Is Arctic Permafrost a Climate Tipping Element?

Potentials for Rapid Permafrost Loss Across Spatial Scales

Motivation

- Permafrost commonly depicted as a Climate Tipping 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
- Permafrost carbon–climate feedback contributes to global warming but is too weak for self-perpetuation

... accumulating to a globally gradual response!

Permafrost carbon content shows similar gradual decline with GMST increase

References


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)