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# NUMERICAL SIMULATION OF TYPHOON-GENERATED WAVES WITH WAVEWATCHIII MODEL

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**ABSTRACT**

Typhoon-generated waves are simulated with the nested numerical models developed by the third generation wave model WAVEWATCHIII. The model drived by wind field of NCEP analysis date is applied to simulate wave propagation in China seas. The analysis data of significant wave height from the National Oceanic and Atmospheric Administration (USA) is adopted as the verification. It shows that the model is good at simulating the Typhoon waves process, meanwhile the NCEP analysis date was suitable for the waves numerical simulation in China seas.

**KEYWORDS**

WAVEWATCHIII mode, typhoon-generated waves, significant wave height.

## 1. INTRODUCTION

The Wave is one of the most significant phenomena in the ocean, which is not only closely related with Human production and life, but also plays an important role in marine dynamic environment and air–sea interaction field. The numerical simulation methods can obtain wave parameter in spatial and temporal, which not only make up for the shortage of wave observation, but also are used to reveal and analyze the generation, propagation and development of waves. Wave numerical simulation have reached a relatively mature stage by the end of the 20th century. Based on a study, the wave prediction models have been developed to the third generation. WAM, WAVEWATCH and SWAN are the internationally recognized representative of the third generation wave model, which have been successfully applied to different operational wave forecast [1-4]. The nested numerical model are applied to forecast Typhoon wave in Global seas and China seas, which are built by the third generation wave model WAVEWATCHIII and use the NCEP analysis date as driving wind field. The NCEP analysis data amended by satellite altimeter data and Buoy data are adopted to verify the calculation result. Through the distribution of wave field calculation, the nested wave model can reflect the Typhoon wave propagation process in China seas, provided numerical production and technical support for preventing disasters and reducing damages.

## 2. WAVE MODEL

WAVEWATCHIII is a full-spectral third-generation wind-wave model developed at the Marine Modeling and Analysis Branch (MMAB) of the Environmental Modeling Center (EMC) of the National Centers for Environmental Prediction (NCEP), which is based on WAVEWATCHI and WAVEWATCHII as developed at Delft University of Technology, and NASA Goddard Space Flight Center, respectively [5-7]. WAVEWATCHIII adds new physical process and numerical solver on the basis of the WAM model. It has been applied to simulate large-scale wave propagation, considered wave refraction induced by the change of terrain and current in space, and shallow water wave deformation, and the linear wave propagation motion, The model also considers the actions of wind, whitecap, bottom friction, and nonlinear energy transferring by wave- wave interaction in the process of wave growth and decay. It made a lot of improvements on the basis of the past model such as the governing equations, the program structure, the numerical approaches and the physical mechanism, which not only made it more reasonable to consider wave-current interaction and wind-wave physical mechanism, but also made it beneficial to use parallel computation and improve the model performance and efficiency. According to a study, SWAN is a third- generation wave model developed at Delft University of Technology, designed for coastal areas, lakes and estuaries [8,9]. It perfectly considers energy dissipation due to depth-induced wave breaking and triad wave-wave interactions. In theory, the SWAN model is more suitable for shallow waters.

### 2.1 Tropical Storm SANBA

The 16th tropical storm SANBA was generated in the east of the Philippines at 00 UTC on 11 September 2012 (UTC, the following times were UTC). The strom center transferred to the East Sea on the east-southeast Zhoushan in about 600km, with central SLP of 930 hPa and near central maximum wind of 16-level at 06 UTC on 16 September. At 02 UTC 17 September, it weakened into typhoon in offshore area of Southern Korea, and it landed in coastal area of south Gyeongsang Province of Korea at 03 UTC 17 September. The path of SANBA was shown in Figure 1.

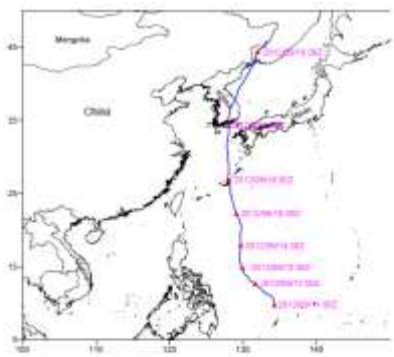

**Figure1:** The path of SANBA.

## 2.2 Model Set-up

Wave model adopted two sets of nested grids built by WAVEWATCHIII model. The coarse-resolution large scale computational domain covered 180W- 180E and 60S-60N, containing 120×288 grids. The grids were 1 degree resolution in latitude and 1.25 degree resolution in longitude. The fine-resolution smaller computational domain covered 100E-150E and 0-50N， containing 200×200 grids. The grids were 0.25 degree resolution in latitude and longitude. In both models latitude-longitude projections were adopted. The coarse-resolution model provided non- stationary 2D wave spectral boundary conditions for the fine-resolution model on the north, east and south boundaries. The models adopted the basic source term, the discrete interaction approximation (DIA) used to calculate nonlinear wave-wave interactions, bottom friction formulation (JONSWAP) and wind linear interpolation. In both models, 24 direction and 25 frequency bins were used, where the lower frequency was set at 0.04177 HZ, and frequency bins were defined by $f_{m+1} = 1.1f_m$. In order to ensure stable and accurate numerical results, the simulation time was chosen from 00 UTC 1 January to 00 UTC 6 January 2012. The global time step $\Delta t_w$ was 900s.

## 2.3 Wind

Wave model used the NCEP Global Reanalysis winds as the input wind field. These winds were 0.5 degree resolution in latitude and 0.5 degree resolution in longitude, and available every 3 hours. In the process of wave model calculating, the winds could be automatically interpolated into the computational grids in space and time.

## 3. WAVE SIMULATIONS

The verification data was based on NOAA Reanalysis data. The test object was the significant wave height. In order to reduce the influence on calculation precision by cold star, the verification time range was from 00 UTC on 15 September to 00 UTC on 18 September 2012. Figures 2 and 3 showed the calculated wave field forced by NCEP Reanalysis wind field and provided by NOAA in the global scale. Figures 4 and 5 showed the calculated wave field forced by NCEP Reanalysis wind field and provided by NOAA in the China Sea.

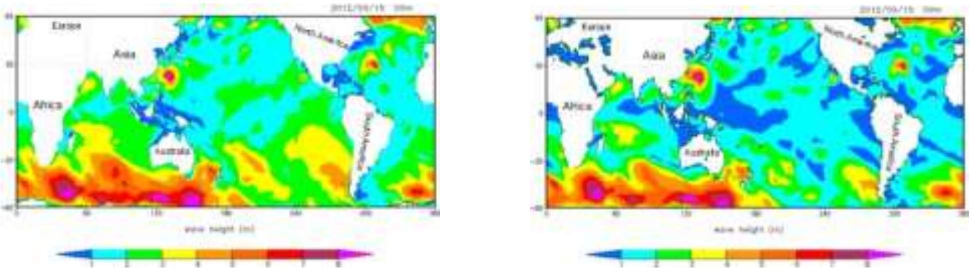


**Figure 2:** Simulated significant wave height in the global scale at 00 UTC on 15 September 2012 (the upper figure provided by WW3 model, the lower figure provided by NOAA data).

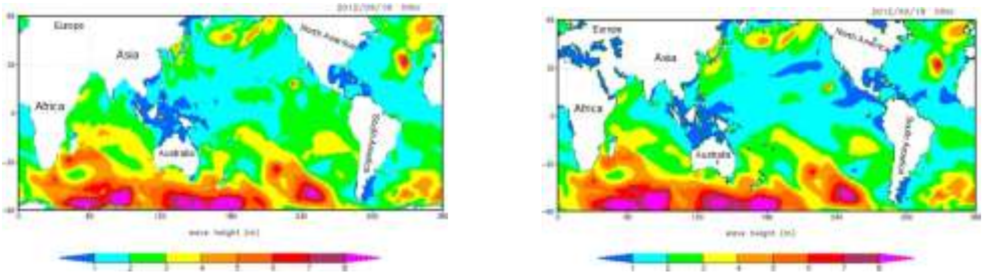


**Figure 3:** Simulated significant wave height in the global scale at 00 UTC on 18 September 2012 (the upper figure provided by WW3 model, the lower figure provided by NOAA data).

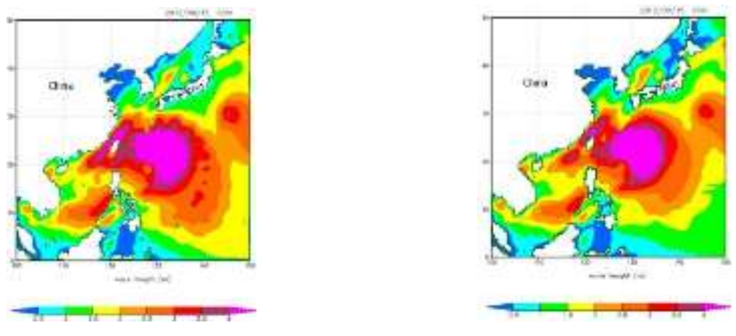


**Figure 4:** Simulated significant wave height in the China Sea at 00 UTC on 15 September 2012(the upper figure provided by WW3 model, the lower figure provided by NOAA data).

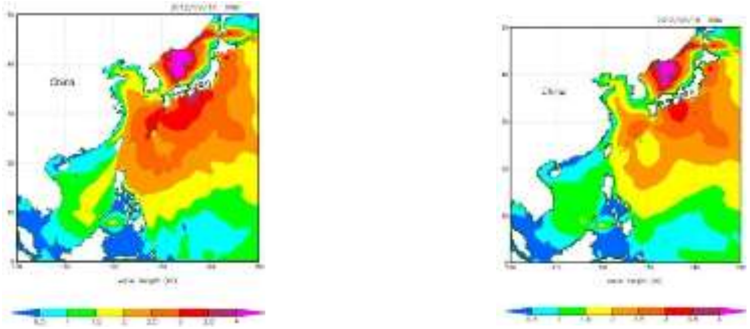


**Figure 5:** Simulated significant wave height in the China Sea at 00 UTC on 18 September 2012(the upper figure provided by WW3 model, the lower figure provided by NOAA data).

It could be seen from Figures 2 and 3 that the distribution of significant wave height calculated by WW3 model was basically consistent with The NOAA Reanalysis data in Global area. The result showed that Global wave model could well simulate the distribution of wave field. Affected by typhoon SANBA, significant wave height in Taiwan Strait and Southeast Taiwan Sea area was above 8 m at 00 UTC on 15 September. Along with the typhoon center moved north, it appeared above 8 m wave height in the East Sea. It moved into the South Korea Sea area, with decreasing intensity at 00 UTC on 17 September. The maximum significant wave height was below 8 m in Korea Sea area. It could be seen from Figure 4. to Figure 5. that the distribution of significant wave height calculated by WW3 model was basically consistent with the NOAA Reanalysis data in China Sea area. The result showed that Global model could provide accurate boundary condition for China model.

## 4. CONCLUSION

The nested numerical model of Typhoon- generated waves ranged from Global area to China Sea area were developed by the third generation wave model WAVEWATCHIII, which used the NCEP Reanalysis date as driving wind field. Comparing the calculational result with NOAA Reanalysis data, It showed that the nested model could well simulate wave field which induced by typhoon SANBA. Additionally the model could provide wave numerical products, serving for the disaster prevention and reduction.

## ACKNOWLEDGMENT

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