Volumetric distribution and velocity of inertial particles in a turbulent channel flow

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HIGHLIGHTS

• We study a particle-laden turbulent channel flow, in a regime in which preferential concentration and two-way coupling are both important.
• 2D PIV/PTV is used to measure statistics of the inertial particle concentration and velocity.
• Digital in-line holography is used to reconstruct instantaneous 3D distributions of inertial particles.
• The particles have a flatter velocity profile and higher velocity fluctuations compared to the fluid.
• Using Voronoi analysis on the 3D particle distribution, strong particle clustering is found especially in the near-wall regions.

ABSTRACT

The segregation of inertial particles in specific regions of a turbulent fluid flow is a well known phenomenon, but experimental observations of its three-dimensional nature have been lacking. Here we are concerned with the transport of small inertial particles in a vertically oriented turbulent channel flow. The working fluid is air laden with size-selected glass particles. We focus on a regime in both preferential concentration and turbophoresis as well as two-way coupling are expected to be significant. We measure statistics of particles and fluid using two-dimensional imaging, and we reconstruct volumetric distributions of the inertial particles using digital in-line holography. The inertial particles are found to accumulate near the wall, but in a much less extreme fashion than what direct numerical simulations indicate. The particles have a flatter velocity profile and higher velocity fluctuations compared to the fluid. Using Voronoi analysis we find strong particle clustering especially in the near-wall regions (Fig. 1), indicating that preferential concentration is driven by the near-wall turbulence structures.

Fig. 1: Left: Wall-normal location of the different particle bins. Right: standard deviation of the PDF of the Voronoi volumes.