GLOBAL WARMING &

TROPICAL CYCLONE IMPACT

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DSO 110 FINAL REPORT

PROJECT BACKGROUND

OVER THE LAST TWENTY YEARS THERE SEEMS TO BE A TREND OF SOME OF THE WORSE TROPICAL CYCLONES IN HISTORY.

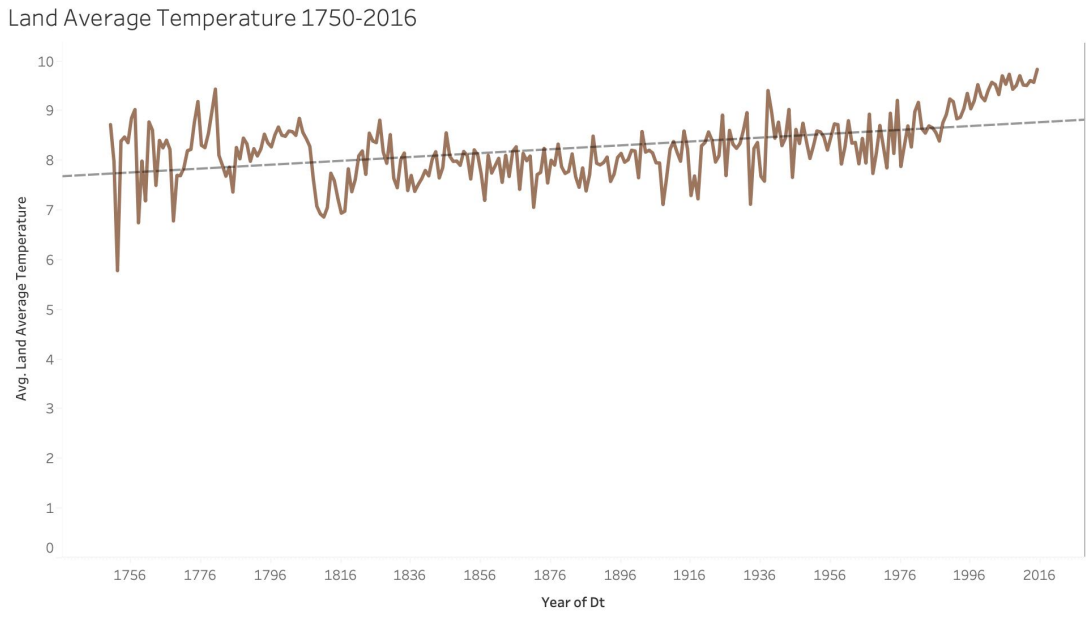
Is this a cause of global warming, is global warming even a real thing? If there is in fact global warming occurring is it having an effect on Tropical Cyclones? We will be looking at data collected on the temperature of the earth and the ocean. We will be looking at Tropical Cyclones in the Atlantic and Pacific Ocean, we will also be looking at sea level rise and human populations of the earth. The goal of this project is to see if there are any correlations to the temperatures of the earth and Tropical Cyclone impacts.

Tropical Cyclones are the scientific name for a rotating system of clouds and thunderstorms that form over tropical or subtropical waters. Cyclones gain their strength from the warm waters that they travel over. The lower the pressure of the system the stronger the storm. Tropical Cyclones, cause huge floods from storm surges, heavy rains, and wind speeds over 200mph. Tropical Cyclones, Typhoons, and Hurricanes are the exact same type of storm the only difference is where they are located in the world. These storms are the most devastating natural disasters in the world causing hundreds of billions of dollars globally every year.

There are four classifications of Tropical Cyclones, first is a Tropical Disturbance, which is a low pressure column with rotating storm clouds. A Tropical Depression, where wind speeds are between 25mph and 38mph, a Tropical Storm is when wind speeds are between 39mph-74mph, and a Typhoon or Hurricane is any Tropical Cyclone above 75mph. Traditionally scientists have used the storms minimum pressure and maximum wind speed as a gauge of the cyclones strength. We will be looking at these parameters to see if there is an increase over time, and any relation to the earths temperature.

IS THE EARTH WARMING?

For this question we will be looking at two different visuals and data sets. The first data set we will be looking at comes from Berkley Earth and is a collection of temperatures around the world. This is an Average Land Temperature across the globe from all countries and cities that were reporting from 1750-2016. As you can see there is a definite trend upwards especially when looking at 1996-2016. The Y axis is measured in celsius.



The trend of average of Land Average Temperature for Dt Year.

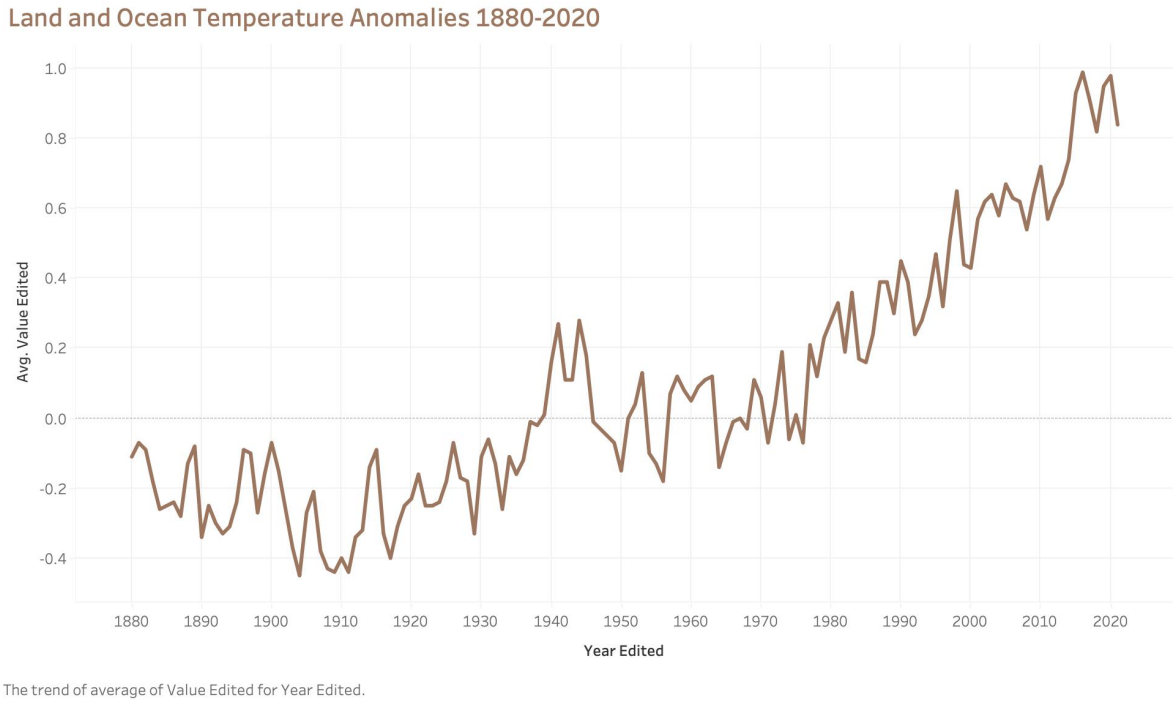
Technical Description of this Visual

Data Source: Berkley Earth, Average Land Temperature 1750-2016

Wrangling: none, this data was pretty easy to work with.

Program: Tableau, I did not need to filter or add anything to this data other than a trend line. I used the year as my X axis and and the Land Average temperature as my Y axis.

The next visual that we will be looking at is a land and ocean anomalies graph. This data is from NOAA (NCEI). This data is showing a timeline from 1880-2021, this is the difference in temperature compared to a baseline temperature, which is a standardized set from a data collection, of strict quality controlled sites. Anomalies are a better way to see climate trends than an average of absolutes, because of elevation and recording station differences. As you can see there is a drastic upward trend in the temperature of the earth.



Technical Description of this Visual

Data Source: NOAA (NCEI) , Land and Ocean Anomalies, 1880-2021

Wrangling: Excel, I had to adjust year and readings, to be easier handled in Tableau. I did this by making new columns and rows within the data frame.

Program: Tableau, I did not need to filter or add anything to this data other than a trend line since I did my data wrangling in Excel. I used the year edited as my X axis and and temperature reading as my Y axis.

EARTH WARMING CONCLUSION

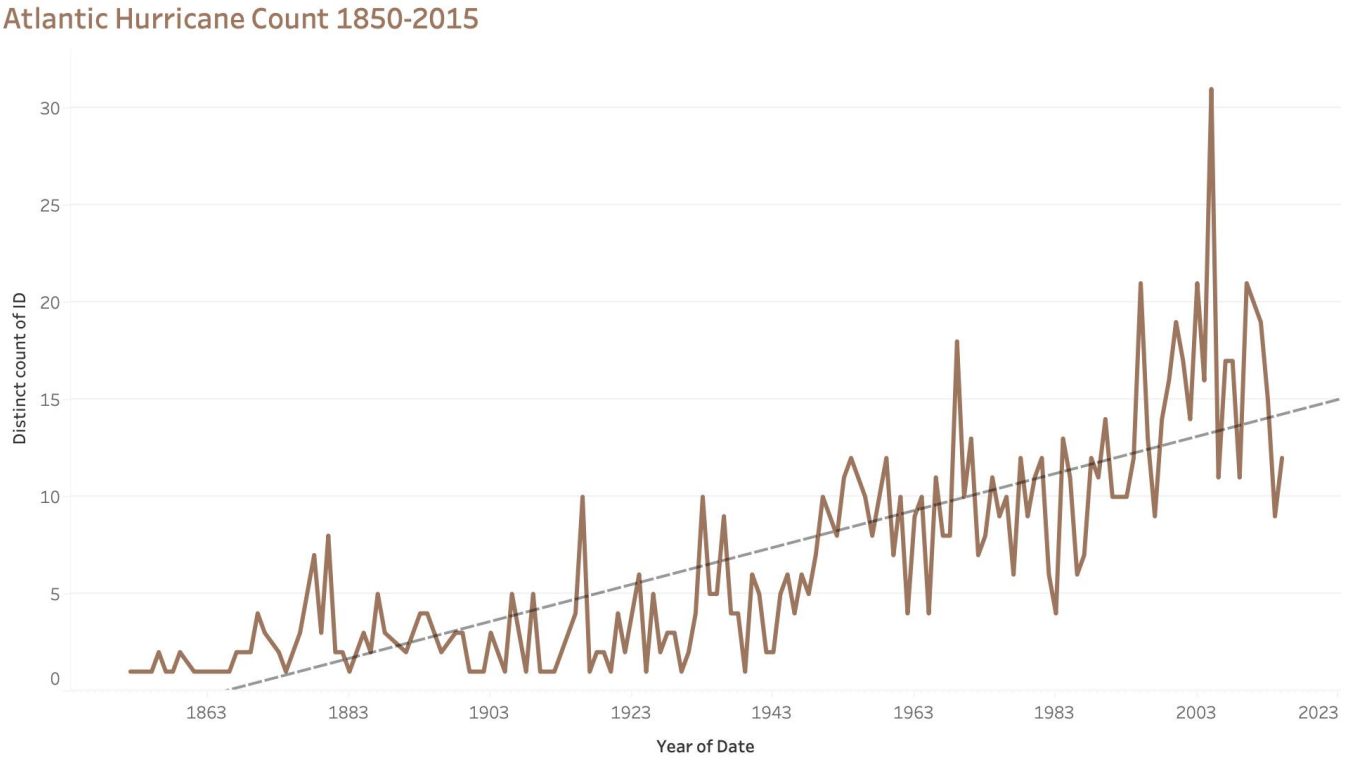
It appears that the earth is in fact getting warmer. In viewing two different sets of data one being an Average Land Temperature of absolutes rising, and the second showing Anomalies of Land and Ocean Temperatures compared to a standardized historical baseline. This is not just a cyclical trend, every year the earth is warmer than the year before and it is continuing to rise. With the earth warming, the Oceans are warming and as we know warm ocean water is a contributing factor to the strength of Tropical Cyclones.

IS THE EARTH WARMING EFFECTING TROPICAL CYCLONES ?

To see if the earth warming has had an impact on Tropical Cyclones we will be looking at NOAA HURDAT, data set, this data set has all recorded Tropical Cyclones in the Atlantic and Pacific Ocean, from 1851-2015. The Pacific Oceans data is starting from 1950-2015, initially we will be looking at the frequency of storm count, minimum pressure, and Maximum wind to see if there is any correlation to the earth warming. A couple of notes to make about the data before we get into the visuals is that we are looking at all Tropical Cyclones, this means that there is Tropical Depressions, Tropical, Storms, and Hurricanes/Typhoons. Another factor is in reporting, in the 1800s and early 1900s the only way a lot of the storms were reported was by seafarers, or if they hit or came close to land. With the advancement in Technologies we can now see every storm and formation.

The first visual that we will be looking at is Tropical Cyclone Count for the Atlantic, to do this we used Storm ID as our Y axis and Year as our X Axis. These are all the storms that occurred in the Atlantic Ocean from 1850-2015. As you can see there is a definite upward trend here. Now remember these are all Tropical Cyclones of all magnitudes and

classifications from 1850-2015, advance tracking technologies have been able to track, the storms better, but even still the fact is the last fifty years there has been a major increase in storm count. You can kind of see a pattern in the hundred years from 1850-1940s, then we get a jump and increase.

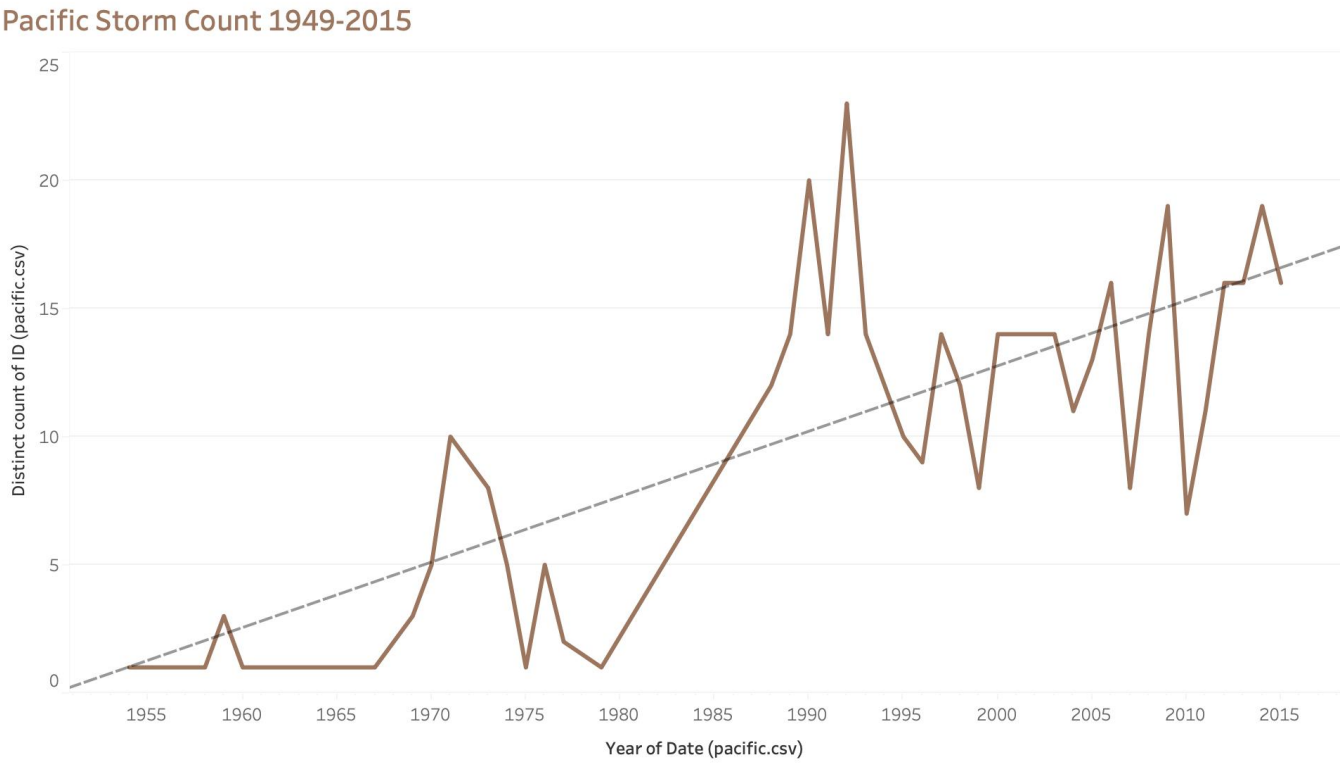


The trend of distinct count of ID for Date Year.

Technical Description of this Visual

Data Source: NOAA, HURDAT Atlantic and Pacific Ocean Tropical Cyclone Data 1850-2015
Wrangling: PYTHON, initial data research was done, Code will be attached at the end. Also merged Atlantic and Pacific data frames in Python for analysis.
Visual Program: Tableau, I added in this program, I used Distinct Storm ID as my Y axis, and year as my X axis.

The next visual is under the same parameters as the Atlantic Hurricane Count but instead of reporting from 1850s, the data set starts in the 1950s and goes to 2015. As you can see there is a very similar trend here. The count is increasing over this time period. So both in the Pacific and in the Atlantic we are seeing a similar trend of increasing Tropical Storm Counts.

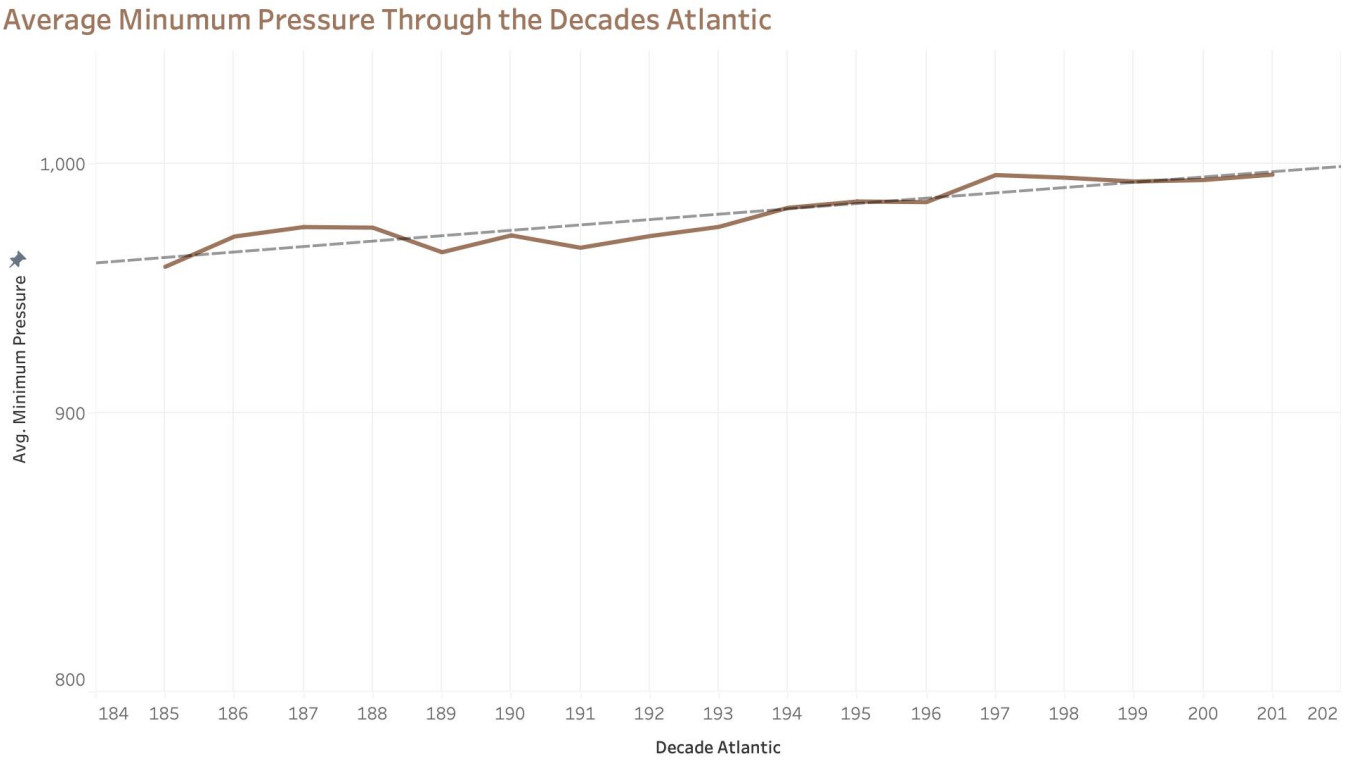


The trend of distinct count of ID (pacific.csv) for Date (pacific.csv) Year.

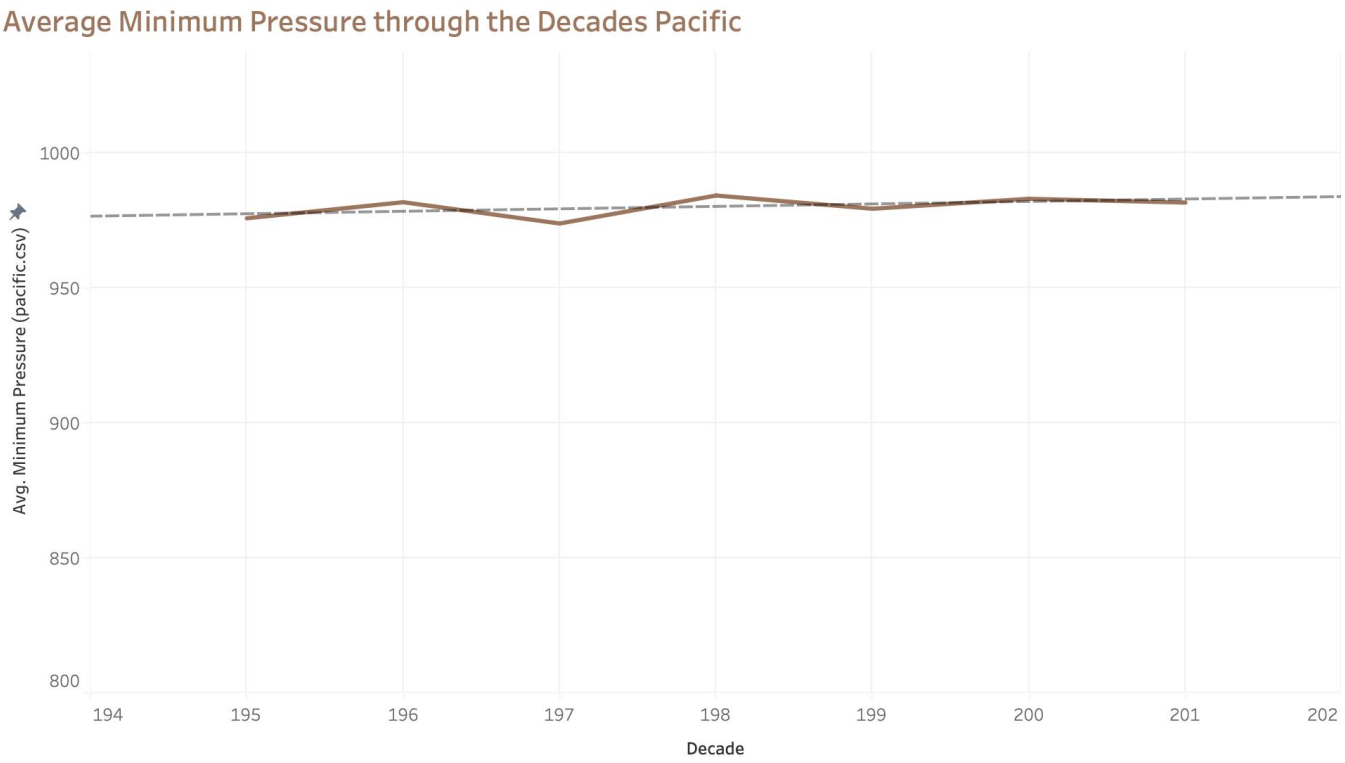
Technical Description of this Visual

Data Source: NOAA, HURDAT Atlantic and Pacific Ocean Tropical Cyclone Data 1850-2015
Wrangling: PYTHON, initial data research was done, Code will be attached at the end. Also merged Atlantic and Pacific data frames in Python for analysis.
Visual Program: Tableau, I added a trend line in this program, I used Distinct Storm ID as my Y axis, and year as my X axis.

Next we are going to look at what meteorologists look for in the strength of the storm and that is the minimum pressure, the lower the minimum pressure the stronger the storm. This data is also coming from NOAAs HURDAT data set. Looking at the Pacific and Atlantic by Decades we can actually see there is not a real big change. In fact the slight trend that you see in the Atlantic increasing is actually an indication that the storms are weaker. One thing to note is that, this average may be higher because of total storm count being high and some storms never making it to Hurricane status. The pacific has a much more liner trend indicating that there is not much difference in the strength of storms now than 50 to 100 years ago.



The trend of average of Minimum Pressure for Decade Atlantic . The view is filtered on average of Minimum Pressure, which ranges from 957.50 to 995.52.



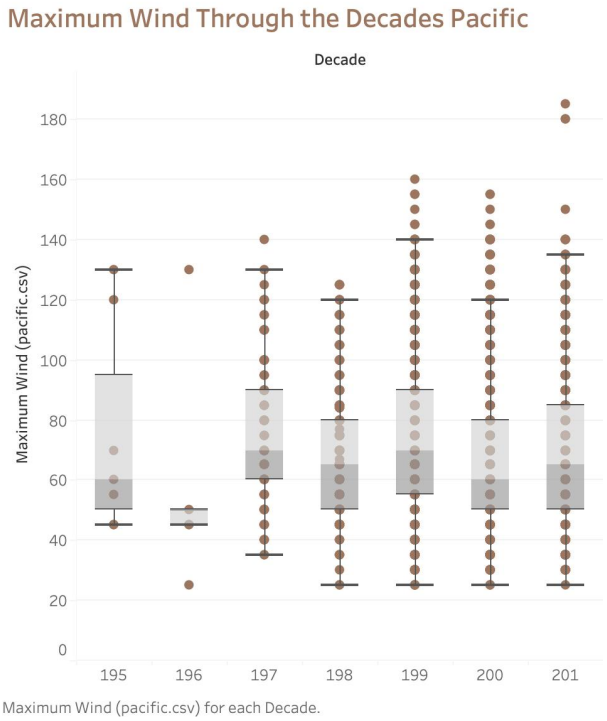
The trend of average of Minimum Pressure (pacific.csv) for Decade. The data is filtered on average of Minimum Pressure, which ranges from -999 to 0 and keeps Null values.

Technical Description of this Visual

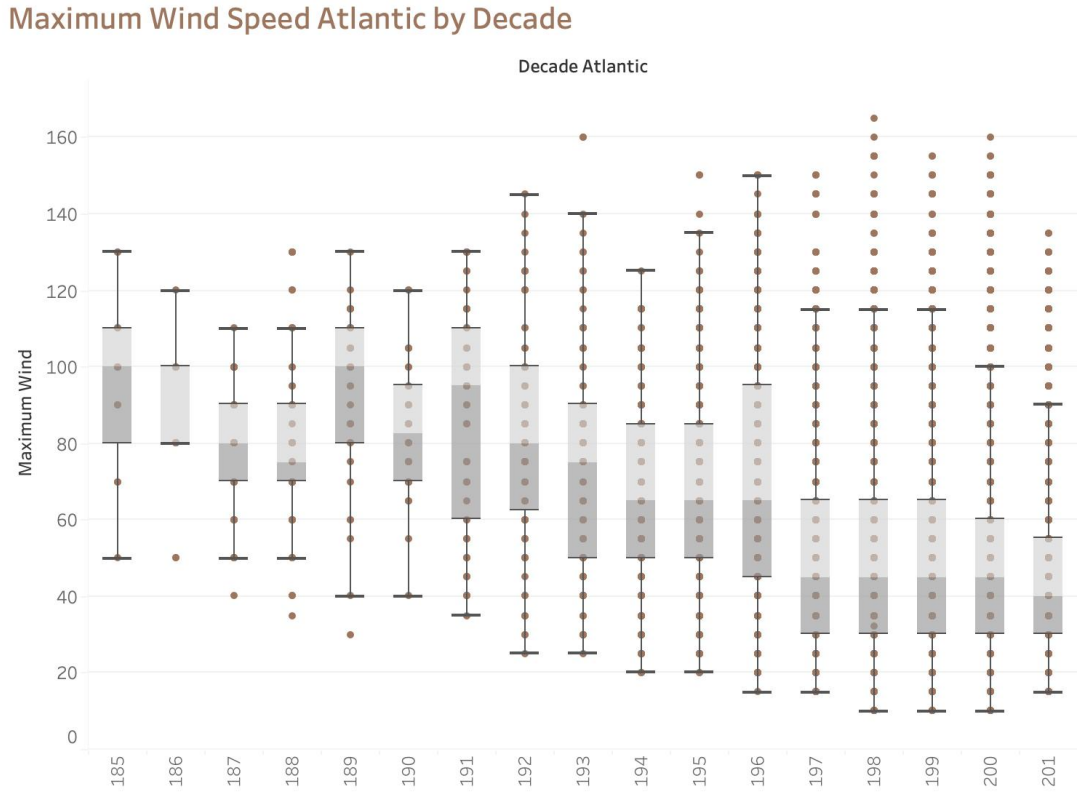
Data Source: NOAA, HURDAT Atlantic and Pacific Ocean Tropical Cyclone Data 1850-2015
Wrangling: PYTHON, initial data research was done, Code will be attached at the end. Also merged Atlantic and Pacific data frames in Python for analysis.
Visual Program: Tableau, I filtered my Y axis to show a better changes, I also filtered out NA values, I created a calculated field for decade to be used for both Atlantic and Pacific.

Now we will be looking at Maximum Wind Speed this is another way to see if there is a an increase in Tropical Storm severity over time. This data also comes from NOAA HURDAT, data sets. We are looking at Maximum Windspeed which is defined as sustained wind speed for at least one minuet. Now remember a Hurricane is defined as having a windspeed of over 74mph. The measurement in this data set is done in knots, and 1 knot is equal to 1.15078mph. The boxplots graphs of both the Atlantic and Pacific are showing

a median of the averaged windspeed. As you can see there is an actual trend downward of the median max wind speed. This may have to do with the higher number of storms, now bringing the median down. Still though there is not a lot of evidence to show the average getting stronger. The Pacific has a more linear trend, but it is not increasing. I think one thing to point out is their outliers there is an increase in some very strong wind storms.



Maximum Wind (pacific.csv) for each Decade.



Maximum Wind for each Decade Atlantic .

Technical Description of this Visual

Data Source: NOAA, HURDAT Atlantic and Pacific Ocean Tropical Cyclone Data 1850-2015
Wrangling: PYTHON, initial data research was done, Code will be attached at the end. Also merged Atlantic and Pacific data frames in Python for analysis.
Visual Program: Tableau, I created a calculated field for decade to be used for both Atlantic and Pacific, I used Decade as my X axis and Max Wind Speed as my Y axis.

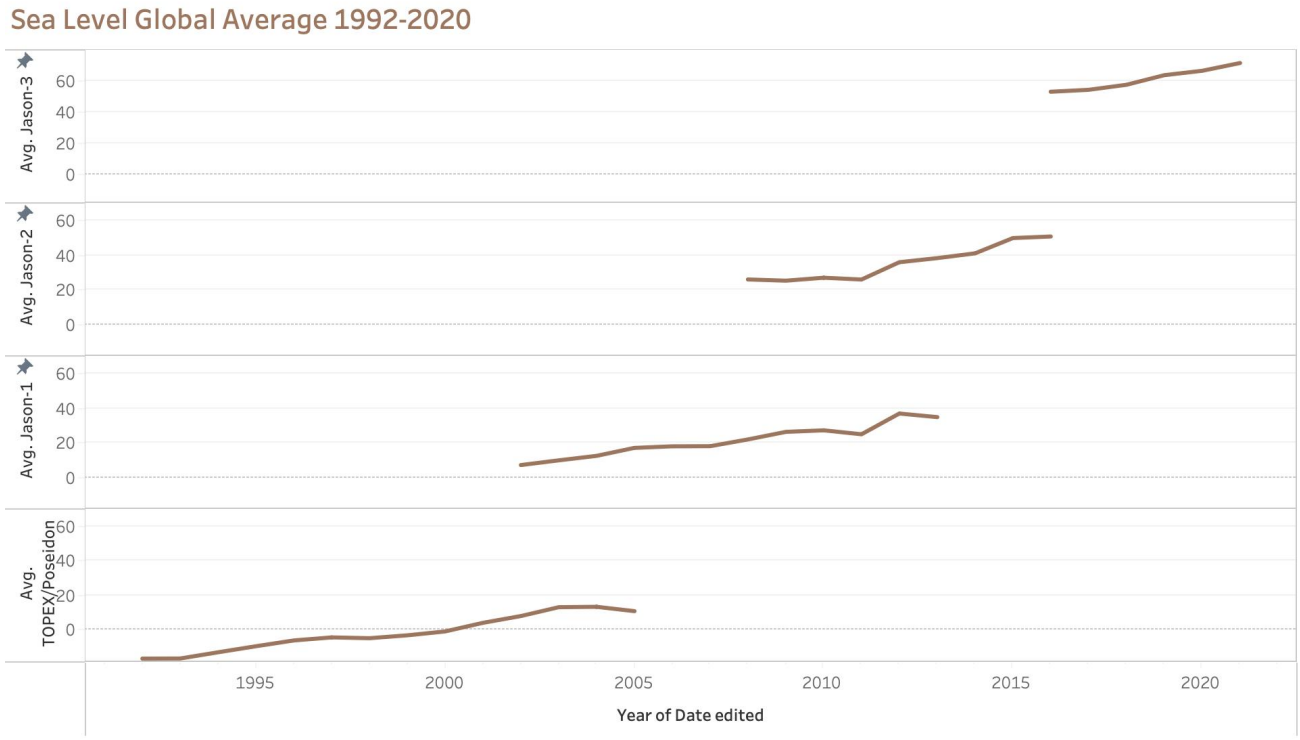
WHAT IS THE DATA SAYING SO FAR ?

There is a definite increase in the number of storms increasing over time. But overall there is not enough statistical evidence to show that they are stronger, in minimum pressure and in max wind speed. There are some very strong storms and they are having some huge winds, but to say there is a significant increase in the severity, I do not think we can. The strongest storm on record was Typhoon tip in 1970, based on minimum pressure. If we are looking at strongest winds then Hurricane Patrica with sustained wind of 2015mph. This now brings up the question why does it appear that we are having some of the most costly Tropical Storms in the last twenty years? First we need to see if this is actually true.

We will be using data collected by NOAA, on the cost of Hurricanes in the United States we are only looking at this data because it is the most accurate data I could find. This is data on the cost of Hurricanes in the U.S. this was a lot more reliable data to use. Hurricanes alone have cost the US almost 1 Trillion dollars in damages. Almost a third of the the total damages of hurricanes happened between 3 storms Hurricane Katrina CAT 3 2005 $125 Billion, Harvey, and Irma were a CAT 4 at landfall and cost $240 Billion combined. This is also showing that the strongest storms don't always cost the most damage. On Average a Hurricane that hits land in the U.S. will cost $19Billion in damages. So why are storms more costly now than in the past? Flooding is the main cause of damage in Hurricane, so lets start looking at some data to see if there are any correlations between global warming and flooding from tropical cyclones.

GLOBAL SEA LEVEL RISE

This is data from NOAA Laboratory of Satellite Altimetry, they have used satellites to measure the sea level since 1992, these Altimetry satellites can notice a bump of a nickel on a floor. This is global sea level, measured from 1992-2021 with 4 different satellites. There is some overlap in there reporting but as you can see there is a growth of over 60 mm from 1992 to 2020, that is a little over 3 inches. From 1990-2000 there was a .5-1.5 mm rise a year, and around 2016 till now we are at a 3.-3.5mm per year.



The trends of average of Jason-3, average of Jason-2, average of Jason-1 and average of TOPEX/Poseidon for Date edited Year.

Technical Description of this Visual

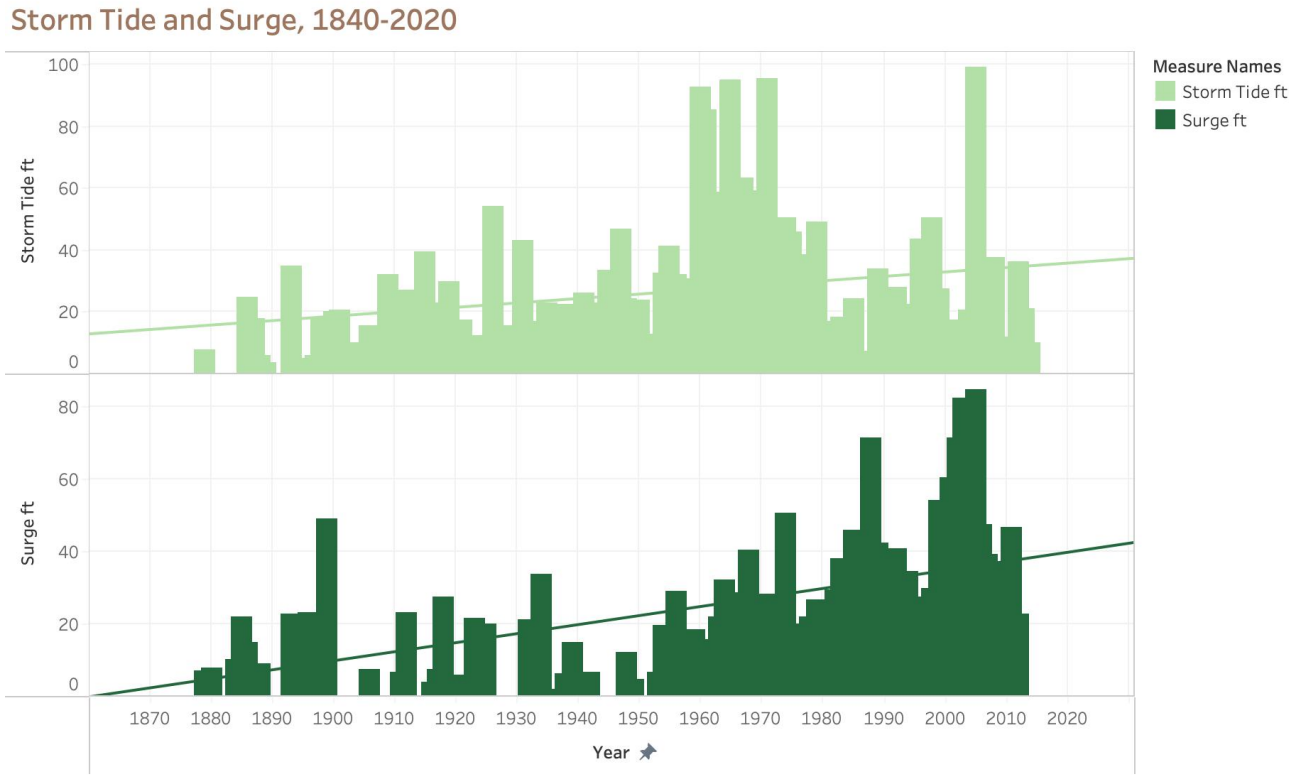
Data Source: NOAA, Laboratory of Satellite Altimetry 1992-2021

Wrangling: Excel, I had to create a new column and do some date editing so tableau could read it better.

Visual Program: Tableau, I filtered the Y-axis so there was some consistency between each of the reporting satellites.

WITH SEA LEVEL RISE WE GET HIGHER STORM SURGES

This next graph is showing Storm Surge, and Storm Tide. This data is coming from Louisiana State University SURGEDAT. This is data that has been collected globally from 1840-2020. This is a global storm surge and storm tide from 1840-2020. Storm surge is water that is brought in from the storm and storm tide is the total of storm surge and normal tide. As you can see there is a an upward trend in the amount of flood waters



Technical Description of this Visual

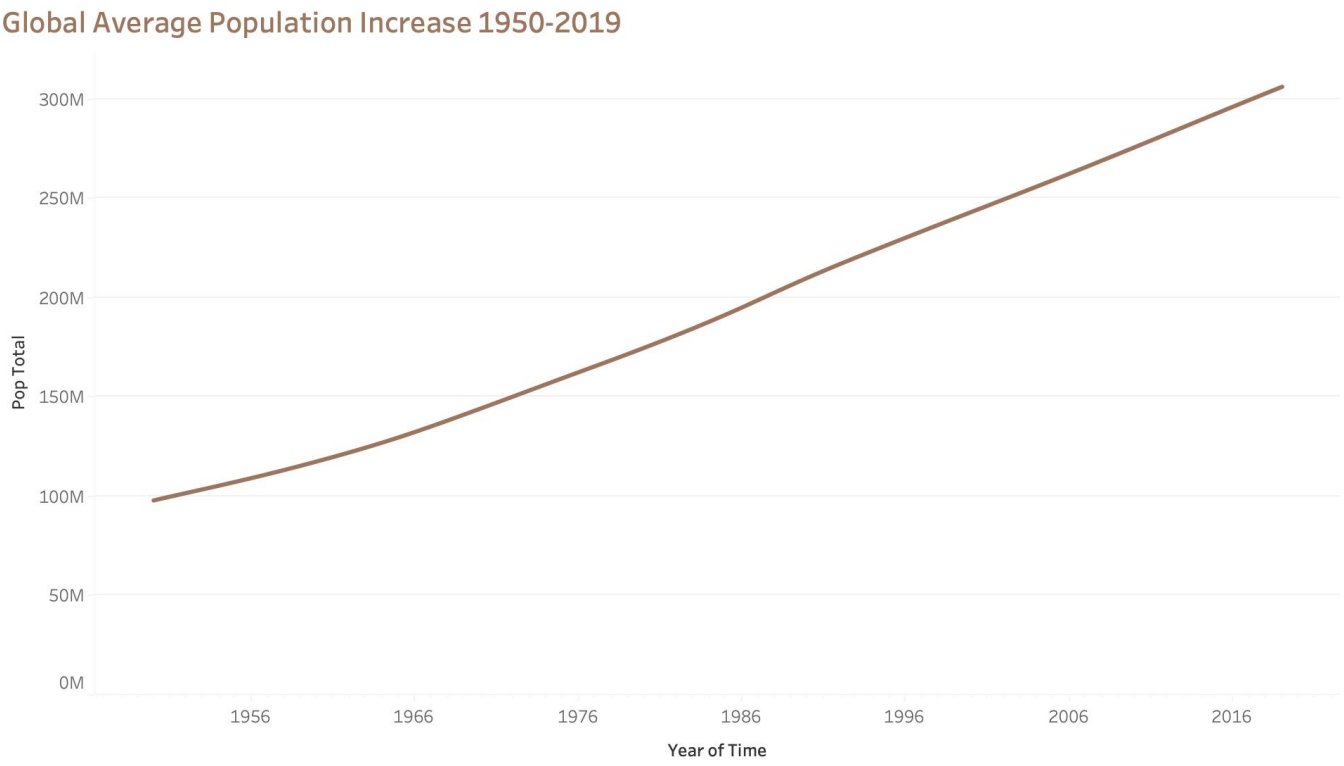
Data Source: SURGEDAT LSU, 1850-2015

Wrangling: None, this data was very easy to use in Tableau.

Visual Program: Tableau, I filtered the year it started at 1740 with a lot of NA values. I used Year as my x axis and sum of storm surge and storm tide, in my y axis.

POPULATION RISE

It's not just the fact that there is sea level increase that is causing the high amounts of damage we need to look at population as part of this equation. This next visual is an Average Global Population, this Is an average of every country In the world from 1950-2019. This data is from the United Nations Population Division, as you can see in this time span the Global Population has tripled.



The trend of sum of Pop Total for Time Year. The view is filtered on Time Year, which ranges from 1950 to 2019.

Technical Description of this Visual

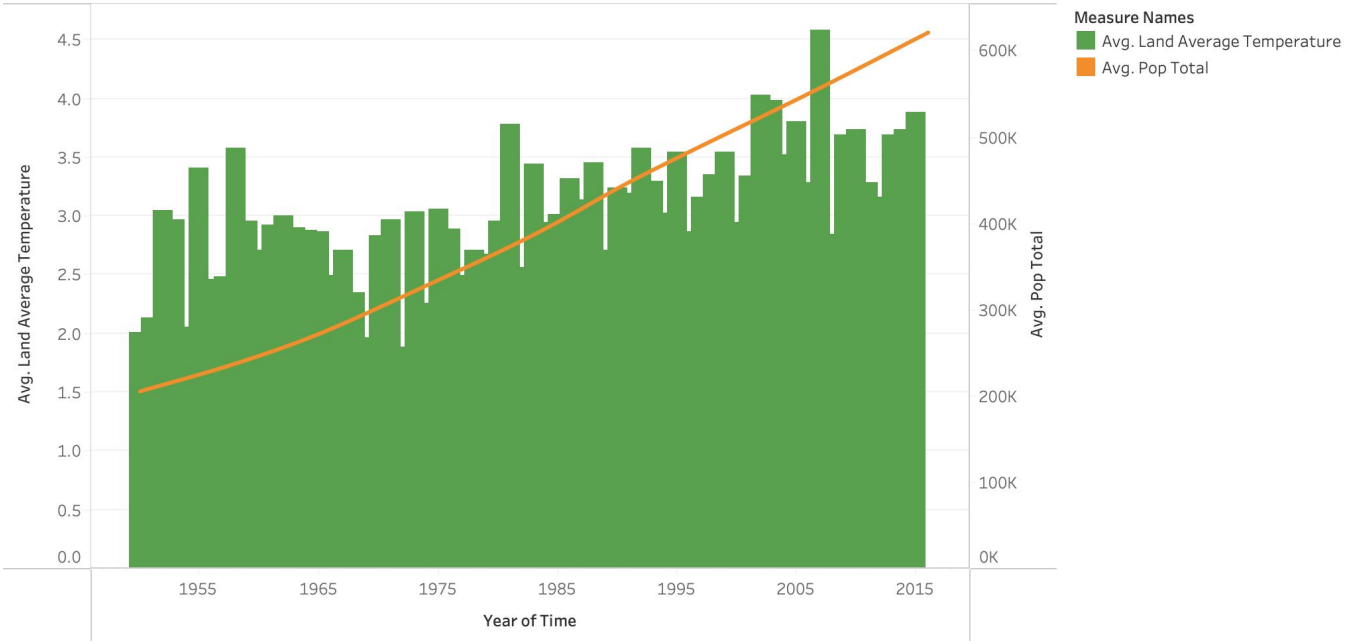
Data Source: United Nations Population Division, 1950-2019

Wrangling: None, this data was very easy to use in Tableau.

Visual Program: Tableau, I used filter on year to make it consistent, and year was x axis and ya xis was the Average of population totals.

This next graph is going to show the increase in Land Average Temperature compared to Global Population increase. This is all from data that we have previously used before, as you can see that as the population is rising there is an increase in temperature. Regardless of the how or why there is a correlation between population increase and the earth warming.

Average Global Temperature, and Average Global Population
1950-2016



The trends of Avg. Land Average Temperature and Avg. Pop Total for Time Year. Color shows details about Avg. Land Average Temperature and Avg. Pop Total. The data is filtered on sum of Pop Total, which ranges from 97,990,304.759 to 1,261,273,498.036. The view is filtered on Time Year and average of Pop Total. The Time Year filter ranges from 1950 to 2016. The average of Pop Total filter ranges from 205,430 to 642,081.

Technical Description of this Visual

Data Source: United Nations Population Division, 1950-2019, Berkley Earth, Average Land Temperature 1750-2016

Wrangling: None, this data was very easy to use in Tableau.

Visual Program: Tableau, year was x axis and y axis was population totals, and Land Average Temperature.

FURTHER CONNECTIONS

Even if the world population is increasing does it mean that they can be effected by Tropical Cyclones? According to the UN, 40% of the Global Population live within 100km of a coast. Rainfall from a Tropical Cyclone can effect a radius of 200km. Census Bureau data shows us that 29% of the U.S. population live within a coastline county, of that population 64% live within a Hurricane effected area. That is a 15% growth since 2000, there are more people and more development along coastal regions, than there ever has been, and this trend is increasing. The trend of people populating costal regions, is leading to higher tropical cyclone damage costs when these extreme flooding and cyclones hit.

CONCLUSION

The earth is warming and sea levels are rising, population is increasing, and populating near coastal regions. Storms don't have to be strong to have large economic impacts, the flooding and storm surges that are produced from sea level rise are causing more damage. Even though statistically there might not be evidence of global warming having a direct impact on Tropical Cyclones, the increase in Tropical Storm numbers and raising sea level is what is causing these heavy economic impacts. That doesn't mean that we are not going to see strong storms in the future according to a report from NOAA, there could be a 1-10% increase in Tropical Cyclone Strength, and a 10-15% increase in rainfall with a effected radius of 100 km. This increases could occur with a global rise in temperature of 1-2 degrees Celsius.

WHERE TO GO FROM HERE

I have really just raised a few more questions than answers but I will be looking into some of these topics to see if any more light can be shed on the matter. These storms are devastating and they occur every year. If population increase is not going to slow down then we need to figure out a way to combat the earth from warming too quickly.

- Looking at carbon emissions
- Looking into Thermal Expansion of Ocean Waters
- Digging deeper into population and coastal region development
- Looking into impacts of COVID and our global temporary break from mass travel
- Is there a way that we can change, that can have a positive effect?

SOURCES

- Global Temperature Data was gathered from Berkley University, Berkley Earth, This data is a collection of data from 1750-2016 (http://berkeleyearth.org/data/)
- Cyclone Data is from NOAA, HURDAT this is a collection of all Tropical Cyclones, in the Atlantic and Pacific Oceans 1851-2015 (https://www.kaggle.com/noaa/hurricane-database?select=pacific.csv)
- Global Storm Surge Data, From SURGEDAT LSU, 1850-2015 (http://surge.climate.lsu.edu/data.html)
- Sea Level Rise Data from NOAA, Laboratory of Satellite Altimetry, 1992-2021 (https://www.star.nesdis.noaa.gov/socd/lsa/SeaLevelRise/LSA_SLR_timeseries.php)
- Population Data from United Nations, Population Division, 1950-2019 (https://population.un.org/wpp/Download/Standard/CSV/)
- Land and Ocean Temperature Anomalies, NOAA (NCEI), 1880-2021 (https://www.ncdc.noaa.gov/cag/global/time-series/globe/land_ocean/ann/1/1880-2021?trend=true&trend_base=10&begtrendyear=1880&endtrendyear=2021)
- https://www.gfdl.noaa.gov/global-warming-and-hurricanes/
- https://coast.noaa.gov/states/fast-facts/hurricane-costs.html
- https://www.nhc.noaa.gov/help/tcm.shtml?PRESS#MOTION
- https://www.un.org/esa/sustdev/natlinfo/indicators/methodology_sheets/oceans_seas_coasts/pop_coastal_areas.pdf
- https://www.census.gov/library/stories/2019/07/millions-of-americans-live-coastline-regions.html

- https://www.climate.gov/maps-data/dataset/global-temperature-anomalies-graphing-tool
- https://www.ncdc.noaa.gov/billions/dcmi.pdf
- https://en.wikipedia.org/wiki/List_of_the_most_intense_tropical_cyclones
- https://coast.noaa.gov/states/fast-facts/hurricane-costs.html
- https://oceanservice.noaa.gov/facts/cyclone.html
- https://www.ncdc.noaa.gov/monitoring-references/dyk/anomalies-vs-temperature