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Temperature sensitivity of extreme precipitation events in the south-eastern Alpine forelands

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How will convective precipitation intensities and patterns evolve in a warming climate on a regional to local scale? Studies on the scaling of precipitation intensities with temperature are used to test observational and climate model data against the hypothesis that the change of precipitation with temperature will essentially follow the Clausius-Clapeyron (CC) equation, which corresponds to a rate of increase of the water holding capacity of the atmosphere by 6-7 % per Kelvin (CC rate). A growing number of studies in various regions and with varying approaches suggests that the overall picture of the temperature-precipitation relationship is heterogeneous, with scaling rates shearing off the CC rate in both upward and downward directions.

In this study we investigate the temperature scaling of extreme precipitation events in the south-eastern Alpine forelands of Austria (SEA) based on a dense rain gauge net of 188 stations, with sub-daily precipitation measurements since about 1990 used at 10-min resolution. Parts of the study region are European hot-spots for severe hailstorms and the region, which is in part densely populated and intensively cultivated, is generally vulnerable to climate extremes. Evidence on historical extremely heavy short-time and localized precipitation events of several hundred mm of rain in just a few hours, resulting in destructive flash flooding, underline these vulnerabilities. Heavy precipitation is driven by Mediterranean moisture advection, enhanced by the orographic lifting at the Alpine foothills, and hence trends in positive sea surface temperature anomalies might carry significant risk of amplifying future extreme precipitation events. In addition, observations from the highly instrumented subregion of south-eastern Styria indicate a strong and robust long-term warming trend in summer of about 0.7°C per decade over 1971-2015, concomitant with a significant increase in the annual number of heat days.

The combination of these factors leads to the urgent questions of what we might expect from future heavy precipitation, particularly summertime convective storms, and how the associated risks will change if the observed trends persist. Working on an event basis allows us to consider a robust diversity of indicators such as storm duration, total sums, and peak intensities of the individual rainfall events in our analysis.

First results suggest that the temperature sensitivity of precipitation events in the study region generally rises in accordance with the CC rate, but rates diverge dependent on the spatio-temporal properties of the sampling. At high temperatures above about 25 °C, the heaviest events do not show increases beyond the CC rate, as have been reported in some other studies for temperatures below 25°C. This is likely due to limitations of moisture availability in hot summer conditions. Observations of relative humidity available for 77 out of the 188 stations used support this hypothesis. When events where humidity is well below saturation are excluded from the sample, quantile regression results show higher scaling rates. The preliminary findings underline the need for a more sophisticated analysis of the temperature-precipitation relationship especially in heterogeneous regions with complex terrain.