Experimental Investigation of Small Inertial Droplets in Turbulence: an effort to develop quantitative models of turbulence-induced collisions from laboratory data coordinated with direct numerical simulations.

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The influence of turbulence on the dynamics of small inertial droplets, such as the droplets resulting from condensation in warm rain formation, is an important source of uncertainty in current microphysics cloud models. Specifically, the contribution of turbulence in the air flow on the droplet collision kernel, through preferential concentration and enhanced settling, is a fertile area for model improvement.

Laboratory experiments can provide detailed information on droplet dynamics, including collisions, under very well characterized and controlled conditions. In coordination with field data, laboratory measurements of droplet size evolution, velocity and local concentration can lead to better understanding of the influence of turbulence on the collisional growth of small inertial droplets ($20\ \mu m < d < 100\ \mu m$, $0.25 < Stokes < 10$).

We have conducted experiments with homogeneous isotropic turbulence laden with micro droplets in a wind tunnel setting, where we can measure the droplet relative velocity, local concentration and evolution of the droplet size using laser interferometry. These laboratory measurements, obtained in conditions representative of incipient warm rain in clouds, are compared to direct numerical simulations. The experimental data is used to validate the short range inter droplet interaction model, while the DNS data is used to complete some of the statistics that are missing from the experimental measurements (i.e. 3 dimensional radial distribution function or 3 dimensional relative velocity statistics). These quantitative data has been used to develop models for droplet collision kernels in order to predict droplet growth rate as a function of local conditions.

We have also perform high-speed, high-resolution, visualizations of droplet-droplet interactions in the wind tunnel. The objective is to study collision-coalescence mechanisms through deterministic data, to complement the statistics collected through interferometry. This data is also been used to develop coalescence efficiency models that incorporate turbulence characteristics.