SENSITIVITY ANALYSIS : A GRAPHICAL APPROACH TO ASSESS THE NECESSARY NUMBER OF SIMULATIONS IN A RANDOM SCANNING

S. Payraudeau (1)*, F. Cernesson (2), M.G. Tournoud (1),

(1) Laboratoire Hydrosciences, Université Montpellier 2 – CNRS – IRD (UMR5569), cc056 34095 Montpellier France,
(2) Laboratoire Structures et Systèmes Spatiaux, CEMAGREF-ENGREF, 500 J.F. Breton 34093 Montpellier, France.
*Contact : sylvain.payraudeau@msem.univ-montp2.fr

Introduction

A sensitivity analysis consists in scanning, in a random or systematic way, the entire range of each parameter of the model and in studying the variability of the output variables. **A random scanning** is usually more thrifty in simulations than a systematic scanning for a comparable description of the variability of the output variables (*Gaume and al, 1998*). The **choice** of the **number of simulations** is important because it conditions the duration and the exhaustiveness of the model sensitivity analysis (*Saltelli, 2000*). However, in random scanning, this number is **a priori unknown**.

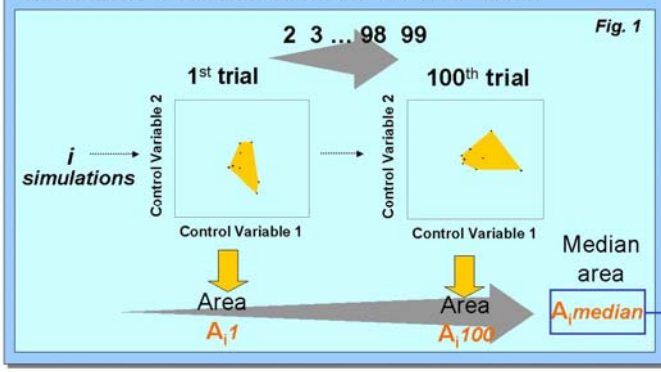
An **original method is proposed** allowing to determine the **optimal number of simulations,** to assess afterwards a full sensitivity analysis on two synthetic control variables.

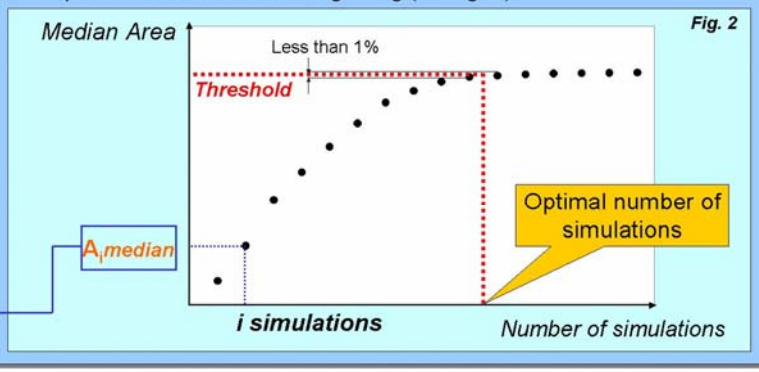
Method

The method is based on **the analysis of the shape** obtained by plotting, in a two axis graph (control variable 1 versus control variable 2), the results **corresponding to different sets of parameters**. For each simulation, the set of parameters is randomly selected. The convex shape corresponding to the plotted points is extracted and the associated area is calculated with Arc-Info® tool.
We study how **the area of the shape evolves** when the **number of simulations is increased**.

For a given number of simulations (***i*** simulations in the Fig. 1), 100 trials are made. The median area corresponding to ***i* simulations** is calculated from the 100 area values.

When the number of simulations is increased (from 2^2 to 2^{16}), the area increases until a threshold. The **optimal number of simulations** corresponds to the **threshold** beginning (cf. Fig. 2).



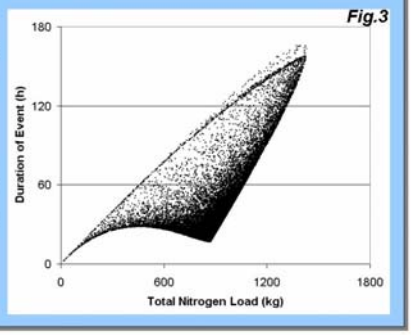


Application

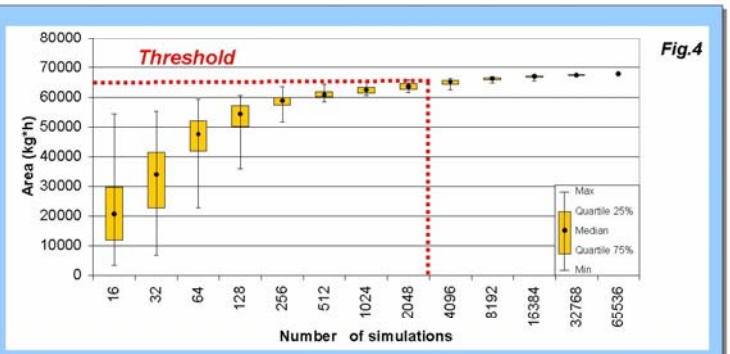
We applied this method on the model POL *(Payraudeau and al, 2002)*. POL is a semi-distributed model developed to reproduce the daily nitrogen loads produced at the outlet of a catchment.
The two synthetic control variables of model are the total nitrogen load produced during a flood event, and the duration of this event.

The *figure 3* represents the shape of model output responses obtained with 65536 simulations.

How many simulations are necessary to correctly describe the model output variability ?



Results



A number of **4 000 simulations** is acceptable to obtained a steady output model area (cf. Fig. 4). For the same precision degree, a systematic scanning imposes more than one million simulations.

Conclusions

This method presents some advantages and limits :

Advantages : • This statistical and geometrical method is **easily applicable ;**
• The two synthetic control variables are **simultaneous analysed ;**
• It can be applied in the case of models presenting a **great number** of **parameters.**

Limits : • The **distribution of the plotted points** in the shape is not taking into account ;
• This method is applicable for a model with **two synthetic control variables.**

This study has been used to realize a full sensitivity analysis of the POL model (*Payraudeau, 2002*).

References

Gaume E., Villeneuve J.P. and Desbordes M., 1998. Uncertainty assessment and anlysis of the calibrated parameter values of an urban storm water quality model. Journal of Hydrology, Vol 210, n°1-4. pp 38-50.

Payraudeau S., 2002. Modélisation distribuée des flux d'azote sur des petits bassins versants méditerrannéens, PhD, 424 p.

Payraudeau S., Tournoud M.G. and Cernesson F., 2002. An adapted modelling approach for the nitrogen load management on a catchment scale. 14th International Conference on computational methods in water resources, Edited by S. M. Hassanizadeh and R.J. Scotting. June 23-27, Delft, in press.

Saltelli A., 2000. What is sensitivity analysis ? In Mathematical and statistical methods for sensitivity analysis, Saltelli A., Chan K. and Scott M. Probability and Statistics Series, J Wiley & Sons. pp 1-22.