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The dependence of vertical cloud profiles from CloudSat-CALIPSO retrievals on the degree of convective aggregation

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Previous work (Tobin et al. 2012, Tobin et al. 2013) has found that the degree of aggregation of convection in satellite observations, as measured by the Simple Convective Aggregation Index (SCAI), is associated with systematic differences in mean environmental moisture and outgoing longwave radiation for a given large-scale forcing. This suggests that climate models need to simulate the degree of organization of convection, and not just the mean precipitation and convective fluxes, in order to fully represent interactions between convection and larger scales. In this study, we use five years of CloudSat-CALIPSO cloud profiles alongside TRMM rainfall, geostationary IR data, ERA- Interim water vapor, and other observations to investigate the relationship between vertical cloud distributions and the SCAI aggregation index. We find that there is a significant decrease in anvil cloud (and in cloudiness as a whole) and increase in clear sky and low cloud (including cumulus) as aggregation increases (for a given precipitation rate). The changes in anvil and shallow cumulus are proportional to the changes in total cold cloud area (CCA), meaning that anvil per CCA and cumulus as a fraction of non-cold cloud area (1-CCA) do not change much even as CCA decreases with increased aggregation; in contrast, the change in clear sky occurs in both an absolute sense and as a fraction of non-cold cloud area (1-CCA).