Spatial Patterns of Snow Distribution in the Sub-Arctic

Katrina E. Bennett,[1*] Greta Miller,[1] Robert Busey,[2] Min Chen,[1] Emma R. Lathrop,[1] Julian B. Dann,[1] Mara Nutt,[1] Ryan Crumley,[1] Baptiste Dafflon,[3] Jitendra Kumar,[4] W. Robert Bolton,[2] Cathy J. Wilson,[1] and Stan Wullschleger,[4]

[1]Los Alamos National Laboratory, Earth and Environmental Sciences, Los Alamos, NM;
[2]University of Alaska Fairbanks, International Arctic Research Center, Fairbanks, AK;
[3]Lawrence Berkeley National Laboratory, Berkeley, CA;
[4]Oak Ridge National Laboratory, Oak Ridge, TN

Contact: (kbennett@lanl.gov)
BER Program: ESS
Project: NGEE Arctic
Project Website: https://ngee-arctic.ornl.gov/

The spatial distribution of snow plays a vital role in sub-Arctic and Arctic climate, hydrology, and ecology due to its fundamental influence on the water balance, thermal regimes, vegetation, and carbon flux. However, the spatial distribution of snow is not well understood, and therefore, it is not well modeled, which can lead to substantial uncertainties in snow cover representations. To capture key hydro-ecological controls on snow spatial distribution, we carried out intensive field studies over multiple years for two small (2017-2019, ~2.5 km^2) sub-Arctic study sites located on the Seward Peninsula of Alaska. Using an intensive suite of field observations (>22,000 data points), we developed simple models of spatial distribution of snow water equivalent (SWE) using factors such as topographic characteristics, vegetation characteristics based on greenness (normalized different vegetation index, NDVI), and a simple metric for approximating winds. The most successful model was the random forest using both study sites and all years, which was able to accurately capture the complexity and variability of snow characteristics across the sites. Approximately 86% of the SWE distribution could be accounted for, on average, by the random forest model at the study sites. Factors that impacted year-to-year snow distribution included NDVI, elevation, and a metric to represent coarse microtopography (topographic position index, or TPI), while slope, wind, and fine microtopography factors were less important. The models were used to predict SWE at the locations through the study area and for all years. The characterization of the SWE spatial distribution patterns will be used to validate and improve snow distribution modelling in the Department of Energy's earth system model, and for improved understanding of hydrology, topography, and vegetation dynamics in the sub-Arctic and Arctic regions of the globe.