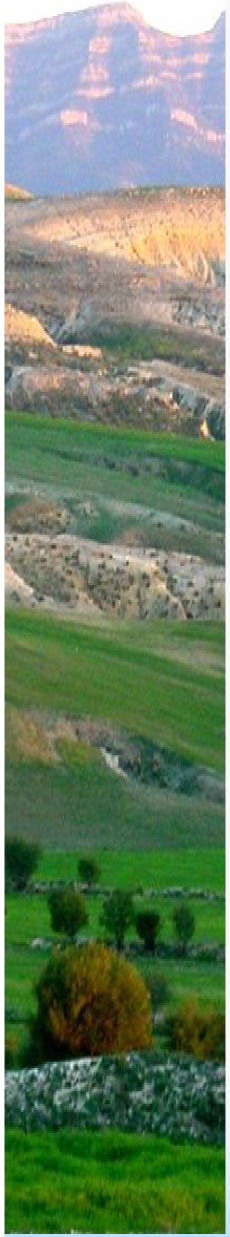

On the significance of the performance criteria of event-based flood models

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High School of Agronomy

National Institute for Agricultural Research

Institute of Research for Development

Objectives

Analysis of the properties of the Nash-Sutcliffe Efficiency (NSE)

Observed Discharge — Calculated Discharge

$$NSE = 1 - \frac{\sum_{t=1}^{n} \left[Q_o(t) - Q_c(t) \right]^2}{\sum_{t=1}^{n} \left[Q_o(t) - \overline{Q_o} \right]^2}$$

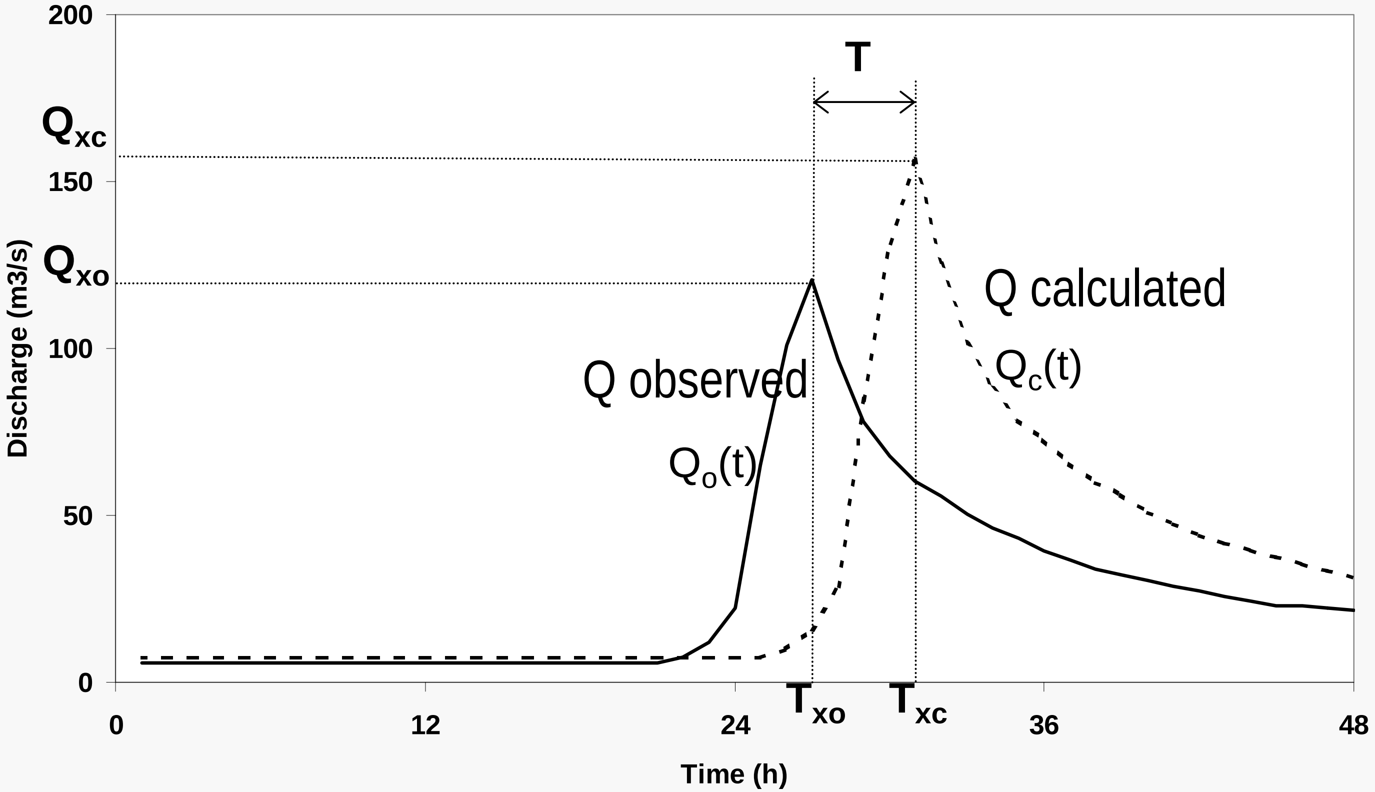
Benchmark : mean discharge

of event-based flood models as a function :

- of the calculated hydrograph shape

- of the benchmark reference model

Methodology :
Case where the calculated hydrograph is obtained with a translation (T hours) and homothetic (coefficient α) to the measured hydrograph



Cas où : $Q_c(j) = \alpha \, Q_o(j-m)$

What Nash-Sutcliffe (NSE) value = f(α, T) ?

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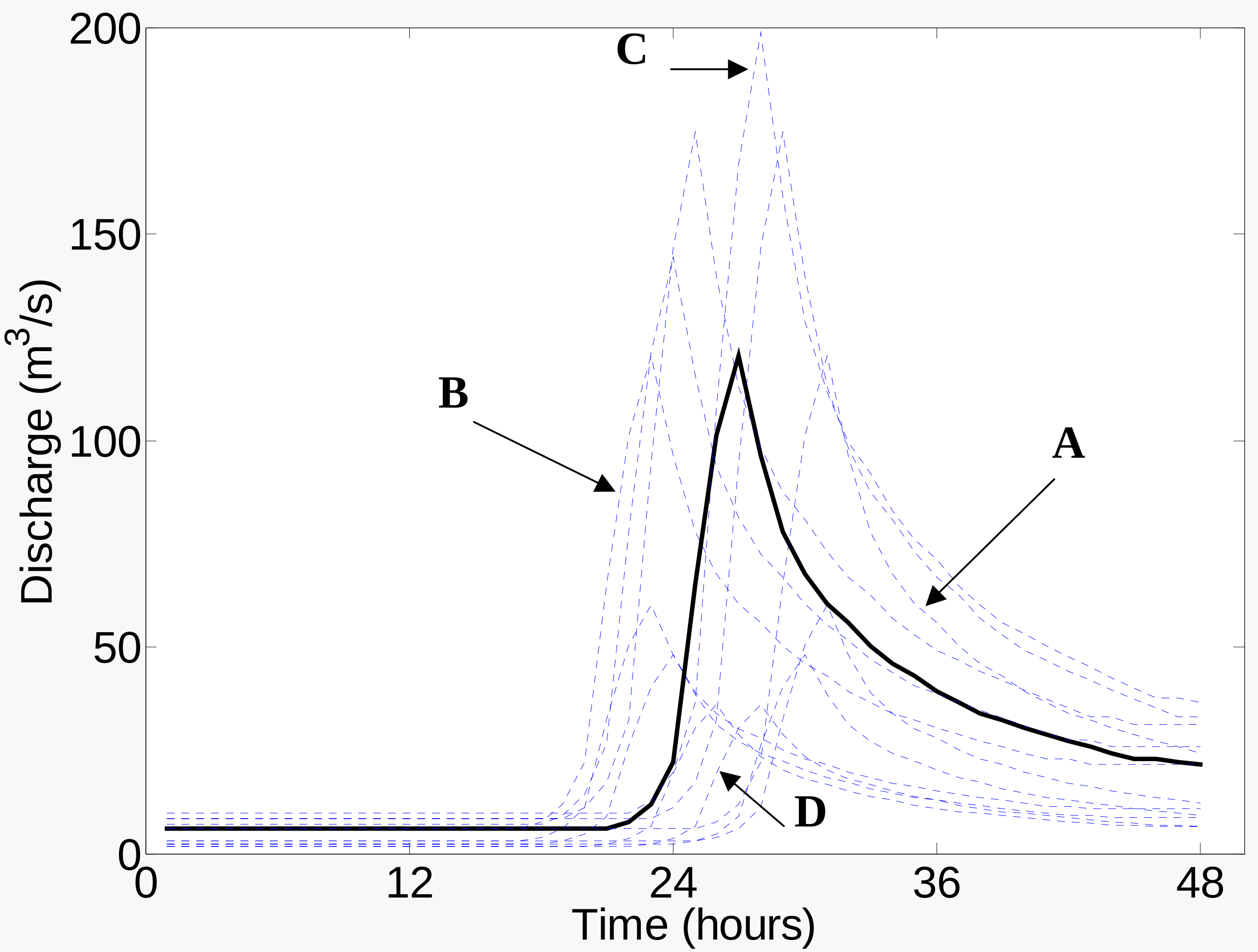
What can we learn from simulations with low *NSE* values ?

Example : various hydrographs such as NSE = 0



First remark : NSE = 0 doesn't mean systematically a « bad simulation » but can result from a translation T and homothetic α.

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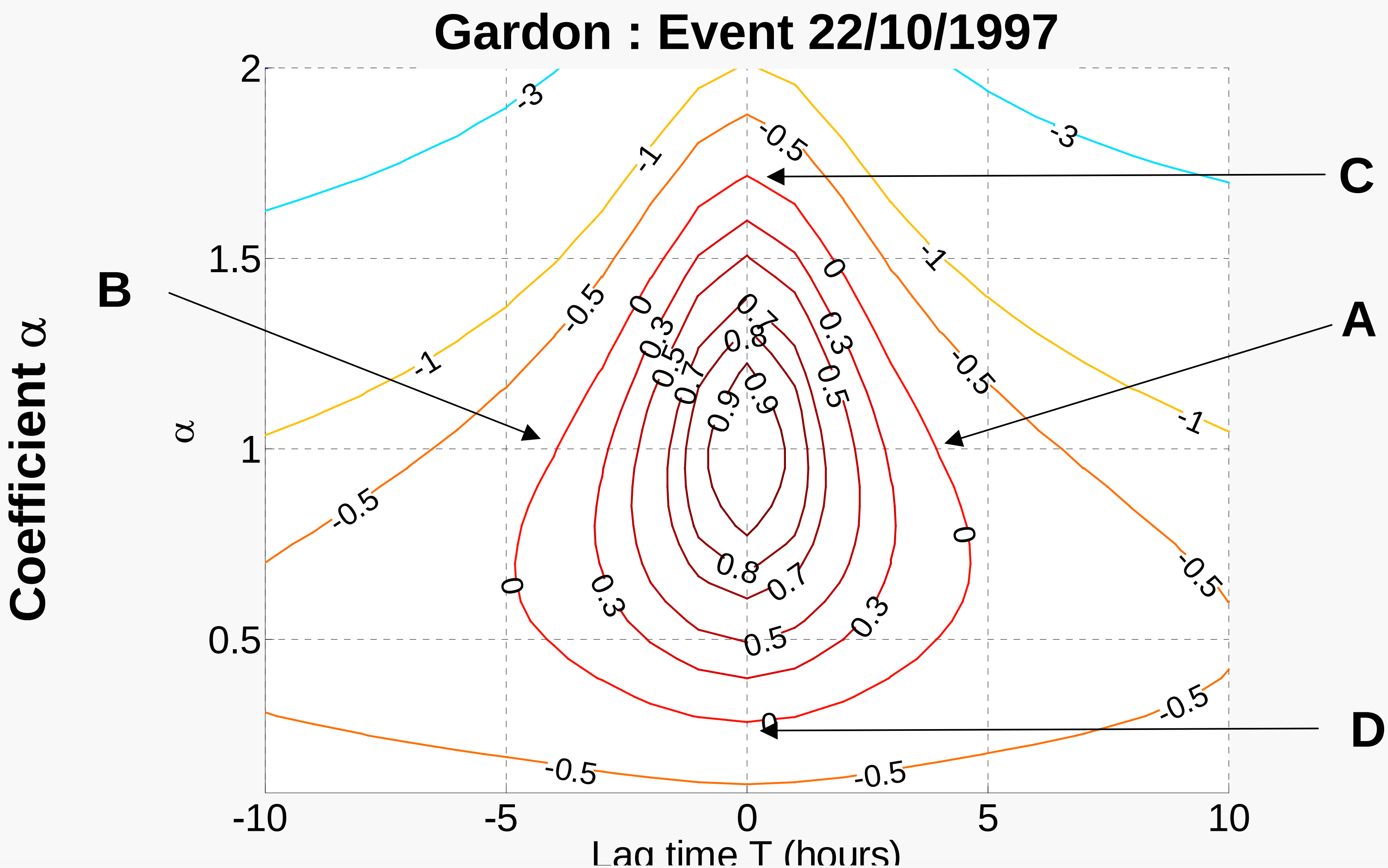
Iso-values of NSE as a function :
translation *(T hours)* ; homothetic *(coefficient α)*



The same value of NSE can correspond to various values of (T, α).

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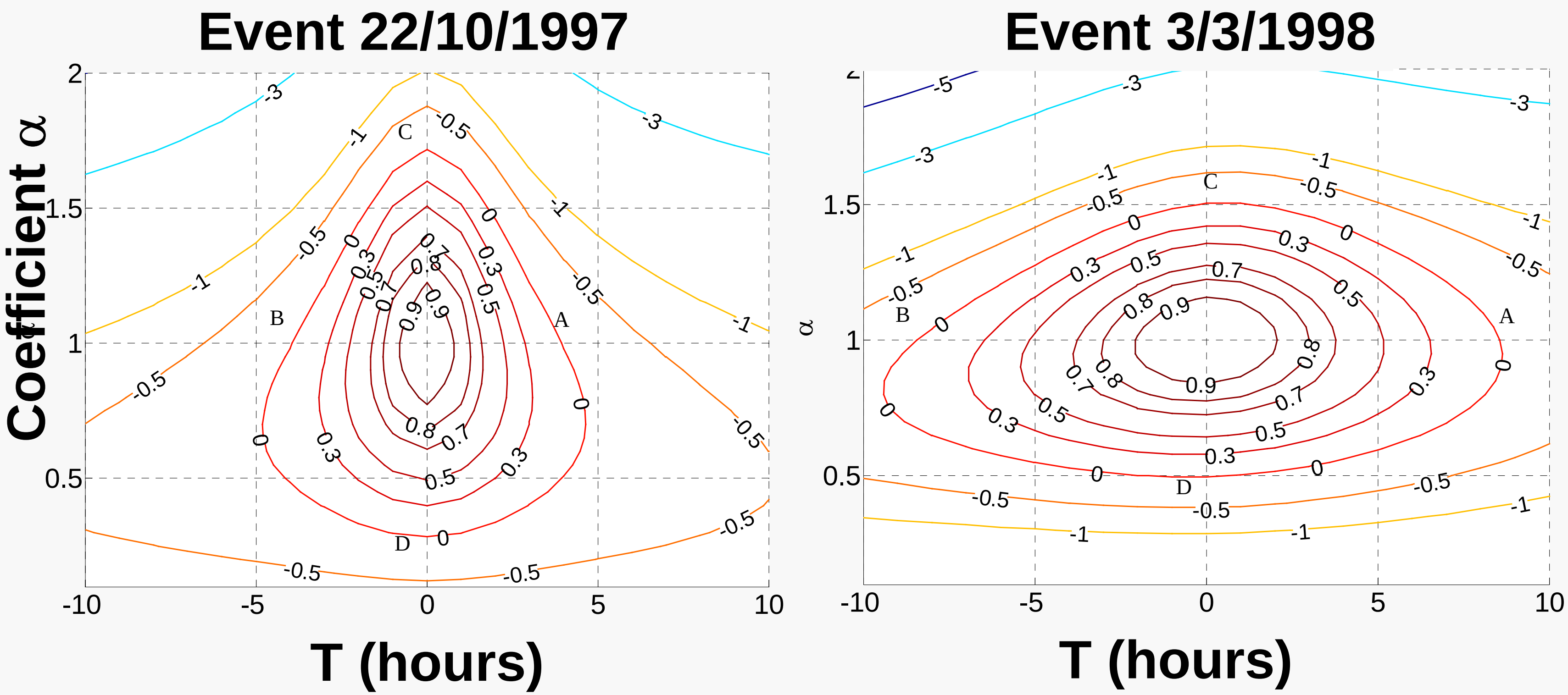
Iso-values of NSE as a function : translation *(T hours)* ; homothetic *(coefficient α)*

(example of two different flood events)



The same value of NSE can correspond to various values of (T, α).

NSE is event-depending

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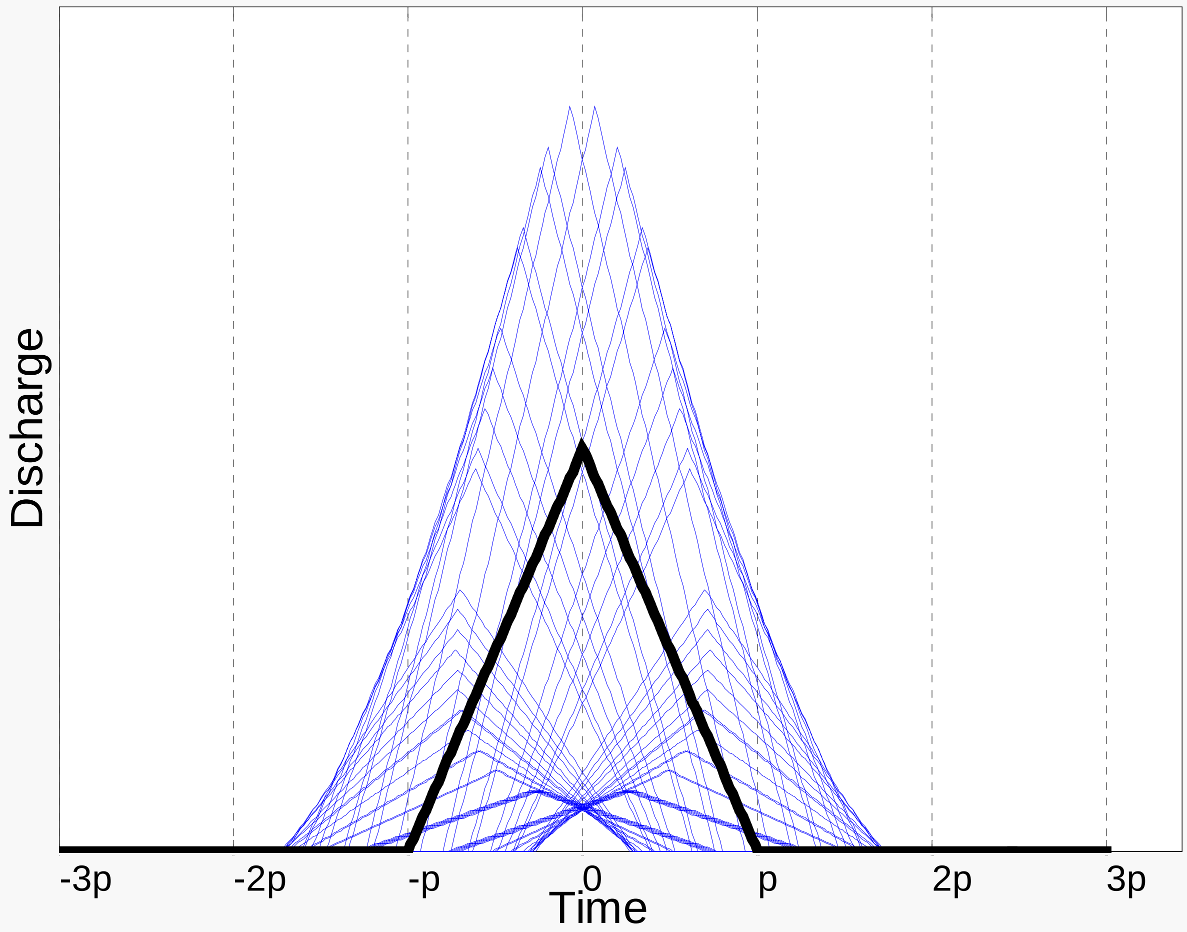
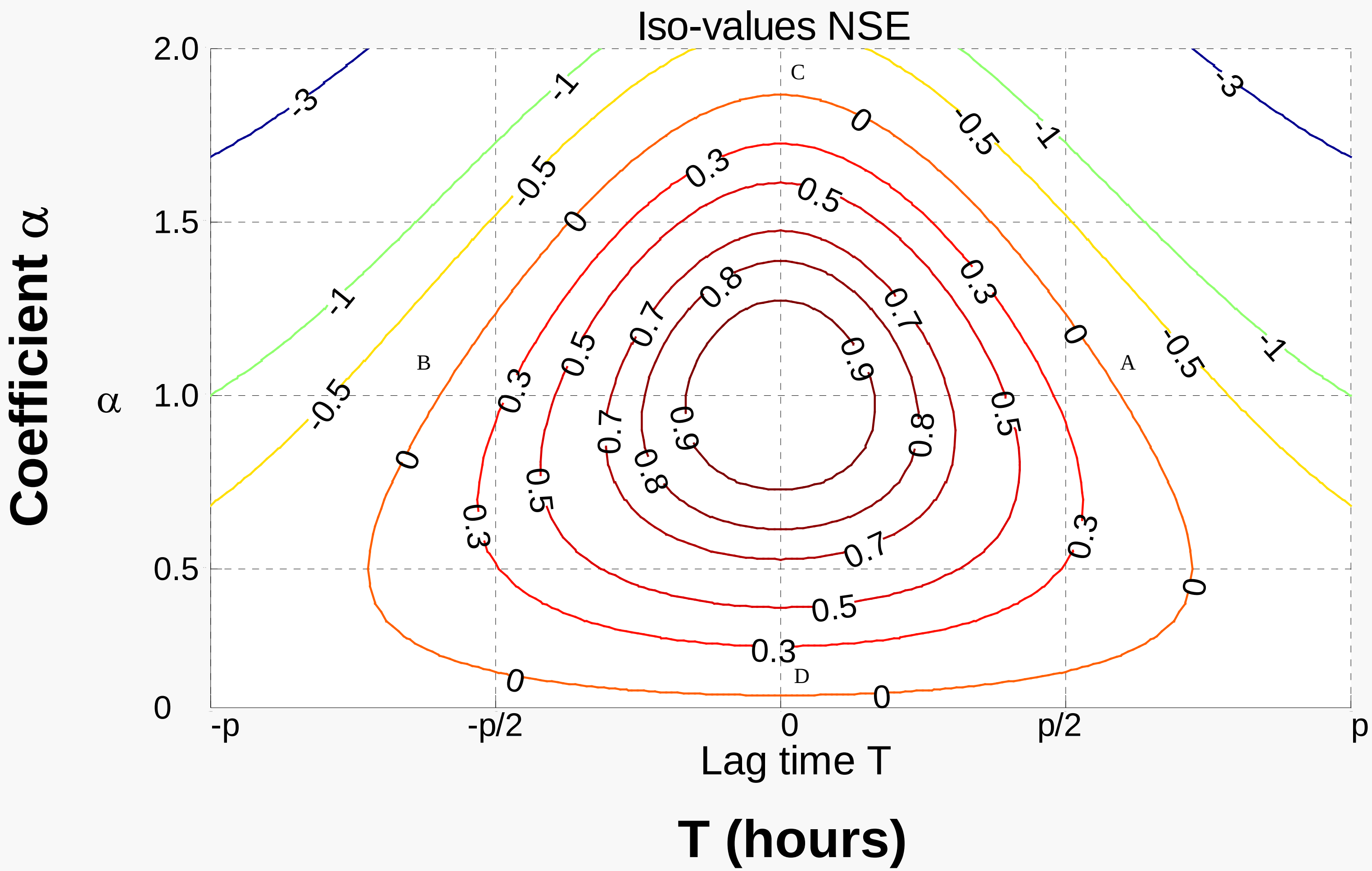
Particular case of triangular hydrographs : various hydrographs such as NSE = 0



Particular case of triangular hydrographs : Iso-values of NSE



NSE = 0 for α = 1 and T = +/- 0.58 p

NSE = 0 for T = 0 and (α = 0.04 or α = 1.77)

When does a *NSE* close to 1 may hide “bad” results ?

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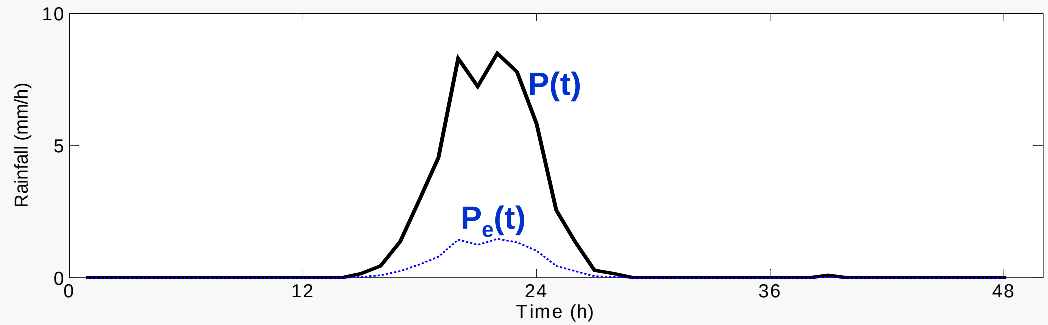
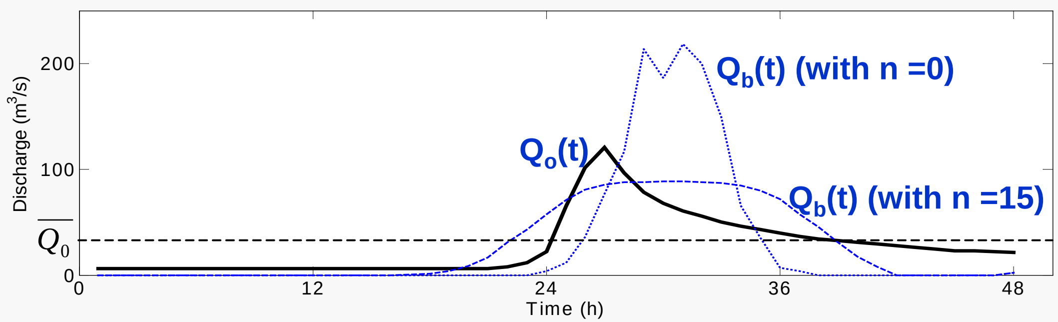
Choice of the reference model





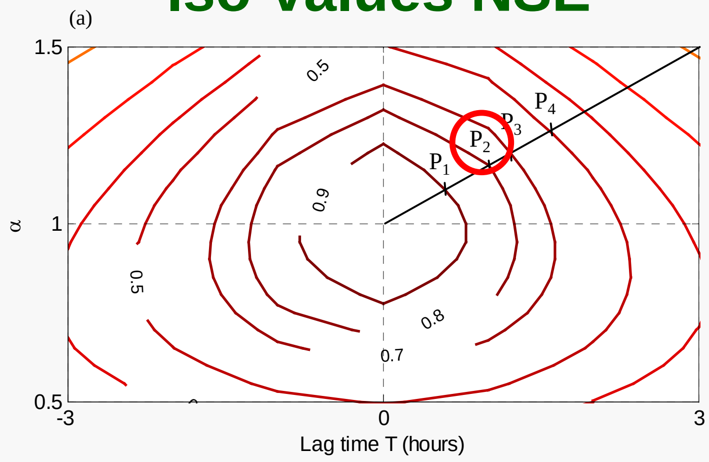
$$\mathrm{NSE} = 1 - \frac{\sum_{t=1}^{n} \left[Q_o(t) - Q_c(t) \right]^2}{\sum_{t=1}^{n} \left[Q_o(t) - \overline{Q_o} \right]^2}$$

$$G = 1 - \frac{\sum_{t=1}^{n} \left[Q_o(t) - Q_c(t) \right]^2}{\sum_{t=1}^{n} \left[Q_o(t) - Q_b(t) \right]^2}$$

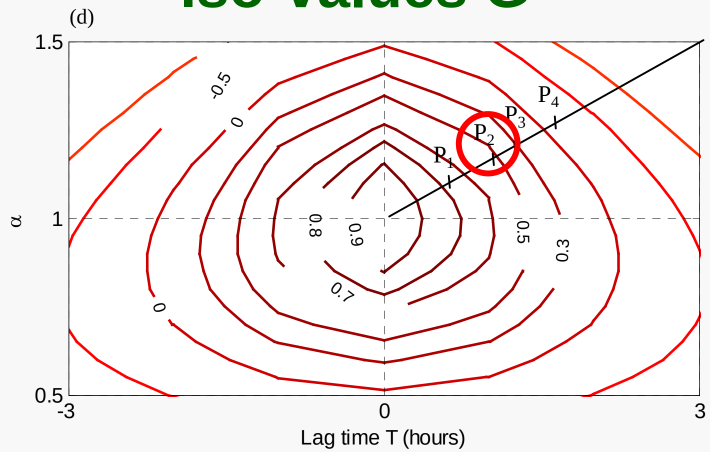
Replacing the reference discharge (mean discharge) in the NSE NSE by an elementary model Q_b (translation T and smoothing).

Comparison NSE vs G

Iso-values NSE



Iso-values G



Second remark : A « good » NSE (e.g. P_2, NSE = 0.8) may have a « bad » G (e.g. P_2, G = 0.5)

Comparison NSE vs G for three values of n = 0, 11 and 15 (noted respectively G_0, G_{11} and G_{15}) on the example of the flood event of 20/11/1977 on the Gardon

	NSE	G_0	G_{11}	G_{15}
P_1	0.90	0.97	0.85	0.67
P_2	0.80	0.92	0.71	0.53
P_3	0.70	0.88	0.55	0.32
P_4	0.50	0.82	0.28	-0.15

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Need of a multi-criteria calibration approach

Definition of 2 new criteria functions on the basis of the NSE :

- $NSE_T(i)$ which is the NSE calculated using a lag translation $i\Delta t$.

- $NSE_H(\alpha)$ which is the NSE calculated using α Qc(t).

The $NSE_T(i)$ enables to determine if low values of the NSE are due to a translation of $i\Delta t$ by the model,

The $NSE_H(\alpha)$ enables to determine if possible low values of the NSE are due to a systematic over- or under-estimation of the hydrograph by the model.

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Example of the $NSE_T(i)$ and $NSE_H(\alpha)$ for the flood event of 16/10/1980

NSE	0.617
$NSE_T(-2)$	0.402
$NSE_T(-1)$	0.600
$NSE_T(+1)$	0.481
$NSE_T(+2)$	0.259
$NSE_H(0.4)$	0.585
$NSE_H(0.6)$	0.827
$NSE_H(0.8)$	<u>0.837</u>
$NSE_H(1.2)$	0.164
$NSE_H(1.4)$	-0.518
$NSE_H(1.6)$	-1.432

In this example, the best NSE = $NSE_H(0.8)$ = 0.837 corresponds to α = 0.8

Conclusions

- Simulated hydrographs with low or negative values of NSE can be due solely to a simple lag translation or a homothetic ratio of the observed hydrograph.

- Simulations with a NSE close to 1 can give very low values (even negative) of the criteria function G, if the average observed discharged used as a benchmark reference model in the NSE is modified.

- On the basis of the previous results, we propose a new simple quick-to-use method to analyse the model performance using multi-criteria functions.

Moussa R. 2010. When monstrosity can be beautiful while normality can be ugly: assessing the performance of event-based flood models. Hydrological Sciences Journal, 55(6), 1074 – 1084, DOI: 10.1080/02626667.2010.50589.

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