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Retrieval of soil water capacity at intra-plot scale using a data driven approach by combining unsupervised classification, crop modeling and Sentinel-2 remote sensing

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Water fluxes and soil properties are notoriously hard to estimate because of their high-spatial variability. The inversion of agronomic models in water stress conditions can deliver accurate retrieval of soil parameters at local and basin scales. In this work we provide a methodology for regional scale inversion of the soil water capacity at an intra-plot resolution using high resolution optical data provided by satellites such as Sentinel2, Formosat2 or SPOT5. The methodology relies on intra-field unsupervised classification of remotely-sensed GAI followed by bayesian retrieval to reduce the number of inverted/simulated entities and observational noise. Several configurations for the unsupervised classification are tested to retain the soil heterogeneity while increasing retrieval efficiency using multi-temporal images. The identified classes are compared in a multi-annual framework. A prior per-field model calibration is also applied to account for cultivar variability and constrain the vegetation module of the crop model. Only a restricted set of vegetation parameters are used in this step. The inversion scheme is applied on sunflower fields chosen for their proneness to exhibit water stress in the agro-climatic context of southern France. We use a sum of temperature and FAO-56 based crop model (SAFYE) in a bayesian inversion algorithm (DREAM). The results show that the use of unsupervised classification reduces the computational needs significantly (x100) while preserving the identifiability of soil classes and providing a good accuracy (RMSE Available Water Content = 11mm, RMSE evapotranspiration = 0.56 mm/day and RMSE soil moisture = 0.02 - 0.07 m3/m3). This study provides new insights on the significant efficiency of the combined use of machine learning, physical modeling and remote sensing data to solve agronomic problems.