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Estimation of Soil Water Balance Components Based on Continuous Soil Moisture Measurement and Inversed Richards Method in an Irrigated Agricultural Field of a Desert Oasis

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An accurate assessment of soil water balance components (*SWBCs*) is necessary for improving irrigation strategies in any water-limited environment. However, quantitative information of *SWBCs* is usually challenging to obtain, because none of the components (i.e., irrigation, drainage, and evapotranspiration) can be easily measured under actual conditions. Soil moisture is a variable that integrates the water balance components of land surface hydrology, and the evolution of soil moisture is assumed to contain the memory of antecedent hydrologic fluxes, and thus can be used to determine *SWBCs* from a hydrologic balance. A database of soil moisture measurements from six experimental plots with different treatments in the middle Heihe River Basin of China was used to test the potential of a soil moisture database in estimating the *SWBCs*. We first compared the hydrophysical properties of the soils in these plots, such as vertical saturated hydraulic conductivity (K_s) and soil water retention features, for supporting the *SWBC* estimations. Then we determined evapotranspiration and other SWBCs through a method that combined the soil water balance method and the inverse Richards equation (a model of unsaturated soil water flow based on the Richards equation). To test the accuracy of our estimation, we used both indirect methods (such as power consumption of the pumping irrigation well, and published SWBCs values at nearby sites), and the water balance equation technique to verify the estimated *SWBCs* values, all of which showed a good reliability of our estimation method. Finally, the uncertainties of the proposed methods were analyzed to evaluate the systematic error of the *SWBC* estimation and any restrictions on its application. The results showed significant variances among the film-mulched plots in both the cumulative irrigation volumes (652.1~ 867.3 mm) and deep drainages (170.7~364.7 mm). Moreover, the unmulched plot had remarkably higher values in both cumulative irrigation volumes (1186.5 mm) and deep drainages (651.8 mm) compared with the mulched plots. Obvious correlation existed between the volume of irrigation and that of drained water. However, the ET demands for all the plots behaved pretty much the same, with the cumulative ET values ranging between 489.1 and 561.9 mm for the different treatments in 2016, suggesting that the superfluous irrigation amounts

had limited influence on the accumulated ET throughout the growing season because of the poor water-holding capacity of the sandy soil. This work confirmed that relatively reasonable estimations of the *SWBCs* in coarse-textured sandy soils can be derived by using soil moisture measurements; the proposed methods provided a reliable solution over the entire growing season and showed a great potential for identifying appropriate irrigation amounts and frequencies, and thus a move toward sustainable water resources management, even under traditional surface irrigation conditions.