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)=k^-β, where k=wavelength
Slope for wind free turbulence β = -5/3

Universal Multifractal parameters fully define statistics across scales[1,2,3]
- c∈[0,2] (multifractivity index): the variability of intermittency with respect to intensity level
- C1 (mean intermittency): mean inhomogeneity of the field at large and small scales (C1=0 for homogeneous fields)
- γs: the largest possible singularity. It can be calculated using[4]

γs = C1 α α − 1 (1 − α) − 1

For this purpose C1 and α are estimated with the Trace Moment (TM) technique[1]

Special Increments: usually Δt=Δt

Δt has been increased to optimal multiple of Δt to observe scaling of velocities thus introducing a second scale of observation

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 10Nv data spectrum. Scaling break found at H=α,=3.7

Spectral analysis of u-velocity 20180103
Spectral analysis of v-velocity 20180103
Spectral analysis of pressure 20180103
Spectral analysis of rel. humidity 20180103
Spectral analysis of temperature 20180103

Analysis

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

Conclusions

- 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 n².

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