UAV NIR photometry observation over Qaanaaq Ice Cap in northwest Greenland

Teruo Aoki[1, 2], Guillaume Jouvet[3], Yvo Weidman[3], Marin Kneib[3], Andrea Walter[4], Tomonori Tanikawa[2], Masashi Niwano[2], Hiroki Motoyoshi[5], Sumito Matoba[6], Shin Sugiyama[6], and Rigen Shimada[7]

[1]Okayama University, [2]Meteorological Research Institute, JMA, [3]ETH Zurich, [4]University of Zurich, [5]Snow and Ice Research Center, NIED, [6]ILTS, Hokkaido University, [7]Earth Observation Research Center, JAXA

Ice caps in Greenland are one of the most rapidly changing snow/ice region, where the melting snow/ice mass could contribute global sea level rise. Surface albedo of the ice cap is one of the most important parameter for the surface mass balance. Visible and near-infrared (NIR) albedos in general depend on snow impurity concentration and the snow grain size, respectively (Wiscombe and Warren, 1980). Many ice caps in Greenland distribute at low elevation area, and thus the surface albedo in ablation area during summer season is strongly influenced by snow/ice impurities including glacial microbes and that in accumulation area mainly controlled by snow grain size. Albedo reduction rate due to snow/ice impurities furthermore depend on the snow/ice grain size. Snow/ice grain size has thus important role for albedo distribution of overall surfaces in ice cap. We conducted the NIR photometry (Matzl and Schneebeli, 2006) observation at the wavelength 890 nm onboard a Unmanned Aerial Vehicle (UAV) similar to Ryan et al. (2015) over Qaanaaq Ice Cap (~ 69°N, 77°W) in northwest Greenland on 19 July 2017 to measure the snow/ice grain size. The UAV flew at a constant altitude of 1,570 m a.s.l. from above SIGMA-B automatic weather station (AWS) at an elevation of 940 m a.s.l. on the ice cap to above a terminus of Qaanaaq Glacier at an elevation of 200 m a.s.l. The UAV traveled a distance of 5.9 km during 6 min 20 sec and took 151 NIR images (example: Fig. 1) spaced by 40 m. Synchronizing with this flight in-situ measurements of optically equivalent snow/ice grain size using a handheld lens along the same route as the flight were performed. The measured snow/ice grain radius varied from 0.5 mm (SIGMA-B) to 10 mm (4.7 km from SIGMA -B) depending on the elevation. The preliminary analysis for snow/ice grain radius (example: Fig. 2) retrieved from the NIR images showed larger grains 1.8 -6.0 mm near SIGMA-B and the somewhat smaller grains 2.4 - 10.1 mm around a position at 4.7 km from SIGMA-B compared to the in-situ measurements, although slope effect of ice cap surface is not taken into account for the NIR image analysis.

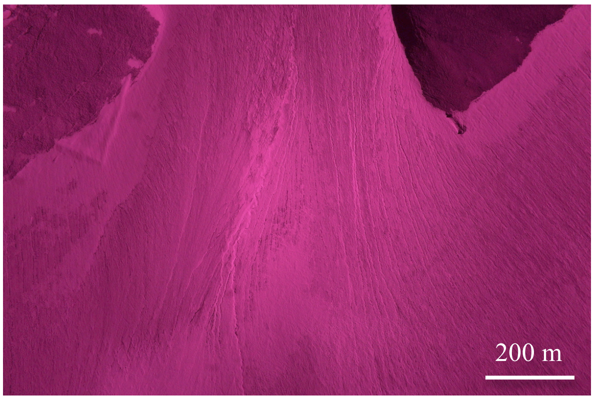

Fig. 1 Sample NIR image observed from UAV. The position is 2.7 km from SIGMA-B down to the Qaanaaq Glacier.

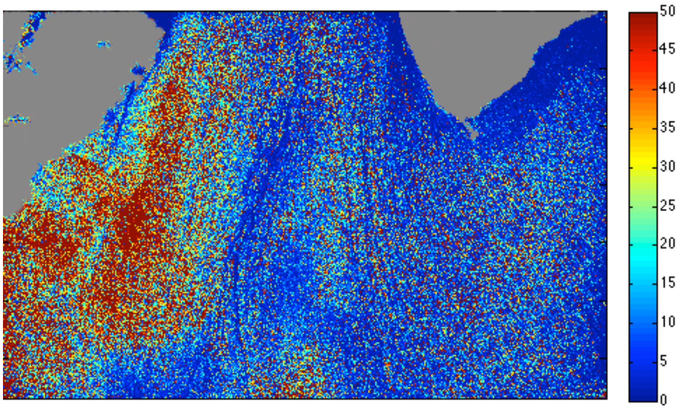

Fig. 2 Snow grain radius (unit: mm) retrieved from NIR image shown in Fig. 1. Gray-colored areas indicate bare rock.

References

Matzl, M. and M. Schneebeli, (2006): Measuring specific surface area of snow by near-infrared photography. *J. Glaciol.,* **52**, 558-564.

Ryan, J. C., A. L. Hubbard, J. E. Box, J. Todd, P. Christoffersen, J. R. Carr, T. O. Holt, and N. Snooke. (2015): Uav photogrammetry and structure from motion to assess calving dynamics at store glacier, a large outlet draining the greenland ice sheet. *The Cryosphere*, **9**, 1–11.

Wiscombe, W. J. and Warren, S. G. (1980): A model for the spectral albedo of snow, I: Pure snow. *J. Atmos. Sci*., **37**, 2712-2733.