Snow Depth Mapping on Canada's Sub-Arctic Lakes

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ABSTRACT

Snow accumulation on lake ice influences ice growth and the timing of ice melt due to snow's highly insulative and reflective properties. Therefore, the lake ice thickness is expected to vary spatially over the lake due to heterogeneous snow accumulation from wind redistribution and snowpack metamorphism. Although lake ice models perform well in simulating ice thickness, they are very sensitive to the value of snow depth and density. However, mapping snow depth spatially over the entire lake has presented challenges partially due to poorly known lake ice surface elevation and snow variability. Current snow depth and ice surface elevation observations are sparse and mostly restricted to point measurements. This study used a multi-sensor approach utilizing Ground Penetrating Radar (GPR) and Remotely Piloted Aircraft System (RPAS) acquisitions collected over Canadian sub-Arctic lakes to map the distributed snow depth during the 2021 to 2022 winter season. The resulting one-meter spatial resolution snow depth maps were compared to *in situ* observations, showing a relative error of 33% in December 2021 (RMSE = 4.15 cm, Bias = -1.52 cm), and 14% in March 2022 (RMSE = 5.87 cm, Bias = 4.64 cm). Using this multi-sensor approach, we have developed a framework for mapping the snow depth distributed on lakes. Simultaneously collecting ice thickness observations furthers understanding of the spatial relation between snow depth, ice thickness, and ice surface elevation. The findings of this research can lead to an improved understanding of snow and lake ice interactions, which is essential for northern communities' safety and well-being.

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