Projecting future greenhouse gas release by global land surface-vegetation coupled model with explicit permafrost dynamics

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Permafrost is distributed widely over polar region. Polar region is sensitive to climate change owing to the feedback processes related and ice and snow. Increase in permafrost temperature and thickening of active layer of frozen ground (upper layer of permarfrost where frozen ground thaws in summer and freezes again during the autumn) are already observed. In addition, large-scale and irreversible melting of ice-rich permafrost layers called “Yedoma” and their ground subsidence are also reported in various places. Permafrost contains large amounts of organic carbon that has not been decomposed since last ice age, and thus melting of permafrost cause increase in the atmospheric greenhouse gases and possibly contribute to positive feedback to global warming. However, considerable uncertainty remains in the possible effects of permafrost melting on future climate change because global distribution of permafrost and details in the processes of GHG release from the permafrost are not known well. In the three-year project “Assessing and projecting greenhouse gas release from dynamic permafrost degradation” (2-1605, Environment Research and Technology Development Fund of the Ministry of the Environment, Japan: 2016-2018), we aims to assess and project the impacts of greenhouse gas 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. In this presentation, we report the status of the numerical modeling. We use a global physical land surface model MATSIRO (Takata et al. 2003, Nitta et al. 2014), which is a component of global climate model MIROC (Watanabe et al. 2010). In addition, a global land vegetation model VISIT (Ito et al. 2012) is coupled to MATSIRO and exchange variables such as soil moisture, temperature, and leaf area index with each other. We improved the physical processes related to permafrost melting (e.g., increasing in numbers in vertical layers; considering of changes in thermal conductivity of frozen/unfrozen soil water, and shielding effect by soil organic layer) in MATSIRO and found that seasonal distributions of permafrost tend to be improved. We also try to implement the carbon dioxide and methane release due to permafrost melting in VISIT to estimate the future greenhouse gas emission.

Keywords: Permafrost, Greenhouse gas, Climate change