Assessing and projecting greenhouse gas release from dynamic permafrost degradation

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Permafrost is a large reservoir of frozen soil organic carbon (SOC; about half of all the terrestrial storage). Therefore, its degradation (i.e., thawing) under global warming may lead to a substantial amount of additional greenhouse gas (GHG) release. However, understanding of the processes, geographical distribution of such hazards, and implementation of the relevant processes in the advanced climate models are insufficient yet so that variations in permafrost remains one of the large source of uncertainty in climatic and biogeochemical assessment and projections. Thermokarst, induced by melting of ground ice in ice-rich permafrost, leads to dynamic surface subsidence up to 60 m, which further affects local and regional societies and eco-systems in the Arctic. It can also accelerate a large-scale warming process through a positive feedback between released GHGs (especially methane), atmospheric warming and permafrost degradation. This three-year research project (2-1605, Environment Research and Technology Development Fund of the Ministry of the Environment, Japan) aims to assess and project the impacts of GHG release through dynamic permafrost degradation through in-situ and remote (e.g., satellite and airborn) observations, lab analysis of sampled ice and soil cores, and numerical modeling, by demonstrating the vulnerability distribution and relative impacts between large-scale degradation and such dynamic degradation. Our preliminary laboratory analysis of ice and soil cores sampled in 2016 at the Alaskan and Siberian sites largely underlain by ice-rich permafrost, shows that, although gas volumes trapped in unit mass are more or less homogenous among sites both for ice and soil cores, large variations are found in the methane concentration in the trapped gases, ranging from a few ppm (similar to that of the atmosphere) to hundreds of thousands ppm We will also present our numerical approach to evaluate relative impacts of GHGs released through dynamic permafrost degradations, by implementing conceptual modeling to assess and project distribution and affected amount of ground ice and SOC.

Keywords: Ice-rich permafrost degradation, Methane, climate change, tipping point

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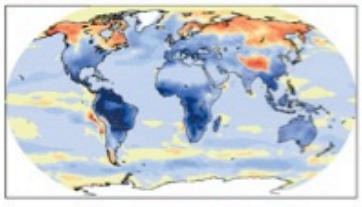
Model improvement, Projections

・Quantification of potential methane release
・Refined future climate projections
etc.

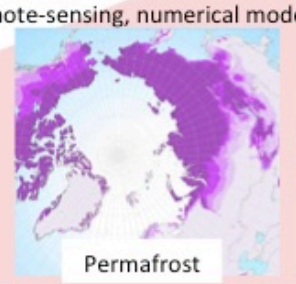


Carbon release [kgC/m^2/K]

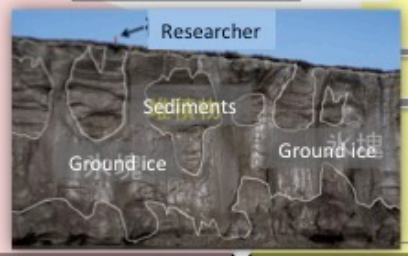
Previous studies
Incremental and kinetic degradation
→Need to incorporate local but dynamic degradation

Sub theme 3 :
Projecting future gas release by integrated land surface model with explicit permafrost dynamics (NIES)

Understanding of vulnerability (remote-sensing, numerical modeling)



Ice-rich permafrost



Sampling and lab-analyses of methane in ice cores

Sub theme 1 :
Assessing dynamic permafrost degradation mechanism and vulnerability (JAMSTEC)

Sub theme 2 :
Quantifying organic carbon content (GHG) in large permafrost ice and sediments (Kitami Inst. of Technology)