2019 U.S. Hurricane Season Preview

Michal Clavner, Ph.D.

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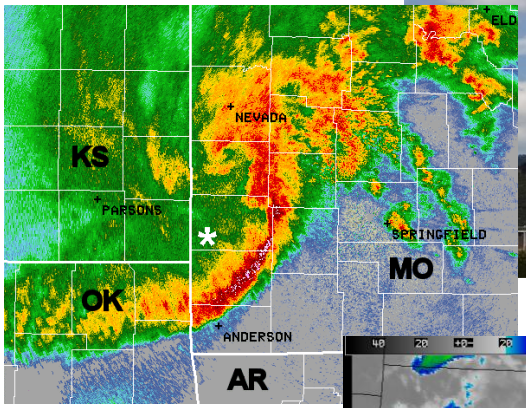
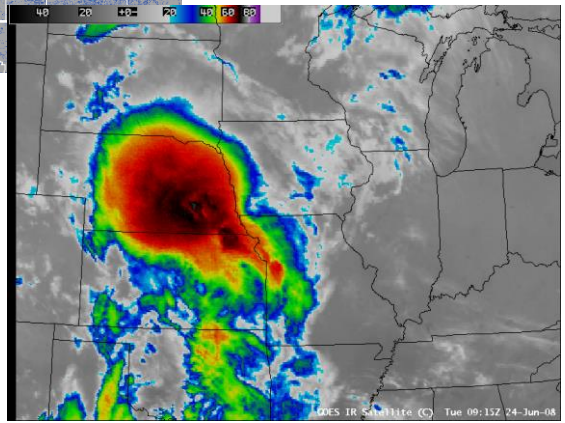
Meet Dr. Clavner

Michal Clavner, Ph.D.
Scientist II





Agenda

- 2018 Hurricane Season Recap
- Primary Factors Influencing Hurricane Activity
- Seasonal Forecasts
- Secondary Factors Influencing Hurricane Activity
- Tropical Cyclones and Precipitation in a Changing Climate
- AIR Hurricane Contest

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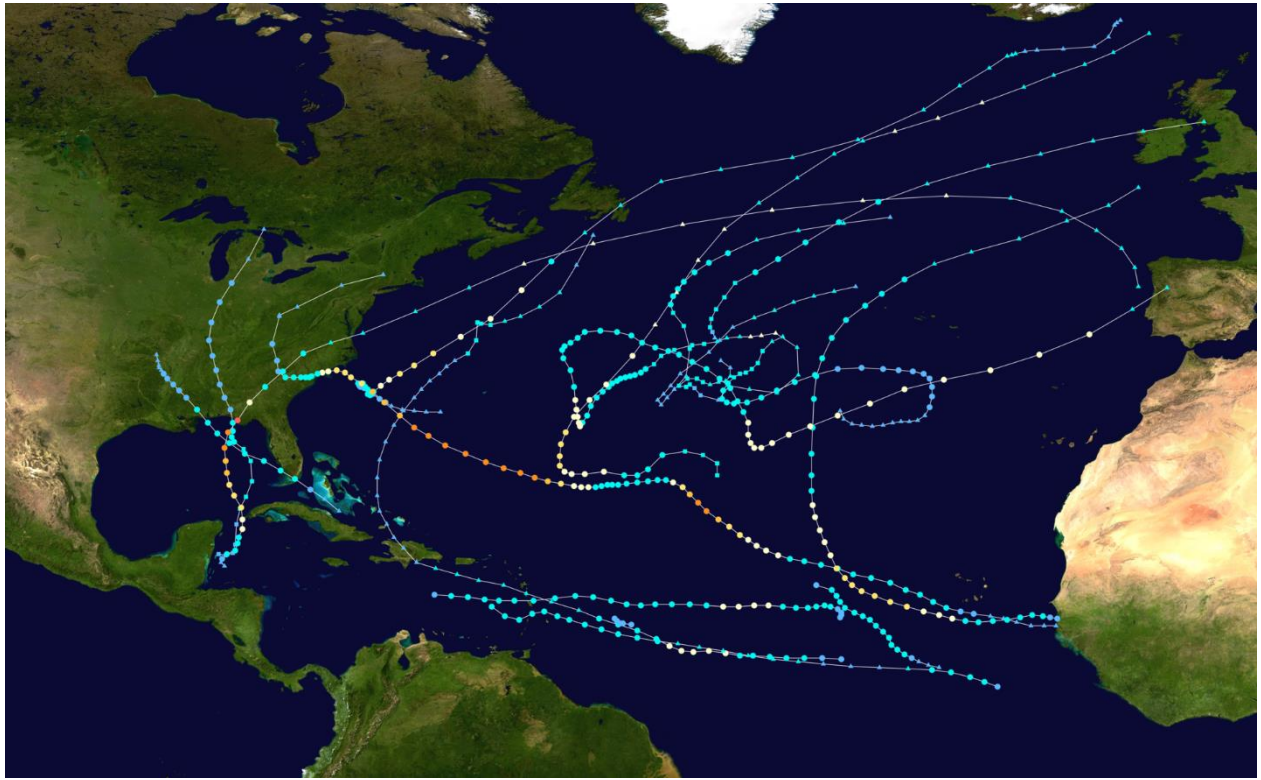
2018 Hurricane Season Recap



	2018	Avg.
Named Storms	15	12
Hurricanes	8	6
Major Hurricanes	2	3
Landfalls	2	1–2
Major Hurricane Landfalls	1	<1

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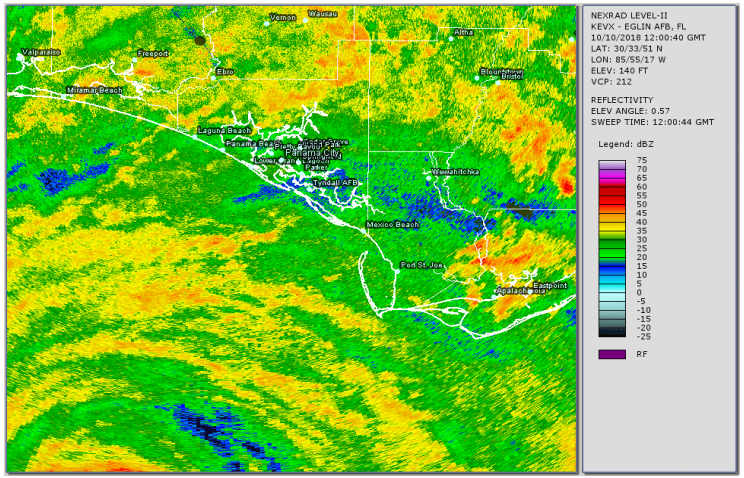
2018 Hurricane Season Recap

Landfall 1: **Hurricane Florence**
Category 4
Landfall as a Category 1

- Brought record-breaking flooding
- One of the deadliest and costliest hurricanes ever to hit the Carolinas

Landfall 2: **Hurricane Michael**
Category 5
Landfall as a Category 5



- Strongest hurricane on record to make landfall in the Florida Panhandle
- Spread damage far inland, as well as into Georgia, the Carolinas, and Virginia

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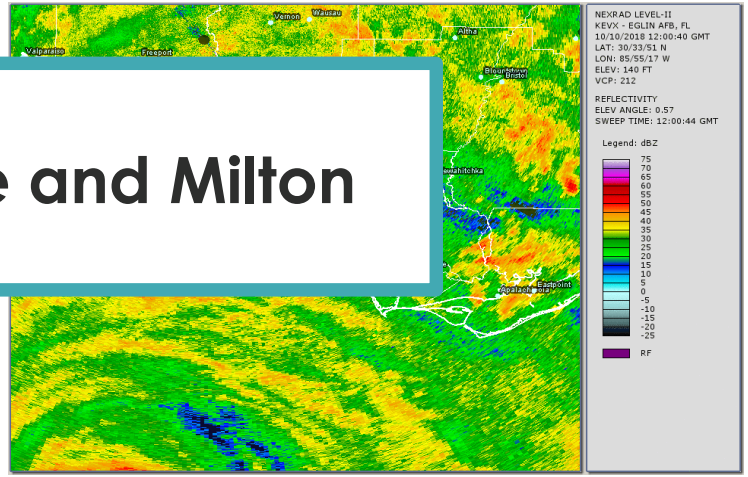
2018 Hurricane Season Recap

Landfall 1: **~~Hurricane Florence~~**

Landfall 2: **~~Hurricane Michael~~**

Retired



In 2024: Francine and Milton

- Brought record-breaking flooding
- One of the deadliest and costliest hurricanes ever to hit the Carolinas

- Strongest hurricane on record to make landfall in the Florida Panhandle
- Spread damage far inland, as well as into Georgia, the Carolinas, and Virginia

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2019 Atlantic Basin Storm Names

Andrea	Humberto	Olga
Barry	Imelda	Pablo
Chantal	Jerry	Rebekah
Dorian	Karen	Sebastien
Erin	Lorenzo	Tanya
Fernand	Melissa	Van
Gabrielle	Nestor	Wendy

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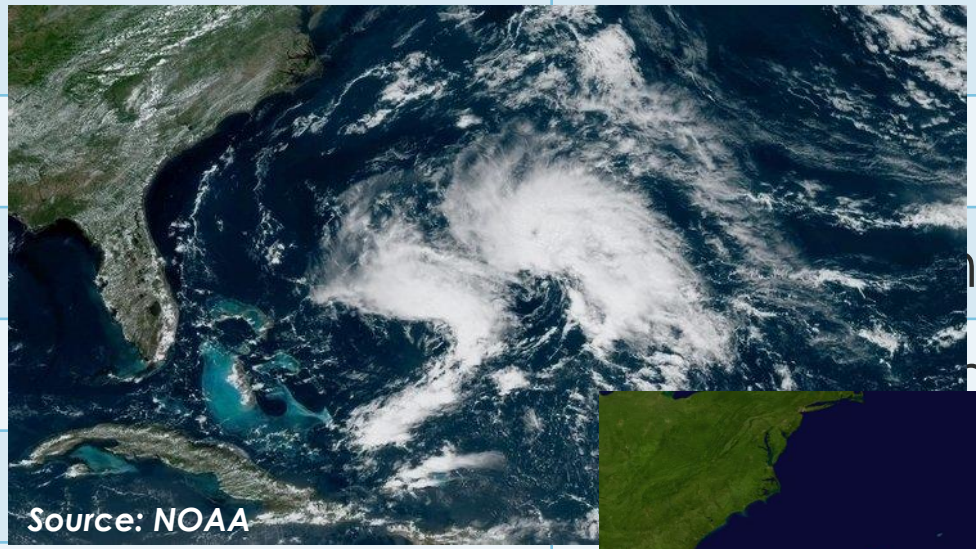
2019 Atlantic Basin Storm Names

~~Andrea~~		
Barry		
Chantal		
Dorian		
Erin		
Fernand	Melissa	
Gabrielle	Nestor	



Primary Factors Influencing Hurricane Activity

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Factors Influencing Seasonal Hurricane Activity

Two main factors:

1. Phase of the El Niño-Southern Oscillation (**ENSO**)
2. Atlantic Sea Surface Temperatures (**SST**)

Impacts the vertical wind shear in the Atlantic; can limit cyclone intensification

Provides the energy for storms to form and develop

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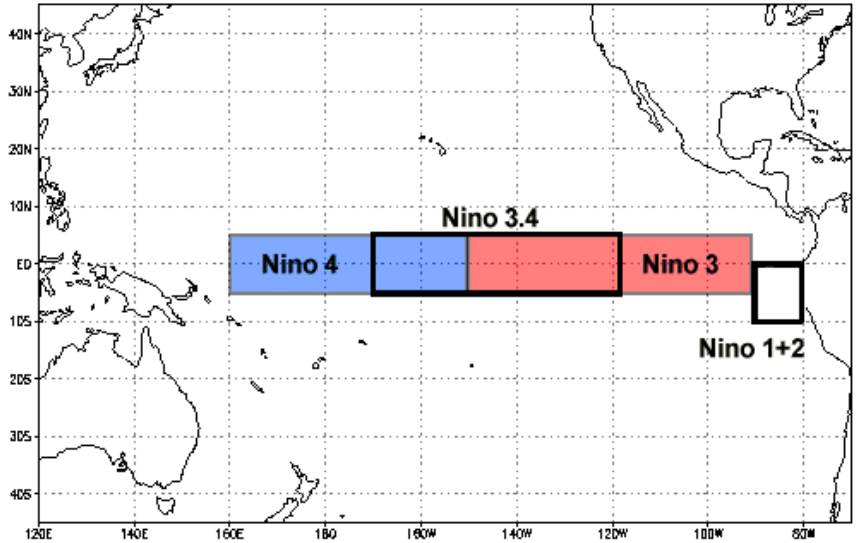
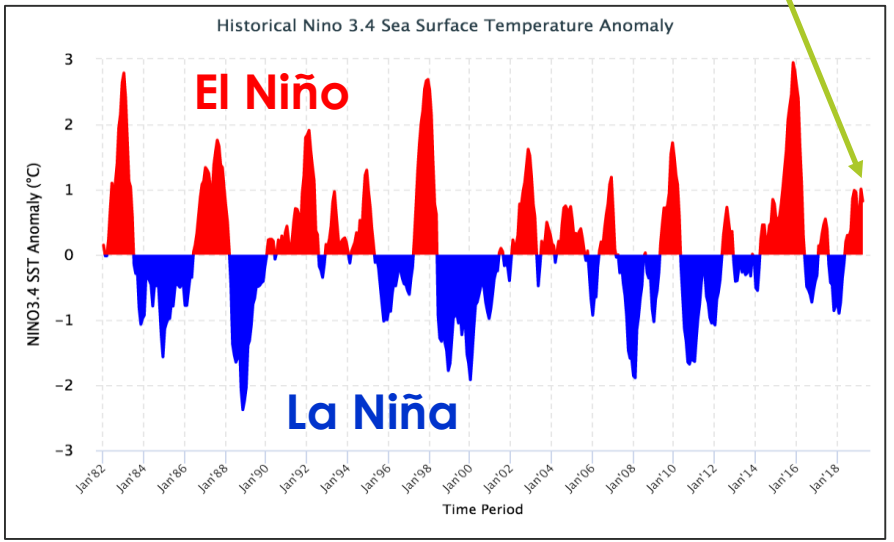
Factors Influencing Seasonal Hurricane Activity:
The El Niño-Southern Oscillation (ENSO)

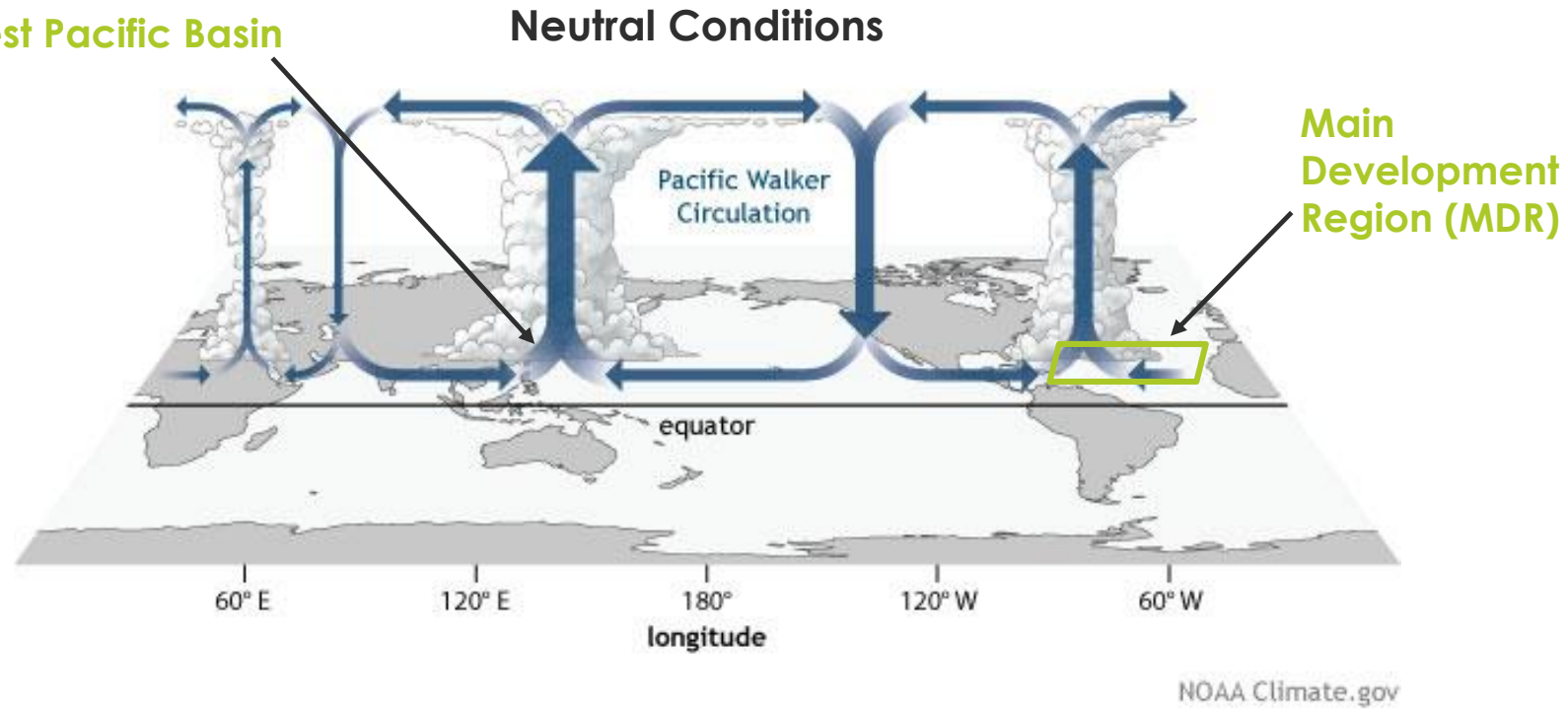
Niño 3.4: The area where the sea surface temperature anomaly is calculated for the ENSO phase



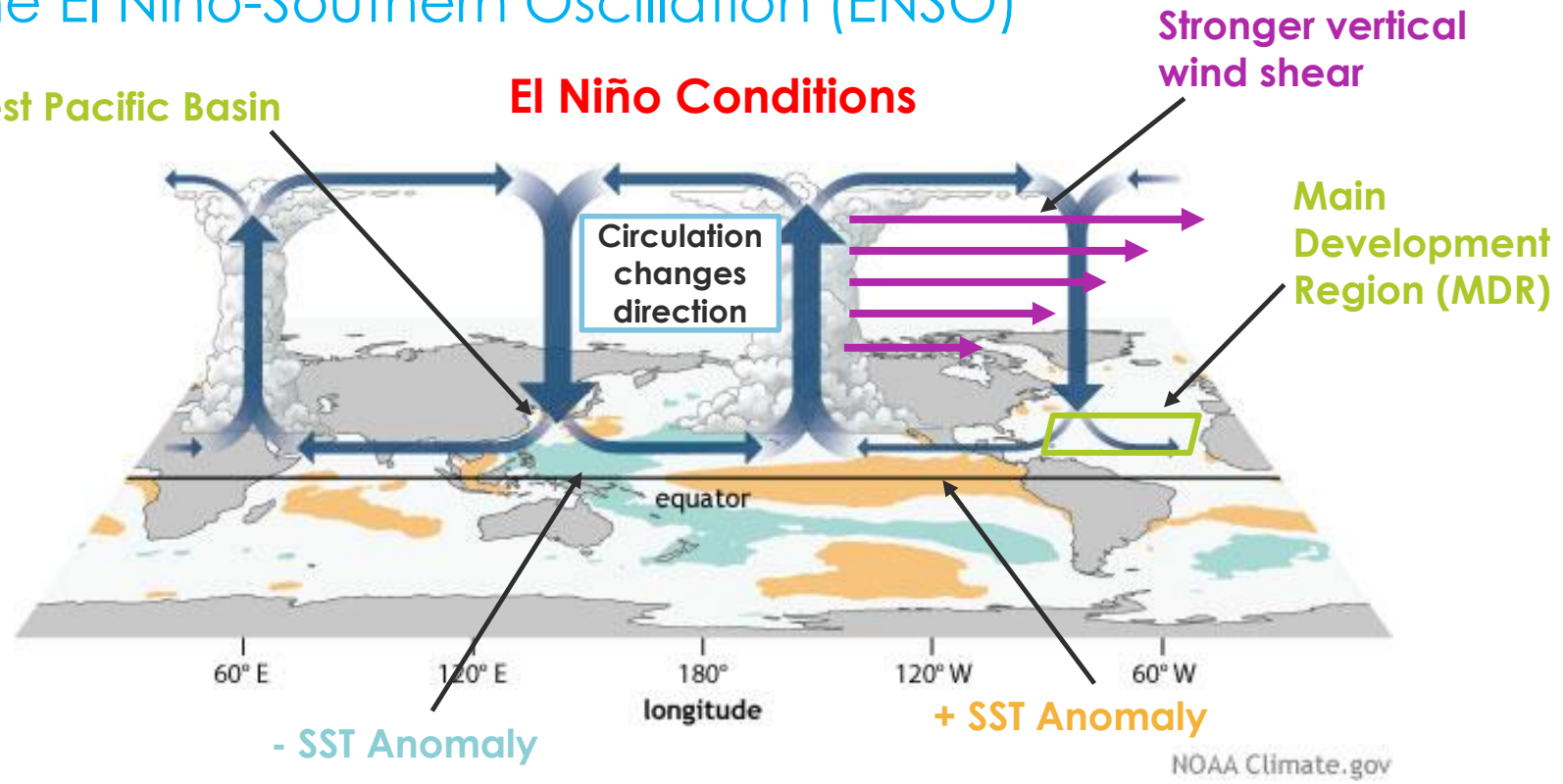
Weak El Niño Conditions



Factors Influencing Seasonal Hurricane Activity:
The El Niño-Southern Oscillation (ENSO)



Factors Influencing Seasonal Hurricane Activity:
The El Niño-Southern Oscillation (ENSO)



Atlantic hurricane activity decreases

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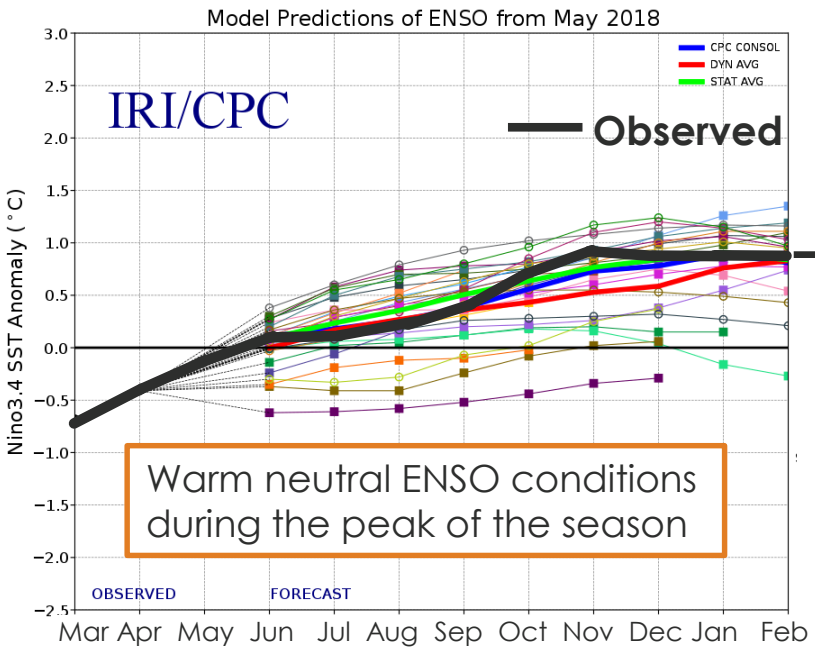
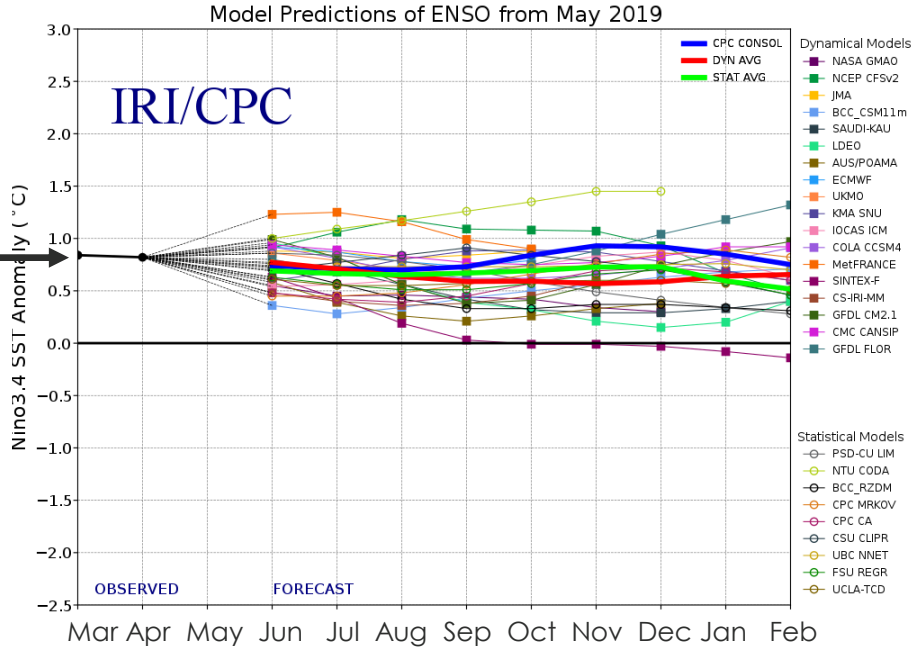
Factors Influencing Seasonal Hurricane Activity:
The El Niño-Southern Oscillation (ENSO)



Warm neutral ENSO conditions during the peak of the season



Consensus is that El Niño is likely to persist this year

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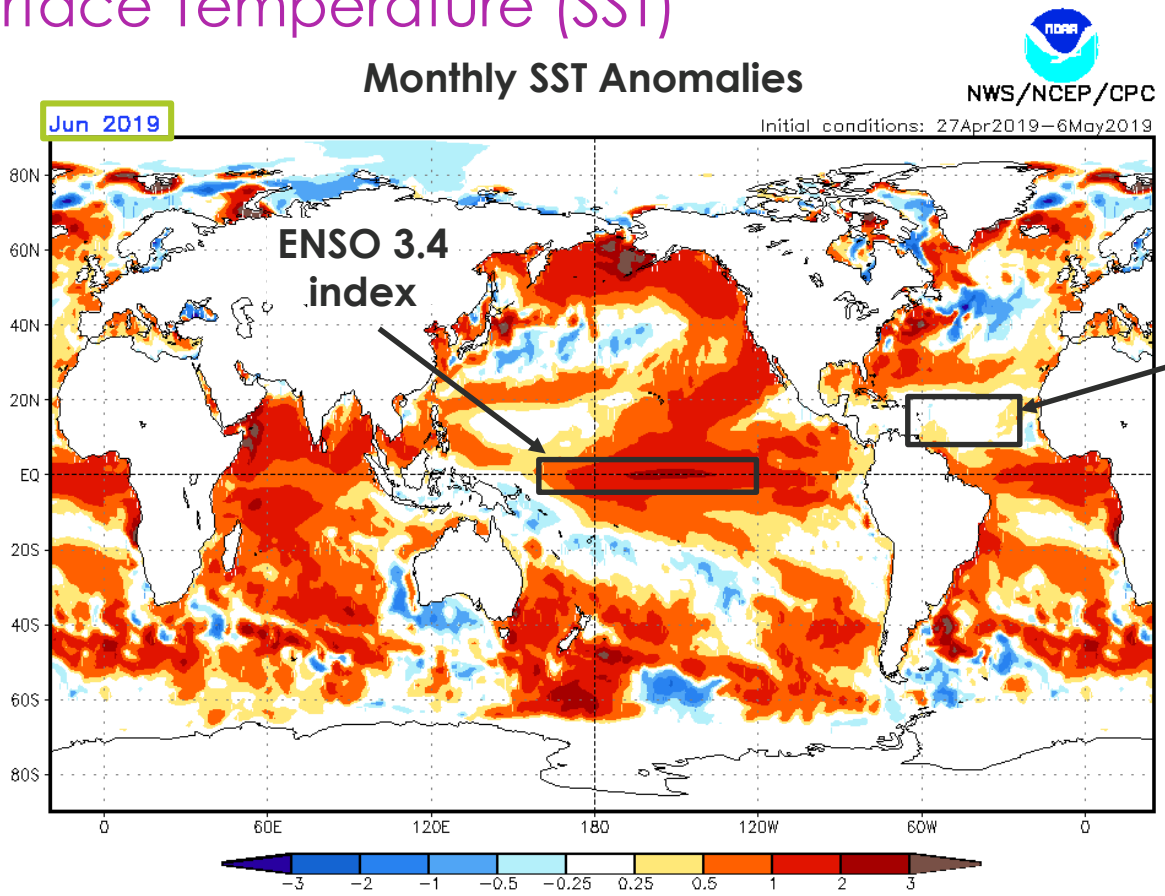
Factors Influencing Seasonal Hurricane Activity:
Sea Surface Temperature (SST)



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Factors Influencing Seasonal Hurricane Activity

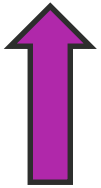
Two main factors:

1. Phase of the El Niño-Southern Oscillation (**ENSO**)
2. Atlantic sea surface temperatures (**SST**)

Ongoing and expected to persist positive phase

Decrease in hurricane activity

Warmer-than-average SSTs expected in the **Tropical Atlantic Ocean** and **Caribbean Sea**



Increase in hurricane activity

Current forecasts for 2019 hurricane activity take into account these two competing climate factors

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Seasonal Forecasts

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Seasonal Forecasts

http://www.bsc.es/seasonalhurricanepredictions

Colorado State University

COASTAL CAROLINA UNIVERSITY

WeatherBELL Analytics LLC

University of Missouri

SEOUL NATIONAL UNIVERSITY

Met Office

FAN Climate Forecast Applications Network

Tropical Storm Risk.com

The Weather Company An IBM Business

NC STATE UNIVERSITY

AnuMS Antigua Meteorological Service

WEATHER DESK

INSMET Instituto de Meteorología

AccuWeather

WEATHERTIGER Now you know.

PennState

StormGeo

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Seasonal Forecasts

Number of agencies: 18

Forecast:

- **Number of named storms (tropical storms and hurricanes)**
- **Number of hurricanes (all categories)**
- **Number of major hurricanes (Category 3 or higher)**

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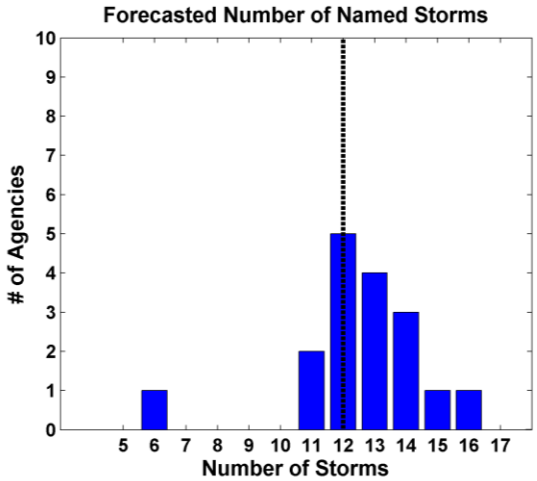
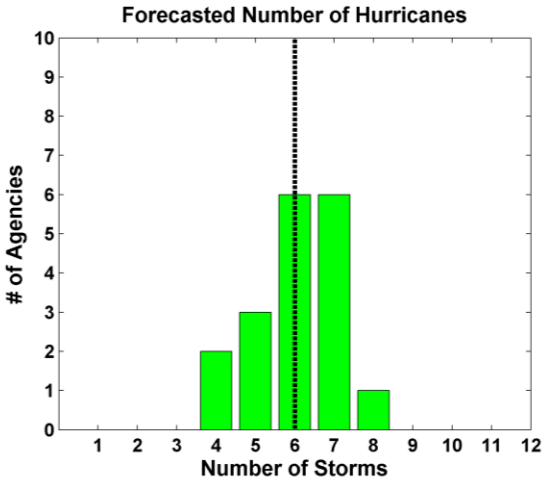
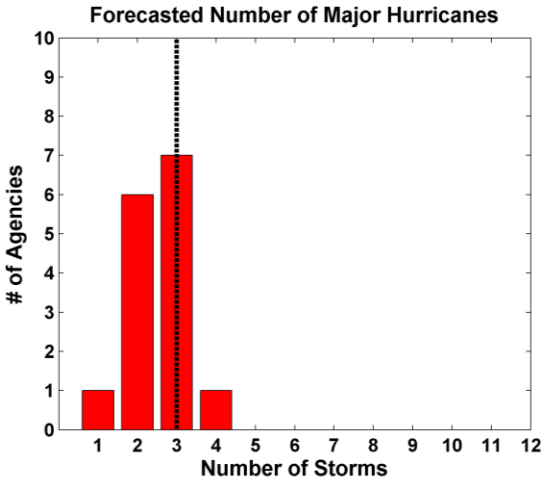
Seasonal Forecasts







	Named Storms	Hurricanes	Major Hurricanes
Climatological Mean	12	6	3
Agency Forecast Mean	12.62	6.176	2.6

Seasonal Forecasts

Number of agencies: 18

Forecast:

- Number of named storms (tropical storms and hurricanes)
- Number of hurricanes
- Number of major hurricanes
- **Accumulated Cyclone Energy (ACE)**

  Provides a measure of *potential* tropical cyclone activity over an entire season

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Seasonal Forecasts

Storm Accumulated Cyclone Energy : $ACE_{STORM} = \sum_{1}^{T} V_{max}^2$

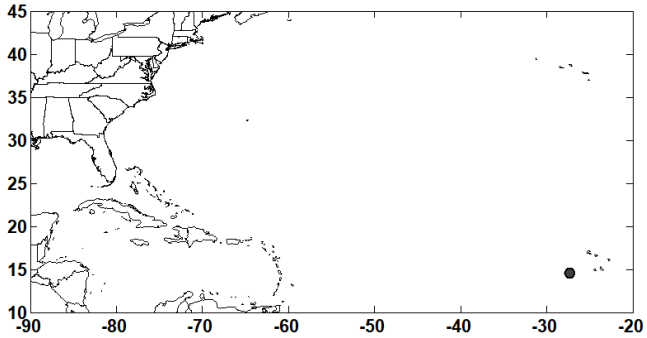
- **Storm Intensity**
- **Storm Duration**

Tropical Cyclone ACE:

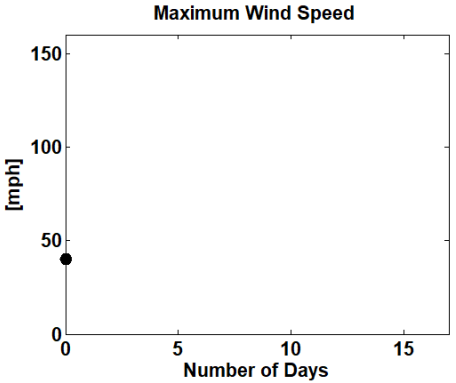
Value accounts for both strength (based on wind speed) and duration

Season's ACE:

Computed over each storm and depends on the frequency of occurrence of storms

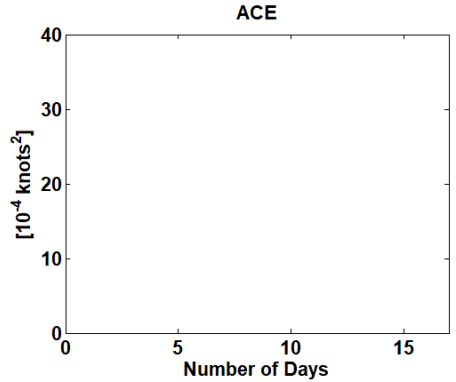


Hurricane Florence

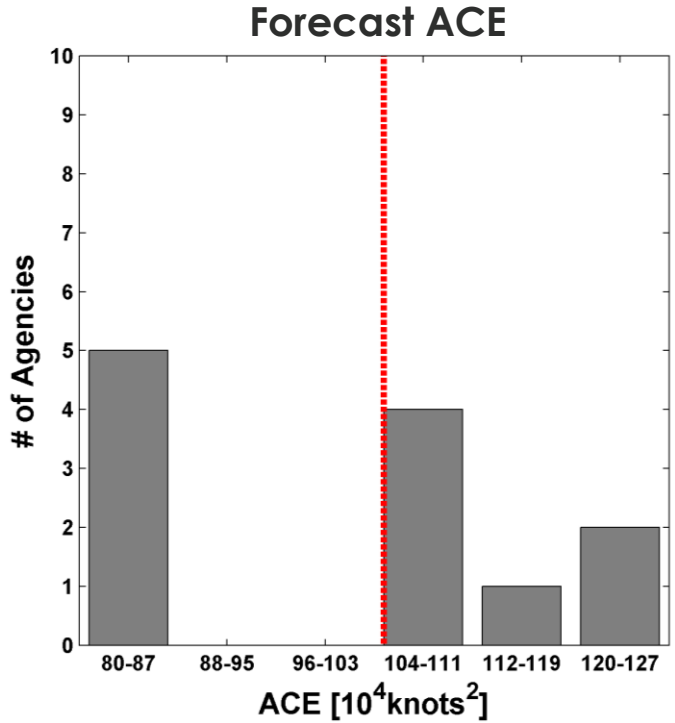


$$ACE_{SEASON} = \sum_{1}^{N} ACE_{STORM}$$

$$ACE_{SEASON} = \sum_{1}^{N} \sum_{1}^{T} V_{max}^2$$



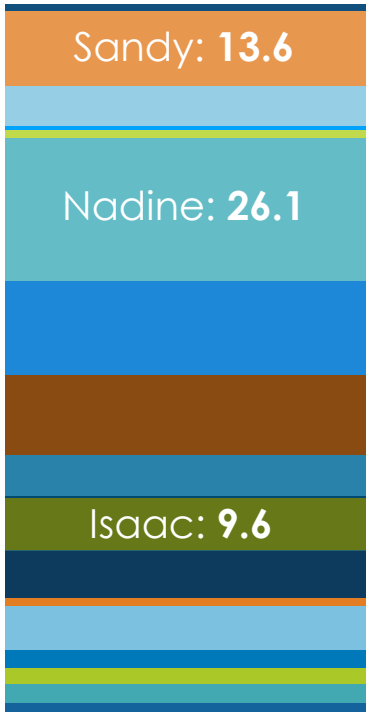
Seasonal Forecasts



$$\overline{\mathrm{ACE}_{1981-2018}} = \mathbf{104}\ 10^4 knots^2$$

A Tale of Two Seasonal ACEs of 133

2012: 19 Named Storms



2018: 15 Named Storms

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Seasonal Forecasts

Number of agencies: 18

Forecast:

- Number of named storms (tropical storms and hurricanes)
- Number of hurricanes
- Number of major hurricanes
- Accumulated Cyclone Energy (ACE)
- **Analog Years**

  Years in the historical record with global oceanic and atmospheric trends that are similar to 2019

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Seasonal Forecasts: Individual Agencies

Colorado State University

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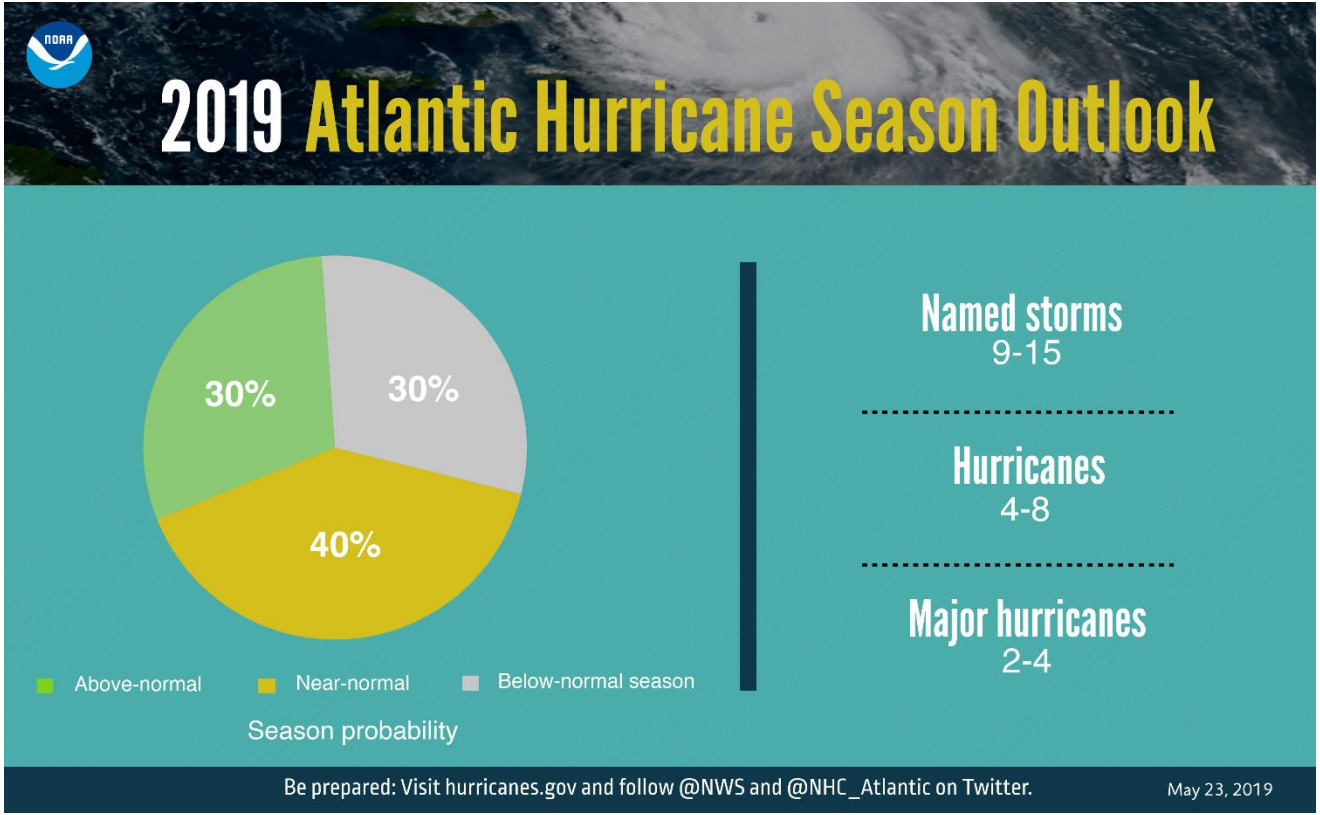
Seasonal Forecasts: Individual Agencies



Secondary Factors Influencing Hurricane Activity

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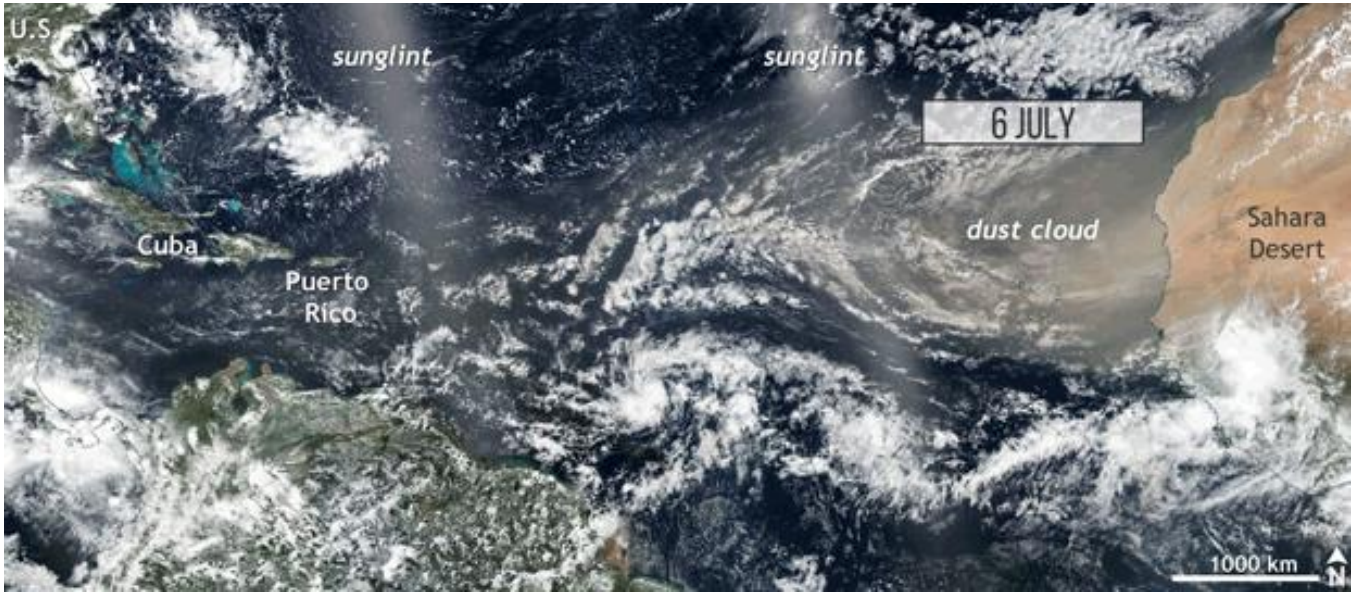
Factors Influencing Seasonal Hurricane Activity

Secondary factors:

1. Saharan Air Layer (**SAL**)

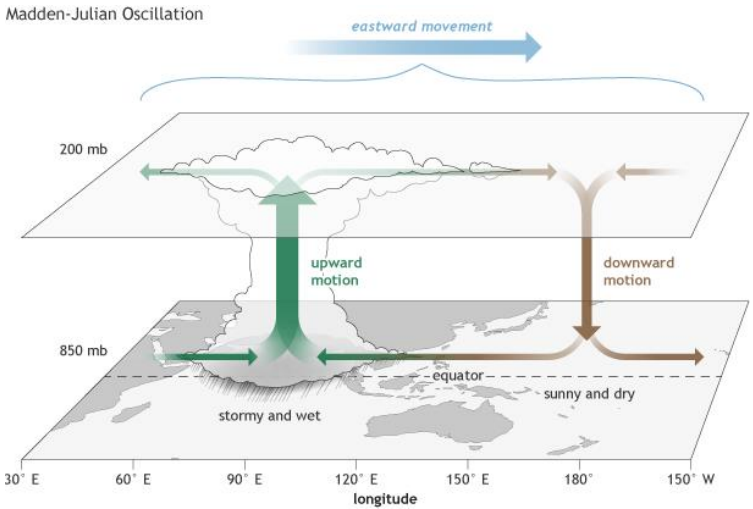


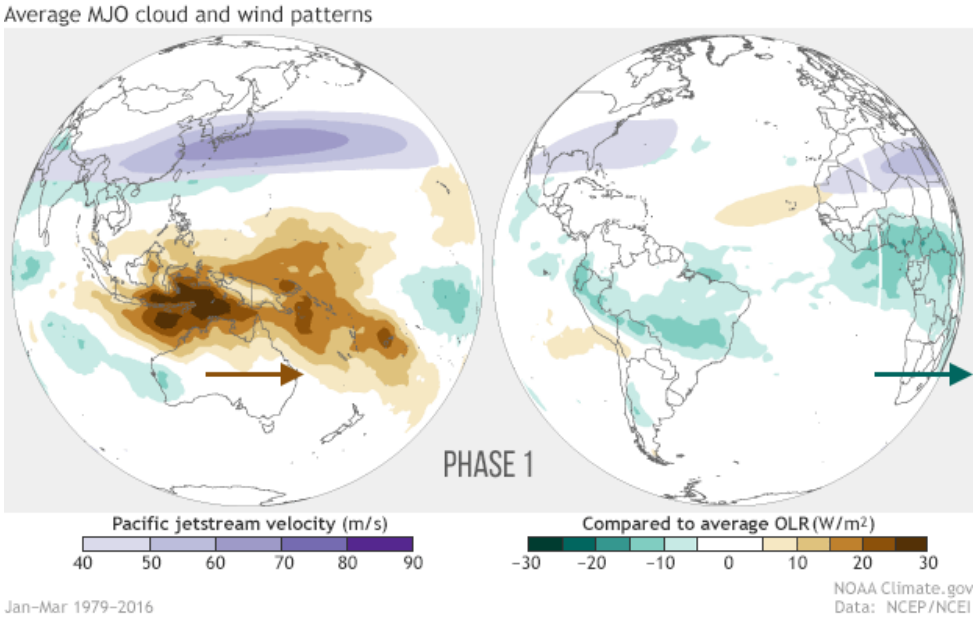
Dust blows across the Atlantic from Africa to the Caribbean between July 6-12, 2018. Suomi/NPP satellite images from NASA Worldview website. Animation by Climate.gov.

Factors Influencing Seasonal Hurricane Activity

Secondary factors:

1. Saharan Air Layer (**SAL**)
2. Madden-Julian Oscillation (**MJO**)





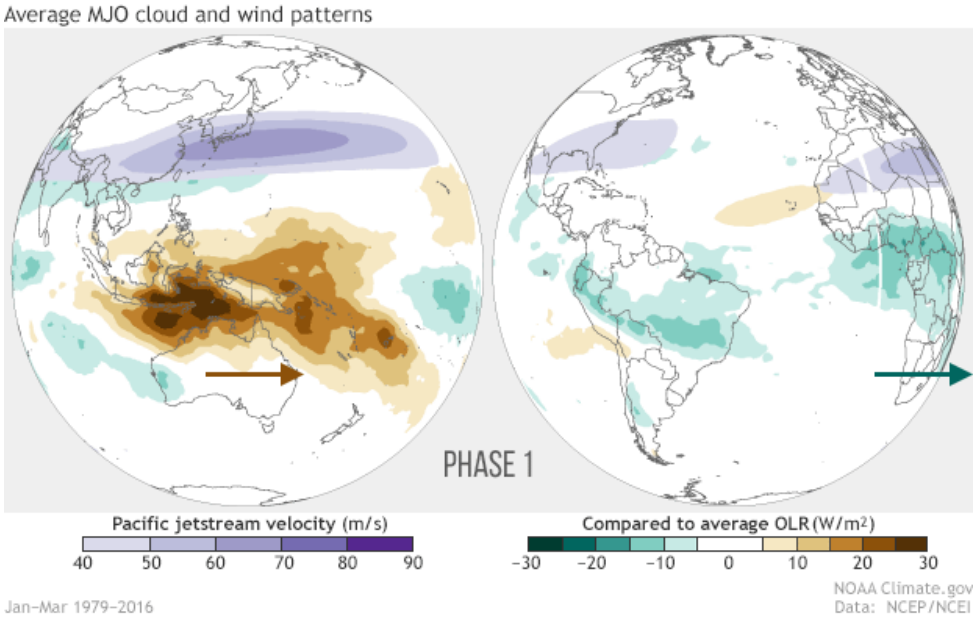
Factors Influencing Seasonal Hurricane Activity

Secondary factors:

1. Saharan Air Layer (**SAL**)
2. Madden-Julian Oscillation (**MJO**)

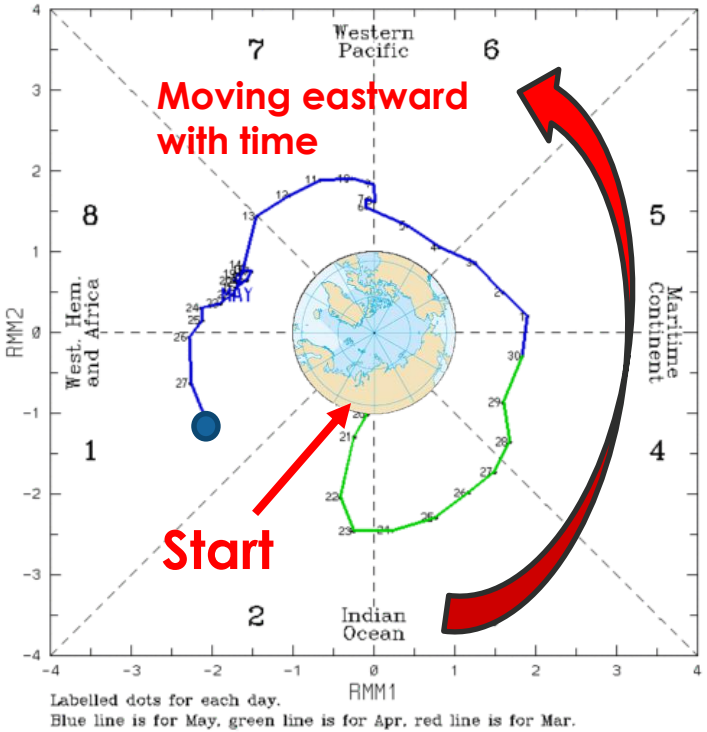
Gulf of Mexico and **Caribbean Sea** hurricanes are four times more likely to occur when the MJO phase is 1 and 2*.

(*Climate Variability and Predictability program)



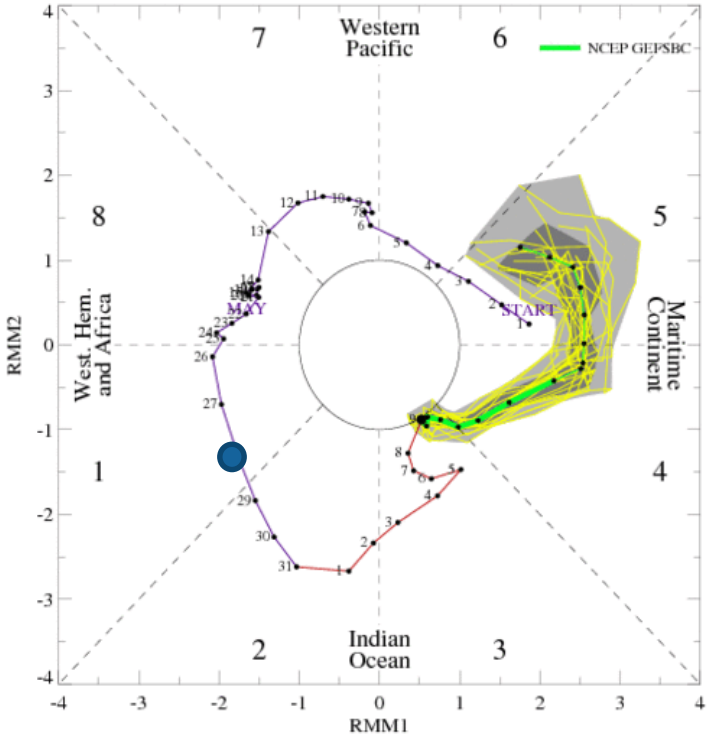
Factors Influencing Seasonal Hurricane Activity: Madden-Julian Oscillation (MJO)

Phase Space: April 19 to May 28



Source: Bureau of Meteorology

Phase Space: May 1 to June 9
Forecast: June 10 to June 24



Source: NOAA

Factors Influencing Seasonal Hurricane Activity

Secondary factors:

1. Saharan Air Layer (**SAL**)
2. Madden-Julian Oscillation (**MJO**)

} Impacts the formation of hurricanes

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Factors Influencing Seasonal Hurricane Activity

Secondary factors:

1. Saharan Air Layer (**SAL**)
2. Madden-Julian Oscillation (**MJO**)
3. North Atlantic Oscillation (**NAO**)
   Impacts the steering of the hurricanes

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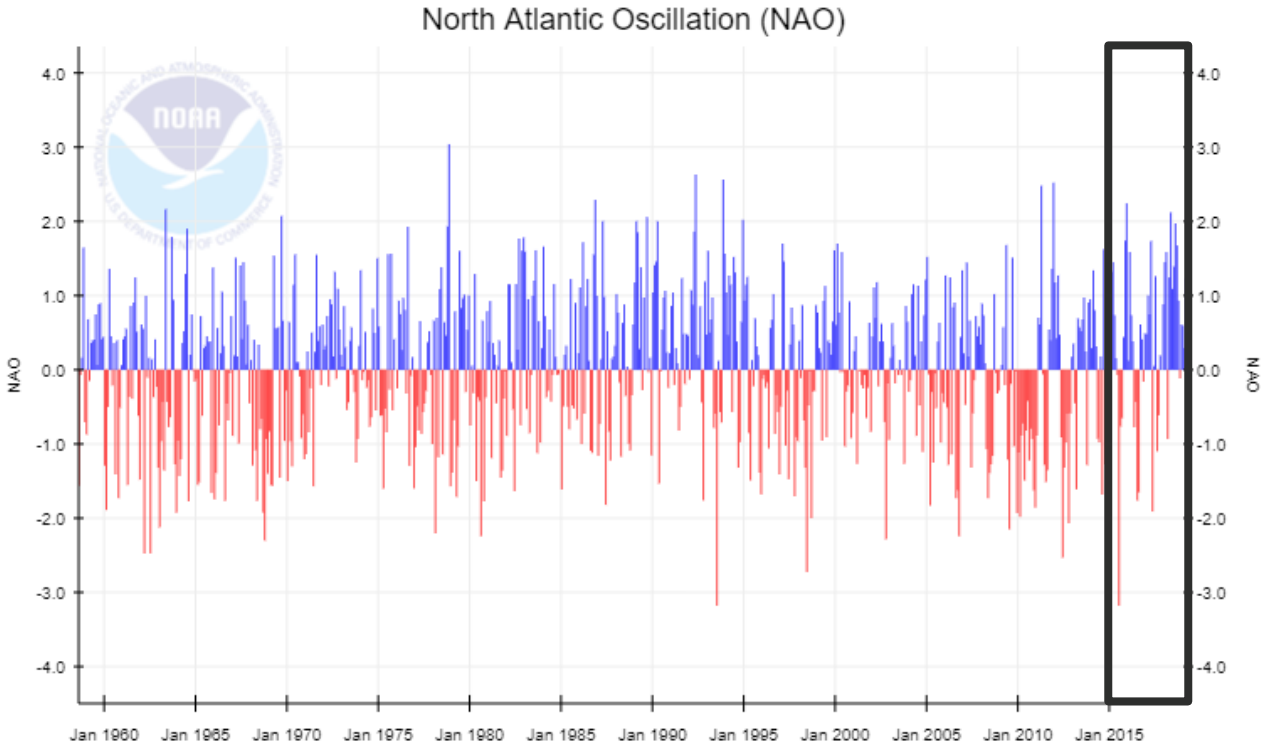
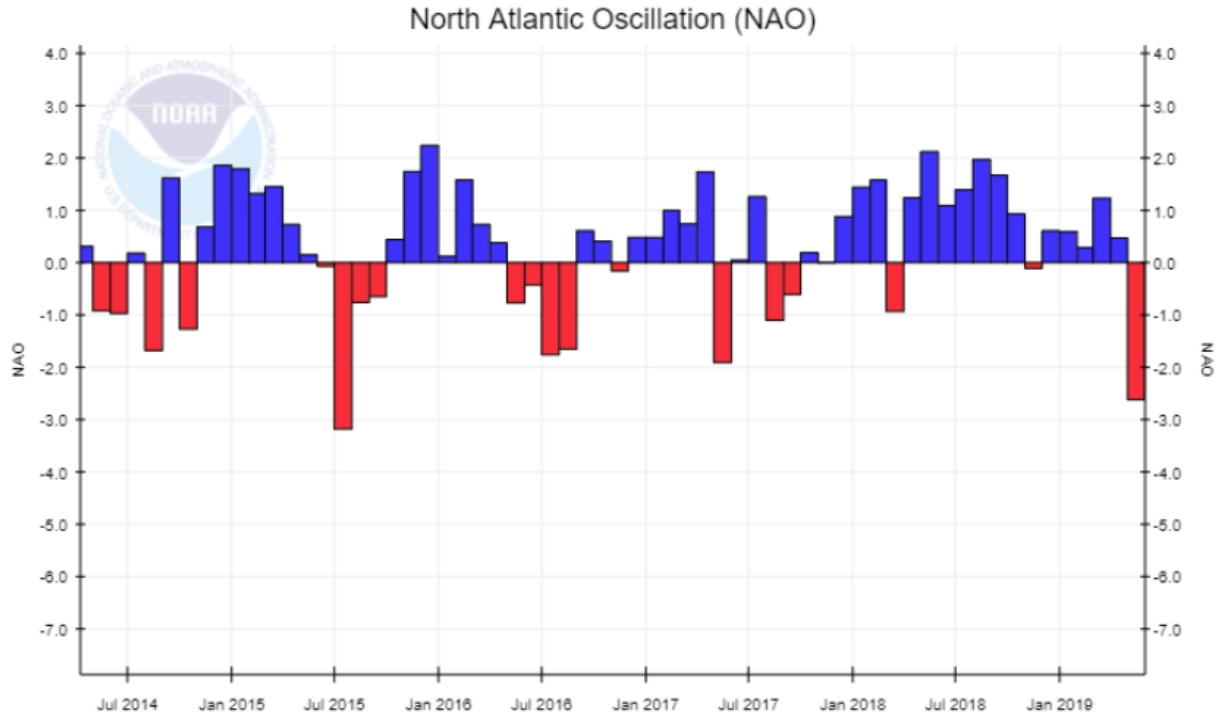
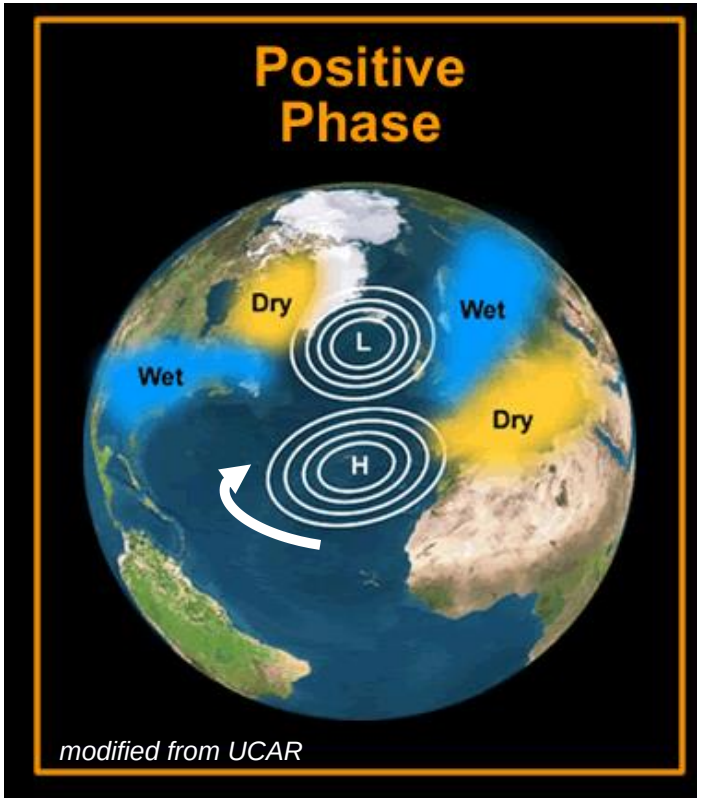
Factors Influencing Seasonal Hurricane Activity: North Atlantic Oscillation (NAO)

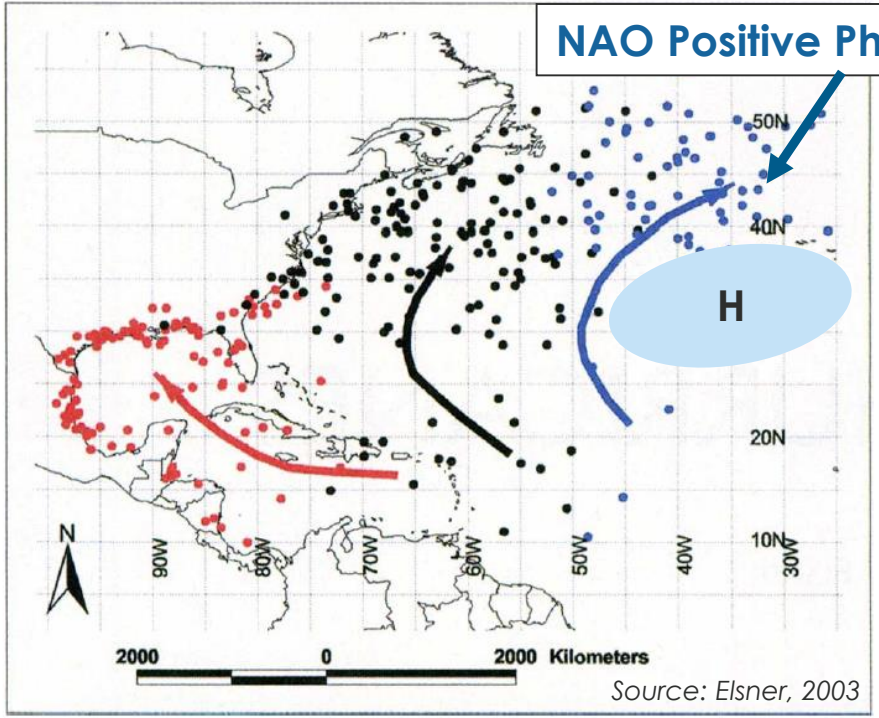


Factors Influencing Seasonal Hurricane Activity: North Atlantic Oscillation (NAO)



Factors Influencing Seasonal Hurricane Activity:
North Atlantic Oscillation (NAO)





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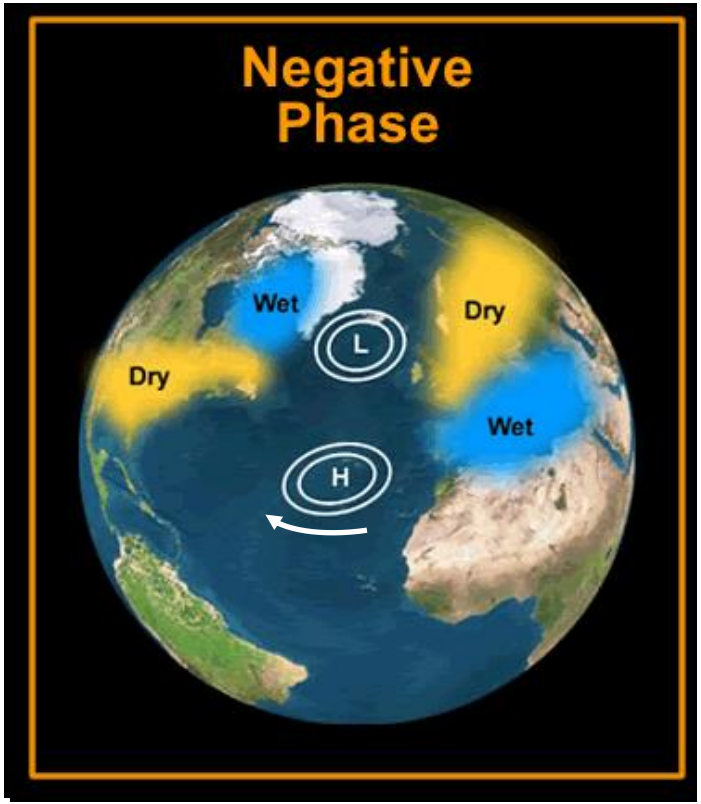
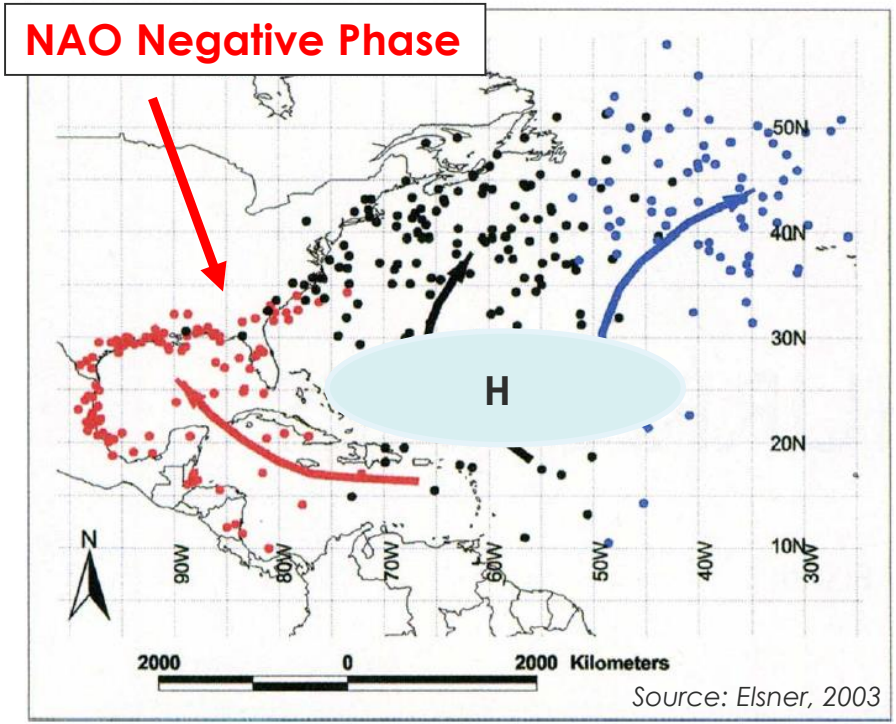
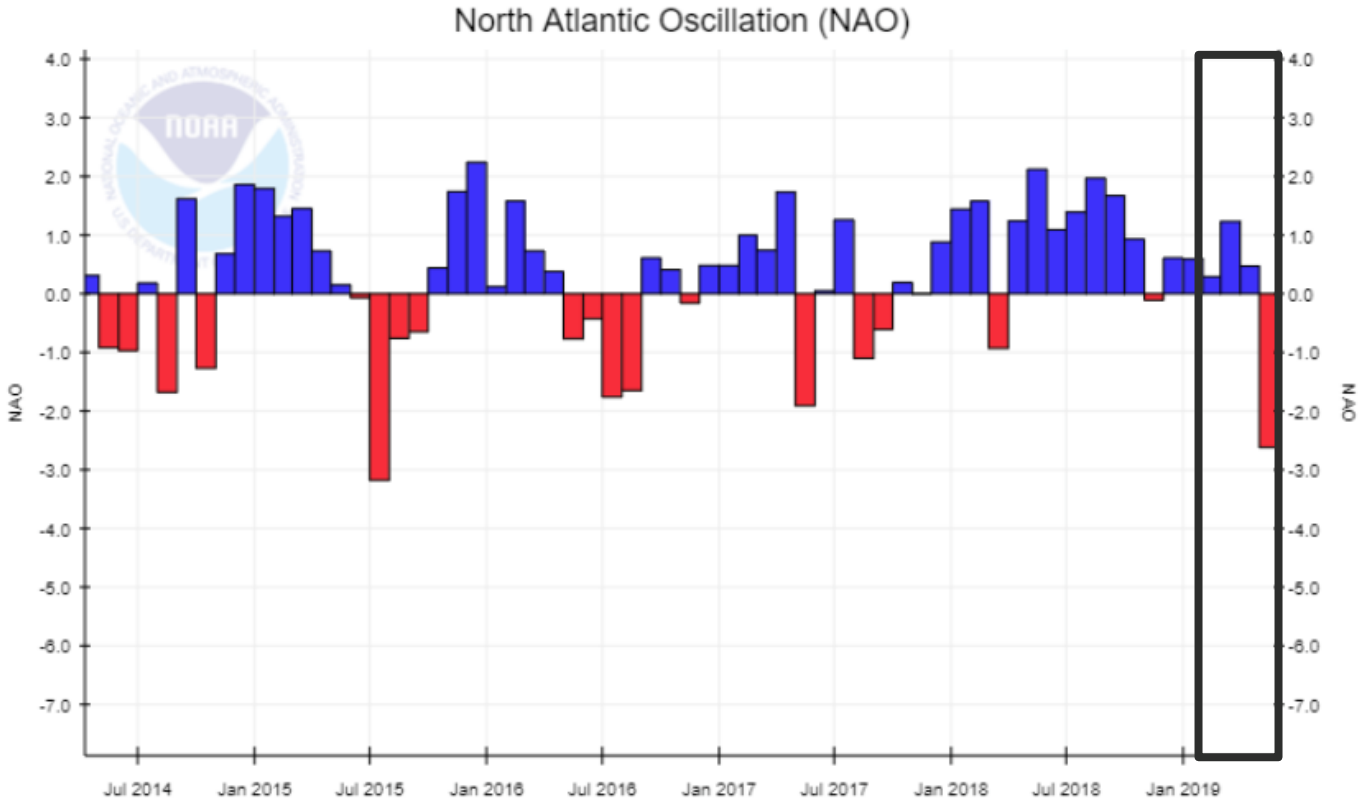
Factors Influencing Seasonal Hurricane Activity: North Atlantic Oscillation (NAO)

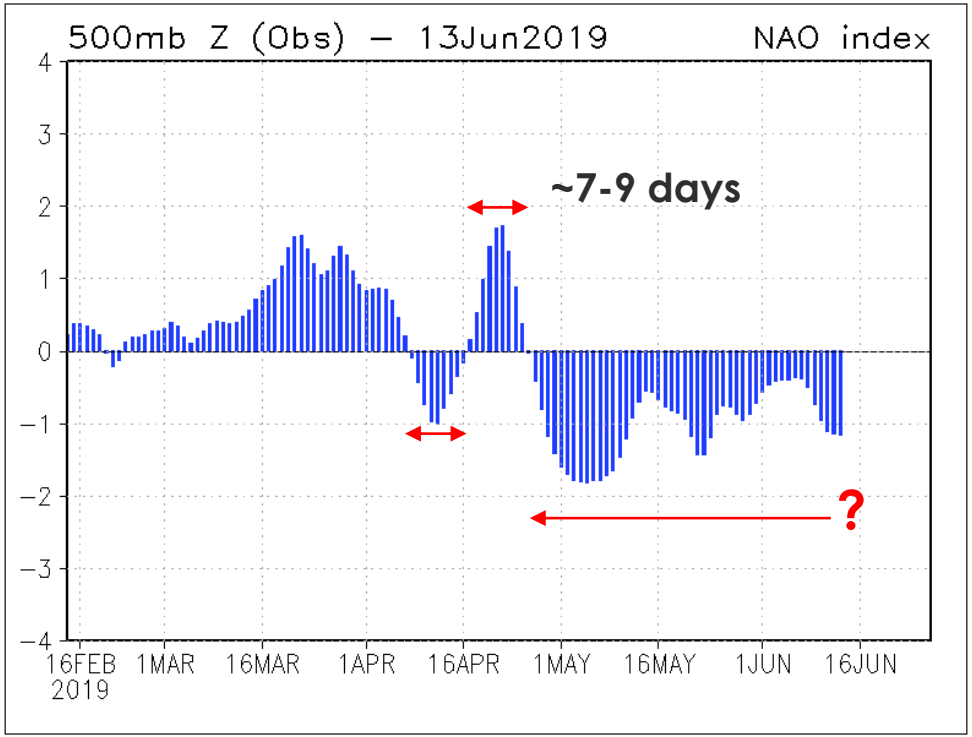




Factors Influencing Seasonal Hurricane Activity:
North American Oscillation (NAO)

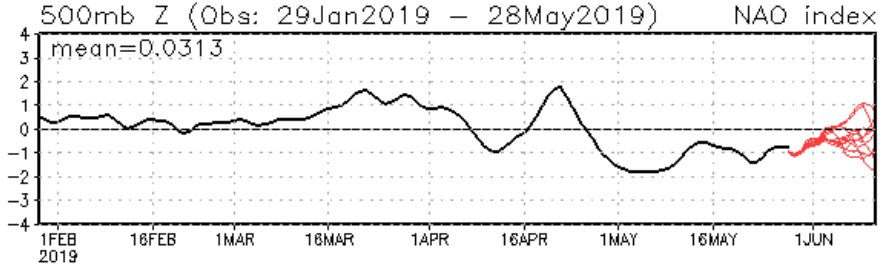


Factors Influencing Seasonal Hurricane Activity: North American Oscillation (NAO)

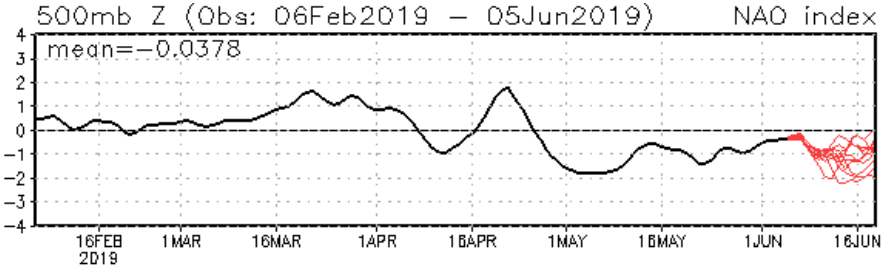


Factors Influencing Seasonal Hurricane Activity: North American Oscillation (NAO)

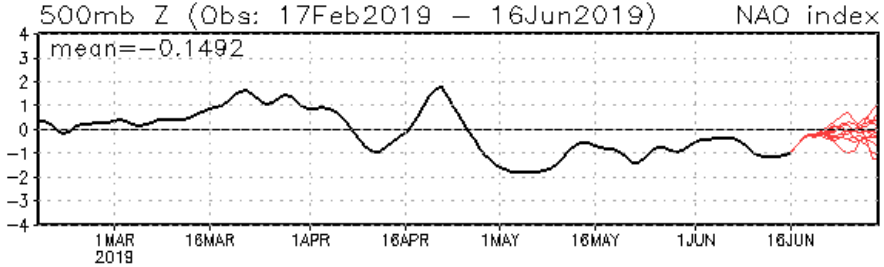
Early June Forecast



Mid-June Forecast



Late June Forecast



Factors Influencing Seasonal Hurricane Activity

Secondary factors:

1. Saharan Air Layer (**SAL**)	Outburst ~3–5 days
2. Madden-Julian Oscillation (**MJO**)	Changes phase ~4–8 days
3. North Atlantic Oscillation (**NAO**)	Changes phase ~weeks to months

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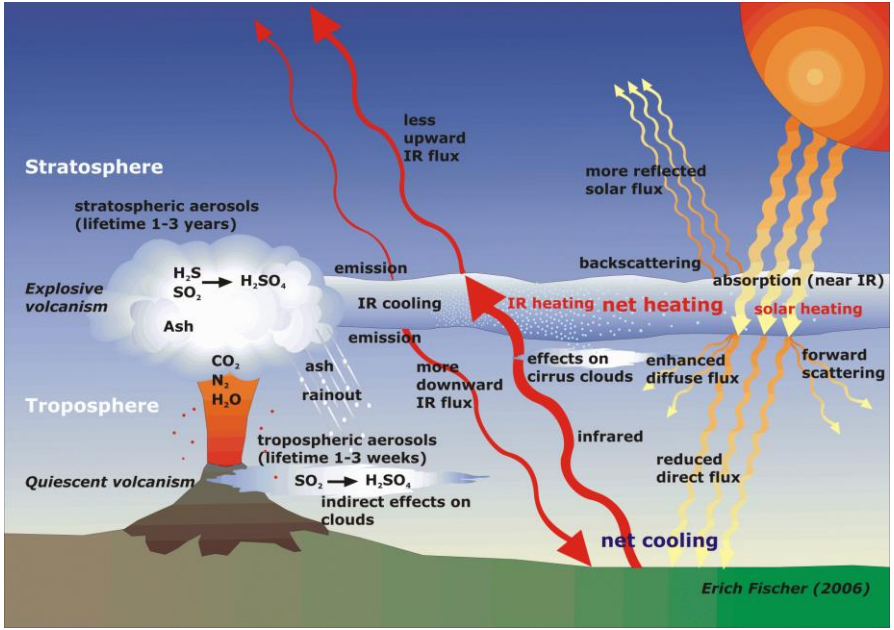
Factors Influencing Seasonal Hurricane Activity

A huge column of ash was blasted ~5 miles into the sky above the Indonesian island of Sumatra June 11, 2019.
Source: www.independent.co.uk



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Factors Influencing Seasonal Hurricane Activity

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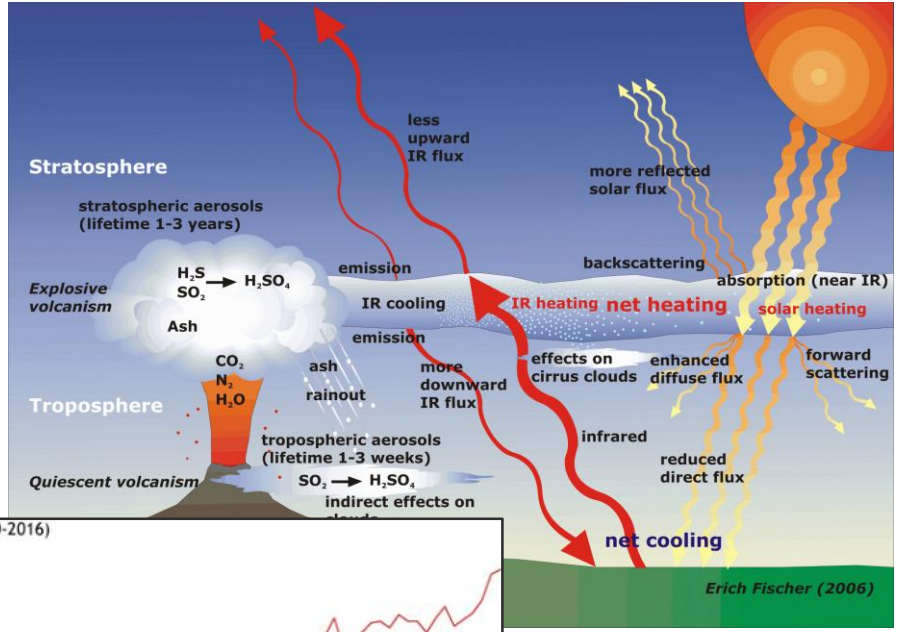

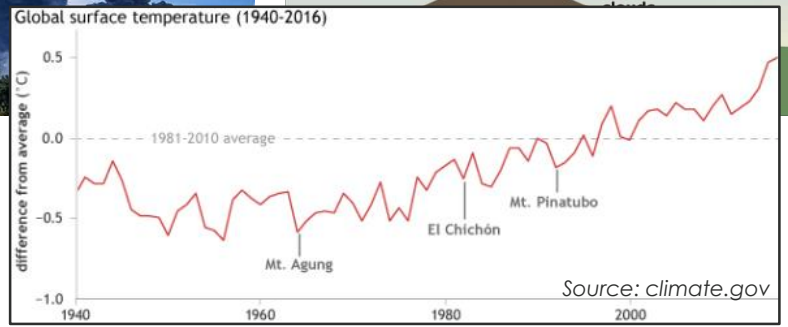

Tropical Cyclones and Precipitation in a Changing Climate

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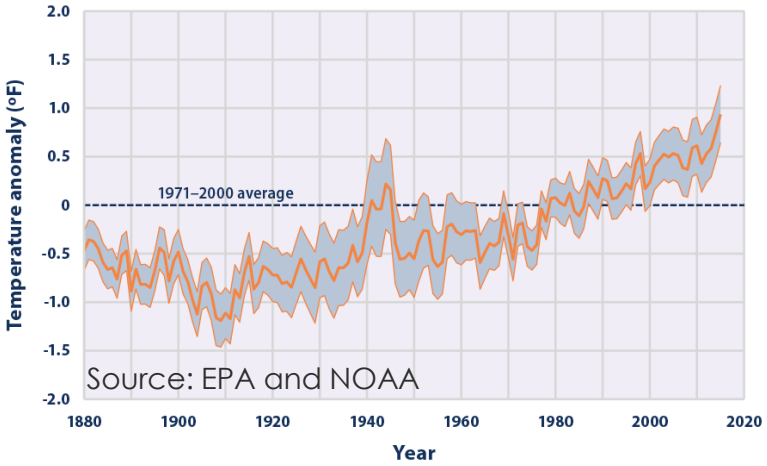
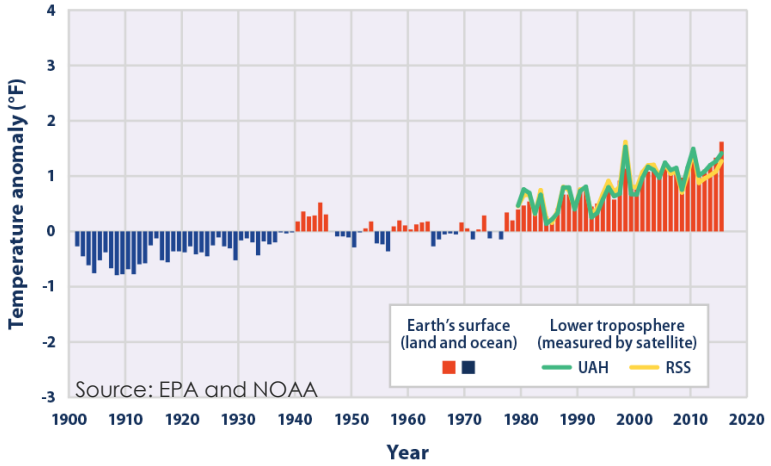
Tropical Cyclones and Precipitation in a Changing Climate

Increase in sea surface temperatures



Increased evaporation rates

Increase in air temperatures

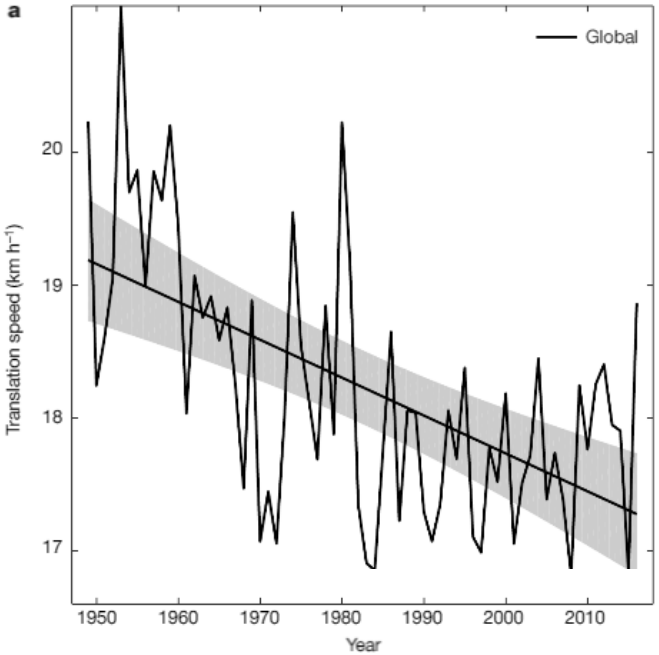


Warmer air can hold more water vapor (+7% per 1°C)

Increase in Tropical Cyclone rainfall

AIR

Tropical Cyclones and Precipitation in a Changing Climate



Kossin, J.P., 2018. A global slowdown of tropical-cyclone translation speed. *Nature*, *558*(7708), p.104.

A recent study showed that tropical cyclone propagation speeds have decreased by 10% over the last 68 years.

In our changing climate, it has been observed that tropical cyclones have:

- Increasing rainfall totals
- Decreasing storm propagation speeds

The combined effect:
The increase in local rainfall would be compounded by a concurrent slowdown in tropical cyclone propagation speed

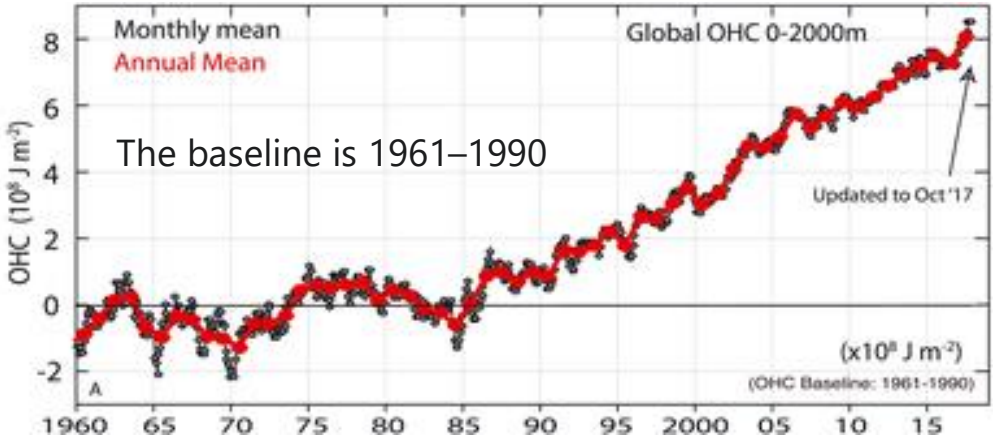
AIR

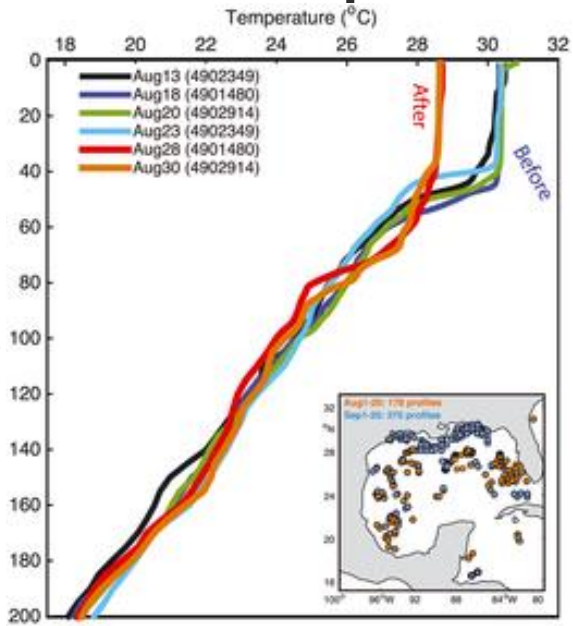
Tropical Cyclones and Precipitation in a Changing Climate

Before Harvey SST > 30°C **+4°C**

After Harvey SST = 28.5°C **+2.5°C**

Increase in Ocean Heat Content (OHC)





Trenberth, K.E., Cheng, L., Jacobs, P., Zhang, Y. and Fasullo, J., 2018. Hurricane Harvey links to ocean heat content and climate change adaptation. Earth's Future, 6(5), pp.730-744.

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Tropical Cyclones and Precipitation in the changing climate

Summary:

Warmer sea surface temperatures

\+ Higher ocean heat content

\+ Warmer air + more moisture = More potential precipitation

\+ Slower moving storms

\+ Increase in coastal populations and exposure

More energy to fuel the storms

More precipitation in a specific location

= Losses due to hurricane precipitation induced flooding will increase

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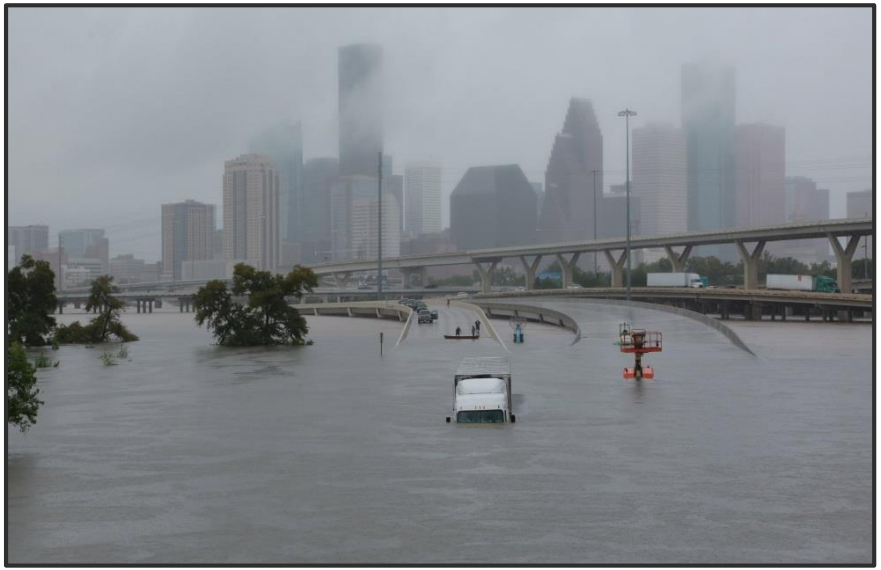
Tropical Cyclones and Precipitation in a Changing Climate

Harvey (2017)



Houston, Texas
Source: REUTERS/Richard Carson

Florence (2018)

Lumberton, North Carolina
Source: Washington Post

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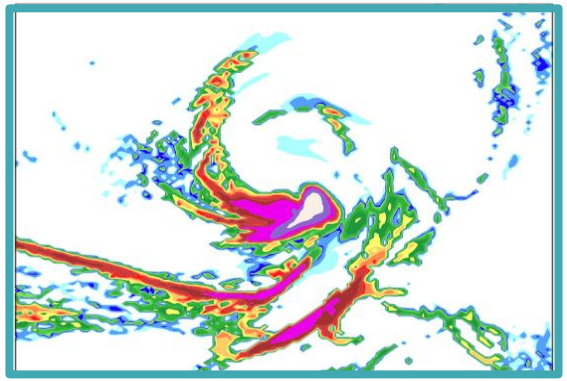
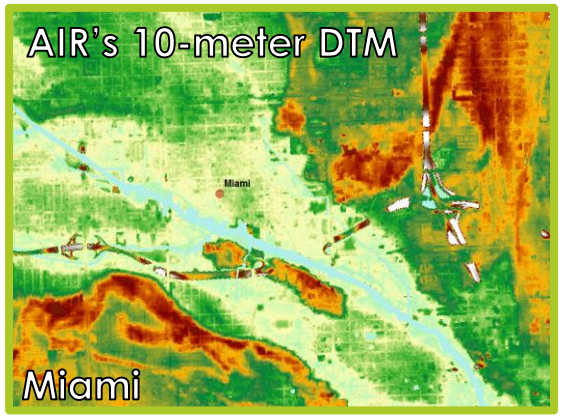
Inland Flooding in AIR's U.S. Hurricane Model

Inland Flooding Enhancements in AIR's U.S. Hurricane Model



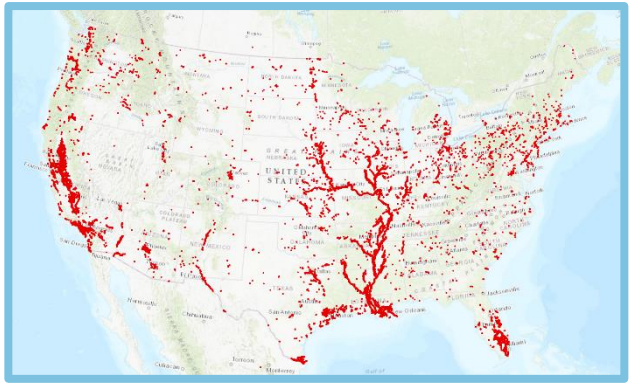


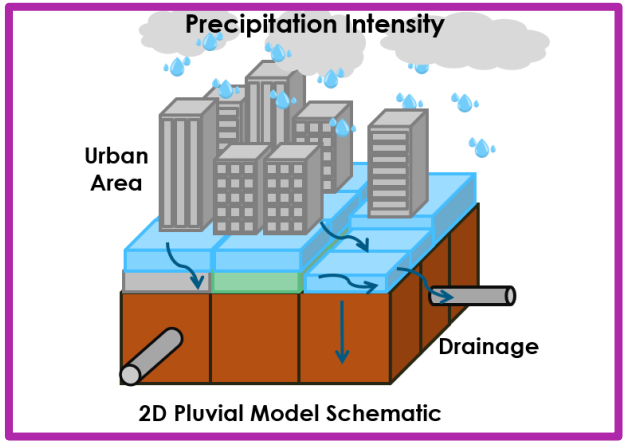
Precipitation is simulated using fully coupled GCM-NWP

Enhanced 10-meter high-resolution Digital Terrain Model

Extensive levee data set

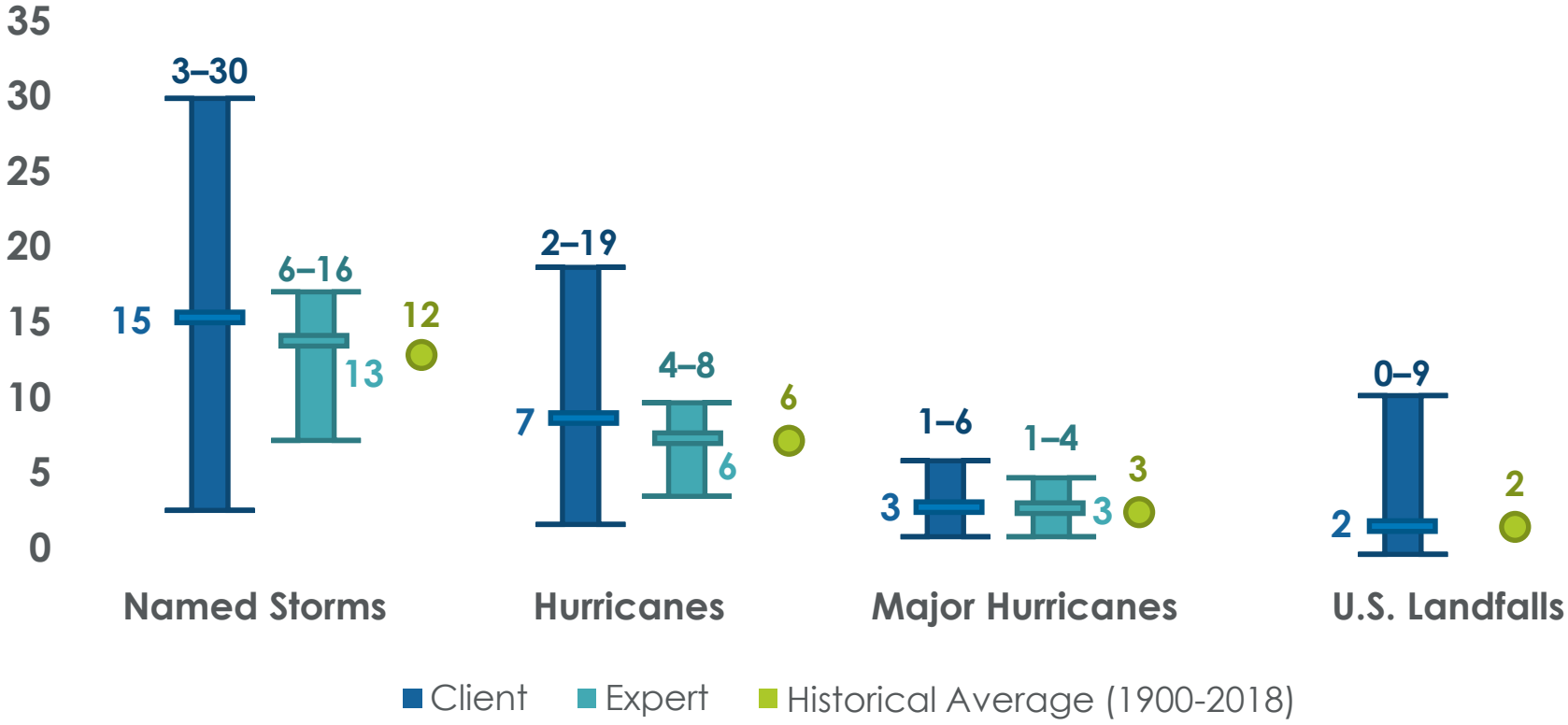
Flooding is simulated using a physically based 2D model





AIR Hurricane Contest

2019 AIR Hurricane Contest



Thank You!

A recording of today's webinar and the slide deck will be distributed shortly.

Thank you for submitting your questions online; they helped to shape today's content!

If your question isn't covered during Q&A, please reach out to your account rep or email airconference@air-worldwide.com.

Image source: Lannis Waters / The Palm Beach Post