A two-step global sensitivity analysis of a SWAT model, using simple screening methods and advanced quantitative methods

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A SWAT model includes a large number of parameters
Uncertainty in parameters is a well-known reason of model output uncertainty.

Parameters

\[ X_1 \]
\[ X_2 \]
\[ \vdots \]
\[ X_k \]

Uniform distribution

Model output

SWAT Model

Time
Model calibration

to estimate the parameters values

A large number of parameters
Lack of data

Low calibration efficiency

Solutions to improve the calibration efficiency:

Identification the most sensitive parameters
Identification the less sensitive parameters
Reduction of the number of parameters

Sensitivity analysis
Global sensitivity analysis methods

- Simple screening methods
- Advanced quantitative methods

Two-step global sensitivity analysis of a SWAT model

Results and discussion

Conclusion
Global sensitivity analysis methods analyze the whole parameter space

Simple screening methods

Advanced quantitative methods
Global sensitivity analysis methods analyze the whole parameter space

Simple screening methods:

Latin-Hypercube – One-factor-At-a-Time (LH-OAT)

Regression-based method

  - conceptually simple
  - Easy to implement
  - Low computational cost
  - Cannot provide quantitative information about the importance of parameters.
  - Parameter interactions
  - Not reliable for highly non-linear systems
Global sensitivity analysis methods analyze the whole parameter space

Simple screening methods

Advanced quantitative methods:

Variance-based method of Sobol’

Density-based method of PAWN

Sensitivity indices: quantitative importance measures

Applicable for non-linear systems

Parameter interactions

Computationally expensive
Two-step approach for a global sensitivity analysis: simple methods + advanced methods

Model parameters → Simple methods → Sensitive parameters → Advanced methods

Non-sensitive parameters

Quantitative sensitivity indices
Reliable parameter ranking
Parameter interactions
Global sensitivity analysis of a SWAT model using two-step approach

Upstream catchment of the River Zenne, Belgium

26 water quantity related parameters

Sample size:

- **LH-OAT**: 75 samples (2025 simulations)
- **SWAT-CUP**: 2000 samples (2000 simulations)
- **Sobol’**: 9000 samples (135000 simulations)
Sobol’ method

Non-sensitive

252000 simulations
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Second step: advanced quantitative method

Sobol’ total sensitivity index: total contribution of the parameters to the output variance

135000 simulations
Two-step approach reduces the required computational cost of the Sobol’ method.

135000 simulations

Non-sensitive

252000 simulations
Conclusions:

• Advanced sensitivity analysis need many simulations

• SWAT-CUP uncertainty analysis gave different ranking but LH-OAT gives similar ranking.

• LH-OAT can be used or a two step process using LH-OAT in a first step
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