Emir Polat, Joseph Greene
Professor Rzeszotarski
INFO 4310
16 May 2024

INFO 4310 — Final Project Report
Online version: https://jgreene114.github.io/INFO4310-FP/index.html

Goals and Motivation
The purpose of our project is to inform users about the 2024 Atlantic hurricane season by following Hurricane Katrina's path. We will show how hurricanes form as well as some variables that make them more likely to occur and intensify. Along the way, we will use these explanations to contextualize the expectations for this year's Atlantic hurricane season.

Our project aims to provide an in-depth, interactive analysis of the predicted intense 2024 Atlantic Hurricane Season. The primary goal is to educate and inform the public about the potential severity of the upcoming hurricane season, the science behind hurricanes, and the impact of climate change on their intensity and frequency. This motivation stems from the increasing relevance of climate change and its effects on extreme weather events.

Intended Use Case
Audience:
- General public interested in climate change and natural disasters.
- Researchers and meteorologists studying hurricane patterns.
- Policy makers and emergency response teams preparing for hurricane seasons.

Use Cases:
- Education: Informing the public about hurricane formation, impacts, and safety measures.
- Research: Providing a detailed case study of Hurricane Katrina to compare with future hurricanes.
- Preparation: Helping policy makers and emergency responders plan and prepare for the upcoming hurricane season.

Related Materials
Our project drew inspiration from several sources, notably from articles published by The New York Times and academic articles. The following materials directly influenced our visualizations and design choices:

- Map Visualization of Hurricane Katrina: This aspect of our project was inspired by the New York Times article, "The Great Flood of 2019: A Complete Picture of a Slow-Motion Disaster." The article's detailed and interactive map visualizations provided a framework for how we could effectively present the path and impact of Hurricane Katrina.

- Bubble Chart of Billion-Dollar Natural Disasters: The idea for our bubble chart, which displays billion-dollar natural disasters since 1980, was inspired by the chart in the New York Times article, "The Cost of Hurricane Harvey: Only One Recent Storm Comes Close." This article's clear and impactful presentation of economic data influenced our approach to visualizing the financial impact of natural disasters.

- Line Plots of Sea Surface Temperatures and Ocean Heat Content: Both of our line plots, depicting historical sea surface temperature data, were inspired by the University of Miami's article on "Ocean Heat Content." This source provided both the data and the conceptual basis for illustrating the long-term trends in ocean temperatures.

- Oceanic Niño Index (ONI) Graph: Our visualization of the Oceanic Niño Index was inspired by a chart in the National Oceanic and Atmospheric Administration's report on El Niño/Southern Oscillation. The report's clear depiction of ONI data helped us design an intuitive and informative graph for our project.

These materials not only provided inspiration but also set high standards for data visualization that we aimed to meet or exceed in our project.

Data Sources and Processing

Data Sources

- Hurricane Katrina Map: International Best Track Archive for Climate Stewardship (IBTrACS) (available here)

- Niño Regions Sea Surface Temperatures (1982-2024) Line Plot: Sea surface temperature in Niño regions data from the National Oceanic and Atmospheric Administration (NOAA).

- Ocean Heat Content in Main Development Region Line Plot: Data from the University of Miami's article on "Ocean Heat Content."

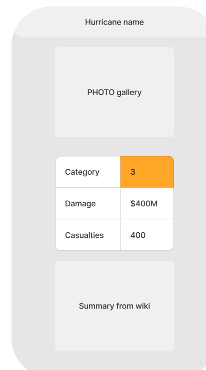
- Bubble Chart of Billion-Dollar Natural Disasters: Data from NOAA's report on Billion-Dollar Weather and Climate Disasters.

Data Processing

- Niño Regions Sea Surface Temperatures (1982-2024) Line Plot: Initially, temperature values in the 'NINO1+2', 'NINO2', 'NINO3.4', and 'NINO4' columns were cleaned by removing the '°F' string and converting them to floats. An average temperature was then calculated across these columns for each record. The 'MM/YY' column was split to extract and standardize the month and year, converting month names to numerical values. Unnecessary columns, including the original 'MM/YY' and individual Niño columns, were dropped, leaving only the 'Year', 'Month', and calculated 'Temperature' columns. This process ensured the data was consistent, accurate, and ready for creating insightful visualizations to analyze SST trends and patterns over time.

- Ocean Heat Content in Main Development Region Line Plot: No additional processing was required for this data.
- Bubble Chart of Billion-Dollar Natural Disasters: Key cleaning steps included processing the 'Name' column to extract the month and year using regular expressions, converting seasonal descriptions to specific months for consistency. The 'Begin Date' and 'End Date' columns were converted to datetime format, and the midpoint date of each event was calculated to accurately represent the event timeline. The 'Total CPI-Adjusted Cost' was converted from millions to billions of dollars to improve readability and comparability. Additionally, any text within parentheses in the 'Name' column was removed to clean up event descriptions.

Process and Other Designs Considered

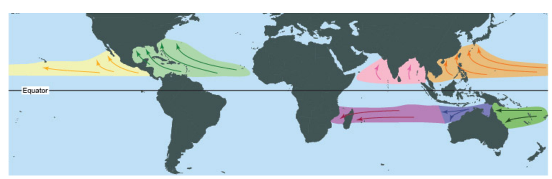


Early on, our idea behind the structure of the article was very different. We had intended to create a set of 3-panel pages, in which users could swipe left and right to switch between (left) historical, (center) explanation, and (right) 2024 prediction.

At one point, we also wanted to scrape Wikipedia to create these hurricane overview tiles. However, we ended up not going in this direction to put more time into the more visual elements. We also wanted to show an ocean overlay with Sea Surface Temperatures; however, we ended up not having enough time for this idea.

As will be mentioned in the contributions section, we explored multiple avenues for scroll-triggered transitions. We ended up using GreenSock (GSAP), which was a fun, intuitive library with a lot of nifty features for bringing the page to life. Additionally, we had wanted to use GSAP for the SVG morphing, however, this would have required an expensive subscription. So, we found a free package that would suffice for the task.

We got feedback to scope down our project and focus in on the elements we had. I think we did a good job of stopping the brainstorming period (though, yes, a bit late). However, there were plenty of other elements we thought of to add, such as 3d global maps instead of PNG images with geographic elements (see right).



Final Design

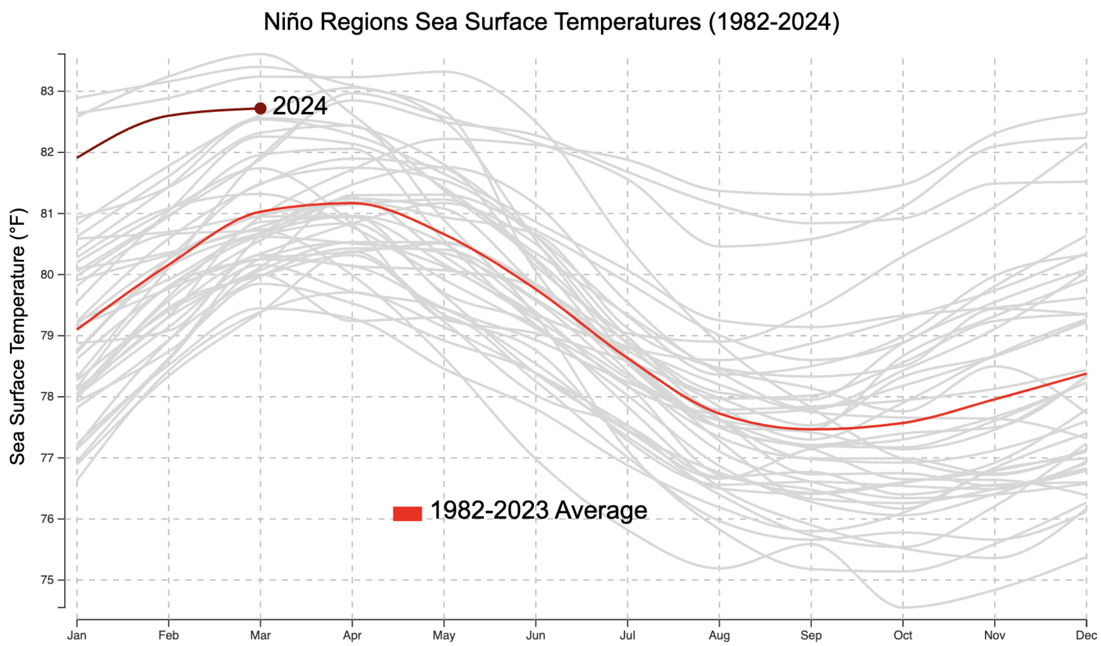
Visual channels:

We use many different visual channels throughout our article, including size to indicate intensity, both in elements like the map as well as the bubble chart. Additionally, the map header information (wind speed and SSHS value) uses color to show the transition of values (green for decreasing and red for increasing, or becoming worse.

One tradeoff of the map was that in order to make it easier to develop, we used wind speed to depict the shape of the storm, rather than using geographic data to depict the actual reach of the storm. Another tradeoff was with the map header transitions. In our demo, the values slid up and down to indicate increasing and decreasing, respectively. However, we were not able to nail out all the bugs with this component, so we modified it to be a simpler transition in which only the color of the text changed.

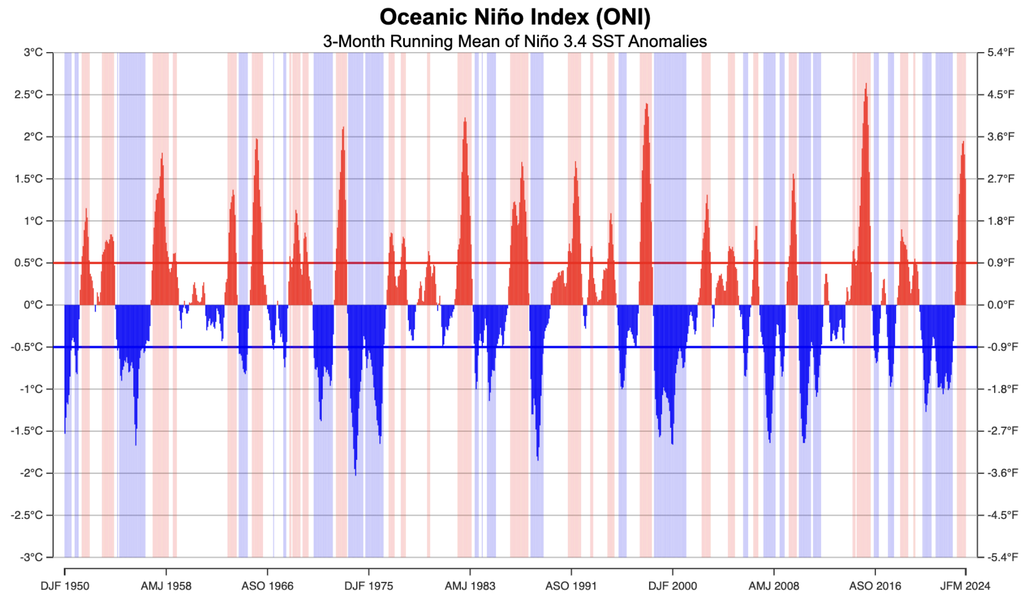
<u>Implementation</u>

Niño Regions Sea Surface Temperatures Line Plot



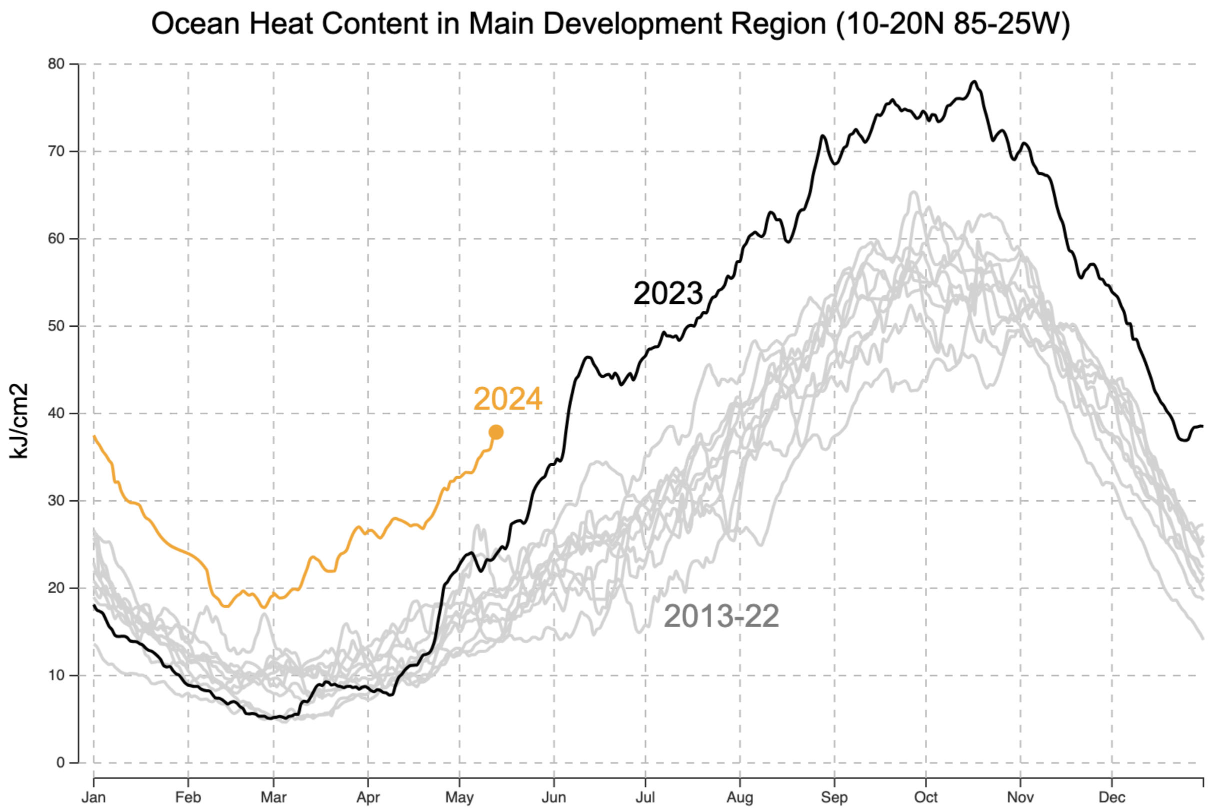
The line plot visualizes the sea surface temperatures across the Niño regions from 1982 to 2024, aiming to highlight temperature trends and anomalies over time. The Y-axis represents temperature, scaled linearly, while the X-axis represents months with linear scaling and month names as ticks. The data is parsed, and monthly average temperatures are calculated for each year. Lines are drawn for each year, with the 2024 data highlighted in a distinct color. An average line for 1982-2023 is also plotted. Interactivity is achieved through tooltips displaying the year and average temperature on hover, with lines changing color and width for better visibility. The design goal is to provide a clear, interactive visualization of temperature trends to understand climate patterns.

Oceanic Niño Index (ONI) Bar Chart



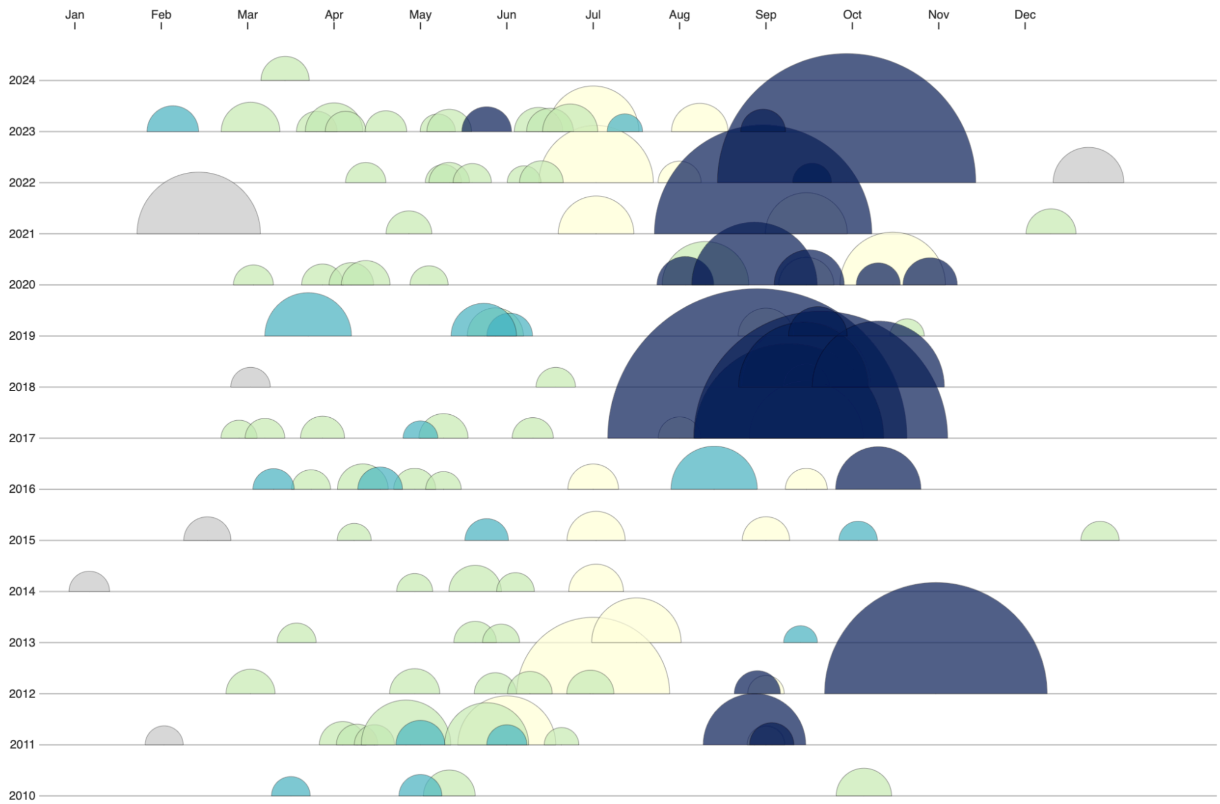
This bar chart displays the Oceanic Niño Index, emphasizing temperature anomalies in the Niño region over several decades. Dual Y-axes represent temperature anomalies in Celsius and Fahrenheit, while the X-axis shows seasons and years with selected ticks for readability. ONI data is parsed, and bars are drawn to represent temperature anomalies, with positive anomalies in red and negative ones in blue. Highlighted intervals of significant anomalies are shaded to emphasize notable periods. Interactivity includes a vertical line and tooltip that follow the mouse pointer, displaying detailed anomaly information. The chart aims to provide an intuitive and interactive means to study the historical patterns of the ONI, aiding in climate analysis and research.

Ocean Heat Content in MDR Line Plot



This plot focuses on the ocean heat content in the Main Development Region (MDR), crucial for understanding hurricane formation.The Y-axis, representing thermal energy content in kJ/cm², is scaled linearly, while the X-axis represents dates within the year. Data is parsed, with midpoint dates calculated for each entry. Lines are drawn for each year, with special highlights for the 2024 and 2023 data to enable comparison. Labels for 2024, 2023, and the average from 2013-2022 are added for context. The aim is to provide a detailed and interactive visualization of heat content trends in the MDR, aiding in the prediction and study of hurricane activity.

Bubble Chart of Billion-Dollar Natural Disasters



This bubble chart visualizes billion-dollar natural disasters, categorized by type and cost, to emphasize the economic impact of extreme weather events. The Y-axis represents years, and the X-axis represents months, both scaled linearly. Disaster events data is parsed, filtering out events with costs below $2 billion to focus on significant events. Half-circle arcs are drawn to represent the cost of each disaster, with color coding based on disaster type for easy differentiation. Tooltips provide disaster names and costs on hover, with arcs changing opacity and stroke width for emphasis. The design goal is to create a visually engaging and informative chart that highlights the financial impact of major natural disasters, aiding in awareness and policy-making.

Katrina Storm Path Map

This visualization shows the path of Hurricane Katrina as it progresses through the Gulf and over the US. This chart is meant to be a teaching aid to help users follow a concrete, historical example as they learn about the 2024 Atlantic Hurricane Season. Integrating this map beneath the information and interactive layers was, at times, a pain. Over our process, we figured out how to overlay these layers in a way that afforded user interactions where need. For example, in order to scroll through the article, the text had to be on top. But with the map underneath this info layer, the interactive elements could no longer be accessed. We added an interactive layer on top that allows users to click on the SSHS class value and learn more about the Saffir-Simpson Hurricane Scale (SSHS).

Contributions

Emir:

- Conducted data preprocessing and cleaning, ensuring datasets were accurate and ready for visualization.
- Implemented four data visualizations: Niño Regions Sea Surface Temperatures Line Plot, Ocean Heat Content in MDR Line Plot, Oceanic Niño Index (ONI) Bar Chart, and Bubble Chart of Billion-Dollar Natural Disasters.
- Developed the interactive features and tooltip functionality for the charts, enhancing user engagement and information accessibility.
- Authored the textual content for the article

Joseph

- Researched and processed Katrina path data from aggregate NOAA North Atlantic basin storm history. Once filtered, and after some minor data reformatting, I convert the CSV structure to a geoJSON file. This data contains information on the storm's location and intensity at 3-hour intervals.
- From this data, I create polygons containing pairs of consecutive points, sizing the 'storm blob' by the intensity of the wind at that point. I then merge them together, creating several increasingly larger blobs. By breaking the polygon down like so, we were able to implement the SVG polygon morphing effect using flubber.js, which simply takes two polygons and creates a tweening function to move from one shape to the other.
- We also implemented many scroll-triggered transitions. We first attempted to use Scrolly.js; however, this package would not allow for scroll-sync'd transitions, only scroll-triggered ones. The difference can be seen in the final version, in which the Katrina path polygon morphs as the user scrolls from one page to the next. To do so, we used GreenSock or GSAP. This change was a complete 180, as the code was written and working but the result did not look good enough, so we tried a completely different implementation.