Country Reports

Reports from the Adhering Bodies of the International Permafrost Association

2019

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Reports are provided by the country members and are minorly edited for compilation.

Germany

University of Bayreuth
In the framework of the project Alpine Rock Slopes ("Predicting the effects of climate change on alpine rock slopes: Evaluation of paraglacial and periglacial drivers of rockfall in the European Alps") the research team led by D. Draebing in cooperation with M- Krautblatter (TU Munich), M. Dühnforth (former LMU Munich), S. McColl (Massey University, NZ) and S. Binnie (University of Cologne) conducted field campaigns at the Turtmann Valley, Switzerland, and Gaisberg Valley, Austria. The aim of the project is to identify periglacial and paraglacial drivers of rockfall. The team de-installed rock temperature loggers and crackmeters that successfully monitored temperatures and kinematics in six rockwalls between 2016 and 2019. In addition, the laser scan time series used to monitor rockfall was prolonged by one year. First results from a laboratory study on frost weathering was published in *Geophysical Research Letters* (doi: 10.1029/2019gl081981). In addition, a review book chapter was contributed to the book *Geomorphology of Proglacial Systems* (doi: 10.1007/978-3-319-94184-4_8).

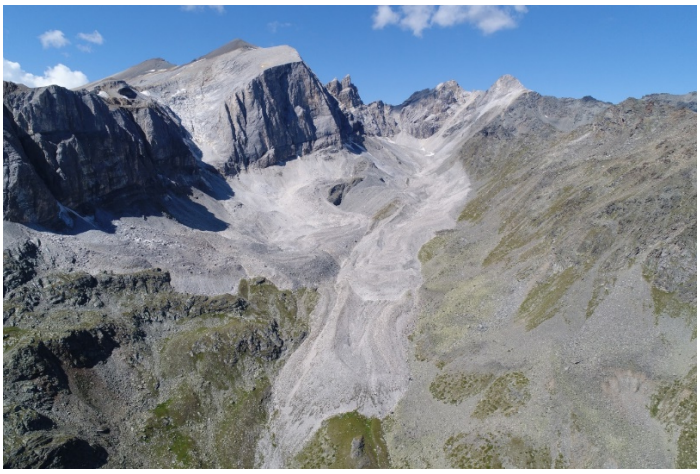


Figure. 1: Periglacial landforms in the Pipjitälli. Solifluction movement measurements were performed on lobes located on the rock glacier front (Photo by D. Draebing).

A research team composed of J. Eichel (Karlsruhe Institute of Technology, now Utrecht University), D. Draebing and H- Mithan (Dundee University) mapped solifluction lobes (Fig. 1) in the Turtmann Valley and measured solifluction movement using UAV on three selected turf-banked solifluction lobes. Contact: d.draebing@uni-bayreuth.de

University of Bonn
The research group of L. Schrott continued investigations on the hydrologic function and kinematics of rock glaciers in high mountain watersheds in the Austrian Alps and the dry Central Andes of Argentina.

In 2019, the last field campaign within the framework ***project PermARG*** ("Rock glacier permafrost in the Central Andes of Argentina", 11/2015-10/2019) was conducted at the Morenas Coloradas (Fig. 2) and Dos Lenguas rock glacier complexes in cooperation with the team of D. Trombotto (IANIGLA, Mendoza, Argentina). The main objective of this project is to quantify water storage capacities of rock glacier permafrost in the semi-arid Andes of Argentina. Field work was carried out by L. Schrott, C. Halla, J. Blöthe (all University of Bonn), J. Götz (University of Bayreuth), E. Bottegal and C. Tapía (IANIGLA, Mendoza). A major outcome of the project was submitted to The Cryosphere by Halla et al.: doi: 10.5194/tc-2020-29. Contact: christian.halla@uni-bonn.de

Figure 2: View to the lowlands of Mendoza above the Morenas Coloradas rock glacier complex, situated ~60 km southwest of Mendoza. GPR and drone surveys were conducted at ~3850 m asl (Aerial photo: Jan Blöthe, Date: 21.02.2018).

Between July 2018 and July 2019, ***fieldwork on the Kaiserberg rock glacier in the Austrian Alps*** (Fig. 3) was conducted within the framework of a joint research project between J. Blöthe (University of Bonn) and S. Kraushaar (University of Vienna). The aim of the GeoHyPe project (Geomorphic and hydrologic implications of permafrost degradation in the Alps), funded by the Dr. Hohmann Stiftung and the Hanna Bremer Stiftung, is to disentangle the contribution of active layer and permafrost to summer runoff from the upper Kaiserberg catchment. For this, we combine repeated geophysical measurements, continuous discharge monitoring, and UAV-derived kinematic analysis with monthly sampling and isotopic analysis of meltwaters in the valley. Field work was carried out by S. Kraushaar, J. Blöthe, V. Kapustova, D. Morche, T. Groh, C. Halla, S. Terweh, J, Alsleben, N, Griesang, S, Walker, C. Moser, and J. Müller. A first study that investigates the surface kinematics of a rock glacier inventory for the entire Kaunertal

valley has been published. doi: 10.3390/geosciences9090373. Contact: jan.bloethe@uni-bonn.de

Figure 3: Hydrological station on the small mountain stream that drains the upper Kaiserberg valley. View to the east towards the Kaunertal, the Kaiserberg rock glacier is located ~ 1km upstream (Picture by Jonas Alsleben, Date: 16.07.2019).

Technical University of Munich

The Landslide Research Group of M. Krautblatter investigated permafrost-affected slopes in the European Alps (Germany, Austria, Switzerland) as well as in Norway, Canada and Ecuador. In the AlpSense project, a benchmark project of the European Strategy for the Alpine Space, new techniques for the remote sensing of climate-change affected permafrost phenomena in the European Alps were tested (https://www.bgu.tum.de/landslides/alpsensebench/projekt/). PhD student R. Scandroglio works deciphering critical hydrostatic pressure levels in permafrost rock for the HydroPF project at the Zugspitze (D) and Gemsstock (CH). He combines (i) snow and water infiltration modelling, (ii) development of a sound benchmark method to derive hydrostatic pressure and (iii) mechanical modelling of the impact of sudden hydrostatic pressure variations on rock instability and recently demonstrated his work in an AGU talk. PhD student P. Mamot developed a thermo-mechanical failure model for degrading permafrost rock slopes which is currently submitted in two papers (doi: 10.5194/tc-2020-18). PhD student R. Pläsken continued her research on a mechanical model of the Kitzsteinhorn (A) considering the mechanical interaction of permafrost rock and alpine infrastructure. Funded by the Elite Network of Bavaria, PhD student T. Schröder develops a thermal model of the Zugspitze summit crest showing permafrost distribution and evolution during the last decade. In the Cryowall project, funded by the Norwegian Research Council, PhD candidate B. Jacobs in cooperation with the University of Oslo focused on the development of long-term dynamics and stability of extreme fjord topographies. T. Raab studied secondary lahars at the Cotopaxi volcano in Ecuador. The possible effect of permafrost degradation was considered as one potential trigger of climatically-induced lahars. Her PhD research is part of the RIESGOS project (www.riesgos.de) funded by the German Federal Ministry of Education and Research. The PhD student S. Eppinger works on giant retrogressive thaw slumps on Herschel Island (Canada). Contact: m.krautblatter@tum.de

University of Hamburg

In early 2020, the European Commission approved the Horizon2020 proposal for a research project on “Drivers and Feedbacks of Changes in Arctic Terrestrial Biodiversity” (CHARTER, 2020-2024). The aim is to examine Arctic biodiversity change and social-ecological systems on four critical fronts: (1) Feedbacks: To understand transitions in vegetation cover, energy balance and cryospheric change at centennial, decadal, and present-day time scales; (2) social-ecological systems and biodiversity: To understand the effects of biodiversity changes on indigenous/local communities and traditional livelihoods, e.g. reindeer herding; (3) Modelling: To integrate biochemical/permafrost soil carbon exchange, sea ice and albedo into an Earth System Model, and incorporate these into the latest Arctic Regional Climate modeling efforts; and (4) Policy: To develop strategies supporting Arctic communities with co-benefits and synergies between adaptation, mitigation and policy implications. Currently, the grant agreement is being prepared. Among the 21 participating organizations are the Alfred Wegener Institute (AWI) and Universität Hamburg, the latter acting as the lead for the project’s Workpackage 3, “Changing grazing regimes and Arctic biodiversity at local and regional scales”. Expertise in this field cross-cuts with the work of the “Permafrost and Culture” (PaC) Action Group of IPA, portrayed at the beginning of this report. Contact: otto.habeck@uni-hamburg.de

German Research Centre for Geosciences (GFZ)

At the end of 2019, permafrost incubation studies were commenced for the MicroModel project (Microscale controls to model microbial greenhouse gas production). This project is funded through the ‘GFZ Discovery Fund’ allowing young scientists to perform innovative projects closely related to one of GFZ's research topics for three years. MicroModel will combine laboratory (incubations, high-throughput amplicon sequencing, metabolic pathway analyses of metagenomic data, and high-resolution organic matter characterization) and modeling (geochemical rate models and Bayesian probability analysis) approaches to characterize microscale controls on microbial organic carbon decomposition. Improved understanding of these

controls can aid in reconciling discrepancies between published permafrost greenhouse gas emission estimates using experimental versus modeling approaches, leading to improved estimates of future permafrost greenhouse emissions and subsequent global climate feedbacks. Contact: jheslop@gfz-potsdam.de, sliebner@gfz-potsdam.de

Alfred Wegener Institute (AWI)

The ThawTrendAir 2019 Flight Campaign was carried out across the North Slope of Alaska for surveying permafrost landscape dynamics and carbon fluxes. The campaign was conducted as a collaborative effort of AWI, DLR and GFZ Potsdam, using AWI's Polar-6 aircraft, equipped with a very-high-resolution aerial camera system (MACS), full waveform Lidar and a gas analyzer. The work was based for three weeks in Barrow/Utkiagvik in July 2019. Target sites included, for example, large fire scars and rapidly eroding coastal stretches. In total, about 20TB of data were acquired during 45 flight hours.
Contacts:
Ingmar.Nitze@awi.de,
Guido.Grosse@awi.de

Lena Expedition 2019

The 2019 season of the yearly Russian-German Expedition Lena, organized from the German side by AWI's Permafrost Research section and the logistics department, ended mid-September. Fieldwork concentrated on Samoylov Island and its vicinity in the central Lena River Delta with operation of the Samoylov permafrost long-term observatory as well as studies of biogeochemical, meteorological, geomorphological, hydrological, geophysical processes and their interaction with the area's permafrost conditions. Contact: anne.morgenstern@awi.de

Since November 2017 AWI in Potsdam coordinates the Horizon2020 EU-project "**NUNATARYUK: Permafrost thaw and the changing Arctic coast; science for socioeconomic adaptation**" (https://nunataryuk.org/). The project has a duration of 5 years (2017-2022) and a budget of 11.5 million EUR bringing together 26 partners from 11 countries. NUNATARYUK brings together world-leading specialists across disciplines in natural science and socio-economics to: (1) develop quantitative understanding of the fluxes and fates of organic matter released from thawing coastal and subsea permafrost; (2) assess what risks are posed by thawing coastal permafrost to infrastructure, indigenous and local communities and people's health, and from pollution; and to (3) use this understanding to estimate the long-term impacts of permafrost thaw on global climate and the economy. Up until now, major results include a unique new submarine permafrost map (doi: 10.1029/2018JC014675), new estimates on greenhouse gas release in response to coastline collapse (doi: 10.1029/2019GL084303) and model results on the contribution of coastal permafrost erosion to the sedimentary carbon budget (doi:10.1029/2019GL085897). In addition, NUNATARYUK produced an atlas of population, societies and economy in the Arctic, concentrating also on societies on permafrost (doi: 10.30689/WP2019:3.1403-2511).
Contact: Hugues.Lantuit@awi.de

Field work in NW Canada took place from April to September 2019 by various groups on the Peel River, Herschel Island, on the Yukon coast, in the Mackenzie River delta and offshore in the Beaufort Sea. As part of the EU Horizon 2020 project NUNATARYUK, fieldwork focused on coastal permafrost erosion, and on organic carbon and nutrient release to the Arctic nearshore zone. The work on Herschel Island involved cooperation between many partners, including the Alfred Wegener Institute, the Geological Survey of Canada, University of Amsterdam, University of Stockholm, University of Vienna, University of Lisbon, University of Venice. The campaigns on Herschel Island throughout the spring and summer 2019 focused on lateral organic matter fluxes from thawing permafrost coasts towards the ocean including marine ecology. The work on the Peel River was a group effort between AWI Potsdam, the Vrije Universiteit Amsterdam, University of Oslo and GFZ in Germany, together with Canadian partners. The 6-week expedition focused on how permafrost degradation is affecting the river and its tributaries over the 700 km from source to mouth. The Mackenzie Delta campaigns between spring and autumn was led by the Takuvik laboratory at University of Laval, in collaboration with AWI and local partners from Inuvik and Aklavik. It explored the seasonality of organic matter throughout season by examining optical and biogeochemical variables within the delta. Contact: Hugues.Lantuit@awi.de, Michael.Fritz@awi.de

The ***NSF-funded "Permafrost Discovery Gateway" project***, led by A. Liljedahl (Woods Hole Research Center, formerly UAF), in collaboration with AWI (G. Grosse, I. Nitze), is focusing on Big Data and Machine Learning applications for permafrost data processing with High Performance Computing and new ways of data distribution. Permafrost thaw has been observed at several locations across the Arctic in recent decades, yet the pan-Arctic extent and potential spatial-temporal variations in thaw are poorly constrained. Thawing of ice-rich permafrost can be inferred and quantified with satellite imagery due to the subsequent differential ground subsidence and erosion that also affects land surface cover, storage and flow of

water, sediment, and nutrients. However, a lack of supporting cyberinfrastructure necessary to harness information from the existing and rapidly growing collection of high-resolution satellite imagery (Big Imagery), has limited our advances in understanding the nature of pan-Arctic permafrost degradation. In this four-year project we seek to empower the broader Arctic community with a cyberinfrastructure platform, the Permafrost Discovery Gateway (PDG), aimed at making Big Imagery permafrost information accessible and discoverable. This will include 1) utilizing existing public and license-restricted Big Imagery, 2) developing automated remote sensing classification tools based on machine and deep learning techniques, 3) applying our tools to pan-Arctic satellite imagery to address a fundamental research question, 4) making our permafrost map products and tools publicly accessible, and 5) enabling discovery and knowledge-generation through novel visualization and analysis tools designed with input from users of the PDG, e.g. the diverse peoples living, working, and/or studying in the Arctic. Contact: Ingmar.Nitze@awi.de, Guido.Grosse@awi.de

HGF MOSES (Modular Observations Solutions for Earth Systems) is a novel observing system of the Helmholtz Association, developed by the Helmholtz Centres in the research field “Earth and Environment”. It comprises highly flexible and mobile observation modules which are specifically designed to investigate the interactions of short-term events and long-term trends across Earth compartments. One event chain focus group “Permafrost thaw” is led by AWI Potsdam (J. Boike). Updates of recent work, as well as planned work for the second half of the project period was presented at the mid-term MOSES workshop in Leipzig (February 11-12). Directly following this, a four-day workshop was organized at AWI Potsdam for 22 expedition members in preparation for the planned expedition to Siberia (April-September 2020). Contact: julia.boike@awi.de

In the ***BMBF KoPf Project,*** led by the University of Hamburg (E—M. Pfeiffer) and AWI Potsdam Permafrost Research (G. Grosse), the close cooperation between several German Helmholtz and university partners together with several Russian partner institutions were continued with the focus on better understanding of permafrost region carbon cycle dynamics. The project concluded its field activities in the Siberian Lena Delta in summer 2019. Contact: guido.grosse@awi.de; Eva-Maria.Pfeiffer@uni-hamburg.de

The overarching aim of the ***German-British CACOON (Changing Arctic Carbon cycle in the cOastal Ocean Near-shore) project*** are to quantify the effect of changing freshwater export and permafrost thaw on the type and fate of river-borne organic matter delivered to Arctic shore, and resulting changes on ecosystem functioning in the coastal Arctic Ocean. We are achieving this through a combined observational, experimental and modelling approach. In 2019 fieldwork was the focus of the project. In total, four campaigns to the Lena and Kolyma River Delta and near-shore were conducted. In March and April 2019, the CACOON team sampled water, sediment and ice samples from the Sardakhskaya Channel in the Lena Delta (Fig 4a) and the near-shore zone in order to investigate carbon export and carbon lability from permafrost to the near-shore zone. In August 2019, the second Lena Delta CACOON campaign re-sampled the locations from the spring campaign (Fig. 4b) and extended the sampling transect 80 km into the Laptev Sea. As a result, water and sediment samples were collected along a 200 km long transect beginning at Stolb Island in the central Lena Delta extending into the near-shore zone of the Laptev Sea. The third and fourth field campaigns took place in the Kolyma Delta and were carried out by our project partner from Northumbria University, Newcastle, in June/July and August/September 2019. As a result, during almost the entire open water season water samples could be collected in the Kolyma Delta on transects from Cherskiy to the near-shore of the East Siberian Sea.
Contact: jens.strauss@awi.de

Figure 4a: Field work (CACOON) during spring in the Lena Delta

Figure 4b: Field work (CACOON) during Summer in the Lena Delta

The ***BMBF young investigator group PermaRisk*** (M. Langer) aims to investigate the impact of permafrost degradation in infrastructure and ecosystem functions. The project successfully finished its field work program with the second expedition to Churchill (Manitoba - Canada) and Deadhorse (Alaska – USA) in 2019. Novel tools for analyzing shoreline changes of thermokarst lakes with very high resolution remote sensing data were developed. The permafrost model CryoGrid was further developed to represent infrastructure and thermokarst in agreement with the project timeline. A workshop (hackathon) on modeling permafrost with CryoGrid was organized and hosted by PermaRisk. Scientific outreach was provided by a digital exhibit for the floating science center onboard the MS Wissenschaft under the topic "Artificial Intelligence".
Contact: moritz.langer@awi.de

The ***BMBF Ralf Dahrendorf Award*** (50T€) was awarded for the ERC PETA-CARB Team (G. Grosse, J. Lenz, J. Strauss) for their Outreach proposal "Changing Permafrost / Permafrost im Wandel". Contact: guido.grosse@awi.de; josefine.lenz@awi.de

The outcome of the last year's efforts in data management conducted by the ***Global Terrestrial Network for Permafrost (GTN-P)*** led by B. Biskaborn (AWI), was published in January 2019 with the help of 48 co-authors in Nature Communications. This new study shows for the first time the extent to which permafrost around the world has warmed in boreholes in the Arctic, Antarctic and various high mountain ranges for ten years (Fig. 5). The data were gathered at depths greater than 10 meters, so as to rule out the influence of seasonal temperature variations. The complete dataset encompasses 154 boreholes, 123 of which allow conclusions to be drawn for an entire decade, while the remainder can be used to refine calculations on annual deviation. The results show that, in the ten years from 2007 to 2016, the temperature of the permafrost soil rose at 71 of the 123 measuring sites; in five of the boreholes, the permafrost was already thawing. In contrast, the soil temperature fell at 12 boreholes, e.g., at individual sites in eastern Canada, southern Eurasia and on the Antarctic Peninsula; at 40 boreholes, the temperature remained virtually unchanged. Globally, ground temperature near the depth of zero annual amplitude in the continuous permafrost zone increased by 0.39 °C. Over the same period, discontinuous permafrost warmed by 0.20 °C. Permafrost in mountains warmed by 0.19 °C and in Antarctica by 0.37 °C. At averaged global scale permafrost temperature increased by 0.29 °C.
Contact: boris.biskaborn@awi.de

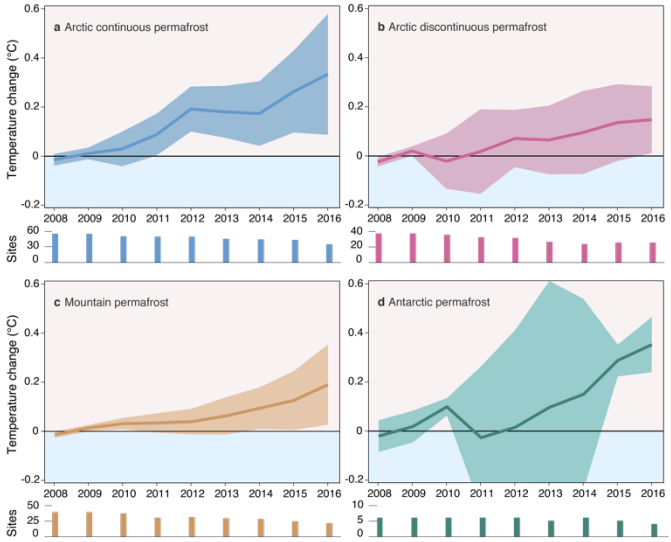


Figure 5: Annual permafrost temperature change in boreholes near the depth of zero annual amplitude relative to the 2008–2009 reference period (doi: 10.1038/s41467-018-08240-4)

ESA GlobPermafrost and ESA CCI+ Permafrost: Permafrost region disturbances were mapped across four major permafrost transects in Siberia and North America, covering a total of 2.5M km^2, using Landsat-based trend analysis of multispectral indices for the period 1999-2014. Remote Sensing based lake change studies were conducted in four major lake districts in Siberia and Alaska. The ESA Permafrost Information System PerSys was implemented in the Arctic Permafrost Geospatial Centre, an open access data portal for permafrost geospatial datasets hosted at AWI. PerSys and APGC now host many of the ESA GlobPermafrot datasets. Both products from GlobPermafrost and CCI+ Permafrost are used for model evaluation of a regional Arctic Earth System Model. This allows for the first time spatial quantification of biases in ground temperature and active layer thickness of the model, which will considerably help to improve the permafrost representation. Contact: Birgit.Heim@awi.de, Heidrun.Matthes@awi.de, Guido.Grosse@awi.de

The ERC project "Glacial legacy on the establishment of evergreen vs. summergreen boreal forests" started in 2018. Glacial Legacy focuses on the question why Northern Asia - in contrast to Northern America - is dominated by deciduous boreal larch forests and how these forests will change in the future. It is hypothesized that the deciduous Siberian larch forests are a legacy of the previous ice age and stabilized due to their unique vegetation fire-permafrost climate system, which prevents the invasion of evergreen taxa. Climate warming could lead to an irreversible transition into evergreen forests, with spruce and pine being stronger competitors compared to larch. The project team pursues a coherent empirical and modelling approach, integrating pollen data synthesis, sedimentary ancient DNA analyses, vegetation & biophysical surveys, micro- and macro-charcoal analyses including fire biomarkers, soil analysis and vegetation modelling. Field data were collected on several expeditions to Siberia in 2018 and 2019, with transects across the tundra-taiga ecotone from the boreal taiga to tundra in Eastern Siberia and within the summer green-to-evergreen boreal transition zone in Central Yakutia (Fig. 6) comparing also burnt and unburnt sites. Beside lake and vegetation sampling activities, microclimate stations and soil temperature sensors were installed to understand heat and water transfer processes in larch dominated boreal forest areas and whether these might protect permafrost from degradation.

Contact: Ulrike.Herzschuh@awi.de

Figure 6: Analysing Central Yakutian larch forest that burned in August 2019 (photo: Simone Stünzi)

To understand the role of forest fires in vegetation dynamics, a DFG project within the ICDP priority programme 1006 on ***"Siberian fire regime shifts during interglacials of the last 3.6 Myrs inferred from sedimentary records of Lake El'gygytgyn (NE Asia)"***, started in March 2019. It investigates the role of fires in Arctic and boreal vegetation changes during previous, especially warmer-than-present interglacials and their preceding glacials. Multiple fire proxies (sedimentary charcoal and fire biomarkers) will allow development of fire regime reconstructions to differentiate between past surface fire and stand-replacing fires typical for modern larch and evergreen boreal forest, respectively. Contact: Elisabeth.Dietze@awi.de

In early 2020, the recently granted Horizon2020 EU-project ***CHARTER, "Drivers and Feedbacks of Changes in Arctic Terrestrial Biodiversity"***, will have its kick-off. AWI in Potsdam leads Work package 5, "Designing futures based on system-wide natural and human drivers", which aims to ascertain how cryospheric changes affect biodiversity under several climate and socio-economic futures and to identify and quantify the impacts of changes in animal grazing legislation and practice on Arctic and global climate e.g. via changing the energy budget and carbon storage in the permafrost zone.
Contact: Heidrun.Matthes@awi.de.

Russia

Earth Cryosphere Institute, Tyumen Scientific Centre, Siberian Branch, Russian Academy of Science (**ECI Tyumen Scientific Centre SB RAS**) **http://www.ikz.ru/**

1. Vasiliev, D.S. Drozdov, G.V. Malkova, A.G. Gravis, G.E. Oblogov ,
A.A. Gubarkov, Yu.V. Korostelev,
O.E. Ponomareva, M.R. Sadurtdinov,
I.D. Streletskaya, D.A. Streletsky, E.V. Ustinova,
R.S. Shirokov. *Permafrost degradation: the results of many years of geocryological monitoring in the Western sector of the Russian Arctic // Earth`s Cryosphere, 2020. No. 2 (accepted in print).*

Based on the long-term data monitoring of the permafrost zone of European North and North of Western Siberia, a new previously unknown natural phenomenon has been revealed - the widespread degradation of permafrost and the lowering of its upper table by 4-10 m due to climate changes. In the zone of northern taiga and forest-tundra, permafrost thawing from above proceeds most actively at speed up to 0.6 m / year. In the zone of the southern tundra, the permafrost is generally prepared for active thawing. Here, the thawing rate is 0.1 m / year. In the zone of a typical tundra, the permafrost remains stable and according to forecast estimates will remain stable for about 10-20 years. An assessment map of the permafrost state of the Western sector of the Russian Arctic has been compiled.

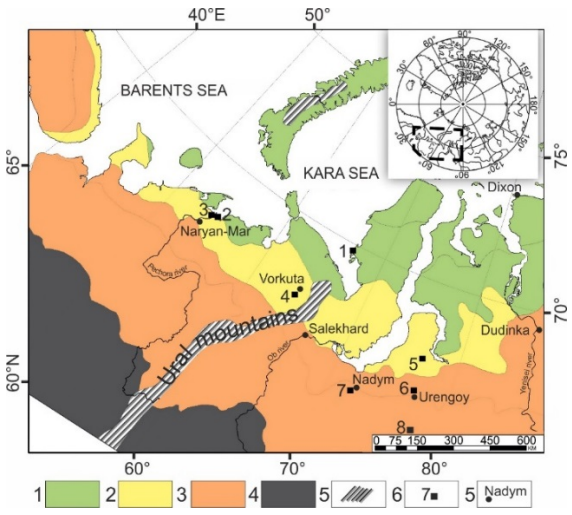


Diagram map of the permafrost state of the Western sector of the Russian Arctic. The regions in which permafrost changes within an acceptable framework are highlighted in green. The yellow regions indicate the beginning of permafrost degradation and the decreasing bearing capacity of the foundations. Regions in which permafrost is actively degrading and lowering its upper table are highlighted in orange. All large cities in this zone are at risk; dangerous deformations and even destruction of buildings and structures are possible here.

2. Studies conducted since the discovery of gas emission craters (GEC) in 2014 in the Yamal Peninsula included field, laboratory, and remote sensing studies. The features of the landforms, specifically geological sections, the properties of frozen deposits in the areas where GEC appeared, and the depth to ground ice in their walls were determined. A conceptual model of GEC formation is proposed and a map for assessing resistance to GEC formation is constructed. Main factors in GEC formation are high gas saturation of the upper geological section, characteristic of the north of West Siberia, and the existence of thick layers of ground ice in the section that contribute to gas accumulation. The trend of permafrost temperature increase, accompanied by extremely high summer temperatures in some years, served as a trigger for the process.

A team of the Earth Cryosphere Institute Tyumen Scientific Centre SB RAS, Lomonosov Moscow State University, Scanex, VNIIOceangeology Institute, Institute of Microbiology RAS, Tyumen State University for the last 5 years worked on the problem of gas emission craters. The main publications are as follows:

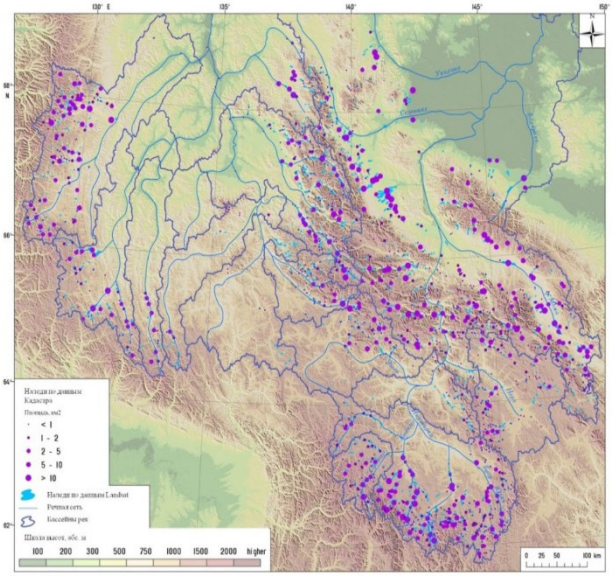
1. Arefyev S.P. et al. 2017. Dendrochronologic reconstruction of gas-inflated mound formation at the Yamal crater location. Earth's Cryosphere XXI (5):107-119.
2. Babkina E.A. et al. 2019. Activation of Cryogenic Processes in Central Yamal as a Result of Regional and Local Change in Climate and Thermal State of Permafrost. April 2019. Russian Meteorology and Hydrology 44(4):283-290.
3. Dvornikov Y, et al. 2018. Terrestrial CDOM in Lakes of Yamal Peninsula: Connection to Lake and Lake Catchment Properties. Remote Sensing, 10(2), 2018, 167.
4. Dvornikov Y, et al. 2019. Gas-emission craters of Yamal and Gydan peninsulas: a proposed mechanism for lake genesis and development of permafrost landscapes. Permafrost and Periglacial Processes, 30, 2019:146–162.
5. Kizyakov A.I. et al. 2015. Sonyushkin A.V., Leibman M.O., Zimin M.V., Khomutov A.V. Geomorphological conditions of the gas-emission crater and its dynamics in Central Yamal. Kriosfera Zemli (Earth's Cryosphere), XIX(2): 15-25.
6. Kizyakov, A. et al. 2017. Comparison of Gas Emission Crater Geomorphodynamics on Yamal and Gydan Peninsulas (Russia), Based on Repeat Very-High-Resolution Stereopairs // Remote Sensing, 9(10), 2017, 1023.

7. Kizyakov, A. et al. 2018. Microrelief associated with gas emission craters: Remote-sensing and field-based study. Remote Sensing, (10) 2018: 677.
8. Savvichev A.S. et al. 2018. Microbiological Study of Yamal Lakes: A Key to Understanding the Evolution of Gas Emission Craters. GEOSCIENCES, 8, 2018, 478.

3. Joint Finnish-Russian project "Mechanisms, pathways and patchiness of the Arctic ecosystem responses and adaptation to changing climate" (ClimEco) held its progress meeting on 5-6 March 2019 at the Finnish Meteorological Institute (Helsinki, Finland). The meeting included keynote presentations by leaders of Finnish and Russian project teams, discussion of the first results and planning further work in each Work Package. Dmitry Drozdov and Gleb Oblogov took part in the meeting from the Russian side from Tyumen State University. In particular, the results of data processing of more than 100 weather stations in the Russian Arctic and Subarctic region were presented.

Melnikov Permafrost Institute, Siberian Branch, Russian Academy of Science (MPI SB RAS, Yakutsk) http://mpi.ysn.ru/en/

A detailed spatial geodatabase of aufeis (icings) within the Indigirka River watershed, Russia, was compiled by a team led by Olga Makarieva, using historical Russian publications (Inventory of Icings in the North-East USSR, 1958), topographic maps, and Landsat images (2013–2017). The Landsat-based dataset includes 1213 aufeis fields with a total area of 1287 km^2. Over 600 icings identified from recent satellite imagery are missing in the 1958 Inventory. The total area of icings, including the giant Moma Icing, is 1.6 times less at present compared to the mid-20th century. The study suggests that the dynamics of icing extent can be a useful indicator for understanding climate change effects on hydrogeology in remote permafrost regions.



Icings in the Yana and Indigirka River basins derived from the 1958 Inventory and recent Landsat images.

Field investigations by MPI continued in East Siberia, northern Tian Shan, Altai, and Verkhoyansk Mountains. Investigations in the northern Tian Shan included monitoring of active layer and permafrost temperatures in the Trans-Ili Alatau and observations of active rock glaciers, ice-cored moraines and meltwater in the Bolshaya Almatinka basin (Vasily Lytkin and Liudmila Lebedeva in collaboration with the Laboratory of Alpine Permafrost and the Kazakhstan Institute of Geography).

V.Lytkin, L.Lebedeva and V.Goncharenko examining rock glaciers in the Trans-Ili Alatau, Northern Tian Shan, summer 2019.

Investigations in southern Yakutia continue as part of the MPI's basic project "Understanding the Development of Subsurface Temperature Fields and Permafrost in Major Tectonic Structures of the Siberian Platform" (Principal Investigator: Mikhail Zhelezniak, D.Sc.). During summer 2019, additional sites were established in three Mesozoic basins, Tokorikan, Guvilgra and Ytymja, within the Aldan Shield to expand the network of ground thermal monitoring stations. Fieldwork also included installation of automatic weather stations, geobotanical description, and stream water sampling for chemical analyses.

An automatic weather station with ground temperature measurements in the Ytymja River area.

A field team comprising landscape scientists, hydrogeologists, geochemists, and geophysicists conducted surveys along the Power of Siberia Pipeline route during the spring of 2019. This field campaign was a second stage of the contract project aimed at assessing potential permafrost-related hazards associated with pipeline construction and climate change (2018-2020, Principal Investigator: Vera Samsonova). Specifically, field work included forest-ROW-embankment snow surveys along the pipeline corridor, UAV topographic mapping of icings and valleys, icing water sampling, hydrological measurements of streams and icing meltwater, and direct observation of natural and pipeline-induced icings for spatial and genetic characterization. These studies provide baseline information on permafrost hazards along the Power of Siberia Pipeline corridor and will be continued during pipeline operation.

Aerial view of Bolshaya Cherepanikha valley crossed by the Power of Siberia Pipeline, March 2019.

A team led by Alexey Galanin continued sampling and analysis of stable isotopes (O^{18} and D) of rain, snow, ground ice, surface water, and ground water from the sand dune areas in central Yakutia as part of the RFBR and SB RAS-funded projects to study the origin and evolution of Late Quaternary periglacial eolian sediments and landforms in North-East Asia. During the last year over 150 samples were added to the stable isotope database which now contains over 450 determinations.

A field camp on a sandbar on the Vilyu River, July 2019.

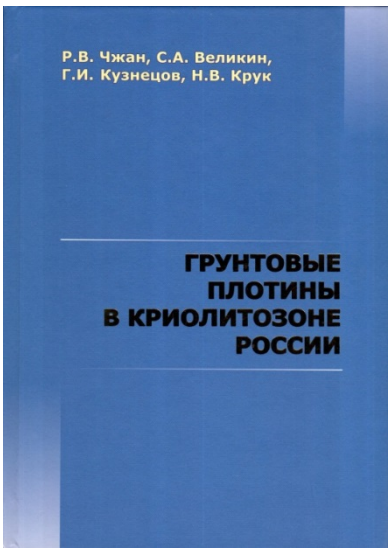
Experimental studies are in progress in a collaborative project with the State Key Laboratory of Frozen Soil Engineering (Lanzhou, China) funded by the Russian Foundation for Basic Research (RFBR) and the National Natural Science Foundation of China (NSFC). The project led by Mikhail Zhelezniak and Zhi Wen aims to compare the influence of convection flows of water and air on the thermal state of permafrost in the Aldan-Stanovoy Upland and the Tibetan Plateau. In the summer of 2019, Alexander Zhirkov and Anatoly Kirillin visited SKLFSE to take part in completing an experimental setup at 4600 m elevation on the Tibet Plateau.

Setting up an experimental system for monitoring rainfall influence on the ground hydrothermal regime, Tibet Plateau, summer 2019.

From 24 to 27 June 2019, MPI hosted the Russian Research and Practice Conference on Thermal Physics and Energy Engineering for the Arctic and Subarctic. The conference was dedicated to the memory of Dr. Rev I. Gavriliev to honor his important contributions to permafrost and thermal sciences. The conference was attended by 118 participants representing research institutes and universities from Yakutsk, Moscow, St. Petersburg, Novosibirsk, Irkutsk, Omsk and Krasnoyarsk, as well as the regional government and energy industry companies. The Program Committee included Academicians Vladimir Fortov, Joint Institute for High Temperatures (Moscow), and Dmitry Markovich, Kutateladze Institute of Thermophysics (Novosibirsk), among other prominent scientists. Over 100 papers were presented in four sessions: 1. Thermal physics: theoretical studies; 2. Thermal physics: practical aspects for cold regions; 3. Energy engineering; and 4. Geo-thermal physics. Extended abstracts of the papers were published in print format before the conference.

A plenary talk by V.A. Stennikov, Melentiev Institute of Energy Systems, Irkutsk.

In November 2019, a 427-paged monograph "Embankment Dams in the Russian Permafrost Zone" by R.V. Zhang, S.A. Velikin, G.I. Kuznetsov, and N.V. Kruk was published in Novosibirsk by Geo Academic Publishers (in Russian). The monograph reviews the case histories of embankment dam construction for water supply and power generation purposes in the Russian permafrost region. The results of field studies are presented which document the thermal evolution of dams which rely on permafrost for structural integrity and seepage control. Environmental issues of dam construction and operation in a changing climate are addressed. The role of geocryological monitoring and its implementation are discussed, along with geophysical methods that are capable of early detection of potential seepage through permafrost. Thermophysical principles of tailings dam performance are considered and guidelines are provided for their construction, operation and maintenance in permafrost regions. An innovative hydraulic well mining technology for dam construction is presented, as well as ways for using Earth's cryogenic resources for dam stability improvement. A location map of embankment dams and description of their current condition are provided. The book is intended for researchers and hydraulic engineers involved in dam design and operation in permafrost regions.



Cover of the book "Embankment Dams in the Russian Permafrost Zone" by R.V. Zhang, S.A. Velikin, G.I. Kuznetsov, and N.V. Kruk, 2019, Novosibirsk: Geo, 427 pp.

In 2019, three young MPI researchers successfully defended PhD dissertations. The doctoral study of Yana Tikhonravova focused on the structure and texture of wedge ice in the northern Gydan Penisula and the Pur-Taz Watershed, West Siberia. Alexander Zhirkov completed and defended his dissertation titled "Influence of Rainfall Infiltration and Internal Condensation on the Ground Thermal Regime in Central Yakutia". Based on the results of manipulated experiments at the Tuymaada monitoring site, the study demonstrated the significance of non-conductive heat transfer by water and water vapor and quantified the effects on the ground thermal regime. The PhD study by Svetlana Kalinicheva titled "A Method for Identifying Frozen and Unfrozen Ground in the Mountainous Regions of Southern Yakutia Using Thermal Satellite Imagery" showed that the late summer land-surface temperature (LST) derived from satellite images can be used as a reliable indicator in mapping the occurrence and distribution of mountain permafrost.

Alexander Zhirkov, Yana Tikhonravova and Svetlana Kalinicheva after the public defense of dissertations, November 2019.

Department of Cryolithology and Glaciology, Faculty of Geography, Lomonosov Moscow State University

The studies of 2019 were conducted in a number of directions, traditionally distinguished in the scientific research of the Department of Cryolitology and Glaciology.

Cryolithological research:

V.V. Rogov continued his study of loess cryogenic properties in Russia. The results of cryolithological analysis confirmed the role of cryogenic factors in formation of loess deposits in the Lower Volga region (Rogov et al., 2019b). The study of the isotopic composition in various water categories in finely dispersed soils was carried out. It was shown that bound water (unfrozen in the frozen state) has excellent isotopic composition characteristics in contrast to free (bulk) water (Rogov et al., 2019a).

N.A.Shpolyanskaya obtained and analyzed data, confirming natural ongoing modern climate changes (Shpolyanskaya, 2019). The published monograph presents the results of a study about Late Cenozoic history of the permafrost zone in the Russian Arctic continent and shelf.

I.D. Streletskaya (2019) obtained new data on permafrost relicts and pseudomorphs distribution of melted polygonal vein ice in the Lower Volga and Ural regions. For interpreting the sections of loose sediment cover in permafrost areas, the main

differences between permafrost structures and seismic dislocations were formulated.

In the north of Western Siberia and Yakutia a study was made of the cryolithological structure of permafrost sections with underground ice inclusions. It has been established that methane concentration can be used as an indicator of occurring permafrost processes, including thawing and redeposition of rocks (Fedin et al., 2019). The data on the cryogenic structure of Quaternary sediments, including underground ice, were summarized for the Yamal and Gydan Peninsulas (Pismenyuk et al., 2019).

Kizyakov A.I. and Streletskaya I.D. with colleagues analyzed the characteristics of chemical, isotopic and gaseous components of annual sea ice, according to core data from BARNEO drifting stations for 2013–2015 (Kizyakov et al, 2019b). The possibility of using data from the composition of salts in polygonal vein ice for paleogeographic reconstructions of the Arctic coastline is proposed.

Yu.B. Badu and K. Nikitin show confinement of pingos to gas-bearing areas in the north of Western Siberia (Nikitin, Badu, 2019).

Complex, morphodynamic zoning of the Kolguev Island shores was performed (Kizyakov et al., 2019a).

V.I. Grebenets, F.D.Yurov and V.A.Tolmanov identified regional aspects of cryogenic processes and infrastructure interactions (Yurov, Grebenets, 2019). For large settlements in the Yamal-Nenets Autonomous Okrug, the degree of damage to the territory by cryogenic processes and danger level for buildings and structures by geocryological processes were estimated (Tolmanov, Grebenets, Yurov, 2019).

Special studies were conducted to assess the destructive effect of large man-made dumps moving similar to rock glaciers (Grebenets et al., 2019, a). Information on the storage of waste in permafrost zones is generalized and the negative impact on the geocryological conditions of economically developed territories is estimated (Grebenets et al., 2019, b).

Snow surveys were carried out in residential areas of Norilsk, the largest industrial center in the permafrost zone (Grebenets et al., 2019, c); it was revealed that snow drifts with a height of more than 2.5 m, that are formed annually at the same places, often have a destructive effect on permafrost and contribute to the activation (during snowmelt) of dangerous cryogenic processes, primarily thermokarst and thermoerosion.

N.V. Tumel and L.I. Zotova summarized the results of many years of work on geoecological research in the permafrost zone (Tumel, Zotova, 2019). A number of conceptual provisions have been proposed for assessing and mapping geoecological situations in case of anthropogenic surface disturbance in the Russian Federation cryolithozone from the point of view of landscape stability to activation of dangerous cryogenic processes. For the first time, a step-by-step procedure for diagnosing permafrost-ecological situations on a regional-regional scale using the methods of landscape indication, interpretation, expert estimates and statistical calculations is shown.

L.I. Zotova and A.Donetskov conducted a multivariate expert assessment of the geosystems lithocryogenic resistance to the development of dangerous exogenous processes using weight coefficients and an interval cent scale. The Medvezhye key site was selected as example (Donetskov, Zotova, 2019).

V.I. Grebenets and A.A. Maslakov carried out annual monitoring work to study the dynamics of seasonal ground thawing as part of the CALM (Circumpolar Active Layer Monitoring) program at sites in the Talnakh region (in the north of Krasnoyarsk Territory) and in Eastern Chukotka. The 20-year series of observations on seasonal ground freezing in Central Russia was continued by V.I. Grebenets at the Zvenigorod Biostation of Moscow State University.

In the atlas-monograph “The Russian Arctic: Space. Time. Resources” (2019) a series of maps is presented showing the distribution of permafrost and glaciation in the Arctic, prepared by the Cryolitology and Glaciology department.

Glaciological research:

Under the leadership of V.V. Popovnin, a 4-month field campaign was carried out in the basin of the representative mountain glacier Dzhankuat in the Central Caucasus (Rets et al., 2019). The most important indicators of the glacier’s condition for the 2018/19 balance year were calculated. The accumulation and ablation modulo 15-18% exceeded long-term average values, so the final mass balance was negative (-400 mm), which means a net decrease of mass by about 120 mm more than the 50-year average. A dynamic increase of surface moraine cover was revealed in the upper part of the ablation region.

For Kyrgyz glaciers of the Inner Tien Shan (Karabatkak, Sary-tor and Bordu) V.V. Popovnin calculated the negative values of their mass balance. Data on the retreat of the De los Tres glacier in Patagonia is obtained.

D.A. Petrakov and N.V. Kovalenko continued field research on the Kolka glacier. It was established that in 2014–2017 the surface of Kolka glacier increased by an average of 2.2 m per year, which contrasts sharply with a decrease in the surface of the Dzhankuat and Garabashi glaciers, which are representative for the Caucasus. Since 2002, the Kolka glacier continues to gain mass against the reduction of other Caucasian glaciers (Aristov et al., 2019).

D.A. Petrakov continued his cycle of work on the study of the Tien Shan glaciation (Petrakov et al.,

2019). The catalog of Ak-Shiyrak massif glaciers was created as of 2018. In the Ak-Shiyrak massif, small glaciers located on the slopes of the southern exposure are mostly rapidly shrinking. Faster shrinking of small glaciers, compared to large ones, was observed throughout all high mountain Asia. Against the background of shrinking glaciers, the onset of technogenic rock glaciers continued. They are stacked with ice, displaced from Davydov glacier, and waste rock (Shpuntova et al., 2019).

N.V. Kovalenko conducted expeditionary glaciological studies on glaciers of the Aktru basin (Altai). This glacier was a reference glacier for the World Glacier Monitoring Service (WGMS), but all observations were abandoned in 2012. This year the mass balance operations on the Leviy Aktru glacier have been resumed.

In August 2019, V.V.Popovnin and N.V. Kovalenko, with the participation of students and graduate students of the department, conducted expeditionary research on the glaciers of the northern ledge of the Lama mountains, Putorana plateau (Uspenskaya et al., 2019).

In the Polar Urals, M.N. Ivanov carried out field glaciological studies on the Obruchev and Chernov glaciers for the first time since 2010 (Nosenko et al., 2019).

N.A. Volodicheva and A.D. Oleinikov continued snow-avalanche studies to detect changes in snowfall and avalanche activity at the Elbrus educational and scientific base of Moscow State University. A decrease in the degree of avalanche activity has been established due to predominance of snowy, warm winters in the last decade with a peak in snow accumulation and avalanches in the spring (Oleinikov and Volodicheva, 2019). The past winter season has been identified as moderately snowy and abnormally warm.

The collection and processing of data on the most significant avalanches in the Khibiny mountains was continued. Winter 2018-2019 was characterized by average snow cover thickness of 120 cm and an average degree of avalanche activity of about 100 avalanches in 40 avalanche runout zones near the city of Kirovsk. Especially large avalanches, that go beyond the average values, were not found during the routes along the Khibiny. As part of the GIS “Khibiny Avalanches” and the collection of data on snow avalanche victims, an assessment and analysis of changes in social and individual avalanche risk in the Khibin territory was conducted (Vikulina, 2019).

Student practice, field schools:

Traditionally, second-year students practice in the north of Western Siberia (practice in cryolithology) and in the Caucasus (practice in glaciology).

Under the guidance of V.I. Grebenets and D.A. Streletsky, the International Arctic Field Courses on permafrost and northern science were held in conjunction with the Department of Geography of George Washington University. Students studied the landscape-permafrost features of Alaska in various geographical zones (northern taiga, forest-tundra, southern, typical and northern tundra) and geological and geomorphological conditions: mountains, foothills, coastal plains. Monitoring work was conducted to study the dynamics of seasonal thawing and its geographical differentiation from south to north.

Under the leadership of M.N. Ivanov and M.A. Vikulina, a winter expedition of the scientific student society was held at the Khibiny educational and scientific base of Lomonosov Moscow State University. The studies were conducted as part of the study of winter snowfall and avalanche activity in a changing climate. In the process of work, stationary and route observations were carried out.

A 20-year series of observations on seasonal freezing of soils in Central Russia was continued. Under the guidance of V.I. Grebenets, with the participation of V.A. Fedin, two trips of the winter training school were organized and conducted by the Department of Cryolithology and Glaciology based at the Zvenigorod Biostation of Lomonosov Moscow State University.

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Geocryology Department, Geology Faculty, Lomonosov Moscow State University

"Georadar – 2019" (13-15 March 2019) was a Russian scientific-practical conference. This conference is the new format of the previous GPR-oriented conferences at the Moscow State University in the 2000s. The official program of the "Georadar - 2019" conference included a master class on GPR, an exhibition of geophysical equipment and software, presentations, field demonstration of modern GPR equipment and software, and discussions.

Sergeev Institute of Environmental Geoscience RAS (Moscow)

http://geoenv.ru/index.php/ru/

As a result of field and laboratory studies conducted by the Institute of Geoecology of the Russian Academy of Sciences, the fundamental possibility of filtering greenhouse gases in permafrost with increasing temperature has been proved. The studies are of high importance in connection with the modern hypothesis of the growth of greenhouse gas emissions into the atmosphere of the Arctic during thawing of permafrost soils. The results show that the emission of greenhouse gases into the atmosphere begins earlier than the complete thawing of soils. This circumstance must be taken into account when making forecasts of greenhouse gas emissions from permafrost under the influence of global climate warming and the technogenic impact of engineering facilities.

Moscow State University and IEG RAS realized together with Norway the second stage of the Russian-Norwegian project "Research-based Education in Cold Regions Engineering" (RuNoCORE). Moscow State University and NTNU has a long history of research cooperation on Arctic and cold region engineering that could give better education to students at both universities. Through this cooperation, we have better understanding about culture and traditions that should be spread to students. The main activities in the project are to invite Norwegian students to fieldwork in the northern part of Russia and to arrange an intensive course in both countries for students from Russia and Norway. This project became even more international in 2019. Students from Greenland, Denmark, Italy and Norway participated in educational and scientific practice. Exchange of research methods and teaching practices promotes a common understanding of the trends of landscape changes and infrastructure risks in the Arctic.

International student team near Khanovey Station.

Permafrost affects the railway near Vorkuta.

Institute of Physicochemical and Biological Problems in Soil Science, RAS (Soil Cryology Laboratory)(Pushchino, Russia)

http://www.issp.psn.ru/

1. The results of the "Exobiofrost" experiment aboard the BION-M1 biosatellite showed that the impact of space flight factors (ionizing radiation, g-force, and temperature fluctuations) did not lead to complete sterilization of the permafrost samples. According to the post-flight analysis, a significant part of the bacterial community has remained viable after the

space experiment. A comparison with control samples showed that modern tundra colpodas are more resistant to the effects of space conditions than representatives of ancient permafrost, and that *Colpoda steinii* strains are more resistant than ciliates of the *Exocolpoda augustini* species. The greatest resistance to space flight conditions demonstrated by acanthamoeba cysts (*Acanthamoeba* sp.) makes them model organisms for both Earth and space experiments in the future.

2. The diversity of anaerobic and aerobic microorganisms (prokaryotes) was studied in permafrost soil sampled at a depth of 0.5 to 3.7 m during the 2016 expedition of the State Scientific Centre of the Russian Federation the Arctic and Antarctic Research Institute (AARI). The estimated number of organotrophic microorganisms varies from 3.29 ·10 to 7.0 ·104 CFU ·g–1 for aerobic, and from 3.0 ·10 to 2.3 ·104 cell ·g–1 for anaerobic organisms. In separate anaerobically cultivated samples, methane and acetate were observed, while sulfate and iron reducing prokaryotes were not detected in any of the samples. In the course of the research, 60 strains of aerobic psychrophilic and psychotolerant bacteria were isolated. The taxonomic position of the isolated microorganisms was established by sequencing the 16S rRNA genes and using MALDI mass spectrometry. The created collection of strains consisted of representatives of the *Actinobacteria*, *Firmicutes*, *Betaproteobacteria* and *Gammaproteobacteria* phyla.

3. This study summarizes seasonal thawing data collected in different permafrost regions of northeast Asia over the 1995–2018 period. Empirical observations were undertaken under the Circumpolar Active Layer Monitoring (CALM) program at a range of sites across the permafrost landscapes of the Yana-Indigirka and Kolyma lowlands and the Chukotka Peninsula, and supplemented with 10 years of observations from volcanic mountainous areas of the Kamchatka Peninsula. Thaw depth observations, taken using mechanical probing at the end of the thawing season, and ground temperature measurements were analyzed with respect to air temperature trends. The data from 24 sites reveal different reactions of the active layer thickness (ALT) to recent changes in atmospheric climate. In general, there is a positive relation between ALT and summer air temperatures. Since the early 2000s positive ALT anomalies (compared with mean data from all sites) prevail in the Kolyma and Chukotka area, with only one alas site showing a negative ALT trend.

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4. From 15-18 April 2019, the international permafrost conference “Solving the Puzzles from Cryosphere” was held at the laboratory of Soil Cryology. The conference was attended by 150 participants, including 12 from abroad. Conference materials are available on the laboratory website: http://cryosol.ru/images/phocagallery/conference/cryospherepuzzles/PushchinoPermafrost_ConferenceProgrammAbstracts2019_compressed.pdf

V.B. Sochava Institute of Geography SB RAS (Irkutsk)
http://www.irigs.irk.ru/

The study area is the Tunkinsky intermountain depression (south-western Baikal, Republic of Buryatia) – an area of island permafrost. Soil temperature is a key factor controlling many biotic and abiotic processes in soils. It is important to perform monitoring of freezing and thawing regimes in peat and mineral soils. The object of the study is umbric cryosol on sandy lake-alluvial sediments. The first study site is characterized by natural umbric cryosol under spruce forest, and at the second site soil was affected by anthropogenic activity (abandoned cropland) in the 1960s. During the last 20 years the croplands were abandoned and recovered by steppe grasses. Both sites are located on permafrost. An atmospheric-soil monitoring system was used to study the temperature regime of perennial and seasonal permafrost at both sites. Soil temperature was measured hourly from 1 July 2013 to 30 June 2017 in the soil profile from the surface to 320 cm depth. Anthropogenic influence at one of the sites led to differences in vegetation cover, soil moisture regime, and distribution of fractions of particle size along the soil profile. It was found that these differences are the cause of differences in the soil temperature regime, degradation of the permafrost and lowering of the top of permafrost. The soil at the abandoned cropland site is warmer than at the spruce forest; maximum annual temperature of the former cropland is 10 °C higher on the surface and is 5 °C higher at a depth of 320 cm. The minimum annual temperature is 7 °C lower at the surface and 1 °C lower at a depth of 320 cm. A warm period (soil temperature > 0 °C) on the surface of the former cropland is longer by 22 days than in the natural site, on average. The described differences are observed at all depths. As a result, permafrost is observed under the spruce forest below 130 cm (soil temperature is –0.2 to –0.9 °C throughout the year). On the abandoned cropland site the zero isotherm during seasonal thawing drops much deeper than 320 cm, while the soil in the 240–320 cm layer warms up to 2–5 °C.

The results of the most fundamental and advanced investigations and important results of the programs of the Earth Cryosphere Institute (ECI SB RAS) and of the many other Institutes and organizations specializing on permafrost/cryosphere research are presented in the journal “Earth’s Cryosphere” (“Kriosfera Zemli”). The journal has been translated into English since 2014, and all the articles are available online for free at the website of the journal: http://www.izdatgeo.ru/index.php?action=journal&id=8&lang_num=2.

Spain

Activities of the IPA-Spain group

Following the activities conducted during the previous years, the different research groups working on permafrost and periglacial processes in Spain have carried out research on a wide range of topics in both the Iberian mountains (Pyrenees, Cantabrian Mountains, Sierra Nevada, Iberian Range, Central Iberian Range), as well as in Antarctica and in the Arctic. There has been an intense collaboration between the different teams. Researchers from the universities of Barcelona, Valladolid, Complutense and Autonoma of Madrid, Alcalá, Extremadura, León, the Pyrenean Institute of Ecology and the Basque Centre for Climate Change collaborate in different projects, along with other international centres.

Participation at permafrost and polar meetings

In June 2019, in the nice city of Jaca, heart of the Pyrenees, Spanish and Portuguese researchers met within the umbrella of the VII Iberian meeting of the International Permafrost Association. The meeting was hosted by the Pyrenean Institute of Ecology under the coordination of Dr. Ignacio López-Moreno. Ca. 50 young and senior researchers presented their latest findings and had very fruitful discussions about different matters related to permafrost science.

Fig. 1. Iberian permafrost researchers met in Jaca.

Next European Conference on Permafrost

During the last European Conference in Chamonix, the Spanish permafrost community made an official proposal to organise the next on Permafrost in Puigcerdà, in the heart of the eastern Pyrenees, from June 20 to 23th, 2022. In July 2019, this proposal was accepted by the Executive Committee of the International Permafrost Association. Owing to cancellation of the ICOP in Lanzhou, China, and its subsequent rescheduling for 2022, the regional conference in Puigcerdà has been changed to 2023. Details will be provided as they become available. The conference will be hosted by the University of Barcelona and will count on the support of several other Spanish universities and research centres.

Permafrost research in Spain has significantly increased over the last several decades, both in terms of quality and the number of scientists conducting research in permafrost environments. Since the International Polar Year 2007-08, the Spanish permafrost community has made a step forward on the internationalization and development of a new generation of permafrost scientists. Currently, there are several groups in Spain studying permafrost in both polar regions and mountain environments, namely at the University of Barcelona, Complutense University of Madrid, University of Alcalá, University of Valladolid, University of León, University of Extremadura and the Spanish National Research Council (CSIC).

The Spanish permafrost community will be honoured to host the IPA Regional Conference on Permafrost in 2023 in the Catalan Pyrenees. It will be also a unique occasion to show the importance of permafrost research in a country where most people have never heard of permafrost. It will therefore be a great opportunity to disseminate our research activities as well as to sustain funding and reinforce permafrost science in the Iberian Peninsula.

This event, promoted by the IPA Spanish Adhering Body, is celebrated as one of the IPA Regional Conferences, which are held every two years with the main objective of providing interdisciplinary collaboration and joint initiatives between the different research groups working on periglacial and permafrost subjects.

Fig. 2. Puigcerdà, in the valley floor of the Cerdanya, will host the next EUCOP conference.

Research by Spanish groups

Researchers from the Department of Geography of the University of Barcelona of the Antarctic, Arctic and Alpine environments (ANTALP) Research Group (www.ub.edu/antalp/) have conducted research activities in both Polar Regions (Antarctica, Greenland) and high mountain environments (Pyrenees, Sierra Nevada).

Research activities have been carried out by the Barcelona group in the Sierra Nevada since the late

1990s, together with researchers from the Complutense University of Madrid, University of Extremadura and University of Alcalá. Monitoring activities consist of measurement of ground temperatures at several sites across the massif, as well as on rock glacier dynamics in the Veleta cirque, where frozen masses are degrading. In addition, in 2019 we conducted several geophysical surveys in the Veleta cirque and Machos plateau with Dr. Christian Hauck (University of Fribourg, Switzerland). These activities were framed within the international initiative following the 20 years of the first surveys conducted within the PACE project in order to detect changes in permafrost extent in different European mountain regions.

Fig. 3. Moraine ridge near the Uruguayan research station, Antarctica.

Ferran Salvador has continued his long-term monitoring of soil and air temperatures in the high mountain environments of the Cerdanya area in the Eastern Pyrenees,. Marc Oliva installed loggers to monitor rock temperatures in the surroundings of the rock glacier of Beciberri, Central Pyrenees, in collaboration with Dr. Florence Magnin (University Savoie Mont Blanc, France).

Marc Oliva and David Palacios (Complutense University of Madrid), carried out a field season in Fildes Peninsula (Antarctica) to collect samples for cosmogenic dating to reconstruct the age of deglaciation and formation of permafrost features.

Fig. 4. Visitors near Zackenberg research station.

Marc Oliva, together with Julia García-Oteyza and Jesús Ruiz, conducted research in NE Greenland to reconstruct the timing of glacier retreat and the development of periglacial features.

The Research Group of the University of Valladolid (Pangea, http://www5.uva.es/gir_pangea/), led by Prof. E. Serrano and the University of Caceres group (Nexus), led by Prof. José Juan Sanjosé, have continued working on mountain permafrost and periglacial geomorphology in the Cantabrian Mountains and the Pyrenees. Collaborating with the Ecology Pyrenean Institute (IPE, CSIC) led by Dr. J.I. López-Moreno, the group has worked on mountain permafrost, glaciers and cold environments in the Iberian Peninsula.

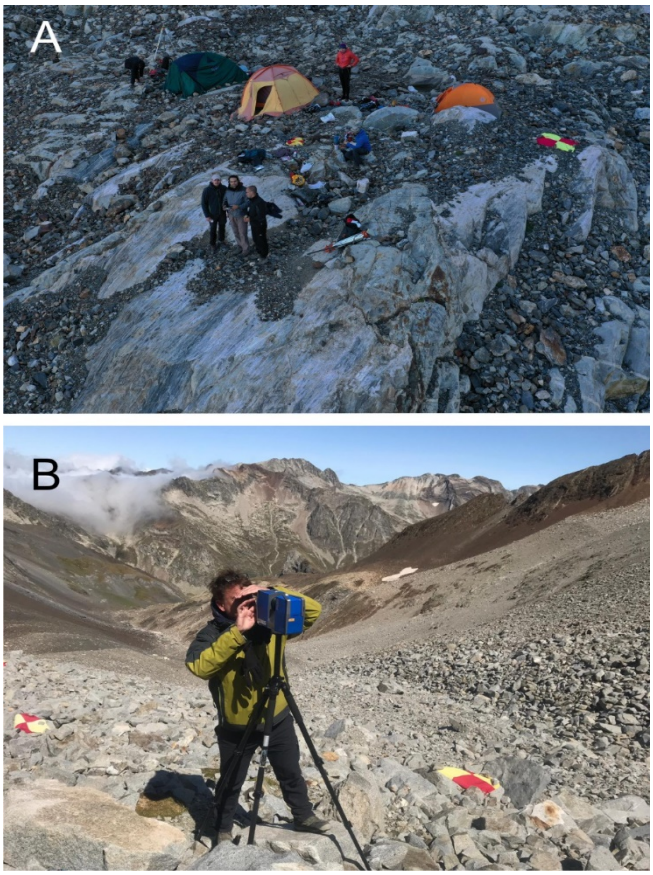

Fig. 5. Field work in the La Paúl Valley, Pyrenees: (A) campsite in the La Paúl rock glacier. (B) TLS survey in the La Paúl rock glacier.

In the Cantabrian Mountains, the team is working on periglacial processes in the Aliva and Campoo area, ice caves in Picos de Europa and León Mountain, and snowpatch degradation in the Picos de Europa. In Áliva and Campoo, three glacial cirques are equipped with data-logger on the ground, and annual surveys are made on solifluction lobes, sheets, and slides using TLS and GPS-RTK. At both sites, there are meteorological stations installed by the IPE and the National Park. Field work conducted in spring and autumn provided information about surface dynamics and movements related to climatic parameters (both air and ground conditions), snow regime, and water availability. Field work and data yielded by loggers

improved our knowledge of periglacial processes at low altitudes in temperate mountains. These works are included in the PhD dissertation of Alfonso Pisabarro, whose thesis was defended at the University of Valladolid in June, 2019. The thesis focused on the mountain hydrology and geomorphology associated with human changes, as well as the role of periglacial processes and the ground thermal regime on periglacial and nival environments in the Valdecebollas massif, located in the High Pisuerga basin.

From 27 July to 12 August, we conducted a field season in ice caves in the Picos de Europa. Together with several speleological groups (CES Alfa, Abismo and AS Charentaise), we equipped four ice caves with dataloggers to conduct an endoclimatic survey (temperatures and moisture) and collect samples for ice dating. Some extremophyles have been extracted from the ice caves of the Picos de Europa.

Fig. 6. Fieldwork in the Picos de Europa ice caves. A. Sampling and changing data-logger in the Altaiz Ice cave, at 57 m depth. B, cavers team in the Picos de Europa campsite.

In the Pyrenees, research in 2019 (as in the previous 8 years) was conducted in three cirques that still host glaciers today (Posets, Monte Pedido and Maladeta massifs) and where periglacial processes and permafrost are prominent elements of the landscape. Systematic surveys of rock glaciers, ice-patches and glaciers have been made during two field surveys in September. Whereas field work on rock glaciers focused in the Posets and Maladeta massifs, glacier characterization was conducted in the Maladeta and Posets massif.

New geomatic techniques, such as photogrammetry from drones, have been added to the previous studies that included GPS-RTK and TLS. We removed ground temperature dataloggers from the Tucarroya and Monte Perdido massifs concluding our studies on periglacial processes and mountain permafrost in these areas. The group is now concentrating on permafrost mapping and data analysis.

The research group has participated in the IPA Action Group Rock Glacier Inventories and kinematics of the IPA, attending the Workshop I of the IPA Action Group in Evolène (Switzerland) from 23 to 27 September 2019. Adrián Martínez spent three months at the University of Graz working on geomatics techniques for surveying rock glaciers and remote sensing techniques applied to high mountain research.

Fig. 7. Small fossil rock glacier in the North face of Peña Negra peak (2023 m), Sierra de Cebollera, Iberian System in the NE Iberian Peninsula, where cosmogenic dating is being applied by the GFAM.

The Research Group of the Complutense University of Madrid “GFAM” is working on the origin, evolution, and stabilization of rock glaciers, through the application of cosmogenic dating methods and detailed geomorphological survey and mapping. The study areas are located in different mountains: Sierra Nevada, Pyrenees, Iberian System, and Cantabrian Mountains, in the Iberian Peninsula; on the Tröllaskagi Peninsula, in Northern Iceland, and in the Rocky Mountains, USA (in the states of Utah, Colorado and Montana).

Fig. 8. Júllogil active rock glacier in the Hjaltadalur valley close to Hólar, where the GFAM is working in geomorphological survey, monitoring and dating.

The group is devoting special attention to the processes of formation of rock glaciers and their relationship with the paraglacial processes, after a fast deglaciation during different periods of the late Pleistocene and Holocene.

The GFAM is also working in monitoring tropical permafrost in the Coropuna and Chachani stratovolcanoes (Southern Peruvian Andes) and the relationship of permafrost recent evolution with global warming.

In 2019, the team of the Research Line 1: Climate Basis of the Basque Centre for Climate Change (BC3) finished the construction of the cold room of the IzotzaLab ("izotz" = ice in Basque): BC3's Low-Temperature Science Laboratory for microscopy of frozen samples (e.g. ice, permafrost, microorganisms). The IzotzaLab (https://izotzalab.bc3research.org/) aims to attract leading experts in low-temperature sciences, enhancing the interaction of BC3 with top-rank climate scientists and related laboratories. Its installations include a -30 °C cold room, optical microscopes and a variety of sample preparation tools, as well as a -80 °C storage freezer with multiple safety features. The IzotzaLab is now undergoing final technical tests and being furnished to become operative in the spring of 2020.

Fig. 9. The IzotzaLab.

From 18 January to 23 March 2019 PhD student Nicolás González, participated in the K2 Winter Expedition'19 led by the alpinist Alex Txikon. Nicolás investigated several debris-laden glaciers in the region (Baltoro, Godwin-Austen and Saboya).

Fig. 10. K2 Winter Expedition 2019.

During 2019, Sérgio Faria participated in the activities of the IPA Action Group on Rock glaciers. In particular, He attended the Workshop I of the IPA Action Group Rock glacier inventories and kinematics, which took place from 23 to 27 September 2019 in Evolène (Switzerland). He is contributing to the revision/preparation of the Baseline Concepts and the Practical Inventorying Guidelines.

The permafrost team of the Alcalá University has continued studying the thermal regime of Antarctic permafrost, collecting ground temperature data and measuring active layer thickness in Livingston and Deception Islands, Antarctica, for the TSP and CALM programs of the GTN-P database. In addition to the Antarctic fieldtrip, they also participated in the "Unexplored Antarctica" expedition to Fuji Dome in the Antarctic Plateau using a windsled, including their own temperature data-logger prototype to be tested under harsh weather conditions. Miguel Angel de Pablo, is part of the Wind Sled Working Group of the Spanish Polar Committee and the National Research Agency, commissioned by the Spanish Minister of Science, Technology and Universities.

In June, the group finished the PERMASNOW project, funded by Spain, focused on the effect of snow cover on the thermal regime of the active layer and permafrost in South Shetland Islands, Antarctica, in collaboration with Oviedo University in Spain, as well as other universities in Portugal and the Czech Republic.

Improvements to the radio communications systems for transmitting TSP data from Antarctica to Spain have been made by Manuel Prieto. Positive results are anticipated for the 2019-20 season. Data from the TSP station of Byers Peninsula, Antarctica, have been deposited in the new SoilTemp database for ecological studies, the first and only station in Antarctica to contribute to this database.

This research group has maintained a high level outreach activity, through conferences and the @Permafrost_UAH profile of Twitter, awarded with the Promotion and Disclosure Award of the University of Alcalá to M. A. de Pablo, in the category of social networks.

The team continues its studies of Mars' environments as part of NASA's Curiosity mission scientific team, contributing to the development of the next mission to Mars through the Mars2020 (NASA) and ExoMars (ESA) programs.

At the Universidad de León, the GEOPAT research group, led by Amelia Gómez Villar, is developing various studies on the numerous relict rock glaciers of the Cantabrian Mountains. Surface fabric analyses have been performed in some of them, with data published recently in PPP. The internal fabric is also being analyzed in some visible sections. Thanks to a research project funded by the Junta de Castilla y León, it has begun to create a relative chronology using the Schmidt hammer in various massifs. They also continue monitoring of the ground thermal regime in diverse periglacial

environments in the highest areas of the Cantabrian Mountains, with ca. 15 years of data in some sites.

Report prepared by:
Marc Oliva
Enrique Serrano
Nuria de Andrés
Sérgio Henrique Faria
Miguel Ángel de Pablo

United States of America

The Year in Review

The Annual Meeting of the US Permafrost Association (USPA) was held on December 10, 2019 during the Fall Meeting of the American Geophysical Union (AGU) in San Francisco, CA. The Meeting convened at the Thirsty Bear Brewing Company and was attended by approximately 135 members and their guests. Results of the Board of Directors elections were announced. Members of the 2020 Board of Directors are John Zarling, President; Dmitry Streletskiy, Past President; Cathy Wilson, President Elect; new members: Peppi Croft, Treasurer; Torsten Mayrberger and Mark Bennett, Board Members-at- Large; and continuing members are Thomas Krzewinski and Frederick Nelson as IPA representatives, and Matthew Whitley, PYRN representative. Gerald Frost, Thomas Douglas, and John Thornley were retiring Board members and their services were acknowledged. Two new USPA members were approved to start terms at the next IPA Council meetings for the following four years; Ed Yarmak and Kevin Shaeffer.

Several informational flyers were prepared for the Annual Meeting and are available on the USPA web site. Kristina Levine, student at Texas A&M University and supported by GW Scientific, prepared a compilation of all AGU abstracts related to permafrost. More than 300 abstracts presented in paper and poster sessions were arranged chronologically and were searchable in real time during the Fall Meeting and archived on the USPA website.

USPA-PYRN Education Fund (UPEF) provided five grants for travel to the AGU Fall Meeting: David Rey, Colorado School of Mines (Andrew Slater Memorial Award); Joel Eklof, University of Washington; Rodrigo Rangel, University of Wyoming; Erin Rooney, Oregon State University; and Aquanette Sanders, University of Texas Austin. The UPEF Committee chaired by Kelsey Nyland was responsible for solicitation of applications and the review process.

The Permafrost Engineering Education Program (PEEP), chaired by Margaret Rudolf, made travel grants for the 18th International Conference on Cold Regions Engineering and 8th Canadian Permafrost Conference that was held in Quebec City to Eva Stephani and Jaimy Schwarber, from the University of Alaska Fairbanks. Funds were provided to Laurin Fisher, a student at UAF, to complete programming on the Permafrost Predictor app that was developed by Dmitry Nicolsky. The new chair of the PEEP Committee is Peppi Croft, Shannon and Wilson Inc. in Fairbanks.

A new Membership Committee was approved in June and began its work during the summer. USPA membership in 2019 increased to 171 with members in 28 States, DC, and four non-US countries. Membership includes 110 individual members, 37 student/PRYN members, 13 corporate/institutional members, and eight lifetime members.

Nine U.S. participants attended the highly successful SouthCOP, the first IPA regional conference held in the Southern Hemisphere, which was convened in Queenstown, New Zealand, December 4-14, 2019 (see abstracts on December 2019 Permafrost Monthly Alert).

USPA, led by Tom Douglas, developed additional plans for the IPA Regional Conference on Permafrost to be held 11-16 July 2021 on the campus of the University of Colorado Boulder. The proposed theme of the conference is "Permafrost Dynamics in Polar and Alpine Environments" and is being organized jointly by USPA, UC Boulder and the American Society of Civil Engineers. The conference website was constructed and is accessible from the USPA website.

The USPA and the American Geosciences Institute (AGI) continue to jointly provide the monthly catalog of world-wide, permafrost literature. The Permafrost Monthly Alert (PMA) program, initiated in 2012, produces professionally reviewed reference material on a monthly schedule and results are made available in multiple locations including the USPA website. The current eight-year collection includes over 97 monthly and special updates containing over 7,390 citations, and in most instances includes abstracts and/or links to original content. The monthly accessions are uploaded by AGI to the Bibliography of Cold Regions Science and Technology (COLD), a searchable database that includes close to 30,000 permafrost references. For 2019, PMA content inquiries (views by individual readers) was the highest on record and exceeded 11,000 inquiries with over 60,000 inquiries since 2012. Poster presentations at both AGU and SouthCOP provided details of the PMA program. During 2019, Arctic Foundations Inc., Campbell Scientific Inc, USPA PEEP, Geo-Watershed Scientific and James Rooney provided PMA financial support. Sharon Tahirkheli, American Geosciences Institute, Michael Lilly, and Jerry Brown are principal participants, under the USPA Communications Committee.

Michael Lilly succeeds Oliver Fraunfeld as Committee Chair and whose long-term service is greatly appreciated.

As reported in the following reports (ASCE, INE and NGEE), two long-term members of the USPA received distinguished awards: Yuri Shur and Vladimir Romanovsky.

Reports from Organizations and Members

American Society of Civil Engineers

The ASCE Cold Regions Engineering Division (CRED) has five technical committees that assess and report on effects of cold regions environments upon engineering design, construction, and operations. The Publication Committee of CRED is responsible for editing the peer-reviewed Journal of Cold Regions Engineering (Jon Zufelt, editor) that publishes 25 to 30 refereed papers per year on topics related to permafrost and seasonal frost, ice engineering, construction, environmental quality, snow and ice control, and cold regions materials. The Frozen Ground Committee of CRED completed the monograph Frost Action in Soils – Fundamentals and Mitigation in a Changing Climate (Sally Shoop, editor). The Environmental and Public Health Engineering Committee of CRED is currently updating the Cold Regions Utilities Monograph that is widely used as a reference by engineers working in permafrost regions. It is scheduled to be published in 2020. ASCE co-sponsored the 18th International Conference on Cold Regions Engineering Conference in Quebec City, Canada, August 18-22, to discuss sustainable infrastructure development in cold regions in conjunction with the 8th Canadian Permafrost Conference. This conference had a total of 120 communications, including 80 papers, 20 posters, and 20 invited plenaries. ASCE presented Student Paper awards to Timothy Ensom (Wilfrid Laurier University), Julie Malenfant-LePage (Université Laval), and Earl Marvin DeGuzman (University of Manitoba). Student Poster awards went to Benjamin Bouchard (Université Laval), Elise Devoie (University of Waterloo), and Georg Lackner (Université Laval). This year, Robert Ettema (Colorado State University) received the Harold R. Peyton Award for Cold Regions Engineering and Brian Morse (Université Laval) received the Can-Am Civil Engineering Amity Award. Additionally, Yuri Shur (University of Alaska, Fairbanks) was chosen to present the Eb Rice Lecture which he did in Fairbanks on January 15, 2020.

Submitted by Ed Yarmak

U.S. Army Cold Regions Research and Engineering Laboratory

CRREL Alaska researchers continue to work at a variety of sites to develop standoff detection technologies and models for permafrost ice content, thaw susceptibility, and thermokarst risks. Increasing use of machine learning and geospatial analyses are being exploited to analyze a variety of field measurements. The CRREL Permafrost Tunnel expansion has entered its fourth year. A major excavation effort in the winter of 2019-2020 will add 100 meters of new tunnel. This includes new excavation into the oldest permafrost (40,000 years old) at the back of the 1960s era tunnel. Extensive upgrades to air quality, safety, and access are also being made.

CRREL researchers are interested in understanding the biogeochemistry of the permafrost-active layer boundary and how that relates to trace element cycling at the watershed level. Particularly, we are focused on understanding redox and temporal trends in late fall/early winter when the active layer is at the deepest annual extent. We have been investigating changes in microbial communities during thaw. Microbes play a key role in the ecosystem by providing key nutrients. This effort provides fundamental knowledge of the effects of climate change across the landscape since permafrost microbiomes are distinct and change differentially during thaw.

CRREL Alaska researchers are also developing a solar paneled thermosyphon system that can be used to extend the ground cooling periods. Solar powered hybrid systems could also be used to retrofit passive thermosyphons where a warming climate or a change in the cooling requirements are needed.

CRREL participated with University of Alaska Fairbanks and the Alaska District of the Corps of Engineers in compiling a threat assessment for all Alaska Villages with regards to permafrost degradation, flooding, and coastal erosion. The project was funded by the Denali Commission and provides a baseline for future evaluation of these evolving environmental threats. CRREL will be leading the revision and rewriting of the Unified Facilities Criteria engineering guidance series on Arctic and sub-Arctic Construction (UFC 3-130). The revision will be conducted as Cold Region amendments to existing and frequently utilized temperate region UFC guidance, and permafrost engineering will obtain significant updates to include climate warming guidance. The project is being funded by the Environmental Security Technology Certification Program (ESTCP) and is three years in duration.

CRREL was asked by the National Academies of the Sciences to help organize and participate in an international workshop on "Understanding and Responding to Global Health Security Risks from Microbial Threats in the Arctic" from 6-7 November 2019 at the Herrenhausen Palace in Hannover, Germany. The first of its kind, the goal of the workshop was to bring together an interdisciplinary, international group of researchers

and public health officials to explore what is known and what critical knowledge gaps remain regarding existing and possible future risks of harmful infectious agents emerging from thawing permafrost and ice in polar climates. The outcome was a helpful state-of-the-science overview and information to help frame new actions that advance research, surveillance, and response capacity. The final report is expected in March of 2020.

Submitted by Tom Douglas, Kevin Bjella, and Robyn Barbato

U.S. Geological Survey

In 2019 the U.S. Geological Survey continued to conduct research in the public interest to provide sound science for decision support to conserve land and water. Thematic areas include permafrost thaw and impacts on carbon cycling, visualization of permafrost through geophysical measurements and remote sensing, hydrologic modeling of thaw and linkages to biogeochemical changes, paleoecology of arctic lakes, and coastal change.

The USGS research contributed to synthesis reports on rapid losses of carbon following abrupt permafrost thaw and a synthesis report on non-growing season losses of soil carbon. Work also continues examining the molecular composition and biodegradability of carbon fractions from vegetation, active layer soils, permafrost and streams. Other work examined in situ microbial activity and water availability in permafrost near freezing (within 1°C), highlighting that microbial communities are active under freezing conditions and modify greenhouse gas concentrations. The USGS also continues to examine the use of unmanned aerial systems for determining methane fluxes.

The USGS completed a synthesis of new data products and analyses from the Yukon Flats of Alaska including: 1) airborne geophysical permafrost mapping, 2) clustering of Landsat derived lake-area time series and lake landscape position; and 3) exploration of hydrologic mechanisms and characteristics that influence lake-area dynamics. The results provide a fundamental basis for interpreting on-going lake-area change in the Yukon Flats in the context of permafrost thaw. Permafrost mapping and characterization using electrical resistivity, in situ NMR, and passive seismic techniques are ongoing.

USGS researchers contributed to hydrologic modeling in permafrost environments. A new modeling study guided by geophysical field evidence from the West Fork Dall Creek watershed in Interior Alaska improved fundamental understanding of processes that enhance and seasonally alter terrestrial-to-aquatic transfer of permafrost carbon, nitrogen, and mercury previously sequestered in thawing watersheds. Additional studies showed how permafrost thaw and mobilization of carbon can be assimilated into invertebrates and fish. New research on Interior Alaskan lakes show they are net CO2 sinks during the open water growing season. These lakes represent an understudied fraction (~25%) of lakes across the circumboreal that behave differently than the common paradigm of boreal lake heterotrophy and are effectively isolated from terrestrial carbon inputs because of semiarid climate and relatively flat landscapes.

USGS scientists also explored the utility of frozen peat pore-water isotopes as a proxy for paleoclimate and paleo-permafrost growth and thaw. Additional work compared macrofossils to peat DNA for paleoecological reconstruction. Other paleoclimatic work showed thermokarst lake expansion, stabilization, and subsequent climate-driven lake level variations during the past ~10,000 years.

In the area of coastal change hazards, the USGS completed an assessment of the past 80 years of shoreline change along Alaska's north coast. This extends the shoreline change assessment of the north coast of Alaska from the Bering Strait to the U.S.-Canadian border. USGS researchers also assessed the impacts of changes in sediment transport patterns on nearshore habitats from construction of an artificial island deemed for oil and gas exploration purposes near Prudhoe Bay. The USGS Climate and Permafrost Observing Network continues to monitor permafrost borehole temperatures on the North Slope of Alaska.

Finally, USGS scientists continue to be a part of the larger permafrost research community and contribute to synthesis activities with the Permafrost Carbon Network, IARPC, the USPA, the Fourth National Climate Assessment, the State of Carbon Cycle Report, and NASA ABoVE. USGS researchers have presented their findings in numerous journal articles and data releases, IPCC reports, and national and international meetings including ASLO, ICOP, EGU, and AGU.

Submitted by Mark Waldrop

Oak Ridge National Laboratory Next-Generation Ecosystem Experiments

The Department of Energy's NGEE Arctic project continues to conduct research near Utqiaġvik, AK, and has also established three field sites outside Nome, AK, on the Seward Peninsula in western Alaska. Every year since 2011 researchers from the NGEE Arctic project have gathered for two days to discuss plans and accomplishments from the previous year's field, laboratory, and modeling activities. This year was no exception as more than 90 participants in the project, joined by many national and international collaborators, spent two days sharing science from across the project. Team members focused their Day 1 efforts on reviewing

2019 research accomplishments and discussing steps required to migrate new knowledge to the DOE E3SM Earth system model. Early career scientists had an opportunity to share their insights during a Real Science, Real Short session moderated by Verity Salmon, Oak Ridge National Laboratory. Day 2 focused on site descriptions, use of the ILAMB software package, and international synthesis activities. An Arctic Café facilitated round-table discussions and engaged team members on what lies ahead for NGEE Arctic, including possible research topics beyond Phase 3. Kaare Erickson, community liaison with UIC Science in Utqiaġvik, AK, spoke at lunch on Sunday and provided an informative and fascinating history of native communities in Alaska, along with personal thoughts on how scientists can better engage local communities. One of many highlights during the meeting was the Data, Safety, and Logistics Awards Ceremony. Dan Stover, sponsor of the NGEE Arctic project, joined the team in awarding plagues to Vladimir Romanovsky (UAF), David Graham (ORNL), Amy Breen (UAF), and Verity Salmon (ORNL). A list of NGEE publications is available: https://ngee-arctic.ornl.gov/publications

Submitted by Stan Wullschleger

University of Alaska Fairbanks

Geophysical Institute Permafrost Laboratory

In 2019, the GI UAF Permafrost Laboratory group has continued to collect data on temperature and active layer depth from about 200 research sites in Alaska. Some of these records go back to the early 1980's. The research sites are distributed all over Alaska with a concentration of sites along the Dalton and Richardson Highways, around Barrow in the Selawik area, Seward Peninsula, around Fairbanks and in the vicinity of Nikolai Village. (Visit the website www.permafrostwatch.org for locations and to download historical data.) This year's data were processed and quality controlled and will be available from the NSF Arctic Data Center. These data show that ground temperatures continue to increase at almost all locations in Alaska. In the Interior, Seward Peninsula and Selawik region the increase in ground temperature triggered development of near-surface taliks. At 26 sites where the active layer has been previously freezing completely during the winter, an unfrozen layer (talik) developed during the last two years. These data were also used to calibrate the Geophysical Institute Permafrost Lab Model (GIPL) at very high spatial resolution. Some results of this modeling for the North Slope of Alaska and Alaska Northwest are presented at the website: https://permamap.gi.alaska.edu/. The results of this modeling can be used by any interested person. The GI Permafrost group is starting several new projects on the evaluation of the impacts of thawing permafrost and coastal erosion on several native villages in the North Slope Borough, as well as the City of Fairbanks and Whitehorse. This work will continue for the next five years with results presented in the coming years.

Submitted by Vladimir Romanovsky

Institute of Northern Engineering/Water and Environmental Research Center

INE received several new permafrost-focused, multi-year research awards in 2019 that contribute to the broader efforts of the US Permafrost Association. Notable awards include an NSF-AccelNet award to build an international network of networks focused on permafrost coastal systems (PI Jones), an NSF-NNA award to develop the Permafrost Discovery Gateway – a new online scientific resource that will document changing permafrost conditions at the sub-meter scale throughout the Arctic (PI Liljedahl), an NSF-EPSCoR award to develop machine learning and multi-dimensional remote sensing techniques for permafrost-region landscape dynamics (PermaSense – PI Jones), and an NSF-P2C2 award focused on rapid permafrost-region landscape changes associated with subsea permafrost degradation, coastal plain permafrost inundation, and pro-glacial lake dynamics (PI Walter Anthony). Additional awards in 2019 were granted by the Alaska DOT&PF program to study frost susceptibility and strength of cement-treated fine-grained soils (PI Darrow) and permafrost protection (PI Goering), by the Army Corps of Engineers/CRREL for soil and water sample analyses associated with expansion of the Fox Permafrost Tunnel (PI Kanevskiy), and by the National Fish and Wildlife Foundation for development of a permafrost-research observatory at Teshekpuk Lake (PI Jones). Also related is the NSF-NNA Fresh Eyes on Ice: Connecting Arctic Communities through a Revitalized and Modernized Freshwater Ice Observation Network (PI Arp). Collectively, INE researchers contributed to more than 30 publications in peer-reviewed journals in 2019. Notable distinctions include, Dr. Yuri Shur being presented with the Eb Rice Award by the American Society of Civil Engineers and its Cold Regions Engineering Division and Dr. Katey Walter Anthony receiving distinction as INE researcher of the year.

Submitted by Ben Jones

International Arctic Research Center

The three-year, NASA ABoVE field project to quantify thermokarst and related carbon release following the historically largest tundra fire on the North Slope (the Anaktuvuk River Fire) was completed by Go Iwahana. During the project, in addition to the Anaktuvuk River Fire, permafrost sampling for analyses of GHG/carbon/ice content and monitoring of thaw depth, surface moisture and displacement were conducted near Utqiaġvik, Kougarok in the Seward Peninsula, and Fairbanks. Laboratory studies continued following the 2017 and 2018 visits to the Barrow Permafrost Tunnel in Utqiaġvik by researchers from University of Washington (PI: J. Deming) and University of Alaska (Co-I: H. Eicken). A number of permafrost samples including massive ice and cryopeg brine were collected for geocryological analyses. The project is a comprehensive effort to explore the biological diversity and genomics of bacterial, algal, and viral communities in a permafrost cryopeg and sea-ice brines.

The IARC and the Chinese State Key Laboratory of Cryospheric Sciences have initiated a collaboration covering a number of scientific themes. As part of this collaboration, Bob Bolton and T. Wu (SKLCS) are leading an effort comparing the discontinuous permafrost and moisture conditions found on the Seward Peninsula and on the Qinghai-Tibetan Plateau. The goals of this collaborative research include: 1) enhancing understanding differences in high-latitude and high-altitude discontinuous permafrost; and 2) monitoring the long-term impacts of climate change to the hydrothermal regimes in these two environments, including field monitoring and modeling activities.

Submitted by Bob Bolton

Alaska Geobotany Center

The AGC led three permafrost-related efforts in 2019 including work on two NSF grants directed at examining the cumulative impacts of infrastructure and climate change to ice-rich permafrost systems, and a review of the likely effects of proposed three-dimensional (3D) seismic exploration of the 1002 Area in the Arctic National Wildlife Refuge, Alaska. A white paper, edited by Skip Walker and Janet Peirce, and a paper accepted with modification in Ecological Applications (Martha Raynolds et al., in press) reviewed the landscape impacts of past 2D and proposed 3D-seismic surveys in the Refuge. AGC is currently synthesizing data collected during an NSF initiative called Arctic Science, Engineering, and Education for Sustainability (ArcSEES) that focused on the cumulative landscape effects of roads and infrastructure in the Prudhoe Bay oilfield. The ArcSEES work laid the foundation for a new award in 2019 titled “Navigating the new Arctic: Landscape evolution and adapting to change in ice-rich permafrost systems (NNA-IRPS)”. The work involves five UAF institutes [Institute of Arctic Biology (IAB: Skip Walker, Anja Kade, Gary Kofinas, Jana Pierce, Martha Raynolds, Lisa Druckenmiller), Geophysical Institute (GI: Vladimir Romanovsky, Dmitri Nicolsky), Institute of Northern Engineering (INE: Yuri Shur, Billy Connor, Misha Kanevskiy), International Arctic Research Center (IARC: Amy Breen), and the Water and Environmental Research Center (WERC: Anna Liljedahl, Ben Jones, Helena Bergstedt)], the Alaska Division of Geological and Geophysical Surveys (DGGS: Ronnie Daanen), the Cold Climate Housing Research Center (CCHRC: Jack Hébert, Vanessa Stewart), partners in the village of Point Lay and the North Slope Borough, and two

international collaborators (Jozef Sibik, Helga Bültmann). The project focuses on evolution of ice-rich permafrost landscapes, the effects of roads in the Prudhoe Bay oil field and the Dalton Highway, and housing issues associated with building on yedoma landscapes in the coastal village of Point Lay.

Submitted by Donald (Skip) Walker

The George Washington University

The Circumpolar Active Layer Monitoring (CALM) program is a network of sites monitoring active layer and near-surface permafrost responses to climate change throughout the polar and select mid-latitude regions. There are approximately 150 annually reporting CALM sites that are maintained by personnel from 11 countries. These include 16 sites in the Antarctic and 40 active sites in Alaska. The program is in its fifth iteration, having been continuously funded by NSF for 25 years. Nikolay Shiklomanov (GWU) is the lead PI on the project assisted by senior personnel, Dmitry Streletskiy, Frederick Nelson, Nathan Moore, and Anna Klene. The project also recently includes Kelsey Nyland as a GWU Postdoctoral Scientist. More information about the program and recent data updates can be found at https://www2.gwu.edu/~calm/, the program wesite. In July 2019 CALM also supported a field course in cooperation with the NSF-funded project "Promoting Urban Sustainability in the Arctic."

Submitted by Nikolay Shiklomanov and Dimtry Streletskiy

Michigan State University

The periglacial group in Michigan State University's (MSU) Department of Geography, Environment, and Spatial Sciences continues to conduct field, remote sensing, and spatial-analytic research on cryoplanation terraces (CTs), large staircase-like series of periglacial landforms found in abundance in Alaska's Interior and Seward Peninsula regions. Clayton Queen completed his M.S. degree in 2018 and has submitted a series of papers on the geomorphometry of cryoplanated uplands to a peer-reviewed journal. Kelsey Nyland finished her Ph.D. in 2019 and has two papers concerned with age determination on CTs currently in press with the journals Earth Surface Processes and Landforms and Quaternary Research. Raven Mitchell, currently an M.S. student at MSU, is writing a thesis on the interplay between hillslope hydrology and periglacial mass movements adjacent to the Juneau Icefield Research Program's Camp 29 facility near Atlin, British Columbia.

Submitted by Fritz Nelson

National Snow and Ice Data Center University of Colorado

NSIDC focused on two areas in 2019: remote sensing of Active Layer Thickness (ALT) and mercury in permafrost. We used Interferometric Synthetic Aperture Radar (InSAR) to measure the surface subsidence resulting when the active layer thaws and the ice changes to water. We published a paper using these InSAR techniques on satellite data to quantify fire recovery in the Yukon-Kuskokwin Delta. We also applied the techniques to GPS interferometry to measure the subsidence over the entire thaw season. We are currently funded by NASA's Arctic Boreal Vulnerability Experiment (ABoVE) to combine airborne L-band and P-band radar to simultaneously estimate ALT and soil moisture for 66 flight lines in Alaska and northwest Canada. We also collect and integrate field measurements of ALT and soil moisture to validate the remote sensing products to produce a dataset of 350,000 measurements. In 2019, we extended our observations to Yellowknife, Northwest Territories.

Permafrost contains a great deal of mercury bound to the frozen organic matter. Mercury is a naturally-occurring contaminant that accumulates in organic matter, and thus accumulated in the high latitudes as the organic matter froze into permafrost. We collaborated with the US Geological Survey and the Northern Circumpolar Soil Carbon Database team to process additional samples to improve estimates of mercury stocks. We formed a new collaboration team through the Permafrost Carbon Network to improve estimates of mercury stock by leveraging published measurements. We created a new model of permafrost mercury and made estimates of future releases of mercury from thawing permafrost.

Submitted by Kevin Schaefer

Woods Hole Research Center

The WHRC permafrost-related fieldwork was focused in the Yukon Kuskokwim Delta, Alaska, which is the location of the summer field expedition for the Polaris Project undergraduate research program. We also worked with several Alaska Native communities to set up community-based permafrost monitoring networks. WHRC scientists are also using remote sensing data to detect changes in landscape characteristics associated with climate change and permafrost thaw, including changes in vegetation, surface water, and ground freeze-thaw. The WHRC Arctic group began a new project focused on monitoring and predicting carbon fluxes across the northern permafrost region. We are working with Harvard University's Belfer Center Arctic Initiative to bring this research to the policy community, and have partnered with ESRI to develop new data visualization tool. The WHRC co-hosted Permafrost Day in the Cryosphere Pavilion at the UN Climate Change Conference in Madrid (COP 25), and participated in and led several break-out sessions at the Permafrost Carbon Network annual meeting.

Submitted by Susan Natali

The University of Texas at El Paso (UTEP) Systems Ecology Laboratory

Funded by NSF, NASA, NOAA, and DHS, UTEP faculty spanning the Department of Biological Sciences and the Environmental Science and Engineering programs maintained a range of research and education projects in the Arctic related to permafrost dynamics and/or permafrost landscapes. Sites near Utqiagvik, Atqasuk, Toolik Lake, and Imnaviat Creek are partnered to the International Tundra Experiment (ITEX) that explore the responses of tundra ecosystems to warming. Our participation in NASA-ABoVE is focused on improving the representation of plant functional types as indicators of microtopography, soil moisture and other ecosystem parameters in land cover classifications; and developing new methods for using Solar Induced Fluorescence to monitor photosynthetic function and advance Arctic carbon cycle research. Our participation in the new NSF-funded Beaufort Lagoon Ecosystems Long Term Ecological Research project is exploring spatiotemporal patterns and controls, and the fate and transport of land-lagoon exports from runoff and coastal erosion. Students in the NOAA-CESST program are innovating ground to satellite remote sensing approaches for studying coastal dynamics. TeamVole is exploring the impact of herbivory on ecosystem processes at multiple localities on the North Slope and Seward Peninsula. Annually we host field schools for both the Arctic Summer Internship Program at the DHS-funded Arctic Domain Awareness Center and the NSF-funded Research Opportunities in the Arctic for Minorities (ROAM2) program at UTEP.

Submitted by Craig Tweedie

University of Virginia, Department of Environmental Sciences

The Arctic field group at UVA (Howie Epstein, Claire Griffin, and Kelcy Kent) are collaborating on an NSF-funded project led by Anna Liljedahl (also with Torre Jorgenson, Misha Kanevskiy, Ronnie Daanen, and Yuri Shur) to study the dynamics of ice wedges (degradation and aggradation) in polygonal landscapes of the Alaska North Slope and Coastal Plain. We are working at three locations: Jago River in ANWR, Deadhorse / Prudhoe Bay, and Utqiagvik (Barrow). Our group is focusing on the ecology and biogeochemistry of the dynamic ice-wedge complexes, examining the vegetation, and carbon and nitrogen cycling components in soils and surface water, as ice wedges degrade and potentially re-stabilize.

Submitted by Howard Epstein

Permafrost Carbon Network

The Permafrost Carbon Network facilitates synthesis of permafrost carbon science and communicates our current understanding to help society respond to a rapidly changing Arctic. Our two science highlights in 2019 were: 1) a comment piece in Nature (Turetsky et al. 2019; doi:10.1038/d41586-019-01313-4) showing that sudden collapse of thawing soils in the Arctic might double the warming from greenhouse gases released from tundra and 2) a synthesis of winter carbon dioxide emissions published in Nature Climate Change (Natali et al. 2019; doi:10.1038/s41558-019-0592-8, 2019). The study provides a baseline for winter carbon dioxide emissions from northern terrestrial regions and shows that winter emissions can offset carbon gains during the growing season. Members of the steering committee of the Permafrost Carbon Network participated and contributed to the Arctic Futures 2050 conference held in Washington, DC, in September of 2019. The Permafrost Carbon Network organized its 9th Annual Meeting in San Francisco, CA, December 8, 2019 with 130 participants in attendance. Synthesis leaders and co-leaders presented updates on synthesis activities in the morning and smaller breakout discussions in the afternoon focused on individual syntheses as well as new emerging topics. www.permafrostcarbon.org

Submitted by Christina Schädel

Permafrost Young Researchers Network (PYRN)

The Permafrost Young Researchers Network (PYRN) is an international organization established under the patronage of the International Permafrost Association (IPA) that fosters innovative collaboration, and seeks to recruit, retain and promote future generations of permafrost researchers. Its website currently lists 1,418 members and provides a newsletter of current activities: https://pyrn.arcticportal.org/. The current President, Helena Bergstedt, has recently taken a post-doctoral position at the University of Alaska Fairbanks working in the Water and Environmental Research Center at the Institute of Northern Engineering. The PYRN Executive Committee submitted a letter of support to restore budget cuts to the University of Alaska system. https://pyrn.arcticportal.org/images/docs/Reports/PYRN_letter_budget_cuts.pdf

PYRN Early Career Researcher (ECR) groups are involved in reviews of Intergovernmental Panel on Climate Change (IPCC) reports and its Sixth Assessment Report (AR6): The Physical Science Basis. PYRN, along with the Past Global Changes Early Career Network (PAGES-ECN), the United States Association of Polar Early Career Scientists (USAPECS), and the Young Earth System Scientists (YESS), is part of a Project

Group involved in preparation of the Second Order Draft (SOD) of the IPCC AR6. Currently there are 16 PYRN representatives on the SOD-WGI-AR6, with Helena Bergstedt, Rebecca Finger Higgens, and Matthew Whitley representing the USA. This effort is important to the permafrost community as it engages early career researchers in IPCC activities, improves the overall quality and diversity of the content in IPCC reports, provides valuable editing and organizational challenges for young researchers, and generally provides exposure to PYRN and the permafrost community. The North American chapter of PYRN was approached by ECRs from Chile to improve collaboration in permafrost endeavors. PYRN continues the process of conducting its second census, in an effort to complete demographic and statistical information of its members.

Submitted by Matthew Whitley, U.S. PYRN Representative

Alaska Ecoscience

Torre Jorgenson collaborated on several permafrost-related projects in 2019. On Yuri Shur's NSF project related to the upper permafrost, he participated in field studies at Bylot Island, Itkillik River, Toolik Lake, and along the Dalton Highway to quantify permafrost characteristics in the intermediate layer. As part of the outreach for the project, Jorgenson worked with the Denali Park (Gosling Lake), the Koyukuk Refuge (Two Lakes) and the Innoko Refuge (Innoko Flats) to develop their thermokarst monitoring programs. As part of Anna Liljedahl's NSF polygonal ecosystems project, Jorgenson has been analyzing ecosystem changes in response to ice-wedge degradation at the Jago site in ANWR and at Prudhoe Bay. In collaboration with Tom Douglas's Strategic Environmental Research and Development Program (SERDP) project on climate change effects on permafrost-affected habitats, research focused on remote sensing of ecological state transitions associated with permafrost degradation and fire, as well as continuing thermokarst monitoring on the Tanana Flats. As a contribution to Michele Walvoord's ABoVE permafrost hydrology project, Alaska Ecoscience has continued monitoring of four thermal erosion gullies along the Dalton Highway, Alaska.

Submitted by Torre Jorgenson

Overall report compiled by Jerry Brown, Chair, USPA Membership Committee

In Memoriam of USPA Members

- **Hugh French**, Professor Emeritus, University Ottawa, May 2019 https://www.uspermafrost.org/In_Memoriam/In_Memoriam_French.shtml
- **William Wayne**, Professor Emeritus, University of Nebraska, November 2019 https://news.unl.edu/newsrooms/today/article/obituary-william-bill-john-wayne/
- **Robert H. Rutford**, University of Texas Dallas, Professor and Emeritus President, December 2019 https://americanpolar.org/about/leadership/robert-h-rutford-phd/

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