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Irrigation management though the assimilation of multiple remote sensing data into an energy-water-crop model

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The agricultural sector is the biggest and least efficient water user, accounting for around 80% of total water use in South Europe, which will be further impacted by climate change in the incoming years. Precision agriculture tools are then needed to increase water use efficiency.

Here, the proposed system couples together remotely sensed land surface temperature (LST), leaf area index (LAI) and ground soil moisture data (SM) with a pixel wise crop-water-energy balances model, for improving irrigation management. The SAFY (Simple Algorithm for Yield) crop model has been fully coupled with the energy water balance FEST-EWB model, exchanging in a double direction the LAI evolution in time from SAFY, which is used by FEST-EWB for evapotranspiration computation, while FEST-EWB provides soil moisture (SM) and LST to SAFY model for constraining crop growth.

A data assimilation framework, based on the Ensemble Kalman filter approach, is implemented to reduce the requirements for parameters calibration, either for soil assimilating satellite LST and for crop growth using LAI. This framework allows overcoming the issues related to crop exposure to shocks due extreme events non-reproducible by the model alone, as well as nutrient lack, crops hybrids or precise amount of irrigation water.

The FEST-EWB-SAFY model has been applied in two Irrigation Consortia in the North and South of Italy which differ for climate and agricultural practices, using data from Sentinel2, Landsat 7 and 8 satellites. The model has then been validated in specific fields where ground measurements of evapotranspiration, soil moisture and crop yields are available.

Overall, the results suggested that the under-calibrated model estimates of LST, LAI, SM and yield are enhanced through the assimilation of satellite data, suggesting the potential for improving irrigation management at both field and Irrigation Consortium scales.