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Comparing extreme sub-daily rainfall projections from convection-permitting climate models and temperature-scaling across an Alpine gradient

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Understanding projected changes in sub-daily extreme rainfall in mountainous basins can help increase our capability to adapt to and mitigate against flash floods and debris flows. Here we compare the changes in extreme rainfall projections from apparent Clausius-Clapeyron (CC) temperature scaling against those obtained from convection-permitting climate model simulations. Temperature and precipitation projections are obtained from an ensemble of convection-permitting climate models (CPM), which are suitable to the task given their ability to explicitly represent deep convection and to resolve the mountainous topography. The CPM data provided by the CORDEX-FPS Convection project at 1-hour temporal and remapped to 3 km spatial resolution, cover historical and far-future (2090-2099) time periods under the extreme climate change scenario (RCP8.5). Due to the computational demands however, CPM simulations are still too short (typically 10-20 years) for analyzing extremes using conventional methods. We use a non-asymptotic statistical approach (the Metastatistical Extreme Value, MEVD, Marani and Ignaccolo, 2015) for the analysis of extremes from short time periods, such as the ones of CPM simulations. We use hourly precipitation and temperature data from 174 stations in an orographically complex area in northeastern Italy as a benchmark.

In this study, we considered two temperatures approach for computing CC scaling: the mean annual temperature and the temperature during extreme events (top 20% of ordinary events). Our findings indicate that elevation significantly influences temperature changes during storms, with higher elevation areas experiencing more pronounced temperature increases in the future. This is further highlighted by seasonal shifts in storm occurrence, as we found storms moving from summer to fall in lowlands, suggesting a lower delta T for those storms. This same pattern was detected using the temperature during storms for CC scaling, showing that extremes are increasing more in higher elevations than in lowlands. We found this comparably captured by CC scaling approach, however, variations in return levels are also notable in CPMs when considering different return periods, as we find CPM changes depending on them, which contradicts the results from both CC scaling approaches. These findings identify that CC scaling agrees with CPM changes to some extend when the right temperature is selected, however, it emphasizes the need for a nuanced understanding of the scaling method's applicability under various conditions.