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Setting up an atmospheric-hydrologic model for seasonal forecasts of water flow into dams in a mountainous semi-arid environment (Cyprus)

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Due to limited rainfall concentrated in the winter months and long dry summers, storage and management of water resources is of paramount importance in Cyprus. For water storage purposes, the Cyprus Water Development Department is responsible for the operation of 56 large dams total volume of 310 Mm^3) and 51 smaller reservoirs (total volume of 17 Mm^3) over the island. Climate change is also expected to heavily affect Cyprus water resources with a 1.5%-12% decrease in mean annual rainfall (Camera et al., 2016) projected for the period 2020-2050, relative to 1980-2010. This will make reliable seasonal water inflow forecasts even more important for water managers. The overall aim of this study is to set-up the widely used Weather Research and Forecasting (WRF) model with its hydrologic extension (WRF-hydro), for seasonal forecasts of water inflow in dams located in the Troodos Mountains of Cyprus. The specific objectives of this study are: i) the calibration and evaluation of WRF-Hydro for the simulation of stream flows, in the Troodos Mountains, for past rainfall seasons; ii) a sensitivity analysis of the model parameters; iii) a comparison of the application of the atmospheric-hydrologic modelling chain versus the use of climate observations as forcing. The hydrologic model is run in its off-line version with daily forcing over a 1-km grid, while the overland and channel routing is performed on a 100-m grid with a time-step of 6 seconds. Model outputs are exported on a daily base. First, WRF-Hydro is calibrated and validated over two 1-year periods (October-September), using a 1-km gridded observational precipitation dataset (Camera et al., 2014) as input. For the calibration and validation periods, years with annual rainfall close to the long-term average and with the presence of extreme rainfall and flow events were selected. A sensitivity analysis is performed, for the following parameters: partitioning of rainfall into runoff and infiltration (REFKDT), the partitioning of deep percolation between losses and baseflow contribution (LOSS_BASE), water retention depth (RETDEPRTFAC), overland roughness (OVROUGHRTFAC), and channel manning coefficients (MANN). The calibrated WRF-Hydro shows a good ability to reproduce annual total streamflow (-19% error) and total peak discharge volumes (+3% error), although very high values of MANN were used to match the timing of the peak and get positive values of Nash-Sutcliffe efficiency coefficient (0.13). The two most sensitive parameters for the modeled seasonal flow were REFKDT and LOSS_BASE. Simulations of the calibrated WRF-Hydro with WRF modelled atmospheric forcing showed high errors in comparison with those forced with observations, which can be corrected only by modifying the most sensitive parameters by at least one order of magnitude.

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