Laboratory Studies of the Influence of Turbulence on Accumulation and Settling Velocity of Inertial Droplets

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The dynamics of inertial droplets (or particles) immersed in a turbulent air flow is strongly influenced by their interaction with the vorticity field in the continuous phase. In particular, turbulence in the air flow has a very strong effect on the concentration and settling velocity of small inertial droplets. This phenomenon, which had been previously predicted theoretically and computed numerically, is still poorly modeled and quantified.

This talk will present some results from experiments aimed at improving our understanding of the role of turbulence in the formation of inertial clusters, pockets of highly concentrated inertial droplets in an otherwise diluted droplet-laden air flow. The key interaction parameters for droplets in an isotropic turbulent flow are the Stokes number (ratio between the droplet relaxation time and the Kolmogorov eddy turn-over time) and the ratio between the terminal velocity and the Kolmogorov velocity scale. When both of these parameters are close to unity, the droplets are optimally tuned to the turbulence fluctuations and accumulate strongly in regions of low vorticity and high strain. Because of this local accumulation, the settling velocity of the droplets is enhanced beyond the effect of turbulence on isolated droplets. A simple phenomenological model for these coupled phenomena has been developed.

Both the local concentration of droplets and the enhancement of their settling velocity will increase the probability of collisions between droplets. By skewing the distributions of the interdroplet distance and relative velocity, turbulence can modify the collision kernel of small inertial droplets, therefore significantly reducing the time it would take for these small droplets ($d \approx 10$ μm) to grow by collisions into the regime where gravitationally-induced collisions become dominant.