Effects of cloud condensate vertical alignment on radiative transfer calculations in deep convective regions

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Effects of cloud condensate vertical alignment on radiative transfer process were investigated using cloud resolv- ing model explicit simulations, which provide a surrogate for subgrid cloud geometry. Diagnostic results showed that the decorrelation length Lcw varies in the vertical dimension, with larger Lcw occurring in convective clouds and smaller Lcw in cirrus clouds. A new parameterization of Lcw is proposed that takes into account such varying features and gives rise to improvements in simulations of cloud radiative forcing (CRF) and radiative heating, i.e., the peak of bias is respectively reduced by 8 W m−2 for SWCF and 2 W m−2 for LWCF in comparison with Lcw = 1 km.

The role of Lcw in modulating CRFs is twofold. On the one hand, larger Lcw tends to increase the standard deviation of optical depth $\sigma \tau$, as dense and tenuous parts of the clouds would be increasingly aligned in the vertical dimen- sion, thereby broadening the probability distribution. On the other hand, larger $\sigma \tau$ causes a decrease in the solar albedo and thermal emissivity, as implied in their convex functions on τ. As a result, increasing (decreasing) Lcwleads to decreased (increased) CRFs, as revealed by comparisons among Lcw = 0, Lcw = 1 km andLcw = ∞. It also affects the vertical structure of radiative flux and thus influences the radiative heating. A better representa- tion of $\sigma \tau$ in the vertical dimension yields an improved simulation of radiative heating. Although the importance of vertical alignment of cloud condensate is found to be less than that of cloud cover in regards to their impacts on CRFs, it still has enough of an effect on modulating the cloud radiative transfer process.

Keywords: horizontal inhomogenity, vertical alignment, cloud resolving model

