Ground Control Point Survey Strategy for Snow Depth Retrieval Using Drone-based Structure-from-Motion Photogrammetry

Song Shu[1], Ok-Youn Yu[2], Chris Schoonover[2]

[1]Department of Geography and Planning, [2]Department of Sustainable Technology and the Built Environment, Appalachian State University

Introduction

The drone-based structure-from-motion photogrammetry is recently gaining its popularity in the mapping of snow depth, owing to the efficiency and simplicity of this technique in the process of data collection. This technique collects optical photos with an ordinary drone-based camera for an area of interest before and after snowfall. The snow-free and snow-on Digital Surface Model (DSM) for the area are generated separately using the optical photos. Snow depth is retrieved by subtracting the snow-free DSM from the snow-on DSM. To derive snow depth accurately, a survey of Ground Control Points (GCP) for the snow accumulation field is often necessary. However, the influences of the GCP elevation accuracy and GCP survey strategies (i.e., same GCPs for two flights or different GCPs for each flight) on the retrieval of snow depth have not been investigated in depth. In this study, the elevation of GCPs were surveyed with two different instruments (i.e., low-accuracy handheld GPS and high-accuracy total station), generating two sets of GCPs. These two sets of GCPs have the same set of coordinates but different set of elevation values. These GCPs were then incorporated in the generation of snow-free and snow-on DSMs that were further used to retrieve snow depth.

Objectives:

- **Evaluate the influences of GCP elevation on the accuracy of drone-based snow depth estimates**
- **Assess the effects of different GCP survey strategies on the accuracy of drone-based snow depth**
- **Identify the optimal GCP survey strategy for efficient and accurate drone-based mapping of snow depth**

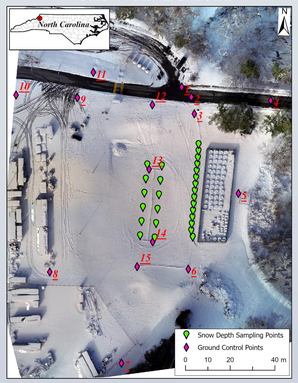
Study Area & Data Collection

Data Collection

- Date: Snow-on 1/9/2021; Snow-free 2/24/2021
- Instruments: DJI Phantom 4, Snow depth probe, Trimble GPS, Total station

Study Area

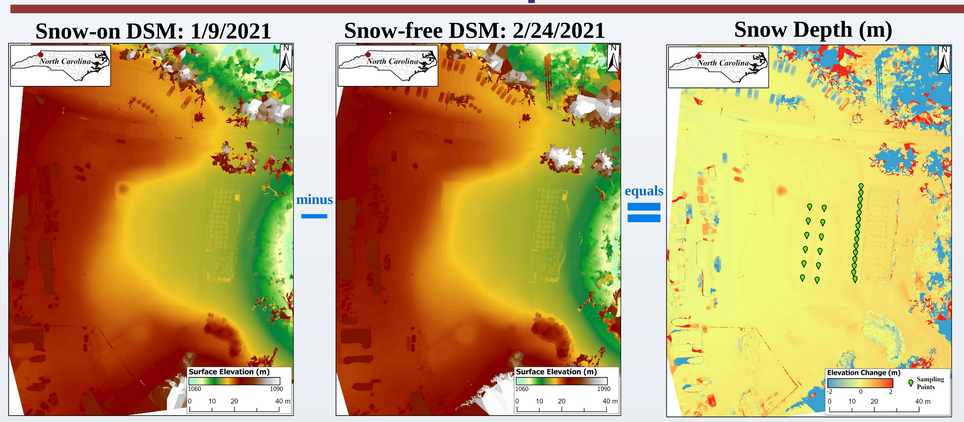
Snow-on: 1/9/2021



Snow-free: 2/24/2021

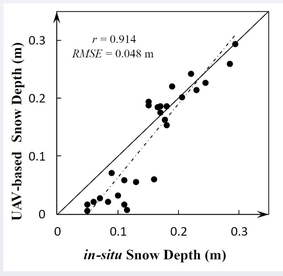
Derive Snow Depth with Drone-based DSM

Snow-on DSM: 1/9/2021 minus **Snow-free DSM: 2/24/2021** equals **Snow Depth (m)**



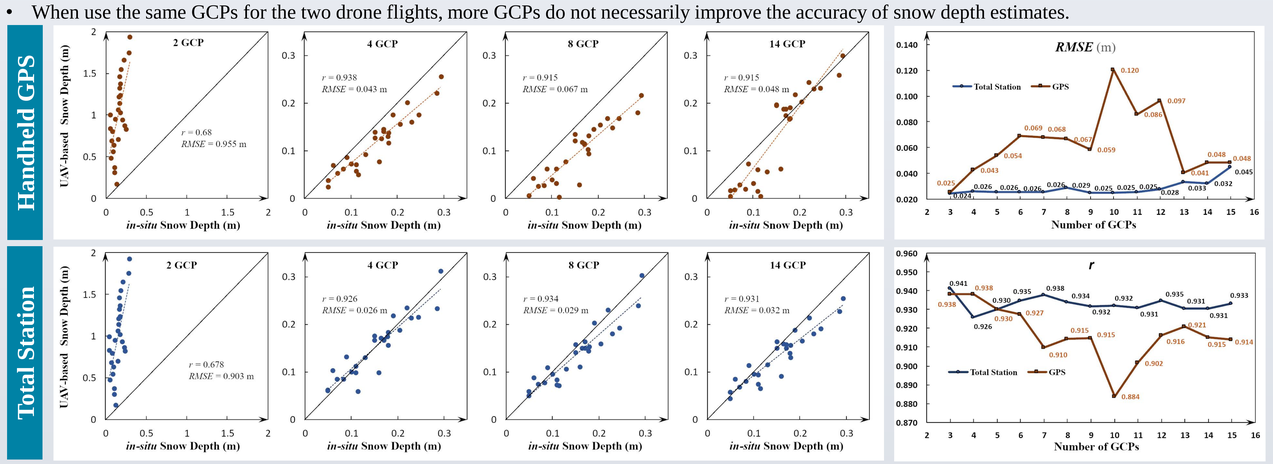
GCPs: handheld low-accuracy GPS

Survey Strategy: the same 15 GCPs were used for the two drone flights



Apply Same GCPs to the Generation of Snow-on and Snow-off DSMs

- In general, the GCPs collected by total station result in higher accuracy of snow depth estimates than the GCPs collected by handheld GPS.
- When GCPs collected by handheld GPS were used to generate DSMs, the accuracy of snow depth estimates is heavily influenced by individual GCPs.
- When use the same GCPs for the two drone flights, more GCPs do not necessarily improve the accuracy of snow depth estimates.

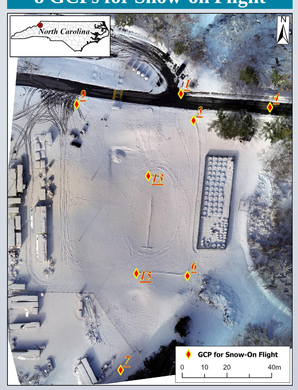


Apply Different GCPs to the Generation of Each of Two DSMs

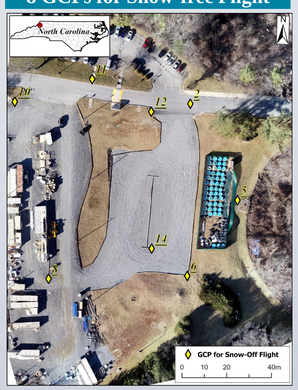
4 GCPs for Snow-on Flight

4 GCPs for Snow-free Flight

8 GCPs for Snow-on Flight

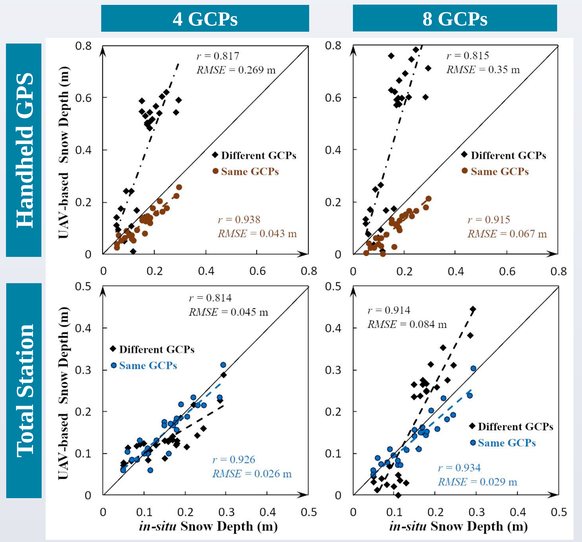


8 GCPs for Snow-free Flight



Apply Different GCPs

- When different GCPs were used for each of the two flights, the accuracy of snow depth estimates is clearly lower than the accuracy of snow depth estimates using the same GCPs for the two flights.
- When different GCPs were used for each of the two flights, the GCPs with more accurate elevation significantly improve the accuracy of snow depth estimates.



Conclusion

- ❑ The accuracy of GCP elevation has heavy influence on the accuracy of drone-based snow depth estimates. The more accurate the GCP elevation, the higher accuracy of drone-based snow depth can be achieved.
- ❑ Applying the same GCPs to the generation of both snow-on and the snow-off DSMs can significantly increase the accuracy of drone-based snow depth estimates.
- ❑ The results suggest that when GCPs with high elevation accuracy are not available (e.g., when in a field with an ordinary handheld GPS unit), a better strategy for deriving accurate drone-based snow depth is to use the same GCPs for the generation of both snow-on and snow-off DSMs.

References

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