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The structure and environment of tropical deep convective clouds from a CloudSat-centric A-Train and ECMWF analysis data set

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The representation of tropical deep convective clouds and the associated precipitation in global climate models remains a major source of uncertainty in climate projections and weather forecasts. Recent advances in satellite retrievals, especially the vertically resolved cloud condensate observations from CloudSat, offer a new opportunity to evaluate and improve the key processes in numerical models. A CloudSat-centric, multi-parameter A-Train and high-resolution ECMWF analysis data set is being developed in the present study, as a contribution to the WMO Year of Tropical Convection (YOTC) research activity, to adequately characterize the structure and properties of moist convection. Applying the co-located parameters from CloudSat, CALIPSO, AIRS, AMSR, MODIS, CERES, MLS, and the ECMWF analysis, relationships are analyzed between the vertical distribution of hydrometeors, precipitation intensity, thermodynamic environment, radiation, and aerosol microphysical impacts in tropical convective clouds. Distinct and robust patterns are identified, such as the threshold value of column water vapor controlling precipitation intensity, and the trends of humidity profiles associated with conditionally averaged rain rates. The sensitivities of cloud structure and precipitation to the boundary-layer characteristics, moisture availability, vertical instability, and aerosol abundances are further examined by the plume model analyses and Weather and Research Forecast (WRF) model simulations. The current study demonstrates the observational constraints on tropical deep convection provided by the co-located multi-parameter data set, which will be useful in validating and revising the moist convection and precipitation parameterizations in global and regional models.