Spatiotemporal variation of thaw subsidence and frost heave of permafrost caused by wildfire around Batagay, East Siberia

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Thawing permafrost release soil organic carbon as a greenhouse gases, and it can be positive feedback on global warming (Shuur et al. 2015). To estimate terrestrial carbon budget precisely, permafrost degradation should be observed in the entire circumpolar region. However, it is impractical to perform field observation over all the permafrost areas in northern hemisphere. Especially in Siberia, observation sites by the international network (e.g. GTN-P, CALM) is very few despite the largest area in terms of permafrost distribution. Therefore, remote sensing techniques to cover wide areas are indispensable. Observing ground deformation by InSAR (Interferometric Synthetic Aperture Radar) can tell us the state of permafrost with high spatiotemporal resolution. Some previous studies are conducted in a part of Alaska, Canada and Siberia that can be easy to compare with field work (Liu et al. 2010; Short et al. 2011; Antonova et al. 2018).

We focused on East Siberia, where no previous studies by InSAR are conducted. Study area is around Batagay town (67’39N, 134’39E). At ~10 km southeast of Batagay, there is a well-known and one of the largest slump terrains caused by thawing of permafrost (Murton et al. 2017). Processing ALOS and ALOS2 InSAR images, we found the deformation signal due to wildfire at the hill to the 20 km northwest of Batagay. Loss of surficial vegetation layer by wildfire accelerates permafrost thawing, and the degradation continues for several years to decades after a fire (Yoshikawa et al. 2002). Furthermore, given the fact that the frequency and intensity of wildfires are increasing in the Arctic region with global warming (Alexander et al. 2018; Gibson et al. 2018; Masrur et al. 2018), it is important to reveal the spatiotemporal variation of the ground deformation in the post-wildfire area.

Here, we report our detection of the post-wildfire ground deformation in the place where the fire occurred in 2014. We used SAR images obtained from ALOS 2 (L-band) and Sentinel-1 (C-band) satellites from 2014 to 2018. Secular deformation is detected by ALOS2 data. The results indicated that thawing subsidence up to 10cm in the satellite line of sight direction continued after 2-3 years after the fire. Seasonal deformation from 2017 to 2018 is detected and compared with both satellites data. The magnitude and spatial patterns of subsidence and uplift was consistent in both satellites. Especially, short-term InSAR images with Sentinel-1 data revealed detailed temporal variation from the start to the end of thawing and freezing. Estimation of permafrost thawing amount from ground deformation amount detected by InSAR can contribute to reducing uncertainty of terrestrial carbon budget. Those physical models are under discussion (Liu et al. 2014; Hu et al. 2018; Molan et al. 2018). In this study, we verified the Molan model in our study area, and developed it taking into account the deformation in the slope direction.

Keywords: permafrost, InSAR, ALOS2, Sentinel-1, wildfire, Batagay

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