ASSOCIATING EXTREME NYC PRECIPITATION EVENTS WITH TROPICAL CYCLONES

This research was supported by NOAA CREST (NOAA CREST– Cooperative Agreement No: NA11SEC4810004) and funded by The Pinkerton Foundation.

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INTRODUCTION

Research done by the Intergovernmental Panel on Climate Change (IPCC) has shown that extreme precipitation events will increase in intensity in many regions. This prediction suggests that New York City will become more vulnerable to flooding. Tropical cyclones have a low-pressure wind system that has winds of hurricane force. To better understand how the storms may change in the future, we need to study the past and current climate. The objective of this project is to analyze extreme precipitation in NYC and associate it with tropical cyclones (hurricanes) that have occurred in the past 33 years. Studying these hurricanes that impact NYC will provide the public with information to be prepared and stay safe.

TABLE 1 Classification and Weather Patterns: (Prior Research)

Classification	Conditions	Number of Events
Tropical cyclone with closed low pressure	The greatest amount of precipitation exists over a closed area of low pressure.	10
Tropical cyclone without closed low pressure	No enclosed area of low pressure exists. Great amount of precipitation is concentrated over the Eastern United States.	2
Extra-tropical cyclone (comma-shape)	Is not associated with a tropical cyclone. Large enclosed area of low pressure exists. Area of precipitation has a 'comma-shape'.	18
Frontal system with offshore high pressure	An elongated area of precipitation is present. Area of high pressure exists to the east of the system.	9
Offshore high, with weak or no front	Area of high pressure exists to the east of the system. Demostrates relatively weak precipitation.	3

These are the 48 rainfall events from 1979-2013 from previous research. These events were divided into five classes based on their conditions. According to the new research there is a more wide variety of investigation.

METHODS

Daily precipitation, tropical cyclone tracks, and gridded precipitation data for 1979-2012 were acquired from the Global Historical Climatology Network (https://www.ncdc.noaa.gov) , National Hurricane Center Atlantic Hurricane database (HURDAT) http://www.nhc.noaa.gov/data/ and ECMWF-ERA-Interim Reanalysis (Dee et al. 2009), respectively. We calculated the precipitation values for the 99th percentile and then selected the dates when these values occurred during the hurricane season (June 1 – Nov. 30). We investigated the tropical cyclone events by associating them with the dates of tracks in HURDAT: using the cyclone tracks, those which occurred within 300-400 miles of NYC were considered to have a direct effect on the NYC region. An internet search was conducted on these cyclones and key words about the type of cyclone information from each website were documented. Finally, map plots were generated showing the accumulated precipitation before and after each storm for the 6 strongest precipitation events in NYC.

Dee D. P., and co-authors., 2011: The ERA-Interim reanalysis: configuration and performance of the data assimilation systems. Q. J. R. Meteorol. Soc., 137, 553-597

WEBSITE ANALYSIS

Date of TC events	Name of events	Duration of NYC Precipitation Extreme	Indirect/direct	Websites	Key words for information from the website
7/26/1985	Hurricane Bob	1 day	indirect	http://www.wpc.ncep.noaa.gov/tropical/rain/bob1985.html (*)	Tracks and Weather conditions
9/27/1985	Hurricane Gloria	1 day	direct	http://www.nhc.noaa.gov/archive/storm_wallets/atlantic/atl1985-prelim/gloria/prelim03.gif http://www.weather.gov/mhx/Sep271985EventReview	Impacts
8/19/1991	Hurricane Bob	1 day	direct	http://www.oocities.org/hurricane/hurricanebob.htm	Impacts
7/24/1997	Hurricane Danny	1 day	direct	https://en.wikipedia.org/wiki/Hurricane_Danny_(1997) http://www.nhc.noaa.gov/1997danny.html	Storm Evolution
09/16/1999-09/17/1999	Hurricane Floyd	2 days	direct	https://www.baruch.cuny.edu/nycdata/disasters/hurricanes-floyd.html http://www4.ncsu.edu/~nwsfo/storage/cases/19990915/	Storm Evolution
10/12/2002	Hurricane Kyle	1 day	indirect	http://www.wunderground.com/hurricane/atlantic/2002/Hurricane-Kyle	Raw Data(Table)
9/8/2004	Hurricane Frances	1 day	indirect	http://www4.ncsu.edu/~nwsfo/storage/cases/20040908/ http://www.nws.noaa.gov/om/data/pdfs/FrancesPSDA.pdf	Satellites Images
9/18/2004	Hurricane Ivan	1 day	direct	http://disc.sci.gsfc.nasa.gov/hurricane/additional/science-focus/HurricaneIvan2004.shtml http://www4.ncsu.edu/~nwsfo/storage/cases/20040917/(*)	Satellite Images, Storm Evolution
9/28/2004-9/29/2004	hurricane Jeanne	2 days	direct	http://www.hurricanescience.org/history/storms/2000s/jeanne/ http://www.history.com/this-day-in-history/hurricane-jeanne-crashes-into-haiti	Storm Evolution
6/4/2007	tropical storm Barry	1 day	direct	http://www.nasa.gov/mission_pages/hurricanes/archives/2007/h2007_barry.html http://www.nhc.noaa.gov/data/tcr/AL022007_Barry.pdf	Storm Evolution, Raw Data
9/6/2008	tropical storm Hanna	1 day	direct	http://www.nasa.gov/mission_pages/hurricanes/archives/2008/h2008_hanna.html http://www4.ncsu.edu/~nwsfo/storage/cases/20080906/	Satellite Images, Tracks and Weather conditions
8/28/2011	1-hurricane, 2-days, 1-tropical storm Irene	3 days	direct	http://www.nhc.noaa.gov/archive/2011/al09/al092011.discus.001.shtml? http://www.noaa.gov/extreme2011/StormEvents/storm08282011.html http://www.noaa.gov/extreme2011/irene.html	Satellite Images, Raw Data

TABLE 2. Web Analysis. This was created when beginning this research. It indicates the types of hurricanes that occurred and websites that represented information about the hurricanes. To have an idea of what each website represented we wrote keywords to help identify what each website is indicating. These were the last events that directly affected the NYC area out of 75 extreme event dates.

RESULTS

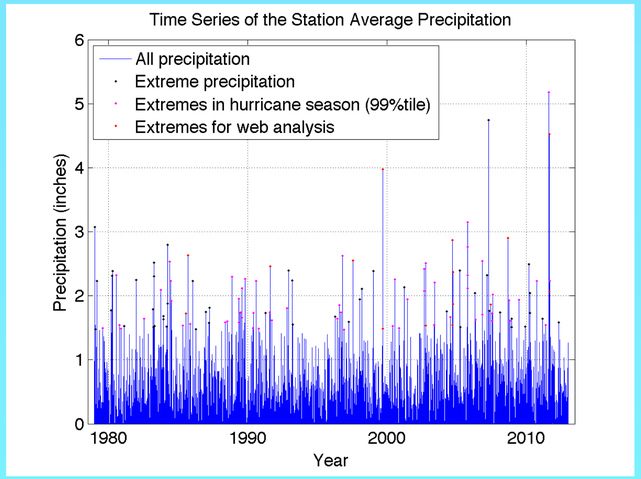
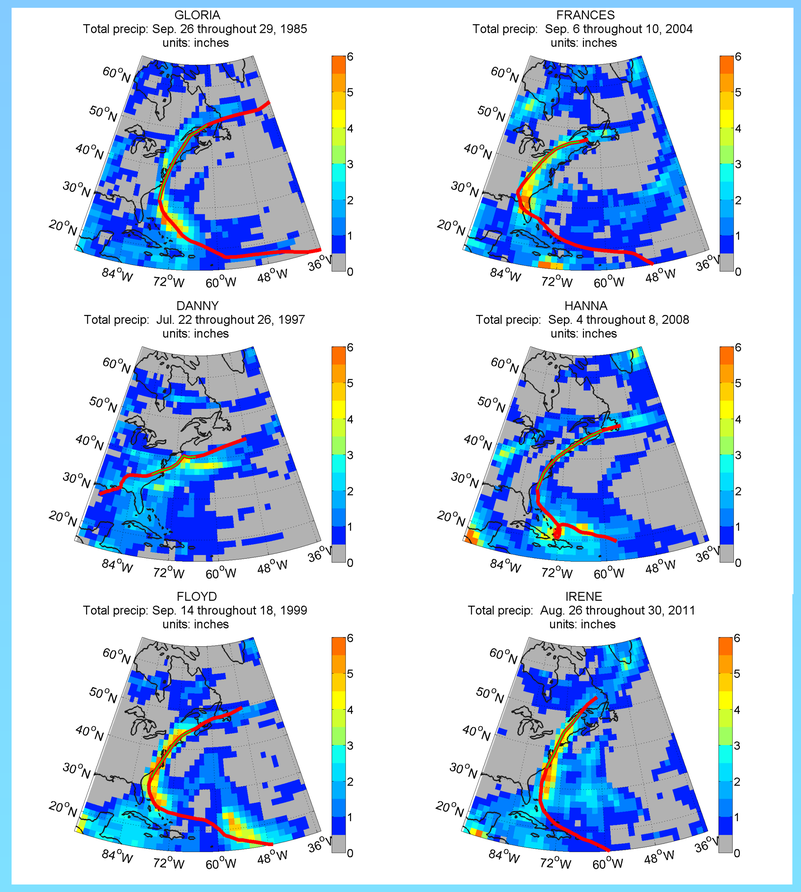


Figure 1:Time series of the station average precipitation
This graph represents the extreme precipitation of the hurricane seasons (pink dot) and the extreme for web analysis (red dot). I graphed this by using the data from the 99th percentile of the hurricane seasons and calculated the station average of daily data.

RESULTS (continued)



Figures 2-7. ECMWF ERA-interim reanalysis
(global climate model with ground and satellite observations assimilated)
These diagrams indicate the 48 hr. accumulated precipitation for each hurricane in NYC. The red line indicates the full track of the hurricane, The green line indicates 48 hrs. around the time it was closest to NYC. The color bar represents the amount of precipitation in inches.

CONCLUSION:

Over the past 33 years, there have been 75 total extreme events that occurred in the NYC area. 35 of these occurred during the hurricane season and 12 directly passed over the NYC area. From the 12 events, there were 3 tropical cyclone events that occurred before 1995 and 9 that occurred after 1995.The National Hurricane Center Atlantic Hurricane database was the most useful site in the web analysis because it contained all the information related to the keywords. The other websites had limited information. The motivation was to study tropical cyclones because extreme precipitation causes flooding, According to the hurricane tracks, hurricanes don't necessarily need to have the same paths. Precipitation follows closely the tracks of hurricanes. These particular storms usually produce heavier rain in the south of New York City. Initially, there was a total of 75 extreme dates that needed to be categorized between hurricanes and tropical storms. However, after classifying the data, only 35 dates remained because the other dates were not in the hurricane season.