Geophysical Research Abstracts
Vol. 12, EGU2010-11266, 2010
EGU General Assembly 2010

A multiscale lumped particle modeling framework for the simulation of tubidity currents

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January 18, 2010

Abstract

Turbidity currents are a highly turbulent sand-laden subaquatic flow, often triggered by tsunamis, earthquakes, or underwater avalanches. Flows such as these contribute significantly to the transport of sediments into deep marine areas. Deposits from turbidity currents are common in the deep water stratigraphic record throughout the world, and are known as Turbidites. The accurate simulation of the particle dynamics and the correct modeling of turbulence are two central aspects for understanding turbidity currents. Moreover, turbidity currents constitute a multiphysics phenomena, where the physical scales vary over many orders of magnitude. These flows usually consist of huge number of particles with a great deal of variation in size and shape, where the spherical assumption is more the exception than the rule. Furthermore, the dynamical evolution of the particles, and the buildup of sediments are both highly dependent on shape and size. In this talk, we will discuss the lumped particle model for simulating turbidity currents. The lumped particle model is a minimal multiscale framework for the modeling granular flows. This framework embodies basic features that are intrinsic in particle flow, including advection, diffusion and dispersion of the particles. Moreover, we have included procedures for particle deposition, and interparticle collisions, both of which are highly relevant for dense particle flows. In this model, the particles obey the Bassinet-Boussinesq-Oseen equation for a single spheroid particle. However, instead of tracking the individual dynamics of each particle, a weighted spatial averaging procedure is used where the external forces are applied to a “lump” of particles, from which an average position and velocity is derived. The temporal evolution of the suspended particles is computed by partitioning the lumped particle into smaller entities, which are then transported according to local physical effects. These smaller entities recombine into new particle lumps at their target destinations. For the particles prone to the effects of Brownian motion or similar phenomena, a symmetric spreading of the particles is included. We will present the most recent results on the multiscale simulation of a set of particle constituents. The numerical experiments include; The effects of non-spherical particles on deposition, particle collisions on the hindered settling effect, and brownian diffusion of sedimenting particles. Furthemore, we will outline future work that includes erosion of deposited sediments and the effect of turbulence on the granular flow.