STUDY OF RAINFALL INTENSITIES FOR MICRO-SCALES IN A SEMI-ARID ZONE (TUNIS) BY FIF MODEL

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Introduction

This work focuses on studying the rainfall intensities of time increment less than a few hours. Multifractal fractionally integrated model (FIF) which is a universal multifractal model devoted to nonstationnary processes, based on a multiplicative cascade and having three parameters is used.

Data: The data used for this study come from the database of the General Directorate of Water Resources (DGRE) of the Ministry of Agriculture of Tunisia (Table 1). The study sites are those of Tunis-Manoubia, Mornag and Sidi Thabet (Fig. 1). They belong to the network SYCOTRAC of flood alert.

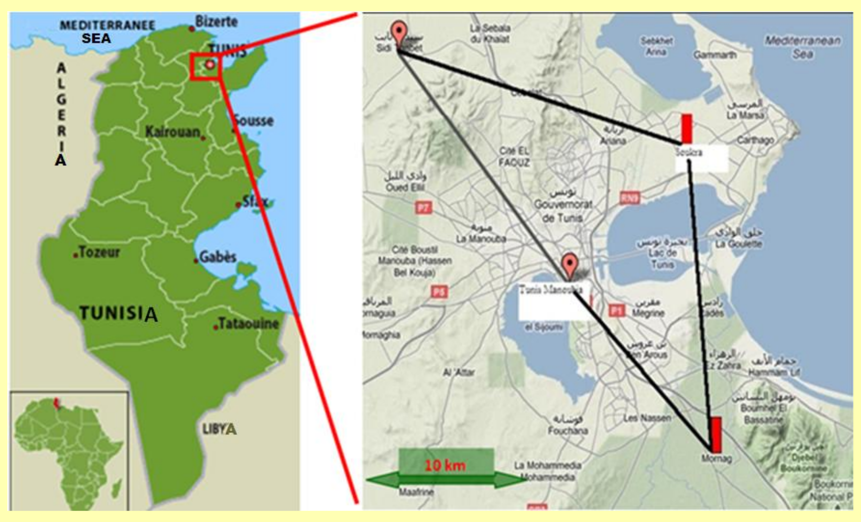

Fig. 1 Localization of gauging stations

The study sites are equipped with automatic tipping bucket rain gauges. The capacity of a bucket is 0.1 mm of rain. The obtained time series have a resolution of 5 mn (Fig.2).

Station	Long.	Lat.	Alt. (m)	Start	End	% of zero
Manoubia	8Gr, 7060	40Gr, 8711	66	31/12/2007	05/08/2010	99,17
Mornag	8Gr, 8500	40Gr, 6600	35	31/12/2007	31/07/2010	98,99
Sidi Thabet	8Gr, 5580	41Gr, 0040	20	31/08/2007	14/05/2010	99,03

Table. 1 Data, Time Resolution: 5minutes (source: DGRE)

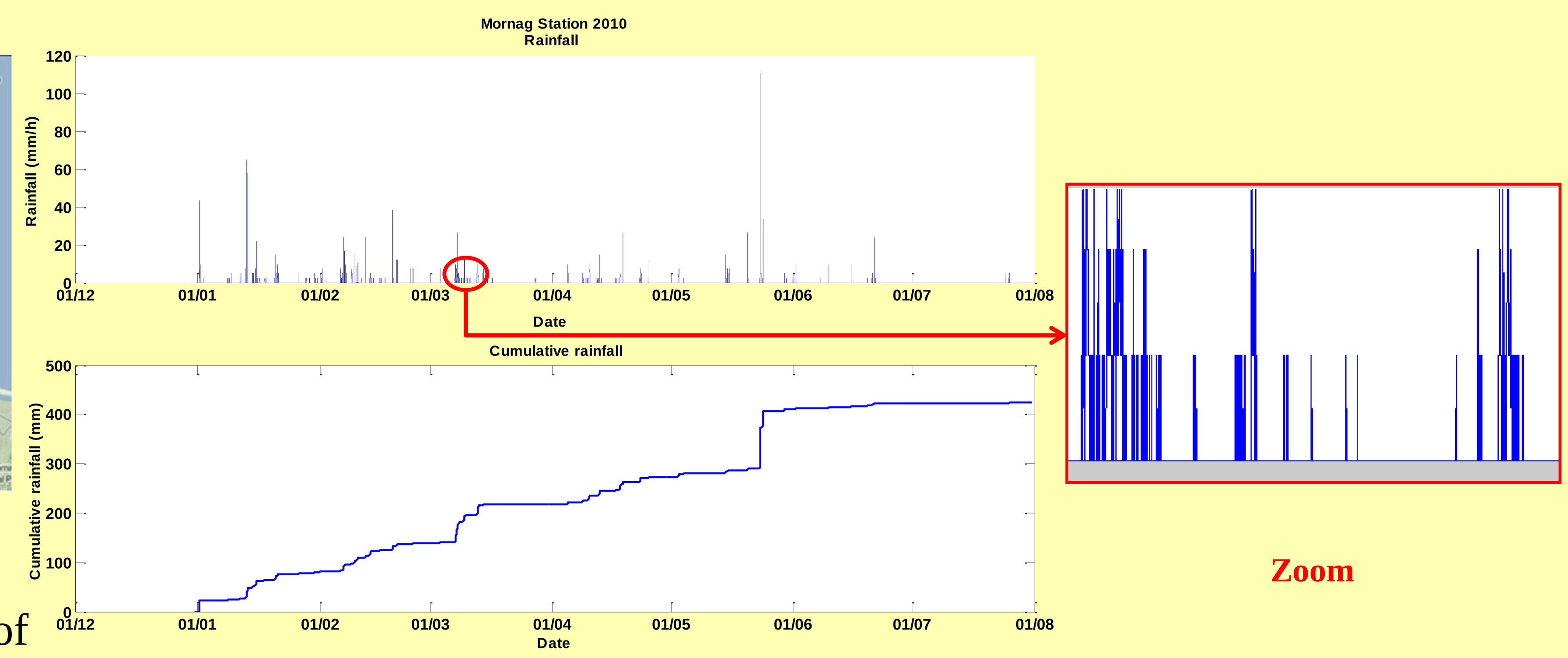

Fig. 2 rainfall recorded at the station Mornag, during the year 2010

Methodology

1/ Universal's Multifractal (MU):

- Opportunity to return to a simple form by considering universal continuous multiplicative cascades Schertzer & Lovejoy, (1987) (Fig. 3)
- This simple form has properties of an attractor and depends only on two parameters C_1 et α :

$$\begin{cases} K(q)=\dfrac{C_1}{\alpha-1}\, q^{\alpha}-q \\ c(\gamma)=C_1\left(\dfrac{\gamma}{C_1\alpha'}+\dfrac{1}{\alpha}\right)^{\alpha'} \\ \alpha\neq 1 \ \text{ et } \ \dfrac{1}{\alpha}+\dfrac{1}{\alpha'}=1 \end{cases}$$

$C_1 \in (0,2)$: distance to homogeneity (C_1=0, homogeneous)

$\alpha \in (0,2)$: multifractality parameter (α=0, mono fractal)

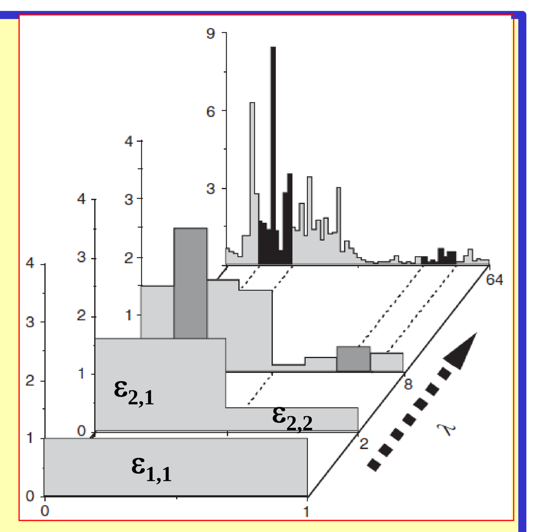

Fig. 3 multiplicative cascades (Yaglom, 1966)

2/ The fractionally integrated flux model (FIF)

- Conservative fields - **not conservative** : $\begin{cases} E(\varepsilon_\lambda)=\text{cte},\ \forall\lambda \\ E(\varepsilon_\lambda)\approx\lambda^{-H}\neq\text{cte}\end{cases}$
- Fractional derivation of ε_λ to order H : $\Phi_\lambda=\left|\Delta R_\lambda(t)\right|\Delta t^{-H}$
- Three parameters define the model characterizing the field: C_1, α, H

Analysis performed

1/ Spectral analysis

- Scaling regimes are associated with power-law spectra, i.e $E(\omega)\sim\omega^{-\beta}$ (Fig. 4)
- At small frequencies (i.e. timescales > 1 week), the spectrum is almost flat .
- However, we will look only at the micro-scale, which takes place for the time increments less than 2h30min. We note that ***β*>1**, → Process **not conservative**.
- Flattening behaviour at the end of the spectrum (high frequencies) is observed which may be explained by quantization noise

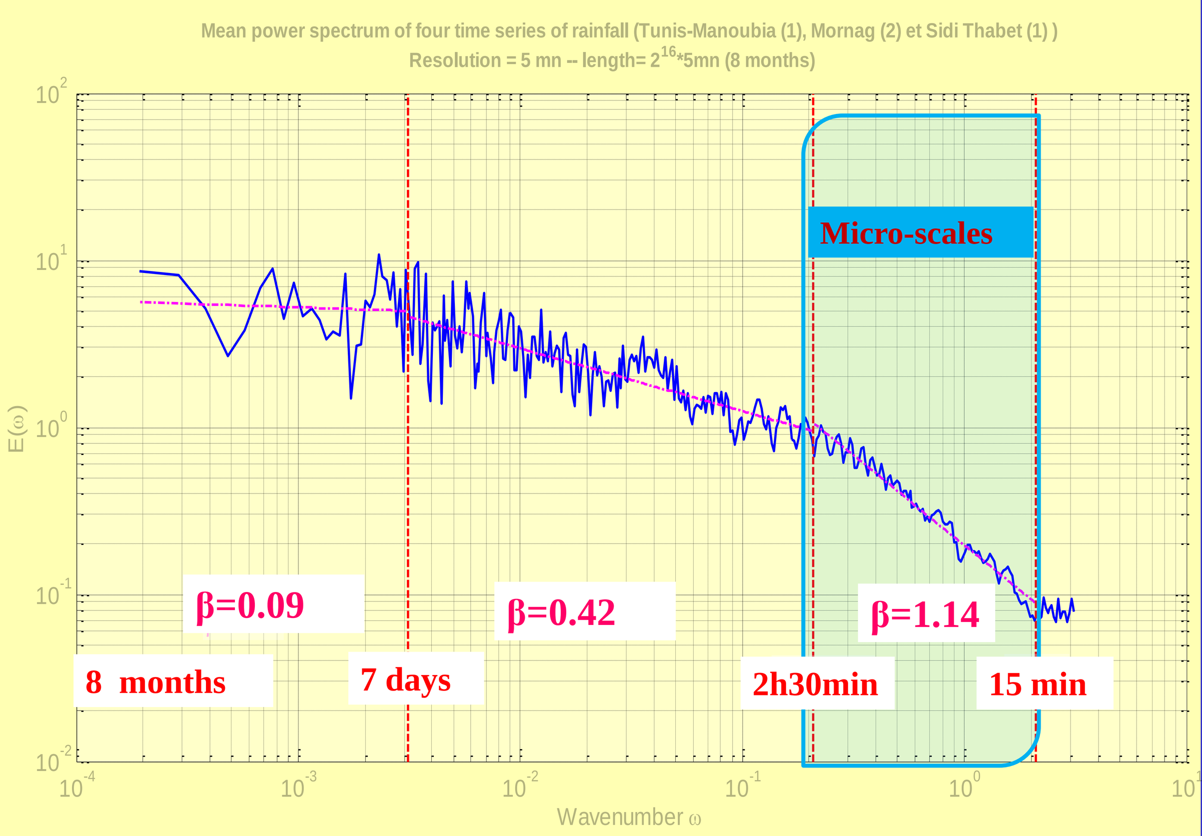

Fig. 4 Averaged power spectrum of four series of rainfall length of about 8 months, measured at 5-minutes time step

2/ Estimation of parameter H

H quantifies the degree of non-conservation process, and the increment from which the phenomenon becomes conservative:

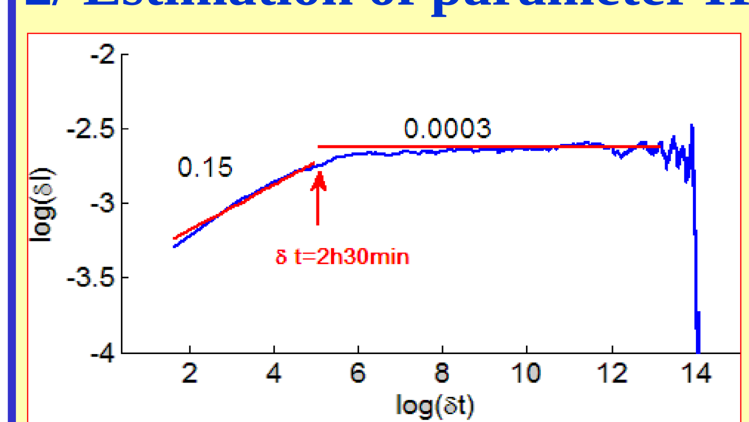

Fig. 5 Parameter estimate H for Δt = 5mn for Tunis-Manoubia Station. Resolution of series = 5min and series length = 2.5 years (λ = 1)

2/ Estimation of parameters C_1 and α:

K (q) was adjusted to obtain MU parameters. According to literature finding, C_1 is close to studies for which the effect of intermittency has not been taken into account. However, the estimate of α seems not good. But they are both biased.

Station	Manoubia	Mornag	Sidi-Thabet
C_1	0.53	0.46	0.46
α	0.06	0.00	0.00

Table. 2 Parameter Estimation of MU model for sets of lengths 2.5 years

Explanation: (1) High percentage of null value (Table 1) (2) Problem of quantifying of the data (Fig. 2) } Overestimation of C_1, underestimation of α

Parameters correction

1/ Study of continuous events (*)

To overcome the errors introduced by the bias, an analysis of micro-scale regime is performed by selecting shorter continuous series.

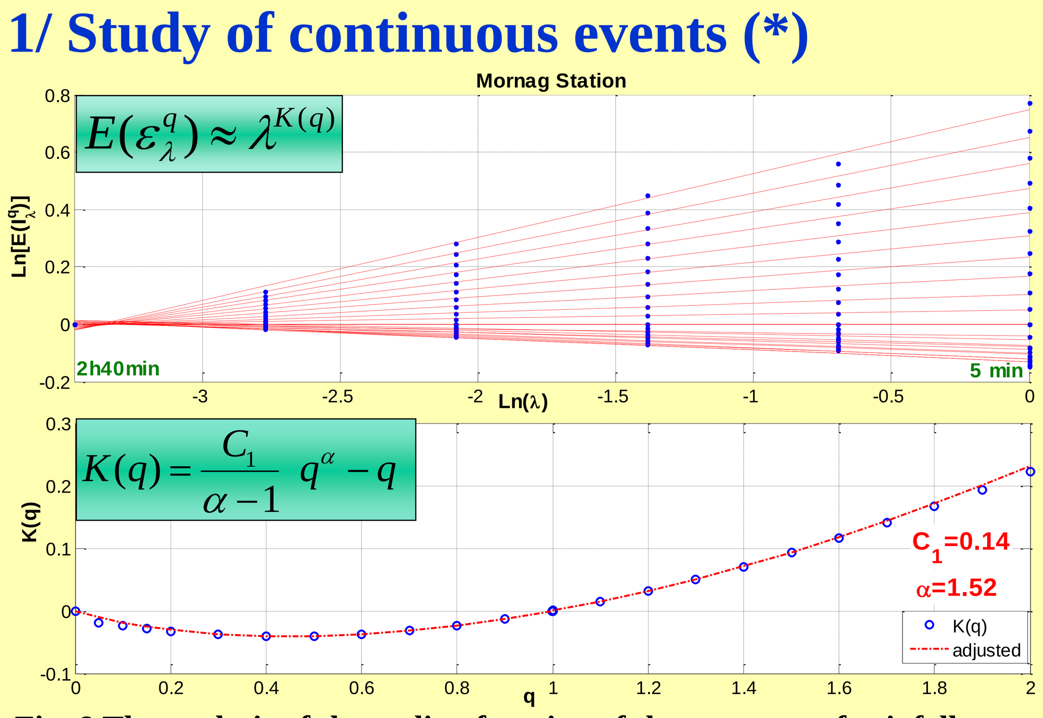

Fig. 6 The analysis of the scaling function of the sequence of rainfall recorded on 23-May-2010 at 13h15 and lasted 2 hours 40 minutes at Mornag station. (Top) The statistical moments of order and (bottom) the moment scaling function K (q).

Table. 3 comparison between the two methods

Method	C_1	α
(*)	0.14	1.40
(**)	0.07	1.63

2/ Empirical method for correcting the bias (**)

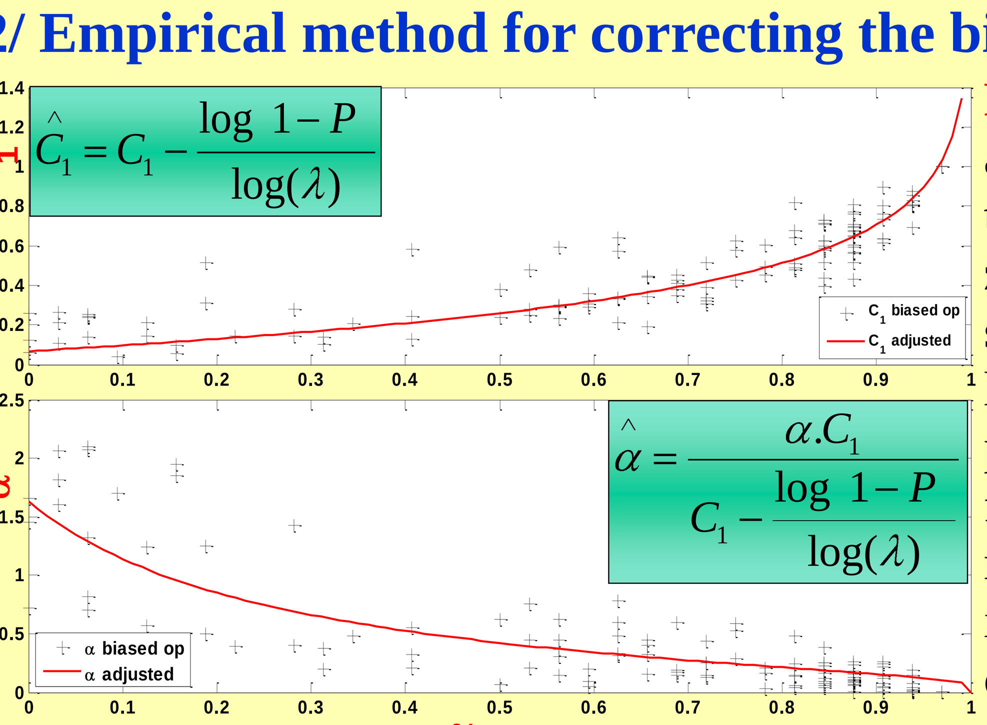

Fig. 6 Presentation of parameters C_1 (plus, top) and α (plus, below),. Unbiased estimated parameters are: α = 1.63 and C_1 = 0.07.

Principle: This approach consists in analyzing sequences of length 2h40mn taking into account the percentage of zero values they contain. For each sequence of 2h40min containing at least one non-zero value; the percentage of zeros (P) is determined for a window that starts from the first non-zero value. The window is slided in 5 min. Only sequences that correspond to a decrease in the number of zeros are kept. The calculation of the parameters α, C_1 is then established for each of the sequences.

Conclusion

The application of universal multifractal FIF model on datasets of rainfall intensity of very intermittent rain results in a biased estimate of the parameters: overestimation of C_1 and underestimation of α. To overcome this situation, we have limited the investigation to sequences of continuous rain. This method is difficult to implement because of the scarcity of events strong enough to override the problem. Effectively we have few events useable despite 2.5 years of data. So it was necessary to propose an alternative. An explicit relationship between the percentage of zero and the model parameters has been highlighted. This method gives satisfactory results and showed its relevance. These results should be taken with caution pending further study on other data sets, which will consolidate these results.As a perspective, it is envisaged to extend this study on larger time scales. Then we will exploit the results in the development of the Intensity-duration-area-frequency (IDAF) curves.

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