Stony Brook University
The Graduate School

Doctoral Defense Announcement

Abstract

Modeling sediment transport in estuarine environment: effects of tidal asymmetry, lateral circulation and sediment-induced stratification

By

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Effects of tidal asymmetry, lateral circulation and sediment-induced stratification on suspended sediment transport are investigated with a numerical modeling study. The two-equation turbulence closures can appropriately present the effect of sediment-induced stratification under sub-saturation condition and predict the reduction of friction velocity in the similar order as the observed from laboratory experiments. In sediment-laden flows, velocity is reduced near bottom and is enhanced near surface while suspended sediment concentration profile shows opposite alteration.

Without non-local transport, the settling lag is an arc tangent function of the ratio between tidal period and sediment settling time that is the time taken for a particle to settle from surface to bottom. It increases with decreasing settling velocity. The direction of local residual sediment flux is controlled by barotropic tidal asymmetry and settling lag. For large settling velocity comparing to tidal frequency, flood dominant tidal current produces sediment infill and ebb dominant tidal current leads to the export of sediment. For very fine sediment, both of flood and ebb dominant tidal currents favor import and export of sediment. The introduction of non-local sediment transport results in more complicated relations.

In partially mixed estuaries, the pattern of lateral circulation varies significantly over a tidal cycle due to the tidal variation of stratification caused by tidal straining. During highly stratified ebb tides, the lateral circulation in an asymmetric transverse section exhibits a two-layer structure which results from a lateral asymmetry of turbulent mixing. The tidally averaged lateral advection acts a driving forcing for lateral distribution of sub-tidal estuarine circulation. It strengthens outflow on the shoal but compensates outflow over the channel. For cross-channel sediment transport, the lateral advection dominates horizontal transport and produces a net transport of sediment from the deep channel to the shoal. Also, the lateral entrapment of sediment occurs at a certain range of grain size. For longitudinal sediment transport, the lateral circulation acts as a mechanism for exporting sediment from the estuary.

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