Geophysical Research Abstracts
Vol. 20, EGU2018-3118, 2018
EGU General Assembly 2018

Observing the tropical atmosphere in moisture space

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Measurements from the Barbados Cloud Observatory are analyzed to identify the processes influencing the distribution of moist static energy and the large-scale organization of tropical convection. These measurements sample the seasonal cycle of the atmosphere over Barbados, and in so doing construct a cross section which includes deep convection in the ITCZ in the wet-season, and the trades in the dry-season. Five years of water-vapor- and cloud profiles, from a Raman lidar, and cloud radar are composed to construct the structure of the observed atmosphere in moisture space. The large-scale structure of the atmosphere is similar to that now familiar from idealized studies of convective self-aggregation, with shallow clouds prevailing over a moist marine layer in regions of low rank-humidity, and deep convection in a nearly saturated atmosphere in regions of high rank-humidity. With the help of reanalysis datasets the overall circulation pattern is reconstructed in moisture space, and shows evidence of a substantial lower-tropospheric component to the circulation. This shallow component of the circulation helps support the differentiation between the moist and dry columns, similar to what is found in simulations of convective self-aggregation. Radiative calculations show that clear-sky radiative differences can explain a substantial part of this circulation, with further contributions expected from cloud radiative effects. The shallow component appears to be important for maintaining the low gross moist stability of the convecting column. A positive feedback between the shallow circulation, and the low-level moisture gradients that help support it, is hypothesized to play an important role in conditioning the atmosphere for deep convection. Hence, processes thought to be important for the self-aggregation of convection in radiative-convective equilibrium similarly play a role in shaping the intertropical convergence zone, and hence, the large-scale structure of the tropical atmosphere.