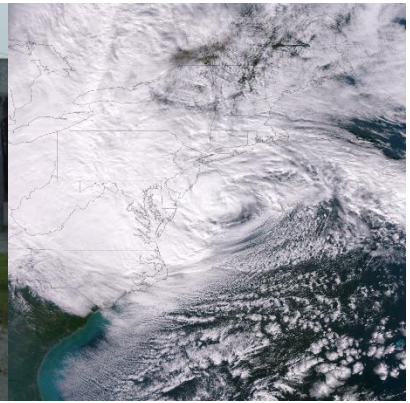
National Hurricane Program Tools and Resources

FEMA Region II Hurricane Program




NOAA/NWS

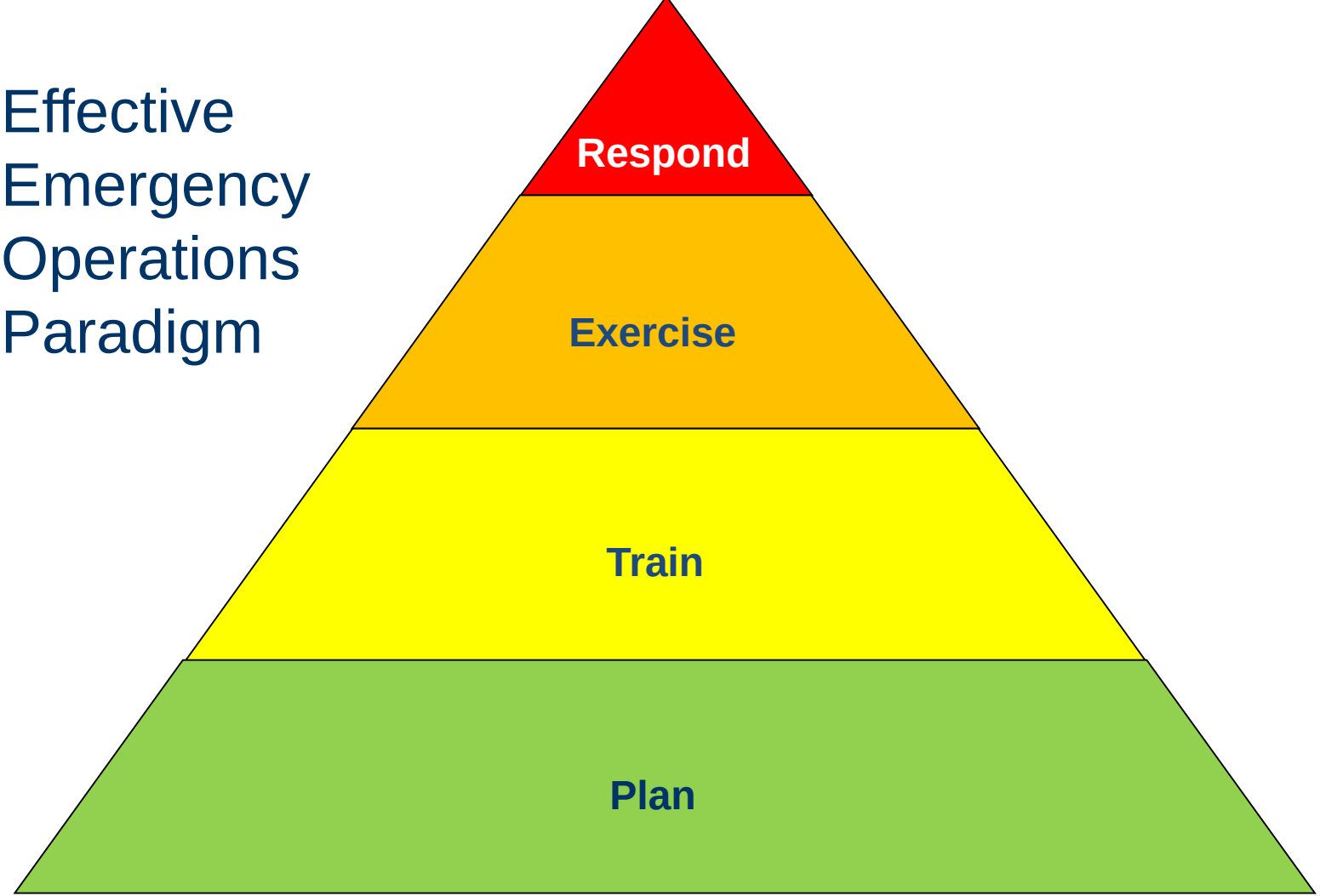
Why We Plan…

"Plans are nothing, planning is everything."

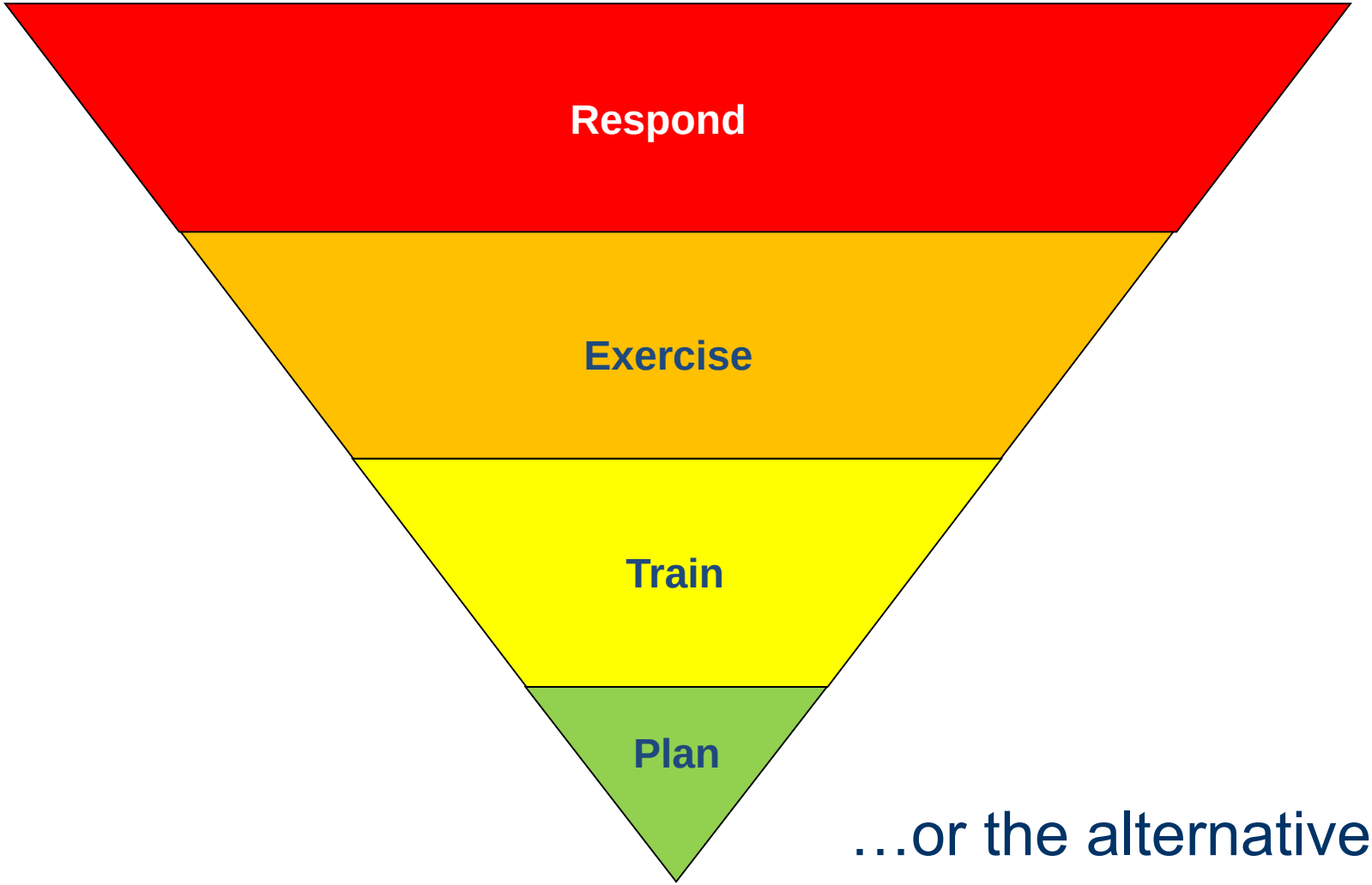
-Dwight D. Eisenhower

US Army Center of Military History

Effective Emergency Operations Paradigm

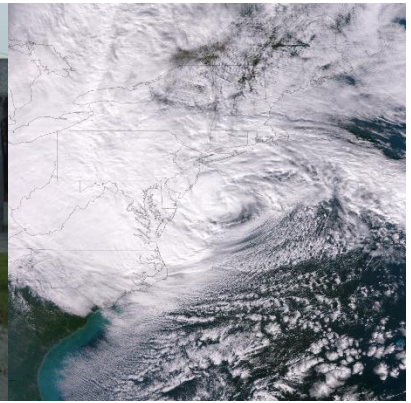


FEMA

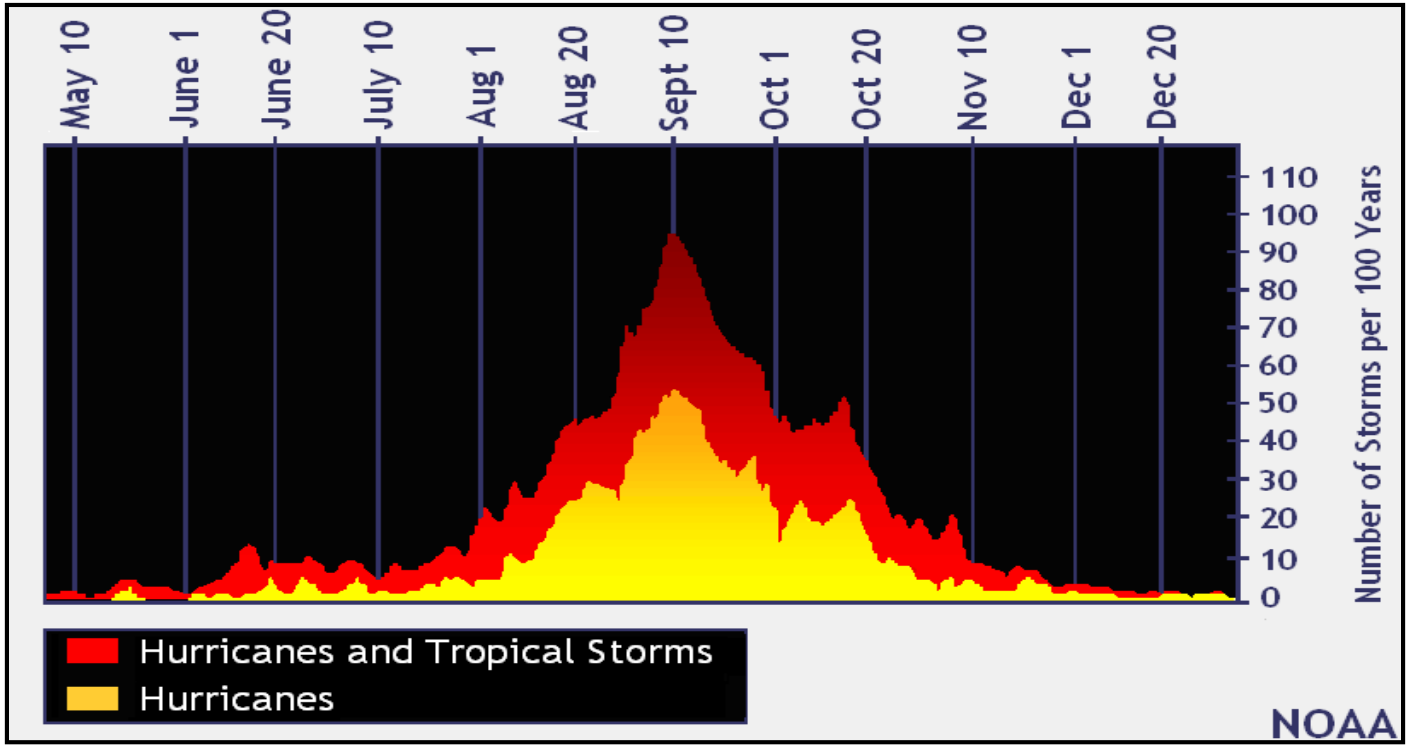


…or the alternative

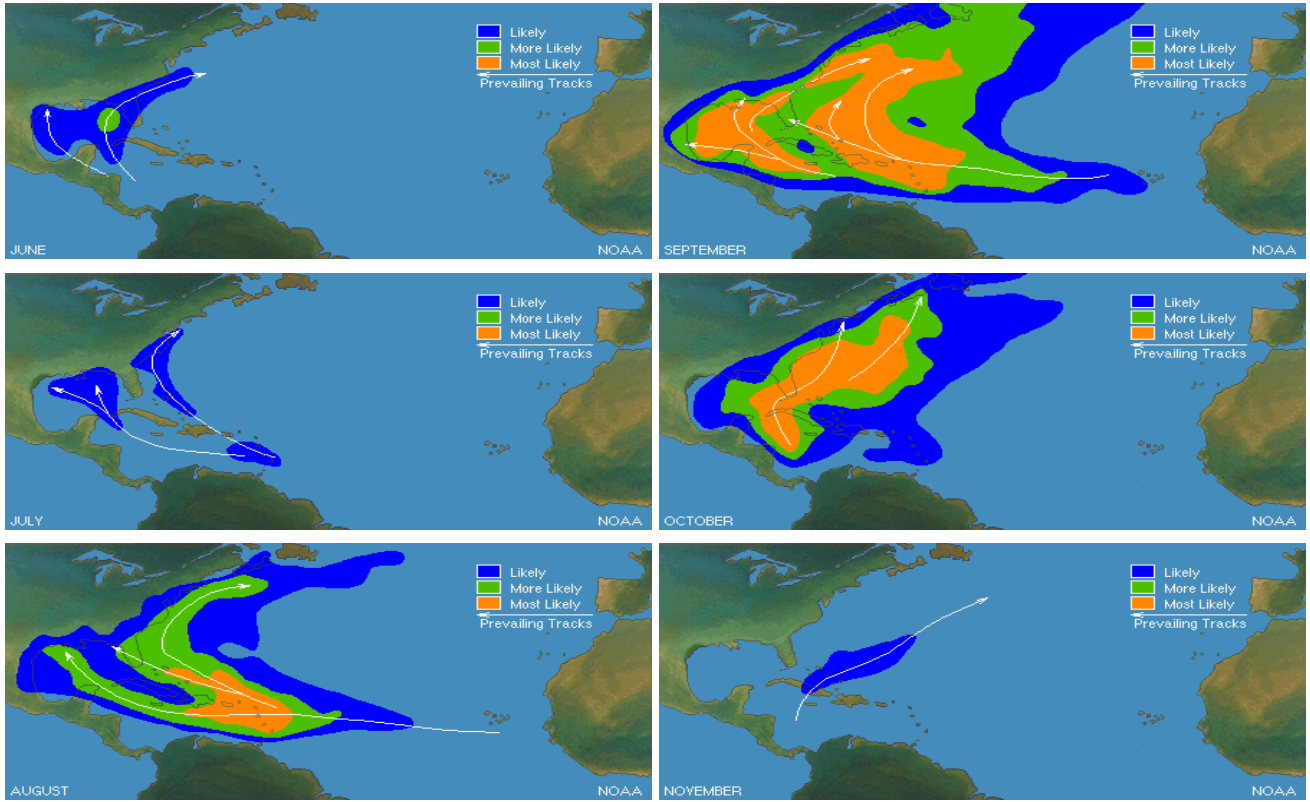
Tropical Cyclone Formation and Hazards



Seasonal Hurricane Activity

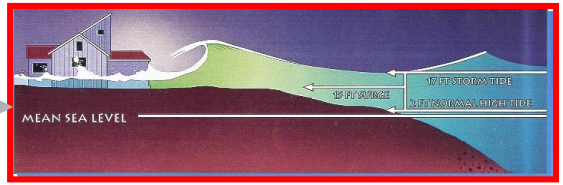


Tropical Cyclone Formation



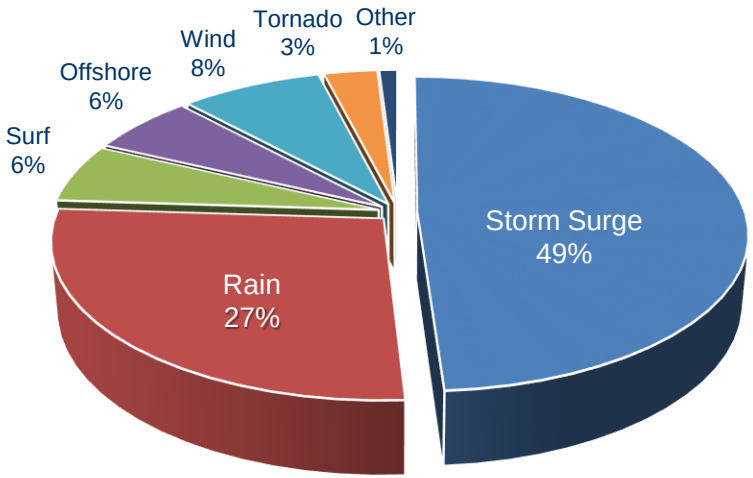
Hurricane Hazards

Wind
Storm Surge
Flooding
Tornados



Atlantic Tropical Cyclone Deaths

2,544 Fatalities From 1963–2012



- Almost 50% of deaths are due to storm surge
- Over 80% of deaths are due to water
- Wind causes less than 10% of deaths

Edward N. Rappaport, 2014: Fatalities in the United States from Atlantic Tropical Cyclones: New Data and Interpretation. Bull. Amer. Meteor. Soc., 95, 341–346.

Category 1 Wind Damage

FEMA

Category 4 (130 – 156 mph)

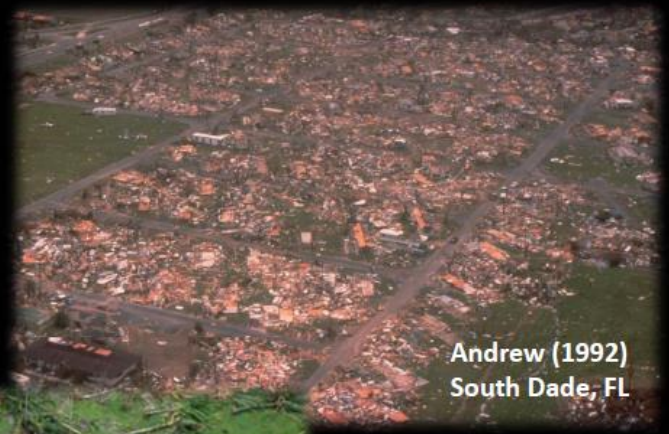
Catastrophic damage will occur

FEMA

Category 5 (greater than 156 mph)

Catastrophic damage will occur

Andrew (1992)
Florida City, FL



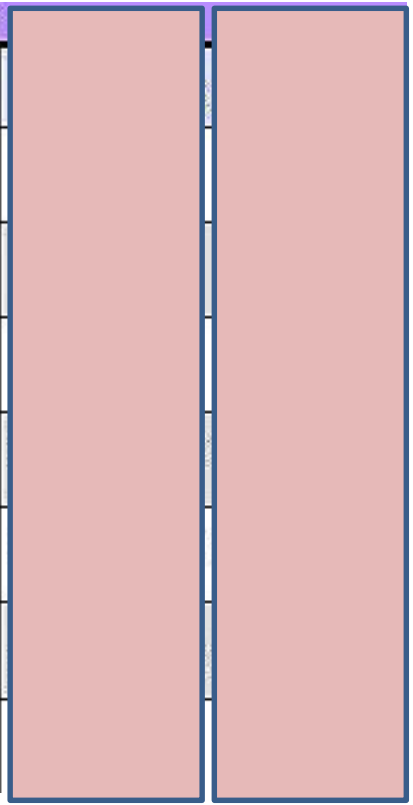
Andrew (1992)
South Dade, FL

Felix (2007)
Nicaragua

FEMA

Saffir-Simpson Scale and Surge

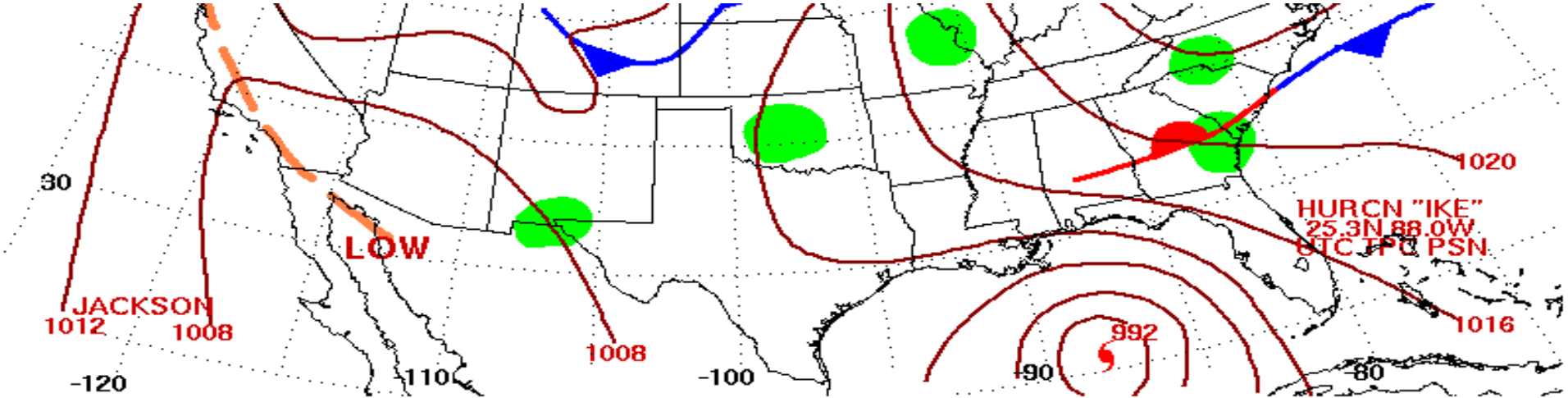
SAFFIR-SIMPSON SCALE			
Type	CG	WInds (mph)	Winds (knots)
Tropical Depression	TD	< 39	< 34
Tropical Storm	TS	39 - 73	34 - 63
Hurricane	1	74 - 95	64 - 82
Hurricane	2	96 - 110	83 - 95
Hurricane	3	111 - 130	96 - 113
Hurricane	4	131 - 155	114 - 135
Hurricane	5	> 155	> 135



FEMA

Factors Affecting Storm Surge:

- Central pressure
- Storm size and intensity: size and strength of the wind field
- Forward speed
- Bathymetry: slope of sea floor near the shore
- Wave Set up (Right side of Storm)



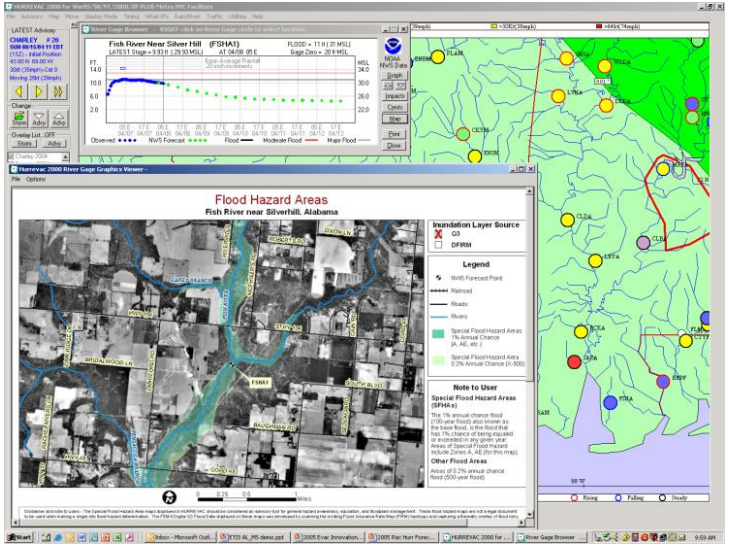
Surface Weather Map at 7:00 A.M. E.S.T.

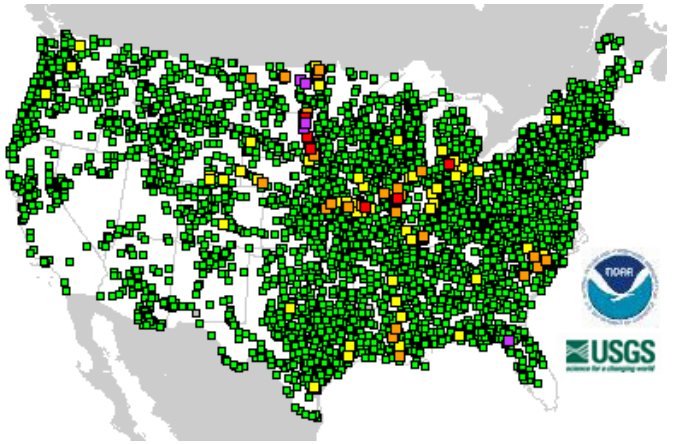
Rainfall

- The speed of movement is the primary influence on amount of rain
- Intensity of storm not a factor in amount of rain produce

FEMA

Hazards: Flooding

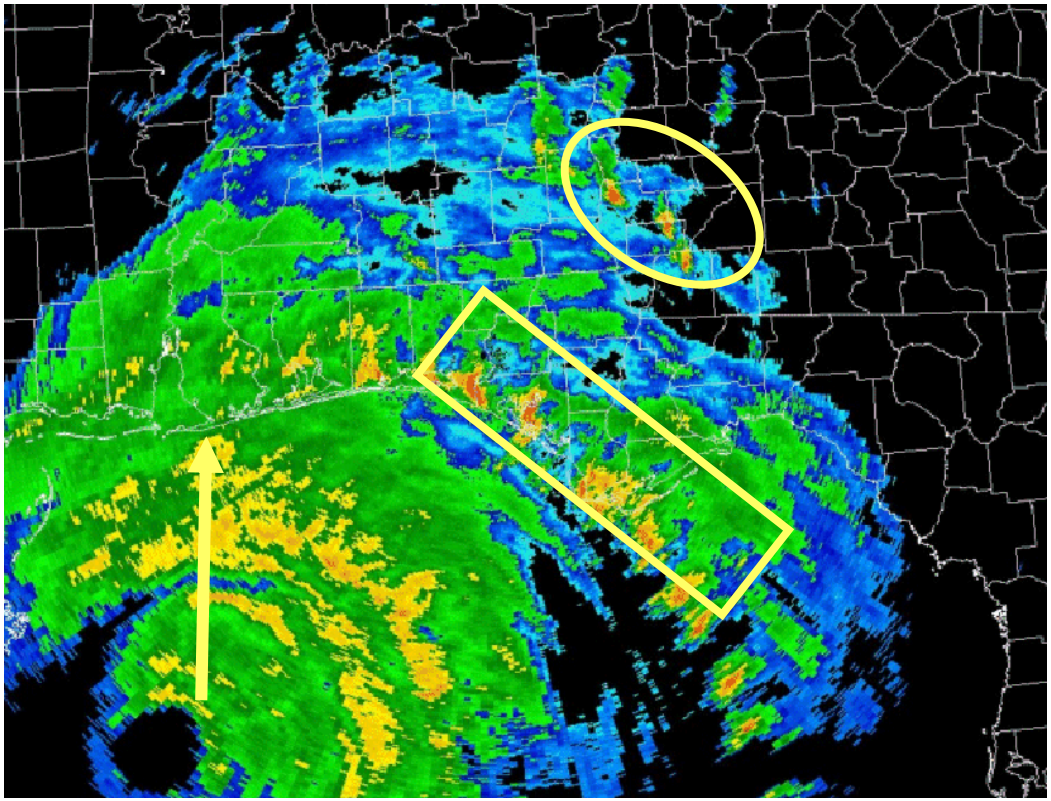




- http://water.weather.gov/

Hazards: Tornados

Tornadoes-Far from the Center



Critical Considerations: Evacuation

Medical Evacuation

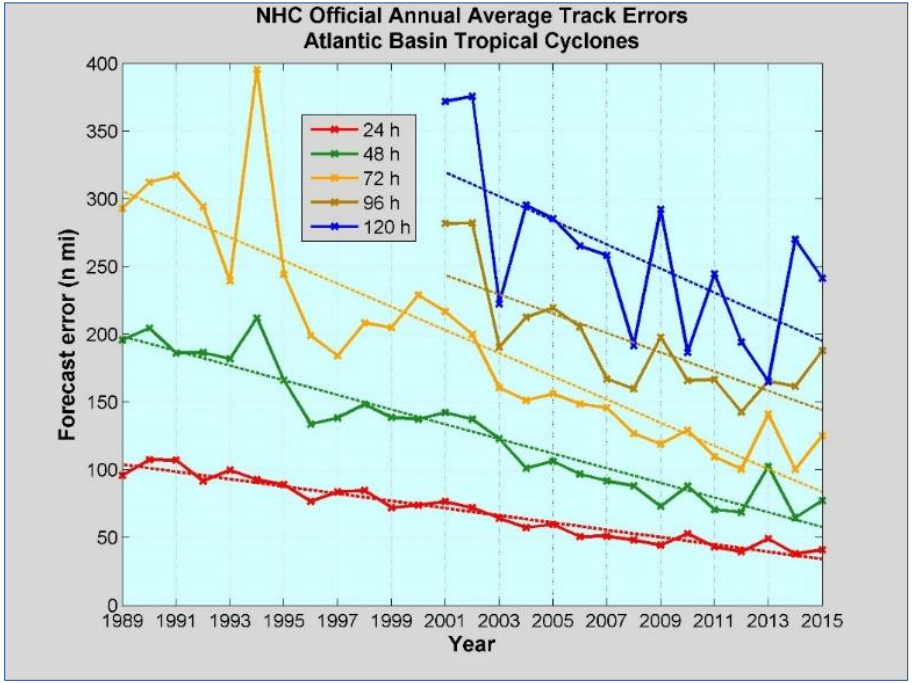
Critical Considerations: Shelter and Transportation

- The transportation component of evacuation is based on the numbers of:
  - People needing evacuation
  - Availability of privately owned transportation
  - Numbers of evacuees with special mobility and medical, functional or access needs
  - The time available to conduct operations
  - The distance to (and availability of) shelters

National Hurricane Center Forecast Products

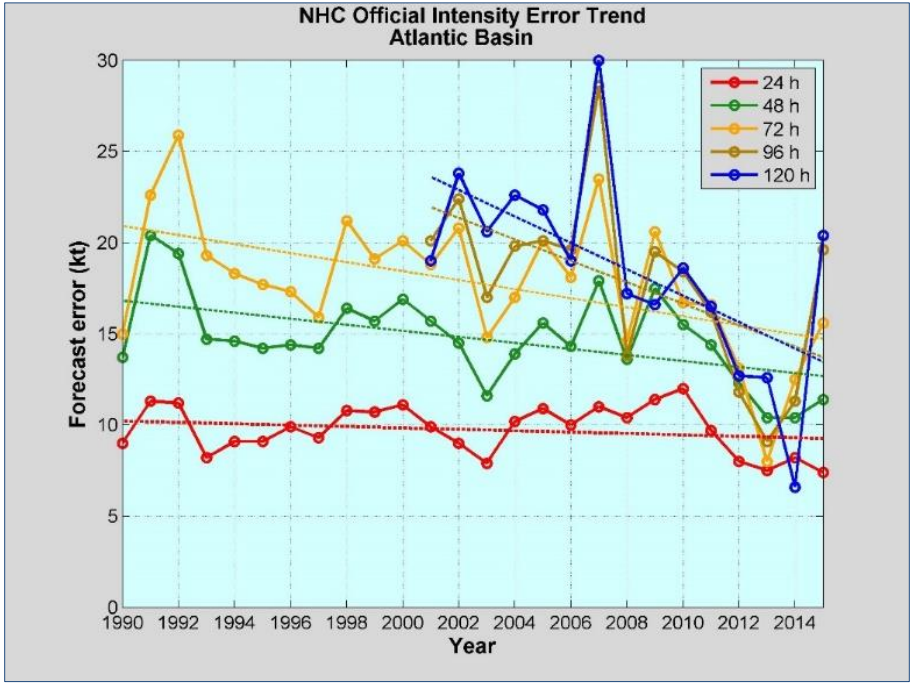
NHC Track and Intensity Forecast Errors

Track Errors (1989-2015)



2011-2015 Average Error:
24-hr: 42.0 nautical miles
48-hr: 73.8 nautical miles

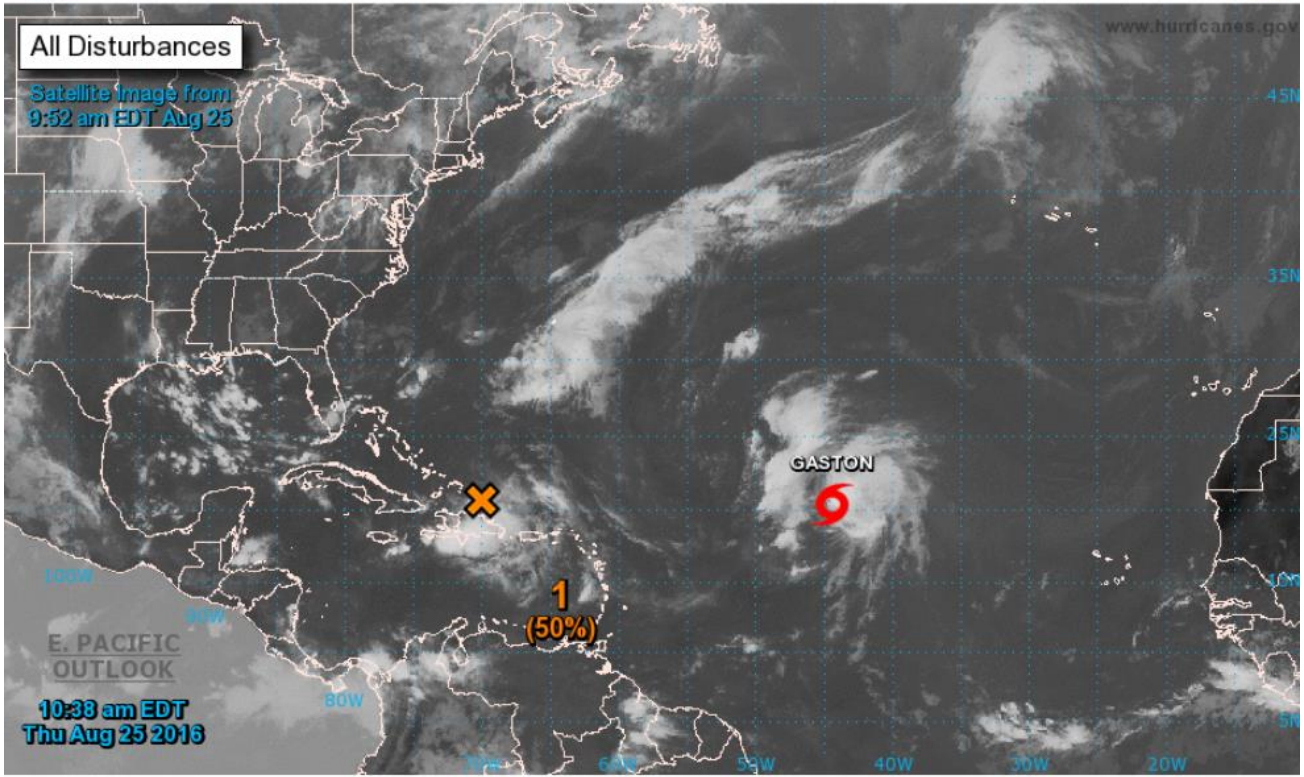
Intensity Errors (1990-2015)



2011-2015 Average Error:
24-hr: 8.3 knots
48-hr: 12.3 knots

Two-Day Graphical Tropical Weather Outlook

National Hurricane Center Miami, Florida



Current Disturbances and Two-Day Cyclone Formation Chance: < 40% 40-60% > 60%

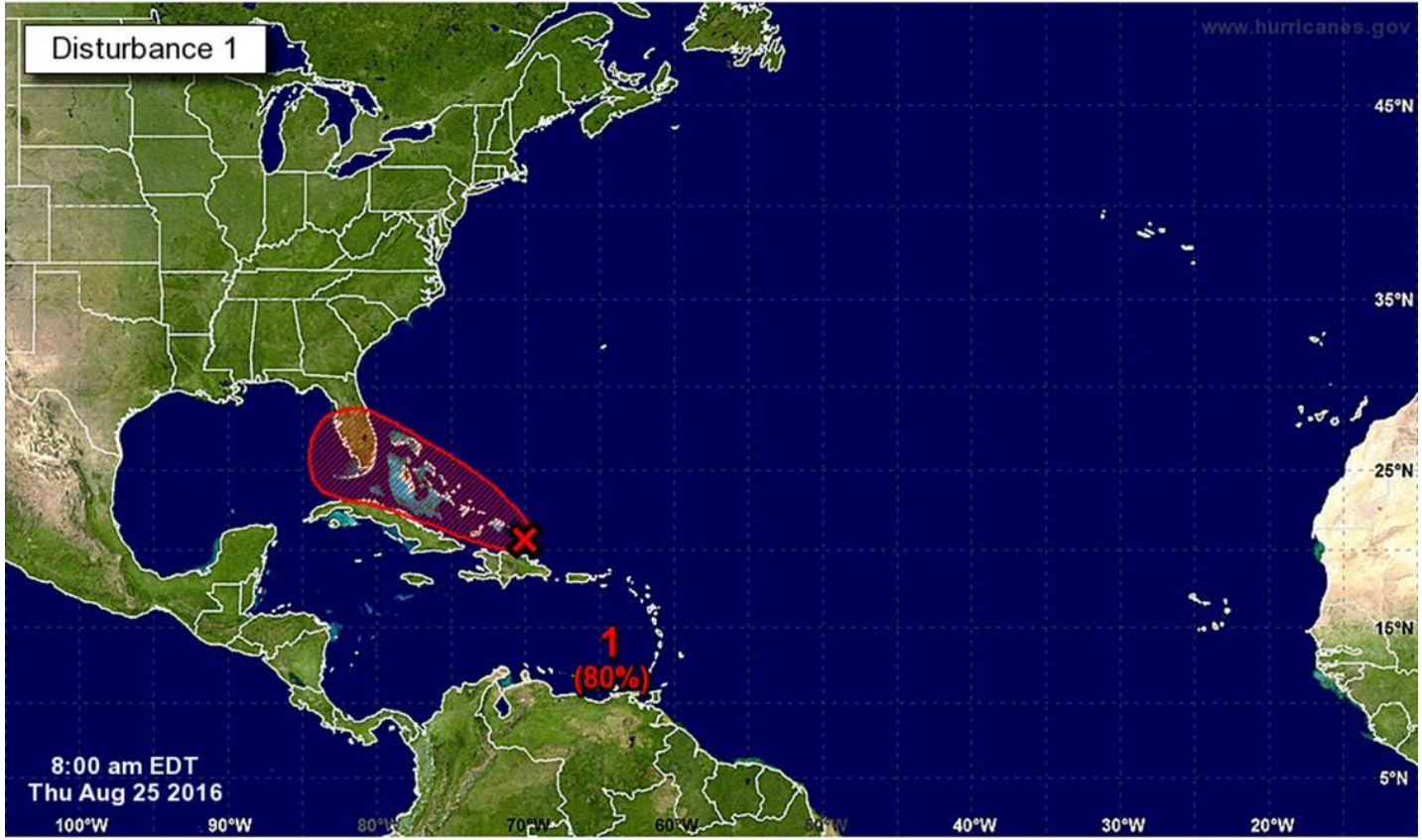
Tropical or Sub-Tropical Cyclone: Depression Storm Hurricane

Post-Tropical Cyclone Remnants

FEMA

Five-Day Graphical Tropical Weather Outlook

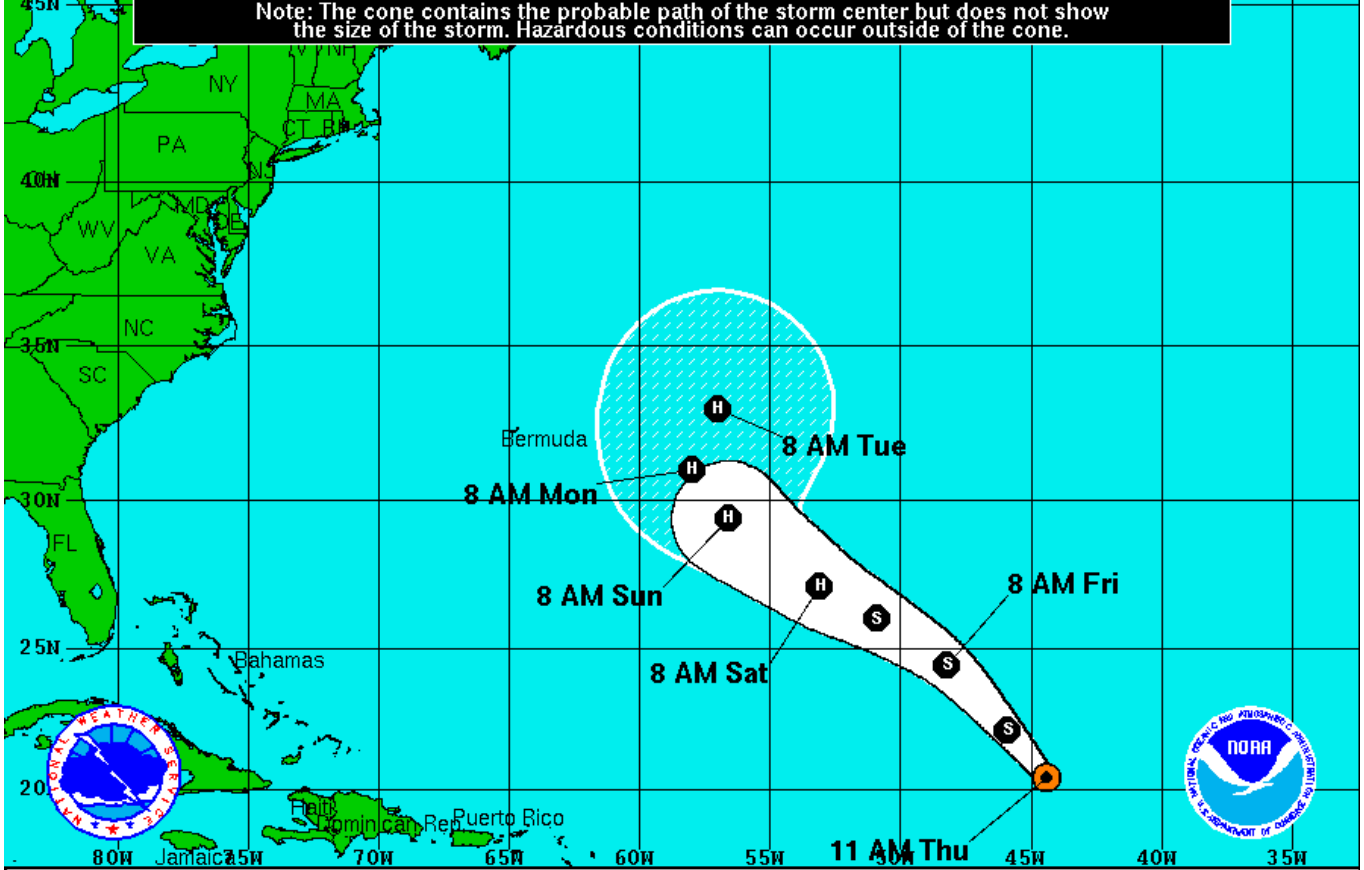
National Hurricane Center Miami, Florida



Tropical Cyclone Formation Potential for the Five-Day Period Ending at 8:00 am EDT Tue Aug 30 2016

Chance of Cyclone Formation in Five Days: Low < 40% Medium 40-60% High > 60%

X indicates current disturbance location; shading indicates potential formation area.



Tropical Storm Gaston
Thursday August 25, 2016
11 AM EDT Advisory 12
NWS National Hurricane Center

Current Information:
Center Location 20.4 N 44.4 W
Max Sustained Wind 70 mph
Movement NW at 17 mph

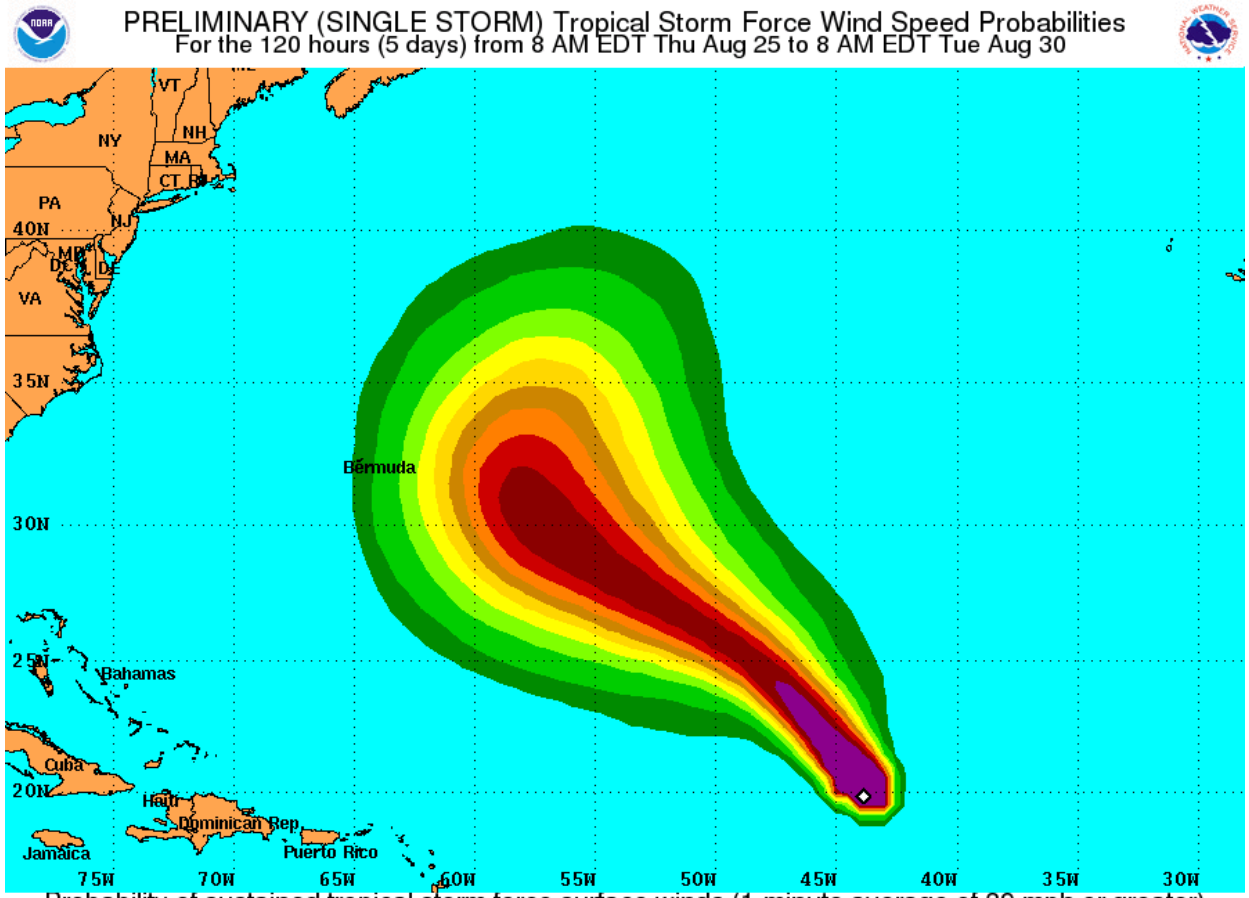
Forecast Positions:
Tropical Cyclone Post-Tropical
Sustained Winds: D < 39 mph
S 39-73 mph H 74-110 mph M > 110mph

Potential Track Area:
Day 1-3 Day 4-5

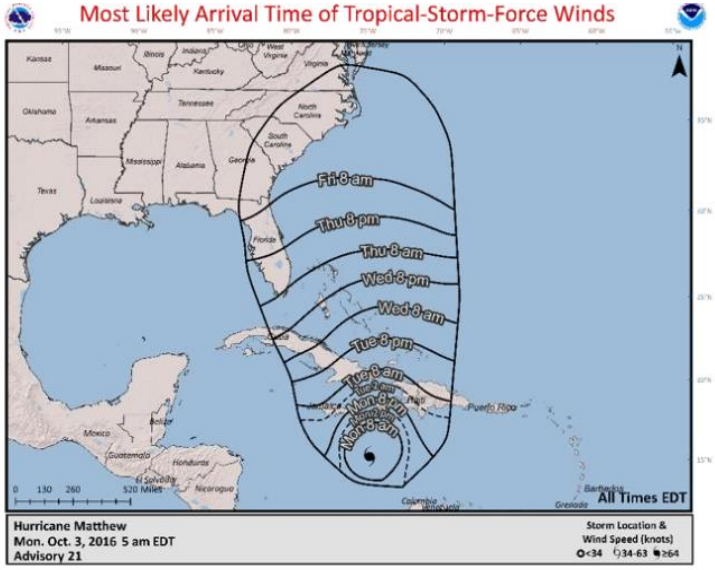
Watches:
Hurricane Trop.Storm

Warnings:
Hurricane Trop.Storm

FEMA

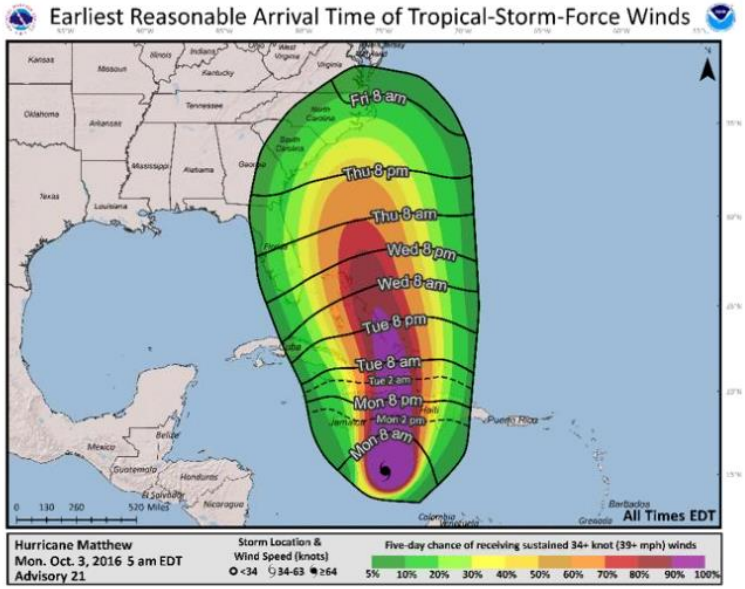

PRELIMINARY (SINGLE STORM) Tropical Storm Force Wind Speed Probabilities
For the 120 hours (5 days) from 8 AM EDT Thu Aug 25 to 8 AM EDT Tue Aug 30
VT
NH
NY
MA
CT RI
PA
NJ
40N
MD
DC
DE
VA
35N
Bermuda
30N
25N
Bahamas
Cuba
20N
Haiti
Dominican Rep
Jamaica
Puerto Rico
75W
70W
65W
60W
55W
50W
45W
40W
35W
30W
Probability of sustained tropical storm force surface winds (1-minute average of 39 mph or greater)
indicates TROPICAL STORM GASTON center location at 8 AM EDT Thu Aug 25 2016 (Forecast/Advisory #12)
5% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

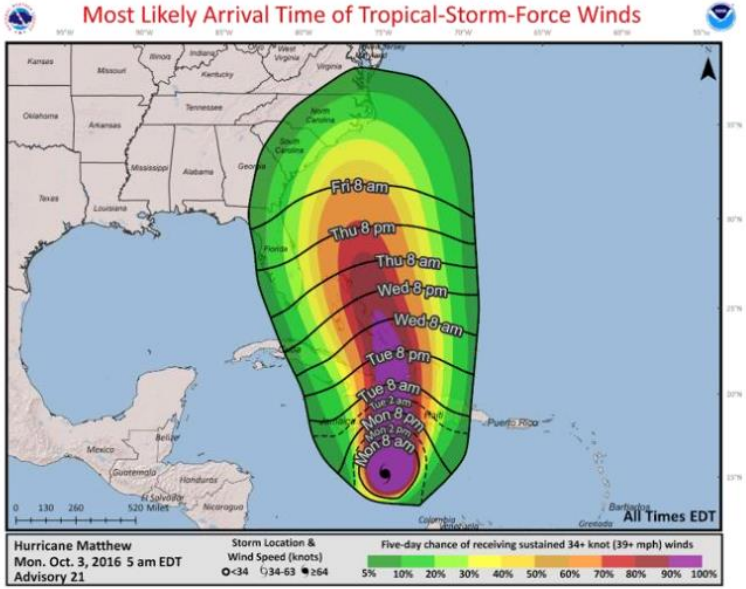
New for 2017



- Arrival of Tropical-Storm (TS)-force winds is a critical planning threshold. Preparations become dangerous once winds reach TS force
- These graphics account for forecast uncertainty (track/intensity/size) from the same realizations used to create the wind speed probability products
- Users have the option to display graphics with or without the underlying wind speed probabilities

New for 2017





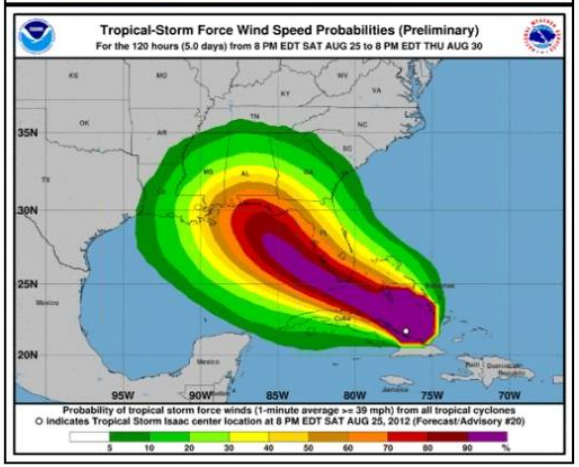
- Primary graphic depicts the time window that individuals can safely assume will be free from tropical-storm-force winds ("earliest reasonable" arrival time - no more than a 10% chance of onset).
- A secondary graphic will show the "most likely" arrival time – the time before or after which the onset of TS-force winds is equally likely.
- Available on hurricanes.gov with the tropical cyclone graphics in 2017

Tropical Cyclone Graphics: In kml and Shapefile

The following kml files and shapefiles are proposed to be available in 2017 at: www.nhc.noaa.gov/gis/

- The estimated extent of 34-kt, 50-kt, and 64-kt winds at advisory time, as well as the forecast extent of 34-kt, 50-kt, and 64-kt winds
- The estimated cumulative wind swath of hurricane-force and tropical-storm-force winds
- The 5-day probability of 34-kt, 50-kt and 64-kt winds would be available on a 5 km grid *(previously, these files used 10 km grid spacing. The resolution of the model used to generate the input data has not changed)*

Comments collected on proposed TC Graphics changes through April 9 (PNSWSH 17-10)



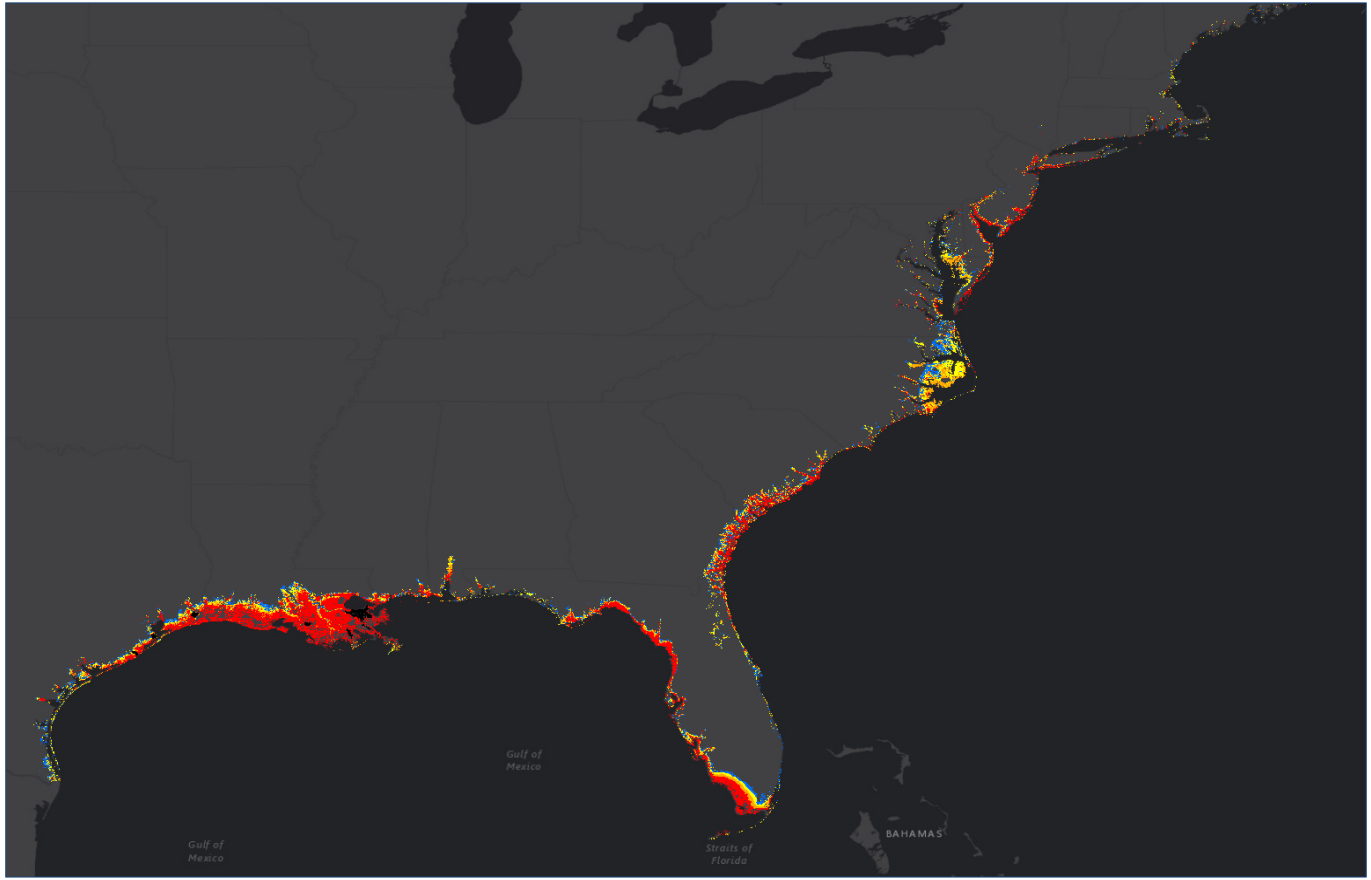
Potential Tropical Cyclones - 2017

- The NWS now has the option to issue watches and warnings for disturbances that are **not yet** a tropical cyclone, but pose a threat to bringing tropical cyclone conditions **to land** within 48 hours.
- Tropical Cyclone Watch and Warning criteria will not change
  - Watch-conditions possible within 48h
  - Warning-conditions expected within 36h
- Systems would be identified as: ***Potential Tropical Cyclones***
  - Same numbering system as depressions- “One”, “Two”, etc.
  - The standard tropical cyclone products will be issued

Enhanced Messaging from the NHC

- Special messages will be posted to the NHC website and Twitter simultaneously to indicate when advisories will be initiated

Storm Surge Hazard Maps: CONUS



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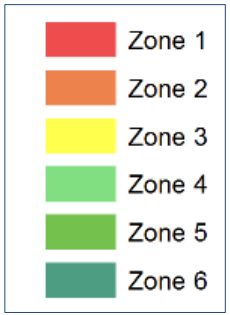
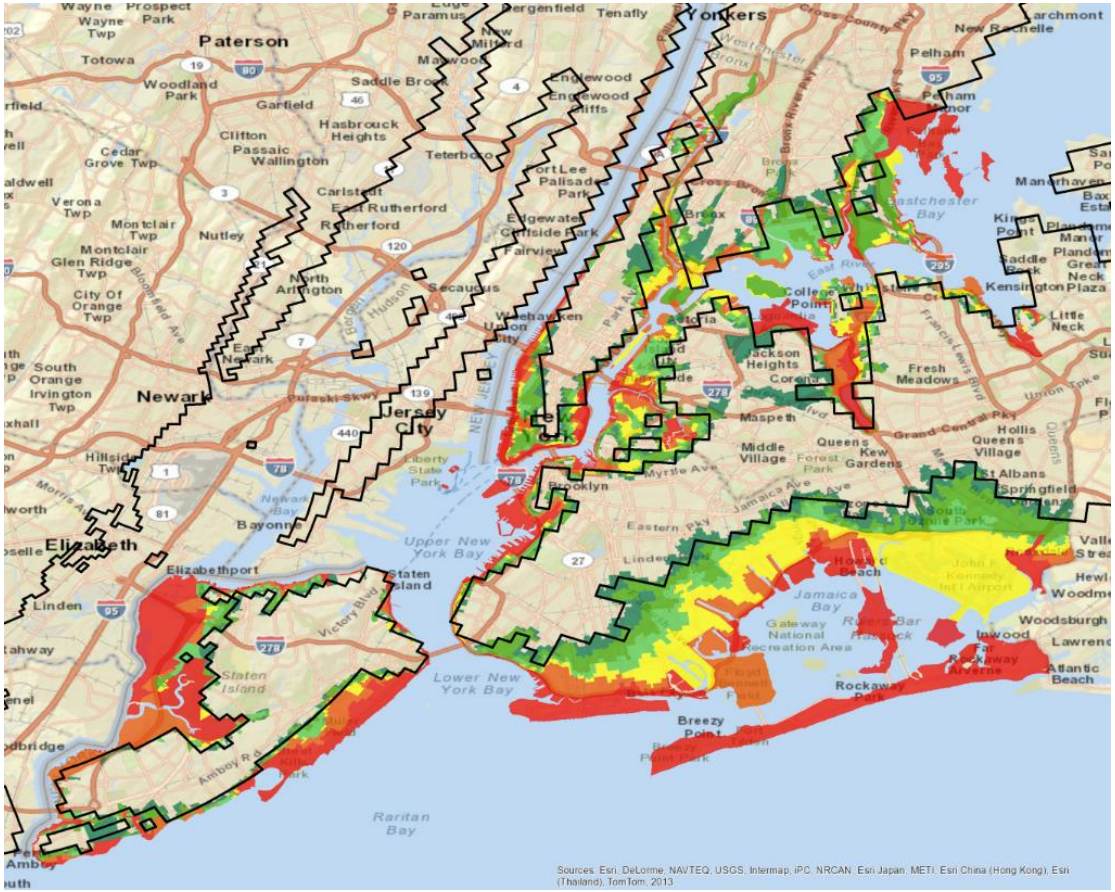
Storm Surge and Evacuation Zones



2010 Population	
Zone 1	370,000
Zone 1+2	620,000
Zone 1+2+3	1,020,000
Zone 1+2+3+4	1,470,000
Zone 1+2+3+4+5	2,230,000
Zone 1+2+3+4+5+6	2,990,000



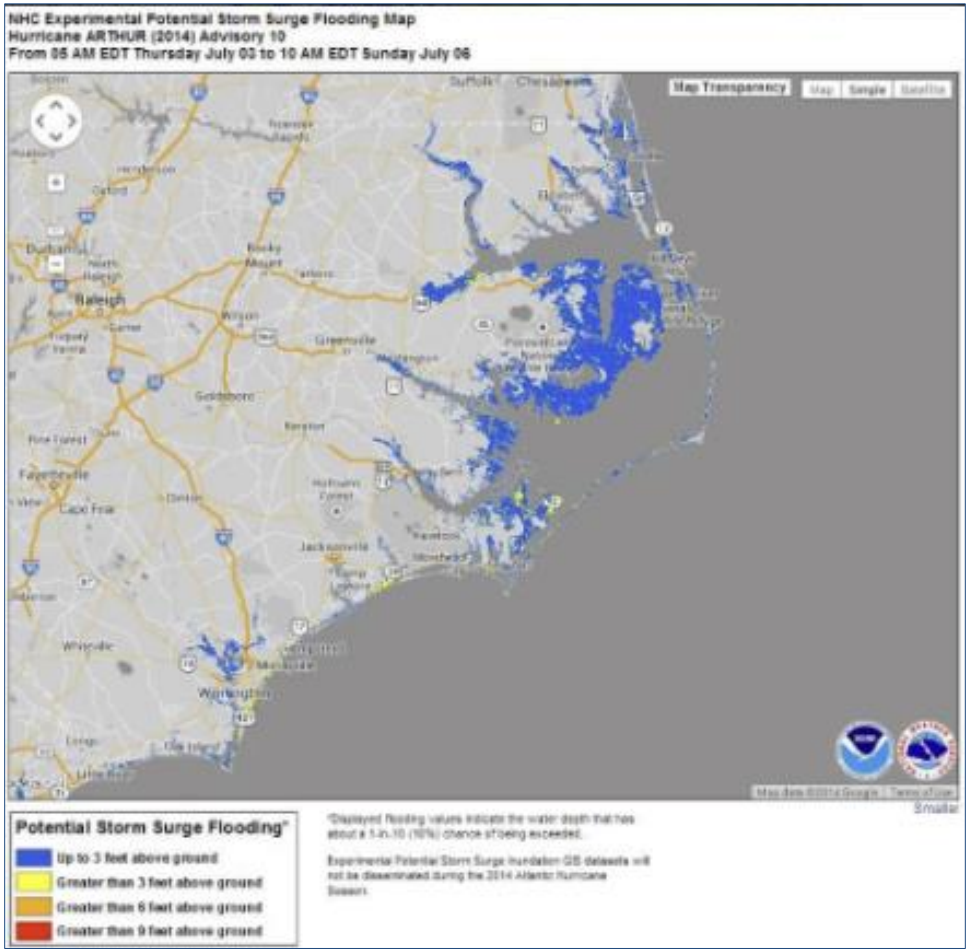
FEMA

New(ish) Storm Surge Products

Potential Storm Surge Flooding Map

- Guidance on where inundation from surge could occur and the height above ground the water could reach

- **Operational in 2016**



Potential Storm Surge Flooding Map

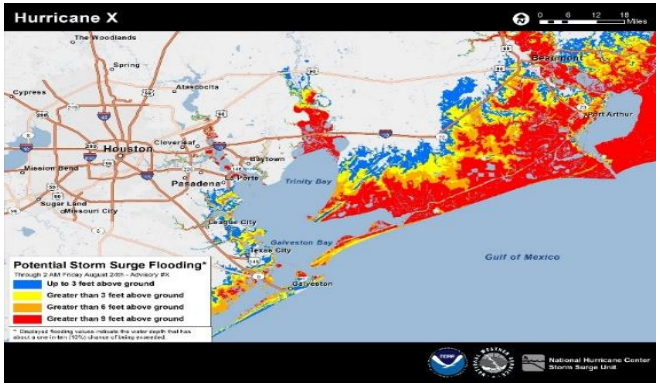
Provides a quantitative risk assessment for decision makers

Depicts a reasonable worst-case scenario at any individual location

Inundation levels have a 10% chance of being exceeded

Available about 60 to 90 minutes following the advisory release

First map issued at the same time as the initial hurricane watch or in some cases, with a tropical storm watch



Intertidal Zone/Estuarine Wetland Mask

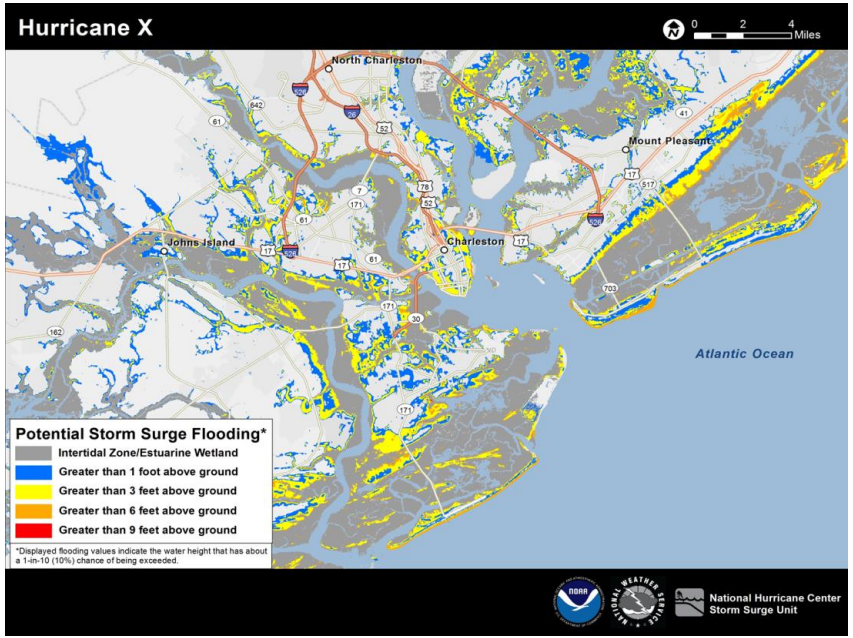
Areas that are often inundated by seawater without a storm are masked in gray

Allows users to focus on areas that could experience consequential flooding of normally dry ground

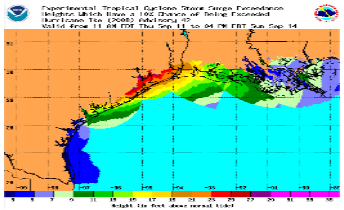
Potential Storm Surge Flooding*

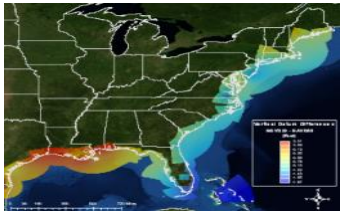
- Intertidal Zone/Estuarine Wetland
- Greater than 1 foot above ground
- Greater than 3 feet above ground
- Greater than 6 feet above ground
- Greater than 9 feet above ground
- Leveed area
  Consult local officials for flood risk

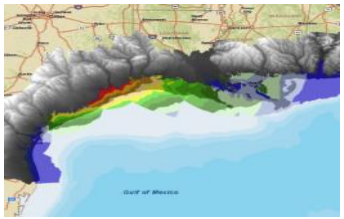
*Displayed flooding values indicate the water height that has about a 1-in-10 (10%) chance of being exceeded.



NHC Potential Storm Surge Flooding Map







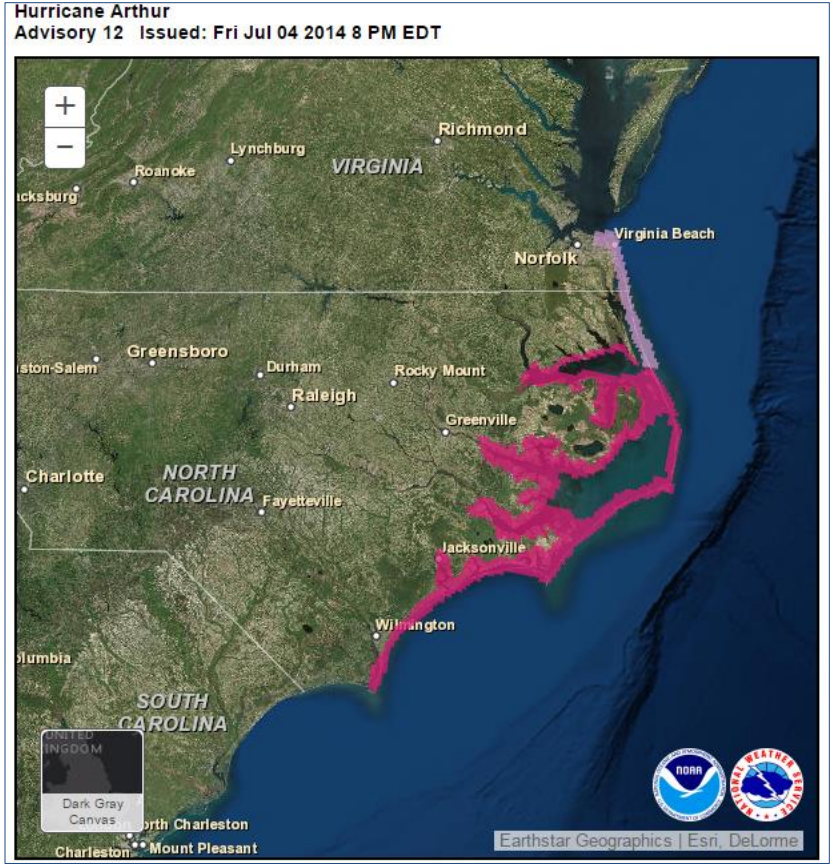
DOES NOT account for:

- Wave action
- Freshwater flooding from rainfall
- Riverine discharge
- Flooding resulting from levee failures
- Flooding inside levee systems
- Overtopping of levees

New Operational Storm Surge Products

Storm Surge Watch / Warning Graphic

- Highlights areas that have a significant risk of life-threatening surge, but does not provide depth of water



Operational in 2017

Storm Surge
Watch & Warning Graphic

Intended to enhance public response to instructions from local officials, and, ultimately, to help guide EM decisions

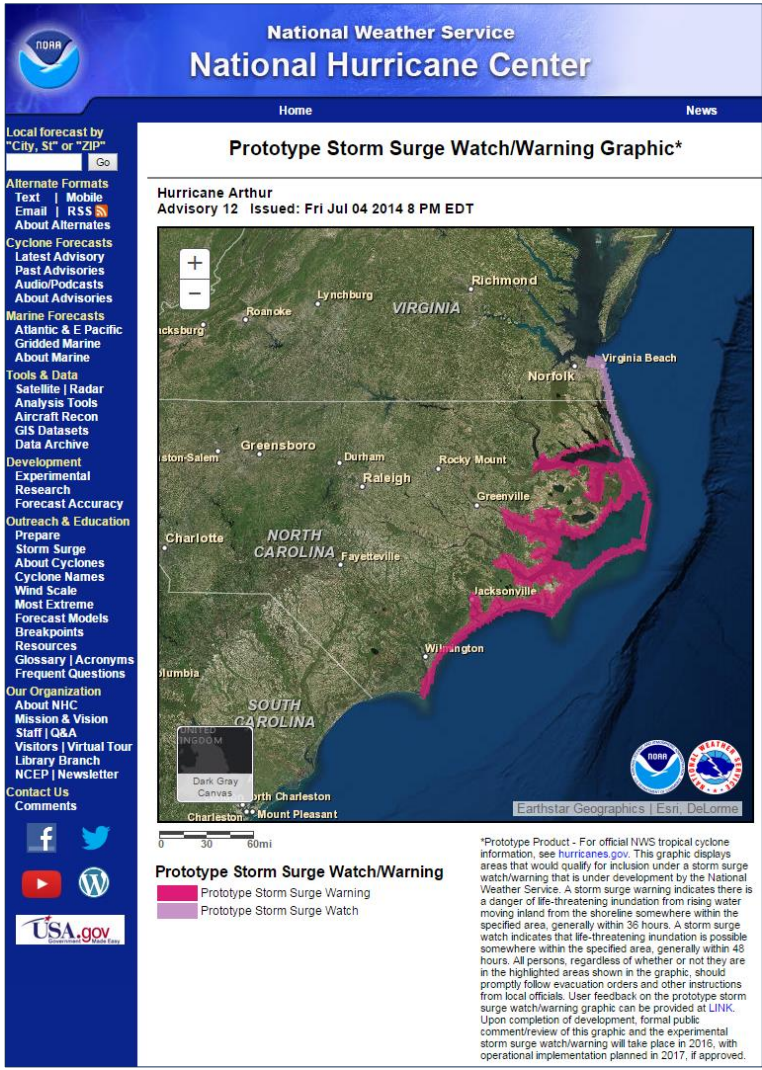
Current threshold is 3 ft above ground level

Issued 48 hours before possibility of life-threatening surge, or other hazards that would hinder evacuations

Collaboration of NHC Hurricane Specialists, surge experts, and local NWS WFOs

Introduces a storm surge watch/warning

Operational in 2017



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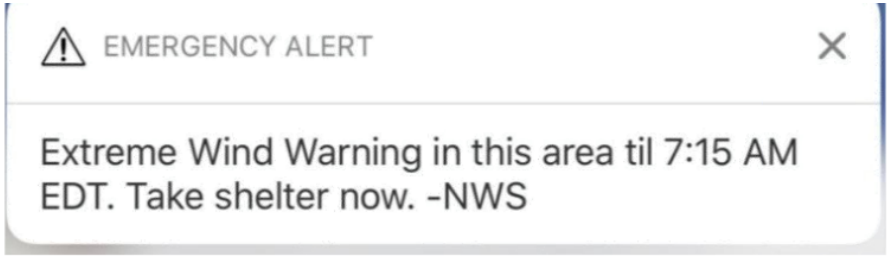
Proposed Storm Surge Watch and Warning Definitions

Watch: The ***possibility*** *of life-threatening inundation from rising water* moving inland from the shoreline somewhere within the specified area, **generally within 48 hours**, in association with a tropical, subtropical or post-tropical cyclone. The watch may be issued earlier when other conditions, such as the onset of tropical-storm-force winds, are expected to limit the time available to take protective actions for surge (e.g., evacuations). The watch may also be issued for locations not expected to receive life-threatening inundation, but which could potentially be isolated by inundation in adjacent areas.

Warning: The ***danger*** *of life-threatening inundation from rising water* moving inland from the shoreline somewhere within the specified area, **generally within 36 hours**, in association with a tropical, subtropical or post-tropical cyclone. The warning may be issued earlier when other conditions, such as the onset of tropical-storm-force winds, are expected to limit the time available to take protective actions for surge (e.g., evacuations). The warning may also be issued for locations not expected to receive life-threatening inundation, but which could potentially be isolated by inundation in adjacent areas.

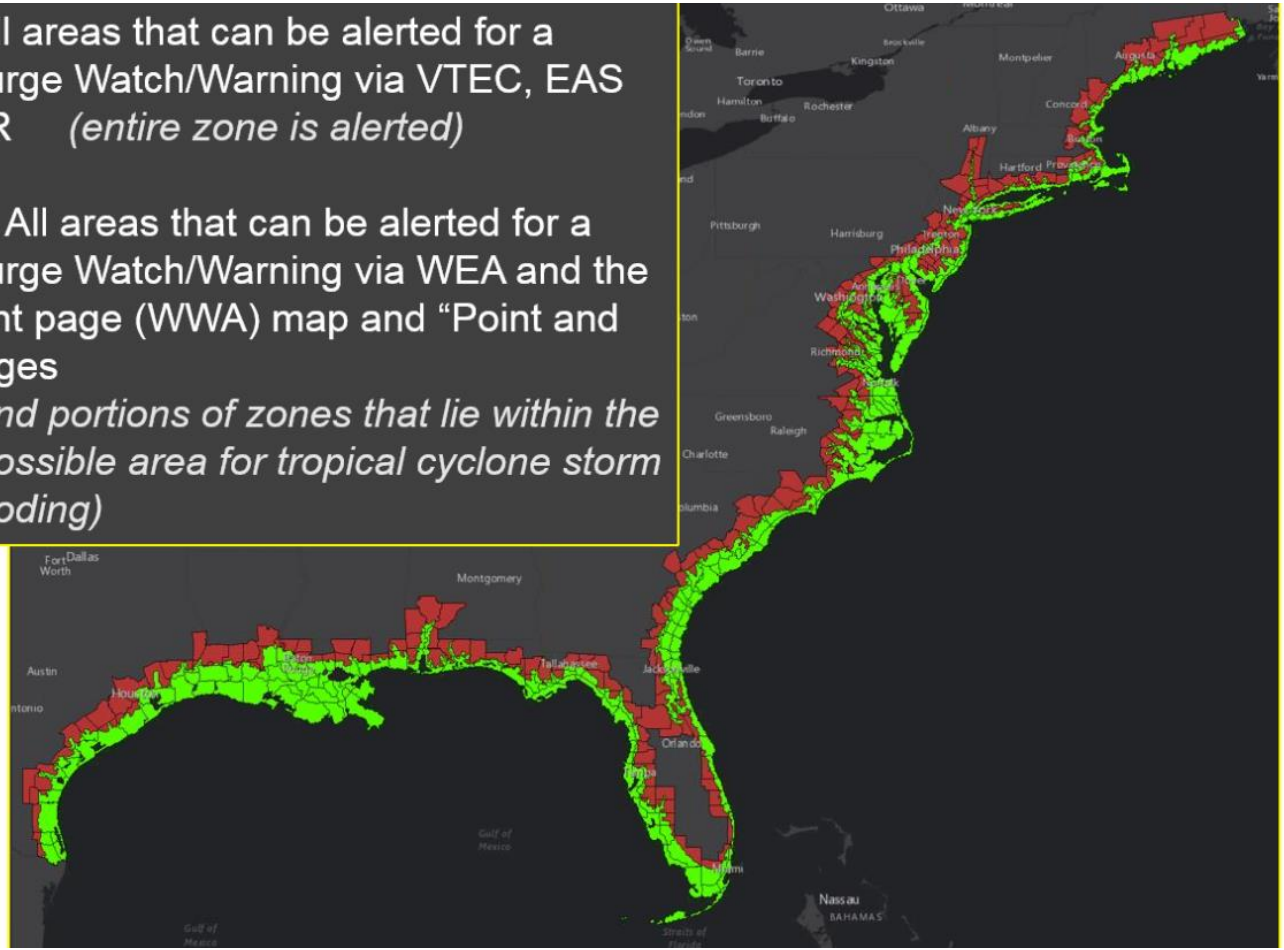


A Wireless Emergency Alert (WEA) is an emergency message broadcast to cell phones. The NWS will trigger WEA messages for NEW issuances of the following tropical warnings:

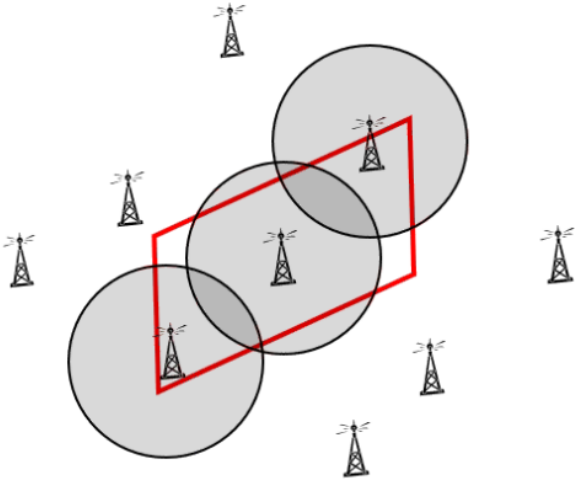
Warning Type	WEA Message
Extreme Wind Warning	Extreme Wind Warning in this area til hh:mm tzT ddd. Take shelter. –NWS
Hurricane Warning	Hurricane Warning this area. Check local media and authorities. -NWS
Storm Surge Warning	NWS: Life-threatening storm surge danger. Check for possible evacuation orders.

Red = All areas that can be alerted for a Storm Surge Watch/Warning via VTEC, EAS and NWR *(entire zone is alerted)*

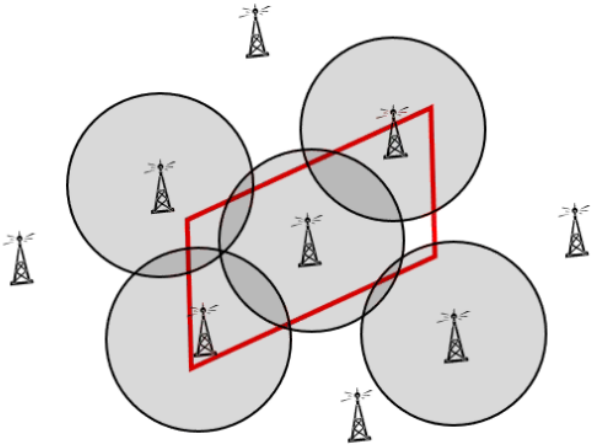
Green = All areas that can be alerted for a Storm Surge Watch/Warning via WEA and the NWS front page (WWA) map and "Point and Click" pages
(zones and portions of zones that lie within the largest possible area for tropical cyclone storm surge flooding)



While efforts are underway to make NWS triggered WEA activations more targeted, there is still the potential for the message to be spread outside the intended warning area

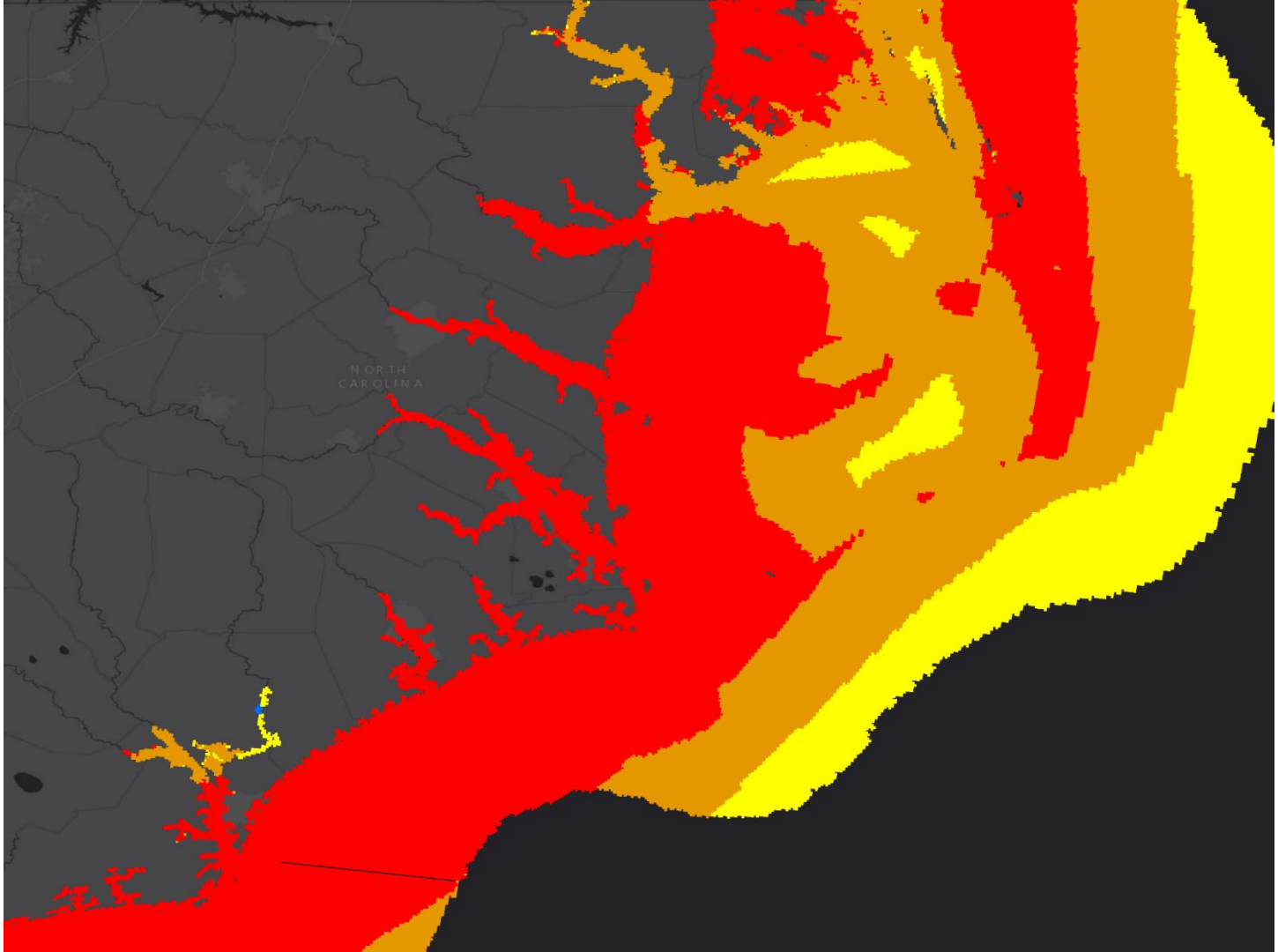


Carriers generally broadcast WEA from cell towers within the defined warning area



They may broadcast from towers where signal overlaps the defined warning area

Note: Map is not drawn to scale and is for illustrative purposes only.



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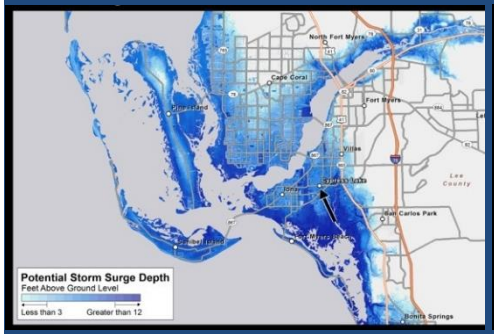
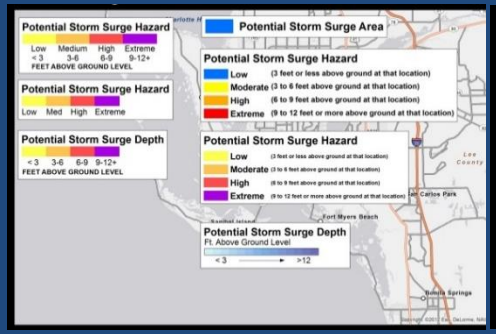
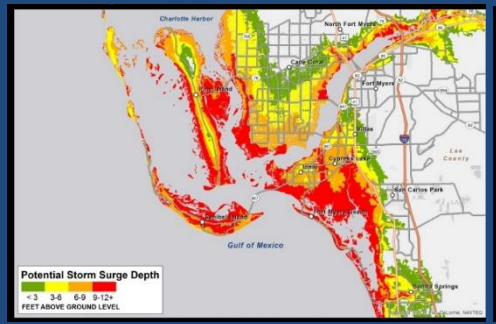

Potential Storm Surge Depth
Feet Above Ground Level
Less than 3
Greater than 12

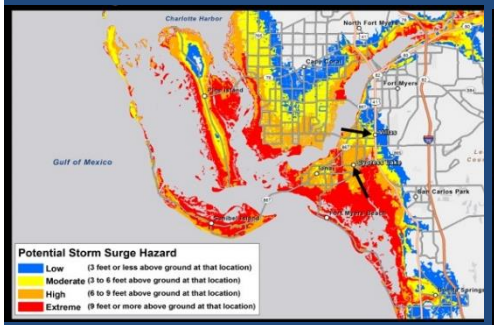

Potential Storm Surge Hazard
Low Medium High Extreme
< 3 3-6 6-9 9-12+
FEET ABOVE GROUND LEVEL
Potential Storm Surge Hazard
Low Med High Extreme
Potential Storm Surge Depth
< 3 3-6 6-9 9-12+
FEET ABOVE GROUND LEVEL
Potential Storm Surge Area
Potential Storm Surge Hazard
Low (3 feet or less above ground at that location)
Moderate (3 to 6 feet above ground at that location)
High (6 to 9 feet above ground at that location)
Extreme (9 to 12 feet or more above ground at that location)
Potential Storm Surge Hazard
Low (3 feet or less above ground at that location)
Moderate (3 to 6 feet above ground at that location)
High (6 to 9 feet above ground at that location)
Extreme (9 to 12 feet or more above ground at that location)
Potential Storm Surge Depth
Ft. Above Ground Level
< 3 >12

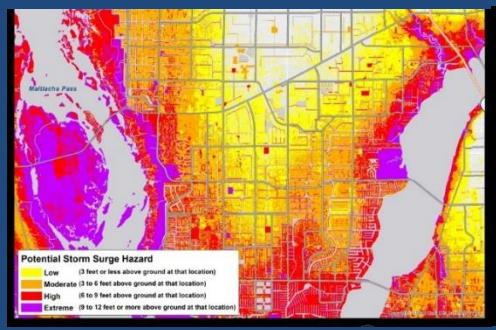

Potential Storm Surge Area

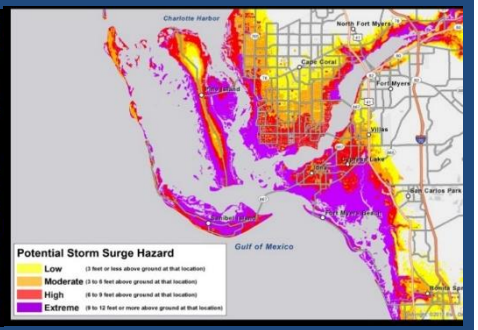

Charlotte Harbor
Gulf of Mexico


Charlotte Harbor
Gulf of Mexico
Potential Storm Surge Depth
< 3 3-6 6-9 9-12+
FEET ABOVE GROUND LEVEL


Charlotte Harbor
Gulf of Mexico


Charlotte Harbor
Gulf of Mexico
Potential Storm Surge Hazard
Low (3 feet or less above ground at that location)
Moderate (3 to 6 feet above ground at that location)
High (6 to 9 feet above ground at that location)
Extreme (9 feet or more above ground at that location)


Matlacha Pass
Potential Storm Surge Hazard
Low (3 feet or less above ground at that location)
Moderate (3 to 6 feet above ground at that location)
High (6 to 9 feet above ground at that location)
Extreme (9 to 12 feet or more above ground at that location)


Charlotte Harbor
Gulf of Mexico
Potential Storm Surge Hazard
Low (3 feet or less above ground at that location)
Moderate (3 to 6 feet above ground at that location)
High (6 to 9 feet above ground at that location)
Extreme (9 to 12 feet or more above ground at that location)

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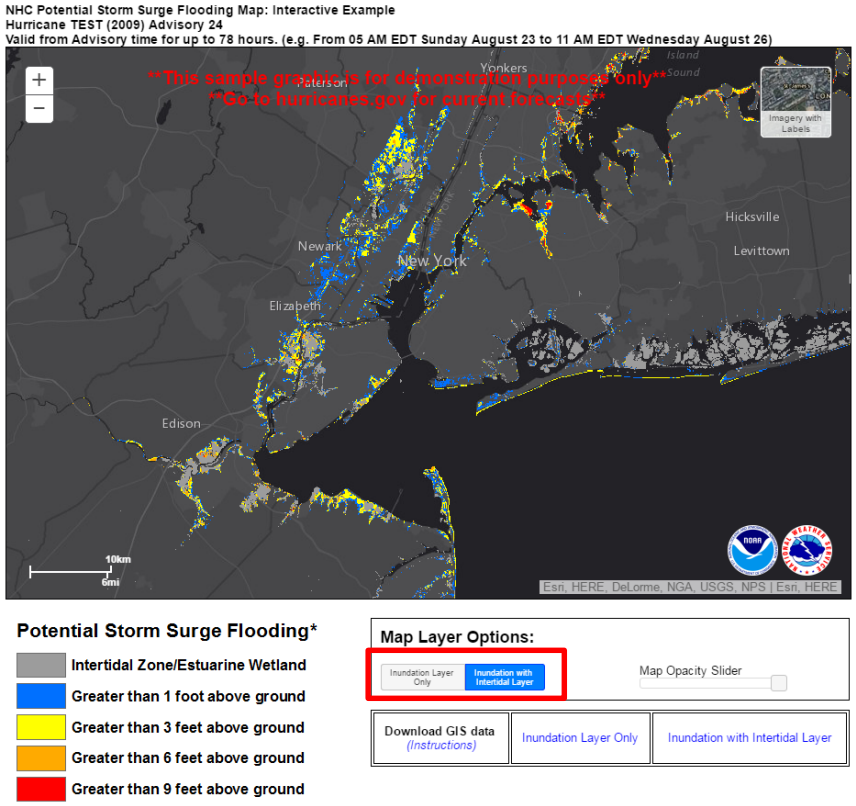
Viewable in Interactive Map Interface

http://www.nhc.noaa.gov/surge/inundation/



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GIS Data Available for Download

Potential Storm Surge Flooding Map- Data Downloads Description

For each advisory the Potential Storm Surge Flooding Map is active, NHC will provide a download to those datasets in GeoTIFF format for use in Geographic Information Systems (GIS) software. Each dataset will contain an ESRI World File (.tfw) and metadata .xml file. These GeoTIFFs will be 8-bit unsigned integer rasters. Listed below are the RGB colors, labels in the map legend, and class values used in this map.

There will be two datasets available for download. Each dataset can be downloaded as a .zip file from the link found below the map viewer of the active storm on the NHC webpage or from the links found on the NHC GIS webpage. Listed with each sample legend is the generic naming format for the .zip file and the name of the GeoTIFF that would be found inside the given .zip file.

inundation.zip - Potential Storm Surge Flooding GeoTIFF, which contains, 'STORMNAME_YEAR_Adv##_e10_ResultRaster.tif'

RGB Values	Legend and Labels	Class Values in GeoTIFF
(0, 112, 255)	Greater than 1 foot above ground	2
(255, 255, 0)	Greater than 3 feet above ground	3
(255, 170, 0)	Greater than 6 feet above ground	4
(255, 0, 0)	Greater than 9 feet above ground	5

tidalmask.zip - Potential Storm Surge Flooding with Intertidal Mask Layer GeoTIFF, which contains, 'STORMNAME_YEAR_Adv##_e10_ResultMaskRaster.tif'

RGB Values	Legend and Labels	Class Values in GeoTIFF
(156, 156, 156)	Intertidal Zone/Estuarine Wetland	15
(0, 112, 255)	Greater than 1 foot above ground	2
(255, 255, 0)	Greater than 3 feet above ground	3
(255, 170, 0)	Greater than 6 feet above ground	4
(255, 0, 0)	Greater than 9 feet above ground	5

Data & Products

Please note these GIS datasets are provided as a convenience to users. Support for these data may not always be available or timely in nature. Please provide your feedback and need for NWS GIS data in this National Weather Service GIS Survey. For issues directly related to the datasets below, please contact us.

	As of Fri, 03 Jun 2016 16:53:48 UTC		
	Atlantic	Eastern Pacific	Archive
Advisory Forecast Track, Cone of Uncertainty, and Watches/Warnings‡ Lines: metadata sample Point: metadata sample Cone: metadata sample Watch/Warning: metadata sample	TD BONNIE: [shp] [kmz]	No current data	Year
Advisory Wind Field† Surface Wind Field: metadata sample Forecast Wind Radii: metadata sample	TD BONNIE: [shp]	No current data	Year
Preliminary Best Track‡ Cumulative Wind Swath: metadata sample Track: metadata sample Points: metadata sample Wind Radii: metadata sample	TD BONNIE: [shp] [kmz]	No current data	Year
Graphical Tropical Weather Outlook† metadata sample	Outlook areas (if any): [shp]		Atlantic E Pacific
Wind Speed Probabilities‡• Points: 34 knot metadata sample Polygons: 34 knot metadata sample	Points: [shp] Polygons: [shp] - kmz [34kt] [50kt] [64kt] GRIB1 and GRIB2 data: via HTTP via FTP		Year
Probabilistic Storm Surge‡• metadata sample	No current data GRIB2: via HTTP via FTP	N/A	Year
Potential Storm Surge Flooding (Inundation) metadata sample download instructions interactive example with sample downloads	No current data	N/A	Year
Breakpoints‡ metadata sample (updated for 2015)	2015 update: [shp] [kmz] Interactive Map		View
Storm Surge Communication Points‡ metadata sample (updated for 2015)	2015 update: [shp] [kmz] Interactive Map		N/A: New in 2015
GIS Data RSS Feed description	Atlantic GIS	Eastern Pacific GIS	N/A
Active KML Feed (Google Earth) description	All Tropical Cyclones: [kmz]		

http://www.nhc.noaa.gov/gis/

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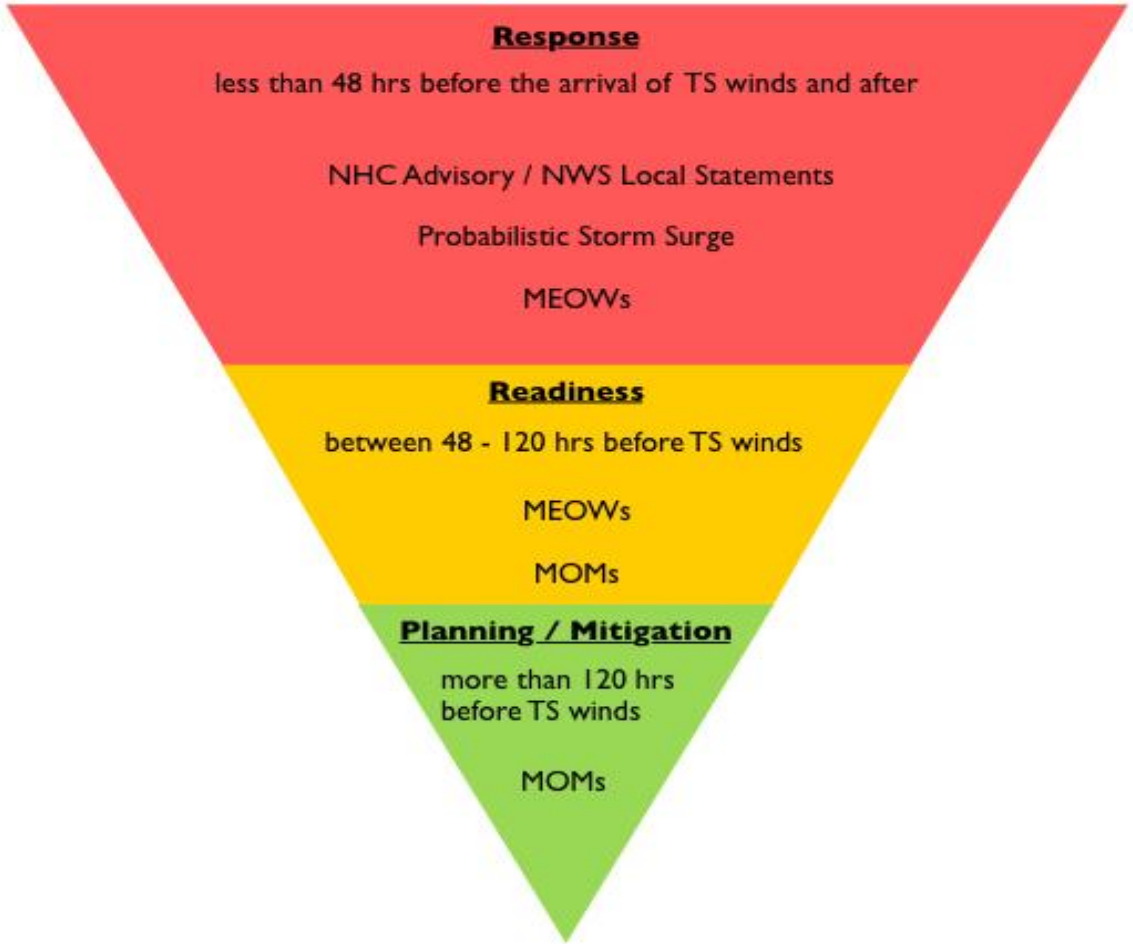
Decision Support Wedge Based on the Arrival of Tropical-Storm-Force Winds



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NHC/NWS/NOAA

Hurricane Evacuation Studies (HES)

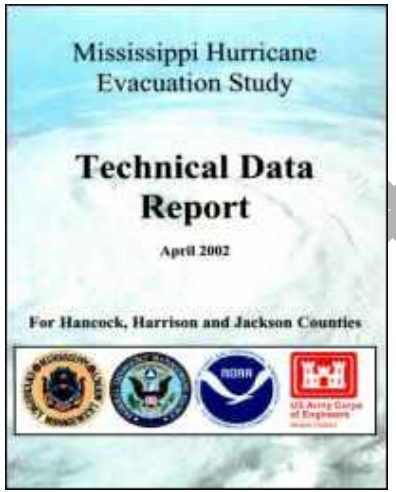
Funded By: FEMA/USACE

Purpose: ***Provide emergency management officials information that will assist in hurricane evacuation decisions.***

Objective: Determine:

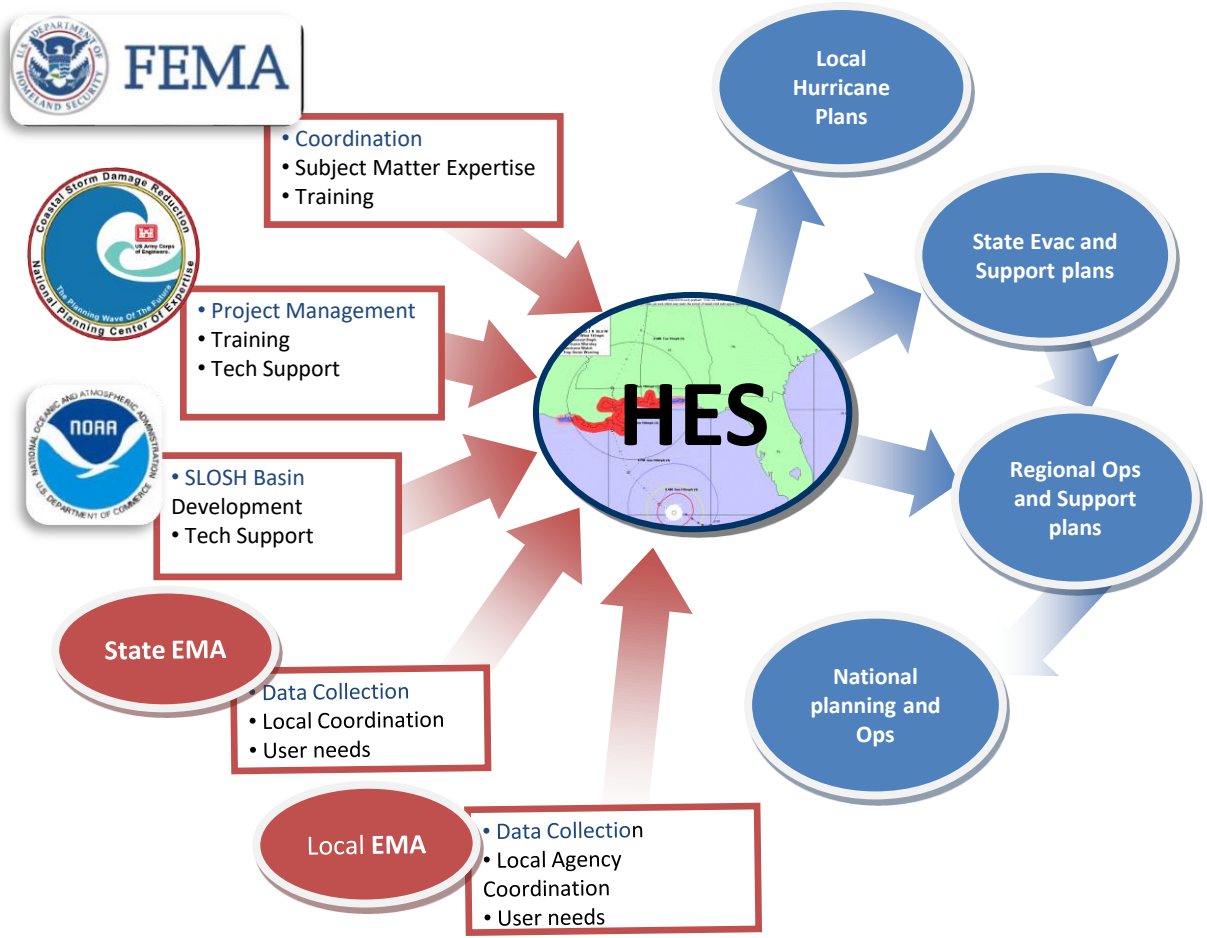
- ***Area of Hurricane Impact***
- ***Who/What Is In That Area***
- ***How People There Will Respond***
- ***Shelter Requirements***
- ***Evacuation Clearance Times***

HES Partnerships



- Federal Emergency Management Agency
- Army Corps of Engineers
- NOAA: National Weather Service & Coastal Services Center
- State & Local Emergency Management
- Regional Planning Councils
- Volunteer Organizations

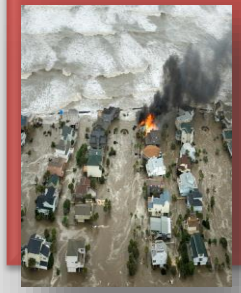
Roles and Responsibilities



Hurricane Evacuation Study Components

Hazards Analysis

- SLOSH Model Development
- Surge MOMS
- **Surge Maps**
- **Evacuation Zones**

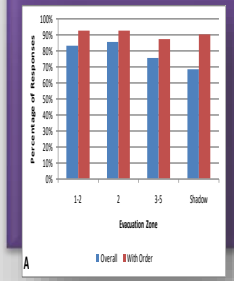


Vulnerability Analysis

- **Identify at Risk:**
- Populations
- Infrastructure
- Critical Facilities
- **Local Planning Data**

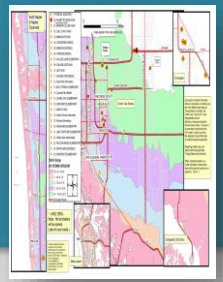
Behavioral Analysis

- Public Survey
- Analysis of Survey Responses
- Results for Input into Shelter and Trans. Analysis



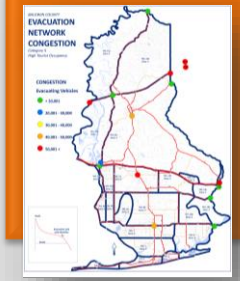
Shelter Analysis

- Determining the Shelter Need
- Estimate Number of Shelter Spaces
- Potential Vulnerability
- Identify Shelter Deficit



Transportation Analysis

- Analysis of Traffic Volumes, Evac. Routes, and Destinations
- Traffic Patterns
- **Evacuation Clearance Times**



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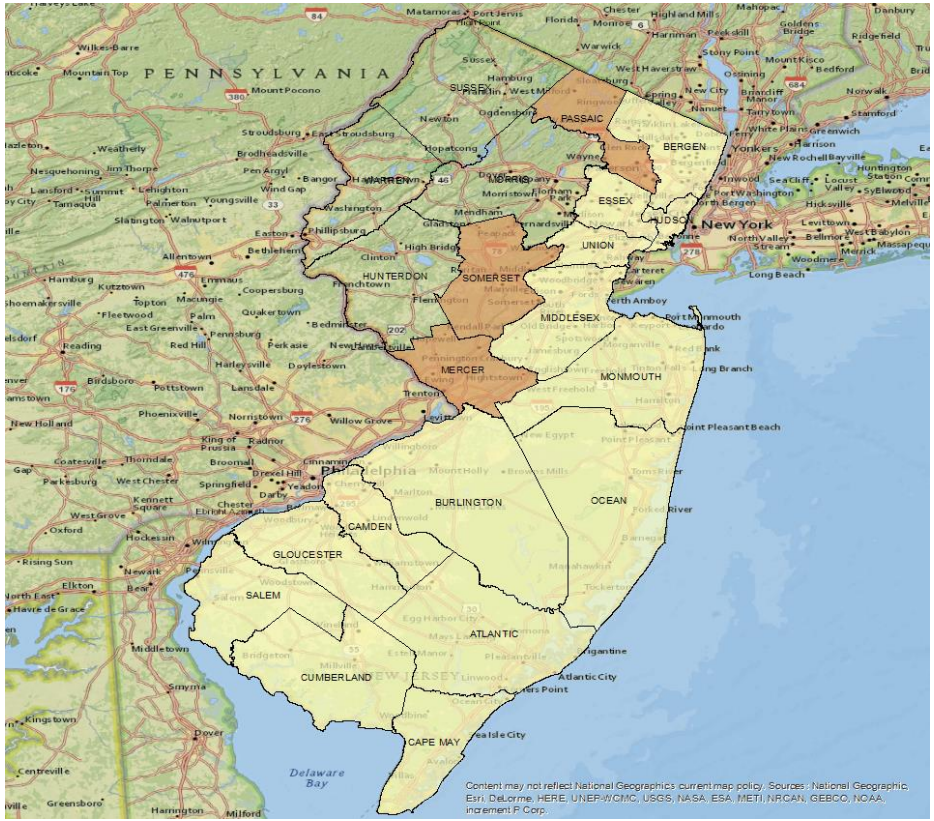
Hurricane Evacuation Study Area



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Hazards Analysis

Helping coastal decision makers understand the maximum impact associated with the main hurricane hazard - Storm Surge

Wind

Storm Surge

Flooding

FEMA

Hazards Analysis

Understanding Storm Surge Potential

- Storm surge has the highest potential for death and damage
- Storm surge is the main reason we evacuate the coast
- Hurricane Evacuation Studies utilize SLOSH for storm surge estimation

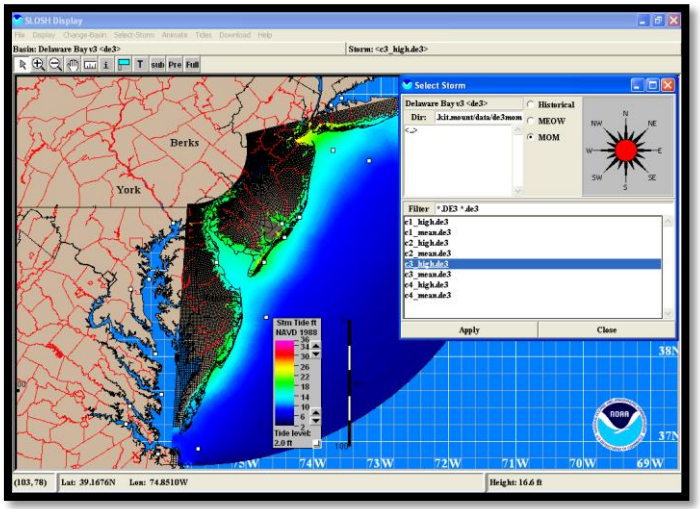
Hurricane Ike Damage, TX. Photo: FEMA

What are the zones based on?

Storm surge vulnerable areas created using the SLOSH model

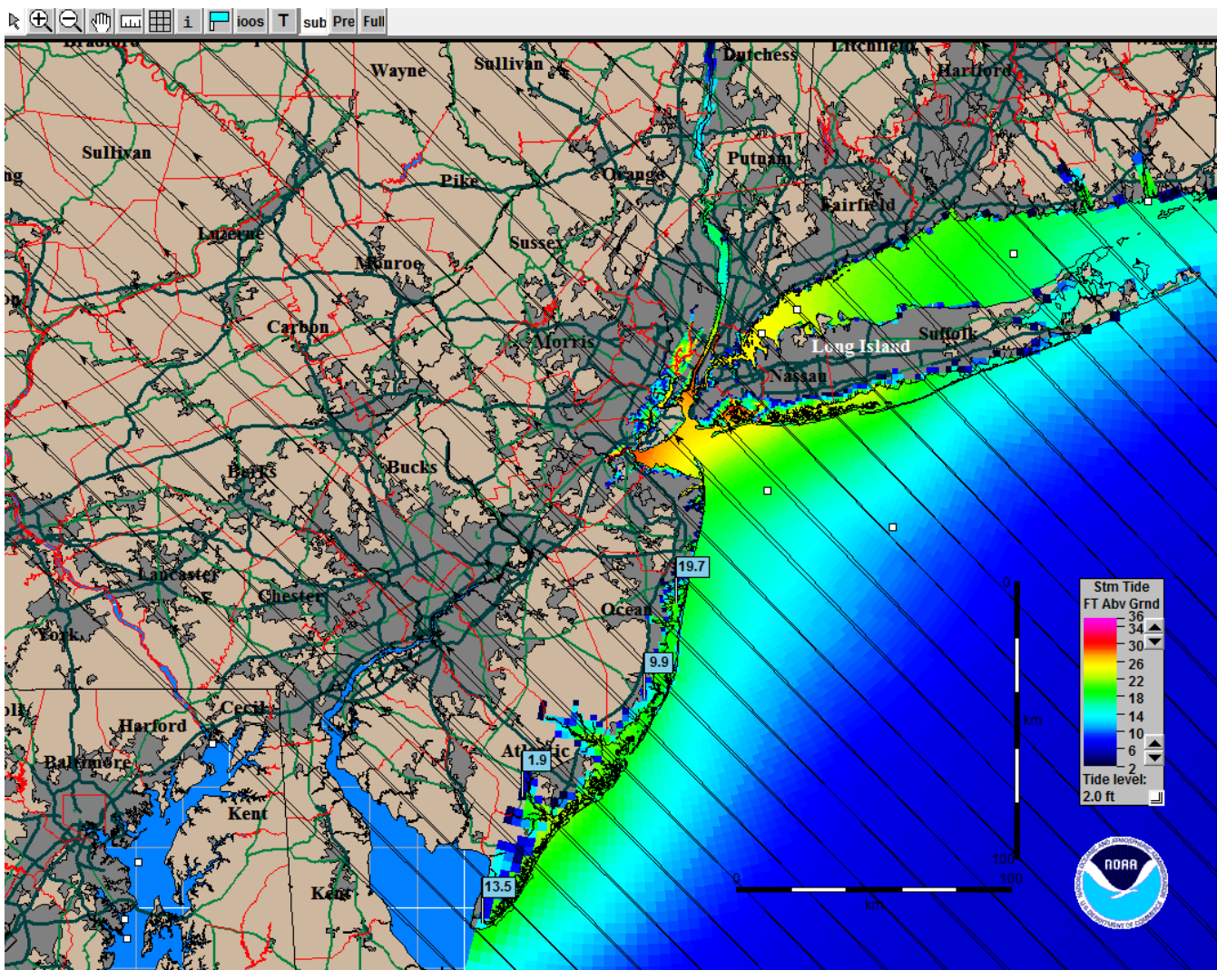
Maximum of Maximum Storm Surge Potential “MOM”

- Consist of thousands of runs
- Different intensities, pressure, angles of approach, forward speed, wind radii
- One per category – Worst case scenarios



SLOSH Model MEOWs

MEOWs — Maximum storm surge using storms of varying forward speed, size, intensity, and location, approaching the coast from one direction.



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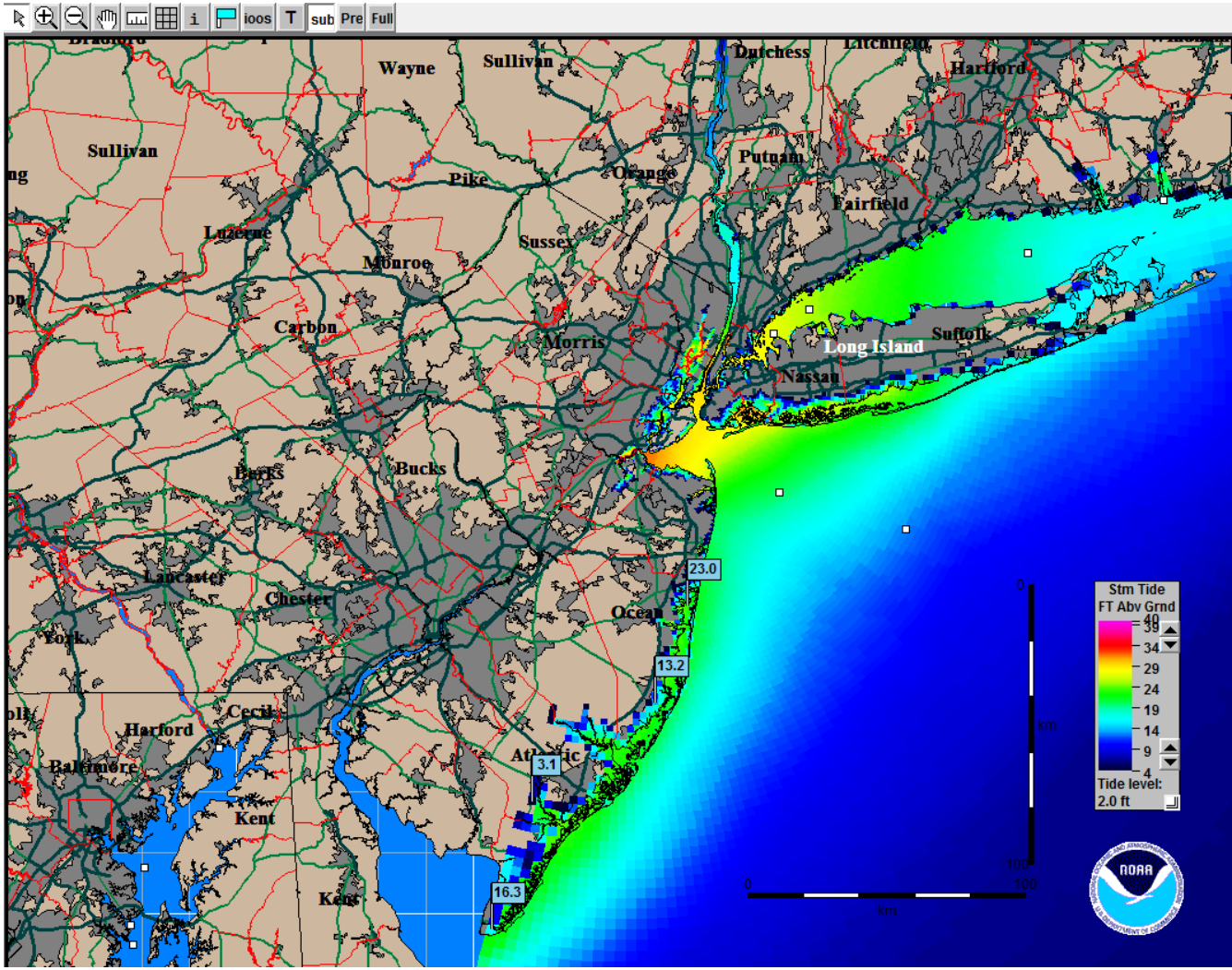
SLOSH Model MOMs

MOMs — Created by combining all MEOWs for each category and showing the maximum value in each grid cell



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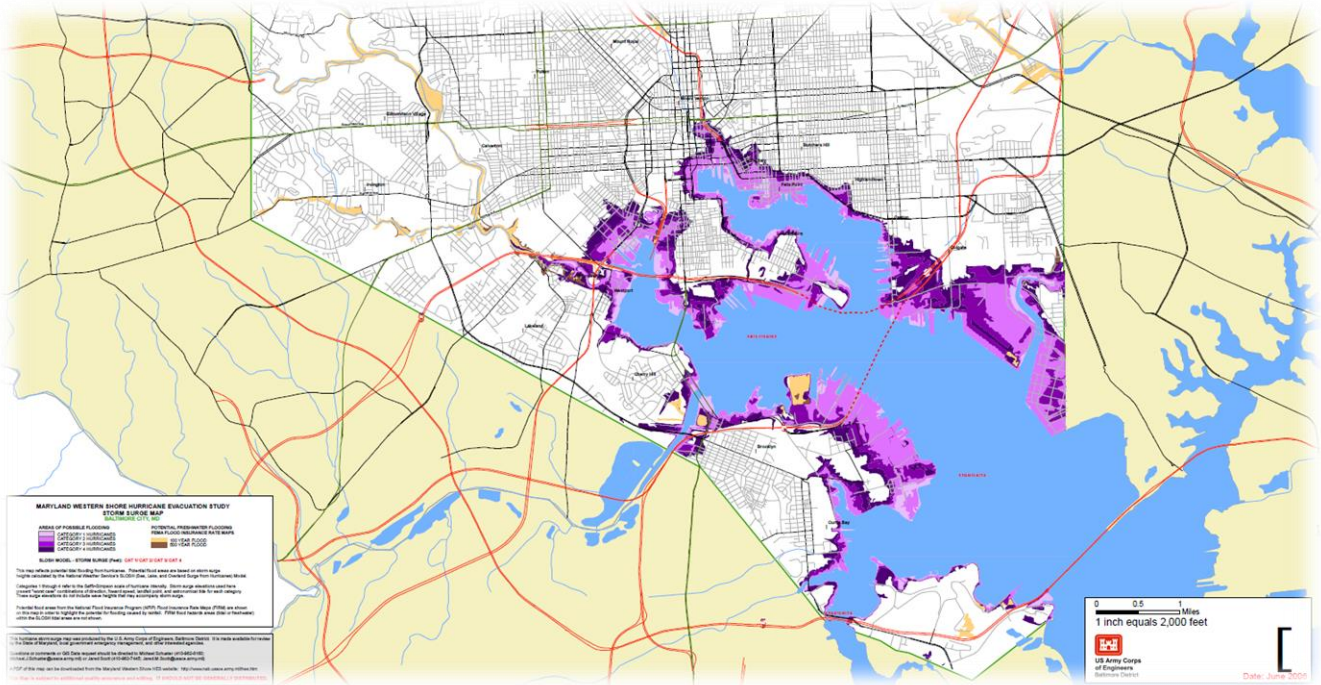
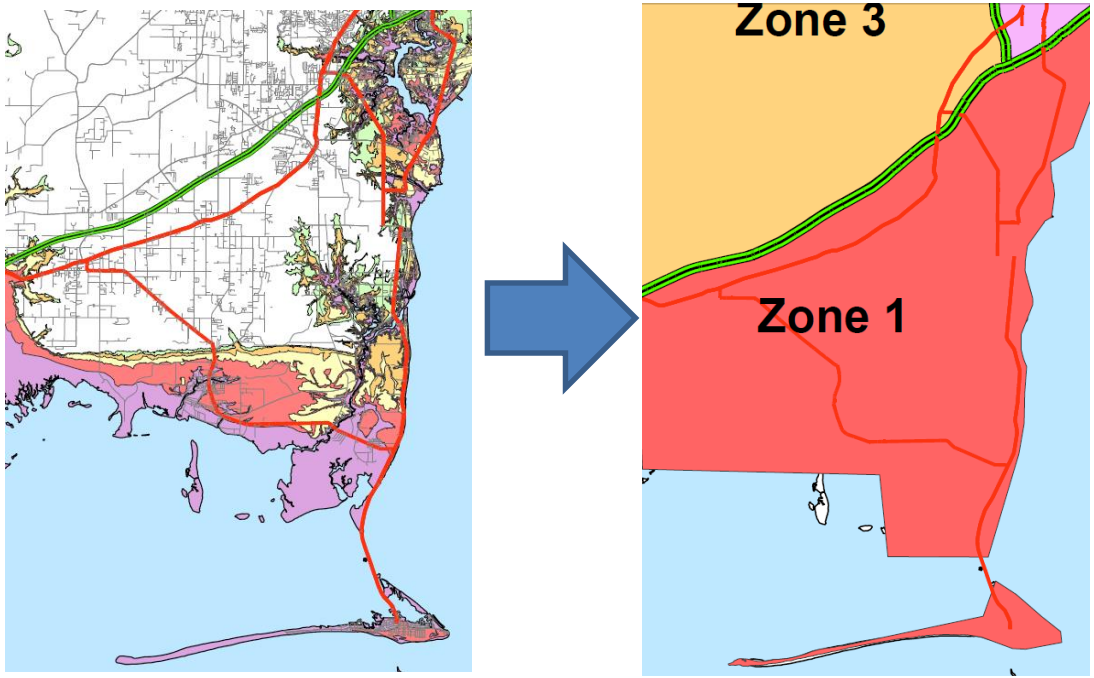
Storm Surge Atlas – Map Books & GIS Files

Providing a picture of the maximum storm surge vulnerability



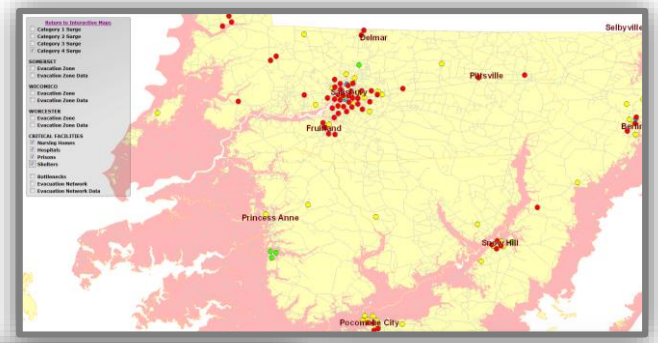
Evacuation Zones

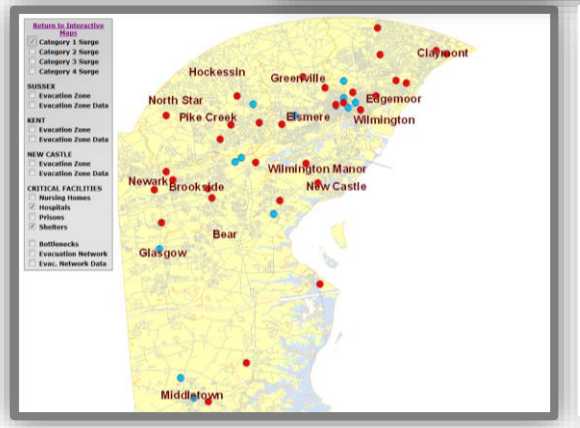
Question: How does an Emergency Manager communicate the maximum storm surge risk to the public?



Vulnerability Analysis

Helping coastal decision makers identify Who may need to evacuate and What is at risk





Metro New York Evacuation Project

Table 6: Critical Facility Summary – By County

Location	Total # of Facilities	# of Surge Vulnerable Facilities				# of Wind Vulnerable Facilities	# on HURREVAC List
		Cat 1	Cat 2	Cat 3	Cat 4		
New York							
Manhattan Borough	69	59	61	61	62	7	26
Brooklyn Borough	30	17	24	25	28	2	10
Queens Borough	58	33	36	43	47	10	21
Staten Island Borough	10	3	5	5	6	4	6
Bronx Borough	23	10	13	13	15	7	11
Nassau County	13	9	11	11	11	2	10
Suffolk County	23	16	16	16	16	7	15
Westchester County	33	24	24	24	24	9	7
Dutchess County	4	4	4	4	4	0	1
Putnam County	3	3	3	3	3	0	1
Rockland County	1	1	1	1	1	0	0
New Jersey							
Bergen County	13	4	9	10	12	1	7
Essex County	3	1	3	3	3	0	1
Hudson County	29	23	25	26	26	2	11
Middlesex County	4	3	3	4	4	0	1
Monmouth County	1	1	1	1	1	0	1
Passaic County	2	0	0	0	0	2	0
Union County	3	0	0	1	1	2	1
Connecticut							
Fairfield County	5	5	5	5	5	0	2

Note: Each facility is susceptible to only one hazard (wind or surge).

- Citizens residing in surge prone areas
- Critical facilities
- Mobile/Manufactured home communities
- Vulnerable shelters
- Roadway network, bridges, tunnels
- Other areas to be considered?

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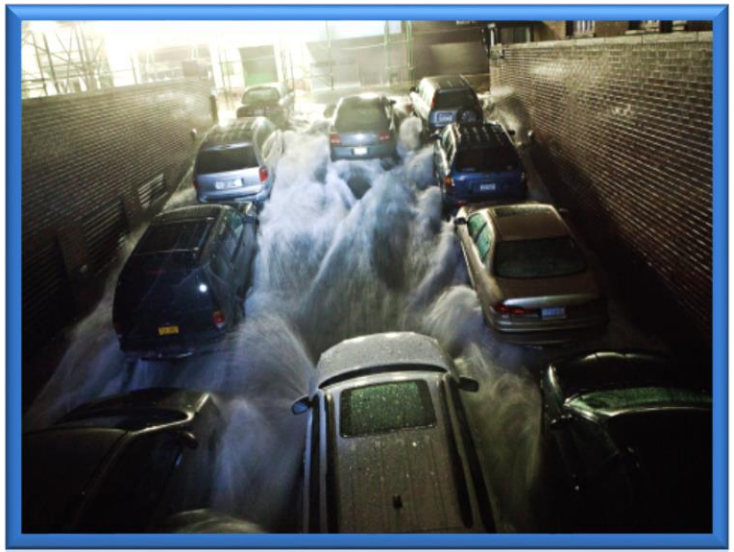
Hurricane Behavioral Analysis



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SOURCES OF INFORMATION

U. S. CENSUS

- **Population Size**
- **Demographics**
- **Household Composition**
- **Home Tenancy**
- **Language**
- **Vehicles**

BEHAVIORAL STUDY

- **Attitudes About Risk**
- **Hurricane Experience**
- **Sources of Information**
- **Evacuation Intent**
- **Transportation Needs**
- **Evacuation Destination**
- **Evacuation Route**

BEHAVIORAL STUDY METHODOLOGY

SURVEY DATA COLLECTION METHODS

- Face-to-Face Interviews
- Mailed Questionnaire
- Internet Questionnaire
- Telephone Survey – Cell and Landline

Pros and Cons – Factors such as seasonal population, internet access etc.

BEHAVIORAL STUDY METHODOLOGY

SOME EXAMPLES OF QUESTIONS

To what extent are you concerned about the threat of a hurricane? Are you very concerned, somewhat concerned, or not concerned?

How likely do you think it is that your home would ever be flooded as a result of a category 1 hurricane" Is it very likely, somewhat likely, or not likely at all?

If a Category 3 or above hurricane was threatening your community, how likely is it that you would leave your home? Is it very likely, somewhat likely, or not likely at all?

On a scale of 1 to 5, with 5 being the most likely, how likely do you think it is that you will leave If government officials issue a mandatory evacuation order for a hurricane for your area?

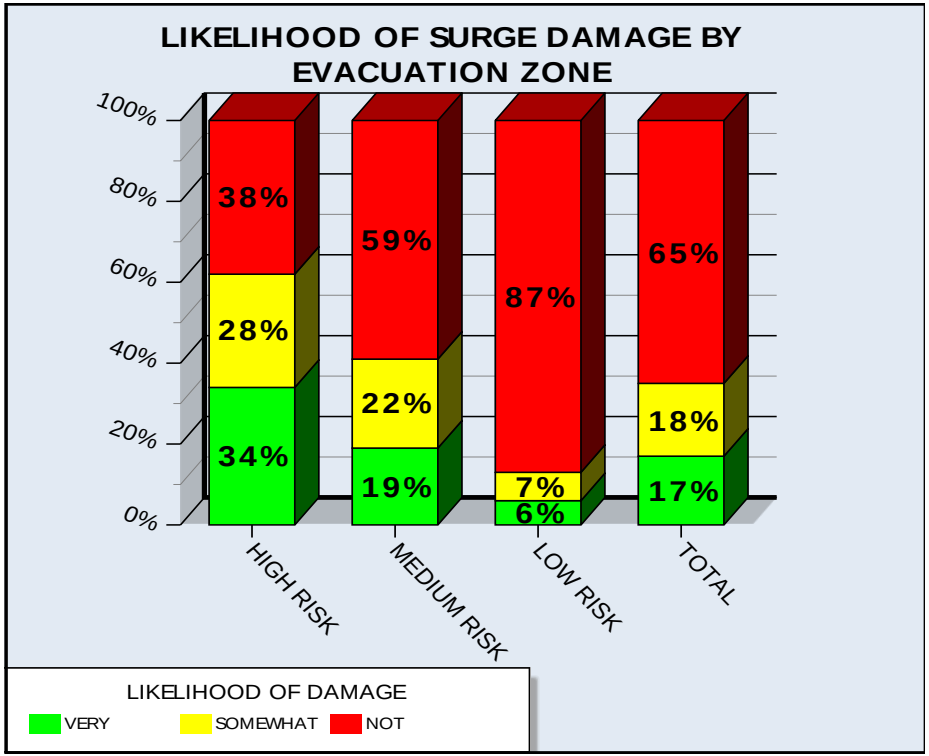
Considering both wind and flooding, do you think it would be safe for you to stay in your home if a category 3 hurricane with 125 MPH winds passed directly over your location?

Simple Percentages

Intended Destination and Distance Expect to Travel

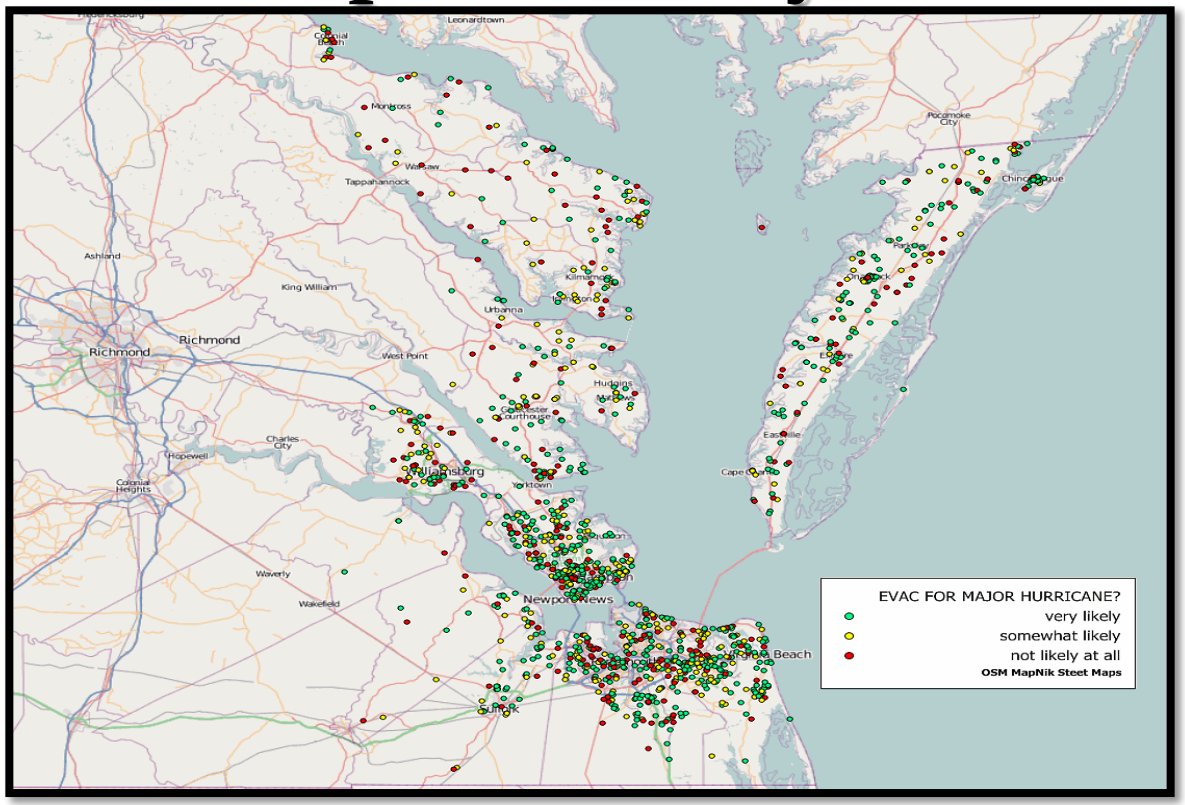
How Far Would Go	Public Shelter 10%	Family/Friends Inside Area 17%	Family/Friends Outside Area 47%	Hotel 21%	Other 6%
< 10 Miles	27%	16%	2%	1%	7%
10-50 Miles	30%	41%	11%	18%	19%
50-100 Miles	19%	21%	30%	38%	29%
100-200 Miles	17%	11%	28%	26%	23%
> 200 Miles	6%	11%	30%	17%	22%

Cross-Tabulation

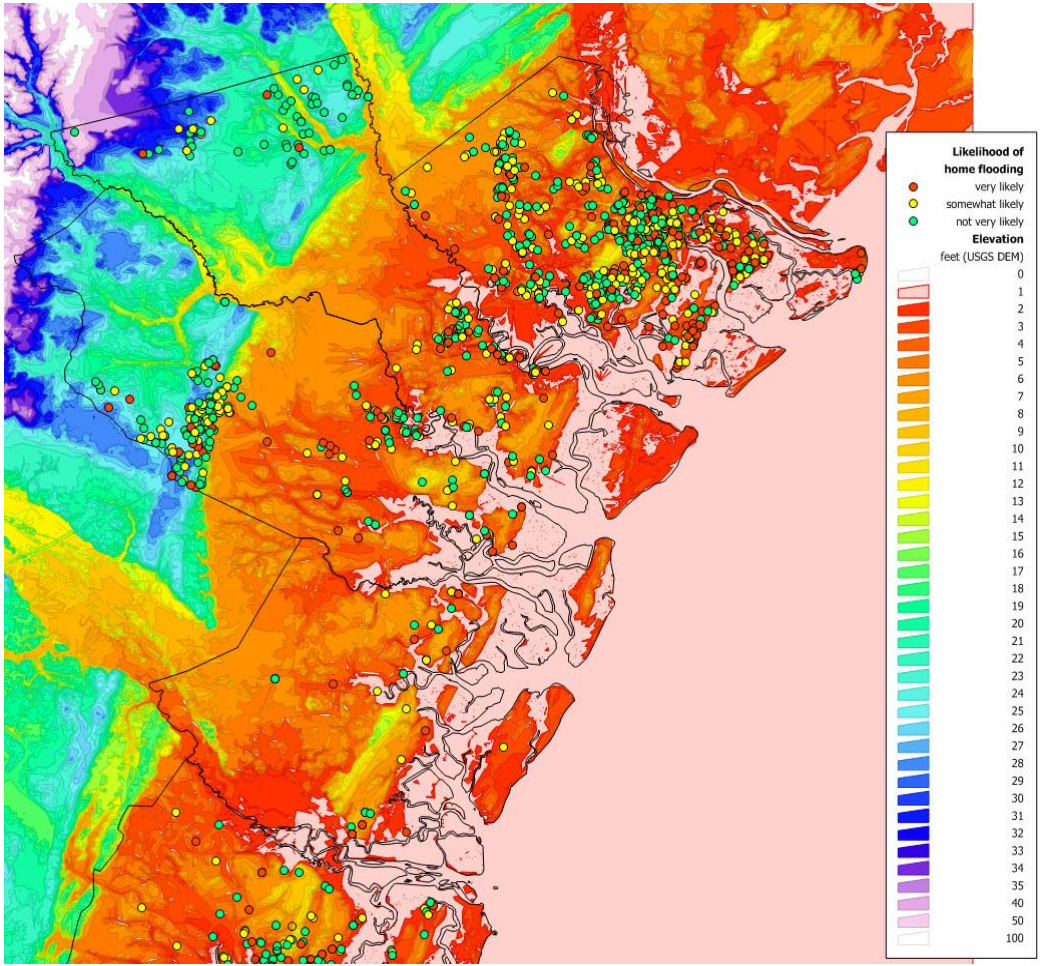


Coastal Mississippi Behavioral Study. 2011. Morrow & Gladwin through Dewberry for FEMA and UCACE

Spatial Analysis



Hampton Road VA Evacuation Study. 2010. Morrow & Gladwin through Dewberry for FEMA& USACE



Each dot = one interview

Likelihood Would Be Flooded in Major Hurricane:

- Not Very Likely
- Somewhat Likely
- Very Likely

Coastal Georgia Evacuation Study. 2010. Morrow & Gladwin through Dewberry. 2009 for FEMA and USACE.

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BOTTOM LINE

- **Behavioral studies can provide important information for evacuation planning**
- **They involve a complex process**
- **Methodology is extremely important**
- **Destination data helps identify where people will go and where their final destinations may be. It's this information that drives the route choices used in the transportation modeling**
- **Behavioral analysis data can be used to develop evacuation participation rates to provide insight to scenarios that may be something less than the worst case**

Some Key Findings

- Serious under-concern about surge
- Evacuation intent over-stated
- Evacuation intent highest (and better predictor of actual behavior)
  - For major storms
  - For mandatory or ordered evacuations
  - For households with children
  - With recent real hurricane experience
- Often get “False Experience” effect
  - Earl/Irene/Sandy?

Shelter Analysis

Understanding Shelter Need

Key Sheltering Issues:

- Location/Identification
- Capacity
- Response Rates
- Coordination between Organizations
- Pet Friendly or Co-located?

Shelter Analysis Example

Understanding Shelter Capability in Delmarva

Table 5-1: *Public Shelter Demand / Capacity by County*

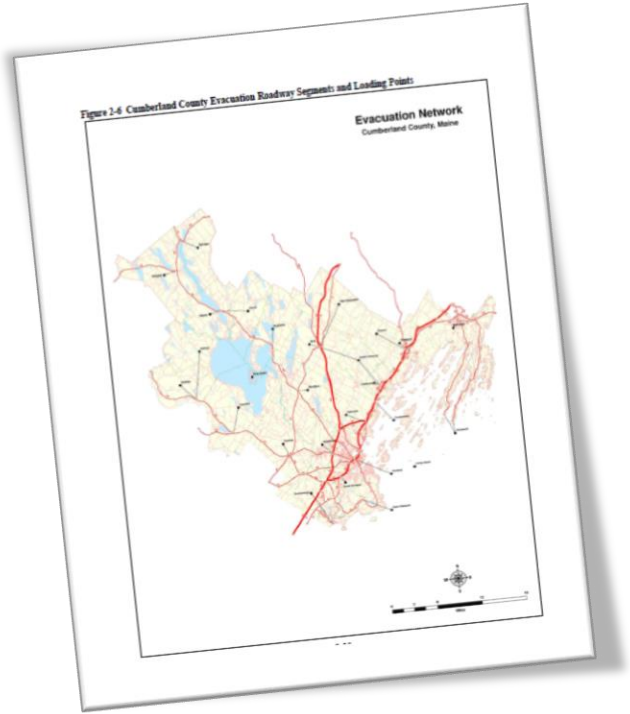
State	County	Hurricane Category	Public Shelter Demand (People) - LOW	Vehicles to Public Shelters - LOW	Public Shelter Demand (People) - HIGH	Vehicles to Public Shelters - HIGH	Public Shelter Capacity (People)
Delaware	Kent	Category 1	1,793	957	1,843	993	8,128
		Category 2	2,494	1,330	2,559	1,379	8,128
		Category 3	3,735	1,996	3,824	2,063	8,128
		Category 4	4,479	2,415	4,568	2,481	8,128
	New Castle	Category 1	1,775	846	1,885	919	17,322
		Category 2	2,340	1,114	2,493	1,215	17,322
		Category 3	4,443	2,064	4,662	2,209	17,322
		Category 4	7,359	3,372	7,578	3,517	17,322
	Sussex	Category 1	4,889	2,740	7,442	4,792	9,407
		Category 2	7,985	4,460	11,150	6,990	9,407
		Category 3	11,787	6,503	15,727	9,628	9,407
		Category 4	13,624	7,460	17,564	10,585	9,407
	Cecil	Category 1	743	379	959	548	11,304
		Category 2	1,075	546	1,373	779	11,304

* Virginia capacity shown at 10 per

Transportation Analysis

The Transportation Analysis utilizes data produced by the other analysis to determine traffic congestion and clearance times

- Inputs
  - Demographics
  - Behavioral Assumptions
  - Evacuation Routes
  - Levels of Service (Roadway Capacities)
  - Travel Destinations
  - Evacuation Scenarios



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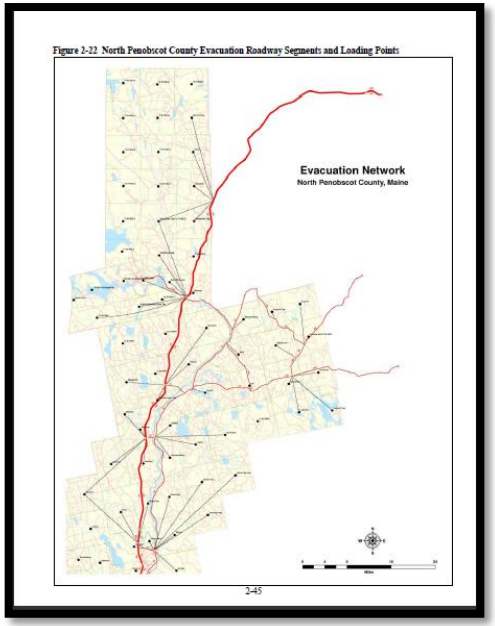
Transportation Analysis

Helping coastal decision makers understand traffic congestion potential based upon evacuation decisions

Products of the Transportation Analysis

- Traffic Patterns (bottle necks)
  - Evacuating Vehicles
- Clearance Time tables
  - Variables of:
    - Response
    - Population
    - Evacuation Scenarios (one way, Multi state)
    - Storm Category



Evacuation Clearance Times

"*Response Curves*" used in modeling evacuation behavior

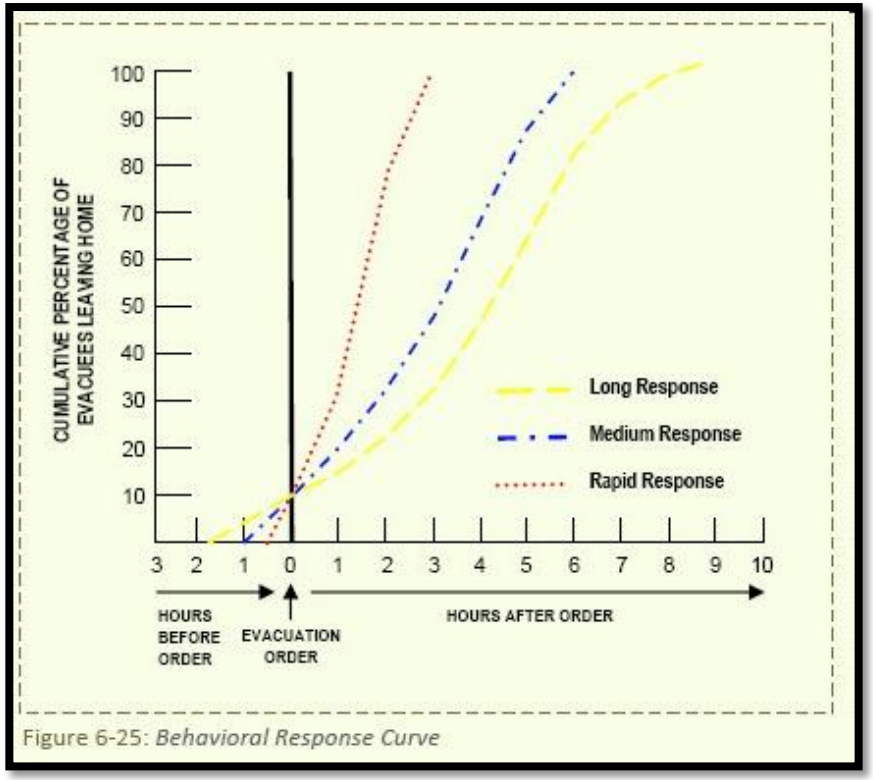


Figure 6-25: *Behavioral Response Curve*

Transportation Analysis

A sample of Transportation Output products:

Table 6-8: *Evacuating People and Vehicles by County (High Tourist Occupancy)*

State	County	Hurricane Category	Total Evacuating People	Vehicles to Local Destinations	Vehicles to Out of County	Total Evacuating Vehicles
Maryland (Lower)	Wicomico	Category 1	5,027	2,039	689	2,728
		Category 2	7,199	2,674	1,206	3,880
		Category 3	10,836	3,500	2,301	5,801
		Category 4	14,020	3,861	3,522	7,383
	Worcester	Category 1	78,848	4,184	30,534	34,718
		Category 2	97,637	7,918	38,147	46,065
		Category 3	115,443	8,708	45,928	54,636
		Category 4	118,667	7,977	48,285	56,262
Virginia	Accomack	Category 1	14,998	3,028	3,649	6,677
		Category 2	21,271	4,173	4,898	9,071
		Category 3	25,191	4,413	6,279	10,692
		Category 4	27,621	4,167	7,497	11,664
	Northampton	Category 1	2,400	575	408	983
		Category 2	3,672	799	659	1,458

Evacuation Clearance Times

Definition

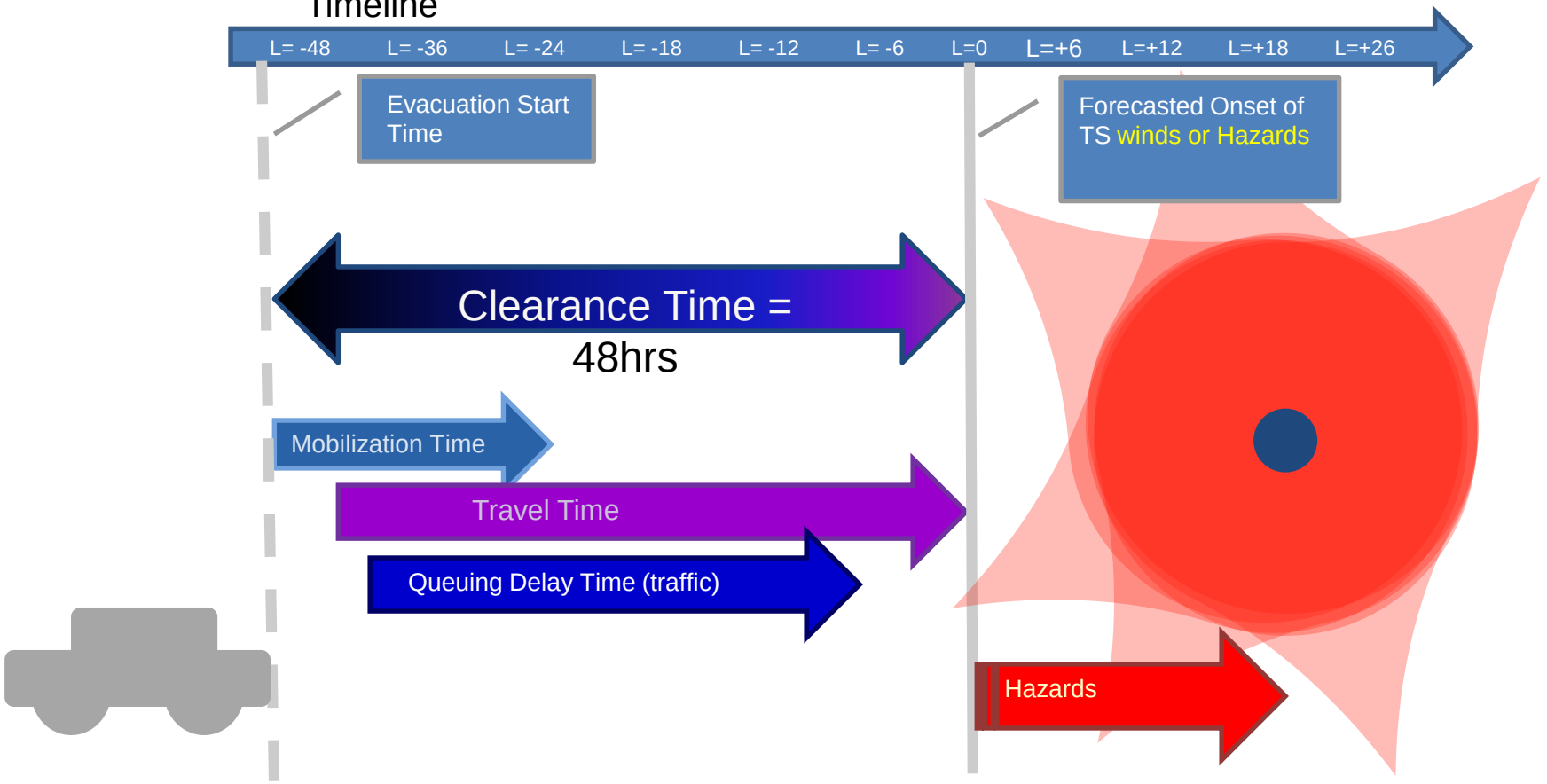
Begins when the first evacuating vehicle enters the road network, ends when the last vehicle reaches an assumed point of safety

-Includes travel time and waiting in traffic congestion (does not relate to any one particular vehicle)

-Driven by bottlenecks

Evacuation Clearance Times

Timeline



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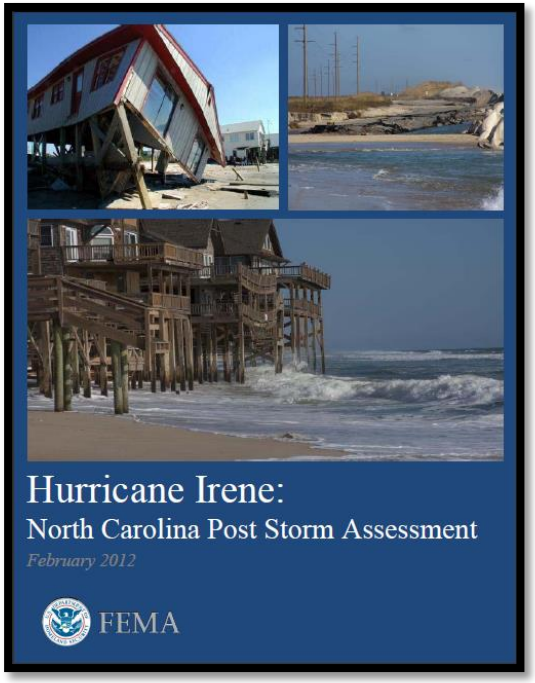
Post Storm Assessment

To understand how HES products are utilized, the following are conducted:



- ✓ High Water Mark Survey
- ✓ High Wind Survey
- ✓ Local/State EMA Meetings
- ✓ Behavioral Analysis
- ✓ Transportation Analysis
- ✓ Findings Report
- ✓ Other reports as needed

Summary: Hurricane Evacuation Studies

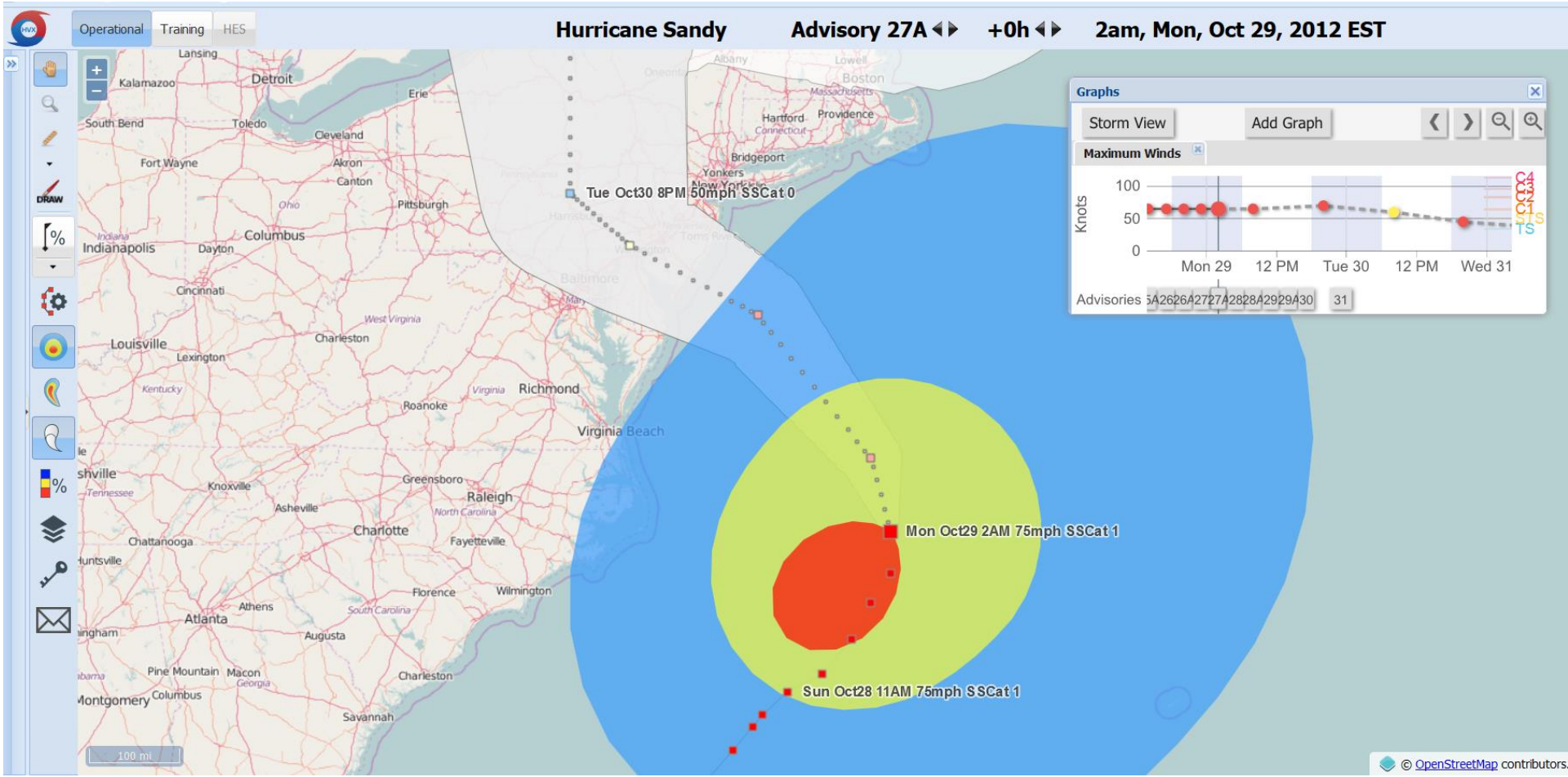
HES contain valuable information for planning and operational purposes:

- Technical Data Report
  - **Hazards Analysis**: Wind, Surge, Flooding
  - **Vulnerability Analysis**: *Who* is at risk? *What* is at risk?
  - **Behavioral Analysis**: What do residents do? Where do they go?
  - **Shelter Analysis**: Capacity, Anticipated Use
  - **Transportation Analysis**: Roadway network
- Surge Atlases & Evacuation Zones
- Evacuation Clearance Times
- Decision Support Tools

New Jersey Hurricane Evacuation Study

- **Hazard Analysis**
- **Vulnerability Analysis**
  - Estimated 80-85% complete.
  - Need to confirm and finalize Evacuation Zones for comment.
- **Behavioral Analysis**
  - Surveys completed. Full report documents will be developed.
- **Shelter Analysis**
  - Need to confirm and finalize data sources for shelter inventory with local jurisdictions.
  - Shelter vulnerability and demand will follow.
- **Transportation Analysis**
  - In the process of developing Scope of Work for Transportation Analysis.


THE NATIONAL HURRICANE PROGRAM'S DECISION SUPPORT TOOL
FOR GOVERNMENT EMERGENCY MANAGERS
HURREVAC
2016 Season Version
FEMA
US Army Corps
of Engineers
NOAA/NWS


Operational
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HES
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Graphs
Storm View
Add Graph
Maximum Winds
Knots
100
50
0
Mon 29
12 PM
Tue 30
12 PM
Wed 31
Advisories
31
Tue Oct30 8PM 50mph SSCat 0
Mon Oct29 2AM 75mph SSCat 1
Sun Oct28 11AM 75mph SSCat 1
Detroit
Cleveland
Pittsburgh
Columbus
Indianapolis
Cincinnati
Louisville
Charleston
Richmond
Virginia Beach
Raleigh
Charlotte
Atlanta
Augusta
Savannah
Wilmington
Boston
Providence
Hartford
Bridgeport
Albany
Baltimore
100 mi
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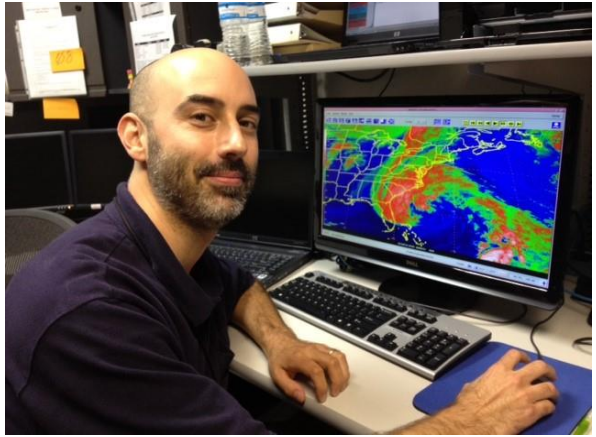
Hurricane Liaison Team (HLT)



Any Questions?

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