Soil organic carbon along a geothermal gradient in North-West Canada

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Introduction

Climate change will lead to warming of soils, which affects soils globally, but has the strongest impact on soils in high latitudes, where highest temperature increases are expected and soils are permanently frozen (Biskaborn et al. 2019). Warming leads to increased microbial activity and thus soil carbon loss, inducing a positive feedback loop. Predictions about the responses of soil organic carbon (SOC) to warming are difficult and uncertain as there is a lack of long-term warming experiments. This study uses a geothermal gradient, produced by a natural hot spring, in a Canadian forest ecosystem, to explore the long-term impact of soil warming on the SOC-stock and –quality.

Study site and methodology

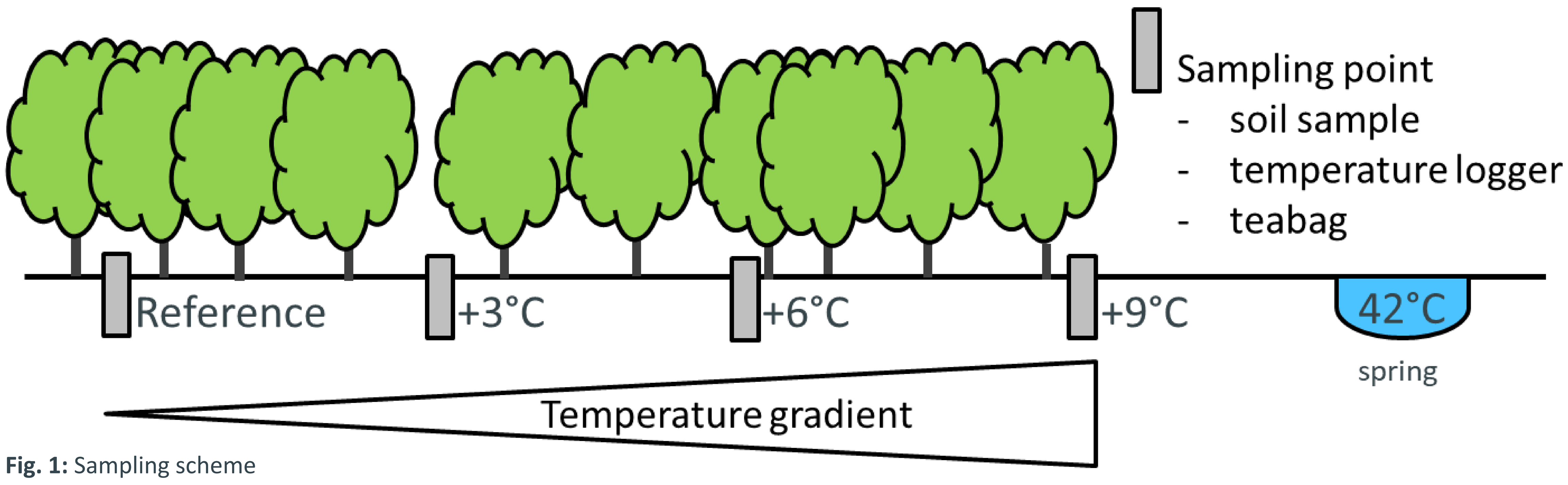

Fig. 1: Sampling scheme

The study site is located in the southwestern Yukon Territory, west of Whitehorse in the discontinuous permafrost region. At the Takhini Hot springs (60°52'43.9"N, 135°21'30.7"W, http://takhinihotpools.com/), thermal water is reaching the surface with a temperature of 42°C, heating the surrounding soil and produces a natural temperature gradient between the spring and the uninfluenced permafrost. Sampling was done in July 2019 along a transect with four plots of different soil warming intensities. Sampling plots were determined by measuring soil temperature at 50 cm. A corer of 6 cm diameter was used to sample five depth increments (0-10, 10-20, 20-40, 40-60 and 60-80cm) where possible. Additionally, teabags and temperature loggers where buried in 10 and 50 cm depth and will be sampled after one year. The soil samples where fractionated with the method described by ZIMMERMANN et al. 2007, slightly modified. In brief, 30g sample material are first wet sieved with a 63µm sieve. The coarse fraction is mixed with sodiumpolytungstate for density fractionation to gain a light (particulate organic matter, POM) and heavy (sand and stable aggregates, s+a) fraction. The fine fraction gives the silt and clay (s+c) fraction, which is then oxidized with sodiumhypochloride to gain the recalcitrant fraction (rSOC).

Results

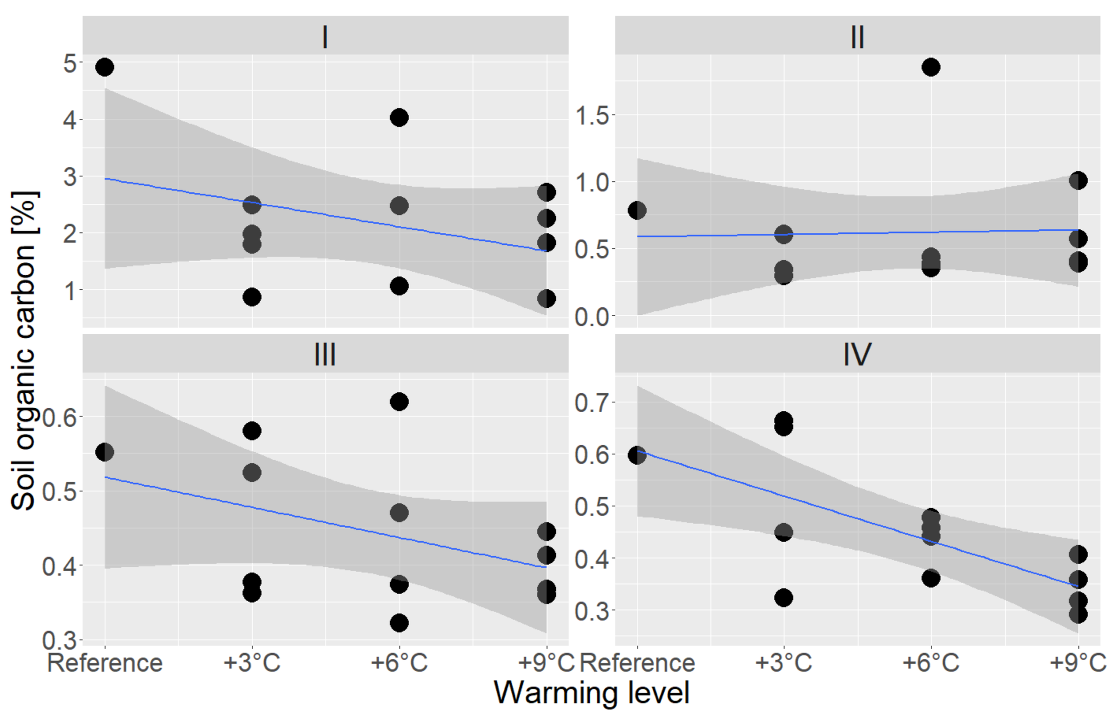

Fig. 2: Total soil organic carbon per depth increment

Preliminary results show that total SOC tends to decrease with increasing temperature (Fig. 2), which fits well with findings from other studies. Higher temperatures lead to an enhanced soil respiration, which results in greater mineraliation rates of organic matter. The total SOC contents decreased with depth, as most of the C input from the surface becomes mineralized before transported in deeper layers. However, temperature sensitivity of SOC appeared to increase with depth, which might be related to the facts that i) the soil is warmed from below and/or ii) enhanced plant growth compensated topsoil losses to some extent. So far, it was not possible to determine the carbon content of the fractions. With increasing temperature, a redistribution of soil mass from the s+a fraction to the s+c fraction can be observed, indicating structural changes induced by SOC loss, especially in the upper depth increments (Fig. 3). With increasing temperature, the POM fraction decreases due to an accelerated mineralisation of fresh organic matter. The contribution of rSOC (not shown) remains stable over all warming stages, indicating that the observed warming has no effect on the enrichment or loss of recalcitrant carbon.

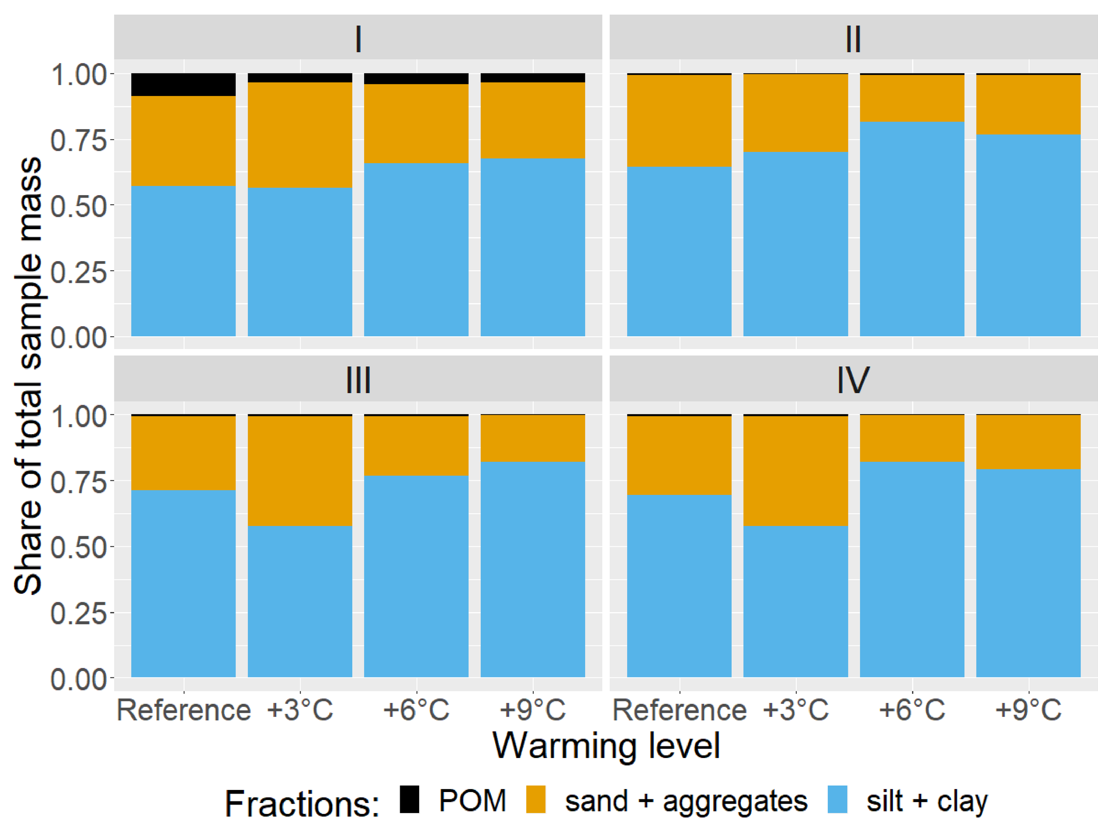

Fig. 3: Mass share of the fractionated samples per depth increments (based on means of the four field replicates)

Outlook

The results give a first glimpse on the fate of SOC in high-latitude soils under chronic warming. The carbon content of the isolated fractions will allow a deeper understanding of SOC in the long term warmed soils. Together with the information of the, so long still buried, teabags and temperature loggers we can give a detailed picture of what happens to SOC when soils are warmed to a certain extend.

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