Yamal Land-Cover Land-Use Change Workshop

Moscow, 28-30 January 2008

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Table of Contents

Yamal Land-Cover Land-Use Change Workshop
(NASA LCLUC)

Moscow, 28-30 Jan 2008

AGENDA

Monday Jan 28: (1) Welcome addresses, project overview, (2) natural systems of the Yamal region, and (3) results of NASA Yamal LCLUC remote sensing and field projects to date

10:00-10:15 **Marina Leibman**: Welcome and logistic issues

10:15-10:45 **Academican Vladimir Melnikov**, Director of the Earth Cryosphere Institute: Permafrost: contemporary state, stability and dynamics. Technogenic influence

10:45-11:00 **Skip Walker**: Overview of the NASA Yamal LCLUC project, goals, and agenda of the workshop

11:00-11:30 *Coffee break*

The natural systems in the Yamal region

11:30-12:00 **Olga Ponomareva**: Overview of Nadym region: Climate, zonation, physiography, geology, permafrost

12:00-12:30 **Nataliya Moskalenko**: Overview of vegetation, dynamics, and disturbance and recovery studies in the Nadym and Yamal areas

12:30-12:45 **Pavel Orehov**: Lake ecosystems in different landscapes in the Nadym region

12:45-1:15 **Marina Leibman**: Overview of Yamal Peninsula with focus on Laborovaya and Vaskiny Dachi: Climate, zonation, physiography, geology, permafrost

1:15-1:45 **Artem Khomutov:** Landscape structure in natural and disturbed conditions of Yamal peninsula, field results and local GIS

1:45-2:15 **Vladimir Romanovsky**: Pan-Arctic thermal conditions: Where does the Yamal Peninsula fit?

2:15-3:15 *Lunch*

Results of NASA Yamal LCLUC remote sensing and field projects to date

3:15-3:45 **Joey Comiso:** Decadal changes in the Arctic sea ice cover and surface temperature with a focus on the Yamal, Alaska and Canadian regions

3:45-4:15 **Gensuo Jia:** Decadal trends of vegetation greenness driven by climate change and human activities in the Arctic

4:15-4:45 **Martha Raynolds:** Spatial patterns of land surface temperature and NDVI, and their relation to vegetation distribution on the Yamal Peninsula

4:45-5:15	**Uma Bhatt:** Pan-Arctic climate dynamics in relationship to sea-ice, land-surface temperatures, and NDVI with focus on Yamal region and comparison with North America.
5:15:45	*Coffee break*
5:45-6:15	**Skip Walker and Elina Kaarlejärvi**: Overview of 2007 field season and data report
6:15-6:45	**Georgy Matyshak**: Soils in the Nadym and Yamal area
6:45-7:15	**Patrick Kuss**: Plant communities at Nadym, Laborovaya, and Vaskiny Dachi
7:15	*Adjourn for day, dinner (no planned event)*

Tues 29 Jan: (1) Land-cover and land-use change in the Yamal region and (2) planning for 2008 field season

Land-cover and land-use change in the Yamal region

10:00-10:15	**Skip Walker**: overview of the day
10:15-10:45	**Bruce Forbes**: Effects of petroleum development on reindeer herding in Northwest Siberia: Combining scientific and traditional knowledge
10:45-11:15	**Florian Stammler, Keynote Address**: "Socio-cultural dimensions of land use changes on the Yamal Peninsula among Nenets nomads"
11:15-11:45	*Coffee break*
11:45-12:15	**Anatoly Gubarkov**: Overview of gas and oil development on the Yamal Peninsula.
12:15-12:45	**Dmitri Drozdov:** Mapping and remote sensing of natural and technogenic geosystems in West Siberia
12:45-1:15	**Timo Kumpula**: Remote sensing of land-cover/land-use change in Bovanenkovo gas field on the Yamal Peninsula.
1:15-2:15	*Lunch*

Planning for 2008 Field Season

2:15-5:00	Plenary meeting: Planning for 2008 field season (sites, timing, participants, helicopter support, camp logistics, costs
5:00	Management meeting for the 2008 field season
6:00?	*Adjourn for the day (no planned evening activities)*

Wed 30 Jan: (1) Modeling and (2) publications and synthesis products

Modeling

10:00-10:15	**Skip Walker**: Overiew of schedule for the day
10:15-10:45	**Howard Epstein:** (1) LAI, NDVI, and vegetation biomass for Low Arctic sites in the Yamal Region of Russia (2) An overview of modeling vegetation and ecosystem dynamics in arctic tundra

10:45-11:15 **Jed Kaplan and Heike Lieschke**: Dynamic modeling of circumpolar arctic biogeography and biogeochemistry and vegetation-permafrost interactions

11:15-11:45 **Qin Yu:** Modeling arctic tundra vegetation dynamics in North America and the Yamal region of Russia

11:45-12:15 *Coffee break*

Publications and synthesis products

12:15-12:45 Plenary discussion: Integration and synthesis of the results to date.

12:45-2:00 Break-out groups:
- NASA IPY book chapters
  - Remote-sensing, modeling chapter
  - Social dimensions chapter
- Permafrost studies
- Field observations, sea-ice, LST, NDVI, linkages

2:00-2:30 *Lunch*

2:30-6:00 Afternoon: Breakout groups to discuss other publications and other synthesis products
- Papers for NEESPI session at 2008 EGU meeting
- Papers for 2008 AGU meeting?
- Other meetings?
- Journal publications
  - Nenets/reindeer studies
  - Climate and sea ice
  - Land cover, land-use change
  - LAI/NDVI
  - Permafrost and thermal conditions
  - Vegetation
  - Modeling

6:00-6:30 Plenary: Summary and final questions, next meeting, discussion of future funding opportunities

6:30 *Adjourn meeting*

Permafrost: contemporary state, stability and dynamics. Technogenic influence

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Abstract

The most significant event in the geocryological society nowadays is the International Polar Year (IPY). Half a century past since the previous Polar Year (III International year of geophysics, 1957-1959) and it is time to make some conclusions and to outline the new tasks. The end of 1950's was a time of rather cold climatic and the main investigations in permafrost zone concerned cryogenic structure of soil. Than due to the temperature rise resulted into the global warming concept more and more attention was paid to the problem of permafrost degradation and destructive exogenic processes especially in case of technogenic influence. Basic problem is the investigation of seasonal and annual changing of climatic–permafrost conditions and interaction in order to reveal the nature of trend or the presence of the cyclic recurrence. So our contemporary researches are coordinated with numerous international IPY programs and also by Russian Integrative and Regional Programs and are aimed to assess permafrost changing. Collecting and processing of climatic and geocryological data are performed using GIS-technique applied to model observed phenomena at global, regional, local and elementary level.

Researches conducted in the Polar regions of Eurasia present such main directions:

- Geocryological structure and cryogenic features;
- Contemporary climate and sea hydrodynamics changing in Arctic regions;
- Continental and submarine permafrost forming and evolution;
- Natural and technogenic cryogenic physical and geological processes;
- Permafrost monitoring (including coastal permafrost);
- Developing of GIS-oriented cartographical models;
- Development of the new techniques of the permafrost research.

Geocryological researches, mapping and monitoring of the northern territories influenced by climate changes and intensive technogenic impact is functional to held with use of global, regional and local GIS and data-bases. A multiversion generalization of data and drawing-up and redraft of thematic digital maps make it possible to reflect the present-day state, trend, and dynamics of natural and technogenic features. Contemporary permafrost and climatic trends extrapolation shows that there will be no significant changing of geocryological conditions in the coming 20-25 years. But the decreasing of climate continentality can accelerate the development of the negative destructive cryogenic processes coursing permafrost degradation. E.g., at Urengoy gas-field the temperature of permafrost increased approximately up to 1°C during the period 1975–1993 owing to the natural climate dynamics. That's why the descending of permafrost roof started somewhere at forest sites. Technogenic impact added extra 1…2.5°C, but this ground temperature rise is located close to human constructions. At tundra and boggy sites the worming of permafrost was changed by meaningful cooling in the mid 1990's. The more significant freezing can be found on different hillocks.

Keywords: Natural and natural-technogenic geosystem (geocryosystem), global climatic and permafrost changes, air and ground temperature, geocryological monitoring and prognoses, GIS & database.

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Overview of the Yamal LCLUC Project and Objectives of the Meeting

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Abstract

This meeting is the first opportunity for all the project participants to come together to share their results and knowledge. It is an exciting opportunity for all of us to learn first hand about the history of research in the Yamal region and to plan for the next steps in the project. I am particularly grateful that the Earth Cryosphere Institute has agreed to host this meeting. This project is the outgrowth of discussions that Marina Leibman, Nataliya Moskalenko and I had many years ago when I first realized the exceptional nature of the Yamal region and wanted to work with these people who have such a deep base of knowledge about the region.

The project is part of NASA's Land-Cover Land-Use Change (LCLUC) program. It will use and contribute to NASA's global-change observations, particularly work exploring the consequences of the dramatic decline in the Arctic sea ice and the greening of terrestrial vegetation that is occurring in the northern latitudes. It is also part of the Northern Eurasia Earth Science Partnership Initiative (NEESPI). It principally addresses the NEESPI science questions regarding the local and hemispheric effects of anthropogenic changes to land use and climate. The project will combine the long-term record available through AVHRR and Landsat and other sensors with the most recent sensors that provide very detailed spatial and spectral information regarding land-cover/land-use change in the Arctic. The project is also the intersection of three International Polar Year (IPY) initiatives: (1) "Greening of the Arctic" (GOA), (2) "Cold Land Processes in NEESPI" (CLPN) and (3) "Circum-Arctic Rangifer Monitoring and Assessment" (CARMA).

The Yamal Peninsula in northern Russia has undergone extensive anthropogenic disturbance and transformation of vegetation cover over the past 20 years due to gas and oil development and overgrazing by the Nenets reindeer herds. It has been identified as a "hot spot" for both Arctic climate change and land-use change. The overarching goal of the Yamal Greening of the Arctic Project is to use remote-sensing technologies to examine how the terrain and anthropogenic factors of reindeer herding and resource development, combined with the climate variations on the Yamal Peninsula, affect the spatial and temporal patterns of vegetation change and how those changes are in turn affecting traditional herding by indigenous people of the region.

The project has four major components that will be discussed at this meeting: (1) a *human dimensions* component, which is examining the effect of land cover/ land-use changes on the Nenets people and their reindeer; (2) a *remote-sensing* component, which is examining the climate-sea ice relationships in the Arctic basin, and how these affect the temporal and spatial patterns of vegetation greenness indices; (3) a *modeling* component, that will link the remote sensing information and history of land-cover change with predictions of future change; and (4) a *field observation* component, where detailed ground-based studies of vegetation, soil and permafrost are being made along a north-south bioclimate transect of the Yamal Peninsula.

During the first day of the meeting we will hear six talks that describe the natural systems of the Yamal region including climate, physiography, geology, vegetation, lake ecosystems, and permafrost conditions. We will also hear four talks that describe the early remote sensing results, including the spatial and temporal patterns of the land-surface temperatures and greening in the region, and a discussion of the climate dynamics affecting the sea-ice. A keynote talk by Joey Comiso will describe the history of sea ice in the Arctic basin with special emphasis on the Yamal Peninsula and a similar transect in North America. Finally, we will hear three talks that describe the 2007 Expedition to the Yamal sites at Nadym, Laborovaya, and Vaskiny Dachi. The afternoon of the second day will focus on planning for the 2008 field season.

On the third day we will hear three talks that describe the modeling components of the project. In the afternoon we will break into smaller groups to discuss publications and synthesis products from the project.

We are already nearly in the last year of the project. So it seems a shame that some of us are just now meeting for the first time, but that is one of the consequences of our extremely tight budget. I know this meeting will foster friendships, new ideas, and dialogue between all the project members. I hope that we can also somehow find the time to discuss how and where we might continue this project with new proposals. Most of all I hope that everyone can relax and absorb as much as possible and enjoy these days in Moscow.

Overview of Nadym Region: Climate, Zonation, Physiography, Geology, Permafrost

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Abstract

The Nadym region is situated in the north of northern taiga subzone (Melnikov et al., 1983). All–Union Institute of hydrogeology and engineering geology began studies of permafrost, landscapes and vegetation of this region since 1967. This research was continued by Earth Cryosphere Institute from 1995 to present time.

Climate of area □ continental, with the big amplitude of annual air temperatures)more 39°□(, insignificant amount of precipitations)478.0 mm(in the long severe winter, with the short not hot summer. The mean□annual air temperature varies from – □2.4° up to □8.0°□, averaging – □5.6°□ that provides conditions for formation migratory frost mounds)Ponomareva, 2007(. The analysis of the data of the Nadym weather station for all period of supervisions, climate warming took place in 1967-1997. Since 1997 the air temperature began to be reduced.

The area of research represents flat low plain. In research area 5 geomorphological levels are developed: the fifth marine plain 55-100 m high; the third fluvialvial-lacustrine plain 25-35 m high; the second fluvial terrace of the Nadym river 14-20 m high; the first fluvial terrace of the rivers Nadym and Khejgi-Jakha 7-12 m high and floodplains of the rivers 1-5 m high. The marine plain is composed by middle Quaternary Salekhard clays. The fluvial-lacustrine plain is composed by upper Quaternary Zyryan (now Ermakov), Melnikov, Grechishchev eds., 2002) sands interbedded with clays, with an occasional covering of peat. The second fluvial terrace is composed by Karga sands, and the first fluvial terrace - by Sartan sands covered in some places by peat.

Permafrost underlies the area sporadically. Patches of permafrost are closely associated with peatlands, tundras, bogs and frost mounds. The mean annual permafrost temperatures on the depth 10 m changes from 0 to -2 ^{0}C in different landscape conditions. The highest temperatures are characteristic for dry sites with forest near the rivers composed by sands. The lowest temperature is peculiar to large peatlands. Seasonal thaw depth varies from 0.5□0.7 m on peatlands up to 4,0 m on sands of frost mound tops underline by clay. Seasonal freezing depth changes from 0.5 – 0.8 m on mires up to 1.5 – 2.5 m)in forest on sands). For permafrost of the northern taiga subzone it is characteristic high total ice content. Prominent feature of northern taiga areas also is intensive modern formation of permafrost at change of conditions of heat exchange both due to periodic fluctuations of a climate, and due to natural development of a vegetation cover.

From modern exogenous processes are widely developed bogging, seasonal and long□term frost heave. As a result of long□term frost heave are formed individual frost mounds and the areas of frost heave on peatlands and individual frost mounds on mineral grounds)Ponomareva, O.E., Shur Y.L. 2008). There are data on separate displays of modern thermokarst.

Keywords: Landscape, soil, climate, permafrost, geology.

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Overview of Vegetation, Dynamics, Disturbance and Recovery Studies in the Nadym and Yamal areas.

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Abstract

Studies of vegetation dynamics were performed by author in different bioclimatic subzones of West Siberia North since 1966. Representation about spatial distribution of plant communities in the investigated region a plant community map of scale 1:4,000,000 is given. The map is compiling on a basis of decoding space images, use of landscape map of scale 1:1,000,000, vegetation map of USSR at scale 1:4,000,000 (Belov, ed., 1990), vegetation map of Yamal-Nenetzky national district at scale 1:1,000,000 (Avramchik, 1961). This map was used by compiling the Circumpolar Arctic Vegetation Map (Walker et al., 2003). For the central intensively disturbed part of region a geobotanical map of scale 1:200000 was compiled. This map is compiling on a basis of decoding space images, use of landscape maps of scale 1:100000, aerial photos of scale 1: 25000, aero visual supervisions, our ground routing and detailed geobotanical descriptions.

Performed repeated mapping of plant communities on our stationary sites in different bioclimatic subzones has enabled to investigate vegetation dynamics under impact of climatic changes and anthropogenic factor. The ecological factors determining development of plant communities are revealed on materials of long-term stationary observations along fixed transects and at plots established both in natural and disturbed conditions. Main environmental factors in development of plant communities in West Siberia are water and thermal regime of soil. In process of moisture content increase in soil dry dwarf shrub-lichen tundras are replaced by dwarf shrub-moss-lichen tundras, then by moist dwarf shrub-sedge-moss and low shrub-forb-moss tundras and further by polygonal sedge-dwarf shrub-moss mires, and in valleys by sedge-moss mires and graminoid-moss willow stands. Temperature of soils in this series of plant communities is lowered; its increase is marked only under shrub tundras and in the river valleys, where the increase of snow cover thickness is marked.

Long-term research has allowed revealing features of vegetation recovery in different landscape conditions. Changes of species structure, spectra of growth forms and degree of ground coverage and frequency of plant species, total biomass in derivative and initial communities are shown. A smaller variety and the greater similarity secondary communities are observed in comparison with initial. In structure of derivative communities the species earlier met in initial communities or the species distributed from near by communities, instead of adventitious plants prevail.

Studying interactions of different ecosystem components has allowed revealing geobotanical indicators of seasonal thaw depths, soil temperature and soil moisture. Parallel studying of vegetation and permafrost conditions has shown that indication of a hydrothermal soil regime and seasonal thaw depths on North plains should be carried out at a level of associations and microassociations. For example, the minimum values of seasonal thaw depths on all investigated sites are observed under *Rubus chamaemorus-Ledum palustre-Sphagnum-Cladina* cover developed on peatlands.

The interannual variability in the frequency of plant species is correlated with the thaw index of air temperature (sums of summer temperatures) and amount of precipitation. Frequency dynamics of the same species sharply differs in initial and disturbed communities. For example, frequency of *Ledum palustre* on a natural plot has clearly expressed trend to the increase, caused by rise in air temperature. On the disturbed plots frequency changes of this species have other character. Frequency of *Ledum palustre* increases in dry years with the lowered amount of precipitation, and then after 1990 decreases in connection with some increase in amount of precipitation and development of bogging, but during all period of observations remains much below, than in not disturbed conditions.

Results of performed works were published in monograph “Anthropogenic vegetation dynamics of Russia permafrost plains” (1999) and collective monograph “Anthropogenic changes of ecosystems in West Siberian gas province” (2006).

Keywords: Vegetation, soil, dynamics, climate, human-induced disturbances, mapping, permafrost.

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Lake ecosystems in different landscapes in the Nadym region

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Abstract

The investigation of aquatic ecosystems within the area of the SB RAS (Siberian Branch, Russian Academy of Science) Nadymsky Station was started in 2006. The investigations included the analyses of temperature conditions, depth, bottom deposits and association of aquatic and coastal plants. The aquatic ecosystems investigation has been applied to the following geomorphological levels: III lacustrine-alluvial plain, II terrace above the flood plain of the Nadym River and the current flood-plain of the Kheigiyakha River (Landscapes…1983). All the lakes studied are grouped based on their origin into thermokarst lakes and residual lakes (oxbow lakes). Thermokarst lakes of III lacustrine-alluvial plain are split into three groups considering their geo-cryological conditions and depth levels: small-basin, medium-basin and large-basin lakes (Shamanova, Uvarkin, 1974). In this group an overgrowing process takes place as a successive variation of sphagnum moss belts, cotton-grass-and-sedge belt and further penetration of dwarf shrubs.

Oxbow lakes have been studied in the area of the Kheigiyakha River. The lake overgrowing process takes place due to the formation of floating mats consisting of cowberry, willow, sedge and moss. Aquatic plants of the oxbow lakes are presented by small yellow pond-lily (Nuphar pumila), two pondweed species (Potamogeton perfoliatus, Potamogeton sp.), bottlebrush (Hippuris vulgaris), and bladderwort (Utricularia sp.). (Eroshenko, Orekhov, 2007).

The lakes investigated in II alluvial terrace have been found to have two different overgrowing patterns that depend on the lake basin morphology. Earlier the overgrowing mechanism was described by Tirtikov A.P for small-basin lakes (Tirtikov, 1969), but an overgrowing pattern for deep lakes of this area has been studied for the first time. (Orekhov, 2007).

Keywords: thermokarst lakes, oxbow lakes, overgrowing process, morphometry of lake basins, geomorphological levels.

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Overview of Yamal Peninsula with focus on Laborovaya and Vaskiny Dachi: Climate, zonation, physiography, geology, permafrost

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Abstract

Yamal Peninsula in the North of West Siberia extends from the Arctic Circle (city of Salekhard) to about 73°N (Bely island). Though it lies in the zone of continuous permafrost, a variety of natural environments and climatic zones set conditions for a wide range of ground temperature, active layer depth, complex of cryogenic processes (Melnikov & Grechishchev 2002, Pavlov & Malkova 2005). Southern portion of the study area is located in the Ural mountains piedmont with clastic deposits dominating ontop the hills and on slopes, and is characterized by drained surfaces, deep active layer, relatively high ground temperature and a number of slope processes and sorted grounds, dellies and kurums. Further northward (central portion) thickness of fine-grained deposits grows with the decrease of the altitude. In general, ground temperature is lower, drainage much worse, so prevailing are processes of thermokarst, frost heave, and polygonal ice wedges. North of Yuribei river (northern portion) high marine terraces appear with low ground temperature, thick permafrost, a variety of sandy to clayey and peaty deposits, saline soils and ground water (cryopegs), and thick layers of ground ice. Tabular ground ice is a reason for a complex of modern and relic cryogenic processes and phenomena, such as thermal denudation (landslides, retrogressive thaw slumps), very deep thermokarst lakes. Relic ice wedges degradation causes active thermoerosion. Sandy deposits and relatively high surfaces give rise to active wind erosion and huge areas with windblown depressions (Dubikov 2002, Ershov 1998).

Details of permafrost features at two research locations – Laborovaya at the southern portion and Vaskiny Dachi at the northern are discussed (Leibman & Kizyakov 2007). Strongly pronounced difference in a complex of cryogenic processes at both locations is determined by a character of deposits (clastic at Laborovaya and sandy to clayey at Vaskiny Dachi), by occurrence of massive ice widely distributed at Vaskiny Dachi, peculiarities of permafrost evolution: south of Yuribei river permafrost thawed from the surface to the depth of hundreds of meters during the climate optimum of Holocene, ground ice melted, while north of Yuribey river Holocene optimum thaw occurred only locally, did not exceed first meters, massive ground ice is found 1.5-15 m beneath the ground surface, saline marine deposits thus are not washed away since they got frozen in Pleistocene. Thermodenudation and occurrence of saline soils near the surface resulted in a unique for high latitudes phenomenon of high willow shrub thickets, distributed north of Yuribey river and most widespread at the latitudes of Vaskiny Dachi (Ukraintseva & Leibman 2000).

Keywords: Permafrost distribution and thickness, cryogenic processes, climatic parameters, relief, geologic construction, permafrost evolution

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Landscape Structure in Natural and Disturbed Conditions of Yamal Peninsula, Field Results and Local GIS

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Abstract

The landscape pattern of Yamal Peninsula is presented using E.S.Melnikov's scheme of landscape zoning of the North of West Siberia (Landscapes… 1983). The scheme of zonal structure of vegetation (Il'ina et al. 1985, Nature... 1995, Monitoring… 1997) is considered as well. Large extent of Yamal Peninsula from south to north (1200 km) leads to well-noticeable zonality of vegetation cover; Yamal province of marine tundra plains is divided into three subprovinces: northern tundra, middle tundra and southern tundra. Overview of the first-year landscape data from Laborovaya key site in southern tundra is provided. Results of long-term field work on Vaskiny Dachi key site in middle tundra are considered. Landscape structure on potential Kharasavey and Bely Island key sites is reviewed as well. On Laborovaya key site preliminary description of landscapes and their disturbance by construction and exploitation of railway and motorway crossing this area is given. Vaskiny Dachi key site laid a bases for several studies. Firstly, considered is connection between active layer depth and landscape features. Secondly, a cartographical analysis of cryogenic landslides distribution with prediction of their probable catastrophic activation is performed. Thirdly, landscape disturbance is an object of study on this key site. Vaskiny Dachi key area is mostly out of immediate gas field development zone. Therefore, cryogenic landsliding, truck ways/parkings, quarries and reindeer overgrazing are main disturbances here. Kharasavey and Bely Island key sites are in northern tundra zone and have coastal position. They can be considered in comparison with Laborovaya and Vaskiny Dachi key sites having midland position. The presentation concludes that there is correlation between main landscape components and active-layer dynamics, cryogenic processes and degree of landscape change under natural and technogenic disturbances. Vegetation as one of the main landscape components is subject to severe disturbance and responds to environmental changes faster than other landscape components.

Keywords: Active layer depth; cartographical analysis; landscape disturbance; landscape structure; landscape zoning; vegetation.

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Pan-Arctic permafrost thermal conditions: Where does the Yamal Peninsula fit?

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Abstract

Permafrost has received much attention recently because air and ground surface temperatures are rising in most permafrost areas of the earth, bringing permafrost to the edge of widespread thawing and degradation. The thawing of permafrost that already occurs at the southern limits of the permafrost zone can generate dramatic changes in ecosystems, in water and carbon cycles, and in infrastructure performance. To monitor the present thermal state of permafrost, the International Permafrost Association launched its International Polar Year project # 50, Thermal State of Permafrost (TSP). This project will measure temperatures in existing and new boreholes to provide a snapshot of permafrost temperatures in both time and space. The acquired temperature data set will serve as a baseline assessing the rate of change of near-surface permafrost temperatures and permafrost boundaries, to validate climate model scenarios, and for temperature reanalysis. In our paper we will present the first results of the project based on data obtained from Alaska and Northern Eurasia. Observations show a general increase in permafrost temperatures during the last few decades. Most of the observatories show a substantial warming during the last 20 years. This warming was different at different locations, but was typically from 0.5 to 2°C at the depth of zero seasonal temperature variations in permafrost. Thawing of the Little Ice Age permafrost is going on at many locations and there are some indications that the late-Holocene permafrost started to thaw at some specific undisturbed locations in the European North-East, in the northwest of West Siberia, and in Alaska. Some projections of possible changes in permafrost distribution during the 21st century based on application of a calibrated permafrost model will be provided in our presentation.

Decadal Changes in Sea Ice Conditions and Temperatures in the Arctic with a Focus on the Yamal, Alaska and Canadian regions

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Abstract

Among the most notable manifestations of a rapidly changing polar regions, as observed by satellite data from 1978 to 2007, is the decline of about 11%/decade in the Arctic perennial sea ice cover. Even more remarkable is the precipitous drop in the ice cover in 2007 as shown in Figure 1, with the perennial ice area during the year being 38% less than climatological average and 27% less than that in 2005 when the previous lowest perennial ice cover during the satellite era occurred. It appears that the conditions were favorable for such a big change in 2007, with the temperature anomalies unusually high in 2007, especially in February and April, and the winds were coming from the south, transporting warm air and advecting ice towards the north (Comiso et al., 2008). But preconditioning was likely a big factor as well. Open water in the region increased at the rate of 23% per decade during the 1978 to 2007 period while sea surface temperature increased at 0.7 °C per decade. Bottom ice melt was also observed to be more than 1 meter in some regions of the Western Arctic (i.e., Beaufort Sea) during the summer in 2007. These are evidences that ice-albedo feedback already has a significant effect and this may have caused a thinning in the ice cover caused in part by the delay of freeze-up in autumn and the early occurrence of spring melt. Meanwhile, the decline in the total ice cover, which includes the seasonal ice, has changed from a modest rate of 3.7 % per decade to more than 10 %/decade since 1996, indicating that it is not just the perennial ice cover that is being lost. Regionally, the Kara-Barents Sea ice sector, has been declining at -8% per decade while the ice cover in both the Central Arctic and the Canadian Archipelago have been declining at about -2% per decade (Comiso and Nishio, in press). In the meantime, the surface temperature to the north of the Arctic Circle (66.5°N), as measured from satellite infrared data, has increased at the rate of 0.6 °C per decade from 1981 to 2007. The warming rate was highest at 0.8 °C per decade, in Greenland, also high in North America at 0.7 °C per decade but more moderate in Eurasia at about 0.2 °C per decade. Over the sea ice cover, the rate of warming was about 0.23 °C per decade.

Three study regions were examined in greater detail: one in the Yamal/Kara Sea Region (called region 1), another in the Alaska/Chukchi Sea region (called region 2) and the third in the Canadian Archipelago (called region 3). In region 1, trends in ice extent, ice area and ice concentrations from 1978 to 2007 are -5.31, -6.46, and -3.69 %/decade, respectively. This is consistent with observed trend of 0.53 °C per decade in SST, but the observations over land and the entire box are only 0.02, and 0.2 °C per decade, respectively. The trends in region 2 for ice extent, ice area and ice concentrations are -3.44, -4.39, and -1.51 % per decade, respectively, while those for surface temperatures over ocean, land, and the box are 0.84, 0.63, and 0.79 °C per decade. In this case, the land part have similar trend as the ocean part. In the Canadian Archipelago, the trends in extent, area and ice concentrations are -1.54, -2.15, and -0.86 % per decade, respectively. The correlations between the ice cover and surface temperatures are relatively good but not very strong with the correlation coefficient being around 0.5 but this is mainly because of a hysteresis effect. If the months of April, May, June, July and August are excluded, the correlation is much stronger with the correlation coefficient being at around 0.9. The general relationships of ice cover and surface temperatures with land surface parameters including albedo, snow melt and NDVI will also be discussed.

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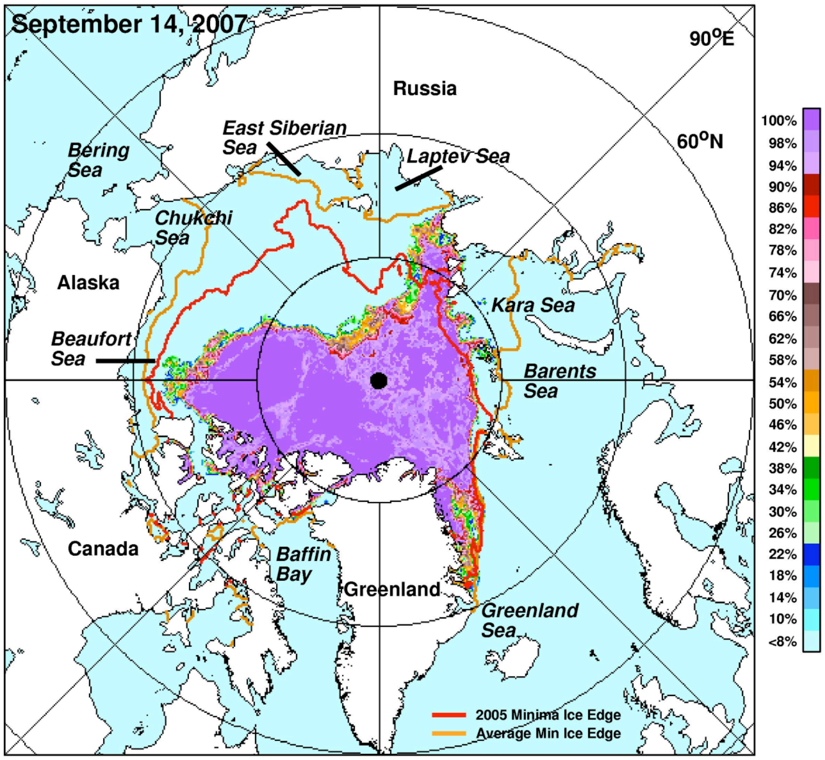

Figure 1. Daily ice concentration map of the Arctic on 14 September 2007 when the ice cover reached it minimum extent. The gold contour represent the ice edge inferred from the average of the ice concentration maps during minimum extent from 1979 to 2006, while the red contour represents the ice edge during ice minimum in 2005, which was the previous record low.

Decadal Trends of Vegetation Greenness Driven by Climate Change and Human Activities in the Arctic

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Abstract

This talk focuses on the decadal trends of vegetation greenness driven by climate warming and human activities in Yamal region. Since this NASA funded project was launched data availability has changed and some relevant studies at both circumpolar and regional scales have emerged. We will start the talk with a review of recent update of long-term satellite data records of vegetation indices, including spatial and temporal coverage, calibration, and problems still existed in the new datasets. We will also briefly review high latitude NDVI studies recently published by other groups, e.g. Goetz et al, to show what have been done and what the key problems unsolved.

The Arctic region has experienced a continuous trend of warming during the past 30 years. Meanwhile, many areas of the Arctic are undergoing large-scale industrial development, e.g. oil and gas exploration, at a rapid pace, indicating an increasing human pressure on ecosystems even in this frontier wilderness. Satellite derived vegetation indices have often been used to detect what will happen to the tundra ecosystems while driven by climate change and human activities. Here we will analyze and test the up-to-date NOAA AVHRR NDVI dataset with 15 day temporal resolution and 8 km spatial resolution over circumpolar north, with special focus on Yamal region. Subpixel fractional vegetation cover was analyzed in order to select homogenously vegetated areas of tundra. Autoregression analysis was performed on NDVI time series of those homogenous pixels for each region. We will demonstrate the trends and magnitudes of changes in vegetation greenness, changes of vegetation phenology (onset, dates of peak, and length of growing season), and identify the areas experienced greatest greening. We will also discuss data quality issues and related uncertainties in interpretation.

Keywords: Arctic, Land cover, NDVI, tundra, vegetation, warming

Spatial Patterns of Land Surface Temperature and NDVI, and their Relation to Vegetation Distribution on the Yamal Peninsula

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Abstract

Arctic vegetation is largely controlled by climate, particularly summer temperatures. Satellite data can be used to calculate land surface temperatures (Comiso 2003), resulting in spatially detailed maps that are an improvement over interpolated data based on few, mostly coastal weather stations. Temperature data most relevant to arctic plants between 1982-2003 was summarized as average summer warmth index (SWI = the sum of monthly mean temperatures > 0 ºC) (Raynolds et al. 2008 in press). As mapped by the CAVM, the Yamal bioclimate subzones are warmer than average for the Arctic, especially for Subzone C (Fig. 1). A bioclimate map based on satellite temperatures shows coldest areas along the coast and in areas with many lakes.

The Normalized Difference Vegetation Index can also be calculated from satellite data. NDVI is a measure of relative greenness calculated as: NDVI = (NIR – R) / (NIR + R), where NIR is the spectral reflectance in the near-infrared where reflectance from the plant canopy is dominant, and R is the reflectance in the red portion of the spectrum where chlorophyll absorbs maximally. It is a good indicator of variation in arctic vegetation, and has been found to increase with the amount of vegetation as measured by leaf area index (LAI), phytomass, and productivity (Shippert et al. 1995, Riedel et al. 2005). It can be used to distinguish between arctic vegetation types (Hope et al. 1993, Stow et al. 1993).

I analyzed the spatial distribution of NDVI on the Yamal Peninsula, to better understand the factors controlling vegetation distribution patterns. The analysis included maps created by the Earth Cryosphere Institute as part of the Circumpolar Arctic Vegetation Map (CAVM 2003) project (including landscape, Quaternary geology, soil texture), the CAVM classes, elevation, and SWI. The main trend in NDVI values is an increase from north to south, a gradient along with both temperature and elevation increase. NDVI increases about 0.0036 units for every degree of SWI, which is less than the response of the Arctic as a whole (0.0137, Raynolds et al. 2006) (Fig. 2). The increase in NDVI with elevation is mostly due to the higher elevations occurring in the areas farthest south, but also holds true on the Peninsula itself, where NDVI increases 0.0012 units for every meter in elevation, though R2 values were low (Fig. 3). For the Arctic in general, NDVI decreases with elevation (Raynolds et al. 2006). There was no evidence of differences in NDVI due to age of surfaces as mapped by Quaternary geology, but NDVI of marine sediments were lower than NDVI of glacial and glacio-fluvial deposits (0.46 vs. 0.49, Fig. 4).

GLM analysis showed that landscape (as mapped by "landschaft") and elevation together accounted for 49% of the variation in NDVI among CAVM polygons (Table 1). Lithology, vegetation type, SWI and percent lake area together accounted for an additional 13% of the variation.

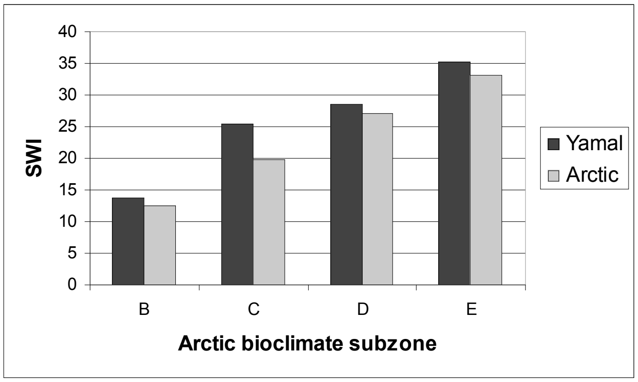

Figure 1. Summer warmth index of bioclimate subzones, contrasting values for the Yamal Peninsula and the whole Arctic.

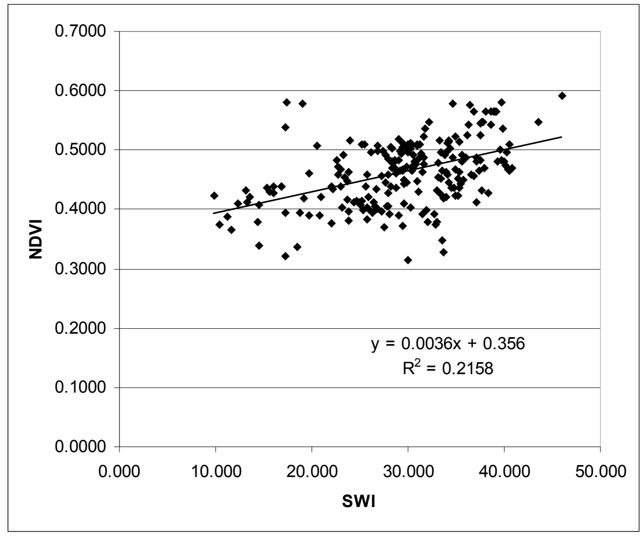

Figure 2. Regression relationship between NDVI and SWI of CAVM polygons on the Yamal Peninsula. Polygons with values < 0.3 (lakes) were excluded.

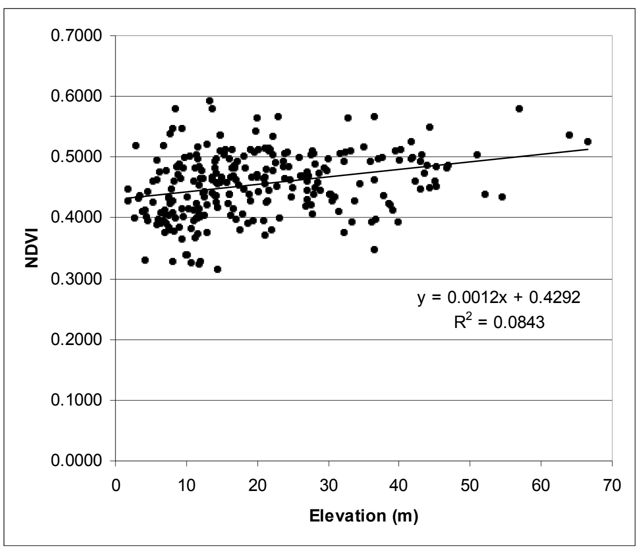

Figure 3. Regression relationship between NDVI and elevation of CAVM polygons on the Yamal Peninsula. Polygons with values < 0.3 (lakes) were excluded, and polygons > 70 m elevation (foothills of the Urals) were excluded to clarify the relationship on the Peninsula itself.

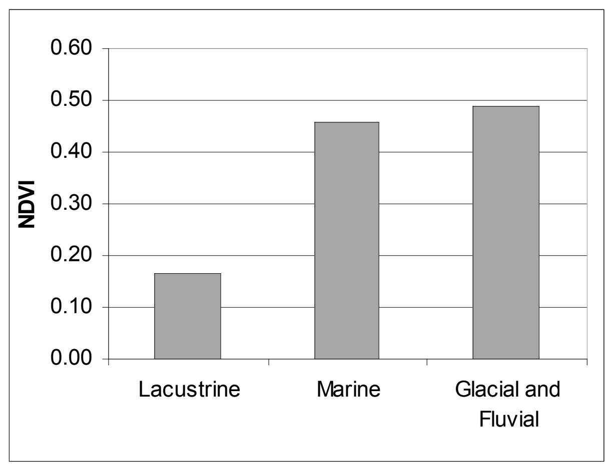

Figure 4. NDVI of different categories of Quaternary geology classes on the Yamal Peninsula

Table 1. Results of General Linear Model (GLM) analysis of NDVI on the Yamal Peninsula. Input data are mean NDVI values for CAVM polygons.

	Df	Deviance	Residual Df	Residual Deviance	% Deviance accounted for	Significance
NULL			280	2.06516		
ELEV	0.60322	0.60322	279	1.46194	29.21	< 2e-16 ***
LANDSCHAFT	0.40732	0.40732	278	1.05462	19.72	< 2e-16 ***
LITHOLOGY	0.10083	0.10083	277	0.9538	4.88	2.91e-07 ***
VEGET_ID	0.08868	0.08868	276	0.86512	4.29	3.50e-06 ***
SWI	0.03856	0.03856	275	0.82655	1.87	1.12e-04***
LAKEAREA	0.03245	0.03245	274	0.7941	1.57	9.34 e-04***
TOTAL					61.55	

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Pan-Arctic climate dynamics in relationship to sea-ice, land-surface temperatures, and NDVI with focus on Yamal region and comparison with North America

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Abstract

Recent dramatic reductions in sea ice and changes in Arctic vegetation have been well documented and are of growing concern because of how they may impact the ecosystem at high latitudes, which includes permafrost, soils, fauna, as well as humans. It is hypothesized that an earlier ice melt forces atmospheric and land surface temperatures changes, leading to increased summer warmth, higher NDVI and enhanced greenness of vegetation. To investigate the nature of these relationships, climate analysis techniques are applied to high-resolution passive microwave sea ice concentration and AVHRR land surface temperatures to evaluate the direct relationship between coastal ice and the adjacent land. The analysis employs 25 km resolution SSMI passive microwave Sea Ice Concentration (Comiso 1999) and AVHRR Surface Temperature (Comiso 2006, 2003) covering the 24-year period from January 1982 to December 2007. The spatial variations of the climate-vegetation relationships are examined by performing analysis on the Yamal both regionally (Treshnikov 1985) in a 50-km terrestrial zone along the Arctic and for specific sites (Kharasavey, Vaskiny Dachi, Laborovaya, and Nadim). These relationships are compared with those of the North American Transect.

We find a relationship between sea ice cover and nearby land surface temperatures that is generally consistent with the notion that cooler land surface temperatures are found with above average ice conditions. For the Yamal, a regional analysis reveals that spring sea ice is decreasing, the Summer Warmth Index (SWI-degree months above 0 ˚C) is increasing, and NDVI displays no trends. Variations in the Kara-Yamal region are more closely associations with the North Atlantic Oscillation, a large-scale climate variability measure. SWI and ice area are significantly negatively correlated while correlations with NDVI are weak. Site specific analysis reveals small differences between the various stations for ice and SWI variability. In contrast, over the North American transect, the regional analysis displays strong upward NDVI trends and a large differences between individual sites. The North American Transect is more closely associated with variations of the Pacific Decadal Oscillation. A direct relationship between sea ice and vegetation greenness has not been established and our analysis suggests there exists a fairly complex set of interactions.

Keywords: Arctic climate, climate variability, climate dynamics, ocean-ice-atmosphere-biosphere interactions.

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2007 Expedition to Nadym, Laborovaya and Vaskiny Dachi, Yamal Peninsula Region, Russia: Overview of the Expedition and Results of the Species Cover and Biomass Studies

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Abstract

The terrain and vegetation of the Yamal Peninsula in northern Russia have undergone extensive changes during the past 20 years due to gas and oil development, grazing and trampling by reindeer herds, and changes in climate. A transect across the Yamal Peninsula is being examined with remote-sensing and ground-based studies to provide a baseline of information to compare with past and future land-cover changes in the region. The information will be used to help develop models that predict the consequences of climate change to the vegetation, the reindeer, and the Nenets people. In 2007, we examined the vegetation, soils, permafrost conditions, and spectral characteristics at three research sites in the southern part of the Yamal Peninsula region: Nadym (northern boreal forest), Laborovaya (southern tundra, bioclimate subzone E), and Vaskiny Dachi (typical tundra, bioclimate subzone D). A data report is presented that contain the results from the 2007 expedition (Walker et al. 2008). Seven study sites were studied – two at Nadym, two at Laborovaya, and three at Vaskiny Dachi. The sites were representative of the zonal soils and vegetation, but also included variation related to substrate differences (clayey vs. sandy soils). At each site, a variety of information was collected along five transects, five permanent vegetation study plots, and 1-2 soil pits at each site. The information in the data report includes: (1) background for the project, (2) general descriptions of each locality with photographs, (3) maps of the sites, (4) summary of sampling methods, (5) tabular summaries of the vegetation data (species lists, estimates of cover abundance for each species within vegetation plots, measured percent ground cover of species along transects, site factors for each study plot), (6) summaries of the Normalized Difference Vegetation Index (NDVI) and leaf area index (LAI) along each transect, (7) soil descriptions and photos of the soil pits at each study site, (8) summaries of thaw measurements along each transect, and (9) contact information for each of the participants. One of the objectives of the data report is to provide the Russian partners with full documentation of the methods that are also being used along a similar transect in North America.

Monitoring future vegetation changes in the Arctic must rely largely on satellite-derived indices of vegetation productivity, such as the Normalized Difference Vegetation Index (NDVI), which is really a measurement of vegetation greenness. Often, particularly in tundra regions, the vegetation greenness has little relationship to plant biomass or to quality of the reindeer forage. For example, lichen-rich areas often appear barren on space-based images, but in fact are highly productive with some of the highest quality forage for reindeer. Bright green areas are sometimes interpreted as having high forage quality, when in fact they may be dominated by species such as alder or dwarf-birch, which have abundant toxic secondary plant compounds that protect them from grazing. Many factors affect both biomass and the spectral properties of the vegetation including the amount of woody and senescent tissues, the color of the live plant tissues, and structure of the plant canopy, as well as the abundance of standing water and the color of the background soils. The ground-based measurements of vegetation spectral properties, species composition, and vegetation structure along the Yamal transect will help remote-sensing specialists properly interpret the spatial and temporal patterns of satellite-derived NDVI.

Our total above-ground biomass data show a clear trend related to the climate gradient in the southern part of the Yamal transect, varying from about 2000-2300 g m^{-2} for tundra and forest understory at Nadym to about 1000-1300 g m^{-2} at Vaskiny Dachi (**Figure 1**). Total above-ground tree biomass at the Nadym forest site, as determined using height and diameter at breast height and allometric equations developed in Europe, adds another 4,121 g m^{-2} ± 851 g m^{-2} to this site. Areas with sandy soils have 250-350 g m^{-2} less biomass than comparable clayey sites, with less mosses and graminoids, and much more lichen biomass. Lichen biomass was especially large in the ungrazed sandy areas near Nadym – over 1000 g m^{-2} in two areas studied at Nadym compared to less than 250 g m^{-2} in sandy areas where reindeer grazing has occurred annually. Quantitative cover data obtained using a Buckner point-intercept sampling device are shown in

Figure 2. Compared to the biomass values, there is less correspondence between the cover data and the climate gradient; but the cover data do appear to show general correspondence with the trends of the hand-held LAI and NDVI values at the same sites (Epstein et al. 2008).

The baseline of information collected along the Yamal transect will help us gain a more complete understanding of the relationships between climate and key biophysical variables, and will be extremely useful for monitoring long-term changes in plant biomass, and spectral properties as temperatures warm in the region and as grazing and industrial impacts change. Comparison with data from a similar bioclimate transect in North America will further help us interpret circumpolar patterns of vegetation change (Walker et al. 2007 submitted).

Keywords: Species cover, biomass, vegetation, plant functional types, soils, reindeer grazing, bioclimate gradient.

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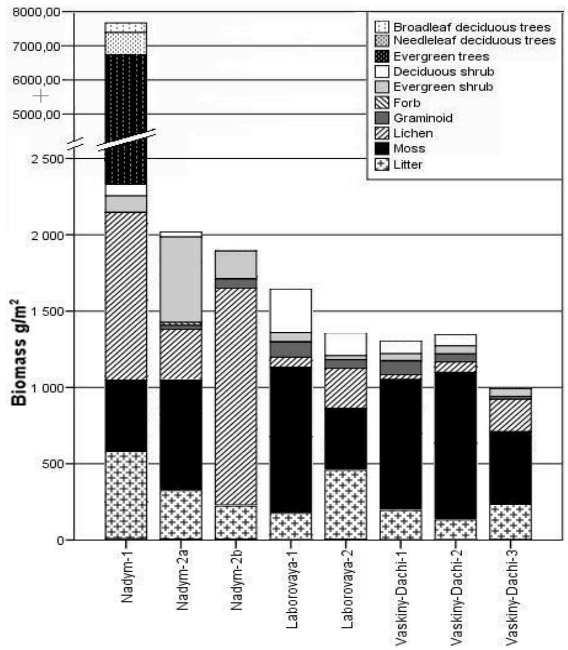

Figure 1. Average biomass for each of the study sites including litter, dead moss, dead lichen. Nadym-1 is forested and includes tree biomass. All other sites are tundra. Nadym-1, 2, Laborovaya-2, and Vaskiny-Dachi-3 are sandy sites. The Nadym sites are not grazed by reindeer.

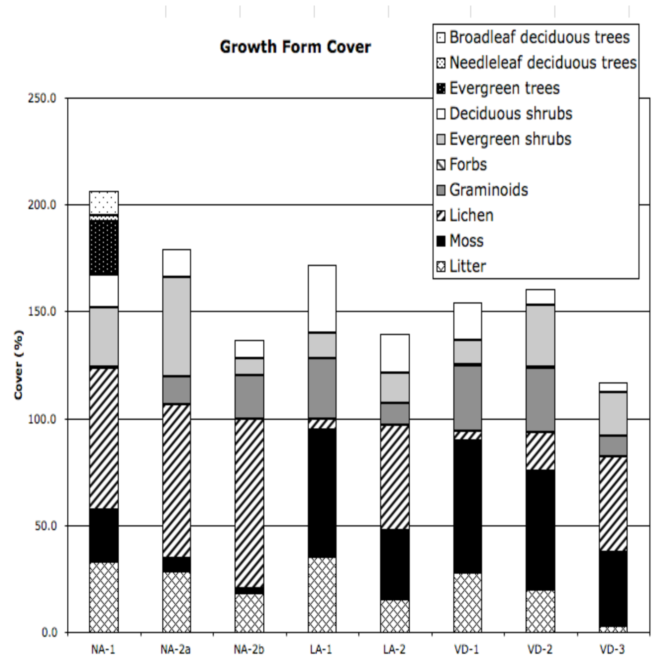

Figure 2. Average percentage cover for growth forms at each study site. Data were obtained using a Buckner point-intercept sampling device (Buckner, 1985). The data were collected at the species level and grouped here into plant functional types to compare with the biomass data in Figure 1.

Soils in the Nadym and Yamal area

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Abstract

There were examined the soils of three research sites in the southern part of the Yamal Peninsula region: Nadym (northern boreal forest), Laborovaya (southern tundra) and Vaskiny Dachi (typical tundra). Types of examined soils are different. It is conditioned by changing of main soil-formers – parent material, vegetation, time of soil forming – from north to south. One of the most important factors is permafrost. Generally histoturbels (peat gleyzems in Russia) and haploturbels (cryozems in Russia) are described, but in the northern boreal forest, in the absence of permafrost, variants like haplocryods (podzols in Russia) are found. The similar characterictics of studied soils are low-capacity organic profile (under 40 cm), composed of moss and lichen in the different extent of conversion; signs of the eluvial leaching of R_2O_3 and humic materials; signs of the gley process; intense turbation; different-sized frost cracks, filled with decomposed organic material. At once, studied soils have differences, associated with changing of hydrothermal gradient and type of vegetable cover from south to north, difference of grading, and influence of some specific factors like microrelief, availability and occurrence depth of permafrost, wind-formed processes. Microrelief has a considerable influence on soil properties. Soils of microlows are more turbated; there are many frost cracks in them. The main feature is augmentation of organic horisons' deepness and extent of their conversion as against soils of microhighs.

Data of emission of such gases as CO_2 and CH_4 from soil surface, and data of gas emission from permafrost surface before and after its degradation, are received. At all research sites after permafrost melting there was fixed sharp increase of emission of gases, exceeding background emission by several digits.

Keywords: cryopedology, organic matter, permafrost, soil

Plant Communities at Nadym, Laborovaya, and Vaskiny Dachi

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Abstract

In order to efficiently use remote sensing products for studies of most terrestrial ecosystems it is import to assess and correlate the spectral, structural and compositional properties of the vegetation on the ground with the satellite derived information. As part of the interdisciplinary project "Application of Space-based Technologies and Models to Address Land-cover/Land-use Change problems on the Yamal Peninsula, Russia" we selected six representative study locations along a bioclimate gradient for detailed investigation of the zonal plant communities. At each location we established permanent plots at two or three study sites and recorded the presence and abundance of all vascular plants, bryophytes and lichens using the Braun-Blanquet scale. Additionally we investigated structural and functional vegetation parameters, noted environmental site factors and took mineral soil samples to analyze soil physical and chemical properties. In subplots of 20×50 cm we harvested all above-ground biomass which were sorted, dried and weighed according to plant functional types upon arrival in the lab. For each study plot as well as for selected transects we measured the Normalized Differenced Vegetation Index (NDVI) and Leaf Area Index (LAI) with hand-held instruments. In each study plot we also placed data loggers at the surface as well as at the interface between organic layer and mineral soil to calculate the *n*-factor as a proxy for the insulating properties of the vegetation.

Here we will present the preliminary results from the southern portion of the transect covered in the summer of 2007 (Nadym, Laborovaya, and Vaskiny Dachi) with a short introduction to the standard phytosociological methods used. To illustrate the potential of the complete and combined vegetation, biomass, soil and climate data set that will be available at the end of 2008 we present results from the conceptually related North American Arctic Transect (Kade et al. 2005, 2006, Kuss et al. *in prep.*, Vonlanthen et al. *in press*).

Keywords: Bioclimate subzones; biomass; phytosociology; soils; species diversity; plant community diversity.

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Effects of Petroleum Development on Reindeer Herding in Northwest Siberia: Combining Scientific and Traditional Knowledge

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Abstract

Oil and gas activities over the past 30+ years have had profound impacts on the social-ecological systems of northwestern Russia. The region has also been undergoing pronounced and rapid climatic warming, with important ramifications for tundra vegetation and permafrost soils. We are investigating the extent of visible and perceived changes by using a case study approach in two areas of intensive oil and gas development. Migratory Nenets reindeer herders, whose 'brigades' (herding units) interact directly with oil and gas infrastructure and workers, are active participants in the project. Our aim is the co-production of knowledge relevant to assessing the overall impacts – both positive and negative – from past exploration and current production phases. This approach combines state-of-the-art quantitative methods, such as very high-resolution satellite image analysis, with the qualitative 'traditional' knowledge that comes from the collective experience of herding, hunting,fishing, and gathering throughout the same territories for centuries. Gross changes in land cover, such as desertification and expanding infrastructure, are relatively easy to detect via remote sensing. However, understanding how contemporary livelihoods actually are affected by and respond to these processes requires extensive participant observation and interviews with Nenets herders both in the tundra and in the villages.

Ecologically, the mires and riparian habitats of the region can certainly handle heavy pasturing loads. However, some scientists have argued that the sustained pressure of combined grazing and trampling is capable of turning dwarf-shrub heath to graminoid-dominated steppe tundra over extensive areas. The varioustrends and drivers have to be well understood if we are to properly interpret the growing amount of remotely sensed data telling us that the Arctic is 'greening'. One important trend appears to be the amount of terrain that has switched from shrub-dominated to graminoid-dominated. Mechanical disturbance can lead either to erosion, on sandy substrates, or to highly productive swards on more organic soils. Preliminary findings indicate that herders recognize weather patterns interpreted by scientists as clear signals of a warming climate, e.g. later freeze-up, earlier thaw, increasing shrubs, mid-winter icing events. Yet they feel that changes associated with petroleum development present more serious short- and long-term threats due to losses of pastureland and a lack of meaningful input into development-related decision-making.

Socio-cultural Dimensions of Land Use Changes on the Yamal Peninsula among Nenets Nomads

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Abstract

The Yamal-Nenets are considered today the world's most successful herders of domestic reindeer. The steady increase of reindeer as well as humans permanently living on the tundra is exceptional. This has led to increased use of on-surface natural resources, mainly reindeer pastures and fishing in lakes and rivers. With the intensification of natural gas development on the peninsula, the discussion on overgrazing, resource competition and regulatory responses has gained pace and changed tones. This presentation looks at the background of these developments and analyses current changes on the basis of social anthropological data from the last 100 years. Using literature and own fieldwork, I introduce Nenets changes and continuities in grazing regimes and kingroup-distribution, as well as their own perception and principles of responding to these changes. I argue that the current discourse is dominated by approaches external to the Nenets socio-cultural universe. Therefore regulatory responses and recommendations often are not compatible with the nomads' way of knowing and relating to their land and their animals. Future research should integrate better intensive anthropological fieldwork and Nenets human-environment relations, if the ambitious goal of fruitful coexistence between the gas industry and reindeer herding stated by all sides involved should be reached.

Overview of gas and oil development on the Yamal Peninsula

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Abstract

Presentation deals with the peculiarities of hydrocarbon resources development on Yamal peninsula. Yamal gas fields contain 10.4 trillion m^3 of proven deposits inland, reaching 50 trillion m^3 with additional deposits of the Kara sea shelf. The largest deposits of Yamal: Bovanenkovo, Kharasavey and Novy Port contain 5.8 trillions m^3 of gas, 100.2 millions of tons of gas condensate, and 227 millions of tons of oil. Proven Yamal deposits exceed North American (7.5 trillion m^3), and South American (7.1 trillion m^3). "Gazprom" plans to invest $40 billions in the development of Bovanenkovo deposit. Entire Yamal development will involve $70 billion. In 2030 gas production on Yamal will be as high as 250 - 260 billion m^3/yr. To compare, contemporary Russia's production is more than 600 billions m^3 of gas (20% of the world consumption).

"Gazprom" has accepted the Yamal hydrocarbons transportation scheme through main pipeline across the Baidarata Bay of the Kara Sea. Four pipelines will transport 50-60 trillions m^3 of gas each.

Yamal gas field development needs reliable transport pathways to provide delivery of people and cargo to the construction and production sites. It is planed to open a cargo train operation in 2009 along the route "Obskaya-Bovanenkovo". The passenger train service is due by 2011. There are plans to build the aerodrome and river port in Bovanenkovo settlement. The seaport and car park are expanding in Kharasavey settlement as well. The winter roads will be built on Yamal following a unique technology "Arctic Elephant". The roads will be carrying 6000 and 26 million tons of cargo for pipeline and production complex construction to be finished by 2020.

It is predicted that 165 families of nomadic Nenets people will move to live in the settlements as a result of reduction of the pastures, and 286 families will have to change the pasture routes for the same reason. Expert estimations are that expenses exceeding several billions dollars are needed to minimize negative impact of development on the human life and disturbed environments by 2011.

Keywords: Gas deposit development, main pipeline, transport pathways, investments, nomadic people, environmental disturbance.

Mapping and remote sensing of natural and technogenic geosystems in West Siberia

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Abstract

The current conditions of natural and natural-technogenic geosystems in cryolithozone are controlled by interaction of external environment with the geological sphere. The system of information and graphical (cartographical) models is designed to asses this interaction. It is completed as a set of electronic digital maps with appropriate databases.

The complete set of small-scale electronic of landscape, geocryological and environmental maps by results of regional, local and regime researches is made in the Earth Cryosphere Institute (ECI SB RAS). The creation of such maps requires operating and generalizing vast information on natural and technogenic geosystems, structure, properties and temperature of permafrost but also exogenic geological processes, hydro- and meteorological parameters. Initially preliminarily the digital landscape map (1:4 000 000) was compiled for Russian permafrost zone. This map is a basis for creation of several derived maps: map of permafrost extent, map of cryogenic geological processes and prognosis map of cryogenic geological processes under the different scenario of climate changes. Digital derived maps of lake cover, surface geology and bedrock geology, permafrost, vegetation map were generated for Arctic Region of Russia (to the north of wood vegetation boundary) as the result of the analysis of the databases with the use of GIS-technique.

Being based on the common for the whole cryolithozone relationships displayed on small-scale global and regional maps (1:2 500 000 … 1:10 000 000) both on local databases the medium-scale maps (1:100 000 … 1:200 000) as graphical-model of natural and natural-technogenic geocryosystems are made for particular territories. These are the maps of well investigated areas modern economical activity and technogenic impact all over the Russian cryolithozone which can be considered as environmental «key sites». Different accompanying maps are derived and made also.

The maps of geocryosystems serve for interpolation of data and the statistical criteria allow to estimate the probability of data interpolation. Regime and repeat measurements make it possible to consider climatic and permafrost changes. If the problem of data interpolation is solved and proved statistically for the «key site» polygon, it allows evaluate possibility of data extrapolation outside the «key site». The complete set of maps added by environmental and geocryological monitoring gives an opportunity to predict background and current natural and technogenic conditions in any spatial point for any date (tolerance limits should be evaluated in each case).

The structure of cartographical models, i.e. content of the main and derivatives of maps is determined by their designation and necessities of the user. So according to this idea were designed different graphical models for several territories. The most simple and complete in the same time realization is made for the territory of a Bovanenkovo gas field. The series of 1 or 2 component maps displaying space variability of active layer, permafrost temperature, exogenic processes, ice-content, lithology and cryogenic structure was drawn in middle 1990s and is updated each 2-3 years. Another method was used for Norilsk region: the traditional "synthetic" 2-page engineering-geocryological map was created by overlay of different parameters. For Urengoy gas field the map of geocryosystems is supplemented by series of monitoring maps)1977, 1997 and 2007(of the most changeable parameters)ground temperature(, and also by quantitative rating of various sorts of technogen.

Keywords: Natural and natural-technogenic geosystem (geocryosystem), climatic parameters, permafrost, geocryologic construction, exogenic processes.

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Remote sensing of land-cover/land-use change in Bovanenkovo gas field on the Yamal Peninsula

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Abstract

This study is focusing on land-cover and land-use changes mainly in the vicinity of Bovanenkovo gas field in the Yamal peninsula. Aim was to estimate how much original tundra vegetation has destroyed permanently and how much has changed from vegetation type to another. Main remote sensing data source to evaluate the current situation were Quickbird-2 (2004), ASTER TERRA VNIR (2001) and Landsat ETM (2001) images. In addition field dataset of 230 sites with vegetation and land-use characterizations were collected in July 2005. Landsat MSS/TM and SPOT images (1980's and 1990's) were used in change detection.

Road network, off-road vehicle tracks, industrial sites, garbage fields, pipelines, power lines sand quarries and drilling sites were digitized from Quickbird-2 and ASTER TERRA VNIR images. With buffer analysis areas of impacts were estimated. One aim was to produce a map depicting the total area of cumulative disturbance around the Bovanenkovo Gas Field. The estimation was carried out by outlining the furthest visible signs of industrial impacts from around Bovanenkovo gas field.

The area of disturbance covers 451 km^2. Permanently lost pasture-land includes roads and infrastructure areas covers 8,1 km^2. Totally 2546 km of off-road tracks were interpreted and that covers 29 km^2. Bovanenkovo gas field affects directly most of all to two brigades of Yarlinski sovhoze. Gas field is situated on their migration path towards Kara sea coast which is important July-August summer pasture. Area of disturbance (451 km^2) already covers about 20 % of brigades 8 and 4 July-August pastures.

(1) LAI, NDVI, and vegetation biomass for Low Arctic sites in the Yamal Region of Russia

(2) An overview of modeling vegetation and ecosystem dynamics in arctic tundra

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Abstract

An understanding of ecosystem interactions in any system is predicated by knowledge of the spatial distribution of vegetation properties. In many regions of the Siberian arctic tundra, this baseline information on tundra vegetation in a spatial context does not exist in a systematic fashion. As part of a NASA/NEESPI Land Cover Land Use Change (LCLUC) project, we analyzed in detail the vegetation properties of three tundra locations along a latitudinal gradient in forest-tundra and arctic tundra east of the Ural Mountains, including the Yamal Peninsula. Our locations were situated near Nadym (65° 18' N), Laborovaya (67° 41' N), and Bovanenkova (Vaskiny Dachi – 70° 17'). At a minimum of two sites per location, using 50m x 50m grids, we systematically sampled leaf area index (LAI), Normalized Difference Vegetation Index (NDVI), species composition, vegetation biomass, and foliar nutrient concentrations. The LAI of vascular plants declined from an average of 1.08 m^2 m^{-2} at Nadym to 0.36 at Vaskiny Dachi along the 5° latitudinal transect. NDVI values of the tundra vegetation did not decline with latitude and were 0.60 for Nadym, 0.67 for Laborovaya and 0.58 for Vaskiny Dachi. This is likely due to the contribution of non-vascular, understory vegetation to the NDVI signal. Related, average foliar nitrogen concentrations were greatest at Laborovaya, the site with the highest NDVI. Average tundra vegetation biomass decreased with latitude from 1130 g m^{-2} at Nadym to 636 g m^{-2} at Laborovaya and 451 g m^{-2} at Vaskiny Dachi. Biomass was linearly related to LAI ($r^2 = 0.60$), but not so to NDVI; outliers for Nadym showed lower than expected NDVI values, probably due to the dominance of highly reflective lichens. A key result is that, even along this transect of approximately 500 km, the heterogeneity of vegetation properties within a location can be greater than that over the entire transect.

In addition, I present on overview of four simulation models used in examining arctic tundra and boreal forest vegetation and ecosystem dynamics in the context of both "the greening of the Arctic" and land-cover, land-use change. (1) The ArcVeg (Epstein, Yu) model simulates interannual variability and trends in tundra biomass and plant functional type composition, using a nitrogen mass-balance approach, and forced by climate, freeze-thaw disturbances, and herbivore grazing. (2) The BIOME4 model (Kaplan) simulates the circumpolar equilibrium changes in arctic tundra and boreal forest plant communities, using a plant functional type – ecophysiological approach, and forced by climate patterns and changes. (3) The TreeMig model

(Lischke) is a forest stand dynamics model, operated at the population and species level, that can analyze treeline migration through seedling dispersal and establishment mechanisms. (4) Last, a GCM-DVGM approach (Cook) was used to examine ecosystem-level responses to changes in climate, snow cover, and snow thermal properties for northern Eurasia systems.

Keywords: LAI, NDVI, vegetation biomass, plant foliar nutrients, vegetation dynamics modeling

Dynamic Modeling of Circumpolar Arctic Biogeography and Biogeochemistry and Vegetation-Permafrost Interactions

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Abstract

Climate-induced land cover change in the Arctic may be strongly influenced by edaphic and plant demographic factors, perhaps more than any other terrestrial ecosystem. These factors include the interplay between permafrost and vegetation, and the role of plant succession and migration influenced by seed production, dispersal and establishment. Understanding the effect of ongoing climate change on the land cover of the Arctic, and the potential for biophysical and biogeochemical feedbacks of land cover change to the climate system, requires dynamic vegetation models that incorporate these external mechanisms as well as a comprehensive description of tundra plant types. To quantify these two different aspects of the response of Arctic vegetation to climate change, we have developed and applied two dynamic vegetation models in a series of experiments. We applied the TreeMig dynamic, spatiao-temporal vegetation model along a latitudinal transect in central Eurasia to estimate the effect of climate warming on the northward encroachment of the boreal forest into areas currently occupied by tundra. Dispersal-limited model simulations indicate that particularly under scenarios of intense future climate warming in the Arctic, vegetation remains out of equilibrium with climate for several centuries, with the northward advance of the treeline retarded by several hundred km. In order to quantify the effect of permafrost on tundra biogeography and biogeochemistry, we developed a new dynamic vegetation model (WSL-DGVM) with a complete description of soil thermal properties to ~70m depth and an extended description of tundra plant functional types. Preliminary results with the WSL-DGVM indicate that vegetation cover itself may play an important role in influencing permafrost dynamics, with the buildup of biomass in response to climate warming resulting in a negative feedback to active layer depth. Furthermore, model results suggest that the influence of permafrost dynamics on surface hydrology has important implications for CO_2 and methane emissions from tundra soils. Future work will include incorporating the strengths of both vegetation models into a comprehensive framework that includes both the biogeochemical effects of permafrost and plant migration.

Keywords: Arctic biogeochemistry; Boreal forest; DGVM; Land-atmosphere interactions; Plant migration; Tundra

Modeling Arctic Tundra Vegetation Dynamics in North America and the Yamal Region of Russia

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Abstract

Arctic tundra is undergoing dramatic changes in both North America (NA) and the Yamal region of Russia due to human activities and climate change. Direct observations from field studies indicate that there are more woody shrubs in the High Arctic, and more tall shrubs and even trees in and the Low Arctic. However, the controlling factors and to what extent arctic tundra is affected under a changing climate is still under investigation.

In this study, we applied a nutrient-based transient vegetation dynamics model (ArcVeg) to simulate two different typical arctic tundra ecosystems in North America and the Yamal region of Russia. We first validate our model using total and species biomass from field measurements. The model results and field data are relatively consistent both on the species level and in total biomass, indicating our model is making reasonable predictions. Second, due a present lack of soil organic nitrogen data from the Yamal region, we extrapolated soil organic nitrogen for the Yamal using the ratio from field soil data in Alaska and soil organic nitrogen data from an IGBP global soil survey. We also assumed that for NA, caribou tend to graze more randomly and less frequently than the managed reindeer in the Yamal region. These differences are reflected in our simulation parameters. For the Yamal region, we assumed that Subzones C, D and E (Mid- and Low-Arctic) are grazed more intensely than Subzones A and B (polar desert and High Arctic), which are off the mainland peninsula. We used two parameter combinations: for NA and Subzones A and B in Yamal, (0.1, 25%) indicating the system would be grazed every ten years, and 25% of plant biomass was removed by grazing; for Subzones C, D and E in Yamal, (0.5, 50%) 50% of plant biomass is removed every two years. In general, tundra in both NA and Yamal for all subzones responds to climate warming scenarios with increasing total aboveground biomass. In both regions, woody plant biomass increases with warming. In Subzones C, D and E in the Yamal region, there are fewer abundant plant functional types and less biomass compared to the same subzone in NA, due to heavy grazing by reindeer herds.

Key Words: vegetation dynamics modeling, ArcVeg, biomass, climate change, soil nitrogen, caribou, reindeer grazing

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