Can the super model(SUMO) method improve hydrological simulations? Exploratory tests on lumped rainfall-runoff models

Léonard Santos, Guillaume Thirel, Charles Perrin

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Léonard Santos, Guillaume Thirel and Charles Perrin

Irstea, HBAN - Hydrosystems and Bioprocesses, Antony, France

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Contact:

✓ PhD student: Léonard Santos
leonard.santos@irstea.fr
+331-40-96-61-97
http://webgr.irstea.fr

Objectives

- ✗ Improve the robustness of rainfall-runoff models
- ✗ Test an unusual multimodel method: the SUMO (SUper MOdel) method

1. What is a Super Model?

- ✗ Dynamical multimodel method created by climatologists (van den Berge *et al.* , 2011)
- ✗ Based on the continuous correction of internal variables during the run
- ✗ Addition of linear correction terms to the differential equation of the model variables
- ✗ Correction terms depend on other model variables and are parameterized by coefficients

The equation for a Super Model with two models (model 1 with a state vector $\vec{x_1}$ and model 2 with a state vector $\vec{x_2}$) and parameterized by two diagonal matrices $\mathbf{C_1}$ and $\mathbf{C_2}$ is:

$$\vec{x_1} = f_1(\vec{x_1}) + \mathbf{C_1}(\vec{x_2} - \vec{x_1})^T$$
$$\vec{x_2} = f_2(\vec{x_2}) + \mathbf{C_2}(\vec{x_1} - \vec{x_2})^T$$

basic equation | SUMO correction

2. The first tested hydrological Super Model

- ✗ Two GR4J models (Perrin *et al.* , 2003, represented as state-space, see EGU2017-4851) with different parameterizations
- ✗ Calibrated using a simple "split-sample test" and the KGE' as an objective function, the first GR4J model is calibrated on the high flow component and the second one on the low flow component (log)
- ✗ Correction of the levels of the production and routing stores

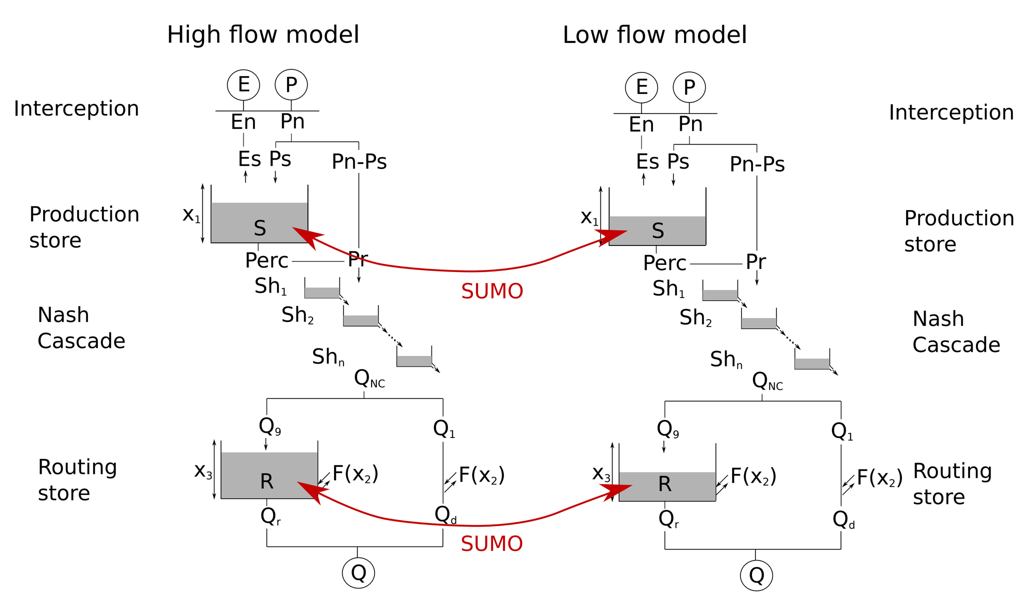

Fig. 1: Location of SUMO corrections in the GR4J conceptual structure

3. Evaluation methodology

- ✗ 250 French catchments to test the robustness of the Super Model
- ✗ Calibration of the SUMO coefficients using the KGE' calculated on square root transformed flows
- ✗ Performances comparison with a benchmark GR4J model calibrated on the same objective function to test the real added value of the Super Model
- ✗ Sensitivity analysis of the Super Model coefficients
- ✗ Analysis of behaviour of the store levels during the run

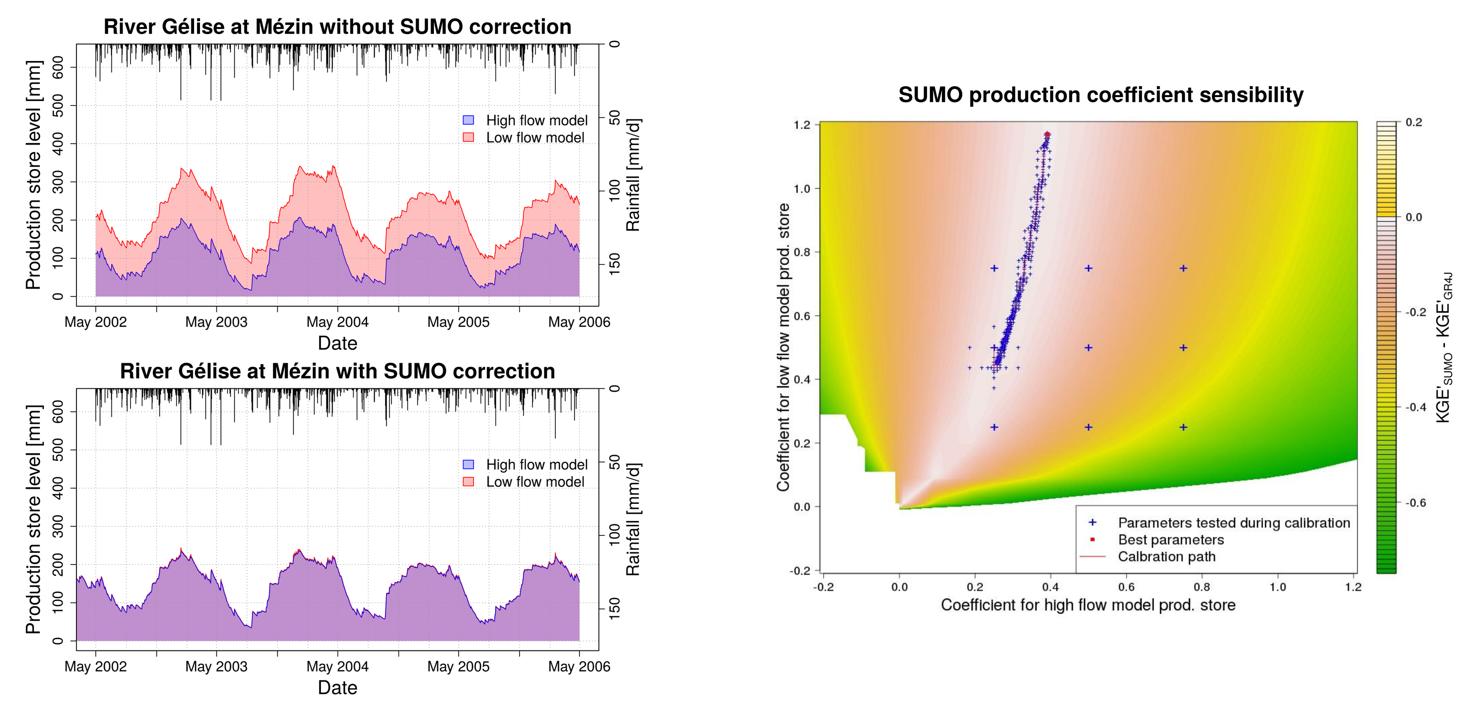

Fig. 2: Synchronization of the production store levels in the Super Model for the River Gélise at Mézin, the production store levels of the 2 GR4J models are different which makes the SUMO coefficients sensitive

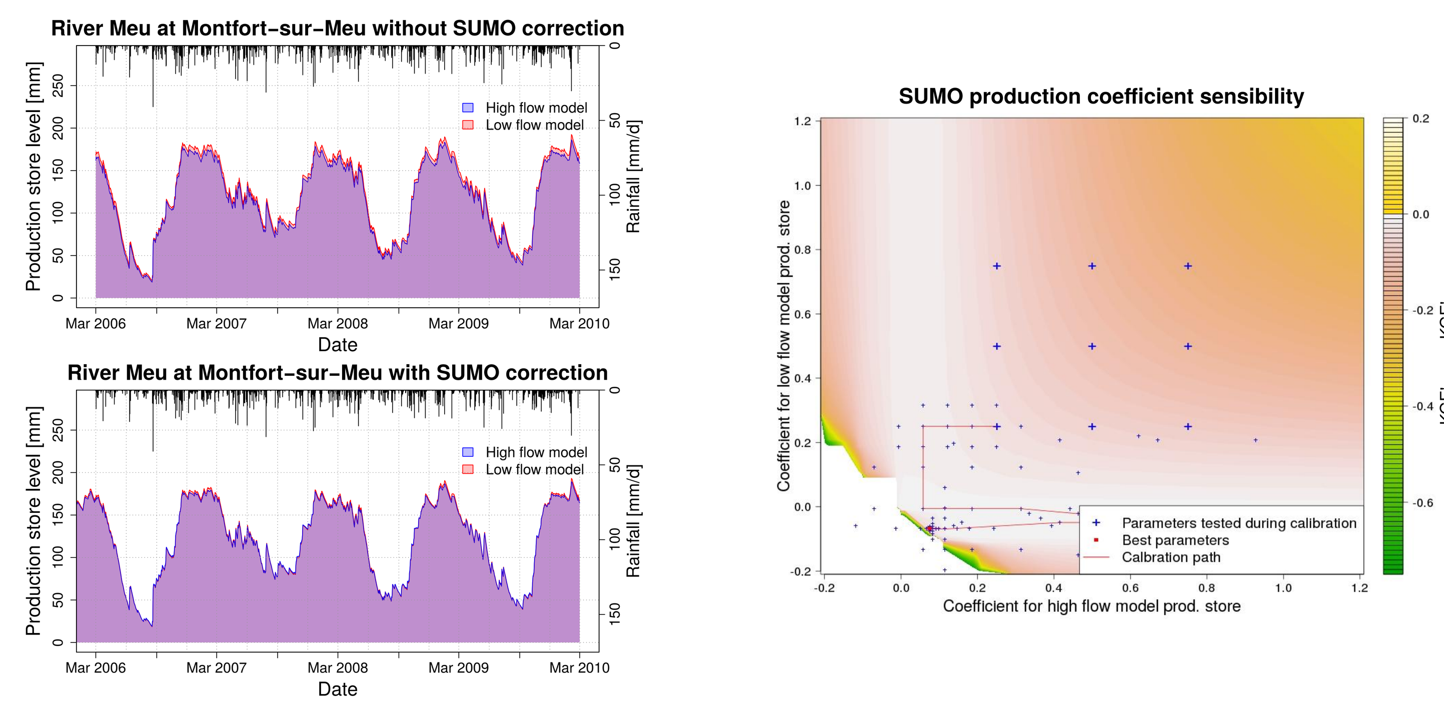

Fig. 3: Synchronization of the production store levels in the Super Model for the River Meu at Montfort-sur-Meu, the production store levels of the 2 GR4J model are similar which makes the SUMO coefficients non sensitive

4. Results

Performances

- ✗ No global improvement on average for the 250 tested catchments regarding the performances of the simple model GR4J
- ✗ BUT interesting results in particular catchments

SUMO behaviour

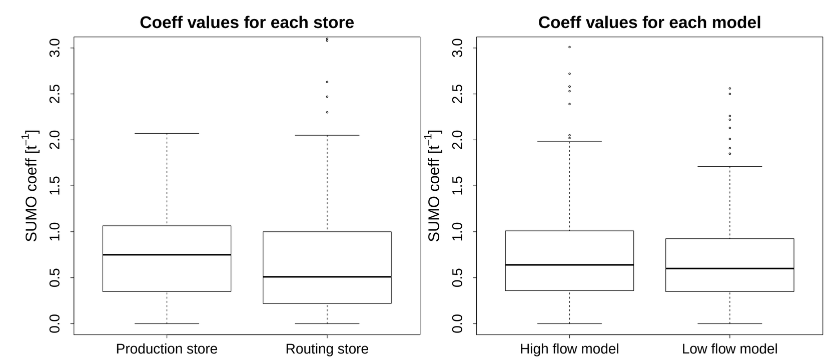

Fig. 4: Calibrated SUMO coefficient values for the 250 tested catchments

- ✗ SUMO coefficient values are informative (figure 4)
- ✗ The high flow model and the production store coefficients seem more sensitive in the Super Model
- ✗ Internal variables synchronize themselves, the two models come to a "compromise" (figure 2 left)
- ✗ Parameter sensitivity may depend on initial difference between internal variables (figure 2 and 3)

5. Test on different models

- ✗ With simple models implemented using the SUPERFLEX framework (Fenicia *et al.* , 2011)
- ✗ The Super Model significantly improve the simulations of the 2 simple models on the tested catchments

Conclusion

- ✗ The Super Model does not improve the performances on average
- ✗ Tests on models which are different (*e. g.* SUPERFLEX) could lead to more interesting conclusions
- ✗ SUMO still shows interesting behaviour and can help to understand how its constitutive models work

References

Fenicia, F., Kavetski, D., & Savenije, H. H. G. 2011. Elements of a flexible approach for conceptual hydrological modeling: 1. Motivation and theoretical development. *Water Resour. Res.*, **47**(11).

Perrin, C., Michel, C., & Andréassian, V. 2003. Improvement of a parsimonious model for streamflow simulation. *Journal of Hydrology*, **279**(1-4), 275–289.

van den Berge, L. A., Selten, F. M., Wiegerinck, W., & Duane, G. S. 2011. A multi-model ensemble method that combines imperfect models through learning. *Earth System Dynamics*, **2**(1), 161–177.