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Estimation of root-zone soil moisture by combining the FAO-56 dual crop coefficient model with land surface temperature and vegetation index data for irrigation management

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By controlling the plant transpiration, the root-zone soil moisture (RZSM) plays a crucial role in meteorological modeling and hydrological studies over vegetated areas. In agriculture, RZSM can be used to detect the onset of crop water stress to trigger irrigations. The crop water requirements have been commonly estimated from FAO-56 dual crop coefficient (FAO-2Kc) model by simulating evapotranspiration (ET) and its two main components: soil evaporation (E) and plant transpiration (T). FAO-2Kc is a water balance model driven by meteorological forcing variables and the water supply (precipitation and irrigation) to simulate the soil water availability for ET. Given that the main limitation of FAO-2Kc for operational irrigation management over large areas is the unavailability (over most irrigated areas) of irrigation data, this study investigates the feasibility to constrain the FAO-2Kc RZSM from land surface temperature (LST) and vegetation index (VI) data. In practice, the vegetation and soil temperatures retrieved from LST/VI data are used to estimate the FAO-2Kc vegetation stress coefficient (Ks) and soil evaporation reduction coefficient (Kr), respectively. The methodology proposes to retrieve irrigation amounts and dates from LST-derived estimates and precipitation only and then to estimate the RZSM on a daily basis at the field scale. The modeling and remote sensing combined approach is tested over a wheat crop field in central Morocco by using ground-based measurements along the agricultural season. The total irrigation depth (67 mm) is correctly estimated and is very close to the actual effective irrigation (69.8 mm) applied by the farmer. Daily RZSM is estimated with an R2 value of 0.68 and a RMSE value of 0.034 m3 m-3 by forcing FAO-2Kc using the retrieved irrigation (from LST/VI data and precipitation only). Since spaceborne LST data are currently not available at both high-spatial and high-temporal resolution, a sensitivity analysis is finally undertaken to assess the potential and applicability of the proposed methodology to temporally-sparse thermal data.