Evaluation of LiDAR Snow Depth Estimates from Portable Consumer Devices and their Application Towards Advancing Citizen Science

FRASER KING[1] AND RICHARD KELLY[1]

ABSTRACT

Snow is a critical contributor to the regional water-energy budget with impacts to springtime flooding and water resource management practices. *In situ* snow depth measurements are incredibly useful reference observations as inputs to hydrologic models and reanalysis. However, Canadian measurement station counts have declined by over 70% since 1990, and the current observational network is sparsely distributed with large unobserved gaps. Laser altimetry (LiDAR – Light Detection and Ranging) is a remote sensing technique that has demonstrated promising results at mapping changes in snow depth, but the expense of purchasing and transporting traditional LiDAR equipment has generally limited their use to large institutions. We demonstrate that the combination of vertical cavity surface-emitting lasers (VCSELs) and single-photon avalanche diodes (SPADs) installed on the iPhone 12 Pro comprise a portable LiDAR sensor that acts as a real-time, handheld measurement instrument for accurately observing changes in snow depth. Two independent field experiments in southern Ontario found that the iPhone LiDAR measurements were able to accurately capture daily changes in snow depth when compared to *in situ* snow ruler measurements. *In situ* and LiDAR comparisons of $n = 50$ days at measurements site 1 exhibit a correlation of $r \approx 0.98$, mean absolute bias less than 1 mm, and an RMSE of approximately 5 mm. Similar positive agreement was also noted at the second field study site for $n = 10$ measurements over the same period. As LiDAR sensors become ubiquitous components of future smartphones, their capabilities as portable snow depth measurement instruments cannot be understated. The high accuracy of the LiDAR sensor suggests that a mobile application could be developed which allows users to quickly scan a snow-covered area before and after a snowfall event and consequently use this data to aid in filling current observational gaps through a citizen science-based approach of measuring local-scale changes in snow depth.

[1] Department of Geography & Environmental Management, University of Waterloo, Waterloo, ON, Canada