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The effect of permafrost thaw on short- and long-term carbon accumulation in permafrost mires

Carolina Olid (1,2), Jonatan Klaminder (1), Sylvain Monteux (2), Margareta Johansson (3,4), and Ellen Dorrepaal (2)

(1) Department of Ecology and Environmental Science, Umeå University, Umeå, Sweden, (2) Climate Impact Research Centre, Department of Ecology and Environmental Science, Umeå University, Umeå, Sweden, (3) Department of Physical Geography and Ecosystem Science, Lund University, Sweden, (4) Royal Swedish Academy of Science, Stockholm, Sweden

Permafrost stores twice as much carbon (C) as is currently present in the atmosphere. During recent years, warmer temperatures in the Arctic has caused rapid thawing of permafrost, which have dramatically altered permafrost C storage by increasing both microbial decomposition and plant productivity. Although current research focuses on the effects of climate change on these two processes, there are still no scientific consensus about the magnitude or even the direction of future C feedbacks from permafrost ecosystems.

Field manipulation experiments have been widely used during the last decade to improve our knowledge about the net effects of permafrost thaw in the permafrost C storage. However, due to the slow response (decades) of permafrost ecosystems to environmental changes and the short-time nature of these experiments (usually shorter than 5-9 years), there are still concerns when attempting to extrapolate the results to predict long term effects. In addition, measurements are mostly taken exclusively during the summer season, without taking into account inter-annual variability in C fluxes and underestimating microbial activity throughout the cold season. The need to develop a comprehensive understanding of C fluxes over the entire year and at long temporal scales sets the basis of this study.

This study aims to quantify the effects of permafrost thawing in permafrost C fluxes using a 12 years permafrost thaw experiment in northern Sweden. Our aims were to quantify the effect of permafrost thaw in both decomposition and primary production in active layer and newly thawed permafrost, and its implications for the C balance. Based on previous observations, we hypothesized that 1) soil decomposition rates were higher in manipulated thaw plots. However, 2) the observed increase in nutrients availability and the higher presence of vascular plants after thawing stimulate primary production, which compensates to some extent the increased C losses by respiration.

To validate these hypotheses, an empirically based peat development model was applied to peat cores collected from manipulated thaw (n=6) and control (n=6) plots. Short- (decades) and long-(centuries) term C accumulation rates were estimated using a combined 210Pb and 14C chronology. In contrast to previous studies, our approach is long term and allows applying an empirical mass balance to evaluate depth-explicit changes in C inputs, C losses, and net C accumulation rates in response to permafrost thaw. Comparing shallow versus deep soil C does not only reflect short versus long-term C dynamics but also shows how the responses vary depending on different soil conditions. Our goal is to provide insights to better understand permafrost C dynamics to improve theoretical and predictive climate impact models.