Applications to Storm Surge Predictions in Denglongshan, Guangdong, China

Sudong Xu¹, Kai Yin¹, Yimei Chen¹, Xiuhua Chen², Guiping Zhang¹, Wenrui Huang³,⁴
¹ Department of Port, Waterway and Coastal Engineering School of Transportation, Southeast University, Nanjing, China
² Pearl River Hydraulic Research Institute, PRWRI
³ Department of Civil and Environmental Engineering, Florida State University, Tallahassee, USA
⁴ Department of Hydraulic Engineering, Tongji University, China.

ABSTRACT

Located in the South China Sea, Guangdong Province is suffering severe storm surge disasters almost every year. Effective prediction of storm surges can protect life and property safety of residents who living along the coast. In this study, the three-layer feed-forward backpropagation neural network was applied on predicting storm surge during typhoon in Denglongshan. This paper selected Typhoon Hagupit and Koppu for model training and verification respectively. The comparisons between model predictions and observed storm surge series indicate that model predictions of storm surge hydrograph reasonably follow the general trend of the observations. The ANN model could be used to predict the storm surge during typhoons and serve for the flood warning and protection system.

KEY WORDS: ANN model; Storm Surge Prediction; Fujita-Takahashi formula ; Harmonic Analysis.

INTRODUCTION

Guangdong Province involves the Pearl River Delta and the lower Pearl River basin, being the highly developed region in terms of socio-economy in China. Guangdong Province is characterized by low-lying terrain and is sensitive to floods, droughts and also typhoon-induced flash floods. Highly developed economy and dense population make the infrastructure of South China sensitive to natural disasters. In recent half century, the flood-induced economic loss accounted for 52.3% of the total economic loss. The Guangdong coastal area and PDR region have been hit by storm surges frequently in summer and autumn every year. For example, the typhoon Fanapi in 2010 caused 75 deaths in Guangdong, 144 million people were affected, the direct economic loss of 5.05 billion yuan. Typhoon Hagupit landed in 2008, resulting in six deaths in Guangdong with direct economic losses of up to 60 billion yuan. The areas have dense population and intense economic activities. Taking correct and effective defense measures to minimize the destruction and losses caused by storm surges in important for the sustainable development of economy in those regions (Tang, 2011). Therefore, the storm surge caused by the typhoon to make timely and accurate forecast, will have significant social and economic meanings. The storm surges are mainly forced by the wind speed and low pressure. When the typhoon comes, we can get the path, central pressure and wind from the meteorological department predicted by modern means. If the storm surge hydrographs in a studied station can be predicted by the wind speeds and air pressure using Artificial neural network (ANN) model, the ANN model could be an effective and easier tool for storm surge prediction instead of the time consuming hydrodynamic model calculation.

There have been some successful applications of ANN model in coastal engineering. Tsai and Lee (1999) conducted ANN model in tidal-level forecasting using historic data for the same station, the non-periodic sub-tidal sea levels and the correlation with tidal data at other stations are not addressed in the study. Deo and Naidu (1999) applied ANN on real-time wave forecasting. Huang and Murray (2003) applied the ANN in the coastal water level predictions. The RNN—WL model was developed to enable coastal engineers to predict long term water levels in a coastal inlet. The input of data of ANN model is from a remote NOAA station in the region. ANN model is also considered as an alternative way for widely used hydrodynamic numerical simulation. Chen et al. (2012) applied artificial neural networks and hydrodynamic model to simulate the water stage time-series of the Danshui River estuary in northern Taiwan. The comparisons reveal that the vertical 2D and 3D hydrodynamic models could not capture the observed water stages during an input of high freshwater discharge from upstream boundaries, while the ANN could match the observed water stage. During the testing phase, the ANN approach was slightly inferior to the 2D and 3D models at the Xinhai Bridge, Zhongzheng Bridge, and Rukouyan locations. The study shows that the ANN was able to predict the water stage time-series with reasonable accuracy and ANN model could be used as a valuable tool for estuarine management.

Huang and Xu (2009) employ the inputs of hourly local atmospheric pressure and wind speeds to predict time series of storm surge hydrograph by using ANN model. In that study, the three-layer feed-forward backpropagation neural network was developed for storm surge water level recovery has been tested using two data sets in Panama City Beach. In the study, the ANN model uses the inputs of hourly local atmospheric pressure and wind speeds to predict time series of storm surge hydrograph. Results from model verifications using the data sets of Hurricane Ivan and Hurricane Opal indicate that model predictions of the storm surge hydrograph reasonably follow the general trend of the observations. The peak elevations of the storm...