Assessment of the Water Levels and Currents at the Mississippi Bight During Hurricane Katrina

OS23B-1388

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INTRODUCTION

In 2005 hurricane Katrina passed to the west of Buoy 42067 (figure 1) that was part of the Central Gulf of Mexico Ocean Observing System. The wind and wave observations were reported in Howden et al., (2007), and Bender et al. (2010a,b). Although the buoy survived the storm, it and its mooring were advected approximately 2 km to the northwest as the storm surge came in and about 17 km to the southeast as the surge went out (inset of Figure 1). The buoy (figure 2) had a survey grade Novatel Global Positioning System (GPS) receiver for an ONR-funded project to extend the baseline range of Real-Time-Kinematic (RTK) positioning in the marine environment. The nearest RTK base stations on Horn Island and Gulfport, MS were destroyed during the storm, preventing a Post-Processed Kinematic (PPK) height solution to be produced for the entire event (figure 3). The maturation of the Precise Point Positioning (PPP) technique has allowed for a WGS84(2011) ellipsoidally referenced water level time series at the buoy throughout the storm. Using the resultant time series prior to Katrina, a water level datum transfer from the NOAA gauge 8747766 in Waveland, MS resulted in a water level time series referenced to Mean Diurnal Tidal Level (DTL). An additional motivation for this study was to extend data offshore of Mississippi that are used for vertical datum separation models such as NOAA's VDATUM tool, which is used in Ellipsoid Reference Surveys (ERS). ERS is enhanced with GPS and the more general Global Navigation Satellite System (GNSS). An Acoustic Doppler Current Profiler (ADCP) was also installed on the buoy for current measurements. The current data were processed alongside the velocity data from the GPS. The two were combined to extract the current of the sea during the storm. A compass was also installed on the buoy to measure angular motions.

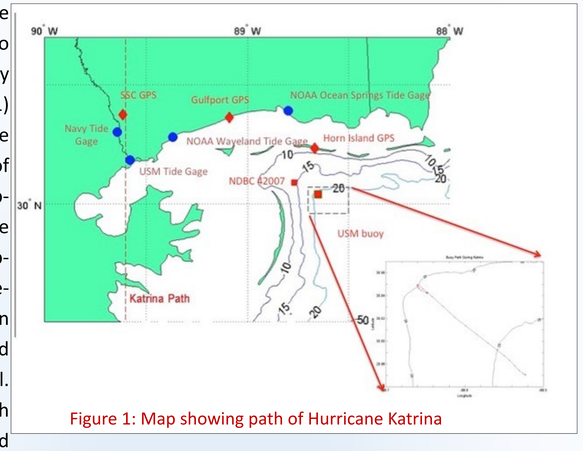

Figure 1: Map showing path of Hurricane Katrina

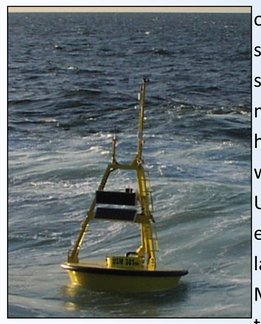

Figure 2: Image of the offshore buoy

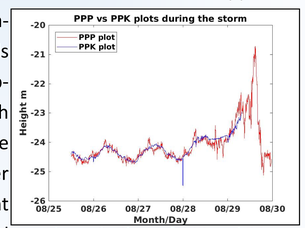

Figure 3: Plots of PPP and PPK solutions during the storm

RESULTS

Figure 4 shows the plots of the ellipsoidal heights of the PPP solutions which were corrected for buoy tilt (blue) and predicted tide generated from a harmonic analysis tool t_tide (green). Residuals which were not within two standard deviations from the mean of the residuals were removed (red). This made the observed data similar to the harmonically generated tide. Figure 5 shows the comparison of the residuals from the buoy data and the residuals from Waveland tide gauge data. Figure 6 shows results from wind, water level and processed ADCP data. Table 1 shows results of the transferred tidal datums at the buoy with respect to WGS 84 ellipsoid. Figure 7 shows the height of the storm surge with respect to North American chart datum: Mean Lower Low Water.

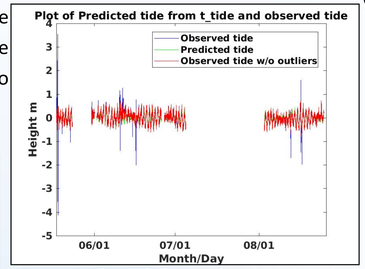

Figure 4: Plots of observed and predicted tide

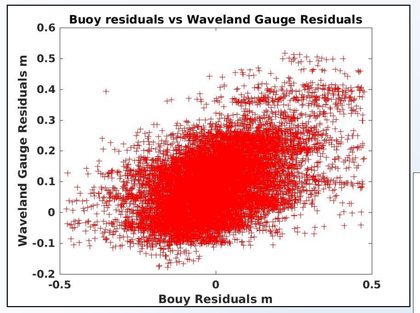

Figure 5: Plot of buoy and Waveland gauge tidal residuals

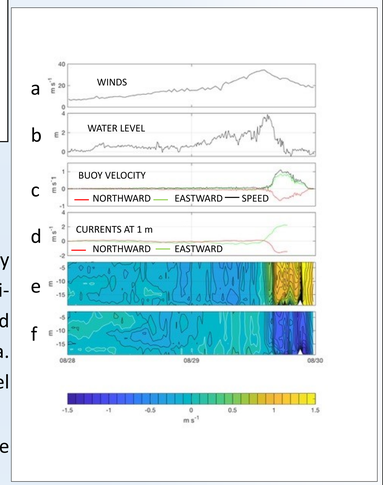

Figure 6: (a) Wind, (b) Water Level wrt (DTL), (c) Buoy Velocity components, (d) Water Current at 1 m wrt to Earth, (e) ADCP East Component and (f) ADCP North Component

Table 1: Table showing values of transferred datums

Transferred Vertical Datums wrt	
DTL	-27.31 m
GT	27.7 m
MLLW	-27.6 m
MHHW	-27.02 m

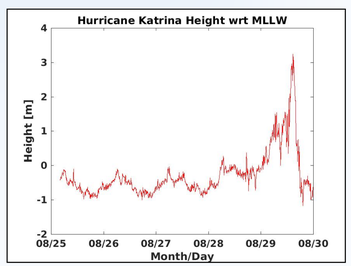

Figure 7: Height of the storm surge

CONCLUSIONS

- PPP technique has been shown to be a viable means of GPS/GNSS positioning when RTK/PPK base stations are not available.
- The height of the storm surge was found to be about 3.60 m with respect to MLLW. This compares well with estimates by Fritz et al, (2007) of 4-5 m storm surge at the barrier islands.
- It took the storm over 40 hours to build up, but just under 3 hours to drop back down after Katrina moved onshore. The strength of the retreating storm surge (over 2 m s^{-1} at the surface and strong throughout the water column) point to the need of storm surge modeling to focus not just on getting the height of the surge correctly, but also simulating the retreat correctly to better forecast and understand the full damage that storms can produce.
- The PPP GPS/GNSS positioning technique allows for offshore buoy water level time series to be used to extend tidal-datum to ellipsoid separation models further offshore.

ACKNOWLEDGMENTS

This study has been funded by grants from The Office of Naval Research (ONR) and National Oceanic and Atmospheric Administration (NOAA)(NA16OAR4320199). The authors wish to thank Venice Tang of Waypoint Customer Support, NovAtel Inc. for her efforts in attending to the challenges which resulted from processing the files in Grafnav.

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