Progressive refining of spatial and temporal resolutions in a hydrological model : how far should we go ?

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PROGRESSIVE REFINING OF SPATIAL AND TEMPORAL RESOLUTIONS IN A HYDROLOGICAL MODEL: HOW FAR SHOULD WE GO?

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We propose to analyse the potential synergy between spatial and temporal resolutions in a hydrological model. We aim to understand in which situations higher resolutions are needed for better simulation performances.

General methodology and input data

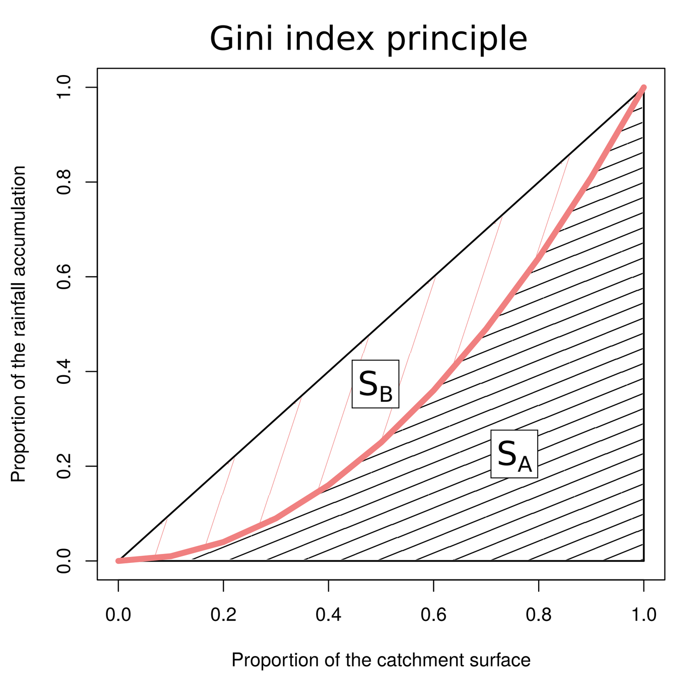
- *Rainfall*: Antilope dataset at 1h and 1km^2 resolutions (Météo-France)
- *PET*: daily SAFRAN database disintegrated at hourly time step
- *Discharge*: Hydro database at variable time step
- *Hydrological model*: GRSD semi-distributed model *(Lobligeois et al., 2014)* at 5 temporal resolutions (from 1h to 24h) and 5 spatial resolutions (from 50km^2 to catchment scale).
- *General methodology:*
  - i) Calibrate GRSD at each resolution and for 240 catchments (2006-2014)
  - ii) Extract 10 most important rainfall-runoff events by catchment *(Ficchì et al. 2016)* Describe the spatio-temporal variability of each event using different indexes
  - iii) Aggregate time series at 24h time steps (for comparison)
  - iv) Analyse performances according to rainfall and catchment characteristics

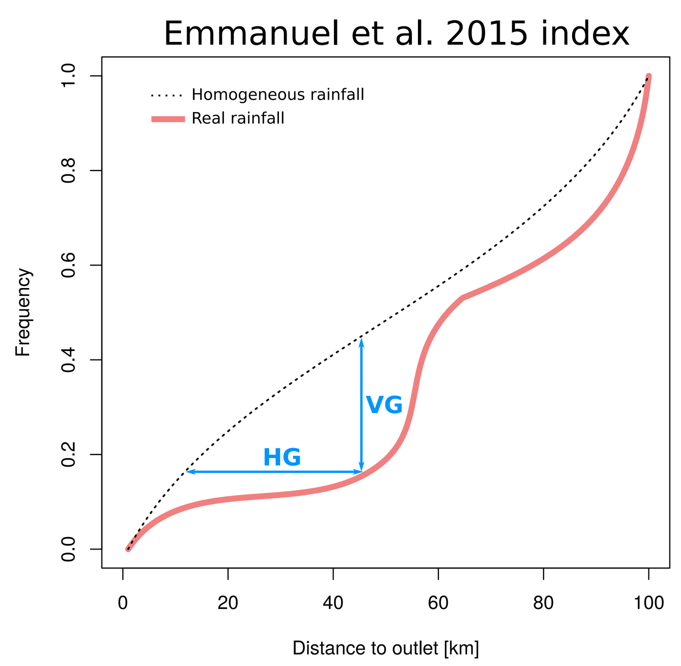
1) Rainfall-runoff events description

Different indexes performed to describe spatial variability, localisation and movement of the rainfall events:

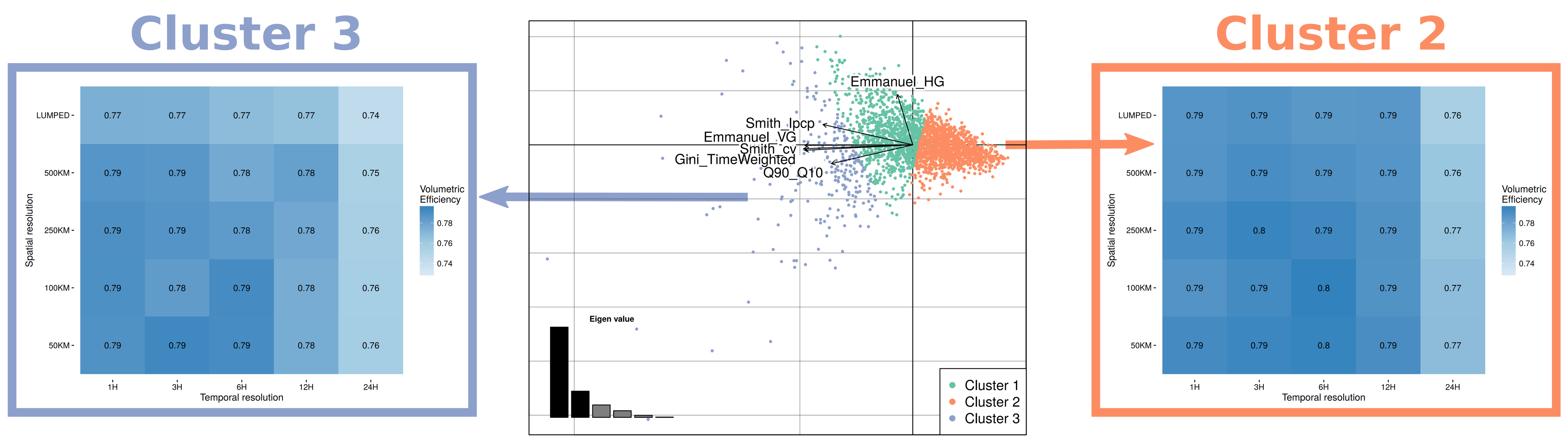
- Weighted standard deviation *(Smith et al., 2004)* — $I_\sigma = \frac{\sum_{t=1}^{T} \sigma_t . P_t}{\sum_{t=1}^{T} P_t}$
- Gini index applied to rainfall (Fig. below) — $Gini(t) = \frac{S_B}{S_A + S_B}$
- Vertical gap (VG) and horizontal gap (HG) as proposed by *Emmanuel et al. 2015* (Fig. below)
- Ratio of 90th and 10th quantiles of rainfall values
- Localization index *(Smith et al., 2004)* according to the distance to the outlet L_i — $I_{pcp} = \frac{C_{pcp}}{C_{bsn}}$

$$C_{bsn} = \frac{\sum_{i=1}^{N} A_i . L_i}{\sum_{i=1}^{N} A_i} \qquad C_{pcp} = \frac{\sum_{i=1}^{N} P_i . A_i . L_i}{\sum_{i=1}^{N} P_i . A_i}$$





2) Higher resolutions for which rainfall-runoff events?



- Highlight highly correlated rainfall indexes
- Highly variable events benefit markedly more from higher resolutions than homogeneous events.

3) Higher resolutions for which catchments?

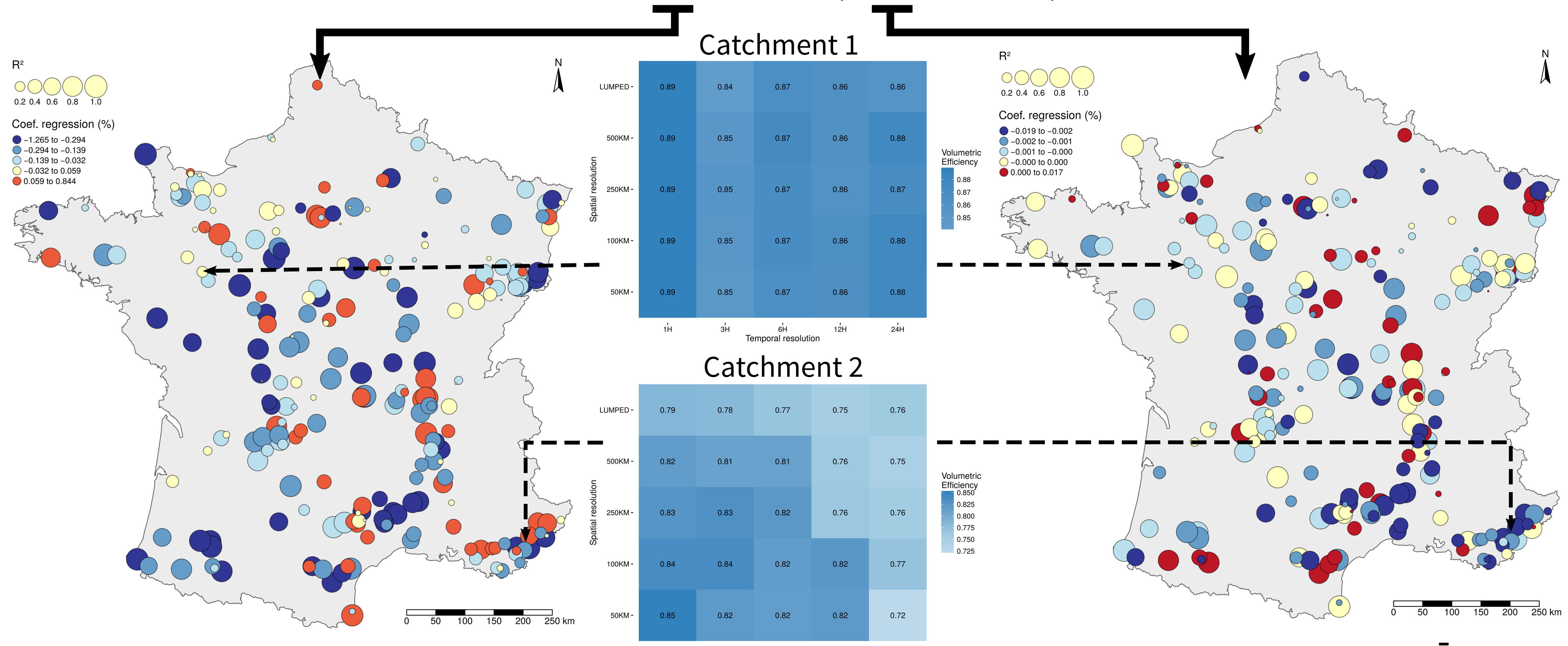
$$VE = a \cdot \delta T + b \cdot \delta S + c$$

Volumetric Efficiency VE

Temporal resolution δT

Spatial resolution δS

Regression coef. $a\ b\ c$



Example catchment 1: *L'Argens at Roquebrune-sur-Argens (2530 km^2)*

Example catchment 2: *La Sarthe at Saint-Denis-d'Anjou (7380 km^2)*

- *Catchment 1:* No synergy detected between spatio-temporal resolutions
- *Catchment 2:* Both spatial and temporal resolution lead to better performance

- No particular region seems to benefit from an increase of temporal resolution (coef. a) whereas an increase of spatial resolution seems to be more beneficial in the South (coef. b)

- Catchments that benefit from simultaneous increase of both resolutions are few

4) Conclusion

- Higher resolutions do not always lead to better performance
- Increasing resolution should be thought both on time and space in order to overstep some thresholds in performance
- A semi-distributed model that can deal with different resolutions is useful to better catch hydrological responses
- Temporal and spatial resolutions do not affect performance similarly, a synergy is observed only for few catchments
- Further efforts will be placed in a better anticipation of the resolution that suits catchment and rainfall characteristics (eg. for modelling ungauged catchments).

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