SIMULATION OF STORM SURGE FOR 2005 HURRICANE KATRINA

Taisei Corporation Member ○*D.P.C. Laknath*
Taisei Corporation Member *Kazunori Ito*
Taisei Corporation Member *Yukinobu Oda*
Taisei Corporation Member *Takahide Honda*

1. INTRODUCTION

As a result of global warming effect, frequency and severity of extreme weather events such as hurricane, typhoon and cyclone are expected to increase in future. Therefore, fast and easy handling pre-processing tools and modeling systems are essential to reproduce the extreme weather events in disaster response preparation and resource planning stages. In the case of storm surge simulation, accuracy of the computed surge levels is highly depended on the imposed wind and pressure gradient forces. However, grid systems in conventional meteorological models are not capable to capture the strong variation of wind and pressure gradients near the center area (*i.e.* eyewall region) of the cyclone due to the lack of grid resolution. Hence, generally, metrological models are not capable to bring out the hurricane features completely and consequently lead to underestimate the intensity and size of the cyclone. In this study, as an alternative approach, we used Hurricane Tool included in Delft Dashboard (hereafter DDB) developed by Deltares (2013), and Delft-3D modeling system to simulate the storm surge effects resulted in Gulf of Mexico from 2005 Hurricane Katrina (see *Fig 1*). As the main objective of the present study, we assessed the applicability of DDB together with Delft3D modeling system for a storm surge simulation application.

2. METHOD

Spatially varying wind and pressure fields, generated by hurricane were reproduced by using DDB Hurricane Tool. As input of DDB, hurricane track data (maximum sustained wind speed and coordinates of the center of hurricane) was provided. DDB Hurricane Tool generates the surface wind and pressure fields on a moving circular spider web grid for the given track information data, based on the Wind Enhancement Scheme (WES) following Holland (1980). The high grid resolution at the center of spider web grid enables to capture the strong wind and pressure gradient at the center of the low pressure atmospheric system (see *Fig. 2*). Hydrodynamic effects (including wind driven surge and pressure surge) caused by wind, atmospheric pressure changes and tidal forces were simulated by using Delft 3D-FLOW model, in which calculations are based on shallow water assumption. Further, Delft 3D-WAVE model based on the Booij et al. (1999) SWAN model was used to calculate the wind driven waves. Bathymetric and tidal boundary data used in this simulation were obtained from the online data sources connected to the DDB. FLOW and WAVE models were coupled so that to exchange the model results between each model at 1 hour communication interval (see *Fig. 3*). Both FLOW and WAVE models were run in nested grid setup, consisted of 3 levels of grids (L1= 0.05^0 , L2= 0.02^0 and L3= 0.005^0 grid resolutions) (see *Fig. 1*), allowing the use of coarse resolution grids in the overall region and fine resolution grids closer to the area of interest. Simulation was carried out for August 25, 2005 - August 30, 2005 period. Spatially varying atmospheric pressure fields, wind fields and simulated water level variations are shown in *Fig. 4* and *5* respectively. Finally, calculated surge levels were compared with the NOAA observed surge levels at a selected station P1 (see *Fig. 5*).

3. RESULTS AND DISCUSSION

Observed surge levels at station P1 (SW Pass, Mississippi, Louisiana) was compared with the computed surge levels of domains L1, L2 and L3 (see *Fig. 6*). It is clear that peak surge level of about 2 m height, is in agreement with the Delft3D calculated results. This could be resulted due to the enhanced wind and pressure gradient forcing generated by DDB. Further, accuracy of the peak surge level has been increased in finer resolution grids (L2 and L3). Therefore, selection of finer grid for the interested area is an important step to increase the accuracy of simulation results. Further, before the peak surge level, Delft3D calculated surge levels are lower than the actual values. Therefore, this system is more appropriate to accurately simulate the peak surge levels rather than forerunner surges.

4. CONCLUSIONS

Applications of DDB (Hurricane Tool included) together with Delft3D FLOW-WAVE coupled modeling system is an easy and fast approach to hindcast the peak storm surge levels with an acceptable level of accuracy.

Keywords: Hurricane, storm surge, Delft Dashboard, Wind Enhancement Scheme, Delft3D
Contact address: Taisei Corporation, 344-1, Nase-Cho, Totsuka-ku, Yokohama, 245-0051, Japan, Tel: 045-814-7234

REFERENCES

Booij, N., Ris, R., and Holthuijsen, L.: A Third-Generation Wave Model for Coastal Regions, Part I: Model Description and Validation, *Journal of Geophysical Research*, 104 (C4), 1999, pp. 7649-7666.

Deltares Delft Dashboard: https://publicwiki.deltares.nl/display/OET/DelftDashboard.Accessed on 3rd April, 2013.

Holland, Greg J.: An Analytic Model of the Wind and Pressure Profiles in Hurricanes, *Monthly Weather Review*, 108-8, 1980, p. 1212.

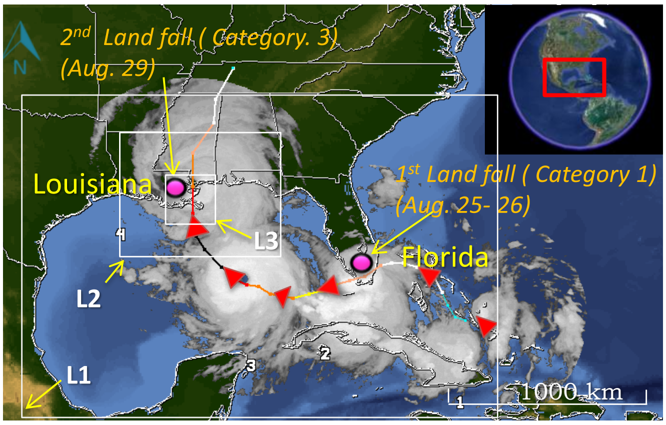

Fig.1. Observed track of the Hurricane Katrina in Gulf of Mexico *(Source: NOAA)*

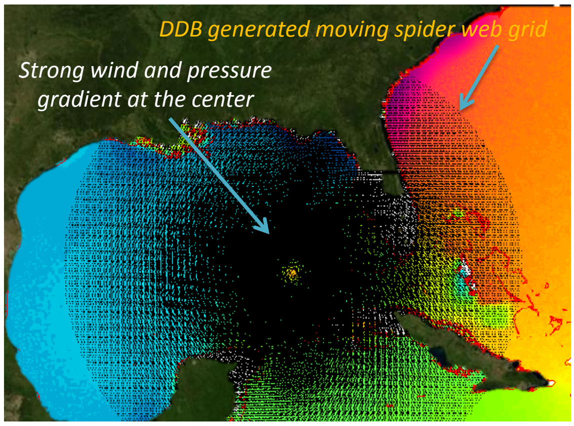

Fig.2. DDB generated wind field

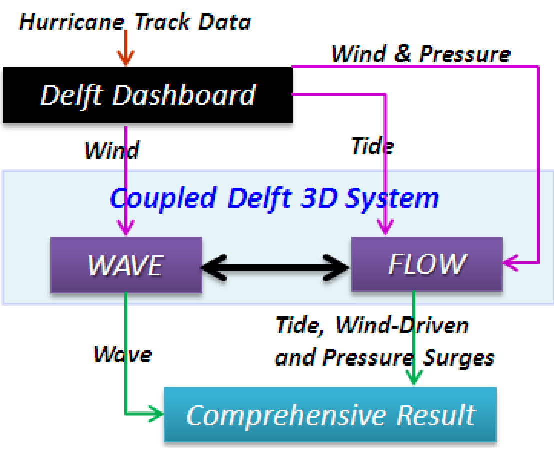

Fig.3. Numerical modeling framework

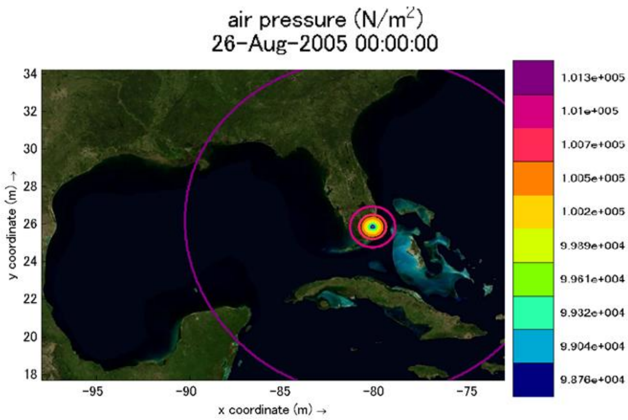

Fig.4. Delft3D Simulated, spatially varying atmospheric pressure (in N/m^2) at the time of 1st landfall of the Hurricane Katrina in Florida.

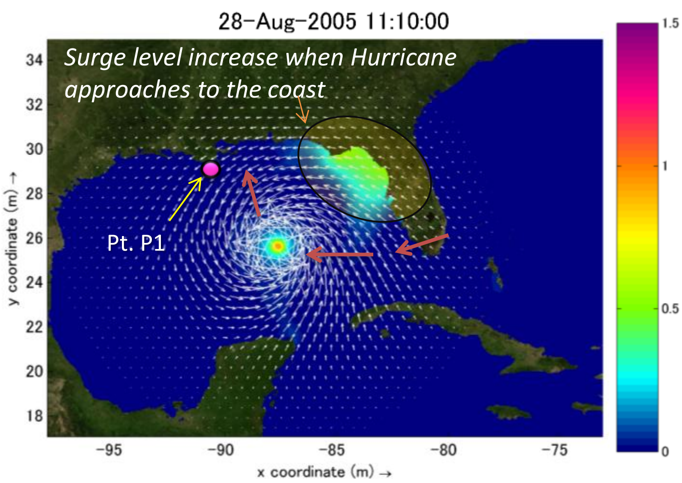

Fig.5. Delft3D Simulated water level variations (in *meters*) before the 2nd landfall of the Hurricane.

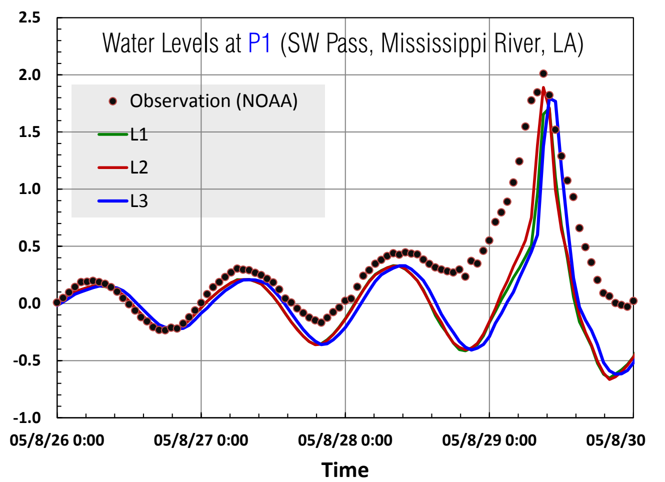

Fig.6. Comparison of calculated (L1, L2 and L3 domains) and observed water levels (in *meters*) at point P1 (28° 55.9' N, 89° 24.4' W)