Storm Surge and Associated Impact Factors in Tianjin

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ABSTRACT

Using 55-year (1965-2019) tidal data observed at Tanggu Marine Environmental Monitoring Station, this study examined characteristics of storm surges in Tianjin and potential impact factors. It was found that high tide water level associated with storm surges has strong seasonal and interannual variability. High tide water levels with 50-year and 100-year recurrence intervals are 578cm and 595cm, respectively. Water level increase induced by storm surges are substantially affected by typhoon path, sea level pressure pattern associated with extratropical cyclone, wind direction, ocean waves, ground subsidence, sea level rise and land reclamation.

KEY WORDS: storm surge; recurrence interval; typhoon path; extratropical cyclone; waves.

INTRODUCTION

Storm surges accompanied with high water level increase are disastrous hazard along the coastal region. Located near the sea shore of Bohai Bay in the Northeastern China, Tianjin is where storm surges most frequently occur and severely influenced by storm surge due to geography effect. Moreover, the occurrence of storm surge along the coastal region of Tianjin continued to rise during recent years, bring destructive impacts over broader regions like the newly developed Binhai district. In April 2009, one of the most intense storm surge associated with extratropical cyclone occurred in Tianjin, causing direct economic loss as high as 249 million RMB (Ma et al., 2016). The occurrence of storm surge has strong seasonality with the highest occurrence falling in typhoon/hurricane season in summer and the transition period of spring and autumn. According to historical statistics, Zeng et al. (2012) discovered that the maximum water level increase induced by storm surge mostly occurs in summer and autumn, while the moderate water level increase (>100cm/50cm) appears in spring, autumn and winter. Typhoon, extratropical cyclone, cold front and the sudden change of atmospheric pressure are primarily responsible for the abrupt water level increase during storm surge (Wu et al., 2002; Zhang et al., 2005). Studies showed that the storm surge induced water level increase in Tianjin in October, 2012 is associated with a northward propagated typhoon. Strong winds associated with typhoon in the middle and northern part of the Yellow Sea transported large body of water northward into Bohai Sea. Water is then pushed westward by eastly wind in Bohai Sea and accumulated along coastal regions (Wang et al., 2013). Cold air outbreak accompanied by low pressure system is the typical weather system that can result in intense storm surge and water level increase in Bohai Bay. Cold front is another weather system that is favorable for storm surge occurrence (Liu et al., 2012; Wang et al., 2020; Wu et al., 2002). Li et al. (2014) analyzed the causes of the storm surge of Tianjin coastal based on the astronomical tide, meteorological factors, sea level rise, land subsidence and geographical factors. Liu et al. (2020) simulated that the potential energy density of extratropical storm surge had a relatively increasing trend because the storm surge elevation increased after the land reclamation. Using observational tidal data from 1965 to 2019 at Tanggu Marine Environmental Monitoring Station (TGS), this paper analyzed high tidal water level and storm surge induced high tide water level in Tianjin in the past 55 years, calculated the recurrence interval of extreme high tide water level. Two storm surge cases associated with typhoon and extratropical cyclone respectively are selected to study environmental factors that contribute to the water level increase during storm surges.

DATA AND METHODS

The primary data analyzed in this study is tide level data (1965-2019) observed and collected at Tanggu Marine Environmental Monitoring Station (TGS, Fig.1). Bias exists between the real and recorded tide water level due to multiple adjustments of hydrographic zero before 1978 as well as ground subsidence. To solve this, tide level in this study is uniformly calibrated and all referenced to 1m below hydrologic zero of Dagu. Quality control of the tidal data further verified the accuracy, completeness and continuity of this observed data.

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