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Calibration of a distributed eco-hydrological model using only remotely sensed surface soil moisture.

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Traditional calibration approaches for distributed hydrological models only rely on the discharge at the catchment outlet (Q), including one or more objective-functions (OF). These approaches have limited capabilities and is always necessary to have observed data at the discharge point. To face those limitations, mainly the lack of discharge data or its poor quality, parameter setting could be improved by considering only spatio-temporal state variables for calibration, assuming the study area as ungauged basin. Its main advantage is the spatial coverage of state variables, even though it presents higher uncertainty.
In our case study, an ephemeral Mediterranean catchment of 1513 km2 with a computational grid size of 100 m, the daily historical data was split into two periods: calibration and validation. The SMOS/MODIS remotely sensed surface soil moisture (SM) product was the main spatio-temporal state variable. Its temporal resolution is twice a day and its spatial resolution is 1 km. The average for both daily values were used in this work. We used the distributed eco-hydrological model called TETIS for the generation of simulated Q and the needed spatial state variables.
Here, four different OFs were optimized in calibration step using a mono-objective approach for the SM trying to incorporate the spatial pattern and temporal dynamics. These OFs are: (1) the number of cells with Nash-Sutcliffe Efficiency (NSE) index between observed and simulated SM that are greater than 0.5 divided by the total number of cells; (2) the sum of NSE index between the simulated and observed loadings of the SM divided by the number of principal components; (3) the product of each explained variance times the difference of its simulated and observed loadings; and (4) an expression composed by the sum of the product of the explained variance for each principal component times the NSE index between the simulated and observed loadings divided by the number of principal components. For OF2, OF3 and OF4 the number of principal components that explain at least 95% of the variance were considered.
Each OF was optimized using the algorithm known as Shuffled Complex Evolution - University of Arizona (SCE-UA). In order to complement the study, the following was performed: (1) a temporal validation between observed and simulated flows using the parameters of the best result of each approach and (2) a spatio-temporal validation comparing observed and simulated Leaf Area Index (LAI). These validation tests were carried out for both calibration and validation periods. Also for comparison, it was done a calibration using only Q.
All OFs provided satisfactory results within the calibration period, however the OF4 was selected since it was the most robust in the spatio-temporal index reduction from calibration to validation. In addition, it showed the best value and robustness in the NSE for Q also presenting a good performance in LAI validation for calibration period. Of course, in terms of Q, the calibration using Q is better, but with a higher degradation in validation than using SM and with awful results in the spatial representation of SM and LAI.