EGU2020-4368
https://doi.org/10.5194/egusphere-egu2020-4368
EGU General Assembly 2020

Soil hydrology and crop evapotranspiration modeling in a dry agricultural region of the Tibet Plateau

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Vapor flow plays major role in soil–atmosphere water exchange in arid regions, and can be partly driven by airflow, but its impact is often neglected. In this study, a two-year field experiment was conducted in a dry agricultural region on the Tibet Plateau (TP) to investigate the effect of airflow on soil hydro–thermal dynamics and evapotranspiration modeling under three cultivation patterns: ridge-furrow planting with black-film mulching (RM), flat planting with black-film mulching (FM), and flat planting with no mulching (FN). An airflow-incorporated, based on Philip and de Vries (PdV) model, STEMMUS (Simultaneous Transfer of Energy, Mass and Momentum in Unsaturated Soil) was adopted. Considering objective's (*Lycium barbarum* L.) sparse canopy, excluding Penman-Monteith (P-M) algorithm which already employed in STEMMUS, Shuttleworth-Wallace (S-W) model was incorporated into STEMMUS model to simulate evapotranspiration rate. Validation results showed that STEMMUS reliably captured the behaviors of observed soil moisture, soil temperature, and evapotranspiration (index of agreement d = 0.4, 0.6 and 0.5 for soil moisture under FN, FM and RM; 0.9 for soil temperature under three treatments; 0.6, 0.6 and 0.8 for evapotranspiration under FN, FM and RM; 0.6, 0.5 and 0.5 for evaporation under FN, FM and RM). Incorporating airflow extended the 0-1 m soil profile temperature modeling precision (d value improved 1%), led to the maximum 5% gap of soil moisture at 20 cm depth, and 3.7 mm d^{-1} gap of daily evapotranspiration compared to pattern without airflow under non-mulched treatment. However, the impacts of airflow are weak under mulching treatments (the gaps between including/excluding airflow modeling were within 0.1% for soil moisture, 0.1 ▯ for soil temperature and 0.1 mm d^{-1} for evapotranspiration). Furthermore, the effect of coupling airflow became significant when water inputs (precipitation/irrigation) were higher than 18 mm. Incorporating S-W model successfully improved evapotranspiration modeling precision, with d values increased by 0.5% and 1% for FM and FN respectively in evapotranspiration simulation, increased by 0.5%, 6.4% and 2.2% for RM, FM and FN respectively in evaporation simulation. The results here provide insights into the role of airflow in soil hydrology modeling in arid and semi-arid regions.