Bulk Snow Density Retrievals from Passive Microwave Remote Sensing and Automatic Weather Stations in a Tundra Environment

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ABSTRACT

Available methods to monitor snow density are limited spatially and temporally. *In situ* methods require substantial labour and are relatively costly. This research proposes a novel technique to retrieve bulk snow density estimates from passive microwave (PM) remote sensing. A traditional style PM snow water equivalent (SWE) model is rearranged so snow density is the variable of interest instead of snow depth. Daily automatic weather station (AWS) observations are used to parameterize the snowpack in the scene with snow depth and air temperature observations. The Environment and Climate Change Canada AWS in Eureka, Nunavut is chosen to train and validate the algorithm. Snow density records are available for the Eureka site through the Canadian Historical Snow Water Equivalent dataset. Two snowpack models are investigated for this algorithm – a one-layer model (typically used in PM SWE retrievals) and a two-layer model (a slab layer with underlying depth hoar layer). In the two-layer model, 3D gradient descent is used to produce density estimates for each layer, which are then aggregated for a bulk snow density estimate. Climatological analysis of the site provides some prior knowledge of the conditions of the scene, to further control the behaviour of the machine learning (ML) algorithm. These controls are included as components of the ML's cost function (with the PM signal component of standard ML) to introduce temporality, inertia, and logic into the algorithm. Ultimately, this approach could be expanded to retrieve snow density estimates from PM observations over the Northern Hemisphere.

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