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Toward the assessment of the role of cloud turbulence in warm-rain processes

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Cloud turbulence has been argued to play a significant role in the development of precipitation through the warm-rain (collision/coalescence) processes. In recent years, we developed collision kernels that include effects of cloud turbulence on collisions between cloud droplets. The kernels apply the theoretical model of the turbulent droplet collisions verified by direct numerical simulation (DNS) of droplet-laden turbulent flows. The impact of cloud turbulence on the collision efficiency was also included and it was assessed using a novel DNS methodology that includes hydrodynamic interactions between droplets carried by the turbulent flow. In general, the turbulent collision kernel depends on the characteristics of the small-scale turbulence, the turbulent dissipation rate in particular. We quantified the impact of turbulent collisions in simulations with increasingly complex setups, from the evolution of the initial droplet spectrum with collision/coalescence alone; through rising adiabatic parcel simulations that included droplet activation, diffusional growth and growth by collision/coalescence; and in idealized rising thermal simulations mimicking processes within a single cloud. The latter simulations show that cloud turbulence not only leads to earlier rain formation, but can also result in higher precipitation efficiency of a single cloud. The next logical step is to apply the new kernel in realistic cloud field simulations to include feedbacks between clouds and their environment. Such simulations are underway and will be discussed at the conference.