AG-WaMED

Soil and Water Assessment Tool (SWAT) for sustainable water management in the Mediterranean Area

PRIMA
PARTNERSHIP FOR RESEARCH AND INNOVATION
IN THE MEDITERRANEAN AREA

Funded by
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SWAT masterclass – 20/11/2023

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Session 2: Calibration and validation of the SWAT+ model

Outline:

1. Sensitivity analysis
2. Strategies and methods in hydrological model calibration
3. Model calibration and related uncertainties
4. Validation
5. Performance measures and evaluation criteria
6. Calibration and validation of the Robit model exercise

Sensitivity analysis

Sensitivity Analysis

Definition and objective

- A method of identifying the **most important** model parameters that **controls** the output variable (Srinivasan et al., 2012).
- Focus on **sensitive parameters** can result in **better-estimated** parameter values and **reduced uncertainty** (Arnold et al., 2012).

Methods in the SWAT+ Toolbox

- Sobol
- Fourier Amplitude
- Random Balance Designs Fourier Amplitude
- Delta Moment-independent Measure

SWAT+ Toolbox v1.0

Strategies and methods in hydrological model calibration

Calibration phase

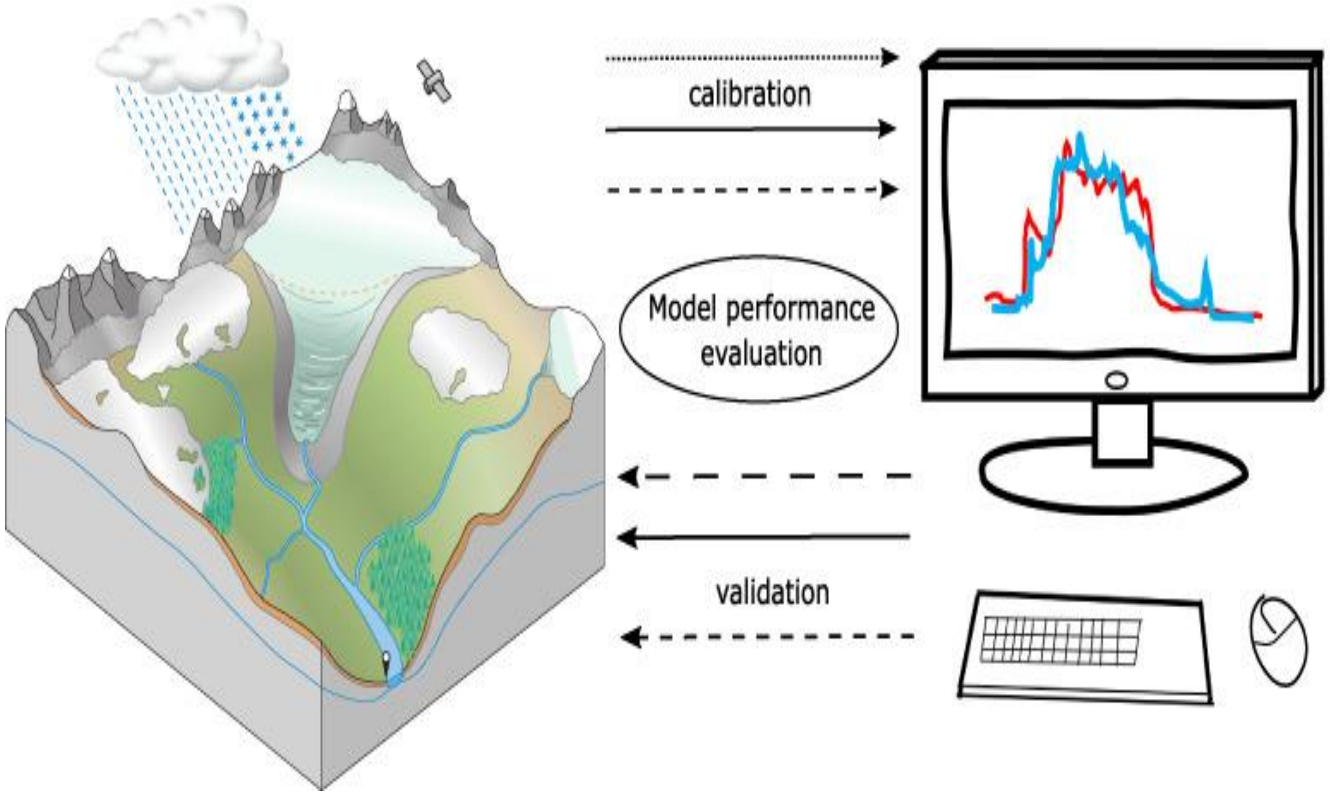
- The process of estimating values for the model parameters enables the model to **closely match** the behavior of the real system it represents (Gupta and Sorooshian, 1998).

Calibration methods

- Manual calibration by **trial and error.**
- Automatic calibration by **optimization algorithms**.

Calibration variables (Soft calibration, annual average, water balance)

- Streamflow, sediment
- ET, soil moisture, etc.



Calibration approaches

- Split-sample test
- Proxy-basin test

Calibration procedures

- Single-site, single variable calibration
- Multi-objective calibration (Multi-site, multi-criteria, multi-variate calibration)

SWAT calibration and related uncertainties

Equifinality

- **Multiple sets** of parameters can yield the **same results** for a given model (Duan et al., 1992).

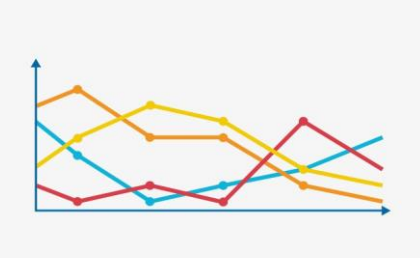
- Introduces **uncertainty** in determining the effective parameters during calibration. (Beven and Binley, 1992).

Over parameterization

- A hydrological model includes **more parameters** than can be **reliably estimated** or constrained by **available calibration data** (Jakeman and Hornberger, 1993).

- The model has more degrees of freedom than the data can support, leading to difficulties in accurately determining the values of the model parameters. (Bashford et al, 2002 ; Andréassian et al, 2012).

Validation phase



Validation

Objective

- To assess the **accuracy and reliability** of the model's predictions.

Method

- By running a model using parameters that were determined during the calibration process, and comparing the predictions to observed data **not used** in the calibration.

Performance measures and evaluation criteria

- Statistical and graphical methods (e.g., NSE, PBIAS, or R2 ; Graphical visualization)

Performance criteria	Formula	Optimal value
Coefficient of Correlation (CC)	$CC = \frac{\sum_{i=1}^{n}\left[\left(P_i^{Obs} - P_i^{Obs}\right)\left(P_i^{Sim} - P_i^{Sim}\right)\right]}{\sqrt{\sum_{i=1}^{n}\left(\bar{P}_i^{Obs} - P_i^{Obs}\right)^2}\sqrt{\sum_{i=1}^{n}\left(P_i^{Sim} - \bar{P}_i^{Sim}\right)^2}}$	1
Root Mean Square Error (RMSE)	$RMSE = \sqrt{\frac{\sum_{i=1}^{n}\left(P_i^{sim} - P_i^{obs}\right)^2}{n}}$	0
Percent BIAS (P_{BIAS})	$P_{Bias} = \frac{\sum_{i=1}^{n} P_i^{Sim} - \sum_{i=1}^{n} P_i^{Obs}}{\sum_{i=1}^{n} P_i^{Obs}} \times (100)$	0
Mean Error (ME)	$ME = \frac{\sum_{i=1}^{n}\left(P_i^{sim} - P_i^{obs}\right)}{n}$	0
Nash-Sutcliffe-Efficiency (NSE)	$NSE = 1 - \frac{\sum_{i=1}^{n}\left(Q_i^{sim} - Q_i^{obs}\right)^2}{\sum_{i=1}^{n}\left(Q_i^{sim} - \bar{Q}_i^{obs}\right)^2}$	1

- The NSE and CC : To assess the **degree of fit** between simulated and observed variables.
- RMSE, PBIAS, and ME : To **quantify errors** in variable values.

Calibration and validation of the Robit watershed

SWAT+ Toolbox

Swat+ toolbox guideline : https://celray.github.io/docs/swatplus-toolbox/v1.0/index.html

SWAT+ user group : https://groups.google.com/g/swatplus

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