Modeling Nearshore Waves for Hurricane Katrina

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Outline

• Introduction
• Modeling Approach
• Hurricane Katrina Simulations
• Sensitivity Analysis
• Summary and Conclusions
Hurricane Katrina

- Cat 3 on 27 August 2005 to Cat 5 on 28 Aug
- Peak: 280 km/hr, 902 mb
- Landfall Louisiana: 29 Aug, Cat 3, 205 km/h, 920mb
- Landfall Mississippi: Cat 3, 195 km/hr
- Hurricane force winds 190 km from center
- Offshore wave heights ~17 m
IPET

- Interagency Performance Evaluation Task Force
  Evaluate performance of Louisiana levee system
  https://ipet.wes.army.mil/
  Review: ASCE and National Research Council

- Hydrodynamic modeling methodology
  Characterize waves and water levels along entire periphery of the hurricane protection system
  Winds, waves, and surge
Wind and Atmospheric Pressure Fields

- Primary input to Wave and Storm Surge Modeling
- Wind fields are blend of measurements and modeling
  - NOAA HRD H*Wind snapshots
  - Blended to NCEP model winds and data using IOKA wind analysis process (OWI)
- Most anemometers close to the storm failed near the peak

Mark Powell, HRD
Vince Cardone & Andy Cox, OWI

Max wind speeds exceed 51 m/s
Offshore Wave Model -- WAM

- Basin – Regional WAM c4.5
- Resolution 0.1 deg, 0.0083 deg
- Wave-storm surge interaction neglected at basin & region level
- WAM-WAVEWATCH III comparisons
Buoy 42040

Wave Height

- Max 16.8

Peak Period

- Max 15 sec

Mean Period

- Max 13 sec

Wave Dir

- Max 30.9 m/s

Wind Speed

- Max 33.4 m/s

Buoy 42007

Wave Height

- Max 7 m

Peak Period

- Max 15 sec

Mean Period

- Max 12 sec

Wave Dir

- Wind Dir
ADCIRC – Surge Model
1165122 elements
598240 nodes

Joannes Westerink, Notre Dame
Hurricane Katrina Peak High Water Elevations Plotted with High Water Marks Superimposed with Error Values Labelled Beside
Katrina STWAVE Grids
South Louisiana Wave Heights

Significant Wave Height (m)

- Metro New Orleans
- Mississippi River
- Mississippi River Delta
Southeast Louisiana Wave Heights

- Chandeleur Islands
- Lake Borgne
- Mississippi River Delta
Southeast Louisiana Wave Periods

- Chandeleur Islands
- Lake Borgne
- Mississippi River Delta
Mississippi-Alabama Wave Heights

Significant Wave Height (m)

0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0

Biloxi, MS
Mobile, AL
Mobile Bay
Mississippi-Alabama Wave Periods

Peak Wave Period (sec) at Maximum Wave Height

Biloxi, MS

Mobile, AL

Mobile Bay
Lake Pontchartrain Wave Heights

Significant Wave Height (m)

- 2.6
- 2.4
- 2.2
- 2.0
- 1.8
- 1.6
- 1.4
- 1.2
- 1.0
- 0.8
- 0.6
- 0.4
- 0.2
- 0.0
Lake Pontchartrain Wave Periods

Peak Wave Period (sec) at Maximum Wave Height
Lake Pontchartrain

Peak Wave Period (sec)

Date (August 2005, UTC)

Tp Meas 22 (24 DOF)
Tp Meas 23 (24 DOF)
Tp STWAVE
Sensitivity Analysis

- Wind Input
  +/- 5% wind speeds
- Bathymetry
  degraded Chandeleurs Islands
- Bottom Roughness
  pre- and post-Katrina roughness
- Time Dependence
Wind Sensitivity
Wave Height Differences: +5% – Base

Result: ± 0.3 m near the shoreline
± 0.3 to 1.0 m offshore
Bathymetry Sensitivity
Wave Height Differences: Degraded – Base

Result: Maximum Difference 1.8 m
near zero difference at the shoreline
Roughness Sensitivity: Pre-Katrina – Post-Katrina Roughness

Result: 0.3-0.5 m decreased surge with decreased roughness
0.2 m increase in surge in limited areas
Sensitivity: Time Dependence
Time-Dependent v. Steady-State SWAN

Date (August 2005, UTC)

Hmo (m)

Gauge 22 (24 DOF)
Gauge 23 (24 DOF)
STWAVE
Steady-State SWAN
Time-Dependent SWAN

Time step 1 min
Steady 99% accuracy (15 iterations)
Summary

• **STWAVE Applied for Hurricane Katrina**
  • High resolution, half- and full-plane mode
  • Interactions with surge critical
  • Results used to evaluate design/response

• **Results**
  • Katrina wave heights near or exceeded design
  • Periods in many areas 2-3 times design values
  • Wave-surge-wetland interaction not simple “rule of thumb”
  • **SHALLOW-WATER MEASUREMENTS NEEDED!**

• **Continuing Work**
  • More validation (Katrina, Rita, Camille, Ivan, Betsy, Andrew)
  • Design studies for Mississippi and Louisiana coasts
  • FEMA flood mapping