Effect of vapor transport on soil evaporation under different soil textures and water table depths in an arid area of northwest China

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Abstract

In arid area, the liquid water and water vapor states in soil profiles and fluxes at the upper and bottom interfaces are extremely complex due to heterogeneity of soil textures and the driving forces of heat and matrix potential. In this study, we used Hydrus-1D to simultaneously simulate liquid water, water vapor, and heat transports based on the observed data of atmosphere, soil and groundwater at three soil profiles in an arid area of northwest China. Comparison and contrast of the observed and simulated results at the three soil profiles show that there are diurnal vapor entry and outlet fluxes at the dry surface layer (DSL) of 30 cm in the summer season. The vapor entry and re-evaporation account for about 14% of annual precipitation for the heterogeneity soil profile with a mean groundwater depth of 210 cm. Because of limited soil moisture in this arid area, vapor induced re-evaporation occurs shortly in the early daytime. Moreover, the extent of vapor entry, condensation and re-evaporation strong depends on soil properties and water table depths. The lower water table produces the drier soil surface, allowing more vapor entry, condensation and re-evaporation. Whereas the finer grained soil layers benefits the vapor fixation to produce zero fluxes that substantially inhibit the upward liquid water and vapor fluxes, and thereby reduces soil evaporation. The reduced soil evaporation correspondingly decreases the capillary effect on phreatic evaporation, proven by that soil evaporation decreases slowly with decline of water table and the large extinct depth of phreatic evaporation for the finer grained soil profiles. The estimated extinct depth is 180 cm and 200 cm for the soil profiles consisting of silt loam and loamy sand, respectively, much larger than 100 cm of the sandy soil profile. Additionally, as water table is higher and lower than the extinct depth, the models neglecting the vapor - heat function could respectively overestimate and underestimate soil evaporation.

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