

# Global sensitivity analysis of a SWAT model: comparison of the variance-based and moment-independent approaches

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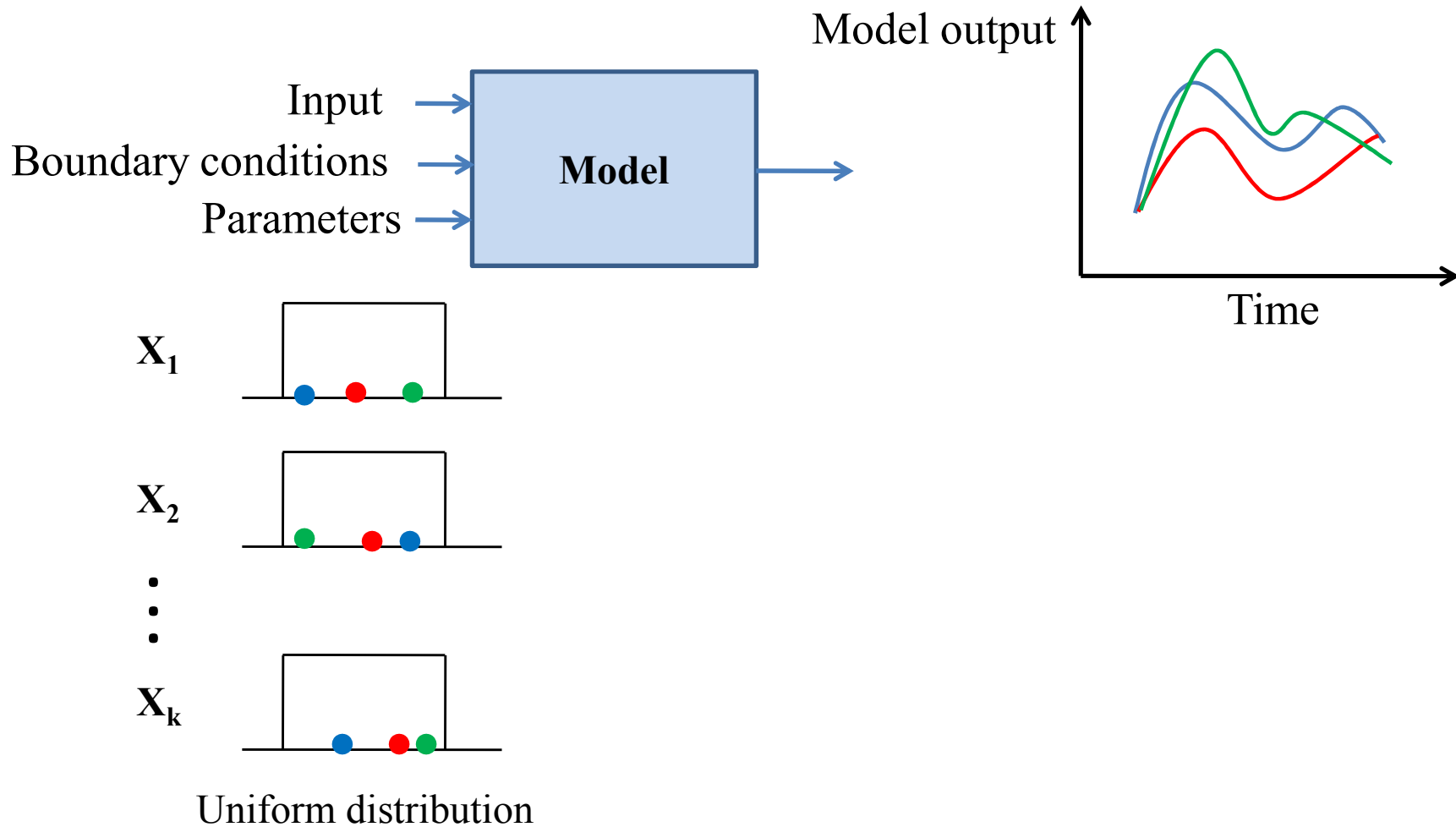


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# Uncertainty in parameters

is a well-know reason of **model output uncertainty**



# Model calibration

to estimate the parameters values

A large number of parameters

Lack of data

# Sensitivity analysis

to improve the calibration efficiency

Reduction of the number of parameters incorporated in the calibration

Influential vs. non-influential parameters

# Global sensitivity analysis methods

Variance-based method (Sobol')

Moment-independent method (PAWN)

## Global sensitivity analysis of a SWAT model

Results and discussion

Conclusions

# Global sensitivity analysis methods

analyze the whole parameter space

## Variance-based method (Sobol')

Well-established and widely applied

Model-independent

Sensitivity indices: contribution of parameters to the total model output variance

Individual parameter contribution

Contribution resulting from parameter interactions

**Variance is sufficient to describe the output variability.**



# Global sensitivity analysis methods

analyze the whole parameter space

Variance-based method (Sobol')

## **Moment-independent method (PAWN)**

Density-based method: entire model output distribution

Applicable regardless of the shape of the output distribution

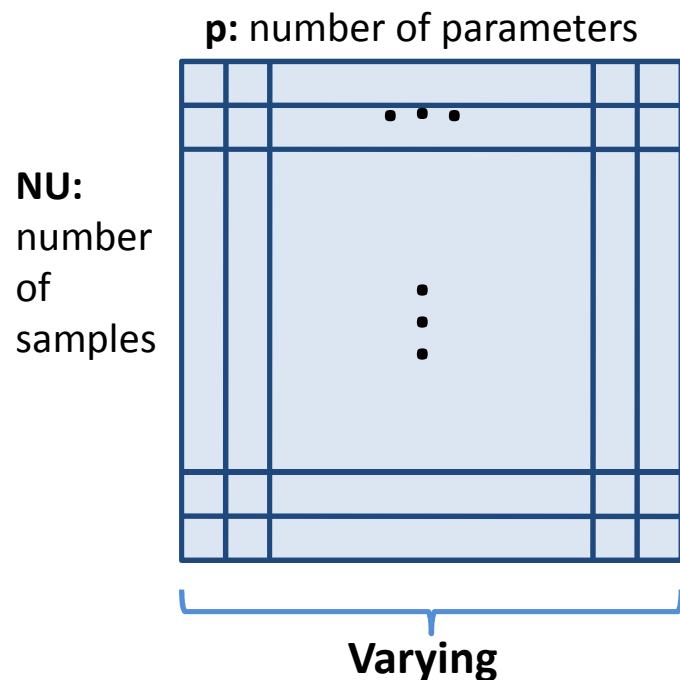
# Global sensitivity analysis methods

analyze the whole parameter space

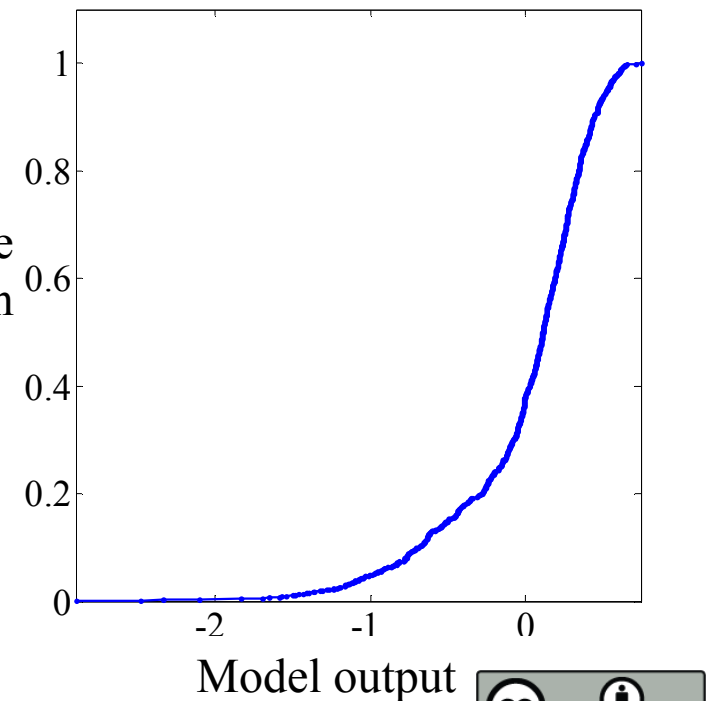
Variance-based method (Sobol')

**Moment-independent method (PAWN)**

Unconditional output distribution



Cumulative  
distribution function



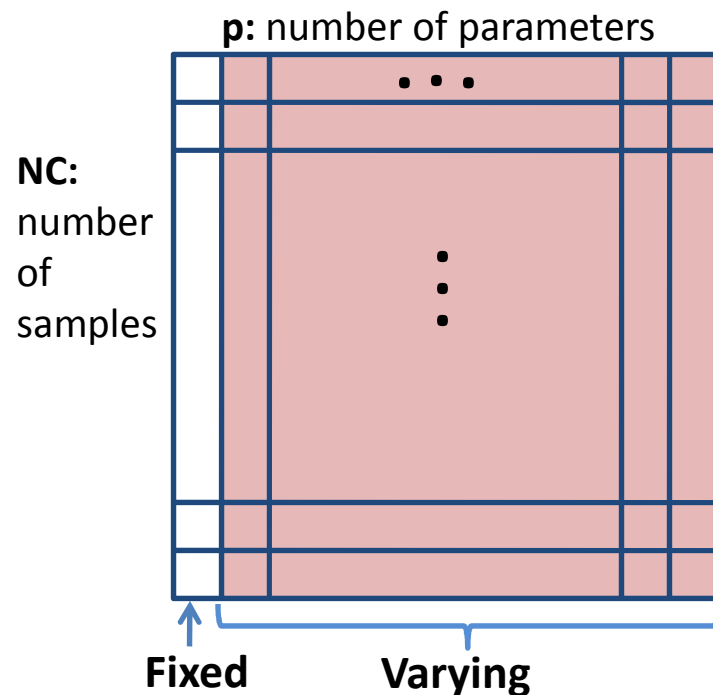
# Global sensitivity analysis methods

analyze the whole parameter space

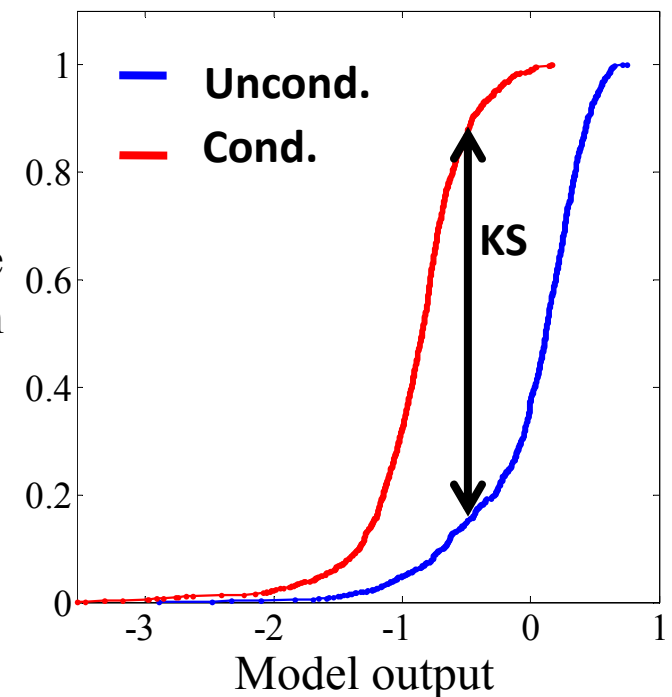
Variance-based method (Sobol')

## Moment-independent method (PAWN)

Unconditional and Conditional output distribution



Cumulative distribution function





# Global sensitivity analysis of a SWAT model to compare the Sobol' and PAWN methods

## Soil and Water Assessment Tool (SWAT)

Semi-distributed

Physically based

Hydrological simulator

26 water quantity related parameters

Dummy parameter: no influence on the model output

Model out put: Nash-Sutcliffe efficiency (NSE) and mean error (ME)

# Global sensitivity analysis of a SWAT model to compare the Sobol' and PAWN methods

Soil and Water Assessment Tool (SWAT)

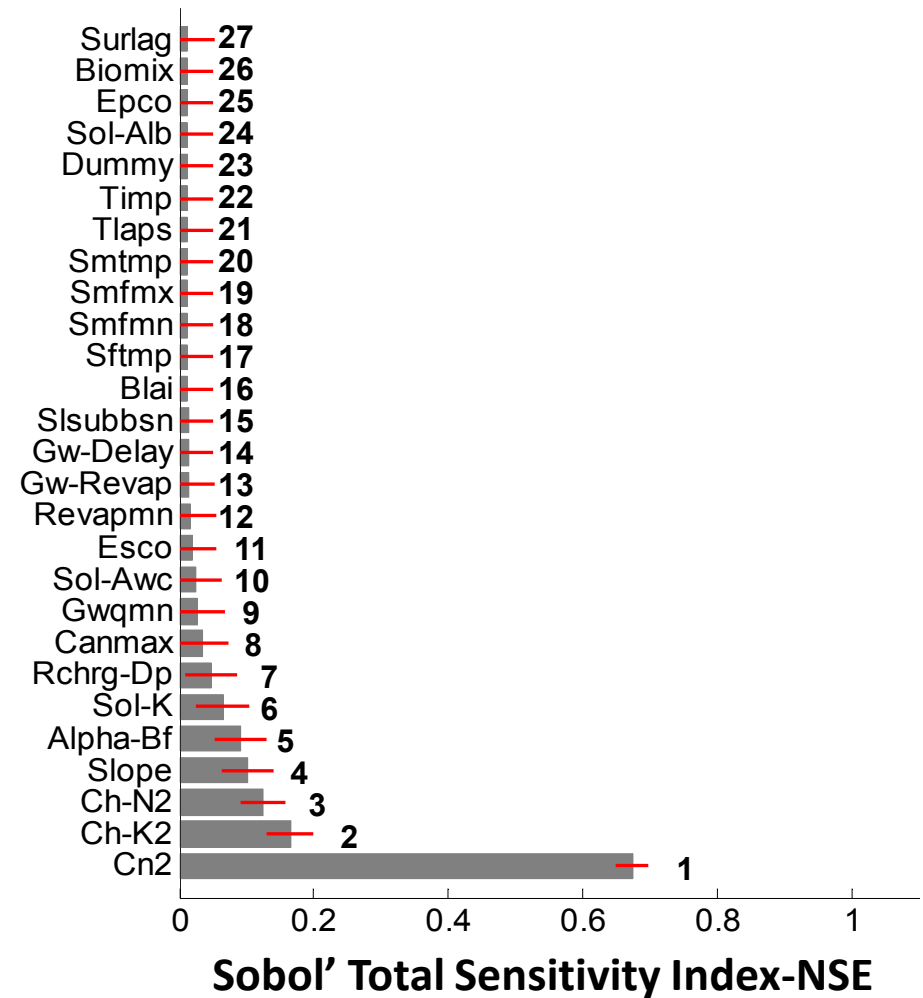
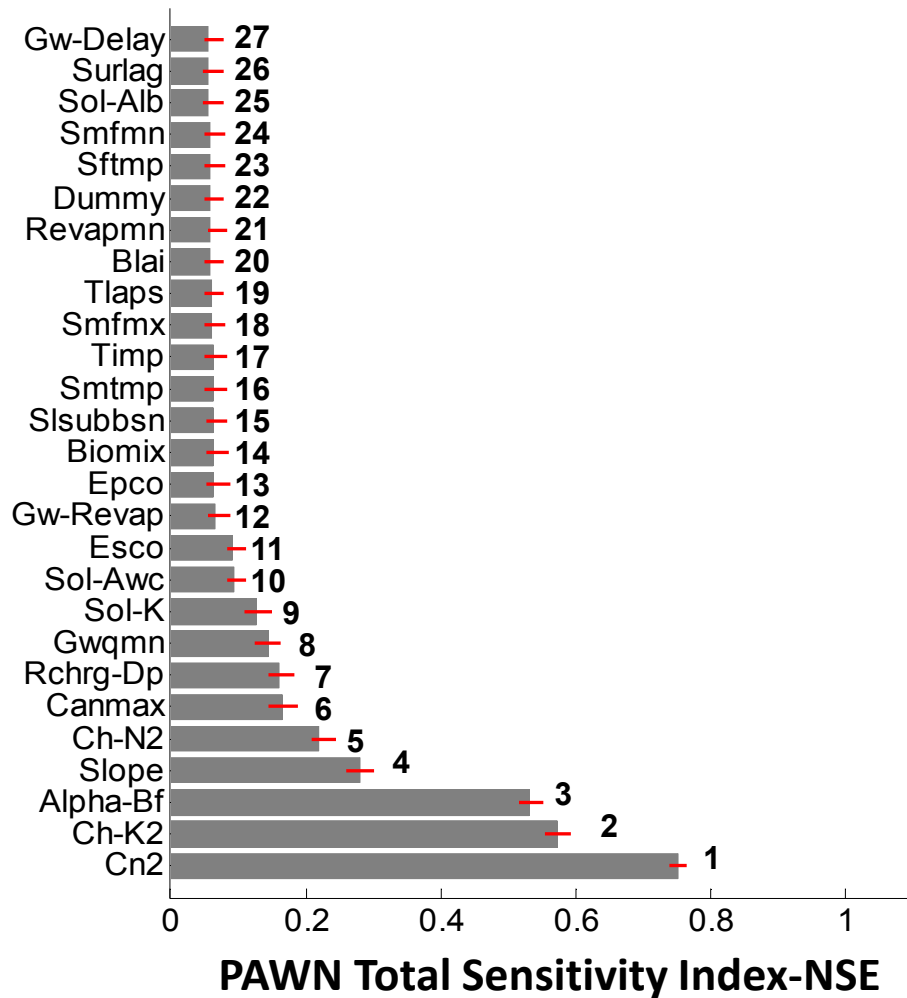
Upstream catchment of the River Zenne, Belgium

Sample size:

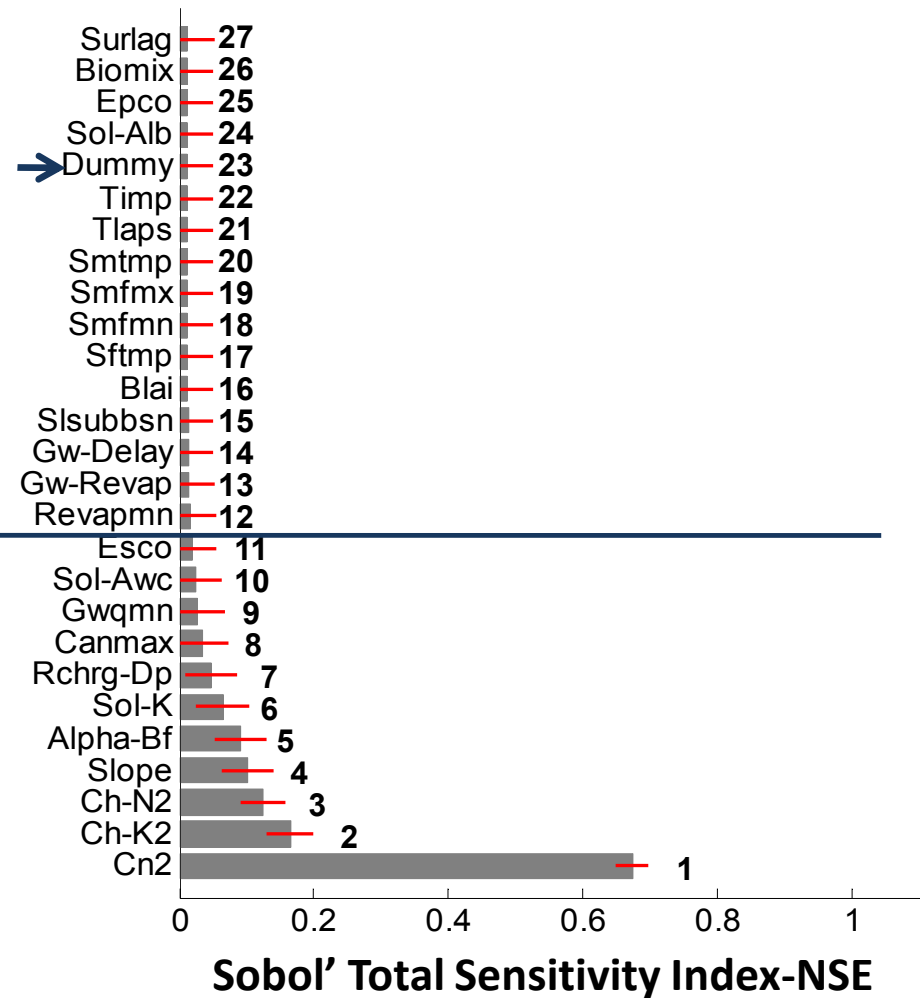
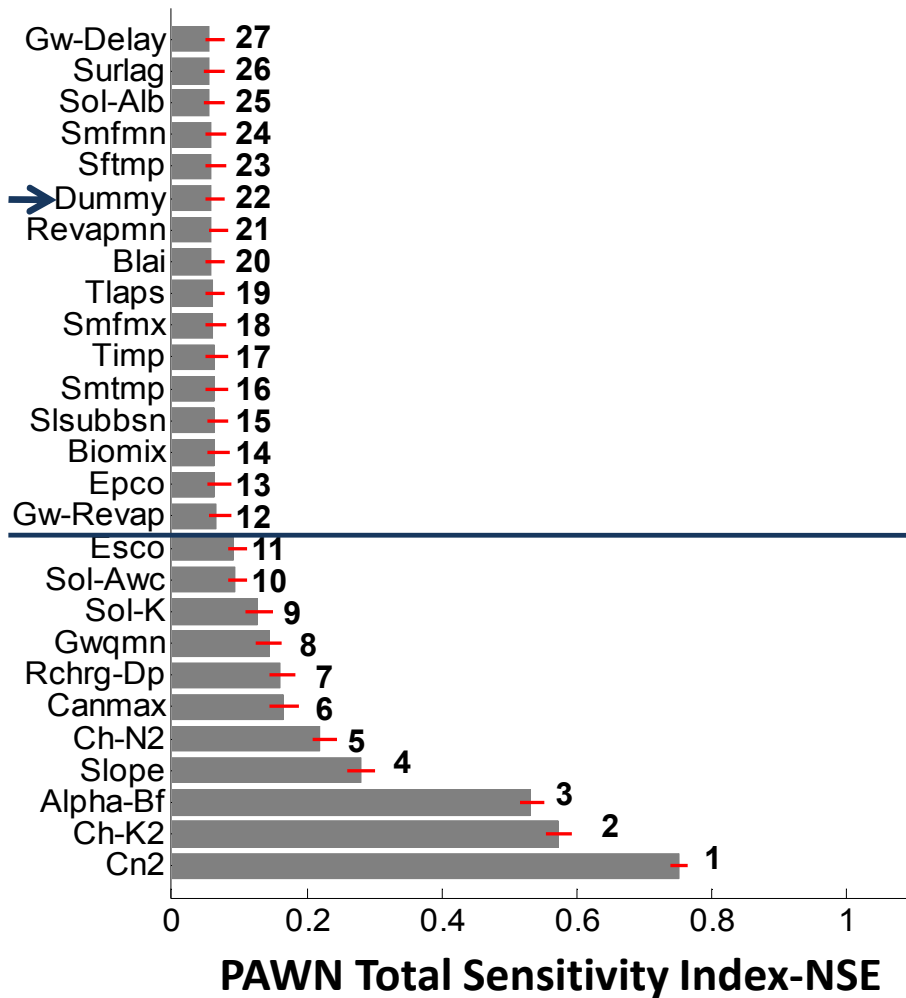
**Sobol'**: 9000 samples (252000 simulations)

**PAWN**: 1000 samples, 10 conditioning values for each parameter  
(261000 simulations)

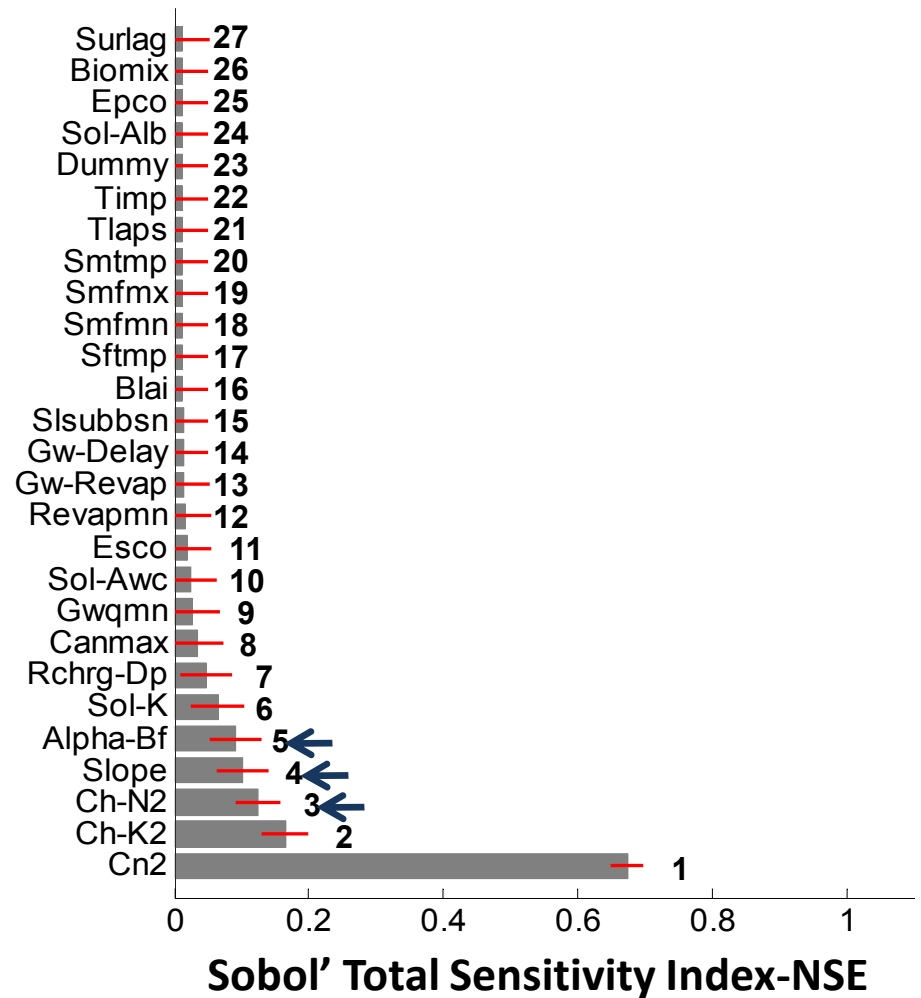
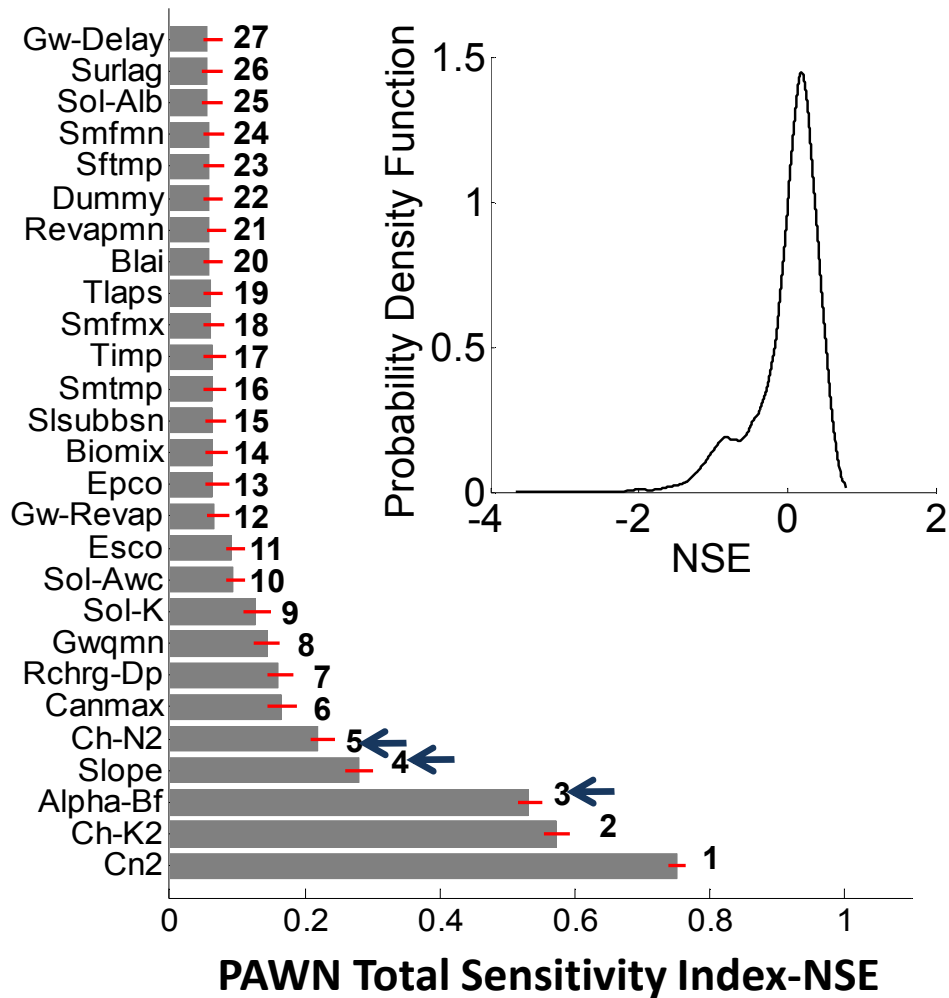
# Applying the Sobol and PAWN methods results in different parameter ranking for the SWAT model



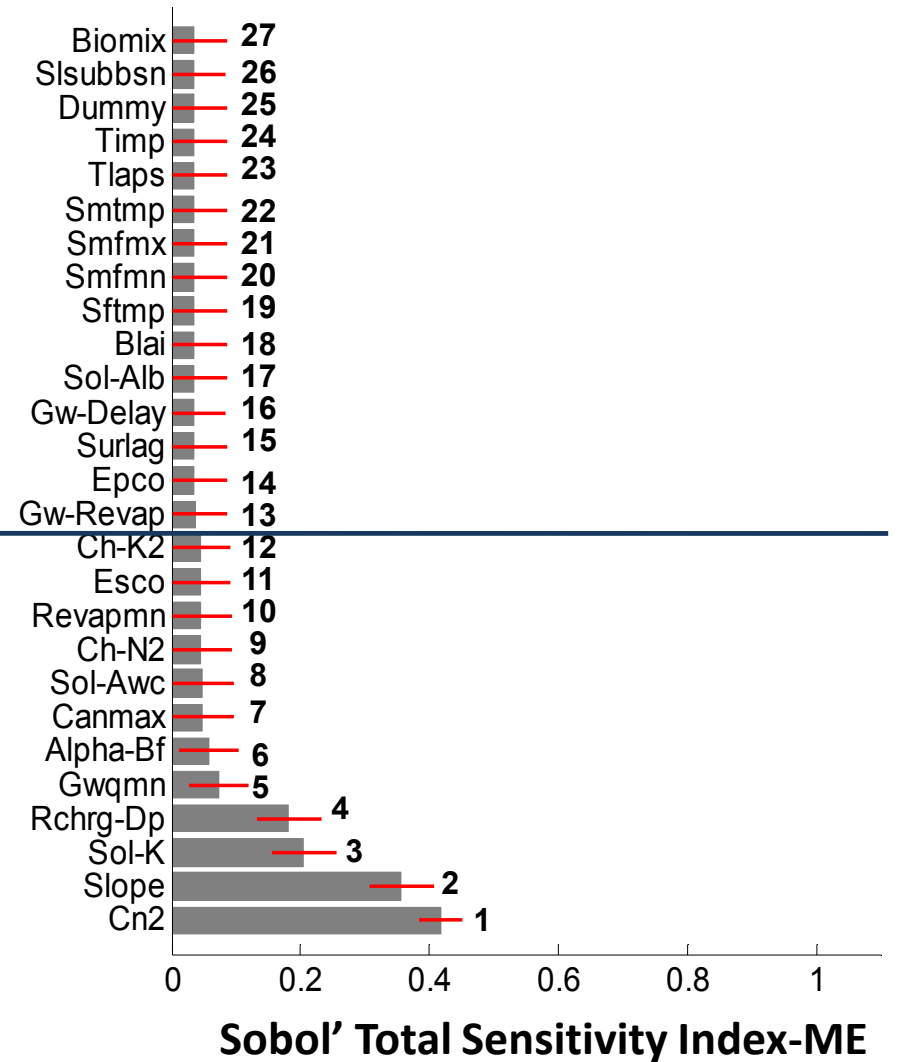
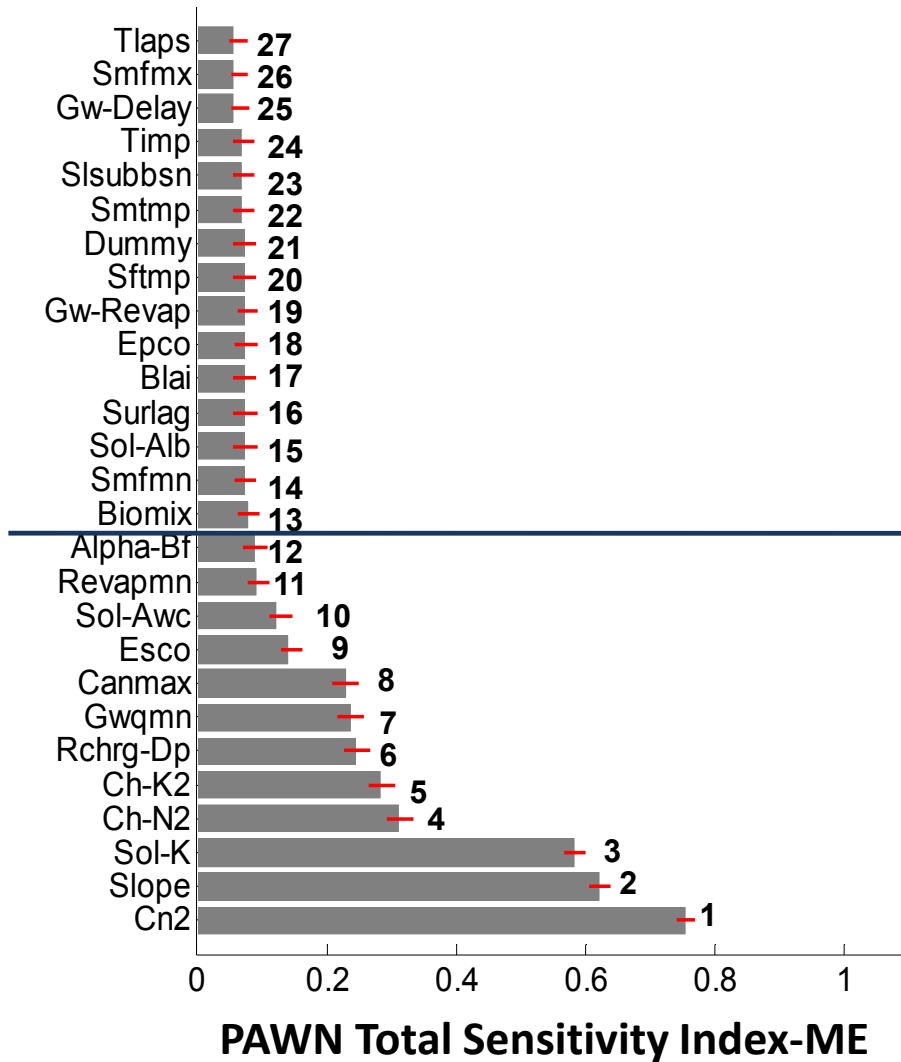
Although there are some shifts in the parameter ranking results, the top eleven parameters are similar in both methods



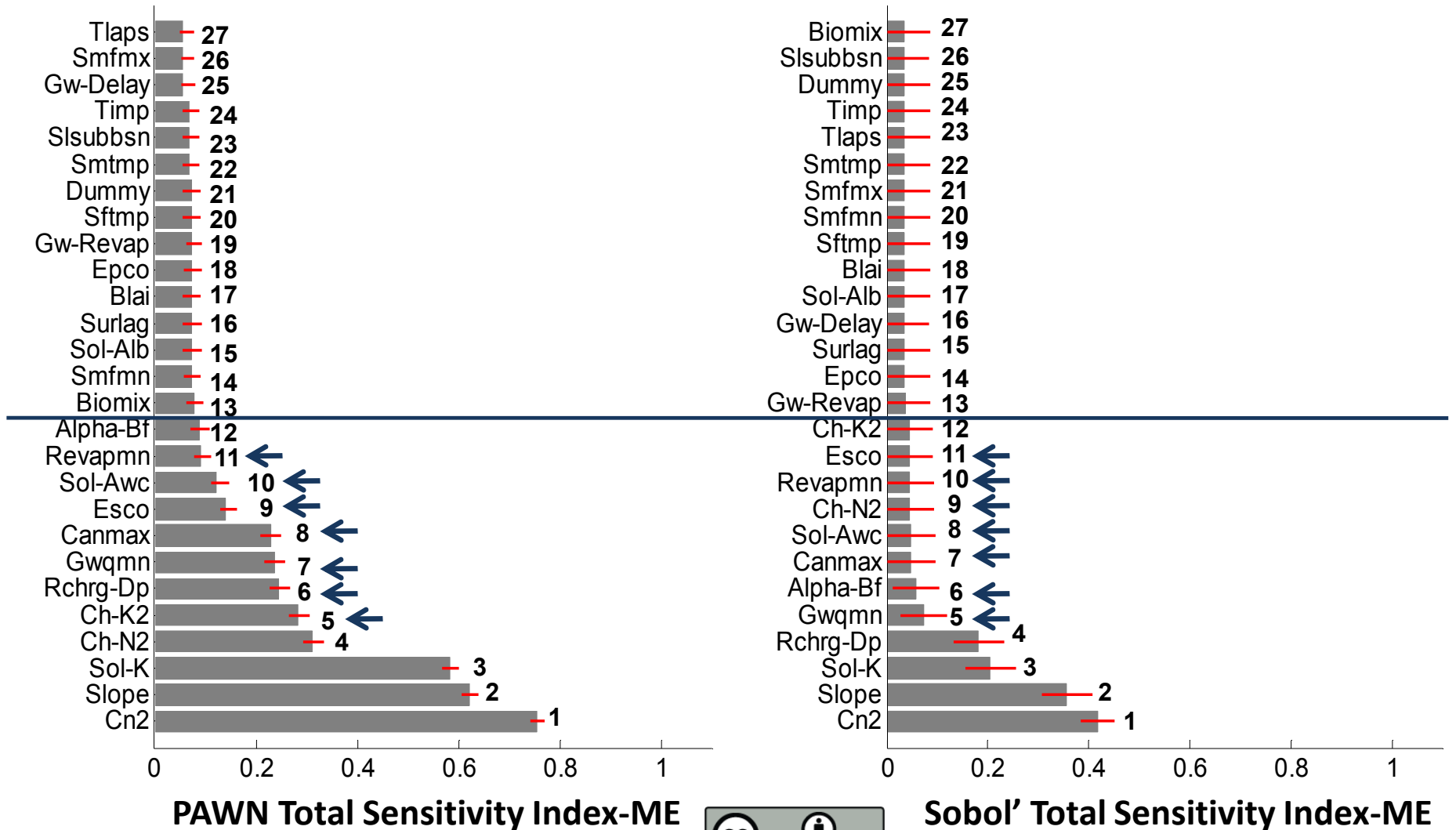
The difference between the importance of the influential parameters is more highlighted in the PAWN method as compared to the Sobol' method



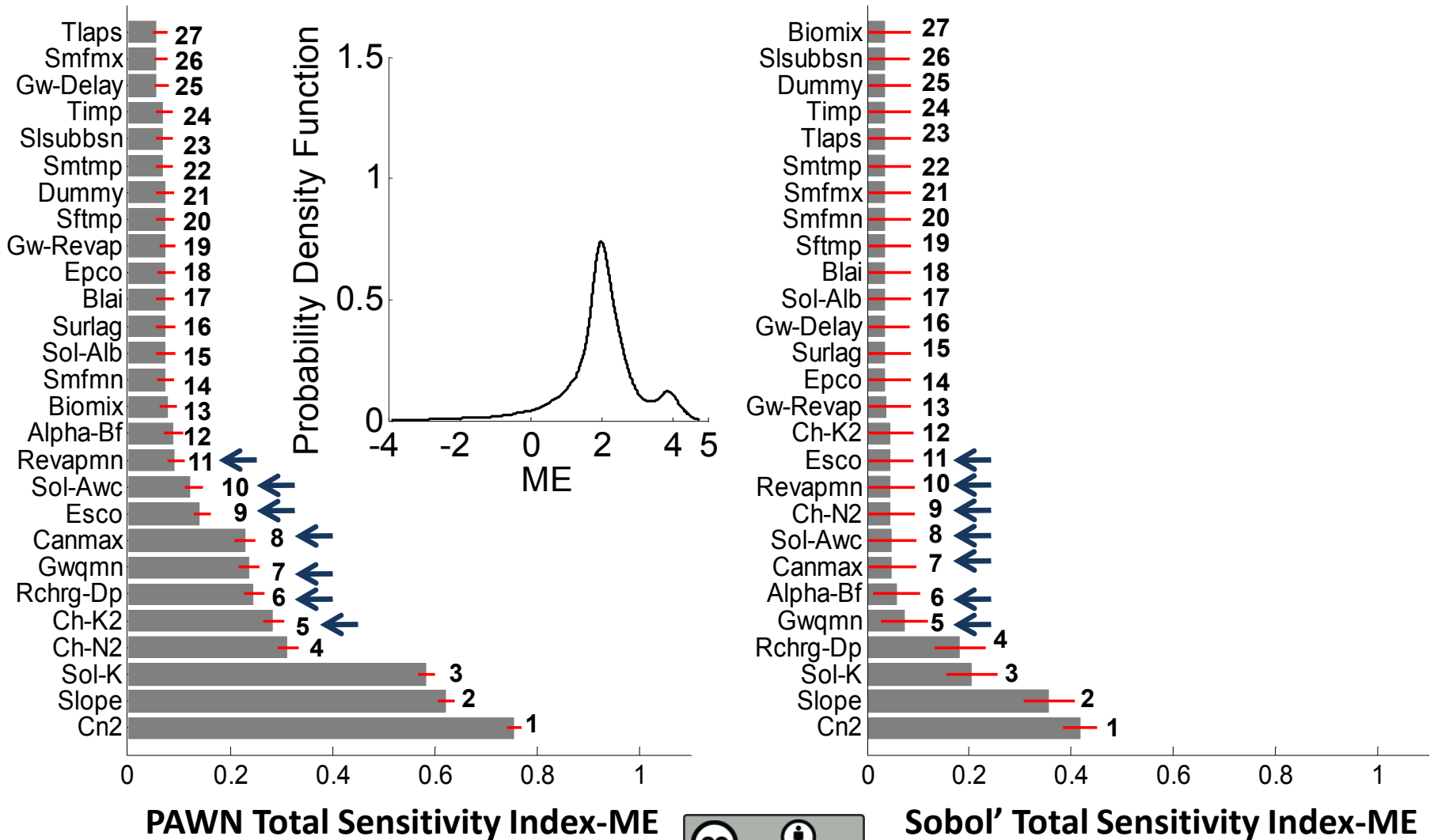
Top twelve parameters are similar in both methods, using the mean error performance measure



The difference between the importance of the influential parameters is more highlighted in the PAWN method as compared to the Sobol' method



The difference between the importance of the influential parameters is more highlighted in the PAWN method as compared to the Sobol' method





# Conclusions:

Global sensitivity analysis:

- to understand the parameter effect on the model output
- to increase the calibration efficiency

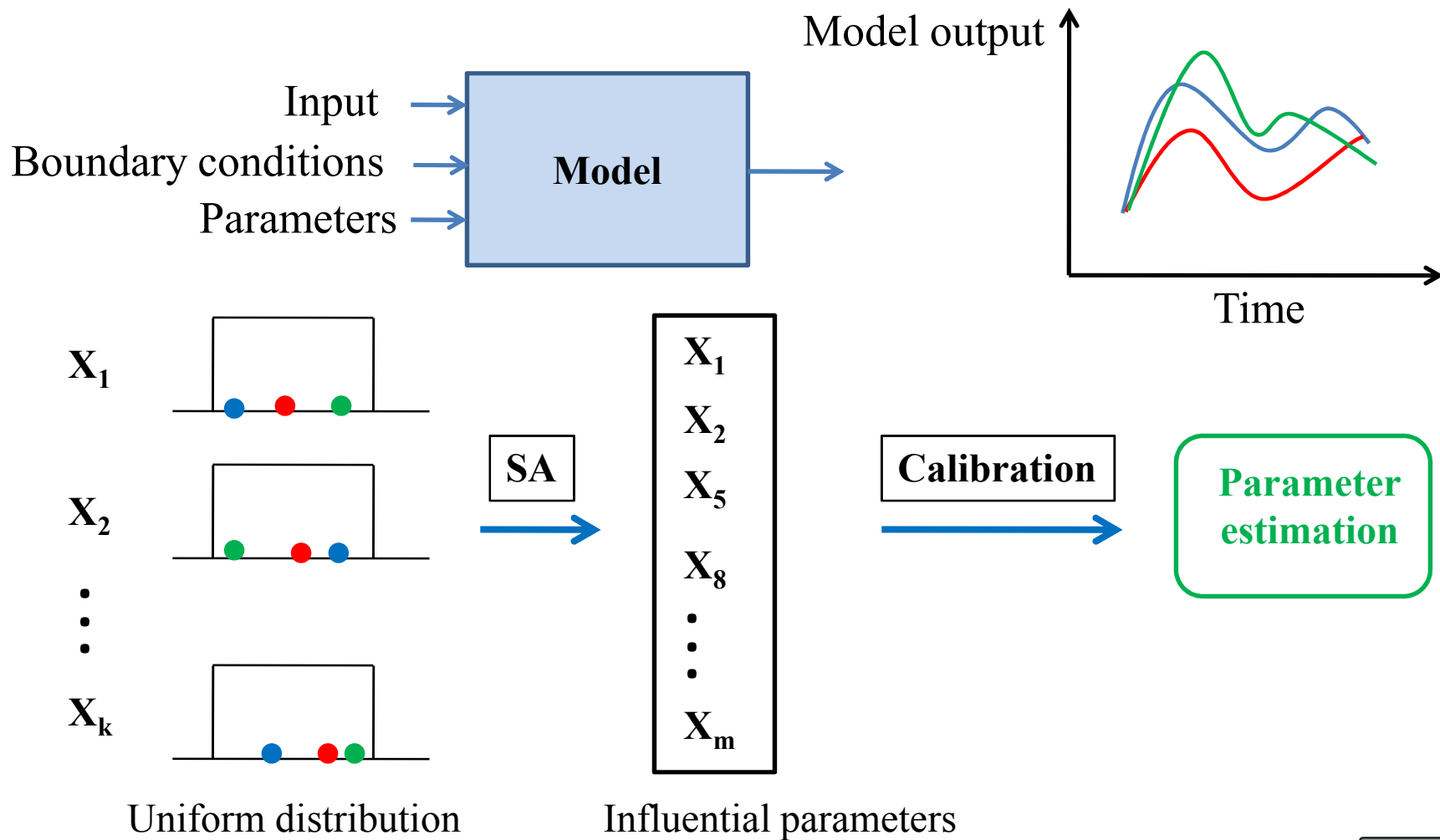
Two important categories of global sensitivity analysis techniques are variance-based methods and moment-independent methods.

Both the Sobol' and PAWN methods result in the same set of important parameters for the SWAT model using the NSE and ME.

In case of highly-skewed or multi-modal model output, moment-independent methods can be used as a complementary tool to variance-based approaches.

# Uncertainty in parameters

is a well-know reason of **model output uncertainty**



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## **PAWN method:**

Pianosi, F. and Wagener, T. (2015). PAWN: a simple and efficient method for Global Sensitivity Analysis based on cumulative distribution functions. *Environmental Modelling & Software*, 67, 1-11.



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