Permafrost Action Team: Short statement for ASSW 2016

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Overview: The Arctic is warming rapidly (IPCC, 2013) causing permafrost to thaw and exposing massive stores of organic matter to microbial decomposition (Schuur *et al.*, 2015). Degradation of near-surface permafrost (perennially frozen ground) caused by modern climate change is adversely affecting human infrastructure, altering arctic ecosystem structure and function, changing the surface energy balance, and has the potential to dramatically impact arctic hydrological processes and increase greenhouse gas emissions. The Permafrost Action Team (AT) as one component of the Study of Environmental Arctic Change (SEARCH) addresses critically important knowledge gaps about the causes and consequences of degradation and loss of near-surface permafrost. The Permafrost AT objectives are: 1) improve observation and prediction of the nature, timing, and location of permafrost thaw; 2) improve prediction of how degradation of near-surface permafrost will influence the dynamics of the Arctic landscape; 3) improve prediction of how permafrost degradation will influence fish, wildlife, and human communities. The planned activities span the broad context of permafrost research, including changes in permafrost temperature, extent, and landscape evolution. In addition the Permafrost AT is aimed at facilitating connections between new knowledge generation and potential stakeholders including community leaders, industries, nongovernmental organizations, and governmental decision makers. There is growing realization of the strong interactions between degradation of near-surface permafrost the dynamics of ecosystems, and that these interactions together influence local and global environmental, economic, and social systems.

Science Synthesis: The Permafrost Action Team is focusing its efforts to develop new knowledge about the impacts of permafrost degradation through research synthesis. This framework of synthesis builds on activities of the Permafrost Carbon Network (PCN) (www.permafrostcarbon.org), which is now a subcomponent of the Permafrost AT. This network is an international scientific effort that links biological carbon cycle research with networks in the physical sciences focused on the thermal state of permafrost. Approximately 1330-1580 billion tons of soil carbon is stored in soils of the northern circumpolar permafrost zone, about twice as much carbon as currently contained in the atmosphere (Hugelius *et al.*, 2014, Schuur *et al.*, 2015). Sustained and substantial carbon release from the Arctic is a wildcard with the potential to alter the future trajectory of climate change. While modern climate change is largely due to human activities, the future path also depends on the responses of terrestrial and ocean systems. A key societal question is whether there are *tipping points*, global carbon cycle surprises that will make climate change effects such as sea-level rise, extreme weather, droughts, and impacts on agriculture occur faster than currently projected by models. Recently, attention has been drawn to permafrost thaw as a mechanism that could move significant quantities of Arctic carbon into the atmosphere in response to a changing climate. This vulnerable carbon pool

has been identified to be susceptible to both the direct and indirect effects of climate change, but the level of risk and timescale of change is currently highly uncertain. The critical question centers on how fast this process will occur. Abrupt releases of methane forecast to cause trillions of dollars of economic damage to global society contrast with predictions of slower, sustained carbon gas release that would give society more time to adapt

Yet, the picture is complicated by limited information on the quantity and form of carbon sequestered in permafrost, by inadequate knowledge of cryospheric biogeochemistry, and by insufficient understanding of the interactions between the terrestrial cryosphere, hydrology and vegetation in northern high latitudes in a warming climate. The activities within the PCN to address these knowledge gaps and to promote synthesis and outreach include: 1) organization of an interrelated sequence of meetings and working groups designed to synthesize existing permafrost carbon research, and 2) formation of a consortium of interconnected researchers to disseminate synthesis results about permafrost carbon to other scientific networks and activities. There are five working groups organized around the linked themes of Carbon Pools, Carbon Quality, Thermokarst, Anaerobic/Aerobic Issues, and Upscaling & Modeling Integration. These working groups are producing synthesis products both within and among individual groups. Over the last five years, the network has produced new knowledge through multiple synthesis products within each of these working groups (e.g. Harden *et al.*, 2012, Hugelius *et al.*, 2014, Hugelius *et al.*, 2013, Olefeldt *et al.*, 2013, Schädel *et al.*, 2014, Strauss *et al.*, 2013, Treat *et al.*, 2015). Individual synthesis products have then been linked in crosscutting activities designed to address the highest level question about the permafrost carbon feedback to climate change (Schuur *et al.*, 2015). The current estimated amount of carbon vulnerable to release to the atmosphere in a warming climate is between 5-15% of the 1330-1580 Pg carbon pool, which is of similar magnitude to other historically important biospheric carbon sources. This synthesis also concluded that carbon release is likely to be a gradual, long-lasting process over many decades rather than an abrupt pulse.

Science synthesis produced by the PCN, in turn, has led to publications aimed at broader audiences designed to bring information to a wide array of stakeholders. Activities and people within this network have informed, for example, the Intergovernmental Panel on Climate Change Working Group I Fifth Assessment 'Chapter 6: Carbon and Biogeochemical Cycles' (Ciais *et al.*, 2013) and a United Nations Environmental Program report 'Policy implications of warming permafrost' (Schaefer *et al.*, 2012), among other documents. These types of articles that are designed to reach broader audiences have been made possible with the integration and synthesis of individual primary science publications, the core activity of the network. In turn, the knowledge within these publications has been widely disseminated to the public by the media through interviews by PCN scientists. The sheer size of the Arctic carbon pool, the rapid changes observed in the permafrost region, and the potential tipping-point impacts on both local and global stakeholders warrant focused attention on these remote landscapes. This process of knowledge delivery and use was facilitated by the networking efforts of the PCN to bring the best science available on this topic to a wide range of stakeholders.

This example of the PCN that is focused on the global climate impacts of thawing permafrost was the first step, and an ongoing effort, of the Permafrost AT. The next goal is to enable this science synthesis and networking approach for understanding local impacts of changing permafrost. Knowledge of the impacts of changing permafrost on wildlife, ecosystems

and the services they provide to human society is critical for residents of the permafrost zone. The Permafrost AT will be making use of data sets from the two components of the Global Terrestrial Network for Permafrost (GTN-P), the Thermal State of Permafrost (TSP) and the Circumpolar Active Layer Monitoring (CALM) initiative in synthesis studies. The carbon cycle synthesis of the Permafrost AT is already promoting the use of these data sets in the benchmarking of coupled carbon-permafrost-climate models, and there is great potential for these data sets to contribute to syntheses involving infrastructure and ecosystem services.

The Permafrost AT has developed a steering committee of scientists and other stakeholders in the realm of local and global impacts of permafrost thaw with the intent of replicating the PCN science synthesis and network approach to focus on other critical aspects of changing permafrost. Individuals with interest in these topics are invited to join this process aimed at creating knowledge and finding solutions for impacts related to changing permafrost in a warmer world.

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