

The Calculation of Check Water Levels in the Jiaozhou Bay and Adjacent Sea

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ABSTRACT

The annual extreme elevations in the Jiaozhou Bay and adjacent sea during 1989-2005 are simulated with a high-resolution three-dimensional hydrodynamic storm surge model considering the atmospheric pressure and wind. The simulated annual extreme elevations agree well with the observed data at two tide gauges within the domain of interest in the selected typhoon events, with the root mean square errors less than 12cm. Sensitivity experiments show that the atmospheric factors, such as the variation of sea surface pressure and the radius of the maximum wind, play a remarkable role on the simulation and prediction of storm surges. Both the astronomical tides and storm surges affect the annual extreme elevations in 14 cases of the 17 ones selected. The check water level of 50-year return period varies from 2.0 to 3.5m and its isolines are nearly parallel to the isobaths. The value larger than 3.2 m mainly appears in the northeast of the Jiaozhou Bay.

KEY WORDS: the Jiaozhou Bay and adjacent seas; check water level; annual extreme elevation; storm surge; numerical simulation; nesting technique.

INTRODUCTION

The knowledge and prediction of long term sea level variation, and the associated determination of check water level are important for both the scientific research and practical activities. The sea surface elevation, especially the extreme elevation during a storm surge, is critical for coastal engineering strategies. A storm surge accompanied by severe waves and high sea surface elevation can damage the coastal area heavily, and leads to distinct changes of the marine environment. As a semi-closed area located at the northwest of the Yellow Sea (Fig. 1b), the Jiaozhou Bay is vulnerable to storm surges, as surrounded by an important economic district, the research of the storm surge is of great significance (Zhang, 2004).

The real time sea surface elevation is a combined result of the oscillations in different temporal and spatial scales. Some researches

have been done on the interaction of the long-term sea level variations and instantaneous sea surface elevation in the East China Sea (ECS for short, hereafter). Cui and Shi (2001) suggested that the intensification of storm surge is another factor that enhances sea level rise in the last decade of the 20th century in addition to the effects of global warming and crust motion at some stations. Du et al. (2005a) found that the engineering water level responses remarkably to the long-term sea level variation from both the numerical simulation and statistical analysis. The amplitude of the astronomical tide of M₂ could increase by about 5cm, given a 100cm increment of mean sea level. Zuo et al. (2001) pointed out that the variation of the design water level and check water level caused by the long-term sea level change can be larger than 80cm. Chen and Xu (1995) concluded that the crust descending and sea level rise could cause an ascending of the maximum high water and an increase in the occurrence of strong tides by a statistical analysis of 40-year observation data.

Several numerical models were used in the recent 30-year studies on storm surges to exhibit the sea surface elevation during a storm event in the ECS. The annual maximum elevation occurs mostly in storm surge accompanied by severe waves and astronomical high tides (Guo et al., 1998). Yu and Yu (2003) studied the coupling of astronomical tides and storm surge in the Bohai Sea and proposed an empirical formula for calculating the extreme water level of multi-year return periods in 5 typical areas. The sea surface elevation during a storm event is strongly influenced by bathymetry and wind on a wide continental shelf (E Álvarez Fanjul et al., 2001); and the remarkable variation of atmospheric pressure is another significant contributor (Duan et al., 2005).

Annual extreme elevations of last 17 years in the Jiaozhou Bay and adjacent sea (JBAS) are investigated in this paper. A high-resolution three-dimensional hydrodynamic storm surge model is used to simulate the motion of the sea water around the extreme elevation periods during 1989-2005. For the sake of scientific engineering strategies in this domain, the check water level of 50-year return period at 5 stations and the spatial distribution in JBAS are illustrated.

ANALYSIS METHOD AND DATA

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