Yamal lakes (Siberia): properties derived from optical and SAR remote sensing

Yury A. Dvornikov (1,2), Marina Leibman (1,3), Birgit Heim (2), Annett Bartsch (4,5,6), Artem Khomutov (1,3), Barbara Widhalm (4,5)

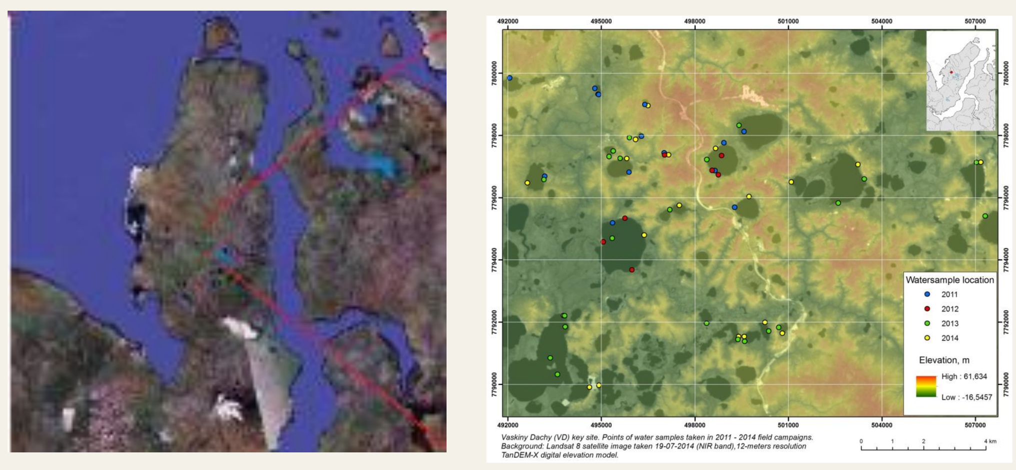
1 – Earth Cryosphere Institute Siberian Branch Russian Academy of Sciences, Tyumen, Russia; 2 – Alfred-Wegener-Institute for Polar and Marine Research, Potsdam, Germany; 3 – Tyumen State University, Russia; 4 – Austrian Polar Research Institute, Austria; 5 - Zentralanstalt für Meteorologie und Geodynamik, Austria; 6 -Technical University of Vienna, Austria

Introduction

Climatic and environmental fluctuations in the permafrost zone lead to activation of various cryogenic processes. This activation results in a strong redistribution of substances and changes in biochemical composition of the water bodies. Lakes in the Arctic are good indicators of changing natural conditions. These indicators are expressed in both: areal changes of thermokarst lakes, and changes in biochemical composition of water.
Thus, we analyze the interconnection between water bodies and their catchments on Yamal peninsula in temporal and spatial extent. Main objective of this research is to study which processes affect the quality and quantity of dissolved organic matter in the water bodies across the Yamal peninsula (central, eastern and coastal parts) in the continuous permafrost zone. The studies are based on batymetric in-situ measurements and water sampling, optical and SAR remote sensing, and topographic data analysis.


Climatic and environmental fluctuations in the permafrost zone lead to activation of various cryogenic processes. Photo by Author 2013, 2014 thermocirque.

Study area



Location of the study area in Central Yamal

Central Yamal has widely distributed tabular ground ice. Tabular ground ice degradation results in the formation of deep lake basins. There is a wide range of different lake types, small water bodies on river floodplains up to large lakes on higher older morphological terraces composed of marine sediments and on old river terraces. The landscape is strongly dissected by river network and landslides.

The long-term monitoring site Vaskiny Dachi (VD) is located in central Yamal, close to the Bovanenkovo gas field. The Circumpolar Active Layer Monitoring CALM site VD was established by Leibman M.(ECI) in 1993 and is part of the Global Terrestrial Network for Permafrost, GTN-P. ECI has ongoing cooperations with US, Finnish, Austrian and German institutions (e.g., AT/RU COLD-YAMAL, DE/RU DAAD/OSL POLYAR). First water sampling at VD started in 2011, then continued in 2012, 2013 and 2014 with including a large number of different lake types.

Acknowledgements

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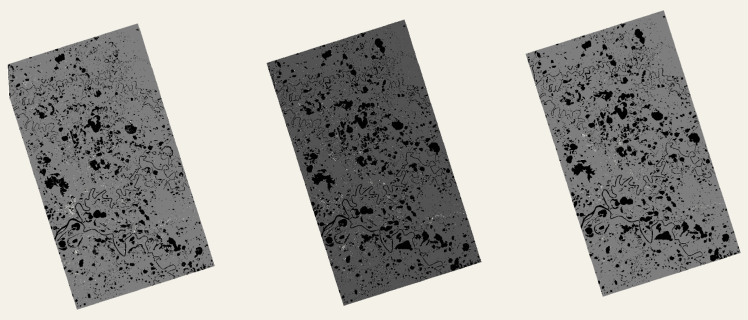
RSF Russian Science Foundation
Russian Foundation for Basic Research RFBR
DAAD Deutscher Akademischer Austausch Dienst German Academic Exchange Service
POLMAR Helmholtz Graduate School for Polar and Marine Research

Lake extent analysis

To analyze lake extent dynamics we used radar remote sensing data TerraSAR-X. The water bodies detection algorithm is based on a TSX time series establishing a threshold value. Inter-annual changes in lake extent is highly pronounced for floodplain lakes and occur less for lakes located in higher geomorphic levels.



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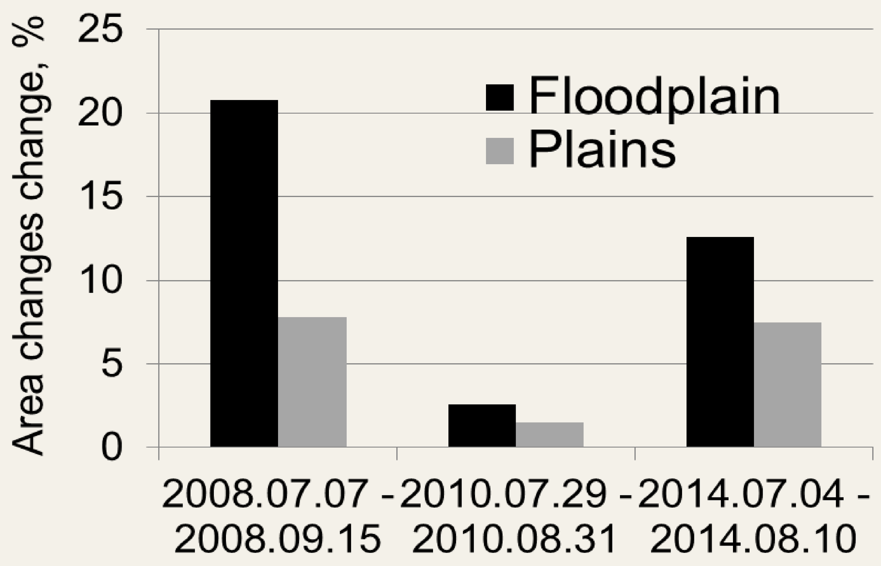
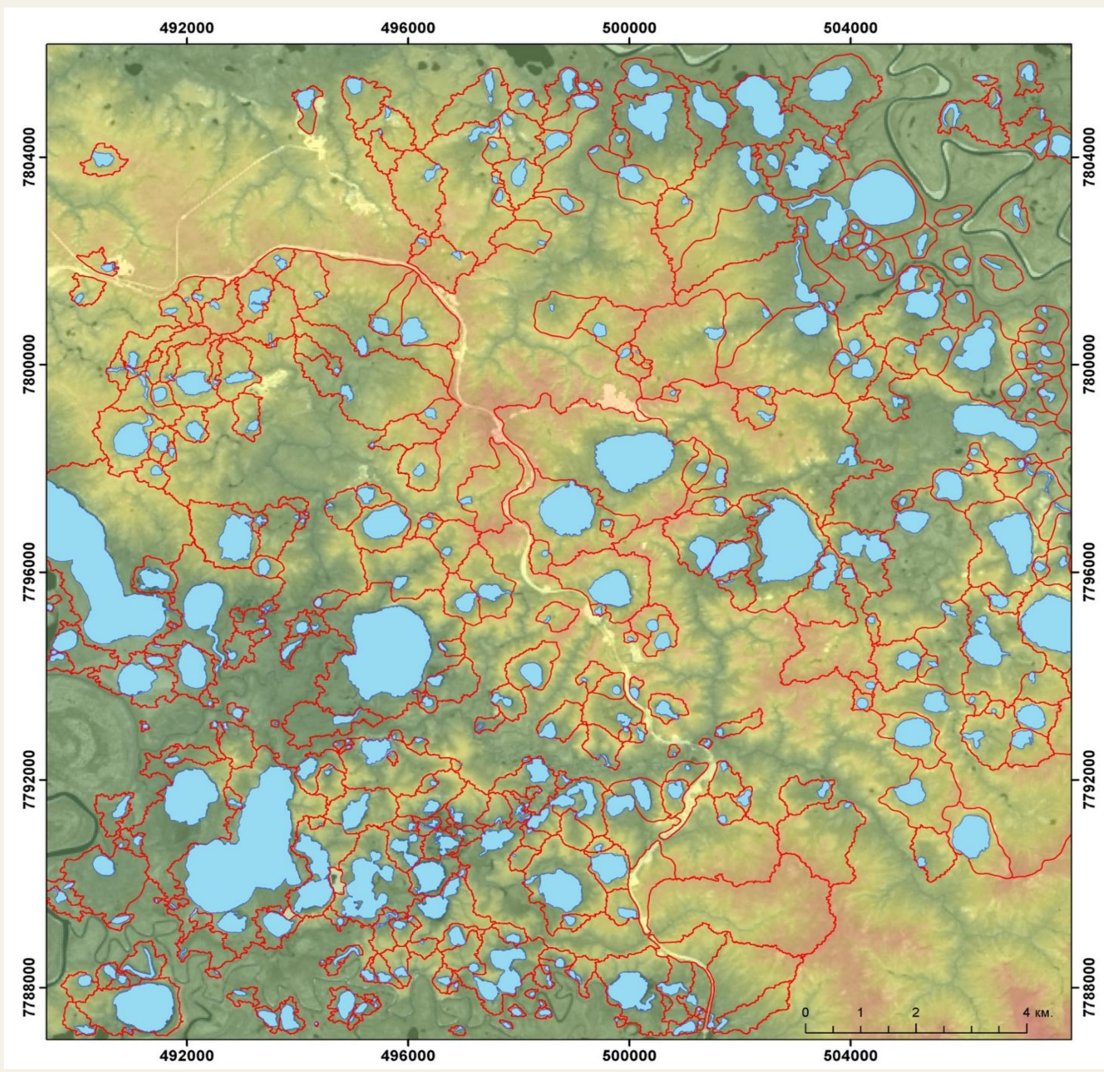


Area changes (%) of lakes located on high geomorphic levels versus the floodplain lakes of Mordy-Yakha and Se-Yakha rivers.

Catchment delineation

In order to understand the matter transport in lake – catchment systems of the study area, vector polygons of lake catchments are required.



catchments

High resolution (12m) TanDEM-X IDEM was used to derive the lake catchments using i) the flow direction raster model in ArcHydro (Djokic et al. 2011) and then ii) delineate the catchment polygons. All automatically calculated catchment areas were manually corrected in case if there were outflows from the lake

Acknowledgements

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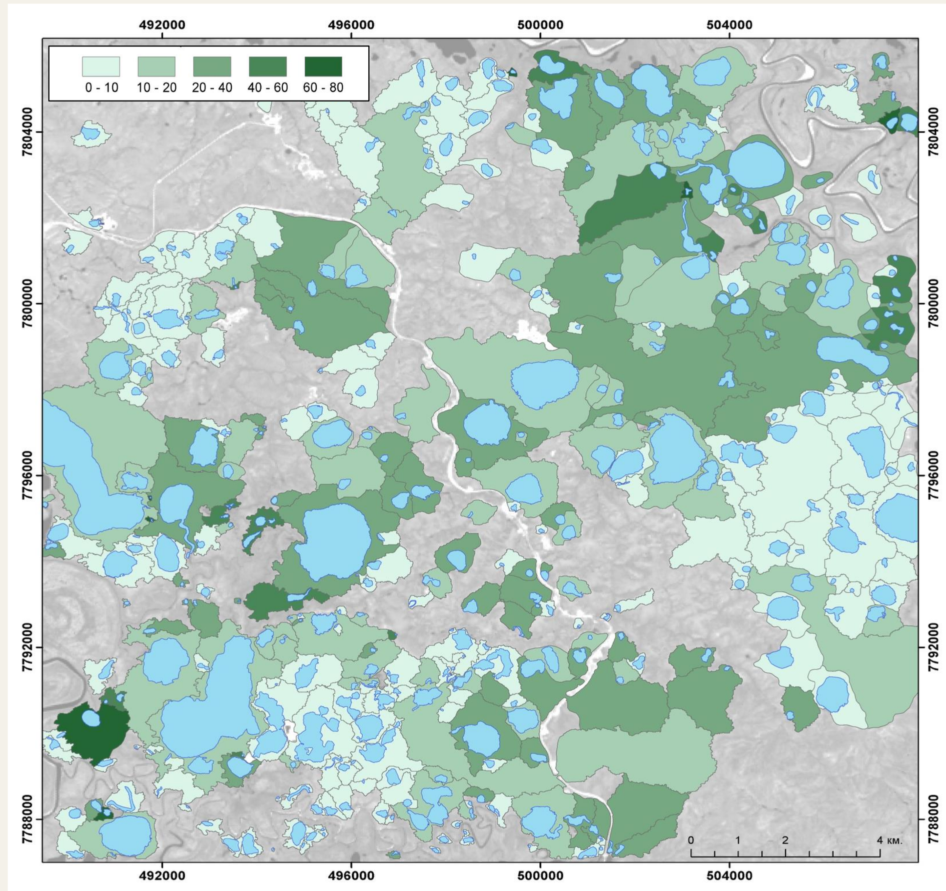
Catchment based approach - vegetation

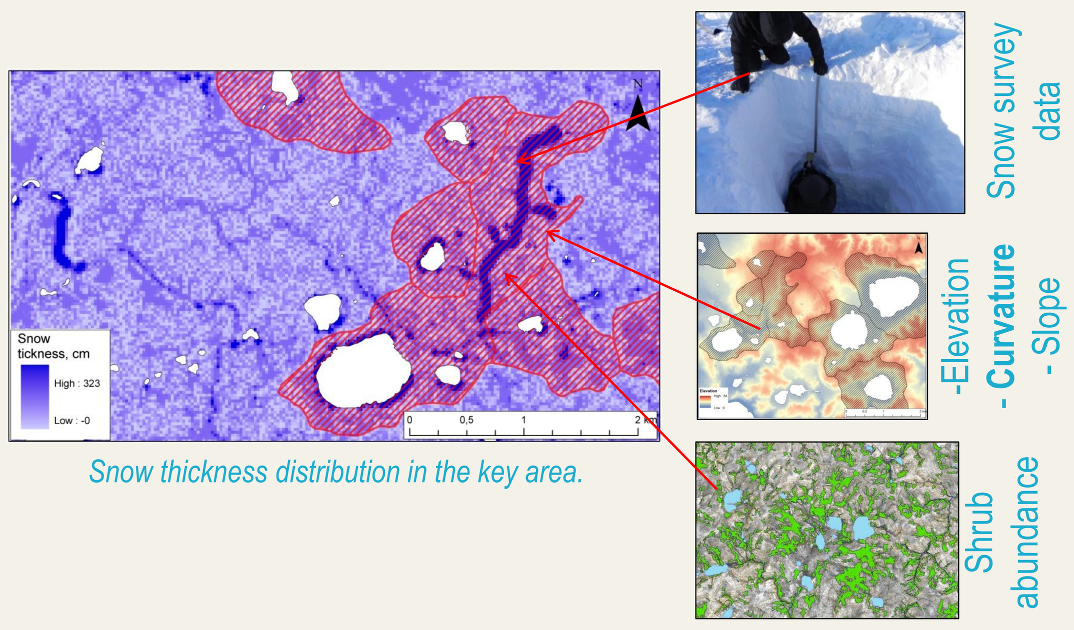
The ALOS PALSAR satellite data was used to create a shrub map for the study area and derive the percentage of shrub coverage within the catchments. Processed ALOS PALSAR data was used to extract the polygons of high shrubs applying the threshold of -25dB. The shrub percentage is calculated as the ratio of area covered by high shrubs and the area of the catchment.



Multispectral 10 meters resolution SPOT-5 image was used to calculate the median NDVI and CHL values for 363 catchments.

Catchment based approach - snow

It is assumed that the more snow is in catchment the more active erosion processes will be in spring season and more matter can be transported into the lakes. To analyze a snow distribution in catchments an approach for snow water equivalent (SWE) spatial mapping for tundra landscapes has been developed. The methodology is based on statistical analysis of snow survey data and on GIS-analysis.



Snow thickness distribution in the key area.

Controls under study are: topographic surface properties (curvature, level, slope, and aspect), the presence of shrub vegetation, wind direction, participating in re-distribution of snow.

The curvature parameter is selected as the main factor to control snow thickness. It describes the surface properties from the viewpoint of the degree of convexity and concavity.

Contact Information

Yury A. Dvornikov
Earth Cryosphere Institute
Moscow, Russia
Alfred Wegener Institute
AWI, Potsdam, Germany

Tel: 007 - 9852879220
ydvornikow@gmail.com
yuri.dvornikov@awi.de