ALOS/PALSARで捉えたアラスカ/ユーコン山岳氷河の時空間変動
-サージ型氷河の静穏期における冬期加速-

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Spatial and temporal variations of Alaska/Yukon Glaciers revealed by ALOS/PALSAR
- Winter speed-up during quiescent phases at surge-type glaciers -

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Recent advances of space geodetic technique allow us to map ice velocity distribution over wide area with high spatial and temporal resolution. In paticular, flow velocity variations at mountain glaciers have been revealed by synthetic aperture radar (SAR), which can acquire data regardless of weather conditions and data aquistion time because it is a microwave active remote sensing sensor. The Japan Aerospace Exploration Agency (JAXA) launched Advanced Land Observation Satellite (ALOS) in 2006 that carries Phased Array-type L-band (wavelength of 23.6 cm) Synthetic Aperture Radar (PALSAR). The PALSAR data have been used for a wide range of applications such as the detection of crustal deformation associated with earthquakes and volcanic eruptions and the mapping ice velocity evolution at mountain glaciers; both the crustal deformation observations and the ice velocity measurements have been difficult in remote areas by fieldwork (e.g., Furuya and Yasuda, 2011; Yasuda and Furuya, 2013; Abe et al., 2013).

There are numerous glaciers in Alaska and Yukon, which are significant contributiors to global sea level rise due to global warming (Radic and Hock, 2011). One notable feature in this area is its dense distribution of surge-type glaciers. Glacier surge occurs quasi-periodically with an interval of decades or more, exhibiting orders-of-magnitude speed-up and accompanying with km-scale terminus advance. The surge episodes are known to often initiate in winter, which has been interpreted as caused by cavity closure and subsequent water pressure increase; this interpretaion is basically following the surge mechanism proposed for the 1982-83 surge at the Variegated Glacier by Kamb et al. (1985). However, the surge generation mechanisms remain uncertain particularly because in the absence of surface meltwater input water supplying sources in winter have not yet been identified. Moreover, even spatial and temporal velocity changes at normal glaciers in this area have been unknown, and the ice velocity maps have been only recently published (Burgess et al., 2013). In this study, we focus on the seaonal cycle of surge-type glaciers during their quiescent phases to better understand the wintertime behaviors.

We have examined spatial and temporal changes in the ice velocity at surge-type glaciers in Alaska/Yukon using ALOS/PALSAR data acquired from 2006-2011, and found significant upstream accelerations from fall to winter at seven surge-type glaciers (Chitina, Anderson, Walsh, Logan, Hubbard, Agassiz, and Donjek) regardless of surging episodes (Fig. 1, Abe and Furuya, 2014). The winter speeds in the upstream are comparable to, or even faster than those in spring to summer. Moreover, whereas the summer speed-up was observed near the terminus, the winter speed-up propagated from upstream to downglacier. This acceleration and propagation indicate that the basal condition changes from fall to winter, which can enhance basal slip.

Recalling the surge mechanism proposed by Kamb et al. (1985), the winter speed-up may be explained by cavity closure and subsequent water pressure increase. However, in order to maintain the winter velocity that is as fast as that in spring or early summer, we need to consider any mechanisms that can trap water in the upstream in winter so that the subglacial water pressure can be maintained to be high enough to generate basal slip.

The presence of englacial water storages proposed by Lingle and Fatland (2003) appears to be also helpful to interpret our observations. Using the few ERS1/2 tandem radar interferometry data with the 1-3 day's observation interval, Lingle and Fatland (2003) detected faster speed in winter than in fall at non-surging Seward Glacier in the St. Elias Mountains. Moreover, the detected bull's eye-like localized signals that are also expressed as circular motion anomalies at both surging and non-surging glaciers were interpreted to represent local uplifting and/or subsidence caused by transient subglacial hydraulic phenomena. Given these observations combined with earlier glacier hydrological studies, they proposed englacial water storages and gravity-driven water flow toward the bed in winter regardless of whether a given glacier is surge-type or not (Lingle and Fatland, 2003). We do not observe any localized signals in our offset-tracking displacements because the observation interval, at least 46 days, is much longer than the case in Lingle and Fatland (2003). However, we may interpret that both Lingle and Fatland's and our observation are caused by the same physical processes. This is because the locally increased basal water pressure could enhance basal sliding and contribute to larger horizontal displacements in winter.

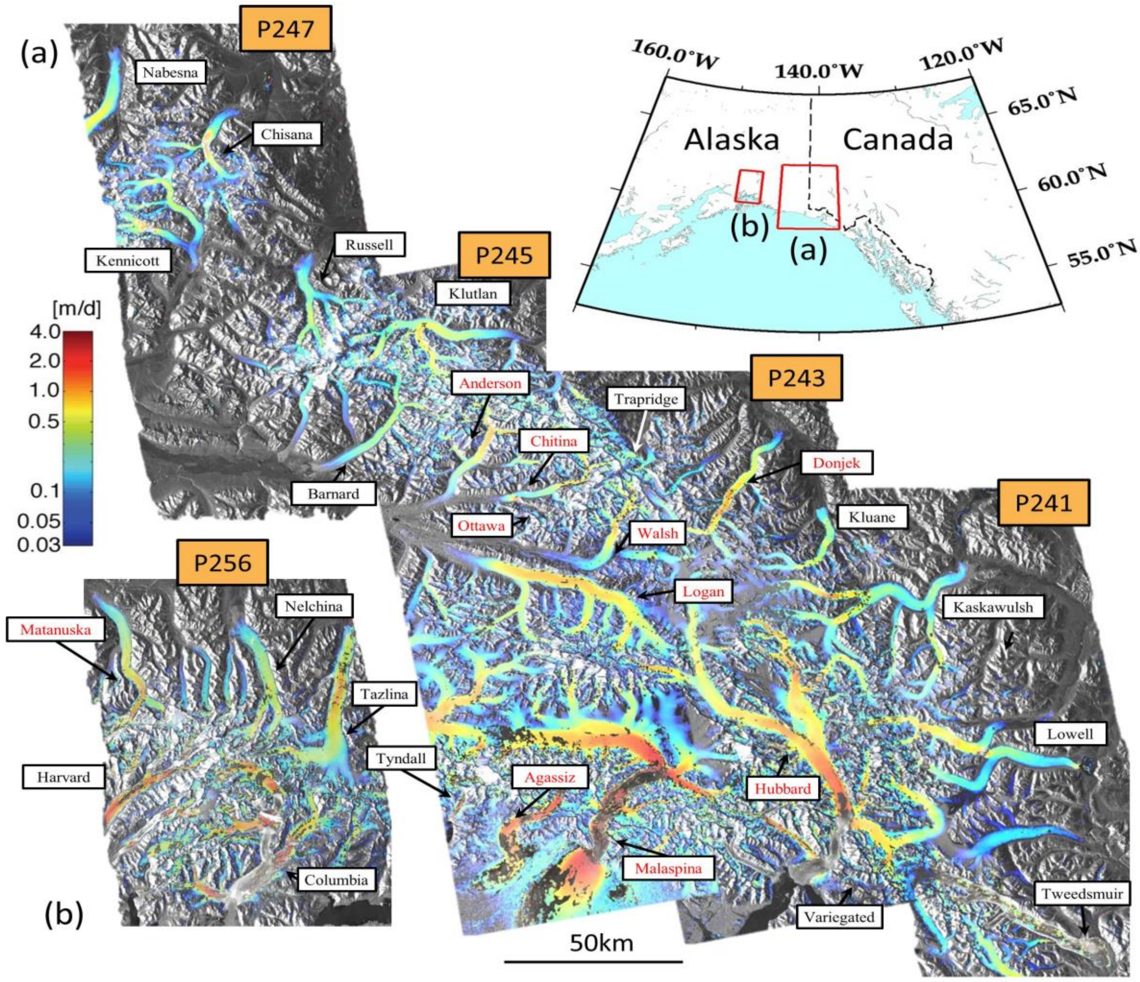

Figure 1. Study area and Ice velocity maps derived from five paths of ALOS/PALSAR. Please note the color scale is shown as logarithm. Red-letters indicate the winter speed-up glaciers revealed by this study.

Acknowledgement

The PALSAR level 1.0 data used in this study were provided by the PALSAR Interferometry Consortium to Study our Evolving Land surface (PIXEL) and the ALOS 3rd PI project, under cooperative research contracts with JAXA. The PALSAR data belong to JAXA and the Ministry of Economy, Trade, and Industry (METI). ASTER GDEM is a product of METI and NASA. We acknowledge KAKENHI (24651001) for supporting this study.

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