A particle-in-cell modeling framework for simulating riverine and oceanic suspended sediment transport

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Suspended sediments contained in the river water (and glacial melt water) runoff is one of the primary source for the terrigenous trace elements supply to the ocean and hence it plays an important role in the marine material circulation and biogeochemical cycle. The transport, settling and re-suspension processes of sediment particles in the ocean are controlled by the interaction between the dynamics of individual particles depending on its composition and size-distribution and the complex current systems in the coastal regions. In particular, the suspended sediment concentration at the greater discharge events is several orders of magnitude greater than that in the normal time runoff. In such cases the existence of suspended sediments increases the apparent density of turbid runoff water, and thereby dynamically affects the current structure. In numerical ocean models, the suspended materials have been usually represented by the cell-volume averaged concentration in the Eulerian form as well as salinity and other dissolved materials. However, individual particle is settling with its own settling velocity relative to the ocean current primarily determined by its size and composition. Therefore, the bulk representation of Eulerian cell-averaged concentration has limitations to trace wider range of sediment size-distribution. To address this issue, we introduce a new particle-in-cell (PIC) type modeling framework to simulate oceanic dispersed multiphase flow such as the turbid river water discharge, where the dispersed suspended materials are represented by large number of Lagrangian particles. In the present model Lagrangian particles are solved at each time-step simultaneously with the time progress of the ocean current predicted by a finite-volume non-hydrostatic ocean model. The dynamical effects of the suspended particles are included by appending the sum of the contribution of particles existing inside each cell to the right hand side of the Navier-Stokes equation that predict the velocity at corresponding cell. In the presentation we introduce the detail of the implementation and the result of an idealized experiment on the formation of hyperpycnal flow.

Keywords: sedimient transport, Lagrangian particle tracking, non-hydrostatic ocean model, hyperpycnal flow

