Disks falling in turbulent air

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The fall speed of snowflakes and ice crystals is influenced by atmospheric turbulence. Quantifying such an effect is necessary to reach a predictive understanding of frozen precipitation, which in turn is a prerequisite for accurate weather forecasts and reliable climate projections. In this experimental study we employ a large zero-mean-flow chamber in which different intensities of air turbulence are prescribed by the randomized firing of hundreds of jets. We release in it thousands of solid disks with size, density, and aspect ratio comparable to the plate crystals observed in the atmosphere. High-speed imaging and Lagrangian tracking is used to reconstruct their trajectory, orientation, and rotation rate (Figure 1a,b), and their behaviour is compared with observations in quiescent air[1]. It is found that turbulence progressively reduces the probability of steady and fluttering falling styles: virtually all disks tumble when the turbulence velocity fluctuations are comparable to their fall speed. Moreover, the fall speed increases significantly with turbulence intensity. This behaviour is opposite to recent findings for disks descending in turbulent water[1], highlighting the crucial role of the density ratio in determining the particle-fluid dynamics for this class of objects. The hindered fall speed is cast as an increase in drag coefficient, which offsets the decreasing trend with particle Reynolds number observed in quiescent air. The result is an approximately constant drag coefficient over a wide range of Reynolds numbers (Figure 1c).

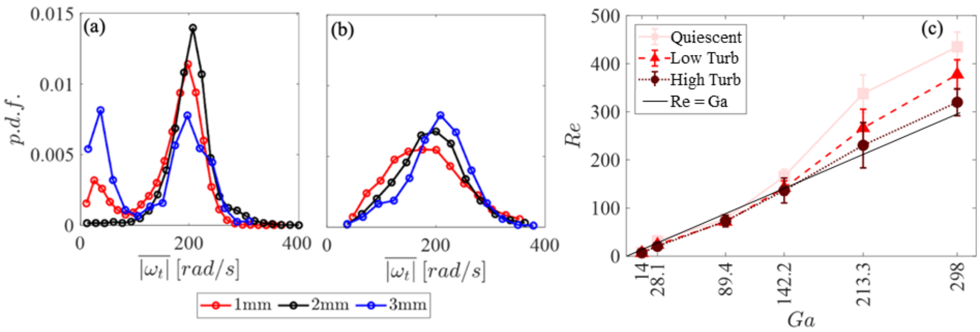

Figure 1. Distribution of mean tumbling rates for disks of 1, 2, and 3 mm in diameter falling in (a) quiescent air, and (b) turbulent air. (c) Reynolds number, Re, based on the disk fall speed versus the Galileo number, Ga. The line Re = Ga indicates a constant drag coefficient, $C_D = 1$.

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[2] Esteban, *J. Fluid Mech.* **604**, 1 (2008).