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Evaluating the "rich-get-richer" mechanism in tropical precipitation change under global warming

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Examining tropical regional precipitation anomalies under global warming in 10 coupled global climate models, several mechanisms are consistently found. The tendency of rainfall to increase in convergence zones with large climatological precipitation, and to decrease in subsidence regions—the rich-get-richer mechanism—has previously been examined in different approximations by Chou and Neelin, and Held and Soden. The effect of increased moisture transported by the mean circulation (the “direct moisture effect” or “thermodynamic component” in respective terminology) is relatively robust, while dynamic feedback is poorly understood and differs among models. The argument outlined states that the thermodynamic component should be a good approximation for large-scale averages; this is confirmed for averages across convection zones and descent regions, respectively. Within the convergence zones, however, dynamic feedback can substantially increase or decrease precipitation anomalies. Regions of negative precipitation anomalies within the convergence zones are associated with local weakening of ascent, and some of these exhibit horizontal dry advection associated with the “upped-ante” mechanism. Regions of increased ascent have strong positive precipitation anomalies enhanced by moisture convergence. This dynamic feedback is consistent with reduced gross moist stability due to increased moisture not being entirely compensated by effects of tropospheric warming and a vertical extent of convection. Regions of reduced ascent with positive precipitation anomalies are on average associated with changes in the vertical structure of vertical velocity, which extends to higher levels. This yields an increase in the gross moist stability that opposes ascent. The reductions in ascent associated with gross moist stability and upped-ante effects, respectively, combine to yield reduced ascent averaged across the convergence zones. Over climatological subsidence regions, positive precipitation anomalies can be associated with a convergence zone shift induced locally by anomalous heat flux from the ocean. Negative precipitation anomalies have a contribution from the thermodynamic component but can be enhanced or reduced by changes in the vertical velocity. Regions of enhanced subsidence are associated with an increased outgoing longwave radiation or horizontal cold convection. Reductions of subsidence are associated with changes of the vertical profile of vertical velocity, increasing gross moist stability.