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Rain re-evaporation, boundary-layer/convection interactions, and pacific rainfall patterns in an AGCM

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Sensitivity experiments with an atmospheric general circulation model (AGCM) show that parameterized rain re-evaporation has a large impact on simulated precipitation patterns in the tropical Pacific, especially on the configuration of the model's intertropical convergence zone (ITCZ). Weak re-evaporation leads to the formation of a ‘‘double ITCZ” during the northern warm season. The double ITCZ is accompanied by strong correlation between precipitation and high-frequency vertical motion in the planetary boundary layer (PBL). Strong re-evaporation leads to a better overall agreement of simulated precipitation with observations. The model's double ITCZ bias is reduced. At the same time, correlation between high-frequency (periods $<$ 15 d) vertical motion in the PBL and precipitation is reduced. Experiments with modified physics indicate that evaporative cooling by rain near the PBL top weakens the coupling between precipitation-related heating and vertical motion in high-frequency motions. The strength of high-frequency vertical motions in the PBL was also reduced directly through the introduction of a diffusive cumulus momentum transport (DCMT) parameterization. The DCMT had a visible impact on simulated precipitation in the tropics, but did not reduce the model's double ITCZ bias in all cases.

Further analyses of mass and water vapor budgets, as well as vertical motion statistics, in the ITCZ complex, show that time-mean, moisture convergence in the southern ITCZ is largely dominated by high- frequency modes, while in the northern ITCZ, time-mean moisture convergence contains large contributions from slower modes. This may explain why the simulated southern ITCZ is more susceptible to parameterization changes that alter high-frequency coupling between moist heating and PBL convergence.