Journée Scientifique SIRTA 2018, 15 juin 2018 Palaiseau (France)

Multifractal detection of extreme events with the help of various meteorological SIRTA data

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Methodology

Spectral analysis: the first indication of the scaling behaviour of the field
Spectral slope β calculated $E(k) \approx k^{-\beta}$,where k:wavelength
Slope for wind at free turbulence β =-5/3

Universal Multifractal parameters fully define statistics across scales[1,2,3]

- $\alpha \in [0,2]$ (multifractality index): the variability of intermittency with respect to intensity level
- C_1 (mean intermittency): mean inhomogeneity of the field at large and small scales (C_1:0 for homogeneous fields)
- γ_s : the largest possible singularity. It can be calculated using[4]

$$\gamma_s = C_1 \frac{\alpha}{\alpha - 1}\left(C_1^{\frac{1-\alpha}{\alpha}} - \frac{1}{\alpha}\right)$$

For this purpose C_1 and α are estimated with the **Trace Moment** (TM) technique [1]

Special Increments: usually Δτ=Δt
Δt has been increased to optimal multiple of Δτ to observe scaling of velocities thus introducing a second scale of observation

Figure 3: Schematic pictior of the increment change

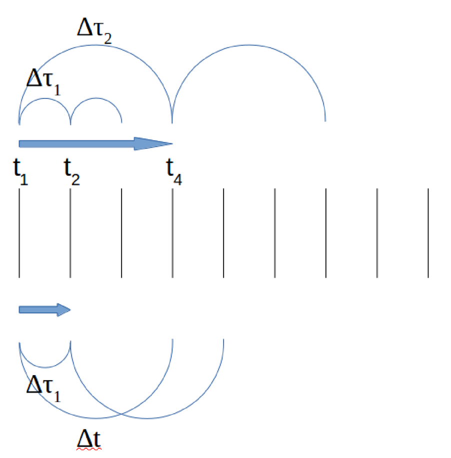
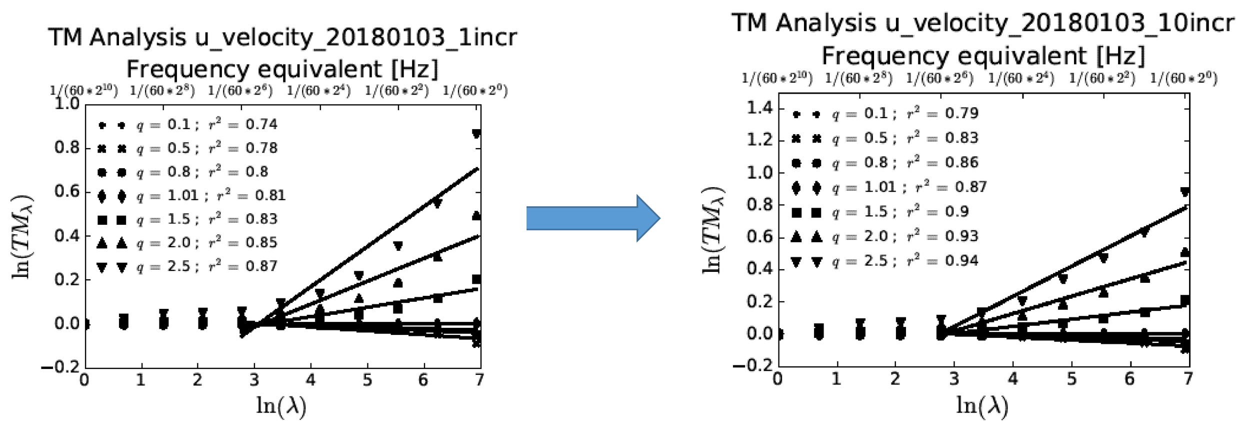


Figure 4: Result of changing the increment size



Data

The analysed data have been taken from the publicly accessible server from SIRTA [5]. The time resolution lies at one per minute as an averaged value for samples each 5 seconds. Velocity measurements are taken at 10m height with sonic anemometers, whilst the other weather properties are taken at 2m. Hence those measurements lie within the boundary layer.

Figure 1: Example spectra for all properties on the day of Storm Eleanor

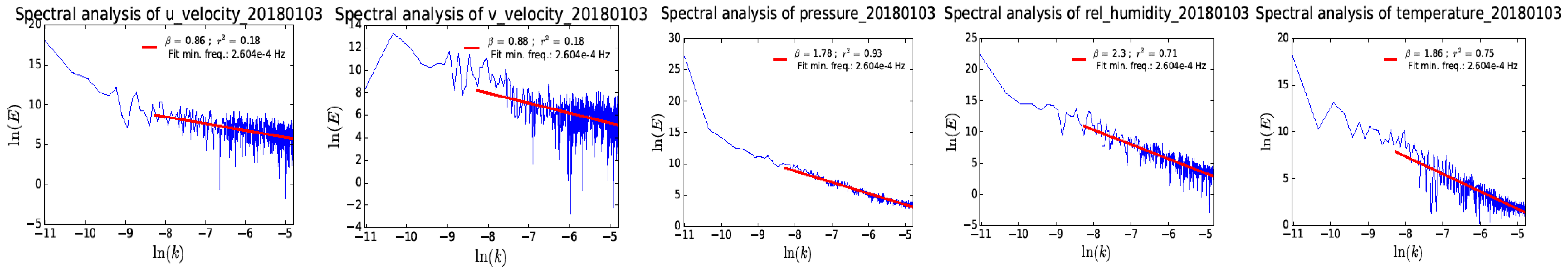
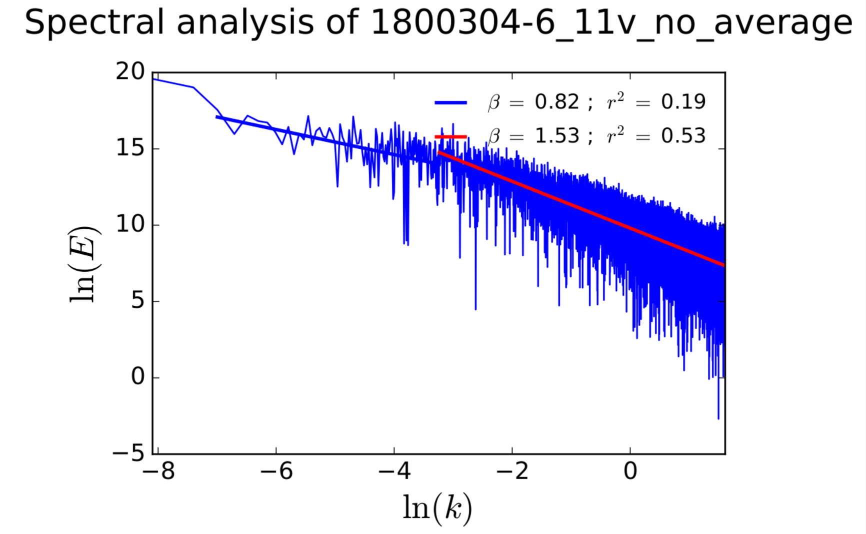


Figure 2: Comparison with 10Hz data spectrum. Scaling break found at ln(-k)= -3.7

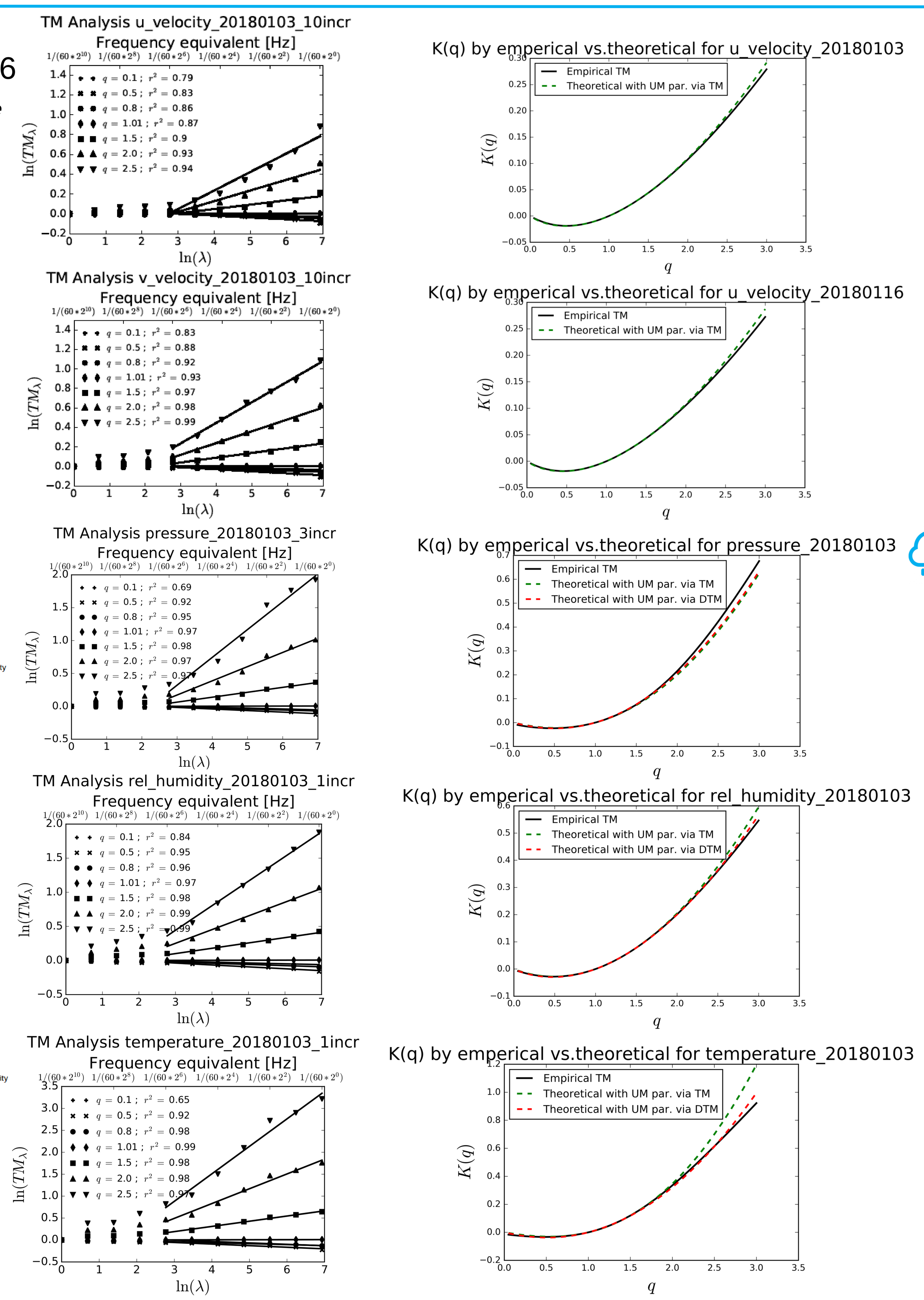


Analysis

The results of the TM analysis is shown in figure 6
In figure 5 the difference between γ_s calculated on one day and γ_s calculated over the full month indicates extreme events if every property has a positive value.

Figure 6: Results of the TM analysis for storm Eleanor

Figure 5: Graphs showing the differentces in γ_s values identifying extreme events



Discussion

- Boundary-layer dependent values like the velocities are strongly influenced by the low height.
- The increment size was chosen as it's respective optimal value in order to improve the UM estimation on every parameter. Important is the shape of the curve and r².

Conclusions

- The method properly identifies Eleanor as an extreme event. Although other events go undetected because they are small in comparison.
- Different properties have different areas where they are scaling properly (linear area in TM)

Future Work

The observed trends in the development of UM parameters will be used to optimise now-casting methods and prediction of extreme events.
Comparison with other methods to increase accuracy.

References

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[4]Hoang, (2011) Prise en compte des fluctuations spatio-temporelles pluies-débits pour une meilleure gestion de la ressource en eau et meilleur évaluation des risques. Université Paris Est
[5]Wei. et al (2016). Experimental and Numerical Study of Wind and Turbulence in a Near-Field Dispersion Campaign at an Inhomogeneous Site