Examination for estimating snow depth in mountainous areas by using aerial photos and SfM-MVS technique

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Preface: Snow around mountainous areas plays an important role as water resources, and the estimation of snow water equivalent is essential to comprehend the amount of the water resources. Also, the amount of snow in mountainous area is indicator of environmental variation. Snow depth is important factor for calculating the snow water equivalent and understanding the environmental variation in mountainous area. However, it is not easy to measure the snow depth widely in sub-meter accuracy. Although wide-area snow depth was measured by difference of airborne laser data during the snowy season and no snowy season (e.g. Kitahara et al., 2005; Deems et al., 2006; Akiyama et al., 2009), this approach is costly. Recently, there are cases of measuring snow depth combined with unmanned aerial vehicle (UAV) and SfM (Structure from Motion)-MVS (Multi-view Stereo) technique (e.g. Uchiyama et al., 2014; Jagt et al., 2015; Matsuyama et al., 2016). However, in this approach, the measurement range is limited, and it is generally necessary to set and observe the ground control points (GCPs) on the field. Therefore, in this study, positional accuracy of digital surface model (DSM) created by SfM-MVS technique was examined without using GCPs observation at the field, using aerial photos taken by aircraft in the snowy mountainous area.

Method & Result: Aerial photos on March and April 2005 taken around Yamakoshi district in Niigata Prefecture were used for creating the ortho-image and DSM by SfM software (PhotoScan Pro). Location coordinate of GCPs were acquired from simple ortho-images and digital elevation model (DEM) of airborne laser data measured from April to June 2005. The GCPs were acquired in the following two patterns on the no snow cover ground: (A) A pattern focused ideal arrangement of GCPs and targeted even natural features, (B) A pattern excluded ideal arrangement of GCPs and targeted only artificial features. Additionally, nine verification points (VPs) were extracted from airborne laser data apart from the GCPs. As a result, the height accuracy in the case of March, which is covered widely with snow, was better for pattern (B). RMSE of difference of the VPs was approximately 2.1 m. The height accuracy in the case of April, which is covered narrow area with snow, was better for pattern (A), and RMSE of difference of the VPs was approximately 0.1 m. However, as the RMSE of pattern (B) in the case of April was approximately 0.2 m, the height error in the case of April was predominantly small compared to the March case.

Summary and Challenges: The above results indicate the following. (1) In the mountainous area, if it is covered widely with snow and it is difficult to acquire GCPs, it is preferable not to take ideal arrangement of GCPs into account, but to acquire artificial features as GCPs. (2) In the case of narrow snow cover area and relatively easy acquisition of GCPs, it is desirable that while acquiring GCPs on an artificial feature, the GCPs are supplemented by acquiring GCPs on a natural feature if the GCPs arrangement is insufficient. However, as the height accuracy of case (1) is insufficient for estimating snow depth, further study is necessary in the future.

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