Estimating Snow Water Equivalent (SWE) Using Passive Microwave SSM/I and Active Microwave Radarsat

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1. The Goal of the Study & Location

The goal of this study is to develop a method to retrieve SWE (Snow depth in Great Lakes Area, United States). The method uses passive microwave EASE-GRID SSM/I and active microwave RADARSAT1 C-Band SAR. Previous studies have shown satisfactory correlations between SSM/I and SWE. On the other hand, C-Band SAR has shown the good potential for mapping SWE/snow depth too. Passive microwave SSM/I is obtained from Defense Metorological Satellite Program (DMSP) Special Sensor Microwave Imager (SSM/I). These images provide brightness temperature, TB, in different frequencies and polarizations (19 V, 19 H, 22 V, 37 V, 37 H, 85 V, 85 H). Active microwave C-Band SAR is obtained from CANADIAN satellite RADARSAT1. The landcover image is from USGS online data distribution system.

2. Passive Microwave SSM/I & Active Microwave Radarsat Images

Passive Microwave SSM/I Passive microwave SSM/I is produced by Defense Metorological Satellite Program (DMSP) Special Sensor Microwave Imager (SSM/I). SSM/I data are obtained from National Snow and Ice Data Center in EASE-GRID format (NSIDC). The data are produced in daily temporal resolution and 25km spatial resolution for all the channels.

Radarsat images Radarsat images are active microwave images in C-Band SAR. The original purpose of launching Radarsat was navigation in Antarctic. But later they showed a potential for snow depth estimating. Radarsat images come in different resolution varying based on type and swath of the image. Left, the ScanSar images of Radarsat, one for winter and one for summer are shown. The spatial resolution is 100 m. The images are processed in PCI Geomatica XPACE. The images are georeferenced to a LANDSAT image of the area. To obtain backscattering value from DN values SARSIGM accompanied with SARINC were applied to each of the images.

3. Land Cover & Estimated SWE Based on GTV (37V-19V)

Landcover image

4. Ground Truth Data: Gauge Measurements and SNODAS SWE

SWE & GTV The retrieved SWE from the GTV. The algorithm tends to underestimate SWE/SD in the area with dense vegetation and forests located below the lake. More than 400 gauges in our the study area are reporting daily snow depth. The data are interpolated and then gridded in 25km resolution to match the EASE-GRID SSM/I data.

5. Neural Networks & Training

Artificial Neural networks have proven their capability in identifying non-linear relationships between various parameters. In this study, we used Neural Networks to identify the relationship between Microwave channels (SSM/I & Radarsat), NDVI, and snow water equivalent (SWE).

6. Estimated SWE by Artificial Neural Network Model

Backscattering Ratio and SWE Estimation The backscattering ratio of summer and winter images is averaged for 1km resolution. The matrix of the averaged DBs along with an NDVI image was used to derive the estimated SWE image. The NDVI can be used as a representative of variety in land cover. The neural network model has two sets of inputs: 1- Backscattering Ratio, 2- NDVI. The network has two hidden layers with 20 neuron for each layer and the output layer includes only one neuron two represent the estimated SWE. The transfer functions for the ANN are ‘tansig’, ‘tansig’, and ‘purelin’ for input, hidden, and output layers successively. Having ‘purelin’ for the output layer transfer function reduces the error and increases the correlation between output and target more than 5 percent.

Adding the NDVI as the second input to the model significantly increase the accuracy of the prediction. The model has a inclination to underestimate the SWE values. This can be due to the fact that C-band SAR estimates SWE based on underlying frozen soil. This effect may not follow the same pattern in our study area especially because of lake’s effect.

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Input Layer Hidden Layer Output Layer

Target

Compare

Output

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