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Instability and Turbulence of Propagating Particulate Flows

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Propagation of particle-laden fluid into an ambient is a common fluid mechanical process that can be observed in many industrial and environmental applications. Sedimentation fronts, volcanic plumes, dust storms, powder snow avalanches, submarine turbidity currents, explosive powder dispersal and supernovae offer fascinating examples of advancing particulate fronts. The propagating interface can undergo Rayleigh-Taylor, Kelvin-Helmholtz and double-diffusive instabilities and result in the formation of lobes and clefts, spikes and bubbles, and particulate fingers. The interplay between suspended particles and turbulence is often complex due to interaction of competing mechanisms. In problems such as turbidity currents, turbulence controls sediment concentration through resuspension and settling of particles at the bed. Also, turbulent entrainment at the propagating front is observed to be influenced by the sediments. Stable stratification due to suspended sediment concentration can damp and even kill turbulence. This complex turbulence-sediment interaction offers possible explanation for massive sediment deposits observed in nature. The talk will also address challenges and recent advancements in the modeling and simulation of such particle-laden turbulent flows.