Mapping thermokarst subsidence in Central Yakutia using L-band SAR interferometry

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Thermokarst is an irreversible phenomenon with geomorphological change, resulted from the thawing of ice-rich permafrost or the melting of massive ice. The formation of large depressions in the ground surface by thermokarst processes results in surface inundation, and causes damages on infrastructure. Central Yakutia in Eastern Siberia is one of the regions where ice-rich permafrost is broadly distributed. The remarkable surface subsidence due to thermokarst has been observed in recent years, which could cause destruction of building and infrastructure in this area (Shiklomanov et al., 2017; Hjort et al., 2018). The thermokarst settlement are frequently observed in continuous permafrost zones in arctic regions, especially in Alaska and the Northeastern Siberia. However, it is so difficult to know where and how surface deforms in vast permafrost zones.

Remote sensing technique, especially Interferometric Synthetic Aperture Radar (InSAR), has a great potential to monitor the thermokarst subsidence, and seasonal permafrost melting and heaving. SAR sends microwave toward ground, and receive the reflected and scatter signals under all-weather and day-and-night condition without any instrument on ground. Thus, InSAR can provide essential information to understand thawing process of ice-rich permafrost and to predict the future stage over arctic permafrost region. Many studies about permafrost dynamics using SAR images have been reported so far (e.g., Liu et al., 2010; Iwahana et al., 2016; Antonova et al., 2018; Strozzi et al., 2018), but there is no study using SAR in Central Yakutia.

In this study, we used ALOS/PALSAR (2007-2010) and ALOS-2/PALSAR-2 (2014-2018) images to examine ground subsidence caused by thermokarst development. GAMMA software was used to generate Single Look Complex data from Lv1.0 data in ALOS/PALSAR and Lv1.1 data in ALOS-2/PALSAR-2. ALOS world DEM derived from ALOS/PRISM was used to simulate and remove topographic effect. We generated many interferograms, selected some of them, and applied stacking procedure weighted on period between two SAR data acquisition time, estimating the mean change rate along line of sight (LOS). Assuming ground displacement is only vertical component, the LOS change was converted to vertical displacement using incidence angle.

At the last JpGU, we reported ground subsidence in Mayya, on the right bank of Rena River, Central Yakutia, derived from ALOS/ALOS-2 InSAR stacking. To validate the InSAR signals, we carried out the ground observation in Mayya at the end of September, 2018. As a result, the subsidence rate of 2-3 cm/yr was obtained at the two measurement points in 2017-2018. The result of ground observation is consistent with that of InSAR result from ALOS-2. We also went to some places where there are subsidence signals in the ALOS-2 results. As a consequence, the two large subsidence signals were found in alasses. Alas is considered as a final geomorphological stage of old thermokarst development. Significant amount of the subsidence may be due to consolidation settlement associated with soil desiccation under recent dry climate conditions. However, judging from new developments of polygonal subsidence in the bottom areas of alasses, ground ice still remains under the alasses, which may cause further thermokarst progress.

Moreover, we extended our target to other cities, Amga, and Churapcha, where thermokarst has been also developing (e.g., Saito et al. 2018). The similar subsidence signals were obtained in the two cities, where it is in area of many polygons. It suggests that the signals be presumably due to thermokarst development.

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