STUDY TITLE: Analysis of the Real-time MMS ADCPs from Oil Platforms and the Effects of Loop Current and Loop Current Eddies

REPORT TITLE: Analysis of Ocean Current Data from Gulf of Mexico Oil and Gas Platforms

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BACKGROUND: On April 21, 2005, the U.S. Department of the Interior's Minerals Management Service (MMS), now the Bureau of Ocean Energy Management, issued a Notice to Lessees and Operators (NTL) No. 2005-G05 to require oil and gas companies operating on the Gulf of Mexico OCS (outer continental shelf) region to monitor and report real time velocity profiles using ADCPs based on oil platforms. The data have been presented starting April – June 2005 through a publicly available internet web site maintained by the National Oceanic and Atmospheric Administration (NOAA) National Data Buoy Center (NDBC). Data were recorded in waters with a total depth deeper than 400 m at 10-20 minute intervals from near surface (~ 30 m) to ~ 500 - 1000 m. In places with depth greater than 1100 m, two ADCPs may be used.   This provides an unprecedented amount of velocity profile time series in the deep ocean in northern Gulf of Mexico. This study investigated the hydrodynamics and oceanographic conditions in this region using these ADCP data.

OBJECTIVES: The main objectives are to determine the three-dimensional characteristics of the deepwater flow in the area by a systematic analysis of the current data from the dozens of ADCPs installed on oil platforms and explore the mechanisms that drive the flow field. More specifically, the analysis was conducted for all data

available between April 2005 and March 2008. The in situ current data was be analyzed in light of satellite observations.

DESCRIPTION: Long-term and continuous current velocity profile time series obtained from acoustic Doppler current profilers (ADCPs) mounted on several dozens of oil platforms were analyzed. All of these oil platforms were in the northern Gulf of Mexico, mostly along the shelf slope. About 20 of these platforms were fixed in location. The rest occasionally moved but remained stationary for at least a few months for most of them. We analyzed and discussed the basic statistics of the current velocity profiles, the vertical variations, horizontal variations, and temperature variations. The basic statistics includes the mean and standard deviation of the vector flow records at different depths, in different regions, and during different times. The flow velocity vectors are examined in a way similar to the general analysis to wind data, such that predominant flow directions, if any, are identified and discussed. We also discussed the spectra of the flow speed as functions of time, depth, and location. Rotary spectra of the velocity fields are also discussed. Between 2005 and 2008, several major hurricanes and tropical storms impacted the northern Gulf of Mexico. Among them are Hurricanes Katrina and Rita of 2005, and Hurricanes Gustav and Ike of 2008. Near-inertial oscillations (NIO) induced by hurricane and non-hurricane events are discussed.

SIGNIFICANT CONCLUSIONS: In the analysis of hurricane-induced NIO, we proposed a model using the frictional rotary inertial function and Laplace transform to the barotropic shallow water equations. We found that the atmospherically-forced NIO depend on water depth and bottom friction in a dramatic manner: the above mathematical model behaved effectively as a "band-pass filter" that passes the NIO and damped the rest of the frequencies. The model predicts no peaks for counter-clockwise rotating components in both shallow and deep waters. This "filter" is more efficient in deeper waters than in shallower waters: in deeper waters the NIOs are much stronger. This is in contrast to the tidal currents which are weak in deep waters but amplified in coastal waters. The atmospheric forcing contributes to the pressure gradient which in turn contributes to NIOs through a barotropic process. This makes it appropriate to use a baotropic rather than a baroclinic model for a secondary quantity (the baroclinic response). With a baroclinic model, it would have a rigid-lid and the effect of the atmospheric pressure gradient would be suppressed. All baroclinic models show that it takes a much longer time for the NIOs to propagate to the bottom of a deep ocean (e.g. > 1000m), while the barotropic model allows the pressure gradient effect's to be instantaneous at depth. Because of this band pass filter, NIOs are only obvious in deep waters.

STUDY RESULTS: Comparing among different years, with more than 4 million data points, we have found that the mean velocity magnitude and standard deviation are not very different from year to year; they are all about 12-14 cm s^{-1}. The standard deviations for these three years are between 12 and 16 cm s^{-1}. Comparing different vertical locations, it is found that the mean velocity is the largest near the surface and decreases with depth until a depth of about 1000 m where the velocity varies with depth but remain relatively uniform. Some of the near-bottom velocity increased substantially.

This near-bottom increase may be an artificial result because of a lack of backscatter at such deep water and the flow could be biased toward large velocity values.

We examined the flow direction statistics. It was found that there are several types of variations: uni-modal, bi-modal, multi-modal, and omnidirectional. This result can be misleading because direction does not necessarily have a good tie to the dynamics. For a specific time frame, this can be true, though: for example, during certain times, if the NIO is particularly strong, the flow experiences all directions almost equally (unless there is a strong background mean flow), it will then be shown as omnidirectional. For the same NIO, if the background mean flow is very strong in one direction, then this NIO may appear as a uni-modal with background smaller counts of omnidirectional feature.

The temporal variation of the flow velocity is as large as the vertical variation. These temporal variations have two major components: one with a daily oscillation – the NIO, and one with a much longer time scale of a few months.

We have plotted all the velocity vectors at all depths as functions of time for all stations for the years 2005 to 2007. These plots provide much information about the NIO, Loop Current, Loop Current frontal eddies, and their impacts to their nearby areas. The results show that NIO are almost ubiquitous in the Gulf of Mexico. NIO wax and wane, but the dependence on wind or weather is not investigated except for some case studies of hurricane-induced NIO. It is clearly shown that major hurricanes such as Hurricanes Katrina and Rita produced large NIOs. Some less intensive hurricanes did not produce large NIOs partly because of the relative position of the hurricane track to the locations of the stations – if the stations are on the left of the tracks, the NIOs are usually not as large and obvious.

STUDY PRODUCTS: Li, Chunyan, Lawrence J. Rouse, Jr. 2014. Analysis of ocean current data from Gulf of Mexico oil and gas platforms. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEM 2014-040. 141 pp.

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