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Assessment of dynamic probabilistic methods for mapping snow cover in Québec Canada

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Hydro-Quebec is the leader in electricity production in North America and uses hydraulic resources to generate 97% of its overall production where snow represents 30% of its annual energy reserve. Information on snow cover extent (SC) and snow water equivalent (SWE) is crucial for hydrological forecasting, particularly in Nordic regions where a majority of total precipitations falls as snow. Accurate estimation of the spatial distribution of snow cover variables is required to measure the extent of this resource but snow surveys are expensive due to inaccessibility factors and to the large extent nature of the Quebec geography. Consequently, the follow-up of snowmelt is particularly challenging for operational forecasting resulting in the need to develop a new approach to assist forecasters. For improved understanding of the dynamics of snow melting over watersheds and to generate optimized power production, Hydro-Québec's Research Institute (IREQ) has developed expertise in in-situ, remote sensing monitoring and statistical treatment of such data.

The main goal of this Hydro-Quebec project is to develop an automatic and dynamic snow mapping system providing a daily snow map by merging remote sensing (AVHRR and SSMI) and in situ data. This paper focuses on the work accomplished on passive microwave SSM/I data to follow up snow cover. In our problematic, it is highly useful to classify snow, more specifically during the snowmelt period. The challenge is to be able to discriminate ground from wet snow as it will react as a black body, therefore, adding noise to global brightness temperature.

Two dynamic snow classifiers were developed and tested. For this purpose, channels at 19 and 37 GHz in vertical polarization have been used to feed each model. SWE values from gamma ray in situ stations (GMON) and data snow depth from ultrasonic sensor (SR50) were used to validate the output models. The first algorithm is based on a standard K-mean clustering approach, combined with an ensemble mapping approach. The ensemble was generated from a Monte Carlo method. The second one relies on a probabilistic clustering method based on Bayesian Gaussian mixture models. Mixtures of probability distributions become natural models to represent data sets where the observations may have arisen from several distinct statistical populations.

Each method can provide a map of uncertainty for the ground and the snow classes, which is a huge benefit for forecasters. Initial results have shown the difficulty of mapping the border between the snow and the ground with traditional approaches. In addition, the application of the mixture models reveals the presence of a third class, which seems to characterize the transition zone between snow and soil.