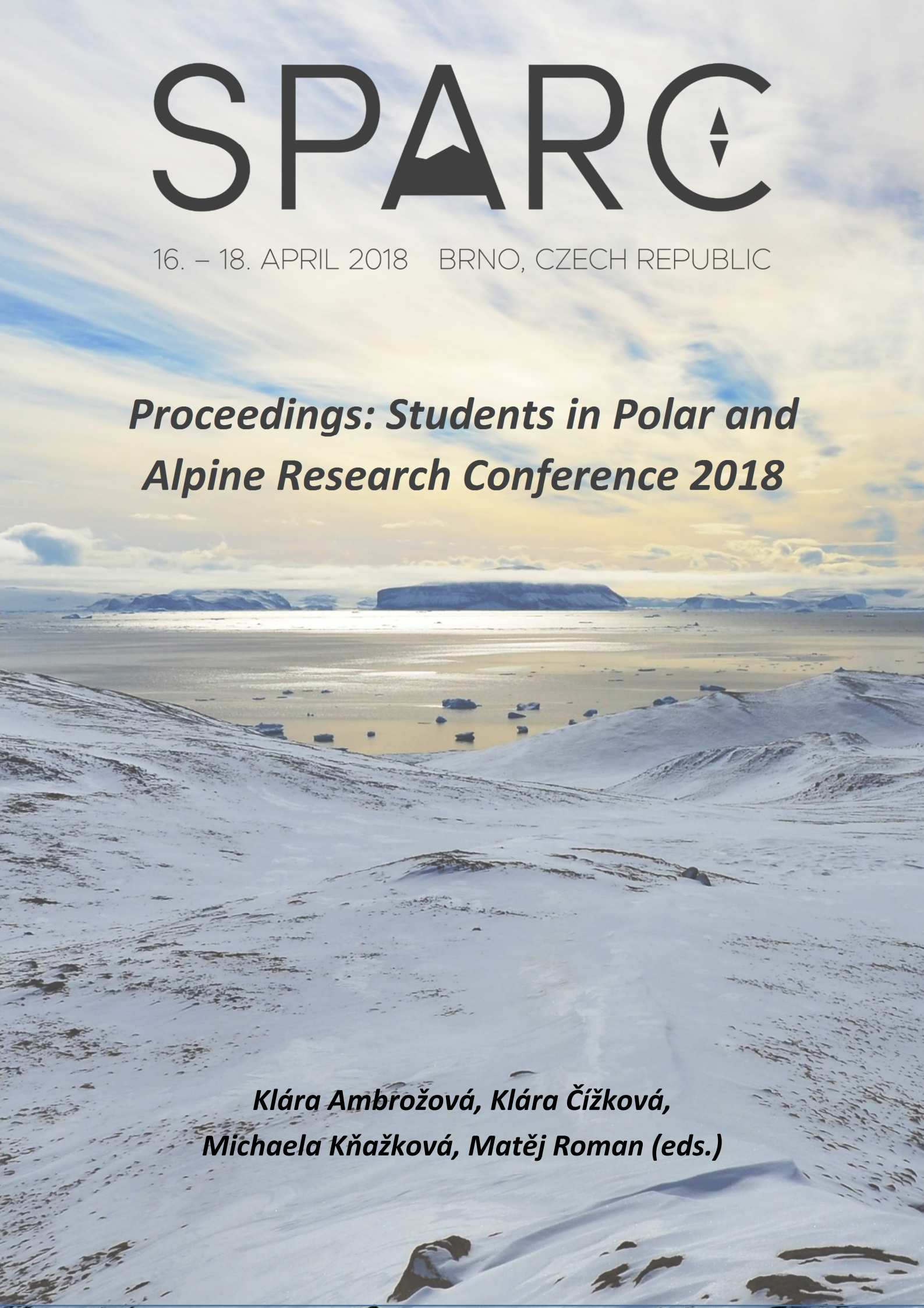
SPARC

16. – 18. APRIL 2018 BRNO, CZECH REPUBLIC

Proceedings: Students in Polar and Alpine Research Conference 2018



Klára Ambrožová, Klára Čížková, Michaela Kňažková, Matěj Roman (eds.)

Students in Polar and Alpine Research Conference 2018 - preface

Dear Young Polar Researchers,

We are very happy that we could have met again at the Students in Polar and Alpine Research Conference, which was held at the Department of Geography, Masaryk University, Brno, Czech Republic, for the fourth time. It is great to see that polar and alpine research is still attractive to young researchers and that we are all still interested in networking and seeking cooperation, which can be crucial, not only in the tough conditions during fieldwork. In order to increase the awareness of the conference, we have established a website https://sparc-brno.webnode.cz/, where all important information on the conference can be found year-round.

It was pleasure to see the word spread and welcome new young researchers as well as many attendants to return and show how their research developed. This year we received 25 abstracts both in bioscience and geoscience sections, of which there were 19 oral presentations and 6 posters. Moreover, we are very grateful to our four key-note speakers, who presented very interesting lectures and shared their knowledge and experience with us.

We are looking forward to meeting again next year.

In Brno 19 April 2018
Klára Ambrožová

Proceedings:
Students in Polar and Alpine Research Conference, 2018

Place • Date
Brno (Czech Republic) • 16–18 April 2018

Editors:

Klára Ambrožová, Klára Čížková,
Michaela Kňažková, Matěj Roman

Technical editor:
Filip Hrbáček

Acknowledgements:
The organizing committee of Students in Polar and Alpine Research Conference 2018 gratefully thanks the Department of Geography, Masaryk University. The funding support for the conference was provided by the project MUNI/A/1251/2017 and the large infrastructure project LM2015078 “Czech Polar Research Infrastructure”. We acknowledge the keynote speakers who had the will to contribute to the conference.

ISBN 978-80-210-8957-0

Published by Masaryk University, Žerotínovo náměstí, 617/9, 601 77 Brno, Czech Republic, 1st edition.

Contents:

Microbiological research on James Ross Island focused on rock-inhabiting fungi

Monika Laichmanová[1*], Ivo Sedláček[1]

[1] Czech Collection of Microorganisms, Department of Experimental Biology, Faculty of Science, Masaryk university, Kamenice 5, 625 00 Brno, Czech Republic
* monikadr@sci.muni.cz

Keywords**:** Antarctic bacteria, rock-inhabiting fungi, black fungi, melanised fungi

The Antarctic Continent provides unique environment for the study extremophilic microorganisms. The aim of the Antarctic microbiological research performed in the northern deglaciated part of James Ross Island is to study the diversity, taxonomy, physiology, biochemistry and phylogenetic relationships of microscopic fungi and heterotrophic bacteria from various sources.

The sampling in the field followed by isolation of microorganisms using different isolation techniques according to sources type and target group of microorganisms and their basic phenotypic characterization was done in the laboratory of Mendel Polar Station (S63°48′02.3″, W57°52′59.9″). Subsequent identification based on extensive morphological, physiological and biochemical characteristics will continue in the laboratories of Masaryk University, including DNA analysis of selected microbial isolates. All isolates are maintained in -70 °C and the representatives of novel taxa will be deposited in the public collection of the Czech Collection of Microorganisms (CCM).

The mycological research is focused mainly on the isolation and description of rock-inhabiting fungi (Figure 1). The preliminary analysis of regolith and rock samples collected during expeditions 2007–2009 revealed occurrence of psychrophilic species *Elasticomyces elasticus*, *Rachicladosporium antarcticum* and *Oleoguttula mirabilis* (Egidi et al., 2014) on James Ross Island. These fungi belong to the class *Dothideomycetes*. The rock-inhabiting fungi are considered to be the most resistant fungi on the Earth (Selbmann et al., 2015). These fungi colonize rock surfaces together with other organisms such as algae, bacteria, cyanobacteria or lichens. The rock-inhabiting fungi are characterized by slow growth, poor morphology, production of high amounts of melanin and exhibition of meristematic growth (Selbmann et al., 2015). Their typical morphophysiological characteristics enable them to survive in an extreme environment where they are exposed to stress conditions such as strong solar radiation, osmotic stress, nutrient deficiency, low water availability and repeated freeze–thaw cycles.

The study of rock-inhabiting fungi is significant for the understanding the possible limits for life as well as evolution and adaptation to extreme conditions (Selbman et al., 2015). Some of them are used as model organisms for astrobiological studies (Onofri et al., 2004).

The other part of bacteriological research is focused on microflora of the gastrointestinal tract of Antarctic animals, especially penguins and seals. The occurrence of zoopathogenic species *Escherichia albertii* was proved in excrements of these Antarctic animals (Grillová et al., 2018). In the last years the microbiological research was extended by the study of bacterial diversity in water. The water samples were collected from lakes, streams created by melting water from snowfields and cryoconites forming on glaciers.

Isolated fungi and bacteria are now in the process of deposition and identification. The intended output of this research will be a summary publication describing the phylogeny and taxonomy of the rock-inhabiting fungi on James Ross Island in Antarctica and description of new species. Although many new organisms have been isolated and described, it is still just a fragment in the overall biodiversity of the James Ross Island.

The study of bacterial community on James Ross Island started in 2007. In the beginning, bacteriological analysis was focused on microflora of regolith and rock fragments. Wide spectrum

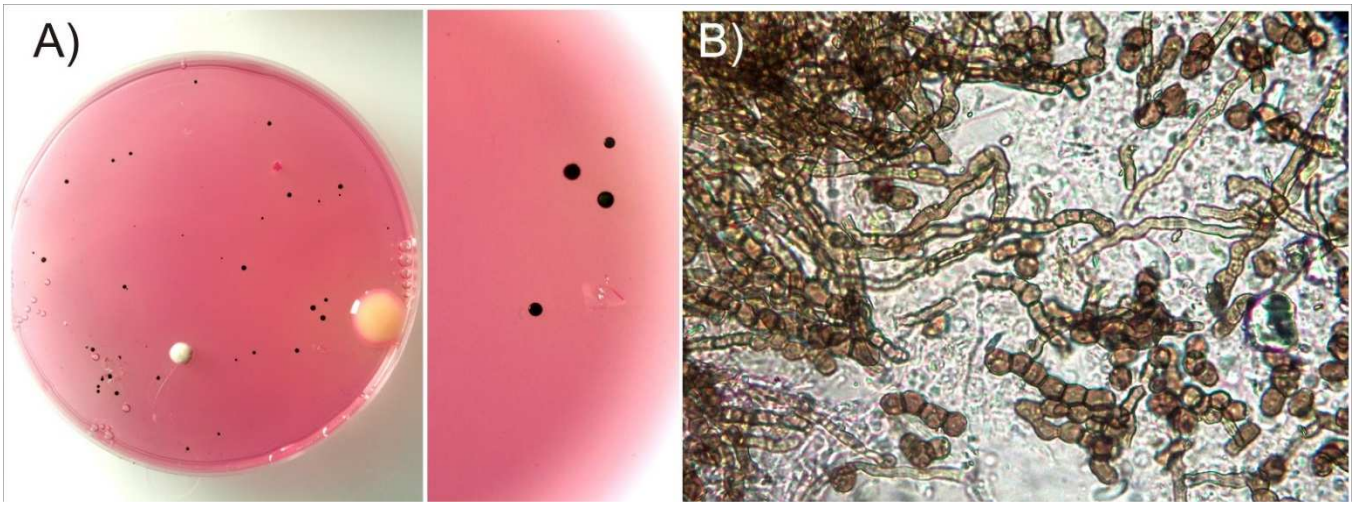


Figure 1 A) Colonies of black fungi isolated from rock sample. B) Melanised, swelling hyphae of rock-inhabiting fungi under light microscope.

of bacteria both Gram-positive and Gram-negative was isolated from these substrates. Polyphasic approach including phenotyping and molecular methods such as ribotyping, protein profile analysis and fatty acids determination, phylogenetic study or sequencing of housekeeping genes was used for characterization and description of new species of bacteria.Oligotrophic bacteria of the class *Gammaproteobacteria* with dominative occurrence of fluorescent *Pseudomonas* strains were the most frequent. Newly described taxa of bacteria from this group are psychrotrophic *Pseudomonas prosekii* (Kosina et al., 2013) and *Pseudomonas gregormendelii* (Kosina et al. 2016). The second group of frequently isolated bacteria from environmental samples is represented by yellow or orange colored psychrophilic species of *Flavobacterium*. Bacteria with pink to red pigments belonging to the genera *Pedobacter*, *Hymenobacter, Mucilaginibacter* and *Massilia* were isolated from regolith. Generally, Gram-negative bacteria predominated over Gram-positive bacteria due to their higher nutrition requirements.

Acknowledgements

Research was supported by Czech Ministry of Education large infrastructure project LM201 5078 “Czech Polar Research Infrastructure”.

References

Egidi, E., de Hoog, G. S., Isola, D., Onofri, S., Quaedvlieg, W., de Vries, M., Verkley, G. J. M., Stielow, J. B., Zucconi L., Selbmann L. (2014). Phylogeny and taxonomy of meristematic rock-inhabiting black fungi in the Dothideomycetes based on multi-locus phylogenies. Fungal Diversity, 65, pp. 127–165.

Grillová, L., Sedláček I., Páchniková G., Staňková E., Švec P., Holochová P., Micenková L., Bosák J., Slaninová I., Šmajs D. (2018). Characterization of four Escherichia albertii isolates collected from animals living in Antarctica and Patagonia. Journal of Veterinary Medical Science, 80, pp. 138-146.

Kosina, M., Barták, M., Mašlaňová, I., Vávrová Pascutti, A., Šedo O., Lexa, M., Sedláček I. (2013). *Pseudomonas prosekii* sp. nov., a novel psychrotrophic bacterium from Antarctica. Current Microbiology. 67, pp. 637-646.

Kosina, M., Švec, P., Černohlávková, J., Barták, M., Snopková, K.,de Vos, P., Sedláček, I. (2016). Description of Pseudomonas gregormendelii sp. nov., a novel psychrotrophic bacterium from James Ross Island, Antarctica. Current Microbiology, 73, pp. 84-90.

Onofri, S., Selbmann, L., Zucconi, L., Pagano, S. (2004). Antarctic microfungi as models for exobiology. Planetary and Space Science, 52, pp. 229 – 237.

Selbmann, L., de Hoog, G. S., Mazzaglia, A., Friedmann, E. I., Onofri, S. (2005). Fungi at the edge of life:cryptoendolithic black fungi from Antarctic desert. Studies in Mycology 51, pp. 1-32.

Selbmann, L., Zucconi, L., Isola, D., Onofri S. (2015). Rock black fungi: excellence in the extremes, from the Antarctic to space. Current Genetics, 61, pp. 335-345.

Recent progress in understanding paraglacial landslides

Tomáš Pánek[1*]

[1] Department of Physical Geography and Geoecology, Faculty of Science, University of Ostrava
* tomas.panek@osu.cz

Key words: Paraglacial landslides, rock-slope failure, deglaciation, alpine valleys, glacier forelands

Large ($\geq 10^6$ m^3) landslides in deglaciated mountain valleys have been traditionally related to glacier withdrawal following the Last Glacial Maximum and/or Late Glacial/Holocene transition. However, recent boom in dating techniques, monitoring and numerical modeling reveal much complex temporal behaviour of landslides in respect to ice retreat history. Large rock-slope failures (RSFs) like deep-seated gravitational slope deformations (sackung), rockslides and rock avalanches seldom originate immediately after the deglaciation of mountain valleys. This millennial-scale time lag is explained by prolonged stress release within the rock mass, subcritical crack growth, progressive failure of intact rock bridges and action of external triggers. Growing datasets of dated RSFs in different world mountain belts suggest that paraglacial mechanisms work most efficiently together with external factors like earthquakes, extreme hydrometeorological events or climate changes. Furthermore, some dating results and recent monitoring suggest that some RSFs might survive glaciation and rockslides can move into the glaciers. Besides rock slopes, there are other paraglacial landsystems prone to large-scale mass movements. Recent studies reveal that exceptionally susceptible to large landslides are glacier forelands, especially slopes of terminal moraines exposed to fluctuations of water levels of glacial lakes.

Biological soil crusts – engineer of arid and semiarid areas

Klára Řeháková[1]*, Kateřina Čapková[1]

[1] Institute of Botany Třeboň, Academy of Science, Czech Republic
* krehakova@email.cz

Keywords: biological soil crusts, arid and semiarid ecosystems, ecology, functions, microbial community

Biological soil crusts (BSCs) are an amazing ecosystem, which is created by cyanobacteria, bacteria, microalgae, fungi and lichens, and can be found in arid and semiarid areas. BSCs are key players and ecological engineers of these ecosystems. BSCs also often occur in post-mining landscapes, which show similar ecological conditions as the deserted areas. The deserted areas represent more than 1/3 of land's surface, and in the near future, this share is going to increase with the ongoing climatic changes.

Historically, biologists have concentrated mainly on the study of individuals, characterizing their form and function as a result of their own genotype alone. It is however becoming apparent that inter-organismal alliances, especially those involving microorganisms, have been at the basis of major evolutionary milestones.

Together with my colleagues, I worked with a biological soil crust, which represents a simple food chain on the scale of centimetres, where Cyanobacteria are the primary producers, heterotrophic bacteria (Archea) and fungi are the decomposers, and Nematoda, Rotifera and Tardigrades are the primary consumers. The secondary and tertiary consumers are often missing in the areas where BSCs occur (e.g., on the cold desert of Tibetan Plateau). This fact makes the investigation simpler than in the other ecosystems such as forest. This uncomplicated model is suitable for the testing of ecological hypothesis; it can be relatively easily manipulated for experimental purposes and can help uncovering novel aspects of phototrophic-heterotrophic microbe interactions, and microbes–vascular plant interactions in relation to climatic conditions.

This ecosystem is an ideal opportunity to enhance our understanding of the carbon cycling in the deserted soils, because the causal link between changes in temperature, precipitation, and terrestrial processes remains uncertain. We do not know if BSCs remove carbon dioxide from the atmosphere or contribute to it – whether they are the carbon sink or source. Also the interactions between phototrophic and heterotrophic parts of BSCs, and BSCs and vascular-plants still need to be studied because each member of the food chain can react differently to the climate changes.

Extreme processes shaping Arctic coasts in a period of rapid paraglacial landscape transformation

Mateusz Czeslaw Strzelecki[1*]

[1] Institute of Geography and Regional Development, University of Wroclaw, pl. Uniwersytecki 1, 50-137 Wroclaw, Poland
* mateusz.strzelecki@uwr.edu.pl

Keywords: Coastal evolution, landslides, tsunami, iceberg roll wave, Greenland

The recent appeal by Fritz et al. (2017) accentuated an urgent need for transdisciplinary research effort to investigate the physical and human impacts resulting from collapsing Arctic coastlines. The observed intensification of Arctic coastal change is mostly associated with decreased sea ice extent and duration that increases shoreline exposure to greater wave energy (e.g., Barnhart et al., 2014). The loss of sea-ice is, however, only one of the processes that transform Arctic coastal zone. The functioning of the present-day Arctic coastal system is also influenced by permafrost degradation (e.g., Wobus et al., 2011), storm floodings (e.g., Pisaric et al., 2011), and increased sediment supply from deglaciated and snow-fed catchments (e.g., Strzelecki et al. 2017; 2018). The majority of those changes have a strong impact on circum-Arctic coastal communities and their historical (including archaeological) and modern infrastructure (e.g., Ford et al., 2010, Mason et al. 2012, Jaskólski et al., 2018).

In my talk I will draw your attention on the effects of another extreme process transforming Arctic coastal environment – the impact of tsunami waves. Most of us probably know that polar regions are sufficiently far from the major plate boundaries to escape from significant tsunamis, generated by large earthquakes, such as the recent Indian Ocean (2004) or Japanese (2011) events. However, the unstable nature of Arctic landscape in terms of landslides provides a potential tsunami source (Dahl-Jensen et al. 2004; Buchwał et al. 2015). Moreover, calving glaciers and rolling of large icebergs may be potential sources of high waves, particularly in the fjords, the shape of which can amplify the size of the wave. Arctic tsunamis have been mostly recorded in fjord systems, which may amplify wave heights due to their constraining topography. For example, a tsunami wave in Lituya Bay (Alaska), reached the highest run-up ever recorded (516 m a.s.l.). Arctic coasts are also affected by far-field events such as famous Storegga tsunami from ca. 8200 years BP. Storegga event is recorded along many of the coastlines of the northern Atlantic, including east Greenland. In the Disko Bay area (western Greenland) on November 21, 2000 AD, a large landslide took place that caused a tsunami reaching 50 meters above the sea level. The wave destroyed the town Qullissat on the opposite site of the strait, however, material losses were observed in distant places by as far as 150 km from the landslide. The same region is also one of the most threatened by large, often over 5 meters high incident long waves, which are caused by calving glaciers and icebergs overturning. Most of the icebergs in the area are produced by the fastest ice-stream in the northern hemisphere – the Jakobshavn Isbrae.

I will present the selected results of the novel study of the geomorphological, sedimentological and environmental effects of modern tsunamis caused by landslides and collapsing icebergs in Western Greenland carried out together with research partners from Poland and the United Kingdom. Presented results will serve as a guide for further studies of palaeotsunami in Greenland and elsewhere in the Arctic. The results are also of importance for Arctic coastal risk assessments, as almost all the human infrastructure is situated along a narrow coastal strip.

Finally, I will present my recommendations for further Arctic coastal change research directions and some ideas for potential multidisciplinary research cooperation among young polar investigators interested in cold region coastal environments.

Funding for the Greenlandic project was provided by Polish National Science Centre grant No. 2011/01/B/ST10/01553.

References

Barnhart, K., Overeem, I., Anderson, R. (2014). The effect of changing sea ice on the physical vulnerability of Arctic coasts. The Cryosphere, 8, pp. 1777-1799.

Buchwał, A., Szczuciński, W., Strzelecki, M. C., Long, A. J. (2015). New insights into the 21 November 2000 tsunami in West Greenland from analyses of the tree–ring structure of Salix glauca. Polish Polar Research 36, pp. 51-65.

Dahl-Jensen, T., Larsen, L. M., Pedersen, S. A. S., Pedersen, J., Jepsen, H. F., Pedersen, G., Nielsen, T., Pedersen, A. G., Von Platen-Hallermund, F., Weng, W. (2004). Landslide and tsunami 21 November 2000 in Paatuut, West Greenland. Natural Hazards, 31, pp. 277-287.

Ford, J. D., Bell, T., St-Hilaire-Gravel, D. (2010). Vulnerability of community infrastructure to climate change in Nunavut: a case study from Arctic Bay. In Community Adaptation and Vulnerability in Arctic Regions, ed. Hovelsrud, G. K., Smith, B., pp. 107-130. Dordrecht: Springer.

Fritz, M., Vonk, J. E., Lantuit, H. (2017). Collapsing Arctic coastlines. Nature Climate Change, 7, pp. 6-7.

Mason, O. K., Jordan, J. W., Lestak, L., Manley, W. F. (2012). Narratives of shoreline erosion and protection at Shishmaref, Alaska: The anecdotal and the analytical. In Pitfalls of Shoreline Stabilization. Cooper, J. A. G., Pilkey, O. H (eds.). Coastal Research Library, 3, pp. 73–92.

Pisaric, M. F., Thienpont, J. R., Kokelj, S. V., Nesbitt, H., Lantz, T. C., Solomon, S., Smol, J. P. (2011). Impacts of a recent storm surge on an Arctic delta ecosystem examined in the context of the last millennium. Proceedings of the National Academy of Sciences, 108, pp. 8960-8965. doi: 10.1073/pnas.1018527108.

Strzelecki, M. C., Long, A. J., Lloyd, J. M. (2017). Post-Little Ice Age Development of a High Arctic Paraglacial Beach Complex. Permafrost and Periglacial Processes, 28, pp. 4-17.

Strzelecki, M. C., Long, A. J., Lloyd, J. M., Małecki J., Zagórski, P., Pawłowski, Ł., Jaskólski, M. W. (2018). The Role of Rapid Glacier Retreat and Landscape Transformation in Controlling the Post-Little Ice Age Evolution of Paraglacial Coasts in Central Spitsbergen (Billefjorden, Svalbard). Land Degradation and Development https://doi.org/10.1002/ldr.2923

Wobus, C., Anderson, R., Overeem, I., Matell, N., Clow, G., Urban, F. (2011). Thermal Erosion of a Permafrost Coastline: Improving Process-Based Models Using Time-Lapse Photography. Arctic, Antarctic, and Alpine Research, 43, pp. 474-484.

Influence of large-scale atmospheric variability patterns and sea ice on air temperature on James Ross Island, Antarctica

Klára Ambrožová[1*], Kamil Láska[1]

[1] Department of Geography, Faculty of Science, Masaryk University, Czech Republic
* ambrozova.kl@mail.muni.cz

Keywords: James Ross Island, Antarctic Peninsula, air temperature, El Niño – Southern Oscillation, Southern Annular Mode

In the recent decade, the Antarctic Peninsula Region has been experiencing a period of cooling, which was attributed to increased cyclonic conditions resulting in higher sea ice concentration around the northern AP (Turner et al., 2016). There has also been a discussion about the influence of El Niño – Southern Oscillation (ENSO) and Southern Annular Mode (SAM) on air temperature in the Antarctic Peninsula Region which should also depend on the interaction between ENSO and SAM (e.g., Clem et al., 2016).

In this study, we have analysed the relationship between air temperature from the Ulu Peninsula (James Ross Island), ENSO, SAM and sea ice in the vicinity of James Ross Island. Air temperature data were measured at 2 m height above ice-free surface of a marine terrace close to Johann Gregor Mendel Czech Antarctic Station during the period 2005–2016. The ENSO phenomenon was represented by Multivariate ENSO Index (MEI; NOAA ESRL PSD, 2018), while sea ice influence was characterised as a sea ice fraction in the grid point closest to the Johann Gregor Mendel Station in the MERRA-2 Reanalysis (NASA, 2018). All the data including SAM Index (UCAR, 2018) were analysed as monthly means.

There was found a statistically significant negative relationship between air temperature and sea ice (correlation coefficient r = -0.88); however, due to common annual cycle in air temperature and sea ice data, the relationship was only moderate (r = -0.59) when the differences from the monthly mean of the whole study period were utilised. The relationship was strongest in winter and weakest in summer. The influence of SAM on air temperature was only moderate for the whole study period (r = 0.35), even though also statistically significant, and similarly to sea ice, its influence was largest in winter (r = 0.56). Interestingly, there was also a statistically significant relationship between sea ice and SAM in winter (r = -0.52). Finally, no relationship was ascertained between air temperature on the Ulu Peninsula and ENSO.

Acknowledgements

Research was supported by the Czech Science Foundation project (GC16-14122J), the Czech Polar Research Infrastructure project (LM2015078) and ECOPOLARIS project (CZ.02.1.01/0.0/0.0/16_013/0001708) funded by the Ministry of Education, Youth and Sports of the Czech Republic.

References

Clem, K. R., Renwick. J. A., McGregor, J., Fogt, R. L. (2016). The relative influence of ENSO and SAM on Antarctic Peninsula climate. Journal of Geophysical Research: Atmospheres, 121, pp. 9324–9341.

Turner, J., Lu, H., White, I., King, J. C., Phillips, T., Hosking, J. S., Bracegirdle, T. J., Marshall, G. J., Mulvaney, R., Deb, P. (2016). Absence of 21st century warming on Antarctic Peninsula consistent with natural variability. Nature, 535 (7612), pp. 411–415.

Geophysical methods for assessing physical and mechanical properties of frozen soils

Ivan Agapkin[1*], Pavel Kotov[1], Andrey Koshurnikov[1]

[1] Faculty of Geology, Lomonosov Moscow State University, 1 Leninskiye Gory, GSP-1, 119991, Moscow, Russia
*15331533@mail.ru

Keywords: frozen saline soil, mechanical properties, velocity of ultrasonic waves, electrical resistivity

One of the most important investigations in geophysics is the estimation of the stress-strain state of frozen soils in the massif. Today, engineering geology and geotechnics are successfully applied for this purpose (drilling, sampling, laboratory and field testing). As a result of these investigations, there is a geological section, which is divided into engineering-geological elements with a set of physical and mechanical properties of soils. These characteristics are used to calculate the stress-strain state. However, these methods are very laborious, require high material costs and in some cases are difficult to implement. The characteristics of soils obtained during the tests are discrete and do not take into account the spatio-temporal variability of the properties and conditions of frozen soils. Therefore, it is important to use geophysical methods for forecasting and monitoring the properties of frozen soils. Although this estimate is indirect and less accurate than direct testing, it can characterize the massif in its natural form and provide long-term monitoring of the change in its stress-strain state. The scientific significance lies in establishing the basic dependencies used in the transition from geophysical parameters to physical and mechanical. Simultaneous use of electrical and acoustic characteristics to evaluate the same parameters of the composition and structure of the soil can significantly improve the reliability of the results obtained (Wu et al., 2017). From the point of view of increasing the informativeness of the geophysical methods, the establishment of the dependence of strength on geophysical parameters that are correlated with the modulus of deformation, is of particular interest. Therefore, special studies were made on the relationship between strength and geophysical properties (electrical and acoustic).

The studies were conducted on two artificial samples (fine sand, lean clay). Artificial soil belonged to non-saline soils. Solutions with different concentrations of NaCl were mixed to set different degrees of salinity (fine sand – 0.1 %, 0.23 %, and 0.6 %, lean clay – 0.3 %, 0.6 %, and 1.0 %). We have prepared samples of given water content (sand – 9 %, 15 %, and 20 %, lean clay – 20 %, 30 %, and 36 %). The density was set by layering compaction in special forms. All samples had massive cryogenic texture.

Spherical template indenter test and uniaxial compression were carried out according to GOST 12248-2010 at the temperatures of -2 °C, -4 °C, and -6 °C. All tests were carried out with a fourfold repetition. A total of 110 experiments were conducted.

Acoustic and electrical properties were determined on the samples before and after the tests. Measurements of the electrical properties of soils were carried out on a low-frequency alternating current by a four-electrode installation. Measurements were made with a set of equipment "Spectrum 1", developed by LLC "MSU-Geophysics". Measurements of the acoustic properties of soils were carried out using UD4-130 equipment and a set of acoustic sensors with a center frequency of 60 kHz. The choice of such a frequency range was associated with the need to obtain clear first arrivals, provided that the ratio the wavelength and the geometric parameters of the sample are preserved. For the measurement of the velocities of the passage of elastic waves, the X-ray method was used. The speed of passage of elastic vibrations is defined as the ratio of the transmission base to the propagation time of these waves.

Temperature is a significant factor influencing the value of strength of frozen soils. Unfrozen water content has a strong relationship with strength and

it mainly depends on temperature. Velocity of the ultrasonic waves depends on temperature too, because of velocity increases in ice or the mineral part. The ultrasonic wave velocities and electric resistivity dramatically increases as the temperature changes from -2 °C to -6 °C.

This relationship is more noticeable in lean clay because there is far less unfrozen water in sand. So we can see that lean clays under -6 °C have the maximum velocity and maximum strength. With increasing temperature, unfrozen water content also increases, and the values of velocity and strength reduce. Salinity is an important factor, which increases the freezing temperature. In salty samples, electrical resistivity decreases because salt water is a good conductor. The samples with maximum salinity have more unfrozen water, which decreases the strength and geophysical characteristics. Regressive equations were obtained for the dependence of strength and deformation characteristics as a function of salinity and wave velocity, limiting electrical resistance for each soil type. The coefficients of this equation are functions of temperature. Factor analysis shows that the specific electrical resistance is inversely proportional to the concentration of the pore solution. With increasing salinity, electrical properties change more intensively than wave velocities.

References

GOST 12248-2010 (2011). Soils. Laboratory methods for determining the strength and strain. Standartinform, 109 pp.

Wu, Y., Nakagawa, S., Kneafsey, T. J., Dafflon, B., Hubbard, S. (2017). Electrical and seismic response of saline permafrost soil during freeze - Thaw transition. Journal of Applied Geophysics, 146, pp. 16–26.

Spatial variability of soil organic carbon and active layer thickness along a latitudinal transect from taiga to tundra of Western Siberia

Anna Bobrik*[1], Natalia Petrzhik[1], Matvey Tarkhov[1]

[1] Department of Soil Science, Lomonosov Moscow State University, 1-12 Leninskie Gory, 119991, Moscow, Russia
*ann-bobrik@yandex.ru

Keywords: permafrost, CO_2 efflux, permafrost-affected soils, microbial carbon

Through the combination of the permafrost and significant reserves of soil organic matter, such as peat, cryogenic ecosystems are unique indicators of climate change in the early stages. Understanding the controls over element cycling in these ecosystems is important to predict changes in carbon (C) and nitrogen (N) dynamics due to climate change. So how is the variability of environmental factors related to the components of carbon cycle in different permafrost zones along a latitudinal transect? The aim of our study was to assess the spatial variability of the soil organic carbon pool and CO_2 efflux from the soils in north taiga, forest-tundra and south tundra of Arctic West Siberia (Russia). The north taiga research site (Nadym) is located in discontinuous permafrost zone (N 65°18', E 72°52'). The average active layer thickness was 163 ± 8 cm (August 2015). The CO_2 efflux from the peatlands was low (202 ± 37 mg $CO_2 \cdot m^{-2} \cdot h^{-1}$). The upper horizons of the peatland soils statistically differed from those of the bog in the contents of the total (31.88 ± 3.02 %, and 37.96 ± 2.00 %, respectively), labile (1400 ± 300, and 31100 ± 2200 $mgC \cdot kg^{-1}$ of soil) and microbial carbon (4260 ± 330, and 240 ± 50 $mgC \cdot kg^{-1}$ of soil).

The forest-tundra research site (Urengoy Gas Field) is located in continuous permafrost zone (N 66°18', E 76°54'). The average active layer thickness was 85 ± 10 cm (August 2015). CO_2 efflux from the peatland soil was low and characterized by high variability (202 ± 25 $mgCO_2 \cdot m^{-2} \cdot h^{-1}$). The average content of total organic carbon was high (29.58 ± 5.02 %). The average content of labile organic carbon in the peatland soils was smaller than in the bog soils (1350 ± 150, and 25 400 ± 4000 $mgC \cdot kg^{-1}$ of soil, respectively).The south tundra research site (Urengoy) is located in continuous permafrost zone (N 67°48; E 76°69'). Soils of this research site are characterized by low active layer thickness, CO_2 efflux, and content of microbial carbon (August 2016).

The spatial distribution of CO_2 efflux and content of water-extractable organic carbon are strongly correlated with hypsometric levels ($r = -0.33$, and $r = -0.42$ respectively, $p < 0.05$) in tundra ecosystems. Despite the wide array of changes in both physical (soil temperature, soil moisture) and biological conditions (vegetation composition, content of labile and microbial soil carbon), our results show that soil CO_2 flux did not vary significantly throughout the transect (taiga-forest tundra-south tundra). However, the depth of permafrost table differed significantly. It explains the necessity of an adequate assessment of the active layer thickness spatial variability a significant factor influencing regional CO_2 emission. The results show that the active layer thickness in our experimental area in the Siberian taiga and forest tundra is an important control on soil organic carbon efflux, but in continuous permafrost zone (forest-tundra), this relationship is stronger than in discontinuous permafrost zone (north taiga).

References

GOST 12248-2010 (2011). Soils. Laboratory methods for determining the strength and strain. Standartinform, 109 pp.

Wu, Y., Nakagawa, S., Kneafsey, T. J., Dafflon, B., Hubbard, S. (2017). Electrical and seismic response of saline permafrost soil during freeze - Thaw transition. Journal of Applied Geophysics, 146, pp. 16–26.

Variability of the vertical ozone profiles at the Marambio Base, Antarctic Peninsula Region

Klára Čížková[1,2*], Martin Staněk[1], Ladislav Metelka[1], Kamil Láska[2]

[1] Czech Hydrometeorological Institute, Solar and Ozone Department, Hradec Králové, Czech Republic
[2] Department of Geography, Faculty of Science, Masaryk University, Czech Republic
* cizkova.klara@hotmail.com

Keywords: ozone, depletion, ozone hole, Antarctica, Umkehr, vertical profiles, stratosphere

Ozone (O_3) is a gas most abundantly occurring in ozonosphere (about 20–30 km above the surface), and it protects the life on Earth against the harmful ultraviolet radiation. In the 1980s, severe ozone losses were observed over the Antarctica (Farman et al., 1985), and although the first signs of recovery have already been reported (e.g., Solomon et al., 2016), ozone depletion is still an ongoing issue. Therefore, it is important to continuously monitor the ozone layer and its vertical structure.

There are several different ways of vertical ozone profile retrievals, such as ozone soundings, satellite observation, or the Umkehr method, which is based on ground-based spectral ultraviolet radiation measurements. This method was first described by Götz et al. (1934) and the currently most used algorithm has been proposed by Petropavlovskikh et al. (2005).

At the Marambio Base, Antarctic Peninsula Region (S 64°14′27.65″, W 56°37′36.31″, 196 m a. s. l.), the Umkehr vertical ozone profile retrievals have been carried out since February 2010, when the B199 Brewer spectrophotometer was installed there by the Czech Hydrometeorological Institute. Based on this time series and collocated ozone soundings, an innovative method of retrieving the Umkehr vertical ozone profiles near the edge of the Southern polar vortex, which takes in account the shape of the ozone profile, has been proposed by Čížková et al. (2018). In this study, the vertical ozone profiles time series obtained by this adjusted Umkehr retrieval has been assessed and analyzed.

The shape of the depleted and non-depleted profiles significantly differs especially at Umkehr layer 4 (approximately 15–20 km above surface), however, the signs of ozone depletion have been also observed at layers 5 and 6 (between 20–30 km above surface). In early austral spring (August), the ozone depletion starts in the upper layers of the ozonosphere, which are more exposed to the solar ultraviolet radiation. During late August and September, the depletion propagates downward to layer 4. The ozone layer recovers by the end of November, while the uppermost layers heal sooner than the lower layers of the ozonosphere. However, due to the location of the Marambio Base near the Antarctic Circle and due to the deformations and rotation of the polar vortex, frequent changes in ozone amounts have been observed. In only several days, the total ozone amount can change by more than 100 Dobson Units and the ozone profile from depleted to non-depleted and vice versa. The Marambio time series is therefore a good example for studying the ozone vertical structure near the edge of polar vortex, where the alternating influxes of ozone-rich and ozone-poor air create a unique ozone climatology.

Acknowledgements

This study was performed under the financial support of the Project of the Czech Hydrometeorological Institute No. 03461022 ‘Monitoring of the ozone layer and UV radiation in Antarctica’, funded by the State Environmental Fund of the Czech Republic; Projects of Masaryk University MUNI/A/1251/2017 ‘Integrated research of environmental changes in the landscape sphere III’; LM2015078 ‘Czech Polar Research Infrastructure’ funded by the Ministry of Education, Youth and Sports of the Czech Republic; and Aktion Österreich-Tschechien: On the vertical distribution of ozone within the edge of the Antarctic polar vortex: a comparison of Sounding and Umkehr profiles from Marambio

Base. Data courtesy of the Czech Hydrometeorological Institute.

References

Čížková, K., Rieder, H. E., Staněk, M., Petropavlovskikh, I., Metelka, L., Láska, K. (2018). Can Brewer Umkehr measurements capture ozone variability near the edge of the Southern polar vortex? Geophysical Research Abstracts, 20.

Farman, J. C., Gardiner, B. G., Shanklin, J. D. (1985). Large losses of total ozone in Antarctica reveal seasonal Cl0x/NOx interaction. Nature, 315, pp. 207–210.

Götz, F., Meetham, A. R., Dobson, G. B. (1934). The vertical distribution of ozone in the atmosphere. Proceedings of the Royal Society London. Series – A., 145, pp. 416–446.

Petropavlovskikh, I., Bhartia, P. K., DeLuisi, J. J. (2005). New Umkehr ozone profile retrieval algorithm optimized for climatological studies. Geophysical Research Letter, 32 (L16808), pp. 1–5.

Solomon, S., Ivy, D. J., Kinnison, D., Mills, M.J., Neely, R. R., Schmidt, A. (2016). Emergence of healing in the Antarctic ozone layer. Science, 10.1126, pp. 1–12.

Hydrological modeling based on multiple data approaches in Boreal region with diverse permafrost conditions

Li Han[1*], Lucas Menzel[1]

[1] Institute of Geography, Professorship in Hydrology and Climatology, Heidelberg University, Heidelberg, 69120, Germany
*li.han@uni-heidelberg.de

Keywords: Boreal region, hydrological modeling, permafrost, global gridded data

The boreal ecotone has been experiencing drastic environmental changes, such as temperature increase, rising river discharges, and permafrost degradation. Enhanced by the complex interactions between climate, hydrology, and permafrost, these changes are expected to continue and perhaps accelerate in the coming century. Our project aims at better understanding of these long-term hydro-climatic changes and their possible interactions with permafrost dynamics in the Boreal region. By taking into account the process complexity, the large spatial-temporal variability and facing the challenge of limited data availability, we will apply both observation data and global gridded data to force two different hydrological models, HBV-D and the Raven modeling platform. With this setting, we investigate permafrost hydrological processes and conduct climate driven analyses across different spatio-temporal scales among diverse permafrost conditions.

So far, we have applied the hydrological HBV-D model to simulate the discharge in two meso-scaled catchments in the Selenga basin of Northern Mongolia: Gremyachka (15872 km^2) for the period 1946 to 1997 and Povorot (45018 km^2) for the period 1936 to 1997. The simulations were performed with four types of combinations of two input data and two HBV-D model versions: observation-data-lumped (OL), observation-data-distributed (OD), grid-data-lumped (GL), and grid-data-distributed (GD). For each combination, the HBV-D model shows an acceptable performance, assessed by the Nash-Sutcliffe model efficiency (NSE) and the lnNSE coefficients, with values being above 0.70. While the OD combination was found to have the best performance among the four combinations, the GD combination shows more improvement as basin area increases (from 15872 km^2 to 45018 km^2). This indicates that the gridded data have the potential to run hydrological models in a data scarce environment, especially in the large Siberian river basins, where the availability of observation-based stations is very limited.

Past and present of Arctic terns` studies

Tereza Hromádková [1,*], Michaela Syrová[1], Martin Briedis[2,3], Václav Pavel[1,2]

[1] Faculty of Science, University of South Bohemia, Branišovská 31a, České Budějovice, Czech Republic
[2] Faculty of Science, 17. listopadu 50, Palacky University Olomouc, Czech Republic
[3] Swiss Ornithological Institute, Seerose 1, Sempach, Switzerland
* hromadkova.ter@gmail.com

Keywords: antipredation behaviour, Arctic tern, human impact, incubation behaviour, geolocator, migration

Arctic terns (*Sterna paradisaea*) are colonially nesting birds breeding in the High Arctic area. When the northern winter comes, they migrate to the southern hemisphere where their wintering areas are located around the Antarctica. Aims of our Arctic terns' studies are (i) to examine the impact of human presence on reaction and behaviour of nesting terns in two different colonies in Svalbard (the first with permanent human presence – Svalbard's main settlement, Longyearbyen = LYR; the second without humans present – a colony on a glacier foreland in Adolfbukta = ADOL), and (ii) to track the southbound and northbound path of the migrating Arctic terns from Svalbard.

The results of an incubation behaviour study showed a significant effect of human presence on the behaviour of Arctic terns. Due to the higher ratio of human disturbances in the Longyearbyen colony, the incubating birds tended to spend more time out of the nest per day ($mean_{LYR}$ = 2.20 %, $mean_{ADOL}$ = 3.03 %; linear model, $F_{1,27}$ = 4.36, $p < 0.05$), and average off-bouts were significantly longer than in Adolfbukta ($mean_{LYR}$ = 38.15 s, $mean_{ADOL}$ = 36.85 s; generalized linear model, $p < 0.05$). Moreover, the Longyearbyen terns were also significantly more aggressive towards humans compared to the terns from Adolfbukta, but returned to the nest quickly after the initial disturbance, while the Adolfbukta terns lingered out of the nest for a much longer period ($mean_{LYR}$ = 48 s, $mean_{ADOL}$ = 421 s, Linear model, $F_{1,59}$ = 145.75, $p < 0.001$).

These findings indicate that the reaction of terns is not optimal in either of the breeding colonies. In Longyearbyen, terns are more aggressive, spend less time incubating eggs due to frequent human-induced disturbances, but after disturbing they return to the nest quickly. Whereas the terns breeding in Adolfbukta are not adapted to human presence and as consequence those sporadic disturbances can cause damages to the nests (e.g., chilling eggs, predation) due to prolonged absences of the parents from the nests.

The migration study is in process. In the breeding season 2017 we equipped 30 Arctic terns with geolocators in the breeding colony in Longyearbyen. The selected type/brand of geolocator was Intigeo-W65A9-SEA/Migrate Technology Ltd., and it was mounted to the leg-ring. To obtain the data from geolocators, we plan to recapture as many terns as possible in June and July 2018.

Taxonomy, ecology and biogeography of diatoms (Bacillariophyta) of two isolated sub-Antarctic islands

Barbora Chattová[1,*], Bart van de Vijver[2,3]

[1] Department of Botany and Zoology, Faculty of Science, Masaryk University, Czech Republic
[2] Botanic Garden Meise, Research Department, Domein van Bouchout, B-1860 Meise, Belgium
[3] University of Antwerp, Department of Biology, ECOBE, Universiteitsplein 1, B-2610 Wilrijk, Belgium
* barbora.chattova@gmail.com

Keywords: Bacillariophyta, ecology, Ile Amsterdam, Ile Saint-Paul, new species, sub-Antarctic region

This study brings information about the diatom diversity and taxonomy of two isolated, volcanic islands, Île Amsterdam and Île Saint-Paul (TAAF, Southern Indian Ocean). The first part of the research focuses on the ecological preferences of the freshwater and moss inhabiting diatom flora of Île Amsterdam, its biogeographical position within the southern Indian Ocean Province, and the different diatom communities in relation to several habitat characteristics. A series of physicochemical variables have been measured to allow specific characterisation of the ecological preferences of the observed diatom flora. During this study, more than 400 samples from three different habitat types (freshwater habitats, mosses and soils) have been analysed, resulting in the observation of a total number of 146 diatom taxa, belonging to 41 genera. Main factors influencing species composition of diatom assemblages appeared to be specific conductance, sulphate, pH and moisture content. The biogeographical analysis showed that 19 % of all observed taxa can be considered endemic to Île Amsterdam or Île Saint-Paul, with an additional 14 % showing an exclusive sub-Antarctic distribution. One of the main objectives of this study was to revise the diversity of the dominant genera (*Pinnularia, Humidophila* and *Luticola*) on Île Amsterdam and Île Saint-Paul based on a modern morphological species concept. The study resulted in the description of sixteen new taxa. Detailed morphological descriptions of these taxa are given based on both light (LM) and scanning electron microscopy (SEM) observations. The new taxa are morphologically and ecologically characterized comparing each of them with all at present known species and notes on their ecology, biogeography and associated diatom communities are added. A comparison with the other sub-Antarctic islands in the southern Indian Ocean clearly demonstrated the unique floristic situation of the islands. The results of this study indicate the presence of a highly specific diatom flora on the investigated islands, containing a large number of species with a very restricted, even sometimes endemic distribution, contrary to the generally accepted ideas about the cosmopolitan nature of micro-organisms worldwide.

On the origin and evolution of proglacial lake Ragnar, central Spitsbergen

Jan Kavan[1*]

[1] Department of Geography, Faculty of Science, Masaryk university, Kotlářská 2, 61137, Brno, Czech Republic
* jan.kavan.cb@gmail.com

Keywords: glacier retreat, Spitsbergen, proglacial lake

Central Svalbard experiences rapid deglaciation in last decades resulting in vast areas being exposed to erosion and transformation of landscape in general. Glacier forelands are dynamic areas with high velocity of geomorphic processes and are also perfect places for origin of new lakes.

Ragnar lake is one of the largest (if not the largest one at all) in the area of Billefjorden. It covers an area of 51.6 ha recently (2017). The lake is dammed by a frontal moraine dated back to little ice age. As all the neighbouring glaciers, the Ragnar glacier is retreating as well nowadays. Average retreat rate of approximately 20 m/year in last years allows the lake to spread its surface and also transform its bottom.

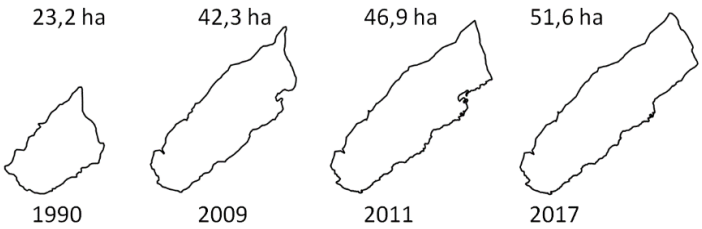


Figure 1 Development of the lake area based on aerial photographs and GPS surveys.

It is possible to reconstruct the evolution of lake based on aerial photographs and field GPS surveys. There was actually no lake on the photographs from 1961, however the lake appears on the pictures from 1991. According to several personal observations of visitors, the origin of the lake can be dated between 1979 and 1984.

The evolution of the lake area based on aerial photos and GPS measurements is well illustrated in Figure 1. Apart the changes in area, an attempt to evaluate changes in volume has also been made with use of GPS map sonar. Two surveys have been made in 2011 and 2017. Rather important changes have been detected especially close to the northern shore line and obviously also close to the retreating glacier front where new volume of lake water was created. This evolution in lake volume is documented in Figure 2.

Lake Ragnar is a perfect example of recent high velocity geomorphic processes connected to fastened glacier retreat within the last decades. It is very likely that such processes will go on with further atmospheric forcings. It can be expected that the lake will continue to grow in its area and volume as far as the frontal moraine is stable enough to hold on the increasing volume of lake water. The origin is documented to be rather fast but it can happen that also the destruction could be a fast going process.

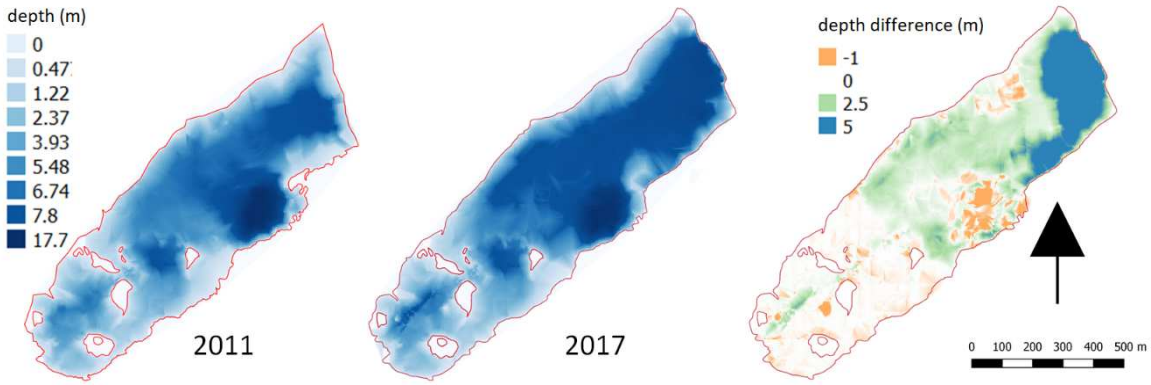


Figure 2 Changes in lake bathymetry.

Environmental factors influencing Svalbard reindeer (*Rangiferus tarandus*) populations as seen through antler characteristics

Jan Kavan[1*], Veronika Anděrová[2]

[1] Department of Geography, Faculty of Science, Masaryk university, Kotlářská 2, 61137, Brno, Czech Republic
[2] Department of Zoology, Faculty of Science, University of South Bohemia, Branišovská 1760, 37005, Ceske Budejovice, Czech Republic
* jan.kavan.cb@gmail.com

Keywords: reindeers, population, fitness, Svalbard

Reindeer fitness can be correlated with antler size and number of tines as described for reindeers and other species of *Cervidae*. Fitness of reindeer is a result of different environmental parameters influencing their ability to feed during the vegetation season. In case of the Svalbard reindeer, the basic parameters influencing feeding success are the length of the summer vegetation season, total biomass production and atmospheric conditions as a general factor influencing the above mentioned parameters.

Two isolated populations of Svalbard reindeer were studied in Billefjorden, central Svalbard. Observation and monitoring was carried out during summer 2017. The first population was located in the northernmost part of the fjord - Petuniabukta and its neighbourhood. The second one was based just in the mouth of Billefjorden near Skansbukta. Petuniabukta is characterised by semi-continental climate with rather sparse and poor vegetation. On the other hand, Skansbukta is relatively rich on vegetation and the climate is generally milder in comparison with Petuniabukta.

The observations were made directly in the field during August 2017. All specimen were photographed in their natural habitat with 300mm tele-objective multiple times to ensure high quality pictures with the possibility to measure relative size of antlers and number of tines. Each individual was measured for its shoulder height and relative antler size from a photo. The number of tines was counted as well.

Total number of 159 individuals was observed and documented from which 65 individuals were found in Petuniabukta and 94 in Skansbukta. The average relative antler size (RAS) was 0.37 for both groups. However, significant differences are to be found between the two populations. Average relative antler size including yearlings is in case of Petuniabukta 0.31 and 0.41 for Skansbukta respectively. These two parameters are documented in figure 1.

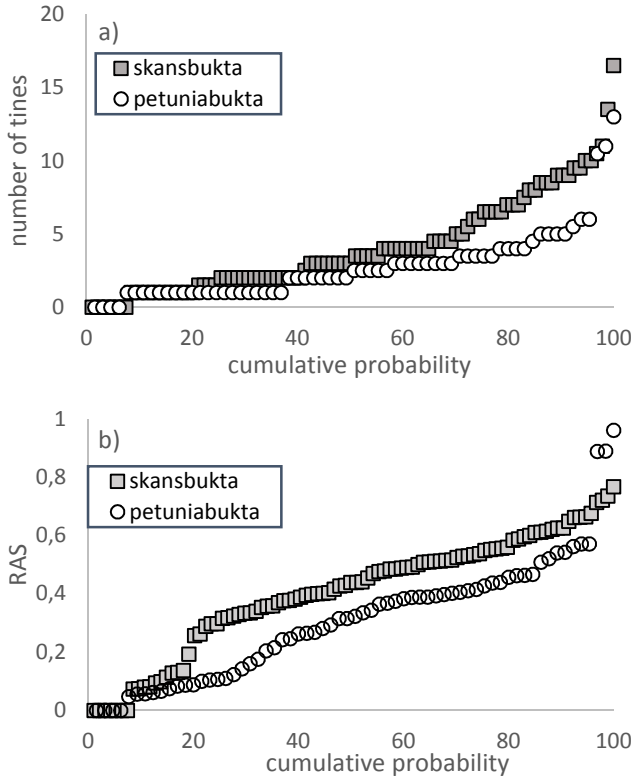


Figure 1. Number of tines a) and relative antler b) size cumulative probability for Petuniabukta and Skansbukta reindeer populations

A similar pattern was found when excluding yearlings from the analysis. RAS in case of Petuniabukta was 0.42 and 0.49 in case of Skansbukta. The average number of tines (NT) was found to be 3.58 for both groups. The difference between the two populations followed the pattern of RAS. NT in case of Petuniabukta was calculated

as 2.81 and 4.12 including yearlings whereas 3.76 for Petuniabukta and 4.95 for Skansbukta when excluding yearlings from the analysis.

The observed populations differ on the basis of both parameters – relative antler size and number of tines. Both parameters were tested with the test on differences of means ($p < 0.001$). It can be therefore concluded that the reindeer population in Skansbukta has higher fitness than the population in Petuniabukta. This correspond with better environmental conditions found in Skansbukta – higher mean annual temperature, higher quality of vegetation, higher land coverage of vegetation and longer vegetation season.

Influence of atmospheric circulation on total cloud cover and cloud types in central Spitsbergen

Sebastian Kendzierski[1,3,*], Leszek Kolendowicz[1], Marek Półrolniczak[1], Kamil Láska[2], Katarzyna Szyga-Pluta[1]

[1] Department of Climatology, Institute of Physical Geography and Environmental Planning, Faculty of Geographical and Geological Sciences, Adam Mickiewicz University in Poznań, Poland
[2] Department of Geography, Faculty of Science, Masaryk University, Brno, Czech Republic
[3] ENEA Trading Sp. z o. o., Świerże Górne, Kozienice, 26-900 Kozienice 1, Poland
* wrf@amu.edu.pl

Keywords: cloud cover, cloud amount, atmospheric circulation, Petuniabukta, Svalbard-Lufthavn, Spitsbergen

The aim of the project is to present the results of studies of the meteorological conditions for the area of western part of the Petuniabukta Bay (Svalbard) in July and August 2016. The report is based on observational data, which were obtained near the Adam Mickiewicz Polar Station and the Czech Station in the Petuniabukta Bay (Svalbard). The data contain information about cloud cover and type of clouds. Measurements and observations were performed every three hours at one measuring site – Petuniabukta. For the comparison of meteorological conditions, data from the Svalbard-Lufthavn station were collected. Regarding the impact of synoptic conditions on the values of the individual types of clouds, the classification of types of synoptic circulation was based on the typology by Niedźwiedź (2017). In terms of the meteorological parameters, the basic statistical measures were calculated. The project analysed the average daily mileages according to the circulation types of weather. For distinguished weather types based on the reanalysis data (NCEP/NCAR) for the sea level pressure (SLP), geophysical altitude 500 hPa, and air temperature at the geopothermic altitude of 850 hPa (T850), composite maps of the synoptic situations and their anomalies for the area W30° to E60°, N70° N85° were created. These weather types, distinguished on the basis of re-analysis of data (NCEP/NCAR), allowed for the creation of composite maps of the synoptic situation and its anomalies. They define synoptic situations during observation of a particular type of clouds and cloud cover.

References

Niedźwiedź, T. (2017). Kalendarz typów cyrkulacji atmosfery dla Polski południowej — zbiór komputerowy, Uniwersytet Śląski, Katedra Klimatologii, Sosnowiec. Available online: http://www.kk.wnoz.us.edu.pl/nauka/kalendarz-typow-cyrkulacji/

Effect of freezing-thawing on CO_2 fluxes from soils in the field manipulation experiment

Dmitry Khoroshaev[1,2]*, Irina Kurganova[1], Valentin Lopes de Gerenyu[1]

[1] Institute of Physicochemical and Biological Problems of Soil Science RAS, Institutskaya st. 2/2, 142290, Pushchino, Russia
[2] Pushchino State Institute of Natural Sciences, Science av. 3, 142290, Pushchino, Russia
* d.khoroshaev@tutanota.com

Keywords: soil respiration, imitation experiment, freeze-thaw events, extreme climate, snowpack depth

Cold-season CO_2 effluxes represent an important component of the annual carbon budget in seasonally snow covered ecosystems of tundra and boreal regions, where they can contribute 5–40 % of the annual CO_2 efflux from soils (Zamolodchikov and Karelin, 2001; Kurganova et. al, 2003; Wang et. al., 2010). It is also suggested that in seasonally snow-covered ecosystems, about 10–50 % of C uptake by plants during the growing season is respired by soil microbes during winter (Blankinship and Hart, 2012). However, the current efforts to estimate and simulate the carbon cycle in northern ecosystems are strongly hindered by the poor understanding of the factors controlling the main biochemical processes during the cold season. This study focused mainly on: (1) the comparison of soil temperature regimes due to differences in snow cover depth and land cover type, (2) the quantification of effect of snowpack pattern on cold-season CO_2 efflux from soils under various land cover types, and (3) the contribution of thawing events to the total cold-season CO_2 efflux from soils in the temperate continental region.

The study was carried out in artificial grassland and bare plots within the framework of a field snowpack manipulation experiment. The removal of snow cover and the use of heat insulation materials during the cold season permitted to maintain the contrasting snowpack and soil freezing regimes, including no frost and continuous freezing conditions. The plots were situated on Haplic Luvisols at the experimental site of the Institute of Physicochemical and Biological Problems in Soil Science of the Russian Academy of Sciences (Pushchino, Moscow region; N 54°50′, E 37°36′). The experimental area (70 m^2) was divided into 12 individual plots (2 m^2 in size). Six plots were planted with a mixture of legume and cereal seeds. The other six plots were bare and regularly weeded during the vegetation season. For each land cover type, the following winter treatments were applied: (1) reference plot, "Ref", with a natural depth of snow cover, (2) no-frost, "NoFr" (simulation of deep snow cover by artificial heat insulation materials, HIM), and (3) no-snow, "NoSn" (without snow cover). The reference plots did not receive any treatments. The "NoSn" plots were covered with a protective netted screen to remove the snowpack from the soil surface without any disturbance. During the whole experiment, snow was usually removed by this treatment on the day after a snowfall of more than 2–3 cm density. To avoid soil frost completely in the "NoFr" treatment, snow cover was manipulated by a 15 cm layer of artificial heat insulation material, which consisted of 3 layers of white padding polyester.

Air temperature (1.5 m above the soil surface) and soil temperature at four depths (1, 5, 10, and 20 cm below the soil surface) were measured 6 times per day at every plot by the thermochrons iButton (USA). At each plot, the rate of CO_2 efflux (ER-CO_2) was measured by the closed chamber method 1–5 times per week, depending on the freezing–thawing regime, from 22nd October 2014 until 4th April 2015 (85 measurements for each factorial combination in total).

The mean values of cold-season T_{soil} varied between 1.0 and 1.7 °C in the "NoFr" plots, and changed from 0.6 to −1.0 °C in the "Ref" and "NoSn" treatments. Minimal T_{soil} values in the "Ref" and "NoSn" treatments reached accordingly from −4.9 to −7.0 °C in the surface layer (1 cm) at bare plots, and from −4.2 to −4.8 °C at the grass areas. The rate of CO_2 efflux (ER-CO_2) from

unfrozen soils ("NoFr" treatment) changed from 13–30 mg $C \cdot m^{-2} \cdot h^{-1}$ during the winter time to 60–80 mg $C \cdot m^{-2} \cdot h^{-1}$ in autumn and spring. The mean cold-season rate of CO_2 efflux comprised here 46.1 ± 5.0 and 33.7 ± 5.6 mg $C \cdot m^{-2} \cdot h^{-1}$ from grass and bare plots, respectively. In the "Ref" and "NoSn" treatments (frozen soils), ER-CO_2 changed very markedly during the cold season, following the dynamics of T_{soil} in the upper soil layer (0–20 cm). The significant changes in CO_2 efflux rate caused by thawing relative to the previous freezing period were observed here only for the third freeze-thaw cycle, and comprised 602 % and 799 % in the "NoSn" and "Ref" treatments, respectively. Generally, the patterns of soil CO_2 efflux were similar for the "Ref" and "NoSn" treatments and included three main phases: (1) progressive decrease of ER-CO_2 from October to December, (2) nearly stable and low ER-CO_2 values (<10–15 mg $C \cdot m^{-2} \cdot h^{-1}$) during the winter months, and (3) sharp pulses (up to 100–250 mg $C \cdot m^{-2} \cdot h^{-1}$) and very high variability of ER-CO_2 values during the thawing period in early spring. The cumulative CO_2 efflux from grass plots during the 5.5 months of field observations varied between 82 ± 13 and 87 ± 11 g $C \cdot m^{-2}$ in frozen soils ("Ref" and "NoSn" treatments), and amounted to 164 ± 20 g $C \cdot m^{-2}$ in the "NoFr" variant. In the bare plots, the cold-season cumulative CO_2 efflux were 1.1–1.7 times lower in comparison with the grassland soils, and varied between 49 ± 6 and 123 ± 19 g $C \cdot m^{-2}$ depending on the treatment. Spring CO_2 effluxes contributed about 42–70 % of the total cold-season CO_2 efflux from frozen soils and comprised only 22–23 % of cold CO_2 emission from the unfrozen soils. The contribution of spring CO_2 pulses after a thawing event to the annual CO_2 efflux was estimated to be at a rate of 5–12 %.

Concluding, during a warm winter with a delay of snow cover formation, the snow addition provided a more notable impact on winter CO_2 effluxes from soils than snow removal. The thawing of frozen soils generally resulted in an abrupt increase in CO_2 emission. Our findings indicate that the cold season plays a principal role in the carbon cycle of the seasonally covered ecosystem in a temperate continental climate, and the alteration of snowpack pattern under current climate changes can crucially affect cold CO_2 effluxes from soils in cold and high latitude regions.

Acknowledgments

This study was funded by the Russian Foundation for Basic Research (grant # 18-34-00691), and by the Program of Presidium of RAS # 51 (AAAA-A18-118013190179-3)

References

Blankinship, J. C., Hart, S. C. (2012). Consequences of manipulated snow cover on soil gaseous emission and N retention in the growing season: a meta-analysis. Ecosphere, 3 (1), pp. 1–20.

Kurganova, I., Gerenyu, V. L. D., Rozanova, L., Sapronov, D., Myakshina, T., Kudeyarov, V. (2003). Annual and seasonal CO_2 fluxes from Russian southern taiga soils. Tellus B: Chemical and Physical Meteorology, 55, pp. 338–344.

Wang, W., Peng, S., Wang, T., Fang, J. (2010). Winter soil CO_2 efflux and its contribution to annual soil respiration in different ecosystems of a forest-steppe ecotone, north China. Soil Biology and Biochemistry, 42, pp. 451–458.

Zamolodchikov, D. G., Karelin, D. V. (2001). An empirical model of carbon fluxes in Russian tundra. Global Change Biology, 7, pp. 147–161.

Quantification of Holocene nivation rates on Cape Lachman, James Ross Island

Michaela Kňažková[1*], Daniel Nývlt[1], Filip Hrbáček[1]

[1] Department of Geography, Faculty of Science, Masaryk University
* michaelaknazkova@gmail.com

Keywords: nivation, snowpatch errosion, James Ross Island, Holocene changes

In a classical morphogenetical concept, the term nivation refers to a range of processes connected with snow-patches and their role in the modelling of landscape (Matthes, 1900). During the recent years, nivation processes have been studied only sporadically, with little effort directed towards a quantitative description. The existing studies have focused on mountainous and Arctic regions, while there is a general lack of any knowledge about the nivation processes in ice-free areas of Antarctica. Because nivation processes are generally operating slowly and on a long timescale, they might be overridden by faster-working periglacial processes such as solifluction, therefore the effect of nivation alone may be hard, if not impossible to quantify (Thorn and Hall, 2002). However, in cold semi-arid to arid climates with limited annual precipitation and resulting very low soil moisture levels, nivation can be considered an important factor in landscape modelling.

The area of interest for this study is located on Cape Lachman, the northernmost tip of James Ross Island. The site itself consists of a semi-circular depression ~2 km long and 200 m wide, with two shallow lakes situated on the bottom. James Ross Island is located off the north-eastern coast of the Antarctic Peninsula in semi-arid polar climate. The average annual precipitation is about 300–500 mm, most of which is in the form of snow. Strong winds redistribute the snow into drifts, which can last all through the following summer. As the snow melts, fine regolith particles are carried by meltwater and accumulate in pronival alluvial fans at the foothill and the depression floor. Long-term downslope transport results in a significant remodelling of the slope profile. Based on exposure dating of erratic boulders from Cape Lachman, it has been determined that the deglaciation of the area occurred 12.9 ± 1.2 ka ago (Nývlt et al., 2014). This means the area has been ice-free throughout the whole Holocene.

This research is based on a field survey using dGPS (Trimble GeoExplorer 6000), conducting measurements along 22 transects across the study area. Furthermore, surficial regolith samples (upper 10 cm) were collected from the selected transects for the purpose of grain-size analysis. Using the dGPS data, a digital terrain model of the study site has been constructed that allows for a more thorough analysis of the affected area, e.g., calculation of the total amount of material displaced by meltwater and slope retreat over the course of the whole Holocene.

Distinction between the profiles affected by nivation processes and those not affected has been made based on the shape of the slope profile. Out of 22 transects, 6 have undergone changes in slope profile due to nivation. The most significant remodelling has occurred on the lee slopes, where largest accumulations of snow form during the winter. In some places, the down-wasting reached up to 10 metres due to the removal of material by meltwater. This corresponds to an average rate of 0.77 ± 0.12 mm per year within the most significantly affected areas since the deglaciation. It should be noted that this average value would have been highly changeable throughout the Holocene in connection with the climate conditions.

Grain-size analysis of the samples supports the removal of the finest fraction and its accumulation on the depression floor in form of pronival alluvial fans. Within transects unaffected by nivation processes, the ratio of the finest fraction (< 0.063 mm) remains more steady along the profile.

However, where extensive remodelling of the slope profile has occurred, the ratio of the finest fraction is 5× higher in the sample from the slope apron when compared to the sample from the middle part of the slope. This suggests that nivation is an important, but slow landscape-modelling factor in the conditions of semi-arid polar climate and its average rate could be quantified even at the scale of millennia.

Acknowledgments

Research was supported by Ministry of Education, Youth and Sports of the Czech Republic project CzechPolar 2 (LM2015078) and Ecopolaris project (CZ.02.1.01/0.0/0.0/16_013/0001708) and by the Masaryk University project MUNI/A/1419/2016.

References

Matthes, F. E. (1900). Glacial sculpture of the Bighorn Mountains, Wyoming. United States Geological Survey, 21st Annual Report, 1899–1900, pp. 167–190.

Nývlt, D., Braucher, R., Engel, Z., Mlčoch, B., ASTER Team. (2014). Timing of the Northern Prince Gustav Ice Stream retreat and the deglaciation of northern James Ross Island, Antarctic Peninsula during the last glacial–interglacial transition. Quaternary Research, 82, pp. 441–449.

Thorn, C.E., Hall, K. (2002). Nivation and cryoplanation: the case for scrutiny and integration. Progress in Physical Geography, 26, pp. 553–560.

Snow cover in the Arctic city of Saint Petersburg in winter in conditions of global warming

Evgenia Kolodiazhnaia[1,2*]

[1] Urban Studies, ITMO University, Kronverksky Pr. 49, 197101, Saint Petersburg, Russia
[2] Economic and Social Geography, Saint Petersburg State University, Universitetskaya emb. 7/9, 199034, Saint Petersburg, Russia
* kes3003@gmail.com

Keywords: snow cover, global warming, urban heat island, climate changes, megalopolis

There is no doubt that in recent decades the facts of developing global warming have become more evident. Obviously, with unfavourable climate changes, large cities will be the most vulnerable objects of the global infrastructure. Megalopolises and agglomerations concentrate large masses of people, industrial sites, transport routes, cultural objects, and many other things, which significantly increase the total vulnerability of urbanized territories under climate changes. Due to global warming, the local climates in large cities and surrounding areas will change significantly and megalopolises will supplement these changes themselves with their locally provoked climatic changes.

Arctic and Subarctic latitudes of the Northern Hemisphere are the region of the globe where, according to experts, the impact of modern climate change should be most significant. In this regard, it seems extremely necessary to assess the possible consequences of global warming for the fourth largest city of Europe – Saint Petersburg.

The following climate changes are predicted to have an impact on the territory of Saint Petersburg, for example increasing the average annual temperature of atmospheric air. As a source of predictive information on the thermal regime and the regime of humidification of the territory of Saint Petersburg in the 21st century, the results of calculations using the model of the general circulation of the atmosphere and the ocean ECHAM5_MPI-OM were used for the three scenarios for greenhouse gas emissions "B1","A1B" and "A2". An empirical-statistical approach was applied to account for the "urban heat island" formed by the megalopolis of Saint Petersburg. In accordance to the obtained results, the average annual air temperature in Saint Petersburg may rise by the end of the 21st century to 8.2 °C in the case of the favourable scenario "B1", and to 9.4 °C for the unfavourable scenarios "A1B" and "A2". The increase in the average surface air temperature by 2100 in comparison with the period 1971–2000 (5.4 °C) will be 2.8 °C (scenario "B1"), or 4.0 °C (scenarios "A1B" and "A2").

Another impact is the increase in the average annual amount of precipitation and the intensity of their fallout. According to the estimates, the increase in the amount of precipitation in comparison with the period 1981–2010 by the end of the 21st century will be 228 mm (the favourable scenario "B1"), or 262 mm (the unfavourable scenario "A2"). The mean annual rainfall for the last 30 years accounts to 653 mm. At the same time, by 2100, the precipitation intensity is expected to increase by 20 %.

Also the level of the Baltic Sea and the Gulf of Finland is expected to rise. Using the regional climate model RCAO, the estimates of the scenarios for the increase of the level of the Baltic Sea show that the greatest increase in sea level will occur in the southern and eastern Baltic. If the favourable "B2" scenario is implemented, sea level rise in the Saint Petersburg area will be about 40 cm by the end of the 21st century.

Snow cover is also expected to change. Due to the increase of the air temperature in the cold season, a further increase in the share of liquid and mixed precipitation is predicted, as well as an increase in the frequency of thaws, which will lead to a further shift in the timing of the formation and destruction

of a stable snow cover in the territory of Saint Petersburg, and to the decrease in its height.

Currently, most cities around the world recognize the problem of climate change and its consequences, and despite the existing financial and organizational difficulties, measures for adaptation to the changes are being developed in many of them.

Variable hydrothermal environmental conditions will affect epidemiological situation, public health, modern building structures, engineering infrastructure, high-precision industrial production, green spaces, protected natural areas, monuments of historical and cultural heritage, and other components of the city.

In 2018, the air temperatures of Saint Petersburg in January rose above the norm by 5 °C and February turned out to be abnormally snowy. The study of the urban environment and the analysis of the quality of winter clearing the open public spaces from snow and ice in the Petrogradsky district of Saint Petersburg in February 2018 showed that the city was not able to cope fully with such a large amount of snow and unstable temperatures. For this purpose, most of the accessible territories of the Petrogradsky district were investigated and about 2000 photos were taken, reflecting the condition of streets, squares, and parks. The evaluation was conducted on a subjective scale from 0 to 10 points, where 0 corresponded to a total catastrophe with clearing and 10 to the ideal. Attention was paid to the condition of sidewalks, footpaths and the carriageway, dangerous ice on the eaves of houses, and obstructing the passage or driveway drifts.

The average score for the entire district was about 5.3 out of 10, while when excluding the parks and squares from the assessment, it decreased to 4.8 out of 10. This means that the example with snow cover shows that the city is not yet ready for such rapid changes in the weather behaviour and Saint Petersburg has to adapt to future climate changes.

The chlorophyll fluorescence of Antarctic lichen *Dermatocarpon polyphyllizum*

Michaela Marečková[1*], Miloš Barták[1]

[1] Department of Experimental Biology, Laboratory of Photosynthetic Processes, Faculty of Science, Masaryk University, University Campus – Bohunice, Kamenice 5, 625 00 Brno, Czech Republic
*mareckova.mm@gmail.com

Key words: Antarctic lichen, chlorophyll fluorescence, OJIP, stress physiology

Lichens are major autotrophic components of Antarctic terrestrial vegetation coping well with extreme environmental factors. Their physiological responses to stress factors are important in respect to the recent climate variability. In our recent studies, we have investigated the effect of extreme environmental conditions on the Antarctic lichen *Dermatocarpon polyphyllizum* (collected on James Ross Island, Antarctica) and its photosynthetic apparatus. The changes of fast chlorophyll fluorescence transients (OJIP) and OJIP-derived parameters were measured during gradually decreasing thallus temperature (22, 18, 14, 12, 10, 7, 4, 0 and -5 °C) with 10 min acclimation at each temperature. The initial photochemical phase of transient (O-J) was found temperature-dependent due to the altered redox state of the primary quinone acceptors (Q_A). The K-step was apparent for the samples measured above 12 °C. Dark- and light-adapted sample measurements (OJIPs) were compared, the differences in the OJIP-derived parameters were attributed to the different production and utilization of high-energy products of primary photochemical processes.

We also measured the responses of *D. polyphyllizum* to the short-term high light stress. The preliminary results suggest that *D. polyphyllizum* is highly resistant to the irradiance of 1000 μmol m^{-2} (2 hours), probably because of strongly pigmented upper cortex providing an effective light absorption on sunny days. We also concluded, that OJIP is a useful tool to investigate temperature-dependent changes in photosystem II functioning. OJIPs, their parameters, respectively, might be used in the studies focused on photoinhibition, i.e., limitation of energy flow through PSII during high light treatment, as well as consequent recovery of primary photosynthetic processes in chlorolichen photobionts.

We thank to CzechPolar2 and ECOPOLARIS for funding.

Introduction to the 2018 field study of braided Monolith and Keller streams, James Ross Island, Antarctica

Lenka Ondráčková[1*], Radim Stuchlík[1], Daniel Nývlt[1]

[1] Department of Geography, Faculty of Science, Masaryk University
* lenkaondrackova@mail.muni.cz

Keywords: gravel-bed rivers, sediment transport, James Ross Island, Antarctica

Braided rivers and their surroundings are very rapidly changing systems of Polar Regions (Carrivick and Heckmann, 2017). The evolution of these areas is connected with the changeable hydrological regime, interaction with glacier melting, thawing of snowfields and active layer, and atmospheric temperature increases. Our aims are to identify the sediment transport regime and bedload material changes of proglacial braided streams influenced by climate change-driven glacier melting and associated discharge changes. During the summer research season, we observed a relationship between the transported bedload lithology and texture, and hydrological regime. The studied catchment of Monolith Stream is located in the northern James Ross Island, north-eastern Antarctic Peninsula. The catchment area is about 31 km^2. The studied streams are the Monolith (5.4 km in length) and Keller streams (6.2 km in length). A complex geomorphological mapping was undertaken during the Czech Antarctic expedition 2017–2018. We used various ortophoto images and DEM (Polar Geospatial Center, University of Minnesota; 2015, unpublished data) for the landforms delimitation. Geomorphological landforms were subsequently verified in the field. The sediment sources important for the studied streams were determined and categorized. The dominant sediment sources were the morainic complex of Whisky Glacier in the upper reaches of the catchment, and the colluvial fans and fluvial fans of side-tributaries. In the Monolith Stream, fine grain-sized lacustrine sediments with more nutrients and algae were also observed. For the sediment transport characteristics, we collected bedload sediment from in-channel bars in two fractions (8–16 mm; 64–256 mm) along the longitudinal profile of streams and measured clast size, shape, roundness and petrology. According to the field survey and a geological map (Mlčoch et al., 2018), basalt, palagonite form hyaloclastite breccia, and sandstone are the main petrological types present in the catchment. The clast-measured characteristics give us an overview of transported material, and together with topographical changes of channels we can evaluate the short-term fluvial changes.

Acknowledgements

Research was supported by Ministry of Education, Youth and Sports of the Czech Republic project CzechPolar 2 (LM2015078) and Ecopolaris project (CZ.02.1.01/0.0/0.0/16_013/0001708) and by the Masaryk University project MUNI/A/1419/2016.

References

Carrivick, J. L., Heckmann, T. (2017). Short-term geomorphological evolution of proglacial systems. Geomorphology, 287, pp. 3–28.

Mlčoch, B., Nývlt, D., Mixa, P., Eds. (2018). Geological map of James Ross Island – Northern part 1:25,000. Czech Geological Survey, Praha.

Digital Elevation Model 2015. Polar Geospatial Center, University of Minnesota.

Use of Structure-from-Motion for morphometry analyses of nivation structures on James Ross Island

Jakub Ondruch[1*], Michaela Kňažková[1], Filip Hrbáček[1]

[1] Department of Geography, Faculty of Science, Masaryk University
* jakub.ondruch@gmail.com

Keywords: structure-from-motion, stereophotogrametry, nivation, James Ross Island, Antarctica

Structure-from-motion has been in recent years successfully used in earth science for numbers of applications. It is a non-invasive and time-efficient method, which offers spatially as well as temporary high resolution digital elevation models and ortophoto maps. When combined with the use of UAV technology, it offers very powerful technique that is capable of substituting conventional LIDAR or stereophotogrametry for micro- and mesoscale points of interest. In our case, it has been applied to study processes forming nivation hollows on a moraine in Brandy Bay, James Ross Island.

The area of interest for this research is a low ridge flanking the south-western coastline of Brandy Bay, about 3.5 km long and up to 0.7 km wide. The moraine was deposited in Mid-Holocene during the advance of Whisky Glacier. There are numerous shallow depressions on the surface of the moraine, which might have initially been of thermokarst origin, but have gradually developed into nivation hollows. The size of these depressions ranges from very small (covering the area of only a few square metres with no prominent headwall) to moderately large featuring a headwall of 0.5 – 1.5 m in height and up to 30 metres long. Based on wind data from nearby Johnson Mesa AWS, the prevailing wind direction in the area is from the south to southwest. The estimates of annual precipitation on James Ross Island range from 300 to 500 mm. Redistribution of snow by wind is a very important factor here. The nivation depressions are most abundant and best developed on the lee slopes of the moraine, where the snow accumulates in drifts. The snow patches trap the fine particles of material also blown by the wind. When the snow melts, the fine material is deposited on the depression floor. With meltwater being the only available source of moisture in the otherwise arid landscape, the bottoms of the nivation hollows are often the only spots with vegetation.

The workflow of data acquisition was as follows. In total, ten sites containing well distinguishable nivation hollows with dimension of approximately 100 × 100 m were chosen. Further, another four sites with similar depression of, most probably, thermokarst origin were established, as well, in order to offer comparison. In each site, six to seven ground control points for postprocessing of the model were established by using wooden pegs and yellow and red A4 paper with precisely marked centre. Then, they were measured for exact position by dGPS Trimble 7× with less than 4 cm relative precision. Aerial images were obtained by a camera mounted to Mavic Pro quadrocopter. The whole process of flying and capturing images was set to be as automated as possible. Pix4D software was used to delineate the area of interest, setting waypoint, height of camera (30-35 m to achieve resolution of less than 2 cm), and overlap of images (around 65 %). Each site was managed to be sampled by one flight limited by the capacity of battery, which varied from 15 to 20 minutes depending on actual weather conditions. Images were further processed in Agisoft Photoscan for the final product of digital elevation model and ortophoto map. Obtained data will be further used for a detailed morphometrical analysis of the nivation hollows on Brandy Bay moraine.

Surface structures characteristics of Antarctic lichens studied by a digital microscope approach

Alla Orekhova[1*], Miloš Barták[1]

[1] Department of Experimental Biology, Laboratory of Photosynthetic Processes, Faculty of Science, Masaryk University, University Campus – Bohunice, Kamenice 5, 625 00 Brno, Czech Republic
* 477268@mail.muni.cz

Keywords: digital microscopy, Antarctic lichen species, surface structures of lichens, morphometric analysis

Digital microscopy is a modern technology, which integrates light microscopy and digital imaging. Technically, digital microscopy technology combines optical, electronic, mechanical, and digital imaging, image processing, and image analysis, which allows to observe, receive, record, analyse and manage the data received from the image analysis. We use this method for studying the microstructure of the upper surfaces of Antarctic lichen species. In the study of living biological objects, the use of this method provides a nondestructive approach of the visualization of the surface morphology with a high-quality resolution.

This paper is devoted to the results of microscopic examination of the surface structures of lichens and the subsequent morphometric analysis. Another goal is to evaluate the changes in 3-D structure of thalli as dependent on hydration status, and their interspecific differences. In addition, we use the digital images of lichen thallus to create a database of lichen species containing detailed morphological microstructures, such as pustulas or apothecia. This way, the use of the digital microscope allows studying in detail the reproductive organs of various species of lichens, their number, position on the surface, dimensions, and profile.

The samples of lichens were collected at the northern part of James Ross Island and analysed using a digital VHX-900F (Keyence, Japan) microscope with a maximum resolution of 19.5 megapixels and the magnification ranging from 5 to 1000. Keyence VHX software allowed to measure the height profile along a selected line placed across a thallus or apothecia. DFP method (Depth From Defocus), which compiles different focal planes, allowed accurate measurements of lichen surface structures viewed in real time. Tiny details of microrelief could be measured on the observed surface. All biometrical data of the measured objects could be exported to any spreadsheet and common data processors.

We studied *Umbilicaria decussata*, *Umbilicaria torrefacta*, *Usnea aurantiaco-atra*, *Placopsis contortpulicata*, *Dermatocarpon polyphillizum*, *Rhizoplaca melaophthalma* and other species. The gained results on a 3-D structure are discussed: interspecific, hydration- and developmental stage-dependent differences.

In conclusion, we think 3D models resulting from digital microscopy offer great opportunities in the study (especially the smallest fragments) of the surface structures of lichen thallus, as well as in their accurate measurement. This approach allows to study the hydration-dependent changes in the morphology of lichens. Information obtained through microscopic analysis is important for identifying lichen species and for building a reliable database.

Acknowledgements: The authors are thankful for the support provided by the CzechPolar2 and ECOPOLARIS projects allocated at the Masaryk University, Brno.

The huge heating experiment: initial results

Nataliia Petrzhik[1*], Georgy Matyshak[1], Olga Goncharova[1], Anna Bobrik[1]

[1] Department of Soil Science, Lomonosov Moscow State University, 1-12 Leninskie Gory, 119991, Moscow, Russia
* petrzhik.nat@mail.ru

Keywords: permafrost, soil, pipeline, CO2 efflux, Arctic, heating process

Northern ecosystems are dynamic and sensitive indicators of the environmental change. The carbon reserve, which is contained in soils and conserved in the permafrost of northern ecosystems, is vulnerable to any climate change and can shift the carbon balance.

Model calculations of temperature changes are based on experimental data from field and laboratory research. Unfortunately, lab research is short-term and cannot consider all natural conditions, and field research is expensive and difficult to conduct. Ambiguous conclusions are obtained as a result of different methods of studying the warming of ecosystems.

The goal of this study is to establish the real response of tundra ecosystems to the increase in soil temperatures. This research is unique, because we are using a ready-made large-scale experiment on heating in the permafrost.

Since the 1960s, the oil and gas industry in Russia has been developing rapidly, especially in the Arctic. This causes the rise of soil temperatures and the thawing of permafrost. Because hydrocarbons can be transferred by pipelines only in the heated state, the temperature of the pipes constantly remains high, which leads to the gradual decay of permafrost. Thus, it becomes possible to use the operation of the pipeline as a large-scale experiment, where the pipeline acts as a "heater" in the permafrost.

The research took place in Russia, on the Taz Peninsula, in the Southern Tundra. The study focused on the condition of Southern Tundra ecosystems (specifically, the vegetation and soils) after the thermal action by the pipeline. The areas that were affected the most were identified by remote sensing. The degree of transformation was determined by significant changes in the structure and composition of the vegetation, and the dynamics of the hydrological situation of the heat lines.

During the field trip in August 2016 and 2017, the transformed ecosystems were investigated by the transect method with the following parameters:

1) 10 perpendiculars, each of which included a natural area (natural site), and a transformed area without mechanical disturbance (heating site);
2) 5 parallels at the natural site, and 5 at the heating site.

The soil and vegetation on each site were described and sampled. The heights of a typical shrub, as well as the ratio of grasses to mosses, were also measured at each point. In addition, the thaw depth of soils, the soil temperature at the depth of 0–10 cm, the soil volumetric moisture, and the CO_2 efflux were estimated. In the laboratory, pH, total carbon, dissolved organic carbon (DOC), and nitrogen were measured. Moreover, microbial biomass carbon (MBC), and basal (BR) and substrate-induced respiration were measured as well.

It was established that the ratio of grasses to shrubs increased by 76 % at the heating site, and the ratio of mosses to lichens decreased by 28 %. Furthermore, the height of the typical shrub was almost 3 times greater at the heating site than at the natural site (55.6 ± 3.8 cm, and 19.3 ± 1.5 cm, respectively). The permafrost thaw at the heating site was 41.6 % greater compared to the natural site (from 32.1 ± 3.1 to 55.0 ± 3.9 cm). The soil temperature at 0–10 cm (in single measurements) at the heating site was almost 2.5 times higher than at the natural site (6.5 ± 0.2 °C, and 2.7 ± 0.2 °C, respectively). The moisture values varied widely and no confirmed changes were detected. The maximum response was established for the crucial CO_2 efflux index. At the heating site, the efflux was measured at 204.5 ± 77.8 mg $C \cdot g^{-1}$ of soil, which is

more than 2 times higher than the efflux at the natural site (104.7 ± 45.3 mg $C \cdot g^{-1}$ of soil). There is a possibility that the CO_2 efflux increases at the heating site because there are many vascular plants and their roots secrete CO_2. Also, there are likely to be physical processes of redistribution of CO_2 flow due to the thawing of permafrost. Remarkably, this integral index keeps increasing at the heating site, regardless of the climatic conditions. Mineral soils have a higher CO_2 efflux and react more strongly than peat soils, which is due to the fact that temperatures change in a similar way. This is probably related to the closeness of permafrost to peat soils.

The microbiological activity of the soils changed as well. The content of DOC tended to increase at the heating site in both types of transects: peat from 1153.4 ± 176.2 to 2843.6 ± 814.6 mg·kg, and mineral from 786.0 ± 77.1 to 990.3 ± 106.1 mg·kg. The values of MBC did not differ significantly at the sites. The BR of peat soils was lower at the heating site than at the natural site (6.20 ± 0.66, and 9.23 ± 0.48 μg $C \cdot g^{-1}$ of soil and hour, respectively), which indicated a negative effect of the warming. It is possible that this is because northern microorganisms are not adapted to high temperatures.

With an increase in temperature by 3 °C, the quantity of vascular plants and shrubs increases, the quantity of mosses and lichens decreases, and the height of shrubs increases three times, indicating the change of species in the vegetation. The temperature of the soils and the depth of thaw are doubled, and the CO_2 efflux increases 2.0–2.5 times, while the value of the volumetric soil moisture remains constant. An unfavorable effect of soil heating is observed in the change of the microbiota and accumulation of the labile compounds. MBC preserves stable values.

This work was partially supported by grants: RFBR (16-04-00808 A; 18-04-00952) and RF President`s grant МК-1181.2018.5.

Profile carbon distribution in soils of typical landscapes of Western Siberia

Anna Rubenovna Sefilian[1*], Olga Yurievna Goncharova[1]

[1] Lomonosov Moscow State University, Department of Soil Science, Moscow, Russian Federation
* annasefilyan@gmail.com

Keywords: organic carbon, carbon of microbial biomass, dissolved organic carbon, permafrost, emission, soil respiration

Soil is one of the largest reservoirs of carbon on Earth. Carbon can remain in soils for millennia, or be quickly released back into the atmosphere. Different conditions, such as climate, natural vegetation, soil texture or drainage affect the amount and length of time carbon is stored. The carbon storage in different soils is an important characteristic, which is necessary for the modelling of carbon cycle, and in the projecting of change in the intensity of the CO_2 release from the soil surface.

The aim of this study is to estimate carbon distribution in a profile of mineral podzol and in permafrost-affected peat soil.

Two typical landscapes, such as tundra forest and peat land, were located in the north of West Siberia (Russia) in the discontinuous permafrost zone. The peat profile was divided into horizons according to the degree of decomposition, age, and botanical composition.

The total carbon storage in peat soil amounts in average to 26 kg·m^2, and in podzol, it is 6 kg·m^2. The peat soil does not have a large profile differentiation of carbon content, but if we estimate carbon storage taking into account bulk density, the main storage will be found in the lower T2 and T3 horizons (Table 1). In contrast to peat soil, podzol has an uneven profile carbon distribution. Maximum carbon content and storage are in the O horizon (litter). This is also worth noting that a half of the total carbon storage is in the mineral part of podzol profile.

Comparing the two contrasting soils by two various forms of carbon (microbial biomass carbon (MBC) and dissolved organic carbon (DOC)), we can notice distinctions in its distribution related to the hydrothermal regime, geocryological conditions (absence of permafrost under podzol), and the vegetation.

Table 1 Physical and chemical properties of soils (average values, standard deviation in parentheses)

Horizon	Thickness [c], (cm)	Density [c], (g·cm^{-3})	Carbon content [d], (%)	C · N [d -1]	Storage of C [c], (%)	C_{MBC} [e], (mg · kd^{-1})	C_{DOC} [e], (mg · kd^{-1})
Lichen litter	–	–	43.6 (0.2)	96 (20.7)	–	2197	548 (9.5)
T1	9 (3.1)	0.08 (0.026)	42.7 (3.2)	27 (0.7)	18 (7)	1859 (834)	445 (71.7)
T2	10 (4.5)	0.20 (0.023)	45.8 (1.4)	20 (2.3)	35 (12)	481 (290)	517 (158.5)
T3	12 [a] (4.9)	0.22 (0.023)	46.8 (0.9)	22 (0.6)	47 (17)	181 (97)	594 (96.8)
O	8 (2.1)	0.09 (0.018)	41.1 (3.5)	41 (2.8)	54 (15)	5401 (1491)	580 (254)
AE	3 (0.8)	0.98 (0.297)	2.6 (0.9)	20 (4.3)	11 (3)	210 (69)	34 (11)
BHF	17 (6.4)	1.05 (0.049)	0.9 (0.4)	22 (0.3)	26 (12)	30 (10)	37 (5)
C	10 [b] (0.0)	1.15 (0.011)	0.5 (0.3)	25 (4.7)	9 (4)	16 (17)	27 (17)

In the peat soil, the maximum content of MBC is in the upper horizons (2197 and 1859 μg MBC·g^{-1} soil in the litter and T1, accordingly). Carbon content is sharply reduced to the T3 horizon (181 μg MBC·g^{-1} soil). The content of DOC is approximately same for all horizons. However, given the bulk density DOC storage of T3 horizon is 5 times greater than in T1 horizon.

In the podzol, the maximum content of MBC is in the upper horizons and it is decreasing by an order of magnitude in each subsequent horizon (from 5000 μg MBC·g^{-1} soil in litter to 6 μg MBC·g^{-1}soil in C horizon). The MBC storage in litter accounts for 80 % of the total profile MBC storage. It is important that the AE horizon has 10 % of the MBC profile storage, despite its mineral content and low capacity. DOC content reduces from 580 μg DOC·g^{-1} soil in litter to 30–40 μg DOC·g^{-1} soil in the mineral part. The total content of DOC in peat soil is 32 g·m^{-2} and it is twice more than in podzol, the total MBC is almost the same for both soils.

In conclusion, I would like to note that in the modelling of carbon cycle, carbon of lower horizons should not be neglected. In some conditions, such carbon can be released to the atmosphere.

This work was funded by the Russian Foundation for Basic Research grant № 16-04-00808.

Peak-summer CO_2 balance on a thawing permafrost peat mire in northern Norway

Isak Haldorsson Slettebø[1*], Hanna Lee[2], Casper Tai Christiansen[2], Joachim Reuder[3]

[1] Geophysical Institute, University of Bergen, Norway. Correspondence: isak.slettebo@student.uib.no
[2] Uni Research Climate, Bjerknes Centre for Climate Research, 5007 Bergen, Norway
[3] Geophysical Institute, University of Bergen, Bjerknes Centre for Climate Research, 5007 Bergen, Norway
* Isak.Slettebo@student.uib.no

Keywords: permafrost, carbon cycle, surface energy balance, micrometeorology, global warming

In this study, we measure the CO_2 balance on a thawing permafrost site in northern Norway. The net CO_2 release to the atmosphere was negative for our 30-day measurement period.

Arctic and boreal soils store approximately twice the amount of carbon currently present in the atmosphere. These regions are currently warming twice as fast as the rest of the world, and models project that about 10 % of their soil carbon is vulnerable for release to the atmosphere as CO_2 or methane (CH_4) as the permafrost thaws during this century. Methane has a global warming potential 25 times higher than that of CO_2 over a 100-year time period, but due to overall greater efflux, CO_2 is expected to dominate the climate forcing from permafrost carbon emissions. However, these projections are still relatively uncertain with more observations needed in order to determine the quantity and timing of greenhouse gas emissions from remote permafrost regions.

For this study, we use the eddy covariance (EC) method to quantify peak-summertime (7th July to 6th August, 2017) CO_2 and surface energy balance on a peat mire with actively thawing permafrost. Our study site is located in Finnmark, northernmost Norway (N 69°), and the area consists of large palsas, which are peat plateaus containing intact permafrost within their thick organic mounds. As the permafrost thaws, the palsas degrade, and they eventually collapse into inundated wetlands. The steep hydrological gradient going from dry palsa mounds into the inundated thaw-ponds drastically alters the local carbon cycle. Therefore, in addition to using an EC tower measuring the CO_2 balance on a catchment scale, we also quantify the small-scale greenhouse gas emissions using a series of well-replicated static chambers deployed along the hydrological permafrost thaw gradient. Together, the main goals of our study are i) to estimate the net peak-summertime CO_2 balance at a degrading palsa mire ecosystem under permafrost thaw, ii) to evaluate the EC method by considering the surface energy balance, and iii) to compare the EC method and the chamber method for carbon flux measurements by upscaling chamber measurements to the whole catchment. Our study adds to similar but scarce field-based research on the permafrost-carbon climate feedback.

For i) we have found the net ecosystem exchange of CO_2 to be negative on average, i.e., the palsa mire was a net sink of CO_2 during our measurement period, despite the permafrost thaw. This suggests that the photosynthetic activity was strong enough to outweigh increased emissions from plant and soil respiration. For ii) we have not managed to close the surface energy balance: The energy input from radiation is greater than the sum of turbulent fluxes and ground heat flux. This is very often the case in experiments, but perhaps not to the same degree as for our study. We plan on comparing the two flux calculation methods later this spring.

The palsa mires in Fennoscandia define the westernmost edge of the Eurasian permafrost zone, and ground temperatures here are generally higher than in other vast permafrost regions. This suggests that changes observed in Fennoscandia today might reveal what lies ahead for similar ecosystems in the much colder and larger areas in, for example, Russia.

The genome sequence of *Pseudomonas prosekii*, a novel Antarctic bacterium

Kateřina Snopková[1]*, Kristýna Dufková[1], Darina Čejková[2], Ivo Sedláček[3], David Šmajs[1]

[1] Department of Biology, Faculty of Medicine, Masaryk University; Kamenice 5, 625 00 Brno, Czech Republic
[2] Veterinary Research Institute, Hudcova 296/70, 621 00 Brno, Czech Republic
[3] Czech Collection of Microorganisms, Department of Experimental Biology, Faculty of Science, Masaryk University; Kamenice 5, 625 00 Brno, Czech Republic
* k.snopkova@mail.muni.cz

Keywords: *Pseudomonas prosekii*, James Ross Island, Antarctica, extremophile, cold-adaptation

Pseudomonas spp. are ubiquitous in various terrestrial and aquatic habitats, even in permanently cold area. Intensive microbial research and new techniques development resulted in description of several new pseudomonads originated from Antarctica, e.g., *P. antarctica, P. deceptionensis, P. prosekii or P. gregormendelii.* Despite the progress in description of polar microbial diversity, our knowledge about surviving strategies of these extremophiles remains insufficient. In Antarctic region only microorganisms coping with extreme conditions, like very low temperature, cyclic freeze-thaw, aridity or limited nutrients, could survive. Psychrophilic *pseudomonads* adapted to local environment could represent undiscovered source of biomolecules active at low temperature.

Pseudomonas prosekii was isolated exclusively from James Ross Island close to Antarctic Peninsula. Two Gram-negative, cold-adapted, aerobic strains, designated P2406 and P2673, were isolated from soil and seaweed samples, respectively, collected in 2007–2008. Genome of both strains were sequenced and analysed with respect to phylogenetical position, low genes conferring adaptability to low temperature and potential biotechnological applications. Sequences could be found in GOLD database under the accession numbers Gp0137070 and Gp0154205 for P2406 and P2673, respectively.

The genome of *P. prosekii* P2406 comprises of 5.9 Mbp and 5,420 genes (GC content 59.69 %) whereas the genome of *P. prosekii* P2673 consists of 6.1 Mbp and 5,579 genes (GC content 59.49 %). Analysis of *P. prosekii* genomes revealed the genes responsible for environmental adaptability. Total number of genes connected to stress response is 234 (P2406) and 232 (P2673), see Table 1. Cold-adaptation strategies include production cold shock proteins and ice-protective solutes, reduction of reactive oxygen species (ROS) or exopolysaccharides protection and biofilm formation. In *P. prosekii* genomes, six homologs of cold shock protein CspA were identified. More than one hundred genes encode proteins reducing oxidative stress; e.g., enzymes catalase, superoxide dismutase or peroxidise, proteins reacting with NO or reduce Fe stress.

Table 1. Stress related genes in the genomes of *P. prosekii* P2406 and P2673.

	P2406	P2763
Total no. of stress genes	**234**	**232**
Osmotic stress	33	33
Oxidative stress	102	105
Cold shock	6	6
Heat shock	17	17
Detoxification	27	28
Universal stress protein family	1	1
SigmaB stress responce regulation	8	8
Bacterial hemoglobins	13	13
Hfl operon	6	6
Carbon Starvation	14	8
Periplasmic Stress	7	7

Freezing periods could be survived by accumulation freeze-protective solutes. In both *P. prosekii* strains, 33 genes were predicted as protective against osmotic stress including genes for synthesis of glycine-betaine and osmotic related-transport systems. Extracellular polymeric substances production and biofilm formation protect cells from various external stressors, e.g., high osmolarity or cold shock. Genes involved in alginate and poly-b-1,6-N-acetylglucosamine (Pga) were detected in *P. prosekii* genomes. Iron availability could be crucial for colonization in the

pristine Antarctic environment. Production of fluorescent iron-scavenging protein pyoverdine was detected both strains and genome analysis revealed corresponding genes. Further, high UV doses and ROS elimination could be mediated by pigments production. Both *P. prosekii* strains encode clusters for yellow aryl polyene (APE) which is related to carotenoids protecting against UV radiation and possess antioxidative properties. Inspection of both *P. prosekii* genomes supports their well adaptation to extreme Antarctic lifestyle. The first genome analysis of *P. prosekii* genomes highlights our insufficient knowledge about low temperature extremophiles and could be helpful in elucidating of adaptation strategies of *Pseudomonas* spp. in polar regions.

Acknowledgements

The research was supported by the Ministry of Education, Youth and Sports of the Czech Republic, Project CzechPolar2 (LM2015078).

Heavy metal and polycyclic aromatic hydrocarbon contamination in soil from Longyearbyen, Svalbard

Thomas Stehrer[1,3*], Anna Polášková[2,3*], Markus Himmelsbach[2], Wolfgang Buchberger[2], Achim Walter Hassel[1], Jan Philipp Kolender[1], Petra Luláková[3,4], Josef Elster[3]

[1] Institute of Chemical Technology of Inorganic Materials, Johannes Kepler University Linz, Austria
[2] Institute of Analytical Chemistry, Johannes Kepler University Linz, Austria
[3] Centre for Polar Ecology, University of South Bohemia, České Budějovice, Czech Republic
[4] Department of Ecosystem Biology, University of South Bohemia, České Budějovice, Czech Republic
* t.stehrer@gmail.com; annapolaskova@gmail.com

Keywords: Svalbard, environmental pollution, soil, heavy metals, polycyclic aromatic hydrocarbons

The Arctic is a sensitive environment reacting to disturbances by human-related pollution. Heavy metals and polycyclic aromatic hydrocarbons (PAHs) are amongst the pollutants of significant importance, being present at various levels in almost every ecosystem. Soil is an environmental sink of these pollutants, representing therefore a suitable indicator of environmental pollution. In this study, the concentrations of selected heavy metals (Cd, Co, Cu, Mn, Ni, Pb, Zn) and 16 US EPA priority PAHs were analysed in surface soil samples from Longyearbyen, Svalbard. In total, 15 samples from the vicinity of Longyearbyen from similar habitats were collected and basic soil parameters (soil organic matter SOM, pH) were assessed. Furthermore, metal and PAH concentrations were determined by ICP-OES and GC-MS, respectively. The sum of 16 PAHs ranged from 0.390 to 7.168 mg · kg^{-1} of soil dry weight and was significantly correlated with the soil organic matter content (Pearson's correlation test, 0.74, $p < 0.05$). The measured concentrations of PAHs were comparable to those measured in 2017 in Pyramiden, a mining town abandoned in 1998 (Marquès, et al., 2017). For the estimation of the extent of heavy metal pollution, two commonly used indices, geo-accumulation (I_{geo}) and pollution load index (PLI), were applied. I_{geo} indicated slight to moderate pollution for copper and zinc at one site, and PLI suggested three sampling sites as generally polluted. No correlation between individual metal concentrations and pH or SOM was found. Between the concentration of the sum of PAHs and heavy metals, no correlation was found either. This indicates different sources of PAHs and metals. To put the results further into context, the assessed values were compared to the Dutch legislative limits, since no thresholds are available for Svalbard. Hence, PAH concentrations generally exceeded the target values but were still below the intervention thresholds. Concerning the analysed heavy metals, only copper and zinc values at one site exceeded the Dutch limits.

References

Marquès, M., Sierra, J., Drotikova, T., Mari, M., Nadal, M., Domingo, J. L. (2017). Concentrations of polycyclic aromatic hydrocarbons and trace elements in Arctic soils: A case-study in Svalbard. Environmental Research journal, 159, pp. 202–211.

Convection of air in the snow cover of sea ice, at the base of the Ice Station "Mys Baranova".

Aleksandra A. Sumkina[1*], Peter V. Bogorodskii[2]

[1] Institute of Earth Science, Saint Petersburg State University, Universitetskaya emb. 7/9, 199034, Saint Petersburg, Russia
[2] Arctic & Antarctic Research Institute, Bering St. 38, 199397, Saint Petersburg, Russia
* alexandrasumkina@gmail.com

Keywords: convection, snow cover, Rayleigh filtration numbers, thermodynamic model, the detailed measurements

Natural ice is covered with a layer of snow, which consists of ice structure and air-filled pores. In the case of temperature differences at its outer boundaries, a macroscopic movement of air begins in the snow, greatly intensifying the heat and mass transfer.

An analytic solution of the problem of the stability of liquid in a porous layer (the Rayleigh-Darcy problem) for the temperature and dynamic boundary conditions is presented here (Warren et al., 1999). This study takes into account oceanographic specifications of the problem within the framework of the linear theory using an integral version of the Galerkin method (Zhekhamukhov and Zhekhamukhova, 2002)

The stability criteria (Rayleigh filtration numbers) obtained with an allowance for heat exchange with the atmosphere and ice can differ significantly from the value of $4\Pi^2$ for a horizontal porous layer with impermeable isothermal boundaries, which is often used to assess the conditions for the occurrence of convective filtration in snow (Bogorodskii et al., 2010).

To find the Rayleigh number under the real conditions, detailed measurements of the thermal structure and the immobile ice cover metric characteristics of the Shokalsky Strait (Severnaya Zemlya archipelago) were made at the AARI Research Station "Mys Baranova" during the winter 2015–2016. The results, including the temporal variability, were supplemented by the calculations on the thermodynamic model of the sea ice, taking into account the processes of energy and mass transfer in the atmospheric boundary layer. The values of temperature gradient in the snow layer were obtained taking into consideration the increase in the ice underlying layer, depending on the changing weather conditions for the same period of time (Sturm et al., 2002). The calculations of the Rayleigh numbers from the thermodynamic model have shown their significant temporal variability due to the variations in atmospheric conditions, primarily air temperature and wind speed. An additional difficulty in calculating the stability criteria created an approximate character of the empirical dependences of the thermophysical parameters of snow on its density, caused by a large spread of the initial data, as well as errors in calculations due to the uneven spatial distribution of the ice cover thickness. In a simplified formulation of the problem of Rayleigh-Darcy convective stability with horizontal boundaries, a series of processes taking place in the real snow cover were ignored. Comparing the Rayleigh numbers, determined theoretically and experimentally, their commensurability was shown. This testified the reality of the convective heat transfer regime and the need to take into account its contribution to the thermal and mass balance of the Arctic sea ice in the winter, especially in the initial period of ice formation, most important from the point of view of energy and mass exchange of the sea and atmosphere. Progress in its solution was expected in complex observations, including continuous measurements of the height of the snow cover and the temperature field in its thickness and outer boundaries with the help of modern equipment (high-sensitivity temperature sensors, acoustic snow height meters, IR radiometers), deployed currently at the base of the Ice Station "Mys Baranova".

References

Bogorodskii, P. V., Marchenko, A. V., Pnushkov, A. V., Ogorodov, S.A. (2010). The formation of fast ice and its effect on the coastal zone. Oceanology, 50 (3), pp. 345–354.

Powers, D., O'Neill, K., Colbeck, S. C. (1985). Theory of natural convection in snow. Journal of Geophysical Research, 90 (6), pp. 10641–10649.

Sturm, M., Perovich, D. K., Holmgren, J. (2002). Thermal conductivity and heat transfer through the snow on the ice of the Beaufort Sea. Journal of Geophysical Research, 107 (C21), pp. 8043.

Warren, S. G., Rigor, I. G., Untersteiner, N., Radionov,V. F., Bryazgin, N. N., Aleksandrov, Y. I., Colony R. (1999). Snow depth on Arctic sea ice. Journal of Climatology, 12 (6), pp. 1814–1829.

Zhekhamukhov, M. K., Zhekhamukhov I. M. (2002). On convective instability of air in snow cover. Journal of Engineering Physics and Thermophysics, 75 (4), pp. 65–72.

Climate variability during MIS-11 (370–440 ka BP) from the isotopic composition (δD, δ18O, δ17O) of Vostok ice core

Arina Nikolaevna Veres[1,2*], Alexey Anatolyevich Ekaykin[1,2], Diana Olegovna Vladimirova[1,2,3], Anna Vladimirovna Kozachek[1], Vladimir Yakovlevich Lipenkov[1], Alexandra Andreevna Skakun[1,4]

[1] Arctic and Antarctic Research Institute, Saint Petersburg, Russia
[2] Institute of Earth Sciences, Saint Petersburg State University, Saint Petersburg, Russia
[3] Centre for Ice and Climate, Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark
[4] The Central Astronomical Observatory of the Russian Academy of Sciences at Pulkovo, Saint Petersburg, Russia
* veres@aari.ru

Keywords: ice cores, Antarctica, paleoclimate, stable water isotopes, Marine Isotope Stage 11

The Earth's climate changes in the Pleistocene appear as a sequence of the glacial and interglacial periods. These periods are conventionally known as marine isotope stages (MIS). The detailed investigation of the interglacials of the Late Pleistocene based on marine and terrestrial sediments aims to: 1) determine the factors influencing the duration of warm periods; 2) understand how climatic conditions could be developed without human impact in the future. Marine Isotope Stage 11 (MIS-11, 370–420 ka BP) is of particular interest, since the climatic conditions of MIS-11 are similar to the conditions in the Holocene (MIS-1).

The analysis of the stable isotope content is one of the leading methods in paleogeography. The ice cores retrieved from polar ice sheets are a unique archive of paleoclimatic information. For the last 60 years, the isotope method has been successfully applied to ice core samples in order to study climate variability in the past (for the last 800 ka). Isotopic composition (concentration of heavy water molecules $HD^{16}O$ and $H_2{}^{18}O$) of the central Antarctica ice cores depends on the local climatic conditions (condensation temperature) and the conditions in the moisture source (sea surface temperature, relative humidity).

In the last decade, a new isotopic method, which is related to the measurement of the concentration of the rare water molecule $H_2{}^{17}O$ relative to $H_2{}^{18}O$ (so-called ^{17}O-excess parameter), has been developed. Although the nature of ^{17}O-excess variations is not fully understood, it is assumed that ^{17}O-excess negligibly depends on condensation temperature but is very sensitive to the variations of relative humidity in the moisture source.

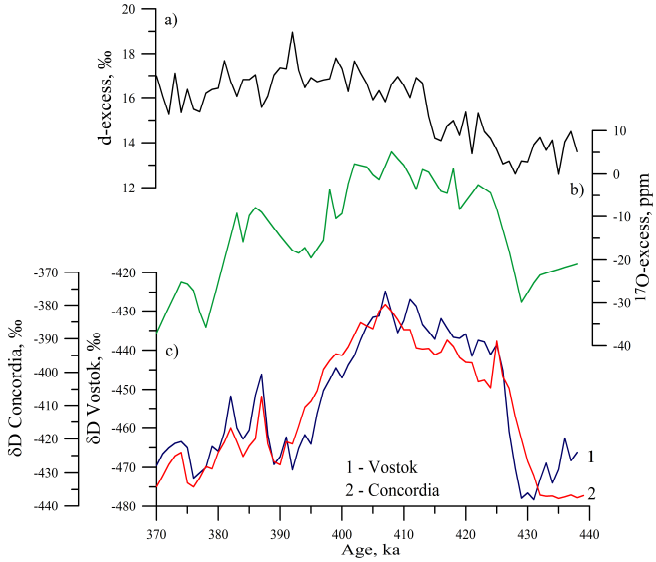


Figure 1 Time series of isotopic characteristics based on the Vostok ice core measurements over the period of 370–440 ka BP: *a* – d-excess; *b* – ^{17}O-excess; *c* – δD: *1* – the Vostok ice core; *2* – the Concordia ice core [1].

Here we present a new detailed isotope data and the first results of ^{17}O-excess measurements in the Vostok (central East Antarctica) ice core samples from the warm stage MIS-11 (370–420 ka BP) (Figure 1). We perform simultaneous analysis of three independent parameters (δD, deuterium excess, ^{17}O-excess), allowing to reconstruct the time-series of the anomalies of sea surface temperature and relative humidity in the moisture source, and also the ranges of the variation of condensation temperature and near-surface air temperature in the vicinity of the Vostok station during MIS-11 (Figure 2).

We, for the first time, present the records of the negligibly small variations of relative humidity above the ocean in MIS-11. In addition, we compare the reconstructed data of climatic conditions during MIS-11 with the published records from the Concordia station (EPICA DC ice core) as well as with the marine core data from DSDP 94-607 and ODP 177-1090 (Figure 2) (Jouzel et al., 2007; Ruddiman et al., 1989; Martinez-Garcia et al., 2010).

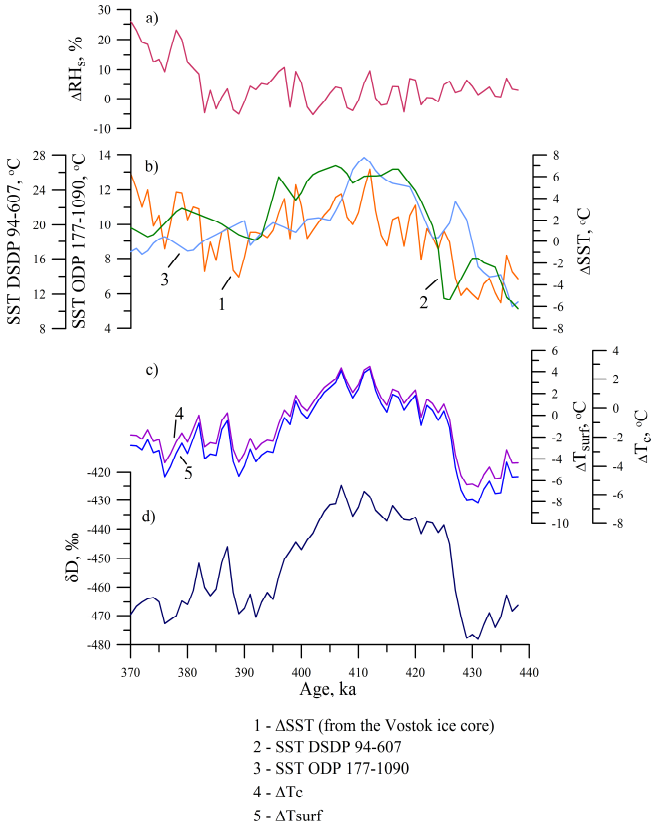


Figure 2 Reconstructed ranges of paleoclimate characteristics during MIS-11 based on isotopic investigations results of the Vostok ice core and the marine cores: *a* – relative humidity in the moisture source ΔRH_S; *b* – sea surface temperature: *1* – ΔSST in the moisture source from the Vostok ice core data; *2* – *SST* from the marine core DSDP 94-607 record (the North Atlantic) [2]; *3* – *SST* from the marine core ODP 177–1090 (the Southern Ocean) [3]; *c* – air temperature in the vicinity of Vostok station: *4* – condensation temperature ΔT_C; *5* – near-surface air temperature ΔT_{surf}; *d* – deuteruim concentration δD in the Vostok ice core samples

The results based on the isotopic composition measurements of the Vostok and Concordia ice cores indicate that the surface temperature during the MIS-11 optimum was 4 °C higher than present-day temperature, while the temperature during Termination V was 8 °C lower than nowadays. We conclude that the similarity of the datasets received from the marine cores DSDP 94-607 (the North Atlantic) and ODP 177-1090 (the Southern Ocean) with our results points at the global change of sea surface temperature during MIS-11. The high coherence of the datasets proves the high quality of the developed methods of the measurement and interpretation of the ice core isotopic composition.

Acknowledgments

This investigation was made under the finance support of the Russian Science Foundation, grant № 14-27-00030 «Evolution of climate, glaciation and subglacial environments of Antarctica from the deep ice core and Lake Vostok water sample studies».

References

Jouzel, J., Masson-Delmotte, V., Cattani, O., Dreyfus, G., Hoffmann, G., Minster, B., Nouet, J., Barnola, J. M., Chappellaz, J., Fischer, H., Gallet, J. C., Johnsen, S., Leuenberger, M., Loulergue, L., Luethi, D., Oerter, H, Parrenin, F., Raisbeck, G., Raynaud, D., Schilt, A., Schwander, J., Selmo, E., Souchez, R., Spahni, R., Stauffer, B., Steffensen, J. P., Stenni, B., Stocker, T. F., Tison, J. L., Werner, M., Wolff, E. W. (2007). Orbital and millennial Antarctic climate variability over the past 800,000 years. Science, 317 (5839), pp. 793–796.

Ruddiman, W. F., Raymo, M. E., Martinson, D. G., Clement, B. M., Backman, J. (1989). Pleistocene evolution: Northern hemisphere ice sheets and North Atlantic Ocean. Paleoceanography and Paleoclimatology, 4 (4), pp. 353–412.

Martinez-Garcia, A., Rosell-Melé, A., McClymont, E. L., Gersonde, R., Haug, G. H. (2010). Subpolar Link to the Emergence of the Modern Equatorial Pacific Cold Tongue. Science, 328 (5985), pp. 1550–1553.

LOOK FORWARD TO MEETING YOU IN 2019!