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Spatial upscaling of in-situ soil moisture measurements based on MODIS-derived apparent thermal inertia

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Soil moisture is a vital variable in the terrestrial water cycle. It is very important to obtain soil moisture for many applications. Soil moisture acquired by remote sensing, land surface modeling, and data assimilation must be evaluated against in-situ measurements before used, but a procedure should be performed to upscale the point-scale measurements to the grid-scale or footprint-scale. In this study, a new upscaling algorithm is developed by introducing MODIS-derived apparent thermal inertia (ATI). Firstly, a functional relationship between the station-averaged soil moisture and the pixel-averaged ATI is constructed. Secondly, this relationship is used to calculate the representative soil moisture time series at a certain spatial scale. Last, the Bayesian linear regression is applied to obtain the upscaled area-averaged soil moisture by using in-situ measurements as independent variables. The algorithm is validated using a network of moisture sensors on the Tibetan Plateau. The results indicate that it can effectively obtain the area-averaged soil moisture, reducing the root mean square error (RMSE) from 0.023 before upscaling to 0.013 after upscaling over the virtual satellite footprint. Finally, the algorithm is implemented to the 100 km $\times$ 100 km grid box where the network is installed, and the temporal pattern of the upscaled soil moisture agrees with the hydro-meteorological knowledge of this region.