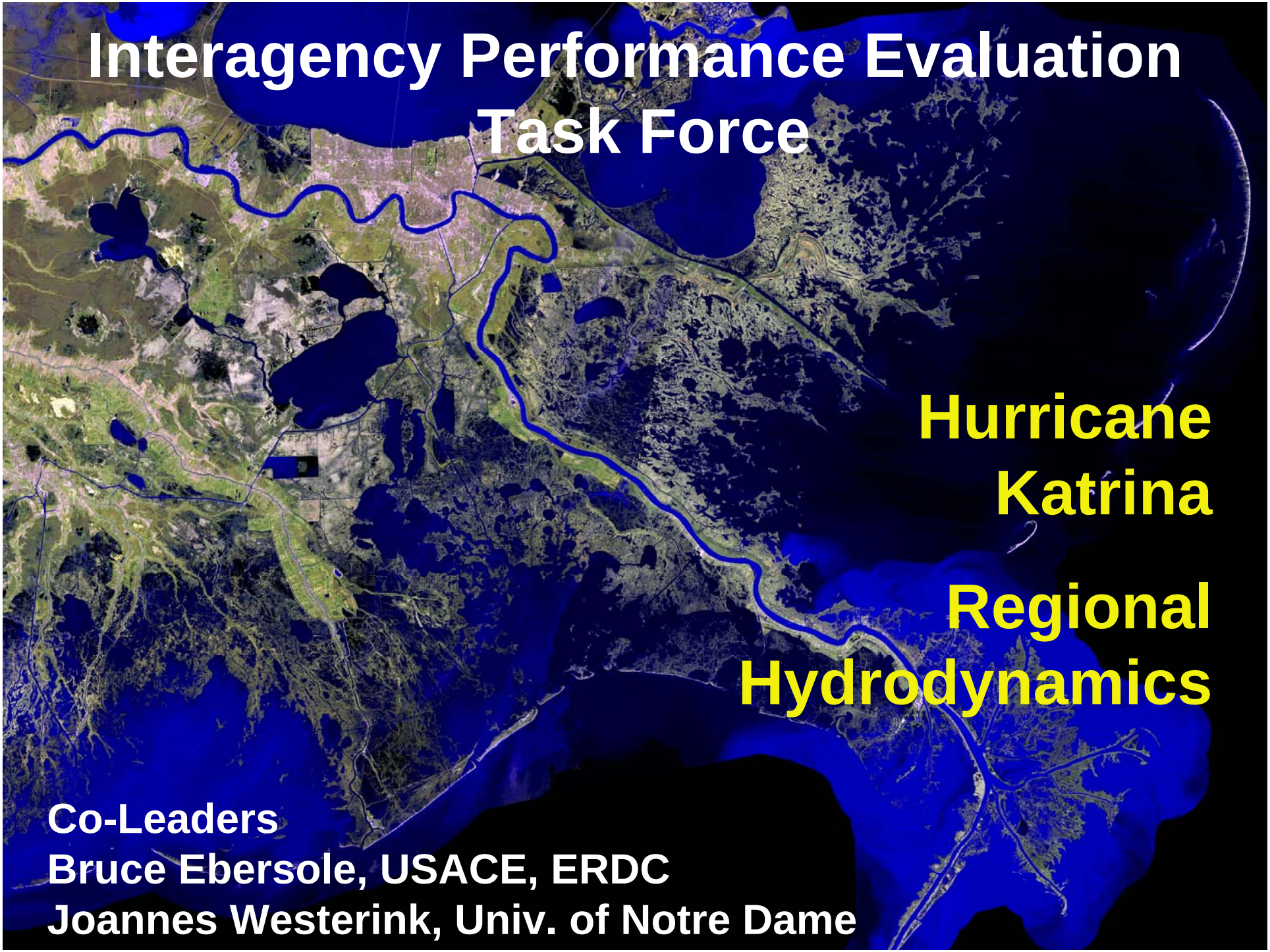


Interagency Performance Evaluation Task Force

Hurricane Katrina

Regional Hydrodynamics

Co-Leaders
Bruce Ebersole, USACE, ERDC
Joannes Westerink, Univ. of Notre Dame

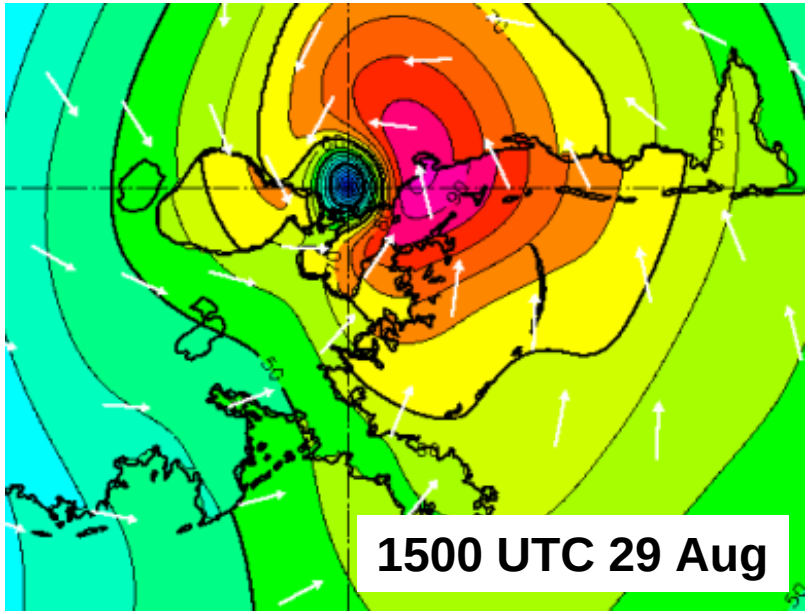
Questions to Answer

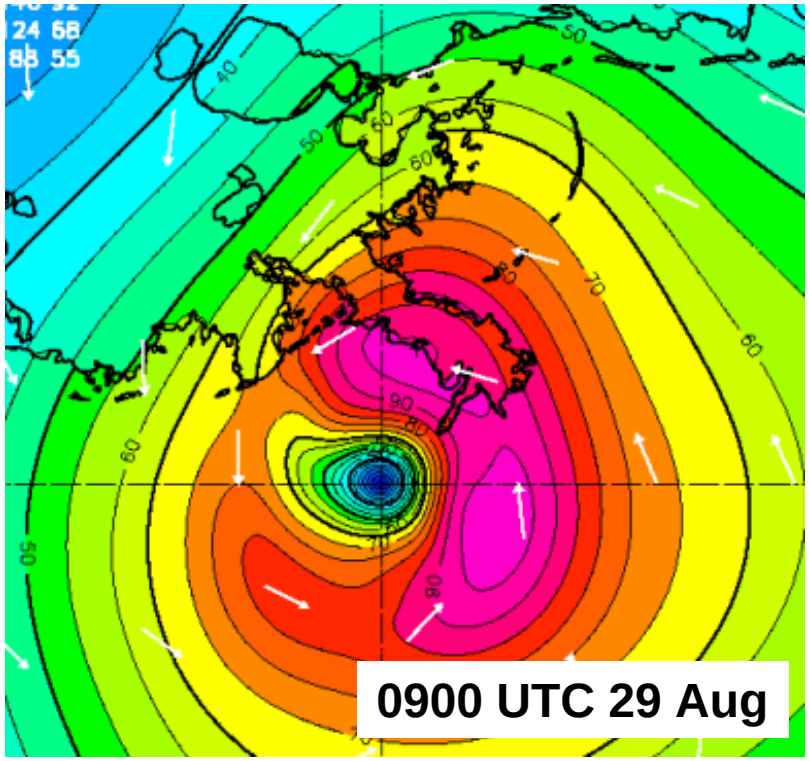
- What were the storm surges and waves during Hurricane Katrina?
- How do these compare to values used as the basis for design?

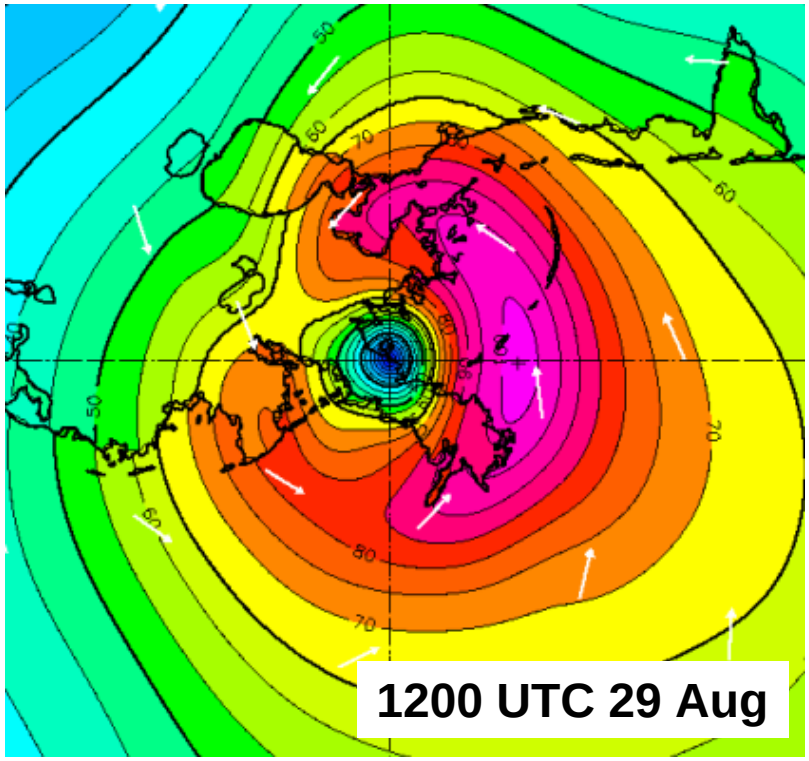
Utilize Measurements and Modeling

H*Wind Snapshots Near Landfall

Quality of Wind Input is Critical

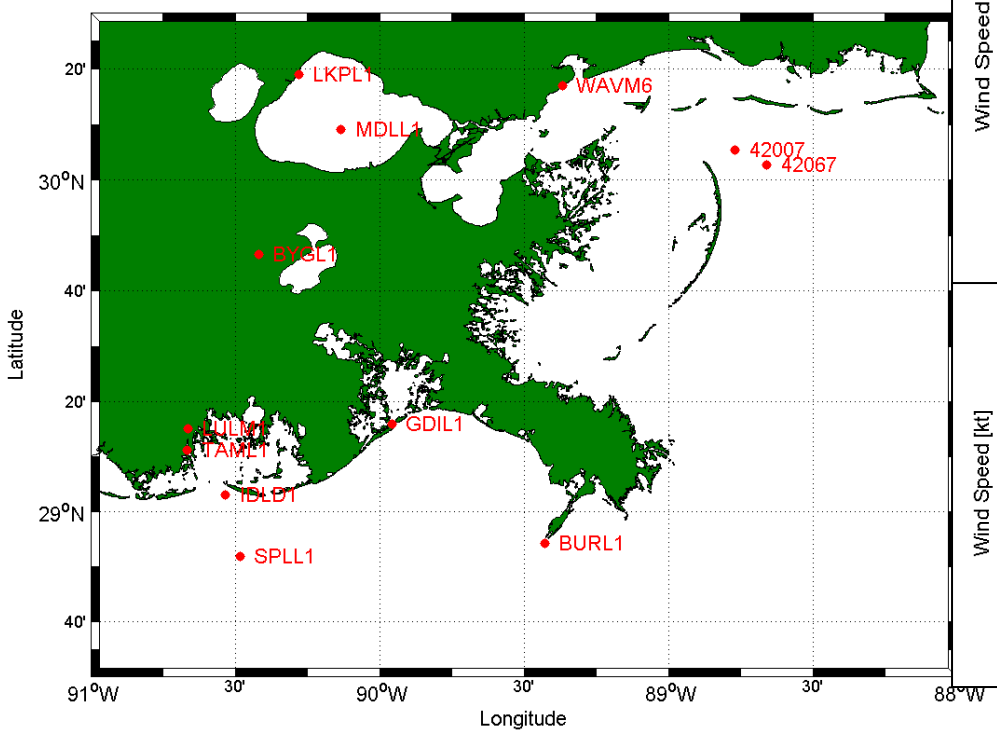


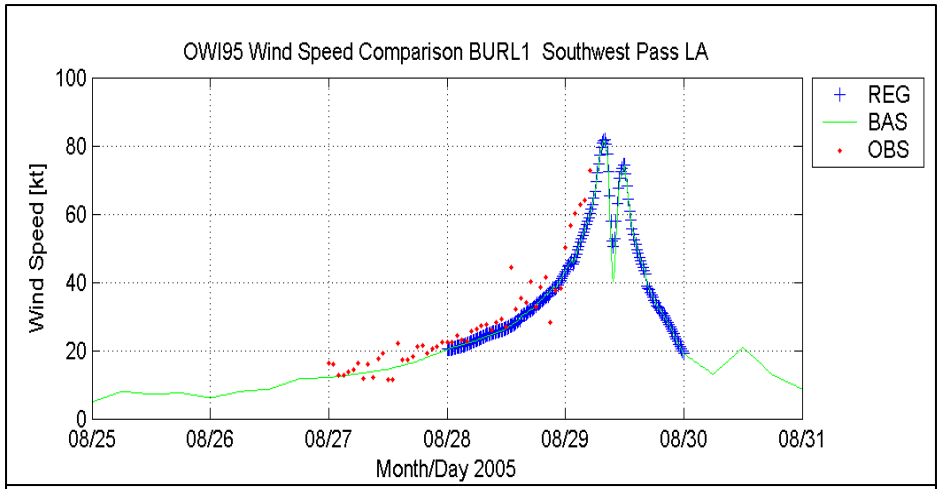


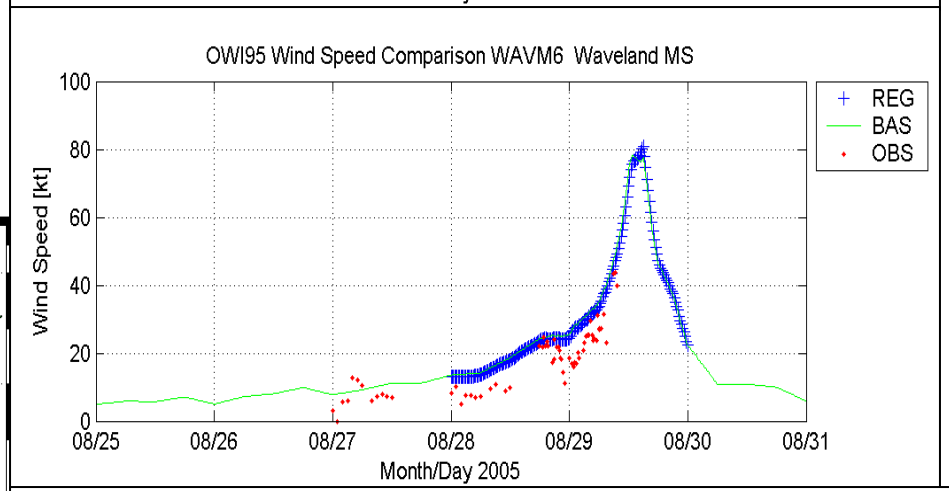


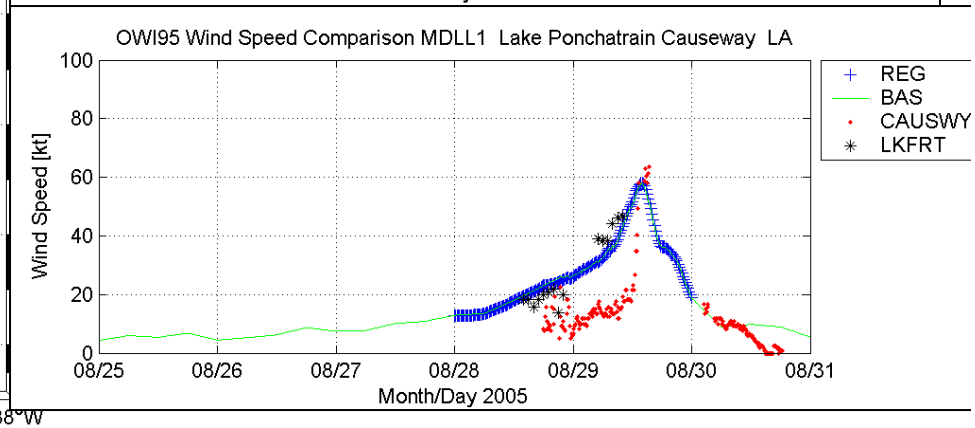
Surface Wind Measurements

- Nearly all surface anemometers in the region failed and did not capture the peak conditions
- Mid-Lake Pontchartrain gage provided most complete record, but data quality is suspect

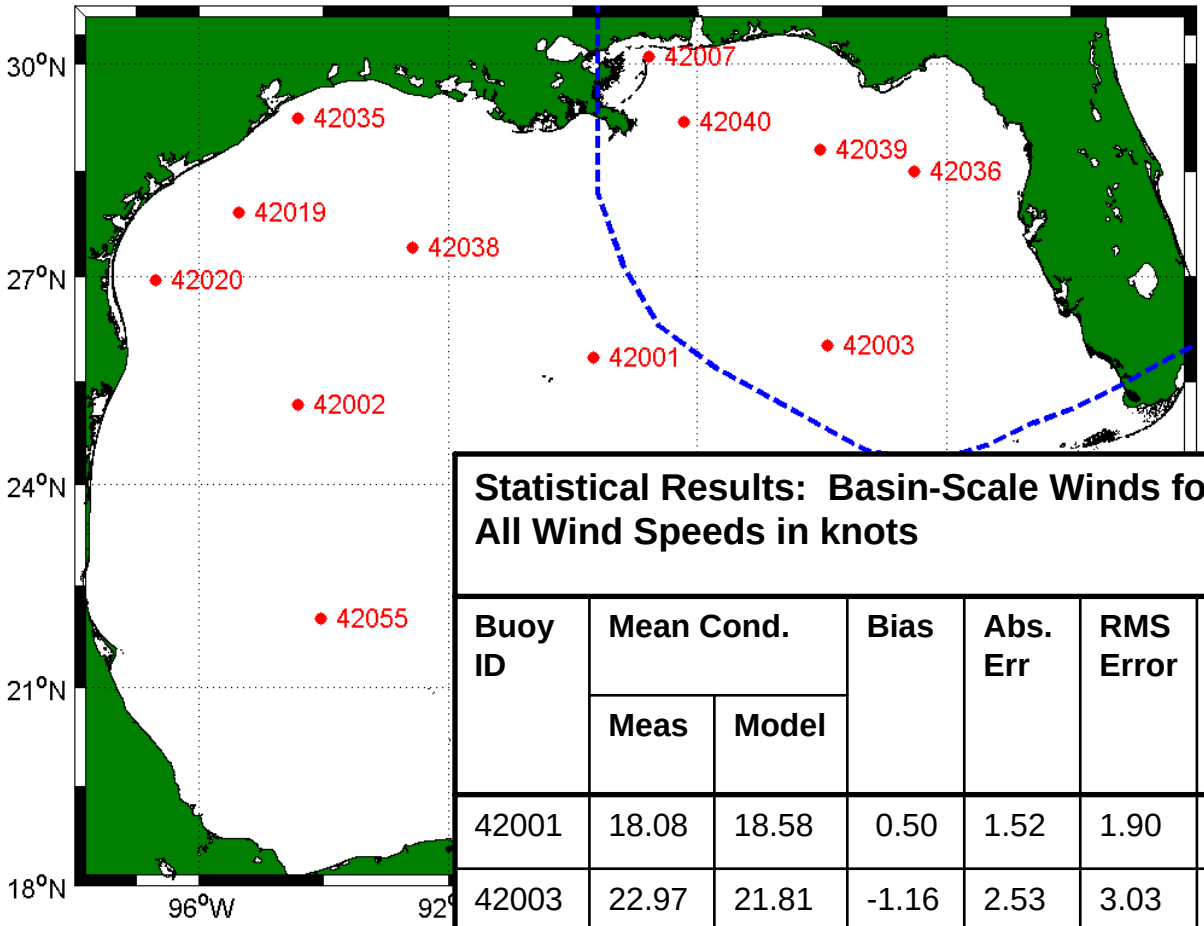








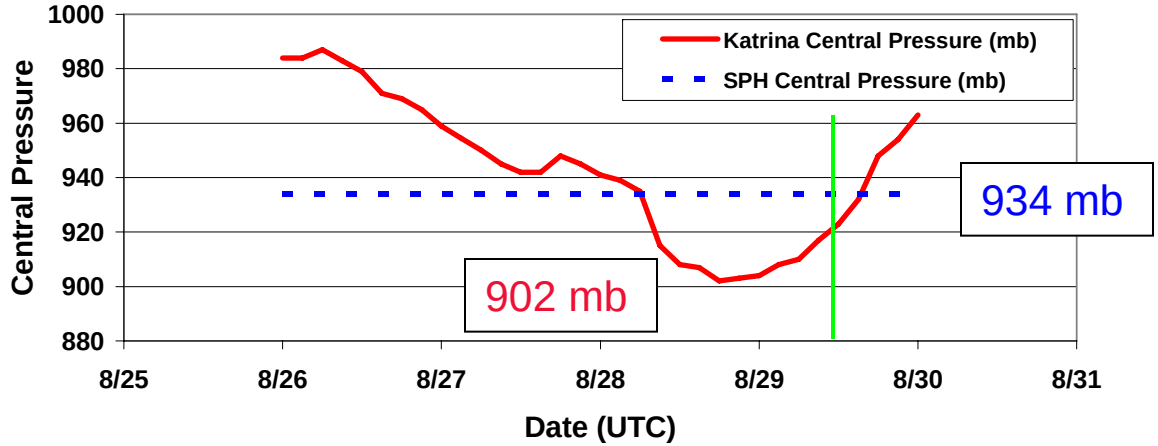
H*Wind/IOKA Product vs Wind Measurements

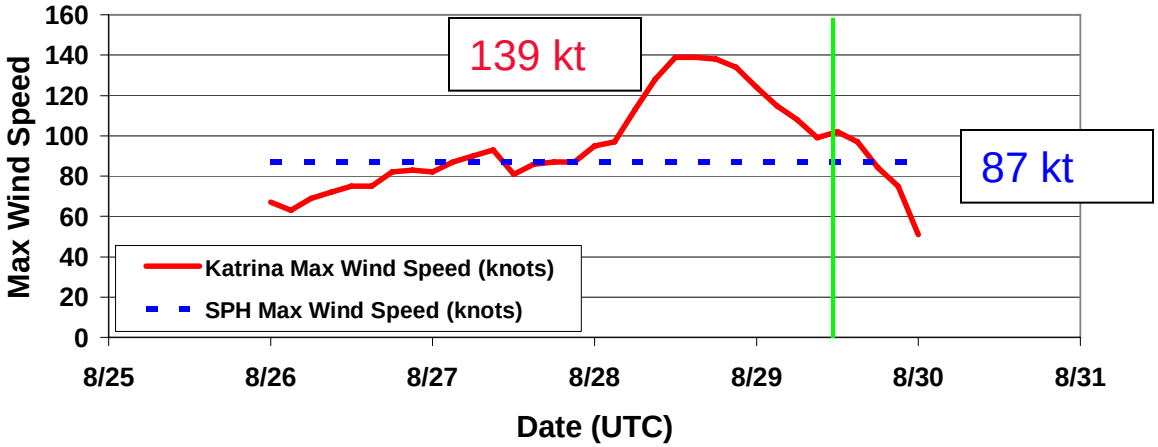


Statistical Results: Basin-Scale Winds for Hurricane Katrina
All Wind Speeds in knots

Buoy ID	Mean Cond.		Bias	Abs. Err	RMS Error	Scat Indx	Linear Regression Estimators				No. Obs
	Meas	Model					Corr r	Sys b	Slope	Intercp.	
42001	18.08	18.58	0.50	1.52	1.90	10	0.99	1.03	1.03	0.04	82
42003	22.97	21.81	-1.16	2.53	3.03	13	0.99	0.92	0.82	3.05	42
42007	15.92	15.49	-0.43	2.60	3.42	21	0.92	0.98	0.93	0.62	57
42036	21.36	21.01	-0.35	1.32	1.73	8	0.95	0.98	0.89	1.92	83
42038	12.97	13.41	0.44	1.94	2.35	18	0.95	1.01	0.90	1.71	82
42039	21.71	22.32	0.61	1.94	2.58	12	0.95	1.01	0.87	3.38	84
42040	20.74	21.62	0.87	2.06	2.72	13	0.98	1.01	0.93	2.27	84
42055	9.43	10.48	1.05	2.92	3.48	37	0.64	1.05	0.44	6.36	84

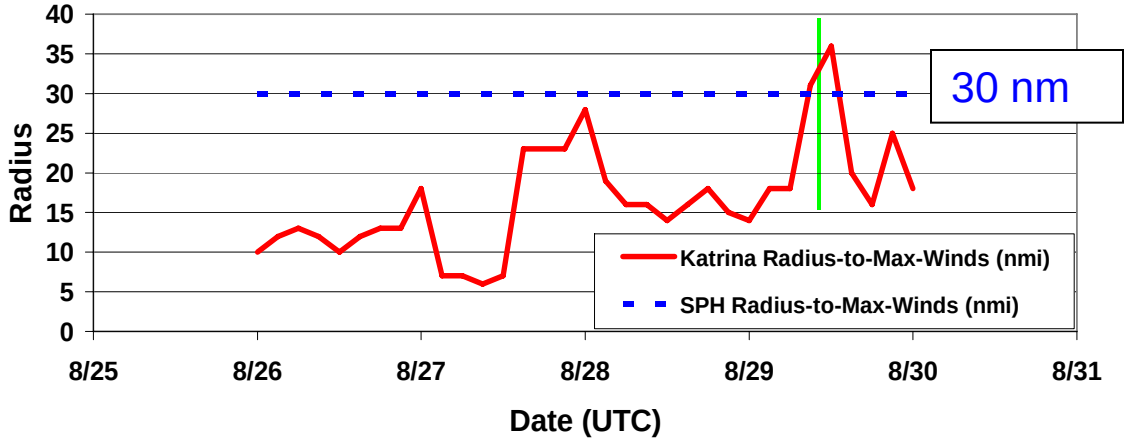
Katrina vs SPH Winds





139 knot (Katrina) vs. 87 knot (SPH) at peak intensity

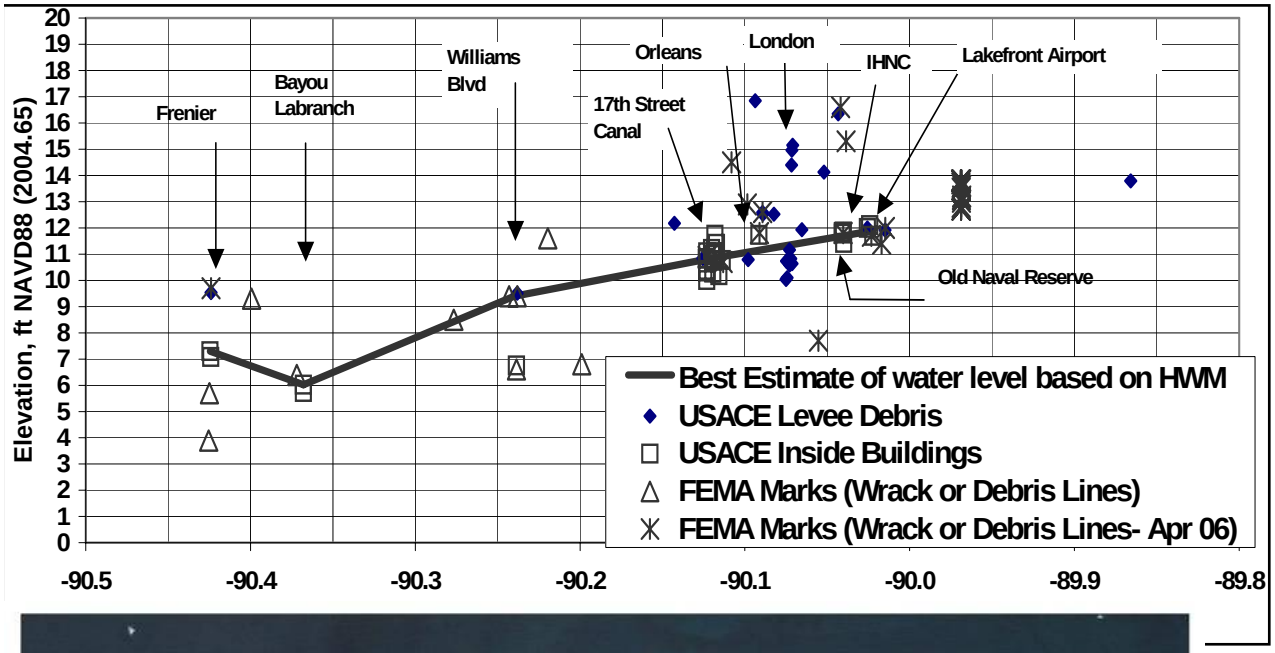
In deeper water, 2.5 times wave producing potential of the SPH



100 knot (Katrina) vs. 87 knot (SPH) at landfall

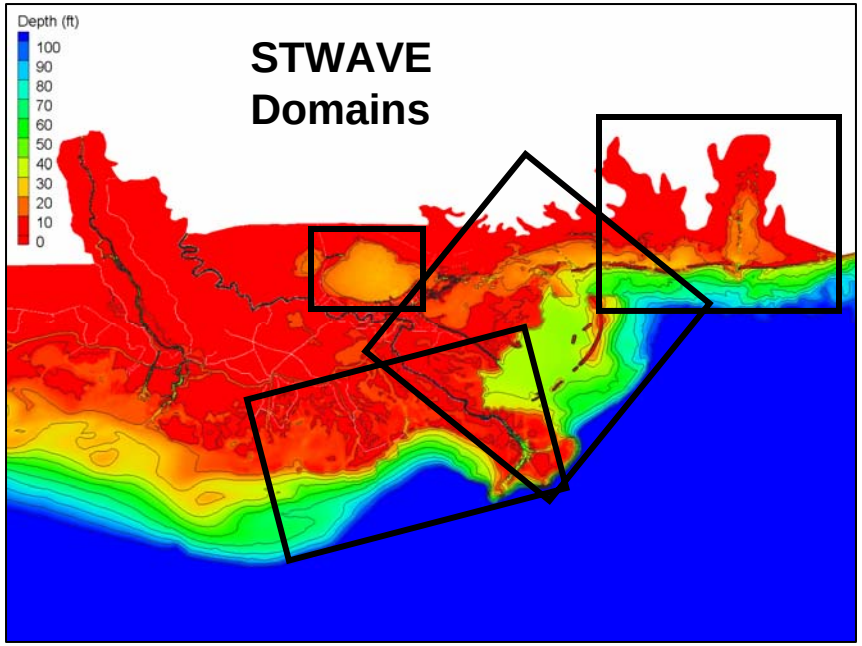
In shallow water, 1.3 to 1.5 times surge producing potential of the SPH

High Water Mark and Hydrograph Analysis

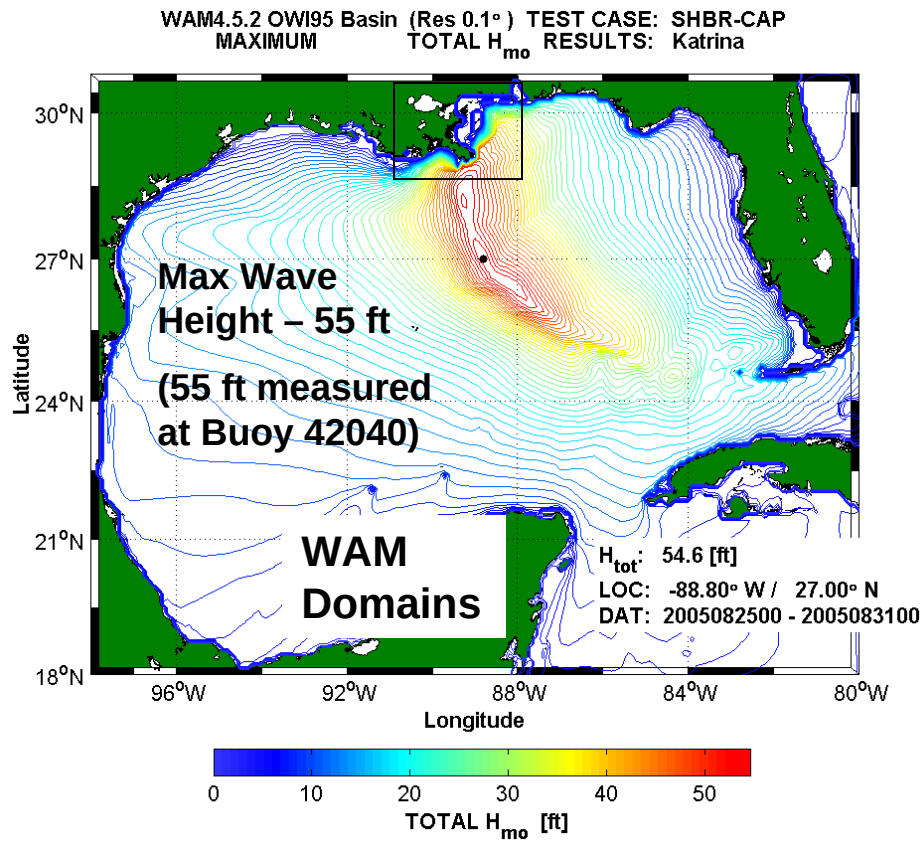


- 13 measured hydrographs considered in the region (**only** 1 captured peak in N.O. vicinity)
- 2 constructed hydrographs from digital photos (17th Street Canal and Lakefront Airport were crucial
- 15% of non-protected HWMs rated excellent
- Debris/wrack line marks contain considerable uncertainty; low reliability as indicator of storm water level

Nested Wave Modeling Approach (3 Levels)

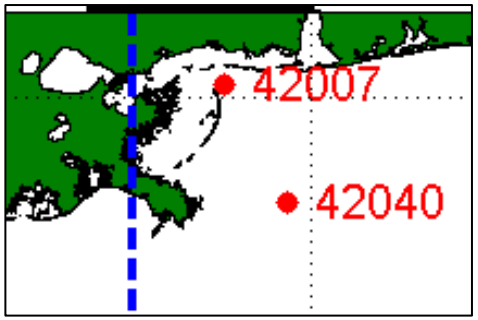


- Basin – Regional – Nearshore
- Wave-storm surge interaction handled at the nearshore level



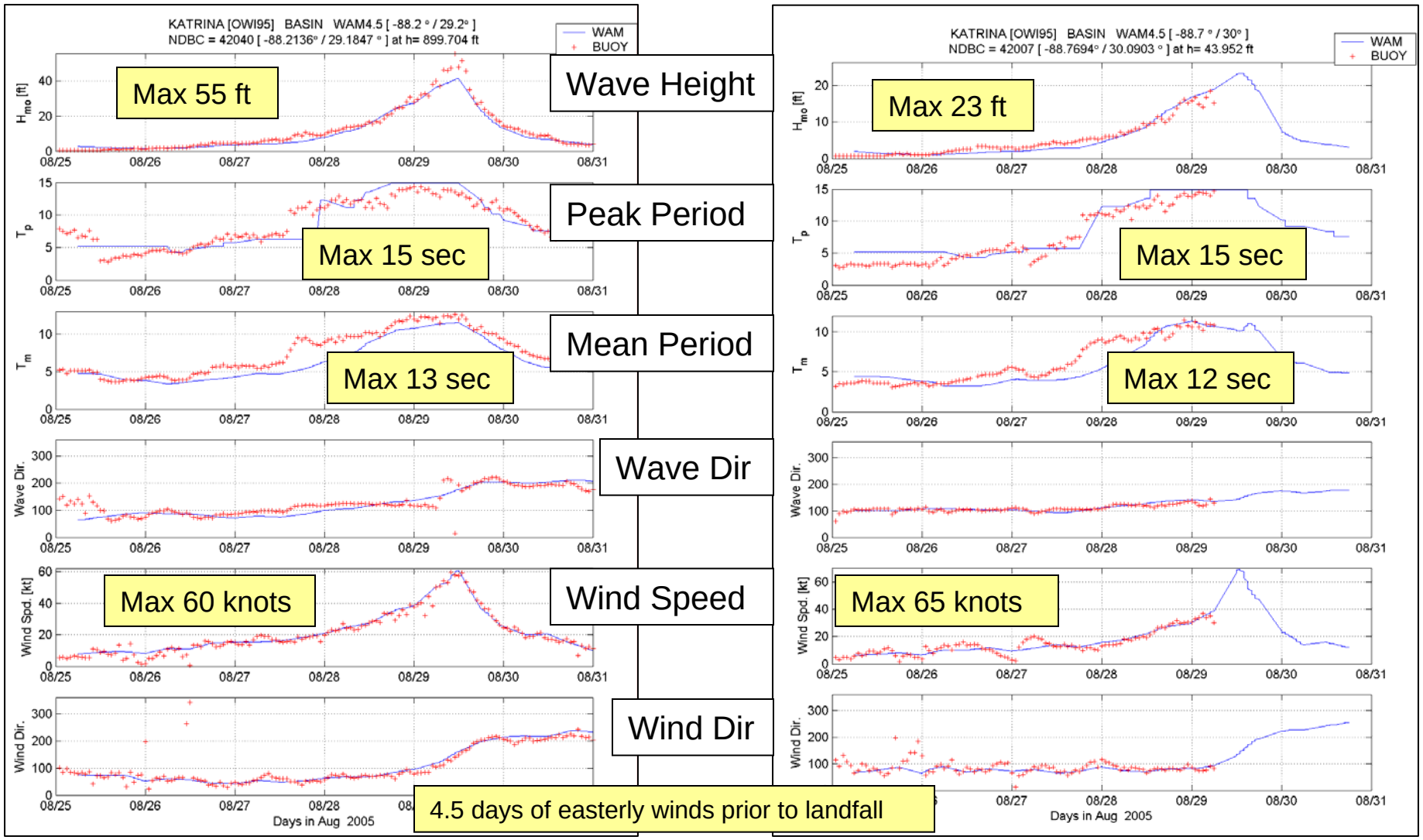
- Maximize model-to-measurement comparisons
- STWAVE compared to SWAN
- Examine steady-state assumption in STWAVE
- WAM compared to WAVEWATCH III

WAM Model Computations and Measurements – SE Louisiana



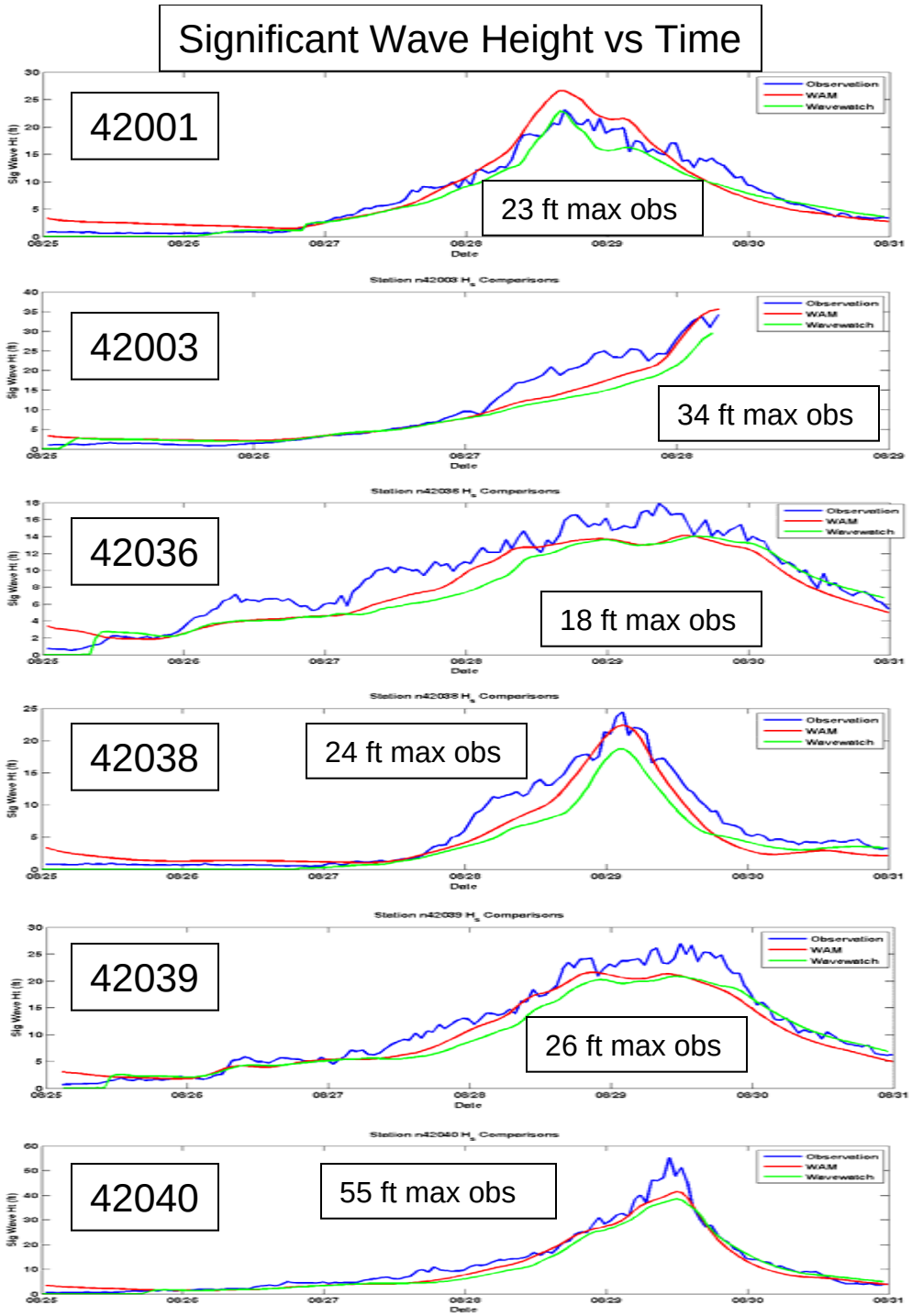
Buoy 42040

Buoy 42007

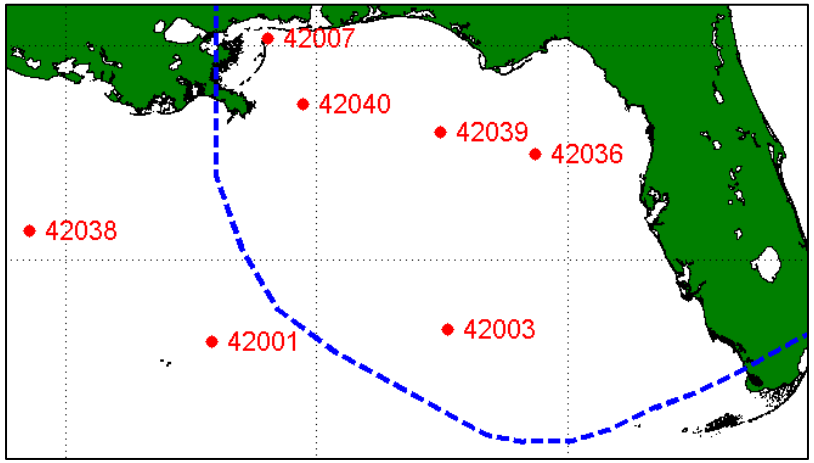


4.5 days of easterly winds prior to landfall

WAM and Wavewatch III Comparisons

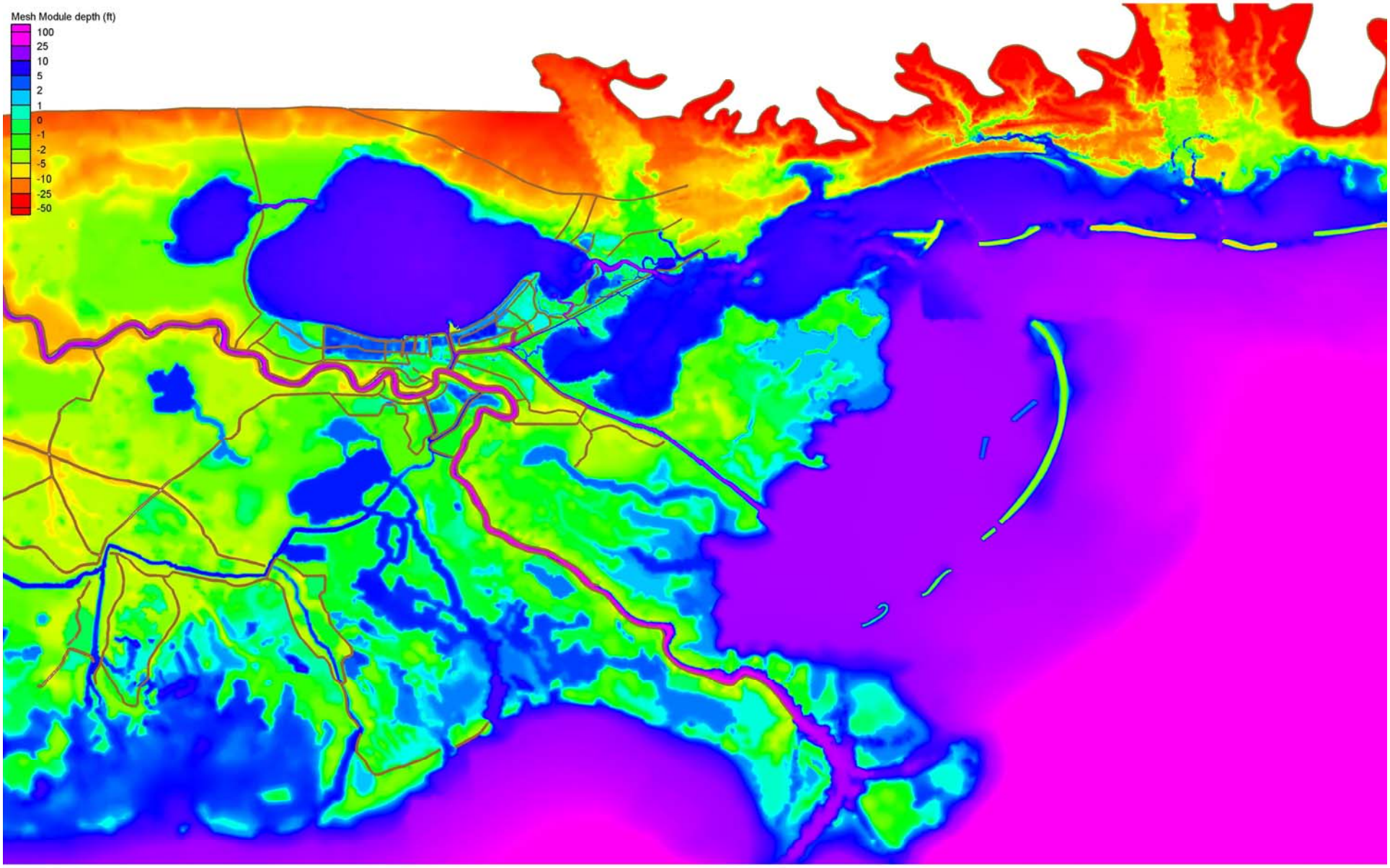


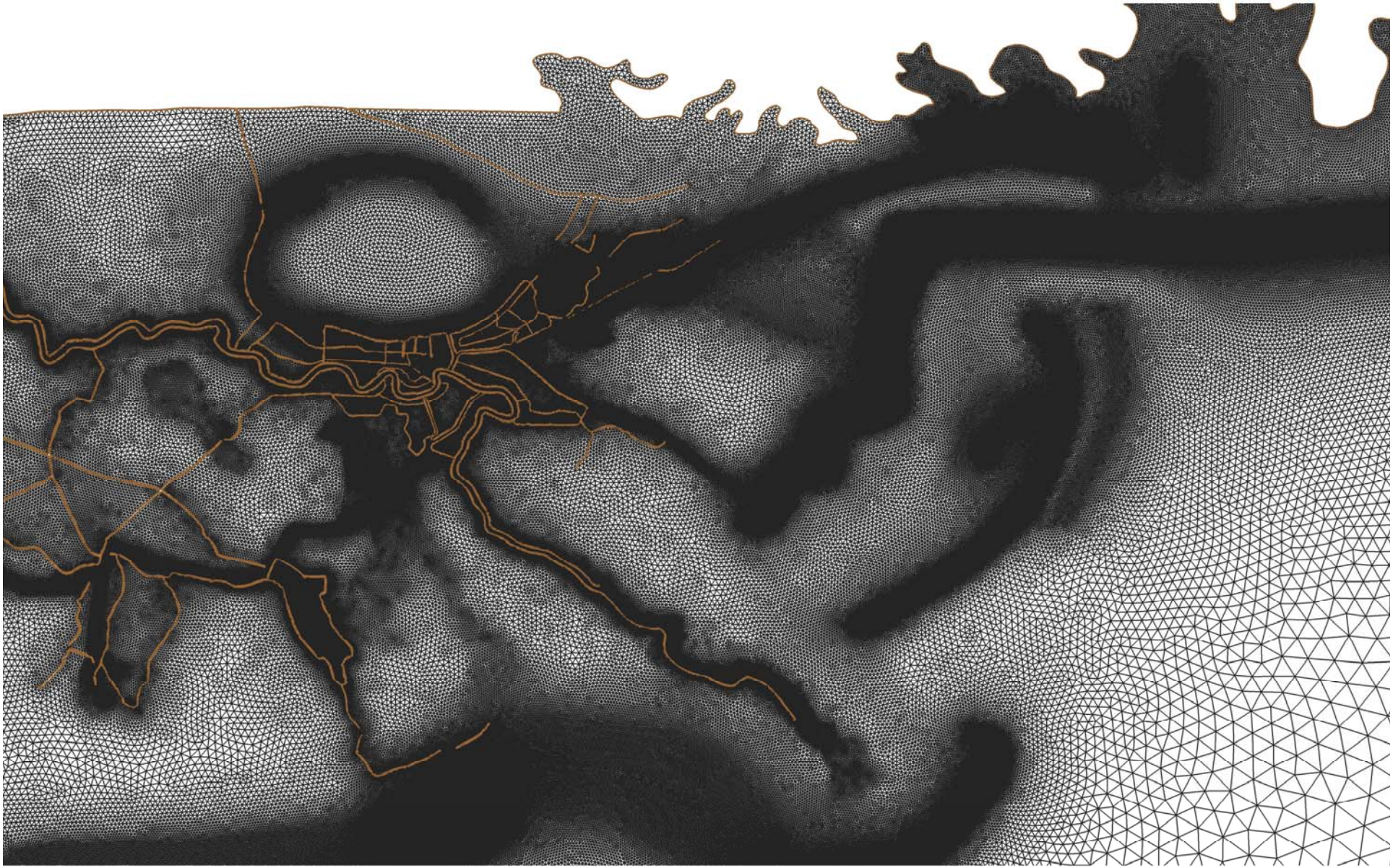
Wave Height Performance Summary				
	Temporal Correlations		Quantile-Quantile	
Component	WAM	WW3	WAM	WW3
Windsea	0.86	0.85	0.87	0.88
Young Swell	0.75	0.74	0.76	0.78
Mature Swell	0.85	0.72	0.87	0.73
Combined	0.83	0.80	0.84	0.82



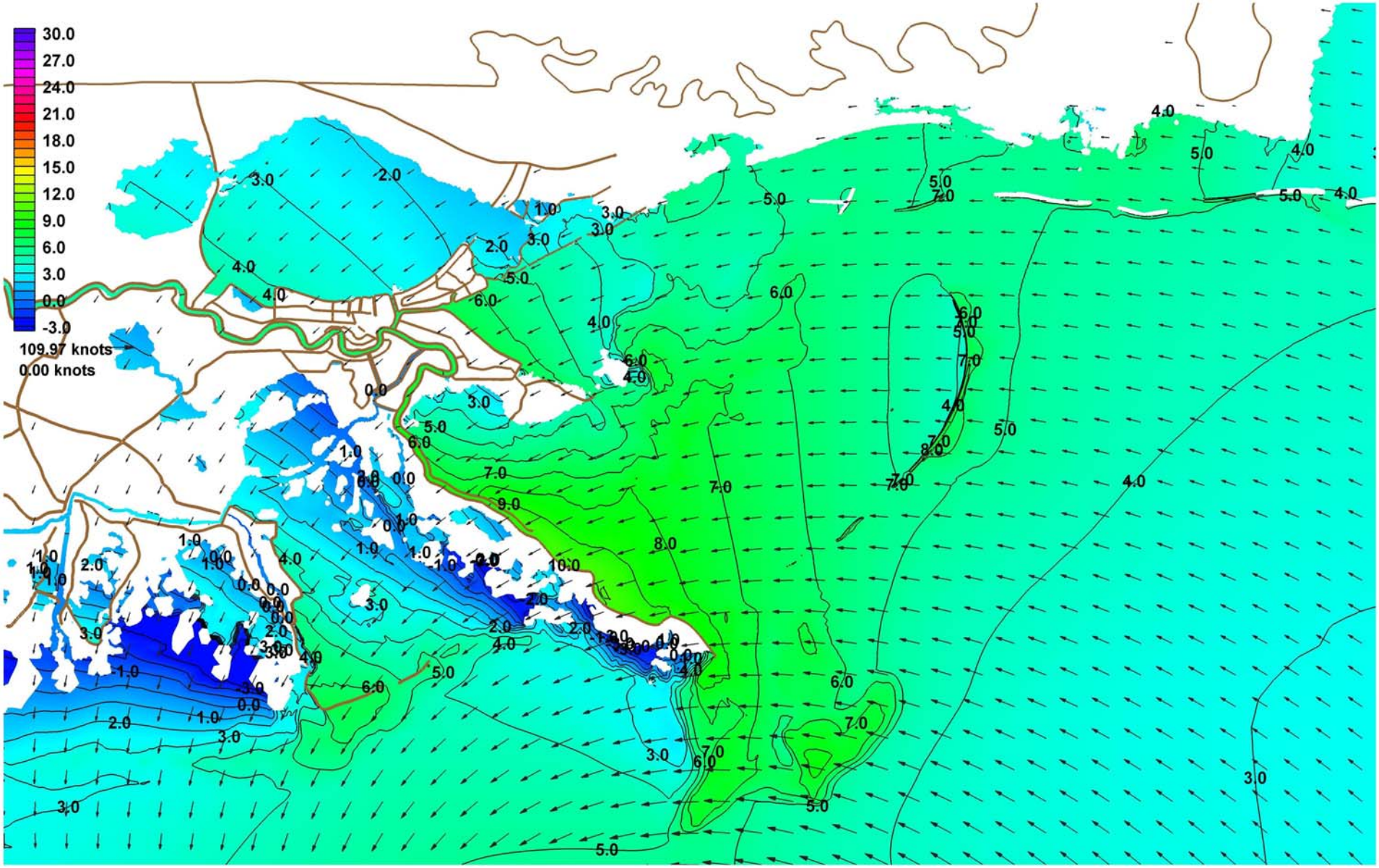
TF01x2 Surge Hindcasts

- Describe and resolve the physical system
  - TF01x2 grid encompasses many new details
- Provide accurate forcing functions
  - Tides
  - Force in Mississippi River at Baton Rouge and Atchafalaya River at Simmesport
  - H*wind/IOKA winds and OWI pressures
  - Carefully consider air-sea interaction
  - STWAVE wave radiation stress forcing along all critical coasts
  - Steric expansion
  - Carefully define reference levels – NAVD 88 2004.65

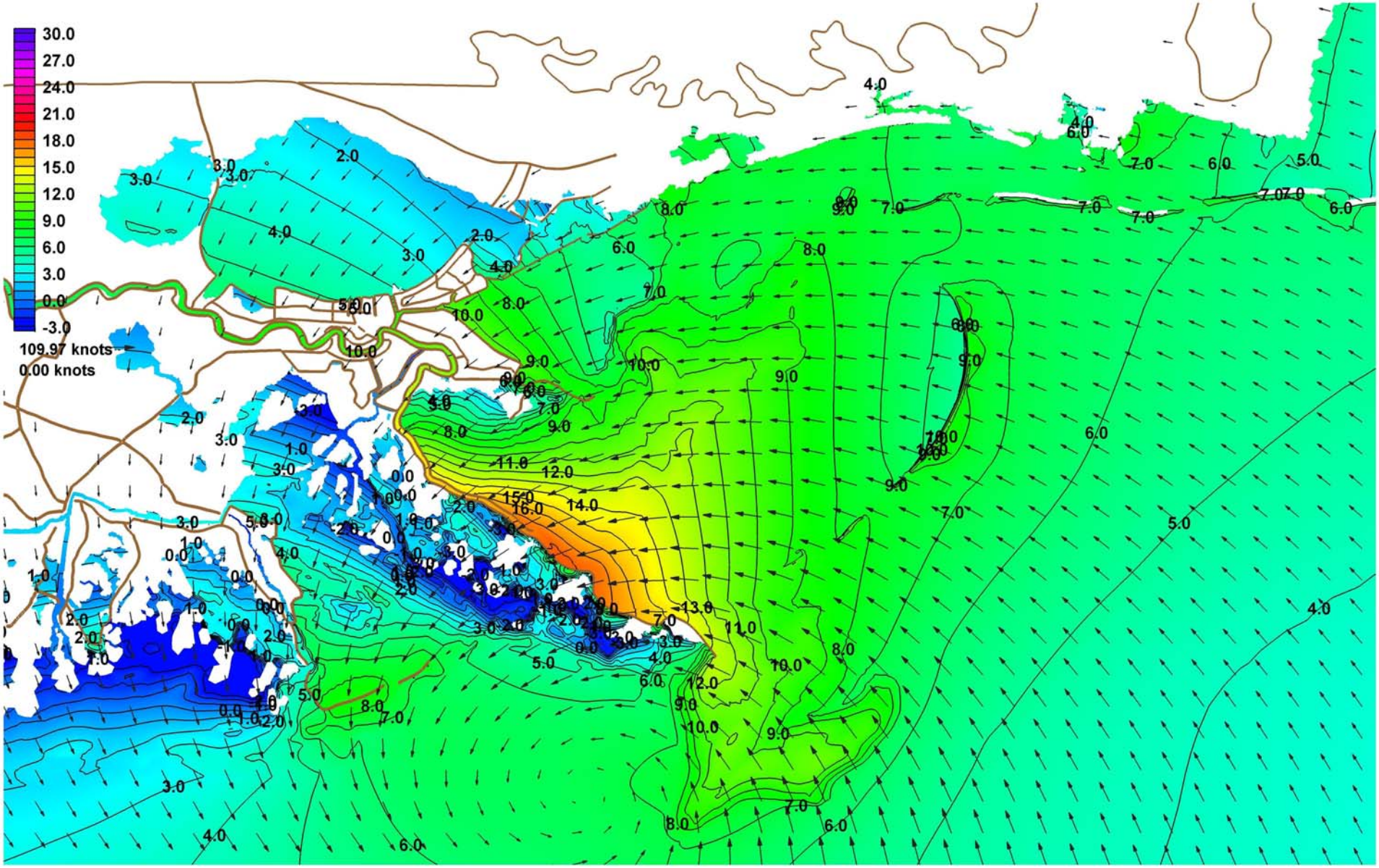

Mesh Module depth (ft)
100
25
10
5
2
1
0
-1
-2
-5
-10
-25
-50



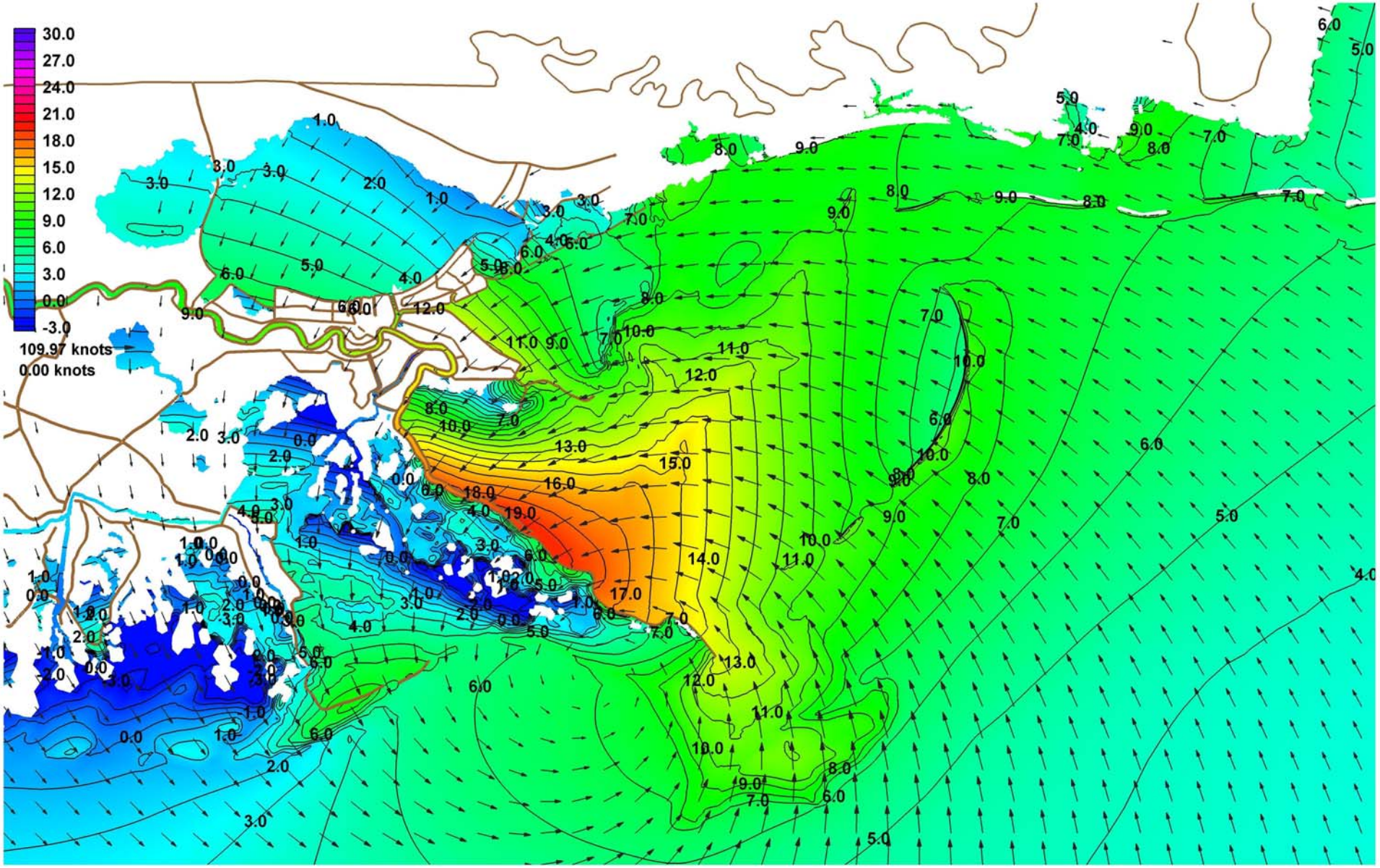
8/29/07Z



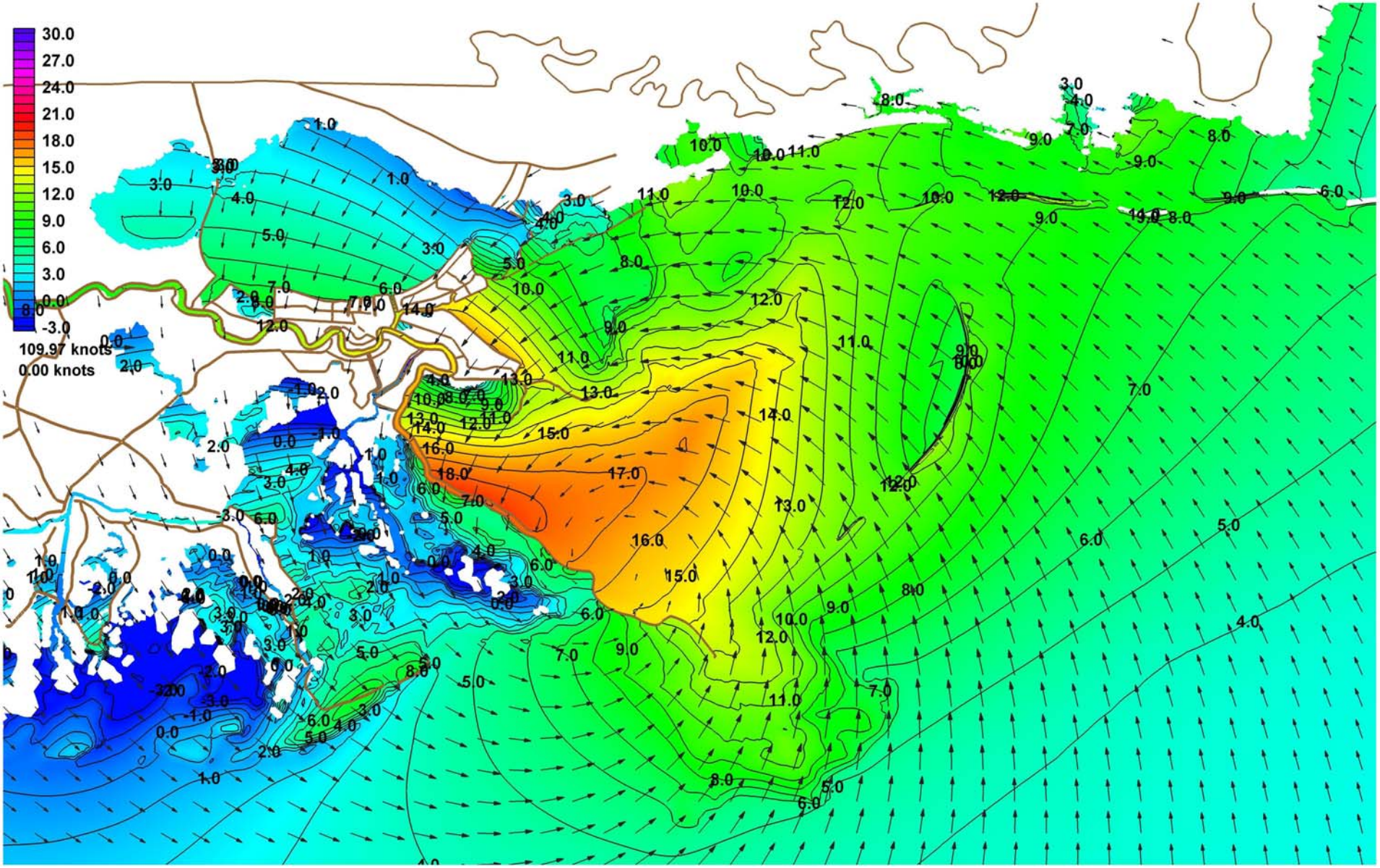
8/29/10Z



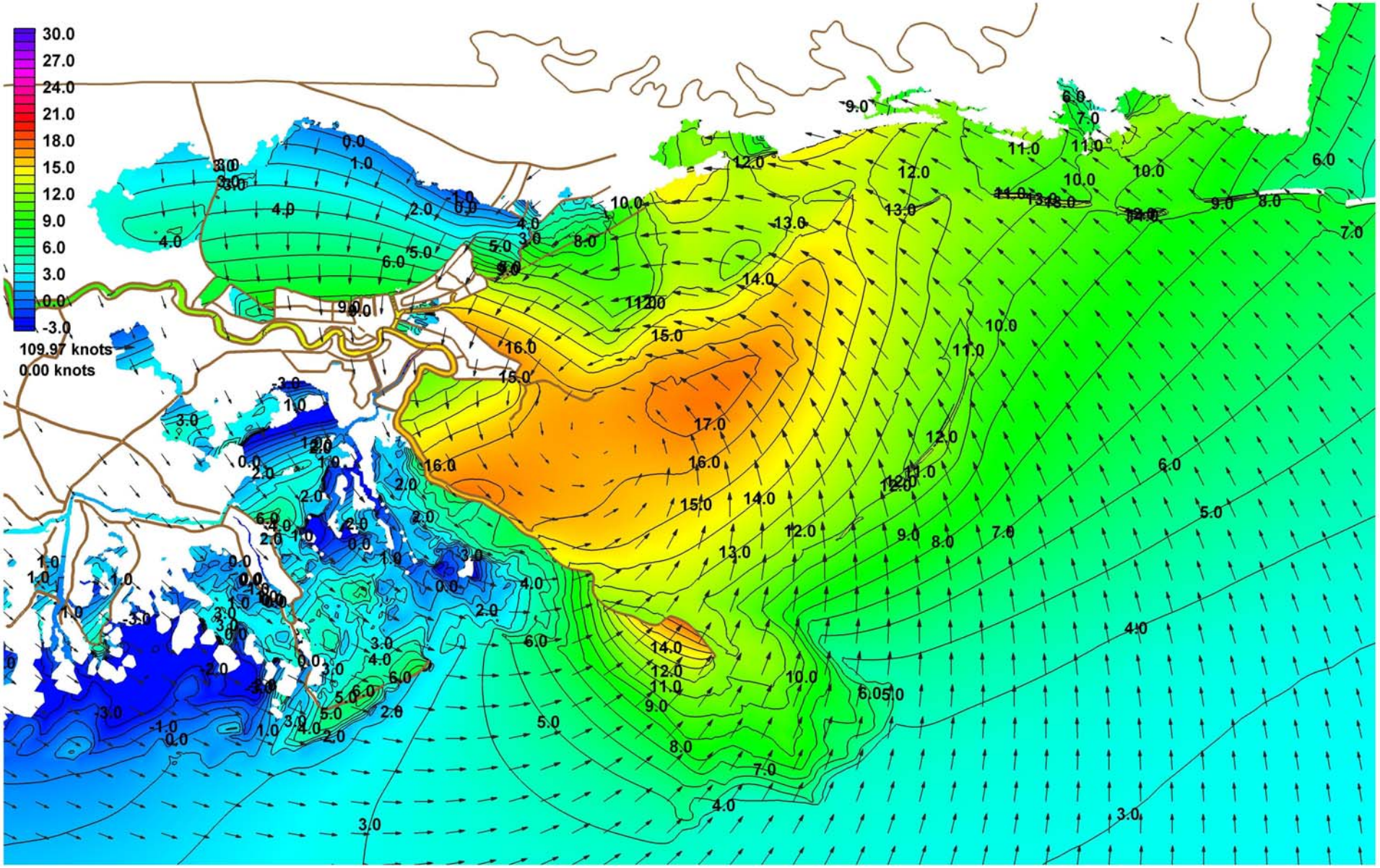
8/29/11Z



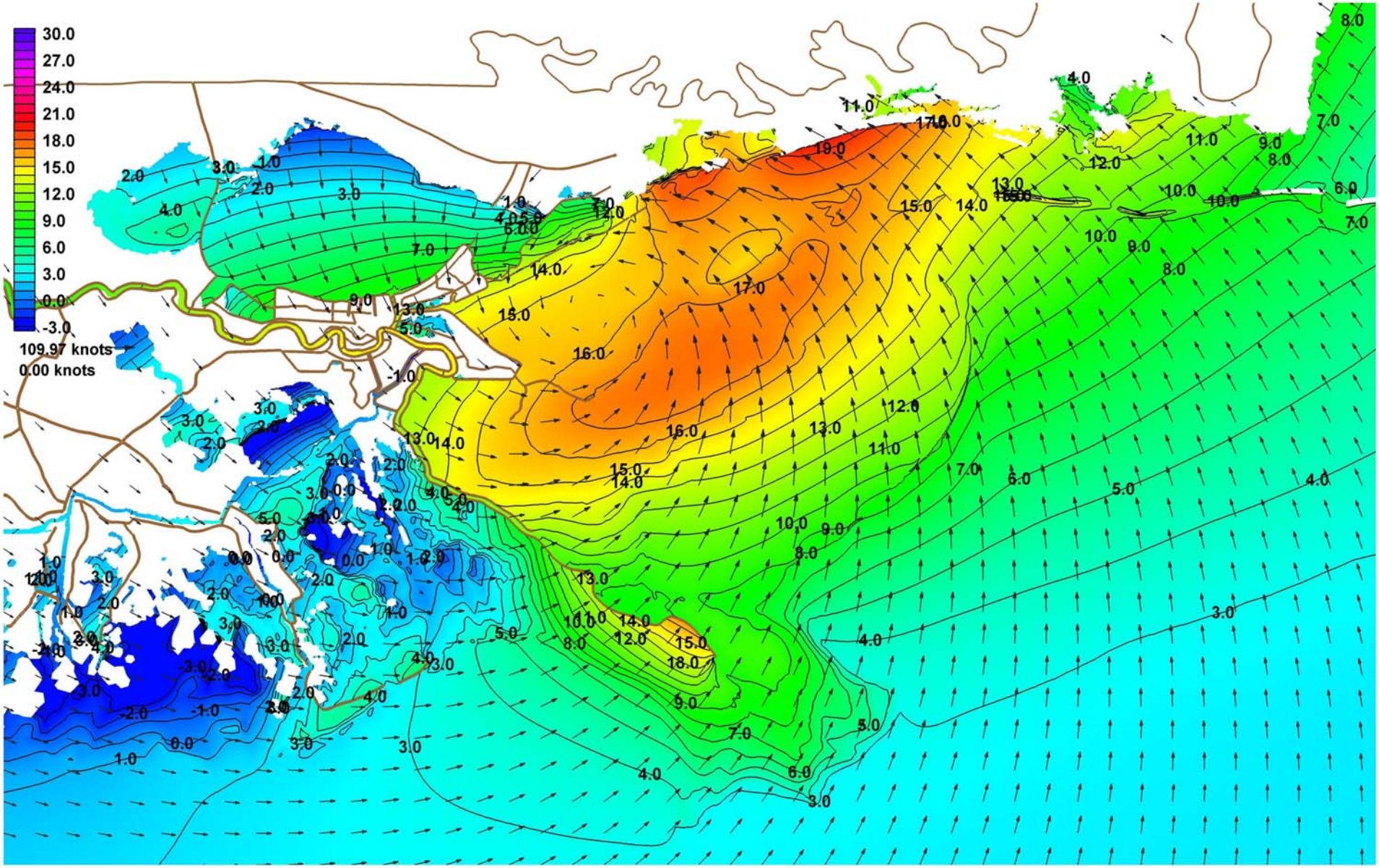
8/29/12Z



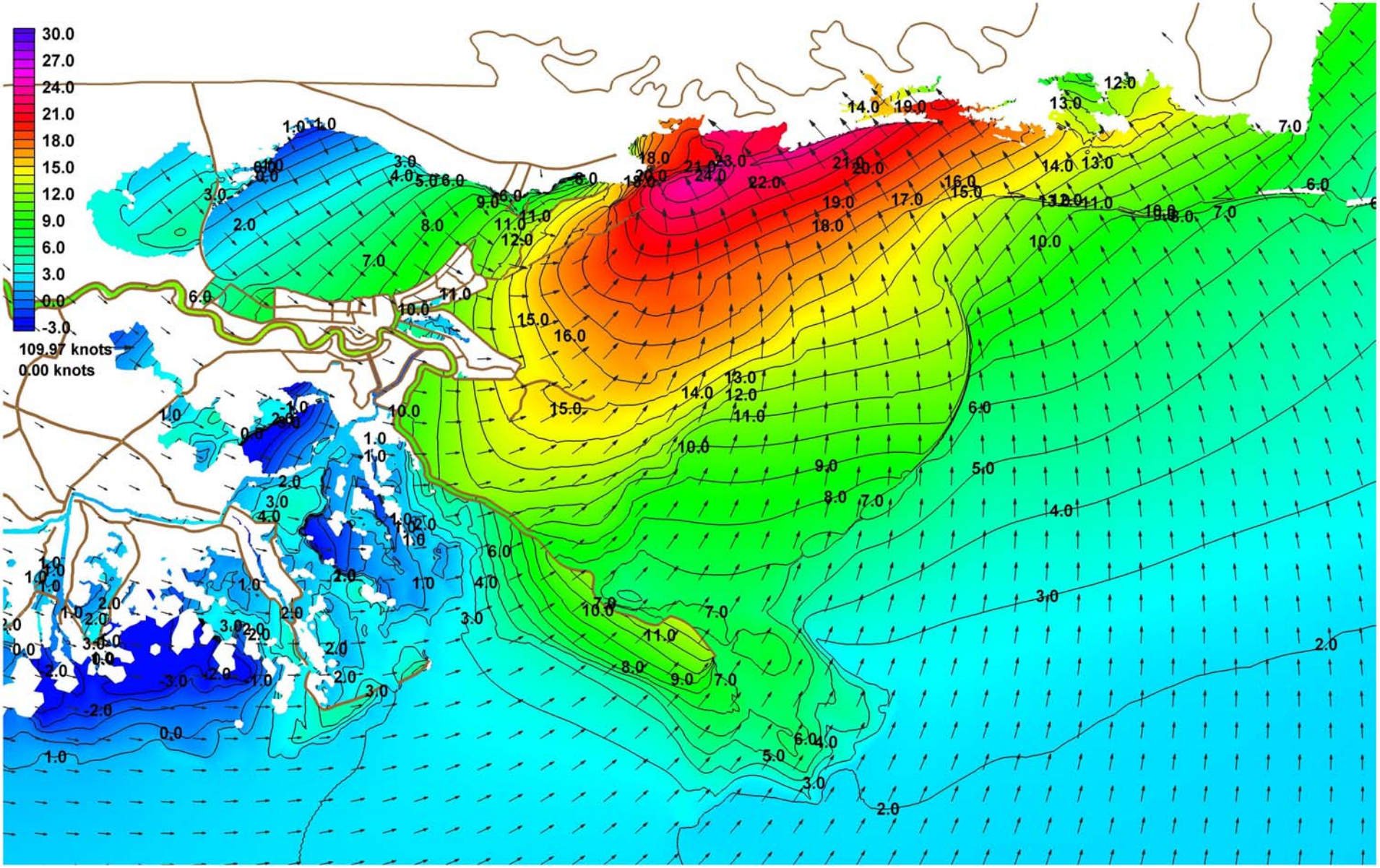
8/29/13Z



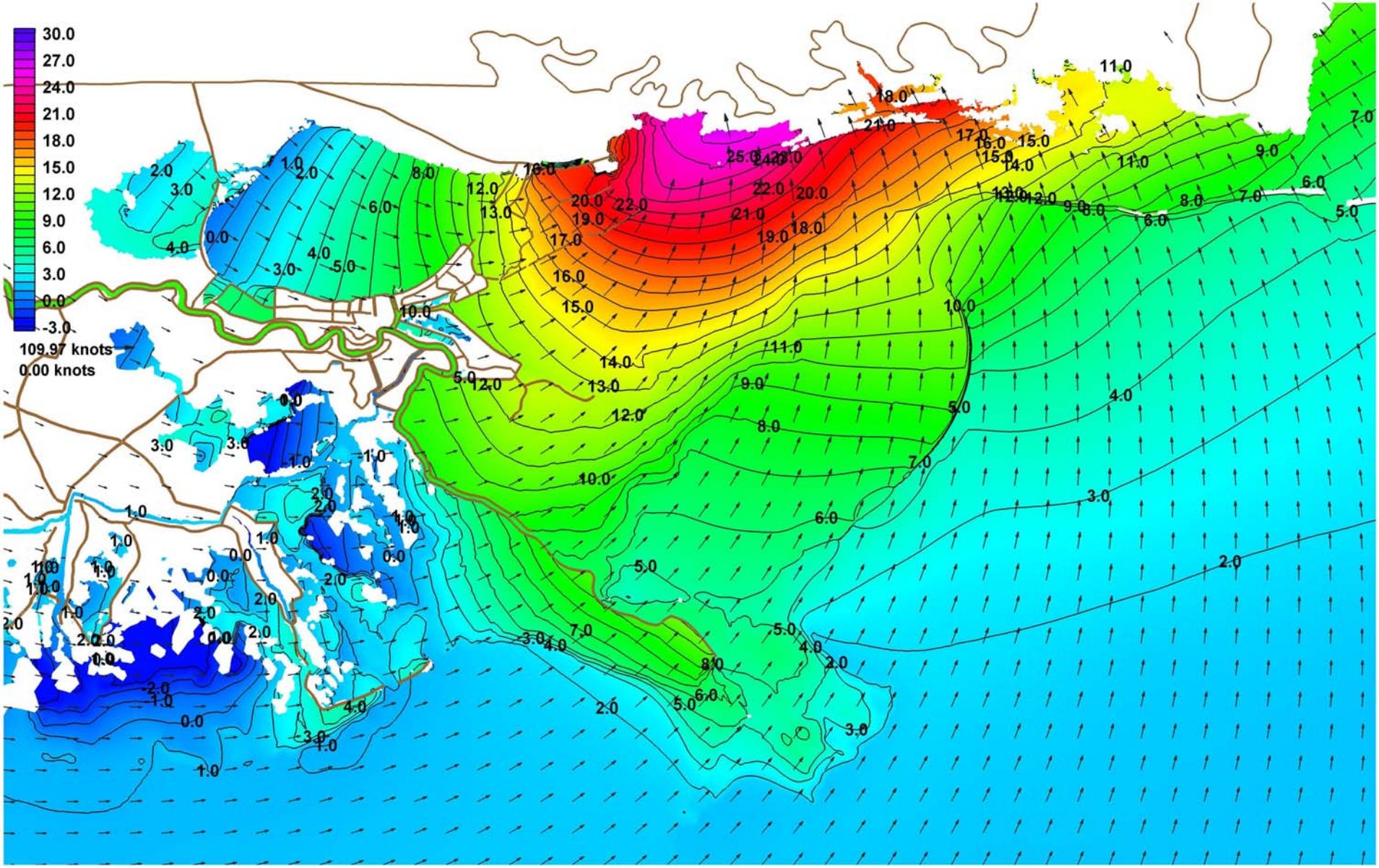
8/29/14Z



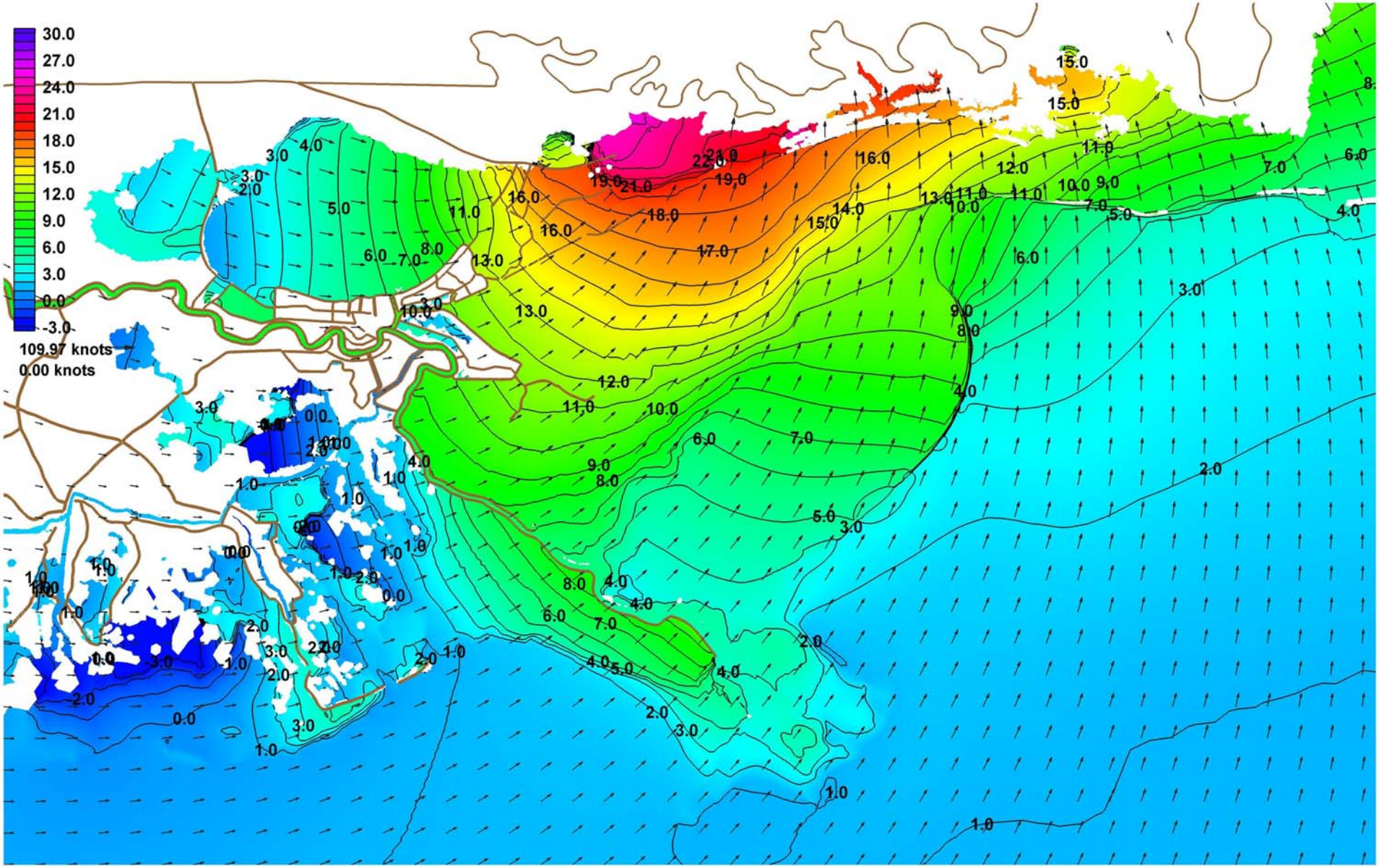
8/29/15Z



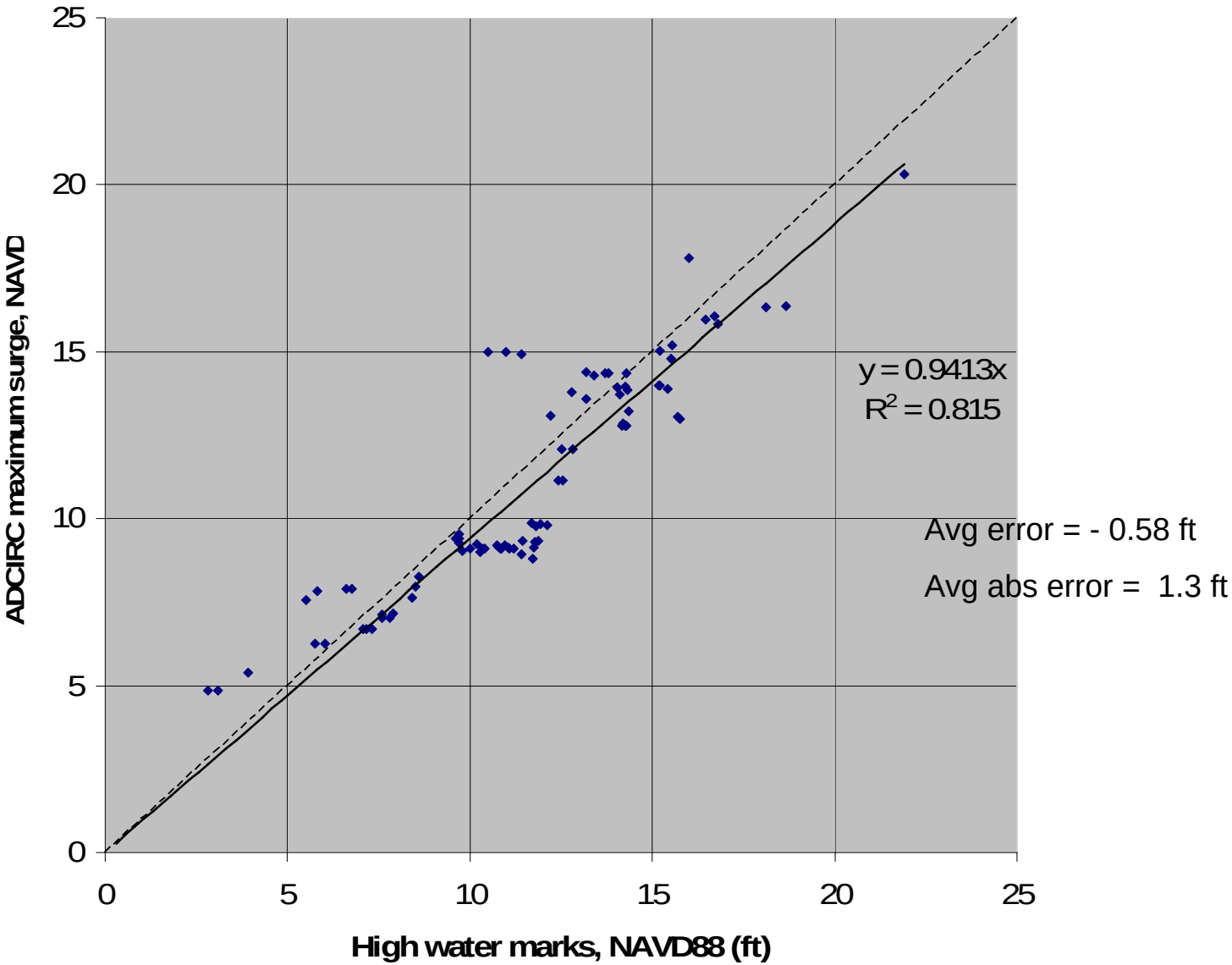
8/29/16Z



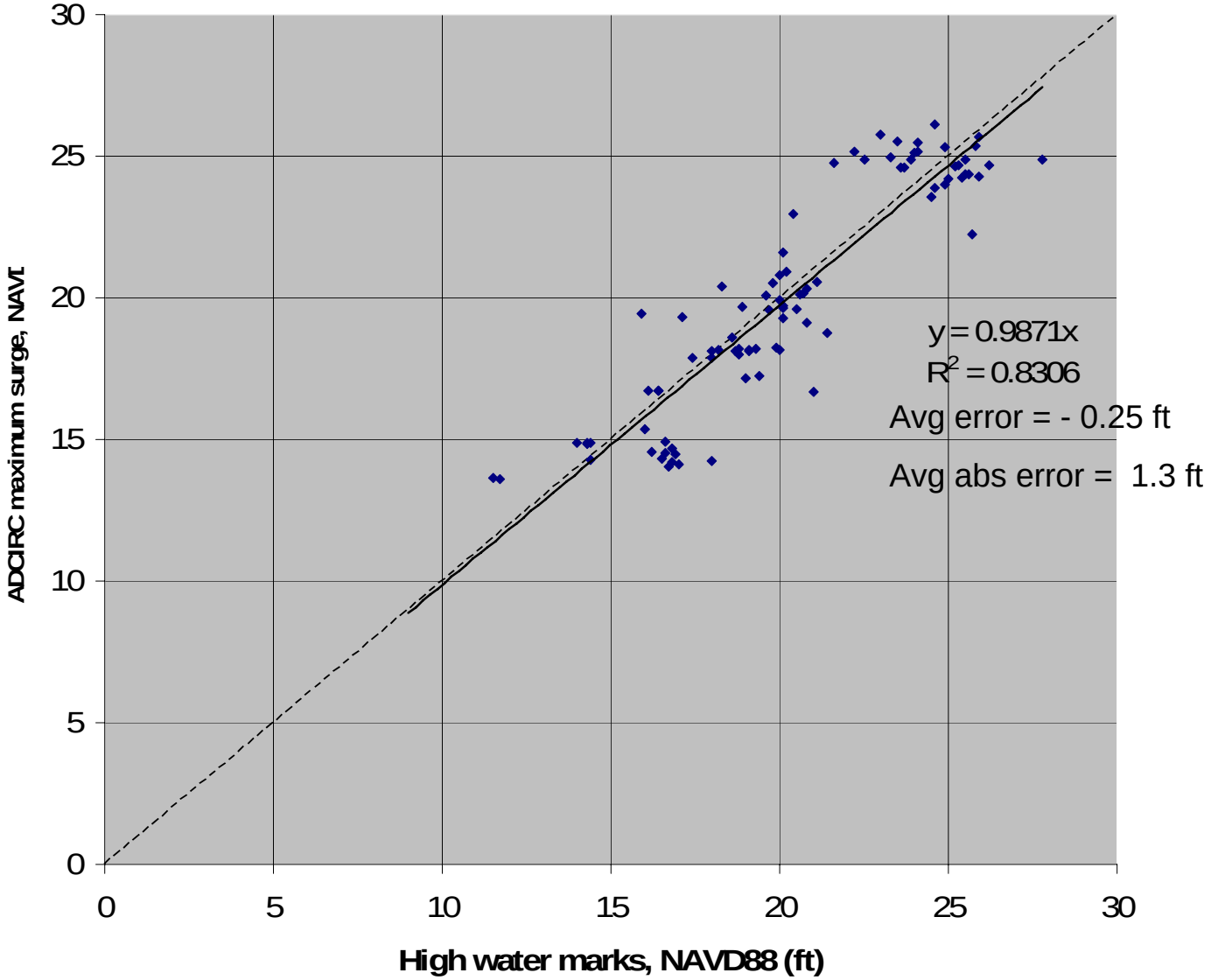
8/29/17Z



High Water Mark Comparison - Louisiana



High Water Mark Comparison - Mississippi



Findings / Lessons Learned

- Katrina produced wave heights (55 ft) and water levels (28-29 ft) that were unprecedented for the U.S. Coast
- Some parts of the system were overwhelmed; waves and water levels greatly exceeded design values in places; in some places they were similar to design values.
- Corps' model technology (ADCIRC, WAM,STWAVE) worked reasonably well with accurate forcing (winds) and high resolution of the physical system
- Topographic controls important in determining storm surge
- Wave setup was up to 2.5 ft away from structures in Southeast LA, 1 to 2 feet at structures; location dependent
- Need measurement systems and data that capture peaks of hurricane waves and water levels; to evaluate design assumptions and methods
- R&D needs: momentum transfer from wind to waves to water column; effect of frictional resistance on surge and waves; seamless methods for computing full wave set-up effect
- Saffir-Simpson scale too simple to capture complexities of factors that determine storm surge and wave conditions
- Need to develop optimal balance between accuracy of detailed modeling and desire to consider many storms in a risk-based design approach.