3D Turbulence Resolving Simulation on Convective Sedimentation of Fine Sediment in the Coastal Environment

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Turbulent resolving numerical simulations of fine sediment transport are carried out to study convective sedimentation in coastal environment. The sediment size considered in this study is in the range of 2 to 60 μm, where the Stokes number is much less than 1. Equilibrium Eulerian approach is implemented to model the sediment phase. A semi-empirical closure of sediment diffusivity due to long-range interaction is adopted (Segre et al. 2007), in which sediment phase can act either as a slow diffusing or fast diffusing agent in a double-diffusive system depending on the size of the particle. Linear stability analysis is first carried out to investigate the key parameters which control the dynamics of the system. Linear stability analysis provides useful information on the growth rate and the characteristic size of the convective finger. For sediment with Stokes settling velocity greater than about 0.1 mm/s, instability can occur at sediment concentration as low as O(0.1)g/L and the finger size is of centimeter scale. To obtain the effective settling velocity due to the convective instability, 3D numerical simulations are further carried out. Using the result from linear stability analysis as a guideline, 3D simulation results show that the enhancement of settling can be up to 100 times for very fine particles of Stokes settling velocity of O(0.01) mm/s (silt and clay) and the resulting effective settling velocity is of several mm/s. For coarser sediment of Stokes settling velocity of O(0.1) mm/s (coarse silt of small floc), convective instability enhances settling by about 40 times and the resulting effective settling is on the order of cm/s, which is consistent what the rapid settling process observed in the field.

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