Precipitation Phase from Atmospheric Model Improves Snowfall Estimates across Canada

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ABSTRACT

The precipitation phase at the surface strongly affects the evolution of the snowpack and the associated hydrological response in cold regions. Snowpack models deployed at continental scales usually rely on ground-based precipitation-phase partitioning methods (PPMs) that use near-surface air temperature and humidity. These PPMs still ignore atmospheric conditions in the layers aloft, thus limiting their ability to predict the precipitation phase at the surface.

In this study, gridded phase estimates from a variety of ground-based and atmospheric-based PPMs are evaluated against manual observations of precipitation phase collected across a large region covering Canada and the northern United States (US) from September 2019 to June 2020. The hourly gridded phase estimates are derived from the High Resolution Deterministic Prediction System (HRDPS) running at 2.5-km grid spacing over the region of interest. Two atmospheric-based PPMs are considered from HRDPS: (i) the Bourgouin method relying on the vertical profile of air temperature and (ii) the Latent Heat Release Method (LHRM) relying on the vertical profile of wet-bulb temperature. Ground-based PPMs of various complexity are also considered: (i) single air temperature thresholds, (ii) snowfall fraction depending on air temperature, and (iii) humidity-based PPMs.

Results show that humidity-based PPMs provides the best estimate of precipitation phase at continental scales among the ground-based PPMs. In particular, they outperform PPMs relying only on air-temperature in the mountainous regions of western Canada and US. In these regions, LHRM offers the best performances thanks to its ability to forecast the height of the snow level. In eastern Canada and US, humidity-based PPMs tends to overestimate the occurrence of snowfall. Atmospheric-based PPMs improves these estimates since they can account for the presence of a melting layer above the surface, often encountered during precipitation events in these regions. These results encourage the use of atmospheric-based PPM for snowpack modeling across Canada.

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