “Glaciers and Sea Ice in Global Climate and Environmental Change Studies”, 11-12 November 2010, St. Petersburg, Russia

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