Sea Ice Thickness Measurement Using UAV-SfM

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Sea ice thickness is important information for elucidating the effects of climate change and for economic activities in ice covered sea area. Declining sea ice has potential for Northern Sea Route（NSR) and resource exploitation. Therefore, it is necessary to understand not only the extent but also the thickness and surface condition of sea ice. Conventional methods for measuring sea ice thickness such as a drill-hole method have some weakness points like high labor and inefficiency. An Unmanned Aerial Vehicle with Structure from Motion (UAV-SfM) is applied for sea ice thickness measurement in order to achieve low cost, high efficiency, and accurate observation over a wide area under low temperature conditions.

Observations of snow and ice surfaces heights by UAV-SfM have been conducted most on the lake ice of the Saroma-ko Lagoon and the land-fast sea ice near the coast. In this study, aerial photographs of sea ice were taken by UAV “DJI Phantom4-pro” and the photographs were analyzed by SfM software “Metashape”. In addition, A Global Navigation Satellite System (GNSS) receiver was mounted on the UAV to get coordinates of each aerial photograph. Figure 1 shows the location and the observation area of the Utoro port of eastern Hokkaido, Japan. The observation date is on February 12, 2022. Ice cake existed in the port on that day (Figure 2). The flight time was from 9:36 a.m. to 10:56 a.m. We got 414 photographs by three flights (approximately 20 minutes each). We measured sea ice thickness at 10 points by a drill-hole method to compare actual and estimated values. The Digital Surface Model (DSM) of sea ice surface height was generated from the SfM software. Freeboard and thickness of sea ice were estimated from the DSM and hydrostatic equilibrium. Figure 3 shows the estimated freeboard distribution in the observation area (Fig. 1). Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE) between actual and estimated values were 2.3cm and 2.8cm. The estimated ice thickness was also compared with the results of sea ice measurements by sea ice / wave radar.

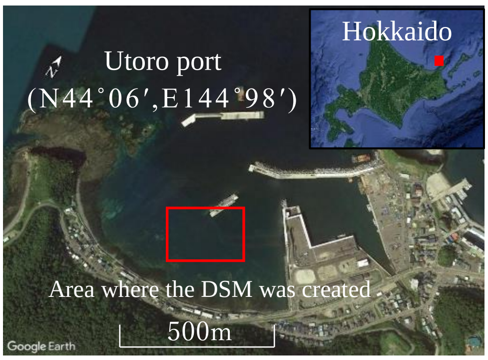
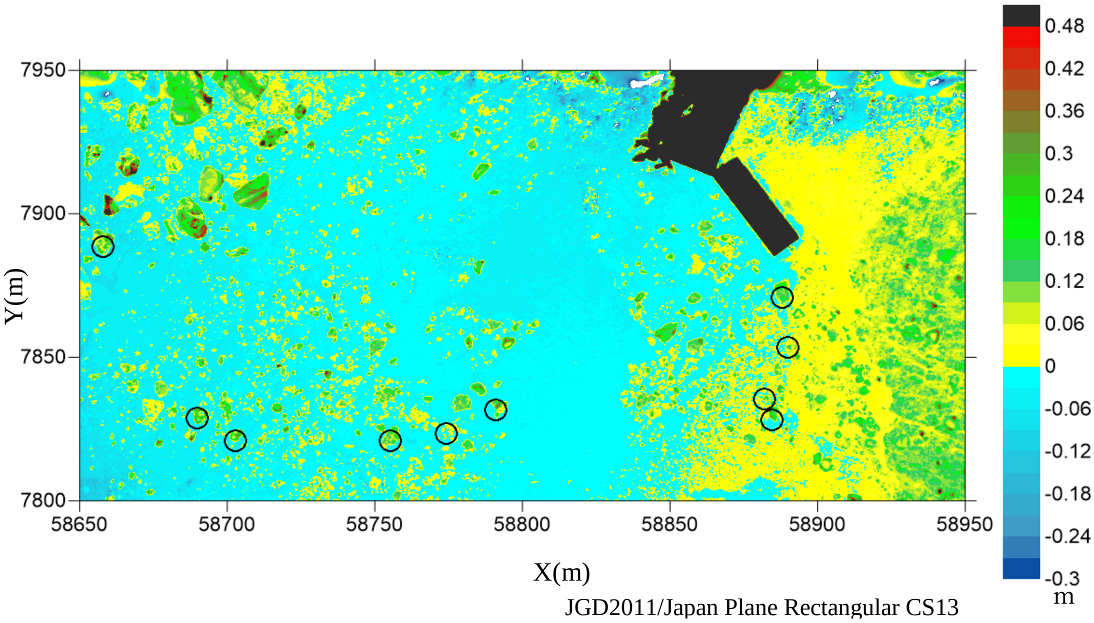


Figure 1. The location and observation area

Figure 2. Ice conditions in Utoro port



○：drilling locations

Figure 3. Spatial distribution of freeboard in the area of red square in Fig.1.

References

Watanabe, T., Tateyama, K: An attempt to measure sea ice freeboard using UAV-SfM, Seppyo, **83**(2), 155-167, 2021.

Sato, K., Tateyama, K., Watanabe, T., Tanikawa T: Observation of Total Ice Thickness Using UAV-SfM in the Saroma-ko Lagoon, The 12th Symposium on Polar Science, online, November, 2021.