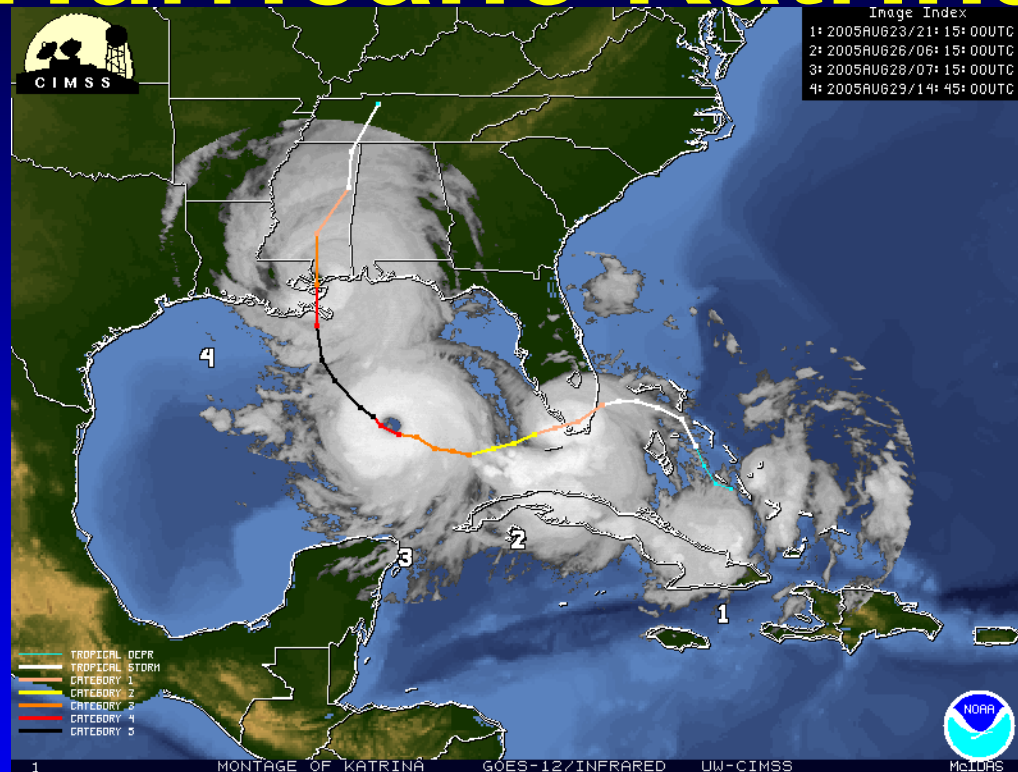
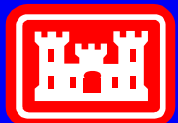


# Modeling Nearshore Waves for Hurricane Katrina



**Jane McKee Smith**

US Army Engineer Research & Development Center  
Coastal and Hydraulics Laboratory

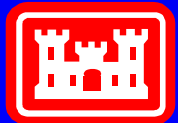
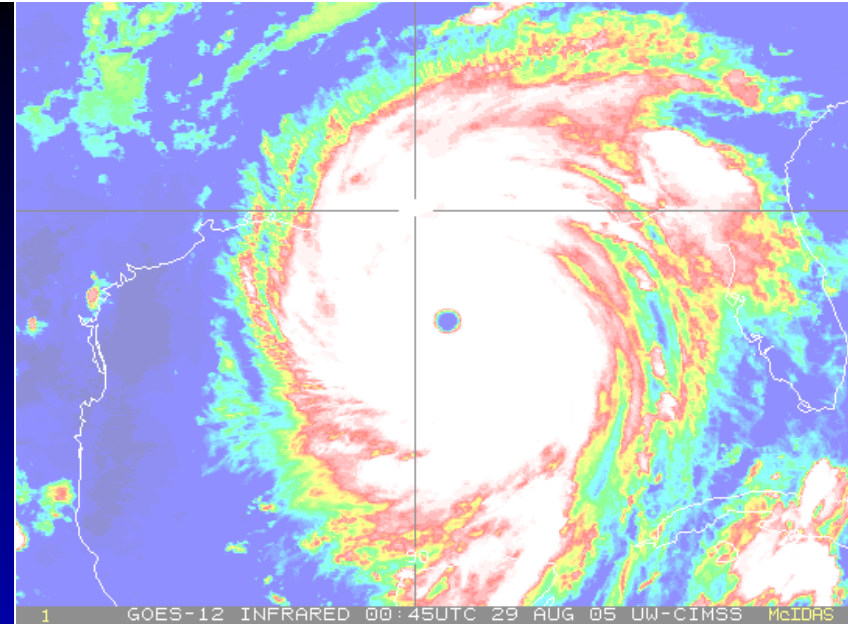


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Coastal and Hydraulics Laboratory - ERDC

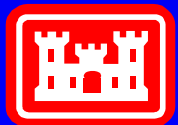
# Outline

- 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



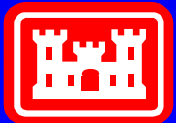
US Army Corps  
of Engineers

Coast

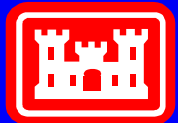
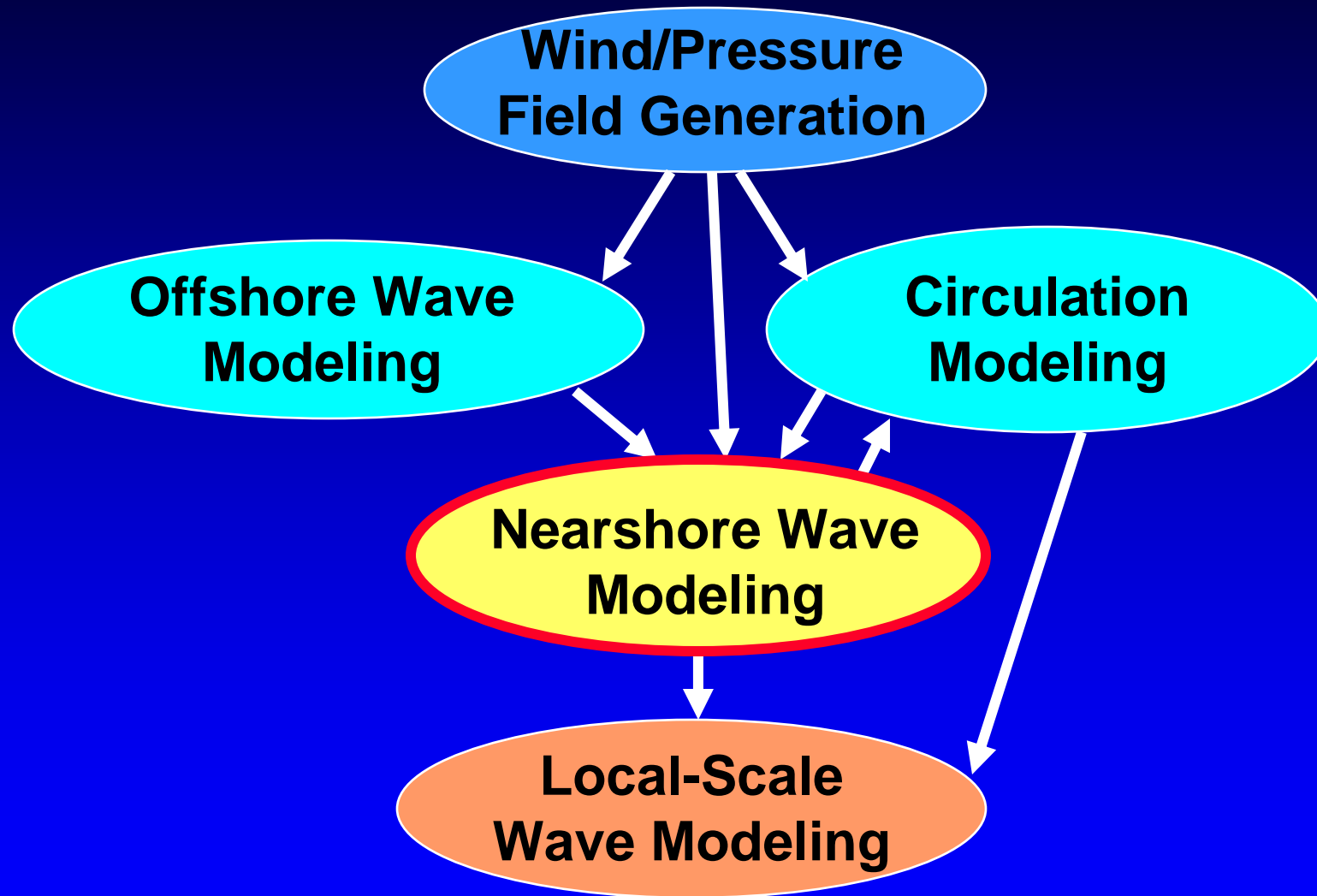


# IPET

- 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



# Modeling Methodology



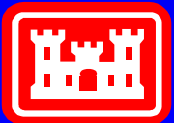


# Wind and Atmospheric Pressure Fields

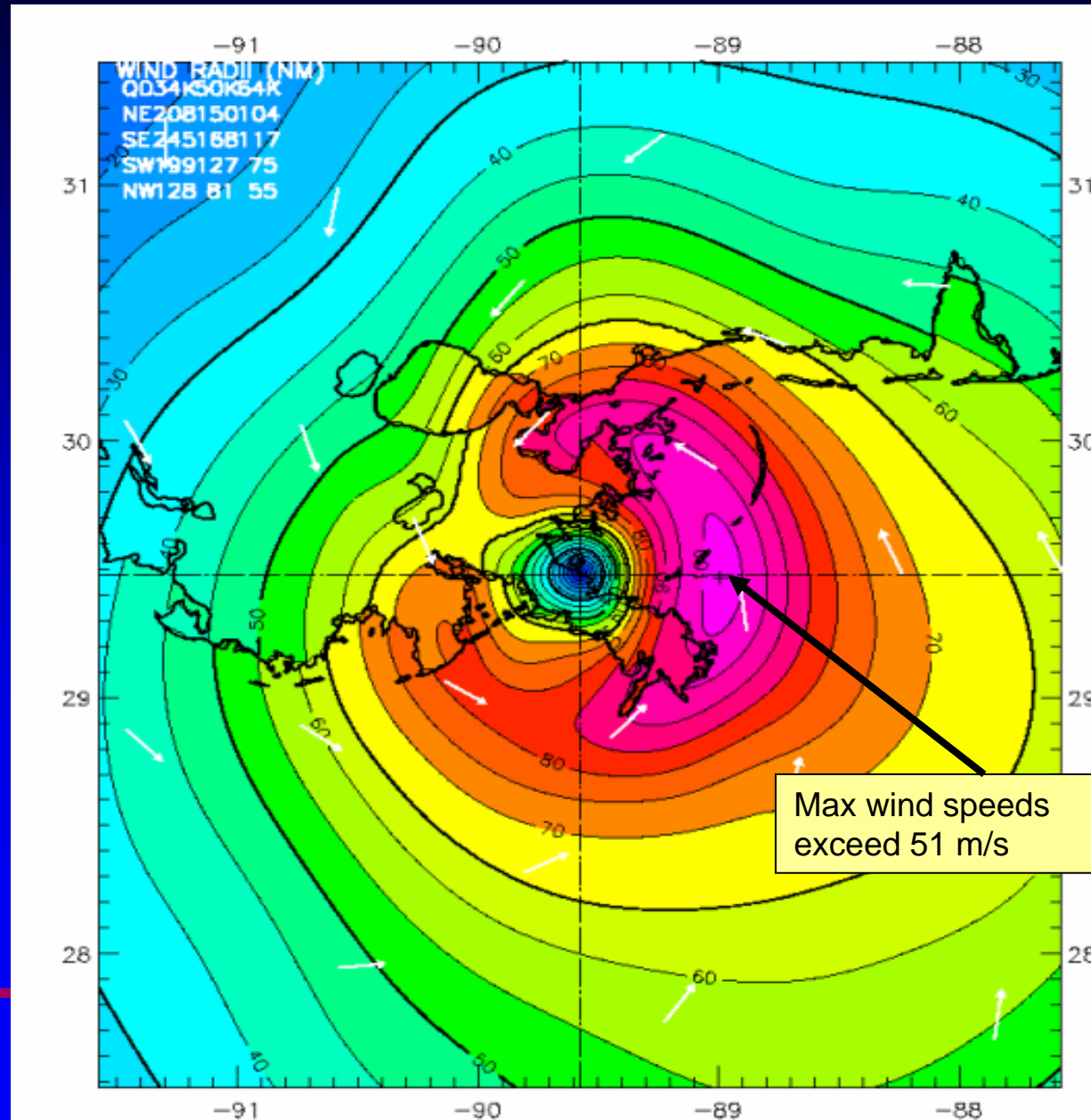
- Primary input to Wave and Storm Surge Modeling
- Wind fields are blend of measurements and modeling
  - NOAA HRD H\*Wind snapshots
  - Blended to NCEP model winds and data using IOKA wind analysis process (OWI)
- Most anemometers close to the storm failed near the peak

Mark Powell, HRD

Vince Cardone & Andy Cox, OWI

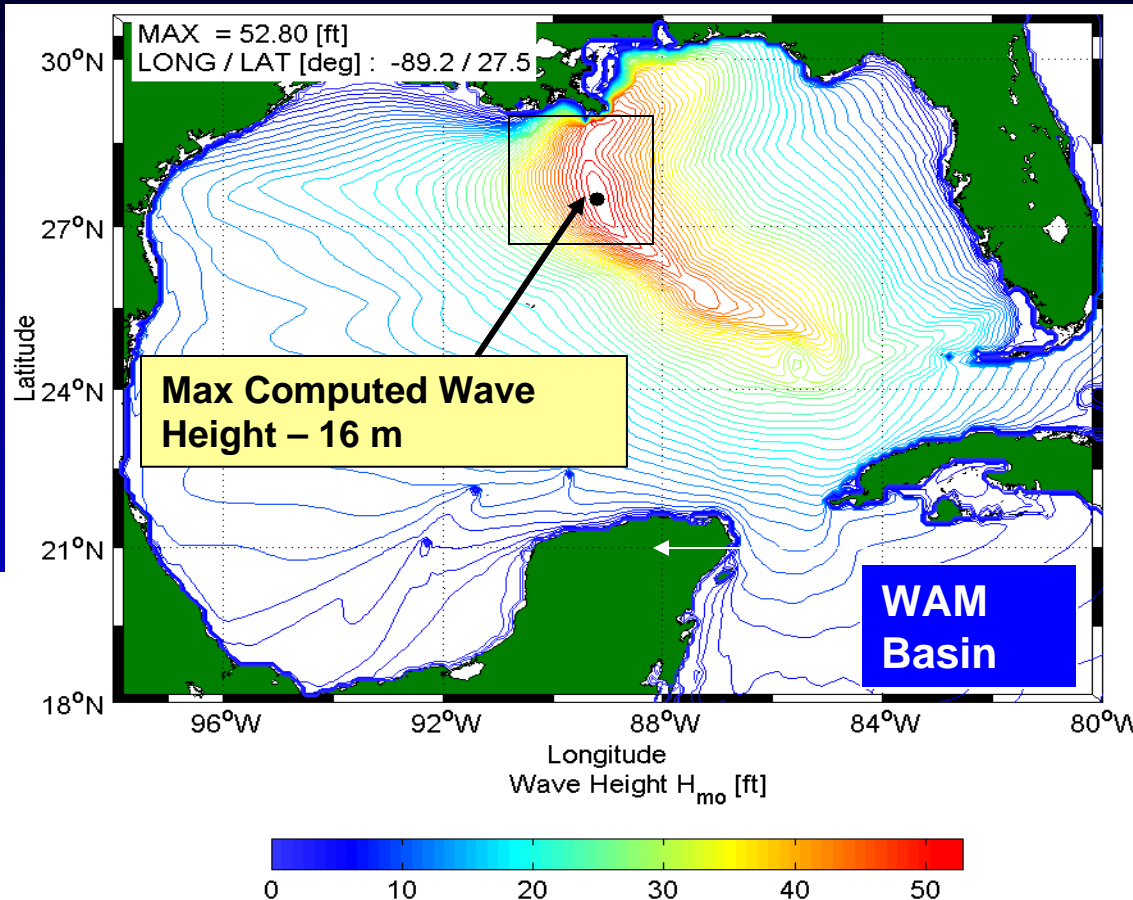
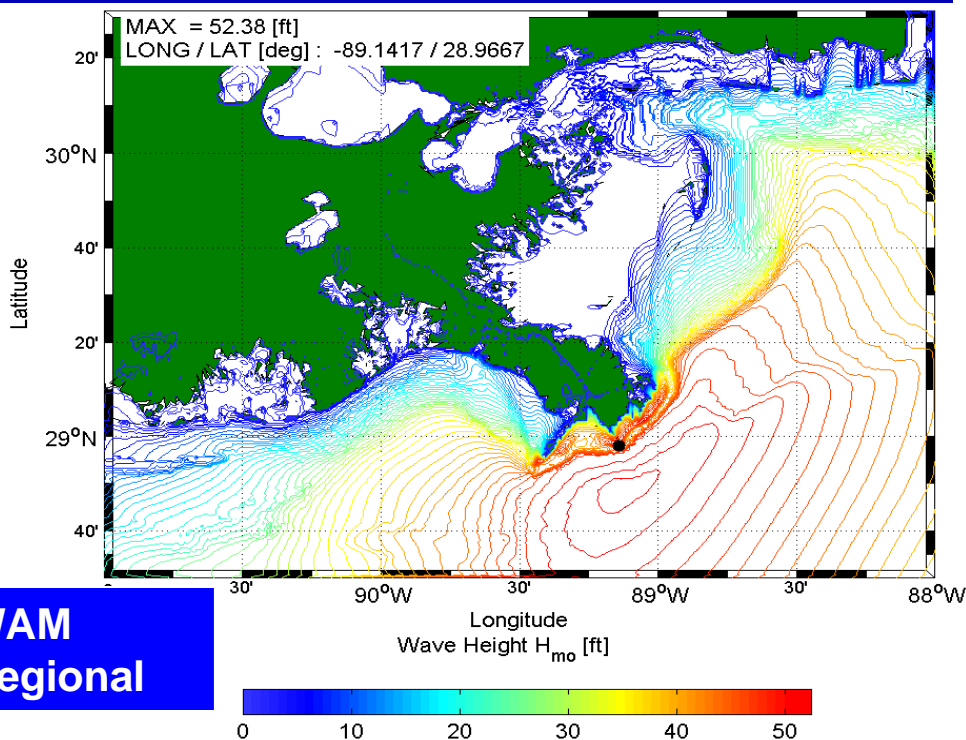


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# Offshore Wave Model -- WAM

- 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



Max Wave Height Map, ft

Bob Jensen, CHL

Barbara Tracy, CHL

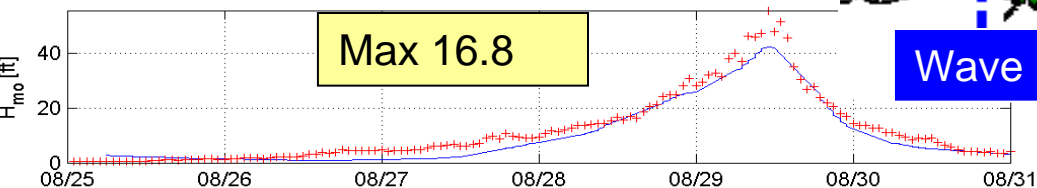
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## Buoy 42040

KATRINA [OWI75] BASIN WAM4.5 [ -88.2 ° / 29.2 ° ]  
NDBC = 42040 [ -88.2136° / 29.1847 ° ] at h= 899.704 ft

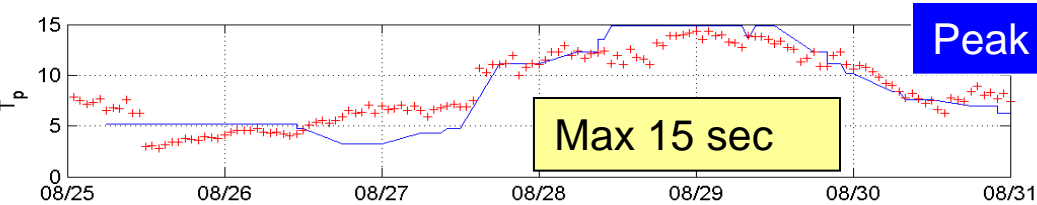
Max 16.8

Wave Height



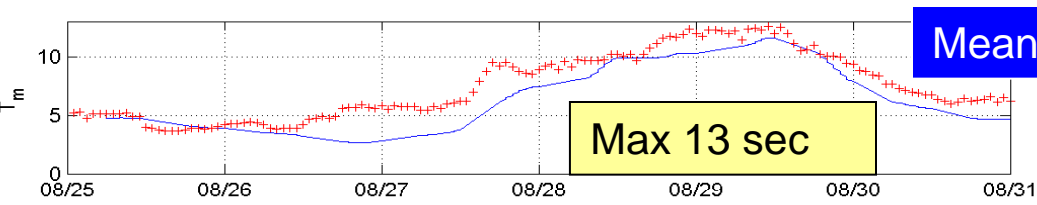
Peak Period

Max 15 sec

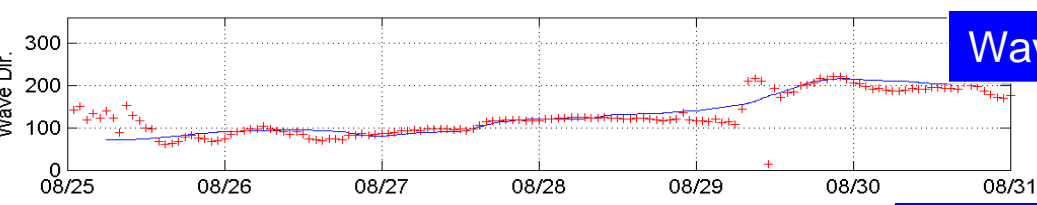


Mean Period

Max 13 sec

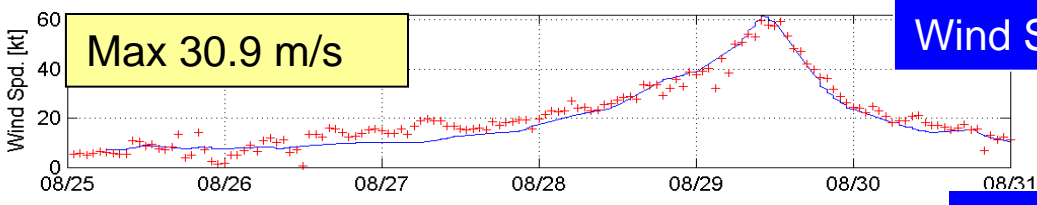


Wave Dir

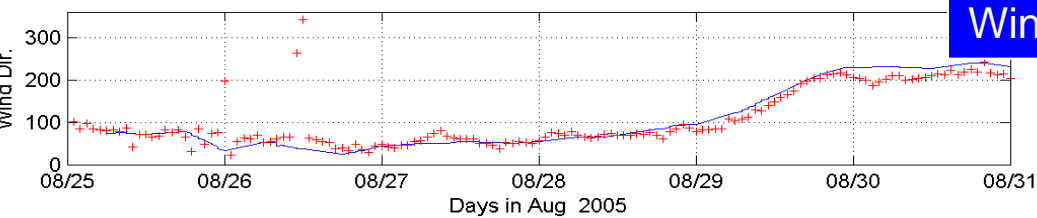


Wind Speed

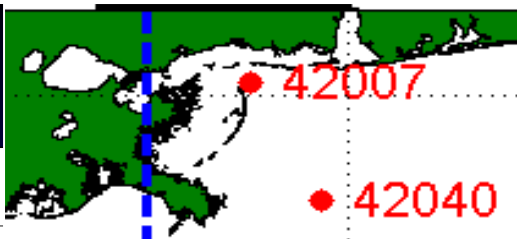
Max 30.9 m/s



Wind Dir



Days in Aug 2005

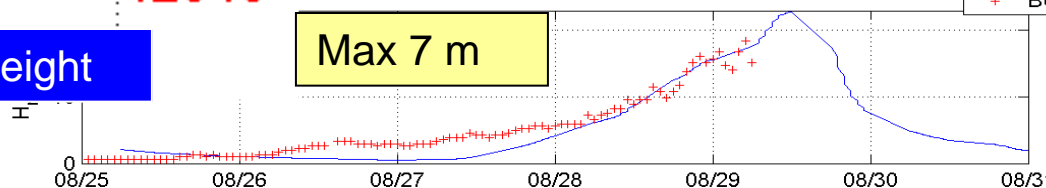


## Buoy 42007

KATRINA [OWI75] BASIN WAM4.5 [ -88.7 ° / 30° ]  
NDBC = 42007 [ -88.7694° / 30.0903 ° ] at h= 43.952 ft

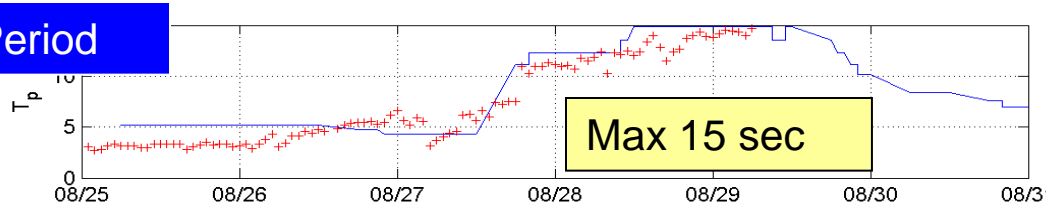
Max 7 m

Wave Height



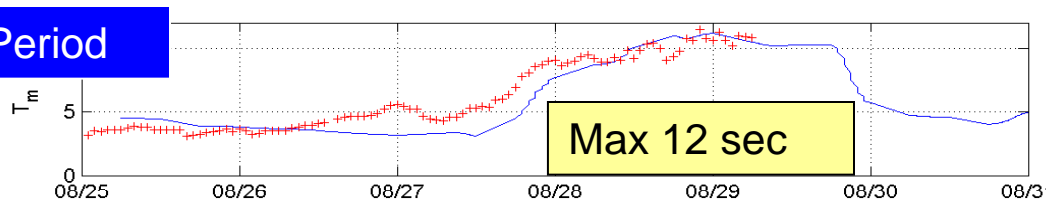
Peak Period

Max 15 sec

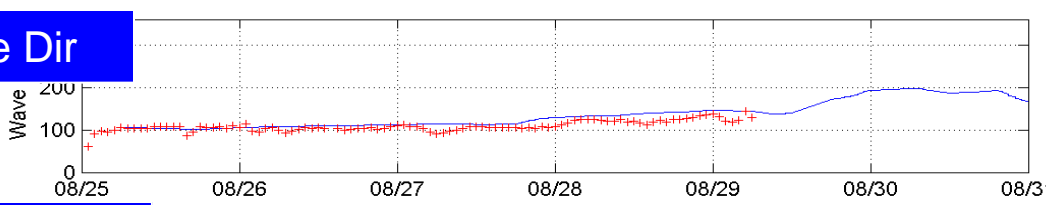


Mean Period

Max 12 sec

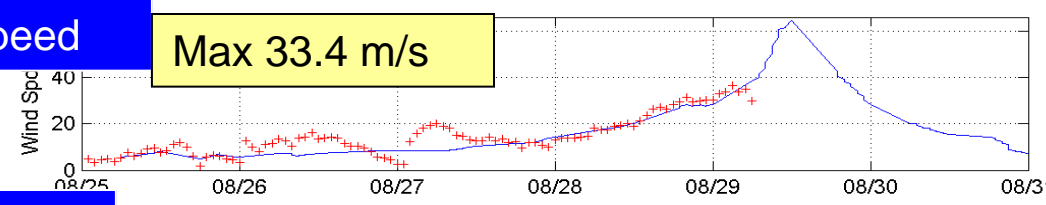


Wave Dir

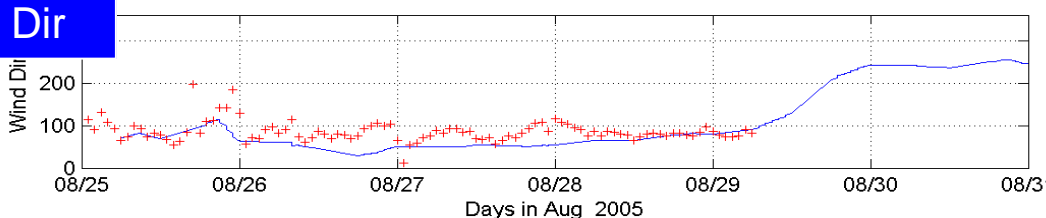


Wind Speed

Max 33.4 m/s



Wind Dir



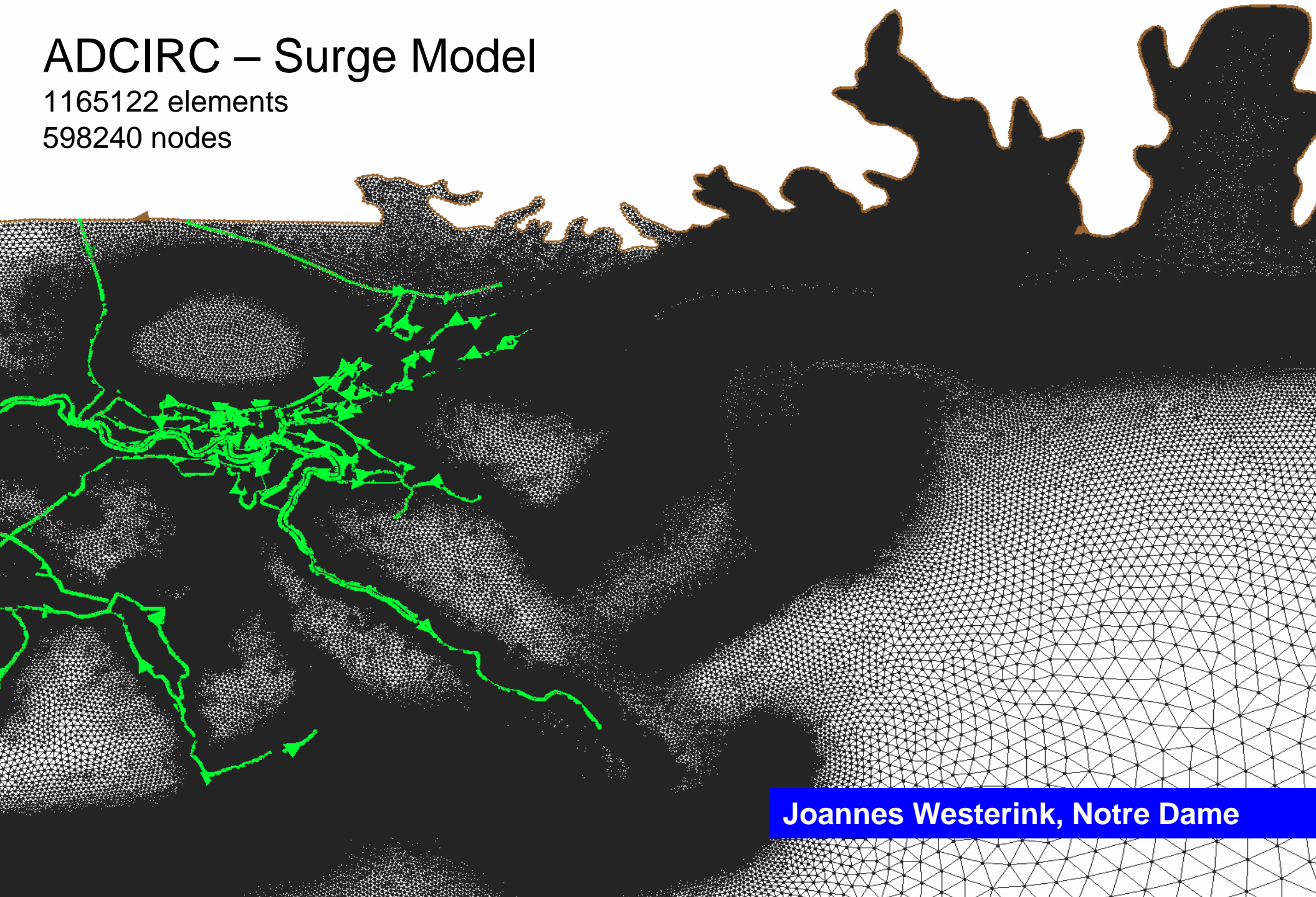
Days in Aug 2005



# ADCIRC – Surge Model

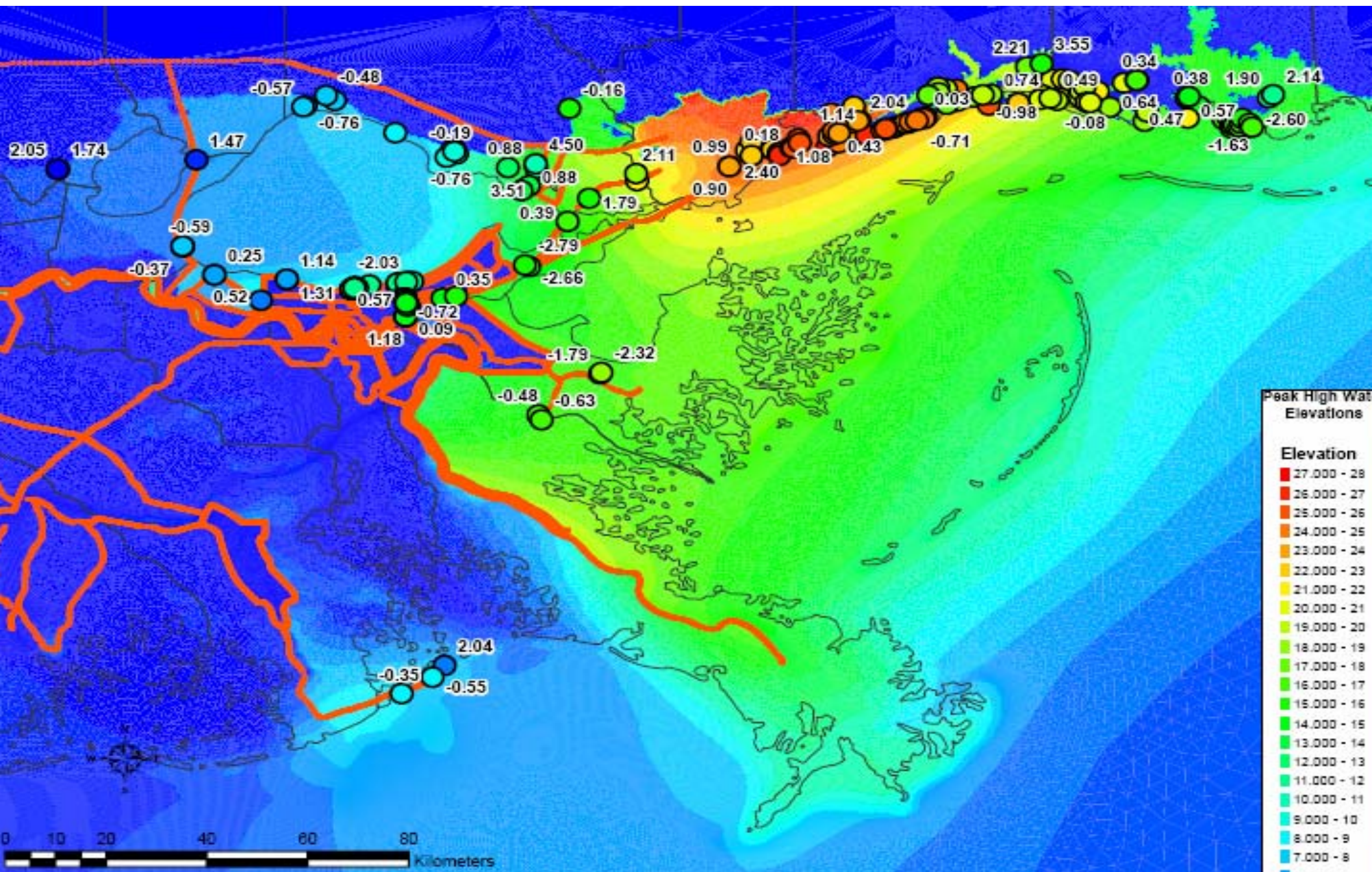
1165122 elements

598240 nodes



Joannes Westerink, Notre Dame

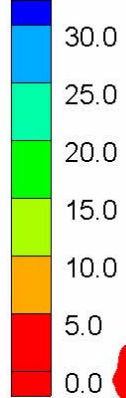




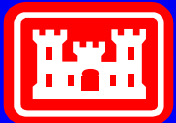
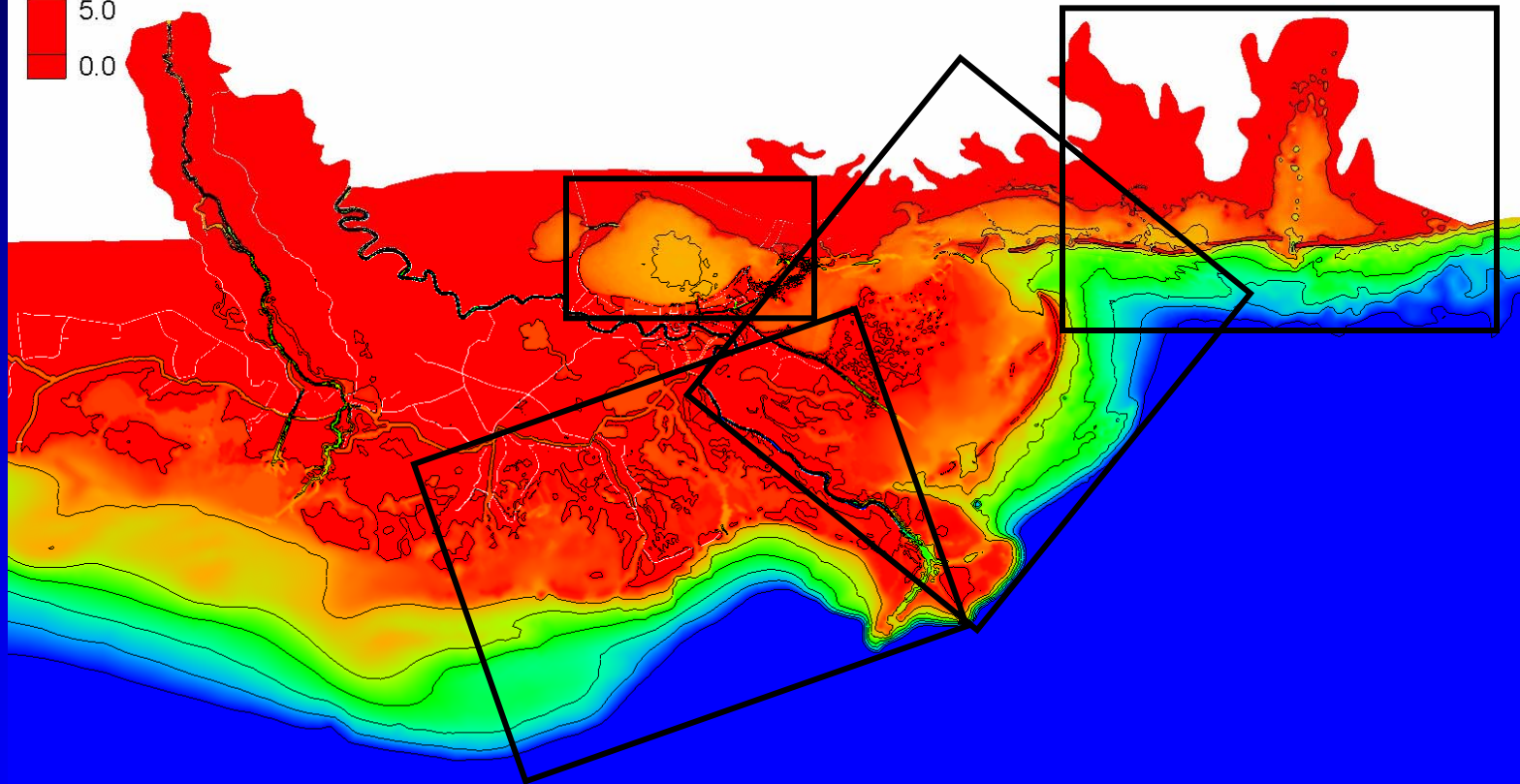
Hurricane Katrina Peak High Water Elevations Plotted with High Water Marks Superimposed with Error Values Labelled Beside



Depth (m MTL)



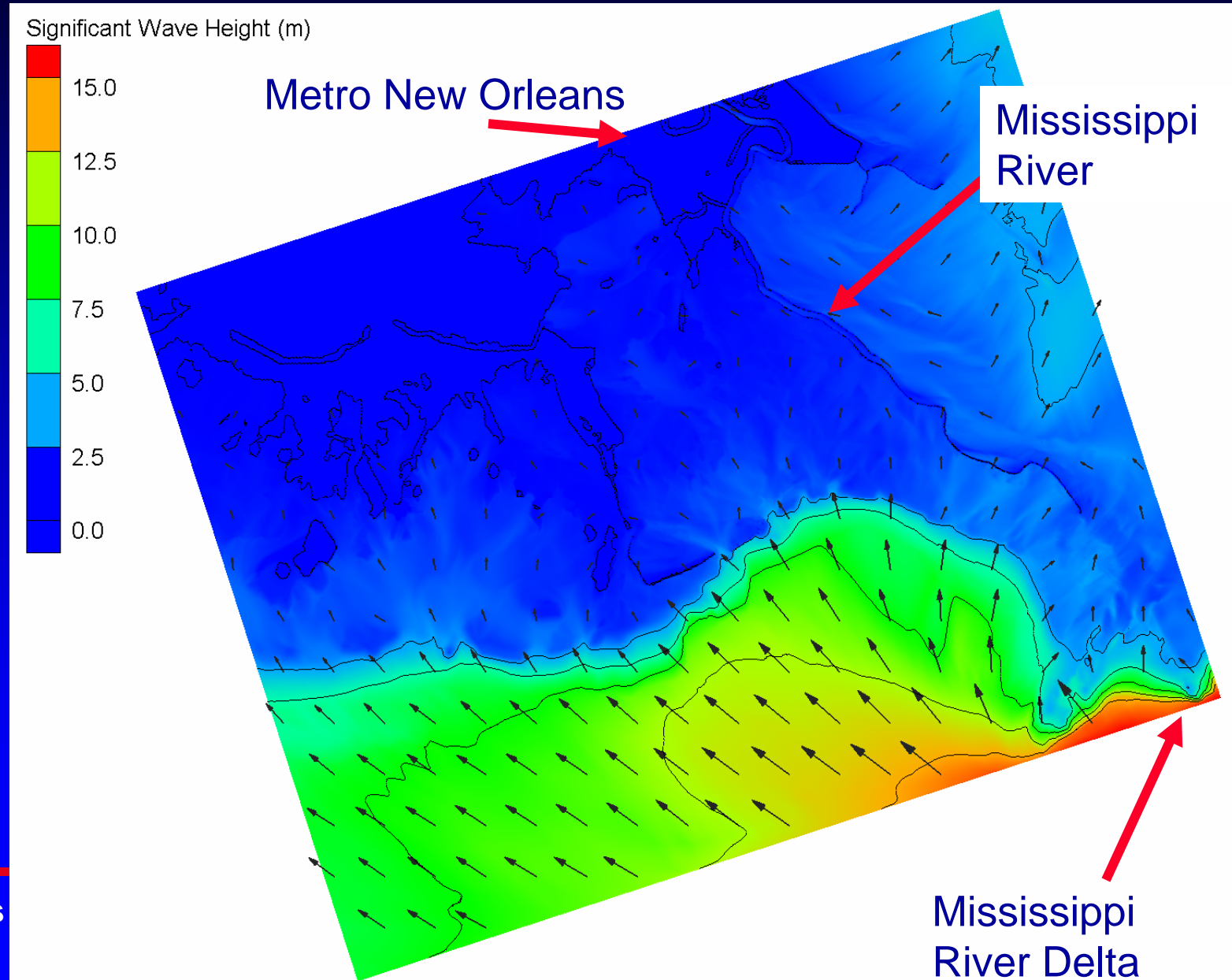
# Katrina STWAVE Grids



US Army Corps  
of Engineers

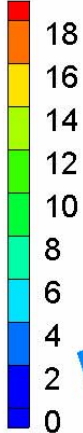
Coastal and Hydraulics Laboratory - ERDC

# South Louisiana Wave Heights



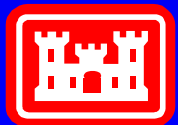
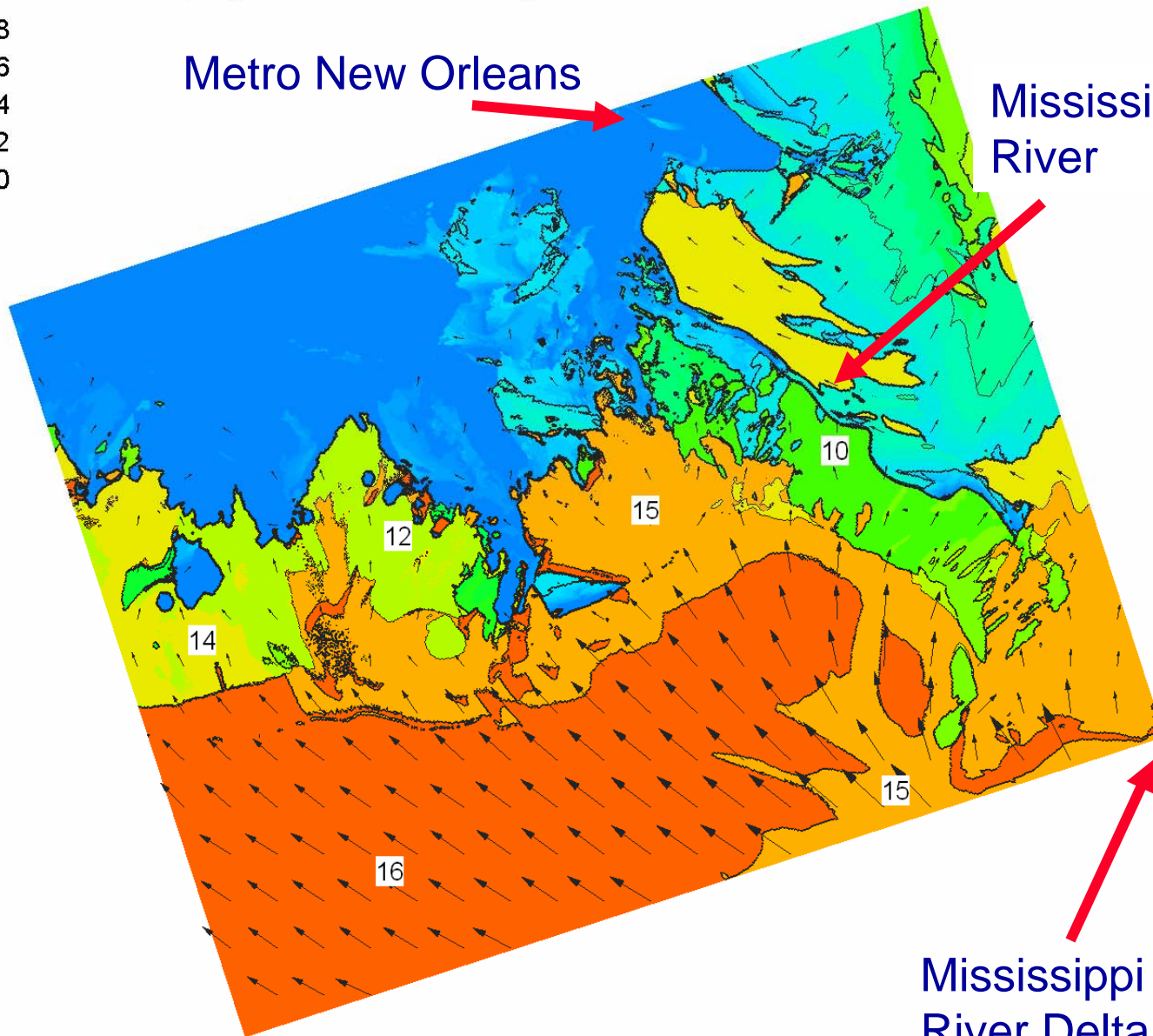
# South Louisiana Wave Periods

Peak Wave Period (sec) at Maximum Wave Height



Metro New Orleans

Mississippi River



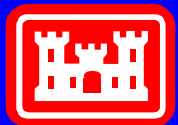
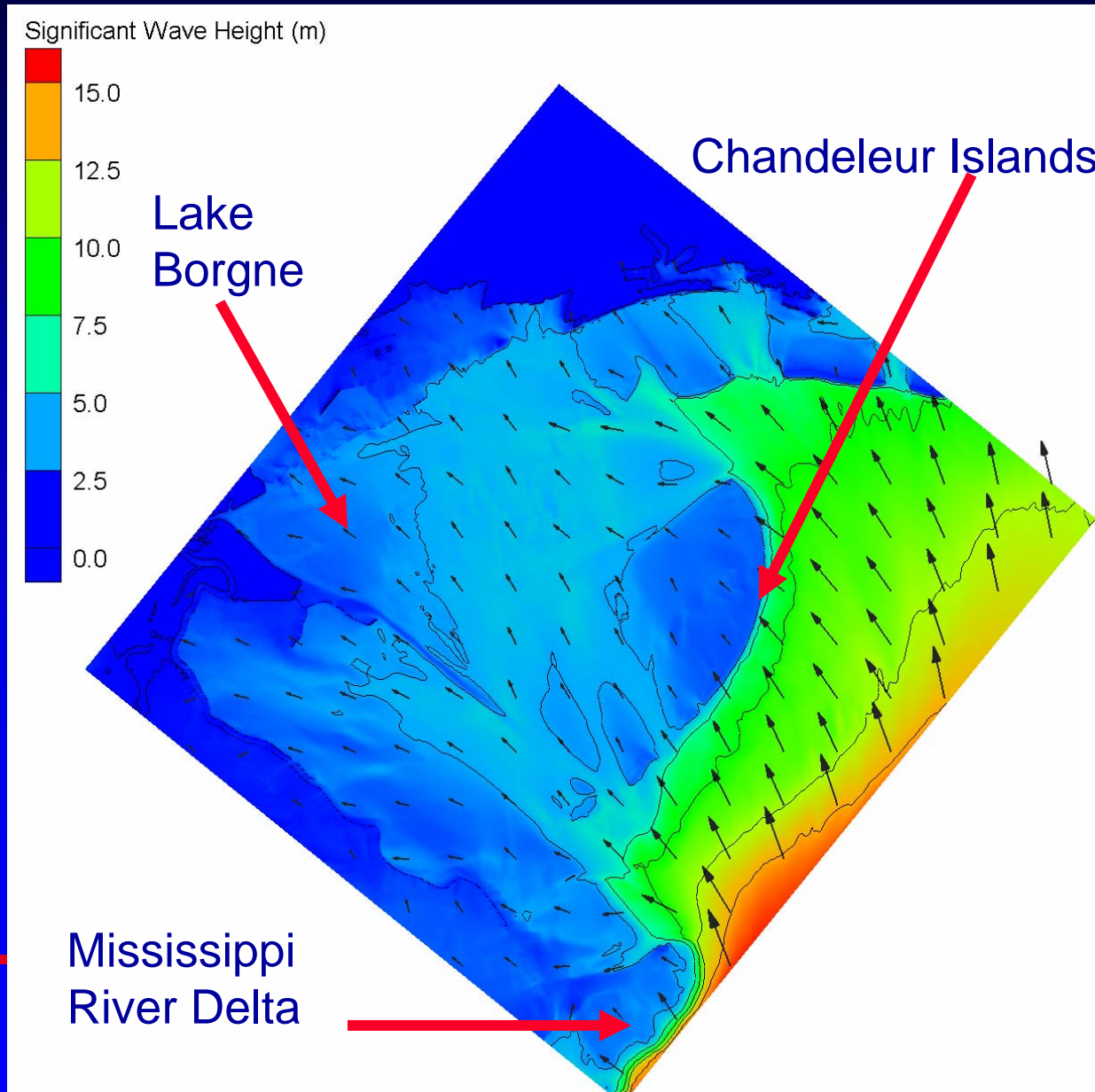
US Army Corps  
of Engineers

Mississippi  
River Delta

- ERDC



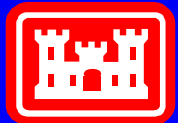
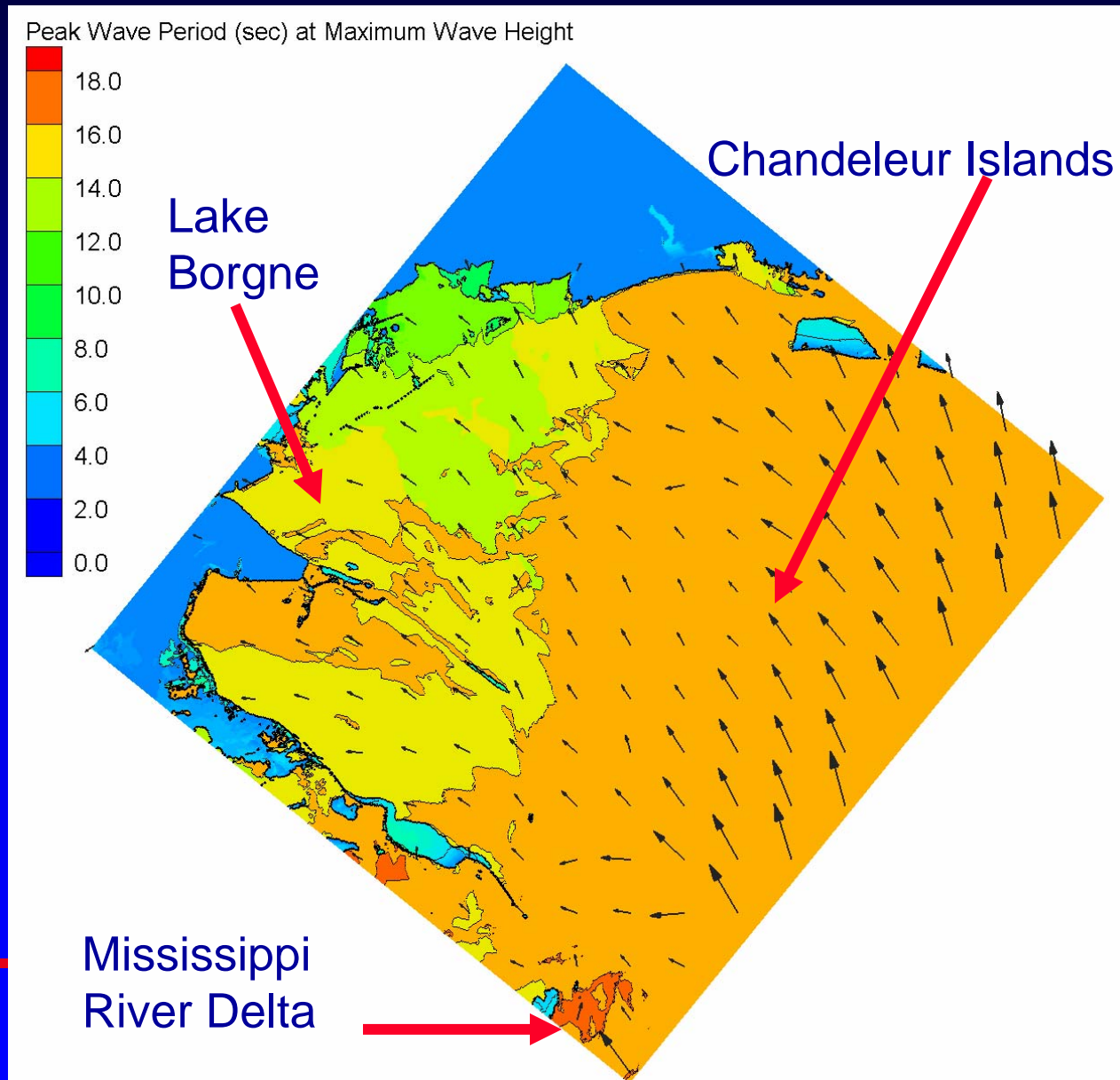
# Southeast Louisiana Wave Heights



US Army Corps  
of Engineers

laboratory - ERDC

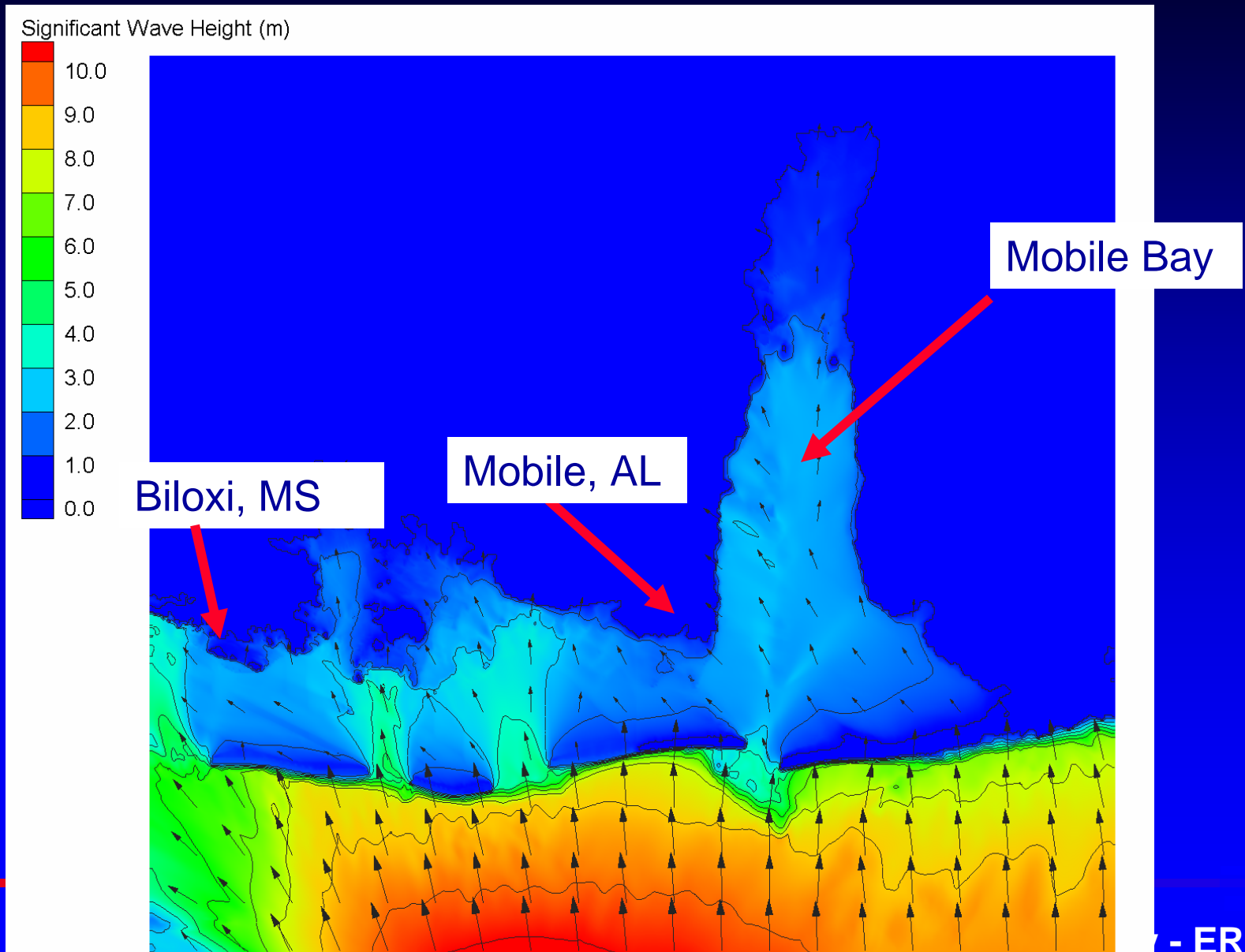
# Southeast Louisiana Wave Periods



US Army Corps  
of Engineers

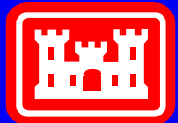
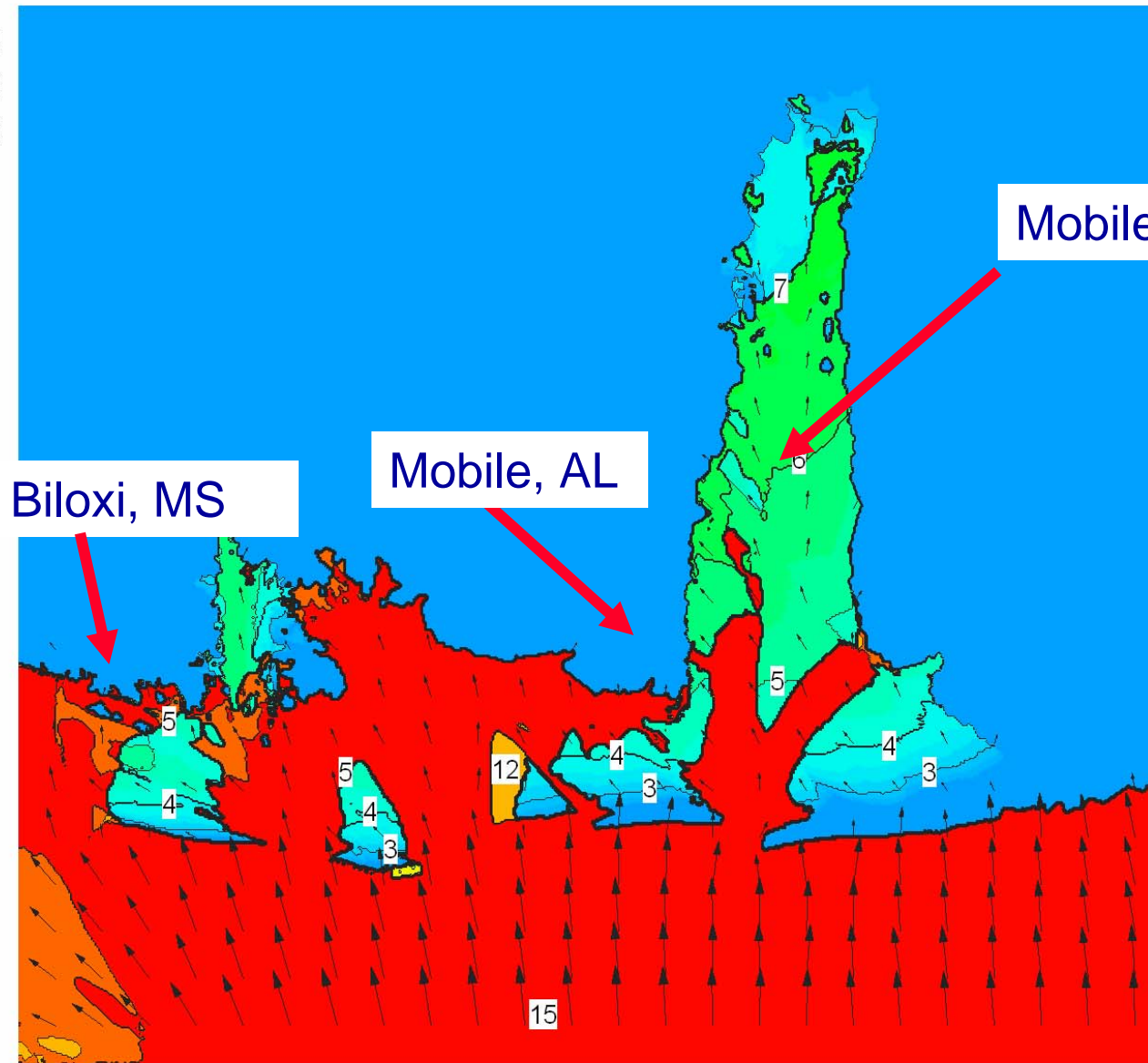
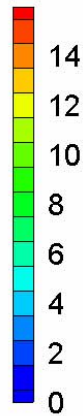
laboratory - ERDC

# Mississippi-Alabama Wave Heights



# Mississippi-Alabama Wave Periods

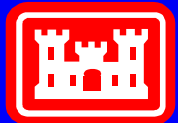
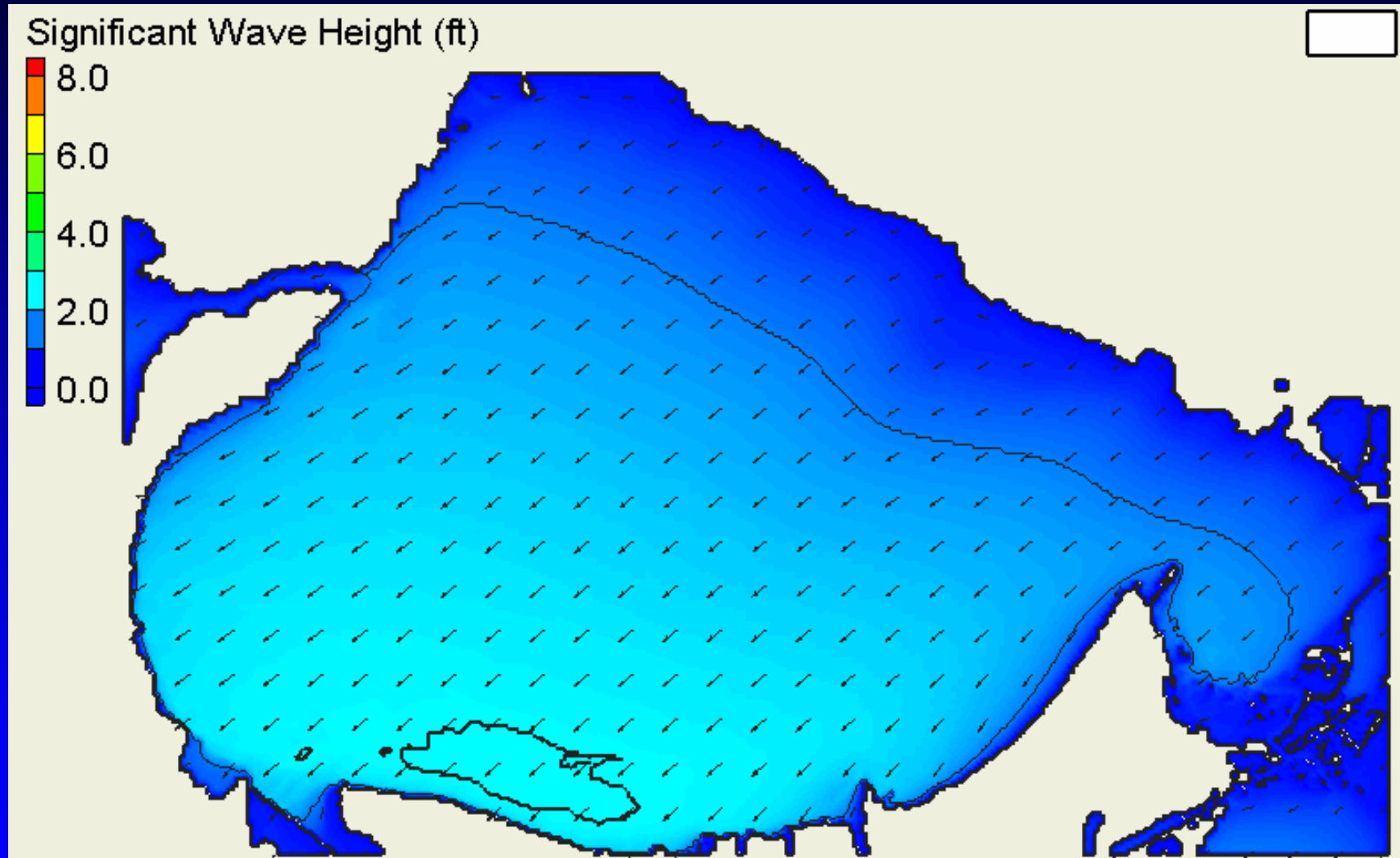
Peak Wave Period (sec) at Maximum Wave Height



US Army Corps  
of Engineers

ERDC

# Lake Pontchartrain



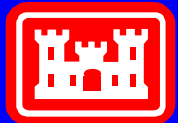
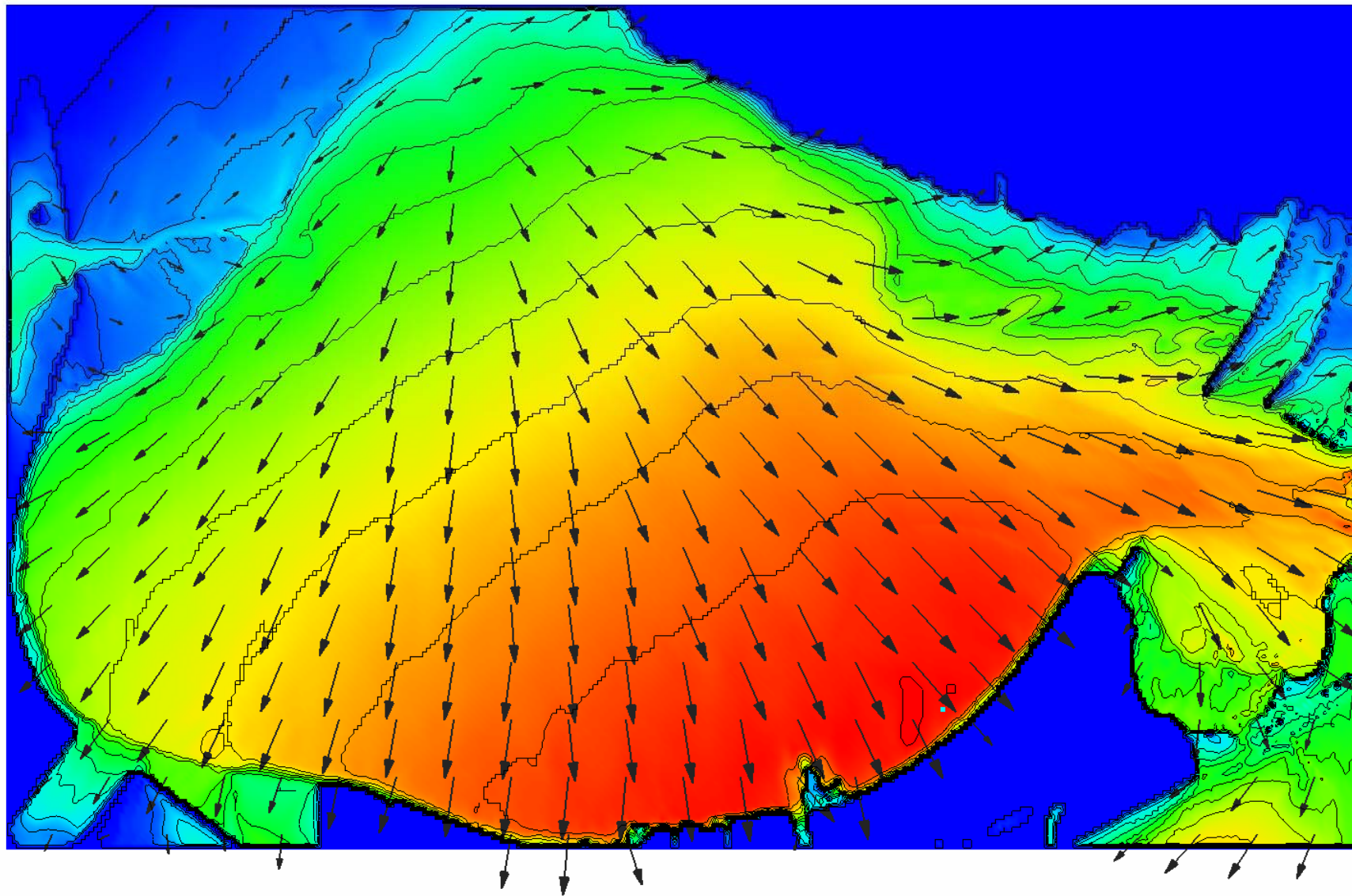
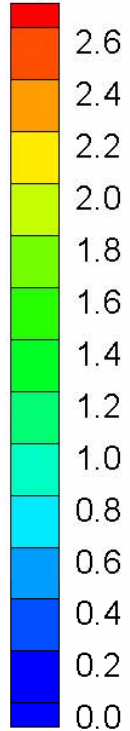
US Army Corps  
of Engineers

Metro New Orleans



# Lake Pontchartrain Wave Heights

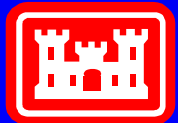
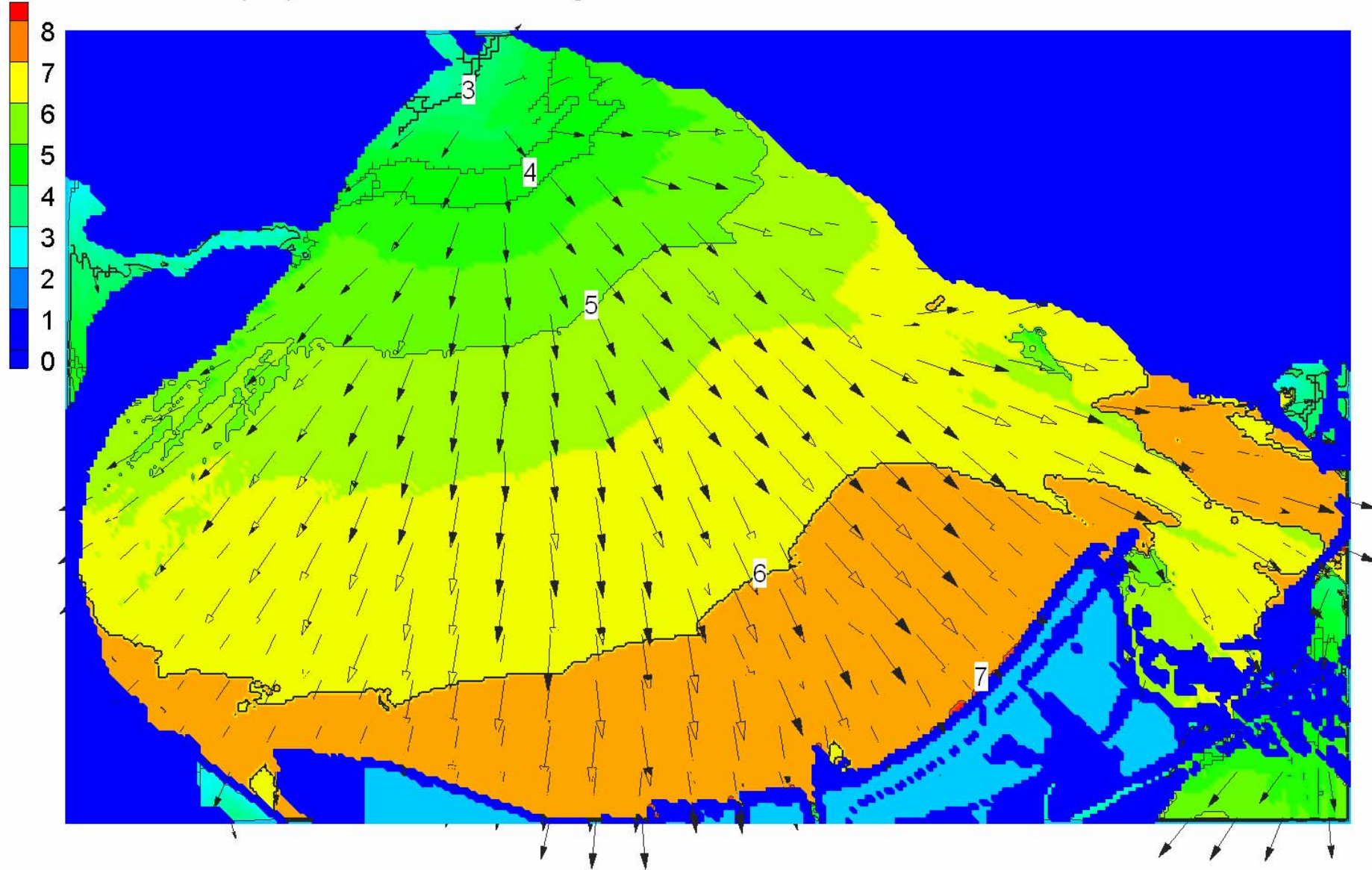
Significant Wave Height (m)



US Army Corps of Engineers

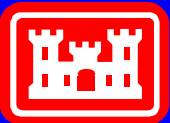
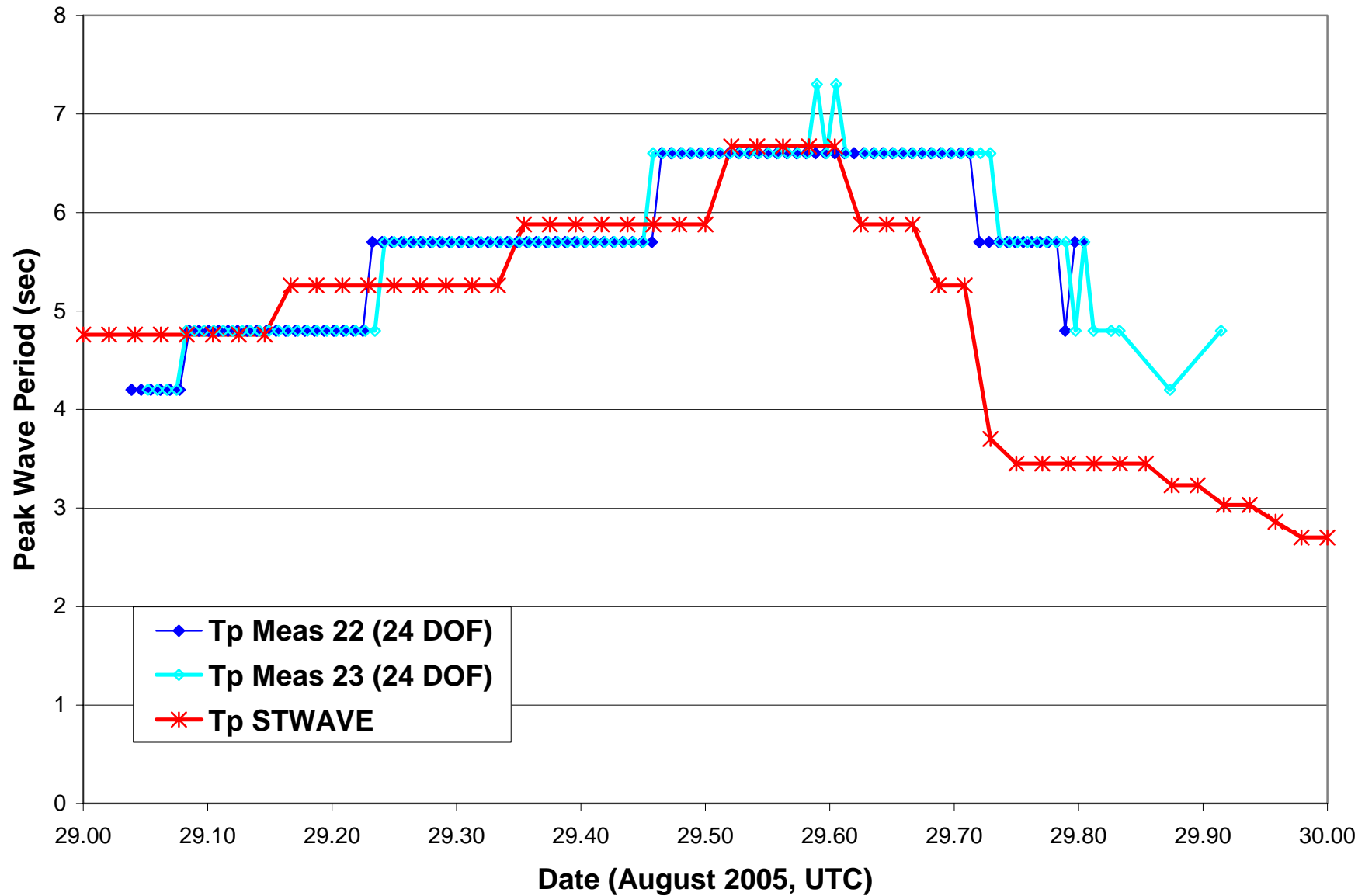
# Lake Pontchartrain Wave Periods

Peak Wave Period (sec) at Maximum Wave Height



US Army Corps of Engineers

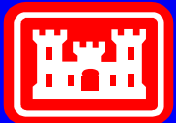
# Lake Pontchartrain



US Army Corps of Engineers

# Sensitivity Analysis

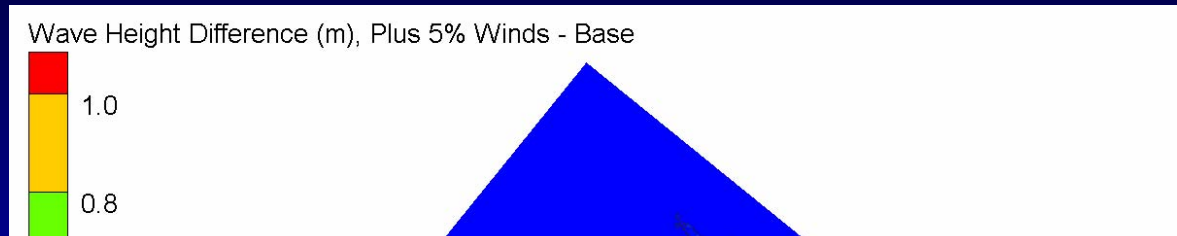
- Wind Input
  - +/- 5% wind speeds
- Bathymetry
  - degraded Chandeleurs Islands
- Bottom Roughness
  - pre- and post-Katrina roughness
- Time Dependence





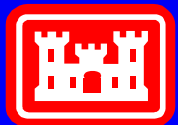
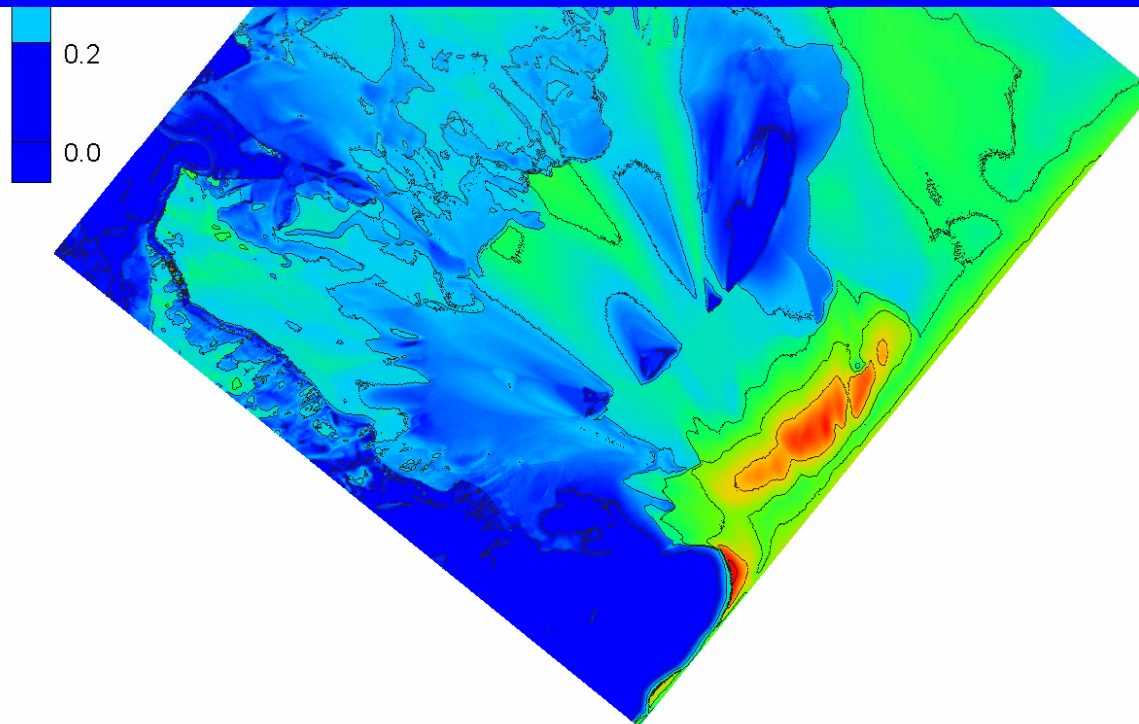
# Wind Sensitivity

## Wave Height Differences: +5% – Base



**Result:  $\pm 0.3$  m near the shoreline**

**$\pm 0.3$  to 1.0 m offshore**



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of Engineers

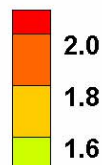
laboratory - ERDC



# Bathymetry Sensitivity

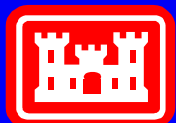
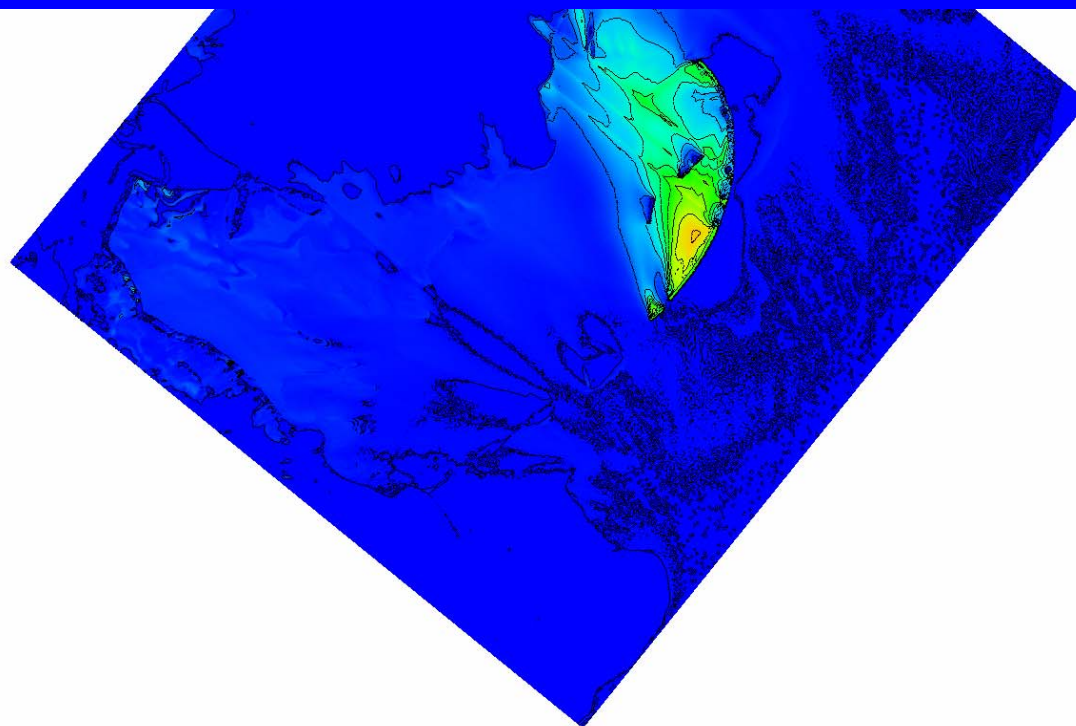
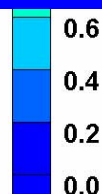
## Wave Height Differences: Degraded – Base

Difference in Wave Height (m), Chandeleurs Degraded - Base



**Result: Maximum Difference 1.8 m**

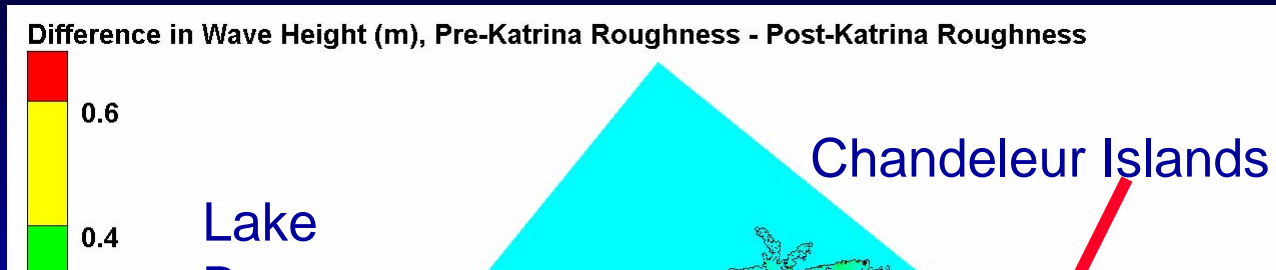
**near zero difference at the shoreline**



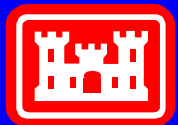
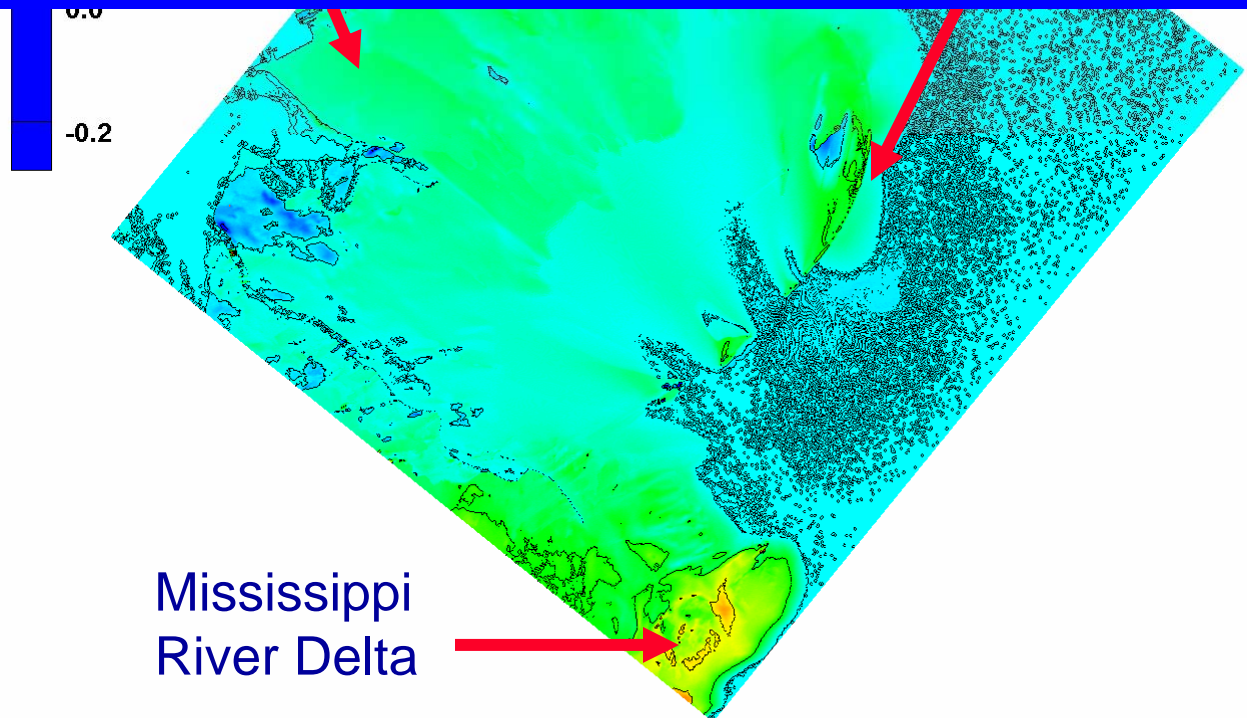
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of Engineers

atory - ERDC

# 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**

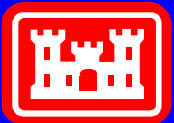
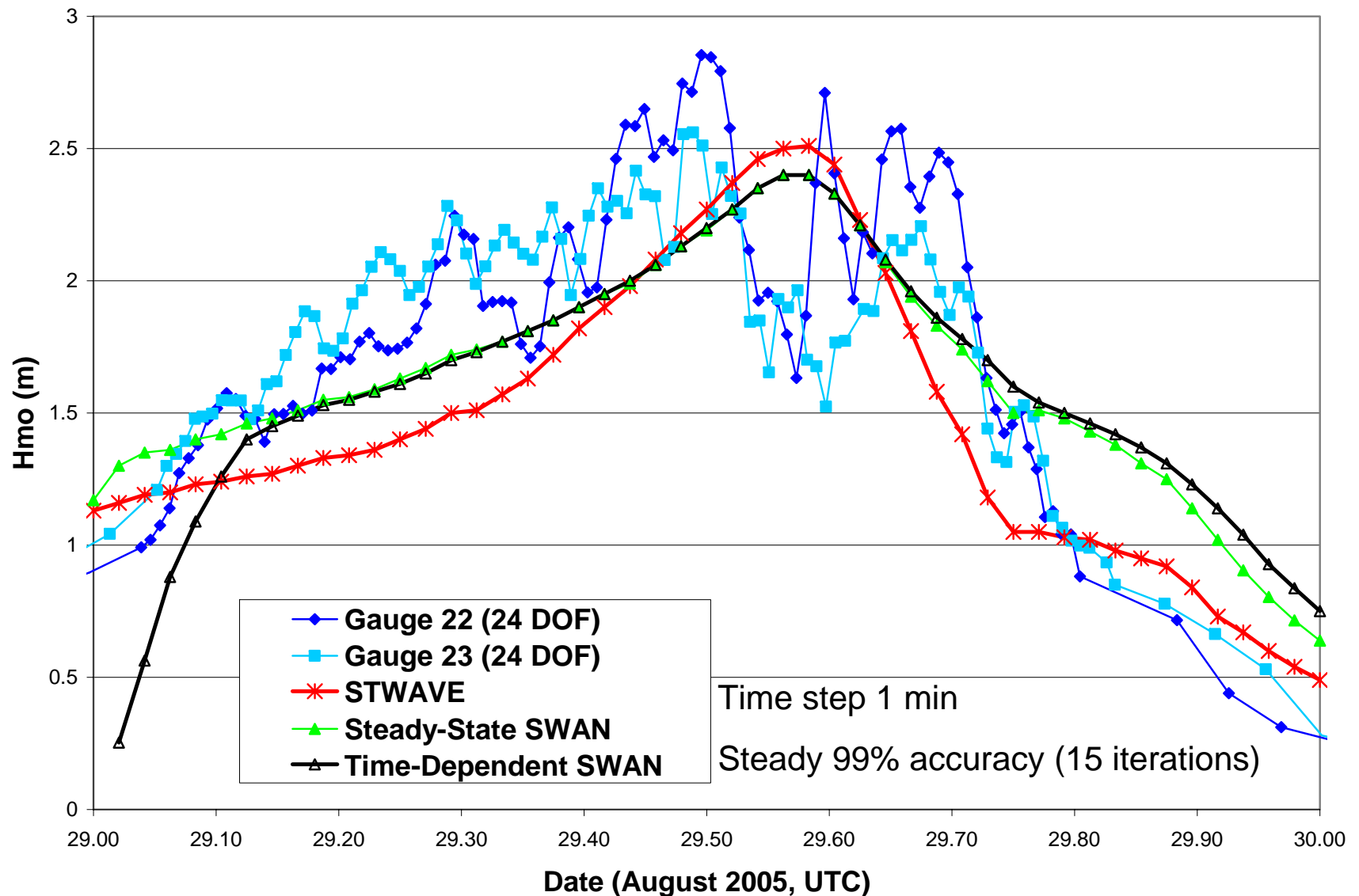


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# Sensitivity: Time Dependence

## Time-Dependent v. Steady-State SWAN



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# 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

