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Modeling future changes in Mesoscale Convective Systems

Presentation Summary

Stationary mesoscale convective systems (MCSs) are responsible for most of warm season major flood events. Recent examples in North America are the West Virginia and Louisiana flooding of 2016, or the Houston flooding after the landfall of hurricane Harvey in 2017. Observations showed that MCSs became more frequent, intense, and long-lived in the Central US during the recent 30 years. State-of-the-art climate models are not able to simulate MCSs realistically due to their coarse grid spacing leading to significant errors in simulating convective precipitation and uncertainties in extreme precipitation projections.

Convection-permitting climate simulations (CPCS), which are able to simulate deep convection explicitly due to their high resolution, are promising tools that improve the representation of convective extremes. Here we use the weather research and forecasting model (WRF) to perform a current and end-of-century business as usual CPCS with 4 km horizontal grid spacing over a North American domain. Tracking MCS precipitation with a novel Lagrangian storm tracking algorithm shows that the current climate simulation can realistically simulate MCSs including the size, intensity, movement speed, and dynamical evolution of MCS precipitation. The future intensification of maximum MCS precipitation rates is with about 7 % per degree warming in line with expectations from the Clausius-Capayron relation. However, these intensity increases combined with the spread of heavy rainfall areas of up to 70 % and additional changes in MCS movement speed lead to an almost doubling of MCS rainfall volume.

The aim of this study is to understand the processes that lead to the rapid response of MCS precipitation volume to global warming. We show that interactions in future storm dynamics, thermodynamics, and microphysics are responsible for the large response. We will discuss the importance of model grid spacings and microphysics to capture these changes. Further, implications for extreme precipitation estimates from coarser resolution climate models and potential strategies and priorities for future model developments will be addressed.