Coagulational Growth of Cloud Droplets in a Turbulent Environment

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We investigate the effect of turbulence on the collisional growth of μm-sized droplets by high-resolution numerical simulations with well resolved Kolmogorov scales, assuming a collision and coalescence efficiency of unity. The droplet dynamics and collisions are approximated using a superparticle approach. We show that the time evolution of the shape of the droplet-size distribution due to turbulence-induced collision depends strongly on the turbulent energy-dissipation rate, but only weakly on the Reynolds number. The size distribution exhibits power law behavior with a slope of −3.7 in the size range of about 10 ∼ 40 μm, which is close to the power law size distribution found for interstellar dust grains. When gravity is invoked, the strong dependency becomes weakened. Turbulence is found to dominate the time evolution of an initially monodisperse droplet distribution at early times. At later times, however, gravity takes over and dominates the collisional growth. With combined turbulence and gravity, the time scale to reach drizzle sized droplets is about 900 s, which is close to the time scale of rapid warm rain formation. The collision rate grows exponentially, which is consistent with the theoretical prediction of the continuous collisional growth even when the turbulence-generated collision is invoked.

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