The Permafrost Monthly Alert (PMA) Program: Informing Engineers, Scientists, Educators, and the Public of Current Permafrost Literature

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The Permafrost Monthly Alert (PMA) Program is a bibliographic compilation of recently published and newly archived permafrost literature that is brought to the public every month. The PMA allows its users – including permafrost engineers, scientists, educators, and the public– to have one location for abstracts and links to the most recent national and international additions to permafrost studies, and at the same time access to the one-stop search of the world permafrost literature dating back to the early 1900s.

References are compiled by the American Geosciences Institute (AGI) which hosts databases including GeoRef and COLD. Monthly accessions are compiled and uploaded to the AGI publicly available database, COLD, which contains over 33,500 recent and historical permafrost references. Currently, the ten-year PMA collection (2012-June 2021), available on the USPA website, includes 113 monthly and special updates containing approximately 8600 citations. Average annual usage of the PMA acquisitions exceeded 11,700 inquiries (views by readers) for 2018 through 2020, and since its inception in 2012 is over 89,000 inquiries.

Our presentation provides results of the recently developed Python code, titled “PMA Query”, that analyzes each PMA in order to better understand trends in the permafrost literature. The script collects information on the sources and types of references. In addition, it has a graphical user interface (GUI) and is searchable for any word of interest. Key findings from our analysis show that the majority of publications are sourced from conference papers and abstracts (5285 references) and journals (3061 references). Of these conferences, recent AGU Fall Meetings (1549 references), proceedings of the International Conference on Permafrost (1400 references), and recent EGU Annual Conferences (565 references) have been the top three sources. For journals, the top five represented are Permafrost and Periglacial Processes (213 references), The Cryosphere (138 references), Cold Regions Science and Technology (102 references), Journal of Geophysical Research: Biogeosciences (98 references), and Geomorphology (95 references). Prevalent permafrost terms such as carbon (in 994 references) and methane (in 335 references) have been mentioned more frequently in the past five years. Details are provided in the conference presentation.

Enhancing STEM education and soil monitoring with a durable DIY low-cost soil temperature data logger

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Many STEM fields rely on automated data logging systems to measure and understanding environmental change. However, commercially produced devices are often costly and users often struggle with troubleshooting when these devices malfunction. Here we provide a two-pronged solution to this problem by designing a low-cost open-source “Do-It-Yourself [DIY]” temperature data logger and producing a series of online videos that allow even novice users to construct and deploy these devices in the field. The DIY data logger was designed around the Arduino platform allowing users to tap into a vast pre-existing collection of educational materials. In comparison to other DIY data loggers, our design is intended to be robust and therefore uses a printed circuit board. The online video series provides a step-by-step tutorial on how to order equipment, assemble, program, and deploy the soil temperature data loggers. We tested the efficacy of the tutorials on college students with minimal experience in electronics and tested the durability of the data loggers by deploying them in permafrost soils on the North Slope of Alaska. Data loggers built by novice users performed well in the field and were able to monitor soil temperature for three years without a battery replacement. Our soil temperature data logger system could easily be scaled to provide greater spatial coverage at an extremely low price point when compared to commercial systems. The low cost and effectiveness of these data loggers position them as a tool that can both increase access to soil temperature monitoring across the globe and train the next generation of scientists and engineers.

Engage the Public in Science and Embrace Future Change with Human-Centric Stories, Art, and Imaginings

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Current human-interest stories with interwoven scientific data effectively engage the public in environmental issues that do not yet directly affect them. Science fiction with artistically rendered futuristic scenarios unleashes the imagination and is a lens to explore and plan for the technological, social, and cultural aspects of transitioning to clean energy. Cultures with strong oral history traditions use stories to record history, pass on environmental lessons, and prepare for future change. Stories, art, and emotional connection are effective ways to engage people, disseminate scientific information, and prepare ourselves for future transitions. Ever-increasing amounts of scientific data do little to engage the public and can lead to disconnected helplessness. To share the relevance of arctic change effectively and make information accessible to enable discovery and public knowledge-generation, scientists should start with art and narratives, real and imagined. We explore these methods by tracing the specific histories of two Inupiaq homes on Alaska's North Slope that are threatened by erosion and permafrost degradation. We use human-centric narratives interspersed with data that illustrate ecosystem processes. Next, we report on a collaborative, interdisciplinary workshop and book project (NREL and Arizona State University) that is creating narratives of hope and visions for the future through inspiring art, short stories, and essays. We discuss the surprising potential of cli-fi and the research behind emotion/imagination-driven engagement in science and futurescapes. We describe various methods that help people visualize their future well-being by creating emotional connections to their future selves and we explore opportunities to spread those methods.

Alaska Voices: Building Bridges of Knowledge Through Shared Conversations

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Dr. Bob Bolton and I co-founded Alaska Voices (originally a science-based storytelling project) after we attended the American Geophysical Union meeting. I felt overwhelmed at the conference and just wanted someone to tell me a story about their research. We partnered with StoryCorps – the leading organization in collecting and sharing stories as conversations between two people – and received funding from the Alaska Climate Science and Adaptation Center. Our year-long StoryCorps partnership included training 12 story-recording facilitators and archiving conversations with StoryCorps and the Library of Congress. While the initial idea was to focus on conversations between scientists about science, we decided to be more inclusive of people with different perspectives and experiences of the Alaskan environment, including Alaska Indigenous peoples, local community members, policy makers, and students. To date, we have recorded over 60 conversations that include: findings from science collaborations, experiences of women in science, different perspectives on changes in the Alaskan landscape, climate change and policy, and some Indigenous perspectives. Consent and trust are at the core of Alaska Voices, wherein a participant may retract a conversation at any point. The conversations were edited from 40 minutes to 5-8 minutes by a culturally sensitive audio producer (Kelsey Skonberg) who collaborated with the participants in the editing process. The stories have been shared via our website (www.alaskavoices.org), other podcasts, and a 6-episode series on local public radio. The stories have reached national and international audiences. Through Alaska Voices, we have observed the power of storytelling and conversation for learning about different scientific findings in an engaging way and different perspectives on environmental change, while experiencing each other as whole people. Stories are powerful for the storytellers, the facilitator, and the listener. Conversation and storytelling allow space for nuance, connection, and inclusivity that is often lost in traditional scientific communication.

Towards a Standardization of Soil Cryogenic Structure and Cryostructure Terminology for the Field Description of Permafrost-Affected Soils

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Freeze-thaw processes and ice segregation in permafrost-affected soils result in unique structures of soil aggregates (cryogenic soil structure) and ice (cryostructures). These morphology of these soil and ice structures together give important clues to soil formation, hydrology, and ecosystem function. However, in the soil science literature and USDA standardized soil field sampling procedures there is yet to emerge a standardized scheme for describing both soil cryogenic structures and cryostructures in individual horizons which can be utilized in the morphological description of permafrost-affected soils. Here, we outline one potential standardized scheme for describing both cryogenic soil structures and cryostructures for use in soil morphological descriptions, and propose rules for standardizing the unification of these descriptions that aligns with both the cryostratigraphic literature and established standards for the field description and sampling of soils.

Towards a revised version of the Glossary of Permafrost and Related Ground-Ice Terms

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The Glossary of Permafrost and Related Ground-Ice Terms has been an essential reference for the Canadian and international permafrost community for more than three decades. It was authored by the Permafrost Subcommittee of the Associate Committee on Geotechnical Research of the National Research Council of Canada and first published in 1988. The IPA's Multi-language Glossary, virtually unchanged with regard to terminology, was compiled in 1998 and revised in 2005 by Robert van Everdingen. An edited version of the latter is available on-line as part of the Cryosphere Glossary at the US National Snow and Ice Data Center.

The Permafrost Terminology Action Group (PTAG) of the Canadian Permafrost Association was formed in January 2021 to update the Glossary. Most of the 400 existing entries are based on knowledge and usage from 1988 or earlier. Using a consensus-based approach, these entries and their associated definitions, comments and references are being systematically reviewed in relation to current use and their suitability for controlled vocabularies and ontologies. Significant advances, reflecting the explosive growth in permafrost research over the past 30-40 years as well as the increasing diversity of scientific disciplines involved, underline the need for a revision. An illustrated plain-language version, focussing on key terms, will also be developed for use in education and by non-specialists and the media.

The members of PTAG are reviewing the formulation of each term, its definition, the associated comment and references. PTAG is committed to operating transparently and all changes will be traceable. Certain terms may be removed because they have been superseded or are formulated as phrases, whereas more than 40 new terms are under consideration. Suggestions for additional permafrost-related entries or for revisions to existing terms are welcome. Over the next three years, proposed revisions and their justifications will be disseminated for comment to the permafrost community and to those in cognate disciplines with the goal of obtaining the widest possible acceptance. The revised version of the Glossary and the plain-language version are planned for completion prior to the International Conference on Permafrost to be held in Whitehorse in 2024.

An interactive website to visualize and communicate how the Arctic is changing

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The Arctic, comprising the tundra and boreal biomes, is warming more rapidly than anywhere else on the planet, prompting scientific endeavors to increase in recent years. As the body of scientific knowledge continues to grow, so too does the challenge of communicating these findings. This is of particular concern because changes in the Arctic will have implications on local, regional, and global scales. Despite far-reaching implications, most people who live in lower latitudes are unaware of the state of the Arctic or how rapidly it is changing. To increase awareness of the rapidly changing Arctic, scientific information needs to be shared beyond academic publications into compelling stories that resonate with broader audiences.To this end, we created a science communication and data visualization website using the Esri Hub platform. We combined compelling photos of the Arctic with informative maps and statistics to showcase how climate change is affecting Arctic ecosystems, permafrost, fires, and carbon. We include interactive mapping applications that encourage users to engage with the data more effectively by, for example, comparing the rate of warming in their location to that in the Arctic region.The website is designed to engage different types of audiences, including the general public, students, policy-makers, and media. In addition to the clear language and emphasis on visuals that will resonate with the general public, we include maps with long-term monitoring of key variables for geospatial specialists and other scientists, and distill complex information into stories that are relevant to policy-makers. In the future, we plan to expand our community and data availability components to include two-way information sharing and comprehensive data sets. Our site provides broad audiences with engaging information and helps them to better understand the Arctic and the local to global impacts of climate change in the north.

Polar Explorer - An Immersive Virtual Learning Environment that Teaches Students about the Impacts of Thawing Permafrost on Society

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Scientists at Northern Arizona University, Arizona State University, the University of Arizona, and the University of Colorado at Boulder recently received funding from the National Science Foundation to develop a new digital learning environment called Polar Explorer. Through innovative learning design and virtual reality technologies, Polar Explorer will provide a novel and transformative approach for improving STEM education; one that will cultivate a sense of curiosity and connection-to-place and will generate new knowledge about STEM teaching and learning. Polar Explorer will consist of a suite of Learning Experiences (LXs) built around interactive Virtual Field Trips (iVFTs), connected via a high-resolution rendered landscape generated from real Arctic terrain data. Seven place-based LXs will teach students about permafrost dynamics, indigenous perspectives on changing landscapes, and impacts of permafrost thaw on infrastructure, climate, and human health. Students will have autonomy in choosing their learning path through the LXs, which will leverage virtual reality technology, an engaging narrative, real scientists, and real-world data and places to provide context to student learning. An intelligent tutoring system will individualize the student experience and help address conceptual gaps in knowledge. Polar Explorer's iVFTs will effectively promote active, inquiry-based learning and resolve the substantial accessibility challenges inherent to polar science. It is predicted that students will: (1) increase their polar science disciplinary knowledge; (2) learn to recognize and work across multiple scales; and (3) improve their comprehension of transdisciplinary connections in polar science. Polar Explorer will run on HTML5 and target students in critical undergraduate introductory STEM courses, such as geology, earth science, climate, and biology. This project will also provide much needed metrics on the degree to which iVFTs and adaptive digital learning environments, and the associated approach to learning design, promote STEM learning.