Experimental investigation of non-spherical pollen grain settling in near homogeneous isotropic turbulence

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In models of atmospheric pollen dispersal, pollen grains are generally modelled as small spheres and any morphological features are thought to be irrelevant to their dispersal characteristics. However, most pollen grains have striking morphological features such as spikes and air sacs that may affect dispersal. Here, we present results on non-spherical pollen grains settling in near Homogeneous, Isotropic Turbulence (HIT). The turbulence is generated in a 40 cm^3 transparent turbulence chamber by 8 woofers mounted on the corners of the chamber [1,2]. Near HIT in the center of the chamber was validated for two woofer amplifications using stereoscopic Particle Image Velocimetry (PIV) with a field of view of ~45 x 45 mm^2. Ratios of rms values of fluctuating velocity components were close to one, indicating isotropy in the center of the chamber. Longitudinal and transverse Turbulent Kinetic Energy (TKE) spectra calculated from the PIV data sets, collapsed. In order to provide an estimate for the Kolmogorov scales and particle Stokes numbers, TKE dissipation rates were estimated using three different methods. Resulting Kolmogorov length and time scales were ~180 μm and ~2ms with Taylor scale Reynolds numbers of about 200.

Corn (*Zea Maize*, 80μm), pine (*Pinus Taeda*, 60μm, Fig. 1), ragweed (*Ambrosia,* 20μm) pollen as well as polystyrene spheres with similar diameter and density as corn, were released into the chamber. Settling trajectories were measured using high-speed (up to 1 kHz), inline digital holographic cinematography using a lensless CMOS camera (Photron Ultima APX, 1k x 1k, 17x17 μm^2 pixels). The volume of interest was 17x17x40 mm^3 located in the center of the chamber. Particle Stokes numbers ranged from 0.1 to 10; the lowest value for ragweed pollen. Holographic movies of particle settling were captured in still air and in near HIT. Between 100 to 700 particles were tracked for each particle type with an average tracking distance of about 40 frames. Still air settling velocities and deduced pollen densities compared well to values found in the literature. In all cases, settling velocities in near-homogeneous, isotropic turbulence are enhanced over their still air settling values; the enhancement is highest for the lowest Taylor Reynolds number. Especially large settling velocity enhancements were obtained for pine that exhibits the most striking morphological features in the form of air sacs (Fig. 1). The settling enhancement of corn pollen and polystyrene spheres were similar. The data is currently further processed to obtain diffusion coefficients and results will be presented. In addition higher resolution (~ 3-5μm/pixel) high speed holographic cinematography is underway in order to resolve the possible changing orientation of non-spherical pollen grains while settling in near HIT.

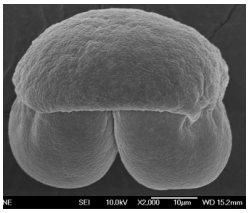

Fig. 1. Pine pollen

References

[1] Hwang W., Eaton J. K. (2004) Creating homogeneous and isotropic turbulence without a mean flow. *Exp. Fluids*, Vol. 36, 444-454.

[2] Sabban L., van Hout R. (2010) Measurement of pollen settling characteristics in near homogeneous isotropic turbulence. *Proceedings of the 7th International Conference on Multiphase Flow*, ICMF 2010, Tampa, FL USA, May 30-June 4.