A Note on Global Position System (GPS) Shoreline Accuracies Gathered by the Mississippi Office of Geology, Coastal Section

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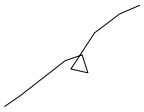
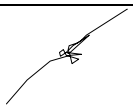
Introduction

This short report is meant to help give guidance to users of the Mississippi Office of Geology (MOG) Global Position System (GPS) surveyed shorelines. Two separate survey examples (Deer Island and Harrison County) are compared and contrasted to establish reasonable error estimation. In both cases, a portion of the shoreline was GPS'ed twice during the same day by different surveyors. This provides two surveys of what should be the same shoreline location. In all cases the high water line (HWL) was chosen as the most repeatable shoreline position indicator. This study attempts to address the issues of the technique – collecting data with a backpack style GPS unit while walking the shoreline (kinematic GPS surveys) and making a consistent determination of the HWL.

Methods

Two separate surveys separated by four years were carried out using Trimble Pathfinder Basic Plus and Pro XL backpack style GPS receivers. Position Dilution of Precision (PDOP) switches were set so that any readings above six (6) were not collected, which reflects the standard collection process. Shorelines were walked using best estimation of the HWL, typically represented by a small beach berm, wrack line, or wet/dry line. Interpretation of the reference line is an important variable in the error analysis. Data were post-processed from base-satiations operated by the MOG and later manually corrected for obvious systematic errors. This included corrections of loops, obvious errant nodes, and clusters of nodes caused by surveyor pauses.

		
Loops	Errant Nodes	Clustered Nodes

Kinematic GPS System Accuracies

During the 2002 field season 10 km of the Deer Island shoreline was surveyed simultaneously over the period of two days in July. Two different GPS receivers were used; one was a Trimble Pathfinder Basic Plus and the other a Trimble Pathfinder Pro XL. The two surveys followed the same shoreline; one surveyor followed directly behind in the others footsteps. The data were both post processed using correction data from a nearby base station in Biloxi, Mississippi. Data (shorelines) were subsequently corrected for systematic errors.

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This situation provided a best-case analysis of GPS shoreline repeatability, as the interpretation of the high water line (HWL) was largely removed from the equation; there was, however, some error in following the exact footsteps. In addition, the surveys were carried out simultaneously so that differences in satellite geometries (PDOP) were minimized. In this analysis, the difference of receiver type, GPS accuracies (using kinematic technique), manual correction techniques, and node spacing (point collection timing) are considered the main components of inconsistencies between surveys. The mapping terrain ranged from open marsh shoreline to sandy shorelines with overhanging trees and represents a good subset of the Mississippi coastline mapped in yearly surveys. Selective Availability (SA) had been phased out several years prior to this survey.

Shoreline Interpretation Accuracies

During the 1998 field season, following Hurricane Georges, the shoreline of Harrison County was GPS'ed. During this survey, a 1 km long section of the shoreline was surveyed by two survey parties at separate times several hours apart. Each survey was performed using Trimble Pathfinder Basic Plus backpack style GPS receivers. Data was post processed using a base station in Jackson, Mississippi, roughly 150 miles away. Data were subsequently corrected using the same manual techniques previously described.

This situation provides a practical analysis of GPS shoreline accuracy. The HWL, as in all cases, was used as a reference; however, the HWL is not necessarily a geomorphic feature so determination of the line requires interpretation by the surveyor. Each surveyor may chose a slightly different reference feature, be it a particular wrack line, wet line or subtle beach berm depending on the wave conditions, geomorphology, slope, or modification of the shoreline. As this survey followed a hurricane, there may have been a considerable amount of debris and multiple wrack lines present. Moreover, the post processing data was from the secondary base station for coastal work, which was used because the Biloxi, Mississippi station was not operating. As the times were also different, different satellites were also used by the receivers. Selective Availability (SA) had **not** been phased out during this survey. These variables will invariably lead to more inconsistencies between separate shoreline surveys than the previous case.

Results

To compare the relative accuracies of the GPS shorelines, both the kinematic method test (Deer Island) and the interpretation of the high water line (Harrison), the differences between each survey party's shoreline were measured. This amounts to finding the spread of offsets between the two data sets. Each shoreline was broken into 1-meter segments and the amount (length) of shoreline within a certain distance of the other shoreline calculated. A cumulative frequency graph was constructed using distance between shorelines versus percent of length (Figure 1).

The Deer Island data was used as a test of the GPS kinematic method and the Harrison data set as a test of repeating the same HWL shoreline location using the method (overall

error). The graph (Figure 1) displays the expected trends. The Deer Island data has far less difference in shoreline position, such that the median (50%) difference in shoreline position was less than 1 meter. Moreover, using the graph, 90% of the time the technique differed by less than +/- 2.75 meters. This suggests that the method can accurately portray the shoreline location to +/- 3 meters if the same HWL indicator is used. The primary causes of systematic errors are likely associated with point spacing (different nodes on a arcuate feature) and internal GPS accuracies.

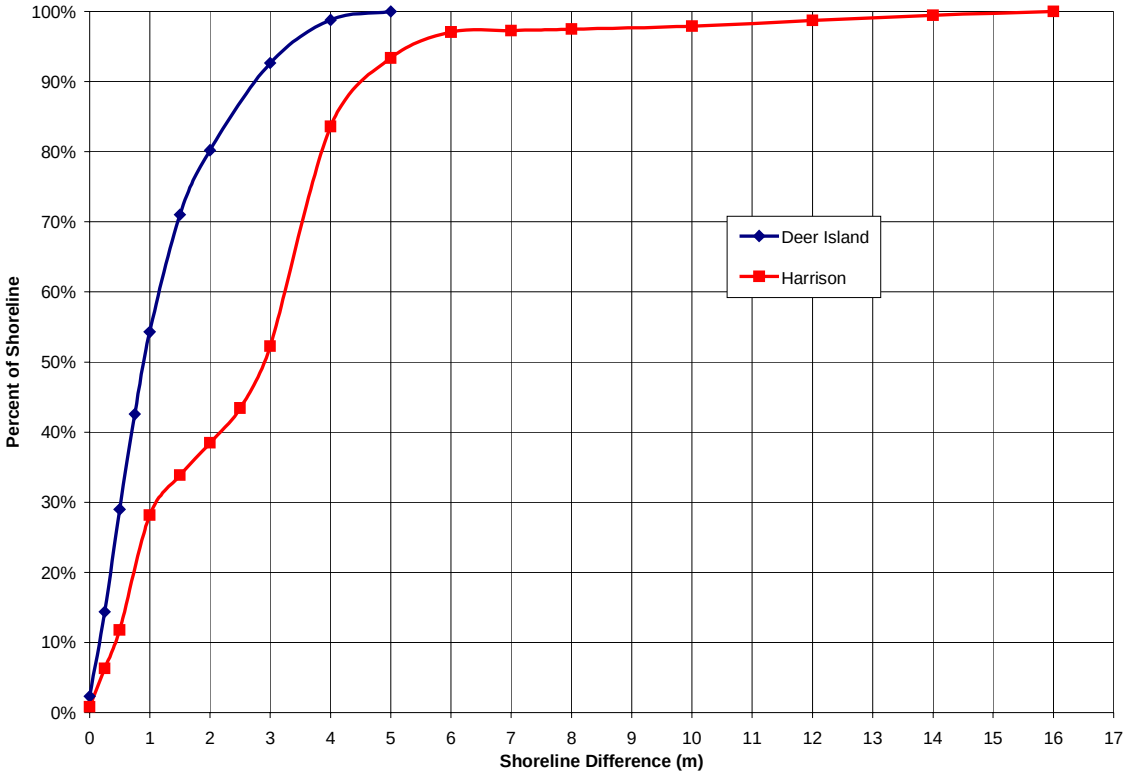

Figure 1. Cumulative frequency graph of GPS shoreline differences

The Harrison data set (Figure 1) shows that the technique, as used to determine the HWL, may not be as accurate. Here the more important problem of accurately or consistently surveying the same exact HWL indicator is born out. In extremely rare cases the difference is more than 15 meters; this occurred down drift of a large culvert (groin), which may have had a considerably low beach slope. However, if using a 90% (0.1) confidence level, the reasonable accuracy or, more correctly, repeatability is 4.5 meters. This includes the real world problems of time differences, using a remote base station, and selective availability. One assumption, which should be noted as it pertains to accuracy, is that one shoreline is assumed to be at the true HWL. This may not be the case, so repeatability may be a better term to use than accuracy. The relative contributions of SA and base station distance to the overall error are not known, but represent the least advantageous situation in the yearly GPS shoreline survey data sets.

Discussion

This study suggests that more than 90% of the time the repeatability (accuracy) of the HWL as portrayed in the MOG Shoreline Surveys is +/- 4.5 meters. These two examples shed some light on the relative accuracy and repeatability of the technique used by the MOG in collecting the shorelines. The Deer Island data set represents the best case scenario with a known HWL and concurrent measurement; the Harrison data set represents a more typical scenario, with the added error caused by a remote base station and timing following a hurricane (Hurricane Georges). The values of shoreline repeatability are consistent with an earlier study by Hutchins and Oivanki (1994), which found accuracies on the order of 2 to 5 meters when using mapping grade GPS units. These data sets, therefore, represent a typical spectrum of the data quality. Each individual survey, however, will differ from the examples above. For this reason, and the fact that in large portions of the coast the HWL is constantly changing it is difficult to assign an exact range of accuracies to each data set. When using the yearly shoreline data sets from the Mississippi Office of Geology the confidence levels (Figure 1) should be considered.

References

Hutchins, P.S. and Oivanki, S., 1994. A Comparison of shoreline measurement techniques: GPS survey, air photo interpretation, and total station survey [abs]. Journal of the Mississippi Academy of Sciences, 39(1): 48.