Session 16

Don Slinn

University of Florida

ADCIRC Hurricane Forecasting Model

Topic Description

An existing model of the St. Johns River is forced with freshwater river inflows, astronomic tides, pressure variations, and wind stresses. Results from a 122-day simulation show that the effects of the offshore and local meteorological forcings far outweigh the influence from freshwater river inflows with respect to an accurate prediction of the water surface elevations for the St. Johns River. In addition, a model of the Loxahatchee River estuary displays the impact of tidal flats and the Atlantic Intracoastal Waterway (AIW) on the tidal behavior occurring within the Loxahatchee River estuary, on a water-level and velocity-residual basis. The overall goal seeks to describe the AIW and the Indian River lagoon in an effort to develop a tidal model for the entire east coast of Florida, providing a hydrodynamic connection between the St. Johns River and the Loxahatchee River estuary. This research will lead to furthered scientific understanding of tidal circulation through the AIW, extending into the South Atlantic Bight.

Speaker Biography

Dr. Slinn teaches Civil and Coastal Engineering at the University of Florida. He specializes in computer modeling of coastal processes. He teaches classes in Open Channel Hydraulics, Fluid Dynamics, Sediment transport and beach erosion, Wave mechanics, and Computer modeling techniques for describing natural systems. In recent years a lot of his work has centered around prediciting hurricane impacts on the coast.

ADCIRC Hurricane Forecasting Model

Don Slinn
and Scott Hagen

Civil and Coastal Engineering
University of Florida

Civil and Environmental Engineering
University of Central Florida

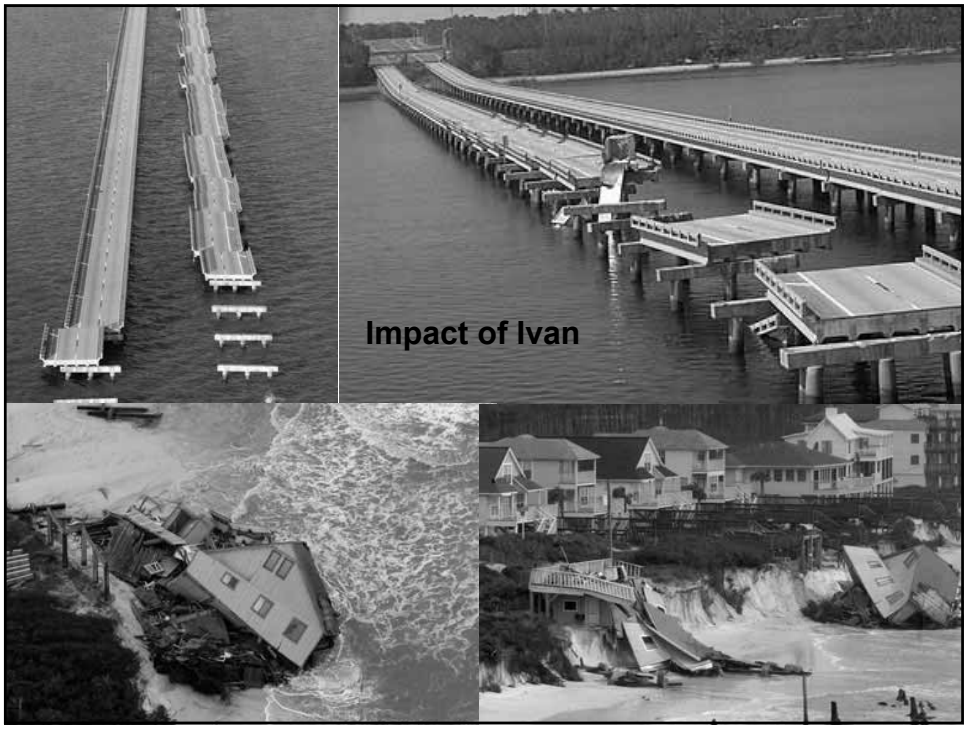
REAL-TIME FORECASTING SYSTEM OF WINDS, WAVES AND SURGE IN TROPICAL CYCLONES

National Oceanographic Partnership Program

- **University of Miami (UM): H. Graber, M. Donelan, M. Brown**
- **University of Florida (UF): D. Slinn**
- **University of Central Florida (UCF): S. Hagen**
- **US Army Corps of Engineers (USACE): R. Jensen**
- **Johns Hopkins University/APL (JHU/APL): D. Thompson**
- **NOAA Hurricane Research Div./AOML (AOML) P. Black, M. Powell**
- **National Weather Service (NWS): John Guiney**
- **Oceanweather, Inc. (OI): V. Cardone, A. Cox**
- **International Business Machines (IBM): C. Colonnese, C. Grassl**

USER GROUPS

National Hurricane Center (NHC), NASA/Kennedy Space Center (KSC)
US Southern Command (SouthCom), FDOT, US Navy, State Emergency Managers


Impact of Ivan

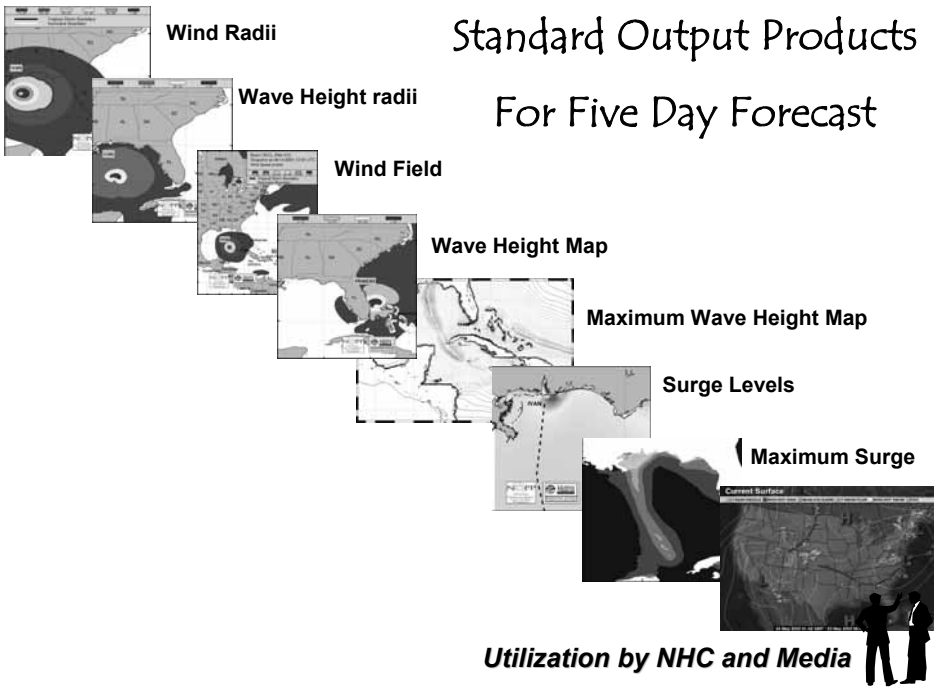
Flooding of streets
Erosion of streets

Project Goals

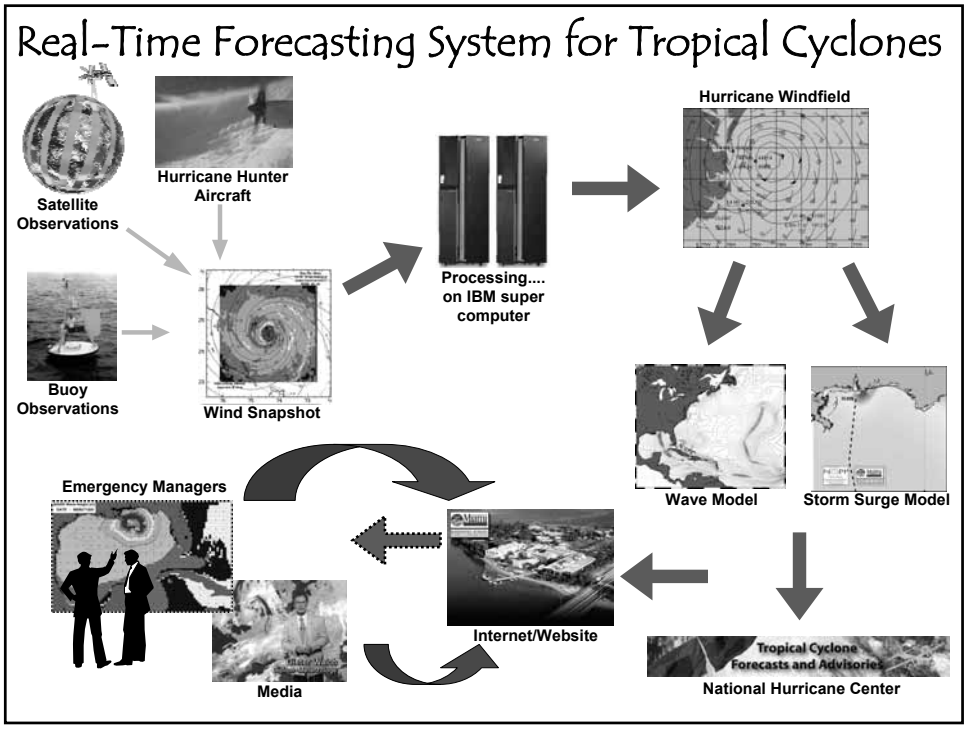
The NOPP forecast system for winds, waves and surge in tropical cyclones will generate:

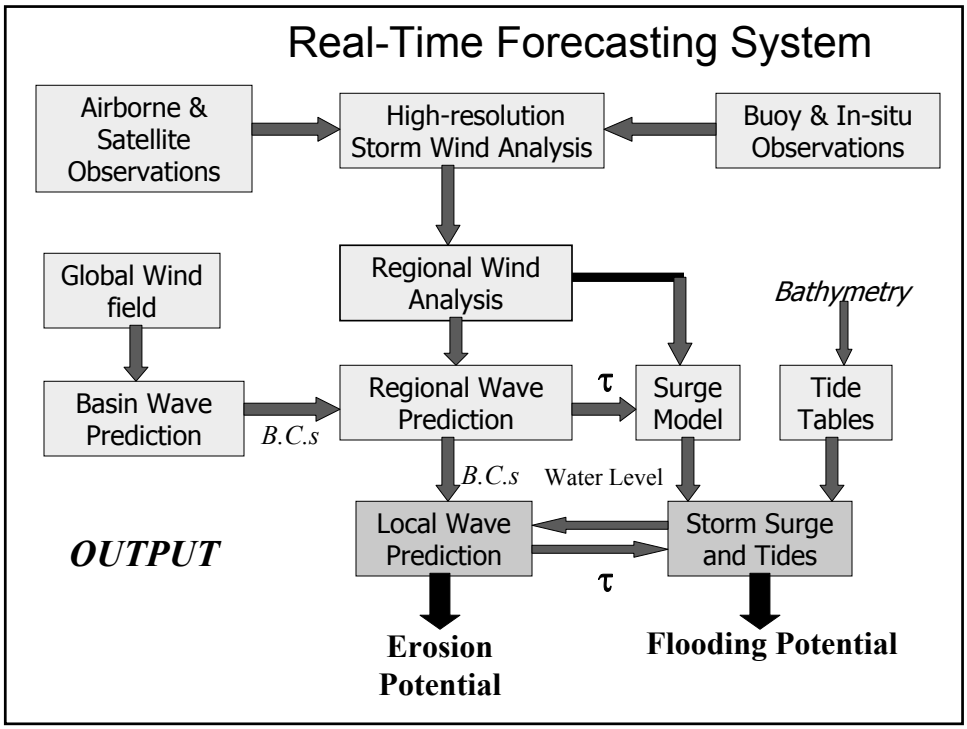
- Improved information of the 5-day advisory for the National Hurricane Center (NHC) by providing:
  - better threshold wind radii
  - better wave radii for more accurate marine advisories for ocean and offshore operations
- High resolution predictions of storm surge and flooding potential of streets and coastal property.
- Risk factors from ensemble of forecasts with alternate storm tracks and intensity changes.

Standard Output Products For Five Day Forecast

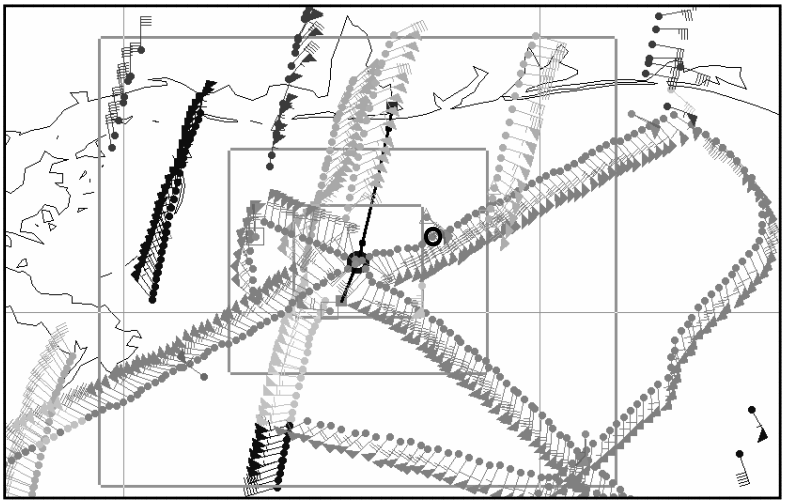


Utilization by NHC and Media


Real-Time Forecasting System for Tropical Cyclones
Satellite Observations
Hurricane Hunter Aircraft
Buoy Observations
Wind Snapshot
Processing.... on IBM super computer
Hurricane Windfield
Wave Model
Storm Surge Model
Emergency Managers
Internet/Website
Media
Tropical Cyclone Forecasts and Advisories
National Hurricane Center

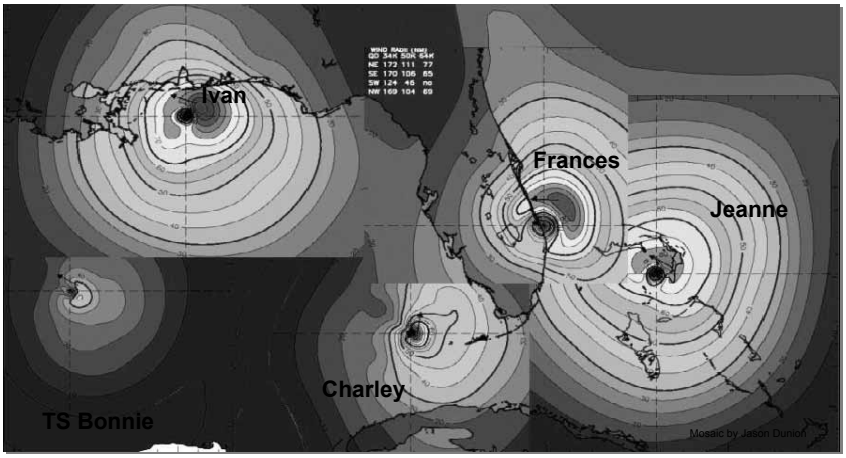

Real-Time Forecasting System
Airborne & Satellite Observations
High-resolution Storm Wind Analysis
Buoy & In-situ Observations
Global Wind field
Regional Wind Analysis
Bathymetry
Basin Wave Prediction
B.C.s
Regional Wave Prediction
τ
Surge Model
Tide Tables
B.C.s
Water Level
OUTPUT
Local Wave Prediction
Storm Surge and Tides
τ
Erosion Potential
Flooding Potential

Ivan at 0403 UTC Sept. 16th



Presentation by
Dr. Mark Powell
Hurricane Research Division

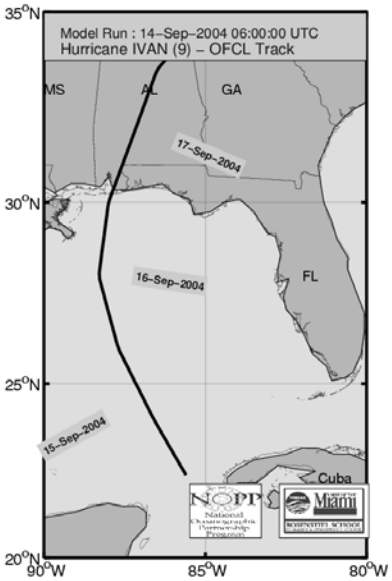
*H*Wind Mosaic 2004*



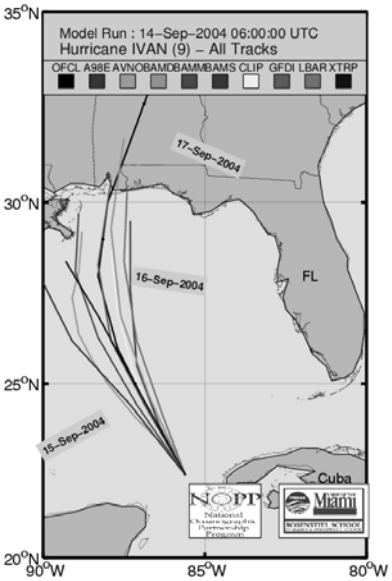
H*Wind Surface wind field Snapshot Product
Available every 6 h, 3 h during warnings
Sole Support by NOPP for wave and storm surge modeling

Presentation by
Dr. Peter Black
Hurricane Research Division

Ivan's Track



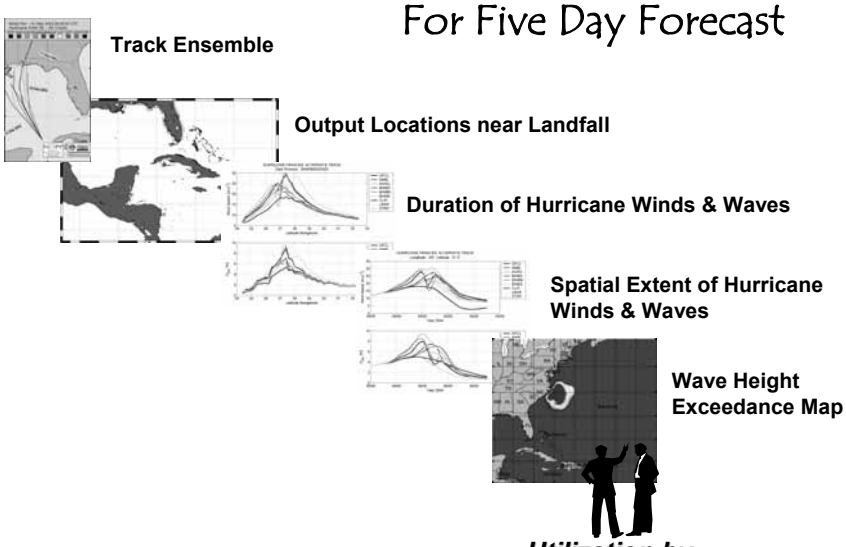
Ensemble of Tracks



Operational Forecast

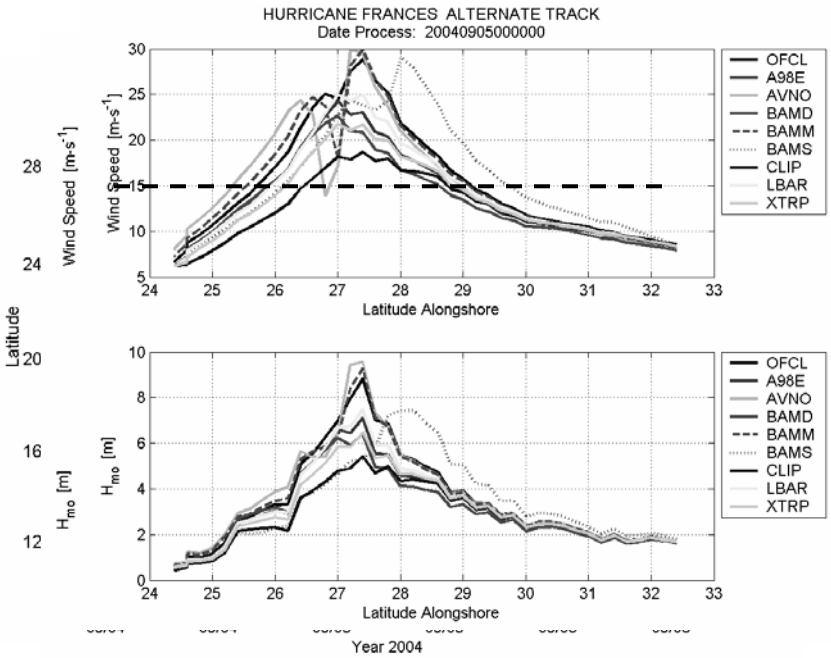
- Runs in an automated mode 4 times / day
  - Interrogates for the winds
  - Interrogates for the *restart file* from previous watch cycle
- 5-day forecast ~15 min
  - Produces wave height fields
  - Produces stress fields: surge model
  - Produces *oneline file* for verification to measurements
- Alternate storm tracks
  - Run after the official storm track 6-8 selected
  - Run higher resolution domain ~72 hours prior to landfall

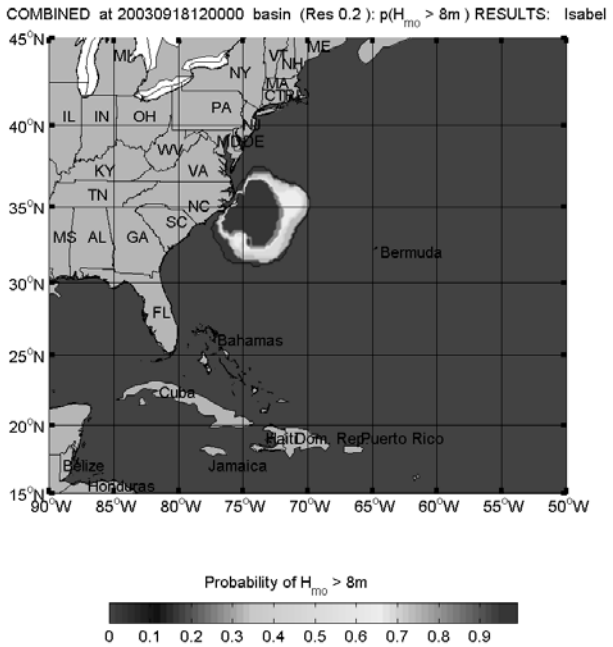
Probabilistic Output Products For Five Day Forecast



Utilization by Emergency Managers

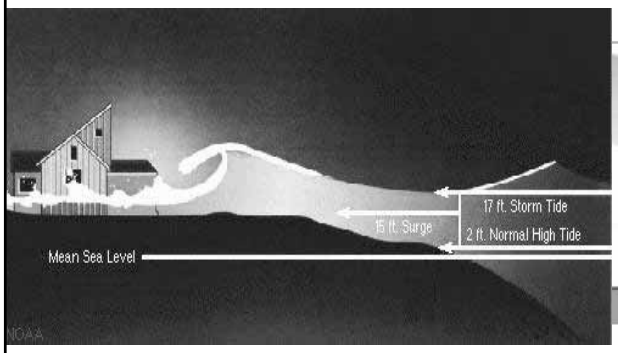
Ensemble of Alternate Track Results for Hutchinson Island, FL

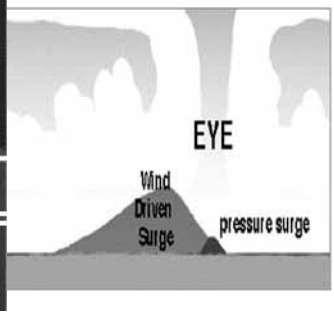


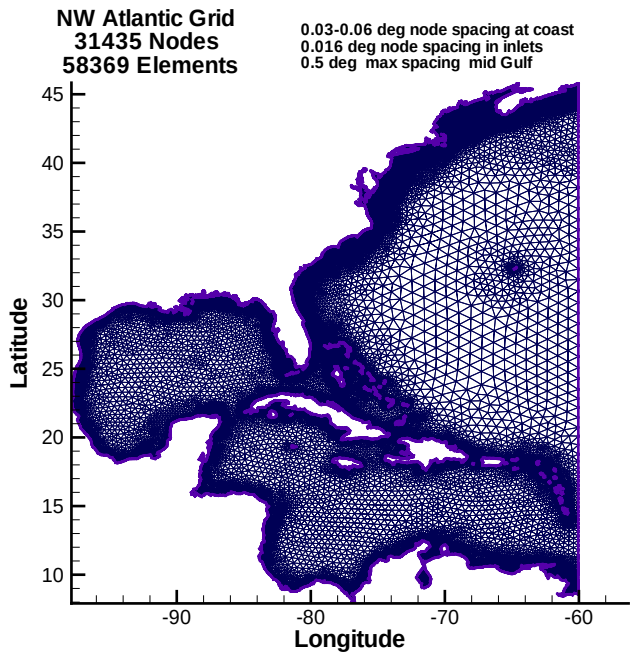


Surge Components

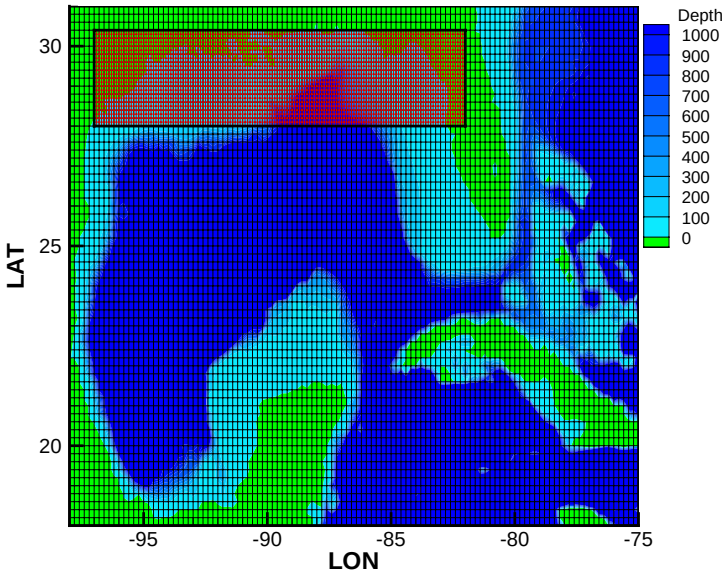
- Wind stress on ocean surface
- Barometric Pressure
- Wave forces on water column
- Astronomical Tides







Nested Grids used to compute the wave field



Radiation Stress & Wave Forcing Components

$$S_{xx} = E\,\frac{1}{2}\left[\left(2\,\frac{C_g}{C}\right)\cos^2\theta + \left(2\,\frac{C_g}{C} - 1\right)\right]$$

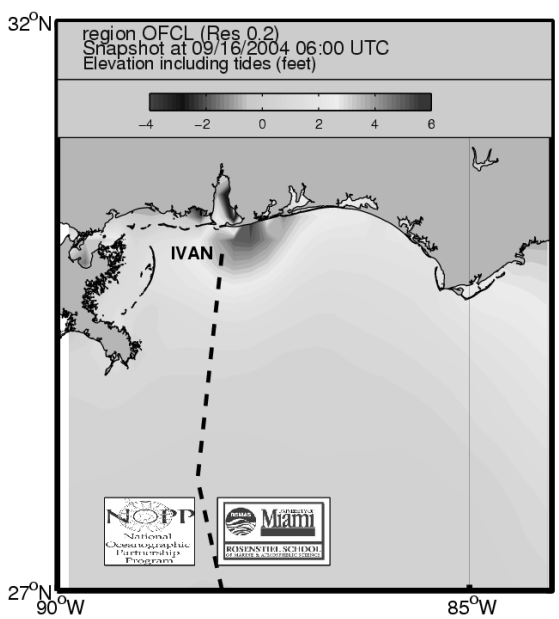
$$S_{yy} = E\,\frac{1}{2}\left[\left(2\,\frac{C_g}{C}\right)\sin^2\theta + \left(2\,\frac{C_g}{C} - 1\right)\right]$$

$$S_{xy} = S_{yx} = E\left(\frac{C_g}{C}\right)\cos\theta\,\sin\theta$$

$$F_x = -\frac{1}{\rho}\left(\frac{\partial S_{xx}}{\partial x} + \frac{\partial S_{yx}}{\partial y}\right)$$

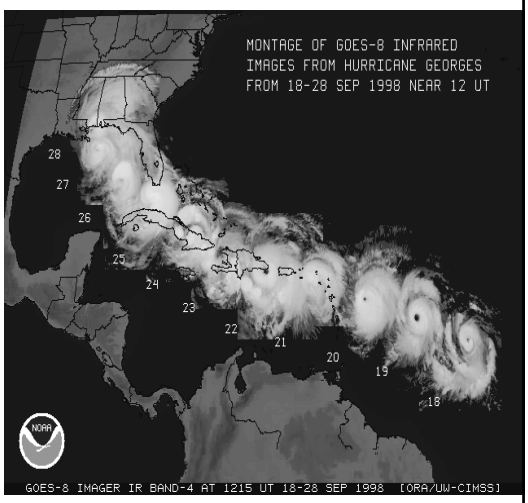
$$F_y = -\frac{1}{\rho}\left(\frac{\partial S_{yy}}{\partial y} + \frac{\partial S_{xy}}{\partial x}\right)$$

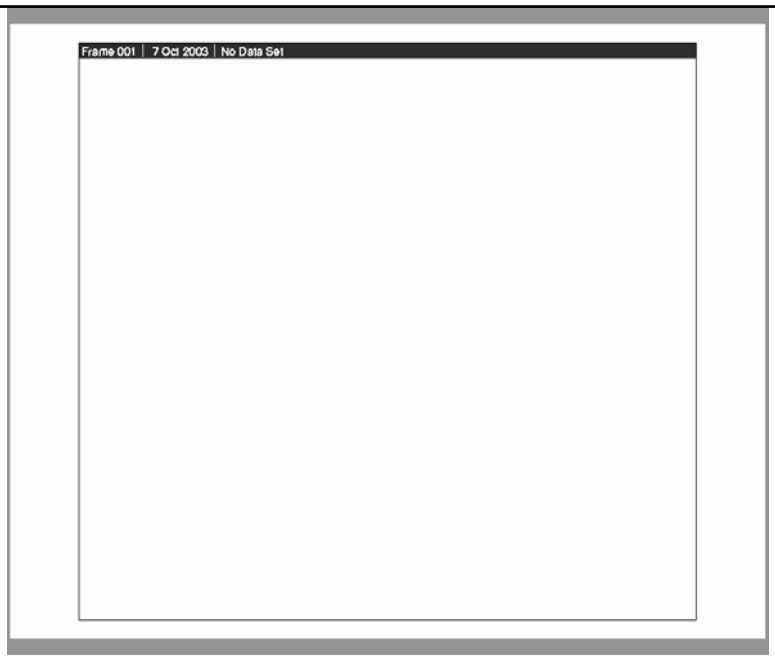
Real-Time Storm Surge Forecast With Zoom Capability



Hurricane Georges Official Track

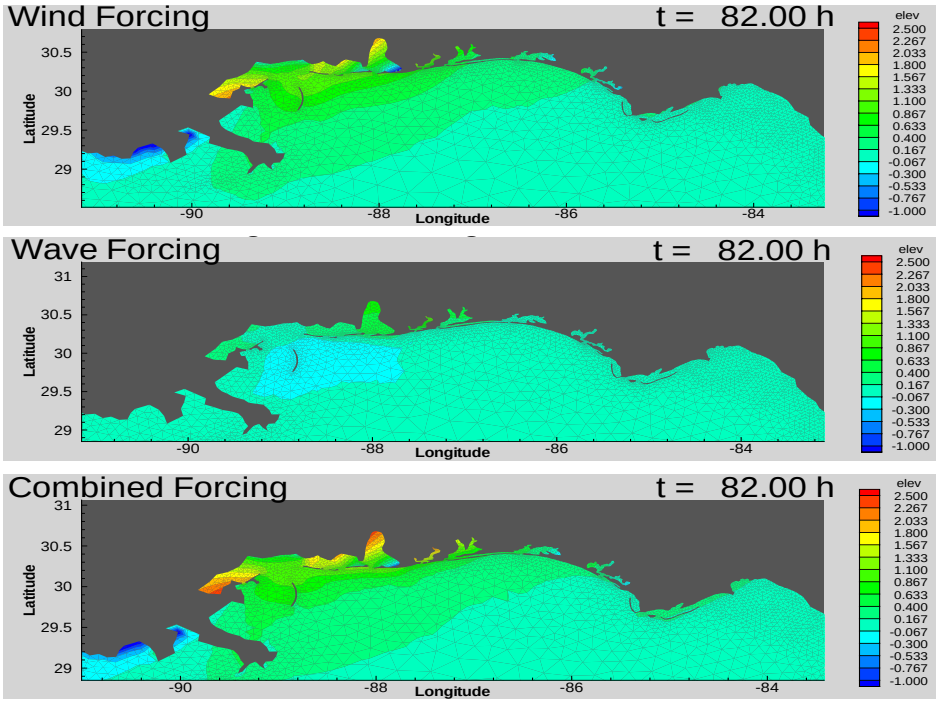
- Wind Surface Stress
- Pressure
- Wave Radiation Stresses
- ADCIRC
- North West Atlantic Domain

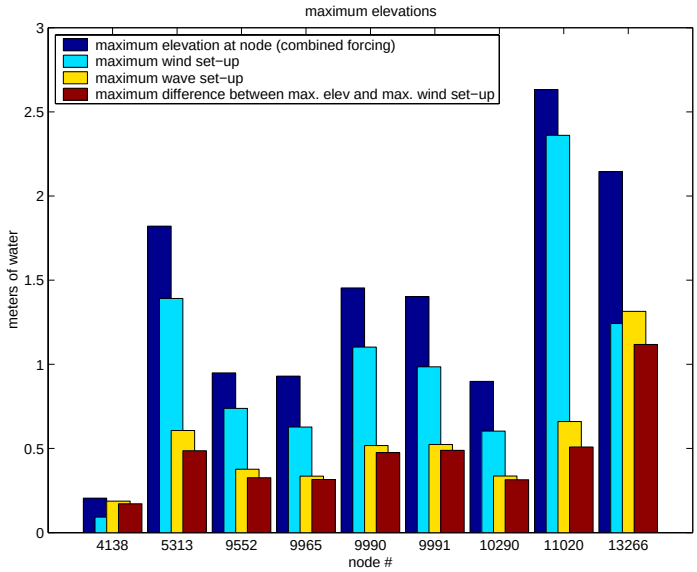




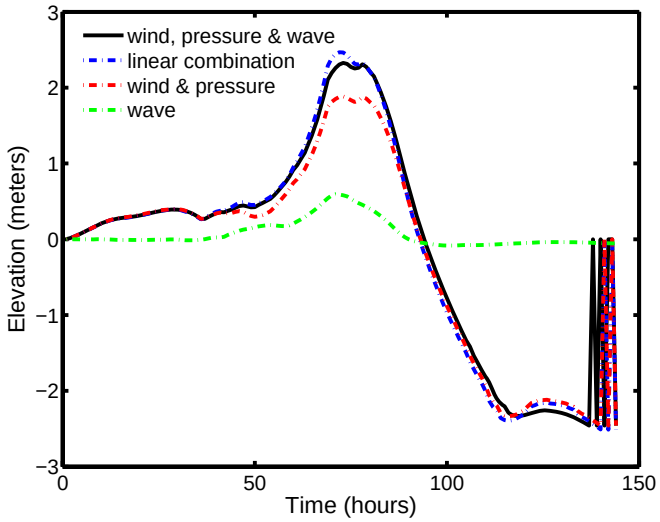
Frame 001 | 7 Oct 2003 | No Data Set

Frame 001 | 6 Oct 2003 | No Data Set

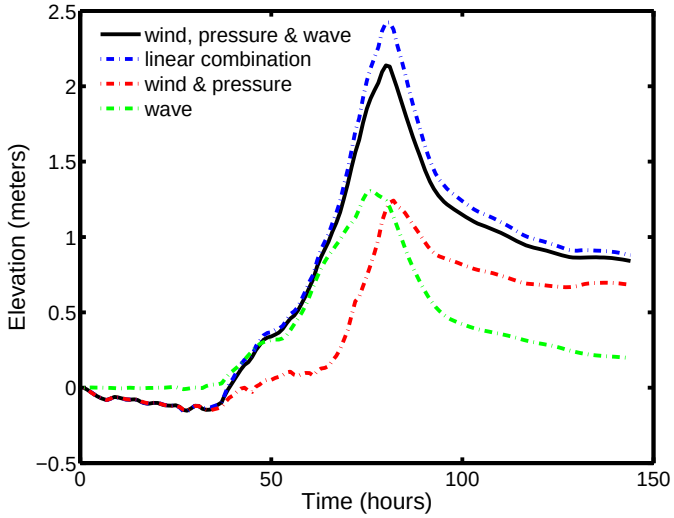

Wind Forcing
t = 82.00 h
Wave Forcing
t = 82.00 h
Combined Forcing
t = 82.00 h
Latitude
Longitude
elev
2.500
2.267
2.033
1.800
1.567
1.333
1.100
0.867
0.633
0.400
0.167
-0.067
-0.300
-0.533
-0.767
-1.000

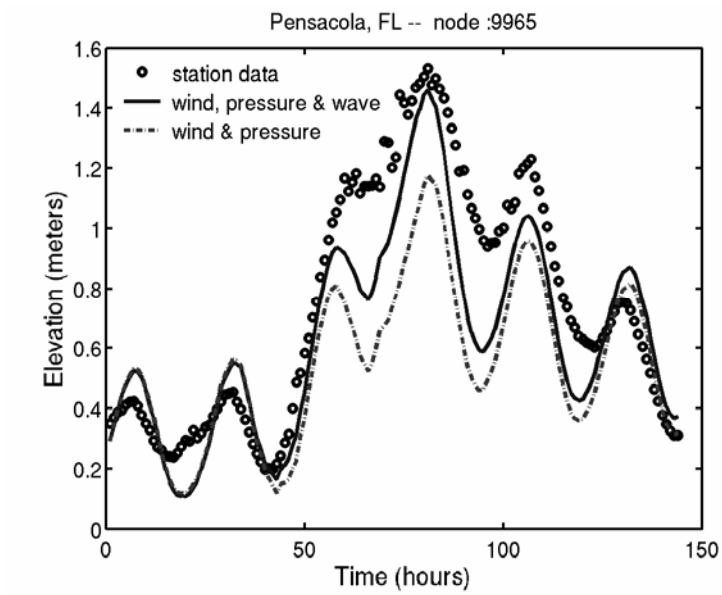

maximum elevations
maximum elevation at node (combined forcing)
maximum wind set−up
maximum wave set−up
maximum difference between max. elev and max. wind set−up
meters of water
node #
4138
5313
9552
9965
9990
9991
10290
11020
13266

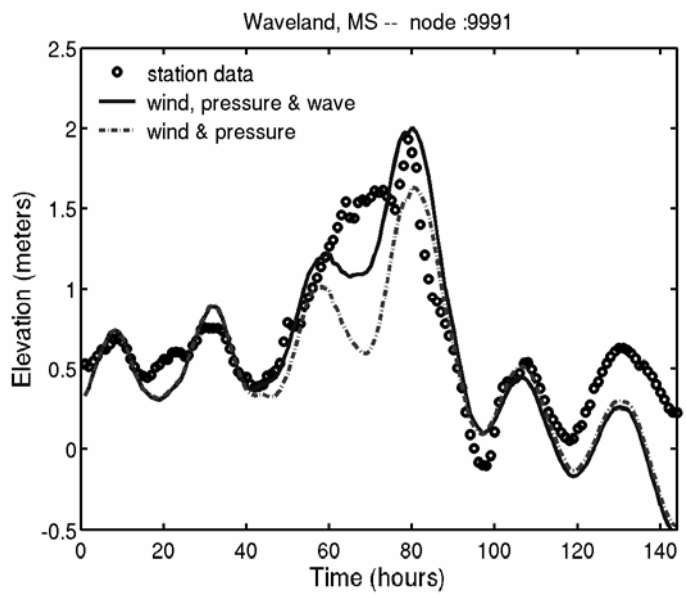
Lake Borgne, LA



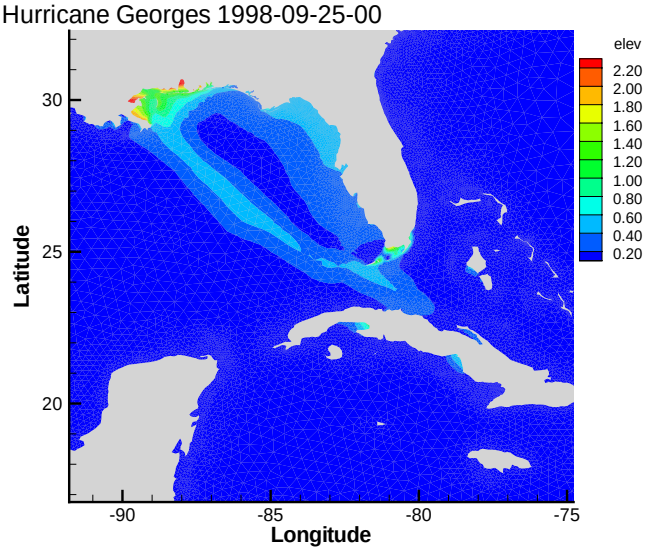
Perdido Bay, FL

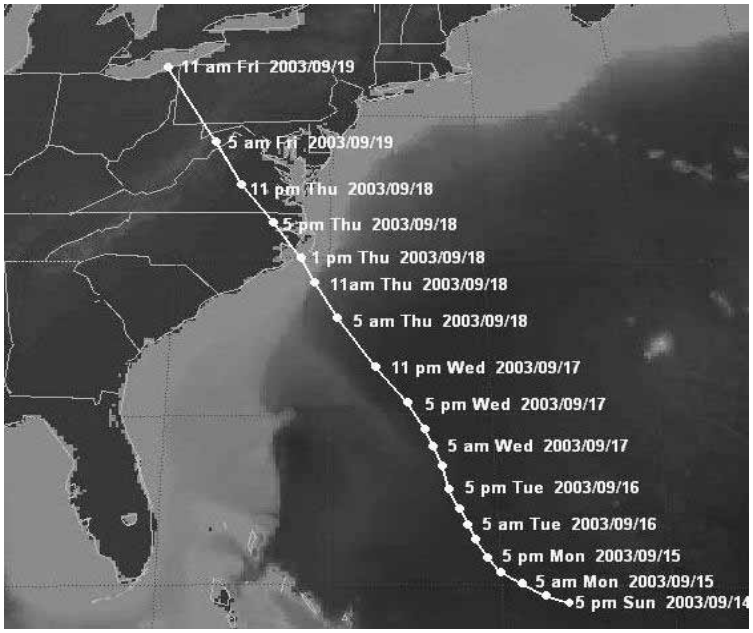


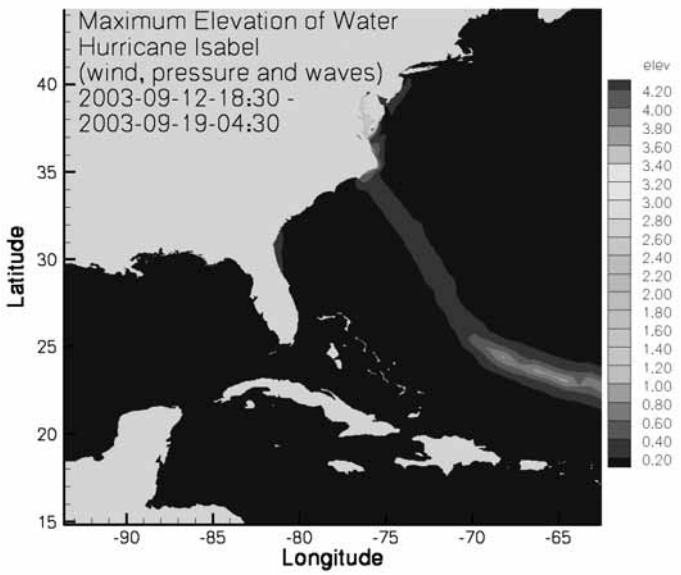

Pensacola, FL -- node :9965
station data
wind, pressure & wave
wind & pressure
Elevation (meters)
Time (hours)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
0
50
100
150

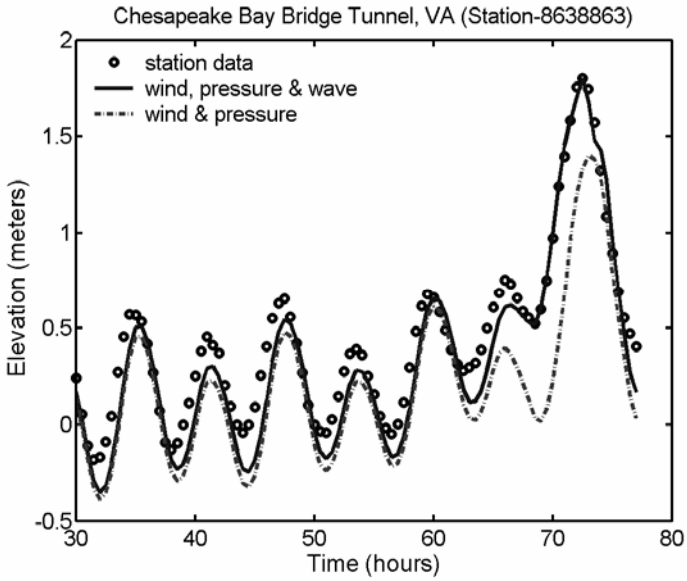

Waveland, MS -- node :9991
station data
wind, pressure & wave
wind & pressure
Elevation (meters)
Time (hours)
-0.5
0
0.5
1
1.5
2
2.5
0
20
40
60
80
100
120
140

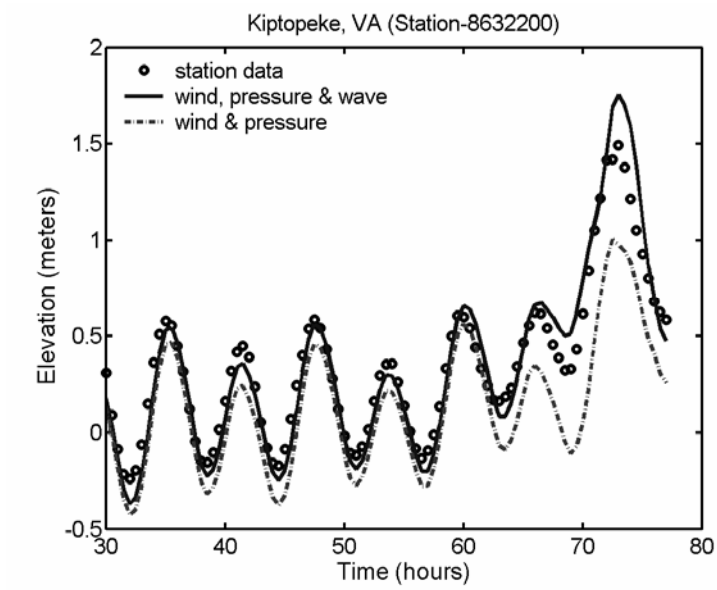
Maximum Elevation of Water
Hurricane Georges 1998-09-25-00






Maximum Elevation of Water
Hurricane Isabel
(wind, pressure and waves)
2003-09-12-18:30 -
2003-09-19-04:30
Latitude
Longitude
elev
4.20
4.00
3.80
3.60
3.40
3.20
3.00
2.80
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20

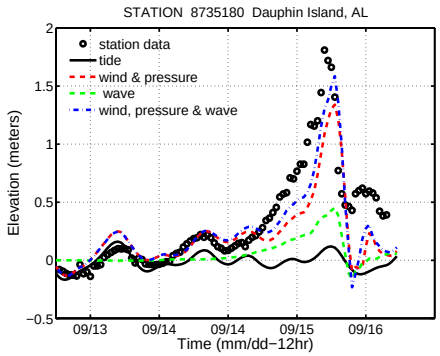

Chesapeake Bay Bridge Tunnel, VA (Station-8638863)
station data
wind, pressure & wave
wind & pressure
Elevation (meters)
Time (hours)

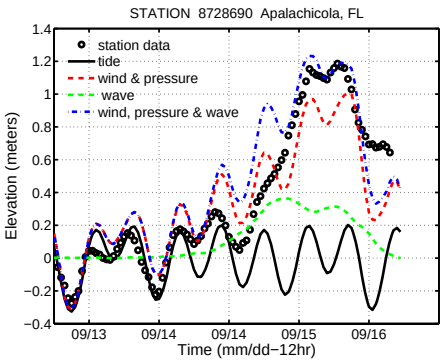


Error Analysis

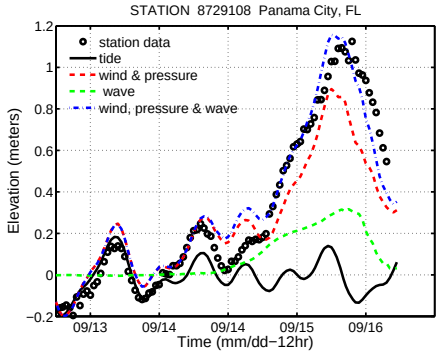
- 50% reduction in RMS error at Chesapeake Bay Bridge Tunnel location
  - From 16% to 8%
- 50% reduction in RMS error at Kiptopeke location
  - From 15% to 8%

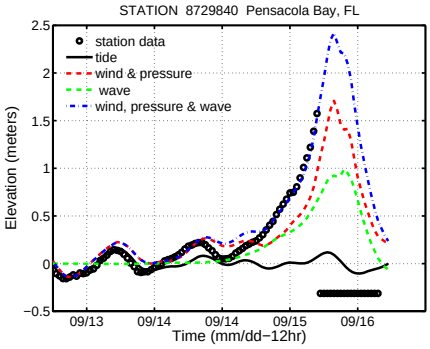
Ivan Surge Comparisons

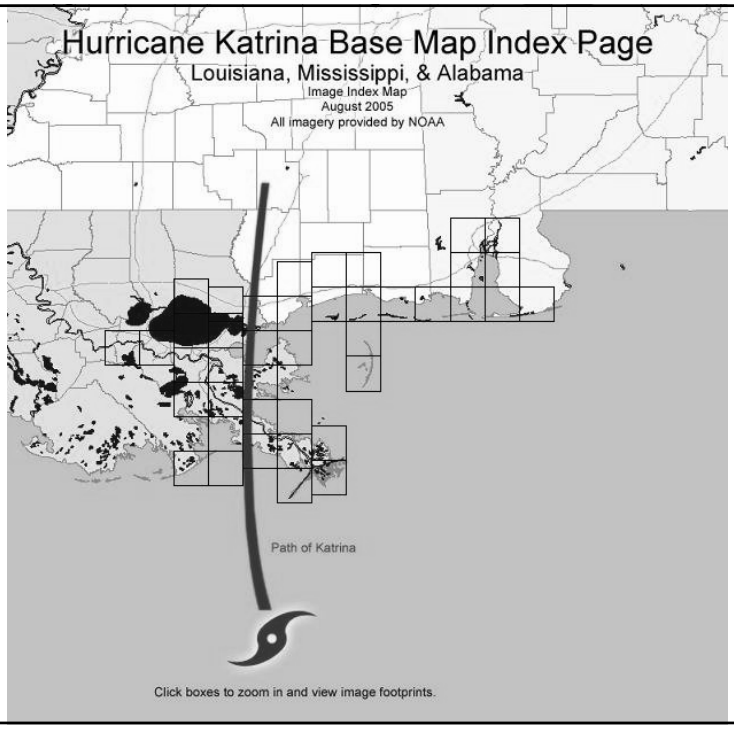


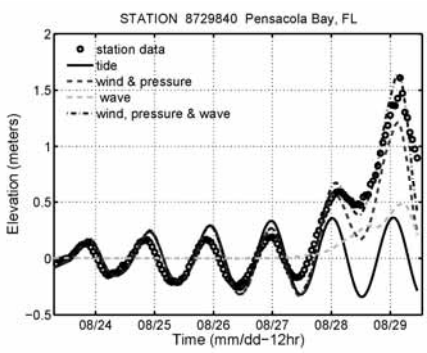


Hurricane Ivan comparison to Tide Gages at Panama City and Pensacola Florida

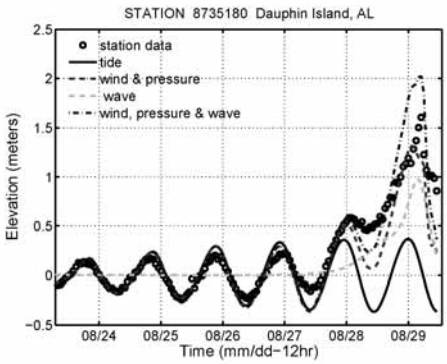


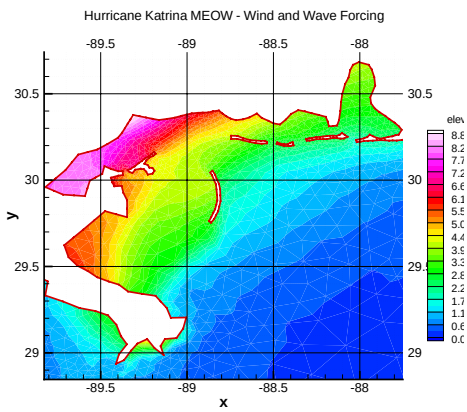


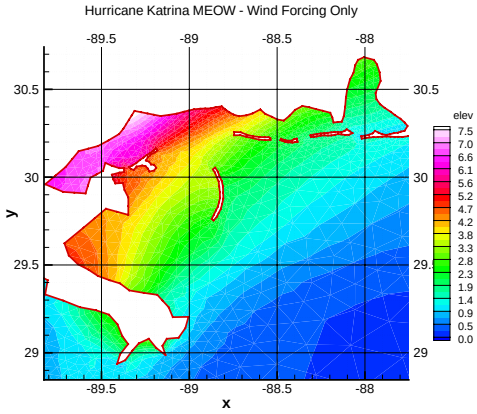




Hurricane Katrina – Comparison to Tide Gages in Pensacola and Mobile Bay







Summary

•A real time forecasting system for wind, waves, and storm surge has been run for the last 5 years in operational mode

• Model predictions are dependent on the unknown hurricane track forecast.

•Model hindcasts come close to matching historical tide gage data for a variety of types of storms.

•Integration of wave forces to the storm surge have typically increased the accuracy from around 80% to 90%.

•System provides information to NHC forecasters to help in their public advisories.