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Sensitivity analysis, calibration and validation of TOPLATS on three Mediterranean catchments

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Hydrological models are complex and powerful tools commonly used by policy makers and water agency managers. To provide managers with the best possible operative tools, models have to be fully understood in their complexity, and have to be properly tested for specific locations, catchment scales and climate conditions. This study presents a complete analysis of the performance of a hydrological model (TOPLATS) on three catchments located in Navarre (northern Spain). This investigation aims to achieve three goals, (1) to identify relevant parameters influencing the main hydrological processes taking place and interacting within the catchments; (2) to implement an optimization routine for parameter calibration; and (3) to compare different calibration/validation strategies

This research focuses on the performance of daily discharge simulations by using the lumped version of TOPLATS. This model has its basis on the TOPMODEL concept which divides the catchment into saturated and non-saturated areas, according to local topography. It also includes a Soil-Vegetation-Atmosphere Transfer scheme (SVAT), which allows its use in a continuous mode. The model has been applied in three catchments ranging in size from 1.5 km2 (La Tejería) to 258 km2 (Cidacos) and 733 km2 (Arga). Simulations have been carried out for a 12 years (2000 – 2012) period. For the sensitivity analysis seven parameters were analyzed, five of them related to soil properties while the remaining two are part of the TOPMODEL concept. The Morris screening method was first explored (with just 40 model runs) and next, the more complex Sobol sensitivity analysis was applied (with 4096 model runs). Both provide an estimation of the individual influence of each parameter and its interaction with other parameters. Once the most relevant parameters were identified, a parameter optimization algorithm (the Powell Method) was added to the model code. This algorithm was programmed to maximize a modified version of the Nash–Sutcliffe efficiency (NSE).

Sensitivity analysis results concluded that both Morris and Sobol methods gave similar results in terms of parameter identification. The bubbling pressure and the TOPMODEL exponential coefficient were identified as the two most influential parameters, being especially relevant on surface runoff, baseflow and evapotranspiration generation. On the other hand, the Brooks – Corey pore size distribution index was the main responsible for average soil moisture content, whereas the saturated hydraulic conductivity appeared as a relevant factor for soil moisture dynamics. The optimization algorithm implemented proved capable of identifying the adequate set of parameter values reaching NSE values on calibration over 0.82 in Tejeria, 0.91 in Cidacos and 0.71 in Arga. Validation NSE values varied between 0.73 and 0.25. Along with the NSE criterion, the absolute discharge error was also minimized to values lower than 5%. It was found that results were highly dependent on the periods selected for either calibration or validation, due to the variability of the precipitation regime from year to year, typical of the local submediterranean humid climate. To overcome this issue, an alternative strategy based on the random allocation of months to calibration and validation sets was implemented. With this random calibration/validation strategy results improved significantly, in particular in Cidacos watershed, which is the one with the most irregular precipitation regime.