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Modeling the effect of flood and drip irrigation on groundwater recharge

Sandra Pool[1,2], Félix Francés[3], Alberto Garcia-Prats[3], Cristina Puertes[3], Manuel Pulido-Velázquez[3], Carles Sanchis-Ibor[4], Mario Schirmer[1,5], Hong Yang[2,6], and Joaquín Jiménez-Martínez[1,7]
[1]Eawag, Swiss Federal Institute of Aquatic Science and Technology, Department Water Resources and Drinking Water, Dübendorf, Switzerland
[2]Eawag, Swiss Federal Institute of Aquatic Science and Technology, Department Systems Analysis, Integrated Assessment and Modelling, Dübendorf, Switzerland
[3]Universitat Politècnica de València, Research Institute of Water and Environmental Engineering (IIAMA), Valencia, Spain
[4]Universitat Politècnica de València, Valencian Center for Irrigation Studies, Valencia, Spain
[5]University of Neuchâtel, Centre of Hydrogeology and Geothermics (CHYN), Neuchâtel, Switzerland
[6]University of Basel, Department of Environmental Science, Basel, Switzerland
[7]ETH Zürich, Department of Civil, Environmental and Geomatic Engineering, Zürich, Switzerland

Irrigation modernization, here defined as the replacement of traditional flood irrigation systems by pressurized drip-irrigation technology, has been widely promoted with the aim to move towards a more sustainable use of freshwater resources in irrigated agriculture. However, the scale sensitivity of irrigation efficiency challenged the predominantly positive value attributed to irrigation modernization and asked for an integrated evaluation of the technological change at various scales. The aim of this study is therefore to contribute to an improved understanding of the hydrological functioning in a landscape under irrigation modernization. We used local field observations to propose a regional scale modeling approach that allowed to specifically simulate the difference in water balance as a function of irrigation method and crop type. The approach focused on the modification of the spatial input data and had therefore the benefit of being relatively independent of the final choice of the hydrological model. We applied the proposed approach to the semi-arid agricultural area of Valencia (Spain), where regional information about the use of irrigation technologies and irrigation volumes at farm level were available. The distributed hydrological model Tetis was chosen to simulate the daily water balance from 1994 to 2015 for an area of 913 km^2 at a spatial resolution of 200 m. Model simulations were based on a random selection of parameter values that were subsequently evaluated in a multi-objective calibration framework. Multiple process scales were addressed within the framework by considering the annual evaporative index, monthly groundwater level dynamics, and daily soil moisture dynamics for evaluation. Simulation results were finally analyzed with a focus on groundwater recharge, which is of particular interest for environmental challenges faced within the study area. Simulation results of groundwater recharge for the entire agricultural area indicated a considerable variability in annual recharge (values from 112 mm up to 337 mm), whereby recharge was strongly controlled by annual rainfall volumes. Annual recharge in flood-

irrigated areas tended to exceed annual recharge in drip irrigated-areas except for years with above average rainfall volumes. The observed rainfall dependency could be explained by the fact that recharge in drip-irrigated areas almost exclusively occurred during rainy days, whereby a few heavy rainfall events could produce the majority of annual recharge. Our results indicated interesting differences but also commonalities in groundwater recharge for flood and drip irrigation, and therefore emphasized the importance of explicitly considering irrigation technology when modelling irrigated agricultural areas.