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

Motivation

- Permafrost commonly depicted as a Climate Tippnig Element
- Proposed GMST threshold >5°C suggests safety margin



• No systematic assessment of Climate Tipping Points (CTPs) for Permafrost Loss has been conducted to date

Approach

• Definition of CTP adopted from Armstrong McKay et al., 2022

"Tipping points occur when change in part of the climate system becomes (i) **self-perpetuating** beyond (ii) a warming threshold as a result of asymmetry in the relevant feedbacks, leading to (iii) substantial and widespread Earth system impacts."

- Review of potential permafrost thaw feedback processes in literature published after *Lenton et al.*, 2008
- Geospatial analyses following approach by Chadburn et al., 2017 for sub-regions susceptible to certain processes

Conclusions

- Climate warming causes locally rapid permafrost thaw and irreversible loss of ground ice and carbon
- Localized tipping, but no evidence for global-scale thresholds
- Every amount of warming matters as detrimental consequences of permafrost thaw unfold proportionally

Local thresholds and thaw feedbacks ...

Thermokarst lake formation and growth spur permafrost thaw and ground ice loss in high latitudes



Thermo-erosion causes rapid ground ice loss and export of sediment and also drives drainage of thaw lakes





Microbial heat released during decomposition of organic matter might accelerate thaw rates locally

... accumulating to a globally gradual response!



Permafrost carbon content shows similar gradual decline with GMST increase







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Future research priorities

• Improved representation of **permafrost-climate interactions** in next-generation Earth system models

 Circum-Arctic quantification of ground ice abundance to constrain permafrost thaw rates

• Targeted model intercomparison projects (e.g. TipMip)

