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Estimation of high-resolution soil moisture using machine learning, satellite observations and ground measurements. A case study in a hilly agricultural region

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Remotely sensed data from microwave sensors have been successfully used to retrieve soil moisture on a global scale. In particular, passive and active microwave sensors with large footprints can observe the same location with a (sub-)daily frequency, but typically are characterized by spatial resolutions in the order of tens of km. Therefore, such coarse scale products can accurately capture the temporal dynamics of soil moisture but are inadequate in providing spatial details. However, several agricultural and hydrological applications could greatly benefit from soil moisture observations with a sub-kilometer spatial resolution while preserving a daily revisit time.

Here, we present a framework for downscaling coarse resolution satellite soil moisture products (ASCAT and SMAP) to high spatial resolution. In particular, we build robust relationships between remotely sensed soil moisture and ancillary variables on soil texture, topography, and vegetation cover. Such relationship is built through Random Forest regressions, trained against in-situ measurements of soil moisture. The proposed approach is developed and tested in an agricultural catchment equipped with a high-density network of in-situ sensors. Our results show a strong consistency between the downscaled and the observed spatio-temporal patterns of soil moisture. Furthermore, including a proxy of vegetation cover in the Random Forest regressions results in considerable improvements of the downscaling performance. Finally, if only limited training data can be used, priority should be given to increase the number of sensor locations to adequately cover the spatial heterogeneity, rather than expanding the duration of the measurements.

Future research will focus on including additional ancillary variables as model predictors, e.g. Land Surface Temperature or backscatter, and on applying the downscaling framework to other regions with similar environmental and climatic conditions.