

ACCELERATED BEACH EROSION ALONG THE UPPER TEXAS COAST

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The upper Texas coast has been severely eroded and beach erosion is going on. It is not extreme comparing past one but its strength is still strong by a magnitude. There are some methods and numbers to determine stability of beach by historical beach observation but they are evaluated only for a certain location. It may not be available in the places which have rare observation data such as the upper Texas coast. The study focused on factors to determine the stability of beach against beach erosion. The pattern recognition of neural network was applied to classification of the factors such as beach width, dune height from field observed data.

Keywords: beach erosion; Texas Coast; Neural Network; Pattern recognition

INTRODUCTION

Beach erosion by overwash was generally produced at landfall of storms but remote storm was suspected as a main cause to induce overwash along the northeast Texas coast (Park and edge, 2011). The northeast Texas coast has been eroded and the Texas highway 87 along the Texas coast was closed by severe recession of beach erosion. The study area is located from Galveston Island, Texas to the boarder of Louisiana State along the Gulf of Mexico. Morton (1997) conducted field measurements for 23 years (1974-1996) and concluded that the study area was mainly retreated by overwash. However, there were seven landfalls of storms last 24 years (1991-2014) and some of them were measured during 6 years field measurement by Park (2006).

The purpose of this study is to analyze accelerated beach erosion. The analysis was carried with beach profiles and tropical storm data for long-term using artificial neural networks. The past severe erosion has not been generated after 2010 comparing with the erosion data which we measured. However, the environmental conditions of beach erosion along the study area will be getting worse considering slope of beach is getting milder and sand dune which acts as a breakwater has been disappeared.

Some studies were carried to determine stability of beach against beach erosion by historical observation data along the east coast of the United States but it is difficult to do in the study area due to lack of observation data. Therefore, we cannot conclude that the study area becomes stable or unstable only by these methods. Due to that reason, we try to find factors of beach stability and apply them to other beach studies.

Study Area

The study area is located from Galveston Island to the boarder of Louisiana State (Fig. 1). It is connected to Gulf of Mexico and its length along the coast is about 80 km. The State Highway 87 was closed temporary due to severe beach erosion. The intensity of erosion is getting stronger near the border of Louisiana State but it is very mild around the Sea Rim State Park.

Average wave heights are 0.76-0.91 m and 1.2-1.4 m in summer and winter respectively and average tidal range is 0.39 m in the study area (Waters, 2003). The height of dune has been lowering by repeated erosion of overwash and the average one is about 1.7 m above Mean Sea Level along the study area. These environmental conditions can explain possibility of overwash in the study area.

We measured beach profiles using Jet-Ski with RTK-DGPS and echo-sound. The study area is a continental shelf and the bathymetry is very mild. The depth of closure is located about 700 m away from the coastline and it is 4 m deep from our data and Morang (2006). However, Wallace et al. (2010) suggest that it should be 8 m deep for sand budget study in upper Texas Coast. The coastline is straight from Galveston Island and the bathymetry is almost flat with a few sand banks. There is no sand source such as river and movement of clay and sand is observed by longshore current along the coast. Longshore current moves from Louisiana State to Texas along the study area and it is very turbid due to very fine sediment.

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Figure 1. Location of study area (yellow line) along the upper Texas Coast.

Tropical Storms

The landfall of tropical storm is important to understand beach erosion by overwash. Keim and Muller (2007) analyzed historical tropical storm data for 105 yr (1901-2005) in North America. The Gulf and Atlantic coast were divided spatially and the study area was located between point 4 and 5 (Fig. 2). Their return periods of storms are the same but one of hurricanes are quite different. Because most of tropical storms make landfalls in Mississippi or Louisiana State, it is surprised that the return period of landfall of storms of upper Texas coast is similar to Morgan city, LA.

For short-term analysis, 318 tropical storms were generated in the Atlantic Ocean and 54 storms among them had affected on the US coast along the Gulf of Mexico between 1991 and 2013. Only seven of them made landfall near the study area and three hurricanes among them were Rita (2005), Humberto (2007), and Ike (2008) in Table 1. It means that no severe storm damage was made before 2005.

Table 1. Landfall of storms in the study area between 1991 and 2013.					
Year	Total no. storms	Name	Date	Speed at landfall (Kt)	Category at landfall
1995	19	Dean	Jul 28-Aug 2	40	TS
2001	15	Allison	Jun 5-7	30	TS
2003	16	Grace	Aug 30-Sep 2	35	TS
2005	28	Rita	Sep 18-26	100	H (3)
2007	15	Humberto	Sep 12-14	80	H (1)
2008	16	Edouard	Aug 3-6	55	TS
2008	16	Ike	Sep 1-14	95	H (2)

The occurrence of storm was analyzed and it is apparent that the total number of storm was increased after 1995 (Fig. 2). The average number of storms is 13.8 in the Atlantic Ocean and only 2.3 storms among them move in the GOM. The year of peak occurrence is the year 2005 but it is not related to the number of storm in the GOM. All hurricanes in the study area made landfall after the year 2005 but beach erosion has been severe for more than 40 years. Because only few storms made landfall and effected on beach erosion between 1991 and 2013, the erosion by remote storms was suspected as a major cause (Park and Edge, 2011). It was observed that overwash by hurricane Katrina was generated in the study area (Fig. 3), though the distance is about 450 km between the study site and landfall of Katrina. It showed that continuous overwash could erode Texas beach by remote storms in GOM. So,

we needed to focus on the number of storms in GOM (Fig. 2) and we expected that the study area became stable after the year 2008.

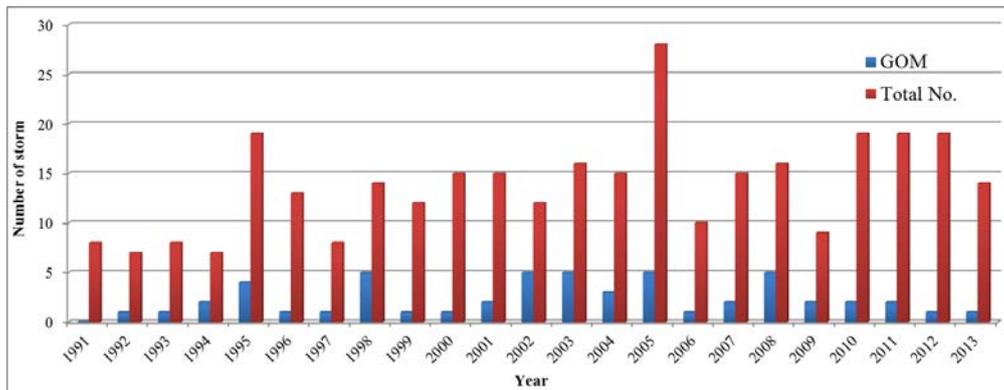


Figure 2. Total number of storms in Atlantic Ocean and some of them affect Gulf of Mexico.



Figure 3. Overwash induced by Hurricane Katrina (2005) in the study area 5 hours after landfall of it in New Orleans.

Beach erosion

More than 80 % of the study area is severely eroded and its rate is 5.66 m/yr between 1958 and 2006 (Paine et al., 2011). It is bigger rate comparing the measured data by Morton (1997) and Park and Edge (2011). Morton measured erosion between 1974 and 1996 and the rate was 3.7 m/yr. Park and Edge's result was 3.5 m/yr between 1999 and 2005. The beach width changed from 39.59 m in 1999 to 32.68 m in 2002 (Park and Edge, 2011) and it was too narrow comparing 150 m of stable condition in the Atlantic Ocean. Even worse is that it was much smaller than 50 m of recovery limit. The standard of stable beach is for the Atlantic Ocean but we do not think that they are available for the GOM due to different beach environment.

Because the storm activities near the study area have been decreased after the year of 2008 in Fig. 2, it is interesting that the study area still continues eroding like before. The beach profiles near the Sea Rim State Park were shown in Fig. 4. The changes were small between 2004 and 2006 but there were some beach deposition between 2008 and 2011. The slope of beach was mild and there was no big change 100 m away from the coastline.

Landfall of three hurricanes has been made since 1991 and they are Rita (2005), Humberto (2007) and Ike (2008). When we consider that the return period of hurricane was 8-15 years by Keim and Muller (2007), most of them happened intensively. The beach erosion by hurricane was massive and sometimes it is unrecoverable. However the impact of hurricane Humberto was slight, because it was quickly generated and disappeared within several days.

Overwash by hurricane Ike was shown in Fig. 5 and overwash fans reached about 500 m from the coastline. There were six artificial geotextile groins by US Army Corps of Engineers only for research purposes and their coordination is 29.657704 N and 94.103901 W. It was severely eroded area but the erosion rate dropped sharply after they were built in 2005. They were completely destroyed by

hurricane Rita (2005) and Ike (2008). It seemed that the erosion was still continued but its rate became low. Because there has been no hurricane since Ike (2008), the area behind dune was covered by some grass and plants. The distance has been kept between the road and the coastline in Fig. 5. The coastline retreat has been small since 2007 but there was no method or survey data to determine stability of beach.

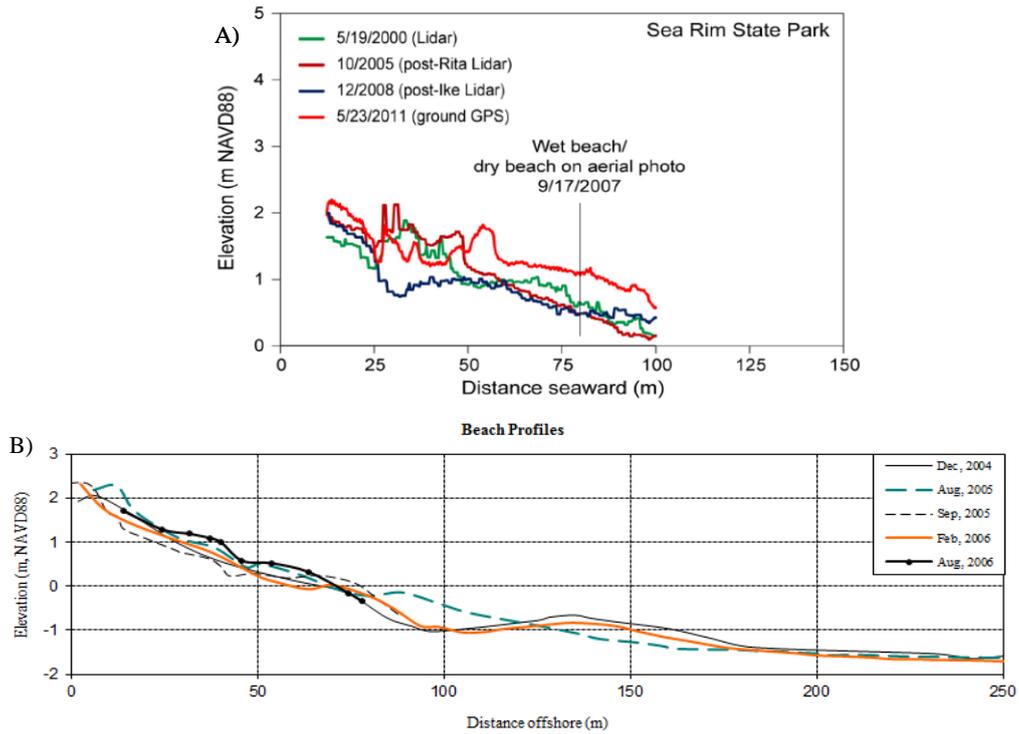


Figure 4. Measured beach profiles near the Sea Rim State Park, A) by Paine et al. 2011, B) by Park (2006)



Figure 5. Aerial photos of beach erosion in the study area between 2007 and 2013.

Pattern recognition

It is difficult to analyze the beach stability with limited historical survey data. It is known that beach width, dune height and other factors is indicator for beach stability but their values need to be decided from the long historical survey results. It needs a new way for the place with insufficient data such as the upper Texas coast.

Pattern recognition is one of method in artificial neural network and we thought that it was suitable for decision of beach stability. It is a branch of artificial intelligence and the procedure of pattern recognition for beach stability was shown in Fig. 6. It is composed of three parts such as Input, Analysis and Output. Many factors can be used for input but they effect on output. When we give some factors for input, pattern recognition classifies output. It is a kind of black box technique and stability is learned by training from the given data. We may think many factors are for input but it has to be decided carefully by many trials. The several other factors were also included to understand the pattern of erosion in the study area.

The study for beach erosion has not been completed due to insufficient survey data. The amount of survey data are corresponding to the number of input. We need to analyze many candidates for input in Fig 6. We selected pattern recognition method due to shortage of data but it also needs more than minimum of data at least. We are trying to apply it but we cannot make it.

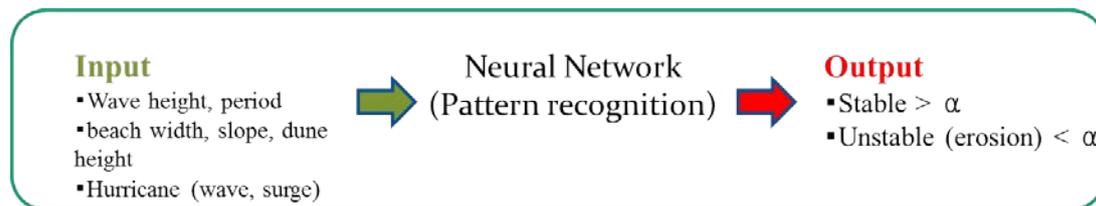


Figure 6. Procedure of pattern recognition for beach stability.

CONCLUSION

The upper Texas beach has been severely eroded without apparent causes such as high wave, strong longshore current, frequent landfall of storms, etc. Overwash was suspected as a major cause of beach erosion by some studies and field survey. The continuous beach erosion without landfall of hurricane was understood by effects of remote storm in the Gulf of Mexico.

Because the erosion in the study area was closely related to storm activities, the status of beach was interesting since the last hurricane in 2008. The erosion rate is becoming zero in the study area but we cannot determine its stability by the aerial photos. We need a new method to determine beach stability with insufficient and short historical survey data. Pattern recognition in artificial neural network is available for this purpose. The stability was decided by training cases of beach erosion.

We cannot complete this study due to shortage of required minimum data. Estimating stability of beach has been done by expert and long historical data until now. We thought that it could be an indicator to determine beach stable with limited amount of data.

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