



# 75th MORSS CD Cover Page

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Original title on 712 A/B: Coastal Ocean Models as Planning Tools: A Case Study of Hurricane Katrina

Revised title: \_\_\_\_\_

Presented in (input and Bold one): (**WG10**, CG\_\_\_\_, Special Session \_\_\_\_, Poster, Demo, or Tutorial):

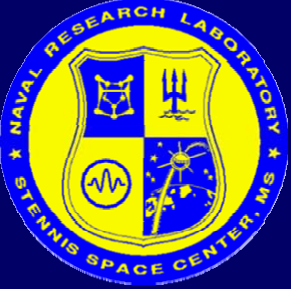
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## Report Documentation Page

*Form Approved*  
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1. REPORT DATE <b>01 JUN 2007</b>	2. REPORT TYPE <b>N/A</b>	3. DATES COVERED <b>-</b>	
4. TITLE AND SUBTITLE <b>Coastal Ocean Models as Planning Tools: A Case Study of Hurricane Katrina</b>		5a. CONTRACT NUMBER	
		5b. GRANT NUMBER	
		5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)		5d. PROJECT NUMBER	
		5e. TASK NUMBER	
		5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Naval Research Laboratory Oceanography Division, Code 7322 Stennis Space Center, MS 39529</b>		8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)	
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release, distribution unlimited</b>			
13. SUPPLEMENTARY NOTES <b>See also ADM202526. Military Operations Research Society Symposium (75th) Held in Annapolis, Maryland on June 12-14, 2007, The original document contains color images.</b>			
14. ABSTRACT			
15. SUBJECT TERMS			
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>	<b>UU</b>
			18. NUMBER OF PAGES <b>58</b>
			19a. NAME OF RESPONSIBLE PERSON



# Coastal Ocean Models as Planning Tools

## A Case Study from Hurricane Katrina Storm Surge

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*Dr. Chris Massey*

*Oceanography Division  
Naval Research Laboratory  
Stennis Space Center, MS*

[blain@nrlssc.navy.mil](mailto:blain@nrlssc.navy.mil)

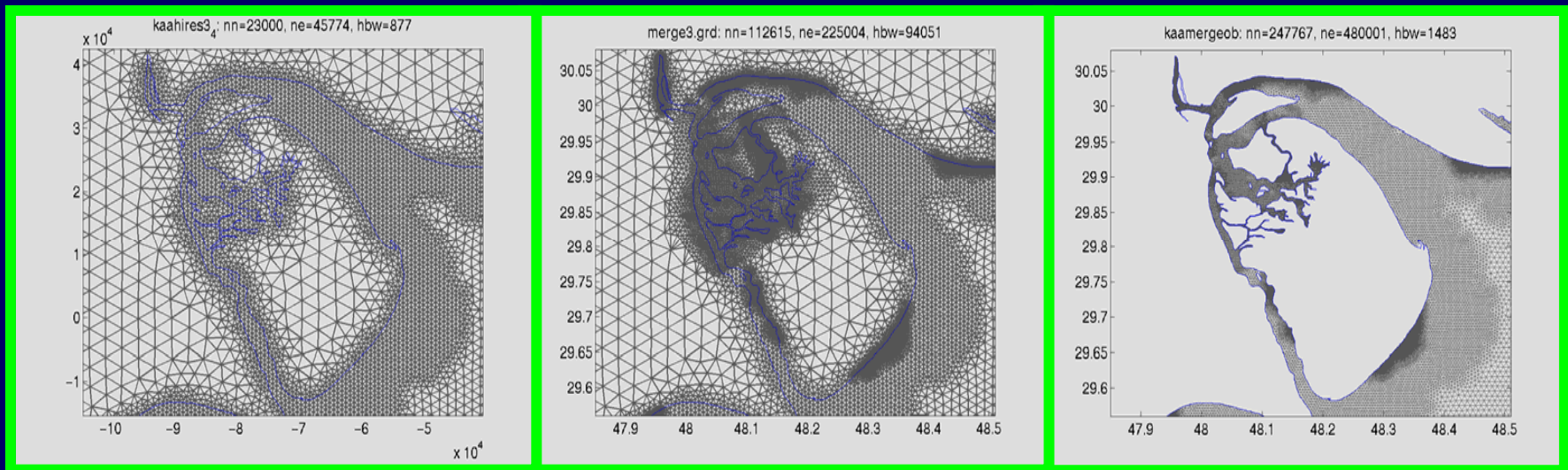
# Why Would the Navy be Interested in Storm Surge?

- Impact on Operations
- Protection of Assets
- Interest in the fate of enemy assets



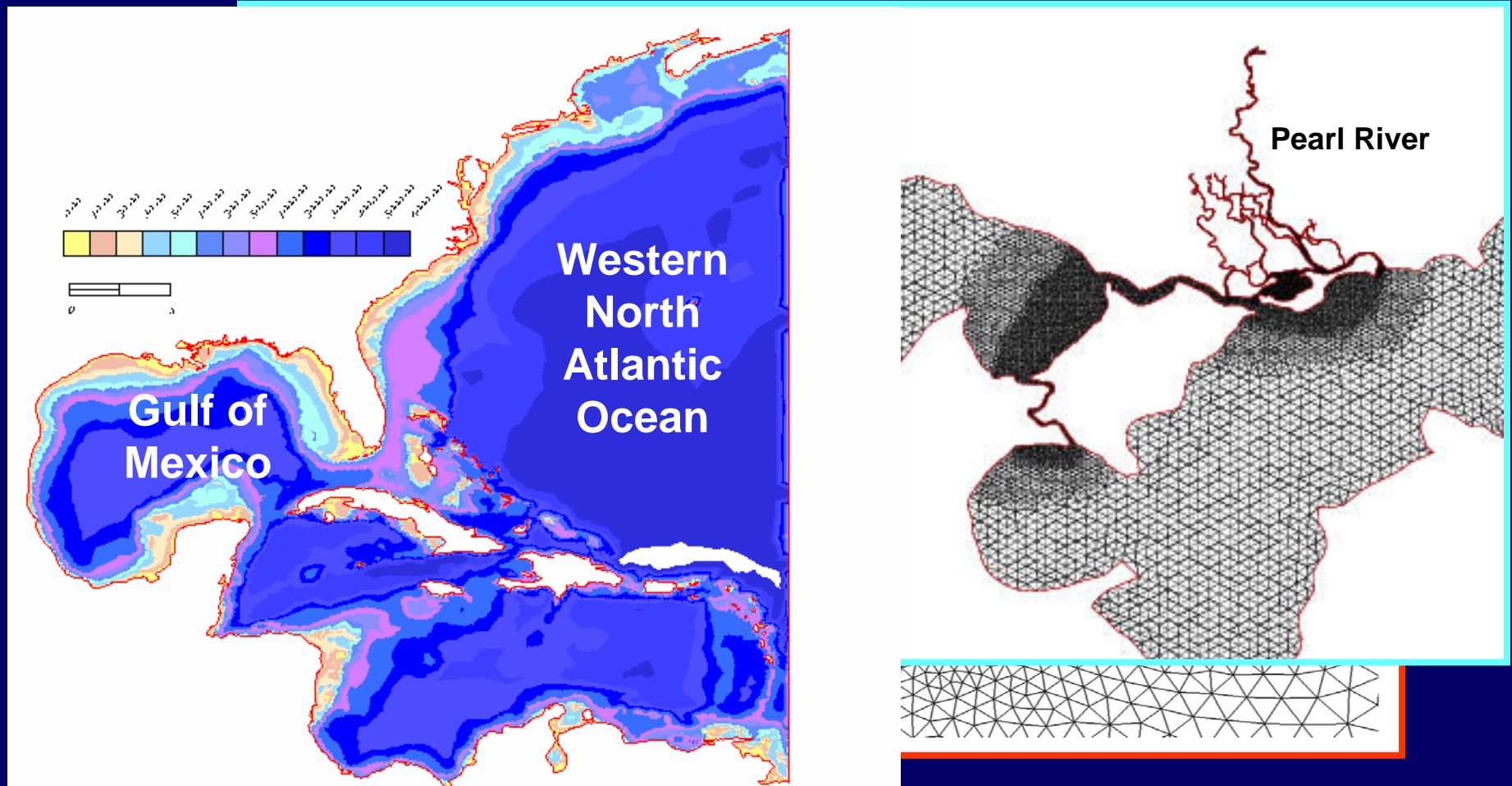
# Katrina Provided An Opportunity to Evaluate Navy Prediction Systems

- Typical applications in denied areas – sparse data
- Rapid deployment a priority – automation of modeling
- Require robust, accurate forecasts



Development of semi-automated mesh generation

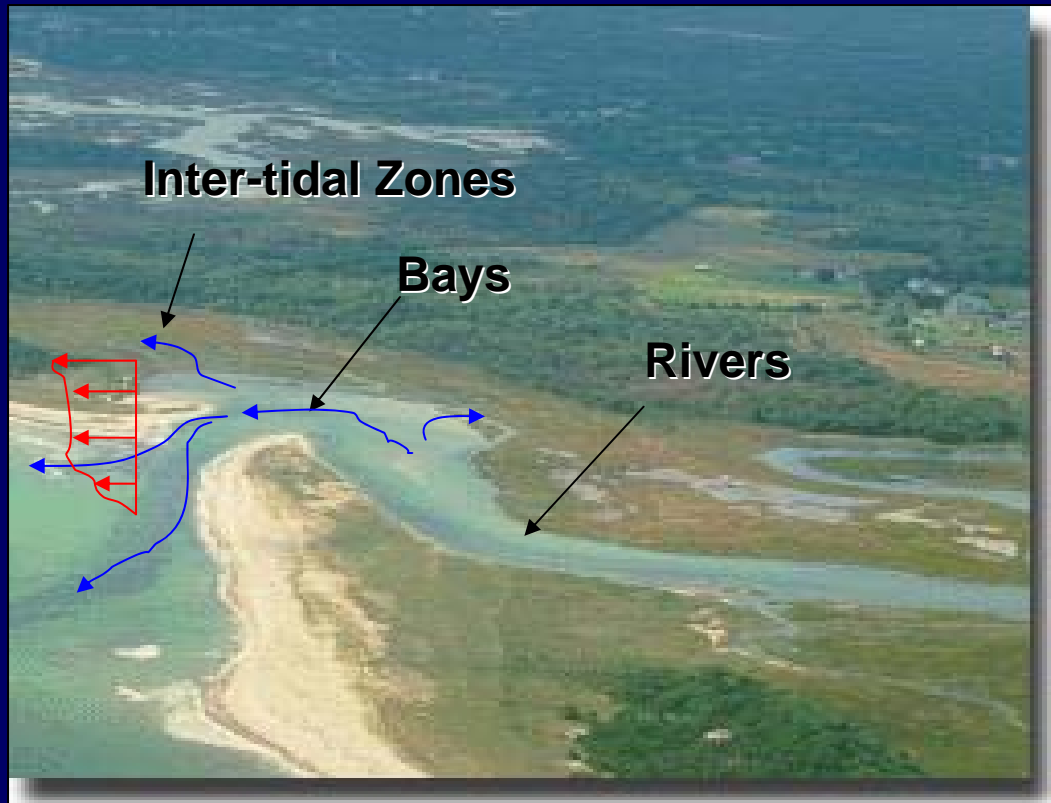
# Approach: Unstructured Grids



- Realistic coastline morphology
- Fine-scale resolution of inter-tidal zones, rivers
- Large domains with remote open boundaries

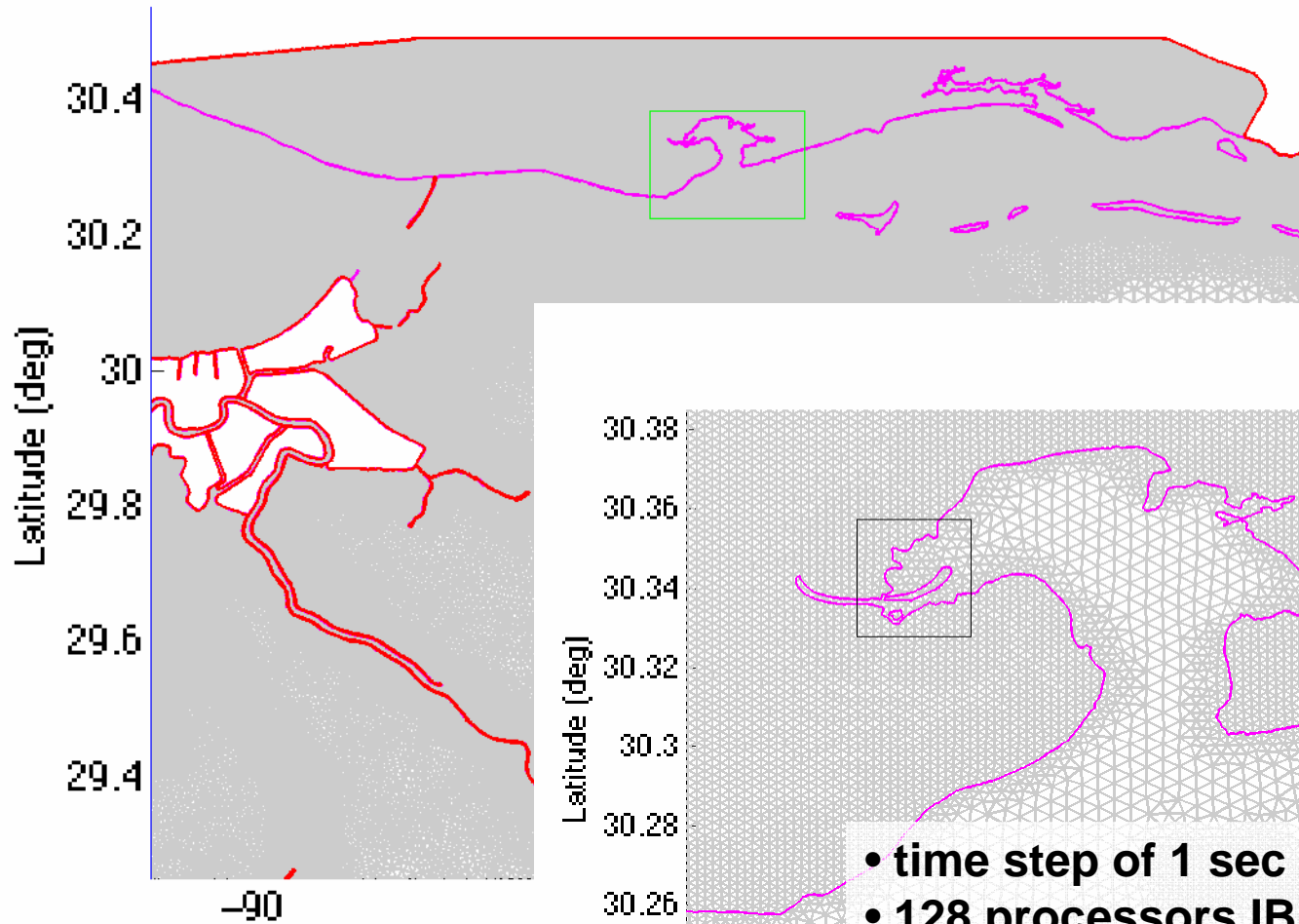
# Coastal Ocean Model

## Advanced Circulation Model for Shelves, Coasts and Estuaries (**ADCIRC**)

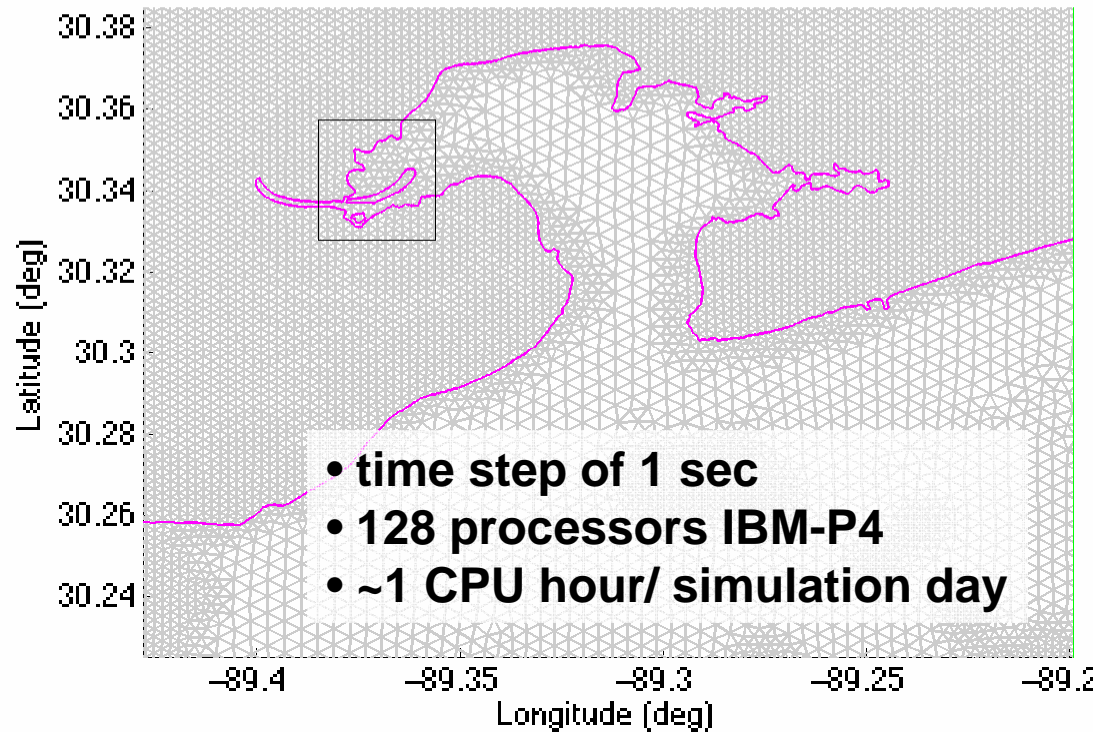


- 3D dynamics
- Forcing from tides and wind (waves, rivers)
- Shoreline inundation/recession
- Utilizes unstructured grids (finite elements)
- MPI parallelization

L. Po



Island, AL



**No. elements = 730,431**  
**No. nodes = 375,479**

# Hurricane Winds

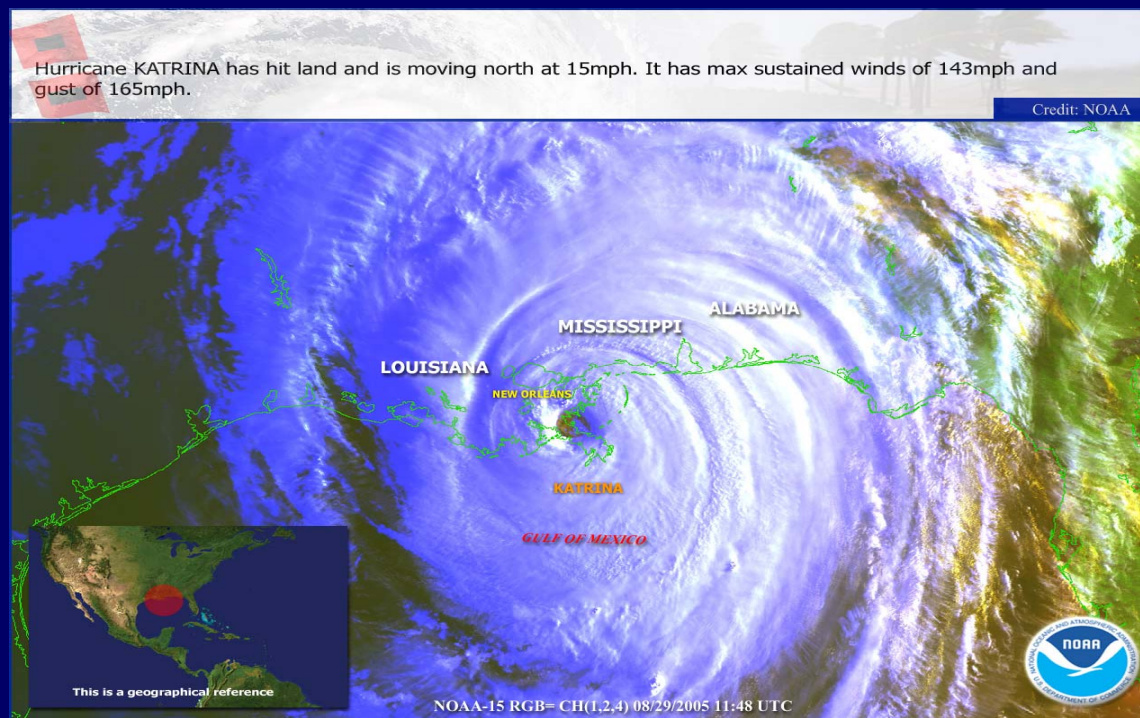
## NOAA HRD H\*Wind Reanalysis

[www.aoml.noaa.gov/hrd/Storm\\_pages/katrina2005/wind.html](http://www.aoml.noaa.gov/hrd/Storm_pages/katrina2005/wind.html)

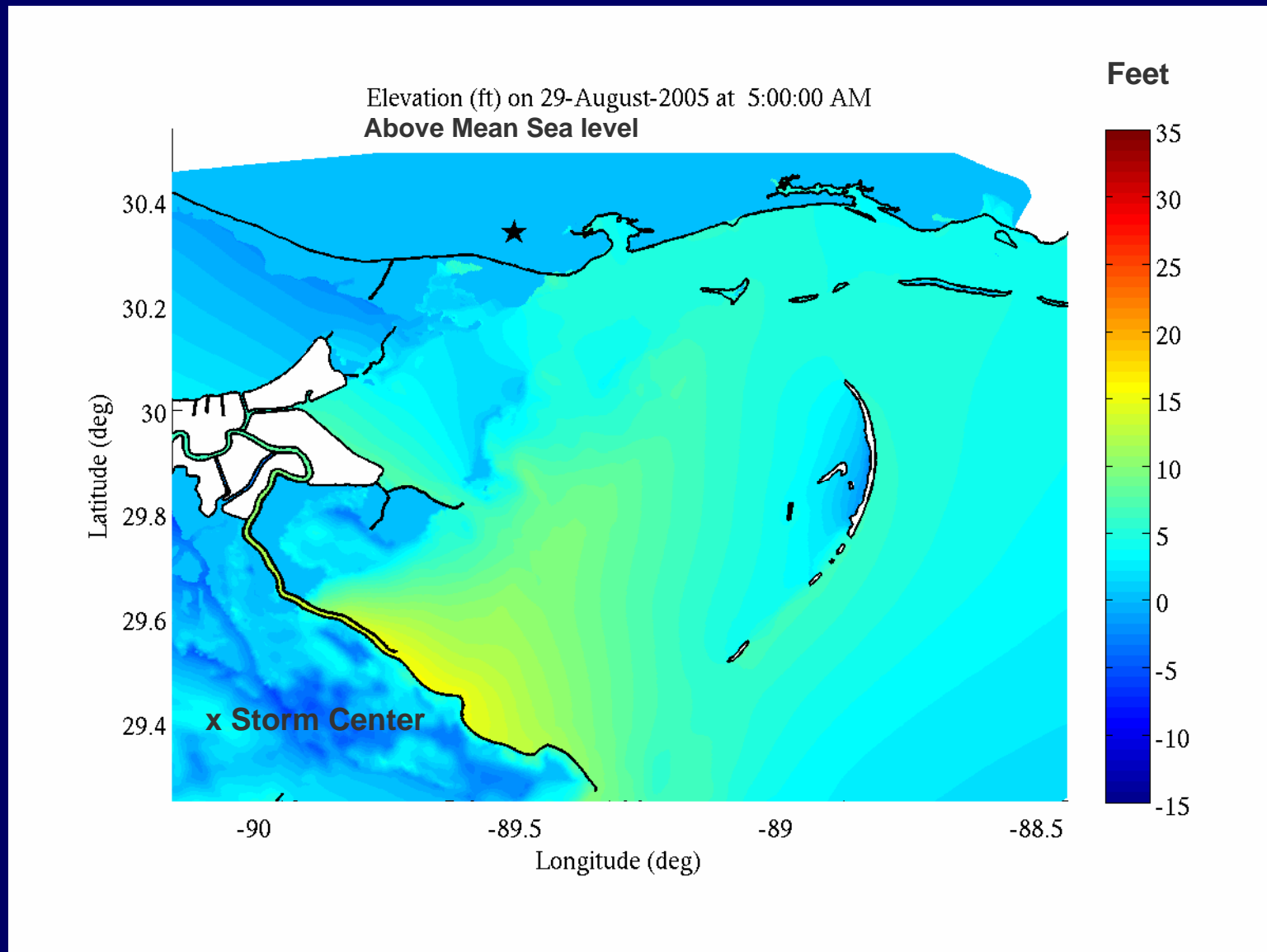
28 Aug 1800 UTC – 30 Aug 1000 UTC

Lagrangian interpolation to 15-minute intervals

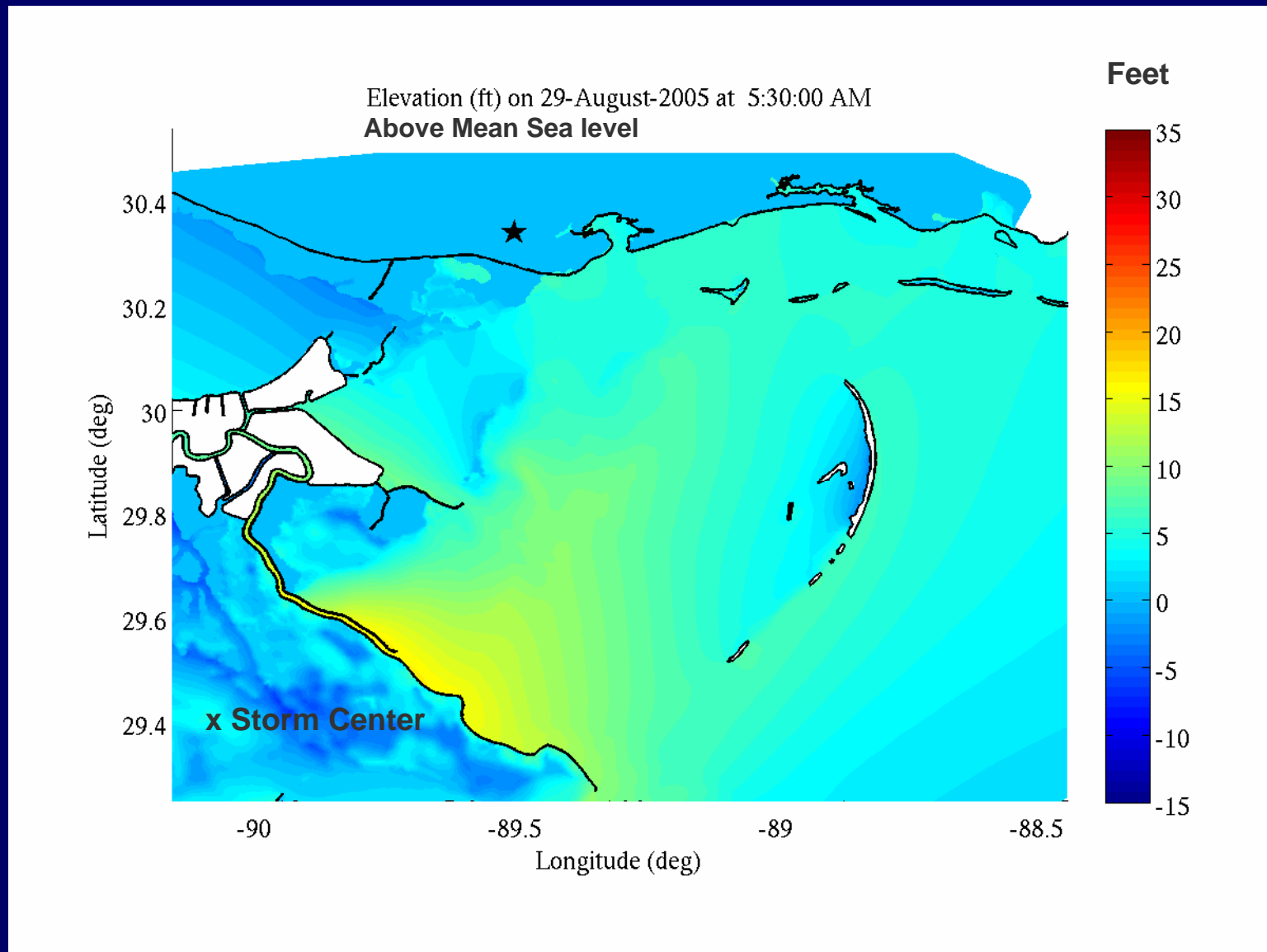
Garratt surface wind drag parameterization



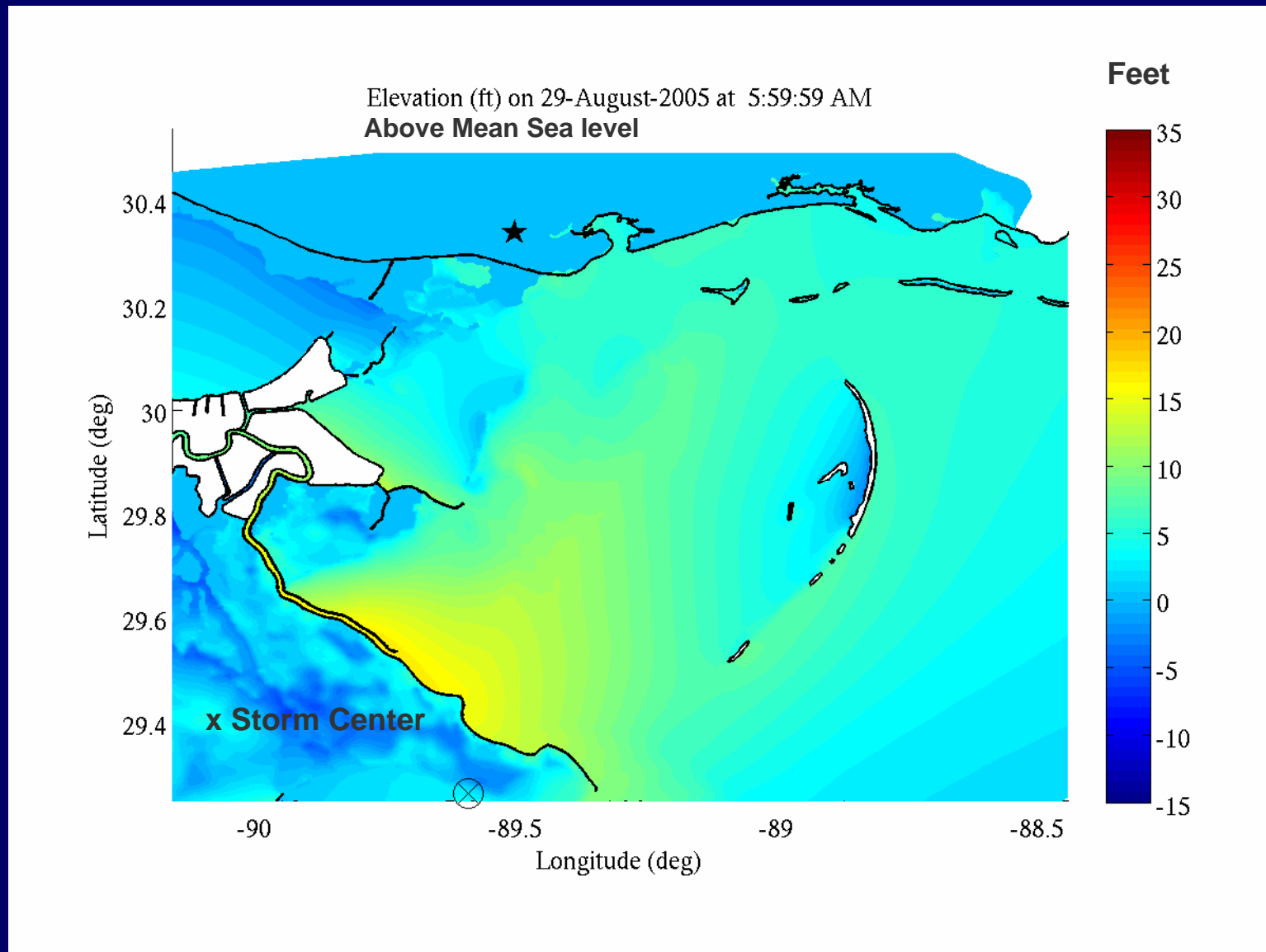
# ADCIRC Computed Tides + Surge



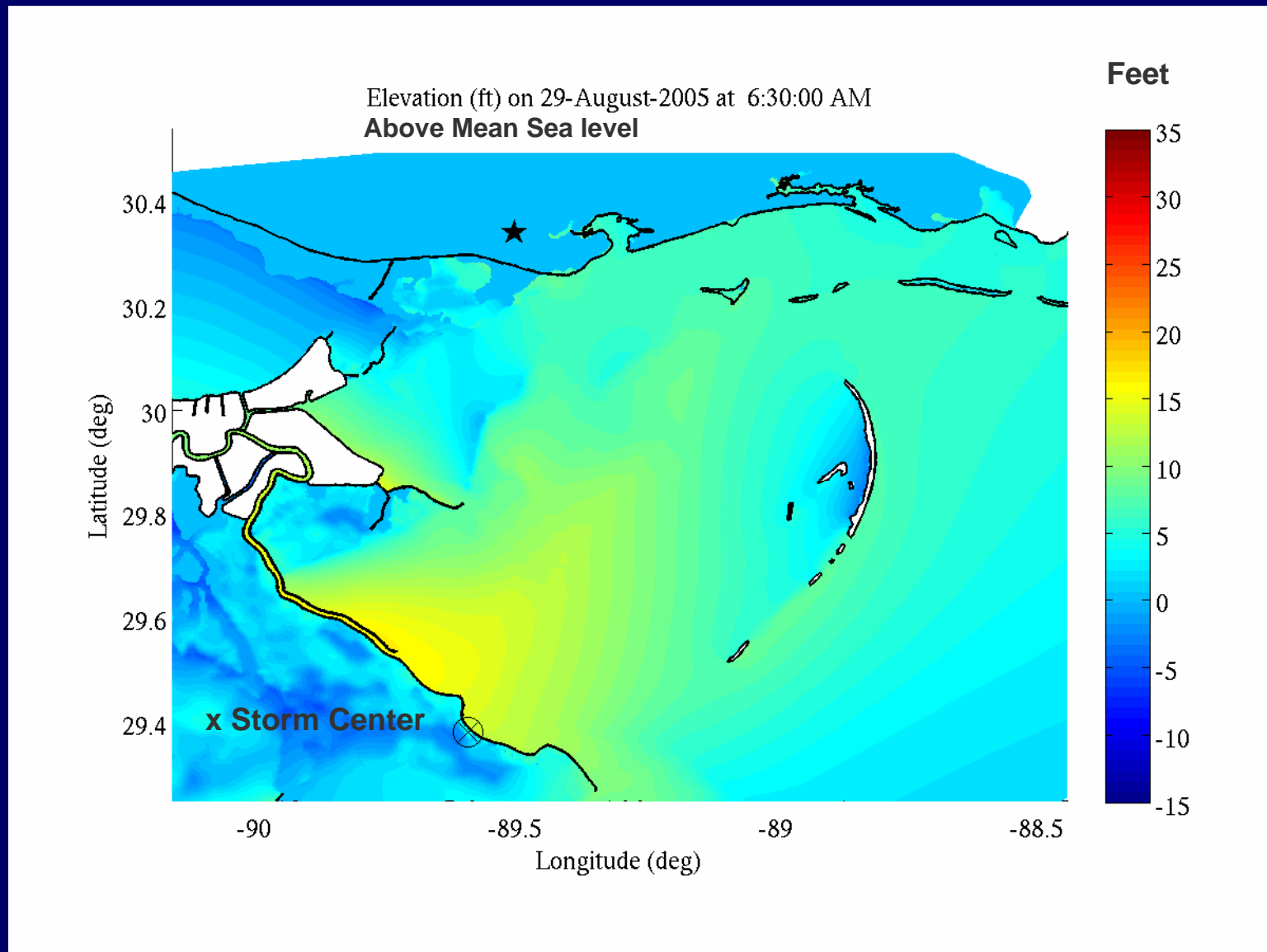
# ADCIRC Computed Tides + Surge



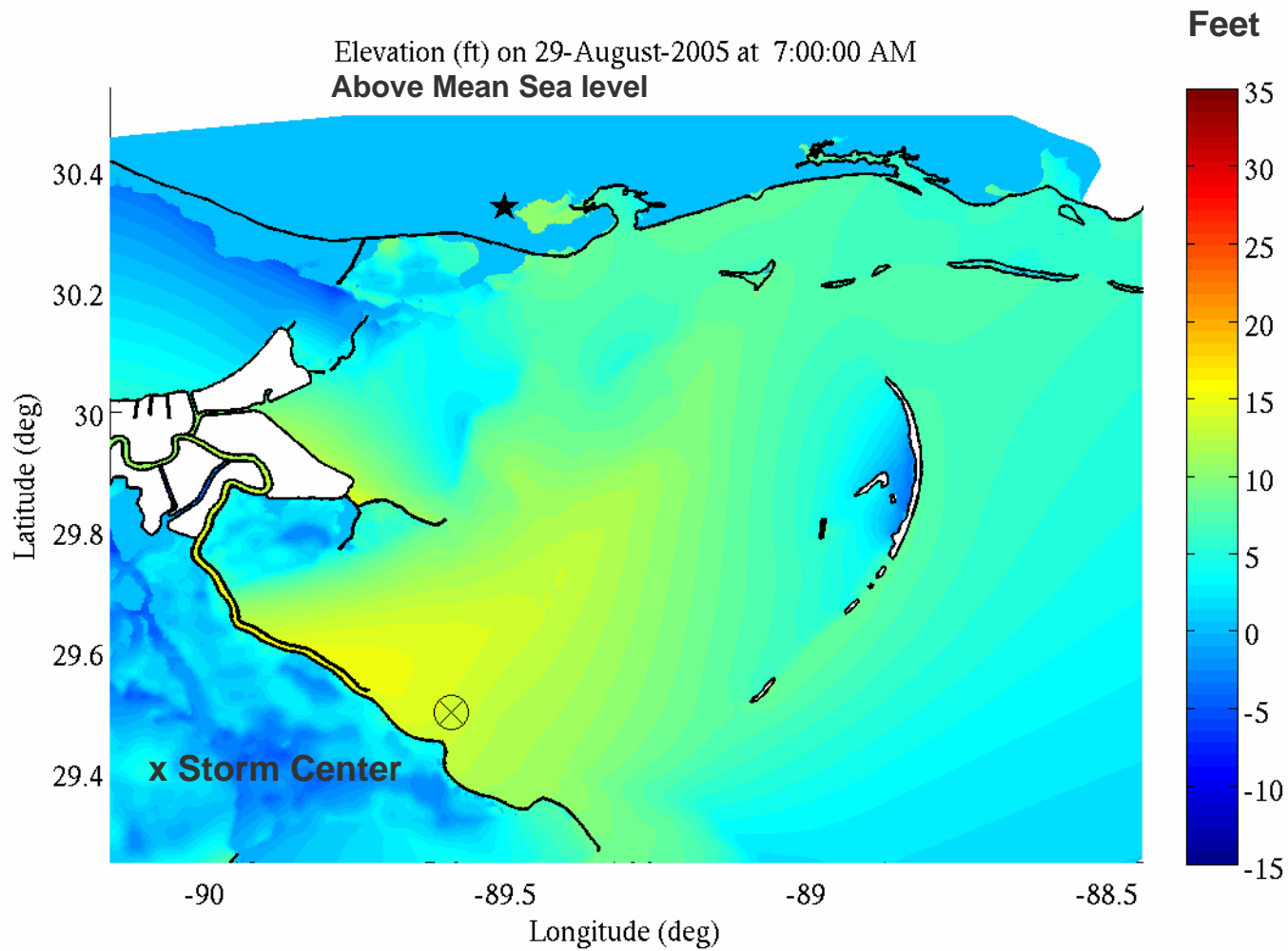
# ADCIRC Computed Tides + Surge



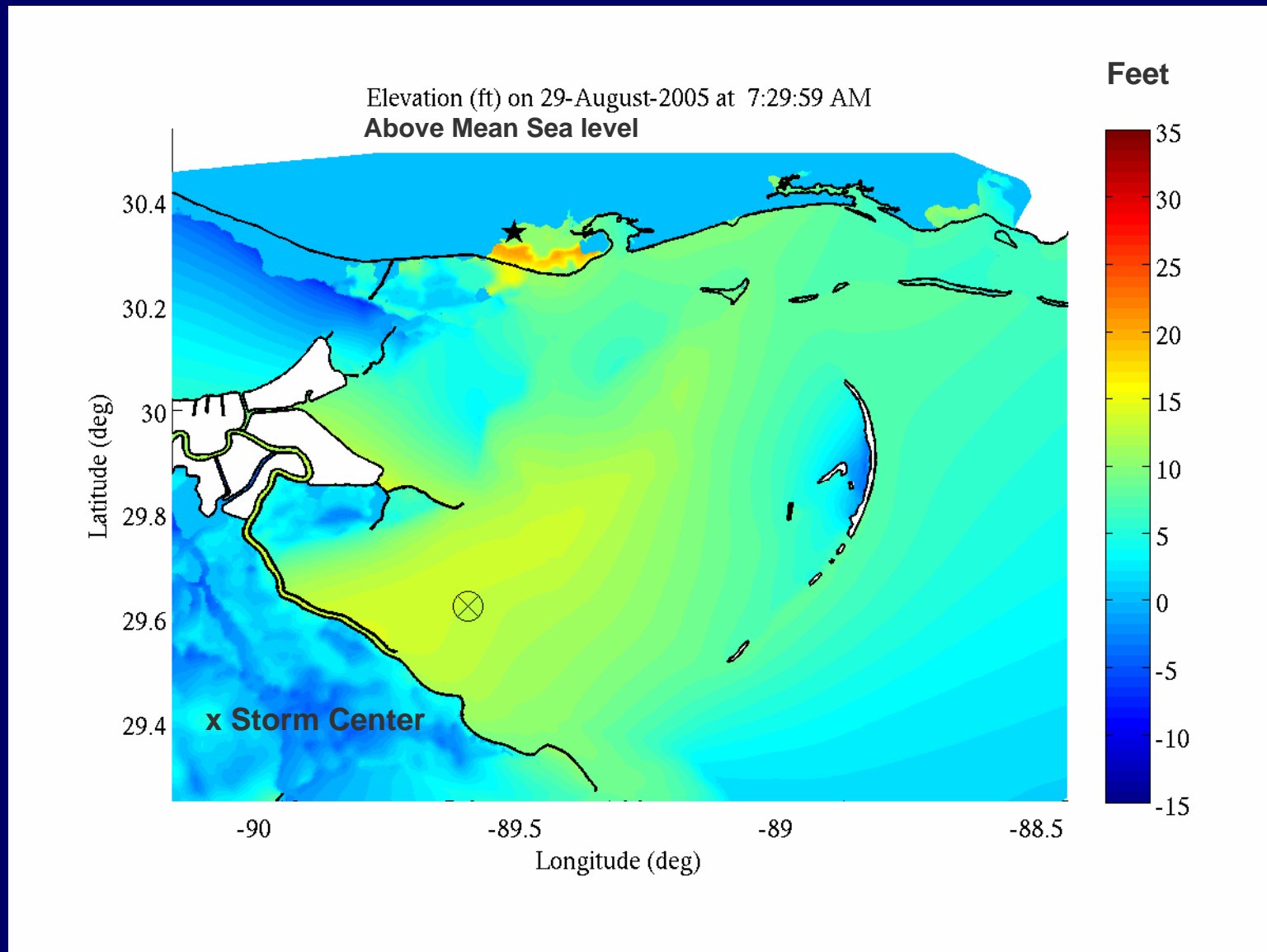
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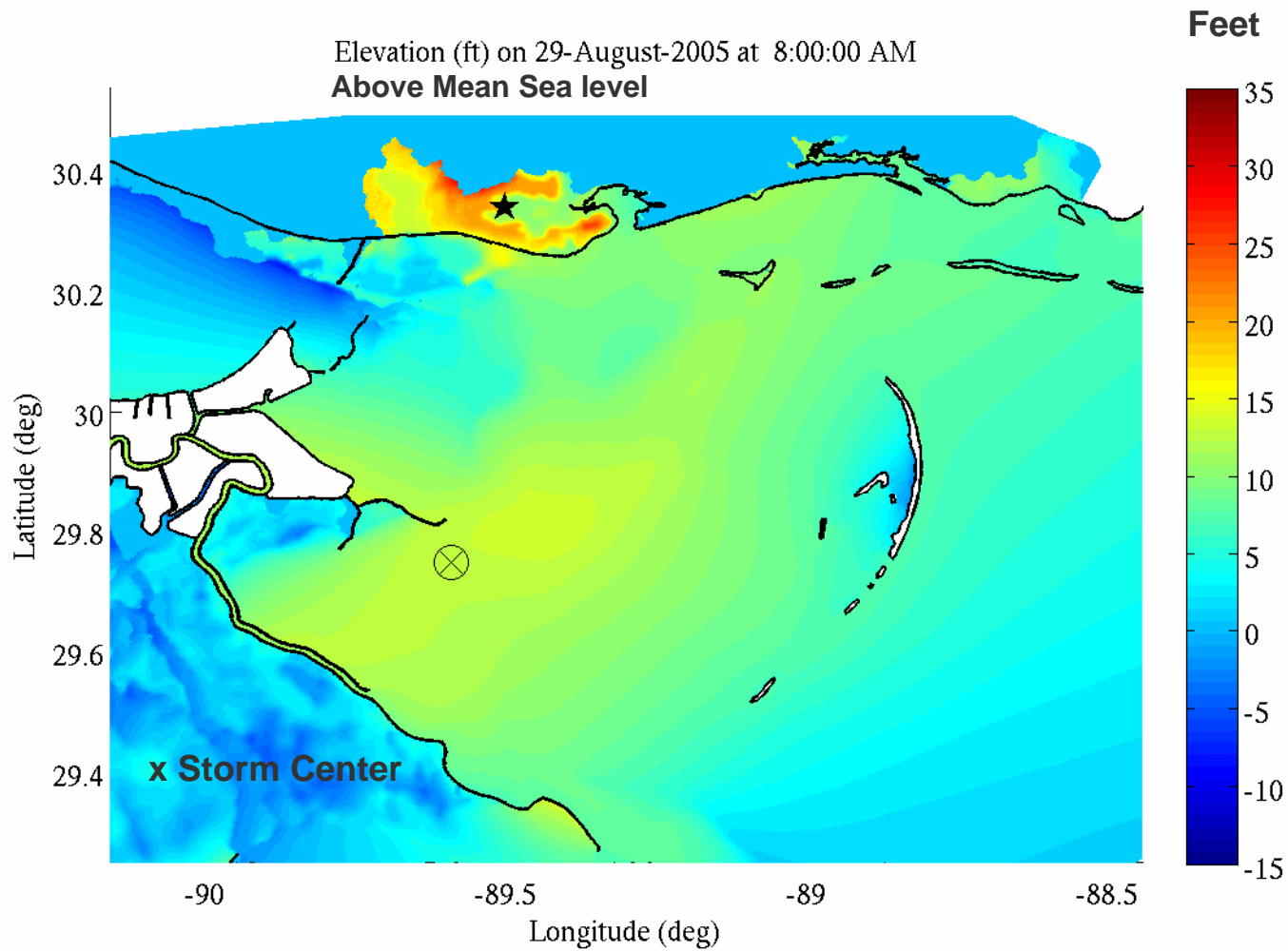
# ADCIRC Computed Tides + Surge



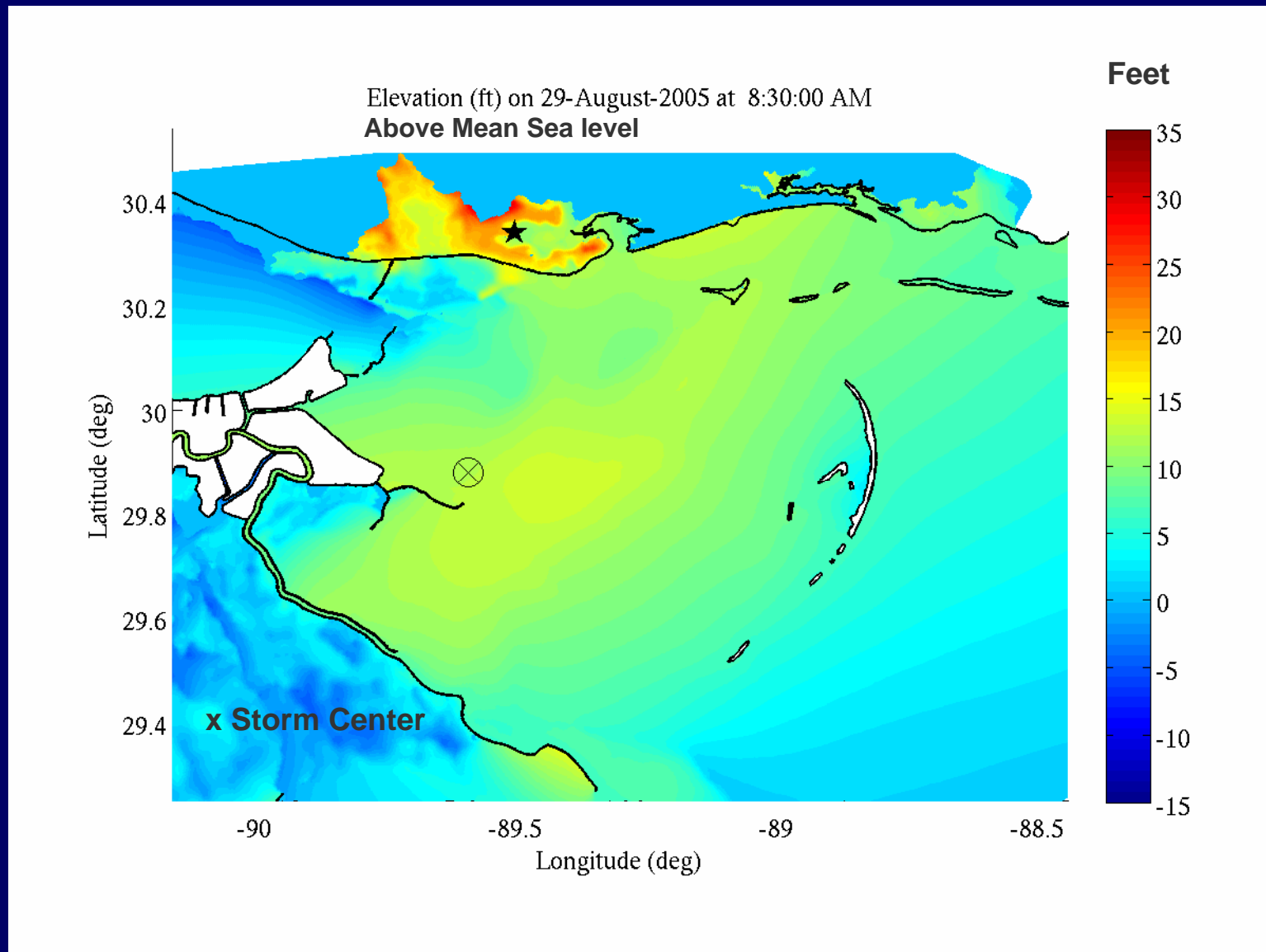
# ADCIRC Computed Tides + Surge



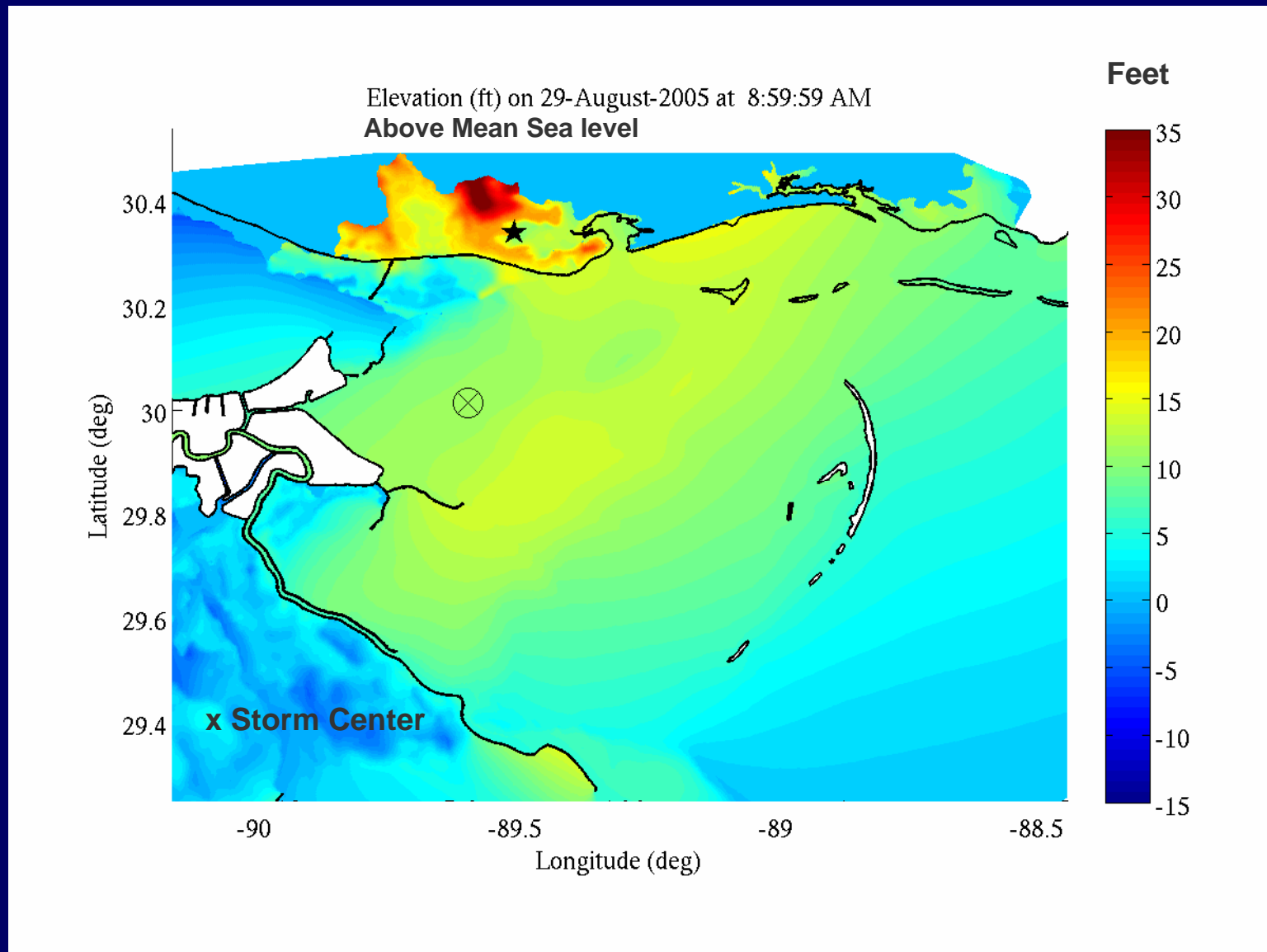
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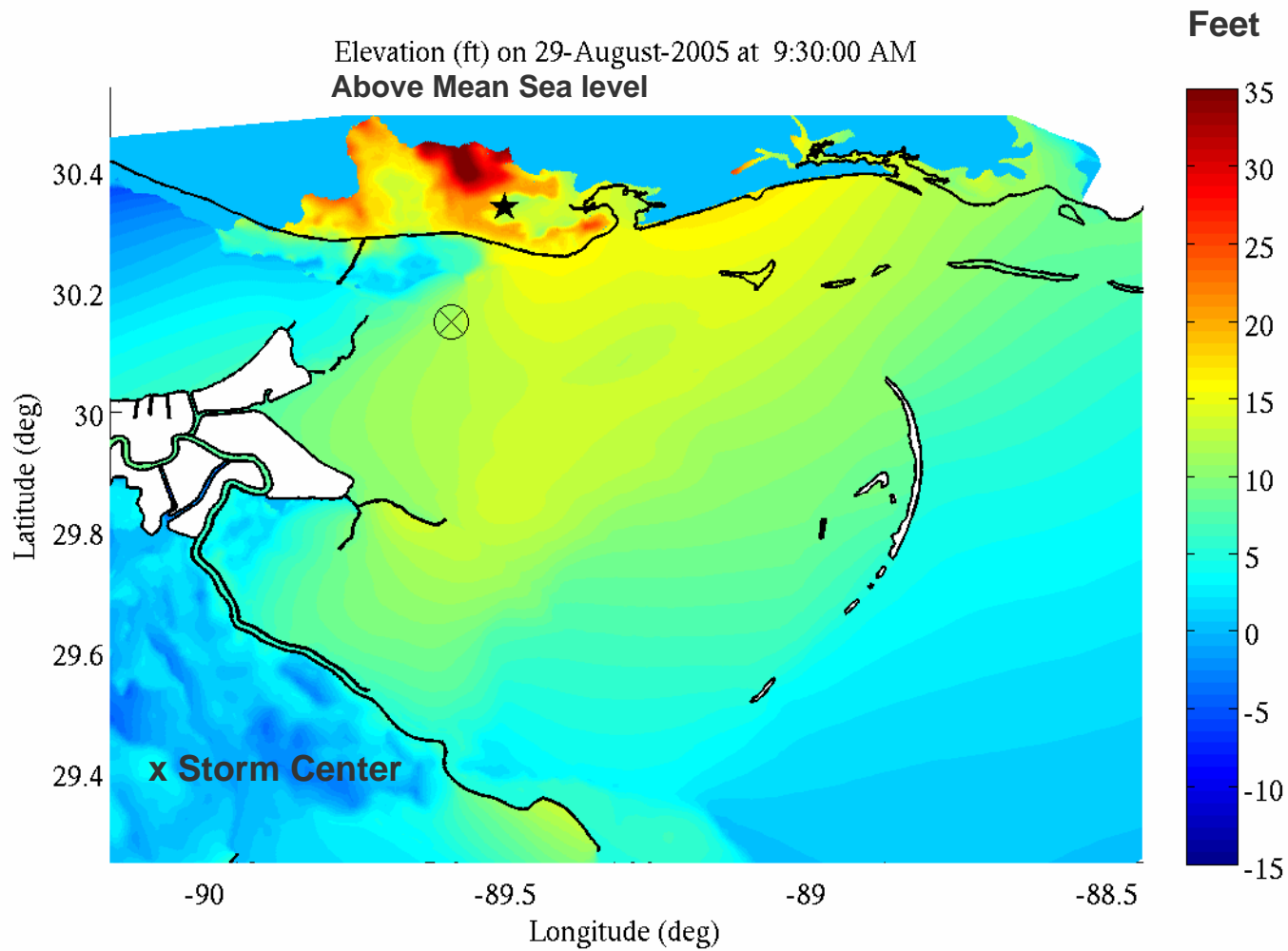
# ADCIRC Computed Tides + Surge



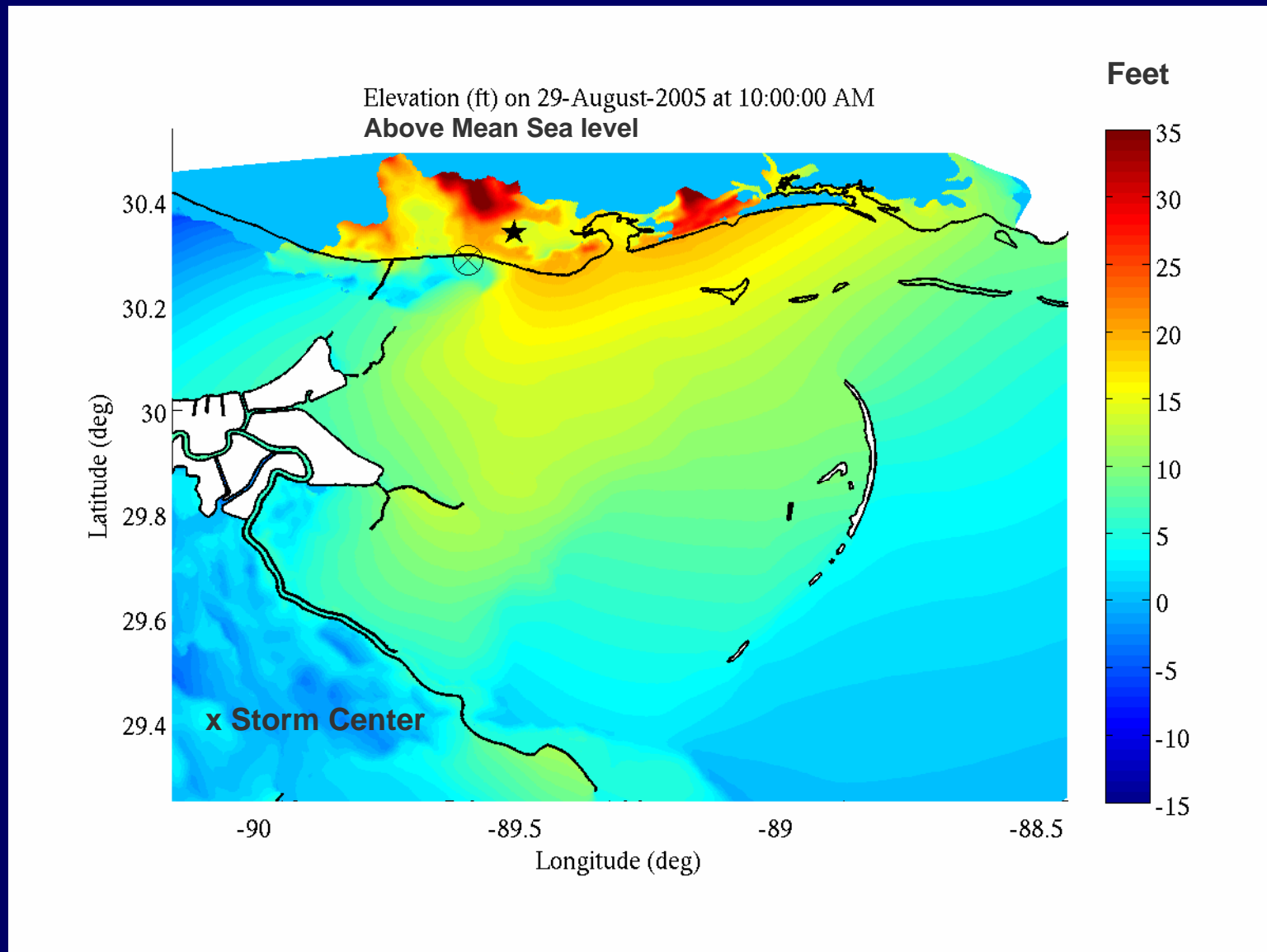
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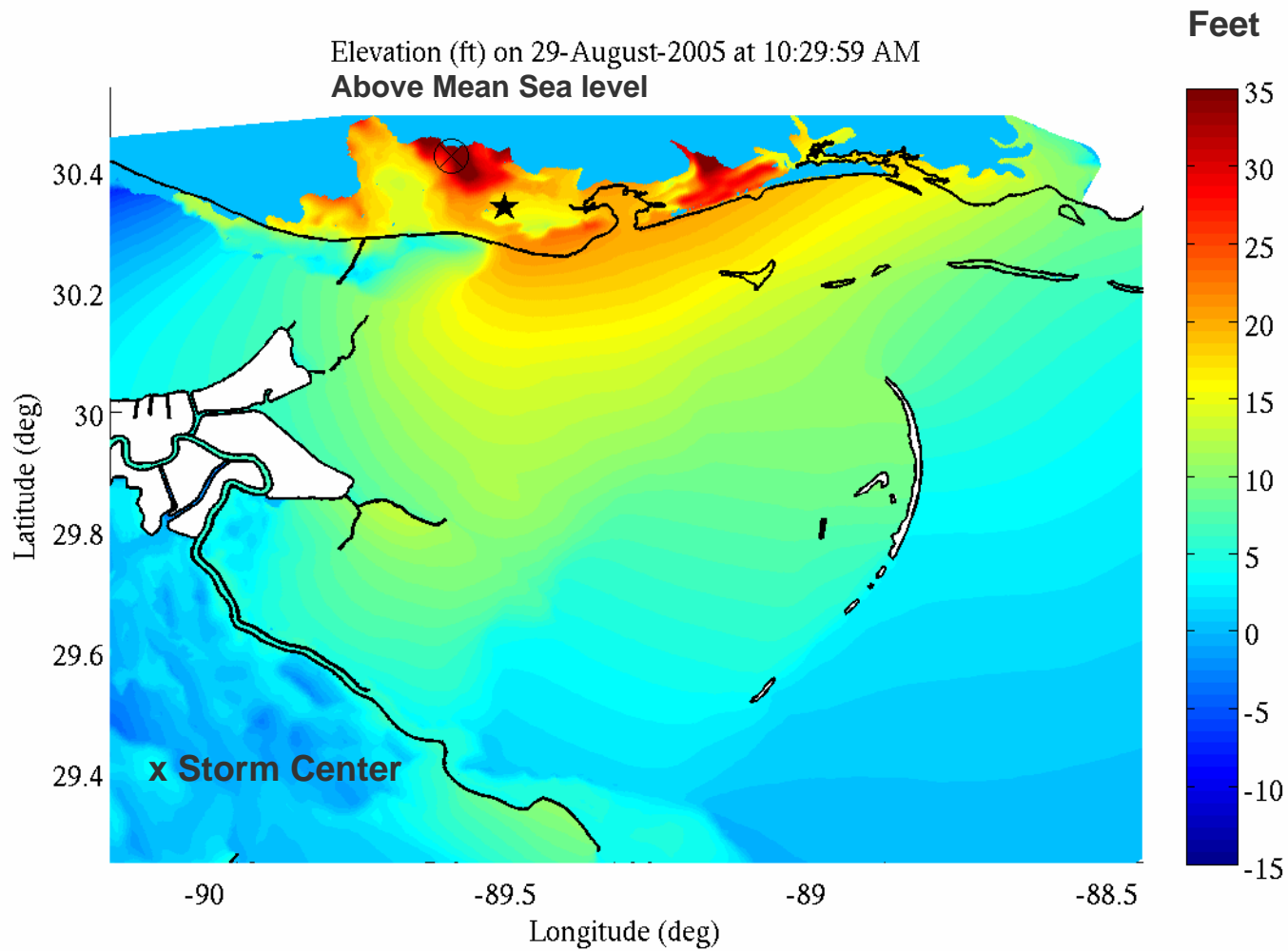
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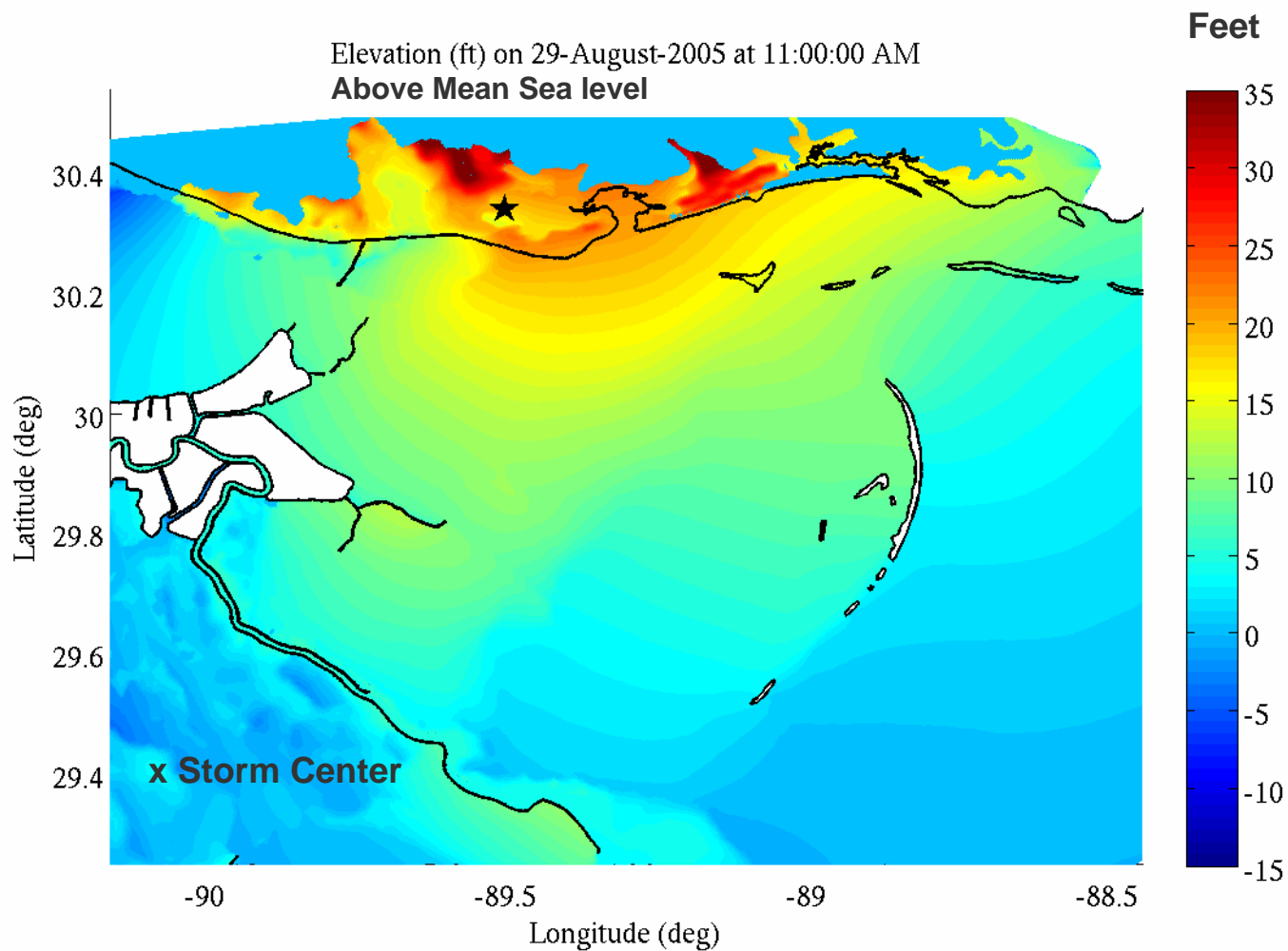
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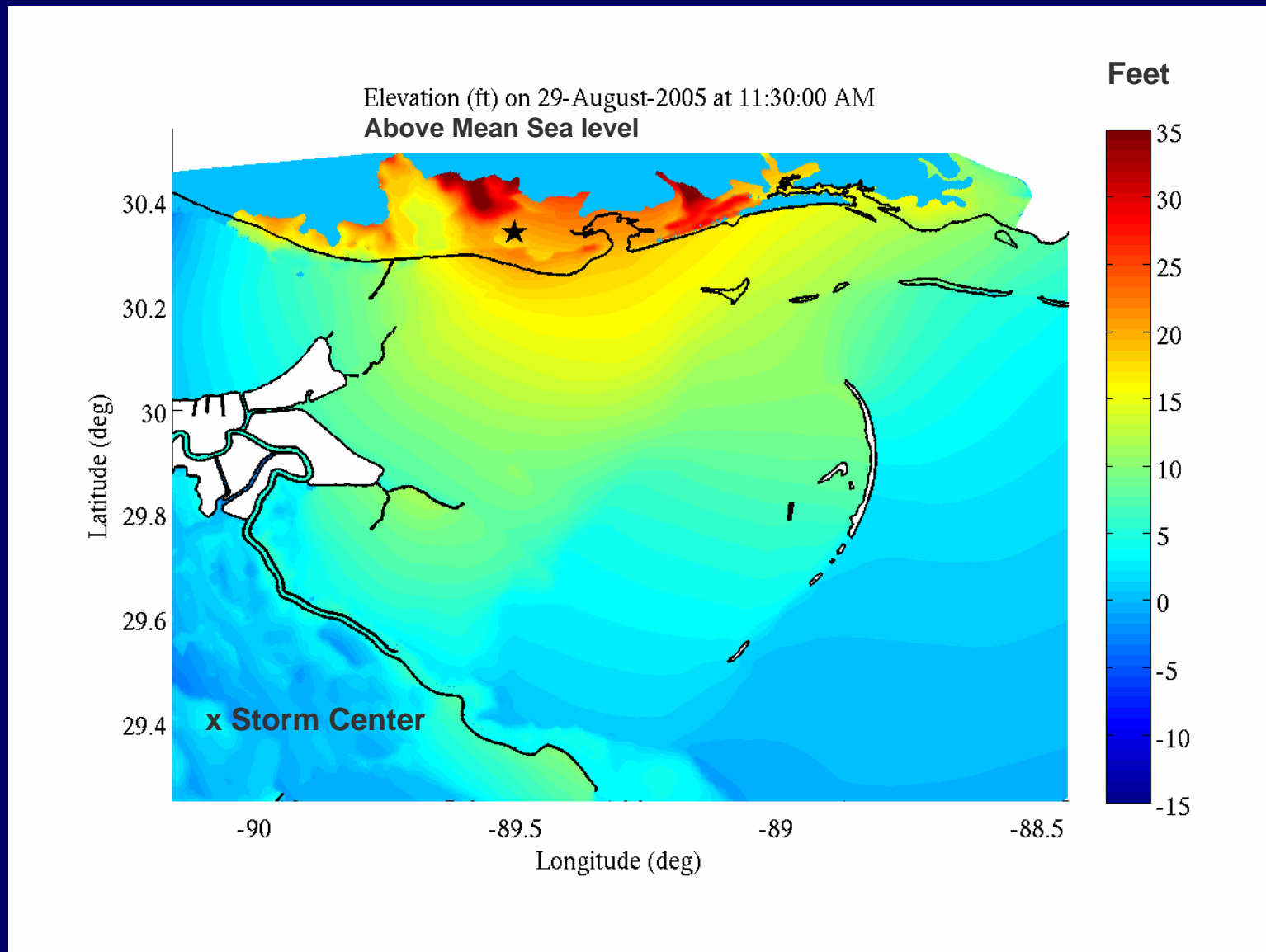
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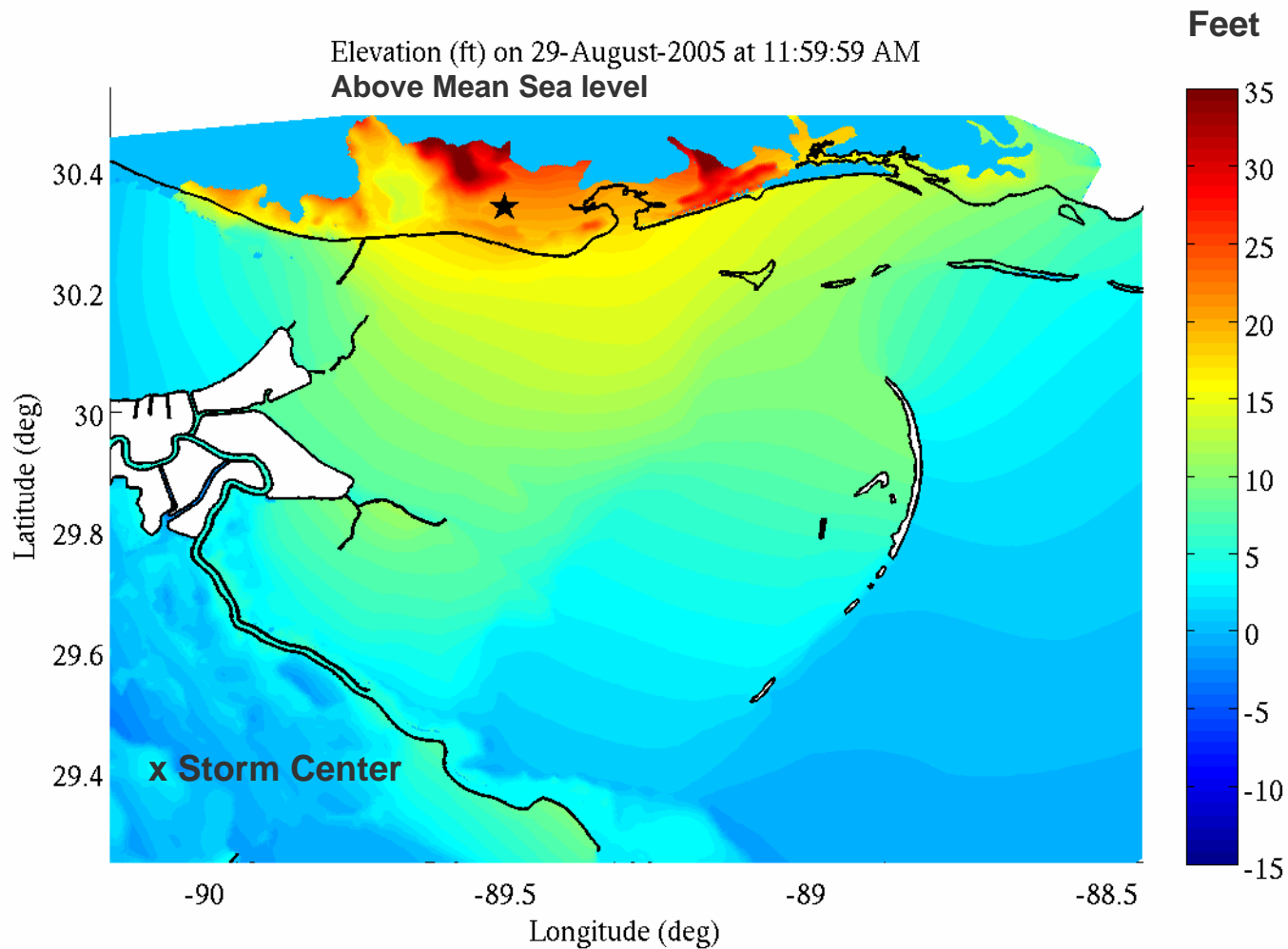
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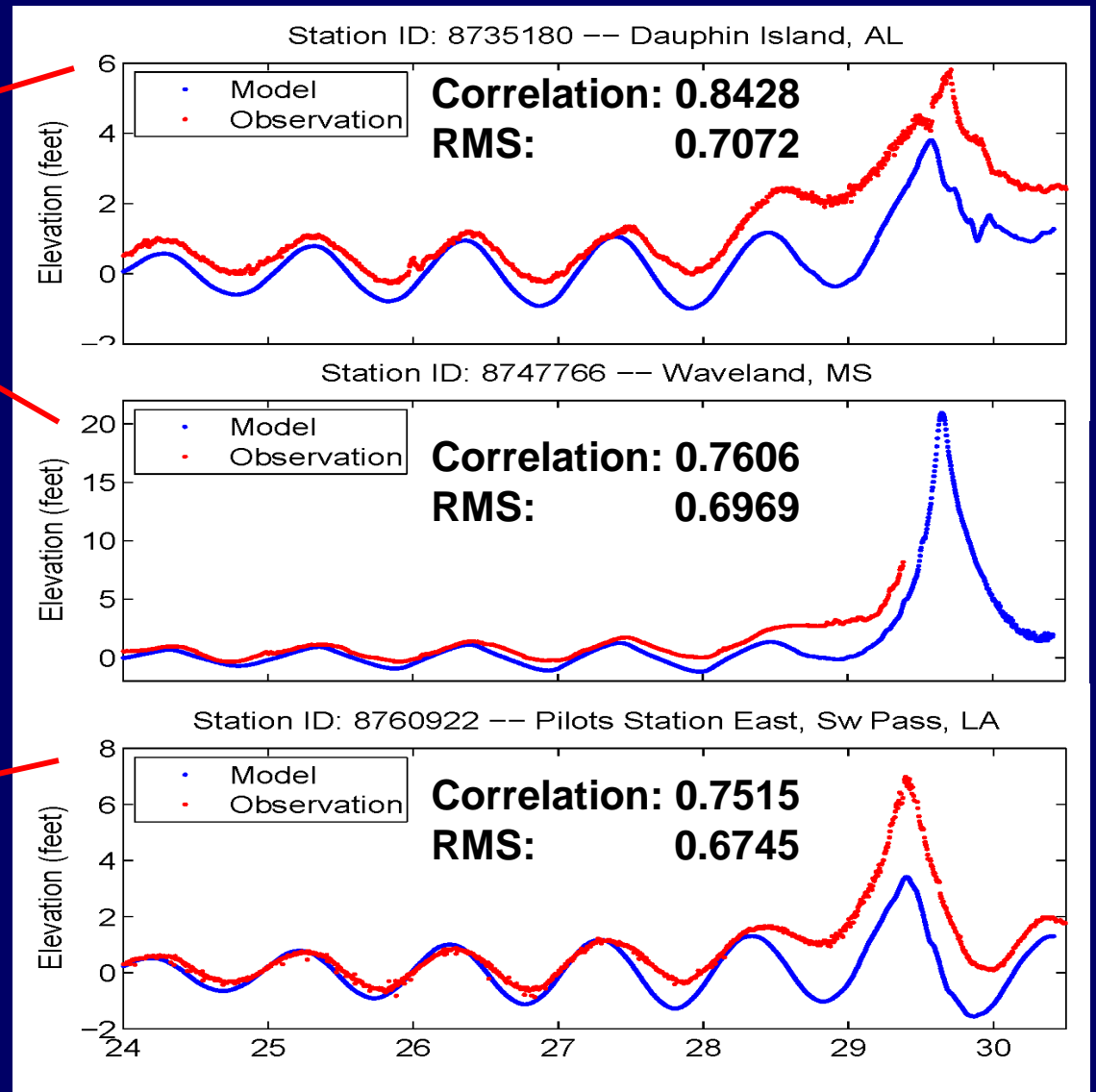
# ADCIRC Computed Tides + Surge



# ADCIRC Computed Tides + Surge

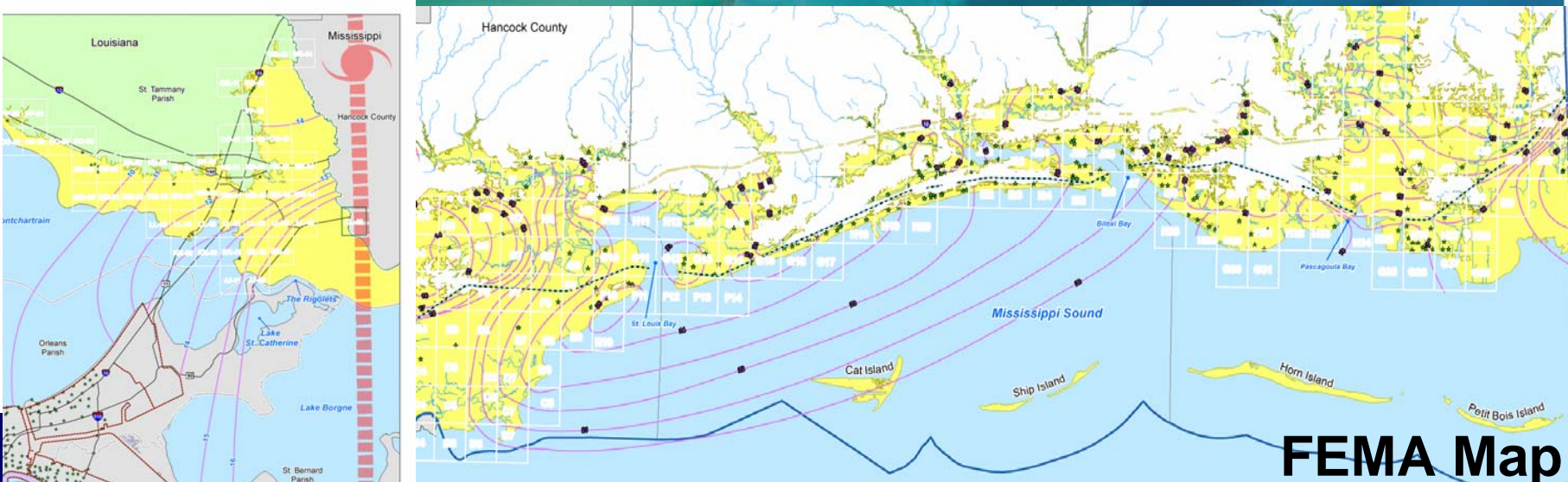
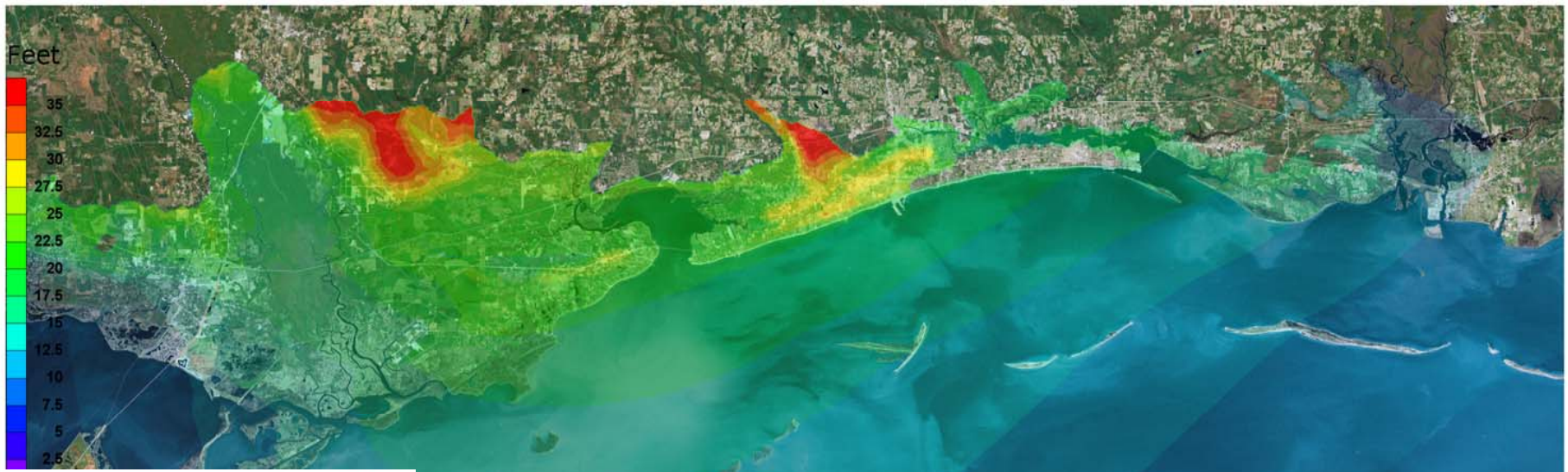


# Water Level Comparisons

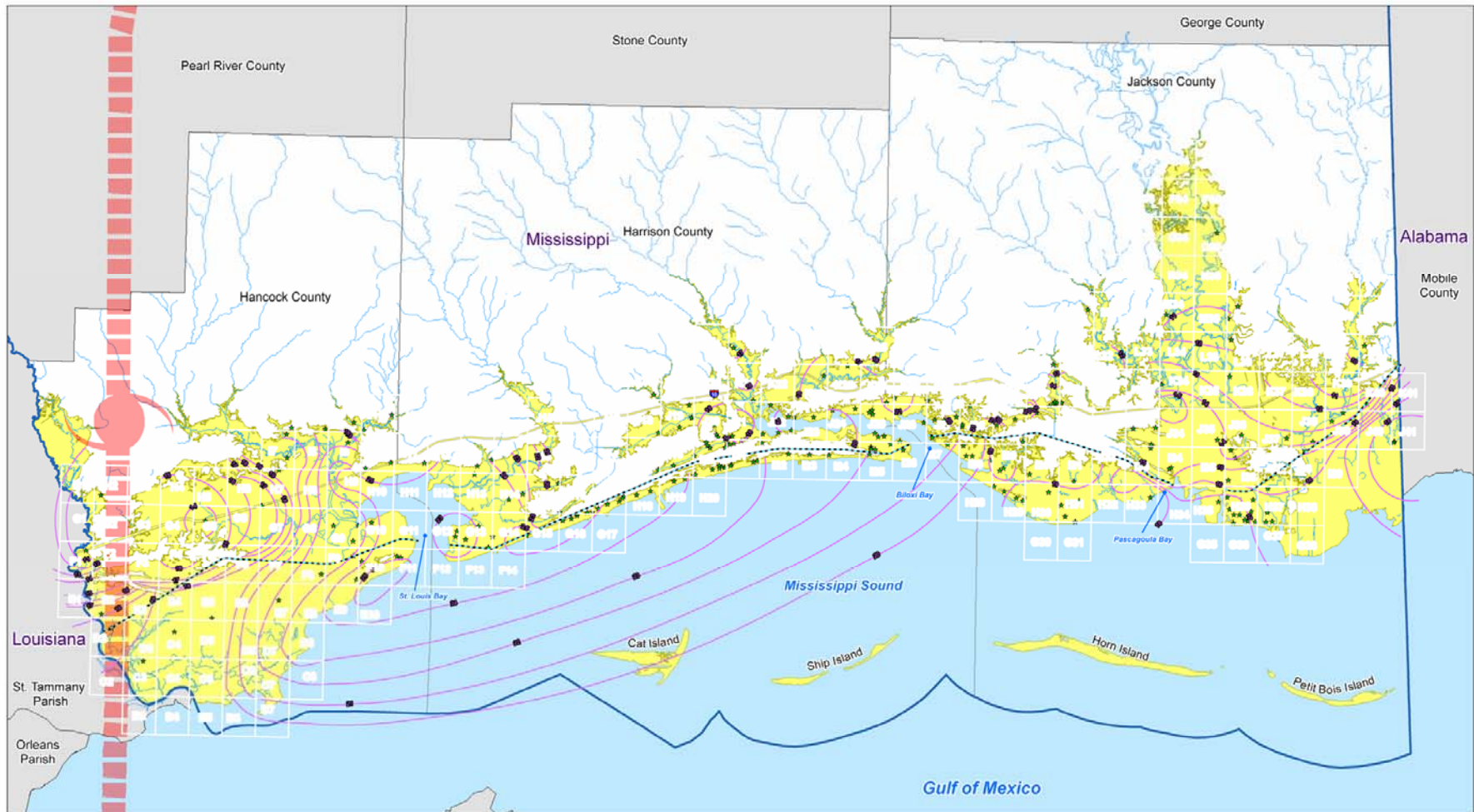


# Surge Inundation Map

ADCIRC Model



FEMA Map



## Mississippi Hurricane Katrina Surge Inundation and Advisory Base Flood Elevation Map Panel Overview

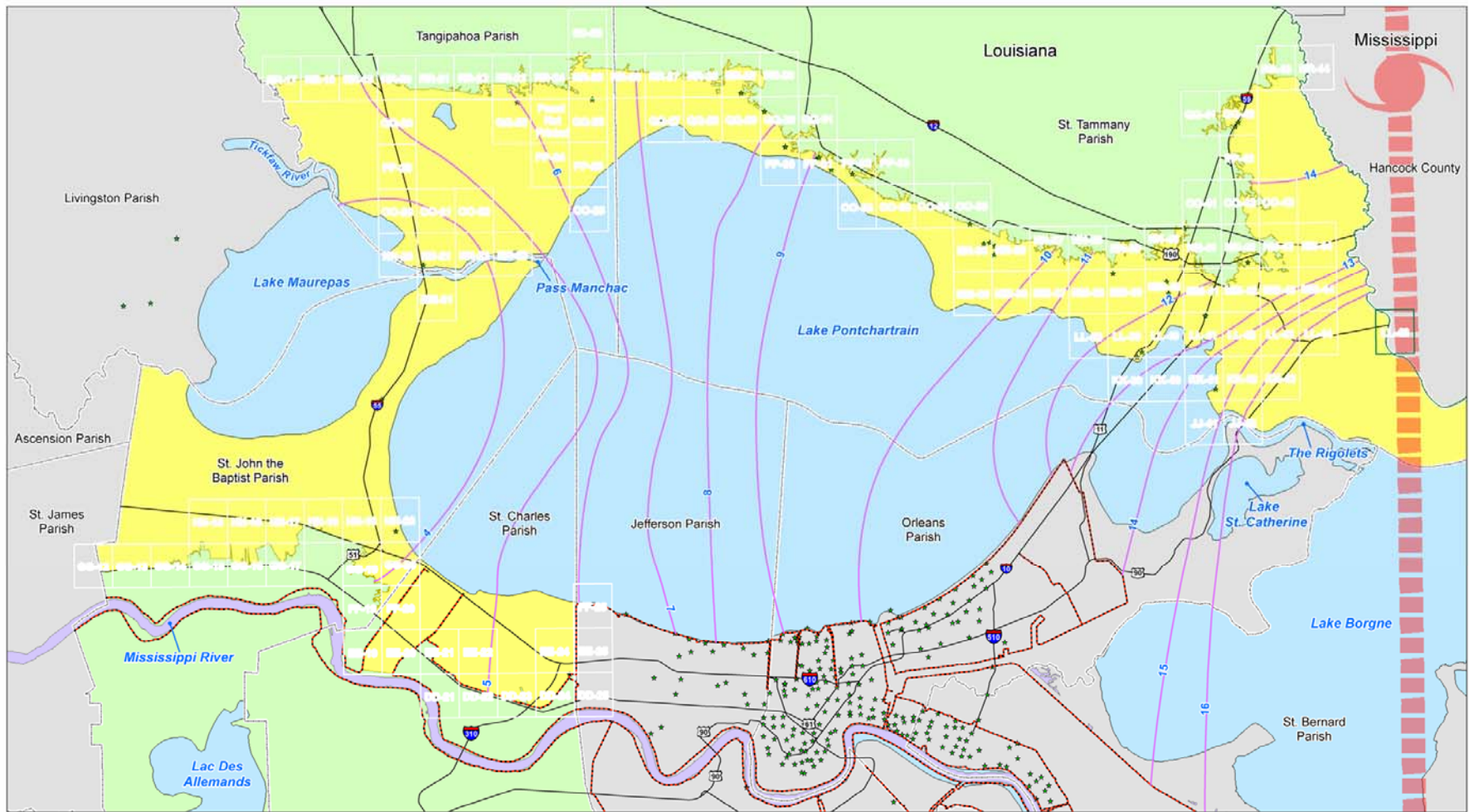
Date of Event: August 29, 2005; Date of Map: November 2005



### Legend

- |                           |                                  |
|---------------------------|----------------------------------|
| State Boundary            | Inundation Map Panel Grid        |
| County Boundary           | Limit of Surge Inundation        |
| Highway                   | Preliminary High Water Marks     |
| Water Feature             | Preliminary Surge Elevations     |
| Path of Hurricane Katrina | ABFE Open Coast/BackBay Boundary |





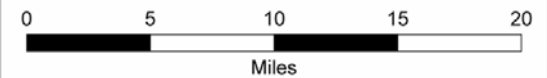
## Louisiana Hurricane Katrina Surge Inundation and Advisory Base Flood Elevation Map Panel Overview North Area

Date of Event: August 29, 2005; Date of Map: January 2006

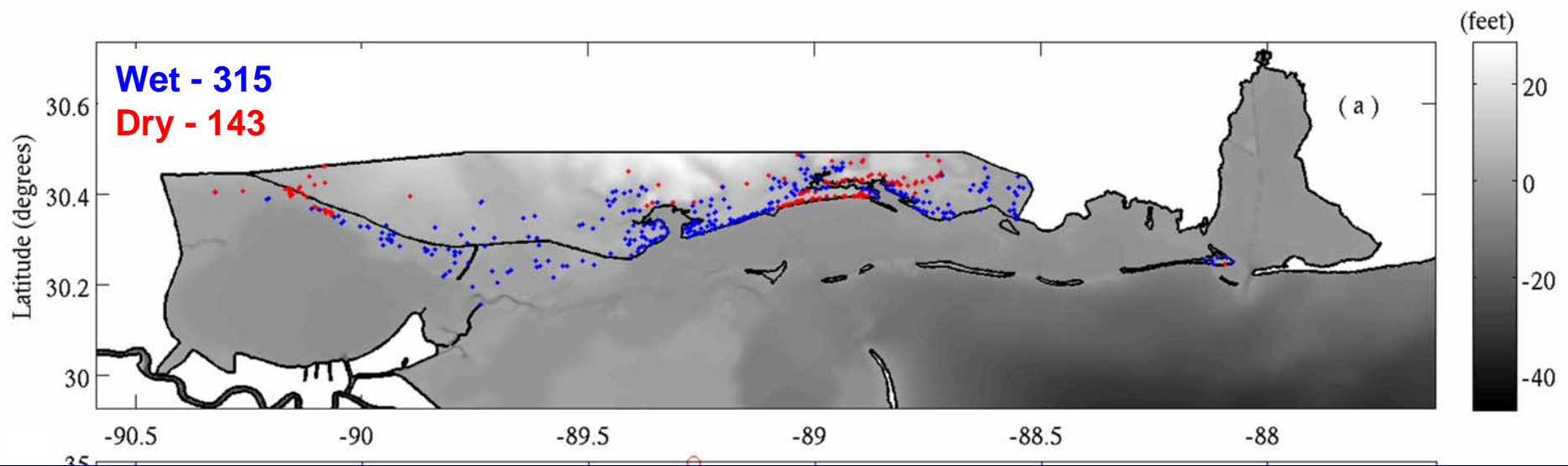


### Legend

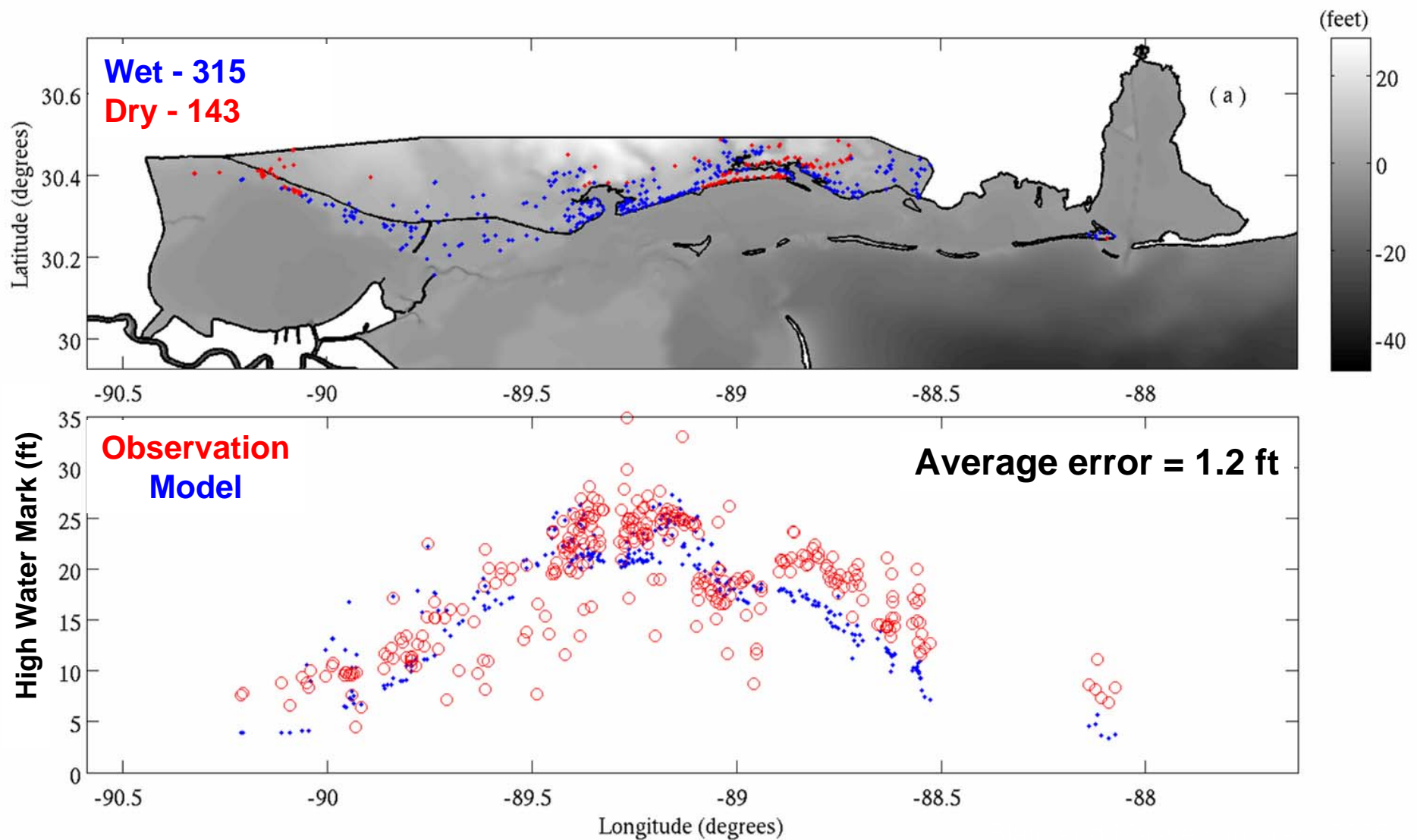
- |                 |                              |
|-----------------|------------------------------|
| State Boundary  | Inundation Map Panel Grid    |
| Parish Boundary | Limit of Surge Inundation    |
| Highway         | Preliminary High Water Marks |
| Levees          | Preliminary Surge Elevations |
|                 | Path of Hurricane Katrina    |



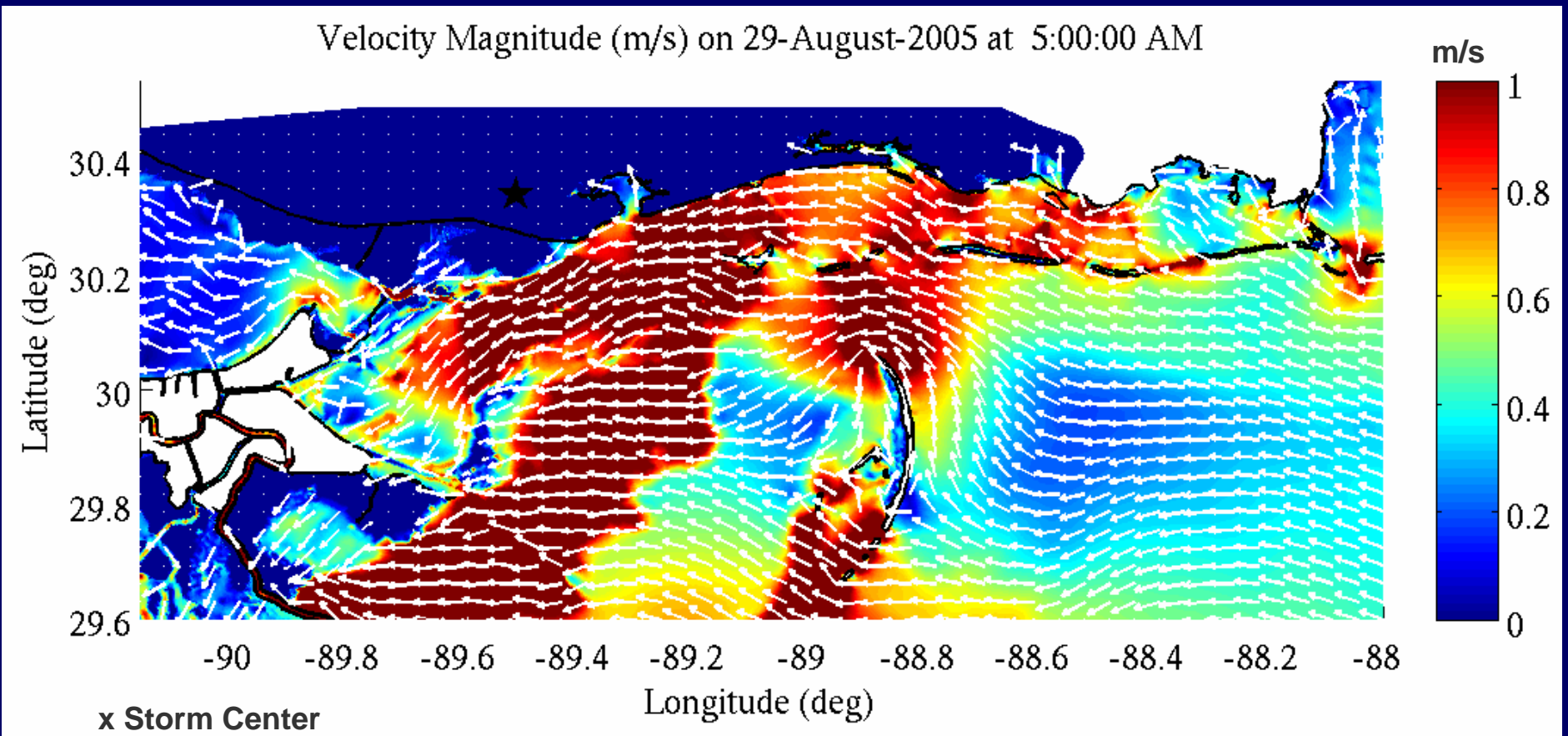
# Comparison to USGS High Water Marks



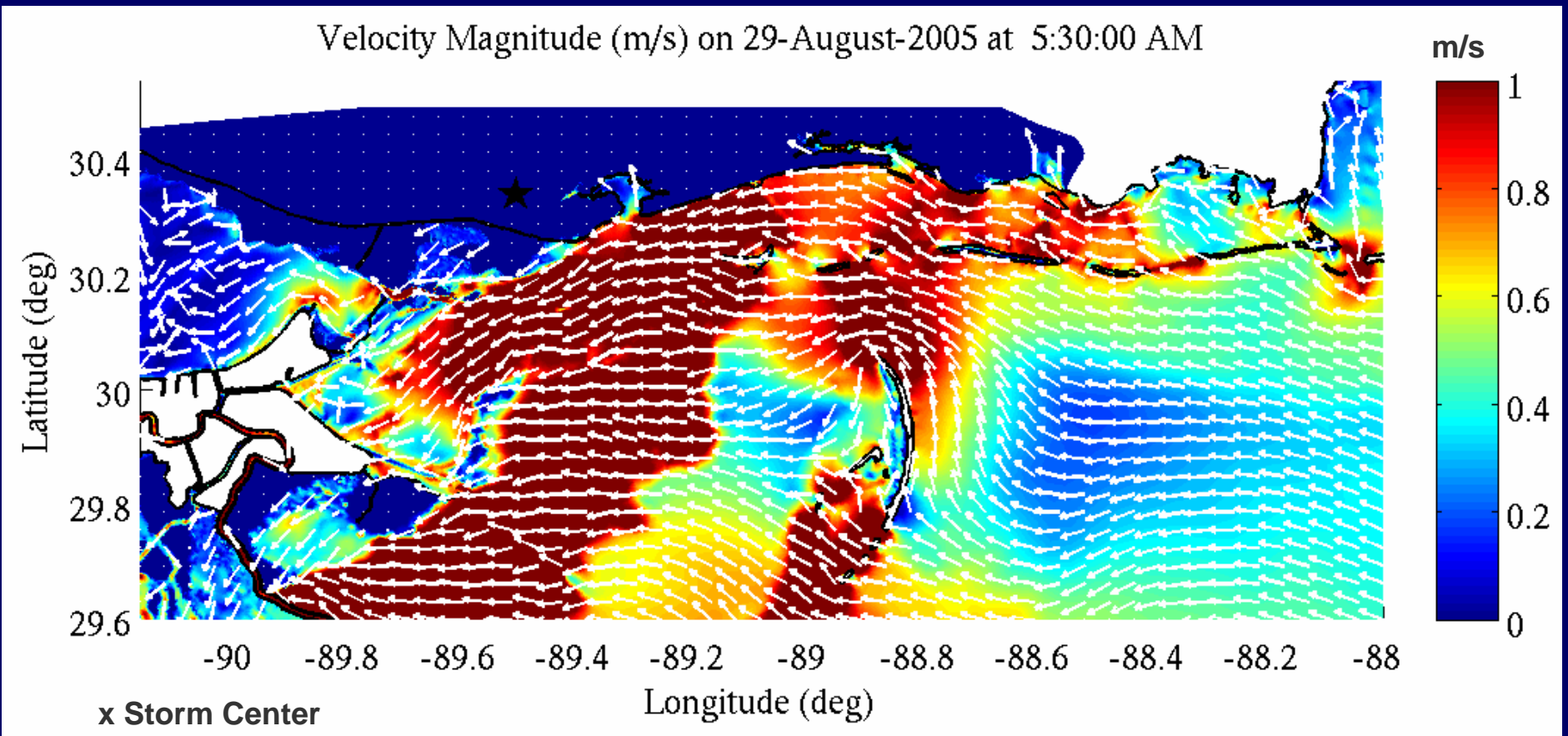
# Comparison to USGS High Water Marks



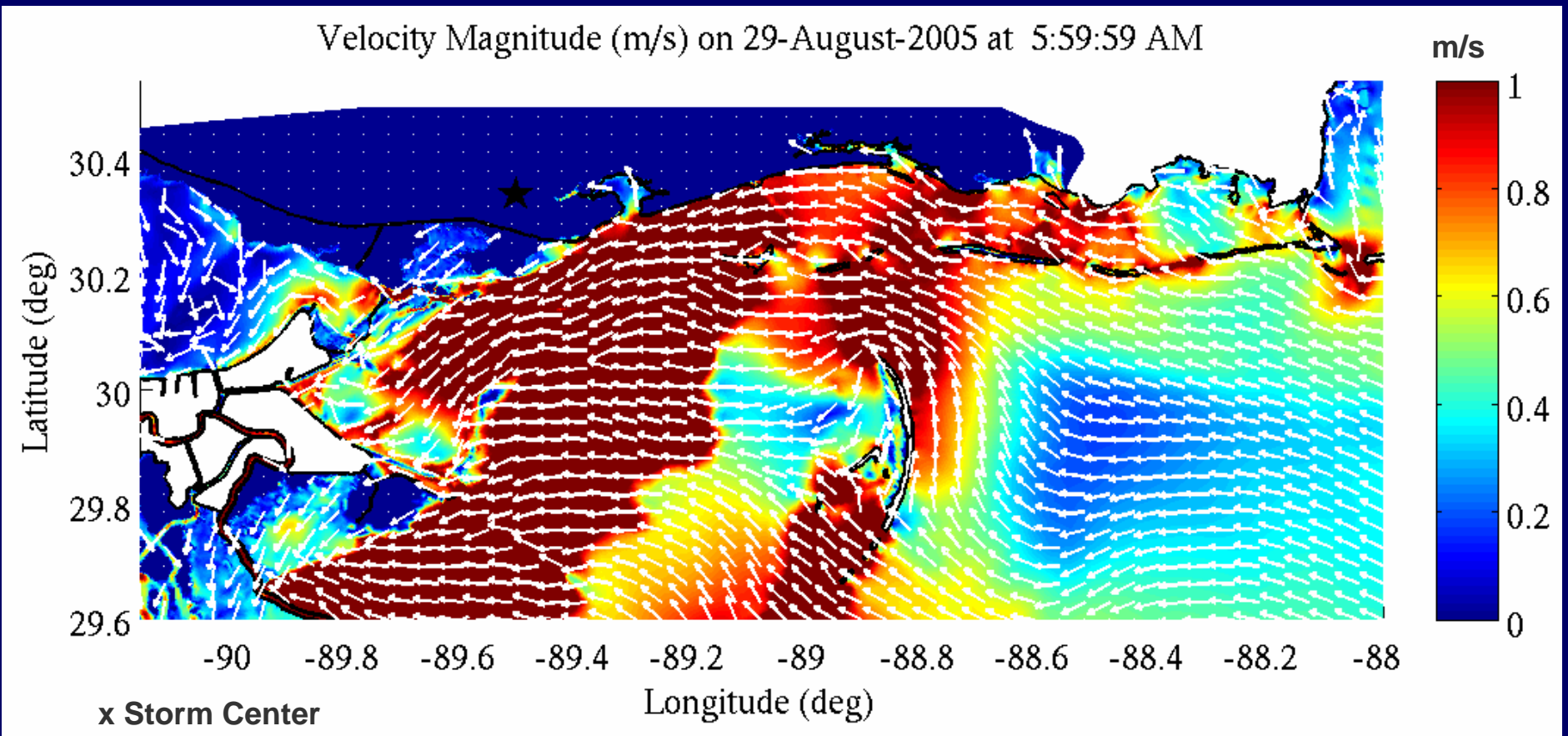
# ADCIRC Computed Currents



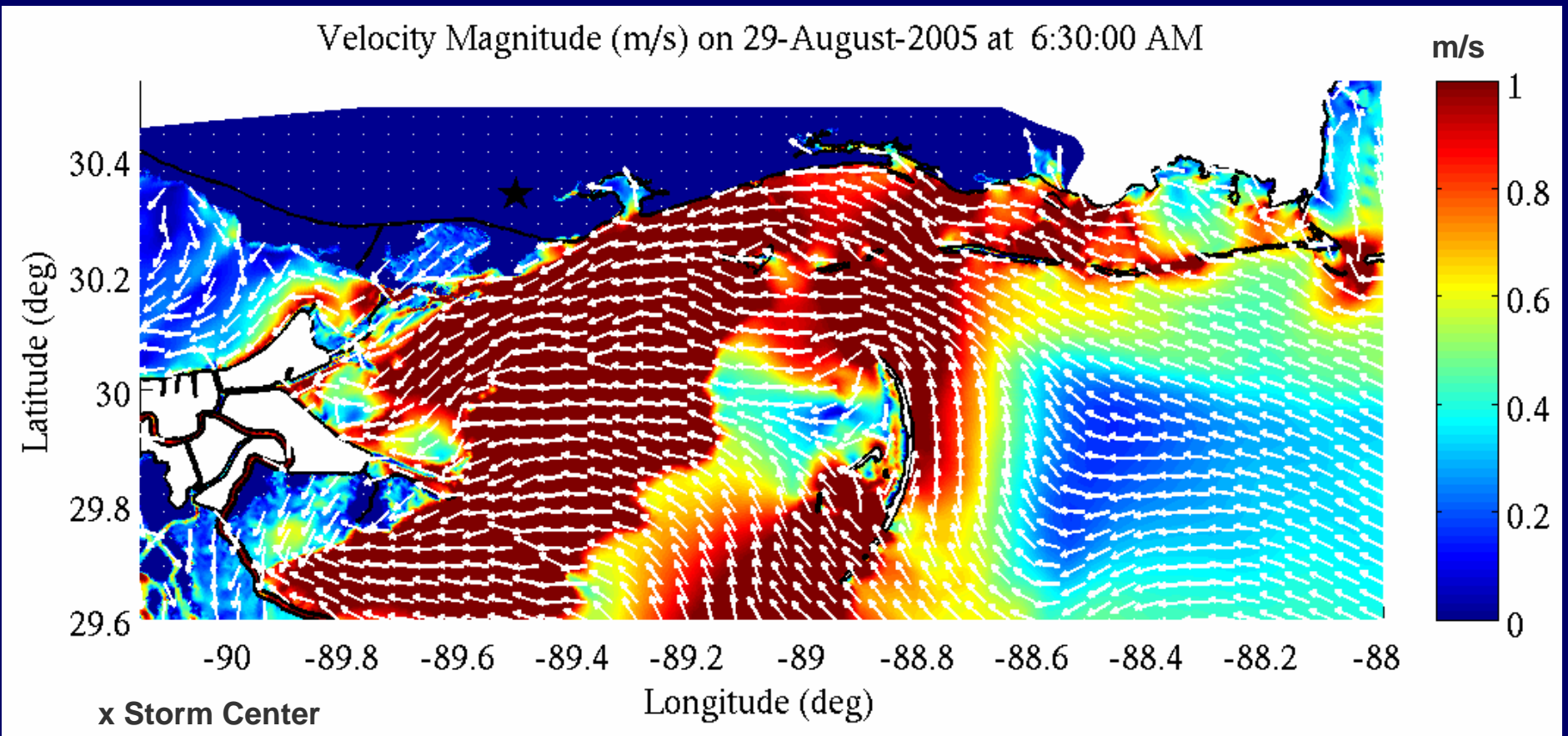
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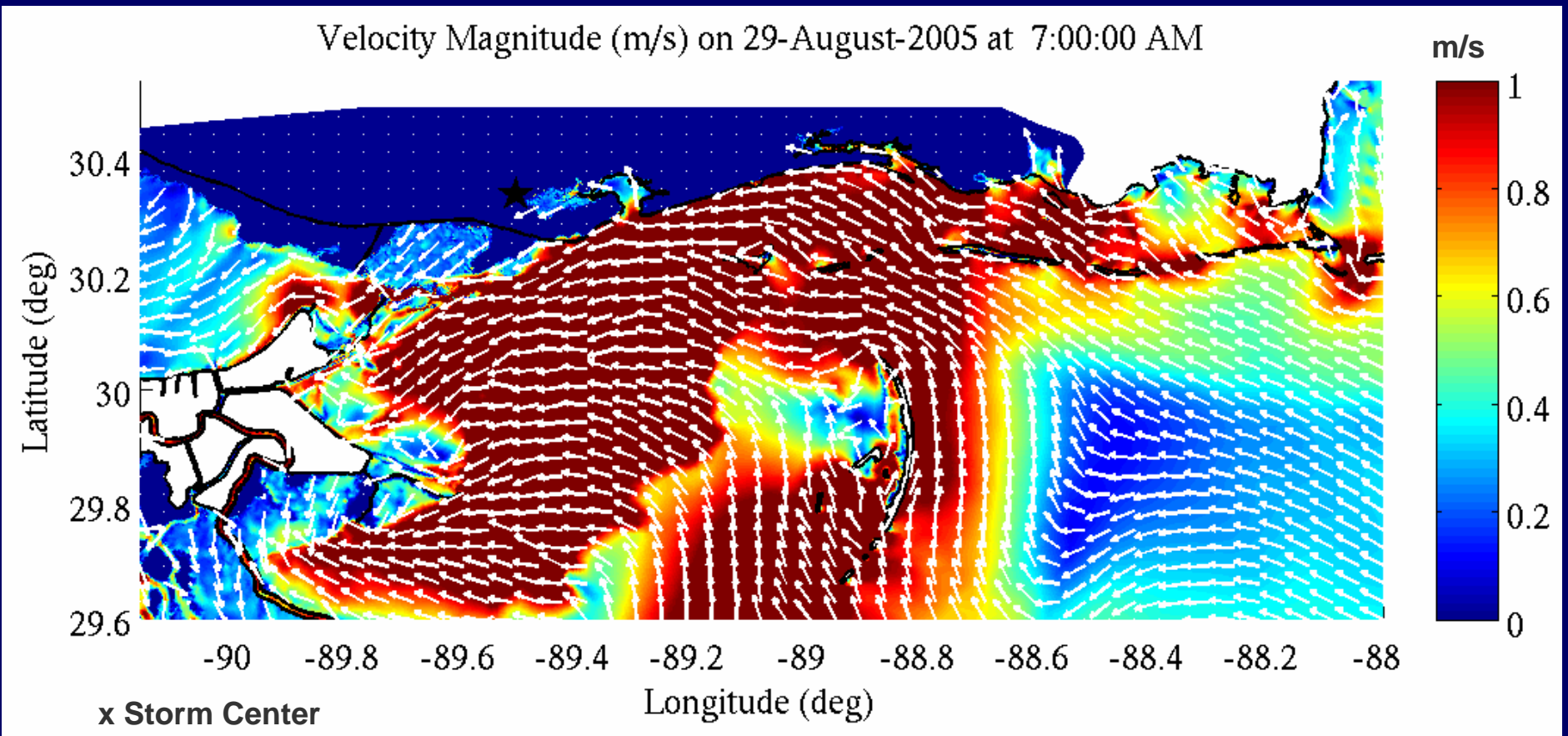
# ADCIRC Computed Currents



# ADCIRC Computed Currents

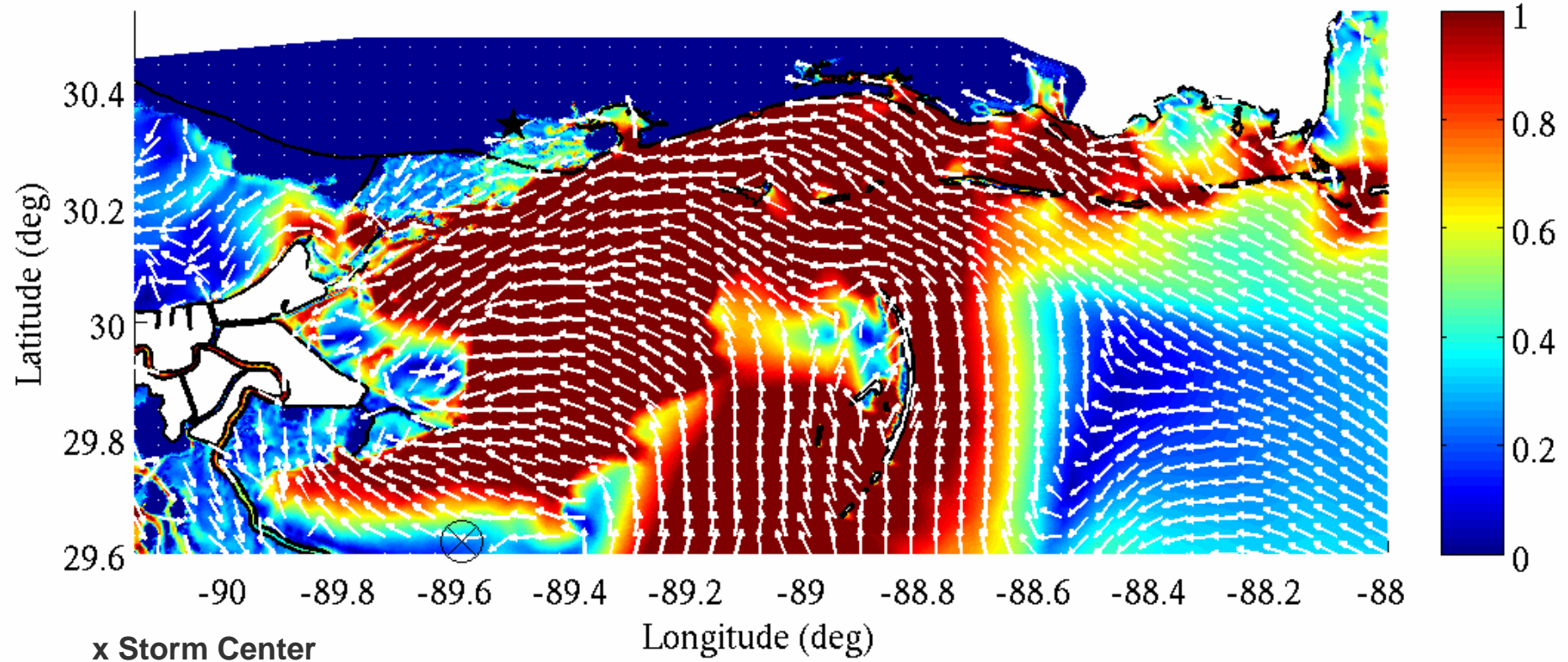


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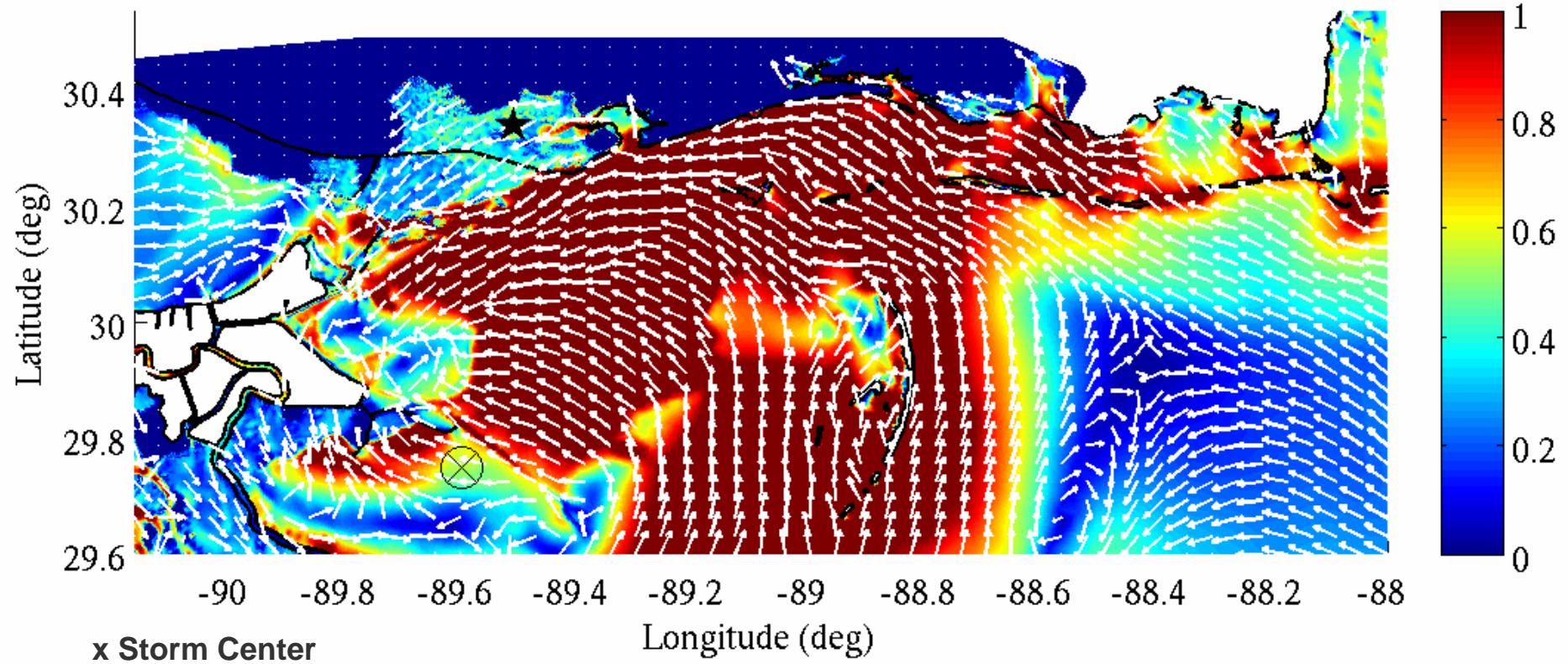
# ADCIRC Computed Currents

Velocity Magnitude (m/s) on 29-August-2005 at 7:29:59 AM

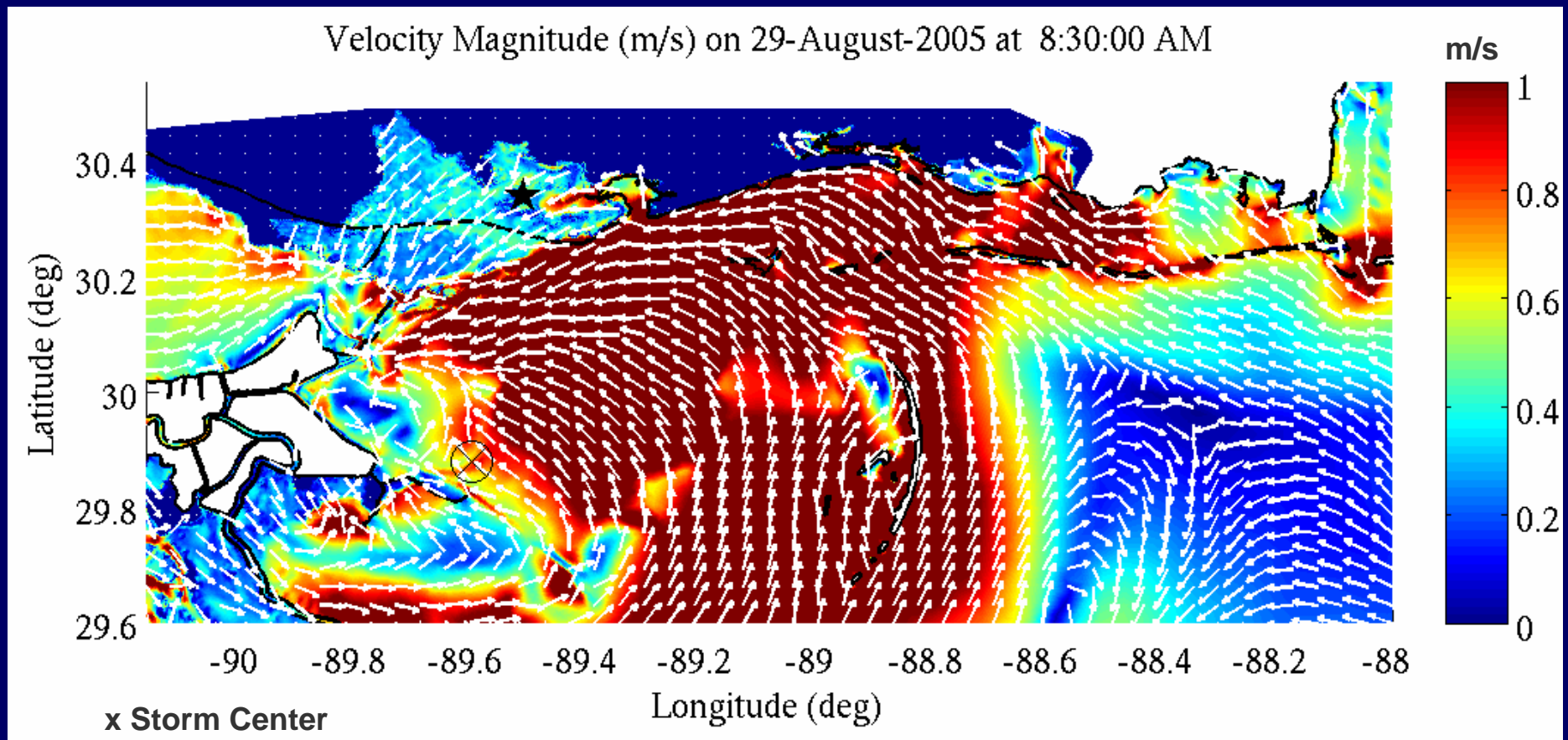


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Velocity Magnitude (m/s) on 29-August-2005 at 8:00:00 AM

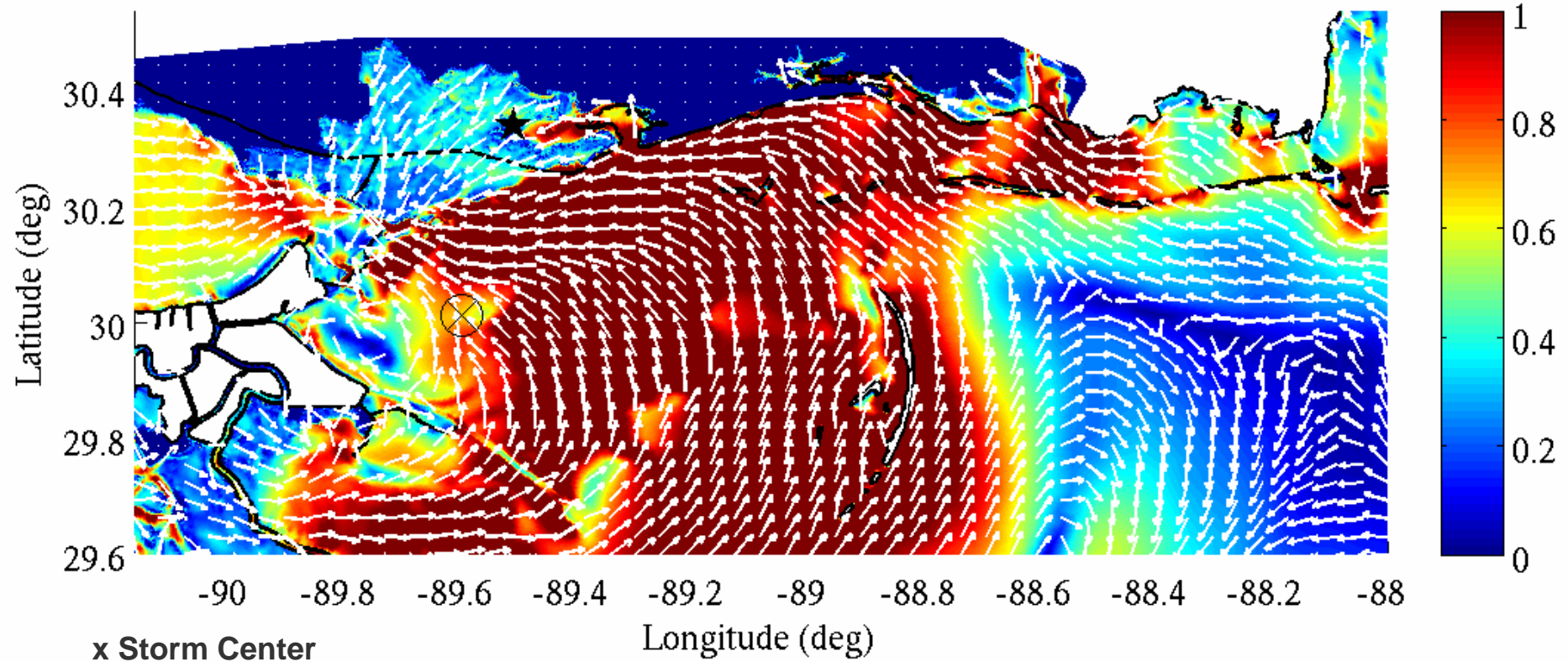


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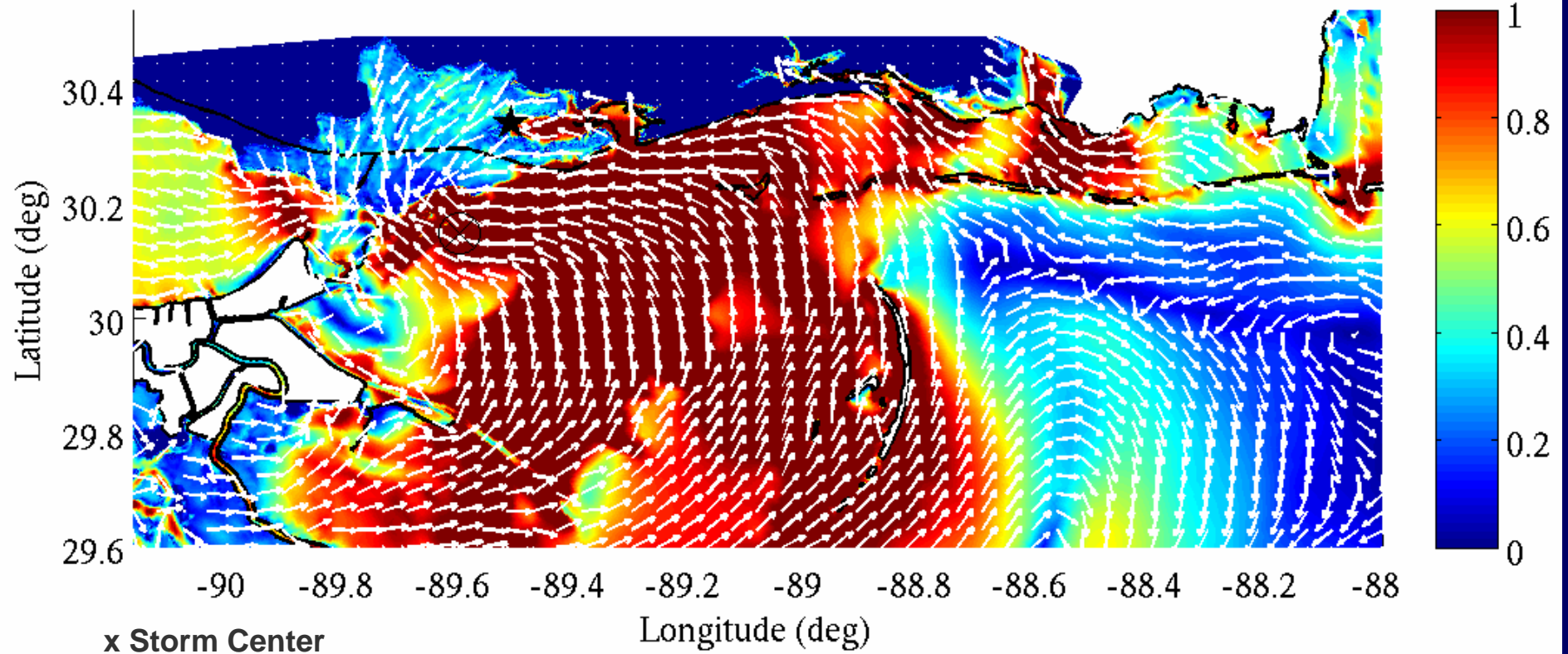
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Velocity Magnitude (m/s) on 29-August-2005 at 8:59:59 AM

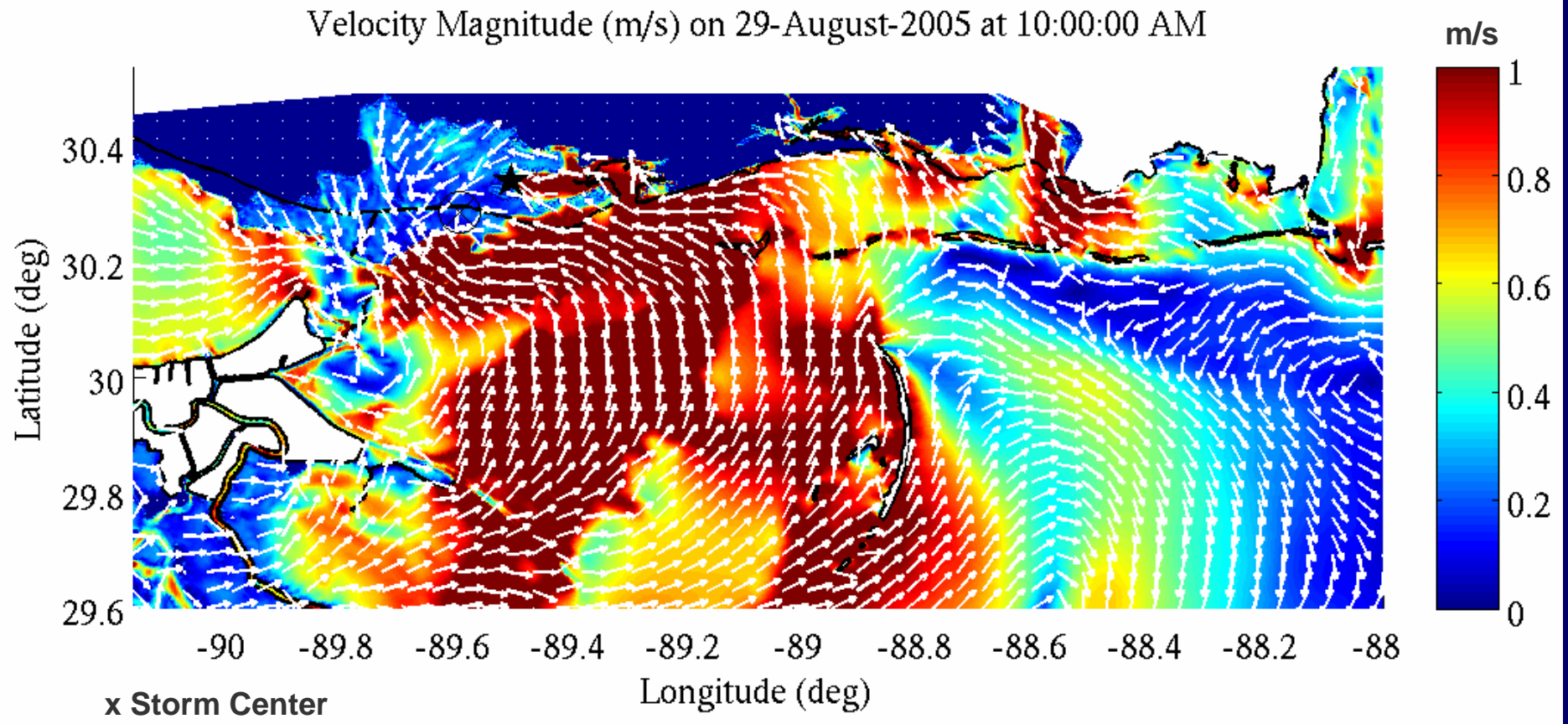


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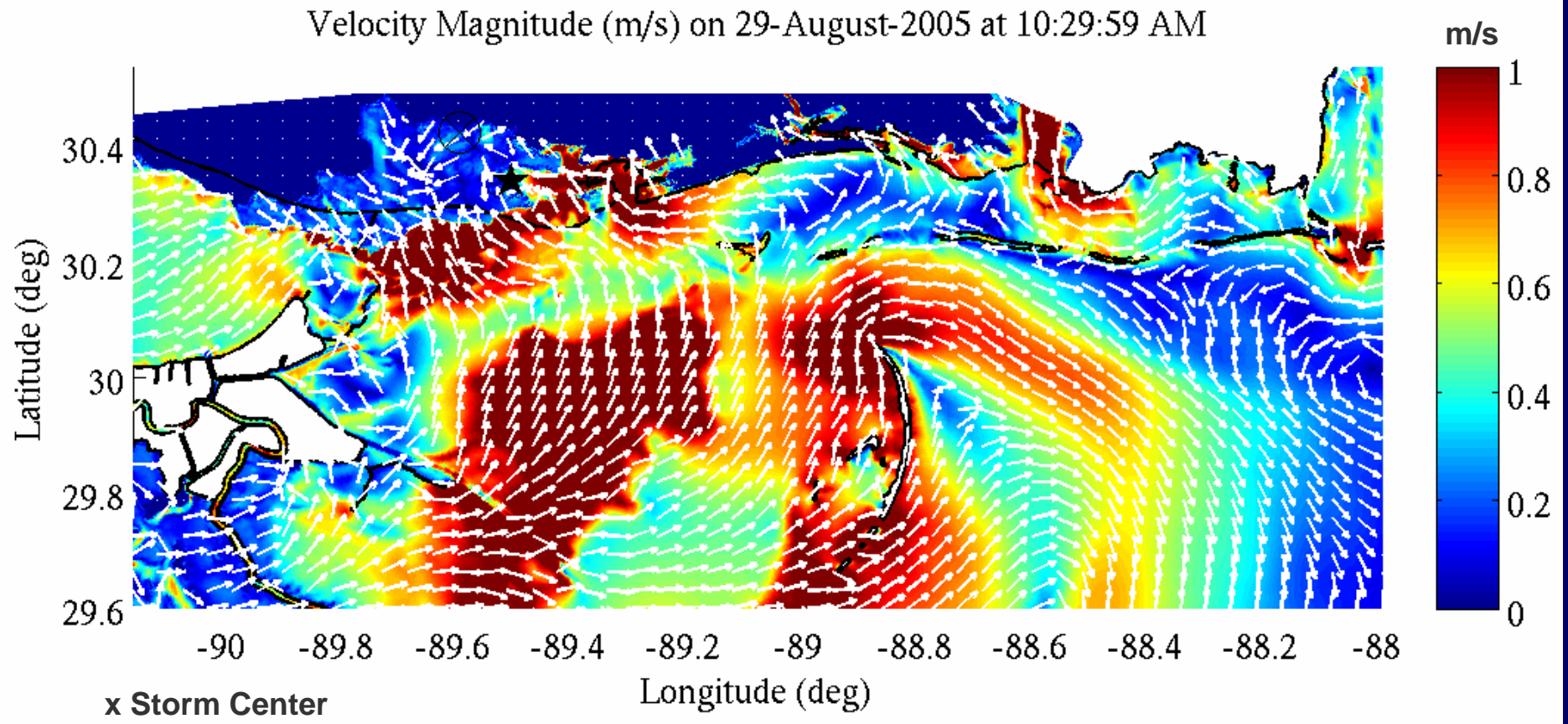
Velocity Magnitude (m/s) on 29-August-2005 at 9:30:00 AM



# ADCIRC Computed Currents

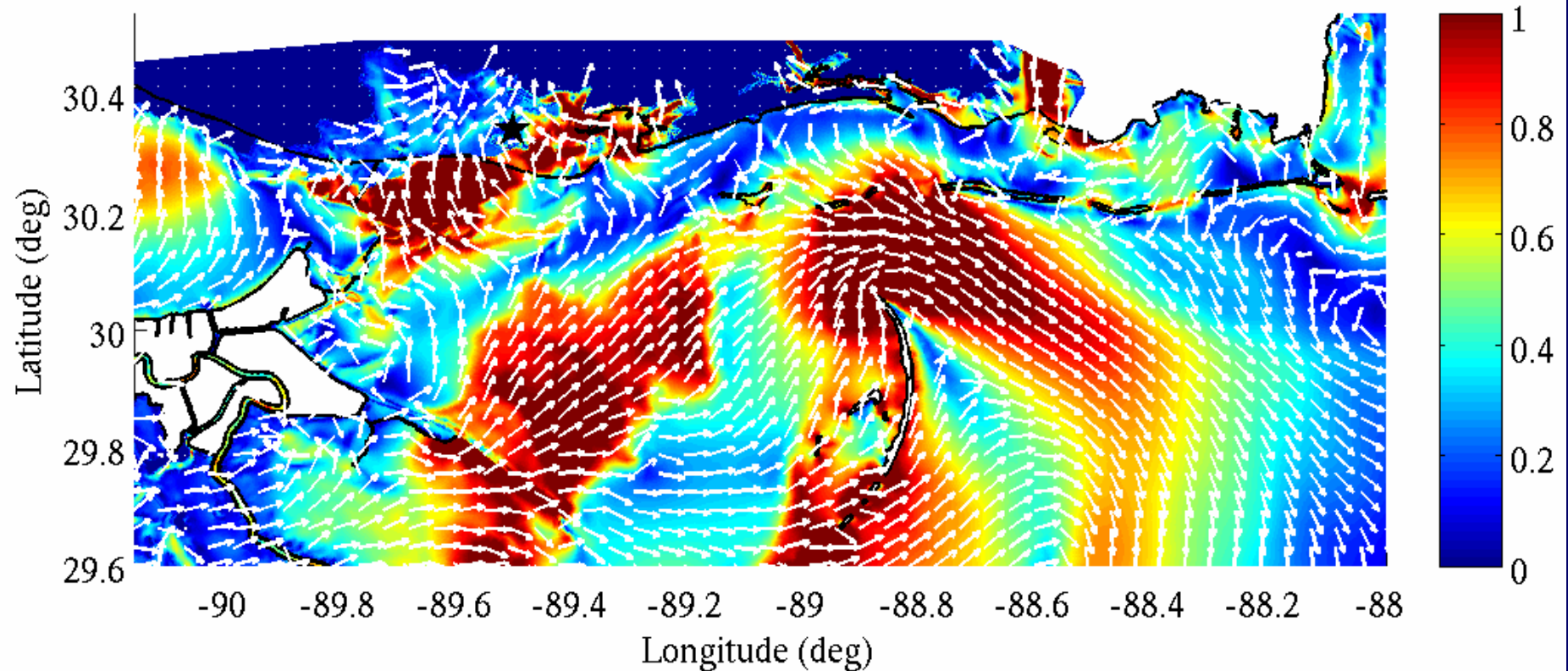


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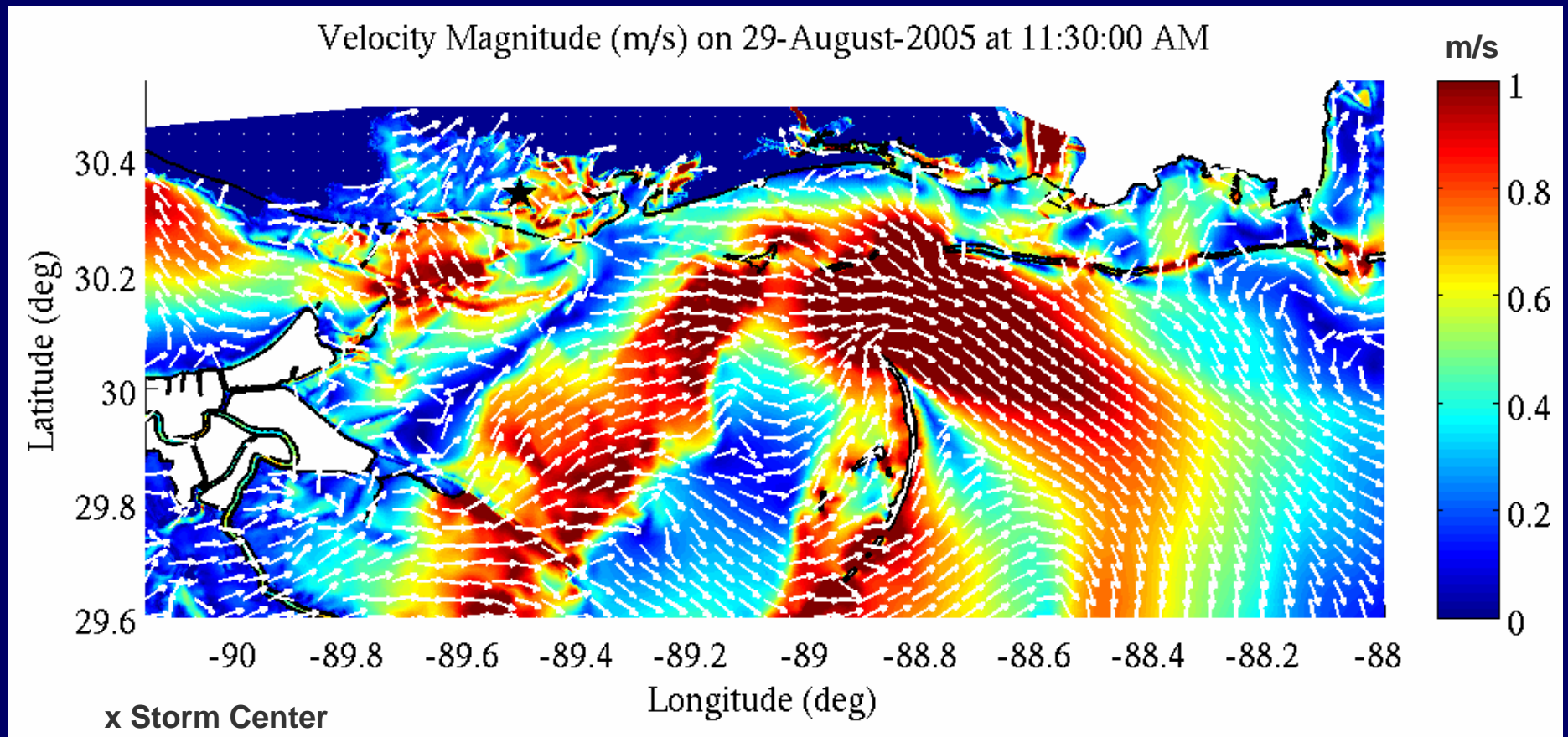


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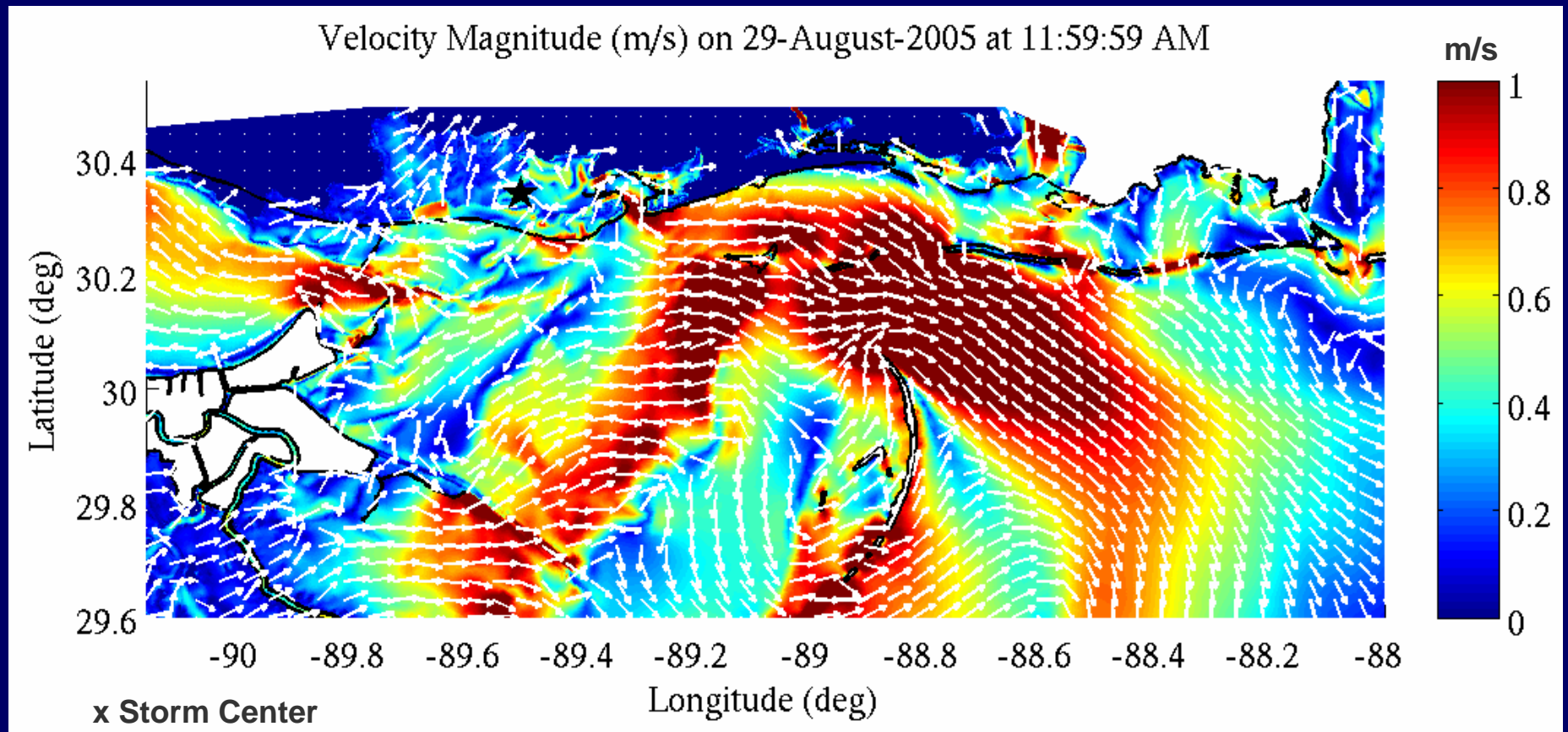
Velocity Magnitude (m/s) on 29-August-2005 at 11:00:00 AM



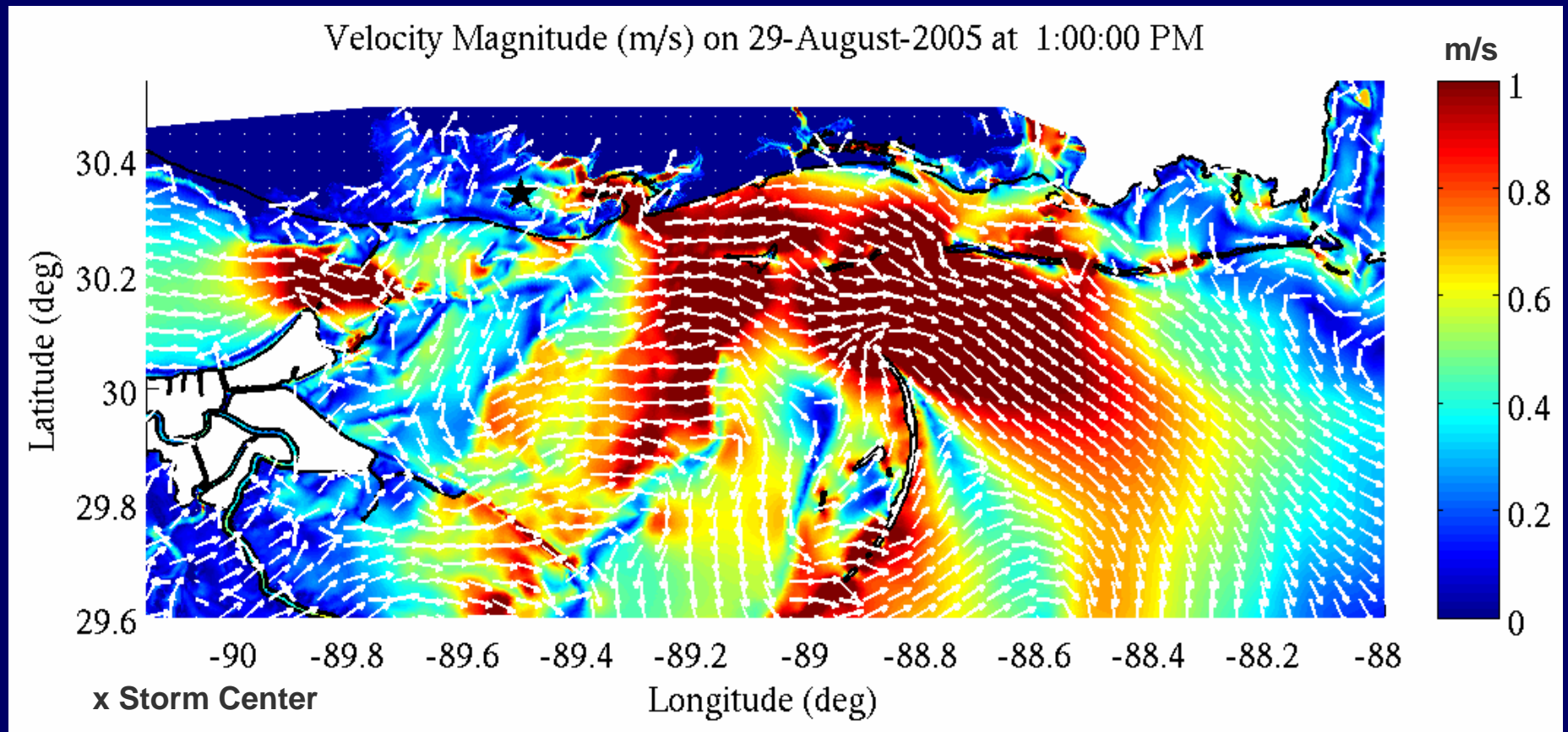
# ADCIRC Computed Currents



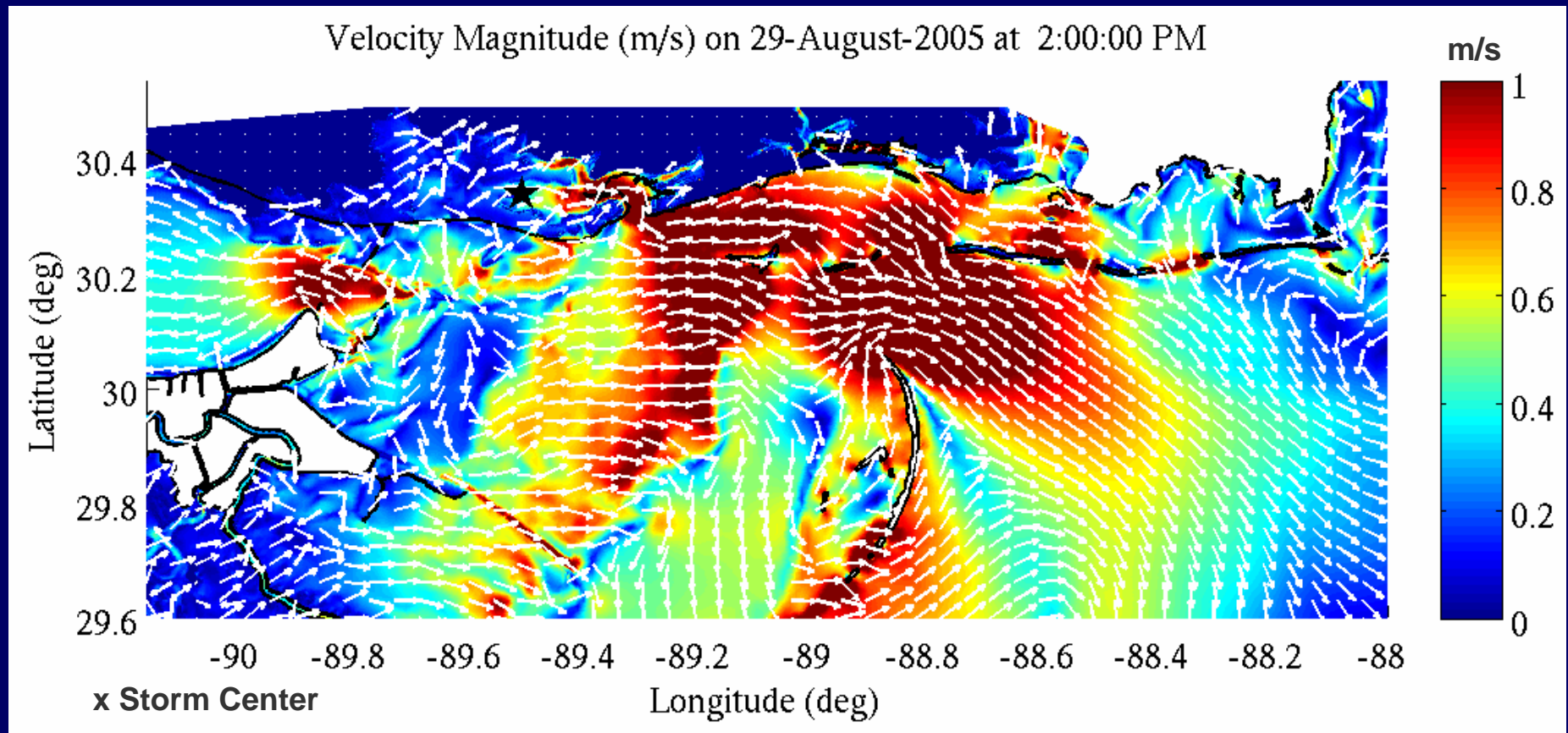
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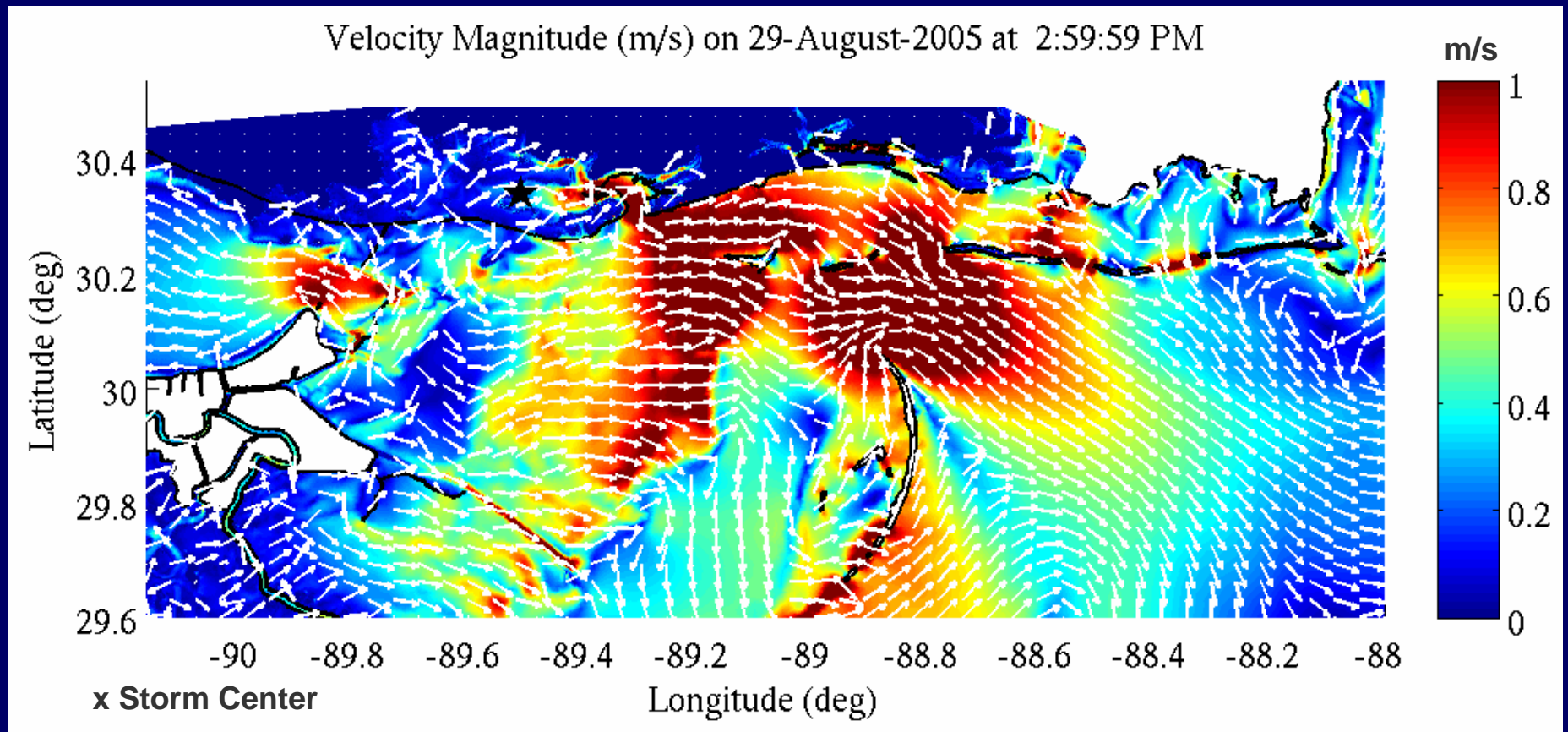
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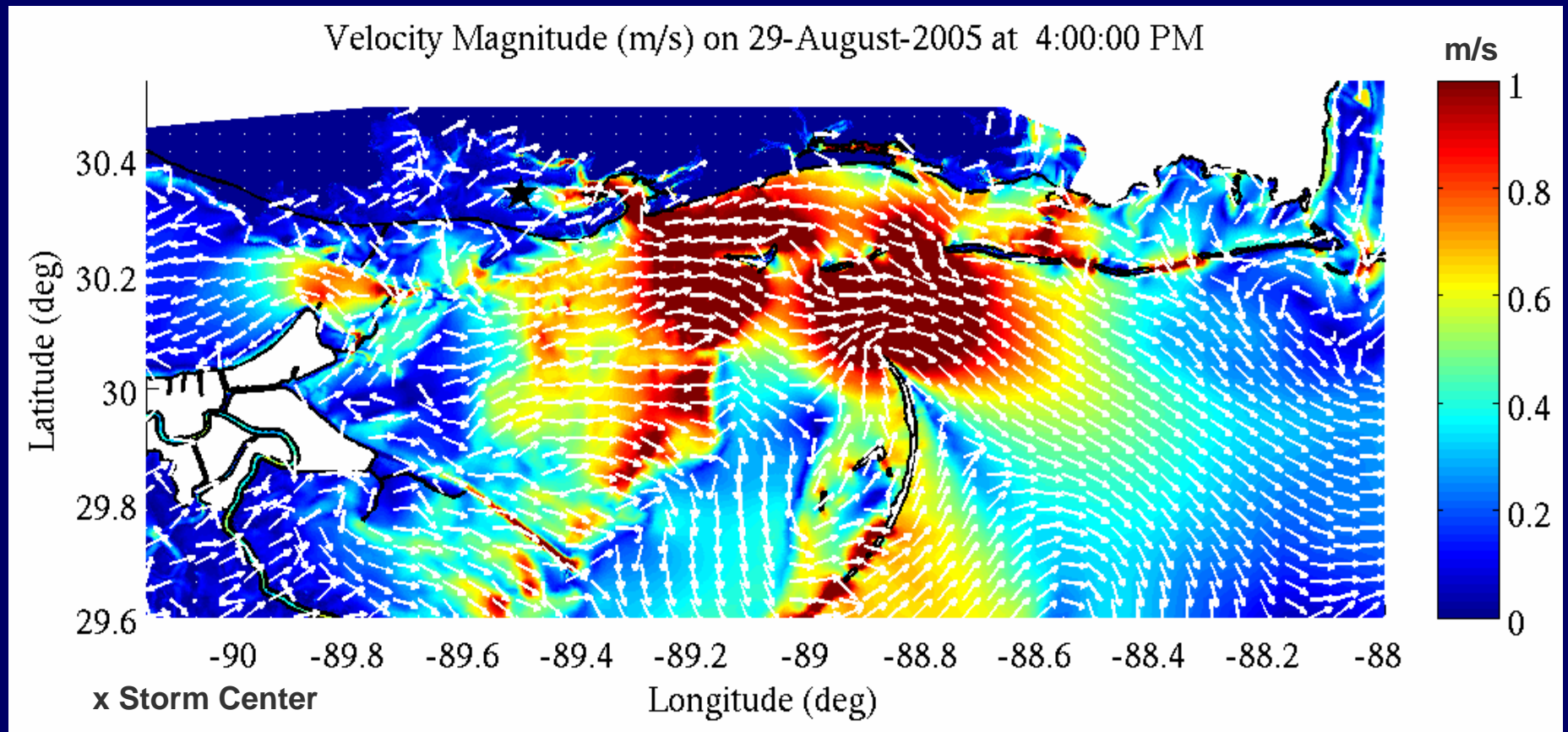
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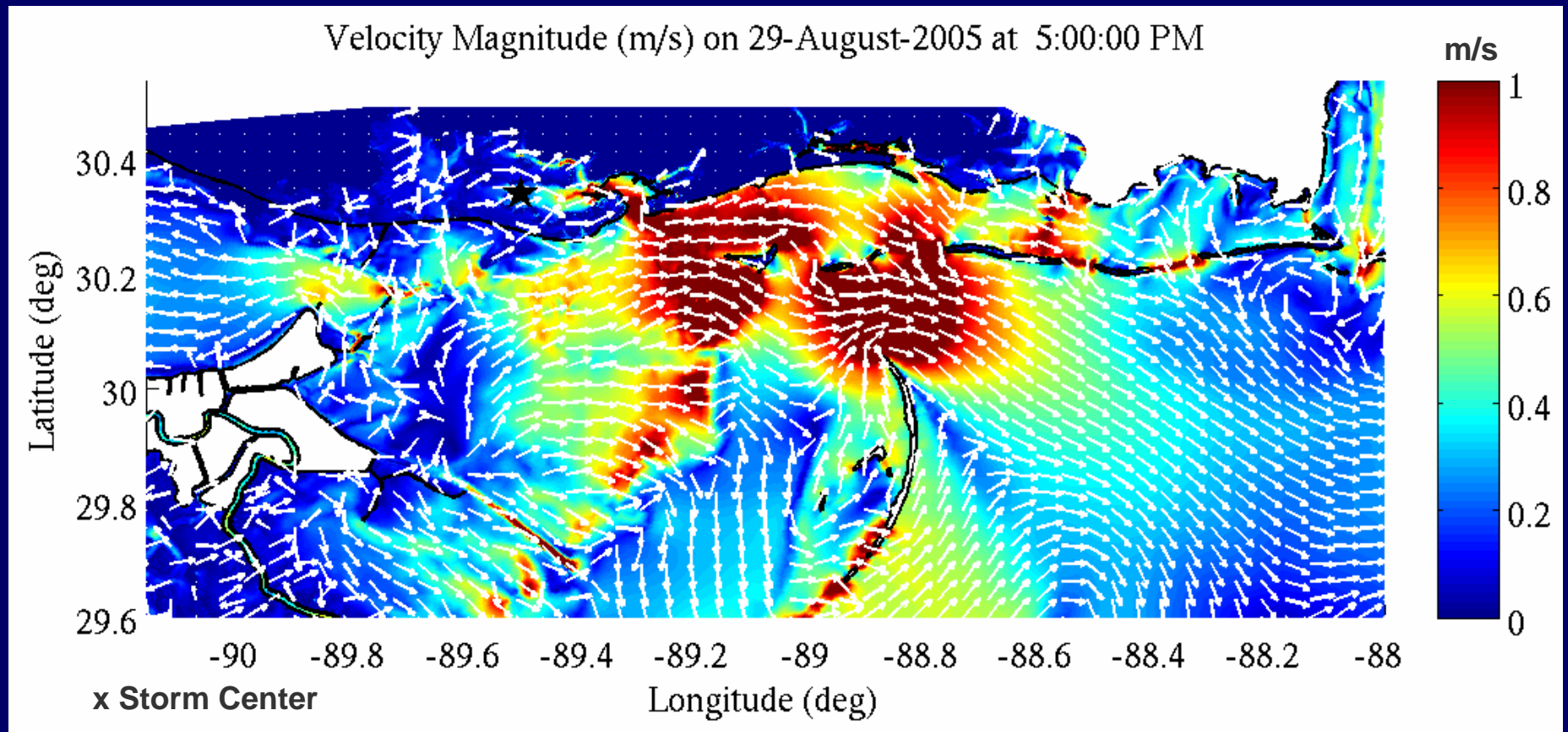
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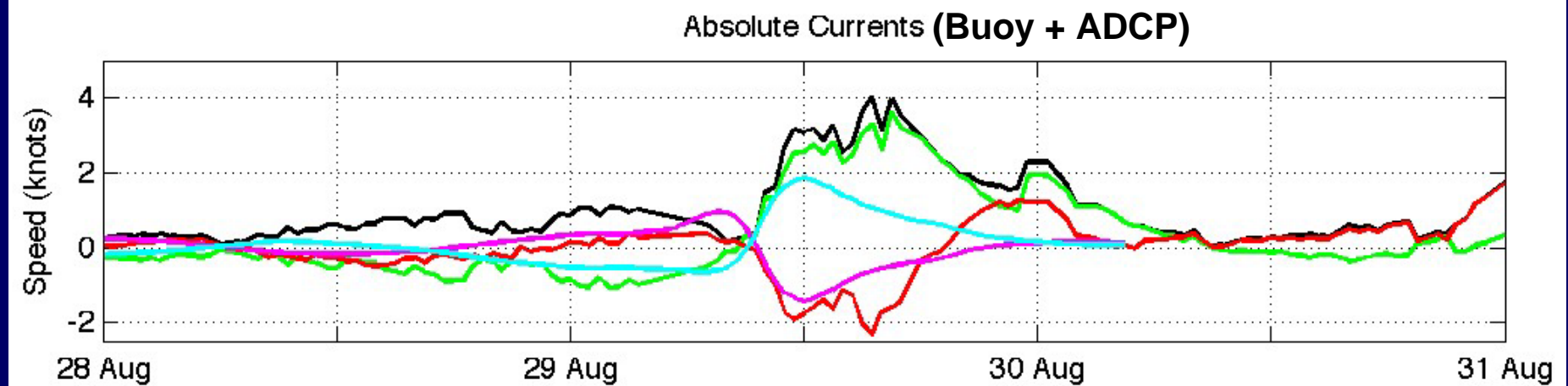
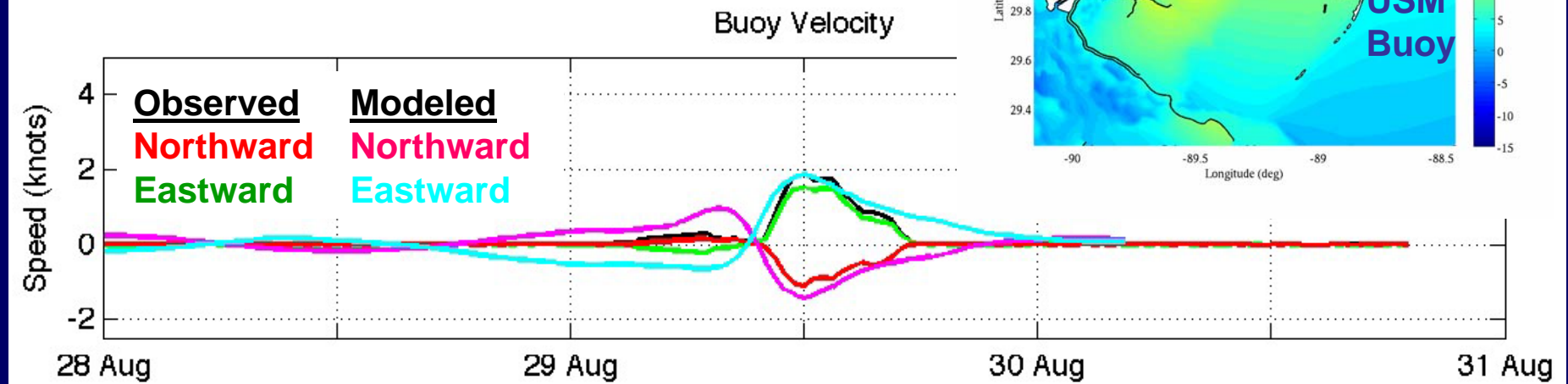
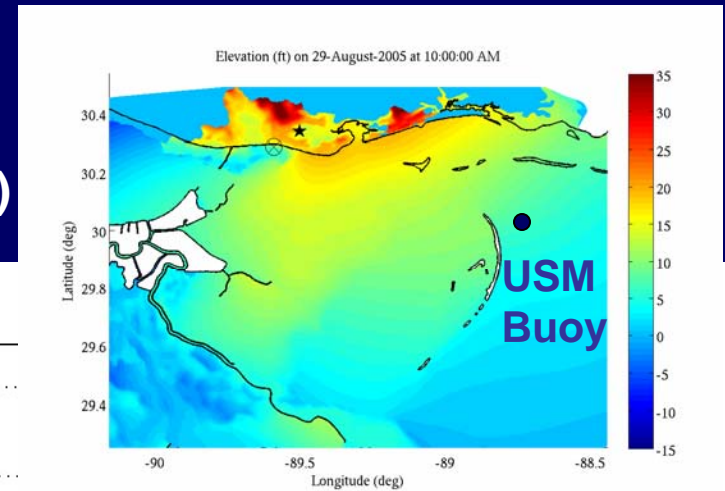


# ADCIRC Computed Currents

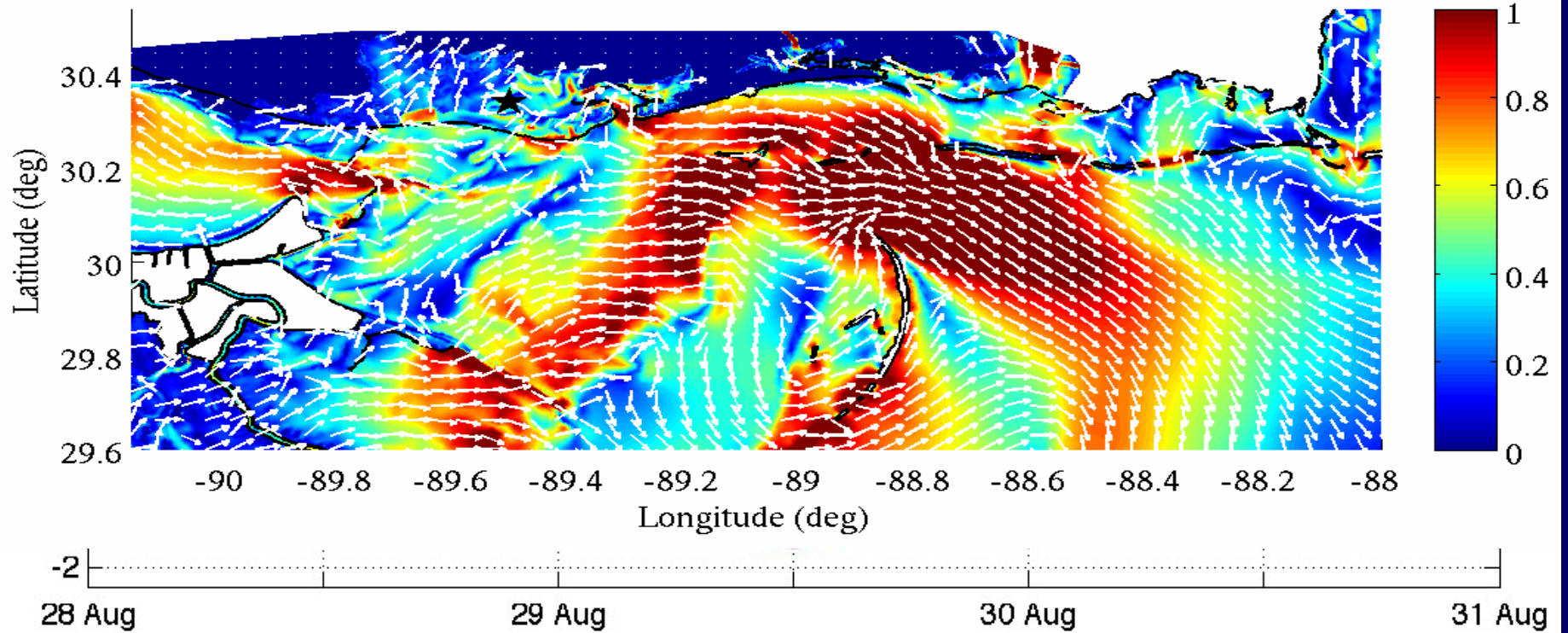


# Current Comparisons

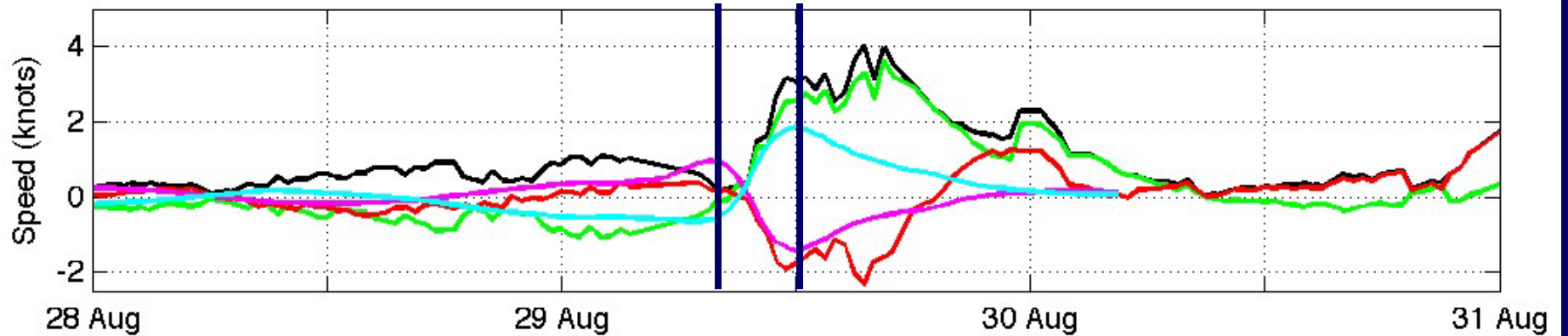
USM Buoy (Courtesy: Dr. Stephan Howden)



Velocity Magnitude (m/s) on 29-August-2005 at 11:59:59 AM



Absolute Currents (Buoy + ADCP)

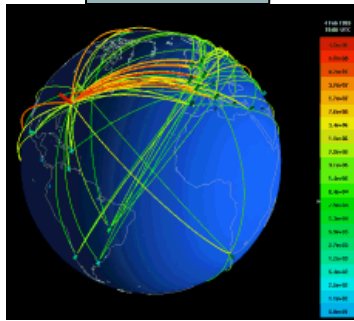




# DEVELOPED STORM SURGE PREDICTION SYSTEM

1

WWW NHC Marine Advisory Data



000 WTNT25 KNHC 062031 TCMAT5  
TROPICAL DEPRESSION ZETA  
FORECAST/ADVISORY NUMBER 30  
NWS TPC/NATIONAL HURRICANE  
CENTER MIAMI

2100Z FRI JAN 6

TROPICAL DEPRESSION

CENTER LOCATED NEAR 23.4N  
50.3W ...

... FORECASTER STEWART \$\$

Interpolate

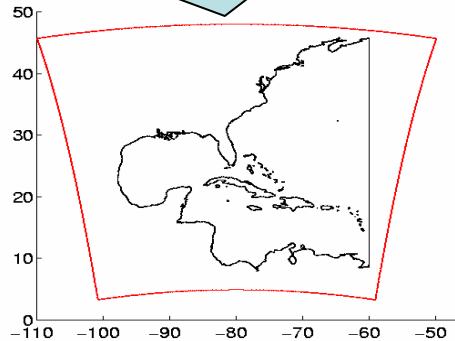
**DELIVERED TO NAVOCEANO, May 2006**



2

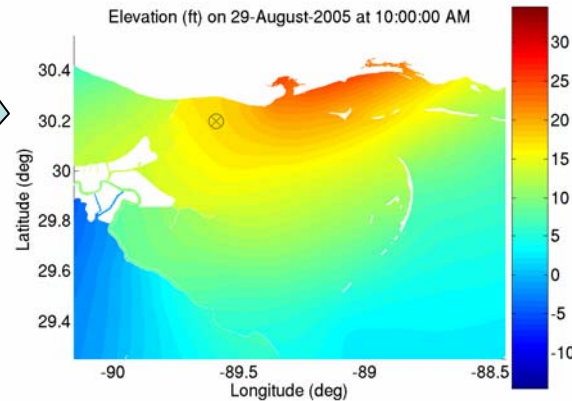
Run PC-Tides –

Obtain Holland Hurricane  
Model Winds



4

Run ADCIRC



# The Model as a Planning Tool

**Modularity of the model permits experimentation:**

- isolate of physical processes
- determine role of geometric constraints
- examine sensitivity of forcing scenario
- begin to assign uncertainty to predictions

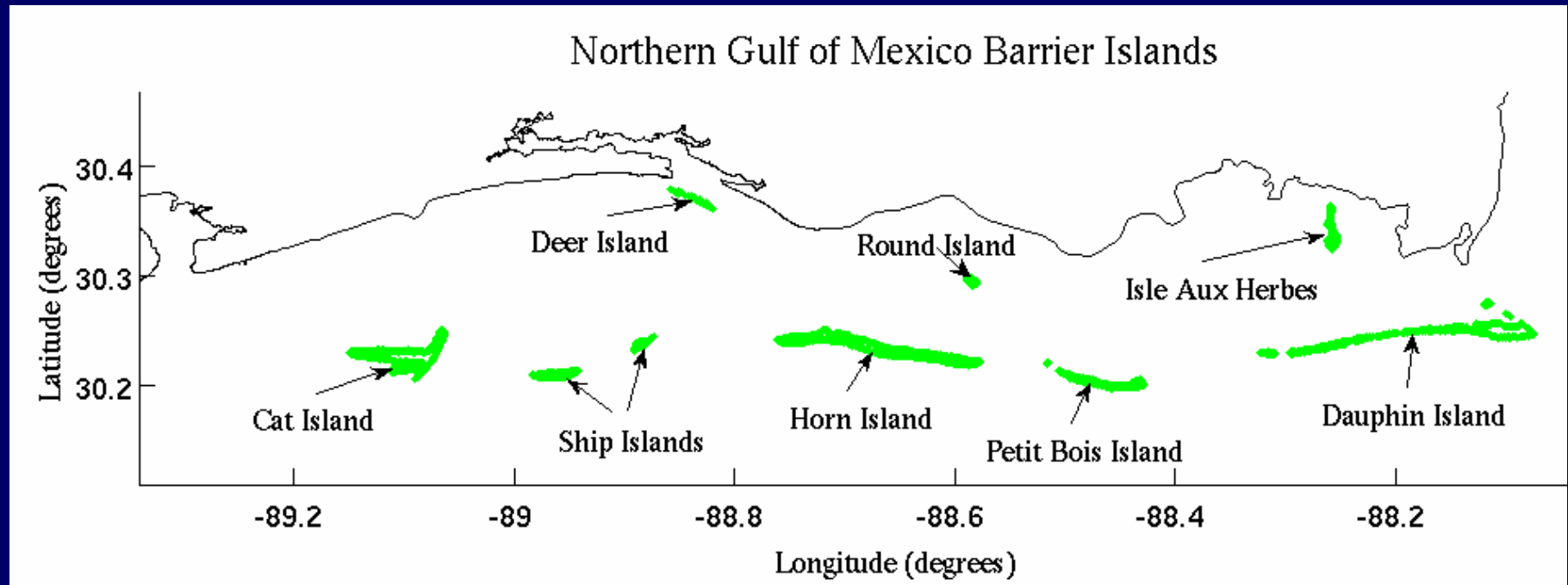
## **Goal:**

**Determine the predictability of storm surge**

- how far in advance can we predict the outcome?
- what are the critical pieces of data?

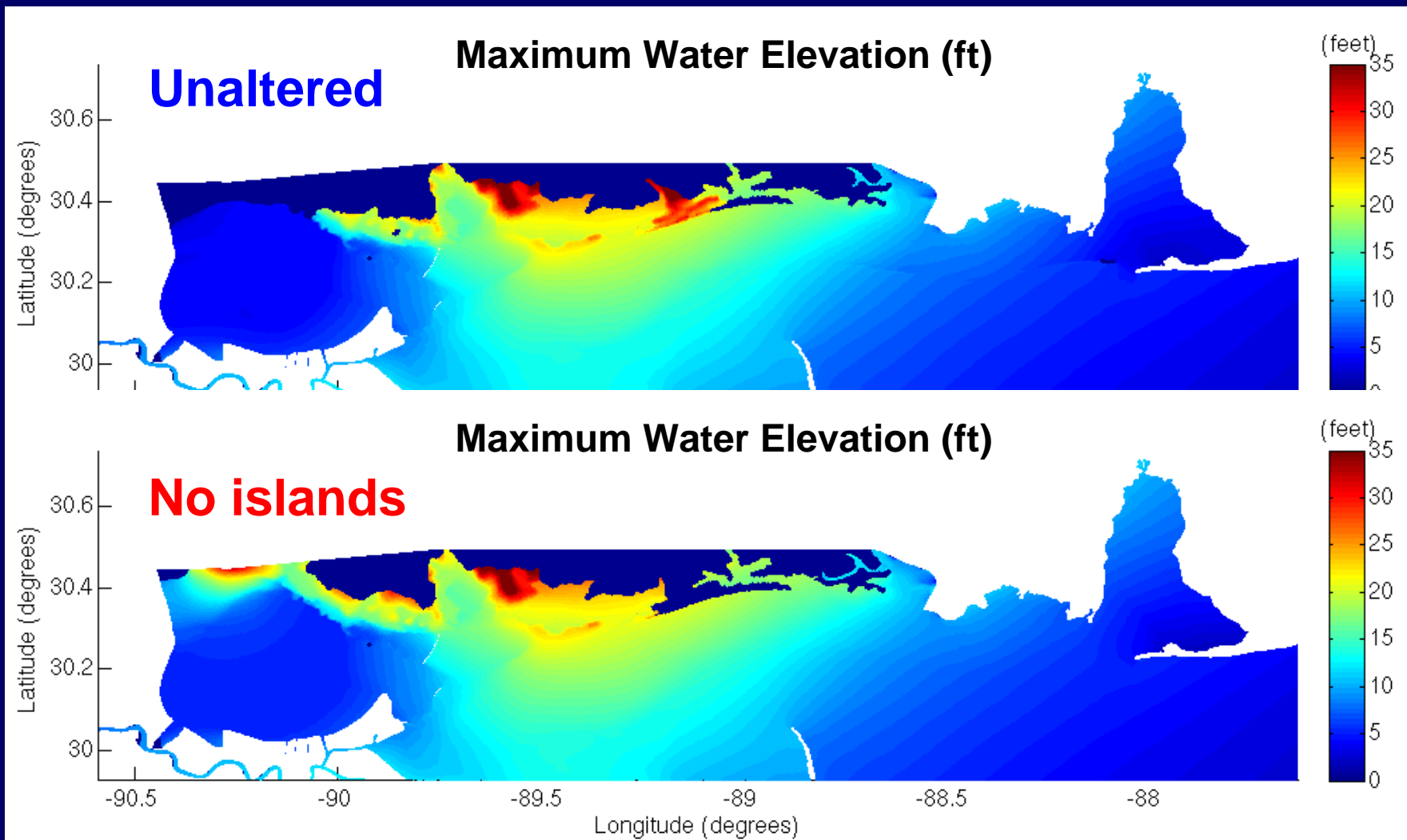
# The Model as a Planning Tool

What is impact of islands on inundation?



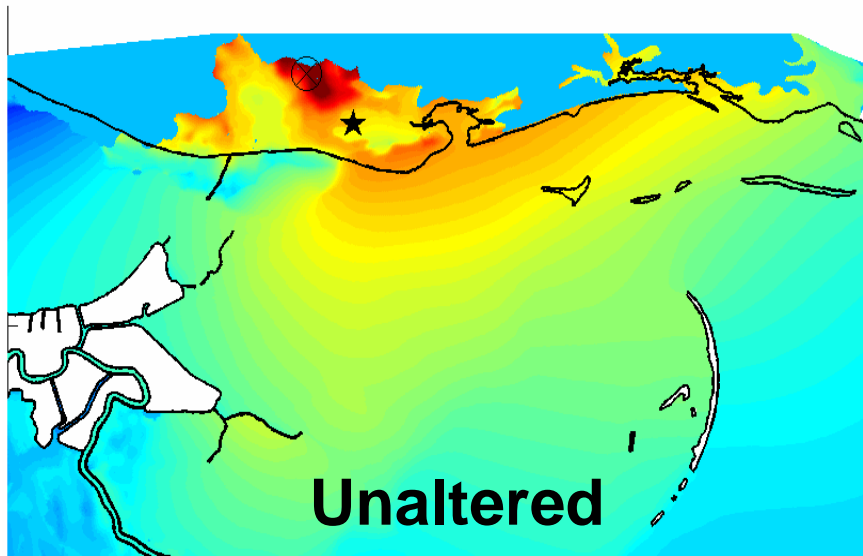
# The Model as a Planning Tool

## What is impact of islands on inundation?

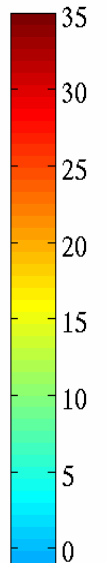
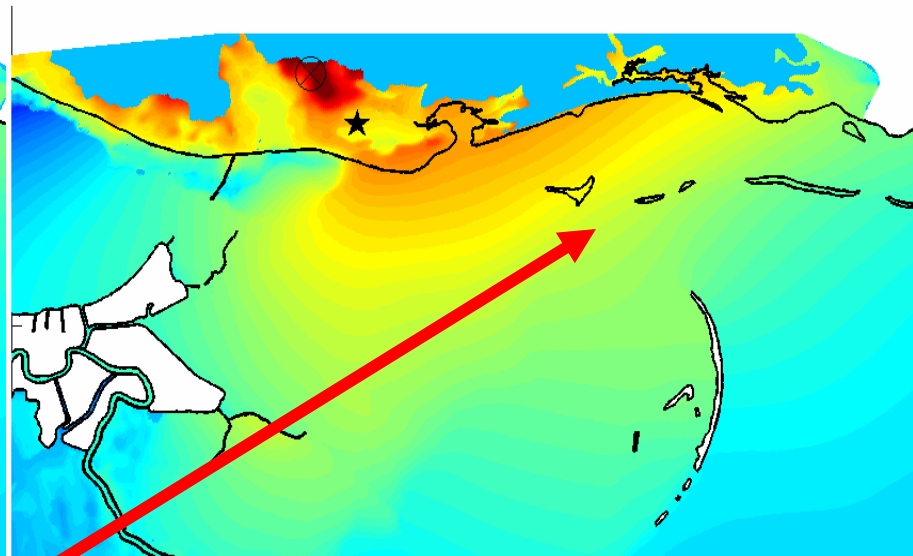


# The Model as a Planning Tool

Elevation (ft) on 29-August-2005 at 10:29:59 AM

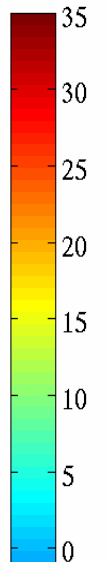
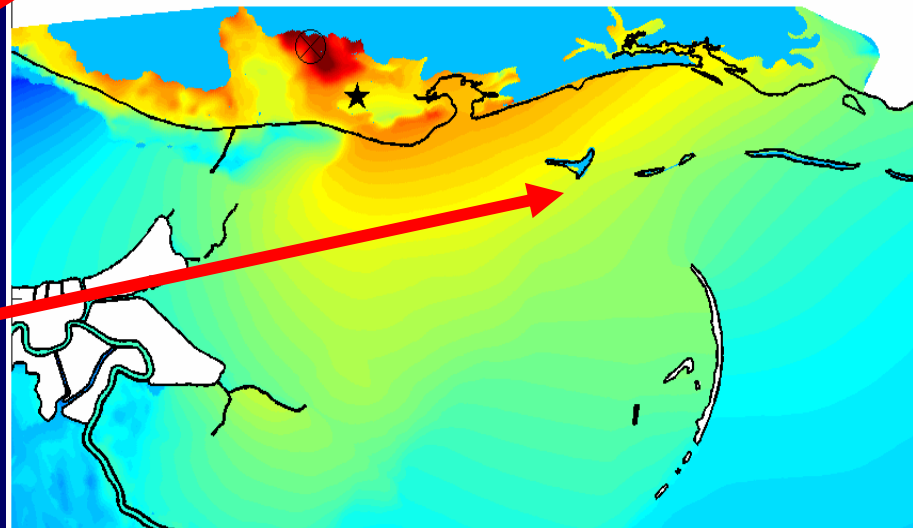


Elevation (ft) on 29-August-2005 at 10:29:59 AM



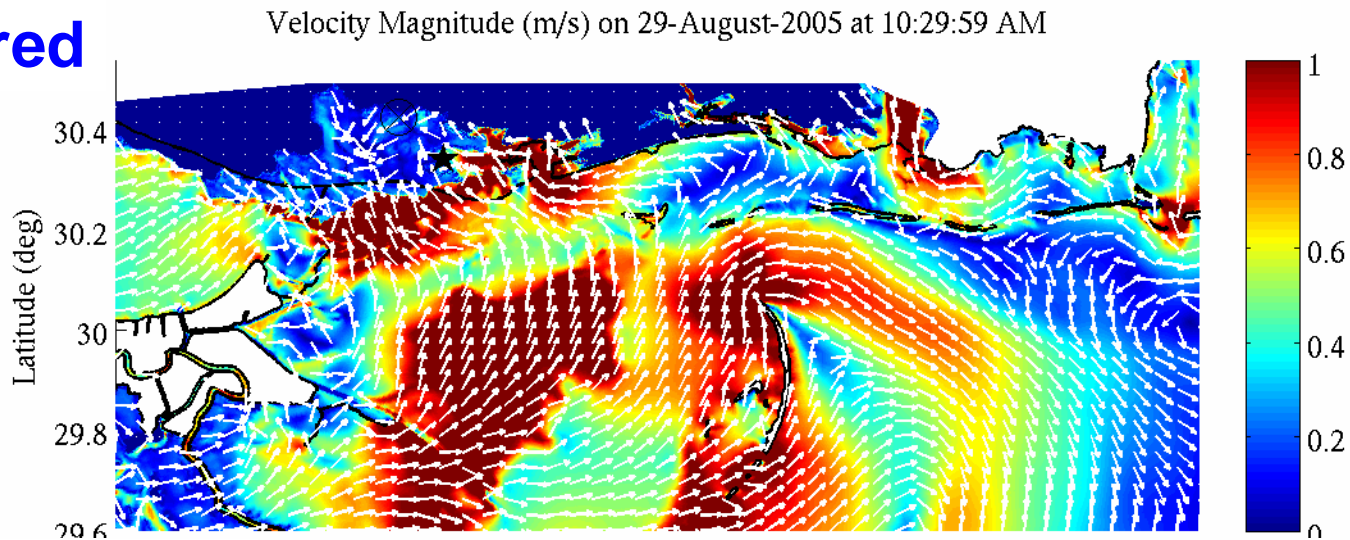
Islands **lowered** to surrounding water depths

Islands **raised** to prevent overtopping

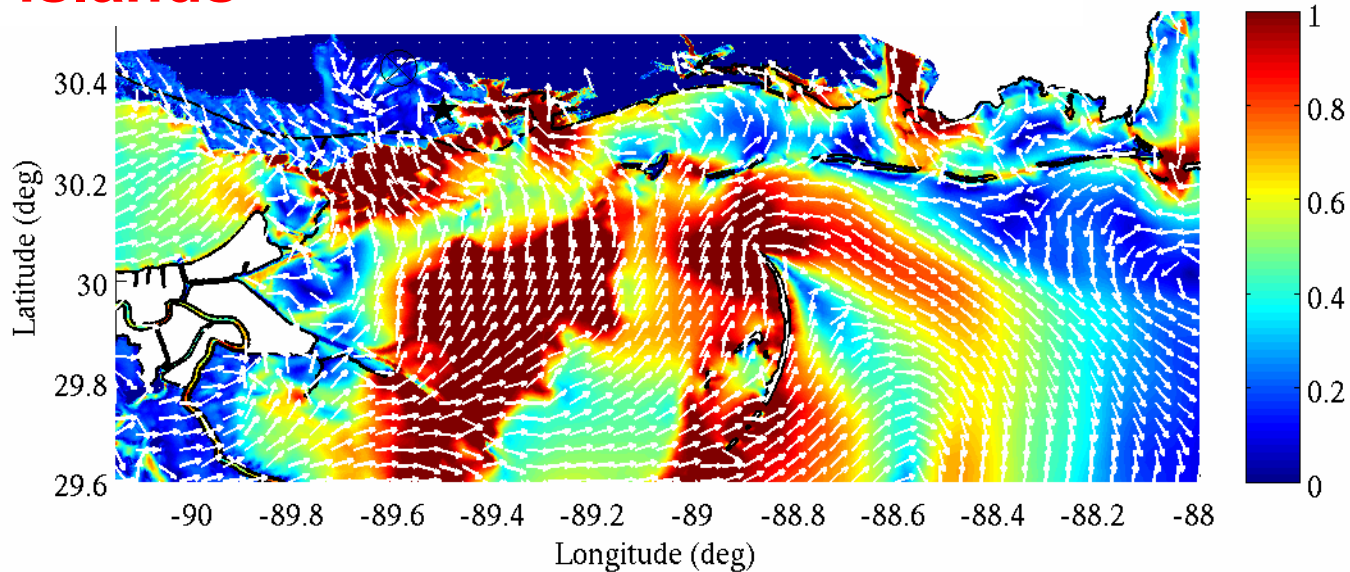


# The Model as a Planning Tool

**Unaltered**



**Raised islands**



# The Model as a Planning Tool

TO BE CONTINUED.....

**Validation** of the inundation prediction system and the **quantification of factors that affect inundation extent and magnitude** transfer to environments containing **tidal flats** and **rivers**.