Assessing topographic mapping accuracy using aerial drone with terrestrial and submerged aquatic ground control points

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Introduction

Rivers, streams, and riparian habitats are dynamic systems providing significant ecological services but have been affected by dams and many other human impacts.

Figure 1. Aerial image of upper Bellamy impoundment study site

Key Physical Assessments:

- Channel Geomorphology
- Sediment Transport
- Habitat Changes

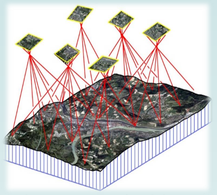


Figure 4. Example of drone aerial image tie-points and image overlap

Drone Technology:

- Cost Effective
- High Resolution
- Optimize Workflows
- Minimize Safety Risk

Conventional Surveying Techniques:

- Labor Intensive
- Time Consuming
- Safety Concerns

Figures 2 and 3. Examples of conventional surveying equipment

This study aims to investigate whether incorporating submerged ground control points (GCPs) into drone surveys is a simple, effective way to increase accuracy of instream topographic models.

Methods

Project Site: Bellamy River, Dover, NH

- Establish land-based and submerged GCP locations
- Complete conventional survey of GCPs and checkpoints using a total station
- Fly drone and collect imagery
- Post-process 4 model iterations
- Accuracy analysis in GIS

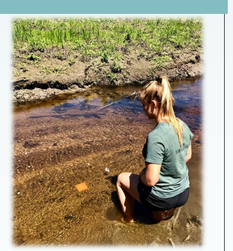


Figure 6. Example of a submerged aquatic ground control point

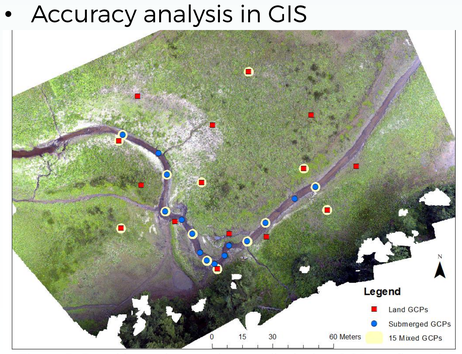
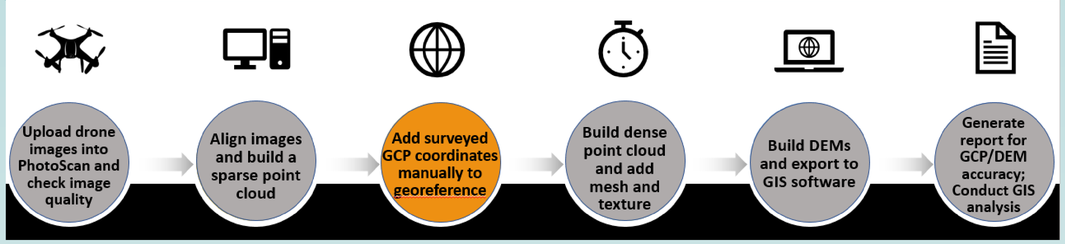


Figure 5. Resulting orthomosaic map displaying GCP configurations

Figure 7. Drone flight of upper Bellamy impoundment site, July 11, 2019

Drone Workflow



Drone Model Iterations:

30 Mixed GCPs — 15 Submerged GCPs
15 Land GCPs — 15 Mixed GCPs

Results

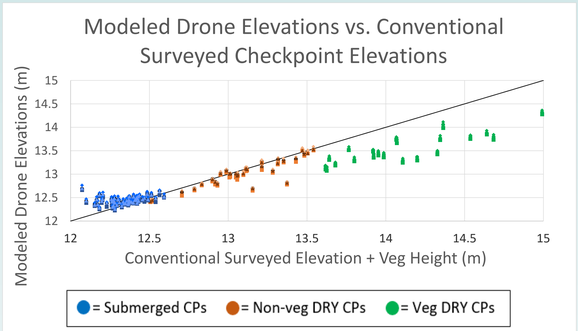


Figure 8. (above) Comparison of modeled drone elevations vs conventionally surveyed checkpoints. Dry, vegetated checkpoints of higher elevations (i.e. reeds) are underestimated by the drone.

Table 1. (below) PhotoScan accuracy assessment
Ground Control Points RMSE
X-Longitude, Y-Latitude, Z-Elevation

GCPs	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)
30 Mixed	2.13	2.06	4.89	5.72
15 Land	1.64	1.66	2.05	3.11
15 Submerged	2.21	2.17	4.34	5.33
15 Mixed	1.82	1.46	4.74	5.28

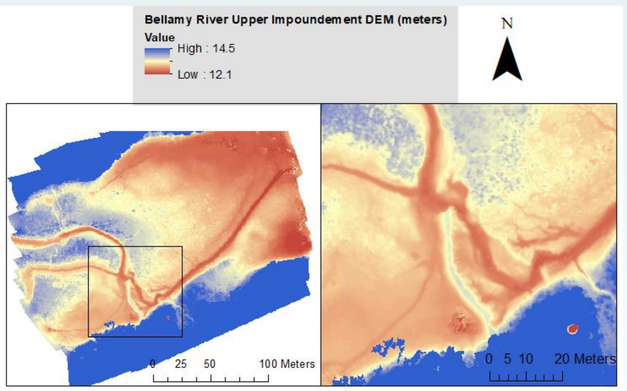


Figure 9. (right) Resulting DEM using 30 mixed GCP model iteration with enlarged view highlighting channel intersection and beaver dam

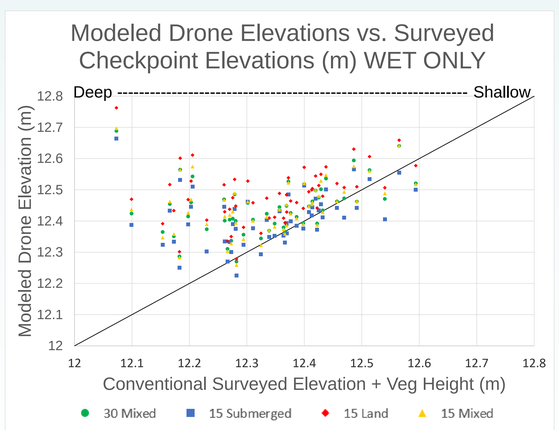
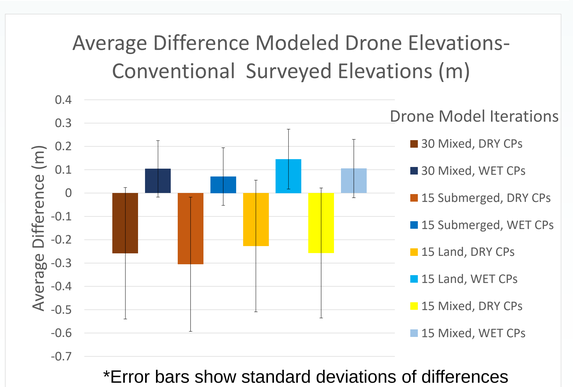


Figure 10. (above) Modeled drone elevations versus conventionally surveyed checkpoints in submerged areas only. Elevations of deeper submerged checkpoints are greatly overestimated by drone (up to +0.7 m).



*Error bars show standard deviations of differences

Figure 11. (right) Average difference of modeled drone elevations to conventional survey elevations. 15 submerged GCP configuration results in highest accuracy of submerged mapping.

Discussion

- Drone models created in this study resulted in GCP accuracies ranging from 1.5 cm to 6.0 cm
- Greatest inaccuracy of drone models are found in the Z direction, especially in deeper water areas
- Although including submerged GCPs in drone workflows may enhance modeling of bathymetry, significant compromises occur in surrounding terrestrial areas mapped
- This study supplements findings from Agüera-Vega et al (2017) that 15 is the most efficient number of GCPs for georeferencing. However, our model using all 30 GCPs did not increase overall accuracy.

Conclusions/Future Work

- Researchers should consider placing GCPs in areas of highest importance to their study for optimal drone mapping accuracy
- Other factors contributing to drone error in modeling submerged areas, such as water turbidity levels, light conditions, light reflectance, air humidity, and water turbulence should be further explored
- Dietrich's refraction correction (Dietrich 2017) will be applied in Cloud Compare to adjust for drone's overestimation of submerged points

Acknowledgements

Special thanks to the UNH Hamel Center and the SURF program for funding this project. Thank you to Dr. Kevin Gardner for serving as my SURF mentor, and to the UNH Environmental Research Group for use of drone and surveying equipment for this project.
Support for this project is provided by the National Science Foundation's Research Infrastructure Improvement NSF #IIA-1539071. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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