Real-time Probabilistic Prediction of Storm Water Level at Japanese Ports

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ABSTRACT

This paper proposes the framework of real-time ‘probabilistic’ storm water level prediction and then examines the prediction for the model typhoon which crosses or passes by target ports in Seto Inland Sea, Japan. The prediction includes the storm surge simulation for 109 typhoon tracks and provides the probability of disastrous storm water level for port facility and coastal defense.

KEY WORDS: Typhoon; storm surge; real-time prediction; probability; disaster prevention work.

INTRODUCTION

Every year several typhoons approach the Japanese Islands and a few ones make landfall on. Among recent typhoons Typhoon Bart in 1999 brought a storm surge of approximately 3.5 m in Yatsushiro Bay near the time of a spring high tide. That triggered flooding water level reaching the roof of one-story houses on low-lying land and took twelve lives in those houses. Fig. 1 shows the variation of the storm water level with time at the affected place. It was difficult to be aware of the difference between the actual storm water level and the usual astronomical tide level rise. From such the event, we should recognize the necessity of storm water level prediction for disaster prevention work such as tide gate operation, piling up sand bags, and evacuation orders before the storm water level reaching disastrous one. In Japan disaster prevention work is often selected or is not taken by considering the possible highest storm water level prediction.

Any numerical meteorological model, however, has a certain range of uncertainty in typhoon track prediction. Meteorological organizations, therefore, provide the most probable typhoon location at several lead times such as 12, 24, and 48 hr and also indicate the standard estimation error. The Japan Meteorological Agency (JMA) uses the prediction error circle which the typhoon center enters with a probability of 70%, and assumes five typhoon tracks which trace the center, leftward, rightward, forward, and backward points respectively on the prediction error circle at each lead time. Then the agency conducts the storm surge simulation for these typhoon tracks, estimates the storm water level as the sum of the storm surge and the astronomical tide level, and has the responsibility on the issue of storm surge warning to the public if the storm water level is estimated to reach disastrous one. Other local governments, institutes, and universities in Japan also are studying or operating their storm surge prediction for local flood prevention works and safe port activities (Yamaguchi et al., 1995; Nukada et al., 2003; Nakahira et al., 2003; Kawai et al., 2005; Tsujio et al., 2007). Some of their simulations take one or several typhoon tracks based on the JMA’s prediction error circle.

If a typhoon locates so far from target ports that the radius of the prediction error circle covering the target ports is large, and if the storm water level prediction examines a small number of typhoon tracks, then the prediction drops the worst typhoon track among numerous theoretically-possible typhoon tracks. Persons in charge of disaster prevention work will lose their confidence for the prediction when the actual storm water level exceeds the prediction. On the other hand, the actual storm water level seldom reaches the highest prediction among several typhoon tracks. Some of the persons may understand the usual over-prediction as a ‘fail’ of the prediction. That may make the persons careless. Therefore, probabilistic storm water level prediction, simulating the storm surge for a certain large number of typhoon tracks and providing the probability density distribution of storm water level at target ports at normal and high tide level would be desirable.