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Bringing coarse scale satellite-derived soil moisture to the field scale using data from low-cost sensors. A case study in a small Austrian catchment

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Monitoring soil moisture at both high spatial and temporal resolution is necessary for a number of applications, ranging from crop irrigation to landslide prediction. Microwave remote sensing has been successfully used to estimate soil moisture globally. Radiometers and scatterometers typically observe the same location with a daily frequency, thus providing adequate temporal coverage. However, most of the soil moisture products currently available are characterized by a coarse spatial resolution ($\sim$ 25-50 km). Clearly, such products lack the ability to monitor the variability occurring at much finer scales ($\sim$ 1-100 m), which is mainly controlled by topography, soil texture and vegetation. The aim of this study is to estimate soil moisture at sub-field resolution by combining coarse scale remotely sensed data and ancillary information.

We employ data collected from dozens of low-cost sensors measuring soil moisture and incoming solar radiation, the latter being then converted to fAPAR. The sensors are installed in the Hydrological Open Air Laboratory (HOAL), a small agricultural catchment (66 ha) characterized by complex topography and different land cover, located in Petzenkirchen (Austria). Additional ancillary data, i.e. soil texture and a Digital Elevation Model (DEM), are available for the study area. We use a Random Forest regression model to estimate high-resolution soil moisture using the following input features: soil texture, topographic indices (derived from the DEM), fAPAR, and the average catchment soil moisture computed from the low-cost sensor measurements. The latter, which represents the ideal scenario where satellite-derived soil moisture perfectly agrees with ground observations, is then replaced with a coarse scale remotely sensed product (ASCAT SM, 25 km spatial resolution), and results compared. The accuracy of the model(s) is evaluated with a cross-validation.

Results show the overall good accuracy of the estimated high-resolution soil moisture as compared to in-situ measurements. Clearly, using the catchment average as input provides better results than using coarse scale satellite-derived data. In fact, the latter might not be fully representative for the study area due to the large spatial mismatch between satellite footprint and catchment size. The inclusion of a proxy of vegetation dynamics (i.e. fAPAR) in all experiment setups improves the accuracy of the estimated soil moisture; indeed fAPAR is the second most important variable for the model, following average catchment or remotely sensed soil moisture.

Overall, the increasing availability of low-cost sensors providing reliable measurements allows to develop catchment-specific models to estimate soil moisture at sub-field resolution. These can provide valuable information both in the spatial and temporal domain (e.g. for locations and periods where sensors are not installed, respectively). Further analysis will assess the suitability of using remotely sensed dataset for monitoring vegetation development (e.g. LAI, NDVI, etc.), and the possibility to employ such model for similar catchments.