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Atmospheric circulation and land-atmosphere interactions in regional climate models during major heat waves in Central Europe

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Heat waves are expected to become more frequent and severe in a future climate along with greater impacts on the natural environment and society. The aim of the study is to analyze atmospheric circulation and land-atmosphere interactions during and before major Central European heat waves in regional climate model (RCM) simulations for the present climate in order to assess their capability of simulating these driving processes properly. We examined 7 RCM runs driven by ERA-40 reanalysis from the ENSEMBLES project. Observed data was taken from the E-OBS gridded dataset and the NCEP/NCAR reanalysis. Heat waves were defined based on regionally significant excesses above the model specific 95% quantile of summer daily maximum air temperature distribution. Atmospheric circulation was examined using circulation indices (flow strength, direction, and vorticity). Land-atmosphere interactions were described by precipitation, evaporative fraction and surface energy budget.
Considerable differences in heat waves were found between RCMs and observed data. The major Central European heat wave that occurred in summer 1994 was reproduced with difficulties in the majority of the RCMs and these errors were linked to unrealistic simulation of precipitation during this event. In summer 1967, all RCMs simulated a heat wave despite no heat wave in observed data; this inconsistency was also related to errors in precipitation. The results suggest that realistic reproduction of precipitation is crucial for the simulation of heat waves in RCMs. Since precipitation and associated cloudiness alter surface energy budget through a decline of incoming shortwave radiation and by an increase of latent heat flux, a further analysis is needed to identify main drivers of these errors in RCMs. A proper reproduction of land-atmosphere interactions is essential for obtaining credible scenarios of future heat waves.