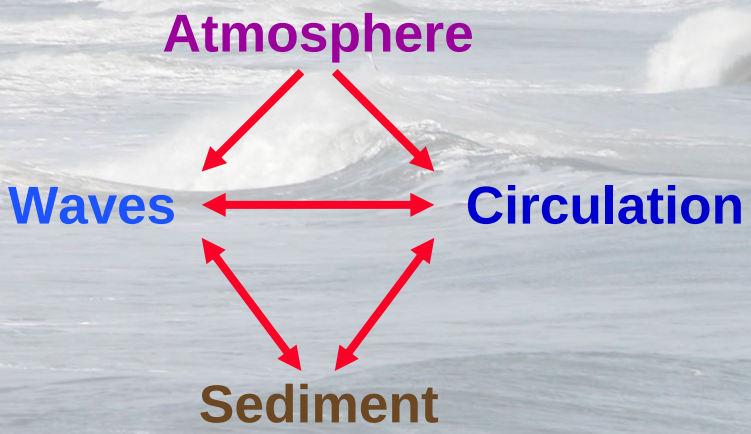
# MORPHOS

## Advancing Coastal Process Research, Modeling and Risk Assessment

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Coastal and Hydraulics Laboratory

# Our Coasts at Risk

FL 2004 Hurricane Season:
Beach Erosion


2005 Hurricane Season:
Inundation/Flooding

## Issues

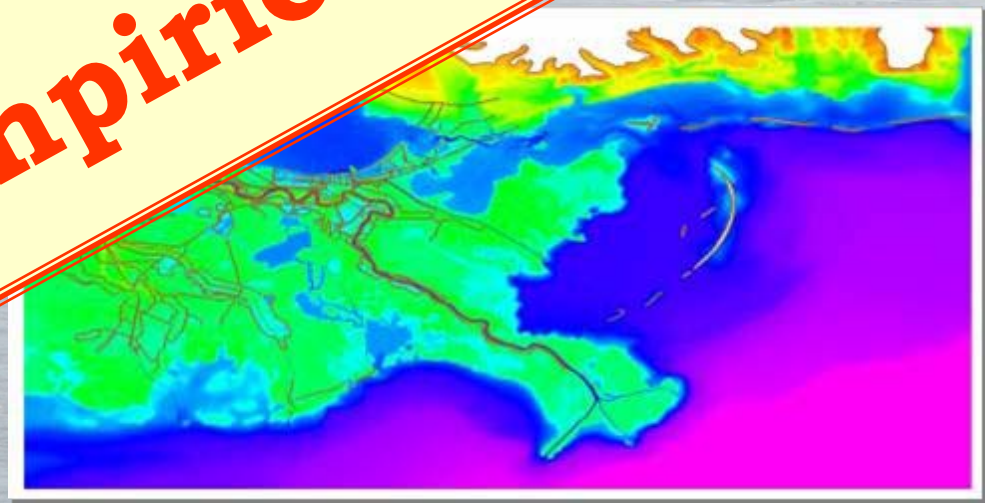
- Developmental Pressure
- Increased Storm Activity
- Wetlands
- Sea Level Rise
- Subsidence

- Modeling Weaknesses Exposed
- Major catastrophes transcend past experience
- Processes exceed range of model tuning

# Critical Needs

- D

g system



**More Model Physics!**

**Less Empirical Tuning!!**

# MORPHOS Mission

Develop, verify and apply a physics based coastal and estuarine simulation and prediction capability with emphasis on storm-driven events

## Initial Focus: Nearshore Beach Response

- 3-Year Demonstration Effort
- 2004 FL Hurricane Season Driven

## New Focus: Coastal Hazards & Risk

- Fully Integrated Process Models
- Systems Approach
- Coastal Risk – All Environments

**Meet Today's Design Needs…**
**…Face Tomorrows Changing Problems**

# MORPHOS Elements

Community Steering

**Research and Development**

Coastal Modeling System

Atmosphere

Waves ↔ Circulation

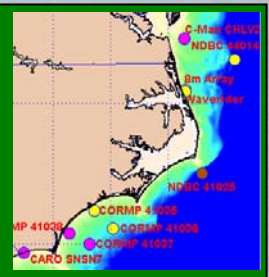
Sediment

**Community Tools**

- Risk Assessment
- Project Design
- Event Reconstruction

**Test and Evaluation**

- Critical Data Sets
- Model Test Bed



# Summary

## Basic Morphos Approach:

- A focus on fundamental science
- A community approach to open-source development
- Maintain a strong field program for model testing improvements
- Long range vision for community engineering/design modeling system

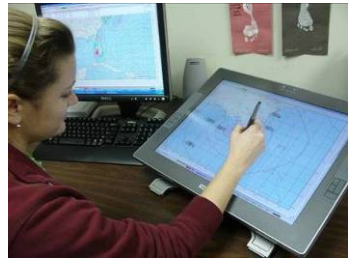
## Progress:

- New perspectives on winds, waves, surge, morphology and risk
- Significant improvements in model fidelity
- Standardized National methodology for assessing coastal risk and inundation flooding

# 2007 Project Team

| | |
|---|---|
| Government Agencies | US Army Corps of Engineers |
| | NOAA NCEP, National Weather Service |
| | USGS Woods Hole Science Center |
| Academic Institutions | University of North Carolina |
| | University of Delaware |
| | Brigham-Young University |
| | DelftTU |
| Private Industry | Oceanweather Inc. |
| | Baird and Associates, Inc |
| | Applied Research Associates, Inc. |
| | Non-Linear Waves, Inc. |
| | Risk Engineering, Inc. |
| | Watershed Concepts Inc |
| | Waves and Solitons, LLC |
| | Alkyon Hydraulic Consultancy & Research |
| | Woolpert, Inc. |

# Climate/Risk



- Role of Climate Variability in Coastal Risk
  - Over past 40 years, short active periods produce all major storms
  - Correlation with principal components of atmospheric forcing and SST

- Joint Probability Method for Hurricane Risk Assessment
  - Not tied to short historical record
  - Probabilistic description of storm features at or near landfall
  - Can incorporate uncertainty due to climate variability and other factors
  - Optimal storm selection with manageable sample sizes

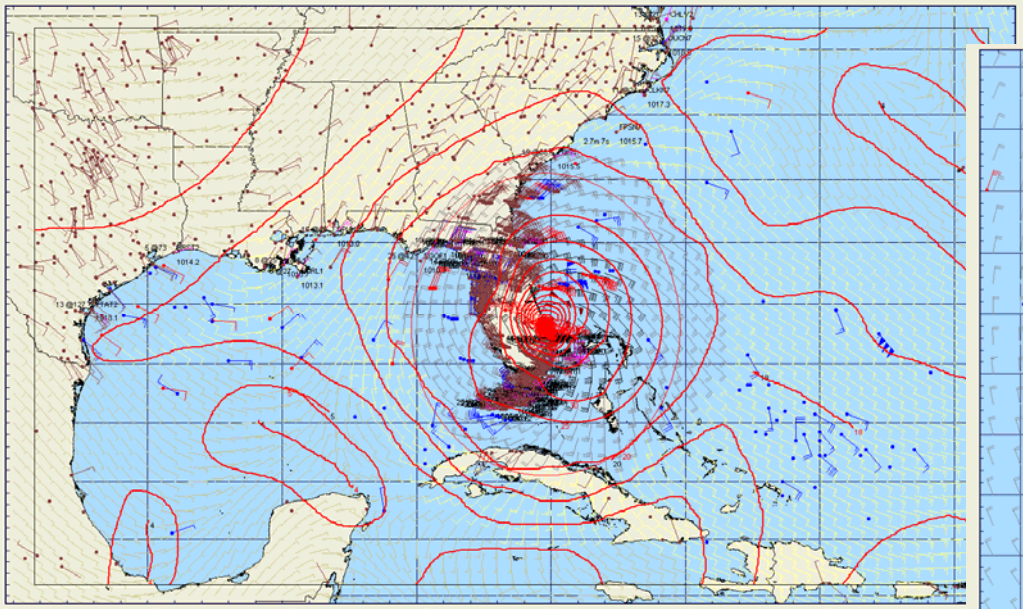
**Probability Set**

$$\eta = \eta(\Delta p, R_p, \alpha, x - x_0 \mid \bar{B}, \bar{V}_f, <\vec{W}>) + \varepsilon(\delta B, \delta V_f, \delta\vec{W}, tide, e_m, e_w)$$

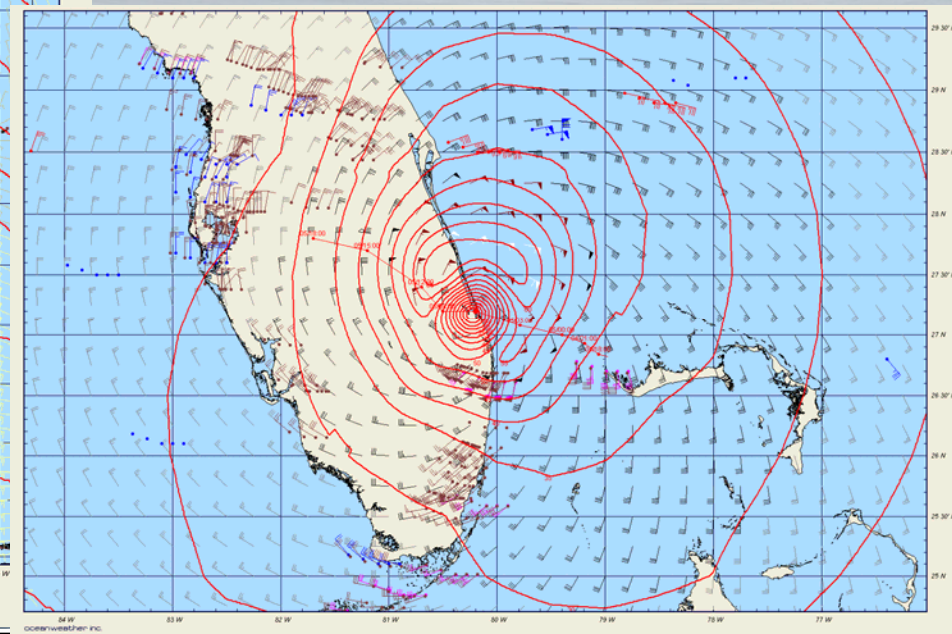
**Storm Characteristics + Secondary Variables (wind errors, tides, etc)**

# Meteorology

- Prediction accuracy absolutely dependant on quality of driving winds
- Hurricane Model Advances - Boundary layer height, land-falling wind effects
- Interactive Objective Kinematic Analysis (IOKA) for careful reconstruction
- Produced FL 2004 Hurricane Wind Fields



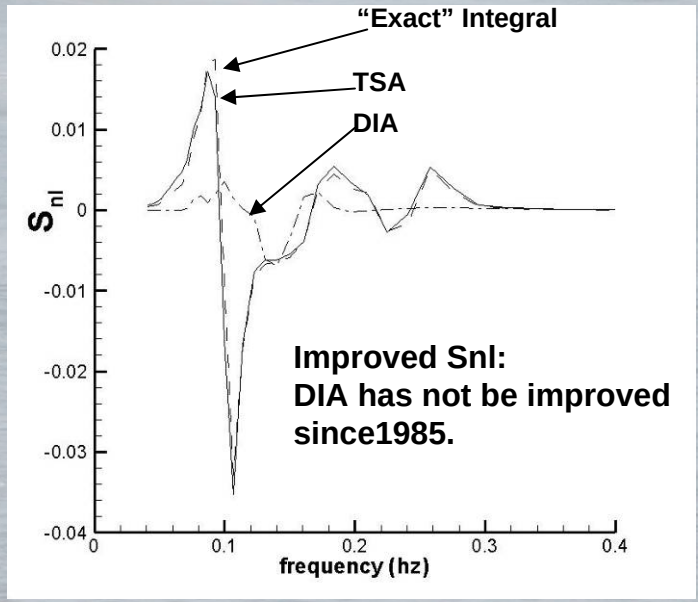
Hurricane Frances



# Waves

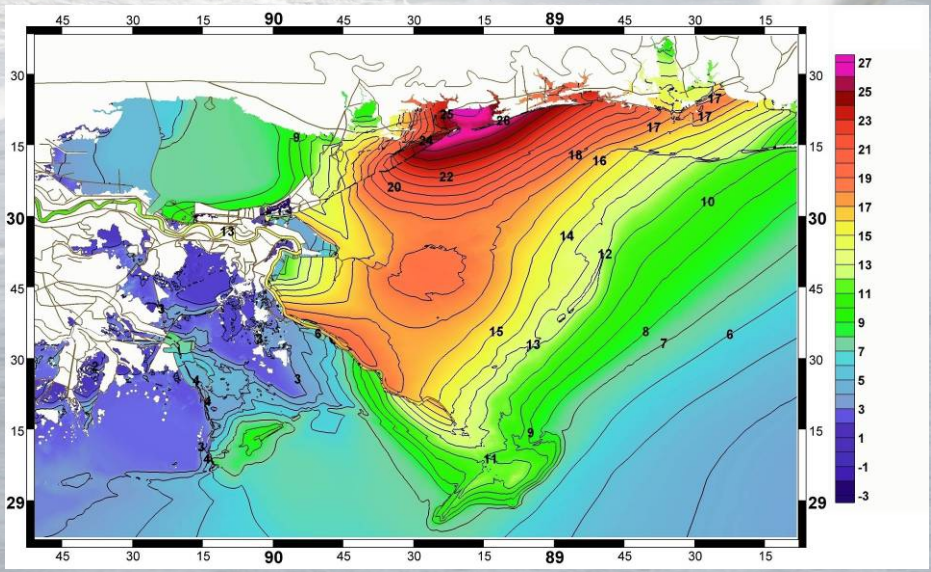
- Shallow Water Source Terms
- Nearshore bottom friction and diffraction
- Semi-Lagrangian wave propagation
- Kinetic Boussinesq equation for arbitrary depths

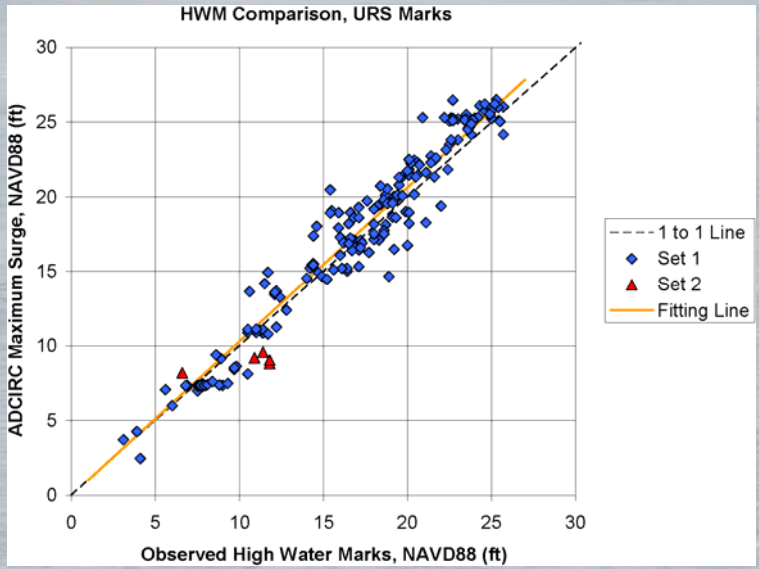
$$\frac{D(f,\theta)}{Dt} = \sum_k S_k(f,\theta) = wind + Snl + dissipation$$



# Currents/Storm Surge

- ADCIRC 2D and 3D Model Developments for Storm Surge Simulations
- Optimizing parallel efficiency of Discontinuous Galerkin (DG) approach
- Robust Wetting/Drying
- Generic serial/parallel dynamic wave coupler



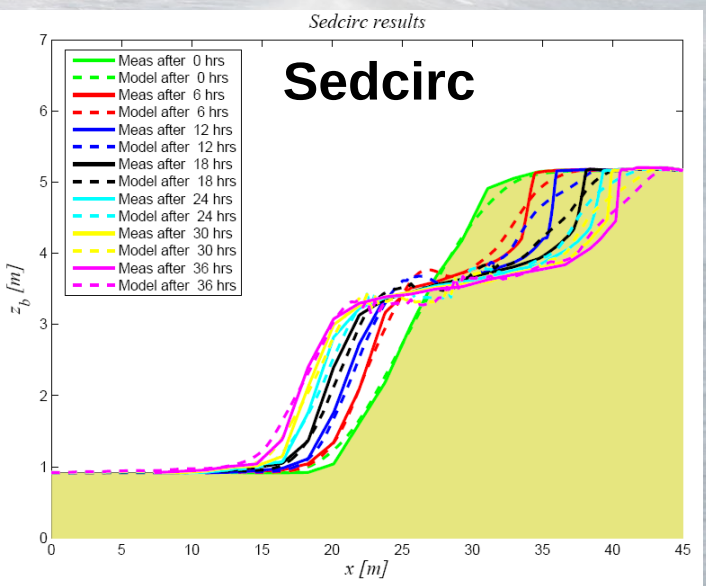


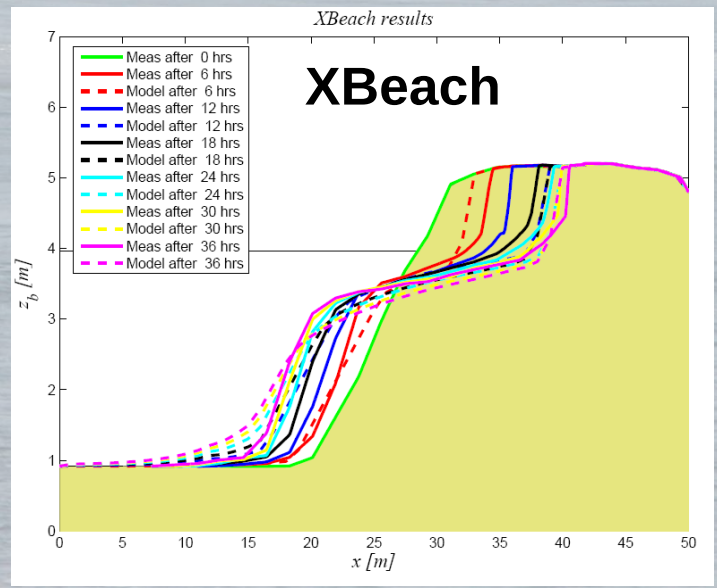

Hurricane Katrina Storm Surge

# Sediment/Morphology

- Nearshore morphology module, forced at ~10-m depth
- New Algorithms for X-Shore Beach Morphology: Sedcirc and XBeach
- Coupled Wind/Wave/Current/Sediment Simulations

**Laboratory Tests**



# Test and Evaluation

High-Quality Measurements

Analysis

MORPHOS

Atmosphere

Waves

Circulation

Morphology

Data Bank
(NCDB, IOOS, SEACOOS, etc.)

Benchmarking Module

Analysis

Performance Evaluation
Model Diagnostics

- FRF Pier Wind Stress Measurements
- X-Shore wave/current array
- Morphology validation tool
- Coupled wave/ADCIRC validation

# System Integration

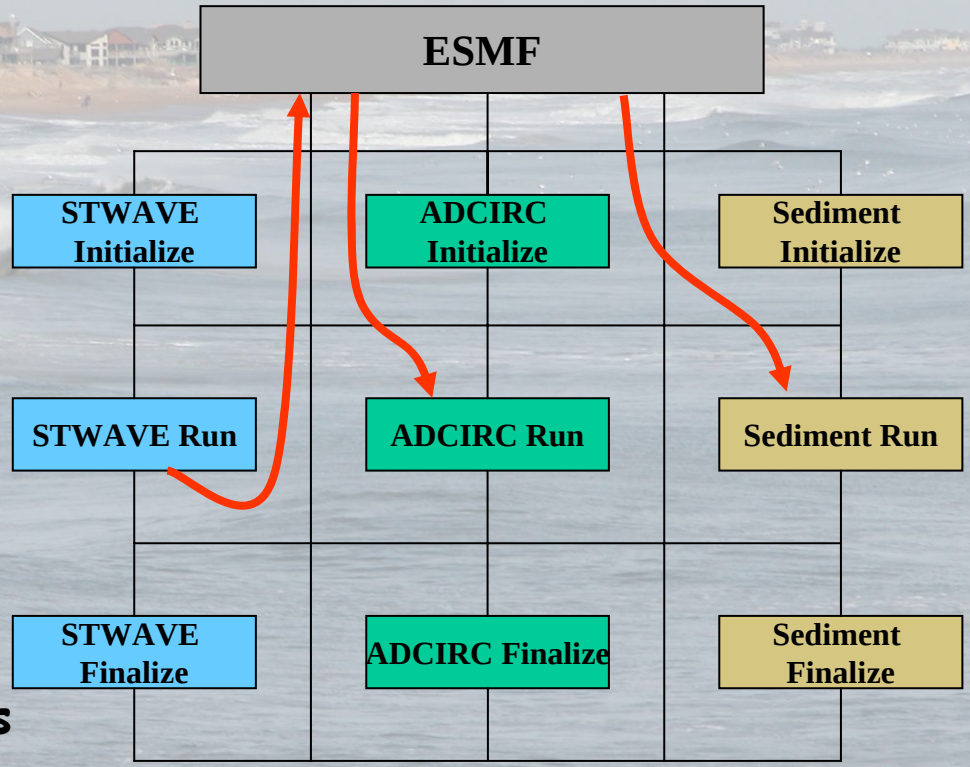
## Separate Configurations are Envisioned for Model Developers and End Users

### Developers System – in Progress

- Robust FORTRAN Coupling
- User Control of Configurations
- SMS Grid Generation / Displays

### Community System –Details TBD

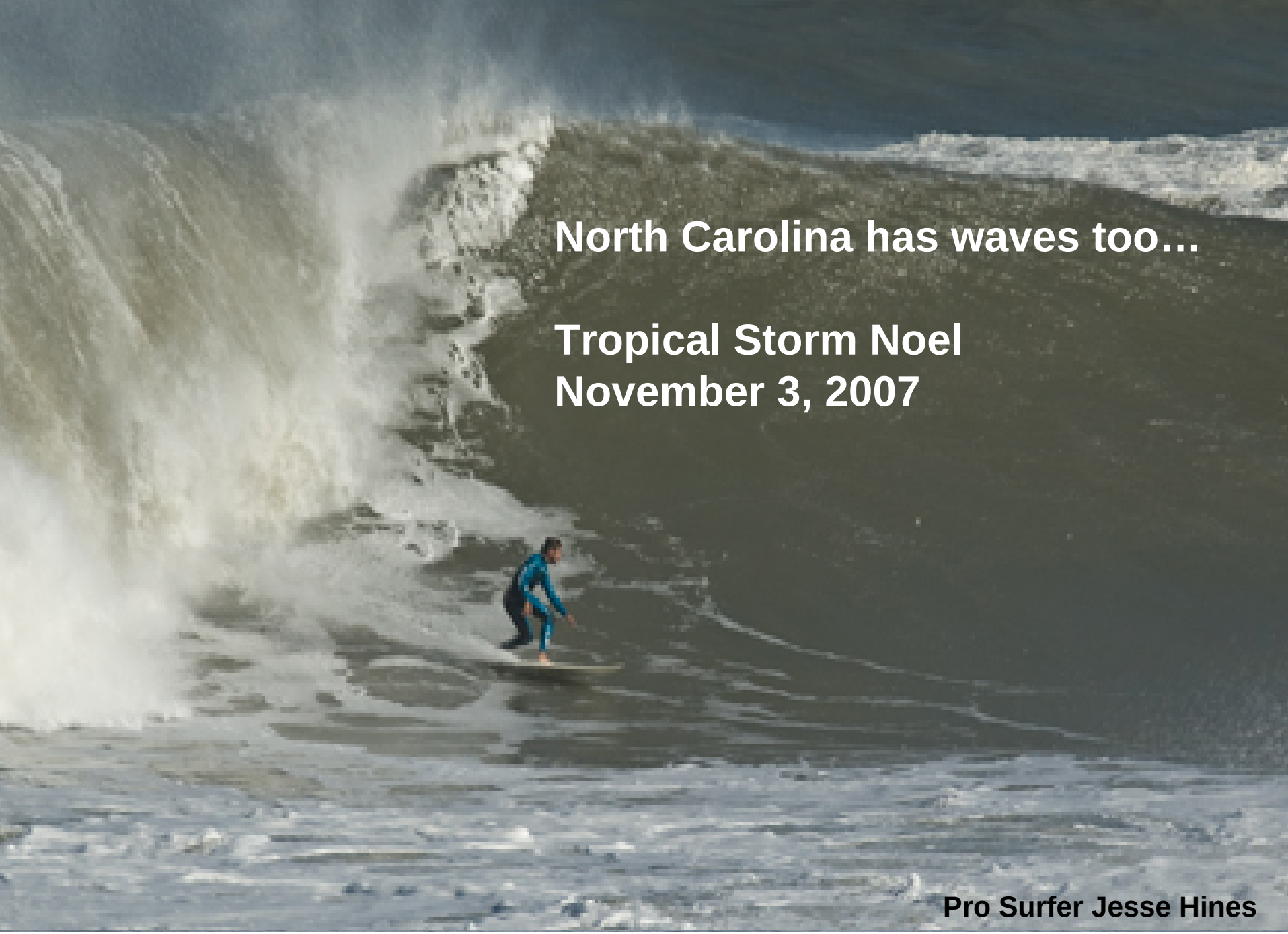
- HPC-based Coupling Environment
- Convenient User Interface
- Focus on End-User Application Tools
- Extensive Documentation and Training Aids



# MORPHOS Presence

## MORPHOS Technology Advancements have had a Significant Impact in many Applications

- Hurricane Katrina IPET Reconstruction
- Louisiana Coastal Protection & Restoration Program
- North Carolina Floodplain Mapping (State Program)
- USACE Wave Information Studies Program (WIS)
- NOAA/NWS Operational Wave Modeling
- FEMA Chesapeake Bay Floodplain Mapping (FEMA)
- NOAA Integrated Ocean Observing System Program


North Carolina has waves too…
Tropical Storm Noel
November 3, 2007
Pro Surfer Jesse Hines