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Development of a Sediment Transport Model for the Estuarine Turbidity Maximum in the Upper Chesapeake Bay, USA

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This paper presents development of a three-dimensional, intratidal sediment transport model for the estuarine turbidity maximum (ETM) in the upper Chesapeake Bay, USA. The model is based on the mass-balance equations for three size classes of fine, medium, and coarse particles with the respective settling velocities of 0.007, 0.26, and 3.3 mm s-1 (corresponding Stokes diameters of 3, 18, and 65 μm). The fine class consists of particles in almost continual suspension in the water column, thus constituting a natural 'background' concentration. The medium class particles are alternately suspended and deposited by tidal currents, thus responsible for intratidal variation in sediment concentration close to the bottom. The coarse class particles stay at the bed most of the time and suspended only during the times of relatively high energy events. No interaction among size classes and no effect of sediment concentration on the hydrodynamic field are assumed. We have examined the previous studies in Chesapeake Bay for the characteristics of erosion and deposition, one of the most unique features in sediment transport modeling, and have employed a box model to investigate various combinations of the modeling methods for erosion and deposition for three size classes, such as depth-limited (Type I) vs. unlimited (Type II) erosion and continuous deposition vs. exclusive erosion and deposition. The model employs for the medium and coarse classes continuous deposition with depth-limited erosion by varying the critical shear stress for erosion as a function of eroded mass. For the fine class, the model employs exclusive erosion and deposition with a small constant value for the critical shear stresses for erosion and deposition to assure quick erosion of deposited fine particles but without allowing further erosion of consolidated bed sediments. The model was run to simulate the annual condition in 1996 and the results were compared with the data. The three size classes and their representation of erosion and deposition seemed to well represent the behavior of suspended sediments in the upper Bay. The model gave a reasonable reproduction of the observed characteristics of the ETM relative to the salt limit and tidal phase, both in intratidal and intertidal time scales. The model results for 1996 were subsequently analyzed to study the characteristics of the ETM along the main channel of the upper Bay in various time scales.