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Day- and nighttime heatwave clusters over Europe and their physical drivers

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Heatwaves rank among the most devastating extreme events over Europe, particularly in terms of mortality and agricultural damage. Heatwaves are often defined as exceedances of thresholds based on daily maximum temperatures, thus considering only daytime effects. However, exceedances of daily minimum temperatures, which often occur at night, are of similar importance, as they can cause additional stress to the human health due to shorter recovery times. For both daytime and nighttime heatwaves, knowledge of the underlying mechanisms is crucial for the successful prediction of the events; however, these mechanisms are not yet fully understood.

Although heatwaves can occur quite locally, the task of heatwave prediction can be simplified by representing heatwaves as recurring large-scale patterns. The aim of the presented work is to identify these dominant coherent spatial patterns over Europe using the SANDRA (Simulated Annealing and Diversified Randomization) clustering method for both daytime and nighttime heatwaves. In a second step, relevant atmospheric, oceanic and land variables are investigated for their physical connection to each of the European heatwave clusters with different time lags.

The results obtained from reanalysis data covering the recent past are compared with those obtained from a long coupled global climate model simulation of the last 2000 years, performed with the MPI-ESM model. The long model simulation is further used to place the recent record-breaking European heatwave of summer 2022 in a historical context.