



HAL
open science

Improving Universal Multifractal parameter estimation for large data sets, a case study in the Greater Paris

I Skouri-Plakali, Auguste Gires, I. Tchiguirinskaia, D. Schertzer

► To cite this version:

I Skouri-Plakali, Auguste Gires, I. Tchiguirinskaia, D. Schertzer. Improving Universal Multifractal parameter estimation for large data sets, a case study in the Greater Paris. European Geosciences Union, Apr 2019, Vienne, Austria. hal-02102486

HAL Id: hal-02102486

<https://hal.science/hal-02102486v1>

Submitted on 17 Apr 2019

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Improving Universal Multifractal parameter estimation for large data sets, a case study in the Greater Paris

I. Skouri-Plakali (1), A. Gires (1), I. Tchiguirinskaia (1), D. Schertzer (1)

(1) HM&Co, Ecole des Ponts ParisTech, UPE, Champs-sur-Marne, France (ilektra.skouri@enpc.fr, +33 (0)164153607)

Introduction

Precipitation is a highly complex and variable phenomenon. The purpose of this work is to analyse, and inter-compare 5 different products of X-band radar with pulsed emissions for simple and dual polarization, using the Universal Multifractal analysis.

Methodology

a. ENPC polarimetric X-band radar

- Oblate drops -> differential phase shift (ΦDP) between the horizontal and vertical polarized wave. The specific differential phase shift (=grad ΦDP) is used for rainfall rate computation.
- Rainfall estimations
 - Strong KDP ($> 1^\circ/\text{km}$) -> directly $R = c \left(\frac{KDP}{f}\right)^d$
 - Low KDP -> Marshall-Palmer relation $Z = aR^b$

b. Spectral analysis: the first indication of the scaling behaviour of the field

$E(k) \approx k^{-\beta}$, where β : spectral slope calculated k : wavelength

c. Universal Multifractals parameters fully define statistics across scales [2,3,4]

- $\alpha \in [0,2]$ (multifractality index): the variability of intermittency with respect to intensity level
- C_1 (mean intermittency): mean inhomogeneity of the field (C_1 : 0 for homogeneous fields)
- H : the degree of non-conservation, the scale dependency of the mean field ($H=0$ considered in our case)

C_1 and α estimated with the **Trace Moment (TM)**

$$K(q) = \begin{cases} \frac{C_1}{\alpha-1} (q^\alpha - q), & \alpha \neq 1 \\ C_1 q \log(q), & \alpha = 1 \end{cases}$$

$$C_1 = \frac{dK(q)}{dq} \Big|_{q=1} \quad C_1 \alpha = \frac{d^2 K(q)}{dq^2} \Big|_{q=1}$$

- and with the (uni/mono) fractal correction [5]

$$K^*(q) = K(q) + c(q-1) \quad C_1^* = \frac{dK^*(q)}{dq} \Big|_{q=1} = C_1 + c \quad C_1^* \alpha^* = \frac{d^2 K^*(q)}{dq^2} \Big|_{q=1} = C_1 \alpha$$

- and **Double Trace Moment (DTM)** technique [1]

$$\langle (R_\lambda^{(n)})^q \rangle \approx \lambda^{K(q,n)} \quad K(q, \eta) = \eta^\alpha K(q)$$

Data

Table 1: The five radar products compared in this study (-SP: Simple Filter, -PS: Pseudo, TFL: Terrain Following Layer)

Product	Dual Polarization	Data used for products	Required parameters	Equation used	Filter	Data considered for TFL below/above lowest/highest elevation
DPSRI_150	✓	dBZ, K_{DP}	$a=150$ $b=1.3$	$Z=aR^b$	FIR	no data
DPSRI_200	✓	dBZ, K_{DP}	$a=200$ $b=1.6$	$Z=aR^b$	FIR	no data
DPSRI_SP	✓	dBZ, K_{DP}	$a=150$ $b=1.3$	$Z=aR^b$	Median	no data
DPSRI_PS	✓	dBZ, K_{DP}	$a=150$ $b=1.3$	$Z=aR^b$	FIR	Data of lowest/highest elevation used
SRI	✗	dBZ	$a=200$ $b=1.6$	$Z=aR^b$		no data

The signal of KDP is noisy so the use of a smoothed signal is used to compute KDP. Two different filters are used: the Finite Impulse Response (FIR) and the median one. The data were processed with standard Rainbow software.

Table 2: Rainfall events and their characteristics

Event	Date	Start time (UTC)	End time (UTC)	Duration (in h)	Time steps
E1	21-23/05/2016	12:25:00	23:50:00	59.42	1264
E2	28-31/05/2016	08:25:00	00:00:00	87.58	1686
E3	17/06/2016	00:00:00	21:15:00	21.25	422

Analysis

The values of UM parameters of event 28-31/05/2016 for TM and TM corrected are presented:

Table 4: Values of UM parameters for TM and TM corrected

Radar Products	α^*	α	C_1^*	C_1	c
DPSRI_150_s	1.443	4.016	0.047	0.017	0.03
DPSRI_150_l	0.861	2.146	0.278	0.112	0.17
DPSRI_200_s	1.854	4.85	0.049	0.019	0.03
DPSRI_200_l	1.137	2.735	0.278	0.116	0.16
DPSRI_SF_s	1.743	4.20	0.051	0.021	0.03
DPSRI_SF_l	1.743	2.244	0.288	0.121	0.17
DPSRI_PS_s	1.545	4.20	0.047	0.017	0.03
DPSRI_PS_l	0.952	2.053	0.277	0.129	0.15
SRI_s	1.296	5.715	0.039	0.009	0.03
SRI_l	0.812	2.178	0.226	0.084	0.14

For every simulation the following figures are obtained (in red: small and in blue: large scales):

Table 6: TM analysis and $K(q)$ for small (in red) and large (in blue) scales

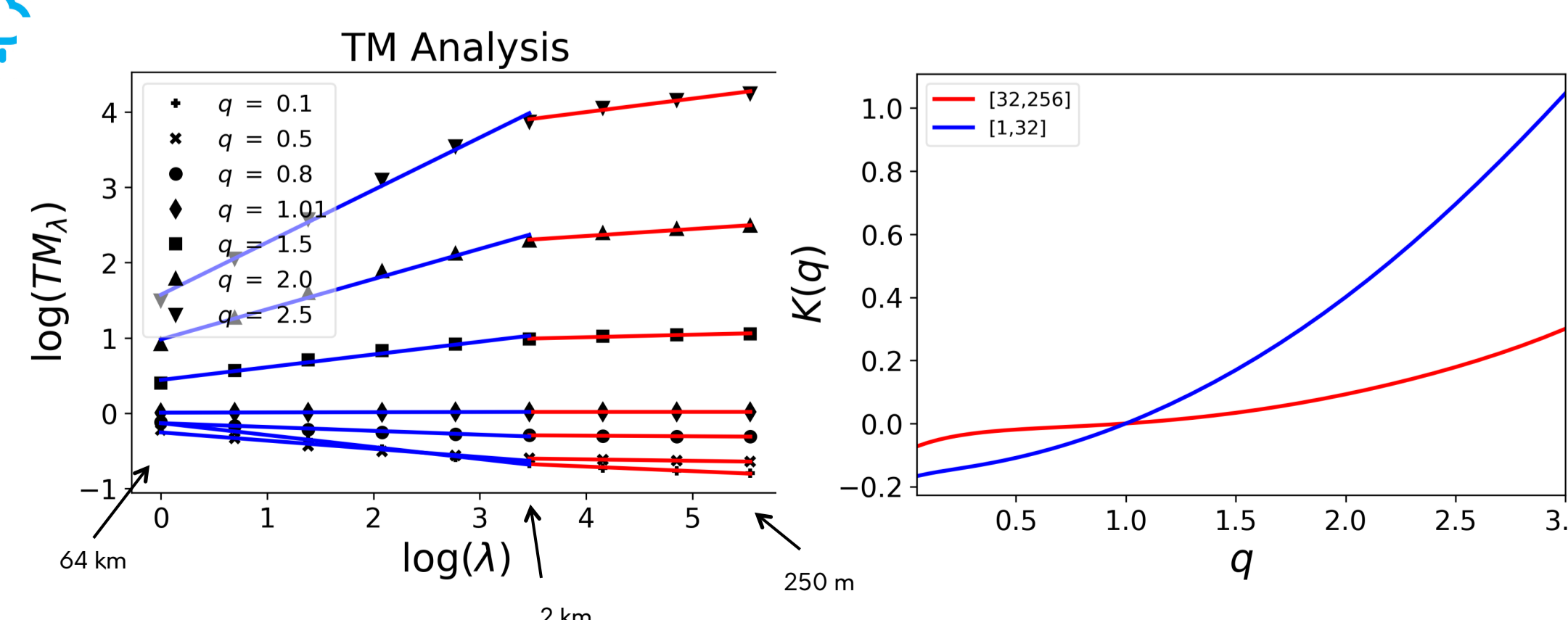
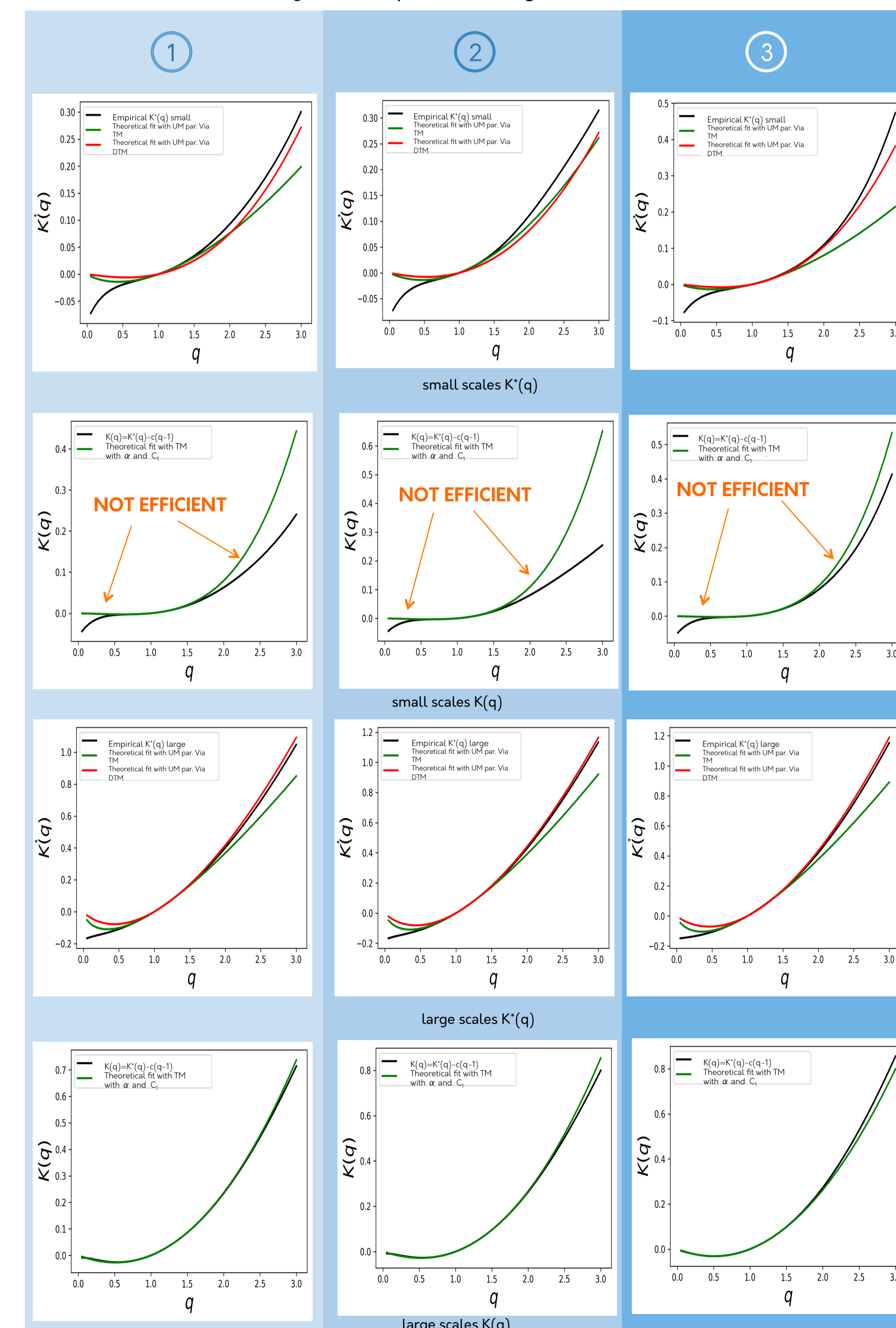
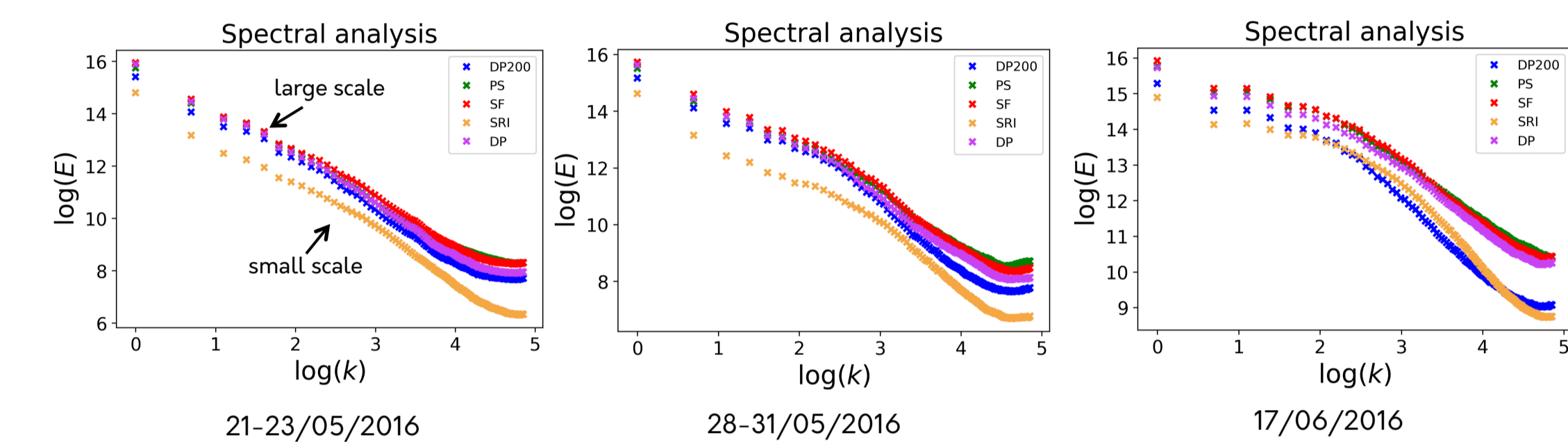


Table 5: Figures of spectral analysis and DTM method



- 1) DPSRI $a=150$ $b=1.3$ 28-31/05/2016
- 2) DPSRI $a=150$ $b=1.3$ simple filter 28-31/05/2016
- 3) PsDPSRI $a=150$ $b=1.3$ 28-31/05/2016

Table 3: Figures of spectral analysis of the selected events



Conclusions

- The correction does not work for small scales (difficulty in estimating c)
- Efficient for large scales (but strong values for α)

Future work

- Test it for events of higher intensity
- Comparing with other types of radar data and with rain gauge measurements
- Use them in urban hydrological models (Multi Hydro) to find out which filter is better to use

Acknowledgements

The authors greatly acknowledge financial support from the Chair "Hydrology for Resilient Cities" (endowed by Veolia) of Ecole des Ponts ParisTech.

References

- [1]Levallée et al. 1993, Nonlinear variability and landscape topography: analysis and simulation. In L. De Cola & N. Lam, eds. Fractals in geography. Prentice-Hall, pp. 171–205.
- [2]Schertzer and Lovejoy 1987, Physical modeling and Analysis of Rain and Clouds by Anisotropic Scaling Multiplicative Processes. Journal of Geophysical Research, D 8(8), pp. 9693–9714.
- [3]Schertzer and Lovejoy 1991, Nonlinear geodynamical variability: multiple singularities, universality and observables. In Nonlinear variability in Geophysics Scaling and Fractals, pp. 41–82, Kluwer, Dordrecht
- [4]Schertzer and Lovejoy 1997, Universal Multifractals do Exist! Journal of Applied Meteorology, 36, pp.1296–1303.
- [5]Verrier S. Modélisation de la variabilité spatiale et temporelle des précipitations à la sub-mésoséchele par une approche multifractale. Météorologie. Université de Versailles-Saint Quentin en Yvelines, 2011.