Geophysical Research Abstracts
Vol. 19, EGU2017-3960-1, 2017
EGU General Assembly 2017

Process-based, forecast modeling of decadal morphological evolution of the Yangtze Estuary

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Understanding the decadal morphodynamic evolution of estuaries and deltas and their controls is of vital importance regarding management for estuarine function and sustainable development. This work addresses this issue by applying a process-based model system (Delft3D) to hindcast and then forecast the morphodynamic evolution of the Yangtze Estuary at a decadal time scale. Forced by the river and tides, the model considers sand-mud mixture and the seasonal variations of river water discharge and sediment discharge. The morphodynamic model is validated against three periods, i.e. an accretion period (1958-1978), an erosion period (1986-1997) and a recent accretion period with human activities (2002-2010). Model results show good performance with respect to spatial erosion and deposition patterns, sediment volume changes, and hypsometry curves. The model reveals quite different behaviors for mud transport between the dry and wet seasons, which is subject to prescription of river boundary conditions and bed composition. We then define four scenarios to project evolution to 2030 under decreased river inputs and increased relative sea-level. The simulations reveal that overwhelming amount of erosion will likely occur in the inner and mouth bar area of the estuary. Particularly, the mouth zone will shift from net deposition before 2010 to net erosion by 2030, mainly because of decreasing sediment supply. Changes in water discharge have minor effects on the projected trend. Net erosion will be considerable when the sediment supply is extremely low (100 Mt yr–1) due to the abundance of erodible modern sediment in the Yangtze Estuary. Erosion within the mouth bar area may be unexpected, including the deepening of the tidal inlet at East Chongming Mudflat and the formation of a flood channel on the seaward side of Jiuduan Shoal. Overall, the model results provide valuable information for sustainable delta management under changing conditions for both the Yangtze system and other similar estuaries and deltas with diminishing sediment supplies.