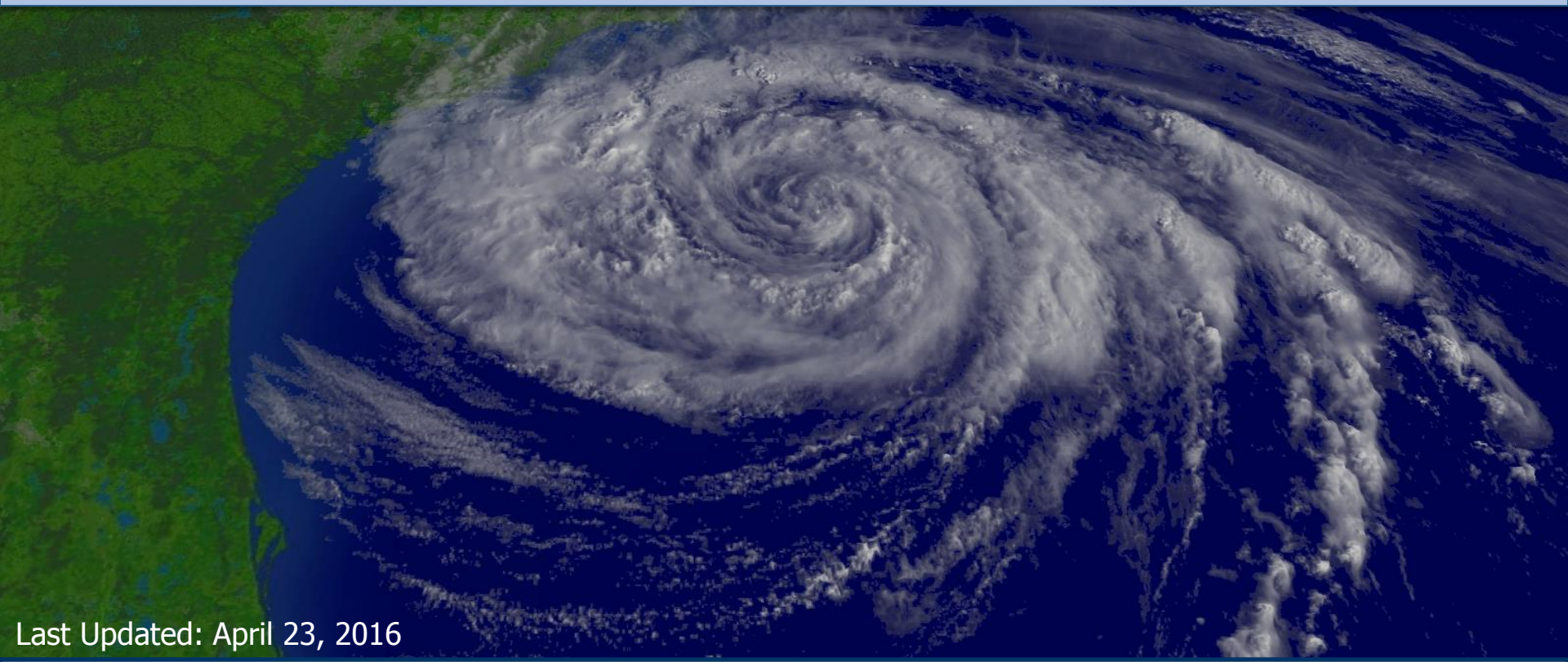
2016 Hurricane Guide for Southeast South Carolina/Georgia

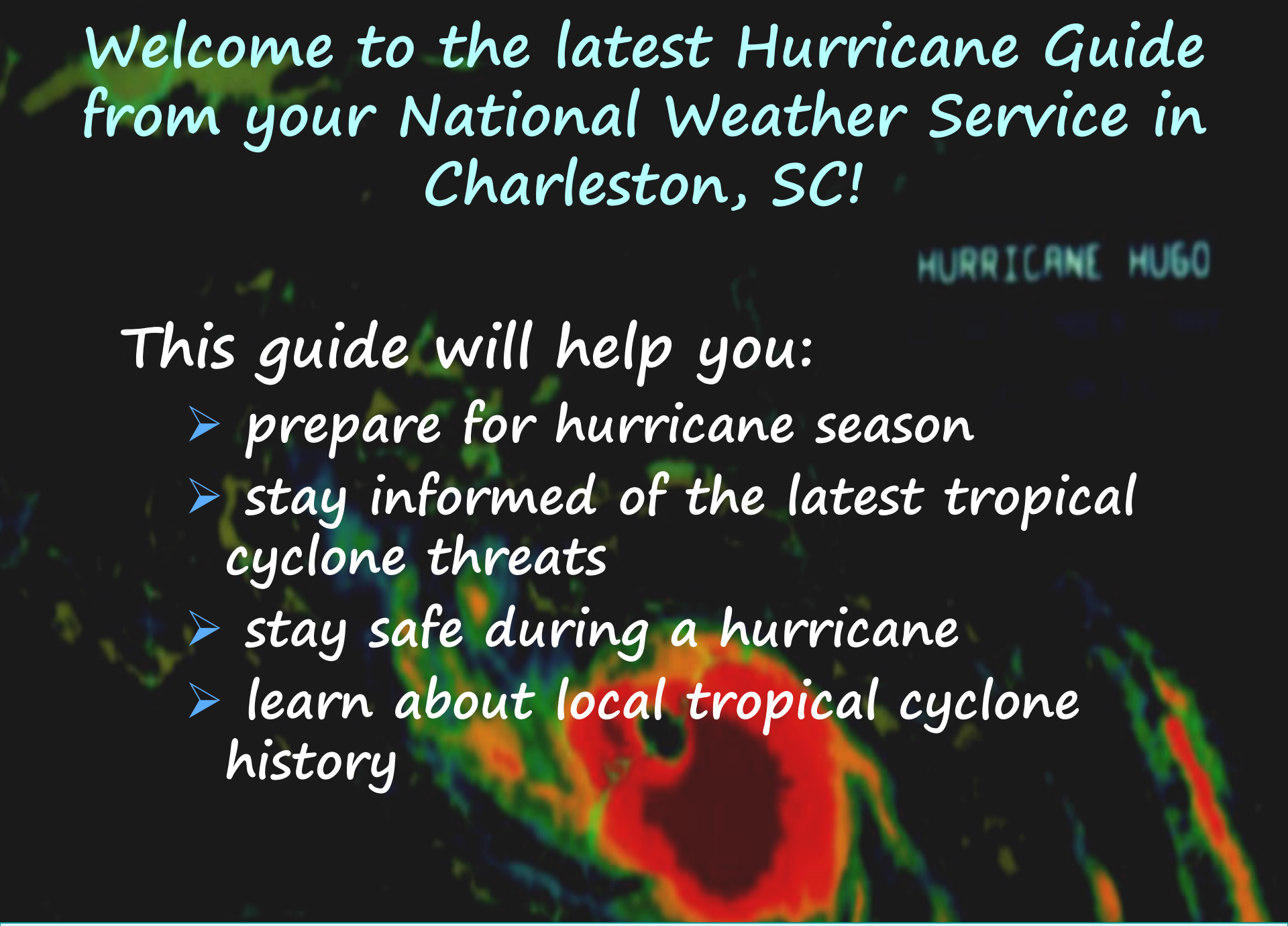
Plan, Act, Survive!



Last Updated: April 23, 2016

National Weather Service
Charleston, SC
weather.gov/chs

Welcome to the latest Hurricane Guide from your National Weather Service in Charleston, SC!



This guide will help you:

- prepare for hurricane season
- stay informed of the latest tropical cyclone threats
- stay safe during a hurricane
- learn about local tropical cyclone history

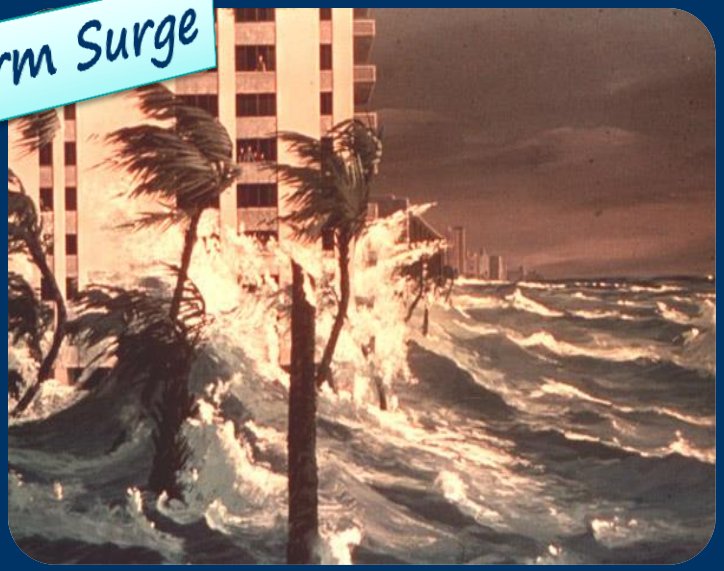
NOTE: Numerous links (in blue) are provided throughout this guide to obtain more information!

Outline

- **Tropical Cyclone Hazards**
- Being Prepared and Staying Informed
- Tropical Cyclone Basics
- Tropical Cyclone Climatology
- Tropical Cyclone History for Southeast South Carolina and Southeast Georgia

Main Tropical Cyclone Hazards

Storm Surge



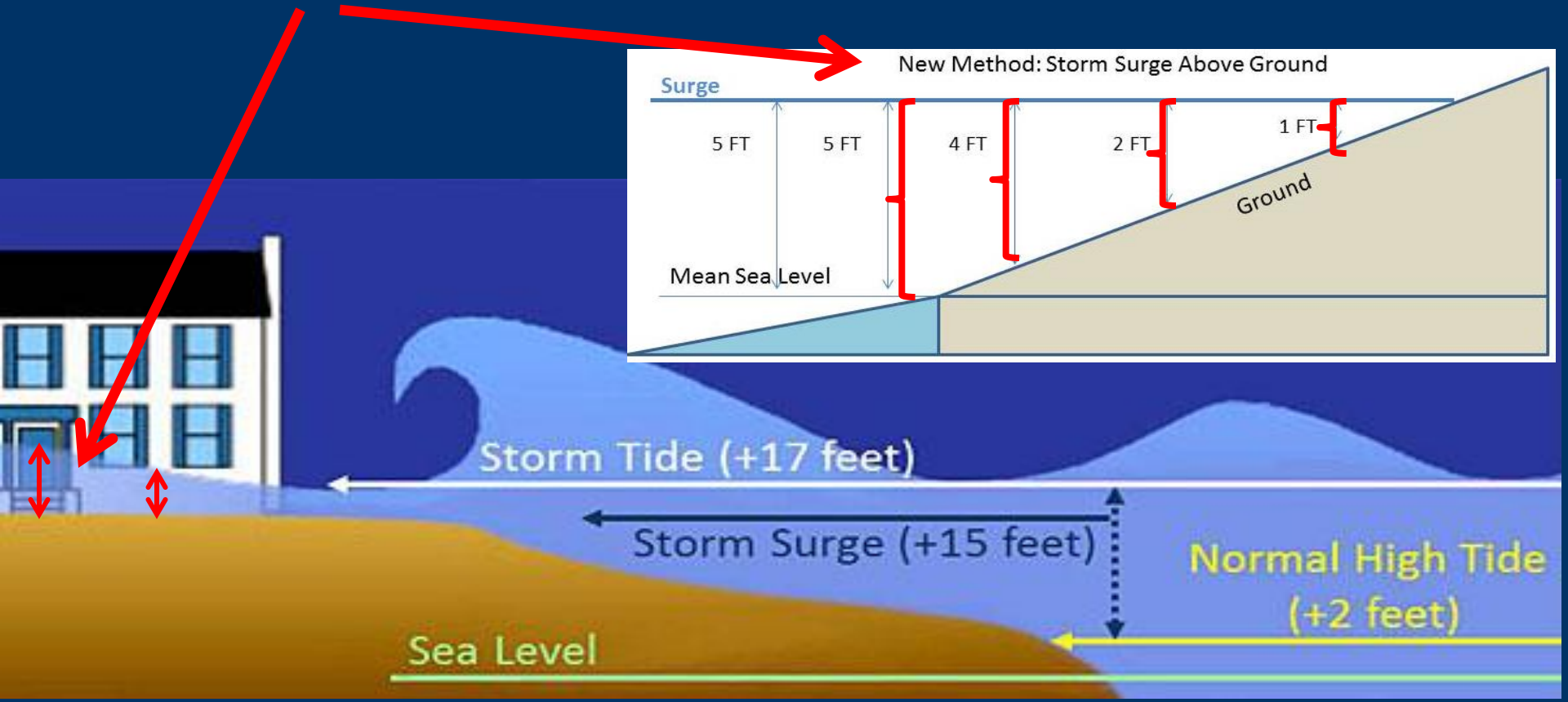
High Winds

Tornadoes/Waterspouts

Flooding Rains

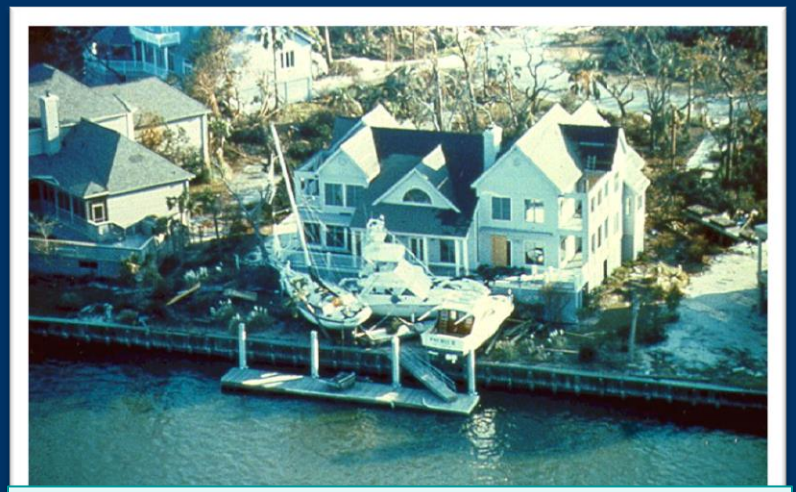
Storm Surge Terminology

- **Storm surge:** abnormal rise of water generated by a storm
- **Storm tide:** storm surge + astronomical tide
- **Inundation: height of water above the ground**

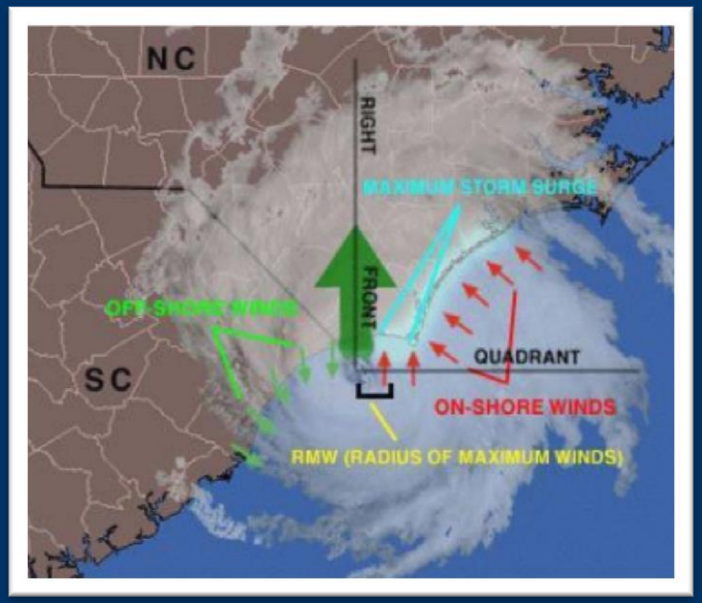


Storm Surge Facts

- Greatest threat to life and property along the coast
- Can occur rapidly and forcefully and travel many miles inland in low-lying areas (such as along the SC/GA coasts)
- Produced mainly by strong winds blowing over the ocean for an extended period
- Stronger, larger and faster storms generally produce higher surge
- The amount of surge is not always the same for each category of storm
- Highest surges at the coast typically occur to the right of where the center of the storm comes ashore (blue area outlined in the image to the right)



Isle of Palms, SC after Hurricane Hugo (1989)



« Images courtesy of NWS

Storm Surge Facts

- There will be more flooding if the highest surge occurs around high astronomical tide compared to low tide
- The coastal areas of SC/GA are the 3rd most surge-prone area in the U.S. given the low elevation and gently sloping continental shelf offshore
- In 1989, Hurricane Hugo produced the highest water levels ever recorded on the U.S. East Coast (~20 foot storm tide above Mean Sea Level at Bulls Bay, SC and ~10 foot storm tide in downtown Charleston, SC)

« *Images courtesy of NWS*

Romain Retreat, SC (near Bulls Bay) after Hugo

The Battery in Downtown Charleston, SC after Hugo

Storm Surge Impacts

Folly Beach, SC – before Hugo

Folly Beach, SC – after Hugo

Hurricane Ivan (2004):
- Category 3; 10-16 foot surge

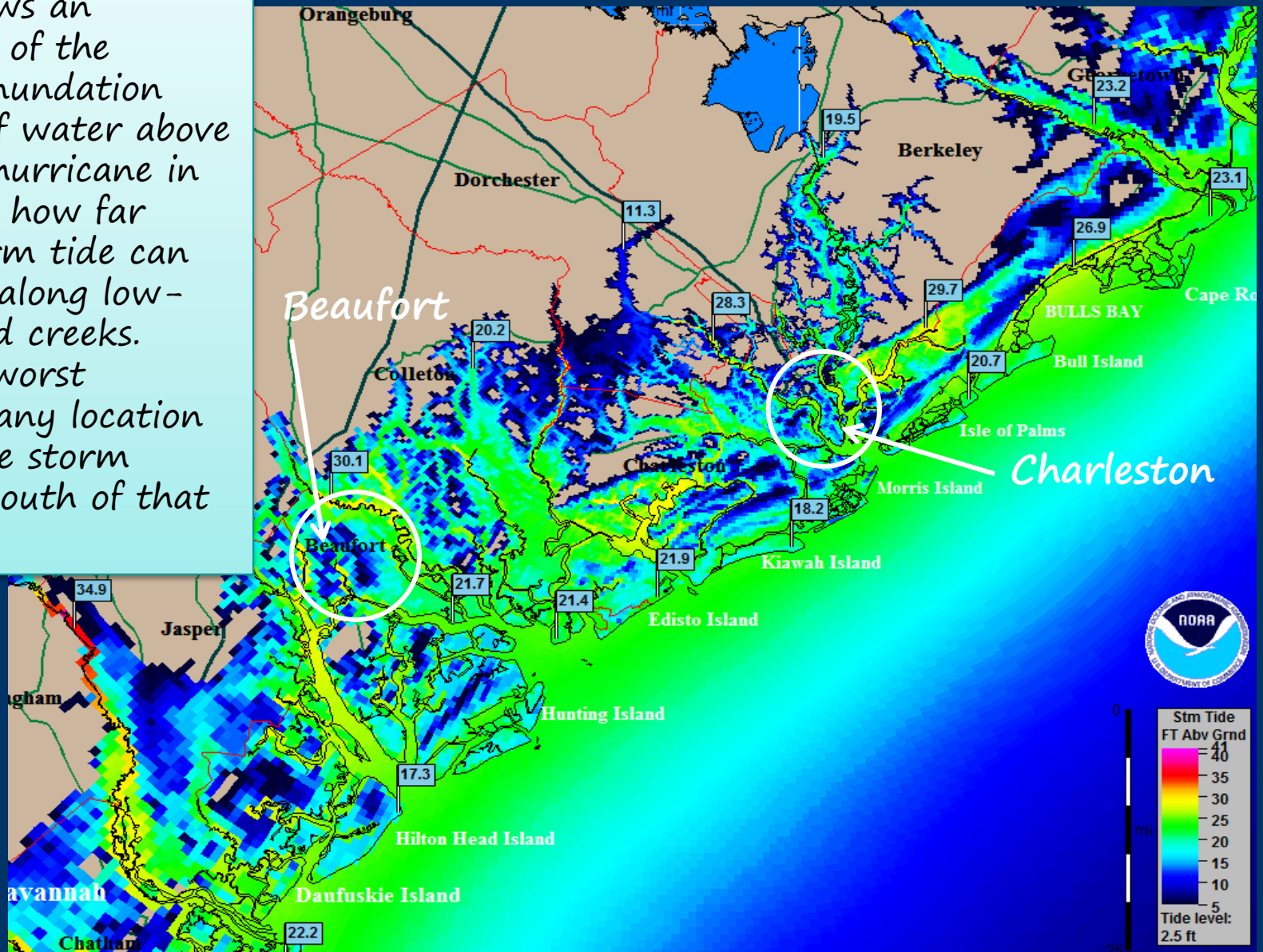
Hurricane Ike (2008):
- Category 2
- 15-20 foot surge

« Images courtesy of NWS

Local Storm Surge Risk

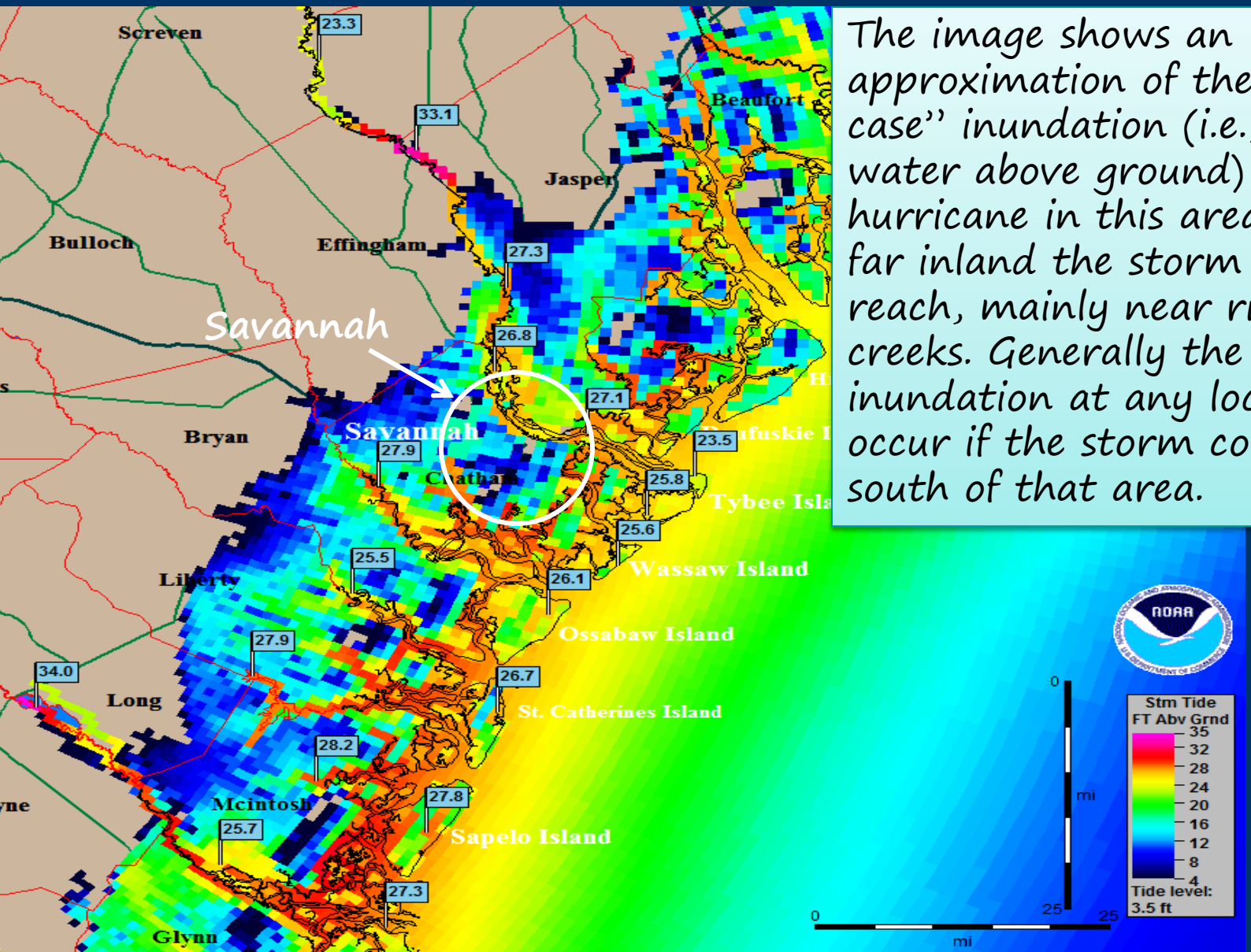
Southern South Carolina Coast

The image shows an approximation of the "worst case" inundation (i.e., amount of water above ground) for a hurricane in this area. Note how far inland the storm tide can reach…mainly along low-lying rivers and creeks. Generally the worst inundation at any location will occur if the storm comes ashore south of that area.



Local Storm Surge Risk

Northern Georgia Coast



The image shows an approximation of the "worst case" inundation (i.e., amount of water above ground) for a hurricane in this area. Note how far inland the storm tide can reach, mainly near rivers and creeks. Generally the worst inundation at any location will occur if the storm comes ashore south of that area.

Are You At Risk From Storm Surge?

- Determine your elevation and whether you live in a flood zone (i.e., if you are vulnerable to storm surge flooding)
  - If you live in/near any of the shaded areas on the maps on the previous 2 slides you are vulnerable to storm surge!
  - Refer to your county emergency management office… SC / GA
  - Check out NOAA's storm surge risk maps
- Learn which pre-designated evacuation zone you live in as well as official evacuation routes… SC / GA
- **Evacuate if advised to do so by local authorities!**
- Keep in mind that if you don't evacuate, your location may become an "island" cut off from emergency officials

High Winds

- Strong, damaging winds can occur hundreds of miles from the coast
- In fact, Hurricane Hugo in 1989 produced hurricane force wind gusts in Charlotte, NC toppling numerous trees and power lines (see images below)

« Images courtesy of NWS

High Wind Facts

- Generally the stronger the storm at landfall the longer it will take for the winds to diminish
- Coastal areas/high-rise buildings:
  - winds normally higher due to less surface friction
- Inland areas away from the immediate coast:
  - sustained winds generally lower than at coast, but gusts can be similar to sustained winds at coast

« Images courtesy of NWS

Charleston Area After Hurricane Hugo (1989)

High Wind Safety

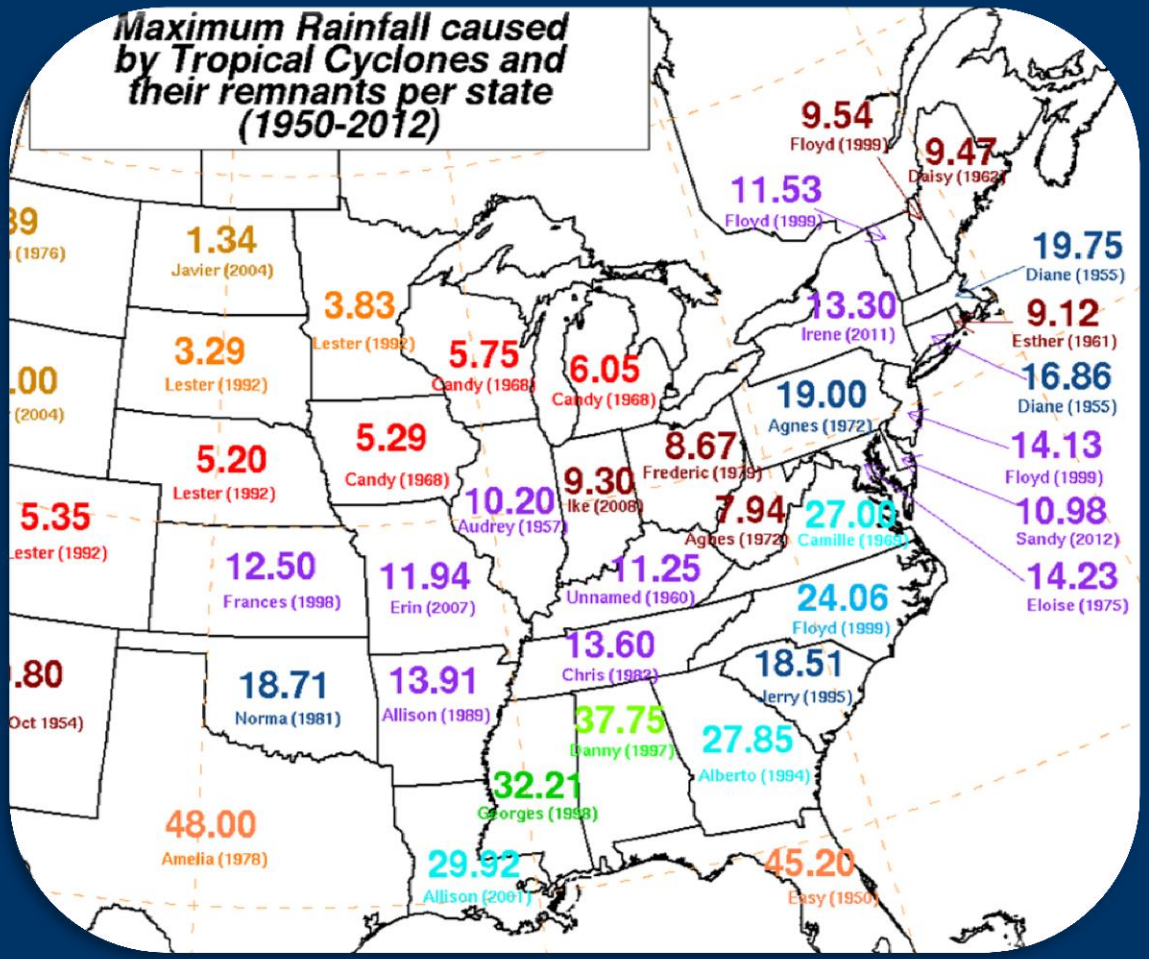
- Cover all windows and doors with plywood or shutters
  - Do NOT leave any windows/doors open to relieve pressure
  - Tape does NOT work!
- Reinforce garage doors as they are typically weak points
- Store all outdoor items that could become deadly missiles
- Evacuate to a more sturdy structure if you live in a mobile/manufactured home, especially if advised to do so by local authorities
- During a storm, go to your "safe place" which should be the most interior room on the lowest floor of your building that is not prone to flooding and protect your head with helmets or pillows

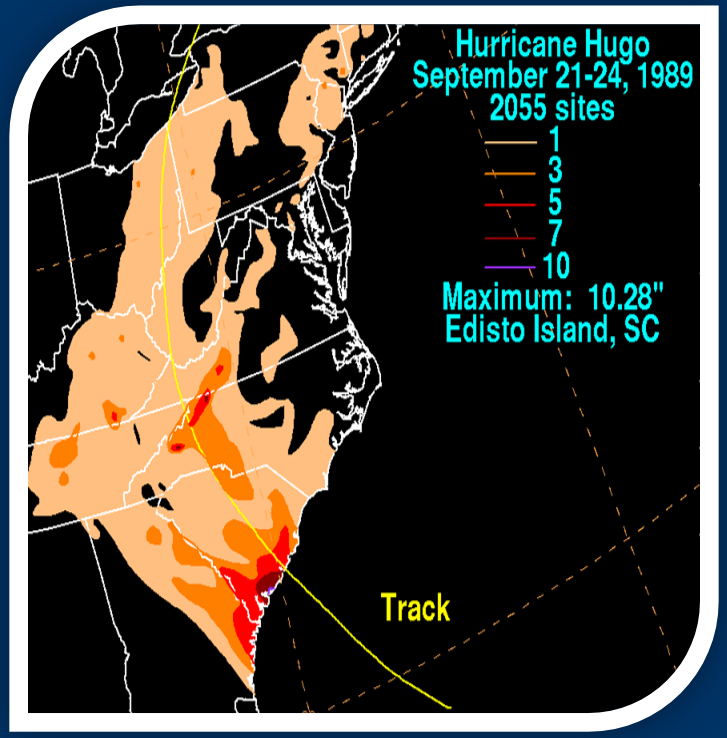
Flooding Rainfall

- **When you think "hurricane", think "flooding"!**
- Most deaths in more recent tropical cyclones have been from inland fresh water flooding
- Weak storms can still produce a lot of rainfall
- Slower storms can produce more rainfall
- Determine whether you live in a flood zone and evacuate if advised to do so by local officials
- Never drive through flooded roads since you don't know how deep the water is and the road may be washed out

Remember, it only takes ~1 foot of water to move most small vehicles!!

Flooding Rainfall





« *Images courtesy of NWS/Weather Prediction Center*

- The coastal areas of SC and GA, particularly in urban areas like downtown Charleston and Savannah, are particularly vulnerable to flooding given the added influence of the storm tides

Tornadoes/Waterspouts

- Typically short-lived (minutes) and weak (EF0-EF1: up to 110 mph), although can be much stronger

- Typically occur within the storm's outer rain bands and near the center (eye wall)

- During the storm, if the NWS issues a "Tornado Warning" or "Extreme Wind Warning" for your location, go to your "safe place" (i.e., most interior room on lowest floor not prone to flooding)

Outline

- Tropical Cyclone Hazards
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- Tropical Cyclone History for Southeast South Carolina and Southeast Georgia

Before the Storm…

- Determine your elevation and whether you live in a flood zone (i.e., if you are vulnerable to flooding from storm surge)
  - If you live in/near any of the shaded areas on the surge maps found earlier in this guide you are vulnerable to storm surge!
  - Refer to your county emergency management office… SC / GA
- Learn which pre-designated evacuation zone you live in… SC / GA
- If you are evacuating, find a hotel/shelter and learn evacuation routes
- Get a disaster supply kit that includes sufficient food and water
- Prepare your home by boarding up windows/doors with plywood and trimming trees and shrubbery
- Review your insurance policy (Note: flooding is not covered and must be purchased via the National Flood Insurance Program for which there is roughly a 30 day waiting period)
- Make plans for your pets since some shelters/hotels do not accept them

Remember…preparation is key!

If evacuating...leave early!!

Motorists Trapped on I-26 During Hurricane Floyd (1999)

An average size car will flip in 115 mph winds!

Tropical Storm/Hurricane Watch & Warning Definitions

- **Watch:**
  - Tropical Storm/Hurricane force winds possible within 48 hours
  - *Get Prepared!*
- **Warning:**
  - Tropical Storm/Hurricane force winds likely within 36 hours
  - *Take Action!*

If a Watch is Issued For Your Area…

- Determine if you are vulnerable to storm surge flooding… SC / GA
- Learn your pre-designated evacuation zone as well as official evacuation routes… SC / GA
- Evacuate if you are advised to do so by officials, and do so early!
- Review your disaster plan and check your supply kit
- Prepare your home by trimming weak/dead branches, covering windows/doors and bringing in unsecured outdoor items
- Inspect/secure mobile home tie downs
- If evacuating, notify your friends/family and note that some shelters/hotels do not accept pets
- Gas your vehicles and get cash since ATMs won't work w/o power
- Store drinking water in jugs, bottles and clean bathtubs (at least 1 gallon per person per day for 3 days)

If a Warning is Issued For Your Area…

- Rush protective actions to completion!!
- Evacuate as soon as possible, especially if advised to do so by authorities!
  - Notify friends/family of where you are going
  - Take your disaster supply kit with you
  - Unplug appliances and turn off electricity/main water valve
- If not evacuating…
  - Be sure you are not vulnerable to flooding… SC / GA
  - Ready your disaster supply kit
  - Turn your refrigerator/freezer to their coldest settings and keep closed as much as possible
  - Cover windows/doors and store outdoor items
  - Fill bathtubs and large containers with water for cleaning/flushing purposes in case clean tap water is unavailable
  - If power is lost, turn off major appliances to reduce power "surge" when electricity is restored

After the Storm…

- If you have evacuated, don't return home until notified by officials!
- Watch for downed trees/power lines, glass, nails, and other debris as well as snakes, insects and other animals
- Don't drive through flooded roads
- Don't run power generators indoors
- Help neighbors, especially the elderly
- Be patient as help may take several days!
- More recovery tips…. http://www.ready.gov/recovering-disaster

« Images courtesy of US DOT/FHA

Staying Informed:
Real-time Storm Information

- Social Media:
  - NWS Charleston Facebook: https://www.facebook.com/NWSCharlestonSC
  - NWS Charleston Twitter: @NWSCharlestonSC
- Mobile:
  - hurricanes.gov/mobile
- Internet:
  - NWS Charleston, SC: weather.gov/chs
  - National Hurricane Center: hurricanes.gov
- NOAA Weather Radio:
  - http://weather.gov/nwr
- Local TV/Radio

NWS Tropical Products/Services

National Hurricane Center

- Forecasts development, track, and strength of tropical cyclones

NWS Charleston, SC

- Localizes the potential tropical cyclone impacts for Southeast SC/GA

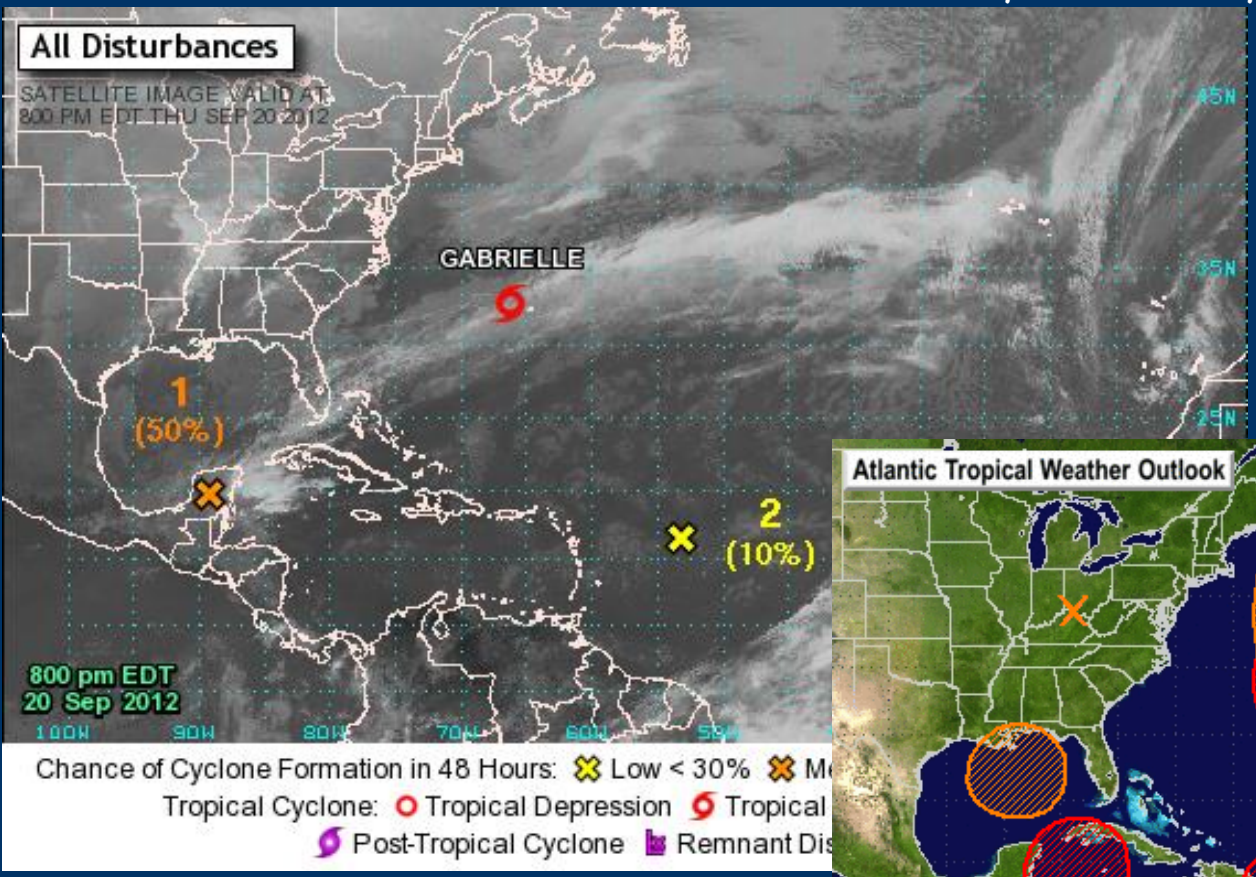
hurricanes.gov

weather.gov/chs

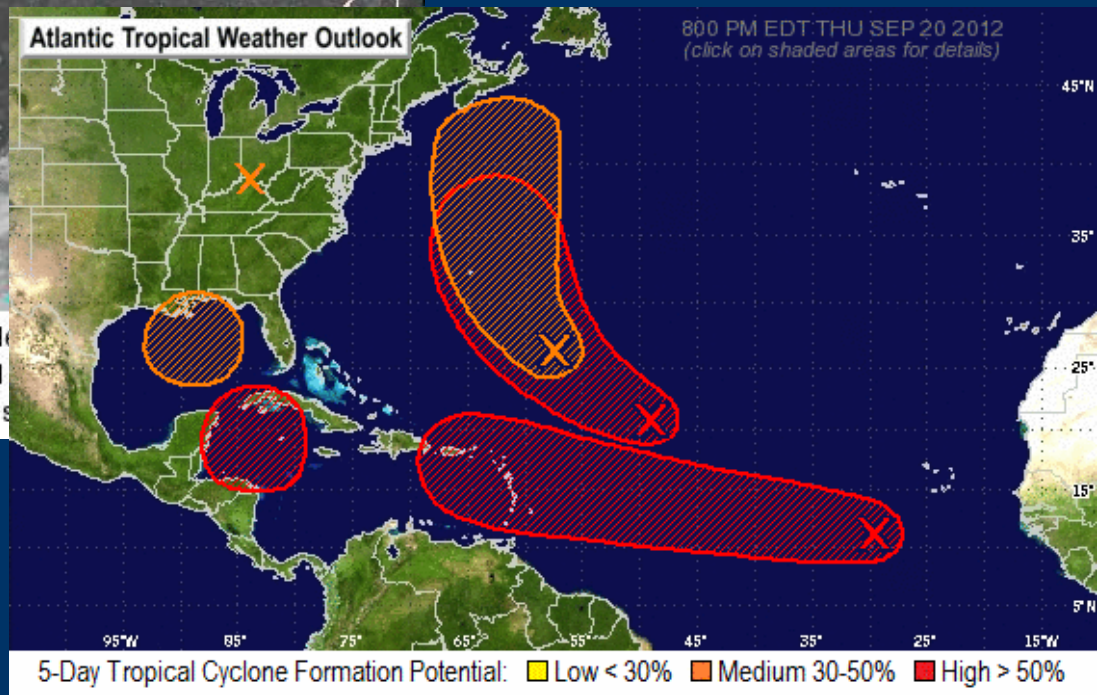
NHC Tropical Weather Outlook

http://hurricanes.gov/gtwo_atl.shtml

- Shows current storms and areas of possible tropical cyclone formation



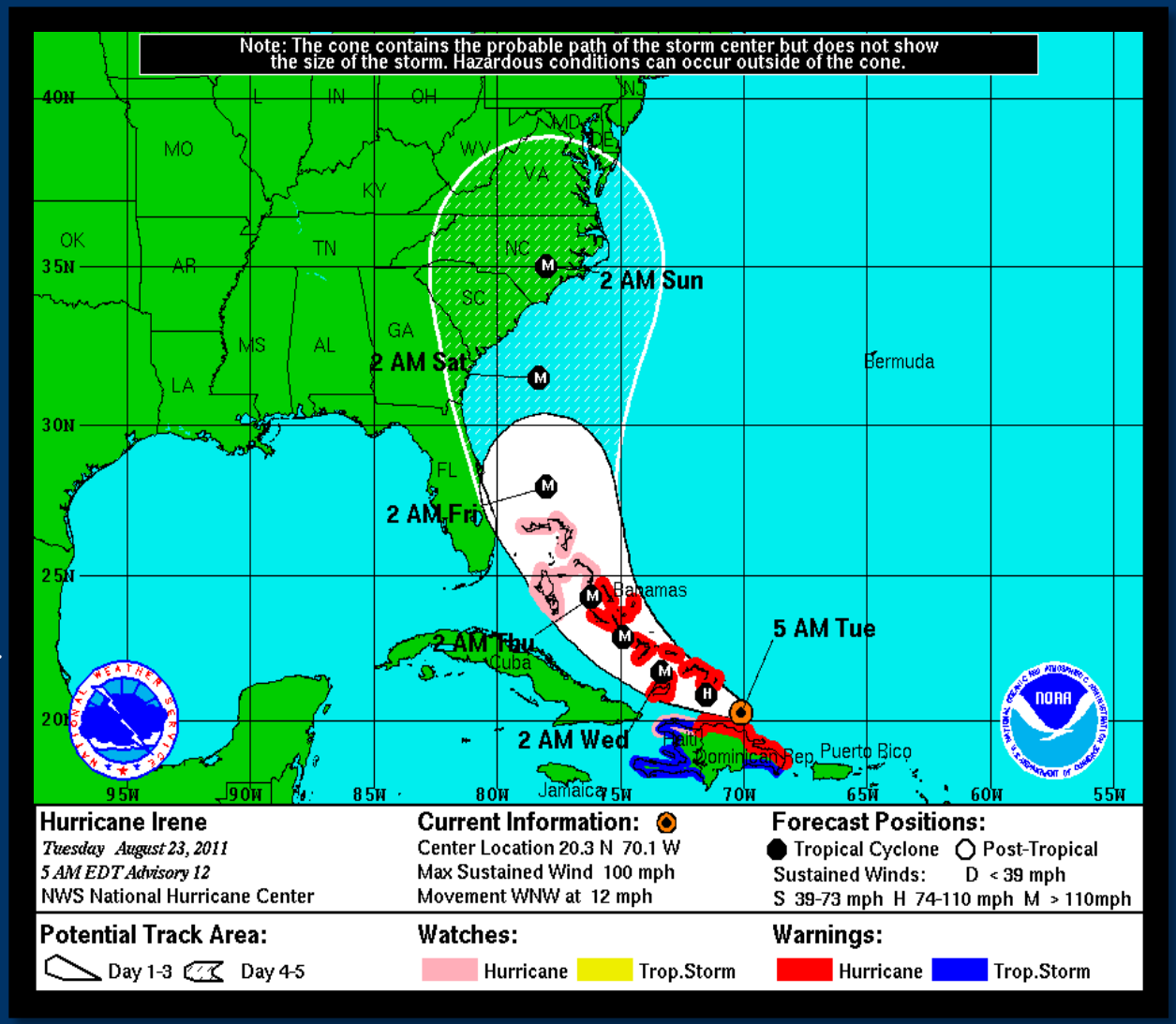
48-hour Outlook



5-day Outlook

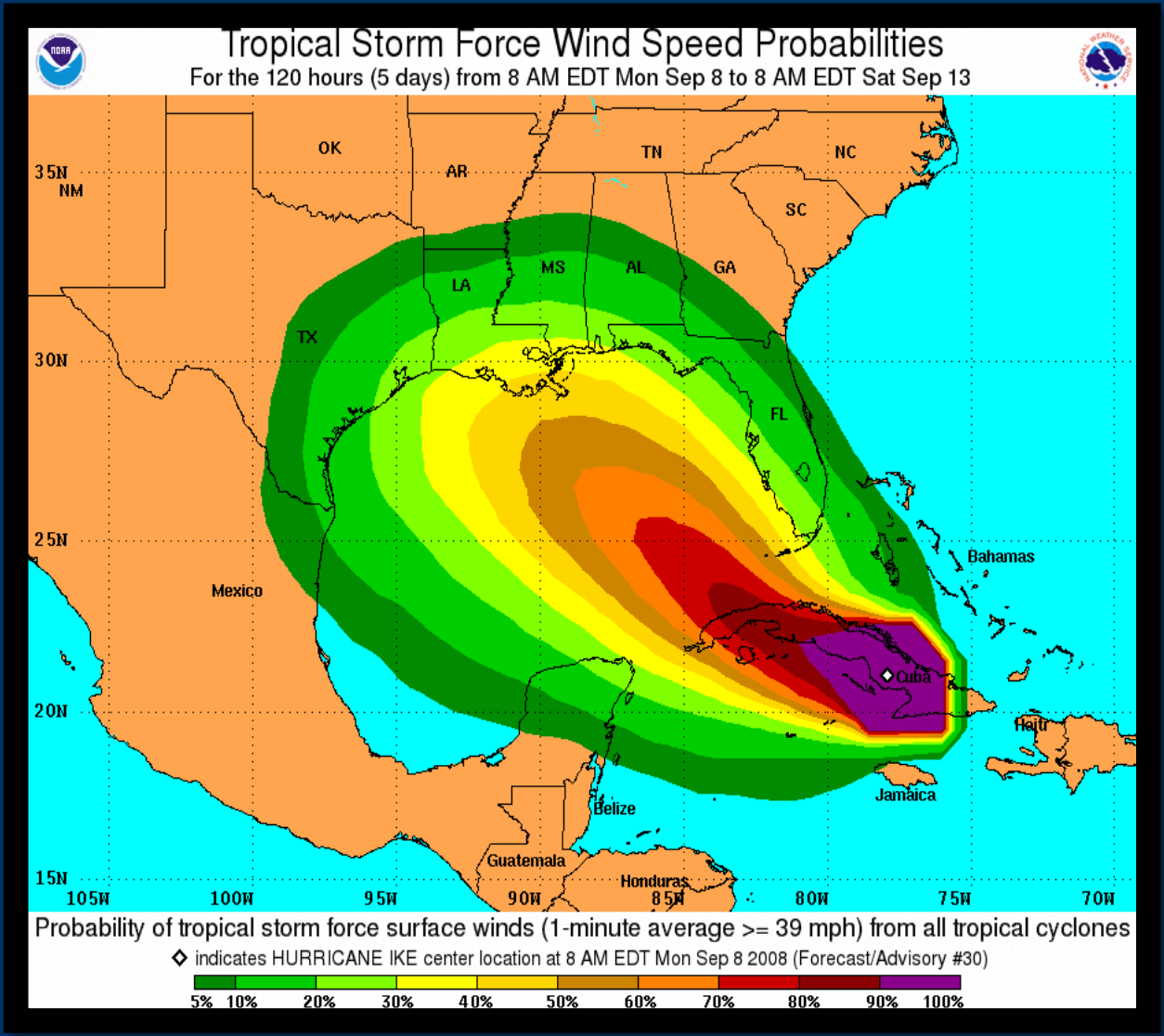
NHC Track Forecast "Cone of Uncertainty"

- Shows the likely storm track along with the latest tropical storm/hurricane watches and warnings
- Remember that the "cone" does NOT indicate the area of possible impact, just the likely track of the storm center!



NHC Wind Speed Probabilities

- Shows the chance of 34 knot (tropical storm force), 50 knot, and 64 knot (hurricane force) winds through the next 5 days, as well as during particular time periods
- Accounts for uncertainty in the storm's track/size/intensity
- NOTE: Low probabilities do NOT necessarily imply low risk!
- Product description:
  - http://www.nhc.noaa.gov/aboutnhcgraphics.shtml#WINDPROB



- The graphic above shows the probabilities of tropical storm force winds during the next 5 days

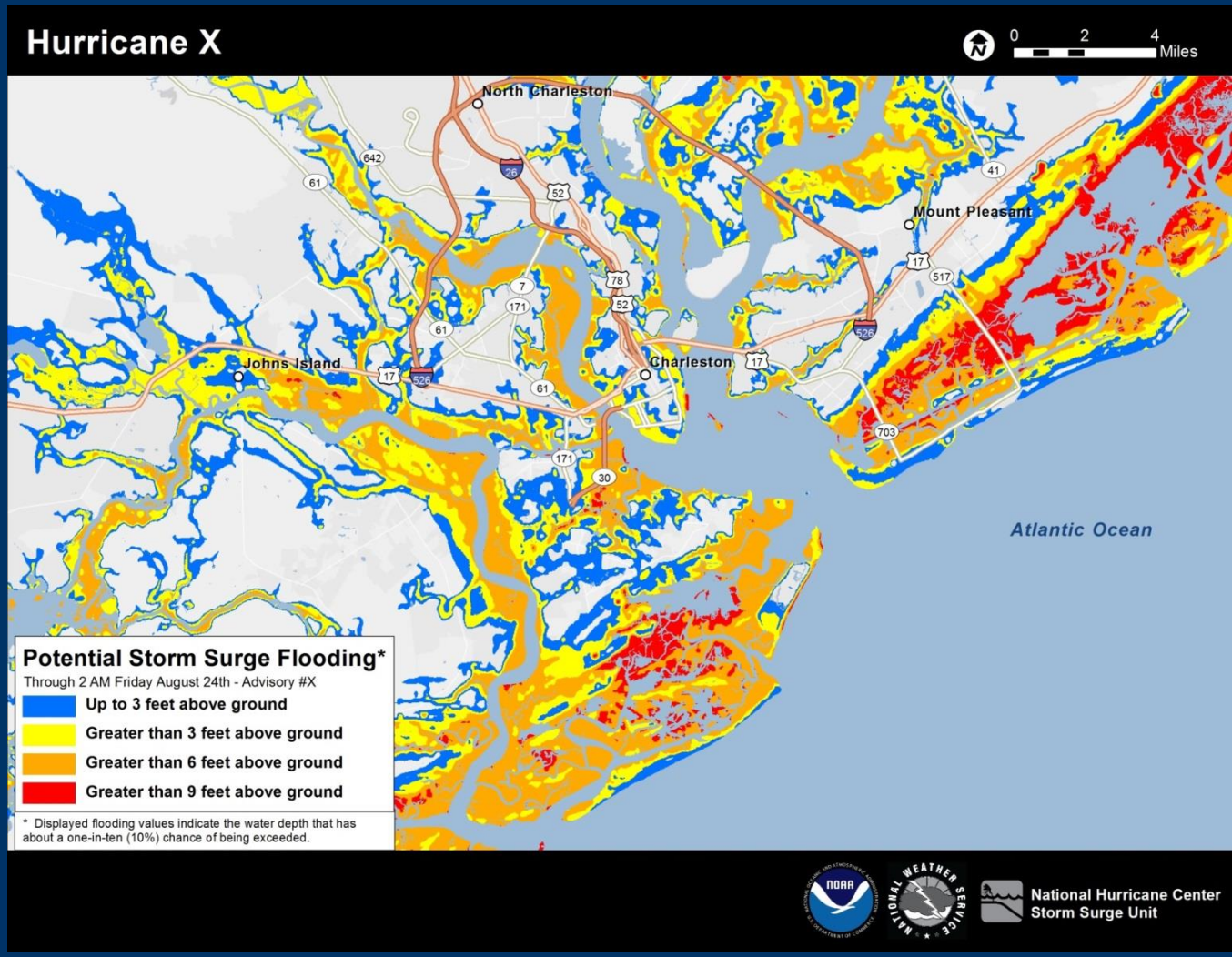
NHC Wind Speed Probabilities Example

Forecast Hour		12	24	36	48	72	96	120
CHARLOTTE NC	34	X	X(X)	X(X)	X(X)	1(1)	3(4)	3(7)
MOREHEAD CITY	34	X	X(X)	4(4)	6(10)	13(23)	4(27)	2(29)
MOREHEAD CITY	50	X	X(X)	X(X)	X(X)	4(4)	2(6)	X(6)
MOREHEAD CITY	64	X	X(X)	X(X)	X(X)	1(1)	1(2)	X(2)
WILMINGTON NC	34	X	X(X)	4(4)	4(8)	6(14)	4(18)	1(19)
WILMINGTON NC	50	X	X(X)	X(X)	X(X)	1(1)	1(2)	1(3)
WILMINGTON NC	64	X	X(X)	X(X)	X(X)	X(X)	1(1)	X(1)
COLUMBIA SC	34	X	X(X)	1(1)	X(1)	X(1)	2(3)	2(5)
MYRTLE BEACH	34	X	1(1)	3(4)	2(6)	4(10)	2(12)	1(13)
CHARLESTON SC	34	X	2(2)	3(5)	X(5)	1(6)	1(7)	1(8)
SAVANNAH GA	34	X	2(2)	2(4)	X(4)	X(4)	X(4)	1(5)

- The probability for tropical storm force winds (34 kt) at Savannah, Georgia in the 12-24 hour time period is 2%, the cumulative probability through 48 hours is 4% and the cumulative probability for the entire 5-day period (120 hours) is 5%.

Storm Surge Inundation Map

- Shows potential water heights above ground that could result from a storm's surge combined with the tide (i.e., storm tide)
- Available on the NHC's website soon after the 1st Hurricane Watch is issued for a storm and updated with each subsequent advisory
- Represents a plausible worst-case scenario and thus what people should prepare for

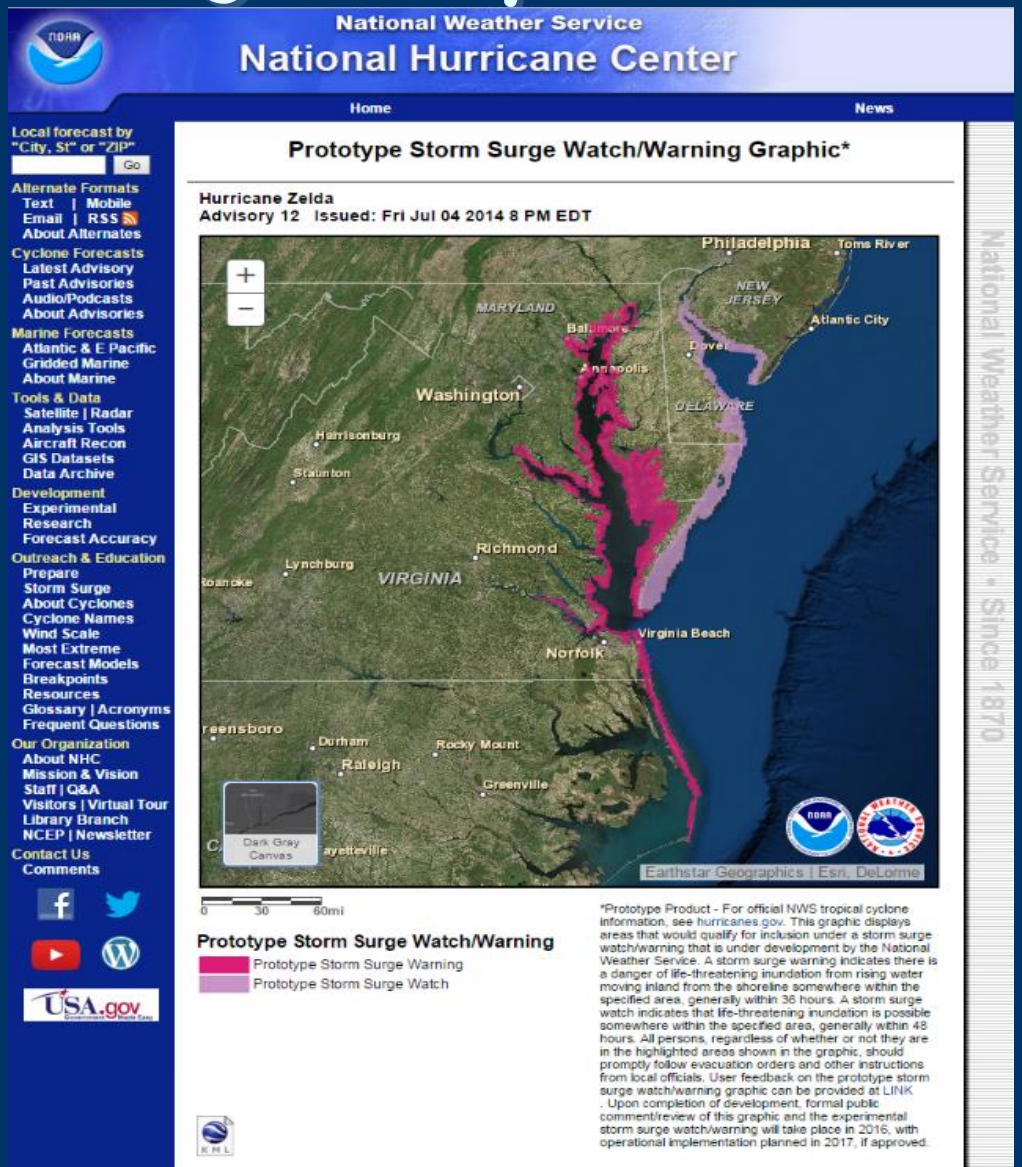


http://hurricanes.gov/experimental/inundation/

Experimental Storm Surge Watch/Warning Graphic

- Highlights areas that have a significant risk of life-threatening storm surge inundation from a hurricane (or tropical storm)
  - Watch: conditions possible within ~48 hours
  - Warning: conditions possible within ~36 hours

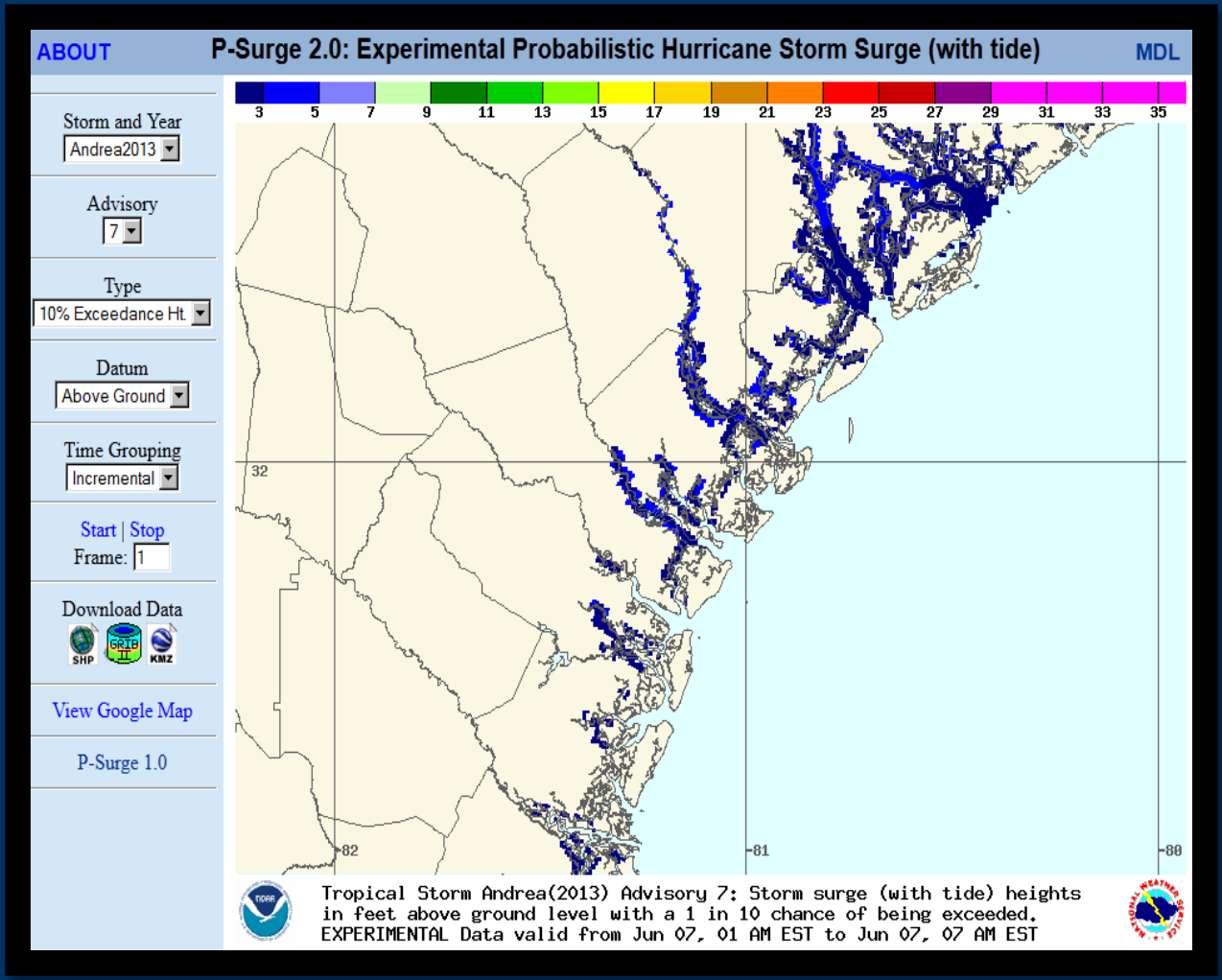
- Available on the NHC's website about 30 minutes after the official Advisory is issued for a storm



http://hurricanes.gov/experimental/surgewarning/

Storm Surge Probabilities

- Shows the potential for inundation (i.e., water height above ground) resulting from a hurricane's storm surge as well as the tide
- Accounts for uncertainty in a storm's track/intensity/size
- Data available as probabilities of particular storm tide heights as well as % exceedence heights
- http://slosh.nws.noaa.gov/psurge2.0/



- The image above indicates the storm tide heights which have just a 10% chance of being exceeded

NWS Charleston Products

Hurricane Local Statement (HLS)

TROPICAL STORM ANA LOCAL STATEMENT INTERMEDIATE ADVISORY NUMBER 8A
NATIONAL WEATHER SERVICE CHARLESTON SC AL012015
826 PM EDT SAT MAY 9 2015

THIS PRODUCT COVERS SOUTHEAST SOUTH CAROLINA AND SOUTHEAST GEORGIA

...TROPICAL STORM WATCH CANCELLED FOR CHARLESTON AND BERKELEY COUNTIES...

NEW INFORMATION
---

* CHANGES TO WATCHES AND WARNINGS:
  - ALL WATCHES HAVE BEEN CANCELED

SITUATION OVERVIEW

TROPICAL STORM CONDITIONS ARE NOT EXPECTED IN CHARLESTON AND BERKELEY COUNTIES.

NEXT UPDATE

AS IT PERTAINS TO THIS EVENT...THIS WILL BE THE LAST LOCAL STATEMENT ISSUED BY THE NATIONAL WEATHER SERVICE IN CHARLESTON SC REGARDING THE EFFECTS OF TROPICAL CYCLONE HAZARDS UPON THE AREA.

$$

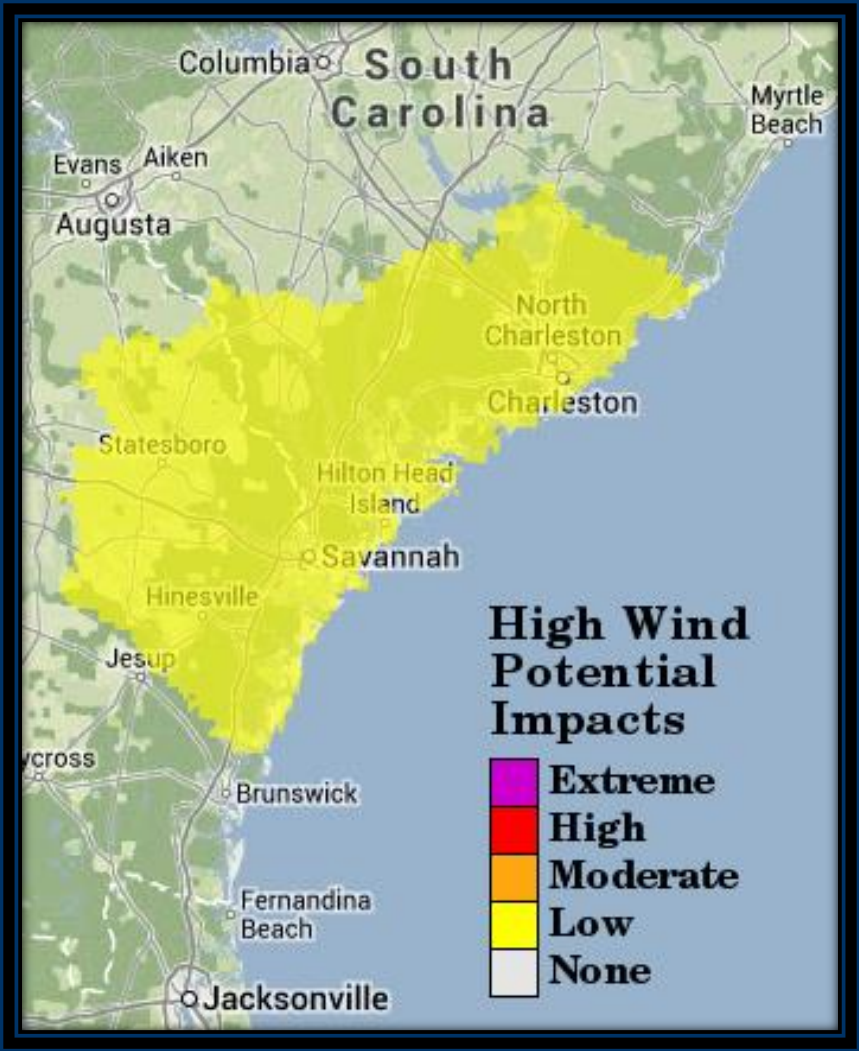
- Overview of the storm and its potential impacts

« Final HLS issued for Tropical Storm Ana in May 2015

NWS Charleston Products

Hurricane Threats and Impacts Graphics

- Shows the potential impacts from wind, storm surge, rainfall and tornadoes that people should prepare for
- Provides recommended protective actions
  - High Wind graphic issued for Tropical Storm Andrea in June 2013



NWS Charleston Products

Post-storm Report (PSH)

POST TROPICAL CYCLONE REPORT...TROPICAL STORM ANDREA...UPDATED
NATIONAL WEATHER SERVICE CHARLESTON SC
1009 AM EDT FRI JUN 14 2013

NOTE: THE DATA SHOWN HERE ARE PRELIMINARY....AND SUBJECT TO UPDATES AND CORRECTIONS AS APPROPRIATE.

THIS REPORT INCLUDES EVENTS OCCURRING WHEN WATCHES AND/OR WARNINGS WERE IN EFFECT...OR WHEN SIGNIFICANT FLOODING ASSOCIATED WITH ANDREA OR ITS REMNANTS WAS AFFECTING THE AREA.

COUNTIES INCLUDED...CHARLESTON...BERKELEY...COLLETON...BEAUFORT...
BRYAN...LIBERTY...MCINTOSH...JASPER

JUN 14...UPDATED FOR...STORM SURGE/TIDE AND INLAND FLOODING.

A. LOWEST SEA LEVEL PRESSURE/MAXIMUM SUSTAINED WINDS AND PEAK GUSTS

METAR OBSERVATIONS...
NOTE: ANEMOMETER HEIGHT IS 10 METERS AND WIND AVERAGING IS 2 MINUTES

LOCATION LAT LON DEG DECIMAL	ID	MIN PRES (MB)	DATE/ TIME (UTC)	MAX SUST (KT)	DATE/ TIME (UTC)	PEAK GUST (KT)	DATE/ TIME (UTC)
KCHS-CHARLESTON INTL AIRPORT SC							
32.91 -80.03		999.4	07/0956	180/024	07/0956	180/034	07/0943
KSAV-SAVANNAH INTL AIRPORT GA							
32.12 -80.20		997.7	07/0753	270/016	07/1346	270/024	07/1346
KNBC-BEAUFORT MARINE CORPS AIR STATION SC							
32.48 -80.72		997.2	07/0856	250/016	07/1137	290/025	07/1608

- Summarizes the local impacts from the storm

« Portion of the PSH issued for Tropical Storm Andrea in June 2013

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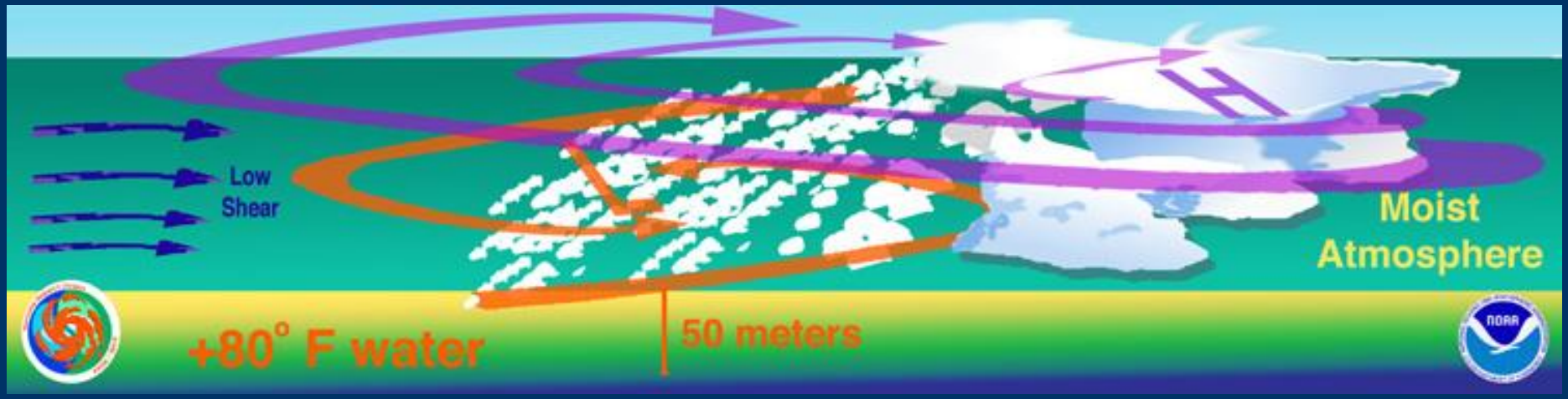
- **Tropical Cyclone Basics**
- Tropical Cyclone Climatology
- Tropical Cyclone History for Southeast South Carolina and Southeast Georgia

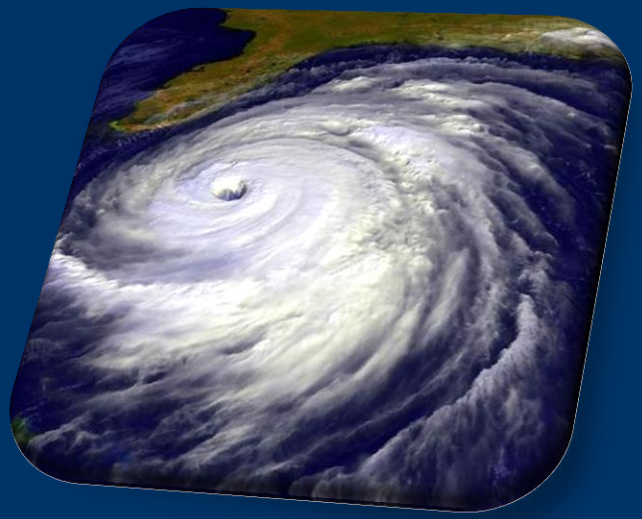
Tropical Cyclone Basics

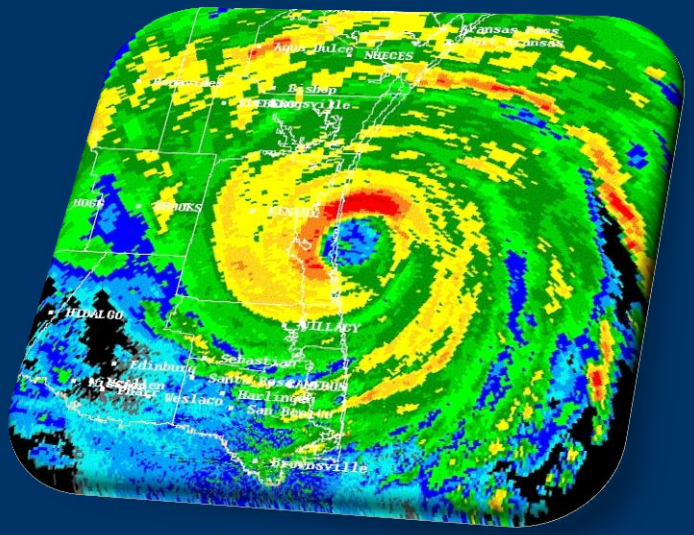
- Tropical Cyclone: rotating system of showers and thunderstorms originating over tropical or subtropical waters and having a closed low-level circulation (i.e., at least one isobar around the center)
- Ingredients needed for development:
  - Ocean water temperatures 80 degrees Fahrenheit or greater
  - Low amounts of vertical wind shear (i.e., winds of different strengths/directions at different heights)
  - Moist and unstable air (i.e., air prone to rising)
  - Pre-existing near-surface low pressure with sufficient spin



Tropical Cyclone Stages

- Tropical Disturbance
- Tropical Depression
- Tropical Storm
- Hurricane



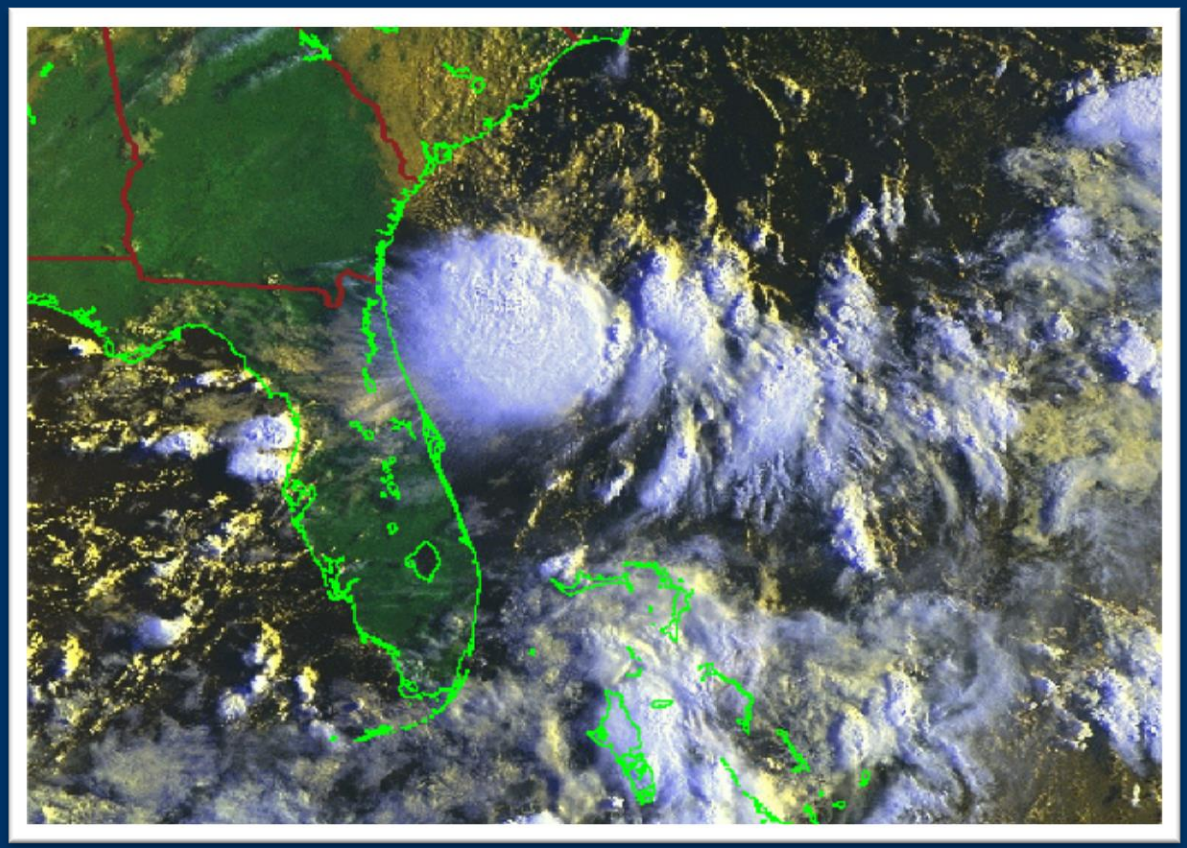


- Post-tropical Cyclone: A former tropical cyclone which no longer possesses sufficient tropical characteristics but can still produce strong winds and heavy rain

Tropical Cyclone Stages

Tropical Disturbance

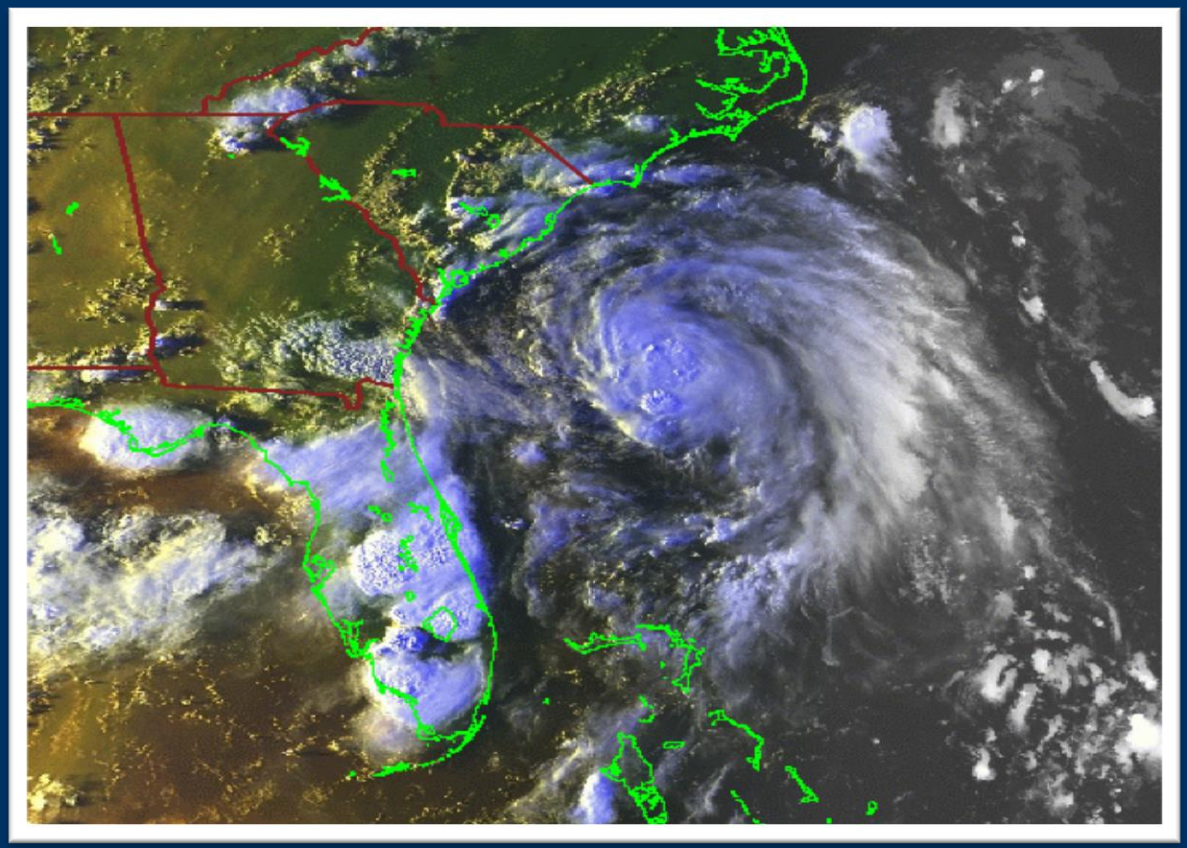
- No organized surface circulation
- Disorganized cluster of thunderstorms



Tropical Cyclone Stages

Tropical Depression

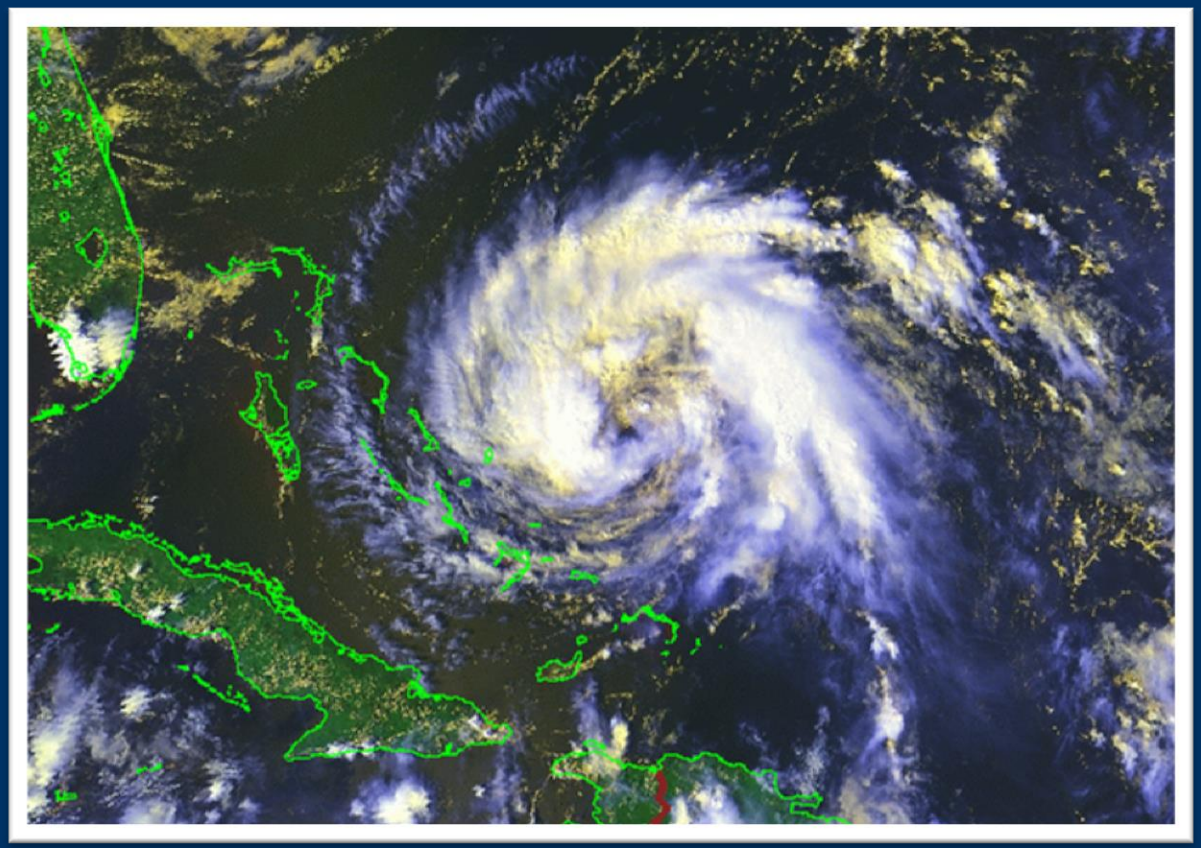
- Sustained winds less than 39 mph
- Surface low pressure better organized



Tropical Cyclone Stages

Tropical Storm

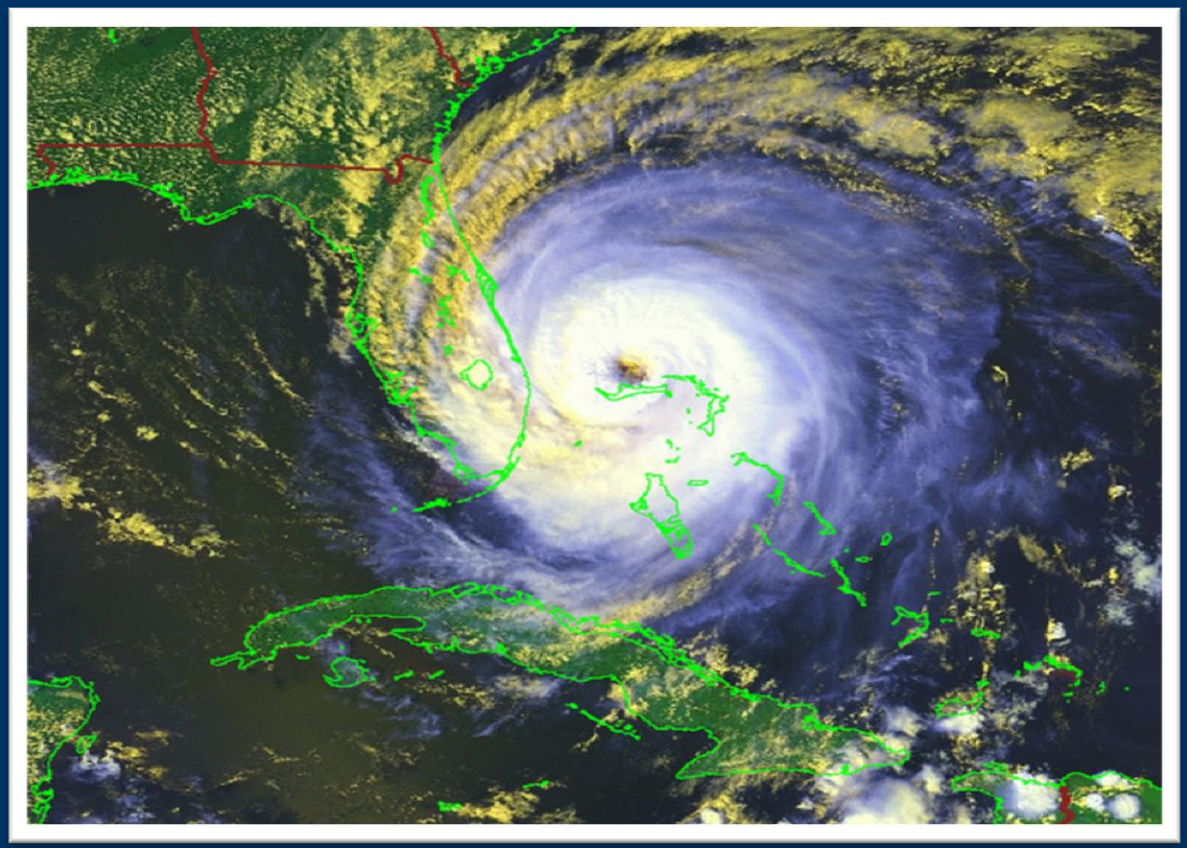
- Sustained winds of 39-73 mph
- Storm gets a name at this stage



Tropical Cyclone Stages

Hurricane

- Sustained winds 74 mph or greater
- Storm typically forms an "eye" at this stage



Saffir-Simpson Hurricane Wind Scale

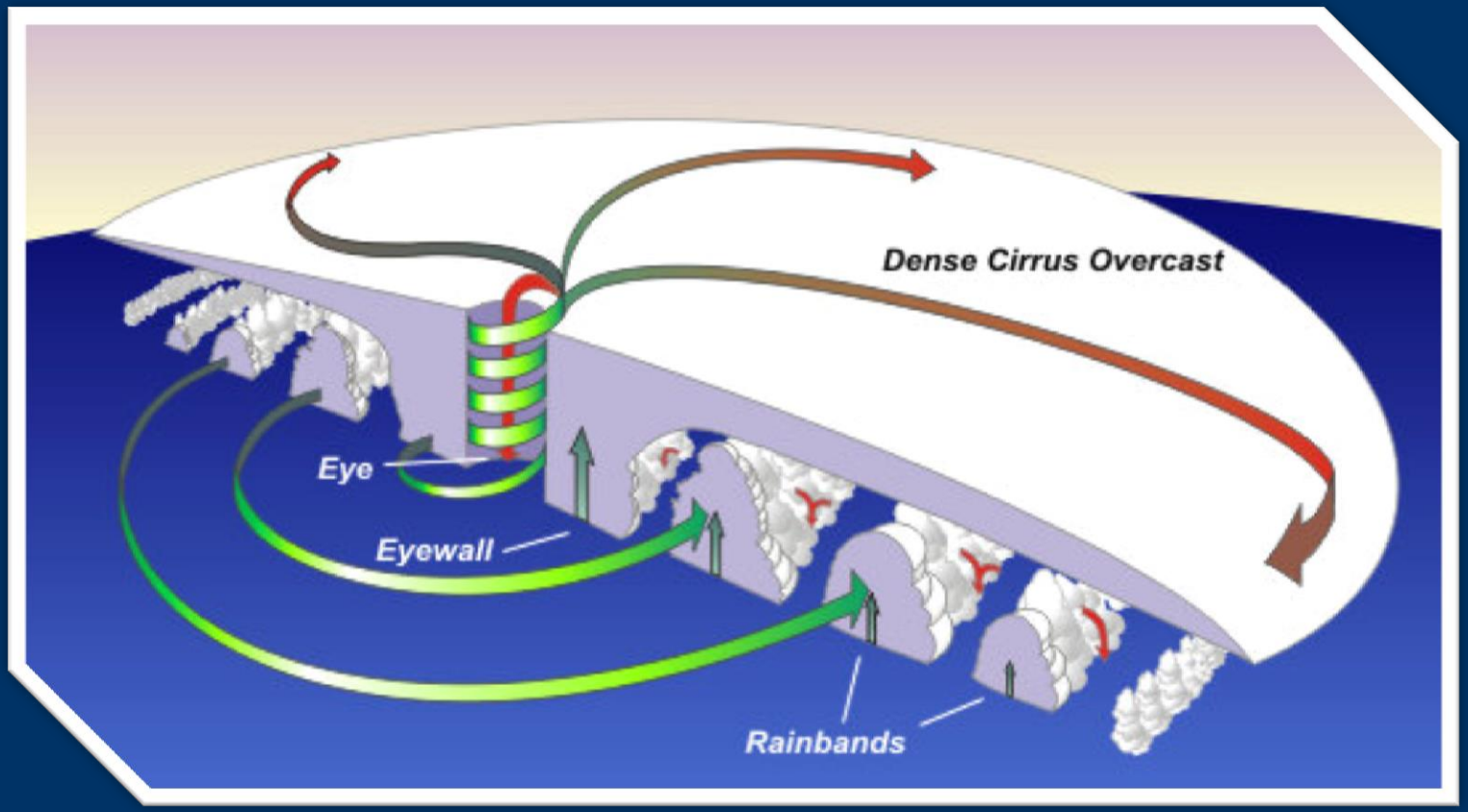
- Category 1:
  - 74-95 mph winds
  - Minimal damage
- Category 2:
  - 96-110 mph winds
  - Moderate damage
- Category 3:
  - 111-129 mph winds
  - Major damage
- Category 4:
  - 130-156 mph winds
  - Extreme damage
- Category 5:
  - 157+ mph winds
  - Catastrophic damage

- http://hurricanes.gov/aboutsshws.php

Major hurricanes (Cat 3-5) produce 85% of all hurricane damage!

Note: This scale should NOT be used to determine the amount of storm surge a hurricane can produce!!

Hurricane Structure



- The eye wall surrounds the calm eye and typically contains the strongest winds
- The outer rainbands contain gusty winds, heavy rain and some tornadoes

Hurricane Observing & Forecasting

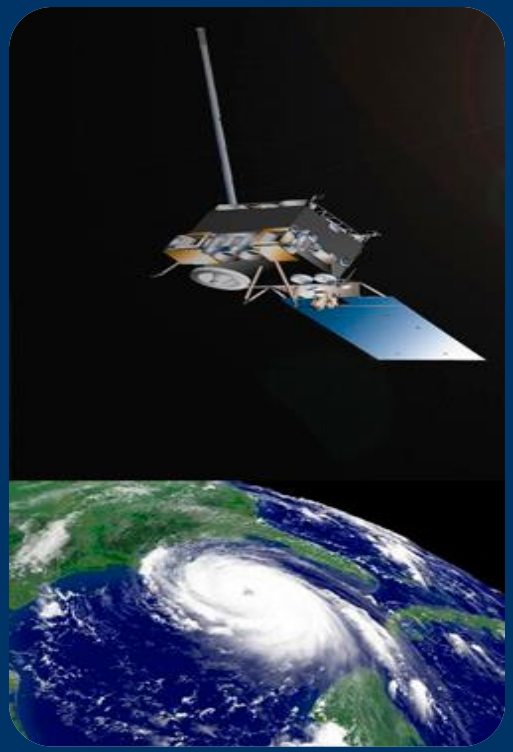
Aircraft – "Hurricane Hunters"

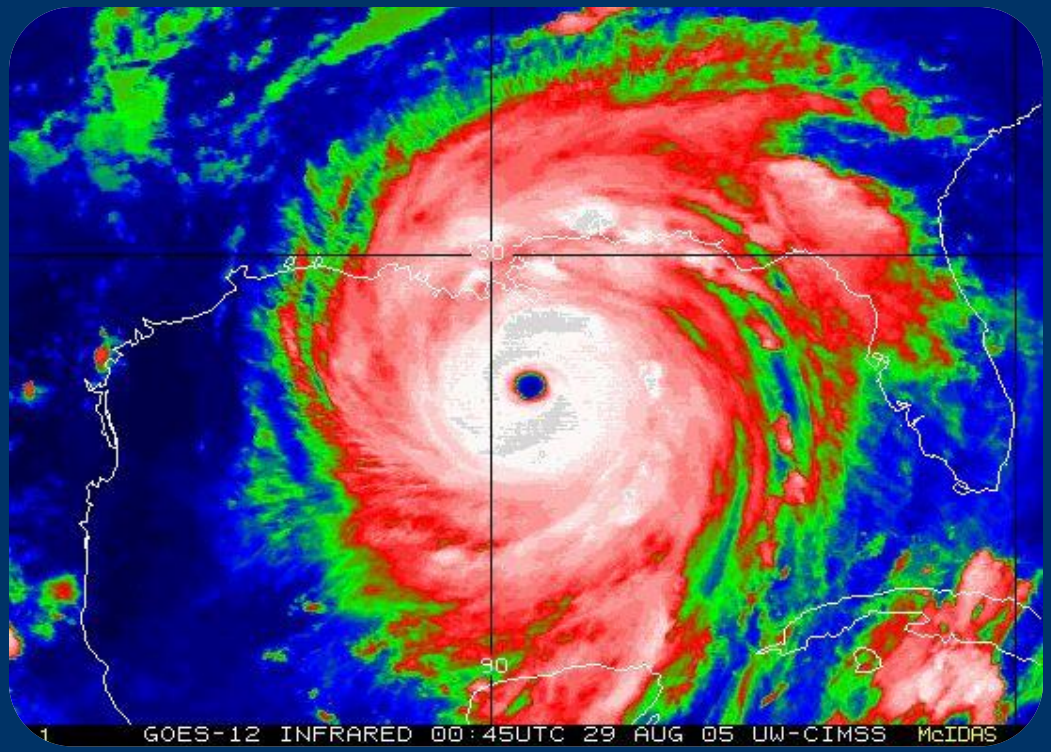
- NOAA P-3/Air Force Reserve WC-130
  - Samples storm environment between 500 – 10,000 feet
- NOAA Gulf Stream IV
  - Samples a large area around storm ~45,000 feet high

Hurricane Observing & Forecasting

Satellites

- Global Network of Geostationary and Polar Orbiters
  - Very important in hurricane analysis, tracking and forecasting

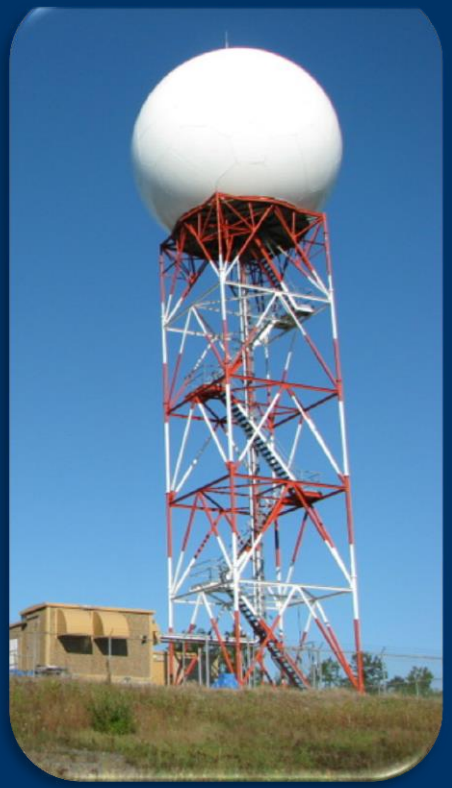


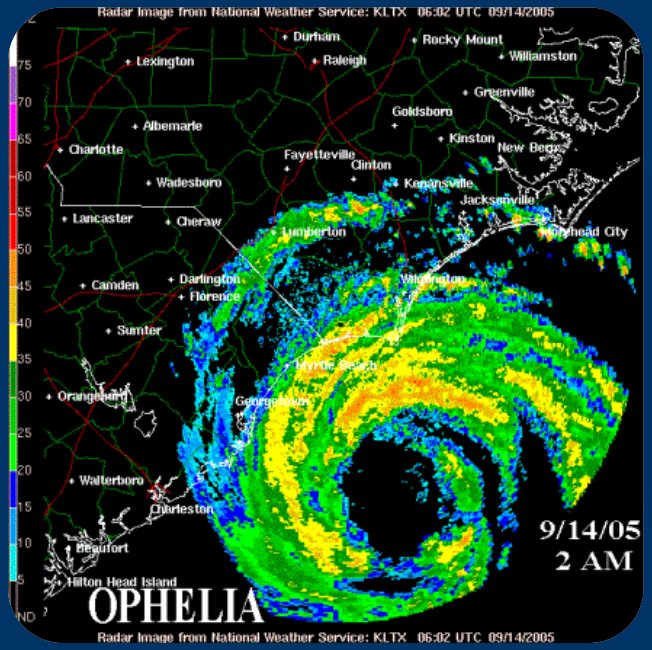


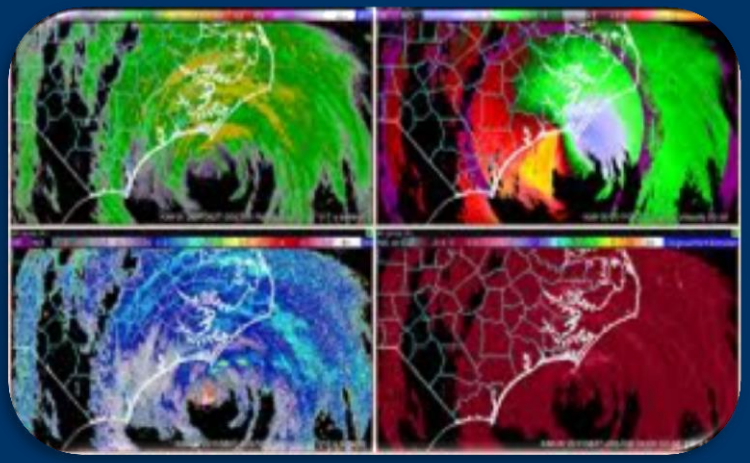
Hurricane Observing & Forecasting

NWS Doppler Radars

- Help detect storm center, max winds, and tornadoes







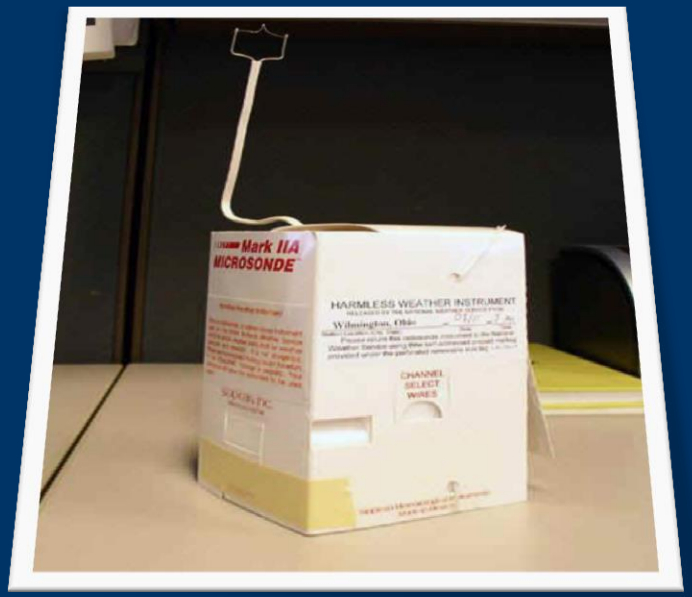
Hurricane Observing & Forecasting

Buoys, Ships, & Land-based Observations

Hurricane Observing & Forecasting

Weather Balloons/Radiosondes

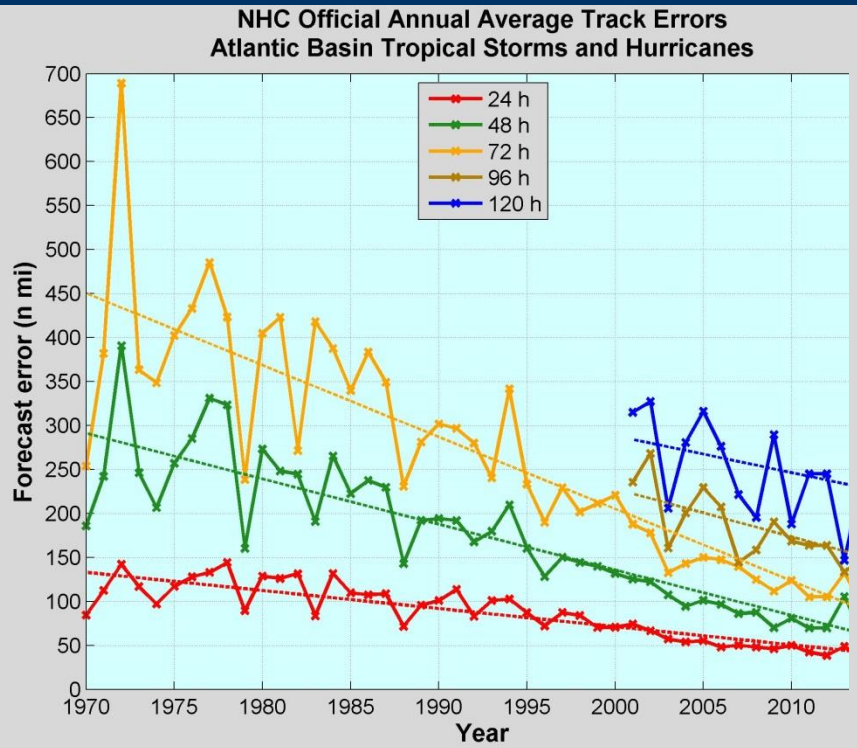
- Released all over the world at the same time to sample the atmosphere and initialize weather forecast models
- Reach over 100,000 feet (19 miles) high
- NWS Charleston launches these balloons 2 times per day (up to 4 times per day before/during hurricanes)

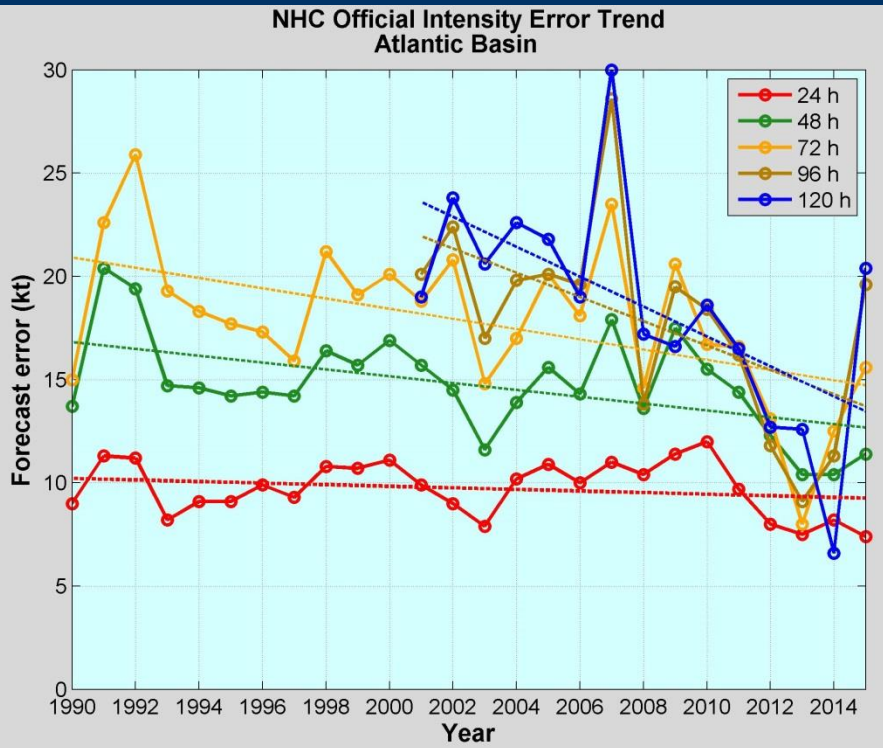


Hurricane Observing & Forecasting

Forecast Models (Dynamical and Statistical)

- There are many models used by the National Hurricane Center in their forecasts of a storm's track & strength
- As shown below, NHC's official forecasts have generally been improving over the last several decades (especially regarding track)





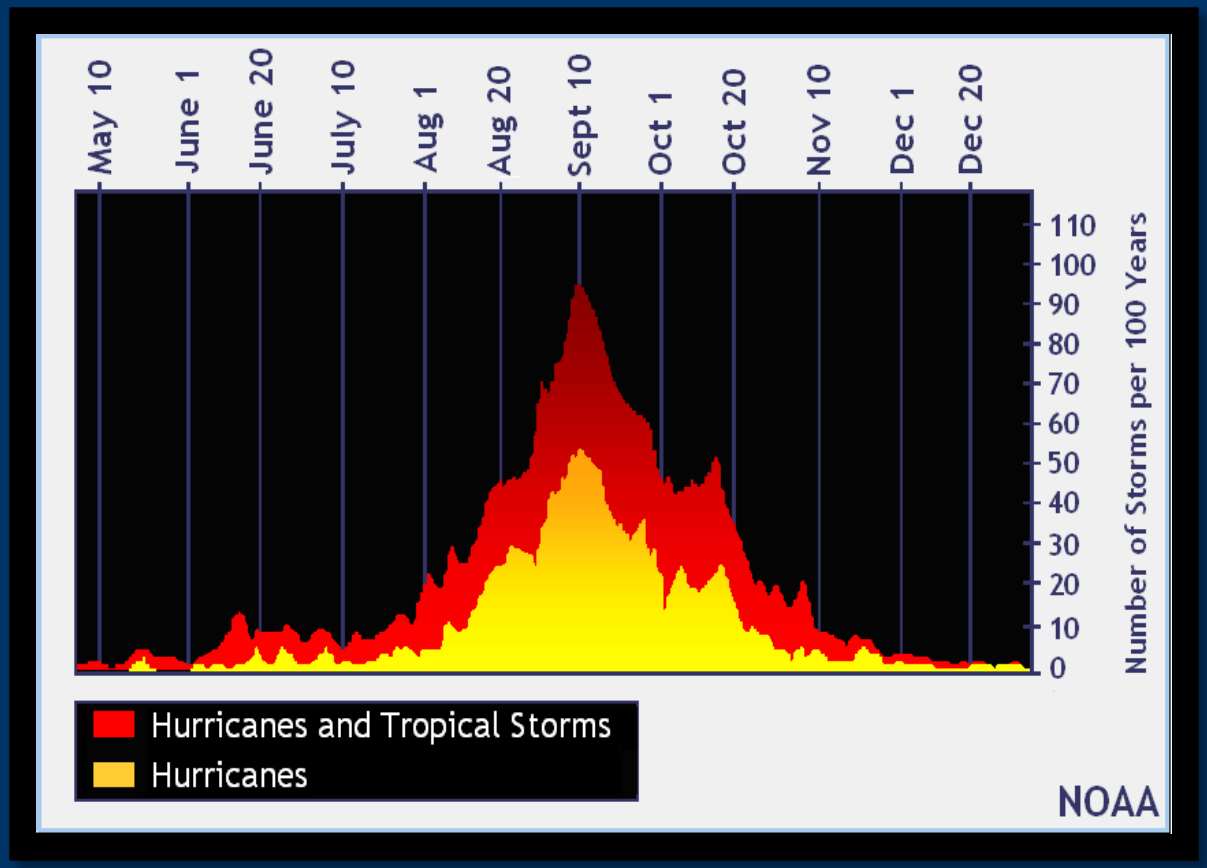
Outline

- Tropical Cyclone Hazards
- Being Prepared and Staying Informed
- Tropical Cyclone Basics
- **Tropical Cyclone Climatology**
- Tropical Cyclone History for Southeast South Carolina and Southeast Georgia

Atlantic Basin Hurricane Season

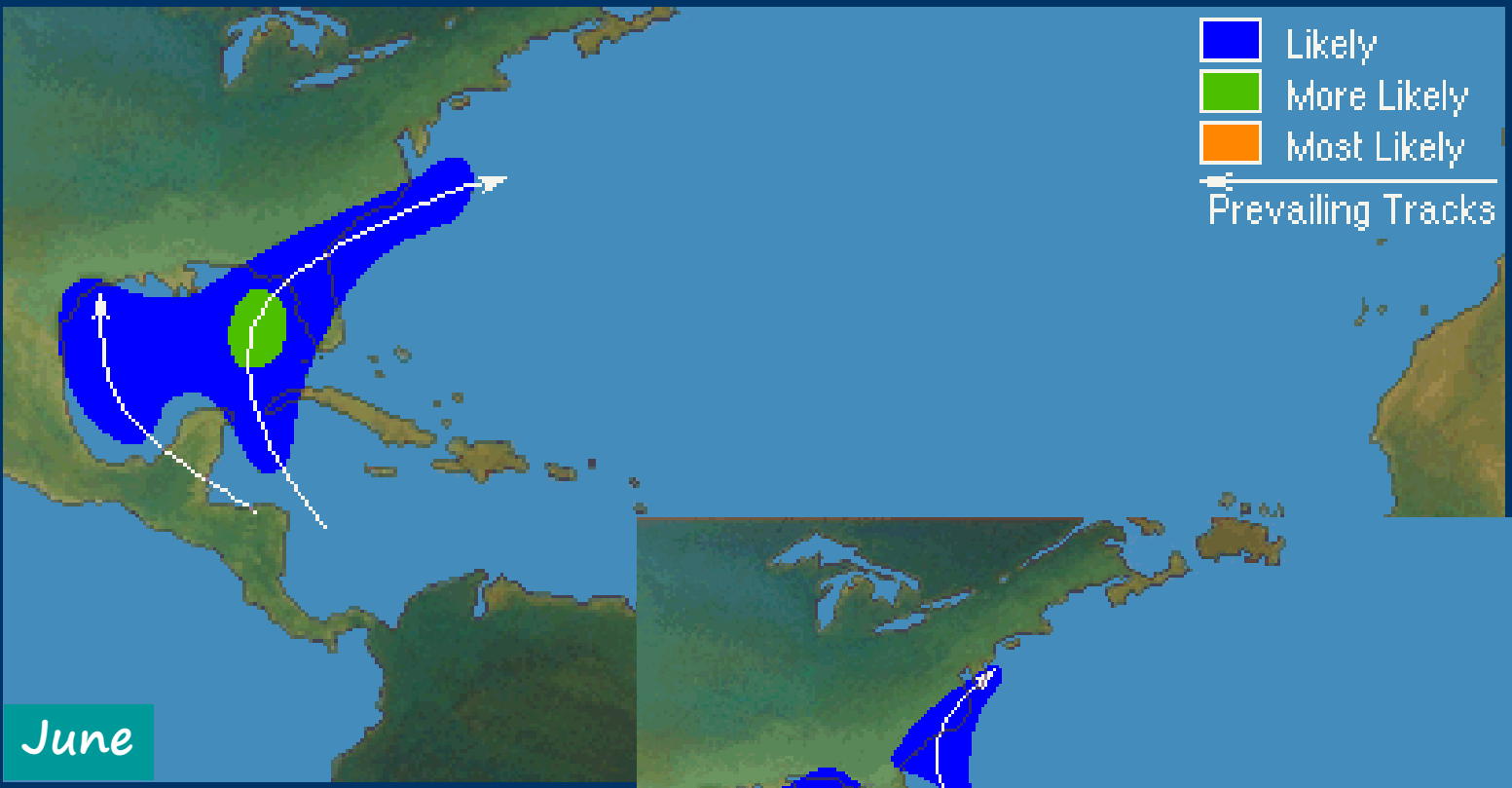
June 1 – November 30

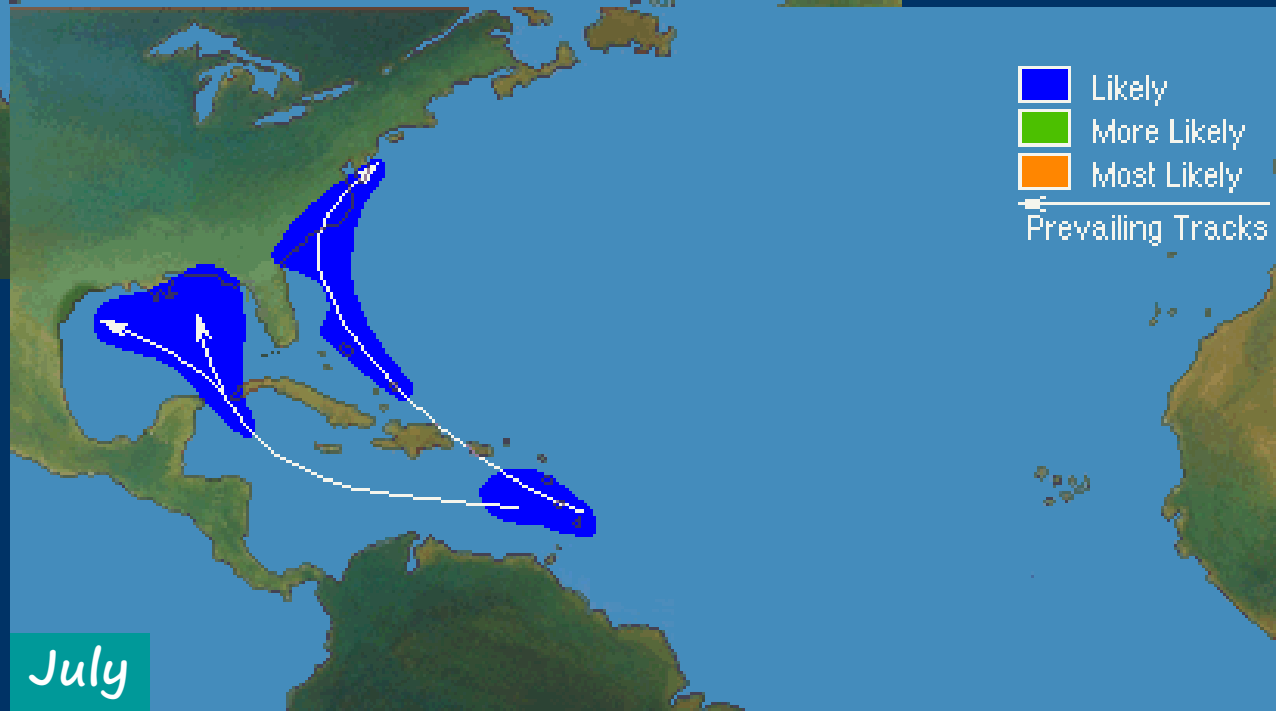
- Atlantic basin includes most of northwest Atlantic Ocean, Caribbean Sea and Gulf of Mexico
- The peak of the season is around September 10
- However, tropical cyclones can occur before June and after November if the conditions are right



» *Image courtesy of NWS/National Hurricane Center*

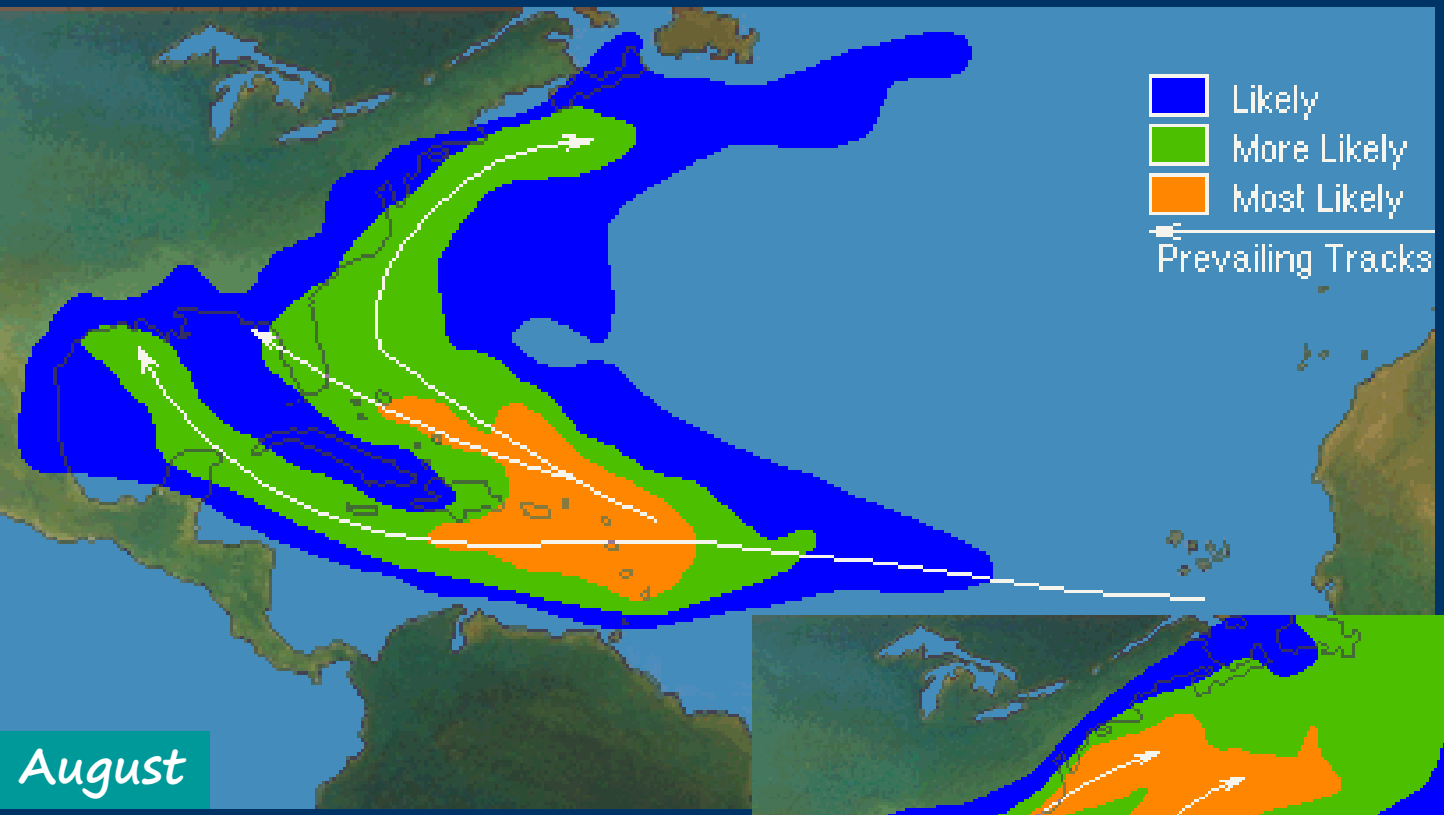
Typical Hurricane Formation Areas/Tracks



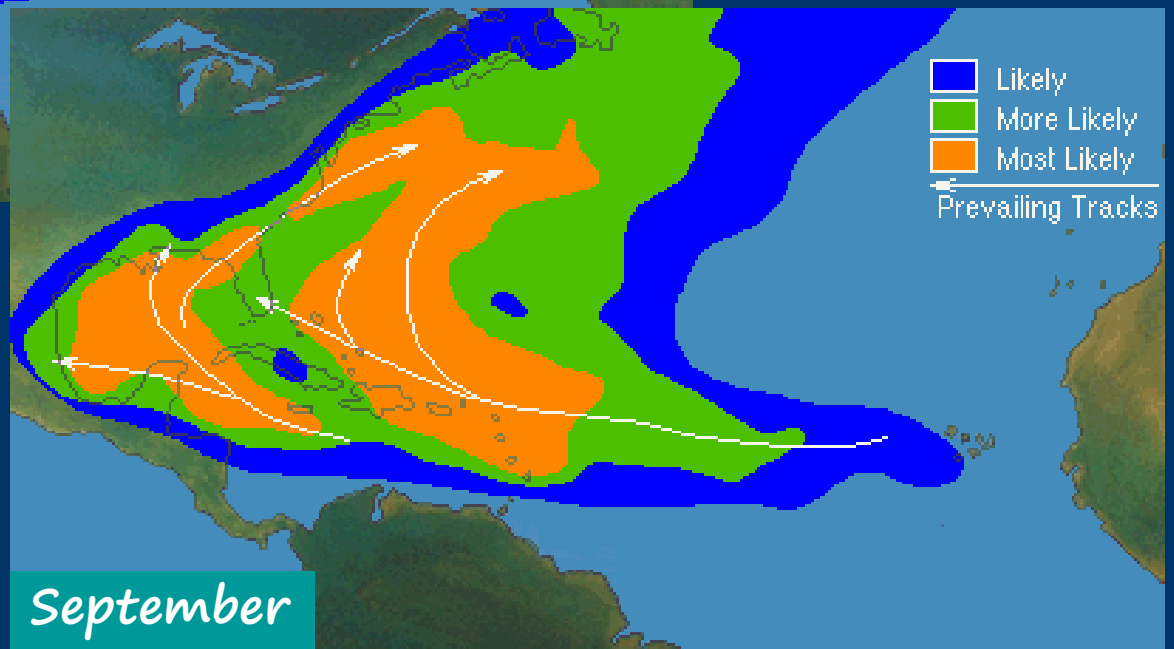


» *Images courtesy of NWS/NHC*

Typical Hurricane Formation Areas/Tracks



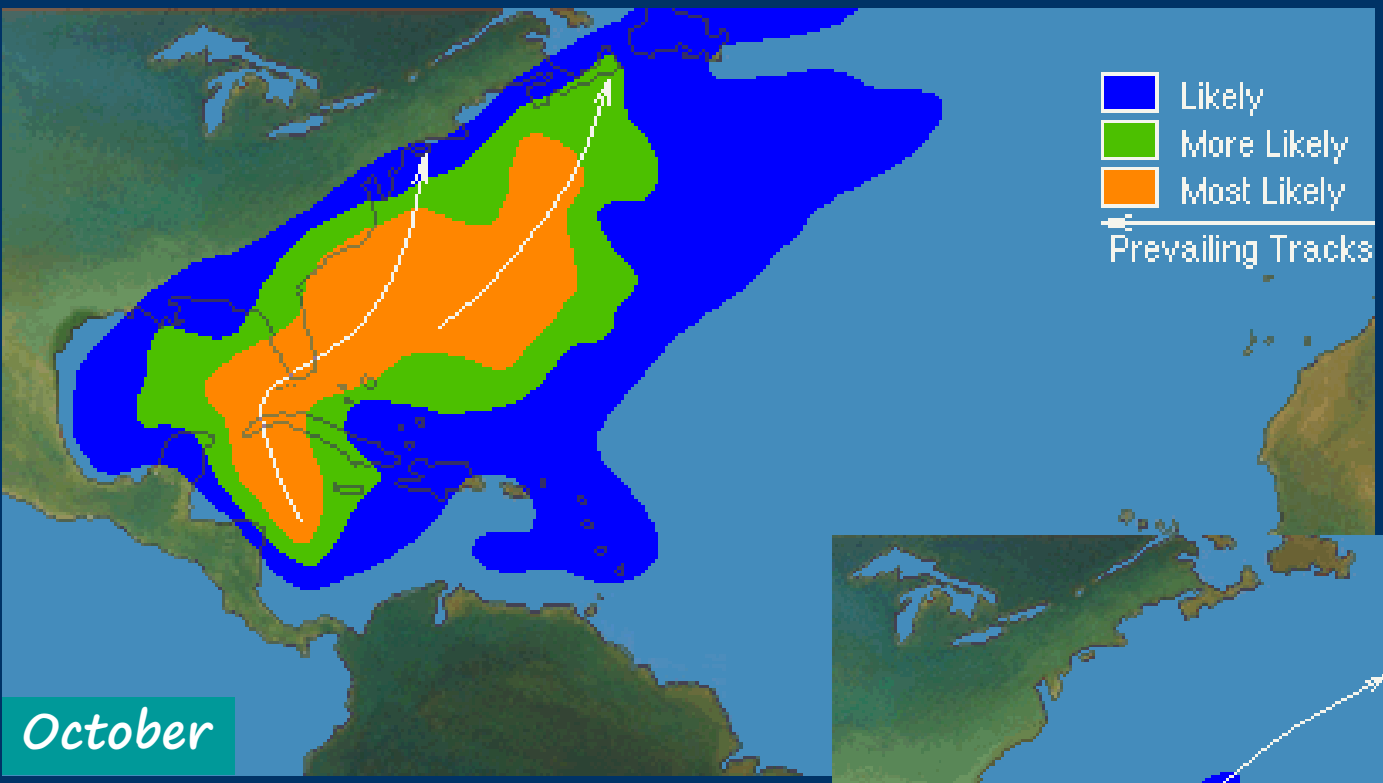
August

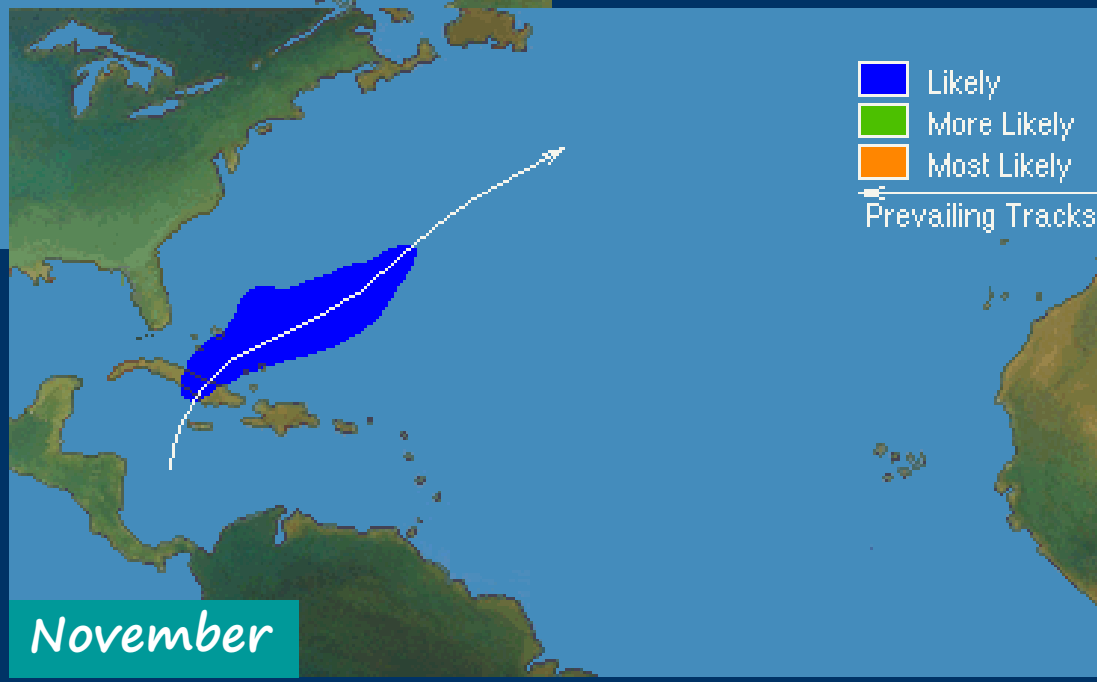


September

» *Images courtesy of NWS/NHC*

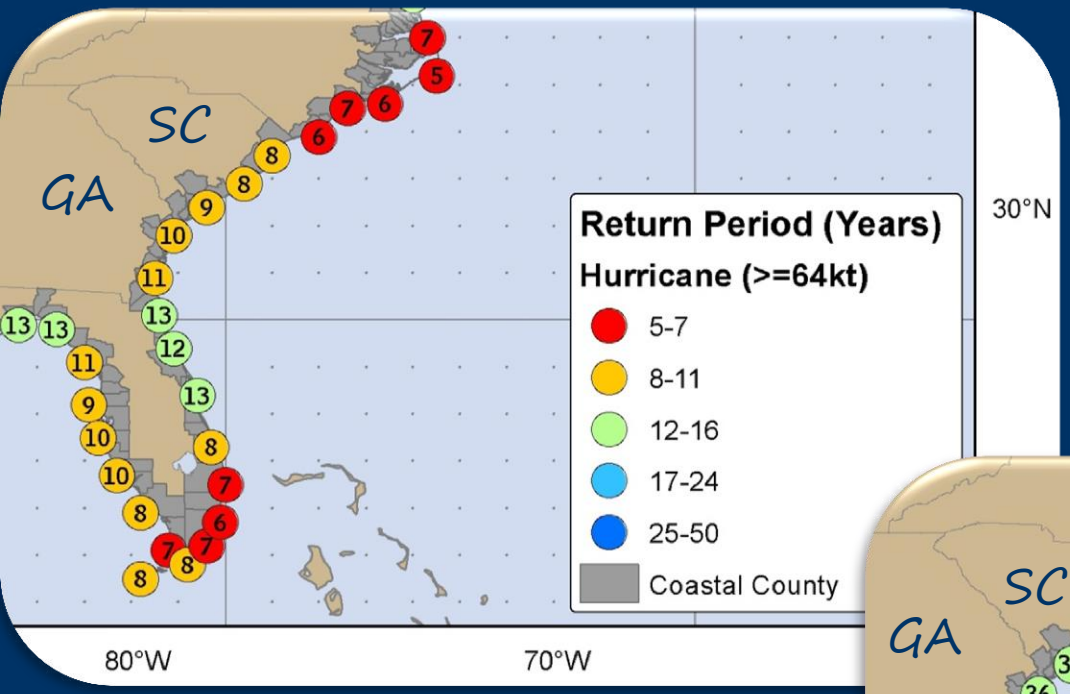
Typical Hurricane Formation Areas/Tracks



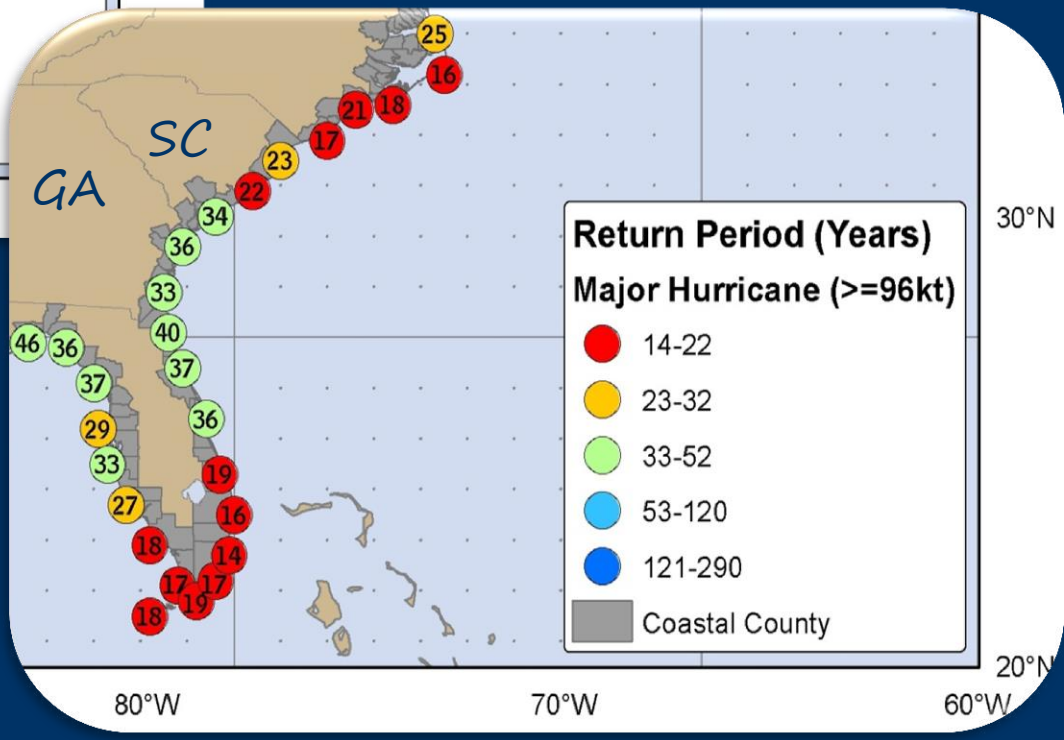


» *Images courtesy of NWS/NHC*

Southeast U.S. Hurricane Return Periods



- **Return Period**: frequency of a particular event



On **average**, a hurricane passes within 50 nm of Charleston (Savannah) every 8 (10) years with a major hurricane doing so at Charleston (Savannah) every 22 (36) years

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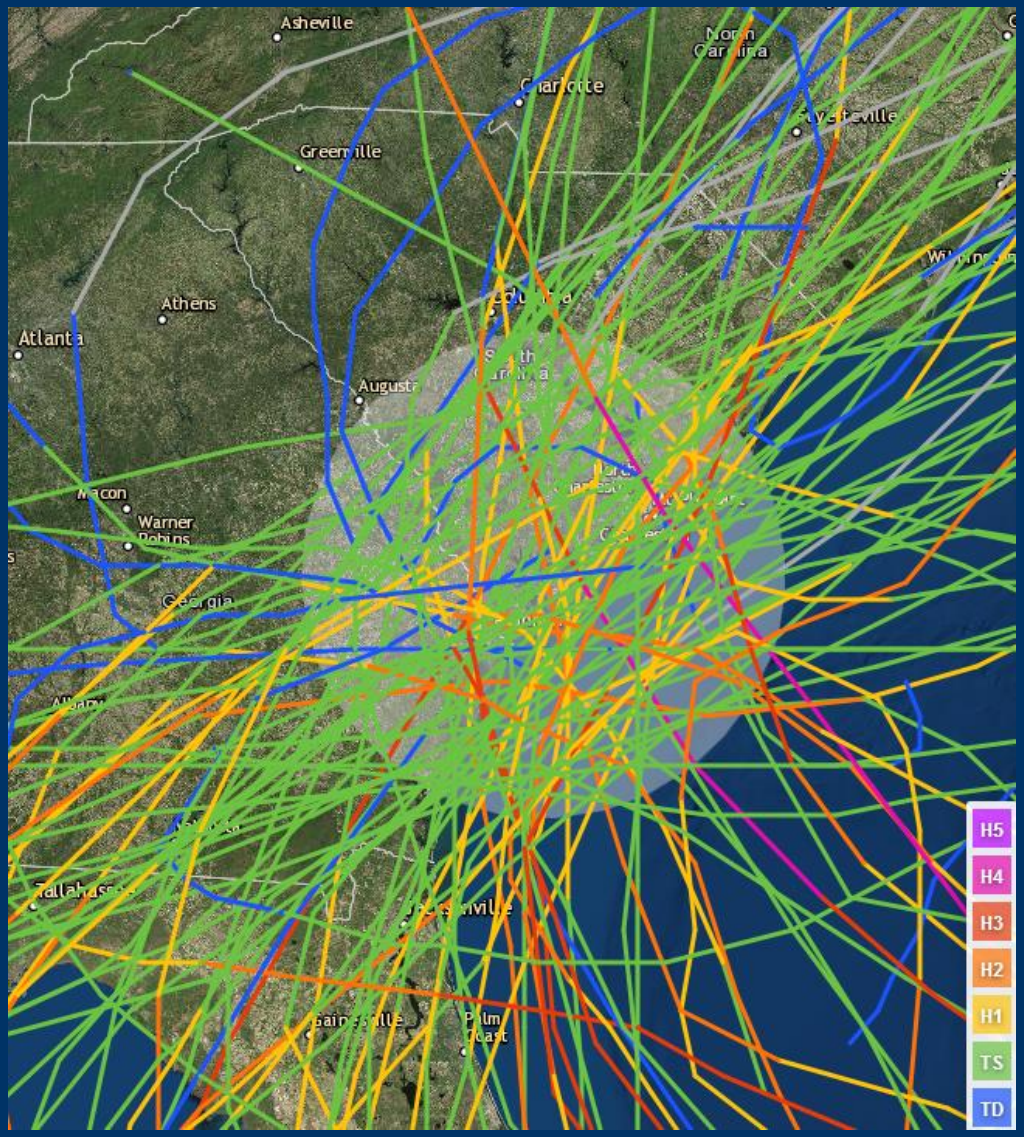
Local Tropical Cyclone History

http://weather.gov/chs/TChistory

- Since 1851 (when official records began), ~88 tropical storms and hurricanes have passed within 100 miles of Beaufort, SC (see image to the right)
- During the same time, 54 tropical cyclones made landfall in South Carolina and Georgia
  - 7 Tropical Depressions
  - 17 Tropical Storms
  - 30 Hurricanes (including 7 Major Hurricanes)



» Image courtesy of NOAA

Local Tropical Cyclone History

http://weather.gov/chs/TChistory

- Since 1851, 5 major hurricanes (Cat 3-5) have made landfall in Southeast SC/North Coastal GA
  - Unnamed - Sep 1854
  - "Great Sea Islands Hurricane" - Aug 1893
  - Unnamed - Oct 1893
  - Gracie - Sep 1959
  - Hugo - Sep 1989

» *Images courtesy of NOAA*

Important Links

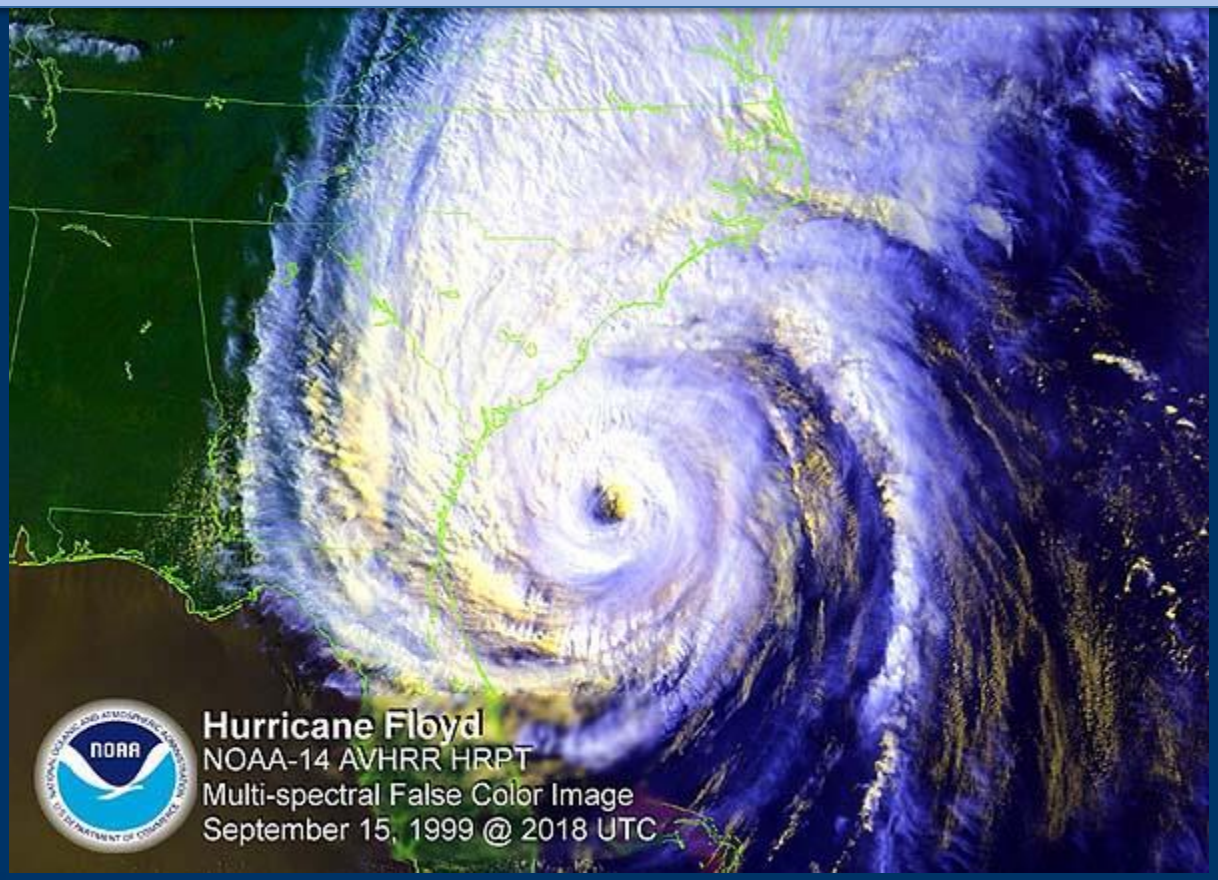
- ***Hurricane Safety/Preparedness***
  - National Weather Service:
    - http://weather.gov/om/hurricane/index.shtml
  - NWS National Hurricane Center:
    - http://hurricanes.gov/prepare
  - Federal Emergency Management Agency:
    - http://www.fema.gov
  - Department of Homeland Security:
    - http://www.ready.gov/hurricanes
  - South Carolina Emergency Management (includes evacuation zone/route info): http://www.scemd.org/
  - Georgia Emergency Management (includes evacuation zone/route info): http://www.gema.ga.gov/

- ***Tropical Cyclone Forecasts***
  - NHC: http://hurricanes.gov
  - NWS Charleston, SC: http://weather.gov/chs/tropical

Important Links

- ***Storm Surge***
  - http://hurricanes.gov/surge
  - Risk Maps
- ***Local Tropical Cyclone History***
  - http://weather.gov/chs/TChistory
- ***Tropical Cyclone Frequently Asked Questions (FAQ)***
  - http://www.aoml.noaa.gov/hrd/tcfaq/tcfaqHED.html
- ***NOAA Education Resources – Hurricanes***
  - http://www.education.noaa.gov/Weather_and_Atmosphere/Hurricanes.html
- ***Tropical Cyclone Names***
  - http://www.nhc.noaa.gov/aboutnames.shtml

We Wish You a Safe Hurricane Season!



http://weather.gov/chs

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