Modelling scale invariance in river flow time series: a search for coherence between approaches

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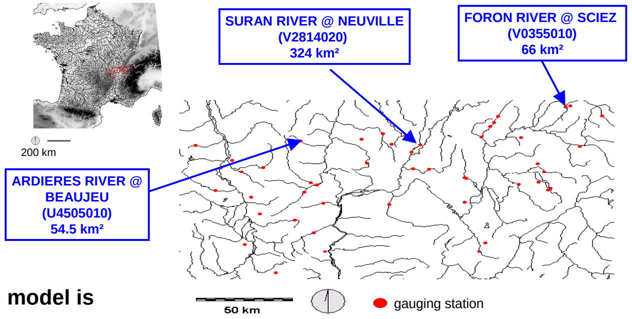


⇨ Objective

To study the scaling properties of river flow time series by comparing the results of three techniques applied to an extended data set of 38 French gauging stations.

The three approaches used, based on different mathematical tools and hypothesis, are:

1 - the flood frequency analysis through the fitted flow duration frequency curves (QdF),
2 - the shape analysis of flood hydrographs,
3 - the empirical energy spectrum in a multifractal framework.

The aim is not to promote one technique against the others, but instead to evaluate the **coherence in the range of durations over which each model is valid** and to establish the links between the limits of the detected ranges and the hydrological processes involved.

(1) The flow-duration-frequency curves QdF

The equation of QdF curves is:

$$V(d,T) = \frac{V(T)}{1 + d/\Delta} \quad \text{for} \quad d \in [0, \Delta] \quad \text{and } T < 20 \text{ yrs}$$

where T denotes the return period; $V(d,T)$, the mean discharge computed over duration d with a T return period; $V(T)$ is a distribution function of V and Δ, a fitted time parameter.

(2) The shape analysis of flood hydrographs

The most severe flood hydrograph $Q(t)$ within each year is selected and scaled by its peak value. For each hydrograph, we calculate the duration δ for which $Q(t)/Q\max > 0.5$. The histogram of δ describes the spreadness of the hydrographs. D is the median of δ. A representative hydrograph Q^* is then calculated by averaging the dimensionless hydrographs to graphically test shape invariance.

(3) Spectral analysis

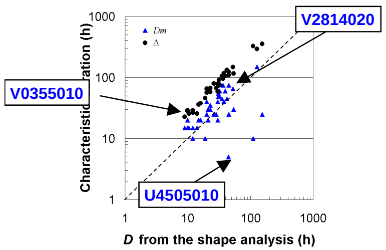
The energy spectrum E is evaluated in the multifractal analysis of time series to investigate their scaling invariance properties. If E shows a power-law behaviour over a given frequency interval, scaling invariance is suggested over the corresponding range of duration. In a log-log plot, a straight line can be fitted and the first cut-off above 1 h, Dm, can be determined. All the data are involved in the calculation, but spectrum variation is mainly controlled by extreme events.

Three selected examples:

SURAN RIVER @ NEUVILLE (V2814020)

FORON RIVER @ SCIEZ (V0355010)

ARDIERES RIVER @ BEAUJEU (U4505010)



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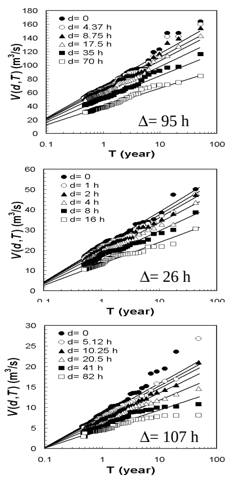

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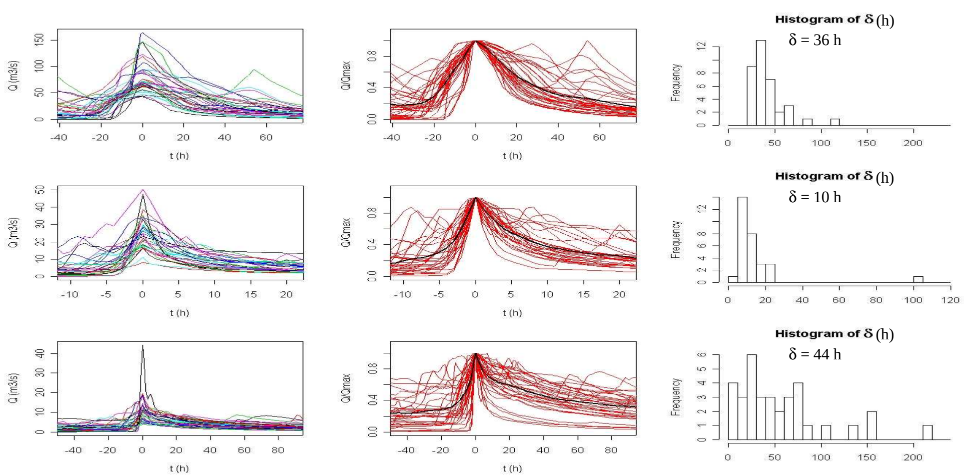

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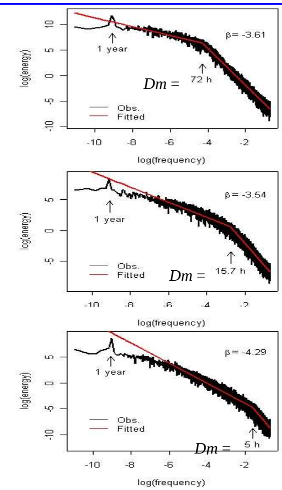

COMPARISON OF CHARACTERISTIC DURATIONS The results obtained from the analysis of 38 time-series show:

1 – On the whole, $D < Dm < \Delta$
2 - Dm < the synoptic maximum (~ 16 days = 384 h) and Dm seems to be linked to the dynamic of the floods
3 - A good correlation between D and Δ ($\Delta = 2.52\ D$; $R^2 = 0.97$) and a poor relation between D and Dm, which can be partly due to the high variability of the hydrograph shapes