Mor-Merge Approach with Multi-Discharge for Morphodynamic Modeling of the Yangtze Estuary

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ABSTRACT

In this paper the input reduction for the morphodynamic model of the Yangtze Estuary is investigated. The classic tidal input reduction has been first carried out with results demonstrating a single representative tide insufficient for morphodynamic model of the estuary. The riverine force, discharge, for the morphodynamic model of the Yangtze Estuary has been schematized into a series of discharge levels. The multi-discharges are used to simulate the bed level change in the estuary based on MM (Mor-Merge) technique. The MM results agree well with the QRT (Quasi Real Time) simulation result. Therefore, the MM approach with multi discharges makes the long-term morphological model of the Yangtze Estuary feasible.

KEY WORDS:  Morphodynamic model, sediment transport, discharge, Yangtze Estuary

INTRODUCTION

A fundamental problem in process-based morphological modeling in coastal and estuarine regions is that the morphological evolution of features of practical interest to usually occur at time scales several orders of magnitude larger than the time scale of the hydrodynamics driving sediment transport. De Vriend et al. (1993) discuss the potential of the separation of scales and distinguish three approaches to accelerating long-term morphodynamic modeling, i.e. input reduction, model reduction and behavior-oriented modeling.

Approaches of model reduction are outlined by de Vriend et al. (1993), Cayooca (2001) and Roelvink (2006), etc. Roelvink (2006) proposes the RAM (Rapid Assessment of Morphology) method, assuming the overall transport pattern to be invariant to small bed level changes, i.e. the tidally averaged transport is a function of flow and wave patterns which only vary on the morphological time-scale. Recently Lesser (2009) presents the “online” method which computes sediment transport and morphological change simultaneously with the hydrodynamic processes and combines the resulting bed level changes with a morphological acceleration factor (MorFac).

These approaches of model reduction were designed for simulation over time spans much longer than those of individual storms and tidal cycles. Since it is practically impossible to run such long-term simulations with real-time boundary conditions, reduction of model input is required. Such techniques have been outlined by de Vriend et al. (1993) and Latteux (1995). One or more morphologically representative tides are commonly used to represent the tidal forcing, and wave forcing is reduced to representative wave conditions. Ideally, the representative input conditions (tide or wave) should produce the same residual sediment transport and morphological change patterns as the naturally varying forces in the whole study area and during the whole simulation period.

The method proposed by Latteux (1995), Cayooca (2001) and Grunnet et al. (2004) is commonly used to select a “morphological tide”. Based on this approach, Lesser (2009) claims that in case of semi-diurnal tide, a M₂ tide with 7–20% larger amplitude can be considered as the morphological tide. An alternative approach to the tidal input reduction is the “ensemble technique” (Bernades et al., 2006).

The objective for selecting a representative wave (wind) condition is similar to that for selecting a representative tide, viz. a limited set of wave conditions producing the same mean sediment transport pattern as the full wave “climate”. Steijn (1992) propose a method to determine the wave height classes and representative wave direction, based on transport computations in a limited number of representative points within the model domain. Dastgheib (2012) uses three methods, potential sediment transport, wave energy flux and optimal wave condition, to select the representative wave condition for the Wadden Sea morphodynamic model.

Besides tide and wave, river discharge is also an important forcing factor of sediment transport and morphological change in an estuarine environment. There is little literature on the application of morphological models to estuaries with a significant river input, nor on input reduction of river forcing (discharge and sediment load). Van Vuren (2005) creates the discharge time series statistically based on the 100 years of daily discharge measurement in the Niederrhein. Hu et al. (2009) use the 5-year mean value of the monthly mean discharge to compose a discharge time series for one representative year. A morphological factor of 5 is used to accelerate the morphological