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On extreme rainfall intensity increases with air temperature

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The water vapour holding capacity of air increases at about 7% per degree C according to the Clausius-Clapeyron (CC) relation. This is one of the arguments why a warmer future atmosphere, being able to hold more moisture, will generate higher extreme precipitation intensities. However, several empirical studies have recently demonstrated an increase in extreme rain intensities with air temperature above CC rates, in the range 7-14% per degree C worldwide (called super-CC rates). This was observed especially for shorter duration rainfall, i.e. in hourly and finer resolution data (e.g. review in Westra et al., 2014). The super-CC rate was attributed to positive feedbacks between water vapour and the updraft dynamics in convective clouds and lateral supply (convergence) of moisture. In addition, mixing of storm types was shown to be potentially responsible for super-CC rates in empirical studies. Assuming that convective events are accompanied by lightning, we will show on a large rainfall dataset in Switzerland (30 year records of 10-min and 1-hr data from 59 stations) that while the average rate of increase in extreme rainfall intensity (95th percentile) is 6-7% in no-lightning events and 8-9% in lightning events, it is 11-13% per degree C when all events are combined (Molnar et al., 2015). These results are relevant for climate change studies which predict shifts in storm types in a warmer climate in some parts of the world.

The observation that extreme rain intensity and air temperature are positively correlated has consequences for the stochastic modelling of rainfall. Most current stochastic models do not explicitly include a direct rain intensity-air temperature dependency beyond applying factors of change predicted by climate models to basic statistics of precipitation. Including this dependency explicitly in stochastic models will allow, for example in the nested modelling approach of Paschalis et al. (2014), the random cascade disaggregation routine to be trained to reproduce the rainfall intensity-air temperature relations observed in data at high temporal resolutions. We believe that the observed relationships of rainfall intensity to air temperature should be reproducible by stochastic rainfall models if they are to be used for climate change impact studies which require high temporal resolution simulation, e.g. for urban drainage analysis, flash flood generation, etc.

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