Impacts of entrainment model in cumulus parameterization on atmospheric general circulation

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Entrainment model is a key parameterization in cumulus parameterization since entrainment affects structure and formation of convective clouds, and thus has influences on atmospheric general circulation. In the past studies, several entrainment models have been proposed based on observation and results of cloud-resolving model simulations. However, there still coarse and inconsistent assumptions exist in those modeling. Considering drawbacks in the modeling procedures, long-range cloud-resolving model simulation was performed and detailed, statistical convective cloud structure was analyzed. Based on the analysis, entrainment model which can represent statistical structure of convective clouds and can be used with detrainment model in cumulus parameterization was proposed.
The new entrainment model was implemented into a spectral cumulus parameterization, and was compared with one of the recent entrainment models used in some cumulus parameterizations. The physical performance of the models was examined using AMIP experiment. The results indicated that the new model could simulate better climatology in terms of the annual mean states of atmospheric circulation. Significant difference in simulated results between two models appeared in vertical profiles of entrainment. Since existing model parameterized entrainment so that it is directly proportional to in-cloud buoyancy, the entrainment especially in low altitude was overestimated, resulting in too much low cloud amount. The new model suppresses the trend due to the consideration of detrainment effect into estimation of entrainment. Finally, further analysis revealed that the new formulation of currently proposed model also could contribute to the improvement of atmospheric variability.

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