Ground deformation over permafrost region in Eastern Siberia, revealed by L-band SAR Interferometry

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Thermokarst development in ice-rich permafrost regions is a natural hazard, and causes irreversible geomorphological changes. Thermokarst is the process by which characteristic landforms result from the thawing of ice-rich permafrost or the melting of massive ice. The formation of large depressions in the ground surface produced by thermokarst processes results in surface inundation, and causes damages on infrastructure. Eastern Siberia is one of the regions where ice-rich permafrost is broadly distributed and thermokarst has been advanceing quickly. 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). However, little quantitative observation is available to examine where and how the surface deforms. Remote sensing technique, especially Interferometric Synthetic Aperture Radar (InSAR), has a possibility to monitor the thermokarst subsidence and seasonal surface displacement over the permafrost regions. Recent studies of permafrost monitoring using SAR data have been reported, and SAR 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 (2014-2018) 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 fringe. 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 (Figure 1), we detected ground subsidence with a rate of 1-3 cm/yr in both PALSAR and PALSAR-2 results. 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. Moreover, we recognized local subsidences after wildfires in PALSAR-2 data. Our results show that the L-band SAR can detect thermokarst subsidence in two dimensions.

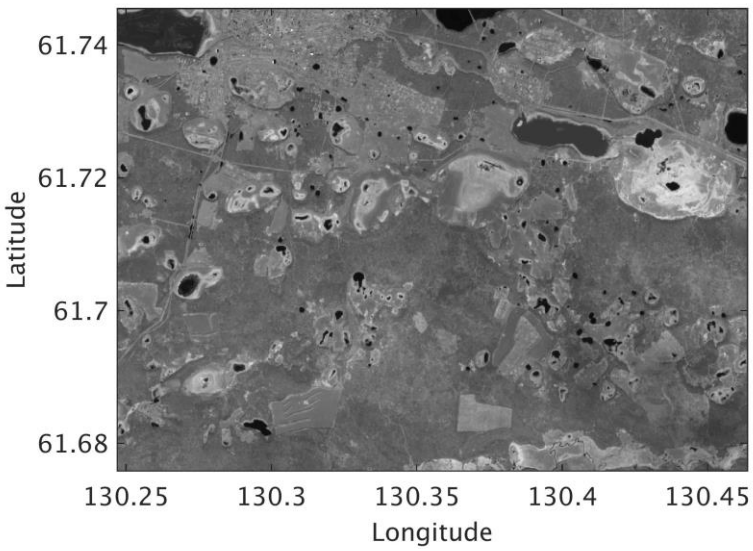

Figure 1. Study area (Mayya, on the right bank of Rena River, East Siberia). The image was acquired on July 9, 2017, by Sentinel-2B.

References

Shiklomanov, N., D. A. Streletskiy, T. B. Swales, V. A. Kokorev, Climate Change and Stability of Urban Infrastructure in Russian Permafrost Regions:Prognostic Assessment based on GCM Climate Projections, Geographical Review, 107(1), 125-142, 2017.