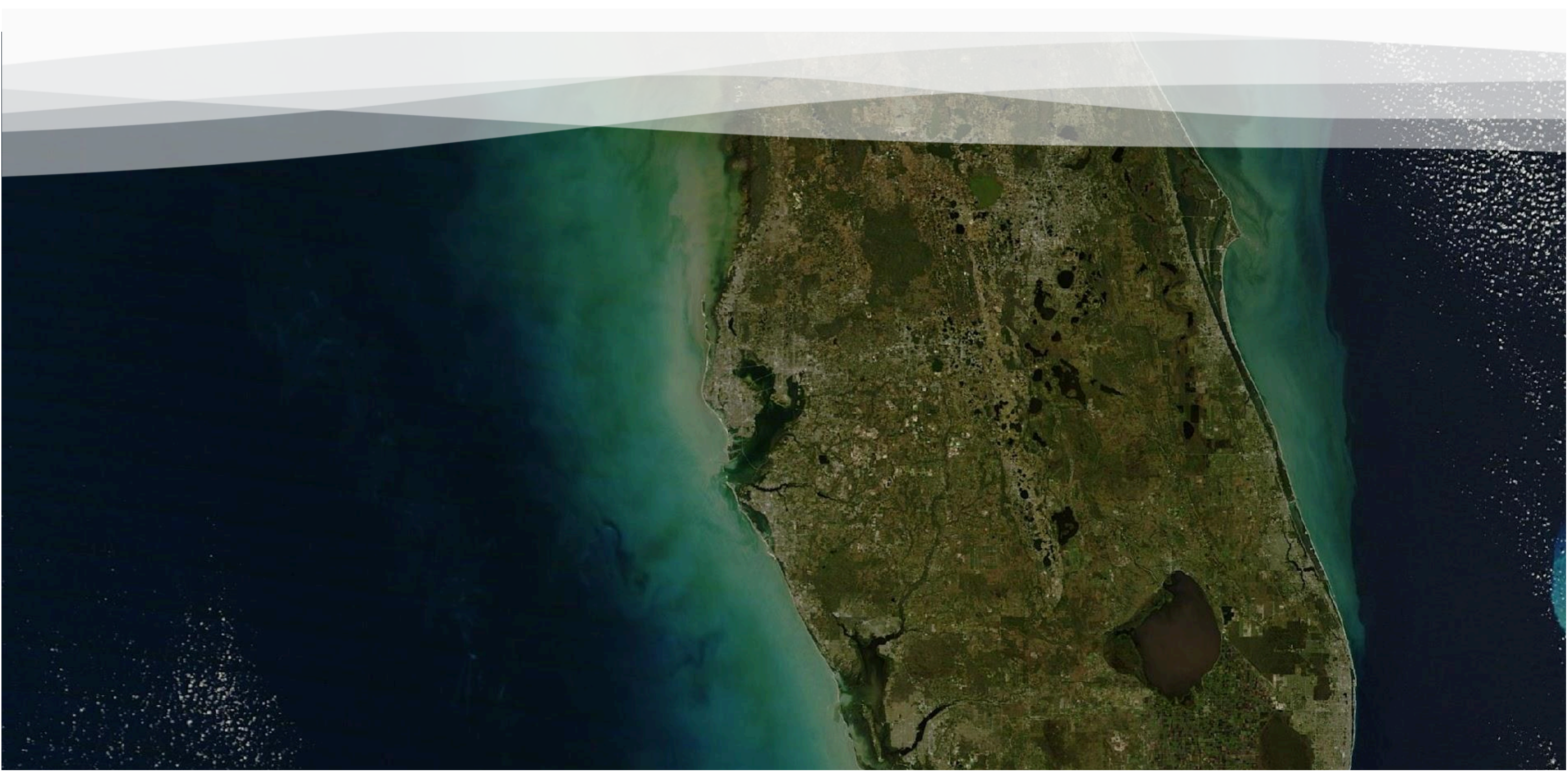
SOUTHEAST
FLORIDA REGIONAL
CLIMATE
CHANGE
COMPACT

Climate Indicators

2025 UPDATE



April 2025

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Tina Batoh-Jenning, City of Boca Raton

Karina Castillo, Miami-Dade County

Lauren Evans, Independent Consultant and Staff to the Southeast Florida Regional Climate Change Compact

Natalie Frendberg, Palm Beach County

Jane Gilbert, Miami-Dade County

Alannah Irwin, City of Boynton Beach

Michelle Irizarry-Ortiz, U.S. Geological Survey

Christian Kamrath, Miami-Dade County

Ben Kirtman, Ph.D., University of Miami

Paul Linton, Palm Beach County

Carolina Maran, Ph.D., South Florida Water Management District

Brian McNoldy, University of Miami

Jayantha Obeysekera, Ph.D., Florida International University

Rajendra Sishodia, Ph.D., Broward County

William Sweet, Ph.D., National Oceanic and Atmospheric Administration

Tiffany Troxler, Ph.D., Florida International University

Introduction

The physical indicators of climate change and variability are already manifesting in Southeast Florida. While sea level rise frequently receives the most attention in the region, there are other impacts of a changing climate that have consequences for communities. Understanding the future evolution of climatic patterns is extremely important for planning and management of agricultural, urban, and environmental systems, and reducing risks to communities.

In Broward, Miami-Dade, Monroe and Palm Beach counties (the four-county Compact region), changes to the climate result in higher temperatures in the atmosphere and in the ocean, potential shifts in rainfall patterns, and more frequent extreme rain events. Rising sea levels are increasing groundwater levels, the severity and frequency of high tide flooding, and exacerbating saltwater intrusion in some areas. Elevated groundwater levels reduce drainage capacity and augment flood risk from rainfall events, even in inland areas. Further, natural systems are being impacted by changing conditions—from the inland migration of mangroves and coastal species, to the degradation of coral reefs from increasing ocean temperatures. Taken together, a changing climate and the impacts on Southeast Florida's physical systems are resulting in cascading socioeconomic challenges.

The Compact endeavors to serve as a central repository for the best available, up-to-date, locally relevant scientific information on physical indicators of climate change in the region. Indicators are scientifically based measurements of observed phenomena that describe and facilitate communication about the various aspects of climate change. These data provide clear evidence of the climate change occurring in Southeast Florida, which is having significant, measurable impacts on the region's people, environment, infrastructure, and economy. This report, to the extent possible, also includes projections of future conditions, exploring the potential impacts of a changing climate based on plausible scenarios.

The Compact first developed the Southeast Florida Climate Indicators in 2016 through a technical work group with contributions from Broward, Miami-Dade, Monroe, and Palm Beach County staff, academic, and agency partners. The Compact updated the Climate Indicators in 2020 and again enlisted the support of technical experts across the academic community, and relevant state and federal agencies to update the indicators in 2025. The Compact intends for this information to help inform practitioners to advance regionally consistent planning, as well as educate elected officials, the media, and the general public regarding the consequences of climate change.

Changes in Southeast Florida's Climate & Impacts to Physical Systems

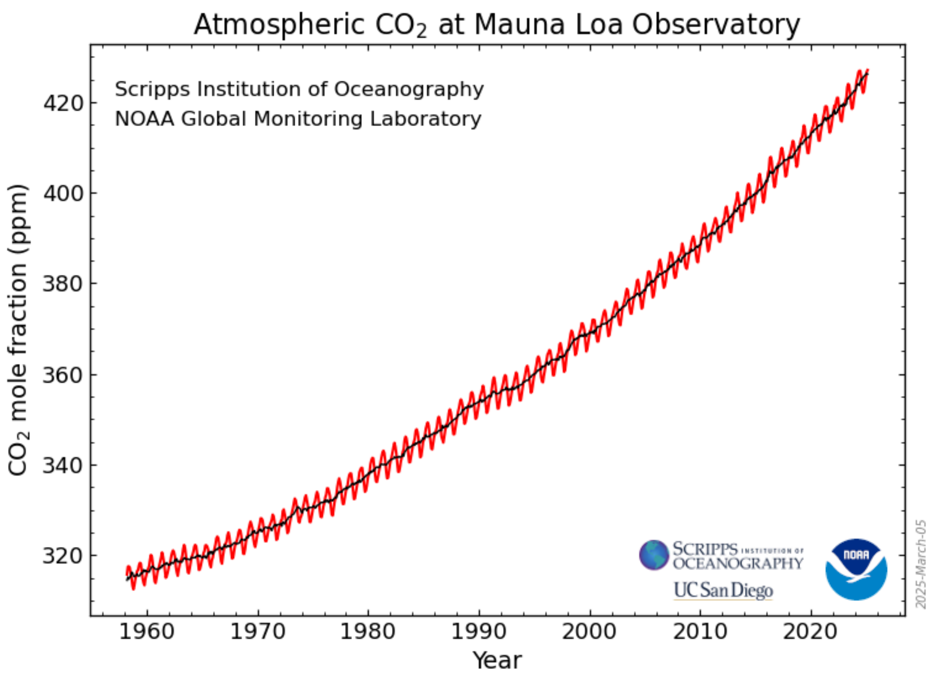
Climate is determined by the long-term pattern of oceanic and atmospheric conditions at a location. It is generally defined as "average weather," usually described in terms of the mean and variability of temperature, precipitation, and wind over a period of time. The evidence that the climate system—the atmosphere, land, and ocean—is warming is unequivocal. A review of temperature data since 1895 for the southeast region demonstrates that the average temperature during the last three decades has been higher than in the previous decades. In each of the four Southeast Florida counties, minimum annual temperatures rose 0.7 to 0.8 °F per decade over the past 40 years (1984 to 2024) (NOAA, National Centers for Environmental Information, 2025). Warming temperatures and changing precipitation patterns have altered Southeast Florida's "physical systems"—with a prominent impact on the ocean, which influences the region's water resources in a myriad of ways. The following indicators show changes in temperature, heat index, precipitation, sea level, high tide flooding, saltwater intrusion, and sea surface temperature as a result of climate change.

Global Concentration of Carbon Dioxide

Since the beginning of the Industrial Revolution, human activities have caused significant increases in emissions of greenhouse gases in the atmosphere, such as carbon dioxide, methane, and nitrous oxides, in addition to natural emissions of these gases due to the biome carbon and nitrogen cycles. Major sources of carbon dioxide are the burning of fossil fuels such as coal, petroleum-based liquid fuels, and natural gas for electric power generation, transportation, and industrial processes. These greenhouse gases trap heat from the sun in a natural process called the "greenhouse effect," which would otherwise be radiated back to space. Problematically, as the concentrations of these gases accumulate in the Earth's atmosphere as a result of human activities, the Earth's average temperature continues to rise.

A warmer atmosphere resulting from increasing levels of greenhouse gases, such as carbon dioxide, can hold more moisture (approximately 7% for every degree Celsius). While higher temperatures will make heat waves more frequent and intense, the increased moisture may lead to heavier rainfall and flooding. A warmer atmosphere contributes to increasing heat in the ocean, leading to more intense storms, rising sea level, and changing wind patterns and ocean currents.

The monthly mean concentration of carbon dioxide has been measured at Mauna Loa Observatory on the island of Hawaii since 1958, and is the longest record of direct measurements of CO_2 in the atmosphere. As of February 2025, the global average atmospheric carbon dioxide concentration was 427 parts per million (ppm), the highest recorded in human history—a level unprecedented in recent geologic history and within the timeframe of human civilization.

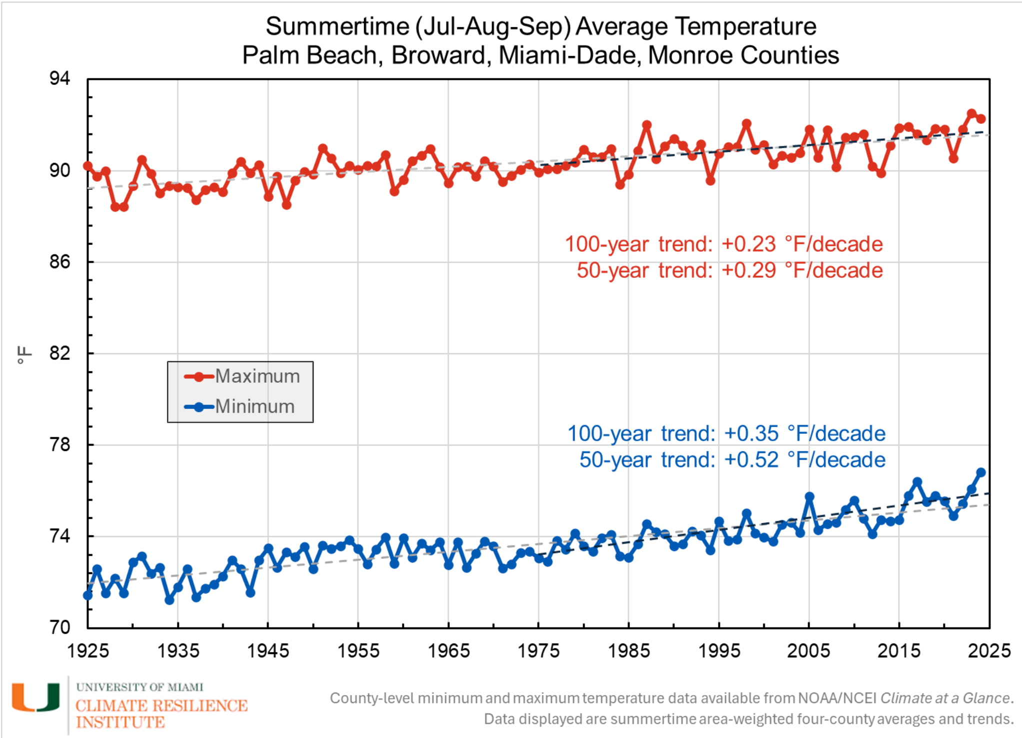


Source: NOAA Global Monitoring Laboratory, 2025

Temperature & Heat Index

Observed Temperature

The chart below shows the average minimum and maximum summertime (July, August, September) temperatures, averaged across Palm Beach, Broward, Miami-Dade, and Monroe counties. Those three months were chosen because climatologically, they are the hottest three months of the year in the region, as measured by temperature and by heat index. Annual average temperatures exhibit interannual variability, however, the long-term trend across the region shows an increasing trend. Over the last 100 years, the average maximum temperature across the region has increased at an average rate of 0.23 °F per decade, and in the last 50 years, it has increased 0.29 °F per decade. The average minimum temperature shows a more significant warming trend, increasing 0.35 °F per decade over the last 100 years, and more than half a degree (0.52 °F) per decade over the last 50 years.



Source: NOAA [National Centers for Environmental Information (NCEI).](#) This chart is provided courtesy of the University of Miami's Climate Resilience Institute, 2025.

Observed Heat Index

Heat Index is a function of both temperature and humidity—it is a measure of how hot it really feels when relative humidity is factored in with the actual air temperature. There is a direct relationship between the air temperature, relative humidity, and the heat index, meaning that as the air temperature and relative humidity increase (decrease), the heat index increases (decreases). The National Weather Service provides a [Heat Index Calculator](#). As shown in the table below, if the air temperature is 88°F and the relative humidity is 80%, the heat index—how hot it feels—is 106°F.

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112+
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136	
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137		
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137			
55	81	84	86	89	93	97	101	106	112	117	124	130	137				
60	82	84	88	91	95	100	105	110	116	123	129	137					
65	82	85	89	93	98	103	108	114	121	128	136						
70	83	86	90	95	100	105	112	119	126	134							
75	84	88	92	97	103	109	116	124	132								
80	84	89	94	100	106	113	121	129									
85	85	90	96	102	110	117	126	135									
90	86	91	98	105	113	122	131										
95	86	93	100	108	117	127											
100	87	95	103	112	121	132											

Off the Charts
Heat index formula becomes invalid with extreme temperature and humidty combinations that will increasingly result from global warming

- 80°F-89°F
- 90°F-99°F
- 100°F-104°F
- 105°F+
- Off the Charts

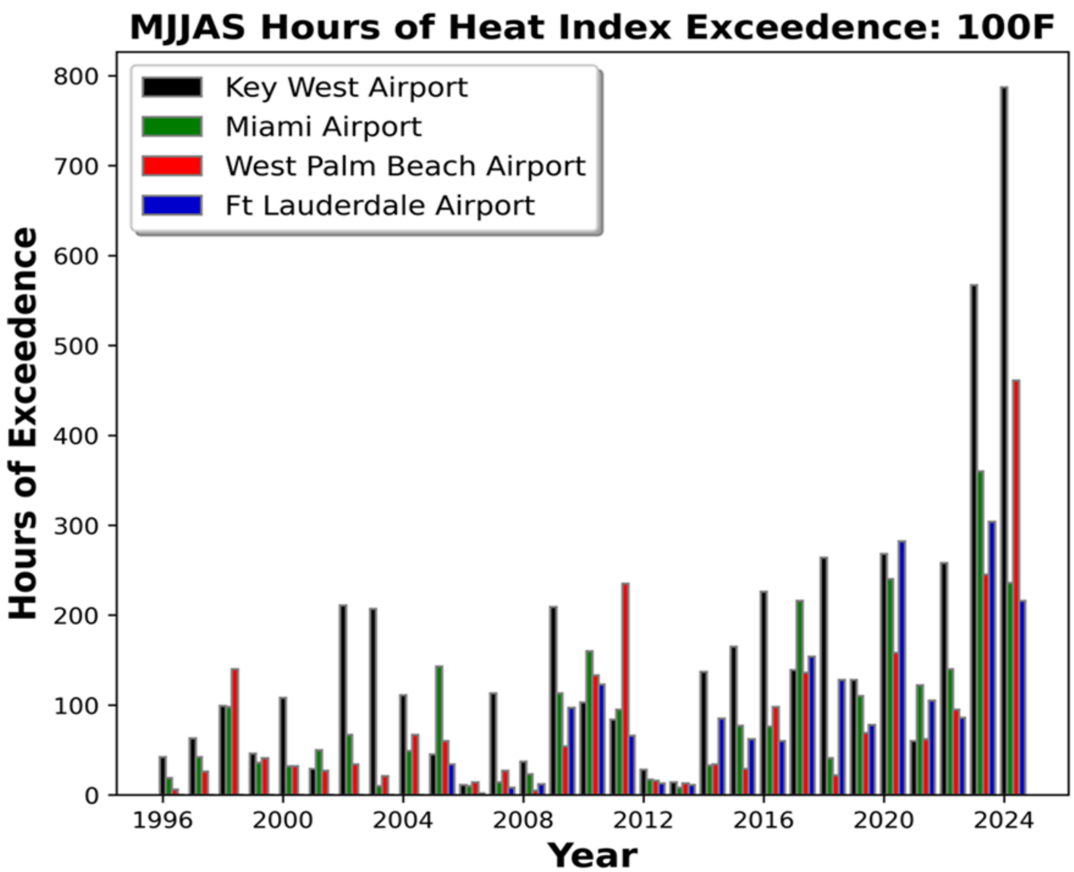
Beginning May 1, 2023, the National Weather Service Forecast Office in Miami (WFO Miami) began testing a change to the heat advisory and excessive heat warning criteria for public forecast zones in Miami-Dade County, and on July 1, 2024, Broward County joined this pilot program.[1] The new criteria for heat advisory/excessive heat warning for both Broward and Miami-Dade counties are better aligned with local climatology, as well as recent health data,

[1] National Weather Service. *New Experimental Heat Advisory/Warning Criteria for Broward County.* National Oceanic and Atmospheric Administration (NOAA). https://www.weather.gov/mfl/HeatCriteriaChangeBroward2024

which indicate that significant health impacts occur at heat index values lower than the current advisory/warning criteria. The Broward and Miami-Dade criteria are as follows:

- Heat Advisory: heat index of 105°F or higher for at least two hours
- Excessive Heat Warning: heat index of 110°F or higher for at least two hours

The chart shows the hours of heat index exceedance of 100°F during the heat season in South Florida (May, June, July, August, September) at stations located at airports across each of the four counties—Key West International Airport (Monroe County), Miami International Airport (Miami-Dade County); Fort Lauderdale International Airport (Broward County), and Palm Beach International Airport (Palm Beach County)—from 1996 to 2024. The hourly ambient air temperature and humidity data were collected from the NOAA National Centers for Environmental Information (NCEI,) and the heat index was calculated using the formula described in the National Weather Service's Heat Index Equation.



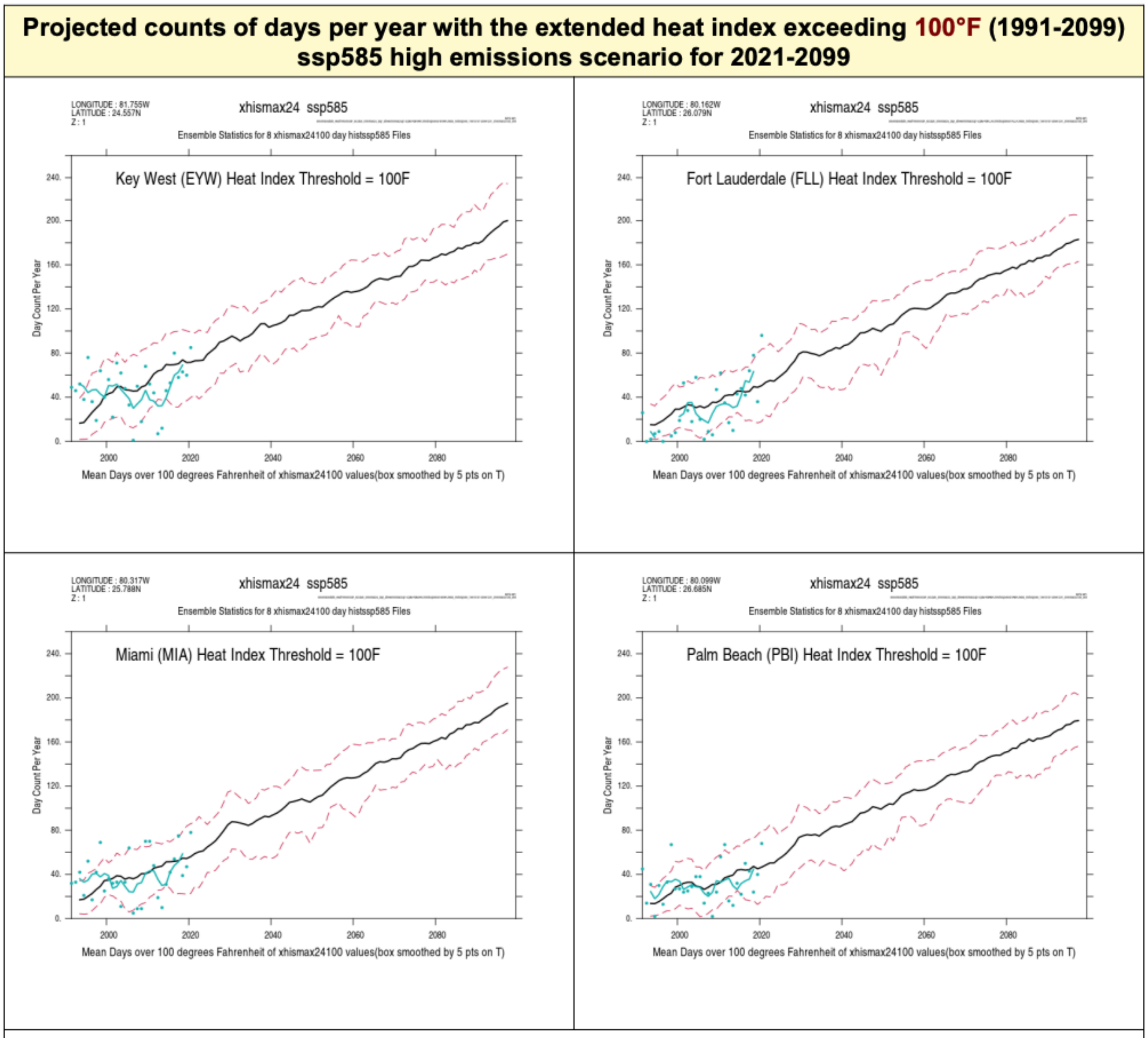
Source: NOAA National Centers for Environmental Information (NCEI).

Projected Heat Index

NOAA's Geophysical Fluid Dynamics Lab Statistical Downscaling Team is actively working on advancing the science related to projecting heat index. At the Compact's request, this team developed projections of days per year with the extended heat index[2] exceeding 100 °F (1991-2099) using station data from four airport locations in Southeast Florida—Key West International (Monroe County), Fort Lauderdale-Hollywood International (Broward County), Miami International (Miami-Dade County), and Palm Beach International (Palm Beach County). Based on eight CMIP6 climate models, NOAA generated bias-corrected daily maximum heat index time series for these four locations in each county. These projections assume the high emission scenario known as Shared Socioeconomic Pathway (SSP)585, which is considered the upper boundary of the range of scenarios described in the literature.

The charts generated by NOAA provide year-by-year statistics of days exceeding the 100 °F threshold across the eight bias-corrected model results, computing the average of the eight, as well as the largest and smallest of the eight. The five-year running average of the maximum and minimum values is shown as dashed red lines. The black curve shows the five-year running average of the eight models. For reference, cyan dots represent the observed counts of the number of days with heat index values above the threshold of interest for the period 1991-2020, for each airport station. The cyan curve is the five-year running mean computed from the annual observational data.

[2] Lu, Yi-Chuan, & Romps, David M. (2022). Extending the Heat Index. Journal of Applied Meteorology and Climatology, 61(10). https://doi.org/10.1175/jamc-d-22-0021.1 The existing heat index is well-defined for most combinations of high temperature and humidity experienced on Earth in the preindustrial climate, but global warming is increasingly generating conditions for which the heat index is undefined. Therefore, an extension of the original heat index is needed. The heat index is a widely used measure of apparent temperature that accounts for the effects of humidity using Steadman's model of human thermoregulation. Steadman's model, however, gives unphysical results when the air is too hot and humid or too cold and dry, leading to an undefined heat index.



Black curve: Five-year running average (plotted at the central year) of the ensemble mean of eight CMIP6 GCMs bias corrected using the QDM-direct method with ISD-lite observations from four Florida airports for training.
Dashed red lines: maximum and minimum five-year running average values of the eight individual bias corrected CMIP GCMs
Cyan curve: Five-year running average of weather station observations.
Cyan dots: single year running values for the weather station observations.

Observed Precipitation

Southeast Florida has a wet season and dry season based on the rainfall amount, with May and October considered transitional months. The six months from November through April are considered the dry season. The four months from June through September are considered the wet season. Long-term averages indicate South Florida has an annual rainfall of 52 to 53 inches, with roughly three-quarters of the rainfall occurring in the wet season and the transitional months.[3] Spatial variability of rainfall is wide-ranging and highly influenced by the oceans surrounding the peninsula, the large lakes within the interior of the state, as well as sea breeze and tropical storm occurrences. Identifying trends in extreme rainfall in Southeast Florida is challenging due to limited data availability, particularly at subdaily time scales. It is also difficult to attribute the historical changes in rainfall to climate change directly, as rainfall changes could be cyclical and affected by intra- and multi-decadal natural climate variability, such as El Niño and other recurrent climate phenomena. Changes in rainfall patterns could impact stormwater volumes and the amount of available fresh water, potentially causing more frequent flooding events or prolonged periods of drought.

The South Florida Water Management District (SFWMD or District) has conducted an analysis of the frequency and long-term trends in available historical rainfall data in Southeast Florida utilizing observed rainfall data until 2018. Overall, the District did not identify significant upward or downward trends in average annual, seasonal or monthly rainfall other than localized observations. The District is currently updating these trend analyses to include observed data through 2024 and are improving data quality, which could be a limiting factor in identifying trends over time. According to the SFWMD, given predicted increases in the frequency and intensity of extreme hydrological events, local changes to extreme wet and dry conditions are likely in future years.[4]

Analysis of observed total annual wet season rainfall trends from 1935 to 2018 from the SFWMD's Resilience Metrics Hub platform is presented in the charts below for Broward, Miami-Dade, and Palm Beach counties (counties within the SFWMD area), exhibiting significant natural variability but no systematic trends.

The second chart analyzes the probability density of the number of daily rainfall events exceeding one inch, using precipitation data from NOAA's National Centers for Environmental Information (NCEI) for stations located at Fort Lauderdale International Airport (Broward

[3] South Florida Water Management District. (2022). *2022 South Florida Environmental Report – Volume I, Water and Climate Resilience Metrics.* https://apps.sfwmd.gov/sfwmd/SFER/2022_sfer_final/v1/chapters/v1_ch2b.pdf

[4] South Florida Water Management District. (2022). *2022 South Florida Environmental Report – Volume I, Water and Climate Resilience Metrics.* https://apps.sfwmd.gov/sfwmd/SFER/2022_sfer_final/v1/chapters/v1_ch2b.pdf

County), Miami International Airport (Miami-Dade County), Key West International Airport (Monroe County), and the Palm Beach International Airport (Palm Beach County). The purpose of this assessment was to determine the potential change in the frequency of moderate rainfall events (defined here as one inch or above). The trend in the number of one-inch events appeared to have increased since about 1980 at all four locations, and therefore, that year was used to split the datasets. The frequency of events was expressed as a probability distribution, before and after 1980. These plots demonstrate a clear trend (shift in the distribution) of increasing frequency of occurrence after 1980 across all four stations. While there was no attempt to determine the statistical significance of this shift, the implication of more frequent moderate events during more recent decades may imply a similar increase in the flood frequency due to such events. Further research is needed to validate this finding.

There has been a concern of a potential increase in major precipitation events for sub-daily duration (lasting less than 24 hours). A notable example of this is the deluge of 25 inches of rain over about 12 hours in Fort Lauderdale in April 2023. Similar events appear to occur more frequently across the State of Florida, particularly those associated with tropical systems.[5] Unfortunately, there is limited continuous data on sub daily rainfall in the region to properly assess the statistical trends. Given the importance of large rainfall events, further work is needed to determine current and future trends in extreme rainfall events.

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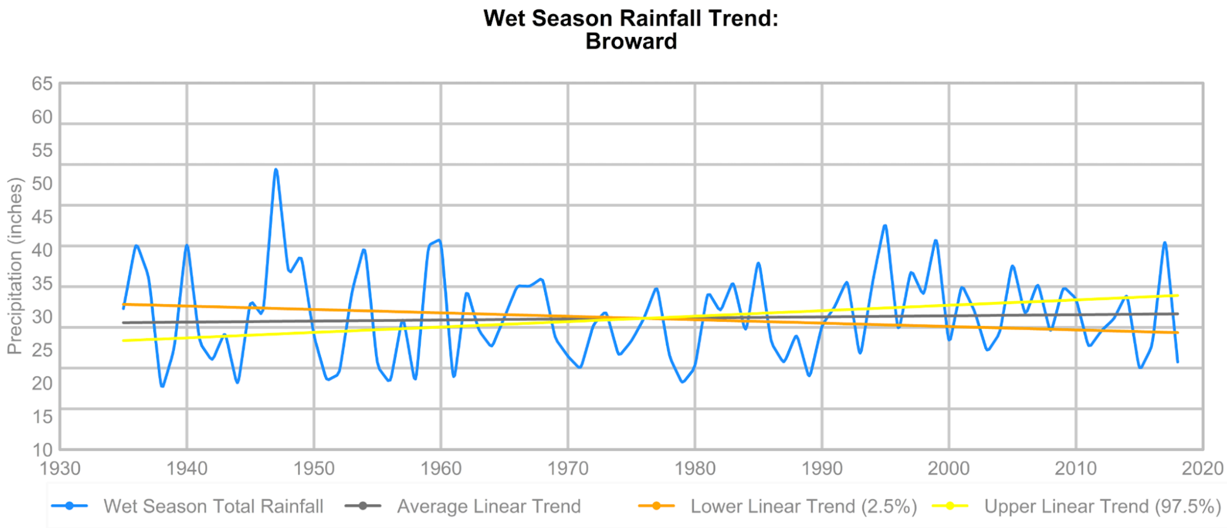
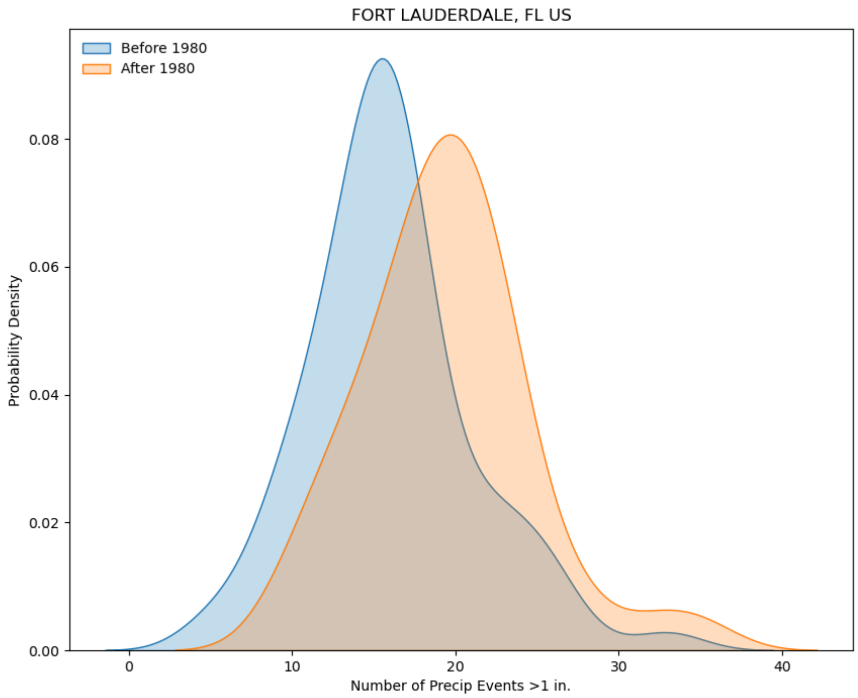
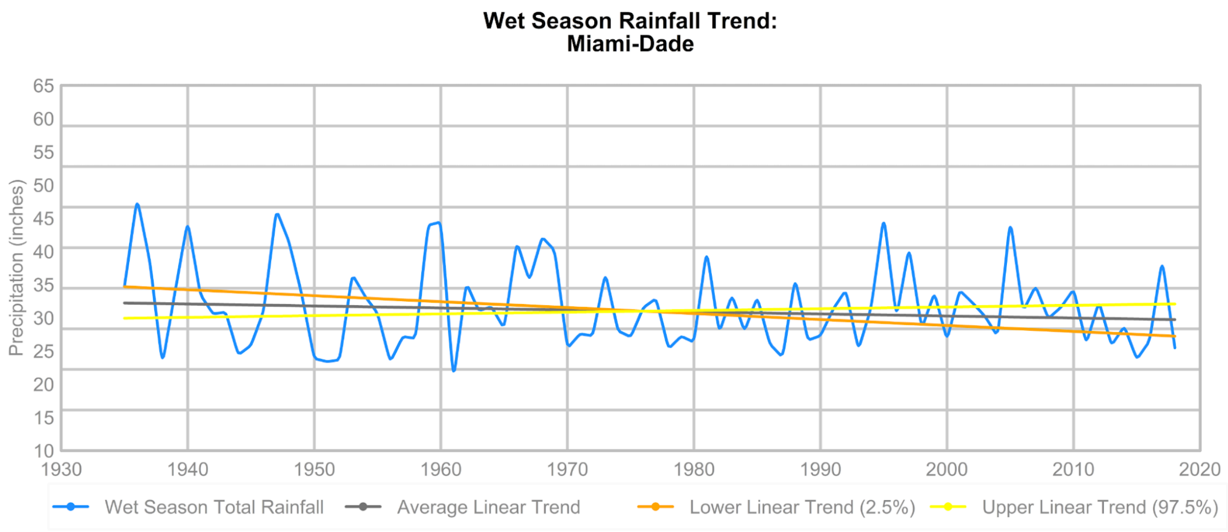
[5] National Weather Service Miami. (2025). *NWS Miami StoryMaps.* National Oceanic and Atmospheric Administration. *https://storymaps.arcgis.com/collections/de42b67c5f2b4167a6b75cfa1984ee8d*

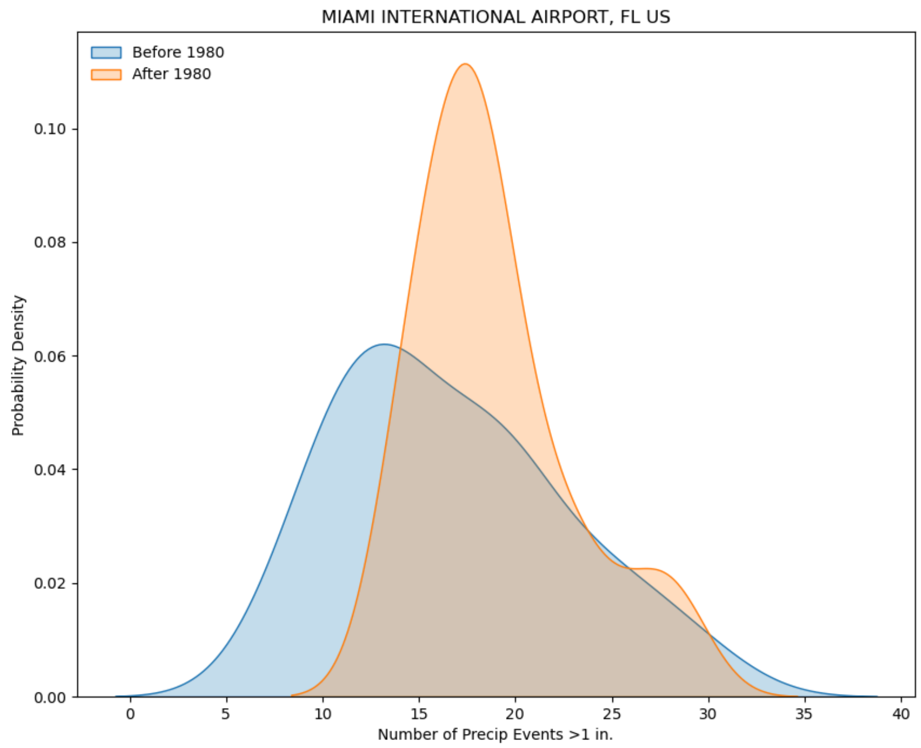
Broward County



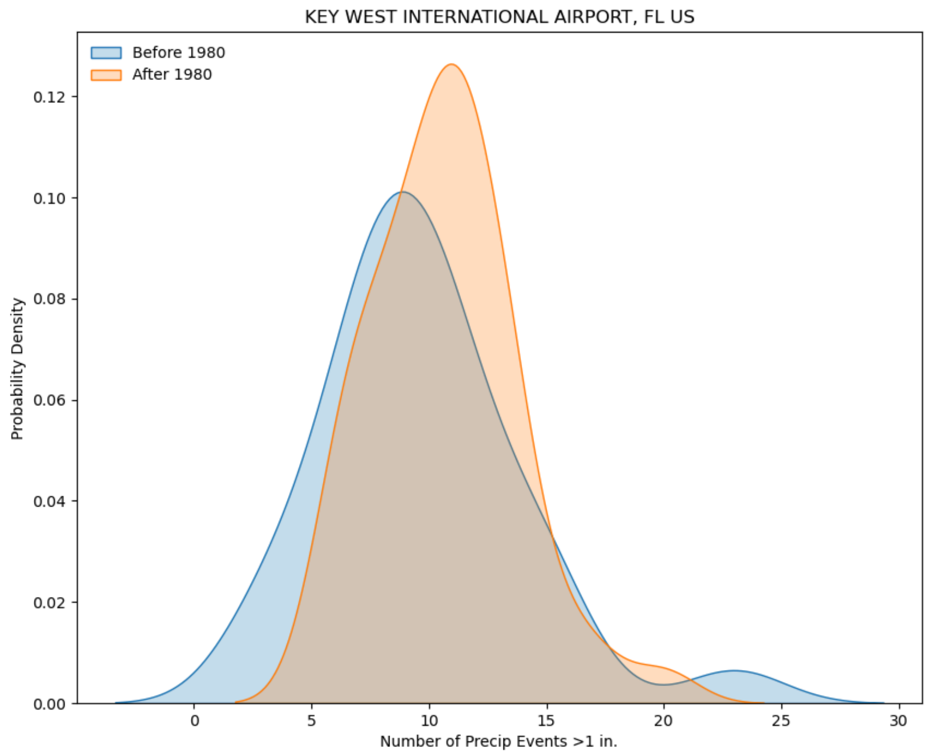


Miami-Dade County

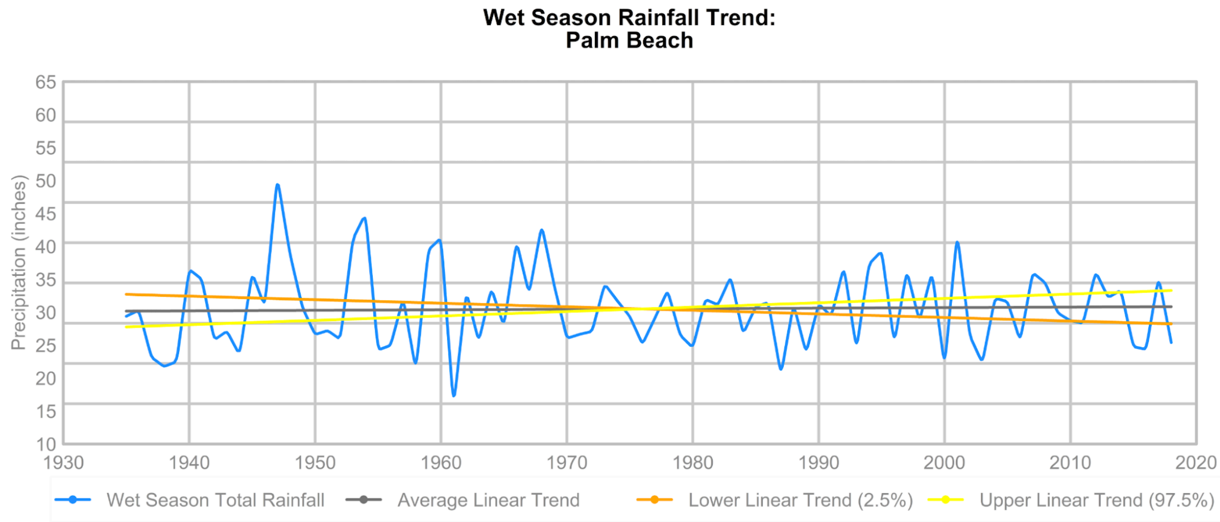


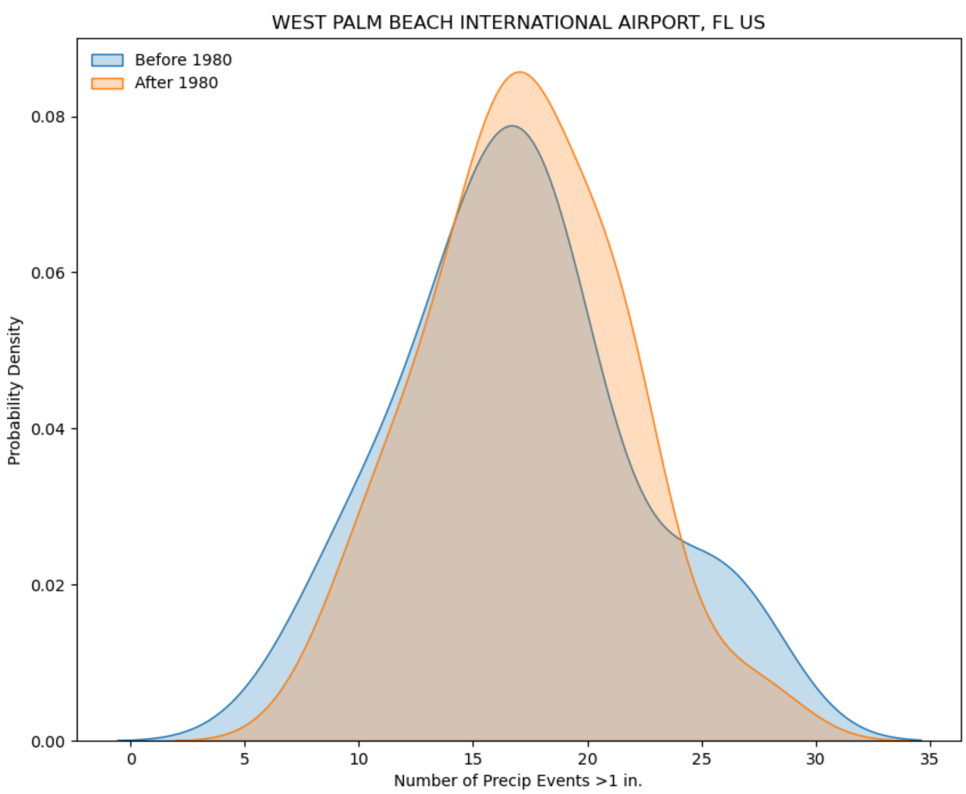


Monroe County



Palm Beach County





Sources: Wet season rainfall trends are provided courtesy of the South Florida Water Management District Resilience Metrics Hub platform. Probability density plots use data from NOAA National Centers for Environmental Information (NCEI).

Projected Rainfall Intensification

Globally, the intensification of extreme rainfall has been widely observed and linked to climate change, with studies confirming increases in heavy precipitation worldwide. Traditional estimates of extreme rainfall often assume a stationary climate, overlooking changes in atmospheric moisture and other meteorological factors. Research indicates that extreme daily precipitation has risen over the past six decades and is expected to continue increasing, with intensities scaling approximately 7% or higher per degree Celsius of warming, following the Clausius-Clapeyron (CC) relationship. However, this scaling rate varies by region, temperature, and moisture availability, with some areas experiencing precipitation increases at rates exceeding 7%. Short-duration storms are projected to see the most significant intensification, heightening flood risks, particularly in arid regions. While thermodynamic changes driving increased atmospheric moisture are well understood, uncertainties remain regarding dynamic effects such as storm intensity, updraft within a storm, and the influence of large-scale atmospheric circulation.

Communities in Southeast Florida frequently experience flooding due to heavy rainfall, and future conditions may worsen due to changing patterns of rainfall extremes. Historically, engineers and policymakers have relied on "design storms" derived from past data, but research indicates that these methods are unreliable for predicting future rainfall patterns as they fail to account for changing rainfall intensity due to a warmer atmosphere and assume the historical climate data will provide the basis for future conditions. Poorly or under-designed drainage systems may fail under increasing rainfall intensity, leading to frequent flooding and infrastructure damage.

The U.S. Geological Survey (USGS), in collaboration with the South Florida Water Management District (SFWMD) and Florida International University (FIU), has expanded studies statewide to support stormwater infrastructure planning. While climate models still contain uncertainties, approaches that use Change Factors (CFs, adjustments to rainfall intensity) help to account for future conditions. Change factors greater than 1.0 (one) represent future rainfall increase, and less than 1.0 (one) represent rainfall decrease for a given event. The USGS released statewide CFs in 2023 to assist in flood resilience planning. The estimates of Change Factors are available from the USGS Data Release,[6] and they cover a range of Representative Concentration Pathways (RCPs) associated with projected climate model datasets, event durations, and return periods for several locations throughout the state. A rainfall return period is the likelihood that a similar rainfall event will occur an equal number of times, or be exceeded a certain number of times, each year or over a range of years.[7]

The Florida Flood Hub for Applied Research and Innovation at University of South Florida, established by the State of Florida, is actively engaged in updating statewide Change Factors, with the latest global climate models, and they are expected to be available by the end of 2025. For the South Florida region, SFWMD has published the CFs until the Flood Hub results are available, based on the 2023 USGS study.[8] For the counties in the Southeast Florida region, the median values of CFs have been reproduced in Table 1. The full dataset from SFWMD is available from its Resilience Metrics platform.

Moving forward, probabilistic and physically based regional climate modeling approaches may help address these uncertainties and improve projections of extreme rainfall patterns.

Table 1. Change Factor values for the Southeast Florida region as published by SFWMD

			Return Period (Years)				
County	**Horizon**	**Rainfall Duration (Days)**	**5**	**10**	**25**	**50**	**100**
BROWARD	2020-2059	1	1.09	1.11	1.14	1.18	1.2
		3	1.08	1.1	1.14	1.18	1.21
		7	1.06	1.09	1.12	1.15	1.18
	2050-2089	1	1.11	1.13	1.17	1.21	1.25
		3	1.08	1.12	1.16	1.2	1.23

[6] U.S. Geological Survey. (2023). *Change factors to derive projected future precipitation depth-duration-frequency (DDF) curves at 242 National Oceanic and Atmospheric Administration (NOAA) Atlas 14 stations in Florida (ver 2.0, May 2024)* Caribbean-Florida Water Science Center.

[7] South Florida Water Management District. (2025). *Resilience Metrics Hub: Regional Rainfall.* https://sfwmd-district-resiliency-sfwmd.hub.arcgis.com/apps/c3549ec83ce64ac7ad9205d1256df44c/explore

[8] U.S. Geological Survey. (2023). *Change factors to derive projected future precipitation depth-duration-frequency (DDF) curves at 242 National Oceanic and Atmospheric Administration (NOAA) Atlas 14 stations in Florida (ver 2.0, May 2024).* Caribbean-Florida Water Science Center. https://www.usgs.gov/data/change-factors-derive-projected-future-precipitation-depth-duration-frequency-ddf-curves-242

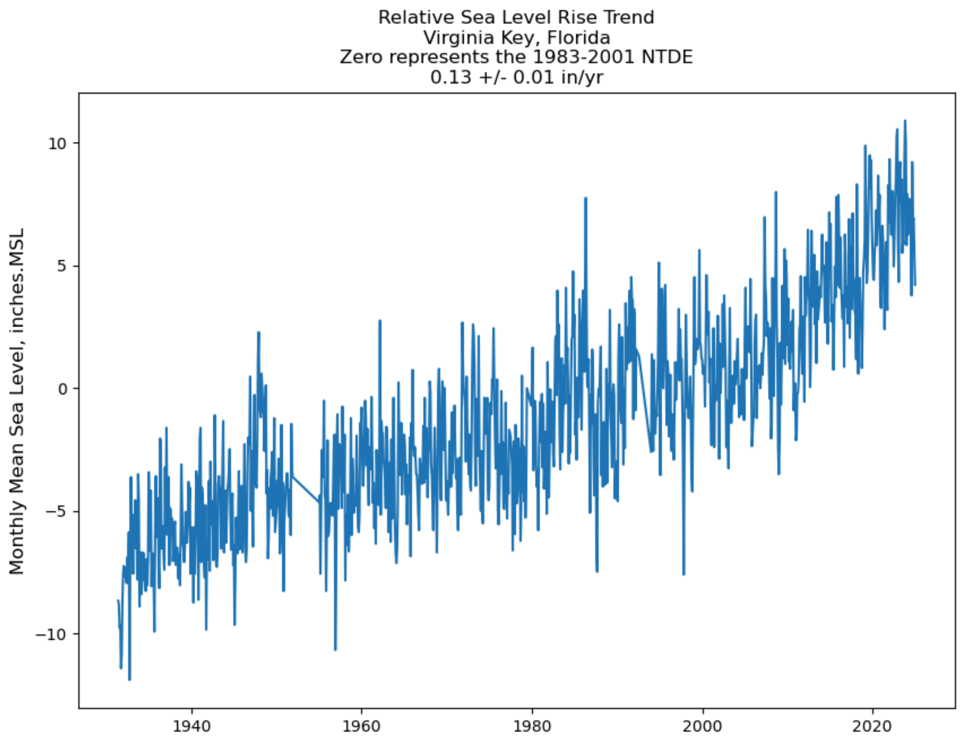
		7	1.06	1.09	1.13	1.165	1.19
MIAMI-DADE	2020-2059	1	1.09	1.12	1.14	1.17	1.19
		3	1.08	1.1	1.14	1.18	1.21
		7	1.06	1.09	1.14	1.18	1.22
	2050-2089	1	1.09	1.12	1.16	1.18	1.21
		3	1.06	1.095	1.14	1.18	1.21
		7	1.05	1.08	1.14	1.18	1.22
MONROE	2020-2059	1	1.08	1.1	1.12	1.13	1.15
		3	1.06	1.08	1.11	1.14	1.16
		7	1.05	1.08	1.11	1.14	1.16
	2050-2089	1	1.08	1.1	1.14	1.16	1.19
		3	1.05	1.07	1.11	1.14	1.18
		7	1.03	1.07	1.1	1.13	1.155
PALM BEACH	2020-2059	1	1.08	1.1	1.12	1.14	1.17
		3	1.08	1.1	1.13	1.15	1.18
		7	1.07	1.09	1.12	1.15	1.17
	2050-2089	1	1.1	1.13	1.17	1.2	1.21
		3	1.09	1.12	1.15	1.17	1.2
		7	1.07	1.09	1.14	1.17	1.19

Sea Level Rise

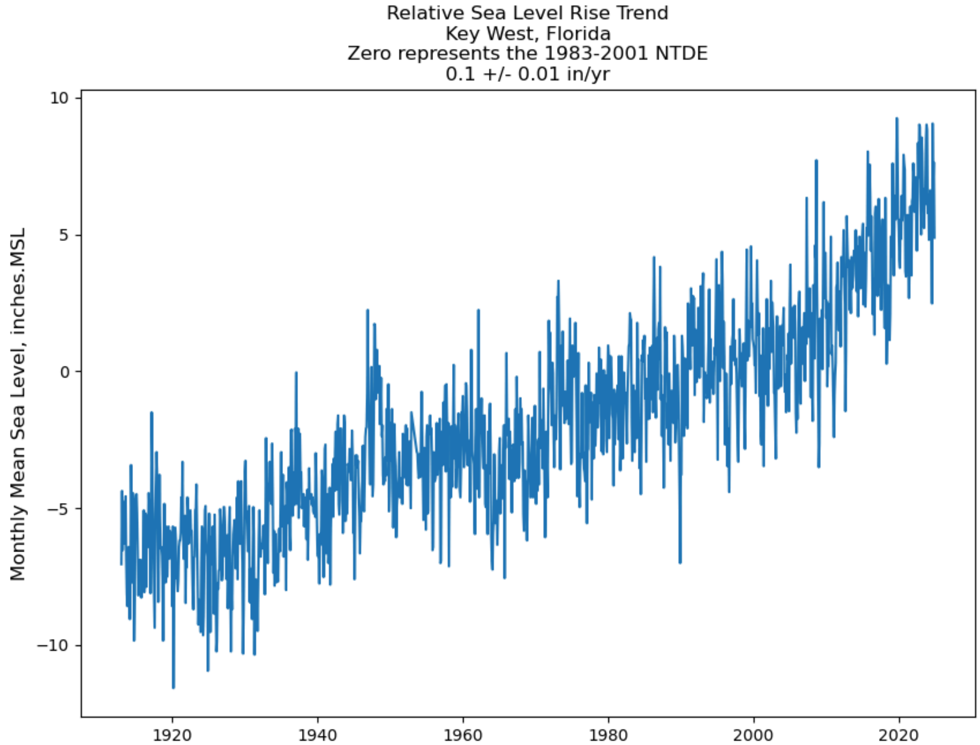
Observed Sea Level Rise

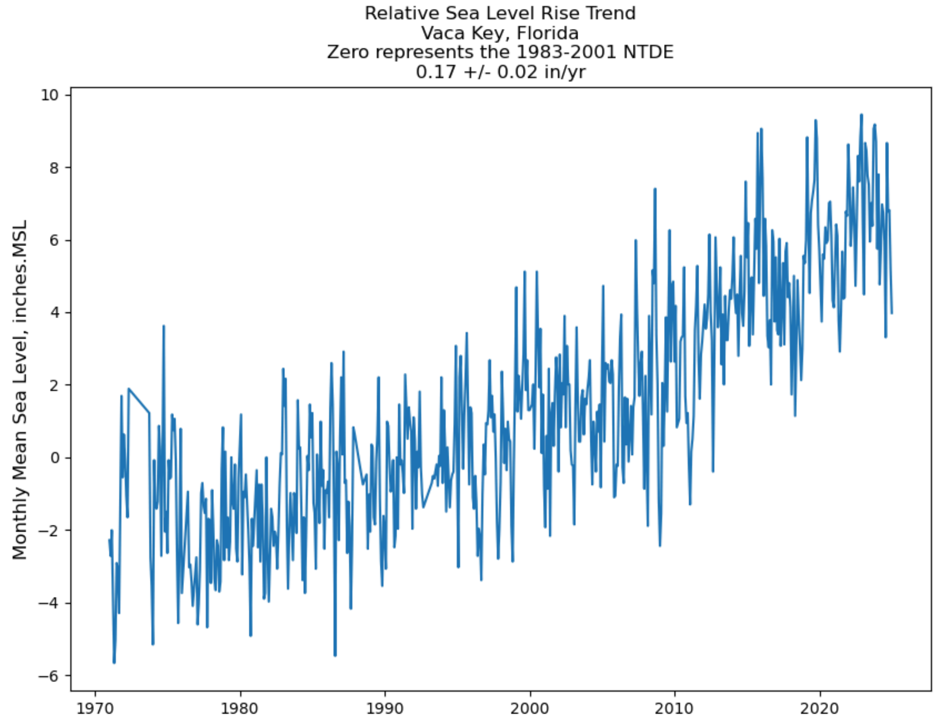
Based on the limited number of National Oceanic and Atmospheric Administration's (NOAA) tide gauges within the Southeast Florida region, and varying records of observation from those gauges, the observed sea level is rising in the range of one to two inches per decade, with a systematic increasing trend of sea level rise across the Compact region. As an example, based on the previous five-year average, the observed sea level rise at the Key West tide gauge from 2000 to 2023 is about six inches. In the period from 2012 to 2023, there was a rapid increase in monthly sea level rise along the Southeast Florida coast. Scientists have not concluded definitively what is causing this observed increase, or whether it is a long-term trend or multi-decadal variability. Observed sea level rise has and will continue to exacerbate the severity and duration of various flood hazards, including King Tides and hurricane storm surge, and negatively impact stormwater drainage infrastructure.

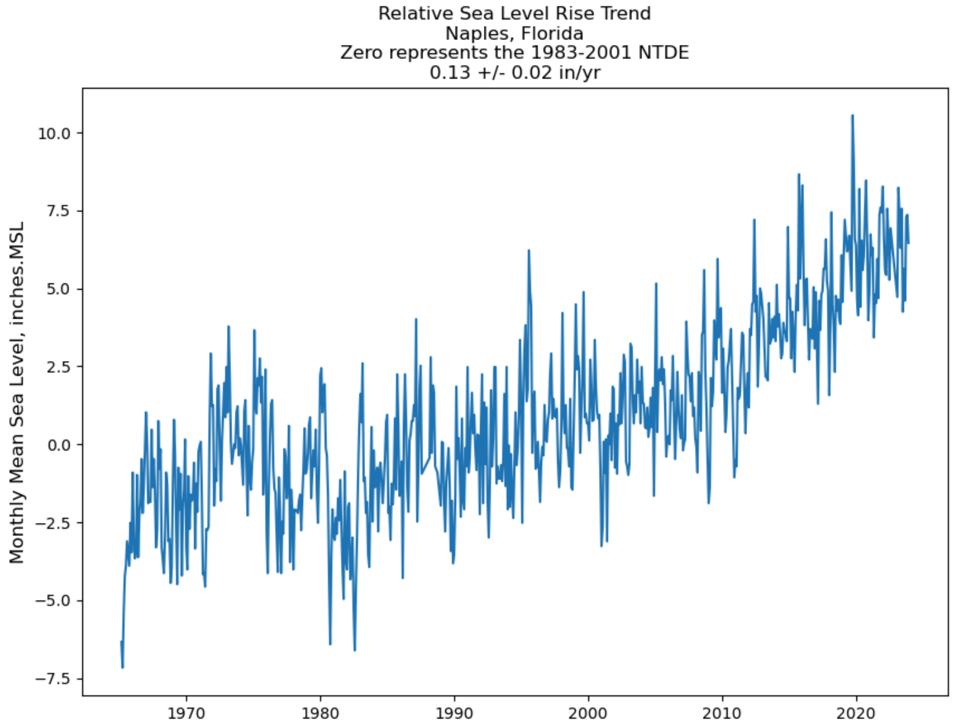
Miami-Dade County



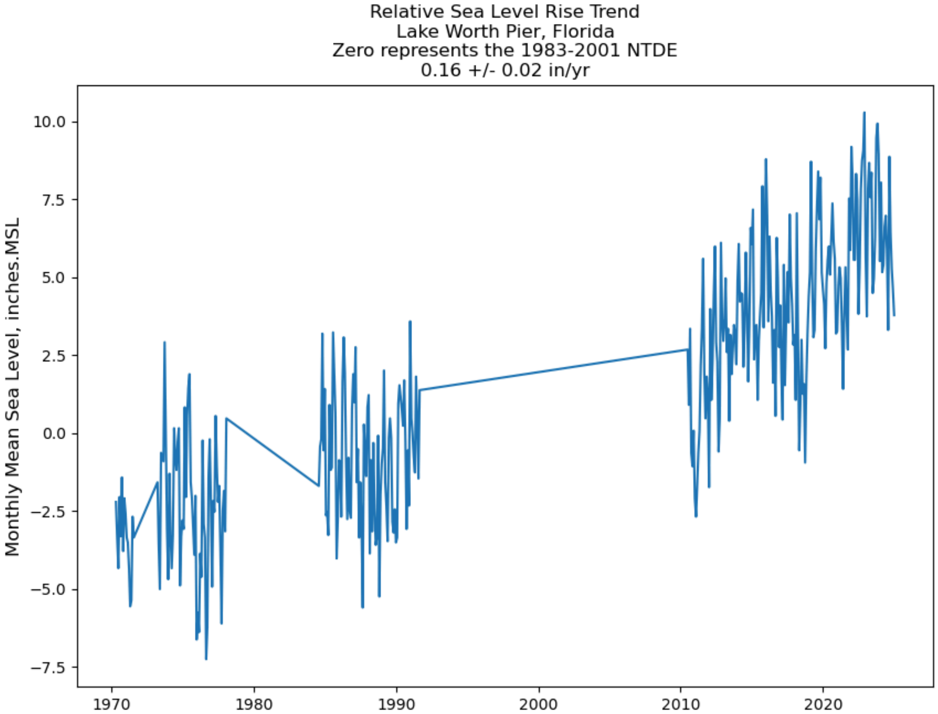
Monroe County




Relative Sea Level Rise Trend
Vaca Key, Florida
Zero represents the 1983-2001 NTDE
0.17 +/- 0.02 in/yr
Monthly Mean Sea Level, inches.MSL
10
8
6
4
2
0
−2
−4
−6
1970
1980
1990
2000
2010
2020


Relative Sea Level Rise Trend
Naples, Florida
Zero represents the 1983-2001 NTDE
0.13 +/- 0.02 in/yr
Monthly Mean Sea Level, inches.MSL
10.0
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
1970
1980
1990
2000
2010
2020

Palm Beach County



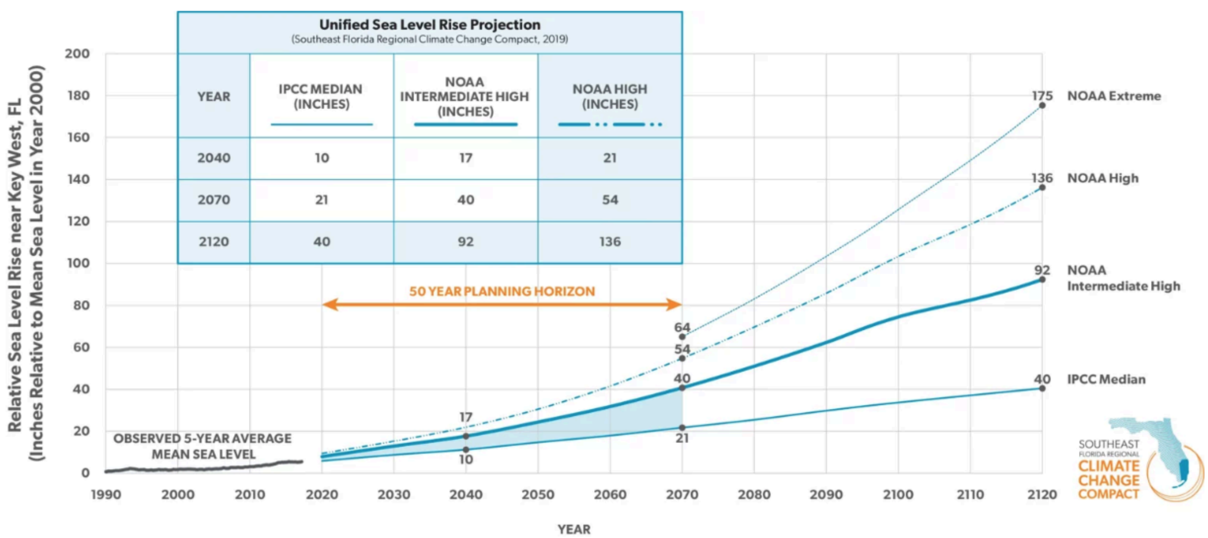
Source: [NOAA, Tides & Currents Relative Sea Level Trends, 2025]

Projected Sea Level Rise

The Compact's Regionally Unified Sea Level Rise Projection for Southeast Florida (updated in 2019) indicates that in the short term, sea level rise is projected to be 10 to 17 inches by 2040 and 21 to 54 inches by 2070 (above the 2000 mean sea level in Key West, Florida). In the long term, sea level rise is projected to be 40 to 136 inches by 2120.

In late 2024, the Compact undertook a review of its 2019 Regionally Unified Sea Level Rise Projection ("2019 Projection") vis-à-vis updates from the NOAA [2022 Sea Level Rise Technical Report](), as well as observational trends in the sea level in the region. Based on the review, the Compact [issued guidance]() for the continued use of the 2019 Regionally Unified Projection in Southeast Florida as a basis for resilience planning, design, and construction.

Projected sea level rise, especially beyond 2070, has a significant range of variation as a result of uncertainty in future greenhouse gas emissions reduction efforts and resulting geophysical effects.



Source: [Unified Sea Level Rise Projection Southeast Florida, 2019.]()

High Tide Flooding

Observed High Tide Flooding

High tide flooding, sometimes referred to as sunny day or nuisance flooding, occurs when sea level rise combines with local factors to push water levels above the normal high tide mark. King Tides are the highest predicted high tides of the year, and the highest tides in the Southeast Florida region occur in the fall, in part because the water is warmer and the seasonal winds drive water levels higher at that time of year. As sea level rises, these extreme high tides are increasing in frequency and length.

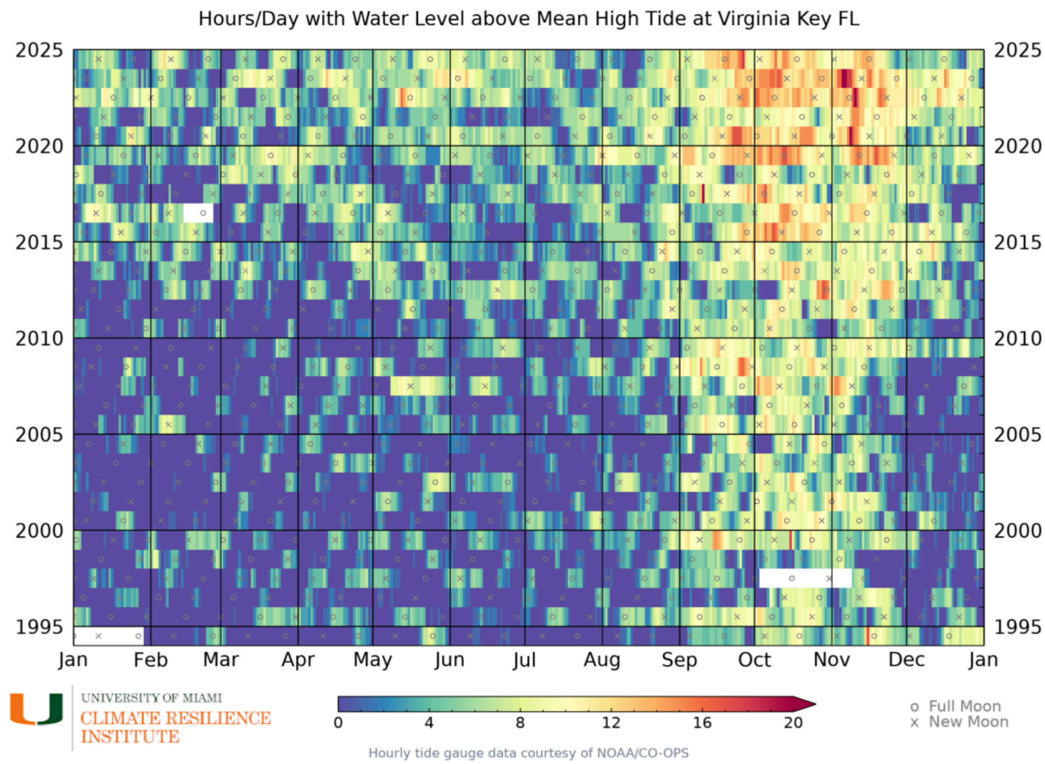
Over the last five to 10 years in the Compact region, increasing occurrences of flooding during King Tide events have been observed across all counties, as demonstrated by the number of hours/day spent with water levels above mean high tide, and the hours/day with peak water levels above the minor flood threshold. This trend is less pronounced at the Lake Worth tidal gauge because the period of record is short (dating back to 2010) in comparison to the other gauges throughout the region. It is expected that these flood events will increase in the future due to accelerating sea level rise.

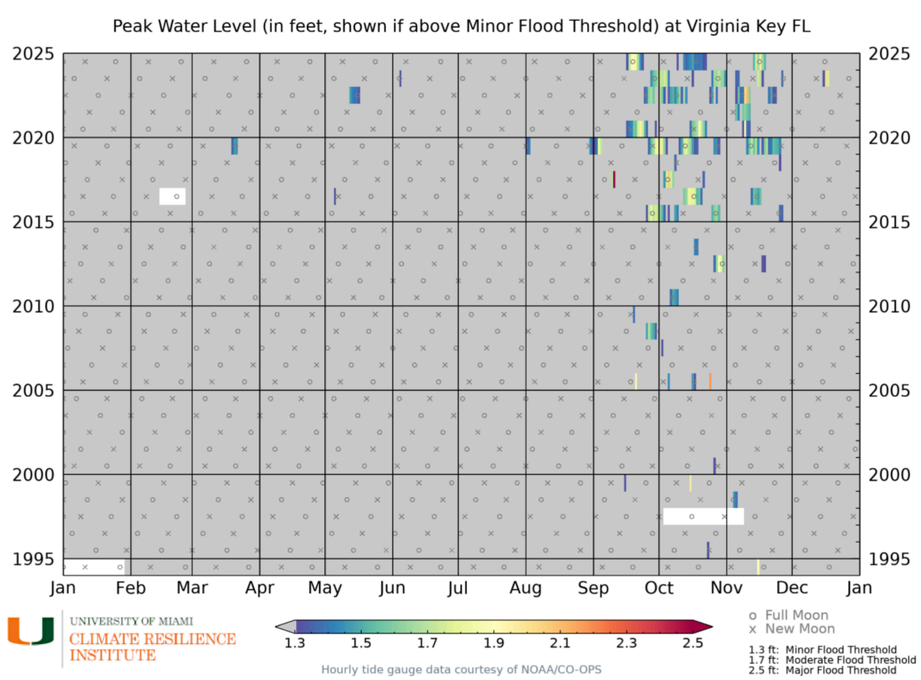
NOAA's National Weather Service (NWS) has established locally relevant minor, moderate, and major flood severity thresholds for dozens of tide gauges along the U.S. coastline. The graphics below use either the station's mean high tide[9] or the NWS's minor flood threshold for each tidal gauge, given that even when the water level is slightly below the "minor flood" threshold, flood impacts can occur in the region. For reference, the table summarizes these values for each tidal gauge location included below.

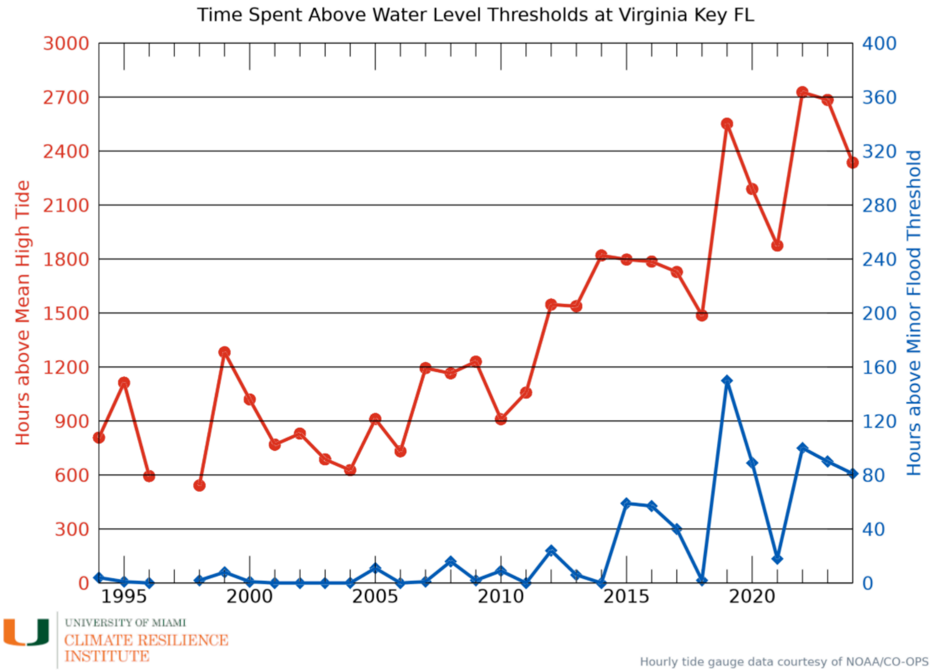
Tide Gauge Location	Mean Higher High Water (MHHW) feet relative to NAVD88	NWS Minor Flood Threshold (feet above MHHW)
Lake Worth (PBC)	0.55	1.3
Virginia Key (MDC)	0.23	1.3
Vaca Key (Monroe)	-0.36	1.1
Key West (Monroe)	0.05	1.1

[9] For the purposes of these indicators, "mean high tide" refers to 1983-2001 mean higher high water (MHHW) at each gauge, the current National Tidal Datum Epoch used by NOAA. MHHW is defined as the average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch. Stated differently, it is the average height of the higher of the two high tides observed each day over a 19-year period.

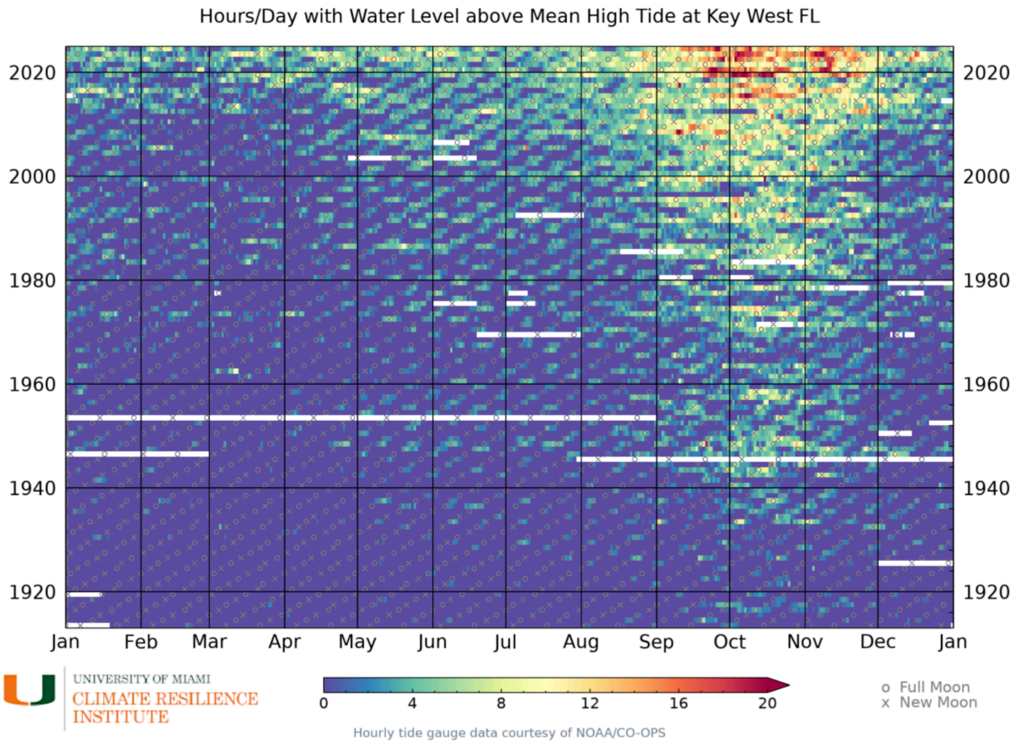
Miami-Dade County

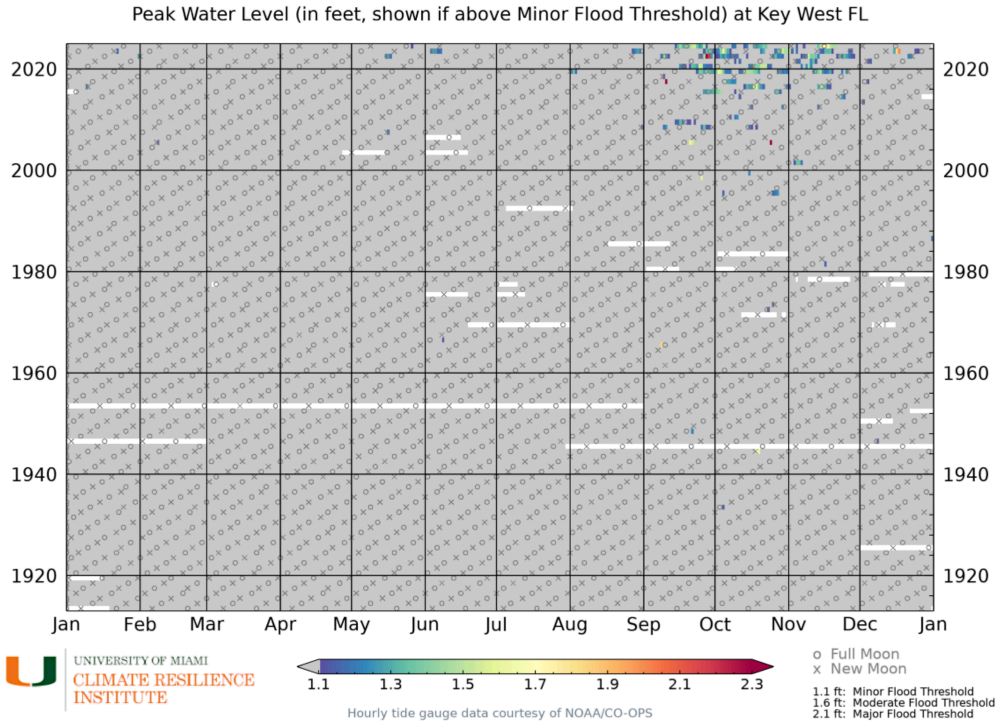




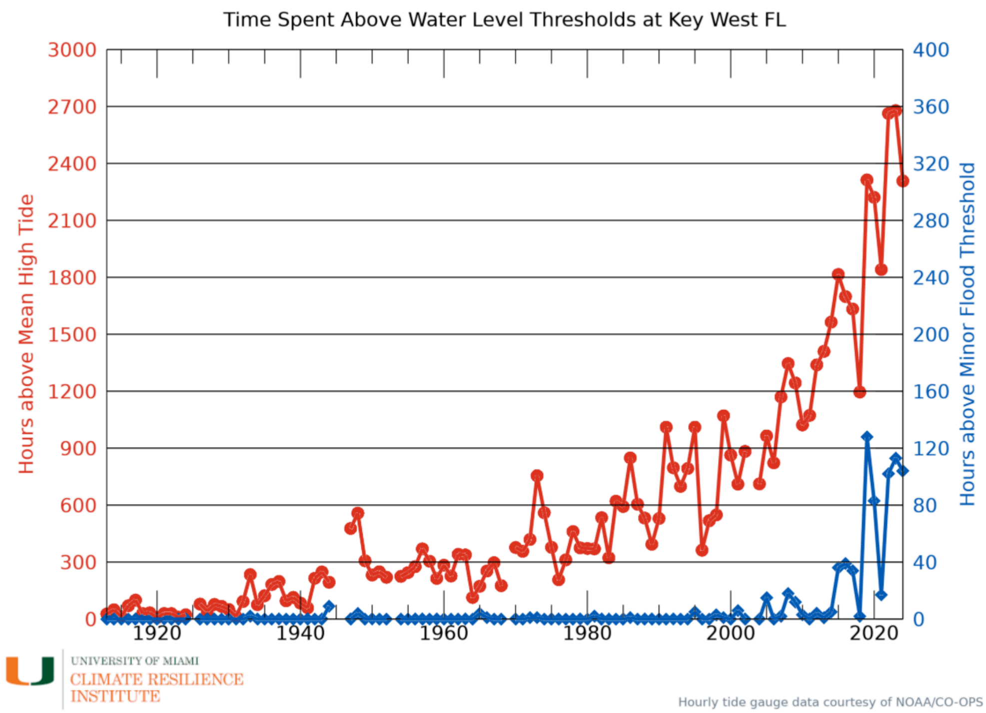


Monroe County

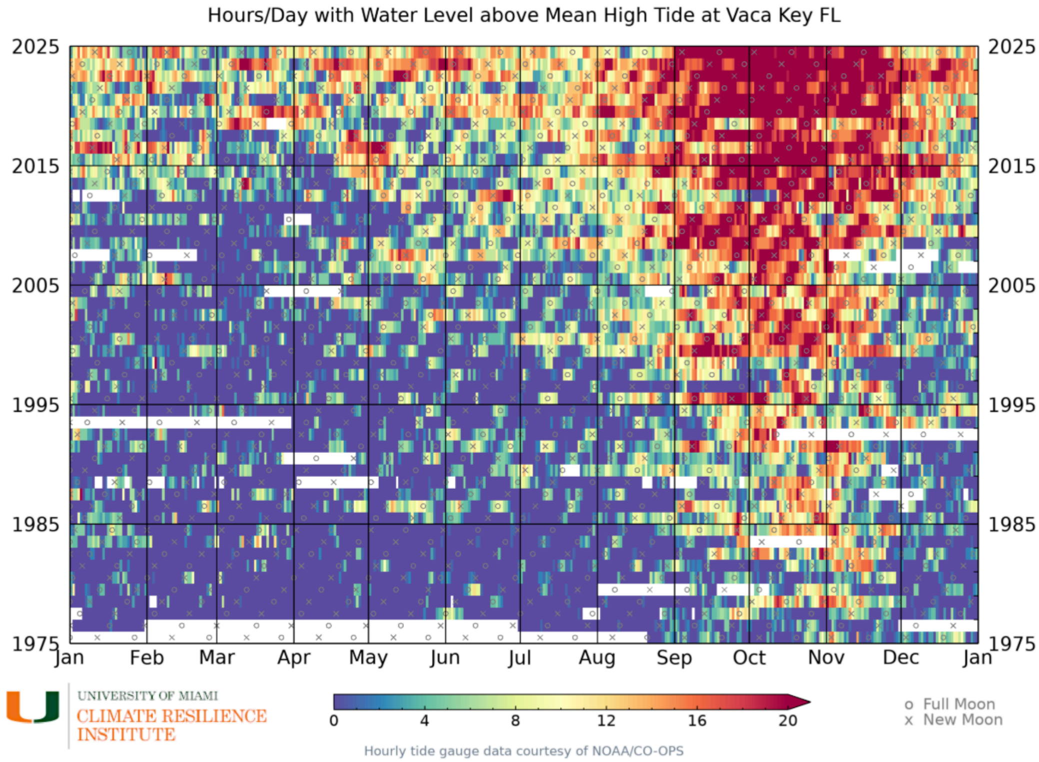


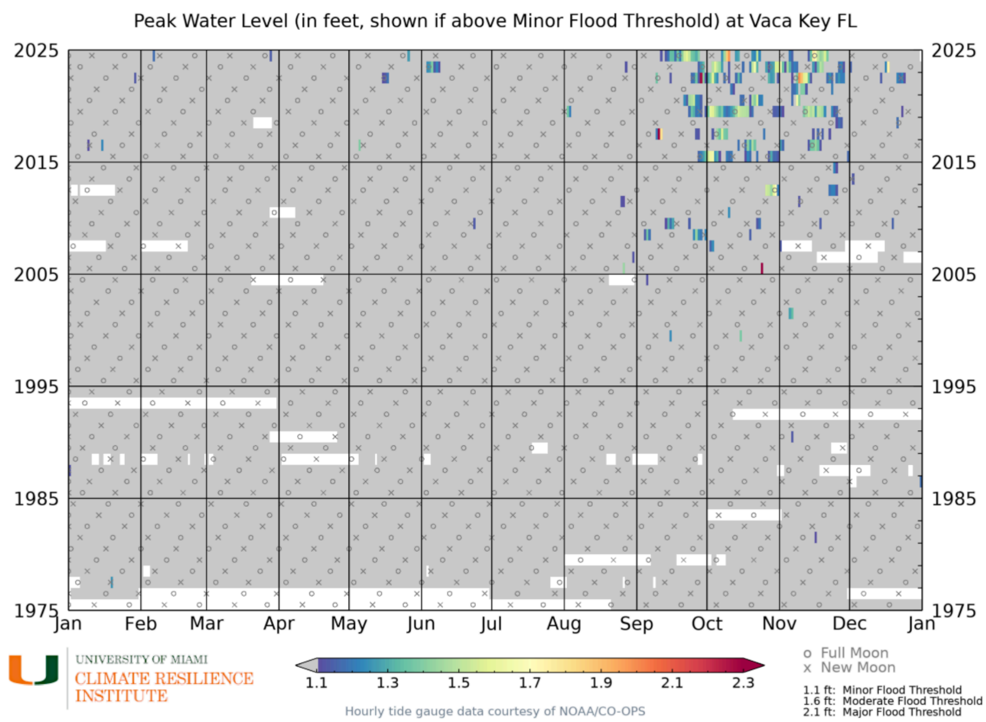


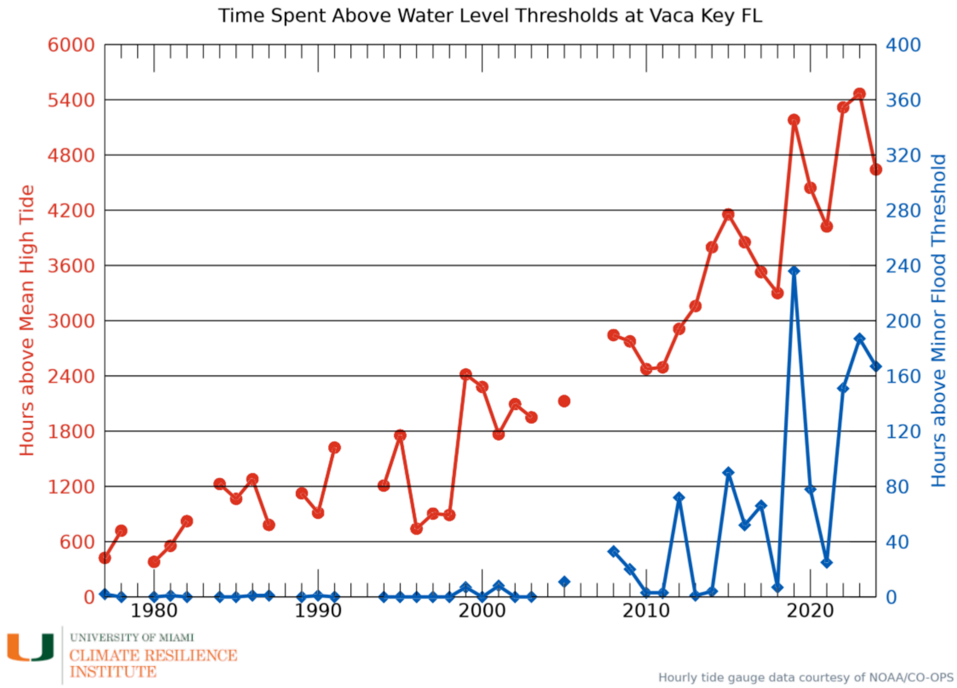
Peak Water Level (in feet, shown if above Minor Flood Threshold) at Key West FL
2020
2000
1980
1960
1940
1920
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
UNIVERSITY OF MIAMI
CLIMATE RESILIENCE INSTITUTE
1.1
1.3
1.5
1.7
1.9
2.1
2.3
Hourly tide gauge data courtesy of NOAA/CO-OPS
o Full Moon
x New Moon
1.1 ft: Minor Flood Threshold
1.6 ft: Moderate Flood Threshold
2.1 ft: Major Flood Threshold



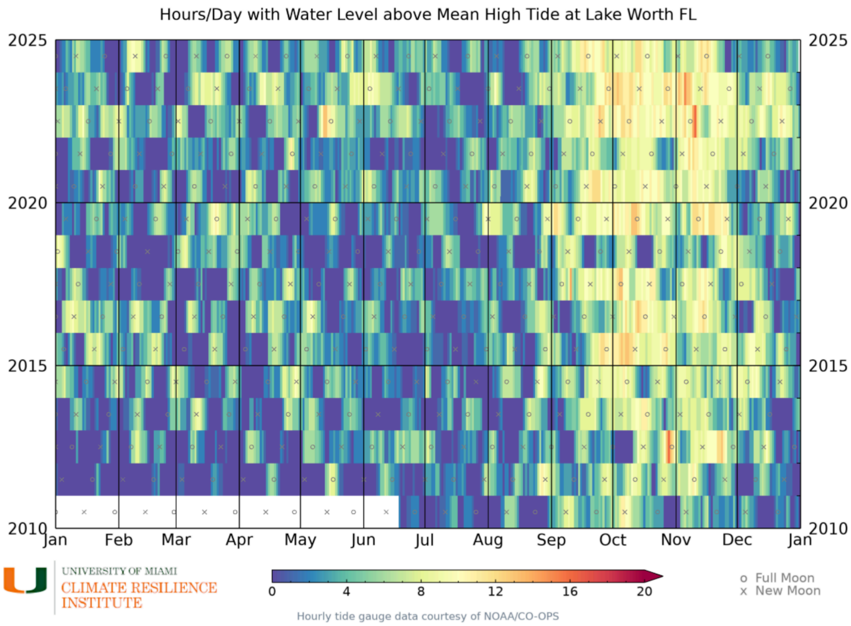
Time Spent Above Water Level Thresholds at Key West FL
Hours above Mean High Tide
Hours above Minor Flood Threshold
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
400
360
320
280
240
200
160
120
80
40
0
1920
1940
1960
1980
2000
2020
UNIVERSITY OF MIAMI
CLIMATE RESILIENCE INSTITUTE
Hourly tide gauge data courtesy of NOAA/CO-OPS

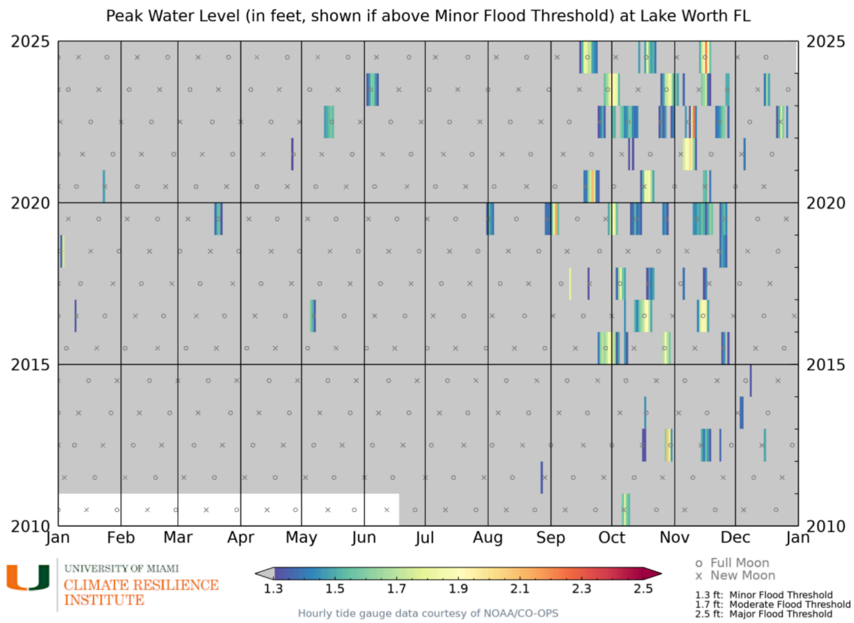

Hours/Day with Water Level above Mean High Tide at Vaca Key FL
2025
2015
2005
1995
1985
1975
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
UNIVERSITY OF MIAMI
CLIMATE RESILIENCE INSTITUTE
0 4 8 12 16 20
o Full Moon
x New Moon
Hourly tide gauge data courtesy of NOAA/CO-OPS

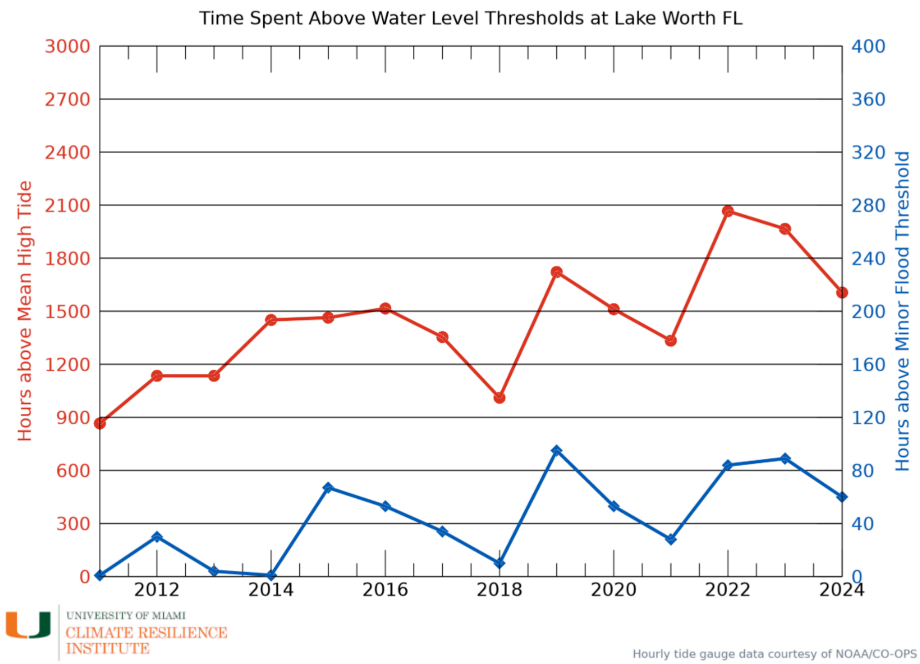

Peak Water Level (in feet, shown if above Minor Flood Threshold) at Vaca Key FL
2025
2015
2005
1995
1985
1975
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
UNIVERSITY OF MIAMI
CLIMATE RESILIENCE INSTITUTE
1.1 1.3 1.5 1.7 1.9 2.1 2.3
o Full Moon
x New Moon
1.1 ft: Minor Flood Threshold
1.6 ft: Moderate Flood Threshold
2.1 ft: Major Flood Threshold
Hourly tide gauge data courtesy of NOAA/CO-OPS



Palm Beach County





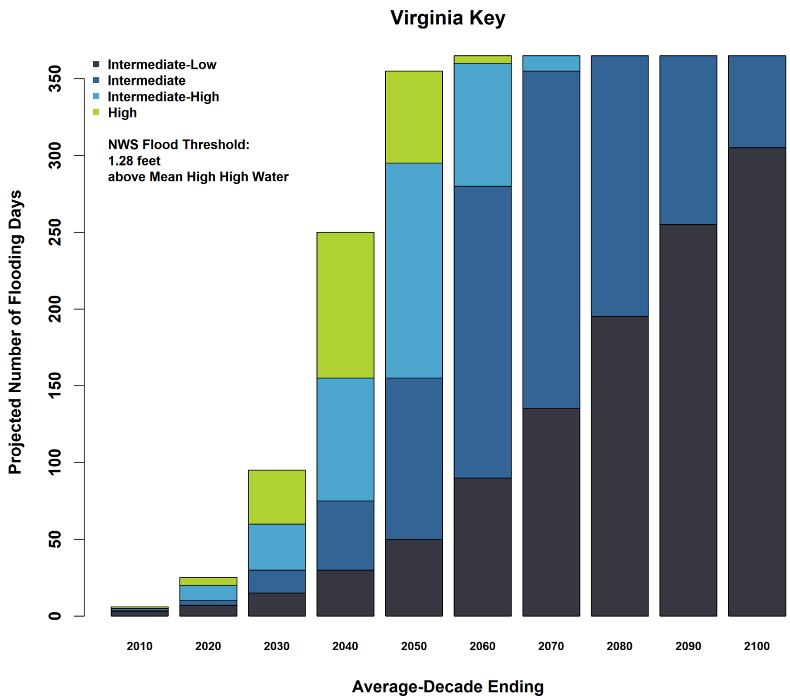


Source: NOAA's Center for Operational Oceanographic Products and Services (CO-OPS), [Tides and Currents](). The above charts are provided courtesy of the University of Miami's Climate Resilience Institute, 2025.

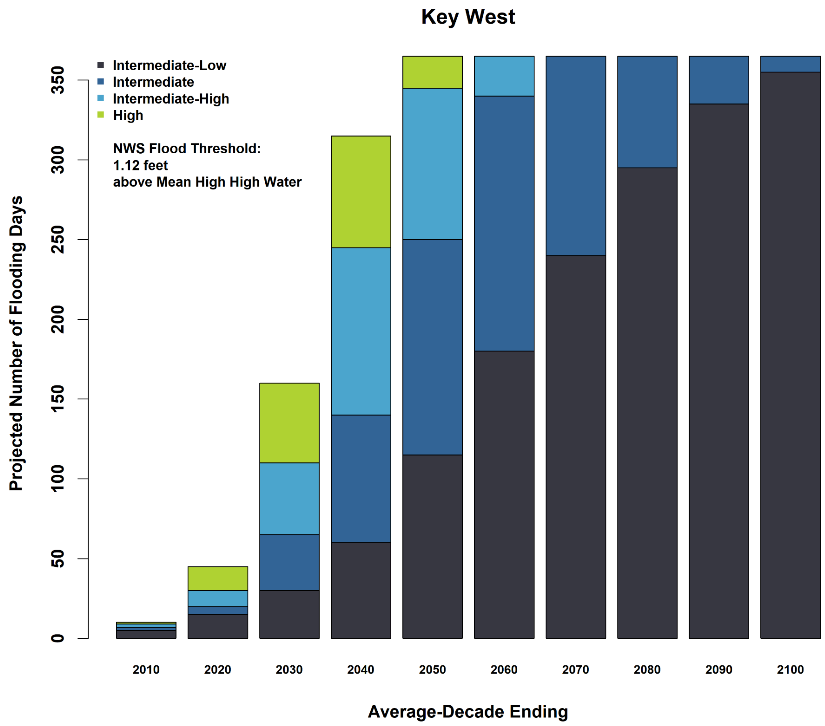
Projected High Tide Flooding

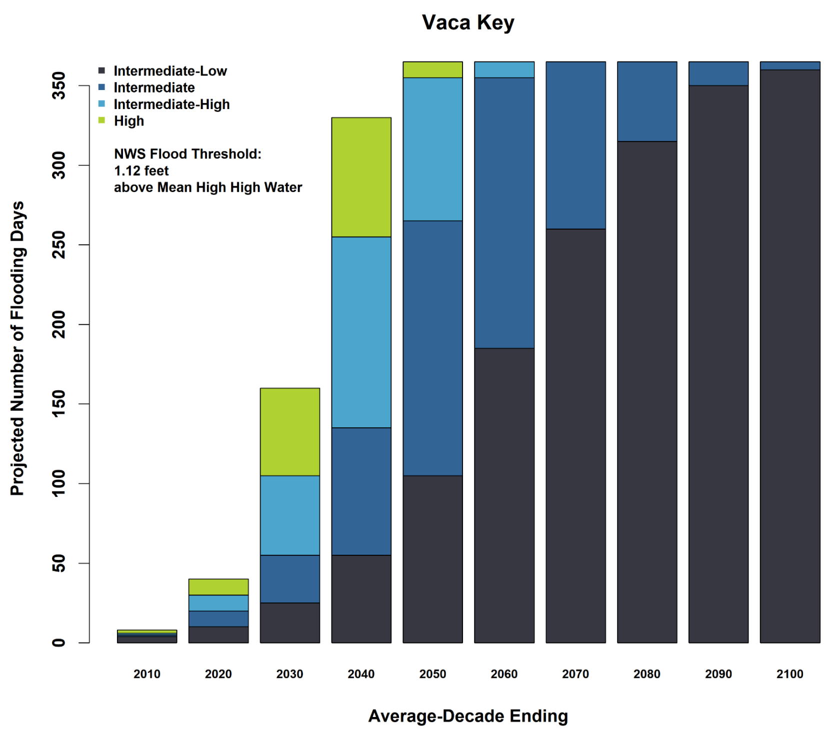
The charts show the projected number of flooding days at tidal gauges in Miami-Dade and Monroe counties, by county, from 2010 to 2100. Note that the scenarios within charts (i.e., “intermediate-low”, “intermediate”, “intermediate-high,” etc.) correspond to the sea level rise projection curves for Southeast Florida. For the below projections, a “flooding day” is considered when the daily maximum exceeds the NWS minor flood threshold. Typically, high tide flooding occurs when the tides exceed the mean higher high water (essentially the average high tides) by a certain amount, depending on the topography of the specific location.

Miami-Dade County



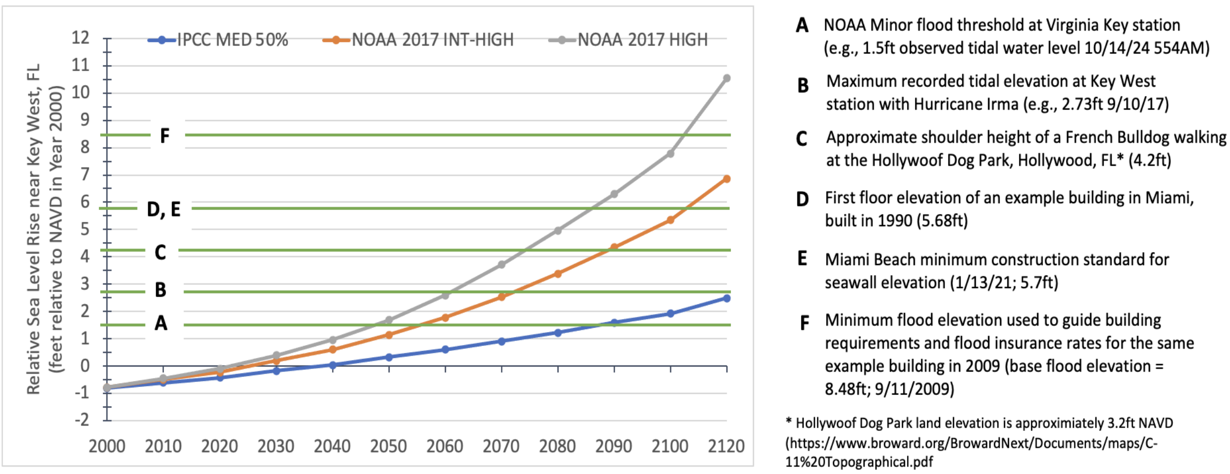
Monroe County





Source: Data computed and provided by William Sweet, NOAA.

In order to help contextualize sea level rise and high tide flooding, the chart below illustrates the sea level rise projections and the NOAA NWS minor flood threshold (Virginia Key station) relative to the built environment and various planning standards, such as base flood elevation, first floor elevation, and seawall elevation within the region.



Saltwater Intrusion

Saltwater intrusion is caused by either increasing sea levels, a reduction in inland freshwater levels, excessive groundwater pumping, or a combination of any of these factors. Lateral intrusion of saltwater from the coast is the most likely type of saltwater intrusion, particularly along Florida's coastline. The boundary between fresh groundwater and saltwater is known as the saltwater interface. Maintaining freshwater levels or ensuring discharges to the coast prevents landward encroachment of saltwater. Saltwater intrusion can lead to contamination of coastal drinking water supplies, and in severe cases, well abandonment. Over time, saltwater has continued to intrude inland in South Florida, compromising some well fields. Significant population growth in Southeast Florida over the last several decades, combined with sea level rise, requires careful monitoring and adaptation strategies for water supply in the region.

While groundwater salinity monitoring of the Biscayne aquifer goes as far back as 1939, the South Florida Water Management District (SFWMD) began mapping the approximate location of the saltwater interface in 2009, updating maps every 5 years.[10] In the Compact region, the

[10] South Florida Water Management District. (2020). *Saltwater Interface Monitoring and Mapping Program, Technical Publication WS-58*. https://www.sfwmd.gov/sites/default/files/documents/ws-58_swi_mapping_report_final.pdf

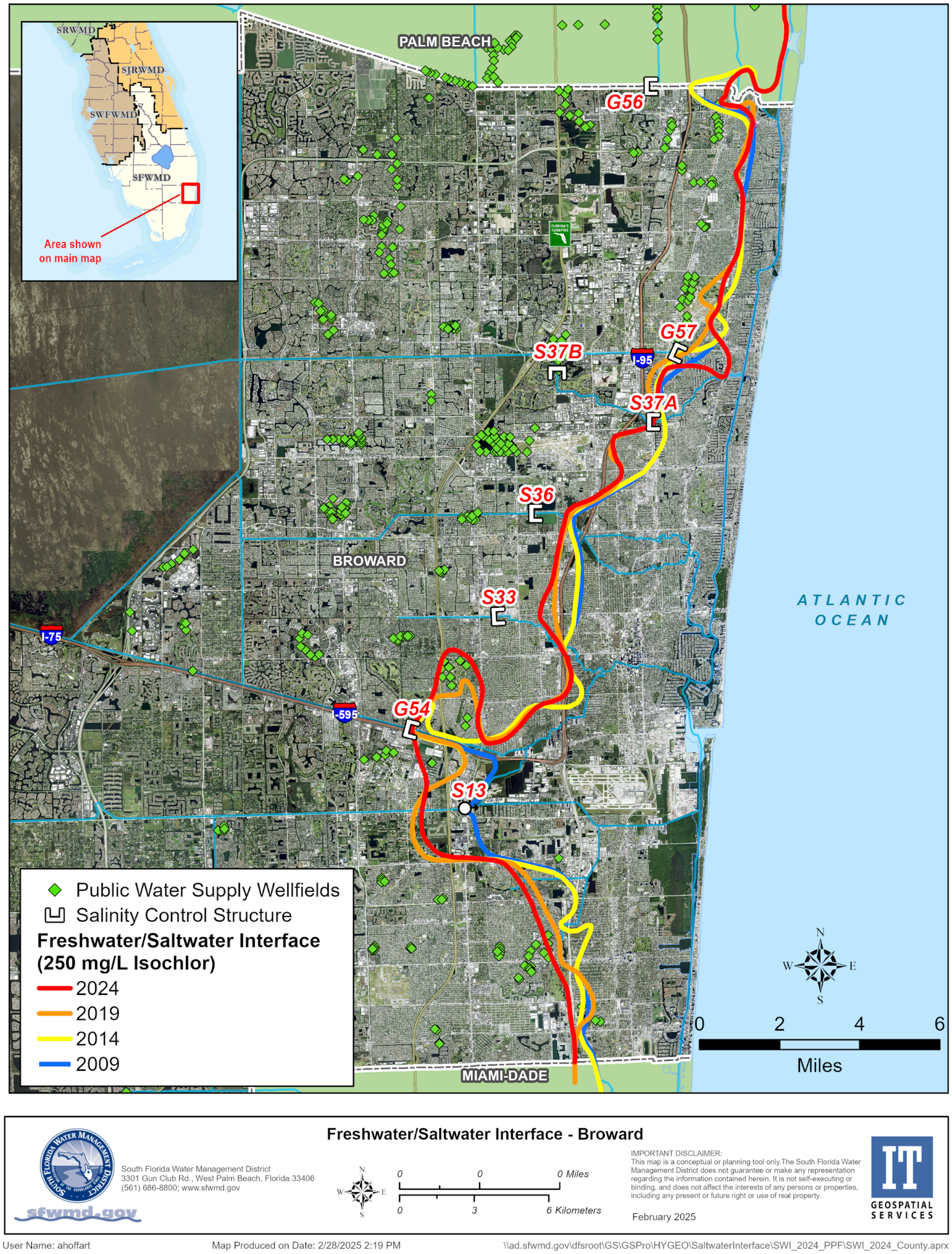
SFWMD maintains maps for Palm Beach and Broward counties, and the U.S. Geological Survey (USGS) conducts saltwater interface mapping for Miami-Dade and Monroe counties. The maps show the extent of saltwater intrusion over the period of record from sites monitored in Southeast Florida. For further information, please visit the SFWMD story map on saltwater intrusion.

In addition, the USGS Water Level and Salinity Analysis Mapper online tool provides automated statistical and graphical analyses on (ground)water-level and salinity data collected from sites monitored by the USGS in South Florida. The tool includes five- and 20-year trends, illustrating a variety of localized upward and downward trends in the region, as well as the approximate inland extent of saltwater intrusion, since 2011.

Source: Data is from the South Florida Water Management District and the U.S. Geological Survey. Maps are provided courtesy of the South Florida Water Management District, 2025

Broward County, Freshwater/Saltwater Interface

It is likely that considerable saltwater intrusion occurred in Broward County following the drainage of the Everglades. By 1945, seawater had already intruded approximately one mile inland in southern Broward County. The construction of salinity control structures since the mid-1950s has been relatively effective in slowing the progression of the saltwater front, though the proximity of some wellfields to the coast continues to lead to salinized wells that generally have to be abandoned. Saltwater intruded inland about one mile between 2009 and 2019 west of Fort Lauderdale-Hollywood International Airport near the salinity control structure S-13. In the 2024 updated maps, there is landward advancement of the saltwater front near the Peele Dixie wellfield in Fort Lauderdale, which may be partially as a result of changes in data and new data points used to produce the maps. Sea level rise is likely to contribute to further saltwater intrusion, depending on pumping and water management.



PALM BEACH
BROWARD
MIAMI-DADE
ATLANTIC OCEAN
G56
G57
S37B
S37A
S36
S33
G54
S13
I-95
I-75
I-595
SRWMD
SJRWMD
SWFWMD
SFWMD
Area shown on main map
Public Water Supply Wellfields
Salinity Control Structure
Freshwater/Saltwater Interface (250 mg/L Isochlor)
2024
2019
2014
2009
0 2 4 6
Miles
Freshwater/Saltwater Interface - Broward
South Florida Water Management District
3301 Gun Club Rd., West Palm Beach, Florida 33406
(561) 686-8800; www.sfwmd.gov
sfwmd.gov
0 0 0 Miles
0 3 6 Kilometers
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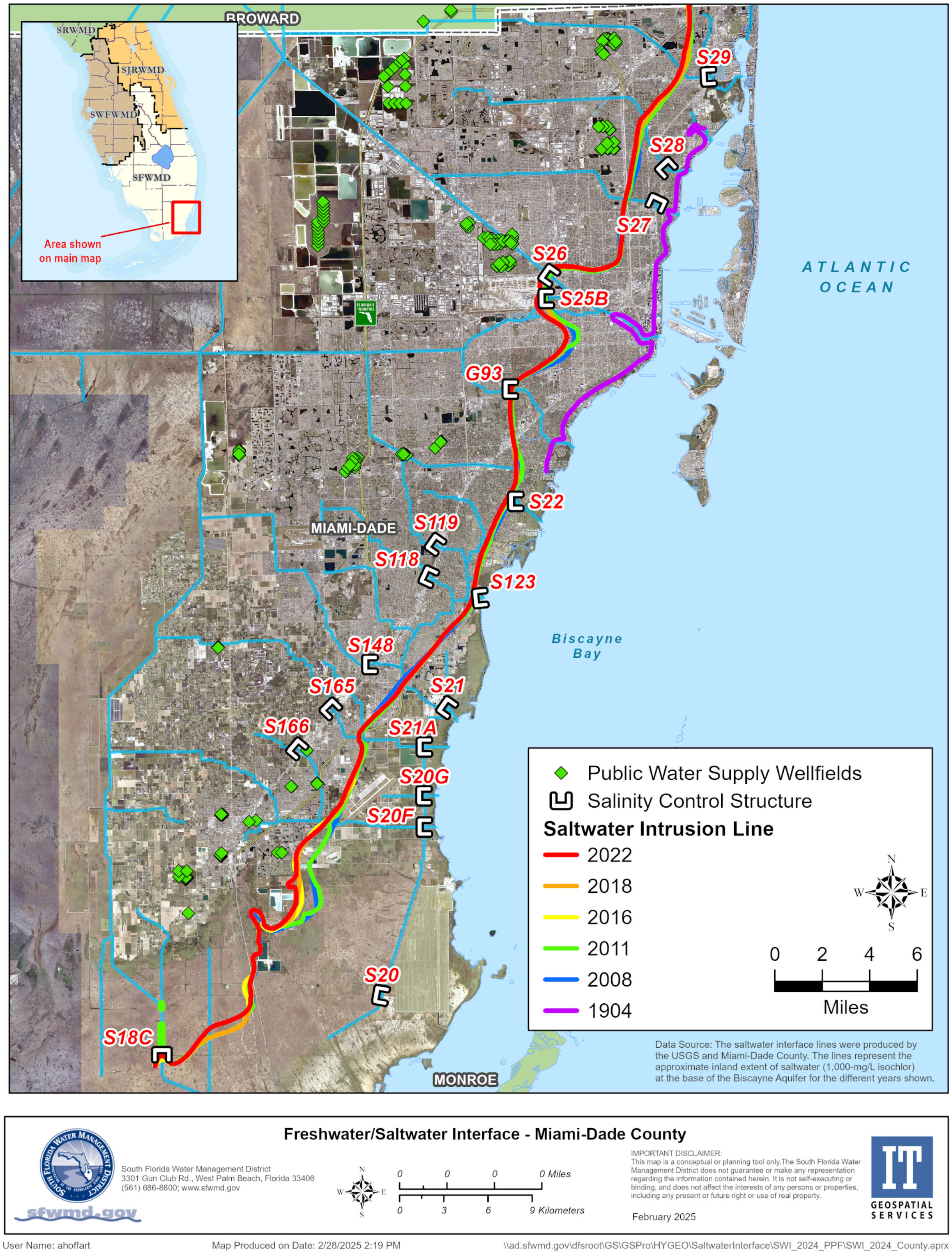
Miami-Dade County, Freshwater/Saltwater Interface

Saltwater intrusion has occurred since the drainage of the Everglades and the earliest days of groundwater withdrawal for the population of Miami-Dade County. The county's primary water supply is the Biscayne Aquifer, which is particularly susceptible to saltwater intrusion because of its proximity to saltwater bodies and because the land-surface altitude for about 70% of the county is below 1.8 meters.[11] By 1904 (purple line), several early wells had to be abandoned. However, the construction of salinity barriers in the canals and control of groundwater levels over the years have largely halted the further inland movement of the saltwater front across most of the county, with the exception of an area of southeastern Miami-Dade County, referred to as the Model Land Area. In 2018, USGS, in cooperation with Miami-Dade County, mapped the approximate inland extent of saltwater intrusion in Miami-Dade County and estimated the average rate of movement of the saltwater interface in the Model Land Area. The 2018 approximation of the inland extent of the saltwater interface at the base of the Biscayne Aquifer is, in most areas, farther inland than that which was mapped in 2011. Little change is seen between the 2016 front (yellow) and 2022 front (red) in most areas.

[11] U.S. Geological Survey and Miami-Dade County. (2019). *Map of the approximate inland extent of saltwater at the base of the Biscayne aquifer in Miami-Dade County, Florida, 2018: U.S. Geological Survey Scientific Investigations Map 3438*. U.S. Department of Interior. https://pubs.usgs.gov/sim/3438/sim3438_pamphlet.pdf


BROWARD
SRWMD
SJRWMD
SWFWMD
SFWMD
Area shown on main map
ATLANTIC OCEAN
Biscayne Bay
MIAMI-DADE
MONROE
S29
S28
S27
S26
S25B
G93
S22
S119
S118
S123
S148
S165
S21
S166
S21A
S20G
S20F
S20
S18C
Public Water Supply Wellfields
Salinity Control Structure
Saltwater Intrusion Line
2022
2018
2016
2011
2008
1904
N
S
E
W
0 2 4 6
Miles
Data Source: The saltwater interface lines were produced by the USGS and Miami-Dade County. The lines represent the approximate inland extent of saltwater (1,000-mg/L isochlor) at the base of the Biscayne Aquifer for the different years shown.
Freshwater/Saltwater Interface - Miami-Dade County
South Florida Water Management District
3301 Gun Club Rd., West Palm Beach, Florida 33406
(561) 686-8800; www.sfwmd.gov
sfwmd.gov
0 0 0 0 Miles
0 3 6 9 Kilometers
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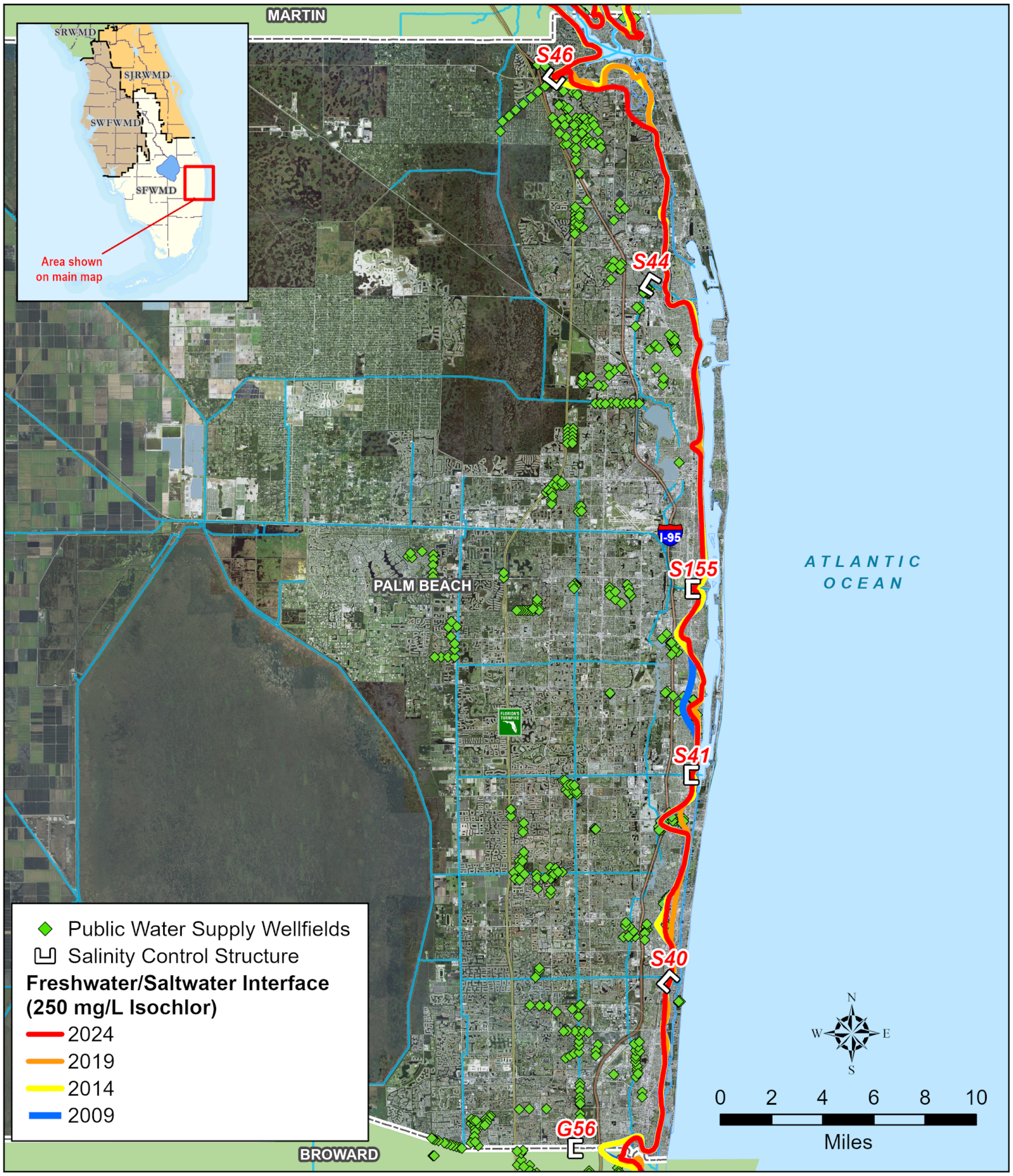
Palm Beach County, Freshwater/Saltwater Interface

Saltwater intrusion has been limited to less than one mile inland in much of Palm Beach County. Comparison of the lines below suggests that the saltwater interface has actually moved seaward in some areas between 2009/2014 and 2024. This is likely due to moving pumping centers further inland and extracting water from the deeper aquifer, although it may also be partially a result of changes in data and new data points used to produce the maps.



Freshwater/Saltwater Interface - Palm Beach

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0 3 6 Miles
0 5 10 Kilometers

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February 2025

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Sea Surface Temperature

Observed Sea Surface Temperature

More than 90% of the excess heat associated with warming that has happened on Earth over the past 50 years has been transferred to the ocean. As the oceans absorb more heat, sea surface temperature increases, and the ocean circulation patterns that transport warm and cold water around the globe change. In Southeast Florida, fluctuations in sea surface temperature, both high and low, have implications for the health of marine life, particularly corals, which are highly sensitive to temperature changes. According to Coral Reef Watch, the threshold for coral bleaching is one degree Celsius (1°C) above the Max Monthly Mean;[12] however, new research indicates that the bleaching threshold for Florida is increasing by almost 1°C over the last decade, which is about 10x faster than any other previous estimates from anywhere else in the world.[13] In 2023, the warmest ever sea surface temperature was recorded, with a sensor in Manatee Bay near Everglades National Park recording 101.1°F.[14] Prolonged elevated water temperatures in 2023 resulted in the most significant coral bleaching event recorded in Florida, with many reefs having 100% of the corals bleached.[15] Coral reefs in Florida have enormous economic value, underpinning critical industries such as tourism, recreation, and fisheries, while also providing significant coastal protection.

This sea surface temperature data was obtained from NOAA 1/4° Daily Optimum Interpolation Sea Surface Temperature (OISST), which is a long-term climate data record that incorporates observations from different platforms (satellites, ships, buoys, and Argo floats) into a regular global grid. The chart shows the summertime (July, August, September) average sea surface temperature for the south Florida region, encompassing the tip of the Florida peninsula from 1982 to 2024. Over this period, we see an increase in summertime sea surface temperature in the region of nearly half a degree (0.49 °F) per decade. The animated map below the chart is a spatial illustration of the data points in the chart.

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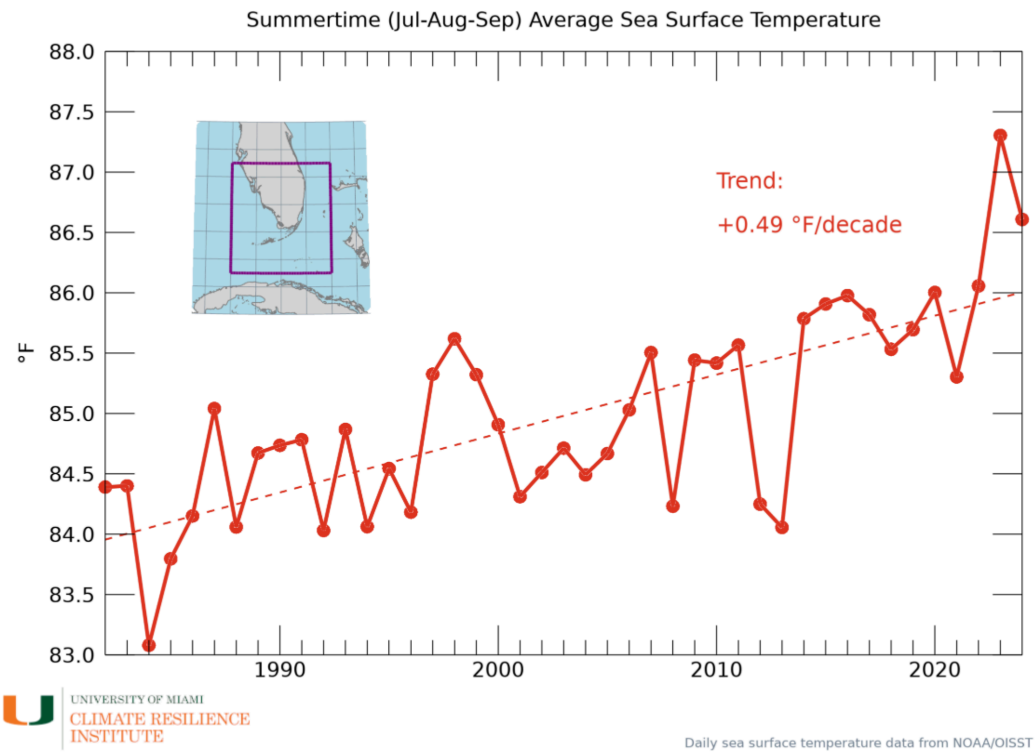
[12] National Environmental Satellite, Data, and Information Service. Coral Reef Watch. *Satellites & Bleaching, Bleaching Threshold.* National Oceanic and Atmospheric Administration. https://coralreefwatch.noaa.gov/product/5km/tutorial/crw08a_bleaching_threshold.php

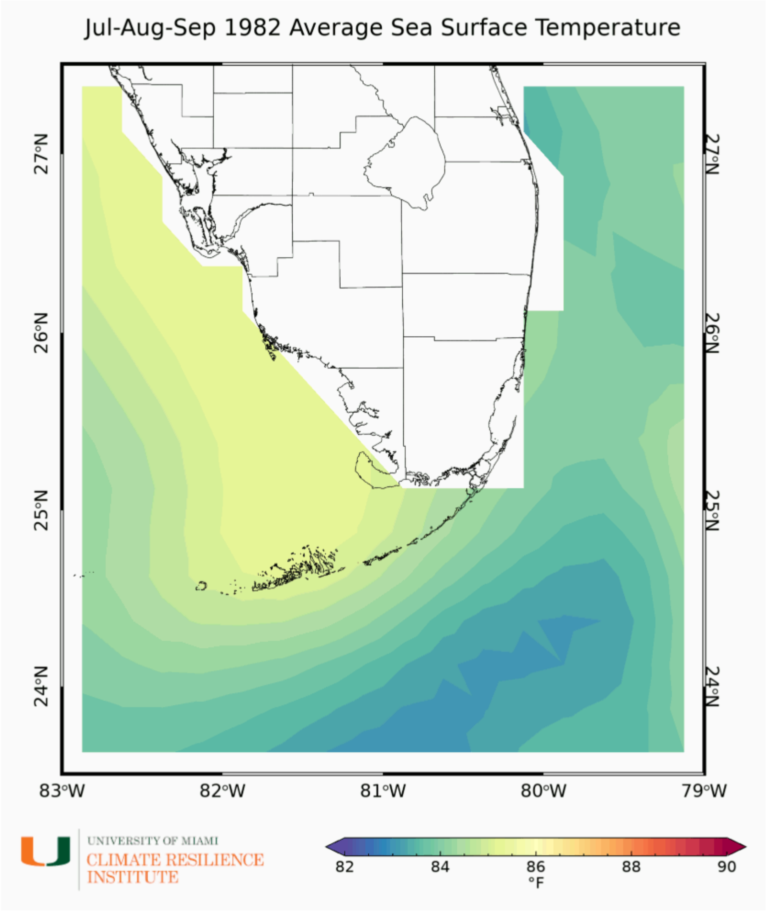
[13] A.Baker, University of Miami/RSMAS, personal email communication, February 25, 2025.

[14] National Environmental Satellite, Data, and Information Service. (2023). *Extreme Ocean Temperatures Are Affecting Florida's Coral Reef.* National Oceanic and Atmospheric Administration. https://www.nesdis.noaa.gov/news/extreme-ocean-temperatures-are-affecting-floridas-coral-reef

[15] Florida Fish and Wildlife Conservation Commission. (2023). *2023 Bleaching Event.* https://myfwc.com/research/habitat/coral/news-information/bleaching/

There is a very close agreement between the trend in the minimum temperature shown in the first figure in the Temperature & Heat Index section (+0.52 °F/decade) and the trend in the regional sea surface temperature shown above (0.49 °F/decade) over the past half century. This strongly suggests that the increasing warmth of the water surrounding South Florida is governing the trend of the overnight low temperatures.

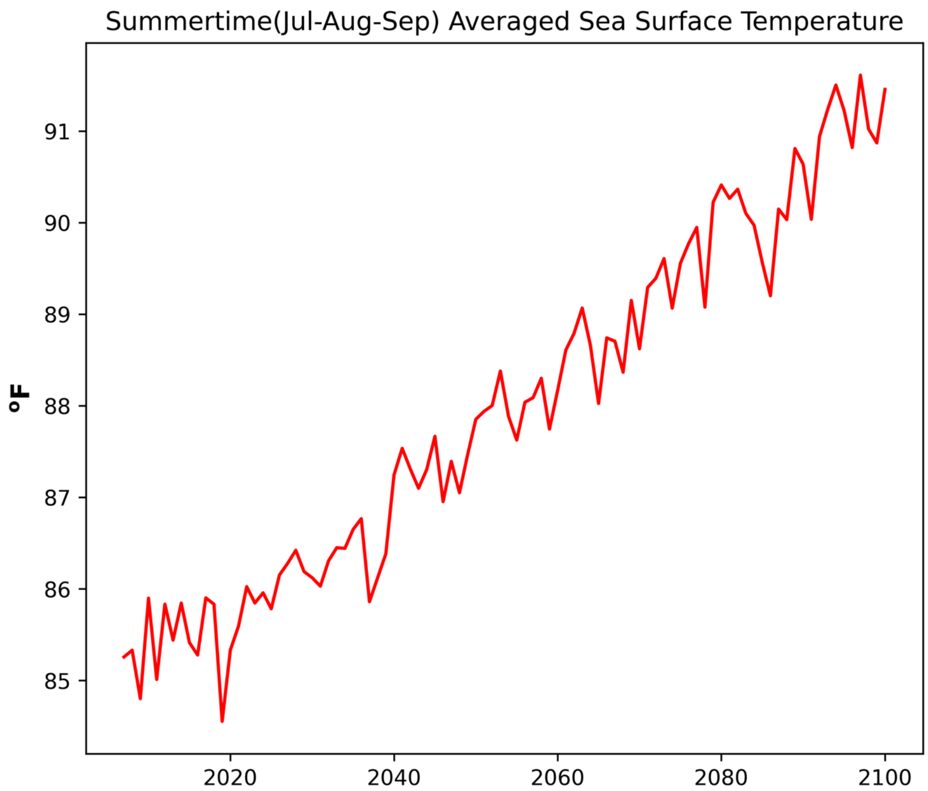




Source: NOAA [Daily Optimum Interpolation Sea Surface Temperature](#) (OISST). The chart and map are provided courtesy of the University of Miami's Climate Resilience Institute, 2025.

Projected Sea Surface Temperature

The chart below shows the averaged projected sea surface temperature for the South Florida peninsula, for the summertime months (July, August, September), from 2007 to 2100. This chart is based on the National Science Foundation National Center for Atmospheric Research (NCAR) [Community Earth System Model](#) (CESM)1.2 run at 0.1 degrees globally and the RCP8.5. RCP8.5 represents a possible future in which global emissions of heat-trapping gases continue to increase through 2100, or what is referred to as a "higher emissions pathway." The chart demonstrates a clear continuation of increasing sea surface temperature, projecting an increase by roughly 6°F by the end of the century.



Source: National Science Foundation National Center for Atmospheric Research (NCAR) [Community Earth System Model](#) (CESM)1.2.