FEMA

HURRICANE READINESS for Coastal Communities

L0311

ADMIN DETAILS

- **Online Course Application – NETC-EMI**
  - Replaces paper application
  - Student Identification (SID) Number required
- **EMI Evaluation Form (Scantron)**
  - Evaluate instruction and content
  - Provide comments and suggestions
- **EMI Certificate**
  - Must attend the entire course to receive credit
  - Submit an online application
  - EMI certificates will be sent via email

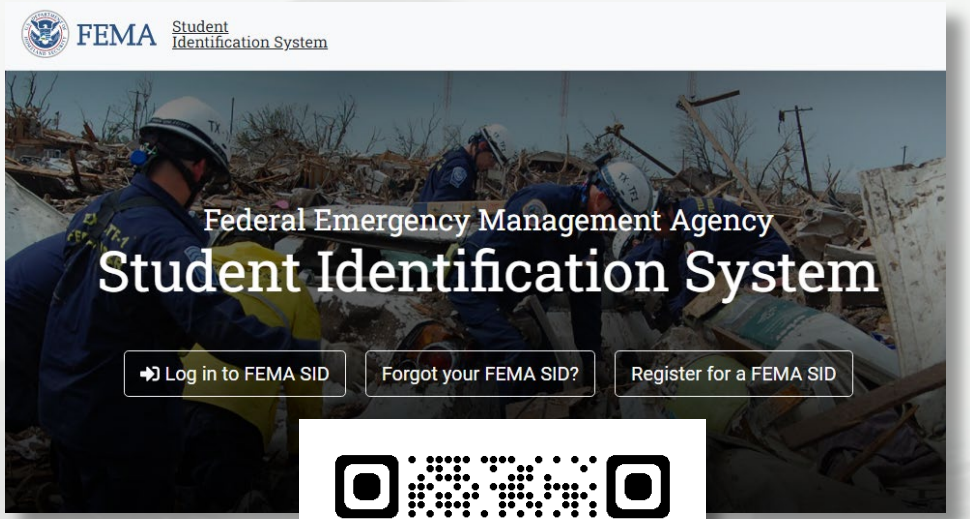
ONLINE NETC–EMI APPLICATION

- https://training.fema.gov/GeneralAdmissionsApplication/
- Applications must be completed within 14 days following the end of the course to get EMI credit
- Student Identification (SID) number is required

https://training.fema.gov/GeneralAdmissionsApplication/staticforms/startapplication.aspx

STUDENT IDENTIFICATION (SID)

- **https://cdp.dhs.gov/femasid**
- **Select 'Register for a FEMA SID'**
  - Follow instructions and you will receive an email with your SID #
- **If you think you have an SID #**
  - Call 866.291.0696



https://cdp.dhs.gov/femasid

HURRICANE READINESS
EMI Evaluation Form

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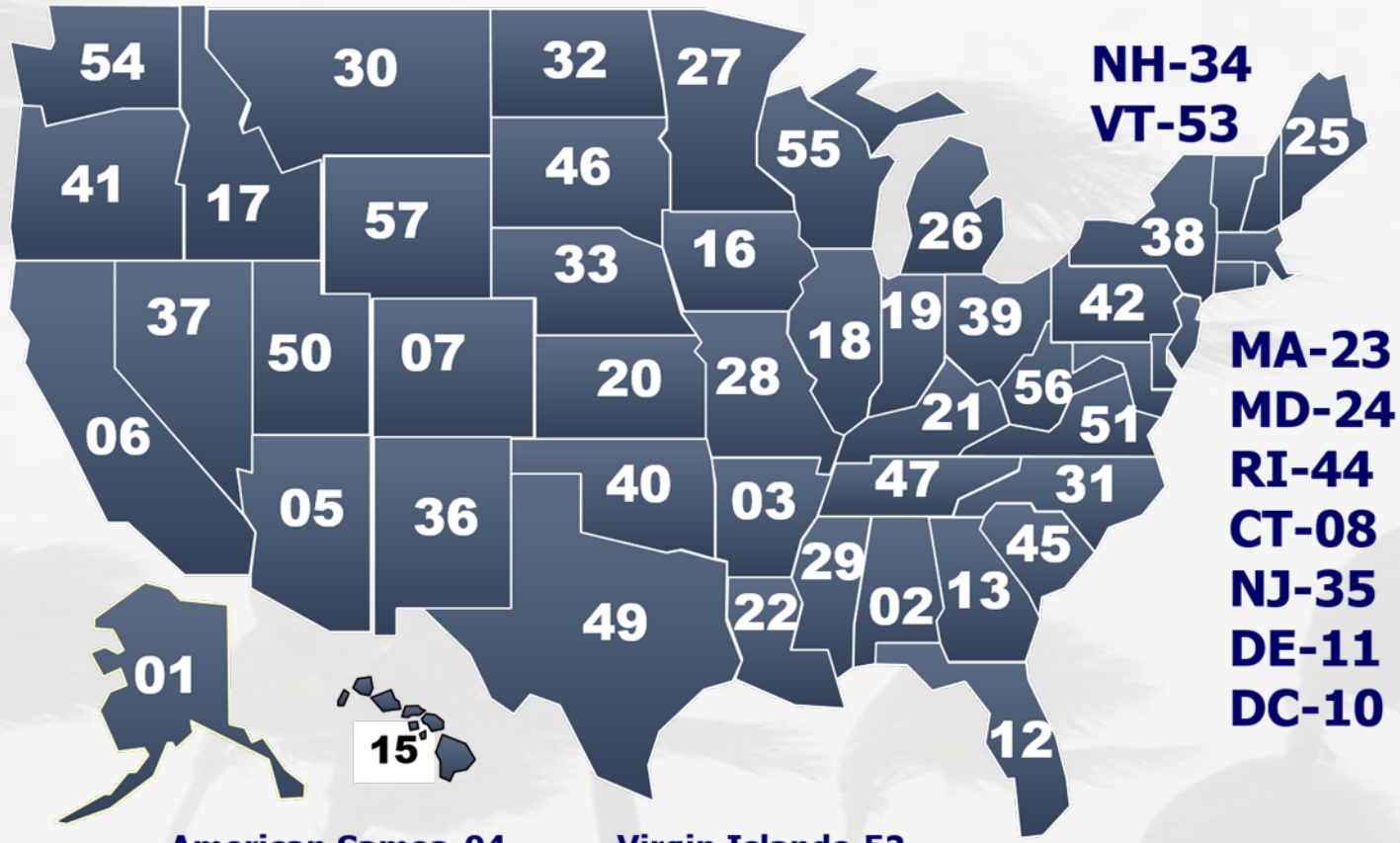
STATE CODES

- Evaluation: Block #3 – Work Location



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TRAINING MATERIALS

- **Download PDFs of presented materials**
  https://www.nhc.noaa.gov/outreach/

NATIONAL HURRICANE CENTER and
CENTRAL PACIFIC HURRICANE CENTER
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

https://www.nhc.noaa.gov/outreach/

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HURRICANE READINESS for Coastal Communities

L0311

HURRICANE READINESS

Hurricane Basics

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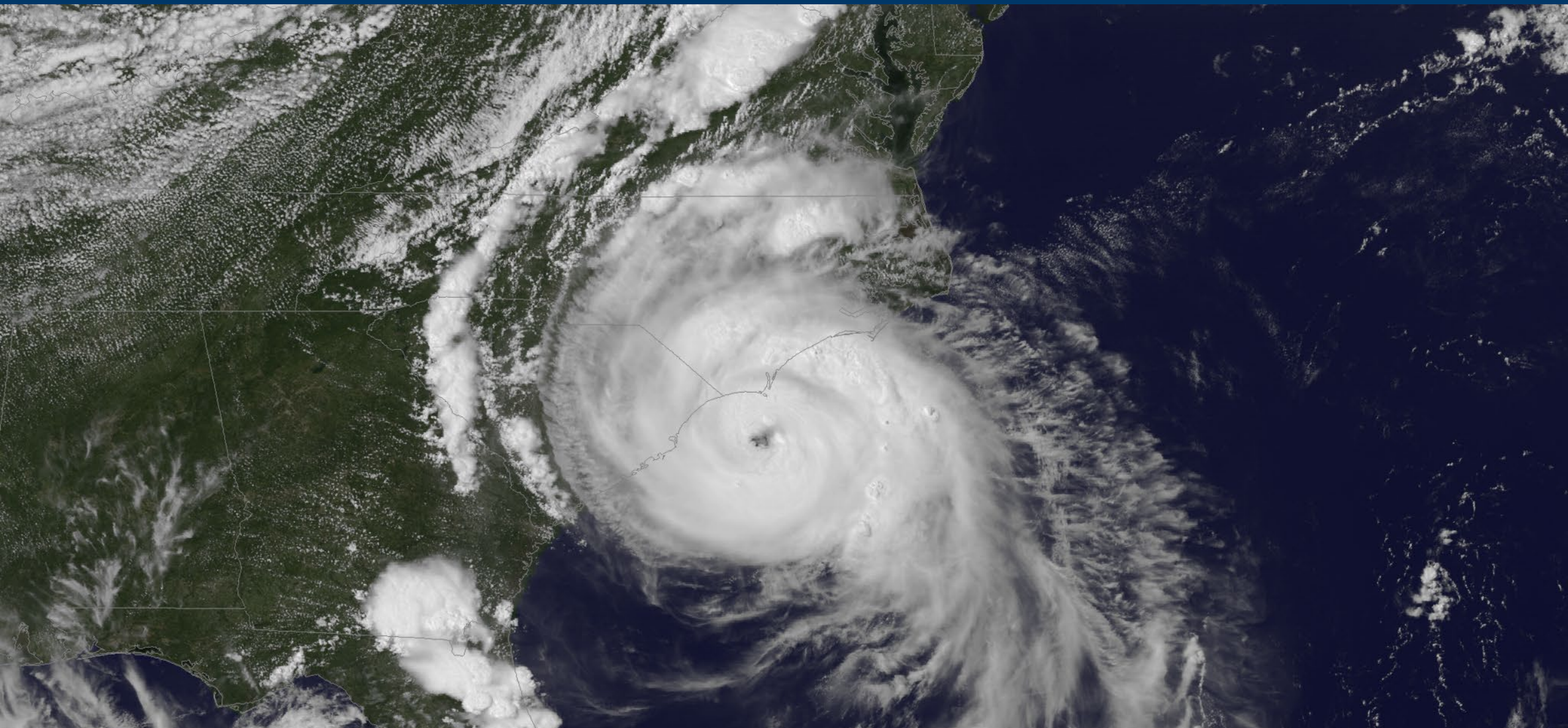

HURRICANE READINESS

There is a Storm. What's the Info?

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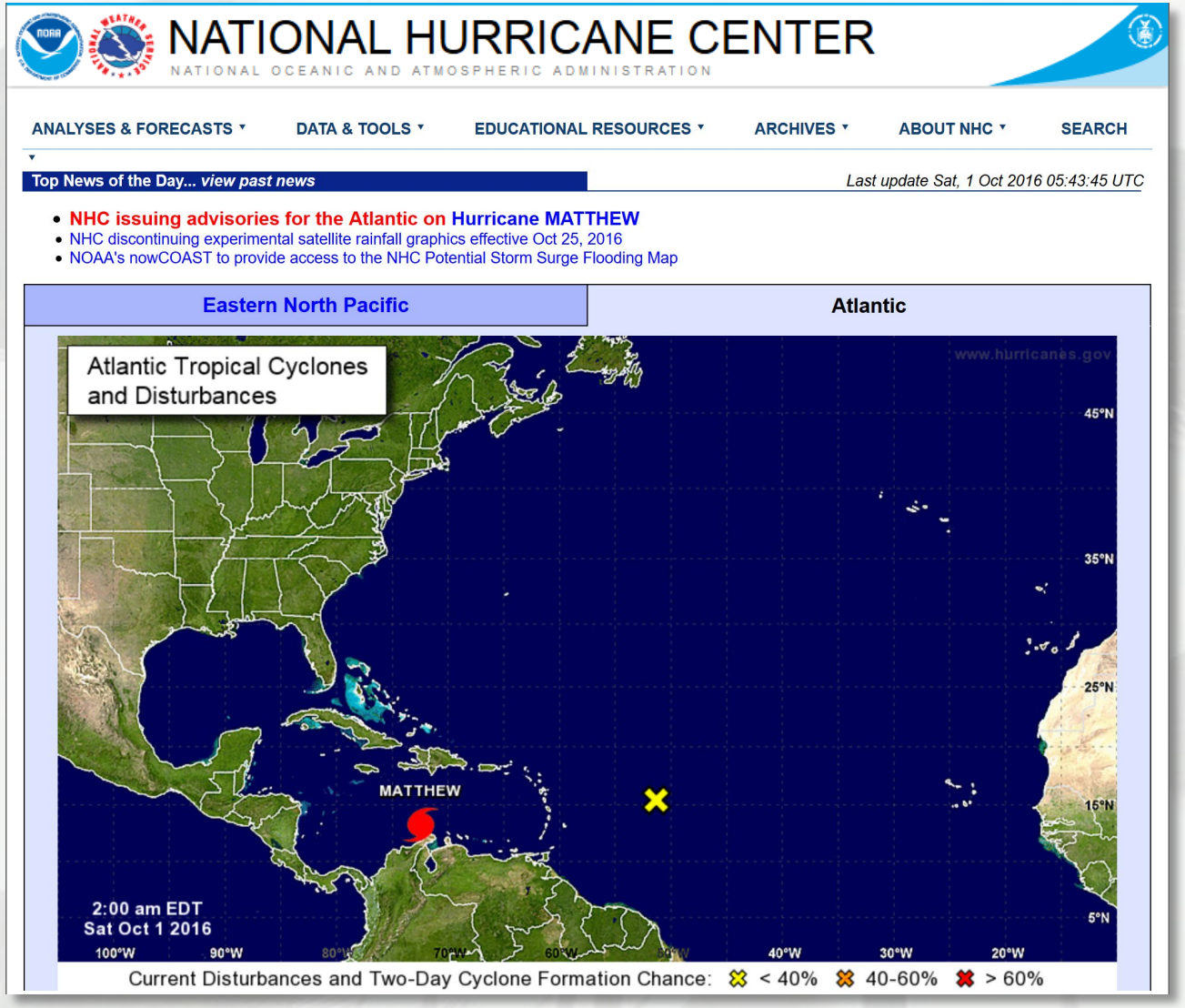

HURRICANE READINESS

Forecast Uncertainty. What, Me Worry?

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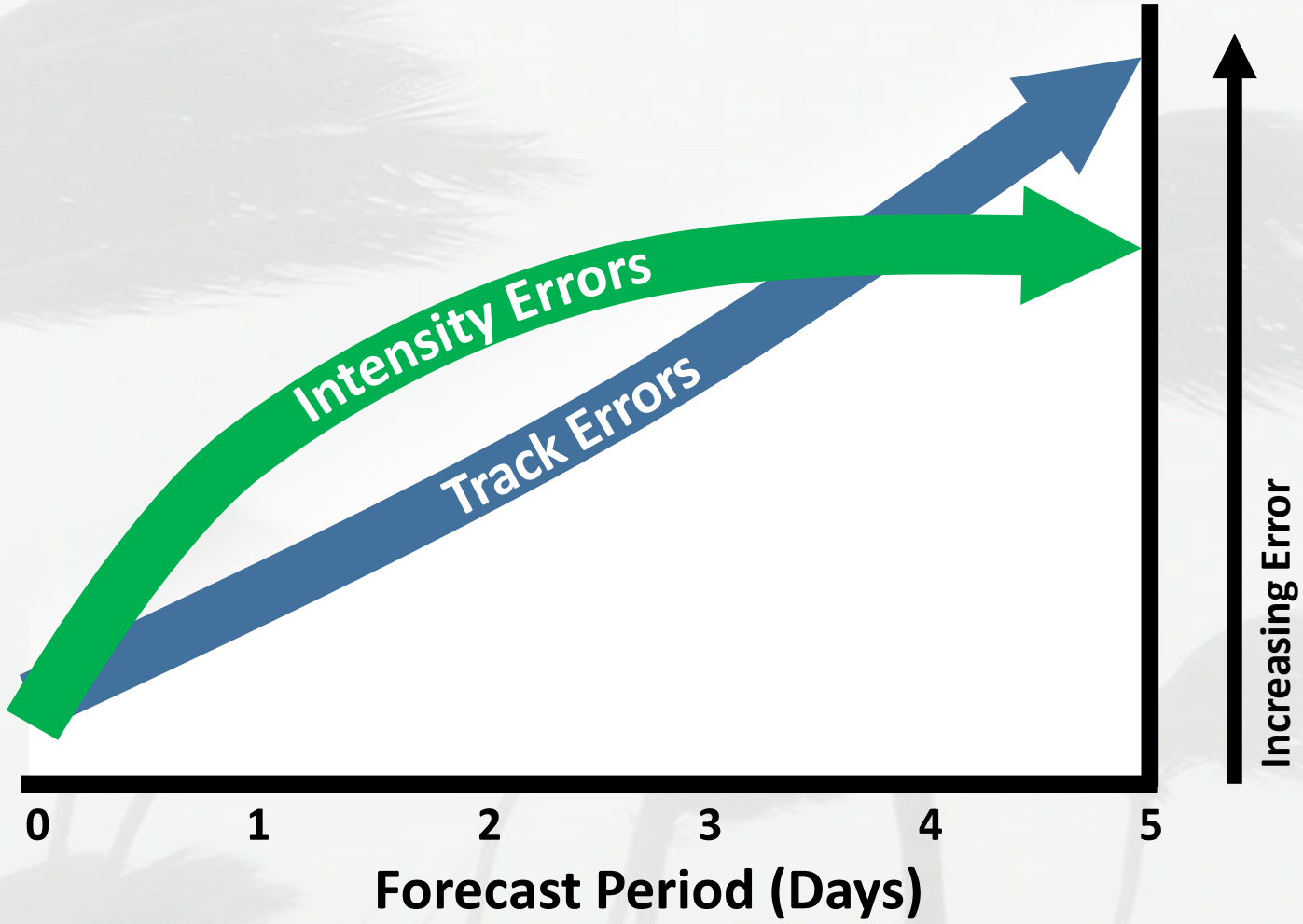

HURRICANE READINESS
Making Better Decisions

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HURRICANE READINESS
L0311

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AGENDA

- **Hurricane Basics**
  Lifecycle, Climatology, and Hazards
  830 am – 10 am
- **Overview of NWS Tropical Products**
  There is a Storm. What's the info?
  1030 am – 12 pm
- **Forecast Uncertainty. What, Me Worry?**
  130 pm – 3 pm
- **Making Better Decisions**
  Hurricane Evacuation Studies and Hurrevac
  330 pm – 5 pm

HURRICANE READINESS
Meet the Instructors

FEMA

INSTRUCTORS

HEATHER NEPAUL
National Hurricane Center
Storm Surge Specialist

BRAD REINHART
National Hurricane Center
Hurricane Specialist

DANIEL BROWN
National Hurricane Center
Hurricane Specialist

JOHN CANGIALOSI
National Hurricane Center
Hurricane Specialist

CHRISTINA FINCH
FEMA National Hurricane
Program Manager

HMARIE HARKENRIDER
FEMA Emergency
Management Institute

MATTHEW GREEN
FEMA Hurricane
Liaison Team

TIFFANY O'CONNOR
FEMA Hurricane
Liaison Team

CHRIS MOORE
FEMA R2 Hurricane
Program Manager

FEMA

UNIT ONE
Hurricane Basics

HURRICANE BASICS

Life Cycle. Climatology. Hazards.

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TROPICAL CYCLONES

- **Large, long-lived low pressure system**
  (Can be hundreds of miles wide, lasting for days)
- **Forms over sub/tropical oceans**
- **No fronts attached**
- **Produces organized thunderstorm activity**
- **Has a closed surface wind circulation around a well-defined center**

TROPICAL CYCLONES
Classified by Maximum Wind Speed

FEMA

- **Tropical Depression: < 39 mph**
- **Tropical Storm: 39-73 mph**
- **Hurricane: 74 mph or greater**
  - ***Major Hurricane: 111 mph or greater***

TROPICAL CYCLONES
Surface Circulation? Organized?

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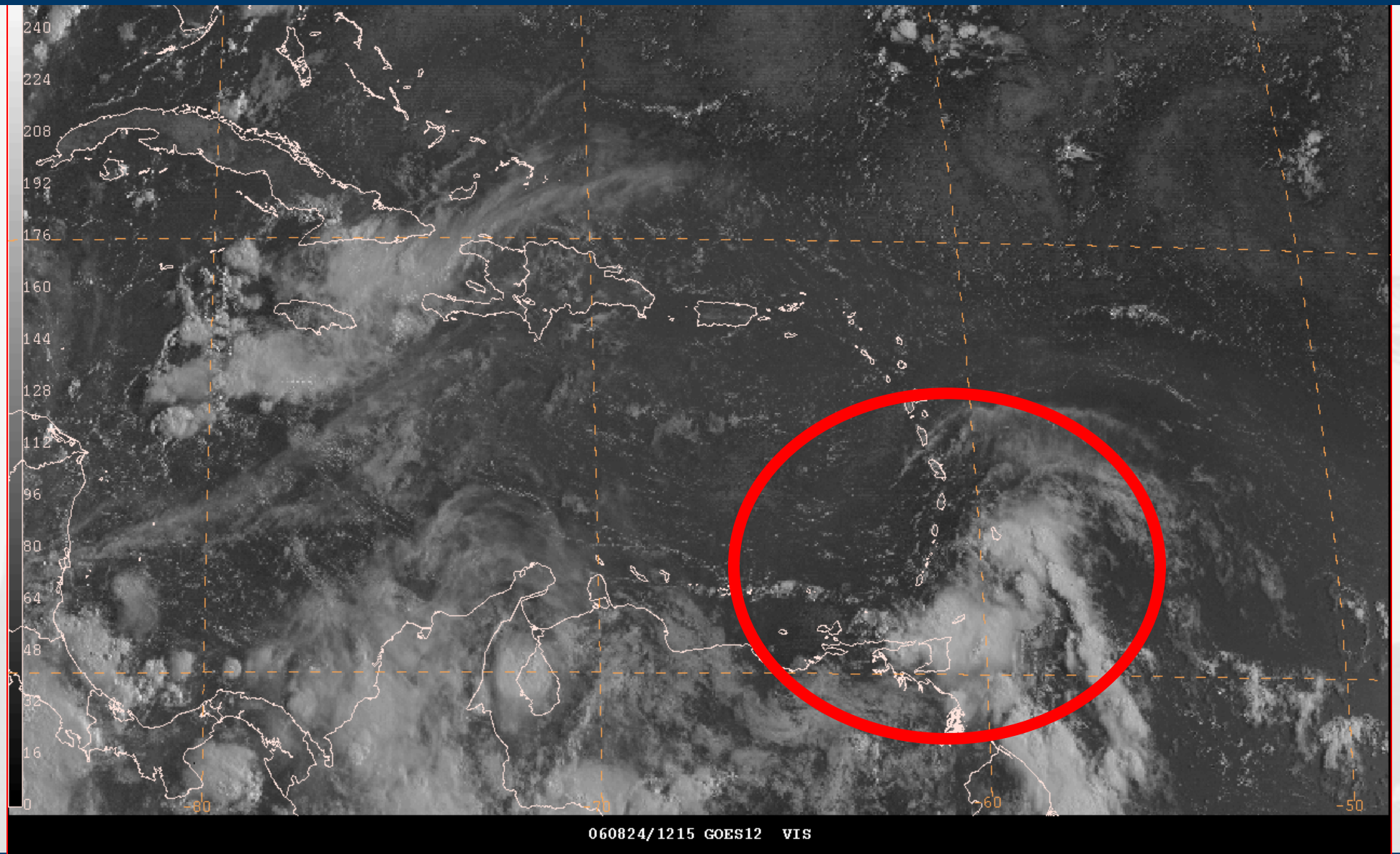
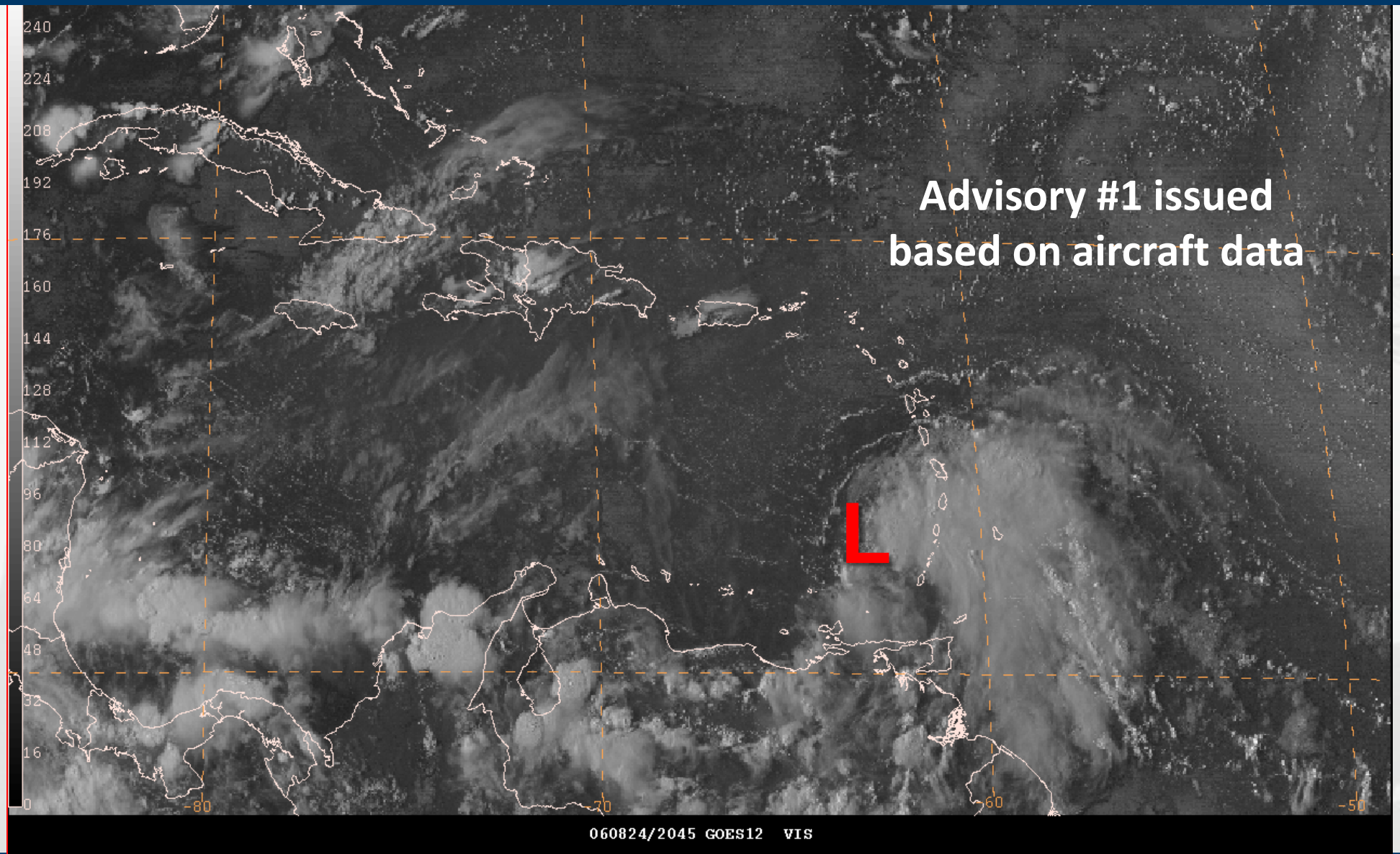


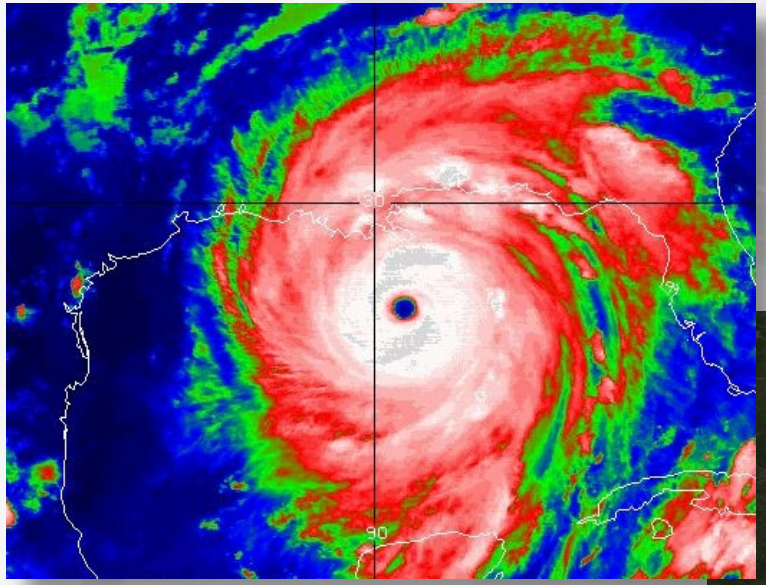
TROPICAL CYCLONES
Ernesto 2006

FEMA

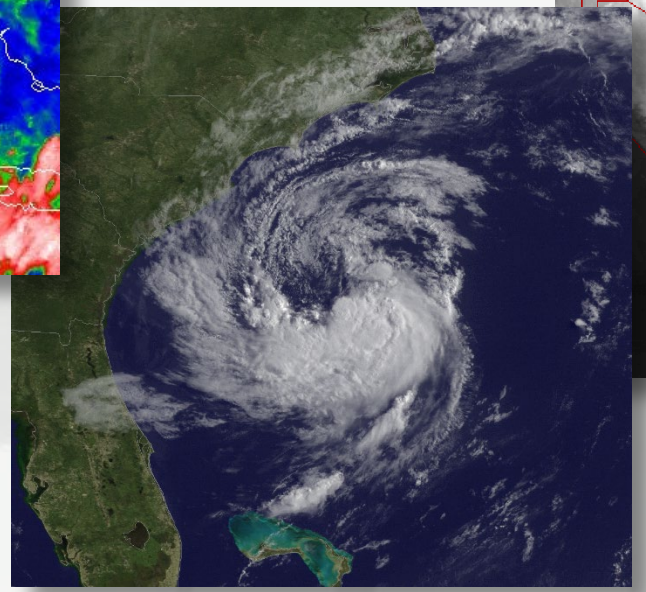


Advisory #1 issued based on aircraft data

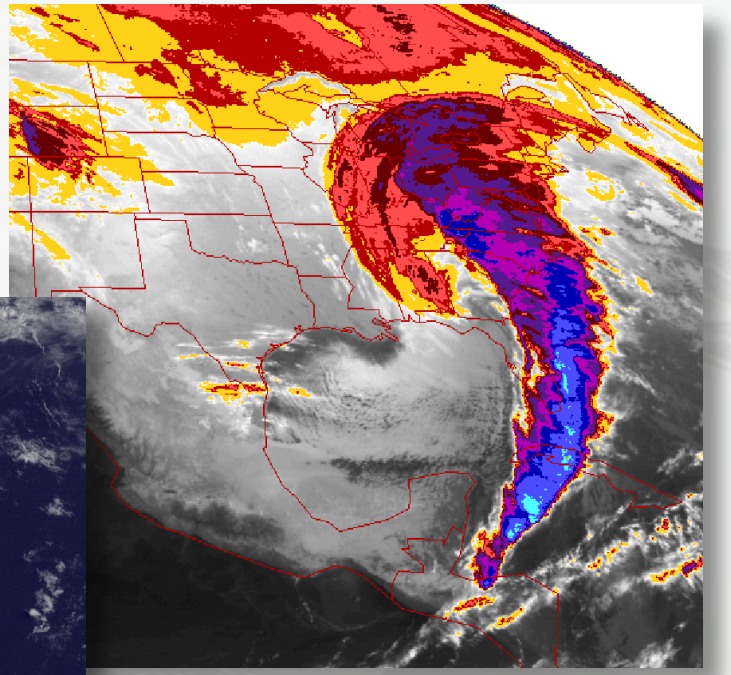
CYCLONES
Tropical, Subtropical and Extratropical



Hurricane Katrina 2005



Subtropical Storm Ana 2015



March Superstorm 1993

TROPICAL CYCLONES

Atlantic since 1851. Pacific since 1949.

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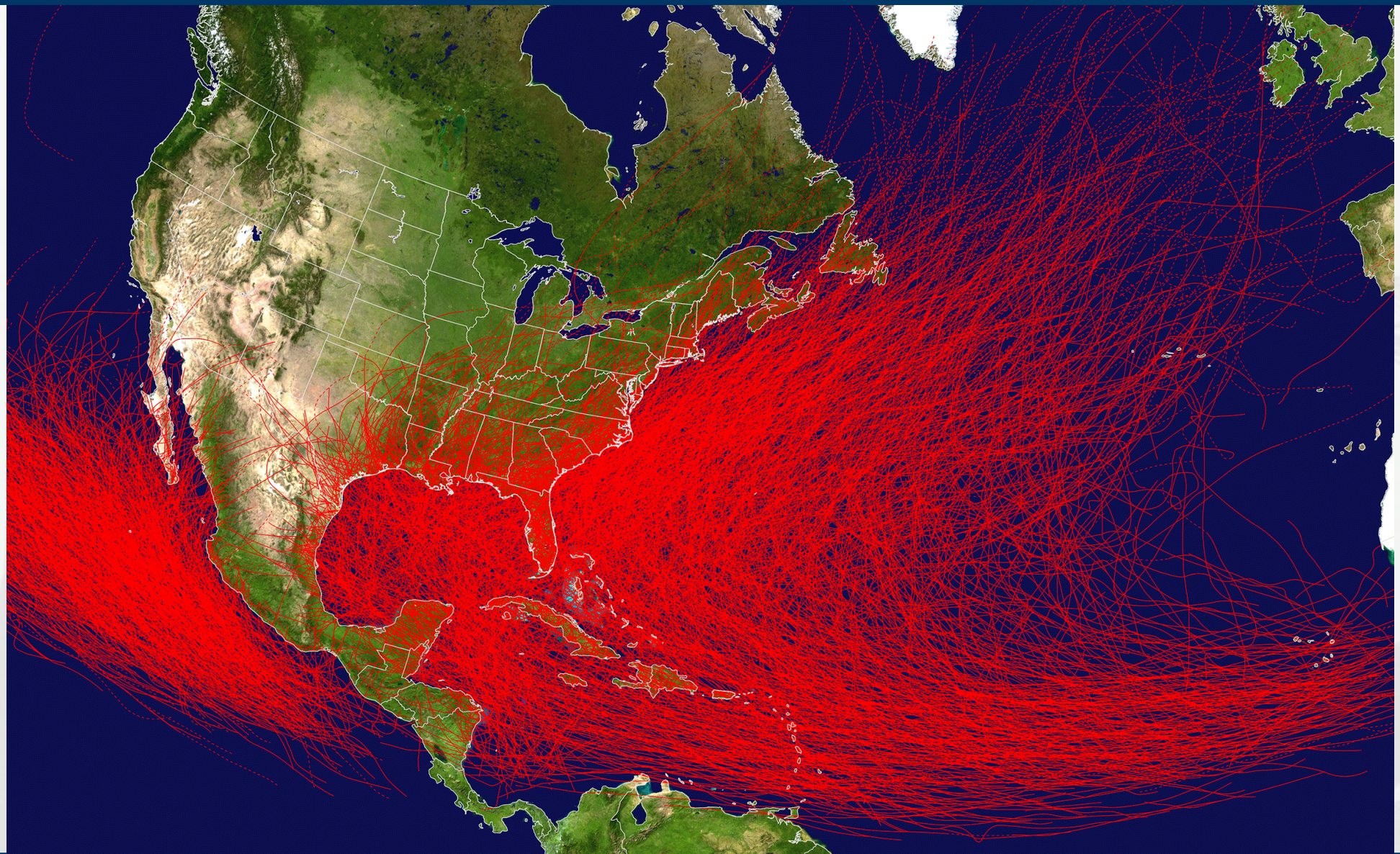
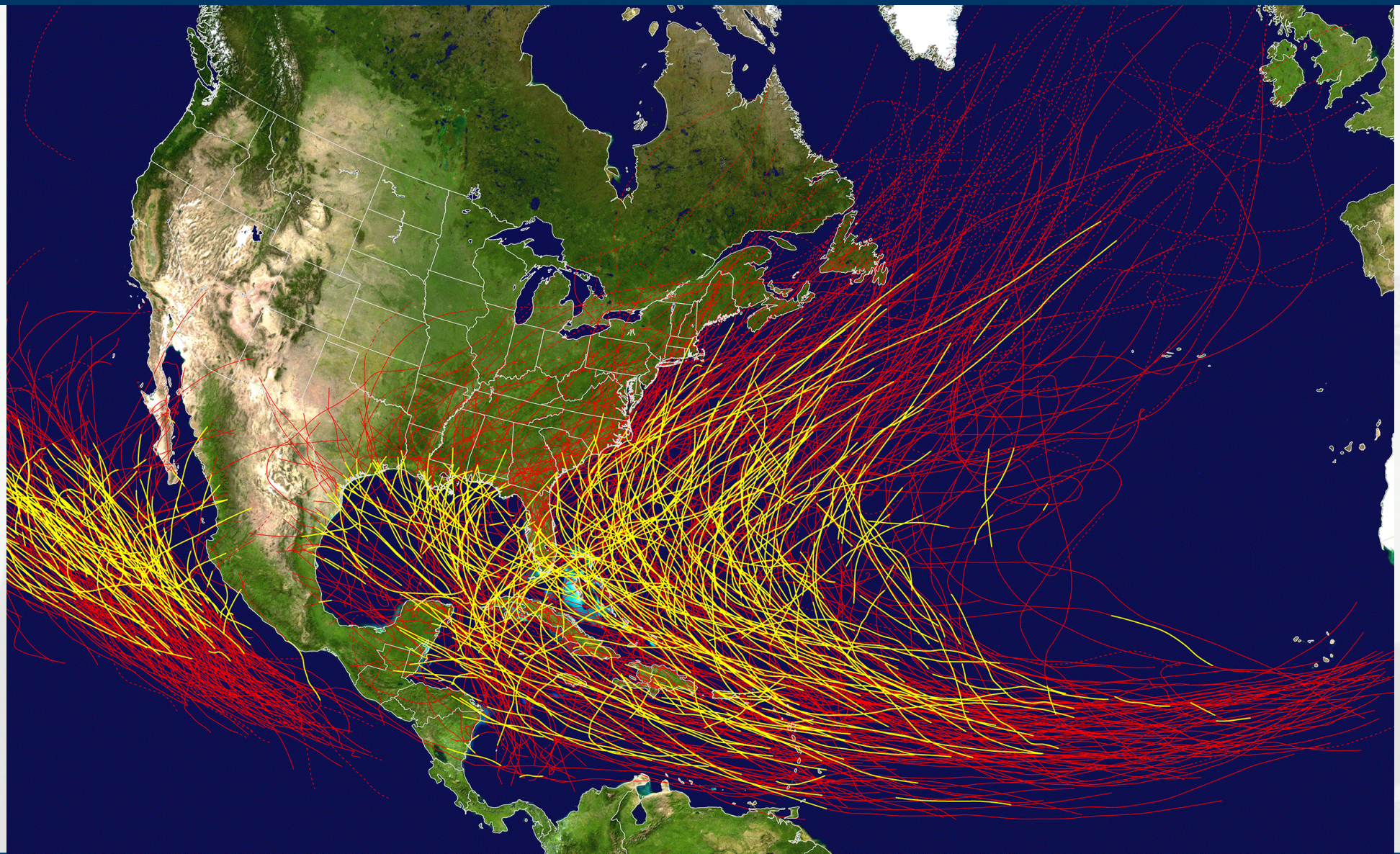


MAJOR HURRICANES

Atlantic since 1851. Pacific since 1949.

FEMA



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QUIZ QUESTION

What month has the most hurricane activity in the Atlantic?

A. December

B. August

C. June

D. September

CLIMATOLOGY
Atlantic Hurricanes & Tropical Storms

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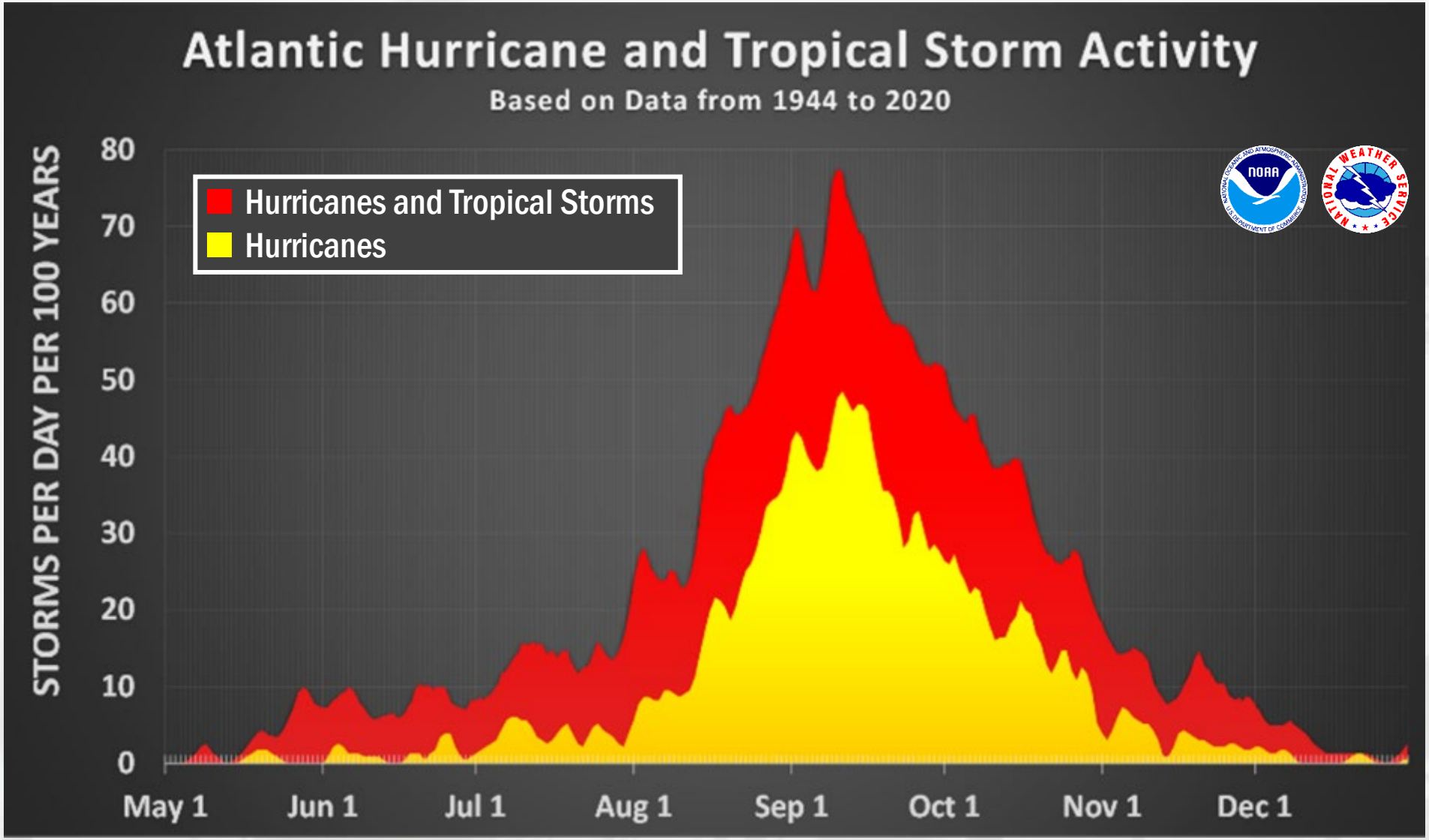
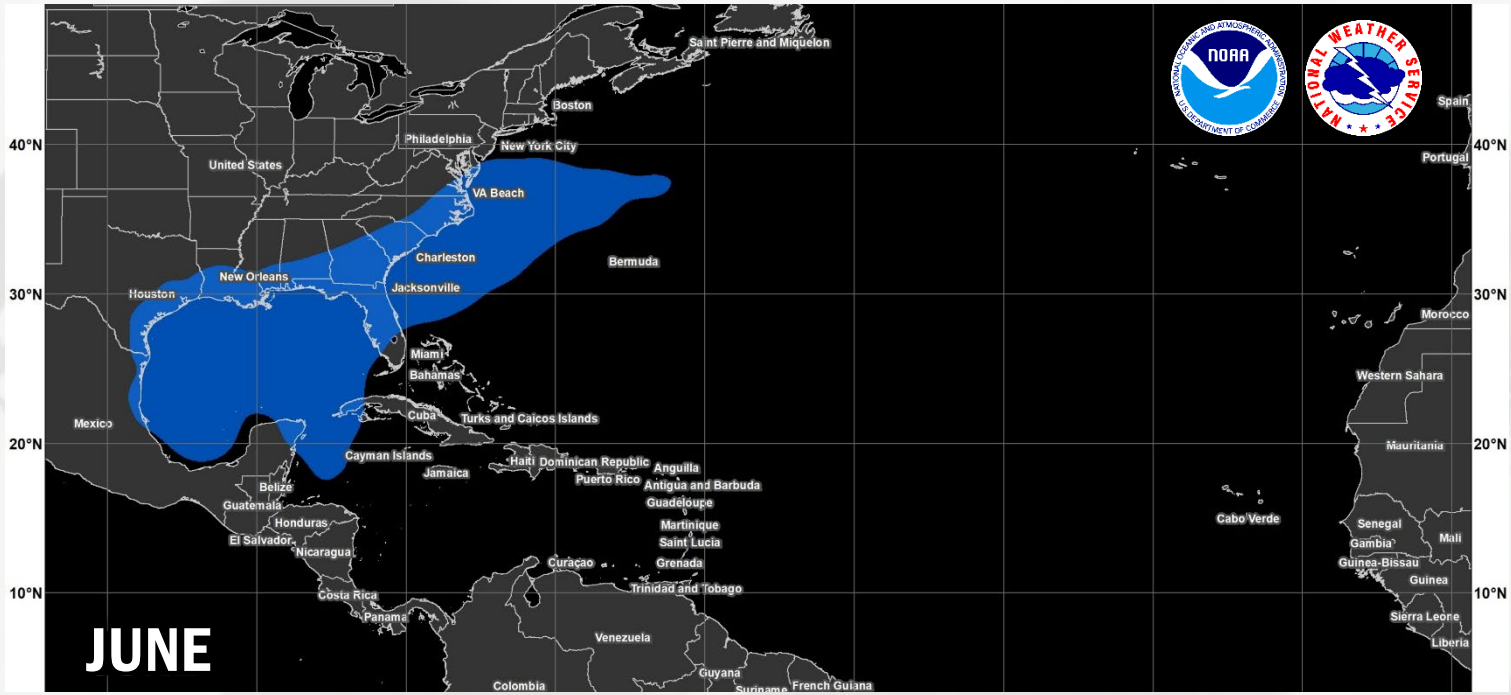
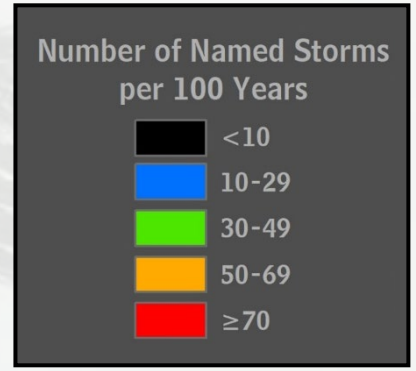


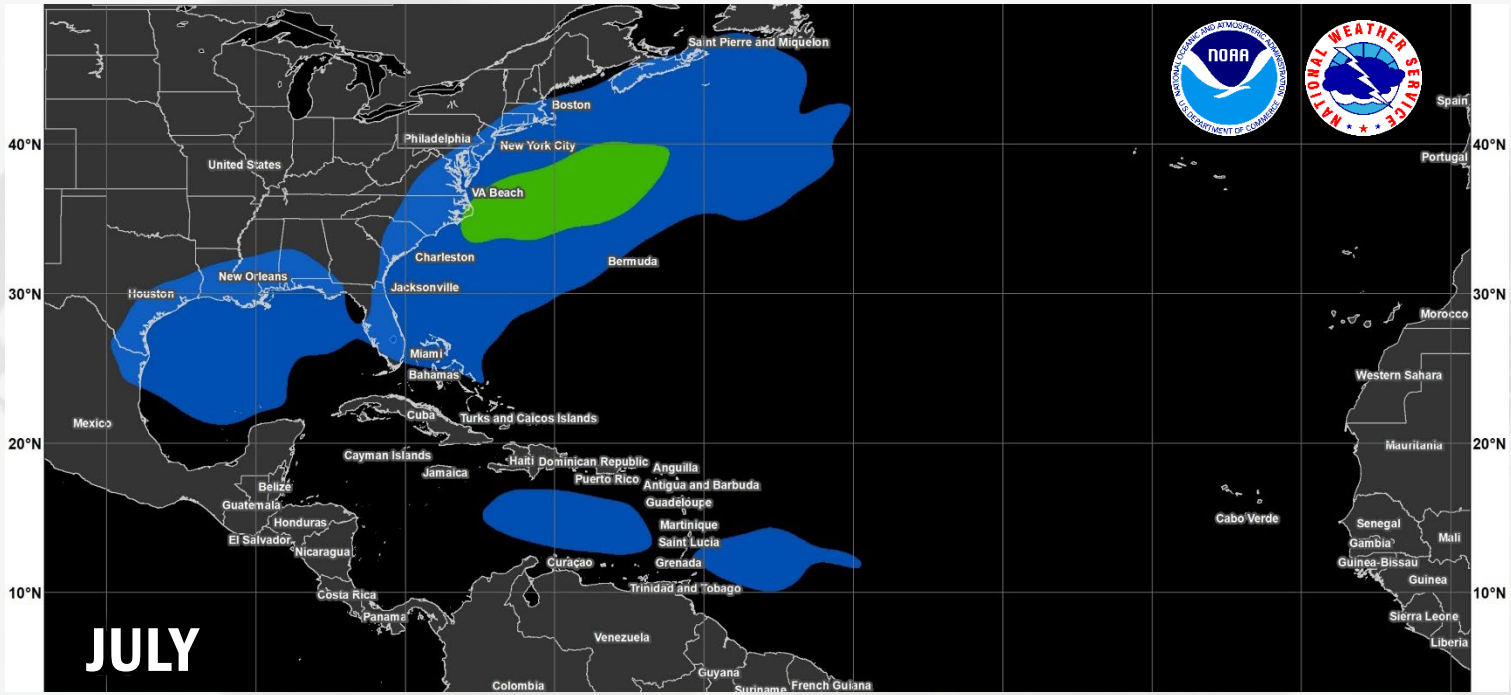
CLIMATOLOGY
June Occurrence Areas

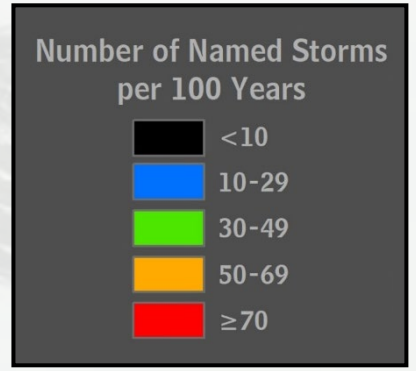




- On average 1 storm per year
- Typically limited to the NW Caribbean Sea and Gulf of Mexico

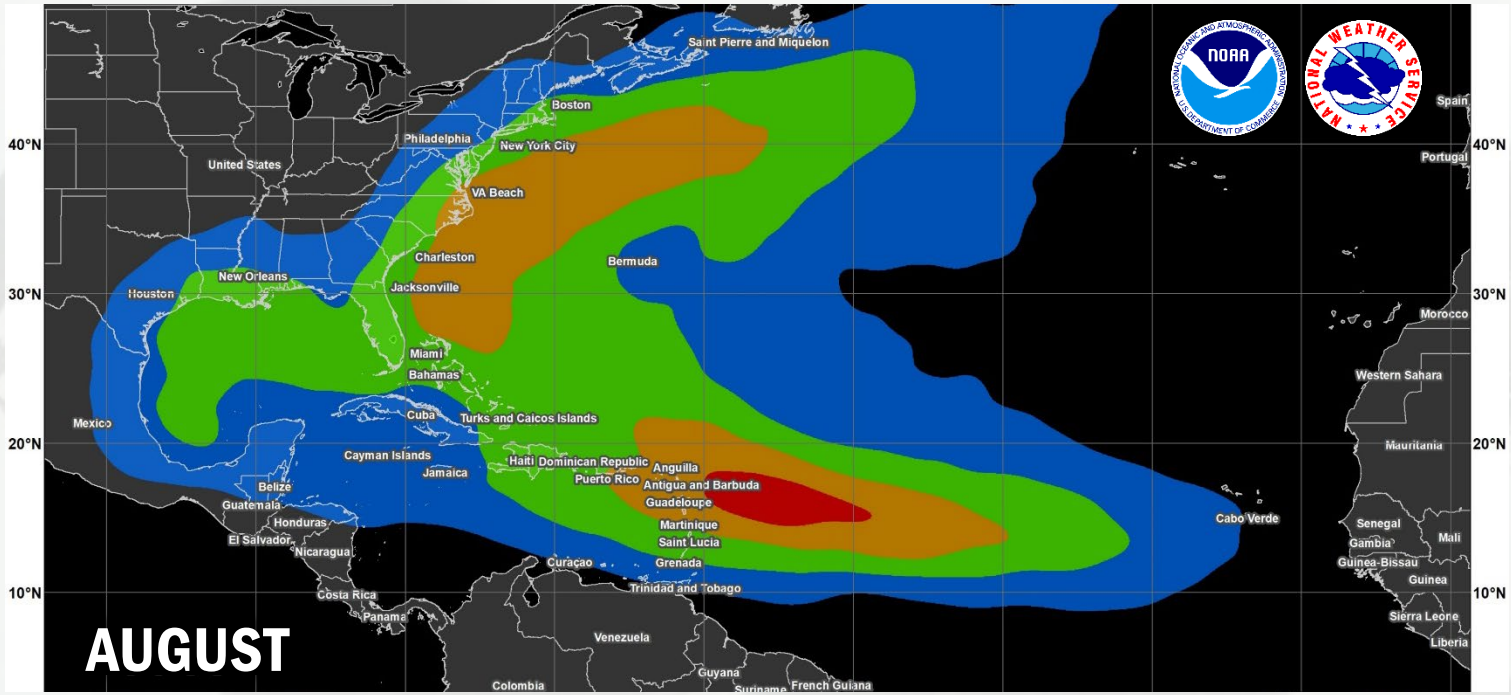
CLIMATOLOGY
July Occurrence Areas

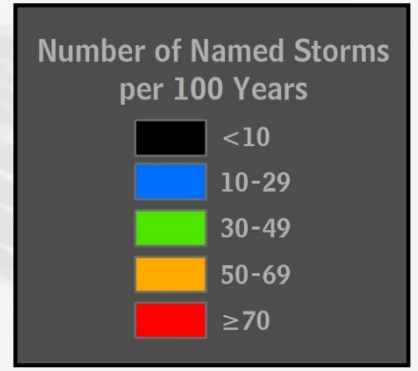




- On average 1-2 storms every year
- Activity spreads east and covers the western Atlantic, Caribbean, and Gulf of Mexico

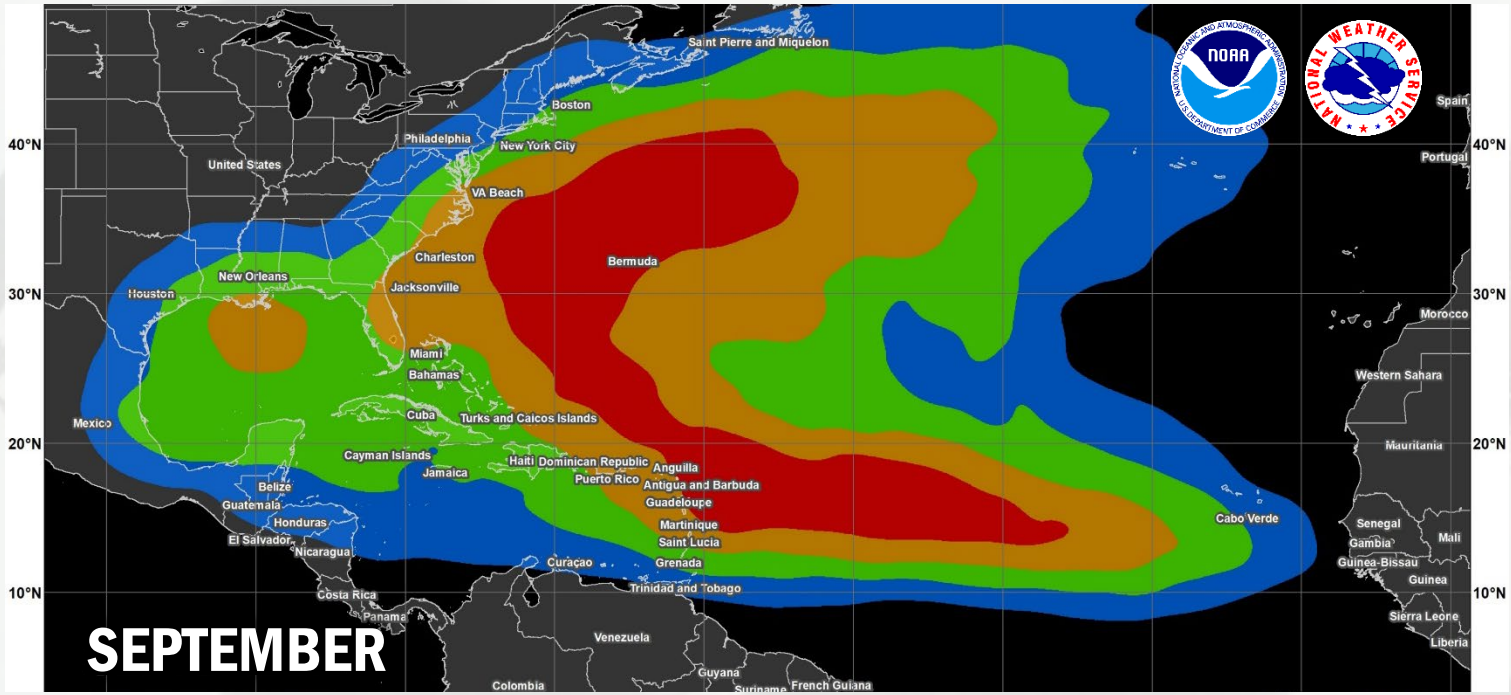
CLIMATOLOGY
August Occurrence Areas

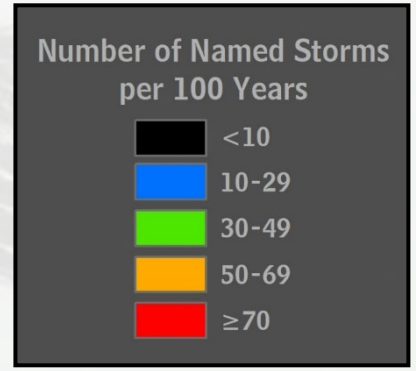




- On average 3-4 storms every year
- Activity increases across the basin as the Cape Verde season typically begins

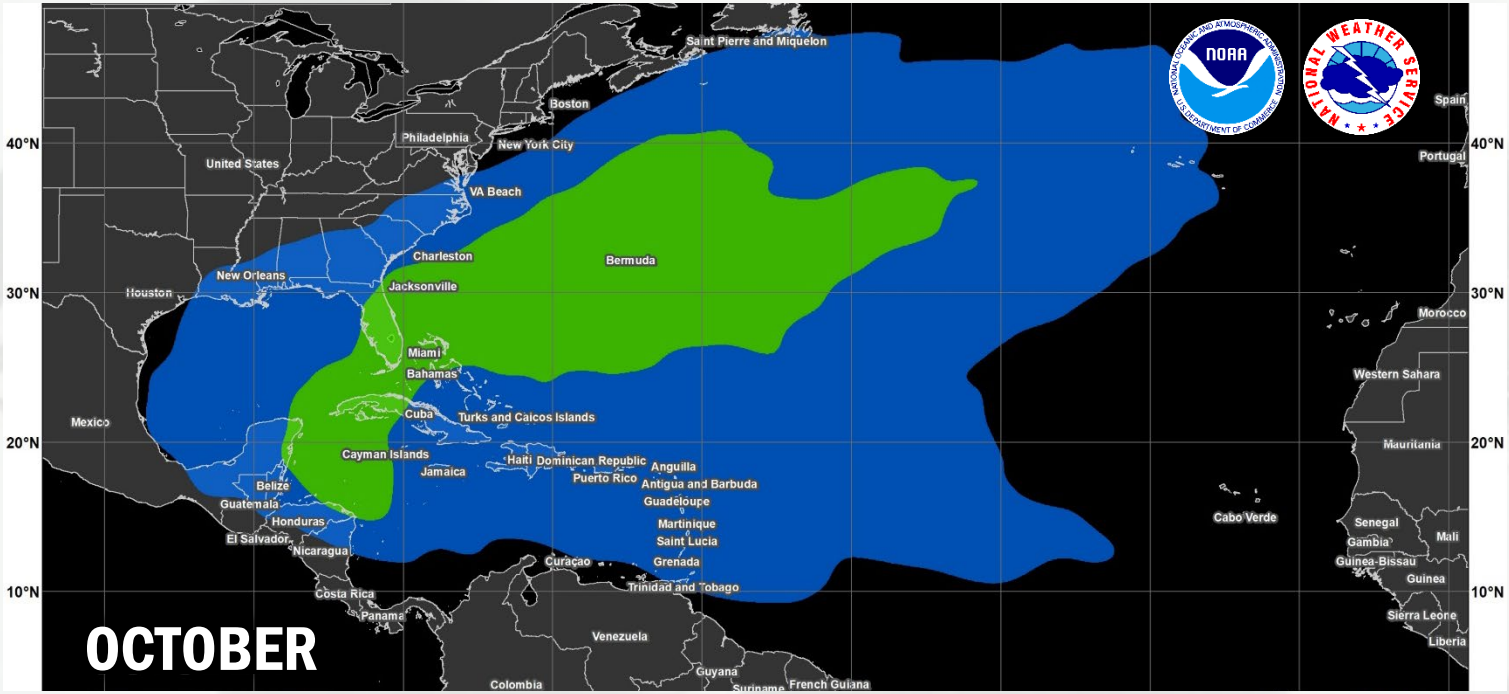
CLIMATOLOGY
September Occurrence Areas

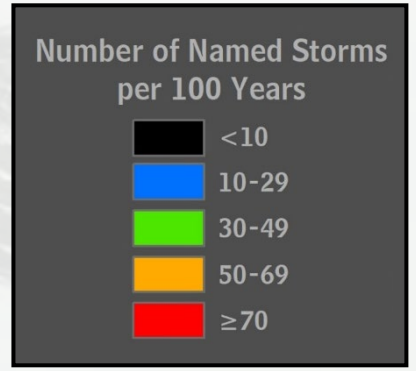




- Climatological peak of the season; on average 4-5 storms
- Storms can occur nearly anywhere in the basin; Long track Cape Verde storms are more likely

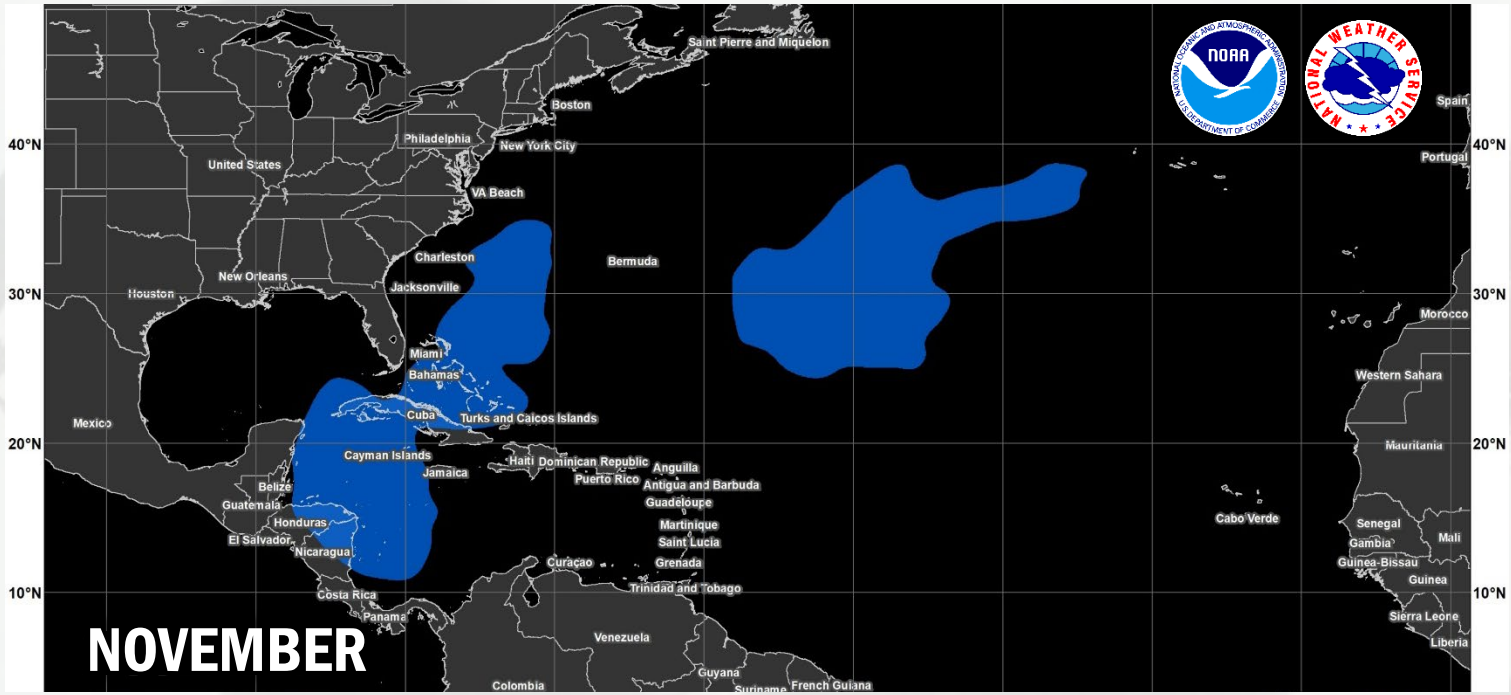
CLIMATOLOGY
October Occurrence Areas

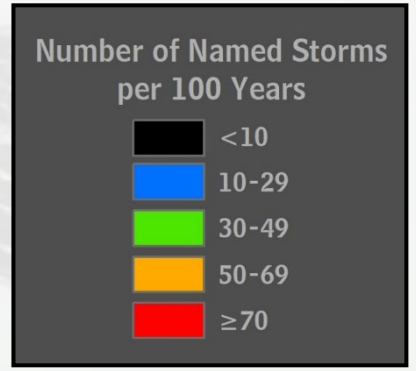




- On average 2-3 storms each year
- Cape Verde season ends. Activity shifts back to the western Atlantic, Caribbean, and Gulf of Mexico

CLIMATOLOGY
November Occurrence Areas



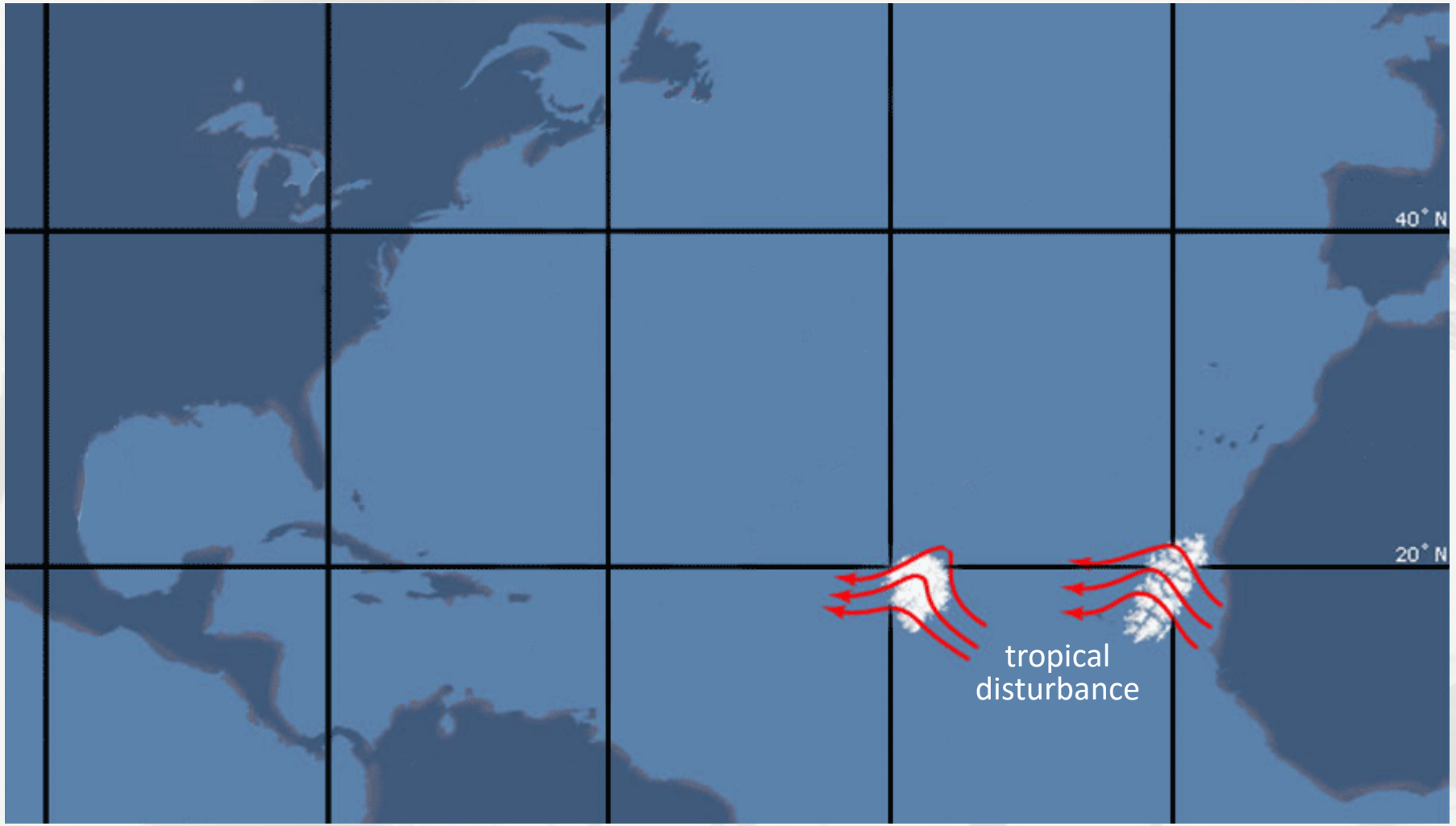


- On average about 1 storm per year
- Typically limited to the western Caribbean, southwestern and central Atlantic

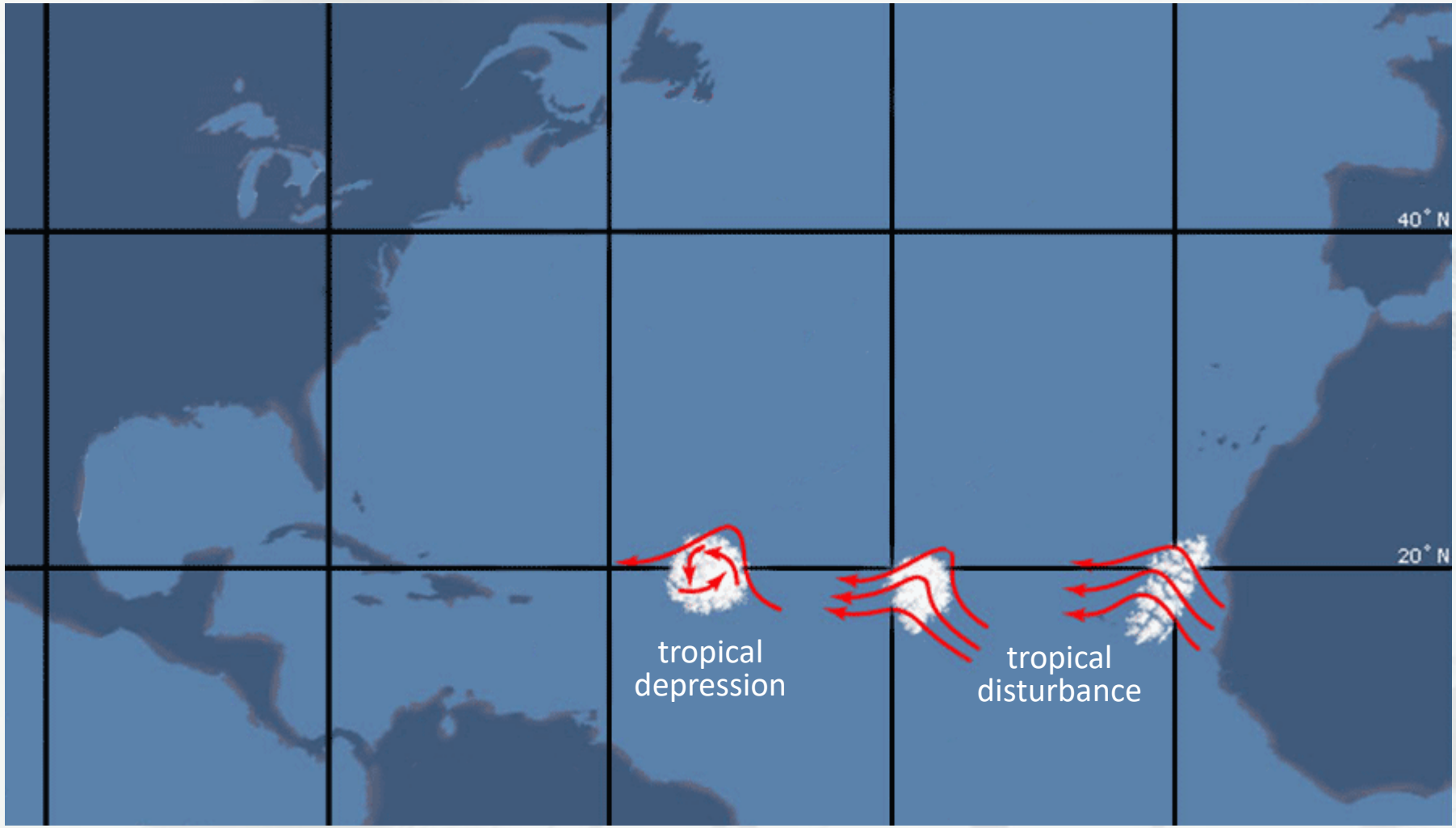
HURRICANE LIFECYCLE
Cape Verde Hurricanes

FEMA

HURRICANE LIFECYCLE
Cape Verde Hurricanes

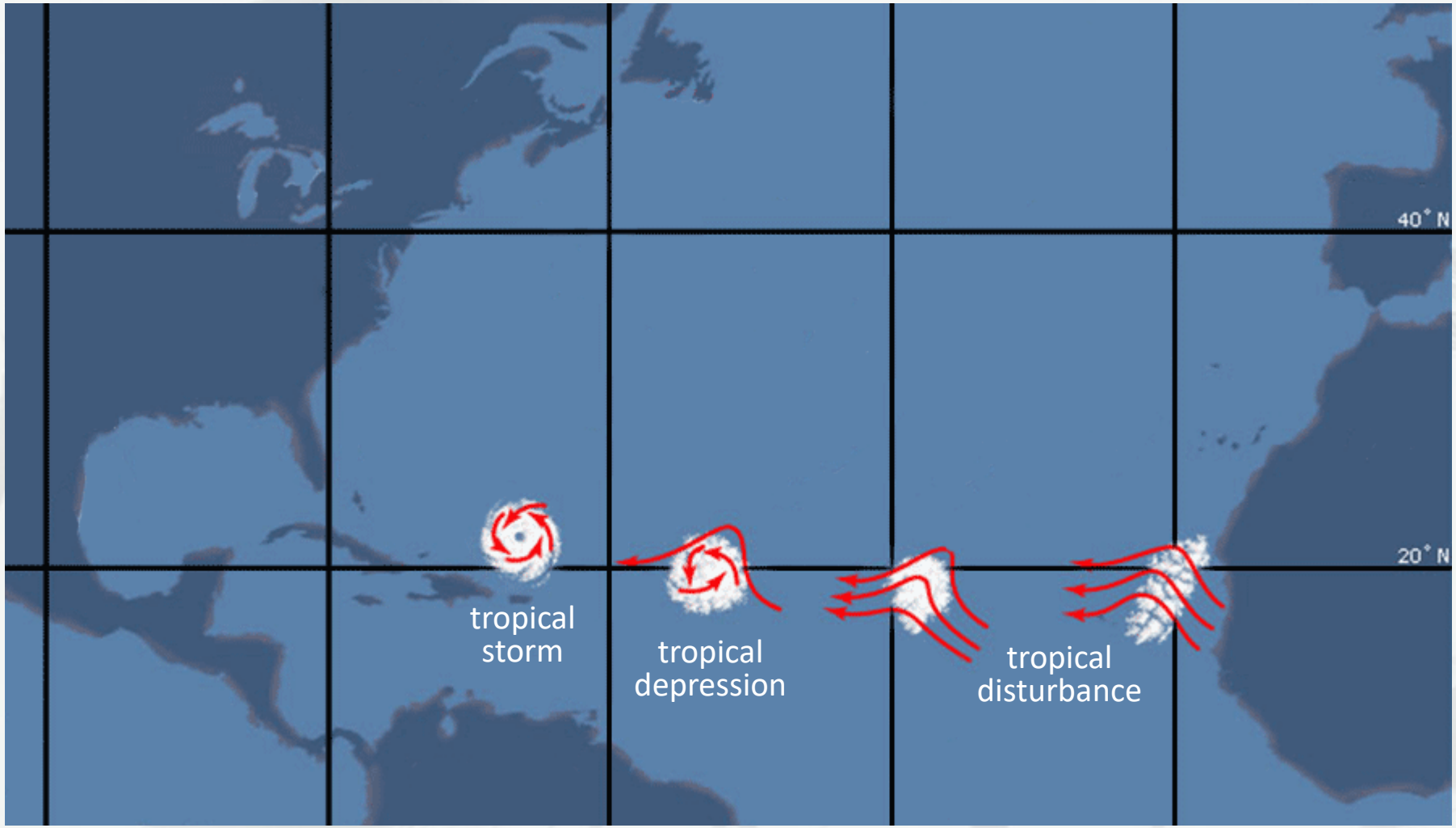


HURRICANE LIFECYCLE
Cape Verde Hurricanes



HURRICANE LIFECYCLE
Cape Verde Hurricanes

FEMA



HURRICANE LIFECYCLE
Cape Verde Hurricanes

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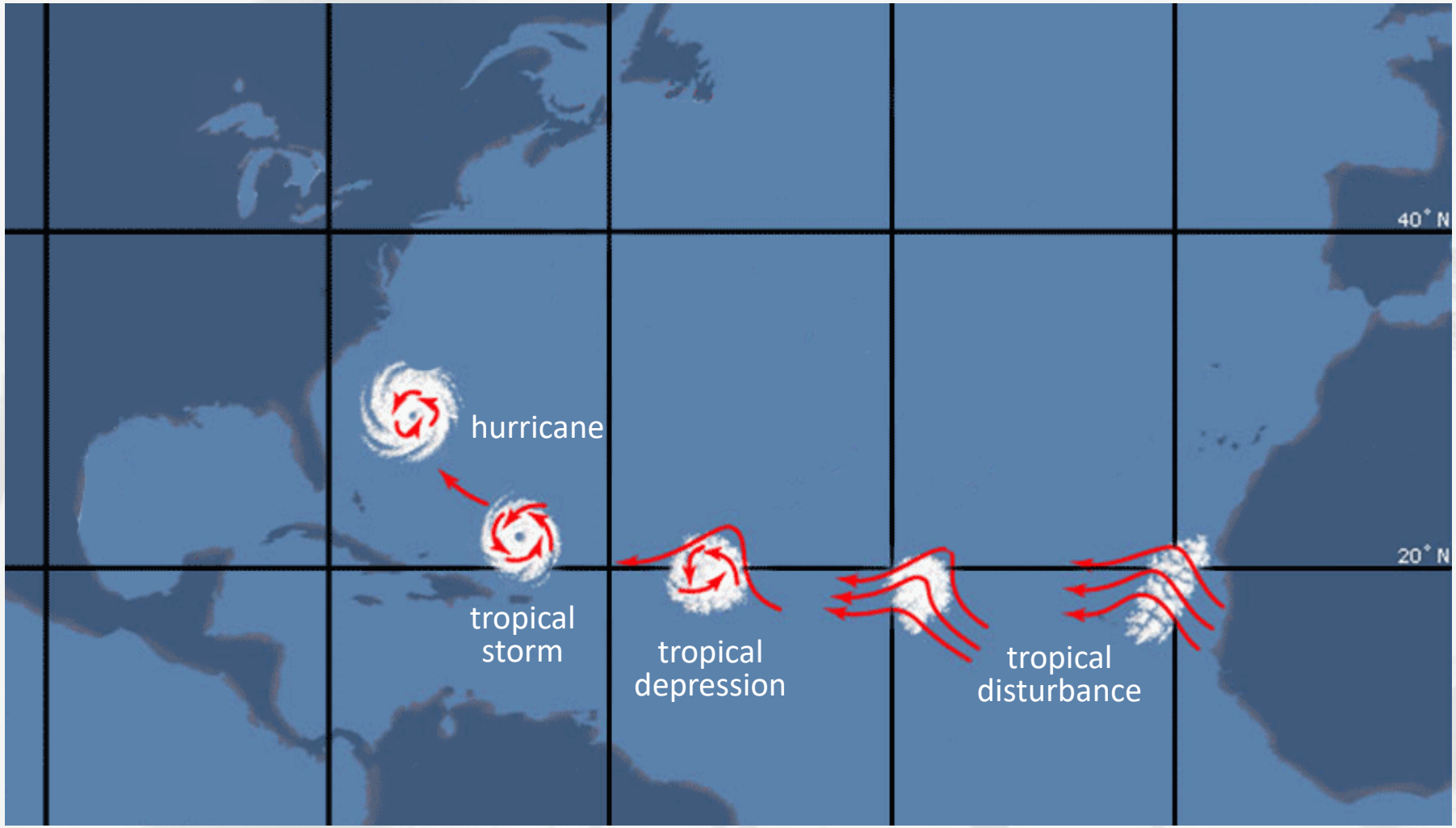
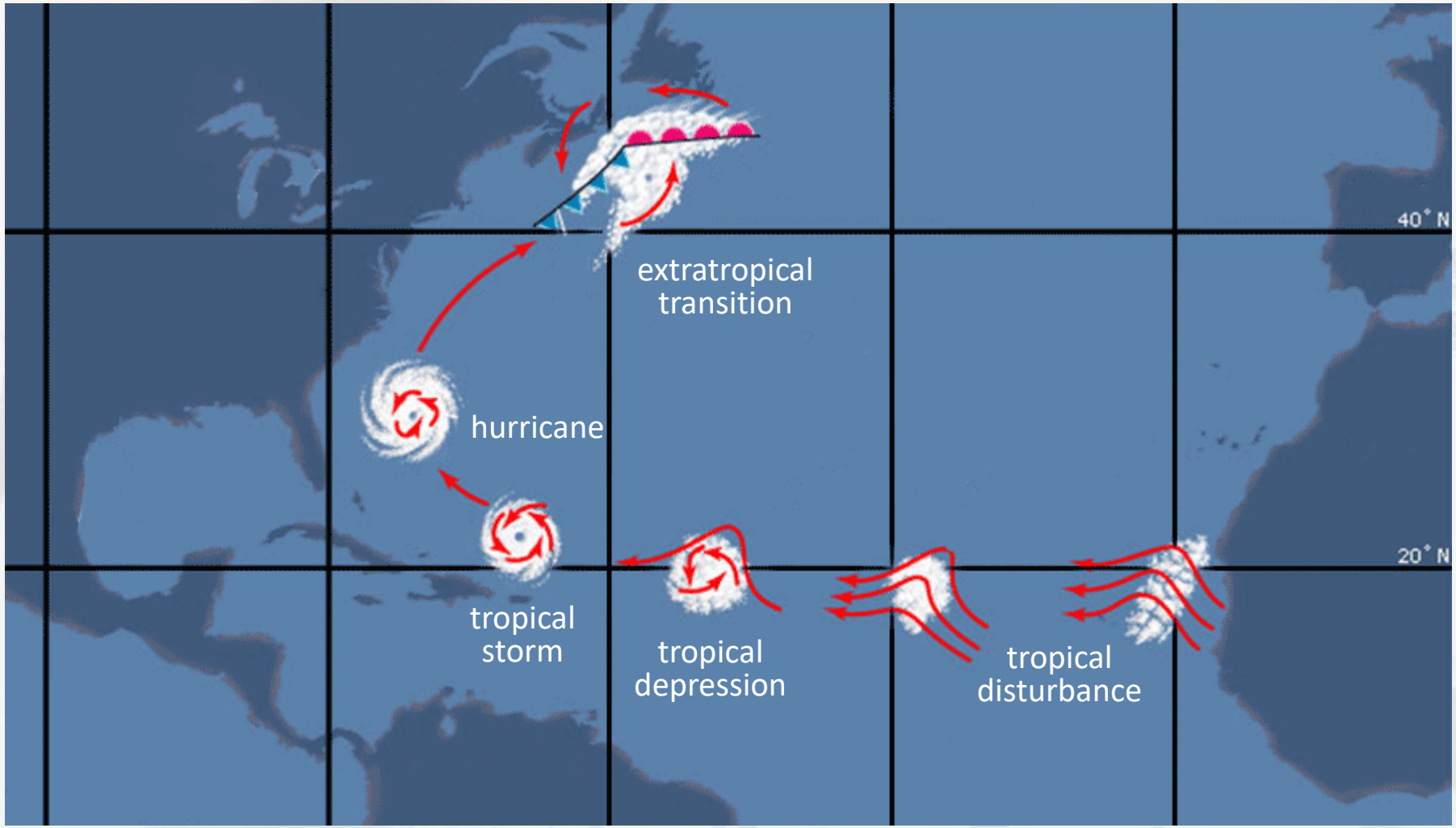


HURRICANE LIFECYCLE
Cape Verde Hurricanes

FEMA



HURRICANE LIFECYCLE
Cape Verde Hurricanes

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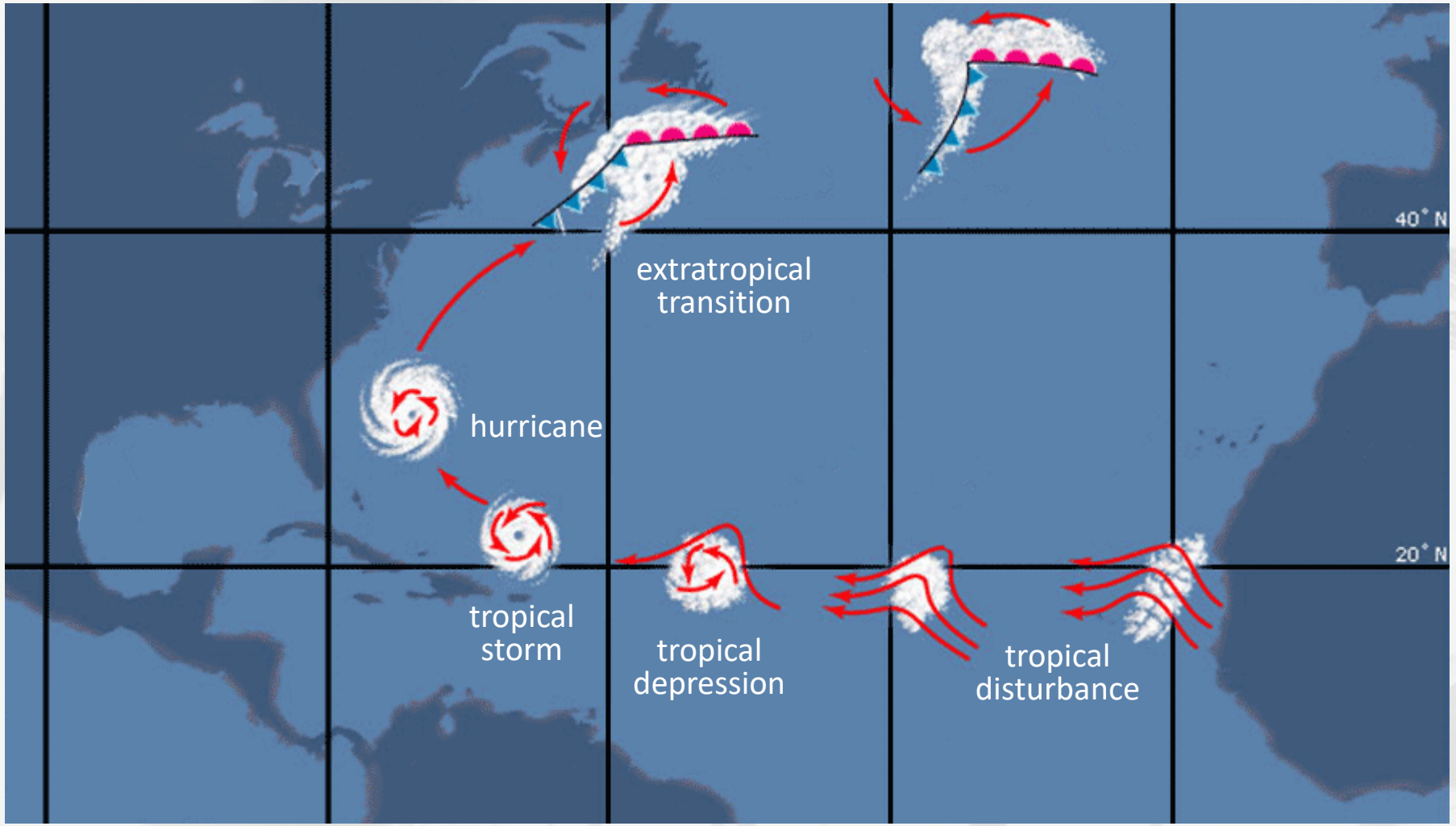

HURRICANE LIFECYCLE

Hurricane Bill (2009)

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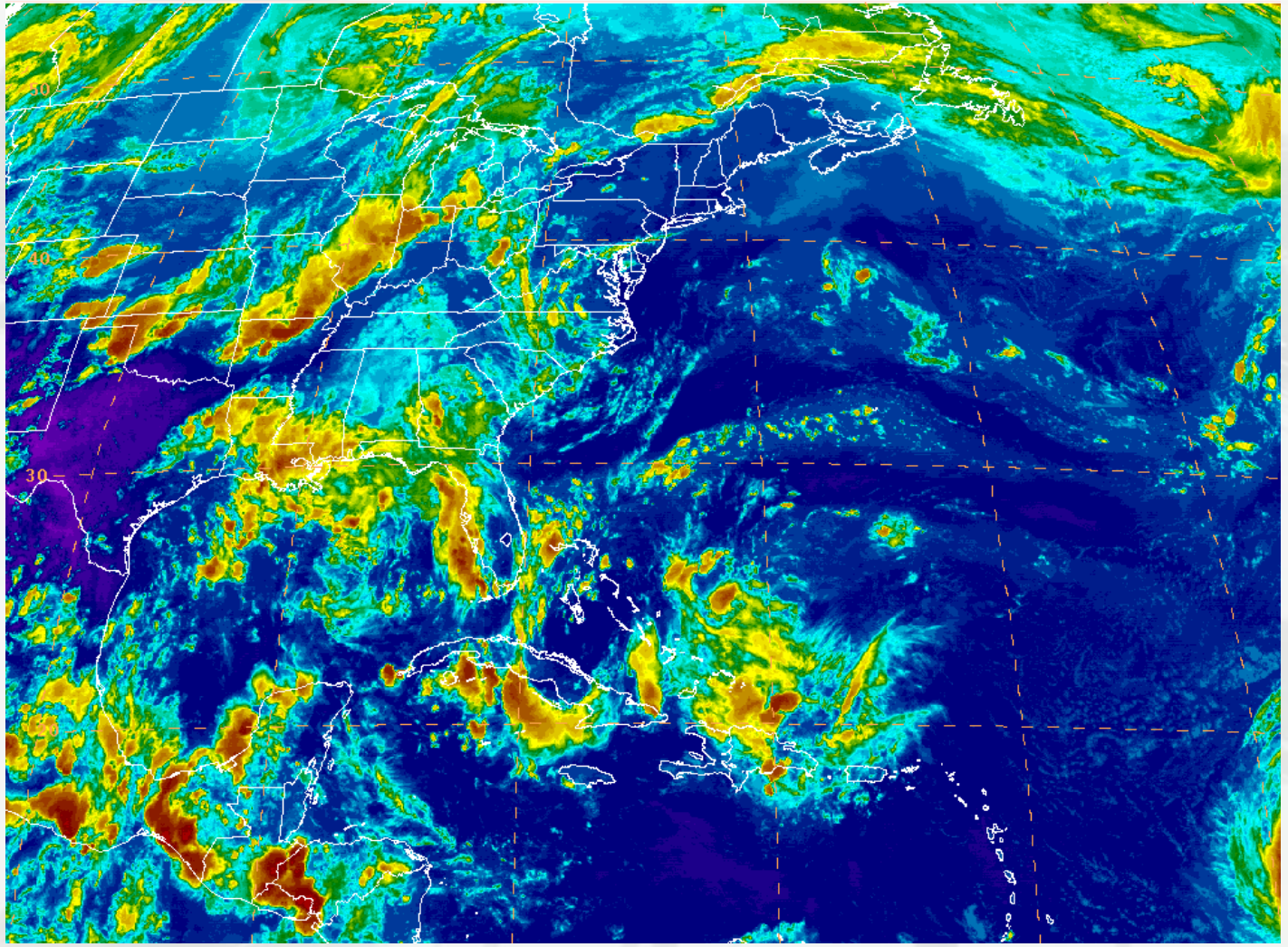
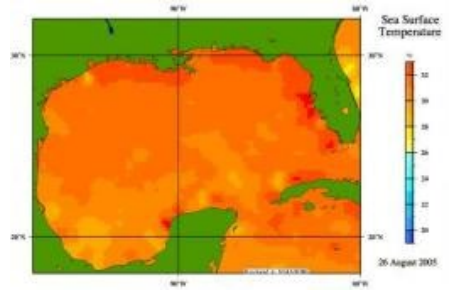


QUIZ QUESTION

Which of these are ingredients for hurricane development?



A. Warm Water
B. Cold Air
C. Lots of Moisture
D. Strong Winds Aloft
E. Icebergs

HURRICANE LIFECYCLE
Ingredients for Formation

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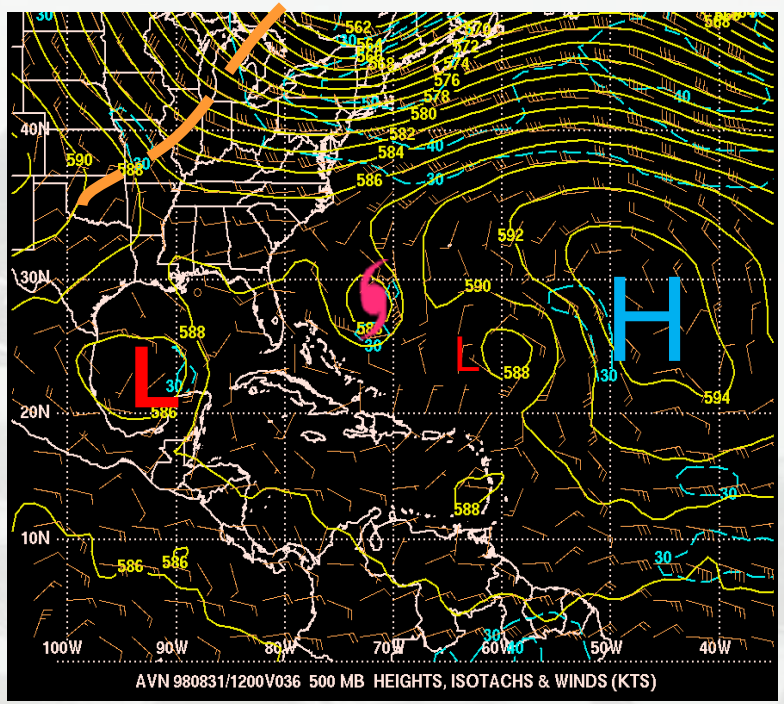
BUILDING BLOCKS	FUEL
1) A pre-existing disturbance (vorticity or spin) 	4) Warm sea-surface temperatures (usually at least 80°F) 
2) Location several degrees north of the equator 	5) Unstable atmosphere (temperature goes down as you go up) 
3) Little change in wind speed and/or direction with height (vertical wind shear) 	6) High atmospheric moisture content (relative humidity) 

DISTURBANCES

- **Tropical Waves**
  - About 70% of all Atlantic basin formations
  - Most major hurricanes
- **Decaying cold fronts**
  - Formation often near Gulf and SE States
  - Typically early or late season storms
- **Non-tropical lows and thunderstorm complexes**
  - Often subtropical systems

FORECASTING

- **Track forecast is usually controlled by large-scale weather features**
  - Cork in the stream analogy
- **Numerical computer models forecast track quite well**
  - Constantly upgrading model physics and resolution
  - Long ago surpassed statistical models in accuracy



HURRICANE FORECASTING
Factors that Influence Intensity

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INTENSITY FACTORS

- **Upper Ocean Temperatures**
  More heat favors a stronger storm
- **Interaction with Land/Topography**
  More land increases weakening
- **Vertical Wind Shear**
  Shear limits strengthening
- **Moisture in Storm Environment**
  Dry air can limit strengthening
- **Structural Changes, Eyewall Replacement**
  Difficult to forecast and not straightforward
- **Interactions with other weather systems**

HURRICANE FORECASTING

One size does not fit all.

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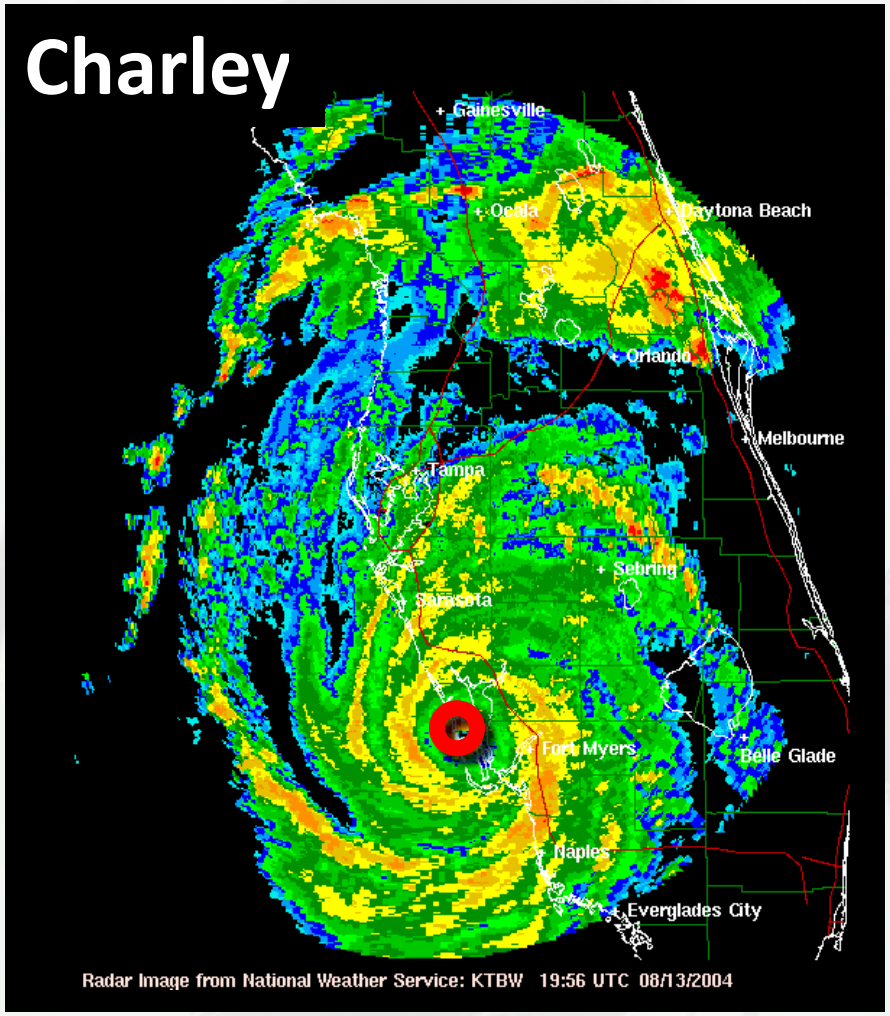

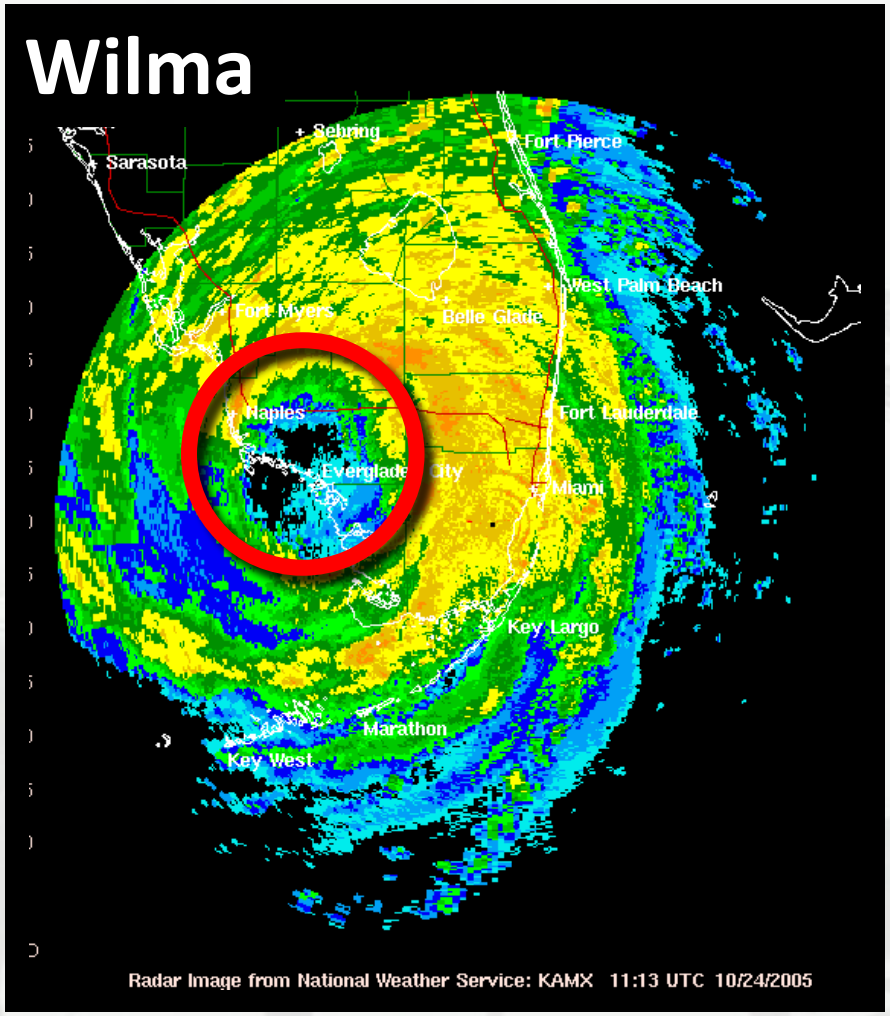

HURRICANE BASICS

Questions?

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UNIT ONE
Hurricane Hazards

QUIZ QUESTION

Which hazard has the greatest potential for large loss of life?

A. Wind
B. Rain induced flooding
C. Tornadoes
D. Storm Surge

TROPICAL CYCLONE HAZARDS

Water is responsible for vast majority

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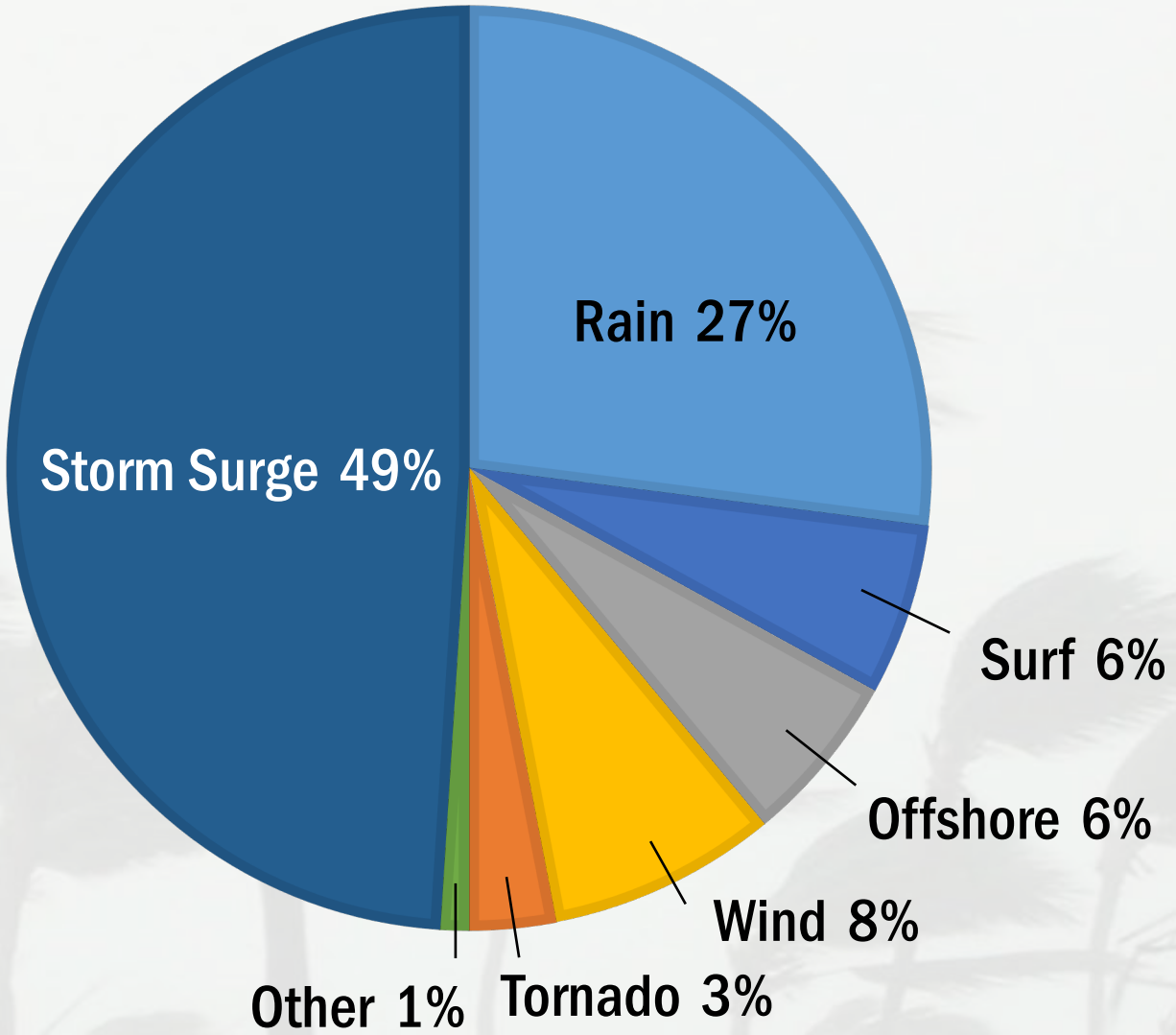
DIRECT FATALITIES

U.S. tropical cyclone fatalities

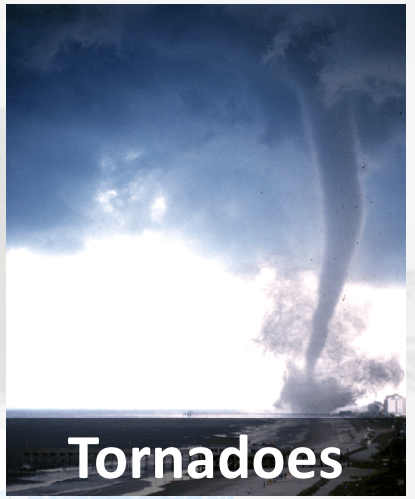
– from 1963 - 2012



TROPICAL CYCLONE HAZARDS

Surge. Wind. Flood. Tornadoes. Waves.

FEMA

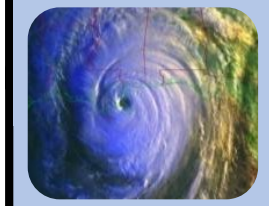
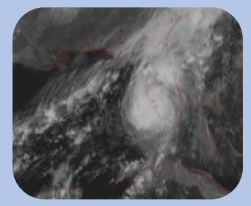
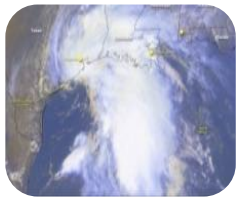
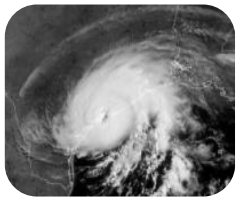
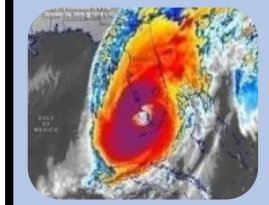
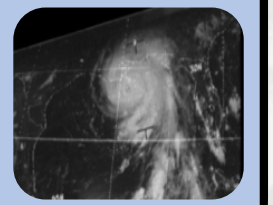


HURRICANE WINDS
Saffir-Simpson Scale

FEMA

SAFFIR-SIMPSON SCALE

- Estimates wind damage

			MAJOR HURRICANES		
TROPICAL STORM 39 – 73 mph (34 – 63 kt)	**CATEGORY 1** 74 – 95 mph (64 – 82 kt)	**CATEGORY 2** 96 – 110 mph (83 – 95 kt)	**CATEGORY 3** 111 – 129 mph (96 – 112 kt)	**CATEGORY 4** 130 – 156 mph (113 – 136 kt)	**CATEGORY 5** > 156 mph (> 136 kt)
					
Debby **(2012)**	**Isaac** **(2012)**	**Ike** **(2008)**	**Katrina** **(2005)**	**Charley** **(2004)**	**Andrew** **(1992)**
					
Allison **(2001)**	**Claudette** **(2003)**	**Isabel** **(2003)**	**Wilma** **(2005)**	**Hugo** **(1989)**	**Camille** **(1969)**

HURRICANE WINDS
Category 1 (74 – 95 mph)

FEMA

CATEGORY ONE

- **Some Damage**
  - Well-constructed frame homes could have roof damage.
  - Large branches of trees will snap and shallow-rooted trees may topple.
  - Damage to power lines and poles; Outages could last a few to several days

Humberto (2007) Southeast TX

Isaias (2020) Oak Island, NC

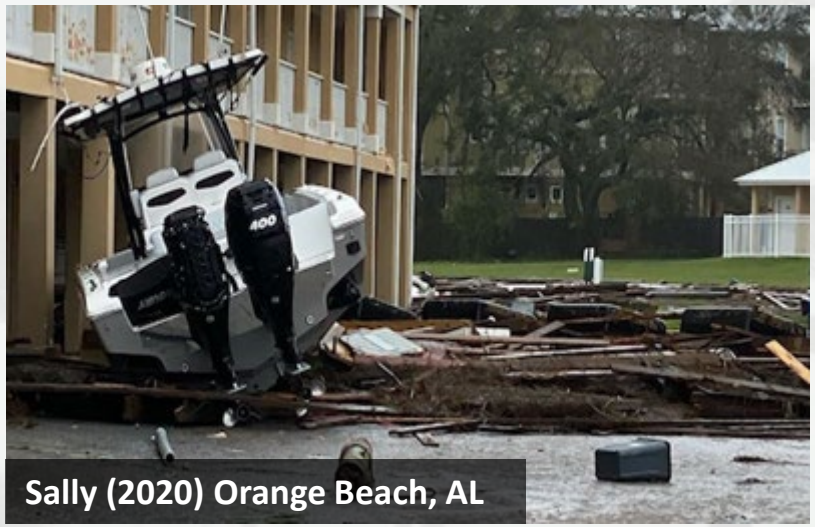
Lili (2002) Louisiana

HURRICANE WINDS
Category 2 (96 – 110 mph)

CATEGORY TWO

- **Extensive Damage**
  - Well-constructed frame homes could sustain major roof damage.
  - Many shallow-rooted trees will be snapped or uprooted.
  - Near total power loss is expected that could last several days to weeks.


Ike (2008) Houston, TX


Sally (2020) Orange Beach, AL


Wilma (2005) SE Florida

HURRICANE WINDS
Category 3 (111– 129 mph)

FEMA

CATEGORY THREE

- **Devastating Damage**
  - Well-built framed homes may incur major damage.
  - Many trees will be snapped or uprooted.
  - Electricity and water will be unavailable for several days to weeks.

Jeanne (2004) Cape Canaveral, FL


Rita (2005) Orange, TX


Rita (2005) Orange, TX

HURRICANE WINDS
Category 4 (130 – 156 mph)

FEMA

CATEGORY FOUR

- **Catastrophic Damage**
  - Well-built framed homes can sustain severe damage.
  - Most trees will be snapped or uprooted and power poles downed.
  - Power outages will last weeks to possibly months.


Charley (2004) Punta Gorda, FL


Maria (2017) Puerto Rico


Laura (2020) Lake Charles, LA

HURRICANE WINDS
Category 5 (>156 mph)

FEMA

CATEGORY FIVE

- **Catastrophic Damage**
  - A high percentage of framed homes will be destroyed.
  - Fallen trees and power poles will isolate residential areas.
  - Power outages will last weeks to possibly months.


Michael (2018) Florida – Getty Images


Felix (2007) Nicaragua


Andrew (1992) South Dade, FL

CONUS HURRICANE HISTORY
Category 5 Landfalls

FEMA

Cat 5 Landfalls

- Labor Day (1935)
- Camille (1969)
- Andrew (1992)
- Michael (2018)

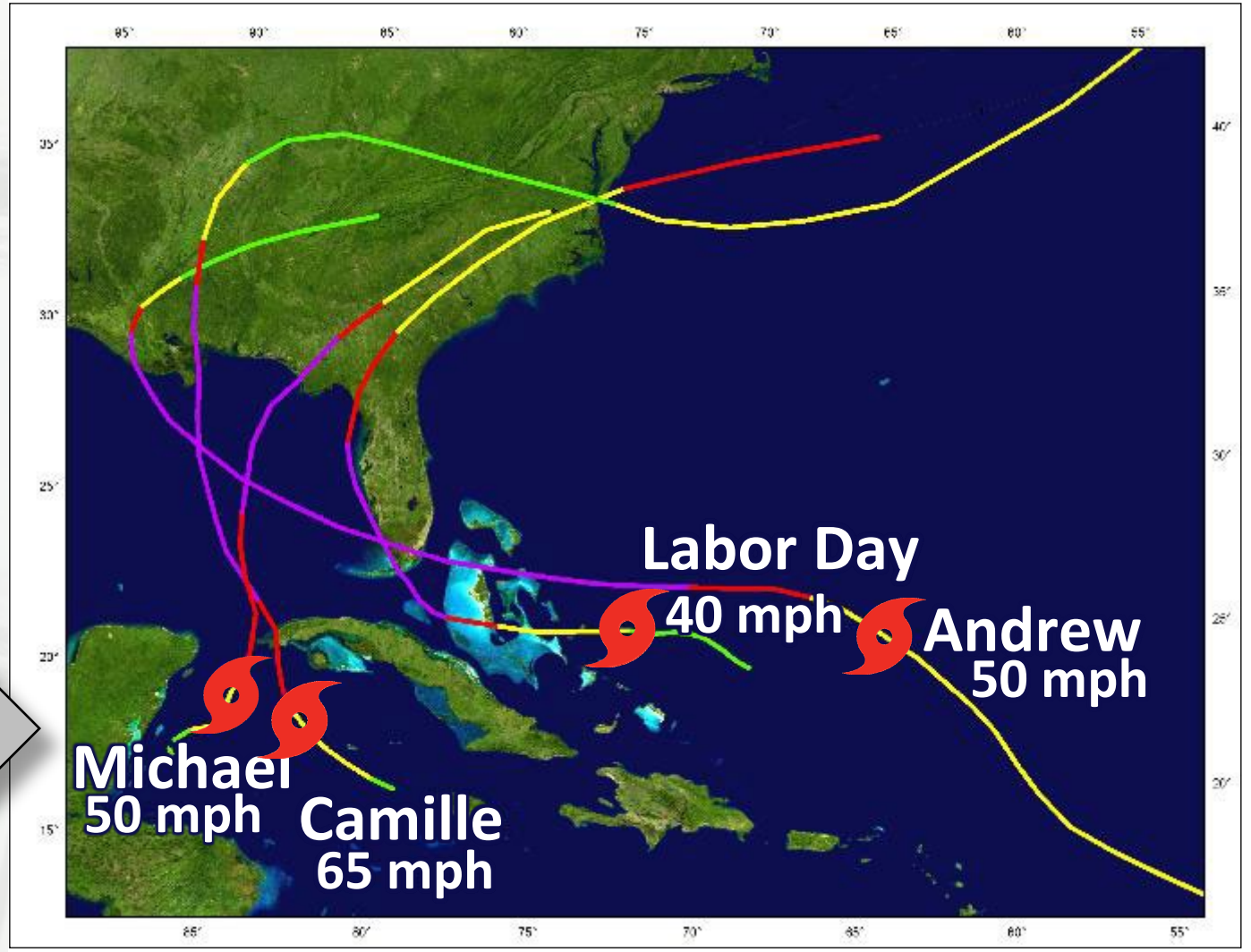
Where were these hurricanes **5 days** before landfall?

CONUS HURRICANE HISTORY
Category 5 Landfalls

Cat 5 Landfalls

- Labor Day (1935)
- Camille (1969)
- Andrew (1992)
- Michael (2018)

Where were these hurricanes **3 days** before landfall?



STORM SURGE

Greatest potential for large loss of life.

FEMA

Hurricane Sandy (2012)

73 deaths
$65 billion damage

Hurricane Katrina (2005)

1200 deaths
$108 billion damage

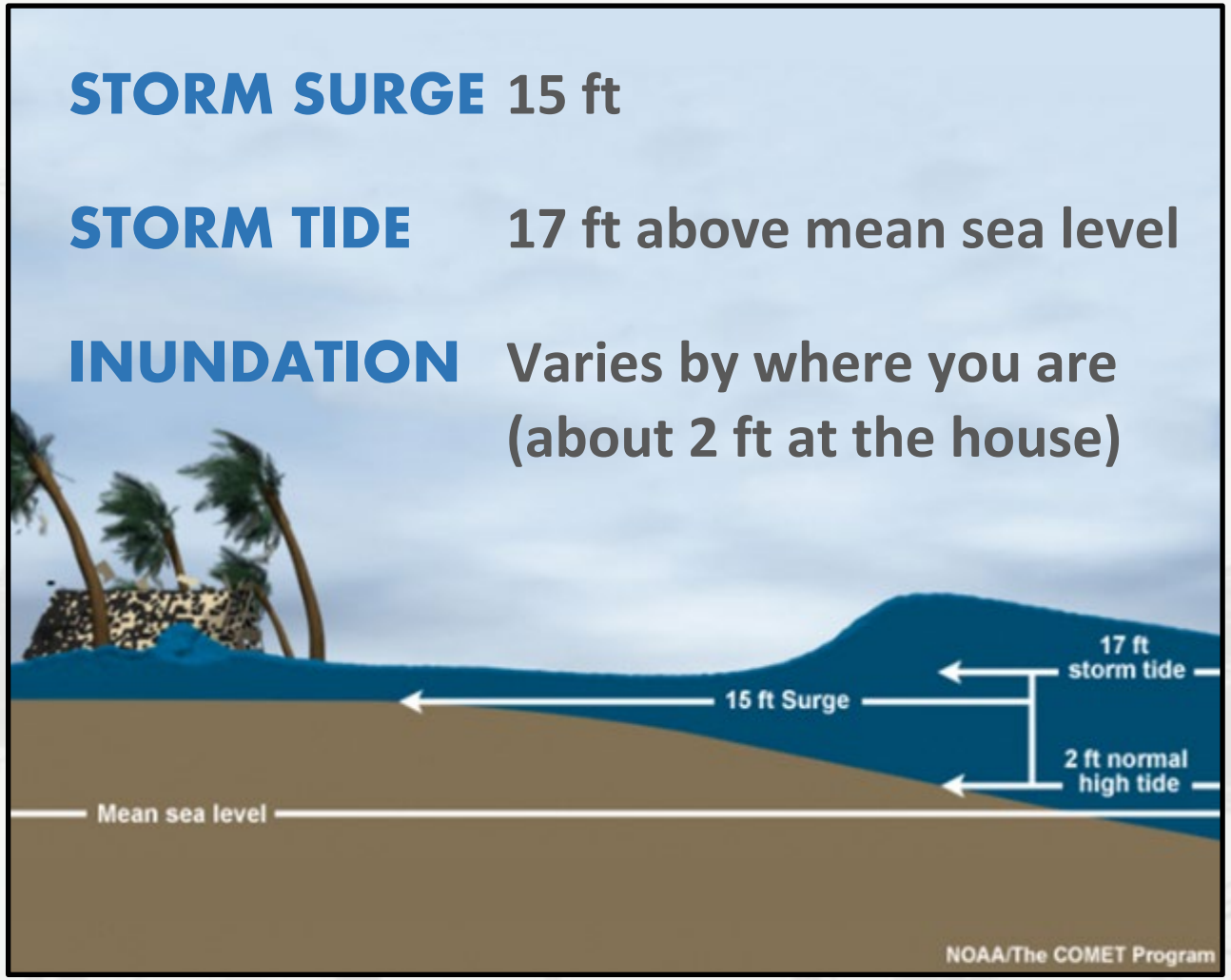
STORM SURGE
Storm Surge vs Storm Tide vs Inundation

FEMA

STORM SURGE
An abnormal rise of water generated by a storm, over and above the predicted astronomical tide.

STORM TIDE
Water level due to the combination of storm surge and the astronomical tide.

INUNDATION
The flooding of normally dry land, resulting from storm tide and possibly other factors.



STORM SURGE HISTORY
Gulf Coast

FEMA

Hurricane Zeta (2020)
Biloxi, Mississippi

Hurricane Laura (2020)
Cameron, Louisiana

Hurricane Michael (2018)
Mexico Beach, Florida

Hurricane Hanna (2020)
Corpus Christi, Texas

STORM SURGE HISTORY
Waveland, Mississippi

Kimberly and David King

STORM SURGE HISTORY
Southeast

FEMA

Hurricane Isaias (2020)
Oak Island, North Carolina

Hurricane Hugo (1989)
Garden City Beach, South Carolina

Hurricane Irma (2017)
Jacksonville, Florida

Hurricane Matthew (2016)
Tybee Island, Georgia

STORM SURGE HISTORY
Mid-Atlantic

FEMA

Hurricane Isabel (2003)
Baltimore, Maryland

Hurricane Isabel (2003)
Hampton Roads, Virginia

Hurricane Sandy (2012)
Brick, New Jersey

Hurricane Sandy (2012)
Staten Island, New York

STORM SURGE HISTORY
New England

FEMA

Hurricane Carol (1954)
Groton, Connecticut

Hurricane Bob (1991)
Falmouth, Massachusetts

1938 Hurricane
Providence, Rhode Island

Hurricane Sandy (2012)
Matunuck, Rhode Island

STORM SURGE

Where does storm surge occur?

QUIZ QUESTION

Which of the following is NOT a significant factor in determining how much storm surge could occur for a storm?

A. Size of the storm
B. Forward speed of the storm
C. Central pressure of the storm
D. Width and slope of the continental shelf

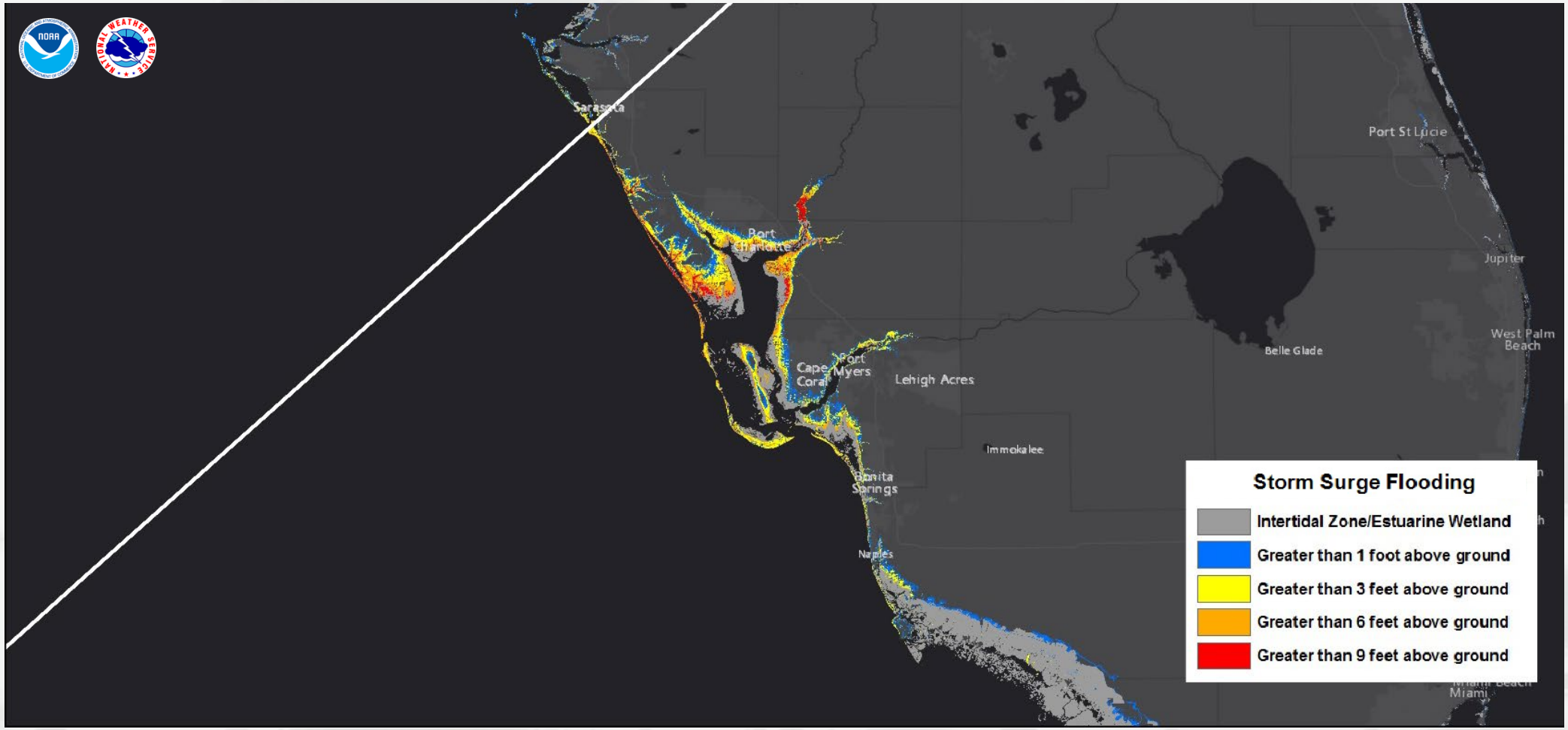
STORM SURGE FACTORS

- **Intensity**
  Stronger storm = More storm surge
- **Size (Radius of Maximum Winds)**
  Larger = More storm surge
- **Forward Speed**
  Slower storm = Storm surge farther inland
- **Angle of Approach**
  Alters focus of storm surge
- **Width and Slope of Shelf (Bathymetry)**
  Gradual sloping shelf = More storm surge

STORM SURGE
What's the effect of intensity?

FEMA

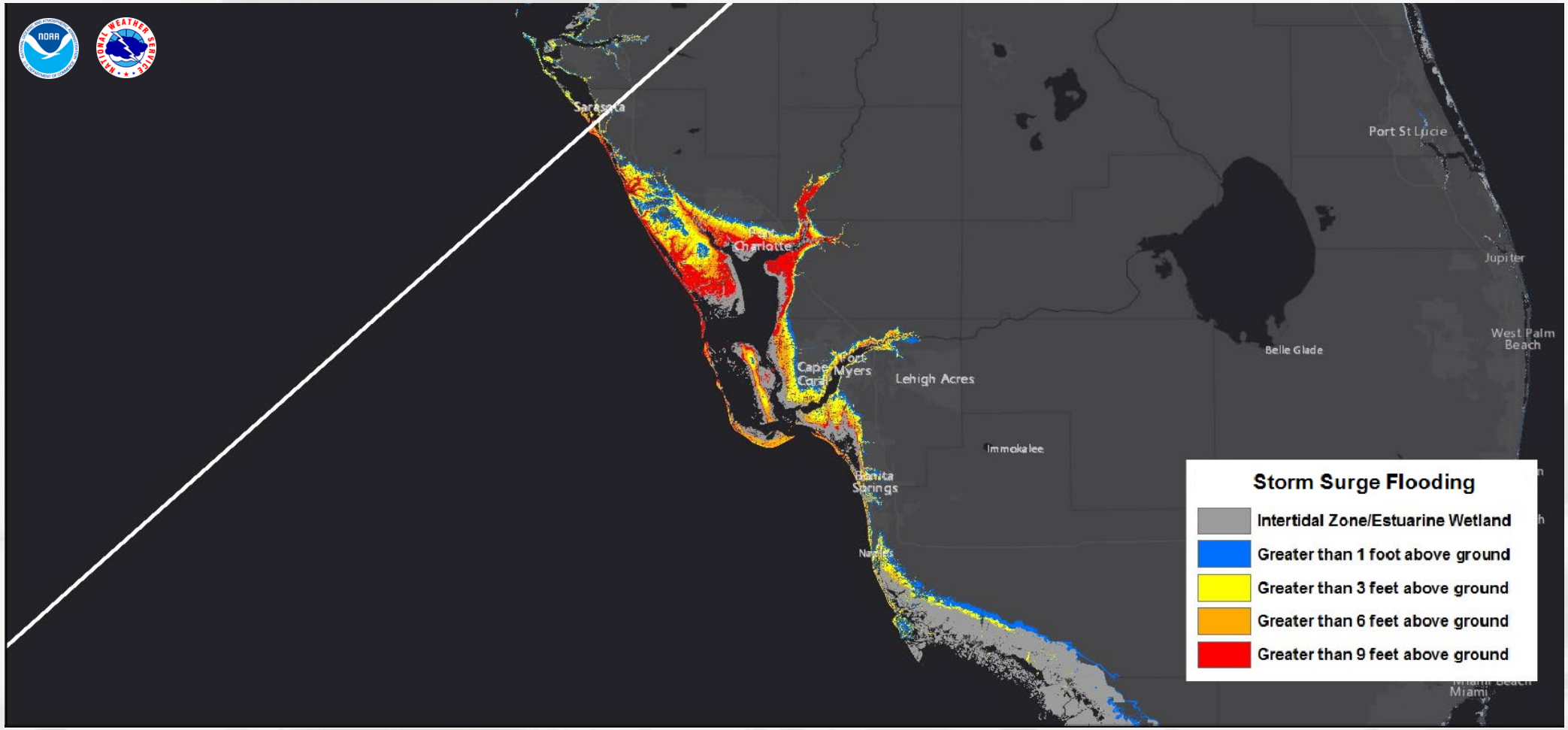
Category 3



STORM SURGE
What's the effect of intensity?

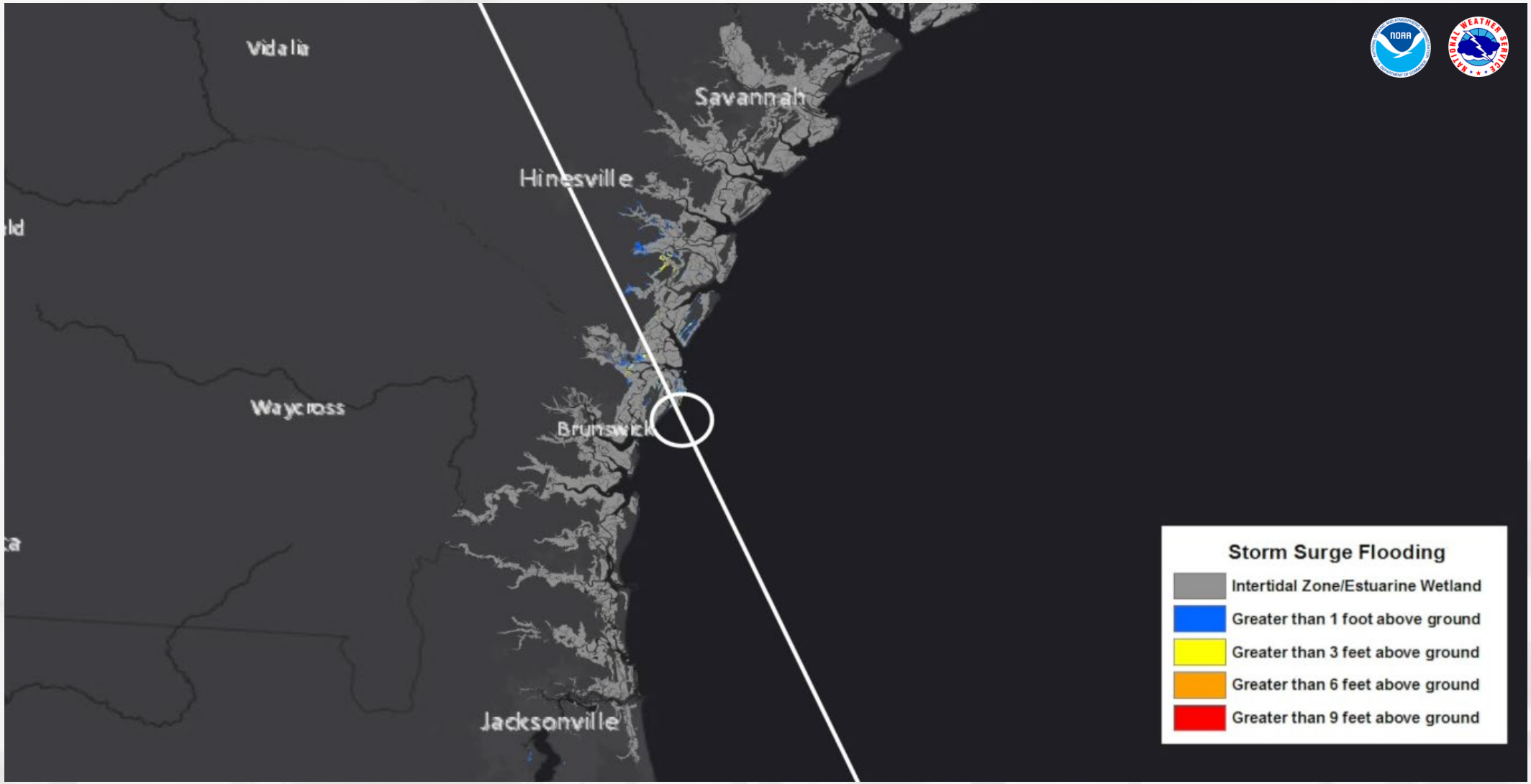
FEMA

Category 4



STORM SURGE
What's the effect of size?

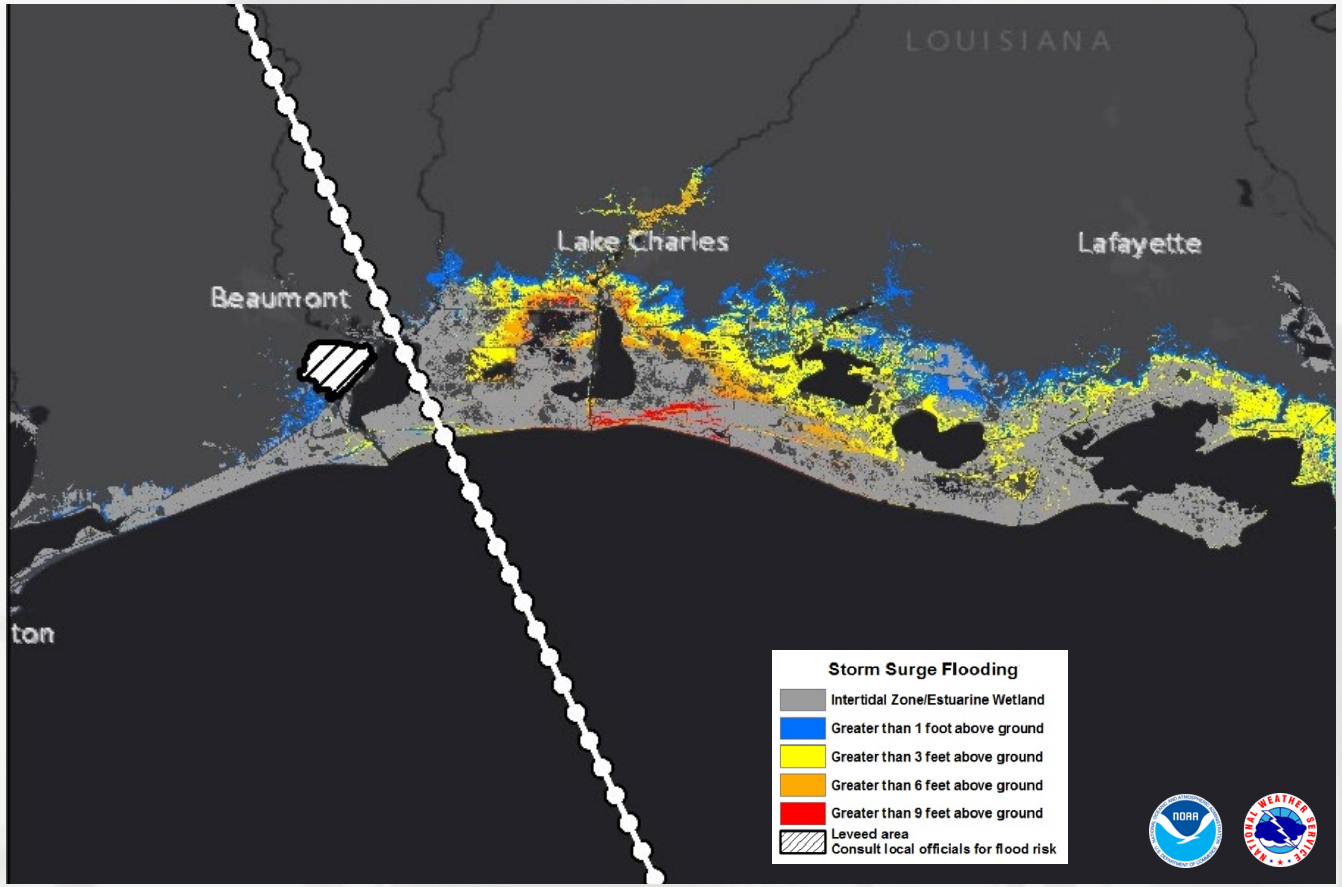
FEMA



STORM SURGE
What's the effect of forward speed?

FEMA

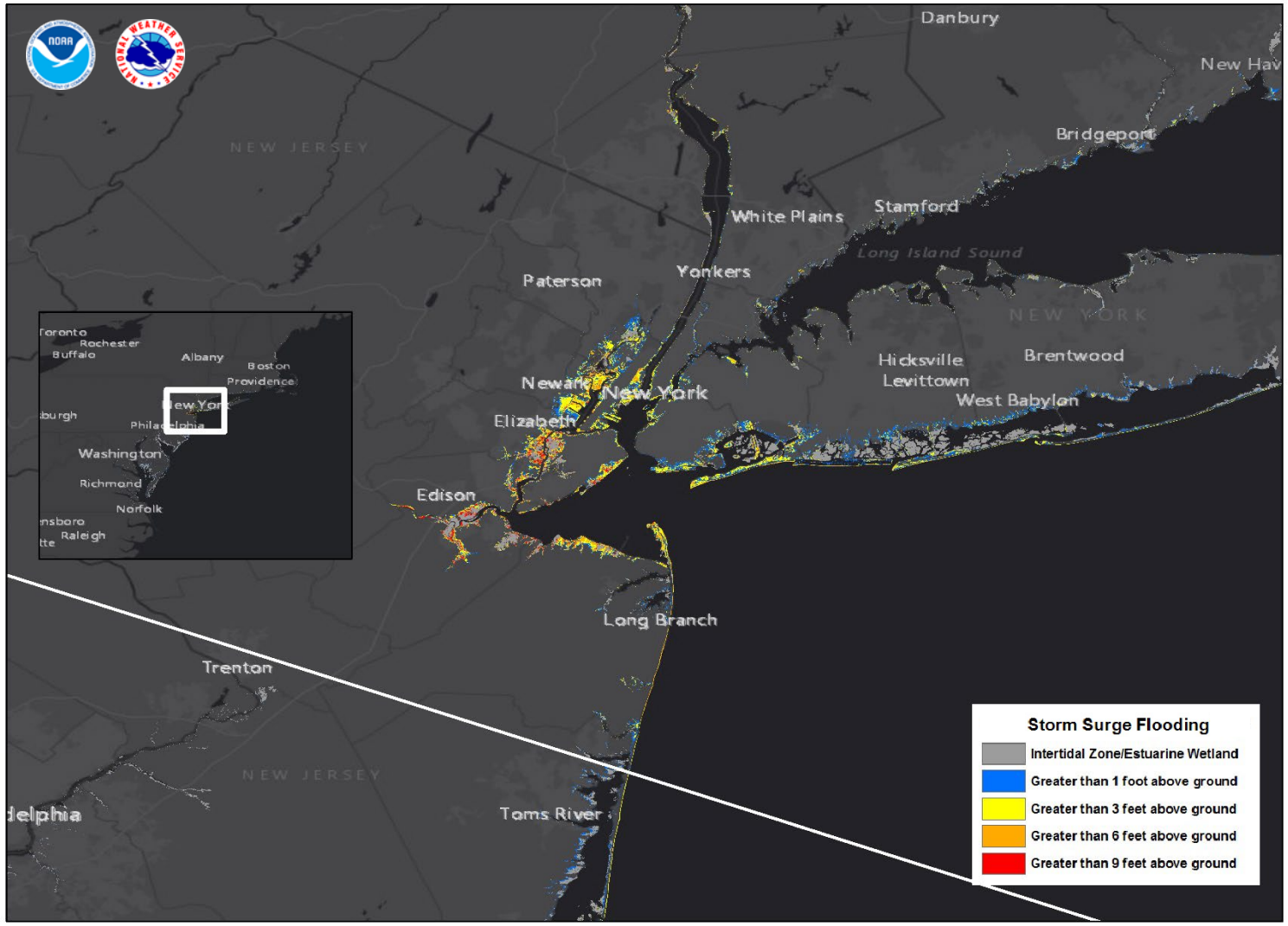
Forward Speed
25 mph



Faster Storms:
Higher maximum at coast

Slower Storms:
Farther inland penetration

STORM SURGE
What's the effect of angle of approach?



Service Layer Credits: Esri, HERE, Garmin, (c)
OpenStreetMap contributors, and the GIS user community

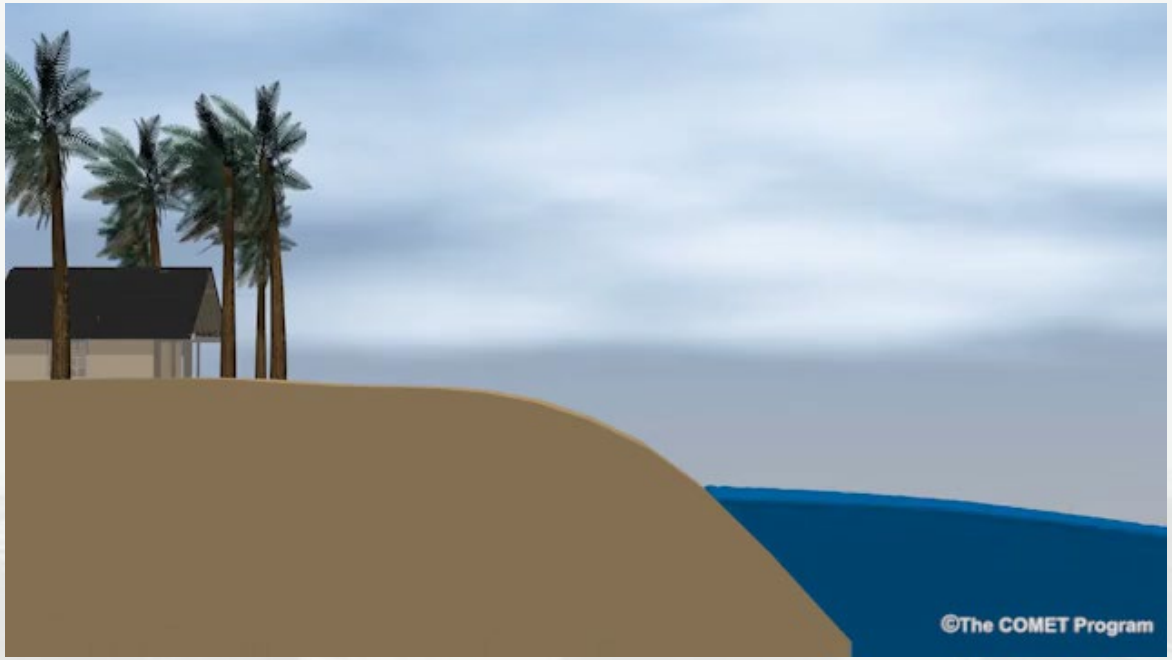
Angle of Approach

NNW

WNW

STORM SURGE
What's the effect of width/slope of shelf?

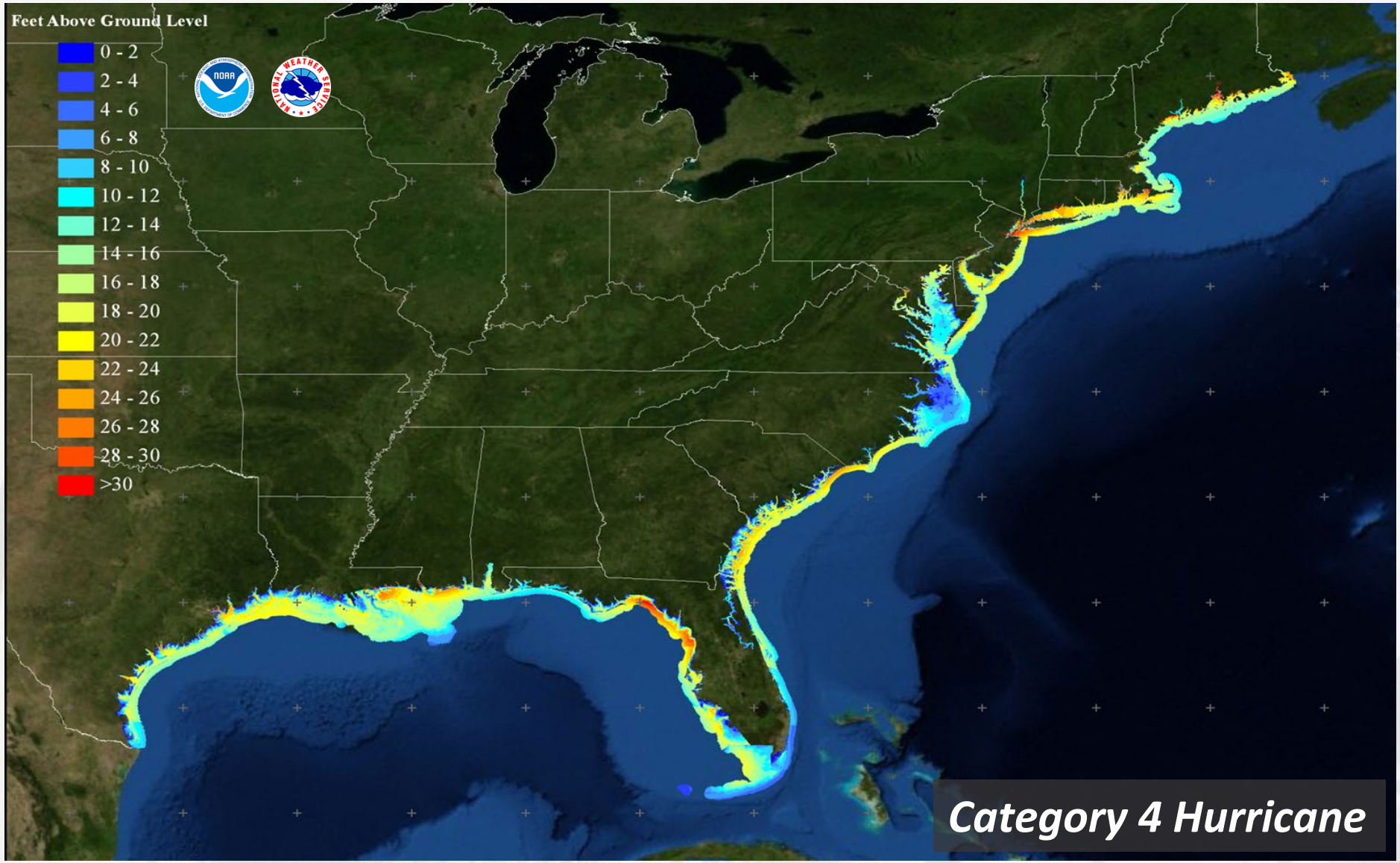
Wide shelf – Gentle slope



Narrow shelf – Sharp slope

STORM SURGE

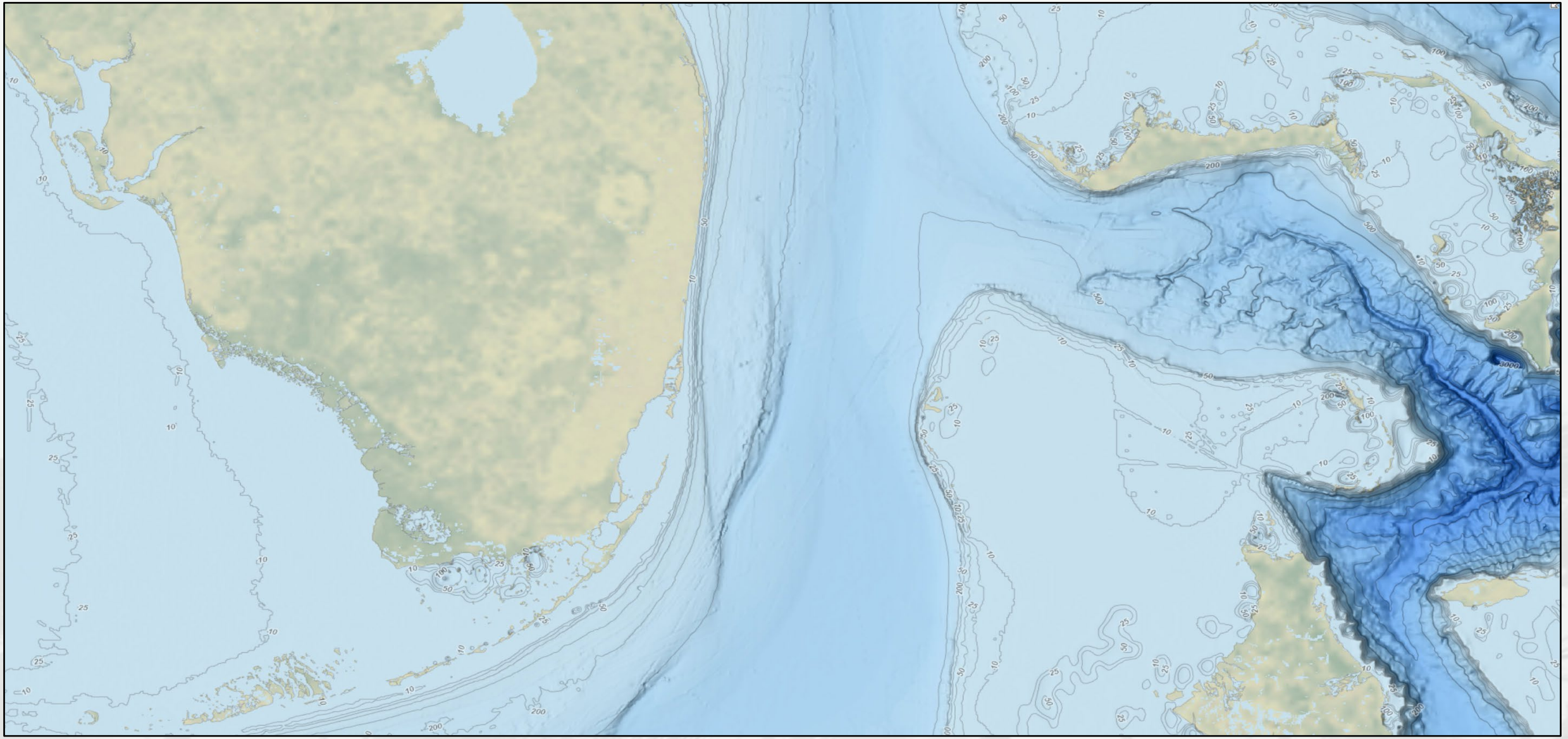
Location. Location. Location.



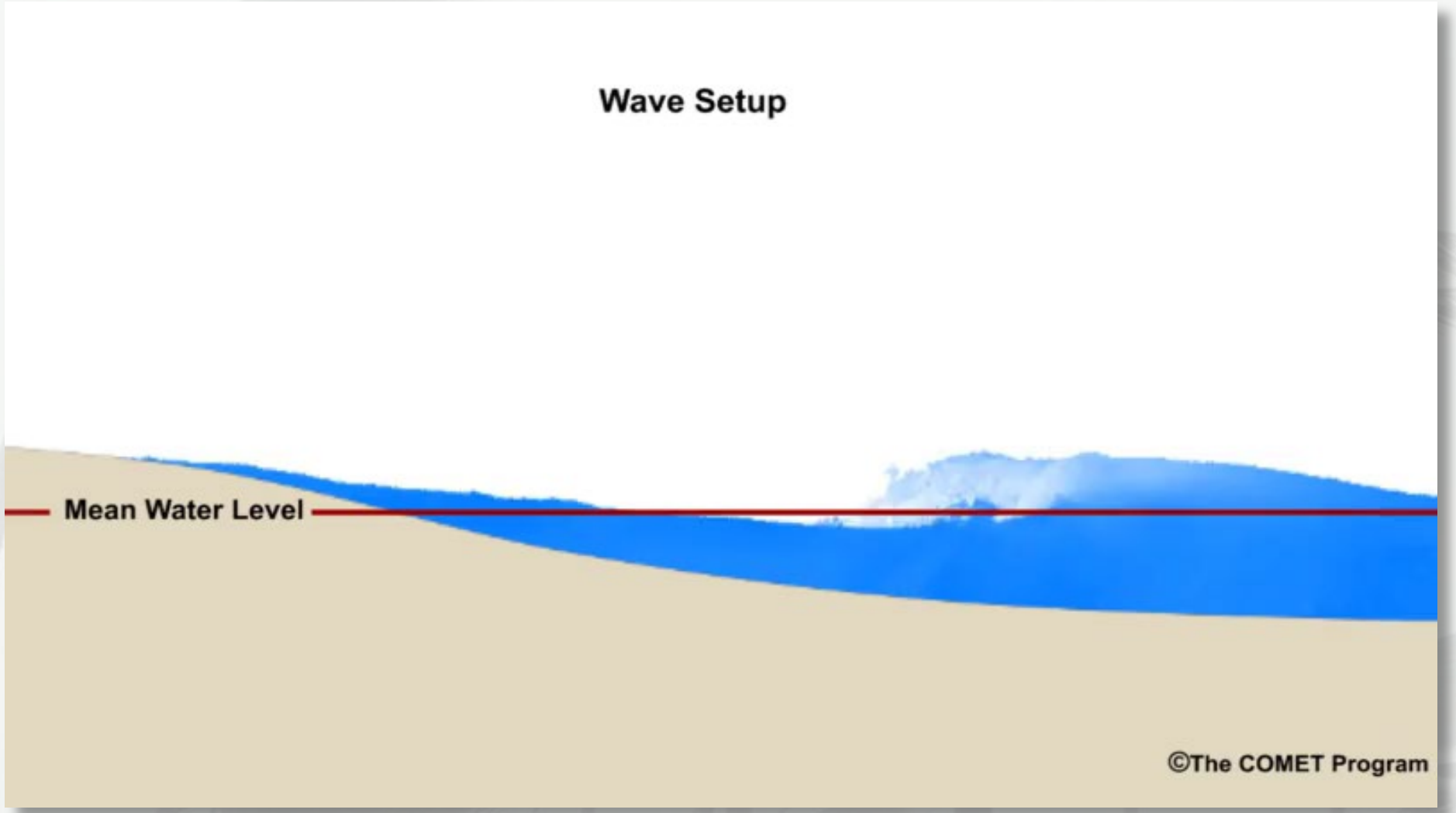
STORM SURGE

What's the effect of width/slope of shelf?

FEMA



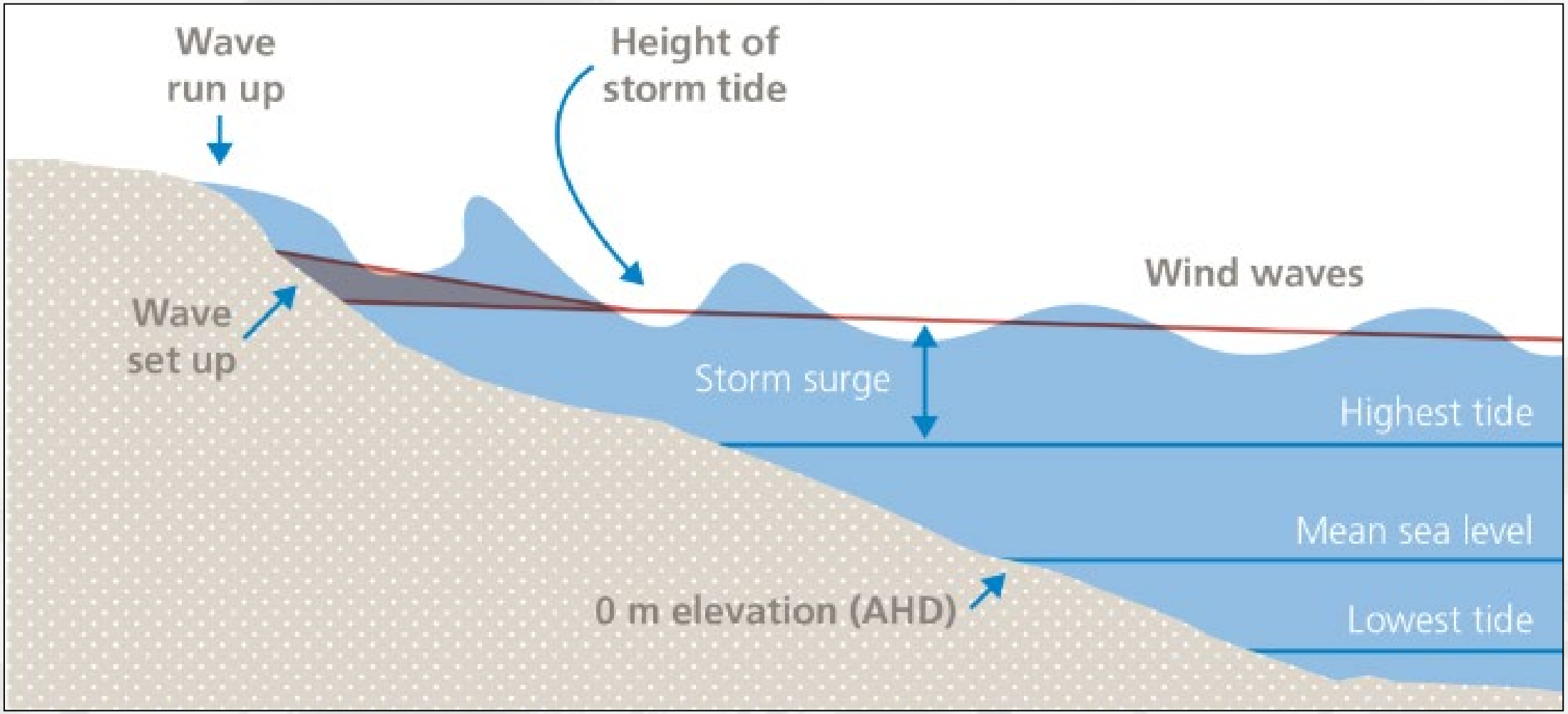
STORM SURGE
Wave Setup



STORM SURGE
Components of 'Total Water Level'

FEMA

Storm surge + Tides + Wave Setup + Freshwater



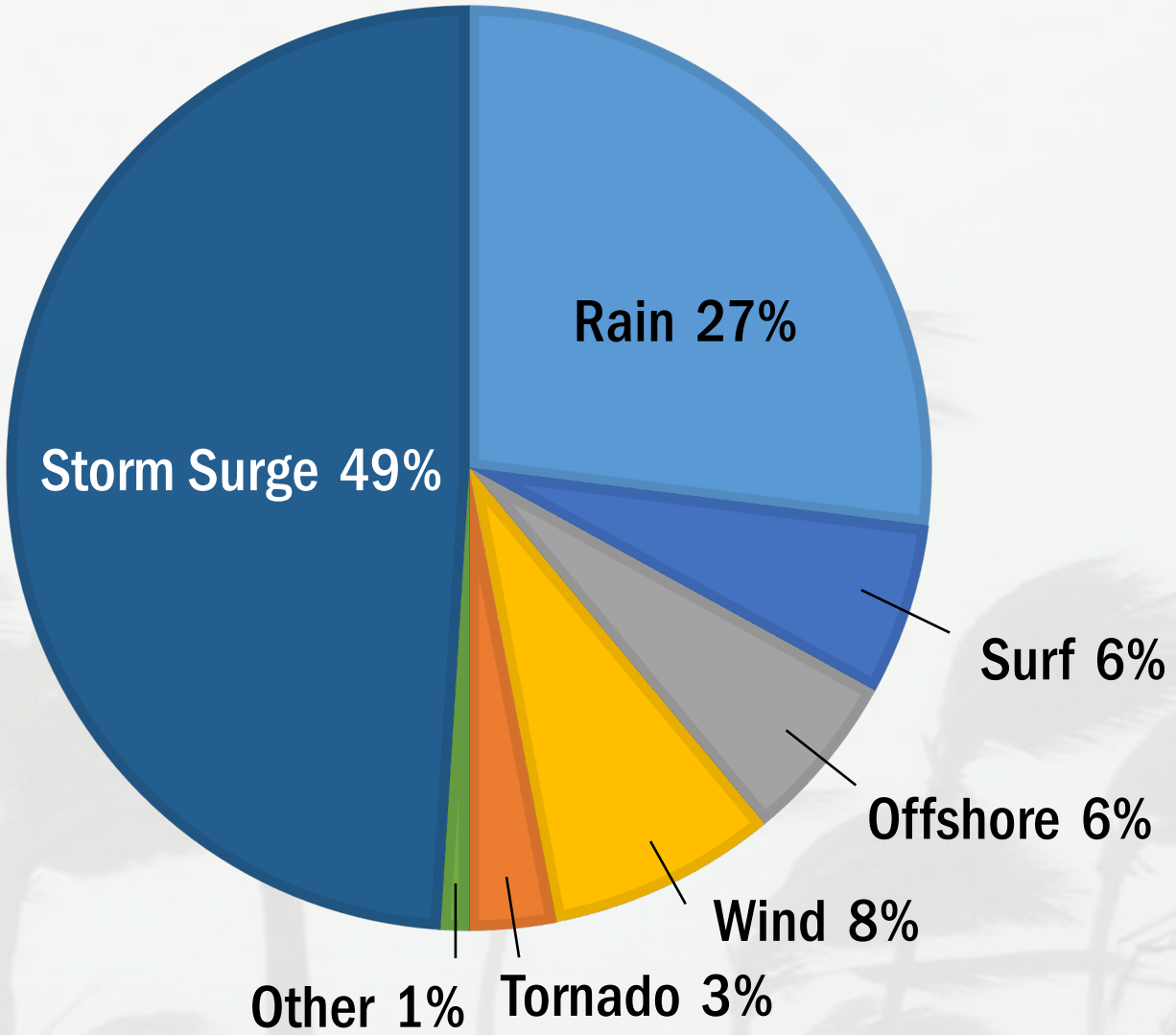
FRESHWATER FLOODING
U.S. Atlantic Tropical Cyclone Deaths

FEMA

DIRECT FATALITIES

U.S. tropical cyclone fatalities

– from 1963 - 2012



FRESHWATER FLOODING
Flash Floods. Riverine Flooding.

FEMA


Times Herald


Mansfield Heliflight


Reuters


US Army Corps of Engineers

FRESHWATER FLOODING
Hurricane Harvey (2017) – Houston, TX

FEMA

FRESHWATER FLOODING

Hurricane Harvey (2017) – Houston, TX

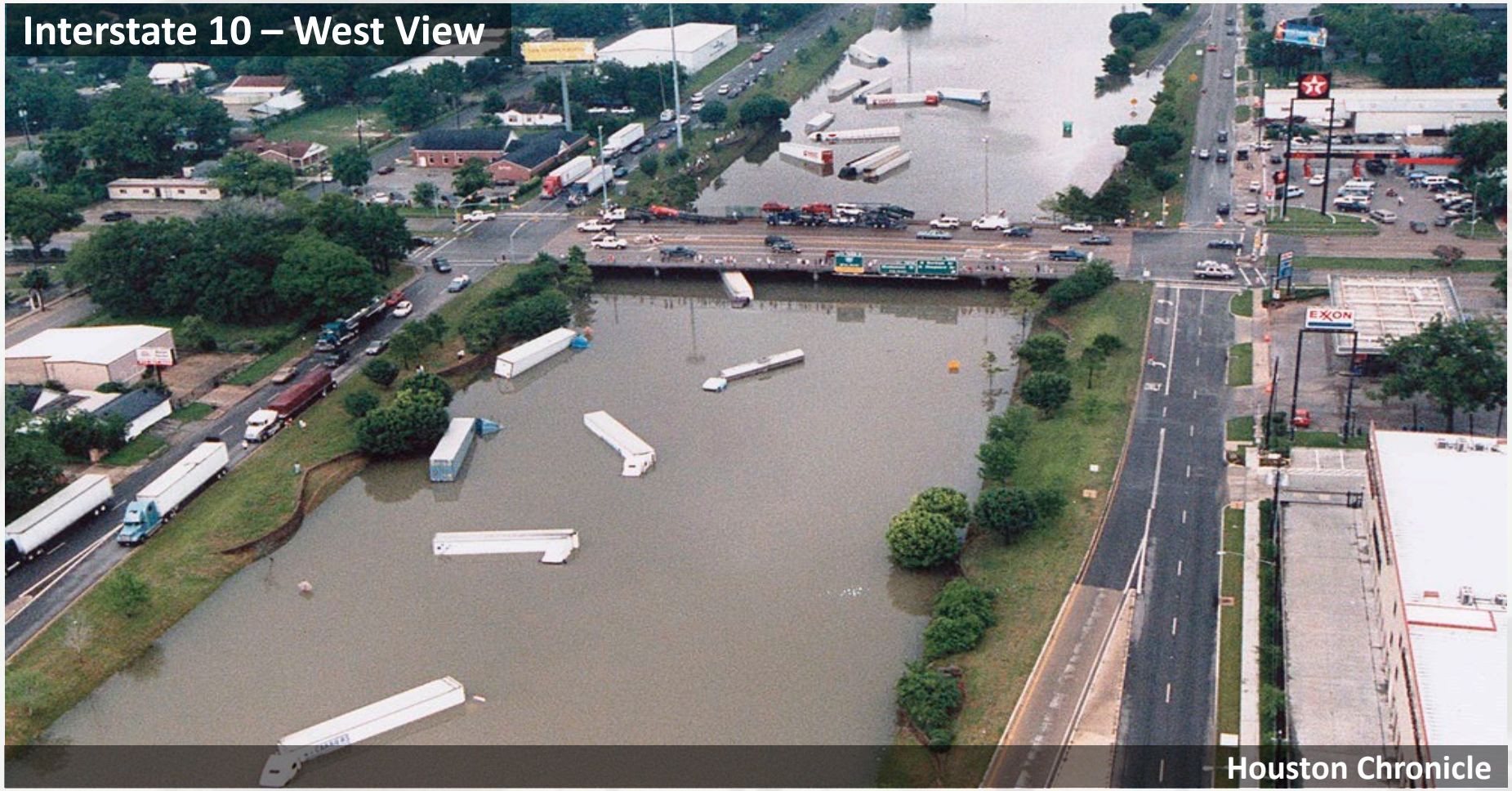
FEMA

FRESHWATER FLOODING

Interstate 10 – Houston, TX

FRESHWATER FLOODING
TS Allison (2001) – Houston, TX

FEMA



FRESHWATER FLOODING

Hurricane Irene (2011) – New York and Vermont

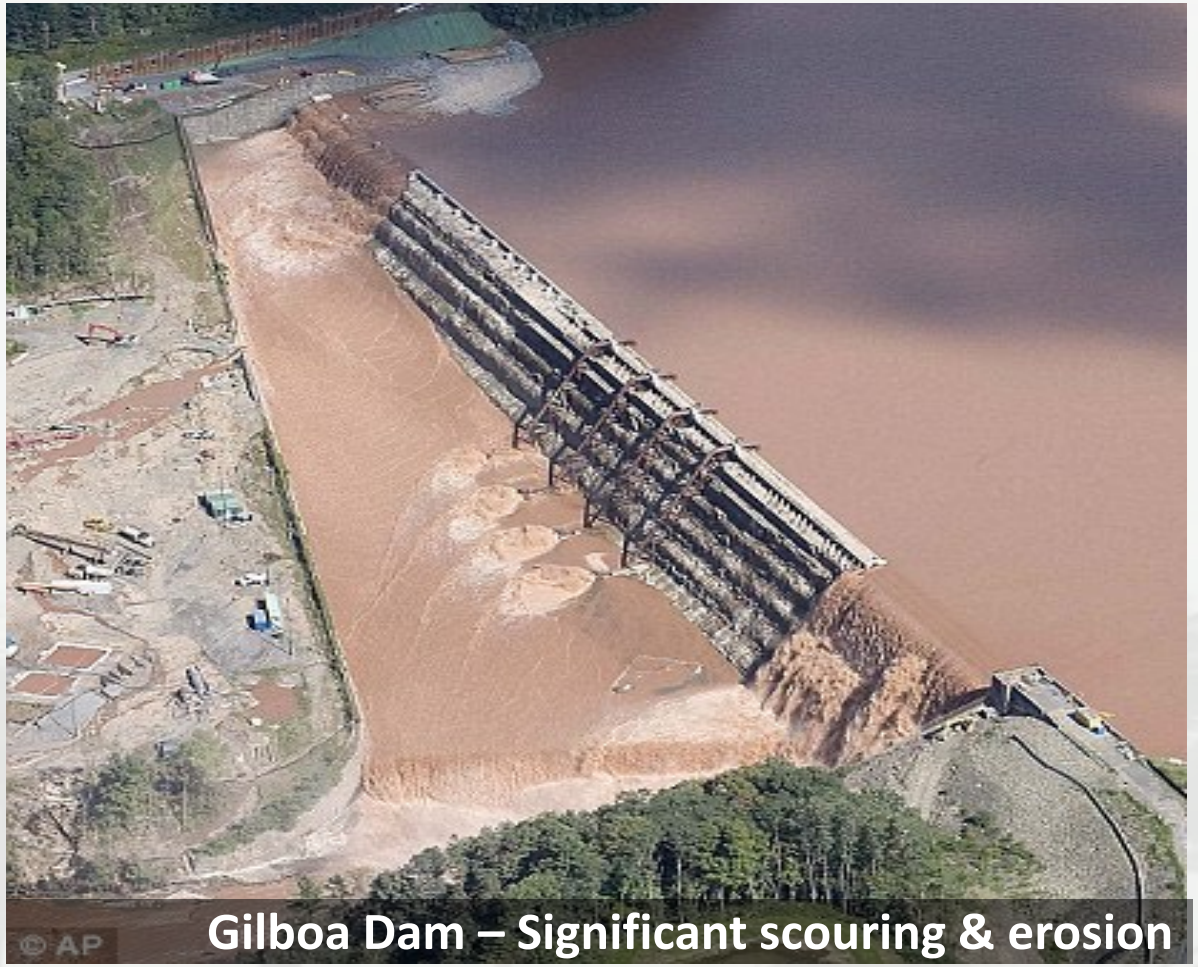
Photo courtesy of L. Gange, Mansfield Helifight

Prattsville, NY Damage (Jimmy Vielkind/Times Union)

FRESHWATER FLOODING
Hurricane Irene (2011) – New York and Vermont

FEMA


Rochester, VT Flash Flooding



Gilboa Dam – Significant scouring & erosion

FRESHWATER FLOODING
Factors Affecting Tropical Cyclone Rainfall

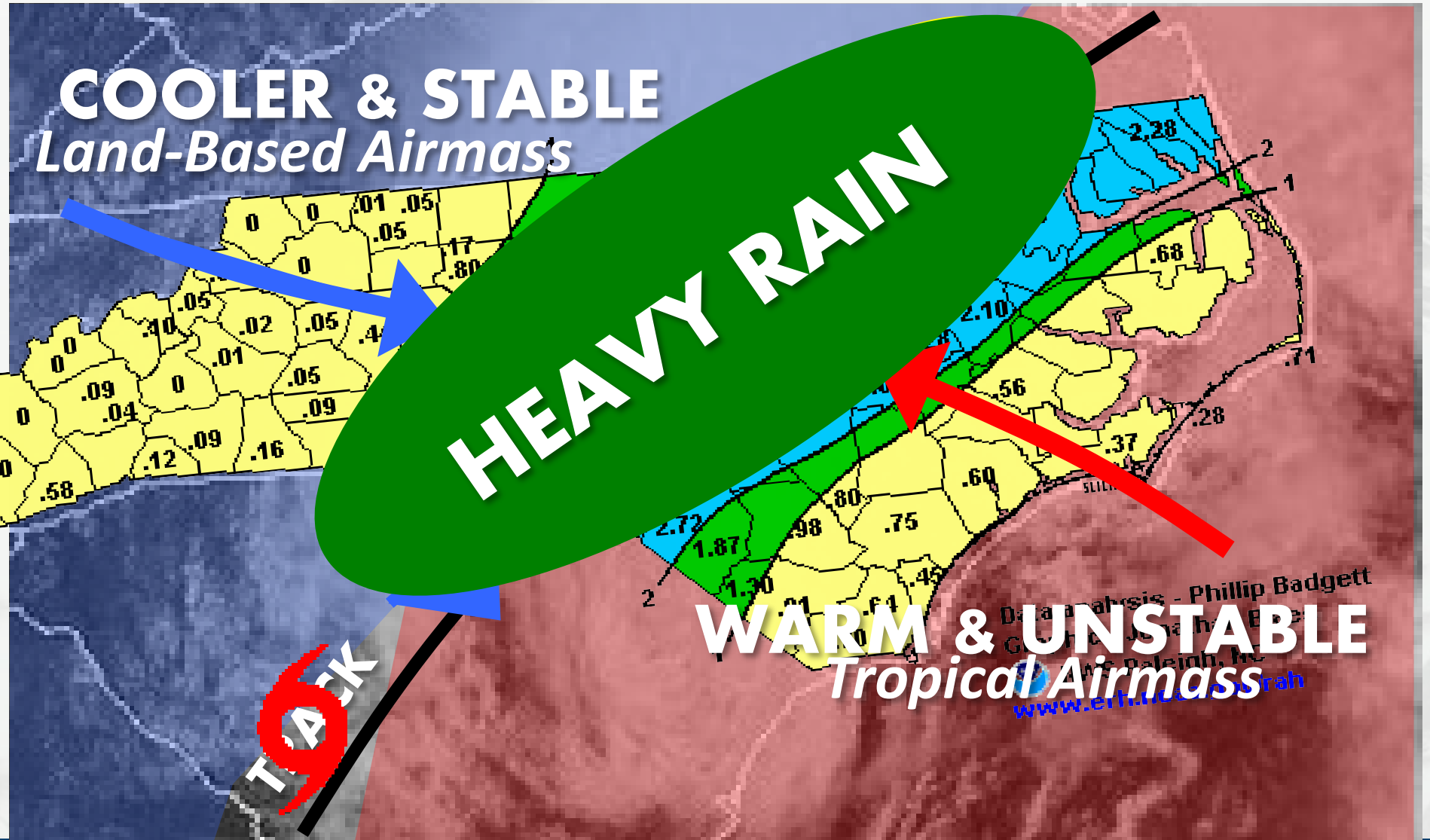
FEMA

RAINFALL FACTORS

- **Forward Speed**
  Slower storm = More rain
- **Size**
  Larger storm = More rain
- **Topography / Mountains**
  More rain on windward side
- **Fronts / Upper-level troughs**
  Enhance rainfall

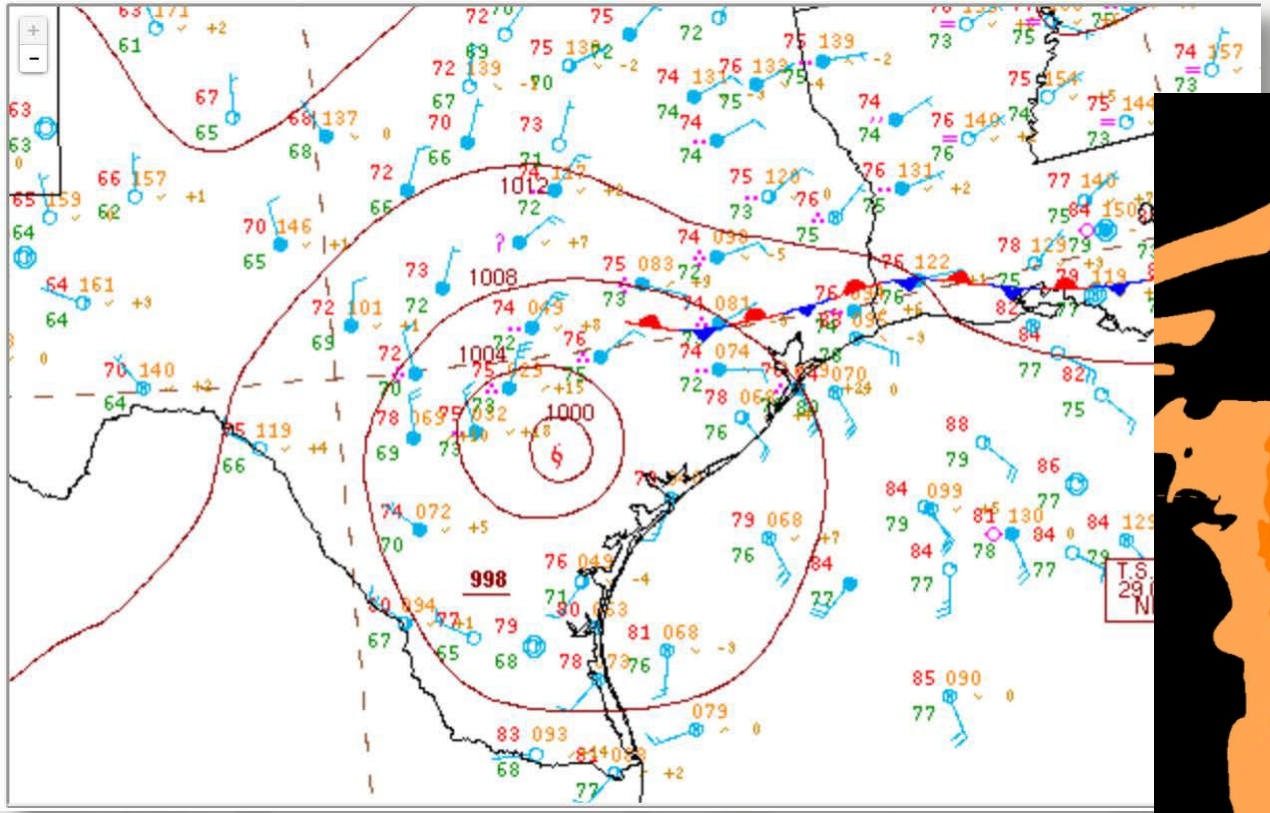
FRESHWATER FLOODING
TS Alberto (2006)

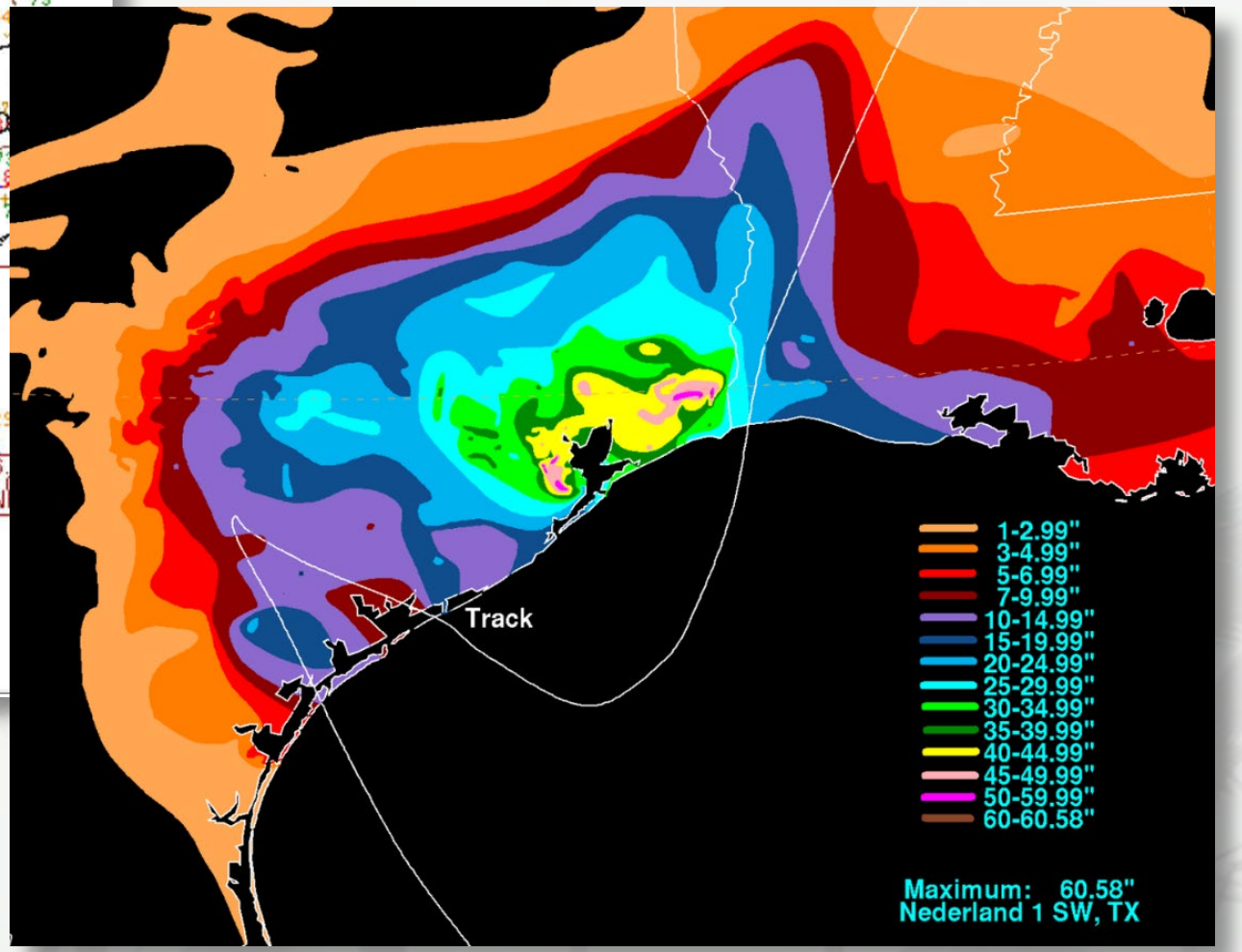
FEMA



FRESHWATER FLOODING
Hurricane Harvey (2017)

FEMA

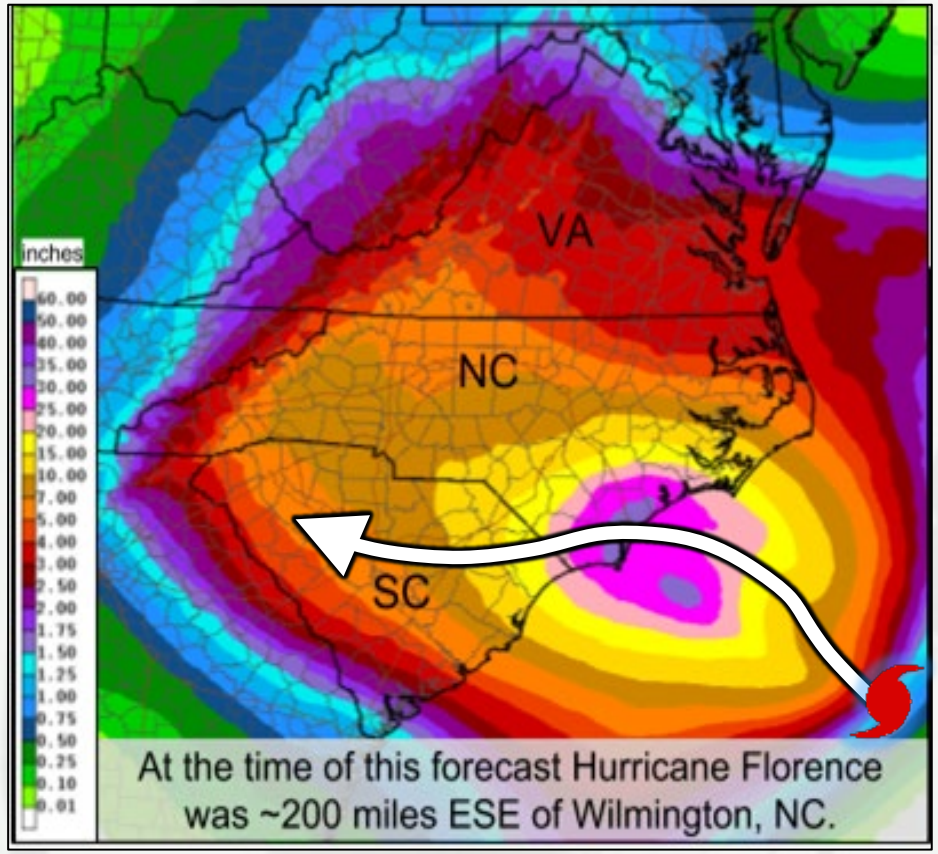




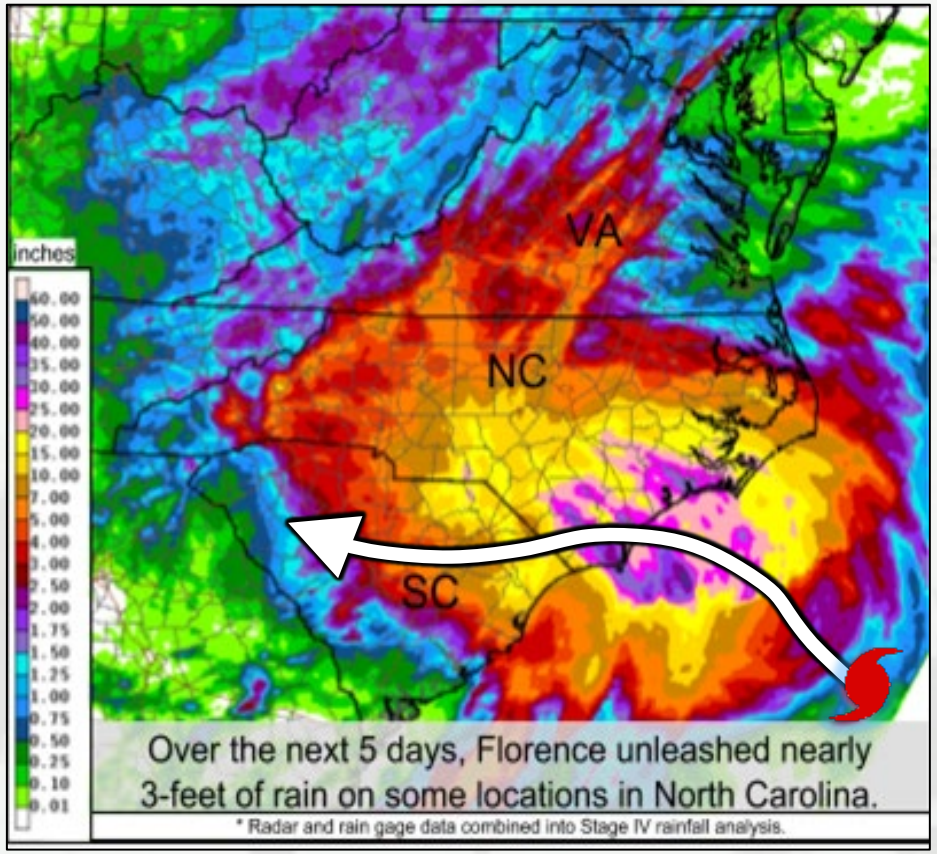
FRESHWATER FLOODING
Hurricane Florence (2018)

FEMA

5-Day Forecast vs. Observed Rainfall



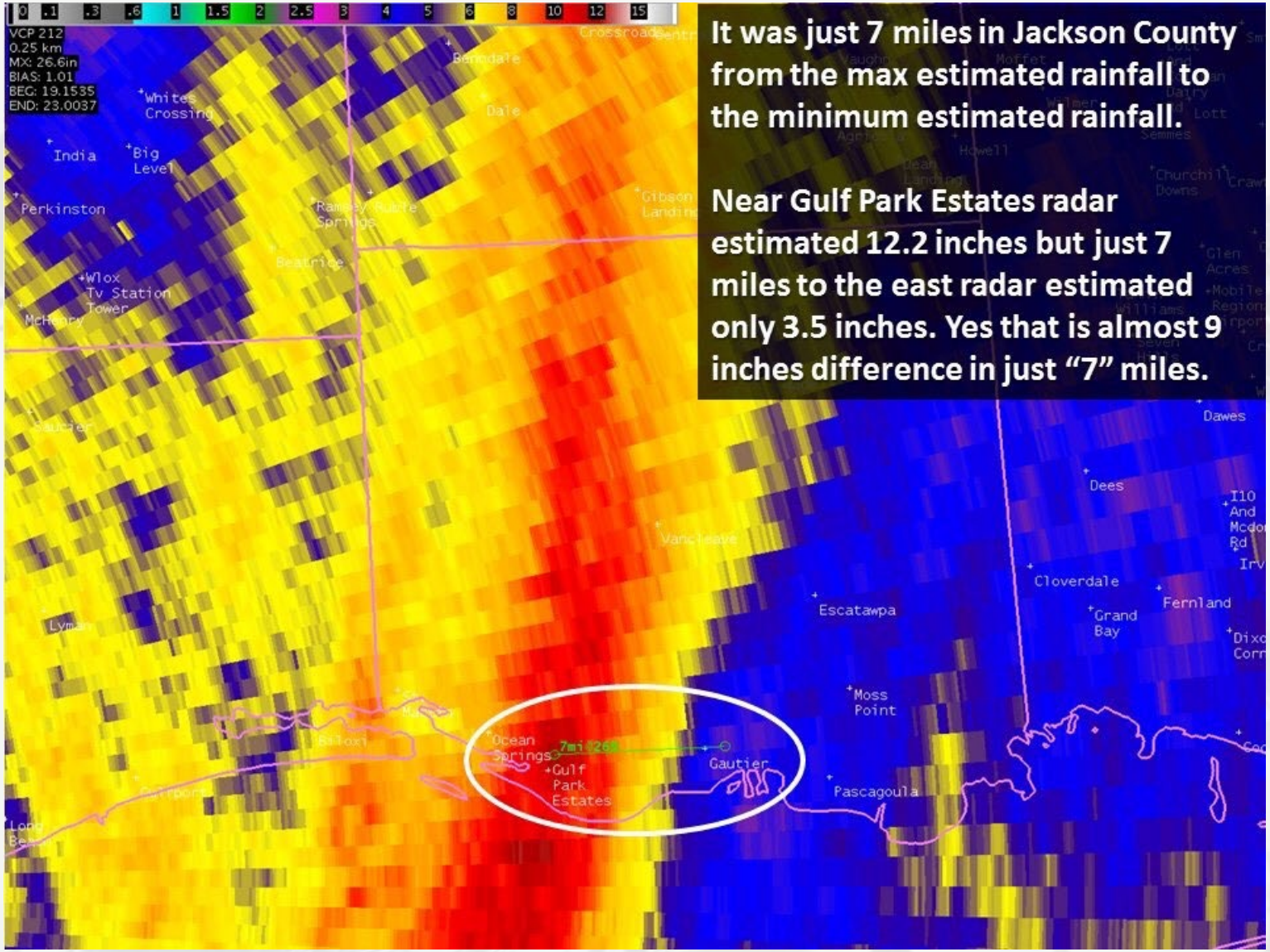
5-day Rainfall Forecast – Issued Sep 13, 2018



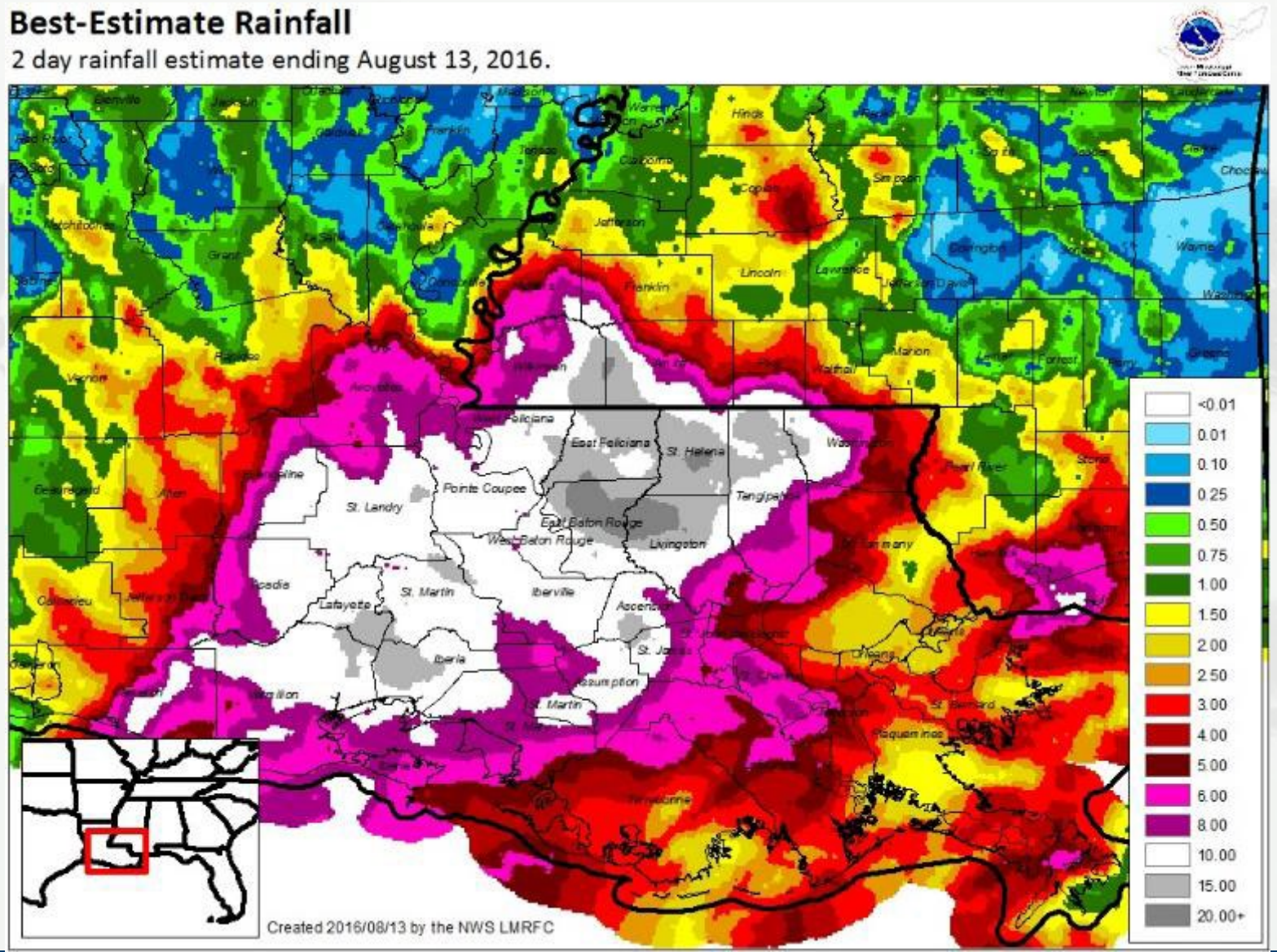
5-day Rainfall – Sep 13-18, 2018

FRESHWATER FLOODING
Tropical Storm Cindy (2017)

FEMA



FRESHWATER FLOODING
Unnamed Low (2016)



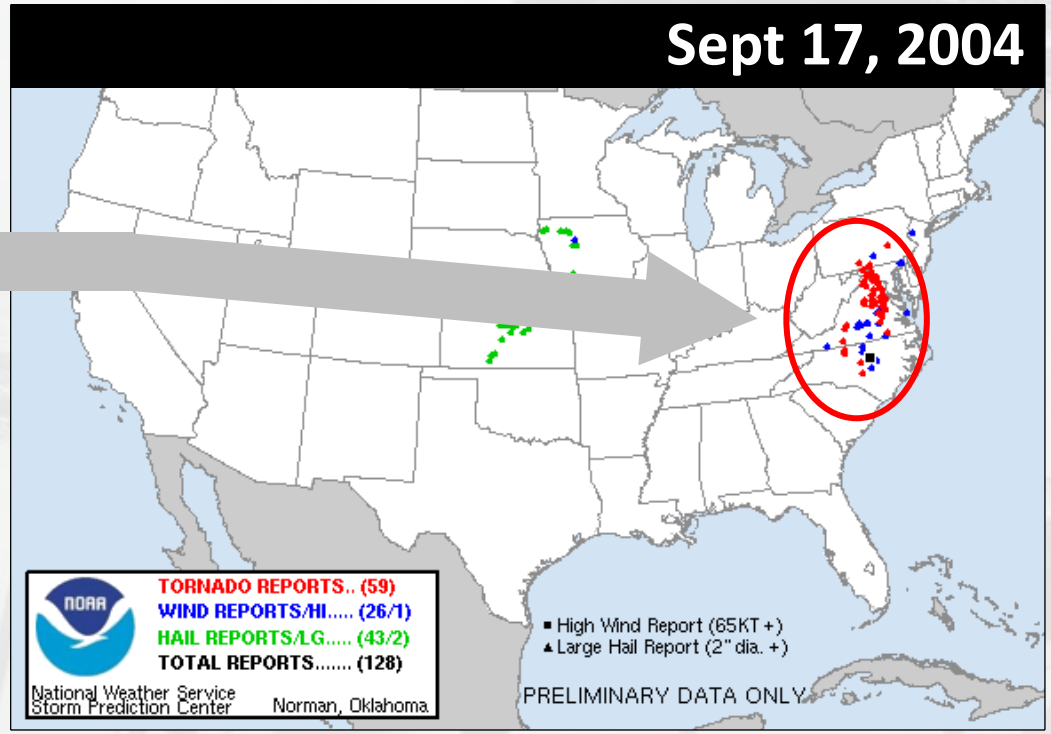
TORNADOES

- 70% produce at least 1 tornado
- 40% produce more than 3 tornadoes

Tornado "outbreak"

Hurricane Ivan (2004)

– 117 Tornadoes



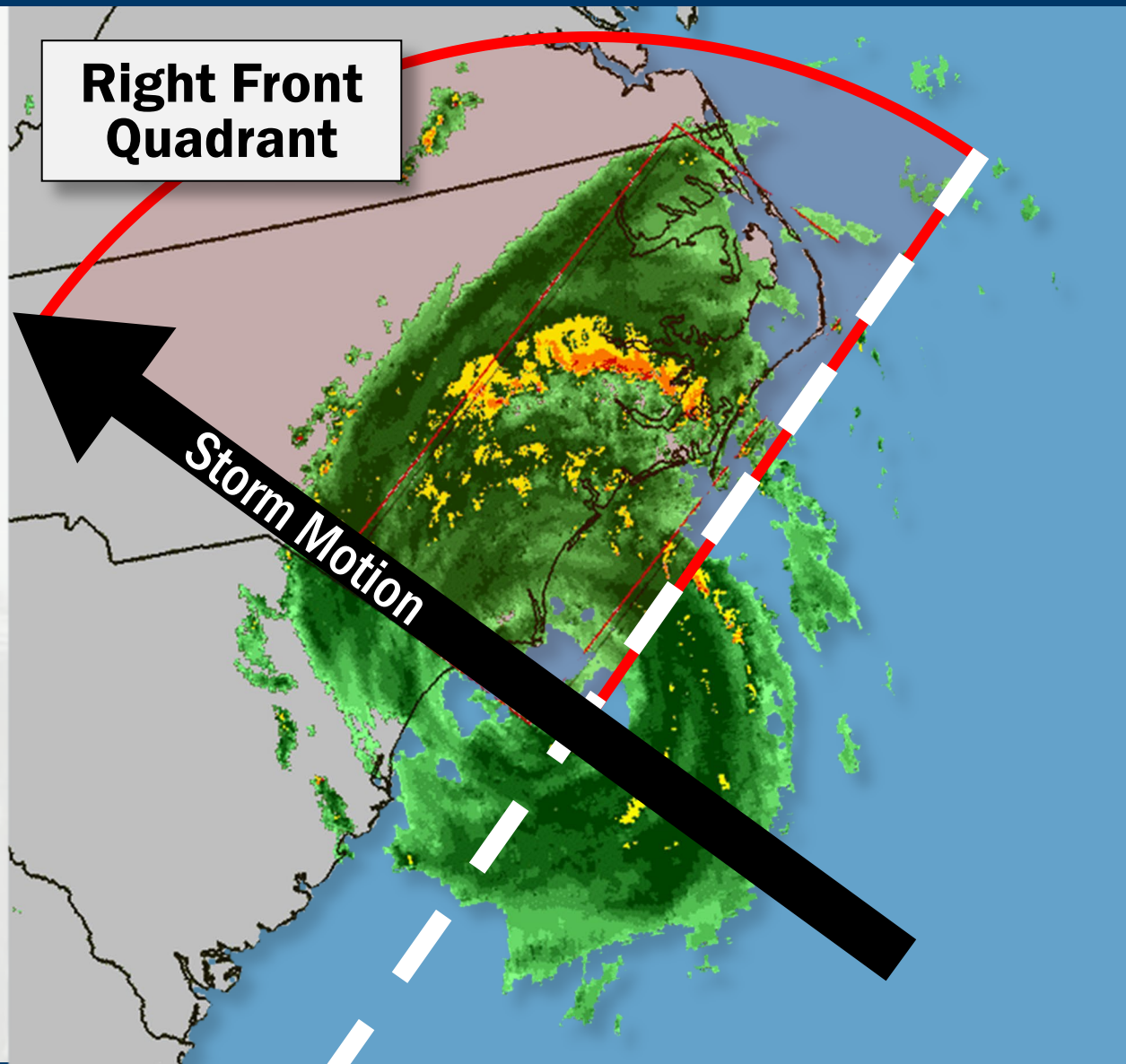
TORNADOES

Landfalling hurricanes spawn tornadoes.

FEMA

TORNADOES

- Right front quadrant
- Friction over land creates low-level wind conditions favorable for the development of tornadoes

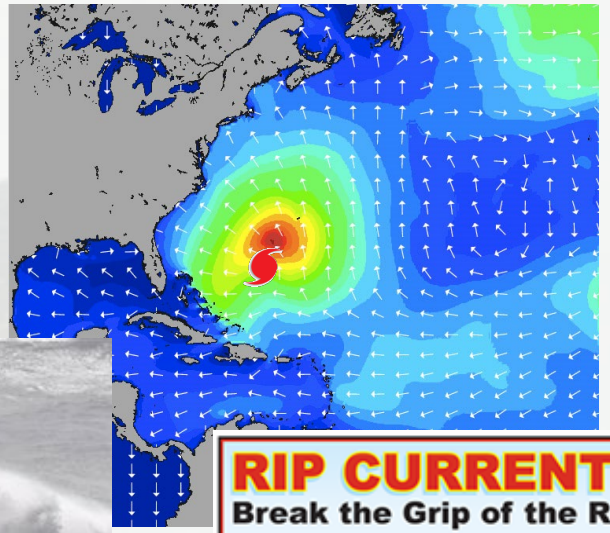


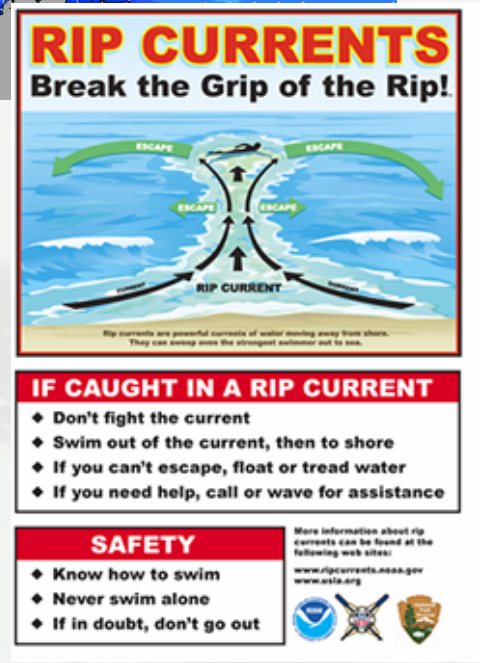
WAVES AND RIP CURRENTS
Can occur when a storm is well offshore

FEMA

WAVES & RIP CURRENTS

- **Swells from a large hurricane can affect beaches of the entire western Atlantic**
- **Hurricane Lorenzo (2019)**
  - 8 people drowned along U.S. East Coast in rip currents and hazardous surf
- **Hurricane Delta (2020)**
  - 2 people drowned along the NW Florida coast





HURRICANE BASICS

Questions?

FEMA