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Time scaling properties of rainfall from 1.5 year to 15 s and applications to the study of the extreme values

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Rain, as many geophysical processes, exhibits a scale invariant behavior over a wide range of space/time scales. In this presentation, the scaling and fractal properties of rainfall are investigated in the time domain, using high-resolution observations. Rainfall intensities were obtained from measurements performed in Palaiseau (France) by a disdrometer- the Dual-Beam Spectropluviometer (DBS). The dataset consists in time series covering a period of 1,5 year long (July 2008- December 2009) that yields a wide range of scales due to the high resolution of the series (15 s). The power spectrum E(ω) displays distinct regimes of different behaviors: a spectral plateau is found at time scales greater than 2 weeks and is followed by a transition regime at scales comprised between 2 weeks and 3 days. Then, two scaling regimes obeying power-laws E(ω) $\approx \omega^{-\beta}$ are found at the smaller scales, separated by a break at the 0.5-1 h scale. The spectral exponents are estimated respectively at β=0.97 from 3 days to 0.5-1 h and β=1.51 from 0.5-1 h to 1 min. Consistently, multifractal analysis techniques show the existence of two multiscaling regimes, respectively extending from about 3 days to 1 h and from 1 h to 0.5 min. Both scaling regimes may be described by using the three-parameter (fractionally integrated) Universal Multifractal (UM) model and differ from each other by the values of the three fundamental exponents α,C_1,H. Whereas the breaks at 2 weeks and 3 days scales may be explained by meteorological considerations, it is suggested that the break at 0.5-1 h scale is an artefact due to the presence of numerous zeroes in the series. In order to improve the estimation of the three parameters, multifractal analysis is also performed on uninterrupted rain events extracted from the DBS full series. This approach provides a 'corrected' set of parameters that applies in the interior of rain events. These 'corrected' fundamental exponents are estimated to be close to α=1.7, C_1=0.1, H=0.3-0.5, differing noticeably from the parameters usually reported in the literature (e.g. Lilley et al., 2006. J. Hydrol. 328, 20-37): the effect of the zero rain rates on multifractal analysis is likely to underestimate α and H and to overestimate C_1. However, the results of this new approach confirm recently published work (de Montera et al., 2009. J. Hydrometeor., AMS, 10, 493-506) devoted to analysis of rain data previously collected at different locations with the same instrument. In particular, the comparison of both studies suggests that the parameter H could be the most sensitive to the local climate. However, H is found strictly greater than zero at small scales in both studies, meaning that the absolute increments of the series- rather than the series itself- should be considered in analysis. Then, the extreme values of the normalized absolute increments of the selected rain events are shown to follow a power-law of the scale ratio, as predicted by the multifractal model. The estimated scaling exponent remains almost constant regardless of the duration of the event and is coherent with the 'corrected' parameters. Finally, the CDFs of the whole series (and of their increments) are considered. The issue of the behavior of the tails of the distributions is discussed, taking into account the predictions of the UM model.