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Halo Size Around Shallow Cumulus Clouds in the Large Eddy simulations

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The halo region, defined as the moist buffering region without cloud liquid water, is critical for the interplay between the cloud and the environment and also has non-negligible impact on radiation, but yet lacks enough attention. This study systematically investigates how the relative humidity in the halo region decays outward to match the environmental relative humidity using high resolution large eddy simulations. A noval algorithm is developed to examine the composite structure outside the clouds. It is found that, whatever the horizontal resolution is, the distribution of relative humidity in the halo region does not depend on the size of cloud, but on the real distance away from the cloud boundary. With finer horizontal resolution, the relative humidity decays outward much more quickly. The halo size converges when the horizontal resolution is no larger than 50 m. The buoyancy length scale can explain the dependency of halo size on model resolution. Sensitivity simulations indicate that these findings are not sensitive to the details of the sub-grid turbulence scheme and the advection schemes. Analyses of autocorrelation length scales and Lagrangian trajectories further shed light on how the halo regions at different vertical levels are connected. Our results can help improve the definition of near cloud environment in the bulk plume model in convection parameterization and also provide evidence to improve the understanding of both dynamical and radiative impact from the cloud-aerosol-environment interactions.