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Estimating the distribution of snow depth via artificial neural networks combined with MODIS snow cover area and ancillary topographic data

Jinliang Hou (1,2) and Chunlin Huang (1,2)

(1) Key Laboratory of Remote Sensing of Gansu Province, Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, Lanzhou,China (jlhours@lzb.ac.cn), (2) Heihe Remote Sensing Experimental Research Station, Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, Lanzhou, China,

Accurately estimate the distribution of snow depth (SD) is particularly difficult in mountainous environments given the complex topography, strong seasonal transition, and scarce observations. Passive microwave snow depth retrievals are too coarse to resolve small-scale terrain-induced variability; Optical sensors have the ability to determine the snow coverage extent at higher spatial resolution but not SD.

By taking advantage of long time moderate-resolution optical sensors (MODIS) fractional snow cover (FSC) data series, the cubic spline interpolation algorithm is used to fill in data gaps caused by clouds in MODIS FSC Products. An innovative method based on multilayer feedforward artificial neural network (ANN) is presented to generate SD at a 500 m spatial resolution. This is trained with back propagation to learn the relationship between SD and FSC, Latitude and longitude, and ancillary topographic (e.g. elevation, slope, aspect) data. In this study, daily snow depth observations at 42 meteorological stationsare chosen to examine the proposed method during 2004 to 2005 snow seasons (from 1 November 2004 to 31 March 2005, 151 days) in northern Xinjiang Province, China. Among them, FSC, Latitude and longitude, and ancillary topographic data extracted from 35 sites are used as input information, and corresponding ground-based SD observations are used as desired output of ANN, thus a total of 151*35 samples are included in the ANN training set; Corresponding data from other 7 sites are used as independent test sample set (151*7 samples) to test the generalization ability of the ANN.

Preliminary experimental results are very encouraging compared with the traditional multiple regression method. The performance evaluation results shows that the ANN derived SD have much higher coefficient of determination (R^2) and lower root-mean-square error (RMSE), with R^2 of 0.89 and 0.88, RMSE of 0.07 and 0.08, the mean absolute error of 2.3 and 2.3 cm for training and test samples, respectively; while R^2 of 0.57 and 0.57, RMSE of 0.14 and 0.15, the mean absolute error of 5.34 and 5.38 cm for the corresponding multiple regression method.