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An Index of the Statistical Heterogeneity of Rain Observations

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It is common knowledge that rainfall occurs over a huge range of both temporal and spatial scales. Most direct observations are collected over relatively brief temporal and small spatial scales. An important challenge, then, is to make these direct measurements relevant to larger scales. It is equally important to relate output from numerical forecast models which often produce output on kilometer scales down to scales appropriate for applications to problems such as urban flooding. This is not a trivial task to do this while retaining fidelity.

A fundamental tool for even tacking such ambitious goals is the application of Fourier techniques to a time (or, on rarer occasions, to a spatial) series of observations. Often a correlation function can be appropriately transformed into a power spectrum so that the most relevant scales can be identified for a particular series of observations. However, in order to do so appropriately, one needs to know whether or not the series of measurements is temporally statistically stationary or spatially statistically homogeneous. If they are not, then the application of the Wiener-Khintchine theorem may lead to erroneous conclusions. However, statistical homogeneity or heterogeneity, for example, is not just a simple ‘yes’ or ‘no’ but a spectrum of ‘maybes’ so that same data may be ‘almost’ homogeneous while other data may be entirely heterogeneous. How can one evaluate this for a particular set of rain observations so that corrective measures can be taken when possible?

In this work an index of statistical heterogeneity (IXH)is developed to indicate when a set of observations are significantly non-stationary or are, instead, nearly stationary or statistically homogeneous. This index is then applied to some theoretical scenarios and then to actual observations of the rainfall rate and to counts of raindrops. Finally, the index is calculated for a small network of disdrometers for both convective and stratiform rain, revealing that there is significant variability of IXH across even a small network in convective rain but not in stratiform rain.