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UAS Based Soil Moisture Downscaling Using Random Forest Regression Model

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Soil moisture (SM) is an essential element in the hydrological cycle influencing land-atmosphere interactions and rainfall-runoff processes. High-resolution mapping of SM at field scale is vital for understanding spatial and temporal behavior of water availability in agriculture. Unmanned Arial Systems (UAS) offer an extraordinary opportunity to bridge the existing gap between point-scale field observations and satellite remote sensing providing high spatial details at relatively low costs. Moreover, this data can help the construction of downscaling models to generate high-resolution SM maps. For instance, random Forest (RF) regression model can link the land surface features and SM to identify the importance level of each predictor.

The RF regression model has been tested using a combination of satellite imageries, UAS data and point measurements collected on the experimental area Monteforte Cilento site (MFC2) in the Alento river basin (Campania, Italy) which is an 8 hectares cropland area (covered by walnuts, cherry, and olive trees). This area has been selected given the number of long-term studies on the vadose zone that have been conducted across a range of spatial scales.

The coarse resolution data cover from Jan 2015 to Dec 2019 and include SENTINEL-1 CSAR 1km SM product, 1km Land surface temperature and NDVI products from MODIS and 30m thermal band (brightness temperature), red and green band data (atmospherically corrected surface reflectance) from LANDSAT-8, and SRTM DEM from NASA. High-resolution land-surface features data from UAS-

mounted optical, thermal, multispectral, and hyperspectral sensors were used to generate high-resolution SM and related soil attributes.

It is to note that the available satellite-based soil moisture data has a coarse resolution of 1km while the UAS-based land surface features of the extremely high resolution of 16cm. We deployed a two-step downscaling approach to address the smooth effect of spatial averaging of soil moisture, which depends on different elements at small and large scale. Specifically, different combinations of predictors were adopted for different scales of gridded soil moisture data. For example, in the downscaling procedure from 1km resolution to 30m resolution, precipitation, land-surface temperature (LST), vegetation indices (VIs), and elevation were used while LST, VIs, slope, and topographic index were selected for the downscaling from 30m to 16cm resolution. Indeed, features controlling the spatial distributions of soil moisture at different scale reflect the characteristics of the physical process: i) the surface elevation and rainfall patterns control the first downscaling model; ii) the topographic convergence and local slope become more relevant to reach a more detailed resolution. In conclusion, the study highlighted that RF regression model is able to interpret fairly well the spatial patterns of soil moisture at the scale of 30m starting from a resolution of 1km, while it is highlighted that the second downscaling step (up to few centimeters) is much more complex and requires further studies.

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Keywords: soil moisture, downscaling, Unmanned Aerial Systems, random forest, HARMONIOUS