

TRENDS IN STORM SURGE EXTREMES ALONG THE SOUTHEASTERN COAST OF CHINA

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INTRODUCTION

Increasing trend in extreme sea levels, caused by the combined effects of mean sea level, storm surges and high tides, can have devastating impacts on coastal communities. Previous studies agree that sea-level rise has been a considerable driver of trends in extremes sea levels since at least 1960 (Rohmer and Le Cozannet, 2019), however, long-term changes in storm surges, which are associated with changes in the intensity, occurrence, and paths of storms and low-pressure systems, are more unclear (Dangendorf et al., 2014). In the most recent study by Calafat et al. (2022), it was found that trends in surge extremes can make comparable contributions to the overall change in extreme sea levels in Europe, which is crucial for coastal adaptation in a changing climate. Along the coast of China, trends in extreme surges remain unclear owing to the sparsity of measurement data. In this study, hydrodynamic modelling was setup to reconstruct the storm surges along the southeastern coast of China from the year 1979 to 2019. Trend analysis was then carried out at both tide gauges and along the continuous coast. Possible cause of the spatiotemporal change in storm surge extremes was also analyzed.

METHODOLOGY

In this study, the two-dimensional depth-averaged mode of the ADVanced CIRCulation model (ADCIRC-2DDI) (Luettich et al., 1992; Westerink et al., 1994) was applied. The unstructured mesh covering the whole coast of China (Figure 1) was generated to simplify the boundary conditions and resolve complicated bathymetric and geometric features with various spatial scales along the coast. Wind at 10 m above the sea surface and atmospheric pressure at the sea surface extracted from the ERA5 reanalysis dataset were used to drive the model. At the offshore boundary, the harmonic constants of the eight major astronomical tide constituents (M2, S2, N2, K2, K1, P1, O1, Q1) were specified using the output of TPXO global ocean tide model (Egbert et al., 1994).

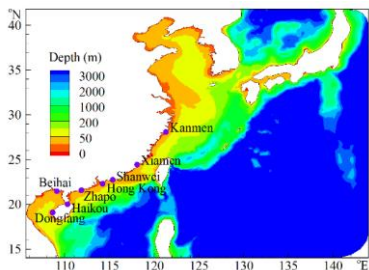


Figure 1 - Model domain, bathymetry and location of tide gauges (purple circles) along the southeastern coast of China

RESULTS

The modelling results were first validated by extreme surges during 65 tropical cyclones at 8 tide gauges along the southeastern coast of China, which shows that there is good agreement between modelled and measured extreme surges (Figure 2).

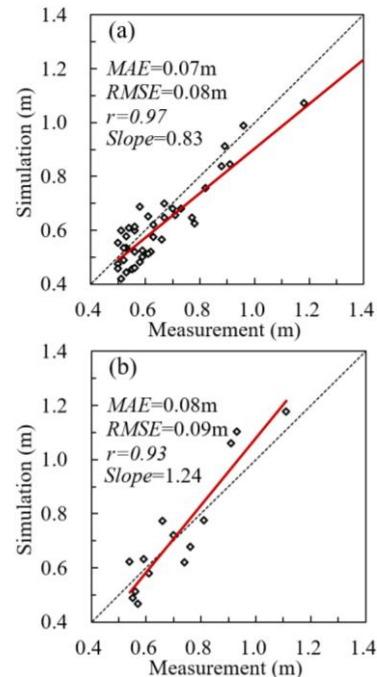


Figure 2 - Comparison of maximum storm surge levels during tropical cyclones at (a) Zhapo and (b) Beihai

Trend analysis was then carried out at both tide gauges and along the continuous coast. The trends of extreme surges observed at tidal gauges were well reproduced by the modelled data, with increasing trend at 3 tidal gauges in the east and decreasing trend at two tidal gauges in the south (Figure 3).

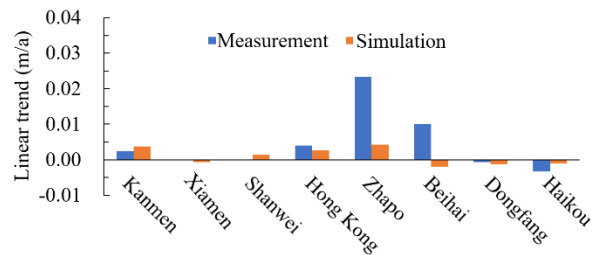


Figure 3 - Linear trends of annual extreme storm surges at tide gauges

Trend analysis based on modelled data along the continuous coast also revealed increasing trend of extreme surges in the east and decreasing trend in the south along the southeastern coast of China (Figure 4).

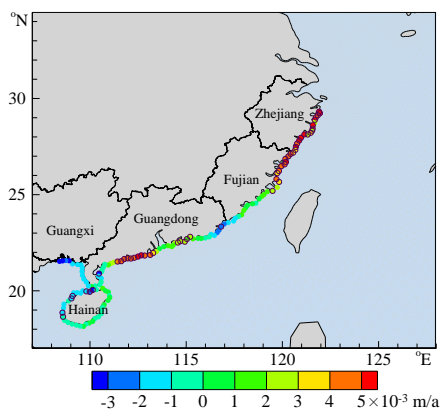


Figure 4 - Linear trends of annual extreme storm surges along the southeastern coast of China. The black circle denotes trends passing 70% significance level test

By analyzing the temporal and spatial distribution of tropical cyclones affecting China, it can be seen that the tropical cyclone activity was enhanced and reduced along the east and south coast of China, respectively, after the year 2000 (Figure 5). It indicates that the trends in storm surge extremes along the southeastern coast of China may be mainly caused by the northward migration of tropical cyclones affecting China.

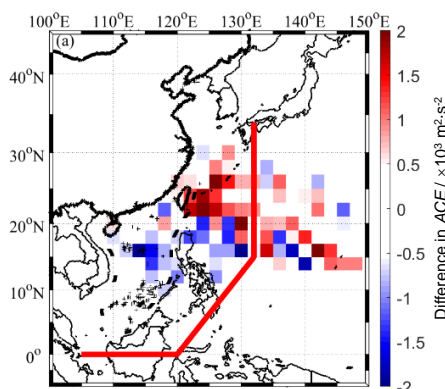


Figure 5 - Difference in the ACE (Accumulated Cyclone Energy) of tropical cyclones affecting China between the period 2000~2019 and the period 1979~1999

CONCLUSIONS AND DISCUSSIONS

In this study, hydrodynamic modelling was setup to reconstruct the storm surges along the southeastern coast of China from the year 1979 to 2019. The modelling result was thoroughly validated by extreme surges during tropical cyclones at tide gauges. Trend analysis was carried out at both tide gauges and along the continuous coast, which revealed increasing trend of extreme surges in the east and decreasing trend in the south along the southeastern coast of China. The main cause of the inhomogeneous trends in extreme storm surges may be the northward migration of tropical cyclones affecting China. More results will be presented and discussed in the full paper.

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