A Wall for Lives

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The devastating force of Hurricane Sandy hit the Atlantic seaboard a few months ago. By tracking hurricane patterns since 1980, it has become apparent that the danger they present is increasing. It is therefore necessary for a wall to be created that will protect vulnerable coasts, saving many lives in the future.

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Introduction

Approximately six months ago, Hurricane Sandy formed in the Atlantic Ocean. It killed nearly one hundred people within a sixty-five mile radius of New York City, brought surges of nearly 4.25 meters high, and broke a nearly 200-year-old record in Manhattan (Walsh). It inundated the streets, highway tunnels, and even the subways of New York City. It caused over $50 billion worth of unprecedented damage to areas that, to this day, have not been completely rebuilt and restored in the United States along its East Coast from North Carolina to Rhode Island. The most catastrophic of the damage that Sandy caused was the power outages. Not only did the floods produce blackouts in certain areas, but they also instigated an explosion at a Con Edison substation that triggered even more power cuts that substantially delayed the company's efforts to restore power. One woman was even fatally electrocuted after stepping in an electrified puddle caused by a fallen power line. (Andrews)

Although Sandy is the most recent hurricane to strike the United States, it is not the only one, nor the most deadly or costly. In 2005, Hurricane Katrina struck the Atlantic Coast, its greatest impact hitting Mississippi and Louisiana. This hurricane caused the death of almost two thousand people, and was estimated at $108 billion in damages (Blake, Landsea). Even today, eight years later, the effects of Katrina can still be felt in some parts of this country.

Studies show that hurricanes have been increasing in both length and strength with alarming advances. In 2011, USA Today claimed that "durations [of hurricanes] have increased by about 60% since 1949, and average peak storm wind speeds have increased about 50% since the 1970s." This means that hurricanes last more than twice as long as they did sixty years ago, and have doubled in intensity over the last thirty years. Hurricanes are becoming a greater threat to coastal areas each year, and these "once in a lifetime" horrors are no longer as infrequent as once expected.

With the horrors brought to us by these destructive natural disasters still fresh in our minds, it is time to recognize the need for preventative measures. Even with the advanced warning of an upcoming hurricane, as is usually the case, these storms are unpredictable, and have proven to exceed their expected destructive force on several occasions. The flood barriers raised at points along the Atlantic Coast that fall below sea level have proven ineffective against the onslaught of a hurricane. Rather than spend billions of dollars on reconstruction after the fact, and remain with the scars of lost loved ones forever, would it be possible to predict which coastlines are susceptible to hurricanes? If this is the case, can we build a protective mechanical wall along the beaches of these areas, which can be activated when a hurricane forms?

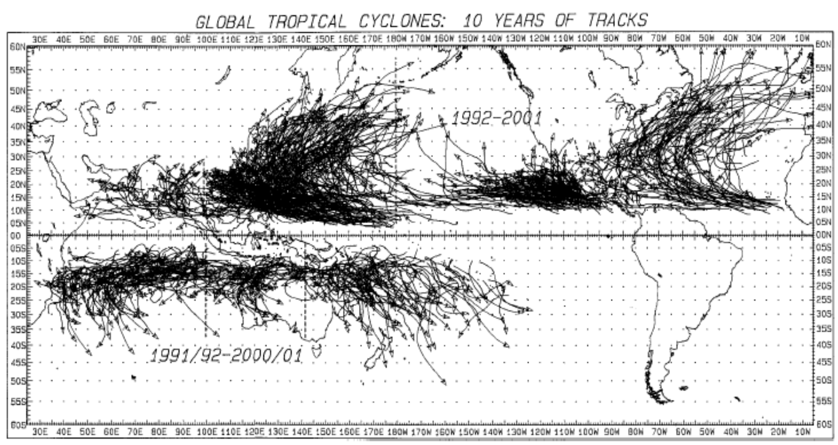
A Wall for Lives will explore this topic, and will attempt to find an answer to these crucial questions. We will discuss the patterns of hurricanes, where they are likely to form, and why. We will consider the flood barriers found in the Netherlands, and along the Thames River in Britain, discussing the strengths and flaws in their designs. Lastly, we will investigate the possibility of a new kind of wall, one which will, perhaps, save lives, while remaining relatively affordable and practical. While we are limited in resources, perhaps a model can be found that will gain the attention necessary to put this project into action.

Mathematical Model

Hurricane Models

Weather Patterns and Climate Change

It is necessary to discuss the behavior of hurricanes in order to understand how to prevent its consequences on public safety and economic cost. First, there are three categories that are determined by wind speeds we must be aware of. Because hurricanes, or tropical cyclones, aren't the only natural disasters that impact our communities, let's get an insight on what makes and does not make a tropical cyclone. The first category involves maximum winds that average to 17 m/s or less which are referred to as tropical depressions. The second category has winds averaging between 18 m/s to 32 m/s inclusively, commonly referred to as tropical storms. The last category are hurricanes, which is another name for tropical cyclones, recognized with winds averaging 33 m/s or greater.



Tropical cyclones are known to develop over the ocean water with a surface temperature of 26 degrees Celsius or greater. When looking at the climatology, the study of climate, of tropical cyclones, we notice how tropical cyclones stay away five degrees latitude from the equator with a tendency to move westward, as shown in the image above. (Emanuel) However, what influences the behavior of tropical cyclones are factors that include temperature and location, as we will discuss further on.

El Nino and La Nino Winds: Its Causes and Effects

El Niño-Southern Oscillation (ENSO), named after the Spanish phrase "the boy," is the periodic warming observed around Christmas in the Pacific Ocean in the area close to South America. As a result, ENSO is commonly referenced to when discussing the sea surface temperature and the air surface pressure in the tropical western Pacific. ENSO is one part of the Southern Oscillation that labels a band on the western coast of South America as a reason for climatic changes across the Pacific Ocean because of its warm ocean water temperatures. On the other hand, La Niña is the cold phase of the Southern Oscillation, demonstrated in the cool pool of the eastern Pacific Ocean intensifying and trade winds strengthening. Caused by hot air produced by the equator and cool air from the north and the south seeping in, trade winds blow from the east to the west, towards the equator over most of the Torrid Zone and are deflected westward as a result of the west to east rotation of Earth.

However, when discussing the United States, ENSO has a profound effect during the winter seasons. During winter, the Northwest, northern Midwest and Mideast sections of the United States experience drier and warmer temperatures as well as reduced snowfalls compared to the averages throughout the rest of the year. El Nino affects the southwestern and southeastern parts of the United States with cooler and wetter winters. Producing western wind departures at the upper levels of the Earth's atmosphere and eastern wind departures at the lower levels, over the eastern Pacific these wind patterns are the opposite of those normally seen in the region, resulting in lower vertical wind shear. Therefore, the eastern Pacific hurricane season is much more active during El Nino as a result of the expanded area of low vertical wind shear (which will be discussed more in detail) in which hurricanes can form. La Niña brings forth a higher than average precipitation across the northern Midwest, the northern Rockies, Northern California, and the Pacific Northwest's southern and eastern regions. Meanwhile, precipitation in the southwestern and southeastern states is below average. Producing eastern wind departures at the upper levels of the Earth's atmosphere and westerly wind departures at lower levels, over the eastern Pacific these wind patterns are in phase with those normally seen in the region, resulting in higher vertical wind shear. Therefore, the eastern Pacific hurricane season is typically less active during La Niña because of the expanded area of high vertical wind shear. (NOAA)

Winds are an important factor when considering how El Nino and La Nina have a profound effect to the hurricane seasons by affecting the Atlantic and Pacific. El Nino contributes to an increase in hurricane occurring in the eastern Pacific, with fewer hurricanes in the Atlantic. In contrary, La Nina contributes to more Atlantic hurricanes, with a decrease in hurricanes in the area of the eastern Pacific. One thing we must keep in mind is that, in order for hurricanes to form, when discussing about winds, requires low vertical wind shear, below eight miles/second, meaning winds must change in height to be fairly uniform throughout the atmosphere. How do the patterns of El Nino and La Nina differ from the normality of winds? What effects do these anomalies have?

Recently, there has been a debate around the patterns of El Niño/La Niña-Southern Oscillation. Since satellite data has only been documented since 1979, the new patterns that have emerged can't be fully explained with a link to global warming and therefore needs more research to be completely understood. These new patterns demonstrate a lack of traditional patterns from the usual places where the temperature anomaly had taken place, now taking place in the central Pacific. As a result, this new phenomenon is referred to as the Central Pacific-El Nino. These new path occurrences have led to more hurricanes making a landfall more frequently in the Atlantic.

Previous Models of Barriers

Delta Works in the Netherlands

The Netherlands received their wake up call for major flood control in 1953 when "Watersnoodramp," Dutch for "flood disaster", occurred . It was caused by a combination of an extratropical cyclone and high spring tides which led to surges of 3.35 meters and waves of over 4.9 meters in not just Holland, but also England, Belgium, and Scotland (Hall). Large areas of these countries are below sea level and to have so much water flood out the land caused an enormous number of casualties. Over 2,000 people were killed in this flood and it caused some of the greatest damages in history. The cost of damages was over $1.7 billion which was considered a large sum of money for the time, especially since it was shortly after the Second World War when everyone was trying to get back up on their feet. After realizing the seriousness of the rising water levels in an area that is below sea level containing almost two thirds of the country's population, the Netherlands decided to have studies done on their land and determine where they needed improvement in their coastal defense systems. The result of these studies and the meetings by the parties involved led to the development of Delta Works, the Netherlands own shield against the force of the floods.

Delta Works is the largest water-controlling structure in the world. It is not just a dam[1], nor just a levee. It is not even just a dike. Delta Works is an extensive network of dams, levees, dikes, sluices, locks, gates, seawalls, and storm surge barriers more than 10,000 miles long, working together to prevent the damage that could be caused by other floods like those seen during the 1953 flooding of the North Sea (The Edge of Ambition). This project took over half a century to complete and cost $13 billion dollars. Its cost does not end there however, because every year the system needs more money pumped into it to keep it running, about $500 million dollars (Walsh). If however, the Netherlands had decided that they would not have built Delta Works, the damage more floods would have caused might have exceeded

[1] Underlined words are defined in Appendix C

the amount of money spent on designing, developing, building, and maintaining the water-battling system.

Delta Works was designed to protect the Netherlands from 1-in-10,000-year floods, which would imply that the Netherlands may be safe for the next 10,000 years (Walsh). This, however, is not the case because of the warmer weather caused by climate change and global warming. Warmer weather causes surges and tides to be higher, increasing the amount of damage that floods can cause.

Thames Barrier in England

The wakeup call for flood control in 1953 was not only received by the Netherlands, but also by England, as its River Thames in London also experienced surges that were never seen before in the North Sea Flood. Since then, it has been noted that the Thames has been rising at a rate of about 30 cm per year. The rising water level increases the likelihood as well as the severity of flooding in the Thames. Completed in 1984, the Thames Barrier has been successfully used more than one hundred times and prevented the damage of over £80 billion worth of property and the deaths of 1.25 million people (Fookes).

Similar to our idea for the design of *A Wall for Lives*, the Thames has a "giant, movable steel and concrete flood barrier" that will, according to TIME Magazine, under "normal circumstances… allow the passage of large ships rise up during flood threats." Like the Dutch, the Thames barrier was decided upon after many other options were considered. The Thames barrier is the second largest moveable seawall after Delta Works. (Walsh)

The barrier is comprised of a series of floodgates with ten openings, six of which are larger than the rest to let ships pass through. These six larger openings are "actually sections of cylinders, rounded on one side, flat on the other, with a disc at either end" (London Fights Off Disaster: A giant bulwark rises in the Thames as a flood barrier). Each of the gates ways 3,200 times but the barrier can be raised in just thirty minutes. It cost over "$2 billion in today's figures" to complete (Walsh).

Our Barrier Model

Methodology

When a company begins a new project, one concern that is modeled is the financial undertaking. In this case, there are several monetary factors that must be considered, mainly the cost of materials. Although there are other concerns, those will be considered the simplifying assumptions, as they are more variable, and difficult to determine.

When determining the expenditure of the barrier in a specific place, the cost of the materials must be calculated. This calculation cannot be found until the height, depth, and length of the wall has been determined based on the models of hurricane activities previously discussed. The height would be decided based on the maximum height of a storm surge that is calculated to be possible. Depth of the wall gives it the strength to withstand the battery of the storm, so the necessary width would be calculated based how much strength a storm hitting the area can be believed to become. The length of the wall is calculated according to the extent of the coastline that is vulnerable to the storm.

Once the dimensions of the wall have been concluded, it can be placed in the model, which will determine approximately how much of the material is needed. The quantity of each material required can then be multiplied by their prices to find the amount of money needed for materials for the wall. The materials, their prices and the quantity needed were determined while conferring with a mechanical engineer.

In this model, we suggest the use of concrete for the base material for the wall, as it is relatively inexpensive, and is less corrosive than metal. The average price of concrete is $75 per cubic yard, or approximately three thousand pounds (Bazian). Based on this information, the volume of the wall can be calculated in cubic yards, and multiplied by $75 per yard. If outside the United States, and using the metric system, the volume of the wall can be found in cubic meters, then multiplied by \$98.10, which is found by multiplying the \$75 by the approximate conversion from meter to yard, 1.30795.

Aside from the base material, there are two important parts of the wall that need to be acknowledged. The first part is the stainless steel gear box, which is at least \$20,000 per unit, and is required approximately every yard. A gear box is a set of gears (at least two) within a casing, which allows for the movement of the wall. The second part is the motor, costing about \$8,000-10,000 per motor, with one for every three or four gear sets (Bazian). This means that, for every four cubic yards, the wall will cost approximately \$90,000. This was found by the following formula:

$$75 \times 4 + 20{,}000 \times 4 + 9{,}000$$

This formula can be made general in the following way:

$$75(xyz) + 20{,}000x + 9{,}000(\frac{x}{4})$$

where x is the length, in yards, of the wall, y is the height, and z is the depth.

Simplifying Assumptions

While our model has taken several factors into consideration, there are many simplifying assumptions. We are assuming that prices of the materials needed would remain relatively constant in each country, an assumption not completely accurate, as prices often vary between countries. It is, however, unlikely to be a significant difference, and attempting to include this into the data would be unnecessary. The possibility also exists that, because of the magnitude of the purchase necessary, the cost per yard of concrete may decrease, however, because this is not likely, and would be difficult to determine, it has been excluded from the calculations.

The calculation for the quantity and cost of gear boxes and motors was an estimate founded upon the equipment used by the mechanical engineer we spoke to. While he was able to give an educated estimate, he also pointed out that this was only an estimate, and may change drastically based upon what, exactly, we needed. In order to obtain a better estimate, we would be required to build a model that would identify the approximate size quantities needed, then request quotes from companies. As this is not in our capabilities to do, we used the estimations, assuming that they are relatively accurate.

This model has also not included the cost of labor and rental of heavy machinery, as that varies significantly depending on the country, and who would be hired for the work. Although it is most likely that, at least in the United States, union workers would be hired, it is possible to find private contractors that would charge less. The cost of heavy machinery was deemed a variable cost, and therefore too difficult to calculate, as it can sometimes be the obligation of the contractor, and other times may require the commissioner of the project to hire separately.

The last simplifying assumption made is the amount of money lost from the businesses on the beach due to closing for construction. This cost can be avoided by only allowing construction when businesses would be closed. If unable to do this, however, the cost would vary greatly, depending on how many businesses there are, as well as how many customers they are losing as a result.

Results

With information attained on how cyclones are caused and thus affects our population across the globe, we will transfer data attained from Wolfram Alpha and record them. We will use Excel and Mathematica to enter and graph this data. We are aiming to visually understand how these effects might play out in the future. By understanding this much more clearly, we can determine what level of action might be required from us in order to prevent further disastrous damage in the future. The data we from the years 1980, 1990, 2000, 2010, and 2012 have been collected from Wolfram Alpha and are divided into the following sections:

i. Hurricanes – each of their individual names in order to identify each with their description with a number that will identify each when plotted.
ii. Ocean – whether the hurricane occurred in the Pacific or Atlantic Ocean, in order to determine which were affected by El Nino and which by La Nina.
iii. Wind Speed – measured in mph, to determine the average (in font color red) of the wind speed in each of the years we measured.
iv. Hurricane Category – directly influenced by the wind speed, to comprehend the strength of each hurricane in the conventional way, with T.S. representing a cyclone being categorized as a tropical storm.
v. Duration – the days each hurricane took until it dissipated, in order to investigate if the duration of hurricanes has drastically changed by taking its average (font color blue) and therefore should be taken into consideration.
vi. Month – the month in which the hurricane took place, which will serve, tied with (ii), to understand if El Nino or La Nina had taken place.

Under the Scope: 1980

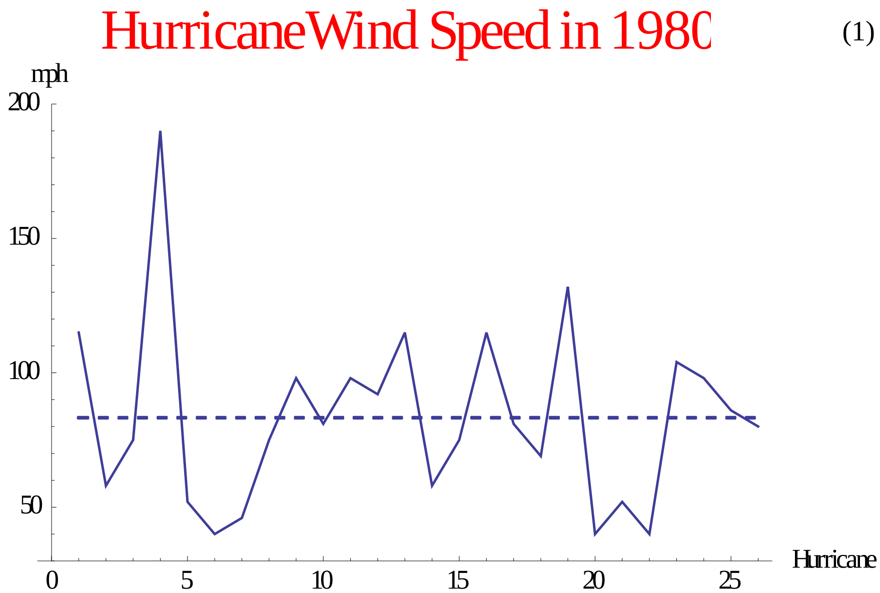
Hurricane Information in 1980

Hurricanes	Ocean	Wind Speed (mph)	Category	Duration (days)	Month
(1) Agatha	Pacific	115	3	7	June
(2) Blas	Pacific	58	T.S.	3	June

(3) Celia	Pacific	75	1	5	June
(4) Allen	Atlantic	190	5	11	July
(5) Darby	Pacific	52	T.S.	3	July
(6) Estelle	Pacific	40	T.S.	1	July
(7) Frank	Pacific	46	T.S.	4	July
(8) Georgette	Pacific	75	1	4	July
(9) Bonnie	Atlantic	98	2	6	August
(10) Charley	Atlantic	81	1	5	August
(11) Howard	Pacific	98	2	7	August
(12) Isis	Pacific	92	1	6	August
(13) Javier	Pacific	115	3	6	August
(14) Danielle	Atlantic	58	T.S.	3	September
(15) Earl	Atlantic	75	1	7	September
(16) Frances	Atlantic	115	3	15	September
(17) Georges	Atlantic	81	1	8	September
(18) Hermine	Atlantic	69	T.S.	6	September
(19) Kay	Pacific	132	4	14	September
(20) Lester	Pacific	40	T.S.	3	September
(21) Madeline	Pacific	52	T.S.	1	October
(22) Newton	Pacific	40	T.S.	1	October
(23) Ivan	Atlantic	104	2	11	October
(24) Jeanne	Atlantic	98	2	9	November
(25) Karl	Atlantic	86	1	3	November
(26) Dinah	Atlantic	80	1	9	November
		83.27		6.08	

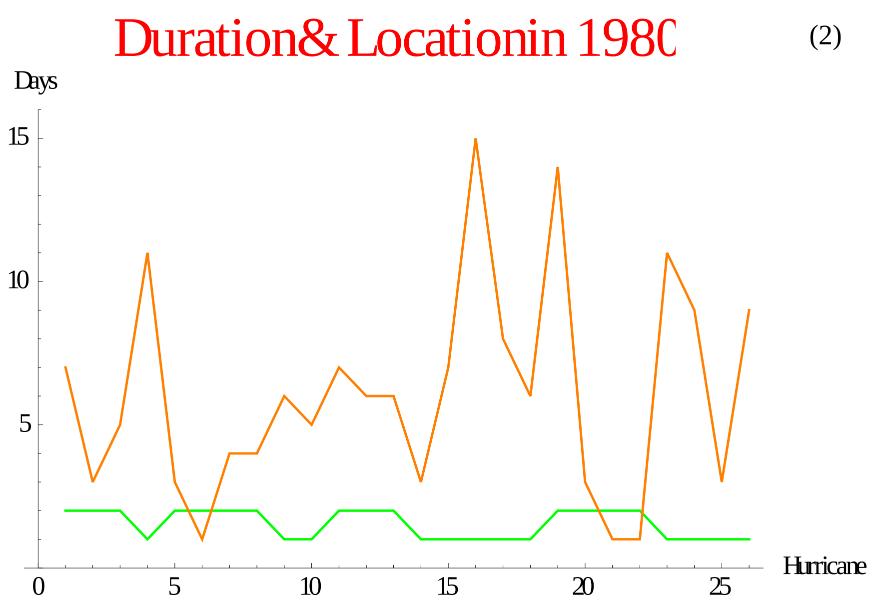
When understanding each section individually, we can graph the following graphs in Mathematica to visually understand what is occurring throughout the year of 1980. The coding of each of the following generated graphs can be found in Appendix B.

The graph to the right starts from June to November, depicting each hurricane that occurred in an almost precise order. As one of the simplifying assumptions, we had to leave them in a slightly off precision,



(1)

making sure, at the very least, that the month each hurricane occurred in was in correct order. The 26 hurricanes that occurred in 1980 seem to have had an equal distribution of high and low hurricane wind speeds, with the lowest wind speeds in July and October.



(2)

The graph to the right describes the duration in days and the location of each hurricane. With the y-axis labeled 'Days', this axis serves only the orange curve, the duration of each hurricane, with the green curve having the ability to just move one unit up or down (or remain the same) because the lowest (a y-value of 1) represents that the hurricane took place in the Atlantic and the highest (a y-value of 2) represents a hurricane taking place in the Pacific. Graph (2) shows a higher percent of hurricanes staying at a higher duration between July and the end of October, with a sharp decline in November. However, in November, these hurricanes occurred mostly in the Pacific. The longest hurricanes occurred in the Atlantic, with the clear exception of Hurricane Kay occurring in September.

When looking into how El Nino and La Nina has affect, if they have, we must keep in mind two of the following facts:

i. El Nino is known to occur during the winter, increasing eastern Pacific hurricane season, and bringing warmer temperatures. For the reasons previously mentioned related to the warmer and drier than average temperatures, El Nino is believed to, for the most part in the United States, suppress hurricanes.

ii. La Nina is known to occur during the winter as well, increasing Atlantic hurricane season. La Nina presents itself with wetter than average conditions in the United States with an unusual increase in the chance of colder temperatures in the Pacific.

When looking now at Graph (2) we observe that during September we have higher duration, higher wind speeds, with most occurring in the Atlantic. The quickest dissipating hurricanes occurred in the Pacific. Therefore, we can conclude that El Nino had a profounder effect during this year.

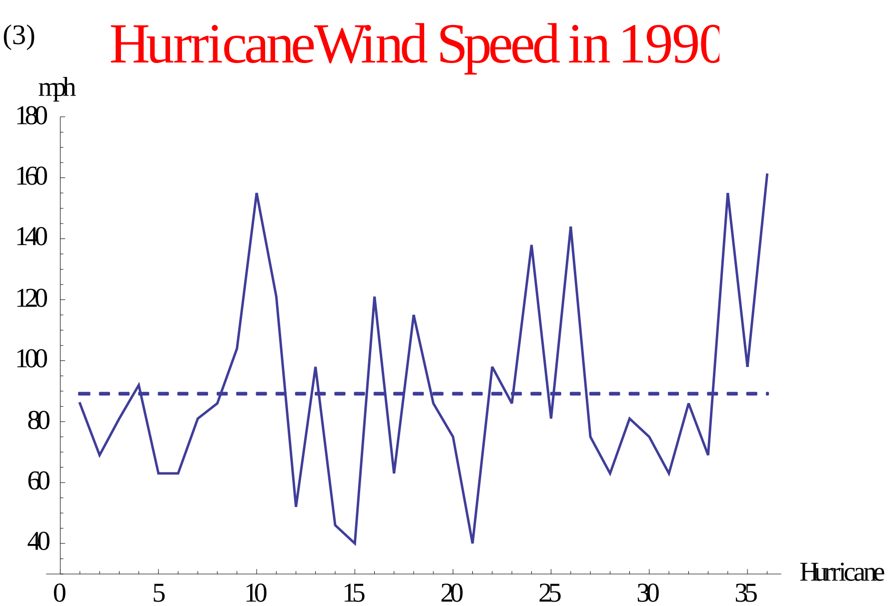
Under the Scope: 1990

Hurricane Information in 1990

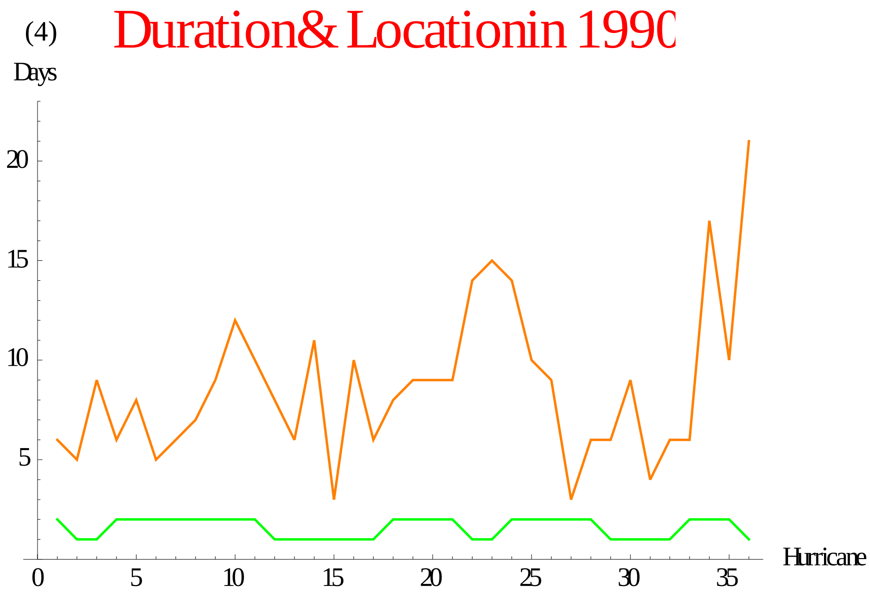
Hurricanes	Ocean	Wind Speed (mph)	Category	Duration (days)	Month
(1) Alma	Pacific	86	1	6	May
(2)Arthur	Atlantic	69	T.S.	5	July
(3) Bertha	Atlantic	81	1	9	July
(4) Boris	Pacific	92	1	6	June
(5) Cristina	Pacific	63	T.S.	8	June
(6) Douglas	Pacific	63	T.S.	5	June
(7) Elida	Pacific	81	1	6	June
(8) Fausto	Pacific	86	T.S.	7	July
(9) Genevieve	Pacific	104	2	9	July
(10) Hernan	Pacific	155	4	12	July
(11) Iselle	Pacific	121	3	10	July

(12) Cesar	Atlantic	52	T.S.	8	August
(13) Diana	Atlantic	98	2	6	August
(14) Edouard	Atlantic	46	T.S.	11	August
(15) Fran	Atlantic	40	T.S.	3	August
(16) Gustav	Atlantic	121	3	10	August
(17) Hortense	Atlantic	63	T.S.	6	August
(18) Julio	Pacific	115	3	8	August
(19) Kenna	Pacific	86	1	9	August
(20) Lowell	Pacific	75	1	9	August
(21) Aka	Pacific	40	T.S.	9	August
(22) Isidore	Atlantic	98	2	14	September
(23) Josphine	Atlantic	86	1	15	September
(24) Marie	Pacific	138	4	14	September
(25) Norbert	Pacific	81	1	10	September
(26) Odile	Pacific	144	4	9	September
(27) Polo	Pacific	75	1	3	September
(28) Rachel	Pacific	63	T.S.	6	September
(29) Klaus	Atlantic	81	1	6	October
(30) Lili	Atlantic	75	1	9	October
(31) Marco	Atlantic	63	T.S.	4	October
(32) Nana	Atlantic	86	1	6	October
(33) Simon	Pacific	69	T.S.	6	October
(34) Trudy	Pacific	155	4	17	October
(35) Vance	Pacific	98	2	10	October
(36) Owen	Atlantic	161	5	21	November
		89.17		8.67	

(3)



When we graph the wind speed, measured in miles per hour, of the 36 hurricanes occurring in 1990, we produce Graph (3). Starting in July, wind speeds of hurricanes increase in mph and in number of occurrences,



starting with 155 mph in July and ending with 161 mph in November. Graph (4) represents the duration and location of each hurricane in 1990. We can witness a clear relationship between both as a higher frequency occurs in the Pacific during the summer and autumn months, as the wind speed increases as shown in Graph (3), the duration of the hurricanes increase. With the exception of Hurricane Owen (number 36), most of the destructive hurricanes occurred in the Pacific, letting us to believe that El Nino had a greater influence during this hurricane season. The distribution of the wind speeds throughout 1990 gives a higher wind speed average of 89.17 with a greater amount of hurricanes with higher wind speeds than 1980.

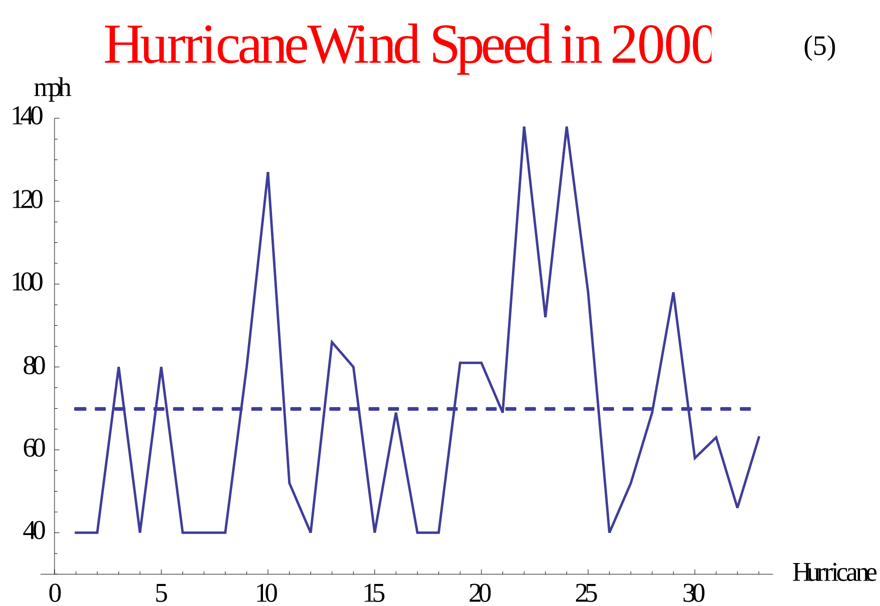
Under the Scope: 2000

Hurricane Information in 2000

Hurricanes	Ocean	Wind Speed (mph)	Category	Duration (days)	Month
(1) Aletta	Pacific	40	T.S.	7	May
(2) Bud	Pacific	40	T.S.	6	June
(3) Carlotta	Pacific	80	1	8	June
(4) Chanchu	Pacific	40	T.S.	4	July
(5) Daniel	Pacific	80	1	14	July
(6) Emilia	Pacific	40	T.S.	6	July
(7) Upana	Pacific	40	T.S.	5	July
(8) Fabio	Pacific	40	T.S.	6	August
(9) Gilma	Pacific	80	1	7	August
(10) Alberto	Atlantic	127	3	22	August
(11) Beryl	Atlantic	52	T.S.	2	August

(12) Chris	Atlantic	40	T.S.	2	August
(13) Debby	Atlantic	86	1	5	August
(14) Hector	Pacific	80	1	7	August
(15) Ileana	Pacific	40	T.S.	4	August
(16) John	Pacific	69	T.S.	4	August
(17) Kristy	Pacific	40	T.S.	3	August
(18) Ernesto	Atlantic	40	T.S.	2	September
(19) Florence	Atlantic	81	1	7	September
(20) Gordon	Atlantic	81	1	7	September
(21) Helene	Atlantic	69	T.S.	10	September
(22) Isaac	Atlantic	138	4	13	September
(23) Joyce	Atlantic	92	1	7	September
(24) Keith	Atlantic	138	4	8	September
(25) Lane	Pacific	98	2	9	September
(26) Miriam	Pacific	40	T.S.	2	September
(27) Norman	Pacific	52	T.S.	3	September
(28) Leslie	Atlantic	69	T.S.	6	October
(29) Michael	Atlantic	98	2	5	October
(30) Nadine	Atlantic	58	T.S.	3	October
(31) Olivia	Pacific	63	T.S.	8	October
(32) Paul	Pacific	46	T.S.	4	October
(33) Rosa	Pacific	63	T.S.	5	November
		67.88		6.39	

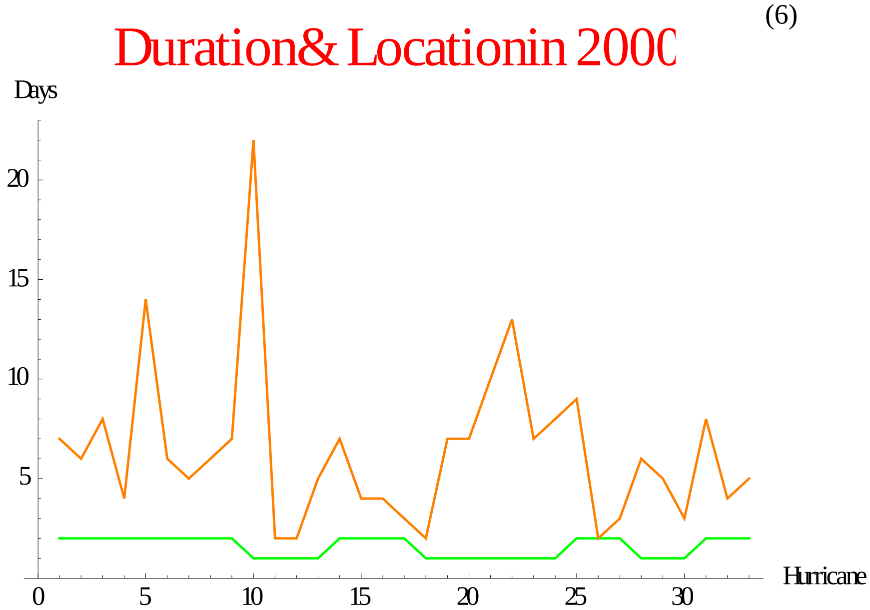
Clearly, off the average calculated by Excel, we can see that both the averages of wind speed and duration decreased. The average of wind speed decreased 24% and duration decreased 26% from 1990 to 2000. Why this sudden decrease? First lets analyze the data. The hurricane season of 2000 starts early off, in May, starts with all of its hurricanes starting in the Pacific with relatively low wind speeds. However, the hurricanes with the



(5)

highest wind speeds occurred in Atlantic (Hurricane Alberto, Hurricane Isaac, Hurricane Keith). The duration of these hurricanes were longer than average. Therefore, we decided to look into the temperature difference between both years. Might the difference in temperature average indicate an explanation for the decrease in hurricane activity overall with a concentration of impact in the Atlantic? Generated by Wolfram Alpha, Chart (1) and Chart (2) in Appendix A shows the temperatures in 1990 and 2000. The year 2000 found itself with lower temperatures, serving a possible explanation to the lower impact of hurricanes. Since the temperatures were higher in 1990, with fewer occurrences in the Atlantic, El Nino had a greater impact. In contrast, 2000 received stronger hurricanes in the Atlantic and less than average impact in the Pacific. Therefore, La Nina had a greater influence in the hurricane season during 2000.

(6)



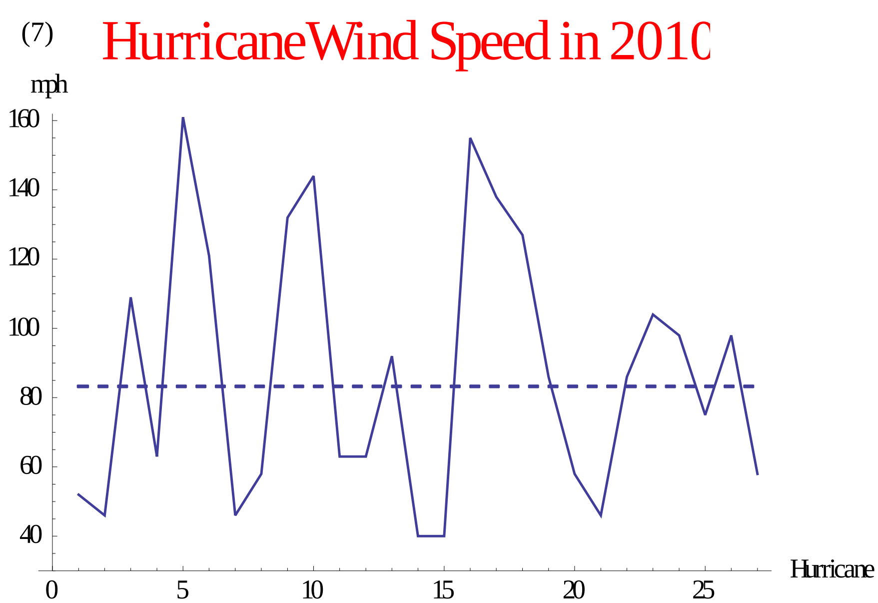
Under the Scope: 2010

Hurricane Information in 2010

Hurricanes	Ocean	Wind Speed (mph)	Category	Duration (days)	Month
(1) Invest	Atlantic	52	T.S.	5	March
(2) Agatha	Pacific	46	T.S.	2	May
(3) Alex	Atlantic	109	2	7	June
(4) Blas	Pacific	63	T.S.	8	June
(5) Celia	Pacific	161	5	12	June
(6) Darby	Pacific	121	3	9	June
(7) Bonnie	Atlantic	46	T.S.	4	July
(8) Colin	Atlantic	58	T.S.	6	August

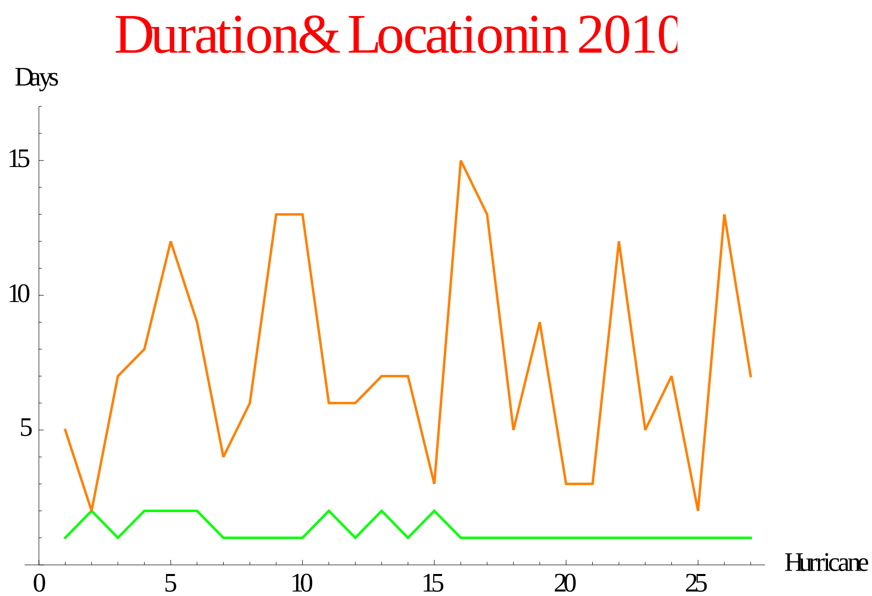
(9) Danielle	Atlantic	132	4	13	August
(10) Earl	Atlantic	144	4	13	August
(11) Estelle	Pacific	63	T.S.	6	August
(12) Fiona	Atlantic	63	T.S.	6	August
(13) Frank	Pacific	92	1	7	August
(14) Gaston	Atlantic	40	T.S.	7	September
(15) Georgette	Pacific	40	T.S.	3	September
(16) Igor	Atlantic	155	4	15	September
(17) Julia	Atlantic	138	4	13	September
(18) Karl	Atlantic	127	3	5	September
(19) Lisa	Atlantic	86	1	9	September
(20) Matthew	Atlantic	58	T.S.	3	September
(21) Nicole	Atlantic	46	T.S.	3	September
(22) Otto	Atlantic	86	1	12	October
(23) Paula	Atlantic	104	2	5	October
(24) Richard	Atlantic	98	2	7	October
(25) Shary	Atlantic	75	1	2	October
(26) Tomas	Atlantic	98	2	13	October
(27) Omeka	Atlantic	58	T.S.	7	December
		88.73		7.58	

(7)



Hurricane season began early in 2010 (March) and, we cannot help but notice, ended later than usual (December). The wind speed increase 31% and the duration increased by 19% from 2000 to 2010. Noticeably, most of the 27 hurricanes occurred in the Atlantic, 74% of the hurricanes to be specific. More landfalls in the Atlantic goes in accordance to the paths taken by Central Pacific-El Nino. When we look at which hurricanes have impacted the most by containing stronger wind speeds, hurricanes in the Atlantic, with the exception of Hurricane Celia with 161 mph winds in the Pacific, all have

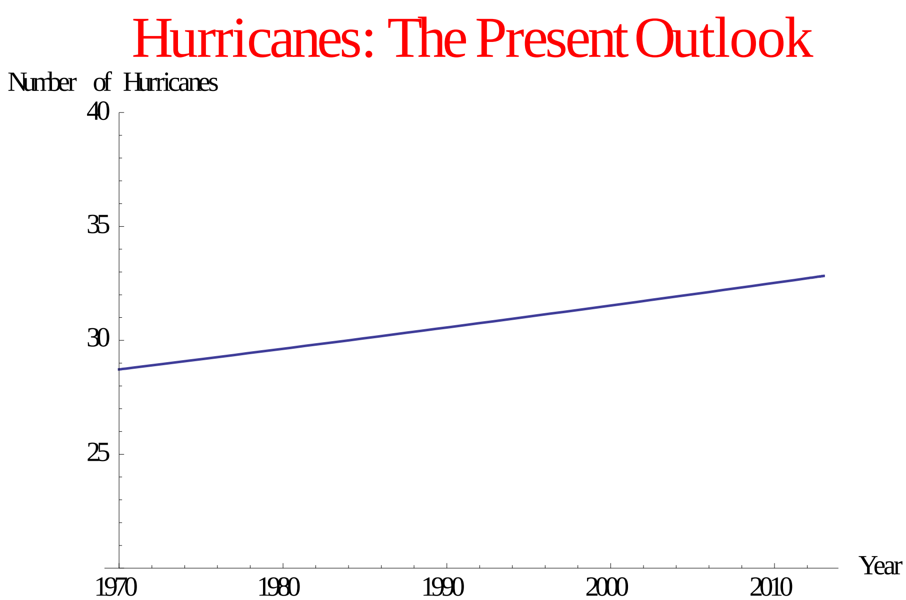
(8)



occurred in the Atlantic. Now looking into the duration in Graph (8), we keep seeing the same pattern: with stronger wind speeds, longer duration for the hurricane.

Discussion

How does all of this information get us closer to finding a model to express the necessity to find a way to prevent future damage? *A Wall for Lives* is a project that aims to prevent the increasing victims whose lives are devastated by hurricanes. Throughout each year, "durations [of hurricanes] have increased by about 60% since 1949, and average peak storm wind speeds have increased about 50% since the 1970s" (USA Today, 2011). As seen in the graph on the left, our data shows the rapidly increase in the number of hurricanes we have witnessed. From 1980 to 2010, the number of hurricanes has increased by 38%. Ending countless lives in its path, there is a silent important call for a project such as this as we see the ongoing climate change bring forth a rising sea level. We started to realize that, in order to find useful resources in an effort to decrease devastation, we had to understand the causes and effects of these cyclones.



With our model, we needed to assume that hurricanes do take their usual paths as depicted in El Nino and La Nina, as temperature levels and ground levels are the typical simplifying assumptions when analyzing hurricanes. With this analysis into how El Nino and La Nina can affect hurricane formation and impact, we can look into way in which we can predict future disaster possibilities. By showing this, we conclude that a barrier, as we have discussed, would be essential to prevent the future hurricanes and their powerful winds and long duration. As can be seen through the number of simplifying assumptions, mathematical model for the financials of the wall is not very accurate. Unfortunately, a more accurate model would require building a part of the wall, to see how best to proportion it. Because of our limitations as college students, this was impossible, however, we hope to show people who have the means that it can, and should, be done. Perhaps they will be able to more accurately produce a model, then the actual wall, that will save the lives of many people.

Conclusion

A Wall for Lives is a project that aims to prevent the increasing victims whose lives are devastated by hurricanes. Ending countless lives in its path, there is a silent important call for a project such as this as we see the ongoing climate change bring forth a rising sea level. While this project only shows preliminary research, it brings to light the fact that there is most definitely the need, as well as the capability, for such a wall.

Appendix A: Image Reference

Generated by Wolfram Alpha, the two following charts show the temperatures in the year 1990 and 2000. When strange occurrences in hurricane patterns take place, it is at times essential to look into the factors that could have caused this anomaly.

Chart (1)

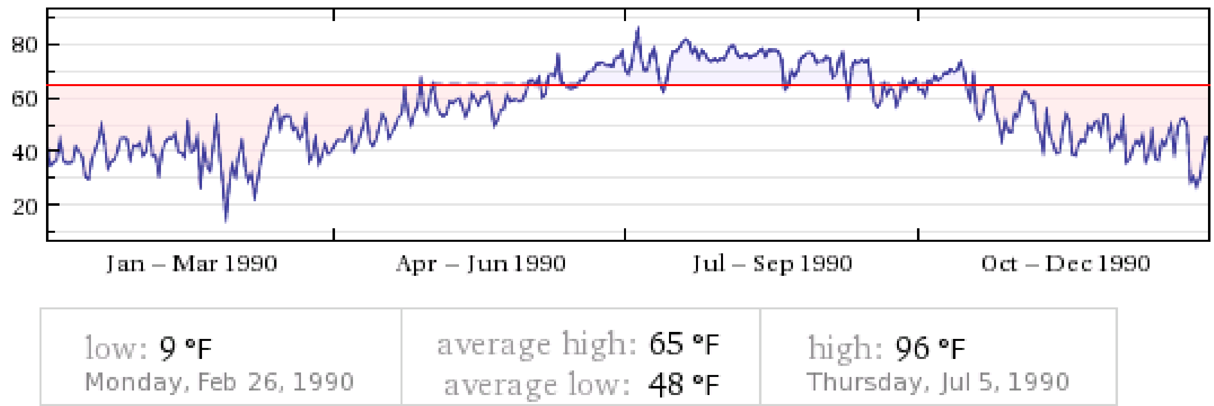
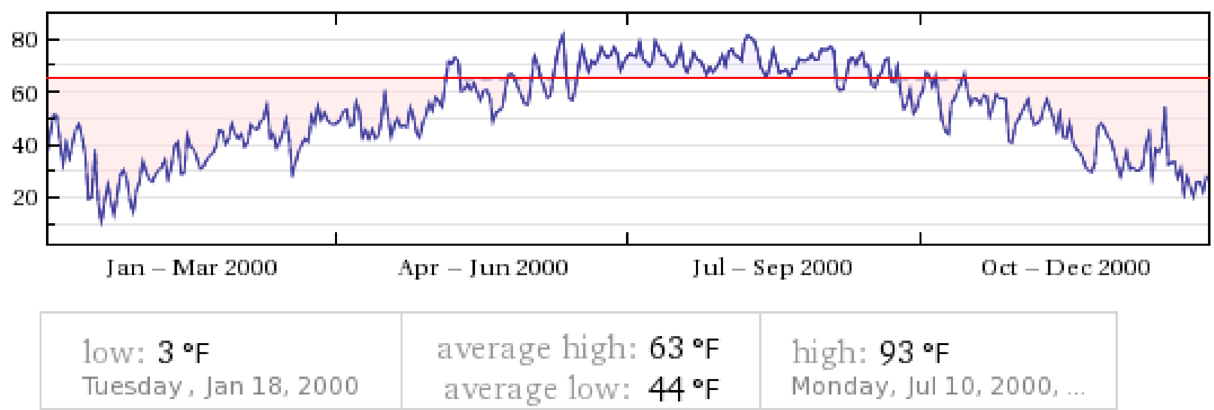


Chart (2)



Appendix B: *Mathematica* Coding

The following is the coding we inputted into Mathematica.

```
Hurricane Speeds in 1980;
c = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,
   19, 20, 21, 22, 23, 24, 25, 26, 27, 28};
d = {115, 58, 75, 190, 52, 40, 46, 75, 98, 81, 98, 92, 115, 58, 75,
   115, 81, 69, 132, 40, 52, 40, 104, 98, 86, 80};
HS1980 = ListLinePlot[Table[{c[[n]], d[[n]]}, {n, 1, 26}],
   PlotRange -> {30, 200},
   PlotLabel -> Style["Hurricane Wind Speed in 1980", Red, 20],
   AxesLabel -> {Hurricane, mph}];
AHS1980 = Plot[83.27 x^0, {x, 1, 26}, PlotStyle -> {Dashed}];
Show[HS1980, AHS1980, PlotRange -> {30, 200}]
```

```
Ocean Affected by Hurricane in 1980;
e = {2, 2, 2, 1, 2, 2, 2, 2, 1, 1, 2, 2, 2, 1, 1, 1, 1, 1, 2, 2, 2, 2,
    1, 1, 1, 1};
O1980 = ListLinePlot[Table[{c[[n]], e[[n]]}, {n, 1, 26}],
  PlotRange -> {0, 3}, PlotStyle -> Green,
  PlotLabel -> Style["Ocean Affected by Hurricanes in 1980", Red, 20],
   AxesLabel -> {Hurricane, Ocean}];
Duration of Hurricanes in 1980;
f = {7, 3, 5, 11, 3, 1, 4, 4, 6, 5, 7, 6, 6, 3, 7, 15, 8, 6, 14, 3, 1,
    1, 11, 9, 3, 9};
D1980 = ListLinePlot[Table[{c[[n]], f[[n]]}, {n, 1, 26}],
  PlotRange -> {0, 20}, PlotStyle -> Orange,
  PlotLabel -> Style["Duration of Hurricanes in 1980", Red, 20],
  AxesLabel -> {Hurricane, Days}];
```

```
Show[O1980,D1980,PlotRange→{0,16},PlotLabel→Style["Duration & Location in 1980",Red,20],AxesLabel→{Hurricane,Days}]
Hurricane Speeds in 1990;
g = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,
   19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35,
    36};
h = {86, 69, 81, 92, 63, 63, 81, 86, 104, 155, 121, 52, 98, 46, 40,
   121, 63, 115, 86, 75, 40, 98, 86, 138, 81, 144, 75, 63, 81, 75, 63,
    86, 69, 155, 98, 161};
HS1990 = ListLinePlot[Table[{g[[n]], h[[n]]}, {n, 1, 36}],
   PlotRange -> {30, 180},
   PlotLabel -> Style["Hurricane Wind Speed in 1990", Red, 20],
   AxesLabel -> {Hurricane, mph}];
AHS1990 = Plot[89.17 x^0, {x, 1, 36}, PlotStyle -> {Dashed}];
Show[HS1990, AHS1990, PlotRange -> {30, 180}]
Ocean Affected by Hurricane in 1990;
i = {2, 1, 1, 2, 2, 2, 2, 2, 2, 2, 2, 1, 1, 1, 1, 1, 1, 2, 2, 2, 2, 1,
    1, 2, 2, 2, 2, 2, 1, 1, 1, 1, 2, 2, 2, 1};
O1990 = ListLinePlot[Table[{g[[n]], i[[n]]}, {n, 1, 36}],
  PlotRange -> {0, 3}, PlotStyle -> Green,
  PlotLabel -> Style["Ocean Affected by Hurricanes in 1990", Red, 20],
   AxesLabel -> {Hurricane, Ocean}];
Duration of Hurricanes in 1990;
j = {6, 5, 9, 6, 8, 5, 6, 7, 9, 12, 10, 8, 6, 11, 3, 10, 6, 8, 9, 9,
   9, 14, 15, 14, 10, 9, 3, 6, 6, 9, 4, 6, 6, 17, 10, 21};
D1990 = ListLinePlot[Table[{g[[n]], j[[n]]}, {n, 1, 36}],
  PlotRange -> {0, 23}, PlotStyle -> Orange,
  PlotLabel -> Style["Duration of Hurricanes in 1990", Red, 20],
  AxesLabel -> {Hurricane, Days}];
Show[O1990, D1990, PlotRange -> {0, 23},
```

```
 PlotLabel -> Style["Duration & Location in 1990", Red, 20],
 AxesLabel -> {Hurricane, Days}]
```

```
Hurricane Speeds in 2000;
k = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,
   19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33};
l = {40, 40, 80, 40, 80, 40, 40, 40, 80, 127, 52, 40, 86, 80, 40, 69,
   40, 40, 81, 81, 69, 138, 92, 138, 98, 40, 52, 69, 98, 58, 63, 46,
   63};
HS2000 = ListLinePlot[Table[{k[[n]], l[[n]]}, {n, 1, 33}],
   PlotRange -> {30, 140},
   PlotLabel -> Style["Hurricane Wind Speed in 2000", Red, 20],
   AxesLabel -> {Hurricane, mph}];
AHS2000 = Plot[69.88 x^0, {x, 1, 33}, PlotStyle -> {Dashed}];
Show[HS2000, AHS2000, PlotRange -> {30, 140}]
```

```
Ocean Affected by Hurricane in 2000;
m = {2, 2, 2, 2, 2, 2, 2, 2, 2, 1, 1, 1, 1, 2, 2, 2, 2, 1, 1, 1, 1, 1,
    1, 1, 2, 2, 2, 1, 1, 1, 2, 2, 2};
O2000 = ListLinePlot[Table[{k[[n]], m[[n]]}, {n, 1, 33}],
  PlotRange -> {0, 3}, PlotStyle -> Green,
  PlotLabel -> Style["Ocean Affected by Hurricanes in 2000", Red, 20],
   AxesLabel -> {Hurricane, Ocean}];
Duration of Hurricanes in 2000;
o = {7, 6, 8, 4, 14, 6, 5, 6, 7, 22, 2, 2, 5, 7, 4, 4, 3, 2, 7, 7, 10,
    13, 7, 8, 9, 2, 3, 6, 5, 3, 8, 4, 5};
D2000 = ListLinePlot[Table[{k[[n]], o[[n]]}, {n, 1, 33}],
  PlotRange -> {0, 23}, PlotStyle -> Orange,
  PlotLabel -> Style["Duration of Hurricanes in 2000", Red, 20],
  AxesLabel -> {Hurricane, Days}];
```

```
Show[O2000, D2000, PlotRange -> {0, 23},
 PlotLabel -> Style["Duration & Location in 2000", Red, 20],
 AxesLabel -> {Hurricane, Days}]
```

```
Hurricane Speeds in 2010;
p = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,
   19, 20, 21, 22, 23, 24, 25, 26, 27};
q = {52, 46, 109, 63, 161, 121, 46, 58, 132, 144, 63, 63, 92, 40, 40,
   155, 138, 127, 86, 58, 46, 86, 104, 98, 75, 98, 58};
HS2010 = ListLinePlot[Table[{p[[n]], q[[n]]}, {n, 1, 27}],
   PlotRange -> {30, 162},
   PlotLabel -> Style["Hurricane Wind Speed in 2010", Red, 20],
   AxesLabel -> {Hurricane, mph}];
AHS2010 = Plot[83.27 x^0, {x, 1, 27}, PlotStyle -> {Dashed}];
Show[HS2010, AHS2010, PlotRange -> {30, 162}]
Ocean Affected by Hurricane in 2010;
r = {1, 2, 1, 2, 2, 2, 1, 1, 1, 1, 2, 1, 2, 1, 2, 1, 1, 1, 1, 1, 1, 1,
    1, 1, 1, 1, 1};
O2010 = ListLinePlot[Table[{p[[n]], r[[n]]}, {n, 1, 27}],
  PlotRange -> {0, 3}, PlotStyle -> Green,
  PlotLabel -> Style["Ocean Affected by Hurricanes in 2010", Red, 20],
   AxesLabel -> {Hurricane, Ocean}];
Duration of Hurricanes in 2010;
s = {5, 2, 7, 8, 12, 9, 4, 6, 13, 13, 6, 6, 7, 7, 3, 15, 13, 5, 9, 3,
   3, 12, 5, 7, 2, 13, 7};
D2010 = ListLinePlot[Table[{p[[n]], s[[n]]}, {n, 1, 27}],
  PlotRange -> {0, 17}, PlotStyle -> Orange,
  PlotLabel -> Style["Duration of Hurricanes in 2010", Red, 20],
  AxesLabel -> {Hurricane, Days}];
```

```
Show[O2010, D2010, PlotRange -> {0, 17},
 PlotLabel -> Style["Duration & Location in 2010", Red, 20],
 AxesLabel -> {Hurricane, Days}]
```

```
Number of Hurricanes from 1980 to 2012;
a = {1980, 1990, 2000, 2010, 2012};
b = {26, 36, 33, 27, 36};
Amount = Table[{a[[n]], b[[n]]}, {n, 1, 5}];
FindFit[Amount, r*k^i, {r, k}, {i}]
AmountCurve = {0.0633265*1.00311^i};
Plot[AmountCurve, {i, 1970, 2013}, PlotRange -> {20, 40},
 PlotLabel -> Style["Hurricanes : The Present Outlook ", Red, 20],
 AxesLabel -> {Year, "Number of Hurricanes"}]
```

Appendix C: Definitions

Dam – "structure built across a stream, river, or estuary to retain water. Dams are built to provide water for human consumption, for irrigating arid and semiarid lands, or for use in industrial processes. They are used to increase the amount of water available for generating hydroelectric power, to reduce peak discharge of floodwater created by large storms or heavy snowmelt, and to increase the depth of water in a river in order to improve navigation and allow barges and ships to travel more easily." (Encyclopedia Britannica)

Dike – "a long wall or embankment built to prevent flooding from the sea." (Oxford Dictionary)

Floodgate – "gate for shutting out or releasing the flow of water over spillways, in connection with the operation of a dam" (Encyclopedia Britannica)

Gate – see *Floodgates*

Levee – "any low ridge or earthen embankment built along the edges of a stream or river channel to prevent flooding of the adjacent land. Artificial levees are typically needed to control the flow of rivers meandering through broad, flat floodplains. Levees are usually embankments of dirt built wide enough so that they will not collapse or be eroded when saturated with moisture from rivers running at unusually high levels. Grass or some other matlike vegetation is planted on the top of the levee's bank so that its erosion will be kept to a minimum." (Encyclopedia Britannica)

Lock – "enclosure or basin located in the course of a canal or a river (or in the vicinity of a dock) with gates at each end, within which the water level may be varied to raise or lower boats. Where the required lift is of considerable height, a series of connected but isolable basins, or locks, is used." (Encyclopedia Britannica)

Sluice – "a sliding gate or other device for controlling the flow of water, especially one in a lock gate" (Oxford Dictionary)

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