Proceedings: Students in Polar and Alpine Research Conference 2017

20 - 22 April • Brno, Czech Republic

Lenka Ondráčková, Klára Ambrožová, Klára Čížková, Filip Hrbáček and Jakub Ondruch (Eds.)

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PYRN Permafrost Young Researchers Network

Students in Polar and Alpine Research Conference 2017 - Preface

Lenka Ondráčková

Dear young polar scientists,
we were very happy to welcome you again at the "Students in Polar and Alpine Research Conference 2017" which was held on the ground of Department of Geography, Masaryk University, Brno, Czech Republic.

This has been the third year of the conference and we clearly face the conference is more attractive for students and young researchers every year basing on the numbers of participants. The conference organisation team enlarged, because our interests in Polar and Alpine research goes deeper and wider.

We were very glad to present four interesting keynote lectures at the conference, which covered various topics of Polar and Alpine sciences and were presented by world-wide experts in their scientific fields.

We received 34 abstracts, including four keynotes, focusing on geosciences and biosciences in Polar and Alpine regions, with 24 oral presentations and 10 posters. The conference lasted two days with six sessions and evening poster session and the field trip was planned for the third conference day. With participants we spent a great time at the margin of Moravian Karst, in Hády Nature Reserve with a beautiful view to Brno and its surroundings.

We believe that the interest of us, young researchers, in a Polar and Alpine research will further grow and we will meet at the Department of Geography, Masaryk University in Brno again in 2018.

In Brno, 20 April, 2017
Lenka Ondráčková

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Keynote section

Short-term geomorphological evolution of proglacial systems

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Proglacial systems within polar and alpine environments are amongst the most rapidly changing landscapes on Earth, as glacier mass loss, permafrost degradation and more episodes of intense rainfall progress with climate change. This presentation addresses the urgent need to quantitatively define proglacial systems not only in terms of spatial extent but also in terms of functional processes. It firstly provides a critical appraisal of prevailing conceptual models of proglacial systems, and uses this to justify compiling data on rates of landform change in terms of planform, horizontal motion, elevation changes and sediment budgets. These data permit us to produce novel summary conceptual diagrams that consider proglacial landscape evolution in terms of a balance of longitudinal and lateral water and sediment fluxes. Throughout, examples of newly emerging datasets and data processing methods because these have the potential to assist with the issues of: (i) a lack of knowledge of proglacial systems within high-mountain, arctic and polar regions, (ii) considerable inter- and intra-catchment variability in the geomorphology and functioning of proglacial systems, (iii) problems with the magnitude of short-term geomorphological changes being at the threshold of detection, (iv) separating short-term variability from longer-term trends, and (v) of the representativeness of plot-scale field measurements for regionalisation and for upscaling. It is considered that understanding of future climate change effects on proglacial systems in polar and alpine environments requires holistic process-based modelling to explicitly consider feedbacks and linkages, especially between hillslope and valley-floor components. Such modelling must be informed by a new generation of repeated distributed topographic surveys to detect and quantify short-term geomorphological changes.

How to unravel the chemical composition and distribution of soil organic matter in polar ecosystems

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A large number of studies predict changing organic matter (OM) dynamics in polar soils due to global warming. In contrast to rather slowly altering bulk soil properties, single soil organic matter (SOM) fractions can provide a more detailed picture of the processes involved in the fate of OM in polar regions. Although there is a large number of studies using physical soil fractionation for temperate soils, there are only scarce information on the distribution of OM in possibly differently stabilized fractions of permafrost affected soils. By combining bulk analytical methods (e.g. C and N analyses, NMR spectroscopy) with state of the art spectromicroscopic techniques (SEM, Nano-SIMS) it is possible to unravel processes stabilizing OC reaching from the formation of organo-mineral associations to soil aggregation. Although climatic stabilization due to reduced microbial decay at low temperatures is the most important factor in permafrost soils at the moment, in a warmer future this may change to other mechanisms, likely OC stabilization in aggregated soil structures and organo-mineral associations.

Radiative and dynamical influences on polar stratospheric temperature trends

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A detailed understanding of stratospheric variability and change is essential for our understanding of the climate system, and since the detection of the Antarctic ozone hole in the late 1980s the state of the Earth's stratosphere has received much attention. Especially changes in stratospheric composition and dynamics are of importance as radiative and dynamical heating rates control stratospheric temperatures. The state of the ozone (O_3) layer is of central interest in stratospheric research and it is well understood that chlorofluorocarbon induced O_3 loss has caused widespread cooling in the middle atmosphere over recent decades. Besides O_3, well-mixed greenhouse gases (WMGHG) such as CO_2, CH_4 und N_2O are of particular importance. While radiative forcing due to WMGHG is positive in the troposphere, their increase causes cooling at higher levels, particularly in the upper atmosphere. Stratospheric cooling influences the stability of the polar vortex and has been shown to significantly alter the large-scale atmospheric circulation. Today it is well understood that changes in stratospheric composition and stratosphere-troposphere exchange have important implications for surface climate variables. While concentrations of ozone depleting substances are projected to decline to pre-1980 values over the course of the 21st century, concentrations of WMGHG are projected to rise under the IPCC's representative concentration pathways. Thus quantifying the radiative and dynamic contributions to past, present and future stratospheric temperature trends is essential for our understanding of the stratosphere's role in the climate system. In this presentation, I will illustrate the role of O_3 depletion and increasing WMGHGs for radiative temperature trends in the Polar regions, quantify radiative and dynamical contributions to observed temperature trends, and present selected aspects of ozone-climate connections from recent modeling studies.

Antarctic glacier snowpack ecology

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Melting snow contributes to about 83%, of all surface and near-surface melting in Antarctica and the magnitude of the melt is now occurring at an unprecedented rate relative to the last 1000 years in the Antarctic Peninsula region. Yet, there are so few insights into how biogeochemical and biological processes are enhanced by this melting that we have little idea of its impacts. In this project, we tried to quantify changes in *in-situ* microbial processes in order to address the enormous uncertainty that exists with respect to how the export of labile nutrients and viable microorganisms by runoff might influence downstream terrestrial and marine ecosystems in South Orkney and South Shetland Islands.

We coupled optical techniques and measuring of biological production from radiolabel incorporation with monitoring of chemistry and microbial diversity in order to draw a new insight into the ecology of maritime Antarctic snowpacks. Our observations revealed significant heterogeneity within the snow: e.g metre-scale patchiness influenced by allochthonous nutrient inputs from marine fauna and dust in the South Orkney Islands. In addition, there was a marked difference in the microbial biomass and community composition of coastal snow patches compared with that found on nearby (and more expansive) glacial snowpacks in the South Shetland Islands. Overall, chemical and physical properties of maritime Antarctic snow are intricately linked to its resident microbial ecosystem.

We have also observed the development of extreme chemical conditions at the base of the snowpack (where many microorganisms are initially present during the summer) and harsh abiotic conditions that can prevent the surface manifestation of snow algae and other photoautotrophs due to burial and impose water supply restrictions due to refreezing. It will be demonstrated that these greatly influence net ecosystem production measurements and, along with photochemical transformation of organic carbon, mean that the estimation of biological production from snowpack and/or boundary layer CO_2 profiles is extremely difficult to achieve. Our findings also showed that glacier meltwater runoff export high quantities of filterable (6–81 kg km^{-2} a^{-1}) and sediment derived iron (27.0–18,500 kg km^{-2} a^{-1}) into the downstream terrestrial and marine ecosystems. As a consequence, iron supplied by glacial weathering results in pronounced hotspots of biological production in an otherwise iron-limited Southern Ocean Ecosystem.

SPARC 2017
Participant section

Factors affecting the formation and development of air temperature inversions in Antarctic Peninsula region in the autumn

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Keywords: James Ross Island, Antarctic Peninsula, temperature inversion, vertical profile

Stable stratification is a very persistent feature in polar regions, although with decreasing latitude, a shallow convective boundary layer can develop, especially in summertime (Nygård et al., 2017). Air temperature inversions possess a huge challenge for both climate and numerical weather prediction (NWP) models; nevertheless, their correct representation is important for the surface energy balance estimation. The spatial variation of air temperature inversion properties in Antarctica has been analysed in several studies; however, boundary layer characteristics can differ significantly over deglaciated areas. For both validation and refinement of climate and NWP models it would be beneficial to understand which factors contribute to air temperature inversion formation in Antarctica.

In this study, we analysed a surface-based air temperature inversion from the deglaciated part of James Ross Island (Antarctic Peninsula), which lasted between 21st and 23rd April 2012. The temperature difference between the top and the bottom of the inversion reached 13°C. The study was based on a set of three automatic weather stations located at 10, 155, and 375 m a.s.l. The inversion was investigated with relation to other meteorological surface variables (wind speed, wind direction, global and reflected short-wave radiation), sea ice (Meier et al., 2016), and regional-scale atmospheric circulation conditions (ERA-Interim, Dee et al., 2011). The analysis revealed that both thermal advection and adiabatic compression played an important role in the formation of the air temperature inversion. It was also found that the lowest air layer got decoupled, as was clearly seen from the wind speed and wind direction measurements.

Acknowledgements

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Nadir and Limb satellite measurements on polar mesospheric clouds

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Keywords: polar mesospheric clouds, SCIAMACHY, GOME, GOME-2, nadir, limb

Polar mesospheric clouds (PMCs) were first observed in 1885 after the eruption of Krakatoa. The optically thin PMCs are found at latitudes poleward of about 50° in an exceptionally cold region of the atmosphere, which can be found near the summertime mesopause, i.e. at the height of 80 to 85 km. Satellite measurements provide a long term global picture of PMC properties. In the nadir mode, the air volume directly below the satellite is observed with a good spatial resolution, so that PMC occurrence rates can be acquired. In the limb observation mode, the atmosphere is observed tangentially. This mode yields a better height resolution and is commonly used to obtain cloud particle sizes. Attributes like the mean size and the size distribution of the cloud particles are still heavily debated. The mean particle size as determined by different studies varies between 20 and about 100 nm (DeLand et al., 2006).

In this study, we examined radiance data in the 260 to 300 nm range, which were measured in the limb viewing geometry of the SCIAMACHY satellite instrument (2002–2012). For the comparison with other studies, the PMC occurrence rate and particle radius were investigated. The ratio of PMC detections versus the total number of measurements yielded the PMC occurrence rate. Particle sizes were determined by calculating the so-called Angstrom exponent for a log-normal particle size distribution with $\sigma = 1.4$. Lookup tables (Baumgarten et al., 2007) provided the connection between scattering angle, Angstrom exponent, and particle radius. Furthermore, we investigated the influence of ozone in the line of sight of SCIAMACHY, as well as the influence of different solar spectra on the determination of PMC particle size.

For latitudes between 70° and 80°, the PMC occurrence rate increased from 0% to up to 80% in the 20 days before the summer solstice, then it reached a plateau, and began to decrease about 30 days after the summer solstice. The PMC occurrence rates at lower latitudes behaved in a similar way, but with lower amplitudes. This depicted the progress of the yearly PMC season and it was in very good agreement with other studies (Robert et al., 2009; DeLand et al., 2006).

Assuming a fixed solar spectrum by Skupin et al. (2003) and disregarding the influence of ozone, we found particle sizes of about 60 nm that were largely independent of latitude. When using the daily solar spectra measured by SCIAMACHY, the particle size showed a more realistic variation throughout the season. With the additional influence of ozone, the mean particle size increased by about 5 nm.

In addition to the limb scattered light study, we did an experimental study on PMC detection in the nadir viewing geometry. Therefore, we applied an algorithm that was already validated to work with SBUV/2 data by DeLand et al. (2003) and Benze et al. (2009) using the datasets of the satellite instruments SCIAMACHY, GOME and GOME-2. In the case of SCIAMACHY, it could be shown that the PMC occurrence rates increased significantly during the PMC season and with increasing latitudes. The satellite instrument GOME showed seemingly random variations in the occurrence rate over time. As the variations were apparently unrelated to the PMC season throughout the entire mission, it can be stated that the PMC detection with GOME is not possible. For GOME-2, only the data from July 2012 were available, but showed higher PMC occurrence rates at higher latitudes: the occurrence rates were in very good agreement with the expectations.

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Changes of the proglacial lakes in the Kaunertal between 1953 and 2016

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Keywords: proglacial lakes, Kaunertal

Proglacial lakes occur in high-mountain environments and are formed by the retreat of glaciers. They can be found in topographic bedrock depressions or in the areas behind moraine dams, which inhibit runoff and retain water and sediments. For proglacial regions, special morphodynamics and permanent changes are typical. The velocity of the changes depends on natural conditions (e.g. permafrost), and on the location in the sediment-supplying catchment area. Therefore, they are good indicators of climate changes and sediment dynamics in the catchment area (Otto, 2017).

The paper about the changes of proglacial lakes in southern Kaunertal, Tyrol, Austria, is structured as follows: an inventory of proglacial lakes, an analysis of the formation and decay of the lakes, and an analysis of alterations and influencing factors of these.

Based on orthoimages from the period of investigation between 1953 and 2016, changes in appearance, morphology and size of the lakes will be analysed and correlated to processes induced by glacier melting and permafrost degradation. Data of permafrost distribution in Kaunertal exist in the form of field data from geoelectrical measurements (Dusik, 2013), there are also data acquired by the empirical statistical model PERMAMAP (Hoelzle, 1992).

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Investigation of plant reproduction systems in Himalayas using flow cytometric seed screen

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Keywords: apomixis, Himalayas, FCSS

Apomixis is a specific way of asexual plant reproduction by seeds. It is hypothesised that in stressful ecological conditions, such as in high altitude or latitude, it may be advantageous to turn from sexuality into apomixis. However, this hypothesis has seldom been tested. To test this hypothesis, we collected seeds of angiosperms from Indian Himalayas, Ladakh, which represent an extreme environment; vascular plants reach there the highest elevations in the world.

The seeds were analysed by the method of flow cytometric seed screen (FCSS); the breeding system was inferred from the ratio of the embryo and endosperm ploidy levels.

Altogether, 232 species were analysed. 3 species had no clearly legible signals, so some modification of the method would be needed. 44 species had no detectable endosperm and the reproduction system could not be assessed. 176 species showed the sexual way of seeds formation, and 9 species were clearly apomictic. Out of the nine apomictic species, five belonged to the genus *Potentilla* (namely *P. gelida*, *P. pamirica*, *P. sericea*, *P. sojakii*, and *P. venusta*); other apomictic species were *Biebersteinia odora*, *Poa attenuata*, *Ranunculus membranaceus*, and *Stipa splendens*. All the apomictic species showed pseudogamous development of seeds; with the exception of *Stipa splendens*, where autonomous endosperm was rarely present.

Analysed apomictic species

Potenilla spp.: all apomictic species showed pseudogamous development of seeds, the endosperm/embryo ratio was mostly estimated as 6:2 (unreduced pollen or pollination with both reduced sperms).

Poa attenuata: the species had seeds created by pseudogamous apomixis, the ratio was always 5:2 (reduced pollen).

Ranunculus membranaceus: the species showed the ratio 6:2, which indicates pseudogamy.

Stipa splendens: the endosperm:embryo ratios indicating autonomous and pseudogamous apomixis were observed; moreover, under pseudogamy, the ratio varied between 5:2 and 6:2.

Biebesteinia odora: this species was mostly pseudogamous; however, the way of fertilisation varied between individual seeds. The usual endosperm:embryo ratios 5:2, and 6:2 were observed. One seed probably originated by the sexual-like fertilisation of unreduced embryo-sac by unreduced pollen: endosperm and embryo showed the ratio 3:2. Based on the comparison of the ratio to the internal standard, the embryo was 4C. We also revealed seeds where triploid sperm cells might have been participating (from the other plants in the population – ploidy variation present?).

The results indicate that there was no affinity of apomictic species to high elevations; apomixis was rather bound to certain taxonomic groups. In the genera *Potentilla*, *Ranunculus* and *Poa*, apomixis is well-known even from low elevations. There was no record of apomixis in *Stipa*; however, in the family Poaceae, many apomictic species were present. *Biebersteinia odora* (Biebersteiniaceae) was the only species in which the occurrence of apomixis was unexpected; however, this small family is little known and data on reproduction systems are missing.

The intercomparison of brewer spectrophotometer and satellite total ozone measurements at the Antarctic Marambio base in 2011–2013

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Keywords: total ozone column, Antarctic Peninsula, brewer spectrophotometer, OMI, GOME-2, SCIAMACHY

In Antarctica, severe stratospheric ozone losses have been observed every austral spring since the 1980s (Farman et al., 1985). Stratospheric ozone monitoring is extremely important because the ozone layer blocks much of the harmful solar UVB radiation. This study aims to provide the comparison of various total ozone column (TOC) data products available for the Marambio Base, Antarctic Peninsula. The Marambio Base is a permanent Argentine Antarctic station located on the Seymour Island to the north of the Antarctic Peninsula region (64°14′27.65″S 56°37′36.31″W, 196 meters above sea level). At this station, numerous scientific activities are carried on, including ground-based TOC monitoring.

For the period 2011–2013, ground-based TOC monitoring by the Brewer spectrophotometer B199 and three different satellite products have been compared. B199, owned by the Czech Hydrometeorological Institute, was installed at the Marambio Base in February 2010. Since then, regular TOC observations have been carried out several times a day. The Brewer spectrophotometer can only perform measurements when the solar elevation is greater than 10°, which means since mid-August to the end of April at the Marambio Base (Metelka et al., 2016). The first satellite TOC data product covered by this study was obtained by the Ozone Monitoring Instrument (OMI), which is installed aboard the NASA Aura Satellite launched in July 2004 (Levelt et al., 2006). The second satellite TOC data product was acquired by the instrument Global Ozone Monitoring Experiment 2 (GOME-2) flying on the MetOp series of satellites, which were launched in October 2006 (MetOp-A) and in April 2013 (MetOp-B). The launch of MetOp-C is currently planned for the year 2018 (Munro et al., 2016). The third satellite TOC data product was obtained by the Scanning Imaging Absorption Spectrometer for Atmospheric Cartograhy (SCIAMACHY) on ESA Earth observation satellite platform ENVISAT, which was launched in March 2002 (Bracher et al., 2005). In the period 2011–2013, up to four data records from OMI and GOME-2 were available for most of the days since the beginning of August to the end of April. The SCIAMACHY data records were only available from January 2011 to the beginning of April 2012. Therefore, there are in total 743 days for OMI, 753 days for GOME-2 and 320 days for SCIAMACHY, in which both the B199 and satellite TOC observations were available. For each of these days, a B199/satellite ratio was calculated.

In the studied period, the GOME-2 and the SCIAMACHY satellites overestimated the mean TOC by about 1%, while the mean TOC from OMI differed by less than 1% from the B199 observations. In extreme cases, the overestimation of the satellite data products reached up to 44% (OMI), 52% (GOME-2), and 31% (SCIAMACHY). When the solar zenith angle was higher than approximately 80°, all the satellites overestimated the mean TOC of a given month (August and April), and also the variability of the B199/satellite ratios was rather high and the coefficients of determination between the daily satellite and B199 TOC ranged from 0.41 to 0.68. The only exception was SCIAMACHY, which showed a very low variability and a high coefficient of determination (0.86) between the daily satellite TOC and B199 data in August. The B199/satellite ratios displayed a high variability also in October (and, in the case of SCIAMACHY, November), when the polar vortex starts to break down each year. In austral summer (December, January, February), the satellite TOC records showed a very good agreement with B199 data, low variability and high coefficients of determination (0.79–0.91).

In conclusion, out of the three studied satellite products, both OMI and GOME-2 seem to be very reliable for the Antarctic Peninsula conditions. On the other hand, SCIAMACHY showed a lower degree of agreement with the ground-based TOC observations during the austral spring months and is therefore not very reliable for studying the spatial differences in the stratospheric ozone over Antarctica. The OMI and GOME-2 data products may be very helpful for various studies when ground-based TOC observations are not available. However, the results must be handled with care, especially when the solar zenith angle is high and the satellite TOC tends to be overestimated compared to ground-based observations.

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Individual analyses of atmospheric aerosol particles north of the Arctic polar circle

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Keywords: aerosol particles, gravimetry, transmission electron microscopy, scanning electron microscope, energy dispersive X-ray spectroscopy

This project will focus on the study of aerosol particulate matter of a diameter smaller than 10 micrometres (PM10) in a clean environment. Sampling will take place at ALOMAR station (Artic Lidar Observatory for Middle Atmosphere Research), located 300 kilometres north of the Arctic circle, in the region of Andenes, Norway. In this region, there will be a lower quantity of contaminated particles due to its remote location, far away from any form of industry.

The first expedition will take place from 12th March to 25th April 2017. The second expedition is planned for 8th June to 20th June 2017.

The sampling will be done using a polycarbonate membrane filter connected to a suction system. The filter will be weighted before and after the collection. Subsequently, the filters will be transported back to the University of Beira Interior and prepared for analysis.

The aerosol particles concentration, size distribution, chemical composition, and morphology will be analysed by the following techniques: gravimetric analysis, Transmission Electron Microscopy (TEM), Scanning Electron Microscope (SEM), and Energy Dispersive X-ray Spectroscopy (EDX).

The data obtained in situ will be studied together with the columnar data acquired by a solar radiometer CIMEL located at the same station. The relationship between the data attained at the ground level and the columnar measurements will help to develop algorithms, which will be used by a new generation of radiometers, which will be able to function during the polar night (lunar radiometers).

Weather patterns in Longyearbyen area (Svalbard) in early spring 2016: the students' case study

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Keywords: weather, synoptic situation, microclimate, Svalbard, Arctic

The Spitsbergen Island as a part of the Svalbard Artic archipelago is a frequent destination of scientific expeditions studying meteorological (e.g.; Kejna and Dzieniszewski, 1993; Rachlewicz and Styszyńska, 2007; Láska et al., 2013) and climatological (Hanssen−Bauer et al., 1990; Bednorz and Kolendowicz, 2010) conditions. Within the Polar ecology course (geosciences), several students of Masaryk University and Charles University observed and analysed weather patterns in the period from 20th March to 4th April 2016 in the Longyearbyen area. The aim of this paper is to introduce the basic results of the students' measurements and analyses. For this purpose, a simple automatic weather station (hereafter AWS) was installed in Endalen Valley. The AWS measured air temperature, snow temperature, and global and reflected radiation from 27th March to 3rd April 2016 (Figure 1). The results of these measurements were compared with data from the Adventdalen AWS managed by the University Centre of Svalbard. The location of the Endalen AWS on a steep slope of a narrow valley proved to have the greatest influence on global and reflected radiation in comparison with the Adventdalen AWS. Moreover, the data related to air pressure, relative humidity, wind speed, and wind direction from Adventdalen AWS (Figure 2) served together with our own measured results to evaluate the weather patterns of the Longyearbyen area. An anticyclone connected with very low air temperatures decreasing to -23.4°C and cloudless sky influenced the first half of the studied period. On the other hand, higher daily air temperatures, mild thaw and cloudy sky accompanied the passage of an occluded front described in the second half of the expedition. This case study enabled several students to deepen their knowledge about meteorology in the Arctic region and acquire the skills related to the operation of AWS and data processing.

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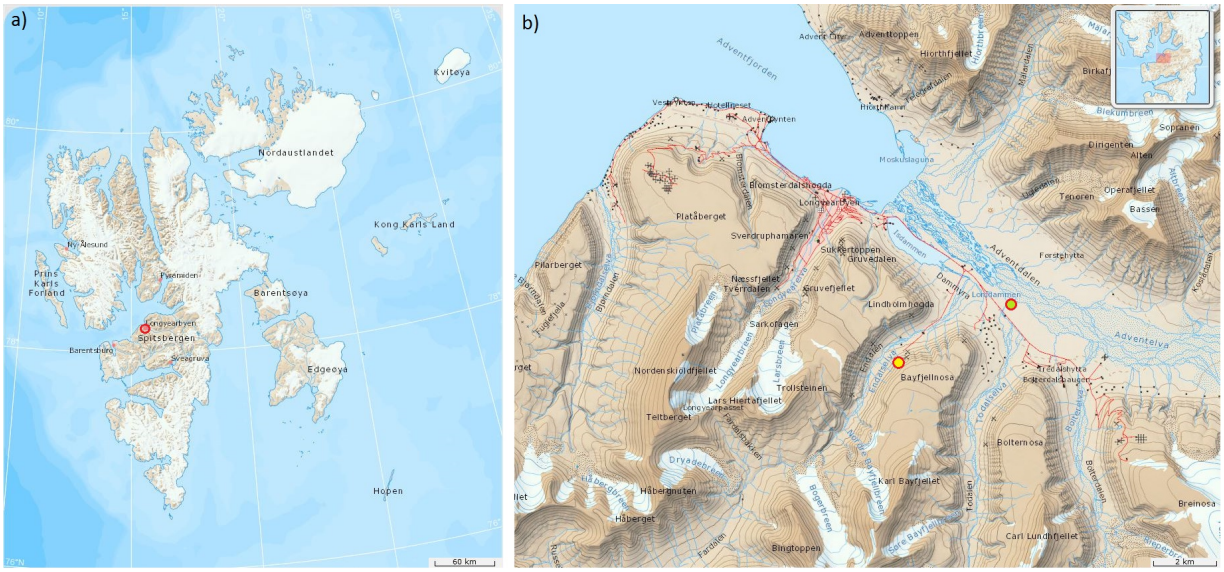

Figure 1 Location of Longyearbyen on Svalbard Artic archipelago (a) and Adventdalen and Endalen automatic weather stations (b). Source: toposvalbard.npolar.no

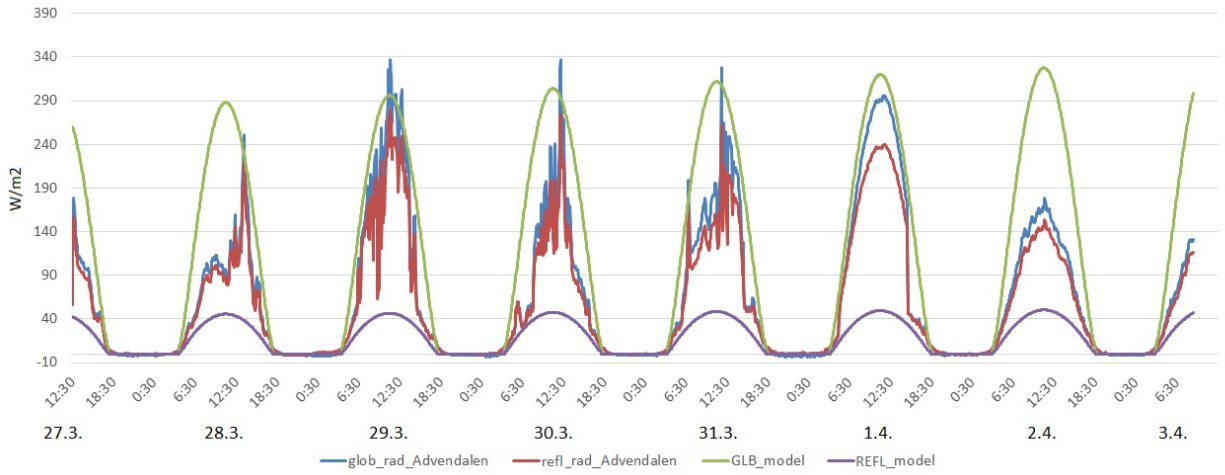

Figure 2 Measured global and reflected radiation at the Endalen automatic weather station and model of global and reflected radiation under clear sky calculated for the Adventdalen automatic weather station.

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The Eco-Grid of Ny-Ålesund: a multidisciplinary approach to investigate the climate change effects in the Arctic

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Keywords: permafrost, active layer thickness, spatial distribution, CALM grid, snow cover

Since the mid-20th century, climate change (CC) has led to significant impacts in the Arctic, with increases in air and permafrost temperatures, snow cover decrease, and glacier retreat. The Arctic ecosystems play a key role in the global carbon cycle because northern permafrost soils account for approximately 50% of the estimated global belowground organic carbon pool. To monitor the effects of the CC at a local scale, a new multidisciplinary approach has been started in Ny-Ålesund since 2014. Here, close to the Climate Change Tower (CCT), which is a 30 m high tower designed to monitor energy balance and fluxes, a grid of 50 x 50 m at 55 m a.s.l. was established. The grid has 36 nodes with a span of 10 m. In each node, a snow stake and a vegetation plot of 1x1 m are installed. The snow stake is used to monitor the snow variability through a snow cam installed on the CCT. The vegetation plot serves the monitoring of vegetation changes such as coverage, species richness and composition and structure, through vegetation surveys performed every year. In addition, the soil in each node was investigated by measurement of the surface grain size, the height of vegetation mats, organic horizon thickness and grain size, water content, pH and organic matter content in the topsoil.

In 12 of the 36 nodes, a borehole with a depth ranging between 79 and 101 cm was equipped with 4 thermistors (accuracy of ± 0.2°C), which were placed at 2, 30, 60 cm and at the bottom of the borehole. The thermistors record the mean ground temperature every 30 minutes. The classical frost probing method of active layer thickness measurement is not applicable here due to the coarseness of the sediments. Finally, CO_2 fluxes measurements with an IRGA system at the scale of the vegetation plot were carried out in summer 2016 and will be analyzed to assess the spatio-temporal variation of CO_2 uptake in different vegetation communities.

Despite the relative morphological homogeneity of this almost flat area, the ground surface and the vegetation show a quite strong spatial variability. The stoniness of the surface is very variable at the vegetation plot scale and ranges from 5 to more than 80%. The vegetation coverage in the same plots varies between 1–2% to 100%. The vegetation height varied from 1 to 8 cm and it was underlaid by an organic litter with the thickness between 0 and 3.5. The pH of the underlying topsoil differed between the plots with grass (4.95) and the plots with barren soil (7.1). The soil water content is also strongly variable, with values between 3% and more than 50%, and so is the thickness of the organic horizon A, which ranges from 0.4 to 7 cm. The prevailing grain size of the soil is the medium-fine sand, although in some cases gravel and pebbles exceed 80%, while the silt and clay never reach 30%.

In addition to the snow cam, the snow variability was also measured manually several times, especially from the maximum accumulation to the melt. During the maximum accumulation in winter 2014/15, snow height ranged between 115 and 65 cm, while during the last week before the onset of melt, it ranged between 98 and 42 cm. The snow melt period, indicated by the zero curtain effect on the surface, ended between the first and the third week of June, with the difference among the 12 plots exceeding 20 days. The first data of ground surface temperature (GST) are from the period 25th July 2014 – 17th July 2015 and they are very variable with an annual mean range between -0.7 and -3.6°C. Vegetation type and snow characteristics seem the most effective factors in the GST differences. The active layer thickness (ALT), defined as the depth of 0°C isotherm, ranged between 117 and 194 cm during summer 2014. Despite the good correlation between GST and ALT, the soil characteristics also seem to be important in the ALT spatial variability.

Effect of recent regional cooling on active layer thickness in the Antarctic Peninsula region

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Keywords: active layer, permafrost, Antarctic Peninsula

The Antarctic Peninsula region constitutes one of the most rapidly warming areas on Earth. Since the 1950s, mean annual air temperatures locally increased by ca. 1.0 to 2.5°C (Turner et al., 2013). This increase resulted in the collapse of several ice-shelves, decreasing glacier volumes, areas and surfaces, as well as permafrost degradation and thickening of the active layer. However, a climate cooling started around 2000 in the northern Antarctic Peninsula region (Turner et al., 2016). Since 2006, glaciers and ice shelves started to record positive mass balances, sea ice expanded, snow cover became thicker and longer-lasting during the summer season (Oliva et al., 2017). In this contribution, we examine the effect of climate cooling on active layer thickness across the northern Antarctic Peninsula region based on studies published from this area over the last 5 years.

The thinning of active layer has been observed across the northern Antarctic Peninsula over the last years. In the South Shetlands, a thinning rate of ca. 1.5 to 2.0 cm year^{-1} has been associated with the prolonged duration of snow cover during summer months. Its presence prevented active layer thawing and, in some localities, even remained over the whole year. Despite active layer thinning, an increase of mean temperatures at the top of permafrost was also reported (de Pablo et al., 2017) In the eastern Antarctic Peninsula region, an active layer thinning rate of about 2.0 to 3.0 cm year^{-1} was detected on James Ross Island. Due to lower precipitation and limited snow accumulation in this area, the main factor driving the active layer thinning was the lower summer temperature recorded during the last decade.

Climate evolution during the last decade in Antarctic Peninsula region showed different reactions of cryospheric systems than during previous decades. In any case, taking into account the period spanning from the second half of the 20th century until now, the Antarctic Peninsula still remains one of the most rapidly warming areas on Earth. However, the future evolution of climate and its effect on active layer thickness in Antarctic Peninsula region remains hard to predict. As the current data showed, the cold period may have ended in 2016, as this year was the warmest ever recorded in the Eastern Antarctic Peninsula region.

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Elemental composition of Tardigrada and Rotifera in cryoconite sediment in Svalbard

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Keywords: ecological stoichiometry, cryoconite, Tardigrada, Rotifera

Cryoconite holes are oligotrophic habitats, with nutrient inputs restricted to atmospheric deposition, wind, melting, and autochthonous production (Fountain et al., 2004; Telling et al., 2012). Because of this, biota inhabiting cryoconite holes must have various strategies to survive in these unfavourable conditions (Guidetti et al., 2011; Marotta et al., 2012).

The top predators inside cryoconite holes are Tardigrada and Rotifera. The abundance of these animals varies on different glaciers, and the main factor influencing their distributions is likely food web structure. Rotifera are mainly bacterivorous, while Tardigrada mainly feed on algae, which implies the possibility of differential food composition as the mechanism for shaping these simple invertebrate communities (Vonnahme et al., 2015). We hypothesize that the elemental composition of Tardigrada and Rotifera can reveal differences in the supply of main nutrients (C, N, P) reflected by their body composition variability.

Samples of cryoconite from 4 glaciers in Billefjorden (Ebbabreen, Nordeskioldbreen, Fedinandbreen and Svenbreen) were collected in the summer of 2016 (July, August). Tardigrada and Rotifera will be isolated by Nycodenz® density gradient, and then the C:N:P ratios of these animals will be analysed. Isotopic analyses are also considered. The results will provide a new view into the study of macroinvertebrates living within cryoconite holes.

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Redox and biogeochemical processes inferred from permafrost porewater extractions

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Keywords: permafrost, biogeochemistry, methane, redox

The western coast of Spitsbergen, located in the zone of continuous permafrost, is kept relatively warm for its latitude by the north Atlantic current. This sensitivity to oceanic and atmospheric warming provides an early warning system for the response of permafrost to climate change. This response includes the release of stored organic carbon and nutrients, which can lead to increased greenhouse gas (GHG) emissions from Arctic wetlands. The aims of this study are to (i) investigate *in-situ* processes contributing to GHG emissions in shallow permafrost, and (ii) correlate the geochemical properties of these permafrost sediments with their potential to support GHG emissions.

The focus of this project is on three locations within 10 kilometres of Longyearbyen, Western Spitsbergen, Svalbard (Figure 1). All locations were covered by warm-based ice during the Last Glacial Maximum, and so it was only after the deglaciation around 10 000 years ago that permafrost aggraded.

After deglaciation, the following depositional environments typical of Svalbard formed: i) a sequence of raised beaches, formed due to isostatic rebound, and ii) a prograding delta overlain by aeolian sediments. Ice-wedge polygons and wetlands developed at all sites that were the subject of this study.

Each location was drilled to a depth of 2 metres. The extracted sediment cores were transported frozen and stored at -18°C. Cores were sub-

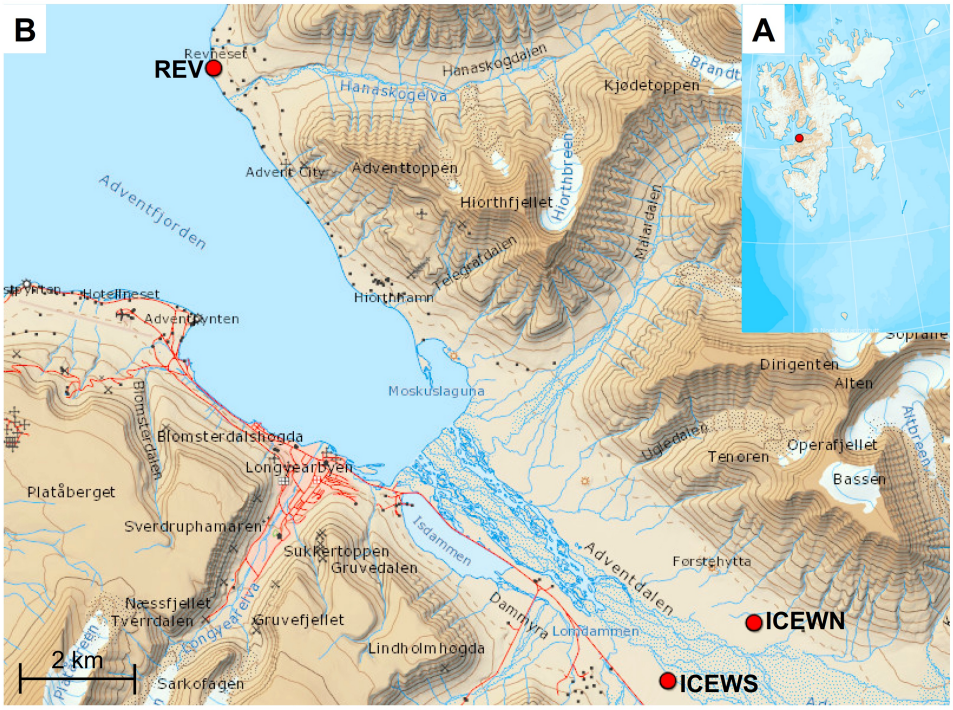

Figure 1 A) Map of the archipelago of Svalbard, where the red dot marks the approximate study location, and B) Map of Adventdalen, a valley on western Spitsbergen, with each study site marked by a red dot. REV is situated on a wetland between raised beaches. ICEWN and ICEWN sites are situated on aeolian deposits overlying deltaic sediments. Maps courtesy of the Norwegian Polar Institute.

divided at 2 centimetre depth resolution and the samples were equilibrated anaerobically with de-ionised, de-gassed water in sealed vials. Concentrations of methane and carbon dioxide in the vial headspace, the chemistry of the supernatant, and the initial moisture content of the sediments were determined.

The three study locations are geochemically distinct from each other. ICEWS is the driest site, with a mean water content of 35%. ICEWN and REV are moister, with mean water contents of 61% and 64%, respectively. The differing redox conditions of the sites reflect this disparity in water content; the concentrations of dissolved iron and sulphate are high at ICEWS, low at ICEWN and negligible at REV. In addition, concentrations of dissolved methane are negligible at ICEWS (driest site), but are greater at the two wetter sites. These results point to less reducing conditions at ICEWS, where the prevailing process is sulphide oxidation driven by Fe^{3+} reduction, and there is negligible dissolved methane. Conditions are more reducing at ICEWN and REV, resulting in substantial concentrations of dissolved methane. This indicates that methanogenesis is limited in the drier environments by competing anaerobic respiration processes, but that in the wetter environments this limitation is less severe. It is crucial to understand the differing redox evolution of these environments in order to predict the timing and magnitude of greenhouse gas release.

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Water temperature and runoff dynamics in two high Arctic streams

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Keywords: stream, water temperature, discharge, environmental factors

Two neighbouring high Arctic streams were examined for their water temperature and runoff dynamics during the summer seasons 2012–2014. The study site is located in central Svalbard, Petuniabukta. The summer season was defined to last from 1st June to 30th September. Elsa glacier – a fast retreating cirque glacier – has an area of 0.36 km^2, Ferdinand glacier 1.17 km^2 (Małecki, 2013; Rachlewicz et al., 2007). The catchment area is approximately the same (4.2 km^2 for Elsa, 4.6 km^2 for Ferdinand), resulting in almost triple the level of glaciation in the Ferdinand catchment (9% Elsa, 25% Ferdinand). Other environmental and physical characteristics of the catchments are similar.

Including below-zero periods, the mean summer water temperature for Elsa is 1.43°C, and 1.19°C for Ferdinand stream; or, excluding below-zero periods, 2.19°C for Elsa stream, and 1.86°C for Ferdinand stream respectively. The standard deviation of water temperature in Elsa stream is 1.37°C, whereas only 0.86°C in Ferdinand stream. A rather large difference is observed also in the duration of the summer season and the onset of the recorded flow season – from 6th June in 2013 to 20th June in 2012 and 2014 in Elsa stream, from 10th June in 2013 to 22nd June in 2014 in Ferdinand stream. The length of the season varied from 80 days in 2014 to 108 days in 2013 in Elsa stream, and from 86 days (2014) to 104 days (2013) in Ferdinand stream.

Runoff from both catchments is controlled predominantly by snow melt at the beginning of the season. This is followed by a more stable meltdown of glaciers and permafrost. Peak discharges in the second half of the flow season are caused by rain events. In general, the average discharge in Elsa stream is 0.15 m^3 s^{-1} and 0.39 m^3 s^{-1} in Ferdinand stream. The overall higher runoff in Ferdinand catchment could be probably attributed to a larger amount of available water stored in the glacier body, and to some extent also to the site specific morphology of the catchment and possibly a larger accumulation of snow during winter.

Water temperature dynamics (Figure 1) is related to atmospheric parameters such as air temperature and global radiation. Both variables are found to be the driving forces influencing the diurnal variation of water temperature in both streams, as well as its seasonal variability. Elsa catchment, however, reacts more distinctly (larger variation) to changing atmospheric variables, probably due to the lower areal proportion of glacier cover. This makes the catchment more sensitive to atmospheric forcings, as described also for other Svalbard streams (e.g.; Blaen et al., 2012).

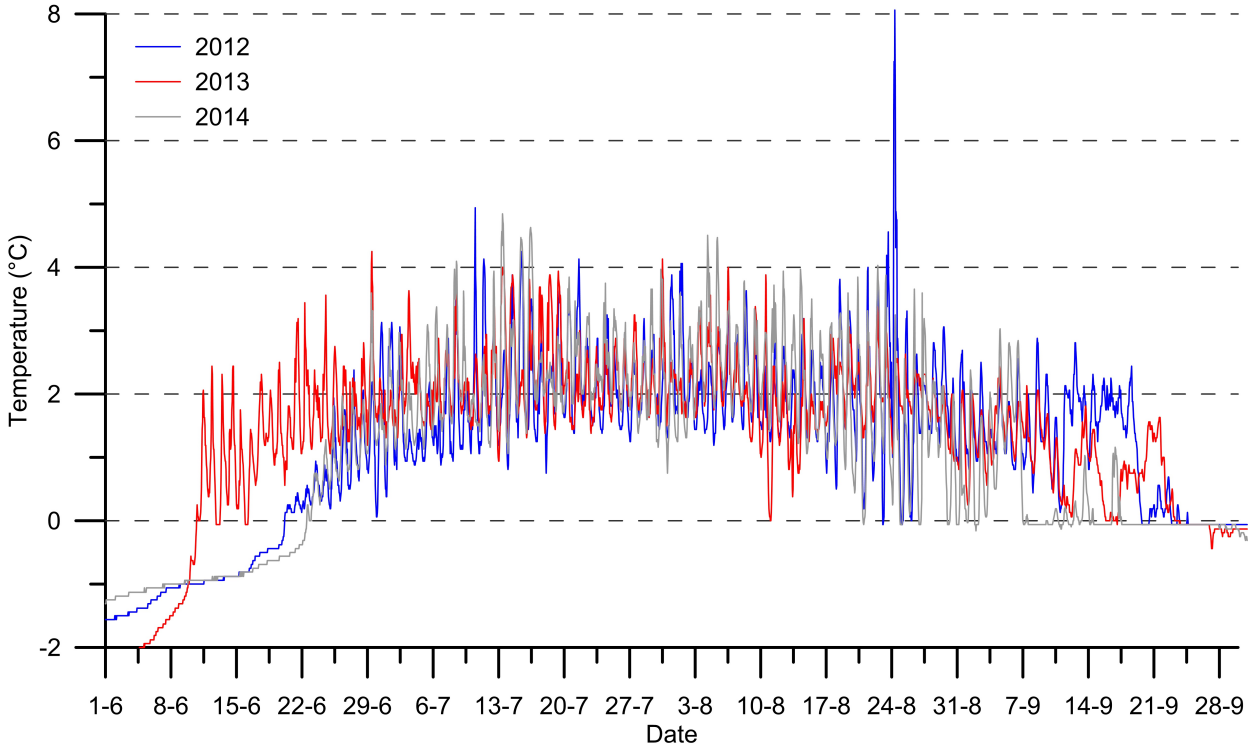

Figure 1 Water temperature in Ferdinand stream for the 2012, 2013, and 2014 summer seasons.

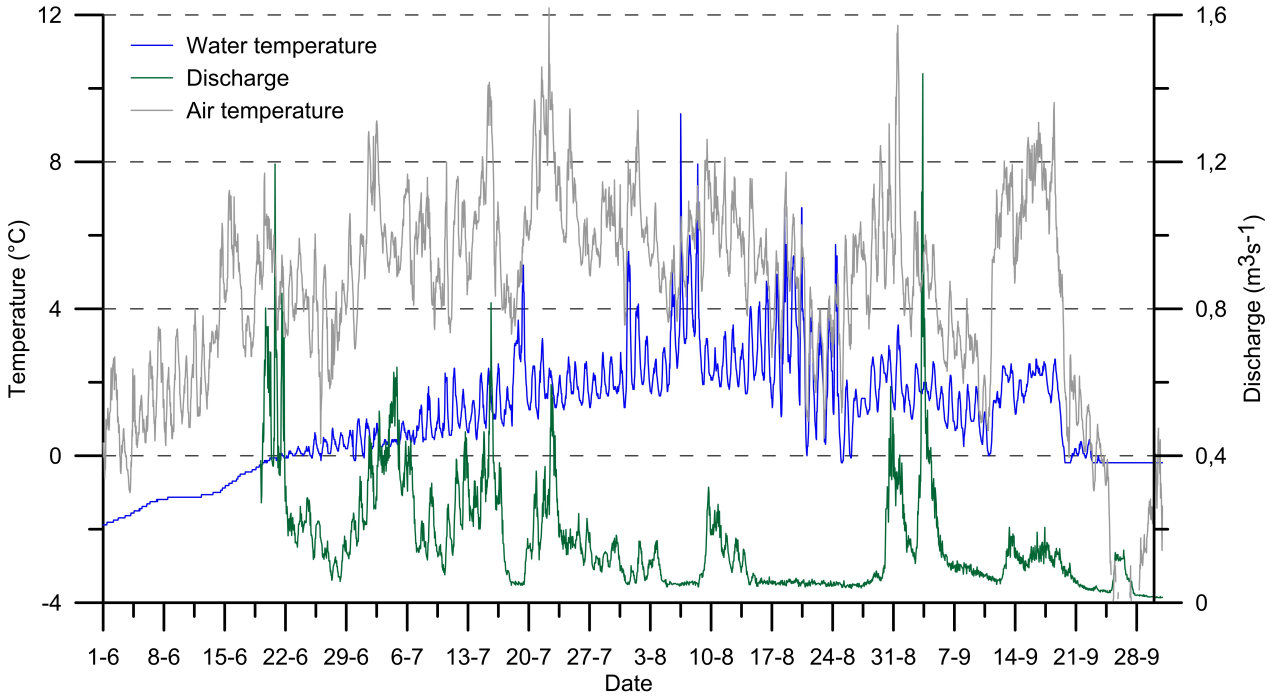

Figure 2 Comparison of discharge and water temperature records from 2012, Elsa stream, and air temperature.

When analysing stream water temperature, it is essential to take in account discharge as the basic controlling mechanism. As shown for example in Figure 2, several periods with highly variable water temperature reaching the seasonal records are concentrated into low flow periods. In such situation, only a relatively small amount of energy is needed to heat up the small volume of water. This is well visible in Figure 2 around 17th July.

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Morphometry of sorted circles around hyaloclastite breccia boulders on James Ross Island, Eastern Antarctic Peninsula region

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Keywords: nivation processes, soil sorting, James Ross Island, active layer

The ground-air interaction is an important factor that controls thawing and freezing of the active layer in the regions where permafrost occurs. The exchange of heat between the atmosphere and ground is affected to a great degree by the surface structure and lithology. Solar radiation is accumulated much more effectively by large boulders than by small pebbles and fine-grained material, and the radiation transfer into the surrounding ground is thus spatially heterogeneous. This work focuses on the description and quantification of the physical processes that lead to the sorting of fine-grained particles around hyaloclastite breccia boulders in Abernethy Flats, located between Whisky Glacier and Brandy Bay on James Ross Island, Maritime Antarctica. Composed of James Ross Island Volcanic Group hyaloclastite rocks, these boulders were transported supraglacially from their source area at Smellie Peak and Lookalike Peaks during the neoglacial Holocene advance of Whisky Glacier, forming a boulder train (Davies et al., 2013).

James Ross Island lies in the precipitation shadow of the mountain range of Antarctic Peninsula, and therefore it receives the annual precipitation of 300–500 mm (Martin and Peel, 1978; Van Lipzig et al., 2004). It is classified under semi-arid polar continental climate. Precipitation falling in the form of snow is subsequently redistributed by wind. On the windward side of the boulders, snow accumulations similar to crescent-shaped dunes are formed during the winter and last into the next spring and summer. Heat accumulated in the boulders causes radial snowmelt to progress in the direction away from the boulder. At the same time, meltwater transports fine particles, which are deposited later, when the snow melts. Aeolian transport is the main source of these fine particles accumulated on and within the snow. The combined result of these processes can be observed in the form of more or less clearly defined circular zones around the boulders, where the particle size decreases with the distance from the boulder.

We measured the dimensions of the selected boulders and the sorting distance in order to determine the relation between the two variables, and to quantify the effect of transferred heat on the sorting process. The sorting was best developed on the windward side of the boulders, assuming thus the prevailing wind direction. Data collected from 50 boulders showed a strong relationship between the circumference of the boulder and the sorting distance, with the coefficient of determination $r^2 = 0.82$ (Figure 1). The prevailing wind direction was south to south-west, which corresponded to the available meteorological data from this area. This is a preliminary study and this phenomenon will be subjected to a more detailed analysis in the near future in terms of semi-automated data acquisition

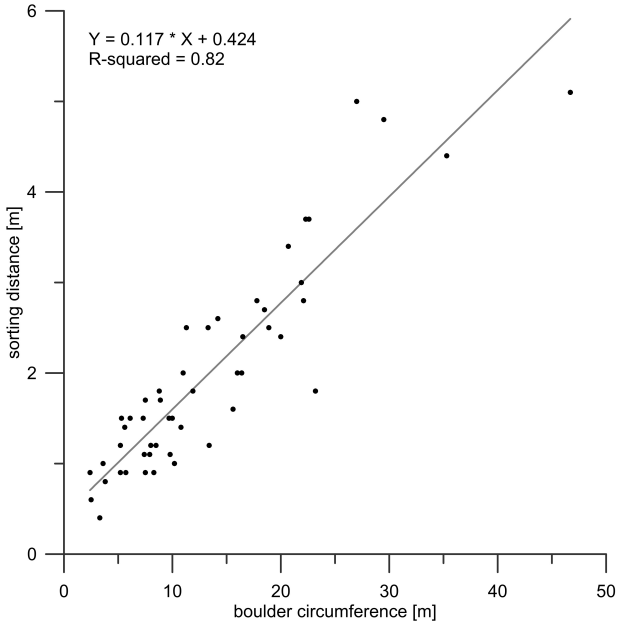

Figure 1 Relationship between circumference of the boulder and sorting distance.

from high-resolution aerial images, as well as continuous field measurements of temperature, humidity, and snow accumulation around the boulders.

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Cold adaptation of cell membrane in Antarctic bacteria

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Keywords: Antarctic bacteria, cell membrane, fatty acids, cold-shock, adaptation

Most of the Earth consists of cold environments. These environments include deep waters, benthic marine waters and sediments, glaciers, permafrost, upper atmosphere, or Arctic and Antarctic areas. Despite of unfavourable conditions, microscopic life in these environments is characterized with high diversity mainly of bacteria, fungi or microalgae. All these microorganisms must have developed adaptation mechanisms allowing them to survive the extreme conditions typical for cold environments. One of the most important adaptation responses of bacteria to cold stress is their ability to maintain the fully functional cell membrane, and thereby sustaining the very life of bacterial cells.

This study was focused on yellow pigmented and gliding Gramstain negative bacteria isolated from the environment in Antarctica during the years 2008–2014 (J. G. Mendel Station, James Ross Island). The aim of this study was firstly to describe the cell membrane properties of these bacteria regarding the composition of their membrane fatty acids. Secondly, we aimed to understand the adaptation responses of these bacteria to cold-shocks.

The description of cell membrane composition was based on FAME analysis (fatty acid methyl ester analysis). In order to determine their cold-adaption response, all analysed strains were subjected to the analysis after cultivation in optimal growth conditions, as well as after a cold-shock.

Our results showed that the composition of fatty acids of Antarctic bacteria was very specific. We found out that the cell membrane comprises numerous fatty acids in high amounts, such as $C_{15:1}$ iso G, $C_{15:0}$ iso, $C1_{15:0}$ anteiso, $C_{15:1}$ ω6c, $C_{15:0}$ iso 3OH, $C_{17:1}$ ω6c, $C_{16:0}$ iso 3OH, $C_{17:0}$ iso 3OH, Summed Features 3 and 9. We also found that the predominant compounds were branched or unsaturated fatty acids, with direct impact on fluidity of the cell membrane. Regarding cold-adaptation, two main mechanisms were found. Firstly, unsaturation of already built fatty acids was detected, and secondly, *de novo* synthesis of branched fatty acids was observed.

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Reconstructing the palaeoecological conditions of near shore environment during Pleistocene/Holocene transition in Mimerbukta, central Svalbard: A methodological approach

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Keywords: Svalbard, palaeoecology, molluscs, early Holocene, growth increments, stable oxygen isotope

Marine bivalve shells can be used as a palaeoecological proxy of past marine environments. The most commonly utilized indicator used to be the species composition in the past (e.g.; Peacock, 1989). However, the isotopic study of shell biogenic carbonate opened new possibilities and allowed high temporal accuracy (Jones et al., 1989). Hence, currently it is possible to disclose past temperature and salinity of seawater with great accuracy.

The main goal of our approach is to reveal detailed palaeoecologic conditions in Mimerbukta (northern part of Billefjorden, central Svalbard) during the Pleistocene/ Holocene transition. Altogether, we have studied three sedimentary sections within uplifted marine terraces with four fossiliferous units aged between 11.2 ± 0.1 cal. ka BP and 7.8 ± 0.1 cal. ka BP (further details in Table 1).

The oxygen isotopic composition (δ18O) of shells will reveal seawater temperature (e.g.; Yuan et al., 2011) during the lifetime of the selected specimen of *Mya truncata*, while the Sr/Ca element ratio will disclose the exact values of seawater salinity (Klein et al., 1996). The results will be compared with data gained from recent specimens. Precise values of seawater salinity will also allow us to improve the calibration of AMS ^{14}C ages to get more accurate ages for the dated samples.

In addition, to reveal details with high (i.e. annual) resolution of past environmental conditions during the lifetime of both fossil and recent molluscs, the annual growth increments will be measured (e.g.; Jones et al., 1978).

Our detailed multi-proxy approach will enable to reveal precise data about the past ecological and climatic conditions of Central Svalbard fjord during the Pleistocene/Holocene transition.

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Table 1 Estimated past environmental conditions for every unit obtained from sedimentology and synthesis of palaeoenvironmental and ecological indicators of the found species based on Peacock (1989, 1993), Gordillo and Aitken (2000), Funder et al. (2002), and Kaczmarek et al. (2005). Our multi-proxy approach will improve the data on seawater temperature and salinity.

	Bertil 1	MD1 Diamicton 3	MD1 Bottomset	MD2a
water temp. during year [°C]	-2 to 8	0 to 10	0 to 14	0 to 12
depth [m]	5 to 15	10 to 30	0 to 10	5 to 20
salinity [‰]	5 to 13	10 to 17	10 to 30	10 to 30
substrate type	fine-medium grained gravelly sand with occasional kelps	diamicton with silty matrix with occasional kelps	fine to medium sand with dispersed pebbles and occasional kelps	fine to medium sand with occasional kelps
age	11.2 ± 0.1 cal. ka BP	10.5 ± 0.1 cal. ka BP	9.7 ± 0.2 cal. ka BP	7.8 ± 0.1 cal. ka BP

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Spatial heterogeneity in functioning and properties of frost boil ecosystems of Taz Peninsula, North-West Siberia, Russia

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Keywords: frost boil, cryogenesis, spatial heterogeneity

Frost boils are one of the most specific tundra landscapes formed by cryogenic processes. These processes are an important factor that controls distribution of soil and phytomass carbon in continuous permafrost terrain.

Our object – frost boil ecosystems – is located in the southern tundra of the Taz peninsula, about 150 kilometres north of Novy Urengoy (57°28′50.6″ N, 76°42′32.6″ E). Frost boils are small, 0.5–2.0 m in diameter and 5–15 cm in height, non-sorted circles of barren soil formed by cryogenic processes and separated by completely vegetated (moss-lichens and shrubs) troughs – inter-frost boil areas.

We set a monitoring section (10×10 m) on a typical frost-boil landscape (35–45 frost boils / 10 m^2). It is estimated within the monitoring site that the total area with mud circles is almost twice as large as interboil areas. Frost boils without organic pit horizon have higher moisture and temperature levels of upper layer (0–10 cm): 25.6 ± 6% and 12.5 ± 0.8°C, as compared with vegetated interboil areas: 15 ± 4% and 8.5 ± 0.8°C. On average, active layer is found at a depth of 125 ± 5 cm under the circles and 110 ± 5 cm under the troughs. Laboratory analysis of samples shows that pH varies from 6.0–6.2 at a bare spot to 5.0–5.3 in troughs. These differences lead to a high contrast in microbiological activity: CO_2 flux is higher in the troughs than in the spots (193 and 55 mg m^2 $hour^{-1}$, resp.). BR and SIR results are the same: values are more than 10 times higher in the troughs than in the spots. Analysis of TC shows the same trend.

Cryogenic processes make a great contribution to the soil formation and redistribution of sub-stances in the studied frost boil ecosystems. It confronts us with the need to take this heterogeneity into consideration in order to better predict ecosystem responses to changing climate and land use.

Response of carbon store in forest-tundra transition to the climate change impact

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Keywords: frozen peatlands, carbon mineralization rate, basal respiration, permafrost thawing

The impact of the climate change at northern latitudes leads to widespread changes in permafrost affected soils (Zubrzycki et al., 2014), alteration of vegetation structure and composition, changes in biodiversity and ecosystem functions (Callaghan et al., 2002; Bhatt et al., 2010), and changes in landscapes as a whole (Jorgenson et al., 2001). Contrasting boundary landscapes, such as the Nadym site in northwest Siberia, Russia, provide unique study areas to examine the distinct effect of climate change (Figure1). This site is situated in the forest-tundra transition, in the zone of discontinuous permafrost. Permafrost is present under frozen peatlands, and absent under forest. Soil cover of the frozen peatlands is represented by a complex of Turbic Cryosols and Cryic Histosols. An increase in annual temperature, which leads to permafrost thawing, has been noted at the Nadym site (Matyshak et al., 2015). This circumstance predetermines two types of development in the Nadym region:

(i) Peatland drying and forest invasion into previously peatland areas in case of good drainage.

(ii) Flooding of peatland areas in case of hindered drainage.

We tried to answer the following question: Which variable exerts more effect on carbon release from frozen peatlands into the atmosphere, temperature increase or the changes of hydrological conditions (drying out and flooding)?

The dependence of carbon mineralization rate, which was estimated by basal respiration, on both factors was investigated. The peat profiles were divided into horizons according to the degree of decomposition (from 15 to 55 – 60%), age (from 1000 to 5700 years), and botanical composition (oligotrophic and eutrophic). To estimate the effects of drying out and flooding, the peat samples with different moisture content (from 5 to 100% of water holding capacity (WHC)) were incubated in a laboratory. The necessary water content was achieved by gentle drying on air (for low values), or by adding water (for high values). To estimate the temperature sensitivity of frozen peatland soils, the peat samples were simultaneously incubated at 5, 15, and 25°C for 1–4 days before the estimation of carbon mineralization rate.

It was found that moisture content has little effect on carbon mineralization rate. The mean basal re-

Figure 1 Landscape of the study area (65°18′54.4″ N; 72°52′10.0″ E).

spiration of oligotrophic peat was 11.2 ± 0.8 mkg C-CO2 m^{-2} h^{-1} within the moisture content between 10–90% of WHC, and the mean basal respiration of mesotrophic and eutrophic peat was 6.1 ± 0.1 mkg C-CO2 m^{-2} h^{-1} within the moisture content between 25–100% of WHC. At the same time, temperature increase involved a significant positive feedback of carbon mineralization rate for all peat types: the microbial biomass activity, estimated by basal respiration, tended to increase with temperature. These results lead to the conclusion that, in contrast to the increase in temperature, drying out and water flooding wouldn't have the determinative effect on peat decomposition.

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The role of sediment sources in downstream changes of clast shape characteristics of bedload sediments in proglacial gravel-bed Muninelva River, Svalbard

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Keywords: gravel-bed braided river, sediment sources, clast shape characteristics, fluvial transport, Muninelva River, Svalbard

The High Arctic landscape is affected by various processes. The proglacial parts of glacierized catchment, where braided rivers evolve, are the most dynamic areas. In this study, we focused on the main sediment sources and their changes due to sediment transport. The sediment sources have been classified according to de Haas (2015), and Tomczyk and Ewertowski (2017), who directly studied the near Petuniabukta area of Central Svalbard.

The Muninelva River flows down the Munindalen Valley in Dickson Land, Western Spitsbergen, ~ 7 km west of the Petuniabukta Bay. The Muninelva River originates from two connected glacier tongues (Vestre and Austre Muninbreen Glacier) in the NNW part of the valley. The river is ~ 6 km long and its channel belt is 50–250 m wide. It has the nature of a valley-train sensu (Hambrey, 1995). We mapped and verified the sediment sources during July–August 2016. For geomorphological mapping, we used orthophoto images, which were subsequently verified in the field. We collected samples for sedimentological study both from the sediment sources, such as moraines and fans (8 localities), and from the present channel bars (52 localities). We studied grain size, clast shape and petrological characteristics.

The dominant petrological types were sandstones and limestones (approx. 70%:30%). We analysed more than 6000 clasts in the fraction 8–16 mm. The moraine complexes in the upper reaches of the river catchment were the most important sediment sources. In general, downstream fining and increasing roundness were well visible in the results obtained from this study. The fluvial material from the localities closer to the main moraine sources was composed by angular clasts; on the other hand, the material from the downstream localities, which were located closer to the mouth, revealed higher shares of rounded clasts. Debris-flow dominated fan material entering the fluvial system from both sides provided predominantly angular to subangular clasts with fine-grained matrix. On the contrary, fluvial-flow dominated fans produced subrounded clasts, which were transported by small active side channels.

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Seasonal water and suspended sediment chemistry in proglacial and pronival streams in Petuniabukta, Central Spitsbergen, Svalbard

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Keywords: Arctic, water chemistry, suspended sediment, XRF, Svalbard

Retreat of Svalbard glaciers since the Little Ice Age is a well-recognised consequence of climate change in the Arctic (e.g.; Małecki, 2013). Such change of the most featuring system in Svalbard archipelago clearly affects and gives rise to the others. One example is a relationship between glacial and fluvial systems. Retreat of glaciers provides a space for streams catchments to develop, as well as substantially influences both quantity and quality of water. However, glaciological studies report different pattern in deglaciation at both regional and local scales (Rachlewicz et al., 2007). This assumes large variability in characteristics of river catchments and their development over time, which in turn emphasizes a necessity of local studies in order to comprehensively understand fluvial processes in glacial, proglacial and periglacial zones. This is a crucial prerequisite for our study, which aims to bring an insight into spatio-temporal pattern of water and suspended sediment chemistry and relate gathered data with recent local history of deglaciation.

This study focuses on three catchments located near former Russian settlement Pyramiden (Billefjorden, Central Spitsbergen), which are characterised by similar size, aspect and lithology, however they substantially differ in a glacier extent. Catchment of Elsa stream (ELS) extends on 4.2 km^2 and is glaciated from approximately 9%, catchment of Ferdinand stream (FER) has an area of 4.6 km^2 and is glaciated from approximately 25% and catchment of Sven stream (SVE), with an area of 9.7 km^2 is mostly glaciated (40%). Over the seasons 2015 and 2016, water was sampled for determination of concentration of selected cations (B, Ba, Ca, Co, Cu, Fe, K, Mg, Mn, Na, Ni, S, Sb, Si, Zn) and anions (sulphates, chlorides, fluorides). Furthermore, suspended sediment was kept for XRF analyses of concentrations of elements.

Our preliminary results points to between-streams differences in water chemistry, with concentrations of B, Ca, Mg, Mn, Na, S, Si, chlorides and sulphates having the highest values in ELS and lowest in SVE. Cations of K and Zn and fluorides do not clearly show a spatial pattern. Concentrations of remaining cations are rather negligible. Furthermore, there is an increasing trend with ongoing season for all cations (except for K, Si, and Zn) and anions, which could be found in all three streams. PCA analyses was applied on data from XRF and highlights the most important elements, which are K, Al, Si, Ti, Mn, Fe, Ca, S. However, only concentrations of Mn apparently differ among catchments.

In conclusion, between-streams variability is more prominent in the chemistry of water than in the chemical composition of suspended sediment. This suggests that there are differences in chemical processes, which are expected to be related to varying input of meltwater into stream, which results from a size of glaciers within each catchment. Further effort of this study would be put in a thorough comprehension of (i) controls, that causes the spatio-temporal variability in a water chemistry and (ii) a linkage between a provenance of suspended sediment and catchments geology.

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The Arctic ecosystem response to permafrost thawing

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Keywords: permafrost, pipeline, emission, soil, Arctic, warming process

Arctic ecosystems are sensitive indicators of environmental change. It is extremely important to study the response of Arctic ecosystems, as the permafrost covers the area of a quarter of the world and more than a half of Russia (65%). The increasing anthropogenic impact perturbs the natural ecosystems balance, and initially, significant changes happen in soil and vegetation.

The goal of this study was to estimate the response of soil and the Arctic ecosystem of north of West Siberia to permafrost melting. We used a unique research object. Since 1960, the oil and gas industry grows rapidly in Russia, especially in the Arctic. The hydrocarbons can be transferred by pipelines in the soil only in a heated state, which causes warming of the soil and degradation of the permafrost. Actually, we observe the result of a long-term experiment on heating permafrost ecosystems.

Firstly, the most transformed areas along the pipelines in the northern taiga and southern tundra, which are characterized by pronounced changes in vegetation, were selected, based on a satellite image. In August 2015 and 2016, ten transects from the pipeline to a natural ecosystem area, of 50 meters in length with sampling points every 5 meters, were investigate in the field. At each point, vegetation and soil morphology were described. Temperature, moisture, thaw depth and greenhouse gas emissions were studied. In the laboratory, the content of total and labile organic carbon (LOC), microbial biomass carbon (MBC) and basal respiration (SBR) of the soil were measured.

The main consequence of the gas pipeline is the degradation of permafrost (from 1 m to 8 m) in a 30 m wide band, where the soil temperature increases from 3.9 to 8.7°C and the moisture rises. Vegetation reacts to these changes very quickly: the portion of vascular plants grows from 20 to 70% and the height of *Betula Nana L.* increases from 13 to 86 cm. CO_2 emission increased by a factor of 2.5 and in the case of watering, CH_4 emission considerably increases as well (30–40 times). It was also found that the activity and the amount of microbial biomass increases in heated soils, which is proved by the increase of MBC and SBR values by a factor of 2 and LOC values by a factor of 1.5. The most rapid and strong reaction was observed in mineral soils.

Thus, as a result of permafrost degradation and 40 years of heating, we observe bright response in the structure and composition of vegetation, increased biological activity and significant changes in the basic properties of soils. The length of pipelines in the Russian Arctic is more than 10 000 km, and the area of transformed ecosystems reaches gargantuan values. With the use of the obtained data, it is possible to estimate the warming effect and the stability of the ecosystems in the Arctic.

Relationships between geomorphic disturbance dynamics and vegetation change in central Alps

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Keywords: alpine vegetation, surficial dynamics, geomorphic disturbance, scree slope, rock glacier

The impact of climate change in Alpine areas has led to changes in ecosystem functions and plants colonization (IPCC, 2013). However, geomorphic disturbance, driven by the climatic variables, may also affect the vegetation composition and distribution in Alpine regions. In these terms, high altitude vegetation distribution and colonization reflects the substratum dynamics (le Roux et al., 2013). In this study, we aim to: (i) characterize the processes generating various types of dynamics, (ii) quantify the periglacial landform movements on a seasonal and annual scale, (iii) assess the frequency of plant species with respect to their tolerance of the movement.

First of all, we examined the Scorluzzo cirque area, which is located in Stelvio Park (central Alps, Italy), on two vegetation maps from different time periods (Giacomini and Pignatti, 1955; Cannone et al., 2007) and by calculating the differences for three ecological communities (bare ground, pioneer species, climax species), we selected the sub-areas (landforms) corresponding to vegetation regression or colonization. Then, we painted red transversal lines on selected landforms (rock glaciers, gelifluction lobes, debris flows, scree slopes, block streams) in Scorluzzo cirque area, in order to spot plant species occurring at each centimetre of the line as well as to survey the movement (planar shift, translation, rotation, rototranslation) of each painted rock. After 30 days, we revisited the study site to measure the landform movements.

Generally, in scree slopes, we registered greater movements of upper lines, while the fastest movement of rock glaciers and rock lobe occurred at the front (lower lines). Even though there are no specific associations growing in the environments with surface apart from a few scree associations tolerating the movement (*Luzuletum spadicae*, *Oxyrietum digynae* and *Androsacetum alpinae*), by calculating the frequency of species growing in parts with different dynamic parts, we were able to distinguish the stress-tolerant species (*Doronicum clusii* 63.6%, *Veronica alpina* 58.6% and *Geum reptans* 50.0%) and stable-condition species (*Poa alpina* 26.2%, *Ranunculus glacialis* 21.2% and *Saxifraga bryoides* 14.3%). Another interesting result was the increase in low-altitude species number (alpine meadow and shrub land) and the decline in high-altitude species per each association during the past 62 years. In particular, during the last 12 years, we registered a gain of 31, 21 and 27 species and the loss of 9, 12 and 15 species respectively for *Luzuletum spadicae*, *Oxyrietum digynae* and *Androsacetum alpinae*. Despite this increase in floristic composition, we should consider the fact that geomorphic disturbance acts as an ecological barrier and helps keeping the frequency of new species low.

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Distribution of soil organic matter in soils from Ulu Peninsula, James Ross Island

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Keywords: soil organic matter, Antarctic Peninsula, physical soil fractionation, organo-mineral associations

The Ulu Peninsula represents the north-western part of James Ross Island, an area that has been ice-free in large parts since the beginning of the Holocene. Under the unique climatic conditions in the Antarctic Peninsula region, soils could develop without direct human interference. Additionally, vegetation in this area consists solely of lichens, mosses and terrestrial algae, whereas no vascular plants can be found. As a consequence, the formation of soil structure is mainly determined by microbial activity. This offers the great opportunity to study fundamental principles of soil organic matter (SOM) sequestration with a very low background of organic carbon (OC). In the steady cold environment of Antarctica, the mostly assumed predominant mechanism that stabilizes SOM is the reduction of microbial decay caused by low temperatures. However, it is not well known how biogeochemical cycle like the sequestration of OC in polar regions will adapt to changing climate.

To gain a better understanding of the mechanisms stabilizing OC, it is necessary to understand how SOM is distributed within specific SOM fractions, the profiles, and the landscape. To approach this objective, six sites on the Ulu Peninsula were selected, whereof five of them form a catena from land to sea and one represents a fresh water affected place as a reference site. Samples were taken from several depth layers (0–5, 5–10, 10–20, 20–50, and below 50 cm) until the permafrost layer was reached. Elemental analysis showed rather low carbon (C) and nitrogen (N) contents, with highest contents within the fresh water affected soils (5.5 mg g^{-1} C, 0.9 mg g^{-1} N). All other sites showed similar low N contents of 0.25 to 0.42 mg g^{-1} homogeneously distributed throughout the profiles. The C contents within the catena feature a wider variability, from around 1.0 mg g^{-1} C throughout the profile to values between 2.7 to 4.5 mg g^{-1} C. The distribution of N and C within the single profiles reveals no particular pattern.

The samples were fractionated according to particle size using wet sieving and subsequent sedimentation to obtain different SOM fractions. All fractions were analysed for C and N by dry combustion. The largest C and N contents were found for the clay fractions in all soils. Organic C was determined by correcting total C values for the amount of inorganic C. In addition to the analysis of the soils, we measured C and N of plant materials (lichens, seaweed). The seaweeds showed a low C/N ratio of around 10, which is typical for marine flora, whereas the prevalent lichen species Usnea antarctica showed a ratio of about 130. As this kind of lichen is found at the site with the highest C/N ratio, an immediate influence of the scarce vegetation on the C and N contents of the soils can be assumed. The westernmost site, which benefits the most from the prevailing wind direction and the sea salt spray, showed the highest contents of organic C of all the sites that are not affected by fresh water.

The analyses indicate that the distribution of SOM within the catena depends on relief features and that no distinct pattern can be found within the soil profiles. But most notably, by performing these methods for the first time on soils from this region, our study provides evidence that in polar conditions, the largest proportion of SOM is associated with clay sized mineral soil constituents. This clearly demonstrates the unique role the Antarctic soils can play in a better understanding of the interactions between microorganisms and soil minerals for organo-mineral associated SOM.

Late Holocene environmental changes revealed in sedimentary cores from two infilled lakes in the Kobbefjord area, southwestern Greenland

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Keywords: palaeolimnology, diatoms, X-ray fluorescence, environmental change, late Holocene, Arctic

The Arctic attracts a pre-eminent interest of Earth scientists working on current climate change, for its processes and feedbacks, such as Arctic amplification (Miller et al., 2010), insert influence upon the whole Earth system. It is therefore essential to assess the past climatic and environmental variability in order to make reliable predictions for the future. The presented palaeoenvironmental reconstruction, based on multi-proxy analyses of lacustrine sediments from two infilled lakes in southwestern Greenland, records ~ 800 years of lake evolution that was nonetheless influenced by in-catchment processes and, importantly, regional climate.

Field sampling was performed in August 2013 in the Kobbefjord bay (64°10´N; 51°19´E), Greenland, some 20 km east from the capital Nuuk. The location of our palaeoenvironmental reconstruction in the proximity to the former Norse Western Settlement then provides an opportunity to assess climatic changes experienced by the Norse colonisers, yet in an area directly unaffected by human occupation and activities. The position of Greenland close to the North Atlantic also means that its weather and climate are interconnected with Europe, although due to the North Atlantic Oscillation in a reverse pattern (Olsen et al., 2012).

The chronostratigraphic framework was established by radiocarbon (^{14}C) and short-lived radio isotopes (^{210}Pb, ^{137}Cs) dating. We further performed analyses of magnetic susceptibility, grain size distribution, element composition by means of X-ray fluorescence, total carbon, nitrogen and sulphur content, and diatom assemblages. Synthesis of physical, geochemical and biological proxies enabled to differentiate between individual factors influencing the sedimentary record, such as trophic lake status, pH, proportion of organic and clastic terrigenous matter, temperature and precipitation. Our record documents a rather variable reaction of lake environments and organisms to external forcings, although clearly distinguishes between the periods of higher organic matter content/lake productivity (reflected in diatom productivity and diversity, and higher organic carbon content), and increased influx of clastic material from the catchment. This assumption is evidenced by increased magnetic susceptibility, higher mean grain size and Si/Zr and Sr/Rb ratios and point to increased activity of hydrologic processes in the catchment, and possibly also dominance of physical over chemical weathering (Davies et al., 2015).

The presented reconstruction is in accord with other, mainly lacustrine, records from Greenland (D'Andrea et al., 2011; Millet et al., 2014). Cooling event documented at the beginning of our record corresponds to the onset of the Little Ice Age in Greenland (AD ~ 1100–1300), which probably contributed to the demise of the Norse Western Settlement (D'Andrea et al., 2011). The following period of intermittent and highly variable climatic amelioration between AD 1400 and 1800 often coincides with negative phases of North Atlantic Oscillation (Olsen et al., 2012), whereas onset of cooling usually occurs during declines in solar activity and the Northern Hemisphere volcanic activity maxima. Culmination of the Little Ice Age (AD ~ 1850–1920) is reflected in maximum input of clastic material into the lake basin and lowest organic matter content and productivity of the

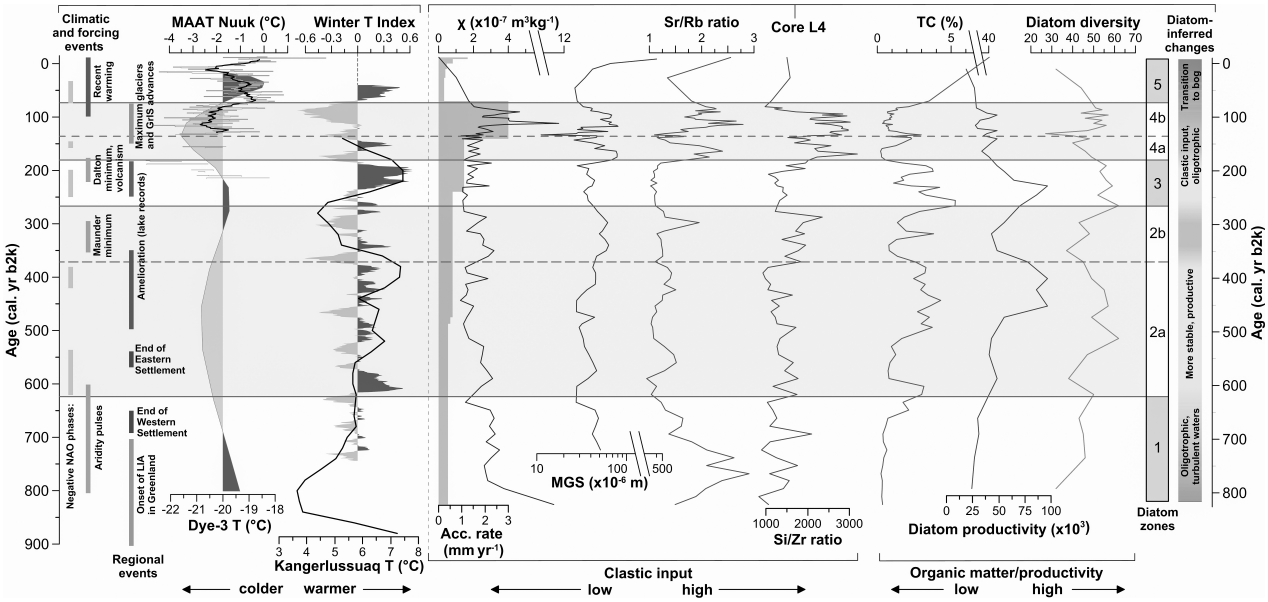

Figure 1 Comparison of regional environmental changes with selected proxies from the studied sedimentary profile in Kobbefjord. Vertical axis represents time (cal. yrs. b2k – calibrated years before AD 2000). From left: Main climatic and regional events; mean annual air temperature (MAAT) record from Nuuk meteorological station (black line) with 11-yr running mean (grey); reconstructed near-surface air temperatures from Dye-3 borehole measurements; Southern Greenland winter temperature index reconstructed from stable isotopes in Greenland ice cores; alkenone-based reconstruction of mid-summer lake water temperatures in two lakes of Kangerlussuaq area (D'Andrea et al. 2011); main proxies from core L4: sediment accumulation rate (Acc. Rate), magnetic susceptibility (χ), mean grain size (MGS), Sr/Rb and Si/Zr ratios, total carbon (TC), diatom productivity, diversity and biozonation.

whole record. The inferred duration of the Little Ice Age maximum is in accord with documented advances of Greenland glaciers, as well as other proxy-based and instrumental data from Greenland. Warming after the Little Ice Age is, however, obliterated in our record by transition of the lake to oligotrophic peat bog that commenced ~ 100 years ago.

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Salix polaris growth responses to active layer detachment and solifluction processes in High Arctic

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Keywords: salix polaris, dendrogeomorphology, solifluction, active layer detachment

Dendrogeomorphology uses growth ring properties stored in woody plants to date back and interpret morphogenetic processes. It has established its position in mid-latitudes where multiple research showed its usefulness and reliability in dating e.g. avalanches, landslides, fluvial erosion, and tourist trail erosion. In the high Arctic, research woody plant material is very limited and restricted to trailing shrub species, whose preparation is much more time consuming due to their small size,. It is a relatively new method and at this stage it is very important to recognize and describe growth patterns of plants exposed to different morphogenetic processes in order to obtain information necessary for further processes interpretation.

The work is dedicated to demonstration of the potential of *Salix polaris* growth properties in the dendrogemorphologic image, analyzing periglacialy induced slope processes in the high Arctic. Observed anatomical and morphological plants responses to solifluction and active layer detachment processes are presented qualitatively and quantitatively as a summary of presented features frequency. The results are discussed against the background of other research results in this field. The investigation was performed in Ebba valley, in the vicinity of Petunia Bay, northernmost part of Billefjorden, in central Spitsbergen (Svalbard). Environmental conditions are characterized by annual precipitation sum lower than 200 mm (Hagen et al., 1993) and an average summer temperature of about 5°C, with maximum daily temperatures rarely exceeding 10°C (Rachlewicz, 2009).

The collected shrub material was prepared according to the methods presented by Schweingruber and Poschlod (2005). Thin (approx. 15–20 μm) sections of the whole cross-section were prepared with a sledge microtome, stained with Safranine and Astra blue, and finally permanently fixed on microslides with Canada balsam and dried. Snapshots were taken separately for each cross-section with a digital camera (ColorView III, Olympus) connected to a microscope (Olympus BX41) and merged into one high-resolution image. Finally, ring widths were measured in 3–4 radii in every single cross-section using ImageJ software.

The processes like contemporary progressive melting of glaciers, faster melt of snow patches, and permafrost degradation significantly affect both dynamics and temporal and spatial extent of water circulation in Arctic catchments as well as the mobility of mineral matter. The released sediment can easily become a subject to intensified periglacial activity, such as slope processes. All of these phenomena can affect the shrub growth by disturbing their habitats and can be recorded in the rings parameters and wood properties. The permafrost degradation, observed on the neighboring slopes, causes shallow landslides, called active layer detachments. The aim of the study was to check how slope processes affect the growth of Salix polaris dwarf shrub and if it is possible to use dendrochronological methods to date back their occurrence.

The analyzed plants revealed extremely harsh environmental conditions of their growth. Buchwał et al. (2013) provided quantitative data concerning missing and partially missing rings in shrubs growing on Ebba valley floor. Mean ring width at the level of 79 μm represents one of the smallest values of yearly growth ever noted. The share of missing and partially missing rings was 11.2% and 13.6%, respectively. The ring width of the plants growing on Ebba valley slope was almost twice as small (41 μm), and the participation of missing and partially missing rings was higher. The share of missing rings in shrubs growing within an active layer detachment and on the valley slope reached 16.22% and 15.36%. The variation was even higher for partially missing rings, which accounted for 31.07% within the detachment and 23.39% on the surrounding slope. Those values are more than two times higher compared to the valley floor. There is also a noticeable difference between the detachment and the surrounding slope, which indicates that the wedging rings are affected by mechanical stress that is higher within the detachment. Comparing the growth patterns in aboveground and belowground plant parts, different growth characteristics were noticed. The growth rings representing the year of detachment event were present only in the aboveground parts. According to Buchwał et al. (2013), mechanical stress delays the onset of the growing season similarly to low temperatures, resulting in lack of time to fully allocate resources for growth in the belowground parts.

The growth pattern is extremely irregular, indicating that the slope is in a constant movement,

which disrupts the growth conditions. Based on theanalyzed shrubs, the event could take place in two years: 2006 and 2008, with the highest participation of missing and partially missing rings. Air and ground temperature data confirmed that active layer detachment happened in 2006.

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Use of climate reanalyses to study of the annual speed and direction of wind on the North-western Spitsbergen

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Keywords: polar climate, wind speed, wind direction, reanalysis

Climate reanalysis is still a subject of much controversy. Most of it concerns the reconstruction of atmospheric pressure fields; therefore, it can be assumed that the meteorological parameters that have been reconstructed most accurately are the wind speed and wind direction. For the purpose of this study, the NCEP Climate Forecast System Reanalysis (CFSR, dataset 094.0 in the period 1981–2015) and ERA-20C (303-497-1343 in the period 1901–2015) were selected. The analysis covered the variability of wind conditions in annual and seasonal courses, as well as the mean and maximum diurnal wind speed within the two selected periods. Wind modelling was also presented, using the example of katabatic wind over the Waldemar glacier. The method of downscaling was applied in order to reconstruct the wind conditions at the polar station of the Nicolaus Copernicus University in Toruń.

Separation of soil respiration components in permafrost zone

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Keywords: soil respiration, microbial respiration, permafrost, peatland

Soil respiration is the second largest carbon flux in most ecosystems (after photosynthesis), and can account for 60–90% of total ecosystem respiration (Goulden et al., 1996). Roots of plants are the main autotrophic producers of carbon dioxide in soil. The contribution of other autotrophic organisms, such as algae and chemoautotrophs, is low. Agents of microbial respiration in the soil are heterotrophic microorganisms (bacteria, fungi, actinomycetes) (Kuzyakov, 2006). One of the primary factors affecting carbon dioxide emission is climate. The components of soil respiration (root and microbial respiration) respond to climate change differently. The research on contribution of individual soil respiration components is essential for prediction of global climate change, and also for evaluation of its potential as a pool or a source of CO_2.

Separation of root and soil microbial respiration in Arctic soils has some special aspects, associated with the influence of permafrost and severe climate. Specifically, methods of separate determination of root and microbial respiration must be selected in view of these special aspects.

The study area is located in the Nadym region of northwest Siberia, Russia (65°19′ N, 72°53′E), within the north taiga and the zone of discontinuous permafrost. Permafrost is present under peatlands but absent under forest (Matyshak et al., 2015). The research took place in August 2014, 2015, and 2016.

Three methods were tested for the separation of microbial and root respiration: (i) "Shading" (shading of green above-ground parts of the plants); (ii) a modified method of roots exclusion (the comparison of emission from "peat spots" soils, without vegetation and roots, and from soils located near the spots with herbaceous vegetation and moss); (iii) "Clipping" (removing the above-ground green plant parts).

For the experiment on the method of "Shading", 6 plots were established in the forest and 6 plots on frozen peatland, including 6 control plots. Measurement of carbon dioxide emissions (the chamber method) was carried out on the first day and after 72 hours of shading.

The experiment on "Clipping" method in the forest and on the frozen peatland was established only in 2015. It was found unsuitable for permafrost zone (increase of microbial respiration as a result of decomposition of roots).

"Shading" and the modified method of roots exclusion experiments showed the following results: the contribution of root respiration in peatlands was 10–50%, in forests 7–50%. These methods gave a positive result and can be used for permafrost-affected soils. In view of high complexity of soil cover, it is necessary to increase the number of replications and the experiment period.

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Spatial thermal diversity and atmospheric circulation including extremes in the area of Forlandsundet (NW Spitsbergen) in 2010–2013

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Keywords: Spitsbergen, Forlandsundet, atmospheric circulation, air temperature, topoclimates

The relationship between atmospheric circulation and climate in Svalbard has been described in dozens of studies. However, the data used for that purpose usually came from permanent stations on the coast. The influence of atmospheric circulation on topoclimatic diversity has not been explored so often and hardly at all for other periods than the Arctic summer. In this article, the relationship between circulation and air temperature is described using daily data from 6 sites located around Forlandsundet (NW Spitsbergen) in 2010–2013. The analysis was conducted independently for 3 seasons identified as: winter (November–March), spring-autumn (April–May and September–October) and summer (June–August) and also for three air temperature parameters: diurnal mean (Ti), maximum (Tmax) and minimum (Tmin) temperature. The atmospheric circulation in the studied area was described using Tadeusz Niedźwiedź's classification of diurnal circulation types for Svalbard. The influence of atmospheric circulation on the spatial pattern of air temperature is not uniform across different parts of the Forlandsundet region. Different temperature patterns to circulation types were noted for coastal and inland parts of the study area. Thus, generalisation of air temperature-atmospheric circulation relationship for the entire area of Spitsbergen based on data only from coastal stations is not appropriate. The influence of atmospheric circulation on the spatial pattern of air temperature in the Forlandsundet region also changes through the year. In the cold season (September–May) it differs significantly from that observed in summer (June–August), and this feature is also seen in analyses of the 10% highest ($\geq 90^{th}$ percentile) and lowest ($\leq 10^{th}$ percentile) thermal differences. In summer, the relation of atmospheric circulation to air temperature in the topoclimatic scale is definitely less stable than in the cold season. The reactions of the three analysed thermal parameters to atmospheric circulation also differ significantly.

The effect of climate on morphology and development of sorted circles and polygons

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Keywords: patterned ground, sorted circles and polygons, morphology, active layer, Svalbard, high Arctic

Sorted circles and polygons are regular alternations of fine and coarse ground materials, commonly found in the periglacial landscape of Svalbard archipelago or elsewhere on Earth. They develop by repeated freezing and thawing of the ground. However, less consensus exists regarding their formation mechanism, developmental dynamics or environmental controls. In this study, we describe the distribution and morphology of a sample of 290 sorted circles and polygons located at 16 study sites in the northern Billefjorden area, central Svalbard (79° N), and we investigate their relation to altitude. We further hypothesize about their developmental rates, chronology and relation to active-layer thickness (ALT) and present-day climate conditions.

One group of sorted circles and polygons (69% of the investigated patterns) is located mainly on raised marine and kame terraces at elevations up to 200–250 m a.s.l. A second group (31%) occurs on adjacent flat mountain tops and ridges above elevations of around 600 m a.s.l. These two distinct elevation zones differ significantly in pattern morphology. The higher-elevated patterns have smaller diameters and shallower sorting depths due to a thinner active layer, suggesting that sorted patterned ground can be indicative of climate conditions and ground thermal state (i.e. permafrost or seasonally frozen ground) when the patterns were initiated. In contrast, the heights and height-to-width ratios of higher-lying sorted circles and polygons are larger. Bedrock lithology is believed to be of less importance for pattern morphology in the study area, causing only fine-scale variations. The diameter-to-sorting depth ratios of sorted circles and polygons have a median of 3.57, which is consistent with previous studies (median of 3.54) and theoretical models of patterned-ground formation involving circulation mechanisms. This allows estimation of the sorting depth based on patterned-ground surficial morphology, which can be used to reconstruct former active layers and associated temperature conditions. Our findings suggest that large-scale sorted circles and polygons may develop over centennial timescales in this high-Arctic environment, unlike those in lower latitudes. Further, they are likely not in equilibrium with present-day climate conditions and have probably been forming throughout the Holocene.

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Assessing the dynamics of thermokarst lakes in Eastern Siberia using remote sensing data

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Keywords: thermokarst, lakes, remote sensing, Eastern Siberia

Permafrost regions deserve special attention as the surface temperatures are rising in different areas of the Earth, resulting in permafrost thawing and degradation. This causes changes both in ecosystems and infrastructure.

Thermokarst is one of the most obvious forms of permafrost degradation in Arctic landscapes. Thermokarst lakes (TKLs) dominate large areas of the Arctic land surface and may expand as permafrost continues to warm and thaw. TKLs change detection can be used to derive information about thermokarst spreading and related changes.

Thermokarst has an important effect on the ecology, geomorphology, hydrology, and local climate in the Arctic. Recent observations indicate that with the warming of permafrost, resulting in degradation of ice-rich and carbon-rich permafrost, TKLs are an important source of carbon release into the atmosphere. Moreover, permafrost thawing is often accom-panied by changes in water and land surface energy balance, which may influence atmospheric processes via feedback mechanisms (Morgenstern et al., 2011). Therefore, the dynamics of permafrost and related changes in the environment is a topic of great importance.

However, due to the remoteness of study areas, their large extent, and the degree of peat formation, field observations are hard to conduct. Mapping of permafrost distribution remains a challenge due to the sparsity of observations. Despite the fact that geophysical surveys and boreholes are the most reliable sources of information about permafrost, they are extremely costly and mostly available from relatively small areas (Jafarov et al., 2012).

The purpose of this study is to explore permafrost environments in a changing global climate, to investigate the reasons for changes in the active layer, and to understand feedback mechanisms associated with increasing greenhouse gas emissions from permafrost zones. Using remote sensing methods, mapping of the thaw lakes dynamics was conducted in order to visualize the detected changes and analyze their spatial patterns. Landsat images were used, since they are superior to other satellite images as the survey has been run continuously since the 1970s. However, these images had different resolution in different observation periods. This is why the error in lake size estimate has to be taken into account and the lakes identified to less than a certain level have to be excluded. The limit of the lake size at which the analysis remains valid amounts to 0.4–2.0 ha.

The study shows the following results: the thermokarst lakes of Eastern Siberia, namely in Yana-Indigirka lowland and Kolyma lowland, which are in the zones of continuous ice-rich permafrost, expand in narrow bands along their margins. The growth is most probably the result of thermal erosion (Kravtsova and Rodionova, 2016). At the same time, some of the thaw lakes in the permafrost zone of Eastern Siberia are shrinking and grassing, mainly being drained by rivers. Therefore, the expansion of lakes in this region under the effect of current warming remains the question for discussion. The variation in size and number of thaw lakes depends on a variety of factors: hydrology, precipitation, tectonics and anthropogenic loads in addition to climate warming, which could trigger permafrost thawing and thermokarst formation.

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Heavy metals in lake sediments of deglaciated area of James Ross Island (Antarctica)

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James Ross Island (JRI) (64°10'S, 57°45'W), located 15 km east of the Antarctic Peninsula in the north-western part of Weddell Sea, is a volcanic island with more than 50 recorded eruptions of alkaline basalts over the last 6 Ma (Smellie et al., 2008; Prošek et al., 2013). The aim of our study is to determine the content of heavy metals associated with basaltic volcanic eruptions: Cr, Ni, and Co in lake sediments and regolith of deglaciated area of JRI, and, in a broader perspective, to contribute to the model of heavy metals mobility in the Antarctic ecosystem.

The total of 13 samples of lake sediments were collected in the northern part of JRI – 6 samples from Lake Lachman 1 (L3A–L3F) and 7 samples from a seasonal lake (L4A–L4G) located near the Czech Antarctic Research Station Johann Gregor Mendel. As the first step, the presence of clay minerals, as the potential sorbents of heavy metals, was proved. The presence of clay minerals was confirmed by X-ray diffraction (Figure 1). In the second step, the contents of heavy metals were studied using ICP-MS method. It was found that both sites differ significantly in their contents of Cr, Ni, and Co (Figure 2). The reasons why the contents of heavy metals are different as well as improving of the model of heavy metals' mobility will be the subject of our further study.

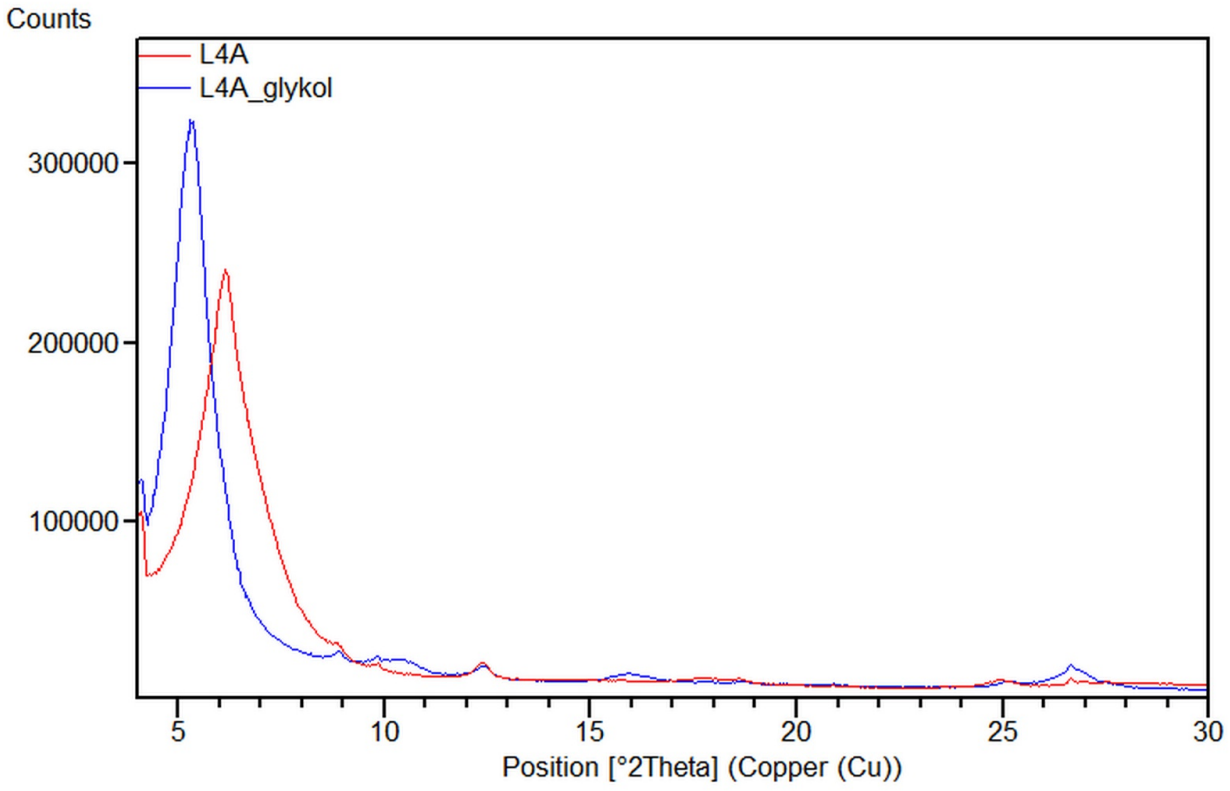

Figure 1 Diffractogram evidencing the presence of clay minerals.

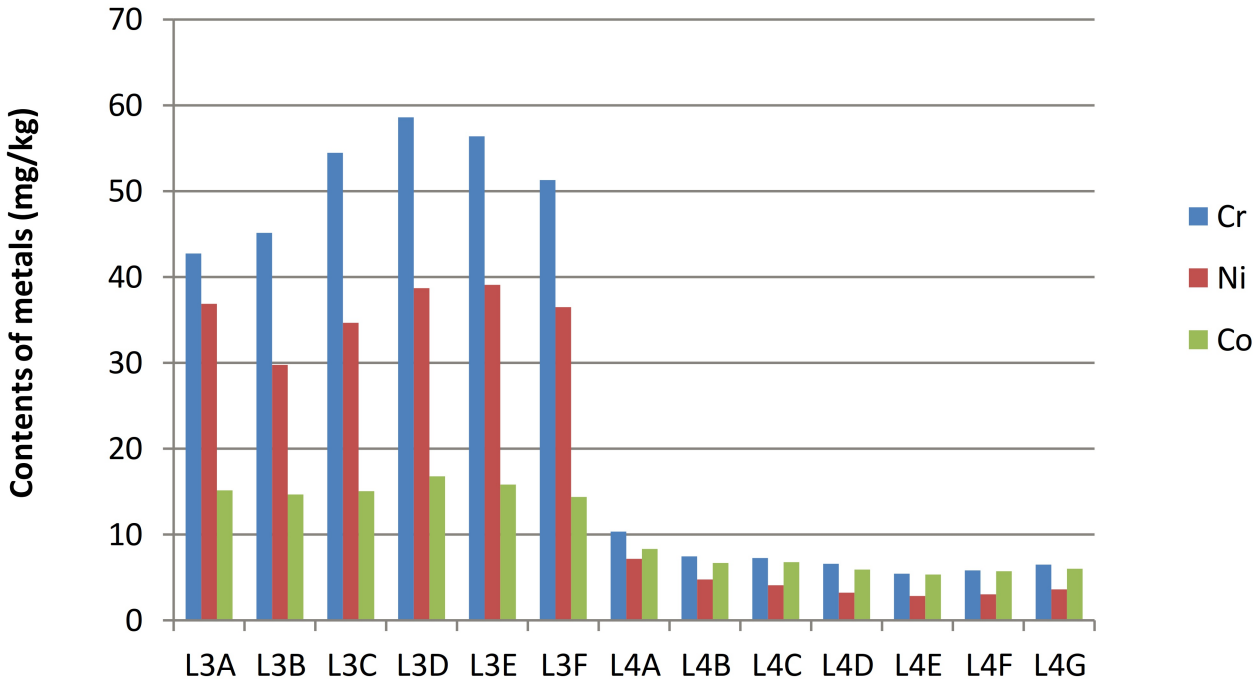

Figure 2 The contents of Cr, Ni, and Co in JRI lake sediments.

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