NC STATE UNIVERSITY

Update on ADCIRC Coupling for Nearshore Simulations of Hurricane Isaac and SCOPE

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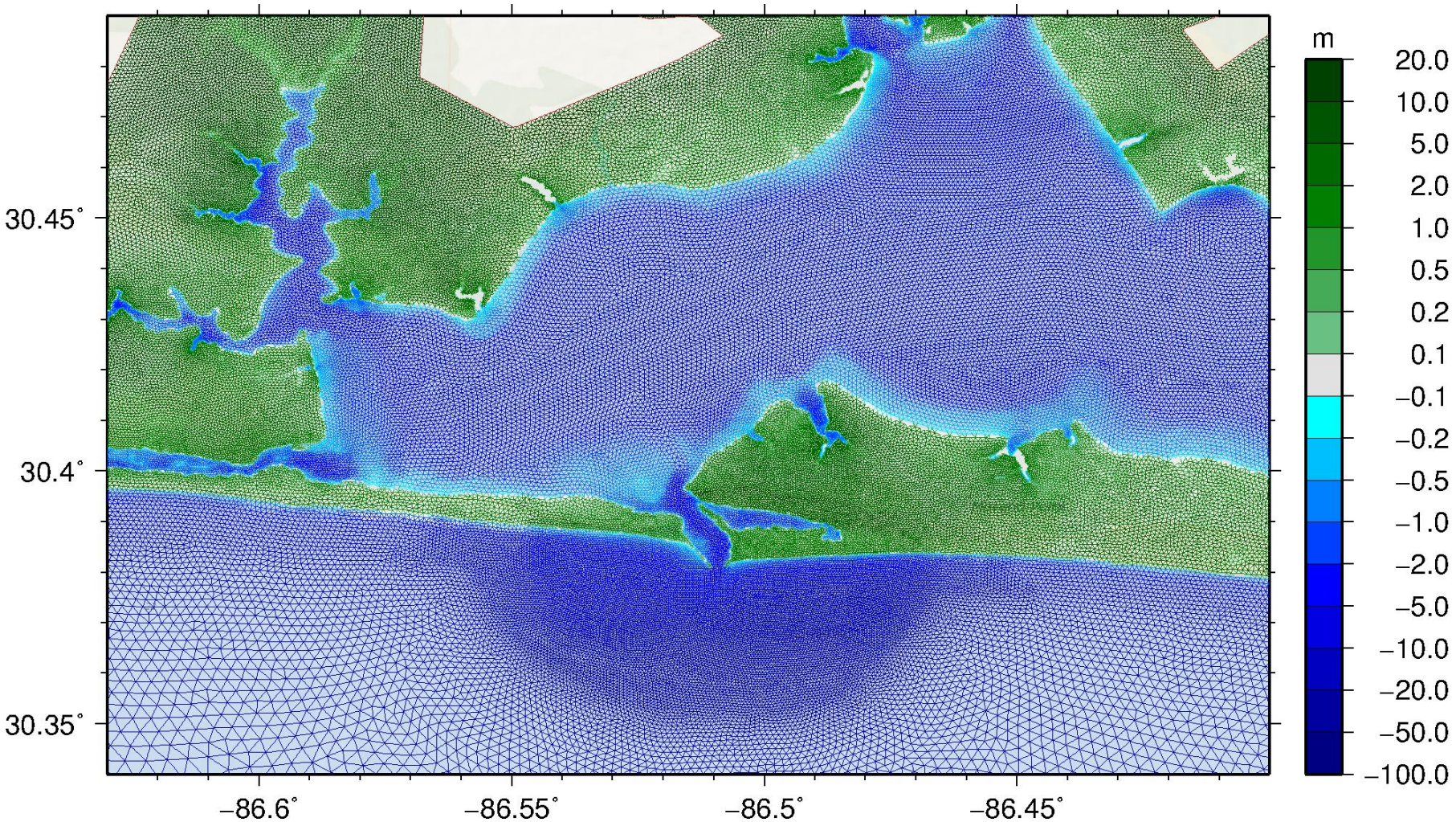
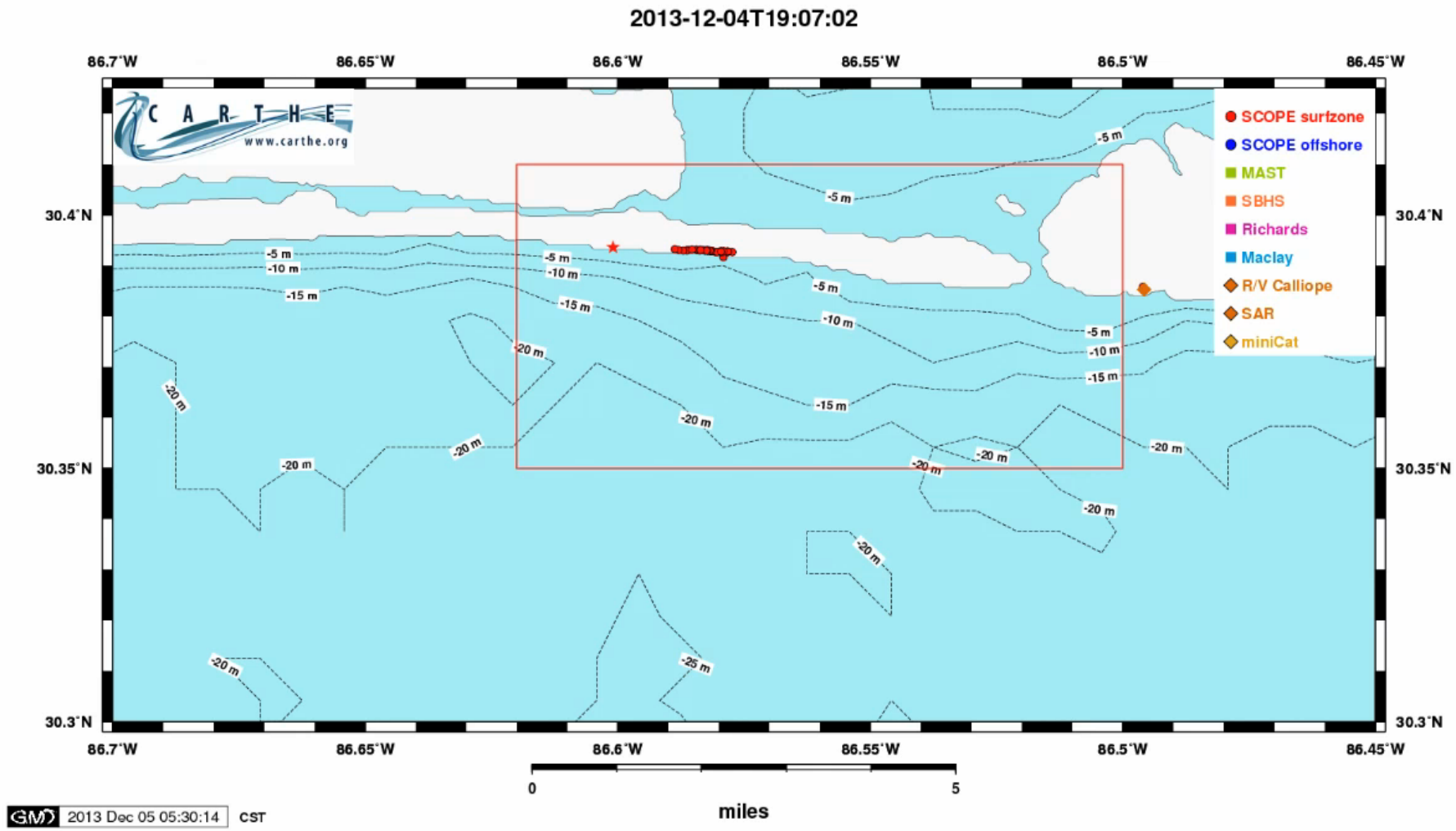
SCOPE - Unstructured Mesh of Florida



SCOPE - Drifters



During SCOPE - Our Predictions

Can we predict the surface currents in the surfzone?

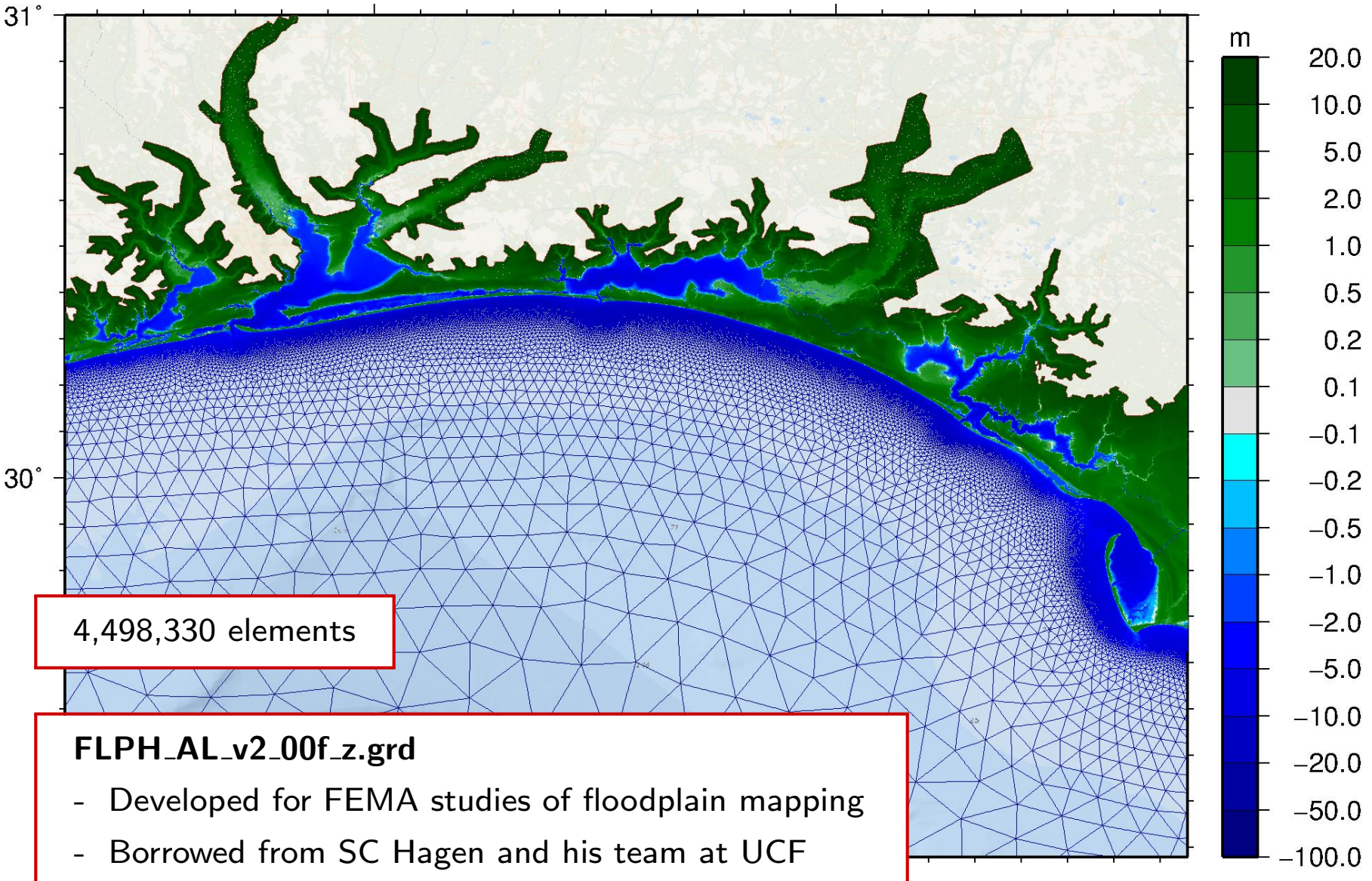
- Useful for field teams as they plan their daily experiments
- **Need to consider baroclinic 3D flow due to density gradients**

If we have ...

1. High-resolution mesh of the Florida coastline
2. Surface boundary conditions for atmospheric pressures, wind speeds, and heat fluxes
3. Initial and boundary conditions for temperature, salinity, etc.

... then we can provide guidance during the experiments

During SCOPE - Florida Panhandle - Full Mesh

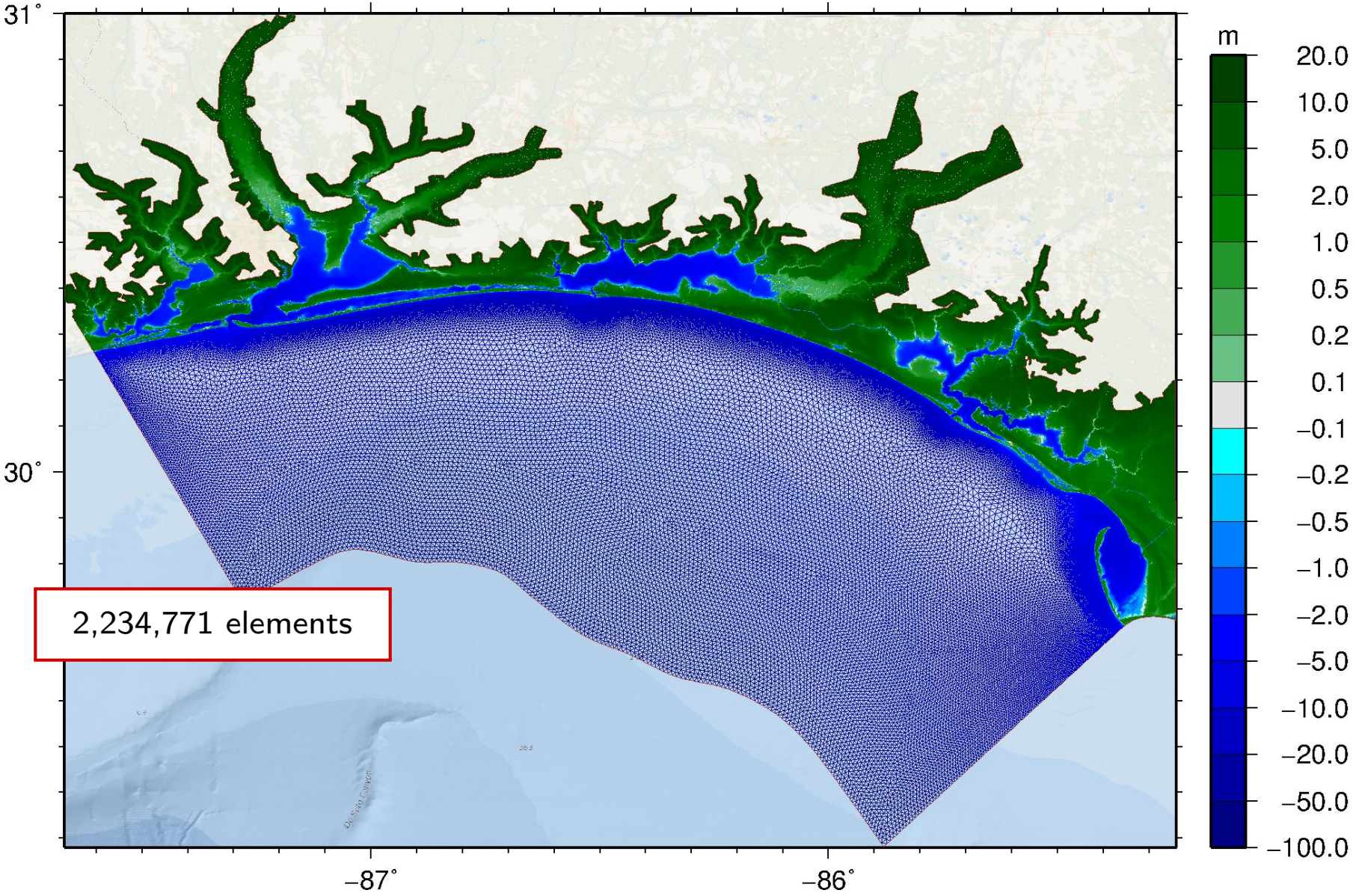


4,498,330 elements

FLPH_AL_v2_00f_z.grd

- Developed for FEMA studies of floodplain mapping
- Borrowed from SC Hagen and his team at UCF

During SCOPE - Florida Panhandle - Shelf



During SCOPE - Coupling with HYCOM

Initial and boundary conditions are provided through a coupling with the HYbrid Coordinate Ocean Model (HYCOM):

- Connect with existing expertise in CARTHE
- NRL operates a high-resolution forecast system for the Gulf
  - Horizontal resolution of $1/25^\circ$ (about 3.5km) with 20 vertical surfaces
  - Navy Coupled Ocean Data Assimilation (NCODA)
    - Satellite altimeter observations
    - Satellite and in situ sea surface temperatures
    - In situ vertical temperature and salinity profiles
  - Model results are available for download from `hycom.org`
    - Hourly output containing temperature, salinity, 3D currents, etc.
    - Output at standard Levitus depths (so fixed vertical layers in output)
- Use HYCOM results as initial and boundary conditions for ADCIRC

During SCOPE - Predictions of Surface Currents

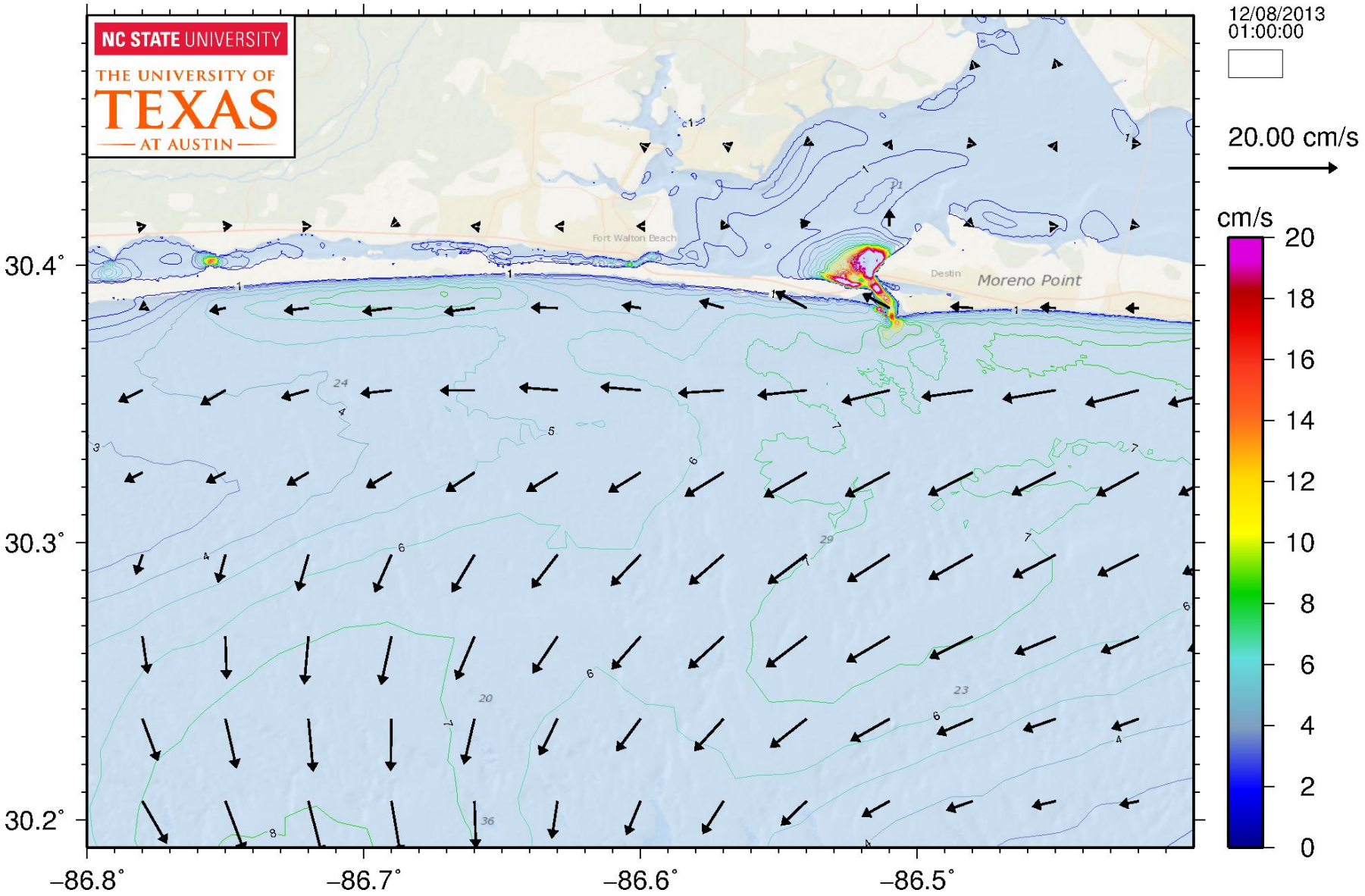
The general procedure was:

1. Interpolate from HYCOM:
   - Initial conditions
   - Ocean boundary conditions
   - Surface boundary conditions
2. Run a 2-day spin-up simulation
   - Diagnostic mode, so salinities/temperatures are constant in time
3. Run a 5-day forecast simulation
   - Prognostic mode, allowing salinities/temperatures to evolve

Semi-automated process:

- Not scripted through forecast system; instead configure manually
- New simulation every 2-3 days during the experiment
- Guidance online (`http://www4.ncsu.edu/~jcdietri/SCOPE/`)

During SCOPE - Surface Velocities - Fort Walton Beach



After SCOPE

Our real-time forecast system uses winds from NOAA:

- Normal conditions:
  - Gridded wind and pressure files from NCEP's NAM
- Extreme conditions:
  - Internal, parametric wind model based on Holland (1980)
  - Storm parameters from NHC forecast advisories

In each case, wind forcing is developed automatically

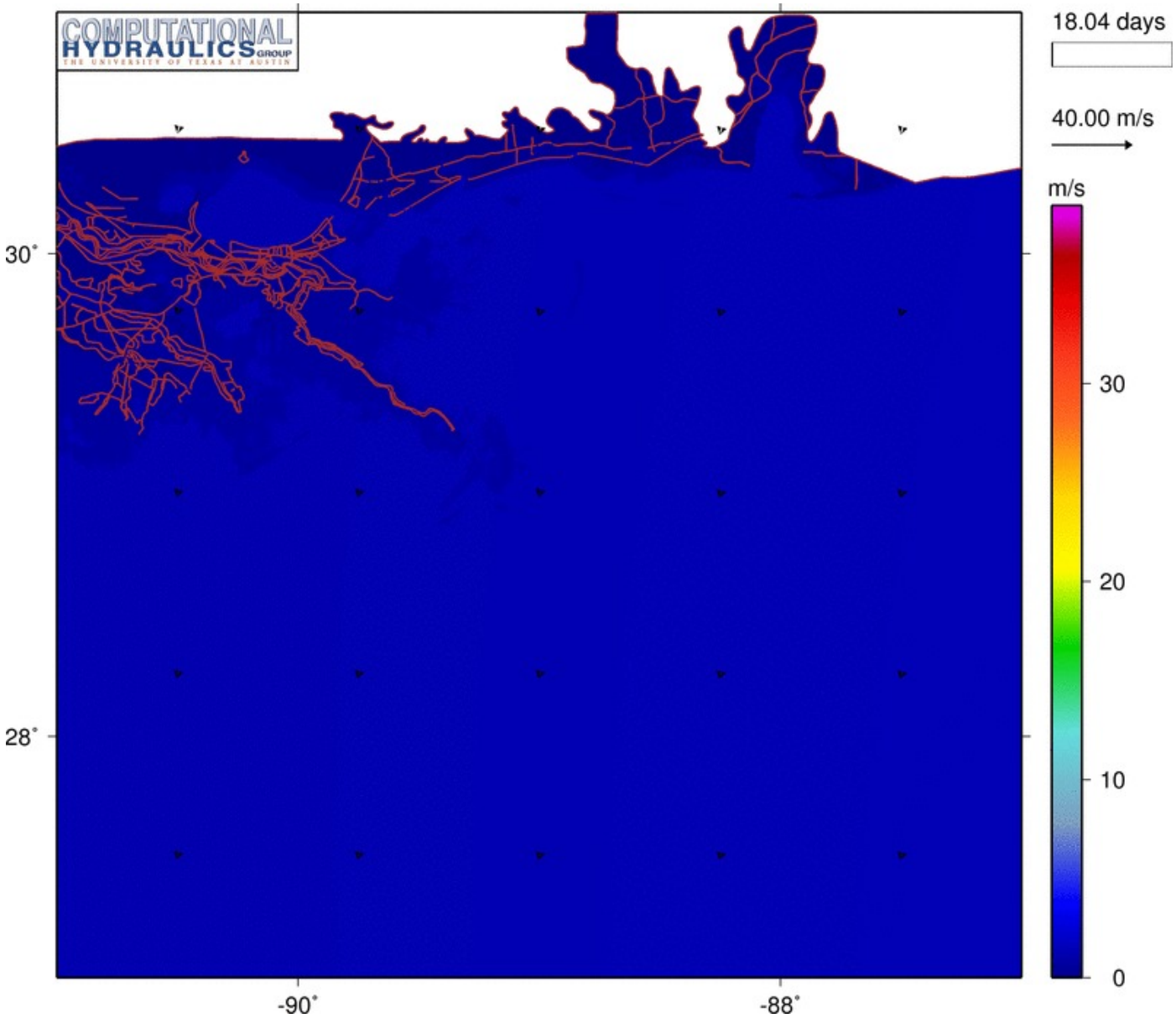
If we have ...

1. Pressure and wind fields from WRF
2. Robust, efficient interpolation routines

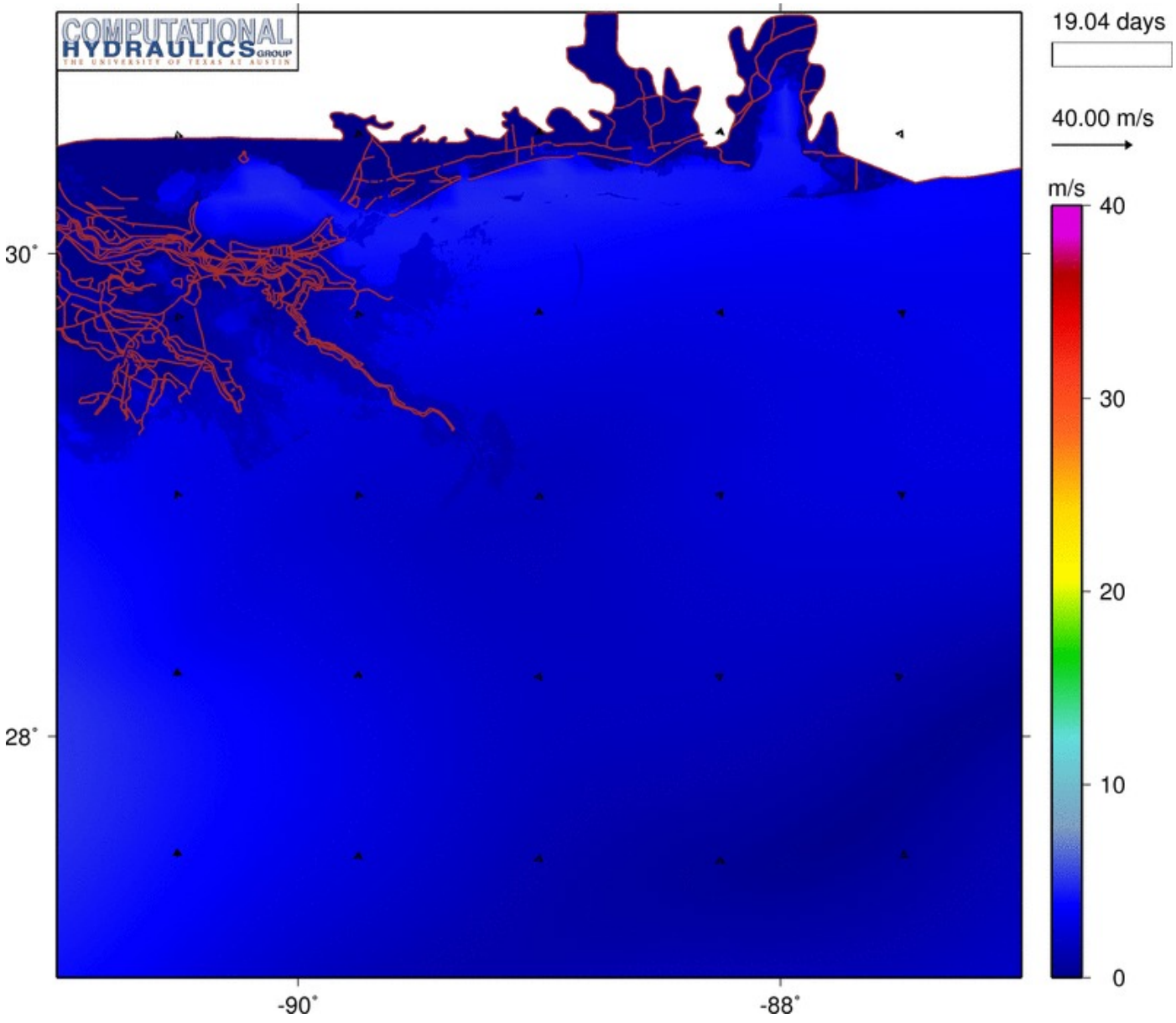
... then we can use meteorological model output in near real-time

Example hindcast during Isaac (2012)

After SCOPE - Isaac Wind Field from Holland Model



After SCOPE - Isaac Wind Field from WRF



After SCOPE

Can we move our boundary beyond the shelf?

- Extend throughout the entire Gulf of Mexico
- Resolve transport over the continental shelf break

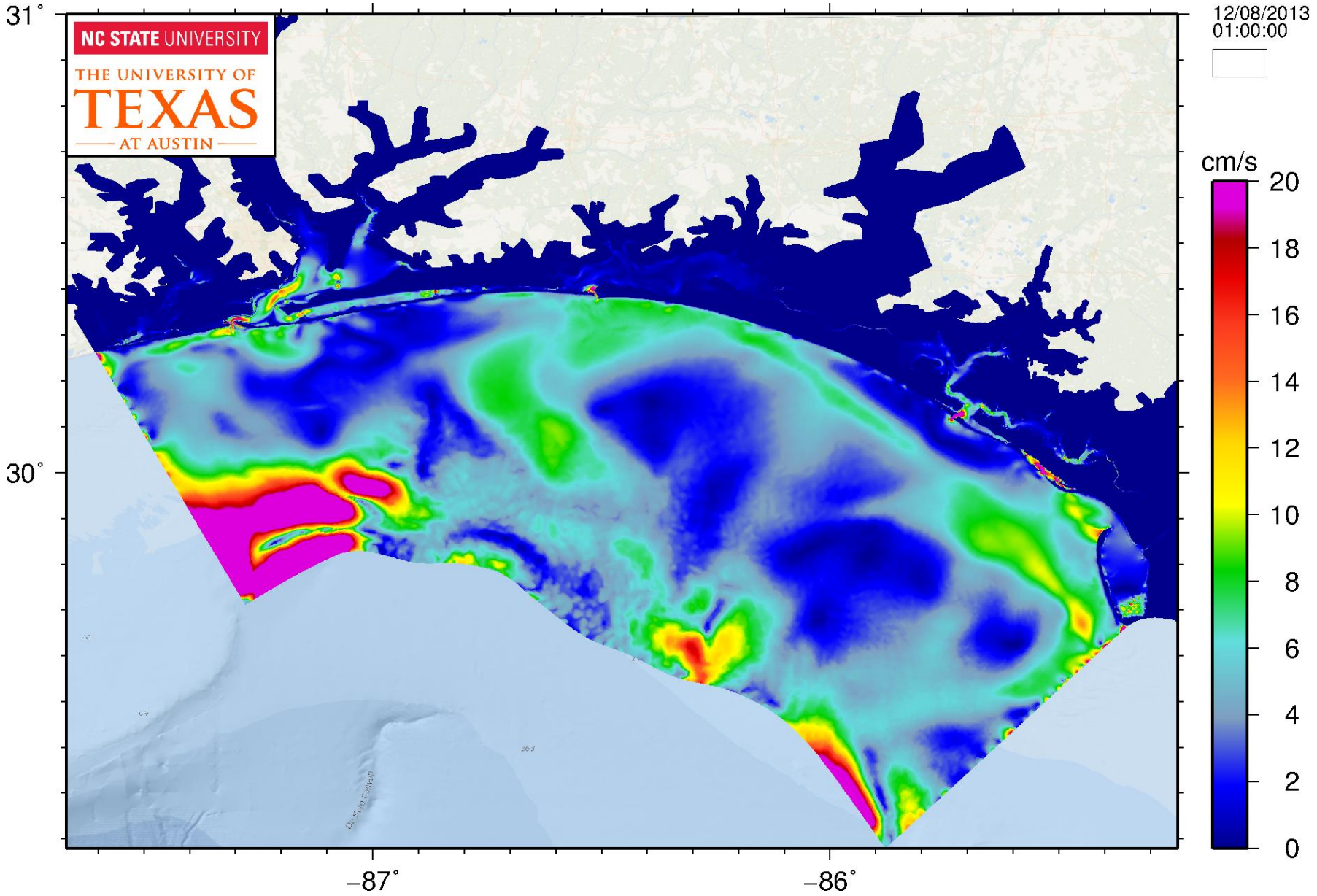
Instead of focusing on boundary conditions, we will focus instead on resolving the steep bathymetric gradients

If we have ...

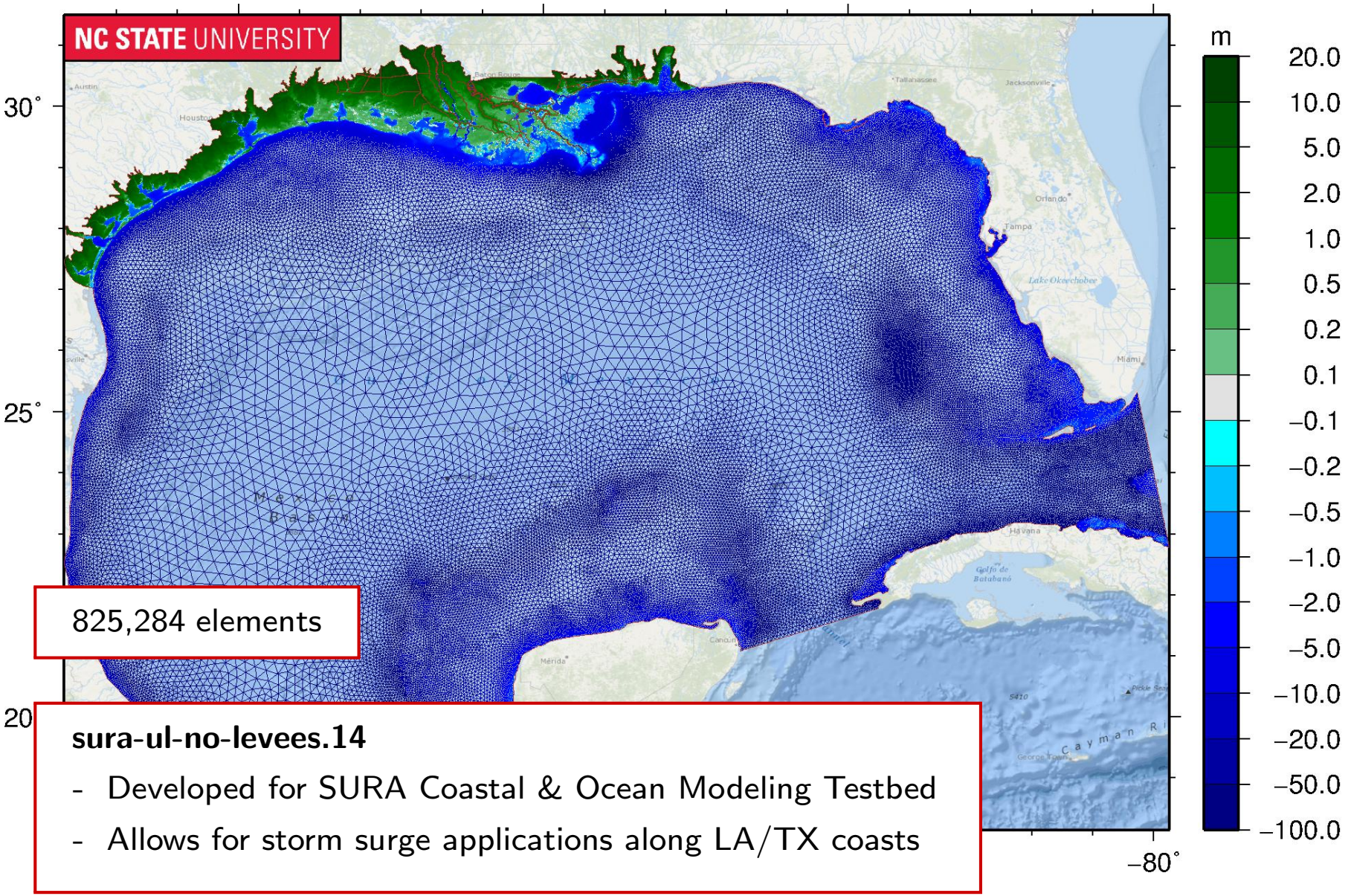
1. High-resolution mesh of the entire Gulf
2. Robust interpolation routines for initial and boundary conditions

... then we can provide guidance from deep water to the nearshore

After SCOPE - Surface Velocities - Florida Shelf



After SCOPE - Gulf of Mexico - Full Mesh



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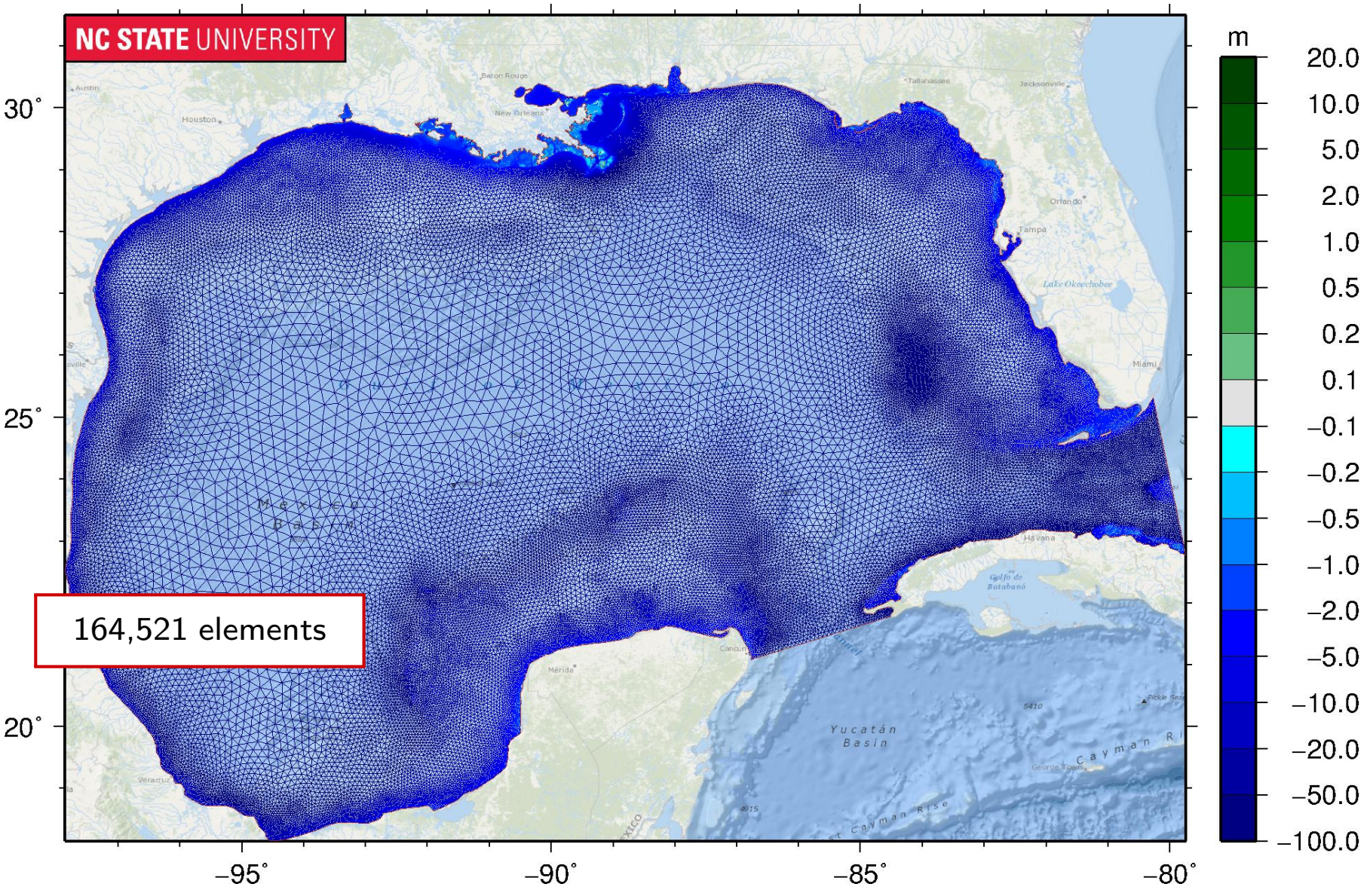
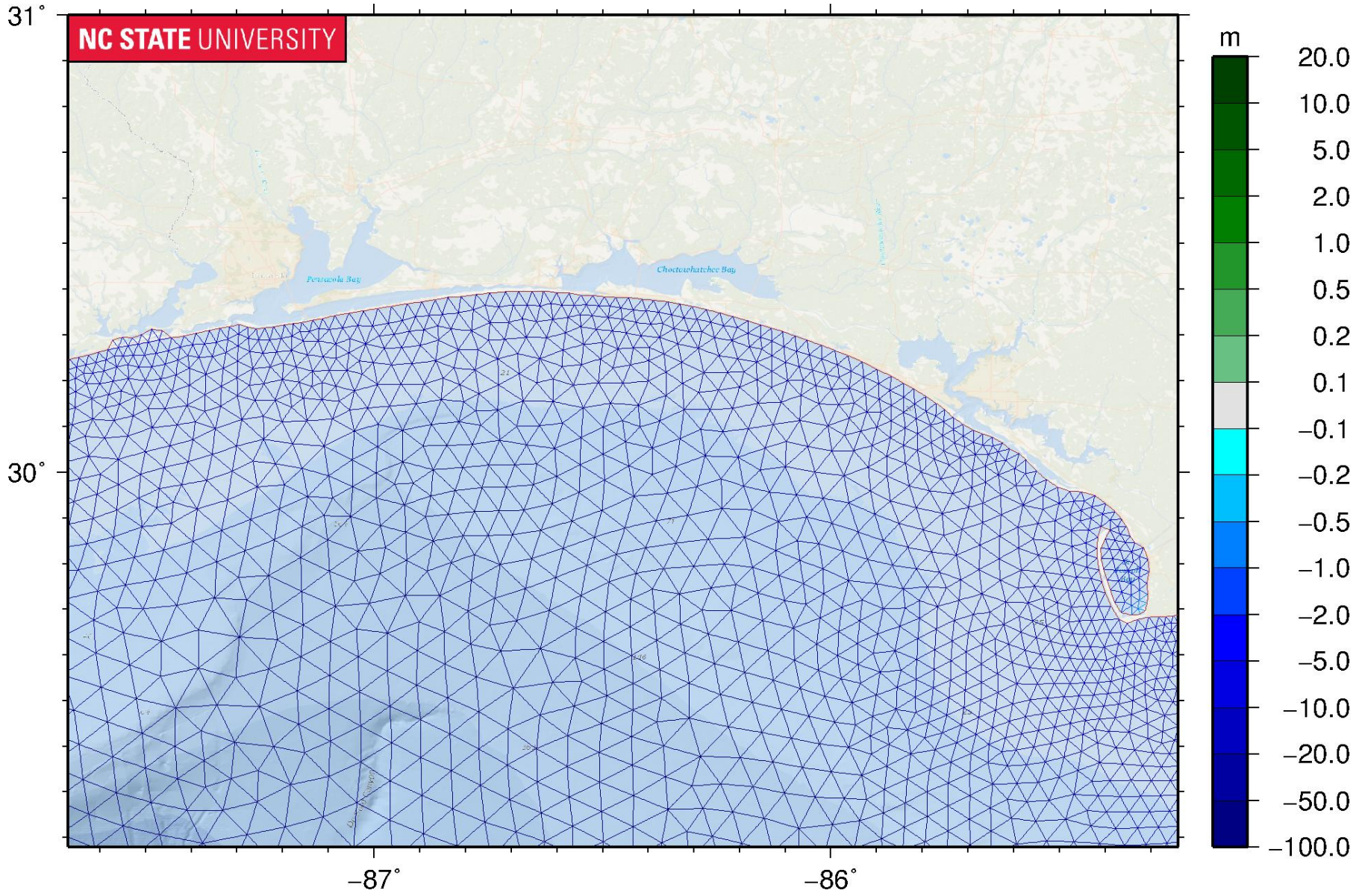
- Developed for SURA Coastal & Ocean Modeling Testbed
- Allows for storm surge applications along LA/TX coasts

After SCOPE - Gulf of Mexico - Open Water



After SCOPE - Gulf of Mexico - Open Water - Zoom

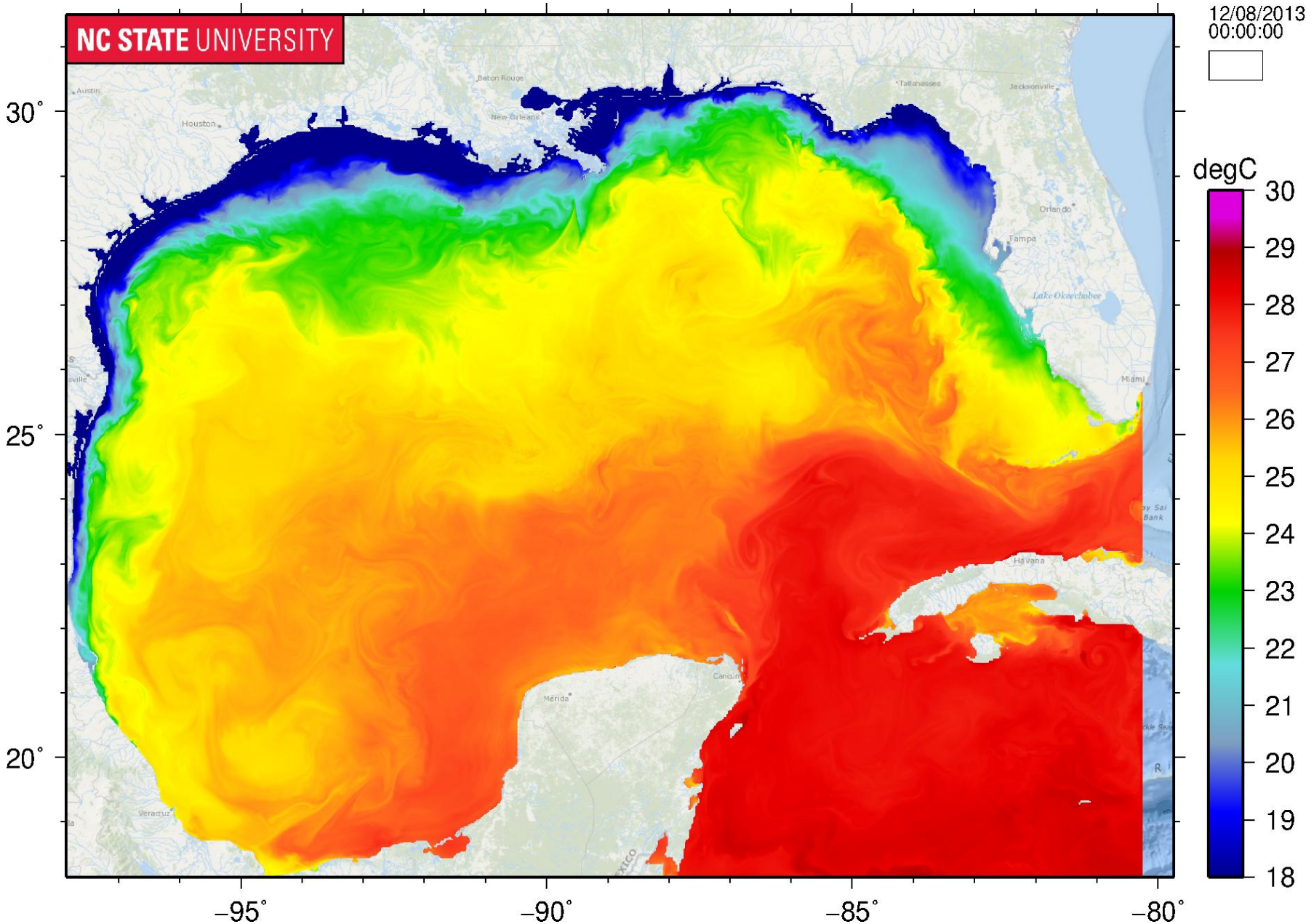


After SCOPE - Coupling with NCOM

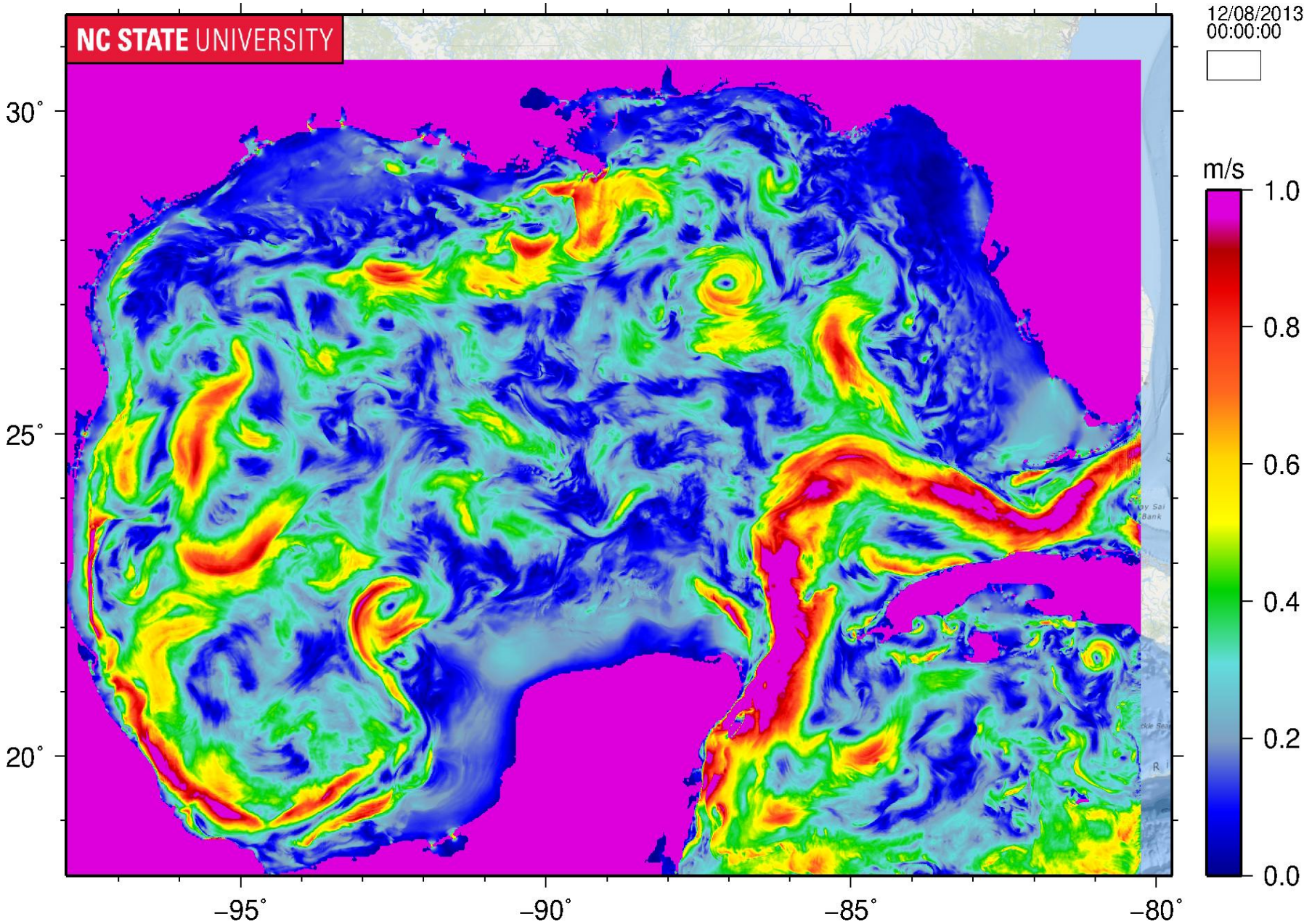
Initial and boundary conditions are provided through a coupling with the Navy Coastal Ocean Model (NCOM):

- Connect with existing expertise in CARTHE
- During SCOPE, NRL operated a forecast system for the Gulf:
  - Four layers of nesting:
    0. Gulf-wide mesh with constant 1km resolution
    1. Nest with 250m resolution
    2. Nest with 50m resolution
    3. Nest with 10m resolution
  - Navy Coupled Ocean Data Assimilation (NCODA)
- 3-day forecasts were posted daily to an FTP site
  - Hourly output containing temperature, salinity, 3D currents, etc.
  - Output at 72 fixed vertical layers
- Use NCOM results as initial and boundary conditions for ADCIRC
  - Initial coupling only to the full-domain nest from NCOM
  - Constant 1km resolution throughout the Gulf

After SCOPE - NCOM Surface Temperatures



After SCOPE - NCOM Surface Velocities



After SCOPE - Hindcasts with 3D ADCIRC

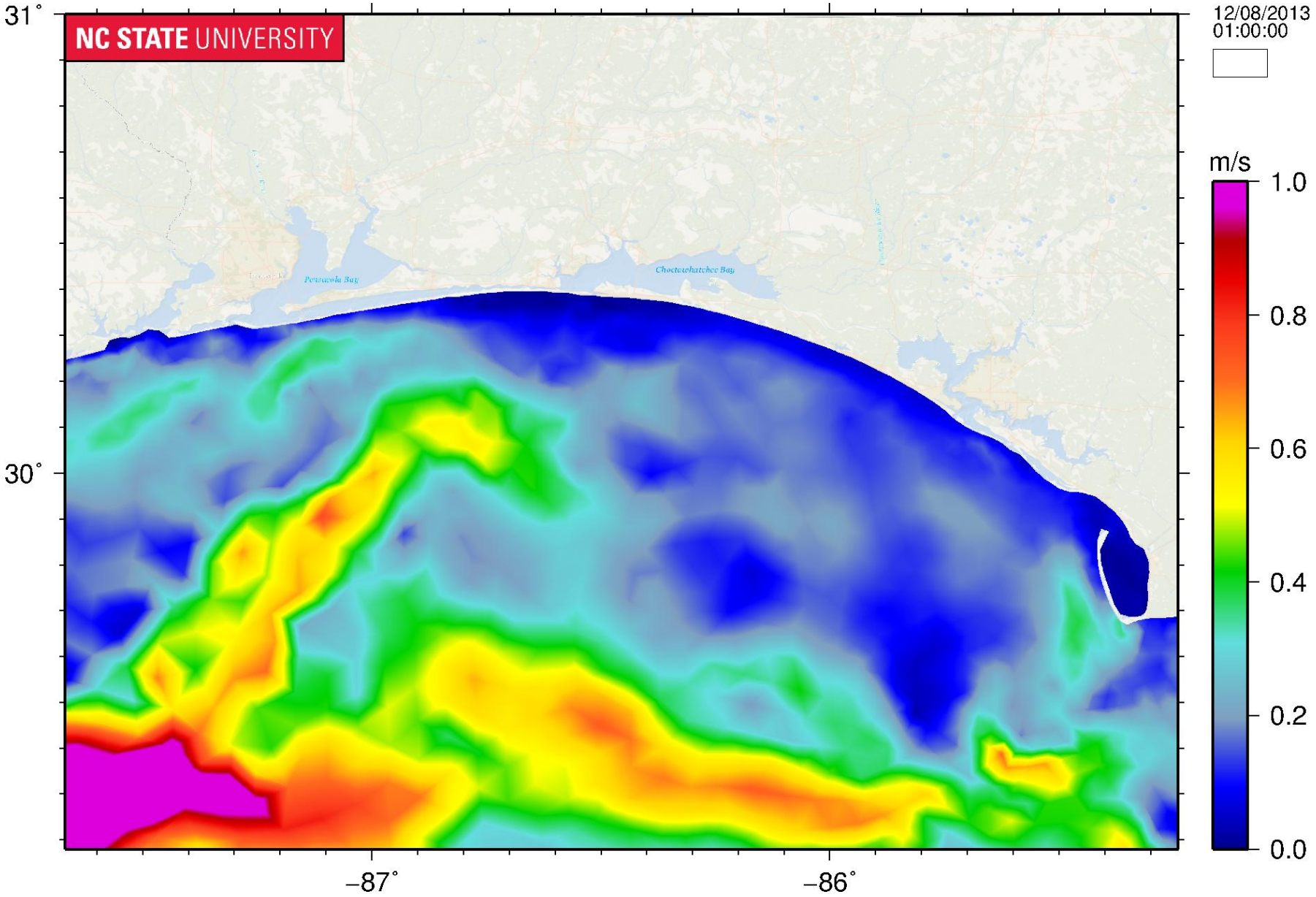
New program to interpolate the initial conditions:

- Compatible with NetCDF output from HYCOM and NCOM
- Code is parallelized:
  - Use ParMETIS to decompose mesh on the fly
  - Each core develops its own sub-mesh, then interpolates

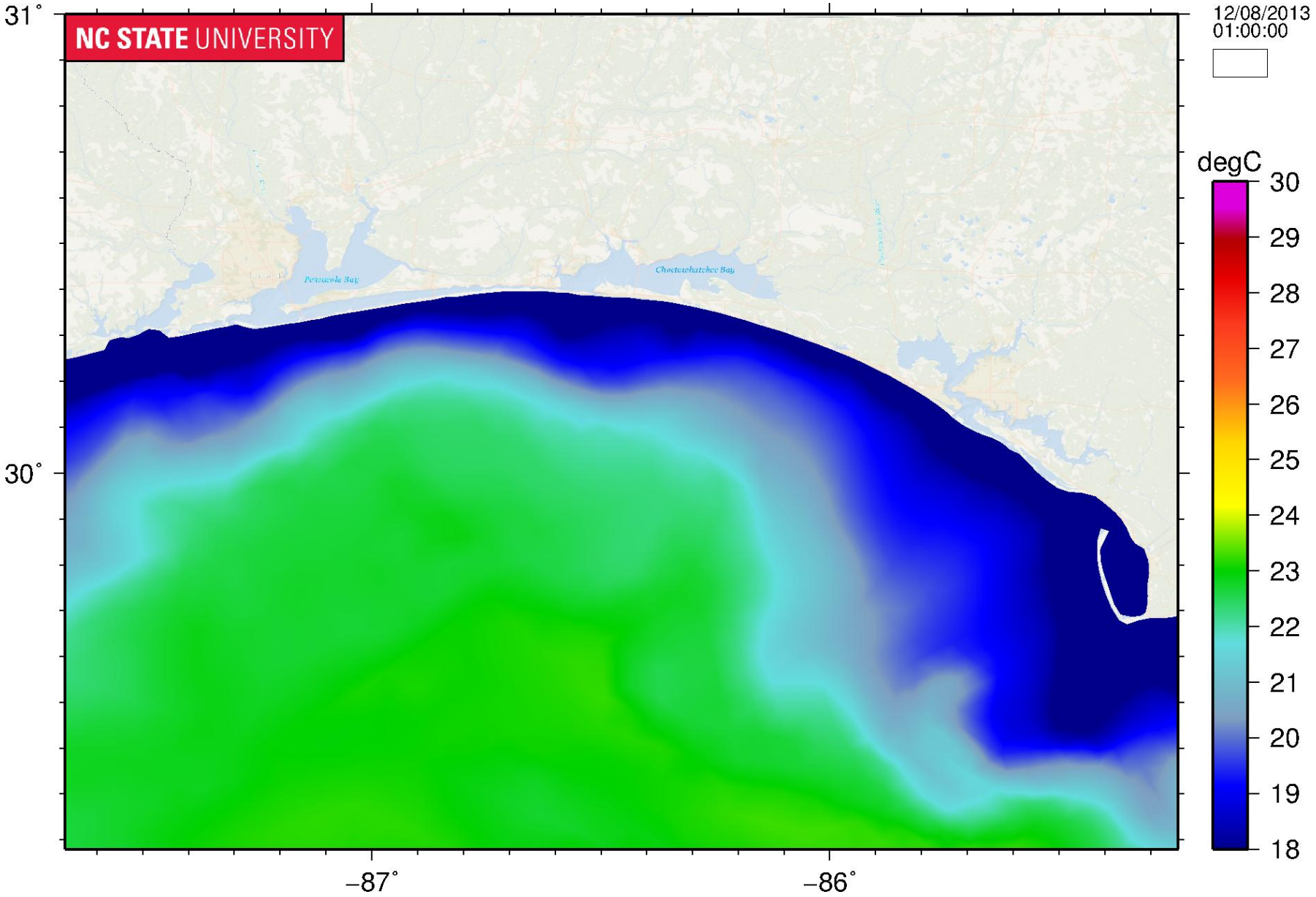
The general procedure is:

1. Interpolate from NCOM:
   - Initial conditions
   - Ocean boundary conditions
   - Surface boundary conditions
2. Run a 30-day spin-up simulation during Nov
   - Diagnostic mode, so salinities/temperatures are constant in time
3. Run a 31-day hindcast simulation during Dec
   - Prognostic mode, allowing salinities/temperatures to evolve

After SCOPE - ADCIRC Surface Velocities



After SCOPE - ADCIRC Surface Temperatures



Summary and Future Work

Summary:

- During SCOPE:
  - Provided guidance for surface ocean behavior along the Florida panhandle for 2+ weeks
- After SCOPE:
  - Coupling with WRF and NCOM
  - Applying on larger, Gulf-wide domain

Future Work:

- Need to introduce additional dynamics
  - Re-enable our coupling with SWAN
  - Velocity fluxes as lateral boundary conditions
  - Freshwater inflow as lateral boundary condition
- Upgrade to higher-res mesh
- Increase resolution near shelf break
- Further validation to field observations during SCOPE