# Study of the variability of wave climate causing flooding events on the north coast of Puerto Rico (2010-2011)



#### Abstract:

A study of the occurrence of storm surges and swells events were done for the coastal area on sible effects of different wave regime as storm surge and swells causing coastal flooding, erosion, and infrastructure and human losses in north coast community as Vega Baja, Puerto Rico. Variability among storm surge and swells were determined using statistical analysis, such Wave height, period and direction data were obtained from the NOAA CariCOOS buoy system located in the San Juan Bay Area. An integration of diverse research techniques, such as the creation of a climatological data bank, GIS, evaluation of published data and interviews were also used in this study. Community risk perception was also defined using tools such as interviews, questionnaires and oral history. Risk perception is an important variable to identify the effects of waves causing flooding in the site. Preliminary results showed that higher waves approaching in the study site were produced by cold front. These events produce important flooding event in the area causing important beach erosion and loss of properties. Swells and wave surge are also producing erosion but not as frequent as cold front in the site. This finding fronts north of Puerto Rico. is so important to insert in the actual coastal management model due that its original coastal risk plans that are mainly define based on the effect of tropical storm system in the area.

#### **Introduction:**

Puerto Rico is a tropical Island that is subject to the constant occurrence of diverse waves regimes produced by different atmospheric events as tropical and extratropical storm, cold front and other low pressure systems. Major studies have been done evaluating the effects of waves produced by hurricanes and other tropical systems have on our coasts and the coastal communities, but few studies has been done using cold front as a major agent causing erosion and loss of properties. Apparently, cold fronts are have a major occurrence in our area in recent years and it is important to evaluate the possible effects of such events over coastal system in order to prepare communities to be ready during the impact of these events over this areas. In this research we include a detail description of the wave climate at the north coast of Puerto Rico. We identified the variability between wave height, period and direction, its variability through time and its possible effects of these waves over coastal erosion, loss of properties and lives. This evaluation was done to identify the specific wave types that are reaching the north coast of Puerto Rico.

The study includes, also, a general evaluation of the perception of local communities of these events. Finally we identify the relation of wave climate with coastal flooding event in the study site.

Study Area: Puerto Nuevo, Vega Baja & Escambrón Beach, San Juan Bay Area



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#### Method:

The method includes an integration of diverse research techniques as data collection from buoys (field the northeast coast of Puerto Rico from 2010 to 2011. This study was done to identify the pos- work), evaluation of published data from National Weather Service (NWS), National Oceans and Atmospheric Administration (NOAA) and Sea Grant, Geographic Information System (GIS) and interviews with communities.

The wave data was acquired from a Buoy owned and maintained by the Caribbean Integrated Coastal as descriptive statistics, two way-correlation, of wave height, wave period and wave direction. Ocean Observing System (CariCOOS) located in the San Juan Bay Area. This buoy measures continuous data of wave height, direction, period, water temperature and of wave height, direction, period, water temperature, among others, every hour. It also measures meteorological variables such as wind speed and direction, gusts, atmospheric pressure and air temperature every ten minutes. For this study we used the data for every six hours, 4 readings per day.  $_{T}$  Information about the intensity, trajectory and possible negative effects such as economic, property or life loses of hurricanes, tropical storms and tropical depressions that occurred from July 2010 to July 2011 was obtained from the NWS on-line archives. Also the NWS office of San Juan Puerto Rico, helped us obtain the North Atlantic Synoptic maps that helped us identify the occurrence of cold

Field visits to the study site were also done to photograph the affected areas.

Findings
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	Ν	Minimum	Maximum	Mean	Std. Deviation	
Wind Speed (m/s)	1383	0.1	9.7	4.84	2.17	
Wave Height (m)	1384	0.2	4.8	1.30	.548	
Wave Period (s)	1384	3.8	16.7	8.93	2.68	
Atmospheric Pres- sure (hPa)	1347	999.3	1019.9	1014.05	2.40	

## Wave Events Generated by Atmospheric Events



## General Wave Climate in the North Coast of Puerto Rico

## **Effects of wave events on our coast:**





## **Results:**

- longer periods of time.

- the impact.
- waves occurring during the tropical storm season.

## **Conclusions:**

- of climate change over these events.

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1. The north coast of Puerto Rico does not have a well-defined seasonal wave climate.

2. High waves practically all year long, in summer and in winter.

3. Highest wave heights were measured during a hurricane and cold fronts generated larger waves for

4. Waves generated by cold front events, therefore, apparently produce more changes to the coastal geomorphology in beaches in the north coastal area in Puerto Rico.

5. Major erosion measured in beach profile lines at Tombolo, Manati were apparently caused by the occurrence of cold front (Barreto, M and CC Costas Citizen Science project)

6. Higher waves arriving from the north from late November to February.

7. Strong tropical systems affect the coast, but we only have 4-5 events which do not had a direct hit during the period studied. These events occur more sparsely, giving the coast time to recover from

8. On the other hand, cold fronts occurred every two weeks, staying in the area for 4-5 days. The frequency of these events does not let the beach recover from the wave impacts.

9. Vega Baja community describes the beach as "a box full of surprises", the worst sea conditions occur during February to April and that the major losses of life and infrastructure are no related with

10. The community recognizes cold fronts as the events that cause more infrastructure damage; they do not protect themselves against it as they do with hurricanes.

1. High waves produced by cold fronts are an important coastal hazard

2. Due to that, actual coastal management plans are mainly defined based on waves produced by storms should be re-evaluated to include the important effects of cold front causing erosion. 3. More cold front and wave data were evaluated from the last 10 years to identify the possible effect