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Dynamical and thermodynamical drivers of variability in European summer heat extremes

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We use the 100-member Max Planck Institute Grand Ensemble (MPI-GE) to disentangle the contributions from colocated dynamic atmospheric conditions and local thermodynamic effects of moisture limitation as drivers of variability in European summer heat extremes. Using a novel extreme event definition, we find that heat extremes with respect to the evolving mean climate increase by 70% under a moderate warming scenario during the twenty-first century. With a multiple regression approach, we find that the dynamical mechanisms representing blocking and anticyclonic conditions are the main driver of variability in extreme European summer temperatures, both in past and future climates. By contrast, local thermodynamic drivers play a secondary role in explaining the total variability in extreme temperatures. We also find that considering both dynamical and thermodynamical sources of variability simultaneously is crucial. Assessing only one type of drivers leads to an overestimation of their effect on extreme temperatures, particularly when considering only thermodynamical drivers. Lastly, we find that although most past and future heat extremes occur under favorable dynamical atmospheric conditions; this occurs 10–40% less frequently over Central Europe in the twenty-first century. By contrast, heat extremes over Central Europe occur 40% more frequently under concurrent extreme moisture limitation in the twenty-first Century. Our findings highlight a new type of neutral-atmosphere, dryness-driven heat extremes, and confirm that the increase in European heat extremes and associated variability increase are dominated by the local thermodynamic effect of moisture limitation.