**Lake Snow Depth Mapping using a Multi-Sensor Approach**

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Snow accumulation on lake ice plays a crucial role in influencing ice growth and the timing of ice melt due to the insulative and reflective properties of snow. In Canada's sub-Arctic, lakes cover 40% of the land surface and are typically frozen for 6-10 months of the year. However, changes to the snowpack are being observed, leading to a decline in lake ice duration and thickness. While lake ice models perform well in simulating ice thickness, they are sensitive to the value of snow depth and density as inputs and mapping lake snow depth spatially has been challenging partially due to poorly known lake ice surface elevation and snow variability. Current snow depth and ice surface elevation observations are sparse and restricted to point measurements. Remote sensing of surface elevation using optical techniques such as structure from motion and LiDAR has gained widespread popularity for mapping snow depth over land but are limited in their ability to accurately map snow depth over lake ice as the elevation of the ice surface as it is constantly changing. To overcome these limitations, a multi-sensor approach utilizing Ground Penetrating Radar (GPR) and Remotely Piloted Aircraft System (RPAS) acquisitions were used to map the distributed lake snow depth during the 2021-2022 winter season in Canadian sub-Arctic. GPR acquisitions were automatically post-processed to derive the ice surface elevation and subtracted from the snow surface elevation processed from RGB imagery collected using RPAS. The resulting one-meter spatial resolution snow depth maps were compared to in-situ snow depth 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). Over the winter season, the baseline ice surface elevation decreased by ~50 cm, and ice surface variability increased from ~8 cm to 13 cm. By incorporating RPAS and GPR, the spatial variability of the ice surface and snow surface can be obtained and used to accurately map the snow depth over lake ice. Using this multi-sensor approach, we have developed a framework for mapping the snow depth distributed over lakes. Simultaneously collecting ice thickness observations further enhances understanding of the spatial relation between snow depth and ice thickness. The findings of this research can lead to an improved understanding of snow and lake ice interactions, which is essential for the safety and well-being of northern communities.