



Climate Trends and Variability – Applications to Agriculture in the Southeast



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*SCCAHS – State of the
Science*

March 7, 2023



Climate/Weather Threats

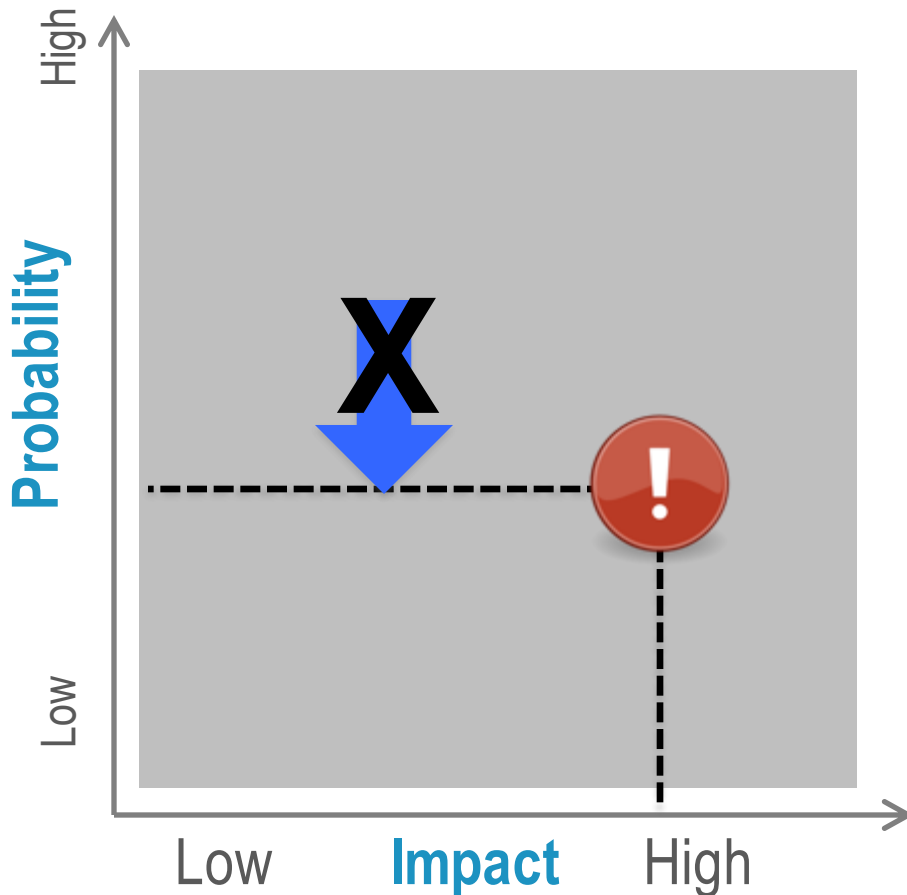


- Changes in temperature, extreme temperature
- Extreme rainfall and flooding
- Drought
- Sea level rise
- Hurricanes and tropical storms
- Severe weather

Defining Risk

$$\text{Risk} = \text{Threat} \times \text{Exposure}$$

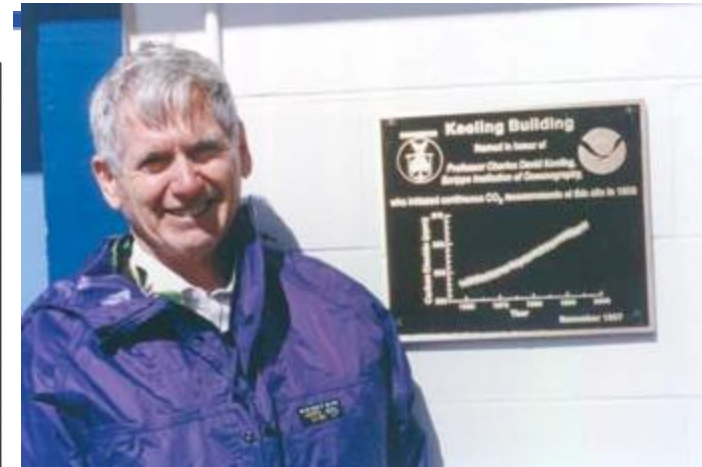
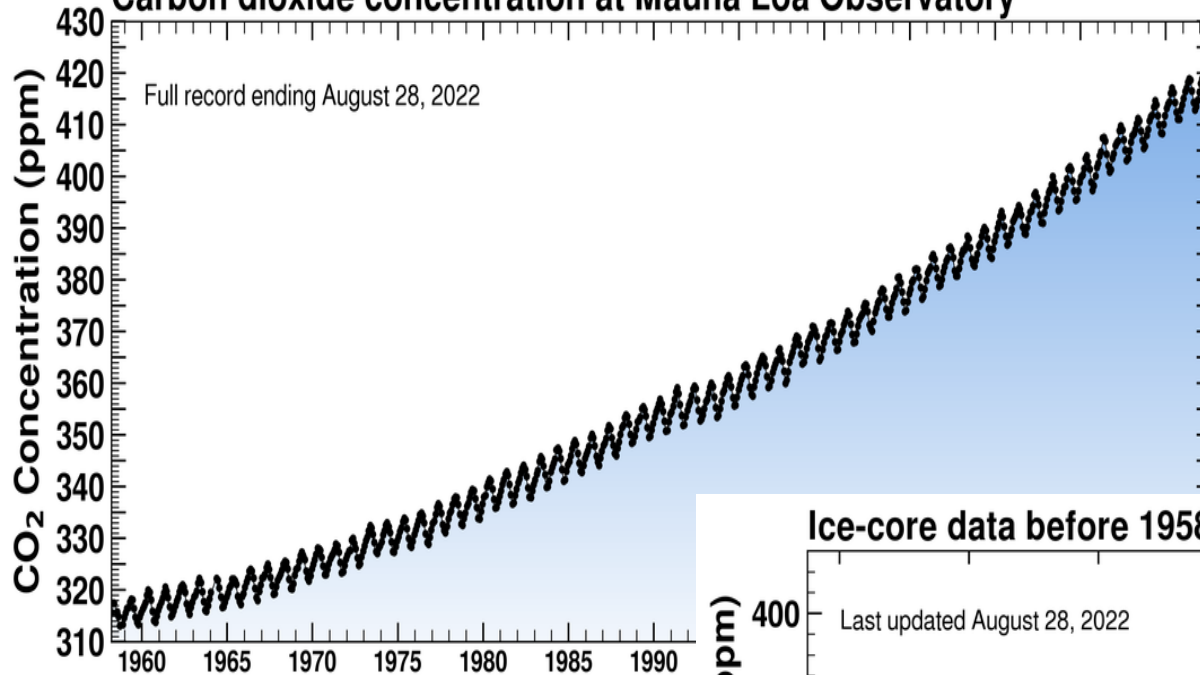
(Probability) (Impact, vulnerability)



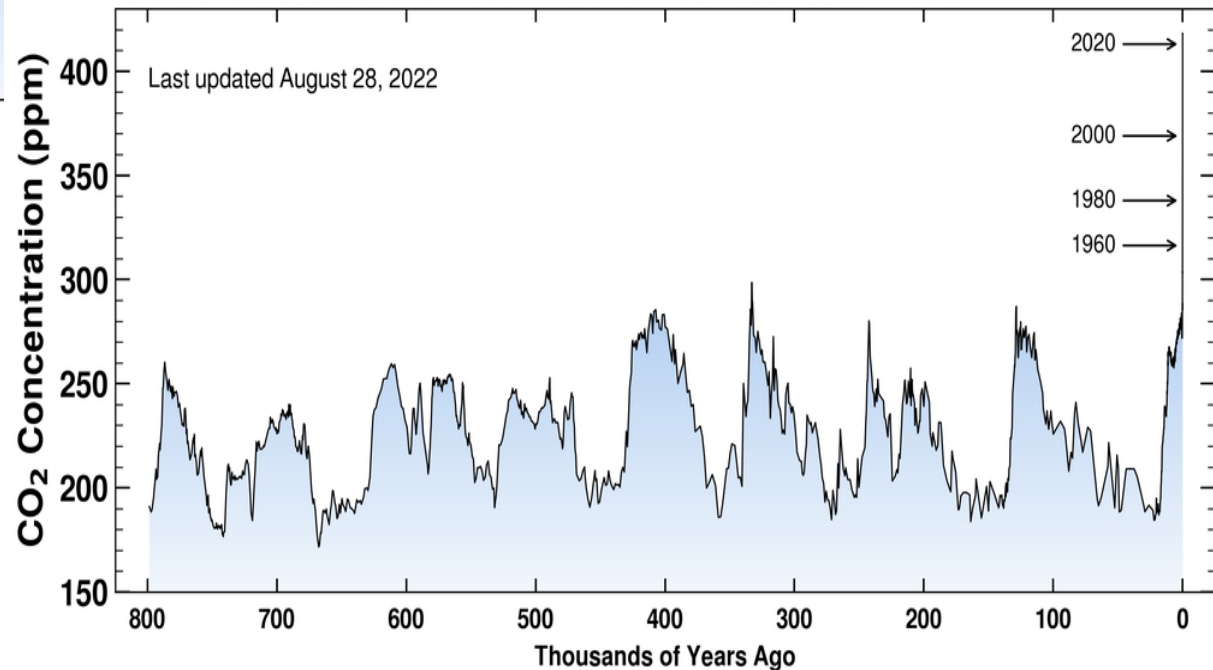


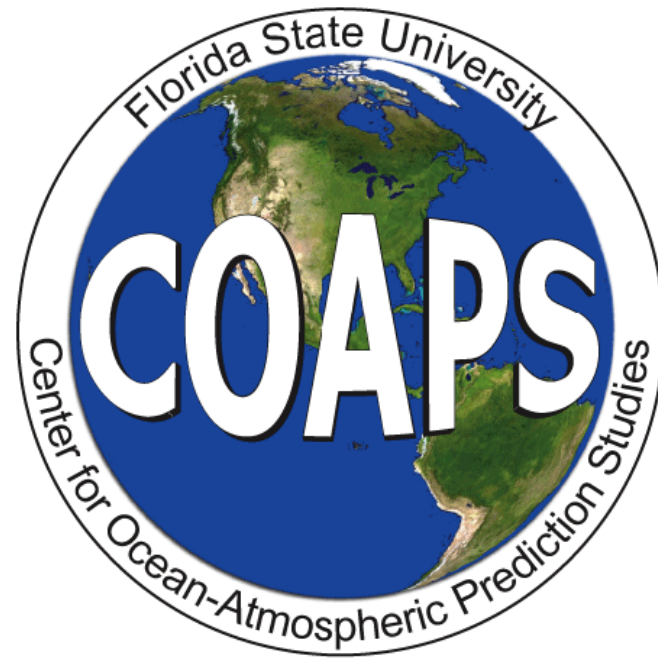
Carbon Dioxide Concentrations

Carbon dioxide concentration at Mauna Loa Observatory



Ice-core data before 1958. Mauna Loa Data after 1958.





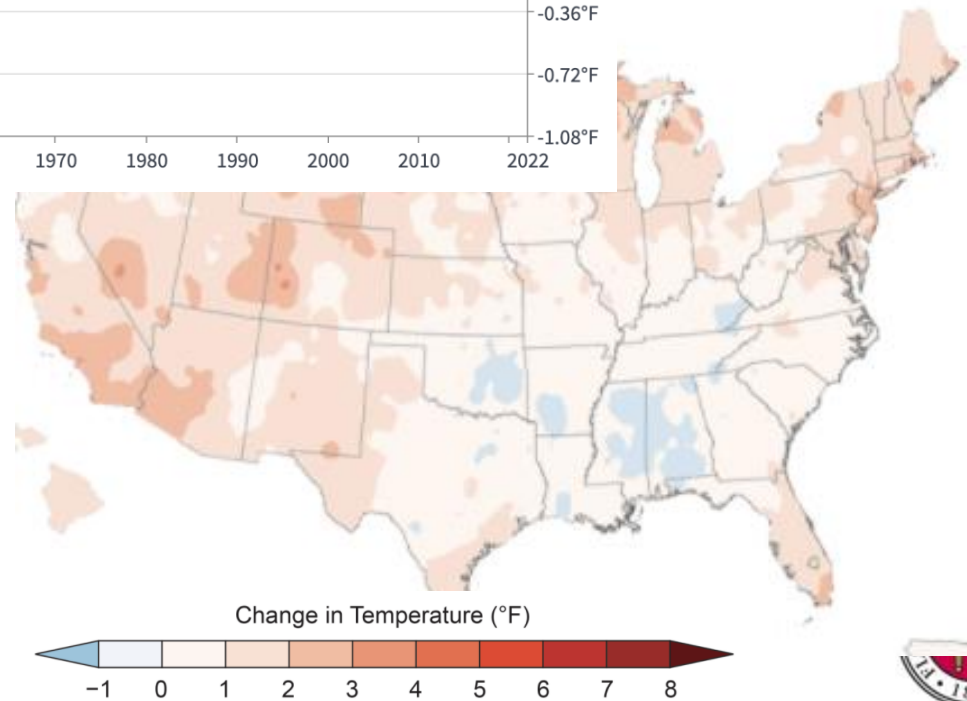
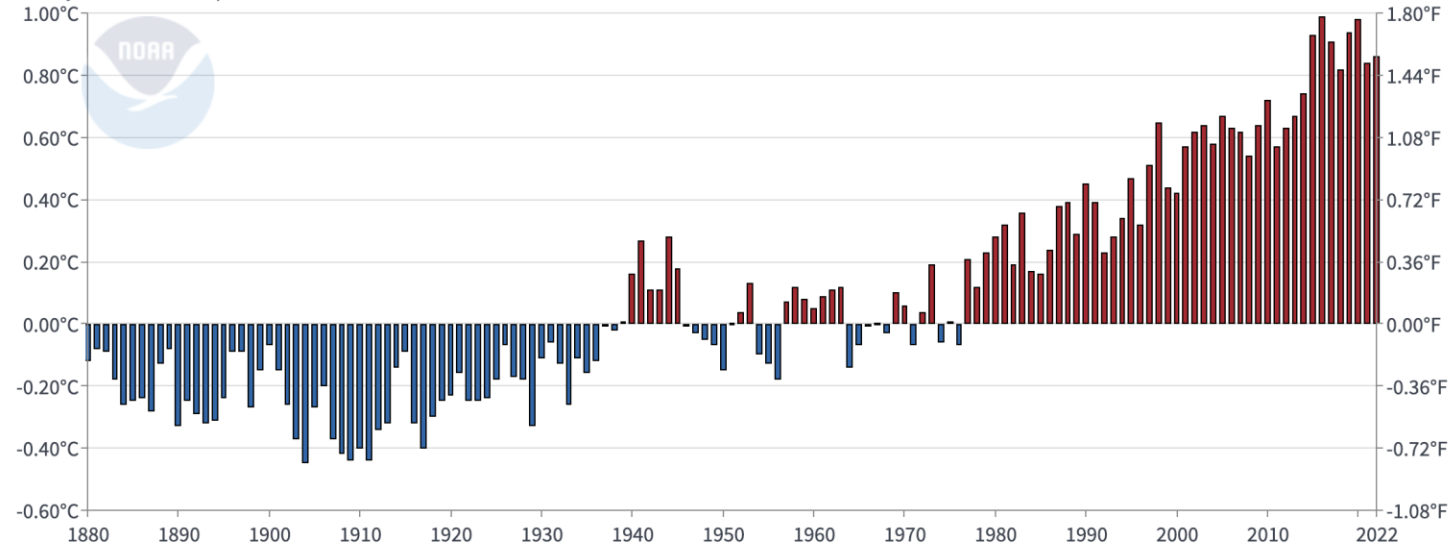
Temperature Trends



Global Average Temperatures

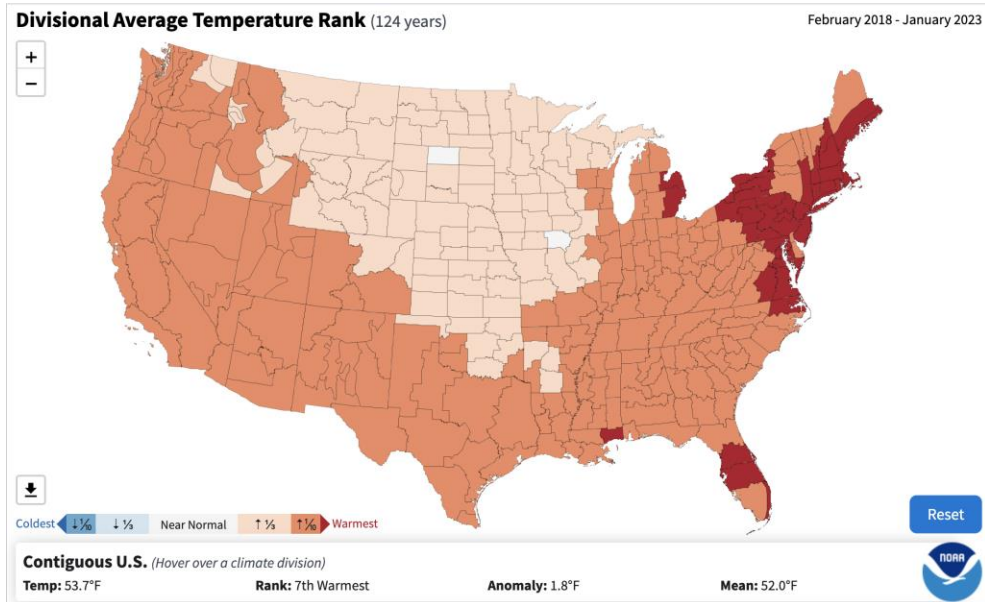
Global Land and Ocean

January-December Temperature Anomalies

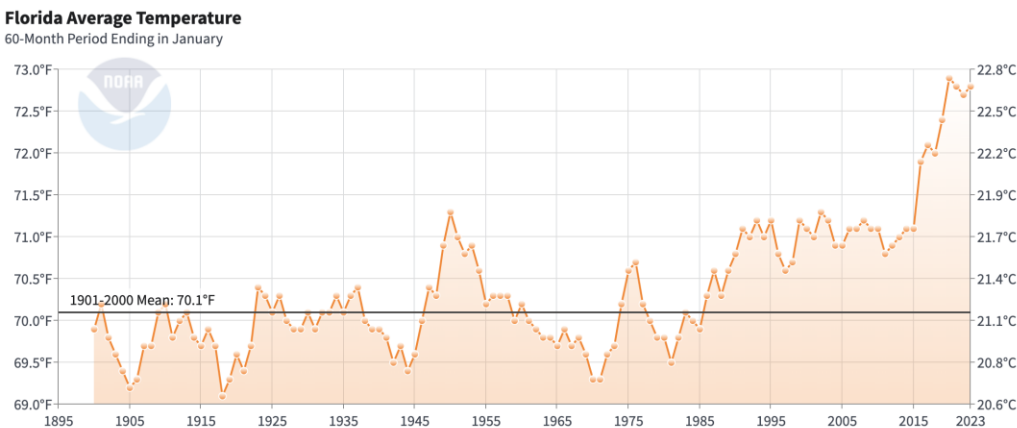




U.S. and Florida Temperatures



- Only 7 months in the last 8 years have been cooler than average
- Includes streak 31 months in a row
- Includes 9 months of record warm
- Overnight temperatures affected most

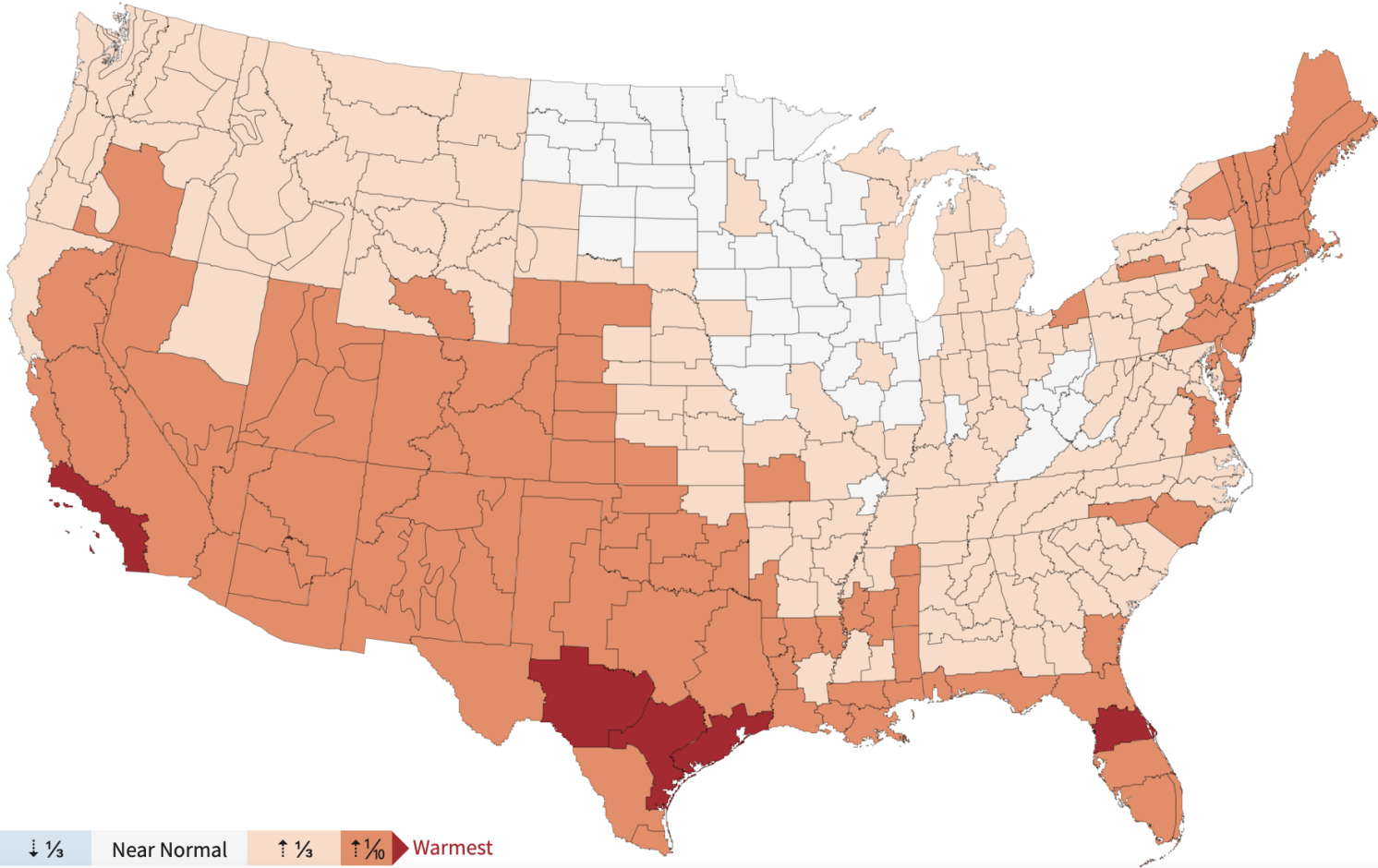




2022 Warm Season

Divisional Average Temperature Rank (128 years)

April - September 2022



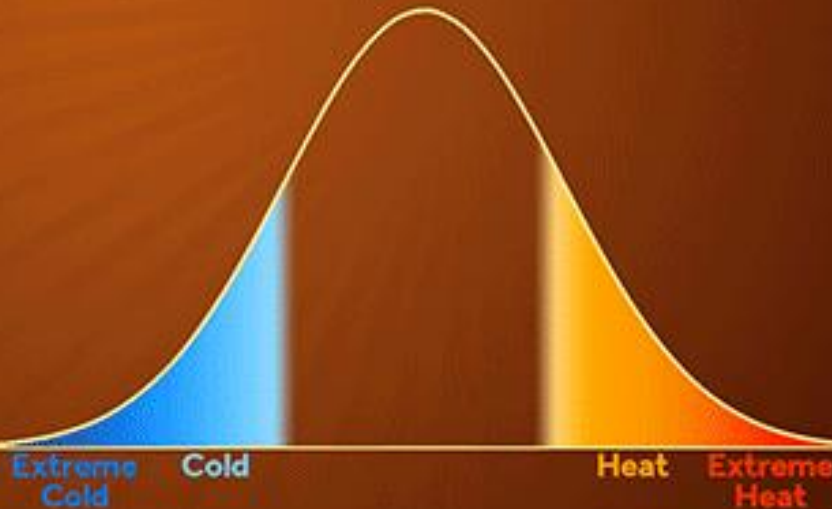
Coldest $\downarrow \frac{1}{10}$ $\downarrow \frac{1}{3}$ Near Normal $\uparrow \frac{1}{3}$ $\uparrow \frac{1}{10}$ Warmest

Reset



Why Do Changes in the Average Matter?

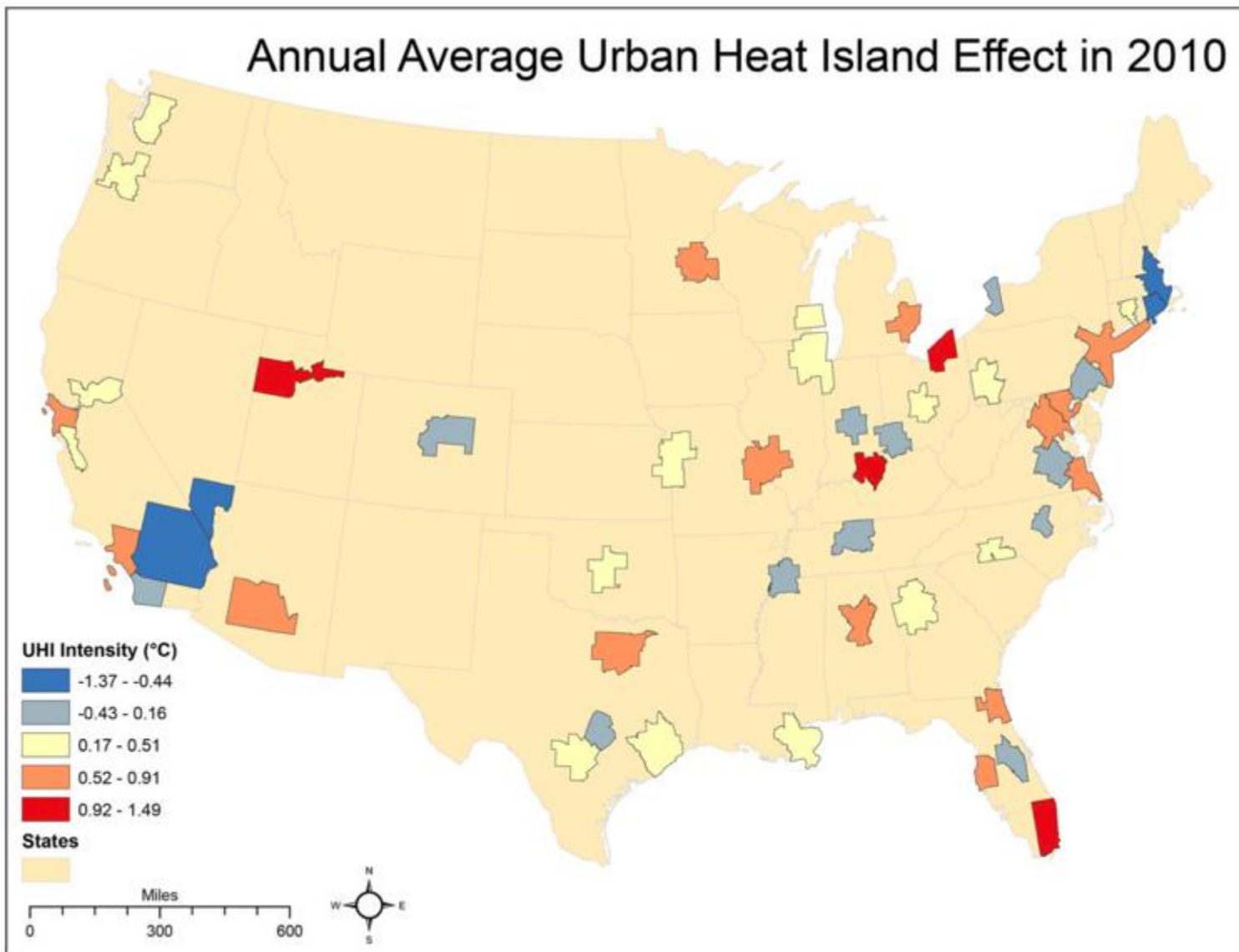
**SMALL CHANGE IN AVERAGE
BIG CHANGE IN EXTREMES**



CLIMATE  CENTRAL

Urban Heat Island

Annual Average Urban Heat Island Effect in 2010





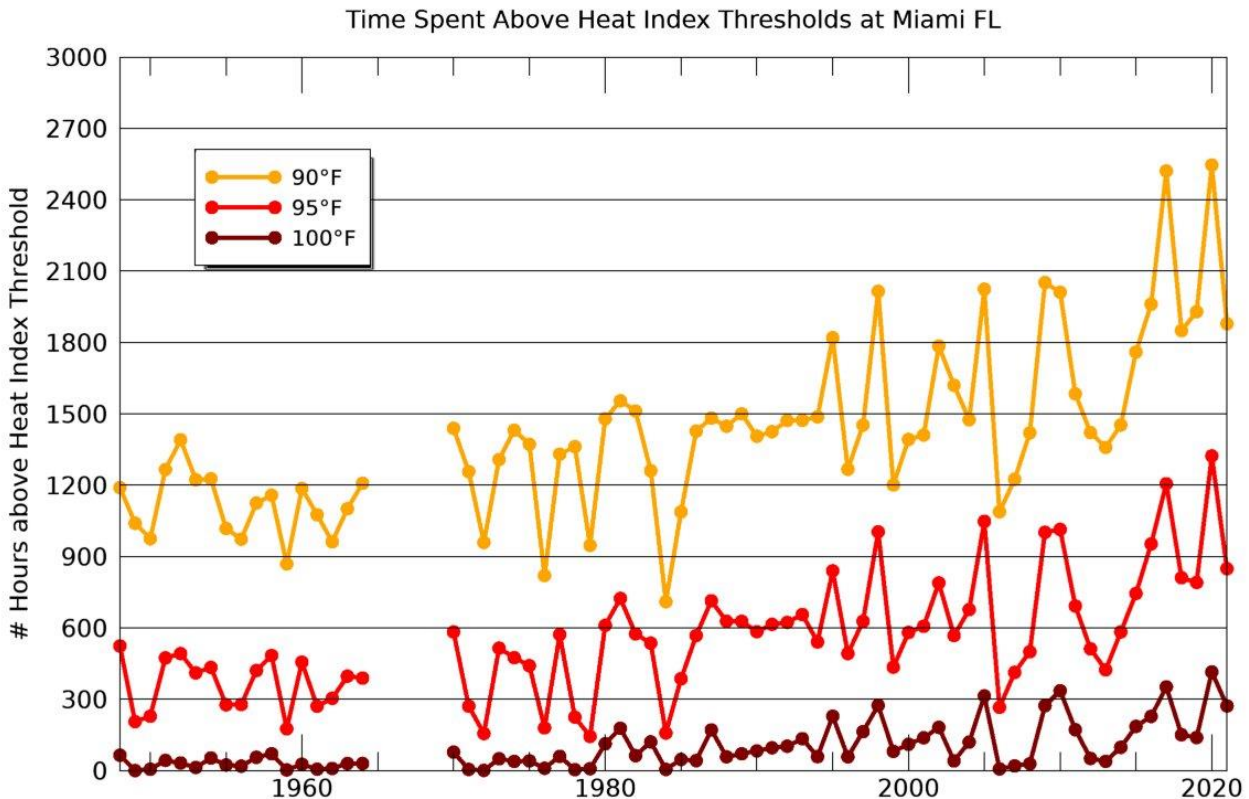
Heat Index

NWS Heat Index **Temperature (°F)**

	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
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										

Likelihood of Heat Disorders with Prob

 Caution
 Extreme Caution

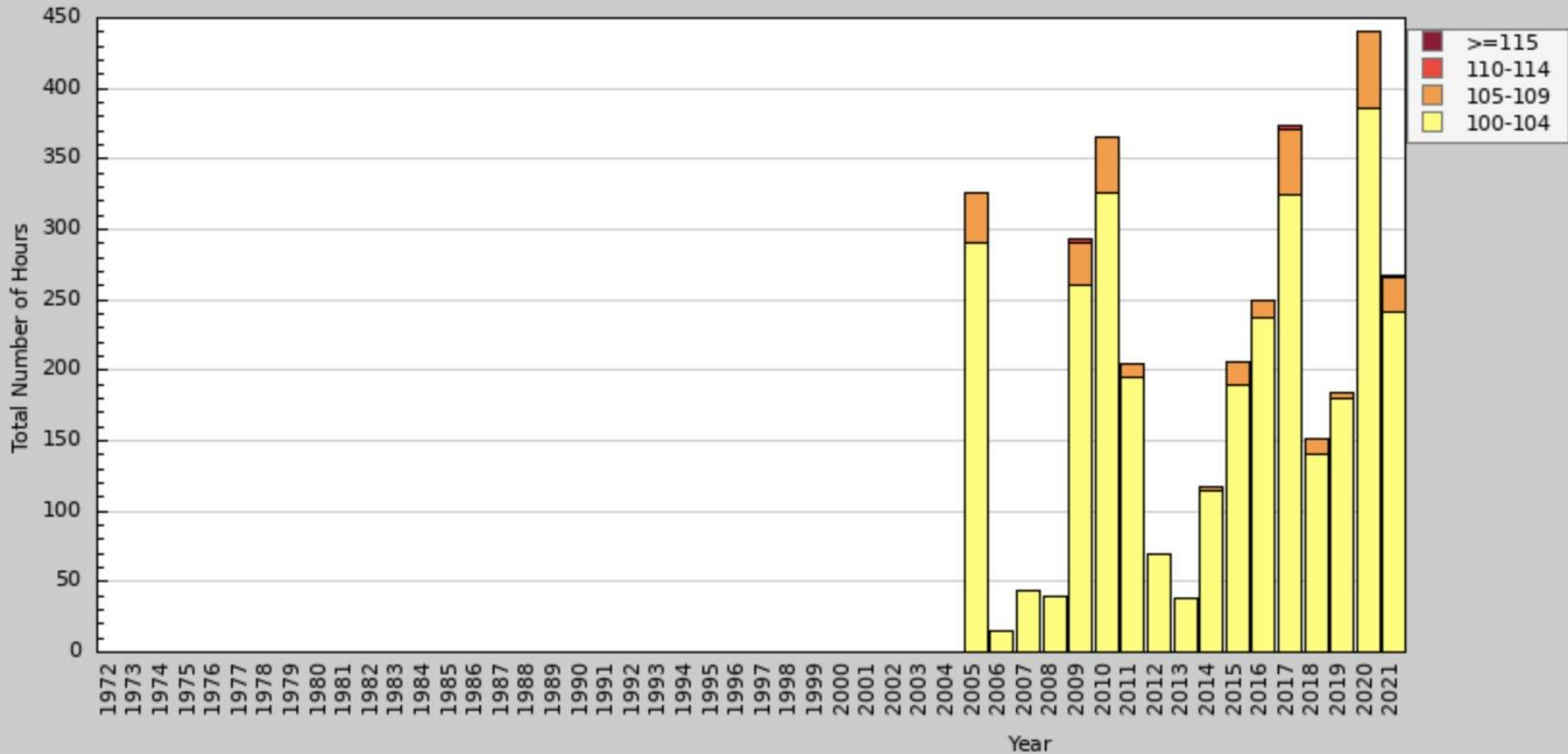




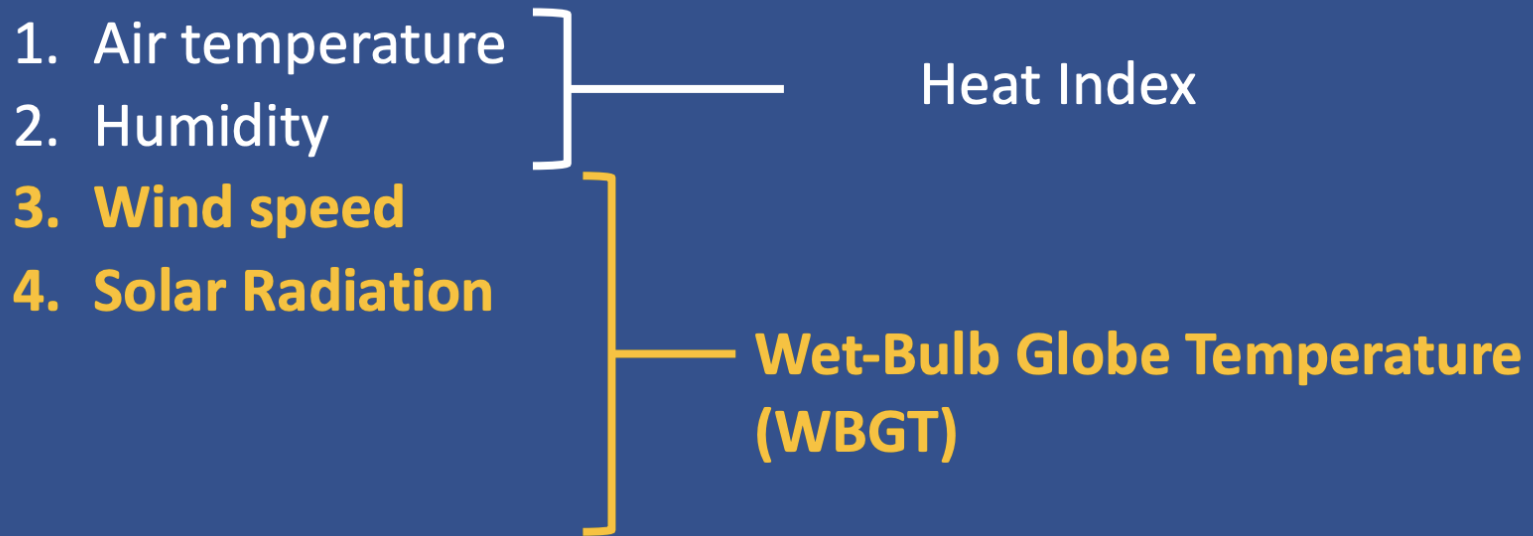
Heat Index



MIAMI INTL AP (KMIA)
Heat Index Counts



Measures of Heat Stress



Work/Rest and Water Consumption Table

Applies to average sized, heat-acclimated soldier wearing BDU, hot weather. (See TB MED 507 for further guidance.)

Easy Work	Moderate Work	Hard Work
<ul style="list-style-type: none"> • Weapon Maintenance • Walking Hard Surface at 2.5 mph, < 30 lb Load • Marksmanship Training • Drill and Ceremony • Manual of Arms 	<ul style="list-style-type: none"> • Walking Loose Sand at 2.5 mph, No Load • Walking Hard Surface at 3.5 mph, < 40 lb Load • Calisthenics • Patrolling • Individual Movement Techniques, i.e., Low Crawl or High Crawl • Defensive Position Construction 	<ul style="list-style-type: none"> • Walking Hard Surface at 3.5 mph, ≥ 40 lb Load • Walking Loose Sand at 2.5 mph with Load • Field Assaults

- The work/rest times and fluid replacement volumes will sustain performance and hydration for at least 4 hrs of work in the specified heat category. Fluid needs can vary based on individual differences ($\pm \frac{1}{4}$ qt/hr) and exposure to full sun or full shade ($\pm \frac{1}{4}$ qt/hr).

- **NL** = no limit to work time per hr.
- **Rest** = minimal physical activity (sitting or standing) accomplished in shade if possible.

- **CAUTION: Hourly fluid intake should not exceed 1½ qts.**

Daily fluid intake should not exceed 12 qts.

- If wearing body armor, add 5°F to WBGT index in humid climates.

- If doing Easy Work and wearing NBC (MOPP 4) clothing, add 10°F to WBGT index.

- If doing Moderate or Hard Work and wearing NBC (MOPP 4) clothing, add 20°F to WBGT index.

Heat Category	WBGT Index, F°	Easy Work		Moderate Work		Hard Work	
		Work/Rest (min)	Water Intake (qt/hr)	Work/Rest (min)	Water Intake (qt/hr)	Work/Rest (min)	Water Intake (qt/hr)
1	78° - 81.9°	NL	½	NL	¾	40/20 min	¾
2 (GREEN)	82° - 84.9°	NL	½	50/10 min	¾	30/30 min	1
3 (YELLOW)	85° - 87.9°	NL	¾	40/20 min	¾	30/30 min	1
4 (RED)	88° - 89.9°	NL	¾	30/30 min	¾	20/40 min	1
5 (BLACK)	> 90°	50/10 min	1	20/40 min	1	10/50 min	1

For additional copies, contact: U.S. Army Center for Health Promotion and Preventive Medicine Health Information Operations Division at (800) 222-9698 or CHPPM - Health Information Operations@apg.amedd.army.mil.

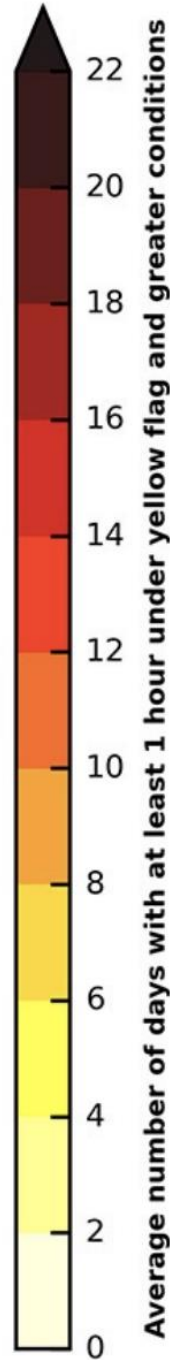
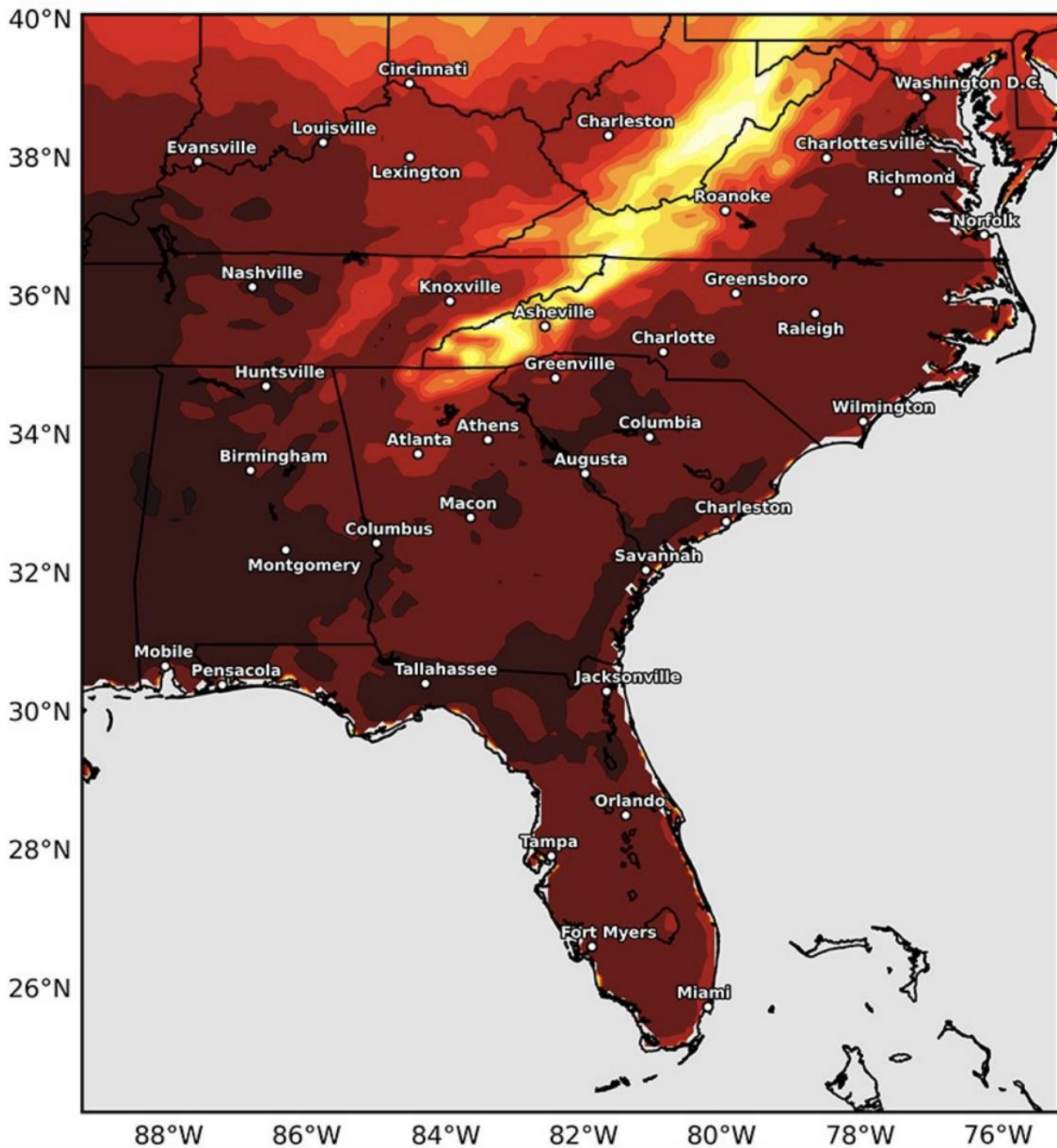
For electronic versions, see <http://chppm-www.apgea.army.mil/heat>. Local reproduction is authorized.

June 2004

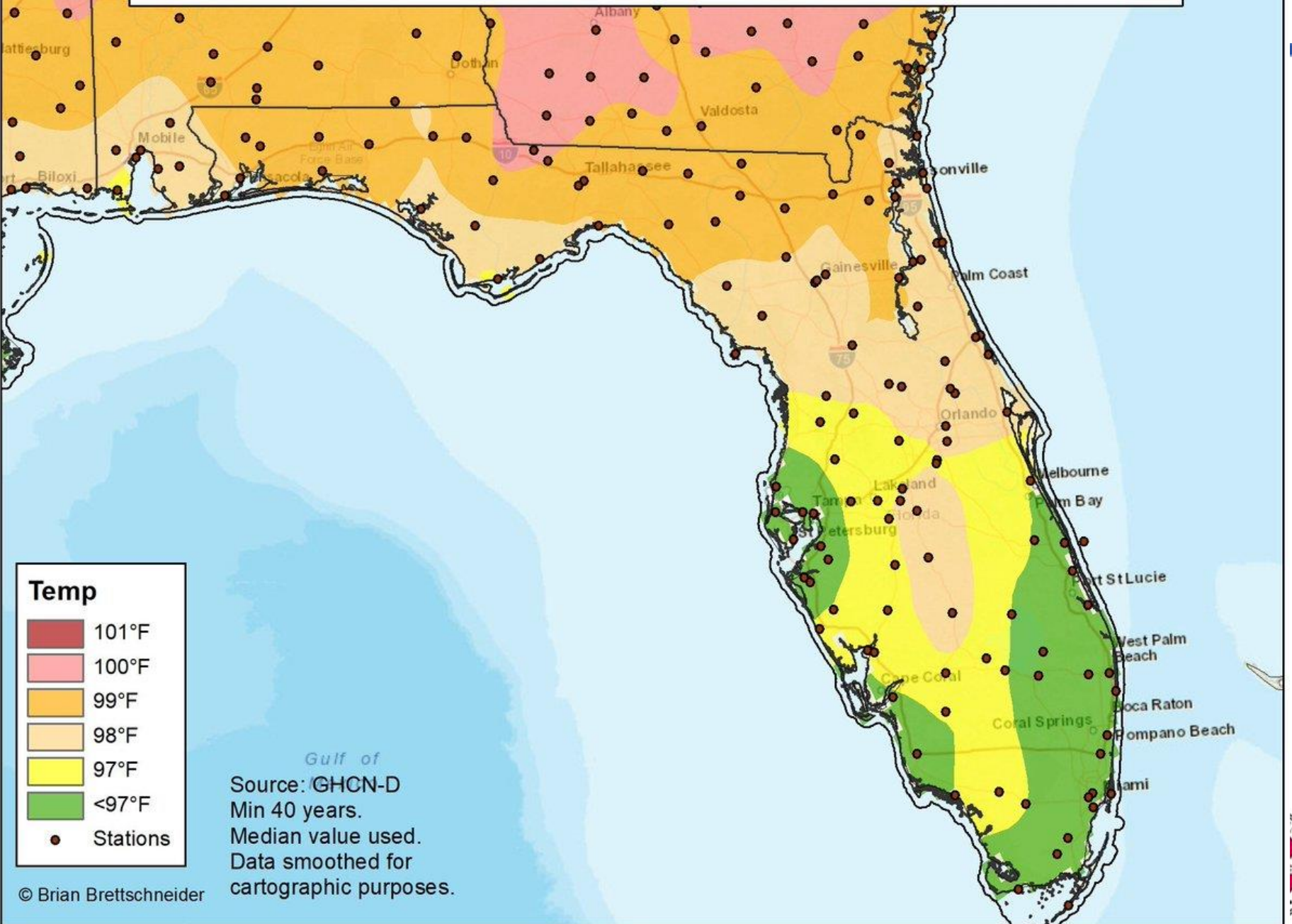


CP-033-0404





The Hottest Day of Summer is Typically This Hot



Temp

Dark Red	101°F
Light Red	100°F
Orange	99°F
Light Orange	98°F
Yellow	97°F
Light Green	<97°F
Black dot	Stations

Source: [GHCN-D](#)
Min 40 years.
Median value used.
Data smoothed for cartographic purposes.

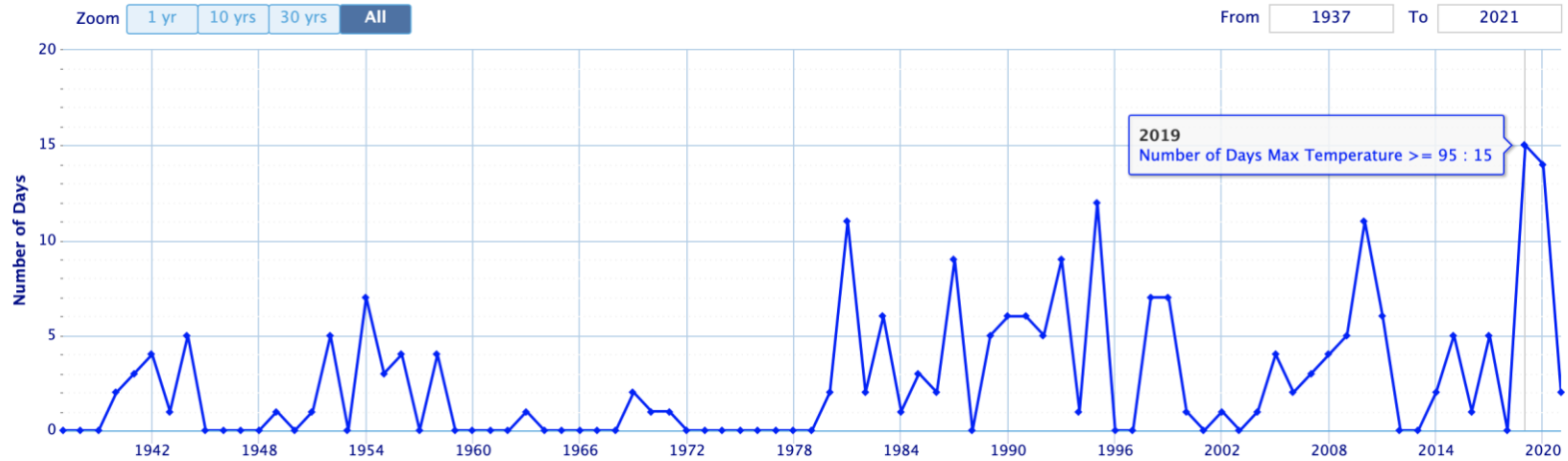




Days of Extreme Heat (Miami)

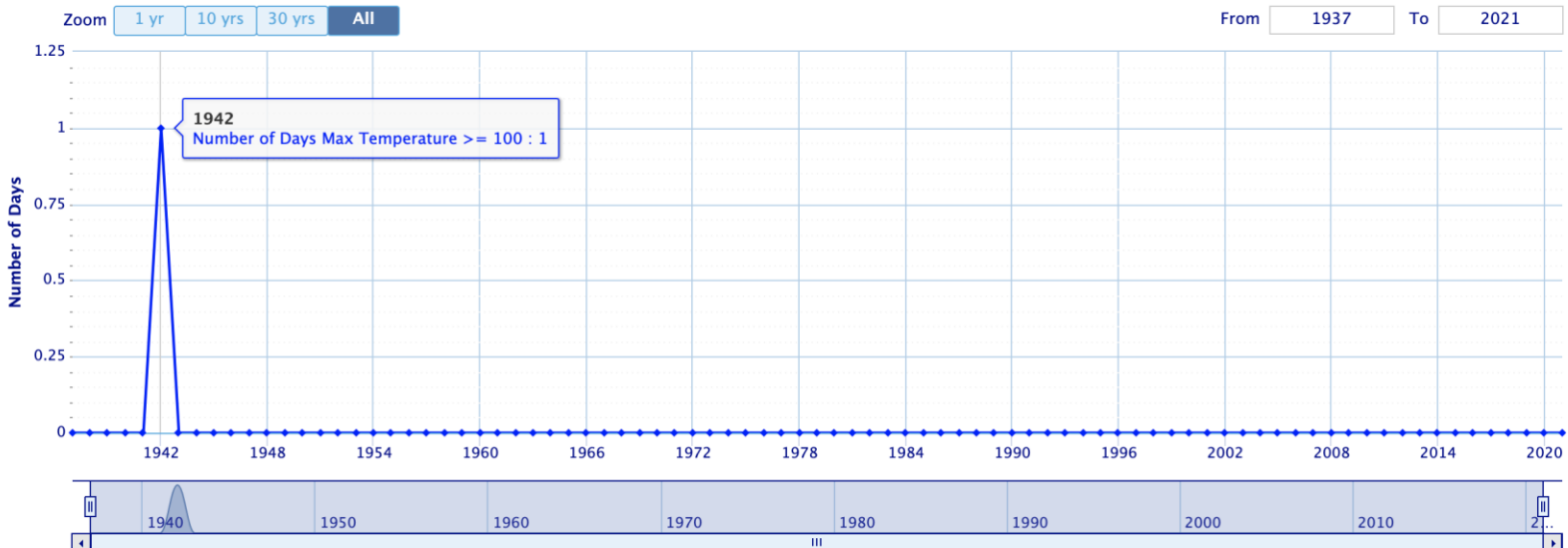
Number of Days Max Temperature ≥ 95 - Jan through Dec - MIAMI INTERNATIONAL AP, FL

Use navigation tools above and below chart to change displayed range



Number of Days Max Temperature ≥ 100 - Jan through Dec - MIAMI INTERNATIONAL AP, FL

Use navigation tools above and below chart to change displayed range

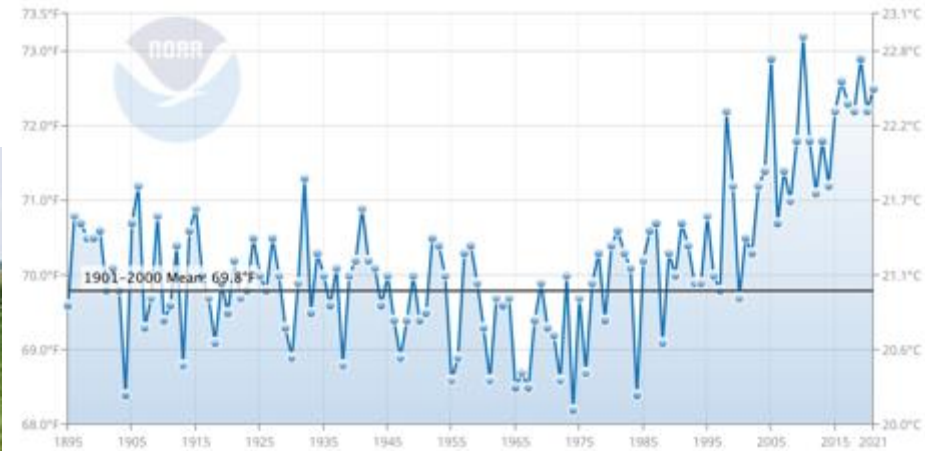




North Florida Summer Nighttime Temperature



Florida, Climate Division 2 Minimum Temperature
June-August

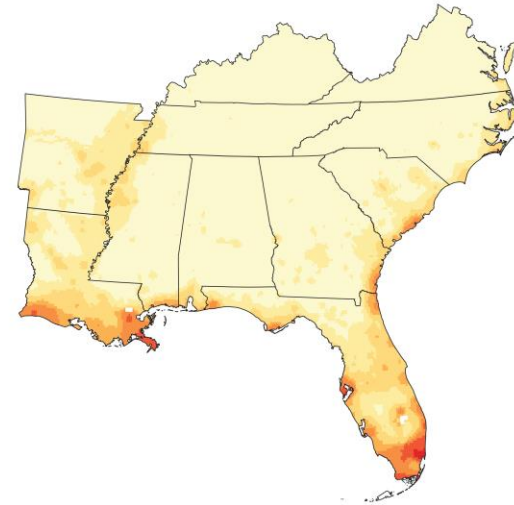


- Elevated soil temperature
- Cumulative stress on livestock
- Heat related illness and stroke
- Vulnerable populations – construction, ag workers, prison populations





Warm Nights – Miami, FL



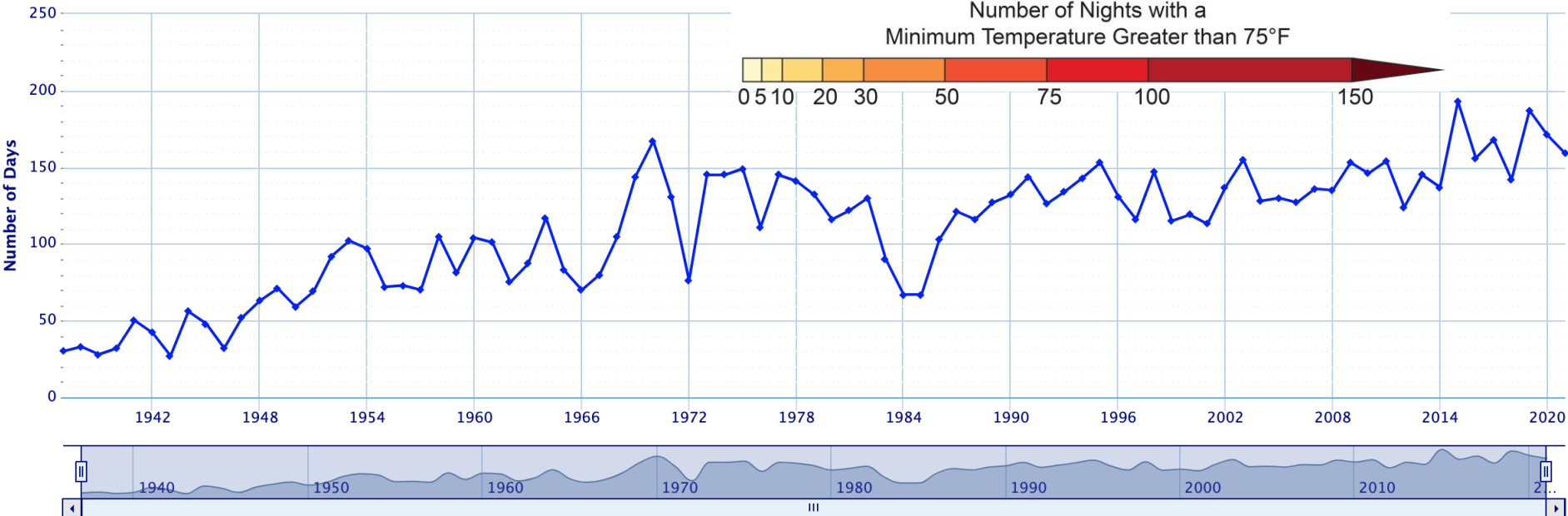
Number of Days Min Temperature ≥ 75

Use navigation tools above a

Zoom 1 yr 10 yrs 30 yrs All

2021

Number of Nights with a Minimum Temperature Greater than 75°F





Climate and Florida Citrus

Adapted from: John Attaway, “A History of Florida Citrus Freezes”



Mature orange grove outside of St. Augustine, FL in the early 1890' s. Trees have obviously grown for decades without major freeze damage.

- from Buel, 1893

Impact Freezes:

February 7-9, 1835

December 29, 1894

February 8, 1895

February 13-14, 1899

December 12-13, 1934

January 27-19, 1940

December 12-13, 1962

January 18-20, 1977

January 12-14, 1981

December 24-25, 1983

January 20-22, 1985

December 24-25, 1989

January 19, 1997



February 13th, 1899



*Snowballing on Capitol Steps—
Feb. 13th 1899. Tallahassee, Florida.*

- - 2 degrees F in Tallahassee (State Record)
- Measurable snow from the Panhandle to Tampa and Jacksonville
- Key West and Jupiter the only cities east of the Rockies without freezing temperatures
- Is this still possible?



Extreme Cold Temperatures

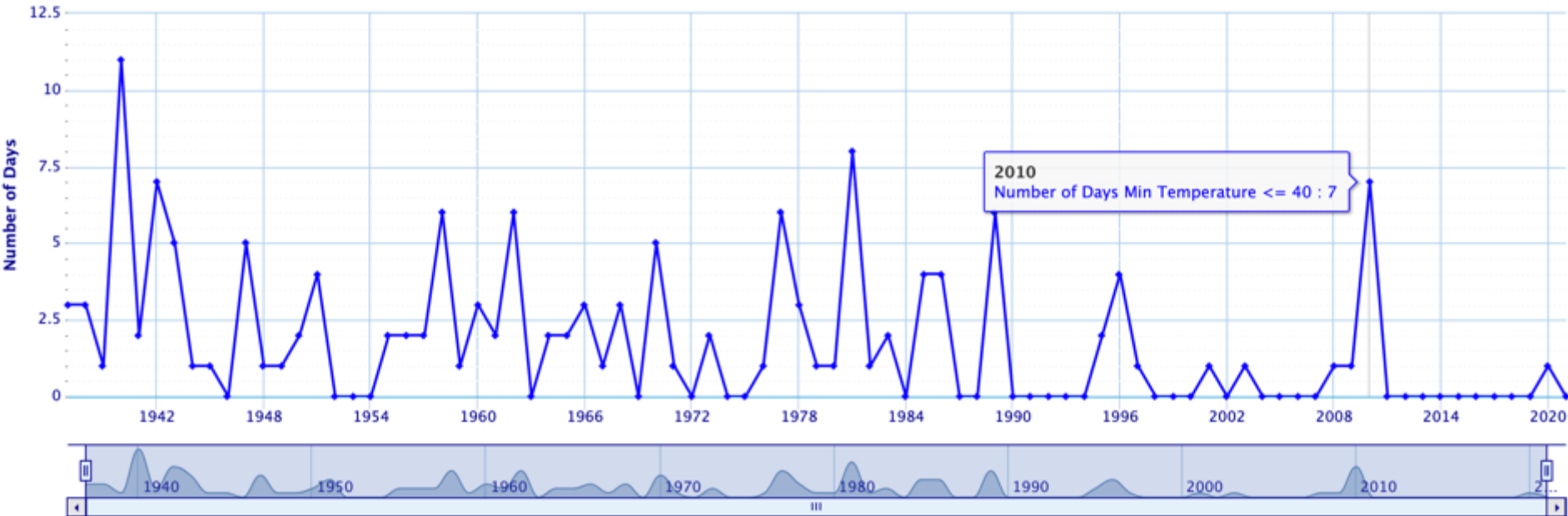
Number of Days Min Temperature ≤ 40 - Jan through Dec - MIAMI INTERNATIONAL AP, FL

Use navigation tools above and below chart to change displayed range



Zoom 1 yr 10 yrs 30 yrs All

From 1937 To 2021

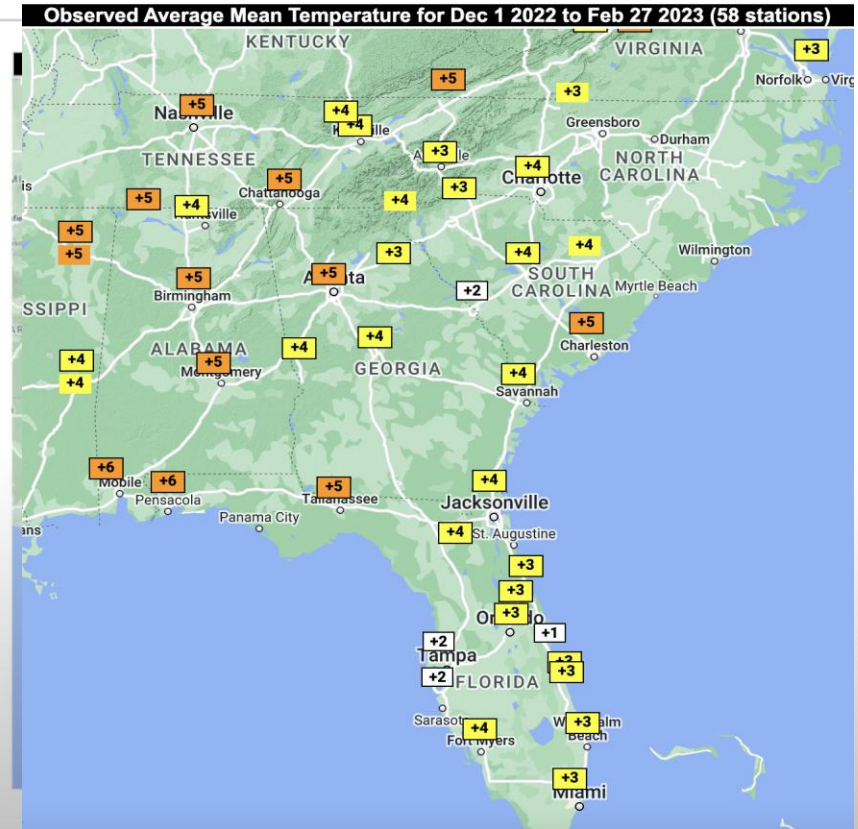
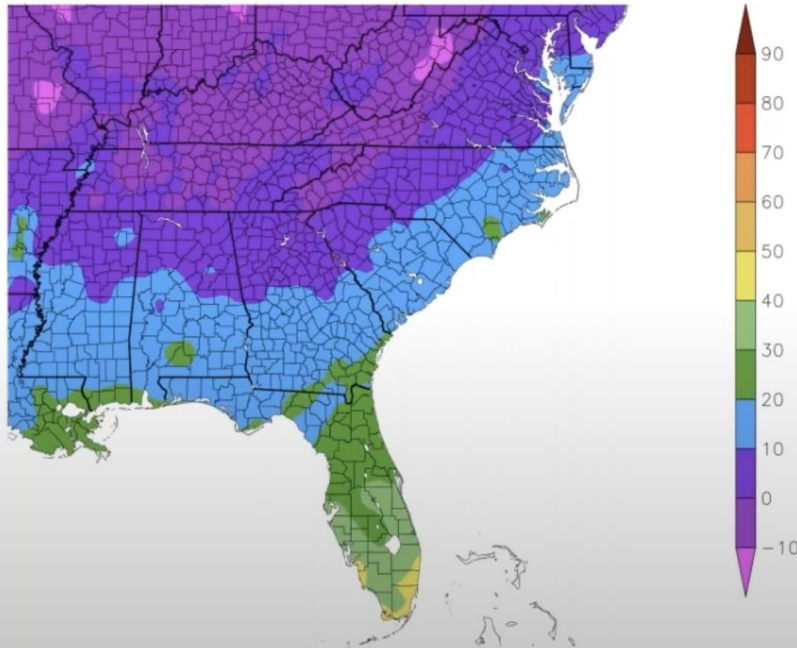


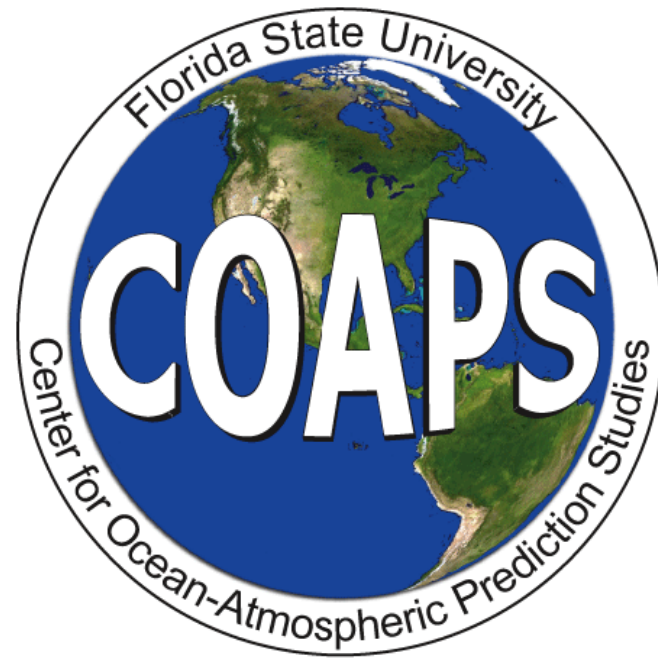
Powered by ACIS



Late December Arctic Outbreak

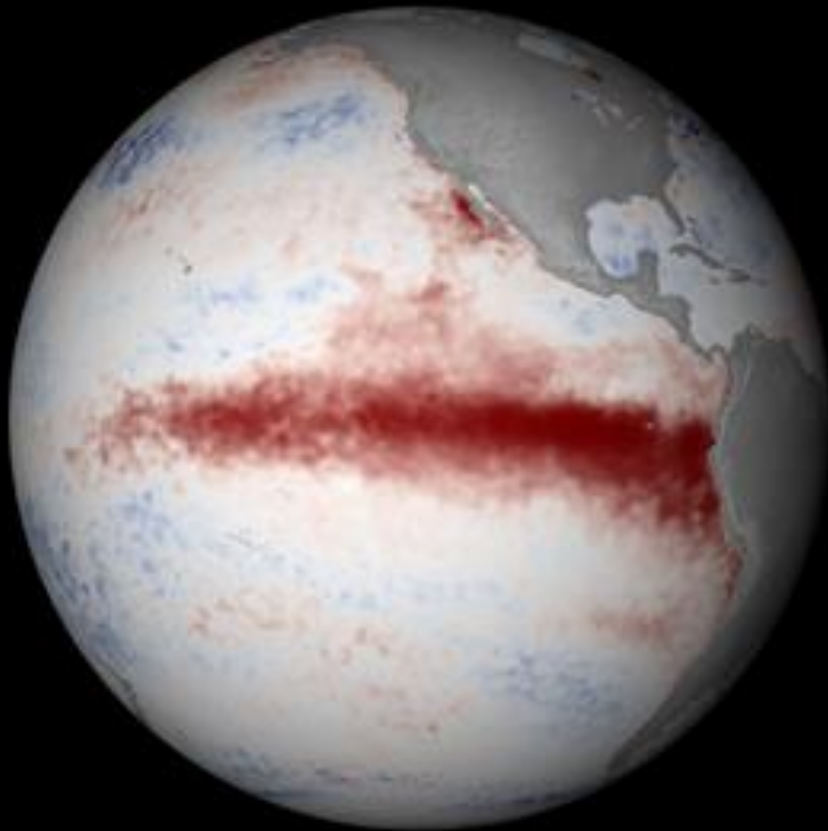
Lowest 1-Day Minimum Temperature (F)
 12/24/2022 - 1/22/2023





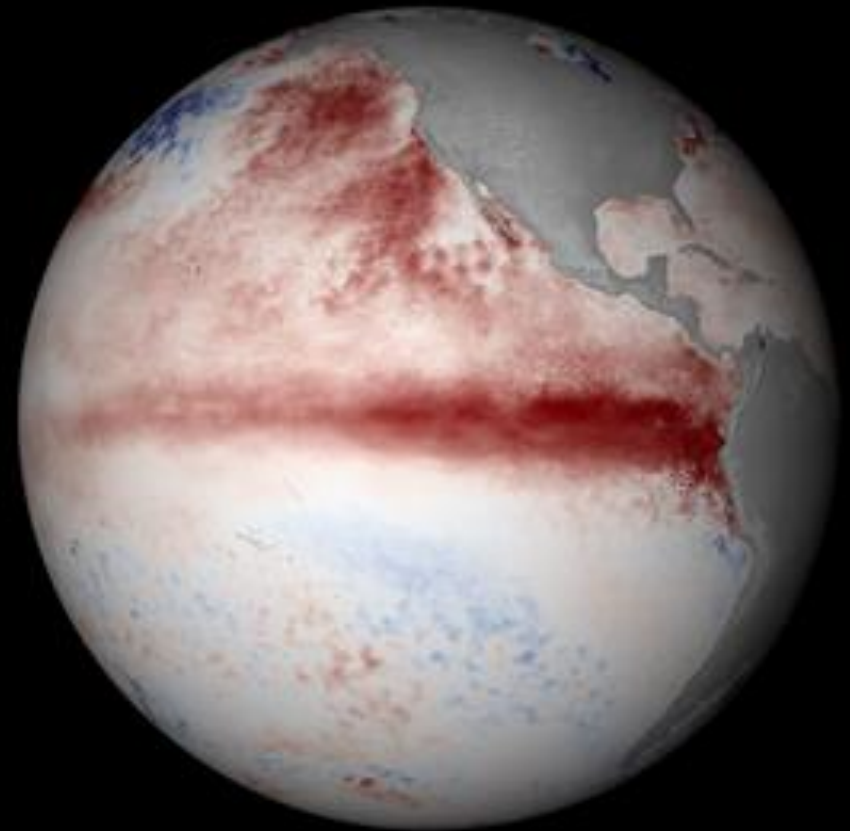
Climate Variability and Drought

El Nino/La Nina Cycle



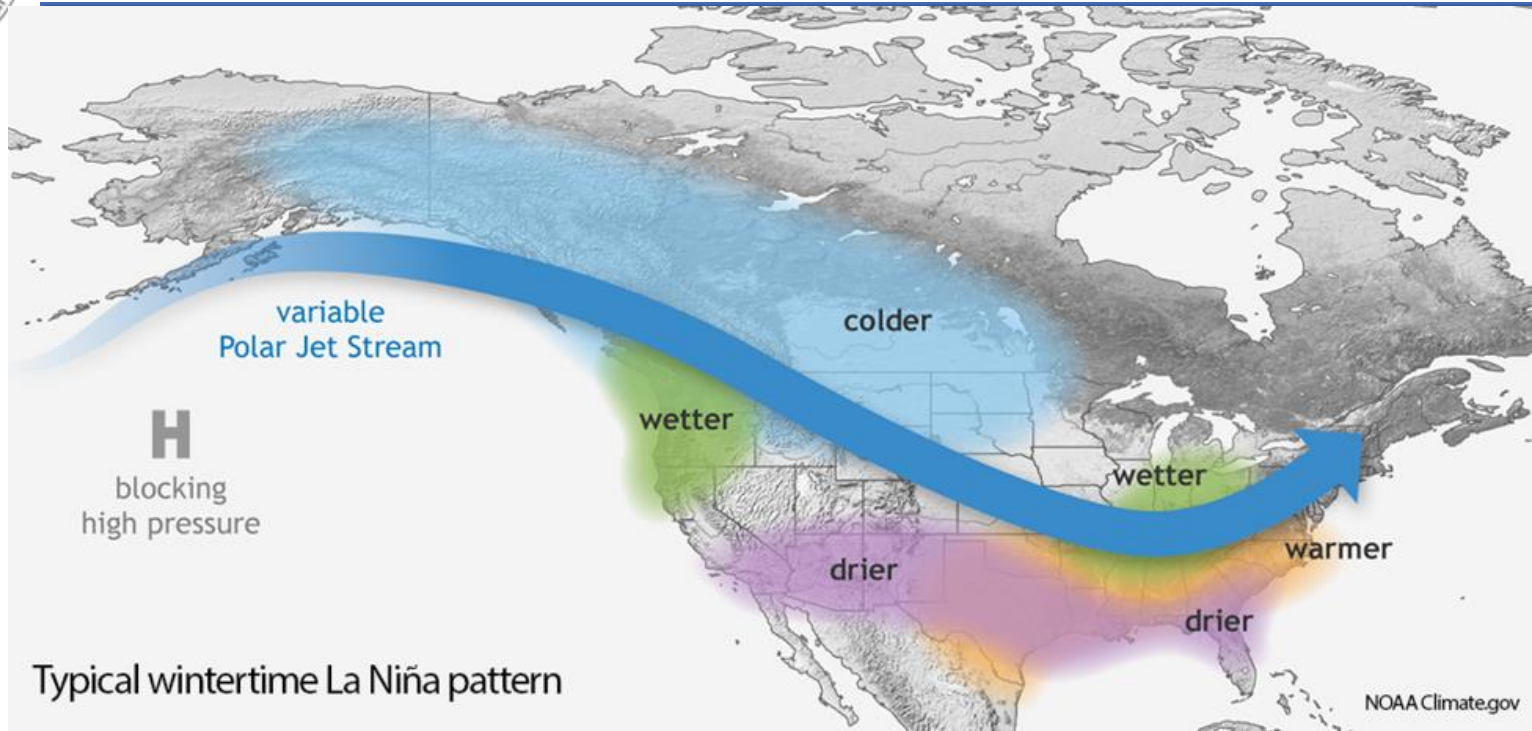
NOAA

November 1997

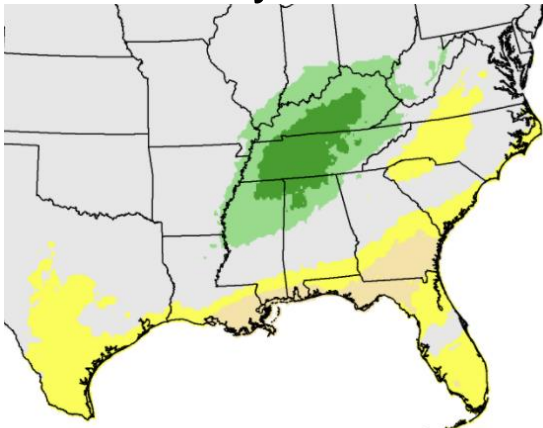


July 2015

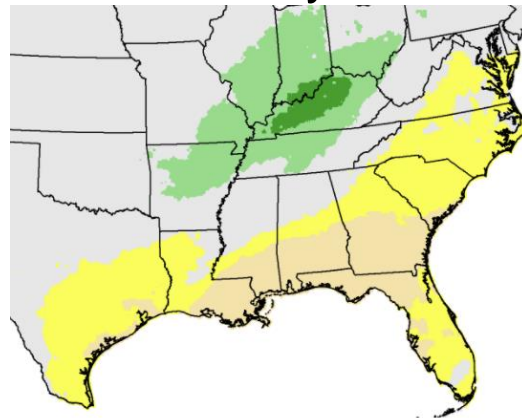
La Nina Impacts



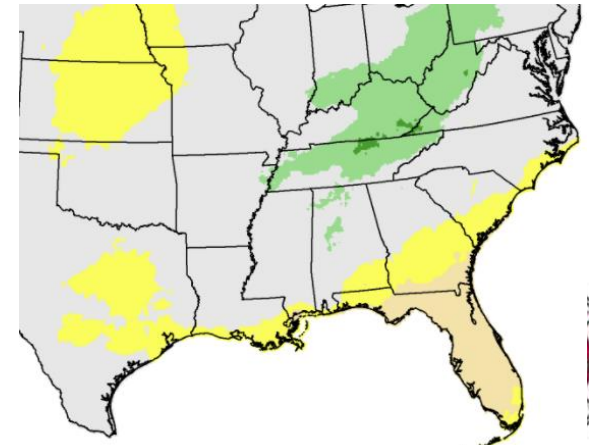
January



February



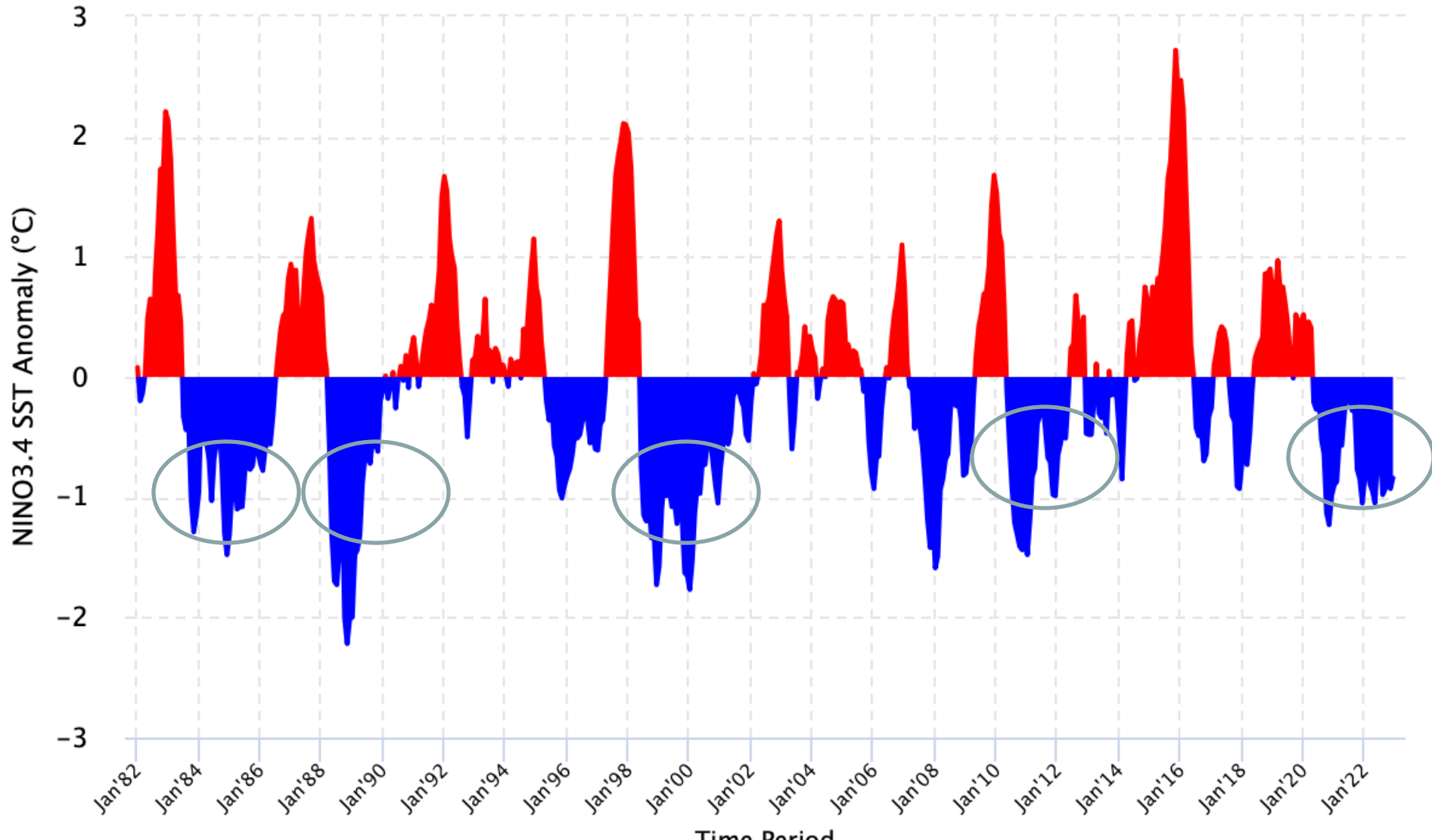
March





Multi-year La Nina's

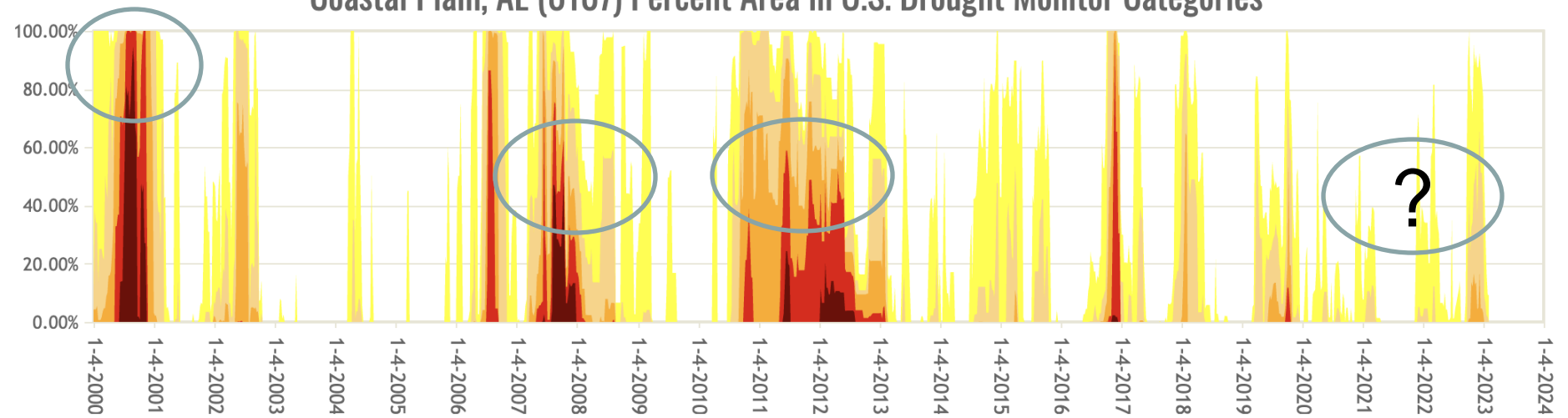
Historical Nino 3.4 Sea Surface Temperature Anomaly





La Nina and Drought

Coastal Plain, AL (0107) Percent Area in U.S. Drought Monitor Categories



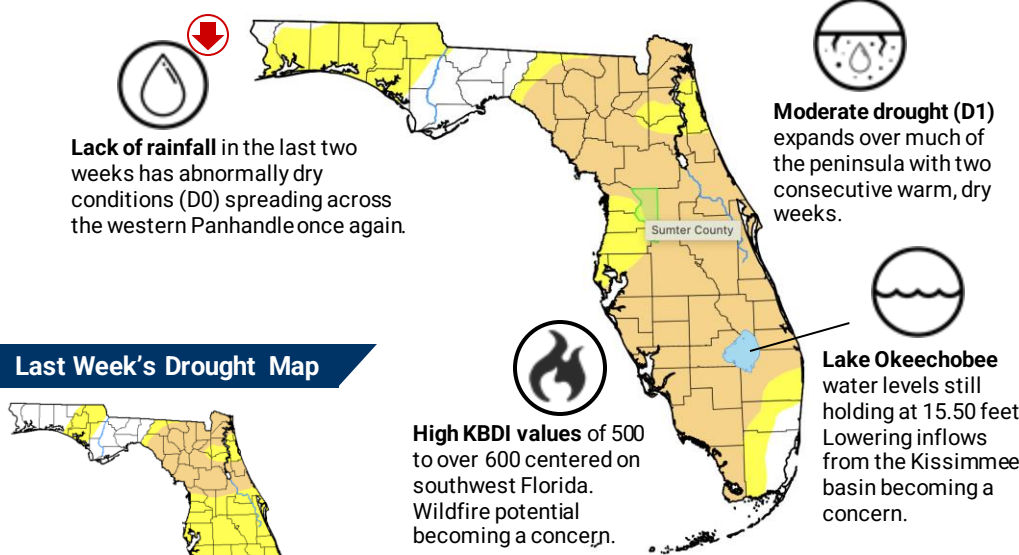


Florida Drought Update

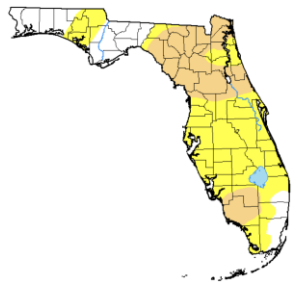
For the assessment period ending February 28, 2023

This Week's Drought Monitor of Florida Map

From the US Drought Monitor, authored by **Richard Heim (NOAA/NCEI)**, with input from the Florida Drought Monitoring Group. URL: <https://droughtmonitor.unl.edu/CurrentMap.aspx>



Last Week's Drought Map



FloridaClimateCenter
Office of the State Climatologist



Statewide Condition Summary

What's Changed? **Two consecutive weeks** of little to no rainfall combined with temperatures running 6 to 12 degrees above normal have hastened the spread of moderate drought (D1) over most of the peninsula.

Current Pattern – High pressure bringing continued warm temperatures and little rainfall holds across the state for at least the coming week. Current storm track well to the north along the Mississippi and Ohio river basins.

What's Next? **La Nina** conditions and cold water in the Pacific continue to warm rapidly. While there could be some lag in the atmospheric response, La Nina will be less of an influence on the spring/early summer climate patterns.

Statewide Coverage By Category

Category	Coverage This Week	Last Week
D0: Abnormally Dry	23.42%	50.77%
D1: Moderate Drought	64.54%	29.51%
D2: Severe Drought	0.00%	0.00%
D3: Extreme Drought	0.00%	0.00%
D4: Exceptional Drought	0.00%	0.00%





Potential Changes to Climate/Weather Threats

Increasing
confidence

Sea level rise – Global sea levels will continue to rise at a minimum the current rate, with the likely range of 1-4 ft. by 2100.

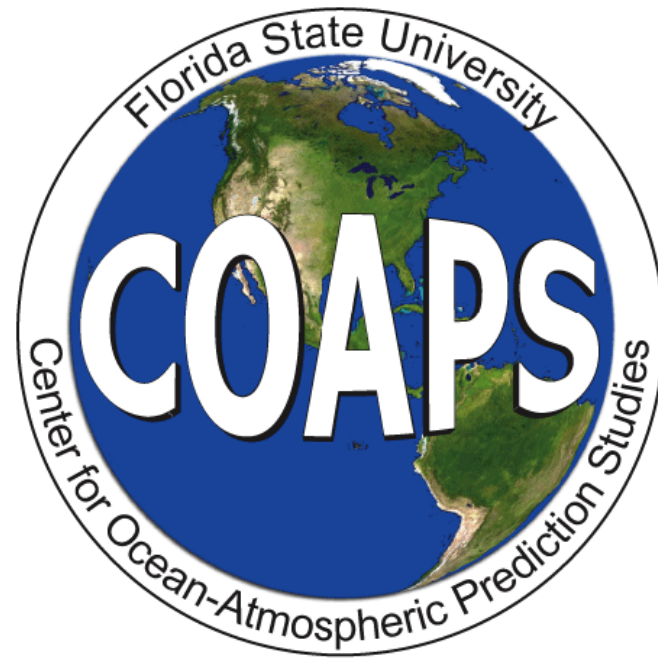
Temperature – very likely to continue rising with increasing CO₂. Florida less than interior North America.

Drought – rising temperature alone could lead to more frequent/longer periods of drought. Rainfall changes uncertain.

Rainfall – more extreme events, changing seasonal patterns uncertain.

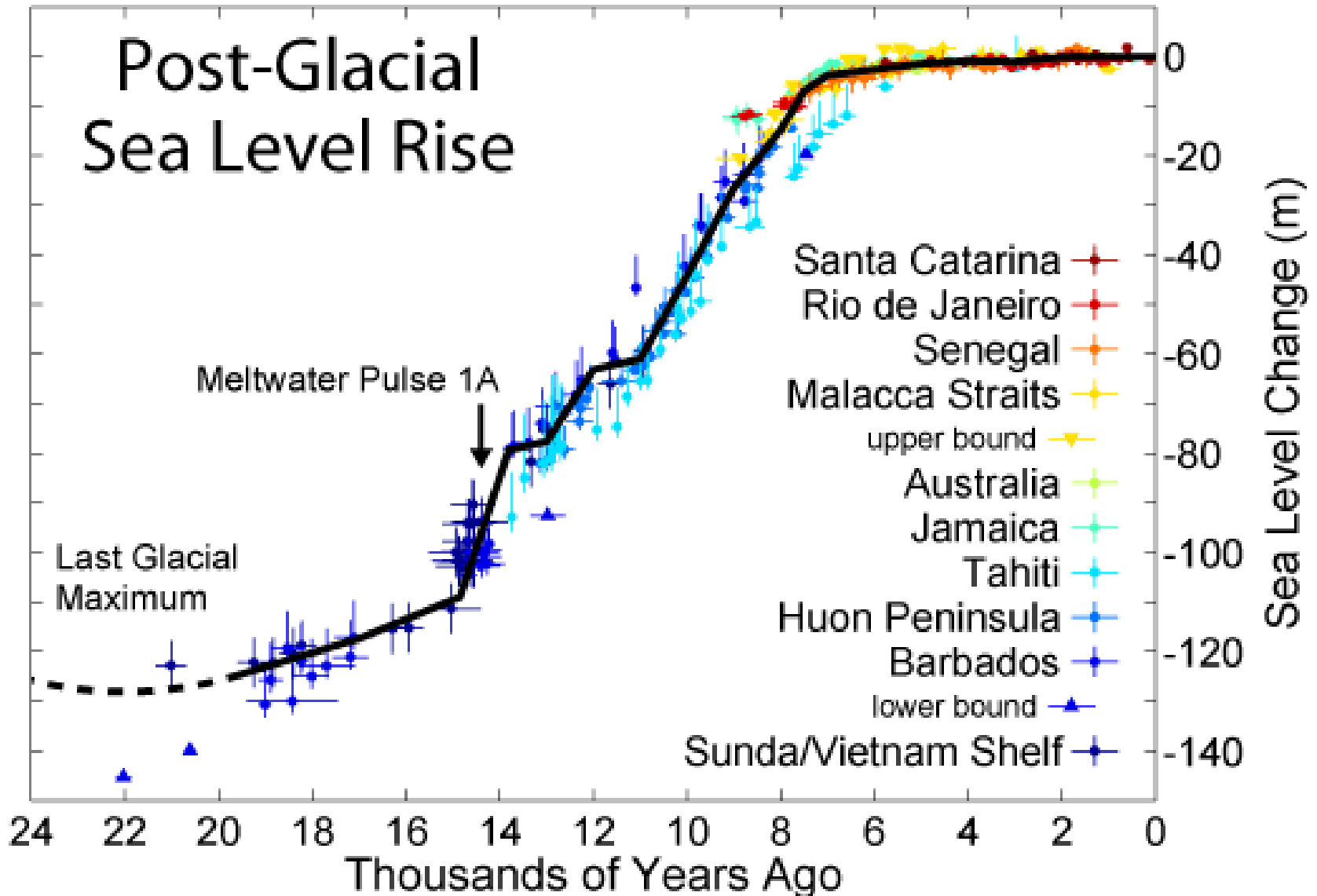
Hurricanes – Number of hurricanes may not change much, more potential for stronger storms, surge compounded by sea level rise, more rainfall and inland flooding





Sea Level Rise

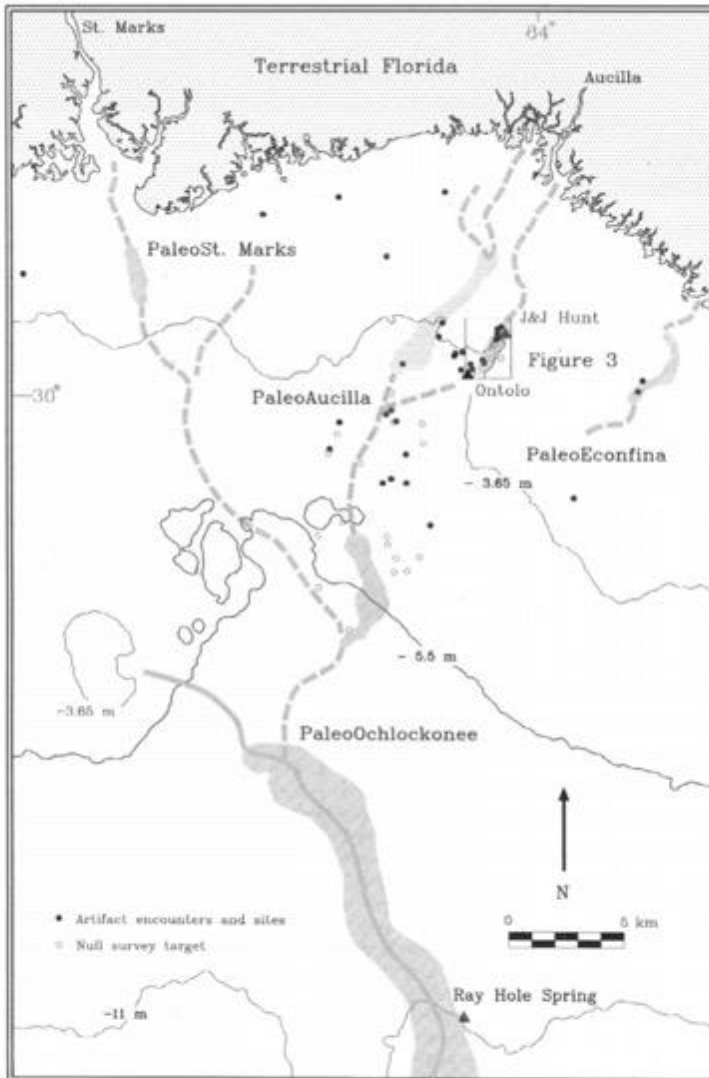
Thousands of years of Sea Level Rise



PaleoAucilla Settlements in the Gulf

REPORTS

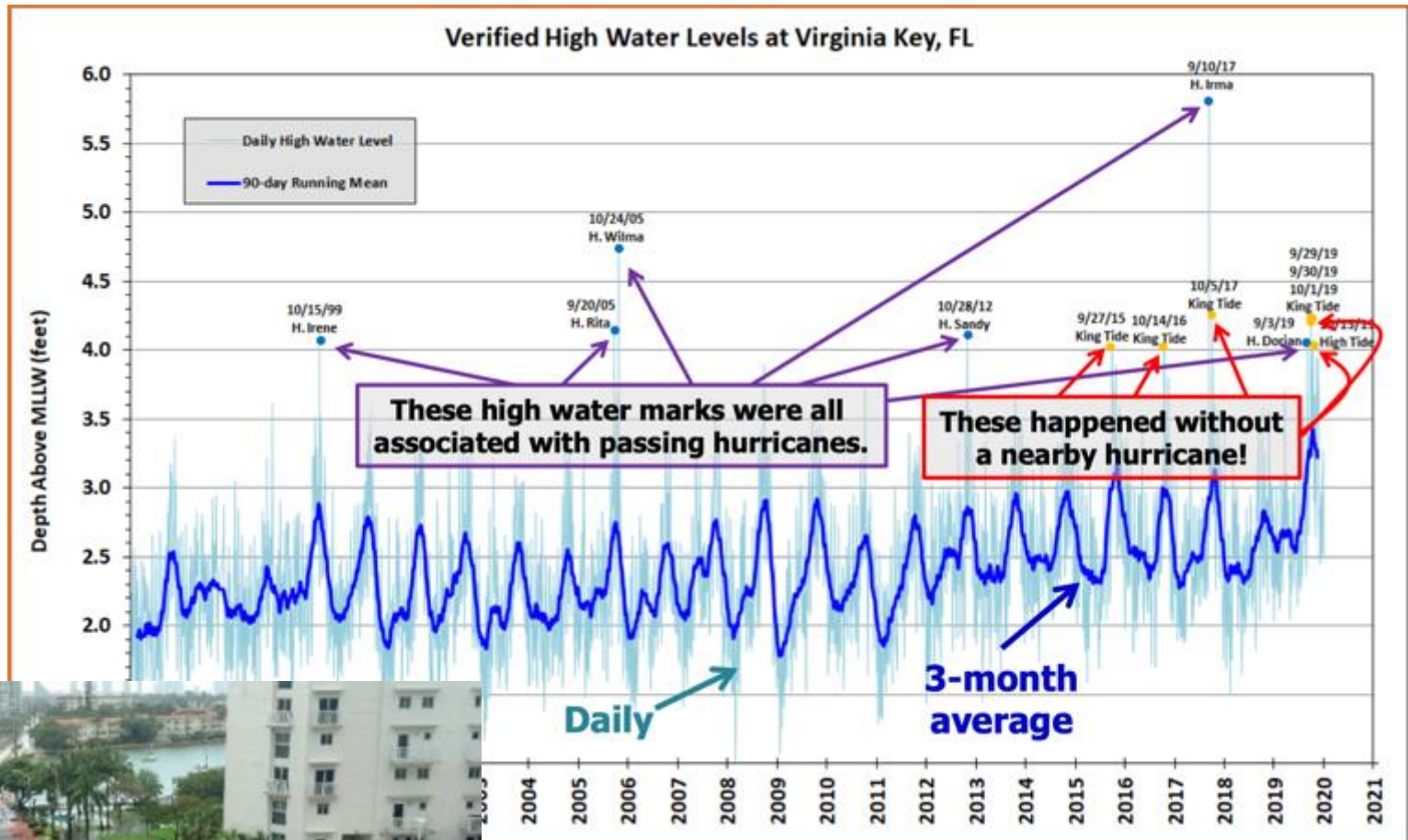
279



Artifact encounters in
Apalachee Bay

- Faught, 2004

Miami Sea Level Rise

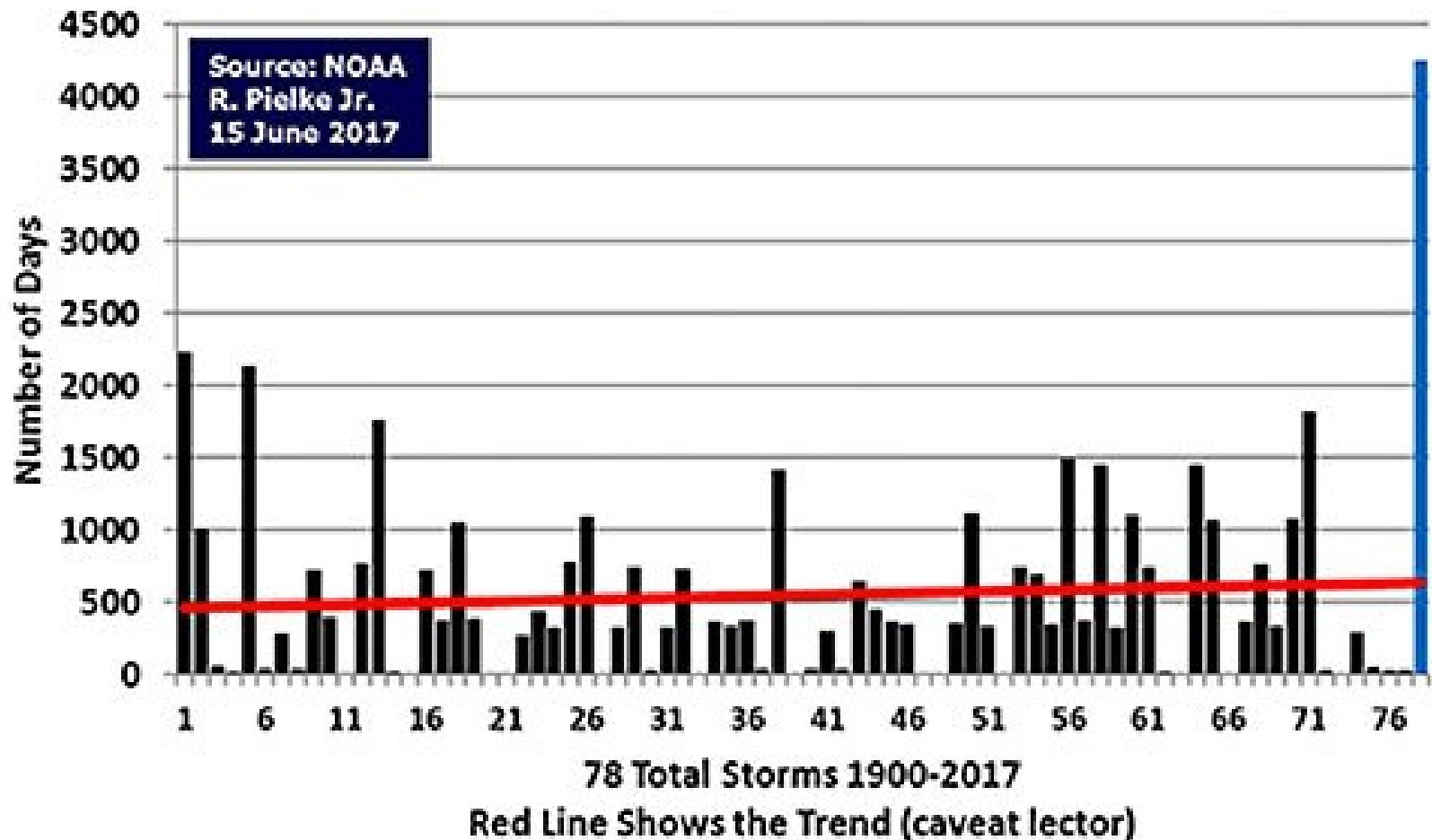




Hurricanes and Tropical Cyclones

Hurricane “Drought”

Days Between Major Hurricane (Cat 3, 4, 5) Landfalls in the US:
1900 to 15 June 2017





Hurricane Season



2021 Hurricane season

- 20 named storms, 7 hurricanes, 4 majors
- 6 landfalls on the Gulf Coast
- TS Claudette, Fred bring heavy rain

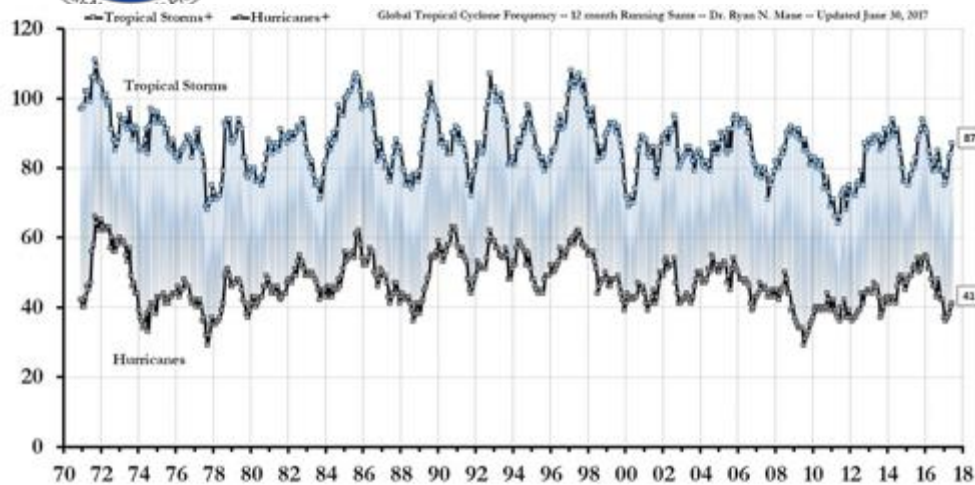


2020 Hurricane Season

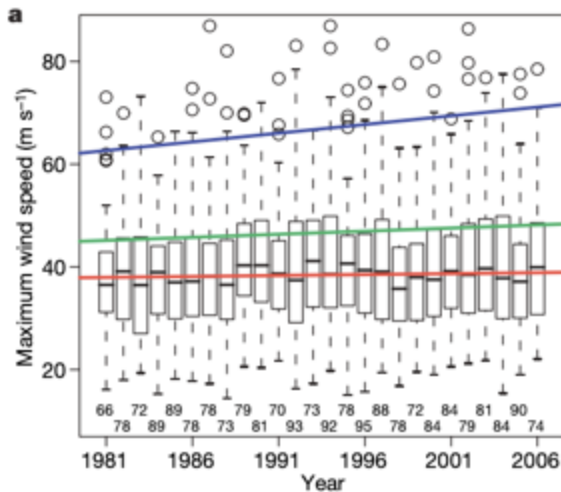
- Record 30 named storms, 14 hurricanes, 7 majors
- 10 landfalls on the Gulf Coast
- Hurricane Sally, Sept. 16



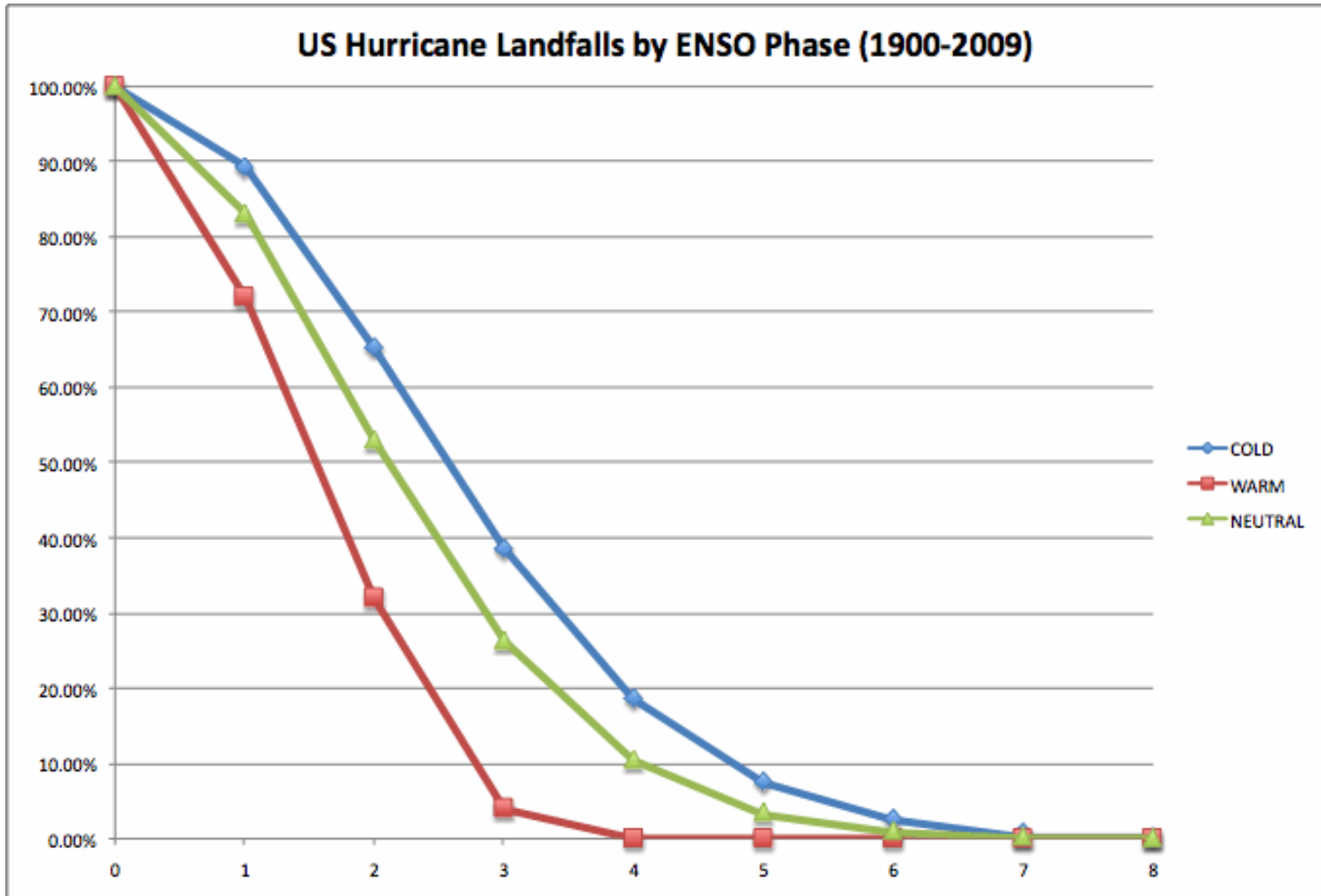
Changes in Tropical Cyclones



- The number of tropical cyclones has remained unchanged globally
- The strongest hurricanes are getting stronger
- Increasing rainfall from tropical cyclones
- Forward motion may be getting slower, tracks may be shifting north



Hurricane Landfall Probabilities





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