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Improving Soil Moisture and Temperature Profile and Surface Turbulent Fluxes Estimations in Irrigated Field by Assimilating Multi-source Data into Land Surface Model

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The optimal estimation of hydrothermal conditions in irrigation field is restricted by the deficiency of accurate irrigation information (when and how much to irrigate). However, the accurate estimation of soil moisture and temperature profile and surface turbulent fluxes are crucial to agriculture and water management in irrigated field. In the framework of land surface model, soil temperature is a function of soil moisture - subsurface moisture influences the heat conductivity at the interface of layers and the heat storage in different layers. In addition, soil temperature determines the phase of soil water content with the transformation between frozen and unfrozen. Furthermore, surface temperature affects the partitioning of incoming radiant energy into ground (sensible and latent heat flux), as a consequence changes the delivery of soil moisture and temperature. Given the internal positive interaction lying in these variables, we attempt to retrieve the accurate estimation of soil moisture and temperature profile via assimilating the observations from the surface under unknown irrigation.

To resolve the input uncertainty of imprecise irrigation quantity, original EnKS is implemented with inflation and localization (referred to as ESIL) aiming at solving the underestimation of the background error matrix and the extension of observation information from the top soil to the bottom. EnKS applied in this study includes the states in different time points which tightly connect with adjacent ones. However, this kind of relationship gradually vanishes along with the increase of time interval. Thus, the localization is also employed to readjust temporal scale impact between states and filter out redundant or invalid correlation. Considering the parameter uncertainty which easily causes the systematic deviation of model states, two parallel filters are designed to recursively estimate both states and parameters.

The study area consists of irrigated farmland and is located in an artificial oasis in the semi-arid region of northwestern China. Land surface temperature (LST) and soil volumetric water content (SVW) at first layer measured at Daman station are taken as observations in the framework of data assimilation. The study demonstrates the feasibility of ESIL in improving the soil moisture and temperature profile under unknown irrigation. ESIL promotes the coefficient correlation with in-situ measurements for soil moisture and temperature at first layer from 0.3421 and 0.7027 (ensemble simulation) to 0.8767 and 0.8304 meanwhile all the RMSE of soil moisture and temperature in deeper layers dramatically decrease more than 40 percent in different degree. To verify the reliability of ESIL in practical application, thereby promoting the utilization of satellite data, we test ESIL with varying observation internal interval and standard deviation. As a consequence, ESIL shows stabilized and promising effectiveness in soil moisture and soil temperature estimation.