Impacts of Hurricane Associated Water Quality Changes to Ecosystem Health

Implications for Future Coordination

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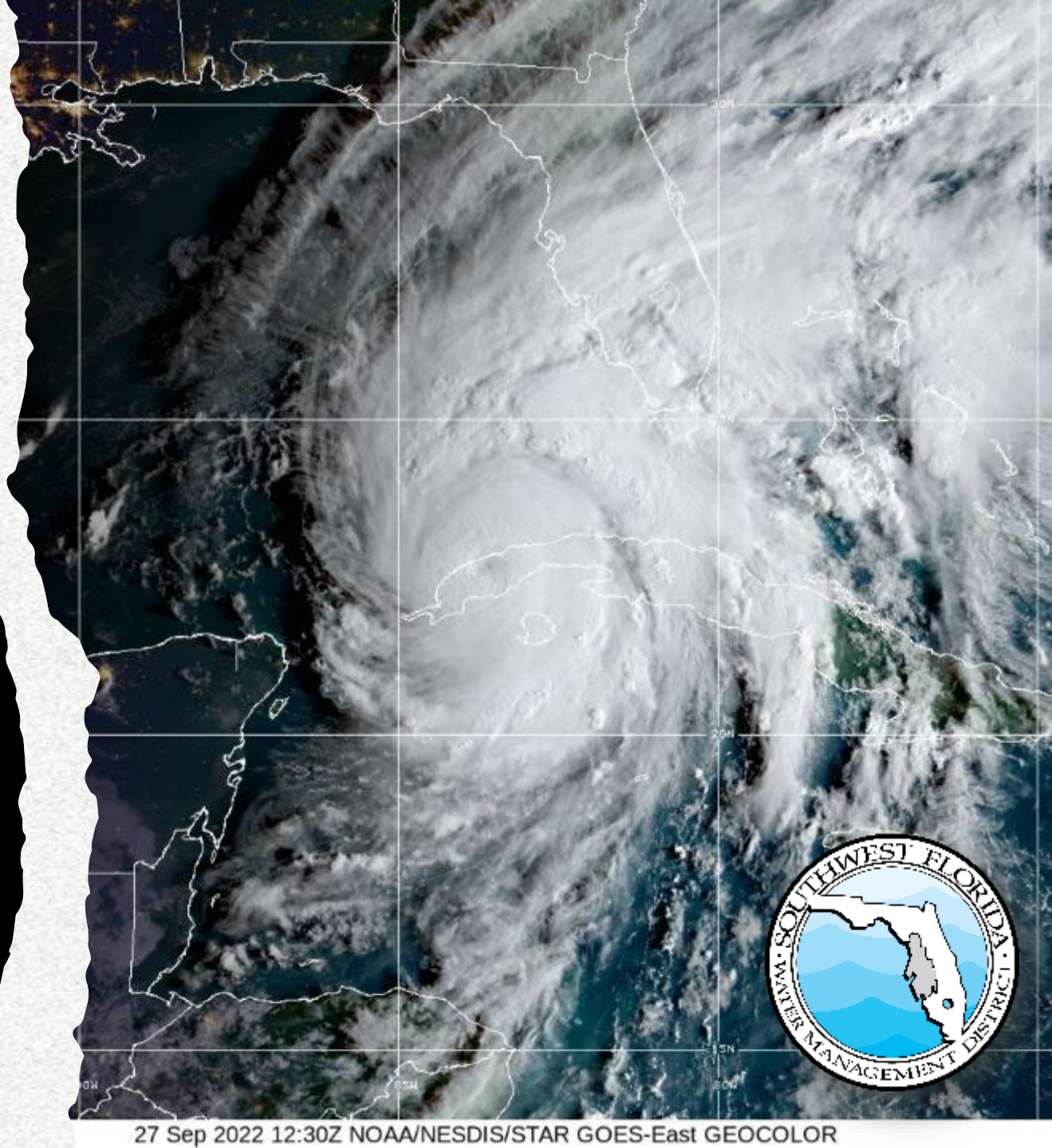
Southwest Florida Water Management District

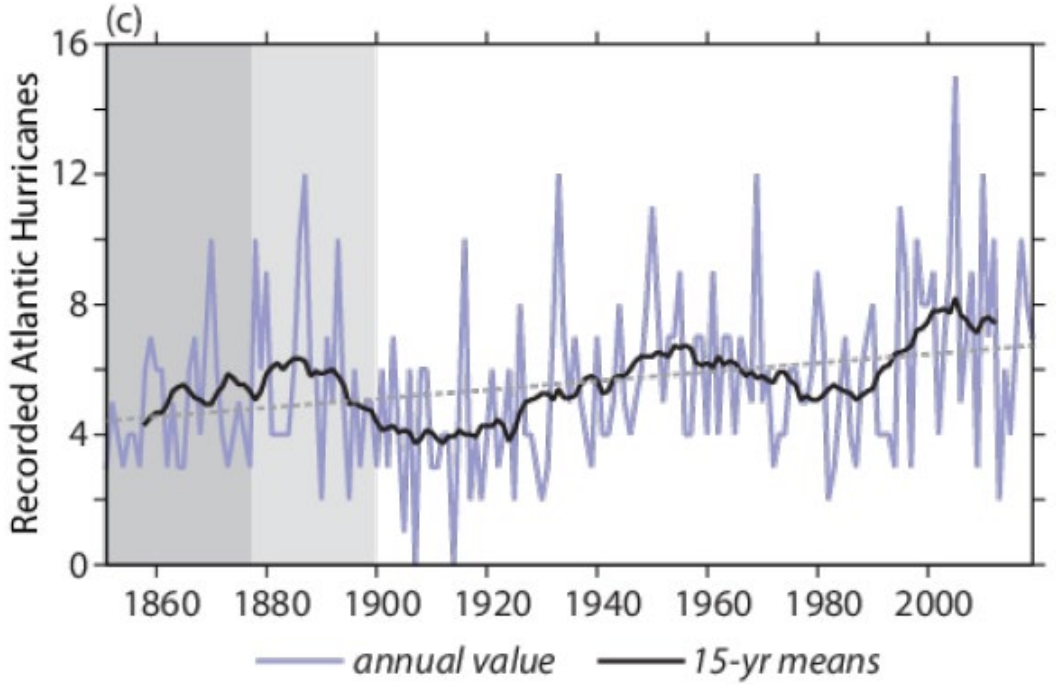
2024 University of Florida Water Institute Symposium
February 20-21, 2024

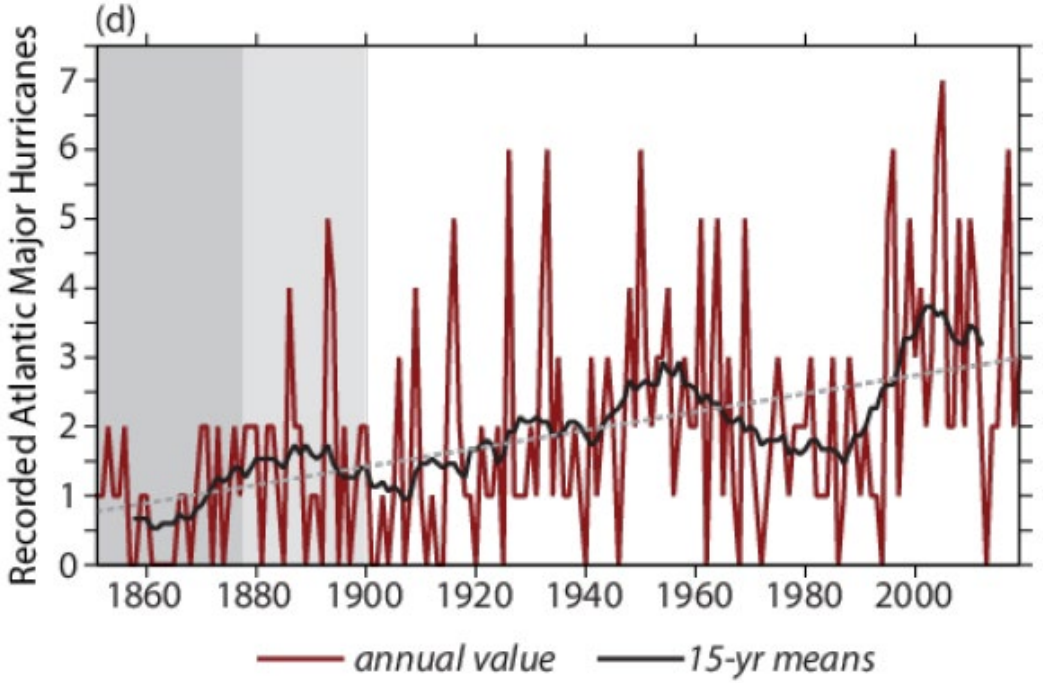


Hurricane Trends

- Hurricanes have occurred for millennia
- Several Atlantic hurricane activity metrics show pronounced increases since 1980
- But weaker trends when considering entire hurricane period of record
- Economic damage in U.S. from hurricanes has increased remarkably over the past century, as has population and value of built infrastructure in hurricane-prone regions
- Coastal ecosystems have become less resilient to episodic events like hurricanes

1.1_SOS_Atlantic_Hurricanes_Climate.pdf (noaa.gov)





Vecchi, G.A., C. Landsea, W. Zhang, G. Villarini, and T. Knutson. 2021. Changes in Atlantic major hurricane frequency since the late-19th century. Nature communications 12: 4054.

Sub-lethal Stress
“Pre-existing Conditions”

- Chronic vs. Acute

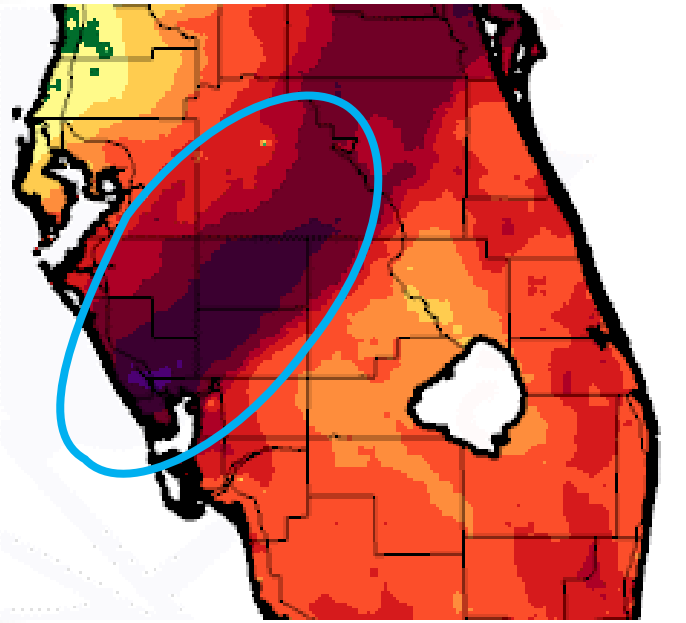
- Stress
- Disease
- Nutrient Over-enrichment
- Algal Blooms
- Climate Change
- Hypoxia/Anoxia

Hypoxia

- Occurs when dissolved oxygen concentrations remain below 2-3 mg/L
- Optimum health for warm-water fish (those in Florida) generally require average dissolved oxygen concentrations of ≥ 5 mg/L
- Fish usually die when dissolved oxygen concentrations fall below 2 mg/L for extended periods of time

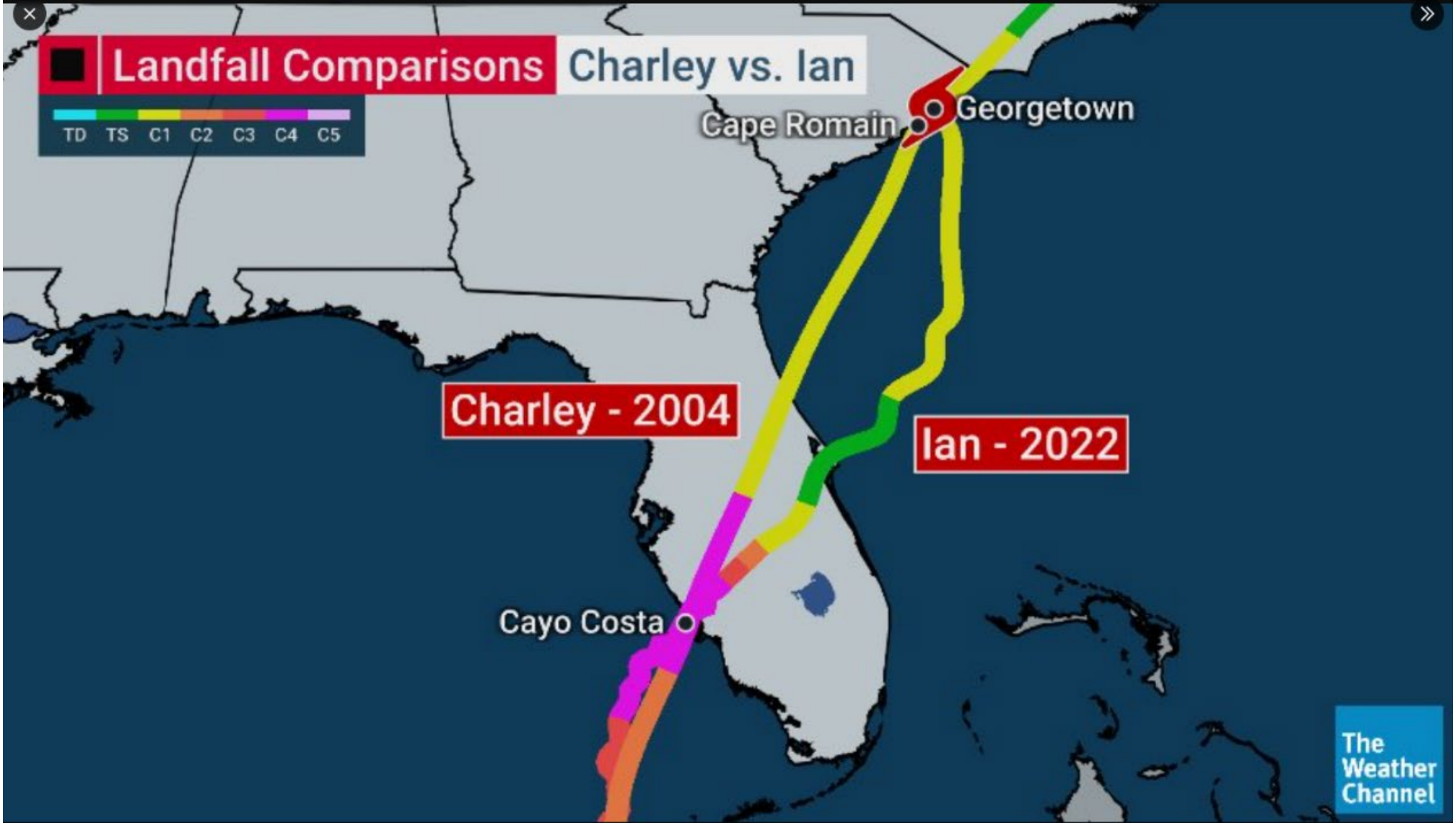
Hurricane Ian

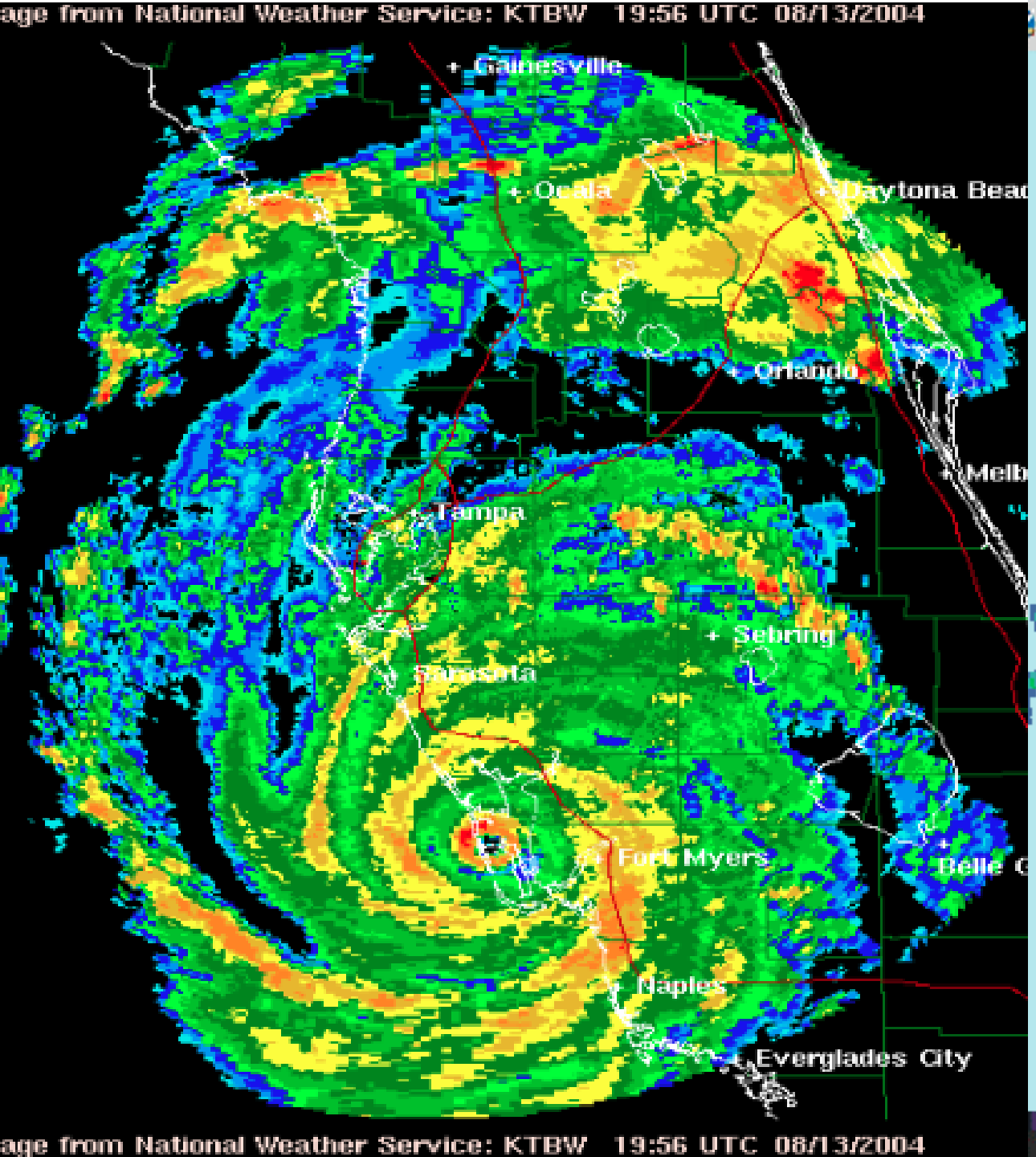
September 28, 2022

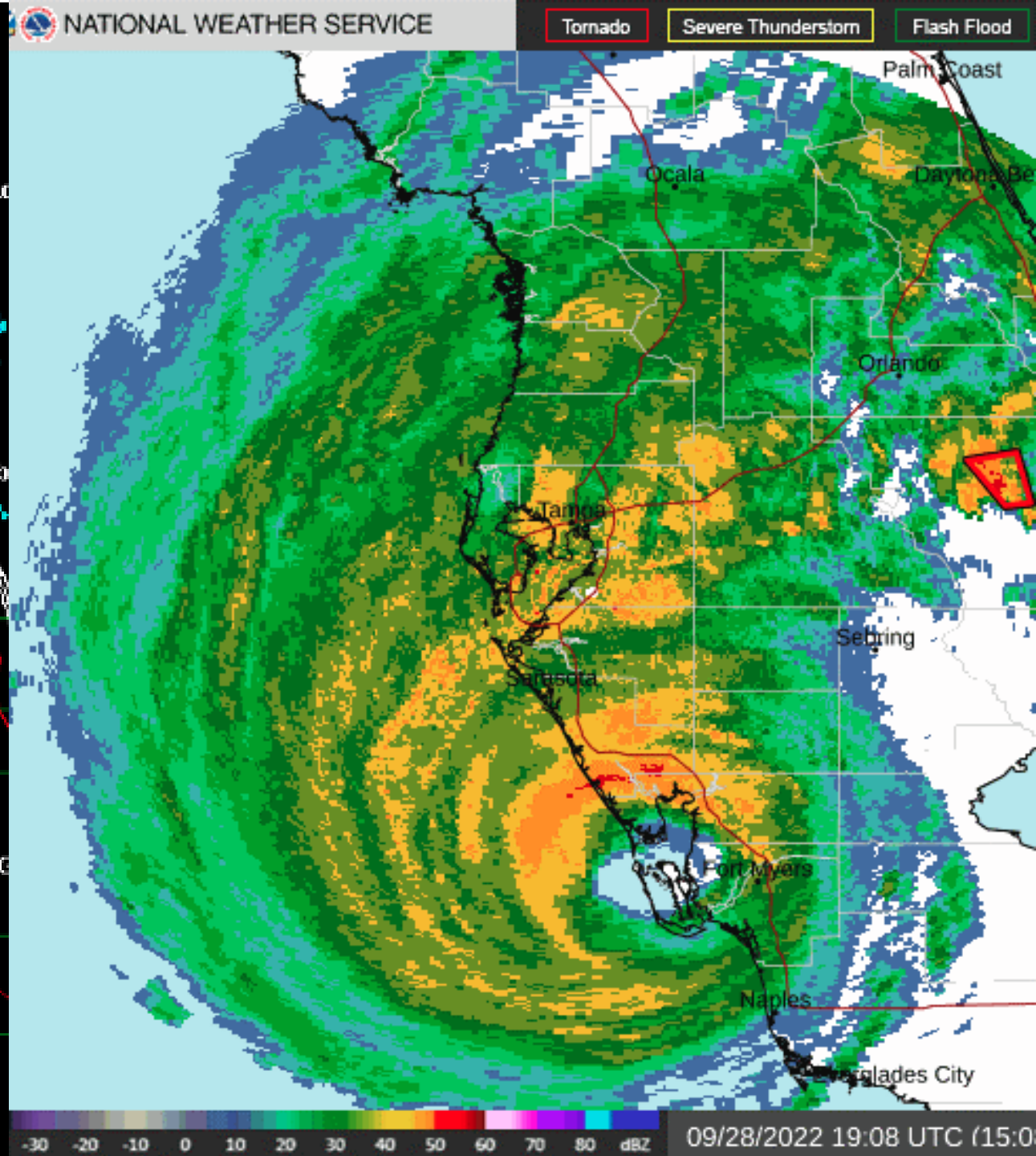


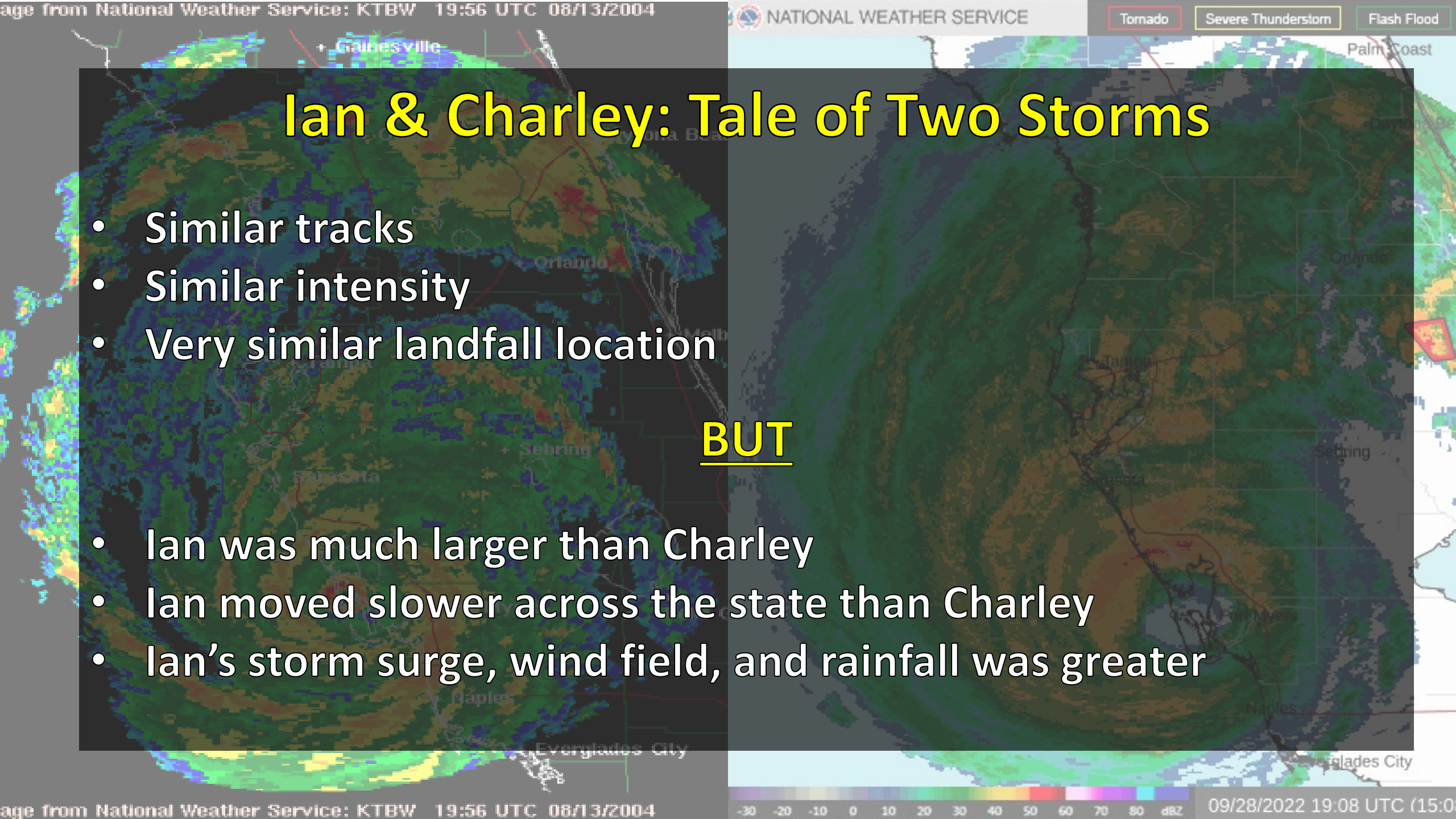
1.00" - 1.49"
1.50" - 1.99"
2.00" - 2.99"
3.00" - 3.99"
4.00" - 5.99"
6.00" - 7.99"
8.00" - 9.99"
10.00" - 14.99"
15.00" - 19.99"
20.00" - 29.99"
30.00" - 50.00+"

Precipitation (in)


Landfall Comparisons
Charley vs. Ian
TD TS C1 C2 C3 C4 C5
Cape Romain
Georgetown
Charley - 2004
Ian - 2022
Cayo Costa
The Weather Channel


age from National Weather Service: KTBW 19:56 UTC 08/13/2004
Gainesville
Ocala
Orlando
Tampa
Sebring
Fort Myers
Naples
Everglades City
age from National Weather Service: KTBW 19:56 UTC 08/13/2004


NATIONAL WEATHER SERVICE
Tornado
Severe Thunderstorm
Flash Flood
Palm Coast
Ocala
Orlando
Tampa
Sebring
Fort Myers
Naples
-30 -20 -10 0 10 20 30 40 50 60 70 80 dBZ
09/28/2022 19:08 UTC

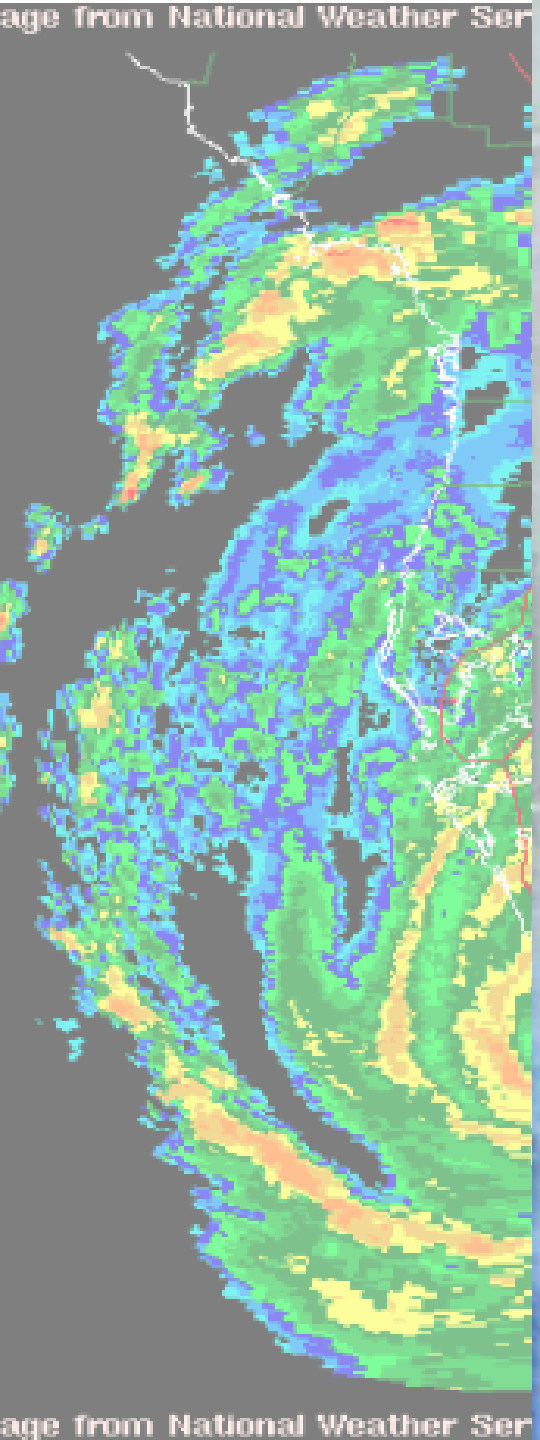


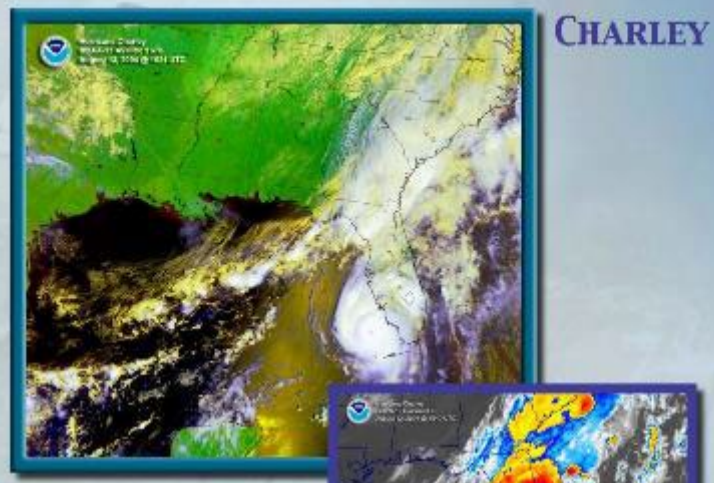
Ian & Charley: Tale of Two Storms

- Similar tracks
- Similar intensity
- Very similar landfall location

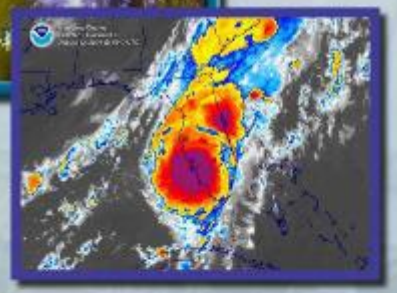
BUT

- Ian was much larger than Charley
- Ian moved slower across the state than Charley
- Ian's storm surge, wind field, and rainfall was greater

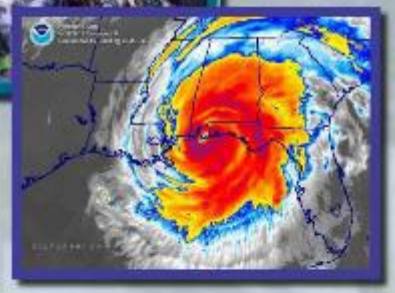




CHARLEY

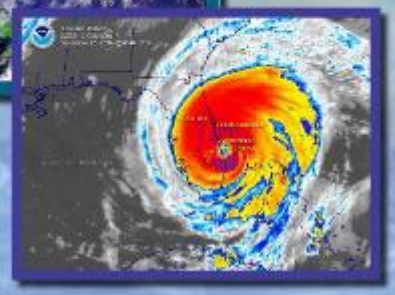


IVAN

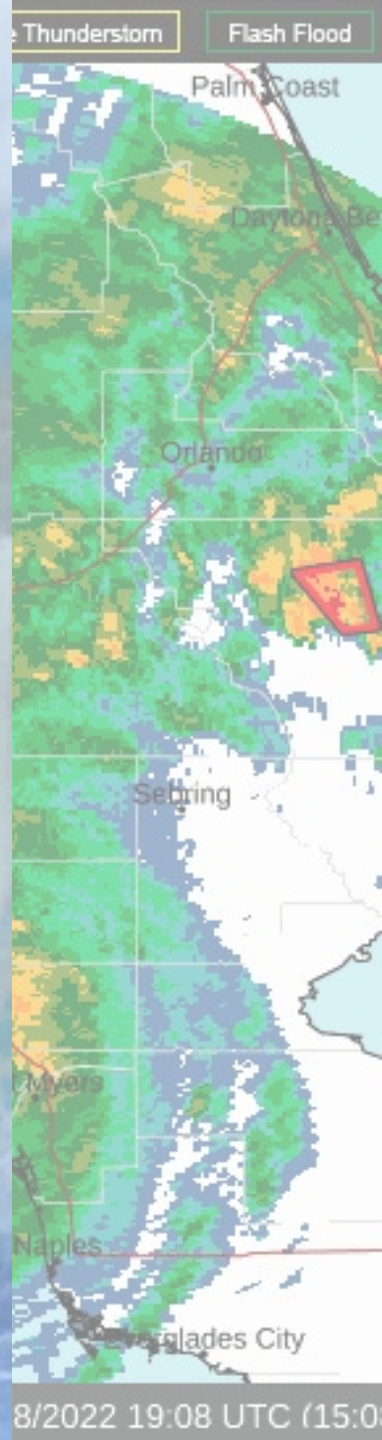


FRANCES

JEANNE



NOAA



Estuaries and Coasts Vol. 29, No. 6A, p. 932–938 December 2006

Dissolved Oxygen Dynamics in Charlotte Harbor and Its Contributing Watershed, in Response to Hurricanes Charley, Frances, and Jeanne—Impacts and Recovery

D. A. Tomasko[1,*], C. Anastasiou[2], and C. Kovach[2]

[1] *Southwest Florida Water Management District, 2379 Broad Street, Brooksville, Florida 34604*
[2] *Florida Department of Environmental Protection, 13051 North Telecom Parkway, Temple Terrace, Florida 33637*

ABSTRACT: On August 13, 2004, Hurricane Charley came ashore in the Charlotte Harbor watershed. Surface winds at the time of landfall were estimated at 130 knots. The track of the hurricane roughly followed the floodplain of the Peace River, causing massive defoliation and mortality of native vegetation and planted citrus groves, as well as substantial damage to human habitation and various infrastructure elements. Eight days after landfall, a water quality monitoring effort documented hypoxic (< 2 mg l^{-1}) to nearly anaerobic (< 0.5 mg l^{-1}) dissolved oxygen (DO) values throughout the vast majority of the Peace River's c. 6,000 km^2 watershed. Low DO values appeared to be related to high values of both dissolved organic matter and suspended materials. Hypoxic conditions in Charlotte Harbor itself occurred within 2 wk of landfall. Approximately 3 wk after the landfall of Hurricane Charley, Hurricane Frances struck the east coast of Florida, causing further wind damage and bringing substantial amounts of rain to the Charlotte Harbor watershed. Three weeks later still, Hurricane Jeanne caused similar damage to the same area. In response to the combined effects of these three hurricanes, DO values in the Peace River did not recover to pre-hurricane levels until approximately 2–3 mo later. The spatial and temporal pattern of DO fluctuations appeared to be related to the proximity of sampling locations to the path of the eyewall of the first of the three hurricanes. Within the Harbor itself, the duration of hypoxic conditions was less than that recorded within the Peace River, perhaps reflecting greater dilution of oxygen-poor waters from the watershed with less-affected water from the Gulf of Mexico.

Introduction

On August 13, 2004, the first of three hurricanes to affect the watershed of Charlotte Harbor made landfall at Cayo Costa, Florida (Sallenger et al. 2006). The first of these three, Hurricane Charley, was a category 4 storm on the Saffir-Simpson scale, with surface winds at landfall estimated at 130 knots. Hurricane Charley was the most powerful hurricane to hit the United States since Hurricane Andrew in 1992 (Pasch et al. 2005). Hurricane-force winds were experienced along the storm's entire pathway across peninsular Florida, from Cayo Costa to Ormond Beach (Sallenger et al. 2006). Nine tornadoes were associated with Hurricane Charley's passage through Florida (Pasch et al. 2005). The initial track of Hurricane Charley closely followed the course of the Peace River, the largest source of freshwater inflow to Charlotte Harbor. Within 6 wk, two additional hurricanes, Frances and Jeanne, struck the east coast of Florida, causing further wind damage and bringing substantial amounts of rain and flooding to the Charlotte Harbor watershed.

Several days after the passage of Hurricane Charley, numerous complaints of foul smelling water in the Peace River were received from the public. Concerns about the quality of water in the Peace River were received from officials at numerous public water supply utilities. Surface water withdrawals from the Peace River are one of the primary sources of drinking water for a population of c. 750,000 people in southwest Florida.

In response to the potential health and environmental issues apparent after the passage of Hurricane Charley, additional efforts were undertaken to supplement existing water quality monitoring efforts in the Peace River watershed. These efforts were designed to increase the monthly monitoring frequency to weekly sampling and to add water quality parameters that might prove useful for determining the basis for observed problems with dissolved oxygen (DO) values in the Peace River. Ongoing water quality sampling efforts in Charlotte Harbor were continued to determine the spatial and temporal extent of hypoxic conditions (DO < 2 mg l^{-1}) in the Harbor.

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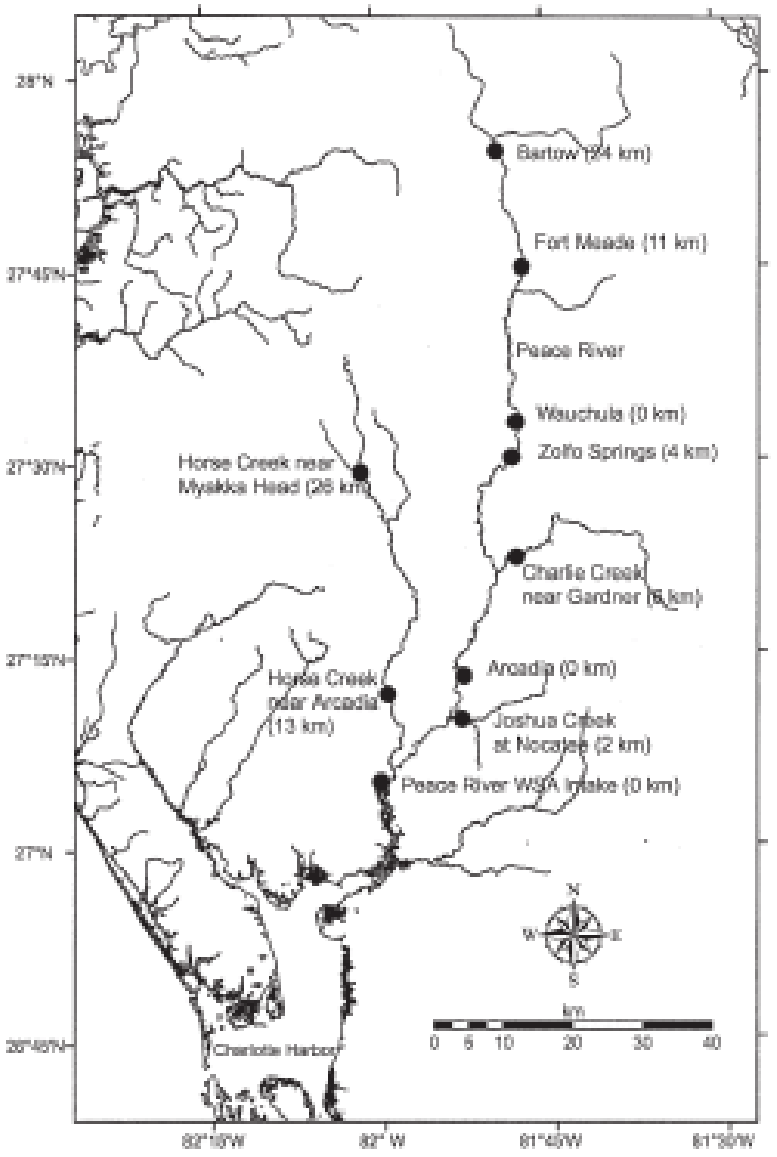
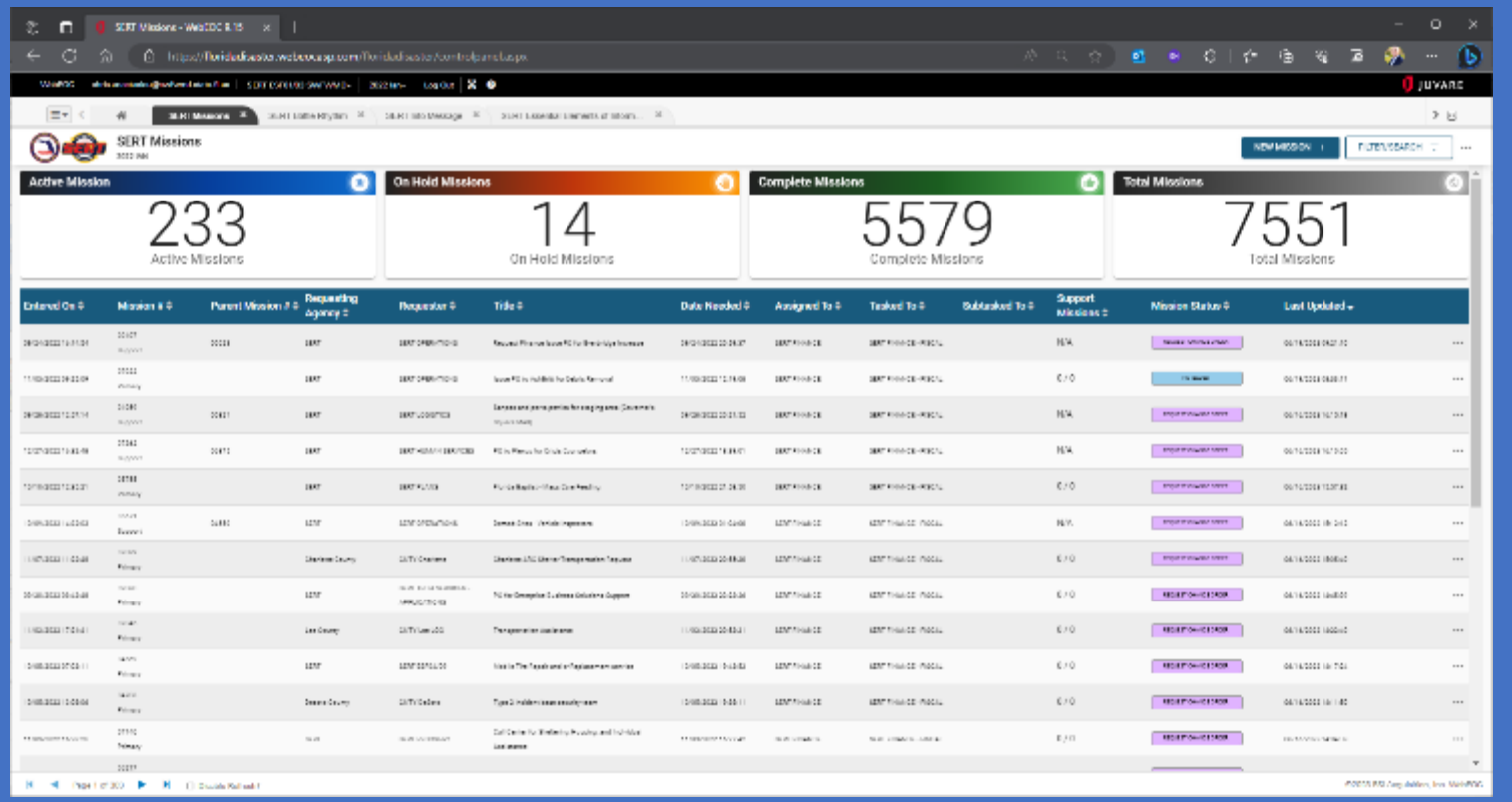


Fig. 1. Location of selected water quality monitoring stations in the Peace River watershed. The headwaters of the Peace River are in central Florida near Lakeland and the river empties into Charlotte Harbor in southwest Florida. Values in parentheses represent distance from the eyewall of Hurricane Charley in kilometers.

JUVARE | WebEOC

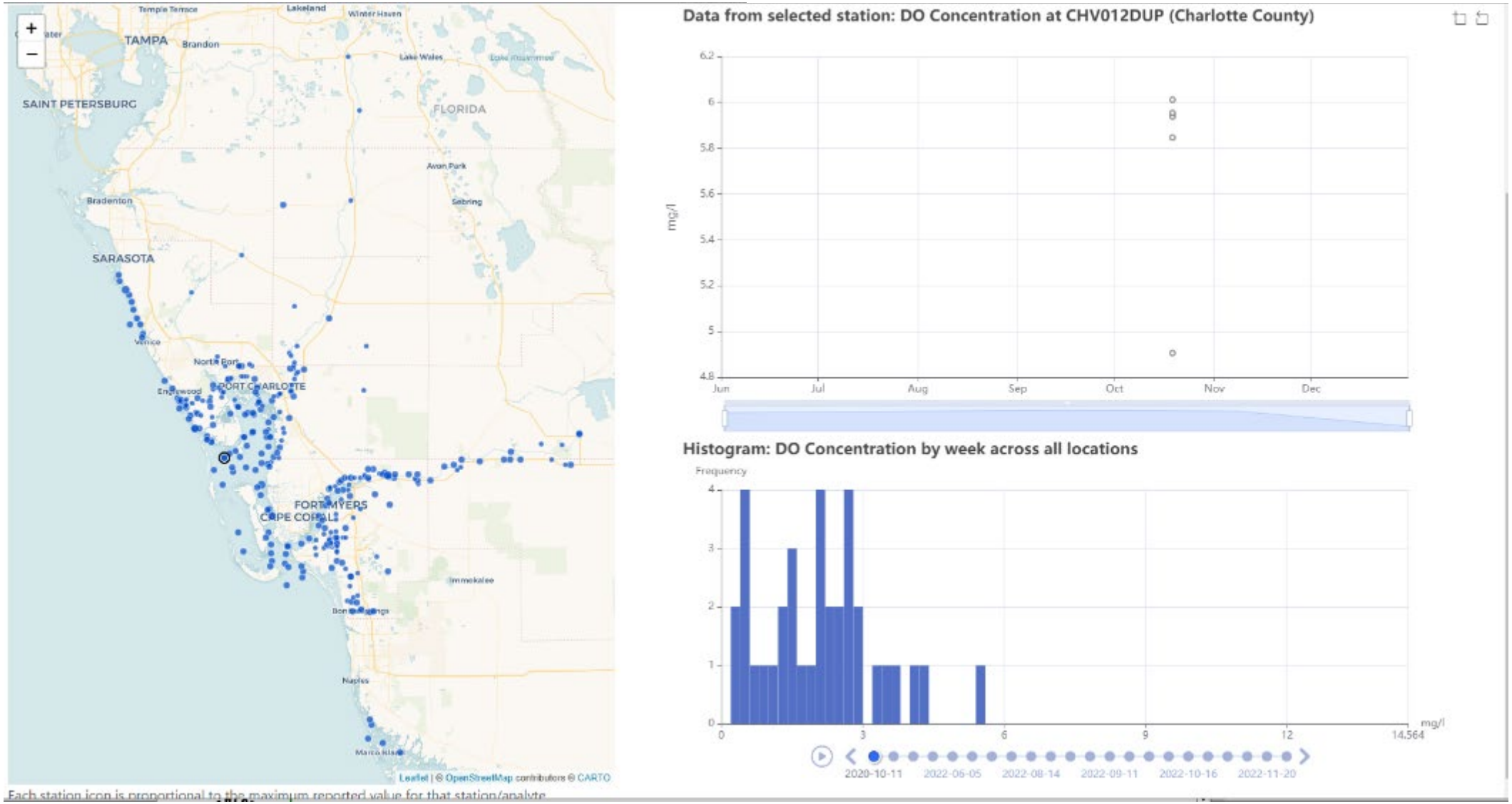
Florida Division of Emergency Management



Ian Water Quality Response Dashboard

UF UNIVERSITY of FLORIDA

Center for Coastal Solutions

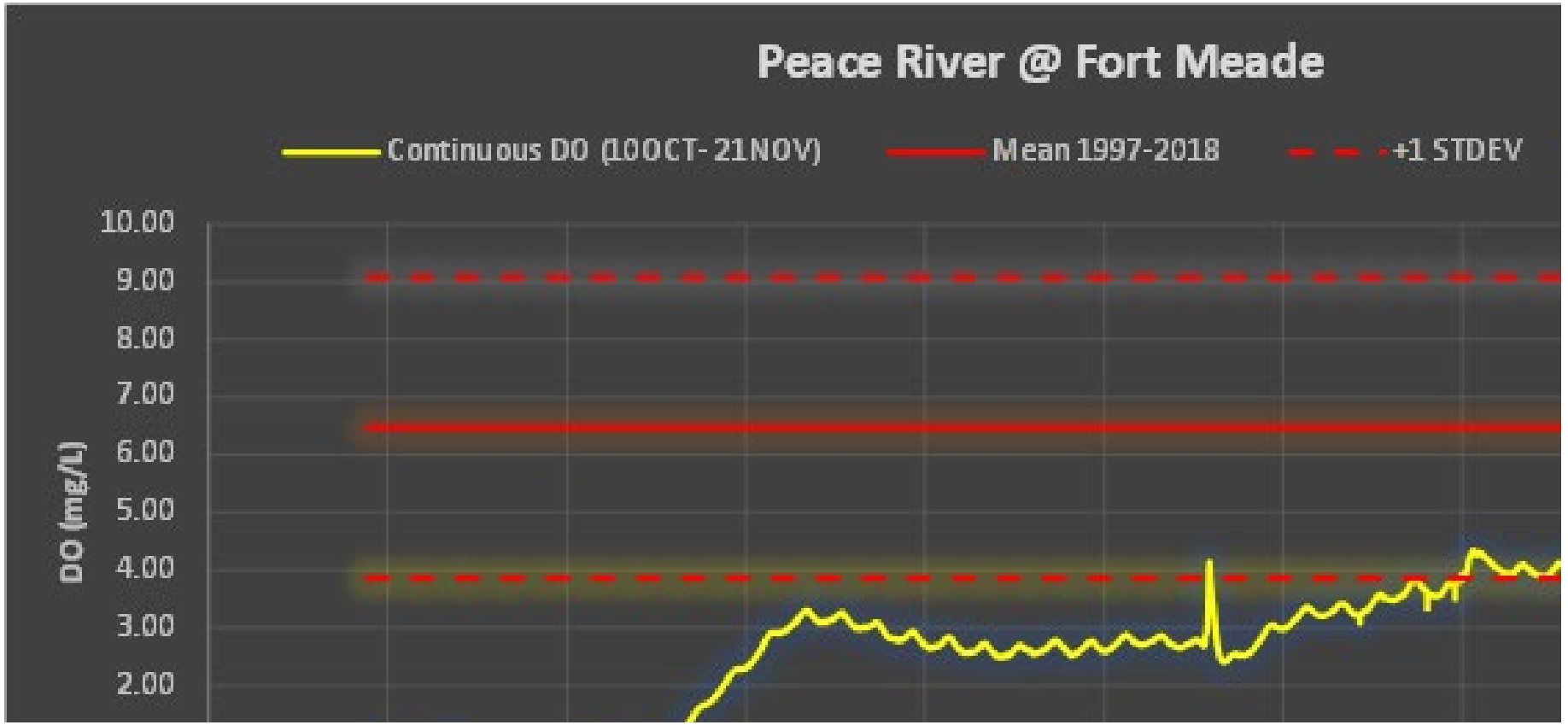


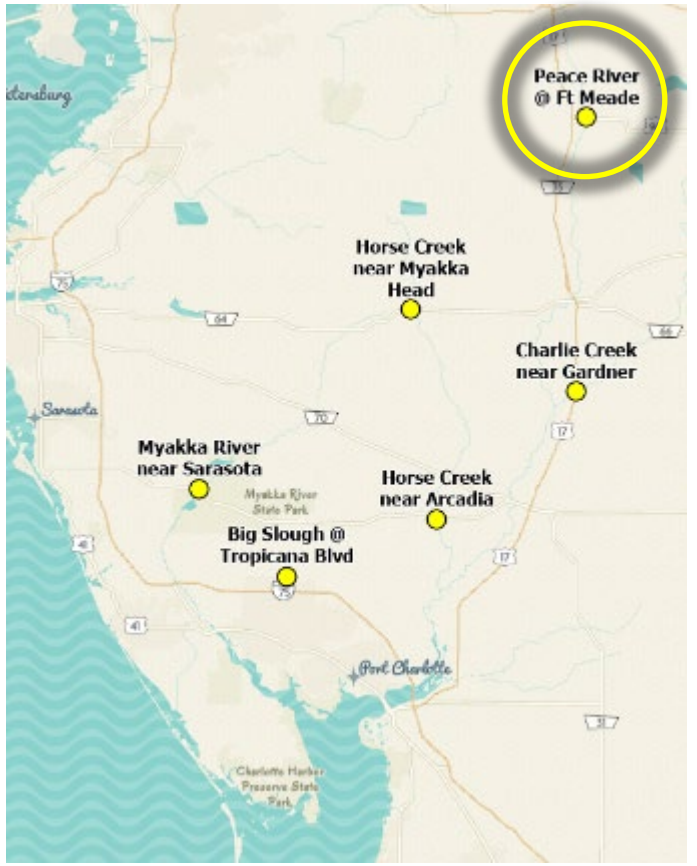
Post Hurricane Ian
Water Quality Response
Continuous DO Monitoring Stations

- Peace River @ Fort Meade
- Horse Creek nr Myakka Head
- Charlie Creek nr Gardner
- Myakka River near Sarasota
- Horse Creek @ Arcadia
- Big Slough @ Tropicana Blvd

Dissolved Oxygen Response

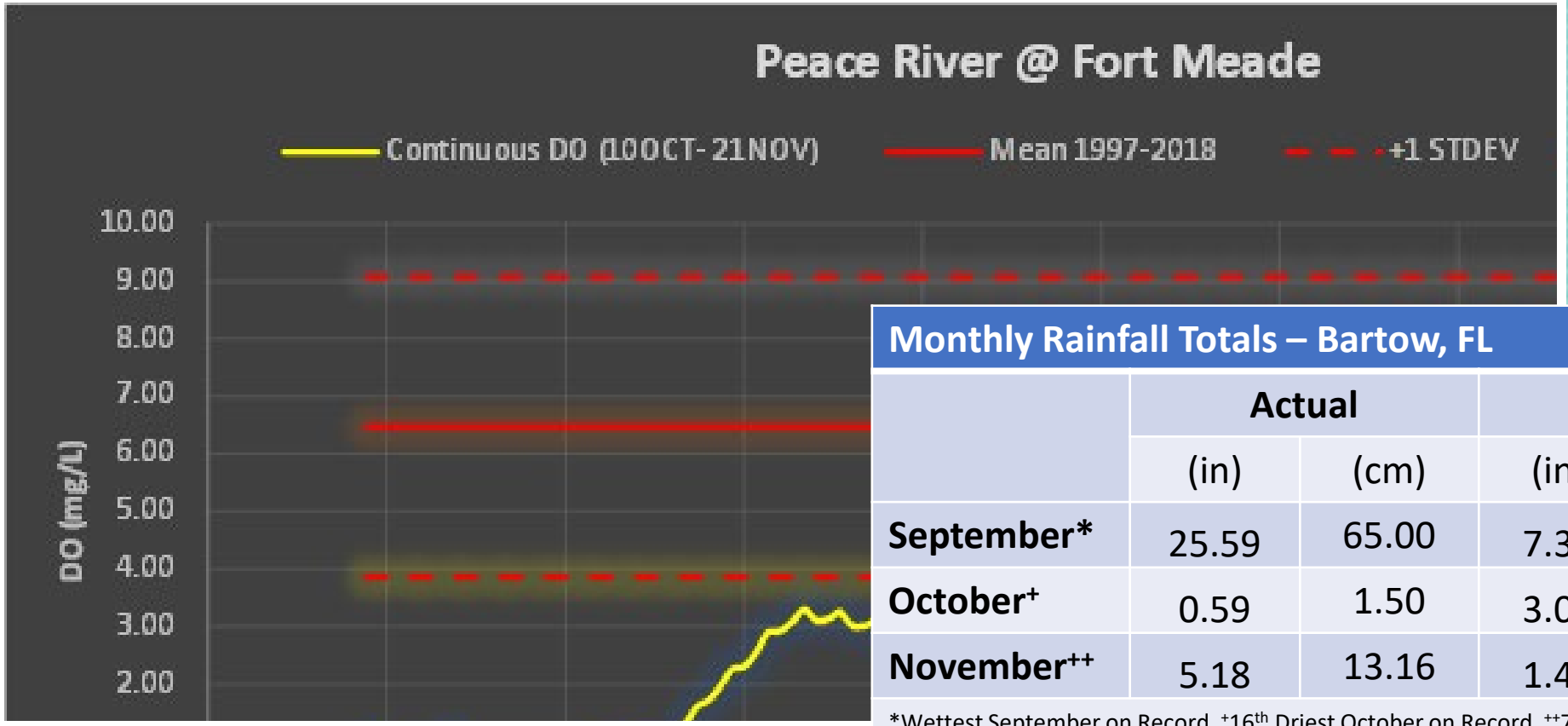
Peace River @ Fort Meade





Dissolved Oxygen Response

Peace River @ Fort Meade



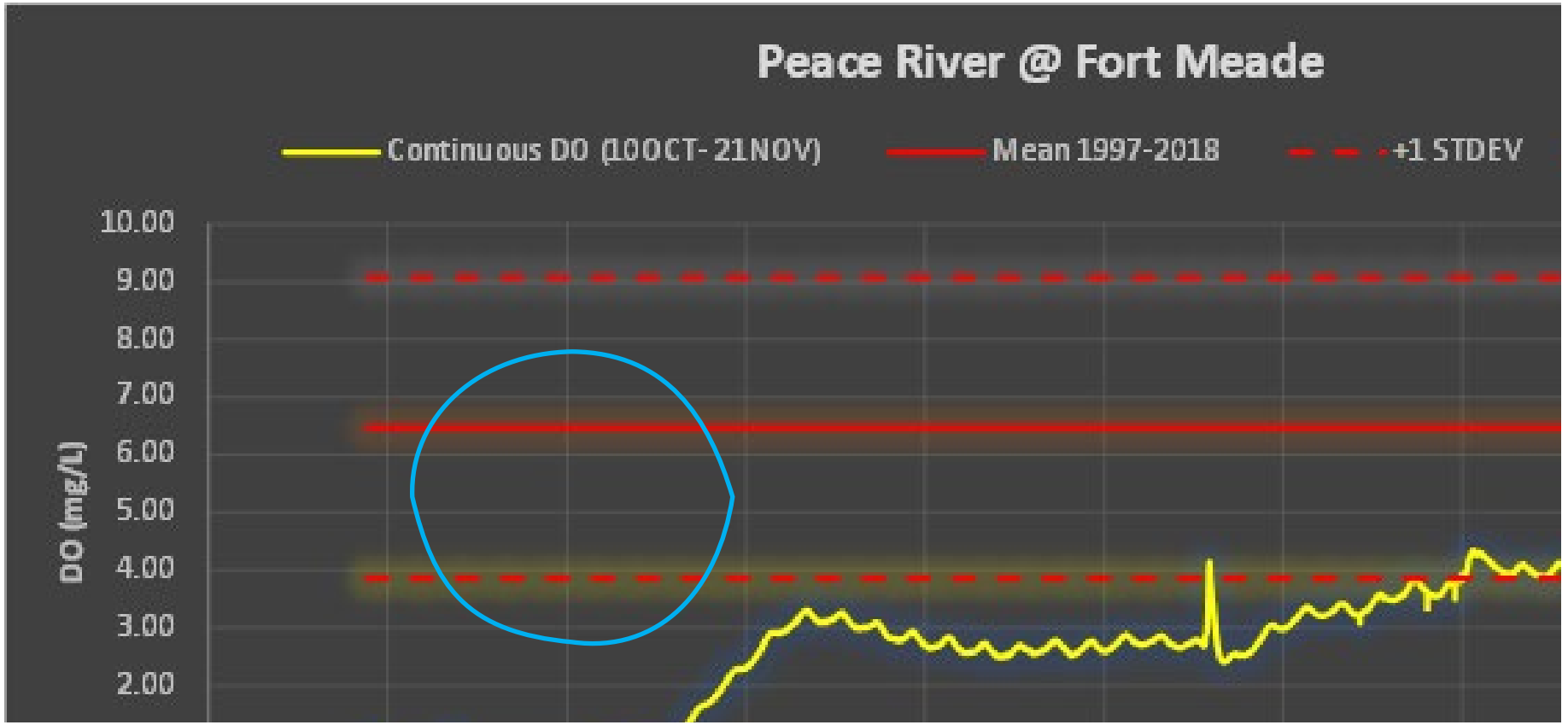
Monthly Rainfall Totals – Bartow, FL

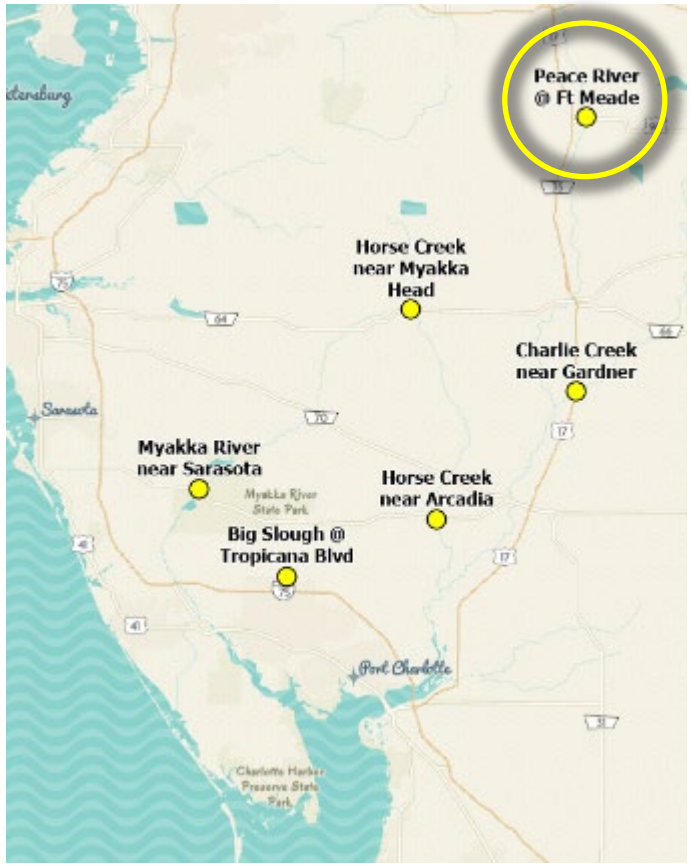
	Actual		Normal		Δ	
	(in)	(cm)	(in)	(cm)	(in)	(cm)
September*	25.59	65.00	7.31	18.57	+18.28	+46.43
October⁺	0.59	1.50	3.03	7.70	-2.44	-6.20
November⁺⁺	5.18	13.16	1.49	3.78	+3.69	+9.37

*Wettest September on Record, ⁺16th Driest October on Record, ⁺⁺7th Wettest November on Record

Dissolved Oxygen Response

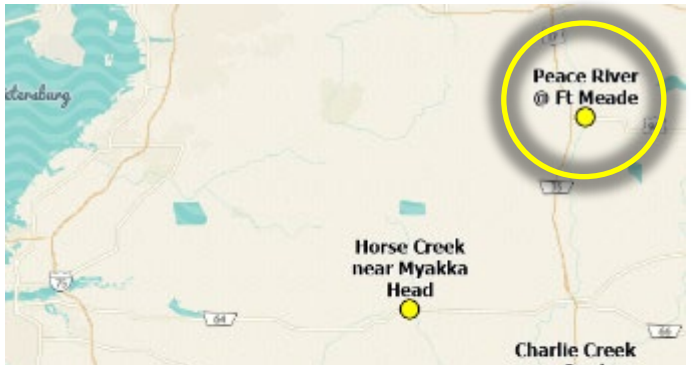
Peace River @ Fort Meade

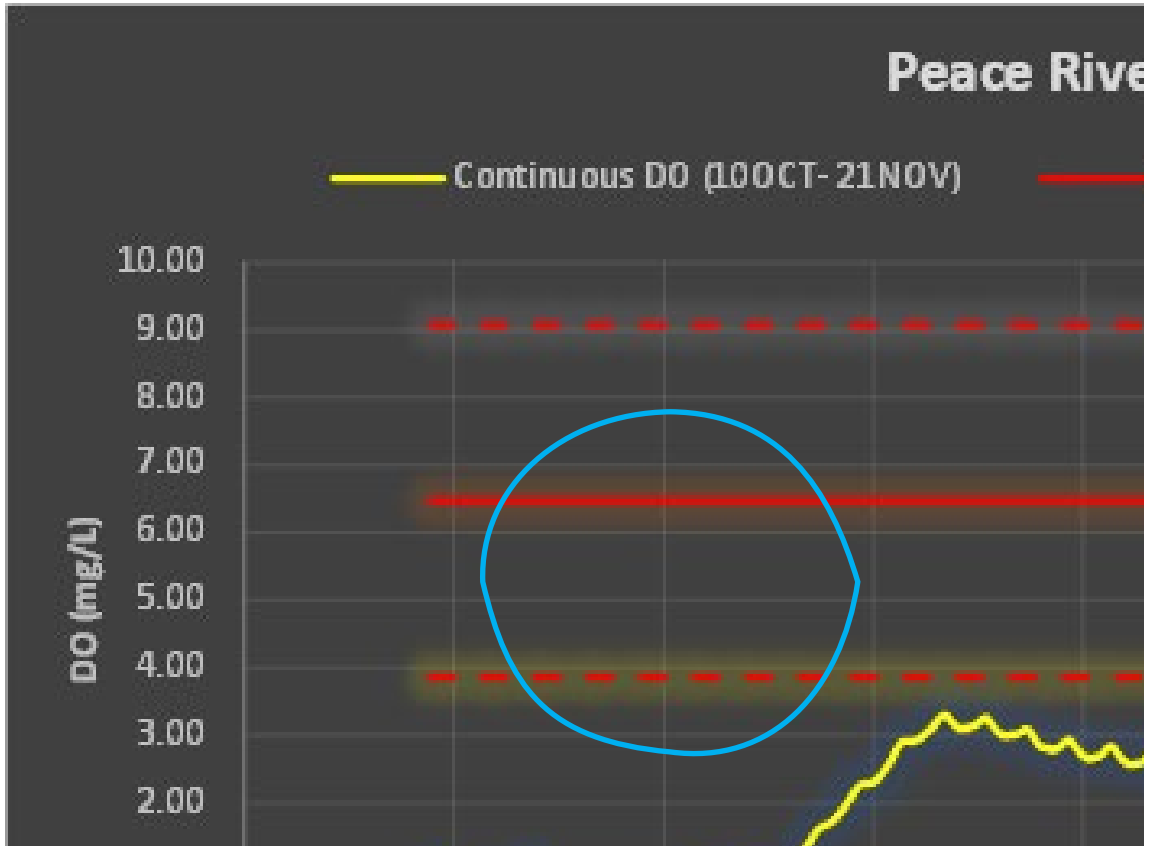


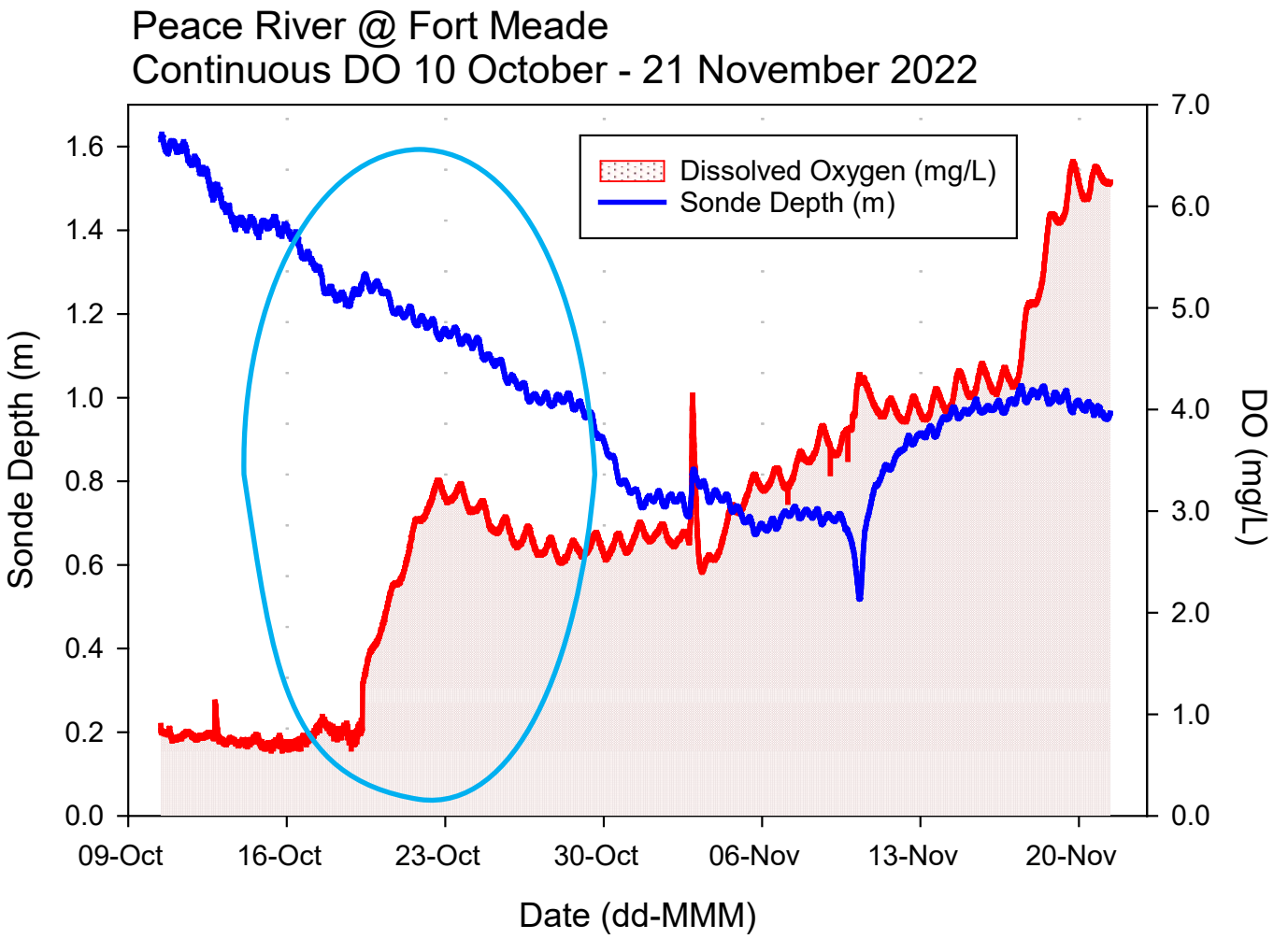


Dissolved Oxygen Response - Depth

Peace River @ Fort Meade

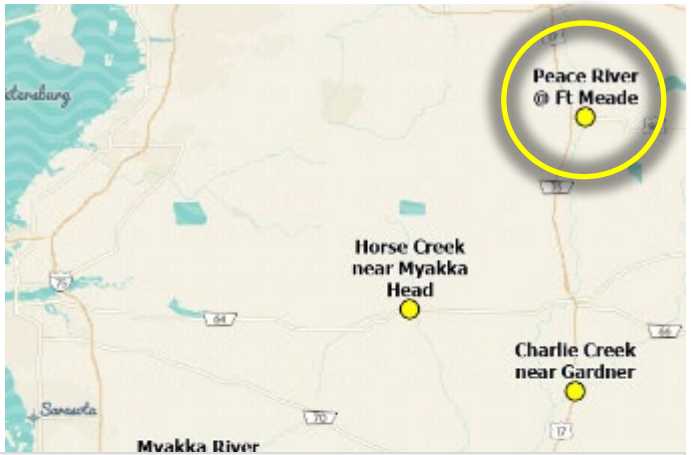


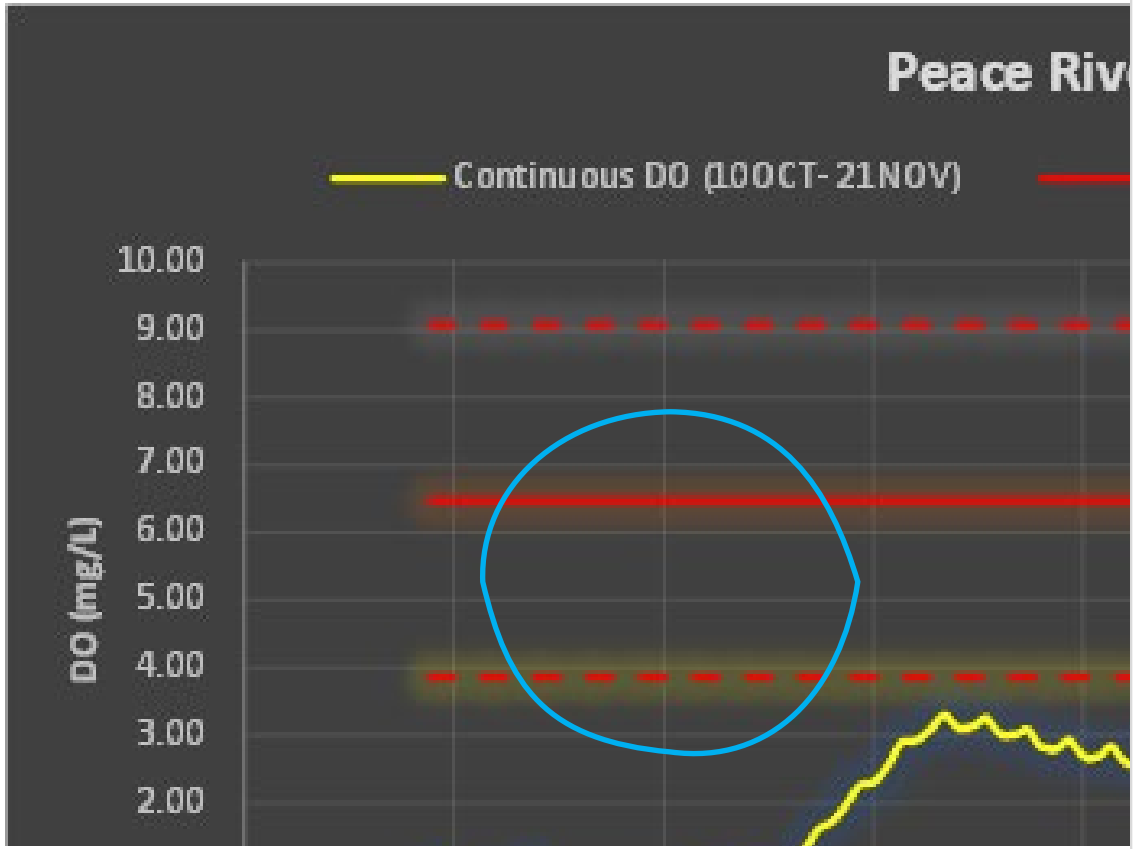


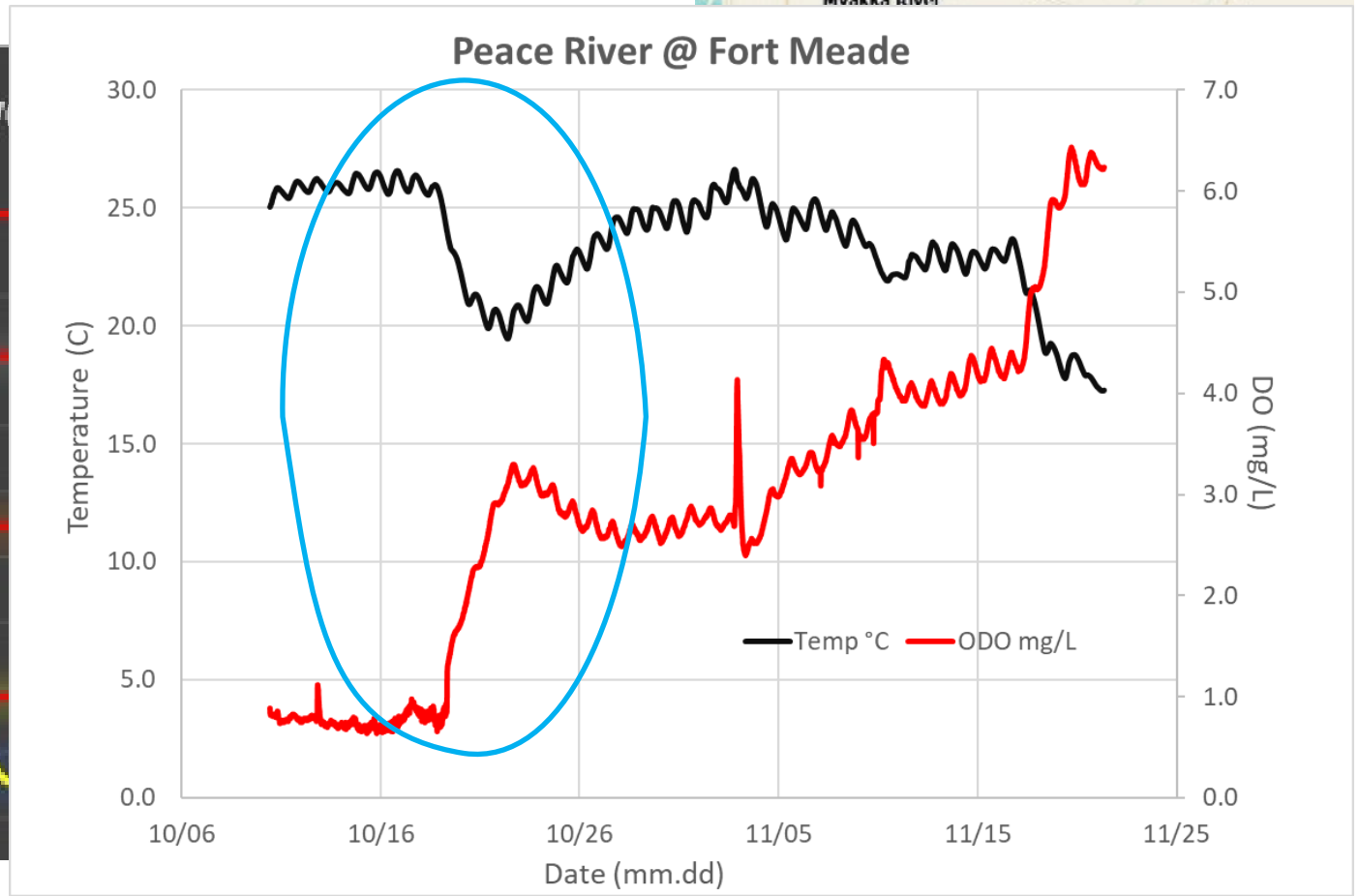


Dissolved Oxygen Response - Temp

Peace River @ Fort Meade

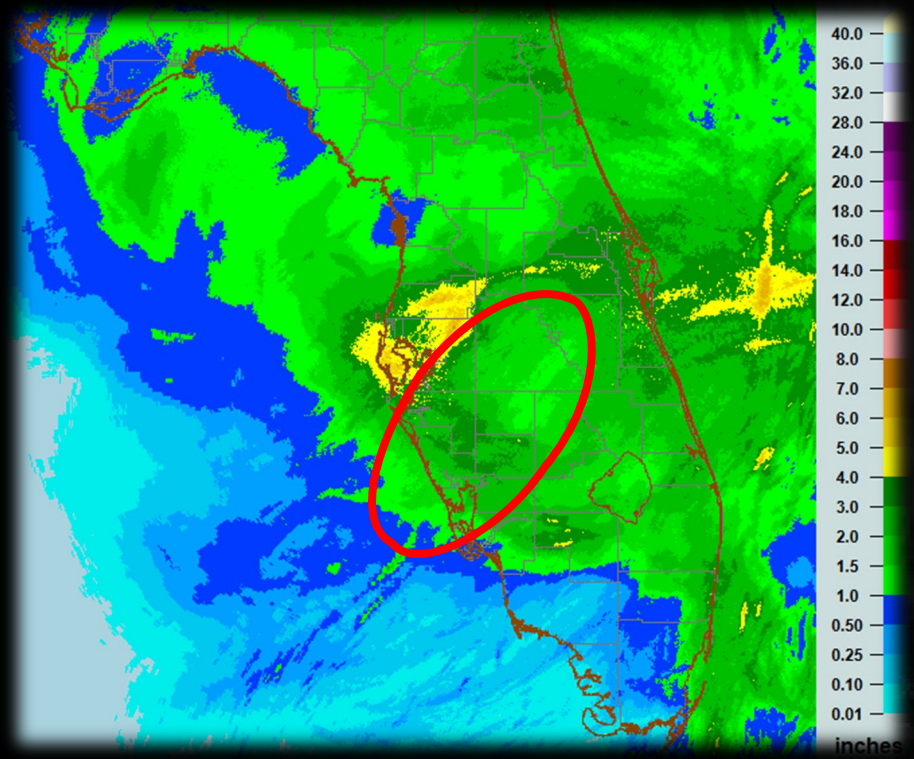




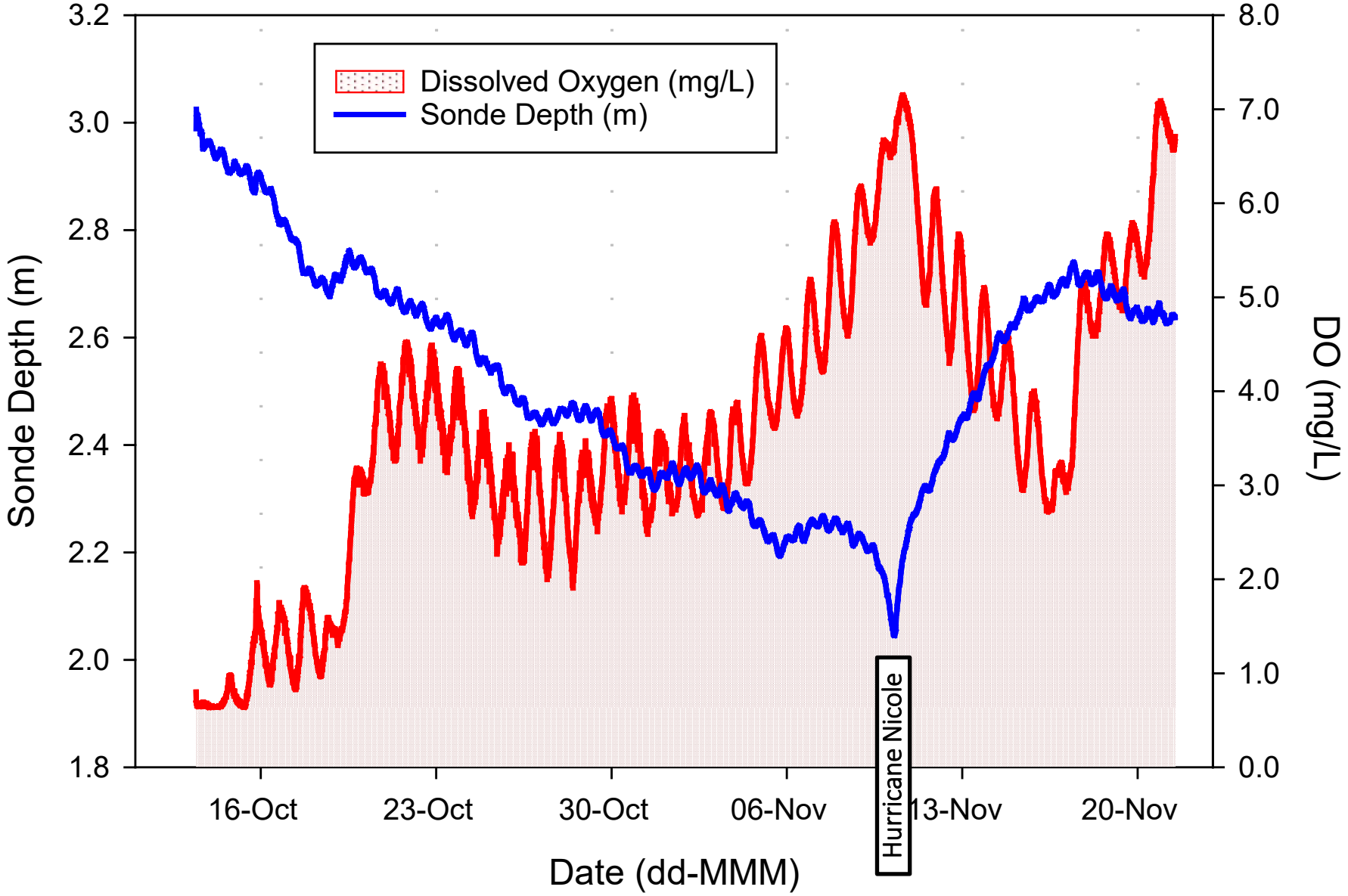


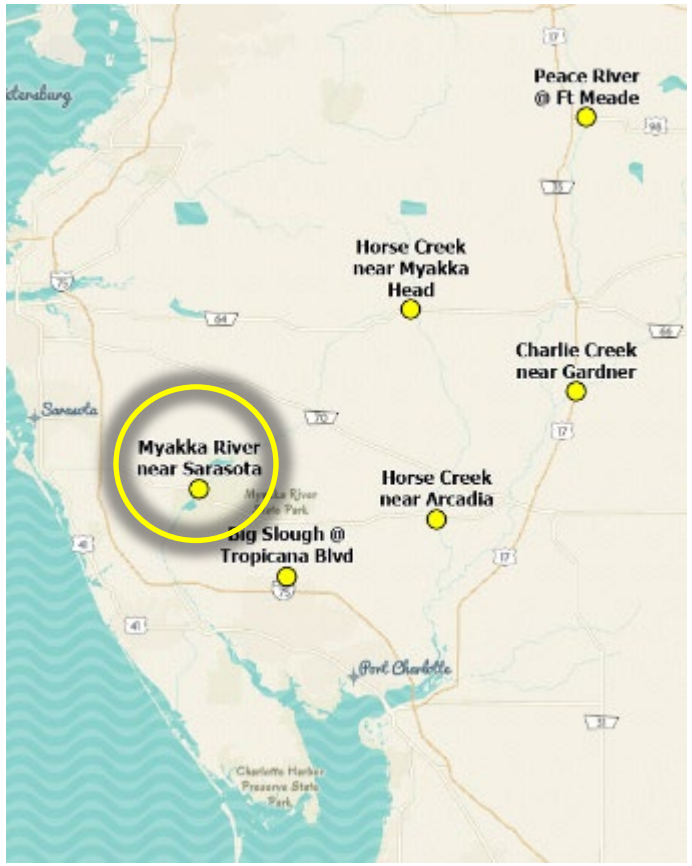
Hurricane Nicole

November 10, 2022



Myakka River near Sarasota
Continuous DO 13 October - 21 November 2022





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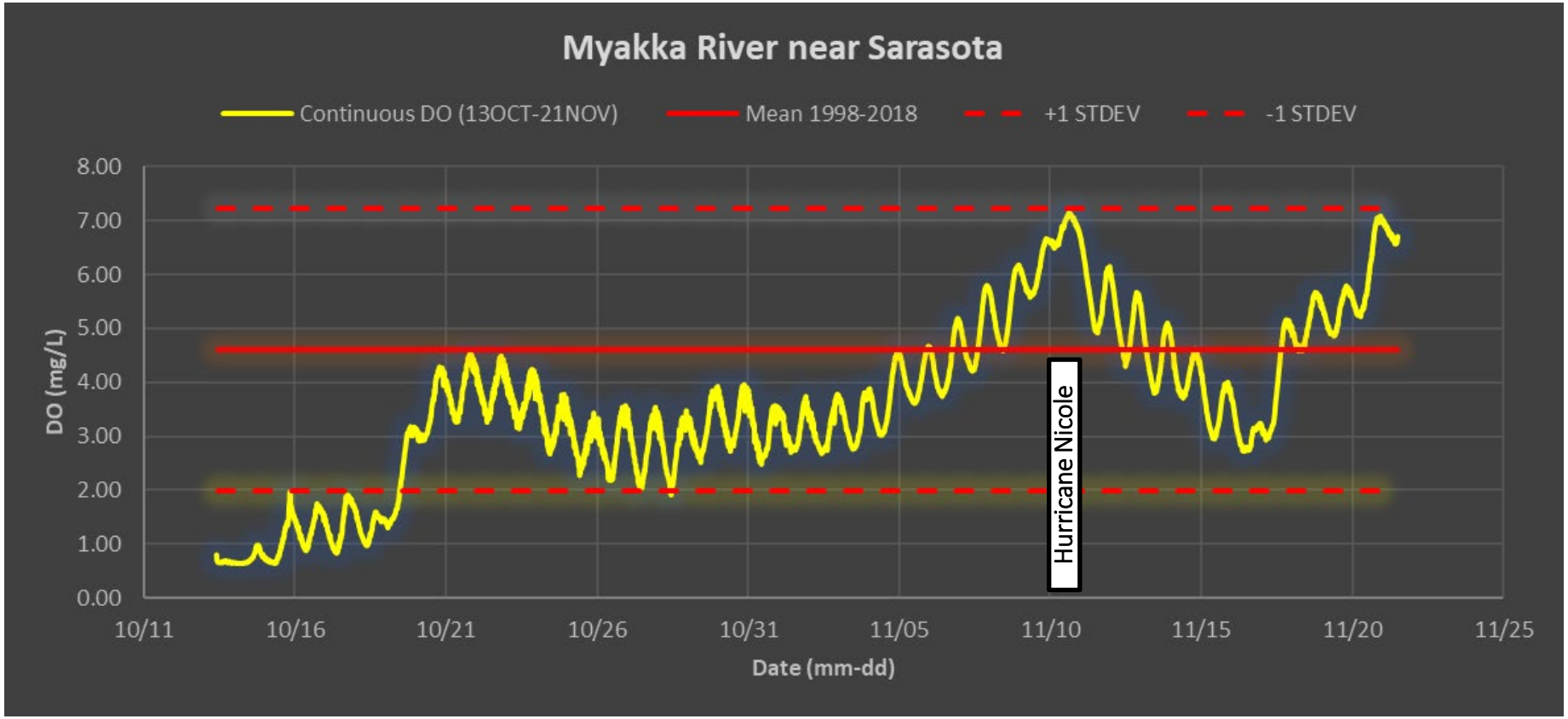

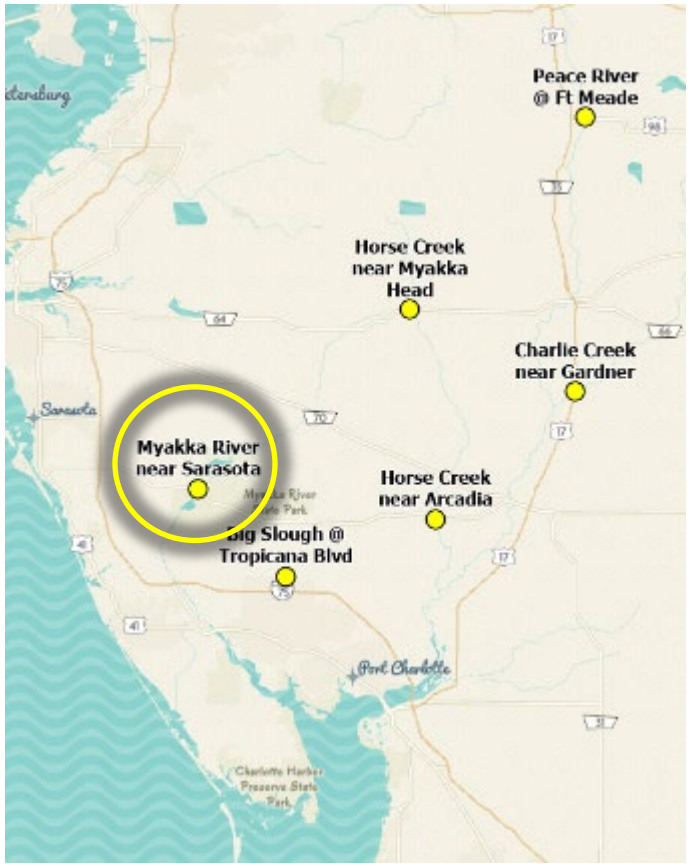

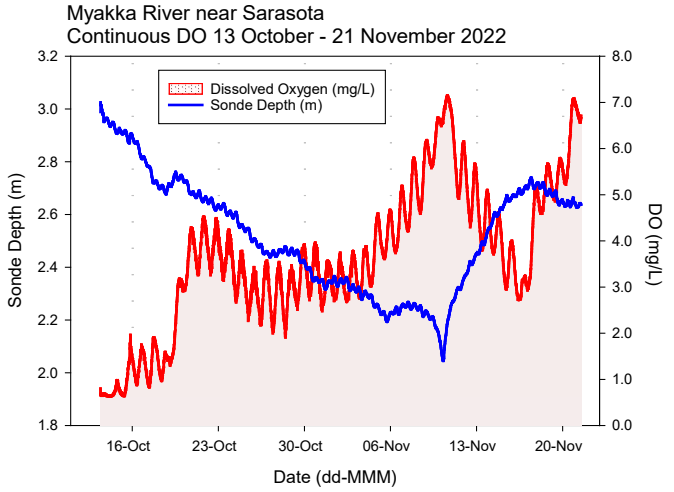

Estuaries and Coasts Vol. 29, No. 6A, p. 932–938 December 2006

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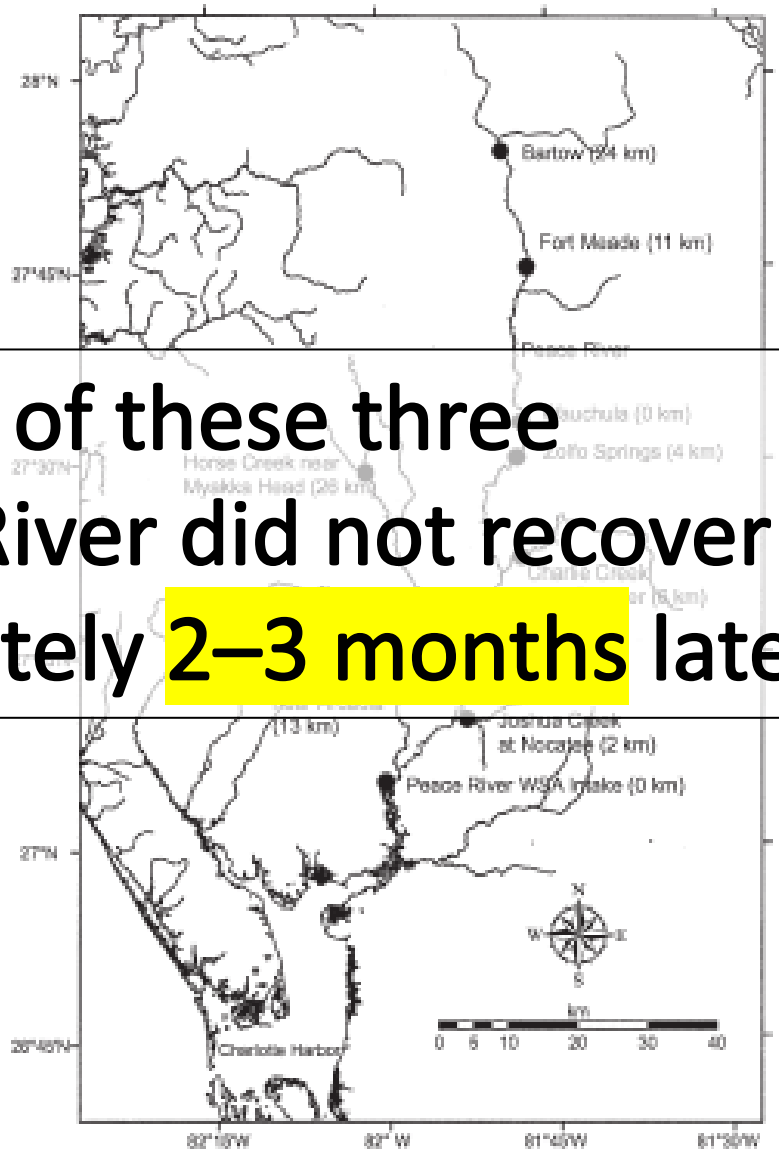
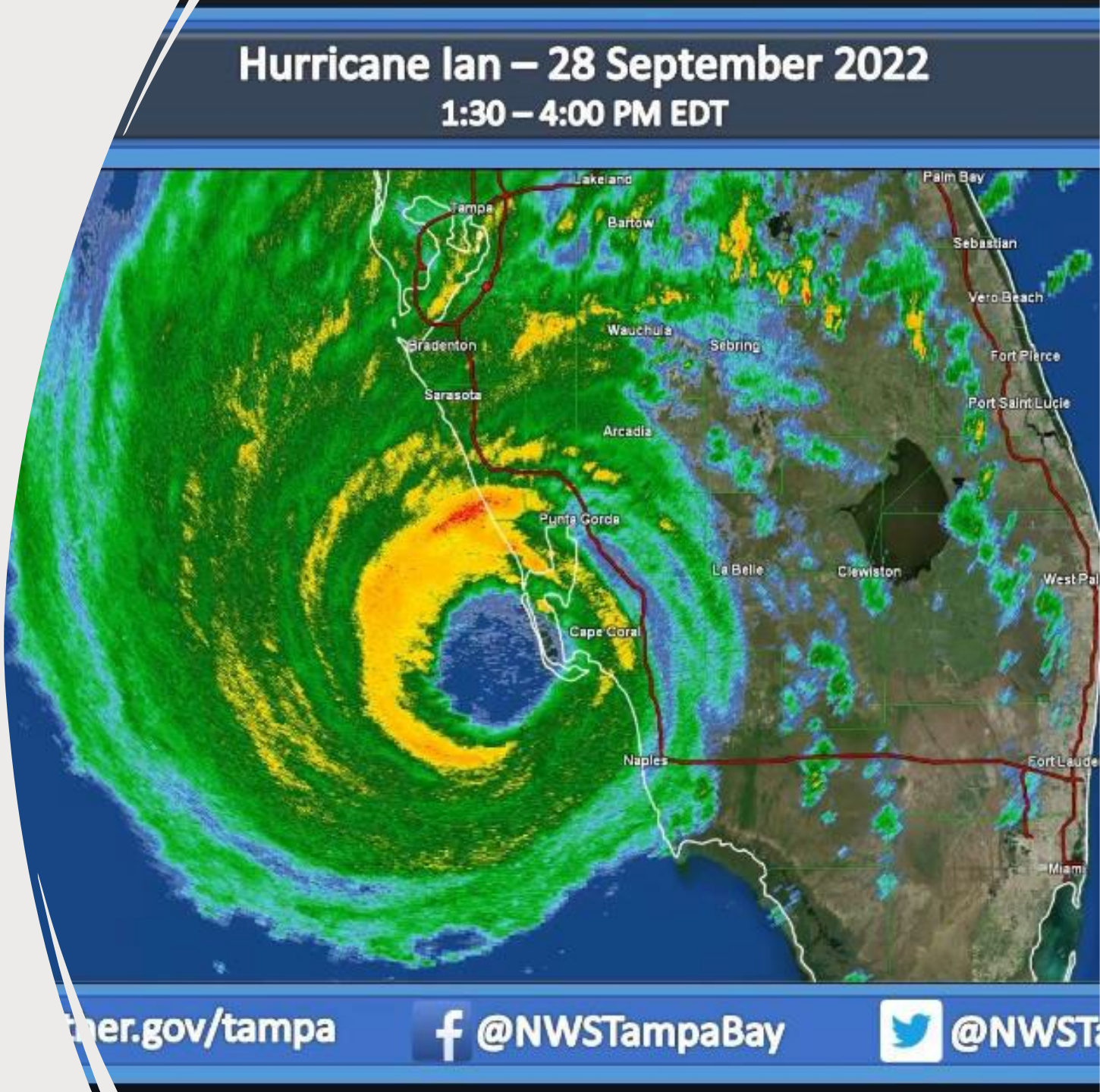


Fig. 1. Location of selected water quality monitoring stations in the Peace River watershed. The headwaters of the Peace River are in central Florida near Lakeland and the river empties into Charlotte Harbor in southwest Florida. Values in parentheses represent distance from the eyewall of Hurricane Charley in kilometers.

Key Takeaways

- Consistent with findings published after Hurricane Charley (Tomasko, et al 2006)
- Dissolved Oxygen concentrations recovered to pre-storm conditions within 2 months after Ian
- DO recovery helped by dry, cool airmass immediately after the passage of Hurricane Ian



Key Takeaways

- State & Local EOC Coordination
  - Connecting Emergency Managers with Natural Resource Managers
  - Public-Private Partnerships
  - Logistical Considerations
  - Funding (No Bucks, No Buck Rogers)
- Universities

Herbert Wertheim College of Engineering
UF Center for Coastal Solutions

UNIVERSITY OF CENTRAL FLORIDA

em.fsu.edu FSU EMERGENCY MANAGEMENT & HOMELAND SECURITY PROGRAM

DIVISION OF EMERGENCY MANAGEMENT
FDEM
OFFICE OF THE GOVERNOR

EMERGENCY OPERATIONS
Water Quality Response Unit

Chris J. Anastasiou, Ph.D.

Chief Scientist
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