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Breakdown of Clausius-Clapeyron scaling: a statistical artifact?

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It is well known that short-duration extreme precipitation approximately follows an exponential dependence on temperature, as dictated by the Clausius-Clapeyron (CC) relation. In the majority of the corresponding empirical studies, however, the estimated relation (the so called CC scaling) breaks down for the warmest of temperatures and, correspondingly, the most extreme and hazardous precipitation events. The breakdown has been attributed to various causes, such as the inability to sustain the necessary precipitation amounts over a sufficiently long timespan, but the fact itself has rarely been questioned.

In this study we at first verify this behavior by applying the same estimation to a group of 14 German weather stations. Then we show that the breakdown of extremes can indeed be understood, in large parts, as a statistical artifact of the applied estimation procedure. That procedure is based on a simple nonparametric calculation of plotting positions and corresponding high quantiles, and suffers from undersampling. This is demonstrated through a Monte Carlo experiment, by using synthetic data from a range of prescribed distributions typical for precipitation modeling and by systematically varying the sample size. While the single estimates turn out to be highly uncertain, they are nevertheless clearly biased towards zero with deceasing sample size. This applies for all distributions.

If we apply, for each distribution, a parametric estimation procedure instead, the large uncertainty remains but the bias disappears. We also test the case of a wrongly prescribed distribution, which most likely applies to the real world. In that latter case, that is, for precipitation itself, we show that the procedure yields estimates that have, within the range of uncertainty, no visible breakdown in the CC relation.