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The Response of the Large-Scale Tropical Circulation to Warming

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Previous work has found that as the surface warms the large-scale tropical circulations weaken, convective anvil cloud fraction decreases, and atmospheric static stability increases. Circulation changes inevitably lead to changes in the humidity and cloud fields which influence the surface energetics. The exchange of mass between the boundary layer and the midtroposphere has also been shown to weaken in global climate models. What has remained less clear is how robust these changes in the circulation are to different representations of convection, clouds, and microphysics in numerical models. We use simulations from the Radiative‐Convective Equilibrium Model Intercomparison Project (RCEMIP) to investigate the interaction between overturning circulations, surface temperature, and atmospheric moisture. We analyze the underlying mechanisms of these relationships using a 21-member model ensemble that includes both general circulation models and cloud resolving models. We find a large spread in the change of intensity of the overturning circulation. Both the range of the circulation intensity, and its change with warming can be explained by the range of the mean upward vertical velocity. There is also a consistent decrease in the exchange of mass between the boundary layer and the midtroposphere. However, the magnitude of the decrease varies substantially due to the range of responses in both mean precipitation and mean precipitable water. This work implies that despite well understood thermodynamic constraints, there is still a considerable ability for the cloud fields and the precipitation efficiency to drive a substantial range of tropical convective responses to warming.