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Observed relationships between cloud vertical structure and convective aggregation over tropical ocean

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Using the satellite-infrared-based Simple Convective Aggregation Index (SCAI) to determine the degree of aggregation, 5 years of CloudSat-CALIPSO cloud profiles are composited at a spatial scale of 10 degrees to study the relationship between cloud vertical structure and aggregation. For a given large-scale vertical motion and domain-averaged precipitation rate, there is a large decrease in anvil cloud (and in cloudiness as a whole) and an increase in clear sky and low cloud as aggregation increases. The changes in thick anvil cloud are proportional to the changes in total areal cover of brightness temperatures below 240 K (cold cloud area, CCA), which is negatively correlated with SCAI. Optically thin anvil cover decreases significantly when aggregation increases, even for a fixed CCA, supporting previous findings of a higher precipitation efficiency for aggregated convection. Cirrus, congestus, and mid-level clouds do not display a consistent relationship with the degree of aggregation. We present the lidar-observed low-level cloud cover (where the lidar is not attenuated) as our best estimate of the true low-level cloud cover and show that it increases as aggregation increases. Qualitatively, the relationships between cloud distribution and SCAI do not change with sea-surface temperature, while cirrus clouds are more abundant and low-level clouds less at higher sea-surface temperatures. For the observed regimes, the vertical cloud profile varies more evidently with SCAI than with mean precipitation rate. These results confirm that convective scenes with similar vertical motion and rainfall can be associated with vastly different cloudiness (both high and low cloud) and humidity depending on the degree of convective aggregation.