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Assimilation of cosmic-ray neutron counts for updating of soil moisture and soil properties with application to irrigation scheduling

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The soil moisture is a good indicator of water stress during the irrigation scheduling. The cosmic-ray probes can measure the soil moisture at an intermediate scale through the interaction between the land surface neutron counts and soil moisture profile. This study investigated the assimilation of neutron measurements by a cosmic-ray probe for updating root zone soil moisture as well as soil properties (sand fraction, clay fraction and organic matter density) in Community Land Model (CLM) using the Local Ensemble Transform Kalman Filter (LETKF) for the real time optimal scheduling of irrigation. In order to map the soil moisture into measured neutron counts, the new COSMIC model is used as the non-linear measurement operator. The background uncertainties in CLM forecast were described by the uncertain model forcings and soil properties in the assimilation.

Two groups of synthetic scenarios were studied for the optimization of real-time irrigation scheduling for fields of citrus trees: for the first group of scenarios soil texture was systematically finer with more clay and less sand than in the reference ("Wet bias") whereas for the second group of scenarios soil texture was coarser with less clay and more sand than in reality ("Dry bias"). The irrigation requirements were calculated based on the water deficit method using as input updated soil moisture contents after assimilation of neutron counts. For each of these two groups of scenarios seven scenarios, in which different combinations of ensemble weather forecast, data assimilation, soil properties optimization, were defined to estimate the irrigation requirement.

Results show that the joint soil moisture and soil properties updating results overall in the best estimation of soil moisture, actual evapotranspiration and irrigation requirement. The characterization of soil moisture and soil properties can be improved after assimilation of cosmic-ray neutron counts. The biased soil properties result in wrong irrigation requirement. If soil parameters are also updated, the sensible and latent heat flux characterization is improved for biased soil properties.