

# How Extreme Weather is Reshaping Florida's Coral Reefs:

## Linking Coral Bleaching Severity with Increasing Tropical Storms in Florida (1987-2018)

Moanna Blaksteen, moanna.blaksteen@student.chaminade.edu, Chaminade University of Honolulu



### Introduction

Tropical coral reefs, such as those along the coast of Florida, are among the richest and most diverse marine ecosystems on our planet. They play a crucial role in supporting marine life and are intricately connected to various aspects of human existence. However, these reefs are increasingly threatened by coral bleaching, a phenomenon that occurs when corals expel their symbiotic algae, or zooxanthellae, due to environmental stressors such as rising temperatures and pH fluctuations<sup>1</sup>. The loss of this algae deprives the coral bodies of both their color and primary energy source, leaving behind white, lifeless skeletons<sup>1</sup> (Figure 1).

Florida's location between the Atlantic Ocean and the Gulf of America (formerly Gulf of Mexico) makes it highly vulnerable to tropical storms and hurricanes. Every part of its coastline has experienced at least one hurricane since 1850<sup>2</sup>. These storms not only cause physical damage to coral reefs but also disrupt ocean conditions, making marine ecosystems increasingly uninhabitable. Hurricane-force winds and turbulent waves can break apart coral structures and trigger fluctuations in water temperature and quality, further stressing marine life<sup>2</sup>. As climate change continues to warm ocean waters, stronger and more frequent storms will only amplify these threats, increasing the likelihood of coral bleaching and long-term reef decline.

The rising intensity of storms, coupled with long-term climate change, is accelerating the decline of Florida's coral reefs. As ocean temperatures continue to rise and water conditions become more unstable, struggling coral reefs are at risk of making a recovery which can lead to lasting damage to the delicate balance of these ecosystems. Without intervention, these combined effects could push Florida's reefs toward irreversible degradation.

### Hypothesis

In recent decades, the increasing frequency and intensity of extreme weather events in Florida have significantly contributed to widespread coral bleaching, leading to a decline in the health of coastal ecosystems.

- **H1:** The significant occurrence of extreme weather events (severe storms and tropical cyclones) will increase the vulnerability of Florida's reefs to coral bleaching.
- **H2:** The exponential increase in extreme weather events intensity and frequency will accelerate coral degradation in Florida's reefs in the coming years.

### Methods

- Coral bleaching data for Florida was obtained from the 'Global Bleaching and Environmental Data' public dataset from the Biological and Chemical Oceanography Data Management Office<sup>4</sup>.
- Weather data for Florida was sourced from 'Florida's Summary: Billion-Dollar Weather and Climate Disasters' public data set from the National Centers for Environmental Information<sup>5</sup>.
- Data was curated using R Studio, the TACC Analysis Portal, the Frontera Supercomputer, and Microsoft Excel.
- Statistical analysis was used to determine correlations or lack thereof between rates of coral bleaching in reefs along the coast of Florida between the years of 1987-2018 and the occurrence of tropical storms 1987-2024.

### Data Visualizations

Figure 1:



Figure 1: An image of elkhorn coral off the coast of Key Largo, Florida [6]. The left shows healthy coral, while the right illustrates bleached, unhealthy coral.

Figure 2:

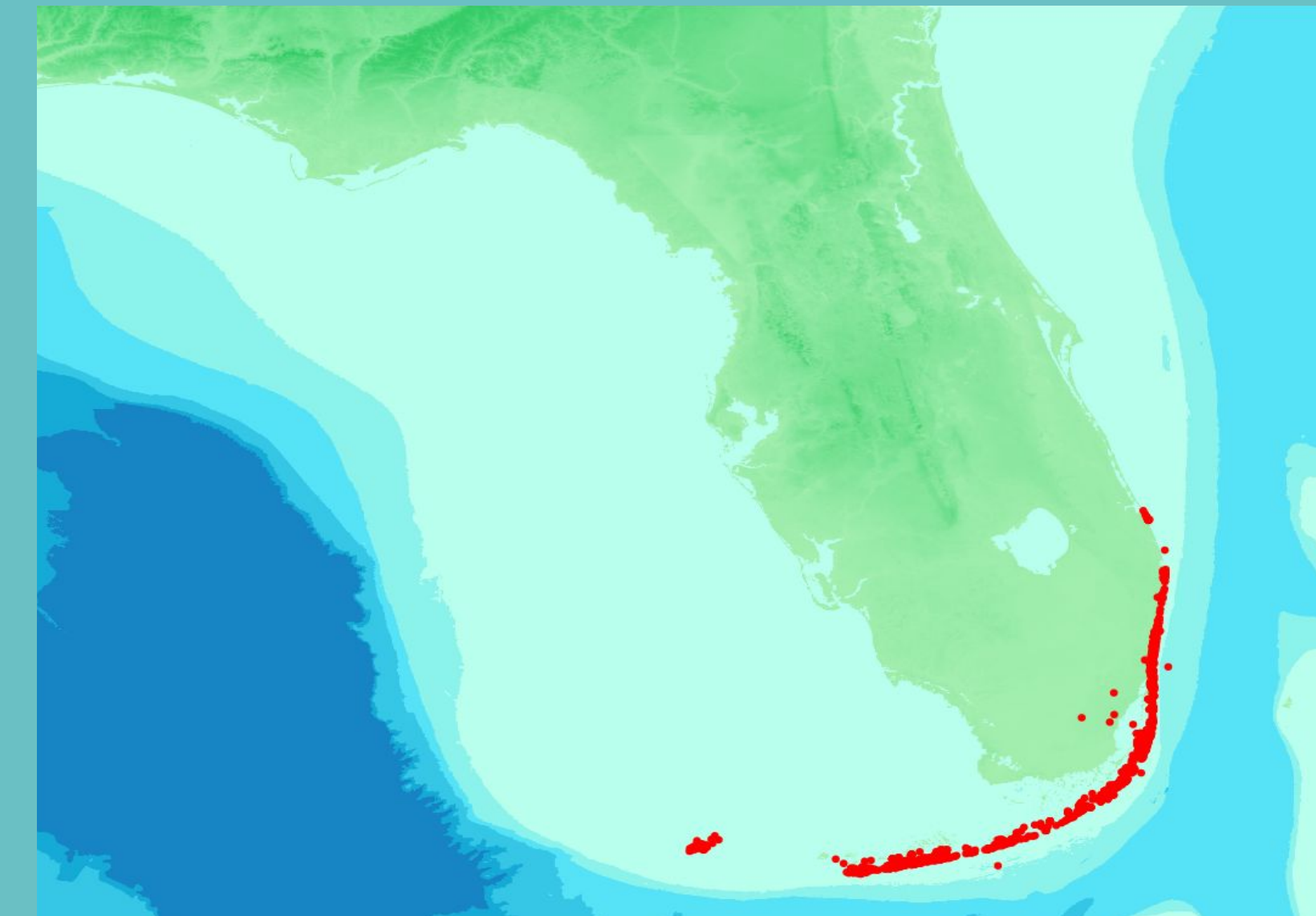


Figure 2: A bathymetric map showing Florida with the sample sites displayed in red plot points [7]. For the purpose of this research investigation, the outlier plot points (plot points on land areas) are omitted.

Figure 3:

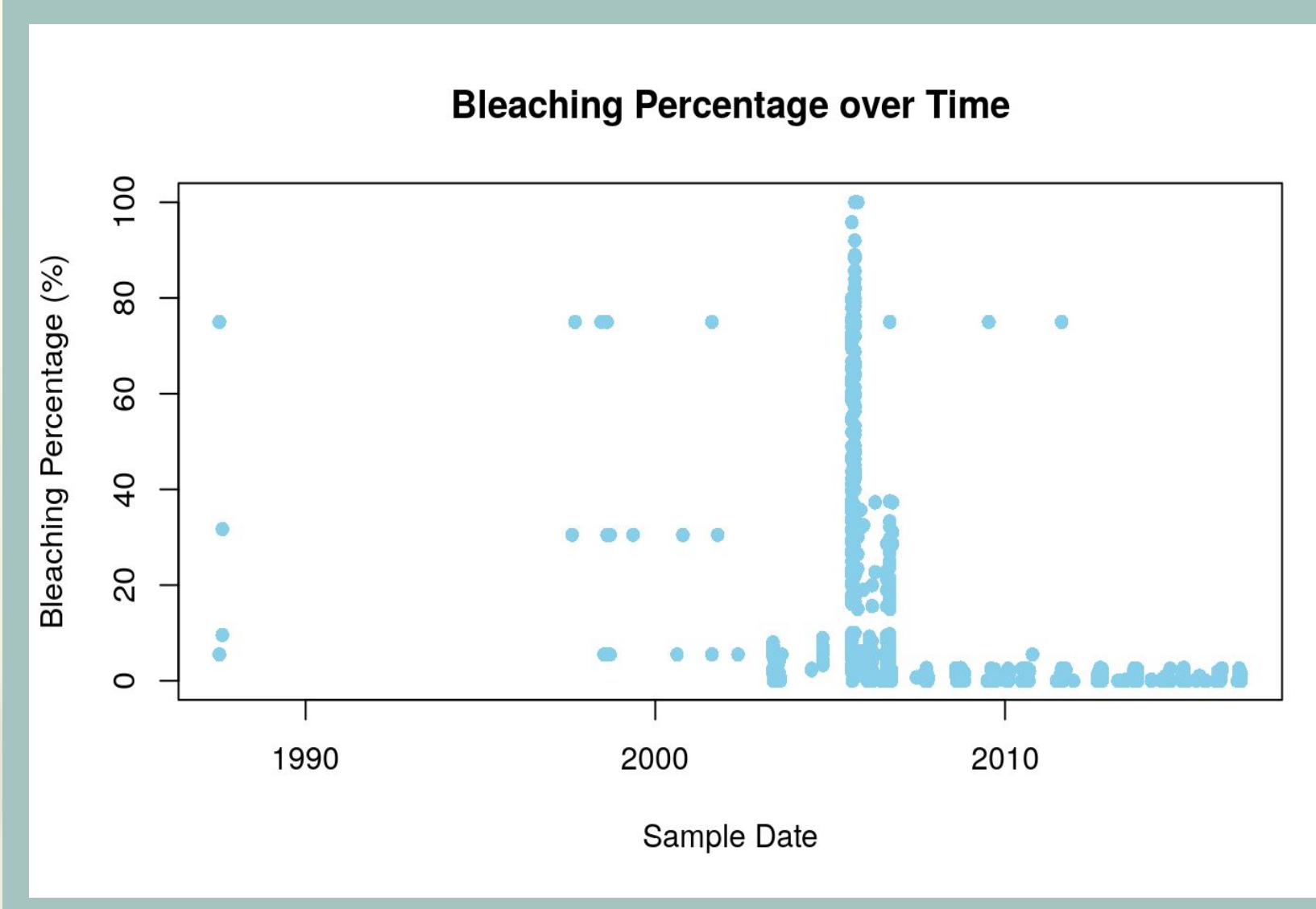


Figure 3: A scatter plot showing the percentage of coral bleaching recorded for the sample sites in Florida from 1987 to 2018, with data points representing individual observations.

Figure 4:

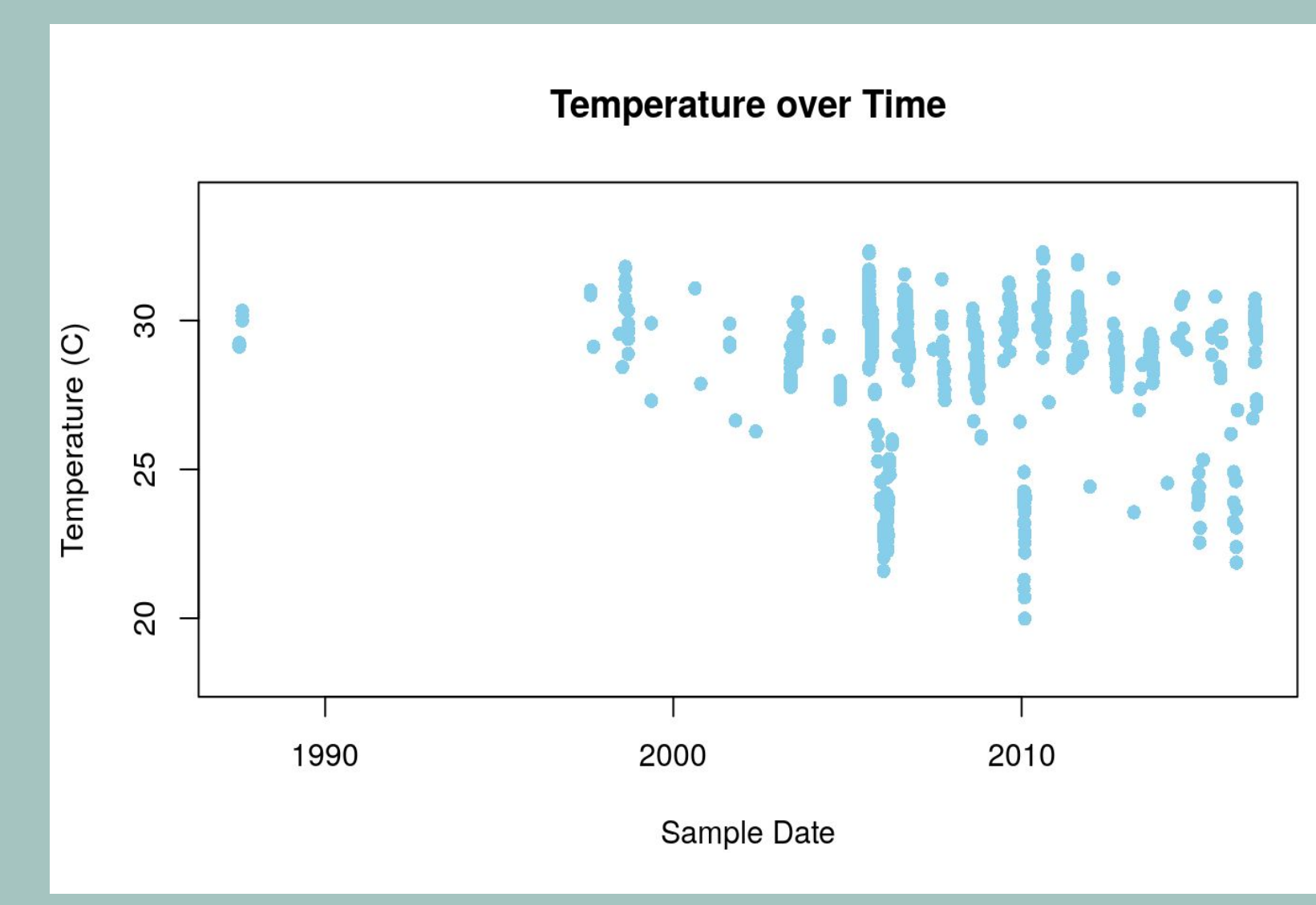


Figure 4: A scatter plot depicting the recorded sea temperatures for the sample sites in Florida from 1987 to 2018, with data points representing individual measurements.

Figure 5:

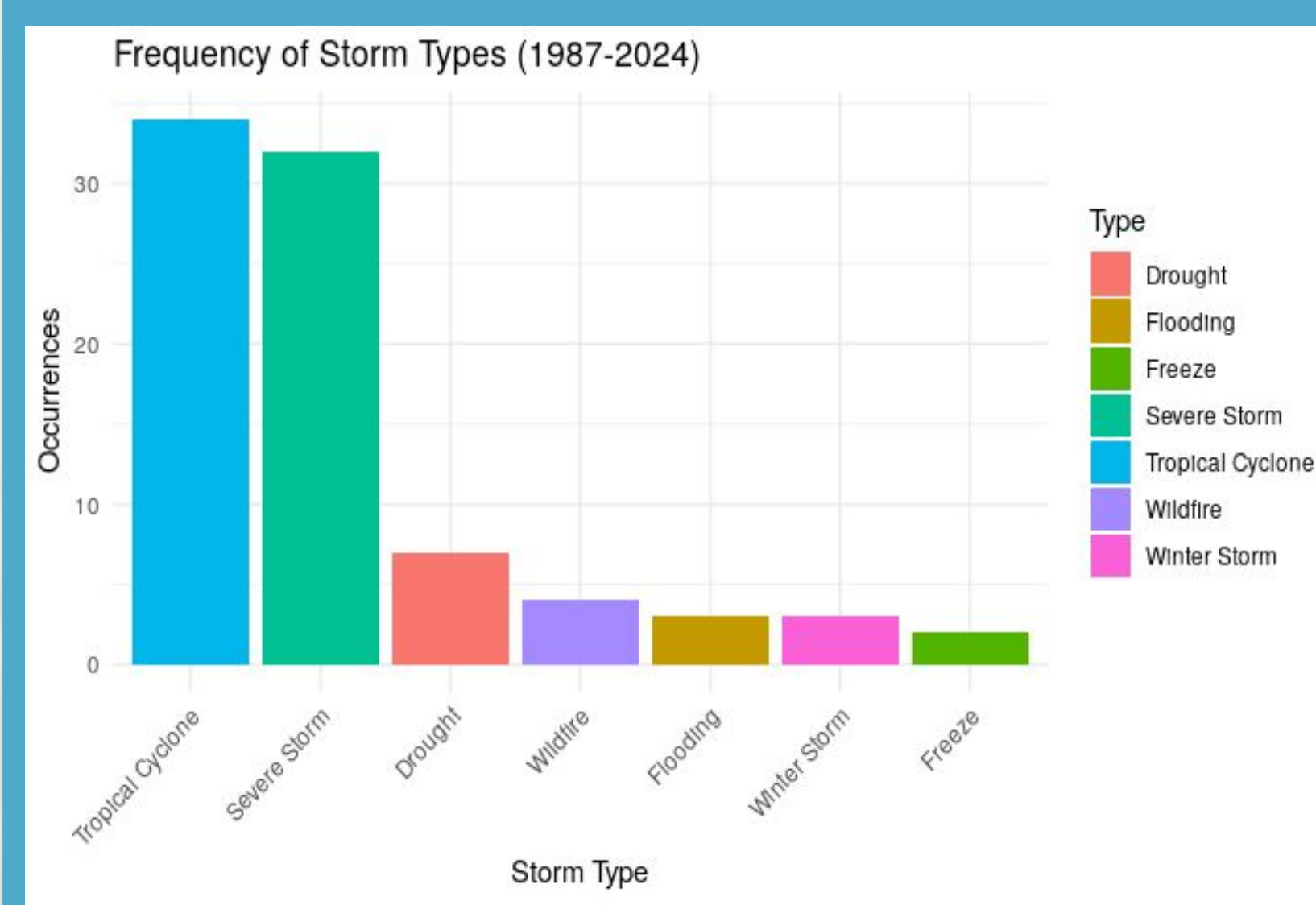


Figure 5: A bar chart displaying the total number of occurrences for each type of storm occurring in Florida from 1987-2024.

Figure 6:

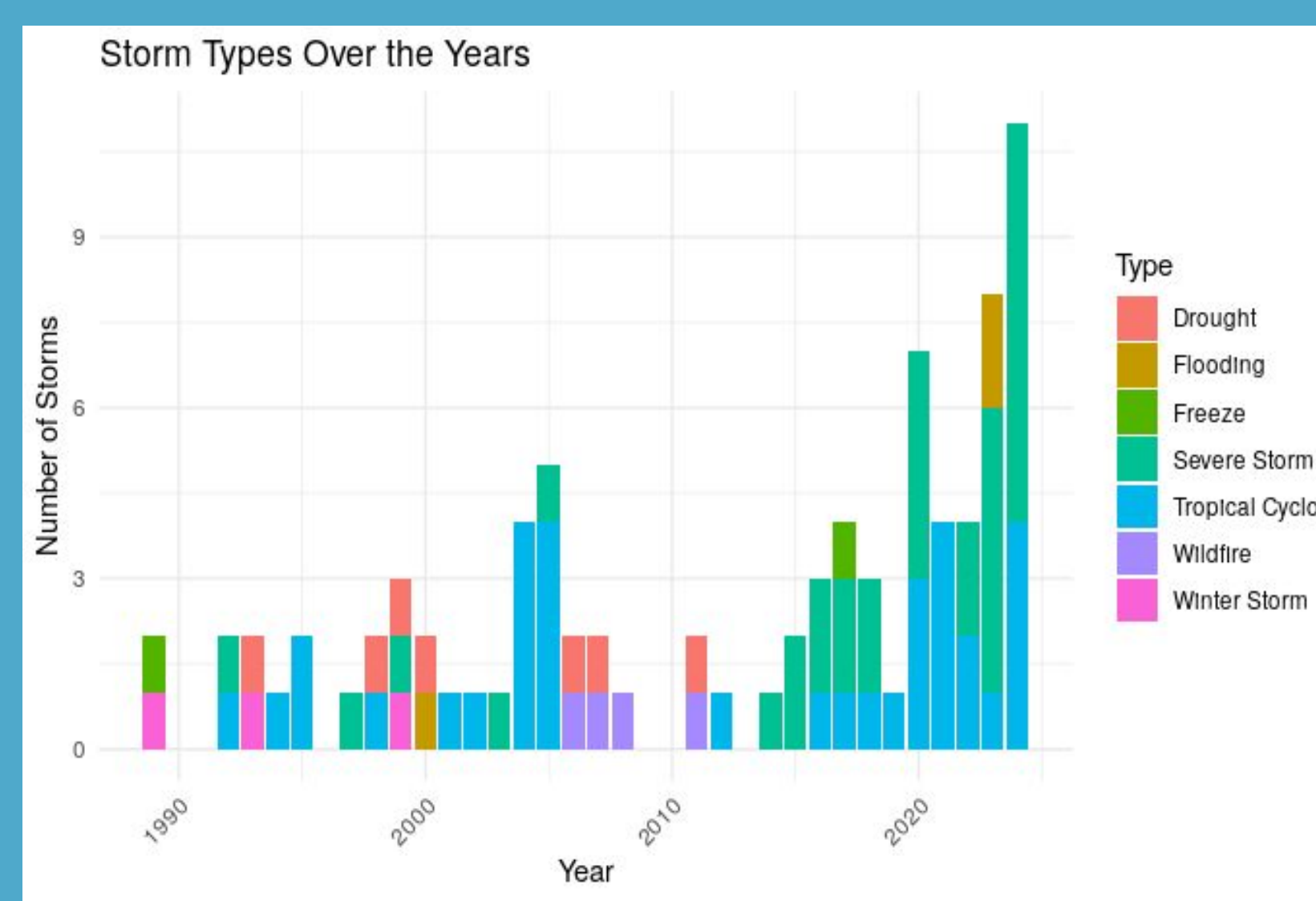


Figure 6: A stacked bar chart tracking the number and types of storms each year in Florida from 1987-2024.

### Results

- **Weather Trends:**
  - Between 1987 and 2018, there were 19 tropical cyclones and 14 severe storms.
  - 2004 and 2005 saw significant spikes in tropical storm activity.
    - Additional spikes in storm activity seen in 1999 and 2015-2017.
  - Since 2018, there have been 15 tropical cyclones and 18 severe storms.
    - Storm frequency exponentially increased.
- **Coral Bleaching and Weather Correlation:**
  - Years with increased tropical storm activity (e.g. 2005) correspond with temperature spikes (32.33°C) and higher bleaching percentages (exceeding 70%).
    - Occurrence of influential storms (Hurricane Katrina [2005] and Hurricane Wilma [2005])
  - Periods of less storm activity (e.g. 2010) align with lower temperatures (19.99°C) and lower bleaching percentages (below 10%) recorded.
- **Hypothesis Results:**
  - **H1:** More extreme weather occurrences and the resulting increase in ocean temperatures are speeding up coral bleaching and reef degradation.
    - High storm activity years, like 2004-2005, align with temperature spikes and major bleaching events, linking extreme weather to reef degradation.
  - **H2:** Tropical cyclones and severe storms in Florida have become more frequent and intense, especially since 2015.

### Limitations

- **Data Availability and Quality:** Reliance on pre-existing data may introduce limitations in accuracy, completeness, and potential omission of certain measurements.
- **Temporal/Spatial Constraints:** Focusing on specific times and locations may fail to capture the full variability of bleaching and storm trends.
- **Confounding Factors:** Environmental variables (e.g. temperature) may influence the relationship, making it harder to isolate the effects.

### Future Works

- Gather additional scientific measurements that the 'Global Bleaching and Environmental' dataset lacked (e.g. salinity) to strengthen the study and explore relationships between more variables.
- Predictive modeling can be used to estimate future coral bleaching risks under various weather scenarios, helping Florida better prepare for the increasing frequency and intensity of extreme weather.

### Acknowledgements

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### References

- [1] "What is coral bleaching?" 2024. NOAA's National Ocean Service. [https://oceanservice.noaa.gov/facts/coral\\_bleach.html](https://oceanservice.noaa.gov/facts/coral_bleach.html)
- [2] Florida Climate Center. n.d. "Hurricanes - Florida Climate Center." Florida Climate Center. Accessed March 10, 2025. <https://climatecenter.fsu.edu/topics/hurricanes>
- [3] "Coral Bleaching | FWCC." n.d. Florida Fish And Wildlife Conservation Commission. Accessed June 23, 2024. <https://myfwc.com/research/habitat/coral/news-information/bleaching/>
- [4] "Dataset: Bleaching and environmental data for global coral reef sites from 1980-2020." n.d. Biological and Chemical Oceanography Data Management Office. Accessed June 24, 2024. <https://www.bco-dmo.org/dataset/773466>
- [5] "Billion-Dollar Weather and Climate Disasters | Florida Summary | National Centers for Environmental Information (NCEI)." n.d. National Centers for Environmental Information. Accessed March 6, 2025. <https://www.ncsc.noaa.gov/access/billions/state-summary/fl->
- [6] Dam, Derek V., and Eric Zerkel. 2023. "Extreme heat might have been the 'nail in the coffin' for these critical Florida coral." CNN. <https://www.cnn.com/2023/10/08/us/coral-death-ocean-heat-florida-climate-index.html>
- [7] "GEBCO Gridded Bathymetry Data." n.d. General Bathymetric Chart of the Oceans. Accessed June 24, 2024. [https://gebcoset.net/data\\_and\\_products/gridded\\_bathymetry\\_data/](https://gebcoset.net/data_and_products/gridded_bathymetry_data/)