# Looking at catchments in colors: why not? But what if we can not even look at them?

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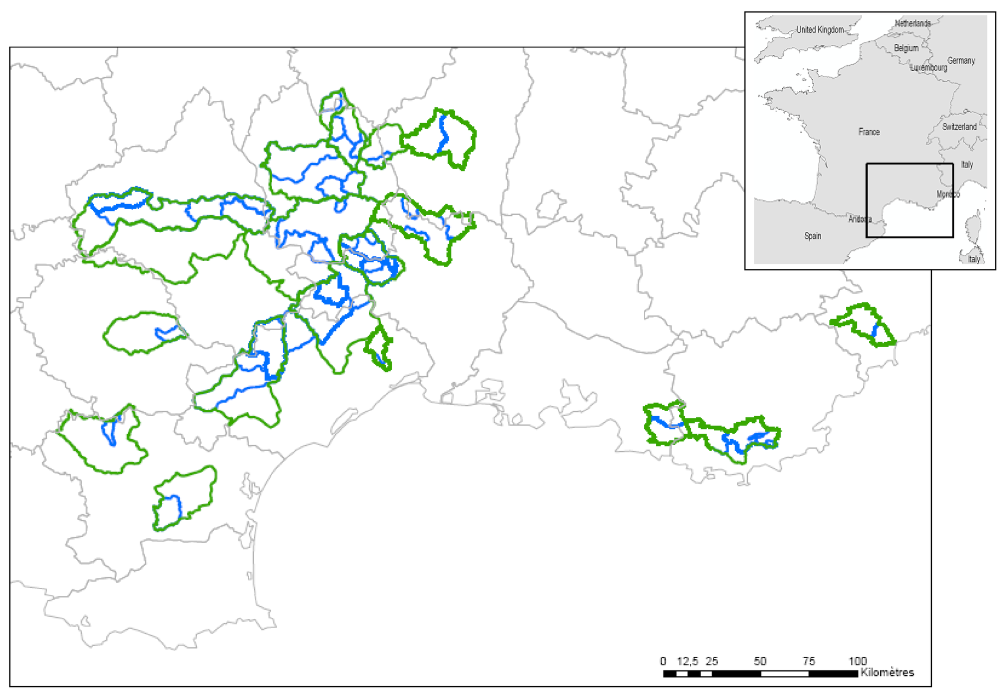
The flood of the Nartuby and Argens rivers claimed the lives of 25 people in June 2010. These two French rivers were not monitored at that time. This dramatic event highlights the need for an operational flood alert system dedicated to **ungauged watersheds.**

## Objectives

- We want to assess the ability of a simple conceptual and parsimonious rainfall-runoff model to deliver flood alerts on ungauged catchments. To do so, we applied a proxy-basin scheme using several sets of nested catchments.
- We want to know if allowing spatial variability in our model improves its performances. To answer this question, we tested different levels of spatial variability into our model.

## Data

- Runoff data from 67 watersheds in southern France:
  - 20 "downstream" catchments ranging from 150 to 2170 km²
  - 47 "upstream" catchments, considered as ungauged, nested within the "downstream" ones
- Rainfall radar data (provided by a radar network) for 15 events between 2005 and 2008
- Time step: 1h; spatial resolution: 1 km²



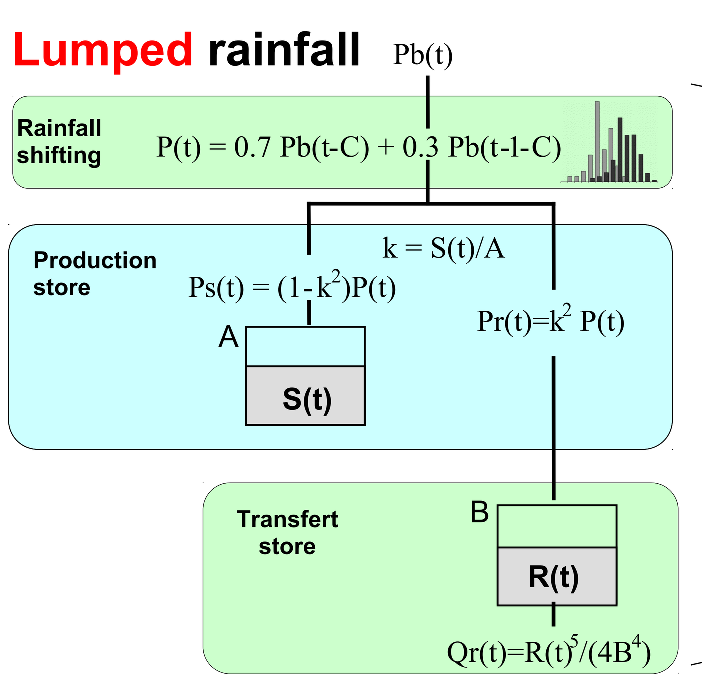
*Studied catchments in southern France. The downstream catchment are drawn with a green border, the upstream ones are drawn with a blue border.*

## Three cases of spatial variability

### Case A: lumped

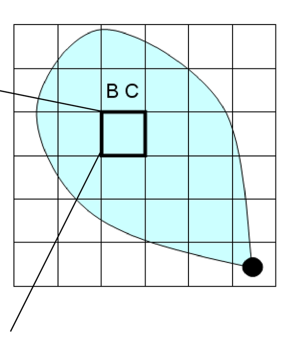
**Lumped rainfall**

**Lumped production function with one parameter**: initial soil moisture condition $S_0/A$, to be initialised a the beginning of each event



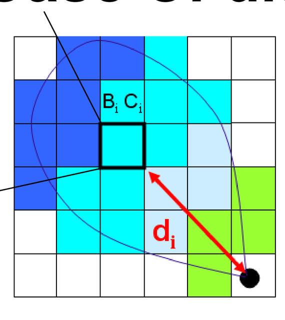

**Lumped routing function with two parameters**:
- a shape parameter B
- a lag parameter C

### Case B: semi-distributed




**Constant routing function**
B and C identical for each cell within a given catchment

### Case C: distributed




**Distributed routing function**
$B_i$ and $C_i$ parameters values in pixel i are functions of the $d_i$ distance to the outlet:
$B_i = B_0\,(pB.d_i + 1)$ $C_i = C_0 + pC.d_i$

### For each B and C cases

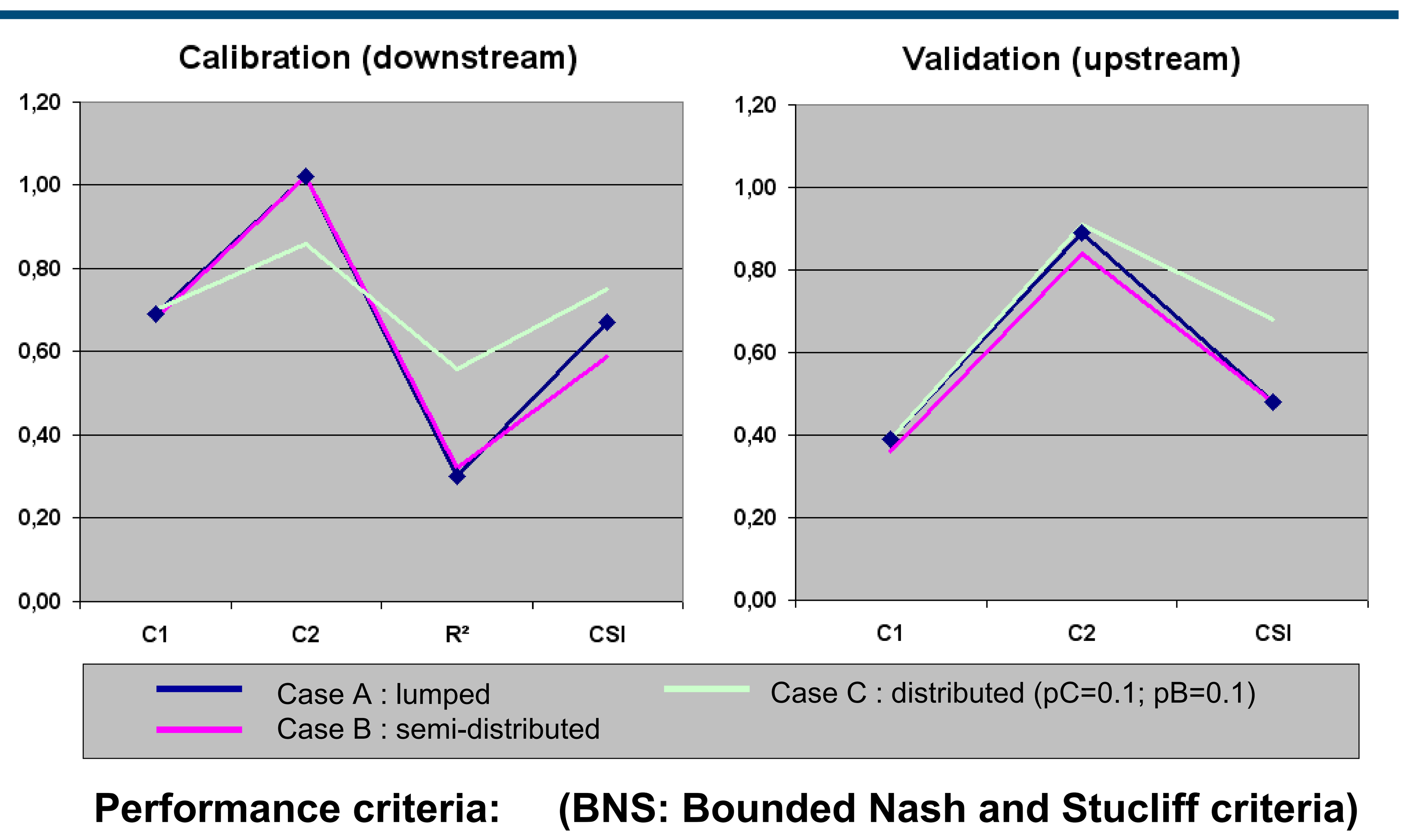
- **distributed rainfall**
- **distributed production function**
- $Q_{outlet} = \Sigma\, Q_i$

## Calibration and validation

- **Calibration** at the 20 downstream outlets:
  - calibration of the initial level of the production store ($S_0/A$) for each flood
  - calibration of the routing parameters for each watershed
  - optimisation of the bounded Nash and Sutcliff criteria ($C_{2M}$, sea Mathevet *et al.,* 2006) with optimal lag
- **Validation** at inner points transferring parameters and initial production condition calibrated downstream
- **Multi-criteria** evaluation in order to assess:
  - how well the upstream calculated floods fit the observed ones (C1 to C2 criteria);
  - how well the calibrated production parameters correlate to the moisture index of a continuous daily soil moisture accounting model ($R^2$ criteria, for the downstream catchments only);
  - if the model delivers correct alerts (CSI index).

## Results

- The distributed version performs slightly better than the lumped version.
- Fully distributing the routing parameters results in better alerts than using uniform routing parameters in the distributed version.
- To fully assess the performance of the model, further evaluation should be carried out in an operational mode, i.e. using an initialisation procedure to determine the value of the production parameter at the beginning of each event instead of using a calibrated value (see Javelle *et al*, 2010). However, the $R^2$ coefficients calculated between the calibrated initial level of the production store ($S_0/A$) and a daily moisture index gives an indication about the "ability" to initialise the model in a operational use. The $R^2$ values obtained at the downstream calibration indicate that the distributed version of the model seems the most promising for an operational use.




**Performance criteria:** **(BNS: Bounded Nash and Stucliff criteria)**

C1: median flood BNS
C2: mean flood relative peak error
R²: correlation with continuous init. index
CSI: critical success index

for all criteria: the closer to 1, the better

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Javelle, P., Fouchier, C., Arnaud, P., Lavabre, J., Flash flood warning at ungauged locations using radar rainfall and antecedent soil moisture estimations, Journal of Hydrology (2010), doi: 10.1016/j.jhydrol. 2010.03.032

Mathevet T., Michel C., Andréassian V. et Perrin C. (2006). A bounded version of the Nash-Sutcliffe criterion for better model assessment on large sets of basins. IAHS-AISH Publication, n° 307, 211-219.

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