École Nationale
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STUDY OF THE OCCURRENCE OF RAIN IN THE REGION OF TUNIS IN A MONO-FRACTAL FRAMEWORK

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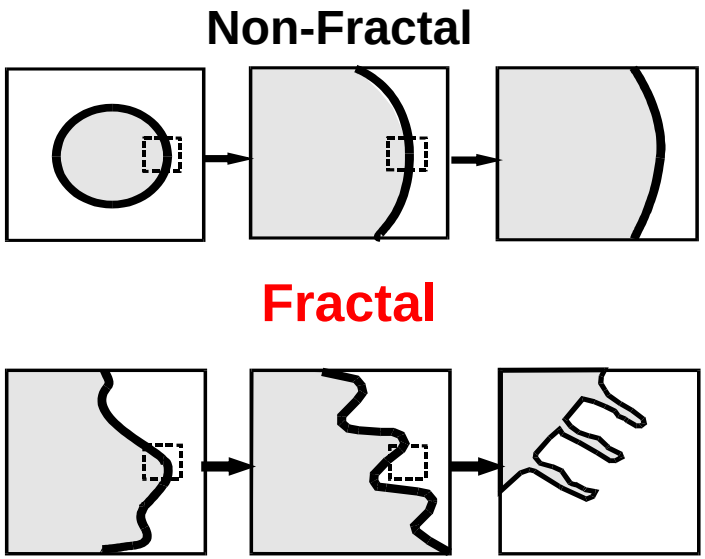
Fractal



Définition

The term "fractal“ It refers to an object type whose irregularity distinguishes Euclidean geometric figures such as straight or circle. In Euclidean geometry, the figures have an entire dimension: 0 for a point, 1 for curve, 2 for a surface and 3 for a volume. However, the dimension of a fractal can take non-integer values.

Examples of fractal geometry

D_f is the fractal dimension, λ the magnification ratio, and N (λ) the number of identical forms:

$$N = \lambda^{D_f}$$

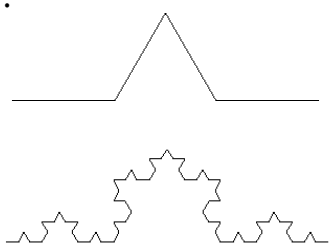
$$D_f = \log(N)/\log(\lambda)$$

- Von koch curve

we remplaces :

by:

Iteration 4:

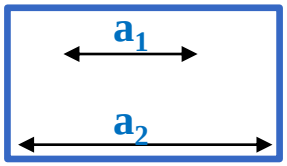


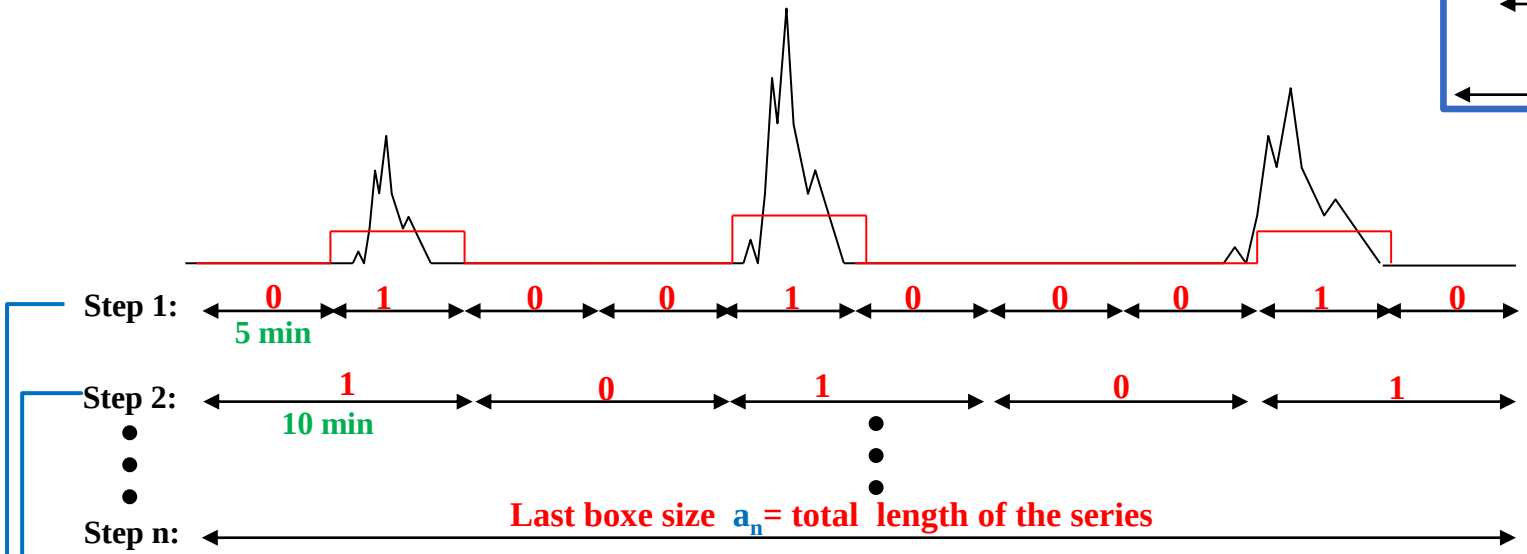
$$D_f = \log(4)/\log(3) \approx 1.26$$

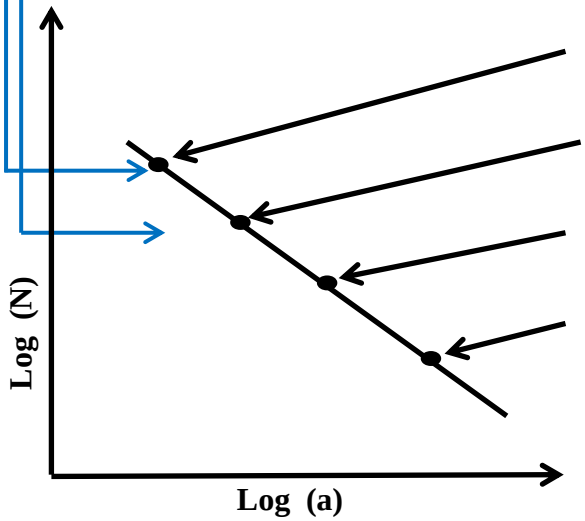
- Cantor's triadic set

$$D_f = \log(2)/\log(3) \approx 0.63$$

Calculating the fractal dimension







$$Log\left[N_\lambda(A)\right] = -D_f \; Log\left[a\right] + K$$

D : **Euclidian dimension**

$N_\lambda(A)$: **number of boxes needed, side a, to cover map**

Data

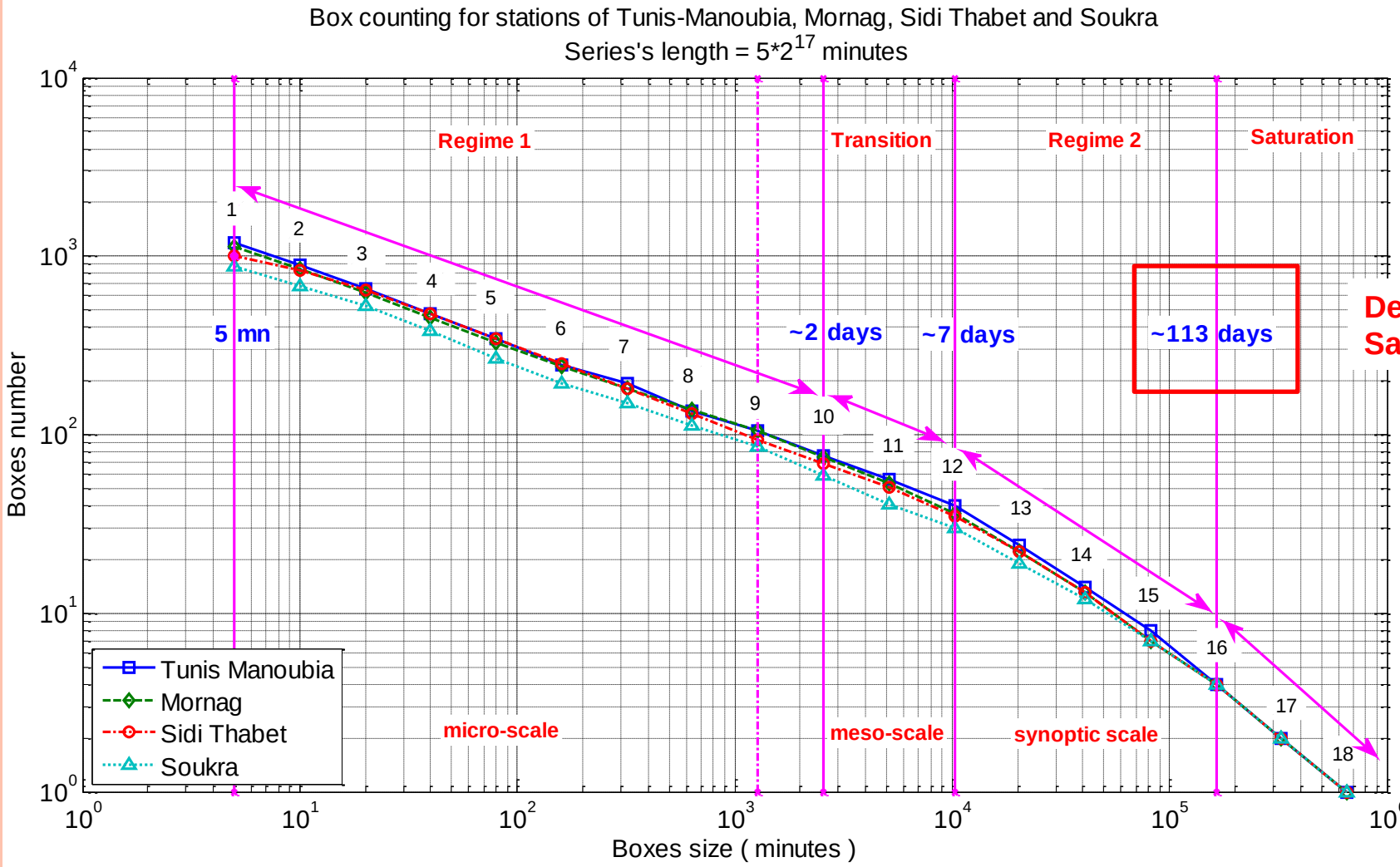
Table. 1 Data, Resolution: 5 minutes (source: DGRE)

Station	Long.	Lat.	Alt. (m)	Start	End	Resolution
Tunis-Manoubia (A)	8Gr, 7060	40Gr, 8711	66	31/12/2007	05/08/2010	5 minutes
				31/12/1872	31/08/2009	1 day
Mornag (B)	8Gr, 8500	40Gr, 6600	35	31/12/2007	31/07/2010	5 minutes
Soukra (C)	8Gr, 3770	40Gr, 9540	15	31/12/2007	23/05/2010	5 minutes
Sidi Thabet (D)	8Gr, 5580	41Gr, 0040	20	31/08/2007	14/05/2010	5 minutes

- Climate: Semi-arid Mediterranean
- Average rainfall : 444 mm/ year (Tunis-Manoubia [01/09/1973-31/08/2009]
- Percentage of zero ≥ 99 %
- Length of mean event < 10 min
- Length of max event =255 min (in Soukra)
- Length of max dry period =117 days (Sidi Thabet)

The fractal dimension of rainfall support

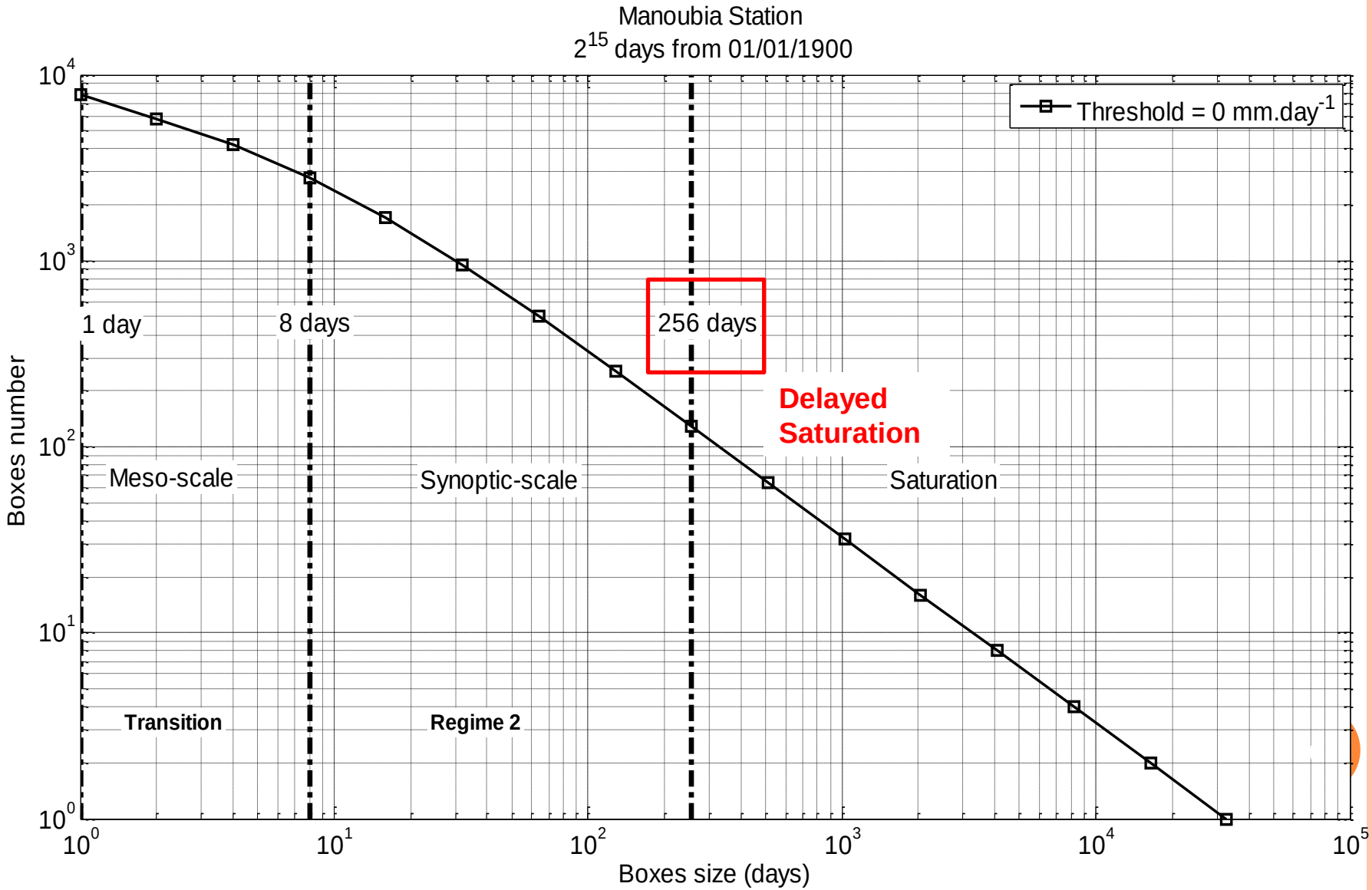
5 min-time step series



Delayed Saturation

The fractal dimension of rainfall support

Daily series of Tunis-Manoubia station(1900 -2009)



The fractal dimension of rainfall support

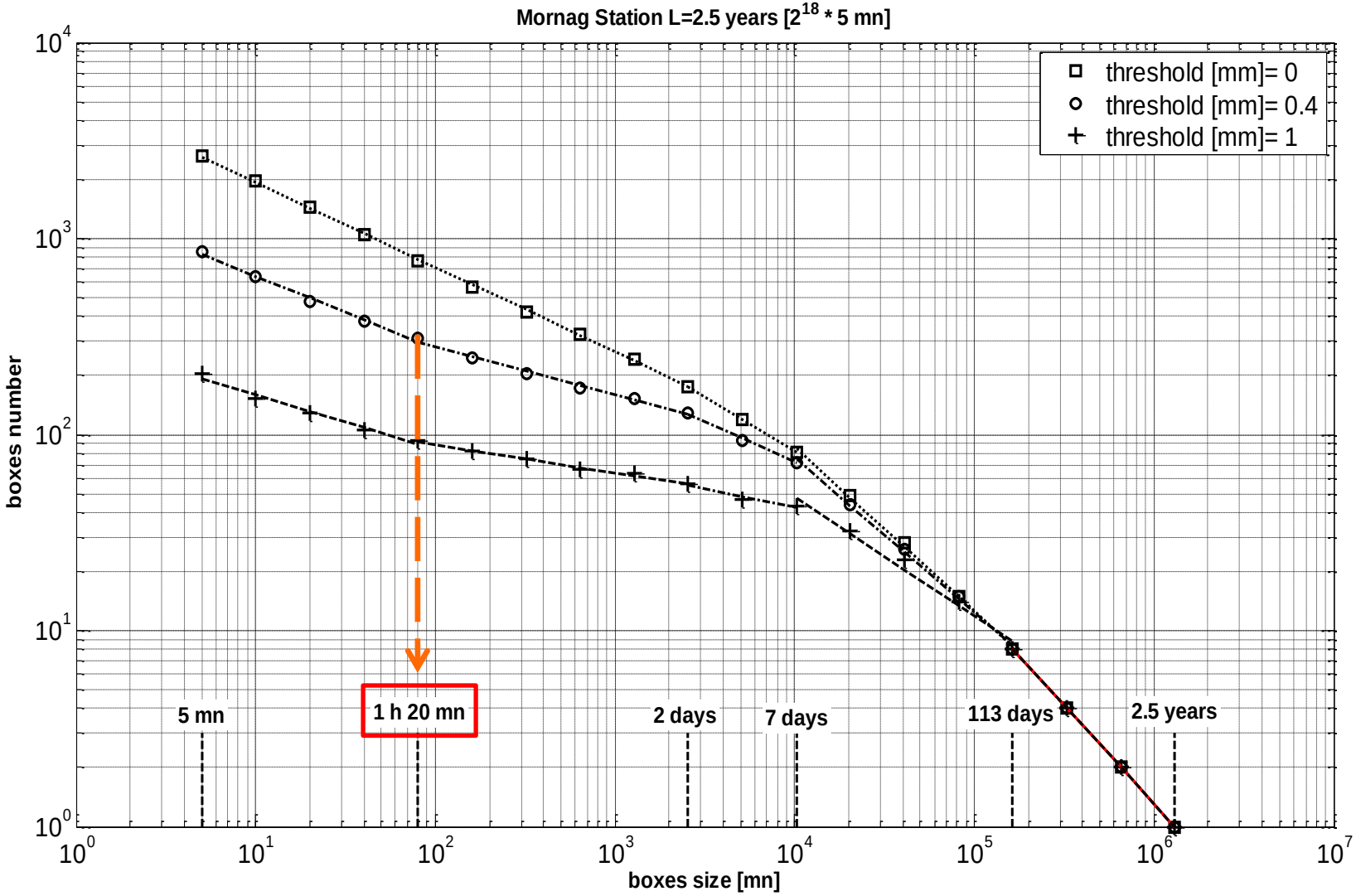
Table. 2 Coefficients of linear regression and coefficients of determination

	Stations	D_f	mean	R^2
Time step 5 minutes				
Regime 1 5 minutes to 2 days	Tunis Manoubia	0.44		0.999
	Mornag	0.43	0.44	0.999
	Sidi Thabet	0.44		0.997
	Soukra	0.43		0.999
Transition 2 days to 7 days	Tunis Manoubia	0.46		-
	Mornag	0.53	0.5	-
	Sidi Thabet	0.49		-
	Soukra	0.49		-
Regime 2 7 days à 113 days	Tunis Manoubia	0.82		0.996
	Mornag	0.80	0.8	0.998
	Sidi Thabet	0.79		0.997
	Soukra	0.73		0.998
Daily time step				
Transition : 1 - 8 days	Tunis Manoubia	0.49	-	0.994
Regime 2 : 8 - 256 days		0.89	-	0.996

- regime [one day -one week] identical estimation of Df equal to 0.5
- regime [one week –four month] a period of two and a half years is not sufficient to characterize this regime

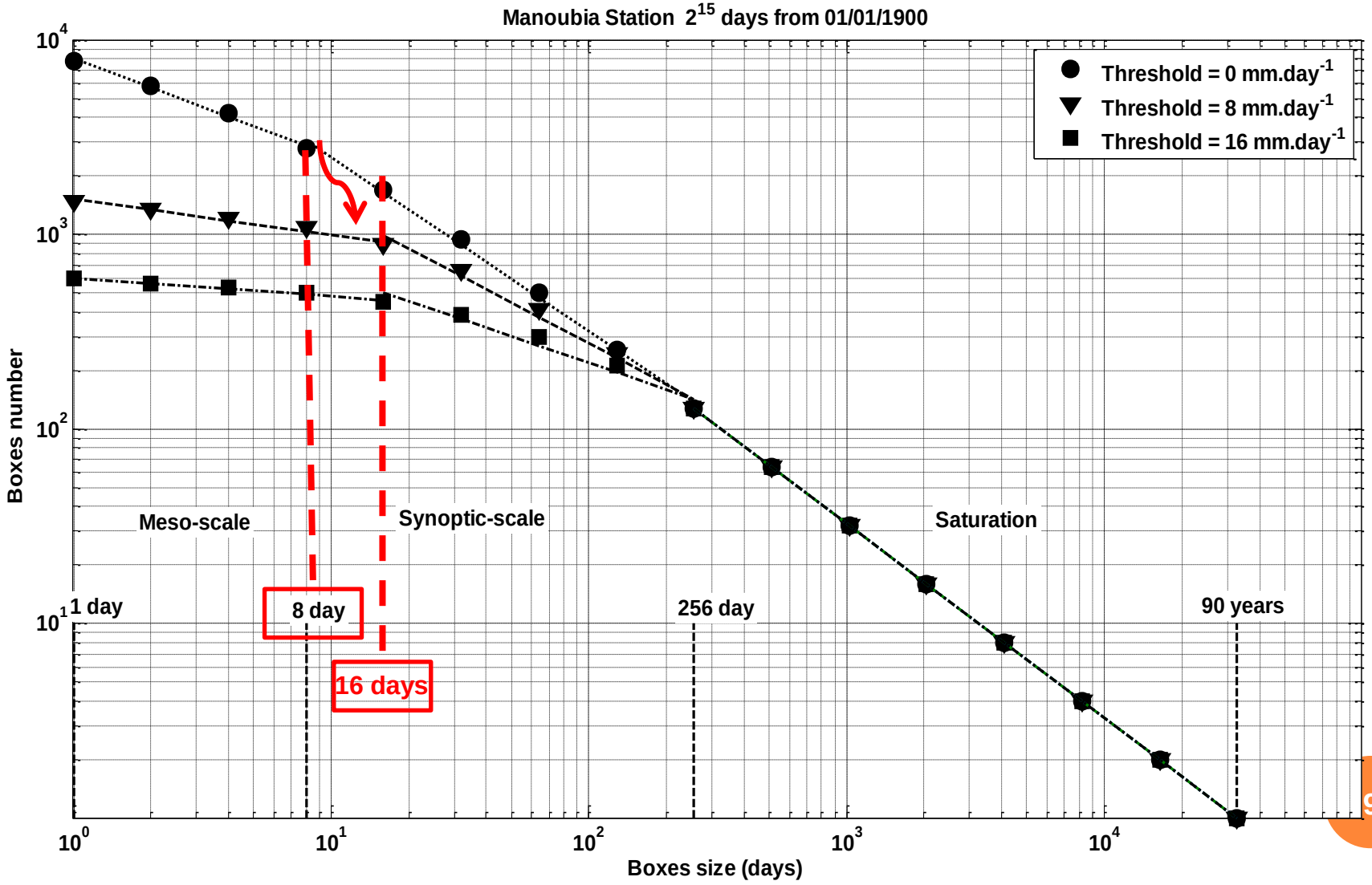
Application of different thresholds of rain intensity

Series with 5 min time step



Application of different thresholds of rain intensity

Daily series of Tunis-Manoubia station



Application of different thresholds of rain intensity

Series 5min:

I. The structure of rainfall support seems not affected by a small increase in detection threshold.

II. From a threshold ≥ 0,3mm/5mn (3,6 mm/h), structure of rain fields change, there is :

i. Supplementary rupture at 1h 20 min (specific Tunis)

ii. decrease of D_f

Comment: Increasing the threshold would '**filter**' the frontal structure to keep only the convective structures. The low value of the fractal dimension for time increments 5 min - 1h 20 can be interpreted as a high degree of irregularity in the distribution of these support structures.

Daily series :

I. increasing the threshold does not show additional breaks.

II. -Ranges of scaling previously observed are not modified.

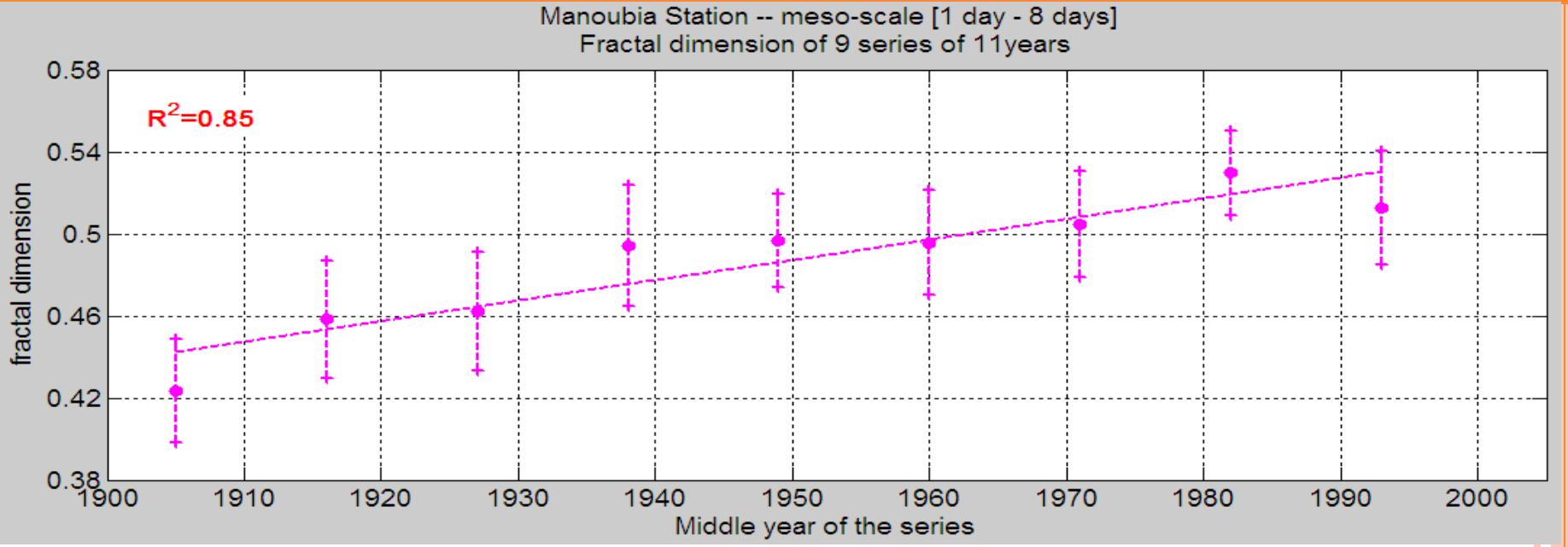
III. From a threshold ≥ 8 $mm.d^{-1}$:

i. A decrease of D_f

ii. Move of break points towards higher time increment.

Comment: The scale invariance zones are similar with slightly different fractal dimensions for both resolutions. Especially the synoptic scale for which we found a fractal dimension of 0.8 for 5- minute time step data for which we can deal only with 2-year data, which a priori allows a less reliable estimation than that based on the longer daily series (D_f=0.9).

Temporal evolution of the fractal dimension [1day-1week]



i. Whatever the width of the window break in **8 days is identified** → **stability** of range of scale invariance

ii. Identical evolution of D_f values regardless of the size of the considered sequence

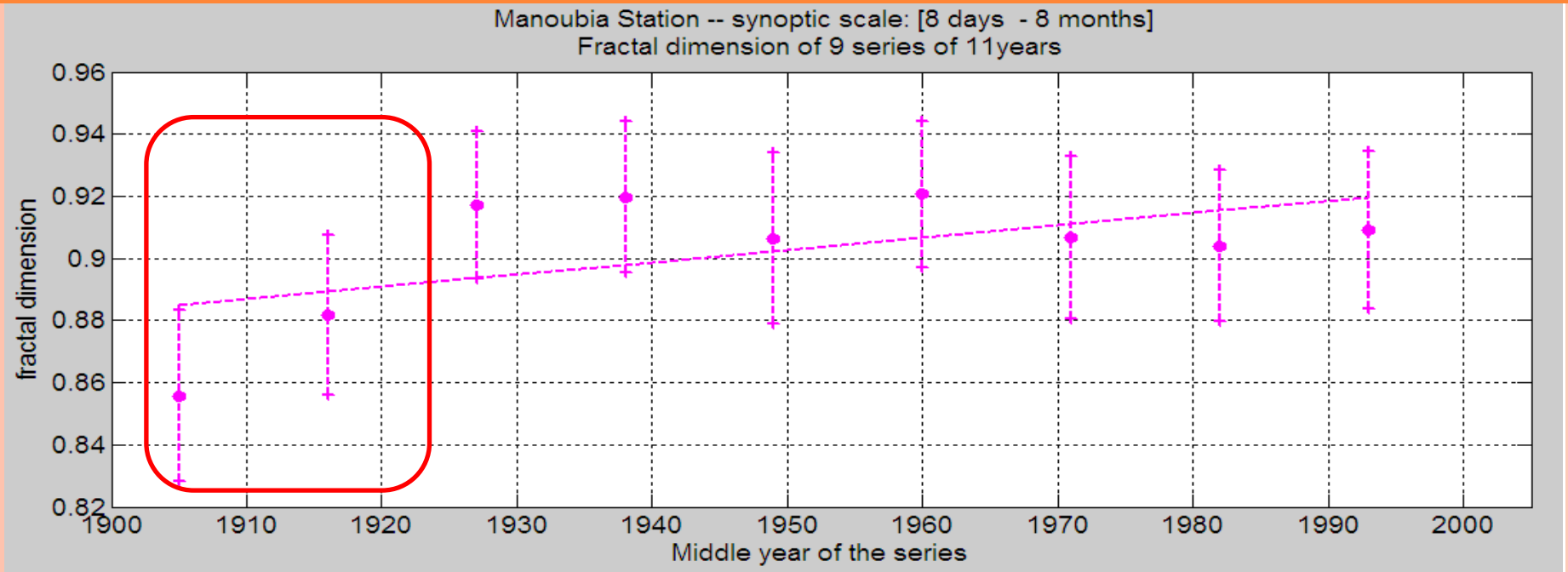
Tableau. 2 Etude de tendance

		Seq_22y	Seq_11y	Seq_6y
t-test	H0=trend absence (5%)	accepted	rejected	accepted
Mann Kendall	H0=trend absence	-	rejected	rejected

A priori null hypothesis can be rejected, however, a study of other long data sets should be done for confirmation.

→ It is worth noting that an increase of Df signifies an increase of rain occurrence which represents an interesting research path.

Temporal evolution of the fractal dimension [1week – 8 months]



i. Whatever the width of the window break in **8 months is identified** → **stability** of range of scale invariance

ii. a slightly lower value of D_f before 1930 compared to the following period which is more stable (the same things for others sequences.

Tableau. 2 Etude de tendance

		Seq_22 y	Seq_11 y	Seq_6 y
t-test	H0=trend absence (5%)	accepted	accepted	accepted
Mann kendall	H0=trend absence	-	accepted	accepted

→ The null hypothesis of trend absence is accepted

Conclusion

I. Specificities of the area studied

a. A delay of saturation that comes to about 4 months against a saturation on one week found in literature findings (temperate climate).

b. We get for micro-scale regime a fractal dimension of 0.44 against a value ranging from 0.5 to 0.8 in literature (reflects the particular climate aridity).

c. The analysis performed with different threshold on the 5 minutes times series have shown a break near 1h20mn that can be interpreted as a different scaling regime characteristic of convective situations.

II. Temporal evolution of fractal dimension

Unlike the fractal dimension at synoptic scale that is relatively stable, the fractal dimension at meso-scale, steadily increases during the last century.

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Thank you for your attention