



# HOKKAIDO UNIVERSITY

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## Abstract of Doctoral Dissertation

Degree requested    Doctor of Science    Applicant's name    Muhammad Usman

### Title of Doctoral Dissertation

Saptio-temporal velocity variability of the Eastern Karakoram Glaciers observed by ALOS-1/2 data  
(ALOS1/2 データで観測された東カラコルム山脈の氷河流動速度の時空間変動)

Unlike in most other regions, Karakoram glaciers are either stable or advancing, a phenomenon known as the Karakoram anomaly. Despite studies of glacier surges and the derivation of surface velocity maps, the spatio-temporal variability of glacier dynamics still remains poorly understood, particularly in the Eastern Karakoram Range.

In the Eastern Karakoram Range, we applied offset tracking technique to nearly all the available L-Band Synthetic Aperture Radar (SAR) data of Advanced Land Observing Satellite (ALOS)-1/2 to determine the surface-velocity trends of five glaciers, during 2007–2015. ALOS-1/2 data has retained its coherency and has produced high quality results with unprecedented detail. These are the major findings:

**(a)** Five glaciers (Baltoro, Siachen, Gasherbrum, Kundos and Singkhu) showed clear seasonal changes in velocity, but with inter-annually modulated amplitudes and spatial-extents. Trends for each glacier appeared independent of the others, indicating that their velocities are probably not controlled by the climate but by their local and internal mechanisms.

**(b)** The input from tributaries created bands of lower speed, leading to a segmentation of the velocity trends along the length of the glaciers.

**(c)** Our study has not only complemented the previous studies of surge, related to the Gasherbrum Glacier (Mayer et al. (2011) and Quincey et al (2011)) but has also detected “mini-surge” events at the Siachen and the eastern tributary of Kundos glaciers, that have not been reported before.

**(d)** Apart from these surge events, we have also detected high velocity events: in 2008, 2014-15 in various parts of the Baltoro; and in 2010, in Singkhu glaciers. These high speed events were also not been reported before.

**(e)** Related to the surge mechanism of Gasherbrum Glacier, Mayer et al. (2011) and Quincey et al (2011) studies resulted in a conflict. As the former proposed Svalbard-type (thermally regulated) while the later proposed Alaskan-type (hydrologically driven) surge mechanism. Our data have indicated that surge phase of the Gasherbrum Glacier is seasonally modulated, having maxima in the summers of both 2006 and 2007, suggesting Alaskan-type surge mechanism. An Alaskan-type is hydrologically-driven surge; the water mainly originates from surface melt. It is characterized by a rapid acceleration and deceleration, and has tendency to initiate in winter (Raymond, 1987; Harrison and Post, 2003) and terminate in summer (Björnsson, 1998).

**(f)** Also, while the previous studies focused on ablation zone to explain the high speed seasonal events, our study have found that it is important to consider the upstream accumulation zone to explain the mechanism related to high speed seasonal events.

**(g)** Related to the velocity variability mechanism, we argued that the intra/inter spatial and temporal changes in englacial/subglacial system of each glacier may vary the input of surface meltwater to the base and result in diverse velocity patterns in these glaciers. Our surface velocity findings show intriguing variations, suggesting that the Karakoram glaciers have more diverse dynamics than previously thought.