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Insights into the 3+1 D structure of rainfall through a multifractal analysis of 2DVD data

Auguste Gires (1), Ioulia Tchiguirinskaia (1), Daniel Schertzer (1), and Alexis Berne (2)

(1) Univ. Paris Est, LEESU, Ecole des Ponts ParisTech, LEESU, Marne-la-Vallée Cedex 2, France (auguste.gires@leesu.enpc.fr), (2) Laboratoire de Télédétection Environnementale, Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland

We investigate the 3+1D (3 spatial dimensions + time) structure of the rainfall field with the help of data recorded by a 2D video disdrometer. The distribution of drop positions and sizes with its associated moments (number, rain rate, radar reflectivity) is analysed. The data was collected in Ardèche during two HyMeX campaigns in the South of France. Five intense events that occurred in September / October 2012 / 2013 are studied. Analyses are performed in the Universal Multifractal framework which has been extensively used to analyse and simulate geophysical fields extremely variable over wide ranges of scales. Only three parameters are used to characterize variability across scales: C1 the mean intermittency, alpha the multifractality index and H the non-conservative exponent.

First, a 35 m column above the measuring device is reconstructed by assuming a vertical fall of drops with a constant velocity equal to the one measured at the ground level by the 2DVD. The latter assumption is very coarse, but we believe that the resulting reconstruction yields some insights; these columns are indeed the best drop by drop data available at this scale. A scaling analysis shows that the distribution of drops (and its associated moments) exhibits a scaling behaviour over scales ranging from 35 m to roughly 50 cm with alpha almost equal to 2 and C1 smaller than 0.1. The distribution within boxes of 50 cm seems homogeneous. Finally the consequences of this inhomogeneous distribution of drops on radar remote sensing through the speckle effect (coherent backscattering) are briefly discussed.

Secondly, extremely high resolution (1ms) time series of the rain rate recorded at the ground level are analysed. In agreement with earlier results obtained with the help of Optical Spectrometer Pluviometer data, two scaling regimes are visible with a transition plateau in between. The small scale regime, between roughly 50 ms and 1 ms, exhibits a monofractal behaviour, corresponding to a flow of individual drops through the sampling area. For the large scale regime which ranges from few hours to few minutes, it appears that UM parameters are quite different according to the event. Estimates of alpha are in the range 1-2, whereas C1's are in the range 0.2-0.5 and exhibits less variability from one event to the other. These results highlight the need to develop a theoretical representation of a 1D temporal cut of a 3+1D field to better understand the link between the column reconstruction and time series analysis.