Project acronym: PERMAFIRE

Project title: Long-term Changes in the Biogeochemistry of Permafrost Forests as a Result of Fire

Project leader: Jukka Pumpanen, University of Eastern Finland, Finland

Discipline: Earth Sciences & Environment: Global change & Climate observation

Station(s): Western Arctic Research Centre (WARC) (Canada)

Currently, there is great uncertainty in predicting future climate because Earth system models cannot predict soil carbon (C) dynamics reliably. Permafrost thawing threatens to release vast amounts of C from about 24%, 23 million km2, of the land area in the Northern Hemisphere, but exact interactions between ecosystem disturbances, permafrost thawing, soil organic matter (SOM) decomposition and vegetation productivity are not known.

About 1% of boreal forests, which lie largely on permafrost, burn each year and the amount of fires is predicted to increase in the future due to climate change. This could lead to increased warming of soil surface and deeper thawing or disintegration of permafrost resulting in an increase in the thickness of biologically active soil layer containing large reserves of easily decomposable C and nitrogen (N). The acceleration of biological processes such as decomposition may lead to substantial changes in CO2, CH4 and N2O greenhouse gas (GHG) fluxes. While these processes are, somehow, established for tundra, there are small amounts of studies on how the disturbances of forests on permafrost affect the C cycle. In this project, we 1) study what is the effect of forest fires on permafrost thawing and its consequences on soil C pools and greenhouse gas (GHG) fluxes in the subarctic boreal forests and 2) quantify how forest fires influence the quantity and quality of SOM as well as soil physical conditions through alterations of heat balance and 3) determine the effect of forest fires on the bioavailability of DOM and associated GHG emissions in water.

This is done by collecting temperature data with loggers installed in forest stands exposed to wildfires along with the Dempster highway. The northernmost area (site burnt in 1969) is in the Northwest Territories in Canada between Inuvik and Tsiigehtchic about 60 km south of Inuvik. The southernmost areas (sites burnt in 2012 and 1990) are in Yukon 60 km south of Eagle

plains.

During the field campaign we measured GHG fluxes at the sites using portable chambers and collected soil water samples for analyzing the amount and quality of dissolved organic matter (DOM). The soil water will be collected using suction samplers installed in soil. The GHG samples collected during the field campaign are analyzed in Finland using gas chromatograph and the DOM quality in water samples by using FT-ICR-MS and specific UV absorbance. Soil samples and vegetation samples collected during the measurement campaign were prepared at the Aurora Research Institute in Inuvik for shipping to Finland.

The PERMAFIRE team member, PhD student Taija Saarela is studying how the quality and microbial degradability of terrestrially derived dissolved organic matter (DOM) vary among catchments with different land cover, and how these processes further regulate the greenhouse gas fluxes from northern lakes and streams. In June 2019, she joined the field campaign measuring the terrestrial and lacustrine greenhouse gas fluxes in Trail Valley Creek, Canadian Arctic tundra. The field campaign was run by the University of Montreal. Another team member, Ms Xuan Zhoul is studying in her PhD thesis how forest fires affect soil microbial community composition and its function. She is also preparing a process model describing the changes in the microbial community function after fire based on the data collected at the fire chronosequence at the Dempster highway.