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Storm surge prediction: present status and future challenges

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Abstract

In the current review, the most pessimistic events of the globe in history are addressed when we present severe impacts caused by storm surges. During previous decades, great progresses in storm surge modeling have been made. As a result, people have developed a number of numerical software such as SPLASH, SLOSH etc. and implemented routine operational forecast by virtue of powerful supercomputers with the help of meteorological satellites and sensors as verification tools. However, storm surge as a killer from the sea is still threatening human being and exerting enormous impacts on human society due to economic growth, population increase and fast urbanization. To mitigate the effects of storm surge hazards, integrated research on disaster risk (IRDR) as an ICSU program is put on agenda. The most challenging issues concerned such as abrupt variation in TC's track and intensity, comprehensive study on the consequences of storm surge and the effects of climate change on risk estimation are emphasized. In addition, it is of paramount importance for coastal developing countries to set up forecast and warning system and reduce vulnerability of affected areas.

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Keywords: Storm surge, Tropical cyclone; Extratropical cyclone; SPLASH, SLOSH; Risk analysis; IRDR

1. Introduction

Storm surge, an extraordinary sea surface elevation induced by atmospheric disturbance (wind and atmospheric pressure), is regarded as a most catastrophic natural disaster. According to long term statistical analysis, total death toll amounted to 1.5 million and property losses exceeded hundred billions USD globally since 1875[1]. They could

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be caused by extratropical cyclone (front or cold air outbreak) in winter and spring and tropical cyclone in summer and autumn. Generally speaking, the latter tends to be more severe and changeable.

In the globe, Northwest Pacific (NWP), Caribbean region/Mexico Bay/NW Atlantic, North Sea, Indian Ocean/NW Australia coast and Adriatic Sea are all storm surge prone areas. For a storm surge in Yishi Bay, Japan on Sep. 26 of 1959, the wind-induced water elevation of Nagoya coast was as high as 3.45 m with death toll more than five thousand. The most serious hazard occurred in Bangladesh on Nov. 13 of 1970. Low-lying land around Heng River delta was drowned and more than 300 thousand people lost lives.

With long coastline and frequent invasion of tropical cyclone (TC), China is heavily subjected to storm surge hazards in history. Total 576 years of grave storm surges from 18 B.C. to 1946 were recorded. Yet, there were some historical records as below:

- Lai Zhou Gulf in 1782: *On Aug. 5 in the fall, wind and storm rose all of a sudden. The areas even hundreds km far from the sea were indulged, a great many people and cattle were drowned.*
- Da Gu in 1895: *On Apr. 28, storm almost ruined all the buildings, the area became a vast expanse of water, more than 2000 people died.*
- Shan Tou in 1922: *At three o'clock on Aug. 2, wind grew stronger and stronger so that mountain was shocked, trees uprooted and buildings collapsed. Water was as deep as 3 meters due to heavy rain and tide, many villages disappeared in the flood. Number of dead inhabitants reached ten thousand.*

Even up to 1950s-1960s in the last century, still there were a number of serious events causing heavy casualties due to storm surge such as in Xiangshan on Aug. 2 of 1956, Nandu on Jul. 15 of 1965 and Shantou on Jul. 18 of 1969[2]. China's forecast of storm surge started in 1970s. Since then the death toll was considerably reduced to hundreds, even tens in the last decades (see Fig.1). However, the economic losses were still shocking due to industrial development and urbanization. And a few individual years claiming abnormally massive lives such as 1994 and 2006 still existed (see Fig.1).

Hence, storm surges are ranked among the most threatening calamities, the impacts can be comparable to earthquake and tsunami. Thus the theoretical prediction and operational forecast have always been put at priority of disaster mitigation.

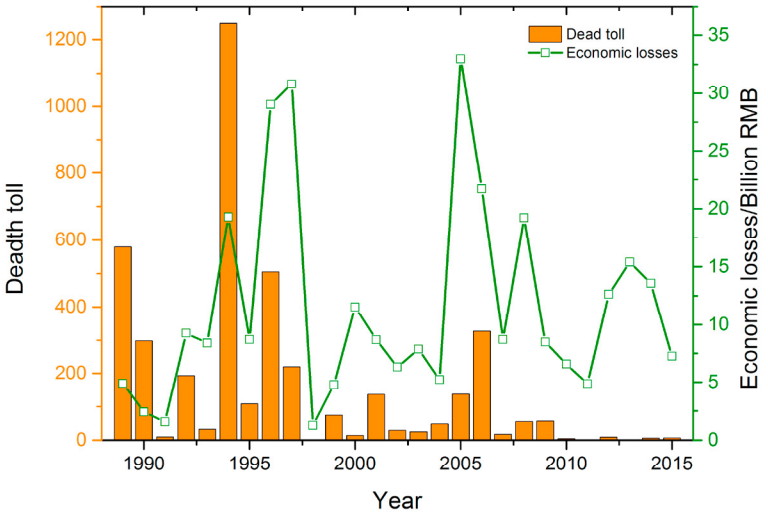

Fig. 1. Economic losses and death toll in China due to storm surge disasters since 1989.