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Separating dynamics and thermodynamics for attribution of climate extremes – First results with the Community Earth System Model (CESM)

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The occurrence of extreme events such as droughts and heatwaves is often associated with particular atmospheric circulation patterns. However, other components such as the ocean state and the land surface can amplify or dampen the atmospheric signal. Sea-surface temperatures play an important role in the transport of heat and moisture, and soil moisture can exert a strong control on the land surface energy balance. Thus, a combination of dynamical and thermodynamical climate driving mechanisms, as well as external factors may all contribute to the build-up of a record event.

The aim of this study is to disentangle the role of these different climatological drivers for recent extreme events. To separate dynamical from thermodynamical effects, we perform simulations with the Community Earth System Model (CESM) that include nudging of horizontal winds and compare them to simulations with a freely evolving atmosphere. In this framework we can evaluate the risk of an event occurring conditional on the observed atmospheric circulation and by that identify the contribution by non-dynamical drivers. We also carry out experiments with interactive and prescribed ocean and soil moisture to assess the role of these components. Making use of this set of model experiments we aim to attribute extreme events of the recent past to climate-change driven changes in the three drivers: atmospheric circulation, land surface/soil moisture and sea-surface temperature. In particular, we will assess the role of these climate components and their interactions with each other for record events. The presented work is a step forward to improve understanding of the processes and mechanisms leading to extreme events. We will present first results from a subset of the described experiments, highlighting the use of nudging for attribution of extreme events and addressing its impacts and limitations.