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On the relationship between cloud vertical structure and the large-scale tropical circulation: observational analysis and evaluation of climate models

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The representation of cloud processes in General Circulation Models (GCMs) is critical for simulating weather and climate. They control both the distribution and intensity of diabatic heating sources in the atmosphere (e.g., convection, radiation), which, in turn, strongly interact with atmospheric dynamics and determine the spatial structures and temporal variability of the large-scale atmospheric circulation simulated by climate models. Thus, the characterization and understanding of relationships between cloud properties, large-scale atmospheric circulations and climate variability should provide guidance for future GCMs improvements. The arrival of both (i) satellite observations of clouds in the tropics, especially from sensors onboard CALIPSO and CloudSat, and (ii) the Cloud Feedback Model Intercomparison Project (CFMIP) Observation Simulator Package (COSP), applied on CMIP5 outputs, provides a consistent framework for evaluating the spatial and vertical cloud distribution. In particular, the relationship between the cloud vertical structure and the associated radiative fluxes is diagnosed for the first time in both observations and CMIP5 coupled model simulations. Using complementary observations from the A-Train and the TRMM radar, the link between the cloud vertical structure, the diabatic heating vertical profiles, and the large-scale circulations in the tropics is assessed, building a reference for climate model evaluation. A particular focus is put on the role of cloud representation (and biases) on the simulation of surface winds over the Pacific Ocean.