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Linking evapotranspiration and infiltration dynamics to variations in soil moistures and changes in groundwater levels

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Variations in soil moisture and changes in groundwater levels are affected by water uptakes due to evapotranspiration (ET) and water inputs of rainfall infiltration (RI). Both ET and RI dynamics play important roles in unsaturated zone processes and land-atmosphere interactions. In addition to surface water exchanges, the latent heat flux of ET also represents land surface response (i.e. energy exchanges) to dryness in atmosphere and available water in subsurface. Infiltrated water contributes to the increase of soil moisture from surface toward deeper soil layers and subsequently recharges groundwater as described in most hydrological models and land process models. The key aspects are how ET and RI dynamics determine the propagation of drying/wetting in soil moisture to changes in groundwater levels consequently. This study presents two-year continuous observations of soil moisture with high temporal and vertical resolutions, along with measurements of solar radiation, wind speed, relative humidity, air temperature, soil temperature, pore water pressure, and groundwater levels, over a grass pilot site to investigate effects of ET and RI dynamics on variations in soil moisture and changes in groundwater levels. Persistent groundwater gradients, due to flat terrain, were observed that limiting influences of horizontal groundwater flows. Averaged groundwater levels were at -6 m. During rainfall events, responses of groundwater levels have two different regimes. At the early stage, the increase of near surface hydrostatic pressures due to infiltrated water triggered fast responses in rising groundwater levels. Responses of groundwater levels were 9.5 hours in average earlier than the increase of soil moisture at -400 cm. The second effect is the direct recharge through infiltrated water. This hypothesis is supported by changes in groundwater temperature were slower than changes in soil moisture at -400 cm. Similarly, we found declines in groundwater levels were earlier than decreases in soil moisture at -400 cm. Declines in groundwater levels at the early stage reflect fast responses to accumulated and slow decrease in soil moisture by ET. This hypothesis is supported by differences between groundwater inflow and outflow velocities were insignificant in drying process. Accumulated drying or wetting in soil moisture will induce fast responses in groundwater levels explained by changes in near surface hydrostatic pressure caused by ET or RI, respectively. Neither hydrological models nor land process models available up to dates are capable of capturing such fast response, which may lead to overestimated or underestimated effects of ET and RI dynamics in variations of soil moisture and changes in groundwater levels. Further investigations are needed to test robustness of our hypotheses of fast responses in groundwater levels to changes in soil moisture.