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Simulation and Prediction of Storm Surges and Waves Driven by Hurricanes and Assessment of Coastal Flooding and Inundation

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ABSTRACT: This paper presents an integrated coastal/estuarine/riverine/ocean process modeling system, CCHE2D-Coast, for simulating and predicting coastal flooding and inundation induced by storm surges, wave setup, tides, and river flood inflow during a hurricane period. A brief description on the framework of mathematical theories and numerical technologies is given. Model validations by hindcasting surface water levels and waves of Hurricane Gustav (2008) in the Gulf of Mexico and Hurricane Sandy (2012) in the Atlantic Ocean are presented. A real-time prediction capability of CCHE2D-Coast is demonstrated by forecasting flooding risk of Hurricane Isaac (2012) in the Mississippi Gulf Coast.

Keywords: Storm Surge Modeling, Wave Processes, Coastal Flooding, Hurricane Wind

1 INTRODUCTION

When a hurricane makes its landfall, it releases its devastating force onto coast and inland, and causes hazardous flood and inundation due to storm surges and waves. Simulation and real-time prediction of wind and storm surge driven by hurricanes are vitally important to assess the impact of tropical cyclones on coastal communities. Risk of coastal hazards due to flooding and inundation must be evaluated before storm seasons for the purposes of flood management and planning; and propagation of storm surges and waves should be forecasted during a hurricane period so that decision of mitigations and evacuation can be made in time.

Fast and accurate assessment of flooding and inundation induced by hurricane is a challenging task due to the complexity of tropical cyclone wind structures and the large- and multi-scale processes of coastal and ocean waters driven by dynamic forcing of astronomical tides, wind waves, storm surges and river inflows. Usually, simulation of wave deformation and transformation in a large regional area from deep ocean water to shallow water in surf zone is much more time-consuming than the effort to simulate storm surges only driven by cyclonic wind forcing. Most existing storm-surge models for hurricane simulations heavily rely on high performance computers which are expensive.

Recently, storm-surges and waves induced by hurricanes have been studied using integrated coastal/oceanic processes models. In particular, ADCIRC (the ADvanced CIRCulation model), a finite elemental model, has been coupled with wave models in multiple studies to produce hindcasts of Hurricane Katrina (2005) (Bunya et al. 2010, Chen et al. 2008), Ivan (2005) (Chen et al. 2008), and Gustav (2008) (Dietrich et al. 2011). However, in most cases, ADCIRC must work in tandem with a wave model such as a Steady-State IrregularWave (STWAVE) nearshore wind wave model (e.g. Bunya et al. 2010), or the ‘‘simulating waves nearshore’’ (SWAN) model (Dietrich et al. 2011, Chen et al. 2008), requiring interpolation of data across grids. Moreover, the time-step size in many existing storm-surge models is limited due to explicit numerical schemes, thus simulations by those models require thousands of computing cores to output simulations within a practical span of time.

A strong need exists for developing a fast, non-infrastructure-intensive hurricane prediction method. To achieve this, the integrated process model CCHE2D-Coast (e.g. Ding et al. 2006, Ding and Wang 2008, Ding et al. 2013) was employed for computing storm surges and waves. This model is designed for simulating hydrodynamic processes including storm-induced surges and waves as well as hydrological conditions such as river flows and tidal currents. It is important to note that all the modules of CCHE2D-Coast share one grid system for simulating these hydrodynamic and morphodynamic processes in sequence. Instead of using the so-called model steering operation adopted in other storm-surge models, CCHE2D-Coast does not need to switch executable codes of the modules. As a result, this model eliminates possible errors and loss of information due to interpolation and extrapolation of the results between different grid systems for different process models. The mesh of CCHE2D-Coast is non-orthogonal, which allows general structural quadrilateral grids. Thus, a structural computational grid with spatially-varying mesh resolutions can be created to model irregular coastlines in a flexible way, and enables to focus on different regions of interest in coastal zones, estuaries, and inland watersheds with complex geometries. Computationally, implicit numerical schemes for solving all the governing equations of waves, currents, and morphological changes make this integrated model efficient and capable of running simulations in a standard laptop computer with a relatively short computational time.

A newly-developed tropical cyclonic wind model with landfall effect was developed and integrated into CCHE2D-Coast to simulate storm surges, tides, and waves in oceanographic and coastal processes under meteorological and hydrological conditions over a simulation area of the Louisiana-Mississippi-Alabama Gulf Coast. This validated cyclonic wind model was extended to produce time-dependent two-dimensional (2-D) fields of wind and air pressure along a hurricane track. The study aimed to evaluate and advance the integrated model's accuracy in simulating spatio-temporal variations of storm winds and water levels while maintaining simplicity, accuracy, and computational efficiency. This integrated wind-storm-surge model was validated intensively by simulating Hurricane Gustav (2008) and comparing the simulated storm surges and waves with the observations at NOAA's gauges. To improve the model's accuracy, the air-sea interaction in the surface wind shear stresses was investigated by examining a number of formulations for calculating the drag coefficient of the wind shear stresses.

This paper highlights NCCHE's research on development and application of CCHE2D-Coast, an integrated coastal/estuarine/riverine/ocean process modeling system, for simulating and predicting coastal flooding and inundation induced by storm surges, wave setup, tides, and river flood inflow during a hurricane period. A brief description on the framework of mathematical theories and numerical technologies will be given. Model validations by hindcasting surface water levels and waves of Hurricane Gustav (2008) in the Gulf of Mexico and Hurricane Sandy (2012) in the Atlantic Ocean will be presented. A real-time prediction capability of CCHE2D-Coast will be demonstrated by forecasting flooding risk of Hurricane Isaac (2012) in the Mississippi Gulf Coast. This presentation will further give an engineering application of this modeling system for seeking solutions of coastal flood protection in the low-lying area in New Jersey by considering the combined condition of tropical cyclone and sea level rise due to climate change.

2 INTEGRATED HURRICANE-INDUCED STORM-SURGE MODEL

Storm surges are induced by wind and low air pressure during a storm or a hurricane. Coastal flood and inundation are driven by multiple hydrodynamic processes (coastal and oceanographic processes) such as wind-induced currents, tidal flows, waves, earth rotation, river flows, etc. The total water level increase during a hurricane is the sum of the expected high tide, storm surge caused by low barometric pressure and onshore winds, wave setup in the surf zone, and inflow caused by flooding rivers. To simulate storm surges during a hurricane driven by the Coriolis force and all the hydrological force such as winds, waves, tides, and river flows, a coast-ocean model, called CCHE2D-Coast, is used in this study. This model consists of a multidirectional wave spectral model and a coastal hydrodynamic model (Ding et al. 2006, Jia and Wang 1999, Jia et al. 2002). It is capable of simulating hydrodynamic processes in coasts, estuaries, rivers, and oceans such as (1) storm surges and waves driven by cyclonic wind, (2) irregular wave deformations and transformation, (3) tidal and river flows, and (4) nearshore currents and wave setup/setdown. This model generally employs a non-orthogonal grid that can model complex coastlines (Ding and Wang 2008, Zhang and Jia 2009).

Figure 1 presents a flow chart and structure of the integrated wind-storm-surge model. The wind and pressure field model is to produce the hurricane conditions for the coast-ocean model. In addition to the parameters for calculating the wind field, the required data for simulating storm surges in a coast region include bathymetrical/topographic data, hydrological data (tides, hydrographs of rivers, waves, etc.), and structure data which are used for generating a computational grid and specifying boundary conditions of tides and river flows.

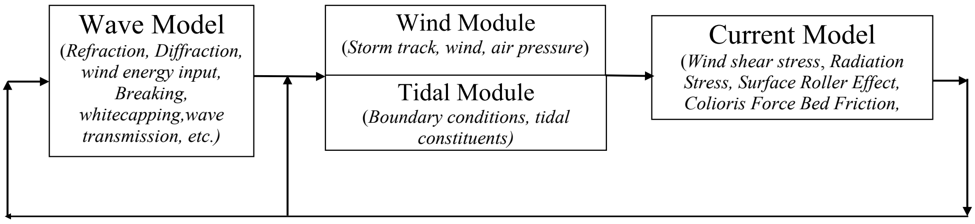


Figure 1. Flow chart of the integrated wind-storm-surge model

The surface wind stress is a major driven force of storm surges, which represents the portion of wind energy input into water columns. Even though the interaction between air and sea water is complex, this wind stress $\vec{\tau}^s$ can be modeled by the conventional bulk formula (e.g. Large and Pond 1981),

$$\vec{\tau}^s = \rho C_d \left|\vec{V}_W\right| \vec{V}_W \tag{1}$$

where $\vec{V}_W$ = vector of wind velocity at 10 meters above ground, and C_d = drag coefficient (distinct from the nonlinear decay parameter C_D). The hurricane wind velocity is a resultant velocity of the tangential velocity and the hurricane forward velocity given by a hurricane track. Calculation of C_d depends on empirical formulae, for which CCHE2D-Coast provides five options for calculating the drag coefficient proposed by Large and Pond (1981), Powell et al. (2003), and Hwang (2005).

In the wave action model, the energy input by wind forcing is modeled as separated sink and source terms proposed by Lin and Lin (2004a,b).The coefficients in the wind energy input are calibrated by hindcasting Hurricane Gustav (2008) which made landfall at the southern Louisiana coast (see Ding et al. 2013 for the details).

3 A CYCLONIC WIND-PRESSURE MODEL WITH LANDFALL DECAY EFFECT

To predict storm surges induced by tropical cyclonic wind and low pressure, spatio-temporal variations of air pressure and wind fields are needed to calculate wind energy input into ocean water column. The widely-used tropical cyclonic wind-pressure model, Holland's wind model (Holland 1980) is a parameterized wind-pressure model. This simple model only needs a few parameters for defining hurricane track, size, intensity, and central pressure to determine the air pressure and wind tangential velocity. However, this simple model doesn't include the decay effect of wind after a hurricane makes its landfall.

Hazardous wind and storm surges occur around the coastal area where hurricane makes its landfall and during the period right after its landfall. It is, therefore, important to predict the location and the intensity of storm wind at hurricane landfall. Mainly due to loss of thermal energy input from warm ocean waters, storm wind speed usually decays quickly after landfall. In general, hurricane intensity decay is influenced by a complex combination of physical factors, including the ocean structure prior to landfall, surface heat capacity of water and soil, surface roughness and moistures of soil and vegetation, and variations between day and night (e.g. Marks and Shay 1998, Shen et al. 2002, DeMaria et al. 2006). Kaplan and DeMaria (1995) approximate hurricane maximum velocity decay by a linear differential equation with respect to time after landfall. Their linear decay model only takes into account the decay due to energy loss of heat input from the ocean.

3.1 *A Nonlinear Cyclonic Wind Model with Landfall Effect*

Correlation analyses of various hindcast storms found that the linear decay model was inadequate in simulating the decay process; in particular, sharp drops in wind velocity immediately following landfall of numerous storms suggested that one or more additional physical factors induce a nonlinear pattern of hurricane decay (Marks and Shay 1998, Shen et al. 2002). Thus, to predict the maximum wind speed and air pressure after hurricane landfall, Ding (2012) developed a new decay model with an additional nonlinear decay term to account for increased surface roughness as the storm moves over land.

$$\frac{d(V_{\max} - V_b)}{dt} = -\alpha(V_{\max} - V_b) - \frac{C_D}{h}(V_{\max} - V_b)^2 \tag{2}$$

where t = time after landfall, V_b = background wind velocity, V_{max} = maximum wind velocity, α = parameter of linear decay (1/s), C_D = non-dimensional drag coefficient and h = mean height of the planetary boundary layer (m), the lowest layer of the troposphere in which wind is influenced by land surface friction (Vickery et al. 2000). Because the last term in Eq. (1) is nonlinear, this equation does not have an analytical solution. A time-marching semi-implicit Euler's scheme is used for computing the maximum wind speed.

The empirical parameters, the decay parameter α and the drag coefficient C_D, have been calibrated by computing the historical post-landfall data of the hurricanes landed in the northern Gulf Coast. The selected hurricanes for calibrations are Andrew (1992), Lili (2002), Ivan (2004), Katrina (2005), Rita (2005), Dennis (2005), and Gustav (2008). Using the calibrated parameter values, Ding (2012) established a statistical database of their optimum parameters. Two regression relations have been developed to predict the two empirical parameter values when a hurricane makes landfall in the Gulf Coast:

$$\frac{\alpha h}{(V_i - V_b)} = 5.1462\times10^{-4} - 1.8312\times10^{-5}\left(\frac{\Delta P}{\frac{1}{2}\rho(V_i - V_b)^2}\right) \tag{3}$$

where V_i = maximum wind velocity at landfall (m/s), ΔP (pascals) is the difference between the central air pressure and ambient pressure at hurricane landfall, ρ = air density (kg/m^3), and

$$C_D \times 10^{-10} = 3.7322\times10^{-8}(V_i - V_b)^{8.8564} \tag{4}$$

Here, h = 1000m. As a result, the decay rate α and the drag coefficient C_D can be directly calculated by using the regression equations, only given the wind velocity and central air pressure at landfall. Ding (2012) also has developed a procedure to reconstruct a two-dimensional wind and atmospheric pressure by combining Holland's hurricane model (Holland 1980) and this nonlinear landfall wind model. In Hurricane Isaac (2012), the decay model produced very accurate prediction results for hurricane maximum wind and the central pressure after its landfall (see Figure 2).

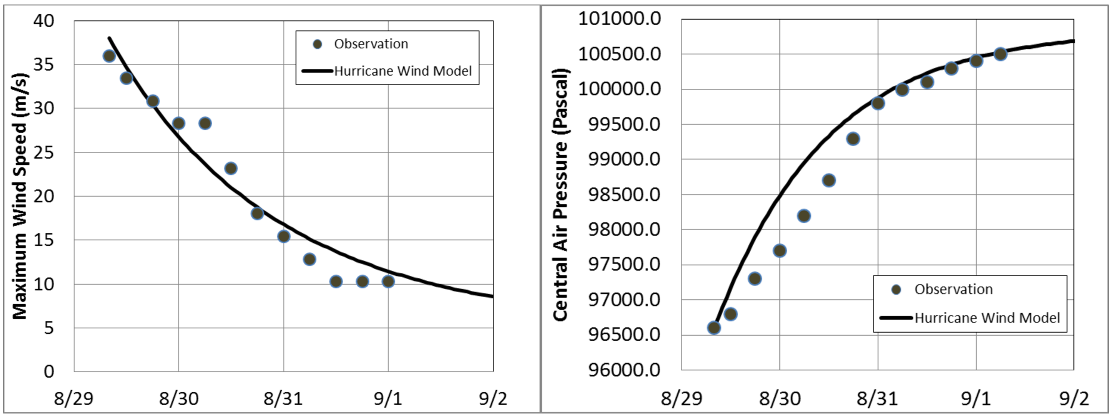


Figure 2. Comparisons of wind speed (left) and central air pressure (right). The observation data are from the best track of Hurricane Isaac (2012) by NOAA

3.2 *Construction of 2D Wind Field with Decay Effect*

Holland's tangential wind field equation (Holland 1980) was used to derive a direct relationship between the decay in maximum velocity and central barometric pressure. This parameterized formula renders hurricane's complex atmospheric processes as a fixed vortex of rotating winds creating a central region of low atmospheric pressure – the eye. Holland's equation is as follows:

This parameterized formula boils a hurricane's complex atmospheric processes down to a fixed vortex of rotating winds that create a central region of low atmospheric pressure – the eye.

$$V(r) = \sqrt{(B/\rho)(R/r)^B(P_a - P_c)e^{-(R/r)^B}} \tag{5}$$

where $V(r)$ = tangential wind speed (m/s) at a distance of r (m) from the center, R = radius of the band of maximum sustained winds from the eye's center, P_c = central pressure, P_a = ambient pressure (both in pascals), B = empirically determined parameter.

An explicit relationship between maximum wind and pressure was derived by setting R equal to r in Holland's equation (4):

$$V_{\max} = \sqrt{(B/\rho)(P_a - P_c)e^{-1}} \tag{6}$$

Combining Eq. (5) with Eq. (4), thus the tangential wind field at any locations can be expressed as a function of maximum velocity and a position function of r.

$$V(r) = V_{\max}\sqrt{(R/r)^{B} e^{(1-(R/r)^{B})}} \tag{7}$$

In order to extend the parametric cyclonic model across an area, a fixed, cylindrical wind field was constructed from the decay curve using Holland's equation and its pressure field analogue P(r), i.e.

$$P(r) = P_c + (P_a - P_c)e^{-(R/r)^{B}} \tag{8}$$

Before landfall, the wind field is calculated from observed central pressure values using the equation of P(r), and the tangential wind velocity at any location by Eq. (4). After landfall, with decay effects, Vmax is calculated from the nonlinear differential equation (1) of the landfall decay model, wind velocity is determined by Eq. (6).

Various methods of calculating the wind field were examined for simulation accuracy. First, the impact of taking decay effects into account after landfall was studied by comparing results from the nonlinear pressure-wind decay model to the results of the basic, non-decay wind field. Second, statistical analysis of the decay model validated the relationship between B and the gauge pressure at the eye of the hurricane after landfall, as showing in Eq. (7). In accordance, a similar empirical relation between B and a gauge pressure and radius of maximum winds before landfall was utilized (Vickery et al. 2000b):

$$B = 1.34 + 0.00328(P_a - P_c) - 0.00309R \tag{9}$$

In numerous simulation cases, the simulation accuracy of changing B with gauge pressure was compared with that of keeping B constant.

4 VALIDATION OF CYCLONIC WIND MODEL AND STORM SURGE MODEL

Prior to application to prediction of storm surges induced by hurricanes in the Gulf of Mexico, this newly-developed tropical cyclone parametric wind model is validated by hindcasting cyclonic wind fields and storm surges during the period of Hurricane Gustav (2008). Gustav was the first major hurricane to track through the northern Gulf of Mexico after Katrina (2005). It briefly became a category 4 hurricane on the Saffir-Simpson Hurricane Scale and caused many deaths and considerable damage in Haiti, Cuba, and Louisiana. Gustav made its final landfall near Cocodrie, Louisiana, around 1500 UTC 1 September with maximum winds near 90 kt (Category 2) (Beven and Kimberlain 2009). Gustav was much weaker than Katrina, and its landfall was farther west to New Orleans. For those reasons, the waves and surges by Gustav should be less threatening to the New Orleans and the Mississippi Gulf coast. However, Gustav increased in size as it approached Louisiana, and its outer, tropical-storm-strength winds impacted the system for 12–15 hours. Gustav generated waves that damaged infrastructure in southern Louisiana and offshore, and its surge nearly overtopped large sections of the levee/floodwall system throughout metropolitan New Orleans (Dietrich et al. 2011). The tremendous power of Hurricane Katrina in 2005 damaged or destroyed many of the NOAA data stations on the LA-MS Gulf Coast; because the instruments at those data stations were repaired or replaced, an unprecedented wealth of accurate observational data exists for storms post-2005 such as Gustav. Thus, a simulation of Hurricane Gustav's landfall in southern Louisiana in August 2008 was performed for model validation.

4.1 *Computational Domain and Conditions*

The hurricane wind field is generated using the nonlinear decay model, Holland's model and observed parameters and is inserted as an input condition in a 440km×320km computational domain mapping topography, bathymetry, and coastal structures of the northern Gulf coast. Though derived from a large-scale unstructured triangular mesh of the western Atlantic basin used in the storm-surge simulations by Bunya et al. (2010) and Dietrich et al. (2011), Zhang et al. (2012) generated a non-orthogonal structural grid (a CCHE2D grid), allowing for more flexible modeling of irregular coastlines to cover the northern Gulf Coast (Figure 3). Each node in the 2103×1088 mesh (i.e. containing 2,288,064 nodal points) includes data for water elevation above the NAVD88 datum, atmospheric pressure, and x-y components of wind velocity for every time step, in this case 2 minutes. The mesh resolution varies from less than one meter in river crosssections to 2 km at the deepwater offshore. Based on this structural CCHE2D grid, the study utilized the coast-ocean model CCHE2D-Coast to simulate background conditions in the region including ambient pressure, background wind velocity, tidal cycles, and river inflows from the Mississippi and Atchafalaya Rivers. Between Aug. 15 and Aug. 30, 2008 in simulated time before Gustav's landfall, the model was spun up to establish discharges of the Mississippi and Atchafalaya Rivers and develop tidal flow conditions offshore. At 0:00 GMT, Aug. 30 (in simulated time), the hurricane wind field calculated using Holland's model was overlaid on its trajectory in the CCHE2D-Coast domain and given a translational velocity to simulate the hurricane's landfall until 0:00 GMT, Sept. 3.

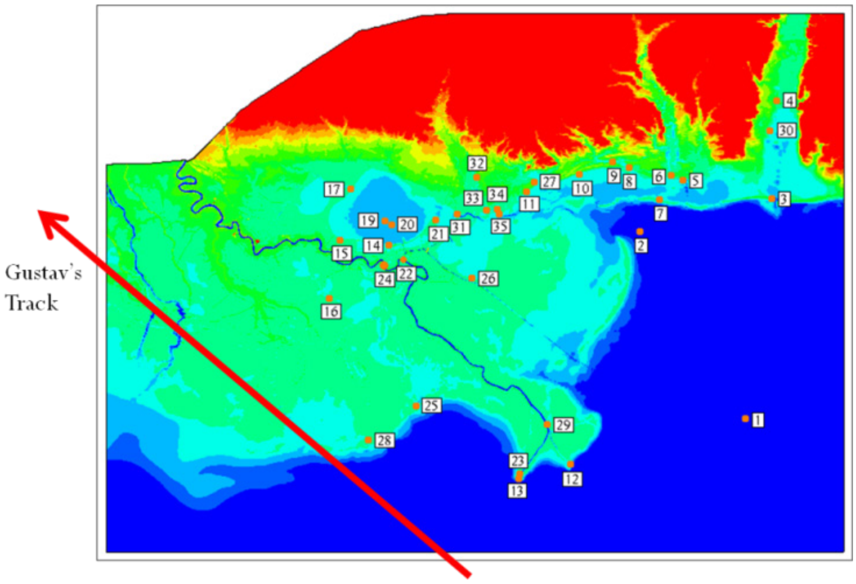


Figure 3. Trajectory of Hurricane Gustav overlaid on the computational domain of the Louisiana-Mississippi Gulf Coast. Locations are marked for NOAA, NDBC, and USGS data stations from which data recorded during Gustav is taken and compared to computed results.

To validate the hurricane wind model and the storm-surge model, Hurricane Gustav (2008) was selected. Observed data at various NOAA, NDBC, and USGS data stations were compared with calculated data at the corresponding locations in the mesh (see Figure 3).

A simulation of Gustav's wind intensity over a 4 day period (8/30 to 9/03) in 2-minutes time steps requires approximately 30 min. wall-time on 2.70 GHz Intel Core i7. The CPU time for simulating a one-day surge tide over this mesh with 2,288,064 nodal points is about 6,904s on a single CPU. The CPU for simulating one wave field over the mesh is about 753 s on a single core. One-day simulation under interaction of wave and current takes 4.5 hours on a single CPU. Thus, the simulation runs 5.3 times faster than real time by only using one CPU.

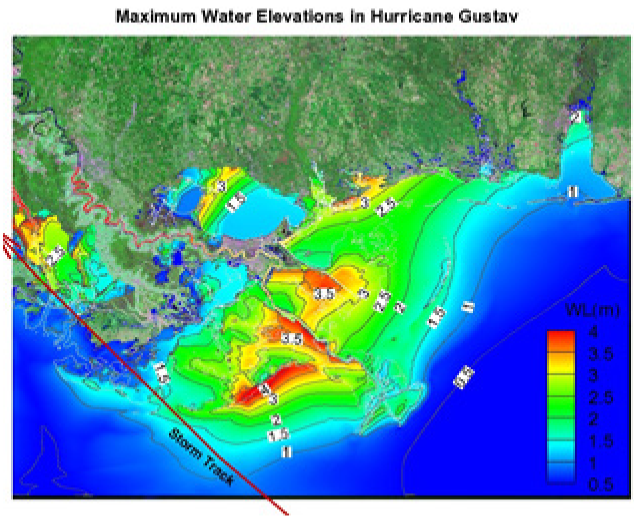


Figure 4. Maximum water surface elevations induced by Gustav (2008) in the northern Gulf of Mexico

The hydrodynamic modeling of Hurricane Gustav was conducted by taking into account wave-current interaction and wave setup. The interaction frequency is one hour. In other words, the wave field was updated every one hour during the computation. Through the period of the hurricane, the maximum flooding extend map was presented by the spatial distribution water surface elevations (above the datum of

NAVD88) in Figure 4, which includes the water depths driven by the astronomical tides, wave setup, and storm surge.

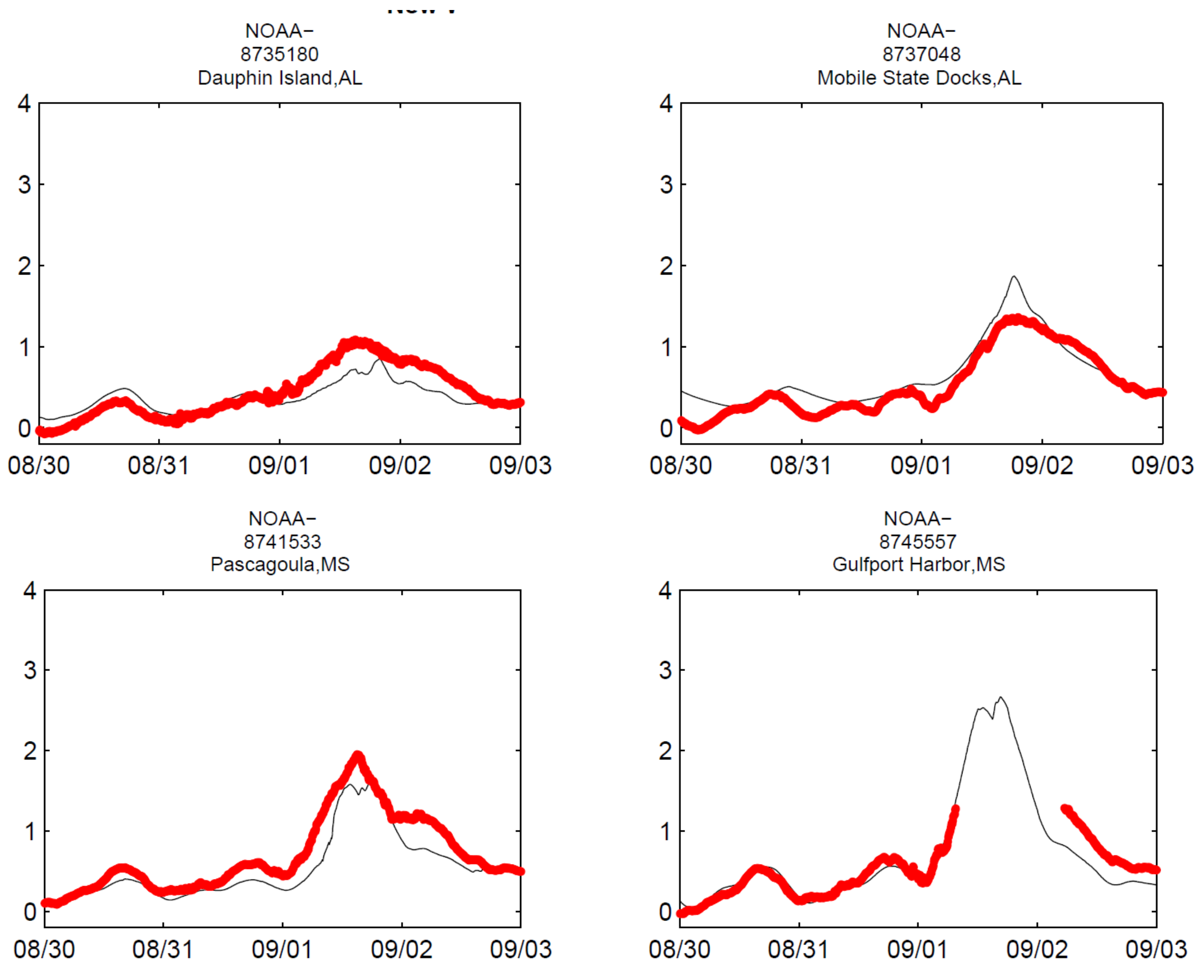


Figure 5. Comparisons of water levels at four NOAA tide gages. The black line stands for computed levels; the red the observations by NOAA

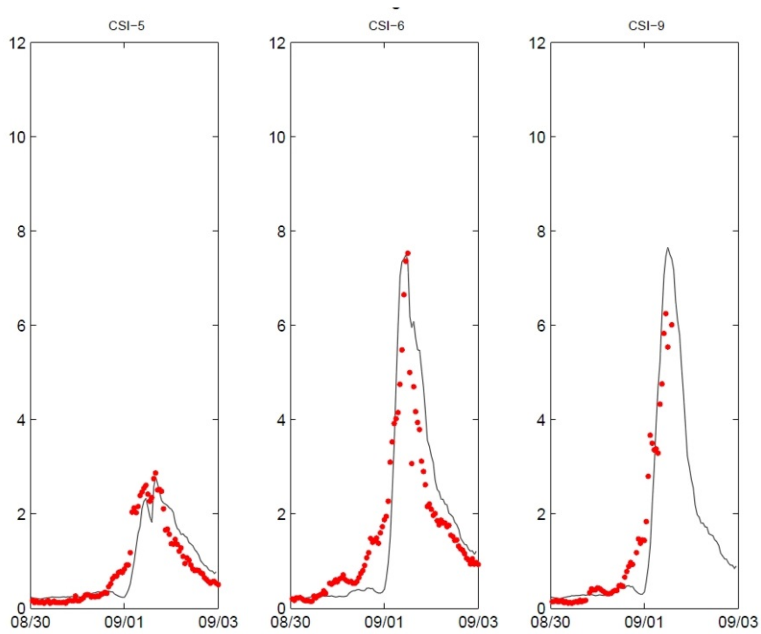


Figure 6. Comparisons of wave heights by Hurricane Gustav (2008) at the observation stations in the coast of Louisiana : CSI-5: South of Terrebonne Bay. CSI-6: Chevron Platform, ST-52B, South of Terrebonne Bay. CSI-9: Grand Isle Blocks.

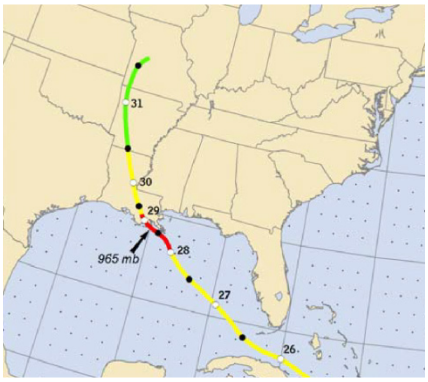
Figure 5 presents the comparison of computed water levels above NAVD88 at four selected NOAA tide gages at Dauphin Island, AL, Pascagoula, MS, Mobile State Docks, AL, and Gulfport Harbor, MS. The computed water levels are in good agreement with the NOAA observations.

The wave model of CCHE2D-Coast has been also validated by comparing the computed wave parameters (heights, periods, and directions) with the observation data measured by NOAA and two other research institutes. As an example, Figure 6 plots the computed significant wave heights and the observed values measured by Louisiana State University (LSU), at three states in the south coast of Louisiana. The simulated wave heights matched well with the LSU's wave data. More comprehensive comparisons of results and computational error analysis have been done, and will be published soon.

Overall, this integrated coastal/ocean process model has reproduced very well storm surges, water surface elevations, and waves generated by Hurricane Gustav (2008) in a regional domain covering the northern Gulf Coasts in Alabama, Mississippi, and Louisiana.

5 FORECAST OF HURRICANE ISAAC (2012)

In August 2012 – exactly five years after Katrina, an opportunity for evaluating the real-time prediction capability of the integrated model arose as Hurricane Isaac approached the northern Gulf Coast. Isaac first made landfall at 2345 UTC on Aug. 28 with winds of 80 mph at the mouth of the Mississippi River (Berg 2013). The eye then moved back over water and only made landfall in earnest near Port Fourchon, LA at 0715 UTC on Aug. 29. The first forecast simulation was performed following the NHC's release of Forecast Advisory #27 at 2100 UTC, Aug. 27. Wind and pressure data given in the advisory were used to extrapolate Isaac's wind fields in the Gulf of Mexico. The storm-surge model was spun up with tidal and river inflow simulations in CCHE2D-Coast beginning Aug. 23 in simulation time. On Aug. 27, Isaac's wind field was introduced and set in motion on its forecasted track. α and C_D decay parameter regressions (Figure 2) were used to estimate Isaac's decay process from forecasted maximum winds and minimum pressure at landfall (Figure 7). Isaac's wind field was represented by the modified Holland's wind model with variable B parameter; rotational velocities were scaled by 0.7 to match surface wind speeds. Hwang's formulation (Hwang, 2005) was used to calculate the drag coefficients for surface wind stress. All the surge forecasting cases included wave setup.



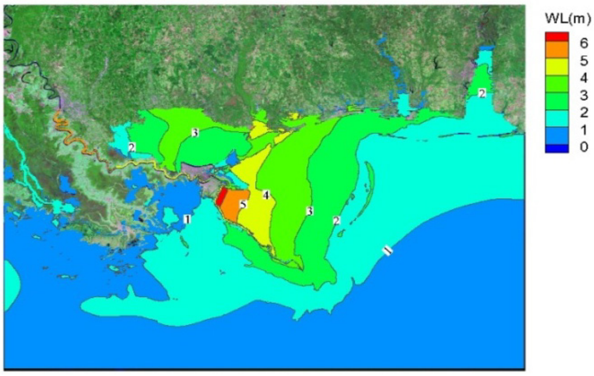


Figure 7. (left) Best track positions for Hurricane Isaac, 26 August – 1 September 2012 (Berg 2013). (right) Predicted maximum water elevations during Isaac for the Advisory #39 forecast

Three more forecasts were performed, each with the release of a new NHC advisory; #29a at 1200 UTC Aug. 28, #30a at 1800 UTC Aug. 28, and #39 at 2100 UTC, Aug. 30. Data for the wind field, track, and decay models were updated with the latest updated observations upon each new simulation, with the Advisory #39 run serving as a best-track simulation. By utilizing the most effective formulations and modeling schemes devised in this study, highly accurate forecasts of wind speeds and water elevations at data stations were achieved (Figure 8 and Figure 9). Though forecast accuracy increased expectedly with additional advisories, culminating in the best-track simulation based on Adv. #39, calculated maximum intensities readily matched observed values even for the initial simulation at Adv. #27, nearly two days before landfall.

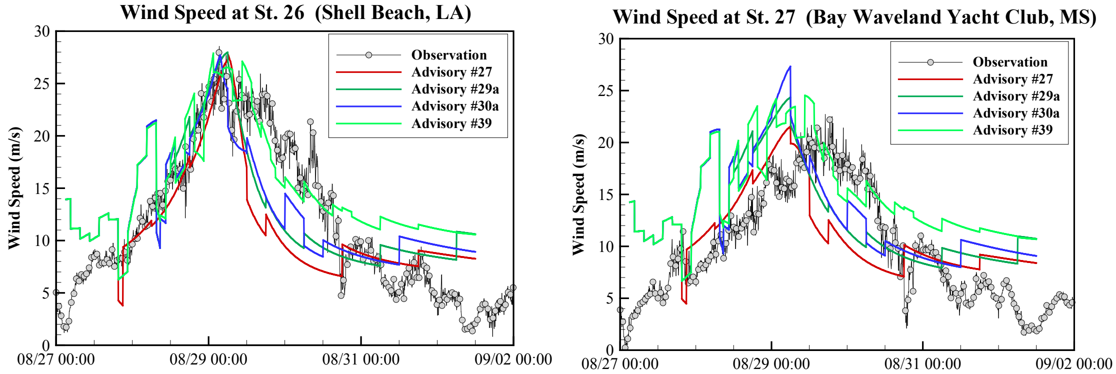


Figure 8. Forecasted wind speed for advisory tracks (#27, 291, 30a, and 39a), and comparisons with observations at NOAA gage stations

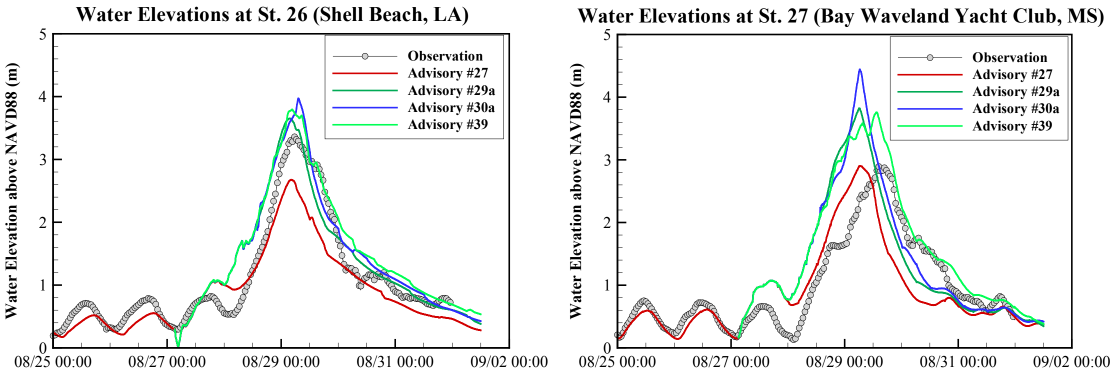


Figure 9. Predicted water elevations at two sample stations for NOAA's advisory tracks (#27, 29a, 30a, and 39) and comparisons with NOAA's observations. Storm surge levels calculated using Hwang's formulation (Hwang, 2005) for the drag coefficient of surface wind stress showed high correlation with observed data, esp. in later forecasts.

6 CONCLUSIONS

This paper presents an integrated coastal/ocean process model, CCHE2D-Coast, for simulating waves, tides, and storm surges in a regional scale domain in the Gulf of Mexico. By implementing an new parametric cyclonic wind model, this integrated model can be used for assessing flooding and inundation caused by hurricane.

The model validation was carried out by simulating storm surges and waves in the northern Gulf coasts induced by Hurricane Gustav (2008). It is found that the model can reproduce the water surface elevations and wind-induced waves.

This integrated model was built on a PC-based computational platform. Therefore, its efficiency for simulating large-scale coastal and ocean processes makes real-time prediction of storm surges and waves possible. Thus, the paper also presents a case to predict the impact of Hurricane Isaac (2012) in the Gulf of Mexico. It shoes that the model can predict quickly the hydrodynamic variables according to the cyclone track data provided by NOAA. Therefore, this model has a potential to be an operating system for real-time forecasting flooding and inundation in coasts induced by hurricanes and cyclonic tropical storms.

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