Droplet evolution in cloud turbulence

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Direct numerical simulation of turbulent air flow and the detailed computation of Lagrangian dynamics of cloud droplets with cloud microphysical processes are very useful and powerful to obtain new knowledge about the fundamental cloud physics. However, the space-time range of the phenomena studied by this approach has still been limited and not enough to link with the macroscopic numerical prediction of the evolution of a whole cloud because the computational barrier is very high. Therefore, in order to bridge the computational gap between the microscopic and macroscopic approaches, the space-time range of the numerical computation from the microscopic view points needs to be overlapped with the smallest space-time resolution scale in the macroscopic computation. For this purpose, we have developed a new method that enables us to seamlessly simulate the continuous growth of cloud droplets to rain drops from the microscopic view points for long time comparable with the time of the macroscopic evolution of cloud. A cubic box ascending with a mean updraft was introduced and the updraft velocity was self-consistently determined in such a way that the mean turbulent velocity within the box vanished[1]. All the degrees of freedom were numerically integrated by using the Lagrangian dynamics for the droplets and the Eulerian direct numerical simulation for the turbulence. The key processes included were turbulent transport, condensation/evaporation, Reynolds number dependent drag, collision-coalescence, and entrainment. We have examined the evolution of the droplet spectrum over 400 s for the single-peaked initial droplet spectra, which had the initial mean radius 10μm and the mean droplet density $n_p = 125$ cm^{-1}. The turbulence was in steady state at $R_\lambda = 130$ and $\epsilon = 100$ cm^{2}s^{-3}. Figure 1 shows that the mass spectrum peak moves slowly toward the larger radius in the early stage and then quickly evolves to have the second peak through the autoconversion to the accretion state . Effects of the condensation and coalescence and the turbulence on the droplet evolution are also discussed.

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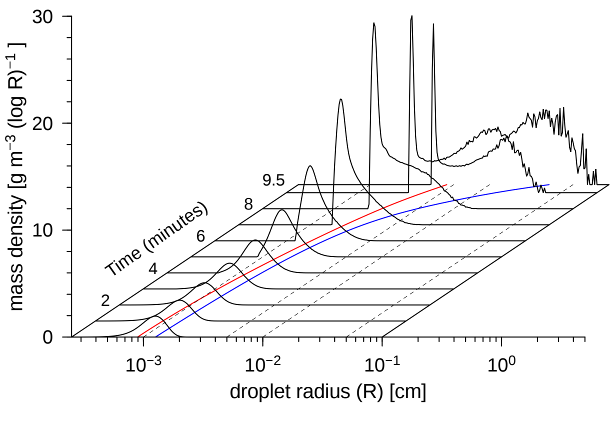

Fig. 1: Evolution of cloud droplet spectrum.

References

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