Hurricane Hazards:
Local Threat Assessments

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2018 WMO RA-IV WORKSHOP ON HURRICANE FORECASTING AND WARNING

Outline

- Risk Tolerance & the Safety Margin Forecast
  - How it relates to probabilistic information
  - Customer thresholds; risk management for communities

- The Local Forecast & Hazard Threat Assessments
  - Deterministic and probabilistic information; threat assessments
    - Wind, Storm Surge, and Flooding Rain Hazards
    - Role of risk tolerance and safety margin forecast
  - *Examples:* Hurricane Threats & Potential Impacts Graphics (HTI), storm surge watch/warning graphic, inundation graphic, decision assistance tools, etc.

Threat *vs.* Risk

- **Threat = Probability x Consequence**
  - As used in this presentation, refers to assessing the likelihood that something harmful may occur
    - such as hurricane wind speeds at a given community

- **Risk = Probability × Consequence × Vulnerability**
  - When the threat of a hazard is considered in terms of potential impacts it might inflict in context of a given community's vulnerability

Community Decision-Makers

- Hurricane Emergency Plans for Communities
  - Risk & Vulnerability Assessments
    - Basis for emergency action plans
  - Intersect hazards with societies; intersecting with a community to consider potential impacts
    - Historical record, climatology, frequency, and event modeling
  - Provide situational context
    - Hot-washing past events, scenario-based exercises, etc.

Community Decision-Makers

- Managing Hurricane Emergencies; Managing Risk
  - Lives & livelihoods at risk
    - Population and associated demographics
  - Properties at risk
    - public and private
  - Critical infrastructure at risk
    - roads and bridges, utilities, communications, medical, etc.
  - Valuable resources at risk
    - personnel, supplies, time, money, group assets, etc.

Community Decision-Makers

- Risk Tolerance
  - Within a hurricane emergency plan (pre-season)
    1. *"How much risk to the community is acceptable?"*
    2. *"What are the corresponding trigger thresholds/points, and resulting triggered actions?"*
  - As enacted during an actual hurricane emergency
    1. *"What is the latest forecast, and how accurate is it?"*
    2. *"What is a reasonable margin of safety?"*

Decision Support Services

Emergence of Probability Guidance

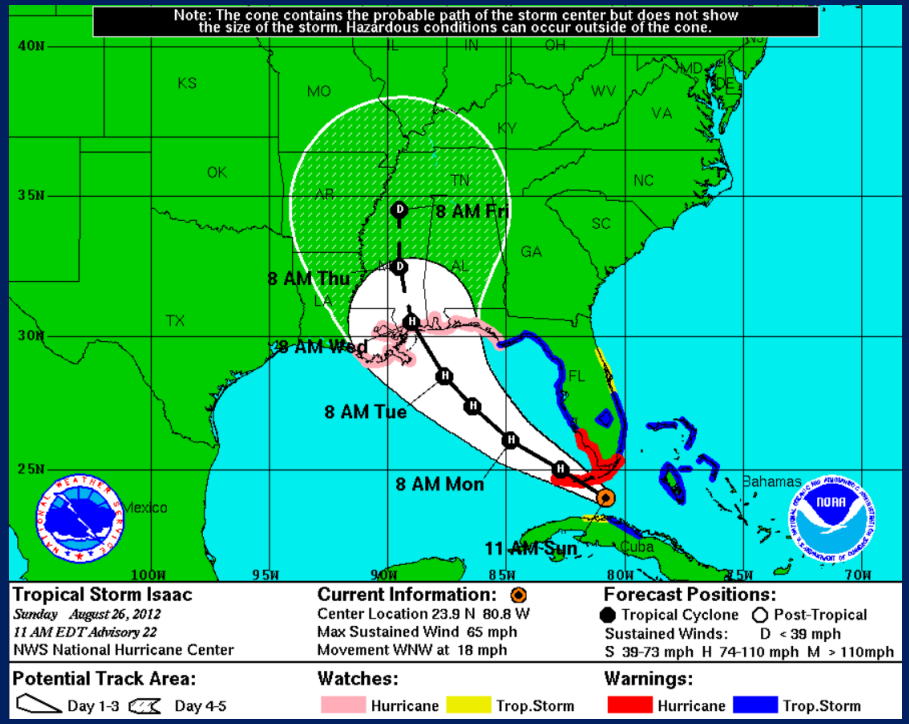
- Using Hazard Probabilities for Decision-Making:
  - *"How can community decision-makers best use it?"*
  - *"How can NWS forecasters best interpret and communicate it for decision support?"*

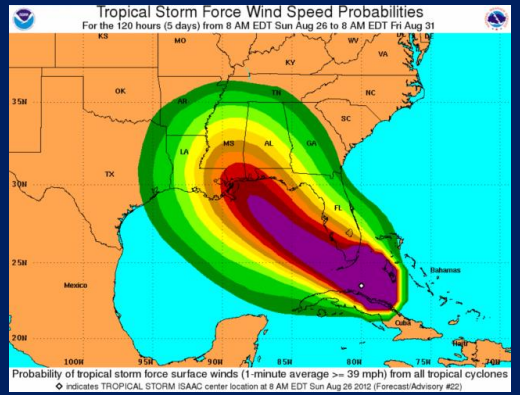
Scenario References:

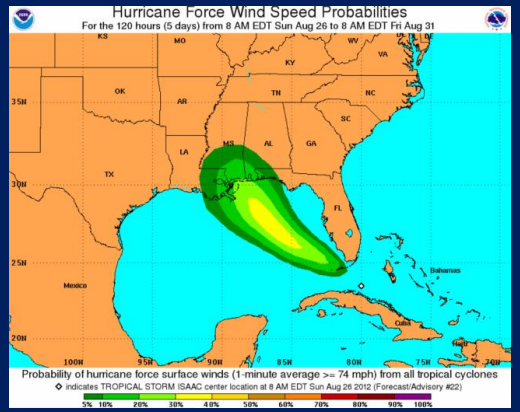
- Most Likely
- Reasonable Worst Case
- Reasonable Best Case

from % exceedance probabilities

***SETUP**: Relative to the spectrum of plausible outcomes, what is a community's wind risk compared to its stated risk tolerance as baselined within its hurricane emergency plan? To what extent should the plan be implemented for the event at hand?*







For example … Wind Hazard

Risk Tolerance: Spectrum of Plausible Outcomes (TC Wind)

(in event context; for a given community)

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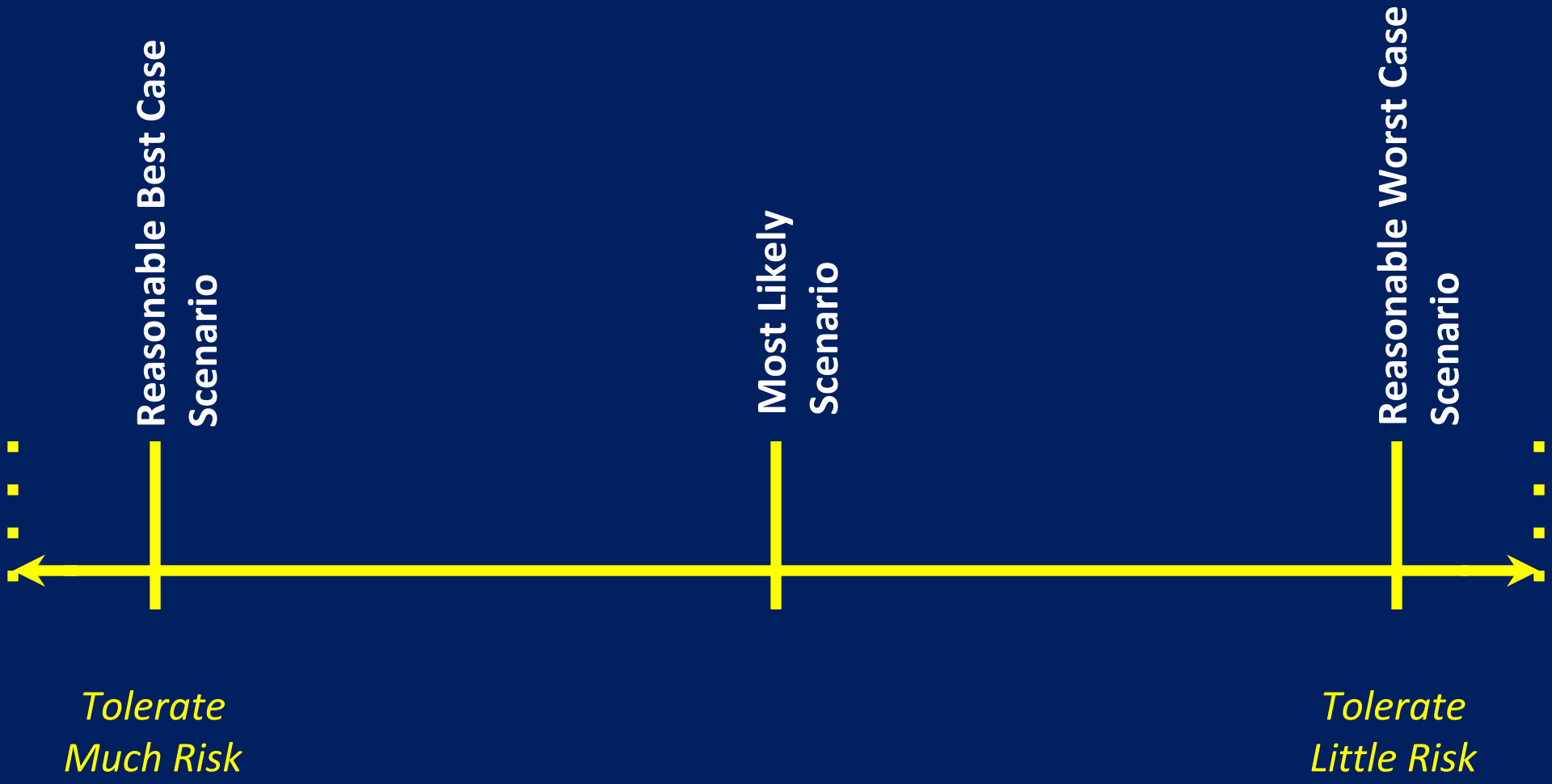

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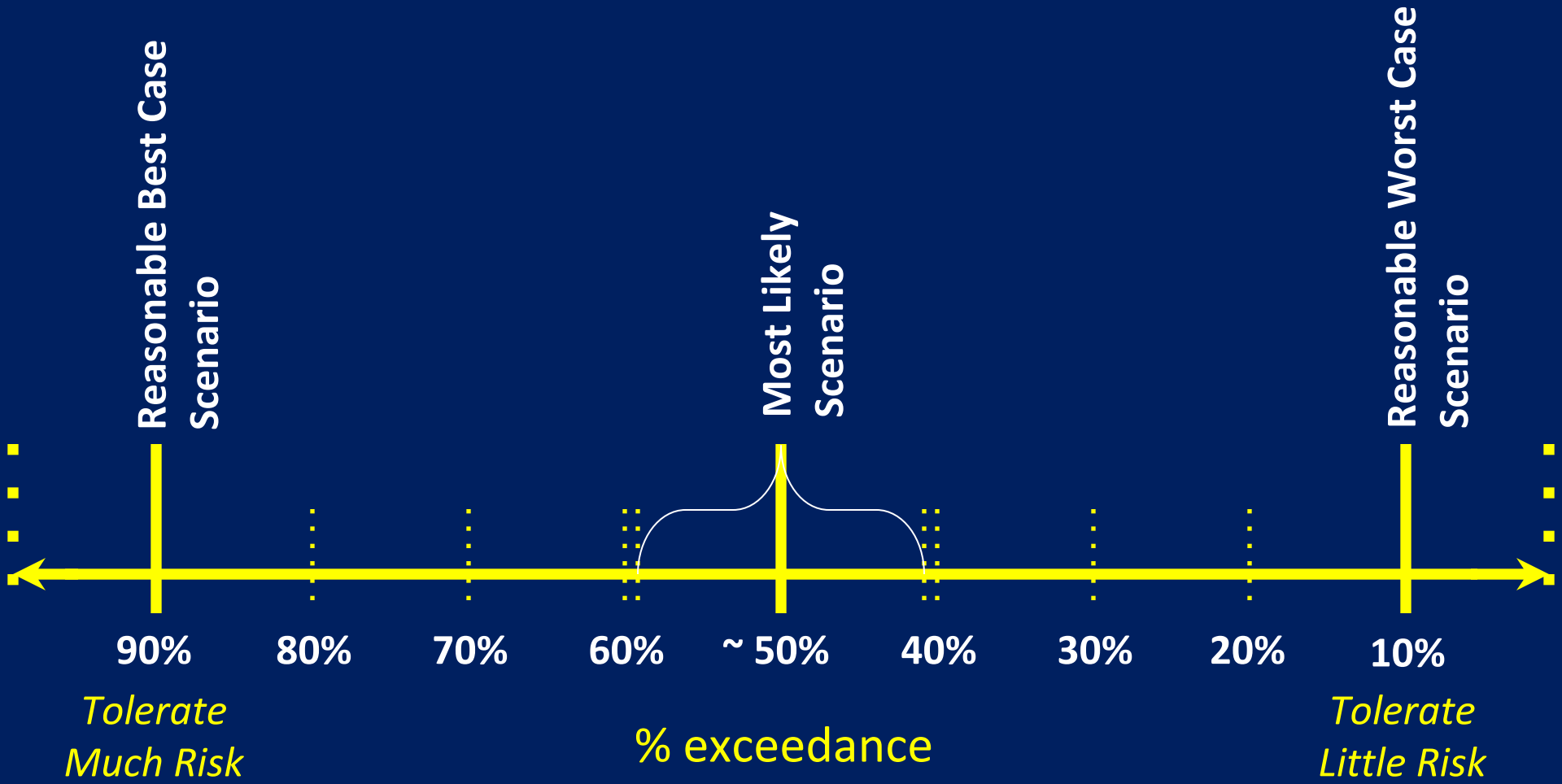

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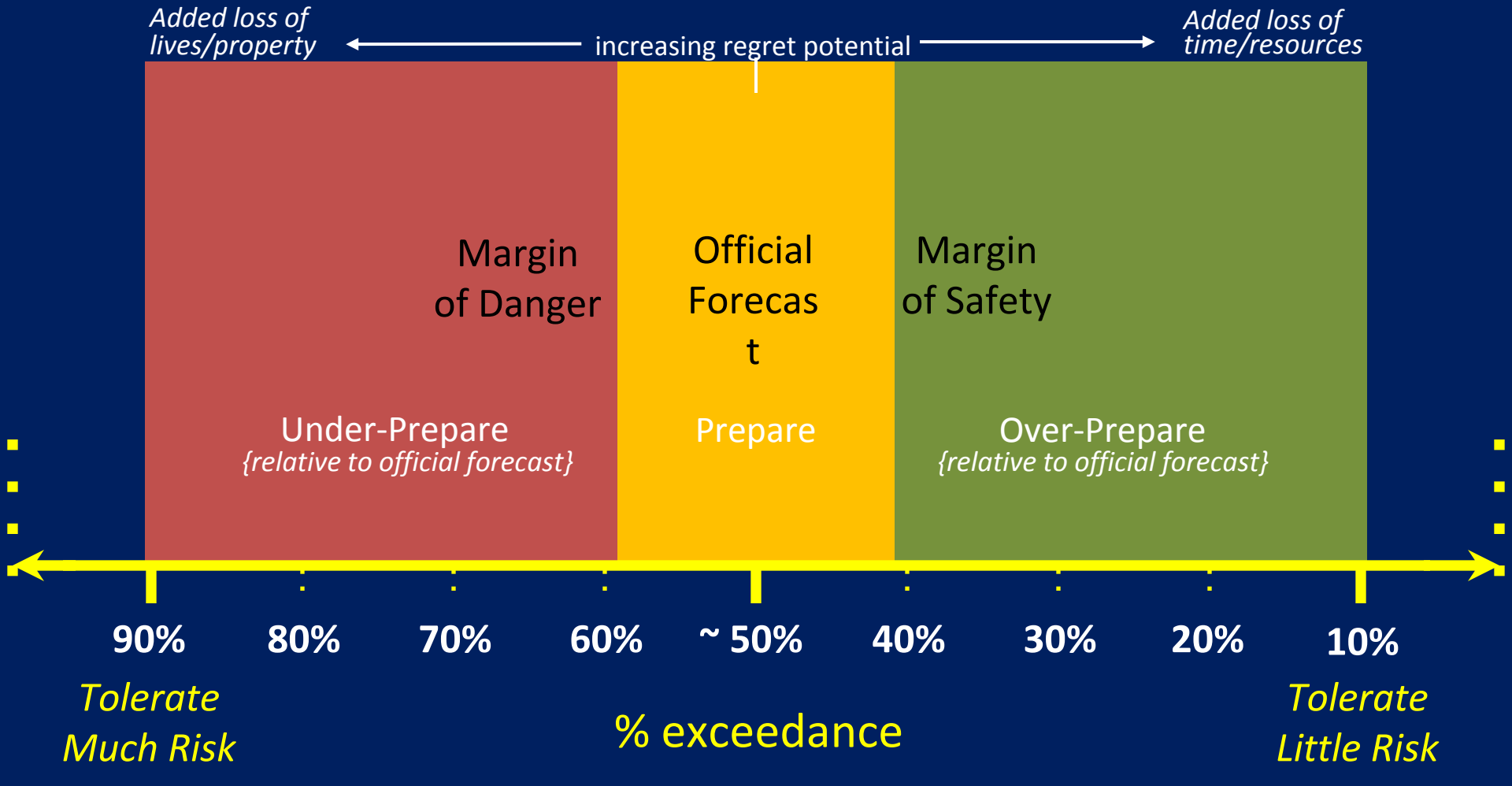

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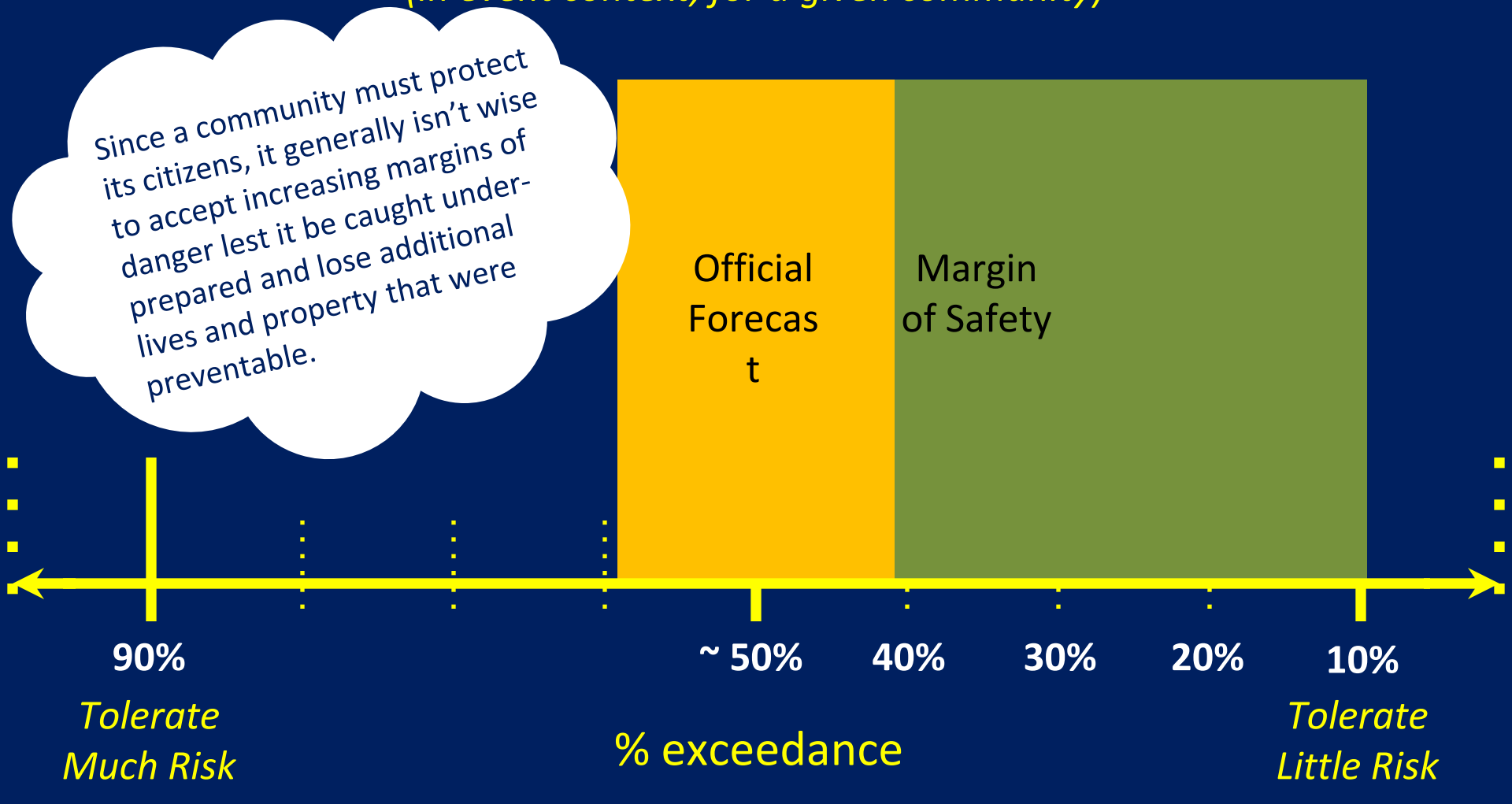

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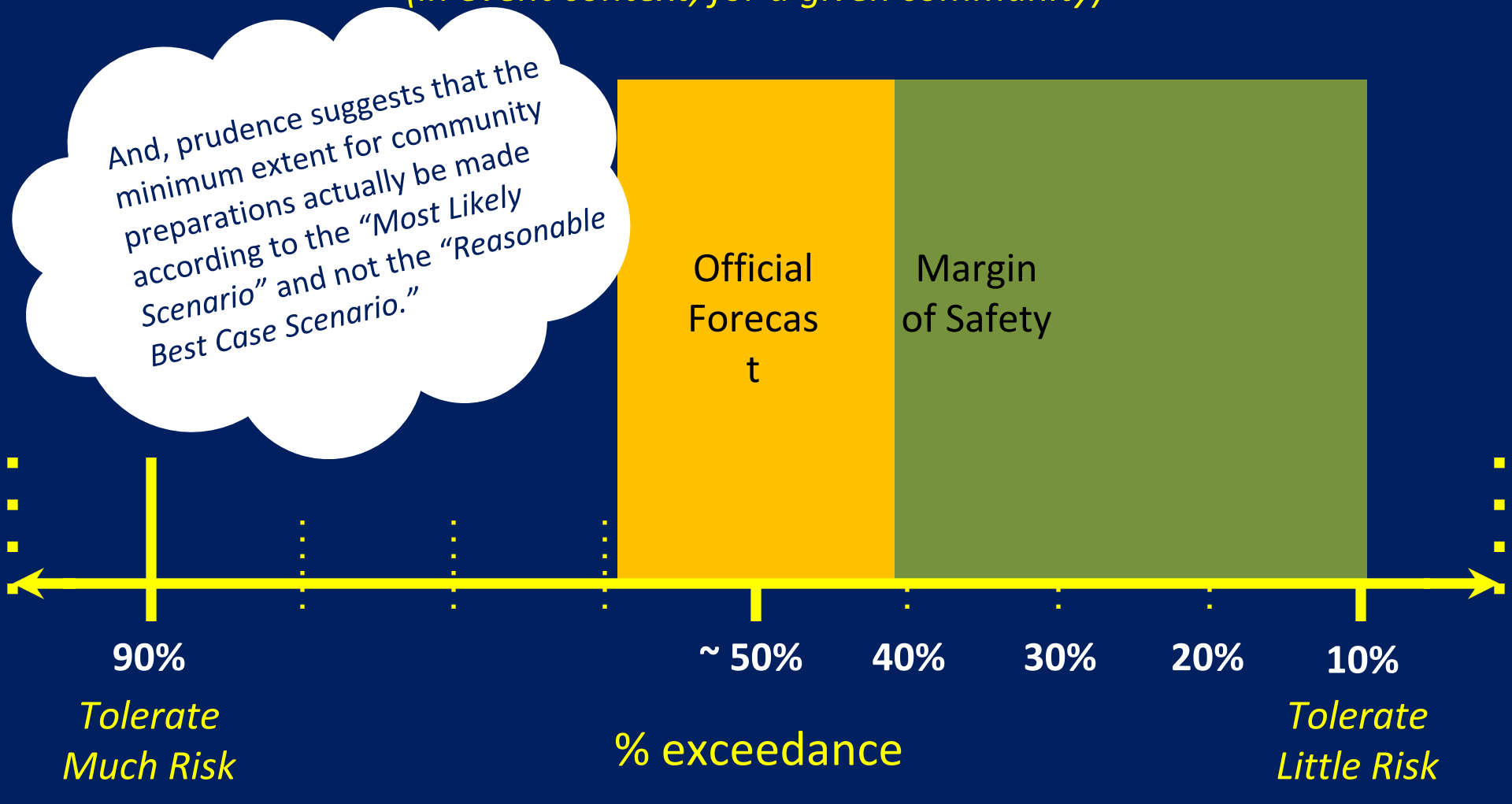
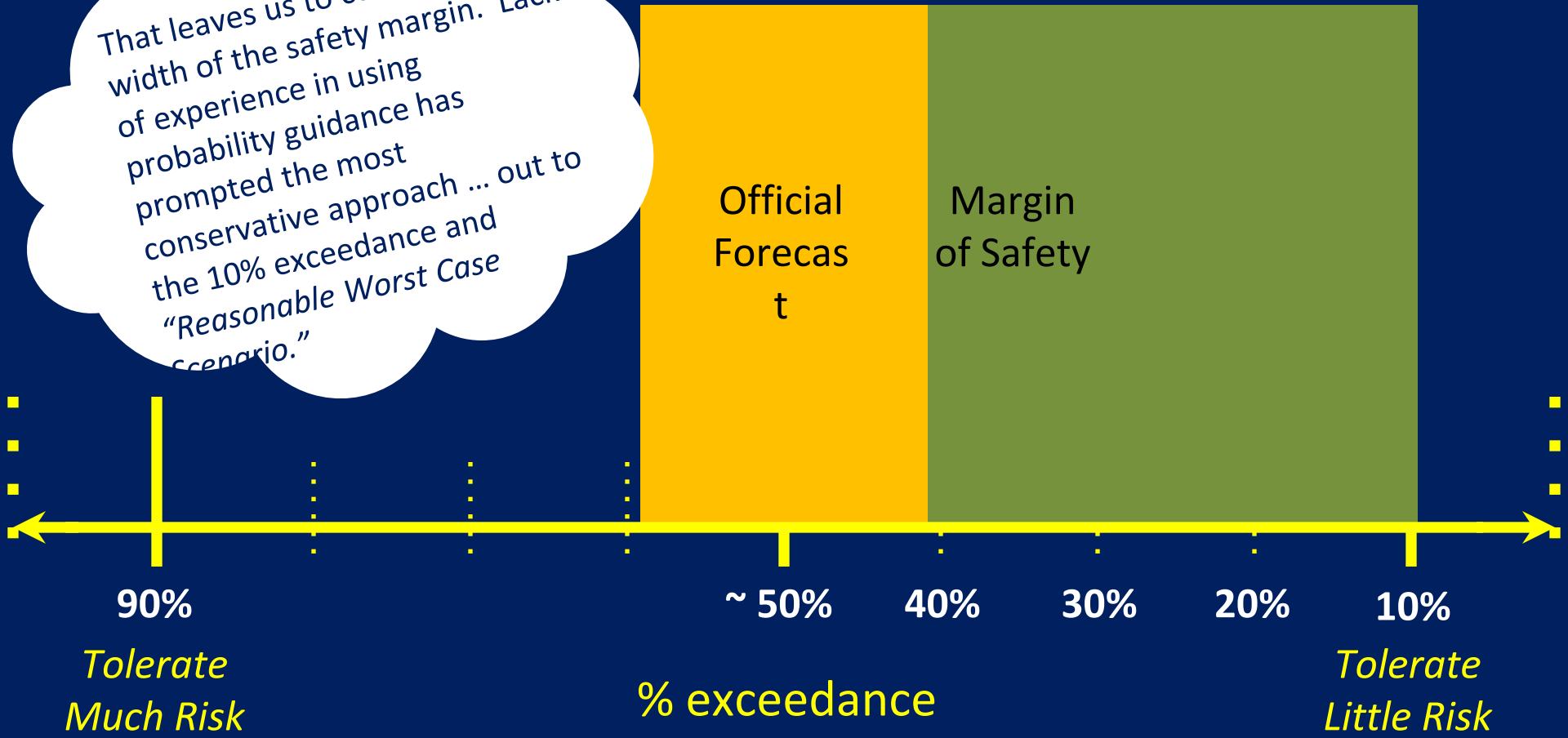


Risk Tolerance: Spectrum of Plausible Outcomes (TC Wind)

(in event context; for a given community)

That leaves us to consider the width of the safety margin. Lack of experience in using probability guidance has prompted the most conservative approach … out to the 10% exceedance and *"Reasonable Worst Case scenario."*



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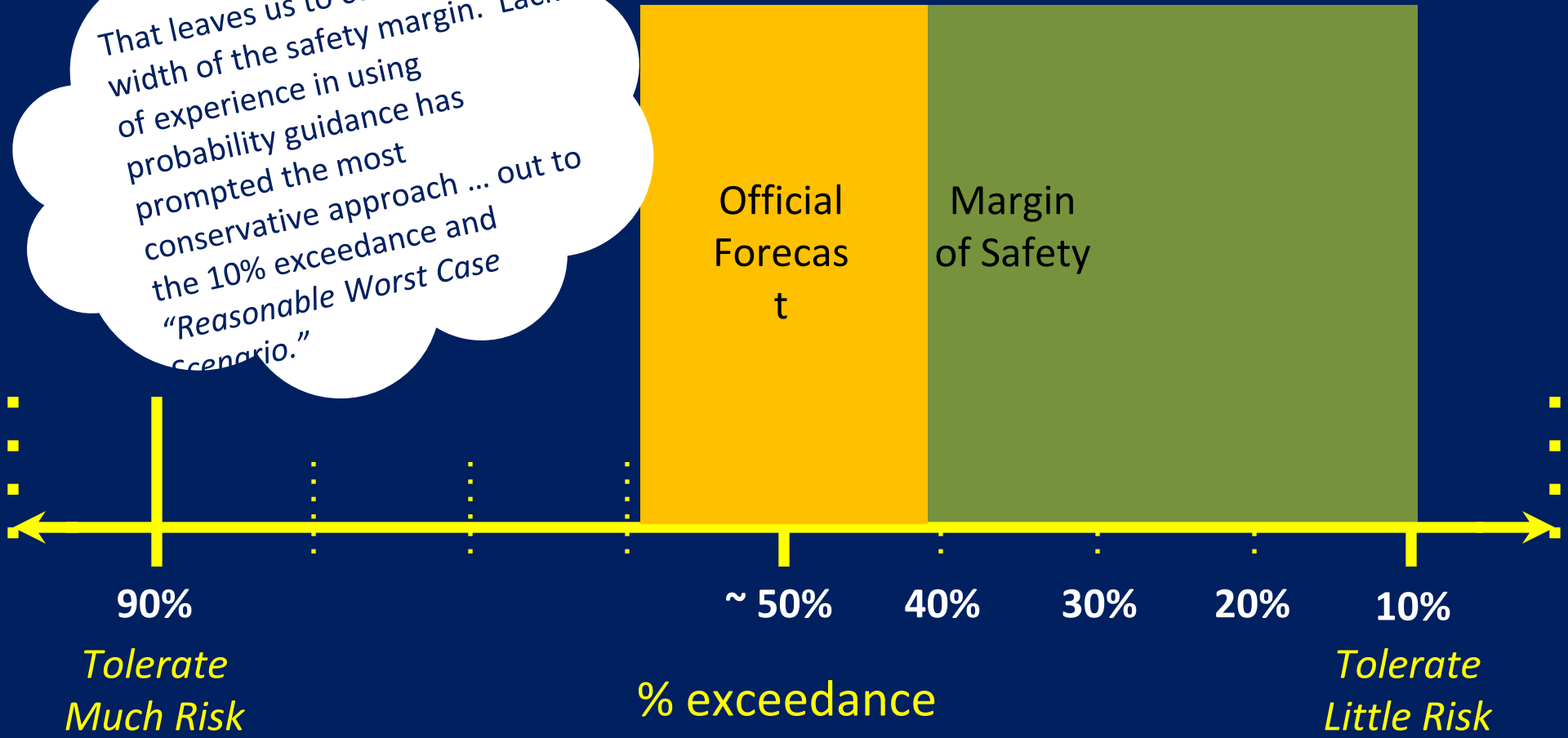

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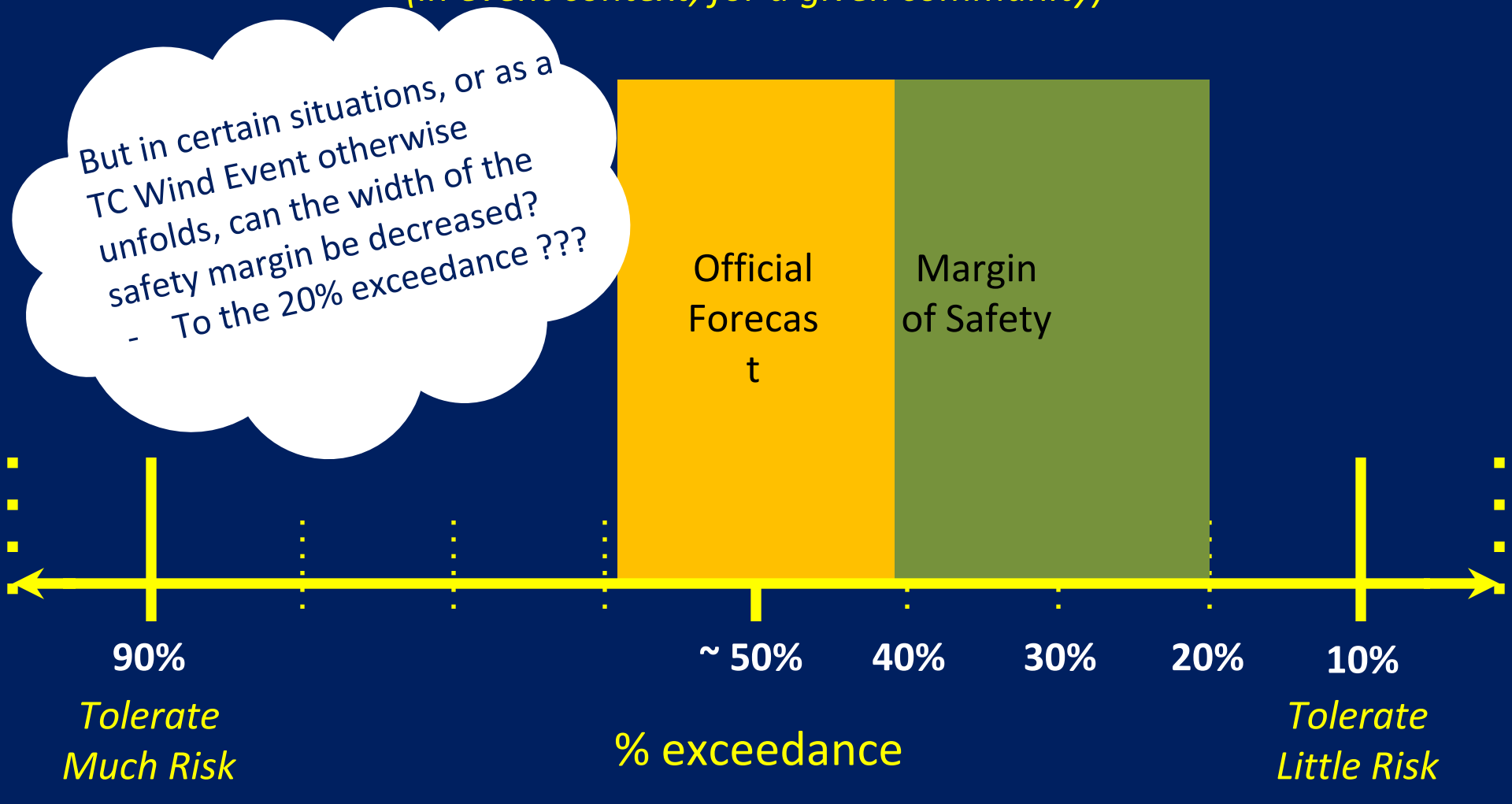

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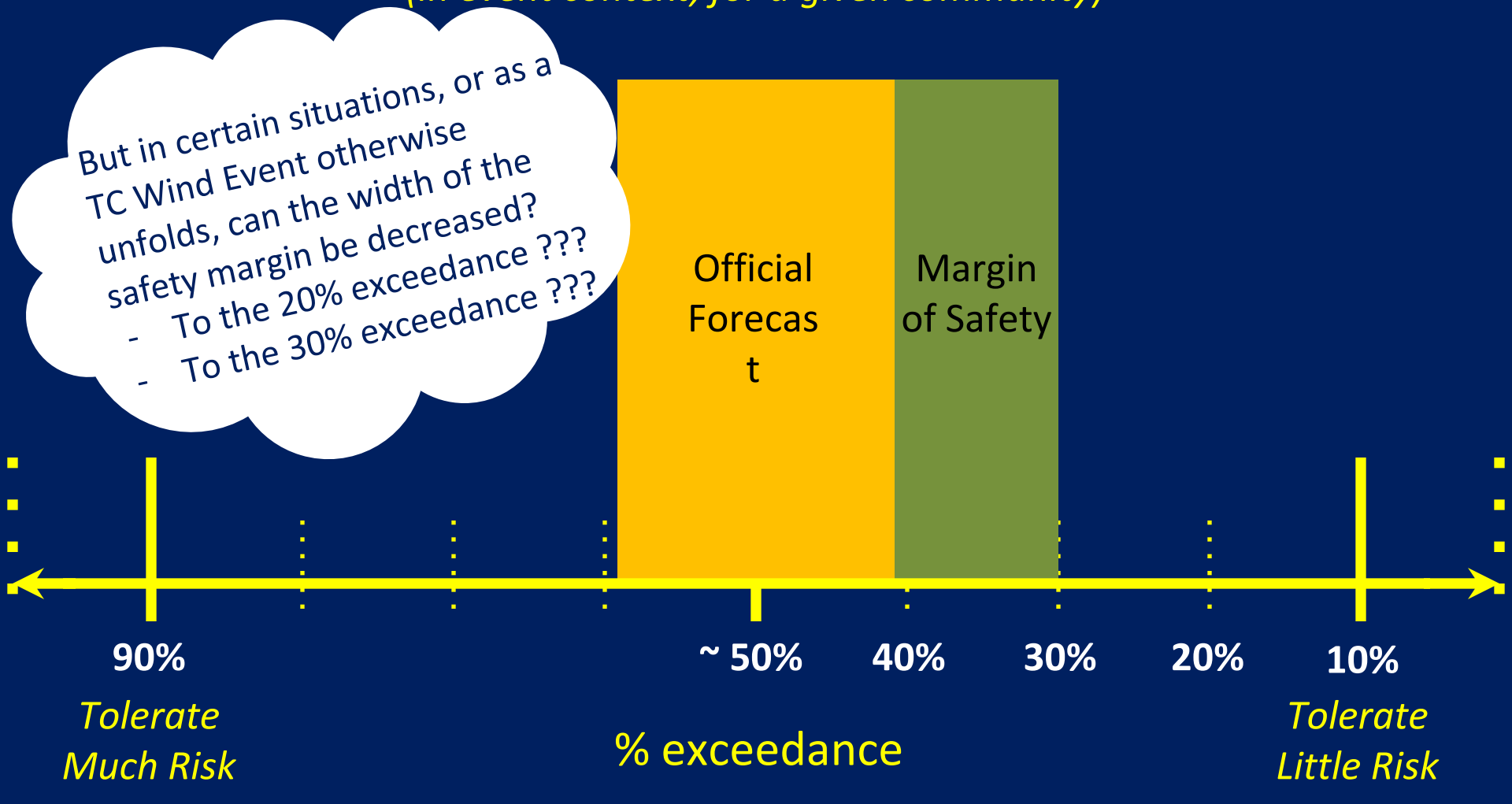


The Safety Margin Forecast

- **10% Exceedance Margin**
  - For preparation phase decisions, for any system within 48 hours of impact event
    - Especially for small/intense or ill-defined/-behaved cyclones
- **20% Exceedance Margin**
  - For refining final preparation phase decisions, for most well-behaved systems within 12 hours of impact event
- **30% Exceedance Margin**
  - For initial response/recovery phase decisions, for well-behaved systems within 6 hours of impact event

One Approach

Learning Check

1. **When looking at the probability of hurricane force winds being exceeded, the lower it is the _____**

A. wider the safety margin

B. narrower the safety margin

C. wider the danger margin

D. narrower the danger margin

One Approach

Now Let's Consider
Local Wind Threat Assessments

HURRICANE CENTER LOCATED NEAR 21.4N 87.1W AT 22/2100Z
POSITION ACCURATE WITHIN 15 NM

PRESENT MOVEMENT TOWARD THE NORTH OR 360 DEGREES AT 2 KT

ESTIMATED MINIMUM CENTRAL PRESSURE 957 MB
EYE DIAMETER 75 NM
MAX SUSTAINED WINDS 85 KT WITH GUSTS TO 105 KT.
64 KT..... 75NE 75SE 50SW 75NW.
50 KT.....120NE 100SE 75SW 100NW.
34 KT.....175NE 175SE 120SW 150NW.
12 FT SEAS..375NE 300SE 100SW 300NW.
WINDS AND SEAS VARY GREATLY IN EACH QUADRANT. RADII IN NAUTICAL
MILES ARE THE LARGEST RADII EXPECTED ANYWHERE IN THAT QUADRANT.

REPEAT...CENTER LOCATED NEAR 21.4N 87.1W AT 22/2100Z
AT 22/1800Z CENTER WAS LOCATED NEAR 21.2N 87.1W

FORECAST VALID 23/0600Z 21.9N 86.8W
MAX WIND 95 KT...GUSTS 115 KT.
64 KT... 75NE 75SE 50SW 75NW.
50 KT...120NE 100SE 75SW 100NW.
34 KT...175NE 175SE 120SW 150NW.

FORECAST VALID 23/1800Z 23.1N 85.7W
MAX WIND 100 KT...GUSTS 120 KT.
64 KT... 75NE 75SE 50SW 75NW.
50 KT...120NE 100SE 75SW 100NW.
34 KT...200NE 200SE 125SW 200NW.

FORECAST VALID 24/0600Z 24.9N 83.5W
MAX WIND 95 KT...GUSTS 115 KT.
64 KT... 75NE 75SE 40SW 50NW.
50 KT...125NE 125SE 60SW 75NW.
34 KT...200NE 200SE 125SW 200NW.

FORECAST VALID 24/1800Z 27.8N 79.6W
MAX WIND 80 KT...GUSTS 100 KT.
50 KT...125NE 125SE 60SW 75NW.
34 KT...200NE 225SE 125SW 150NW.

FORECAST VALID 25/1800Z 38.0N 69.0W...EXTRATROPICAL
MAX WIND 55 KT...GUSTS 65 KT.
50 KT...125NE 125SE 60SW 75NW.
34 KT...200NE 225SE 125SW 150NW.

EXTENDED OUTLOOK. NOTE...ERRORS FOR TRACK HAVE AVERAGED NEAR 250 NM
ON DAY 4 AND 325 NM ON DAY 5...AND FOR INTENSITY NEAR 20 KT EACH DAY

OUTLOOK VALID 26/1800Z 45.0N 58.0W...EXTRATROPICAL
MAX WIND 55 KT...GUSTS 65 KT.

OUTLOOK VALID 27/1800Z 49.0N 44.0W...EXTRATROPICAL
MAX WIND 55 KT...GUSTS 65 KT.

NHC Official Forecast

Full Radii Only Out to 36 Hrs/48 Hrs Starting on 2018

50/34 kts Radii Only Out to 72 Hrs

No Radii Days 96/120 Hrs

NHC/WFO Wind Forecasts Limitations

- From NHC's forecast, local forecast and warning offices (WFOs) must make 2-D wind forecasts at the 1-hourly scale out to 48 hours, 3-hourly out to 72 hours, and 6-hourly out to 120 hours with this guidance on a 2.5 km grid.

- Intensity changes are depicted as a steady trend in space and time.

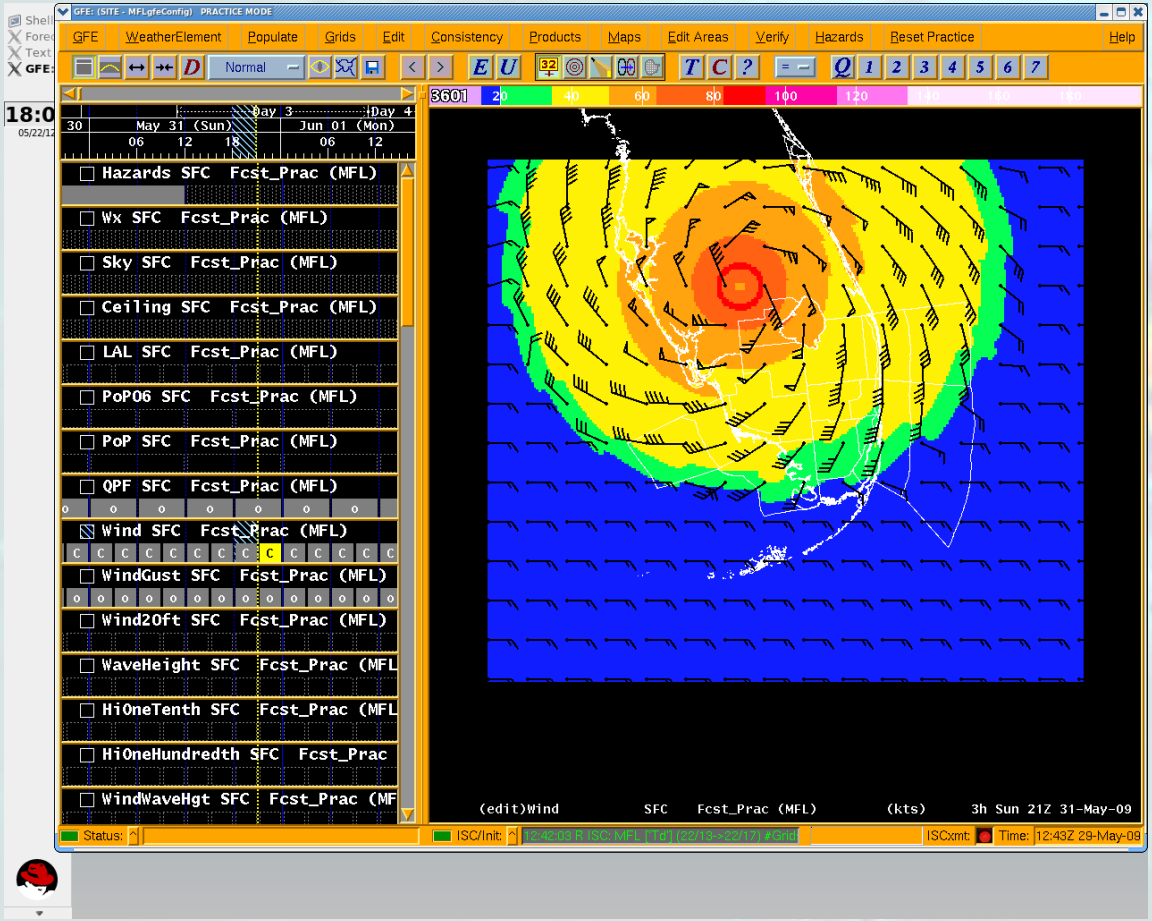
- Wind Speeds can be artificially reduced prior to landfall as they are interpolated between 12-hour forecast points. This artifact is made worse in days 4 and 5 due to 24-hour forecast points.

Downscaled & Refined

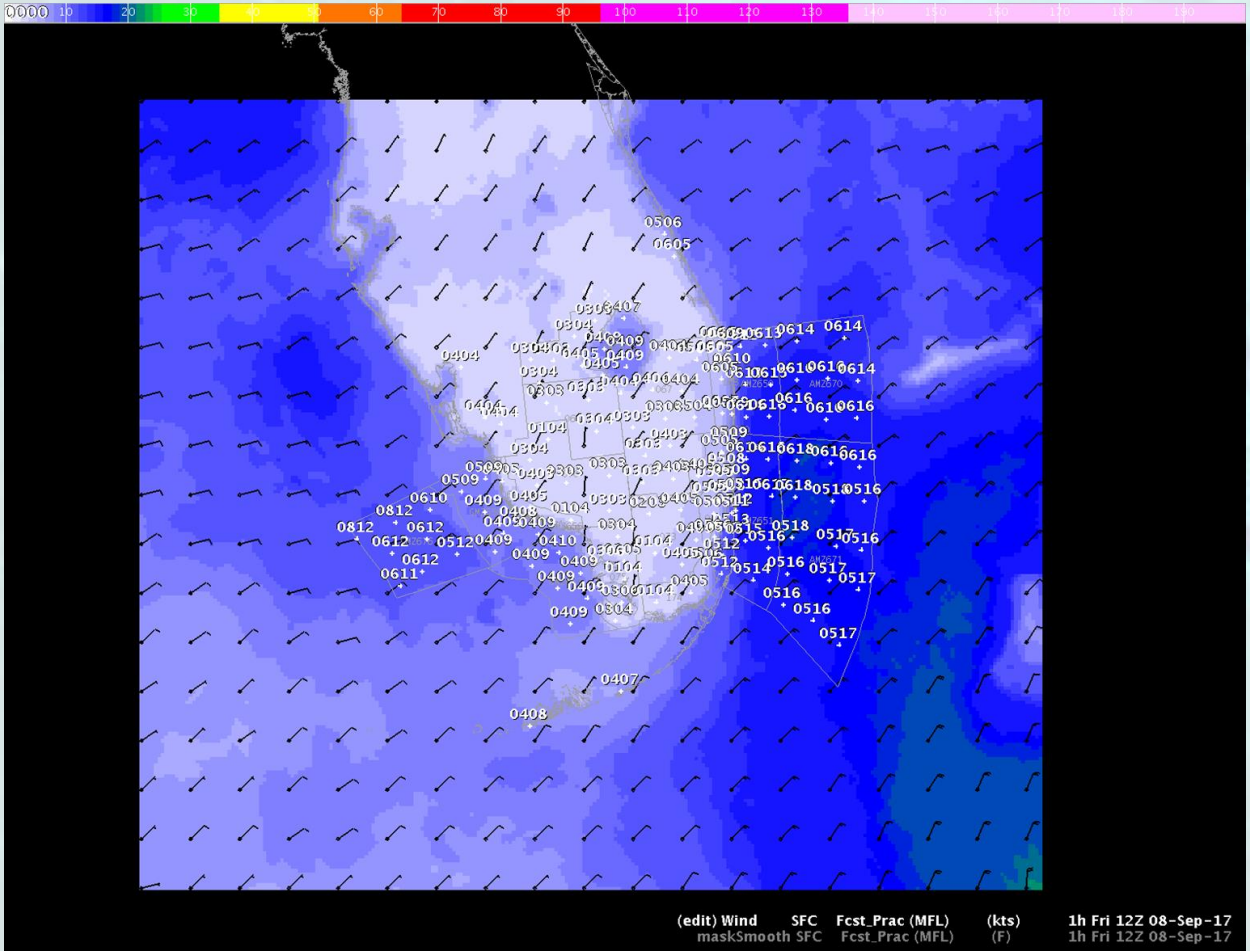
- When making local wind forecasts, WFOs downscale and refine NHC's forecast to create a 2D time dependant wind field based on:
  - Conceptual models; climatologies
  - Local knowledge; geophysical surroundings
  - Understanding of smaller scale processes
  - Diagnostic data for present conditions
  - Empirical algorithms

- **ASSUMPTIONS AND LIMITATIONS CAN RESULT IN GREATLY MAGNIFIED ERRORS when looking at location specific deterministic wind forecasts alone. This is in addition to NHC forecast errors.**
  - **HURRIVAC has the same limitations.**

WFO Wind Grid Forecasts



2D Wind Forecast
Irma - Adv 37



NATIONAL WEATHER SERVICE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Graphical Forecasts

Weather.gov - National Digital Forecast Database Graphical Forecasts

National Weather Service
National Headquarters

Below is a proposed replacement of the National Weather Service Graphical Forecast Page, a product of the National Digital Forecast Database. Comments are encouraged and can be done by taking our survey. Assistance with using this experimental product can be found by clicking here or on the Page Help Link below the map.

National Digital Forecast Database Experimental Display

National (CONUS) | Wind Speed (kts) | At Apr 11, 9 PM EDT

Fri Sat Sun Mon Tue Wed Thu

5 10 15 20 25 30 35 40 45

preview.weather.gov/graphical = digital.weather.gov

Mobile Gulfport Pensacola Tallahassee Jacksonville Metairie Pensacola Gainesville St Augustine Tampa Sarasota Cape Coral West Palm Beach Freeport Fort Lauderdale Miami Everglades National Park Nassau Havana

Google Map data ©2014 Google, INEGI Terms of Use

Wind Speed (kts)
Valid at: Sat, 12 Apr 2014 01 UTC (Fri, Apr 11 2014, 9 PM EDT)

Local Wind Forecast

What is the Point?

- We are able to deliver information with greater precision, BUT IT DOES NOT IMPLY ACCURACY. Service needs are outpacing the state of the science.
- In part, this is why NHC delivers their forecasts the way that they do. Increased demands to provide more detailed local level info are pushing the envelope.
- Message From a Decision Making Perspective:
  - **AVOID OVER-RELYING ON LATEST DETERMINISTIC SINGLE SOLUTION SCENARIO!**
    - It is bad enough to only rely on one scenario alone without having considered the issues raised so far.
  - Become knowledgeable about these issues and adopt a combined deterministic and probabilistic approach that allows for communicating the latest forecast along with a **reasonable** safety margin.

Learning Check

2. Used alone, two dimensional wind depictions in time derived from NHC's official forecast offer adequate means of depicting the threat of tropical storm and/or hurricane force winds.

A. True

B. False

One Approach

D-Day Weather Hazards

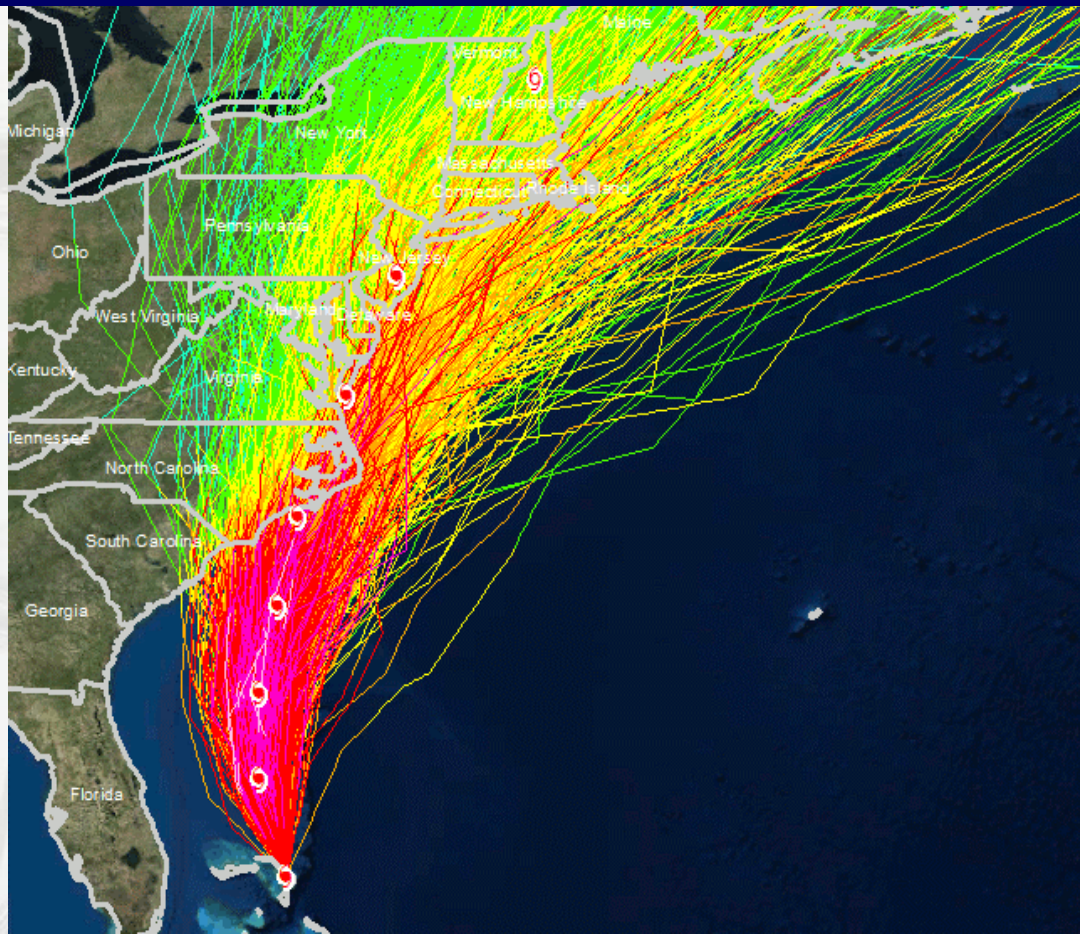
“Give me meteorological probabilities.”

Wind Speed Probabilities

How are they generated?

- **1,000 realistic alternative scenarios are created**
  - Official NHC forecast
  - Historical NHC track and intensity forecast errors
  - Climatology and persistence wind radii model
- **Weakening over land**
- ***Track model spread***

  Past NHC track forecast errors are correlated to the spread of track model guidance



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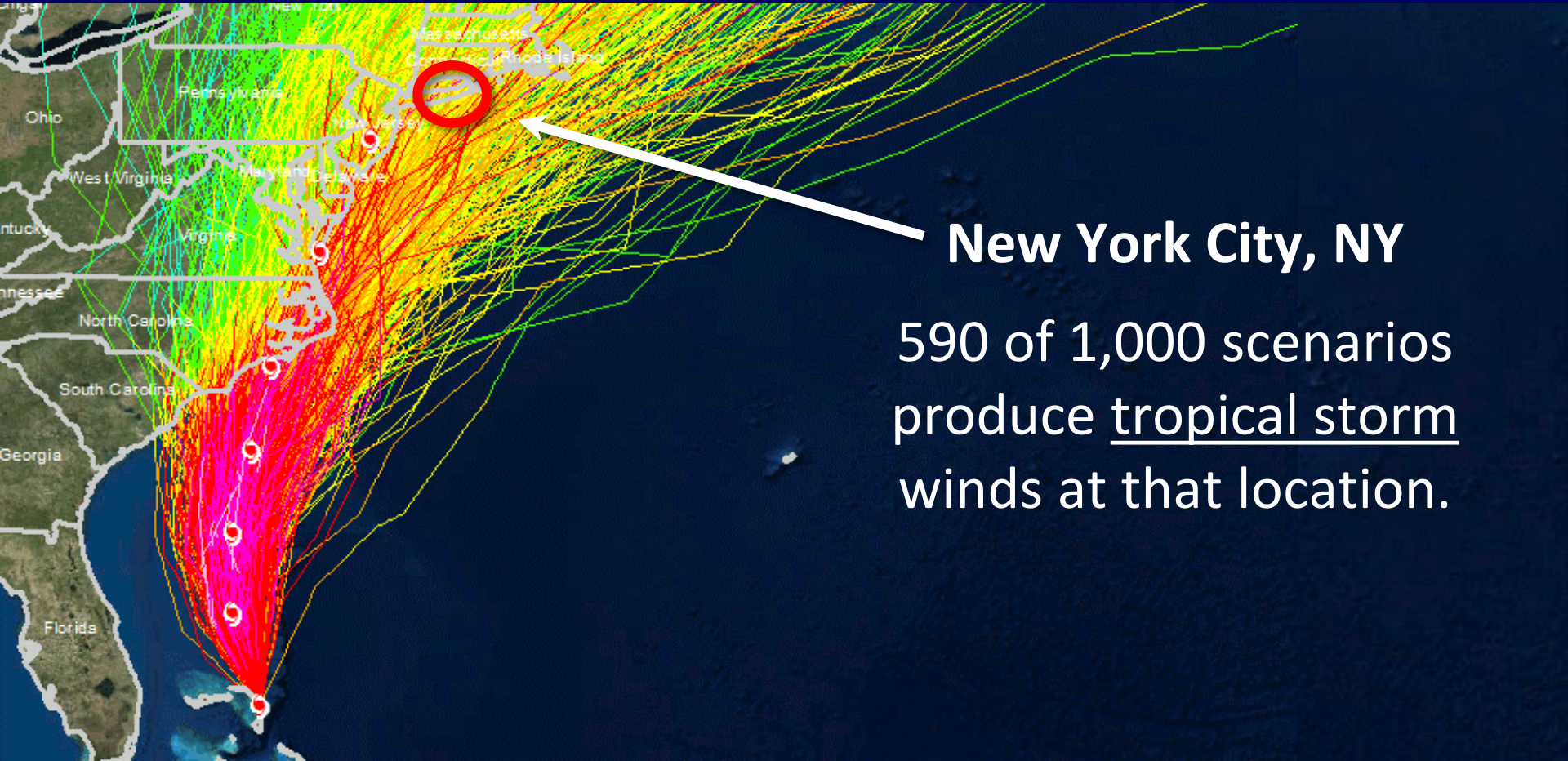
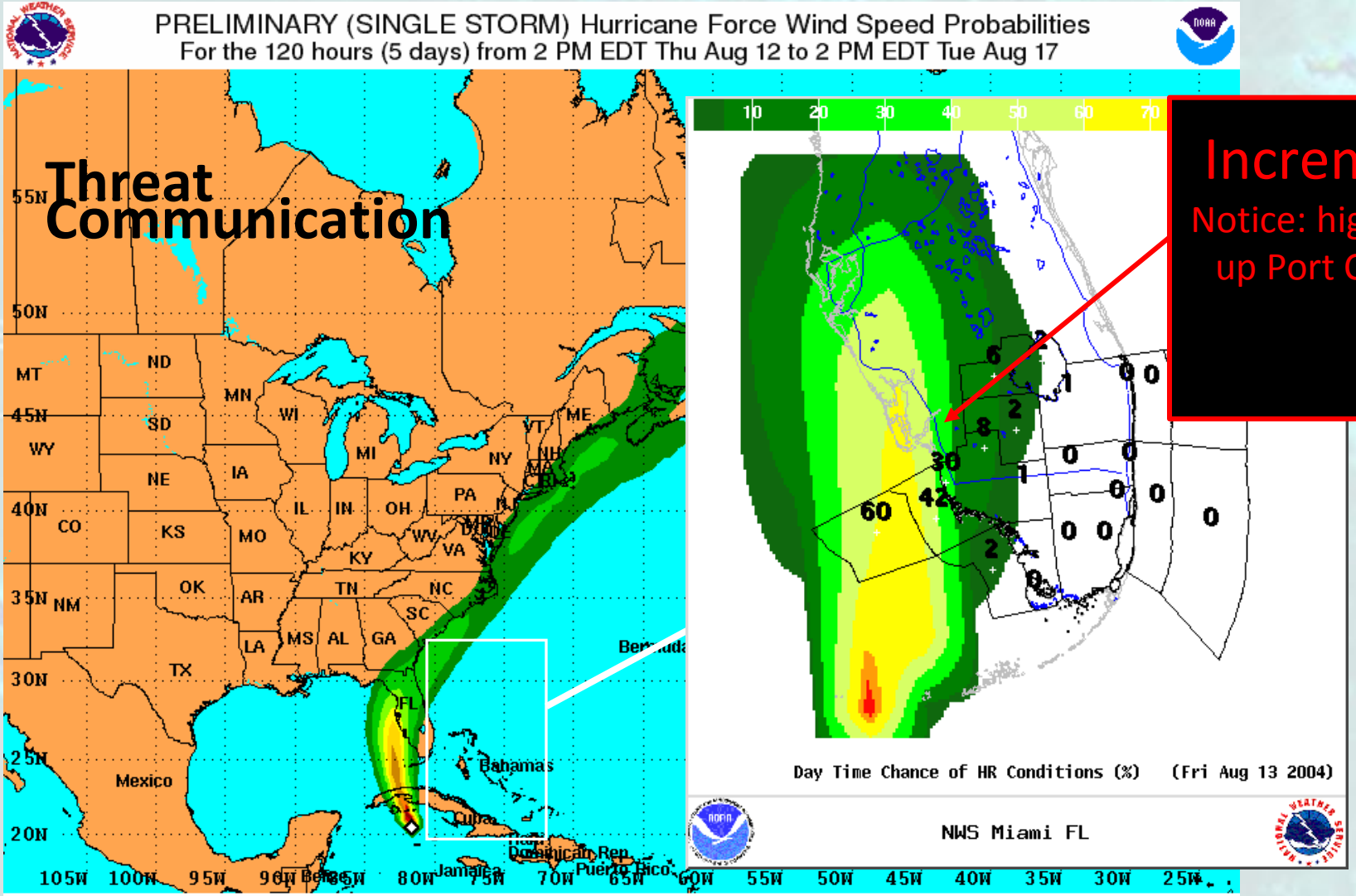
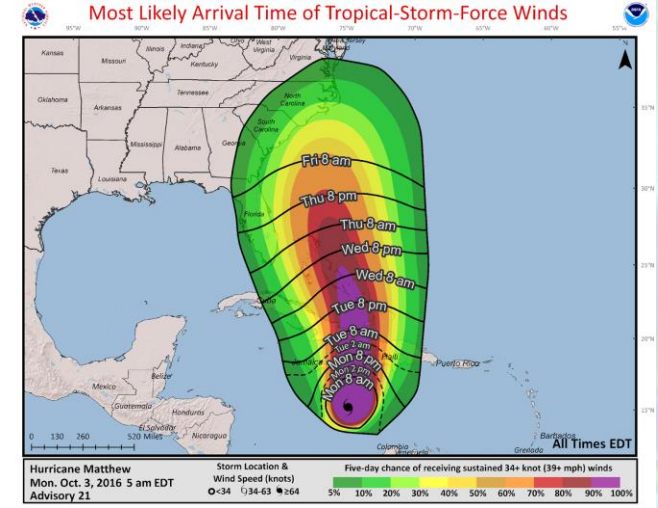


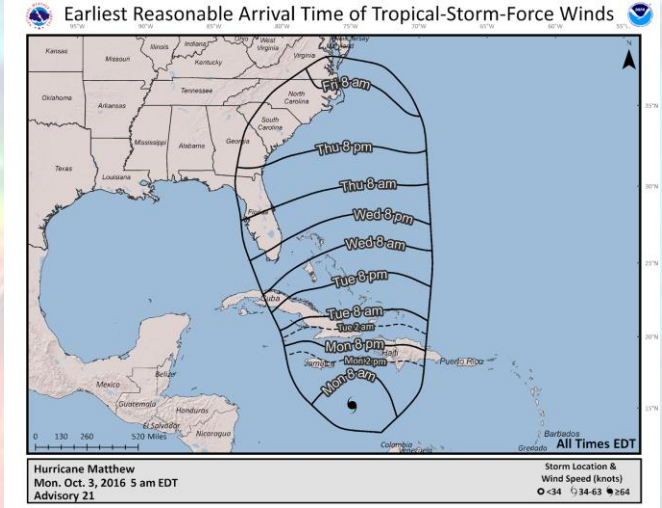
Application Examples

- Provide objective measures of uncertainty for:
  - Communicating Threat
  - Timing assessments with varying safety margins
  - Risk and threat assessments with varying safety margins - hurricane threat and impact graphics
  - For trend analysis of the threat from advisory to advisory for proper risk assessment


PRELIMINARY (SINGLE STORM) Hurricane Force Wind Speed Probabilities
For the 120 hours (5 days) from 2 PM EDT Thu Aug 12 to 2 PM EDT Tue Aug 17
Threat Communication
Incremental
Notice: highest right up Port Charlotte
10 20 30 40 50 60 70
Day Time Chance of HR Conditions (%) (Fri Aug 13 2004)
NWS Miami FL
Probabilities of sustained hurricane force surface winds (1-minute average of 74 mph or greater) from all active tropical cyclones
indicates HURRICANE CHARLEY center location at 2 PM EDT Thu Aug 12 2004 (Forecast/Advisory #14)
5% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

NHC Arrival of Tropical Storm Force Winds





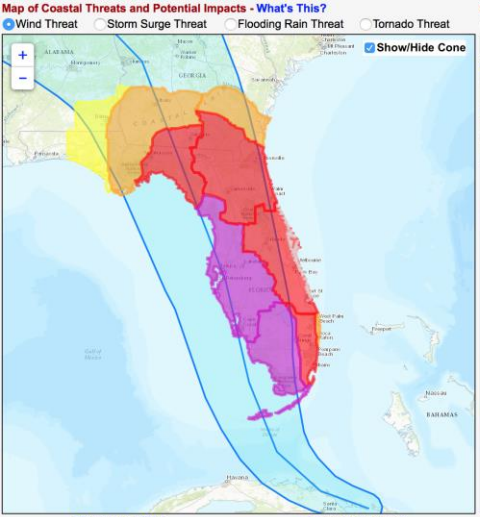
- **Arrival of TS-force winds is a critical planning/action threshold for communities.**
- ***"Most Likely"* arrival time - the time before or after which the onset of tropical storm force winds is equally likely. Often used during the warning period.**
- ***"Earliest Reasonable"* arrival time - time window that individuals can safely assume will be free from tropical storm force winds (no more than a 10% chance of onset). Often used during the watch period and earlier.**

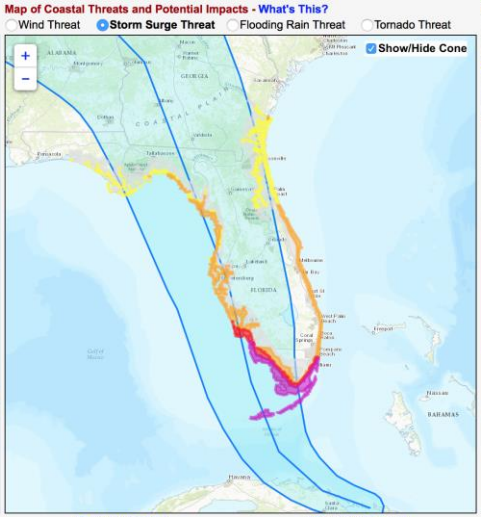
HTI

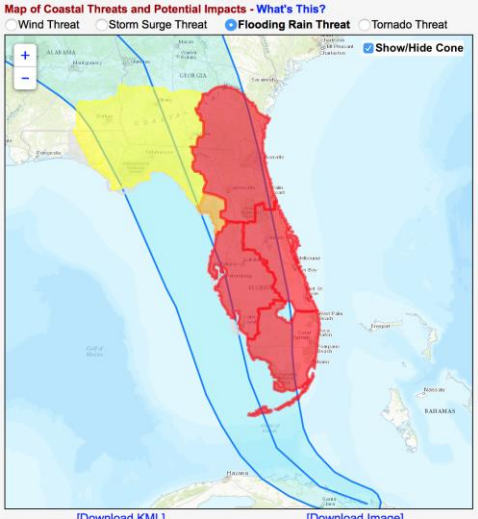
Hurricane Threat and Potential Impacts

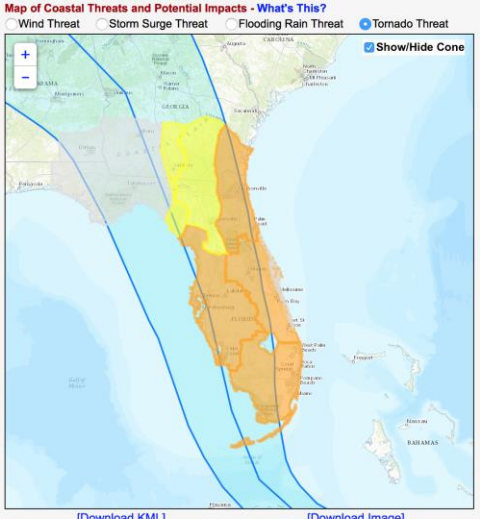
A Risk Communications Tool

(varying safety margins)







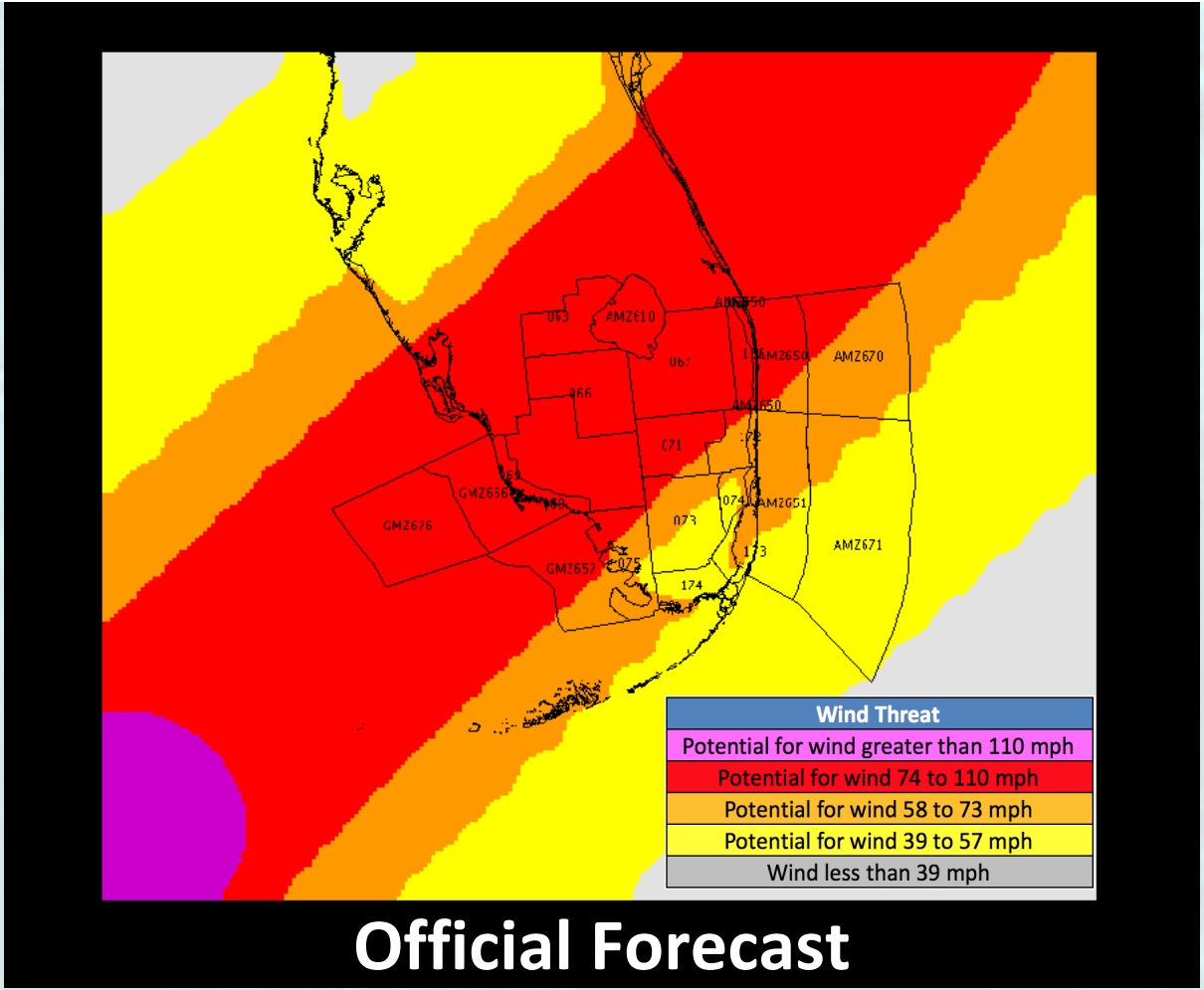


Hurricane Threats and Impacts (HTI) Products

- Clicking on the map provides latest information from the TCV text product for your area relative to the four main tropical cyclone hazards: **Wind, Storm Surge, Flooding Rains, and Tornadoes**.
- You will be able to find information on the meteorological forecast parameters including ***what*** and ***when*** type information, threat level (factoring safety margin and therefore what you should plan for), and corresponding potential impact information (what you should be preparing for) relative to each of those hazards.
- The threat levels account for forecast error and consider a safety margin or "***what conditions to plan for***".
- The potential impact information describes the potential effects or "***what impacts to prepare for***".

Most Likely Scenario

Example: A major hurricane approaching southwest Florida at the onset of the warning period (~ 36 hours)



Official Forecast

Reasonable Worst Case Scenario

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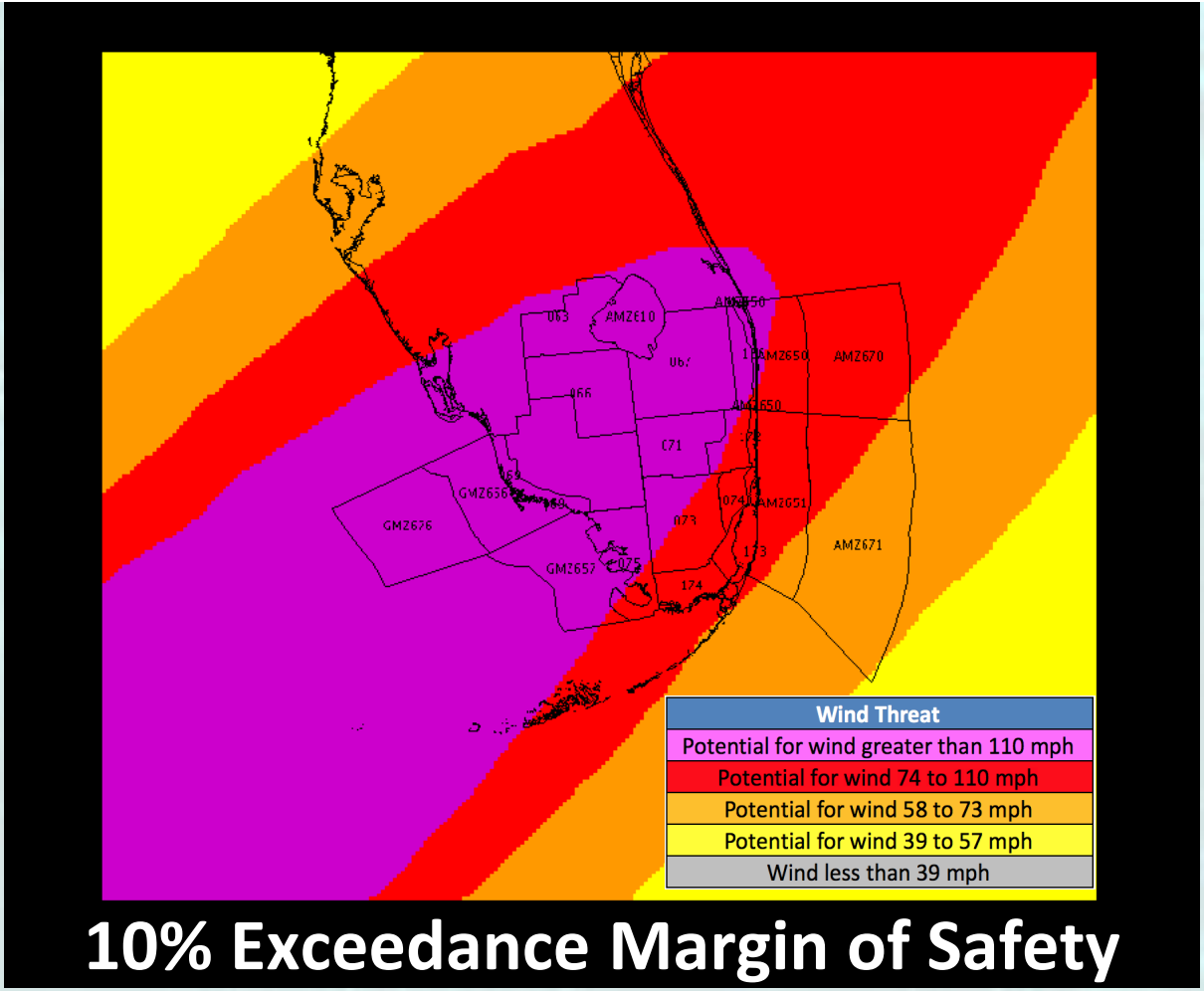

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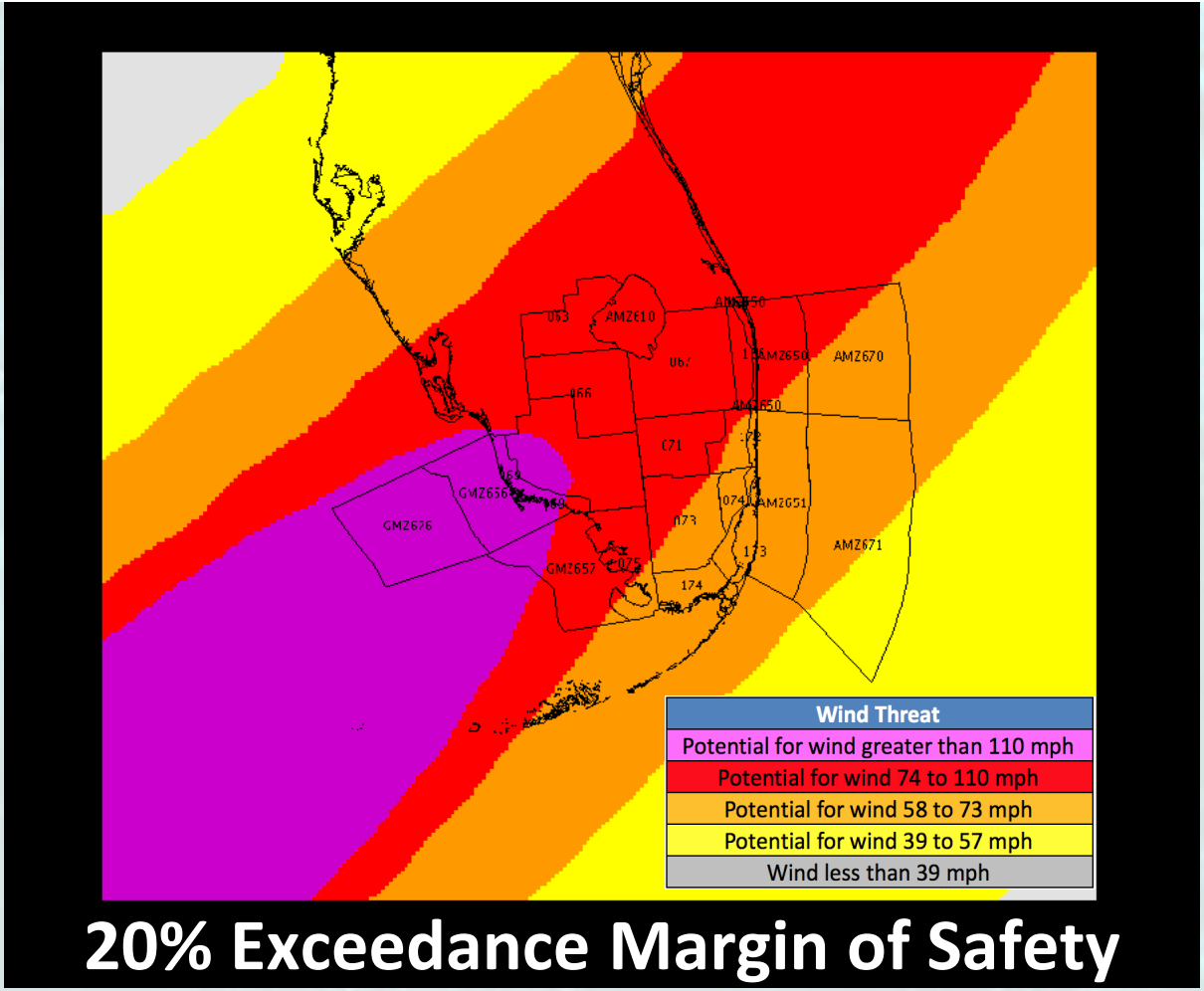

20% Exceedance Margin of Safety

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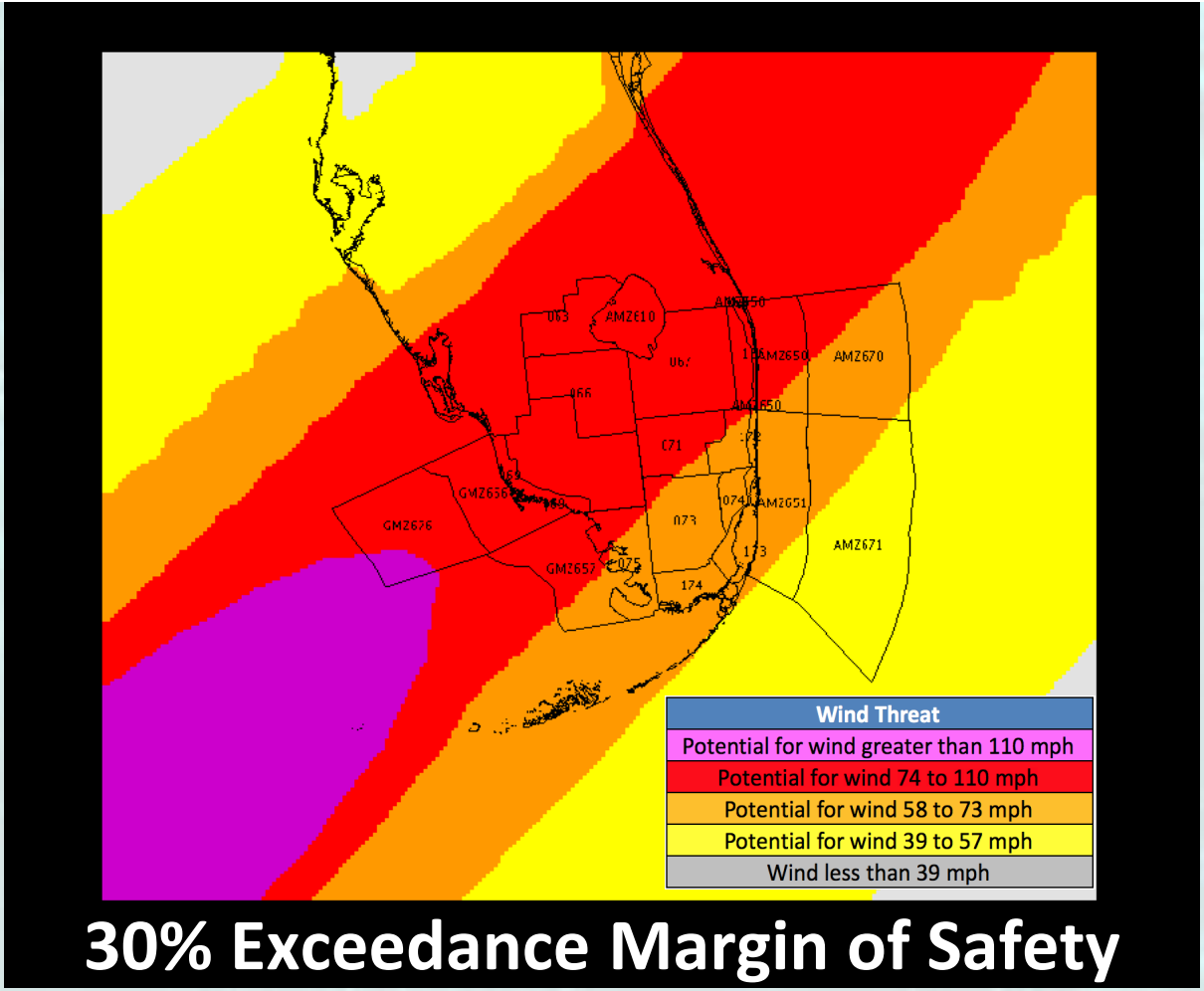
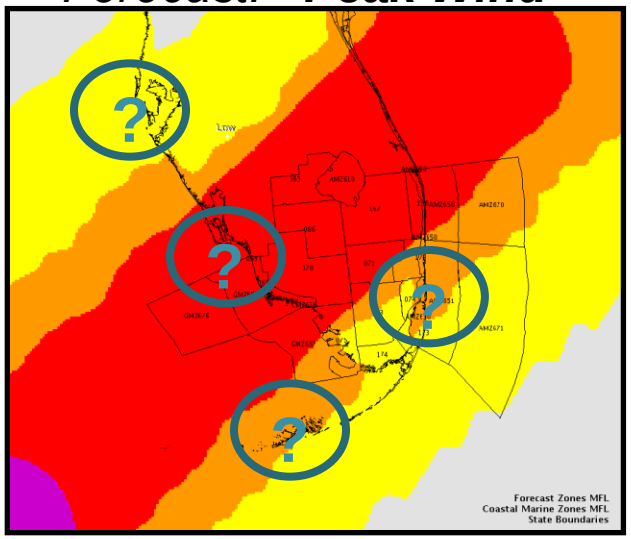


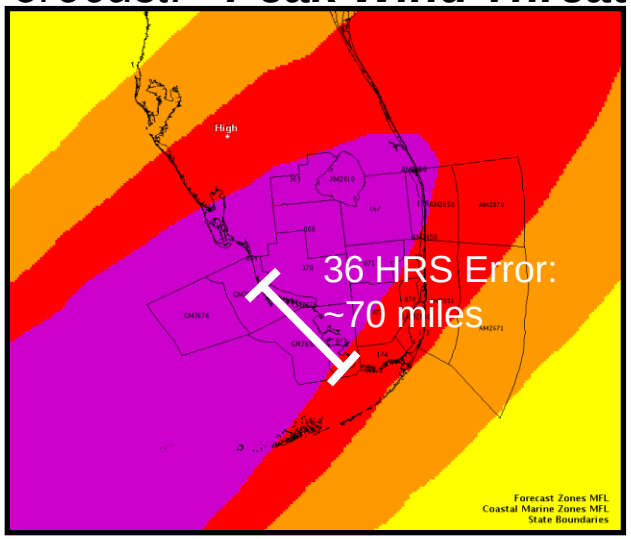
When a hurricane threatens a coastal community, to what extent should wind preparations be undertaken?

*Forecast: "**Peak Wind**"*



Deterministic-only; zero error

*Forecast: "**Peak Wind Threat**"*



Probability included; 10% exceedance

Example: A major hurricane approaching southwest Florida at the onset of the warning period (~ 36 hours)

Wind Threat
Potential for wind greater than 110 mph
Potential for wind 74 to 110 mph
Potential for wind 58 to 73 mph
Potential for wind 39 to 57 mph
Wind less than 39 mph

Decision Support: For a higher risk tolerance/narrower safety margin - What should one be preparing for?

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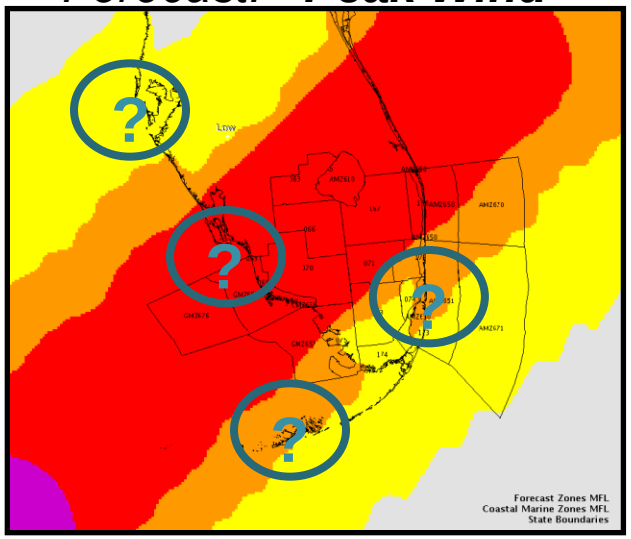

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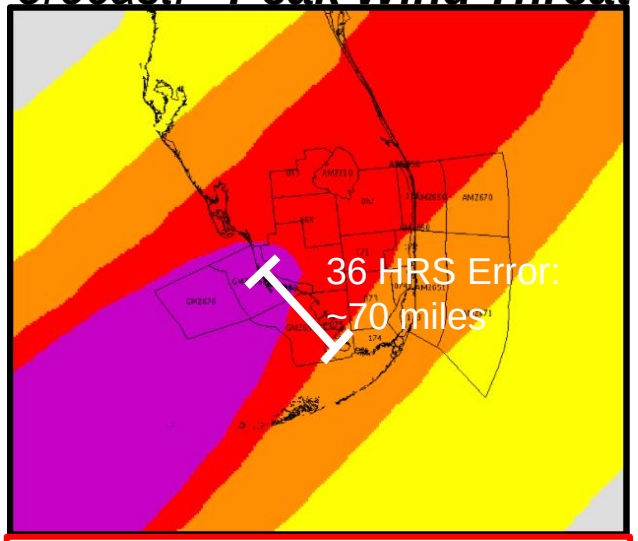

Probability included; 20% exceedance

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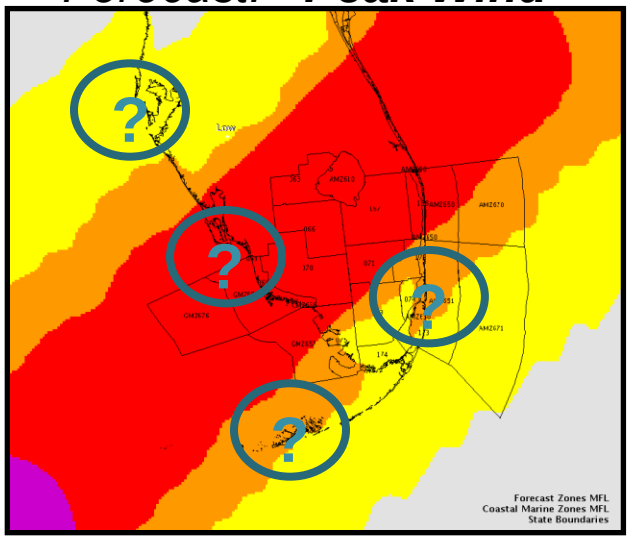
Wind less than 39 mph

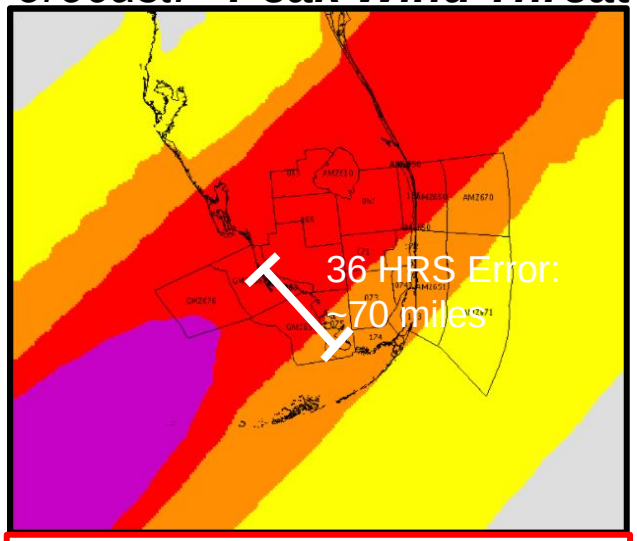
Decision Support: For a higher risk tolerance/narrower safety margin - What should one be preparing for?

*Forecast: "**Peak Wind**"*



Deterministic-only; zero error

*Forecast: "**Peak Wind Threat**"*



Probability included; 30% exceedance

Example: A major hurricane approaching southwest Florida at the onset of the warning period (~ 36 hours)

Wind Threat
Potential for wind greater than 110 mph
Potential for wind 74 to 110 mph
Potential for wind 58 to 73 mph
Potential for wind 39 to 57 mph
Wind less than 39 mph

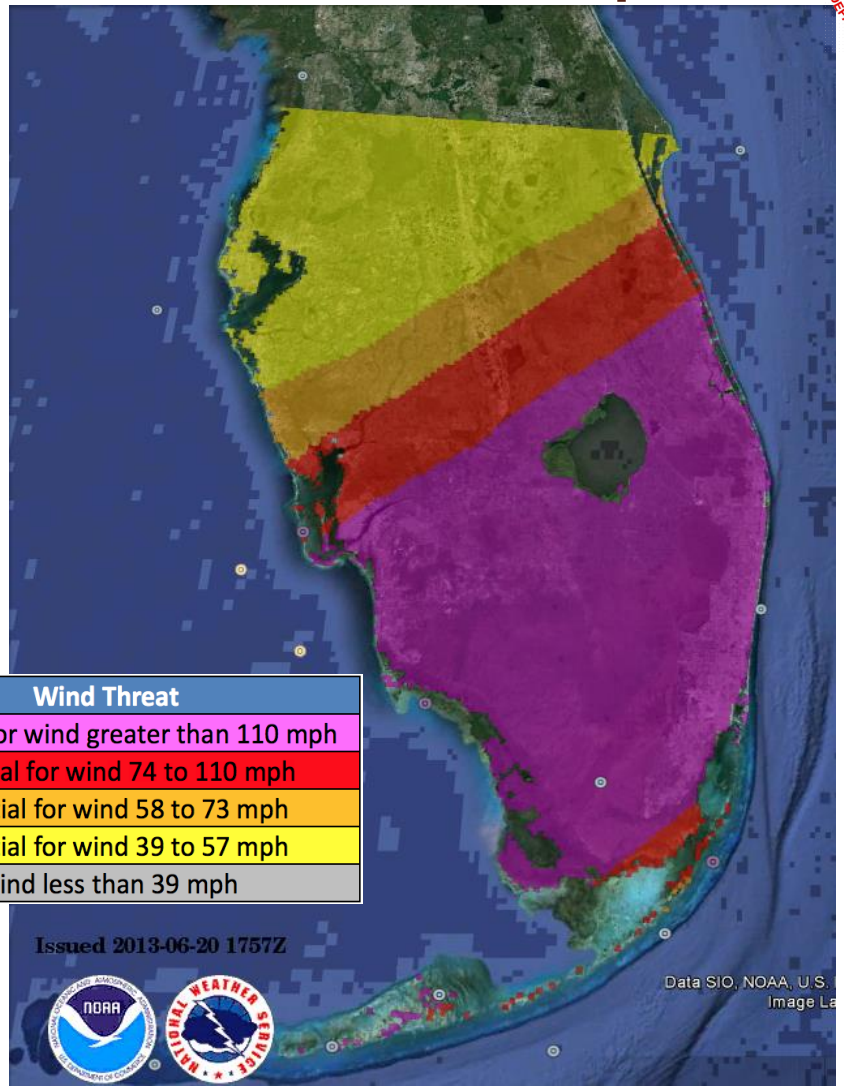
More on Trend – Wilma Example

HTI offer an implicit use probabilistic guidance.

What about their trend from advisory to advisory also?

- **Advisory 30**
- **Advisory 31**
- **Advisory 32**
- **Advisory 35**

Probability included; 10% exceedance



Learning Check

3. What decision-making guidance does HTI convey?

A. What should be planned/prepared for

B. What is expected

C. What is likely to happen

D. They are useless

One Approach

Learning Check

4. **HTI can be adjusted with varying safety margins factored in as the event evolves**

A. True

B. False

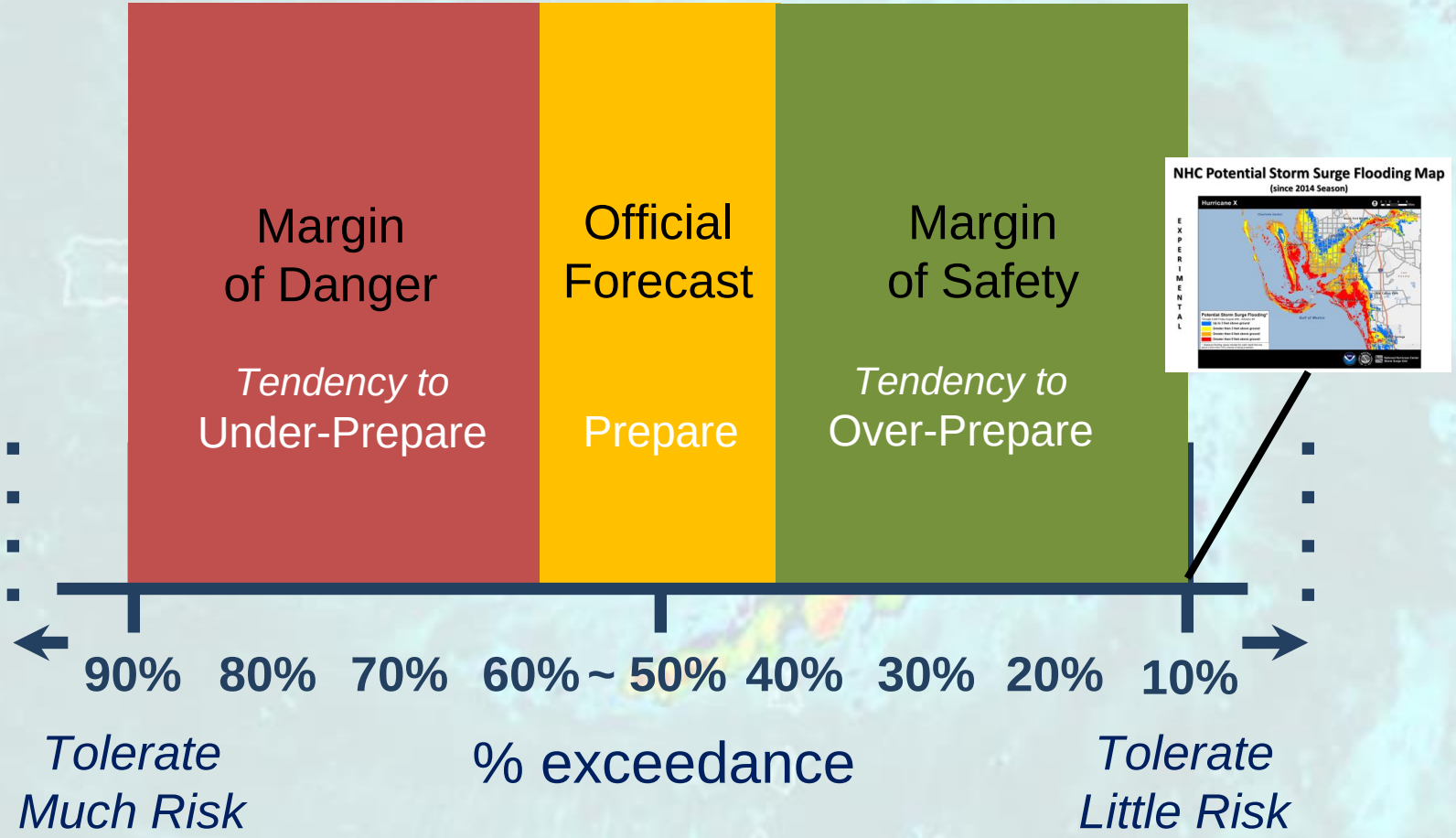
One Approach

Storm Surge Threat Assessment

- In the same context of risk tolerance and safety margin
- Example Graphical Products
  - ➢ NHC high resolution inundation map
  - ➢ Storm surge watch/warning graphic
  - ➢ WFO local threat and potential impact graphics
- Decision Support Services
  - ➢ Example of different risk tolerances (% exceedance levels) in coastal evacuation decision-making
  - ➢ Role of probabilistic data in emergency management decision-making guides
    - Customer thresholds

Risk Tolerance: Spectrum Of Plausible Outcomes

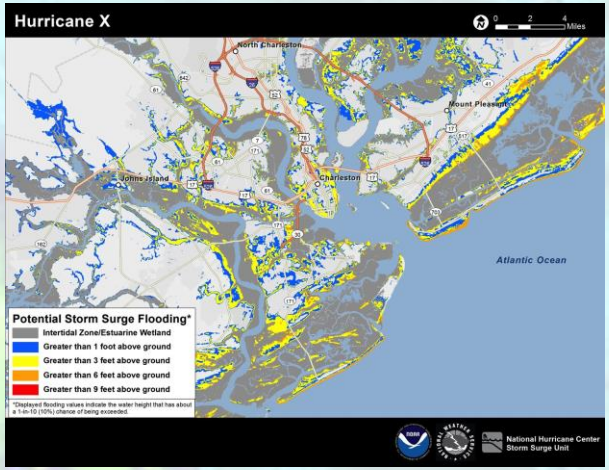
(in event context; for a given community)

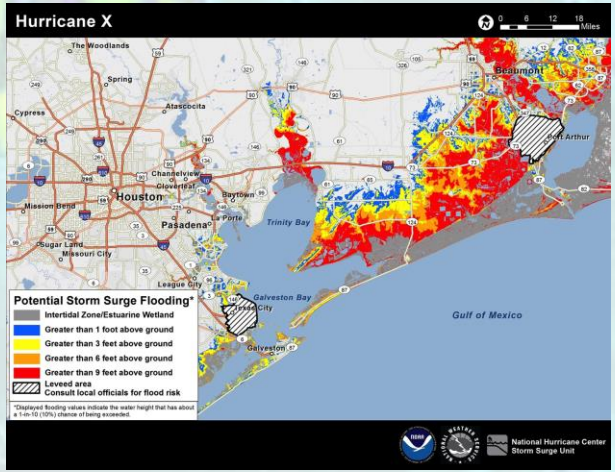


"Fate laughs at probabilities." – Novelist Edward Bulwer-Lytton (1803-1873)

Potential Storm Surge Flooding Map
(Inundation Map)

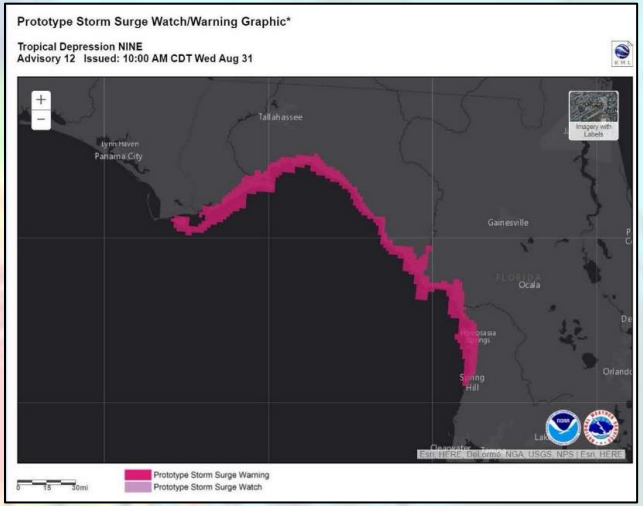
- Provides a quantitative risk assessment for decision makers. Not for public consumption necessarily.
- Shows height above ground that the water could reach.
  - Depicts the reasonable worst-case scenario at any individual location.
  - Shows inundation levels that have a 10% chance of being exceeded **ALWAYS!!!**
- First map issued with the initial hurricane watch or in some cases, with a tropical storm watch.
- Available about 60 to 90 minutes following the advisory release.





Storm Surge Watch/Warning Graphic

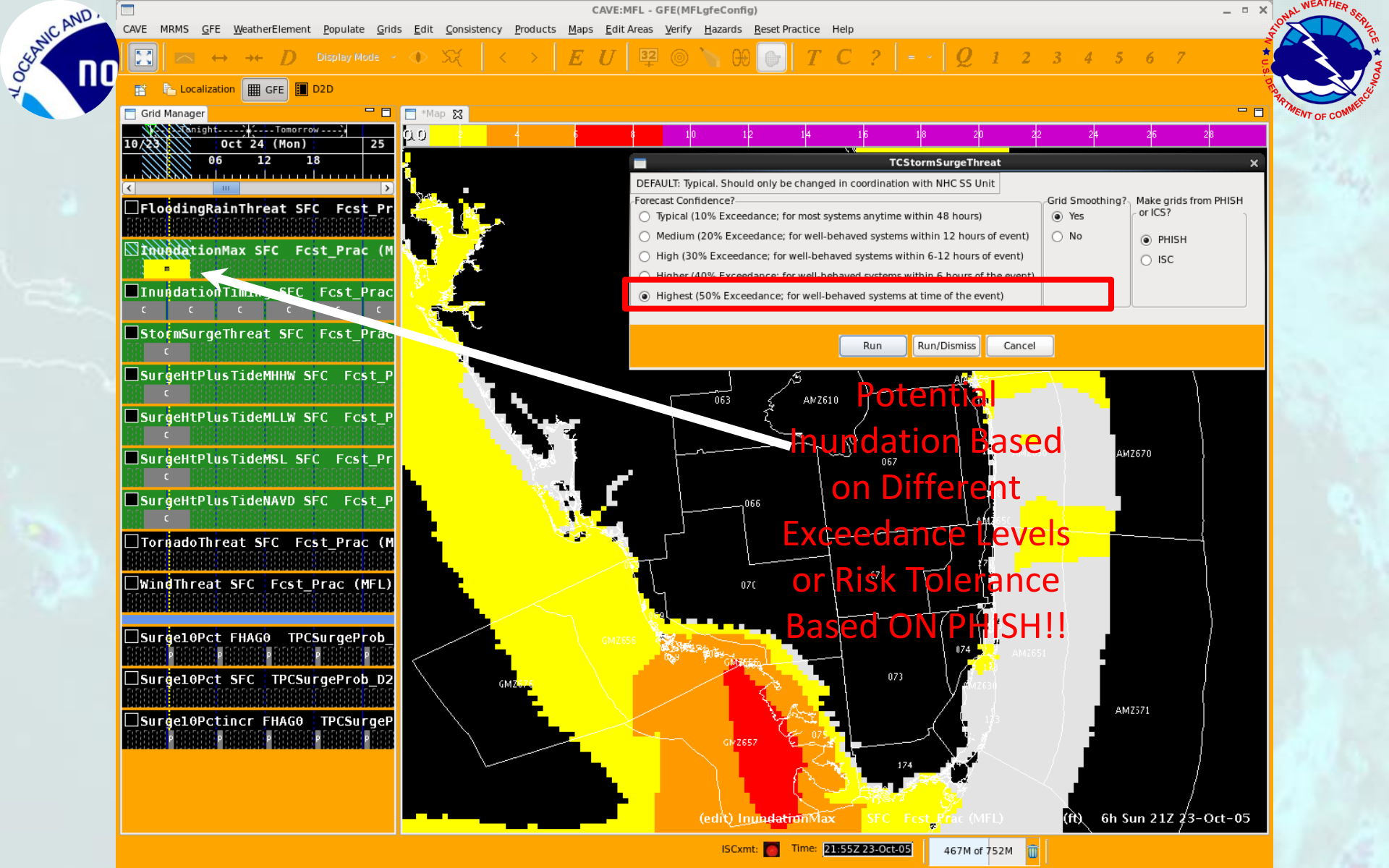
- Storm Surge Watch – possibility of life-threatening inundation somewhere within the watch area generally within 48 hours
- Storm Surge Warning – danger of life threatening inundation somewhere within warned area generally within 36 hours
- Consideration for continuity, areas subject to isolation, etc. Subjectivity plays a role.
- *Complements* the potential inundation graphic
- Together with WFO threat/impacts graphics, meant for public messaging/consumption

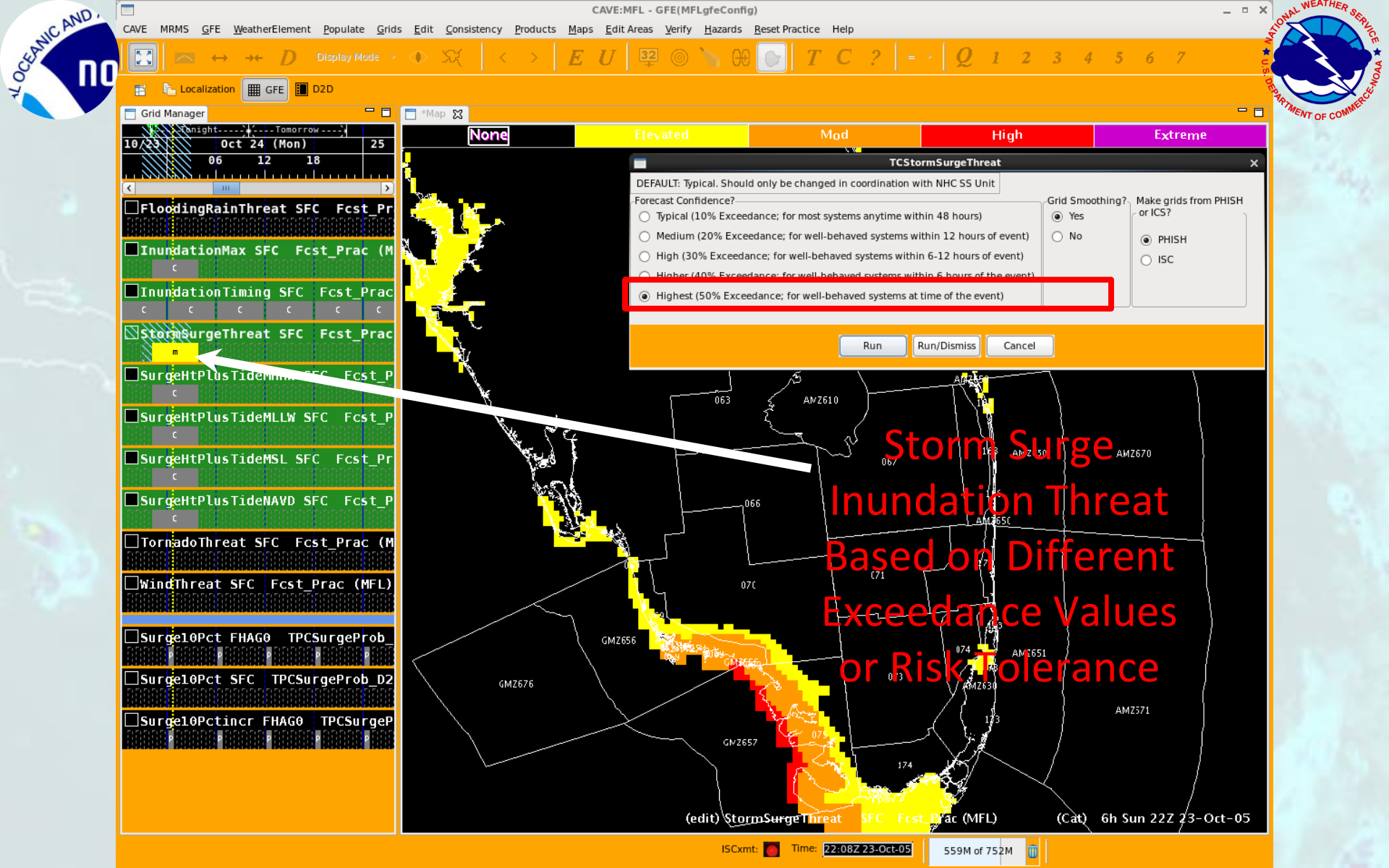


SUMMARY OF WATCHES AND WARNINGS IN EFFECT:

A Hurricane Warning is in effect for…
*** Anclote River to Indian Pass Florida**

A Storm Surge Warning is in effect for…
*** Aripeka to Indian Pass Florida**


CAVE:MFL - GFE(MFLgfeConfig)
CAVE MRMS GFE WeatherElement Populate Grids Edit Consistency Products Maps Edit Areas Verify Hazards Reset Practice Help
Localization GFE D2D
Grid Manager
Tonight Tomorrow
10/23 Oct 24 (Mon) 25
06 12 18
FloodingRainThreat SFC Fcst_Pr
InundationMax SFC Fcst_Prac (M
InundationTiMHHW SFC Fcst_Prac
StormSurgeThreat SFC Fcst_Prac
SurgeHtPlusTideMHHW SFC Fcst_P
SurgeHtPlusTideMLLW SFC Fcst_P
SurgeHtPlusTideMSL SFC Fcst_Pr
SurgeHtPlusTideNAVD SFC Fcst_P
TornadoThreat SFC Fcst_Prac (M
WindThreat SFC Fcst_Prac (MFL)
Surge10Pct FHAG0 TPCSurgeProb_
Surge10Pct SFC TPCSurgeProb_D2
Surge10Pctincr FHAG0 TPCSurgeP
*Map
TCStormSurgeThreat
DEFAULT: Typical. Should only be changed in coordination with NHC SS Unit
Forecast Confidence?
Typical (10% Exceedance; for most systems anytime within 48 hours)
Medium (20% Exceedance; for well-behaved systems within 12 hours of event)
High (30% Exceedance; for well-behaved systems within 6-12 hours of event)
Highest (50% Exceedance; for well-behaved systems at time of the event)
Grid Smoothing?
Yes
No
Make grids from PHISH or ICS?
PHISH
ISC
Run
Run/Dismiss
Cancel
Potential Inundation Based on Different Exceedance Levels or Risk Tolerance Based ON PHISH!!
AMZ610
AMZ670
AMZ651
AMZ571
GMZ656
GMZ657
(edit) InundationMax SFC Fcst_Prac (MFL) (ft) 6h Sun 21Z 23-Oct-05
ISCxmt: Time: 21:55Z 23-Oct-05 467M of 752M


CAVE:MFL - GFE(MFLgfeConfig)
CAVE MRMS GFE WeatherElement Populate Grids Edit Consistency Products Maps Edit Areas Verify Hazards Reset Practice Help
Localization GFE D2D
Grid Manager
Tonight Tomorrow
10/23 Oct 24 (Mon) 25
06 12 18
FloodingRainThreat SFC Fcst_Pr
InundationMax SFC Fcst_Prac (M
InundationTiming SFC Fcst_Prac
StormSurgeThreat SFC Fcst_Prac
SurgeHtPlusTideMLLW SFC Fcst_P
SurgeHtPlusTideMSL SFC Fcst_Pr
SurgeHtPlusTideNAVD SFC Fcst_P
TornadoThreat SFC Fcst_Prac (M
WindThreat SFC Fcst_Prac (MFL)
Surge10Pct FHAG0 TPCSurgeProb_
Surge10Pct SFC TPCSurgeProb_D2
Surge10Pctincr FHAG0 TPCSurgeP
*Map
None
Elevated
Mod
High
Extreme
TCStormSurgeThreat
DEFAULT: Typical. Should only be changed in coordination with NHC SS Unit
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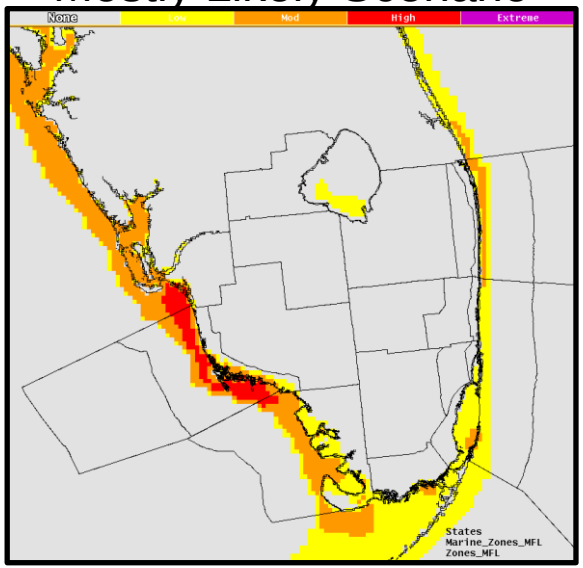
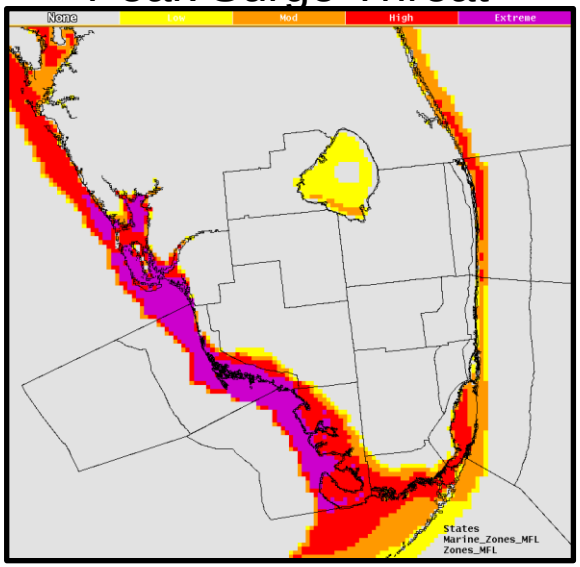
Highest (50% Exceedance; for well-behaved systems at time of the event)
Grid Smoothing?
Yes
No
Make grids from PHISH or ICS?
PHISH
ISC
Run
Run/Dismiss
Cancel
Storm Surge Inundation Threat Based on Different Exceedance Values or Risk Tolerance
(edit) StormSurgeThreat SFC Fcst_Prac (MFL)
(Cat) 6h Sun 22Z 23-Oct-05
ISCxmt:
Time: 22:08Z 23-Oct-05
559M of 752M

Surge Threat/Potential Impacts Graphic

Mostly Likely Scenario



Peak Surge Threat

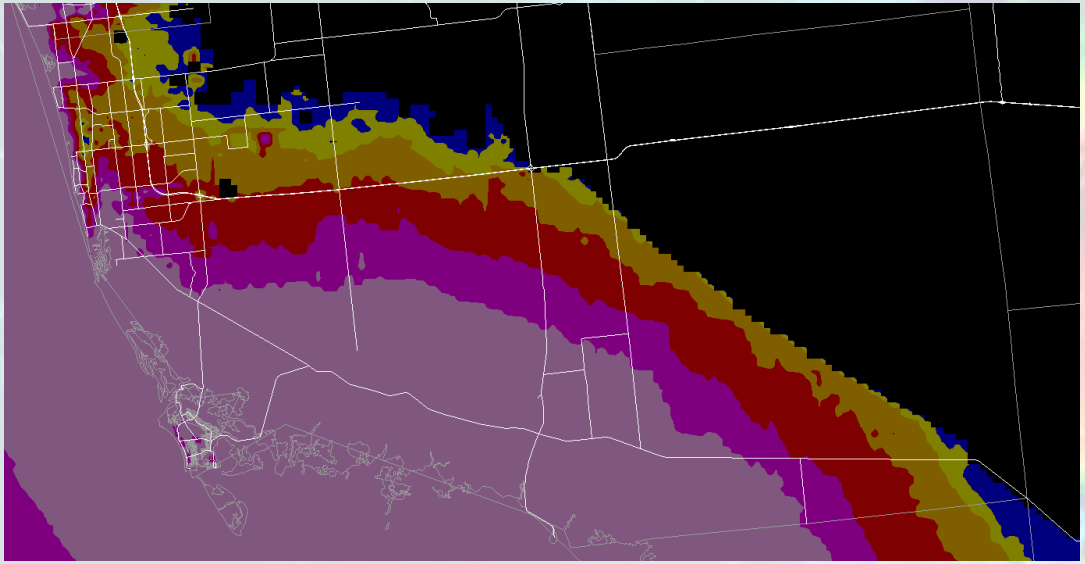


Example: Major hurricane at the onset of the watch period (~ 48 hours).

QUESTION: When advocating the measure of protective actions according to surge impacts, which is better?

Storm Surge Threat
Potential for surge flooding > 9 feet above ground
Potential for surge flooding 6-9 feet above ground
Potential for surge flooding 3-6 feet above ground
Potential for surge flooding 1-3 feet above ground
Little to no surge flooding

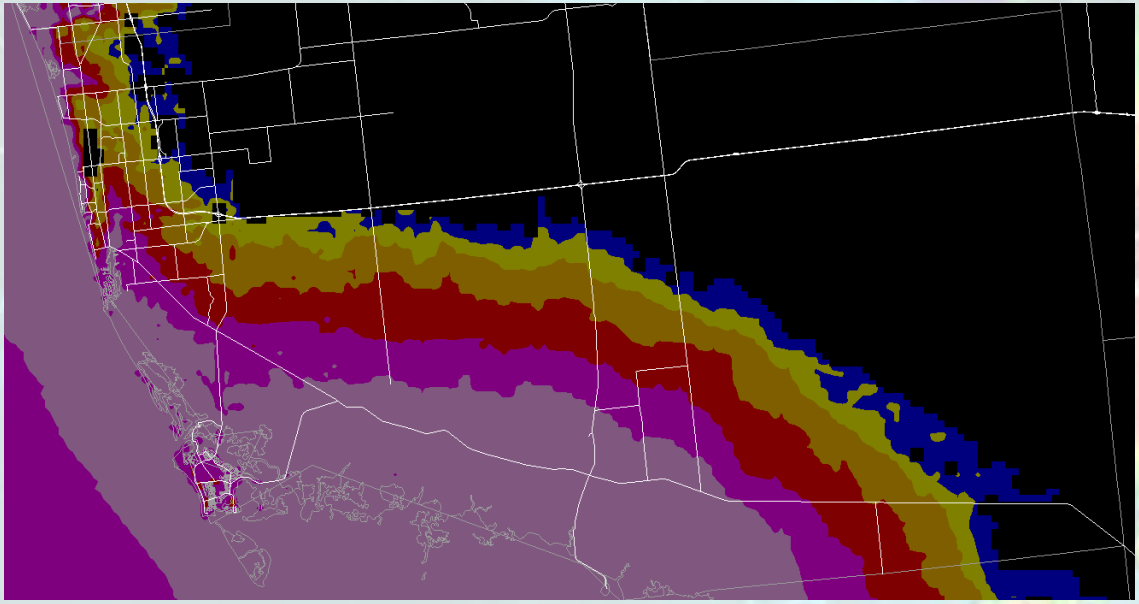
Irma Collier Surge Decision Point



Inundation
(AGL)
Adv 42
10% Exceedance
~ 24 hours to landfall

Blue: < 1 ft
Yellow: 1-3 ft
Orange: 3-6 ft
Red: 6-9 ft
Purple: 9-12 ft
Light Purple: > 12 ft

Irma Collier Surge Decision Point



Emergency manager held from evacuating 10s thousands additional folks based on this.

Inundation
(AGL)
Adv 42
20% Exceedance
~24 hours to landfall

Blue: < 1 ft
Yellow: 1-3 ft
Orange: 3-6 ft
Red: 6-9 ft
Purple: 9-12 ft
Light Purple: > 12 ft

Learning Check

5. **The high resolution inundation graphic is always based on inundation values with a 10% chance of being exceeded.**

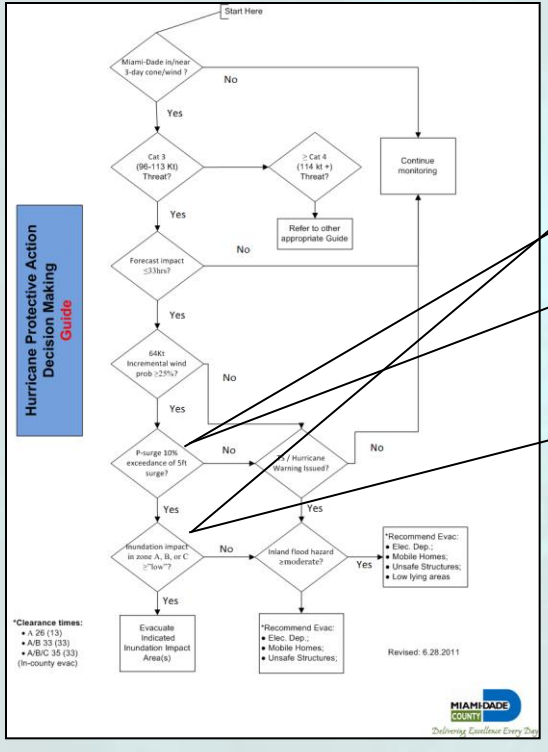
A. True

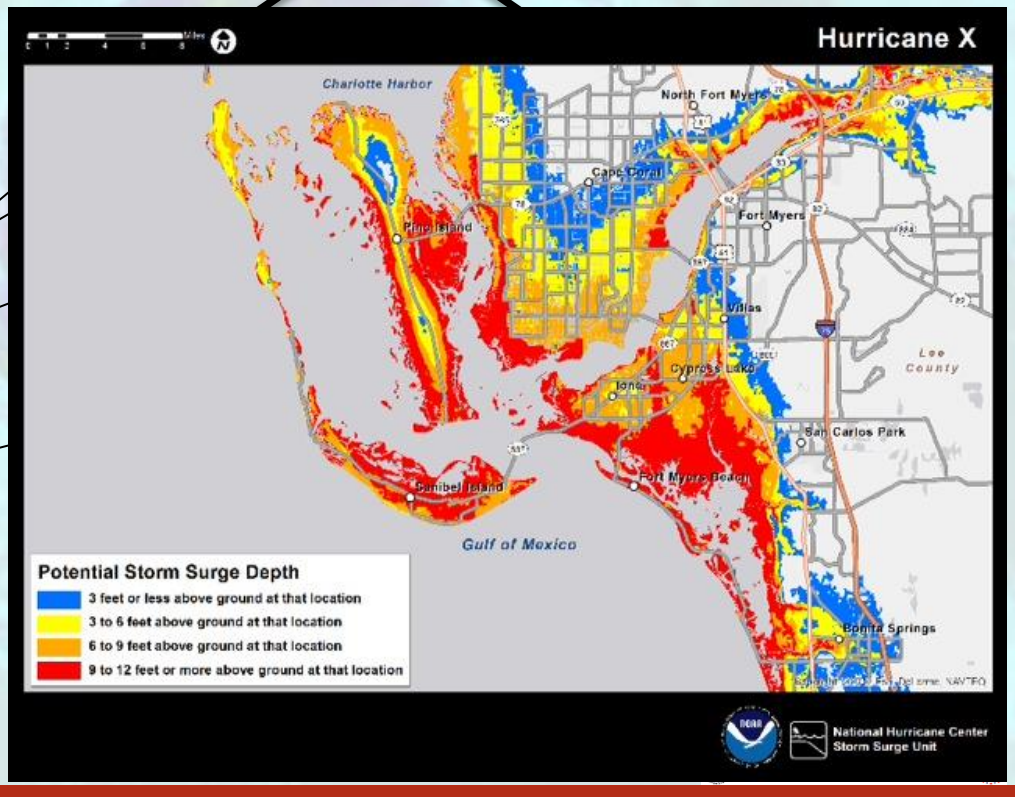
B. False

One Approach

Coastal Flooding (i.e., Inundation) Impact

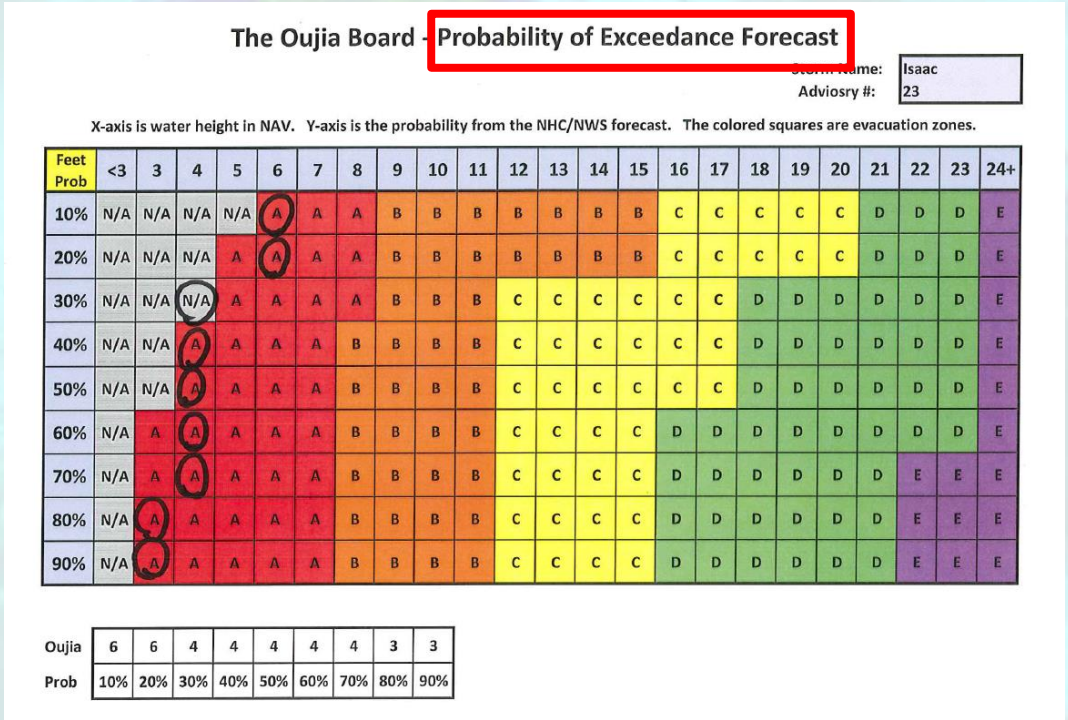
Neal Batista





Risk Assessment Matrix

- Some EMs (Example from Lee County) have developed tools to incorporate probabilistic data into decision making process.
- Each county is different – some sophisticated, some not.



The Oujia Board - Probability of Exceedance Forecast

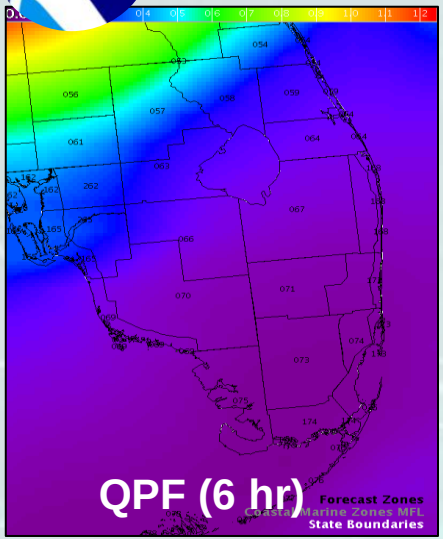
Storm Name: Isaac
Adviosry #: 23

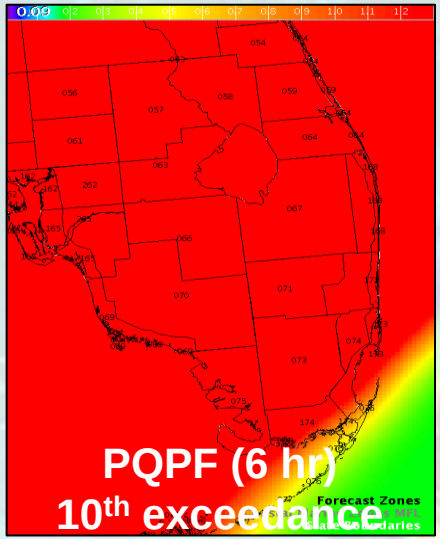
X-axis is water height in NAV. Y-axis is the probability from the NHC/NWS forecast. The colored squares are evacuation zones.

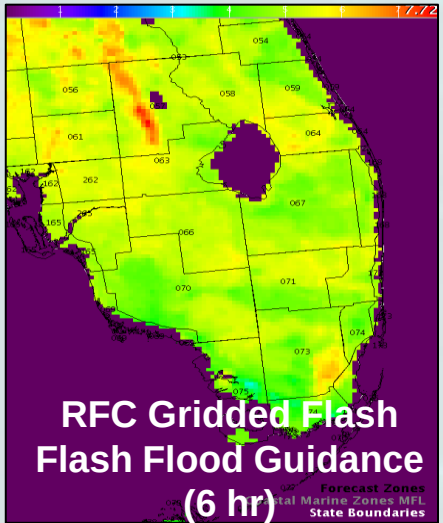
Feet / Prob	<3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24+
10%	N/A	N/A	N/A	N/A	A	A	A	B	B	B	B	B	B	B	C	C	C	C	C	D	D	D	E
20%	N/A	N/A	N/A	A	A	A	A	B	B	B	B	B	B	B	C	C	C	C	C	D	D	D	E
30%	N/A	N/A	N/A	A	A	A	A	B	B	B	C	C	C	C	C	C	D	D	D	D	D	D	E
40%	N/A	N/A	A	A	A	A	B	B	B	B	C	C	C	C	C	C	D	D	D	D	D	D	E
50%	N/A	N/A	A	A	A	A	B	B	B	B	C	C	C	C	C	C	D	D	D	D	D	D	E
60%	N/A	A	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D	D	D	D	D	E
70%	N/A	A	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D	D	D	E	E	E
80%	N/A	A	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D	D	D	E	E	E
90%	N/A	A	A	A	A	A	B	B	B	B	C	C	C	C	D	D	D	D	D	D	E	E	E

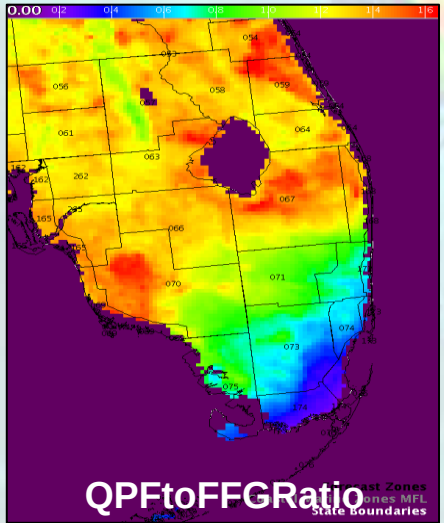
Oujia	6	6	4	4	4	4	4	3	3
Prob	10%	20%	30%	40%	50%	60%	70%	80%	90%

Flooding Rain Threat Assessment





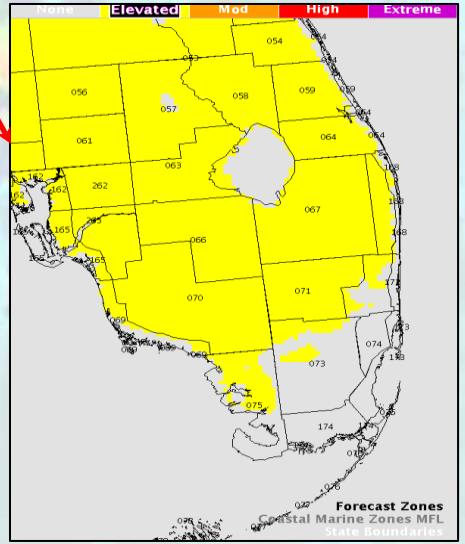




The tool uses the following inputs (to 72 hrs):

- WFO QPF (6 hourly)
- WPC PQPF (6 hourly)
- RFC FFG (6 hourly) – diagnostic field
- WPC Excessive Rainfall probabilities (ERP)
- Inputs checked for each 6 hr period to 72 hrs.
- The final FloodingRainThreat is based on a composite max for the 72 hr period.

Excessive Rainfall Probabilities (Days 1-3)



NOTE: Remember the text is locally adaptable (HTI).

Summary & Conclusions

- **You can brief threat/risk information to community decision-makers relative to:**
  - The Most Likely Scenario
  - The Reasonable Worst Case Scenario
  - The Most Likely Alternate Scenario pessimistic *(if requested)*
  - The Most Likely Alternate Scenario; optimistic *(if requested)*
  - The Reasonable Best Case Scenario *(if requested)*
- **The % Exceedance Probabilities can be harnessed to:**
  - Standardize scenario definitions *(from above)*
  - Help determine the width of the Safety Margin for varying levels of risk tolerances and customer thresholds community to community
- **Advanced tools are needed to exploit the use of probabilistic data in threat assessment especially for purposes of decision support and messaging to the public.**
  - For each hazard - hurricane threats and impacts graphic represent a good example
  - For forecasters and sophisticated decision-makers

The Local Hurricane Hazards Threat Assessment

QUESTIONS ???