Snowdrift permitting simulations across the Cordillera

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The melt of seasonal snowcovers in cold regions provides downstream regions with a critical supply of freshwater, impacting ecosystems and human society. Snowmelt provides over 60% of river flow from the Canadian Rockies, and blowing snow and avalanching redistribute winter snowfall into deep drifts and deposits that support mountain glaciers, can persist through summer in mountain headwaters, and can maintain streamflow through periods of low precipitation. Large-scale modelling of these regions has been problematic due to coarse spatial resolutions in models that neglected key land-surface features (e.g., windswept ridges) and poor or non-existent representation of key cold-regions processes. Snowdrift-resolving models (1 m – 250 m spatial scales) have been proposed as a way forward to accurately simulate snow dynamics and heterogeneity; however, they can be computationally intractable for large extents.

The Canadian Hydrological Model (CHM) is a multi-physics, multi-scale, spatially distributed model development framework capable of a multi-scale surface discretization. CHM was used to evaluate the possibility of simulating snow redistribution processes over the Western Canadian and Northern US Cordillera (1.3M km^2^) and quantifying the impact of neglecting these processes on simulating late lying snow covers. Research questions were: 1) can a deterministic, non-calibrated snowdrift permitting model be applied to such a large spatial extent? 2) are late lying snowpacks well captured by these methods? 3) what are the possible implications of neglecting redistribution processes for future hydrological simulations? It was found that CHM had good agreement with observed snow-covered area (SCA) derived from satellite observations (r2=0.89), and in snow depths as compared to high-resolution UAV lidar snow depth observations taken at Fortress Mountain Research Basin in the Canadian Rockies (RMSE=1.41 m). A model falsification showed that not including snow redistribution processes missed simulating late lying drifts. This miss resulted in up to 100% errors in late spring and summer SWE presence at the basin and regional scale, demonstrating the clear hydrological importance of including snow redistribution processes in snow hydrology models.