CHAZ Florida Hurricane Hazard Map

Interactive Visualization of Tropical Cyclone Wind Hazard Data

Paul Fishwick   Claude Code

January 2026

Abstract

This report documents an interactive web-based visualization tool for exploring tropical cyclone wind hazard data for Florida. The tool displays exceedance intensity data from the Columbia HAZard (CHAZ) model, allowing users to compare historical baseline conditions (1995–2014) with mid-century (2041–2060) and late-century (2081–2100) climate projections under the SSP585 emissions scenario.

1 Introduction

Tropical cyclones pose significant risks to Florida's coastal communities. Understanding how hurricane wind hazards may change under future climate scenarios is essential for long-term planning, infrastructure design, and risk assessment. This project provides an accessible, interactive tool for exploring CHAZ model output data.

The visualization is available online at: `https://metaphorz.github.io/CHAZHazard/`

2 Data Source

The underlying data comes from the CHAZ Hazard Maps dataset published on Dryad:

> Meiler, S., et al. (2025). CHAZ Hazard Maps: Global coastal wind hazard maps from the CHAZ tropical cyclone model. Dryad. `https://doi.org/10.5061/dryad.qfttdz0vz`

The dataset provides exceedance intensity values—the wind speeds (in m/s) expected to be exceeded at various return periods (10, 25, 50, 100, 250, and 1000 years)—for coastal locations worldwide. For this visualization, we extracted 2,094 land-based points covering Florida.

3 The CHAZ Model

3.1 Overview

The Columbia HAZard model (CHAZ) is a statistical-dynamical downscaling model for estimating tropical cyclone hazard. Rather than predicting specific future hurricanes, CHAZ generates thousands of synthetic storms based on climate conditions from global climate models (GCMs), then aggregates statistics to estimate hazard metrics.

3.2 Model Components

CHAZ consists of three primary modules:

1. **Genesis Module**: Uses the Tropical Cyclone Genesis Index (TCGI) to estimate where and when storm precursors form based on environmental conditions.
2. **Track Module**: Employs a Beta-Advection Model (BAM) that moves storms forward using environmental steering flow from the climate model.
3. **Intensity Module**: Evolves storm intensity using an autoregressive model with deterministic forcing (based on potential intensity, wind shear, humidity) and stochastic elements.

3.3 Climate Model Input

The visualization uses data generated from the CESM2 climate model under the SSP585 scenario (high emissions, "business as usual"). Six climate models are available in the full dataset:

- CESM2
- CNRM-CM6-1
- EC-Earth3
- IPSL-CM6A-LR
- MIROC6
- UKESM1-0-LL

4 Time Periods and Climate Projections

The visualization includes three time periods, as shown in Table 1.

Table 1: Time periods available in the visualization

Period	**Years**	**Description**
Historical (base)	1995–2014	Baseline climate conditions
Mid-Century (fut1)	2041–2060	Near-future projection
Late-Century (fut2)	2081–2100	End-of-century projection

4.1 How Future Projections Are Generated

For each time period, CHAZ:

1. Reads climate conditions (SST, winds, humidity, etc.) from the GCM
2. Calculates genesis probability using TCGI
3. Seeds thousands of synthetic storms based on genesis rates
4. Simulates each storm's track using steering winds

5. Evolves intensity based on environmental conditions
6. Aggregates statistics across 80 ensemble members ($\sim$1,600 synthetic years)

Key climate variables that change between periods include:

- **Sea Surface Temperature (SST)**: Warmer oceans provide more energy for storms
- **Potential Intensity (PI)**: Maximum theoretical storm strength increases
- **Vertical Wind Shear**: Affects storm formation and intensification
- **Mid-level Humidity**: Influences moisture availability
- **Atmospheric Circulation**: Alters steering currents and track patterns

5 Visualization Features

The interactive map includes the following features:

- **Time Period Selector**: Switch between historical, mid-century, and late-century projections
- **Return Period Selector**: Choose from 10, 25, 50, 100, 250, or 1000-year return periods
- **Color-Coded Markers**: Circle markers colored by wind speed intensity
- **Hover Tooltips**: Display coordinates, wind speed (m/s, km/h, mph), hurricane category, and all return period values
- **Legend**: Wind speed scale with three unit systems

6 Results

Figure 1 shows the 250-year return period wind speeds for the historical baseline (1995–2014). Figure 2 shows the same metric for the late-century projection (2081–2100).

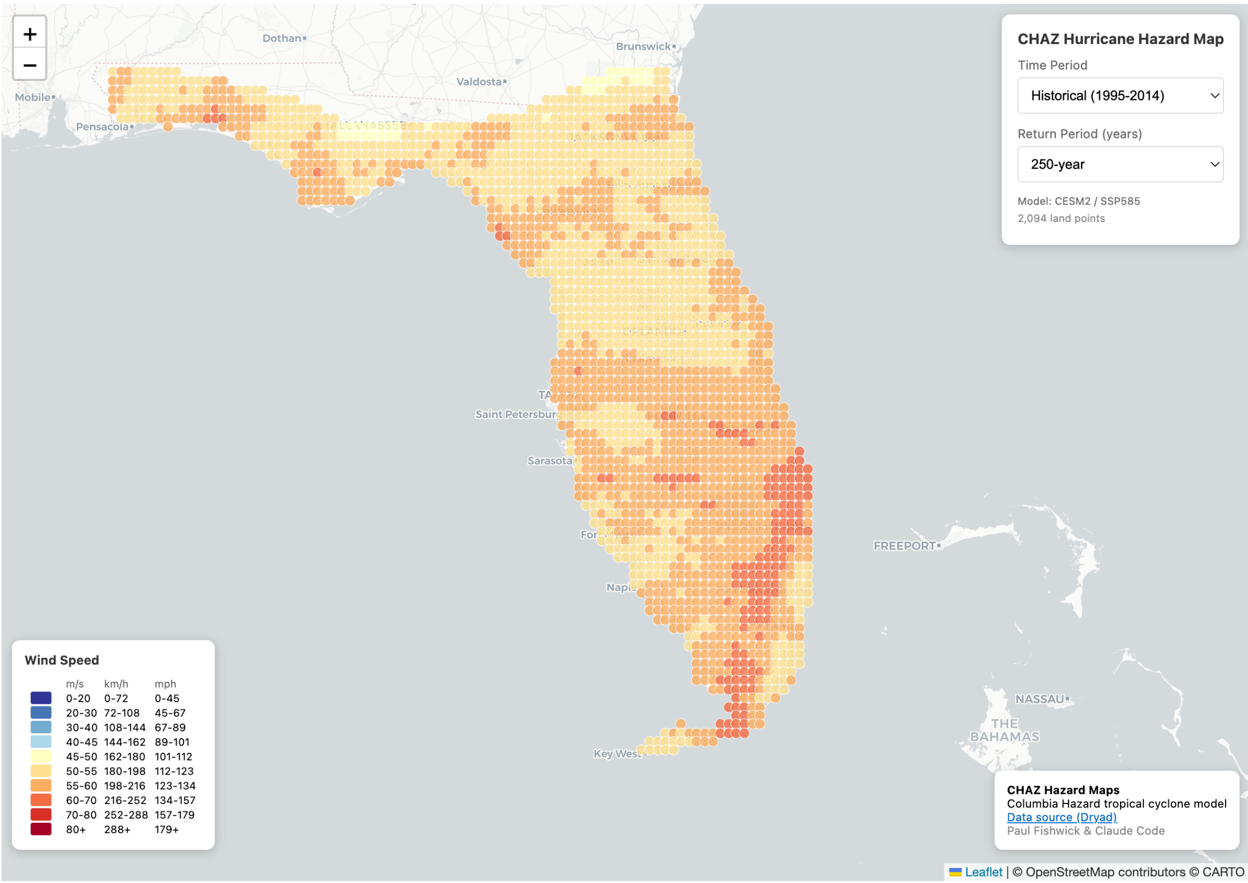

Figure 1: 250-year return period wind speeds for Florida under historical climate conditions (1995–2014). Colors indicate wind intensity from blue (lower) to red (higher).

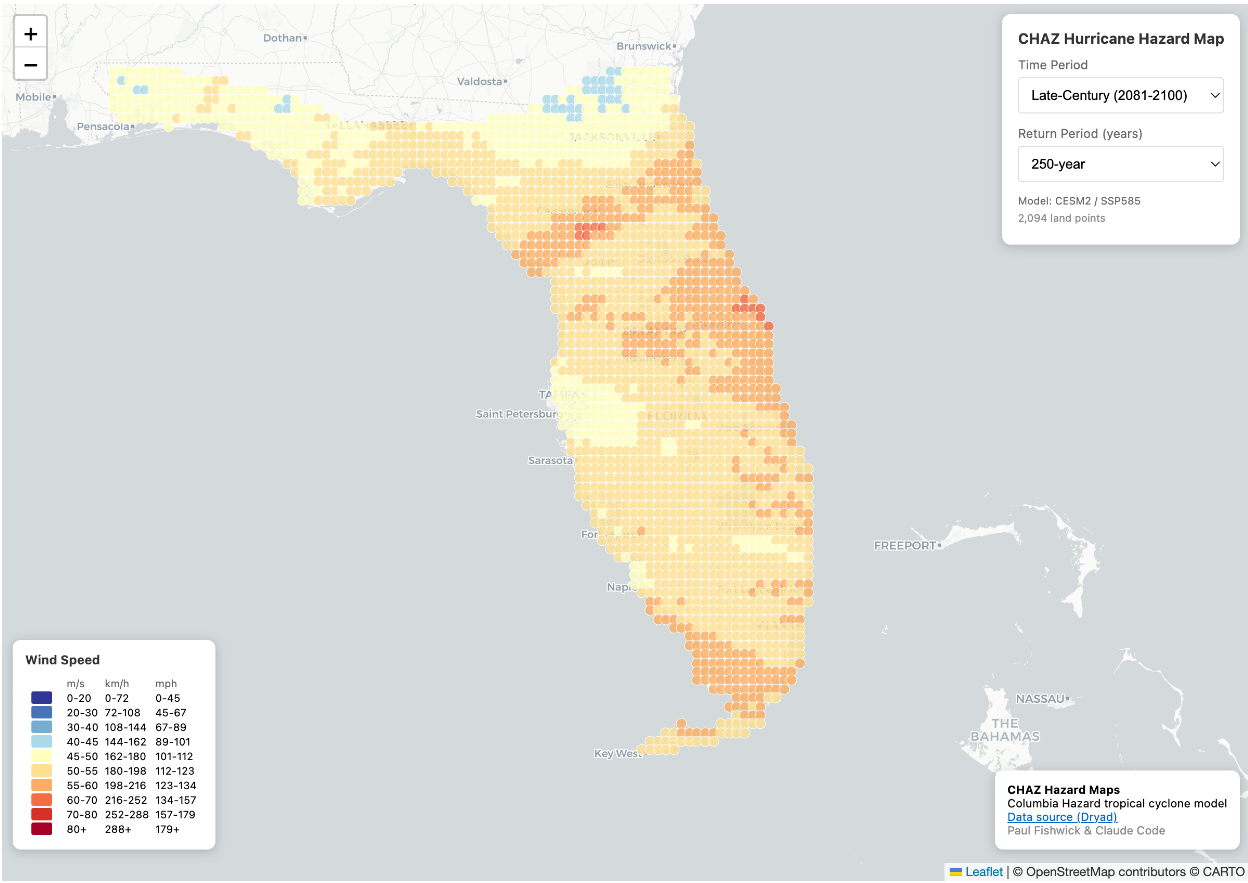

Figure 2: 250-year return period wind speeds for Florida under late-century climate projections (2081–2100, SSP585). Comparison with Figure 1 reveals changes in hazard distribution.

6.1 Key Observations

Comparing the historical and future projections reveals several patterns consistent with climate change projections for tropical cyclones:

- Overall wind intensities show increases in many coastal areas
- The spatial pattern of highest hazard remains concentrated along the southeast coast and Keys
- Some inland areas show modest changes in projected hazard

7 Technical Implementation

The visualization is built using:

- **Leaflet.js**: Open-source JavaScript library for interactive maps
- **HTML/CSS/JavaScript**: Standard web technologies for broad compatibility

- **GitHub Pages**: Free hosting for static web content

Data is embedded directly in the HTML file to avoid CORS restrictions and enable offline use. The approximately 2,094 land points are rendered efficiently using Leaflet's CircleMarker class.

8 Data Processing

The original CHAZ data covers global coastal areas with over 1 million points. For this visualization:

1. Florida points were extracted using a bounding box (lat: 24–31°N, lon: 88–79.5°W)
2. Ocean points were filtered out using a Florida land polygon
3. Data for all three time periods was combined into a single embedded dataset
4. Wind speeds were rounded to one decimal place to reduce file size

9 Acknowledgments

This visualization was developed by Paul Fishwick with assistance from Claude Code. The underlying CHAZ model was developed by the Columbia University team: Drs. Suzana J. Camargo, Chia-Ying Lee, Michael K. Tippett, and Adam H. Sobel.

10 License

11 References

1. Lee, C.-Y., Tippett, M.K., Sobel, A.H., and Camargo, S.J. (2018). An environmentally forced tropical cyclone hazard model. *Journal of Advances in Modeling Earth Systems*, 10, 233–241.
2. Lee, C.-Y., Camargo, S.J., Sobel, A.H., and Tippett, M.K. (2020). Statistical-dynamical downscaling projections of tropical cyclone activity in a warming climate. *Journal of Climate*, 33, 4815–4834.
3. CHAZ GitHub Repository: `https://github.com/cl3225/CHAZ`