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Rain formation via turbulent mixing of droplet distributions

MIHKEL KREE, JAAN KALDA, Institute of Cybernetics, Tallinn University of Technology — It is well known that the growth of water droplets in a cloud due to vapor diffusion alone is insufficiently slow to explain the rapid onset of rain formation. In recent years, there have been several proposals of turbulent mechanisms leading to enhanced collision rates. It has been understood that a broadening of droplet size spectra can provide a sufficient boost to the collision rate. However, the broadening of the droplet size spectra also needs to be explained. Here, we propose a novel approach based on the idea that turbulent mixing brings together droplets of very different histories and hence, of very different sizes, similarly to how passive scalar fronts are formed. We provide relevant analytical estimates, and simulations based on 1D model of turbulence (stochastic triplet map similar to the Baker's map). This mapping model captures the essential stretching and folding nature of turbulent flows. The triplet mapping is accompanied by averaging of neighboring distributions, corresponding to local diffusive mixing of droplets. In particular, we study the widths (variances) of local drop size distributions, which appear to follow a power law. Accordingly, we witness occasional instances of extremely broad drop size distributions, which can trigger the rain formation.

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