DEEP ICE-RICH PERMAFROST AND ITS CARBON VULNERABILITY

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Arctic landscapes, especially those underlain by permafrost, are threatened by climate warming and may degrade in different ways, including active layer deepening, thermal erosion, and development of thermokarst features. In Siberian and Alaskan late Pleistocene ice-rich Yedoma permafrost, rapid and deep thaw processes cause surface subsidence due to loss of ground ice (Ulrich et al., 2014) and may mobilize deep organic carbon. With thawing, currently freeze-locked organic matter can be remobilized and contribute to the carbon-climate feedback, a process of global significance if formerly inactive, old carbon is re-introduced into the active carbon cycle as greenhouse gases, which accelerate warming and inducing more permafrost thaw and carbon release.

Yedoma permafrost, which is widespread in Siberia and Alaska, is estimated to presently store between 83±12 and 129±30 Gt frozen organic carbon (Strauss et al., 2017). During the last glacial period Yedoma deposits potentially stored about 657 ± 97 Gt (Strauss et al., 2017). Focusing on the estimates for the present and including deposits in degradation features, such as thermokarst lakes and basins, we found ~398 gigatons thaw-susceptible carbon in the Yedoma domain. This is more than 25% of the frozen carbon of the permafrost area, while the Yedoma domain is covering only 7% of the permafrost region.

We suggest that greenhouse gas release from the Yedoma domain is orders of magnitudes lower than current human-caused emissions, but will be a persistent source that increases in the future. Based on incubation experiments, up to 10% of the Yedoma carbon is considered especially decomposable and may be released upon thaw (Schädel et al., 2014). In conclusion, the substantial amount of ground ice in Yedoma makes this type of permafrost deposit highly vulnerable to disturbances such as thermokarst and thermo-erosion processes and as a result, mobilization of permafrost carbon is expected to increase under future climate warming. Our results underline the need of accounting for Yedoma domain carbon stocks, as well as rapid thaw processes like thermokarst, in next generation Earth-System-Models for a more complete representation of the permafrost-carbon feedback.

References:

Schädel, C., Schuur, E.A.G., Bracho, R., Elberling, B., Knoblauch, C., Lee, H., Luo, Y.Q., Shaver, G.R. and Turetsky, M.R., 2014. Circumpolar assessment of permafrost C quality and its vulnerability over time using long-term incubation data. Global Change Biology, 20(2): 641-652, doi:10.1111/gcb.12417.

Strauss, J., Schirrmeister, L., Grosse, G., Fortier, D., Hugelius, G., Knoblauch, C., Romanovsky, V., Schädel, C., Schneider von Deimling, T., Schuur, E.A.G., Shmelev, D., Ulrich, M. and Veremeeva, A., 2017. Deep Yedoma permafrost: A synthesis of depositional characteristics and carbon vulnerability. Earth-Science Reviews, under review.

Ulrich, M., Grosse, G., Strauss, J. and Schirrmeister, L., 2014. Quantifying wedge-ice volumes in Yedoma and thermokarst basin deposits. Permafrost and Periglacial Processes, 25(3): 151–161, doi:10.1002/ppp.1810