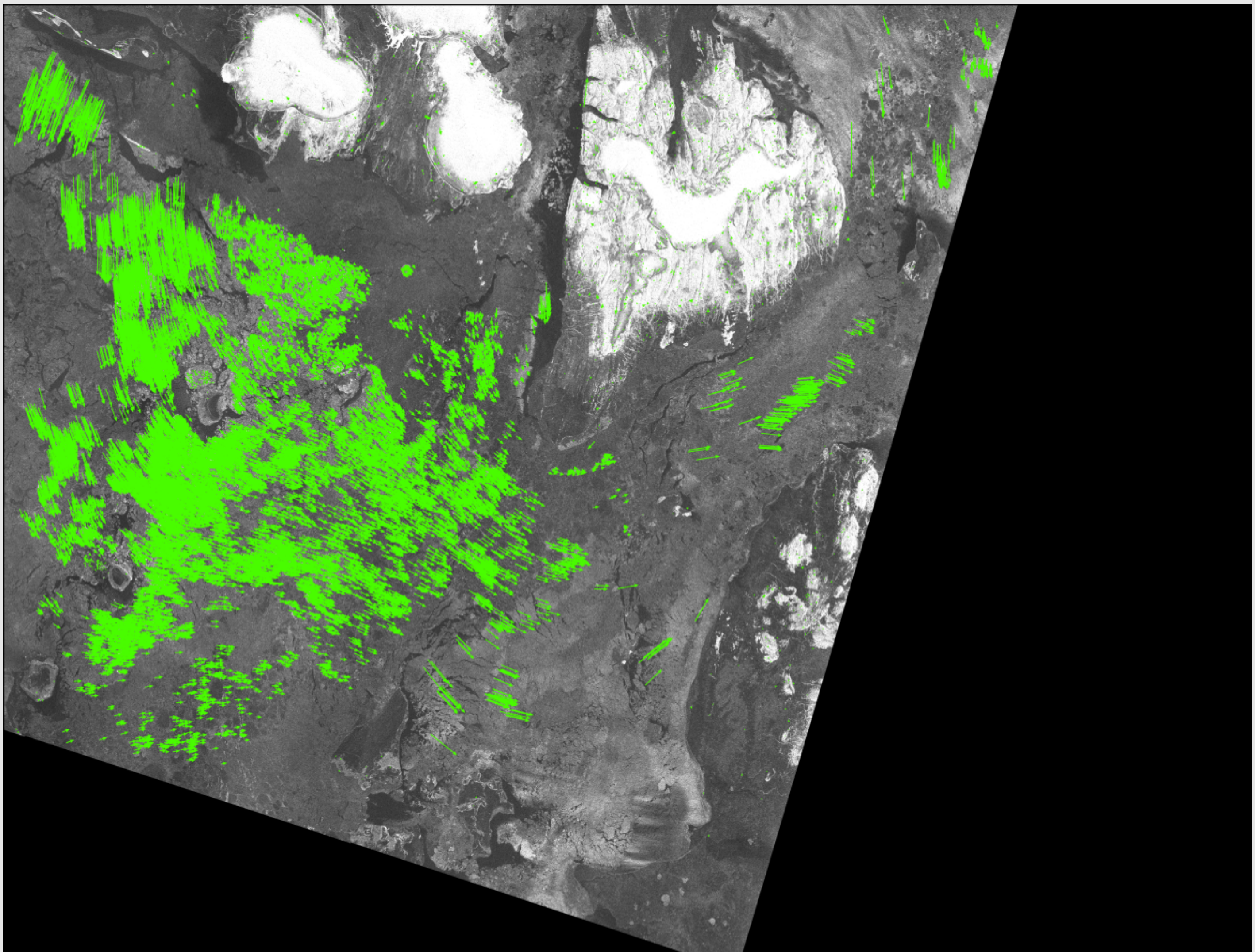
Annual Report 2014

Nansen International Environmental and Remote Sensing Centre

St. Petersburg, Russia

Non-profit international research centre for environmental and climate research

Founded in 1992



Sea ice motion filed over the Vilkitsky Strait area obtained from two sequential HV Radarsat-2 images for October 29-30, 2013

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Dr. Julia S. Merkulova, Legal Advisor

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
- 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, NIERSC receives basic funding from its Founder – Nansen Environmental and Remote Sensing Centre.

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 NIERSC received also a license from ROSCOSMOS for conducting the space-related research activities.

Staff

At the end of 2014 NIERSC staff incorporated 23 employees comprising core scientists, including 1 full Doctor of Science and 5 with a PhD degree, part-time researchers, and administrative personnel. 9 Nansen Fellowship PhD-students were supervised and supported financially, 7 of them holding also part-time positions of Junior Researchers at NIERSC.

Scientific Production

In 2014 totally 36 publications were published, 3 book chapters, 8 papers in peer reviewed journals, 7 papers in other journals and 18 conference proceedings (see the reference list at the end of report).

National and International Activities

NIERSC has close long-lasting cooperation with many 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 European Space Agency, Global Climate Forum, Max-Planck Institute for Meteorology (Germany), Friedrich-Schiller-University (Germany), Finnish Meteorological Institute (Finland), University of Helsinki (Finland), University of Sheffield (UK), Stockholm University (Sweden), Johanneum Research (Austria), and especially with the NIERSC founders. The 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 other. Research area encompasses studies of climate and environmental changes in high northern latitudes by means of combined use of satellite remote sensing, *in situ* observations and numerical modelling. NFP provides PhD-students with Russian and international scientific supervision, 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. NFP is sponsored by the Nansen Centre and the Nansen Scientific Society in Bergen, Norway.

The postgraduate student activity is supervised by at least one Russian and one international senior scientists. All NFP PhD-students have to publish their scientific results in the international refereed journals and make presentations at the international scientific symposia and conferences.

On 18 December 2014, the NFP fellow, Igor Kozlov, successfully defended at the State Hydrometeorlogical University dissertation “The study of internal waves and fronts in the sea using satellite radar remote sensing”. Totally, 25 young Russian PhD-students have since 1994 got their doctoral degrees under the NFP.

Research Projects

The following research projects have being implemented at NIERSC in 2014 in close cooperation with other national and international scientific institutions:

- Monitoring Arctic Land and Sea Ice using Russian and European Satellites (MAIRES, EU FP7, 2011-2014)
- European-Russian Centre for cooperation in the Arctic and Sub-Arctic environmental and climate research (EuRuCAS, EU FP7, 2012-2015)
- CoCoNet (EU FP7/NERSC s/c, 2012-2015)
- Prototype Operational Continuity for the GMES Ocean Monitoring and Forecasting Service (MyOcean-2, MyOcean-FO, EU FP7, 2012-2015)
- Knowledge Based Climate Mitigation Systems for a Low Carbon Economy (COMPLEX, EU FP7, 2012-2016)
- Ships and Waves Reaching Polar Regions (SWARP, EU FP7, 2014-2017)
- Nordic seas climatology (NERSC, 2012-2014)
- Sea ice ECV (ESA, via NERSC s/c, 2012-2014)
- Extreme scenarios of climate change and their impacts on Russian and world economy (RFBR, 2013-2015)
- Great Lakes 2014-1, 2014-2 (Michigan Tech, 2014-2015)
- Arctic climate change (CLIMARC, RFBR-NORRUS, 2012-2014)
- Optimization and system-dynamic approaches in models of economics of climate change (RFBR, 2012-2014)
- Post-fire transformation of permafrost landscapes and its impact on hydrological regime of small and medium rivers in Eastern Siberia (RFBR, 2014-2015)
- Monograph “Sea Ice in the Arctic: Past, Present and Future” (ESA, via NERSC s/c, 2014-2016)

EuRuCAS Summer School

EuRuCAS (European-Russian Centre for cooperation in the Arctic and Sub-Arctic environmental and climate research) is one of the major NIERSC projects funded under EU FP7 Programme, which uses NIERSC as the joint research facility to extend and consolidate scientific co-operation between European and Russian researchers in the area of climate and environmental changes in the Arctic and sub-Arctic in the 21st century and their socio-economic impact. One of the major milestones of this project in 2014 was holding Summer School in Repino, near St. Petersburg on the theme "Land Hydrology and Cryosphere of the Arctic and Northern Eurasia in the changing climate". The goal of the EuRuCAS Summer School was to involve young generation of researchers into EU-Russia scientific cooperation in the field of Arctic and Sub-Arctic environmental and climate science.

Totally 52 participants took part in the Summer School: 27 students and young scientists and 25 lectures/senior personnel (see back cover page). The scientific programme encompassed 21 expert lectures and 26 presentations made by the young scientists. The poster session collected 17 student posters. Examining the topic of land hydrology and cryosphere of the Arctic and Northern Eurasia in the changing climate, four thematic student groups were set up at the school. These groups prepared summarizing presentations and final summaries. The final scientific report, based on these summaries, was prepared later and download to the project website (http://eurucas.niersc.spb.ru/).

St. Petersburg, 1 April 2015

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SCIENTIFIC REPORT

Climate Variability and Change in High Northern Latitudes

Sea ice retreat in the Northern Sea Route over the last years

Dr. Elena Shalina (St. Petersburg State University (SPSU)/NIERSC, St. Petersburg, Russia)

Prof. Stein Sandven (NERSC, Bergen, Norway)

The Northern Sea Route (NSR), shown in Fig. 1 as an inset, is a trade and shipping route nowadays used for the mentioned purposes mostly by Russian Federation, that links the Barents and Kara seas in the west to the Bering Strait in the east. Sea ice and water depths are the two main impediments to the NSR navigation. Though water depths are the stable characteristics of the area, the sea ice presence in the route changes from one season to another. The entire route is affected by ice for much of the year, but in the summer it becomes (partly or even totally) open due to melting and drifting of ice; however not all sections are necessarily open simultaneously. Ice conditions are most favourable for navigation in the period from July through October. Here we examine ice presence in the most positive for navigation period in different parts of the NSR over the last decades using satellite passive microwave data.

The NSR cannot be thought of as one clearly defined linear route, but should instead be thought of as a way with the most favourable ice conditions in the sea area north of Russia. Due to the highly variable and difficult ice conditions the optimal route choice for vessels navigating the NSR will vary. Here we focus on the route (see Fig. 1) as it is shown in the on-line Directory on the ice conditions along the NSR of the Arctic and Antarctic Research Institute (AARI) (http://www.aari.ru/resources/a0011_12/manual_smp/content.html).

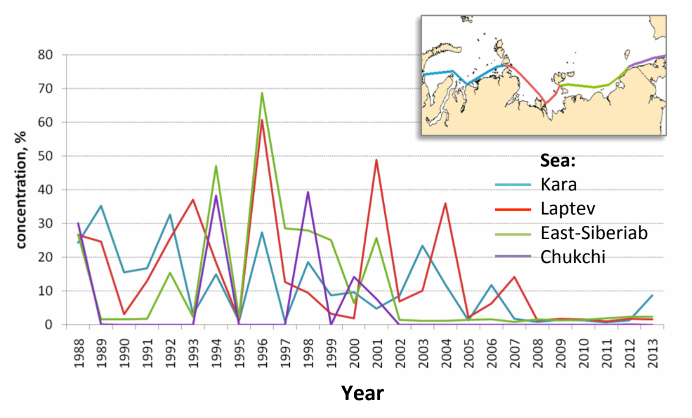

***Figure 1** September monthly mean sea ice concentrations along the Northern Sea Route*

Satellite data used here are SSM/I and SSMIS instrument measurements carried aboard Defence Meteorological Satellite Program provided by NSIDC (http://nsidc.org/data/nsidc-0001). Time period is from July 1987 up to the end of 2013. The ice concentration has been calculated using NORSEX algorithm. The route is divided into four parts that belong to Kara, Laptev, East-Siberian and Chukchi seas. Monthly averaged sea ice concentrations for September are presented in Fig. 1. Different colours show variations of averaged sea ice concentration in different parts of the NSR. Firstly, it is worth to note that variability of sea ice conditions on the route is very high. Average sea ice concentration can change from nearly zero in one year to about 70% in the next year. Secondly, it can be seen that the period when ice free or light ice conditions can be more or less guaranteed is increased. In September (the month with the most favourable ice conditions) the chosen route has been basically ice free in the East-Siberian and Chukchi seas starting from 2002, it was ice free in the Kara sea starting from 2007 (excluding 2013) and in the Laptev sea starting from 2008. The largest improvement of sea ice conditions along the NSR in the last years is observed in the Chukchi Sea.

Sea ice in the Northern Sea Route in the past and future from models and historical data (preliminary results)

Dr. Leonid Bobylev (NIERSC, St. Petersburg, Russia/NERSC, Bergen, Norway)

Prof. Ola M. Johannessen (NERSC/Nansen Scientific Society (NSS), Bergen, Norway)

Dr. Svetlana Kuzmina ((NIERSC, St. Petersburg, Russia)

The objective of this study was twofold: 1) To analyse past and present summer sea ice conditions in the Eurasian Arctic seas; and 2) To estimate future changes in September sea ice conditions in these seas in the 21st century.

Analysis of past and present sea ice extent (SIE) in Eurasian Arctic seas in summer was based on the unique historical Zakharov dataset and satellite passive microwave data. Assessment of the future regional summer sea ice conditions in the seas along the Northern Sea Route was performed by means of simulations using specific for each sea climate model sub-ensemble selected from entire CMIP5 ensemble.

Before selecting model sub-ensembles, evaluation of CMIP5 model performance in reproducing summer sea ice extent and its trends really observed in the past decades in the Eurasian Arctic seas was carried out by means of comparing model simulations with observational data. Then, models from CMIP5 ensemble best matching past and recent observed summer sea ice extent and trends were selected applying special criteria.

Evaluation of CMIP5 models showed that the difference between model mean and observed SIE is significantly smaller than for CMIP3 models and do not exceed 30%. For CMIP5 ensemble spread between

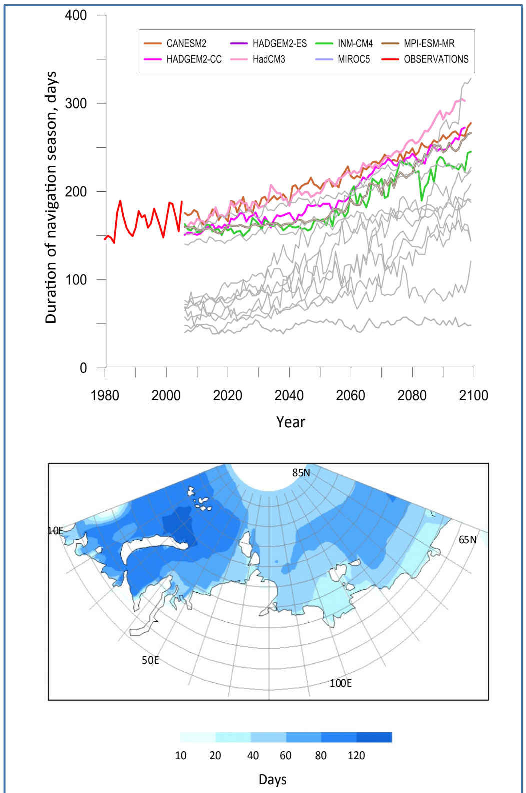

***Figure 2** Observed and CMIP5-modelled average duration of navigation season at the Northern Sea Route (top); CMIP5 model changes in duration of navigation season at the Northern Sea Route for period 2050-2070 relative to 2010-2020 (bottom)*

models is smaller than for CMIP3 for entire Arctic basin and especially for Eurasian seas.

Projections of future sea ice conditions in the Northern Sea Route indicated further dramatic decrease of sea ice with the sea ice-free conditions in summer in all Eurasian Arctic seas in 2030-2050.

Duration of the navigation season at the Northern Sea Route (Fig. 2) is projected to increase about twice to the end of the 21st century.

Estimating the potential of the permafrost sediments to release methane into atmosphere under global warming

Dr. Alla Yurova (NIERSC, St. Petersburg, Russia)

Dr. Elizaveta Rivkina (Institute of Physicochemical and Biological Problems in Soil Sciences (IPBPSS), Pushchino, Russia

Dr. Gleb Kraev (IPBPSS, Pushchino, Russia)

Modelling studies of permafrost degradation under climate warming predict positive feedbacks operating through the methane release from the organic matter and methane-hydrates, currently in the frozen state, into the atmosphere, where it operates as a strong greenhouse gas. Direct measurements of methane concentration in the permafrost allowed us to account for the permafrost methane pool. Permafrost potential for the greenhouse gases release within the upper 25 m of sediments taking into account the topography and sediment type of the 180,106 km^2 Arctic region has been estimated based on field sampling done by the Institute of Physicochemical and Biological Problems in Soil Sciences (IPBPSS). It is demonstrated that more than 60% of the storages is concentrated within the thaw lake sediments complex of Holocene, occupying more than 20% of the surface area and representing the most vulnerable methane pool under permafrost degradation. The modelling using INMCM GCM allowed forecasting the seasonally thawing layer thickness changes by the year 2100.

A simple model accounting for methane diffusion and plant transport has helped to estimate the potential of permafrost methane release to the atmosphere. The findings showed that the depth of the seasonal thawing can raise up to 2 m from current 0.6÷0.8 m in the Northern part of Eastern Siberia (Fig. 3), which leads to liberation of 0.3 Mt C(CH_4) that was previously preserved as frozen gas bubbles in case the gas will be directly released into the atmosphere. As for the actual release of methane it can be restricted by the diffusion in water to the unsaturated zone and, in case of plant-mediated transport, by the diffusion to the rooting depth, if the groundwater level stays high.

The physical mechanisms involved in formation of methane-rich inclusions in permafrost and its liberation due to permafrost degradation were proposed and related to the freezing rate. Then they were validated experimentally by the set of laboratory experiments at IPBPSS and mathematically by the solution of equation system formulated at NIERSC. In the conditions of slow freezing, when water migration is directed towards the freezing front, methane is displaced up and trapped into freezing layers. In the case of fast freezing, the methane follows porous waters and displaced down by freezing front to thawed part. The methane concentration in the thawed part of the soil column rises gradually, and finally when freezing is complete the layer enriched with methane forms. The following up study will estimate the greenhouse gases release from the soil organic matter decomposition.

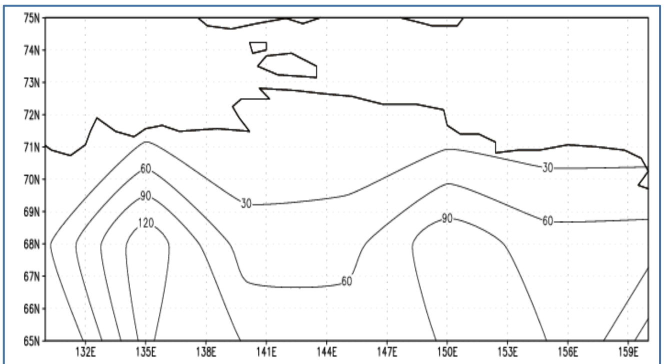

Figure 3 *Change in a seasonal thawing depth (cm) from 1960-1970 to 2090-2100 on the territory of the Arctic Ocean Coastal Plains, Eastern Siberia*

Arctic oceanographic research

Marginal Ice Zone in the Arctic

Dr. Vladimir Volkov (NIERSC, St. Petersburg, Russia)

Aleksandra Mushta (NIERSC, St. Petersburg, Russia)

PhD-student Anna Vesman (AARI/NIERSC, St. Petersburg, Russia)

In 2014, in the frame of SWARP project (see page 3), analysis of oceanographic conditions, temporal and spatial distribution of the Marginal Ice Zone (MIZ) in the Arctic was performed. Oceanographic description of MIZ and stationary polynyas (as an analog of the MIZ areas) in the Greenland, Barents, Kara and Laptev seas was elaborated.

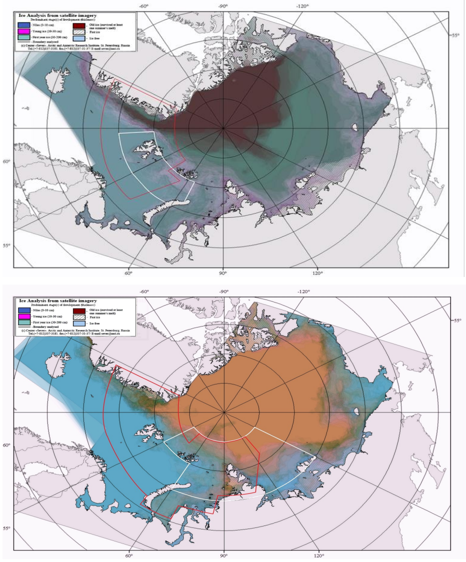

Figure 4 *Location of MIZ (white boundary areas): (top) in winter 2012-2013; (bottom) in summer 2013. SAR coverage areas indicated by red boundary*

Classical Marginal Ice Zone is a border area between the ice cover and the open ocean or sea areas. MIZ is characterized by specific oceanographic conditions: freshened thin layer on the water surface formed by the melting ice, the presence of convection, the formation of mesoscale inhomogeneities in the fields of currents and ice drift, sufficiently rapid attenuation of wind waves and swell waves moving on the ice area, etc. In addition to MIZ in the Arctic seas there are areas with the similar oceanographic conditions, known as extensive polynyas. Actually, they are «closed» marginal ice zones. Substantial waves in these areas can develop only as a result of prolonged exposure to wind and sufficiently large size of the polynyas.

To determine the minimum area of the open water in the MIZ, where essential for navigating waves can exist, we used state equation from (Dietrich et al., 1957). Calculations showed that the waves larger than 1 m might be achieved only at the steady state, when the duration of exposure to wind was more than 4 hours, the wind speed was more than 12 knots (6 m/s), and size of the open water area (polynya) was more than 20 nautical miles (37 km). For wave height of 2 meters these parameters should be, respectively, 7 hours, 30 knots (15 m/s) and 50 nautical miles (92 km). It is known that such conditions may be observed in the Laptev Sea and in the north-east part of the Barents Sea, mainly in summer.

Based on the analysis of the AARI's ice charts a dedicated archive of general maps of ice conditions in the Arctic seas for the period 2012-2014 was created. It consists of 156 ice maps. Areas where MIZ may be observed were determined separately for winter and summer periods, and the temporal scales of MIZ were identified.

MIZ in the Barents Sea existed during the whole year. In the winter 2012-2013 it was located between 75-80°N and 55-75°E. In summer the border shifted to 85°N (Fig. 4). In winter 2014 MIZ was within 75-80°N, in April-May boundary of the ice edge has passed through 75°N. MIZ in the Kara Sea existed mainly in spring-summer (early May) and was located between 75-80°N, 60-85°E (Fig. 4). From July to November, zone boundary moved north to 85°. In 2014, at the end of July the boundary moved to 95°E.

Polynyas east from Zhelania Cape and near the Yamal Peninsula opened periodically during the winter. In the Laptev Sea, MIZ existed from May to October with approximate coordinates between 75-80°N, 110-150°E. By late August, the ice edge moved to the north - to 85°. Polynya ranged along 75°N between 120-150°E.

Improvement of sea ice classification algorithms for Radarsat-2 images

PhD-student Anna Vesman (NIERSC/AARI, St. Petersburg, Russia)

Aleksandra V. Mushta (NIERSC, St. Petersburg, Russia)

Dr. Natalia Zakhvatkina (AARI/NIERSC, St. Petersburg, Russia)

Dr. Anton Korosov (NERSC. Bergen, Norway)

In the framework of MyOcean and SWARP projects (see page 3) NIERSC - NERSC group continued improvement of sea ice classification algorithms for Radarsat-2 (RS-2) SAR images. Thus, classification algorithm for ice/water recognition has been further developed using the Support Vector Machines (SVM) method (supervised learning method with associated learning algorithms that provide data classification). In this algorithm, texture characteristics of SAR images were used as additional information for classification.

The algorithm is based on satellite SAR images from RS-2, which has a dual-polarized mode in ScanSAR mode, i.e. HH (horizontally transmitted and horizontally received) and HV (horizontally transmitted, vertically received) channels available for classification. This mode assembles wide SAR image from several narrower SAR beams, resulting to an image of 500×500 km^2 with 50 m resolution.

In order to classify SAR images, where backscatter coefficient (BSC) is a function of incidence angle, the BSC values were normalized across the swath, using reference angle. Although the difference in radar backscatter between different ice types is slightly higher at far range of SAR image, the backscatter normalization to pre-defined incidence angle allows obtaining homogenous image contrast across the swath. The normalization method consists of the following stages: 1) BSC calculation using image brightness according to the calibration formula developed by ESA; 2) BSC recalculation to predetermined incidence angle using predefined calculated coefficients. They were defined by investigations of BSC dependency from incidence angle at HH-polarization using several RS-2 SCWA images.

The methodology of noise reduction consists of two steps: extracting noise values from metadata file, and subtracting noise values from the raw HV SAR image. Based on analysis of different versions of algorithm results and texture features, number of input texture features was decreased from 26 to 12 without loss in result quality but with improvements in time of processing.

Thus, the following improvements were achieved:

- pre-processing of image on HH-polarization: angular correction
- pre-processing of image on HV-polarization: threshold for low SNR and NaN pixels
- new training data set
- reduced number of textural features from 20 to 12 lead to reduced time of processing
- increased number of grey levels to 32

Validation of a new improved automated sea ice/open water classification algorithm (Fig. 5) was carried out on examples of radar satellite images for the area of the Greenland and Barents seas, with the use of ice charts from Met.no and MODIS optical data. Validation showed that the overall accuracy of improved algorithm increased up to 0.983-0.996

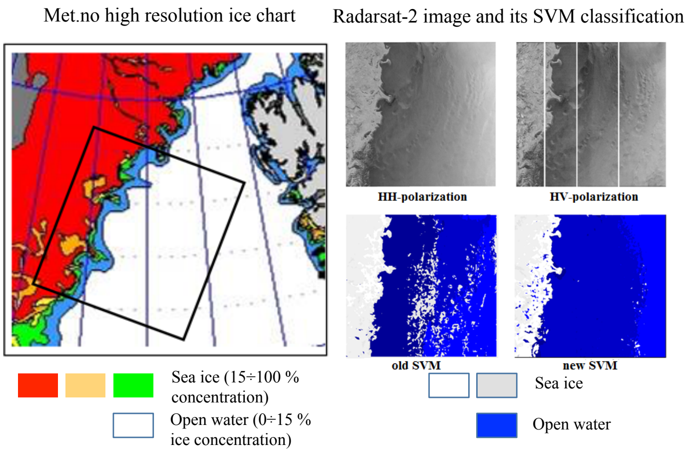

Figure 5 *Validation of improved SVM algorithm for ice/water classification using Radarsat-2 image for 18.03. 2013*

Long-term variability of thermohaline characteristics of the waters surrounding Svalbard Archipelago

PhD-student Anna Vesman (NIERSC/AARI, St. Petersburg, Russia)

Dr. Vladimir Volkov (NIERSC, St. Petersburg, Russia)

Dr. Boris Ivanov (AARI, St. Petersburg, Russia)

The analysis of oceanographic conditions of the waters surrounding Svalbard Archipelago is being performed within the NIERSC Fellowship Program. The main goal of the study is revealing of regularities and specific features in the long-term variability of the waters of West Spitsbergen Current (WSC) and coastal current (CC). WSC is the main path for export of warm and saline Atlantic waters to the polar and sub-polar regions.

For the study, we have chosen the most representative and most secured with data points in the WSC and CC areas. Four points were selected in WSC: at the southern tip of Svalbard, opposite Belsunn, Isfjorden, and the northern tip of the archipelago. In the CC, also four points were selected: at the southern tip of Svalbard, opposite Belsunn, Isfjorden and the Prince Karls Forland. Time period 1950s-present, well provided for homogeneous time-series of data, was considered.

For each selected point, diagrams of temporal variability of temperature and salinity were constructed. To get an averaged grade for the point kriging method was used. Analysing the distribution of water temperature in the WSC region (Fig. 6) quasi-periodic temperature increase was found in the beginning of 1960s, mid 1970s and in

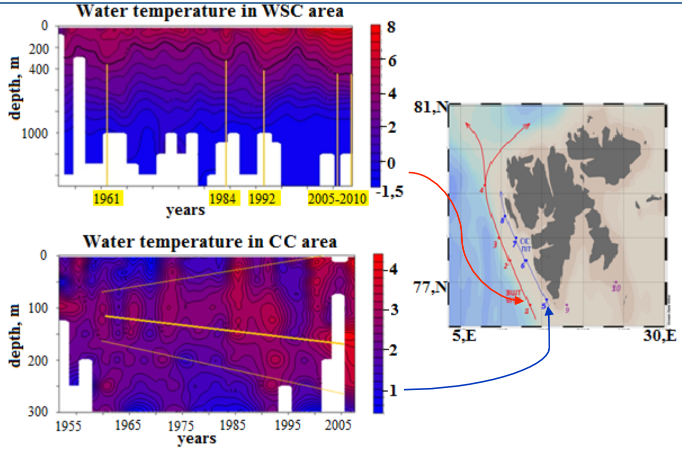

Figure 6 *Water temperature time series in West Spitsbergen Current (WSC) and coastal current (CC) areas*

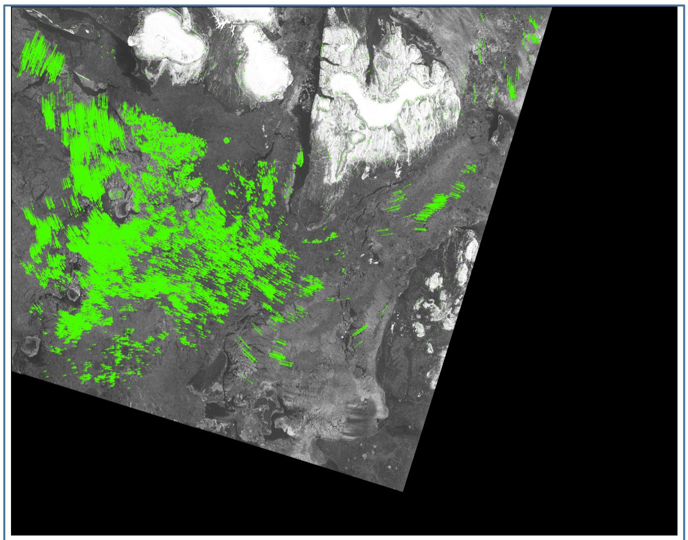

Figure 7 *Sea ice motion filed over the Vilkitskii Strait area obtained from two sequential HV Radarsat-2 images for October 29-30, 2013*

1990-2010. In the 1960s-1970s surface layer (0÷100 m) temperature has increased by 1÷2°C relative to the average for the whole research period. During all these periods deepening of the 3.5°C isotherm for an average of 200 meters (from 200 m to 400÷450 m) has been observed in the southern point. The same time, deepening 3°C isotherm for the northern points was from 100÷250 m to 500 m. For the present warming (1990-2010) duration and intensity of surface water warming increases. Thus, if the temperature of the surface layer in the 1960s rose to 4.0÷4.5°C, in the early 2000s, it reached already 6.0÷6.5°C. Similar but less intense (about 1.0÷1.5°C) quasi-periodic temperature changes were recorded in the CC area (Fig. 6). Positive trends were calculated for all test points that can be regarded as an increase of Atlantic water inflow through the Fram Strait.

High-resolution sea ice motion from SAR images using feature tracking

Dr. Vladimir Volkov (NIERSC, St. Petersburg, Russia)

Victoria Khmeleva (NIERSC/SPSU, St. Petersburg, Russia)

Denis Demchev (NIERSC/AARI, St. Petersburg, Russia)

Stefan Muckenhuber (NERSC, Bergen, Norway)

Stein Sandven (NERSC, Bergen, Norway)

Sea-ice motion is an essential variable to observe from satellites, because it strongly influences the distribution of sea ice on different spatial and temporal scales.

The coverage and quality of high-resolution Synthetic Aperture Radar (SAR) images has strongly improved during the last years (e.g. launch of Sentinel-1), which allows to derive sea ice motion data with high spatial (ca. 1 km) and temporal resolution. Such high-resolution ice drift data are not yet provided and will be important for observation of ice divergence/convergence, leads, ridges and other regional and local ice processes.

The approach is to exploit recent improvements/developments in computer vision by adopting state of the art feature tracking algorithms for sea ice drift. Several open-source feature tracking algorithms have been utilised and adjusted to derive sea ice drift information from various SAR sensors (Envisat, Radarsat-2 and Sentinel-1).

For Envisat ASAR and Radarsat-2 SAR, an algorithm based on SIFT (Scale-Invariant Feature Transform) has been developed, which is fully invariant with respect to scale, rotation, translation and illumination. It has been shown that the SIFT-based algorithm can be used to derive high-resolution ice drift vector fields. Using the NERSC ASAR archive, an ice drift dataset for Fram Strait and Kara Sea covering the period 2007-2012 has been created and will be used for validation and tuning of the NERSC dynamic sea ice model.

For applications and operational use of large data sets, more efficient than SIFT computational algorithm, called ORB (Oriented FAST and Rotated BRIEF), has been considered. The performance of ORB has been tested on 4 representative Sentinel-1 image pairs covering Fram Strait, regions around Svalbard, Franz Josef Land and Kara Sea. The purpose was to tune the parameters of ORB for sea ice drift applications. The best suitable parameter set (including patch size of descriptor, number of pyramid levels and scale factor) has been evaluated.

Using dual polarization data from Radarsat-2 and Sentinel-1 has shown that the HV channel provides several times more drift vectors than the HH channel (Fig. 7). Using HH channel in addition is still recommended, since it can provide drift vectors in areas, which are not well enough covered by the HV derived vectors.

Algorithms were validated against manual derived drift vectors and IAPB (International Arctic Polar Buoys program)/ITP (Ice Thethered Profile) buoy data.

Upcoming work will include the comparison and eventual combination of these algorithms with a pattern matching algorithm from Alfred Wegener Institute and producing gridded products from randomly located drift vectors (as provided from feature tracking). Evenly distributed drift vectors are in particularly of importance for the calculation of deformation, since deformation strongly depends on the spacing of the drift information.

Aquatic Ecosystems in Response to Global Change

Realization of computer codes for processing satellite data from the Russian sensors put in orbit in 2013-2014, and provision of the retrieved water quality parameters to the ROSCOSMOS portal

Dr. Evgeny Morozov (NIERSC, St. Petersburg, Russia)

Prof. Dmitry Pozdnyakov (NIERSC, St. Petersburg, Russia/NERSC, Bergen, Norway)

This work is a continuation of the developments that have been pursued at NIERSC during the last decade in collaboration with the Nansen Centre in Bergen (NERSC) and the Scientific Centre for Operational Monitoring of the Earth (NTsOMZ/ROSCOSMOS) in Moscow.

The main objective is to develop a conceptual system of optical sensors data, specifically from the Russian sensors ШМСА-СР, ШМСА-БР, КМСС, ОЭА. For ШМСА-СР, ШМСА-БР, ОЭА the image processing has been developed for the first time. As for КМСС, it has been already developed by us in 2013. It is run in Python and embedded in NANSAT.

The effected embedding of the aforementioned image processing system is highly advantageous as this allows to *a*) quickly update the system to accommodate new satellite sensors such as "Canopus-B", "Resource-P", Sentinal-2, and Sentinel-3, etc., and *b*) configure the processing of input data in accordance with the end-user's defined parameters and technical facilities (server's computing power, permissible sizes of stored data). Importantly, this approach assures a further improvement/perfection of the system without changing both its basic concept and structure. It also possesses necessary facilities of a further data transfer to the common module of data processing at a higher level. The inclusion of *new* retrieval algorithms is also practically reduced to a mere addition of modules performing concrete tasks without the necessity of any modification of the already existing modules of the system.

Further on, a preparatory work has been performed to tune in 2015 the system for processing real-life spaceborne data from the above sensors (they are already in orbit and their satisfactory functionality is confirmed). This preparatory work was aimed at (1) tuning the retrieval algorithms and neural networks to make them able to process real data, and (2) optimizing and speeding up the algorithm performance (i.e. provision of advanced codes that would permit paralleling of the code running, change of neural networks for cloud masking through working out a dedicated threshold algorithm). These preparatory activities encompassed the tasks of assuring a simultaneous retrieval of concentrations of phytoplankton chlorophyll, dissolved organic matter, PAR (photosynthetically active radiation), inclusion of the coccolithophore mask, determination of Kd (coefficient of sunlight vertical attenuation), nLw (normalized upwelling radiance), and Rrs (remote sensing reflectance).

Through the fall of 2014 our group actively worked as a member of the all-Russia *ad hoc* group organized by the ROSCOSMOS to the effect of assessing the workability of the Russian hyperspectral sensor (ГСА) that had been put in orbit a year ago. Within the framework of this group we assessed the quality of the ГСА data, found numerous defects of this sensor spectral and radiometric calibrations, and formulated in a special official letter on behalf of NIERSC the requirements for their elimination.

Quantitative assessment of the effect of deep cyclones on the annual primary production in the Barents Sea over a decadal time period

Dr. Evgeny Morozov (NIERSC, St. Petersburg, Russia)

PhD-student Dmitry Kondrik, (NIERSC/AARI, St. Petersburg, Russia)

Prof. Dmitry Pozdnyakov (NIERSC, St. Petersburg, Russia/NERSC, Bergen, Norway)

The research conducted in 2013 on the effect of deep cyclones on the primary production (PP) in the Barents Sea (BS) was extended in 2014. It was done to the effect of, firstly, clarify the intrinsic driving mechanisms of this effect, and, secondly, produce a *quantitative* assessment of the previously revealed significantly pronounced cyclone-driven enhancement impact on PP on the *annual* scale.

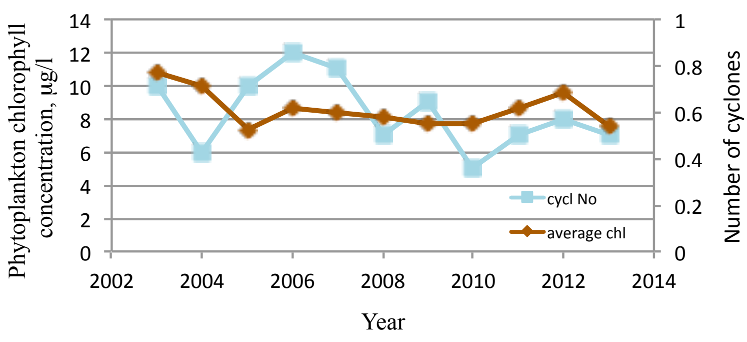

Figure 8 *Interannual variations of phytoplankton chlorophyll concentration and annual number of cyclones that passed over the Barents Sea through 2002-2014*

The nature of the impact has been elucidated based on the Redfield ratio paradigm, according to which the stoichiometric ratio of carbon, nitrogen, and phosphorus (C:N:P) found in phytoplankton throughout the deep oceans is 106:16:1 (Redfield, 1934). The BS nutrient pool is known to be strongly nitrogen-limited (data from along the Kola transect (Reigstadet et al., 2002)).

In the case of availability of data on total phosphorus (TP), the regression equation is as follows: log chl=0.99 log TP + 11 (r^2 = 0.74). To apply this relationship, we employed the aforementioned Kola Transect shipborne data on TP (Reigstad et al., 2002). The results of our numerical assessments: the value of chl prior to the cyclone onset was about 0.6 µg l^{-1}, and the TP value in the surface waters putatively constituted 0.4÷0.5 µ molP l^{-1} (Reigstad et al., 2002). The cyclone impact resulted in an increase in chl-a to ~1.0 µg l^{-1}. As a result of associated cyclone-driven vertical mixing (remember that, according to our estimations, the cyclones considered in our study were strong enough to agitate the water column from bottom to surface), the value of TP increased to ~0.7÷0.8 µ molP l^{-1}. The application of the above equation to two time periods prior to the cyclone arrival and the onset of chl maximum response shows that the calculated values of chl were 0.58 and 0.97 µg l^{-1} as compared with the remotely retrieved values of 0.6 and 1.0 µg l^{-1}, respectively. Thus we succeeded to quantitatively identify the nature/mechanism of surface chl modulation as an aftermath of the cyclone passage and the ensuing water column vertical mixing.

Regarding the total seasonal impact of cyclones on PP in the BS, it should be borne in mind that (1) the number of cyclones per vegetation season suitable for study by ocean colour sensors proved to be generally about 2÷3 or even less (as compared with the total seasonal number); (2) increase in chl due to the cyclone impact covers a wide range (on average, 0.2 µg l^{-1} and never exceeding ~0.4 µg l^{-1}); and (3) the average cumulative area covered by a translating footprint generally accounts for about 14% of the BS area. Also, it should be taken into account that the rate of PP is markedly less in the footprint cloudy areas than in sunlit areas in the wake of the translating cyclone. All the above limitations/uncertainties prevent any quantified assessment of the actual impact of cyclones on PP of the BS based solely on 23 cases. However at the qualitative level, our data seem to imply that cyclones are hardly essential boosters of PP in the BS. A further substantiation of the above corollary concerning the influence of cyclones on chl was obtained through a dedicated correlation analysis performed for 96 cyclones occurring over the vegetation period during the 11-year study. The repartition of 96 cyclones across the spaceborne observation period was compared to the respective inter-annual variation in chl obtained in this study from satellite data and averaged over the ice-free BS area. This analysis yielded a coefficient of correlation as low as 0.35 (level of significance $p > 0.1$) (Fig. 8).

We are of the opinion that because the data analysed include not only those cases amenable to optical remote sensing (i.e. 23 relatively cloud-free), but also cloudy cases unsuitable for optical remote sensing, the results thus obtained better reflect the cause-and-effect correspondence we were investigating. That is why we believe that this is a more robust argument in favour of our above assumption that the inter-annual variation in chl across the BS can be only peripherally affected by passing cyclones. Obviously, other multiple forcing factors collectively control the observed inter-annual variation in chl averaged over the BS.

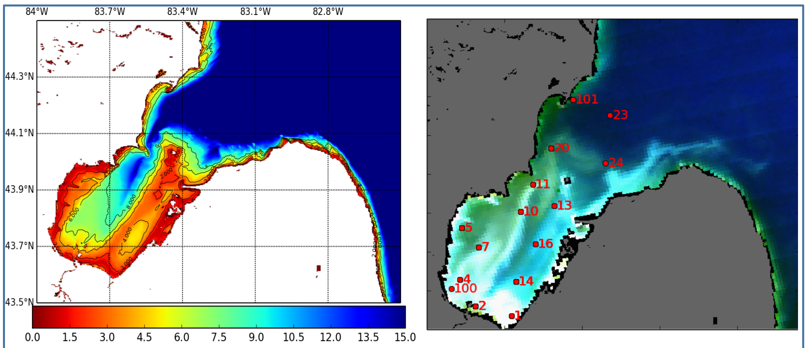

Figure 9 *Topography (left) and location of sampling stations (right) in Saginaw Bay, Lake Huron*

Further improvement of the computer code of water quality parameters retrieval algorithm for optically shallow waters and its application to the case of Saginaw Bay (Michigan Tech Institute)

Prof. Dmitry Pozdnyakov (NIERSC, St. Petersburg, Russia/NERSC, Bergen, Norway)

Dr. Anton Korosov (NERSC. Bergen, Norway)

Dr. Robert Shuchman (Michigan Tech Institute, Ann Arbor, USA)

Lake Huron (LH) generally is an oligotrophic, optically clear water body. However, one of its southern bays, viz. Saginaw Bay is essentially eutrophied due to significant anthropogenic effluents mainly arising from industrial discharges. Notwithstanding this influence, some coastal areas of the Bay are rather transparent for solar light, and the bottom reflection there is appreciably accounts for the light signal coming out of the water (Fig. 9). Therefore, in order to investigate the anthropogenically-affected water quality in such areas of the Bay, special arrangements should be undertaken to minimize the bottom reflection effect.

In 2013 we developed a new bio-optical algorithm called BOREALI-OSW that allows retrieving water quality parameters in optically shallow waters.

A new algorithm BOREALI-OSW based on a forward radiation transfer model, LM specific hydro-optical model and the multivariate optimization technique was developed to produce a tool for operational retrieval from satellite data of water quality parameters in lake's optically shallow areas. The retrieval output encompasses the concentrations of colour producing agents (CPAs: phytoplankton chlorophyll, total suspended matter, coloured dissolved organic matter) and either bottom depth or cover type (sand, silt, stands of Chara, Cladophora, and limestone pebble).

BOREALI-OSW was thoroughly verified through dedicated field experiments in Lake Michigan in 2012-2013. The verification experiments explicitly confirmed the efficiency of BOREALI-OSW: retrieved were realistic values of spectral signatures of subsurface remote sensing and water quality constituents (WQC) concentrations within the ranges of depth (<2 m÷15 m depending on the WQC concentration vector and bottom type), at which the optical impact was detectable.

In 2014 we employed BOREALI-OSW for studying Saginaw Bay. The successfulness of the BOREALI-OSW performance strongly depends on two factors: a) availability of the hydro-optical model inherent to the constituents of the target waters, and b) reliable atmospheric correction. The first condition was met in our studies as such a model has been established some years ago at the Michigan Tech Institute. The second prerequisite was more difficult to fulfil: the NASA atmospheric correction was developed for larger areas not being specified solely for LH.

Nevertheless, our studies explicitly showed that BOREALI-OSW allowed removing the bottom reflection impact. However, the retrieval of water quality parameters on some days proved to be at odds with the *in situ* measured values.

As pointed above, given the availability of a dedicated hydro-optical model, this inconsistence between the ground-truth and remotely sensed water quality parameters could be solely attributed to inaccurate atmospheric correction. This assumption was reinforced through a comparison of spectral values of remote sensing reflectance (Rrs) provided by MODIS and MERIS: ideally, for one and the same water area and timing of sensors overflight the spectral values Rrs should be very close if not identical. This closeness/identity of Rrs (λ) values was not the case for those days when the departures of the retrieved and *in situ* measured water quality parameters were appreciable.

Thus in general, the study conducted in 2014 in Saginaw Bay showed that the bio-optical tool BOREALI-OSW operates well provided the hydro-optical model of water constituents and the applied atmospheric correction are adequate.

Development of a comprehensive database of *in situ*, spaceborne and reprocessed data over the time period 1998-2013 for studying the occurrence and extent of *E. huxleyi* blooms in the North, Norwegian, Barents, Iceland and Bering seas

PhD-student Dmitry Kondrik, (NIERSC/AARI, St. Petersburg, Russia)

Prof. Dmitry Pozdnyakov (NIERSC, St. Petersburg, Russia/NERSC, Bergen, Norway)

In 2014 satellite data on Rrs were obtained for the period of interest, and a further search was initiated to collect all available data on *in situ* measurements relating to E. huxleyi blooms in the marine areas specified above. This preparatory work was necessitated by our plans of forthcoming validation of our coccolithophore chlorophyll concentration retrieval methods. Among others we profited from the PANGAEA database (hosted by Alfred Wegener Institute and Center for Marine Environmental Sciences, University of Bremen).

The PANGAEA database encompasses a huge amount of data on a very wide range of biological species. This ample and versatile information from the past year expeditions and cruises was entered in the database. Each dataset can be identified, shared, published and cited by using a Digital Object Identifier (DOI). From this database we downloaded several datasets containing the parameters that are relevant to our research goals, e.g., number of *E. huxleyi* cells per litre; number of living cells with coccoliths; number of detached coccoliths sea surface temperature, etc. The overall amount of datasets obtained for the regions and the period of interest was 10. Every dataset consists of different amounts of determinations of the desired parameters ranging from 6 to 5244.

These data were concatenated and appropriately formatted for the forthcoming in 2015 validation and calibration of (*i*) our hydro-optical algorithms, including BOREALI (whose output encompasses the concentration of both *E. huxleyi* coccoliths and intracellular chlorophyll, concentration of intracellular chlorophyll in diatoms), as well as (*ii*) *E. huxleyi* bloom delineation (based on both RGB images and spectrometric features of the remote sensing reflectance, Rrs(λ)), data gap filling, and some other automated procedures of ocean colour image analyses.

Integrated Assessment Modelling

Dr. Dmitry Kovalevsky (NIERSC, St. Petersburg, Russia)

Prof. Klaus Hasselmann (Max-Plank Institute for Meteorology, Hamburg, Germany)

In 2014 Integrated Assessment Modelling (IAM) was performed in the framework of EU FP7 projects EuRuCAS and COMPLEX and two research projects solicited by the Russian Foundation for Basic Research (see page 3).

Modelling global impacts of shrinking Arctic sea ice (Arctic feedback model)

It is well known that on-going global climate change is amplified in the Arctic region, and regional climate changes in the Arctic are projected to induce far-reaching economic impacts going well beyond high northern latitudes and affecting the global economy. With potentially easier access to its abundant hydrocarbon resources under projected conditions of shrinking sea ice, the Arctic may there be expected to substantially affect future global energy markets.

The dynamics of the coupled climate–socioeconomic system and its possible futures can be explored by IAMs. To assess the potential impacts of shrinking arctic sea ice on global energy markets, an actor-based system-dynamics IAM tailored to explore the effects of exhaustibility of fossil fuel resources (in the Arctic and globally) is developed. The model includes a positive nonlinear feedback through which global warming and shrinking sea ice in the Arctic leads to an intensification of the offshore extraction of hydrocarbons, thereby enhancing global warming even further. One of the objectives of the modelling study is to explore the strength and the dynamic performance of this positive feedback, and the manner in which the feedback amplifies various uncertainties in the system under study. Model simulations suggest that the positive feedback under consideration is essential for modelling the coupled climate-economic dynamics, and activation of this feedback in the model substantially alters the dynamics of global climate variables.

The results of this research are reported in: Kovalevsky D., Hasselmann K. (2014): Integrated Assessment modelling of global impacts of shrinking Arctic sea ice. Proceedings of All-Russian conference with international participation "State of Arctic seas and territories under conditions of climate change", Arkhangelsk, Russia, 18-19 September 2014, 79-80.

Introducing strong nonlinearities in the model SDEM-2

The level of stock of physical capital is crucial for economic performance. However, it is well known that capital accumulation alone cannot properly explain the global and national economic growth at quantitative level. Therefore incorporating the endogenous technological progress in the modelling framework is crucial for improving the performance of economic growth models and IAMs.

Two nonlinear modifications of an actor-based system-dynamics model SDEM-2 (the Structural Dynamic Economic Model, previously developed in a linear framework) are proposed and studied analytically and numerically. In the first model version the production function is assumed to be nonlinear that leads to increasing returns to scale, while the second model version proposed describes endogenous technological progress by treating the technology parameter of the production function as an additional state variable. Dependent on the values of model parameters and on initial conditions, both modifications of SDEM considered demonstrate two different dynamic regimes: either an explosive economic growth or the collapse of the economy.

The results of this research are reported in: Kovalevsky D. (2015): Introducing increasing returns to scale and endogenous technological progress in the Structural Dynamic Economic Model SDEM-2 (accepted for printing in: Discontinuity, Nonlinearity, and Complexity, 4).

Accounting for stochasticity in climate-economic models

It is broadly accepted that working with IAMs inevitably implies substantial uncertainties. One of established approaches for taking into account these uncertainties is performing Monte Carlo simulations with IAMs. The idea of the method is that instead of one model run a series of model runs is performed with model parameters that are likely to be responsible for critical uncertainties randomly varying from one model run to another, and then the probability distributions of output model variables of interest are constructed on the basis of these model runs.

Given the complexity of state-of-the-art IAMs, many of which need substantial computational resources, these probability distributions can be obtained only numerically. However, in case of simple 'toy' models that have analytical solutions it might be occasionally possible to 'imitate' this numeric Monte Carlo procedure by exact analytical calculations of probability distributions and of moments of random output variables of interest.

A constructive example of such an 'imitation' is provided with a simple climate–economic model based on the AK model with the endogenous (temperature-dependent) depreciation rate and on the exogenous climate (temperature) scenario. The analytical solution of the model is obtained. The uncertainty of climate projections is introduced in the model, the Monte Carlo procedure is imitated, and the moments of the model state variable are calculated analytically.

The results of this research are reported in: Kovalevsky D. (2014): A climate-economic model with endogenous capital depreciation rate under uncertainty of temperature projections. Scientific Journal of KubSAU, No. 10(104), (in Russian). http://ej.kubagro.ru/2014/10/pdf/89.pdf

PUBLICATIONS

Book chapters

Zabolotskikh E.V., L.M. *Mitnik*, *L.P. Bobylev*, *B. Chapron*, (2014). Satellite passive and active microwave methods for Arctic cyclone studies. In: *Typhoon Impacts and Crisis Management* (Editors Danling Tang and GuangJun Sui). Springer, 81-92

Pozdnyakov D., D. Tang, L. Bobylev, P. Golubkin, E. Zabolotskikh, D. Petrenko, E. Morozov, (2014). A pilot satellite-based investigation of the impact of a deep polar cyclone propagation on the phytoplankton chlorophyll spatial and temporal dynamics in the Arctic Ocean. In: *Typhoon Impacts and Crisis Management* (Editors Danling Tang and GuangJun Sui). Springer, 241-252

SuFen Wang, DanLing Tang, Yi Sui, Gang Pan, D. Pozdnyakov, (2014). Typhoon impacts on the surface phytoplankton and primary production in the oceans. In: *Typhoon Impacts and Crisis Management* (Editors Danling Tang and GuangJun Sui). Springer, 205-218

Refereed Papers

Lebedeva L., Semenova O., Vinogradova T., (2014). Simulation of active layer dynamics, Upper Kolyma, Russia, using the Hydrograph hydrological model. *Permafrost and Periglac. Process*, 25 (4), 270–280, DOI: 10.1002/ppp.1821

Semenova O., Vinogradov Y., Vinogradova T., Lebedeva L. (2014). Simulation of Soil Profile Heat Dynamics and their Integration into Hydrologic Modelling in a Permafrost Zone. *Permafrost and Periglac. Process*. 25 (4), 257–269, DOI: 10.1002/ppp.1820

Lebedeva L., Semenova O., Volkova N., (2014). Assessment of wildfire impact on hydrological extremes in eastern Siberia. In: *Hydrology in a Changing World: Environmental and Human Dimensions*. IAHS Publ. 363, IAHS Press Ltd., Wallingford, UK, 90-95

Lebedeva L., Semenova *O., Folton N.,* (2014). Estimation of hydrological response of a small Mediterranean watershed to fire by data analysis and modelling approach. In: *Evolving Water Resources Systems: Understanding, Predicting and Managing Water–Society Interactions*. IAHS Publ., 364, IAHS Press Ltd., Wallingford, UK, 64-69

Semenova O., Lebedeva L., Volkova N., Korenev I., Forkel M., Eberle J. & Urban M. (2014). Detecting immediate wildfire impact on runoff in a poorly-gauged mountainous permafrost basin. *Hydrological Sciences Journal*, DOI:10.1080/02626667.2014.959960 (published online)

Yurova A., Tolstykh M., Nilsson M. and A. Sirin, (2014). Parameterization of mires in a numerical weather prediction model. *Water Recourses Research*, 50(11). DOI: 10.1002/2013WR014624

Kovalevsky D.V., Hasselmann K. (2014). A hierarchy of out-of-equilibrium actor-based system-dynamic nonlinear economic models. *Discontinuity, Nonlinearity, and Complexity*, Vol. 3, Issue 3, 303-318

Kovalevsky D.V. (2014). Balanced growth in the Structural Dynamic Economic Model SDEM-2. *Discontinuity, Nonlinearity, and Complexity,* Vol. 3, Issue 3, 237-253

Other Papers

Bychkova I., Zakhvatkina N., (2014). Contemporary satellite methods for detection and classification of the Arctic sea ice cover. *Russian Polar Researches*, 1(15), 27-31

Fedorova, A., A.V. Popov, A.V. Rubchenia, (2014). Analysis of long-term variability of thermohaline characteristics of water masses near Greenland cyclonic gyre. *Bulletin of Saint Petersburg University, Series 7, Geology. Geography,* Issue. 4, 144-158 (in Russian)

Kovalevsky D.V., Kuzmina S.I., Bobylev L.P. (2014). Projecting the global macroeconomic dynamics under high-end temperature scenarios and strongly nonlinear climate damage functions. *Russian Journal of Earth Sciences,* 14(3), ES3001, doi:10.2205/2014ES000545, URL: http://elpub.wdcb.ru/journals/rjes/v14/2014ES000545/2014ES000545.pdf

Kovalevsky D.V., Kovalevskaya L.D. (2014). Singular growth in an Integrated Assessment model based on a modification of the Solow model. *Scientific Journal of KubSAU,* No. 09(103), IDA [article ID]: 1031409008, URL: http://ej.kubagro.ru/2014/09/pdf/08.pdf *(in Russian)*

Kovalevsky D.V. (2014). The Structural Dynamic Economic Model SDEM-2: from system dynamic solutions to linear and logarithmic utility maximization. *Scientific Journal of KubSAU,* No. 10(104), IDA [article ID]: 1041410011, URL: http://ej.kubagro.ru/2014/10/pdf/11.pdf

Kovalevsky D.V. (2014). A climate-economic model with endogenous capital depreciation rate under uncertainty of temperature projections. *Scientific Journal of KubSAU,* No. 10(104), IDA [article ID]: 1041410089, URL: http://ej.kubagro.ru/2014/10/pdf/89.pdf

Kovalevsky D.V., Kovalevskaya L.D. Singular growth in a climate–economy model with endogenous technology parameter. *Herald of St. Petersburg State University of Economics (UNECON),* No. 8(75), 3-6 *(in Russian)*

Conference proceedings

Lebedeva L., Semenova O., Sazonova D., Tananaev N. Modelling the vulnerability of the active layer features and water fluxes of Russian boreal zone catchments to the climate change. THAW 2014 THermokarst Aquatic ecosystems Workshop, 12-15 March 2014, Quebec City, Canada

Lebedeva L., Semenova O., Volkova N., Forkel M., Eberle J. and Urban M. Dynamic modelling of post-fire transient hydrological behavior of the permafrost basin. EGU General Assembly 2014, Geophysical Research Abstracts Vol. 16, EGU2014-616

Semenova O., Lebedeva L., Volkova N., Kruchin M. Assessment of historical and future extreme flood characteristics for Novorossiysk city on the Black Sea coast of the North Caucasus. EGU General Assembly 2014, Geophysical Research Abstracts Vol. 16, EGU2014-10566

Semenova O., Lebedeva L., Zhirkevich A. Assessment of design flood characteristics for ungauged permafrost basin. Book of Abstracts – 6th IAHS-EGU International Symposium – Bologna 4-6 June 2014, p.2

Semenova O., Lebedeva L., Folton N. Estimation of hydrological response of a small Mediterranean watershed to fire by data analysis and modelling approach. Book of Abstracts – 6th IAHS-EGU International Symposium – Bologna 4-6 June 2014, p 5

Lebedeva L., Semenova O. Modelling of near-surface permafrost and hydrological processes across different scales and landscapes. Book of Abstracts of EUCOP4 – 4th European Conference on Permafrost, 18-21 June 2014, Évora, Portugal, p. 453

Gnatiuk N., Krakovska S., Palamarchuk L., Shpytal T., Bilozerova A. Projections of climate change in the South region of Ukraine. Proceedings of the International Conference for Young Scientists on 'Modern Hydrometeorology: Topical Issues And The Solutions', 7-9 October 2014, Odessa, Ukraine, 162-163 pp

Fedorova A., Morozov E., Kondrik D., Rubchenia A., Pozdnyakov D. Impacts of cyclones on the phytoplankton chlorophyll and sea surface temperature spatial and temporal dynamics in the Barents Sea as revealed from space. EGU General Assembly 2014, Geophysical Research Abstracts, Vol. 16, EGU2014-5501

Pozdnyakov, D., Petrenko, D., and Pettersson, L. Spaceborne quantitative assessment of primary production variations in the Arctic ocean over the previous decade, ISRSE-36 (Berlin, 2015). Extended pier-reviewed proceedings (submitted)

Zakhvatkina N., Bychkova I., Volkov V.A. Methods for automated sea ice classification in the Arctic by satellite radar data. Book of Abstracts – International scientific conference "Regional Problems of Earth Remote Sensing", 23-26 September 2014, Krasnoyarsk, Russia, 150-154

Vesman A., Javlovskaya V., Pochtovalova A. Distribution of the hydrochemical indicators on the oceanographic sections in the White, Barents and Greenland seas according to the results of "Arctic floating university" expedition in June 2014. Abstracts of International Conference "Condition of the Arctic Seas and Coastal Areas in the Context of Climate Change" Arkhangelsk, Russia 18-19 September 2014 (in Russian)

Vesman A., Ivanov B. Longterm variability of thermal regime of the waters surrounding the Svalbard archipelago. Abstracts of International Conference "Condition of the Arctic Seas and Coastal Areas in the Context of Climate Change" Arkhangelsk, Russia 18-19 September 2014 (in Russian)

Vesman A., Ivanov B. Longterm variability of thermal regime of the waters surrounding the Svalbard archipelago. XII International scientific conference "Integrated studies of Spitsbergen nature and offshore" Abstracts Vol.12 p.31 – 32, Murmansk, Russia 6-8 November 2014 (*in Russian)*

Kovalevsky D.V., Hasselmann K. (2014). Assessing the transition to a low-carbon economy using actor-based system-dynamic models. *Proceedings of the 7th International Congress on Environmental Modelling and Software (iEMSs), San Diego, California, USA, 15-19 June 2014,* Vol. 4, 1865-1872

Kovalevsky D.V., Hasselmann K. (2014). Modelling the impacts of a national carbon tax in a country with inhomogeneous regional development: an actor-based system-dynamic approach. *ERSA 54th Congress "Regional Development & Globalisation: Best Practices", St. Petersburg, Russia, 26-29 August 2014 (on a memory stick)*

Kovalevsky D.V., Hasselmann K. (2014). Integrated Assessment modelling of global impacts of shrinking Arctic sea ice. *Proceedings of All-Russian conference with international participation "State of Arctic seas and territories under conditions of climate change", Arkhangelsk, Russia, 18-19 September 2014,* 79-80.

Kovalevsky D.V. (2014). Macroeconomic dynamics in Integrated Assessment models with stochastic climate module. *Proceedings of the 4th All-Russian Conference "Economic Growth, Resource Dependence and Socioeconomic Inequity", 27-29 October 2014, St. Petersburg, Russia,* 127-128 *(in Russian).*

Kovalevsky D.V., Kuzmina S.I., Bobylev L.P. (2014). Long-term projections of global climate–economic dynamics in models with linear and nonlinear climate damage functions. *Proceedings of the 4th All-Russian Conference "Economic Growth, Resource Dependence and Socioeconomic Inequity", 27-29 October 2014, St. Petersburg, Russia,* 128-129 *(in Russian).*

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ADDRESS/LINKS

Scientific Foundation "Nansen International Environmental and Remote Sensing Centre" (Nansen Centre, NIERSC)

14th Line 7, Office 49, Vasilievsky Island, 199034 St. Petersburg, RUSSIA

Phone: +7 (812) 324 51 01 Fax: +7 (812) 324 51 02

E-mail: adm@niersc.spb.ru http://www.niersc.spb.ru

A participant in the **Nansen Group** of research institutes lead by Prof. Ola M. Johannessen, also comprising:

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