Baroclinic Currents along the Florida Panhandle during SCOPE

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CARTHE - Grand LAgrangian Deployment (GLAD)



CARTHE - Surfzone Coastal Oil Pathways Experiment (SCOPE)



CARTHE - SCOPE - Dye Release



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CARTHE - SCOPE - Drifter Trajectories



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During SCOPE

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

For transport of temperature and/or salinity, solve the non-convervative form of the transport equation:

$$\frac{\partial c}{\partial t} + \vec{v} \cdot \nabla c = \frac{\partial}{\partial x} \left(N_H \frac{\partial c}{\partial x} \right) + \frac{\partial}{\partial y} \left(N_H \frac{\partial c}{\partial y} \right) + \frac{\partial}{\partial z} \left(N_V \frac{\partial c}{\partial z} \right)$$

If we have ...

- 1. High-resolution mesh of the Florida coastline
- 2. Initial and boundary conditions for temperature, salinity, etc.

... then we can provide guidance during the experiments

During SCOPE - Florida Panhandle - Full Mesh



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During SCOPE - Florida Panhandle - Shelf



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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)

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Use HYCOM results as initial and boundary conditions for ADCIRC

During SCOPE - Initial and Boundary Conditions from HYCOM



Initial conditions:

- Sea surface heights
- Horizontal currents (u, v)
- Salinities
- Temperatures

Ocean boundary conditions:

- Salinities
- Temperatures

Surface boundary conditions:

Heat fluxes

During SCOPE - Initial and Boundary Conditions from HYCOM



Initial conditions:

- Sea surface heights
- Horizontal currents (u, v)
- Salinities
- Temperatures

Ocean boundary conditions:

- Salinities
- Temperatures

Surface boundary conditions:

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Heat fluxes

During SCOPE - Predictions of Surface Currents

The general procedure was:

- 1. Interpolate from HYCOM:
 - Initial conditions fort.17
 - Ocean boundary conditions fort.36, fort.37
 - Surface boundary conditions fort.38
- 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 ASGS; 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



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During SCOPE - Surface Velocities - Florida Shelf



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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

 \ldots then we can provide guidance from deep water to the nearshore

After SCOPE - Gulf of Mexico - Full Mesh



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After SCOPE - Gulf of Mexico - Open Water



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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)
 - Satellite altimeter observations
 - Satellite and in situ sea surface temperatures
 - In situ vertical temperature and salinity profiles
- 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

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 fort.17
 - Ocean boundary conditions fort.36, fort.37
- 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



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Summary and Future Work

Summary:

- Becoming comfortable with ADCIRC's baroclinic capabilities
- During SCOPE Provided guidance for surface ocean behavior along the Florida panhandle for 2+ weeks
- After SCOPE Learning to apply on larger, Gulf-wide domain

Future Work:

- Need to introduce additional dynamics
 - Stabilize and use the advective terms
 - Velocity fluxes as lateral boundary conditions
 - Freshwater inflow as lateral boundary condition
 - Heat flux as surface boundary condition
- Upgrade to higher-res mesh
 - Carve open-water elements from SL16, etc.
 - Increase resolution near shelf break
- Further validation to field observations during SCOPE