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Tidal responses in the semi-enclosed Bohai Sea to the delta intrusion of a high sediment-laden river

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The Yellow River Delta (YRD) in the Bohai Sea (BS) is one of the most rapidly expanding deltas worldwide, owing to a giant sediment load of 1.2 Bt/a in pre-damming years that emptied into a weak tidal semi-enclosed shallow sea, with 70% of the sediment deposited within the estuarine area. Since 1855, the delta has experienced a land accretion of 20 km²/a, and the channel extends seaward at a rate of 2~3 km/a. These morphological changes have raised the base level of the river, approaching 1 m for every 10 km of the channel elongation. It constitutes one of the two key factors for the peached lower Yellow River. Nevertheless, it is not clear about the impact on the tidal regime under the delta expansion in the BS. Consequently, the long-term sedimentation evolution of the YRD under various tidal dynamics is still not well understood. In this study, tidal responses to the delta evolution were investigated using a hydrodynamic model based on Delft 3D, covering the entire BS and parts of the adjacent Yellow Sea. The historical conditions were simulated with topographic survey data (circa 1855, 1962, 1981, 2003, and 2015), and the future scenarios over the next 200 years were predicted with sediment load data. The results indicate that the main tidal amplitude (M_2 tide) has changed by -1.1~3.8 mm/a, which is larger than the mean sea-level rising rate of 2 mm/a, and the flow velocity has changed by -0.42~0.55 m/s. As the YRD protruded seaward, the flow velocity along the delta increased while the increasing rate decelerated over time, historically maintaining maximum flow velocities below 0.86~0.9 m/s. In future scenarios, it gradually increased to a peak of 1.2 m/s, followed by a 10% decrease. The estuarine sediment transport capacity, which is proportional to the cube of the flow velocity, would remain limited or even diminished by around 30%, exacerbating the sedimentation in the delta estuary. With accelerated sea-level rise and limited lifespan of sand control projects, it could be more challenging to sustain the safe development of the river and delta.