Effect of repeated freeze-thaw cycles on the fluxes of CO_2 and CH_4 along a soil profile in subarctic tundra

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The Arctic plays a key role in controlling the global carbon cycles, since the permafrost not only stores more than half of the global soil carbon stocks, but also faces more threats from global warming. In particular, soil organic carbon (SOC) pools and fluxes in the northern circumpolar permafrost regions exposed to repeated freeze-thaw cycles are more susceptible to climate change than other regions, leading to an amplified global warming that in turn alters soil physicochemical properties and microbial activities. However, the extent of the effect of repeated freeze-thaw cycles on soil carbon storage and turnover remains controversial. Therefore, we hypothesized that changes in soil temperature regimes due to repeated freeze-thaw cycles would cause a difference in the response of SOC decomposition and the ensuing C fluxes would vary along a soil profile. To test the hypothesis, we designed a batch aerobic incubation in which three replicate soil samples taken from each soil horizon were exposed to repeated freeze-thaw spans. Three soil profile cores were sampled at the sites located in a subarctic tundra region, Alaska (64° 51' N, 163° 42' W), by drilling a 2-m depth core from each of three different locations in July 2014. The sites were chosen based on the data obtained by electrical resistivity tomography. The location of high resistivity had a regolith underlain by the C horizon, while that of low resistivity consisted mainly of the O horizon materials, since the resistivity is indicative of soil water regime and soil component. Each soil profile core was dissected following the soil horizon description and incubated to analyze soil physicochemical properties and measure CO_2 and CH_4 fluxes. Each soil sample was incubated for 3 days under the thawing and the subsequent freezing temperature regimes, and the preset temperatures were -10, 0, 10 and 20 ºC. The pH of the soil was about 5.3, and the O_i sub-horizon had lowest pH of 4.5. The C/N ratio at the end of incubation was higher in the organic soil layers than in the mineral soil layers. Part of our results obviously showed that much more CO_2 was produced as air temperatures increased, while CH_4 emissions were greatest 0 ºC.