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The simulation of European heat waves from an ensemble of regional climate models within the EURO-CORDEX project

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The ability of a large ensemble of regional climate models to accurately simulate heat waves at the regional scale of Europe was evaluated. Within the EURO-CORDEX project, several state-of-the art models, including non-hydrostatic meso-scale models, were run for an extended time period (20 years) at high resolution (12 km), over a large domain allowing for the first time the simultaneous representation of atmospheric phenomena over a large range of spatial scales. Eight models were run in this configuration, and thirteen models were run at a classical resolution of 50 km. The models were driven with the same boundary conditions, the ERA-Interim re-analysis, and except for one simulation, no observations were assimilated in the inner domain.

Results, which are compared with daily temperature and precipitation observations (ECA&D and E-OBS data sets) show that, even forced by the same re-analysis, the ensemble exhibits a large spread. A preliminary analysis of the sources of spread, using in particular simulations of the same model with different parameterizations, show that the simulation of hot temperature is primarily sensitive to the convection and the microphysics schemes, which affect incoming energy and the Bowen ratio. Further, most models exhibit an overestimation of summertime temperature extremes in Mediterranean regions and an underestimation over Scandinavia. Even after bias removal, the simulated heat wave events were found to be too persistent, but a higher resolution reduced this deficiency. The amplitude of events as well as the variability beyond the 90th percentile threshold were found to be too strong in almost all simulations and increasing resolution did not generally improve this deficiency. Resolution increase was also shown to induce large-scale 90th percentile warming or cooling for some models, with beneficial or detrimental effects on the overall biases. Even though full causality cannot be established on the basis of this evaluation work, the drivers of such regional differences were shown to be linked to changes in precipitation due to resolution changes, affecting the energy partitioning. Finally, the inter-annual sequence of hot summers over central/southern Europe was found to be fairly well simulated in most experiments despite an overestimation of the number of hot days and of the variability. The accurate simulation of inter-annual variability for a few models is independent of the model bias. This indicates that internal variability of high summer temperatures should not play a major role in controlling inter-annual variability. Despite some improvements, especially along coastlines, the analyses conducted here did not allow us to generally conclude that a higher resolution is clearly beneficial for a correct representation of heat waves by regional climate models. Even though local-scale feed-backs should be better represented at high resolution, combinations of parameterizations have to be improved or adapted accordingly.