WAVE-BOTTOM INTERACTION AND BOTTOM BOUNDARY LAYER DYNAMICS IN EVALUATING SAND MINING AT SABINE BANK FOR COASTAL RESTORATION IN LOUISIANA

Gregory W. Stone, Principal Investigator

Felix Jose, Daijiro Kobashi,
Seyed M. SiadatMousavi, and
Baozhu Liu

Coastal Studies Institute
Louisiana State University

MMS ITM, New Orleans, 6 January 2009

Hurricane Impact along LA/TX Coast

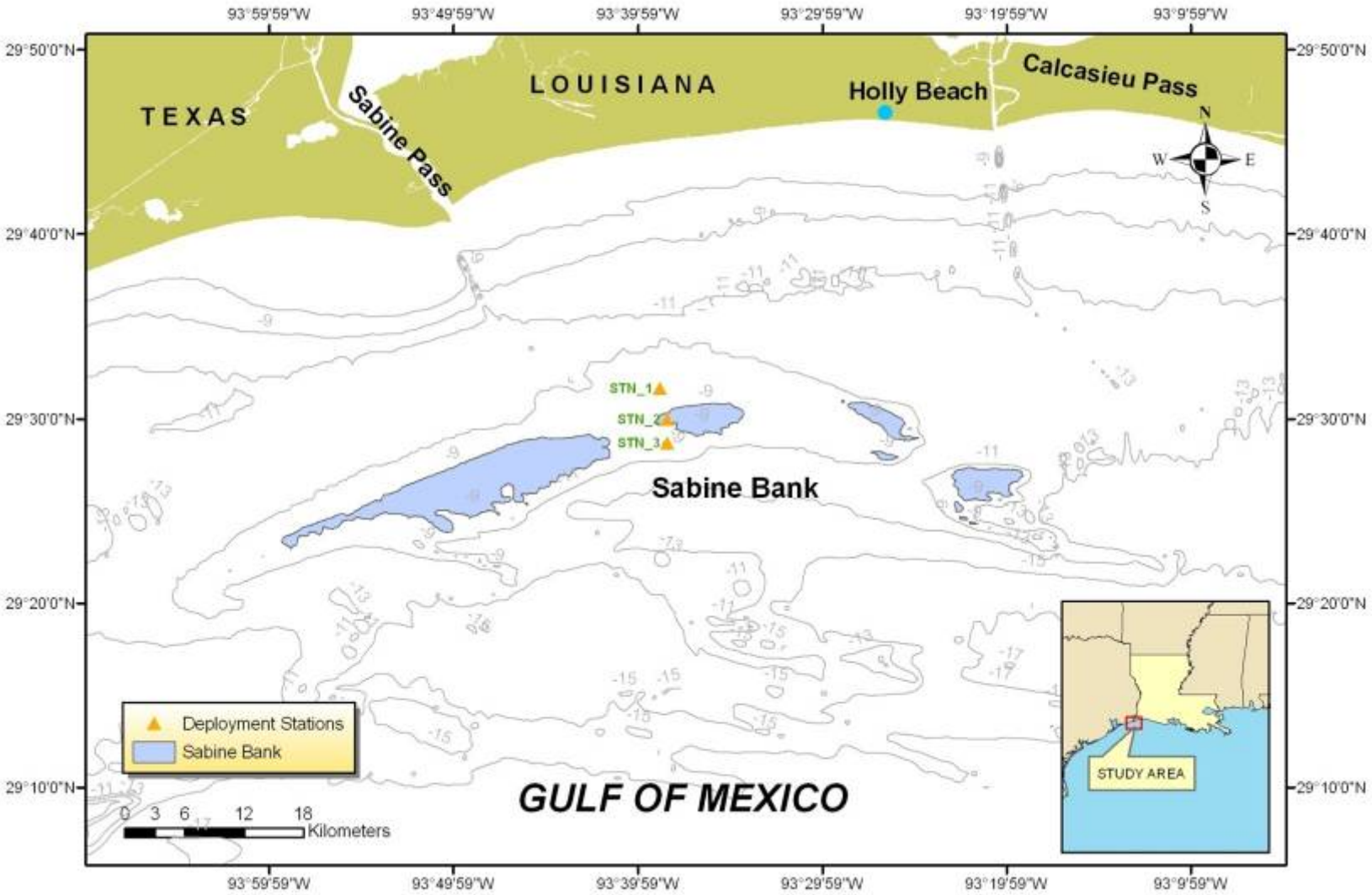
MODIS imagery captured on NASA's Terra Satellite. 26 Oct. 2008

Credit: Jeff Schmaltz, NASA, GSFC

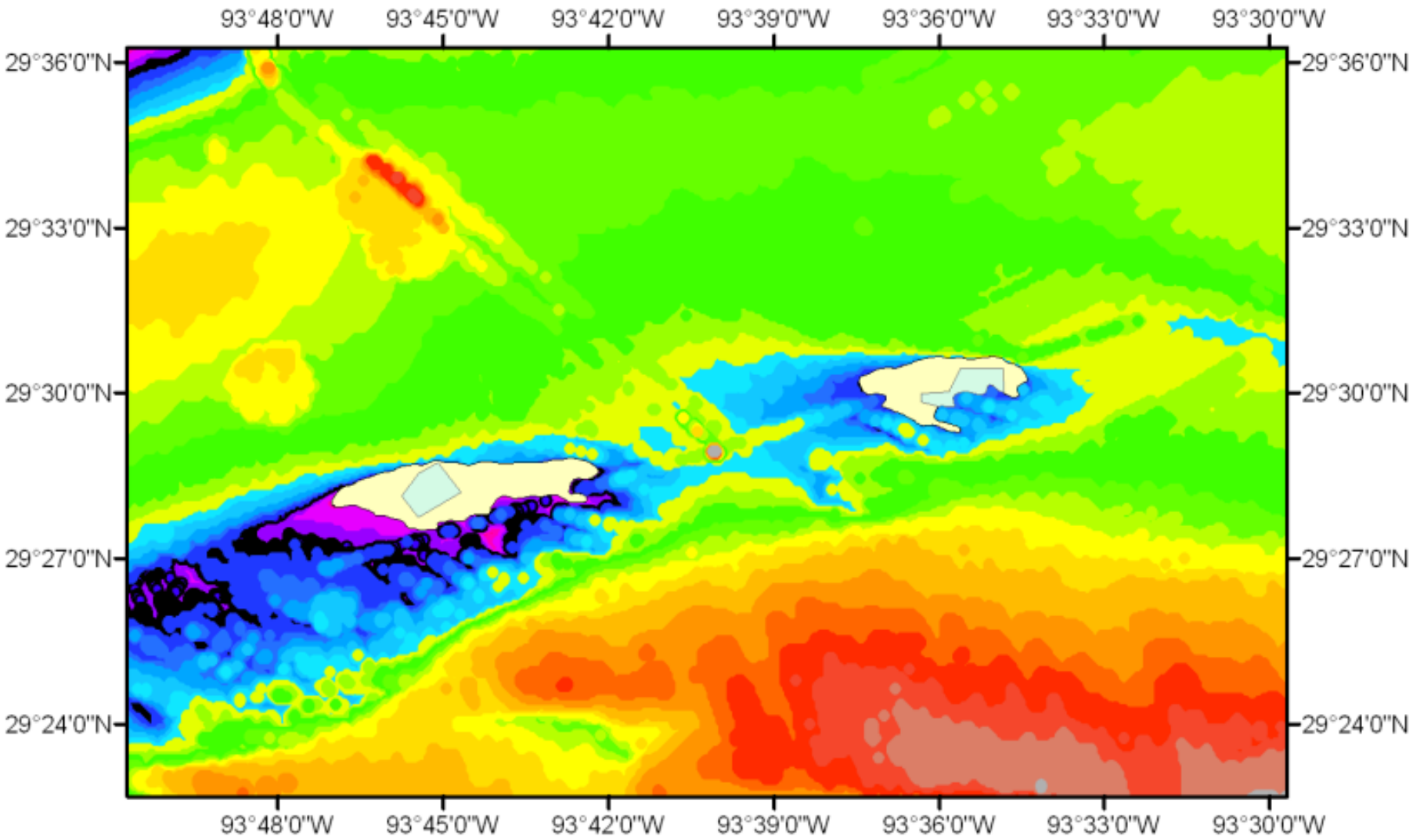
Presentation Outline

- **Prospective Sand Mining Scenarios**
- **Research Progress**
  - **Field Surveys**
  - **Bottom Boundary Layer Dynamics**
    - **Numerical modeling**
    - **Implications associated with Targeted Sand Mining**
- **Final Report Submission**

Study Area


93°59'59"W
93°49'59"W
93°39'59"W
93°29'59"W
93°19'59"W
93°9'59"W
29°50'0"N
29°40'0"N
29°30'0"N
29°20'0"N
29°10'0"N
TEXAS
LOUISIANA
Sabine Pass
Holly Beach
Calcasieu Pass
N
W
E
S
STN_1
STN_2
STN_3
Sabine Bank
GULF OF MEXICO
Deployment Stations
Sabine Bank
0 3 6 12 18
Kilometers
STUDY AREA

Extraction Scenarios



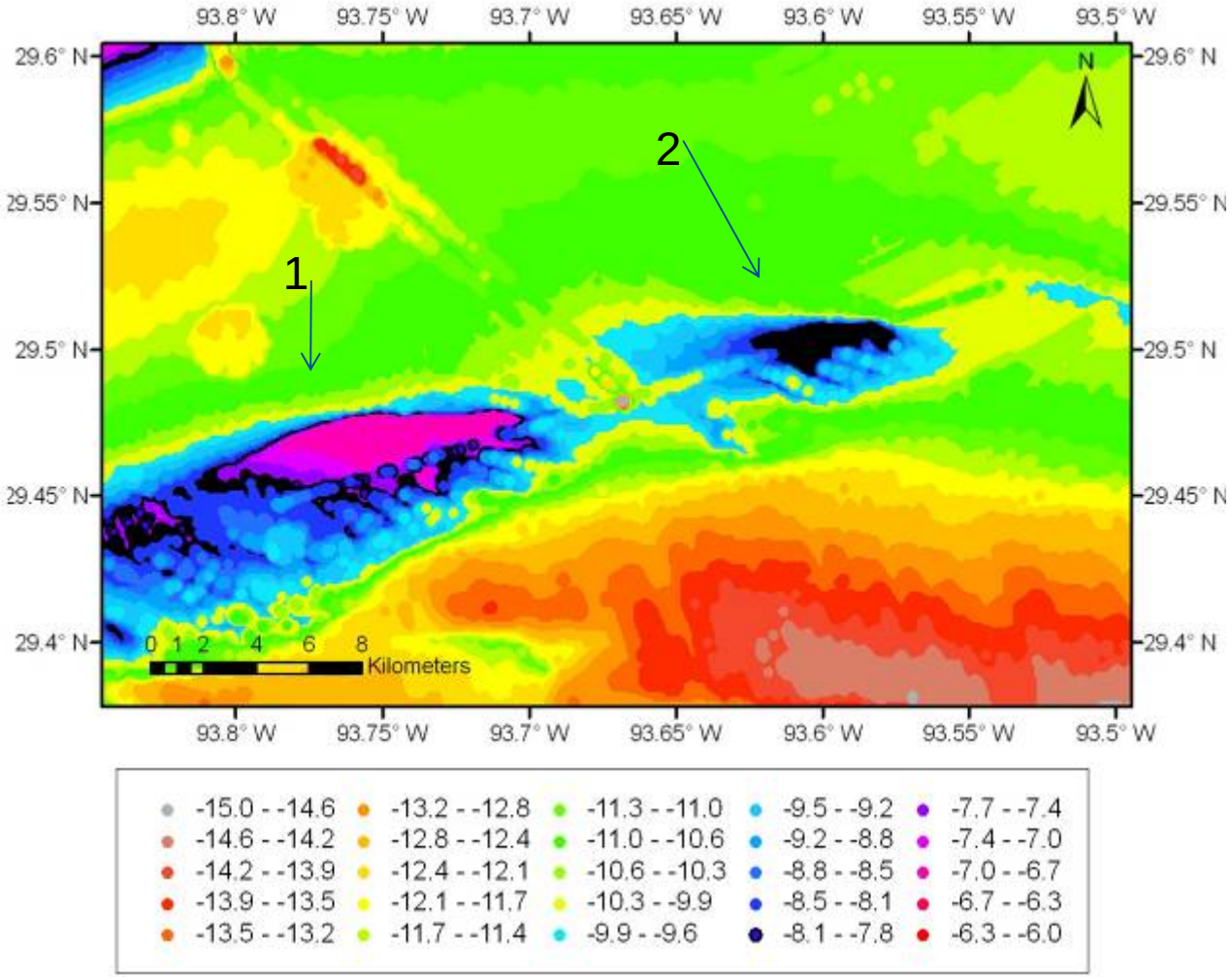
Cumulative Extraction of Sand from the West and East Shoals

Expected Sand Volume: 17,000,000 m^3

Post Dredging bathymetry:

1: 7 m isobath for west shoal and

2: 8 m isobath for east shoal



Targeted Mining Scenario

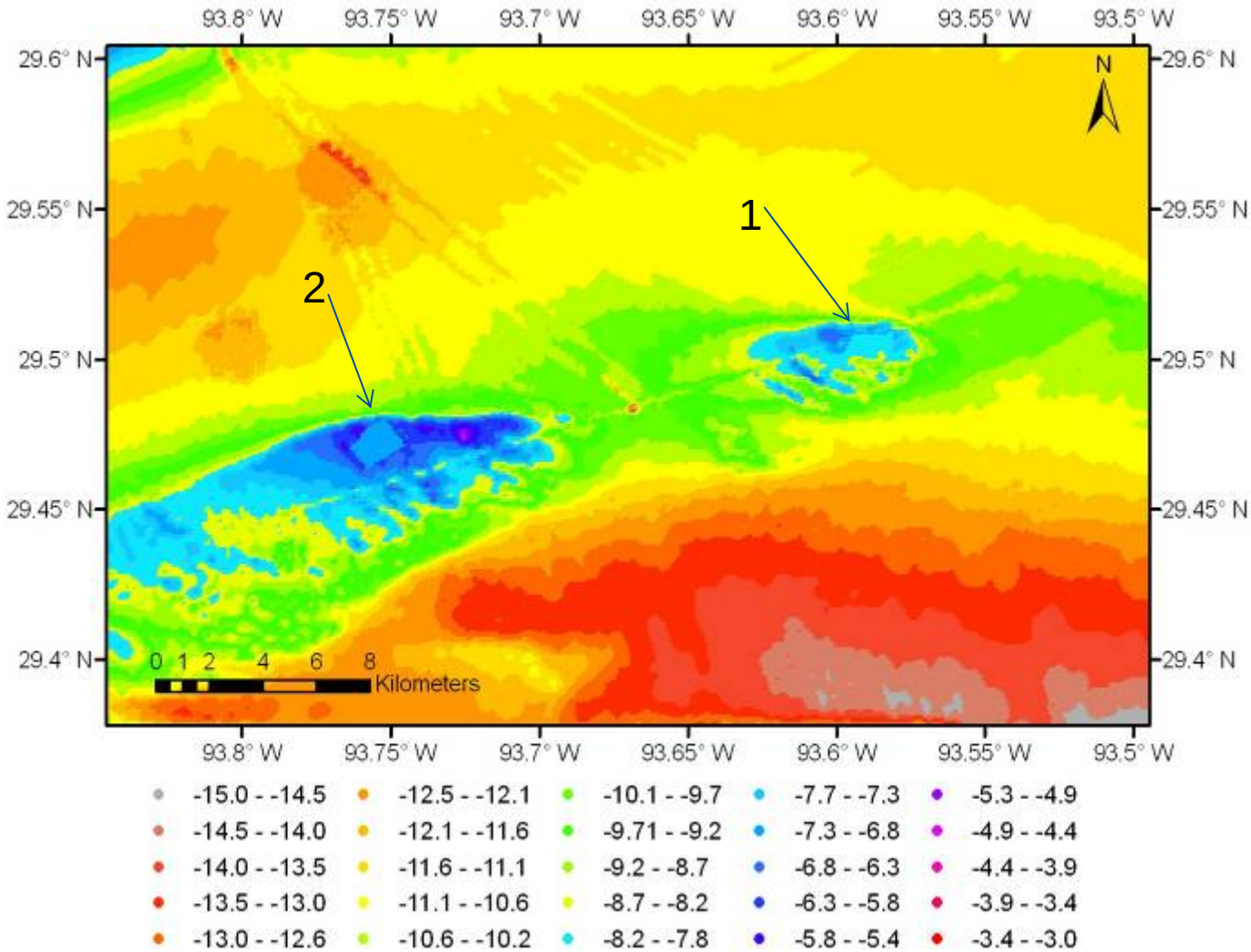
Holly Beach Restoration Project: Proposed Mining Area

Expected Sand

Volume : 3,200,000 m^3

1 East Borrow area

2 West Borrow area



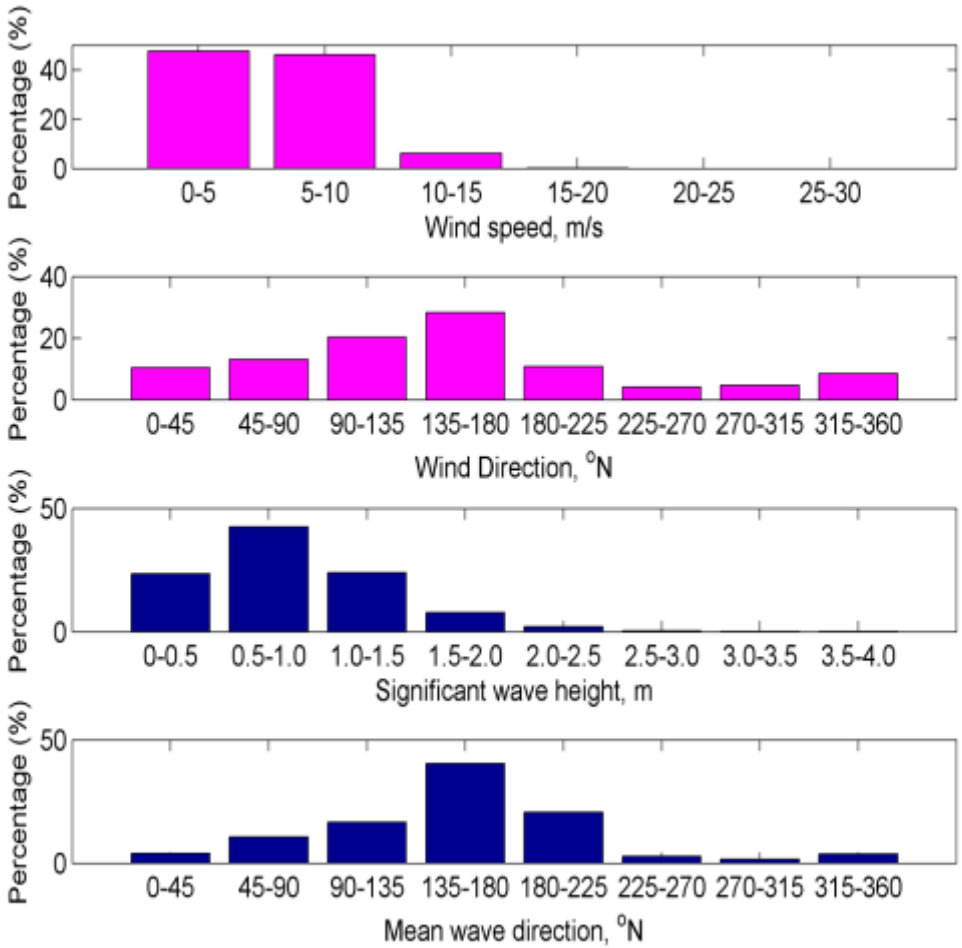
Met-Ocean Conditions: Yearly Statistics

Data compiled from NDBC Buoy 42035

Dominant Wind: Southerly

Speed: 5–10 m/s

- Sig. Wave Height: 0.5–1.5 m
- Wave Direction: E- SSW



Research Objectives

- ***In situ*** **measurement of wave/current/sediment characteristics of Sabine Bank**
- **Quantification of bottom boundary layer parameters**
- **Implementation of 3rd generation wave and current models: Effect/s of sand bank on the local hydrodynamics**
- **Quantification of changes to the hydrodynamics due to targeted sand mining**

Instrumentation & Logistics

PCADP- ADCP Array

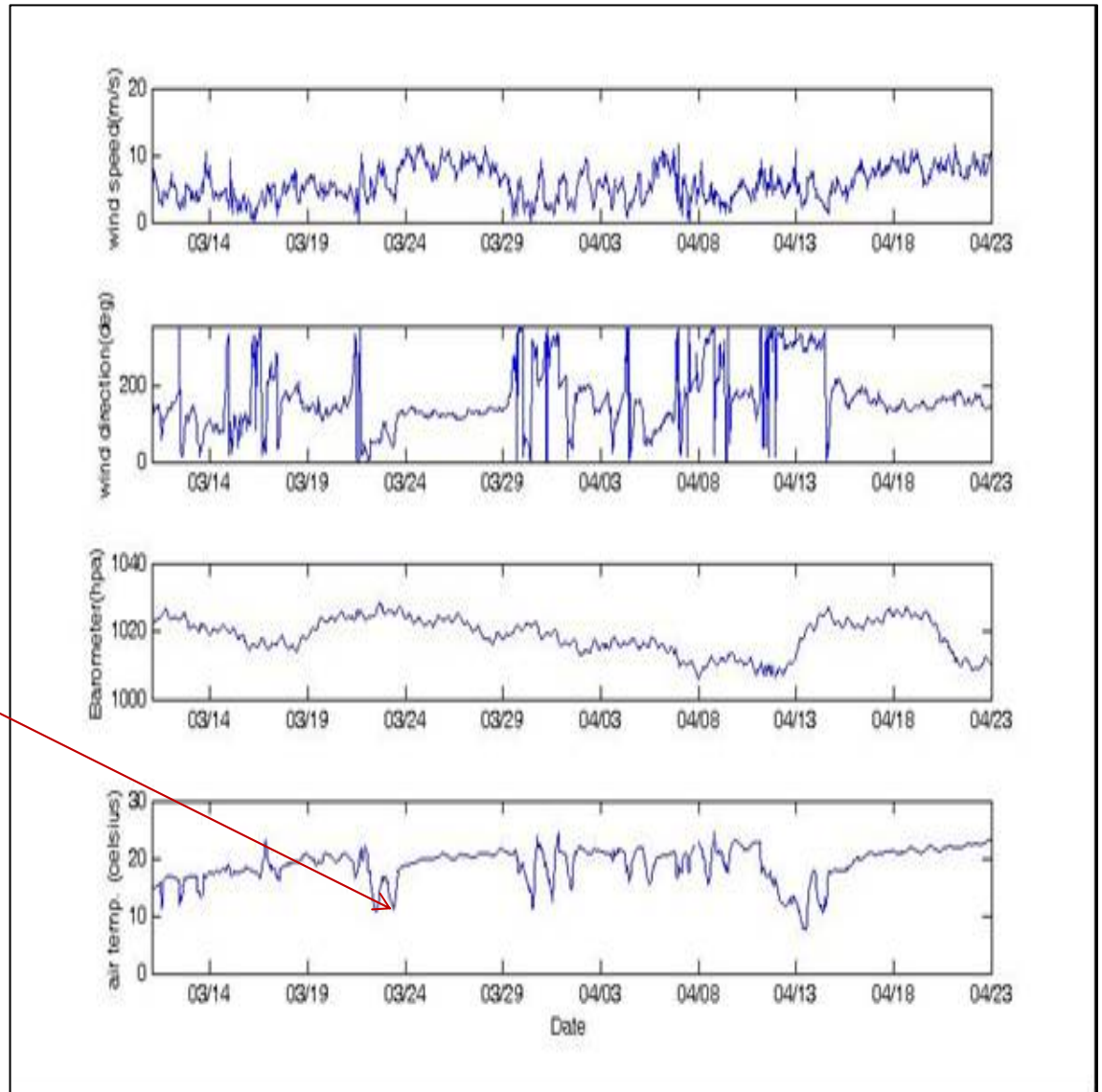
SonTek ADV

Meteorological Data

Spring 2004

<u>Cold Front Season</u> :

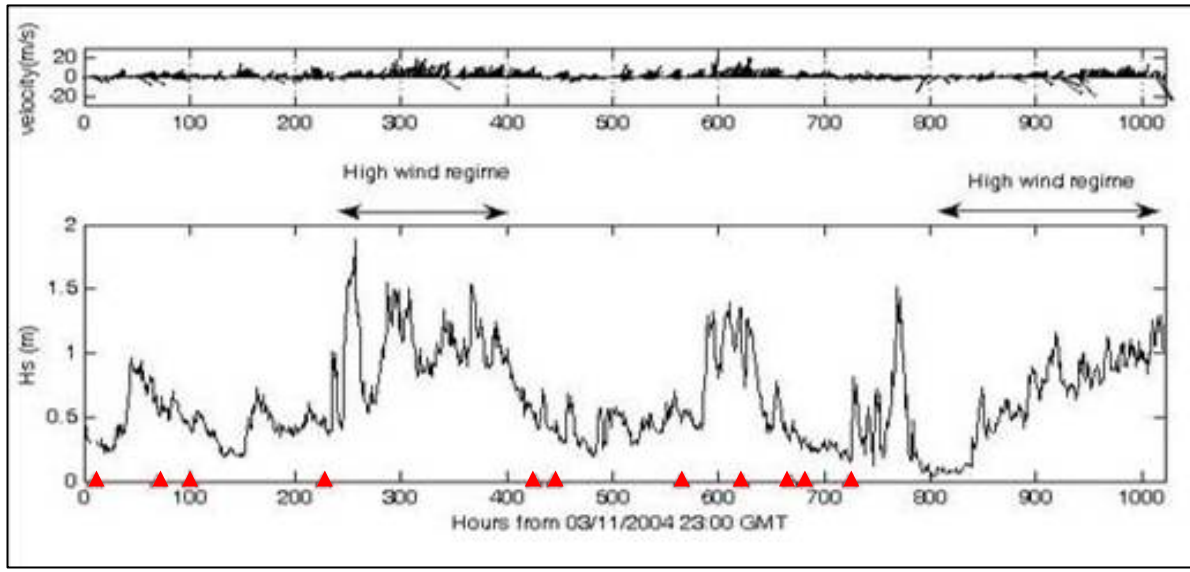
- # of storms passed during the deployment = 10
- Max. wind speed = 10 m/s
- Air temperature drops with the passage of cold fronts



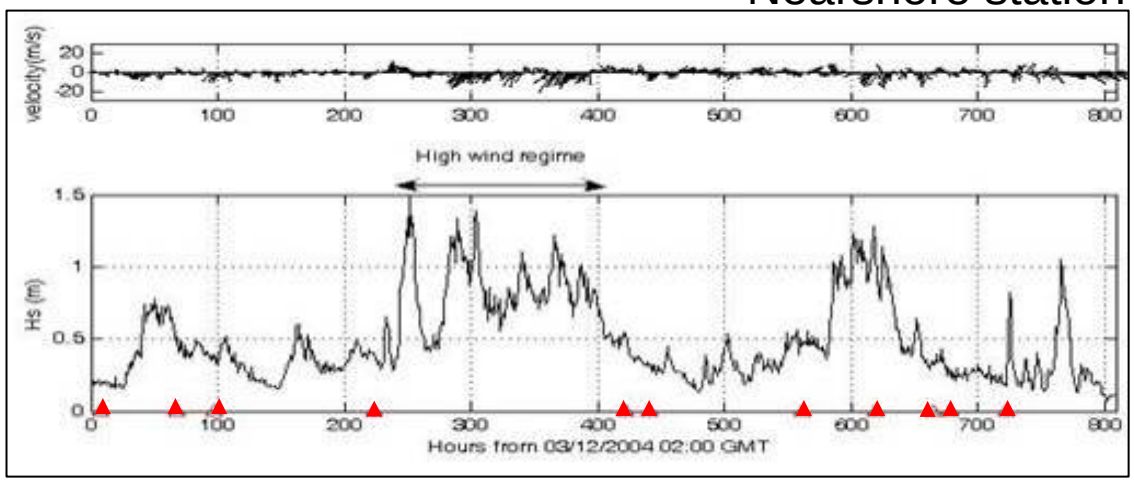
Wave/Current Data

- Wave energy attenuation: offshore to nearshore
- Onshore currents prevail along the shoal crest
- Offshore currents dominate the nearshore station

Shoal crest

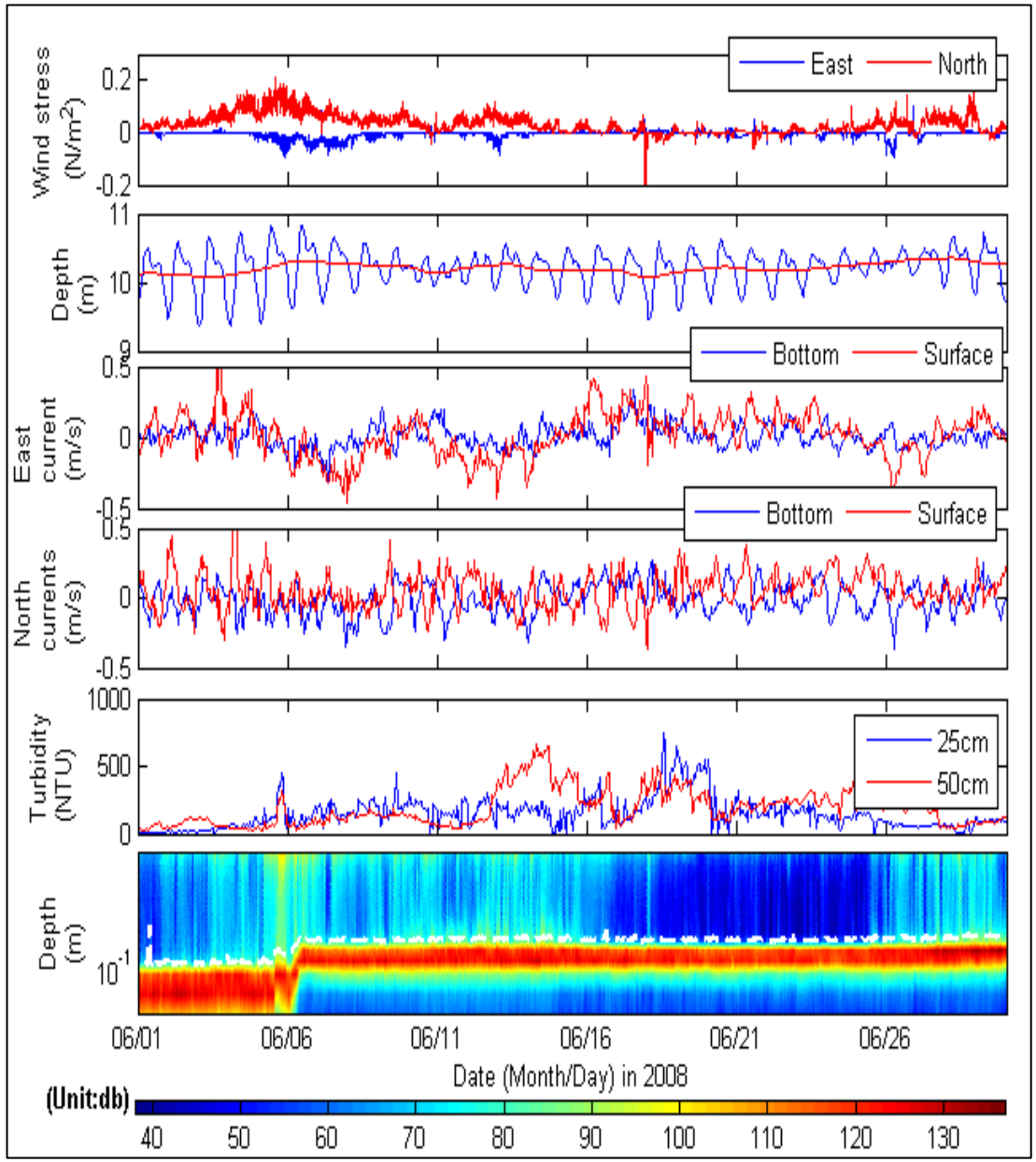


Nearshore station



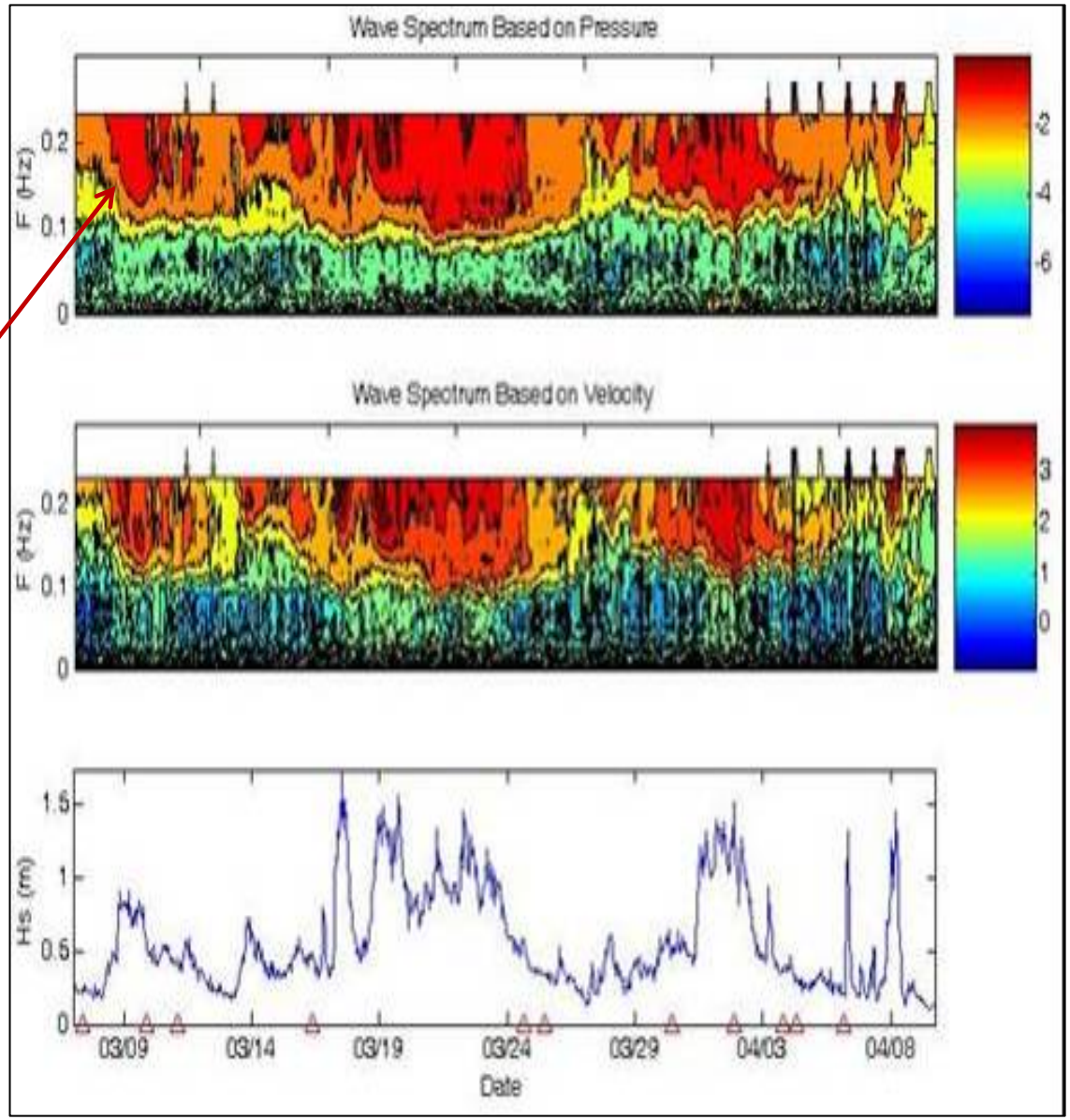
Hydrodynamics During Summer 2008

- Cross-shore wind stress dominates the summer months
- Currents over the shoal during summer: strong easterly surface flow was observed
- High SSC was occasionally observed at the upper OBS
- Heterogeneity of the shoal sediment fabric



Wave Spectral Evolution

Shifting of energy spectrum to higher frequencies during the post-frontal phase of cold front passages

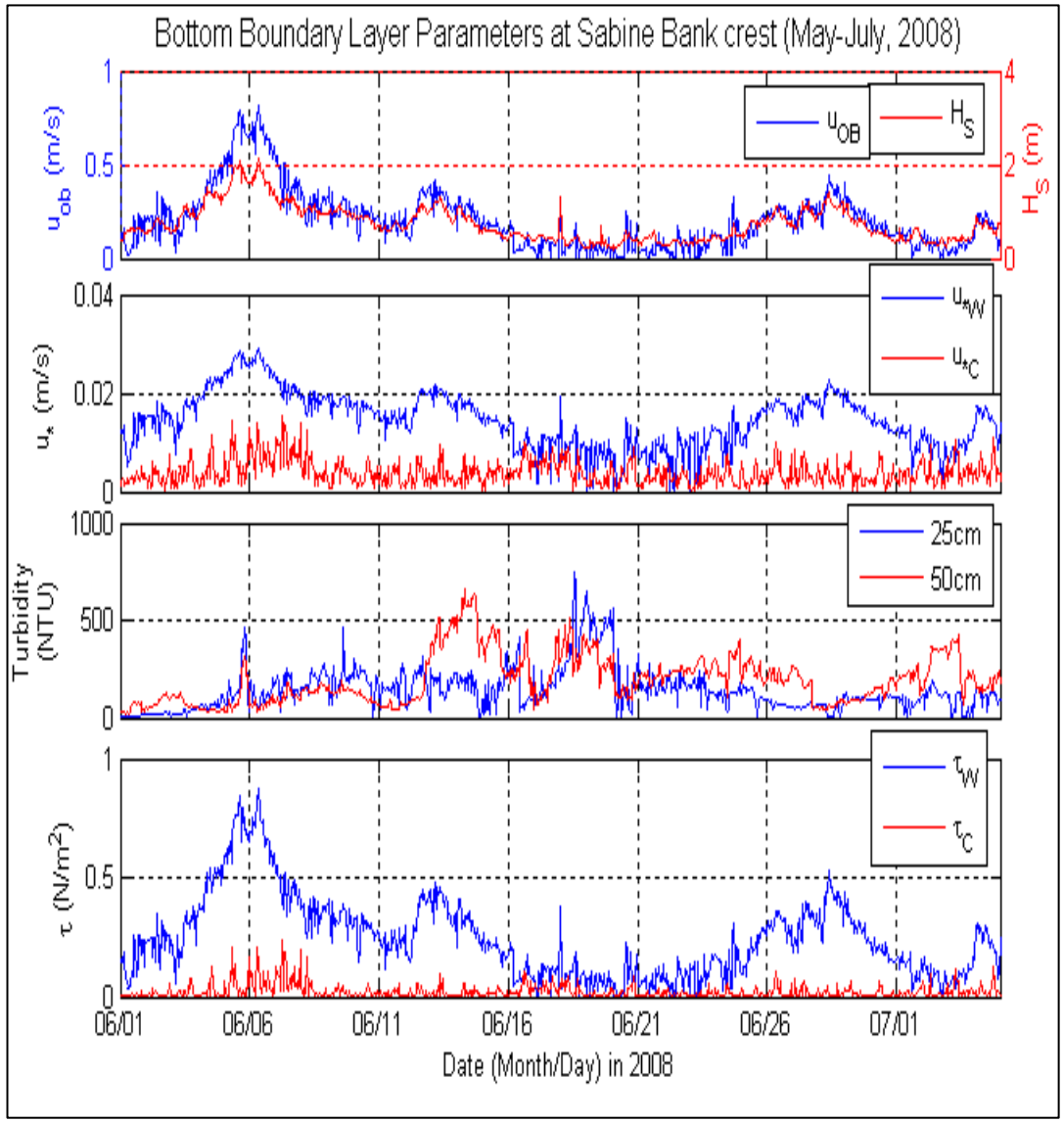


BBL Parameters: 2008

Summer 2008

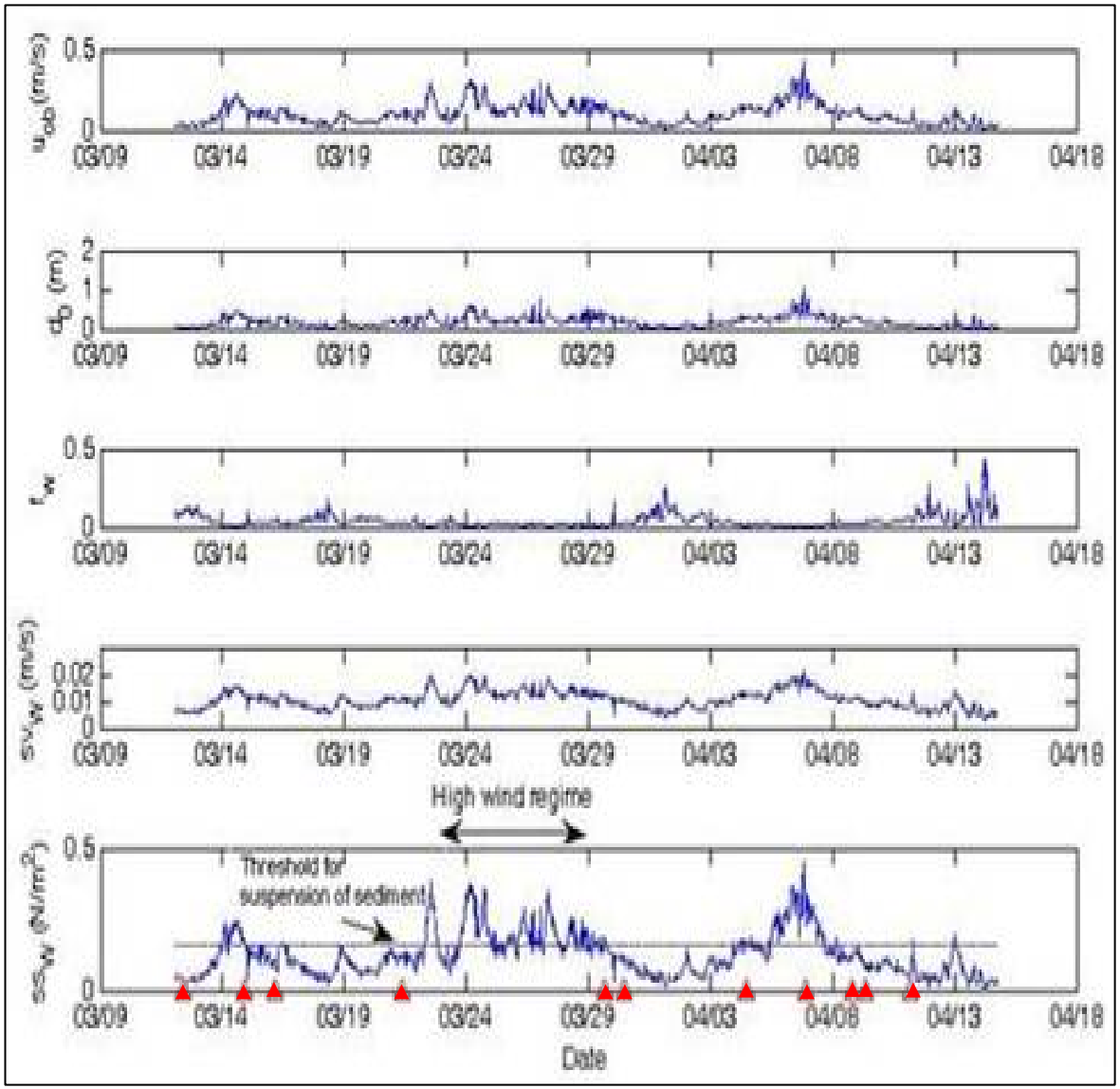
Max Hs = 2 m

- Max wave orbital velocity = 0.75 m/s
- Wave Induced bottom shear stress > current induced bottom shear stress
- High SSC concentration at 50 cm is not attributed to being wave induced



BBL Parameters: 2004

Threshold conditions for sediment re-suspension and transport exceeds during the cold front conditions



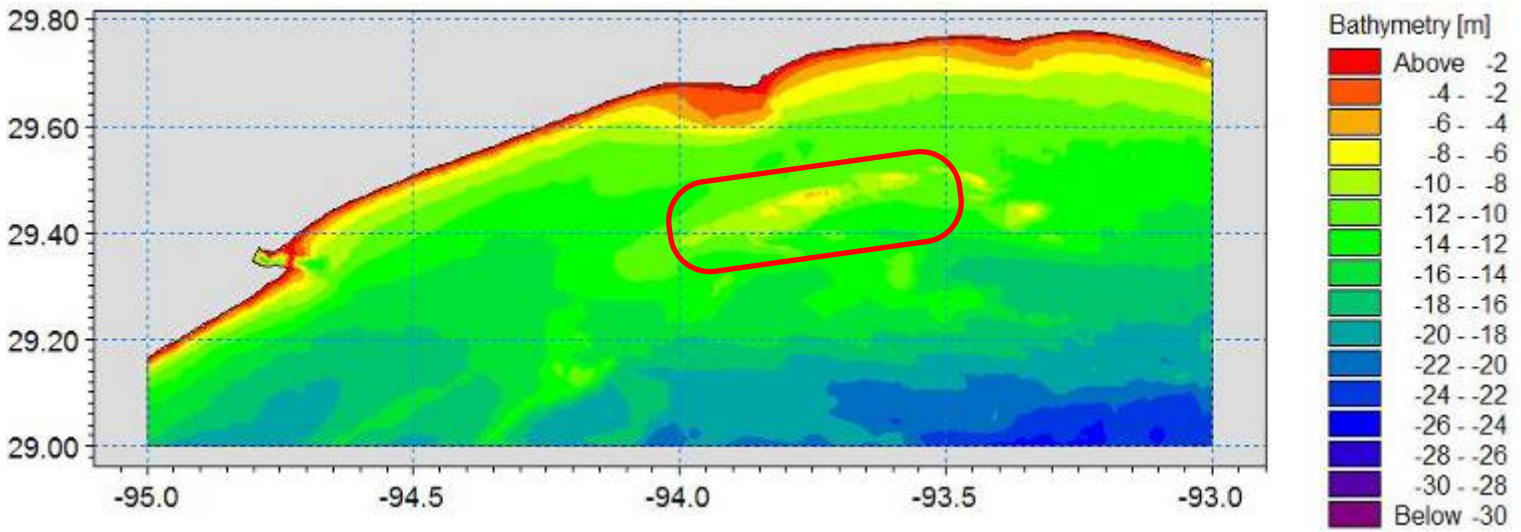
Numerical Modeling

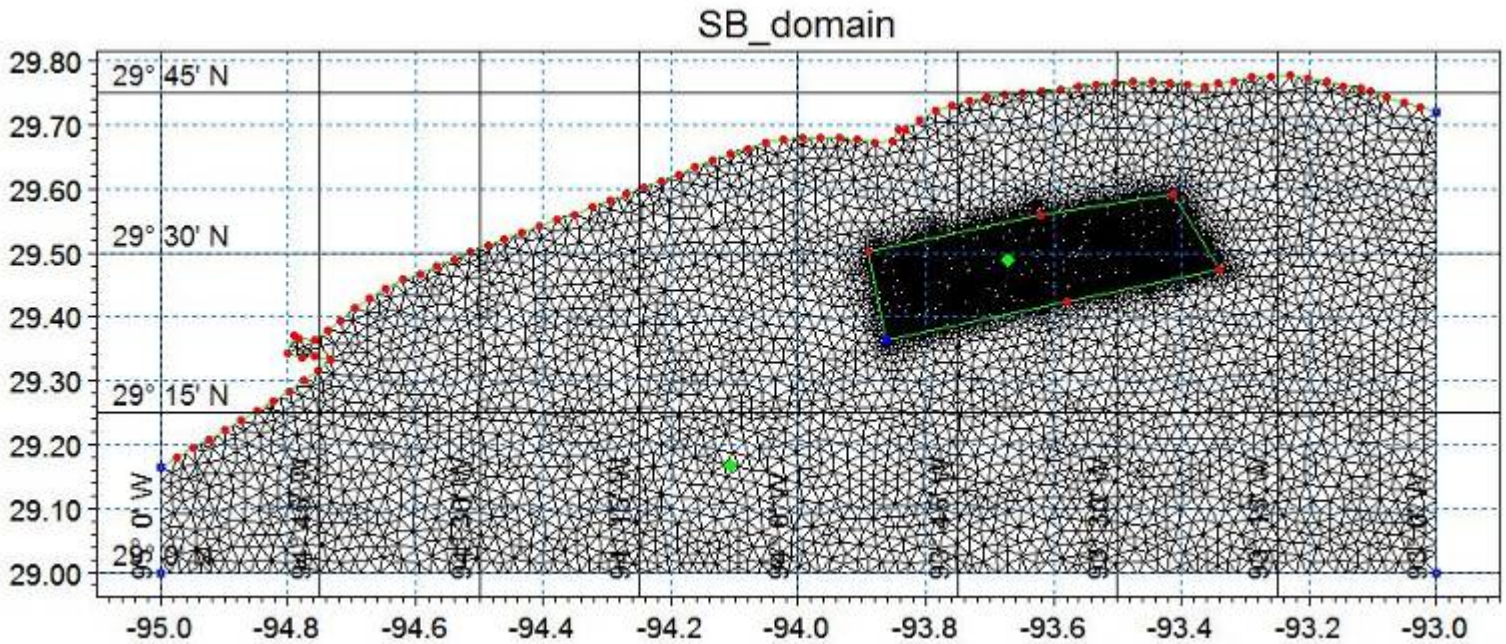
Conventional wave modeling- rectangular structured meshes

Complexities in simulating wave transformation along the coastal waters

MIKE 21 and MIKE 3: Fine flexible mesh helps resolving the wave field around the barrier islands, channels, and shallow banks

Domain Bathymetry & Grid





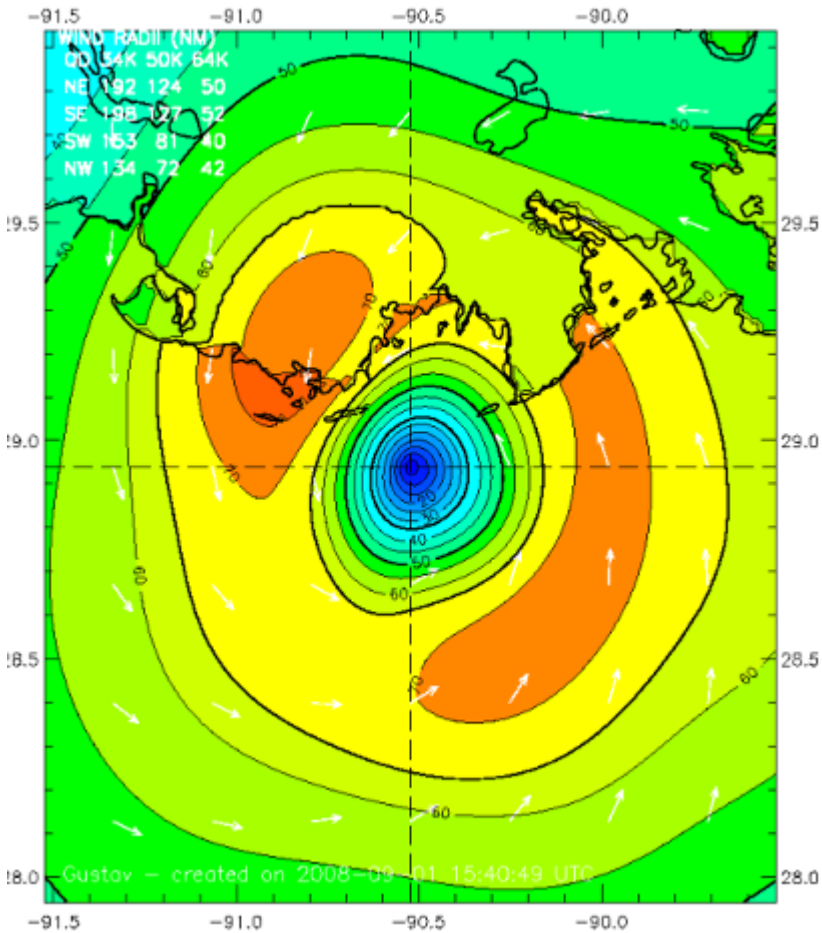
Input Parameters

Wave Modules	Input parameters	Data Sources	Output Parameters
MIKE 21 SW (Flexible Mesh) WAVE WATCH III SWAN (Flexible Mesh)	Wind (10 m above Sea Level)	NOAA (NCEP NARR) NOAA (AOML/HRD)	Bulk wave parameters Directional wave spectra Bottom orbital velocity Radiation stress
	Bathymetry	NOAA NGDC (Gridded data sets)	
	Water level	DHI Global Tide Prediction database	
	Grain Size	USGS usSEABED	
Hydrodynamic Modules			Output Parameters
MIKE 21 HD (Flexible Mesh) MIKE 3 HD (Flexible Mesh)			U & V velocity components for multiple layers in the water column Water level fluctuations Volume transport

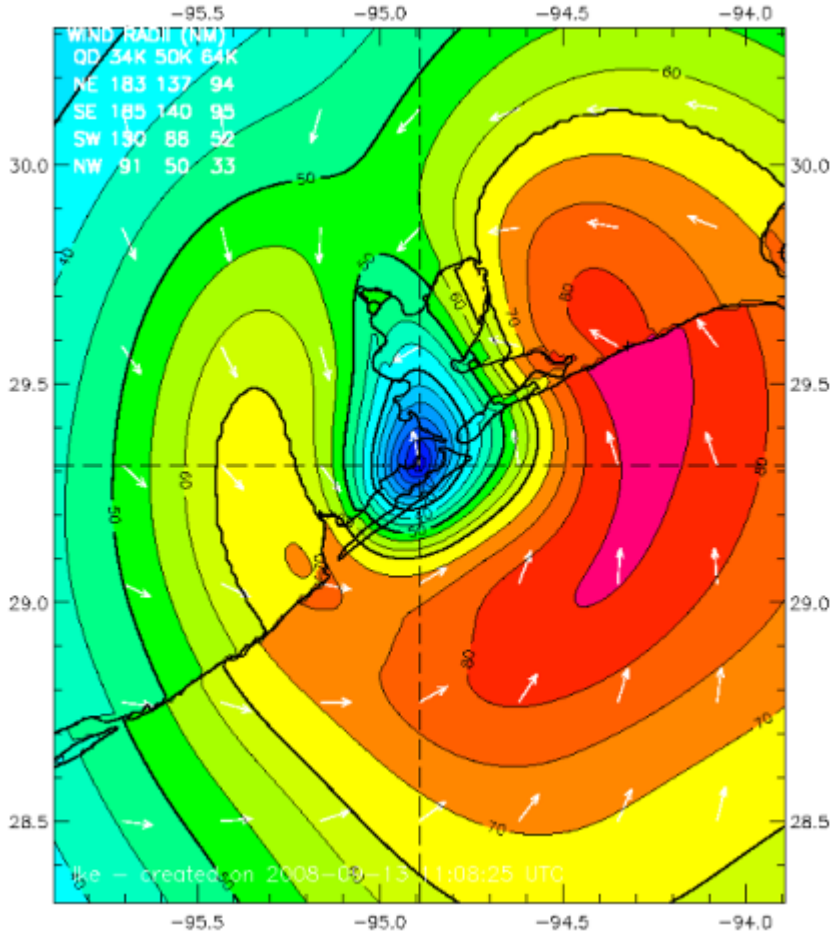
Wind Data

AOML/HRD H* wind (Resolution ~6 km) is blended with NARR/NOAA archived wind (Resolution ~ 32 km)

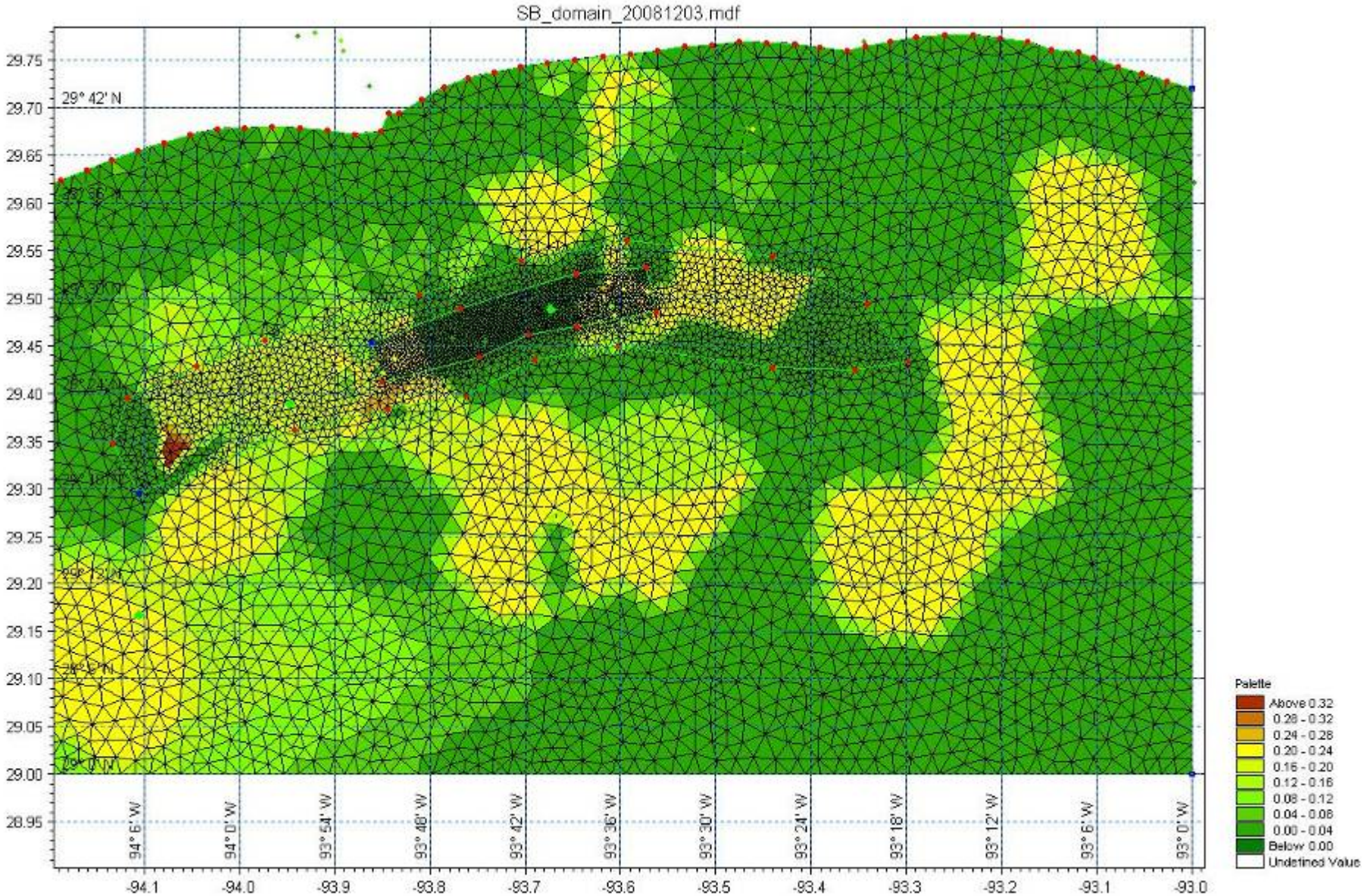
Hurricane Gustav at 1330 UTC, 01 Sept. 2008



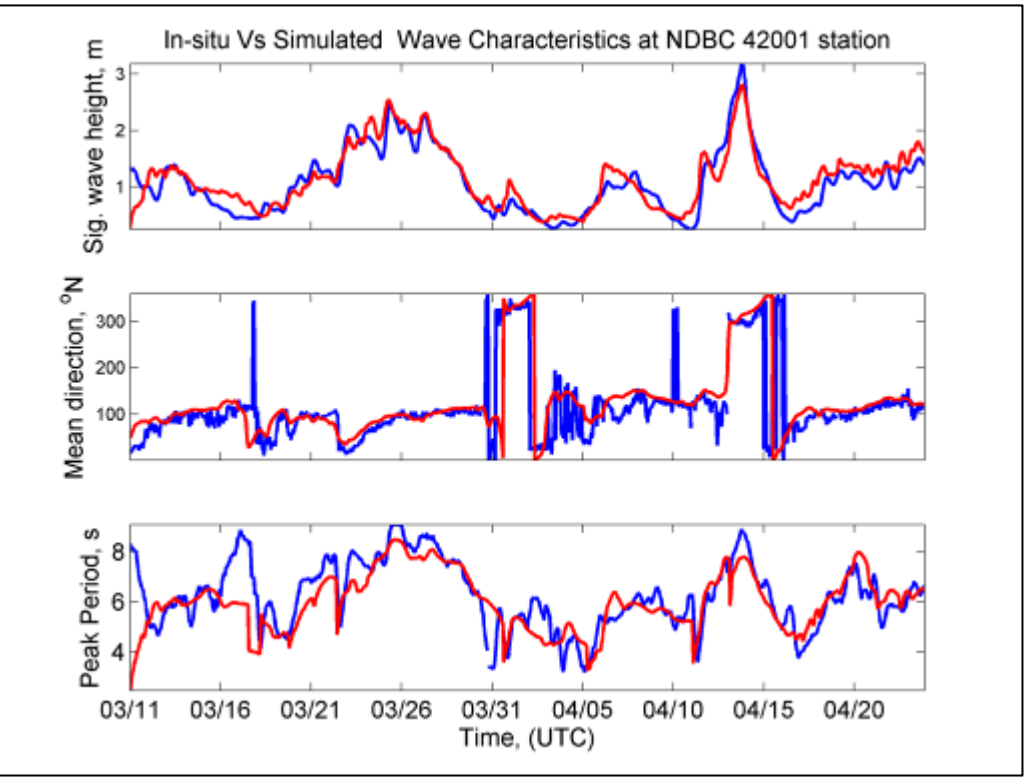
Hurricane IKE at 0730 UTC, 13 Sept. 2008

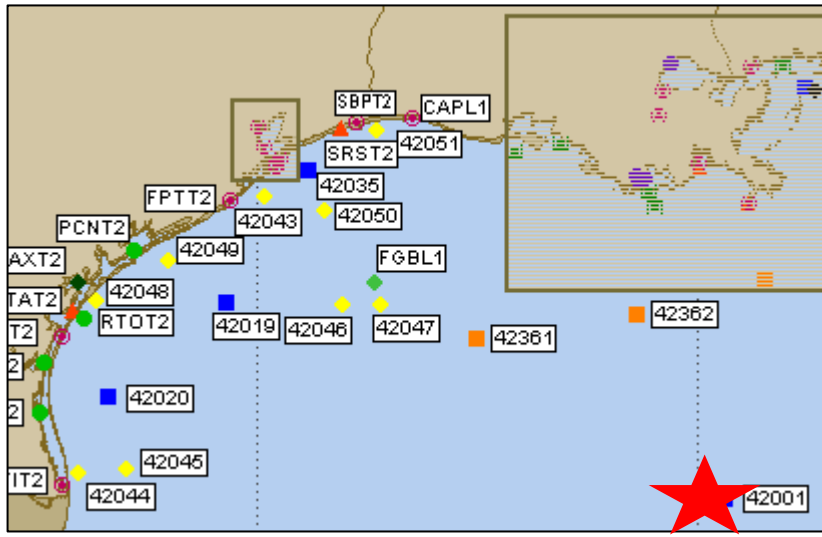


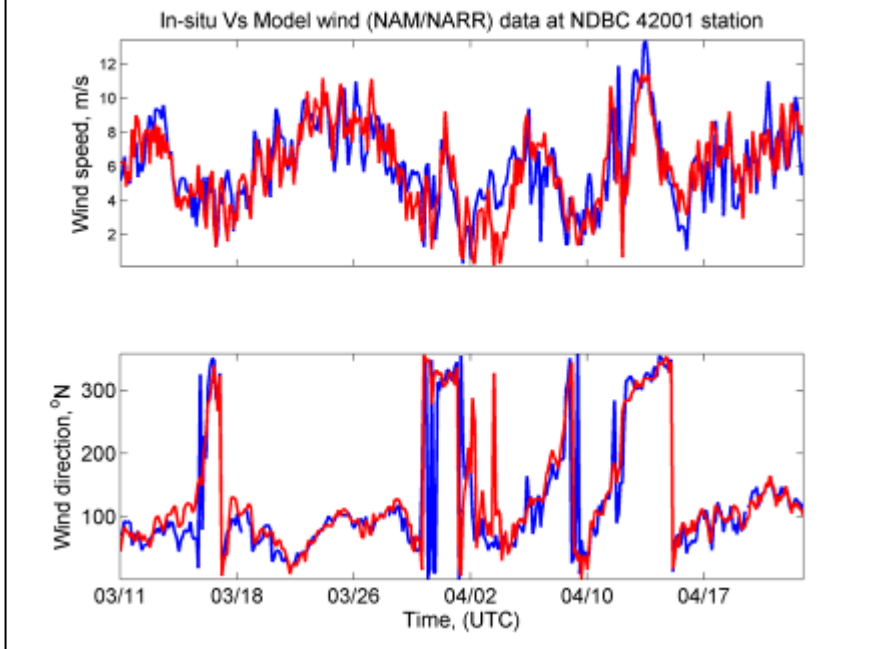
Shoal Sediment Distribution



Model Validation

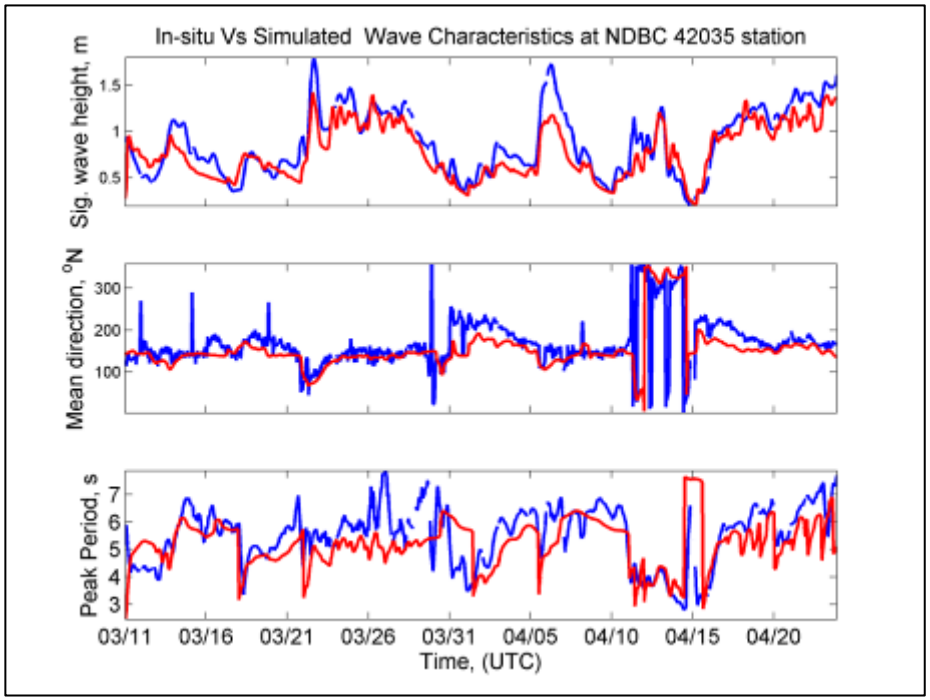


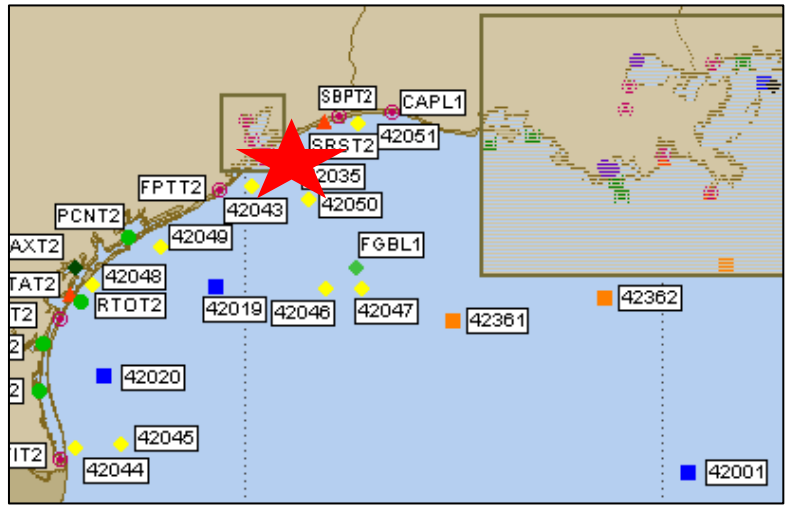


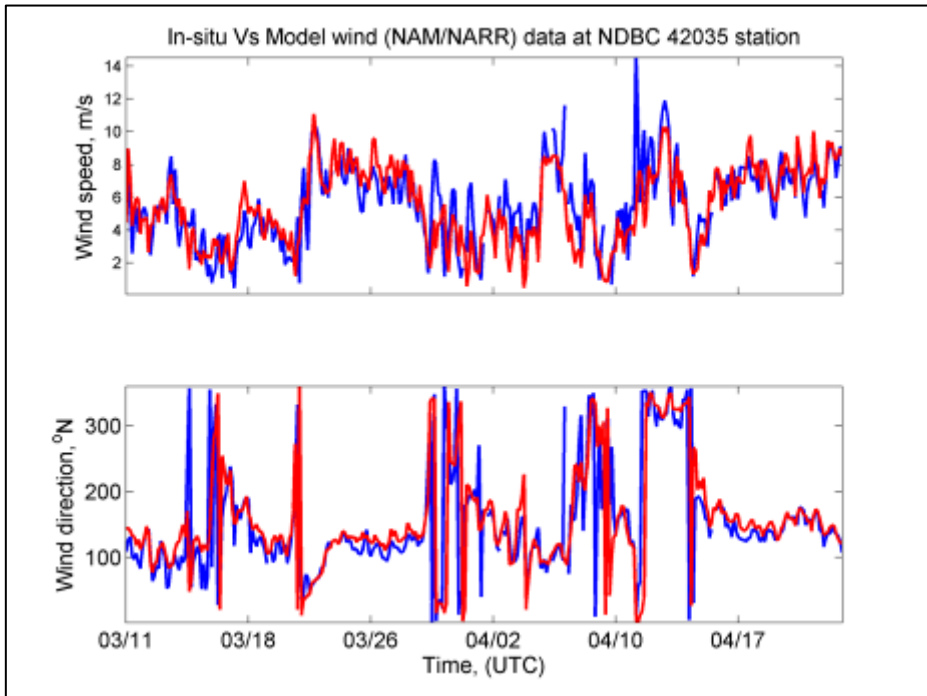


NDBC 42001 Station

Model Validation (continued)

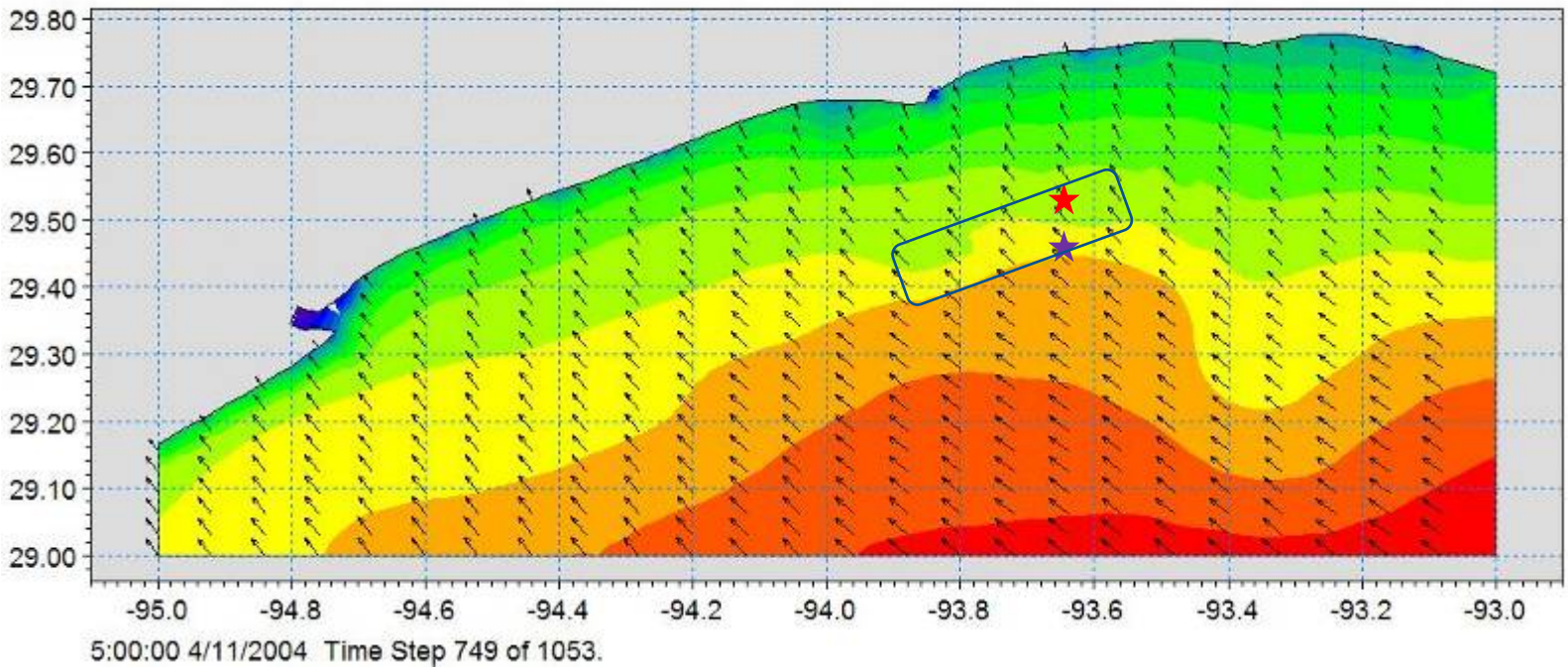


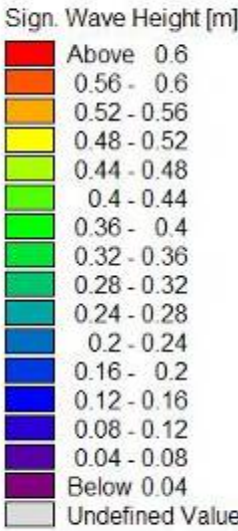


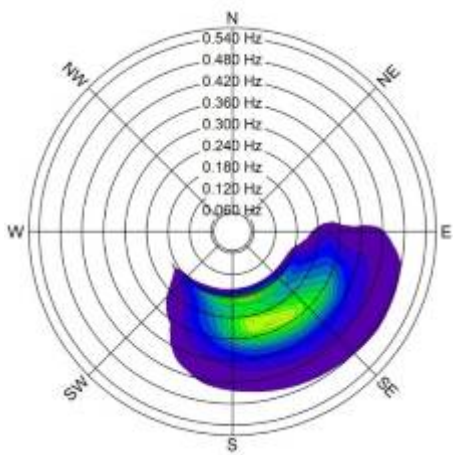


NDBC 42035, off Galveston Bay

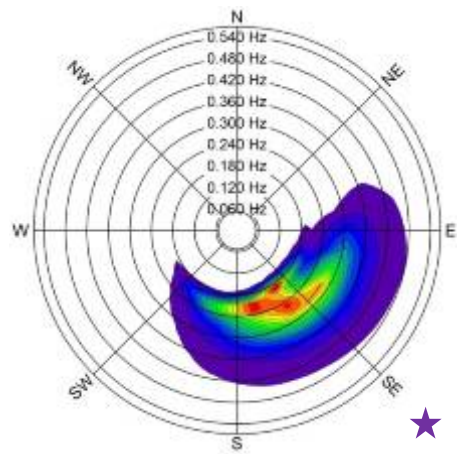
Model Results: Spectral Evolution





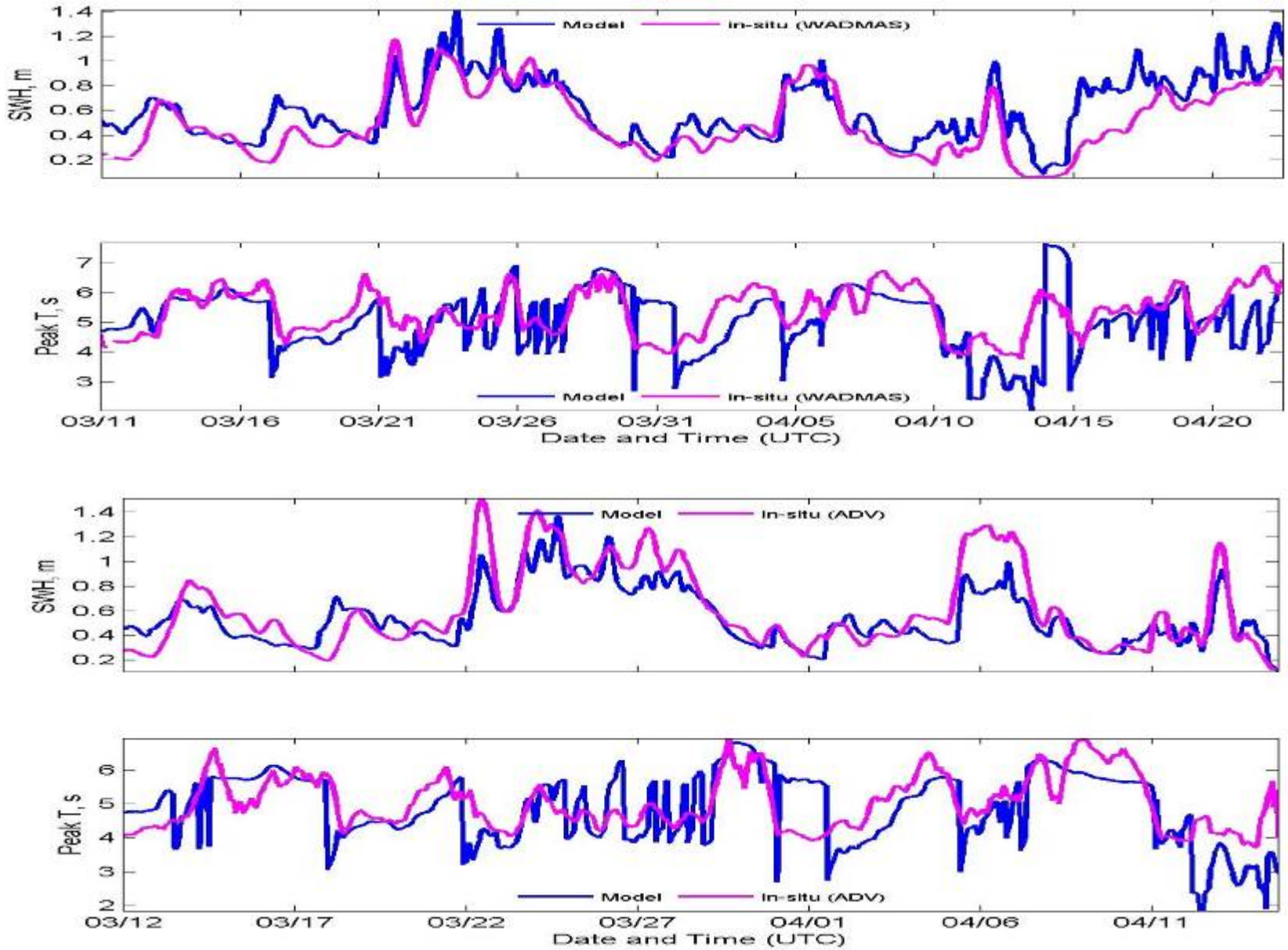


Nearshore



Offshore

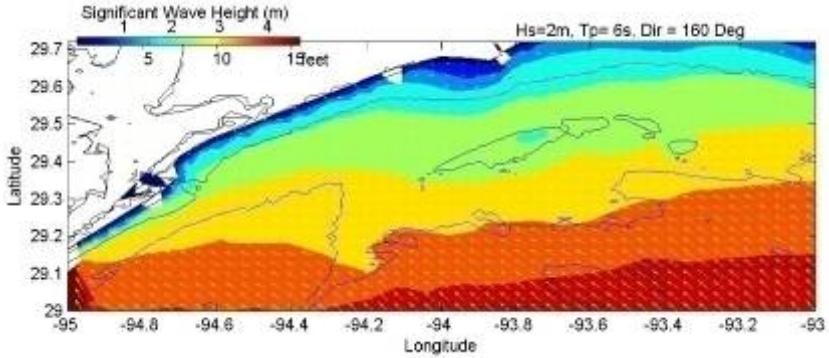
Model Results (continued)



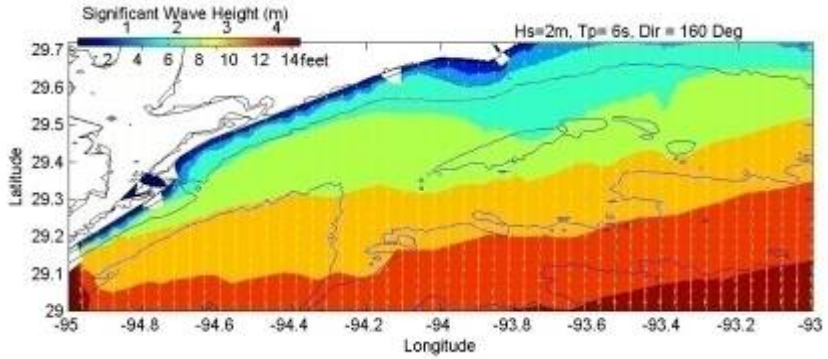
Wave Transformation over the Shoal

Hs= 6m, T_p= 11s, Direction = 160 Degrees (Hurricane Conditions)

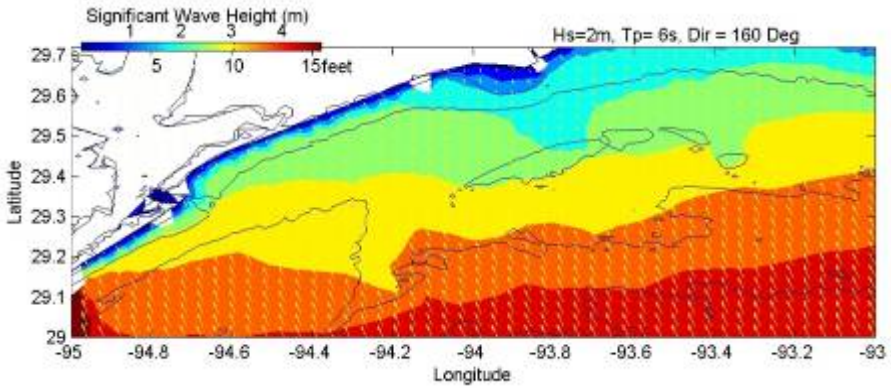
1. NE wind , 15 m/s



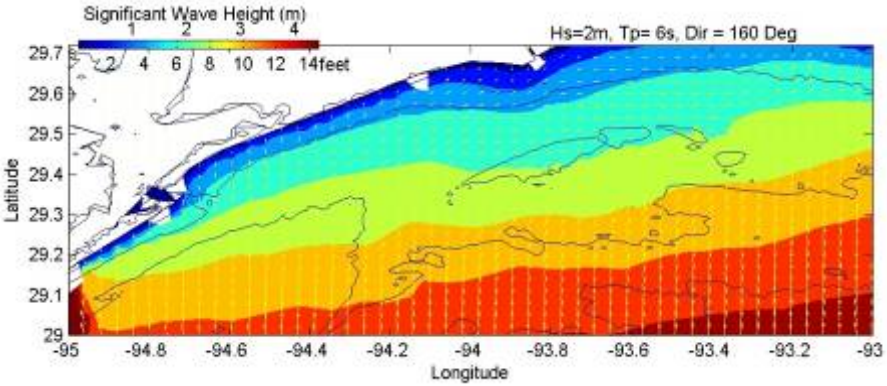
3. SW wind, 15 m/s



2. SE wind, 15m/s



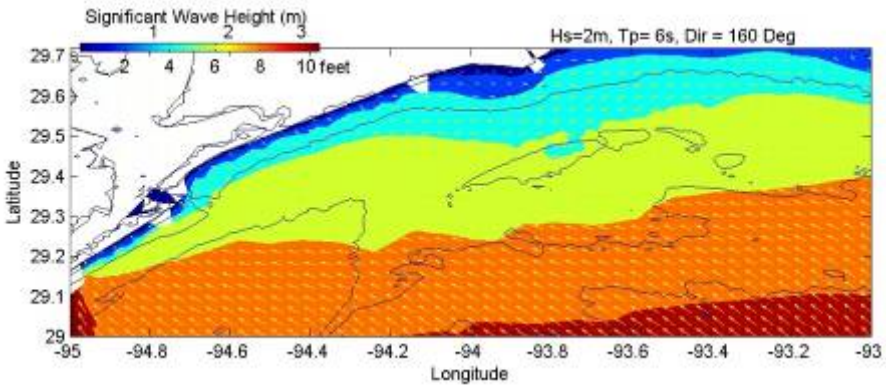
4. NW wind, 15 m/s



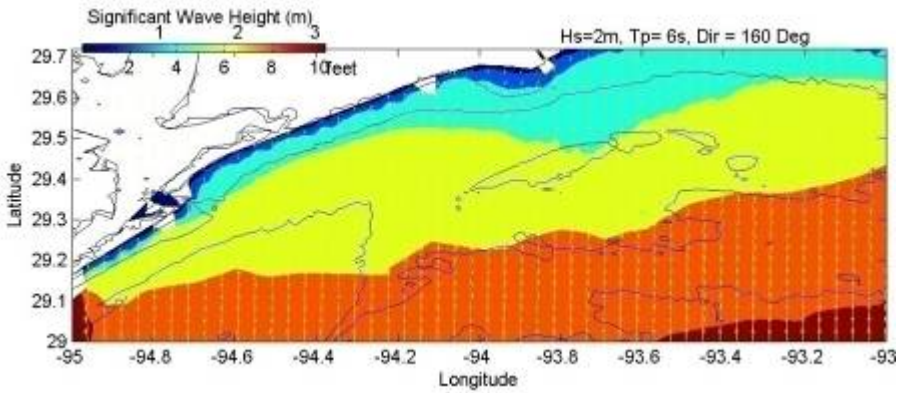
Wave Transformation (continued)

Hs= 4m, T_p= 9s, Direction = 160 Degrees (Tropical Storm Conditions)

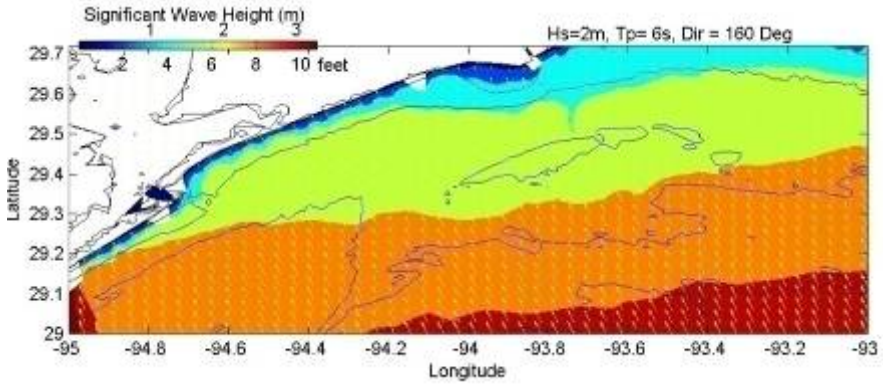
1. NE wind , 12 m/s



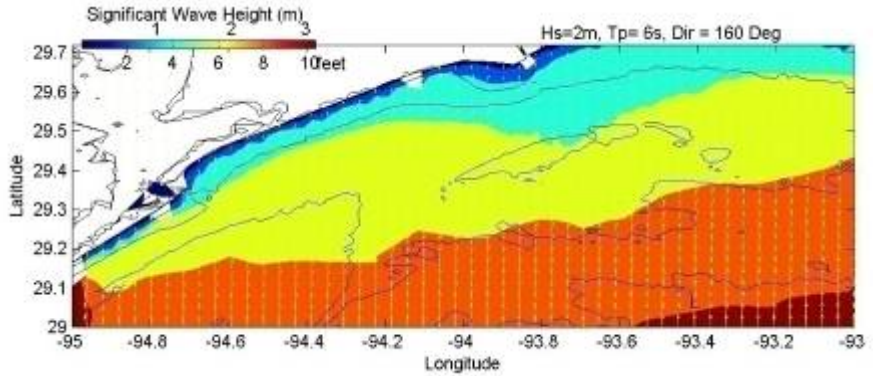
3. SW wind, 12 m/s



2. SE wind, 12m/s



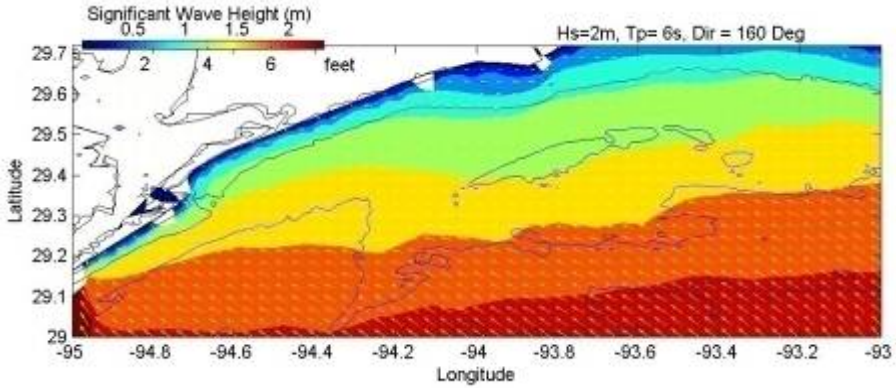
4. NW wind, 12 m/s



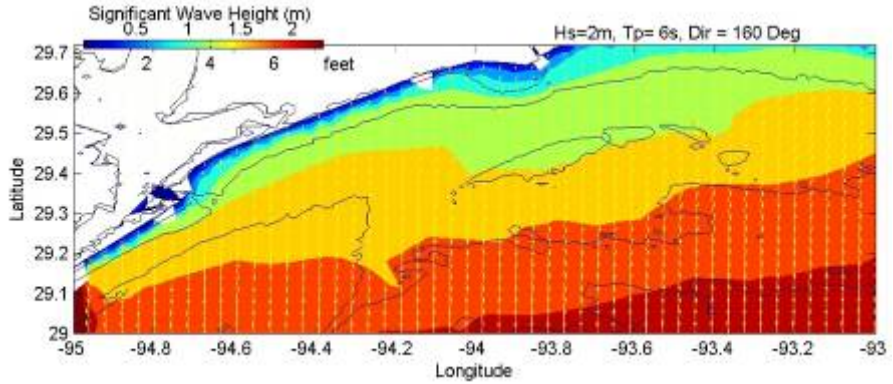
Wave Transformation (continued)

Hs= 3m, T_p= 7s, Direction = 160 Degrees (Extra Tropical Storm Conditions)

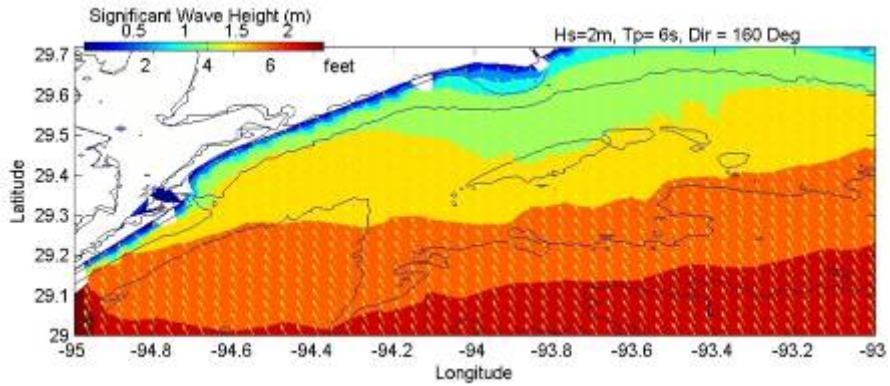
1. NE wind , 10m/s



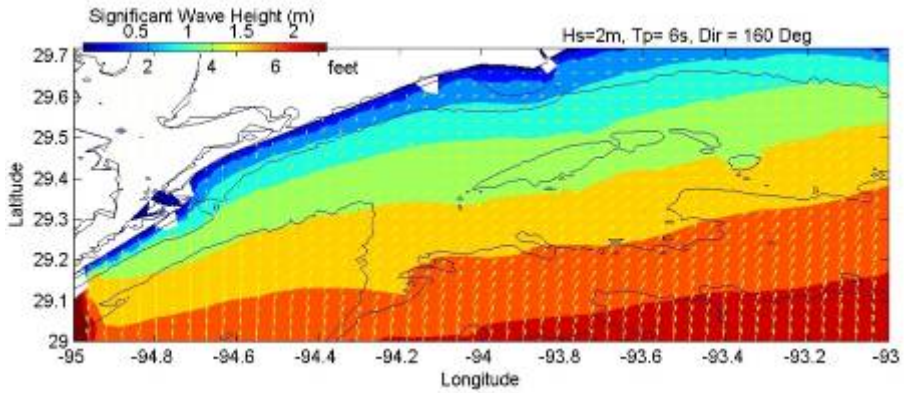
3. SW wind, 10 m/s



2. SE wind, 10m/s



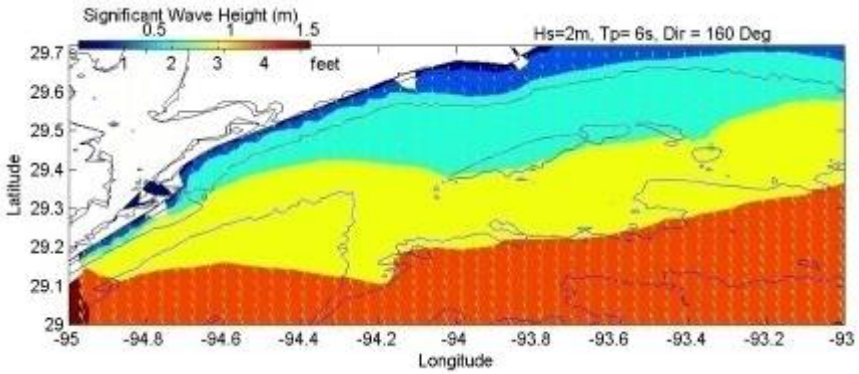
4. NW wind, 10 m/s



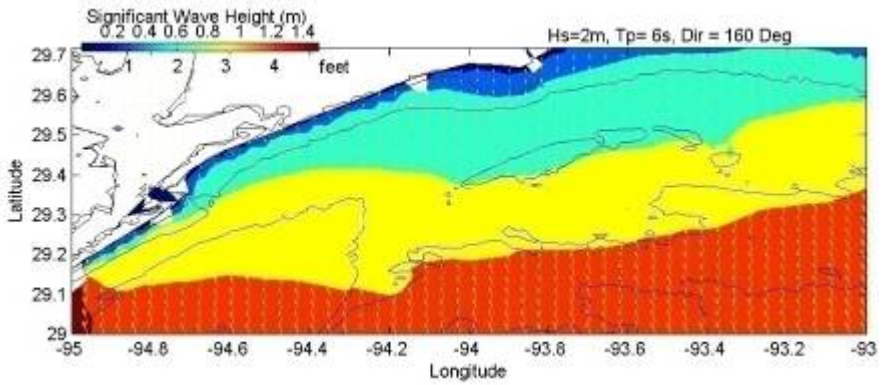
Wave Transformation (continued)

Hs= 2m, T_p= 6s, Direction = 160 Degrees

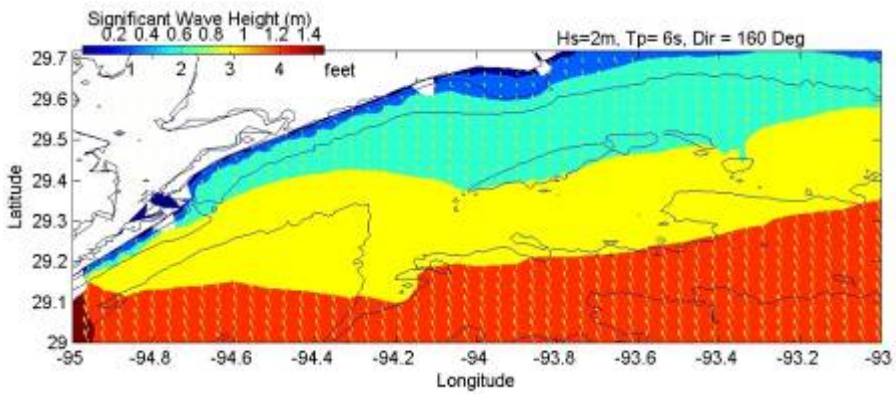
1. NE wind , 5m/s



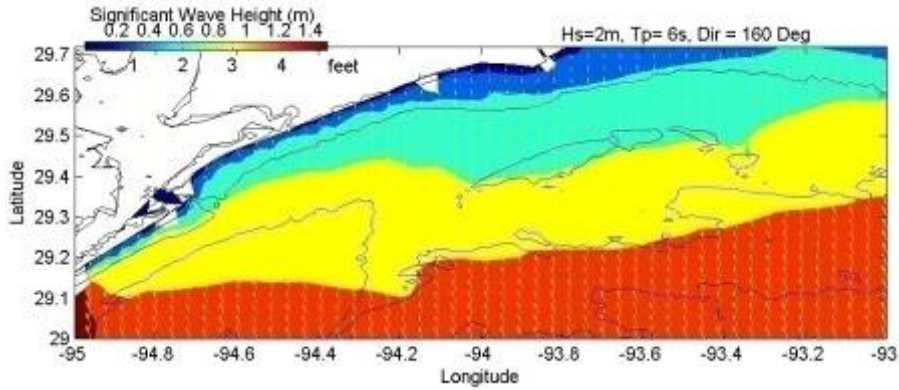
3. SW wind, 5 m/s



2. SE wind, 5m/s



4. NW wind, 5 m/s

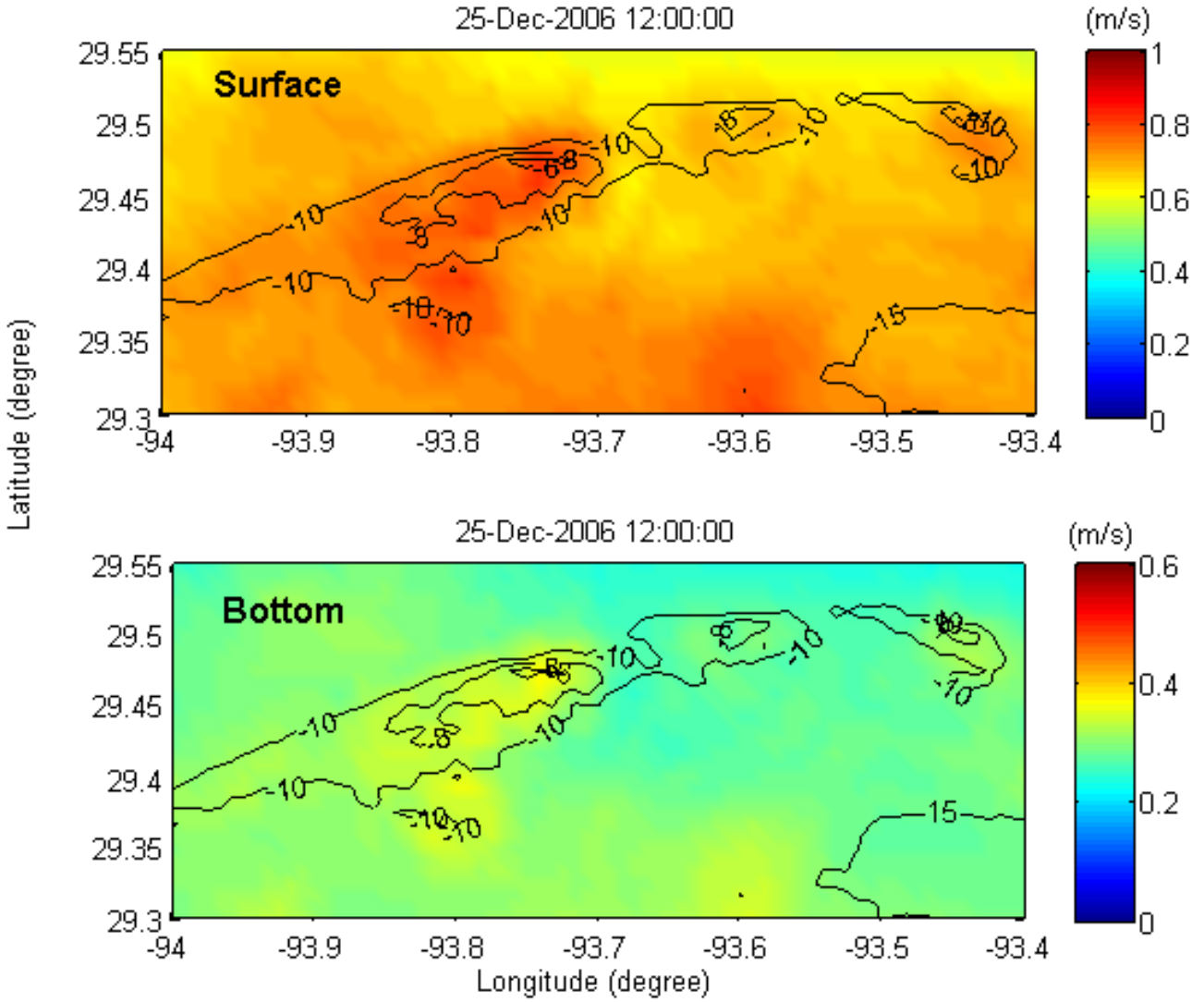


Hydrodynamic Modeling (MIKE 3 HD)

- Simulation period
  December 2006
- Barotropic mode
- Forcing functions:
  Tide and NARR wind fields

RESULTS:

- The current fields are stronger around the shoal
- Bottom currents during winter can transport sediments

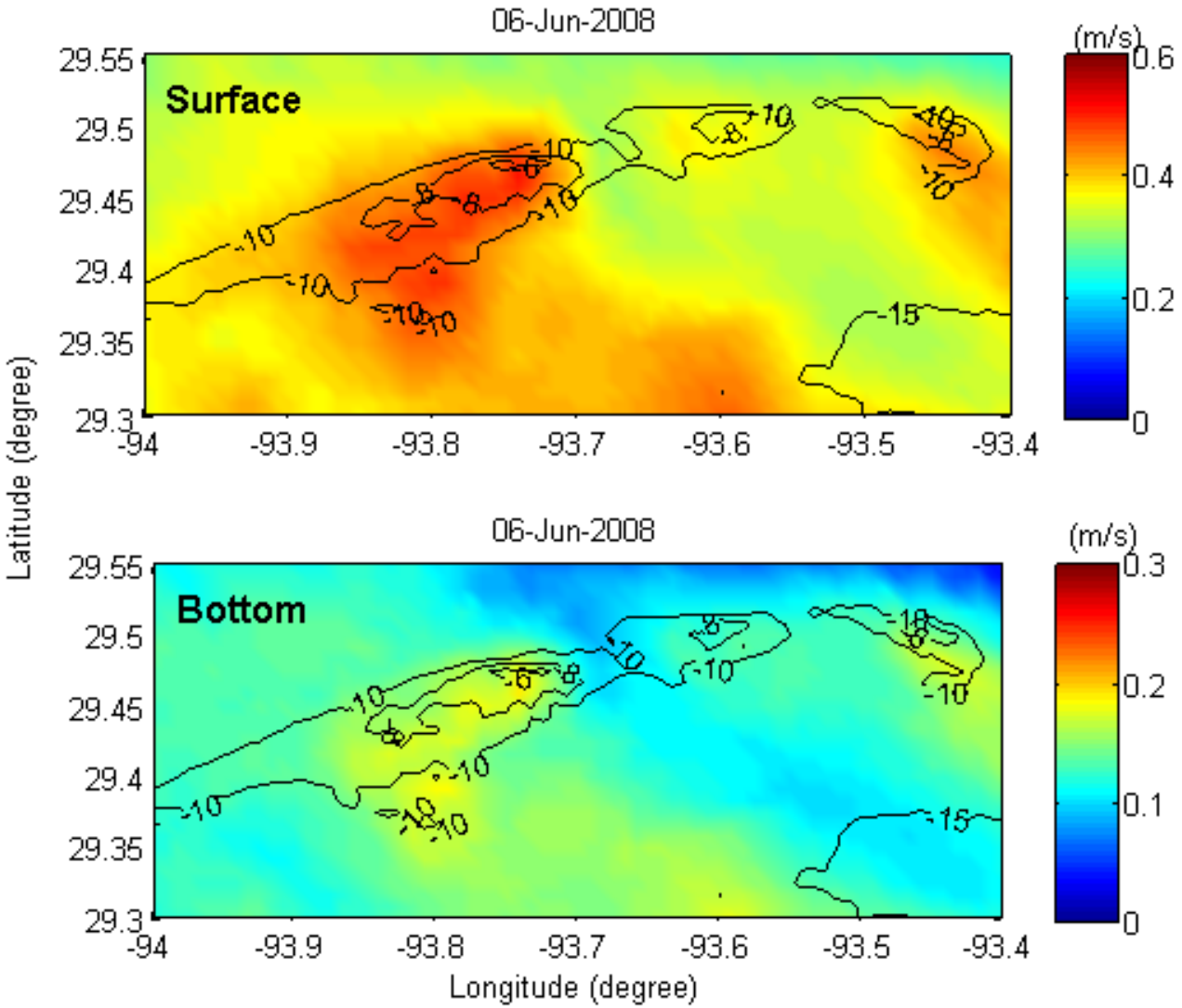


Hydrodynamic Modeling (continued)

- Simulation period
  May–June 2008
- Barotropic mode
- Forcing functions:
  Tide and NARR wind fields

RESULTS:

- The summer current fields are stronger around the shoal
- Bottom currents are feeble

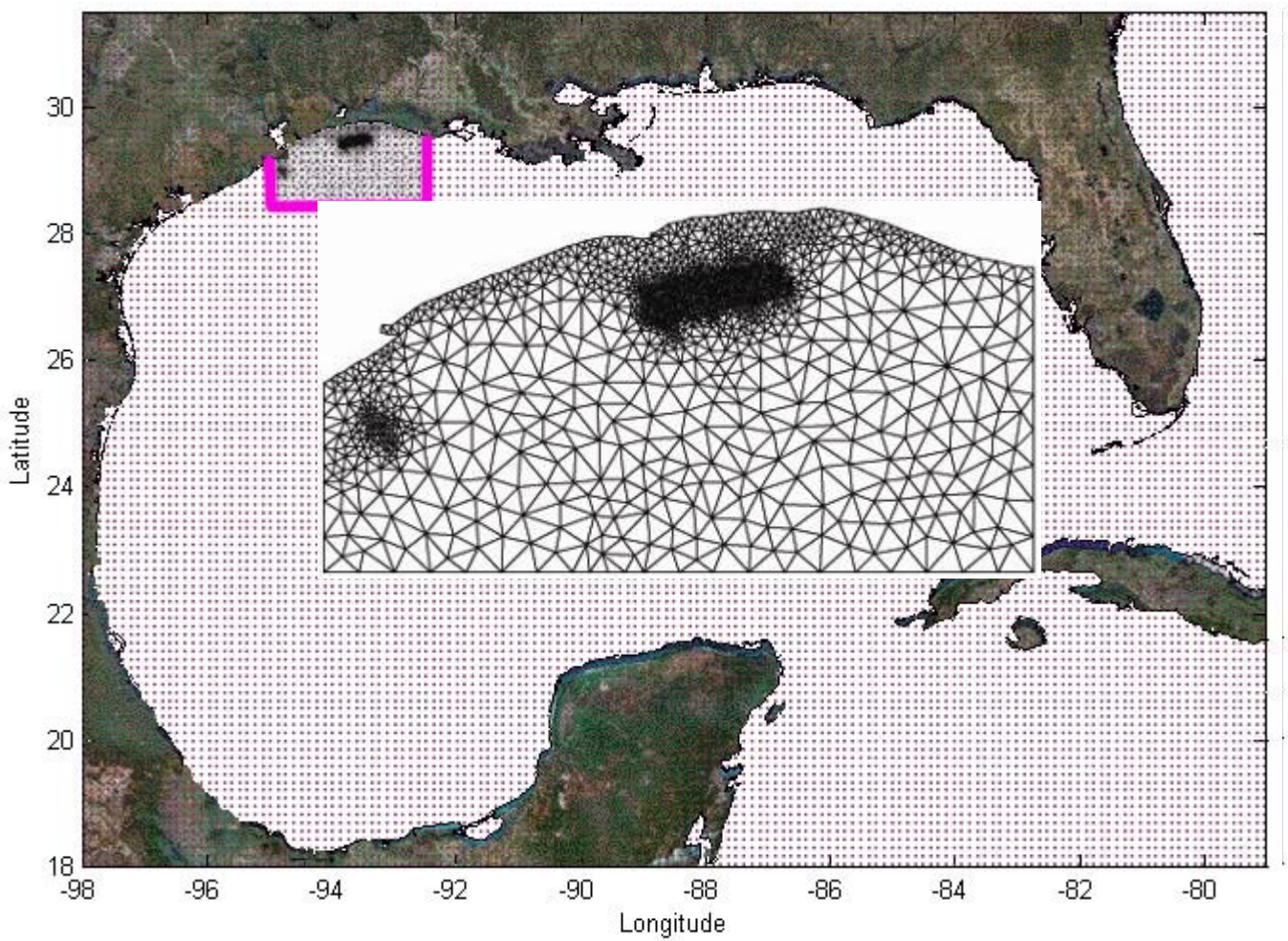


Hurricane Simulation Using WAVEWATCH III and SWAN

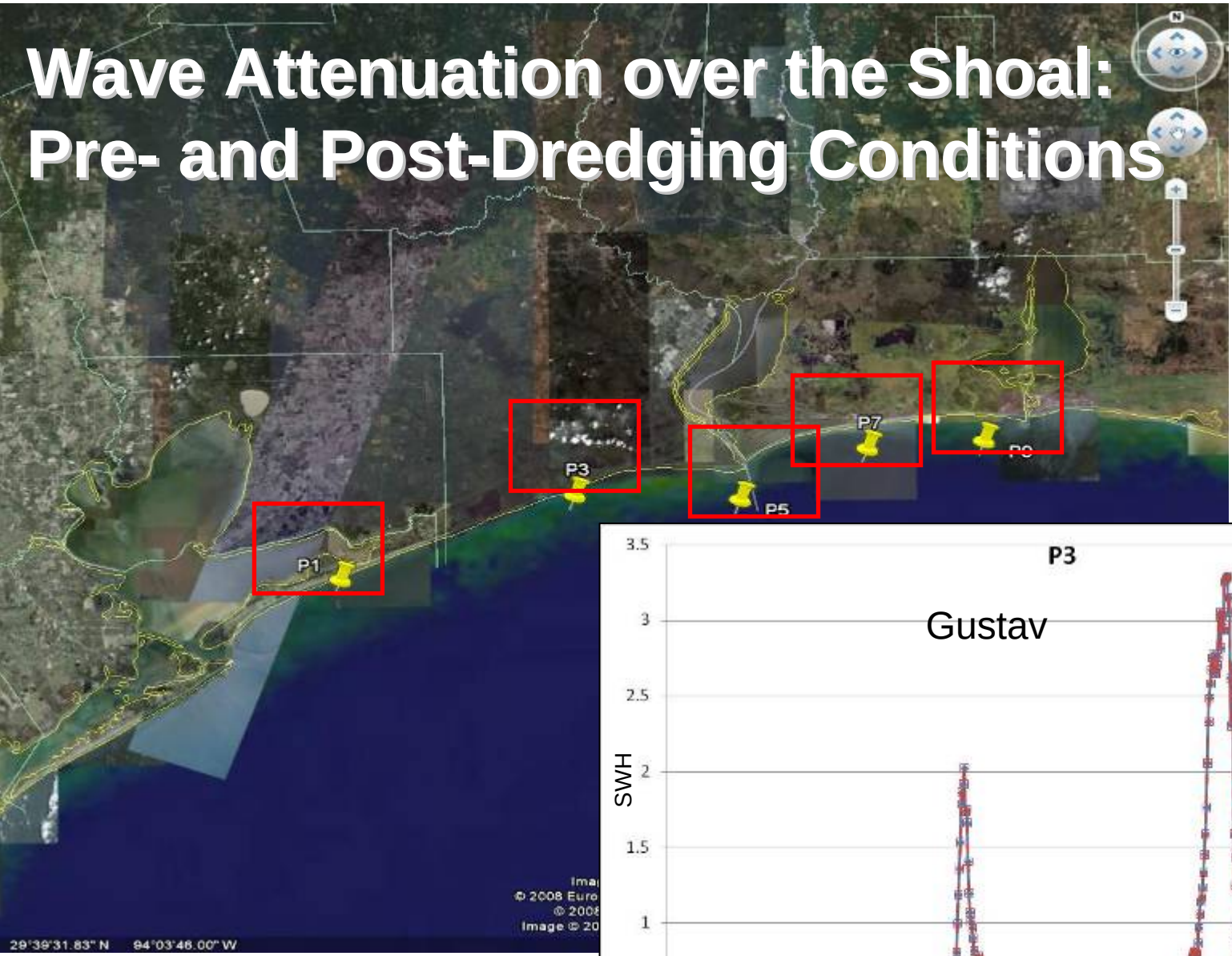
Domain

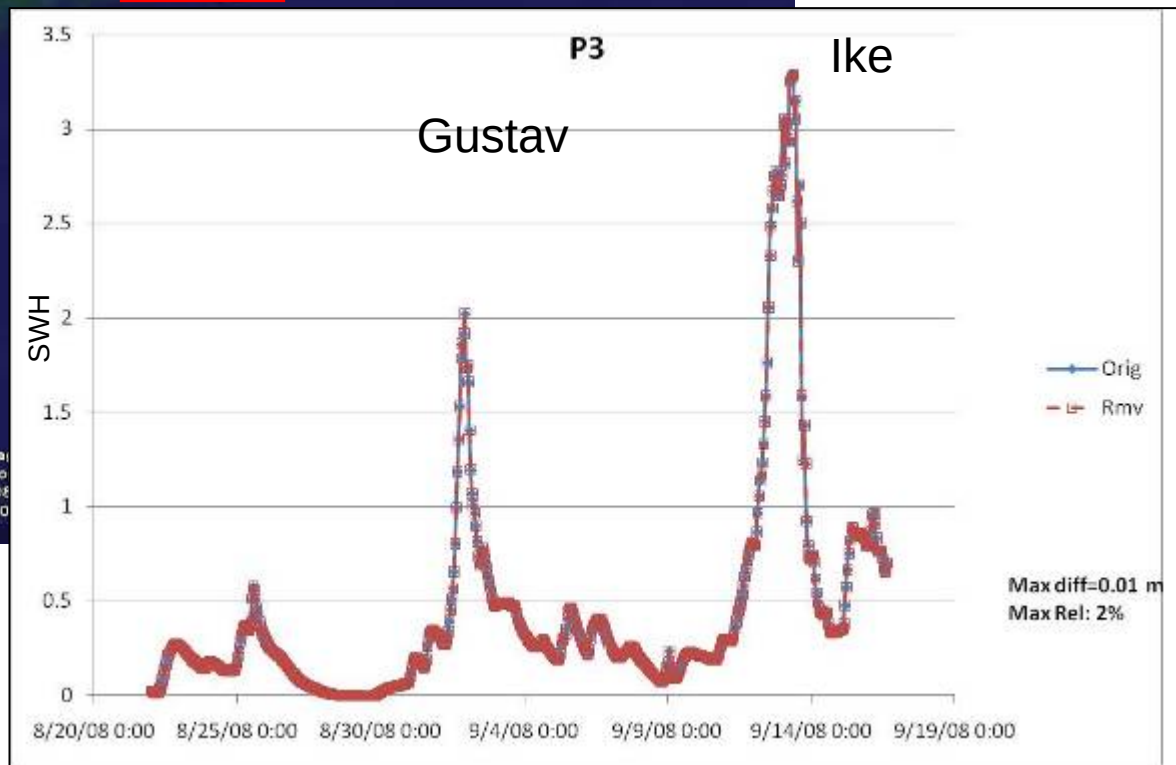
Grid

and Mesh



Wave Attenuation over the Shoal: Pre- and Post-Dredging Conditions





Relevance of the Study

- Extended monitoring of the wave/current/ sediment characteristics of the shoal
- Estimated the bottom boundary layer dynamics associated with different energetic conditions
- Implemented of a suite of 3rd generation wave and hydrodynamic models for simulating the complex wave and current transformation over the shoal
- Evaluated the implications of sand mining, especially in the context of the targeted mining

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