Permafrost degradation and potential carbon release after a tundra wildfire in an ice-rich permafrost region of Alaska

*Go Iwahana[1], Robert Busey[1], Reginald Muskett[1], Hiroshi Ohno[2], Ji-Woong Yang[3], Jinho Ahn[3], Simon Zwieback[4], Franz Meyer[4], Masao Uchida[5], Kazuyuki Saito[6]

1. International Arctic Research Center, University of Alaska Fairbanks, 2. Kitami Institute of Technology, 3. Seoul National University, 4. Geophysical Institute, University of Alaska Fairbanks, 5. National Institute for Environment Studies, 6. Japan Agency for Marine-Earth Science and Technology

Both inter-annual and seasonal ground displacements are closely related to surface carbon/hydrological cycle and spatio-temporal variation in thermokarst subsidence after surface disturbances, and their variations are critical information to estimate rate of permafrost loss. We investigated surface displacement related to frozen ground dynamics and thermokarst development triggered by a tundra wildfire in Alaska and estimated potential carbon loss caused by the permafrost disturbance. The Anaktuvuk River Fire (ARF) combusted surface vegetation and organic mat of the tundra region underlain by ice-rich permafrost in 2002. The development of permafrost degradation triggered by the fire was monitored using optical and L-band microwave remote sensing (2006-2019) as well as in-situ field measurements (2014-2019). Both inter-annual (thermokarst) and seasonal subsidence before and after the fire disturbance were measured by the differential SAR interferometry (DInSAR) using ALOS2-PALSAR and UAVSAR data and validated by the field surveys. In addition to the measurements of the surface displacement, we collected permafrost samples to be analyzed for greenhouse gas, organic matter, and ice contents together with cryostructure at multiple locations in the area of ARF. Significantly large amounts of subsidence (up to 6.2 cm/year as spatial average) were measured by the DInSAR using ALOS-PALSAR exclusively within burned areas relative to unburned nearby in the first three years after the fire (2008-2010). The spatial variation in thermokarst subsidence measured during 2015-2019 (from 8th to 12th years after the fire) by ALOS2-PALSAR2 shows a markedly different pattern from the period just after the fire (1st to 3rd years) although overall spatial average in subsidence decreased to about 2 cm/year. The distribution shift indicates the recent enhancement of natural thermokarst development by climate warming. This was thought to be reflected by spatial variations in sedimentation history, active layer thickness, and location relative to burned areas in addition to burned or unburned status of the site. Based on the measurements of permafrost loss and carbon content in the thawing permafrost, we made a preliminary estimation of the potential carbon loss caused by thermokarst after the ARF.

Keywords: Permafrost, Thermokarst, Tundra, wildfire, subsidence, carbon

