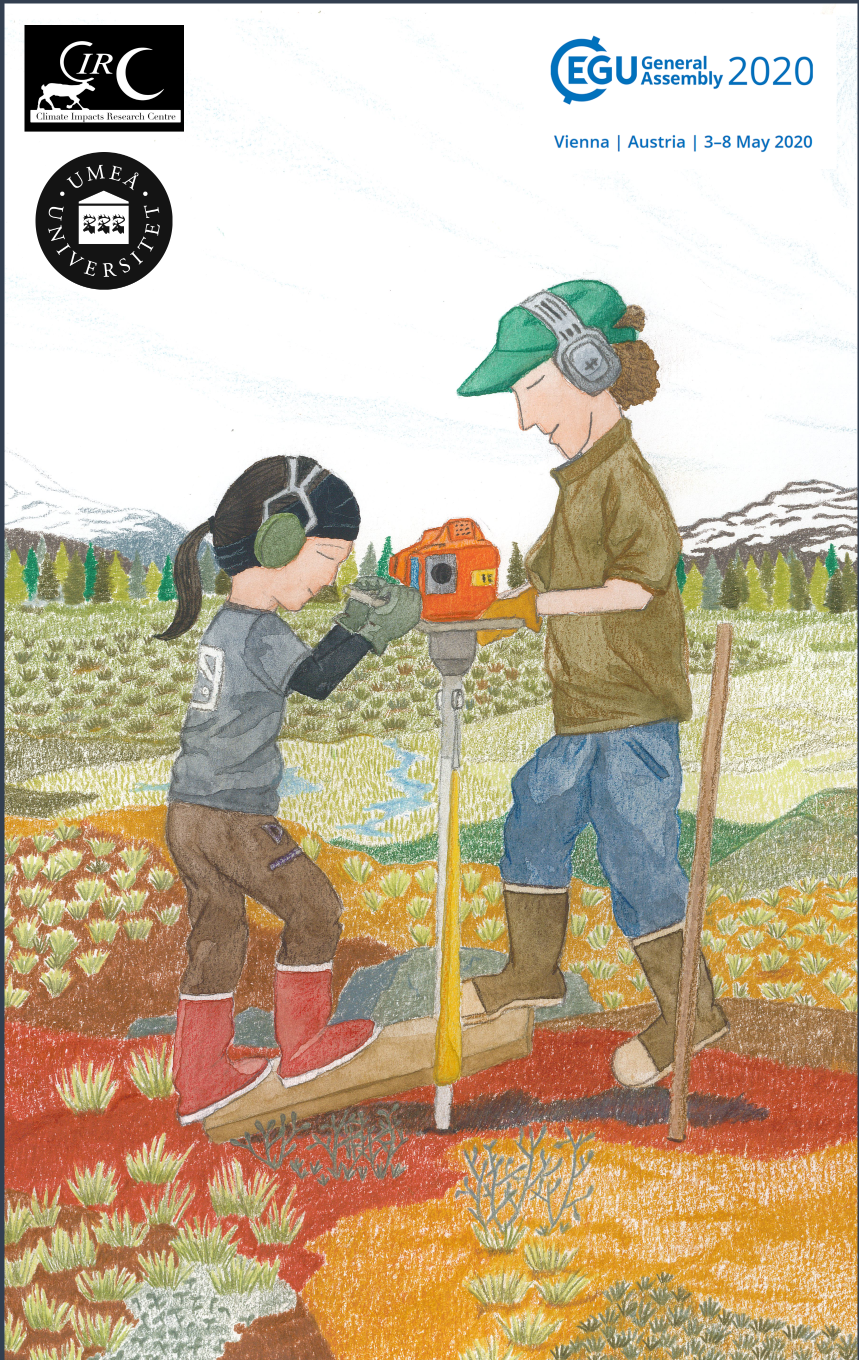


Decade of permafrost thaw in a subarctic palsa mire alters carbon fluxes without affecting net carbon balance

C. Olid*, J. Klaminder, S. Monteux, M. Johansson, E. Dorrepaal

Snow depth increases observed in some artic regions have led to a winter-warming of permafrost-containing peatlands. Permafrost thaw and the temperature-dependent decomposition of previously frozen carbon (C) is currently considered as one of the most important feedbacks between the Artic and the global climate system. However, the magnitude of this feedback remains uncertain because winter effects are rarely integrated and predicted from mechanisms active in both surface (young) and thawing deep (old) peat layers.

Here, we quantified the effects of long-term in situ permafrost thaw in the net C balance of a permafrost-containing peatland subjected to a 10-years snow manipulation experiment. In short, we used a peat age modelling approach to quantify the effect of winter-warming on the net C balance as well as on the underlying changes in surface C inputs and losses along the whole peat continuum. Contrary to our hypothesis, winter-warming did not affect the net C balance regardless of the increased old C losses. This minimum overall effect is due to the strong reduction on the young C losses from the upper active layer associated to the new water saturated conditions and the decline in bryophytes. Our findings highlight the need to incorporate long-term year-round responses in C fluxes when estimating the net effect of winter-warming on permafrost C storage. We also demonstrate that thaw-induced changes in moisture conditions and plant communities are key factors to predicting future climate change feedbacks between the artic soil C pool and the global climate system.

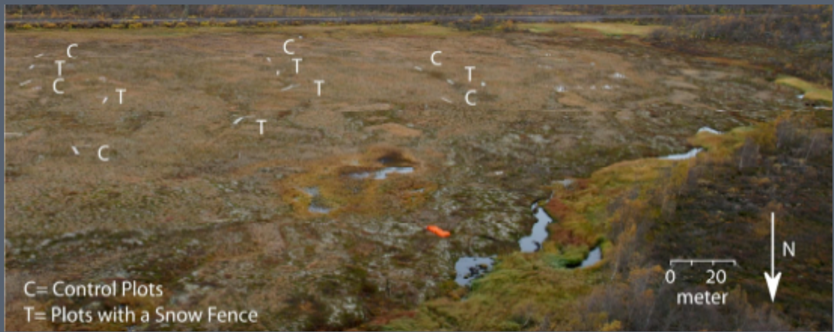
*Carolina Olid
Department of Ecology and Environmental Science, Umeå University, Sweden
Email: carolina.olid@umu.se

OBJECTIVES

- Quantifying primary production and decomposition responses to a decade of permafrost thawing caused by a thicker snow pack.
- Estimate the net effects on the C balance.

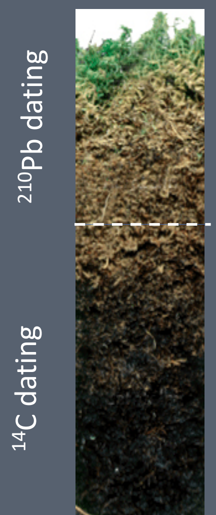
METHODS

- 10 years passive snow addition treatment (winter-warming) in a palsa mire (Abisko, northern Sweden).

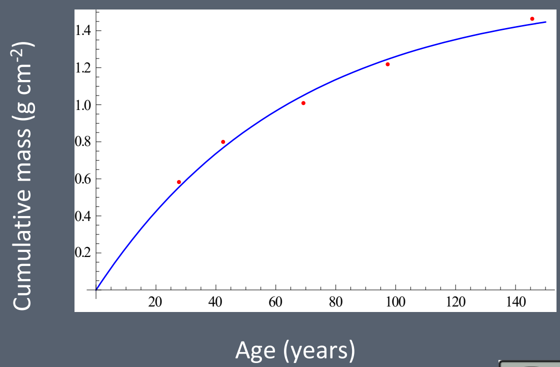


Photos from Johansson et al. (Env Res Lett 2013)

- Peat growth models

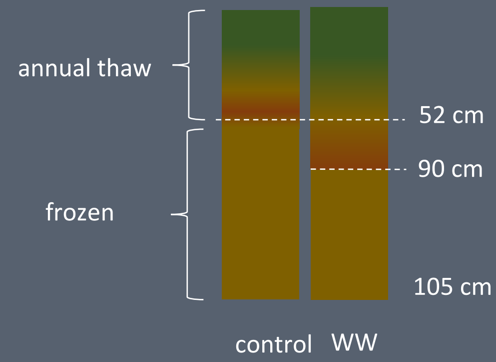


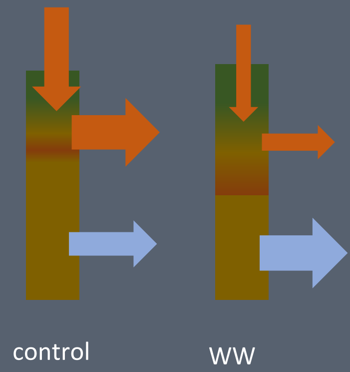
$$m = \frac{p}{k}\left(1 - e^{-kt}\right)$$



RESULTS

Photos from Johansson et al. (Env Res Lett 2013)





- Unexpected decrease in decadal C losses:
  - Warmer soil temperatures during winter.
  - Water-logging conditions.
- 3-fold higher millennial C losses.
  - Deepened active layer.
- Strong decrease in decadal C inputs.
  - Loss of bryophyte cover.
- No effect on the net C balance.

- We demonstrate that the trajectory of the ecosystem C balance requires quantification of all integrating effects (short- and long-term) on young and old C stocks.
- Our age modeeling approach revealed that the overall magnitude of the current permafrost C imbalance depends largely on near-surface hyfrologic conditions and plant cover.