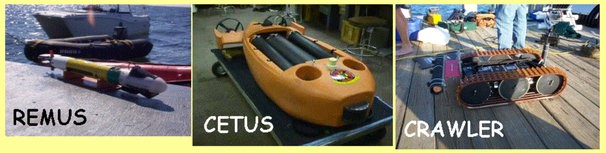
# ADCIRC Coastal Circulation Model Support of AUV Missions

**Cheryl Ann Blain** and **Catherine Edwards**, Naval Research Laboratory, Stennis Space Center, MS

## BACKGROUND

### What is an AUV?

An AUV is an Autonomous Underwater Vehicle used for remote data collection. These robotic vehicles carry a payload of environmental sensors and can utilize GPS and RF/satellite communications to navigate and change their behavior.




Tested AUVs at AUVFEST 2001 held in the Mississippi Sound, MS.

For oceanography, AUVs provide high resolution, non-invasive data collection in denied areas or hostile environments such as under ice packs or in shallow waters. AUVs are particularly suited to adaptive sampling. Other AUV missions can include search, transit, hover and inspection for Naval Mine Counter Measure operations, wreck reconnaissance, or the oil and gas industry.

### How does the environment affect AUV missions?

The maximum speed of AUVs range from 2-5 knots or 1-2.6 m/sec. These speeds are comparable to the local ocean currents driven by tides, wind, and buoyancy flux. Although some AUVs handle sea states up to 5 (high surface wave environment), many cannot and thus knowledge of the wave conditions is paramount. Environmental information is very relevant to the success of an AUV mission.

### Our Objective and AUVFEST 2001

The goal is to develop a forecast capability for coastal circulation that supports AUV missions and mission planning through application of the ADCIRC coastal circulation model, a finite element representation of coastal hydrodynamics.

The forum for testing this forecast system was AUVFEST 2001, a two week period for experimental AUV operations off Ship and Horn Islands in the Mississippi Sound, located in the NE Gulf of Mexico. Real-time 48 hour forecasts produced by the ADCIRC model were provided during the entire AUVFEST from October 22 – November 2, 2001.

Mississippi Sound, NE Gulf of Mexico


Local Test Area

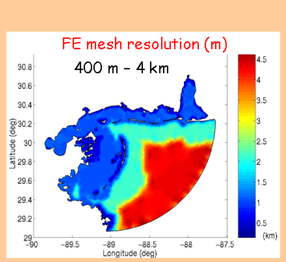


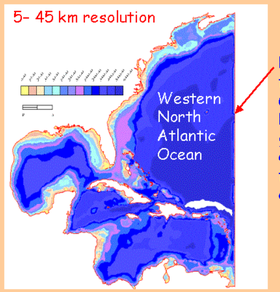

## ADCIRC FORECASTS for AUVFEST 2001

Mississippi Sound, NE Gulf of Mexico, October 22 – November 2, 2001

### The ADCIRC Model Forecast System

- Based on 2-D shallow water equations
- Tidal forcing only (for this application)
- Boundary forcing from the tides ($M_2$, $S_2$, $N_2$, $K_1$, $O_1$, $Q_1$, $P_1$) computed over the ADCIRC WNAT model domain

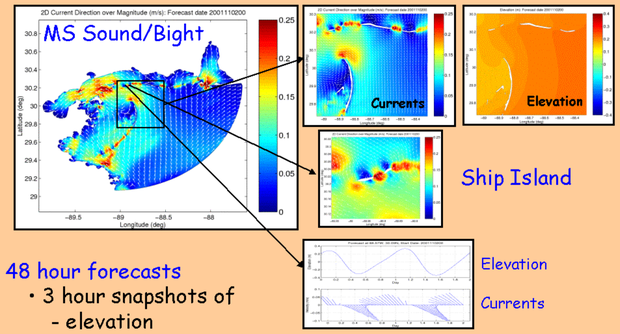



Forcing from Grenoble FES95.2 global tidal database for 7 constituents

- Computations on unstructured finite element grids

### ADCIRC Forecast Products

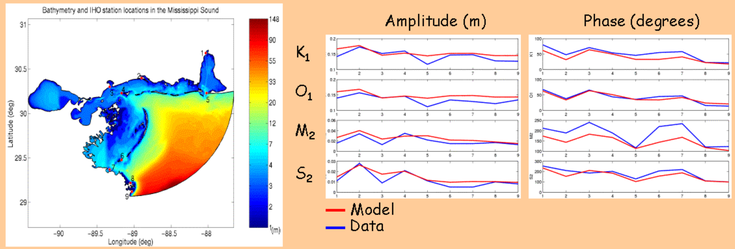



48 hour forecasts
- 3 hour snapshots of
  - elevation
  - current magnitude and direction
- Time series of elevation and currents at 2 stations

### Near-Future Advances

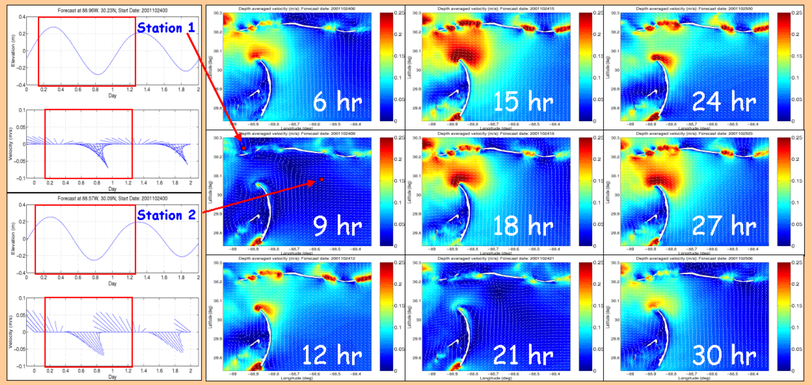
- Add wind forcing from 3 km COAMPS forecast winds
- Apply ADCIRC-3D model equations
- Conduct model-data comparisons using AUV data
- Implement an incremental data assimilation module

### Model-Data Comparison for Elevation




- Diurnal tides are dominant with a range of 10-17 cm in amplitude; they contain a majority of the tidal energy (75%) in the region.
- Semi-diurnal tides are an order of magnitude smaller having amplitudes of 1-2 cm.
- Diurnal errors are reasonable: 10% in amplitude and 10 deg. in phase.
- Larger semi-diurnal errors are a consequence of very small magnitudes and a sensitivity to friction.

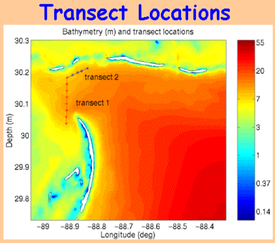
### Circulation over One Tidal Cycle



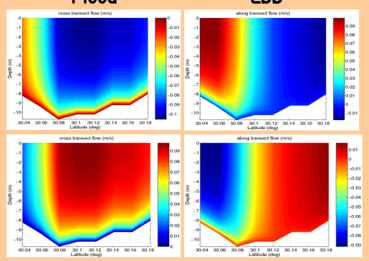

- Offshore currents rotate CW with magnitudes of 4-12 cm/s; flow is orthogonal to the isobaths (E-W).
- Through barrier island inlets, the currents are more rectilinear with magnitudes 15-35 cm/s; flow is oriented N-S.
- Ebb flow results in stronger currents through the inlets, particularly around the Chandeleur Islands.
- Lots of eddy formation occurs around the island tips during the slack transition.

### 3-D Circulation, May 15, 2001

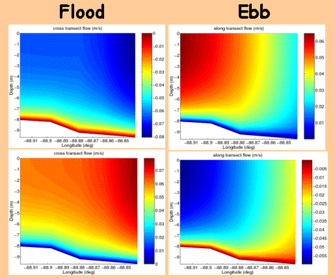
Transect Locations




Transect 1




Transect 2




| Positive: | Cross-transect into page | Along-transect S-N | Cross-transect into page | Along-transect W-E |
|---|---|---|---|---|

- Clearly flow through island passages has a 3-D structure; surface magnitudes are greater than currents at depth
- Regions of well-mixed flow changes location with the flood/ebb cycle
- 2-D currents are much larger than depth-averaged 3-D currents (not shown) → 3-D current forecasts are necessary !