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Inter-Scale Statistical Analysis of Fine-Resolution Rainfall Datasets over the Japanese Islands

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The continuous improvement of remotely-sensed precipitation estimates has greatly favored the inter-scale statistical study of rainfall fields and its potential applications. One of the expected results of this type of analysis is intended to provide the guidelines to effectively reproduce at finer scales (downscaling) the characteristic geometrical structure. Intermittency (no-rain areas contained within large rainfall fields), slow-varying gradients of intensity, and sudden sharp rises of intensity (high-intensity regions enclosed, or rapidly followed, by lower-intensity fields) are within the structural properties that define the rainfall fields. The concept of intermittency, indicates a positive probability of having no rain at some point, and for that reason the actual magnitude of rainfall intensity is not compatible with some scaling operations. However, the deviations of local means (local fluctuations) proved to be a process with noteworthy inter-scale statistical properties. Previous research revealed that local fluctuations can be well adjusted to stable distributions, in which the characteristic exponent α defines the thickness of the tails. If so, it can be inferred that this parameter should be related to the type of rainfall (rate of variation of intensity). However, the abovementioned research showed that in order to portray a self-similar relationship between scales the fluctuations needed to be divided by their correspondent local mean (standardization). The distribution of these standardized values was observed to be almost Gaussian (α = 2), and even though remarkable, with this operation becomes more challenging to relate the frequency of extreme values with the type of rainfall. In our study the local fluctuations of rainfall were analyzed by fitting the data to a folded stable distribution which is a distribution of absolute values. This approach not only allowed to reveal a somewhat invariance of the characteristic exponent between scales, but also depicted a clear inter-scale exponential tendency of the scale parameter γ of the distributions.

In this study we utilized the highly-accurate fine-resolution (1 km) Radar-AMeDAS datasets available over the Japanese islands and surrounding ocean waters. With the purpose of having a broad idea of the parameter range of the characteristic exponent and its relationship with the type of rainfall, different locations were selected to perform this inter-scale analysis for several events between 2006 and 2009. Japan's geographical location in the northwest Pacific Ocean and the long latitudinal extent (from 26.0^{o}N to 45.5^{o}N approximately) permits to observe the outcome of different patterns of rainfall, which include stratiform structures caused by warm fronts, narrow bands of high-intensity rainfalls caused by cold fronts, isolated convection activity, and severe storms caused by the activity of tropical cyclones. The results reported in this study are intended to serve as a basis for further research that, among other topics, may be able to relate the parameters of the folded distribution to other measurable environmental parameters that describe the rainfall patterns.