Southeast Florida Climate Indicators

2020 UPDATE

Implementation support provided by: Institute for Sustainable Communities

This collection of climate indicators was created with significant contributions from the Florida Climate Institute, the South Florida Water Management District, Florida International University, University of Miami, University of South Florida, Florida State University, The Nature Conservancy Florida, and staff from the Compact counties.

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Introduction

The physical indicators of climate change are already manifesting in Southeast Florida. While sea level rise frequently receives the most attention in our region, there are several other impacts of a changing climate that have consequences for our communities. Understanding the future evolution of climatic patterns is extremely important for planning and management of agricultural, urban, and environmental systems. Here in Southeast Florida, changes in our climate mean higher temperatures, shifting rainfall patterns, and more frequent extreme rain events. Our seas are rising, causing increased flooding, saltwater intrusion, and cascading socioeconomic challenges as a result. Further, natural systems and coral reefs are being impacted through changing conditions.

The Southeast Florida Regional Climate Change 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. To this end, 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, in partnership with the Florida Climate Institute, the South Florida Water Management District, and other agencies. In 2020, the Compact again enlisted the support of technical experts from across the academic community, relevant agencies, and a non governmental entity to update the climate indicators for Southeast Florida.

Indicators are scientifically-based measurements that track trends in 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 our people, environment, and economy. The Compact intends for this information to help inform practitioners in advancing 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 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 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 have been higher than the previous decades. In each of the four Southeast Florida counties minimum annual temperatures rose 0.5 to 0.6 °F over the past 34 years (1985 to 2019) (NOAA, National Centers for Environmental Information, 2020).

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 table and water supply. The following indicators show changes in temperature, precipitation, sea level, high tide flooding, saltwater intrusion, and sea surface temperature as a result of climate change.

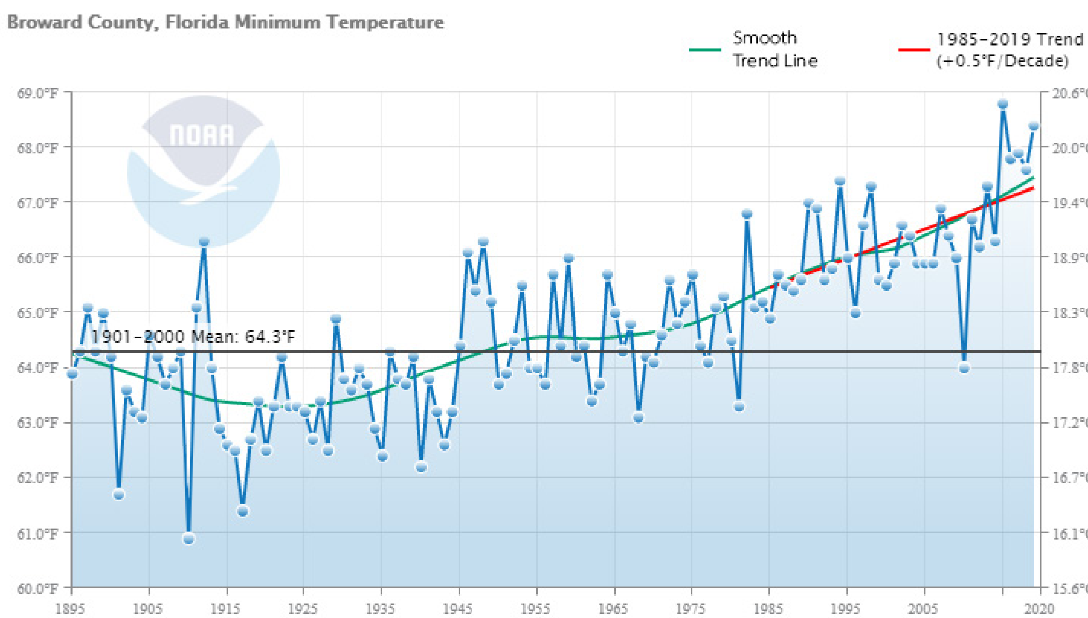
Indicator: TEMPERATURE

Observed Temperature

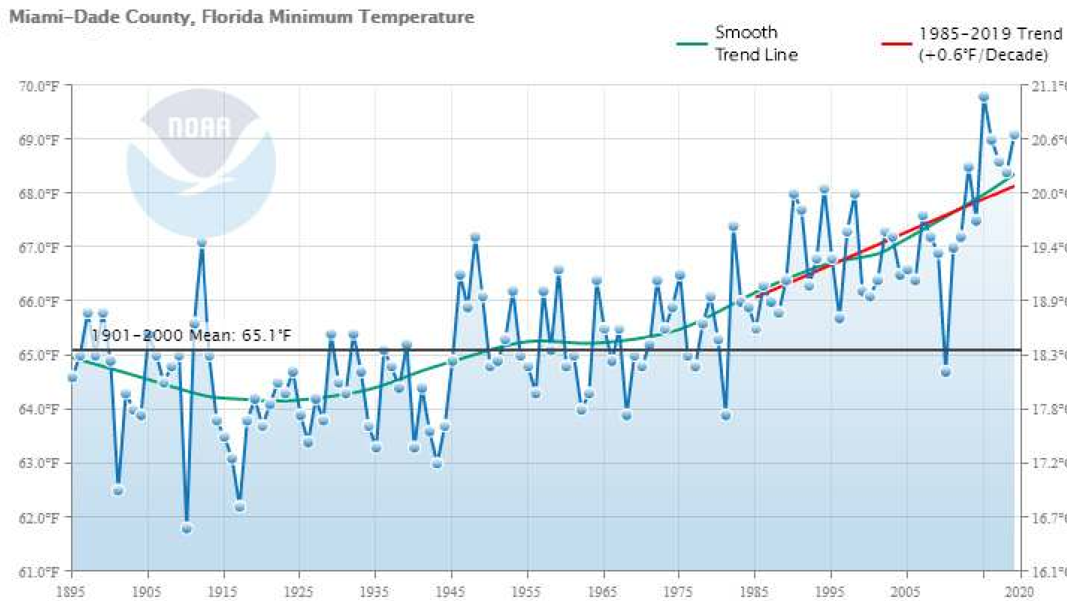
Minimum average temperature is provided as it best reflects the rise in temperature over the period of record. Temperature plots exhibit interannual variability, however, the long term trend across the region shows an increasing annual trend. Additional parameters such as average temperature are also available and can be found here at https://www.ncdc.noaa.gov/cag/county/time-series.

Source: NOAA, National Centers for Environmental Information, 2020

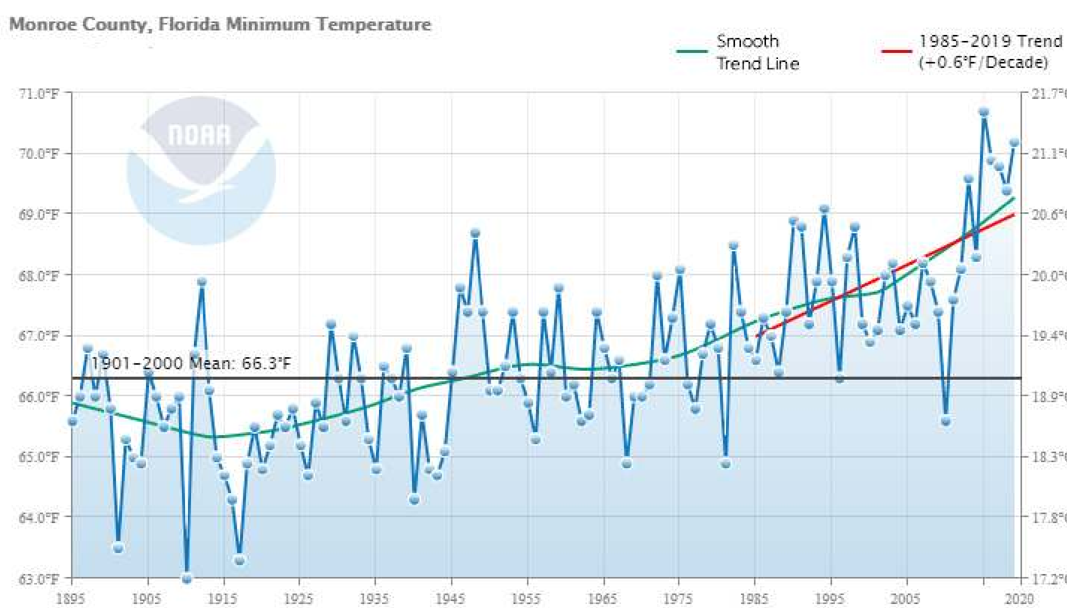
BROWARD COUNTY, MINIMUM ANNUAL TEMPERATURE, 1895 – 2019



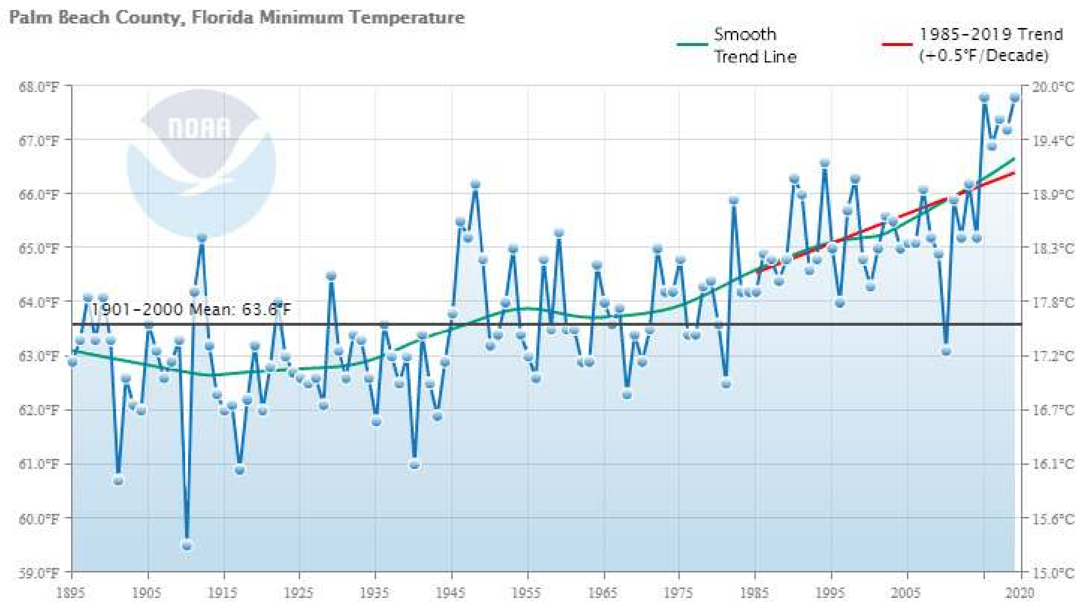
MIAMI-DADE COUNTY, MINIMUM ANNUAL TEMPERATURE, 1895 – 2019



MONROE COUNTY, MINIMUM ANNUAL TEMPERATURE, 1895 – 2019



PALM BEACH COUNTY, MINIMUM ANNUAL TEMPERATURE, 1895 – 2019

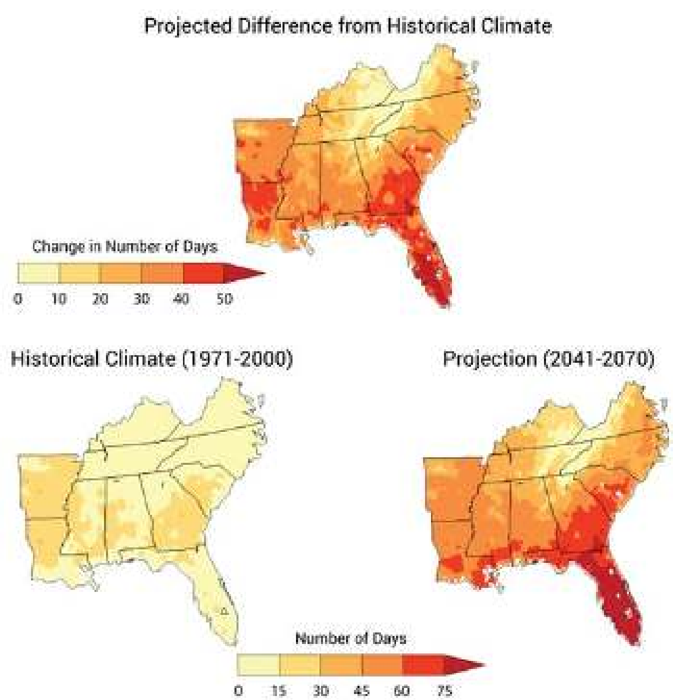


Projected Temperature

The graphic shows the projected average number of days per year with maximum temperatures above 95°F for 2041– 2070 compared to 1971–2000, assuming emissions continue to increase.

Source: National Climate Assessment, U.S. Global Change Research Program, 2014

PROJECTED CHANGE IN NUMBER OF DAYS OVER 95°F IN 2041– 2070 COMPARED TO 1971– 2000

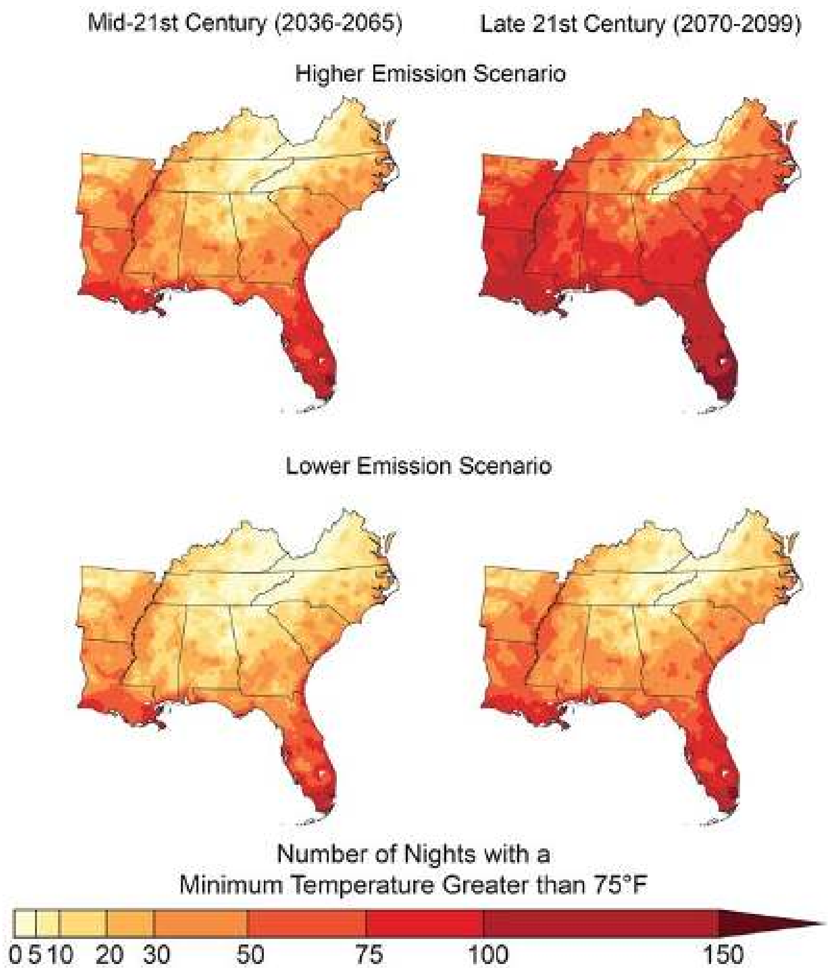


Projected Number of Warm Nights

The maps show the projected number of warm nights (nights with minimum temperatures above 75°F) per year in the Southeast for mid-21st century (left: 2036–2065) and the late 21st century (right: 2070–2099) under a higher greenhouse gas emissions scenario (top row: RCP8.5) and a lower scenario (bottom row: RCP4.5).

These warm nights currently occur only a few times per year across most of the region, but are expected to become common events across much of the Southeast under a higher emission scenario. Increases in the number of warm nights adversely affect agriculture and reduce the ability of some people to recover from high daytime temperatures. With more heat waves expected, there will likely be a higher risk for more heat-related illness and deaths.

Source: National Climate Assessment, U.S. Global Change Research Program



Historical and Projected 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. The tables show the Heat Index by county historically (1971-2000), by midcentury (2036-2065), and by late century (2070-2099). Data for each county was derived from the Union of Concerned Scientist Killer Heat in the U.S. Report, where future values were computed as the average of 18 climate models. The term "Off the Charts" used in the tables refers to levels of exposure to heat index beyond approximately 135°F, which is presumed extremely dangerous for all people and likely to result in heat-related illness or even death.

Source: Killer Heat in the United States: Climate Choices and the Future of Dangerously Hot Days.

BROWARD COUNTY				
Heat Index above	Historical (1971-2000)	By midcentury (2036-2065)	By late century (2070-2099)	By late century, if we limit warming to 2°C (2070-2099)
90°F ------	152 days	184 days	198 days	180 days
100°F ------	34 days	128 days	162 days	109 days
105°F ------	5 days	80 days	132 days	52 days
Off the Charts	0 days	1 days	14 days	0 days

MIAMI-DADE COUNTY				
Heat Index above	Historical (1971-2000)	By midcentury (2036-2065)	By late century (2070-2099)	By late century, if we limit warming to 2°C (2070-2099)
90°F ------	154 days	187 days	200 days	183 days
100°F ------	41 days	134 days	166 days	115 days
105°F ------	7 days	88 days	138 days	60 days
Off the Charts	0 days	1 days	14 days	0 days

MONROE COUNTY				
Heat Index above	Historical (1971-2000)	By midcentury (2036-2065)	By late century (2070-2099)	By late century, if we limit warming to 2°C (2070-2099)
90°F ------	161 days	191 days	203 days	187 days
100°F ------	55 days	144 days	171 days	128 days
105°F ------	12 days	104 days	146 days	78 days
Off the Charts	0 days	1 days	18 days	0 days

PALM BEACH COUNTY				
Heat Index above	Historical (1971-2000)	By midcentury (2036-2065)	By late century (2070-2099)	By late century, if we limit warming to 2°C (2070-2099)
90°F ------	145 days	180 days	196 days	176 days
100°F ------	28 days	121 days	157 days	102 days
105°F ------	4 days	72 days	126 days	45 days
Off the Charts	0 days	1 days	13 days	0 days

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 humidity 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

To find the Heat Index temperature, look at the Heat Index Chart above or check this Heat Index Calculator. As an example, if the air temperature is 88°F and the relative humidity is 80%, the heat index--how hot it feels--is 106°F. The red area without numbers indicates extreme danger. The National Weather Service will initiate alert procedures when the Heat Index is expected to exceed 105°-110°F (depending on local climate) for at least 2 consecutive days.

Caveats to Heat Index data:

When applying these results to any location or population, a number of limitations should be considered:

1. The heat index is based on physiological assumptions that assess the impacts of hot and humid weather on humans. Variations in clothing thickness, height, weight, age, health, and physical activity are not accounted for in the heat index calculation. The index also does not include wind speed, cloudiness, shade levels, or any other factors, although those are known to affect heat-related impacts.

2. The climate model data used for this analysis were created using the Multivariate Adaptive Constructed Analogs (MACA) method. Different climate downscaling techniques could produce different results.

3. The results reported are averages over 30-year periods. Because substantial warming is projected to occur over the course of those periods, the number of extreme heat index days is likely to be lower than the reported averages at the beginning of each 30-year period and higher at the end.

4. The data reported here do not capture the unique characteristics of urban areas and the associated urban heat island effect, nor do the projections consider future urban development or land-cover changes that would influence future climate extremes.

Source: Killer Heat in the United States: Climate Choices and the Future of Dangerously Hot Days.

Indicator: PRECIPITATION

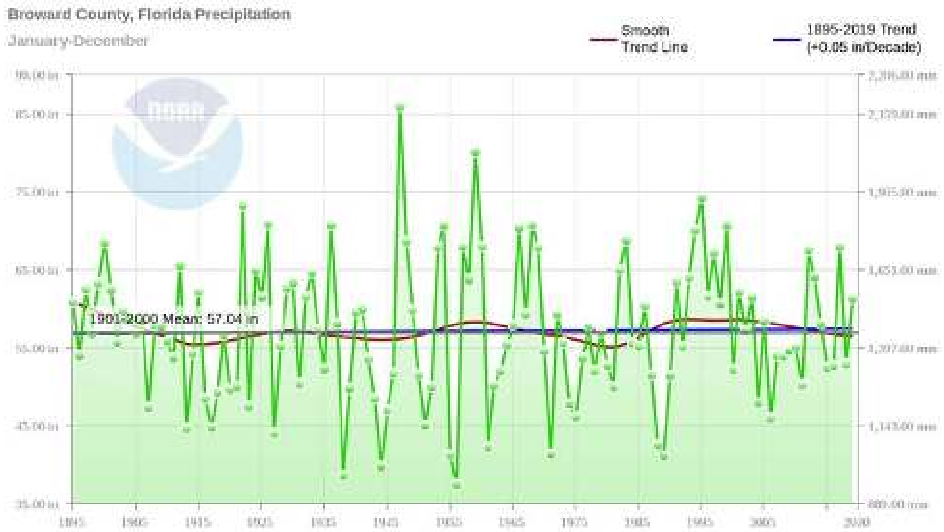
Observed Precipitation

Southeast Florida has a wet season and dry season based on the rainfall amount. The seven months from October through April are considered the dry season. The five months from May 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. 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.

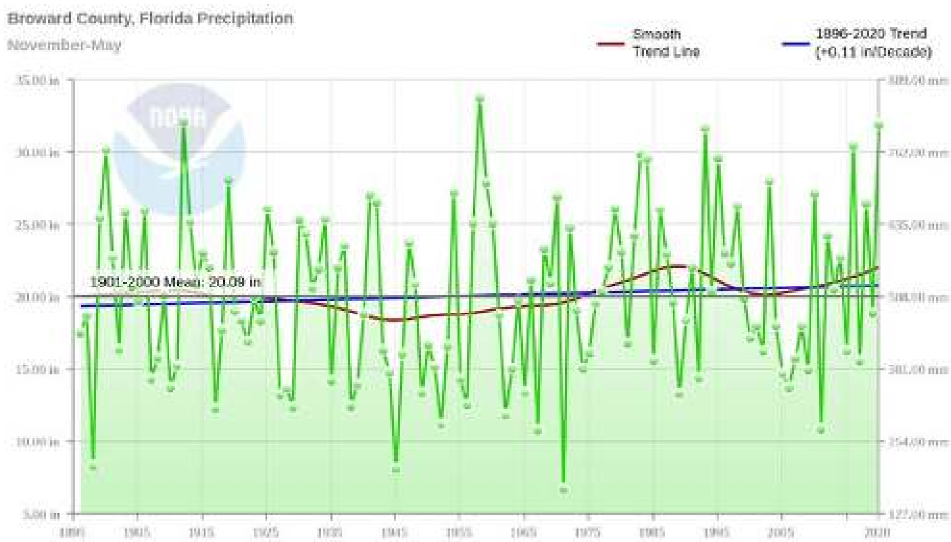
Identifying trends in rainfall observations in Southeast Florida is challenging. It is difficult to attribute the historical changes in rainfall to climate change directly, as rainfall changes could be cyclical and affected by intra and multi-decadal natural climate variability, such as El-Niño and other recurrent climate phenomena. Global climate models used to develop future rainfall projections currently lack the sufficient resolution to incorporate finer-scale regional climate influences that influence rainfall patterns in Southeast Florida, and hence projections are not provided in this set of indicators.

Analysis of observed rainfall trends from 1895 to 2019 is presented in the charts below per county and per season (dry and wet), as well as total annual values, exhibiting, in most cases, significant natural variability but no systematic trends. 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.

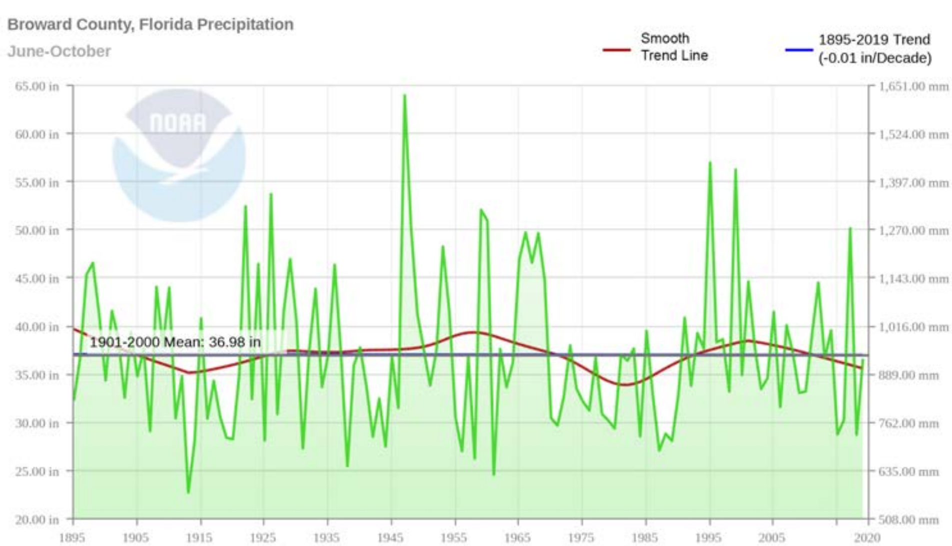
ANNUAL PRECIPITATION, 1895 – 2019



DRY SEASON PRECIPITATION, 1895 – 2019

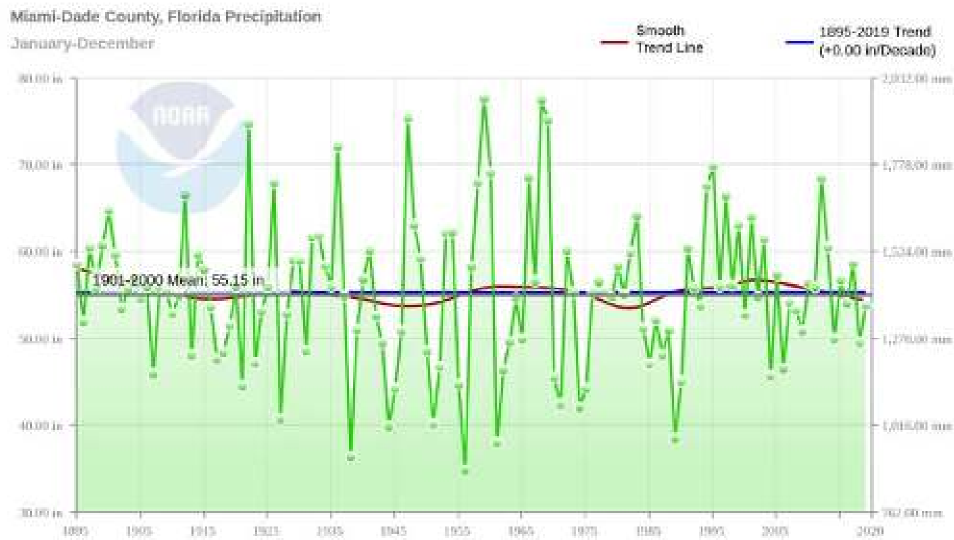


WET SEASON PRECIPITATION, 1895 – 2019

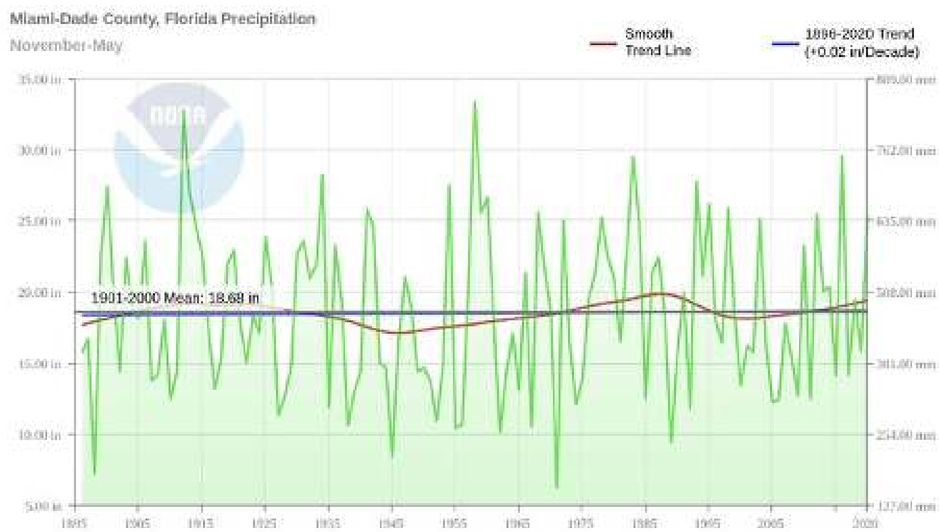


Miami-Dade County

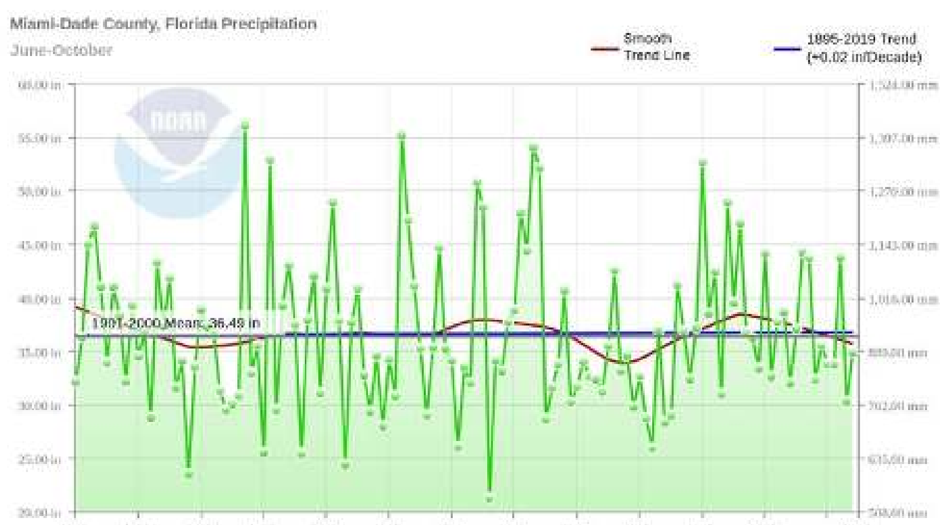
ANNUAL PRECIPITATION, 1895 – 2019



DRY SEASON PRECIPITATION, 1895 – 2019

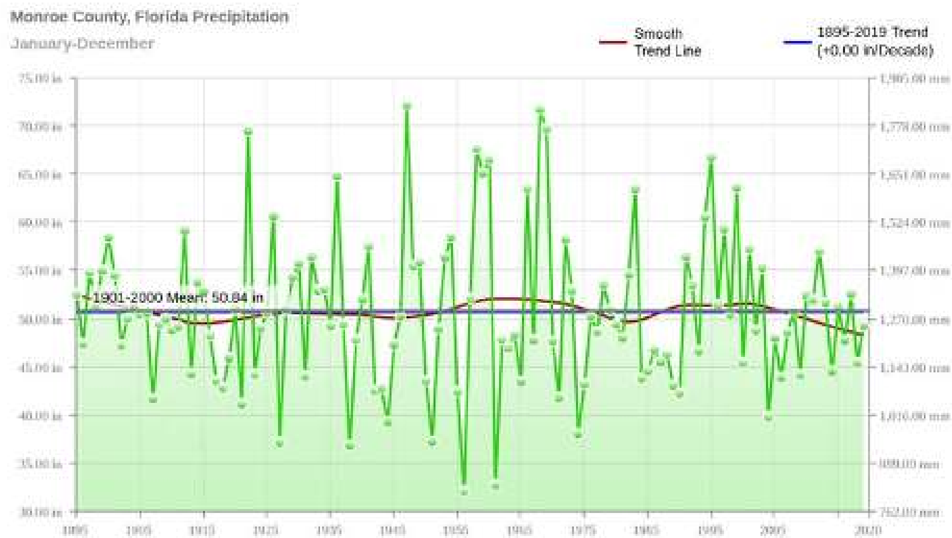


WET SEASON PRECIPITATION, 1895 – 2019

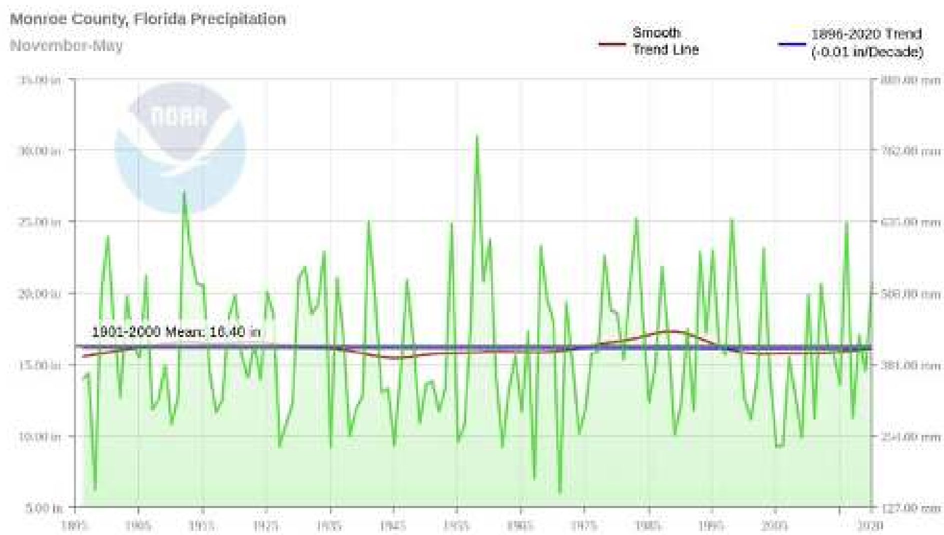


Monroe County

ANNUAL PRECIPITATION, 1895 – 2019



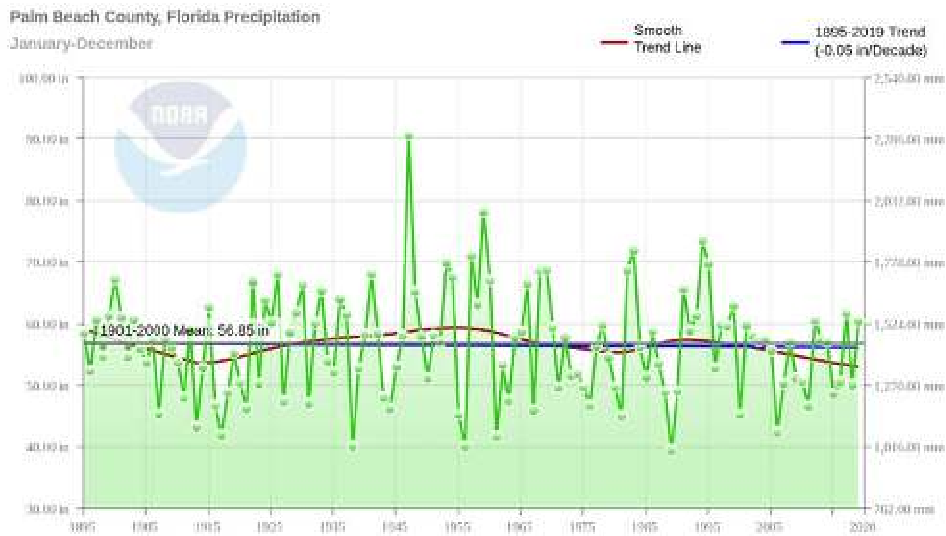
DRY SEASON PRECIPITATION, 1895 – 2019



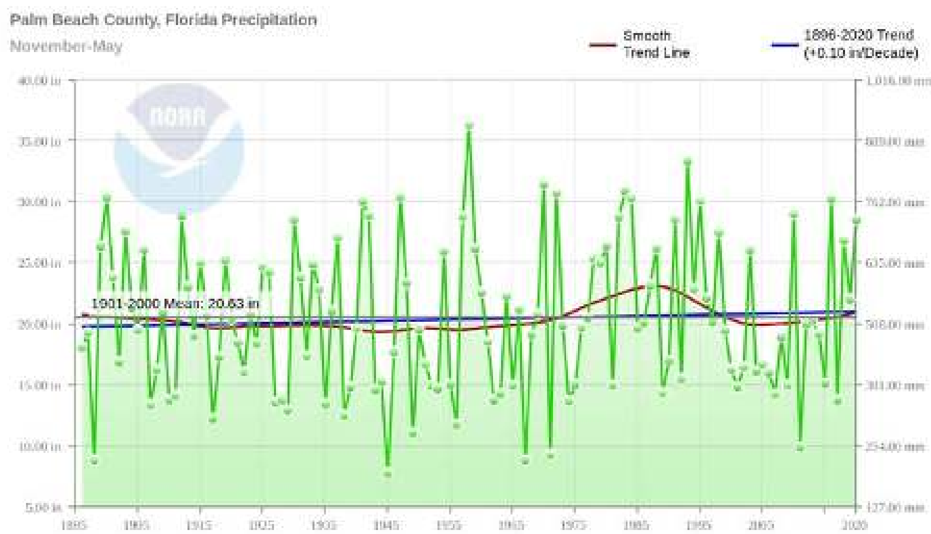
WET SEASON PRECIPITATION, 1895 – 2019

Palm Beach County

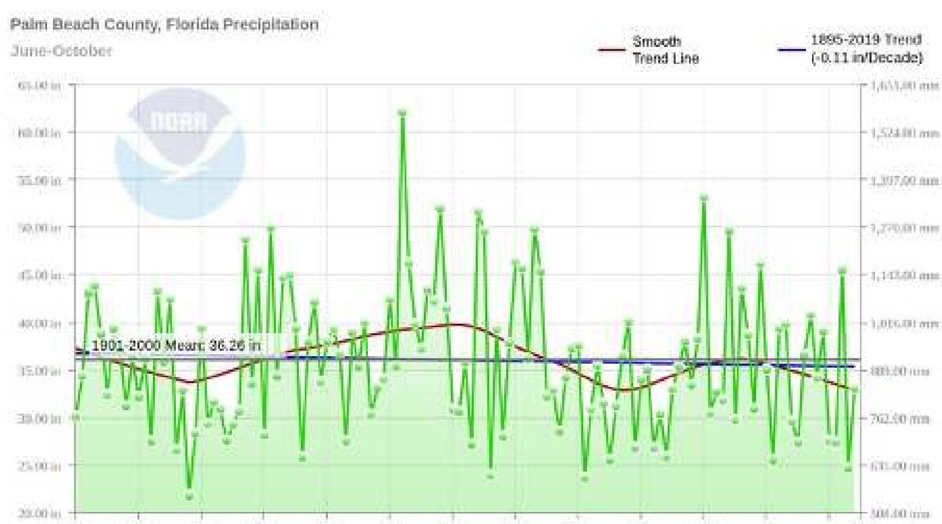
ANNUAL PRECIPITATION, 1895 – 2019



DRY SEASON PRECIPITATION, 1895 – 2019



WET SEASON PRECIPITATION, 1895 – 2019



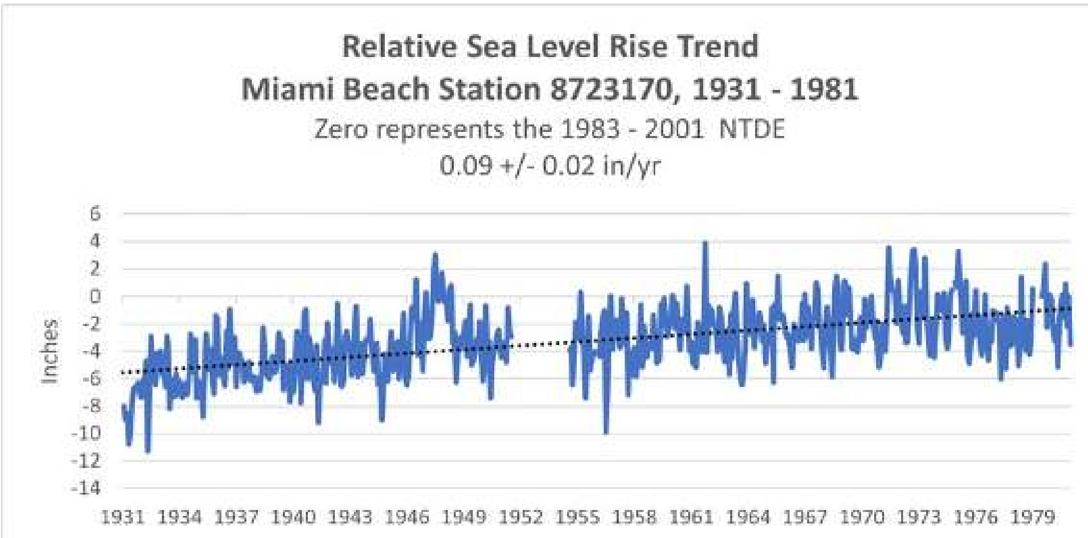
Source: [NOAA, National Centers for Environmental](), 2020

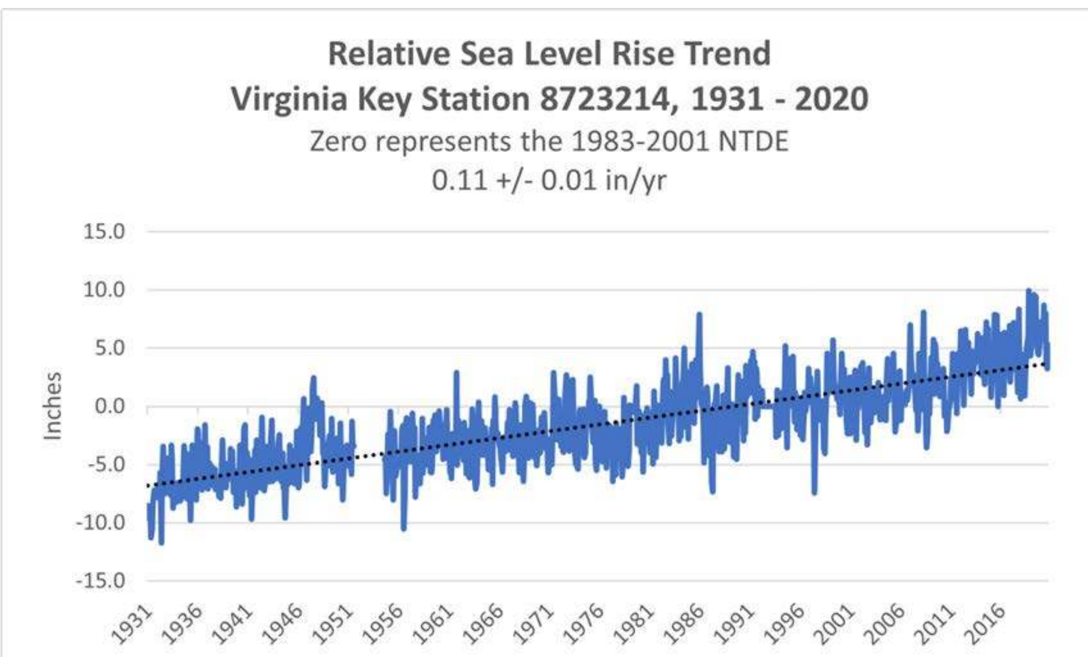
Indicator: SEA LEVEL RISE

Observed Sea Level Rise

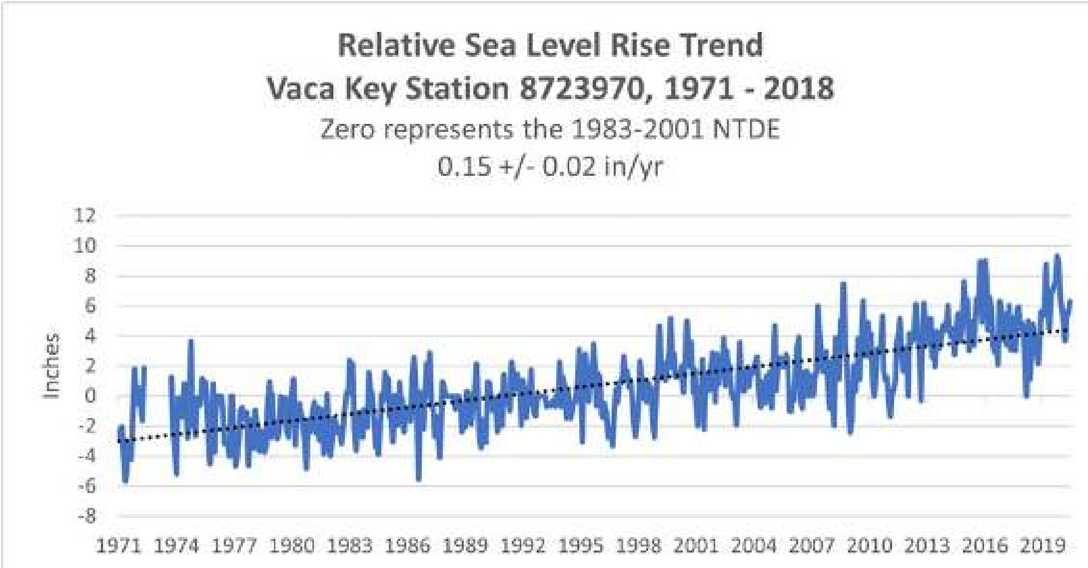
Based on the limited number of NOAA tide gauges within the Southeast Florida region, and varying records of observation from those gauges, the observed sea level is rising in the range of 9-13 inches per century, with a systematic increasing trend of sea level rise across the Compact region.

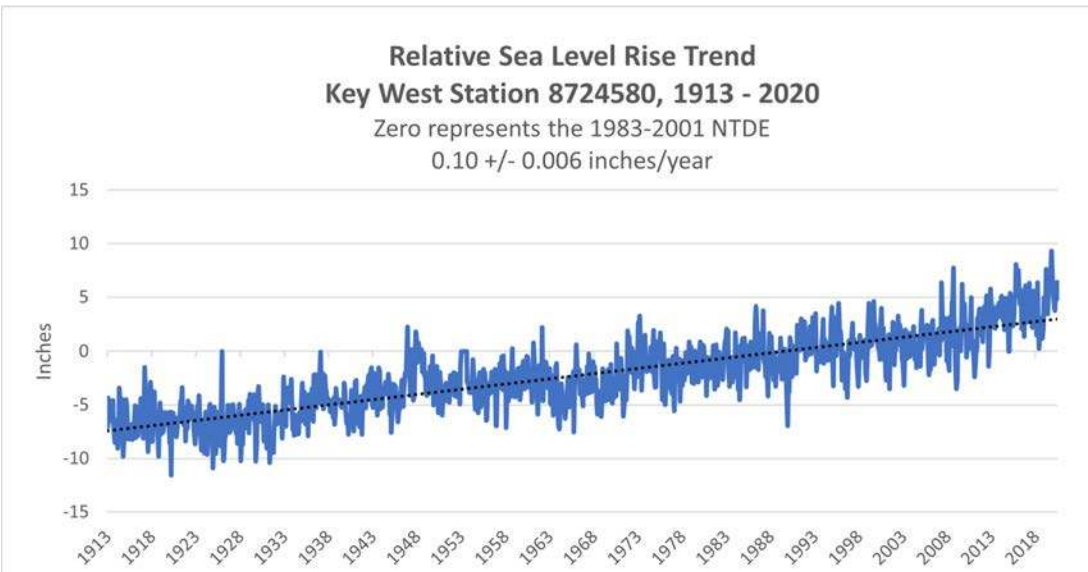
MIAMI-DADE COUNTY, OBSERVED SEA LEVEL RISE

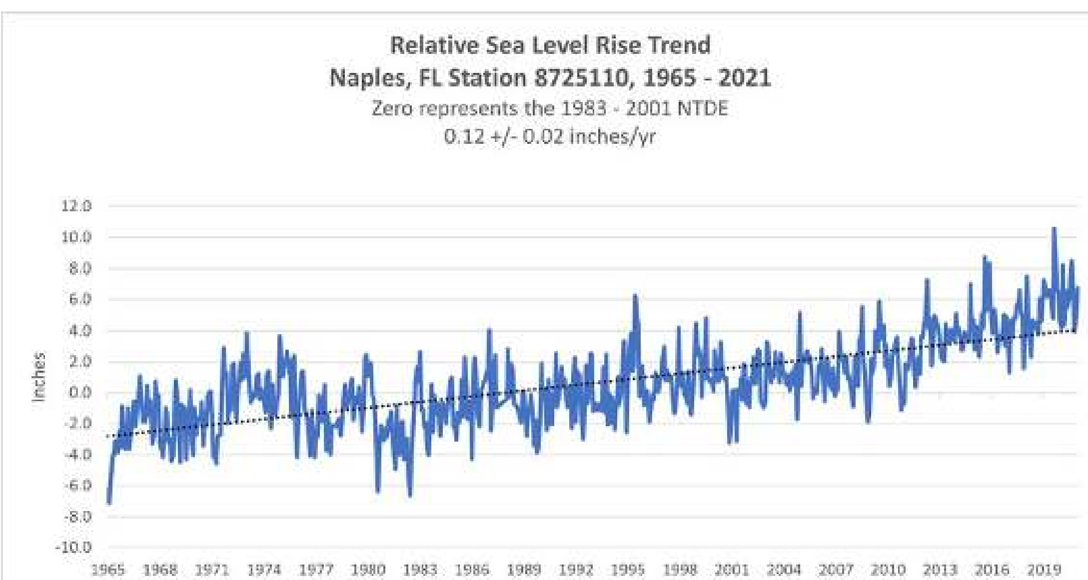




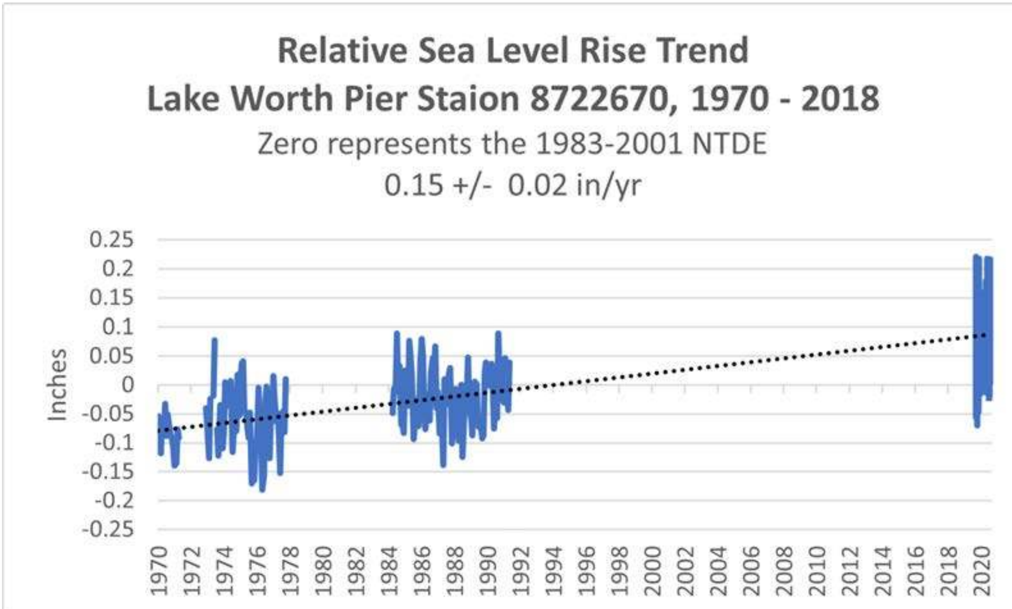
MONROE COUNTY, OBSERVED SEA LEVEL RISE







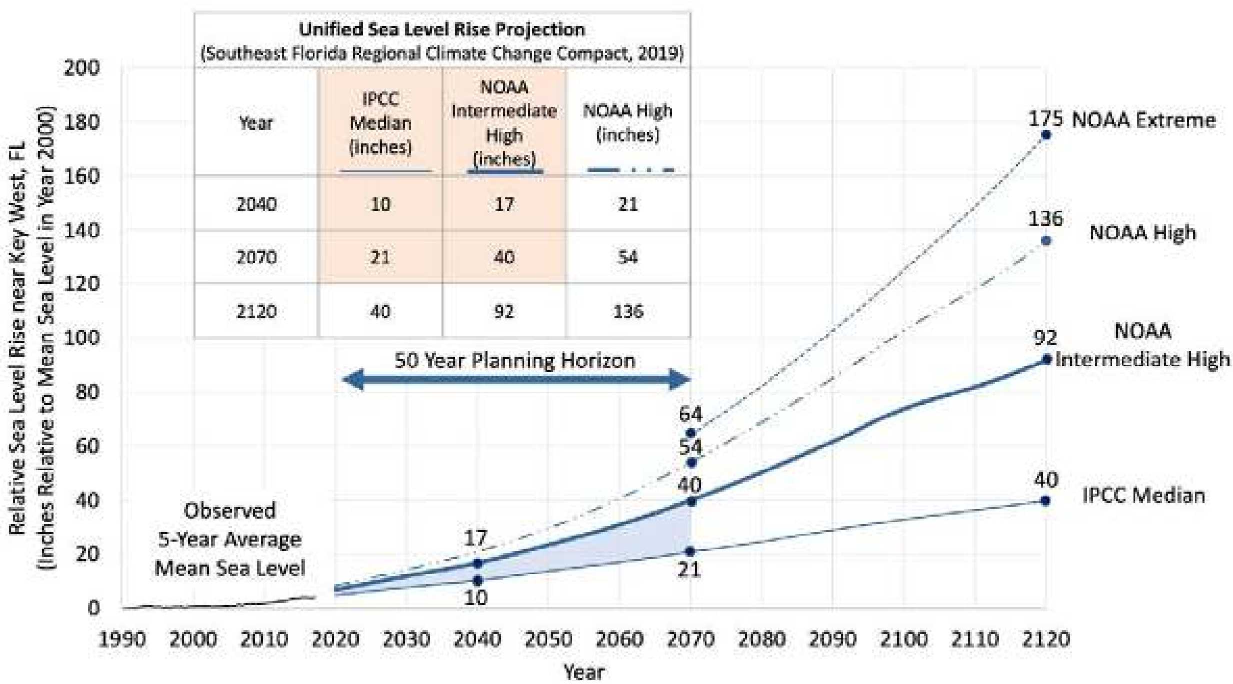
PALM BEACH COUNTY, OBSERVED SEA LEVEL RISE



Source: NOAA, Tides & Currents, 2020

Sea Level Rise Projection

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. 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.



Unified Sea Level Rise Projection (Southeast Florida Regional Climate Change Compact, 2019)

Year	IPCC Median (inches)	NOAA Intermediate High (inches)	NOAA High (inches)
2040	10	17	21
2070	21	40	54
2120	40	92	136

Source: Unified Sea Level Rise Projection Southeast Florida.

Indicator: HIGH TIDE FLOODING

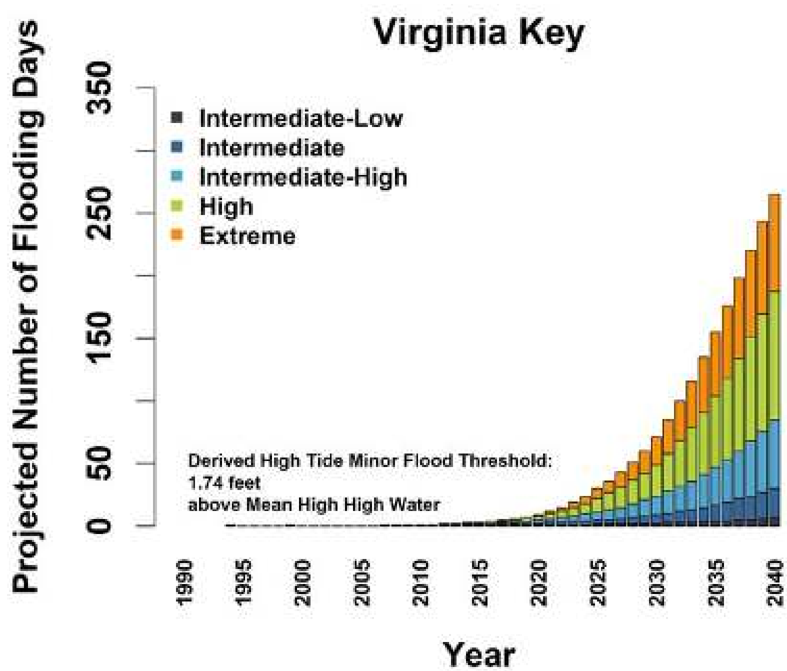
Observed and Projected High Tide Flooding

Over the last five to ten years in the Compact region, we have observed regular occurrences of flooding during king tide events. It is expected that these flood events will increase into the future due to accelerating sea level rise.The charts show the observed and projected number of flooding days by county from 1990 to 2040. 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.

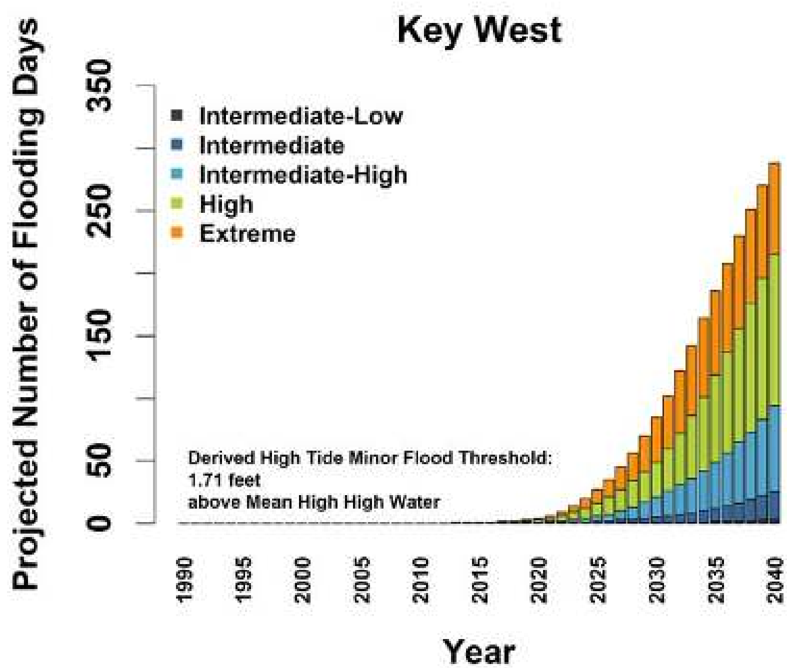
Typically high tide flooding occurs when the tides exceed the mean high high water (essentially the average high tides), by a certain amount depending on the typography of the specific location. NOAA has published the flood thresholds that are used to define a flood event for each of the locations in the Flooding Days charts.

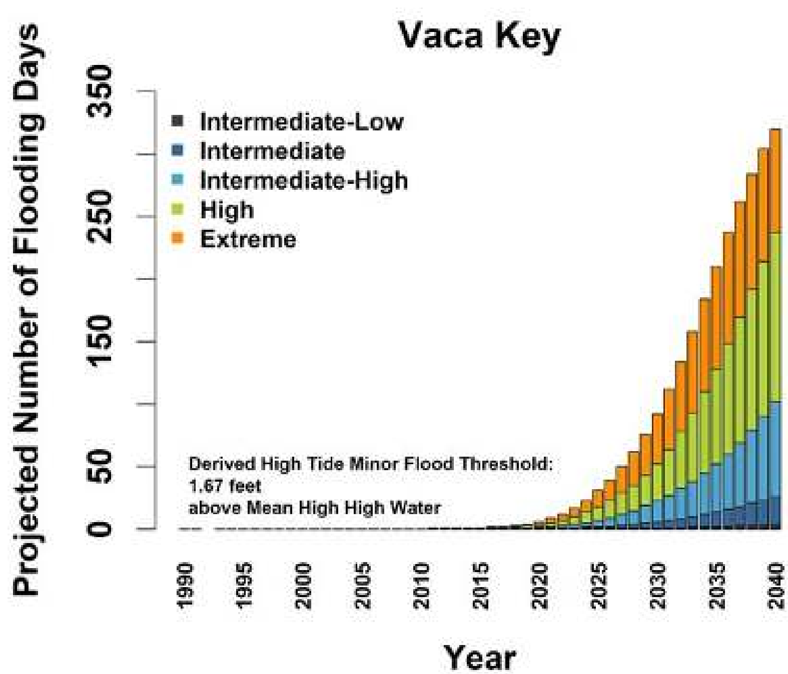
Source: Data adapted from the NOAA Climate Explorer, 2020

OBSERVED AND PROJECTED FLOODING DAYS, MIAMI-DADE COUNTY, 1990 – 2040



OBSERVED AND PROJECTED FLOODING DAYS, MONROE COUNTY, 1990 - 2040





Indicator: SALTWATER INTRUSION

Saltwater intrusion is caused by either increasing sea levels or a reduction in inland freshwater levels. Saltwater intrusion can lead to contamination of coastal drinking water supplies. Over time, saltwater has continued to intrude inland in South Florida, compromising some well fields. As the sea level rises, further intrusion will occur. The maps show the extent of saltwater intrusion over the period of record from sites monitored in South Florida.

The U.S. Geological Survey (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 5- 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 U.S. Geological Survey and South Florida Water Management District. Maps are provided courtesy of the South Florida Water Management District, 2020.

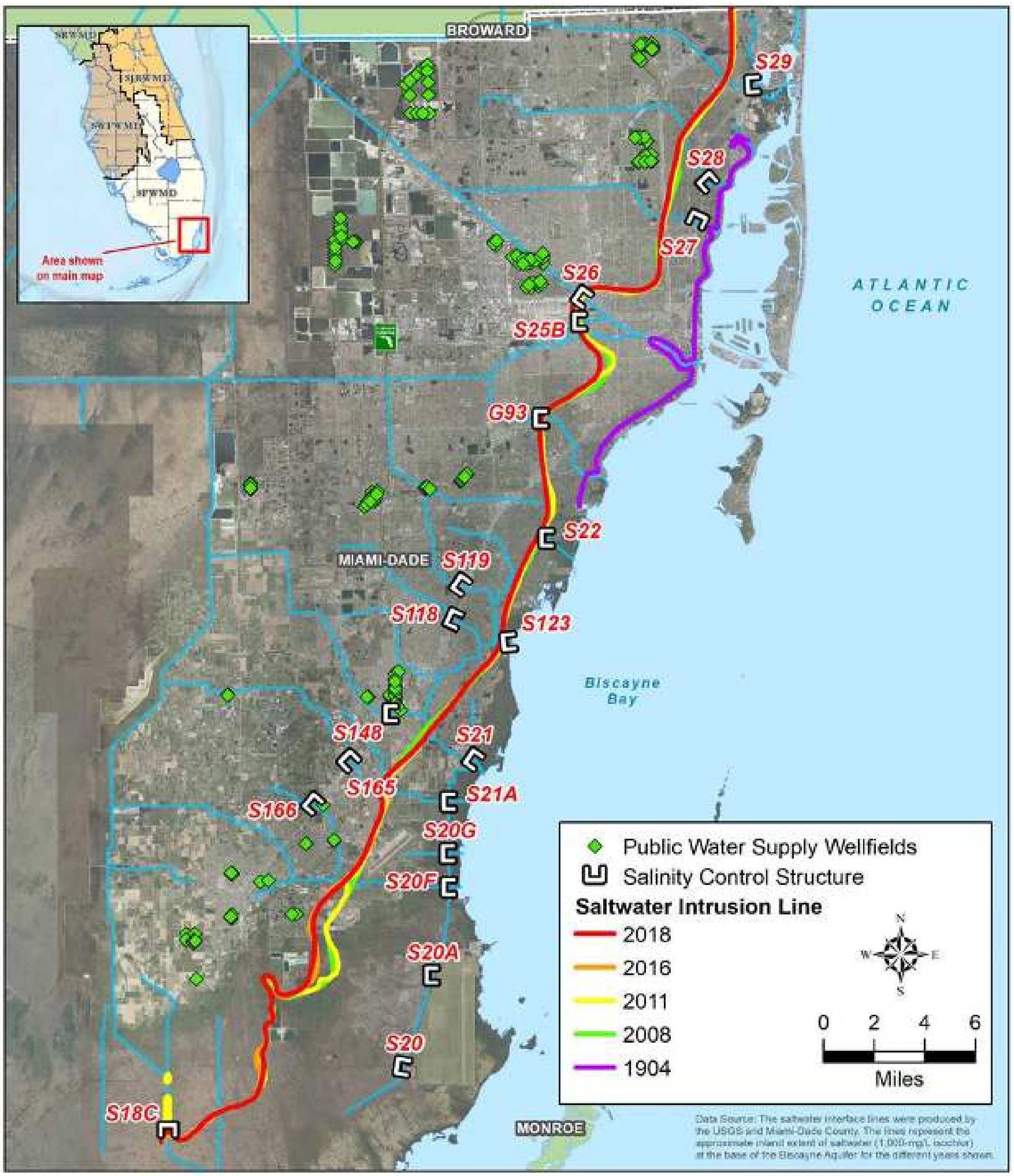
Broward County, Freshwater/Saltwater Interface

It is likely that considerable saltwater intrusion occured in Broward County following 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 1 mile between 2009 and 2019 west of Fort Lauderdale-Hollywood International Airport near salinity control structure S-13. Sea level rise is likely to contribute to further saltwater intrusion, depending on pumping and water management.


SRWMD
SJRWMD
SWFWMD
SFWMD
Area shown on main map
PALM BEACH
G56
G57
S37B
S37A
S36
BROWARD
S33
G54
S13
I-95
I-75
I-595
ATLANTIC OCEAN
MIAMI-DADE
Public Water Supply Wellfields
Salinity Control Structure
Freshwater/Saltwater Interface (250 mg/L Isochlor)
2019
2014
2009
0
2
4
6
Miles
N
S
E
W

Miami-Dade County, Freshwater/Saltwater Interface

Saltwater intrusion has occurred since drainage of the Everglades and the earliest days of groundwater withdrawal for the population of Miami-Dade County. 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 has largely halted the further inland movement of the saltwater front. Little change is seen between the 2011 front (yellow) and 2018 front (red) in most areas. The saltwater front has moved more inland in the southern portion of the County near the Homestead area.



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 moved seaward between 2009/2014 and 2019. This is likely due to moving pumping centers further inland and extracting water from the deeper aquifer.

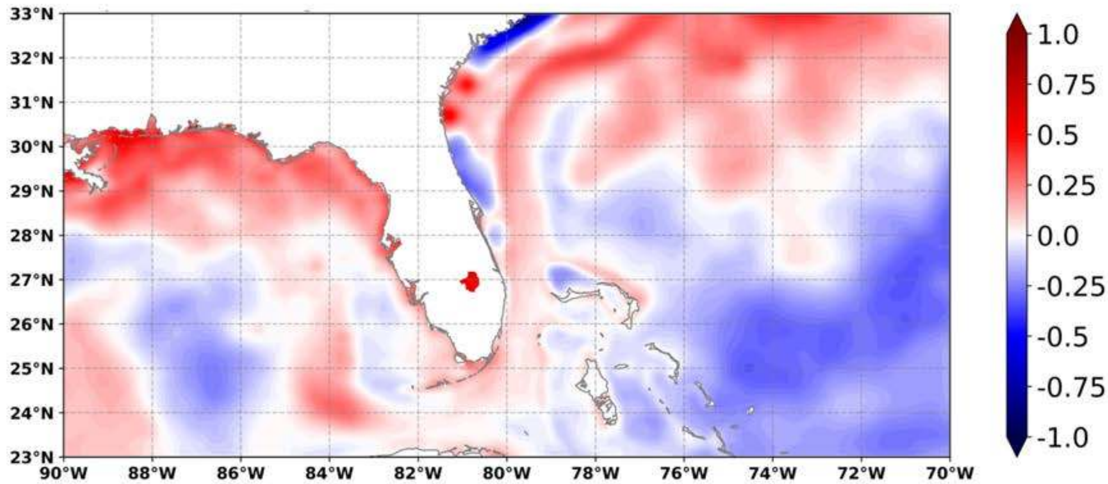
Indicator: SEA SURFACE TEMPERATURE

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. This sea surface temperature data was obtained from high-resolution satellite images. The chart shows the change in the timeframe from September 2016 to August 2020 when compared to temperatures recorded earlier in the timeframe of September 2013 to August 2016. The limited historical range of this chart is due to the fact that this type of high-resolution data has only been available since April 2013, so we don't have the information needed to make comparisons to earlier decades.

Source: [Asia-Pacific Data-Research Center]

SEA SURFACE TEMPERATURE CHANGE

(September 2016-August 2020 average temperature compared to September 2013-August 2016 average temperature in Degrees Celsius)



For more information, visit:

www.climatecompact.org

For more on the Institute for Sustainable Communities: sustain.org

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