The feasibility of using Caernarvon Freshwater Diversion to prevent oil slicks from flushing into the Breton Sound Estuary

Haosheng Huang, Dubravko Justic, Kenneth A. Rose,

and Chunyan Li

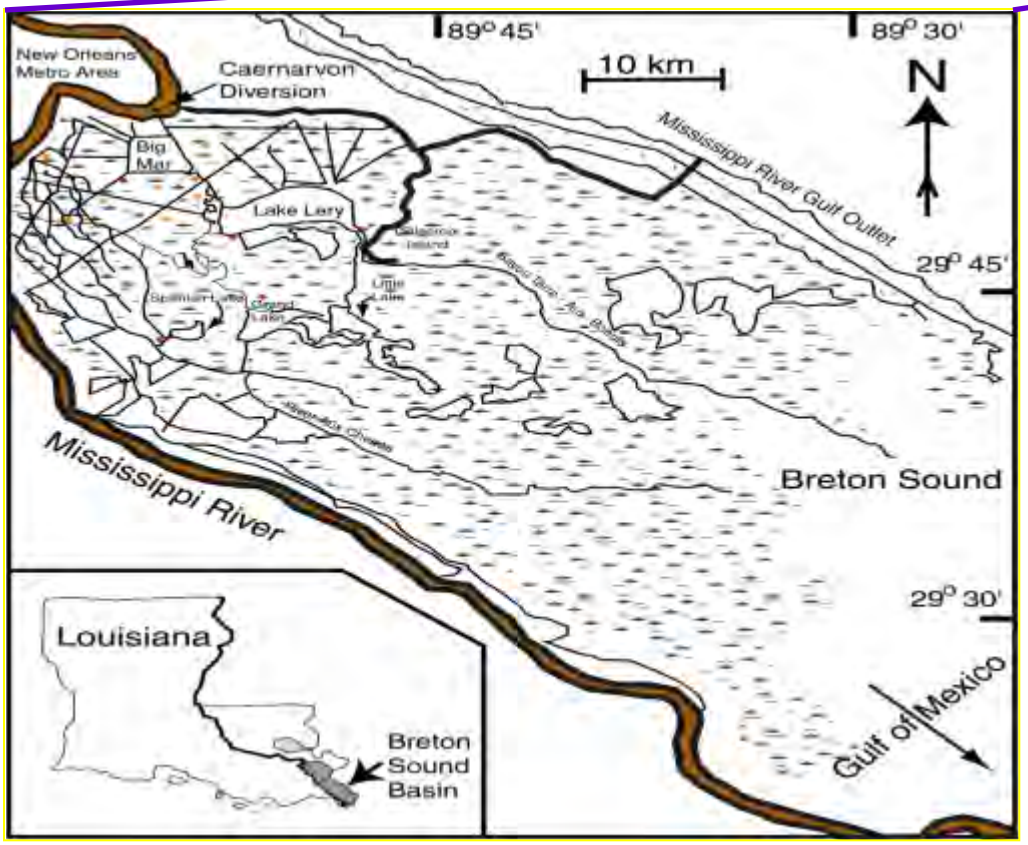
Department of Oceanography and Coastal Sciences

School of the Coast and Environment

Louisiana State University

Baton Rouge, LA 70803

Study Area



Ever since the beginning of the oil spill the idea has emerged to open up all coastal freshwater diversions to flush oil slicks out of coastal estuaries and bays.

- Diversion maximum flow capacity (227 $m^3 s^{-1}$ for Caernarvon Freshwater Diversion in Breton Sound).
- Tidal flux at the bay mouth (on the order of 4000 $m^3 s^{-1}$, Swenson et al., 2006).
- Wind-driven estuary-shelf exchange (same order of magnitude as tidal flux)

Is it possible?

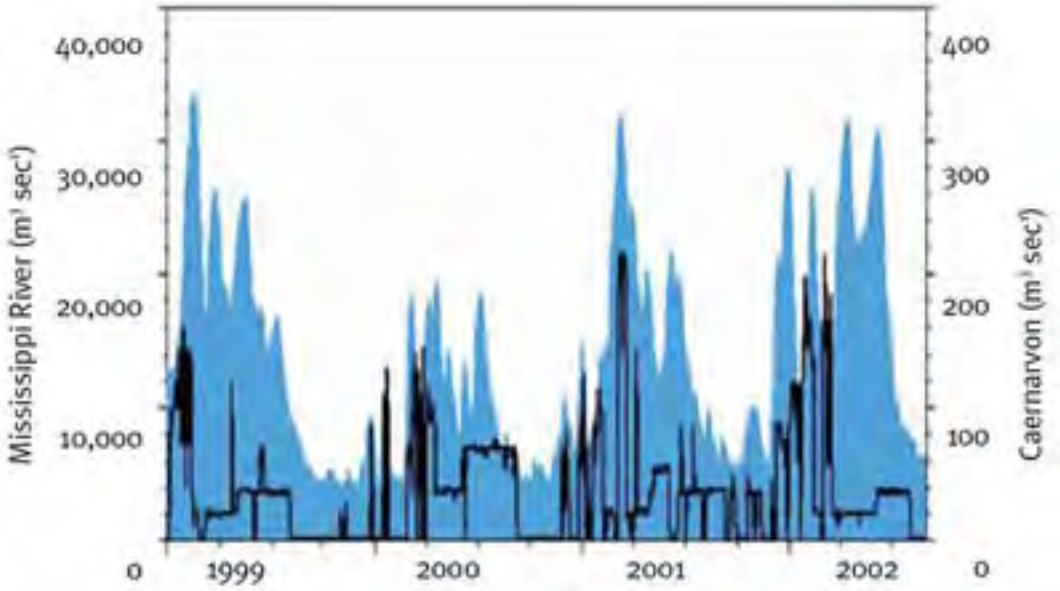
Caernarvon Diversion

From http://www.lacoast.gov/

- In operation since 1991
- Discharge capacity is 227 m^3/sec (8000 cfs)
- Normal operation is up to 113 m^3/sec.
- During 2010 BP oil spill event, pulses are 227 m^3/sec (8000 cfs).

Pulsing diversion discharge

Comparison of Caernarvon and Mississippi River Discharge



The black line is the Caernarvon discharge and the blue line is the natural pattern of Mississippi River discharge (From http://www.lacoast.gov/)

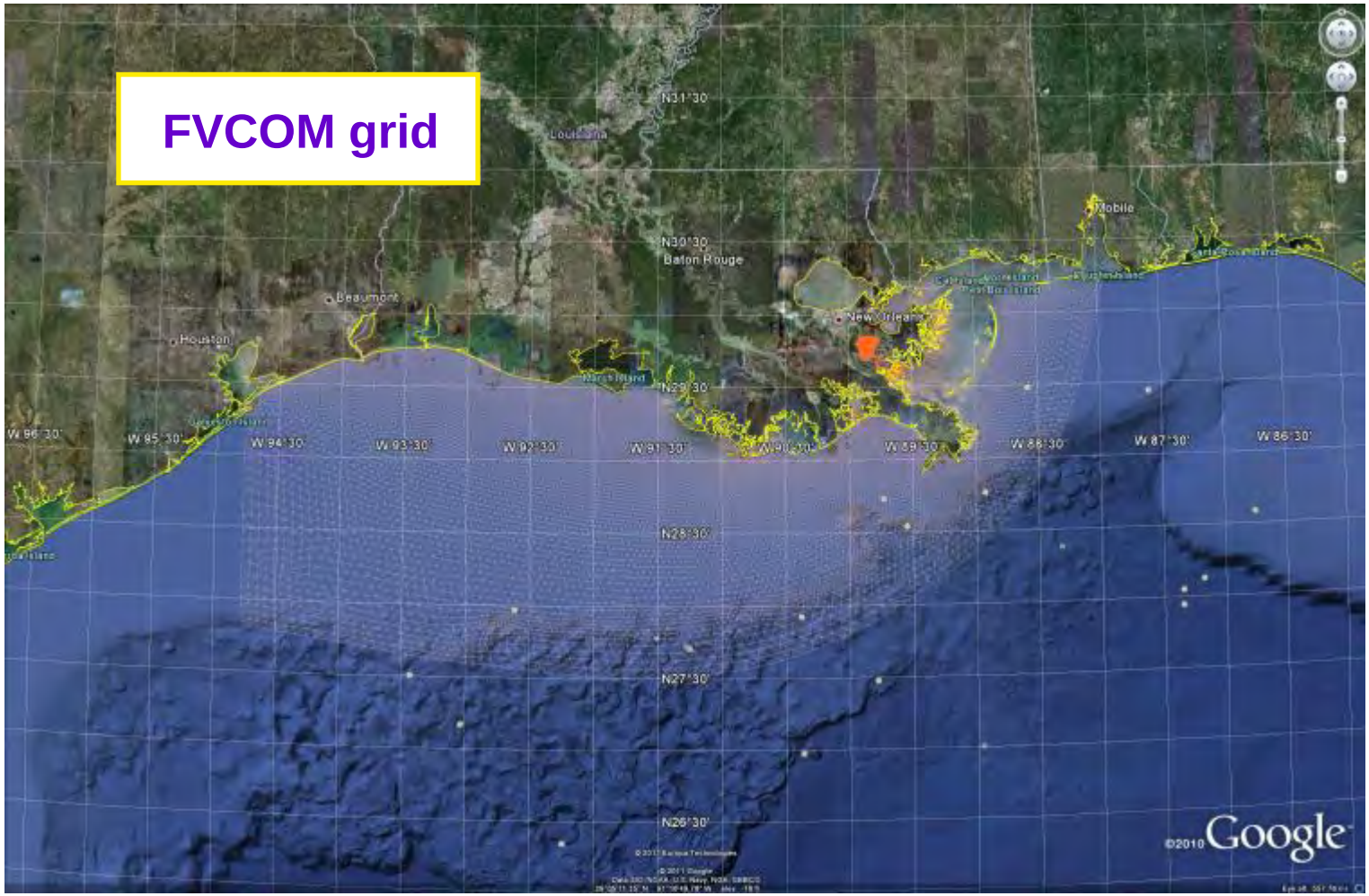
PULSES project tested the hypothesis that the reintroduction of artificial river floods, which mimics the natural seasonal flooding of the river system, will restore some key natural processes, such as wetland building, and using wetlands as nutrient filter.

Hydrodynamic Condition

- Small diurnal tidal amplitude (~30 cm)
- Meteorological forced water level variation (up to 1.0 m)
- Large, shallow (3 m) open water bodies
- Intricate network of channels and bayous
- Large tidal velocity in narrow passes
- Overland flow
- Floating marshes
- Man-made canals, channels, and structures

The impact of Caernarvon discharge ?

Numerical Model



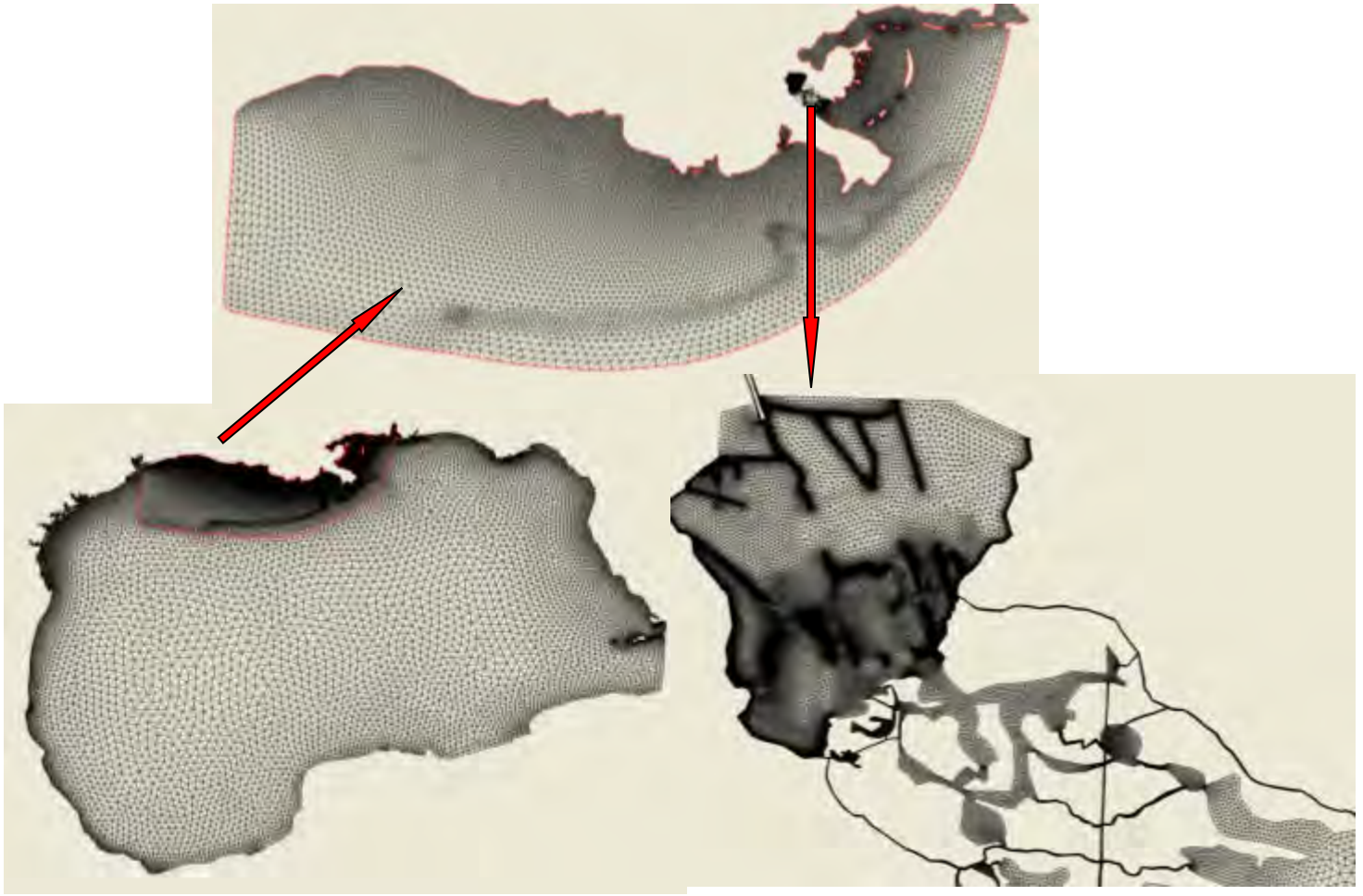
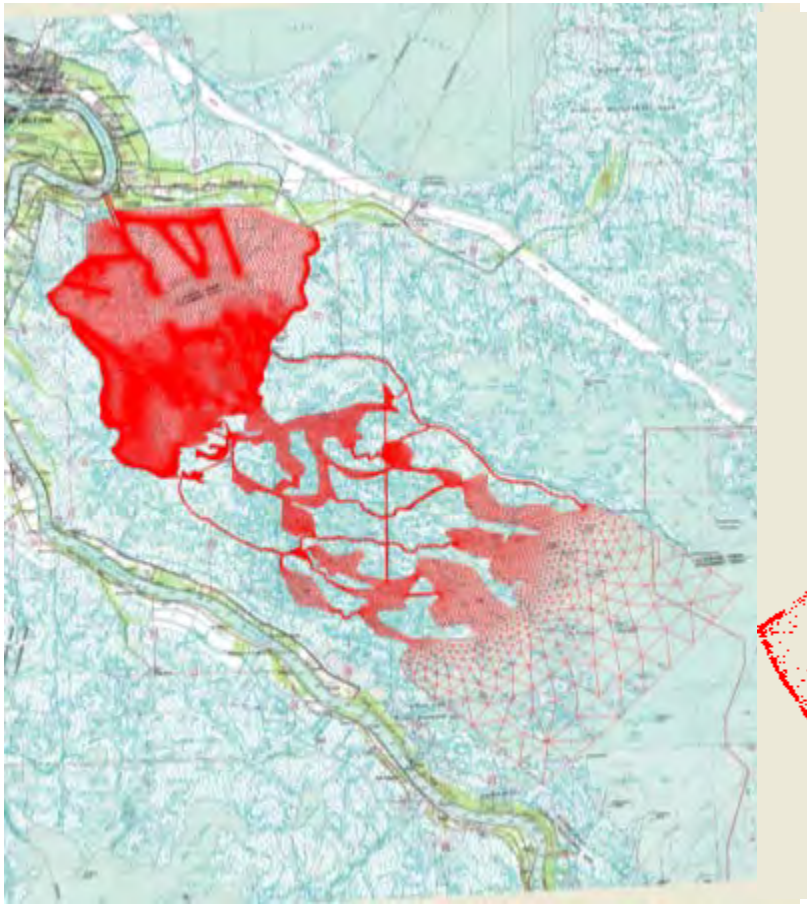
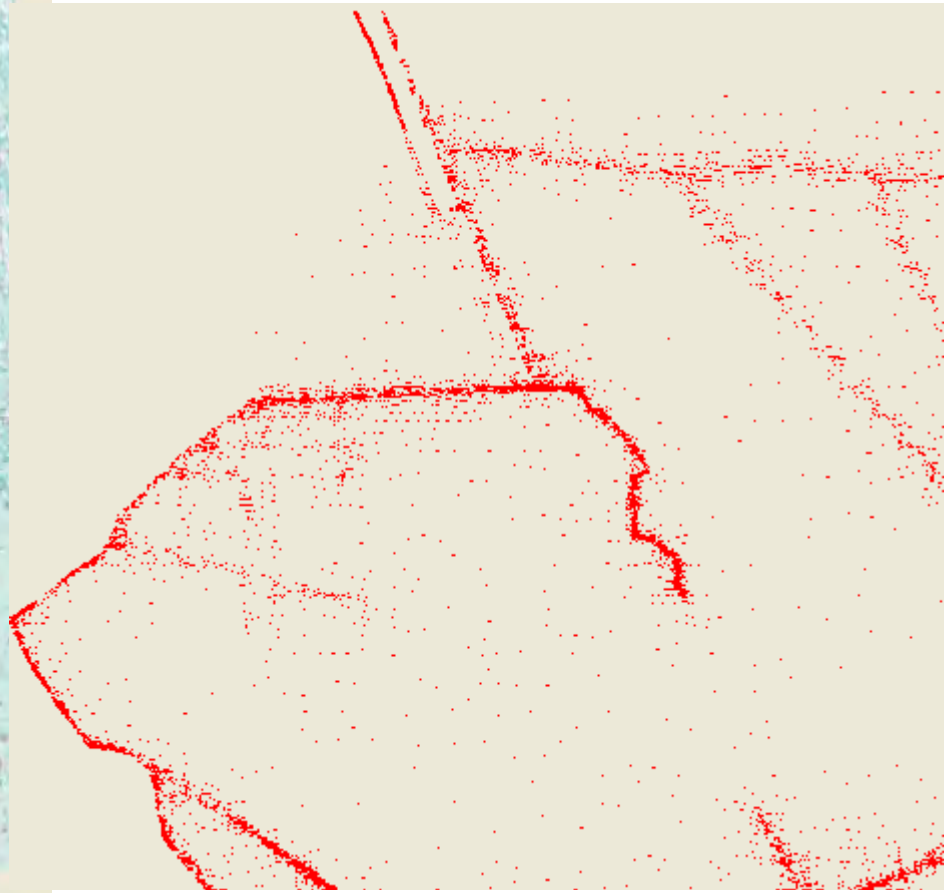


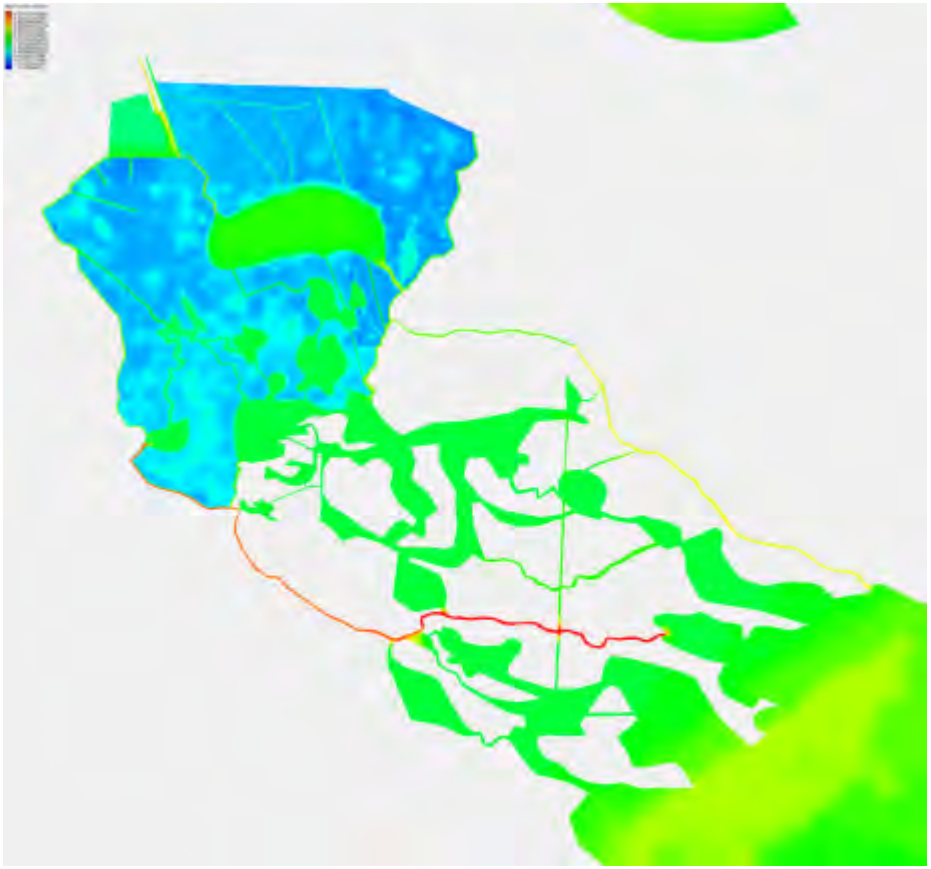
Fig. FVCOM numerical grid for the Breton Sound Estuary.

Numerical Grid





Model Bathymetry

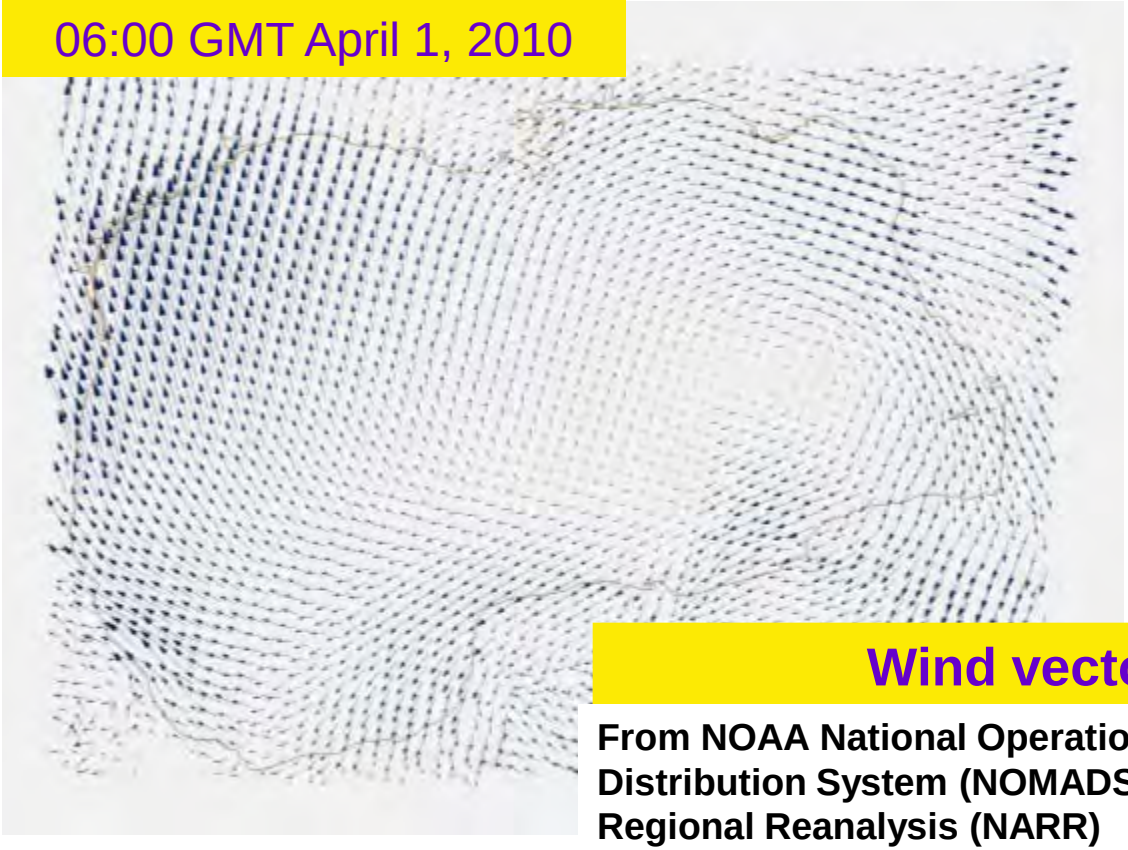


Data sources

- LIDAR Digital Elevation Model: horizontal resolution 5 m X 5 m
- Scanned Topographic Maps (from NOAA nautical charts)

Model Forcing

06:00 GMT April 1, 2010



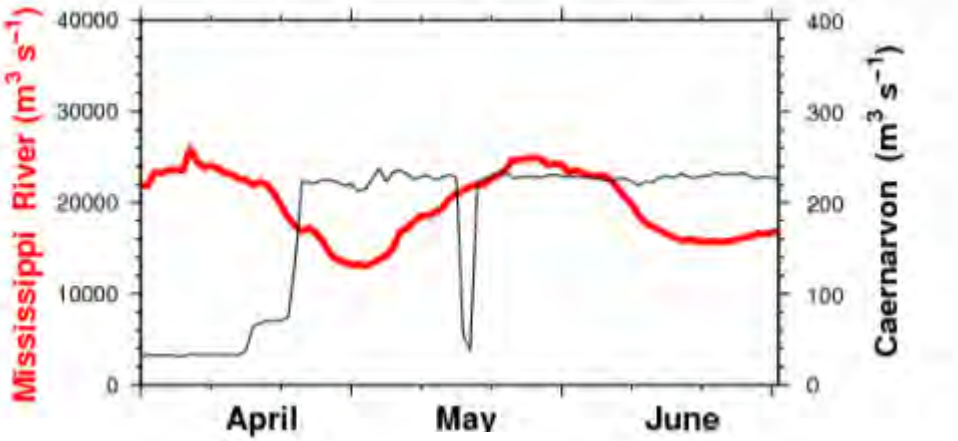
Wind vectors

From NOAA National Operational Model Archive & Distribution System (NOMADS) North American Regional Reanalysis (NARR)

Model Forcing

River and diversion discharge

From USGS stations

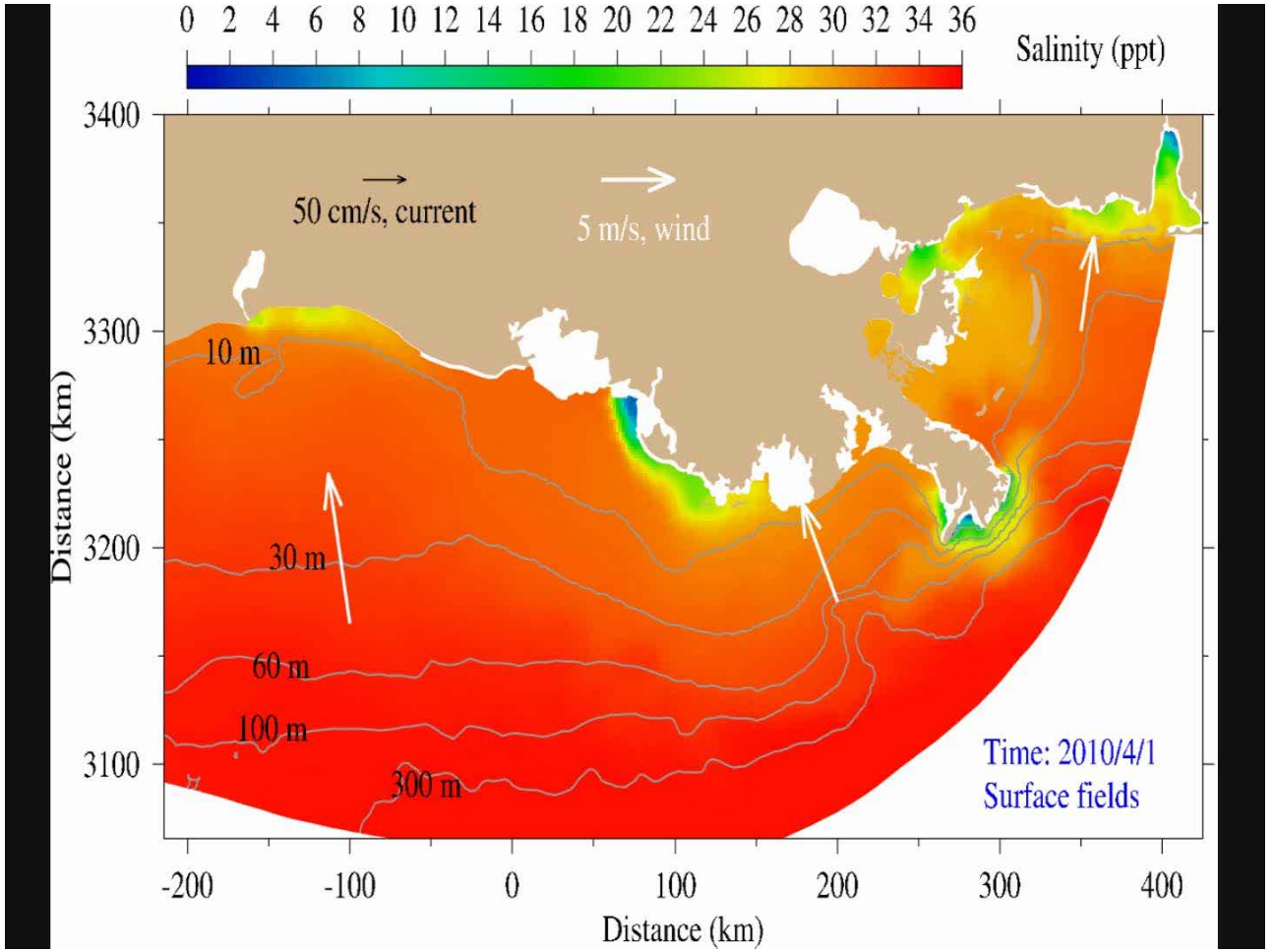


2010

Open boundary water level

Interpolated from NOAA National Water level Observation Network (NWLON) stations

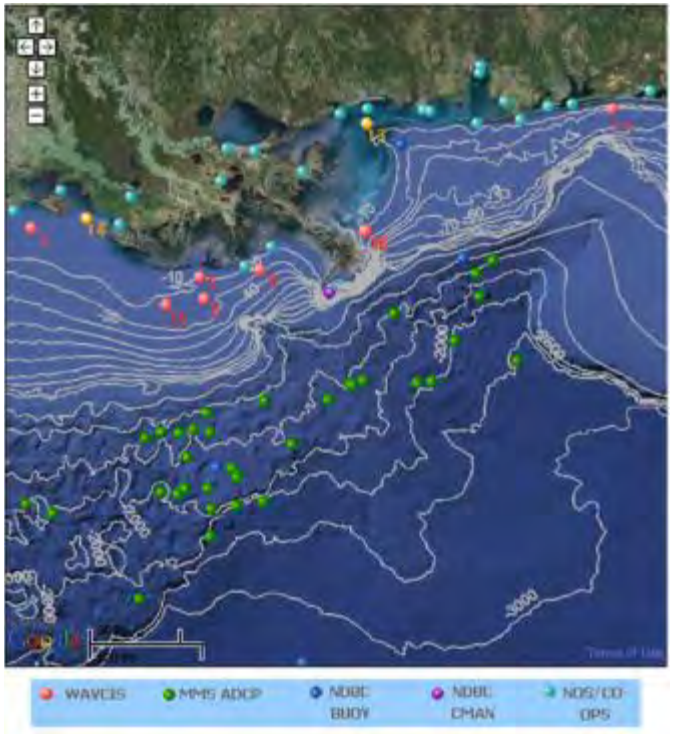
Velocity and surface salinity fields



Animation not available

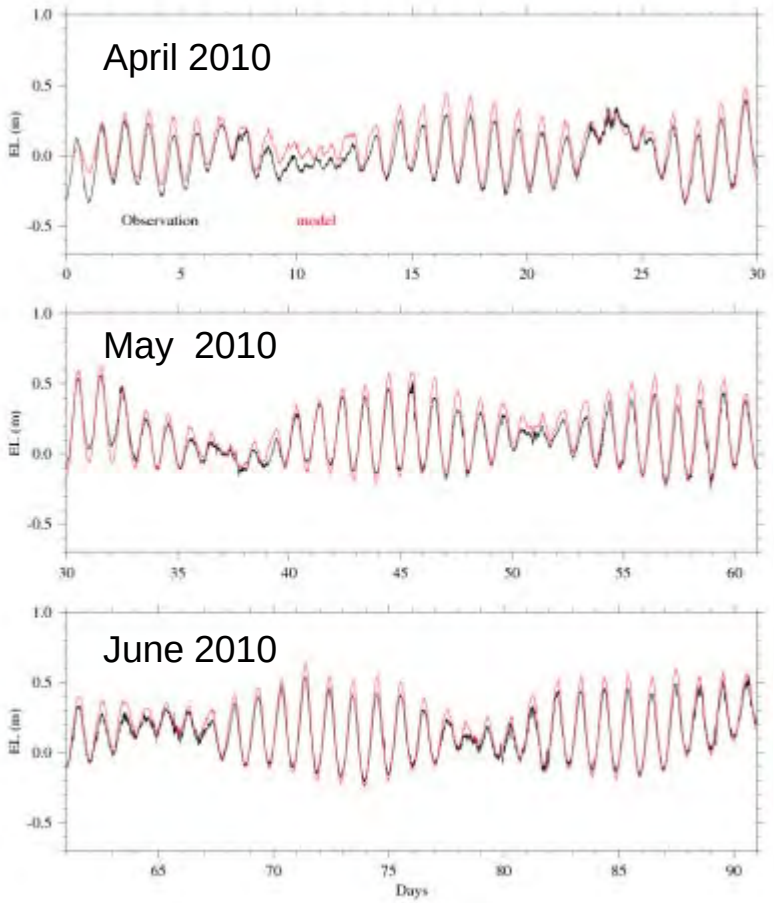
Model-Observation Comparison

WAVCIS stations

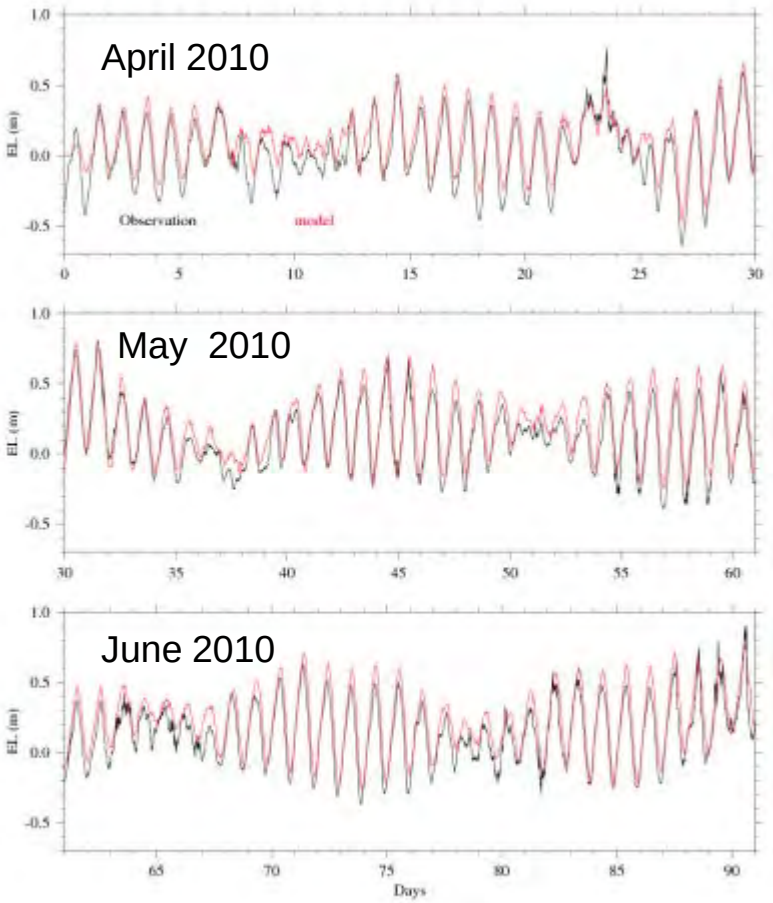


Model-Observation Comparison

Sea surface elevation



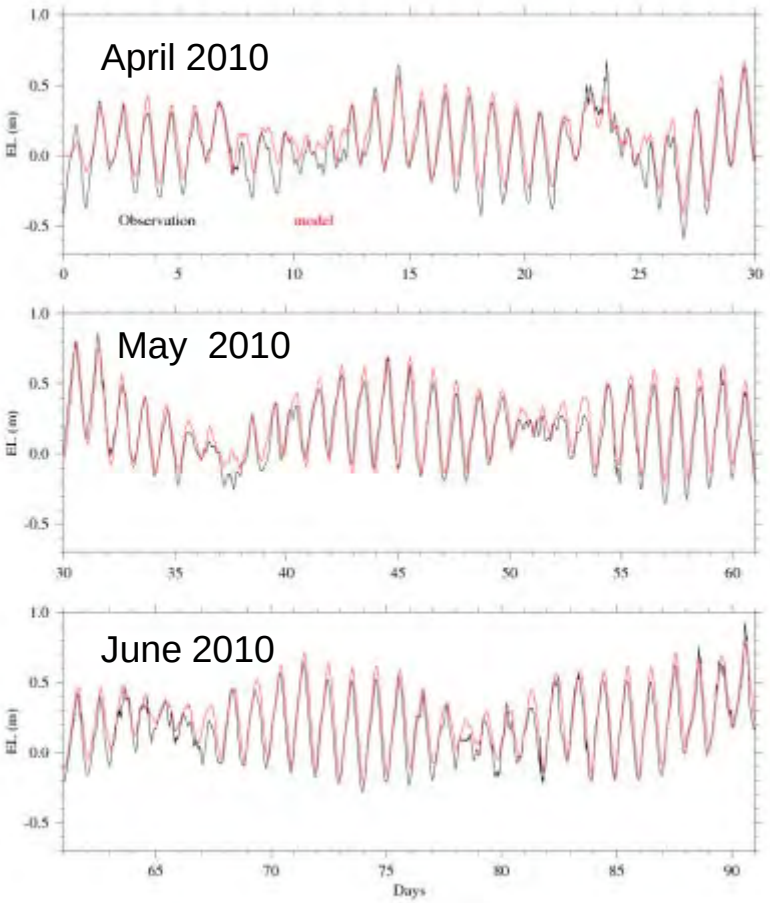
Dauphin Island, AL



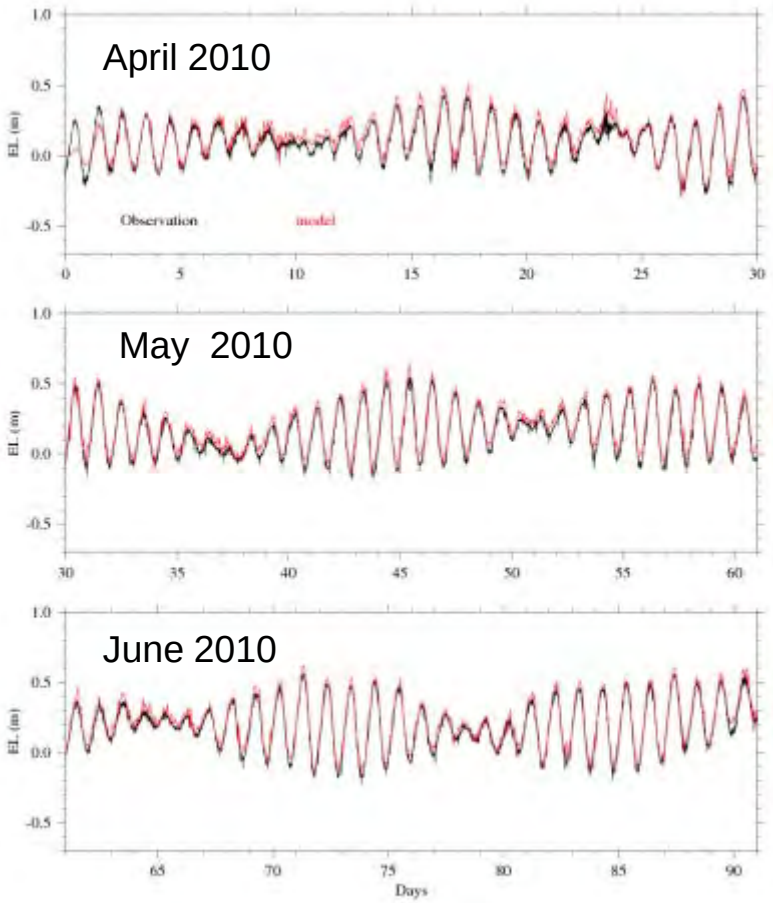
Gulfport Harbor, MS

Model-Observation Comparison

Sea surface elevation



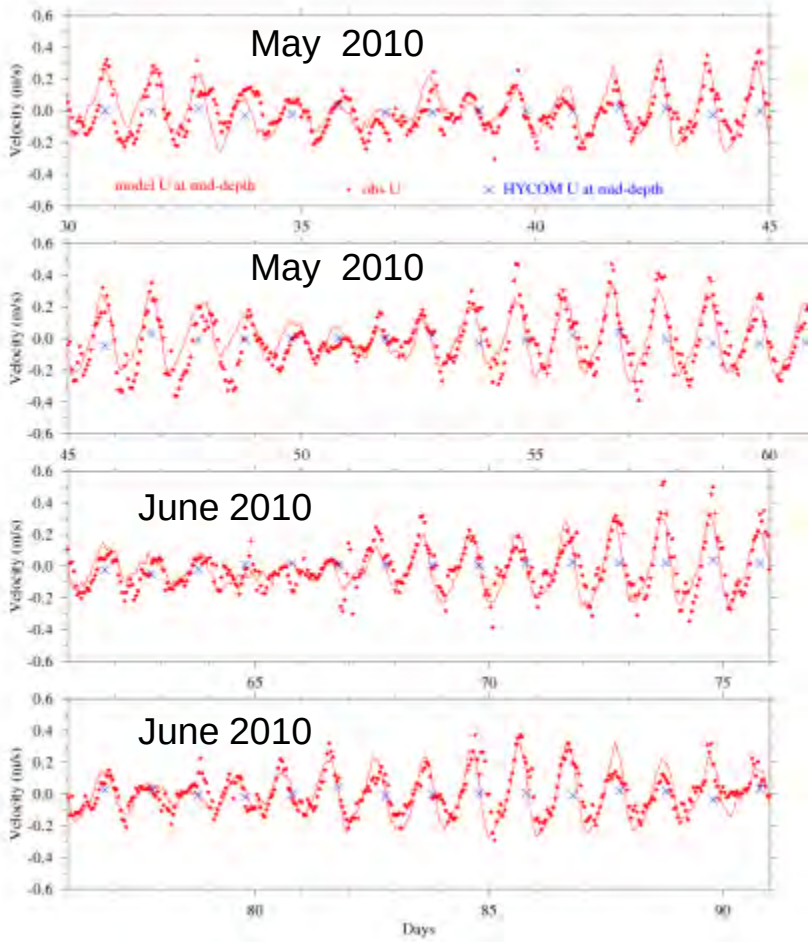
Waveland, MS



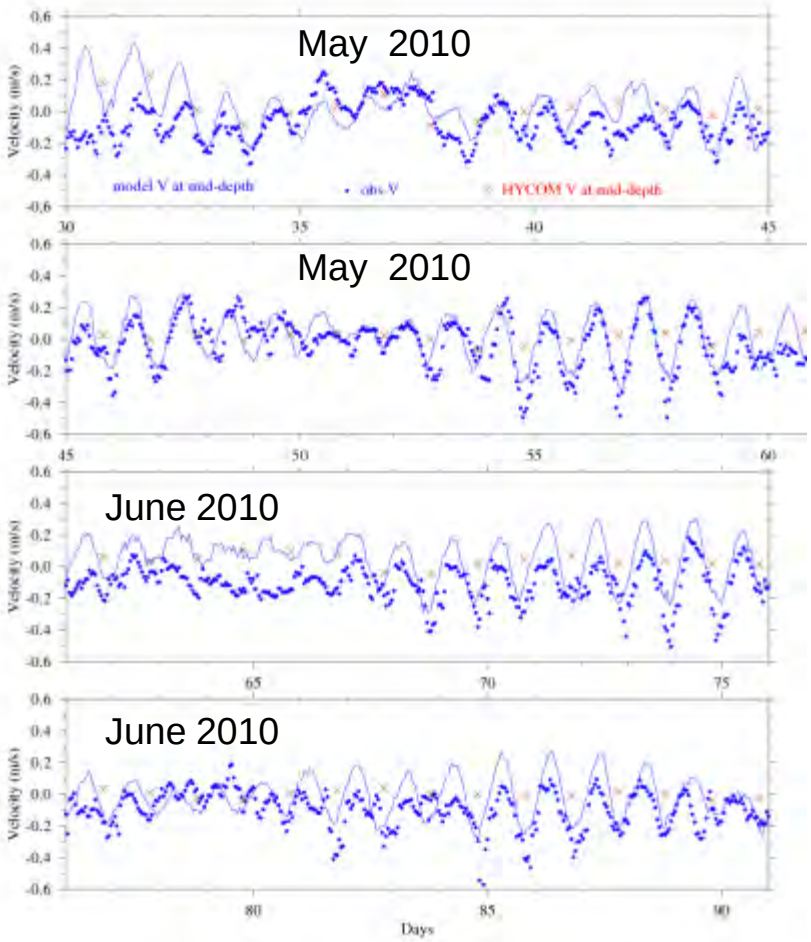
Southwest Pass, LA

Model-Observation Comparison

Velocity components



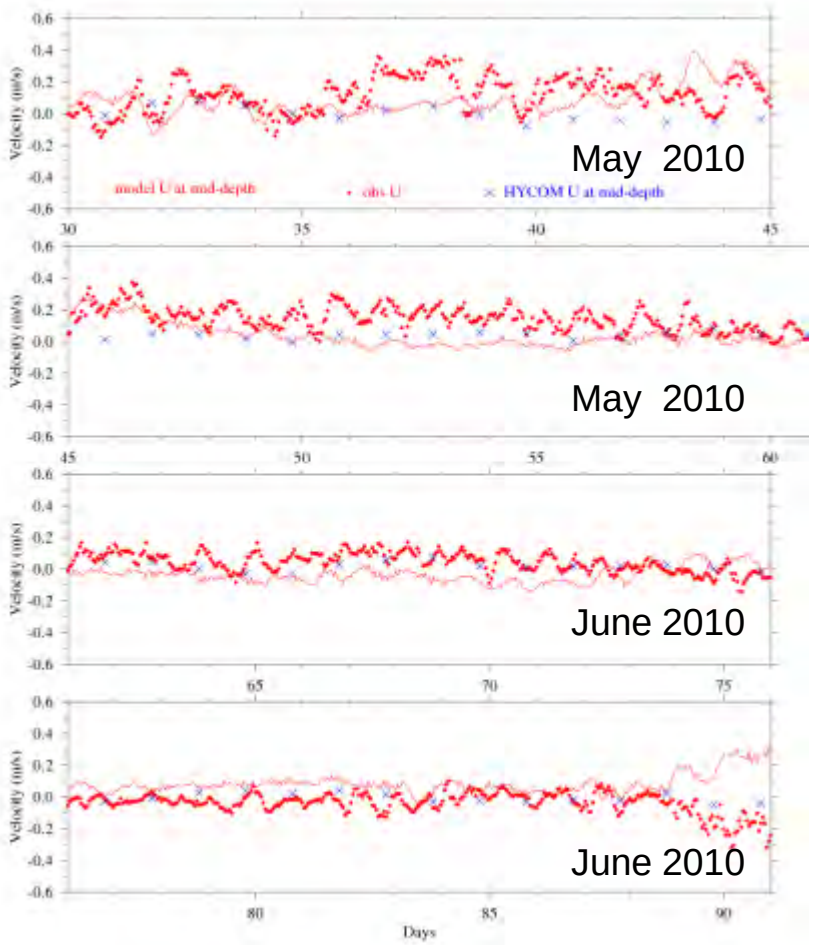
CSI16, East-West velocity component



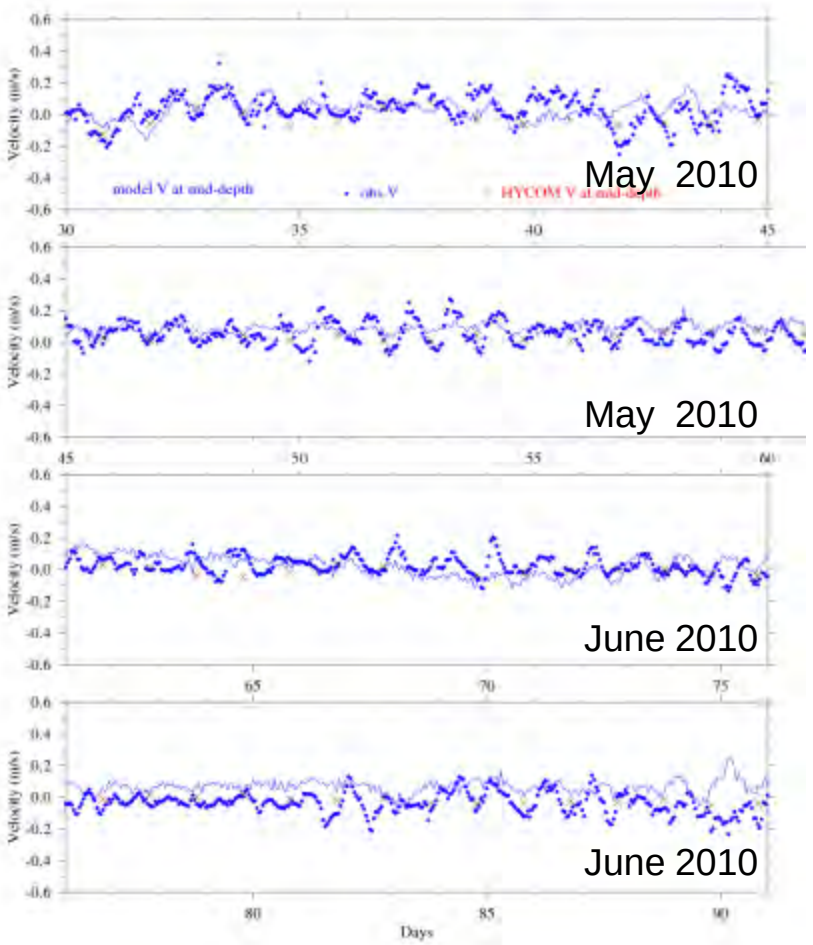
CSI16, North-South velocity component

Model-Observation Comparison

Velocity components



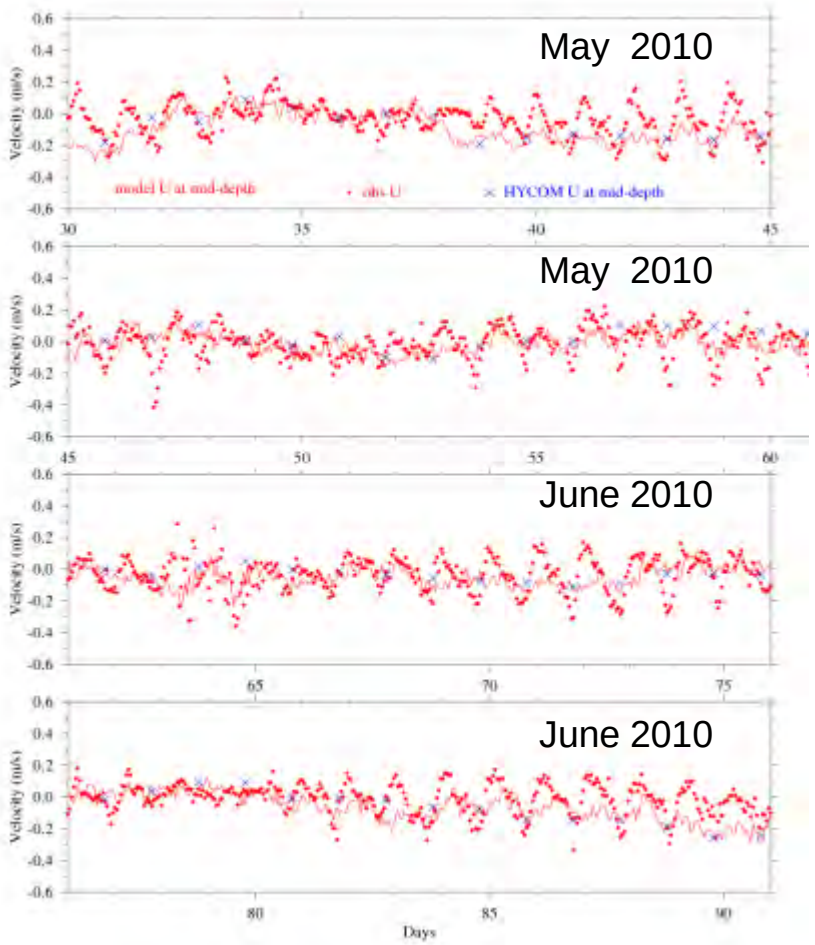
CSI09, East-West velocity component



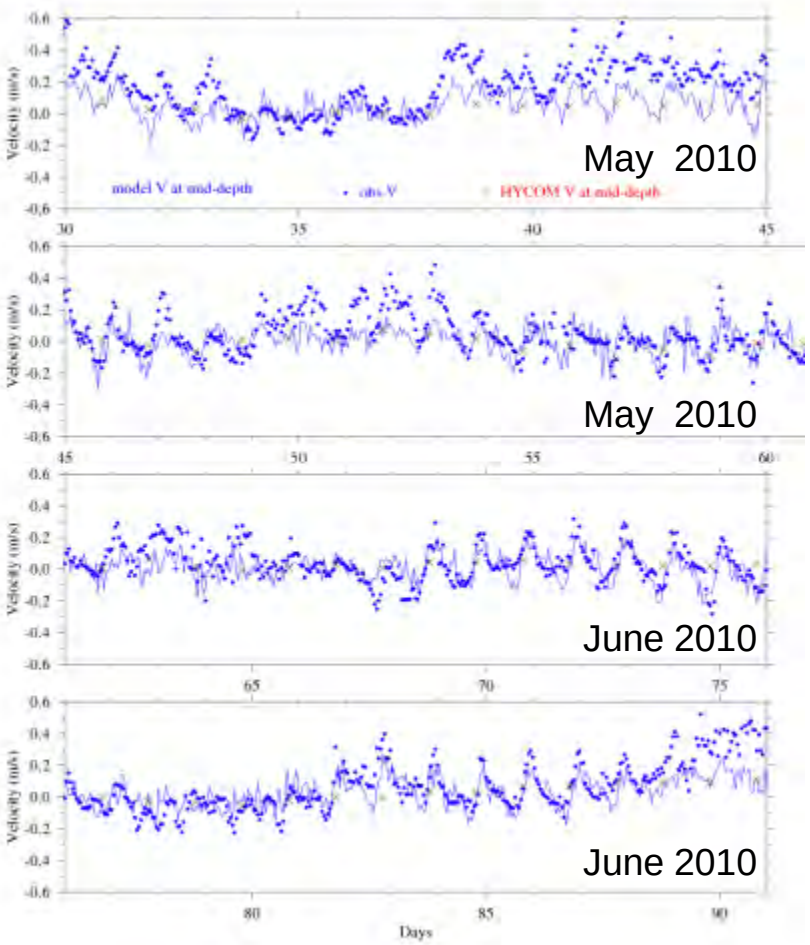
CSI09, North-South velocity component

Model-Observation Comparison

Velocity components

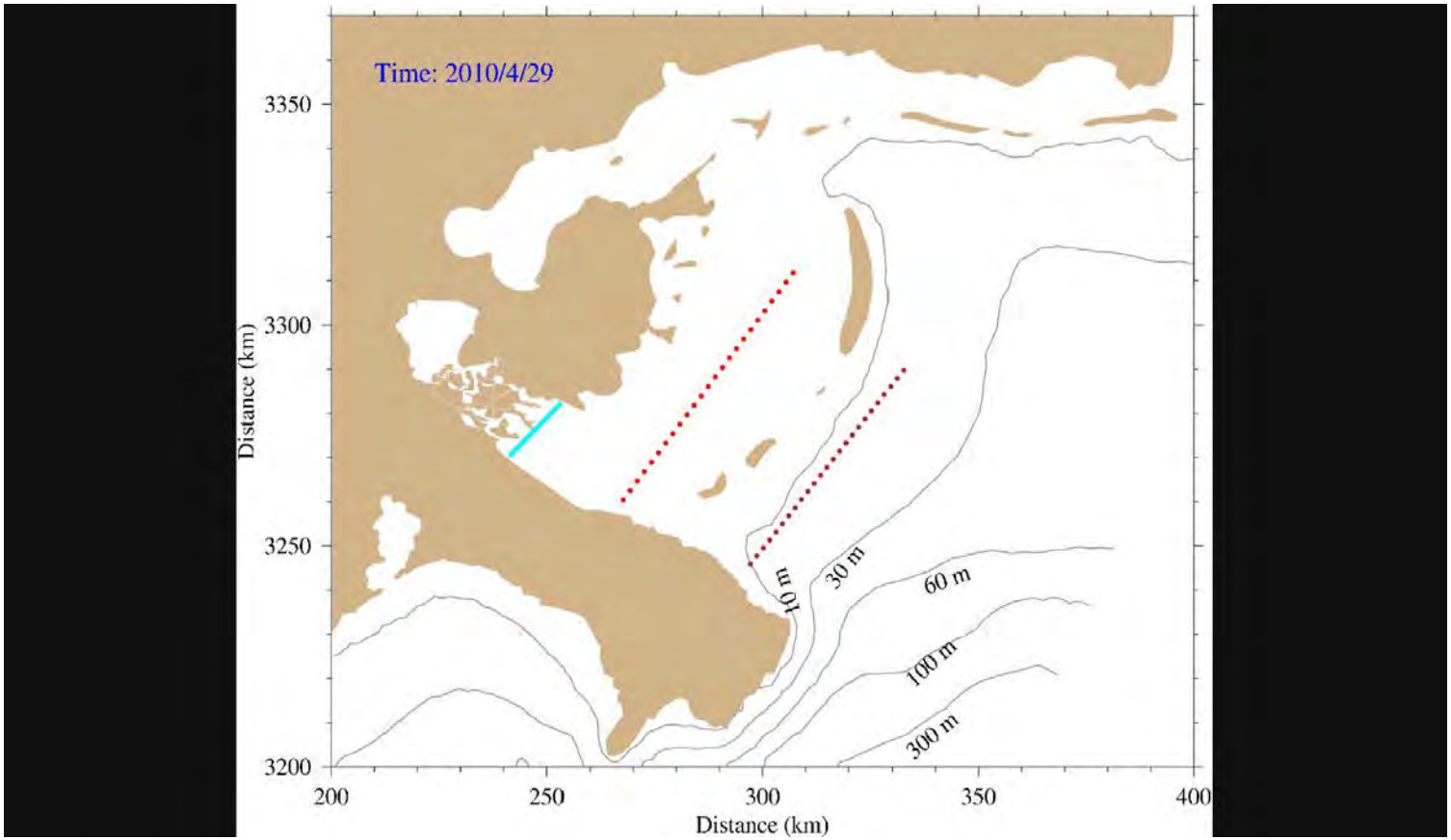


CSI03, East-West velocity component



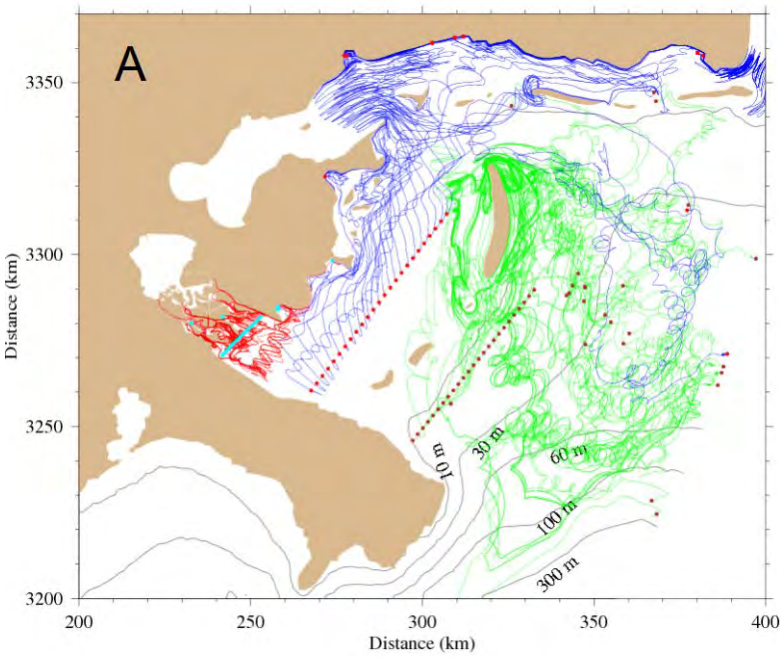
CSI03, North-South velocity component

Surface oil trajectories

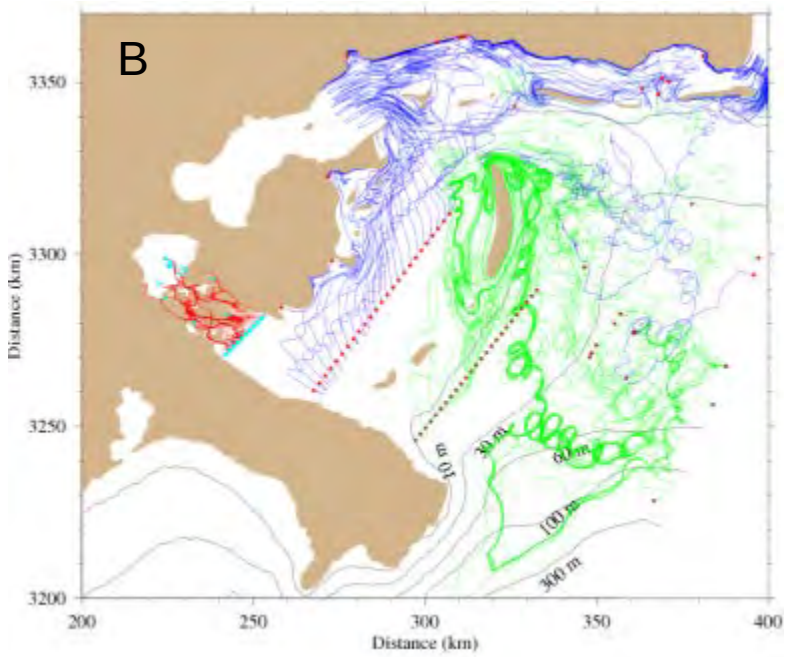


Animation not available

Surface oil trajectories

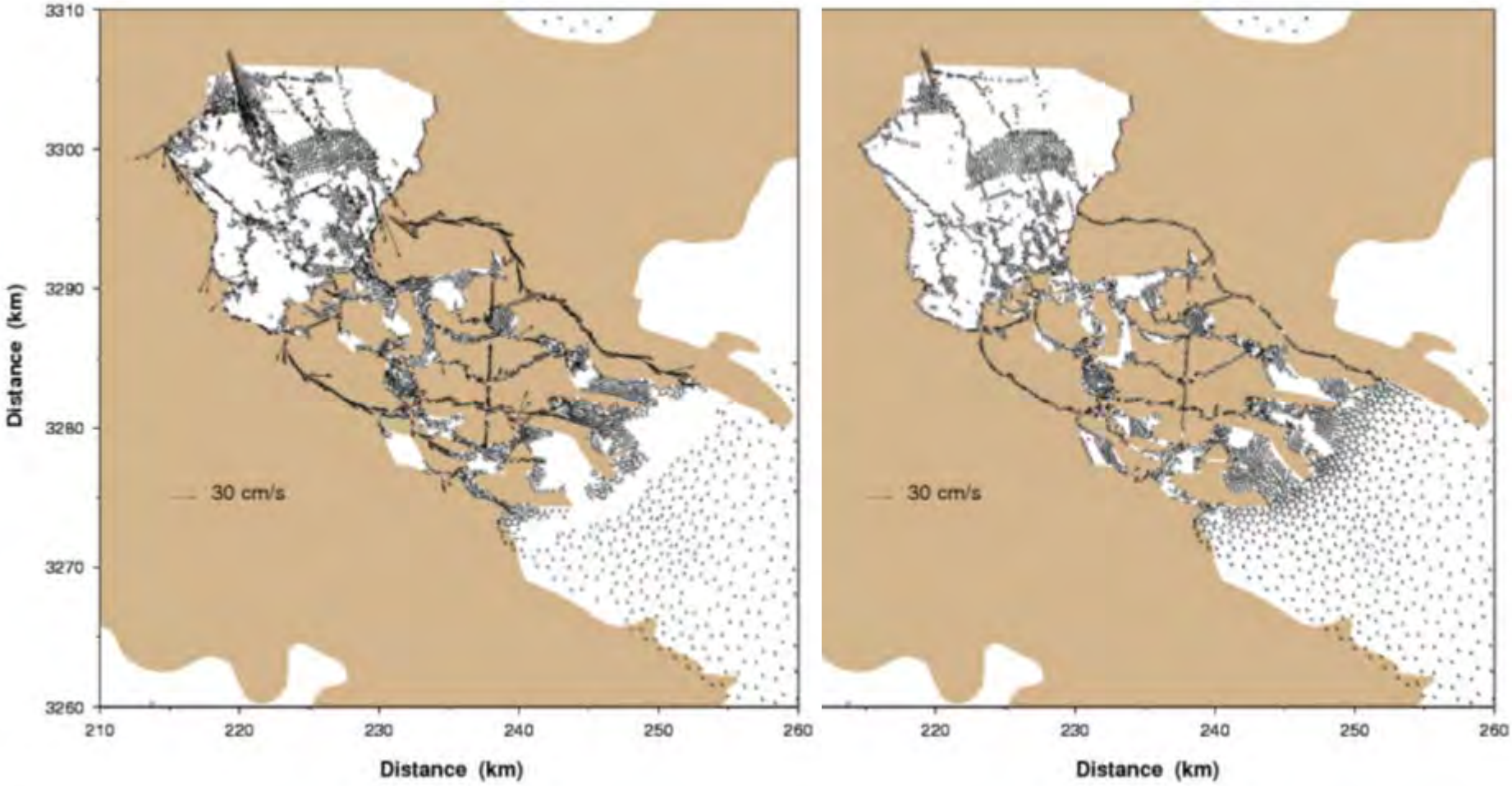


Caernarvon Diversion at its maximum discharge



Caernarvon Diversion flux is turned off

Surface residual currents



Summary

- With high-resolution bathymetric data constructed from LIDAR measurement, FVCOM reasonably captures the hydrodynamics and wetland flooding/drying process in the Breton Sound estuary.

- The water level variation in the upper estuary is controlled mainly by diversion discharge and wind, while tides and wind dominate the water level oscillation in the downstream estuary.

- Maximum overland velocity is ~ 10 cm/s and overland velocity follows closely the wind direction.

- The river diversion tends to greatly shorten the residence time and thus enhance the flushing of the estuary, which has important ecological implications.

- Fish modeling is ongoing

Acknowledgement

- Northern Gulf Institute
- Louisiana Optical Network Initiative (LONI)
- LSU High Performance Computing (HPC)