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On the use of satellite soil moisture data in spatio-temporal model calibration for Mediterranean catchments.

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The calibration of a hydrological model has traditionally only relied on the temporal variation of the discharge at the control point – being the catchment outlet the most common one. However, discharge at the catchment outlet represents an integrated catchment response and provides thus only limited insight on the lumped behaviour of the catchment. It has been long demonstrated the limited capabilities of such an approach when models are validated at interior points of a river basin. The development of distributed hydrological models and the burst of spatio-temporal data provided by remote sensing appear as key alternative to overcome those limitations. Indeed, remote sensing imagery provides not only temporal information but also valuable information on spatial patterns, which can facilitate a spatial-pattern-oriented model calibration.

However, there is still a lack of how to effectively handle spatio-temporal data when included in model calibration and how to evaluate the accuracy of the simulated spatial patterns. Moreover, it is still unclear whether including spatio-temporal data improves model performance in face to an unavoidable more complex and time-demanding calibration procedure. To shed light in this sense, we performed two different calibration approaches: (1) including temporal and spatio-temporal information and (2) only including temporal information. In both approaches, we calibrated the same distributed hydrological model (TETIS) in the same study areas (four Mediterranean catchments) and used the same multi-objective algorithm (MOSCEM-UA).

For the first calibration configuration, the remote-sensed soil moisture fine-scale SMOS/MODIS product was selected as main spatio-temporal variable because it represents a key component of the catchment water balance. As temporal state variable, we considered the discharge at the outlet. Two objective functions were used: (1) a function composed by the product of the Kling-Gupta Efficiency (KGE) index between simulated and observed soil moisture pixel by pixel and a metric based on the similarity between the first five spatial principal components of simulated and observed soil moisture; and (2) the KGE index between simulated and observed discharge at the catchment outlet. For the second calibration configuration, only the discharge at the catchment outlet was selected as temporal state variable. Again, two objective functions were used: (1) the KGE index between observed and simulated discharge and (2) the balance error between simulated and observed discharge.

Even though the performance of the second calibration approach (only temporal information included) was slightly better than the first one (temporal and spatio-temporal information included), both calibration approaches provided satisfactory and similar results within the calibration period. To put these results into test, we also validated the model performance by using historical data that was not used to calibrate the model. Within the validation period, the first calibration approach obtained better performance than the second one, pointing out the higher reliability of the obtained parameter values when including spatio-temporal data (in this case, remotely sensed soil moisture) in the model calibration.