AN EFFICIENT STORM SURGE FORECASTING METHODOLOGY FOR COASTAL TEXAS EMERGENCY MANAGEMENT

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Objective

The Texas Gulf coast is a complex system with numerous narrow inlets and broad back bays with river networks. Due to its intricate topologies, the Texas coast is susceptible to localized water levels and ponding during hurricanes and tropical storms. The Texas coast is one of the most dynamic regions in terms of population and economic growth. According to the Bureau of Economic Geology, twenty five percent of the population and thirty three percent of the economic resources of Texas are located along the approximately 360 miles of the coast. So, it is crucial that emergency managers have an efficient and “easy to use” storm surge forecasting system, based on the uncertainties of an approaching landfall, to serve as a decision aide for minimizing hurricane impacts on local population.

Methodology

The current technology to predict storm surge is to use an integrated, coupled forecasting system for winds and waves. The simulation and prediction of storm surge are intrinsically complex due to the interaction of a wide range of fluid motions, ranging from large-scale tide and wave to small-scale street level turbulence. While the physics based multi-scale simulations provide the most reliable information, their real time applications are always challenged by the availability of computational resources. For example, a typical ADCIRC simulation in real time can take up to 4 to 6 hours in a parallel computing environment. In order to reduce computational requirements and resources an alternative and efficient data mining technique can be used to forecast storm surge. This technique was successfully demonstrated for coastal Mississippi and can be adapted to the Texas coast. .

During 2007-08, the Federal Emergency Management Agency Region 6 (FEMA-R6) and United States Army Corps of Engineers (USACE) conducted two separate studies to identify flood frequency for Eastern Louisiana and coastal counties of Mississippi (Resio et al., 2007, Niedoroda et al., 2010). Approximately, 350 hypothetical storms represented by a unique combination of track, intensity, forward speed, and storm size were simulated using Advanced Circulation (ADCIRC) Model. All model results were archived in a database. Recently, the Department of Homeland Security (DHS) provided research funds to their Center of Excellence for Natural Disasters, Coastal Infrastructure, and Emergency Management (NDCIEM) at Jackson State University (JSU) to develop a toolbox where the central pressure, radius, and landfall location of an approaching hurricane would be used to search for the characteristics of hurricane within the underlying database. The model would then track a group of storms that match, as close as possible, with the hurricane and extract ADCIRC simulated results associated with the identified storms in the database.

For validation, results were compared with observed High Water Marks (HWM) from historical hurricanes such as hurricanes Katrina (2005), Camille (1969) , and Betsy (1965) which made landfall in the Gulf coast. It was found that modeled results using the data mining approach compared well with the observed High Water Marks (Figure 1).

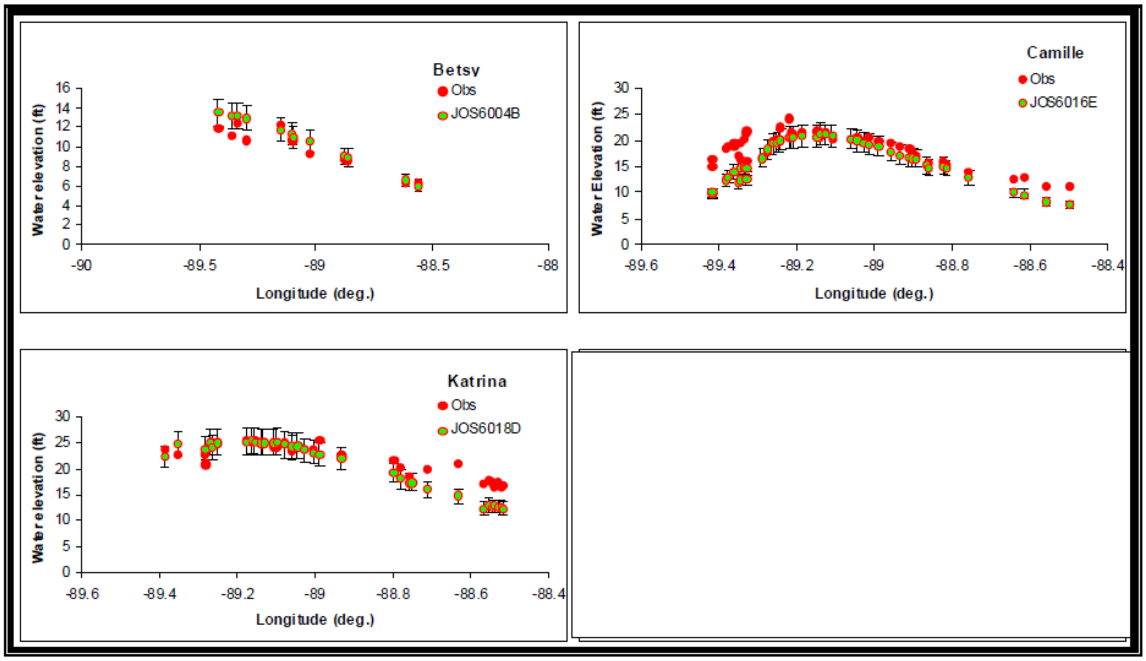

Figure 1: Observed [in red] and simulated [in black with 1.5 ft error bar] High Water Marks along the coast of Mississippi from Hurricanes Betsy, Camille, and Katrina

Later, the data mining tool was expanded to a surge forecasting tool where meteorological forecast information of a future approaching hurricane from National Hurricane Center (NHC) were ingested to establish a relationship of key hurricane parameters, such as, central pressure, landfall location, storm radius between the approaching hurricane and simulated storms within the database. The software tool then identifies a group of storms that closely matches with the approaching hurricanes and then delivers a forecast every 3 or 6 hours of surface wind, storm surge and wave information. Results are displayed in Google Earth environment.

Results

To evaluate real time application of the toolbox, two advisory data sets from the NHC (20A and 27A) issued during Hurricane Gustav (August 29-31, 2008) were used. For each advisory, the toolbox extracted current storm location; C_P and R_{max} values and then the best matching synthetic storms (Figure 2). For validation, model surge elevations were compared with the observed High Water Mark (HMS) for Hurricane Gustav. In general, the model surge elevations extracted from the synthetic storm were in good agreement with the observed HWM(s).

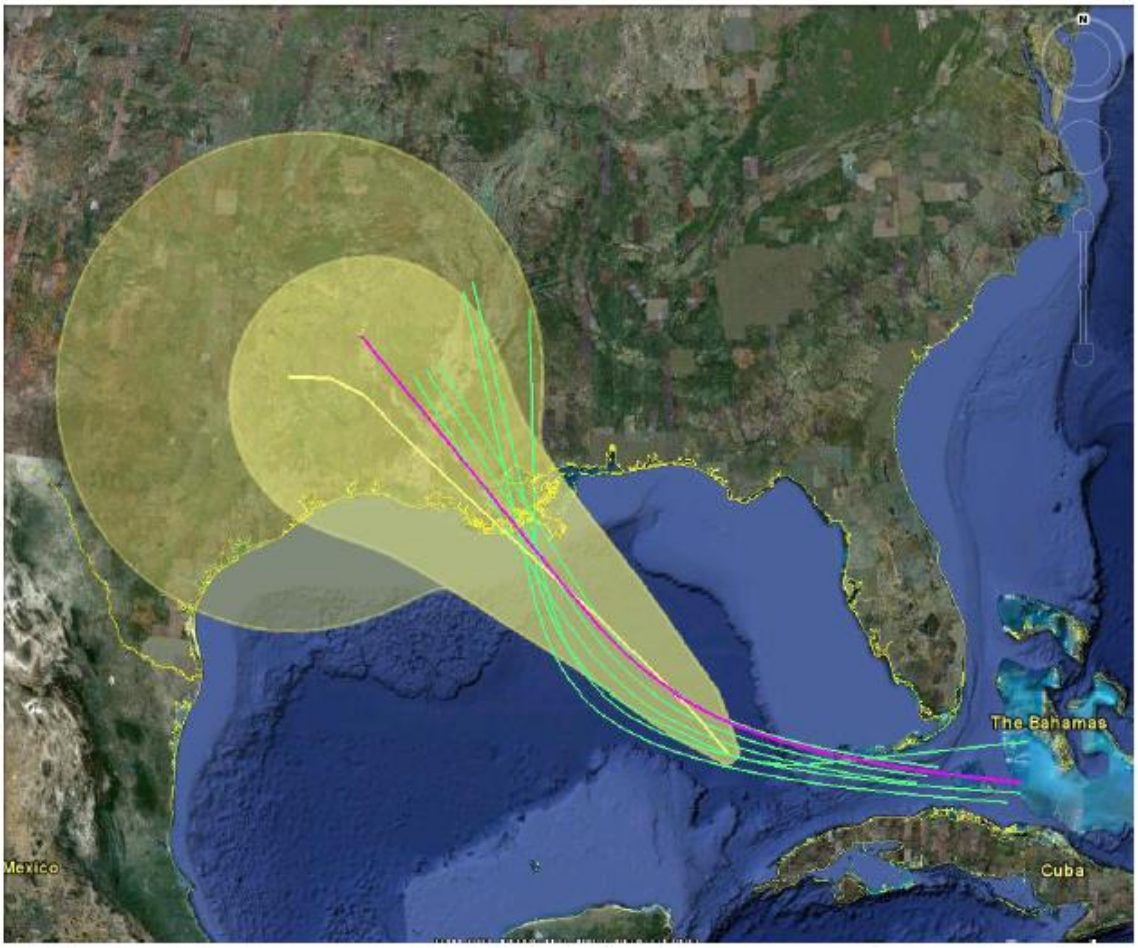

Figure 2: Forecasted hurricane Gustav tracks and synthetic storm tracks identified by the toolbox. The yellow line shows the NHC forecast track and green and pink lines show matching synthetic storm tracks extracted from the database. The track shows in pink has the highest similarity value.

Discussion

The toolbox, which has been successfully demonstrated for an efficient storm surge forecasting in coastal Mississippi, can be adapted to Texas coast. We need to update the database with additional ADCIRC simulations representative to the Texas coast. We anticipate that approximately 1500 simulations with different historical tracks and hurricane intensities covering the 360 mile long coast will be necessary to make the toolbox useful for the Texas coast. We like to emphasize that quite a number of ADCIRC simulations with high resolutions, are already being processed for the recent FEMA Flood Insurance Study for Texas. These simulation results can be directly imported into the toolbox. This certainly reduces the necessity for additional simulations. Once the database is updated with results specific to the Texas coast, the emergency management personnel can quickly predict local storm surge and they will be able to make more quantitative decisions by evaluating .what-if-scenarios. starting one to two days ahead of the approaching landfall.

References

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