Application of LiDAR Data for Monitoring Coastal Change in Galveston

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Abstract Extensive landform alteration in the Texas Coastal zone has created an urgent need to detect changes for disaster emergency response and preservation of coastal habitat. The dynamics of Galveston Island can be quantified and mapped using airborne Light Detection and Ranging (LiDAR) scanners with high vertical and horizontal point density and accuracy. In this research, LiDAR's ability to characterize geomorphic topography of Galveston Island was evaluated, with emphasis on measuring pre- and post- hurricane changes associated with deposition, coastline changes, vegetation coverage and construction.

1. Introduction

The ability of (LiDAR) to characterize coastal topographic change has been previously demonstrated. For example, with its high resolution and detailed 3-D information, LiDAR-based techniques have shown advantages in studies on the effect of invasive vegetation in coastal marshes [1], shoreline change detection[2], and near-shore benthic character identification [3].

2. Objective

The object of this study is to use two airborne LiDAR datasets along the Galveston West and East Bay, acquired in 2002 and 2010 respectively, to estimate and analyze changes in bare earth, shoreline, vegetation coverage, and man-made structures of Galveston Island.

3. Method

A study area was selected on the west bay of Galveston Island. This area comprises an open-ocean sandy beach, active dune fields, swale topography, sub-tidal ponds, wash-over fan/flood tidal delta, upland area, as well as Beach Pocket Park #1, Road F-M 3005, the west end of Seawall Blvd, several buildings, ditches and dikes. The 2002 and 2010 datasets were converted to digital surface models (raster), using simple interpolation of mean elevation value with Quick Terrain Modeler (USA). To preserve local heterogeneities and to match the two LiDAR datasets, a uniform 1.5×1.5 m grid spacing is chosen. Then, the 2002 interpolated surface was subtracted from 2010 to detect changes in the study area. For the purpose of this paper, we consider Coastal change as changes in: bare earth, Shoreline change, Growth or decline of vegetation and construction

4. Discussion

4.1 Change detection for bare earth model: According to prior studies, the range of subsidence levels for Galveston Island is 1.2-12.7 mm/ year. The results of comparison between two dates of referencing hard surfaces show a trend that the nearer to the ocean the surface is, the higher the mean elevation offset between those two datasets. After subtracting the portion of average vertical offset between two datasets, the geomorphologic dynamic analysis of this area can be performed, for example of the area of Beach Pocket Park #1 in Figure 1.

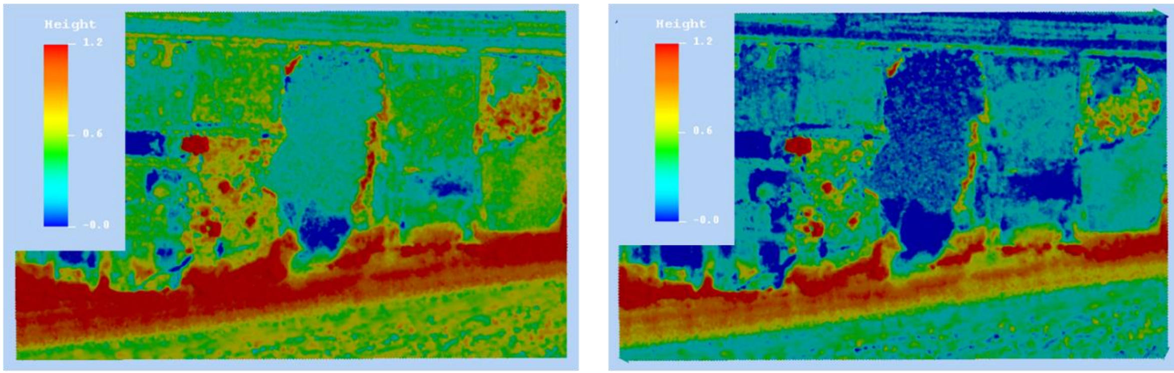

Figure 1 (a) 2002 Bare-earth DEM at 1.5m resolution color coded by change in elevation (meters) with respect to2010 Bare-earth DEM. Blue is gain, green is no change, and red is loss. (b) Bare-earth change detection after subtracting the mean elevation difference of 0.275751m

4.2 Shoreline change: One pair of orthogonal profiles and one pair of shore normal profiles were extracted and plotted. A difference in elevation along the profile of 1.1502 meter can be calculated with a linear fit, which is 0.6436 meters larger than the assumed subsidence value of 0.50664375 meters. Increasing loss of beach elevation close to the shore is evident: assuming a systematic height bias of 1.1502 meter from the beach surface, a net retreat of 22.5m water-sand shoreline was attributed to beach change in between LiDAR collections.

4.3 Growth or decline of vegetation and Construction: To measure tree and roof heights, Above Ground Level (AGL) LiDAR, rather than absolute elevations are appropriate, thus enabling the visual and identification of objects within a certain height range. Buildings and were obviously destroyed by Hurricane Ike in 2008, but had also previously been lost due to erosion and subsidence of the island. Vegetation coverage for the study area shows a significant drop of coverage from 100318.5 m^2 to 65407.5 m^2. However, the number of houses increased from 36 to 42, even though the houses nearest to the beach were totally destroyed by Ike.

5. Conclusion

Comparing to manual surveying, the high density of LiDAR data can improve coastal spatial change detection. After subtracting the portion of average vertical offset between two datasets, geomorphologic dynamic analysis of this area can be performed. A 23 meter retreat of coastline can be observed. West Bay of Galveston has large vegetation coverage loss; however from the comparison it is evident that people are still building more houses in this area, despite the losses from Hurricane Ike.

6. Acknowledgement

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7. References

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