ネパール・ヒマラヤ トラカルディン氷河における氷壁の分布特性
Spatial distribution of ice cliff in the Trakarding glacier, Nepal Himalaya

*佐藤 洋太[1]、藤田 耕史[1]、井上 公[2]、砂子 宗次朗[1]、坂井 亜規子[1]、對馬 あかね[1]、Podolskiy Evgeny [3,4]、Berthier Etienne[5]、Kayastha Rijan[6]

*Yota Sato[1], Koji Fujita[1], Hiroshi Inoue[2], Sojiro Sunako[1], Akiko Sakai[1], Akane Tsushima[1], Evgeny Podolskiy[3,4], Etienne Berthier[5], Rijan Kayastha[6]

1. 名古屋大学環境学研究科、2. 防災科学技術研究所、3. 北海道大学 北極行研究センター、4. 北海道大学 国際連携研究教育局 Global Station for Arctic Research、5. フランス国立科学研究センター、6. カトマンズ大学
1. Graduate School of Environmental Studies, Nagoya University, 2. National Research Institute for Earth Science and Disaster Resilience, 3. Arctic Research Center, Hokkaido University, 4. Global Station for Arctic Research, Global Institution for Collaborative Research and Education, Hokkaido University, 5. Centre National de la Recherche Scientifique, 6. School of Science, Kathmandu University

Glaciers in High Mountain Asia are valuable indicator of climate change, and its melt water have an important role for the regional water resources (e.g. Immerzeel et al., 2010). We thus need to estimate Himalayan glacier melting amount. However, the lower part of large Himalayan glaciers is generally covered with debris mantle, which makes the melting process complicated. Several previous works pointed out a role of ice cliffs that promote local enhancement of the ice melting (e.g. Brun et al., 2018). In previous studies, digital elevation models (DEMs) based on satellite imageries have been analyzed to estimate glacier mass change. However, it is difficult to extract ice cliffs due to their low resolution. Recently, Structure from Motion (SfM), image analysis technology, has been dramatically developed. This method enables to obtain high resolution glacial terrain data and identify the small features on glacier surface such as ice cliffs.

In this study, we generated high resolution DEMs and orthomosaic images from aerial photographs taken at three different times at the Trakarding glacier, Rolwaling region, Nepal Himalaya in order to evaluate area and aspect of ice cliffs, and analyzed the relation between cliff distribution and glacier surface elevation change. We carried out field observations and conducted aerial photogrammetry by fixed wing UAV in 2017 and helicopter in 2018 at the entire debris-covered area (3.1 km^2). We also analyzed photographs taken in 2007, and then created high resolution (0.2~2.0 m/pix) DEMs and orthomosaic images, from which about 500 ice cliffs were extracted.

DEMs shows that the surface elevation of the Trakarding Glacier declined between 2007 and 2017 by -1.65 m w.e. yr^{-1} while it lifted up between 2017 and 2018 by +1.25 m w.e. yr^{-1}. We find that the surface elevation changes are spatially heterogeneous. The more significant surface lowering happens, the higher cliff density is observed, suggesting that the ice cliff locally enhances glacier melting. In addition, the ice cliff length density was 7.9×10^{-3} m m^{-2} in 2017, which remarks the highest density comparing to a previous study in the Khumbu region (Watson et al., 2017). Further, we find significant correlation between ice cliff length and its slope area, which means that it is possible to estimate the slope area of cliff from the cliff length, which can be obtained from satellite images.

Reference
Immerzeel et al., 2010 : Climate change will affect the Asian water towers. Science., 328, 1382-1385.
Brun et al., 2018 : Ice cliff contribution to the tongue-wide ablation of Changri Nup Glacier, Nepal, central

- ACC27-05 -

Himalaya. The Cryosphere., 12, 3439-3457.
Watson et al., 2017 : Ice cliff dynamics in the Everest region of the central Himalaya. Geomorphology., 278, 238-251.

キーワード：氷河、ヒマラヤ、UAV、SfM、リモートセンシング
Keywords: Glacier, Himalaya, UAV, SfM, Remote Sensing