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Benefits of Sentinel-1 backscatter assimilation to improve land surface model irrigation estimates in Europe

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Irrigation has been applied by humans for as long as they have been cultivating plants. Nowadays, the amount of water used for agricultural purposes is rising because of an increasing food demand. However, this human influence on the water distribution on land is typically not, or poorly, parameterized in regional and larger-scale Land Surface Models (LSM). Satellite-based microwave observations indirectly observe irrigation, when they sense the entire integrated soil-vegetation system. The optimal integration of fine-scale modeling and satellite observations using data assimilation (DA) is promising to detect irrigation and possibly improve the estimation of irrigation amounts.

This work was realized in the framework of the European Space Agency (ESA) Irrigation+ project. The main aim of this study was to test potential improvements in irrigation simulation due to the assimilation of 1-km Sentinel-1 backscatter data into a system composed by the Noah-MP LSM, equipped with a sprinkler irrigation scheme, and a backscatter operator represented by a Water Cloud Model (WCM), as part of the NASA Land Information System (LIS). The calibrated WCM was used as an observation operator in the DA system to map model surface soil moisture and Leaf Area Index (LAI) into backscatter predictions and, conversely, map observation-minus-forecast residuals in backscatter back to updates in soil moisture and LAI through an Ensemble Kalman Filter (EnKF). Two separate DA experiments were realized using backscatter data at VV and VH polarizations. The system was tested at two irrigated sites, located in the Po Valley (Italy) and in northern Germany.

Results confirm a stronger link between the backscatter VV with soil moisture and larger updates in the vegetation state variables when using the VH polarization. The backscatter DA introduced both improvements and degradations in soil moisture, evapotranspiration and irrigation estimates. The spatial and temporal scale had a large impact on the outcomes, with more contradicting results for a detailed analysis at the plot scale. Above all, this study sheds light on the limitations resulting from a poorly-parameterized sprinkler irrigation scheme which prevents large

improvements in the irrigation simulation due to the ingestion of Sentinel-1 data and points out to future developments needed to improve the system.