Abstract: A novel convective scheme for the CAM4 AGCM and impacts on the tropical circulation

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The simulation of tropical convection (which drives the tropical circulation) in climate models has been problematic due to the need for parameterization. The intensity of the tropical circulation is affected by the tropical lapse rate profile, which is sensitive to the tropical dry static stability of the tropopause. The observed time-mean tropical lapse rate profile exhibits structure that deviates somewhat from the assumed nearly moist adiabatic profile. Compared to radiosonde observations, a cold bias of ~1K is found over the convecting regions of the deep tropics in simulations with the NCAR Community Atmospheric Model version 4 (CAM4). This lower tropospheric cold bias leads to a tropical lapse rate profile that is more stable than that observed from radiosondes. A new convective scheme for CAM4 (the IF scheme) developed at Dalhousie University, seeks to resolve this lower tropospheric cold bias by using a "leaky pipe" model for convective mixing.

Simulations with CAM4 using the IF scheme (CAM4-IF) in place of the default shallow and deep convective schemes reveal a strengthening of the climatological mean tropical Walker and Hadley circulations. Furthermore, idealized sensitivity experiments with imposed SST warming in CAM4-IF produce stronger weakening of the tropical circulation than the default CAM4. However, attributing these changes to the tropical temperature/lapse rate profile alone is challenging, because the IF scheme also produces a confounding change in the pattern of tropical precipitation. Collectively, these results provide strong additional support that climate models' convective schemes play a critical role in the simulation of the tropical circulations.