ICOP2024 – ACCEPTED SESSIONS

List of Sessions (Grouped by General Themes)

Community

1A - Permafrost in Community: Collaboration and Geohazard Mitigation Strategies.

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As climate change warms the Arctic four times faster than the rest of the planet, permafrost and the northern communities that rely upon it are facing times of immense transition. Permafrost thaw is rapidly changing landscape morphology, hydrological and biogeochemical regimes, and ecosystem services. These changes place existing infrastructure at risk, including transportation and energy networks, and threaten sociocultural well-being in northern communities. Understanding the complex nature of permafrost thaw and its consequences presents a major challenge requiring knowledge from multiple disciplines, sources, and traditions.

This session aims to address this collaboration by highlighting the importance of Indigenous community engagement in permafrost mapping, land-use planning, and geohazard characterization. We welcome contributions on community-based participatory methods, including participatory photography, ethnographic mapping, and interviews, and direct participation in research programs that provide opportunities for community members to share their perspectives and knowledge about their environment, alongside western scientific investigations.

This session seeks to develop a comprehensive and nuanced understanding of the current state of permafrost at the community level. Community members, polar organizations, and researchers are invited to share their experiences of permafrost change, and speak to knowledge sharing in permafrost research, community engagement, and permafrost and geohazard characterization in northern communities.

Keywords: Northern Communities, Cartography, Community-Based Participatory Research, Land-Use Planning

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1B - Applied Permafrost Geomorphology in Support of Northern Communities

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Permafrost-related geohazards are increasingly impacting people living in the North. Thaw-induced changes in ground conditions affect property, damage infrastructure and can even pose hazards to human life. Such changes can also compromise traditional subsistence activities and food security by altering ecosystems and releasing contaminants. Permafrost geomorphology, the study and characterization of permafrost-related processes and landforms, provides northern communities, stakeholders, researchers, and consultants with important information about surficial materials, ground ice and associated thaw sensitivity. Permafrost geomorphology can inform the assessment of permafrost-related geohazards, development of adaptive and mitigative measures, planning of suitable land uses, and design or remediation of infrastructure.

This session focuses on the application of permafrost geomorphology to the identification, characterization, and communication of potential or ongoing permafrost-related threats to the safety and sustainability of northern communities, including their infrastructure, industries, traditional activities, and cultures. It welcomes applied projects of any scale that support the identification, mapping and monitoring of permafrost-related geohazards, the assessment and mitigation of associated risks, or the development of adaptation initiatives aimed at improving northern resilience under a changing climate. Projects involving advancement of geomorphological knowledge, cross-disciplinary and cross-sectorial collaborations, or communication about geomorphological findings to northern communities, are welcome. Any perspectives or experience in the application of the newly published Canadian standard, Risk-based Approach for Community Planning in Northern Regions, would also make valuable contributions.

Keywords: Geomorphology, Geohazards, Communities

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1C - Permafrost and People: Social, Industrial, Economic, and Food Systems

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Human settlements and activities have an impact on, and are impacted by, permafrost systems, including generating permafrost thaw and subsidence, changes in vegetation and key animal species. While great effort has been made in documenting the physical basis for changing permafrost environments, less is known about how changing permafrost conditions affect socioecological systems, communities, cultural practices, livelihoods, built environments and economic systems - including agriculture, and extractive industries. Interdisciplinary perspectives and research are needed to adequately study how human activities and built systems are impacted by changing permafrost conditions.

In this session, we welcome contributions from a range of methodological approaches such as field-based studies, remote sensing, GIS, modelling, surveys, and interviews spanning multiple disciplines including physical, life and social sciences, and engineering. We welcome studies co-producing knowledge with local and Indigenous communities and studies focusing on developing adaptation and mitigation strategies.

Topics of interest include but are not limited to, studies focused on built environments (such as transportation infrastructure, engineering, and buildings), large-scale industrial activities, local businesses and other economic activities, food systems (including agriculture, pastoralism, food-gathering and hunting activities), perceptions of socio-economic and environmental changes and evolving cultural landscapes of permafrost systems.

Keywords: Social-Ecological Systems, Food Systems, Infrastructure, Economy

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1D - Permafrost Climate Services

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Permafrost knowledge and data must be useable and accessible for persons living on permafrost, planning adaptation, or doing research. And yet, few services concerning changing permafrost exist. For comparison, imagine not having weather forecasts, or where atmospheric science would be today without national weather services. Climate-driven permafrost thaw is already observed in polar and high-mountain regions. The benefits of effective adaptation and, conversely, the escalating costs and risks of delayed action are clear from national and international assessments. While policies and standards for adaptation to permafrost thaw are emerging, our ability to deliver the knowledge to underpin adaptation decisions is often inadequate.

The concept of Permafrost Climate Services builds on the WMO Global Framework for Climate Services that emphasizes the importance of user needs and co-development. Climate services are understood as climate information prepared and delivered to meet user needs, and there is growing experience in delivering them. Permafrost Climate Services will have distinct attributes such as the combination of knowledge and data about the atmosphere, the land surface, and the subsurface.

In this session, we invite contributions that envision and demonstrate permafrost climate services from diverse perspectives. For example, about the need for information and its form of delivery from the perspective of Indigenous communities, about turning observations or simulations into user products, about information needs for engineering design, about examples of co-developing prototype services, or about policy related to generating and delivering permafrost knowledge.

Keywords: Services, Hazards, Adaptation, Climate Change

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1E - Permafrost Data: Systems, Sharing, and Interoperability

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The importance of data in permafrost science and engineering continues to grow. Given the role of permafrost in the global climate system, and the increasing relevance of permafrost-related landscape change and geohazards, there is a growing need for interdisciplinary collaboration requiring data sharing across different fields. Extensive and well-organized datasets are important for the development of machine-learning techniques or numerical models and linkages with empirical observations. However, significant challenges and gaps still exist.

This session aims to explore progress in the collection, management, and dissemination of permafrost data, focusing not only on "traditional" permafrost observations such as ground temperature, active-layer thickness, and ground ice type or abundance, but on other types of permafrost data as well, including rock glacier velocity, traditional knowledge, landform inventories, or geophysical data. We aim to cover a broad range of topics, and invite presentations describing (1) software or methodological techniques developed to support the flow of data from observation to application, including quality control; (2) New platforms and portals for permafrost data or developments in existing technological or organizational systems for storing, managing, or distributing permafrost data; (3) examples of applying the FAIR principles (findable, accessible, interoperable, reusable) to permafrost data; and (4) success stories in data sharing or the development of collaborative workflows across organizational boundaries. We are also interested to hear from decision-makers and data users reporting on successes or challenges synthesizing permafrost data, particularly when drawing from multiple existing sources.

Keywords: Data

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2A - Permafrost Education and Outreach for Everyone in a Warming World

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Permafrost is not only a recognized topic of research in the context of continuing global warming and feedbacks but also has significant relevance for local societies and industry across the Arctic and in mountain permafrost areas. The teaching of permafrost to students in K-12 and higher education is of great importance for facing societal challenges locally and globally. As a topic, permafrost crosses disciplinary boundaries and may be integrated across educational programs in engineering, geosciences, and ecology. In this session, we will have a look at current education on permafrost from multidisciplinary perspectives and traditional knowledge. All educational levels from elementary school to PhD level are of interest.

Additionally, we welcome contributions focused on reaching audiences and communities outside the classroom. Projects advancing knowledge and understanding in communities on and far away from permafrost, those who live with its impacts on their lives, infrastructure, and agriculture, as well as those whose concerns are centred on the global climate system. New techniques and materials to reach small and large communities alike are welcome. Those targeting the general public, local stakeholders, policy makers, pre-school, and elders are all welcome. We look forward to a dialogue and resource sharing discussion among teaching and outreach enthusiasts, be they scientists, teachers, community members, or concerned citizens.

Keywords: Education, Outreach, Teaching Materials, Comics

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2B - Arctic K-12 STEM Education: Experiences, Practices, and Challenges

Ming Xiao[1], Anna Wagner[2], Xiaohang Ji[1]

[1]Pennsylvania State University, USA., [2]U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory

Workforce development is an international priority and particularly critical in producing the next-generation scientists and engineers. It is beneficial to start workforce development at an early age to instil STEM interests and concepts in K-12 students. This will help address the increasing environmental and engineering challenges due to accelerated climate change. Our session welcomes educators, researchers, Indigenous community members, and government officials to share their experiences and insights in K-12 STEM education about and related to the Arctic. We particularly invite topics focusing on permafrost to include opportunities, challenges, and successful pedagogies in STEM education. We hope to showcase a wide range of topics, such as curriculum design, teacher training, community-based learning, informal education programs, and the integration of Indigenous Knowledge.

Keywords: STEM, Education, Arctic

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2C - Launching the International Permafrost Internship Service

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In a rapidly evolving society, the higher educational experience of a student must look beyond those of traditional educational experiences i.e. campus-based learning and theoretical-focussed knowledge. To secure the best-educated candidates for our future societal needs, there is a strong need to focus on the relevance of future working life. Importantly, this should occur as early as possible and during the university education of a student. One of the well-known tools for obtaining a closer connection between professional life and universities is through internships and student placements. Permafrost is a particular natural topic to start developing internships for, as an additional important part of higher education because there are a high number of direct applications in many scientific fields, and due to the ongoing climatic changes very related to permafrost.

In this session, we celebrate the launch of the first international online permafrost internship service available to all interested hosts, students and supervisors. We present the result based on a development process run in Norden as a UArctic network project, an area which so far has not had any tradition for internships in higher education except in engineering education. We invite all interested students, hosts and supervisors including permafrost communities to share their experiences with and wishes for internships in permafrost, to use this session to further develop and increase the number of opportunities for internships across the many different permafrost topics. We plan an open to all conference participants short sharing session at the end.

Keywords: Permafrost Internships, Working-Life Experience

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3A - Antarctic Periglacial Environment

Mauro Guglielmin[1], Marc Oliva[2], Stefano Ponti[1]

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The session is proposed within the SCAR Expert Group ANTPAS and it is focused on the climate change effects on geomorphologic and biologic processes of the periglacial and cryotic environment of the ice-free areas of Antarctica and SubAntarctic Islands. As highlighted by several recent studies, the recent climate change, as well as the significant climate change of the past, induce important and sometimes sudden changes in landform evolution, soil formation and vegetation development. The monitoring of the abiotic and biotic changes and the understanding of their mutual relationships and the relations with climate change and their feedbacks are the main issue to address in this session. All types of techniques to achieve these are welcome (geophysical investigations, thermal monitoring, vegetation and soil monitoring as well as remote sensing to monitor surface changes). Weathering changes on rock substrates and coastal evolution are also welcome.

Keywords: Antarctica, Periglacial, Environment, Climatic Change

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3B - Characteristics of Permafrost in the Andes

Dario Trombotto Liaudat[1], Silvio Pastore[2], Lukas Arenson[3], Carla Tapia Baldis[1]

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The Andes of South America are the longest continental mountain range in the world, with an average elevation of about 4,000 m. Due to this height, permafrost plays a crucial role in its morphology and local ecosystems. Similar to many cold regions around the world the Andes are currently facing unprecedented changes in climate conditions, which are leading to the degradation of permafrost and other related processes such as rock glaciers degradation, slope instabilities, and changes in local hydrology. However, today, our understanding of the spatial extent, thermal conditions and its characteristics, including ground ice content, hydrological role, is still very limited, leading to large uncertainties when projecting future behaviour of permafrost conditions in the Andes.

This session will provide an opportunity for researchers and engineers from various disciplines to present their findings on the characteristics of permafrost in the Andes, specifically its spatial distribution, thickness, thermal state, presence of periglacial ice and paleopermafrost. Presenters will have the chance to share their knowledge, experiences, and ideas about the role of permafrost in this particular mountain ecosystems and how climate change impacts the current and future state of permafrost in the region.

The session accepts topics, such as permafrost mapping and modelling, ground temperature observations, use of remote sensing techniques, geomorphological and hydrological effects of permafrost degradation. It is expected that this session will contribute to the advancement of our understanding of permafrost in the Andes and provide opportunities for researchers from different disciplines and background to collaborate and exchange ideas.

Keywords: South America, Andes, Permafrost Distribution, Thermal State, Paleopermafrost

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3C - Yedoma Landscapes in the Past, Present and Future

Alexandra Veremeeva[1], Jens Strauss[1], Scott Cocker[2]

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Late Pleistocene Yedoma deposits, a suite of ice-rich silty sediments that accumulated in vast lowlands of Beringia, are widespread in Siberia, Alaska and north-western Canada. The high ice content of Yedoma, due to the presence of large ice wedges and excess ice, has led to large-scale development of thermokarst lakes and drained lake basins across the Yedoma regions under climate warming conditions in the past and present time.

Interest in Yedoma landscapes has been driven by (1) the exceptional preservation of past environmental records, including the fossil remains of the mammoth steppe fauna and flora, biologically viable plants and microorganisms, cryostructures, stable water isotopes and biogeochemical characteristics; (2) the impact of thaw on these regions due to the Yedoma high ice content driving significant landscape changes; and (3) large amounts of buried freeze locked well-preserved organic matter in deposits which due to the permafrost thawing will be involved in modern biological processes and contribute to greenhouse gas formation. Significant questions remain about the origins and paleoenvironmental conditions of Yedoma formation, its microbiology, landscape changes and vulnerability to the climate warming. Embracing the Yedoma and deep disturbance processes in models has been slow so far.

In this session, we seek contributions focusing on paleoenvironmental records and microbiological studies of Yedoma, the current state and dynamics of Yedoma landscapes with local to circumarctic scope, and assessment of the future development under different warming scenarios that consider the temporal and geographic range of Yedoma regions.

Keywords: Yedoma, Paleoenvironment, Thermokarst, Drained Lake Basins

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3D - Paleo and Relict Permafrost

TBA (ICOP2024 TPC temporarily)

Open session for contributions relating to mud, bones, and ice - old school permafrost.

Keywords:

Current Contact: Technical Program Committee *icop2024@canadianpermafrostassociation.ca*

3E - Extra-Terrestrial Permafrost: from Geology to Technology Development for Resource Utilization

Pooneh Maghoul[1], Richard Soare[2], Justin Lawrence[3]

[1]Polytechnique Montréal, [2]Dawson College, [3]Honeybee Robotics

This session aims to foster collaborative discussions among scientists, engineers, and stakeholders, with the goal of advancing our understanding and capabilities in the exploration of extra-terrestrial bodies. The focus will be on various aspects of surface exploration, ranging from the geology of permafrost geomaterials in low and microgravity conditions to cutting-edge science instrument development for prospecting and processing of space resources.

Participants in this session will have the opportunity to share their expertise and insights on a broad range of topics. This includes but is not limited to: including but not limited to the identification and characterization of potential landing sites, the design and testing of specialized robotic vehicles and equipment for surface operations, and the development of innovative instrumentation and techniques for analysing and extracting valuable resources from extra-terrestrial materials; ; and, the possible detection of ground-ice and ice-rich terrain/landscapes on planets, moons and more minor bodies in the solar system.

By bringing together a diverse group of professionals, this session seeks to promote interdisciplinary collaborations, ultimately advancing our collective understanding and capabilities in exploring the cosmos.

Keywords: Extra-Terrestrial Permafrost, In-Situ Resource Utilization, Space Resources, Technology Development

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3F - Polar Coastlines in Transition: Arctic, Antarctic, Offshore and Shelf Perspectives

Matt C. Strzelecki[1], Louise Farquharson[2], Zuzanna Swirad[3]

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Polar coastlines make up over one-third of the global coastline total and are among the most dynamic in the world. Due to climate change polar coastlines are increasingly vulnerable to rapid change. Patterns of Arctic coastal change are mostly associated with decreased sea ice cover which is leaving coasts exposed to waves and storm action for longer each year. Additional influential factors include permafrost degradation, storm-surge flooding, and intensified sediment supply from glacierised catchments. These changes have wide-ranging impacts on circum-polar Arctic coastal communities through the destruction of culturally important sites and modern infrastructure.

In the Antarctic region accelerated deglaciation has led to the exposure of new coastlines where permafrost-related processes and fluxes of sediments from paraglacially transformed glacial landforms control coastal dynamics. In both regions, climate warming has triggered extreme processes including accelerated permafrost thermoerosion, destabilization of coastal slopes by periglacial processes or landslides leading to formation of tsunami waves that profoundly change the functioning of fragile polar coastal environments.

This session invites submissions that will improve our understanding of polar (Arctic and Antarctic) coastal dynamics on local and regional scales. We encourage submissions focusing on both sub-aerial and sub-aqueous processes driving changes to coastal morphology, and are also interested in submissions which discuss rates of change and socio-economic impacts. The objective of our session will be to raise interest in the topic and provide a platform for discussions on various aspects of coastal change and its impact on the resilience of polar environments and societies. We particularly encourage submission of contributions from members of ACD (Arctic Coastal Dynamics), CACOON (Circum-Arctic Coastal Communities KnOwledge Network), Permafrost Coastal Systems Network (Per-CS), Nunataryuk, and EO4PAC groups.

Keywords:

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4A - Open Session on Rock Glaciers

Kaytan Kelkar[1], Isabelle Gärtner-Roer[2], Francesco Brardinoni[3]

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Rock glaciers are debris landforms generated by the former or current creep of frozen ground (permafrost), where creep refers to the variable combination of both internal deformation and shearing at depth. Their spatial distribution and dynamics are influenced by a combination of factors including topography, lithology, debris supply, internal structure as well as local-to-regional climatic conditions. In recent years, rock glaciers have received growing attention beyond permafrost investigation, involving disciplines such as geomorphology, hydrology, (paleo)climatology, ecology, and engineering. Mountain terrain is very sensitive to climate change. This is evident from observed shifts in mountain permafrost thermal regimes, changing hydrological seasonality, and snowpack variation. Recently, rock glacier velocity has been listed as a new associated parameter to Essential Climate Variable (ECV) permafrost within the Global Climate Observing System (GCOS). Hence, reflecting the importance of rock glaciers as geomorphological indicators to indirectly track the evolution of mountain permafrost in a changing climate. Despite the growing number of studies highlighting the significance of rock glaciers predisposed to cause cascading geohazards from destabilizations, or as key water stores in arid mountain environments, our understanding of the effects of climate-driven permafrost degradation on rock glacier state and evolution is limited. We welcome contributions addressing single rock glaciers, regional inventories, their kinematic or structural characterization and risk assessment, involving for example geophysical surveying, field observations, remote sensing or modelling approaches. We strive to promote discourse outlining novel techniques, monitoring, and multidisciplinary research to enhance our understanding of rock glacier response to a warming climate.

Keywords: Rock Glacier, Mountain Permafrost, Essential Climate Variable (ECV), Permafrost Degradation

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4B - Periglacial Geomorphology

Raquel Granados Aguilar[1], Marc Oliva[2], Kaytan Kelkar[3]

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Periglacial landforms are observed in cold-climate environments, both at high-latitudes and high elevation. Diverse processes such as physical and chemical weathering, mass-wasting, fluvial, aeolian, coastal, and paraglacial phenomena are common in such cold, non-glacial environments.

In periglacial regions, freeze-thaw cycles occur at varying times (i.e., diurnal, seasonal), and spatial scales (i.e., seasonal thawing of the active layer). Local factors including topography, snowfall, snow cover, aspect, and mean-annual ground and air temperatures, determine the presence and distribution of permafrost in periglacial areas. When permafrost is absent, frost-action processes dominate the periglacial environment.

Periglacial landforms can be highly susceptible to anthropogenic forcings and climate warming. Rising temperatures affect the thermal and geomorphological equilibrium of certain landforms. As a result, some areas are experiencing accelerated permafrost thaw and weathering, increased slope instability, thermokarst formation, and subsidence.

Periglacial geomorphology facilitates the integration of expertise from geomorphology, ecology, paleoclimatology, and engineering to address changing permafrost landscape dynamics. This session aims to foster discussions highlighting innovative approaches and multidisciplinary partnerships to improve our understanding of future permafrost thermal regimes within periglacial terrain. We welcome contributions outlining field observations, geophysical studies, laboratory testing, numerical modelling, and remote sensing techniques investigating the spatial and temporal evolution of periglacial landscapes.

Keywords: Periglacial Landforms, Geomorphic Processes, Permafrost Thaw

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4C - Rock Slope Stability in Mountain Permafrost Environments

Michael Krautblatter[1], Lukas Arenson[2], Regina Plasken[1]

[1]TU Munch, [2]BGC Engineering

Permafrost can be found in many mountain regions around the world and for numerous rock faces, sub-zero conditions are essential for maintaining their stability. Unstable mountain permafrost slopes, however, are a critical issue that can affect the safety and stability of various infrastructure projects and communities residing in such regions, impacting the livelihood of many. In order to address this issue, it is essential to understand the complex interplay between permafrost, its degradation and rock slope stability.

The purpose of this session is to bring together experts from multiple backgrounds to present and discuss recent advances in the understanding of rock slope stability in mountain permafrost environments under a changing climate. We invite researchers to present their most recent findings from numerical modelling, laboratory testing or field experiments; practitioners to highlight real-world problems and solutions; as well as infrastructure owners or public sector representatives to discuss their challenges. The multidisciplinary presentations should contribute to the advancement of our understanding of rock slope stability in mountain permafrost environments under a changing climate, and provide valuable insights and information for all participants working in this field.

The session accepts a wide range of topics, including rock mechanics, frozen soil engineering, hydrogeology, geothermal modelling, risk assessment, mitigation design, monitoring, climate change or the impact of human activities, with the objective of contributing to the advancement of our understanding of rock slope stability in mountain permafrost environments and reducing risk for vulnerable locations. Specifically, we are also encouraging the presentation of case studies.

Keywords:

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4D - Permafrost Temperature, Active Layer Thickness, and Rock Glacier Velocity

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Permafrost temperature, active layer thickness, and rock glacier velocity (RGV) are key indicators of permafrost change as well as changes in the earth's climate system. Over the last three decades, the observational record of these key indicates has been extended in both length and extent. There have also been advances in our understanding of the permafrost-active layer system which has facilitated improved interpretation of trends and also led to improvements in measurement techniques and identification of new variables for monitoring.

Keywords: Permafrost Temperature, Active Layer Thickness, Rock Glacier Velocity, Monitoring

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4E - Permafrost Mass-Wasting Processes and Slope Hazards

Ashley Rudy[1], Joseph Young[2], Julius Kunz[3]

[1]Northwest Territories Geological Survey, Government of Northwest Territories, [2]Department of Earth and Atmospheric Sciences, University of Alberta, [3]Institute of Geography and Geology, University of Wuerzburg

Permafrost mass-wasting has increased in frequency and magnitude across permafrost slopes in the last two decades due to a changing climate. This recent acceleration of thaw-driven landscape change can rapidly alter hazards and risks to infrastructure and ecosystems. However, the diversity and variability of permafrost hillslopes make assessing the interactions between permafrost degradation, mass-wasting processes, and associated hazards a complex issue. Bridging these fundamental knowledge gaps remains essential in evaluating spatiotemporal thaw trajectories and the associated hazards of thawing permafrost slopes.

This session, therefore, aims to present developments in permafrost mass-wasting processes and their associated hazards. We welcome contributions from an array of scientific disciplines, timescales (past, current, future), and local- to circumpolar scales that assess permafrost mass-wasting processes and hazards from mountain and lowland settings. This includes studies on field and remote sensing observations, geomorphology, engineering geology, surface-subsurface hillslope interactions, big data processing, machine learning, mapping, and modelling, monitoring, and adaptation strategies.

Keywords: Permafrost Degradation, Slope Processes, Thermokarst

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5A - Carbon Cycles in Cold Regions: Modelling and Observations

Mousong Wu[1], Wenxin Zhang[2], Youhua Ran[3]

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This session focuses on understanding the response of carbon cycles to the rapid warming being experienced in cold regions of the world (the Arctic, Antarctic, Tibetan Plateau, and the alpines, etc.), where year-round or long-term measurements are often limited. We encourage presentations that share recent findings that improve our understanding of the mechanisms that drive the sensitivity of the carbon cycle, including modelling (both top-down and bottom-up approaches) and observations (both remote sensing and in-situ measurements).

This session aims to share current advances in respective research fields and to explore the possibilities of building tight collaborations on climate change and carbon cycle science in the world's climate-sensitive regions as an alliance. The topics of this session will include but are not limited to (1) Model development: improving or developing ecosystem models to improve our understanding of the ecosystem processes in the cold regions; (2) Remote sensing and in-situ observations: introducing new observations or datasets across different spatial and temporal scales, new techniques of measuring greenhouse gas and using remote sensing products that imply vegetation or land surface properties; and (3) Data assimilation methodologies and applications: the data assimilation methodologies used to combine model and observations to improve our understanding of ecosystem carbon cycles, as well as the applications of new observations to constrain ecosystem models.

Keywords: Carbon Cycles, Cold Regions, Modelling, Observations

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5B - Monitoring, Modelling, and Remote Sensing of the Permafrost Carbon Feedback

Elchin Jafarov[1], Ted Shuur[2], Jing Tao[3]

[1]Woodwell Climate Research Center, USA, [2]Northern Arizona University, USA, [3]Lawrence Berkeley National Laboratory, USA

The permafrost region stores 1440-1600 Pg organic carbon in soils, which represents nearly half of the world's soil organic carbon pool. Accelerated warming of the Arctic can impact the global climate system by thawing permafrost and exposing a substantial part of this carbon storage to decomposition and release as greenhouse gasses to the atmosphere. Our session is focused on advances in observations, modelling, and mapping techniques of the permafrost carbon feedback to climate change.

We invite modellers, observers, and remote sensing experts to share their research on permafrost carbon monitoring, modelling, and feedbacks in natural and urbanized settings. We solicit contributions related to in-situ, laboratory, model, and remote sensing observations to improve the understanding of uncertainties of the permafrost carbon feedback.

Keywords: Climate, Carbon, Biogeochemistry

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5C - Reducing Uncertainties for Permafrost Carbon Feedbacks

Peter Morse[1], Lexi Mollica[2]

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Surface warming, amplified in the Arctic, is expected to accelerate over time due in part due to greenhouse gas (GHG) emissions from thawing carbon-rich permafrost (primarily CO_2 and CH_4), resulting in permafrost carbon feedbacks that affects the entire Earth system. Permafrost carbon feedbacks involve biogeochemical carbon cycles in three primary environmental settings: near-shore, terrestrial, and aquatic. In addition, there is geologically sourced CH_4 from sedimentary basins that reaches the atmosphere through taliks, which may enlarge as permafrost degrades. A general lack of data and great uncertainty in estimates of Arctic GHG emissions reflect our poor understanding of natural processes in the Arctic.

Though CH_4 is 25 times more powerful a GHG than CO_2¬ over 100 years and responsible for 30% of global warming since pre-industrial times, there is high uncertainty about Arctic CH_4 emissions because CH_4 quantification to date has focused primarily on anthropogenic sources. Key elements to determining the impact of CH_4 emissions from permafrost on global climate are understanding (1) the amount of carbon stored in permafrost dictated by geological history; (2) the biogeochemical processes in the primary environmental settings that regulate how much CH_4 will be released and over what time frame; (3) the relative emissions of CH_4 versus CO_2; and (4) the relative contributions of CH_4 from biological (biogenic) versus geological (thermogenic) sources.

In this session, we seek presentations about multidisciplinary research to examine CH_4 sources, biogeochemical processes, and fluxes from thawing permafrost across varied spatial and temporal scales.

Keywords: Permafrost Carbon Feedback, Methane Emissions, Carbon Cycling, Multi-Scale Observations

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6A - Implications of Thawing Permafrost on Water Resources in Cold Regions

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Permafrost drives surface and subsurface hydrological regimes in northern and mountainous regions. Its thaw is opening new hydrological pathways and activating biogeochemical processes that have substantial ramifications for water availability and water quality. This session aims to unravel the implications of permafrost thaw on water resources, with a special focus on permafrost hydrogeology and the transport of geogenic and anthropogenic contaminants.

We welcome contributions from various themes that centre around water resources in permafrost regions, including physical hydrogeology and hydrology, water quality and water chemistry, management of mining and industrial wastewater, geotechnical considerations of thawing permafrost, and local and indigenous perspectives on water in a changing climate. The anticipated outcome of this session is to provide an overview of the challenges, opportunities, and required adaptations that will accompany the transition from perennially frozen to thawed conditions in the subsurface.

Keywords: Permafrost Thaw, Water Resources, Hydrogeology

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6B - Drained Lake Basins in Lowland Permafrost Regions

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Drained lake basins (DLBs) are some of the most common landforms in lowland permafrost regions. DLB formation and drainage can form complex landscape mosaics that reflect asynchronous periods of permafrost aggradation and degradation. The presence of DLBs and their relative distribution on the landscape influence permafrost-region topography, hydrology, carbon cycling, GHG and nutrient fluxes, habitat availability, geomorphology, and human land use practices including subsistence practices and agriculture.

This session is intended as a forum for current research on DLBs in permafrost-affected landscapes. We seek contributions that reflect diverse scientific fields, approaches, geographic locations and a range of temporal (e.g. decadal to millennial) and spatial scales (e.g., local observation to large-scale studies). We particularly encourage contributions that (1) provide data on DLB geology, cryostratigraphy, geomorphology, and ecology; (2) outline new strategies to improve process understanding; (3) interface with neighbouring fields of science or apply innovative technologies and methods; (4) investigate model validation, model uncertainty, and scaling issues; (5) couple models of diverse processes or scales, and (6) foster our understanding of the geologic history, current state, and future fate of DLBs and associated permafrost conditions and surrounding terrain.

Keywords:

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6C - Arctic Wetlands in a Changing Climate

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Half of the world's wetlands are located in Arctic regions including peatlands, wet tundra, shallow water areas, and coastal marshes. Arctic wetlands are key components of global biogeochemical cycles, especially for carbon and nitrogen, but also for various contaminants. They are biodiversity hotspots and key breeding and moulting habitat for birds. Intact wetlands also have a hydrological storage function. Climate change threatens to alter some of the main functions of these sensitive wetland systems. For example, the hydrological balance of wetlands in permafrost regions is sensitive to changes in thaw depth, precipitation and evapotranspiration, as well as to changes in geomorphology and local topography caused by permafrost thaw. Such changes have effects on all wetland functions. In addition to uncertainties about wetland resilience and adaptability to climatic warming, the current properties of Arctic wetlands are still not comprehensively understood and quantified.

In this session, we invite contributions related to Arctic region and permafrost wetlands from various scientific fields using a wide range of methods, such as field observations, laboratory analyses and experiments, modelling and simulations, and remote sensing. We particularly encourage studies on (1) carbon and nitrogen cycling, including stocks and fluxes; (2) vegetation change and its effects on wetland ecosystems; (3) ecology of wetland organisms; (4) major contaminants such as mercury and their mobility or stability; and (5) wetland ecosystem response to disturbance events such as wildfire, permafrost thaw, and changes in hydrology.

Keywords: Hydrology, Ecology, Permafrost Biogeochemistry

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6D - The Hydrology of Mountain Permafrost

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Permafrost is a critical component of the cryosphere, affecting mountain hydrology and alpine ecosystems. The accelerating permafrost degradation observed in alpine regions raises concerns about potential consequences for downstream water resources. This session aims to bring together researchers and practitioners from diverse fields to discuss the implications of mountain permafrost thaw for mountain water budgets, hydrological processes, and downstream water resources.

The session will cover a range of topics related to the hydrological behaviour and significance of alpine permafrost, the connections of mountain permafrost to surface waters and groundwater, and potential risks associated with mountain permafrost degradation on water resources and downstream communities. The session will cover the different mountain permafrost features such as rock glaciers, periglacial talus, ice-cored moraines, thermokarst, and frozen rock walls.

We invite presentations focusing on field-based studies, modelling and practical applications at both local and global scales. The session will provide an opportunity for participants to exchange ideas, share knowledge and expertise, and discuss challenges and opportunities related to permafrost research. We particularly encourage submissions from early-career researchers and practitioners, and those working in interdisciplinary fields that intersect with permafrost research. The session will foster collaborations and partnerships among participants from diverse backgrounds and identify research priorities and opportunities for future research in the alpine environment.

Keywords: Hydrology, Mountains, Water Resources

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7A - Permafrost Railways

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Railways built over permafrost terrain are vulnerable to damage arising from ground warming and thaw. They are particularly sensitive to ground subsidence, frost-jacking of piles, and other permafrost processes causing rail bed deformation and negatively impacting rail geometry. Differential settlement and heaving at transition sections (e.g. between road and bridge, excavation and filling, or tunnel and subgrade) are an important cause of railway damage. Additionally, the management of water and prevention of washouts near permafrost railways is complicated by the nature of permafrost hydrology and by warming effects of water accumulation near the embankment foot.

Several mitigation methods can be used to alleviate the impacts of permafrost on railways, including adapted railbed design and improved monitoring and detection of incipient rail deformation. To be effective, these methods should be paired with effective characterization of permafrost distribution and ground-ice content, study of temperature-dependent geotechnical properties, and modelling of expected permafrost and ground surface response to climatic change.

This interdisciplinary session is focused on the characterization, prediction, management, and mitigation of permafrost-related hazards affecting railways in permafrost regions and welcomes research, data, and perspectives from all fields and sectors that aim to increase the resilience of permafrost railways to climatic warming.

Keywords: Railway, Infrastructure, Permafrost Hazard

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7B - Foundations and Infrastructure on Permafrost: Case Studies and Innovations

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42% of Arctic communities and 70% of Arctic infrastructure lie in permafrost, whose temperature has consistently increased in the past four decades. Infrastructure can itself accelerate the thawing of permafrost. Innovative infrastructure and foundation design are needed to meet the challenges of thawing permafrost.

This session welcomes researchers, practitioners, and government officials to share case studies, innovative technologies, and learned lessons and experiences in designing and constructing foundations of civil infrastructures on permafrost.

Keywords: Foundation, Infrastructure

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7C - Permafrost and Infrastructure Dynamics Along the Inuvik-Tuktoyaktuk Highway, NT

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The Inuvik-Tuktoyaktuk Highway (ITH) is a 140 km-long corridor connecting the Beaufort Delta region to the national highway system. It serves as the only all-weather road to the Canadian Arctic Coast. The highway was built over diverse terrain with varying ice contents and intersects a number of geologic and ecological environments. Across the corridor, permafrost temperatures range from cold (<-4 °C) to warm and near 0 °C. The construction of the ITH provided a unique opportunity to develop a societally-relevant, northern-driven permafrost research agenda. One that supports the planning and maintenance of infrastructure, regulation, and monitoring of climate change impacts and informed adaptation.

This session will showcase the diversity of monitoring and research conducted along the ITH and contributions toward understanding permafrost-infrastructure interactions and developing applied solutions to challenges unique to permafrost terrain. The session has a multidisciplinary focus and welcomes talks highlighting different methods and knowledge sources in monitoring and researching permafrost and infrastructure interactions. This includes the importance of baseline information, its management, analysis, and communication to support decision-making, and the necessity for collaborative or interdisciplinary approaches to address infrastructure management challenges in an ice-rich permafrost environment.

Keywords: ITH, Infrastructure

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7D - Permafrost Engineering, Geomorphology, Hydrology for Northern Linear Infrastructure Resilience and Safety

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Northern linear infrastructure such as roads and airstrips are vulnerable to natural processes and geohazards. Climate change is contributing to more frequent and intense geohazards which translate to increased maintenance and repair costs, as well as potentially dangerous travelling conditions.

In northern environments, geohazards result from permafrost thaw and permafrost hydrology and commonly cause damage to, or lead to failure of, transportation infrastructures. Some of these geohazards initiate due to thermal disturbances induced by construction of the infrastructures themselves. Other processes that eventually reach and impact infrastructures occur naturally or as a function of climate change, sometimes hundreds of meters away.

In this context, engineering, permafrost geomorphology, permafrost hydrology, and related disciplines are non-exclusively well suited to efficiently assess permafrost thaw-related geohazard risks. By assessing the above- and below-ground preconditions, the processes responsible for the geohazards can be identified. This knowledge supports decision-making about how best to invest in transportation networks in a time when climate change will continue to generate unprecedented extreme conditions associated with permafrost processes.

This session is dedicated to studies using those disciplines to generate new knowledge applicable to improving the resilience and safety of existing northern transportation infrastructure. Transportation infrastructure managers can use this information to augment remediation strategies, develop risk-management procedures and policies to enhance disaster preparedness, and mitigate disaster by implementing appropriate rehabilitation and reconstruction.

Keywords: Linear Infrastructure, Geomorphology, Geohazard, Engineering

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8A - Vulnerability of Cold-Region Infrastructure to Permafrost Degradation in a Changing Climate

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Globally, permafrost is thawing due to amplified climate warming in cold regions. Permafrost thaw substantially reduces load-bearing capacity of soil and induces differential settlements, leading to potentially catastrophic situations for buildings, pipelines, and roads, as well as increased maintenance costs and reduced lifespans. Nearly 70% of infrastructure built on permafrost is located in areas of high hazard potential. Additionally, construction practices often change or damage vegetation and replace the natural surficial cover with engineered materials such as gravel, sand, and/or asphalt. These surface disturbances result in accelerated permafrost thaw, which is often irreversible. Furthermore, permafrost degradation and talik formation affect the thermal, hydrological, and biogeochemical processes at and below the land surface.

This session is intended as a forum for current research on monitoring and modelling thermal, hydrological, and geotechnical responses of infrastructure built on permafrost to climate change. It addresses (1) investigation of the thermal state of permafrost; (2) recent and upcoming advances in permafrost modelling, including algorithm types, model uncertainties, soil parametrizations, numerical and physical benchmark cases, and land-surface-atmosphere interactions; (3) coupling processes of water, energy, and solute transport through the disturbed ground surface, and their interacting effects on long-term stability of infrastructure, such as permafrost thaw, talik formation, preferential flow; (4) development of mitigation techniques aimed to increase infrastructure resilience against permafrost thawing impacts.

We invite contributions based on laboratory experiments, field observations, or physical and numerical modelling, which advance the characterization, understanding, and models' predictive capacity of cryohydrological processes beneath cold-region infrastructure in a changing climate.

Keywords: Climate Change, Thawing Permafrost, Cold-Region Infrastructure, Changing Environmental Conditions

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8B - Advances in Numerical Modelling of Permafrost

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Accurate forecasting of permafrost behaviour under the influence of climate change requires improvements in numerical modelling for simulation and forecasting, including variety of techniques in physics modelling, statistical modelling, and data science.

Permafrost physics modelling may include advances in finite element / difference / volume techniques for simulating the coupled behaviour under changing thermal, hydraulic, and mechanical conditions to predict aspects of ground behaviour such as thaw settlement, talik genesis, and ice lensing. Statistical modelling may include novel techniques for characterizing historical data and/or generating synthetic forecast data under various climate scenarios that may assist in providing realistic boundary conditions to numerical simulations. Data science may include advances in managing remote field data, data pre- and post-processing, and/or machine learning techniques relevant to permafrost monitoring and simulation.

In this session, we invite submissions from a broad range of science and engineering disciplines that use and apply numerical modelling techniques for understanding permafrost behaviour and soil-structure interaction.

Keywords: Climate Change, Numerical Modelling, Data Science

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8C - Geomechanics and Engineering Geophysics for Permafrost Characterization

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Designing and maintaining resilient infrastructure in cold regions is a critical challenge for northern communities and governments. Stakeholders are looking for geotechnical approaches to improve the resilience of existing infrastructure and to enable the design and construction of new, sustainable, climate-resilient infrastructure in changing cold regions. To this end, it is essential to understand the physical and mechanical properties of permafrost, as these properties will determine the future performance of infrastructure in a changing climate.

In this session, we invite contributions in areas of the novel site or material characterization methods, techniques, and tools that further our understanding of the physical and mechanical properties of frozen ground. These include recent advances in geomechanical and geophysical measurement techniques to assess spatial and temporal variation of the ground's physical properties or incorporate these data for next-generation models of frozen ground and its response. These techniques provide new tools to better understand, analyse, and predict the behaviour of frozen ground.

Keywords: Geomechanics, Engineering Geophysics, Frozen Ground

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8D - Investigating Permafrost Using Geophysical Techniques

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Global warming affects Arctic environments and results in changing permafrost characteristics, alteration of permafrost hydrology, release of previously frozen carbon, and amplified morphological changes that can impact both the natural and built environment. Warming or thawing permafrost can multiply potential risks for infrastructure and lead to rapidly changing landscapes. Geophysical techniques are becoming a common field method for detecting internal structures and changes in permafrost and periglacial features or entire landscape units. Ground penetrating radar (GPR), electrical resistivity tomography (ERT), seismic, and electromagnetic (EM) methods have become well-tested and easily applicable to remote Arctic environments.

Due to their robust survey designs, geophysical methods are very useful for detecting and characterizing different permafrost features. Especially multi-dimensional approaches allow the detection of small-scale heterogeneities and can reveal spatial and temporal changes. In recent times, airborne geophysical approaches have been used, which significantly enlarge the spatial extent of measurements. Combined use of geophysics along with other in situ data can contribute to an enhanced understanding of changing permafrost environments and linkages between surface and subsurface changes.

In this session, we welcome contributions focusing on field-based studies on all kinds of Arctic permafrost and periglacial landforms and landscapes, such as thermokarst features (e.g., retrogressive thaw slumps), ice wedges, pingos, or drained lake basins using geophysical techniques. The focus can be on the characterization of internal structure but also on monitoring changes in active layer thickness, coastal erosion, or sub-sea permafrost. Contributions using multidisciplinary approaches of geophysics and other in situ or remote-sensing methods are highly encouraged.

Keywords: Arctic, Geophysics, Subsurface Changes, Periglacial Landforms

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8E - Drilling Operations and Sampling in Frozen Rocks and Soils

TBA (ICOP2024 TPC temporarily)

Open session for contributions relating to drilling operations and sampling in frozen rocks and soils.

Keywords:

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Cold Region Engineering Modelling, Characterization, Observations and Testing

8F - Laboratory Modelling and Testing of Permafrost Soils

Geoff Eichhorn[1], Pooneh Maghoul[2]

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This session aims to examine all aspects of the laboratory study of permafrost, at all scales and includes element testing, scaled physical modelling, centrifuge modelling, and full-scale lab testing of permafrost. Maintaining a sample of soil at sub-zero temperatures while also investigating strength, permeability, thermal conductivity, and soil mechanisms presents significant challenges compared to the same testing at temperate, above-freezing states. Both laboratory methods and technological developments to maintain and study cold regions samples are of interest, as well as outcomes of studies if the lab methods used are well examined and discussed. Themes of infrastructure modelling, permafrost soils strength, hydrogeology of cold regions soils, and thermal control and measurement are of interest.

Keywords: Laboratory, Testing, Physical Modelling

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9A - Permafrost Microbiology: Combining -omics with Ecological Theory

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Permafrost ecosystem microbiomes are exposed to extreme biotic and abiotic conditions. Unravelling their ecophysiology, genetic potential, community structure and functional response to environmental change has been in the core of permafrost microbiology research for about a decade. In particular, -omics and trait-based approaches have emerged as promising tools for understanding the functional diversity and ecological processes in permafrost microbiomes. These approaches provide a way to link the characteristics of microorganisms with their roles in ecosystem functioning and to predict how microbial communities respond to environmental change. However, integration of these approaches with ecological theory and modelling is still in its infancy.

This session provides an opportunity for researchers to bridge this gap by discussing the latest developments in permafrost microbiology covering a range of topics, including: (1) The role of microbial communities in the permafrost carbon cycle and the impact of climate change on these communities; (2) The genetic and physiological adaptations to long-term frozen conditions; (3) Changes in microbial growth, activity, metabolism, and interactions with the environment during thaw; (4) The use of -omics and trait-based approaches to predict the functional diversity and ecological processes in permafrost microbiomes; (5) The integration of -omics and trait-based approaches with ecological theory, such as niche theory and community ecology; and (6) The implementation of genomic, physiological and trait-based data in permafrost carbon feedback models.

This session will provide a valuable platform for researchers to exchange ideas, promote cross-disciplinary collaborations, and advance our understanding of the permafrost microbiomes and their role in the global carbon cycle.

Keywords: Microbial Traits, Microbial Diversity, Adaptation, Arctic

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Microbial Ecology in Permafrost

9B - Microbial Pattern and Process in Permafrost Affected Ecosystems

Leewis Mary-Cathrine[1], Jessica Ernakovich[2], Sam Bratsman[3]

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Microbial communities in permafrost-affected ecosystems—from soils to wetlands to rivers and lakes—are a critical component of biogeochemical cycles because they drive the transformation of elements from local to global scales. It is increasingly recognized that studies focused on microorganisms and how they interact with their environment are essential because of the vital role microbes play in driving ecosystem processes. The understanding of the response of microorganisms and their functions to disturbance (such as permafrost thaw, wildfire, shrubification, lake drainage, and glacier retreat to name a few) is limited, however important patterns are beginning to emerge. Major processes which are critical for understanding the effects of disturbance can be categorized as those which explore the interactions of permafrost-affected microorganisms with (1) other microorganisms (e.g., bacteria, archaea, viruses, and fungi) and soil fauna; (2) plant communities; (3) soil minerals; and (4) soil water and ice.

This session invites interdisciplinary submissions exploring the complexity of microbial patterns and processes in northern latitude ecosystems. This session invites microbial ecologists and biogeochemists with expertise in laboratory, field, and modelling approaches to explore how interactions between microbial communities and other components of permafrost-affected ecosystems influence cryosphere processes under global change.

Keywords: Microbial Ecology, Biogeochemistry, Ecosystem Function

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10A - Remote Sensing of Permafrost Processes and Impacts on the Environment

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Permafrost is a key component of the northern environment, and it influences major landscape processes including the carbon cycle, geomorphic processes, landscape restructuring, and environmental health. Monitoring surface features of permafrost terrains and typical periglacial landforms are necessary to understand the current and future dynamics of permafrost degradation. Remote sensing techniques are the best to monitor changes across scales, as some of these landforms are typically found in extremely remote and inaccessible locations. Satellite assessments can also bridge the gap between field observations and modelling efforts and support the comprehension of the effects of climate change.

In this session, the entire permafrost community is invited to submit unique advanced remote sensing applications that address evolution and dynamic disturbance processes in permafrost landscapes, both in lowland and mountain regions. We are open to a wide range of remote sensing approaches, including short- and long-term monitoring that makes use of time series analysis, airborne, spaceborne, and machine learning as well as unmanned aerial systems, and is validated from field-based and/or modelling analysis. We also welcome research on landscape disturbances, such as permafrost thaw, active-layer degradation, and talik formation, which affect periglacial landscape processes and the environment.

Keywords: Geomorphology, Landforms, Permafrost Degradation, Remote Sensing

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10B - High Resolution Remote Sensing Applications in Permafrost Studies

Stefano Ponti[1], Benjamin Jones[2], Andreas Kääb[3]

[1]University of Insubria, [2]University of Alaska Fairbanks, [3]University of Oslo

Mapping and modelling of permafrost and surface temperatures have become a widespread and shared aim among research groups to project the climate change effects on regional to hemispherical scale. Conversely, the ground validation dataset is still poor and often related to single temperature profiles in boreholes, not well representative of the local scale variability. Even the CALM experiment is restricted to measurements of nodes, knowing that at the inter-node span, the environmental control on permafrost and active layer might change drastically. Therefore, the increase of validated remotely sensed datasets at very high resolution is of scientific interest both for filling the gap between the in-situ measurements and the hemispheric scale (coarser resolution) in modelling and for reaching the closest assessment to the natural variability of permafrost drivers.

This session embraces studies conducted from ground to air-borne and satellite remote sensing of (1) permafrost thermal state; (2) active layer dynamics; (3) surface energy balance; (4) periglacial processes; (5) their interactions and controls. All the contributions aiming to enhance our understanding of the application of multi-spectral cameras, UASs, self-made sensors, space-borne platforms and validation techniques to permafrost science are welcome.

Keywords: Remote Sensing, UAV, RPAS, Permafrost Modelling, Satellite

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11A - Mining Geotechnics and Reclamation in a Changing Climate

Vincent Boulanger-Martel[1], Pooneh Maghoul[2]

[1]Université du Québec en Abitibi-Témiscamingue, [2]Polytechnique Montréal

There are an increasing number of mining projects being developed in Canada's Arctic regions where continuous permafrost is present. With the development of such mining projects, numerous unique engineering and environmental challenges follow. With respect to geotechnical engineering, mining operations have several critical infrastructures such as tailings dams, tailings, and waste rock storage facilities, which must be designed, operated and reclaimed to ensure optimal mine waste management and minimize environmental risks. The closure of mine waste storage facilities often requires the design and construction of engineered covers which aim to maintain the mine wastes physically and chemically stable.

Such geotechnical infrastructures constructed in continuous permafrost environments require time to freeze-back and reach thermal equilibrium with the natural ground. The aggradation of permafrost conditions within the mine wastes as well as tailings dams and cover systems have the overall beneficial effect of improving their physical stability, reducing water seepage and reducing the potential for the generation and transport of contaminants into the receiving environment. In this context, climate change represents the largest source of uncertainty with respect to the long-term geo-environmental behaviour and performance of mine waste storage facilities and their reclamation strategies.

This session welcomes contributions dealing with the thermal, hydrogeological, and geotechnical behaviour of operating and reclaimed mine waste storage facilities in permafrost regions. Studies focussing on the impact of climate change, extreme events and risk mitigation in mining geotechnics and reclamation are encouraged.

Keywords: Engineered Covers, Tailings Storage Facilities, Waste Rock Piles, Mining Geotechnical Engineering

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Waste Containment in Permafrost

11B - Contaminant Behaviour and Nuclear Waste Safety in Transitional Climates

Wolfram Rühaak[1, 2], Mahsa Malmir[3], Marja Vuorio[4]

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Cryogenic processes play a crucial role in the safety assessments of long-term nuclear waste repositories and the transport of other contaminants. Within the timespan for which a safe enclosure of the waste must be ensured, which depending on the regulations, could be more than one million years, numerous climate cooling and warming cycles must be considered. The presence, aggradation, and degradation of permafrost and ice sheets can exert extensive pressure gradients and changes in pathways that impact the transport of radionuclides and other contaminants from the geosphere into the biosphere. Present-day permafrost regions currently serve as analogues for repository sites in a future cold climate, where processes that influence the migration of contaminants can be studied. Numerical modelling approaches of freezing and thawing of soil and rocks are constantly being improved, as the interplay between different processes and parameters becomes better understood.

In this session, we invite studies on any cold region processes that may impact contaminant transport, including but not limited to the context of long-term safety of nuclear waste repositories. We welcome contributions from numerical modelling, laboratory, field experiments, case studies and assessments in areas including (1) contaminant pathways between glacial, subglacial, and periglacial groundwater systems and surface systems; (2) impact of climatic transitions on contaminant transport; (3) links to ecological systems and biogeochemical transport processes; (4) effects of freezing and thawing of porous and fractured media (e.g. volume changes, cryosuction); (5) fault zone hydrogeology and the role of permafrost formation and thaw; (6) talik forming under freezing and thawing conditions.

Keywords: Nuclear Waste, Cryo-Hydrogeology, Climate Transition, Permafrost Transition

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12A - Monitoring Techniques and Feedback of Snow, Vegetation, and Permafrost

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Snow, vegetation, and permafrost are intricately linked across the cold regions of the globe. Snow protects the ground during the winter and provides insulation for the permafrost, which guards against cold temperatures from penetrating deep into the soils. Vegetation changes, including shrub expansion, are observed, and linked to increases in snow depth, redistribution of the snowpack, and soil moisture changes. However, the dynamic nature of snow and vegetation mean that these interactions could shift with potential for large climate impacts. While the interactions among snow-dominated landscapes and permafrost are abundant, research efforts linking these disparate fields remain sparse.

Part of the challenge is the paucity of accurate distributed snow measurements and model results. Single-point and remote sensing data collection campaigns are limited in their range and/or resolution in space and time. Meanwhile, recent in situ field- and watershed-scale observations using dense sensor deployments have captured multi-scale transformations of permafrost. Such observations create opportunities to test hypotheses and numerical models.

In this session, we invite papers on snow, vegetation, and permafrost interactions—including advancements in remote sensing and monitoring technologies of such interactions--within cold regions across the globe with particular emphasis on the impacts to the hydrologic cycle and climate change effects. We also encourage contributions on novel advances in the field of in situ sensor technology observing the evolution of permafrost systems.

Keywords: Climate Impact, Snow, Vegetation

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12B - Exploring the Roles of Ground Ice on Permafrost Dynamics

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Ground ice is one of the main components of permafrost and is often present in excess of the soil's porosity. It is a critical parameter in the permafrost thermal regime due to (1) its high thermal conductivity and latent heat of fusion; (2) dictating thaw settlement potential and therefore thermokarst processes; (3) affecting geotechnical properties to build infrastructure; (4) is an important characteristic to reconstruct climatic conditions and sediment deposition; and (5) plays a central role in periglacial landscape evolution in general. Despite its significance, means of measuring and mapping ground ice accurately remain limited, and its impacts on permafrost landscape dynamics are understudied. With predictions pointing to a warmer, wetter/drier Arctic, it is becoming increasingly important to have a good characterization of ground ice distribution as well as of the processes relating to ground ice formation and melting to better understand the areas that will be most affected.

This session invites speakers to address subjects pertaining (but not limited) to: (1) ground ice characterization (e.g., cryostratigraphic description of the ice, vertical ice distribution, microtomodensitometry (CT-scan)); (2) distribution and detection techniques of ground ice using geophysics (e.g., ERT, GPR, seismic), satellite/airborne remote sensing (e.g., multispectral imagery, LiDAR, UAV), and permafrost drilling and coring; (3) the biogeochemical properties of ground ice (e.g., DOC, major ions, isotopes, etc.) and their impacts on permafrost aggradation/degradation and hydrology; (4) the thermal properties of ground ice and its impact on the permafrost thermal regime; and (5) thermokarst processes (e.g., ground ice related mass movements) and how they affect landscape evolution.

Keywords: Ground Ice, Cryostratigraphy, Thermokarst, Thermal Regime

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12C - Sentinels of Permafrost Thaw Across Natural and Human Systems

Frédéric Bouchard[1], Ylva Sjöberg[2], Sarah Ollivier[3]

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Permafrost thawing - from localized and abrupt to gradual and widespread - impacts Arctic hydrology and the mobilization of mineral and organic materials, from formerly frozen soils to terrestrial ecosystems and surface water bodies. Mineral and organic components interact along this lateral continuum from soils to aquatic systems, affecting biogeochemical cycles with strong spatial and temporal heterogeneities. These climate-induced impacts of permafrost thaw also affect the quality and quantity of food and water resources at the core of Northern Indigenous culture and livelihoods, including drinking water, hunting, and fishing.

This session aims to foster a holistic perspective on the multifaceted impacts of permafrost thawing on natural and human systems across different spatial and temporal scales, thereby developing a set of indicators (or 'sentinels') of the vulnerability of soils, surface- and groundwater. We welcome contributions from all fields of physical and engineering sciences to approaches integrating Indigenous Traditional Knowledge, and from field-based studies to modelling efforts and monitoring programs. Interdisciplinary and transdisciplinary perspectives on permafrost as a part of sociocultural-ecological systems are especially valued contributions to the session.

Keywords: Thermokarst, Soils, Water Resources, Sentinels

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12D - Multiscale Observations of Permafrost Landscape Dynamics

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Permafrost landscapes are continually shaped and reshaped by interdependent geomorphic, hydrological, and ecological processes. In light of changing climatic conditions and intensifying disturbance regimes, increased rates of permafrost landscape changes have been reported. However, the spatial distribution, drivers, and controls on these thaw processes remain poorly constrained across spatial and temporal scales. Multiscale observations of dynamic permafrost processes from plot to landscape scales are critical for determining the spatial heterogeneity, scale dependence, and interactions and feedbacks with the water, energy, nutrient, sediment, and carbon cycles.

In this session, we aim to advance permafrost research through novel multiscale observational techniques and analyses. We solicit contributions that (1) quantify geomorphic (e.g., thermokarst, coastal erosion), hydrological (e.g., wetland dynamics) and ecological (e.g., postfire succession, shrub expansion) processes and their interactions; (2) elucidate the drivers, controls and consequences of permafrost landscape change through model-data integration; and/or (3) establish new sensing modalities or analysis techniques that bridge spatiotemporal scales.

Keywords: Land Surface Processes, Ecosystem Dynamics, Periglacial Processes

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13A - Permafrost Thaw, Change and Adaptation

TBA (ICOP2024 TPC temporarily)

Open session for contributions relating to permafrost thaw, change and adaptation.

Keywords:

Contact: Technical Program Committee: ICOP2024@canadianpermafrostassociation.ca

13B - Uncanny Geocryological Matters and Loose Ends Engineering

TBA (ICOP2024 TPC temporarily)

Open session for a submission that does not quite have the right fit in any other session at the moment. Place it here and we will help find it the right home!

Keywords:

Contact: Technical Program Committee: ICOP2024@canadianpermafrostassociation.ca