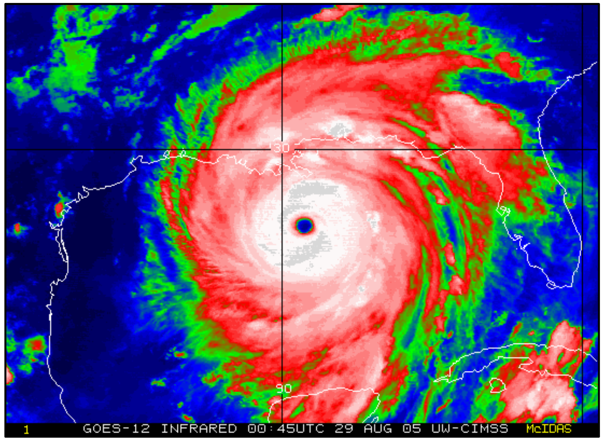
Interagency Performance Evaluation Task Force



Hurricane Katrina Storm Hydrodynamics and Forces

Co-Leaders

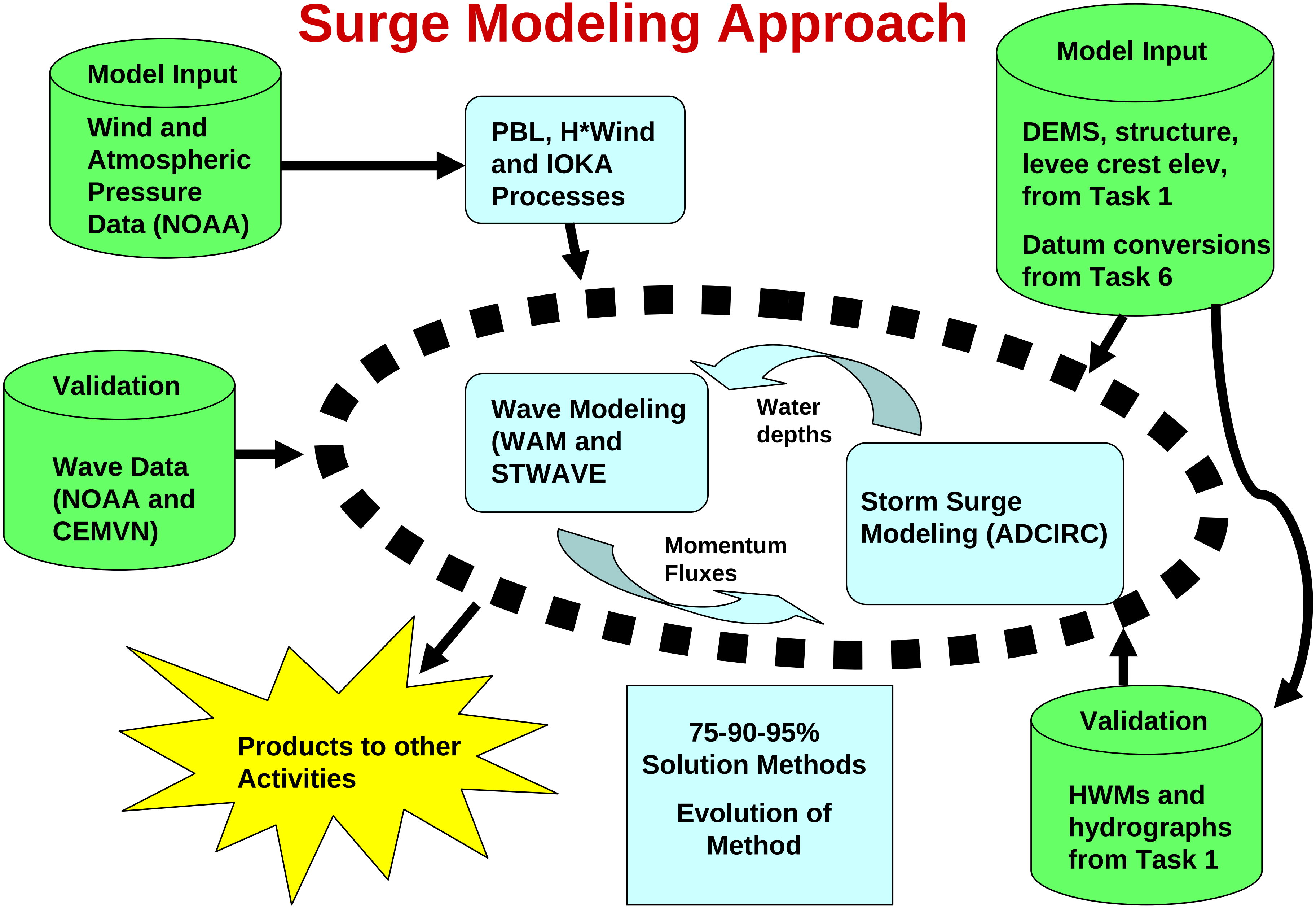
Bruce Ebersole and Don Resio, USACE
Joannes Westerink, Univ. of Notre Dame
Robert Dean, Univ. of Florida

Objectives

- Develop best estimates of time series of water level and wave conditions (height, period, direction, energy spectra) for Hurricane Katrina at key locations - regional perspective
  - entrances to canals along the Lake Pontchartrain south shoreline
  - in the IHNC, GIWW, MRGO and MS River
  - fronting the levees that are part of the flood and hurricane protection projects

- Develop best estimates of time-varying forces acting directly on levees and flood walls per unit width (water levels, wave fields, overtopping rates, vertical distribution of static/dynamic loads, total force/total moment, near-bottom velocities) – local perspective

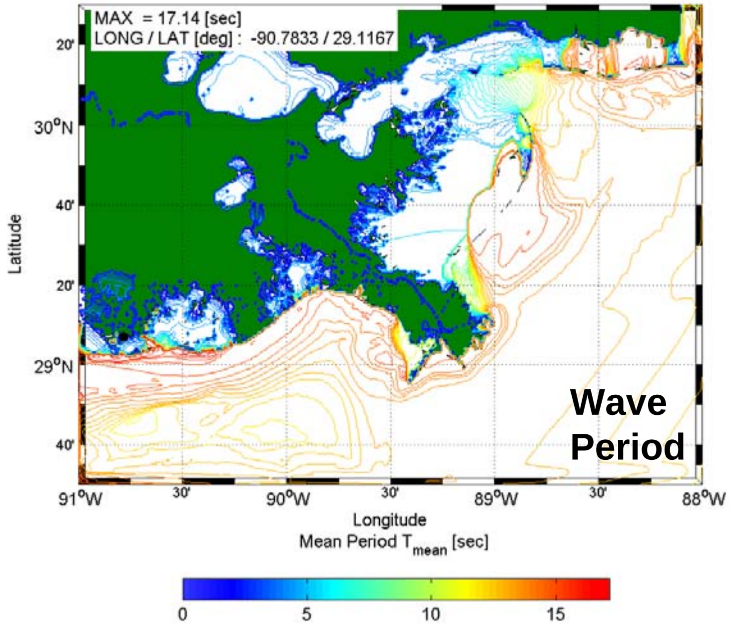
Regional Wave and Storm Surge Modeling Approach

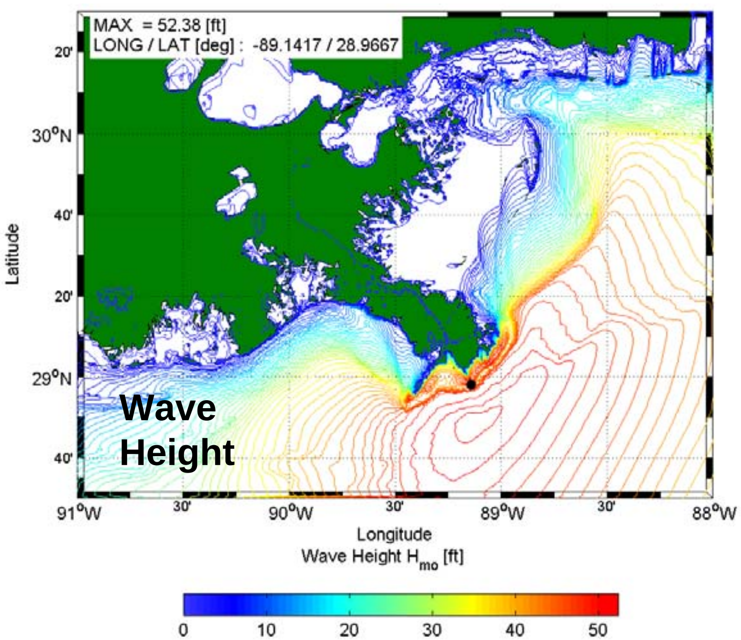


Nested Offshore Wave Modeling Approach

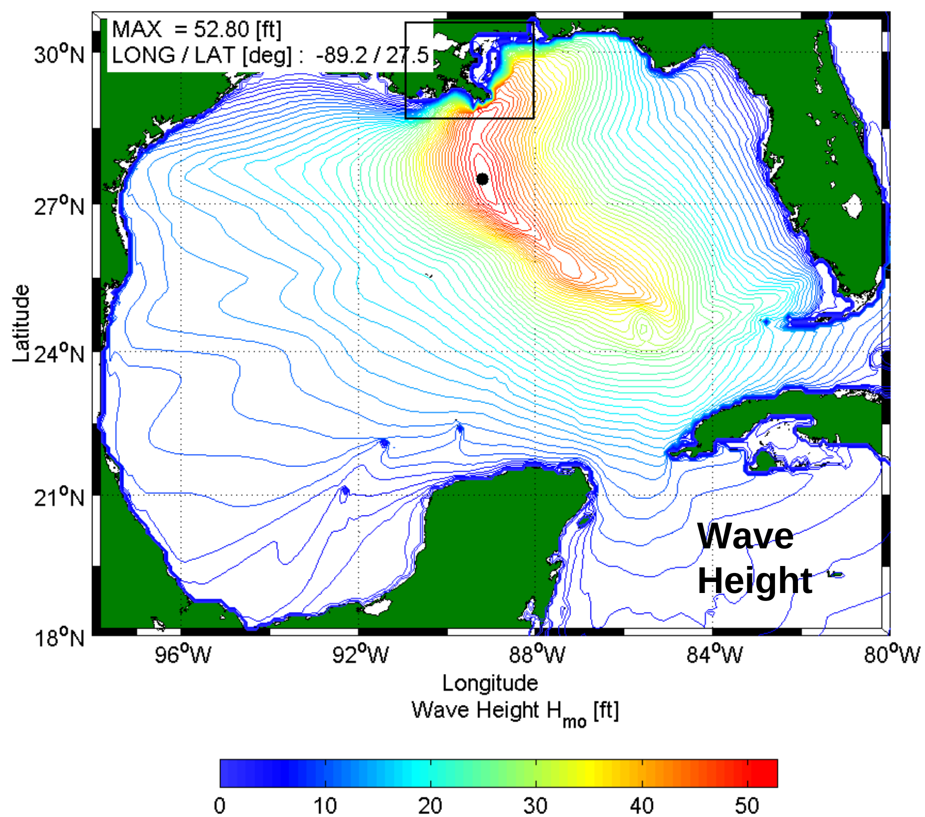
- Lateral boundary conditions for regional-scale model from the basin-scale model
- Winds from higher-resolution regional wind fields

Regional-Scale WAM Model

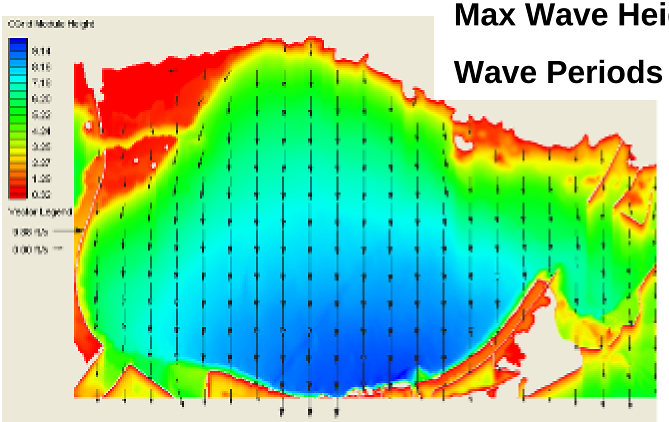




Basin-Scale WAM Model

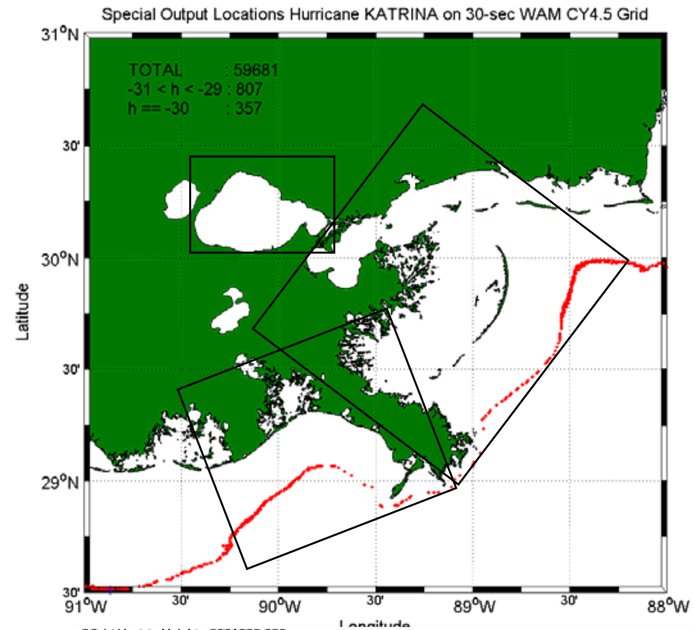


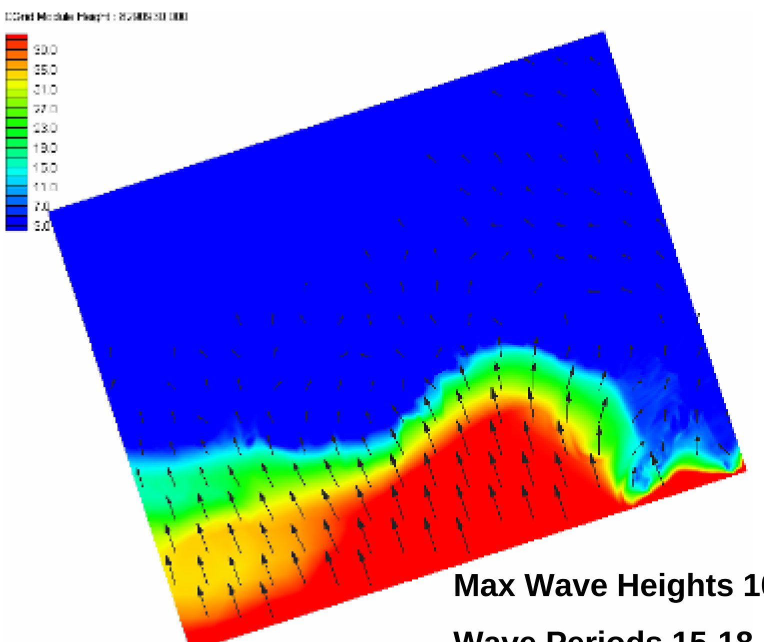
Nearshore Wave Modeling



Max Wave Heights 8-9 ft

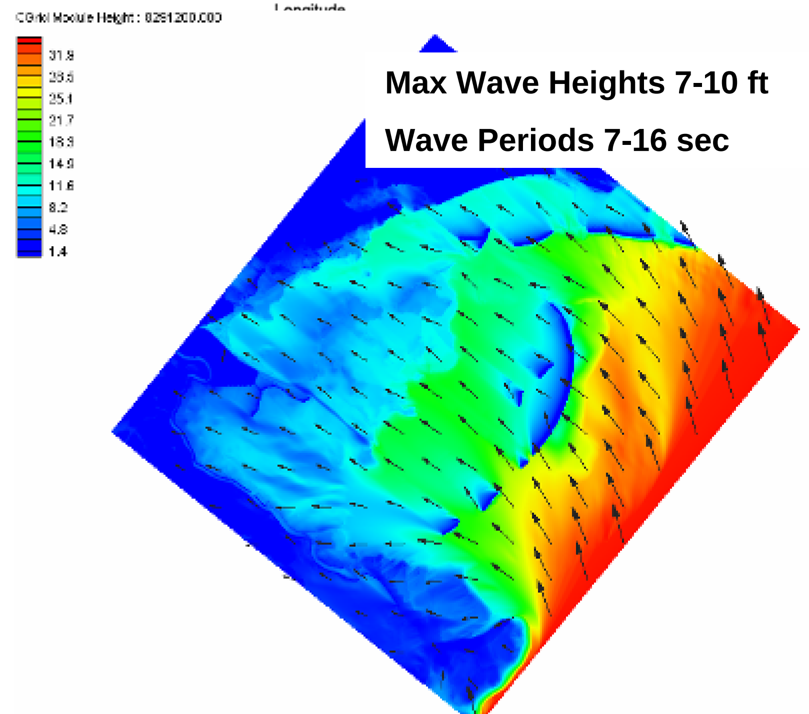
Wave Periods 7-8 sec





Max Wave Heights 10-13 ft

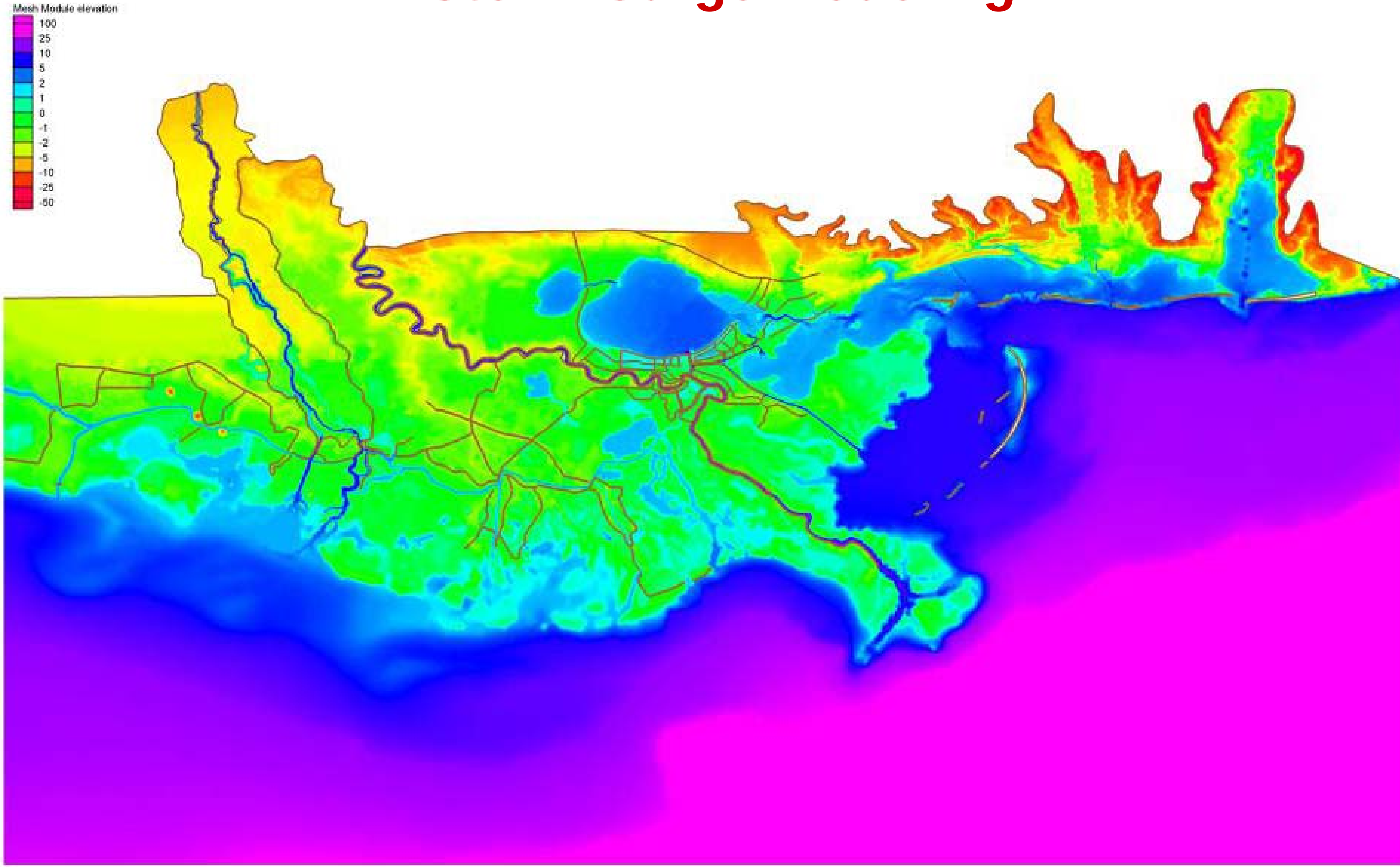
Wave Periods 15-18 sec

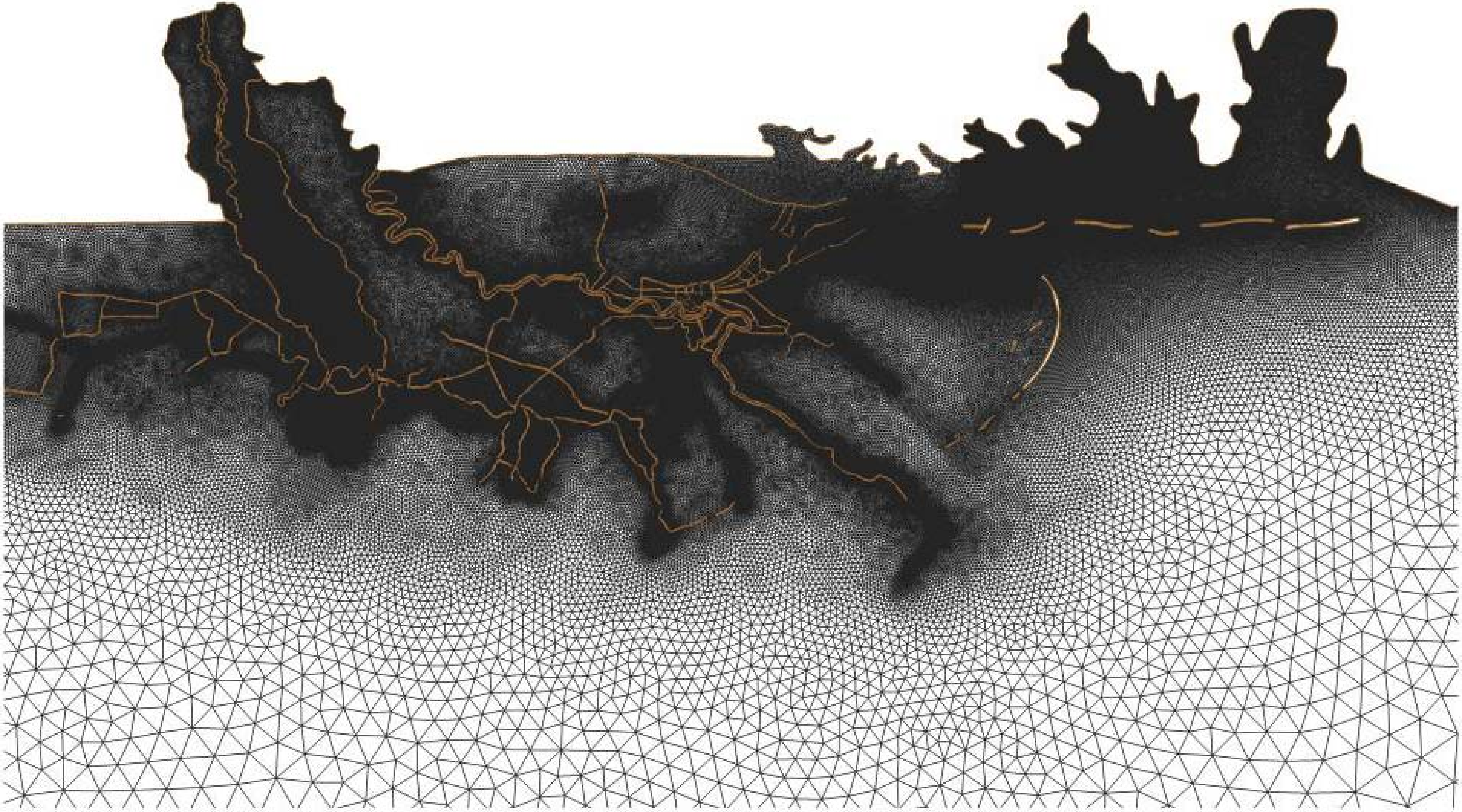


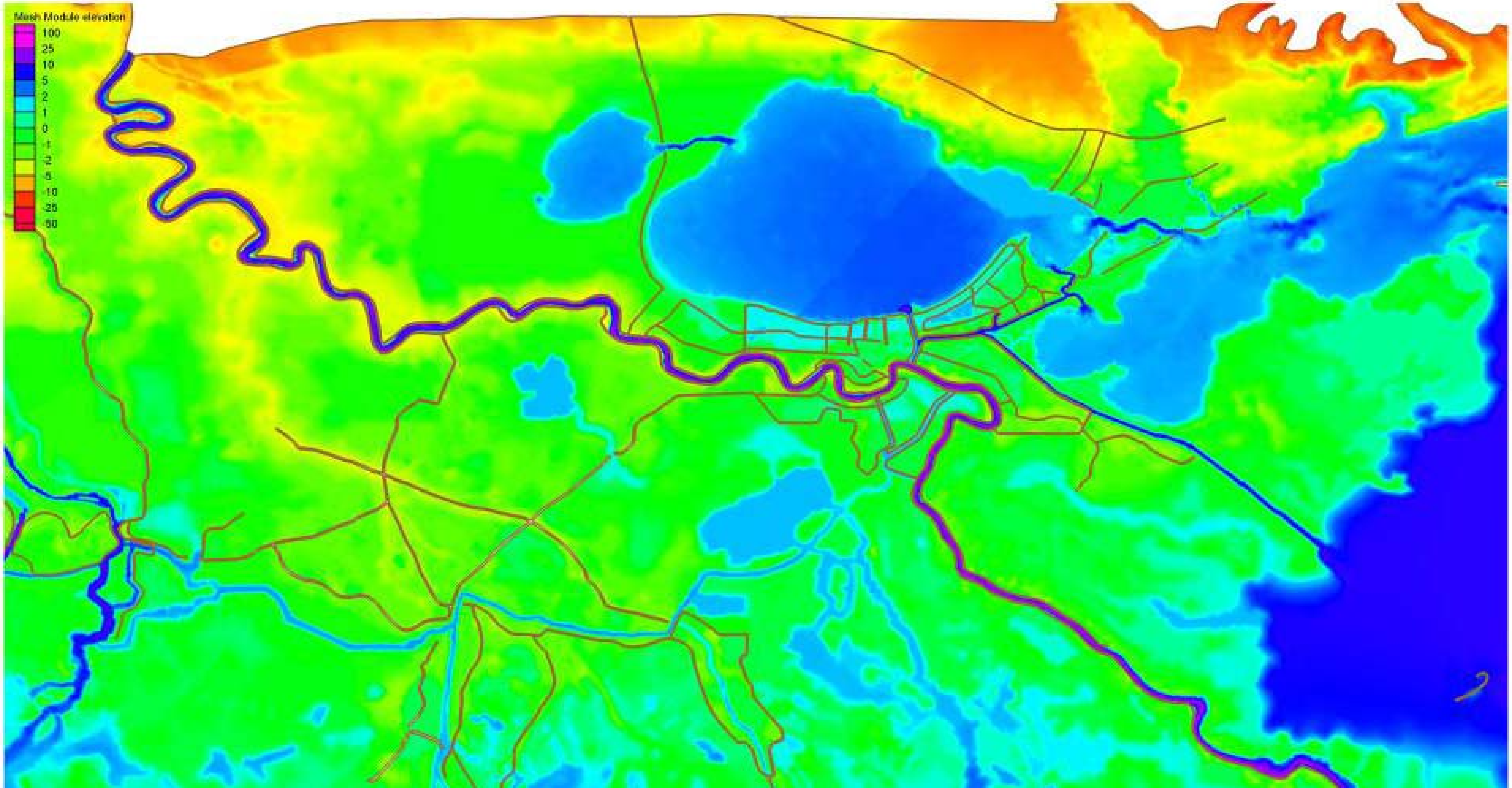
Max Wave Heights 7-10 ft

Wave Periods 7-16 sec

Regional Scale Storm Storm Surge Modeling



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2
1
0
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-2
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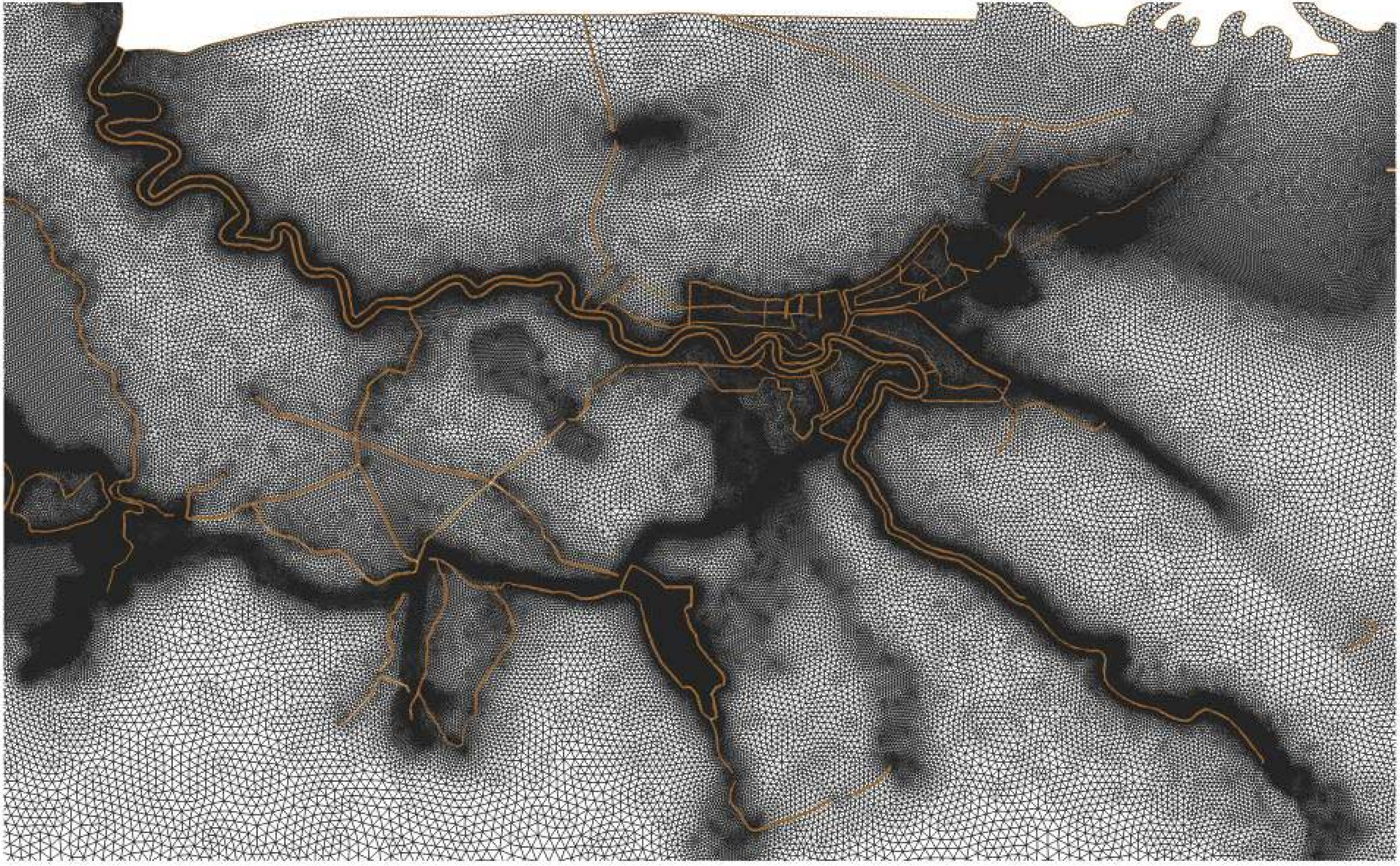
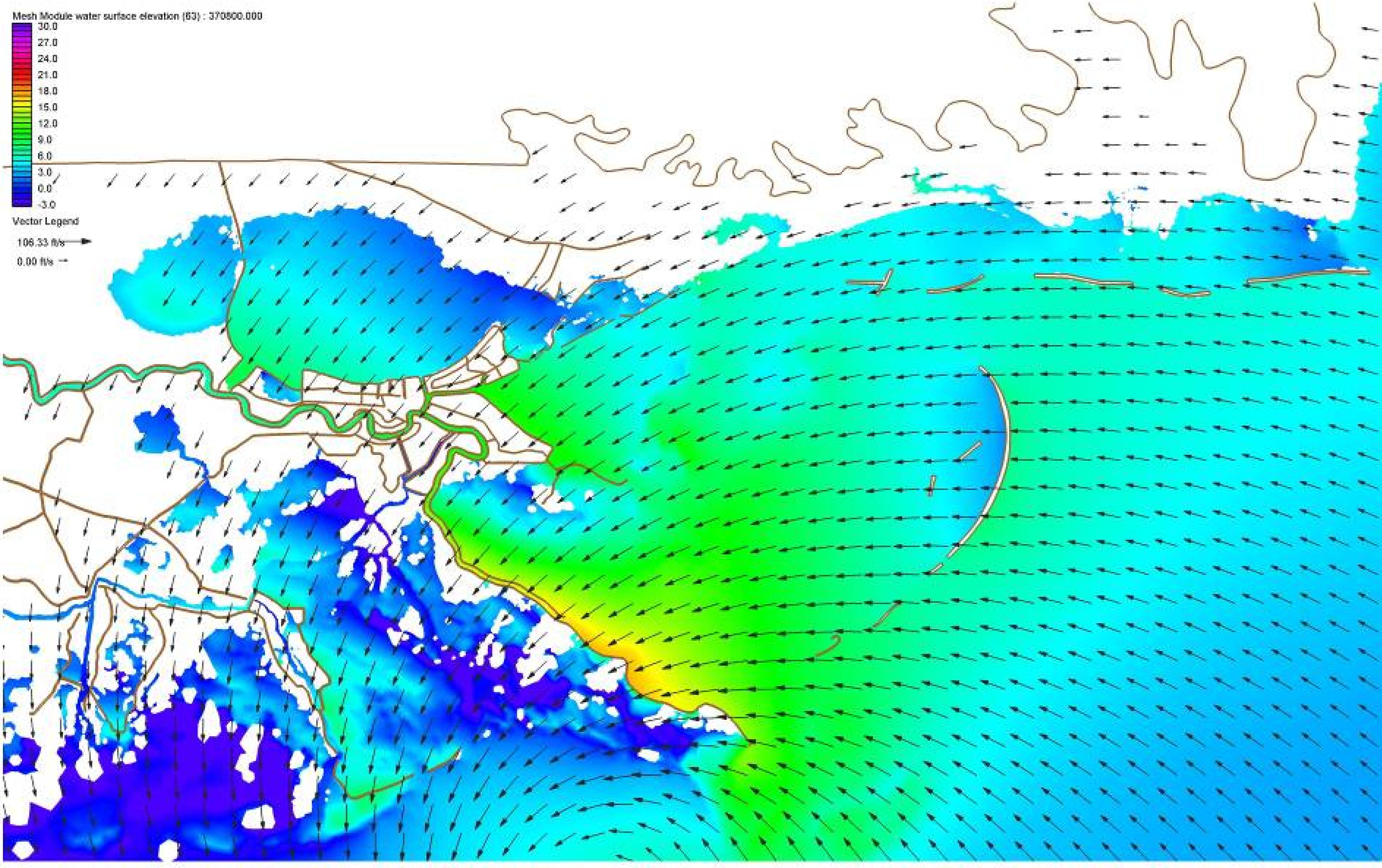
-25
-50

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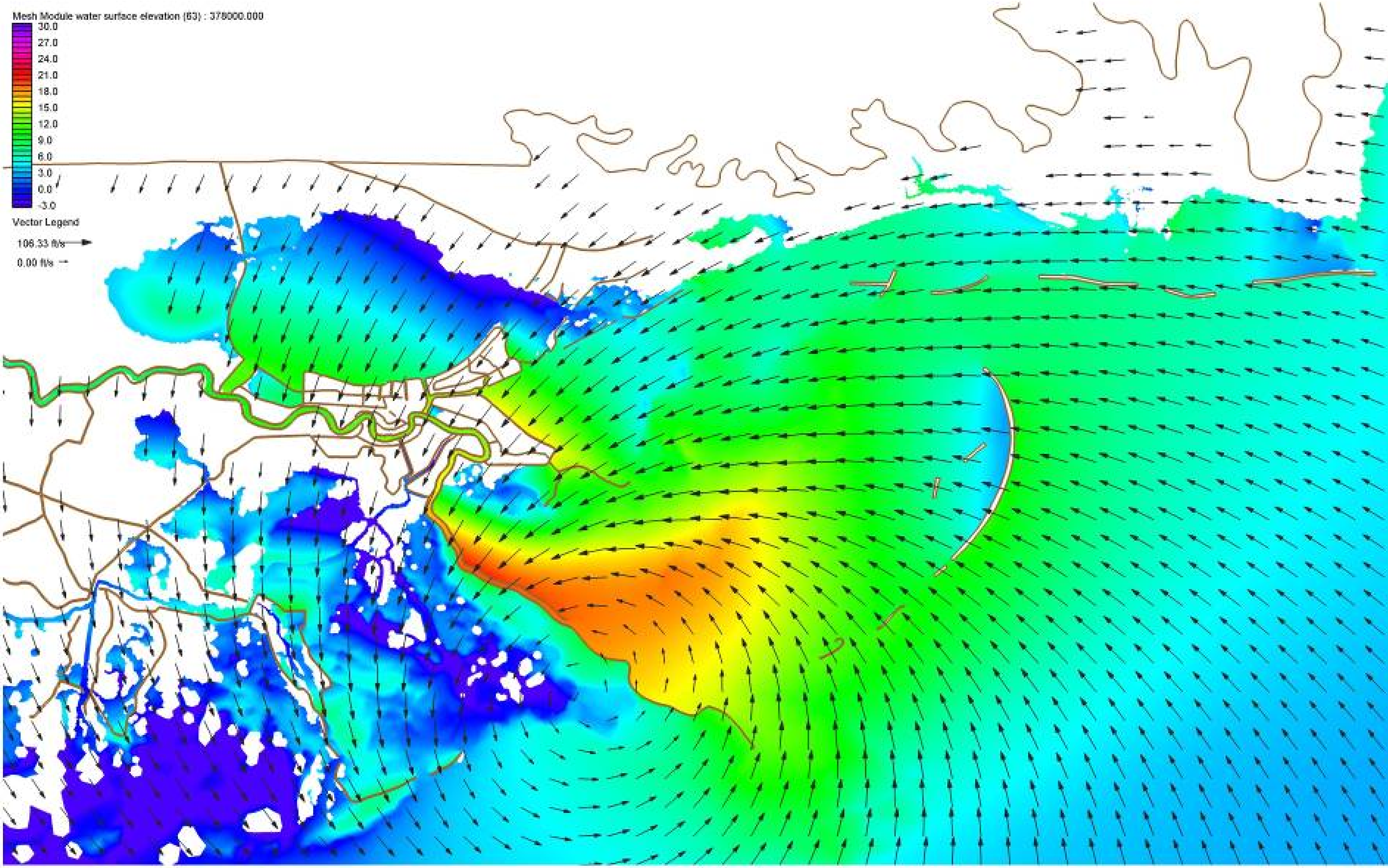
-3.0
Vector Legend
106.33 ft/s
0.00 ft/s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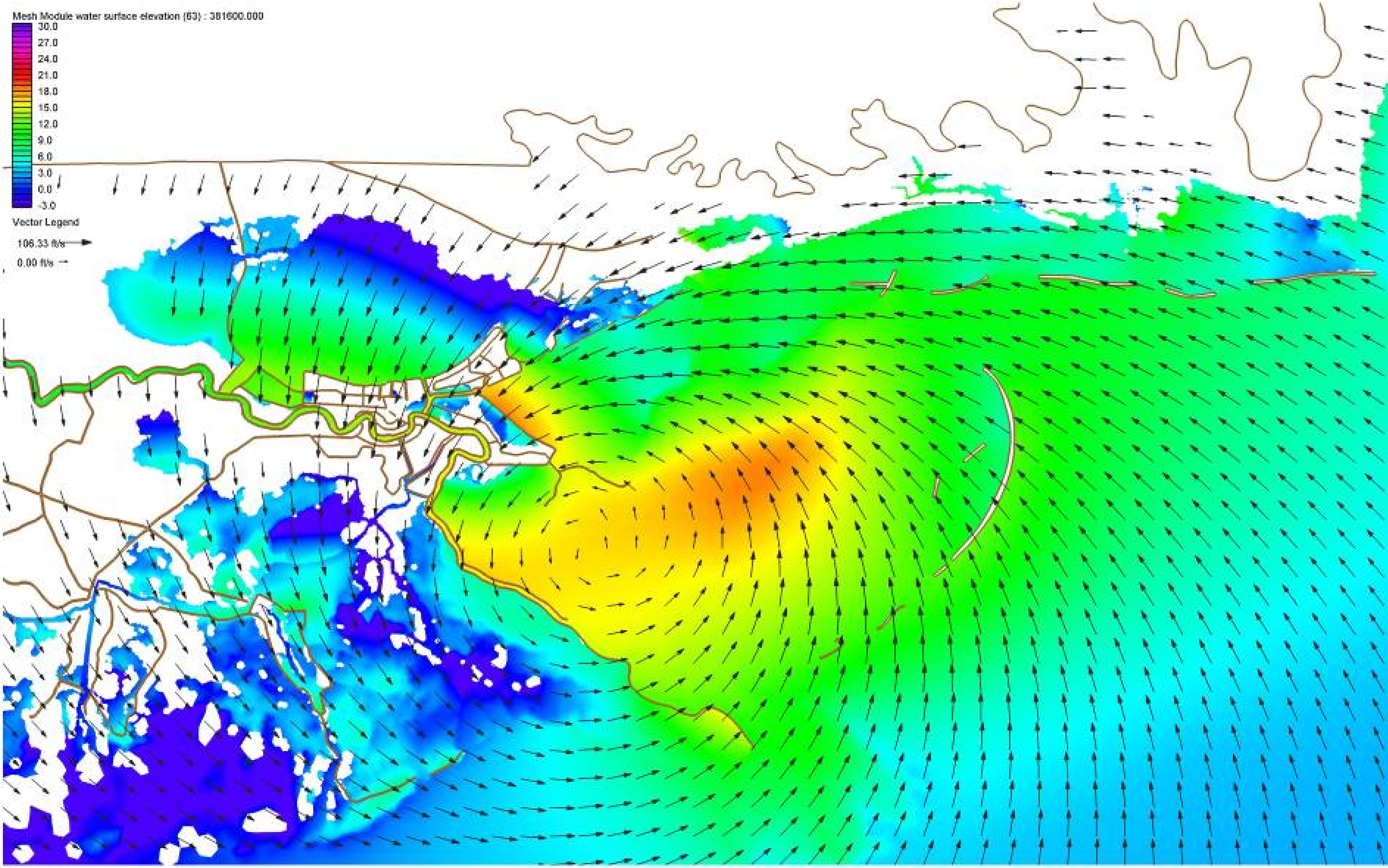
0.00 ft/s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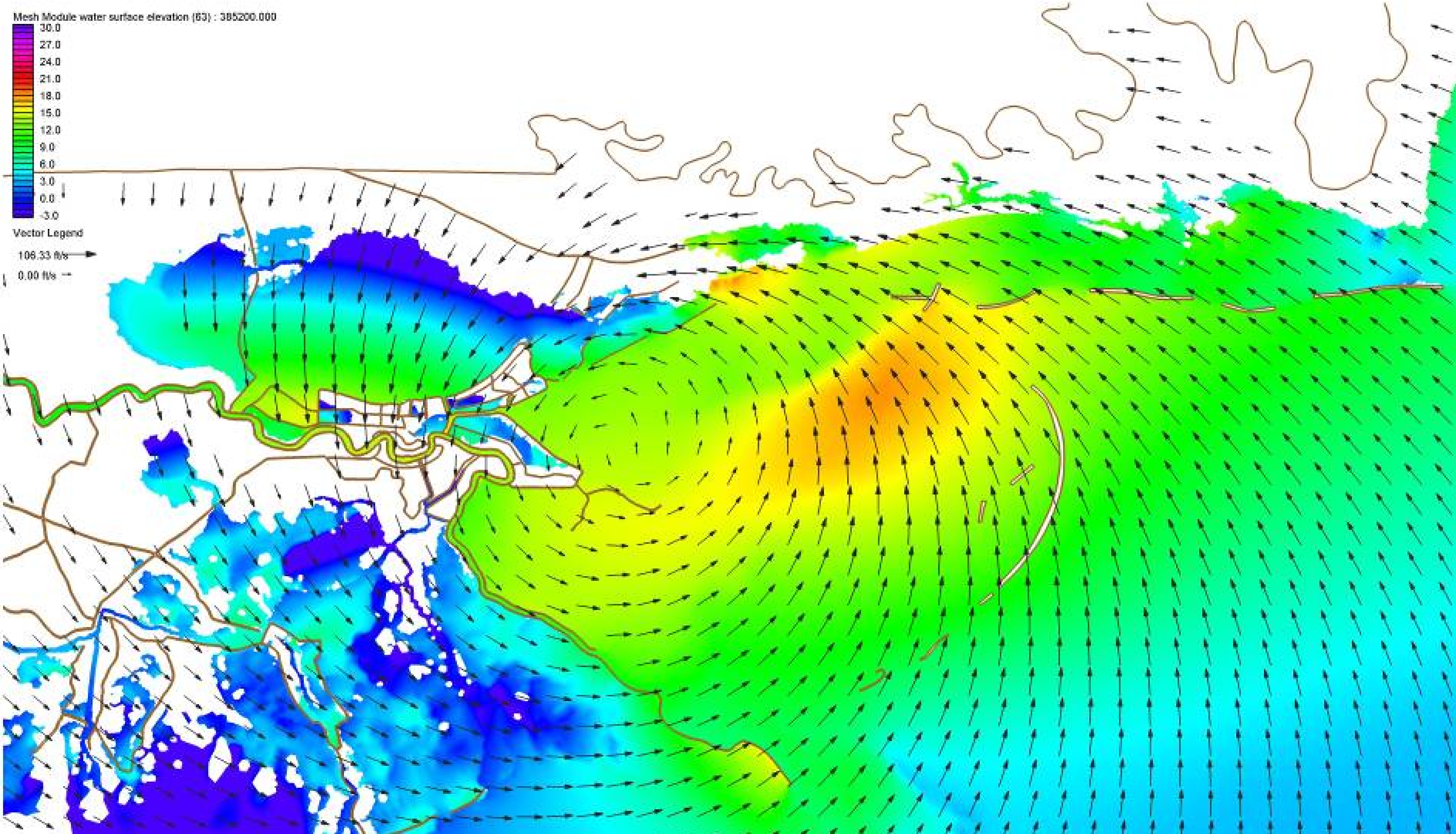
0.00 ft/s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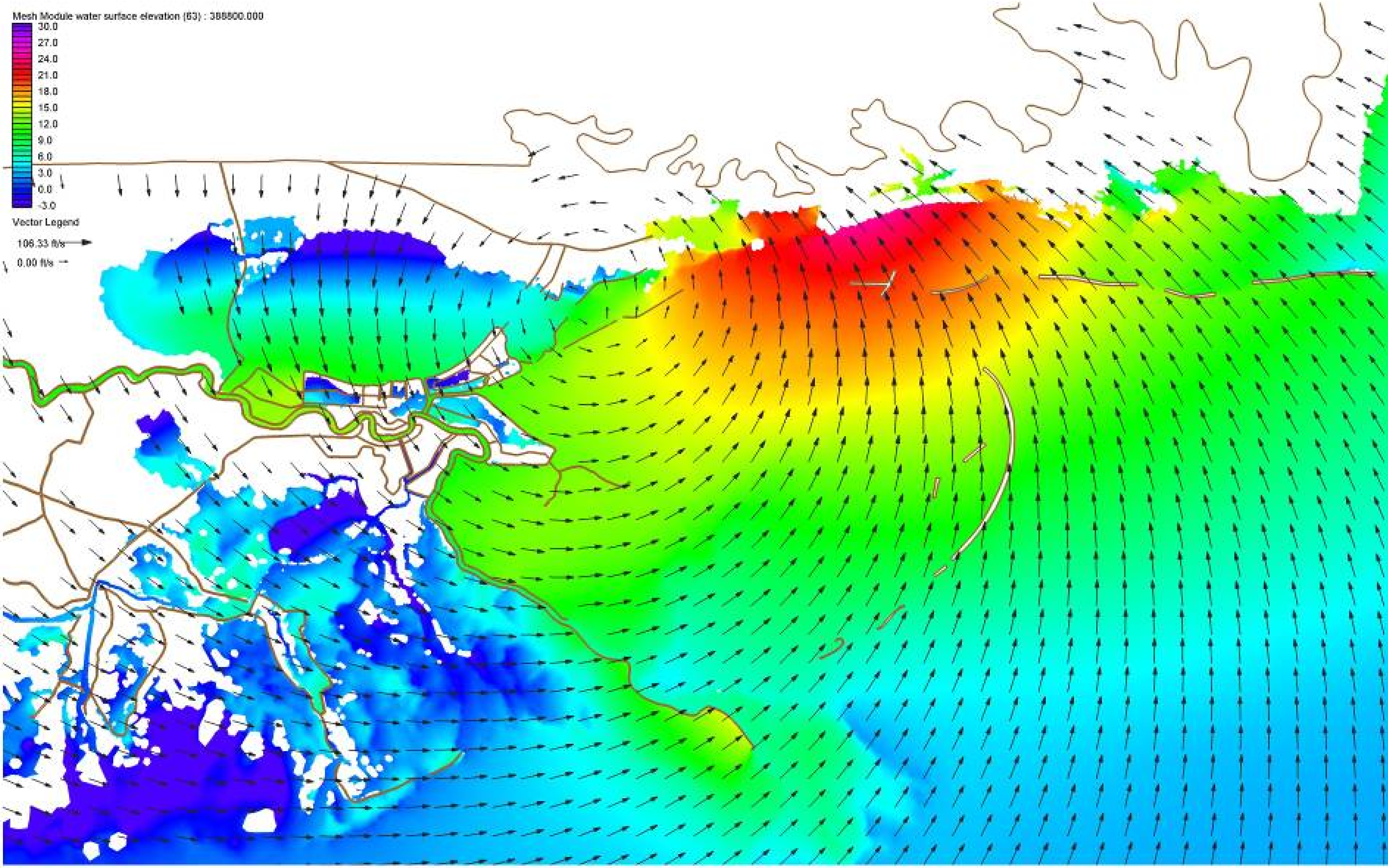

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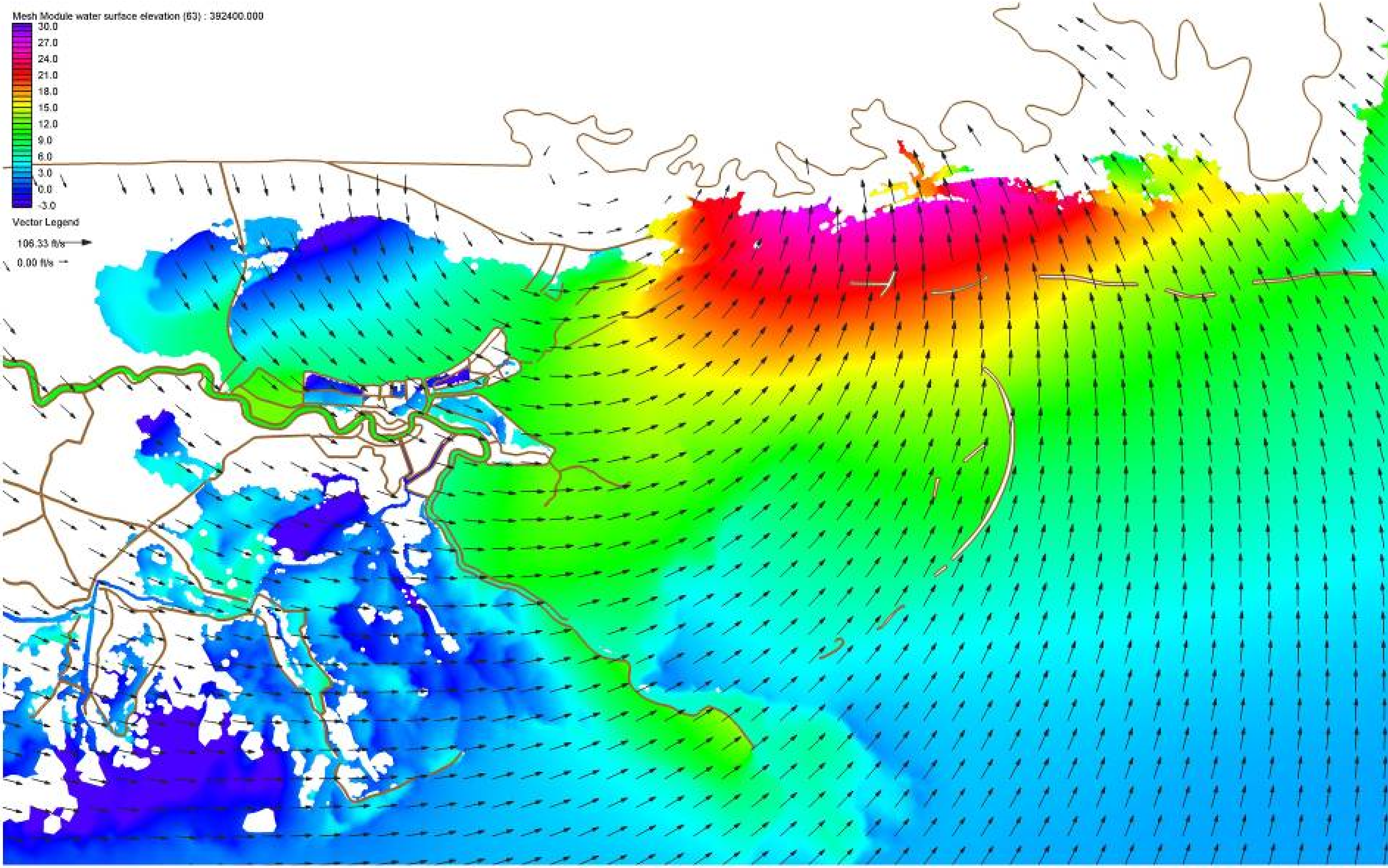
0.00 ft/s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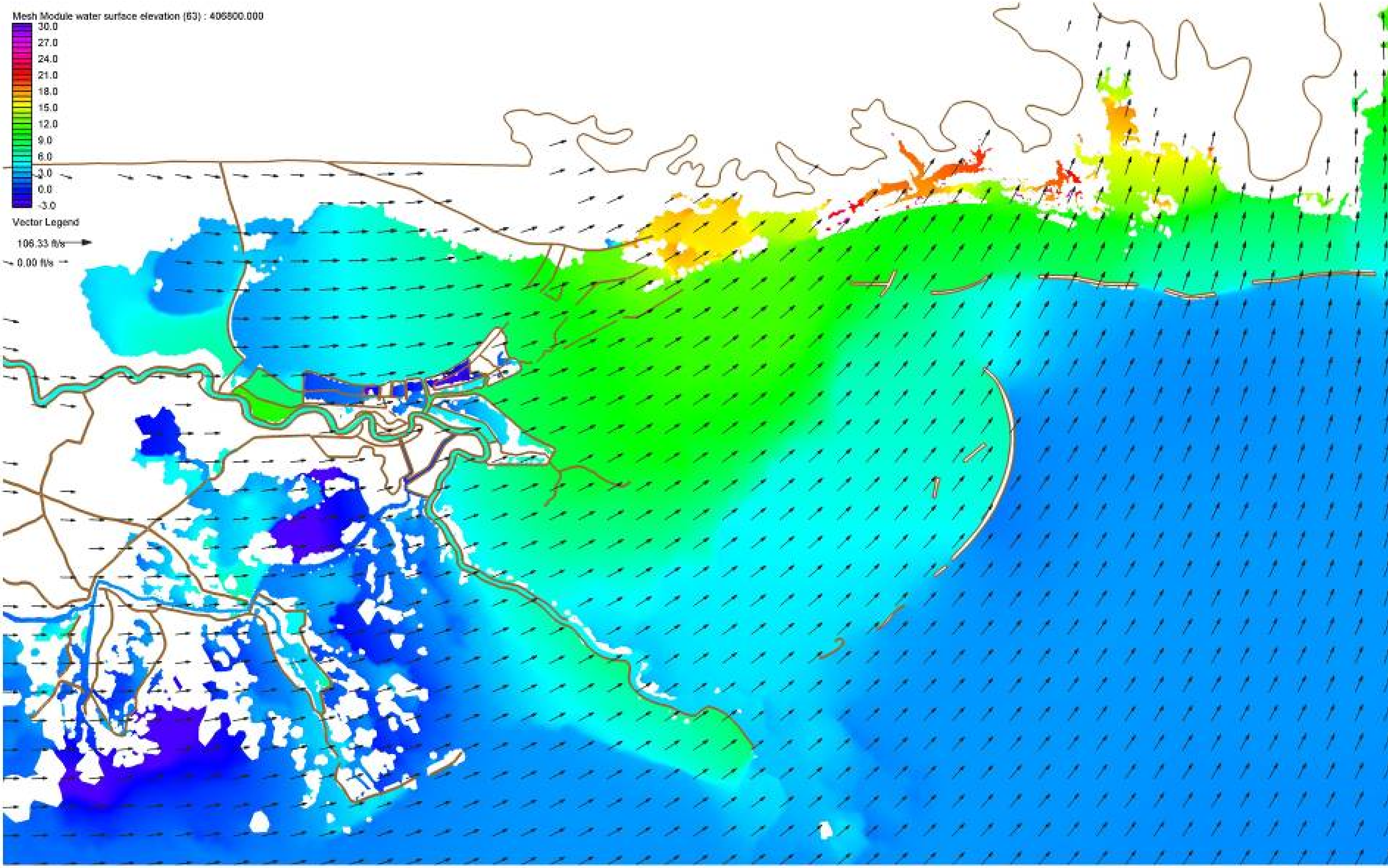
Vector Legend
106.33 ft/s
0.00 ft/s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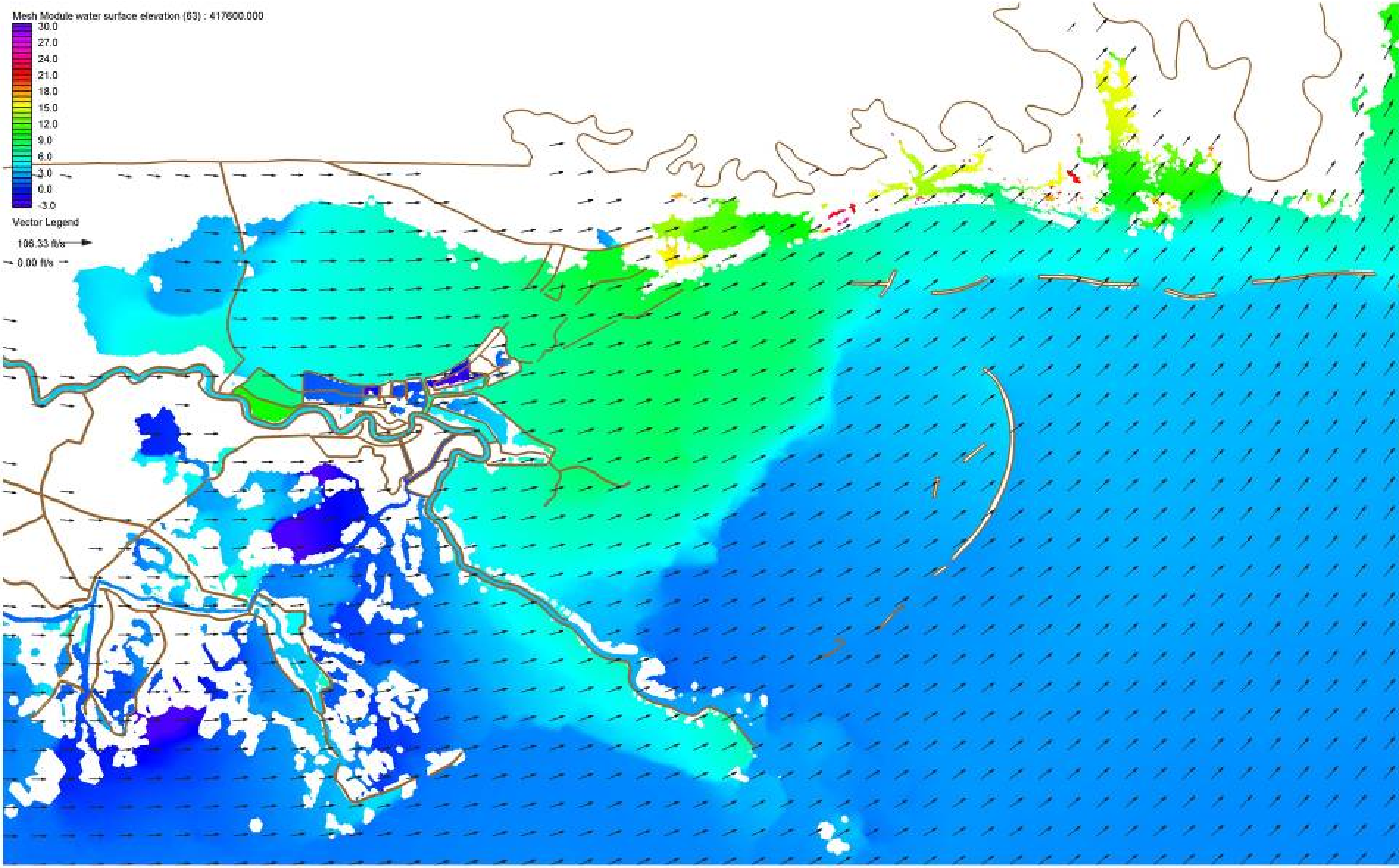
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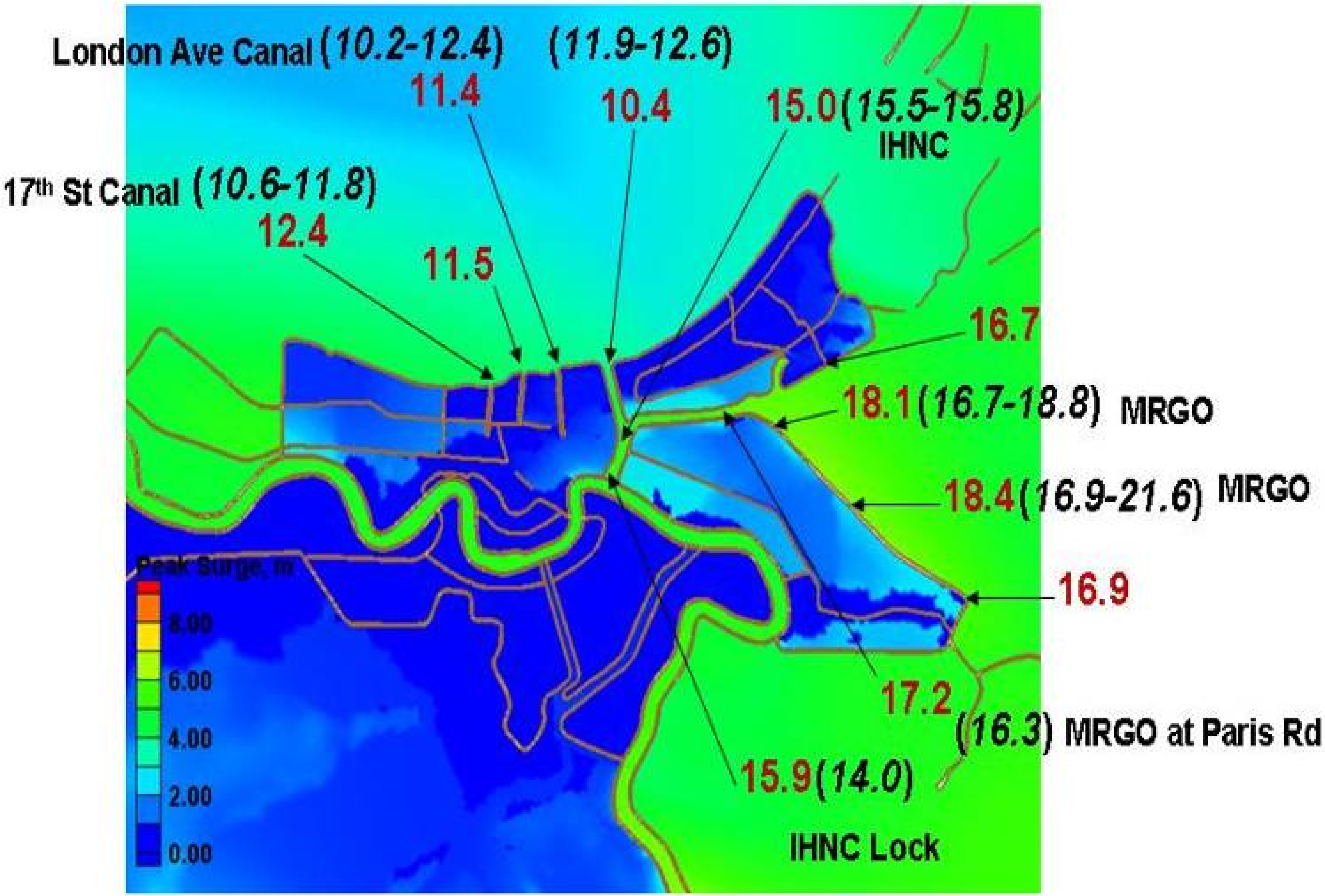
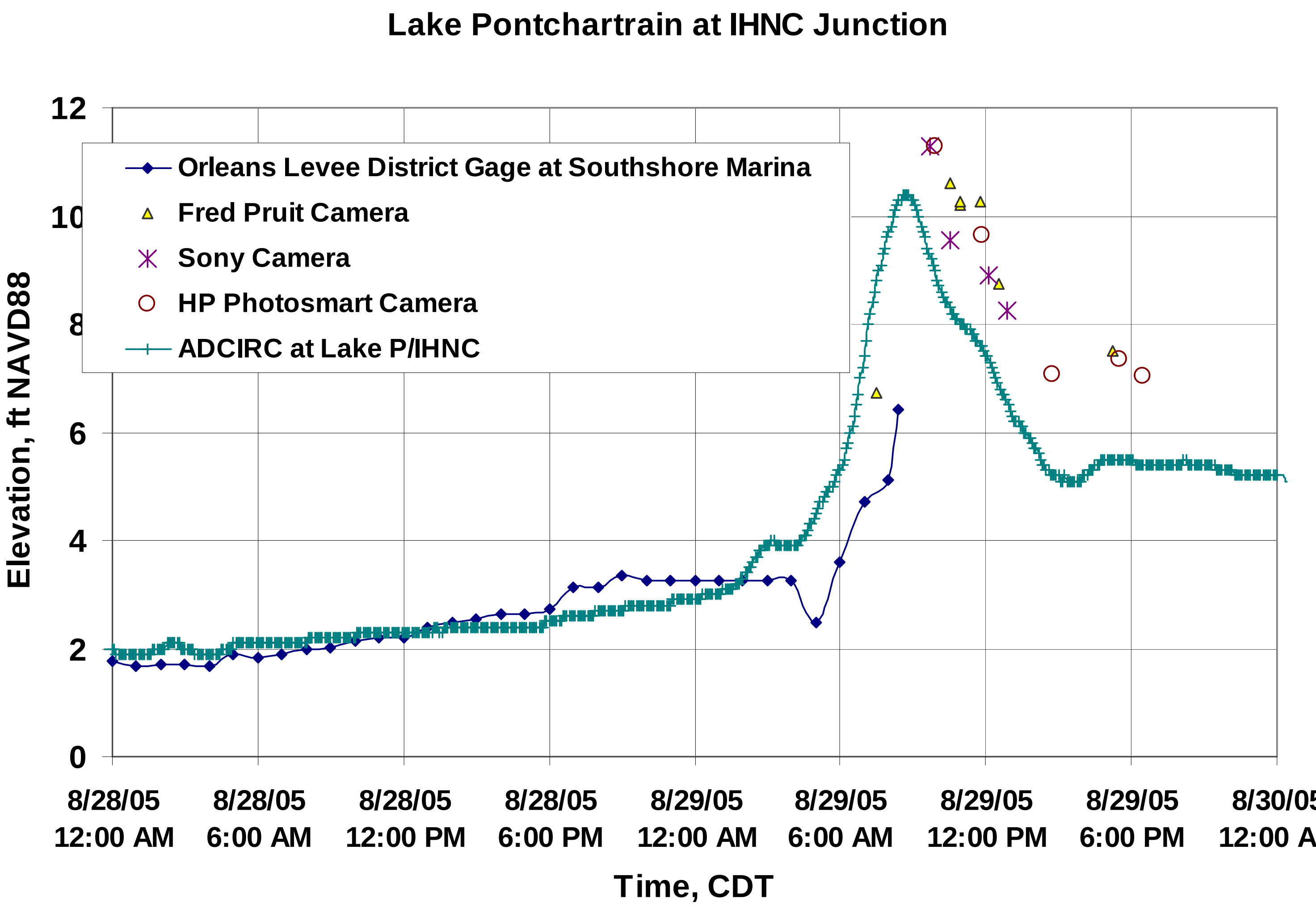
Vector Legend
106.33 ft/s
0.00 ft/s

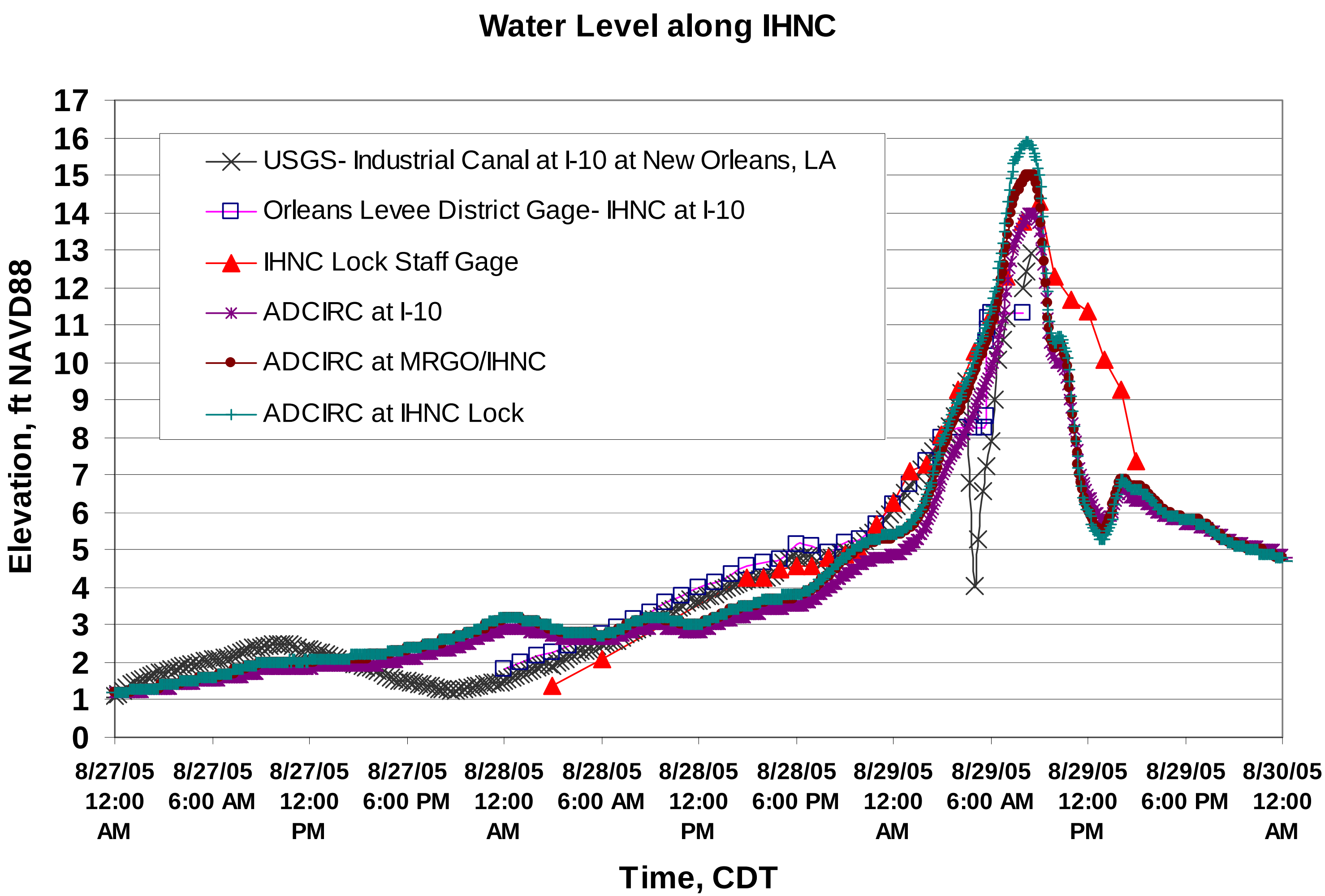
Preliminary Comparison to HWM's in and around New Orleans



Preliminary Comparison to Hydrographs



Preliminary Comparison to Hydrographs



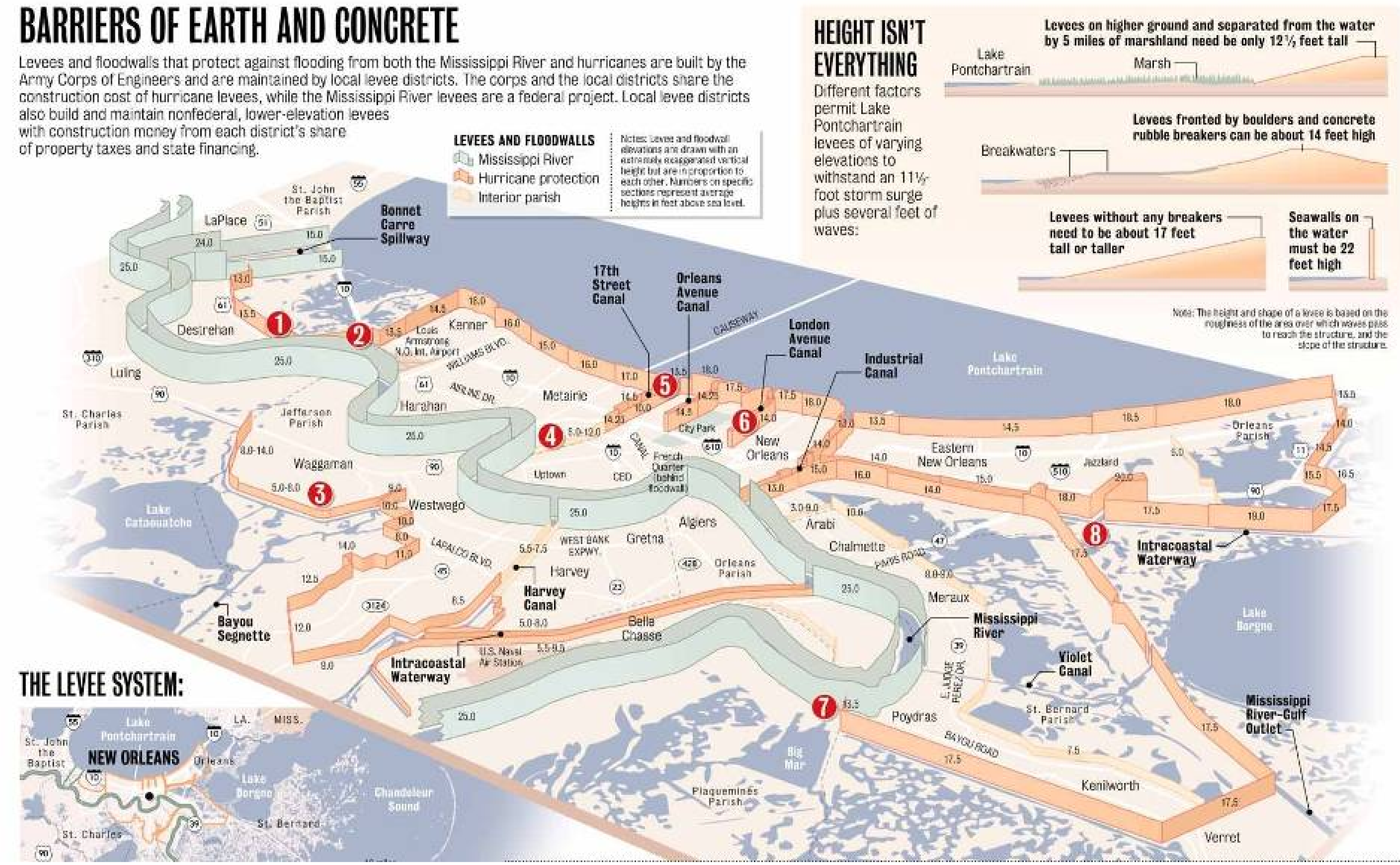
Way Ahead - Regional Wave and Storm Surge Work

- Incorporate HWMs outside metro N.O. area into analysis; perform quality assessment with corrected datums
- Work on final wind and pressure fields; maximize use of measured data
- Incorporate actual tide and river forcing into storm surge modeling
- Work on momentum flux input from wave model to surge model
- Examine time-of-arrival differences for water levels
- Comparisons of modeled storm surge with HWMs and hydrographs
- Incorporate spatially varying wind input to STWAVE
- Add Mississippi Sound STWAVE nearshore wave domain
- Need updated DEMS, levee crest elevations, structure elevations, all to current NAVD88 datums to begin incorporating them into model input data sets for 95% solution
- Sensitivity testing of wave and storm surge models (wind speed uncertainty, drag cut-off, wind averaging conversions)
- Save-point changes and additions; improvement of information products
- Seek Interagency consensus on waves and water levels

Local-Scale Investigation of Hydrodynamic Forces

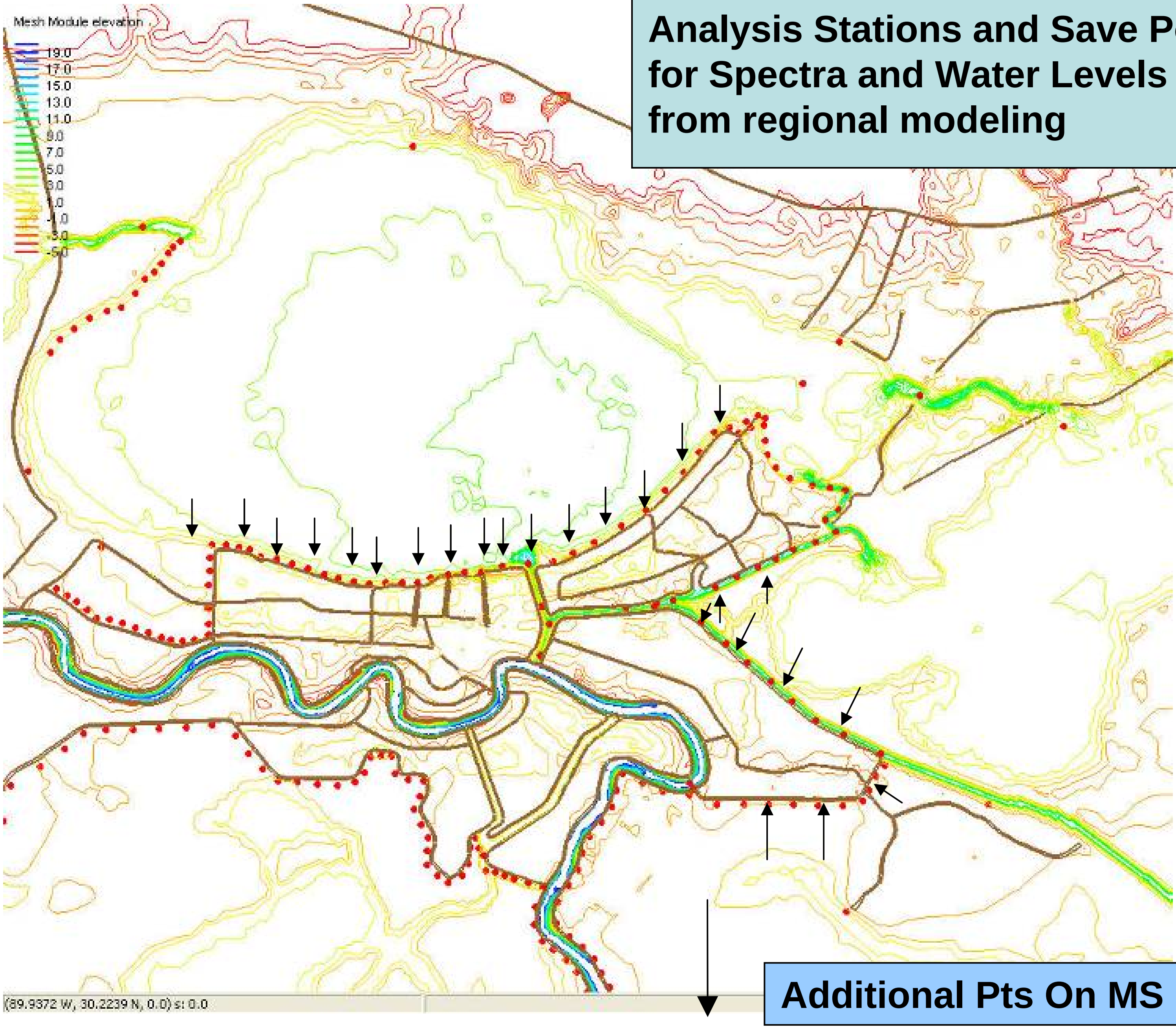
- Takes boundary information from regional-scale wave and storm surge work and focuses on detailed studies in the vicinity of levees and floodwalls
- Estimate time varying forces on levees/floodwalls (per unit width) during Hurricane Katrina:
  - Water levels
  - Wave fields
  - Overtopping rates
  - Vertical distribution of static/dynamic load
  - Total force/total moment
  - Near-bottom velocities
- Estimate uncertainty (lack of measured data)
  - Model-related – run several models
  - Boundary forcing – examine range of boundary values
  - Local forcing (wave/surge generation/decay) – span range of values
- Communication of results to other tasks
- Role of dynamic versus static loads- relative magnitude
- Rule in/out possible causative factors for the breaches

Examination of Federal Levee/Floodwall System



Graphic from Times Picayune

Analysis Stations and Save Points for Spectra and Water Levels from regional modeling



Additional Pts On MS River

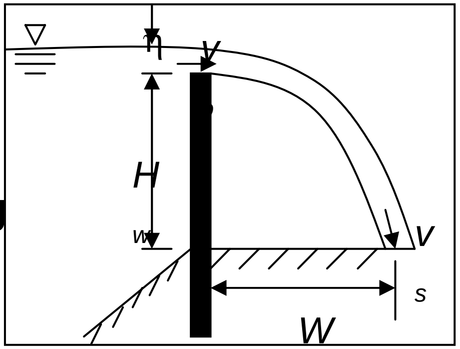
Phenomenological Study

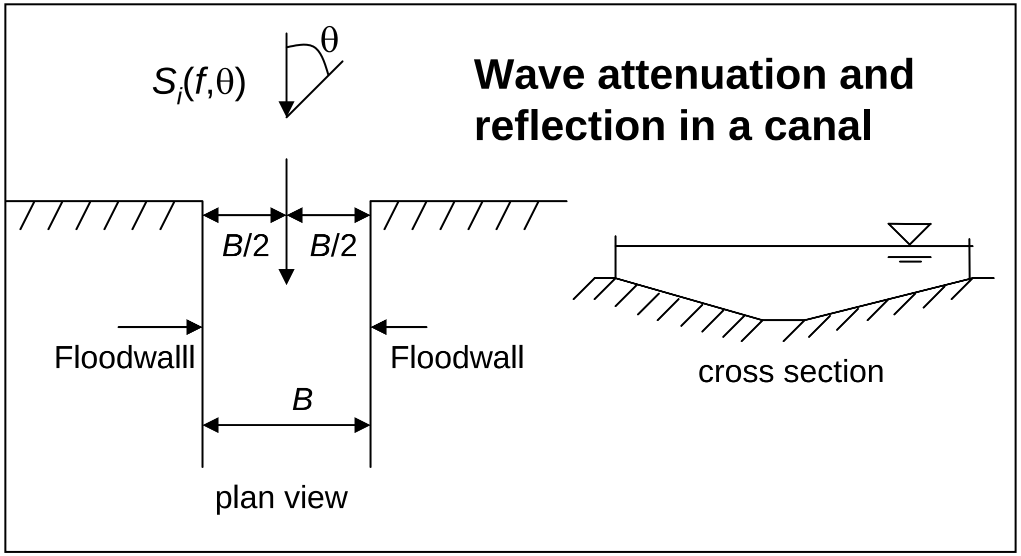
- **Water levels**
- **Slopes of water levels in canals**
- **Evidence of overtopping**
- **Wave action (debris size/distribution)**
- **Erosion of earthen levees (back side/front side)**
- **Distribution of water levels within canals**
- **Trapped/resonant standing waves**
- **Barge impact**

Analytical/Empirical Analysis

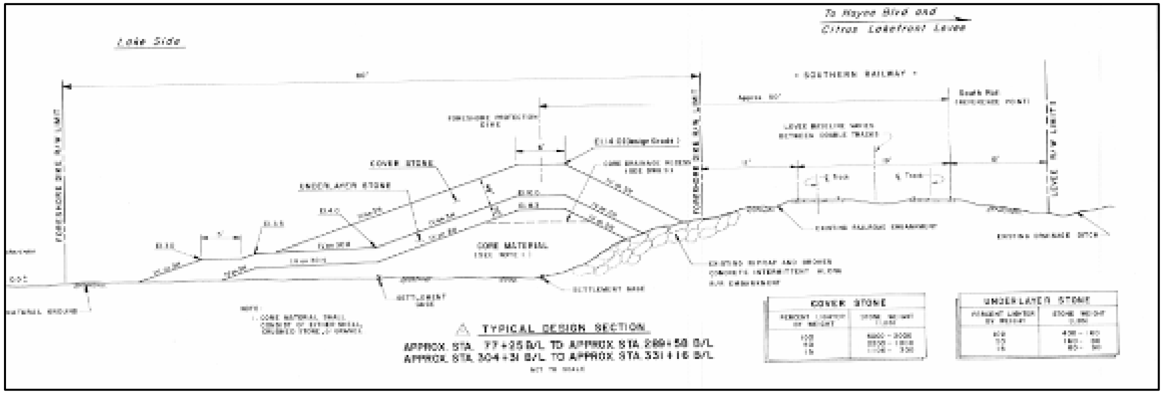
- Waves in Canals
- Wave Runup and Overtopping
- Flood Overtopping
- Scour/Erosion Potential
- Barge Forces

Flood Overtopping





Wave attenuation and reflection in a canal



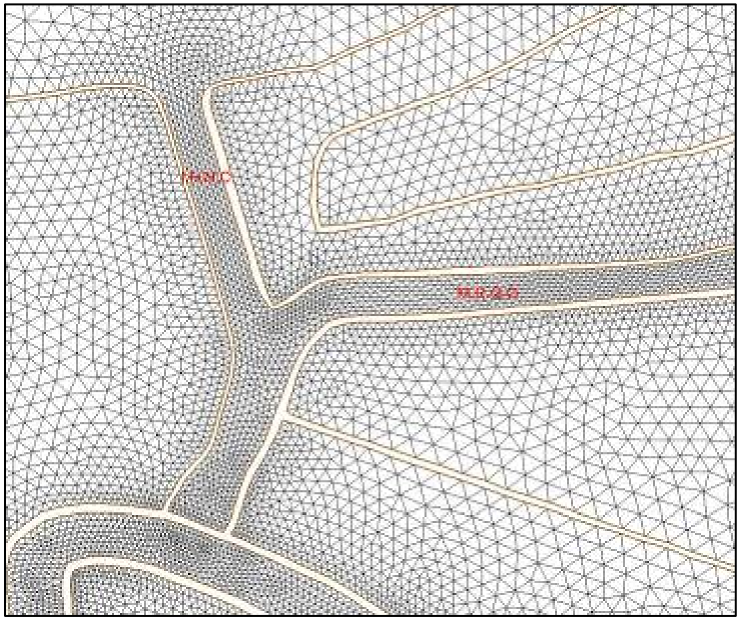
Wave runup and overtopping

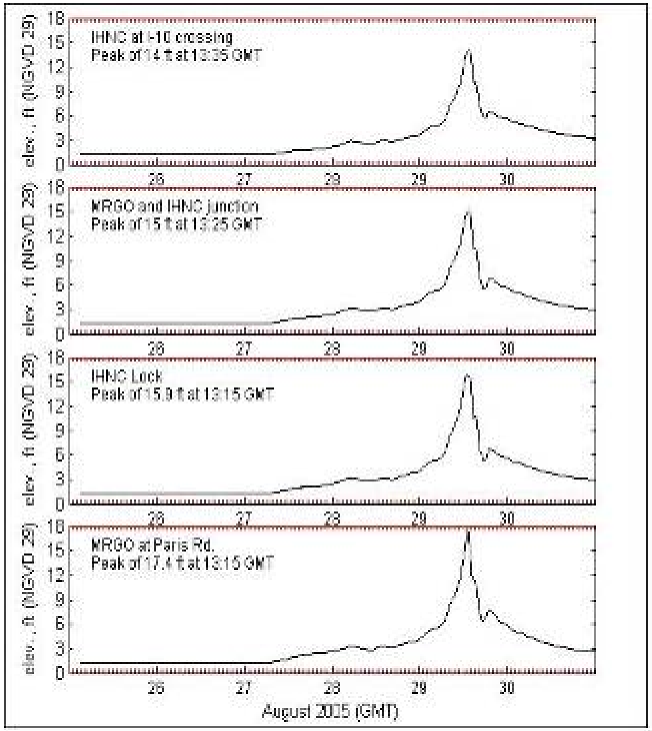
Numerical Modeling

- ADCIRC/ STWAVE
- Coupled depth-averaged flow model
  for surge
- Phase-averaged spectral model:
  Wave generation, propagation,
  and decay
- Simulations for all regions of interest
  Canals (17th Street, Orleans,
  London Ave., Industrial)
  St Bernard levee areas
  Plaquemines levee areas

•Issues

Damping of waves by debris
Feedback of overtopping on
surge levels
Treatment of wave groups
Side/end reflection coefficients





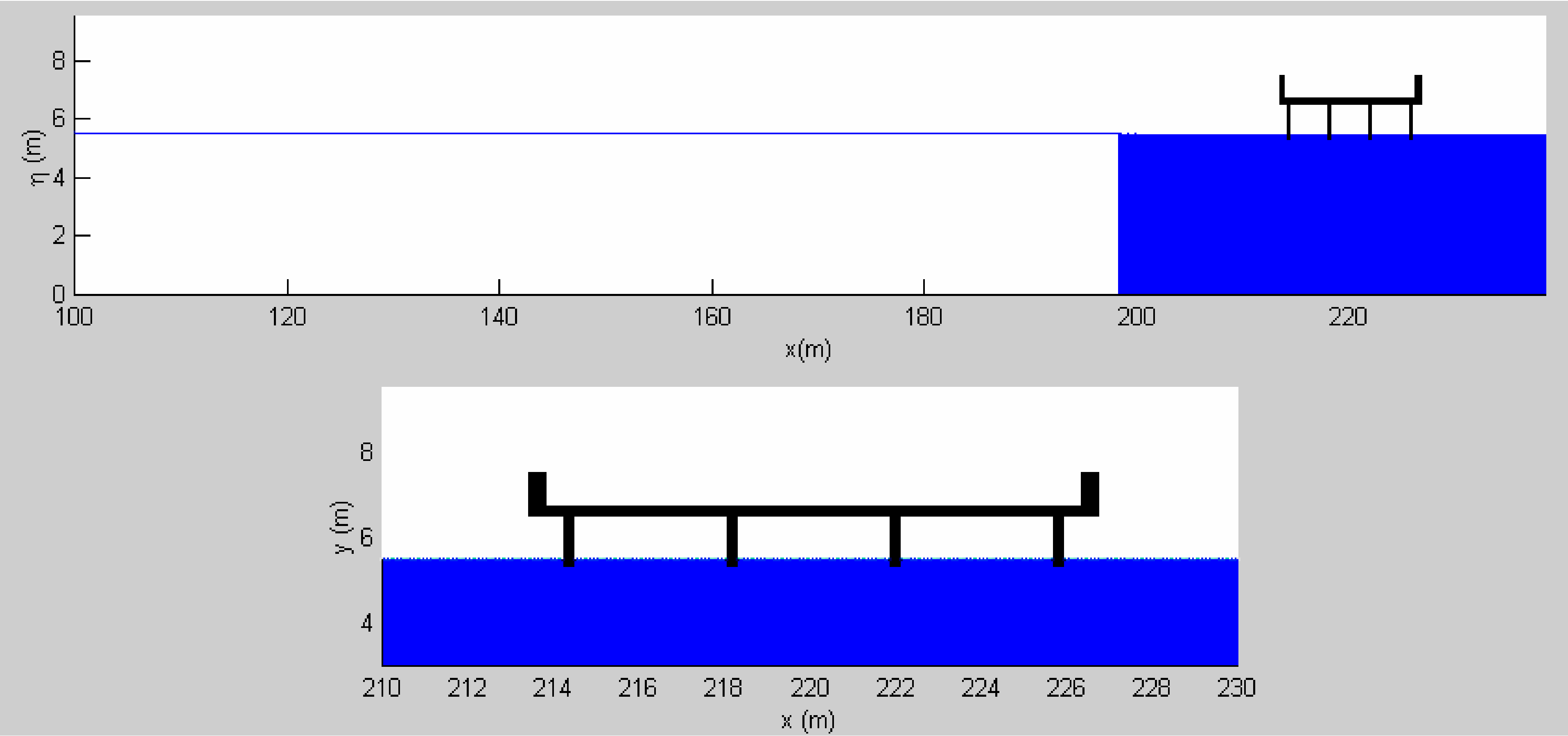
COULWAVE Boussinesq Model

- Resolution ~ O(1m)
- Phase-resolving wave model (1D and 2D)
- Excellent representation of diffraction & nonlinearities (3-wave)
- Simulations for canals/levees
- 17th Street, Orleans, London Ave., IHNC, MR-GO, Plaquemines
- Issues
  - Lack of wave generation
  - Wave transmission past bridge
  - Bottom friction
  - Inclusion of in-canal surge
  - Damping of waves by debris
  - Side/end reflection coefficients
  - Wave behavior in overtopping region
  - Computer time

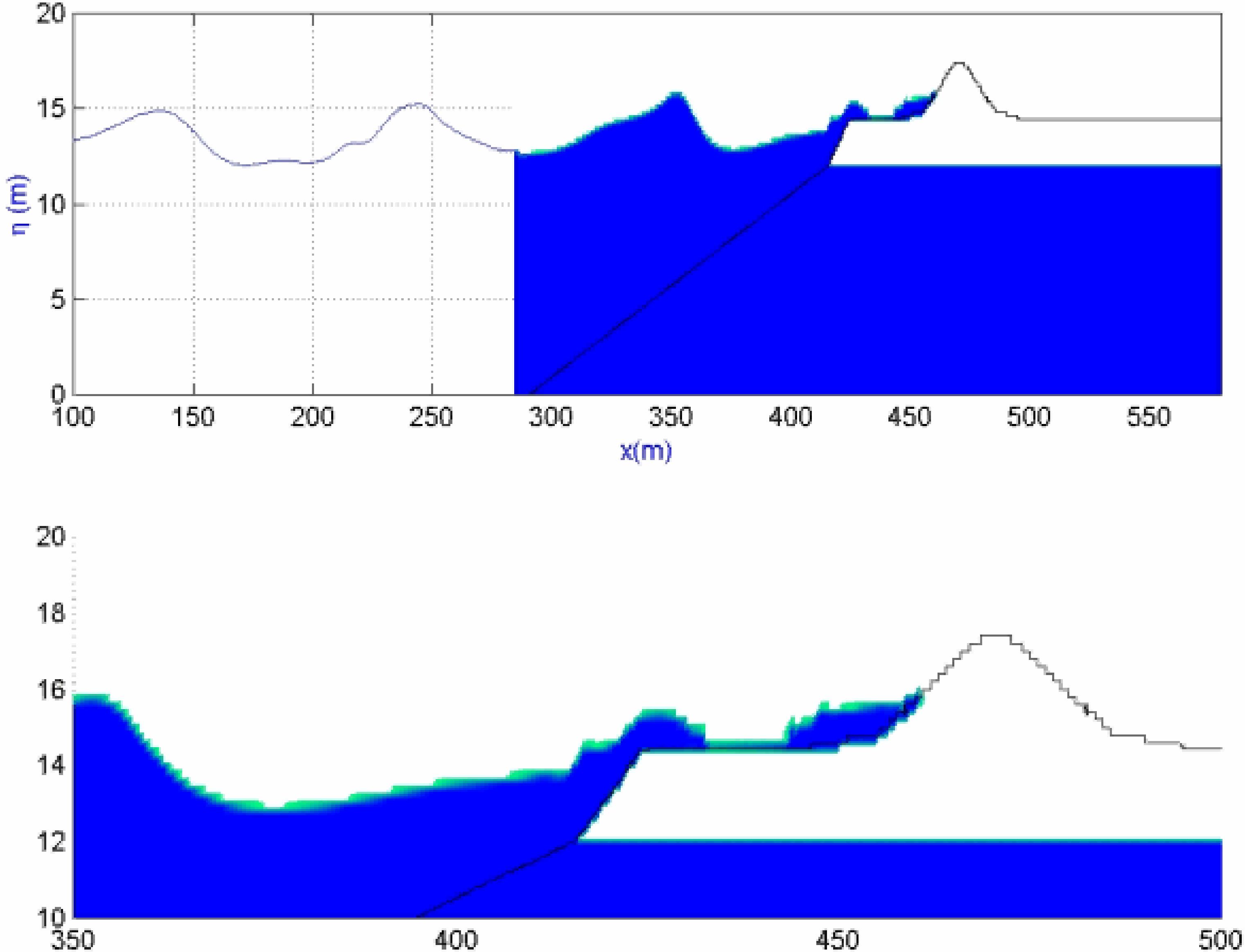
Boussinesq coupled with Navier-Stokes

- Resolution ~ O(0.1m)
- CFD solver (1D)
- Excellent representation of surge and waves
- Simulations for canal sections & other selected areas
- 17th Street, Orleans, London Ave., IHNC
- Wave transmission past bridge
- Issues
  - Lack of wave generation
  - Damping of waves by debris
  - Side/end reflection coefficients
  - Bottom friction
  - Wave behavior in overtopping region
  - Computer time

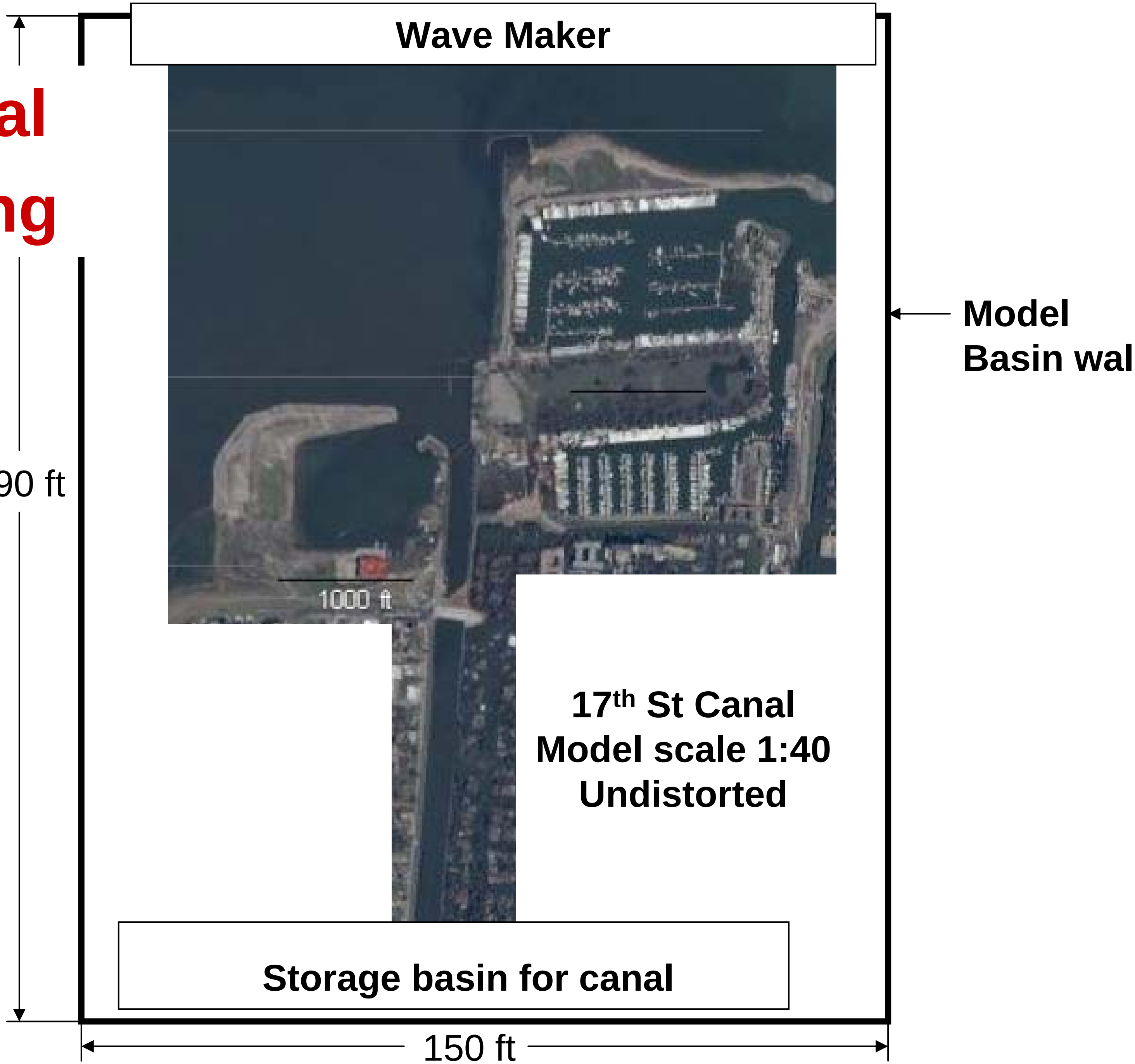
Coulwave Boussinesq/Navier-Stokes Hybrid Simulation
Waves Propagating Past a Bridge



Coulwave Boussinesq N-S Hybrid Simulation on MRGO Levee



Physical Modeling



Focus on Short Wind Wave Processes

Way Ahead – Local-Scale Hydrodynamic Forces

- **March 15 – team review**
  90% runs complete

- **April 15 – team review**
  Final phenomenological study complete
  Final runs complete

- **June 1 – team review**
  Final Reports complete

Questions?

Hurricane KATRINA has hit land and is moving north at 15mph. It has max sustained winds of 150mph and gust of 184mph.
Credit: NOAA
ALABAMA
MISSISSIPPI
LOUISIANA
NEW ORLEANS
KATRINA
GULF OF MEXICO
This is a geographical reference
NOAA-15 RGB= CH(1,2,4) 08/29/2005 11:48 UTC