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Joint multifractal analysis : further developments and implementation on rainfall data

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Universal Multifractals (UM) have been widely used to simulate and characterize, with the help of only two physically meaningful parameters, geophysical fields extremely variable across wide range of scales. Such framework relies on the assumption that the underlying field is generated through a multiplicative cascade process. Derived analysis techniques have been extended to study correlations between two fields not only at a single scale and for a single statistical moment as with the covariance, but across scales and for all moments. Such framework of joint multifractal analysis is used here as a starting point to develop and test an approach enabling to analyse and simulate correlation between (approx.) UM fields.

First, the behaviour of two fields consisting of renormalized multiplicative power law combinations of two UM fields is studied. It appears that in the general case the resulting fields can be well approximated by UM fields with known parameters. Limits of this approximation will be quantified and discussed. Techniques to retrieved the UM parameters of the underlying fields as well as the exponents of the combination have been developed and successfully tested on numerical simulations. In a second step tentative correlation indicators are suggested.

Finally the suggested approach is implemented to study correlation across scales of detailed rainfall data collected with the help of disdrometers of the Fresnel Platform of Ecole des Ponts (see available data at https://hmco.enpc.fr/portfolio-archive/taranis-observatory/). More precisely, four quantities are used : the rain rate (R), the liquid water content (LWC), and the total drop concentration (Nt) along with the mass weighed diameter (Dm) which are commonly used to characterize the drop size distribution. Correlations across scales are quantified. Their relative strength (very strong between R and LWC, strong between DSD features and R or LWC, almost null between Nt and Dm) is discussed.