INFLUENCE OF TIDAL LEVEL ON TSUNAMI HAZARD ASSESSMENT ALONG THE COAST OF PEARL RIVER ESTUARY

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BACKGRAND AND AIMS

Nearshore tsunami hazard can be greatly affected by the tidal level. When large tsunami waves occur at the moment of high tidal level, people would face greater risks. It is necessary to quantify the probability of the peak nearshore tsunami elevation (PNTE) considering the randomness of event occurrence time and the variation of tidal level.

The objective of our study is to quantify the probability of the peak nearshore tsunami elevation (PNTE) around Pearl River Estuary posed by the earthquakes along Manila Trench. The location of the study area is shown in Figure 1. An approach for probabilistic tsunami hazard assessment has been introduced. The procedure to obtain the probability of PNTE is divided into three steps: 1) To compute the joint probability density of tsunami period and height at offshore sites, based on the numerical simulation of millions of potential earthquake scenarios; 2) To calculate the coastal amplification factor at each nearshore point, considering the effect of wave period, height and tidal level. 3) To estimate the exceedance probability of PNTE at each nearshore point based on the offshore boundary condition and the amplification factor. Tsunami waves caused by 1,380,000 potential earthquake scenarios along Manila Trench have been effectively simulated using the previously proposed superposition method (Zhang and Niu, 2020).

This study introduces methods for quantifying tidal uncertainty into the framework of the probabilistic tsunami hazard assessment proposed by the previous studies, and aims to clarify the effect of tidal uncertainty and improve the probabilistic tsunami hazard assessment along the coast of Pearl River Estuary

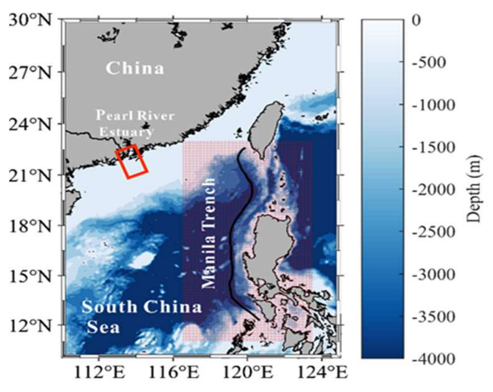


Figure 1 – The location of the study area.

UNCERTAINTY OF TSUNAMI OCCURRENCE TIME

Statistical analysis shows that earthquakes can occur at any time of day, thus peak tsunami elevation may appear at any tidal level. The proportion of earthquake occurrence time corresponding to each time interval is obtained as shown in Figure 2, which is very close to the uniform probability distribution. The tide in Pearl River Estuary is mainly a semi-diurnal mixed tidal regime with prominent diurnal inequality. The probability density distribution of tidal level at Hong Kong station has been statistically analyzed, which is similar to a Gaussian distribution but with a sharper peak.

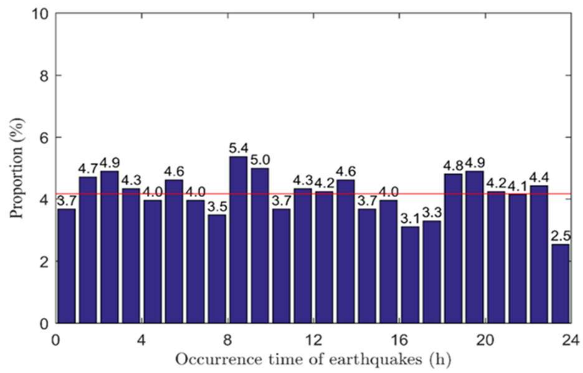


Figure 2 – The proportion of earthquake occurrence time in the subduction zone of Manila Trench. The red line is the uniform distribution.

METHODS TO INVOLVE TIDAL LEVEL

The basic assumption is that tides and tsunamis are independent. The effects of tides can be divided into direct change of water level and influence on tsunami propagation. Two methods are proposed to calculate the PNTE considering the effect of tide in a probabilistic tsunami assessment framework (Gao and Niu, 2022). One is a linear superposition of tsunami wave upon the tidal level (shorten as LS method), and the other considering the influence of tidal level on tsunami nearshore amplification (shorten as TF method). The LS method considers the PNTE is a summation of tidal level and the tsunami peak amplitude calculated based on the mean sea level. The TF method considers the influence of water level on tsunami nearshore amplification by calculating the amplification factors with different tidal levels.

COMPARISON OF DIFFERENT APPROACHES

If the influence of tides is ignored in nearshore tsunami hazard assessment, generally the assessment is conduct based on a reference sea level such as the mean sea level. Taking the tsunami hazard assessment without tidal influence as a reference, the spatial distribution of the PNTE along the coast of Pearl River Estuary is shown in Figure 3. In most areas, the PNTE is less than 0.5 m under the once-in-100-years condition.

Some points located at the southern coast of Zhuhai, the eastern coast of Hong Kong and the front of the offshore islands have PNTE more than 0.5m.

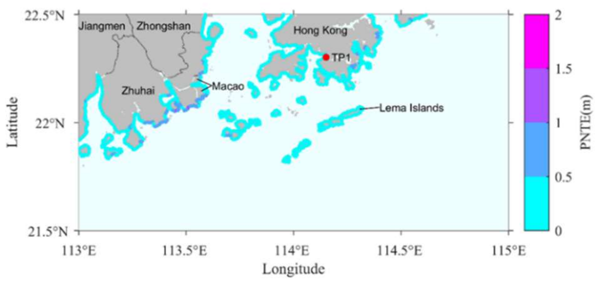


Figure 3 – Map of PNTE with return period of 100 years based on the mean sea level without considering the tidal variation.

Figure 4 show the PNTE at TP1 near Hong Kong using different approaches. The PNTE with tidal influence is higher than that without tidal influence, where a larger difference occurs when the return period is less than 200 years. It means that ignoring the uncertainty of tidal level may underestimate the nearshore tsunami hazard. The difference gradually decreases with the increase of return period. No obvious difference is shown in the case of long return period. Moreover, in the study area, the LS method and TF method show only slight difference in estimating the probability of PNTE, as shown in Figure 4.

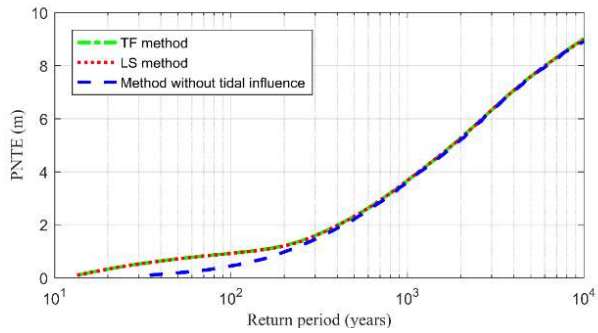
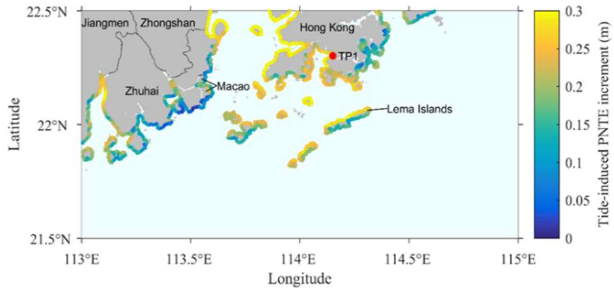
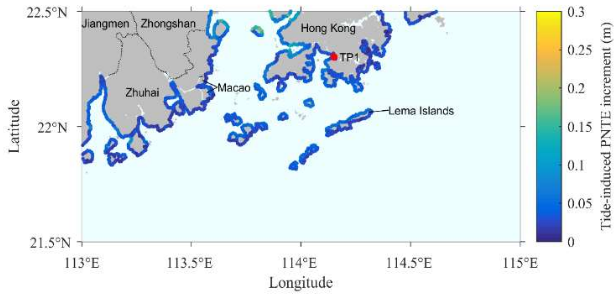


Figure 4 – Comparison of the hazard curve at TP1.

Figure 5 shows the increment of PNTE with return period of 100 years and 1000 years along the coast. When the return period is 100 years, the increment in some regions can be greater than 0.3 m, while the increment can be almost ignored when the return period is 1000 years. For different regions, a clear spatial variation can be also seen in the increment. It can be found that greater tidal influence appears in the bays. This may be due to the shallow water depth in the bays, and more waves can reach inside the bays with less dissipation in higher tidal level.



(a) return period of 100 years



(b) return period of 1000 years

Figure 5 – The spatial distribution of tide-induced PNTE increment with return period of 100 years and 1000 years.

CONCLUSIONS

The results confirmed the influence of tide on the hazard assessment results. Generally, the PNTE is larger with the consideration of tide than the assessment result without tide based on the mean sea level. The tide induced PNTE increment is significant for short return period and decreases with the increase of the return period. For the Pearl River Estuary area, the once-in-1000-years PNTE is barely not affected by the consideration of tide.

REFERENCES

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