Accuracy Assessment of Snow Depth Measurements in Forested and Agricultural Environments by an Unmanned Aerial Vehicle (UAV) LiDAR

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ABSTRACT

With recent advances in remote sensing techniques, UAV LiDAR has been increasingly used to monitor snow depths. Due to its improved accuracy and high penetration ability through canopy gaps, LiDAR techniques have proven to be effective in capturing snow depth even in forested environments. However, it is not without errors. In general, careful system calibration and post-processing can reduce some navigational errors and errors posed by the system. In snow depth mapping or any survey-grade mapping, it is important to assess if the remaining error is within the accepted sensor accuracy and/or if further refinements (e.g. strip aligning) are required. This study demonstrates the procedure implemented to assess the absolute and relative accuracy of LiDAR data (system calibrated and post-processed) in two paired deciduous forested and agricultural sites and a boreal forested site in southern Quebec. We used circular-shaped elevated (1 m diameter) and square-shaped flat (0.5 x 0.5 m^2) ground control points (GCPs) in summer and winter surveys to assess the absolute accuracy of the LiDAR point cloud. Relative accuracy was determined by a repeat flight over one surveying block. Estimated absolute and relative errors were within the accepted accuracy of the LiDAR (~5 cm and ~7 cm, respectively). Validation of LiDAR-derived snow depths with ground-based measurements was also in good agreement. We also tested BayesStripAlign 2.17 software to correct the misalignment between overlapping flight strips over vertical (z) direction. However, the results suggest that the significant improvement of relative accuracy between overlapping flight strips made by this technique was at the cost of the absolute accuracy of LiDAR data. This phenomenon is also confirmed by the degraded performance of strip-aligned snow depths with ground-based measurements. In conclusion, in this study, the system calibrated, post-processed point cloud is adequate to provide reasonable centimeter-level accurate snow depth maps.

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