

## GULF OF MEXICO MODELING SYSTEM WEBSITE

<http://www7330.nrlssc.navy.mil/GOMMS/index.html>

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### SUMMARY

This document describes a comprehensive, interactive website to dynamically create and display a variety of plots based on data from ocean and atmospheric models as well as satellite imagery. The model data are derived from a Gulf of Mexico numerical model reanalysis simulation for the period of 2000-2010, and the satellite data are derived from NASA ocean color for the same period. The interactive web portal allows extensive analysis of data with tools such as surface plots, time-series plots, depth profiles, animations, and basic statistical and comparative analysis. The website is flexible enough to allow addition of new data, and new analysis tools can be incorporated in the future. The site offers users an easy and interactive way for viewing large amounts of data and create production-quality plots. Speed, user friendliness, flexibility, and robustness are important design principles, as is developing a large database of information and many different tools for both visualization and quantitative synthesis.

### INTRODUCTION

This website constitutes a deliverable for NASA ROSES program # NNH09ZDA001N-GULF; “Earth Science for Decision Making: Gulf of Mexico Region”. In order to draw scientific and policy conclusions and conduct research, users must be able to synthesize, analyze, and understand many terabytes of data by creating visualizations, plots, images, and animations. The focus for this website was to automate this tedious process, to provide all users, from scientists to decision-makers, a user-friendly integrated package. All the tools used on the website are automated software modules which create custom plots, images, and animations on demand per the user’s request. The website contains a home page, a few informative pages describing the project, publication references, and data sources. Sub pages include a description of the website’s tools, specific information on a custom-built Gulf of Mexico Atlas, and finally the mapping portal, the heart of the website. The descriptive pages supplement further user information found on the portal, detailing all the data and tools the website supports. The mapping portal consists of a Google Maps based interface centered on the Gulf of Mexico, with a collapsible selection sidebar allowing the user to select parameters and options to display. Data plots are generally overlaid directly onto the insert, while images are generated as pop-ups, so they can be saved for later use. The user can select their data source, the field they want displayed (such as Sea Surface Temperature or Wind Stress), the date or range of dates for the data, and a number of other tools for data analysis (such as custom colorbar or time-series plot creation). There is also a menu of buttons on the map overlay itself, in addition to the usual Google Maps tools. This includes further functions, such as selection of depth profiles, highlighting of particular regions of interest, and placement of “virtual moorings.” to allow comparisons to in-situ data.

Finally, the Atlas section of the sidebar contains a variety of pre-made output for further analysis. There are climatology model plots from a number of sources, which users can compare to automatically generated model data. Complementing this are bathymetry plots detailing the ocean floor, focus regions, and information on local landmarks, such as the oil industry. There is also a database on NOAA ocean buoys in the Gulf of Mexico, with accompanying plots of their data, collected over several years, compared with model data. Finally, the website includes tracks of major Atlantic hurricanes over the last ten years.

The website draws data from ocean and atmospheric models, and satellite observations: NRL’s Gulf of Mexico Modeling System (GOMMS), part of the larger Navy Coastal Ocean Model (NCOM); NASA’s Modern Era Retrospective-analysis for Research and Applications (MERRA), an atmospheric model; and satellite imagery from the older Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and the newer Moderate-Resolution Imaging Spectroradiometer Aqua (MODIS-Aqua).

### BODY / SYSTEM

Specifically, the website consists of the following pages:

- Project Abstract. This abstract states the overall purpose of the GOMMS research projects. Although the

website has expanded to utilize a number of other sources, this still accurately summarizes the overall purpose of the project.

- Data Sources. This details the four main data sources for the website, their origins, the featured fields, and the respective links to their main webpage.
- Tools. This page contains a description of the many tools available to users of the website:
  - *Map Overlay*: The main control panel for overlays of KMLs onto the Google Maps overlay. After selection a date, range, climate or mean as the date-time group, the desired field to plot from GOMMS, MODIS-Aqua, SeaWiFs or MERRA is selected. Some fields can be plotted at various depths or as a line or color contour. Fields plotted as a range can also be displayed as a time series plot. Time series plots can also be created after a KML has been displayed. Several plots can be overlaid together by clicking 'Update Map', selecting other fields and clicking 'Update Map' again. 'Reset Map' is used to return the map to its default (blank) initial state.
  - *Atlas*: All precreated data of general interest available under one category.
  - *Update Map*: Click to plot the KML on Google Maps Inset. While only one file can be plotted at a time, several maps can be overlaid. Once a file has been overlaid, any files placed on top of it will have the same date selection and depth. To change the date-type group and depth, the map must be reset.
  - *Collapse Panel*: Hide the menu structure to expand the map. Once collapsed an outward facing arrow will appear to allow the side panel to be re-expanded. This tool can be found at the top of the side panel.
  - *Download KML*: users may download KML or KMZ versions of output to display map overlays on their own Google Maps and/or Google Earth programs.
  - *Depth Section*: Users can select a starting and ending point, and the website will attempt to draw a straight line between the points and display a depth section (by default, from the surface down to 200 meters) of the ocean currents. Only available for 3D ocean fields like Temperature and Salinity. The tool will not appear if the field being overlain does not have depth enabled.
  - *Virtual Mooring*: Plot a time series of a particular point. Once available, click the icon and then click a sea-based point anywhere on the KML or KMZ. The time series displayed will reflect data from the most recent field that has been overlaid. Useful for tracking long-term changes over a single point.
  - *Status*: Reports status messages on the Map Overlays, Time Series Plots, Depth Sections and Animations, all when applicable. Due to the time needed to create range overlays, climate overlays and animation, a progress bar is provided to help gauge the estimated completion time. In addition, all currently displayed KMLs and/or KMZs will be listed.
  - *Context Help*: Pop-up Help Window that gives details on selected fields. Details include explanations on the model or satellite being used, including what time span of data they cover, the field and the date-time group. This tool can be found to the left of the date selectors in the 'Map Overlay' section.
  - *Reset Map*: Clears all items from the map, including overlays, buoys, KMLs and KMZ, and re-centers the map on the Gulf of Mexico. This only resets the input fields for the date-time, contour type (if applicable) and the depth (if applicable). Does not close any pop-up output or reset time-series plots displayed in the margin beneath the insert. One uses a separate clearing button for these plots, to more easily track changes over time.
  - *Capture Map Image*: Saves the map overlay as a PNG image and opens it in a pop-up window, along with a title, axes, and a colorbar, if necessary. The image can then be easily saved for future use and reference. These images are more polished and professional, and are of sufficiently high quality to be used for some research alongside the mapping portal itself.
  - *Animate as GIF*: Animates a range of KMLs or KMZs as a GIF. The GIF will display as a pop-up window.
  - *Time-Series*: Create time series plots for the Gulf, a region or a point. A time series plot can only be

created for a range or climate. A plot can either be made at the same time as the overlay or afterwards. This button is used to generate a time series plot of the Gulf after the KML or KMZ has been plotted. The time series displayed will reflect data from the most recent field that has been overlaid.

- *Drag-n-Zoom*: Drag a box where you want to zoom, and the map zooms to the area you selected. By clicking the 'Time Series' button right after, the time series plot will reflect data from the selected area. The time series displayed will reflect data from the most recent field that has been overlaid. This tool can be found under the Map Zoom tool.
  
- Atlas
  - **Bathymetry:**
  - *GOMMS Model Bathymetry*: Horizontal Resolution that matches the GOMMS model of 4km. Available as a line or filled contour
  - *GEBCO Bathymetry*: Native Resolution of 30-arc-second  $\cong$  1Km. Available as a line or filled contour
  - **Buoys:**
  - *NDBC (National Data Buoy Center)* - Long Term Time Series plot for Temperature comparing model prediction and observations
  - **Climatologies**
  - *WOA (World Ocean Atlas)* - Temperature and Salinity. Source: NOAA (2009)
  - *GDEM (Generalized Digital Environmental Model V3)* - Temperature and Salinity. Source: NRL
  - *ERSST (Extended Reconstruction Sea Surface Temperature)* - Sea Surface Temperature. Source: NOAA
  - *MODIS-AQUA (4Km Moderate Resolution Imaging Spectroradiometer)* - Chlorophyll. Source: NASA (2002-2012)
  - *SeaWiFS (4Km Sea-viewing Wide Field-of-view Sensor)* - Chlorophyll. Source: NASA (1998-2010)
  - *MLD (Mixed Layer Depth)* - computed from Temperature and Salinity to find density gradient maxima. Source: NRL-GOMMS (2000-2012)
  - **Focus Areas:**
  - *Gulf of Mexico* - ((30.74, -98.00), (18.09, -77.36))
  - *Flower Garden Banks Marine Sanctuary* - ((28.59, -94.51), (27.40, -91.32))
  - *Mississippi Bight* - ((30.70, -90.00), (28.00, -85.00))
  - *West Florida Shelf* - ((30.25, -84.00), (25.50, -81.00))
  - **Gulf of Mexico Features**
  - *Coastline*- Gulf of Mexico Coastline that can be overlaid with satellite imagery to provide context
  - **Hurricanes**
  - *Isabel*: 2003, Category 5
  - *Charley*: 2004, Category 4
  - *Jeanne*: 2004, Category 3
  - *Ivan*: 2004, Category 5
  - *Katrina*: 2005, Category 5
  - *Rita*: 2005, Category 5
  - *Wilma*: 2005, Category 5
  - **Oil Industry**
  - *Gulf of Mexico Pipelines*
  - *Deepwater Horizon*
  - *Mars B Platform*
  - *Olympus Platform*
  - *Atlantis Platform*
  - *Petronius Platform*
  - *Magnolia Platform*
  
- Mapping Portal. This contains the Google Maps insert and the main tools of the website. Most of the plotting and analysis tools are powered by Python modules, while the website also extensively uses Javascript, JSON, and PHP.

## **Mapping Portal**

The following tables detail the date-time and field options, as well as the selection procedure:

### **Date Time Options (Chart 1)**

Daily Snapshot  
Monthly Snapshot  
Yearly Snapshot  
Daily Climatology  
Monthly Climatology  
Climatology  
Daily Range  
Monthly Range  
Yearly Range  
Daily Range Climatology  
Monthly Range Climatology  
Daily Climate across a Range  
Monthly Climate across a Range

### **Data Fields (Chart 2)**

<b>Field Name</b>	<b>Unit</b>	<b>Sources</b>	<b>Depth Available?</b>
Temperature	Celsius (°C)	GOMMS	X
Salinity	Practical Salinity Unit (PSU)	GOMMS	X
Chlorophyll	Millimoles / Meter <sup>3</sup> (mmols/m <sup>3</sup> )	GOMMS, MODIS, SeaWiFS	
Height	Meters (m)	GOMMS	
Currents	Meters / Second (m/s)	GOMMS	X
Latent Heat Flux	Watts / Meter <sup>2</sup> (w/m <sup>2</sup> )	MERRA	
Sensible Heat Flux	Watts / Meter <sup>2</sup> (w/m <sup>2</sup> )	MERRA	
Shortwave Radiation	Watts / Meter <sup>2</sup> (w/m <sup>2</sup> )	MERRA	
Longwave Radiation	Watts / Meter <sup>2</sup> (w/m <sup>2</sup> )	MERRA	
Wind Stress	Pascals (P)	MERRA	

### **Controls**

Plotting data is a multistep process that begins with selecting whether to view data from a single date or across a range of dates (Chart 1). There are four data sources, GOMMS, SeaWiFs, MODIS and MERRA, each with their own data fields (Chart 2). Selected fields also have the option to plot at varying depths and some have the option to be visualized as either a line or filled color contour. For plots across a range of dates, times series charts can be made. To plot, click the “Update” Button and allow it to load on to the Google Maps inset. After it has loaded, a variety of tools are available through a button panel in the map’s bottom left-hand corner. Multiple plots may be layered on top of each other, although they must all be of the same date-time stamp and depth, if applicable. The “Clear Map” button removes all overlays from the viewing screen.

## **CONCLUSION / PLANS**

While this website was created as a deliverable of a NASA sponsored project for decision making tools, it has the potential to be used by a variety of consumers, including NRL scientists, and the public, who may also be interested in learning more about the Gulf of Mexico.

The website has a proven ability to quickly and easily expand to include additional fields, dates, and even models. All the scripts running the website are modularized and generalized, and the framework is flexible enough to allow new tools to be added. A number of interesting ideas have been received, such as more detailed simulation tools, movable user-placed buoys that flow with currents, and additional interpolation analysis. The data could also be extended to be more expansive, covering earlier dates and filling in some current data gaps. More sources of data could be added and expanded to other areas of interest.

On the following pages are a set of representative slides that display the content of this website.