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Heat waves over Central Europe in regional climate model simulations

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Regional climate models (RCMs) have become a powerful tool for exploring impacts of global climate change on a regional scale. The aim of the study is to evaluate the capability of RCMs to reproduce characteristics of major heat waves over Central Europe in their simulations of the recent climate (1961-2000), with a focus on the most severe and longest Central European heat wave that occurred in 1994. We analyzed 7 RCM simulations with a high resolution (0.22°) from the ENSEMBLES project, driven by the ERA-40 reanalysis. In observed data (the E-OBS 9.0 dataset), heat waves were defined on the basis of deviations of daily maximum temperature (Tmax) from the 95% quantile of summer Tmax distribution in grid points over Central Europe. The same methodology was applied in the RCM simulations; we used corresponding 95% quantiles (calculated for each RCM and grid point) in order to remove the bias of modelled Tmax. While climatological characteristics of heat waves are reproduced reasonably well in the RCM ensemble, we found major deficiencies in simulating heat waves in individual years. For example, METNOHIRHAM simulated very severe heat waves in 1996, when no heat wave was observed.
Focusing on the major 1994 heat wave, considerable differences in simulated temperature patterns were found among the RCMs. The differences in the temperature patterns were clearly linked to the simulated amount of precipitation during this event. The 1994 heat wave was almost absent in all RCMs that did not capture the observed precipitation deficit, while it was by far most pronounced in KNMI-RACMO that simulated virtually no precipitation over Central Europe during the 15-day period of the heat wave. By contrast to precipitation, values of evaporative fraction in the RCMs were not linked to severity of the simulated 1994 heat wave. This suggests a possible major contribution of other factors such as cloud cover and associated downward shortwave radiation. Therefore, a more detailed analysis of individual components of the energy budget over Central Europe during and before the 1994 heat wave was performed.