Evaluation of Snow Depth Derived from Ground Penetrating Radar on Canadian Subarctic Lakes

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ABSTRACT

In subarctic regions, a realistic representation of the snow depth and distribution on lake ice is important for climate change studies and lake ice modeling. Small changes in the surface-atmosphere energy balance could alter snowpack dynamics and can have a profound impact on lake ice thickness and formation. Snow depth observations on lake ice are sparse and mostly restricted to point measurements. Therefore, developing accurate methods of estimating the snow depth and spatial distribution across lake ice is important, but challenging. In this study, we applied an algorithm to estimate snow depths on lake ice using ground penetrating radar (GPR) two-way travel-times (TWT) over four small subarctic freshwater lakes (Landing Lake, Long Lake, Finger Lake, Vee Lake), located north of Yellowknife, Northwest Territories. High spatial resolution (~9 cm) observations along transects totaling ~38km were acquired using a 1000 MHz sensor. We derived the snow depth by automatically picking the GPR TWT of the snow-ice interface and combining it with a measured average snow density for each lake. The accuracy of the derived snow depth is assessed using a snow depth GPS magnaprobe. Limited by the spatial accuracy of the snow depth magnaprobe and GPR, a 6 m radius was applied around each *in situ* snow depth measurement, where it is confirmed the GPR estimated the snow depth with an $R^2 = 0.62$, mean bias error of -0.33 cm, and root mean square error of 1.72 cm, on average for all four lakes. The results showed that this algorithm can improve the accuracy of snow depth and distribution retrieval data on lake ice which is essential for climate change studies and the lake ice modeling community.

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