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Soil microbial respiration from various microhabitats in Arctic landscape: impact of soil type, environmental conditions and soil age

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Soil respiration is the second largest C flux between atmosphere and terrestrial ecosystems after gross primary production. Carbon dioxide released from soils is thus a major contributor to the atmospheric CO_2 concentration. Despite the global importance, soil respiration and its components (heterotrophic and autotrophic respiration) remain poorly understood and not well constrained fluxes of the terrestrial C cycle. This is particularly true for the Arctic, where huge amounts of the Earth's soil carbon is stored.

Here, we report on heterotrophic soil respiration rates from various Arctic tundra microhabitats measured in situ. The study site was Seida ($67^0 07'$N, $62^0 57'$E, 100 m a.s.l.) which is characterized by typical sub-arctic permafrost landscape which comprises raised, vegetated permafrost peat plateaus, interspersed with spots of bare peat surfaces (peat circles), and upland mineral soils. We used isotope partitioning approach based on differences in natural abundance of 14C between soil and plants to separate sources of soil-respired CO_2. In addition, the tradition trenching approach was employed. Complementary laboratory incubations with homogenized soil were conducted to assess primary decomposability of the soils and to identify age of the CO_2 released and thus get more information on the nature of the sources of respiration. The major aim was to link SMR rates with of soil type, land cover class, soil physic-chemical properties (e.g. water content), soil C stocks and age of soil.

Results show that, despite profound differences in soil characteristics and primary decomposability of organic matter, surface CO_2 fluxes derived from soil microbial respiration rates were rather similar between microhabitats. The only factor which influenced, at least to some extent, the respiration rates was total soil C (and N) stocks in surface soils. There was some evidence for reduced soil-related CO_2 emissions from peatlands, though results were not consistent between the methods applied. It seems that the lower decomposability of peat is largely outweighed by higher C stocks at field conditions. Surprisingly, the bare surfaces (peat circles) with 3500 years old C at the surface exhibited about the largest soil microbial respiration rates among all sites as shown by both methods. This is likely due to the immature status of the peat which was during the bulk of its developmental time protected by permafrost, together with high C-densities. The observation is particularly relevant for decomposition of deeper peat at the permafrost-active layer interface in the large vegetated peat plateaus, where soil material similar to the bare surfaces can be found. The results suggest that the chemical nature and high age of the soil SOC in deep peat does not solely guarantee for resistance to decay. Thus, the study highlights risks for potential re-mobilization of C in deep peat soils following thawing. Soil microbial respiration rates need to be better known when predicting the overall carbon sink/source character of tundra ecosystems in a warming climate.

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