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Universal multifractal analysis of disdrometer rainfall data and effects on the Z-R relationship

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The relationship between radar reflectivity Z and rain intensity R, called the Z-R relationship, is often modelled as a power law. The high variability of rainfall processes complicates the estimation of this relationship. We use universal multifractal (UM) analysis to investigate the variability of rainfall processes at the small (kilometre) scale, using data from a network of disdrometers over an approximately 8 km by 13 km region in Ardèche, France. The use of raindrop size distributions (DSDs) measured by the disdrometers means that we are able to look simultaneously at the multifractal properties of several bulk variables of interest. The focus of this work is particularly on the rain rates and radar reflectivities calculated from the DSDs. UM analyses provide information on the intermittency and scaling properties of the fields. The analyses are performed for several rainfall events of various lengths, to study the inter- and intra-event variability of the UM parameters. The parameters are shown to vary markedly between events and between different disdrometer stations even within the same event. This variability is analysed in this work. For a set of rainfall events, derived Z-R relationships are compared to the expected power law relationships between derived UM variables. Should the derived Z-R relationships be correct, it would mean that both Z and R exhibit similar scaling properties and that UM parameters from one could be deduced from the other. The validity of this expected behaviour is checked and discussed in light of the DSD variability. Variability in the DSD is hypothesised to disrupt the expected relationships between scaling properties of Z and R. The results quantify changes in the properties of the Z-R relationship through scale change, which is important for rain retrieval in quantitative precipitation estimation.