The Intra-Americas Sea Nowcast/Forecast System for Hypoxia Modeling on the Louisiana Continental Shelf

U.S. NAVAL RESEARCH LABORATORY

Dong S. Ko[1] and Dong-Ping Wang[2]

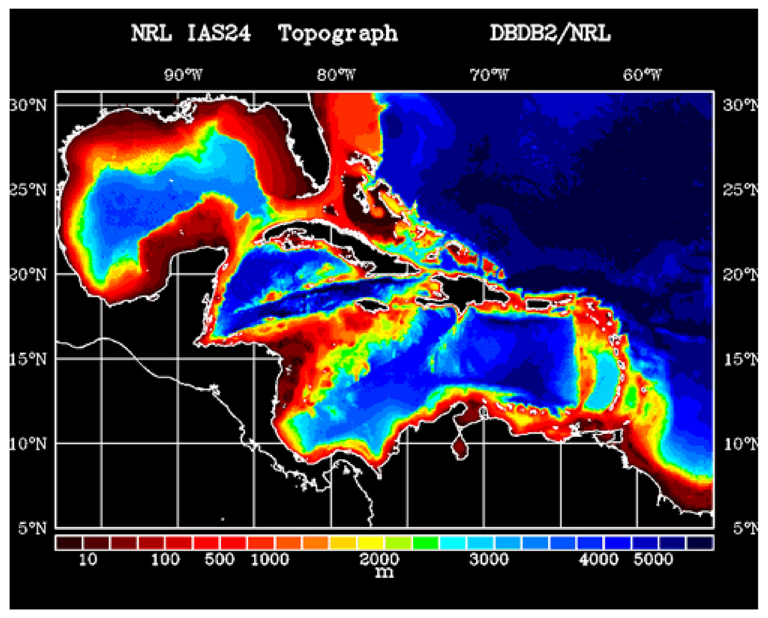
[1] *Naval Research Laboratory* [2] *School of Marine and Atmospheric Sciences, Stony Brook University*

Abstract

Recurrence of extensive hypoxia on the Louisiana continental shelf in the summer has a strong impact on the marine life and ecosystems. The formation of hypoxia depends on nutrient enhanced primary production and subsequent respiration in the water and sediment. It also depends on the physical processes of stratification, transport, mixing and air-sea exchanges. All these processes are spatially and temporally variable. Several coastal circulation models based on NCOM, ROMS, FVCOM, in conjunction with hypoxia models in various degree of sophistication have been applied to better understand the processes of hypoxia formation in the region.

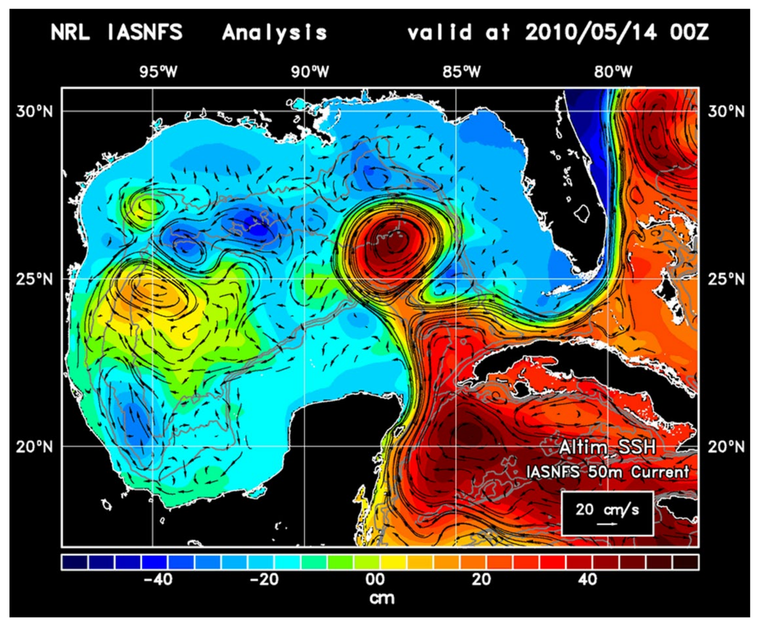
The circulation on the Louisiana shelf is mainly driven by the local wind and river flows and to a lesser extent by heating/cooling and percipitation/evaporation on the surface. The shelf circulation nevertheless is connected to the circulation in the open Gulf of Mexico. In particular, the current on outer shelf is highly influenced by the Loop Current eddies that are often impinging on the shelf break. A basin model, the Intra Americas Sea Nowcast/Forecast System (IASNFS), therefore, was applied to provide the circulations to the coastal models on the open boundaries.

The IASNFS covers the entire Gulf of Mexico and the Caribbean Sea and is based on Navy Costal Ocean Model. The horizontal resolution is 6 km and has 41 sigma-z levels in vertical. The IASNFS is driven by the 3-hr NOGAPS surface forcing and assimilates satellite altimeter SSH and MCSST to produce realistic mesoscale circulations such as Loop Current and Loop Current eddies in the Gulf of Mexico. The open boundary conditions of IASNFS are taken from Navy's Global NCOM. Ten year of ocean reanalysis was produced applying IASNFS and used for the open boundary conditions for the shelf hypoxia models.



IASNFS model ocean topography is derived from the NRL global Digital Bathymetry Data Base 2-min (DBDB2). The topography was further improved by assimilating NOAA National Geophysical Data Center (NGDC) bathymetry data from hydrographic surveys.

Model domain and Topography

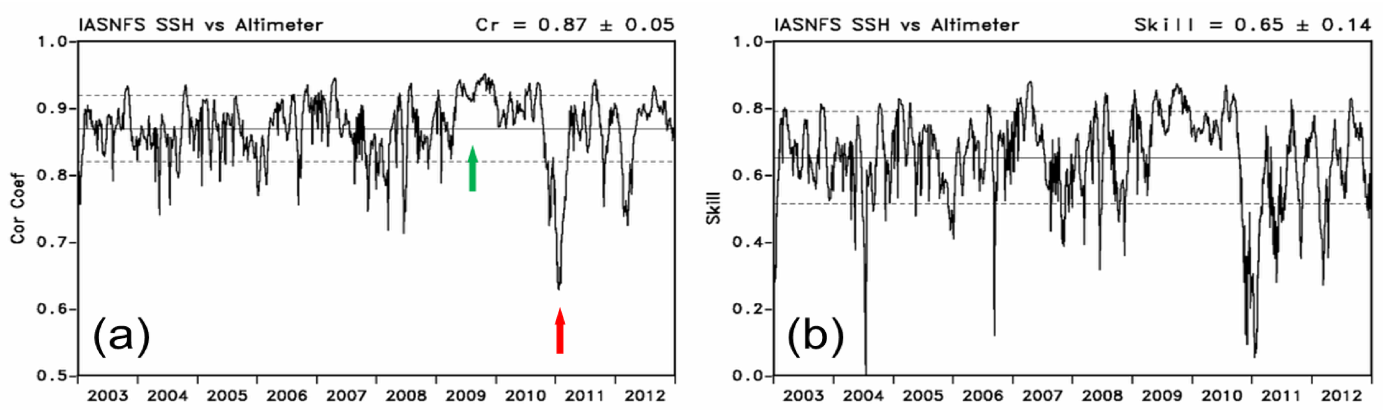


The predicted current below the surface boundary layer followed the altimeter SSH remarkably well. Essence of mesoscale eddies and currents were well captured by the model, even during a time when the Loop Current was evolving rapidly.

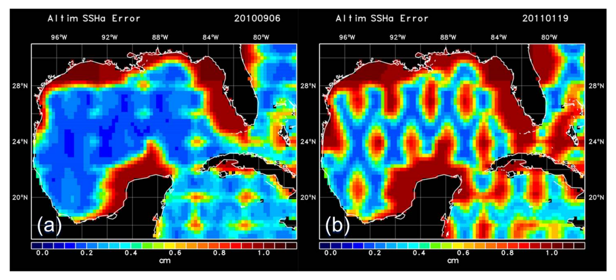
IASNFS Currents superimposed over the Altimeter SSH

Model Evaluations

Sea level prediction evaluated against satellite altimeter data

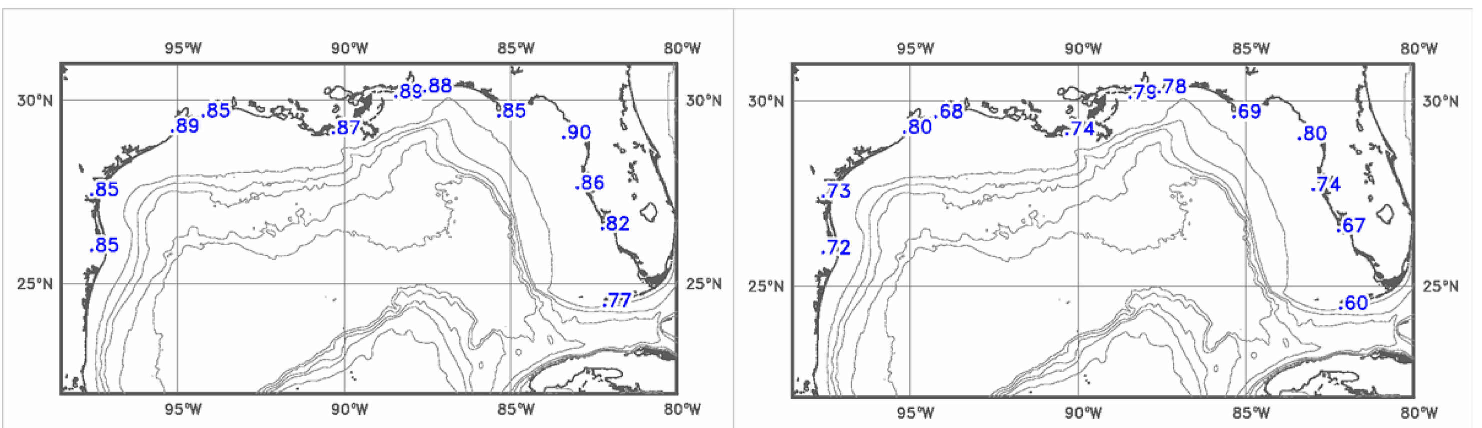


Overall correlation coefficient (a) between IASNFS prediction and satellite altimeter analysis, averaged over 10 years from 2003 to 2012, is 0.87 ± 0.05 and the model skill (b) is 0.65 ± 0.14.

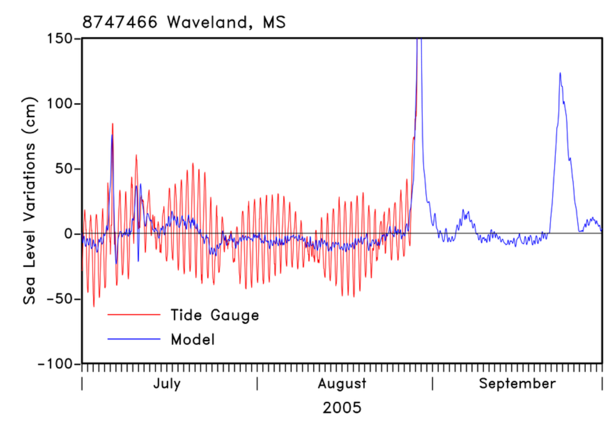


During the period when correlation coefficient and model efficiency are low, e.g., in Jan. 2011 indicated by a red arrow, it is often caused by larger error in altimeter analysis rather than due to decline in model performance. The error maps of altimeter analysis shows that relative to the normal condition at Sep. 2010, the overall error during Jan. 2011 is quite large owing to substantial data outage.

Sea level prediction evaluated against NOS tide gauge data

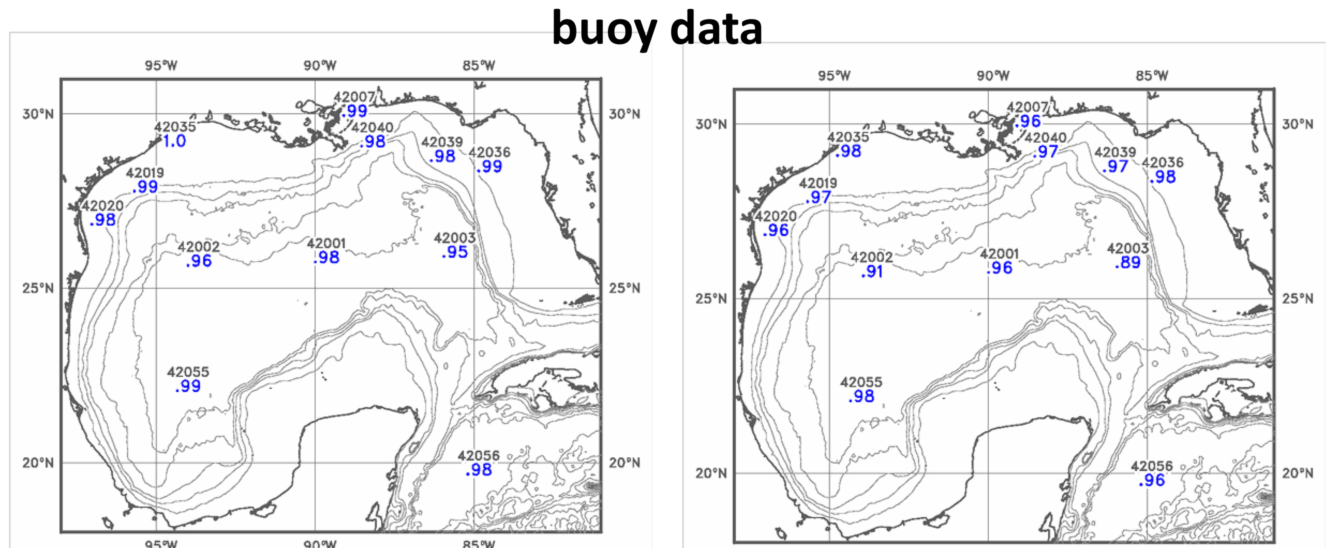


The correlation coefficients between IASNFS subtidal sea level prediction and tide gauge data and model efficiencies (skills) are plotted on the map at the locations of NOS tidal stations. The correlation coefficients and model skills for all stations are quite high ($Cr \geq .82$; $Skill \geq .67$) except for Key West, FL.



Sea level measurement without filtering (in red curve) at Waveland, MS, located right on the track of Hurricane Karina, before the station was overwhelmed by the storm surge. The IASNFS (in blue curve) predicted the arrival time of surge precisely .

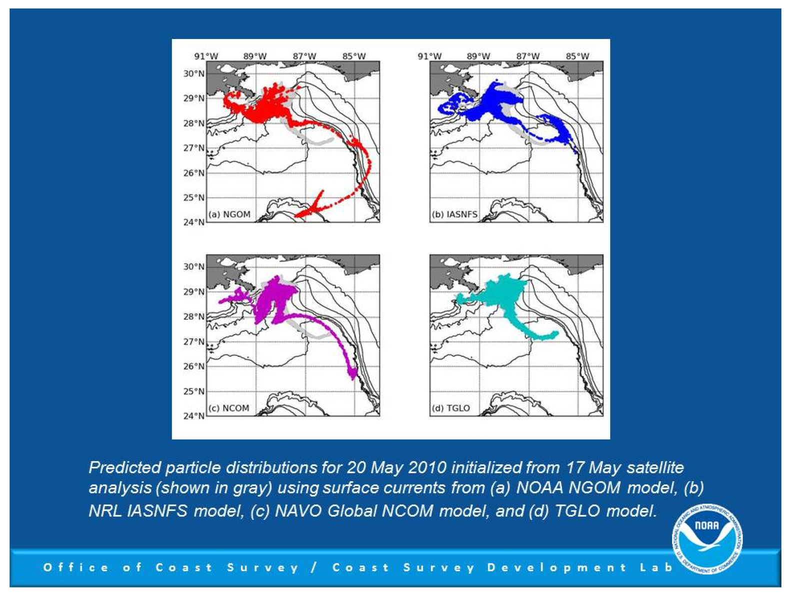
Sea surface temperature prediction evaluated against NDBC buoy data



The correlation coefficients for the SST between IASNFS reanalysis and buoy measurement and model skills are plotted on the map at each buoy location. Despite some errors in the buoy measurements, the correlation coefficients are very high ($Cr \geq 0.95$) for all locations. The model skills are also very high ($Skill \geq 0.89$).

Applications

IASNFS was applied to provide the circulations to the coastal models on the open boundaries for hypoxia studies. It also used by the BOEM/DOI for the oil spill risk analysis in the Gulf of Mexico. In addition, IASNFS and its embedded high-resolution coastal grids have been applied for a wild variety of studies including effects of climate change.



During the 2010 Deep Water Horizon oil spill at Gulf of Mexico, IASNFS is one of the backbone models that provided real-time current forecast to NOAA for oil trajectory prediction. Left figure shows the predicted particle distributions for May 20, 2010 during oil spill using surface currents from (a) NOAA NGOM model, (b) NRL IASNFS model, (c) NAVO Global NCOM model, and (d) Texas General Land Office (TGLO) model. IASNFS performed the best.

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