Comparison of modeled and observed bed erodibility in the York River estuary, Virginia, over varying time scales

In general, the availability of sediment for transport increases with the magnitude of bed shear stress, which varies over various temporal and spatial scales. However, in a muddy setting, consolidation or swelling of the bed also contributes to fluctuations in sediment mobility. One such environment is the York River estuary, a partially-mixed tidal tributary of the Chesapeake Bay, USA. The York River often has a Secondary Turbidity Maximum (STM) mid-estuary at the transition from a shallower, less stratified section upstream to a deeper, more stratified section downstream. Since 2006 various instrument arrays have been deployed as part of the Multidisciplinary Benthic Exchange Dynamics (MUDBED) project to better understand sediment dynamics in partially-mixed estuaries. Estimates using both GUST microcosm experiments and acoustic Doppler velocimeter (ADV) measurements show seasonal variation of bed erodibility near the STM. To further examine feedbacks between sediment trapping and bed erodibility, sediment transport was modeled using the Community Sediment Transport Modeling System (CSTMS) implemented in a three-dimensional domain with the Regional Ocean Modeling System (ROMS). This model accounted for cohesive processes via consolidation and swelling of the sediment bed and represented changes to the critical shear stress of the seafloor with time, and in response to deposition and erosion. In this way, the model tracked changes to the erodibility of the seabed that can be characterized as the amount of sediment mobilized under a given bed shear stress.

The York River three-dimensional model was applied to represent a 200-day time period. In this presentation, we analyzed the model results alongside field observations to investigate how erodibility and hydrodynamic forcing in the York River varied over time scales that ranged from the tidal to the seasonal. Model results showed seasonal variations in bed erodibility with more erodible sediment during times of sediment transport convergence when a salinity front occurs. For the monthly timescale, the overall trend showed higher erodibility during spring compared to neap tides. Past observations from the York River showed that bed stress increased with tidal velocity. The model captured this trend in current velocity and bed stress but slightly overestimated bed stress throughout the tidal cycle. Additionally, observed peak concentrations in suspended sediment slightly lagged peak bed stress. The model correctly predicted the timing and magnitude of the suspended sediment peak; however, it overestimated the suspended sediment concentration over the rest of the tidal cycle.