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The Impacts of Bias in Cloud-Radiation-Dynamics Interactions on Central-Pacific Seasonal and El Nino Simulations in Contemporary GCMs

juilin Li (1), Ettammal Suhas (1), Mark Richardson (1), Wei-Liang Lee (2), Yi-Hui Wang (1), Jia-Yuh Yu (3), Tong Lee (1), Eric Fetzer (1), and Graeme Stephens (1)

(1) Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA, (2) RCEC, Academia Sinica, Taiwan, (3) Department of Atmospheric Sciences, National Central University, Taoyuan City, Taiwan

Most of the global climate models (GCMs) in the Coupled Model Intercomparison Project, phase 5 (CMIP5) do not include precipitating ice (a.k.a. falling snow) in their radiation calculations. We examine the importance of the radiative effects of precipitating ice on simulated surface wind stress and sea surface temperatures (SSTs) in terms of seasonal variation and in the evolution of Central Pacific El Nino (CP-El Nino) events.

Using controlled simulations with the CESM1 model, we show that the exclusion of precipitating ice radiative effects generates a persistent excessive upper-level radiative cooling and an increasingly unstable atmosphere over convective regions such as the western Pacific and tropical convergence zones. The invigorated convection leads to persistent anomalous low-level outflows which weaken the easterly trade winds, reducing upper-ocean mixing and leading to a positive SST bias in the model mean state. In CP-El Nino events, this means that outflow from the modeled convection in the central Pacific reduces winds to the east, allowing unrealistic eastward propagation of warm SST anomalies following the peak in CP-El Nino activity.

Including the radiative effects of precipitating ice reduces these model biases and improves the simulated life cycle of the CP-El Nino. Improved simulations of present day tropical seasonal variations and CP-El Nino events would increase the confidence in simulating their future behaviour.