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Testing the performance of a one-way coupled atmospheric-hydrologic model for the simulation of past extreme events over Cyprus

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Coupled atmospheric-hydrologic models have been continuously improved during the last decade and they are considered a robust tool for investigating feedbacks of hydrologic processes in the atmosphere. However, there are few studies on the evaluation of the hydrologic output of these models when forced with observed rainfall and even fewer when forced with modelled precipitation. This study's objectives were: (i) to calibrate the one-way coupled WRF-hydro model for simulating extreme events in Cyprus with observed precipitation; and to evaluate the model performance when forced with WRF-downscaled (1 x 1 km^2) re-analysis precipitation data (ERA-Interim). Extreme rainfall events that occurred in January 1989 and November 1994 were modeled. For both events, 15 days were calibrated and evaluated over 22 watersheds with areas varying from 5.4 to 98.2 km^2. The model was forced with both observed and WRF-modelled precipitation at a 1-hour time step. The applied model version (version name/code) allows spatially distributed values for model factors controlling rainfall partitioning, saturated hydraulic conductivity, and deep drainage. Optional routines (lake/reservoir and baseflow) were activated too. Calibration was performed manually, following a trial and error procedure, on five parameters (the rainfall partitioning coefficient, the reference hydraulic conductivity parameter, the retention-depth routing factor, the overland-roughness routing factor, soil depth). The performance of WRF-Hydro was evaluated on daily streamflow.

In five watersheds (Xeros, Peristerona, Akaki, Agios Onoufrious and Pedieos), Nash-Sutcliffe Efficiencies (NSE) larger than 0.4 were obtained by calibration on both events. The WRF-modelled rainfall, evaluated on observed daily data on a 1 x 1 km^2 pixel base, showed an average NSE of 0.71 and 0.42 and a percentage bias of -9.6% and 4.4% for the events of 1989 and 1994, respectively. Nevertheless, hydrologic simulations of the two events with the calibrated WRF-Hydro and the modelled rainfall returned negative streamflow NSE values on all watersheds. However, the streamflow volumes (15-day totals) for simulations forced with the observed and with the modelled rainfall were comparable. These results indicate that a small shift in time or space of modelled rainfall, in comparison with observed precipitation, can strongly modify the hydrologic response of small watersheds to extreme events. Thus, the calibration of hydrologic models for small watersheds depends on the availability of observed rainfall with high temporal and spatial resolution. The results also show that the practical application of hydrologic forecasting for small watersheds is limited. However, the use of modelled precipitation input data will remain important for studying the effect of future extremes on flooding and water resources.