Sensitivity analysis of water balance components with the Noah-MP and WRF-Hydro models

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The accurate simulation and partitioning of the water balance components is important for the simulation of hydrological processes and the interaction between the land and the atmosphere. The objective of this study is to identify the model parameters and parameterization options that impact the most the water balance components modelled with the Noah-MP land surface model coupled to the WRF-Hydro hydrological model. The water balance components are runoff and total evapotranspiration (ET), comprised of evaporation, transpiration and interception. Three types of different parameterization options and 12 model parameters were tested and the sensitivity of the model output was investigated for two consecutive hydrological years and for 31 watersheds in the Troodos mountains of Cyprus, in the Eastern Mediterranean. A baseline configuration, based on initial estimates of model parameters from previous literature and suggested default values, of the Noah-MP and WRF-Hydro model system was found to systematically overestimate the total streamflow of the 31 watersheds, with the median runoff coefficient equal to 0.4 compared to the observed value of 0.2. Consistent with the streamflow overestimation, the ratio of total ET to total precipitation was underestimated, with a value of 0.5 compared to the value of 0.8 from local observations. The sensitivity analysis revealed that specific parameters can substantially modify the amount of simulated streamflow and ET. The bedrock drainage parameter, hydraulic conductivity and soil porosity can each reduce or increase streamflow and ET up to 20% on average. Among the vegetation parameters and model parameterization options, the change of the dynamic vegetation option, the use of the Jarvis-based stomatal conductance model, instead of the Ball-Berry model, and the simulation of nocturnal transpiration can each increase ET by about 20%, and thus reduce the overestimation of total streamflow. The findings of this sensitivity analysis can be used to configure the Noah-MP and WRF-Hydro models in order to improve the simulation of the water balance of the studied area and other areas with similar hydroclimatic characteristics.