MODELED 2D and 3D EMBAYMENT DYNAMICS

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Primary Objective

To develop a comprehensive numerical model that can accurately simulate the circulation dynamics of embayment and nearshore environments.

Importance

Circulation and exchange processes in the vicinity of inlets associated with embayment play an integral role in the transport of sediments, the movement of larvae and plankton, and determine the fate of pollutants.

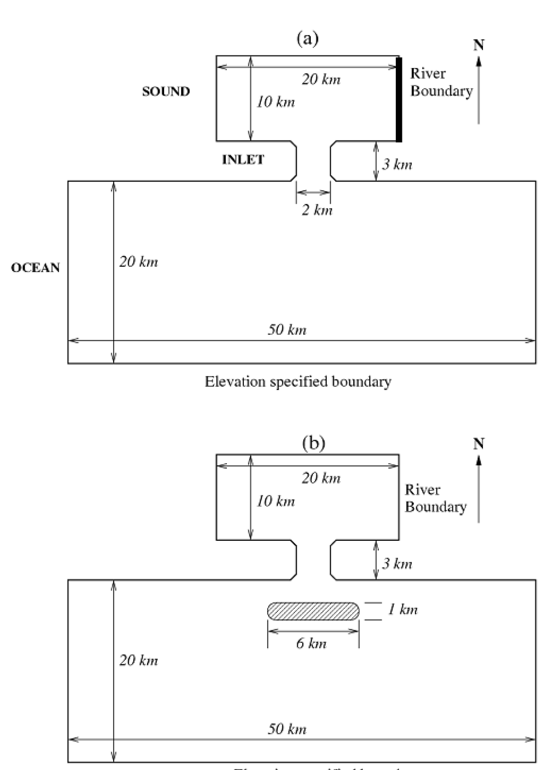
Approach

- Utilize the finite element circulation model, ADCIRC
- Compare idealized embayment dynamics to field cases
- Simulate embayments in the northeast Gulf of Mexico
  - tidal, river, wind and wave-forced processes
- Determine relative influence of forcing mechanisms

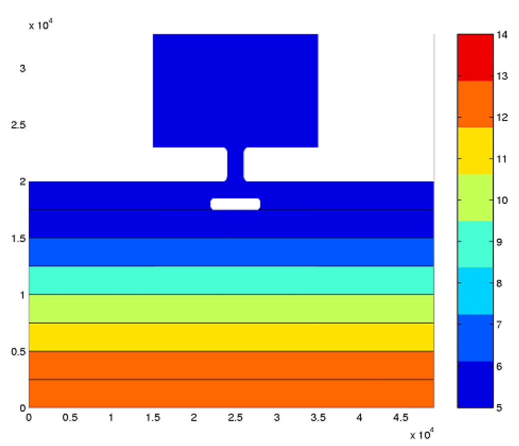
Results

- Diurnal tides dominate in NE Gulf of Mexico embayments
- Even an average river flow into Bay St. Louis results in significant exchange with the coastal ocean
- 3D is important for tide and wind-driven flows
- Complex wave-driven flow generated at inlet entrance

Idealized Geometry



Bathymetry

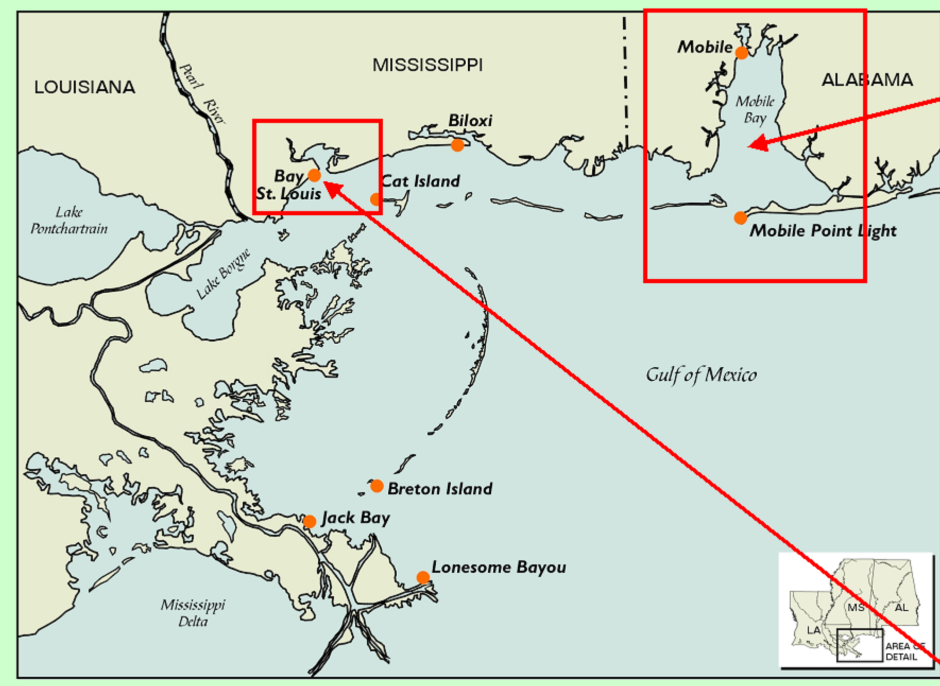


Resolution: 70 *m* to 1000 *m*

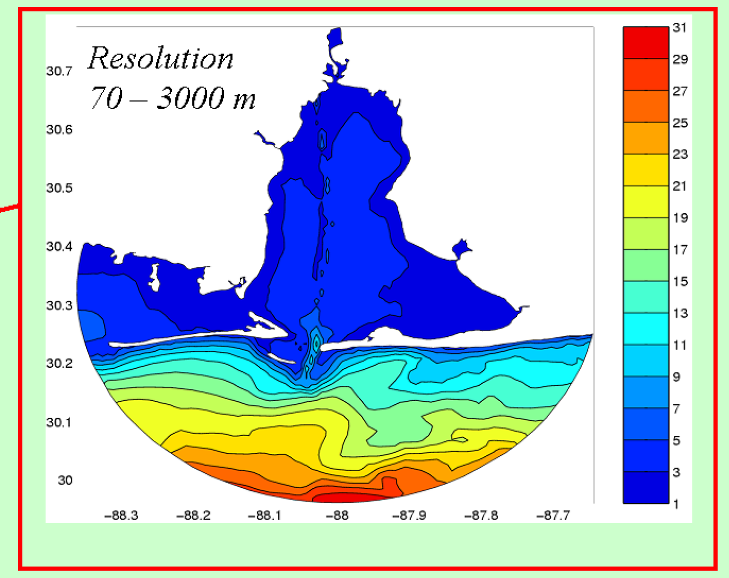
Forcing:

- single tidal component offshore (M_2 or O_1)
- river inflow of 50 m^3/s
- initial wave condition (0.5 m, 10 sec, shore normal)
  - from SWAN phase-averaged wave model

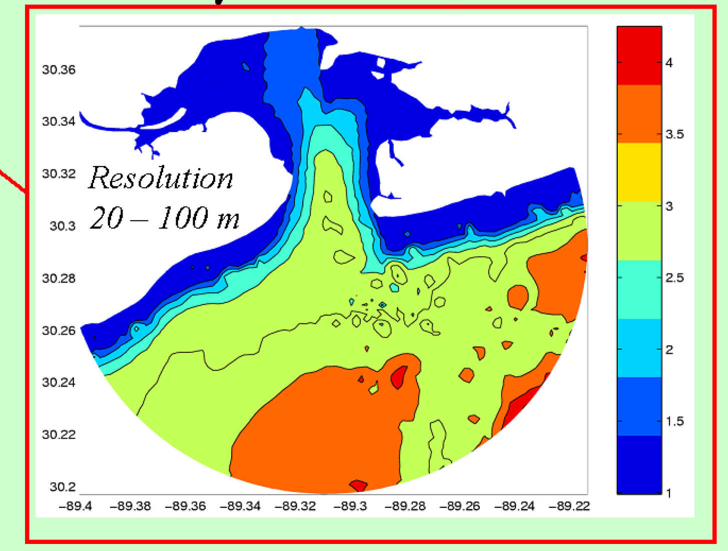
Embayments of the Mississippi Sound, Northeast Gulf of Mexico

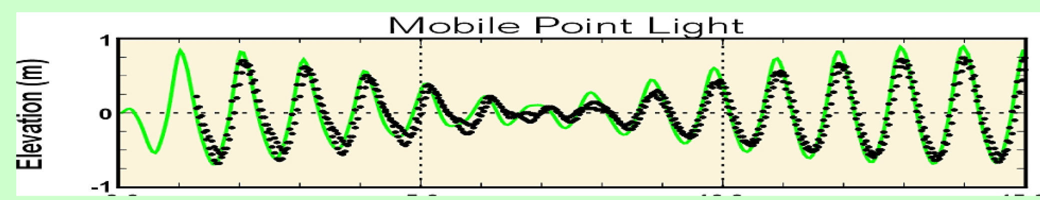


Mobile Bay, AL

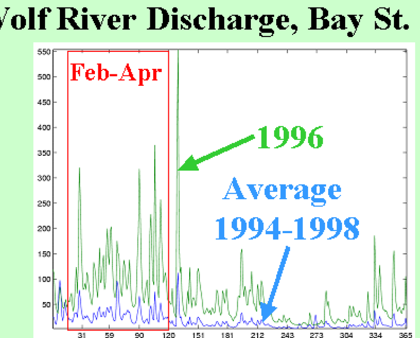


Bay St. Louis, MS



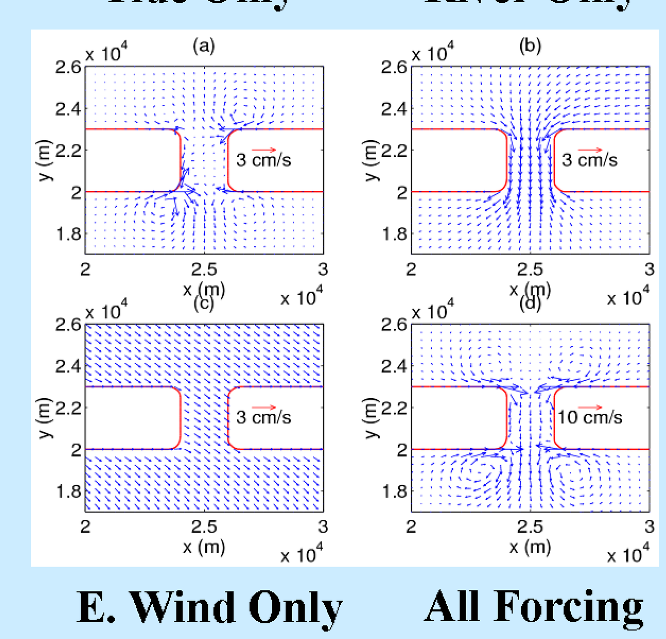


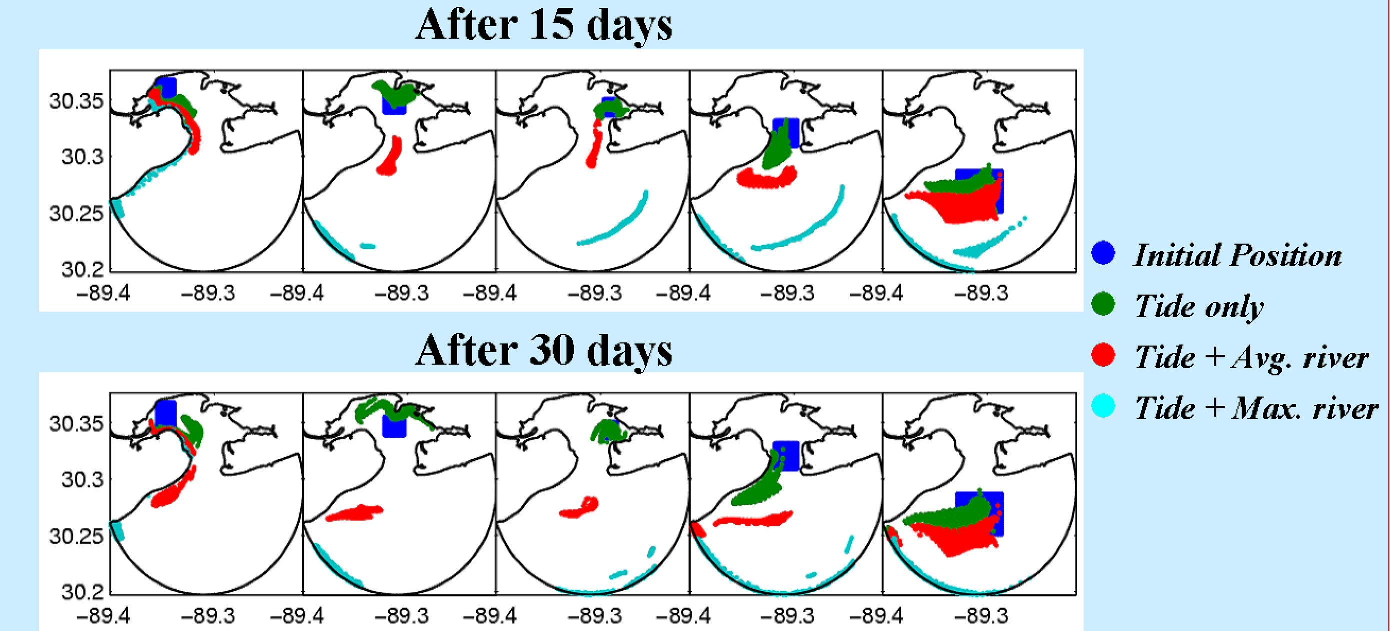
Wolf River Discharge, Bay St. Louis

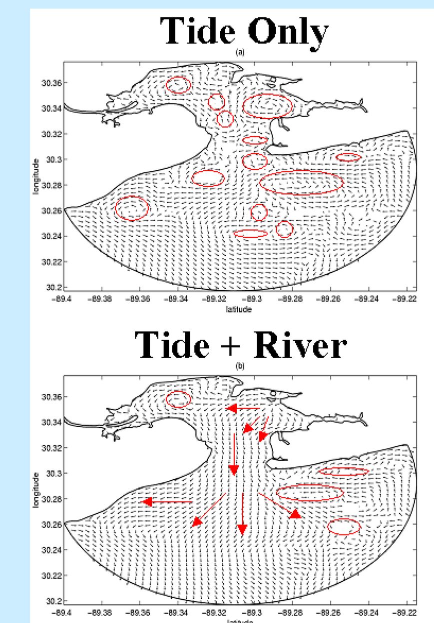


- USGS stream gage data
  - Avg. flow Feb-Apr, 30 m^3/s
  - Max. flow Feb-Apr, 300 m^3/s
- Offshore tidal forcing from 7 tidal components
  - derived from validated Gulf of Mexico ADCIRC prediction

Residual Circulation: Relative Influence of Tides vs. River Flux vs. Wind





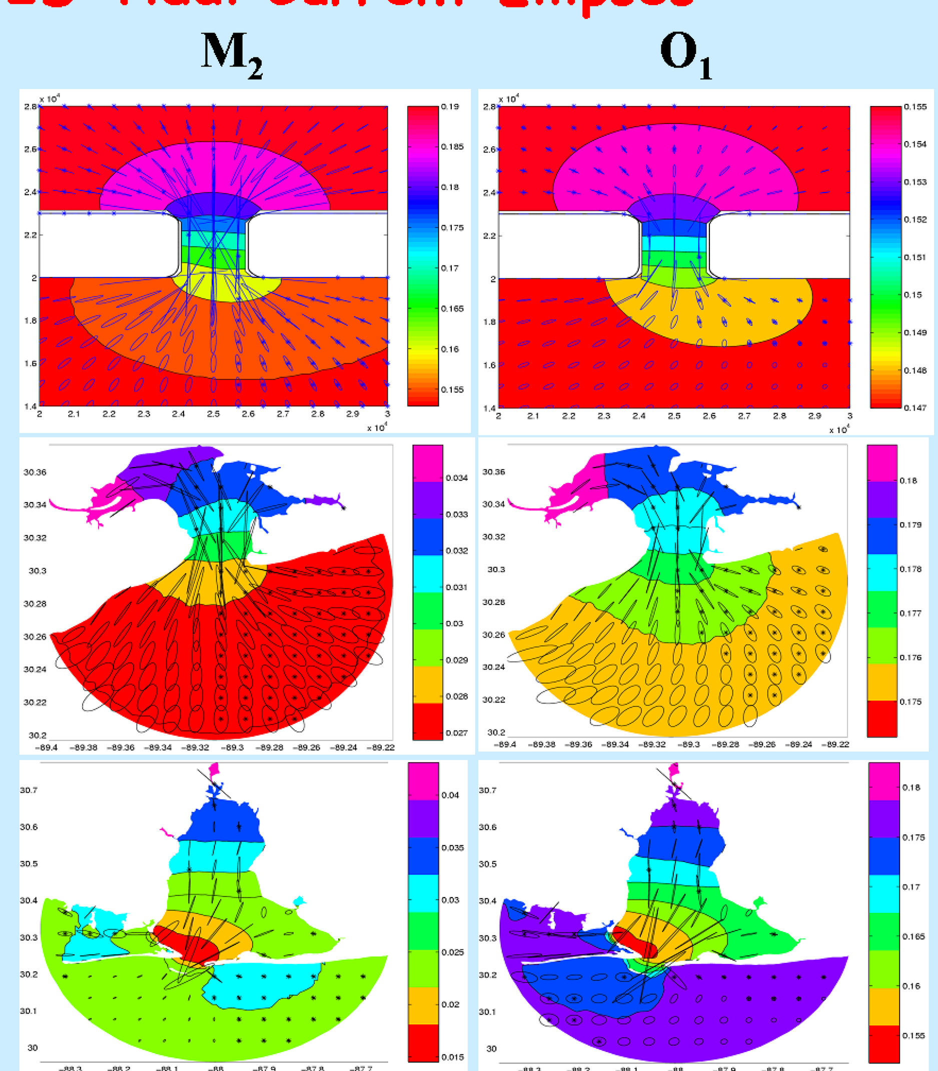


Generation of numerous eddies

River inflow flushes bay

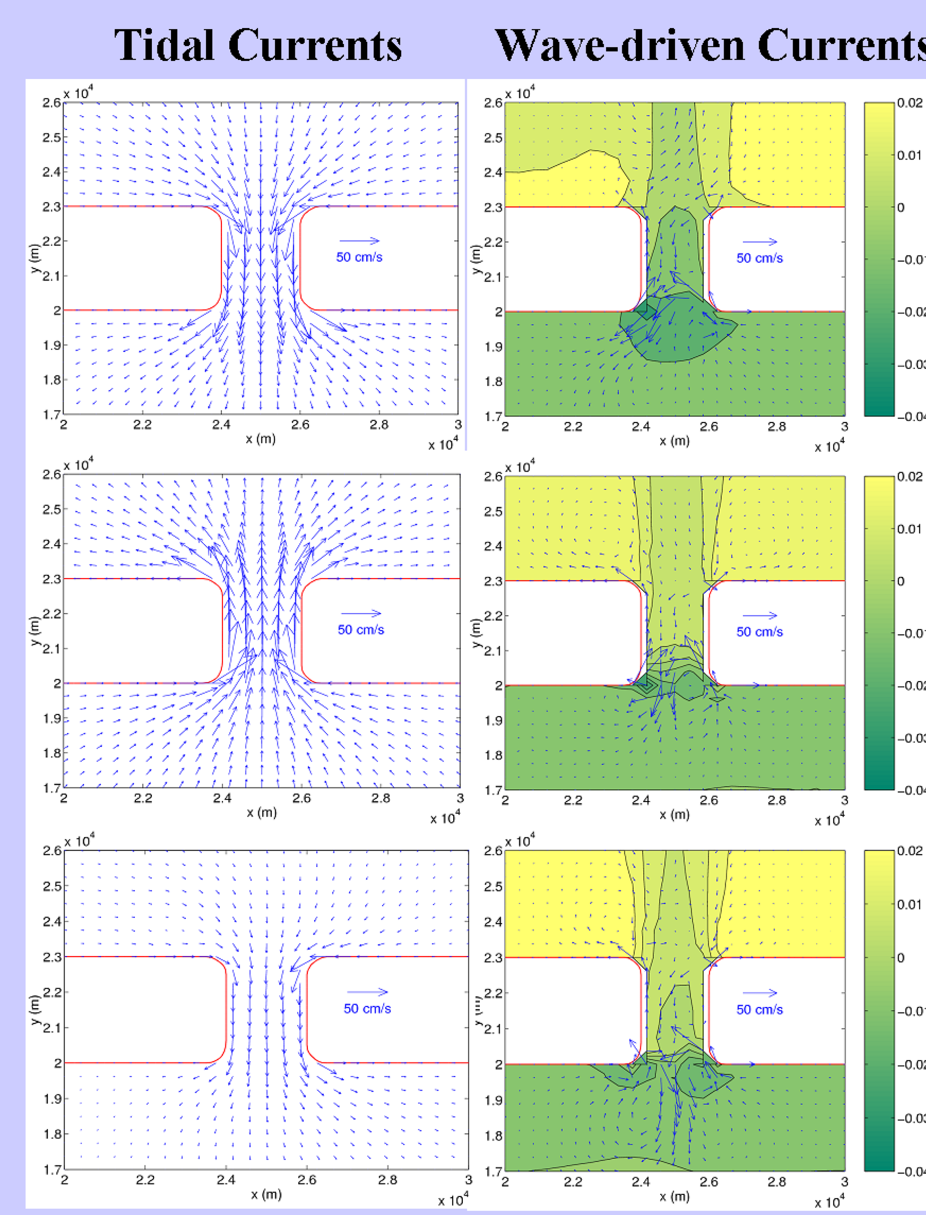
- Tide only
  - weak exchange between bay and coastal ocean
  - particles exit preferentially along western wall of inlet
  - all particles remain in domain after 30 days
- Tide + Average River
  - strong exchange between bay and coastal ocean
  - particles do not exit from the eastern portion of the inlet
  - after 30 days most particles removed from bay
- Tide + Max. River
  - strong flushing of embayment for all particles
  - greater dispersion of particles

2D Tidal Current Ellipses



- Tidal amplification primarily in vicinity of inlet
- Rectilinear flow through inlet and into bays
- CCW rotation located largely east of the inlet
- Coriolis acceleration:
  - affects semi-diurnal tides to greater extent
  - minimal influence within embayment

2D Wave-Driven Currents and Mean Sea Level

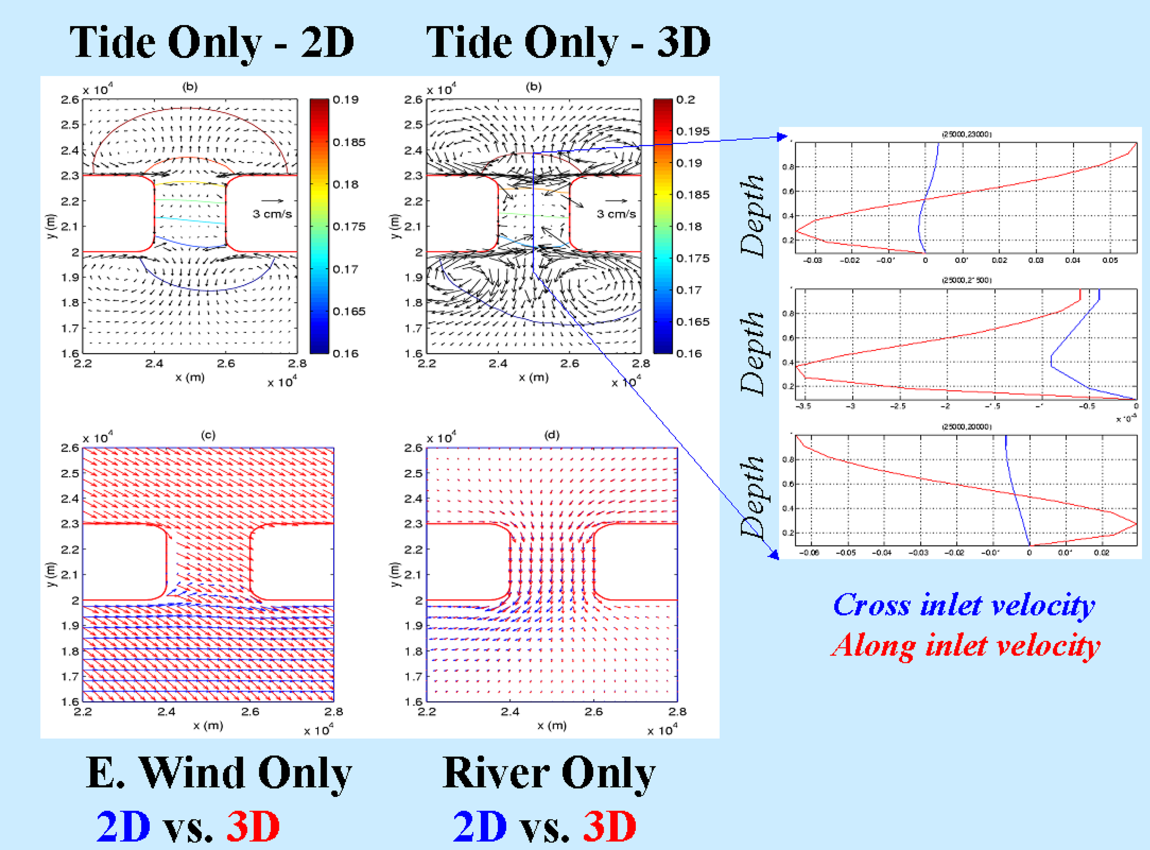


- Ebb Tide
  - set-down of mean sea throughout inlet
  - strong wave-driven currents exit inlet and veer to the west
- Flood Tide
  - set-down region very focused at inlet entrance
  - wave-driven currents still flow out the inlet away from the bay
- Slack Tide
  - complex set-down pattern at inlet entrance; symmetric
  - vortices and offshore-directed rip current form in the coastal waters outside the inlet

FORCING:

SWAN model computed wave heights/directions modified at three phases of the tide (ebb, flood, slack) by ADCIRC computed tidal elevation and currents.

2D vs. 3D Currents



- 3D tidal circulation
  - stronger than 2D tidal circulation; decreases with depth
  - cross-inlet flow is very small
  - flow enters the inlet from the N & S through the bottom
  - flow exits the inlet at the surface
- Wind-driven circulation
  - 3D currents to the right of wind; Ekman spiral develops
  - 2D wind-driven flow coincident with wind direction
- River-forced circulation
  - 3D currents not as influenced by Coriolis acceleration