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Statistical methods for the scaling of precipitation extremes with temperature

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Intense short-duration rainfall is known to cause flash floods that are commonly very destructive, and impact everyday social and economical life. This is particularly true in an urban environment where, due to the surface impermeability, densely populated areas are strongly susceptible to intense precipitation events. The amount of precipitation received during extreme precipitation events is known to increase exponentially with temperature, and can be explained by the Clausius-Clapeyron (CC) equation. In a warming climate, this will lead to an increase in extreme rainfall amounts.

Recently, it was found that above a certain threshold temperature, the rate of exponential growth for short-duration events exceeds the expected rate (Lenderink and van Meijgaard, 2008). The increased scaling between precipitation and temperature is often referred to as super-CC scaling. Although that work led to a wide range of in-depth investigations, the full underlying physical mechanism remains unclear. Most works that follow Lenderink and van Meijgaard (2008) include a simple statistical methodology which is based on percentile calculation of binned data. It was also highlighted that methodological choices (e.g. the temporal resolution of the data, model versus observational data, bin size used for the quantile calculations) strongly determine the scaling of precipitation extremes with temperature.

We propose a firm statistical framework to examine the transition from CC- to super-CC scaling. More specifically, the binning approach is replaced by piecewise linear quantile regression which is able to estimate the change-point, and the corresponding scaling coefficients. The associated information criteria may determine whether or not there is strong evidence of a super-CC relationship. Goodness-of-fit measures, on the other hand, allow to find the best predictor (temperature or dew point temperature). The techniques are tested on hourly station data over Western Europe.

Lenderink, G., and van Meijgaard, E. (2008). Increase in hourly precipitation extremes beyond expectations from temperature changes. Nature Geoscience, 1: 511-514.