Using high resolution climate models to represent sub-daily precipitation upper tail in complex orography

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**Abstract.** Recent literature agrees on the significant increase of short and intense precipitation in the next future, driven by the global warming. Subdaily extremes have specific impact on fast hydro-geomorphic hazards (flash floods, debris flows, shallow landslides). Estimating their changes in climate models is of fundamental importance for improving risk management and adaptation to changing climate. Compared to coarser resolution models, convection-permitting models (CPMs) provide higher confidence in the future estimates of sub-daily precipitation and allow to study the spatiotemporal patterns of heavy rainfall over complex terrain. However, given the high computational cost of CPM runs, the existing simulations cover relatively short time periods (10–20 years), which prevent the use of conventional extreme value methods. Alternative approaches based on the concept of ordinary event have shown the capability of deriving frequency analyses from shorter data records (e.g., Marra et al. 2020), promising improved applications based on CPMs.

In the present work, we investigate the CPM ability to represent sub-daily precipitation extremes in a complex-orography area in North-eastern Italy. This is a challenging test case for CPM simulations because the region lies in a transition zone between Mediterranean Europe and Continental Europe, with opposite projected changes in precipitation and different responses to climate oscillations. Recent works have shown that the region exhibit i) significant temporal trends in the intensity of the extremes during the last few decades and ii) different orographic impacts on sub-daily precipitation extremes at different durations (Formetta et al., 2022). We use precipitation records from ~150 5min-resolution rain gauges to benchmark the CPM simulations from the COSMO model, run at 2.2-km 1-hour resolution and driven with ERA Interim for the period 2000-2009. Hourly time series are created from both stations and CPMs, for the latter by extracting the data at the grid points corresponding to the rain gauges. By applying a storm-based statistical method to each time series, ordinary events upper tails are modelled using a Weibull distribution, which was previously reported to well reproduce the statistics of extremes in the area. We investigate 9 event durations between 1 and 24 hours. The outputs of the model are the distribution parameters and extreme quantiles up to 100-year return period. We evaluate: their dependence on elevation, the bias between the observation and the CPM results, the dependence of the biases with elevation. We find CPM generally overestimates the annual maxima (10-40%), and the modelled quantiles (10-60%), especially for short durations, and the biases have different spatial patterns. The bias significantly depends on elevation, with increasing overestimation of the 1-hour quantiles with elevation. It seems that CPMs can’t well represent the “reversed orographic effect” at the short durations (that is, decreasing extreme intensity with increasing elevation) reported by previous studies and which was linked to the interaction of convective cells with orography.

These findings help improve our understanding on the changes in the meteorological processes underlying the changes in the precipitation extremes and to develop CPMs bias-correction approaches that account for the role of orography and the precipitation durations.

References

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