Multi-objective calibration of a distributed eco-hydrological model using several remotely sensed information

Carlos Echeverría [1,2] (carlos.echeverria@upa.edu.py), Fernando Rivas [1] (ferial@upv.es), María Gonzalez-Sanchis[1] (macgonsa2@upv.es) and Félix Francés García [1] (ffrances@hma.upv.es)

(1) Research Institute of Water and Environmental Engineering, Universitat Politècnica de València - Valencia Spain

(2) Paraguayan-German University (Universidad Paraguayo Alemana) – San Lorenzo – Paraguay

INTRODUCTION

Calibration of eco-hydrological models is difficult to carry on, even more if observed data sets are scarce.

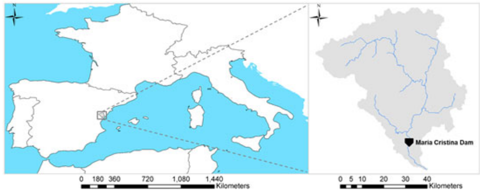
The traditional calibration approach mainly focuses on the temporal variation of the discharge at the catchment outlet point, representing an integrated catchment response and provides thus only limited insight on the lumped behaviour of the catchment. It has been long demonstrated the limited capabilities of such an approach when models are validated at interior points of a river basin.

The development of distributed eco-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.

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 elucidate in this sense, we performed three different multiobjective calibration configurations: (1) including only temporal information of discharges at the catchment outlet (2) including both temporal and spatio-temporal information and (3) only including spatio-temporal information. In the three approaches, we calibrated the same distributed eco-hydrological model (TETIS) in the same study area: Rambla de la Viuda catchment, and used the same multi objective algorithm: MOSCEM-UA. The spatio-temporal information obtained from satellite has been the surface soil moisture (from SMOS-BEC) and the leaf area index (from MODIS).

STUDY AREA

- **Rambla de la Viuda**: ephemeral river
- Approx. area: 1,500 km²
- Semi-arid Mediterranean climate
- Annual mean precipitation: 615 mm
- High precipitation variability
- Two reservoirs (Maria Cristina y Alcora)



METHODOLOGY

Configuration 1

Main state variable: **flow at the catchment outlet** (Q)

Mono-objective calibration: Nash-Sutcliffe Efficiency index (NSE)

Configuration 2

Main state variables: **flow at the catchment outlet** (Q) and **near-surface remotely sensed soil moisture** (SM)

Multi-objective calibration: Nash-Sutcliffe Efficiency (NSE) and Spatio-Temporal Efficiency (STE)

Configuration 3: UNGAUGED BASIN

Main state variables: **remotely sensed leaf area index**(LAI) and **near-surface remotely sensed soil moisture** (SM)

Multi-objective calibration: Spatio-Temporal Efficiency (STE) and Spatio-Temporal Efficiency (STE)

$$NSE = \frac{\sum_{t=1}^{T}\left(Q_{sim}^{t} - Q_{obs}^{t}\right)^2}{\sum_{t=1}^{T}\left(Q_{obs}^{t} - \overline{Q_{obs}}\right)^2}$$

Q_{sim}^{t} is modelled discharge at time t,

Q_{obs}^{t} is observed discharge at time t,

$\overline{Q_{obs}}$ is the mean of observed discharges

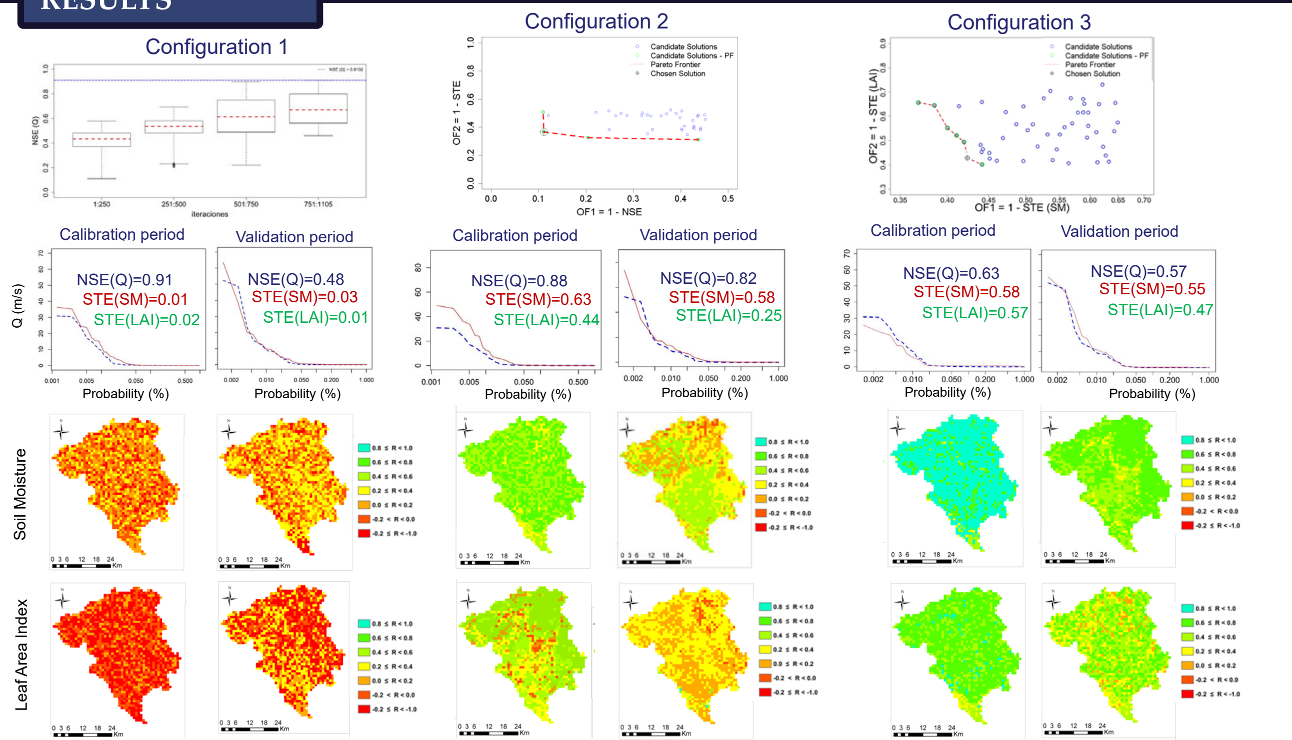
$$STE = \sum_{i=1}^{N} w_i \cdot NSE(load_i)$$

N = number of principal components that explains at least 95% of the variance

$\boldsymbol{w_i}$ = portion of explained variance in the **principal component** *i*

$\boldsymbol{load_i}$ = loadings of the observed and simulated data in the principal component *i*

RESULTS



CONCLUSIONS

1) Multi-objective approaches (configurations two and three) lead to better model performance. The visualization of the **Pareto set** allows to identify whether all objective functions can be simultaneously optimized and pinpoints the optimal set of parameters, assisting thus the parameter selection.

2) The differences among the configurations are more evident during the **validation period**, pointing out which are (configuration two and three) more **robust** and which lead to more **realistic effective parameter values**

3) Even though challenging, spatio-temporal data, in particular near-surface SM and LAI, can be used as relevant source of information to calibrate process-based models.

4) The SMOS/MODIS fine-scale surface soil moisture and MODIS LAI, both remotely sensed data are consistent to carry out calibration process, even more in combination to improve robustness.

5) It is possible to use only remotely sensed information (i.e. configuration three) to calibrate satisfactorily a distributed eco-hydrological model (i.e. TETIS)

ACKNOWLEDGEMENTS AND REFERENCES

1) Brocca, L., Ciabatta, L., Moramarco, T., Ponziani, F., Berni, N., Wagner, W., 2016. Use of Satellite Soil Moisture Products for the Operational Mitigation of Landslides Risk in Central Italy, Satellite Soil Moisture Retrieval: Techniques and Applications. Elsevier Inc. https://doi.org/10.1016/B978-0-12-803388-3.00012-7DIHMA (2001).

2) Un modelo de predicción de crecidas para el SAIH de la Confederación Hidrográfica del Tajo. Informe Final para UTE SAIH TAJO.

3) Li, Y., Grimaldi, S., Pauwels, V.R.N., Walker, J.P., 2018. Hydrologic model calibration using remotely sensed soil moisture and discharge measurements: The impact on predictions at gauged and ungauged locations. J. Hydrol. 557, 897–909. https://doi.org/10.1016/j.jhydrol.2018.01.013

This work has been funded by the Spanish Ministry of Economy and Competitiveness through the research project TETISMED (ref. CGL2014-58127-C3-3-R) and the Paraguayan Funding Program BECAL

Research Group of Hydrological and Environmental Modelling

iiama Research Institute of Water and Environmental Engineering

GOBIERNO DE ESPAÑA MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD