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STUDY TITLE: **Data Assimilative Hindcast for the Gulf of Mexico for Oil Spill Risk Analysis**

REPORT TITLE: Data Assimilative Hindcast for the Gulf of Mexico

CONTRACT NUMBER(S): M12AC00019

SPONSORING OCS REGION: Headquarters

APPLICABLE PLANNING AREA(S): Gulf of Mexico.

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KEY WORDS: ocean modeling and data assimilation, ocean modeling, ocean state hindcast, statistical interpolation, altimetry, oil spill, ocean currents

BACKGROUND:

The Gulf of Mexico (GoM) region accounts for 30% of the total oil production in the US. At present, there are more than 3,500 oil platforms generating more than 1.7 million barrels of oil per day. Oil production in the GoM is expected to continue at these levels into the next decade and thus carries the risk of potential oil spills into the future. Oil spill risk analysis is critical for evaluating the potential environmental impacts associated with the oil and gas development in the Gulf and underpins all preparations for spill response. In these analyses, ocean currents and their statistics are used for simulating trajectories to infer potential pathways and rates of contamination in case of a spill. A necessary requirement for a robust and scientifically rigorous risk assessment is an accurate knowledge of the statistics of powerful, complex and highly variable ocean currents. The cooperative agreement, M12AC00019, was initiated to produce a validated 2003-2012 Gulf of Mexico ocean state hindcast using the HYbrid Coordinate Ocean Model (HYCOM) and an ensemble based data assimilative framework to estimate ocean currents and other state variables necessary for oil spill risk analysis.

OBJECTIVES:

The overall objective is to obtain a reanalysis or a long-term model run with a single model configuration and data assimilation method that provides a consistent dataset for a wide range of applications including oil spill risk analysis. Over the years, ocean models used for studying the GoM circulation have become increasingly sophisticated. However, most models have been configured for process studies and do not address practical needs adequately. For many practical applications, a long time series of model outputs from realistically configured ocean models, forced with observed or analyzed winds and incorporating data constraints, is desirable. A few models such as the US Navy's GoM-HYCOM, used for routine operational forecasting, satisfy many of these requirements. However, improvements and changes in the operational system over time means that the time series of the outputs from such a system is not consistent temporally and/or spatially and might be of uneven quality. Therefore we set up a 10-year hindcast (2003-2012) assimilating both remotely sensed and in-situ data using the one model version and assimilation method to produce a consistent dataset.

DESCRIPTION:

Data assimilative hindcasts blend observations with a dynamical circulation model to provide regular 3- dimensional estimates of ocean currents, taking into account the errors in both observations and the model. Here we use the Tendral–Statistical Interpolation System (T-SIS) to assimilate remote-sensed Sea Level Anomalies (SLA), satellite surface temperature and in-situ temperature and salinity profiles into a 1/25° HYCOM

configured for the GoM. The assimilation scheme is based on multivariate linear statistical estimation and is optimized for the Lagrangian vertical coordinate of HYCOM and uses a multi-scale methodology. Other aspects of model configuration include a model bathymetry derived from a high-resolution bathymetric dataset made available by Florida State University, surface atmospheric forcing from the North American Regional Reanalysis (NARR) and climatological conditions for lateral boundary forcing and freshwater discharge from rivers.

SIGNIFICANT CONCLUSIONS:

This work resulted in a 10-year hindcast model output for use in oil spill risk analysis and other applications. The model data include 3-dimensional ocean currents, temperature, and salinity at hourly intervals. An assessment of the data assimilative hindcast shows robust model skill in reproducing the various features of the Loop Current and other aspects of the circulation in the GoM. The upper ocean temperature and salinity match observations to within 1.5°C and 0.3 psu, both well below the climatological variance.

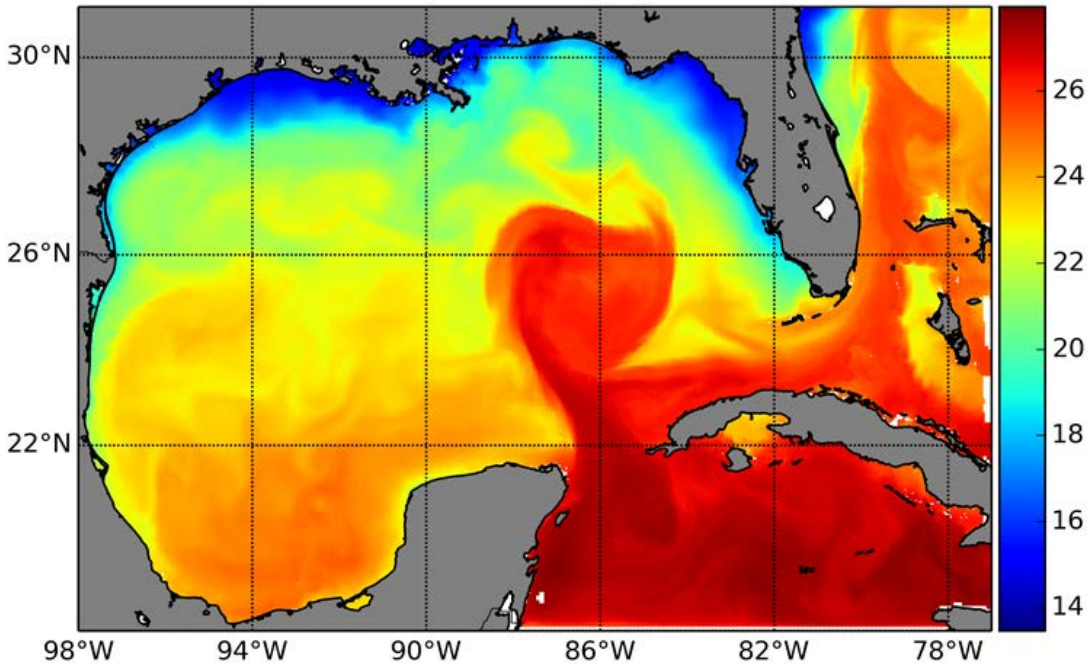
STUDY RESULTS:

The multi-scale assimilation scheme employed here constrains the model state using observed along-track sea level anomalies, gridded sea surface temperature, profiles of salinity and temperature, and provides realistic estimates of the state of the GoM for the 2003-2012 timeframe. There is good agreement between the hindcast and independent estimates of Loop Current behavior inferred from altimetry and ocean color both in terms of temporal and spatial characteristics. The assimilation of a limited number of in-situ and climatological profiles of temperature and salinity is effective in controlling bias and reduces errors in the vertical density structure in the model. Comparisons with independent drifter derived velocity data indicate significant correlation (>0.6) between the drifter data and model velocities. Simplified simulations of the Deepwater Horizon event capture the main features of surface plume indirectly verifying the hindcast.

STUDY PRODUCTS(S):

- Final report for the US Department of the Interior, Bureau of Ocean Energy Management: Data Assimilative Hindcast for the Gulf of Mexico. 2015. Contract No. M12AC00019. 46 pp.
- Hourly model data for the 2003-2012 timeframe including currents, temperature, salinity and 10 m wind speeds in NetCDF format.
- Model and data assimilation code, run scripts, and a ready-to-run test case for 2010.
- A website to distribute the data and communicate results to the broader community. http://stargazer.coaps.fsu.edu/boem_gom_hindcast

* P.I.'s affiliation may be different than that listed for Project Manager(s).



Study Area: Gulf of Mexico