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Impact of horizontal resolution and model time step on European precipitation extremes in the OpenIFS atmosphere model

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Events of extreme precipitation pose a hazard to many parts of Europe but are typically not well represented in climate models. Here, we evaluate daily extreme precipitation over Europe during 1982-2019 in observations (GPCC), reanalysis (ERA-5) and a set of atmosphere-only simulations at low- (100km), medium- (50km) and high- (25km) resolution with OpenIFS (Version43R3). We find that both model simulations and reanalysis underestimate the rates of extreme precipitation compared to observations. The biases are largest for the lowest resolution (100 km) and decrease with increasing horizontal resolution (50 and 25 km) in all seasons. The sensitivity to horizontal resolution is particularly high in mountain regions, likely linked to the sensitivity of vertical velocity to the representation of topography. The sensitivity of precipitation extremes to model resolution increases dramatically with increasing percentiles, which modest biases at the 70th percentile and large biases at 99th percentile. We also find that extreme precipitation mostly consists of large-scale precipitation (~80%) in winter, while in summer it is mostly large-scale precipitation in Northern Europe (~70%) and convective precipitation in Southern Europe (~70%). Compared to ERA5, the model simulations produce higher large-scale precipitation extremes in winter, but weaker in summer. The discrepancy between OpenIFS simulations and ERA-5 decreases with increasing horizontal resolutions. We also examine the model time step’s effect on extreme precipitation. The results show that the convective contribution to extreme precipitation is more sensitive to the model time step than horizontal resolution. This is likely due to the sensitivity of convective activity to model time step. On the other hand, the large-scale contribution to extreme precipitation is more sensitive to horizontal resolution than model time step, which may be due to sharper fronts and steeper topography at higher resolution. In general, the lowest-resolution and longest time step has overall higher biases than the highest-resolution and shortest time step.