

Northeast Coastal Ocean Forecast System (NECOFS): a FVCOM-based regional coastal and local inundation forecast tool

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Outline

1. NECOFS – basic description
2. NERACOOS inundation pilot project
3. IOOS “super-regional testbed” study
4. Summary

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NECOFS is a component of the Northeastern Regional Association of Coastal Ocean Observing Systems (NERACOOS)

NECOFS

Objectives:

1. Produce accurate 3-day forecast of surface weather, waves, water elevation, and 3-D ocean currents, temperature, salinity daily;
2. Distribute forecast results to federal (NWS, USCG, NMFS), state (CZM), town management, the research community and public via UMassD server and website.

Core Models:

WRF (Weather Research and Forecasting Model) – 3 nested domains, with horizontal resolutions of 27, 9 and 3 km, driven by NAM.

SWAVE – unstructured-grid surface wave model based on SWAN, using same grid as FVCOM and driven off-shelf by Wave Watch III.

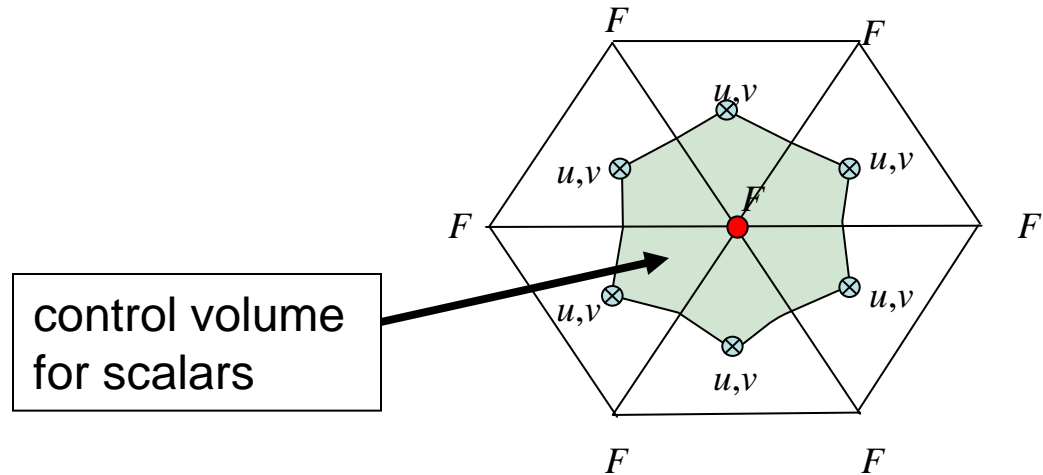
FVCOM (Finite Volume Coastal Ocean Model) – primitive-equation hydrostatic model, with unstructured grid in horizontal, generalized terrain-following coordinate in vertical, driven by surface wind stress, heat and moisture fluxes, river discharge, and boundary tide and ocean forcing.

FVCOM: Unstructured-grid, Finite-Volume Coastal Ocean Model

(Chen, C. R. H. Liu and R. C. Beardsley, JAOT, 2003)

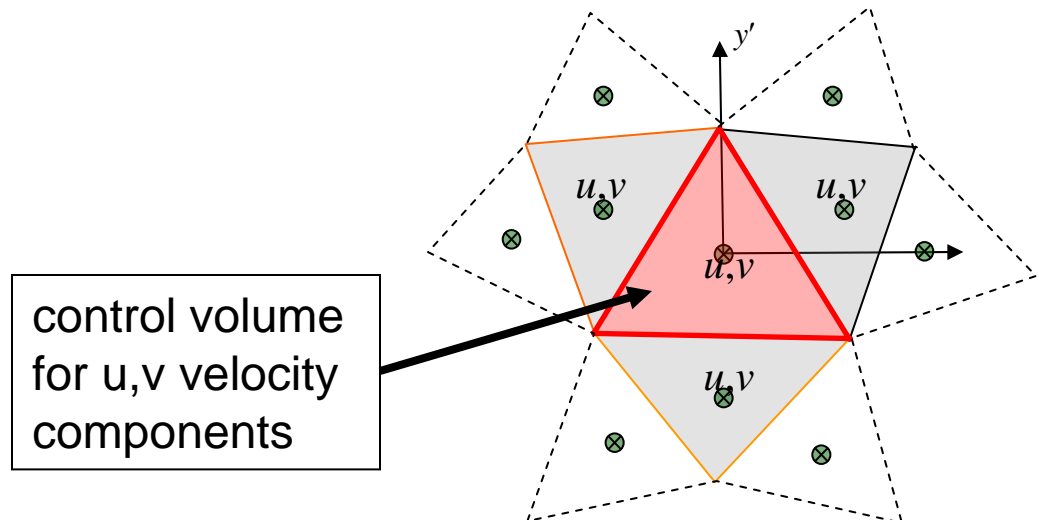
Key Features:

1. Computational domain consists of non-overlapping unstructured cells.
2. Generalized terrain-following coordinate in vertical.
3. Finite-volume approach provides
 - a) second-order accuracy and
 - b) conservation of mass, momentum, heat and tracer both locally and globally.



control volume
for scalars

$F : \zeta, T, S, \rho, H, K_m, K_h, \text{ etc}$



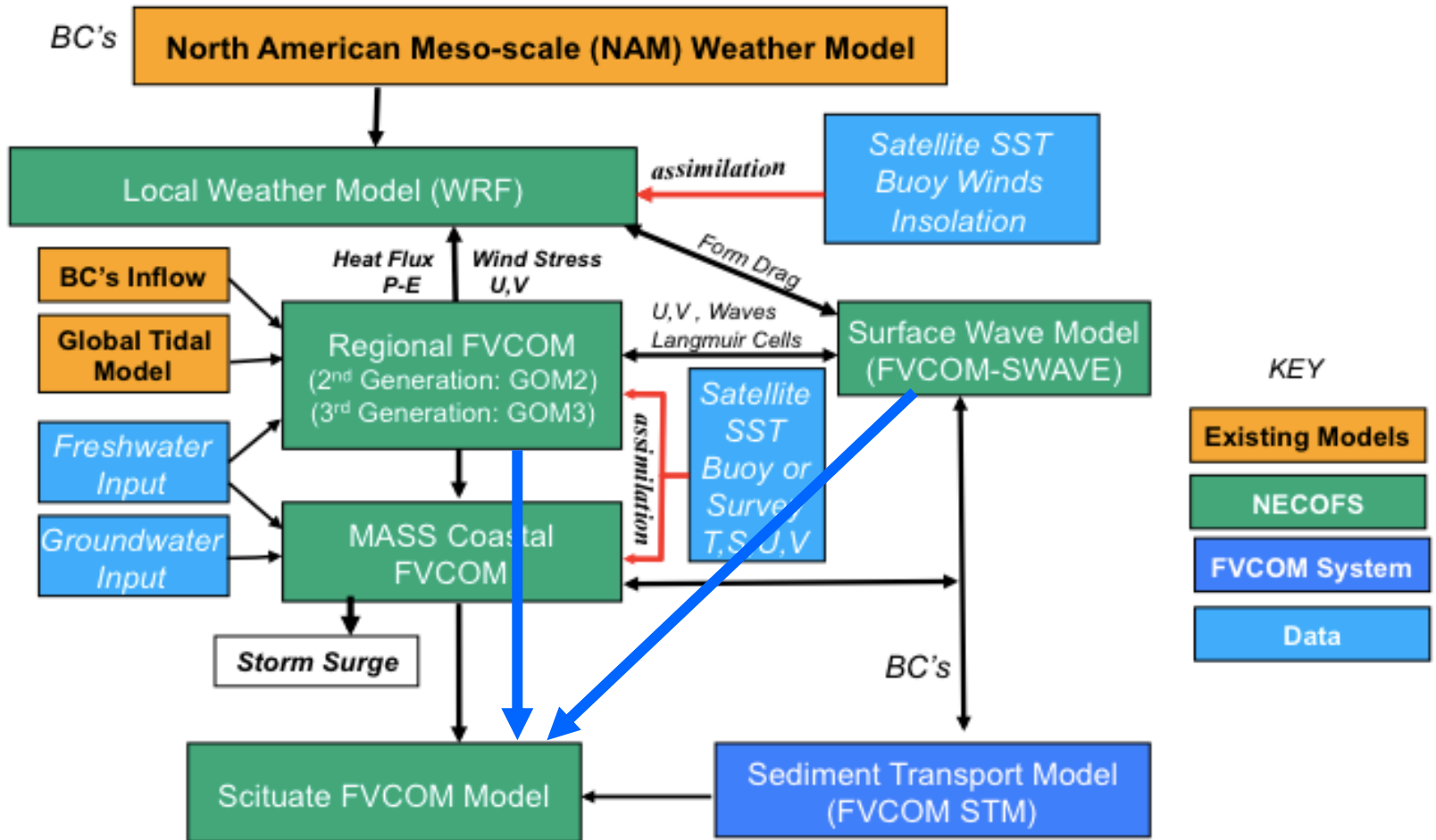
control volume
for u,v velocity
components

FVCOM 3.1

Key Features:

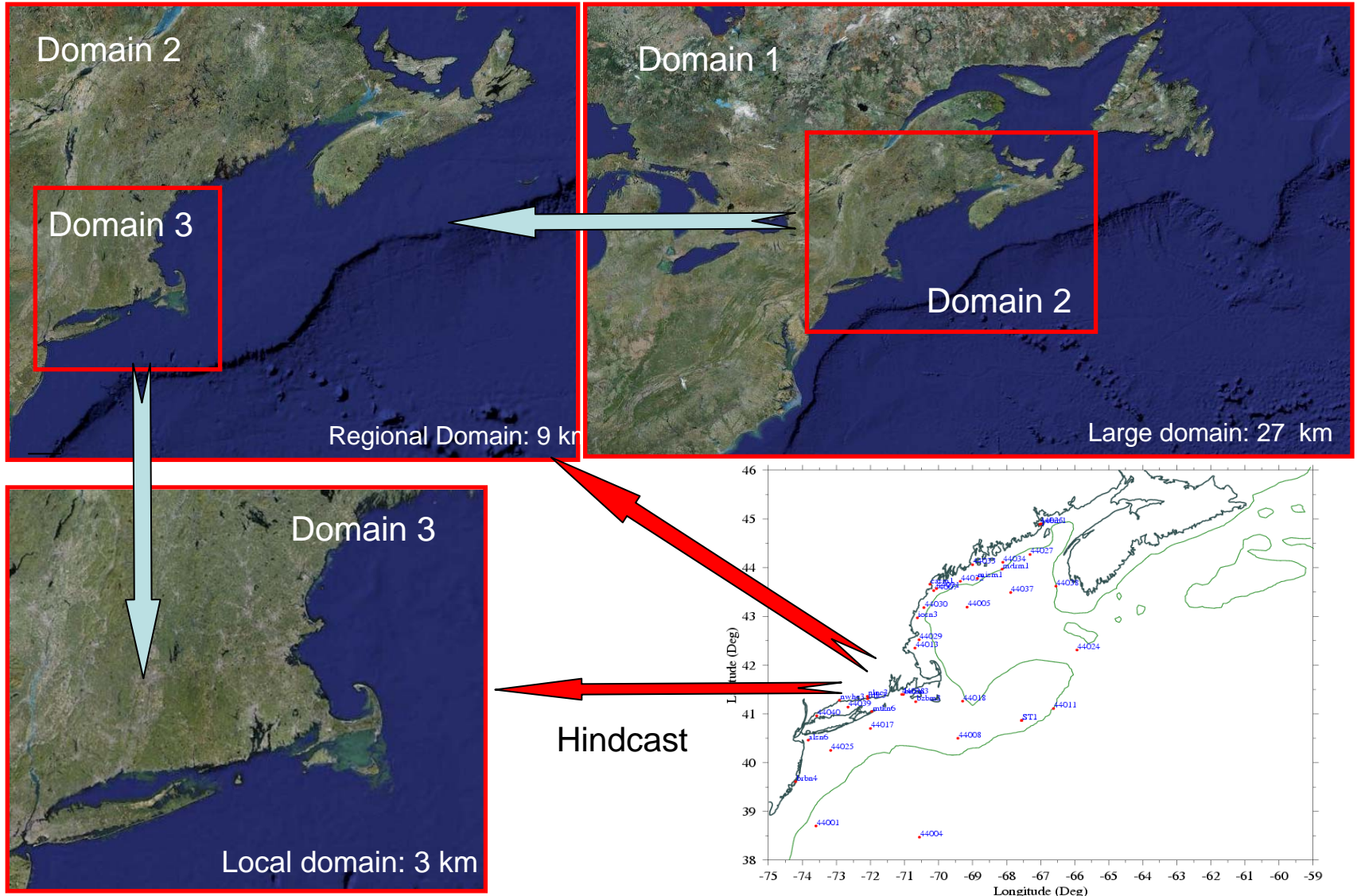
- Same basic horizontal, vertical grid structure as FVCOM 2.7
- 2nd order accurate, either split-mode or implicit
- Non-hydrostatic option
- Automatic nesting capability
- Dike/groyne module
- All input files are in NetCDF format, which allows ViSiT to view initial fields
- Various assimilation algorithms allowed to be run simultaneously for different variables
- Data exchange between computer nodes uses the “POINT” to improve the computational efficiency

Northeast Coastal Ocean Forecast System (NECOFS) (Scituate Inundation Forecast System)



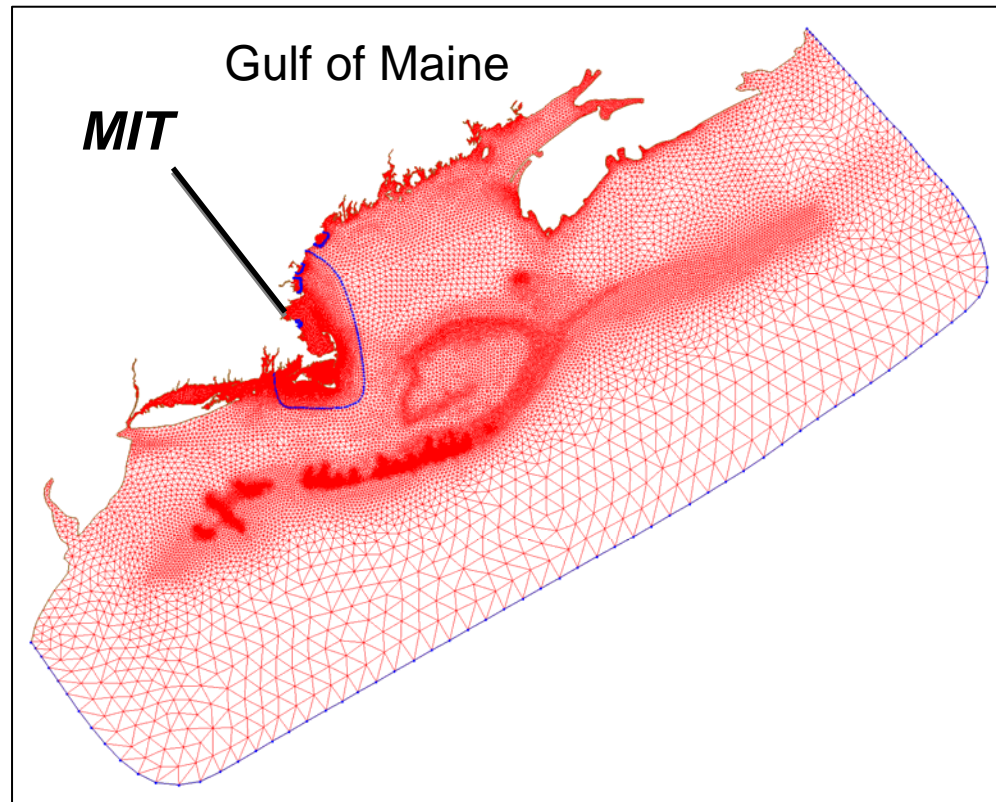
NECOFS WRF Nested Model Forecast Domains

9-km Regional Domain 2 used to drive regional GOM3 and local Mass Coastal FVCOM, Scituate and Saco FVCOM forecast models



NECOFS 3rd regional grid (GOM3)

- Horizontal resolution: 0.3-1.0 km in the coastal region.
- Vertical: 46 layers: 10 uniform layers in the surface and bottom boundary layers, respectively.
- 1500-m cutoff off Georges Bank
- Grid: ~ 91K horizontal cells
- $\Delta T = 30$ sec (explicit)
- Run time: ~1.3 hr (3-day forecast)
- 14 x 4 cpu's
- Capable to nest to the coastal-estuarine model with a horizontal resolution of ~10-500 m



NERACOOS inundation forecast pilot project

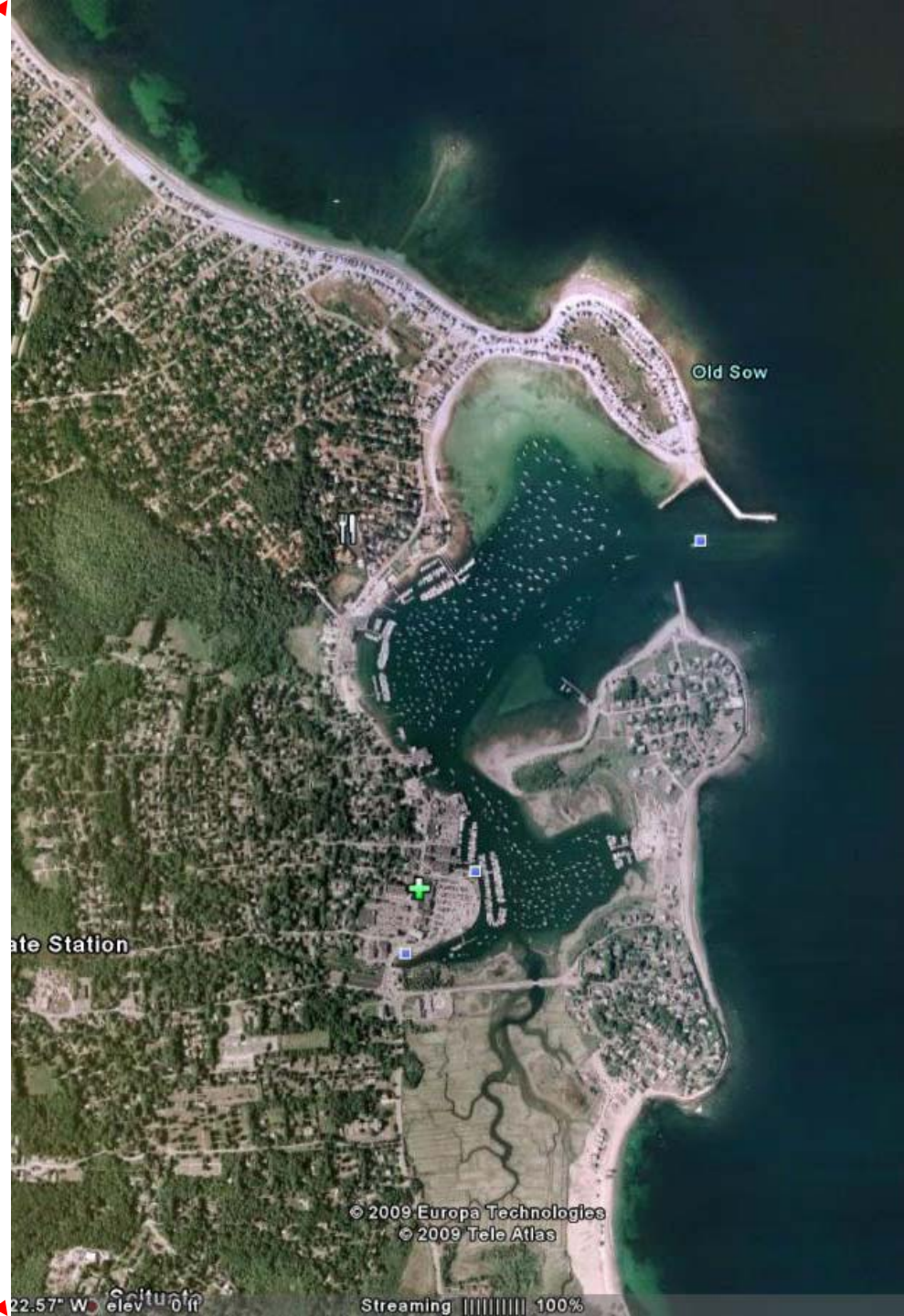
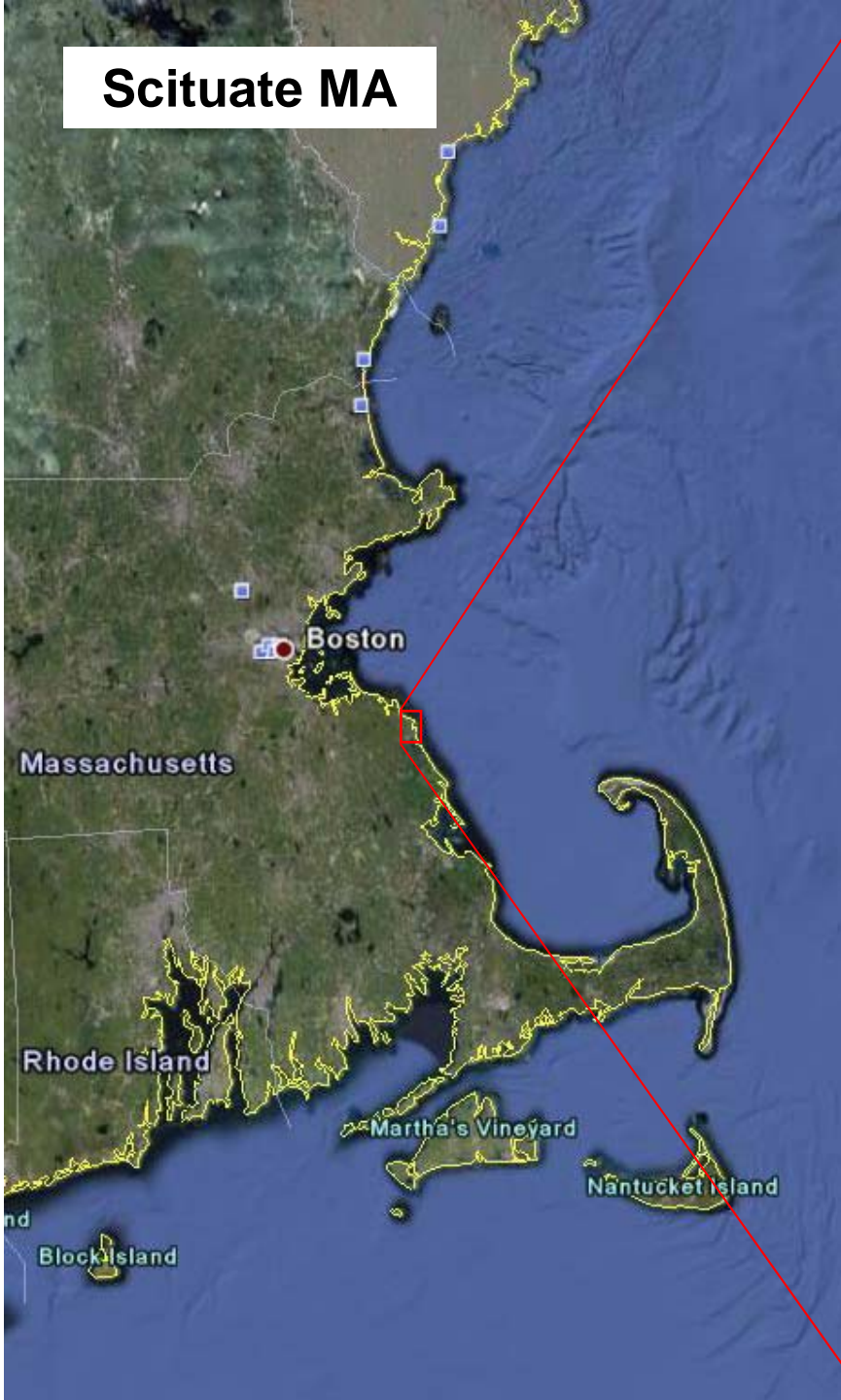
Objective:

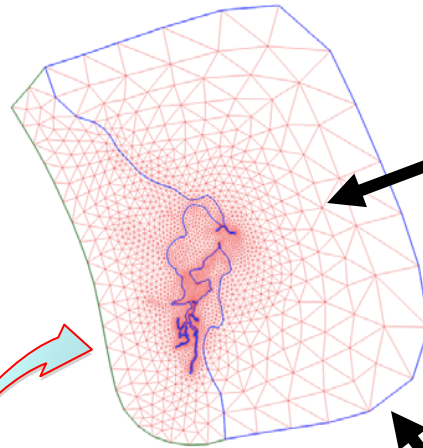
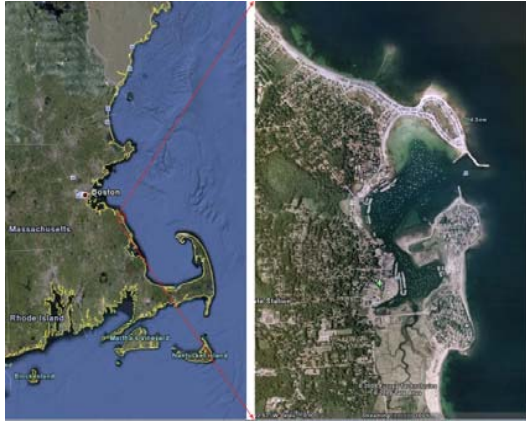
1. Develop local Inundation Forecast System (IFS) for two sites, **Scituate** (MA) and Saco (ME)
2. Serve 3-day forecast to local NWS Weather Forecast Offices, state and town management, and public in useful formats

Approach:

1. Construct **Scituate** inundation model grid using recent LIDAR, USGS bathymetry, state elevation data, etc.
2. Construct **Scituate** IFS with FVCOM 3.1 wetting/drying, dike/groyne overflow treatment, wave-current interaction, wave radiation stress (Warner et al 2005)
3. Drive **Scituate** IFS with NECOFS GOM3 – 1-way nesting

Scituate MA

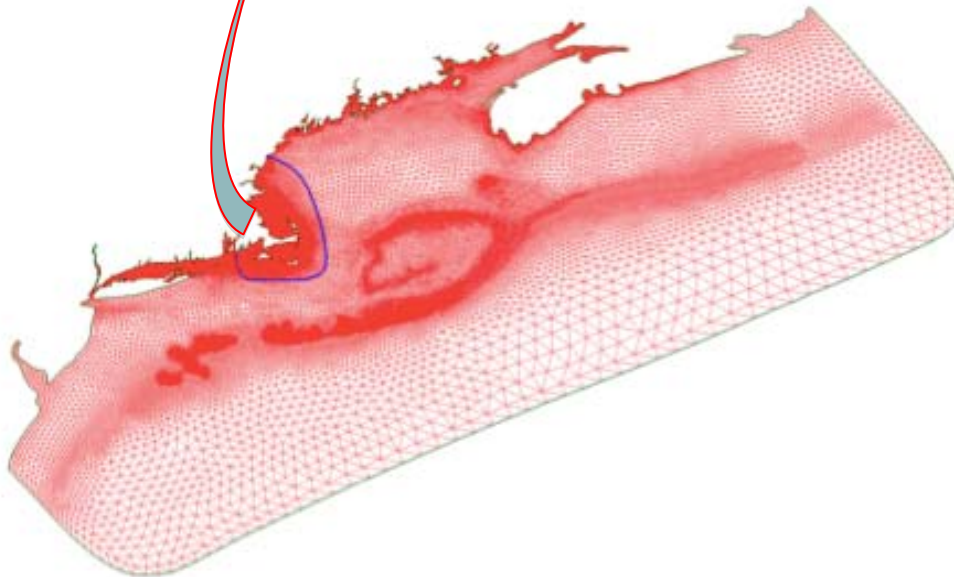




Surface BC's

1. WRF: wind stress, heat flux, moisture flux

One-way nesting



Ocean BC's

1. *FVCOM GOM3*: surface elevation, 3D currents, T, S
2. *FVCOM-SWAVE*: surface waves

Put in movie

SUPER-REGIONAL TESTBED TO IMPROVE MODELS OF ENVIRONMENTAL PROCESSES ON THE U.S. ATLANTIC AND GULF OF MEXICO COASTS

Purpose:

Provide NOAA and other governmental agencies meaningful guidance on the behavior (e.g., accuracy, robustness, execution speed) and implementation requirements (e.g., resolution, parameterization, computer capacity) of models that they presently have in “*operational use*”, or that may be under consideration for such use, for computing total water level (including hydrologic runoff, tides, surge and waves) and associated inundation.

IOOS-funded SURA project – 6/2010 – 6/2011+

Total Water Level and Inundation Testbed

R. Luettich (UNC) – Lead PI

Approach:

1. Evaluate models through systematic hindcast inter-comparison and skill assessment versus observed data.
2. Look for bias, accuracy vs performance, and robustness of model formulations and parameterizations.

Testbed settings:

1. Tropical storms in the Gulf of Mexico
2. Extratropical storms in the Gulf of Maine

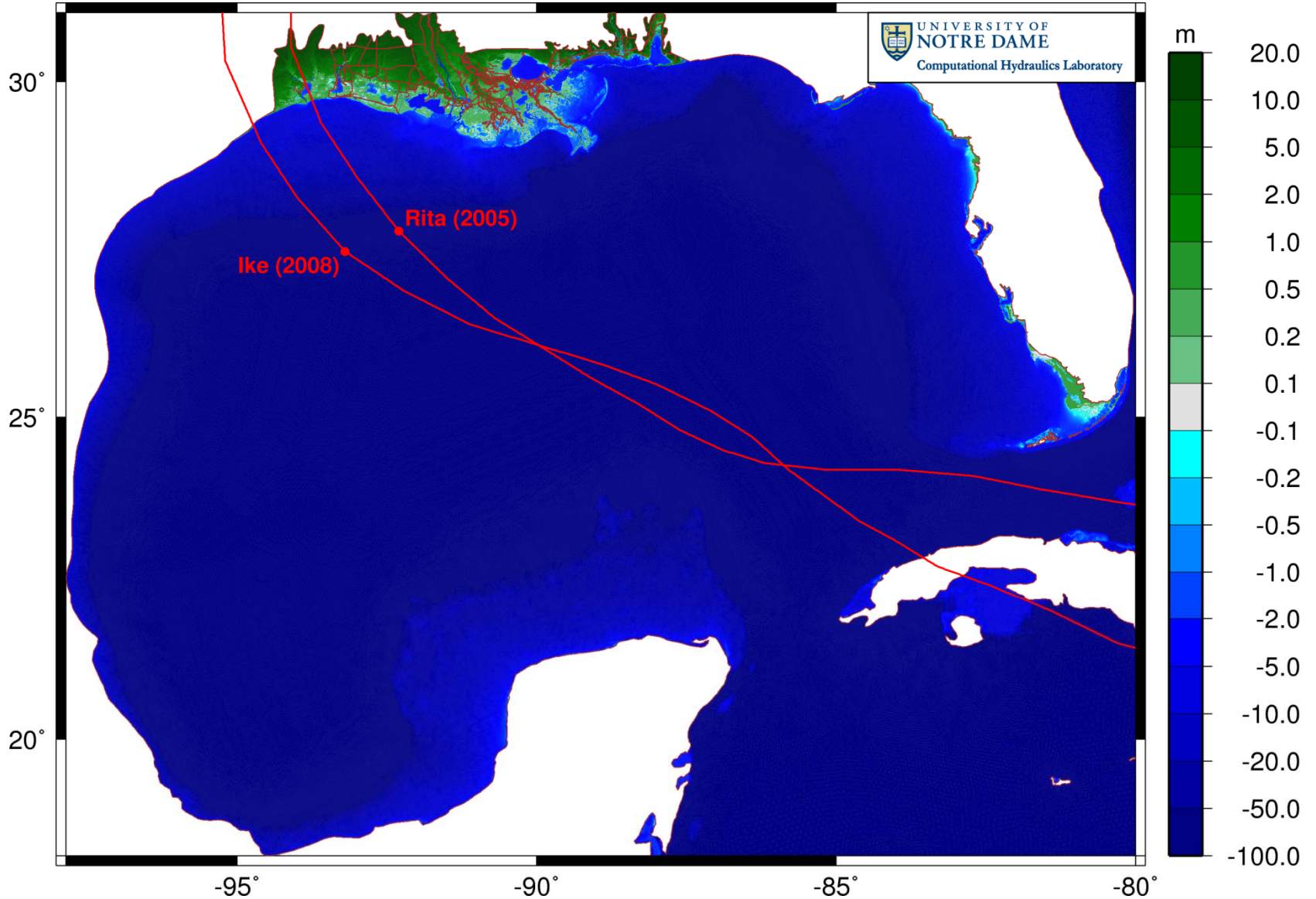
Tropical Storm Testbed Component

- **Objective:** investigate abilities of testbed inundation models to hindcast total water level (TWL) and inundation for Hurricanes Ike and Rita in the northern Gulf of Mexico
- **Site/Grid:** Louisiana-Texas coast/modified **ADCIRC** Gulf of Mexico inundation grid

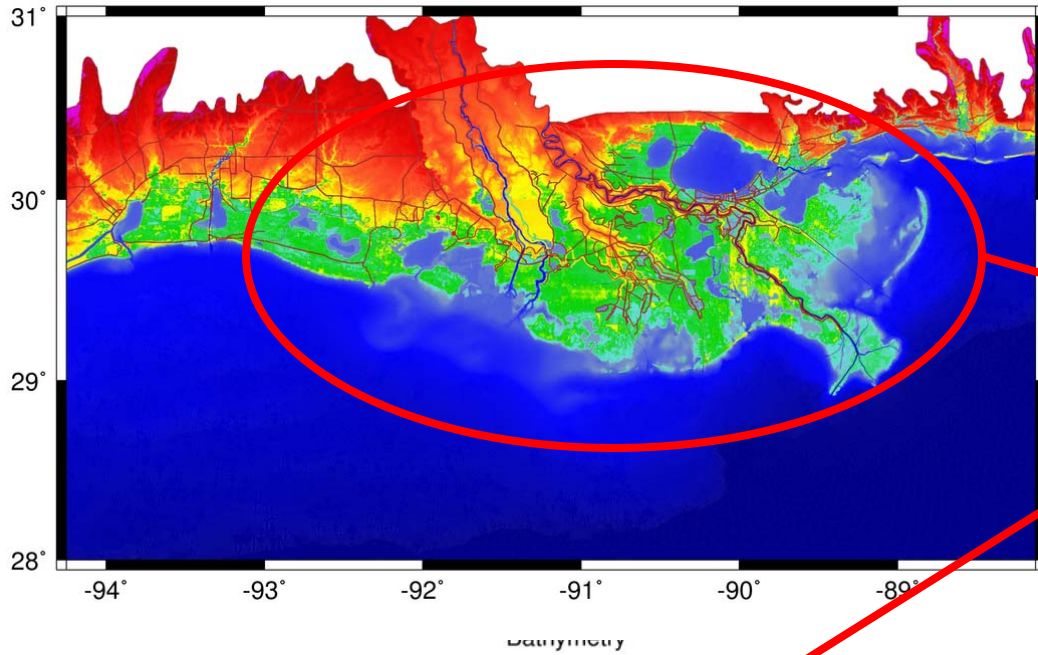
<i>Ocean Model</i>	<i>Wave Model</i>	<i>Lead PI</i>
FVCOM 3.1	SWAVE	C. Li (LSU)
ADCIRC 49	unSWAN	J. Westerink (UND)
SELFE	WWM	H. Wang (VIMS)
SLOSH	unSWAN	D. Slinn (UF)
-	WWIII/unSWAN/SWAVE	W. Perrie (BIO)

Proposed Tropical Storms - Gulf of Mexico

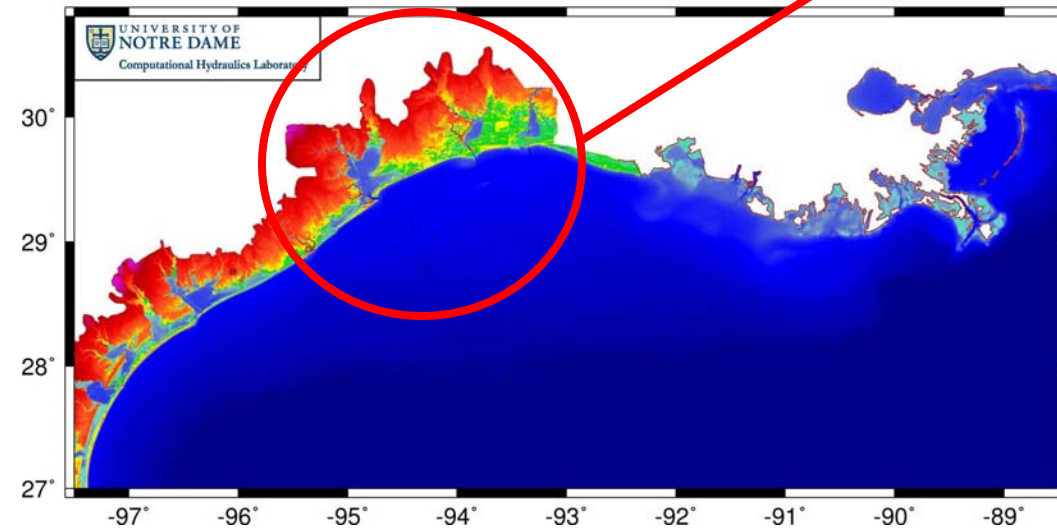
Ike (2008) and Rita (2005)



Proposed Gulf of Mexico Unstructured Mesh



SL-TX-Lite Mesh
2.1 million nodes

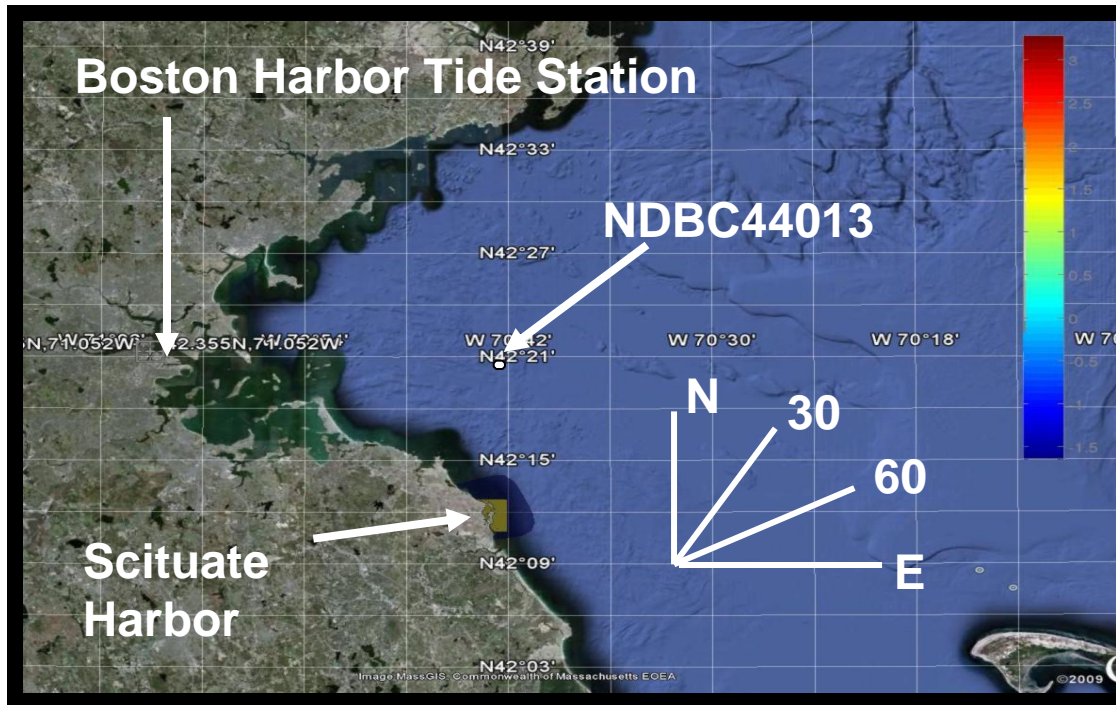


Extratropical Storm Testbed Component

- **Objective:** investigate abilities of testbed inundation models to hindcast total water level (TWL) and inundation for two major extratropical storms in the Northeast US
- **Site/Grid:** **Scituate** FVCOM inundation grid, with initial conditions and boundary conditions supplied by NECOFS GOM3 regional grid.

<i>Ocean Model</i>	<i>Wave Model</i>	<i>Lead PI</i>
FVCOM3.1	SWAVE	C. Chen (UMassD)
ADCIRC49	unSWAN	J. Westerink (UND)
SELFE	WWM	H. Wang (VIMS)
SLOSH	SWAN	D. Slinn (UF)
	WWIII/unSWAN/SWAVE	W. Perrie (BIO)

Extratropical Storms for Scituate Study



Storm	TWL (ft)	Wave Ht (ft)	Wave Per (s)	Wind Spd (kts)	Wind Dir (°)	Impact Level
<i>May 25, 2005</i>	13.8	13.0	6.5	39	30	Moderate
<i>Patriots' Day April 17, 2007</i>	13.8	19.7	8.4	28	30	Moderate

TWL: Boston tide station; Wave and wave statistics: Boston NDBC44013; Impact Level: Scituate - Taunton WFO

Summary

- NECOFS regional GOM3 forecast system operational with FVCOM 3.1
- NECOFS Scituate Inundation Forecast System (IFS) in final testing mode and should be operational this fall
- IFS can be transitioned to other sites (Saco, ...)
- IOOS testbed should provide new insights into the performance and hopefully ideas to optimize and improve ACIRC, FVCOM, SELFIE and wave models for inundation forecasting

Acknowledgements

The authors want to acknowledge the other members of the FVCOM and NECOFS development team plus members of the FVCOM user community who have help improved FVCOM through their questions, bug/error discoveries, and suggestions for improvements.

NECOFS is a component of NERACOOS (the Northeastern Regional Association of Coastal Ocean Observing Systems)

<http://www.neracoos.org/>

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