Particles and snowflakes falling through turbulence

Dr. Filippo Coletti
Aerospace Engineering and Mechanics
University of Minnesota
November 9th, 10:00 am—11:00 am
2004 Black Engineering

Abstract

The fall speed of heavy particles suspended in a turbulent flow is an important parameter in the modeling of numerous natural phenomena and industrial applications. The question of how the presence and structure of turbulence affect the particle settling process remains, however, unanswered. This is of critical importance in meteorology, where an accurate knowledge of the fall speed of hydrometeors, from rain drops to snowflakes, is a necessary prerequisite for reliable precipitation forecasting. Previous numerical investigations identified several mechanisms which may alter particle settling rate as compared to the still-fluid terminal velocity, but different studies often show large qualitative discrepancies.

I will present laboratory and field experiments demonstrating how turbulence may lead to multifold increase of fall speed of heavy particles in air. In the laboratory, we use a novel apparatus in which hundreds of randomly actuated jets create a large volume of homogeneous turbulence, and we simultaneously track flow tracers and inertial settling particles via laser imaging. In contrast with previous experiments, the homogeneous region is several times larger than the integral length scale, allowing the particles to sample eddy motions of all scales. In the field, we image and track snow particles falling through the atmospheric surface layer. To this end, we use stage lights and high speed cameras, while monitoring the wind properties via a meteorological tower. We deduce the aerodynamic response time of the hydrometeors from their acceleration statistics, and find that their behavior is consistent with that of inertial particles in homogeneous turbulence. The analysis highlights the dominant temporal and velocity scales of the process, and paves the way towards parameterizations of weather forecasting models.

.

Biography

Filippo Coletti is Assistant Professor of Aerospace Engineering & Mechanics and member of the St. Anthony Falls Laboratory at the University of Minnesota, where he has been since 2014. Previously he was postdoctoral fellow at Stanford University, and performed his doctoral studies at the von Karman Institute (Belgium) and at the University of Stuttgart (Germany) where he obtained his PhD in 2010. In 2015 he received the NSF CAREER Award and the 3M Non-Tenured Faculty Award. His interests revolve around the transport of particles in turbulent and complex flows, leveraging a wide spectrum of experimental approaches and with applications to both biomedical and environmental problems. His research is funded from the National Science Foundation, the National Institute of Health, the Army Research Office, the Office of Naval Research, the State of Minnesota, and industry partners.

CoMFRE

This seminar counts towards the ME 600 requirement.