Wind Effects on the Choctawhatchee River Plume at Destin Inlet, Florida

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NC STATE UNIVERSITY

Sea Grant North Carolina

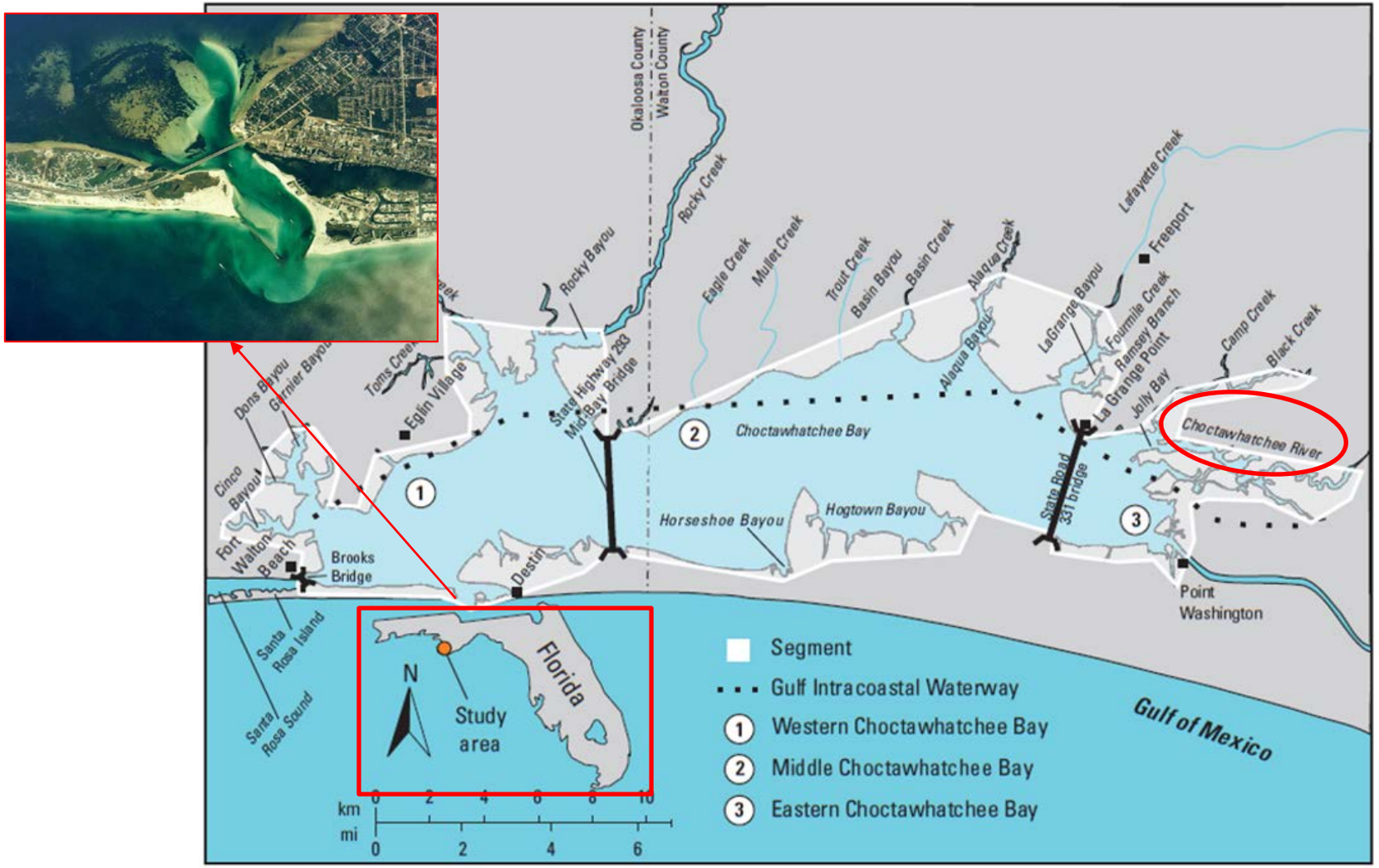
CARTHE CONSORTIUM for ADVANCED RESEARCH on TRANSPORT of HYDROCARBON in the ENVIRONMENT

ADCIRC 301

Track 4: ADCIRC 301 *For Experienced ADCIRC Analysts*

- **Monday:** ADCIRC 3D Barotropic and Baroclinic
- **Tuesday:** ADCIRC Surge Guidance System (ASGS)
- **Wednesday:** MultiStage Modelling; DesignSafe Cyberinfrastructure: Modelling, Storage, and Visualization Resources

Study Area

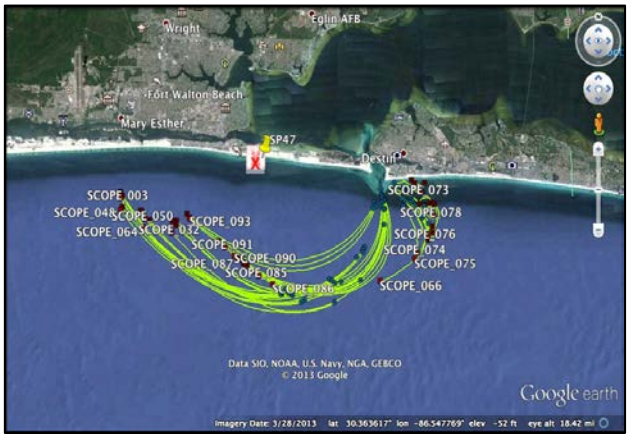

Okaloosa County
Walton County
Rocky Creek
Rocky Bayou
Eagle Creek
Muller Creek
Trout Creek
Basin Bayou
Basin Creek
Alaqua Creek
Lafayette Creek
Freeport
LaGrange Bayou
Fourmile Creek
Ramsey Branch
Camp Creek
Black Creek
Alaqua Bayou
La Grange Point
Jolly Bay
Choctawhatchee River
Toms Creek
Eglin Village
Dons Bayou
Garnier Bayou
Cinco Bayou
State Highway 293
Mid-Bay Bridge
Choctawhatchee Bay
Horseshoe Bayou
Hogtown Bayou
State Road
331 bridge
Fort Walton Beach
Brooks Bridge
Destin
Point Washington
Santa Rosa Island
Santa Rosa Sound
Florida
N
Study area
km
mi
0 2 4 6 8 10
0 2 4 6
Segment
Gulf Intracoastal Waterway
1 Western Choctawhatchee Bay
2 Middle Choctawhatchee Bay
3 Eastern Choctawhatchee Bay
Gulf of Mexico

Surfzone Coastal Oil Pathways Experiment (SCOPE)

- To understand the processes that are important for surface transport, both for oil spills and other pollutants, as well as for natural materials.

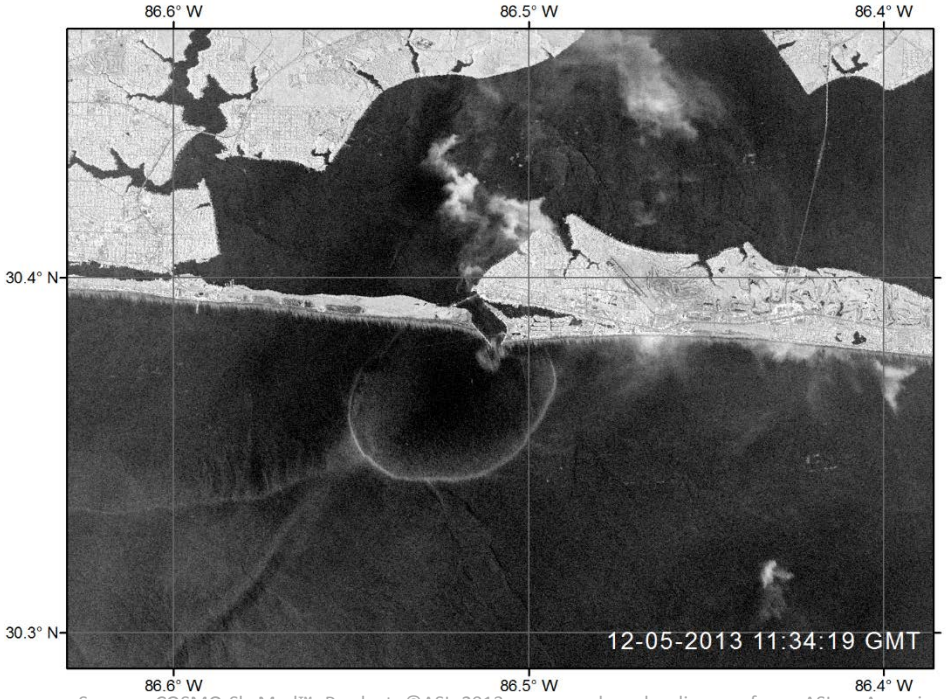
- Performed by CARTHE scientists between December 3-17, 2013

- With the help of:
  - Surface drifters
  - Dye Releases
  - Drones
  - Jetskis
  - Small boats
  - Helicopters
  - ADCPs
  - CTD casts



Source: CARTHE Facebook page

Brackish Plume at Destin Inlet



- Freshwater river discharge that enters an estuary can flow out into the coastal ocean as brackish, buoyant plumes
- Surface material slows down and converges along the plume edges due to the density differences across the plume front
- SCOPE datasets recorded the presence of a distinct ebb-phase plume at Destin Inlet

Research Hypothesis

Ebb-phase plume signature at Destin Inlet exhibits variability as wind forcing changes during the passage of cold fronts

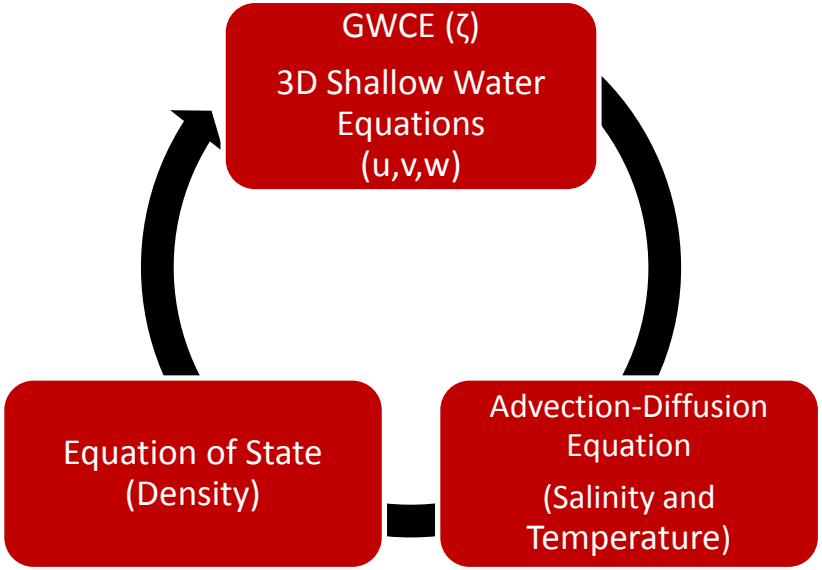
- Observed during SCOPE experiments in December 2013
- Variability in plume signature has implications for the transport of surface material such as chemical and oil pollutants and biological material

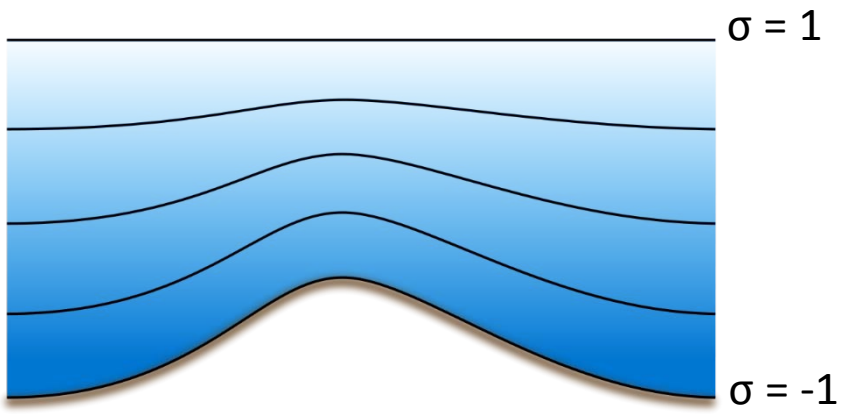
Research Objectives

1. Develop and validate a three dimensional baroclinic model to represent the tide, wind and plume driven circulation in the Choctawhatchee Bay and adjacent shelf waters

2. Quantify plume response during the passage of winter cold fronts over the study area

ADCIRC 3D Baroclinic

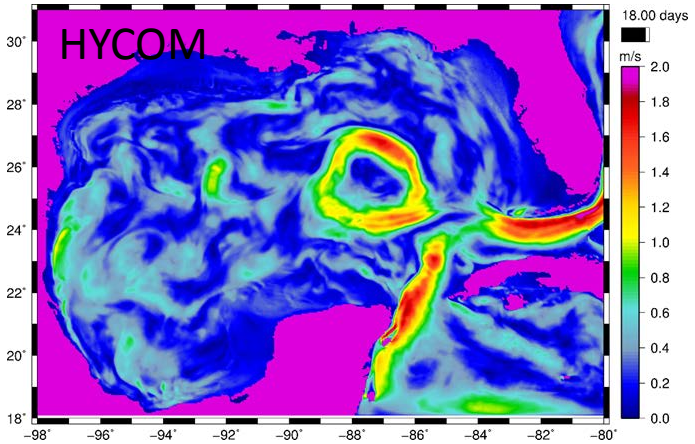


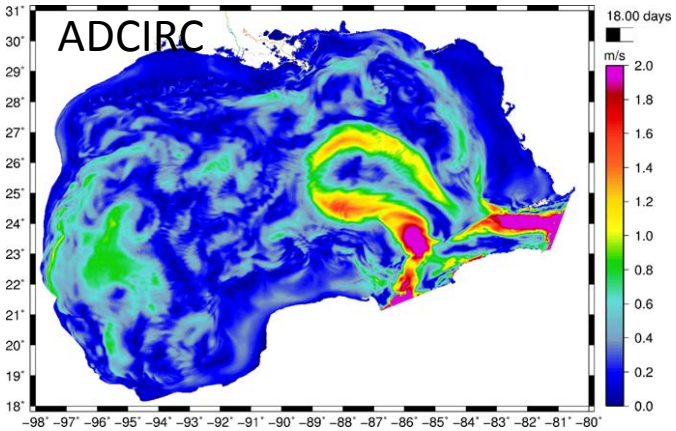


Terrain following sigma co-ordinates in the vertical

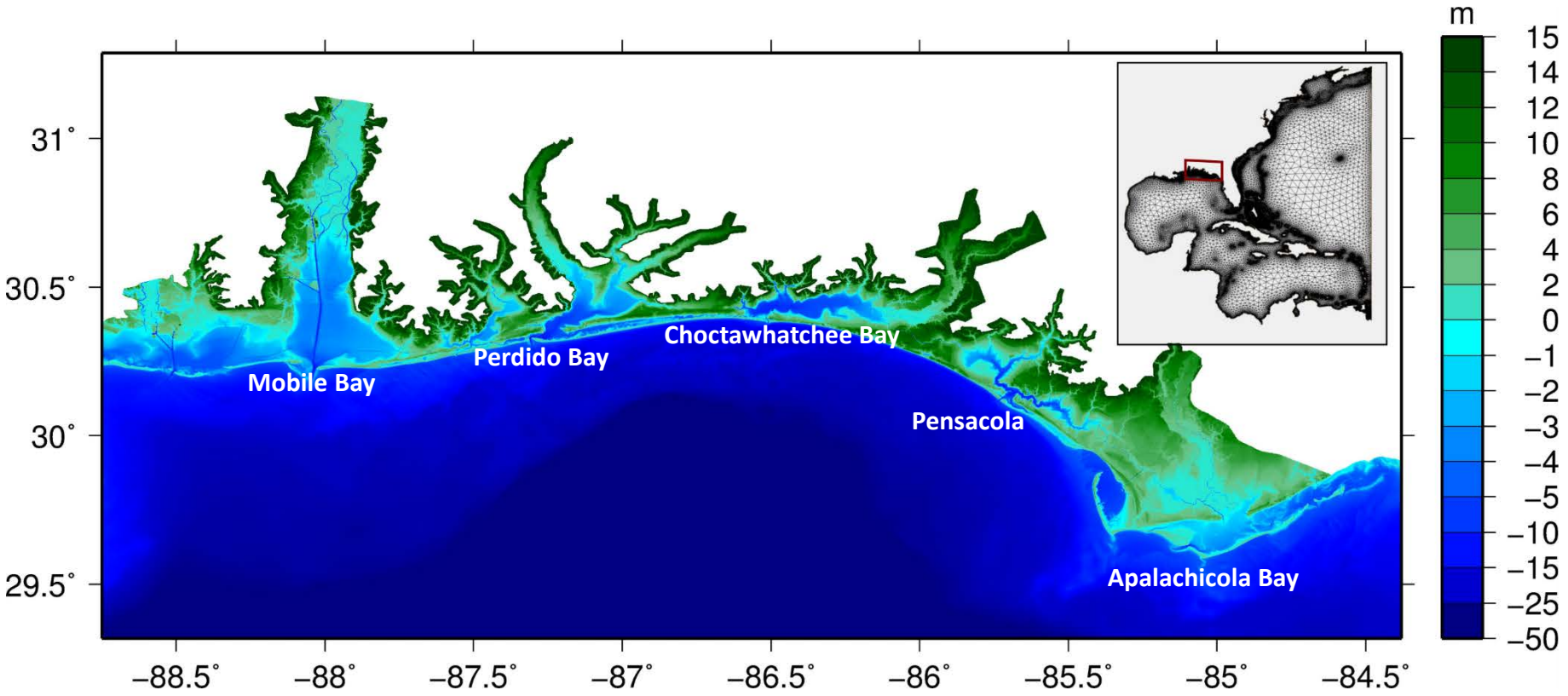
Recent Improvements to ADCIRC 3D by Dr. Arash Fathi

Sea surface velocities in the Gulf of Mexico



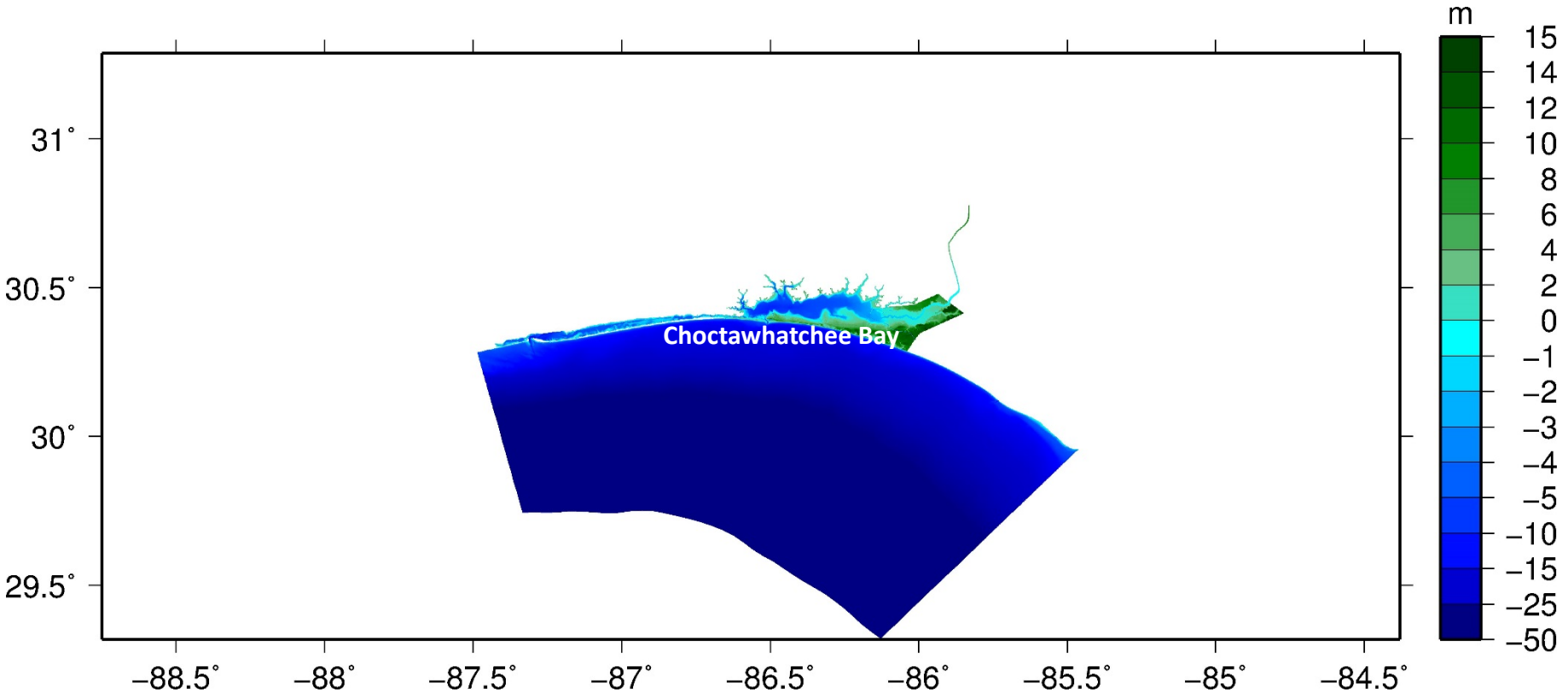


Mesh Development



Source : S. Hagen , A. Daranpob, P. Bacopoulos, S. Medeiros, M. Bilskie, D. Coggin, M. Salisbury, J. Atkinson and H. Roberts. Storm Surge Modeling for FEMA Flood Map Modernization for the Northwest Florida and Alabama Coast, Digital Elevation Model and Finite Element Mesh Development. Prepared for the Northwest Florida Water Management District and the FEMA, 2011.

Mesh Development



- Resolving Choctawhatchee River
- Bathymetry Smoothing above 15m
- Increasing offshore resolution
- Inlet Refinement
- Shelf-scale mesh
  - Ocean boundary at 200m contour

Model Set-up

Simulation Period

- Diagnostic phase : November 1-5
- Prognostic phase : November 5 – December 15

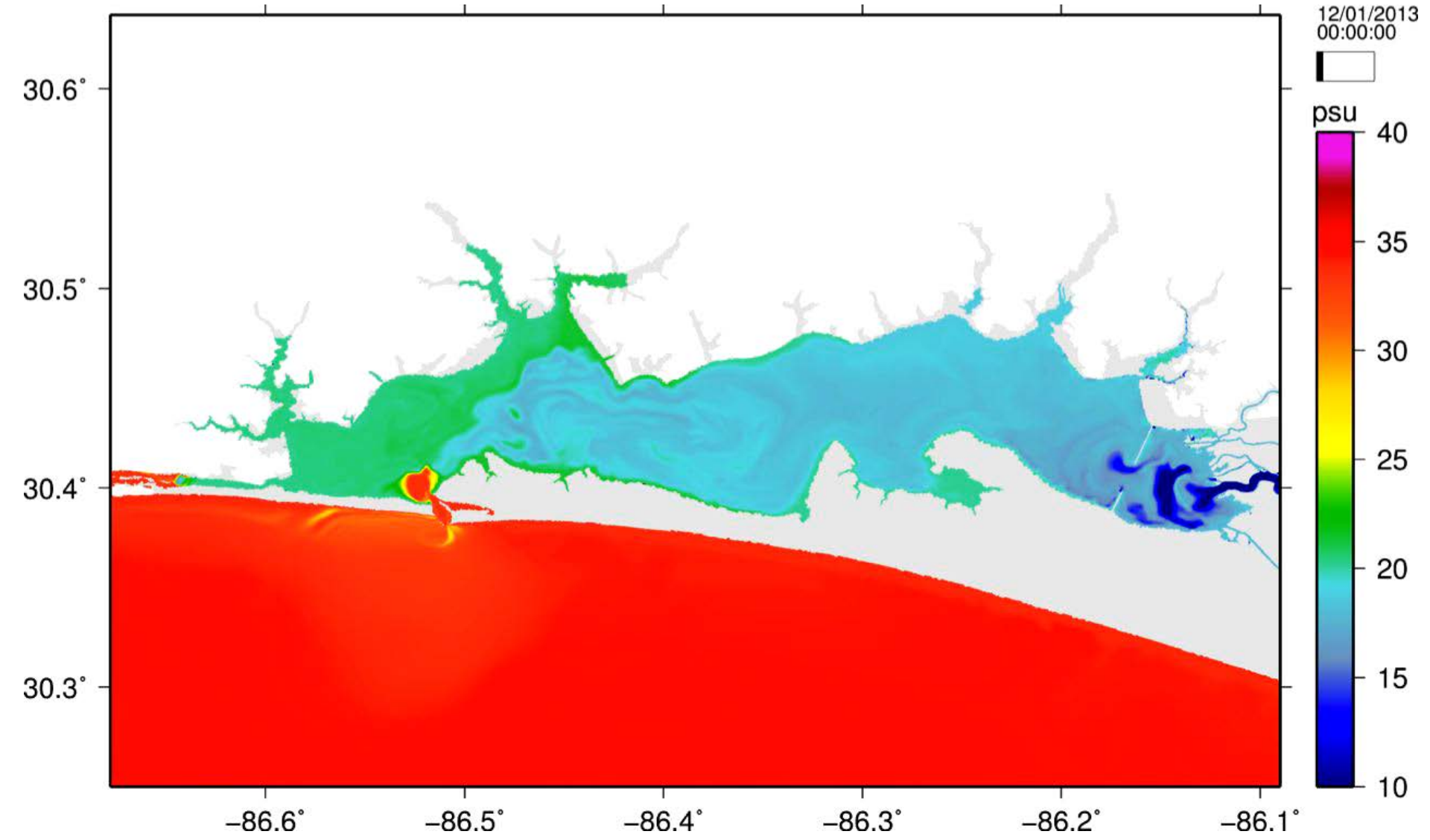
Initial and Boundary Conditions

- Tides
- Vertical Salinities and Temperatures
  - Inside Bay – Measurements taken by Choctawhatchee Basin Alliance group
  - Offshore – Interpolated from publicly archived HYCOM data (HYCOM + NCODA Southeast United States 1/25 Degree Analysis/GOMl0.04/expt_31.0/2013)
- Upstream River Boundary is forced with a discharge of 200 m^3/s
- Surface Heat Flux over model domain

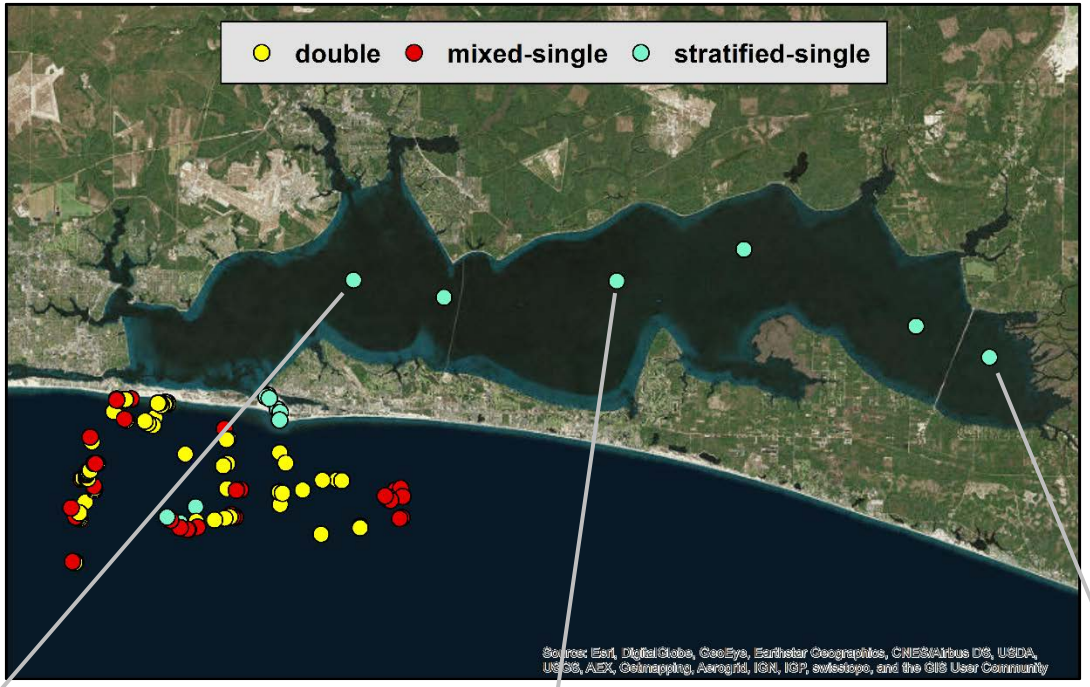
Others

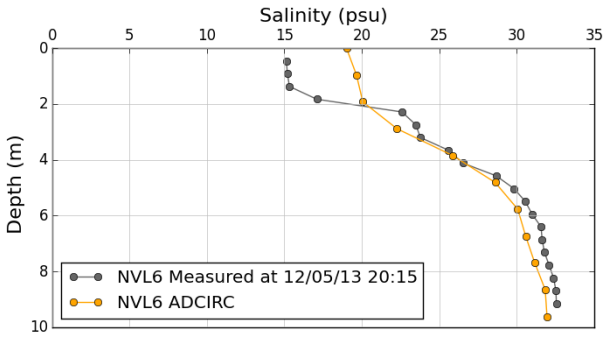
- 11 uniform vertical layers
- Time step = 0.5 s
- Total simulation time is roughly 5 days on 3840 cores at the Texas Advanced Computing Center's Stampede 2 systems

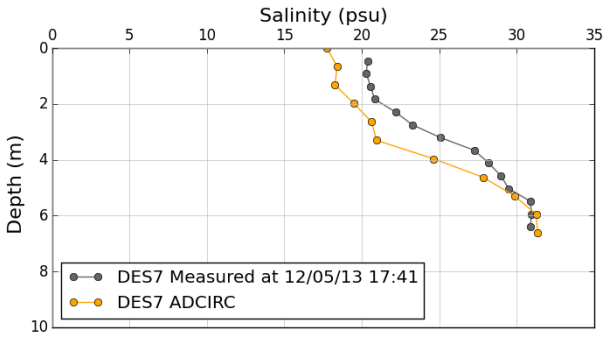
Results: Surface Salinities

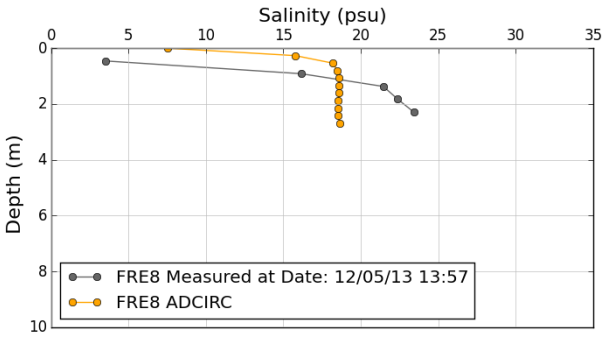


Model Validation: CTD Profiles









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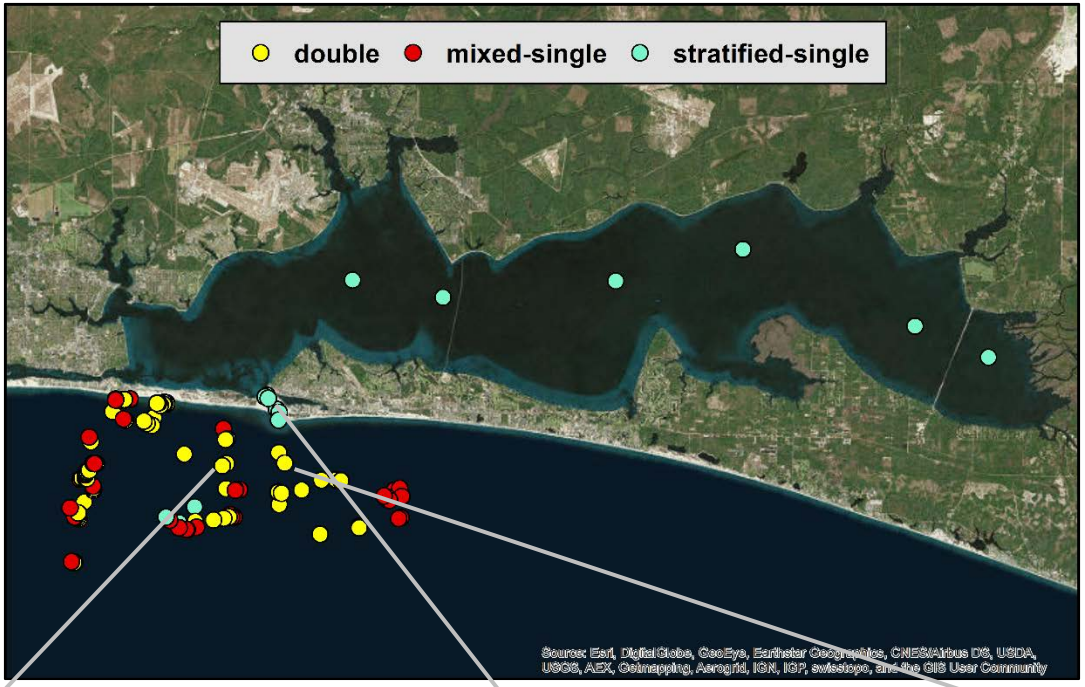

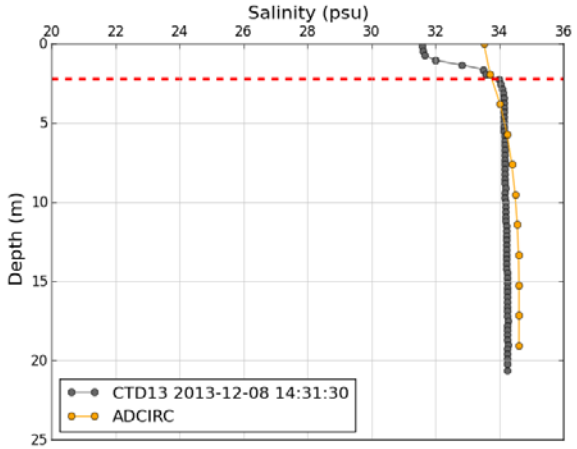

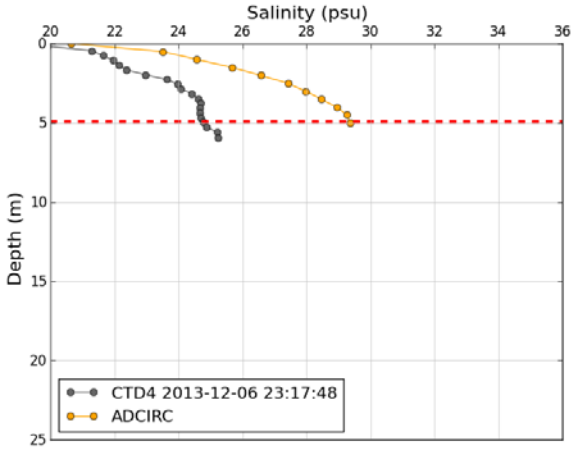

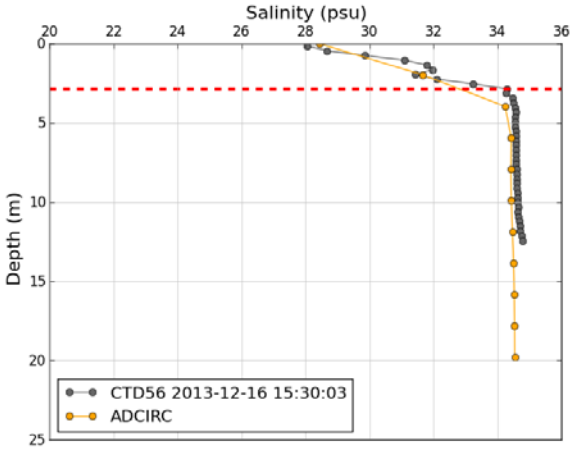

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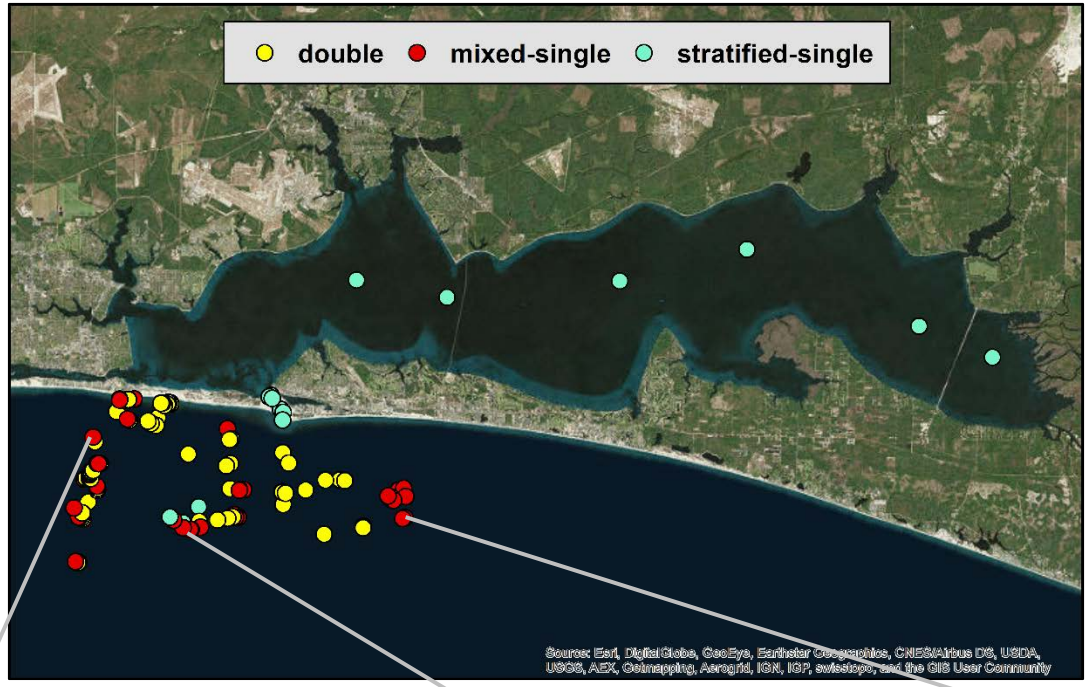
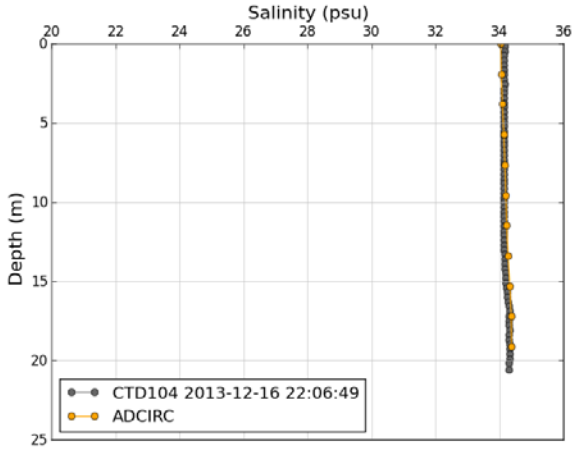
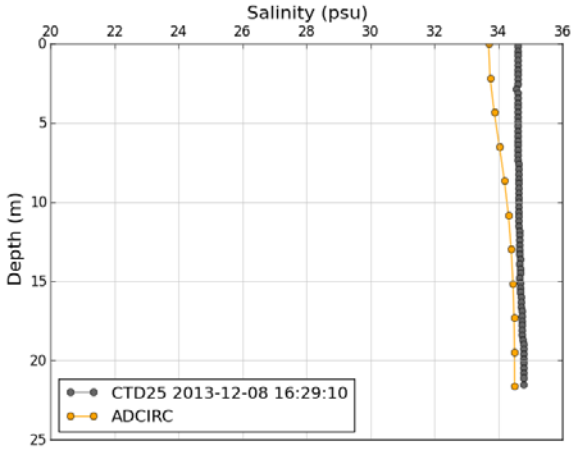
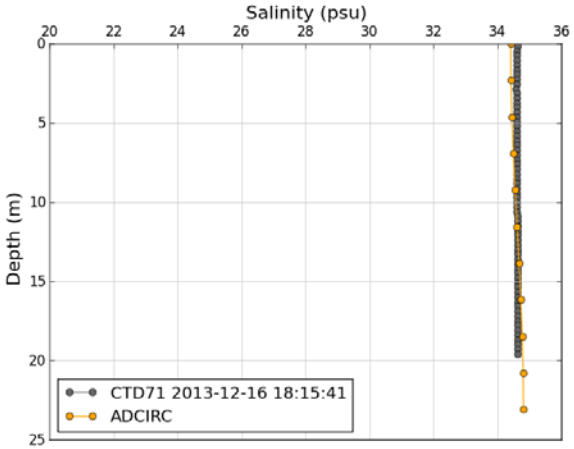
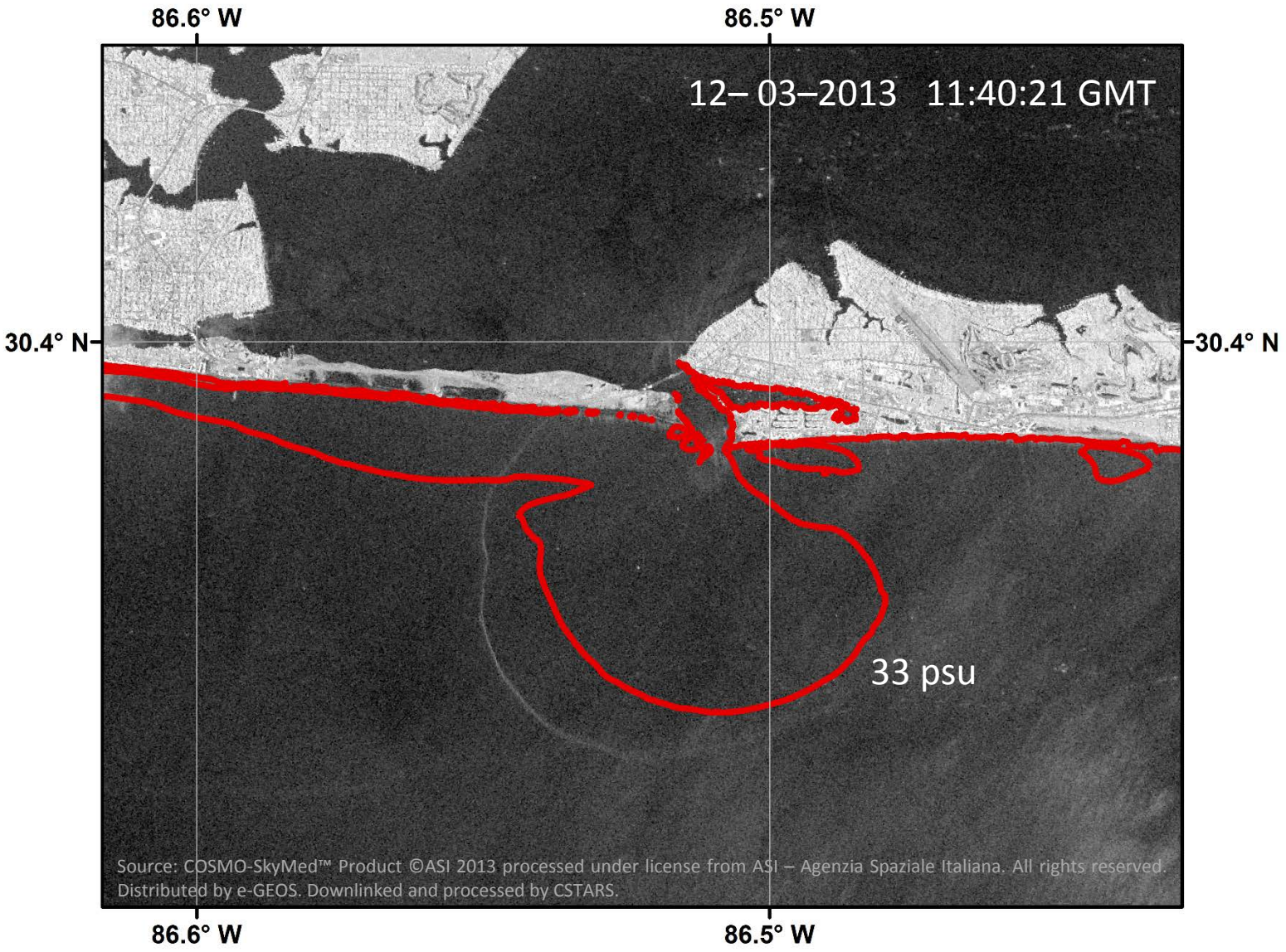








Model Validation: Satellite Imagery



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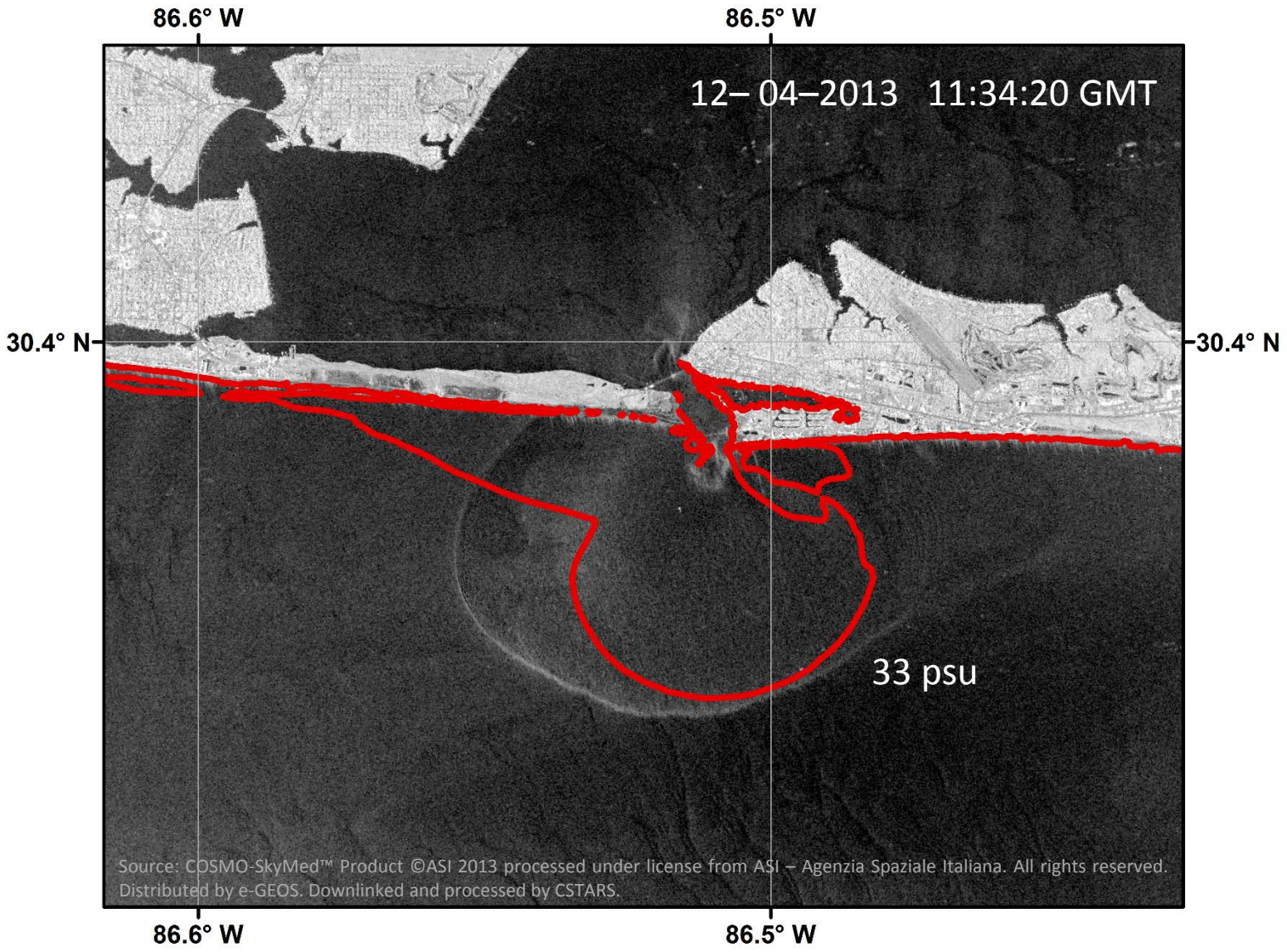

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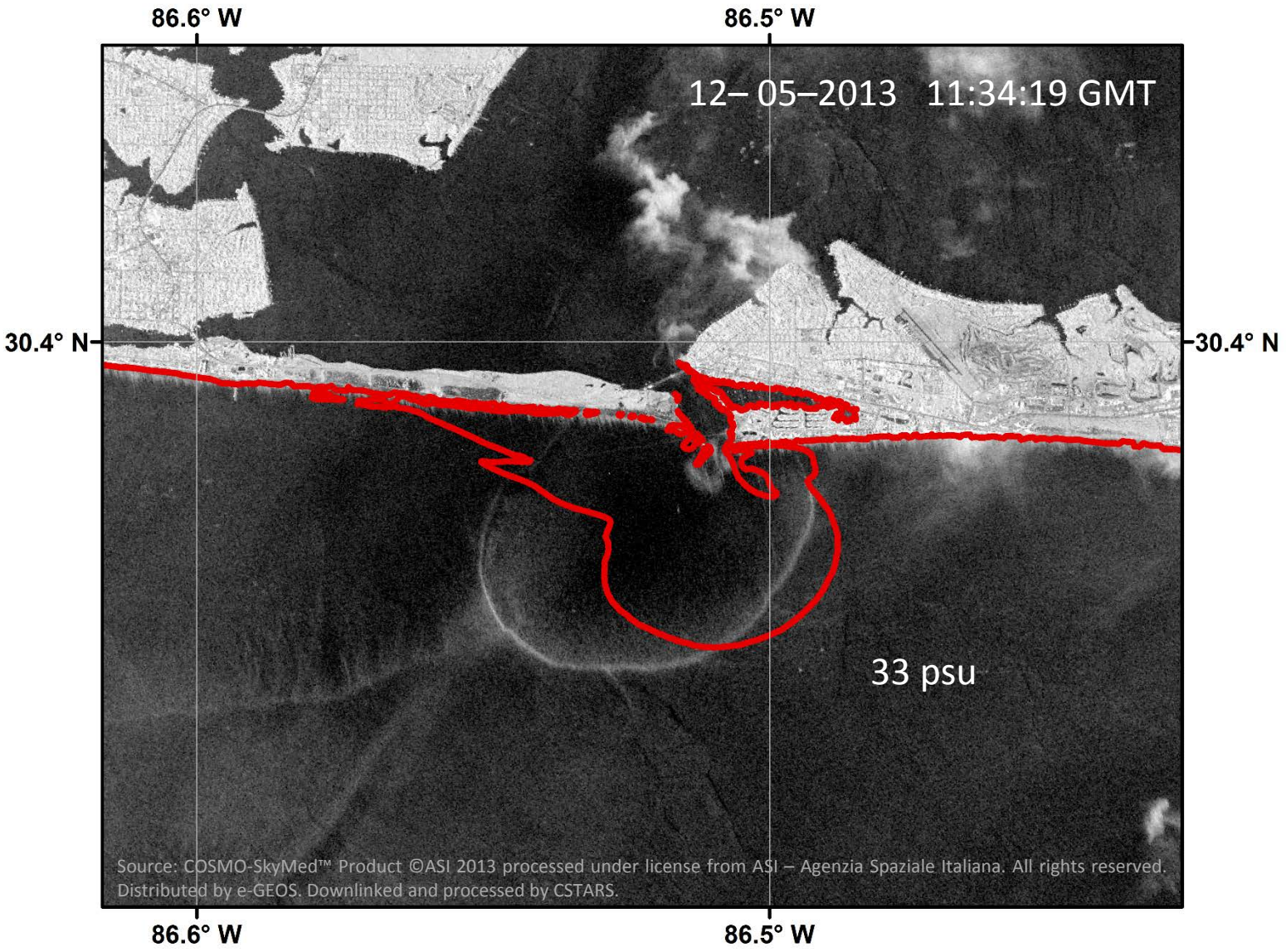
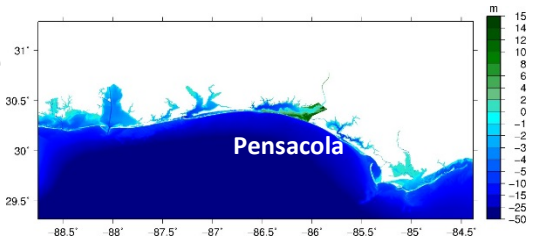
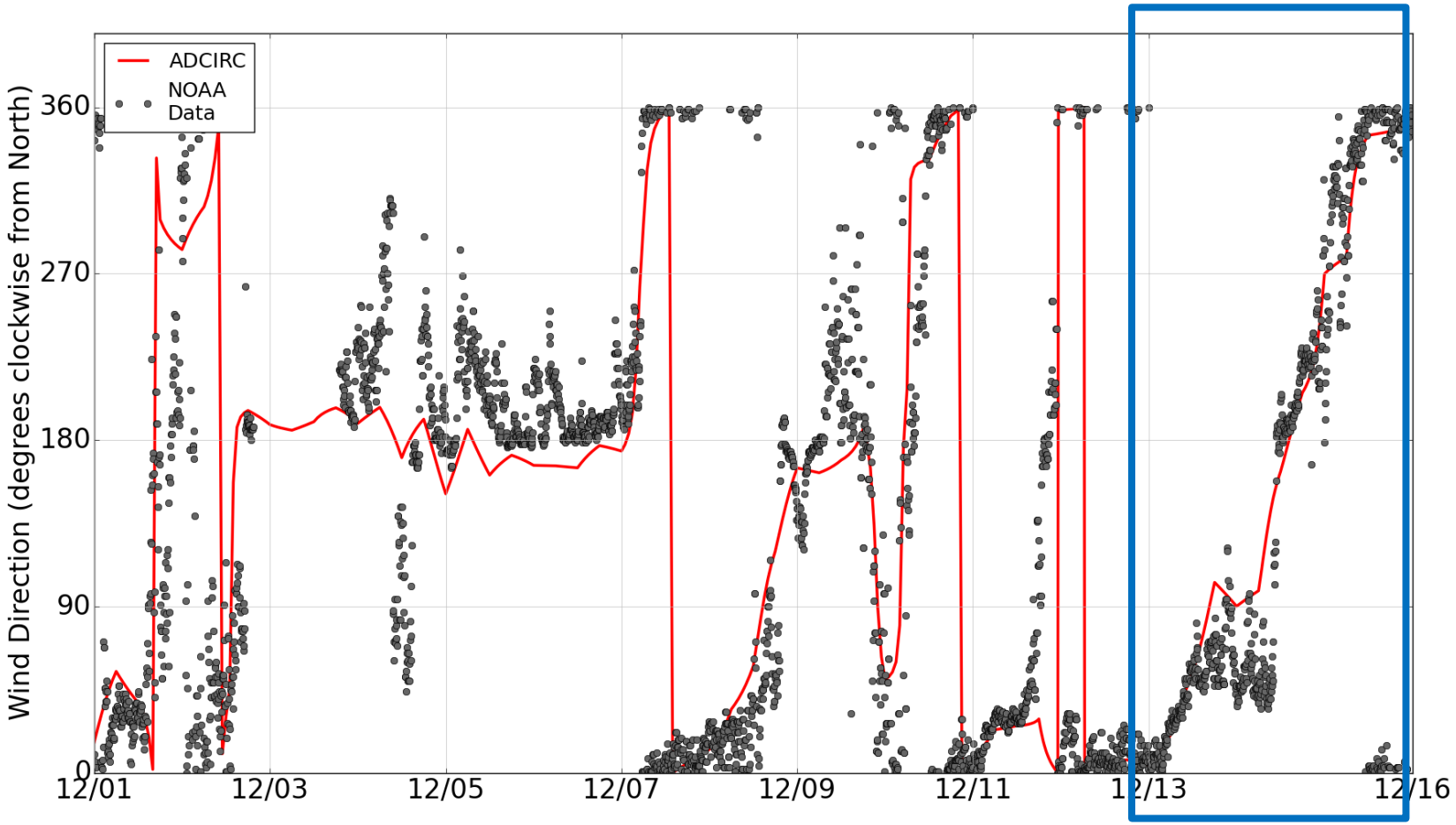


Factors affecting Plume Variability: Winds

Winter cold fronts over the Florida Panhandle cause multiple 360 degree reversals in wind directions during Dec 1-15





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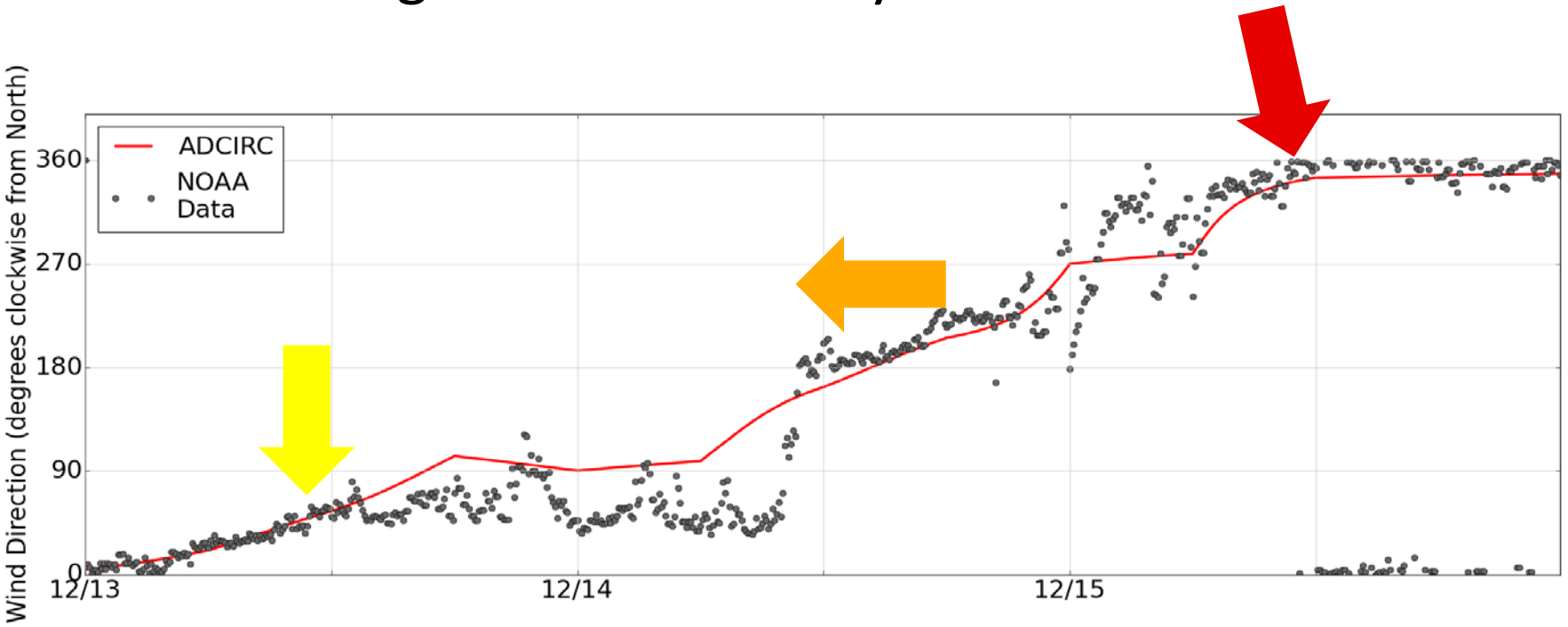

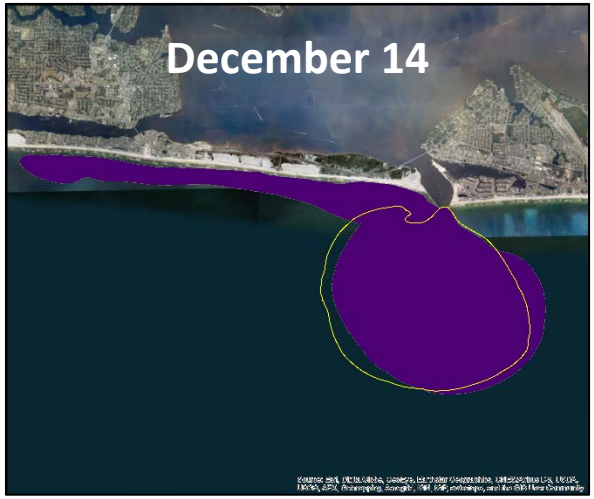

Summary

Research Hypotheses and Objectives

- The ebb-phase plume at Destin exhibits variability with changes in wind conditions
- Aim of the present research is to quantify these changes during winter cold fronts

Modeling Density driven flows in Choctawhatchee Bay using 3D baroclinic ADCIRC

- Model salinities show good agreement with observed vertical salinities
- Plume signature predicted by the model matches the plume edges and offshore extents observed in satellite imagery

Quantifying variability in plume signature

- Changes in wind direction caused by passing cold fronts causes changes in the plume signature
  - Winds with an easterly component push the plume to the west of the inlet
  - Northerly winds push the plume offshore
  - Model salinities are in agreement with plume behavior observed during SCOPE
- Future work will explore plume variability in the absence of winds