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# Scale-dependent representation of extreme precipitation processes in regional and CPM scale simulations for the greater Alpine region

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Extreme precipitation events with return periods above 100-years (Most Extreme Precipitation Events; MEPE) are rare events by definition, as the observational record covers very few of such events. Therefore, our knowledge is insufficient to assess their potential intensities and physical processes on different scales. To fill this gap, large regional climate ensembles, like the one provided by the German Decadal Climate Predictions (MiKlip) project (> 10.000 years), are of great value as they provide a larger sample size of such rare events. The RCM ensemble samples present day climate conditions multiple times (Ehmele et al., 2020) with a resolution of 25 km, and thus it does not resolve the convection permitting scales (CPM).

In this study, we aim to combine the large RCM ensemble with episodic CPM-scale downscaling simulations to derive a better statistical and process related representation of MEPEs for Central Europe. As a first step, we evaluate two re-analysis driven long-term simulations with COSMO-CLM (CCLM) from MiKlip and CORDEX-FPS Convection with respect to their scale-dependent representation.

The simulations span the period 1971 to 2016 with the 25 km simulation and are forced by ERA40 until 1979 and by ERA-interim afterwards. The CPM simulation (~3 km) is forced by ERA-40 between 1971 and 1999 and by ERA-interim between 2000 and 2016. We validate the simulations against E-OBS (25 km) and the unique HYdrologische RASterdatensätze (HYRAS) precipitation data set (5 km). The investigation area is the greater Alpine area. We employ a Precipitation Severity Index (PSI) adapted from extreme wind detection (Leckebusch et al., 2008; Pinto et al., 2012) for extreme precipitation cases. The advantage of the PSI is its ability to account for extreme grid point precipitation as well as spatial coverage and event duration. The events are categorized objectively into composite Weather Types (WT) to enable further generalization of the findings.

The results show a clear overestimation of precipitation for the analysed period and area by the RCMs at both resolutions. However, large differences exist the representation of extreme precipitation. Compared to observations, the 3 km (25km) resolution overestimates (underestimates) precipitation intensity for extreme cases. This agrees with previous literature. Five different WTs are identified for the analysed period, with Autumn-Winter WT being the most common, followed by convective summer WT. The Autumn-Winter WT is characterized by deep, cold, low-pressure areas located over Northern Europe. Summer WT cases are characterized by

stable high-pressure situations affected by incurring small low-pressure systems on its western flank (convective-prone situations). Regarding the scale dependency of precipitation processes, the coarse resolution tends to overestimate surface moisture in situations of heavy precipitation, leading to larger latent instability (CAPE) in the 25 km resolution than in its 3 km counterpart. Furthermore, a large-scale dependency is found in summer extreme precipitation cases for two stability-related variables, Equivalent Potential Temperature ($\theta_e^{850}$) at 850 hPa and moisture flux at the Lower Free Troposphere (LFT-moisture). In these cases, the overestimation (underestimation) of  and LFT-moisture by either resolution is in line with their precipitation overestimation (underestimation).