



# Florida Housing Coalition Hurricane Member Update Webinar

March 4, 2022  
Sponsored by Fannie Mae

# AGENDA

- Announcements
- U.S. Hurricane Damage Drivers and Atlantic Basin Seasonal Hurricane Prediction

## You're Invited: 2022 Hazard Mitigation Grant Program Webinar Series

If you are interested in Hazard Mitigation Grant Program (HMGP) funding you may find FEMA's upcoming webinar series helpful. Next month FEMA is hosting an informative webinar series that will bring together subject-matter experts and practitioners to provide technical information, best practices, and tools and resources for submitting a successful HMGP application. The webinars are being designed for leaders in states, local communities, tribes and territories, as well as private sector entities, private non-profit organizations, and individuals.

**HMGP 101 Program Overview**  
**March 10, 2:30-4:00 p.m. Eastern Time**

<https://femacqpub1.connectsolutions.com/content/connect/c1/7/en/events/catalog.html?folder-id=221257069&from-origin=fema.connectsolutions.com>



# Training Announcement

## Affordable Housing Funding Sources Part 1:

March 15, 2022 at 2:00pm

Register at

<https://attendee.gotowebinar.com/register/9195494335965794831>



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**Thursday, March 24, 2022 2-3:30**



**SHIP Education Efforts  
Made Possible  
Thanks to the  
Catalyst Program**

**Presented by  
Aida Andujar and  
Kody Glazer**

**Avoiding Conflict of Interest  
Issues with Staff, Contractors,  
and Local Officials**

Register at  
<https://attendee.gotowebinar.com/register/3874941076424523279>



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Congratulations to the Florida Housing Coalition's  
**Resilience & Disaster Recovery Team**  
for receiving the *2021 Public/Private Achievement Award*  
from the Governor's Hurricane Conference



GOVERNOR'S HURRICANE CONFERENCE  
MAY 8-13 | PALM BEACH CONVENTION CTR  
& HILTON WEST PALM BEACH

Register at

<https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwi5pdjygZv2AhVKDkQIHfnaBwUQFnoECAgQAQ&url=https%3A%2F%2Fflghc.org%2Fregistration%2F&usg=AOvVaw0BWfM-8xSuS8Chm2kbINMQ>



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# 2022 ANNUAL STATEWIDE AFFORDABLE HOUSING CONFERENCE

HOME **MATTERS**  
 IN FLORIDA




Hosted by the FLORIDA HOUSING COALITION

August 29th – August 31st

IN-PERSON AT THE ROSEN CENTRE, ORLANDO FL



A satellite image of a hurricane, likely Hurricane Ian, showing a well-defined eye and spiral cloud bands over the Atlantic Ocean. The text is overlaid in red.

# **U.S. Hurricane Damage Drivers and Atlantic Basin Seasonal Hurricane Prediction**

**Phil Klotzbach**

**March 4, 2022**

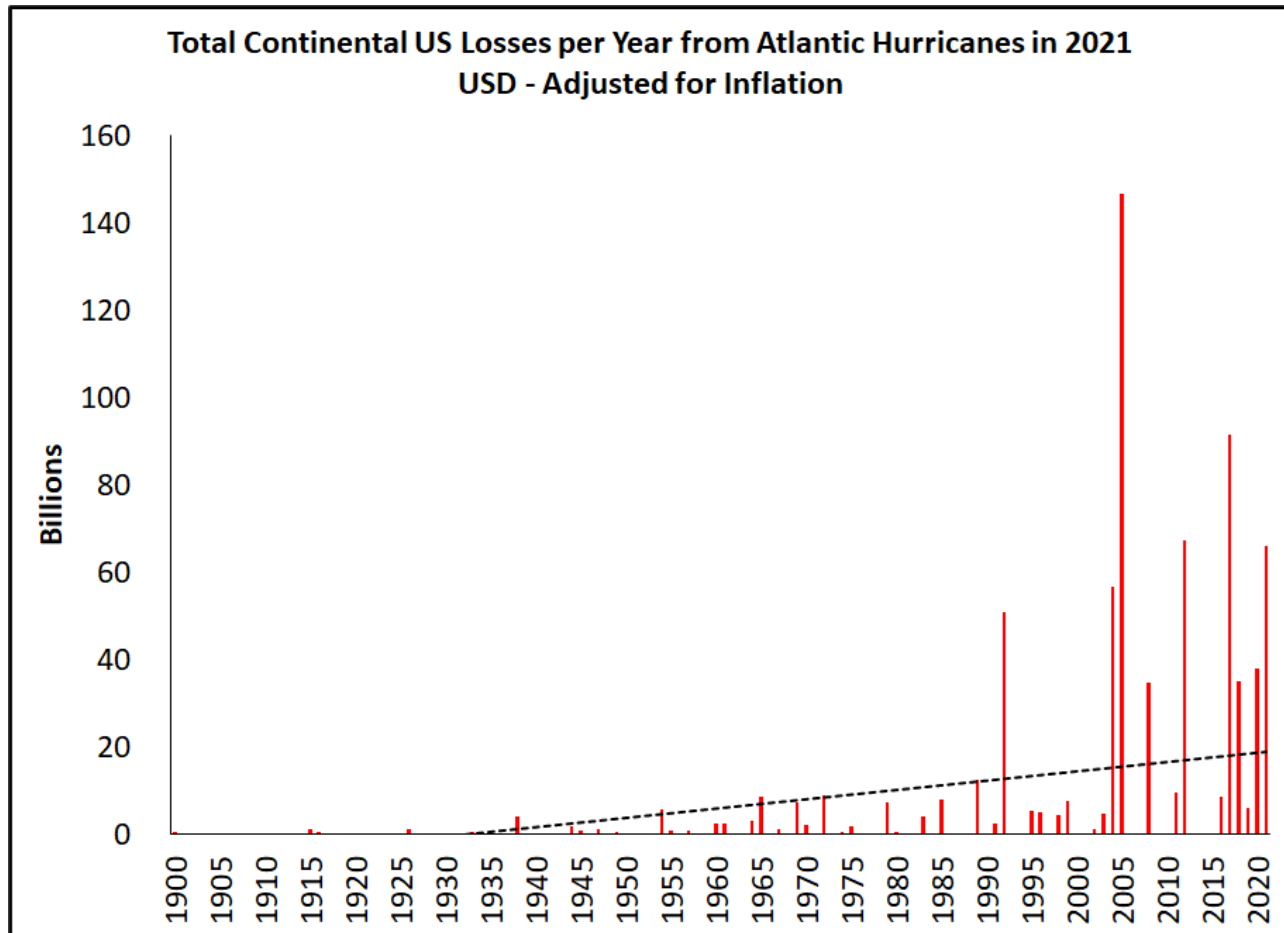
**Florida Housing Coalition Webinar**



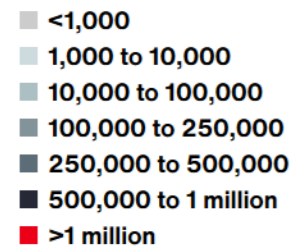
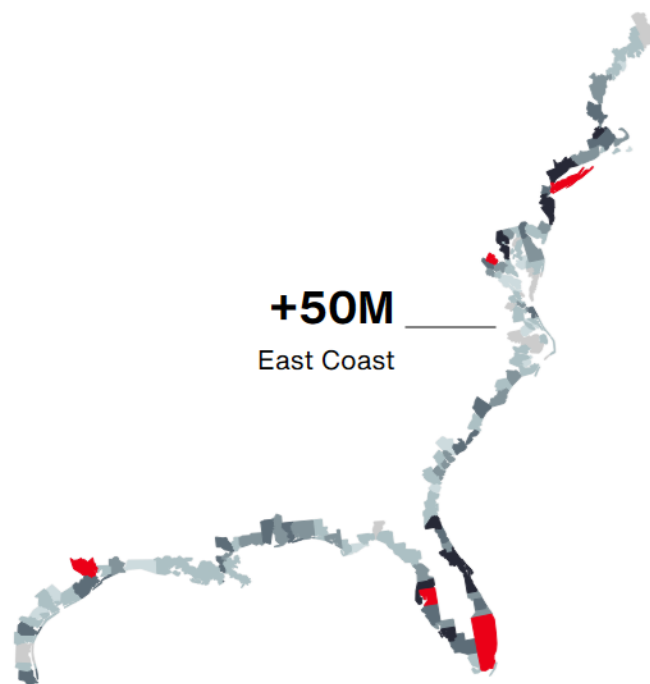
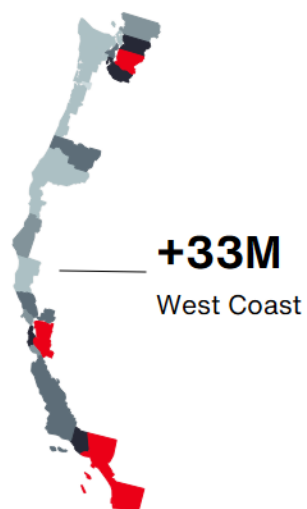
# Outline

- **Past and potential future trends in US hurricane damage**
- **New hurricane categorization scale**
- **2021 Atlantic hurricane season recap**
- **2022 Atlantic hurricane season – preliminary thoughts**

## Continental US Hurricane Damage (1900-2021) – Adjusted for Inflation



# US Coastal Population Change Since 1900



## U.S. Coastal Population

Net Change Since 1900

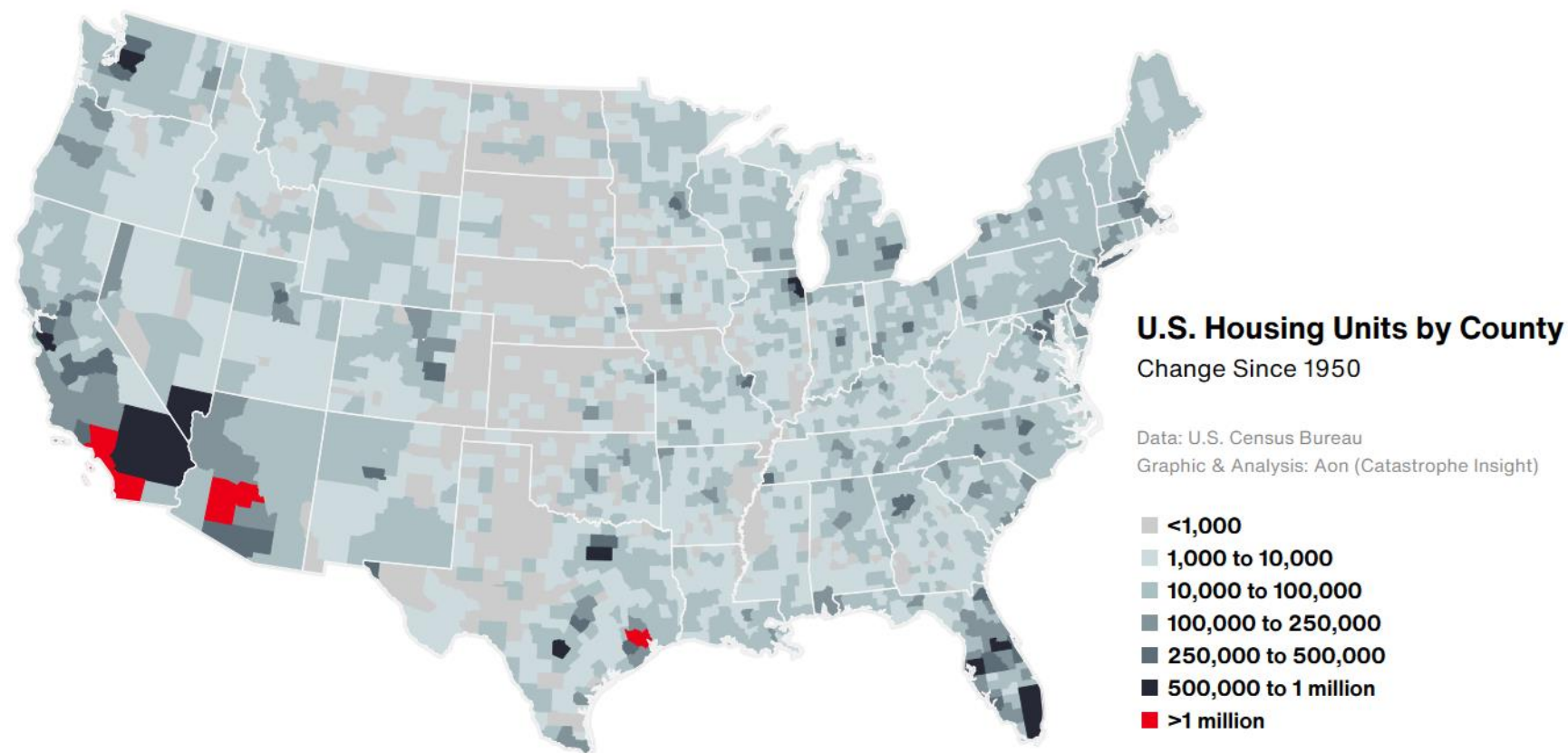
Data: U.S. Census Bureau

Graphic & Analysis: Aon (Catastrophe Insight)

*Steve Bowen (Aon)*

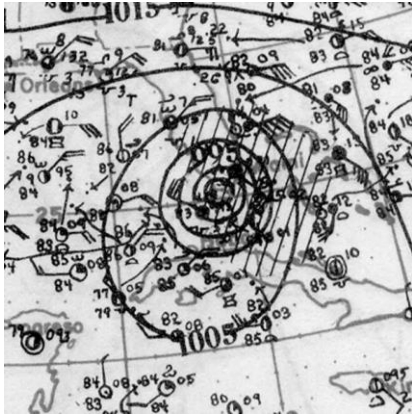


# US Housing Units by County (Change Since 1950)



*Steve Bowen (Aon)*

## 1926 Great Miami Hurricane (145 mph winds, 930 hPa) – Category 4



## Miami-Dade County Population Explosion since 1926

**Miami-Dade County Population: ~100,000**



**1926**

**Miami-Dade County Population: ~2.7 Million**



**2020**

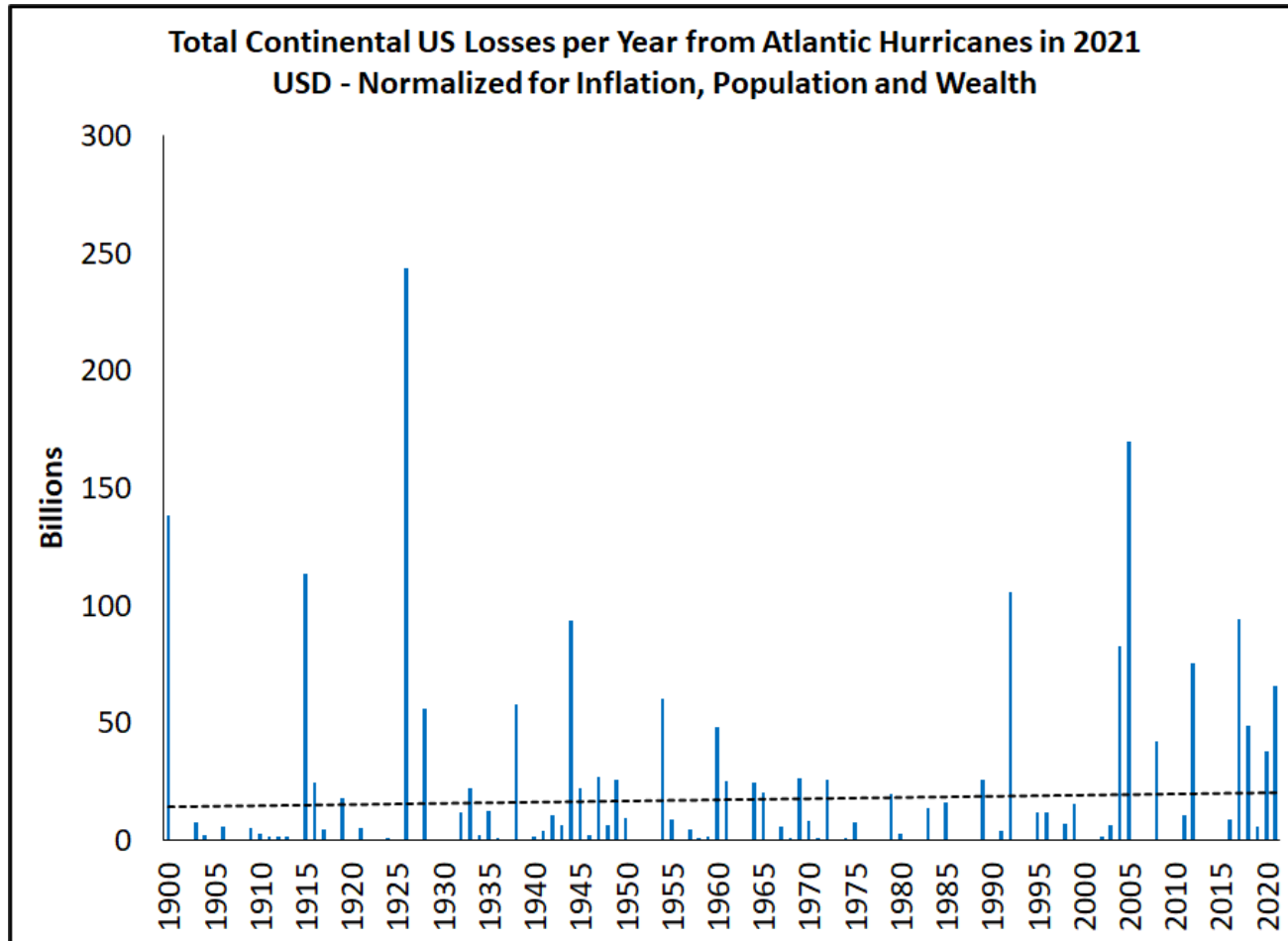
**1926 Great Miami Hurricane - >\$222 Billion Economic Damage in 2020**

Weinkle, J. et al. (2018). Normalized hurricane damage in the continental United States 1900–2017. *Nature Sustainability* 1(12):808-813.

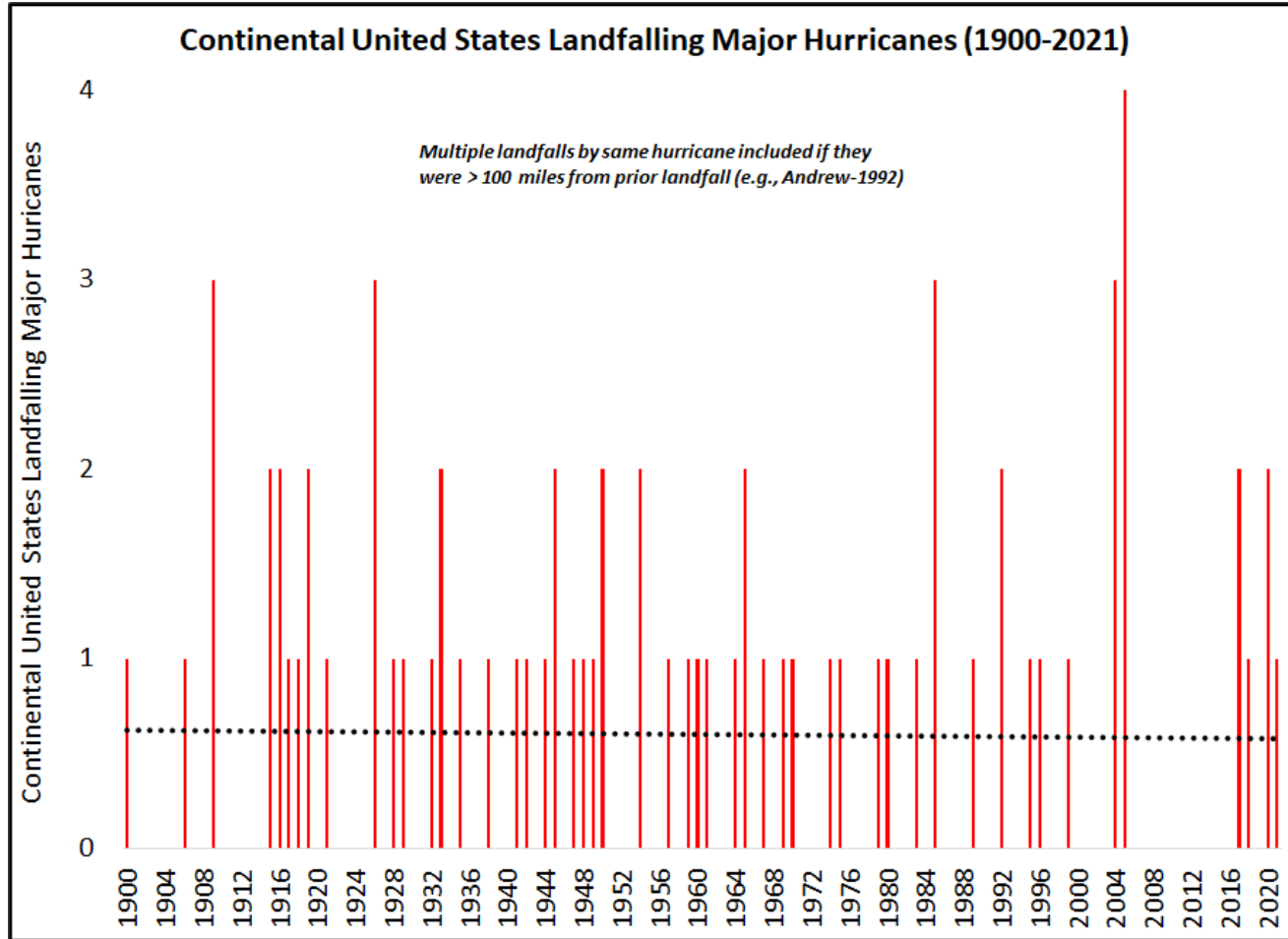
Klotzbach, P. J., Bowen, S. G., Pielke, R., Jr., & Bell, M. M. (2018). Continental U.S. Hurricane Landfall Frequency and Associated Damage: Observations and Future Risks, *Bulletin of the American Meteorological Society*, 99(7), 1359-1376.



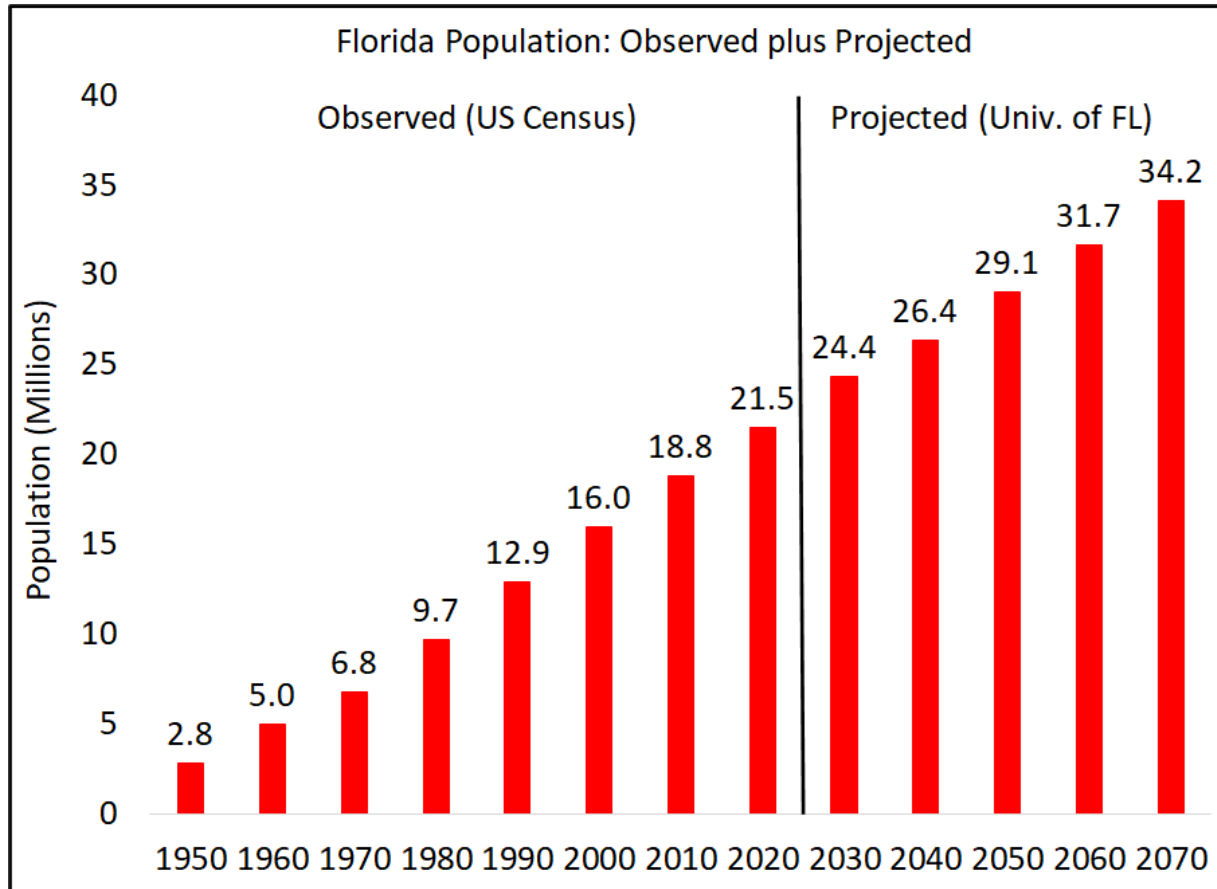
## Normalized Continental US Losses (1900-2021)



# Observed Continental US Landfalling Hurricane Activity (1900-2021)

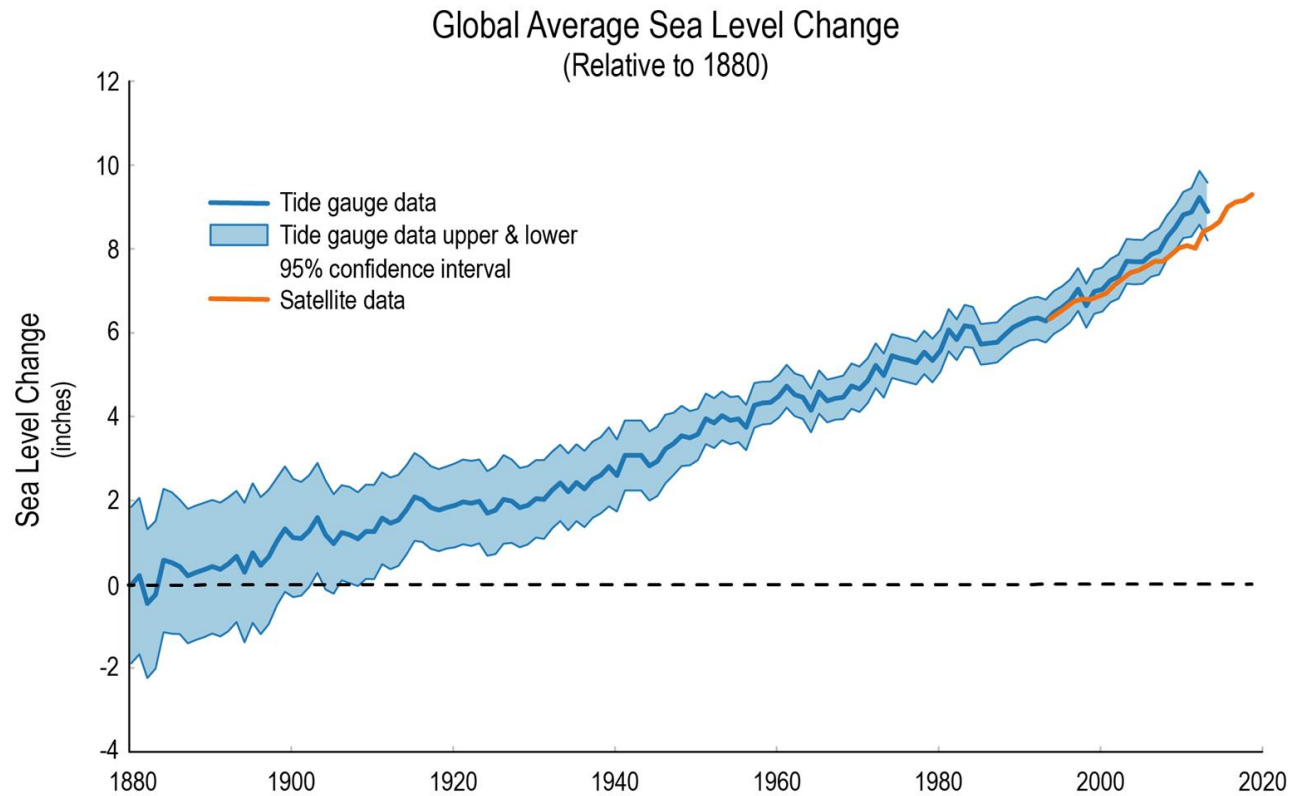


## Observed and Projected Florida Population (1950-2070)

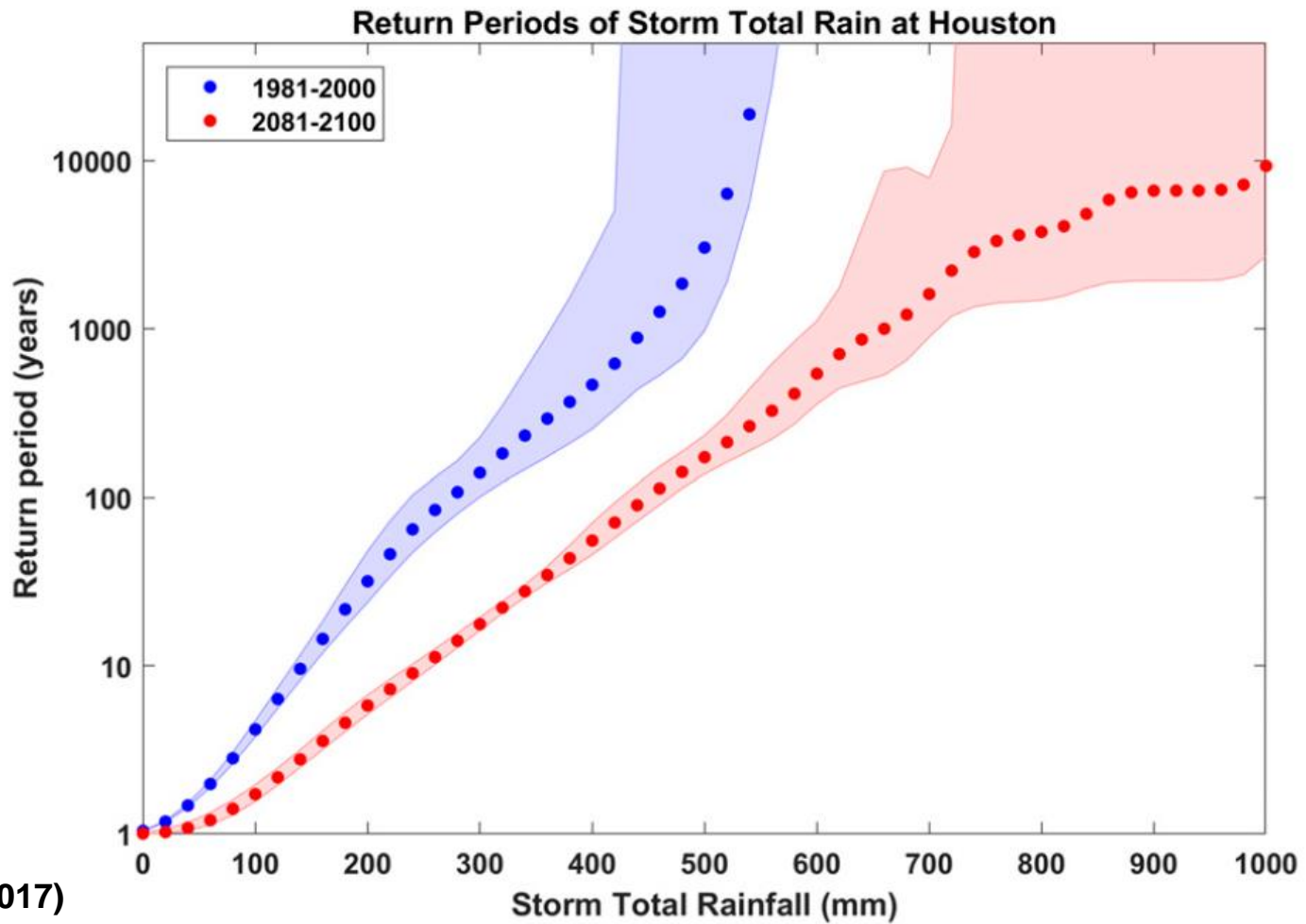




# Observed Sea Level Change (1880-2020)

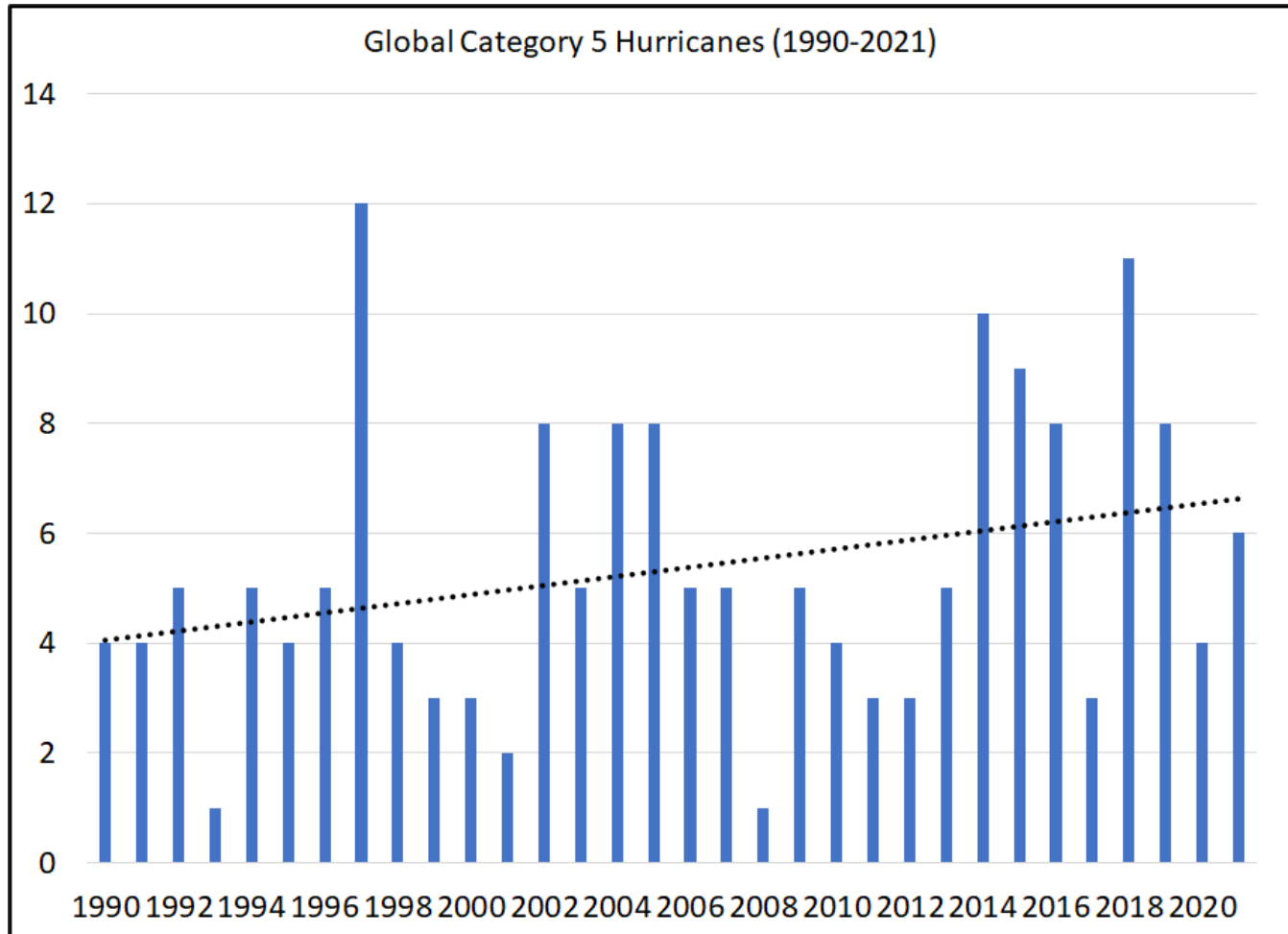


# Projected Increase in Heavy Rainfall Events



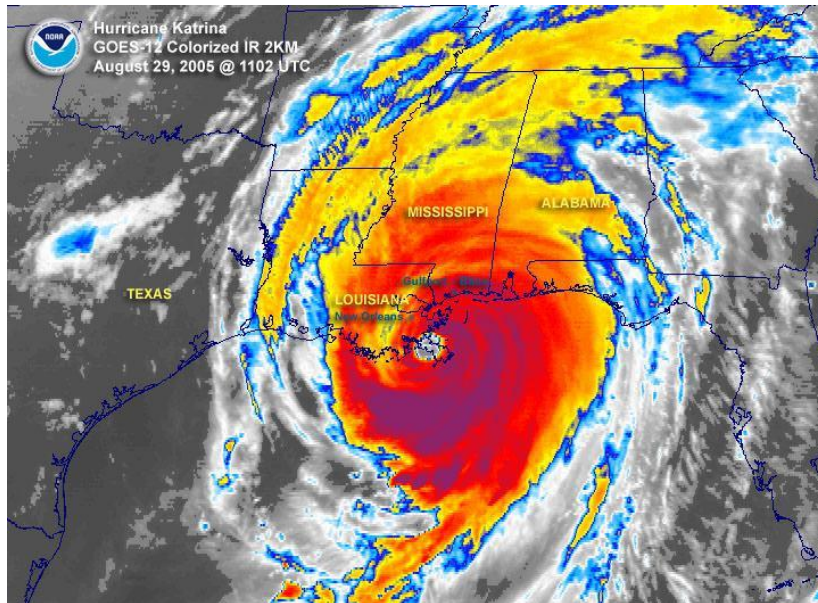
Emanuel et al. (2017)

## Increasing Trend in Category 5 Hurricanes (>156 mph winds)



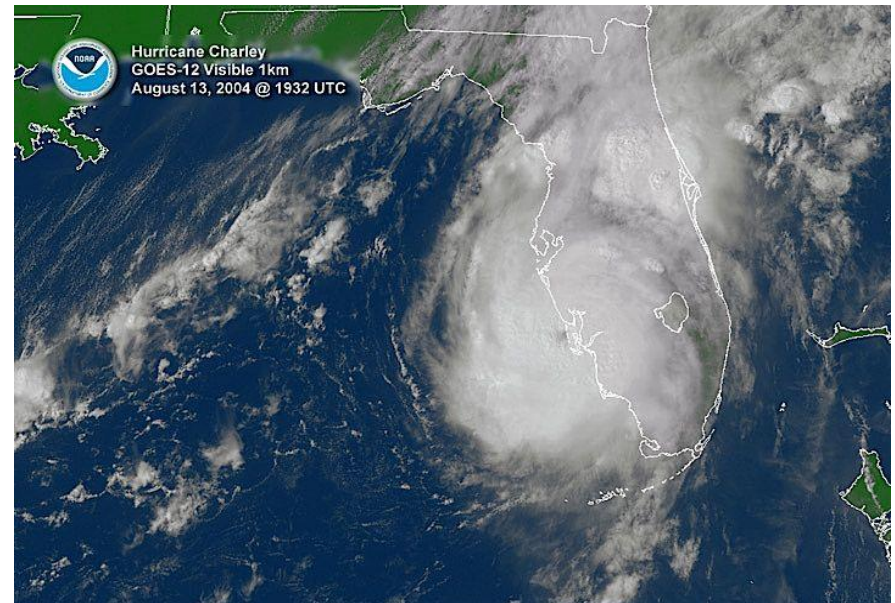
## Which Hurricane Had Higher Damage Potential?

**Hurricane Katrina (2005) – Cat. 3**  
**125 mph, 920 hPa**



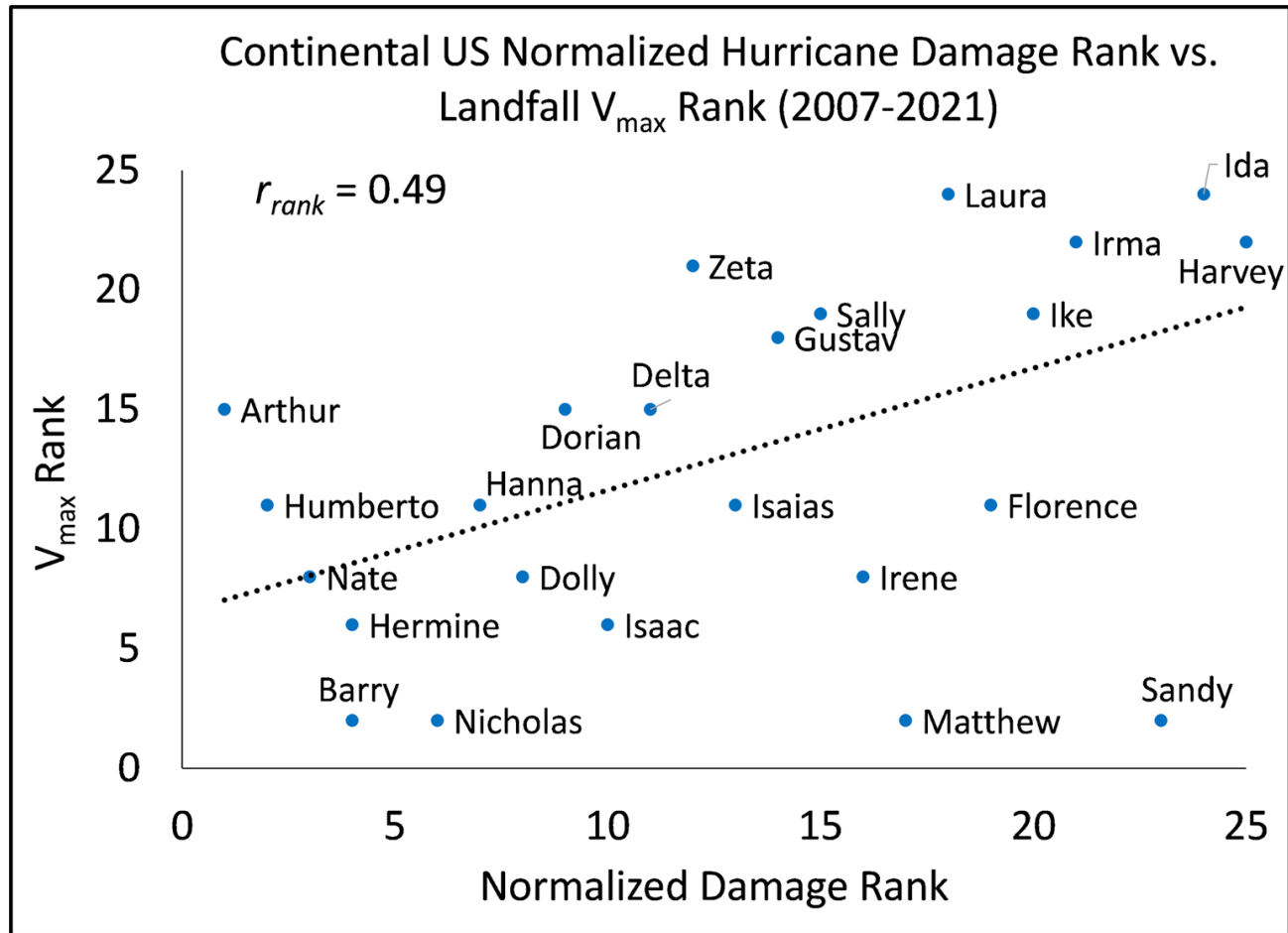
Average 50 kt wind radii: ~105 nm  
Maximum Storm Surge: ~28 ft

**Hurricane Charley (2004) – Cat. 4**  
**150 mph, 941 hPa**



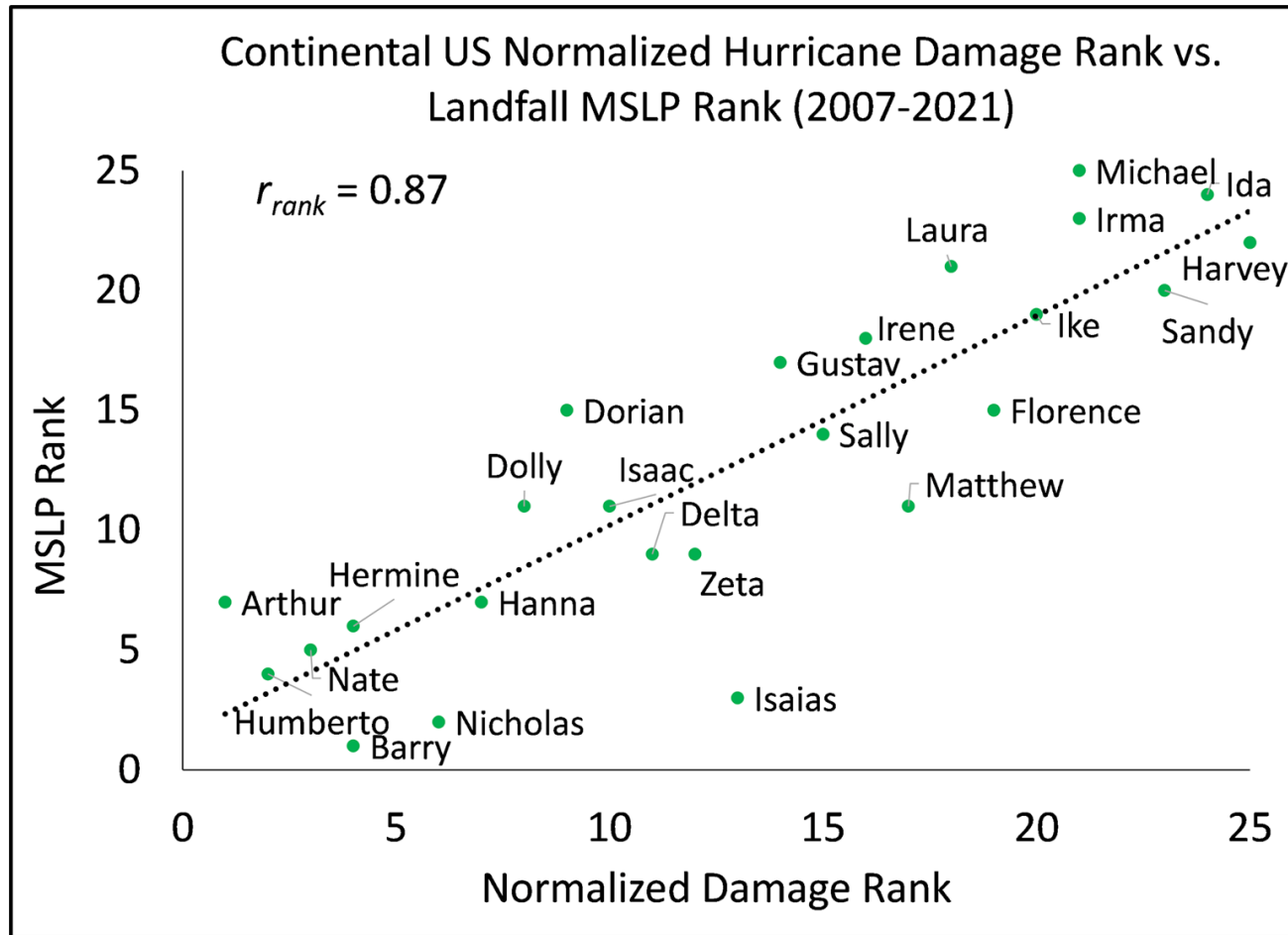
Average 50 kt wind radii: ~35 nm  
Maximum Storm Surge: ~7 ft

## Continental US Relationship between Wind and Damage (2007-2021)

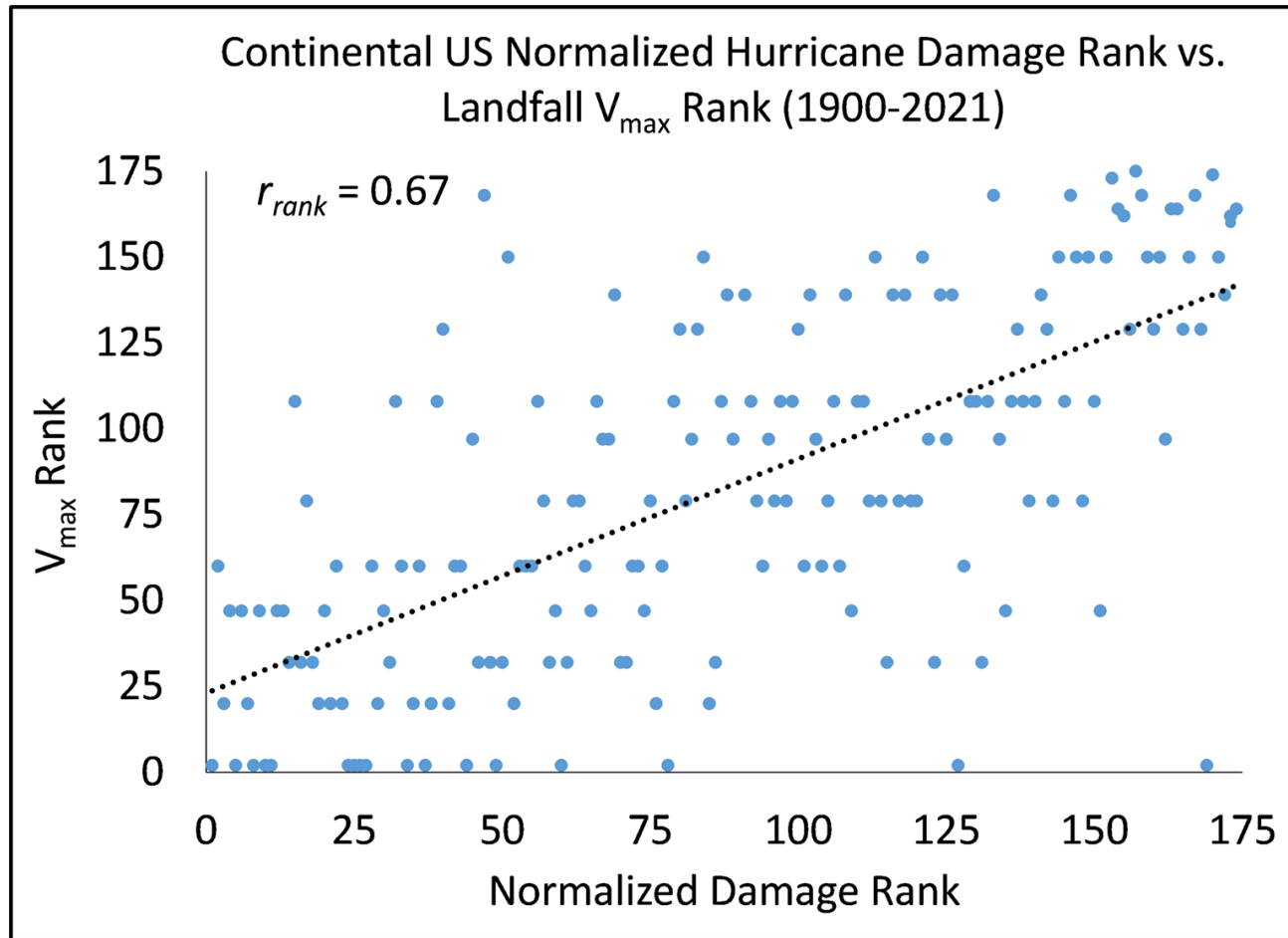




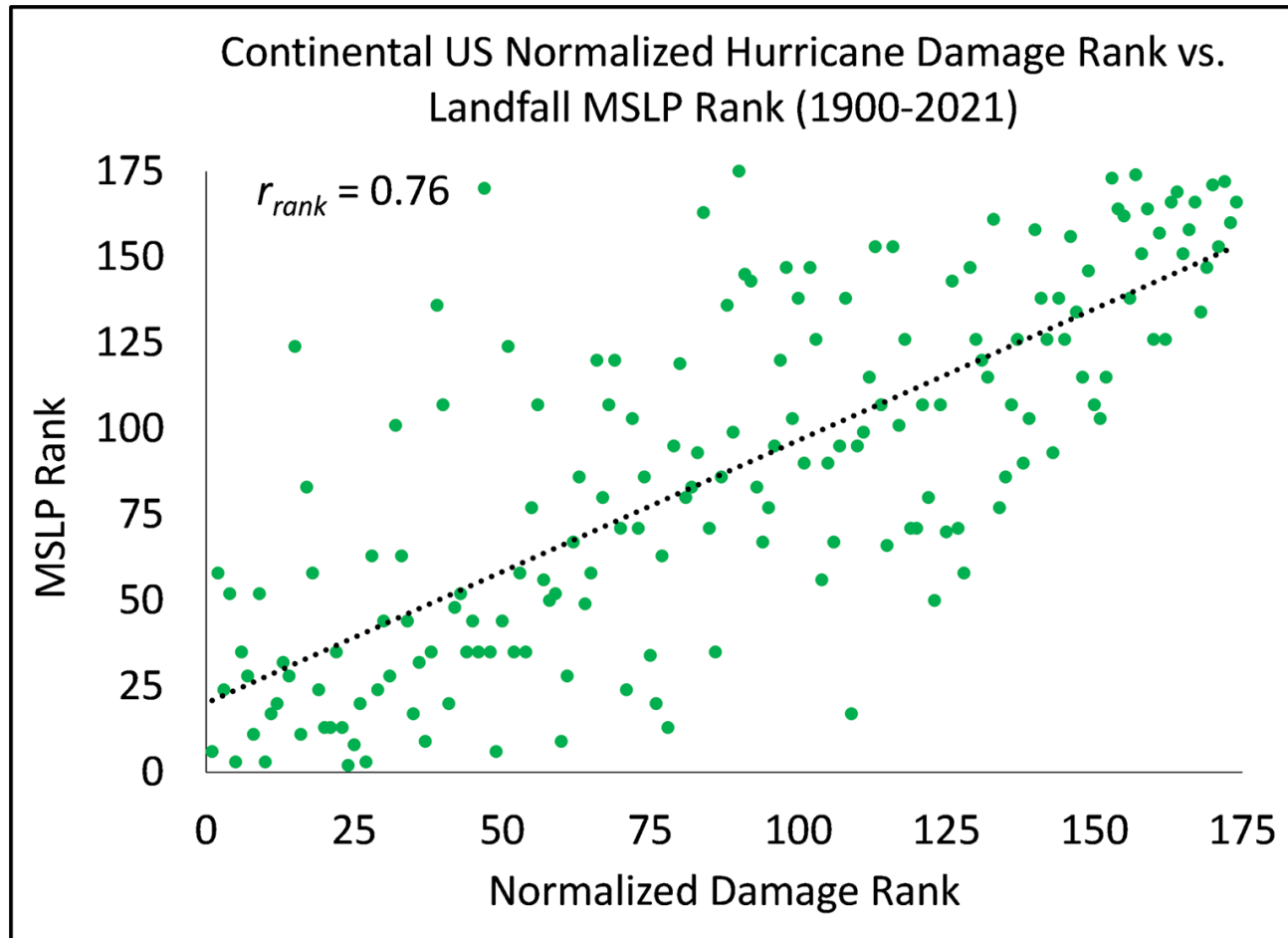
## Continental US Relationship between Pressure and Damage (2007-2021)



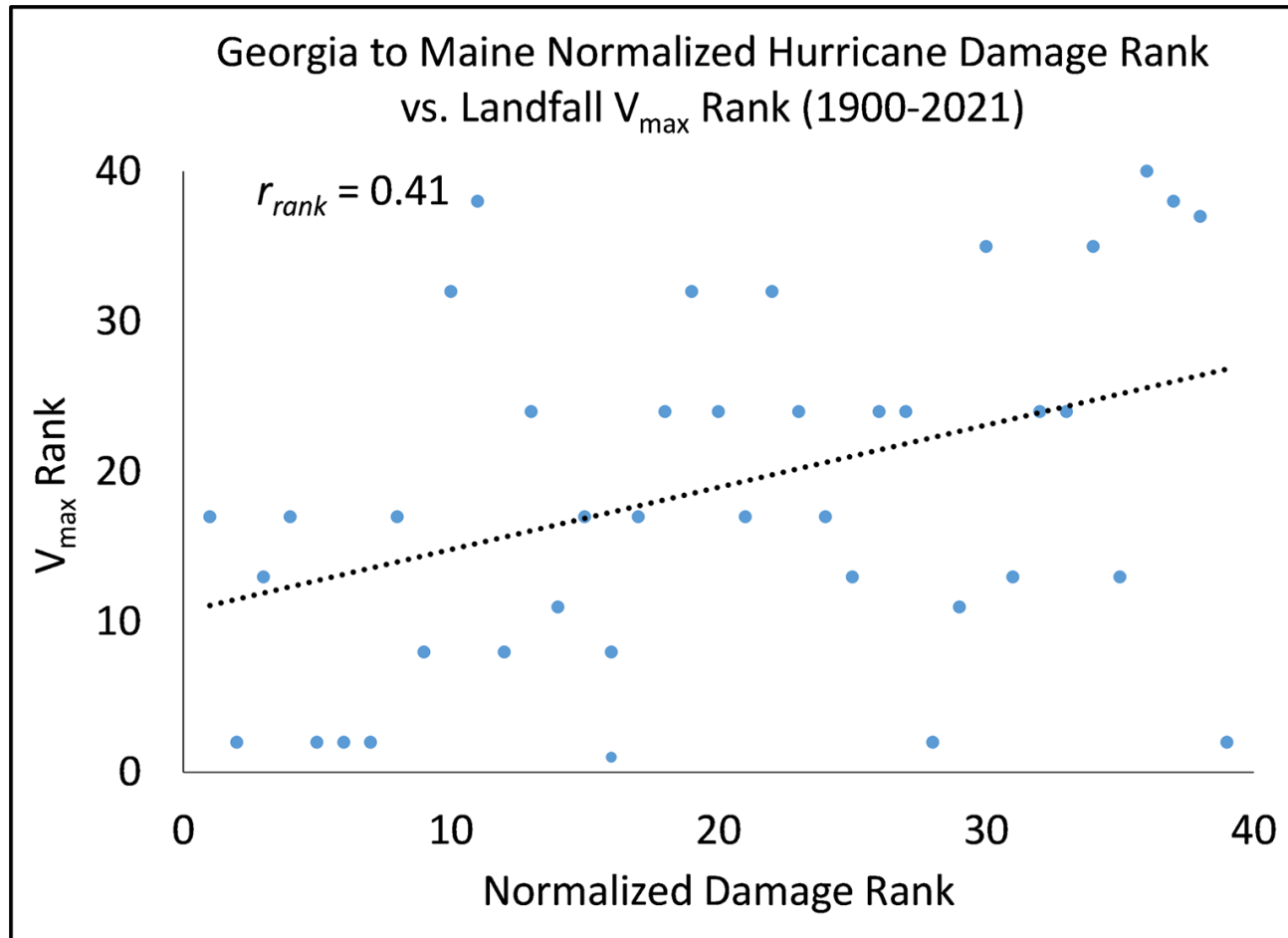
## Continental US Relationship between Wind and Damage (1900-2021)



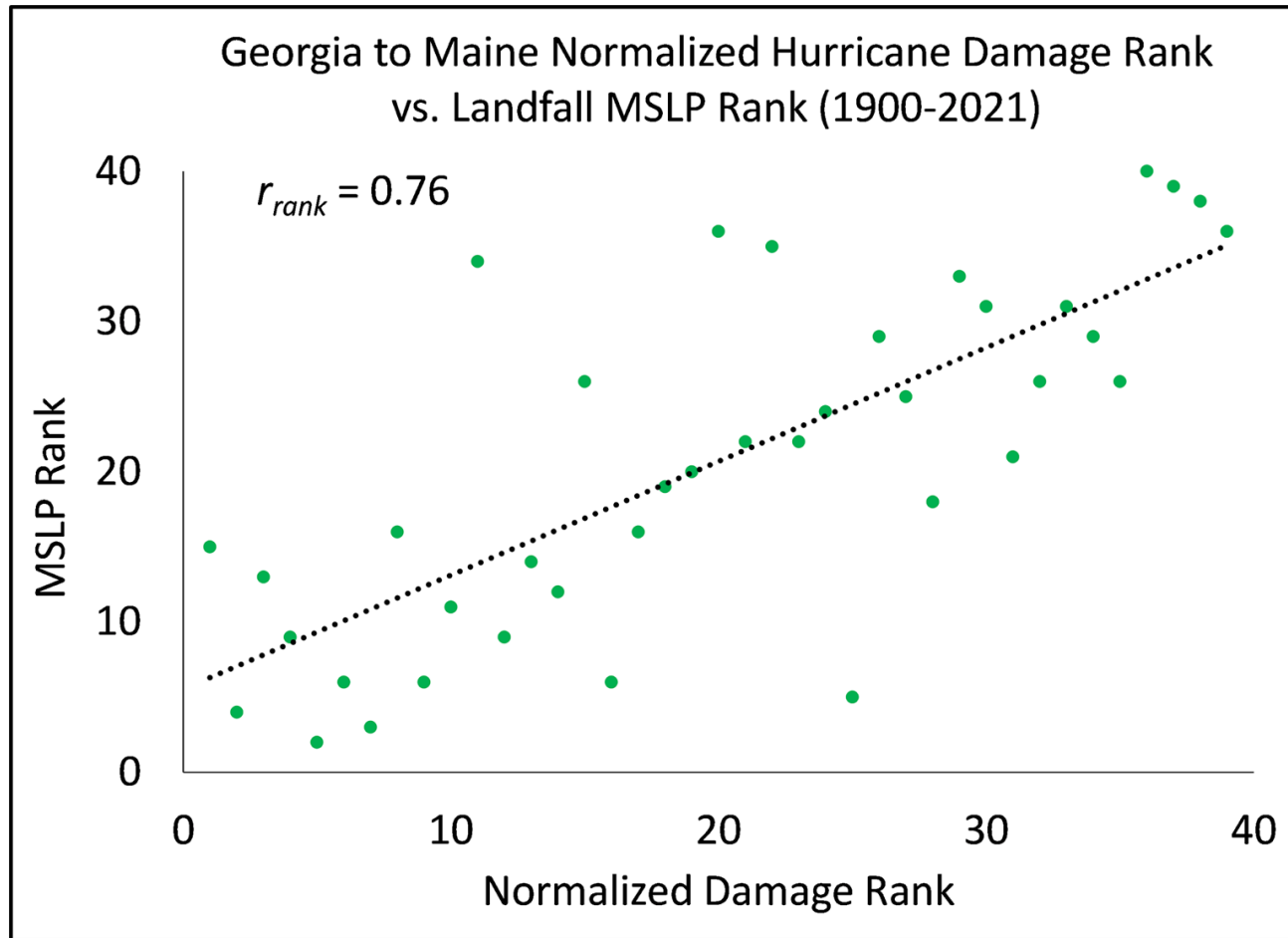
## Continental US Relationship between Pressure and Damage (1900-2021)



## Georgia to Maine Relationship between Wind and Damage (1900-2021)



## Georgia to Maine Relationship between Pressure and Damage (1900-2021)

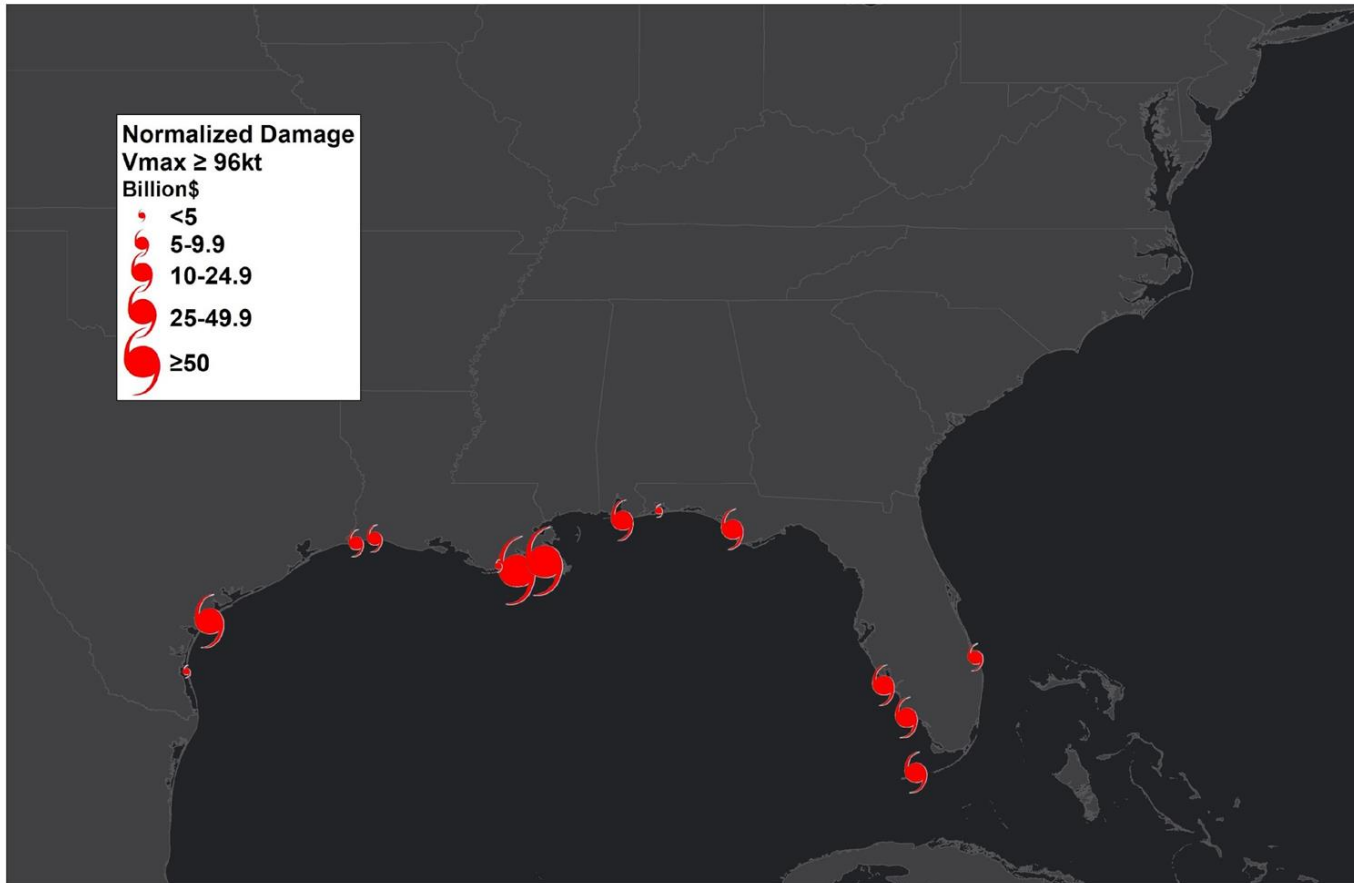




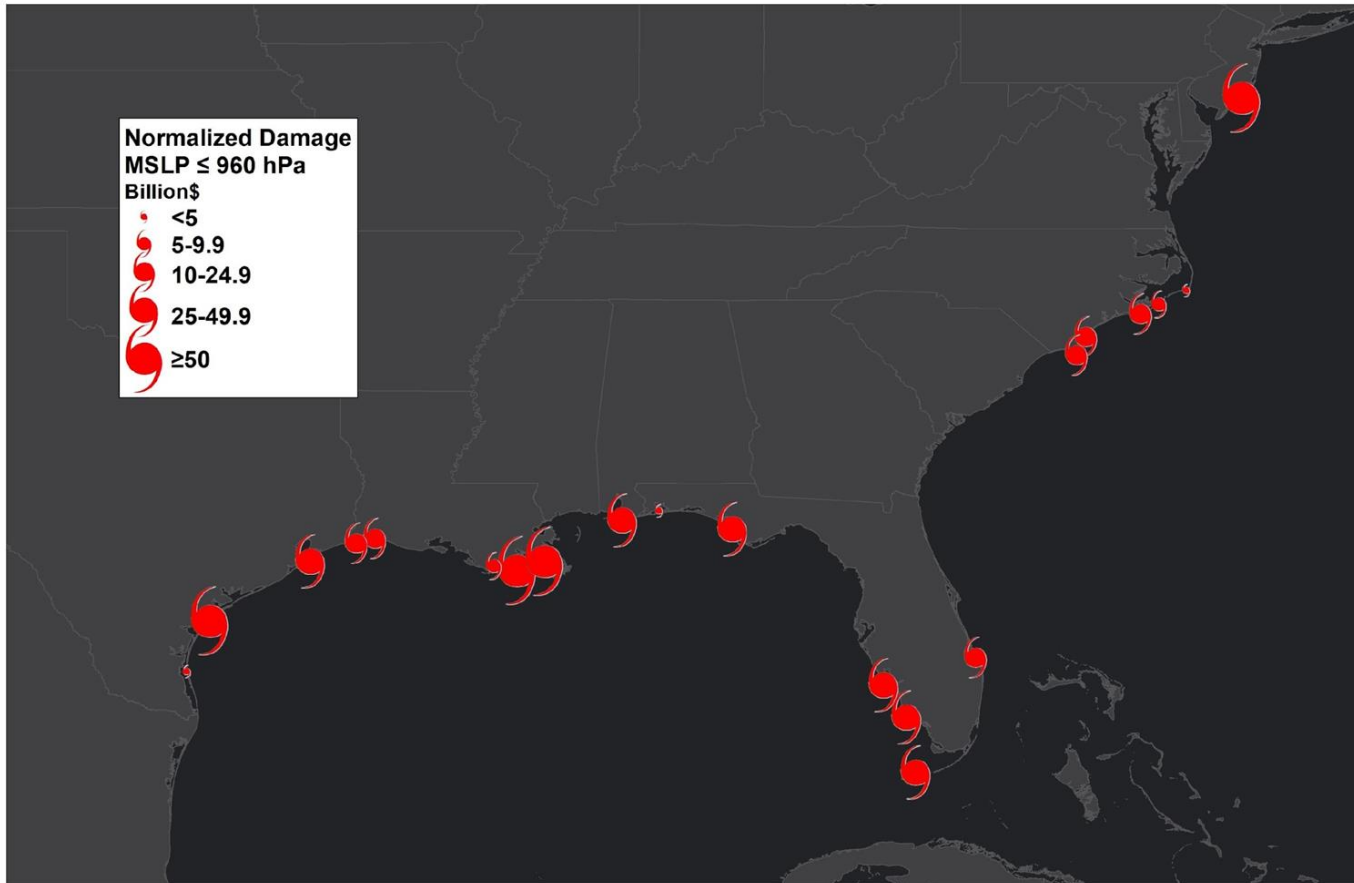
## Saffir-Simpson Scale (Includes Proposed MSLP Addition)

Category	V <sub>max</sub> (kt)	Revised MSLP (hPa)	Original MSLP (hPa)
1	64-82 (52%)	976-990 (55%)	>980 (n/a)
2	83-95 (31%)	961-975 (32%)	965-979 (38%)
3	96-112 (21%)	946-960 (20%)	945-964 (24%)
4	113-136 (13%)	926-945 (12%)	920-944 (12%)
5	>=137 (4%)	<=925 (4%)	<=919 (3%)

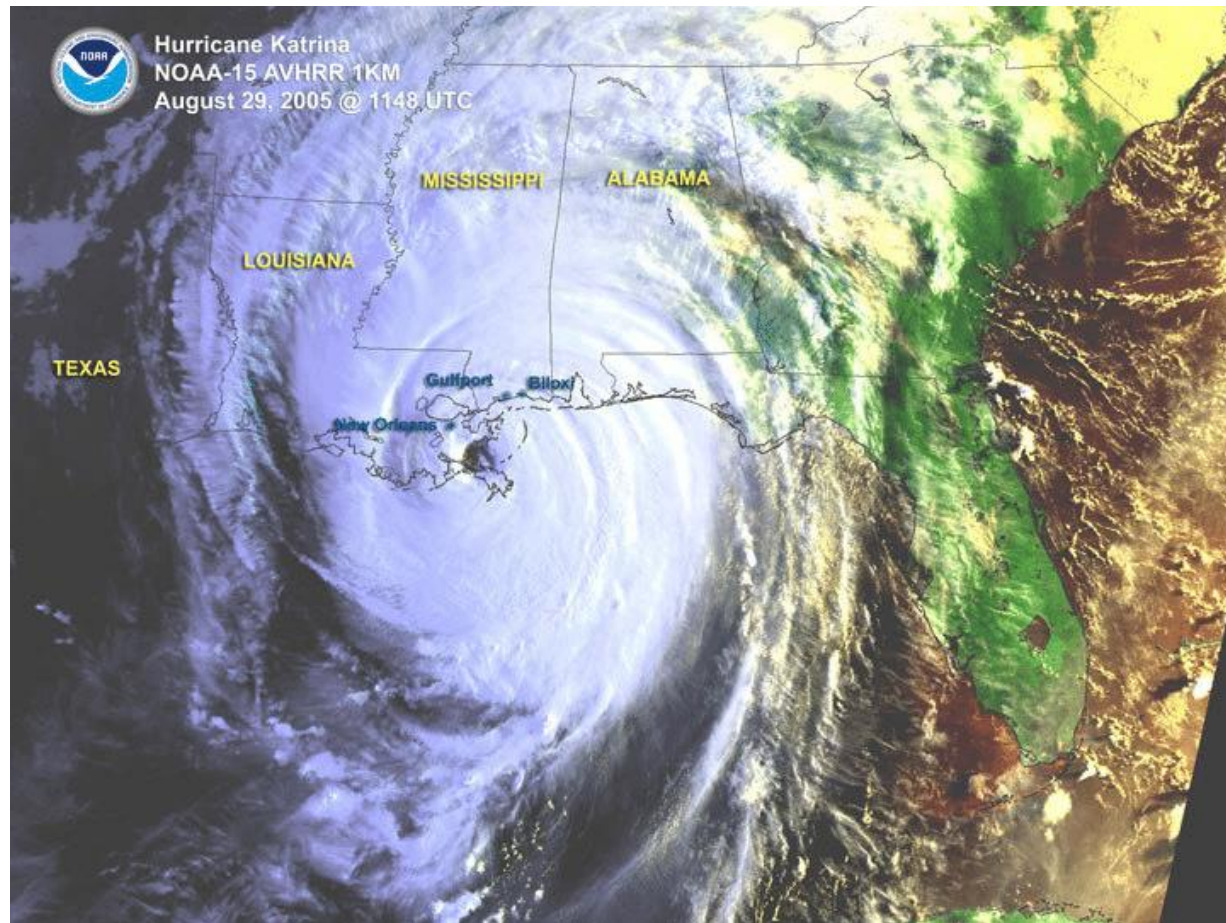
## Continental US Major Hurricanes Using $V_{\max}$ Definition (1999-2021)



## Continental US Major Hurricanes Using MSLP Definition (1999-2021)

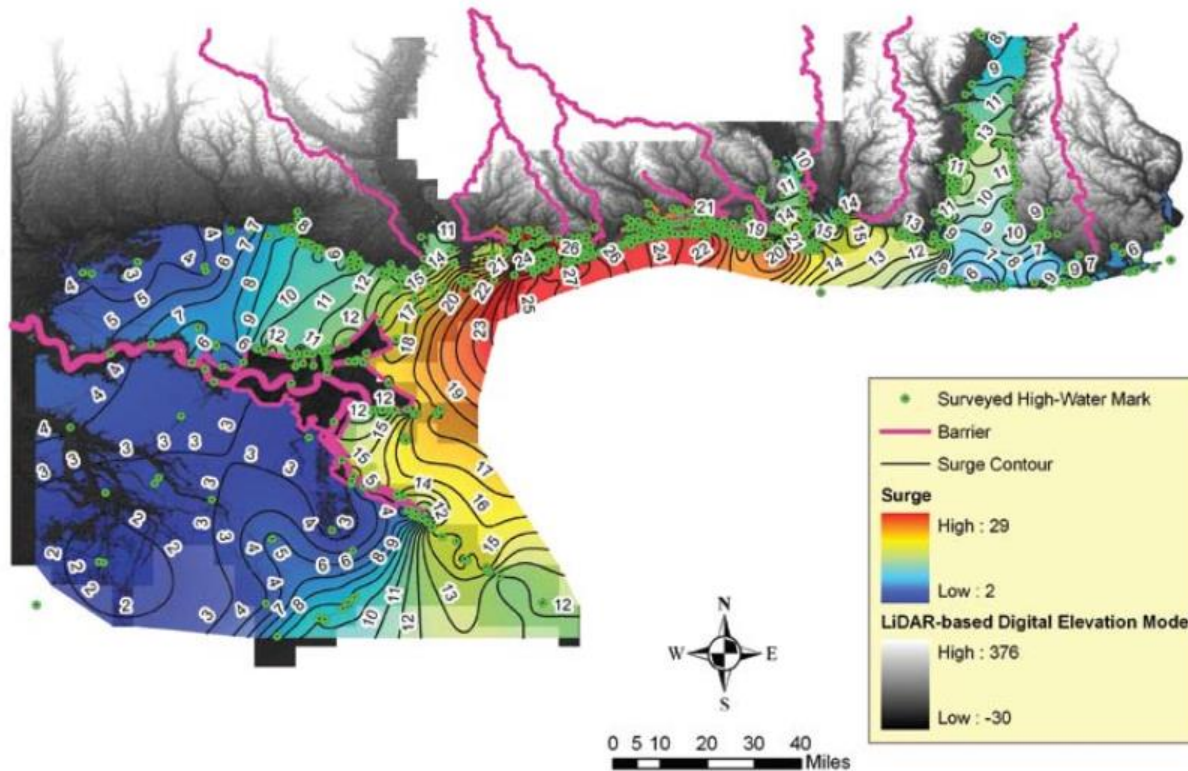


## Hurricane Katrina: Category 3 by $V_{\max}$ , Category 5 by MSLP



# Storm Surge Inundation from Hurricane Katrina (2005)

Hurricane Katrina Peak Storm Surge Inundation Mapping



*Turnipseed et al. (2007)*

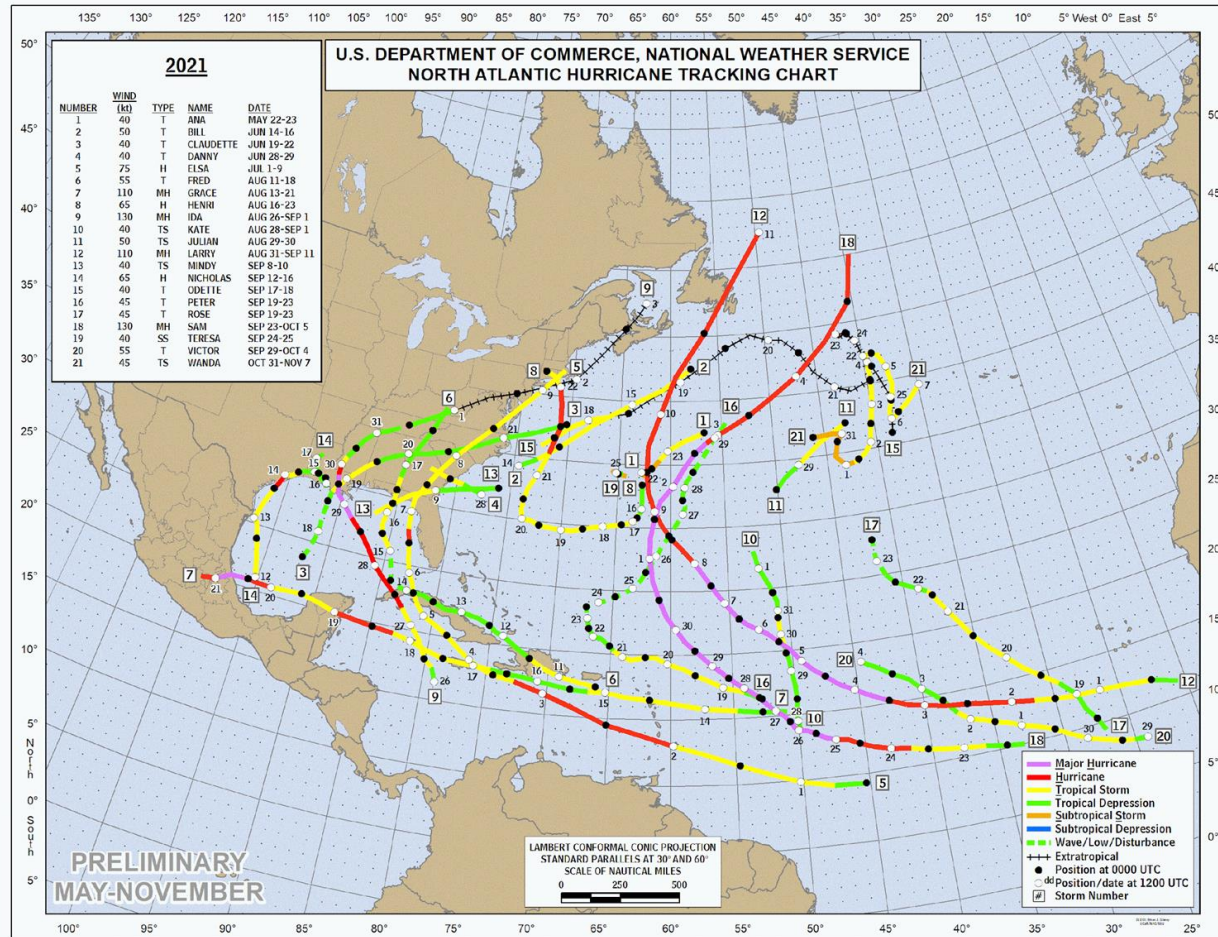


## 2021 Atlantic Hurricane Season Summary Statistics

### 2021 Atlantic Hurricane Season Summary

Forecast Parameter	2021 Observed	1991-2020 Average	2021% of 1991- 2020 Average
Named Storms (NS)	21	14.4	146%
Named Storm Days (NSD)	78	69.4	112%
Hurricanes (H)	7	7.2	97%
Hurricane Days (HD)	27.5	27.0	102%
Major Hurricanes (MH)	4	3.2	125%
Major Hurricane Days (MHD)	13.75	7.4	186%
Accumulated Cyclone Energy (ACE)	145	123	118%
Net Tropical Cyclone Activity (NTC)	176	135	130%

# 2021 Atlantic Hurricane Season Track Map

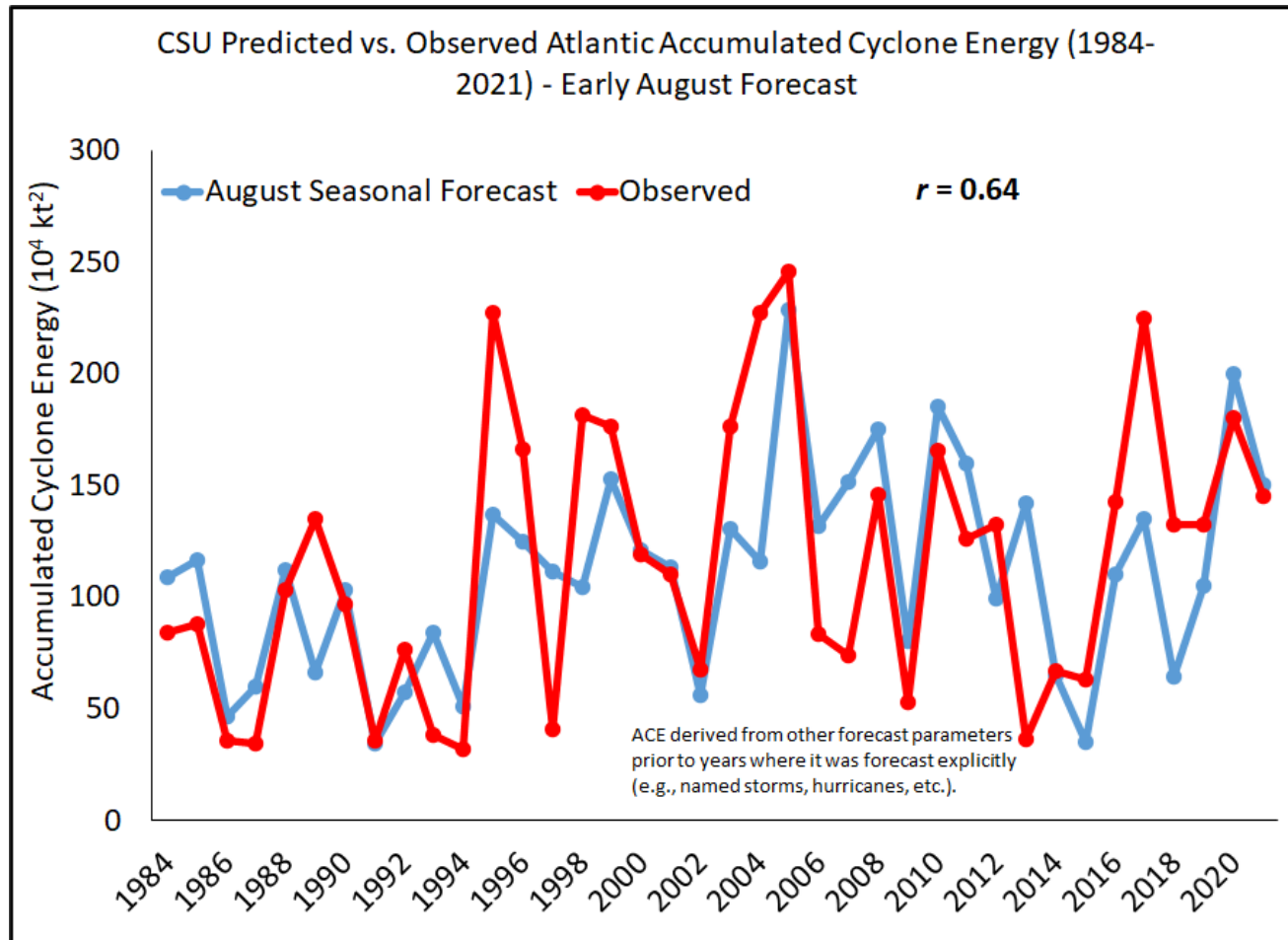


## 2021 CSU Seasonal Hurricane Forecast Verification

Forecast Parameter and 1991-2020 Average (in parentheses)	8 April 2021	3 June 2021	8 July 2021	5 August 2021	Observed	% of 1991-2020 Average
Named Storms (NS) (14.4)	17	18	20	18	21	146%
Named Storm Days (NSD) (69.4)	80	80	90	80	78	112%
Hurricanes (H) (7.2)	8	8	9	8	7	97%
Hurricane Days (HD) (27.0)	35	35	40	35	27.5	102%
Major Hurricanes (MH) (3.2)	4	4	4	4	4	125%
Major Hurricane Days (MHD) (7.4)	9	9	9	9	13.75	186%
Accumulated Cyclone Energy (ACE) (123)	150	150	160	150	145	118%
Net Tropical Cyclone Activity (NTC) (135%)	160	160	170	160	176	130%

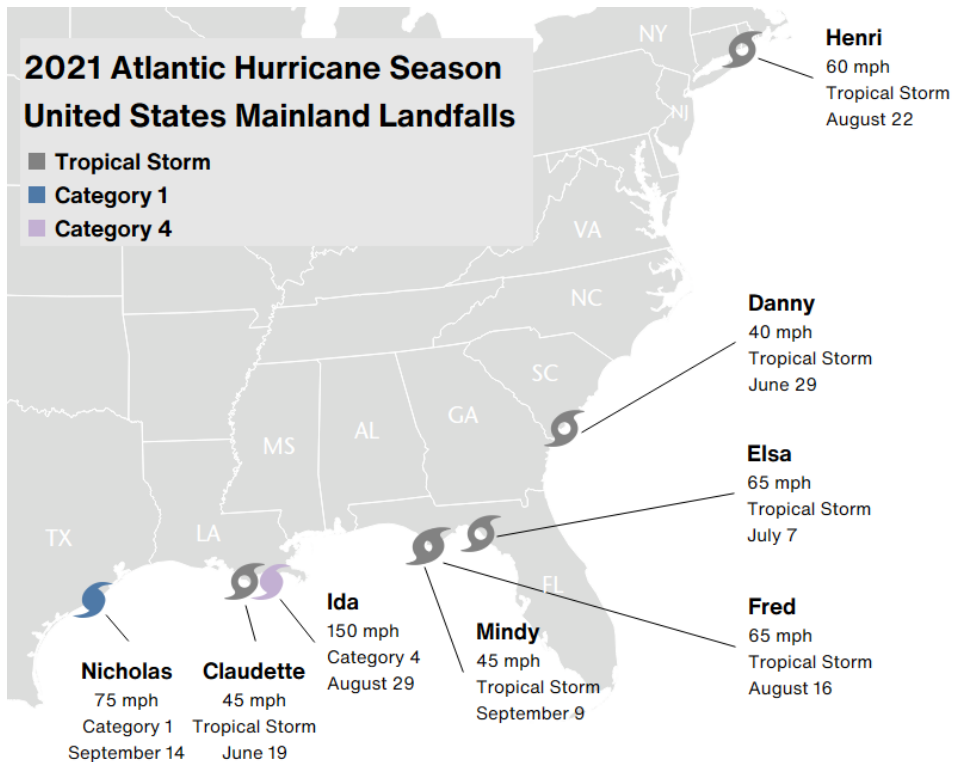


# CSU Long-Term August Seasonal Hurricane Forecast Track Record





## Another busy year for Continental US Landfalls



### 2021 Atlantic Hurricane Seasonal Stat Highlights

**145**

**Accumulated  
Cyclone Energy (ACE)**  
Satellite Era Rank: 14th

**21**

**Named Storms**  
3rd Most on Record  
4th Season w/ 20+ NS

**13.75**

**Number of  
Major Hurricane Days**  
Satellite Era Rank: 6th

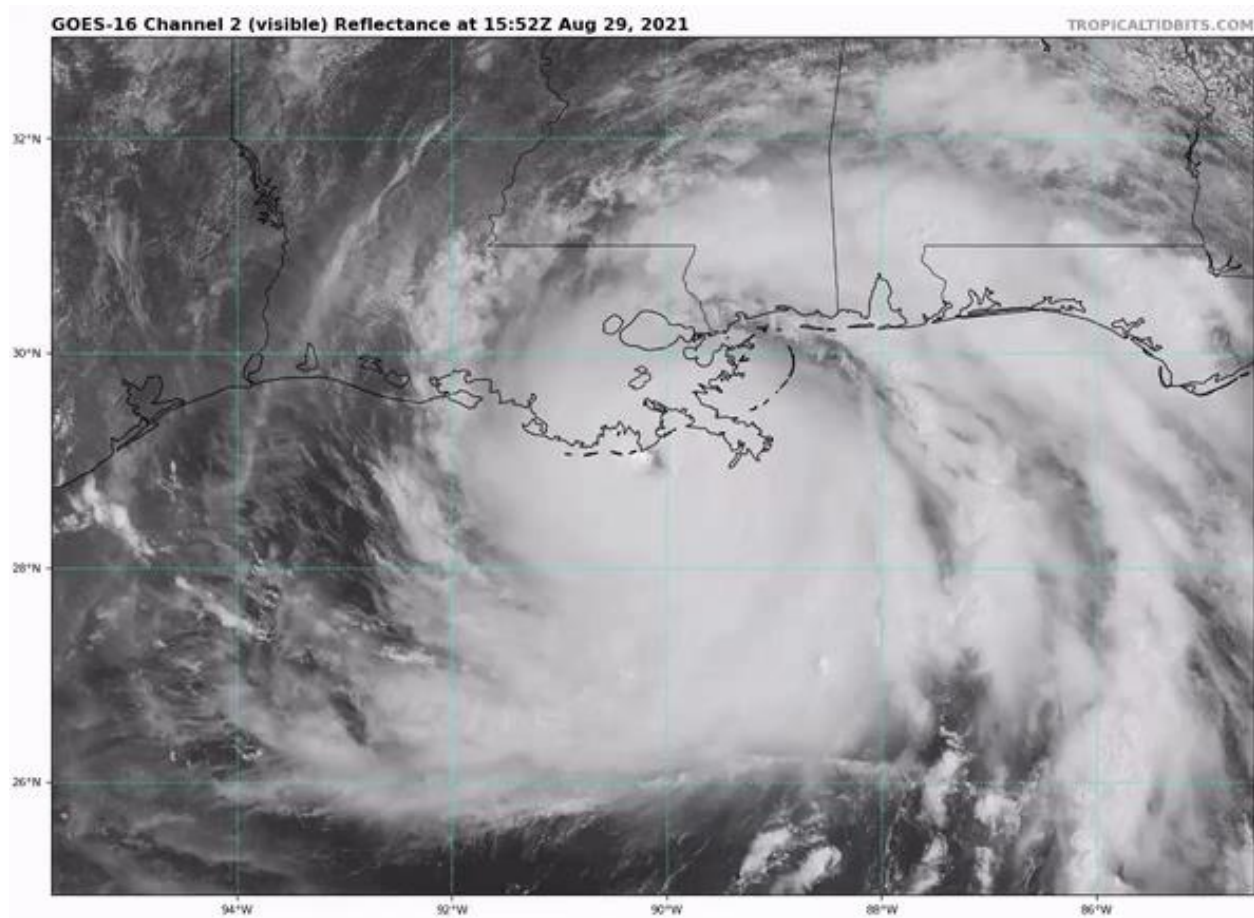
**\$80B**

**United States  
Economic Loss**  
Preliminary Estimate

Satellite Era: 1965-Present (Highest Quality Data)

Data: NOAA & Aon  
Graphic: Aon (Catastrophe Insight)

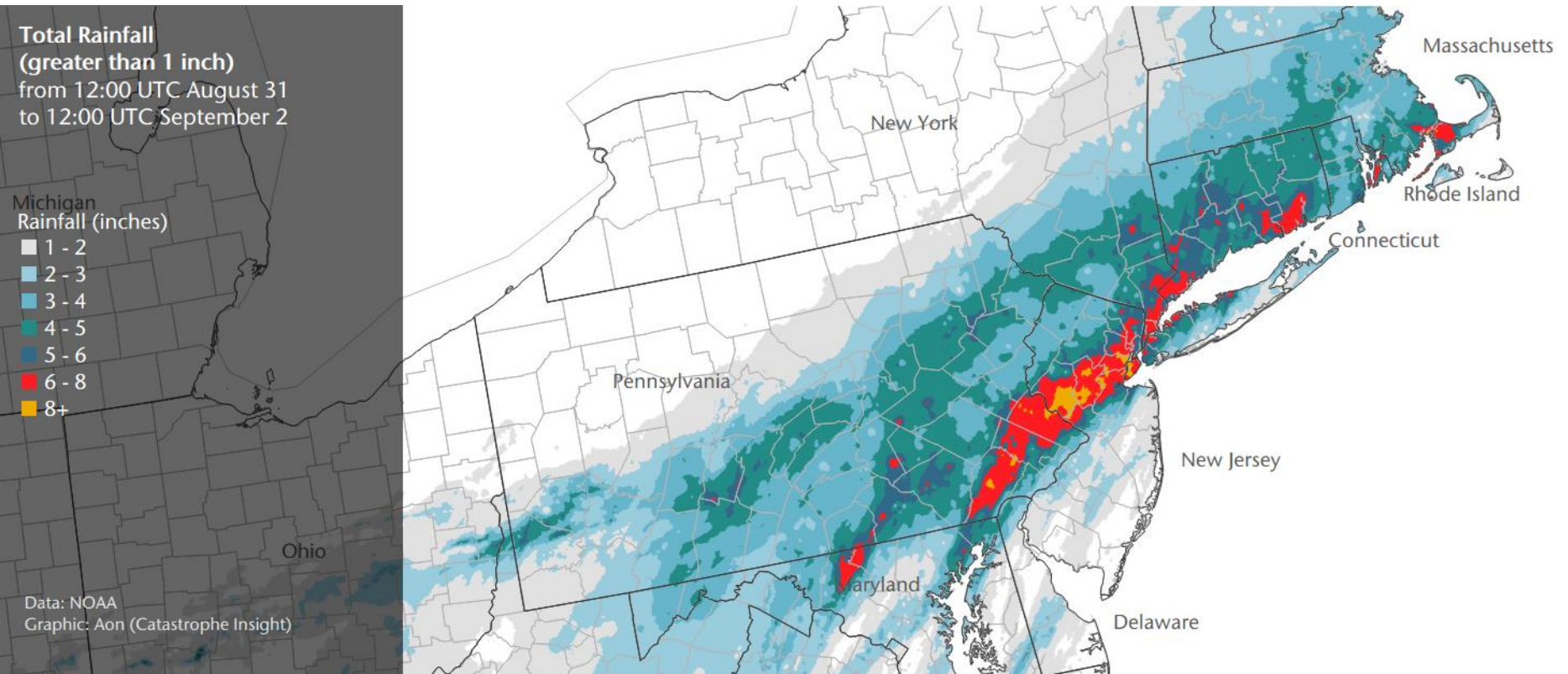
# Hurricane Ida



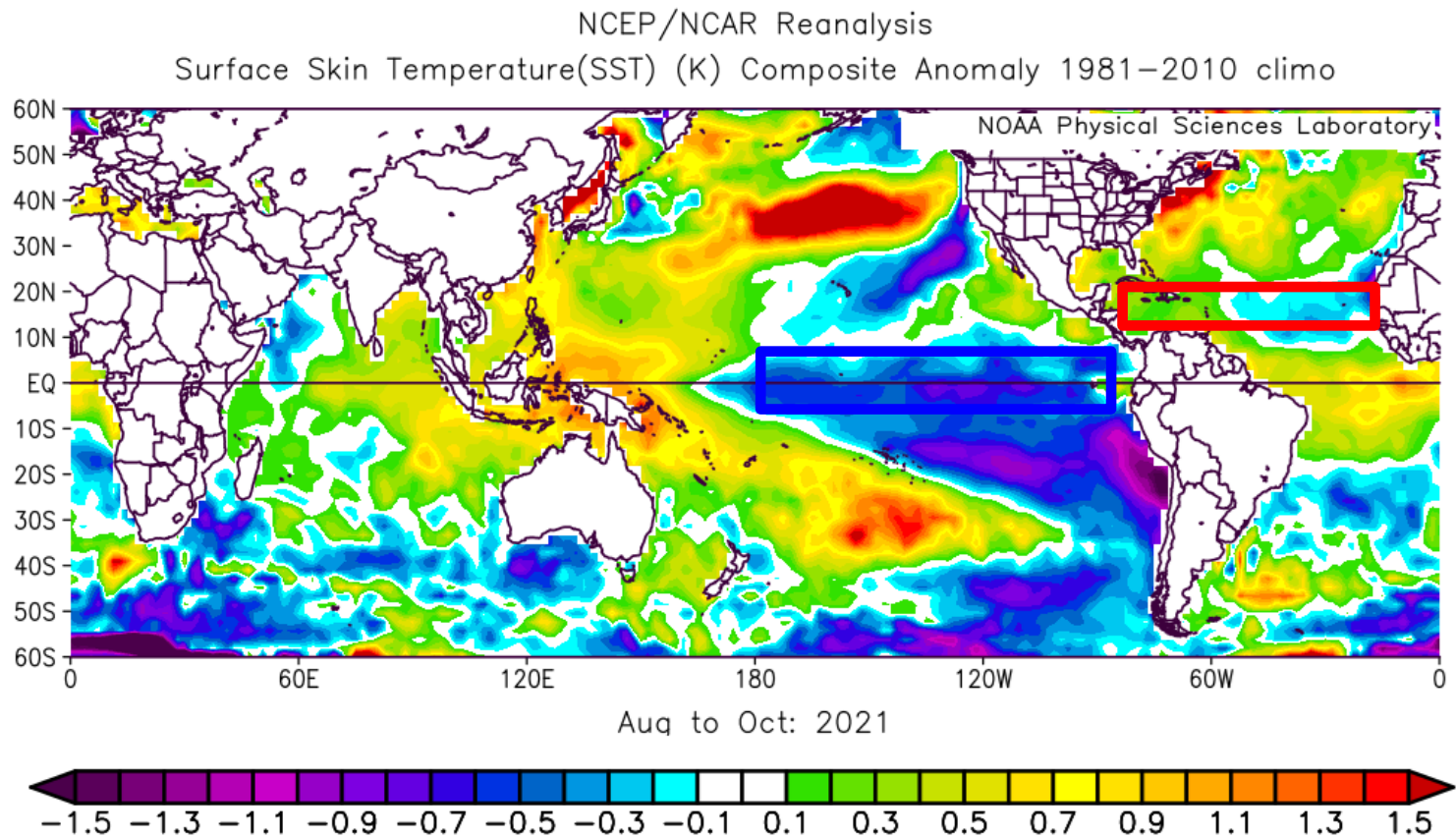
## **Hurricane Ida Notable Statistics**

- Landfall Intensity: 150 mph. Tied with Last Island (1856) and Laura (2020) for strongest max winds at time of landfall in Louisiana
- Landfall Intensity: 930 hPa. 2<sup>nd</sup> strongest hurricane to make landfall in Louisiana by pressure, trailing only Katrina (2005, 920 hPa).
- ~\$75 Billion USD in economic damage
- 95 fatalities in the United States – 53 combined in NJ, NY and PA

## Post-Tropical Cyclone Ida Mid-Atlantic Flooding

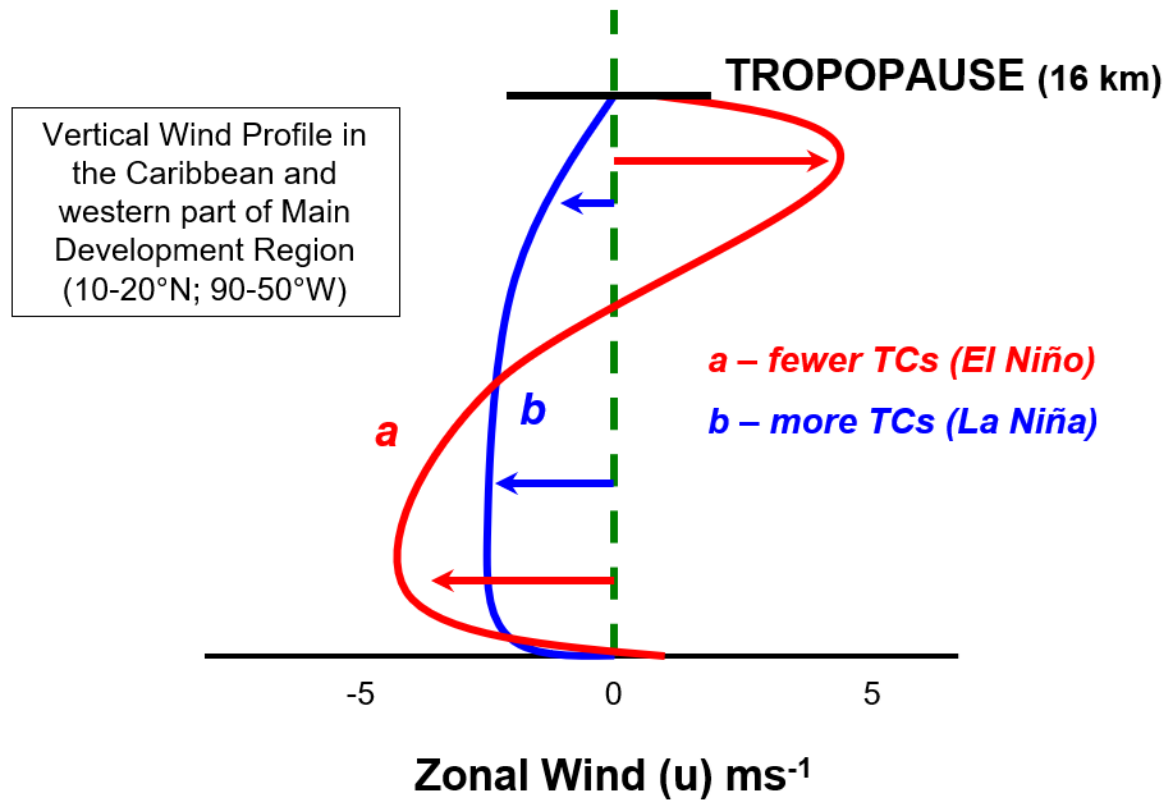


# August-October 2021 Global Sea Surface Temperature Anomalies



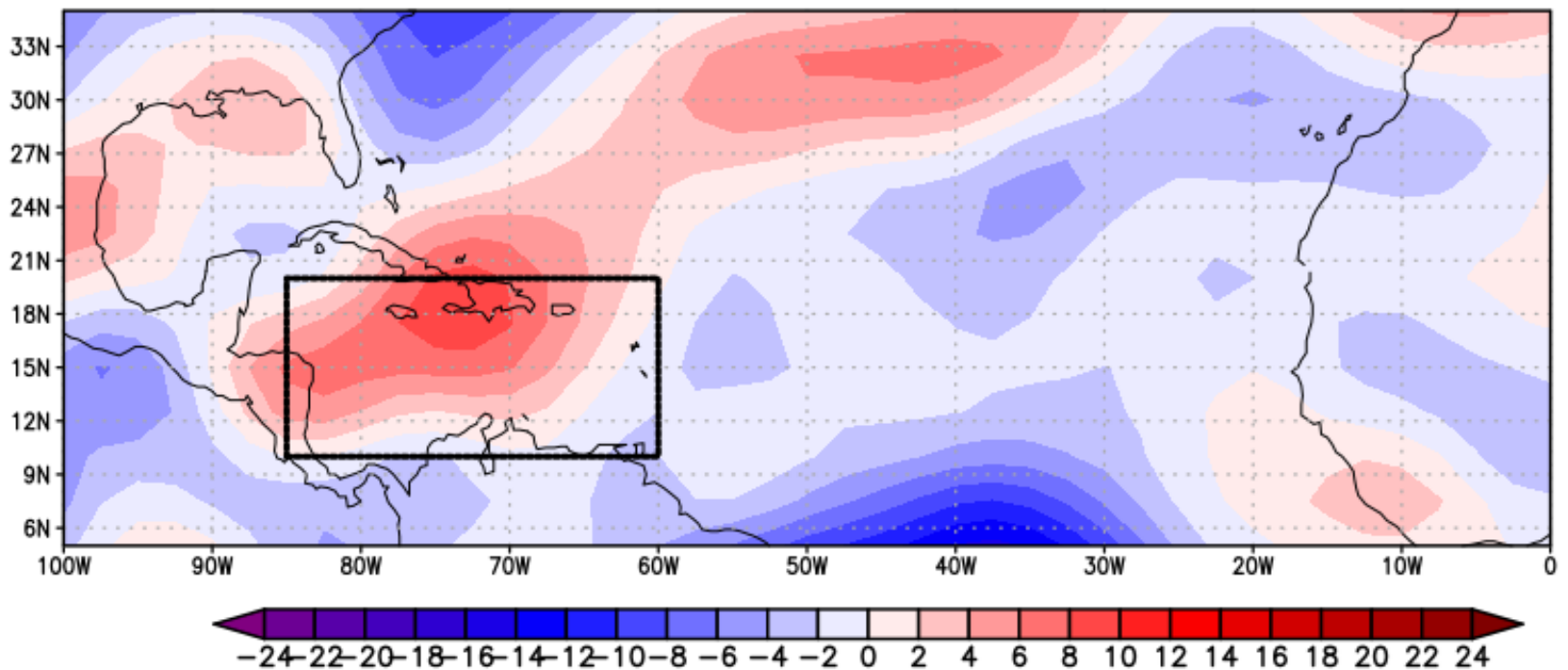


## El Niño/La Niña Typical Relationship with Caribbean Vertical Wind Shear

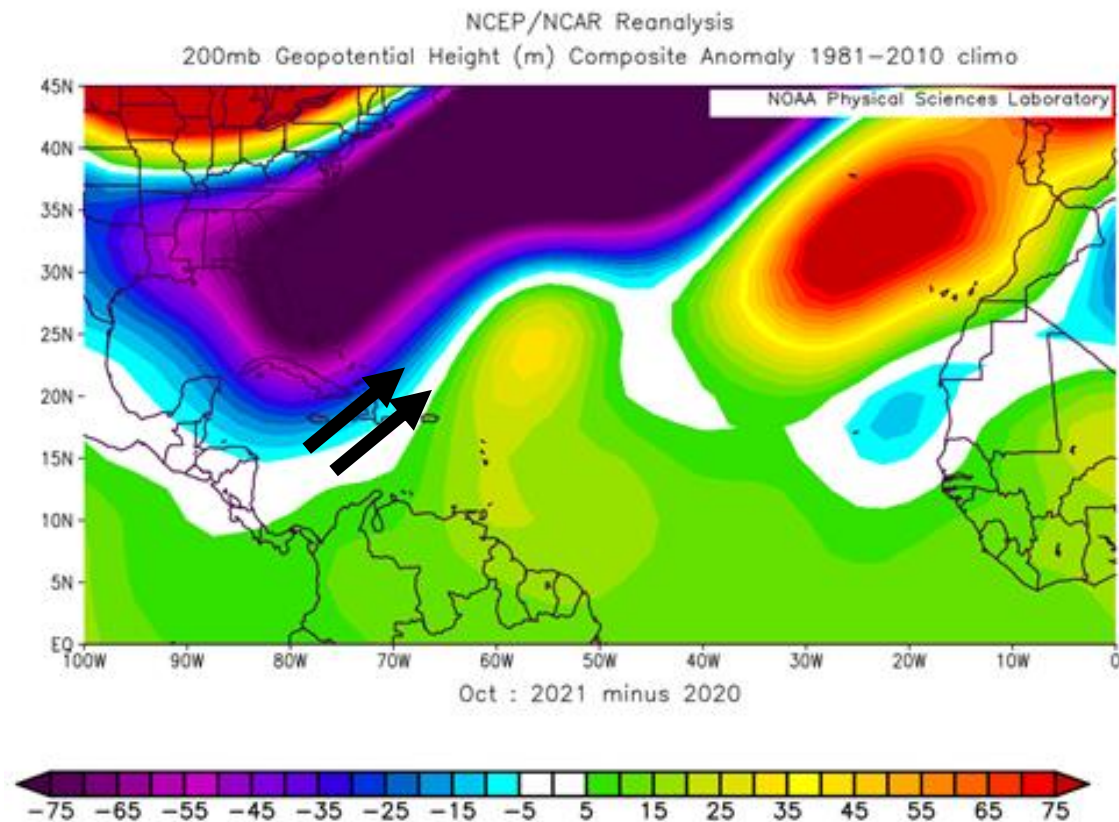


## August-October-Averaged 2021 Atlantic Vertical Wind Shear

August 1 – October 31, 2021 Average  
Zonal (200–850 mb) Vertical Wind Shear Anomaly (kts)  
(1981–2010 Climatology)

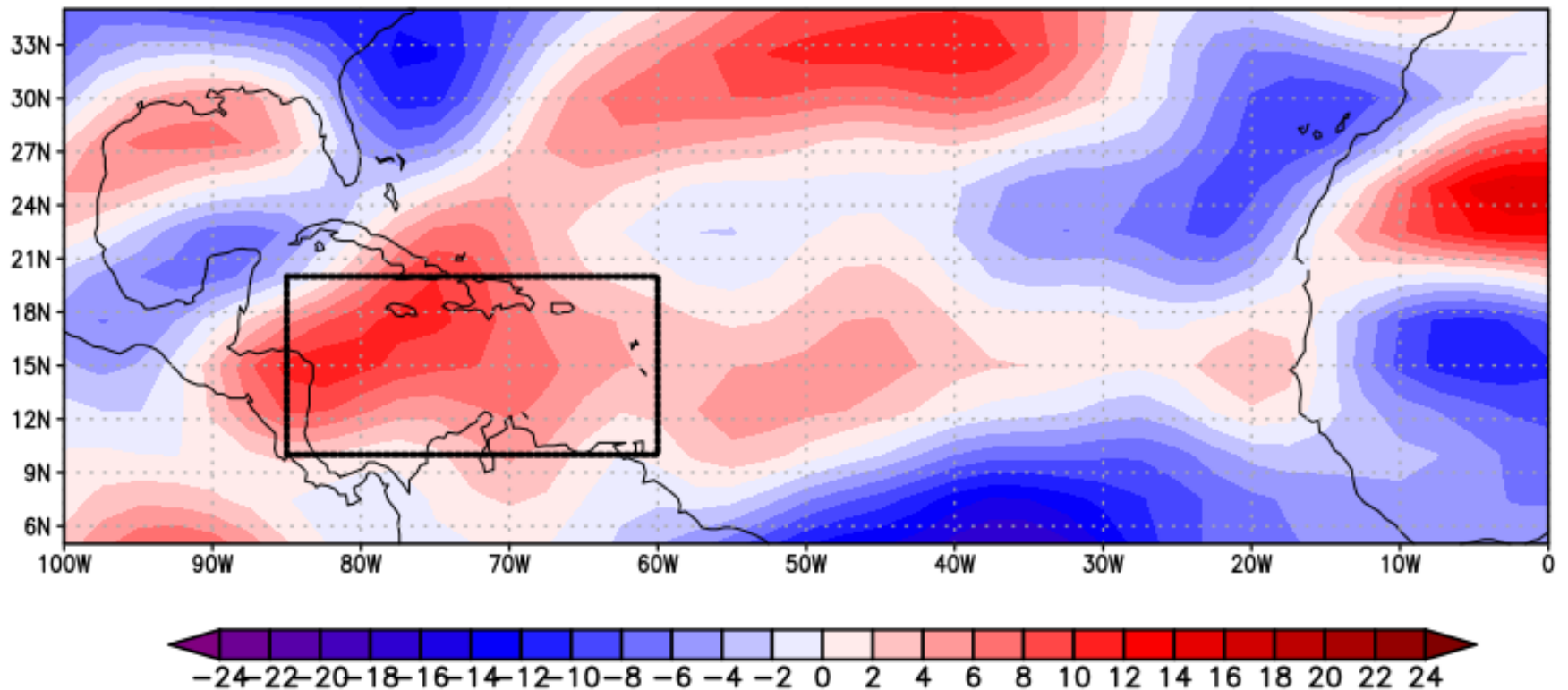


## Upper-Level (~38000 Feet) Pressure Pattern in October 2021 Differenced From October 2020



## October 2021 Atlantic Vertical Wind Shear

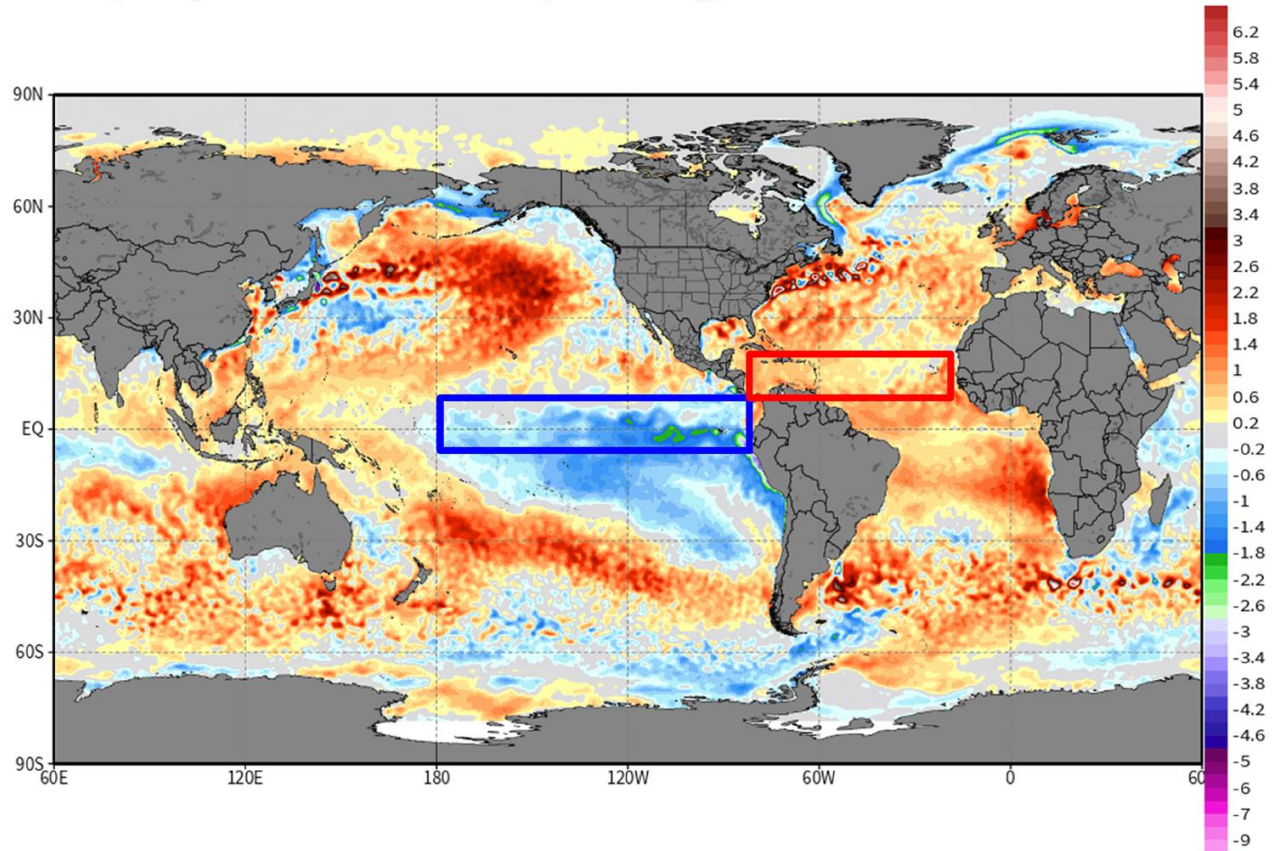
October 1 – October 31, 2021 Average  
Zonal (200–850 mb) Vertical Wind Shear Anomaly (kts)  
(1981–2010 Climatology)



# Current Sea Surface Temperature Anomaly Pattern

0.25° NCEP OISST Sea Surface Temperature Anomaly [SST, °C]  
14-Day Average 16FEB2022 --> 01MAR2022 30-year Climatology 1990-2019

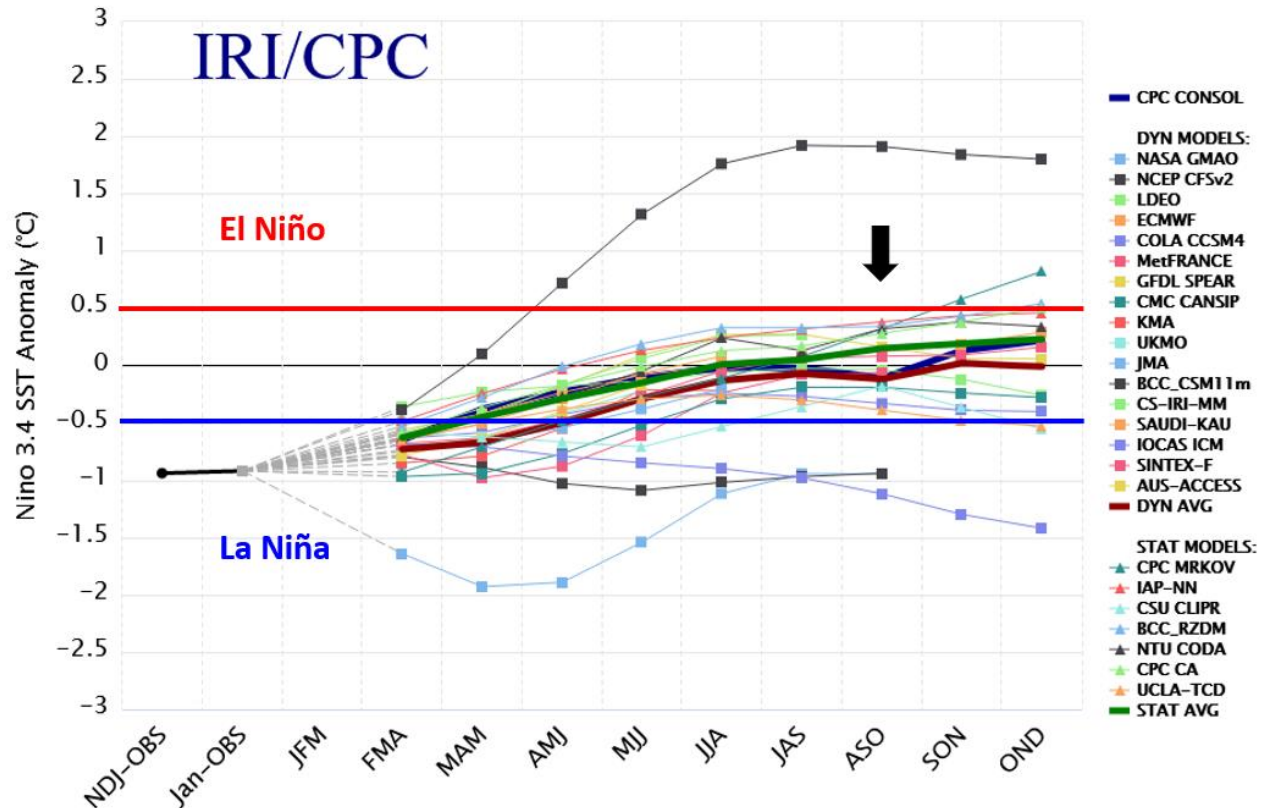
[weathermodels.com](https://www.weathermodels.com)





# Current ENSO Forecasts from Global Models

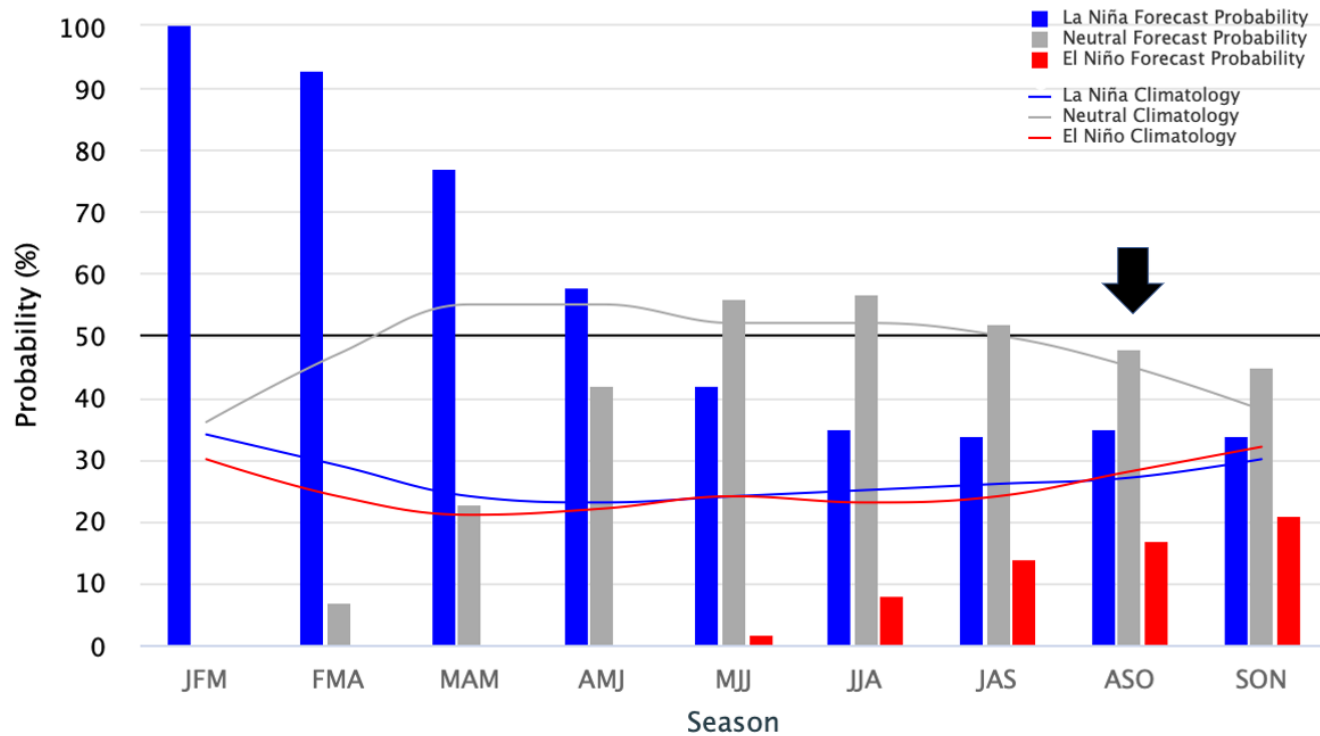
Model Predictions of ENSO from Feb 2022



# Official Probabilistic ENSO Forecast from NOAA

Early-February 2022 CPC/IRI Official Probabilistic ENSO Forecasts

ENSO state based on NINO3.4 SST Anomaly  
Neutral ENSO:  $-0.5^{\circ}\text{C}$  to  $0.5^{\circ}\text{C}$



# ECMWF Forecasts of Sea Surface Temperature Anomalies: June-August 2022

ECMWF Seasonal Forecast

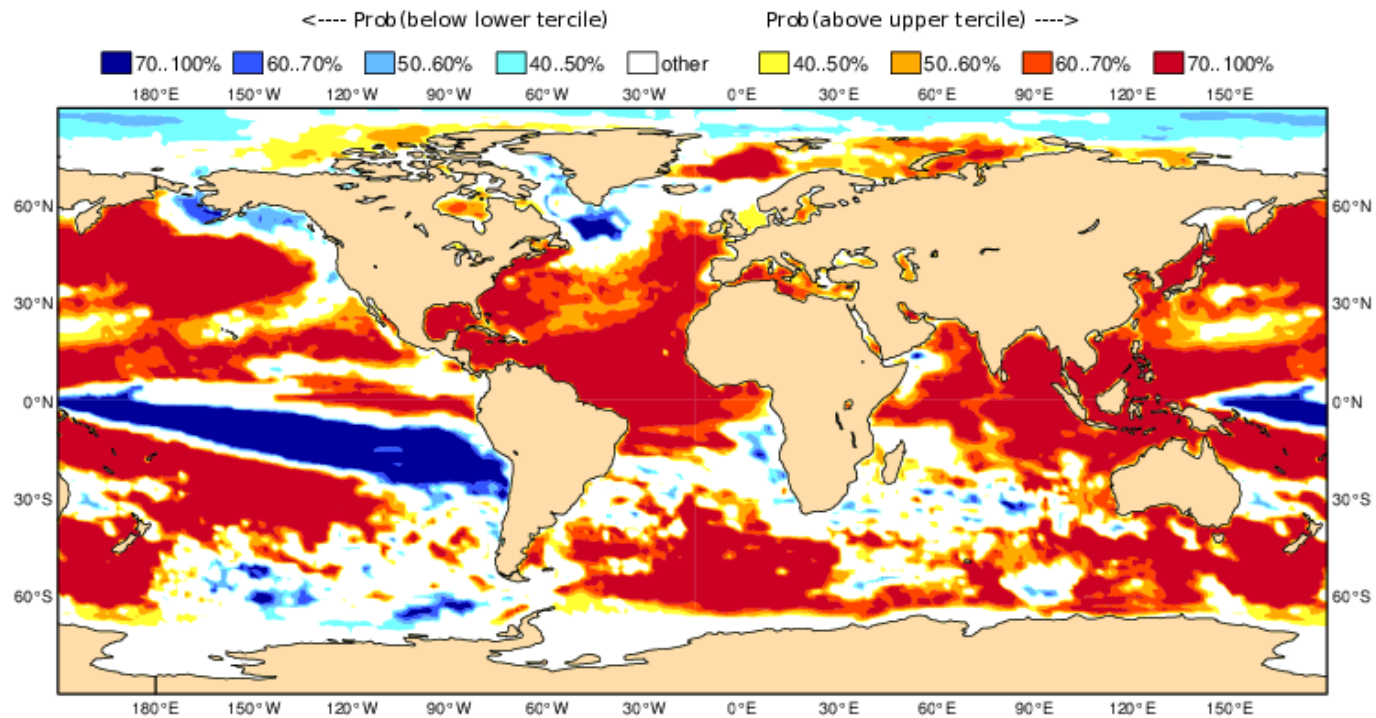
Prob(most likely category of forecast SST)

Forecast start is 01/02/22, climate period is 1993-2016

Ensemble size = 51, climate size = 600

System 5

JJA 2022



# CFS Forecasts of Sea Surface Temperature Anomalies: August-October 2022

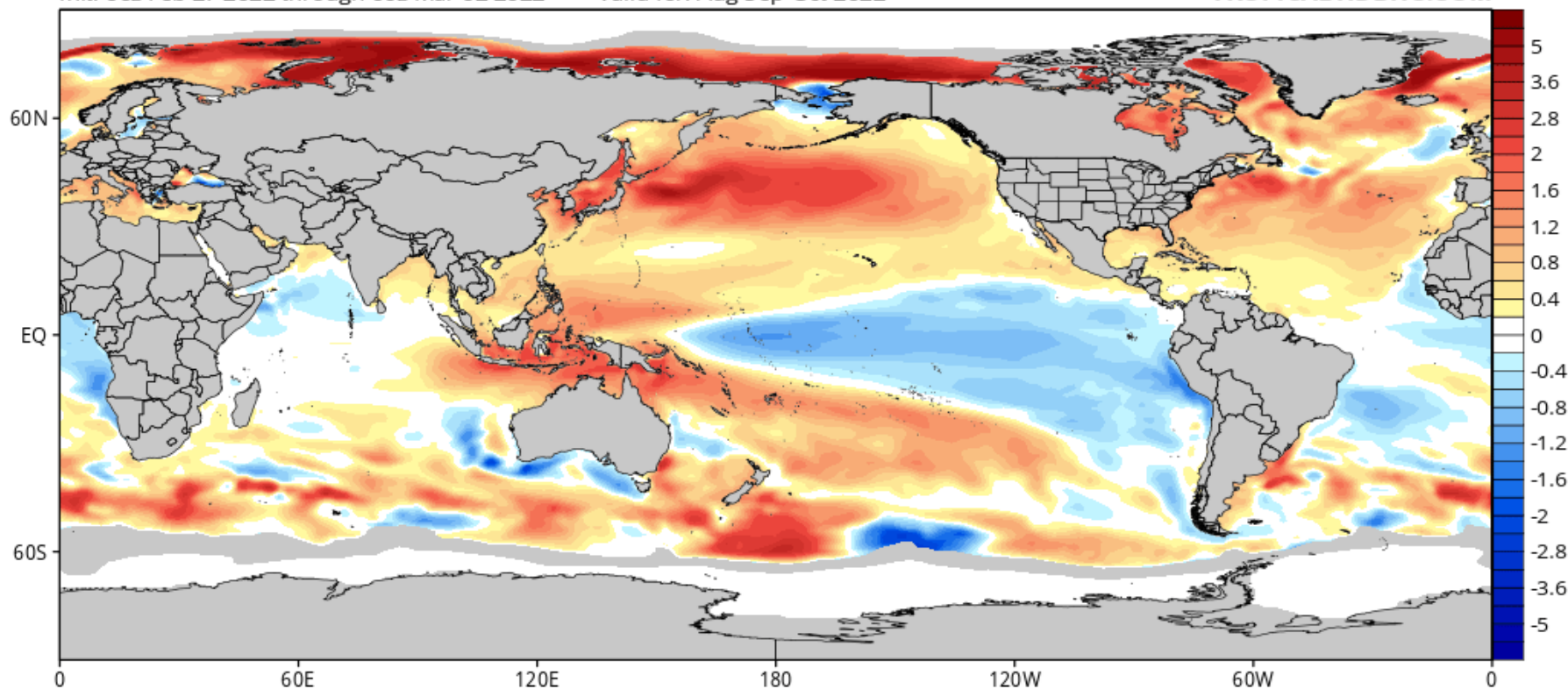
CFSv2 Sea Surface Temperature Anomaly (°C) (based on 1984-2009 Model Climatology)

Average of last 12 forecasts (12 runs x 1 members)

Init: 06z Feb 27 2022 through 00z Mar 02 2022

Valid for: Aug-Sep-Oct 2022

TROPICALTIDBITS.COM



# **2022**

## **Forecast Schedule**

<b>Date</b>	<b>7 April</b>	<b>2 June</b>	<b>7 July</b>	<b>4 Aug</b>
<b>Seasonal Forecast</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>



## Contact Info:

Phil Klotzbach

Email: [philk@atmos.colostate.edu](mailto:philk@atmos.colostate.edu)

Web: <http://tropical.colostate.edu>

Twitter: [@philklotzbach](https://twitter.com/philklotzbach)

# Next Week's Training

## Using SHIP for Manufactured Housing

**March 4 at 1:30 pm**

Register at

[https://us02web.zoom.us/webinar/register/WN\\_ABfS89bUT9q1fupoQnizUg](https://us02web.zoom.us/webinar/register/WN_ABfS89bUT9q1fupoQnizUg)



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# Technical Assistance is Available

Available Daily: 1 (800) 677-4548

## Options for Further Assistance Include:

Phone and Email consultation

Site Visits

Register at [www.flhousing.org](http://www.flhousing.org) for:

Workshops

Webinars



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# Thank You!



Gladys Cook  
[cook@flhousing.org](mailto:cook@flhousing.org)

Michael Chaney  
[chaney@flhousing.org](mailto:chaney@flhousing.org)



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