RAPID ESTIMATION OF HIGH RESOLUTION LOCAL STORM AND INTERACTIVE OPERATION WITH A DISASTER RESPONSE INTELLIGENT SYSTEM

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Abstract: In spite of the rapid development of computer power, the real-time application of coupled storm surge simulation with fine resolution is often constrained by availability of time. In this study, an alternative, efficient and robust data mining technique have been developed to estimate high resolution local storm surge in coastal areas. Recently, this technique has been incorporated into the DRIS to support decision-making prior to, during, and following a major disaster.

Introduction

The United States Gulf of Mexico coast ranging from Texas to Florida is vulnerable to frequent hurricane activities. From 1715 to 1985, approximately forty hurricanes struck in that region. The devastation of Hurricanes Katrina and Rita in 2005 focused new attention on predicting storm surges and assessing risks. In present, it is a common practice to use an integrated, coupled forecasting system for tides, winds and waves to forecast storm surge using the parallel computing techniques. Even with the advent of super computing resources, the applications of process based and coupled simulations with high resolution grids are often constrained by the fact that execution of such numerical models is complex and often time consuming.

Objective

The objective of this study is to develop an alternative, efficient and robust data mining technique to forecast local storm surge, and then incorporate this technique into Disaster Response Intelligent System (DRIS) system to support decision-making for a major disaster.

Methodology

During 2007-08, the United States Army Corps of Engineers (USACE) and Federal Emergency management Agency, Region Six (FEMA-R6) conducted two separate studies to identify flood frequencies for Eastern Louisiana and all three coastal counties of Mississippi (Reiso et al., 2007; Niedoroda et al., 2010). Approximately, 350 hypothetical storms represented by a unique combination of track, intensity, forward speed, storm size and radial wind profile decay were simulated with Advanced Circulation Model (ADCIRC). All model results were archived in a database. In order to identify the best matching synthetic storms for a real storm, a weight based Storm Similarity Index (SSI) was developed. The SSI values is determined by a current storm position central pressure (Cp), radius of maximum wind speed

(Rmax), forward speed of storm, storm track, and landfall location published by the National Hurricane Center (NHC). The SSI ranges from 0 to 1 and is calculated by the following:

$$SSI = (a\cdot H_{LF} + b\cdot H_{Cp} + c\cdot H_{Rmax} + d\cdot H_{FS}) \cdot H_{TRK}$$

where, H_{LF} = parameter indicating landfall similarity (0 to 1); H_{Cp} = central pressure deficit similarity (0 to 1); H_{Rmax} = pressure scale radius similarity (0 to 1); H_{FS} = storm forwarding speed similarity (0 to 1); H_{TRK} = storm track similarity (0 or 1), which indicates the similarity for forward direction of a hurricane. Here, a, b, c, and d = weighting factor whose summation is one. In the present toolbox, fixed values of a, b, c and d were used which were 0.4, 0.3, 0.2 and 0.1 respectively.

Discussions

To demonstrate how the SSI method works in real time, two advisory data (al072008-5day-020A and al072008-5day-027A) issued during hurricane Gustav (August 29-31, 2008) were used. For each advisories, the current Cp and Rmax, storm forward speed, and landfall location data were extracted from the database and then the best matching synthetic stroms were identified based on the SSI values. (Table 1). For the advisory numner 20A, synthetic storm JOS6003A had the highest SSI (0.84), whereas, for the advisory number 27A (Figure 1), the SSI (0.83) was updated and new synthetic storm JOS6001A was selected. For validation, model surge elevations were compared with the observed High Water Mark (HMS) for hurricane Gustav (Figure 2). In general the model surge elevations extracted from JOS6001A synthetic storm were in good agreement with the observed HWMs.

Table 1. The results identifying the group of storms with high SSI values for two advisories (al072008-5day-020A and al072008-5day-027A).

Advisory Number	al072008_5day_020A		al072008_5day_027A	
Date	08/30/00:00		08/31/12:00	
Location (Lat/Long; $_o$)	19.3/-80.0		29.1/-90.4	
Current CP (mb)	980		958	
Current Rmax (nm)	20		15	
Forward Speed (knot)	10.5		10.3	
Landfall (Lat/Long; ^{o})	29.1/-91.0		29.1/-90.4	
Results	Synthetic Storm	SSI	Synthetic Storm	SSI
	JOS6003A	0.84	JOS6001A	0.82
	JOS6001A	0.80	CAT2008A	0.78
	JOS6011A	0.78	JOS6001B	0.73
	CAT2008A	0.77	CAT2008B	0.72
	JOS6003B	0.75	JOS6004A	0.71
	CAT2008B	0.71	CAT2008C	0.63

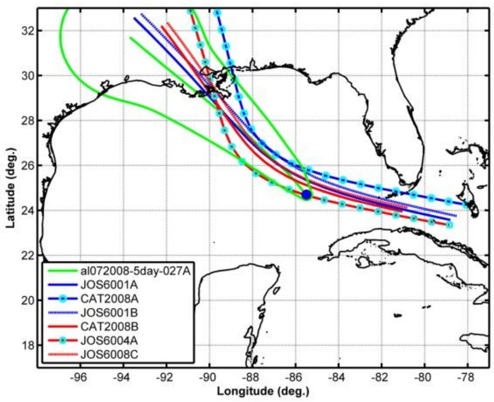

Figure 1. Advisory Number 27 and synthetic storm tracks.

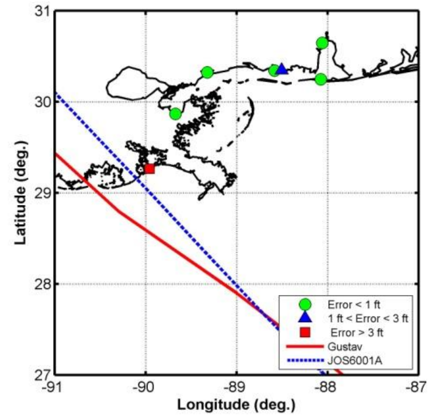

Figure 2. Track of Hurricane Gustav (in Red) and the best matching synthetic storm JOS6001A (in Blue).

Conclusions

Forecasting storm surge using data mining is a very efficient and robust technique. Recently, this technique has been implemented as an analytical component to the widely used DRIS. DRIS is an intelligent decision-support system for use by emergency operators for urban search and rescue, risk assessment, evacuation planning, and resource management which utilizes GIS and fussy logic to support decision-making prior to, during, and following a major disaster. With the help of this technique within the DRIS framework, decision maker and emergency managers can quickly assess the impact of an approaching hurricane and can make objective decisions by evaluating what-if-scenarios starting two to three days ahead of landfall (Figure 3).

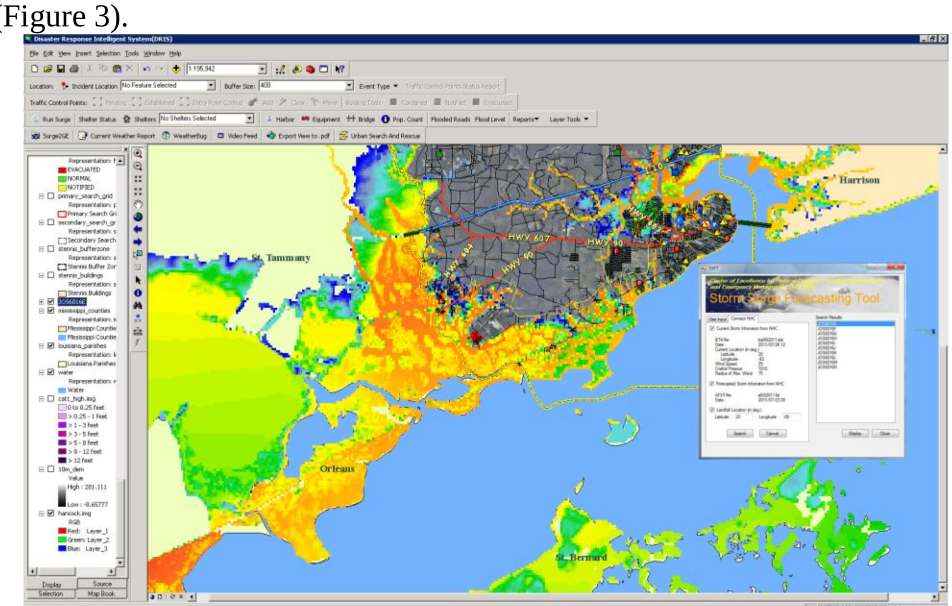

Figure 3. Example of DRIS system showing flood areas predicted from a synthetic storm.

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