Fractional Snow Cover Mapping from MODIS Data over European Alps by Multivariate Adaptive Regression Splines

Semih Kuter (semihkuter@yahoo.com), Zuhal Akyurek, Gerhard-Wilhelm Weber
Department of Forest Engineering, Cankiri Karatekin University / Institute of Applied Mathematics, Middle East Technical University, Turkey

Spatial extent of snow is a significant variable in hydrological studies as well as in general circulation and weather forecasting models. A frequently encountered challenge in snow mapping is the tradeoff between temporal and spatial resolution of satellite imageries. In order to tackle with this problem, subpixel snow mapping approaches have been applied to low or moderate resolution images. Subpixel methods try to surpass the limitations related with mixed pixel problem inherited in coarse resolution imagery by revealing possible mixtures of land cover classes (i.e., snow, soil, rock, vegetation, water etc.) and defining the area fractions of each cover type within a pixel. MODIS is probably the most frequently used instrument in snow cover mapping at both regional and global scales. Fractional snow cover (FSC) mapping methods applied on MODIS data have evolved from spectral unmixing and empirical NDSI methods to latest machine learning-based artificial neural networks (ANNs). This study is the first endeavor to estimate FSC values from MODIS data by using multivariate adaptive regression splines (MARS). MARS is a state-of-the-art nonparametric regression method that can model nonlinear, complex and high-dimensional data. Total 16 Landsat 7/MODIS image pairs taken over European Alps between March 2000 and April 2003 are used in the analysis. Reference FSC maps are produced by binary classification of higher spatial resolution ETM+ scenes. This binary classification scheme is the equivalent of the original MODIS binary snow mapping algorithm where a pixel is labeled as snow if its NDSI ≥ 0.4 and ETM+ band 4 reflectance > 11% and ETM+ band 2 reflectance ≥ 10%. By calculating the percentage of snow-covered Landsat pixels within a circular area of 500 m radius centered at a MODIS pixel, FSC value for each MODIS pixel is obtained. TOA Reflectance values from MODIS bands 1-7, NDSI, NDVI and land cover classes are used as input. A multilayer feed-forward ANN with one hidden layer trained with backpropagation is also developed. MARS and ANN models are compared on five independent test areas. The MARS model performs better than the ANN model with an average RMSE of 0.1288; whereas the average RMSE of the ANN model is 0.1606. Average training times for MARS and ANN models are 3.54 and 13.43 seconds, respectively. The average time required to estimate FSC values on each test area is almost equal for MARS and ANN, which is less than 2 seconds.