Weekly CEAFM Seminar: Fall 2016

JOHNS HOPKINS
Center for Environmental & Applied Fluid Mechanics

Date: **Friday, November 11, 2016**

Time: 11:00 AM

Location: Gilman Hall # 50

Speaker: **Prof. Rodney O. Fox** (Iowa State University)

Title: ***"Cluster-Induced Multiphase Turbulence"***

Abstract

Particle-laden flows with inertial particles display a rich array of fluid dynamics depending on the particle Stokes number and mass loading. In this talk, I will present recent work [1] in collaboration with Cornell University on gravity-driven, gas-particle flow with sufficient mass loading to generate cluster-induced turbulence in an otherwise statistically homogeneous system. Such flows are relevant to many technological and environmental applications, and provide a non-trivial canonical flow for validation of multiphase turbulence models. In these flows, due to the mean velocity difference between the gas and particle phases, particles cluster spontaneously on characteristic length scales much larger than one particle diameter (d_p). In turn, the presence of clusters leads to spatially nonuniform momentum coupling with the gas phase and, hence, to gas-phase turbulence that maintains the cluster size distribution. Analysis of the Reynolds-averaged governing equations points to the importance of particle- volume-fraction fluctuations (i.e. clusters) and their correlation with gas-velocity fluctuations in determining the statistical properties of the fully developed flow. In our work, mesoscale Eulerian-Lagrangian simulations are used to investigate the flow physics and to extract turbulence statistics needed for model validation. Following the pioneering work of Simonin and coworkers [2], the Lagrangian particle data are altered to the Eulerian grid to decompose the particle fluctuating velocity into its correlated and uncorrelated components. For cluster-induced turbulence, large periodic domains $> (896d_p)^3$ with over 55 million particles are required to obtain fully developed energy spectra and turbulence statistics. I will describe how we use the mesoscale data to investigate the flow physics and to validate turbulence models for gravity-driven, gas-particle flows [3, 4].

[1] Capecelatro, J., Desjardins, O. & Fox, R. O. 2015 On fluid-particle dynamics in fully developed cluster-induced turbulence. J. Fluid Mech. 780, 578-635.
[2] Février, P., Simonin, O. & Squires, K. D. 2005 Partitioning of particle velocities in gas-solid turbulent flows into a continuous field and a spatially uncorrelated random distribution: theoretical formalism and numerical study. J. Fluid Mech. 533, 1-46.
[3] Capecelatro, J., Desjardins, O. & Fox, R. O. 2016 Strongly coupled fluid- particle flows in vertical channels. I. Reynolds-averaged two-phase turbulence statistics. Phys. Fluids 28, 033306.
[4] Capecelatro, J., Desjardins, O. & Fox, R. O. 2016 Strongly coupled fluid- particle flows in vertical channels. II. Turbulence modeling. Phys. Fluids 28, 033307.