Spatial variability of snow depth using UAS technology: Study from Lirung Catchment

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ABSTRACT: In this work we generated spatially continuous snow depth maps using photogrammetry-based surveys with Unmanned Aerial Systems (U.A.S) at cm resolution over Lirung catchment area (13.09 km 2). For this purpose, we have designed two field survey during the Aug-2015/April-2016. From the first survey (August 2015, beginning of snow accumulation season), Digital Elevation Model (DEM) of bare soil has been generated. The second survey, made at the end to the snow accumulation season from which DEM with snow is generated. Snow depth distribution is determined by differencing two DEM corresponding to bare soil and snow-covered, respectively. To assess the accuracy of our results we compare the calculated sow depths with hand measurements. The spatial integration of U.A.S snow depth measurements allowed to estimate the snow volume accumulated over the area. We compare this volume estimation with the one provided by classical interpolation techniques of the 7 point measurements. Result show that the U.A.S. technique provides an accurate estimation of point snow depth value (the mean difference with reference to manual measurements of 0.0771 m and RMSE of 0.104), and distributed evaluation of the snow accumulation patterns

Keywords: Lirung Glacier, Himalaya, Structure from Motion, UAS.

1. INTRODUCTION

Snow cover is an extremely dynamic surface that is continuously varying over space and time (Scipiòn, et al.), and this variability has a critical role in climate, ecological and hydrological systems both on a local and on a global scale. It is expected the need to efficiently and accurately estimate snow distribution over time for improving several environmental research sectors, but also for increasing the efficiency of water resources management systems. However, despite its relevance, traditional and state-of-the-art methods for estimating snow depth present some serious drawbacks and limitations. Digital photogrammetry has emerged as a alternative tool to perform such measurements in diverse topography. This project will investigates a new alternative method for estimating snow depth spatial distribution by combining two emerging technologies in the geosciences research sectors which are Structure from Motion (SfM) digital photogrammetry and the use of Unmanned Aerial Vehicles (UAVs) in Lirung catchment, Nepal.

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2. Goals of the project:

The main goal of this project is to provide high resolution and highly accurate measurements of snow depth at the catchment scale to be used in conjunction with density modelling to determine SWE.

3. Data and Methods:

Study is carried out in the Lirung glacier located in Langtang catchment (Fig. 1). We have designed two field surveys during the August 2014/April 2015. From the first survey (August 2014, beginning of snow accumulation season), Digital Elevation Model (DEM) of bare soil has been generated. The second survey, made at the end to the snow accumulation season (April 2015) from which DEM with snow is generated.

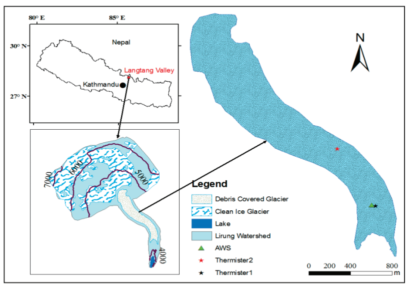

Figure 1: Study area, Langtang catchment, Nepal

Table 1: Table to test captions and labels

Accuracy Parameters	2014	2015
RMSE (m)	0.16	0.10
SD (m)	0.12	0.07
Mean Difference	0.11	0.08

4. Images processing

We used Agisoft's Photoscan Pro, photogrammetric software for image processing, which uses a structure from motion (SfM) algorithm at its core (Koenderink and Van Doorn, 1991) to reconstruct 3D models of objects or scenes from a set of overlapping pictures of the feature itself taken from a normal camera.

5. Results

DEM is generated for the both seasons, and shown in figure 2a (for 2014) and 2b (for 2015) with an overlapping area in the both DEM is 1.09 km2.

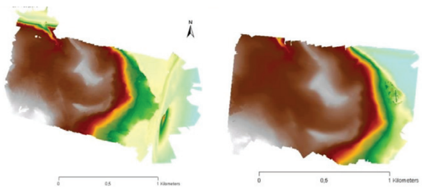

Figure 2: Generated DEM for 2014, 3b. Generated DEM for 2015

5.1. Accuraycy Assessment

Accuracy of the generated DEM is evaluated with the help of ground control points. Elevation form the GCPS and from the generated DEM is plotted for both years and sown in figure 4a& 4b.

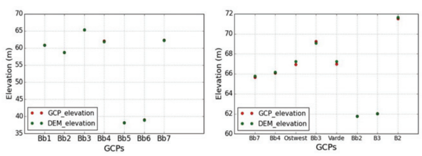

Figure 3: 3a Dem elevation and GCP elevation comparison for the year 2014 and 3b. DEM elevation and GCP elevation comparison for the year 2015.

Furthermore, some statistical analysis are also carried out and presented in table 1. Where RMSE is the Root Mean Square Error and SD is Standard Deviation. From this table we can see that the RMSE and SD are near to 10 cm.

Spatial variability of snow depth is calculated by subtracting the DEM 2014 (i.e with out snow) from the DEM 2015 (i.e with snow). From the difference DEM we can see that, the minimum and maximum values are -4.0 m and 7.5 m. But the numbers of pixels for these extreme values are very less (figure 6b). Maximum values are in the ranges from -2m to 2 (Figure 4b).

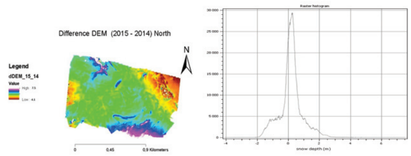

Figure 4: 4a, difference DEM, 4b, Histogram of Difference DEM

We can also see that in 2015 DEM, there is some construction activity (upper right corner). We can see that the most of these extreme values are from this side, but some are also in left part which is the source of errors in this study. Distribution of the pixel value is shown in figure 4b, indicating that most of the area covered by snow with depth ranges from 0 - 2 m.

6. Conclusion

DEM with 5cm resolution for the study area is successfully generated with some issues . Results from point comparison show that the U.A.S. technique provides an accurate estimation of point snow depth value (the mean difference with reference to manual measurements of 0.0771 m and RMSE of 0.104), and distributed evaluation of the snow accumulation patterns. Spatial distribution of snow has some issues that need to be justified. This UAV born snow depth data can be used as input data for snow distribution modelling.

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