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

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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. The next logical step is to apply the new kernel in realistic cloud simulations to quantify its impact.

This paper will review the above developments and discuss application of the new kernel to large-eddy simulations of shallow precipitating convection. We will present an approach to include turbulent collision kernels into large-eddy simulation (LES) model. The problem is in the disparity of spatial scales represented in DNS and LES models. In general,the DNS model attempts to simulate effects of small-scale turbulence only, whereas the LES model has to incorporate the effects of significantly larger range of scales. A relatively simple strategy to bridge the scale gap will be presented and model simulations with various specific variations of the strategy will be discussed.