Is Arctic Permafrost a Climate Tipping Element? – Potentials for Rapid Permafrost Loss Across Spatial Scales

Jan Nitzbon1, Thomas Schneider von Deimling1, Sarah Chadburn2, Guido Grosse3, Sebastian Laboor1, Hanna Lee3, Norman Julius Steinert4, Simone Maria Stuenzi1, Sebastian Westermann5, and Moritz Langer6

1 Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Germany
2 University of Exeter, UK
3 University of Trondheim, Norway
4 NORCE, Norway
5 University of Oslo, Norway
6 Vrije Universiteit Amsterdam, The Netherlands

Arctic permafrost is yet the largest non-seasonal component of Earth's cryosphere and has been proposed as a climate tipping element. Already today, permafrost thaw and ground ice loss have detrimental consequences for Arctic communities and are affecting the global climate via carbon-cycle-feedbacks. However, it is an open question whether climatic changes drive permafrost loss in a way that gives rise to a tipping point, crossing of which would imply abrupt acceleration of thaw and disproportional unfolding of its impacts.

Here, we address this question by geospatial analyses and a comprehensive literature review of the mechanisms and feedbacks driving permafrost thaw across spatial scales. We find that neither observation-constrained nor model-based projections of permafrost loss provide evidence for the existence of a global-scale tipping point, and instead suggest a quasi-linear response to global warming. We identify a range of processes that drive rapid permafrost thaw and irreversible ground ice loss on a local scale, but these do not accumulate to a non-linear response beyond regional scales.

We emphasize that it is precisely because of this overall linear response, that there is no „safe space“ for Arctic permafrost where its loss could be acceptable. Every additional amount of global warming will proportionally subject additional land areas underlain by permafrost to thaw, implying further local impacts and carbon emissions.