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The effect of scaling anisotropy on weather extremes

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Predicting extreme weather events in and around cities is far from straight forward. Even in a stable and unbounded atmosphere, crude numerical approximations of the Navier-Stokes equations are required for reasonable computation times. Hence, numerical simulations of the weather in and around cities become even more complex, and therefore require much coarser space and time scales to model both the macro weather and the complex boundary conditions created by buildings and other urban structures. Such models will severely underestimate extremes due to the necessary truncation of scales to deal with these additional complexities.

While progress in numerical simulation depends on the next fastest processor, measurement techniques on the other hand are becoming rapidly more and sophisticated. There appears however to be a gap forming in the ability to utilise the enormous datasets produced from new measurement techniques. This seems mainly due to outdated statistical methods that are used to make sense of these overwhelming databases.

In this study we propose a method, based on the structure function, that allows one to easily estimate the Levy index α of the wind. We show that due to the complex nature of a three-dimensional wind a rotated frame of reference is necessary in order to obtain a universal multifractal structure function exponent. We show that the angular dependency of the scaling exponent results in either an increase or decrease in dimension. This increase or decrease in dimension causes a first or second-order phase transition respectively. The kind of phase-transition that occurs is directly related to the generation of extremes of the wind.

The combination of this kind of analysis with the advancements in measurement techniques that are coming to light should allow for the better prediction of extreme weather events in and around cities.

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