
Forecast of Nearshore Wave Parameters Using MIKE-21 Spectral Wave Model

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ABSTRACT

Shallow-water wave transformation strongly depends upon coastal geomorphology and bottom sediment characteristics. Accurate prediction of wave parameters is vital for the coastal infrastructure developments and other activities. MIKE 21 SW is a new generation spectral wind wave model based on unstructured meshes. The model simulates the growth, decay and transformation of wind generated waves and swell in off-shore and coastal areas. The entire Gulf of Mexico was selected for the present modeling study. Along the northern Gulf Coast the grid resolution used was ~2 km while for the rest of the boundary a coarser grid of 30 km was used. Fine-scale bathymetry data (6 arc-second resolution) were used for the northern Gulf and coarse bathymetry for the rest of the basin. The data used were compiled and distributed by the National Geophysical Data Center (NGDC) of the National Oceanic and Atmospheric Administration (NOAA). The input for the model, forecast wind data, was downloaded from the National Centers for Environmental Prediction (NCEP) of NOAA database daily (36-hr forecast). A fully spectral approach was used for the computation of the wave parameters.

The model computed the wave parameters using the forecast wind input. Synoptic maps of significant wave height (Hs), wave period, wave direction, *etc.* were generated. For calibration purposes, output was also generated for the NDBC buoy locations and Wave-Current-Surge Information System (WAVCIS) stations located off the Louisiana coast. During fair weather conditions the predicted wave parameters show a strong correlation with measured wave parameters. During extreme weather conditions (hurricanes and tropical storms) predicted values typically were lower than observations. This discrepancy can be attributed to the scale and accuracy of the input wind data.

INTRODUCTION

Wave-prediction and hindcast studies are important in ocean engineering, coastal infrastructure development and management. Knowledge of parameters describing the wave field, currents and water level is essential to almost all marine related activities (Kumar and Stone, *in press*). Wind-generated ocean surface waves are identified as the major driving force for nearshore circulation and sediment transport in the surf zone and inner continental shelf (Wright *et al.*, 1991). As the waves approach shallow water, wave energy spectra evolve due to re-

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fraction and energy dissipation, a partial function of wave breaking and bottom friction (Thornton and Guza, 1983; Sheremet and Stone 2003). A wave simulation study using a numerical model has been implemented for the Gulf of Mexico with an enhanced resolution along the northern Gulf Coast.

NUMERICAL MODEL

MIKE 21 SW is a third-generation spectral wind wave model based on unstructured meshes. The model was developed by the Danish Hydraulic Institute (DHI) and the model simulates the growth, decay and transformation of wind generated waves and swells in offshore and coastal areas. The discretization in geographical and spectral space is performed using a cell-centered finite volume method. In the geographical domain, an unstructured mesh is used. The integration in time is based on a fractional step approach (Sorensen *et al.*, 2004).

The entire Gulf of Mexico was selected for the present modeling study. Along the northern Gulf coast the grid resolution used was 1.25 mi while for the rest of the boundary a coarser grid of 18.6 mi was used. Fine scale bathymetry data (6 arc-second resolution) were used for the northern Gulf and coarse bathymetry for the remainder of the basin. The data used were compiled and distributed by the National Geophysical Data Center (NGDC) of the National Oceanographic and Atmospheric Administration (NOAA).

INPUT DATA

The input for the model, forecast wind data, was downloaded from the National Center for Environmental Prediction (NCEP) of NOAA database daily (60-hr forecast). The forecast wind is available in a grid format with spatial resolution of 7.574 mi² and covering the entire continental USA and the Gulf of Mexico region. Since hourly forecasts are available only for 36 hrs, the present study is limited to that period. The u and v components of the wind vector for the study area were extracted from the regional grid using Matlab[®] routines developed for this study. The simulations were carried out for January 6, 2006, when typical cold-front conditions dominated the domain.

COLD FRONT SEASON

Hsu (1988) and Roberts *et al.*, (1989) provided detailed explanations for the mechanism of cold front generation, sustenance and dissipation in the northern Gulf of Mexico. Once a cold front passes over the northern Gulf of Mexico, wind direction changes from the southern quadrant to the north, wind speed increases and air temperature drops (Kobashi *et al.*, 2005). The northern Gulf of Mexico experiences frequent cold front events between October and May and they have played a critical role in the coastal hydrodynamics of the Gulf Coast of the United States (Stone, 2000).

SIMULATIONS AND SKILL ASSESSMENT

A fully spectral approach was used for the computation of the wave parameters. The model computed the wave parameters using the forecast wind input. Synoptic maps of Significant Wave Height (Hs) (Fig. 1), wave period, wave direction, *etc.* were generated. For the purpose of skill assessment of the model, time series outputs were also generated for selected National Data Buoy Center (NDBC) buoy locations and Wave-Current-Surge Information System (WAVCIS) stations located off the Louisiana coast.

During the simulation period, zones of higher significant wave heights are observed all along the southern region of the Gulf of Mexico (Fig. 1), with a maximum value of 10.6 ft (3.25 m). This is in response to the prevailing northerly winds, associated with the cold front weather pattern. During fair weather conditions winds are blowing from south and south east and hence waves are also from the south (Roberts *et al.*, 1989).

The model outputs were directly compared with measured significant wave height and wind speed at NDBC 42003 (Fig. 2) and WAVCIS station CSI 3 (Fig. 3). It is observed that input wind for the NDBC station 42003 is

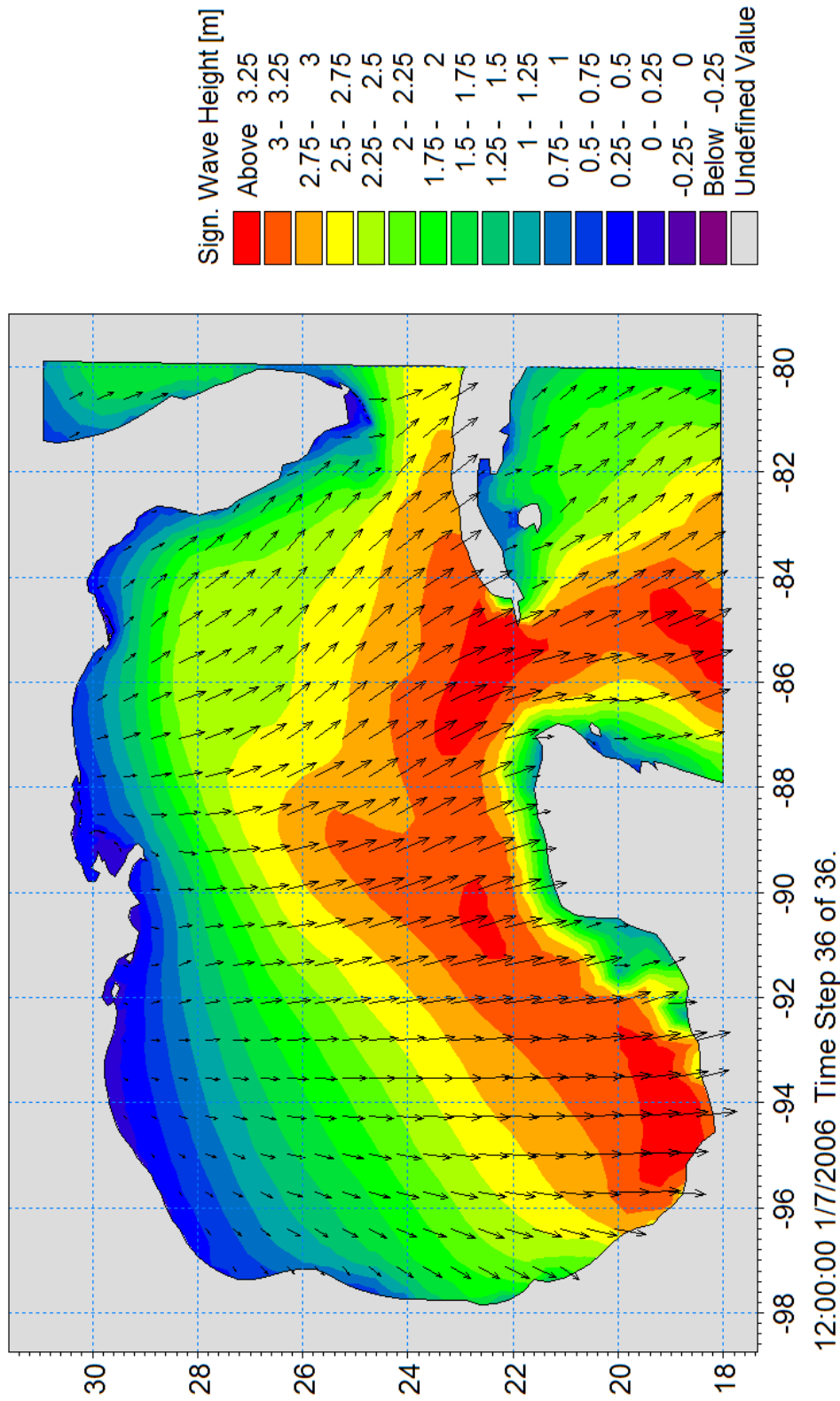


Figure 1. Significant wave height distribution (Hs) simulated using MIKE 21 SW model.

in good agreement with the measured wind data and hence the same level of confidence is also reflected in the simulated wave fields. However, for the shallow coastal station CSI3 ((29°26.47' N and 92°3.68' W), the predicted wind fields are not in agreement with the measured winds and that inaccuracy is reflected in the wave simulations also. Moreover, the bottom sediments at this station are comprised of silt and clay, debouched by the Atchafalaya River and induce much dissipation of wave energy compared to nearby sandy bottoms (Sheremet and Stone, 2003; Sheremet *et al.*, 2005).

In general it is observed that during fair weather conditions the predicted wave parameters show a strong correlation with measured wave parameters. During extreme weather conditions (hurricanes and tropical storms) predicted values typically were lower than observations. This discrepancy can be attributed to the scale and accuracy of the input wind data.

REFERENCES CITED

- Hsu, S. A., 1988, Coastal meteorology: Academic Press, Inc., San Diego, California, 260 p.
- Kobashi, D., F. Jose, and G.W. Stone, 2005, Hydrodynamics and sedimentary responses within the bottom boundary layer: Sabine bank, western Louisiana: Gulf Coast Association of Geological Societies Transactions, v. 55, p. 392-399.
- Kumar, B. P., and G. W. Stone, in press, Numerical simulation of typhoon wind forcing in the Korean seas using a spectral wave model: Journal of Coastal Research.
- Roberts, H. H., O. K. Huh., S. A. Hsu, R. J., Rouse, Jr., and D. A. Ruckman, 1989, Winter storm impacts on the chenier plain coast of southwestern Louisiana: Gulf Coast Association of Geological Societies Transactions, v. 39, p. 515-522.

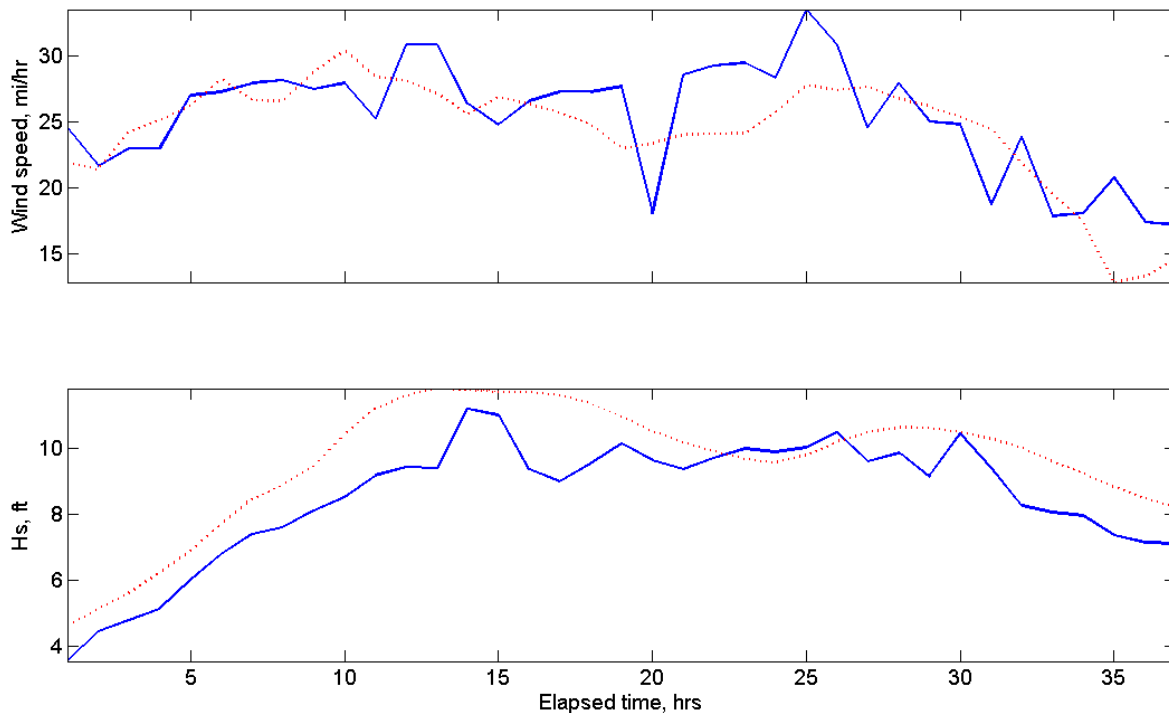


Figure 2. Time series of wind speed (above) and significant wave height (below) measured at NDBC 42003 (dotted red line) and model output (solid blue line).

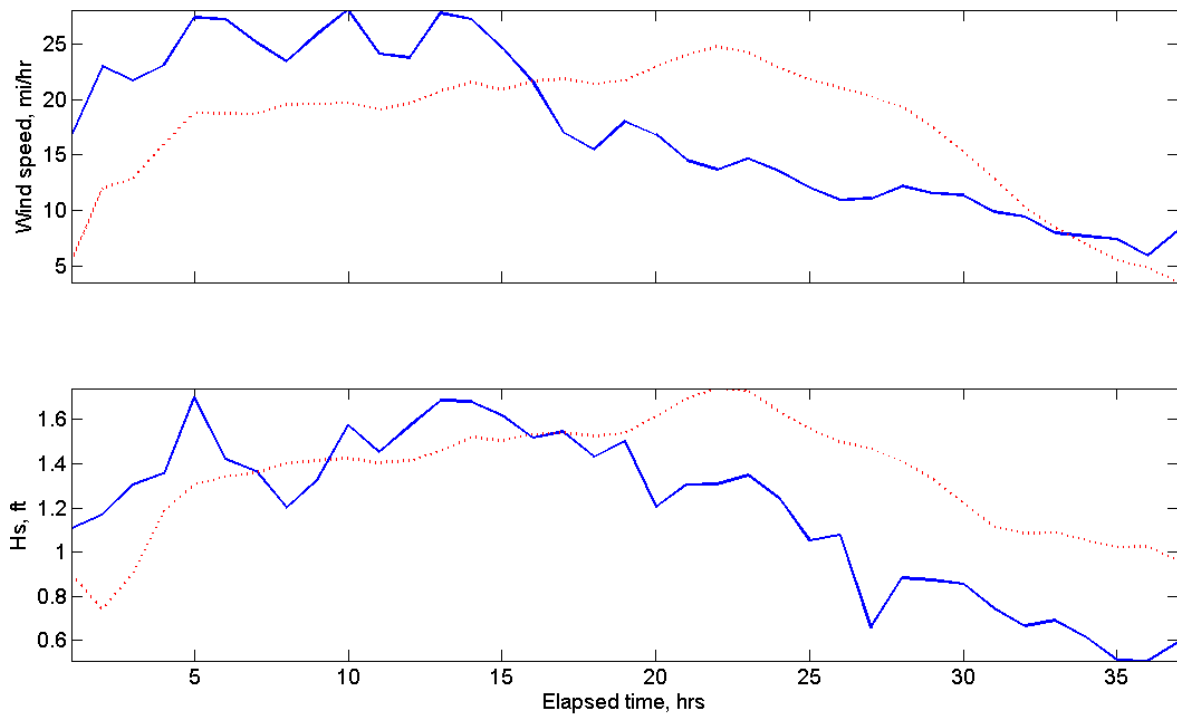


Figure 3. Time series of wind speed (above) and significant wave height (below) measured at WAVCIS station CSI3 (dotted red line) and model output (solid blue line).

Sheremet, A., and G. W. Stone, 2003, Observations of wave dissipation over muddy sea beds: *Journal of Geophysical Research*, v. 108, no. C11, doi: 10.1029/2003JC001885, 11 p.

Sheremet, A., A. J. Mehta, B. Liu, and G. W. Stone, 2005, Wave-sediment interaction on a muddy inner shelf during Hurricane Claudette: *Estuarine Coastal and Shelf Science*, v. 63, p. 225-233.

Sorensen, O. R., H. Kofoed-Hansen, M. Rugbjerg, and L.S. Sorensen, 2004, A third-generation spectral wave model using an unstructured finite volume technique: *International Conference on Coastal Engineering Proceedings*, v. 29, p. 894-906.

Stone, G. W., 2000, Wave-climate and bottom boundary layer dynamics with implications for offshore sand mining and barrier island replenishment in south-central Louisiana: U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico Region, OCS Study MMS 2000-053, New Orleans, Louisiana, 90 p.

Thornton, E. B., and R. T. Guza, 1983, Transformation of wave height distribution: *Journal of Geophysical Research*, v. 88, no. C10, p. 5,925-5,938.

Wright, L. D., J. D. Boon, S. C. Kim, and J. H. List, 1991, Modes of cross-shore sediment transport on the shoreface of the Middle Atlantic Bight: *Marine Geology*, v. 96, p. 19-51.

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