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Ecohydrological evolution model on riparian vegetation in hyper-arid regions and its validation in the lower reach of Tarim River

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The evolution of the ecohydrological system driven by external climatic forcing and internal feedbacks between vegetation and hydrology, which is more remarkable in arid and semi-arid regions, has attracted substantial research attention in recent years. To examine critically the state-of-the-art assumptions and dynamic equations used in the evolution study of an ecohydrological system, the rule of proceeding from simplicity to complexity should be followed. The riparian vegetation ecohydrological system in hyper-arid regions (e.g., the lower Tarim River) can serve as a starting point given its simplicity, which has been seldom examined before in terms of system evolution. Further, the water transfer practice from 2000 to 2006 in the lower Tarim River serves as a valuable prototype experiment for model validation. This is because the remarkable changes in groundwater and vegetation in the area have taken place within a shorter period and thus can be observed easily. In the present study, the Ecohydrological evolution model on Riparian Vegetation in hyper-arid regions (ERV model) was proposed by coupling groundwater movement and vegetation dynamics. In the ERV model, the groundwater table serves as a critical feedback variable which determines the vegetation dynamics (colonization and mortality) and is determined by vegetation transpiration other than groundwater movement. The monitored groundwater table by wells and satellite-observed vegetation coverage from the Moderate Resolution Imaging Spectroradiometer (MODIS) are used for model validation. The simulation results show the good performance of the ERV model with uncalibrated parameters. It was also calibrated manually using a multi-objective method, and the fine-tuned parameters are close to the uncalibrated ones, indicating the robustness of the model. The analysis shows further that the increased evapotranspiration is substantially due to the water transfer and thus the vegetation growth, which implies the importance of ecohydrological coupling for long-term hydrological modeling.