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Thermodynamic and dynamic controls on the amplitude of the zonally anomalous hydrological cycle

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The "wet gets wetter, dry gets drier" paradigm is a useful starting point for under- standing zonal-mean changes in precipitation minus evaporation (P-E). It can explain the expected moistening of the high latitudes and drying of the subtropics in response to global warming. We examine P-E changes over the next century in comprehensive climate models from the Coupled Model Intercomparison Project Phase 5 (CMIP5). We show that "wet gets wetter, dry gets drier" can not be extended to apply to regional variations about the zonal mean, which account for the majority of the spatial variability of P-E in the modern climate. Wet and dry zones shift substantially in response to shifts in the stationary-eddy circulations that cause them. The largest changes are in the tropical oceans where wet zones get drier and dry zones get wetter in response to a restructuring and decrease in strength of tropical circulations such as the Walker circulation. Further progress can be made by examining changes in the zonal variance of P-E. The zonal variance of P-E increases robustly at all latitudes in the Representative Concentration Pathways RCP8.5 scenario, but with a smaller fractional increase than the moisture content of the atmosphere. The variance change can be split into dynamic and thermodynamic components by relating it to changes in surface specific humidity, stationary-eddy divergent circulations, and transient-eddy fluxes. The modeled sub Clausius-Clapeyron change of zonal P-E variance gives evidence of a decrease in stationary-eddy overturning and in zonally anomalous transient-eddy moisture flux convergence with global warming.