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Projecting Future Tropical Cyclone Precipitation Increases using a Hierarchical Modeling Framework

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Extreme precipitation is expected to increase with climate change at the Clausius-Clapeyron rate of approximately 7% per °C of warming; however, tropical cyclone (TC) precipitation may increase at a greater rate due to feedbacks between the storm dynamics and the thermodynamic increase in moisture. Previous modeling studies simulate increasing TC intensities with warming sea surface temperatures (SSTs), which may push the precipitation increase above the Clausius-Clapeyron rate. Recent work by the authors used the Community Atmosphere Model (CAM) in a state of radiative-convective equilibrium (RCE) with globally-uniform SSTs varying between 295 and 305 K to break down the TC precipitation response to warming into thermodynamic and dynamic contributions. Results showed that for 99th percentile TC precipitation, increases in atmospheric moisture (thermodynamics) contributed just over 66% of the precipitation increase while increases in TC intensity (dynamics) contributed about 20%. This work explores if the relationship between TC precipitation, SST, and storm intensities found in the RCE simulations holds for observations and high-resolution climate model simulations. The observations consist of TC tracks and intensities from the IBTrACS database, SSTs from the NOAA OISST dataset, and precipitation from the IMERG satellite product. The high-resolution climate model simulations are from the High Resolution Model Intercomparison Project (HighResMIP), a CMIP6-endorsed MIP that has both historical and future climate runs. The methodology involves extracting TC precipitation using an automated algorithm, binning TCs by relevant characteristics (i.e., their local-environment SSTs, intensities, and outer sizes), extracting various precipitation metrics from their precipitation fields, and calculating relationships between the precipitation metrics, TC characteristics, and SSTs. The goal is to use these relationships to project future TC precipitation changes under different future climate change scenarios using just changes in SST.