



Herbert Wertheim  
College of Engineering  
UNIVERSITY of FLORIDA

## Triage Report (Part 2)

# Hurricane Ian of 28 September 2022

## Recommended Study of its Impacts on Residential Structures

Investigators:

David O. Prevatt , Ph.D., PE & Kurt Gurley, Ph.D.

Univ. of Florida

David B. Roueche , Ph.D.

Auburn University

Sponsor: Florida Building Commission  
6 December 2022

at the Shores Resort & Spa, Daytona Beach Shores, FL

## Deadliest U.S. Hurricanes, 1980-2022

Rank	Disaster	Location	Year	Damage	Deaths
1	Hurricane Maria	PR/VI	2017	\$107 billion	2981
2	Hurricane Katrina	LA/MS/AL/FL	2005	\$186 billion	1833
3	Hurricane Sandy	NY/NJ/CT	2012	\$82 billion	159
4	Hurricane Rita	LA/TX	2005	\$27 billion	119
5	Hurricane Ike	TX/LA/MS	2008	\$40 billion	112
6	<b>Hurricane Ian</b>	<b>FL/SC/NC</b>	<b>2022</b>	<b>&gt;\$50 billion</b>	<b>105</b>
7	Hurricane Irma	FL/GA/SC/PR	2017	\$60 billion	97
8	Hurricane Ida	LA/MS/NJ/NY/CT	2021	\$79 billion	96
9	Hurricane Harvey	TX/LA	2017	\$149 billion	89
10	Hurricane Hugo	SC/NC/PR/VI	1989	\$21 billion	86
11	Hurricane Floyd	NC/SC	1999	\$11 billion	77
12	Hurricane Juan	LA/MS/AL/FL	1985	\$4 billion	63
13	Hurricane Andrew	FL/LA	1992	\$56 billion	61
14	Hurricane Ivan	AL/FL	2004	\$32 billion	57
15	Hurricane Isabel	NC/VA/MD	2003	\$9 billion	55
16	Hurricane Florence	NC/SC	2018	\$28 billion	53

<https://yaleclimateconnections.org/2022/10/deaths-from-ian-pass-100-911-looms/>

# DBPR's Work Order Scope of Work

- Provide an initial triage assessment of residential property damage, provide approximate extent of visible water depths, where evident.
  - Assessment only performed on residential property types, regulated by the Florida Building Code and where sustained wind speeds over land are estimated more than 110 mph, and/or storm surge will be in excess of 9 ft.
  - However, the program manager may request field reconnaissance for a Saffir-Simpson Hurricane Wind Category II and/or for storm surge greater than 6 ft.
- Organize and execute a formal survey and damage assessment effort as directed and approved by the program manager.
  - Formal damage assessment effort may include contracting with a licensed supplier of unmanned aerial vehicles to take photographs above the damaged areas.

# Part 1: at the Gainesville, FL Meeting



Preliminary  
Hurricane Ian's  
Impacts in Florida  
11 October 2022

<https://bit.ly/3Fwr7h9>

# Today's Agenda :

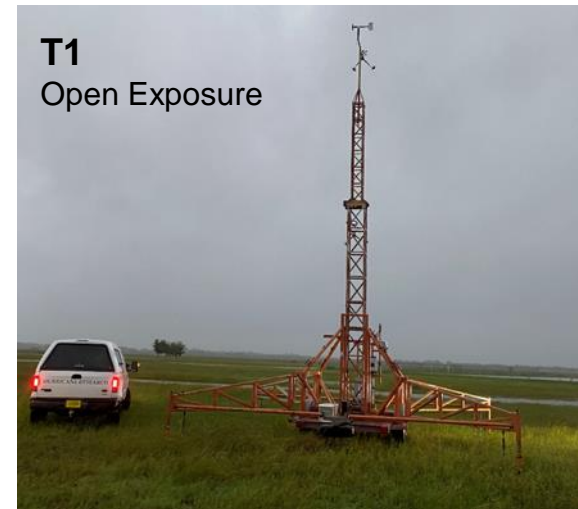
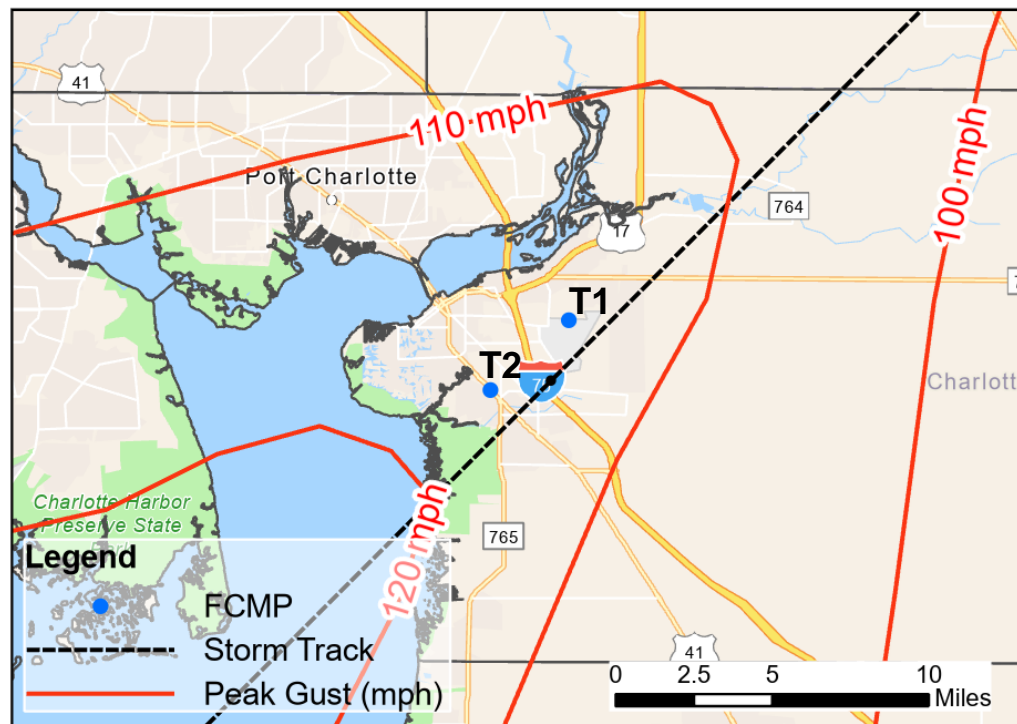
## Part 2: Daytona, FL Meeting - Proposed Study

- Recap: Triage summary - pptx of 11 October 2022
- The Hazards (Wind and Storm Surge)
- Data Collection Methods in Field Deployments
- Performance Observations Summary
- Next Step: Proposed Data Enrichment



# FCMP Tower Observations

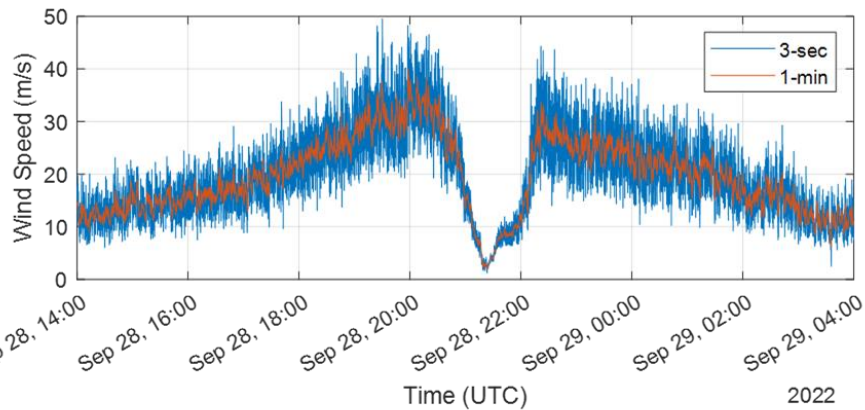
Tower	Lat	Lon	Height (m)	Max $V_{inst}$ (mph)	Max $V_{3sec}$ (mph)	Max $V_{1min}$ (mph)
T1	26.92786	-81.9918	10	119	111	89
T2	26.89584	-82.0279	15	122	113	82



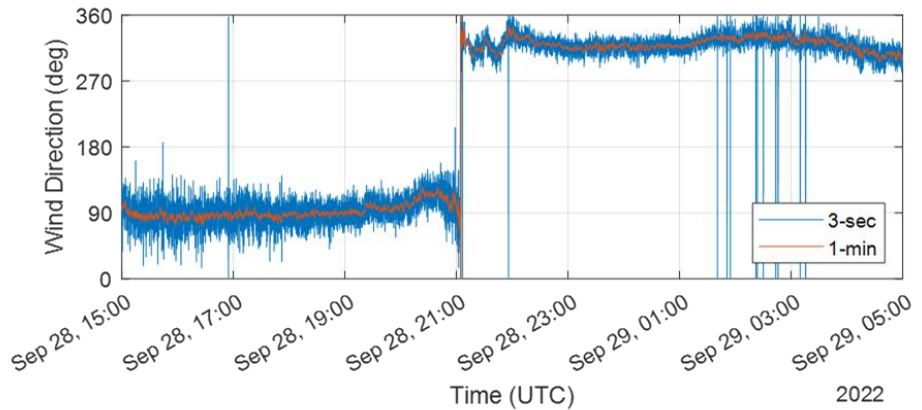
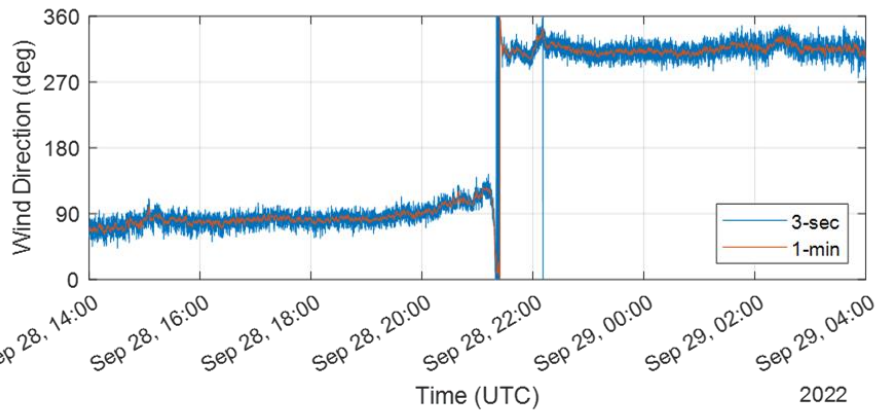
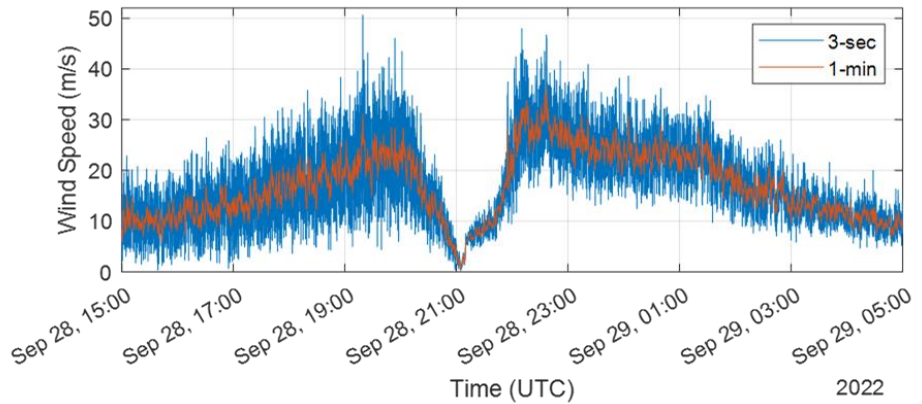
Note: Peak gust contours from ARA model

# FCMP Tower Observations

**FCMP T1**



**FCMP T2**



1 m/s = 2.2 mph

# Definitions

FIRM: Flood Insurance Rate Map

BFE: Base Flood Elevation: The elevation of surface water resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year.

CCCL: Coastal Construction Control Line (CCCL) Program regulates structures and activities that can cause beach erosion, destabilize dunes, damage upland properties or interfere with public access.

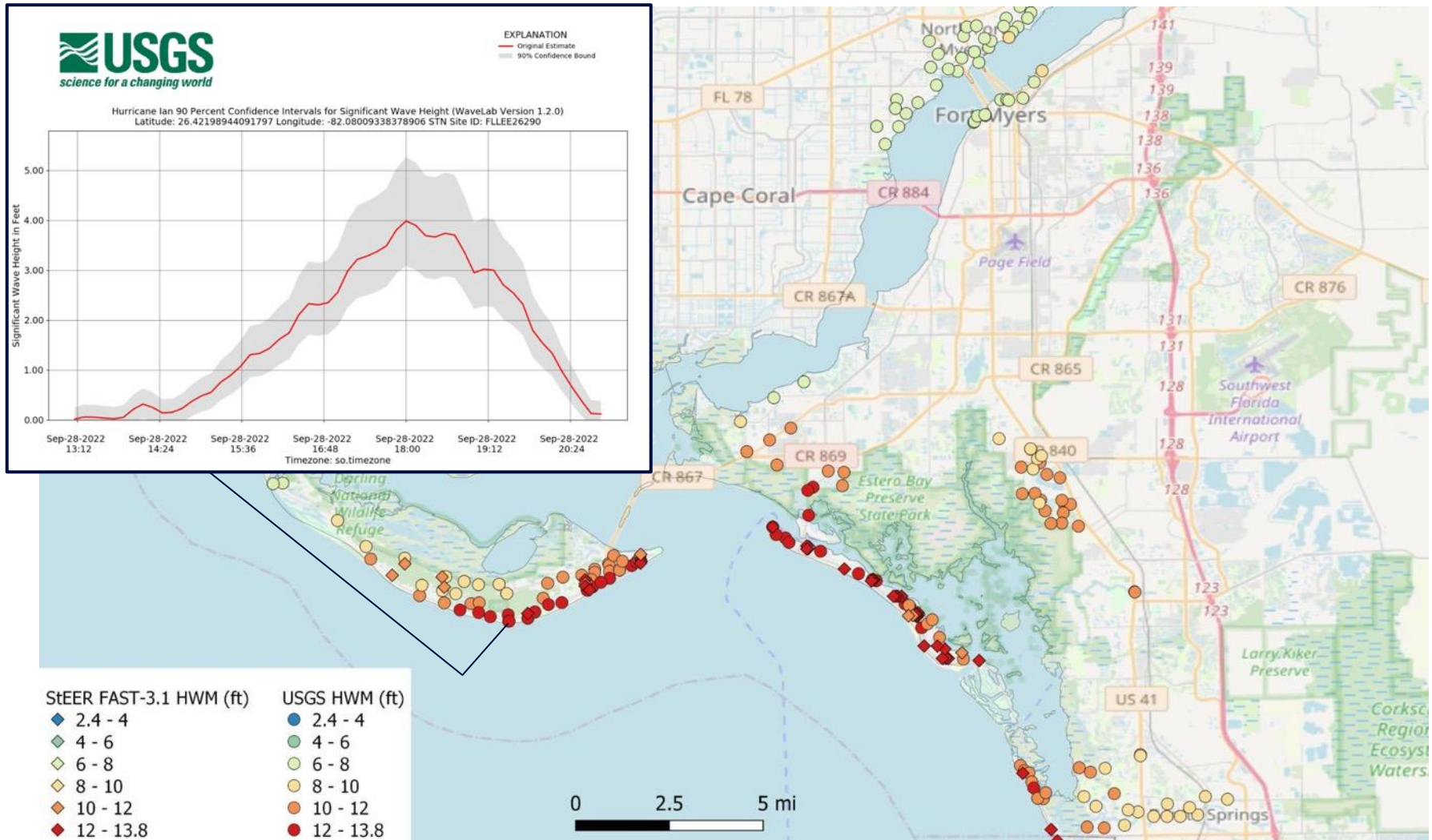
HWM: High water mark

NAVD 88: North American Vertical Datum of 1988

MSL: Mean sea level



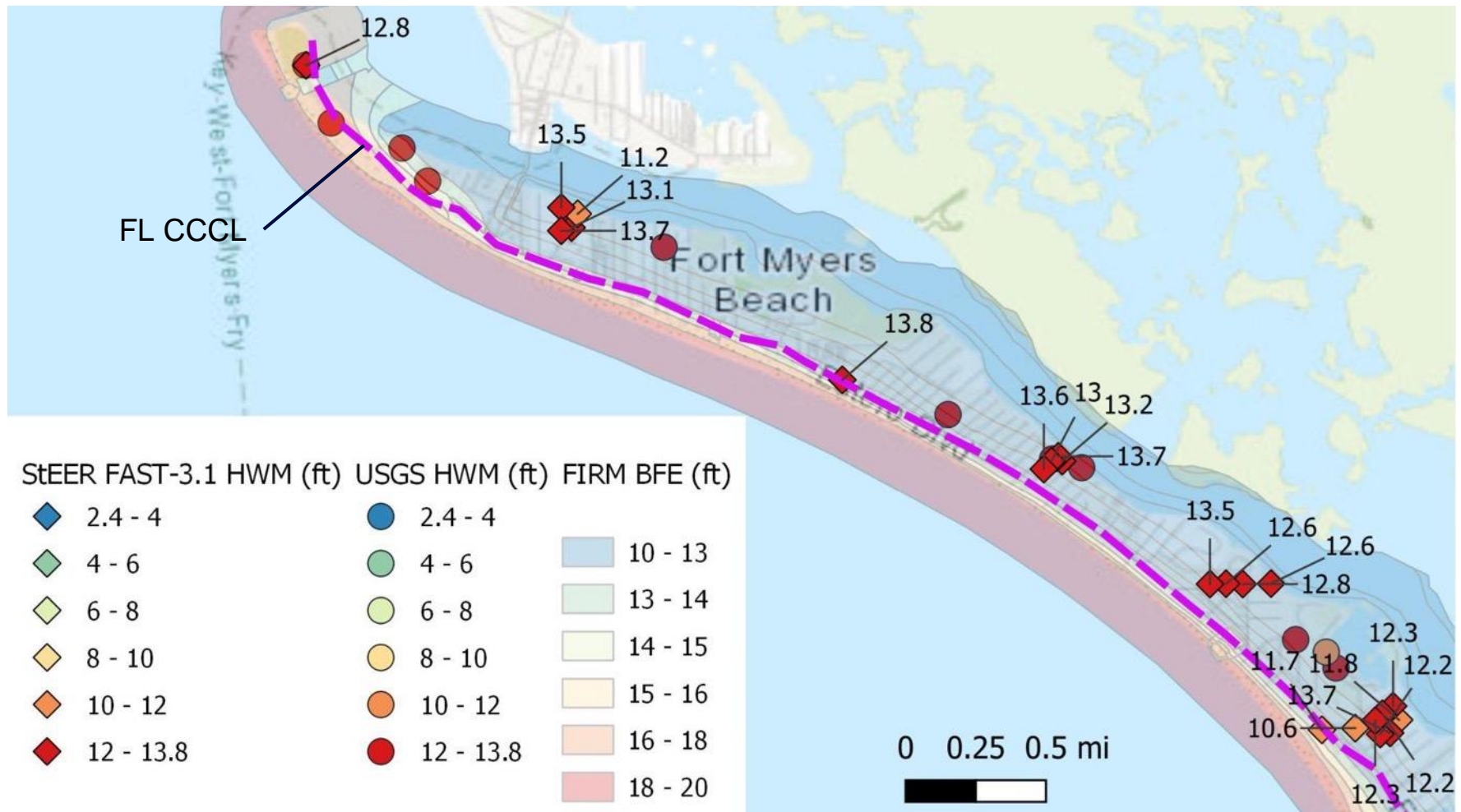
# High Water Marks in Lee County



Note: HWM represent still water depths above NAVD88 (~MSL).

StEER FAST-3.1 HWM collected and processed by Pat Lynett, University of Southern California

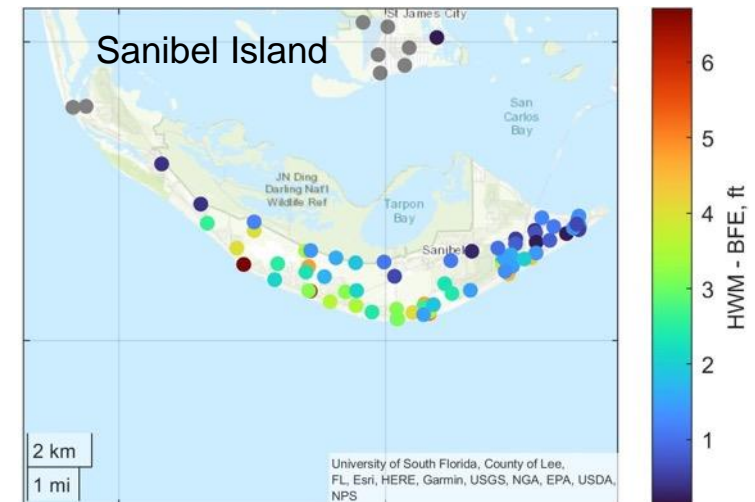
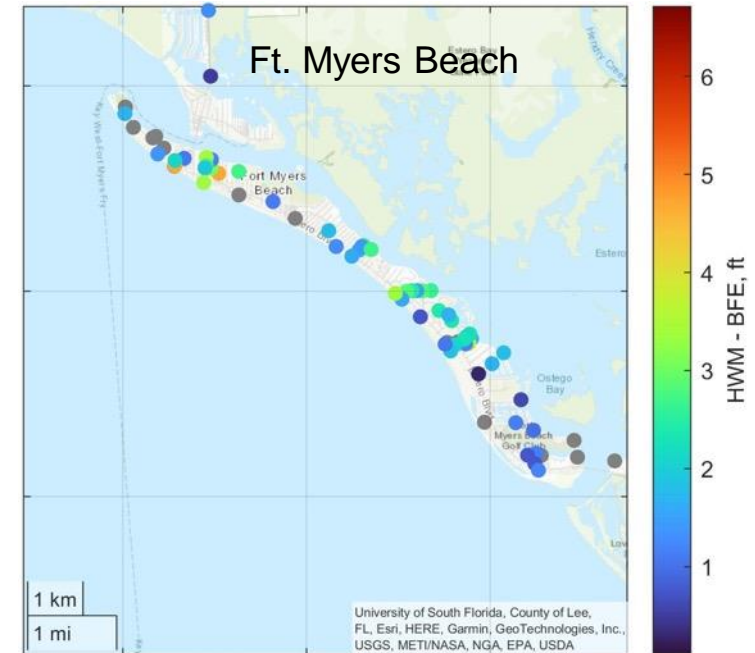
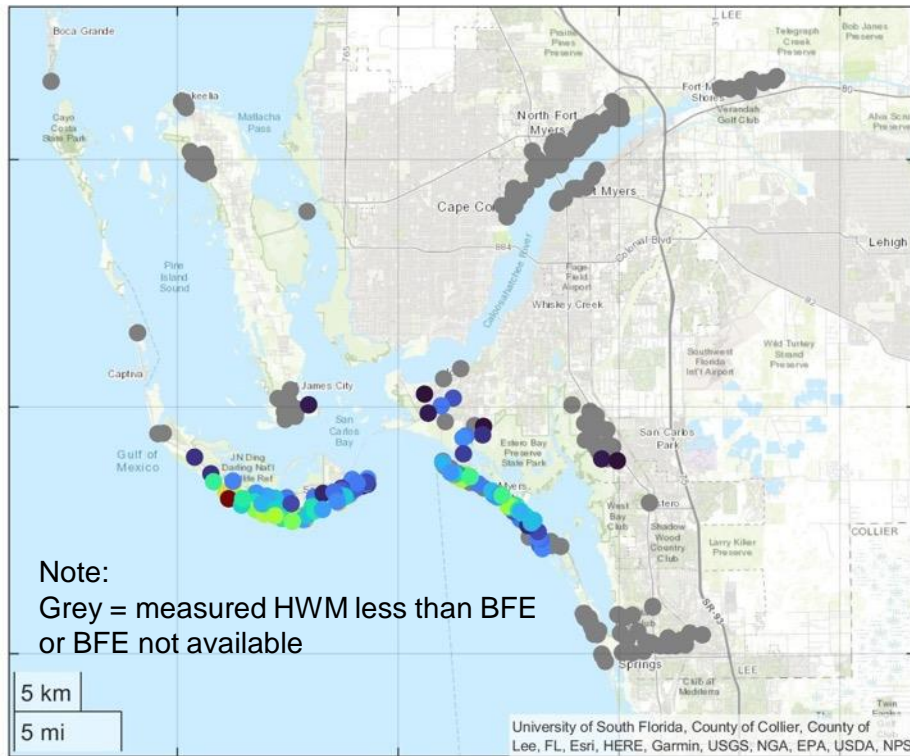
# HWM Relative to BFE in Ft. Myers Beach



Note: HWM and FIRM BFE relative to NAVD88

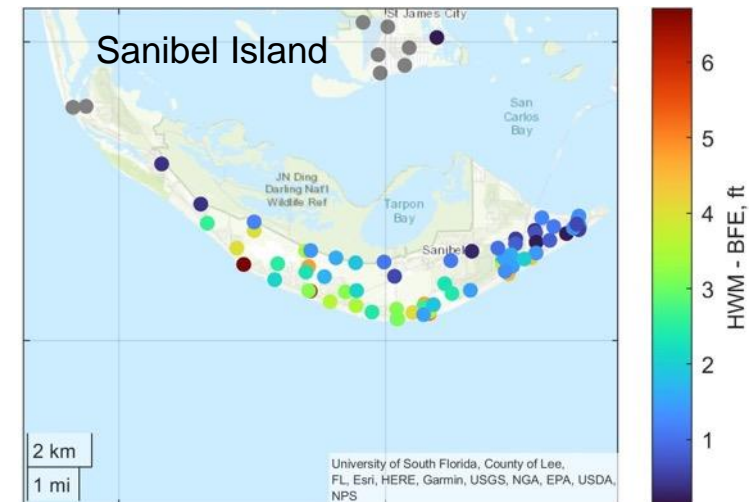
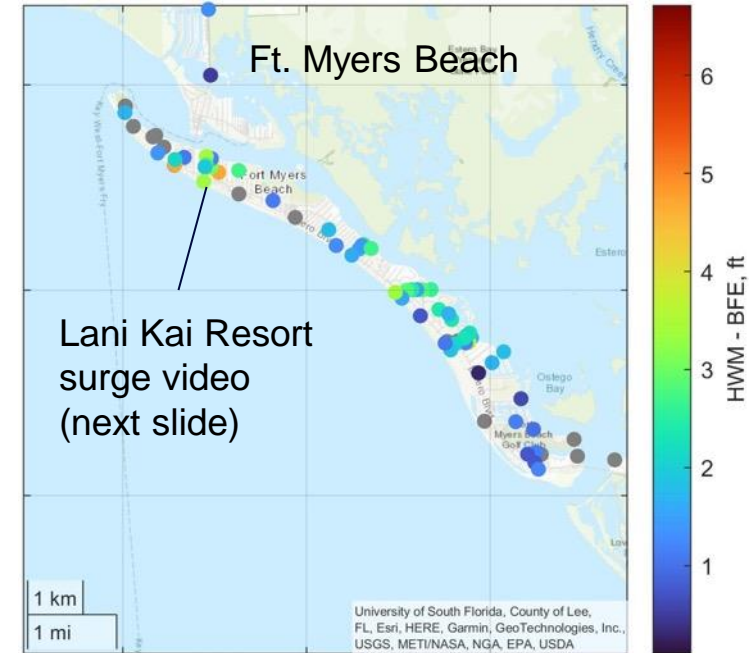
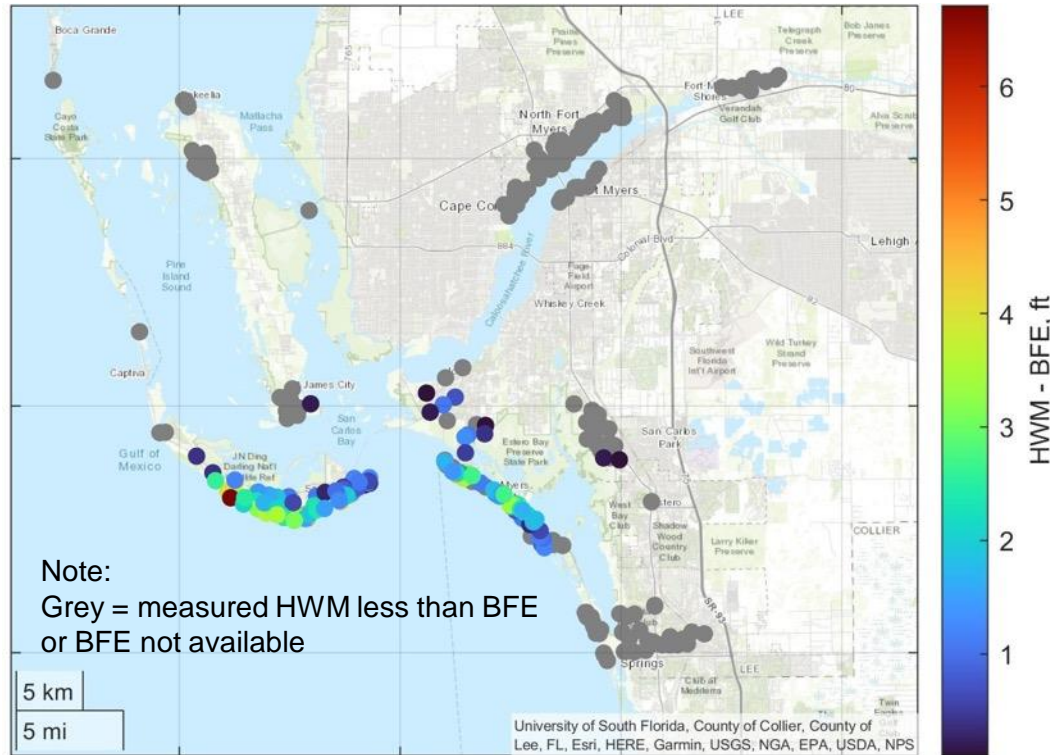


# HWM in relation to BFE



Colored circles provide height by which measured high water marks **exceeded** the current Base Flood Elevation.

# HWM in relation to BFE



Colored circles provide height by which measured high water marks **exceeded** the current Base Flood Elevation.

15ft Storm Surge Washes Away Homes in Ft. Myers Beach - Hurricane Ian

Watch later Share Info



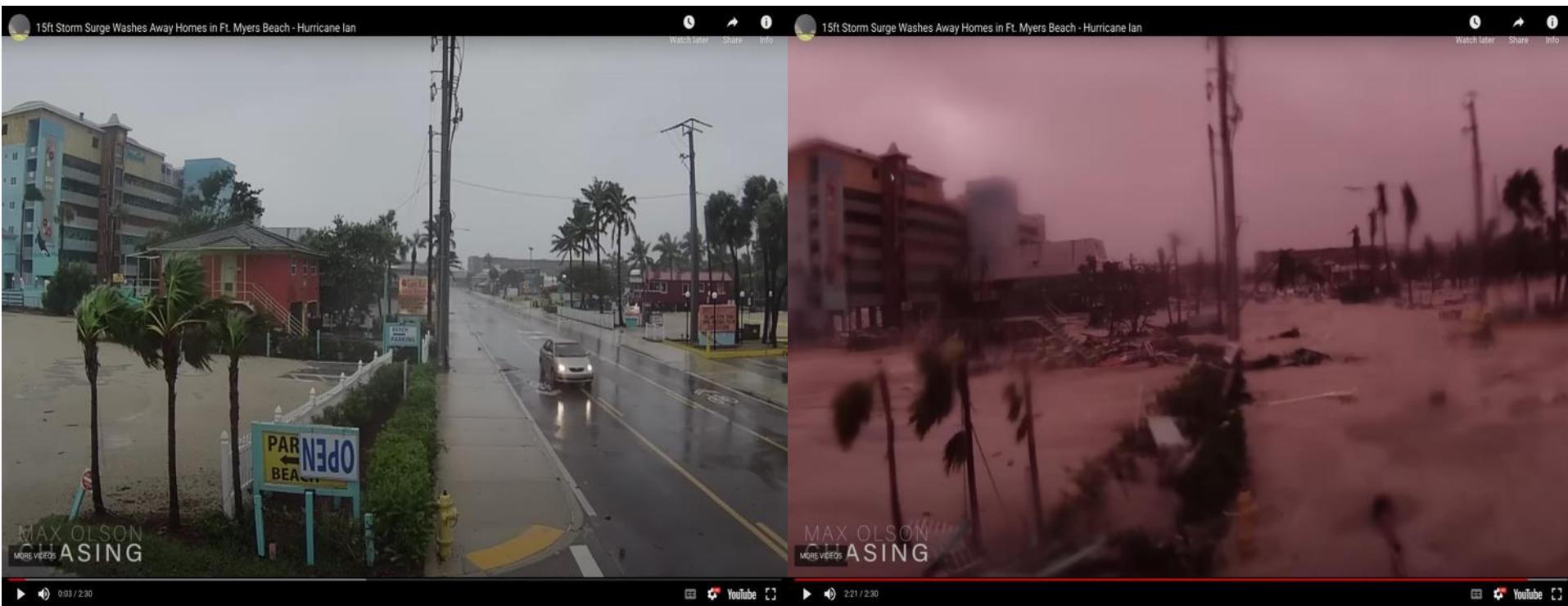
MAX OLSON  
CHASING  
MORE VIDEOS



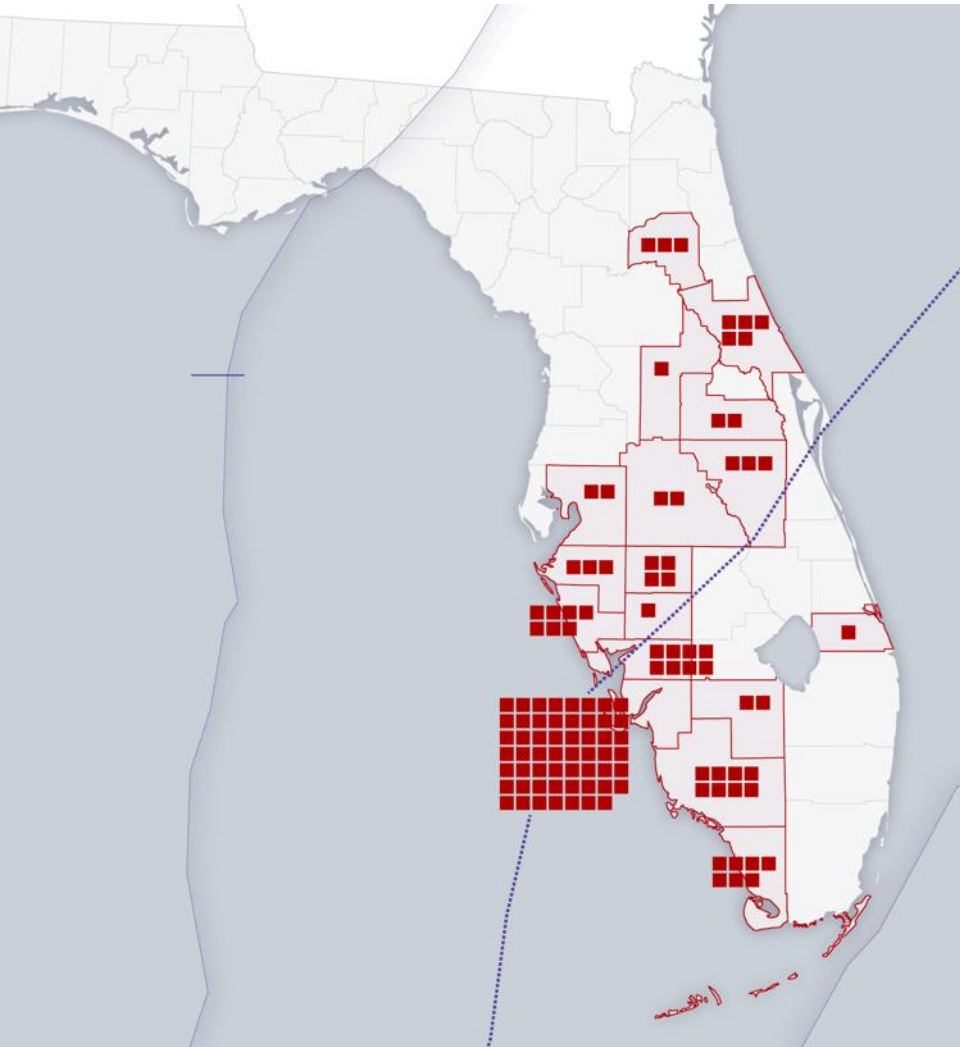
Why your deliberations today matter:

The urgency exists to learn from every natural hazard event, which happen infrequently, at unpredictable, and usually inconvenient times. Our only chance of understanding what occurred is to preserve evidence of the impacts for later study before it is wiped away during the cleanup efforts.

The Florida Building Commission's long-term support of post-hurricane building performance assessment and the emerging research findings from the work of the Hurricane Research Advisory Committee are saving lives and are helping to mitigate the future damage in Florida and the U.S.



# Fatality Numbers from Hurricane Ian

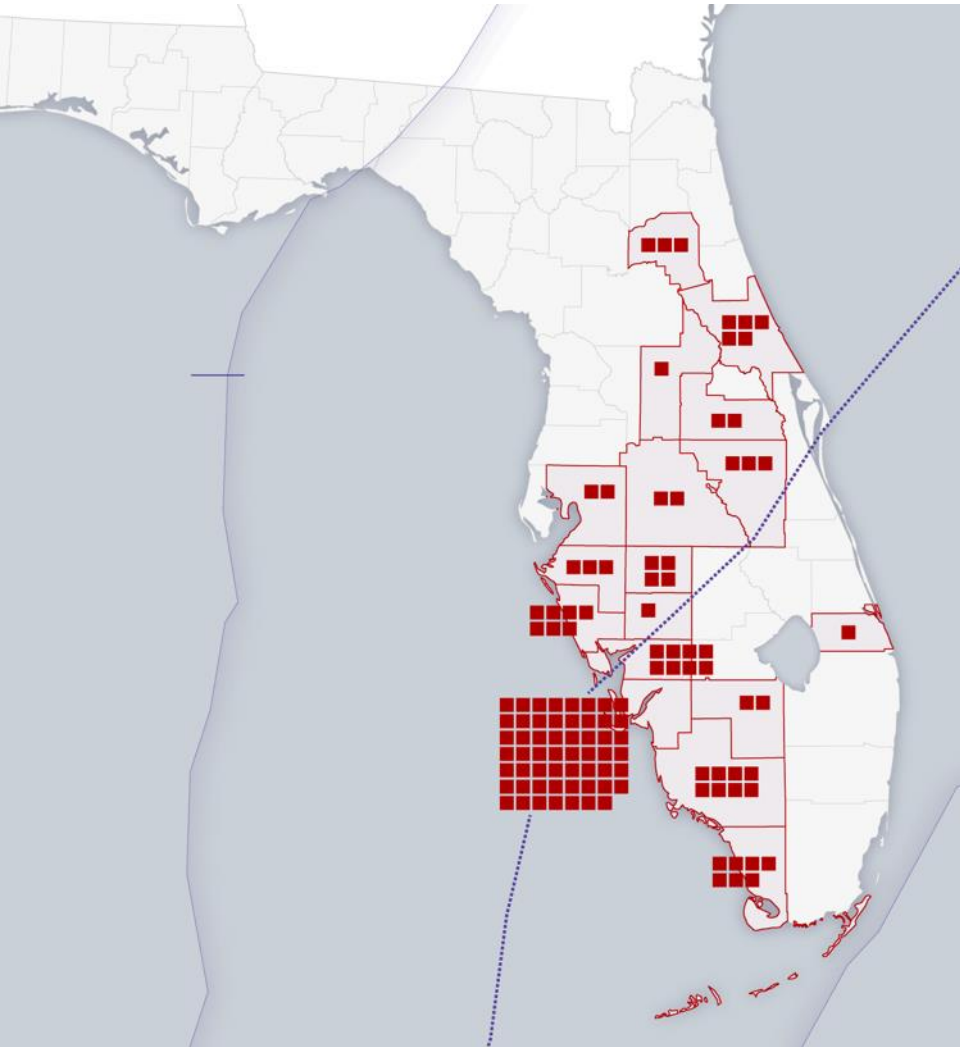


County	# Fatalities
Lee County	55
Charlotte County	8
Collier County	8
Munroe County	7
Sarasota County	7
Volusia County	5
Hardee County	4
Osceola County	3
Manatee County	3
Putnam County	3

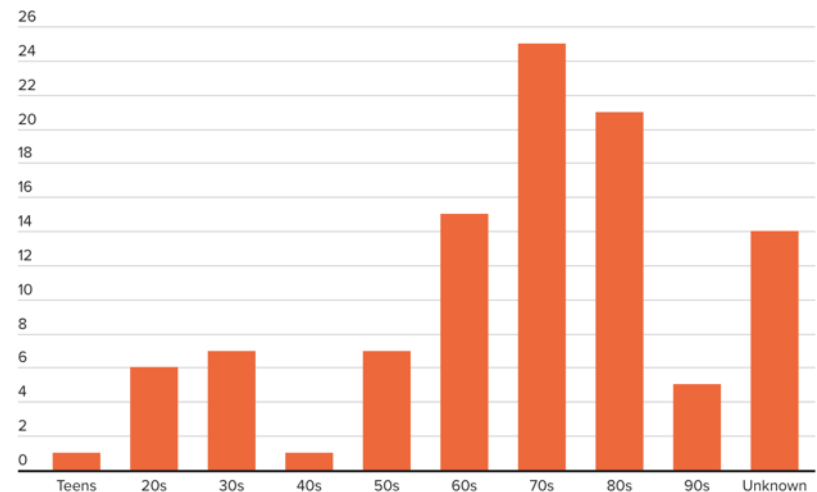
Sources: Florida Department of Law Enforcement (deaths by county); National Oceanic and Atmospheric Administration (hurricane path and wind area) By Zach Levitt

<https://www.nytimes.com/2022/10/21/us/hurricane-ian-victims.html>

# Fatality Numbers from Hurricane Ian



## Florida's Ian-related deaths by age



As of Oct. 10, 2022

Source: Florida Department of Law Enforcement, Medical Examiners Commission

<https://www.foxweather.com/weather-news/most-hurricane-ian-deaths-in-florida-were-drownings-data-shows>

# Data Collection in Field Deployments

# Chronology of Deployments

Organization	Team	Dates	Mission
UF FCMP (11)	Alex Esposito (UF), Chris Ferraro (UF), Wyatt Kelch (UF), Forrest Masters (UF), Ryan Mieras (UNCW), Mesa Nicholas (UF), Ben O'Hern (UF), Brian Phillips (UF), Scott Powell (UF), Taylor Rawlinson (UF), Ian Van Voris (UF)	26-29 Sep. 2022	Pre-landfall deployment of surface observation towers
UF FCMP, StEER FAST-1 (6)	David O. Prevatt (UF), Duzgun Agdas (UF), Arithriya Subgranon (UF), Jorge Santiago (UF), and Jonathon Micali (UF), Oscar Lafontaine (UF)	29 Sep. 2022	Preliminary rapid assessments, scouting
StEER FAST-2 (4)	Dylan Faraone (Site Tour 360), David Prevatt (UF), Ioannis Zisis (FIU), Landolf Rhode-Barbarigos (UM)	29-Sep. 2022 through 14-Oct. 2022	Rapid imaging via 360 cameras
StEER FAST-3.1 (9)	Kurt Gurley (UF), Rob Davis (Plainsman Eng.), Chris Rizer (Simpson), Luis Ceferino (NYU), Jean-Paul Pinelli (FIT), Zhuozuan Wei (FIT), Jaqueline Zdebski (UW Rapid), Mohammad Alam (UND), Joey Civello (Frontier Precision)	19-23 Oct. 2022	High water marks, aerial imaging, forensic assessments
StEER FAST 3.2 (4)	James Kaihatu (TXAM), Sabarethinam Kameshwar (LSU), Bahzad Ebrahimi (USC), Maile McCann (USC)	31-Oct. through 4-Nov. 2022	High water marks, forensic assessments



# Summary of Technologies Deployed

**Trinity F90+ Drone for Aerial Mapping**



**Mosaic51 Vehicle-Mounted 360 Camera**



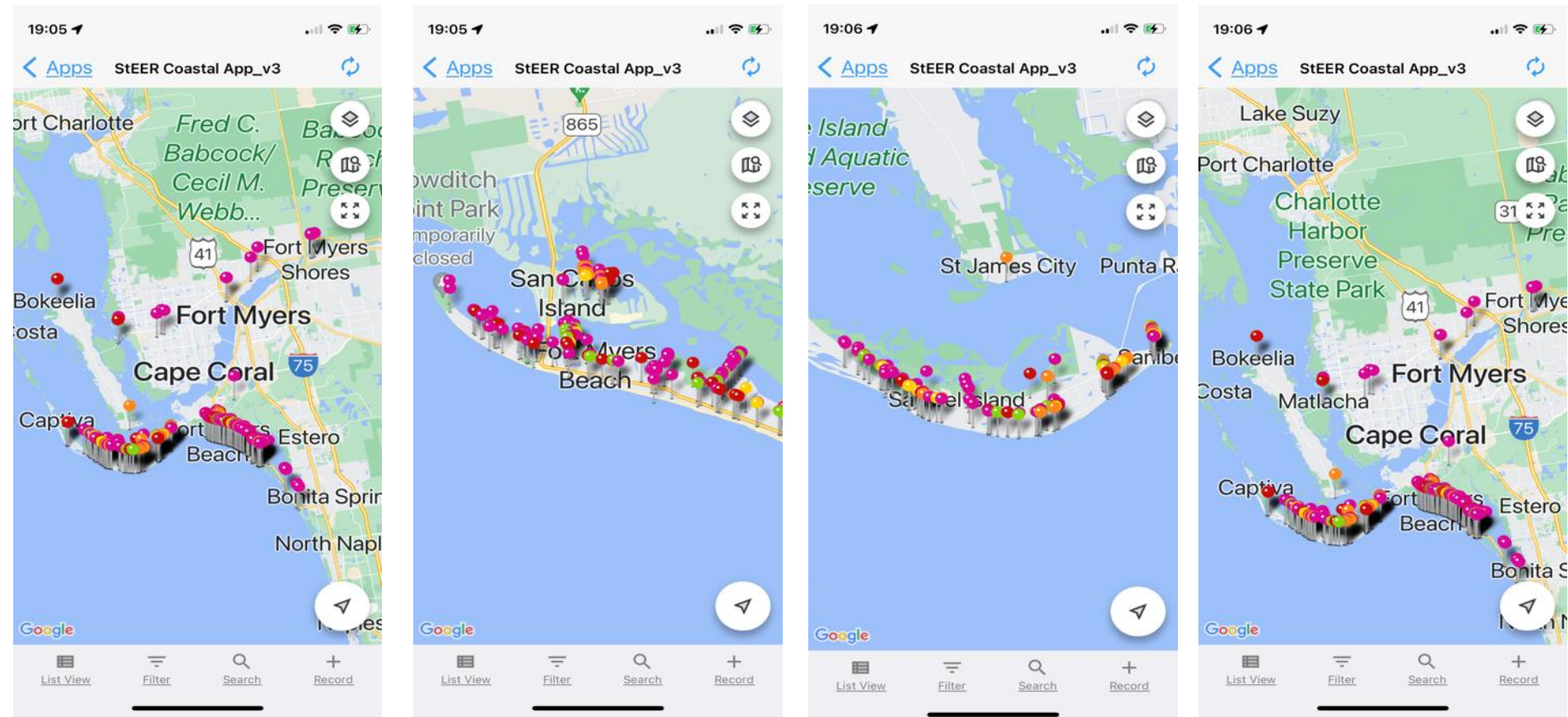
**Rangefinder, Level, and RTK GPS for High Water Marks**



**On-Site Performance Assessments via Fulcrum App and GPS-enabled Cameras**



# On-Site Performance Assessments



16:39

[Back](#) General Information

Inspector Name \*

Inspector Affiliation

Date of Inspection  
November 2, 2022

Time of Inspection  
16:13

Facility Address  
  
Sanibel, Florida 33957  
United States

Contact Info of Facility Owner  
 --  
assistant Manager

Sampling Method  
Opportunistic Sampling

Area Assessed  
Exterior

16:37

[Back](#) Basic Metadata

Site on Beach Front?

Site on Slope?

Facility Material

Building Category

Number of Stories Above Ground

Number of Stories Below Ground

Elevation of Lowest Floor

Elevation Unit

Elevation With Respect to Ground Level

Occupied?

Foundation Category

Is basement or ground floor slab-on-grade a breakaway slab?

Wall

Wall Anchorage Type

Exterior Wall Cladding

Wall Substrate

Fenestration

Front Fenestration Protection Available?

Left Fenestration Protection Available?

Back Fenestration Protection Available?

16:39

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Site on Beach Front?

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Site on Slope?

Yes No Unknown

Facility Material

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Number of Stories Above Ground

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Elevation of Lowest Floor

Elevation Unit

feet m

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Exterior Wall Cladding

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Fenestration

Front Fenestration Protection Available?

Yes No

Left Fenestration Protection Available?

Yes No

Back Fenestration Protection Available?

Yes No

16:38

[< Cancel](#) Exterior Wall Cladding [Done](#)

Search

Veneer

Prefabricated panels

Glazed exterior walls

Glass blocks

Concrete cladding

Aluminum siding

Curtain wall

EIFS

Fiber-cement board

Plywood siding

Stucco

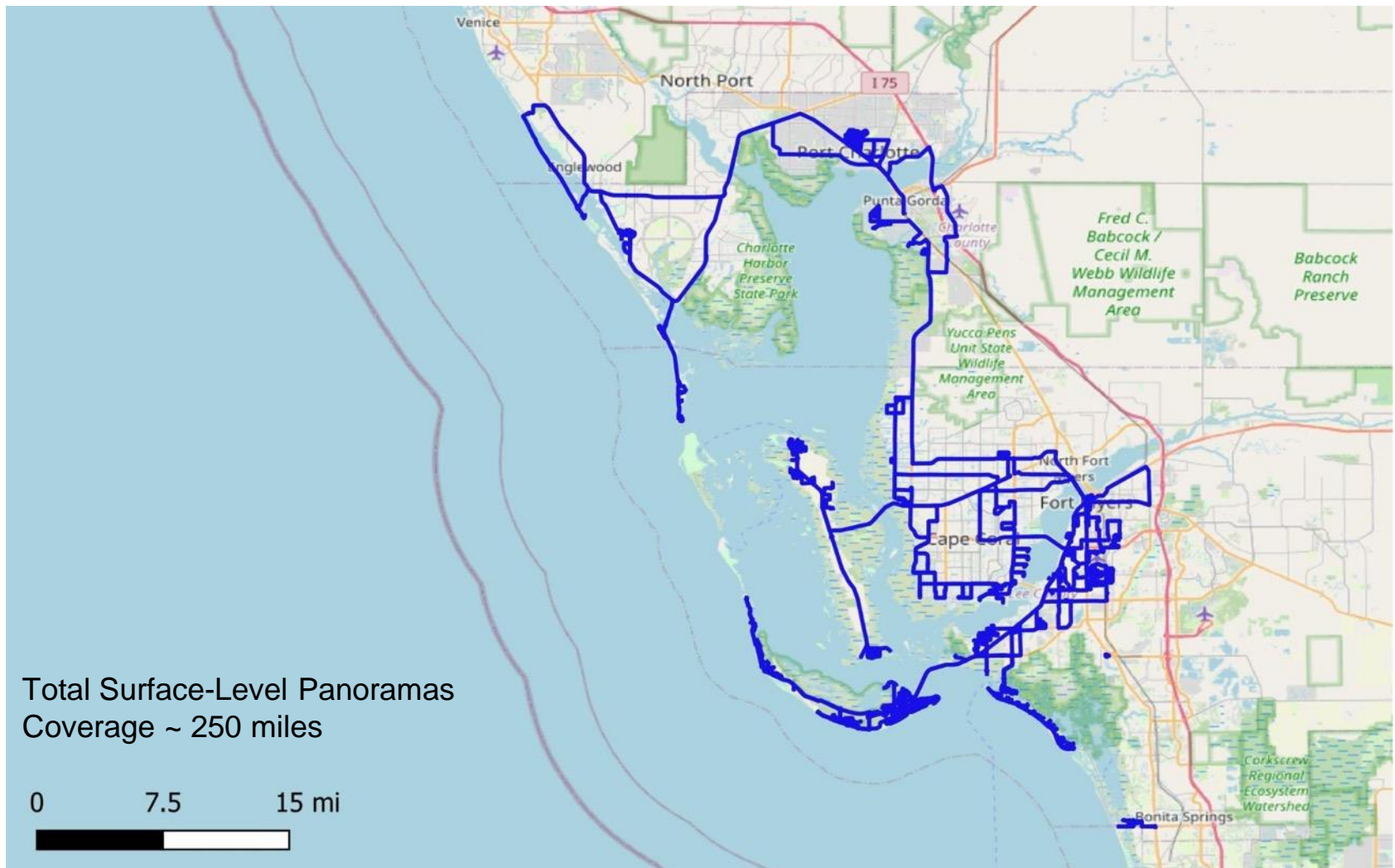
Vinyl siding (standard)

Vinyl siding (high wind rated)

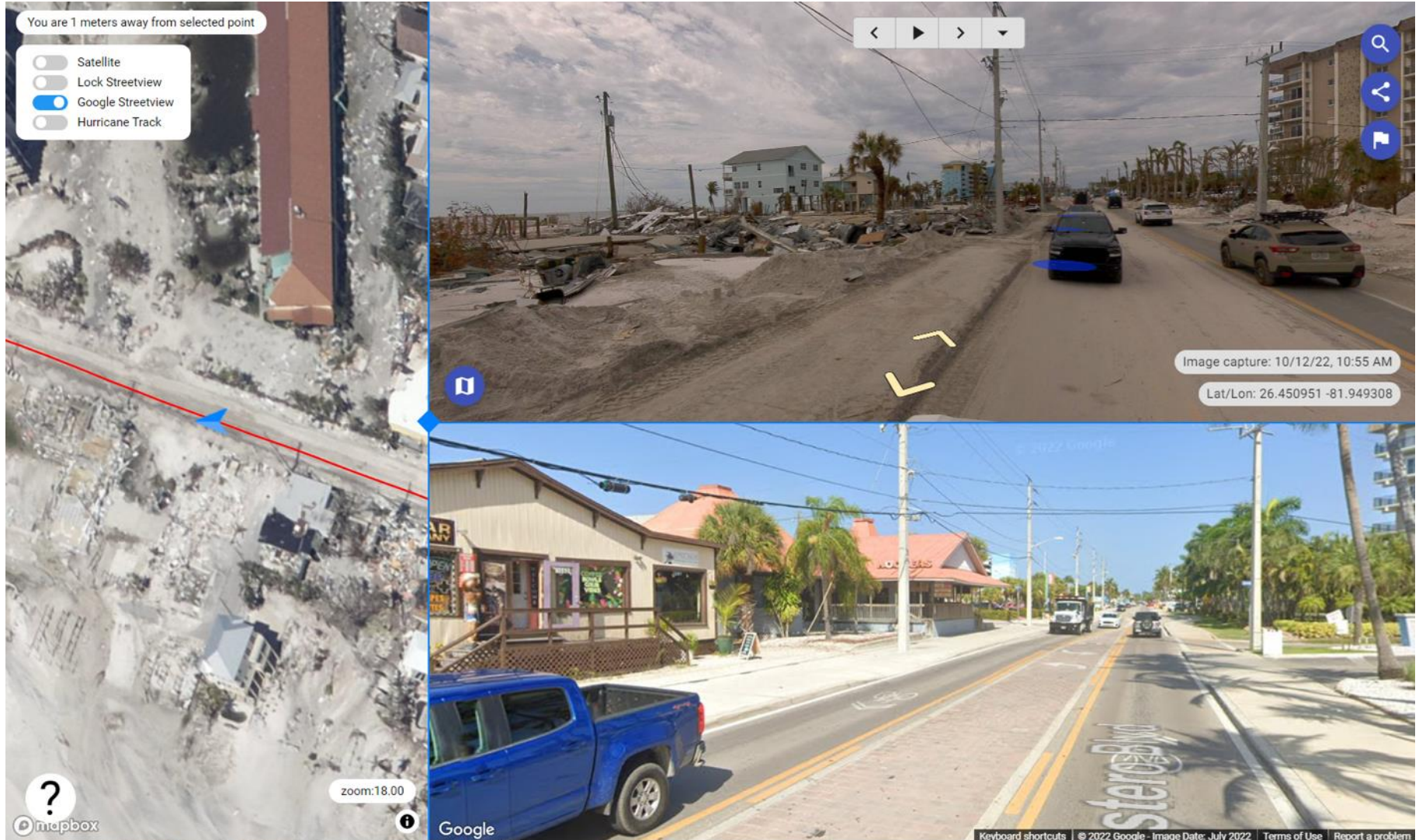
Vinyl siding (unknown)



# Surface-Level Panoramas Coverage



# SiteTour 360 Viewer





# Aerial Imagery from StEER/RAPID

- Complete coverage of Ft. Myers Beach (3.5 sq. mi.) and San Carlos Island (1 sq. mi.) with high-resolution oblique and nadir imagery
- Majority of Sanibel Island (4 sq. mi.) also captured with high-resolution oblique and nadir imagery
- Images combined into high-resolution orthomosaic maps and 3D point clouds using Structure-from-Motion



# FDEP Office of Resilience and Coastal Protection Videography

LAT: 26.434299  
LNG: -82.042729  
UTC: 2022-10-02 18:52:27

FROM: Begin (15256.4 m)  
TO: R-162 (234.7 m)



LAT: 26.440464  
LNG: -81.930590  
UTC: 2022-10-02 19:08:11

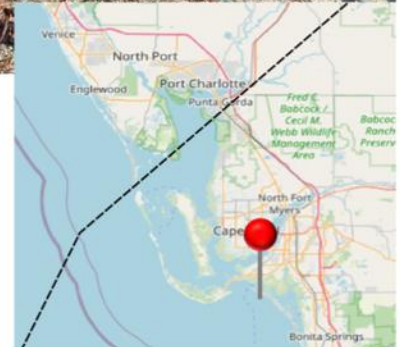
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TO: R-189 (208.8 m)



# Performance Observations Summary



# Representative Performance: Elevated Homes

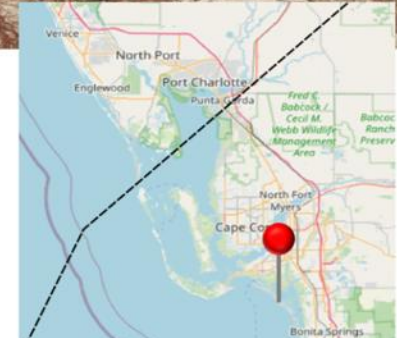


Location:	Seaward of CCCL; Estero Blvd and Washington Ave., Ft. Myers Beach, FL	Year Built:	2018
Wind Speeds:	~100 mph gusts	Storm Surge:	~16 ft relative to NAVD88, ~11 ft relative to ground
Comments:	Photos looking inland from beach side; breakaway walls performed as intended. Minor wall cladding loss. No visible damage to metal roof.		

Photos by Dr. Kurt Gurley (UF)



# Representative Performance: Elevated Homes



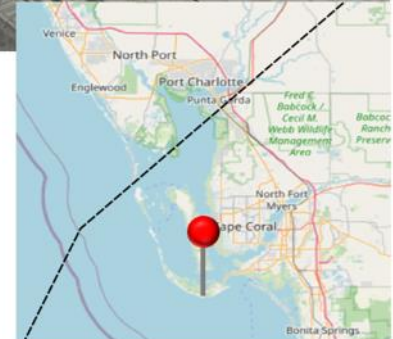
Location:	Seaward of CCCL, Estero Blvd and Avenida <u>Pescadora</u> , Ft. Myers Beach, FL	Year Built:	2015
Wind Speeds:	~100 mph gusts	Storm Surge:	~19 ft relative to NAVD88, ~13 ft relative to ground
Comments:	Breakaway walls performed as intended. No visible damage to metal roof or wall cladding in occupied stories.		



# Representative Performance: Elevated Homes



Location:	Donax St, Sanibel Island, FL.	Year Built:	1978
Wind Speeds:	~110 mph gusts	Storm Surge:	16.5 ft relative to NAVD88 ~12 ft relative to ground
Comments:	Some roof cover damage, exterior cladding damage. Heavy interior damage in 1 <sup>st</sup> (elevated) floor due to storm surge.		

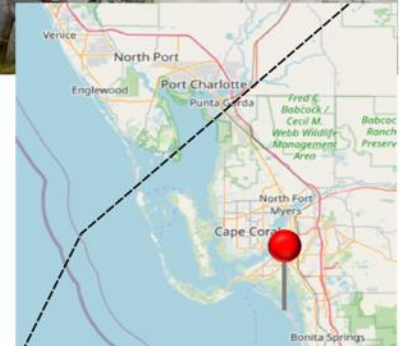




# Representative Performance: Elevated Homes

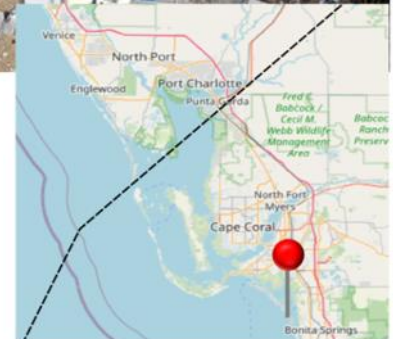


Location:	Driftwood Ln, Ft. Myers Beach, FL. ~0.3 miles from Gulf Coast.	Year Built:	1996
Wind Speeds:	~100 mph gusts	Storm Surge:	~14 ft relative to NAVD88, ~9 ft relative to ground
Comments:	Structure performed well; some loss of asphalt shingles; no other visible signs of exterior damage. Roof replaced in 2017 following Hurricane Irma.		





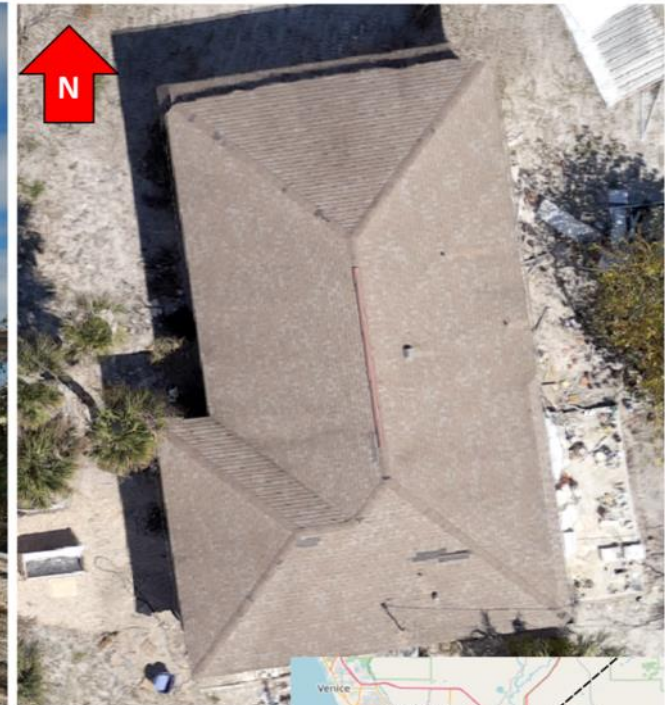
# Representative Performance: Slab-on-Grade Homes



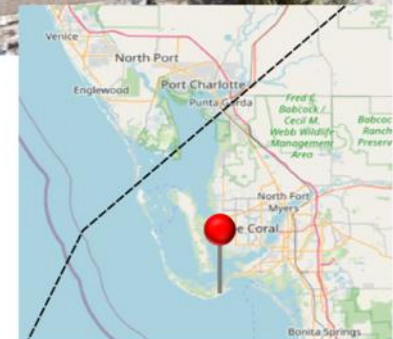
Location:	Buccaneer Dr, Ft. Myers Beach, FL. ~0.18 miles from Gulf Coast.	Year Built:	1974
Wind Speeds:	~100 mph gusts	Storm Surge:	~16 ft relative to NAVD88, ~10 ft relative to ground
Comments:	Partial loss of exterior walls due to storm surge flow-through. Partial loss of asphalt shingle roof that was installed in 2006.		



# Representative Performance: Slab-on-Grade Homes



Location:	Buttonwood Ln, Sanibel, FL. ~0.15 miles from Gulf Coast.	Year Built:	1976
Wind Speeds:	~110 mph gusts	Storm Surge:	~11 ft relative to NAVD88, ~8 ft relative to ground
Comments:	Blow out of garage door; minor roof cover loss. No other visible signs of exterior damage.		

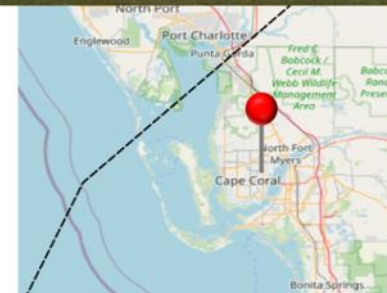




# Representative Performance: Wind Hazards



Location:	SE 17 <sup>th</sup> St, Cape Coral, FL.	Year Built:	Mix of mostly 1980s and 1990s
Wind Speeds:	~105 mph gusts	Storm Surge:	N/A
Comments:	Isolated roof cover loss; generally no other signs of visible exterior damage.		





# Representative Performance: Wind Hazards

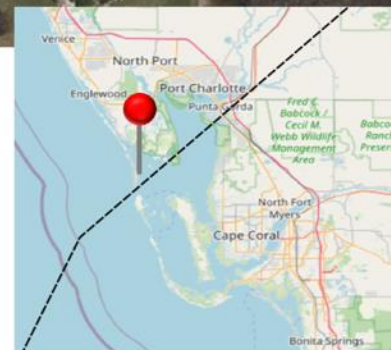
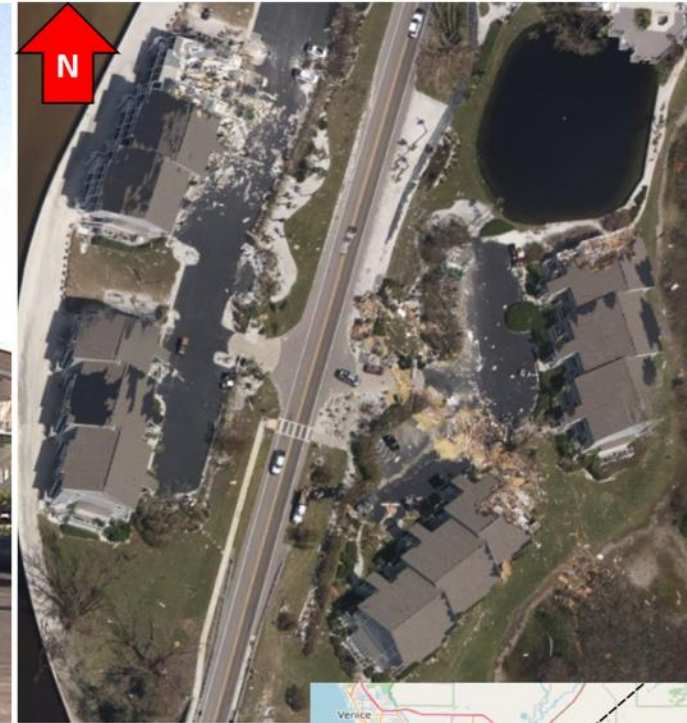


Location:	Porto Bello St, Pine Island, FL.	Year Built:	Mostly pre-FBC construction
Wind Speeds:	~120 mph gusts	Storm Surge:	N/A
Comments:	Frequent roof cover loss; isolated cladding and fenestration damage; isolated damage to attached porches.		





# Poor Wind Performance: Pre-FBC Multi-Family



Location:	Boca Grande Causeway, Boca Grande, FL.	Year Built:	1980s
Wind Speeds:	~120 mph gusts	Storm Surge:	Unknown
Comments:	Collapse of gable ends in multiple multi-family units; loss of asphalt roof shingles.		



# To summarize ....

- Recap: Triage summary 11 October 2022
  - includes Wind field swath (ARA)
- The Hazards
  - Wind: FCMP's Tower Deployment (data access)
  - Storm surge: high water marks
- Data Collection in Field Deployments
  - Teams and Logistics
  - Technology and coverage
    - High water marks summary
    - Door-to-door assessment
- Performance Observations Summary
  - Elevated houses (surge vs. wind damage)
  - Slab on grade houses
  - Multi-family residential units
- Next Steps: Proposal for Data Enrichment
- Further Readings

# Closing Thoughts

DBPR should highlight success stories tied to code improvements and shop to media outlets. The engineers should have a strong voice

Immediate access to locations is a concern - to capture “ephemeral” damage patterns (without this cannot reconstruct what occurred and in what order). FBC can assist coordinating better with state agencies

Expand the pool of researchers and engineers willing to do forensic work (currently mostly volunteers). Working with StEER, FEMA and others is tremendous asset to the state of Florida and the FBC in this work

Outcomes must be shared with people and the leaders within impacted communities, including options (recommendations?) to retreat, to rebuild, or to retrofit. Key: communities need this data support their discussion and rational decision-making. Report findings include knowledge needed for creating policy for future growth/degrowth

# Next Steps: Data Enrichment

1. Continue data enrichment process to augment our dataset with Building Appraisers' data not available in field by building performance relative to
  - a. age,
  - b. edition of FBC Building Code, and
  - c. materials (cladding and structural)
  - d. location
2. Elevated Structures - collate evidence on performance of elevated structures and effects of buoyancy and hydrodynamic forces

Additional field inspections of selected case study structures may be required. Goal: statistical analysis of observations

1. Interim Report March 2023
2. Final Report June 2023

# Further Reading



**StEER**  
STRUCTURAL  
EXTREME EVENTS  
RECONNAISSANCE

**Hurricane Ian**  
Released: November 16, 2022  
NHERI DesignSafe Project ID: PRJ-3709

## PRELIMINARY VIRTUAL RECONNAISSANCE REPORT (PVRR)



Image Source: Wilfredo Lee, AP

Virtual Assessment Structural Team (VAST) Lead:  
Maria D. Cortes Delgado, University of Puerto Rico-Mayagüez

Virtual Assessment Structural Team (VAST) Authors (in alphabetical order)

Prateek Arora, New York University  
Luis Ceferino, New York University  
Haitham A. Ibrahim, Florida International University  
Denis Istrati, University of Nevada Reno

Dorothy Reed, University of Washington  
David Roueche, Auburn University  
Amir Safiey, Auburn University  
Tori Tomiczek, US Naval Academy  
Ioannis Zisis, Florida International University

PVRR Editors (in alphabetical order)

Mohammad Alam, University of Notre Dame  
Tracy Kijewski-Correa, University of Notre Dame

David O. Prevatt, University of Florida  
Ian Robertson, University of Hawaii at Manoa



**StEER**  
STRUCTURAL  
EXTREME EVENTS  
RECONNAISSANCE

PVRR: Hurricane Ian  
PRJ-3709 | Released: November 16, 2022  
Building Resilience through Reconnaissance

<https://www.steer.network/hurricane-ian>



**StEER**  
STRUCTURAL  
EXTREME EVENTS  
RECONNAISSANCE

Coordinating Node: University of Notre Dame  
156 Fitzpatrick Hall  
Notre Dame, IN 46556 USA  
[www.steer.network](http://www.steer.network)  
[admin@steer.network](mailto:admin@steer.network)

Director: Tracy Kijewski-Correa, University of Notre Dame  
Associate Director, Seismic Hazards: Khalid Mosalam, University of California, Berkeley  
Associate Director, Wind Hazards: David Prevatt, University of Florida  
Associate Director, Coastal Hazards: Ian Robertson, University of Hawaii at Manoa  
Associate Director, Data Standards: David Roueche, Auburn University

## PRIORITY RESEARCH AREAS: HURRICANE IAN

Release Date: 16 November 2022

**Event Summary:** On September 28, 2022, Hurricane Ian made landfall near Cayo Costa, FL as a Category 4 hurricane according to the National Hurricane Center, with peak sustained wind speeds over water estimated at 150 mph, a minimum surface pressure of 940 mb, and preliminary storm surge inundation measurements of 13 ft relative to NAVD88. The results were catastrophic in terms of both damage to infrastructure and loss of human life on the densely-populated west coast of Florida, particularly in the barrier islands off Ft. Myers and Cape Coral.

**Available Data:** [Street-level panoramas](#) were collected by Site360/STEER's, with UAV collected by the RAPID EF, and performance assessments and High Water Marks ([FulcrumApp.com](#)). See <https://www.steer.network/hurricane-ian> for links to all data sources and assets.

**Available Briefings/Reports:** [PVRR](#)

**Priority Proposal Topics:** STEER members have been encouraged to develop proposals in the following topical areas.

= Engineering Study; : Interdisciplinary Study

## TOPIC 1: Performance of Elevated Buildings Subjected to Coastal Hazards



### RAPID Proposal Opportunity

- Gather evidence to quantify uplift (buoyancy and hydrodynamic) forces acting on the floor slabs of elevated buildings due to storm surge and wave action, reviewed in the context of the ASCE 7-22 Chapter 6 Tsunami Loads and Effects and the soon to be released Supplement 3 of ASCE 7-22 Chapter 5 on Flood Loads.
- Document performance of breakaway walls and other surge damage mitigation measures used in coastal buildings.
- Document performance of mechanical, electrical, and plumbing (MEP) systems (e.g., plumbing, electrical, HVAC) in maintaining and restoring functionality in line with performance goals.
- Document evidence of scour and overall performance of foundations and in-situ geotechnical conditions.



# Further Reading

FINAL Report:

**Investigation of Optional Enhanced Construction Techniques for the Wind, Flood, and Storm Surge Provisions of the Florida Building Code**  
Project #: P0140189

Submitted to:

**Florida Department of Business and Professional Regulation**

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[bit.ly/ufWIND-01-20](https://bit.ly/ufWIND-01-20)

Recommended enhanced construction changes to practice that exceed mandated minimum code provisions of the 6th and 7th Editions of the Florida Building Code (FBC).

(Changes are shown legislatively)

Submitted to [www.BuildingaSaferFlorida.org](http://www.BuildingaSaferFlorida.org).

- R.C. Quinn Consulting: Optional Enhanced Storm Surge and Flood Provisions
- T.E.Stafford and Associates: Enhanced Wind Hazards Provisions
- Applied Research Associates, Inc.: Site Specific (Wind Speed) Hazards in Florida

*Thank You for your Attention!*

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