Detection of surface deformation induced by ground ice melting around Yakutsk using L-band SAR

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Thermokarst development in ice-rich permafrost regions is a natural hazard, and causes irreversible geomorphological changes (Haeberli and Burn, 2002). Thermokarst is the process by which characteristic landforms result from the thawing of ice-rich permafrost or the melting of massive ice (Czudek and Demeck, 1970). The formation of large depressions in the ground surface produced by thermokarst processes results in surface inundation, and causes damages on infrastructure. These are frequently observed in continuous permafrost zones in arctic regions, especially in Alaska and the Northeastern Siberia. However, little quantitative observation is available to know where and how surface deforms. Remote sensing technique, especially InSAR, has a possibility to monitor the thermokarst subsidence and seasonal surface displacement over the permafrost regions, which could provide essential information to understand thawing process of ice-rich permafrost and to mediate resulting destruction of infrastructure. In this study, we used ALOS/PALSAR (2007-2011) and ALOS-2/PALSAR-2 (2014-2017) data to investigate 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. AW3D, 5 m digital surface model derived from ALOS/PRISM, was used to simulate and remove topographic effect. We generated some interferograms and applied stacking procedure weighted on period between two SAR data acquisition time, estimating the mean change rate along line of sight.
In the Mayya area, on the right bank of the Lena River near Yakutsk, we detected ground subsidence with a rate of 1-3 cm/yr using PALSAR and PALSAR-2 data. The subsidence signals are found in numerous open area (deforested area), and the PALSAR-2 results clearly show the spatial distribution of the subsidence corresponding to visible observation of thermokarst development in high-resolution optical images. The rate differs from location and period. Moreover, we recognized local subsidence after wildfires in PALSAR-2 data. Our results imply that L-band SAR may detect thermokarst subsidence in two dimensions.

Keywords: Permafrost, Thermokarst, Synthetic Aperture Radar (SAR), Interferometric SAR, ALOS, ALOS-2

