Spatial interpolation of snow water equivalent (SWE) by multivariate regression using surface observations and MODIS satellite data

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Abstract. The Moderate Resolution Imagining Spectrometer (MODIS) has provided snow covered area (SCA) estimates on a daily basis since 2000. We used the composite 8-day MODIS SCA product to map the snow water equivalent (SWE) distribution for northern Colorado and southern Wyoming (39.5 to 41.5 N latitude and 105.5 to 106.5 W longitude), from March through July for four years. These maps were developed using SWE data from 55 snow telemetry (SNOTEL) stations located in this area using multivariate regression interpolation with topographic variables and canopy density. Using the interpolated SWE and SCA data we developed depletion curves for each year that relate the total SWE volume in the basin to SCA. These simulated depletion curves were compared to station-based SWE-SCA depletion curves for three specific SNOTEL stations, in particular Joe Wright, Dry Lake, and Dead Man Hill. Station based SWE-SCA curves use 4 to 9 km² areas for calculating SCA.

For the SWE interpolation across the study domain, the goodness of fit metrics were comparable or better than those in the literature (mean $R^2 = 0.63$, mean Nash-Sutcliffe (NSE) = 0.64, mean mean absolute error (MAE) = 84.31mm, and mean root mean squared error (RSME) = 120.35mm). Each of the station-based depletion curves was different, and curves also varied annually. While the bulk depletion represented the average of multiple stations, it overestimated the SWE at low accumulation sites (e.g., Dry Lake) while it underestimated higher accumulation sites (e.g., Joe Wright). All of the SNOTEL stations are located in forested areas, but surrounding pixels for some stations are above treeline, where SCA tends to be lost sooner; thus those pixels may be less representative of regional snow conditions.