ERDC
Engineer Research and Development Center

ERDC's Coastal Storm (CSTORM) Modeling System

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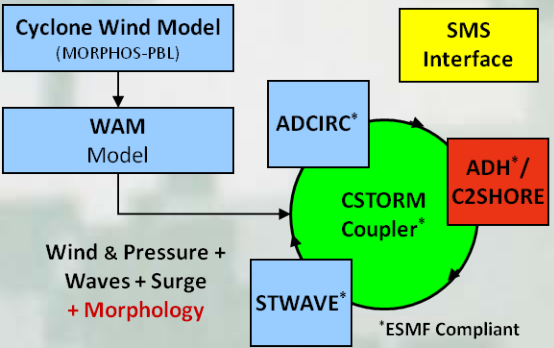
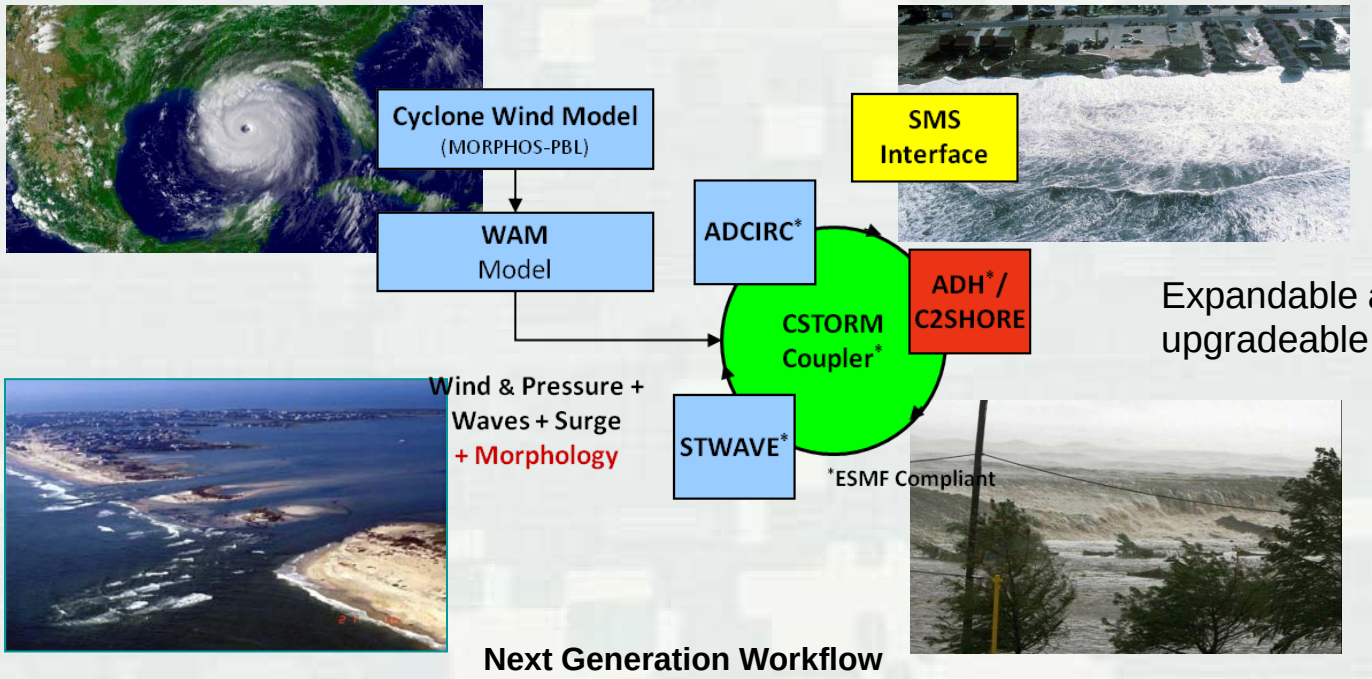


ERDC's Coastal Storm-Modeling System

Application of high-resolution, highly skilled numerical models in a tightly integrated modeling system with user friendly interfaces

Not just hurricanes and not just in the Gulf of Mexico.



Expandable and upgradeable system.

Next Generation Workflow

Provides for a robust, standardized approach to establishing the risk of coastal communities to future occurrences of storm events.

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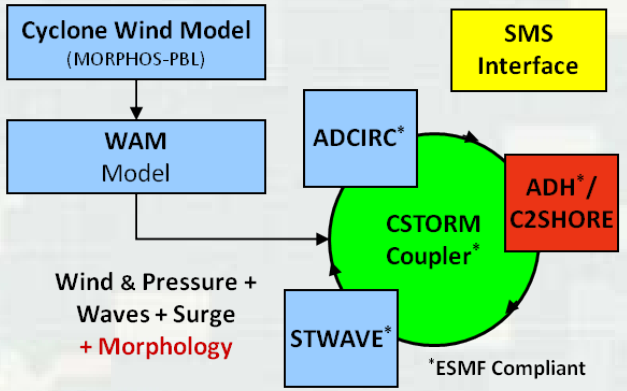
CSTORM-MS Technology Applications

- **Loose Model Coupling** (Prior to 2009)
  - Interagency Performance Evaluation Task Force **(IPET)**
  - Louisiana Coastal Protection and Restoration **(LaCPR - MVN)**
  - Mississippi Coastal Improvement Program **(MsCIP - SAM)**
  - Flood mapping for Texas, Louisiana, Mississippi, North Carolina, Chesapeake Bay **(FEMA)**
  - Morganza to the Gulf Hurricane Protection Project **(MVN)**
  - Inner Harbor Navigation Canal **(IHNC)** closure **(MVN)**
  - Plaquemines Parish flood protection planning **(Plaquemines Parish)**
  - Guidance for new "PMH" coastal surge estimates for licensing **(Nuclear Regulatory Commission)**
  - Waves inside Harbor Mouths **(POA)**
  - New Orleans Litigation **(Department of Justice)**
  - New wave model evaluation technique **(NOAA)**

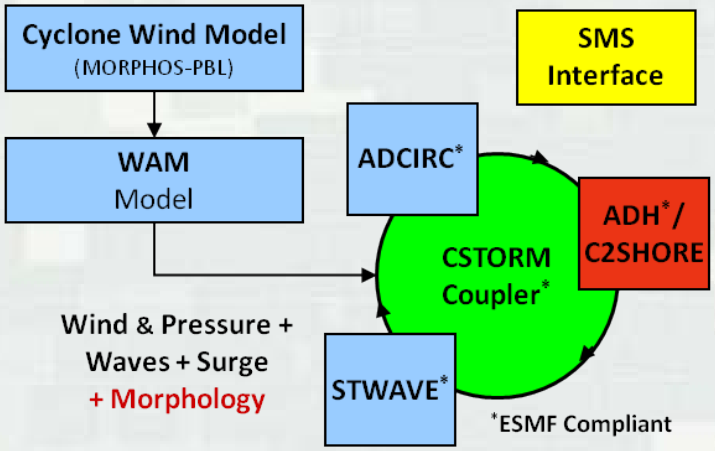
- **Tight Model Coupling (Alpha Version)**
  - Finished in the Fall of 2009
  - ERDC users for Corps projects (MsCIP and LaRose)

- **Tight Model Coupling (CSTORM-MS)**
  - Finished in June of 2010
  - ERDC users for Nuclear Regulatory Commission project 2011-12
  - Hurricane Isaac (HSDRRS Evaluation) 2012
  - Jackson State University (IKE Dike evaluation) 2013
  - North Atlantic Coast Comprehensive Study (NACCS) 2013-14



CSTORM System Components 2014

- **Winds/Pressure:** PBL Cyclone Model
- **Waves:**
  - Regional: WAM
  - Nearshore: STWAVE*
- **Circulation/Surge:**
  - ADCIRC*
  - ADH*
- **Morphology:** SEDLIB/C2Shore
- **Coupling Framework:** CSTORM-MS*
- **Graphical User Interface:** SMS
- **Unstructured Waves, Overland Flow, SEA Ice DEM – FY15-17?**



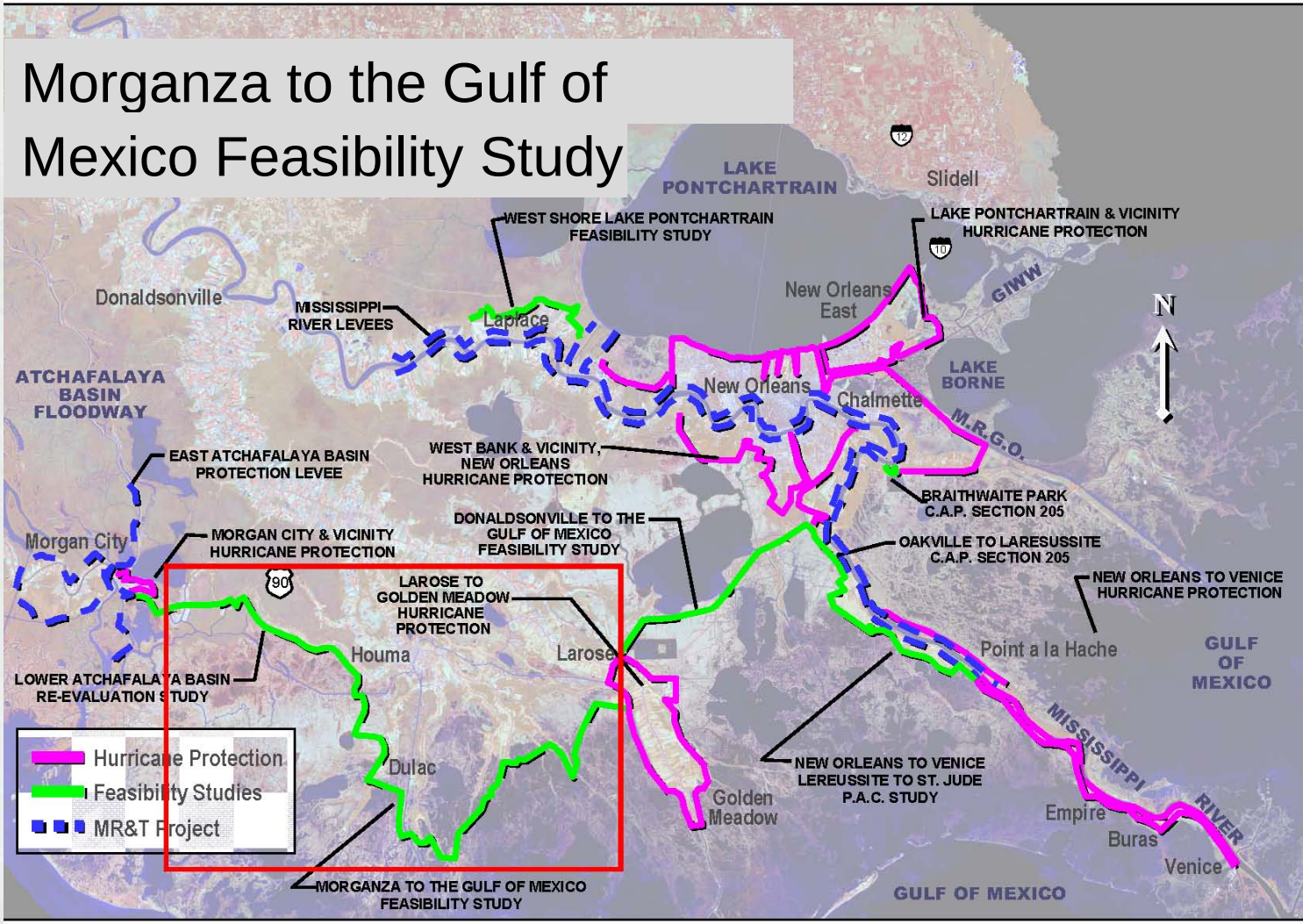
Earth System Modeling Framework (ESMF) Compliance

- Multiple federal agency support ESMF
- ESMF compliant models are readily available to be linked with each other and with other agencies' ESMF compliant models.
- Individual models stay virtually autonomous when coupling.

CSTORM-MS COASTAL STORM MODELING SYSTEM

An Example USACE Storm Surge Project

Morganza to the Gulf of Mexico Feasibility Study



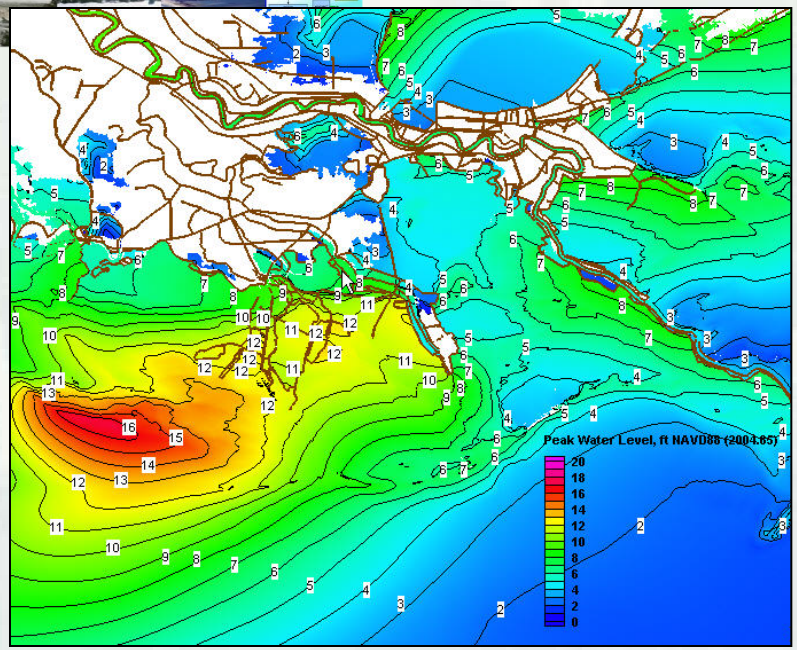
CSTORM-MS COASTAL STORM MODELING SYSTEM

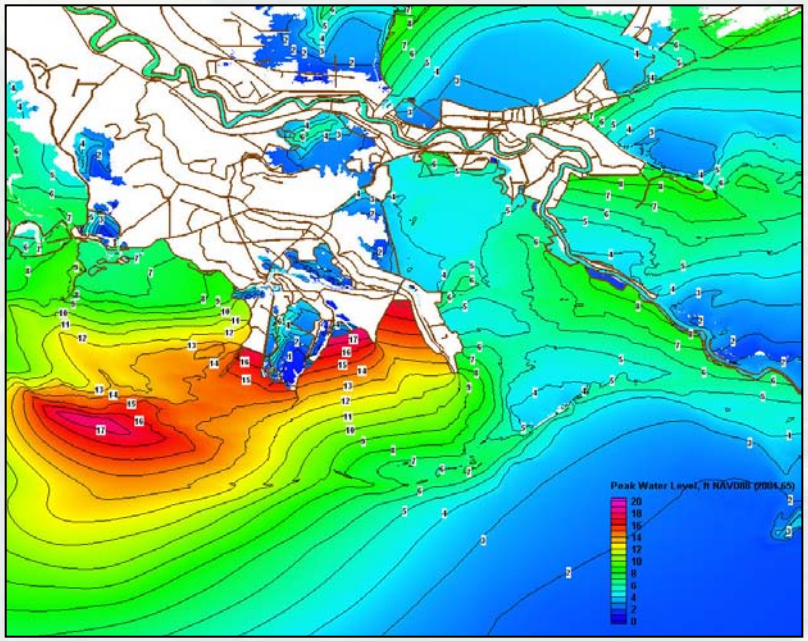
Storm 314

Without Project

With Project

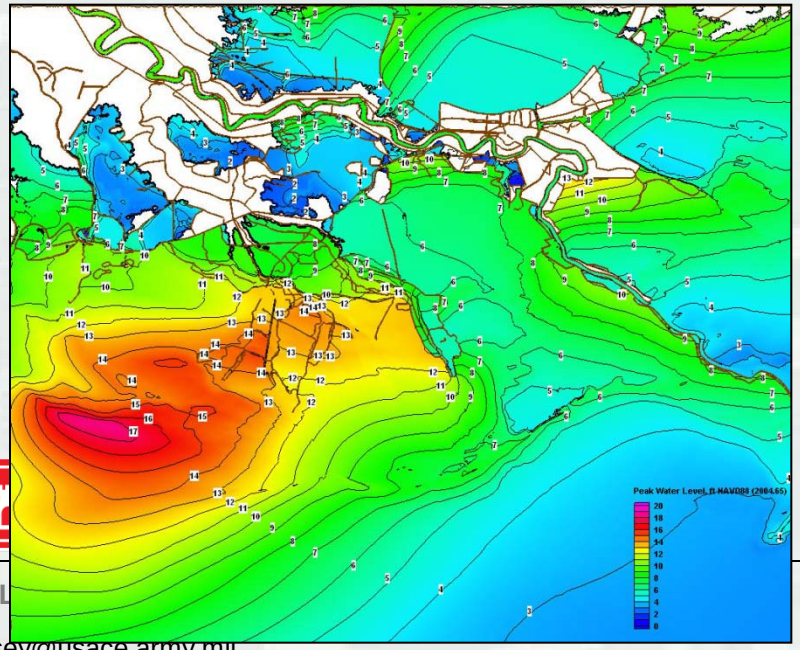
Existing Water Level

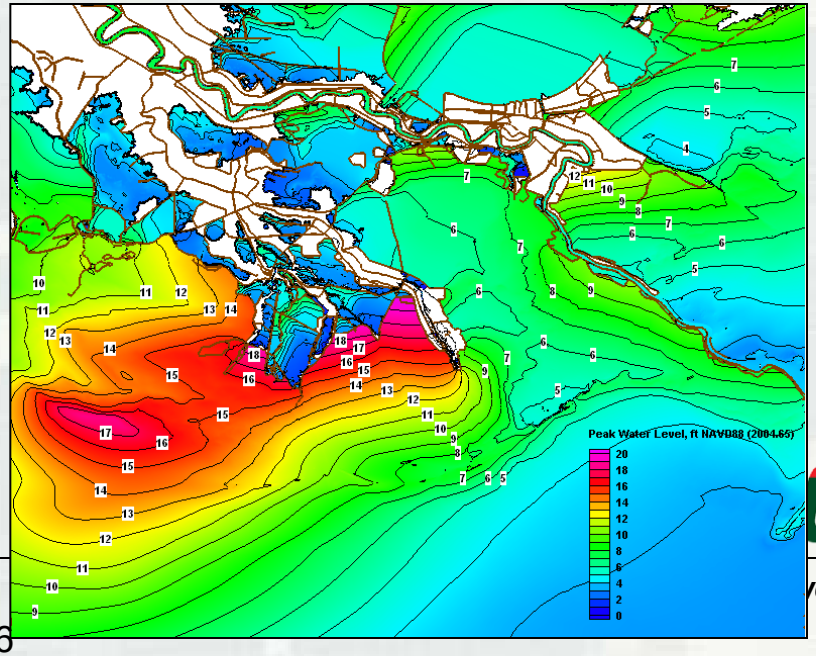




Existing Water Level

Sea Level Rise 0.35 m





Sea Level Rise 0.35 m

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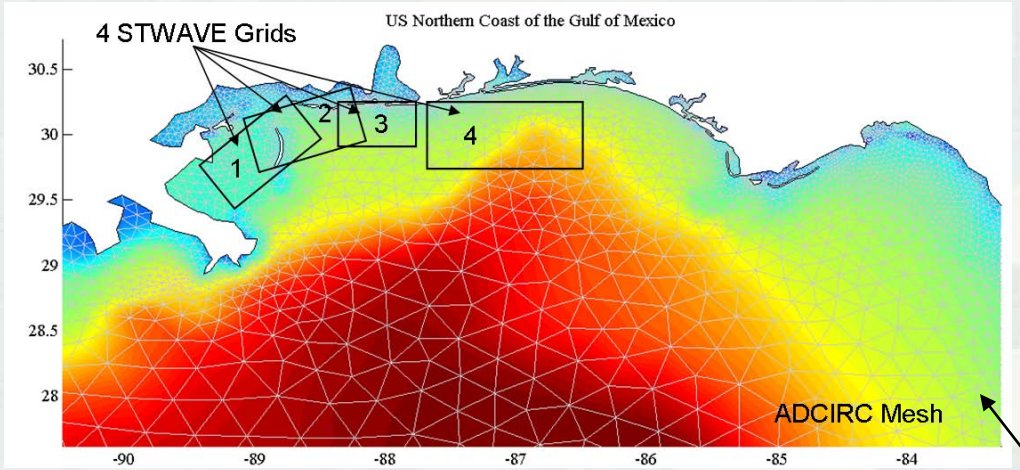
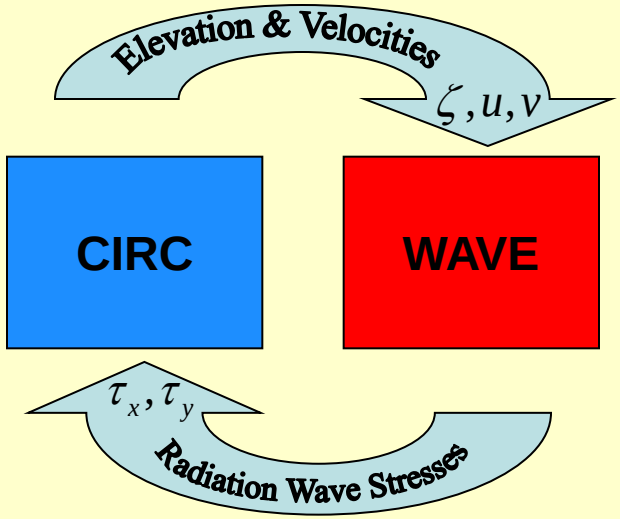
Tight Two-Way Coupling Circulation ←→ Wave

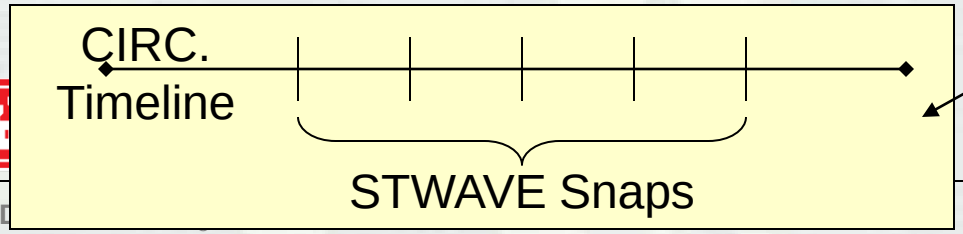
- One unstructured finite element circulation mesh
  - A single instance of ADCIRC/ADH
- One or more structured wave grids
  - Multiple instances of STWAVE
    - Half-Plane
    - Full-Plane



Information to Exchange



For consistency use the same winds and bathymetry (can be passed also)

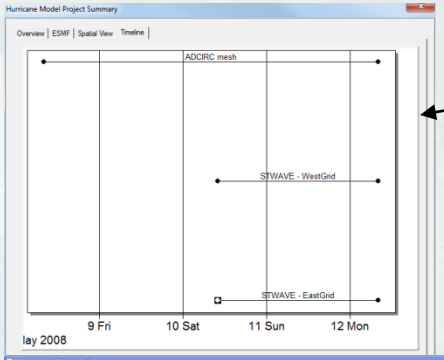


Need to be able to synchronize both time and spatial frames of reference.

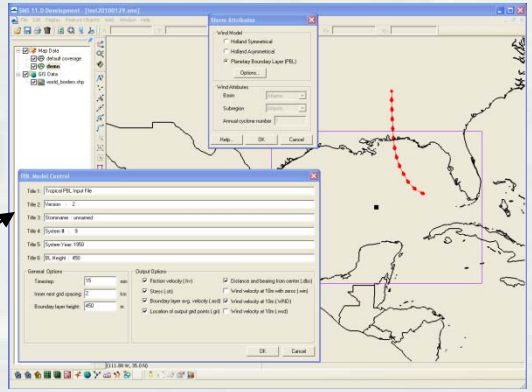
CSTORM-MS COASTAL STORM MODELING SYSTEM

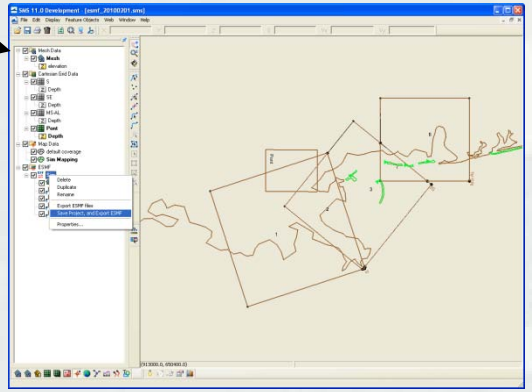
SMS GUI's

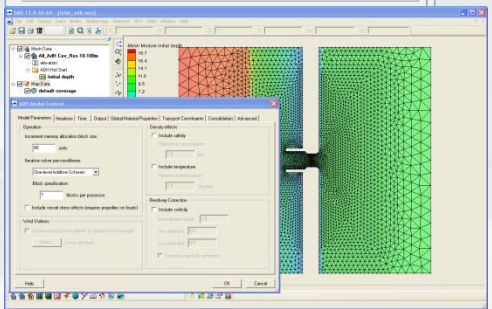
Through the SMS GUI's users can setup and execute models as well as visualize model results.

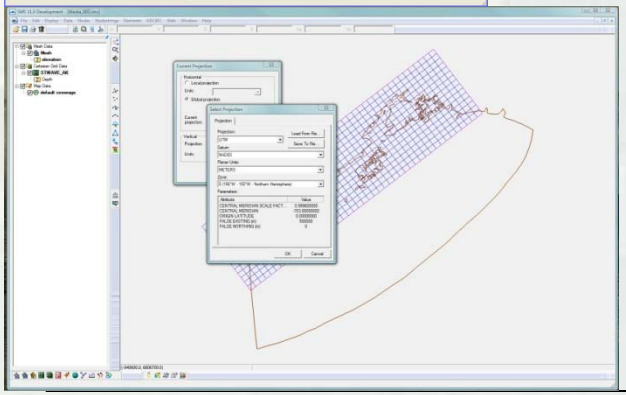


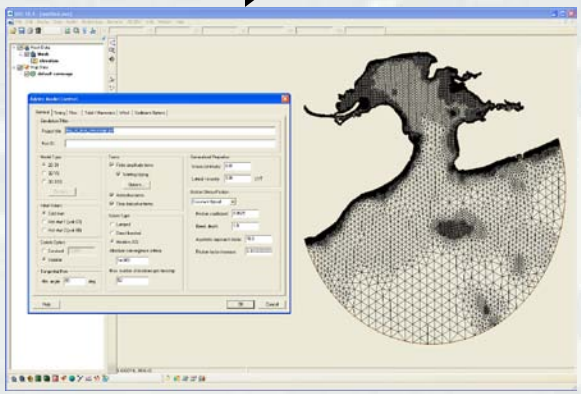
- New GUI for Project Overview
- New GUI for MORPHOS PBL Cyclone Model
- New GUI for CSTORM Coupled Models
- Updated GUI for AdH
- New GUI for WAM Wave Model
- Updated GUI for STWAVE
- Updated GUI for ADCIRC

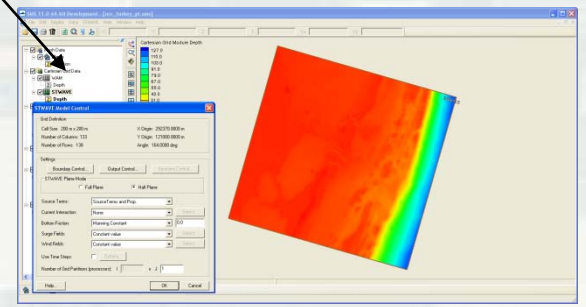












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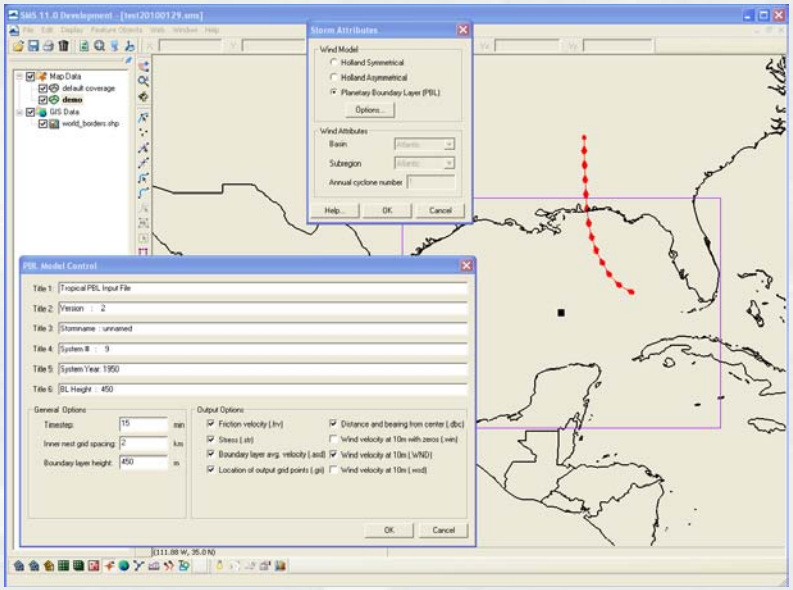
SMS GUI for Cyclone Models

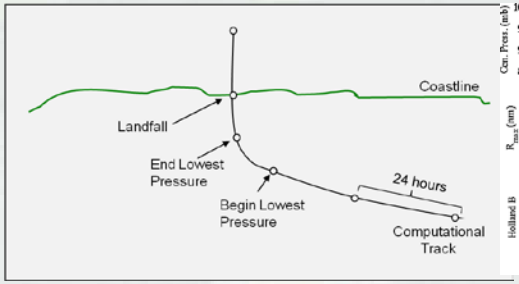


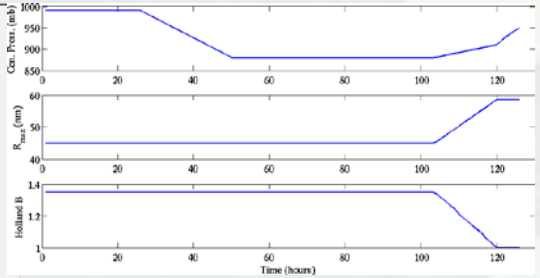
- Setup and run the MORPHOS-PBL Cyclone Wind Model*

*Updated version of TC96

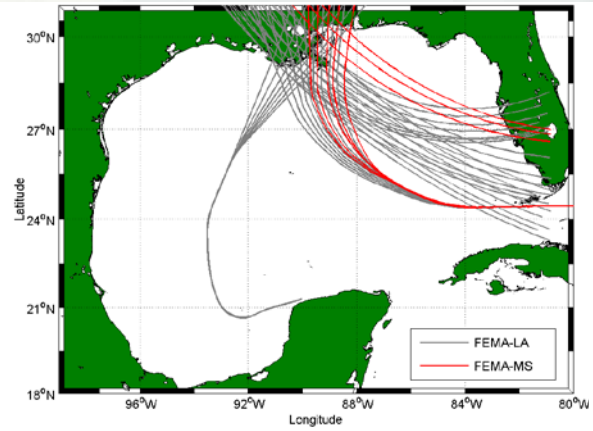
- Import storms from HURDAT

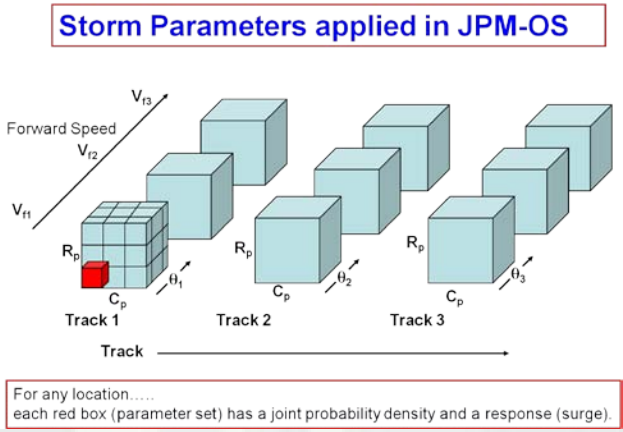
Synthetic storm profile generation routine

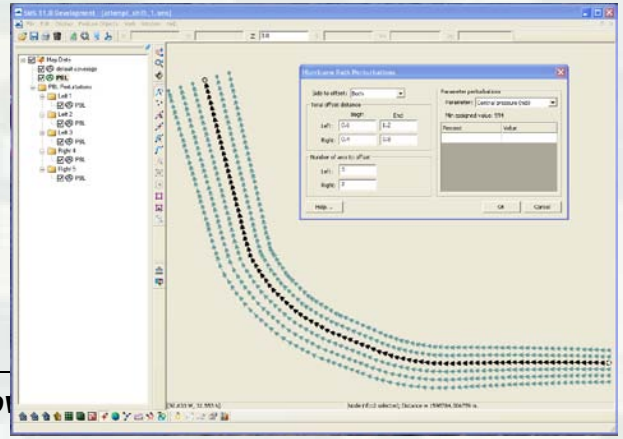




Easily create perturbations for storm track/characteristic



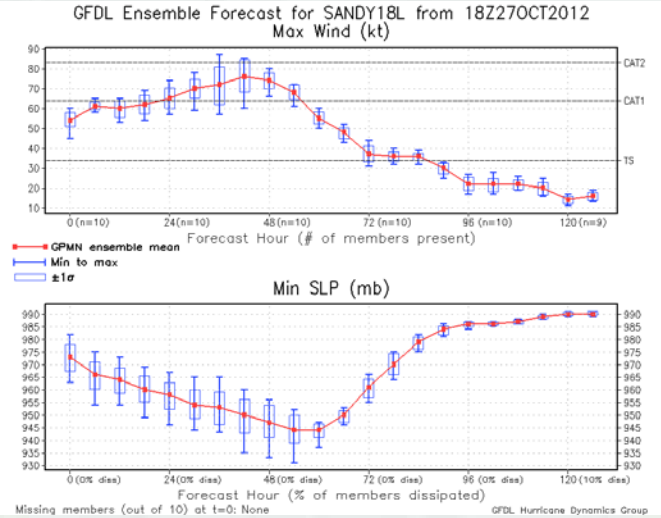


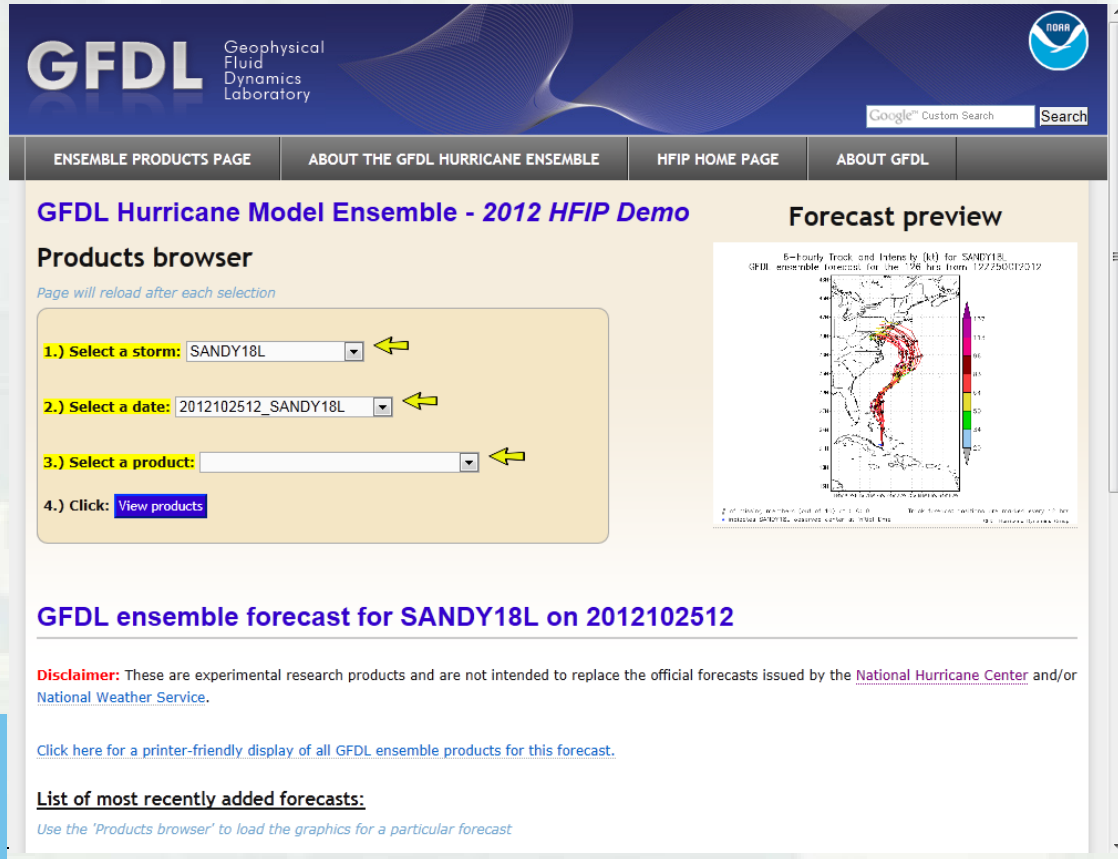


*GFDL Met Option for CSTORM

The NWS/Geophysical Fluid Dynamics Laboratory model. The GFDL and HWRF models are the only models that provide specific intensity forecasts of hurricanes. More detailed GFDL information is available at http://www.gfdl.noaa.gov.

1. Operational Hurricane Forecast
2. Ensemble Hurricane Modeling





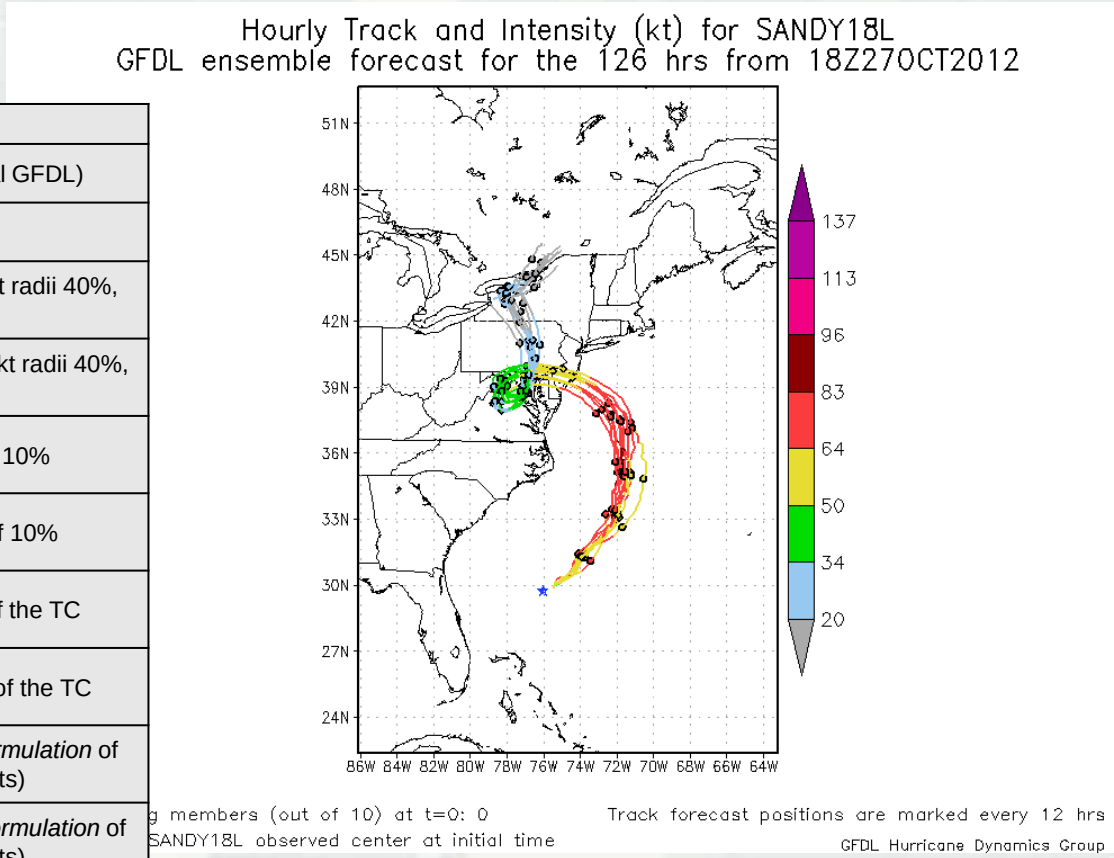
*This is an ongoing collaboration with Morris Bender and Matt Morin at NOAA's GFDL.

Innovative solutions for a safer, better world

*GFDL Ensemble for Hurricane Sandy

Ensemble Members

ATCF ID	Description
GP00/GT00	Control forecast (same model as NCEP 2013 operational GFDL)
GP01/GT01	Unbogussed forecast using the 2013 control model
GP02/GT02 ↑	Increase NHC-observed V_{max} 10%, 34-kt radii 25%, 50-kt radii 40%, ROCI 25%
GP03/GT03 ↓	Decrease NHC-observed V_{max} 10%, 34-kt radii 25%, 50-kt radii 40%, ROCI 25%
GP04/GT04 ↑	Modification to increase inner-core moisture by a max of 10%
GP05/GT05 ↓	Modification to decrease inner-core moisture by a max of 10%
GP06/GT06 ↑	Increase SSTs by a max of 1°C within the initial extent of the TC
GP07/GT07 ↓	Decrease SSTs by a max of 2°C within the initial extent of the TC
GP08/GT08 ↑	Surface physics modification: *GFDL 2011 operational formulation* of C_D & C_H (surface drag and enthalpy exchange coefficients)
GP09/GT09 ↓	Surface physics modification: *HWRF 2012 operational formulation* of C_D & C_H (surface drag and enthalpy exchange coefficients)
GPMN/GTMN	Ensemble mean computed at each lead time where the member availability is at least 4 members (40% threshold)



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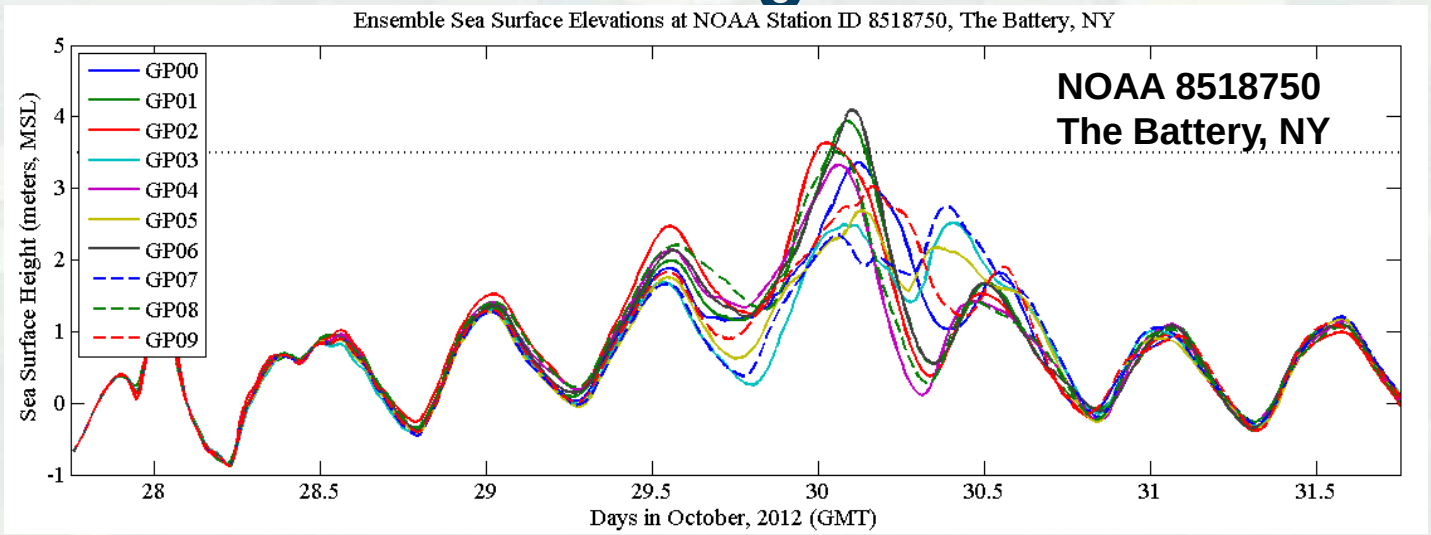
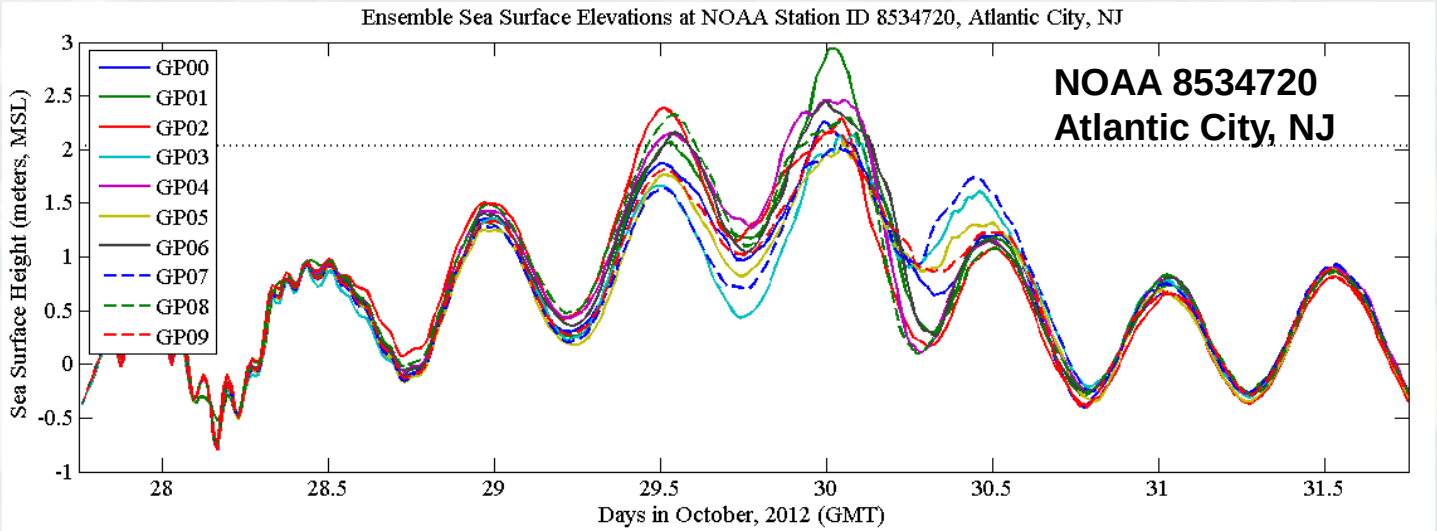
ADCIRC Sea Surface Elevations Using GFDL Ensemble (Sandy)

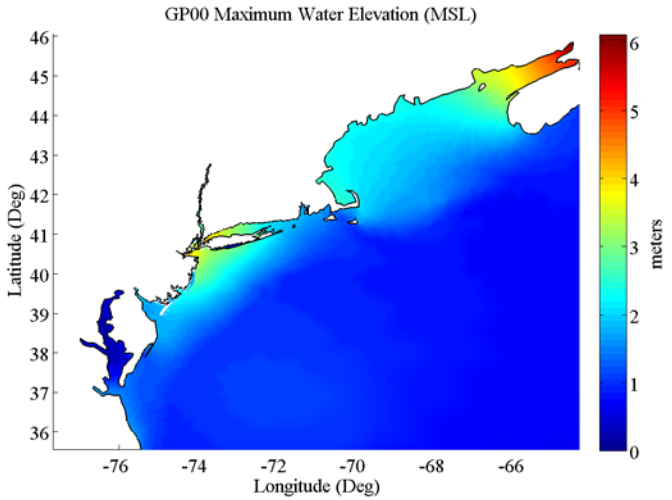


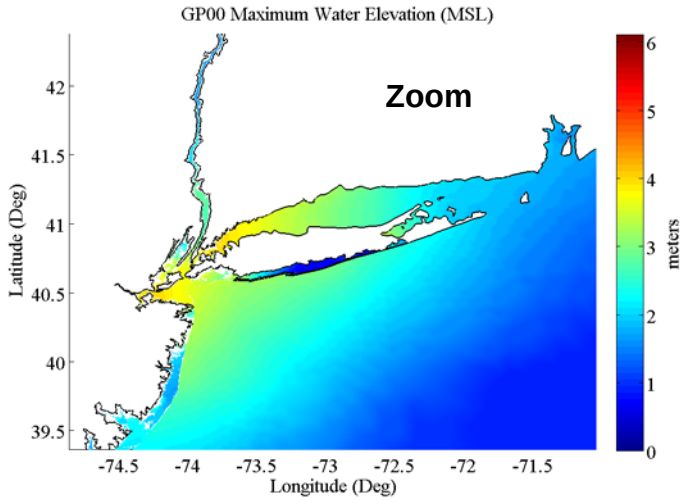


ADCIRC simulations included tides, winds and pressures (no waves)

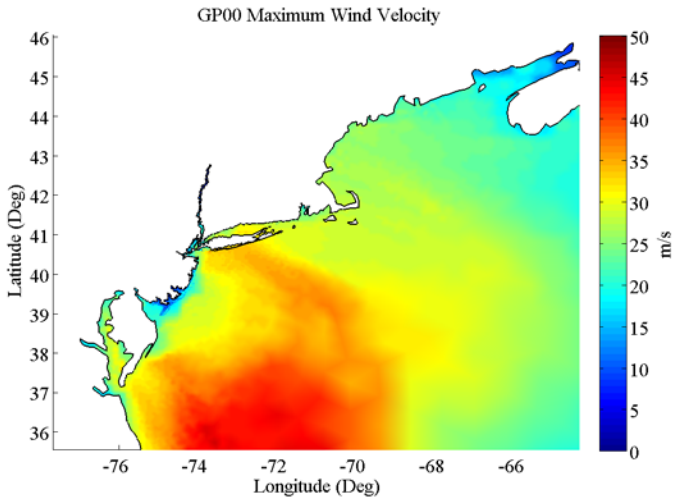
GFDL Ensemble from the 18Z Oct. 27, 2012 product

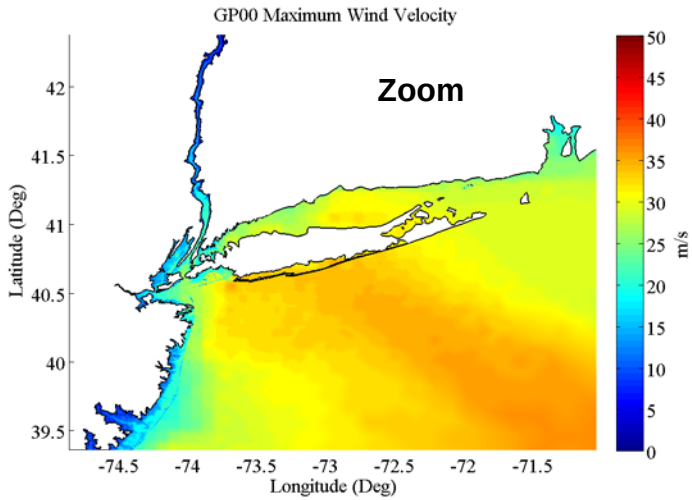
ADCIRC Maximum Sea Surface Elevations/Wind Velocity (GP00)





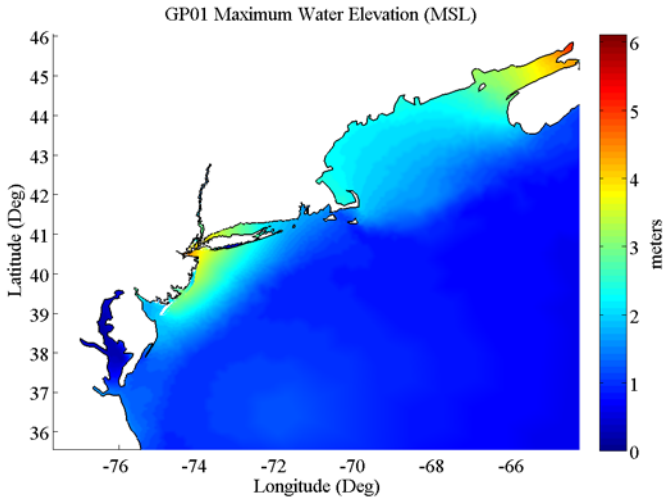
Maximum Sea Surface Elevation

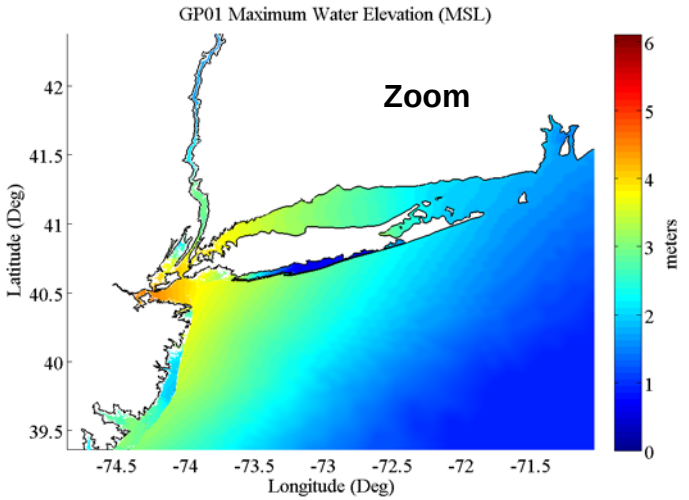




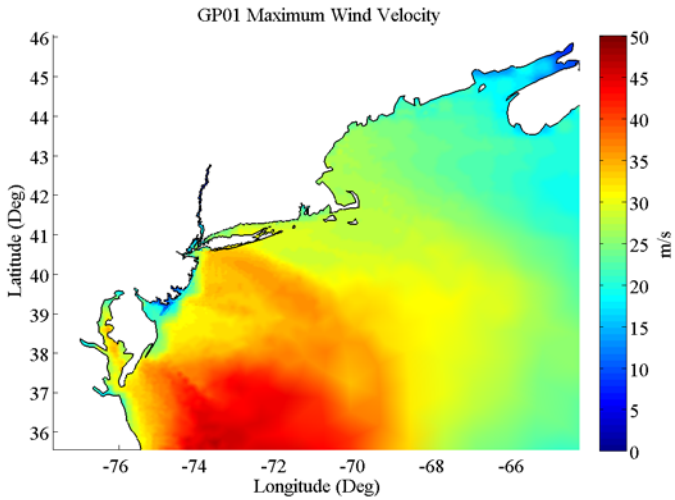
Maximum Wind Velocity (Interpolated)

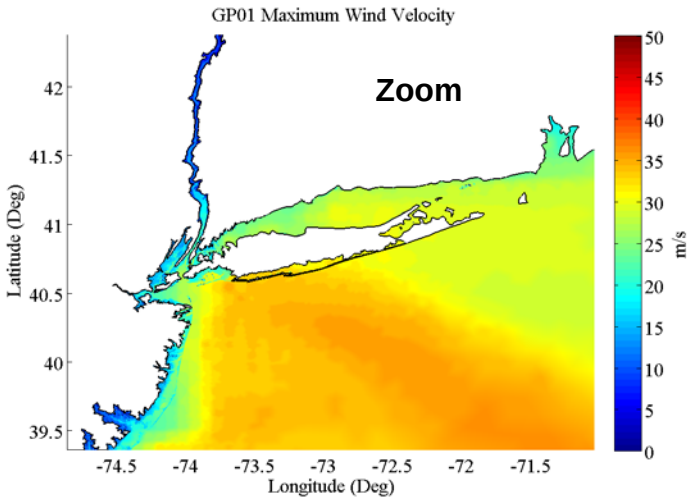
ADCIRC Maximum Sea Surface Elevations/Wind Velocity (GP01)





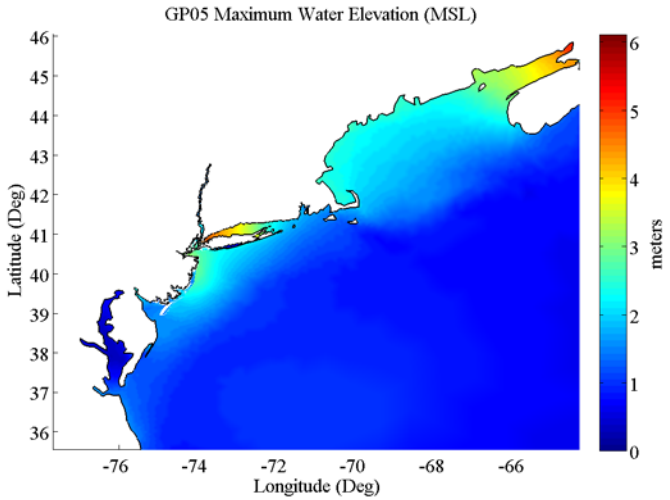
Maximum Sea Surface Elevation

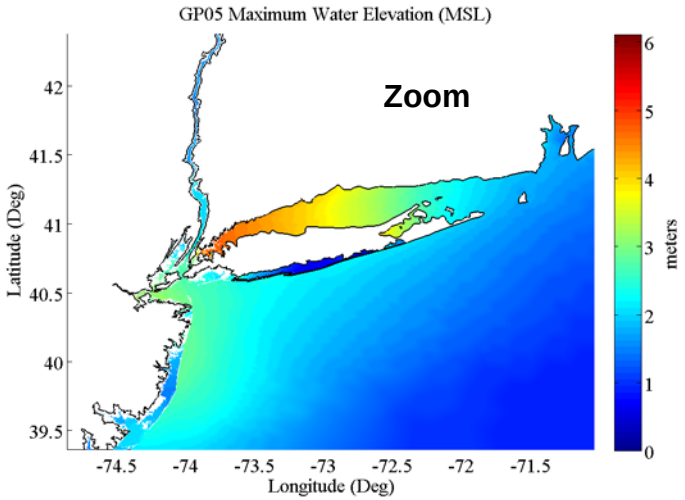




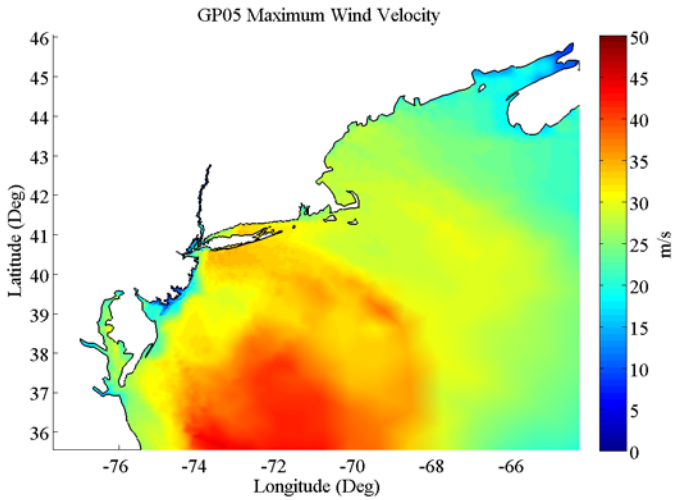
Maximum Wind Velocity (Interpolated)

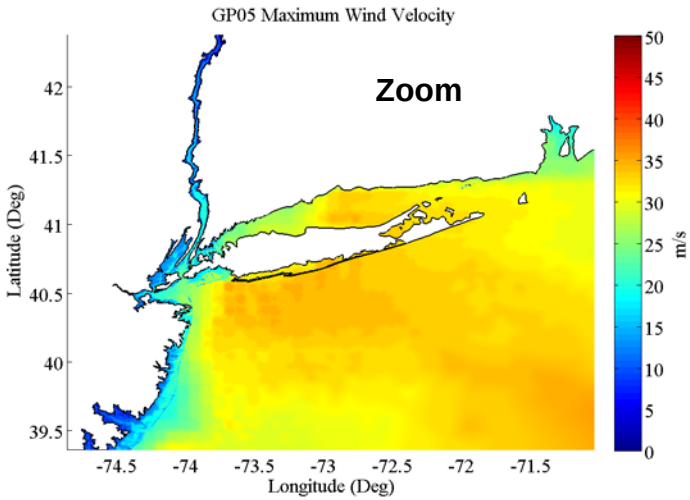
ADCIRC Maximum Sea Surface Elevations/Wind Velocity (GP05)





Maximum Sea Surface Elevation



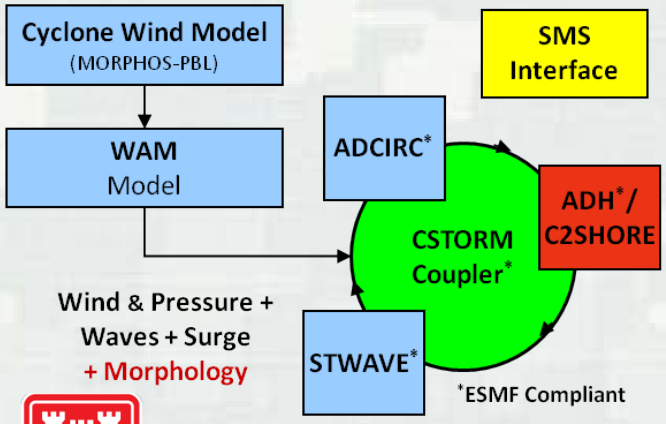


Maximum Wind Velocity (Interpolated)

Summary & Next Steps

- CSTORM-MS is a standardized, efficient, robust, extensible modeling system for quantifying the risk of coastal communities to storm events.
- Its' streamlined workflow saves time and reduces both computational and personnel cost.
- Linkage with GFDL ensemble products allows for "predictive" surge/wave modeling for impending coastal storm events.
- How to incorporate the ensemble "surge" results into a useful predictive product for USACE needs.

Project Level Mode



Ensemble Predicative Mode