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Cloud-resolving regional climate modeling approach in decade-long simulations

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The uncertainties in current global and regional climate model integrations are partly related to the representation of clouds, moist convection, and complex topography. Reducing the grid spacing down to some few kilometers and switching off the convection parameterization (cloud-resolving models) is thus an attractive approach. On climate time scales, cloud-resolving methods have been used for process studies, but application to long-term scenario simulations has been very limited. Here we present cloud-resolving simulations for 10-year-long periods integrated with the COSMO-CLM model and driven by reanalysis data (for present day climate) and a global climate model (control and scenario run). Two one-way nested grids are used with horizontal resolutions of 2.2 km for a cloud-resolving model (CRM) over an extended Alpine domain (1100 km x 1100 km), and 12 km for a cloud-parameterizing simulation (CPM) covering Europe. The CRM is driven by lateral boundary conditions from the CPM run, while the CPM run is driven by lateral boundary conditions from ERA-Interim reanalysis and the Earth-System Model of the Max-Planck-Institut (MPI-ESM-LR). Validation is conducted against high-resolution surface data.

The CRM model strongly improves the simulation of the diurnal cycles of temperature and precipitation, while CPM has a poor diurnal cycle associated with the use of parameterized convection. The assessment of precipitation statistics reveals that both models adequately represent the frequency-intensity distribution for day-long events. For hourly events the CRM has a realistic representation of heavy precipitation events, while the CPM suffers from a strong underestimation. We also present results on the scaling of precipitation extremes with local daily-mean temperature and preliminary results on the projection of heavy precipitation events.