Using Machine Learning to Estimate Snow Cover from Ground Surface Temperature Measurements

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ABSTRACT

In Arctic and Subarctic landscapes, snow cover can significantly affect ground temperatures and can lead to changes in permafrost distribution. Snow cover and snow thickness are highly heterogeneous through time and space leading to profound local scale variability and difficulties in representing snow across large areas. Owing to the high cost of snow monitoring equipment, many researchers working in the north use ground surface temperature (GST) loggers distributed across an area to estimate snow characteristics, including snow onset and melt dates. However, existing methods for evaluating snow cover from GST data depend on arbitrary thresholds selected by trial and error. Such thresholds can vary widely between sites due to snow cover variability, as well as within sites depending on vegetation cover and soil composition. This study established a novel method using supervised machine learning (random forest) to predict daily snow cover from GST data, removing the need for local threshold selection. This random forest method was built using simulations derived from the Northern Ecosystem Soil Temperature model that were calibrated at the Subarctic Pinware River Hills (PRH) research basin in coastal Labrador. Estimates of snow cover derived via application of the machine learning algorithm to GST data were compared against snow thickness observations at PRH from multiple co-located sources. Our results indicate that this novel method more accurately predicts total snow cover days, snow onset, and melt dates compared to previously used threshold-based approaches. These early results show tremendous potential for reducing error in deriving snow cover information from GST observations and can enable more reliable snow cover estimation across larger areas and differing ecotypes. Insights gained from this research could be applied to the large networks of GST observations currently being assembled for the northern circumpolar regions to improve snow cover modeling.

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