



# **Societal Response to Hurricanes:**

## **Risk Perception and Forecast Messaging**

**Betty Hearn Morrow**

Consulting Sociologist

Professor Emerita, Florida International University

**Robbie Berg**

National Hurricane Center

2017 RA-IV Workshop on Hurricane Forecasting and Warning

National Hurricane Center - Miami, Florida

9 March 2017

# TOPICS

- *What's the final step in forecasting?*
- *What are the elements of effective warning messages?*
- *What factors influence risk perception?*
- *How can social science improve forecast communication?*

# TC Forecast Improvements

- Atlantic track error at 24-72 hours reduced by 70% over past 15-20 years
  - 96-120 hour by about 50%
  - NHC forecast cone smaller
  - 7-day forecasts offered on experimental basis
- Improvements in storm surge forecasting
- Steady, less dramatic improvements in intensity forecast

Earlier warnings

More protective actions

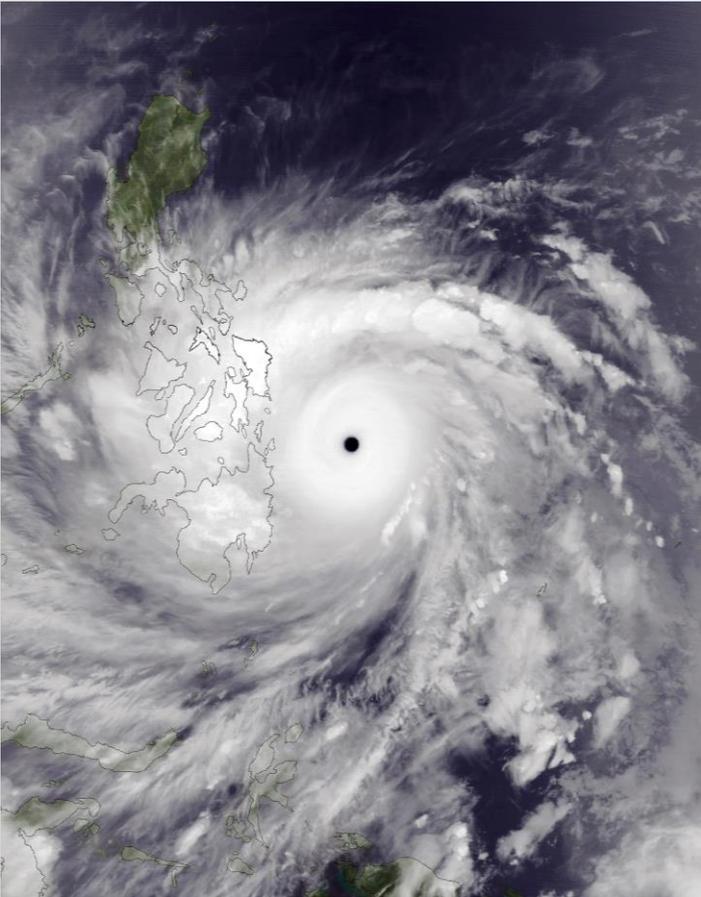
Yet, human toll remains high

# Haiyan (Yolanda) 2013

Deadliest TC to make landfall in the Philippines. Also impacted Micronesia, Southern China, Vietnam

Highest winds (10-min. sustained):  
230 km/h (145 mph)

**6,340 confirmed dead**  
**1,061 missing**





# Katrina 2005

One of 5 deadliest US hurricanes

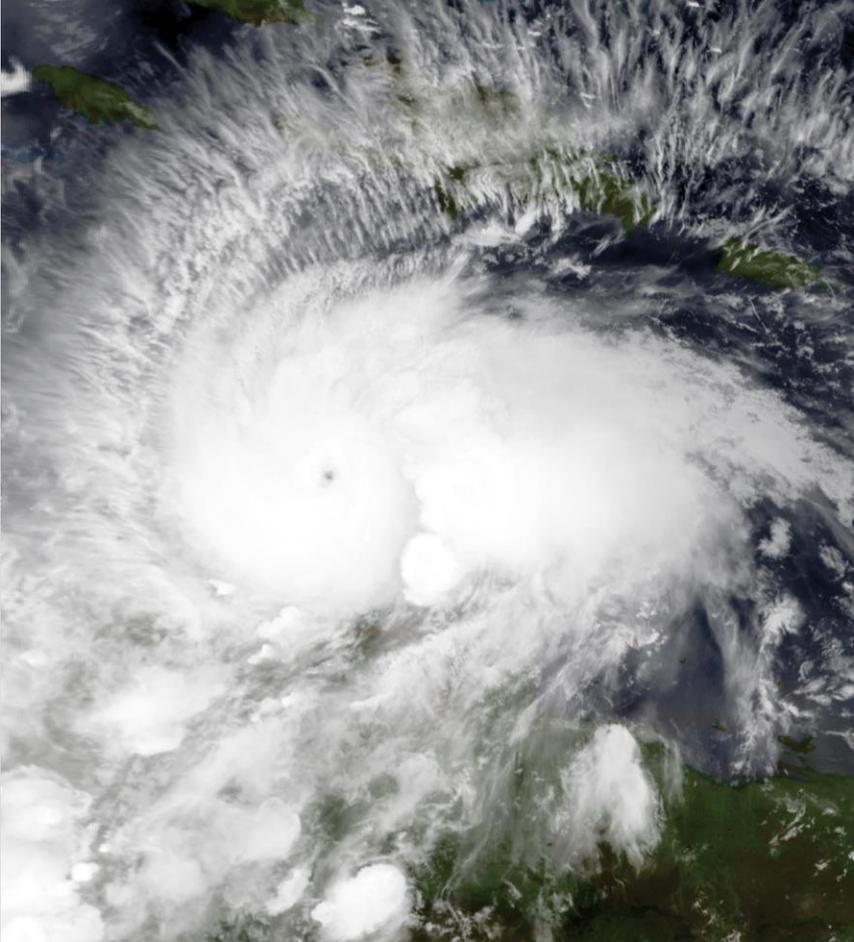
Across Florida, intensified in Gulf before impacting Mississippi and Louisiana

**Over 1200 deaths**

# Matthew 2012

Across Haiti, Cuba, Bahamas,  
SE United States

**Estimated ~700  
deaths**



*Did people get the forecasts?*

*Did they understand the messages?*

*Did they know they applied to them?*

***Did they understand their risk?***

“Do people get the message and understand what it means to them? That’s the only question that matters.”

Bryan Norcross Official Blog  
04 September 2012

# Steps To Effective Warning Response

**1**

**Understand  
Hazard**

**2**

**Receive and  
Understand  
Message**

**3**

**Perceive  
Risk**

**4**

**Believe It  
Applies**

**5**

**Know What  
To Do**

**RESOURCES?**

**Appropriate Protective Action**

1

Understand  
Hazard

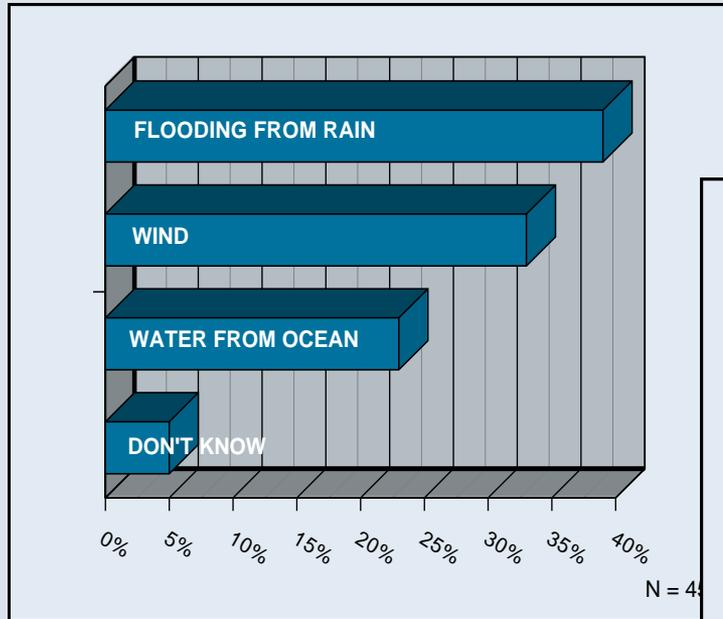
*People in your region are most likely to underestimate the potential impacts of which TC hazard?*

- A. Rain
- B. Wind
- C. Surge
- D. Tornadoes

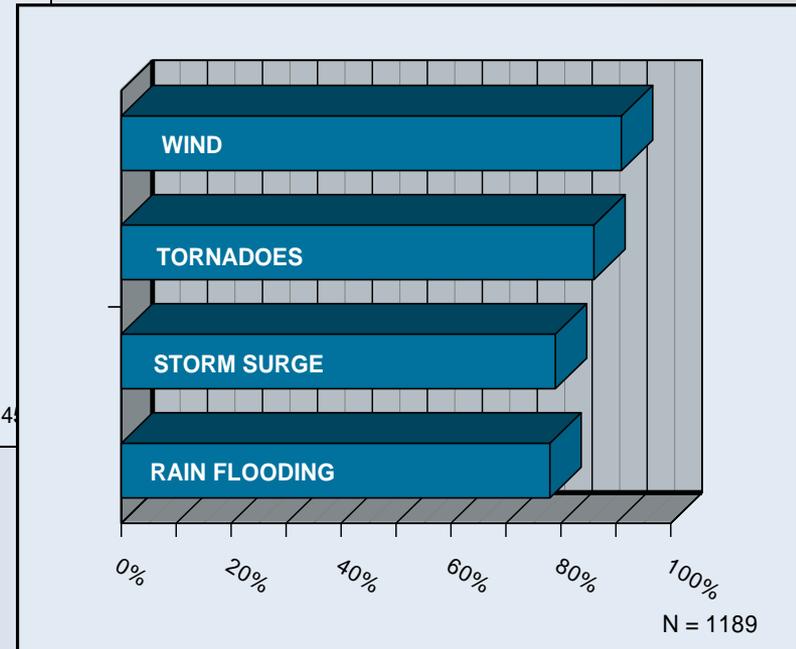
# 1

## Understand Hazard

# Public Opinion on What Hurricane Hazard Causes the Most Deaths



*Coastal Public On-Line Survey on Tropical and Extratropical Cyclone Forecast Communication Products – Report to NOAA. 2012. Eastern Research Group, Inc.*



*HFIP-SEIA Storm Surge Panel Survey. "Likelihood of Deaths from Major Hurricane" NCAR 2010. Lazo, Jeffrey,*

1

**Understand  
Hazard**

*“Slow Rising Water”?*

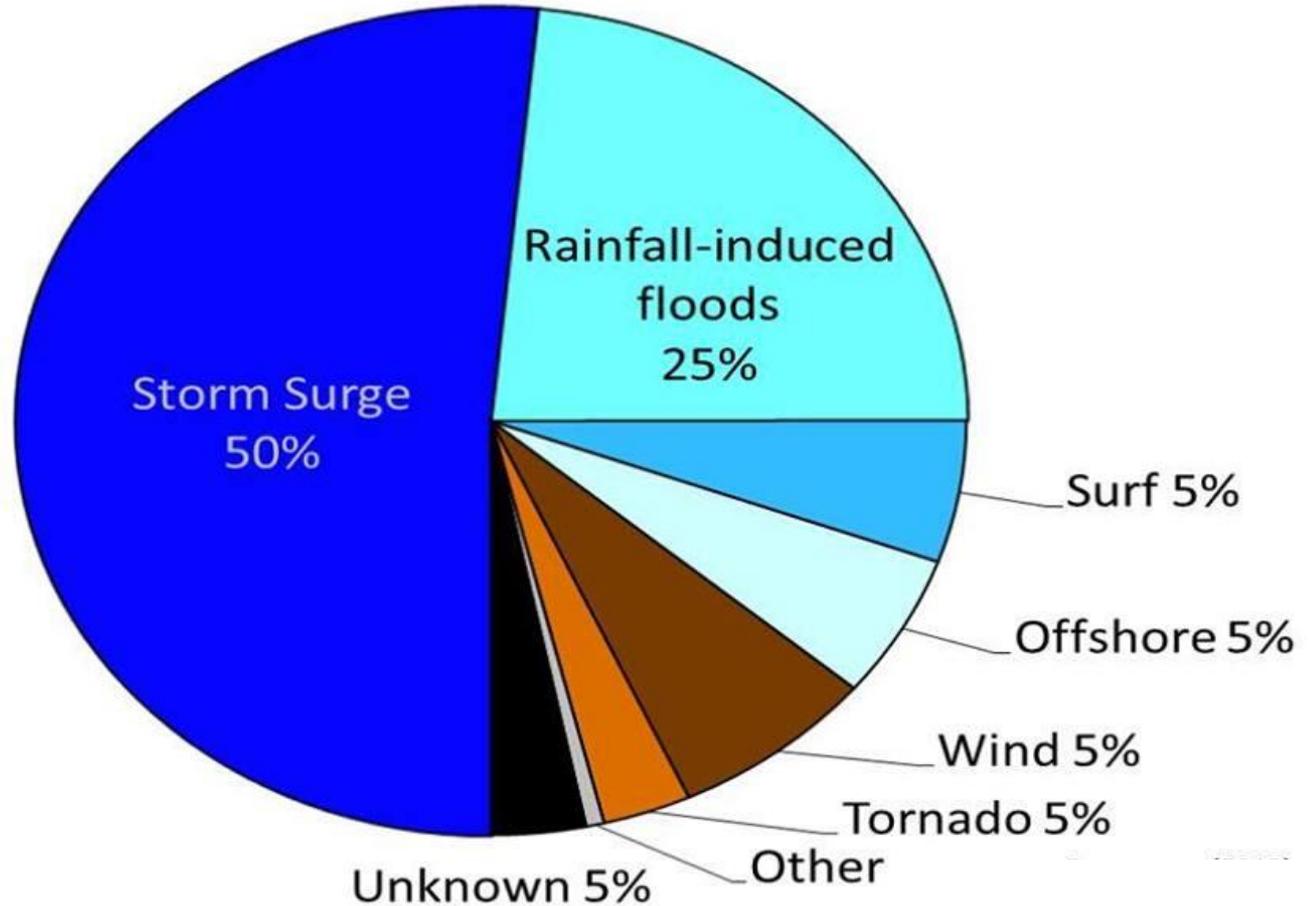


*“I’ll leave if it starts to  
get bad.”*

1

Understand  
Hazard

## U.S. Tropical Cyclone Deaths, 1962-2011



Rappaport, Edward N. 2014. Fatalities in the United States From Atlantic Tropical Cyclones. *Bulletin of the American Meteorological Society*, March.

1

Understand  
Hazard

## Misunderstanding of Storm Surge by Coastal Residents

<b>Incorrect Statement</b>	<b>Somewhat or Completely Agree</b>
Surge only affects within one mile of coast	25%
Storm category refers to wind and surge	41%
Surge caused by rain	20%
Surge and tsunamis are same	17%

N = 1121-1168

Lazo, Jeffrey. 2010. *HFIP-SEIA Storm Surge Panel Survey*. NCAR.

# SURGE EDUCATIONAL RESOURCES

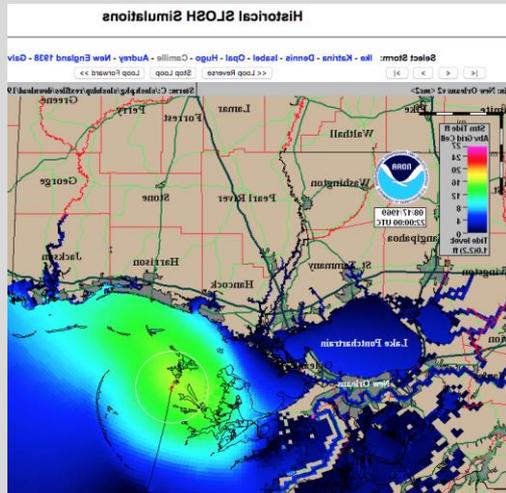
<http://www.nhc.noaa.gov/surge/>

VIDEOS

## ANIMATIONS



## HISTORICAL SLOSH RUNS



## TIP SHEETS



A tip sheet titled "¡La Marejada Ciclónica Puede ser Mortal! 10 Consejos para Estar Preparado". The sheet is divided into two columns. The left column is titled "¡Conozca sus Mapas, Conozca su Zona!" and the right column is titled "Para Más Información". The bottom of the sheet features a photograph of a red car on a street with a large surge of water crashing over it. NOAA and FEMA logos are visible in the bottom right corner.

**¡Conozca sus Mapas, Conozca su Zona!**  
El mapa de Previsión de Inundación por la Marejada Ciclónica se muestra a los mapas de riesgo por inundación y los mapas de zonas de evacuación de huracanes.  
• Use el mapa que vive en una zona inundable para determinar la marea ciclónica de un huracán o tormenta.  
• Las zonas de evacuación pueden ser específicas por muchas razones de seguridad pública y pueden ser diferentes de las áreas mostradas en este mapa.  
• Siempre hoy si usted vive en una zona de evacuación de huracanes!

**Para Más Información**  
El Servicio Nacional de Meteorología (NWS) por sus siglas en inglés, publica comentarios a los canales de radio, el mapa de Previsión de Inundación por la Marejada Ciclónica. Para más información sobre este mapa y para estar más comunicados acerca de sus productos experimentales, visite [www.ndbc.noaa.gov](http://www.ndbc.noaa.gov).

**¡La Marejada Ciclónica Puede ser Mortal!**  
10 Consejos para Estar Preparado

1

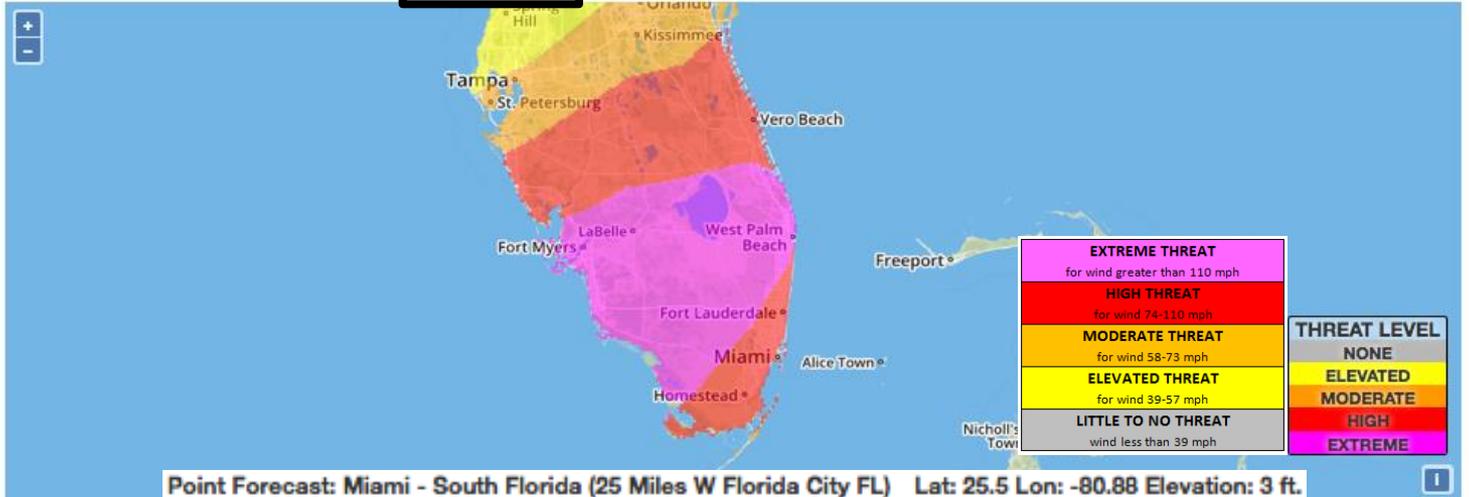
# Understand Hazard

## Hurricane Threats and Impacts

The Hurricane Threats and Impacts web site is an internet-based decision-support service consisting of at least four informational elements: high wind impacts, storm surge impacts, inland flooding impacts, and tornado impacts. During the Atlantic & Caribbean Hurricane Season, the information will be generated and posted by 23 coastal WFOs whenever tropical cyclone watches and/or warnings are in effect for their area.

For more information, visit the [National Hurricane Center](#) website.

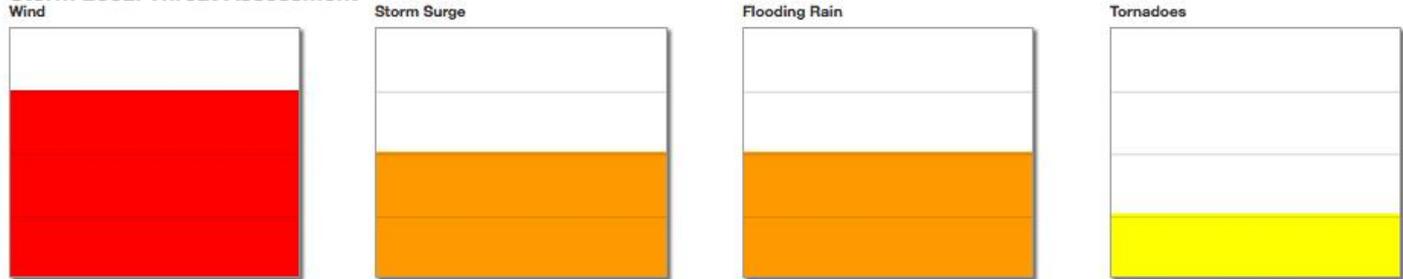
- Local Forecast
- Local Statements
- Local Threats/Potential Impacts**
- Local Threat Meter



- Wind
- Storm Surge
- Flooding Rain
- Tornadoes
- Neighborhood
- Areawide

### Local Threat Meter - Wind (Neighborhood)

#### Storm Local Threat Assessment



POTENTIAL IMPACTS FROM EACH HAZARD WILL BE PART OF PLANNED INTERACTIVE WEBSITE



2

Receiving was more of a problem in the past....

Receive and  
Understand  
Message

## Galveston Hurricane - 1900



10099—Looking North from Ursuline Academy, Showing Wrecked  
Negro High School Building, Galveston, Texas.

**8,000 deaths**



2

Receive and  
Understand  
Message

*Where do you think most people in your region FIRST hear about a TC threat?*

- A. TV
- B. Radio
- C. Smart phones
- D. Social contacts
- E. Other

2

Receive and  
Understand  
Message

*Where do you think most people in your region get MOST of their TC forecast information?*

- A. Local radio
- B. Local TV
- C. Cable or national TV
- D. Smart phones
- E. Social contacts
- F. Other

# 2

## Receive and Understand Message

SOURCE	PERCENT
Local Radio	41
Cable or Satellite TV	24
Local TV	20
Internet	6
The Weather Channel	1
NOAA Weather Radio	1
Friends or Family	1
Other	5

Morrow and Gladwin. 2014. *Puerto Rico Hurricane Evacuation Study Behavioral Analysis*. Through Dewberry for FEMA and USACE.

### Information Sources Used Great Deal During Sandy:

- 62% local TV
- 53% national TV
- 48% The Weather Channel
- 29% local radio
- 21% Internet
- 8% social media
- 8% NOAA radio

Gladwin and Morrow . 2013. Communication and Understanding of Hurricane Sandy Forecast and Warning Information. National Science Foundation #1322088.



2

Receive and  
Understand  
Message

# Understand?

- Tropical cyclone
- Tropical vs. Extratropical
- Convective structure
- Wind radii
- Global models, model consensus
- Barometric pressure

Forecast interpreted by broadcast mets, local WFOs, officials

*What about those received via web and social media?*

# Understand?

**Table 14. Respondents Correctly Defining Watches and Warnings  
(Percent)**

	Louisiana	Alabama	Mississippi	Florida Panhandle	Florida Keys	Total
Hurricane Watch	63	63	64	60	70	62
Hurricane Warning	40	35	43	40	41	40

Gladwin, H. and B. H. Morrow 2005. *Hurricane Ivan Behavioral Study*. Submitted through Dewberry & Davis to FEMA and USACE.

**Receive and  
Understand  
Message**

## Some Implications:

- Multiple channels of communication, including radio
- Simple language and messages with suggestions/links to more in-depth information
- Self-explanatory graphics and maps

**Perceive  
Risk**

## Some Research Findings on Risk Perception :

- Socially constructed out of past experiences (mental models)
- Strong social component
- Affected by cultural differences in attitudes toward risk
- Affected by experience, but with diminishing effects
- Lots of “false” experience

3

Perceive  
Risk

*Which factor do you think MOST influences whether people think they need to take protective action?*

- A. Strength of the wind (Category)
- B. Size of the storm
- C. Potential storm surge
- D. Location of their home in relation to track
- E. Characteristics of their home (shutters, etc.)
- F. Their estimate of the probability it will happen
- G. How much of a chance they're willing to take



**Hazard**

**x Exposure**

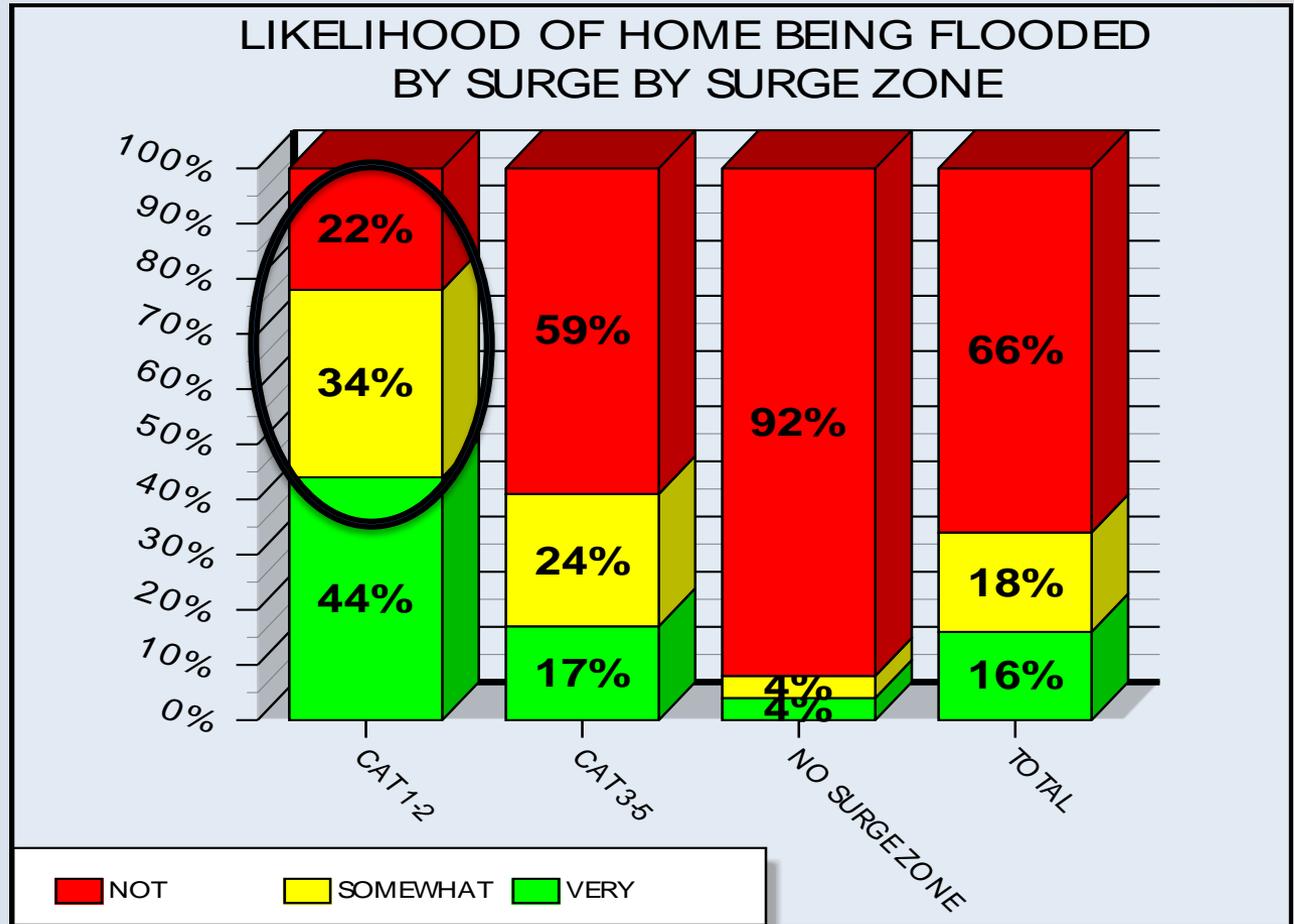
**x Probability**

**x Personal Factors**

3

Perceive  
Risk

# Do people understand their exposure?

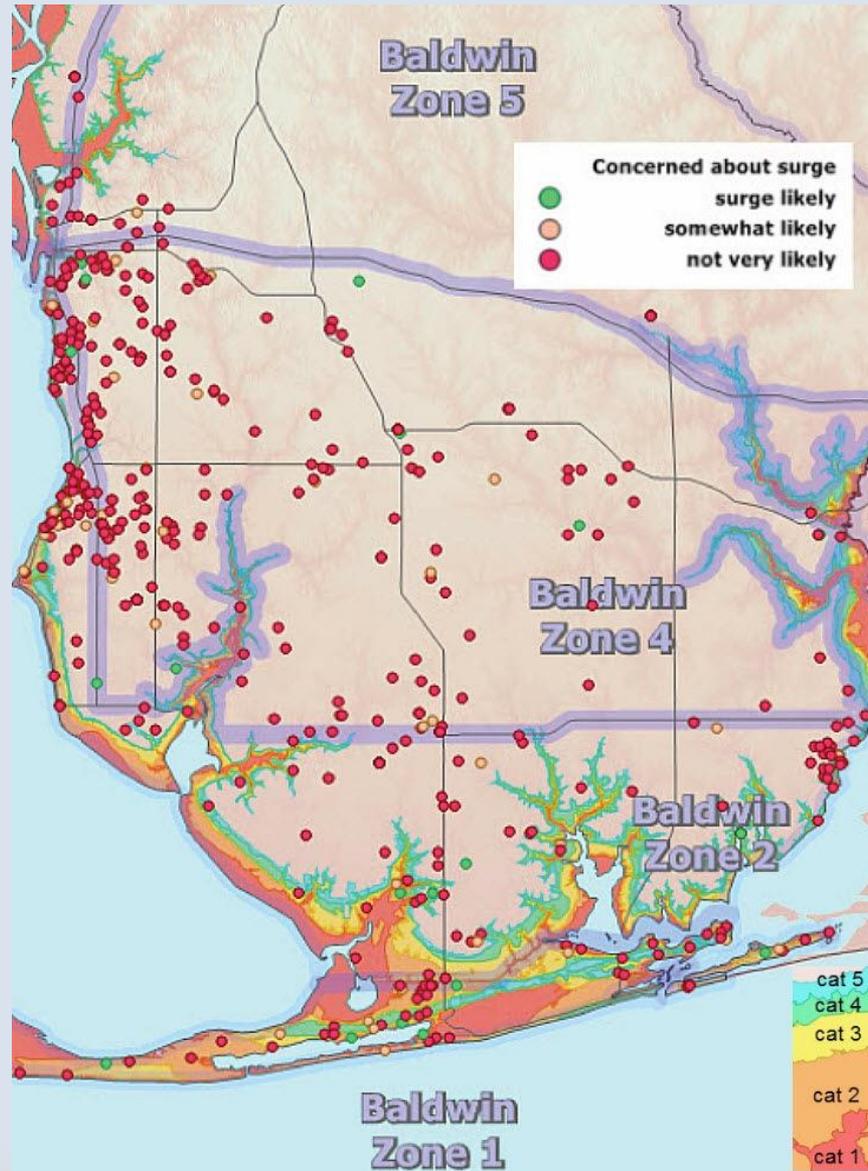


Mississippi Behavioral Analysis. 2011. Morrow & Gladwin through Dewberry for FEMA and USACE

3

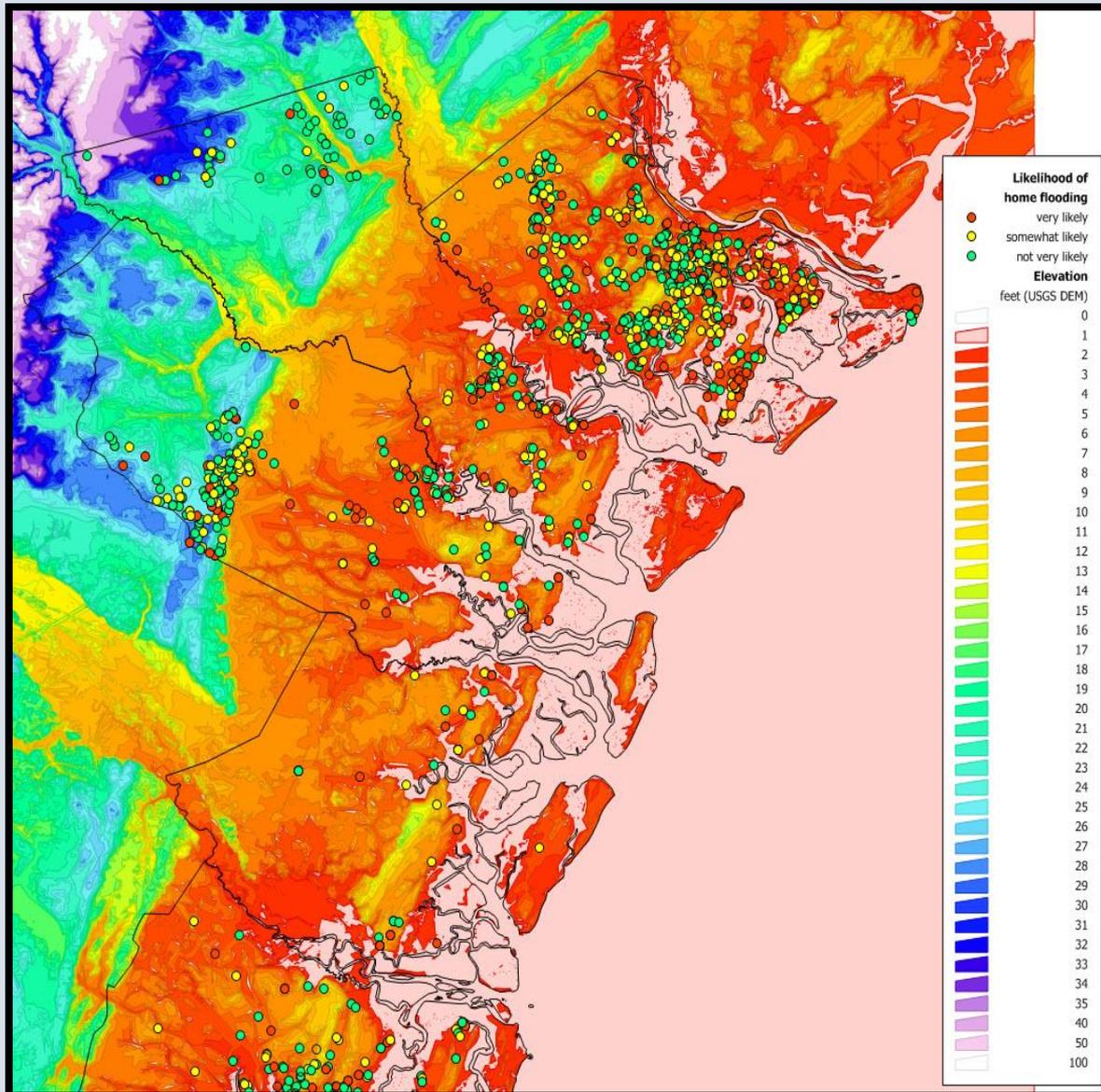
# Do people understand their exposure?

Perceive  
Risk



Alabama Behavioral Analysis for Hurricane Evacuation Study. 2011. Morrow & Gladwin through Dewberry for FEMA and USACE.

# Do people understand their exposure?

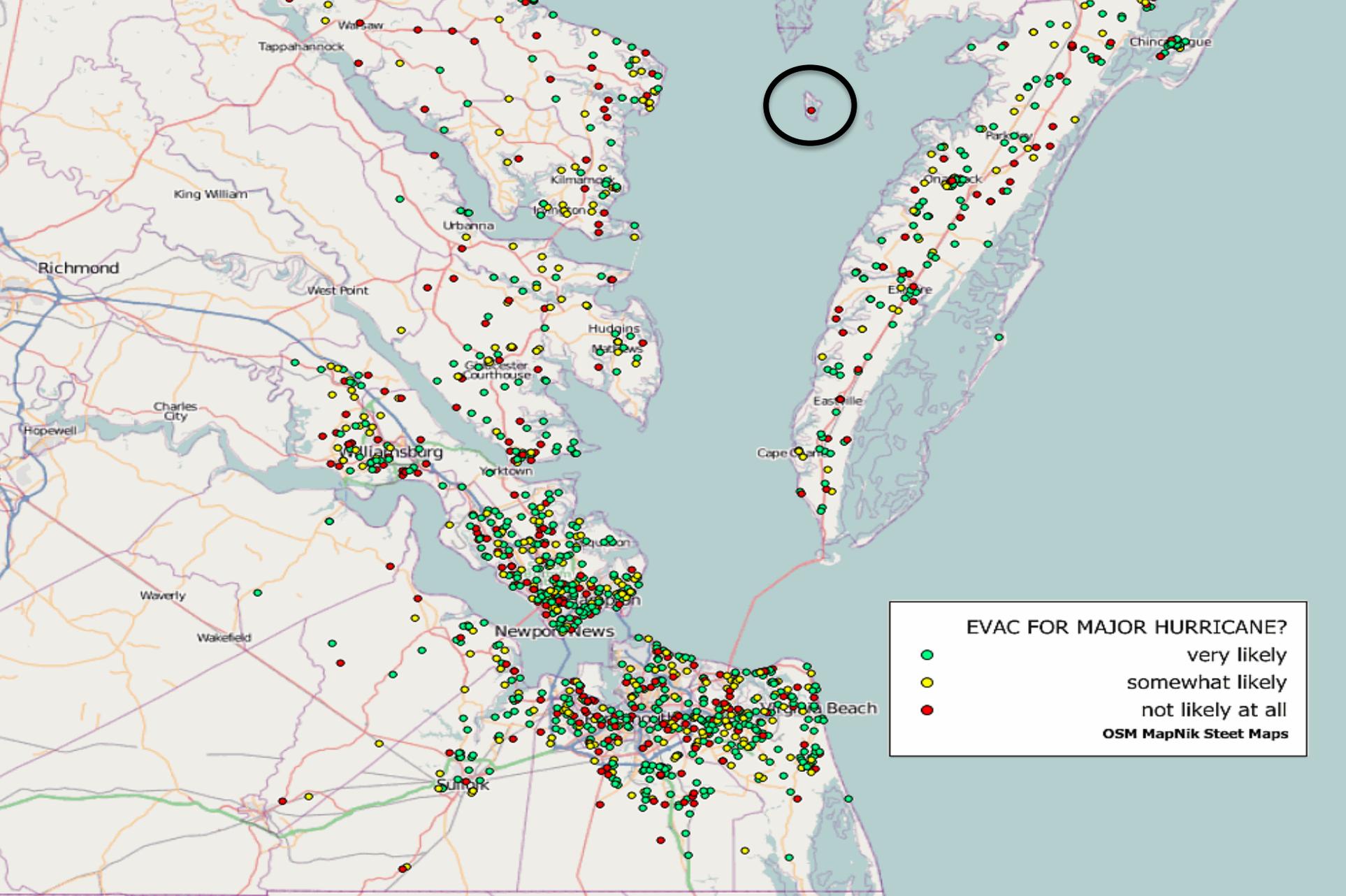


## Likelihood Would Be Flooded in Major Hurricane:

- Not Very Likely
- Somewhat Likely
- Very Likely

Each dot = one interview

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



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

**Perceive  
Risk**

## Vulnerability can be increased by:

- Rapid population growth
- Poverty
- Lack of access to adequate land
- Lack of access to safe housing
- Deforestation
- Urbanization
- Tourism
- Cultural beliefs

3

Perceive  
Risk

*Do you think the public  
understands forecast probability?*

- A. Not at all
- B. Sometimes
- C. Usually
- D. Most of the time

**Perceive  
Risk**

## Some findings related to communicating forecast uncertainty

- Public is used to uncertainty in rainfall forecasts
- People infer uncertainty from deterministic forecasts
- More likely to reduce exposure when uncertainty information provided
- Broadcast mets are in unique position to explain level of uncertainty
- More research needed on the best ways to express TC forecast uncertainty especially in web and social media

3

Perceive  
Risk

## Low Probability, High Impact Events Are Challenging

Compare:

- A. 10% chance of precipitation
- B. 10% chance of TC winds
- C. 10% of life-threatening surge

*What are some examples of people taking protective actions against low probability events?*

3

Perceive  
Risk

*What is the best way to distinguish between a POSSIBLE vs. EXPECTED event?*

- A. Warning, Urgent Warning
- B. Watch, Warning
- C. Alert, Warning
- D. Other



73% Always or  
 Frequently use  
 this map

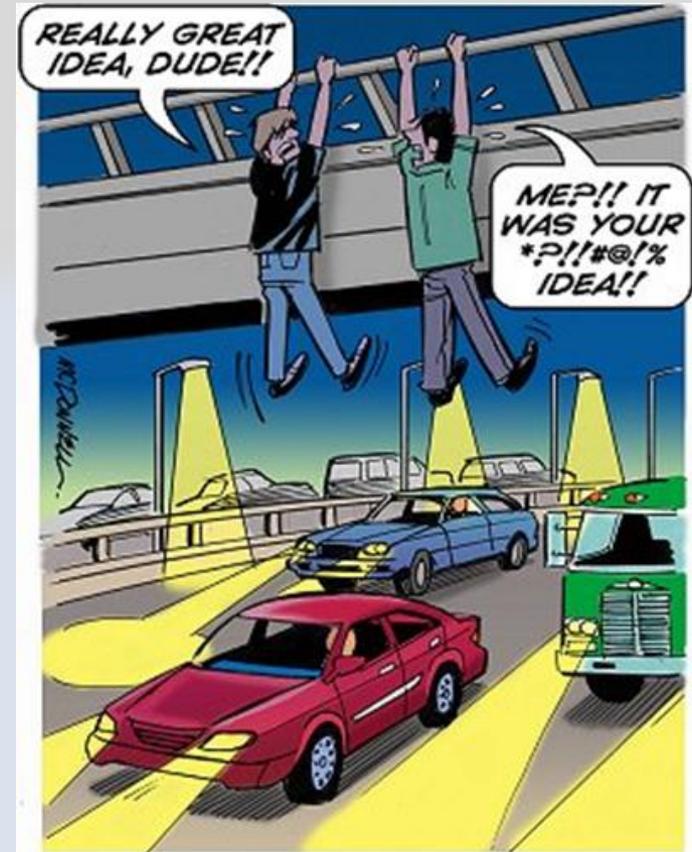
Eastern Research Group for NOAA. 2016. Survey of Coastal Emergency Managers and Media.

## Perceive Risk

# PERSONAL FACTORS

## Individual Differences in Risk Taking

- Personality?
  - Impulsive sensation seeking
  - Aggression
- Biological traits?
  - Sensation seeking (dopamine receptor gene)
- Age Differences
- Gender Differences





# A Little Bit of Psychology



***Which choice would you make?***

- A. Receive \$100 guaranteed**
- B. Take a 50/50 gamble of winning \$200 or nothing?**

***Which choice would you make?***

- A. Take a 50/50 gamble of losing \$200 or nothing**
- B. Lose \$100 guaranteed**



# A Little Bit of Psychology



## Prospect Theory and Loss Aversion:

People tend to be **risk-averse** when they see themselves as ***gaining*** something

- prefer to be certain of receiving \$100, rather than taking their chances at a 50/50 gamble of getting \$200 or nothing

People tend to be **risk-seeking** when they see themselves as ***losing*** something

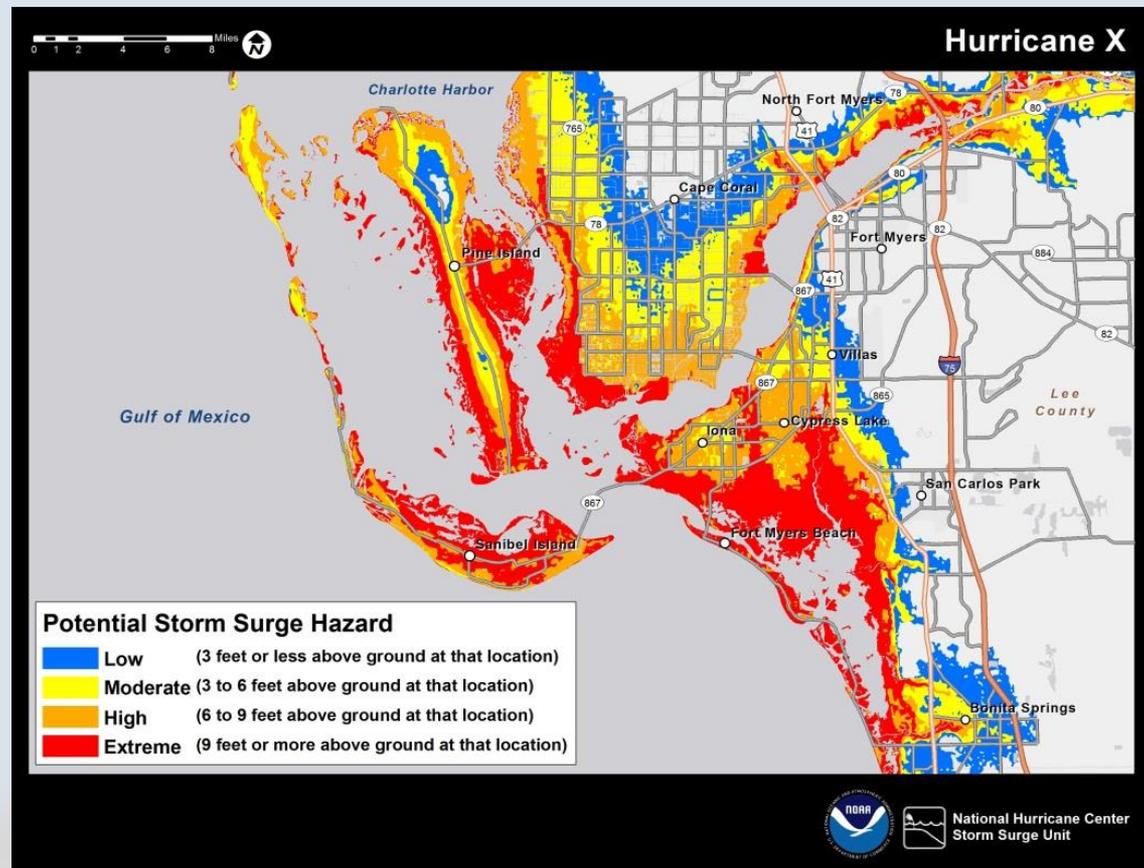
- Prefer to take their chances at a 50/50 gamble of losing \$200 or nothing, rather than being certain of losing \$100

# 4

Believe It  
Applies to  
Them

## Personalizing the Hazard

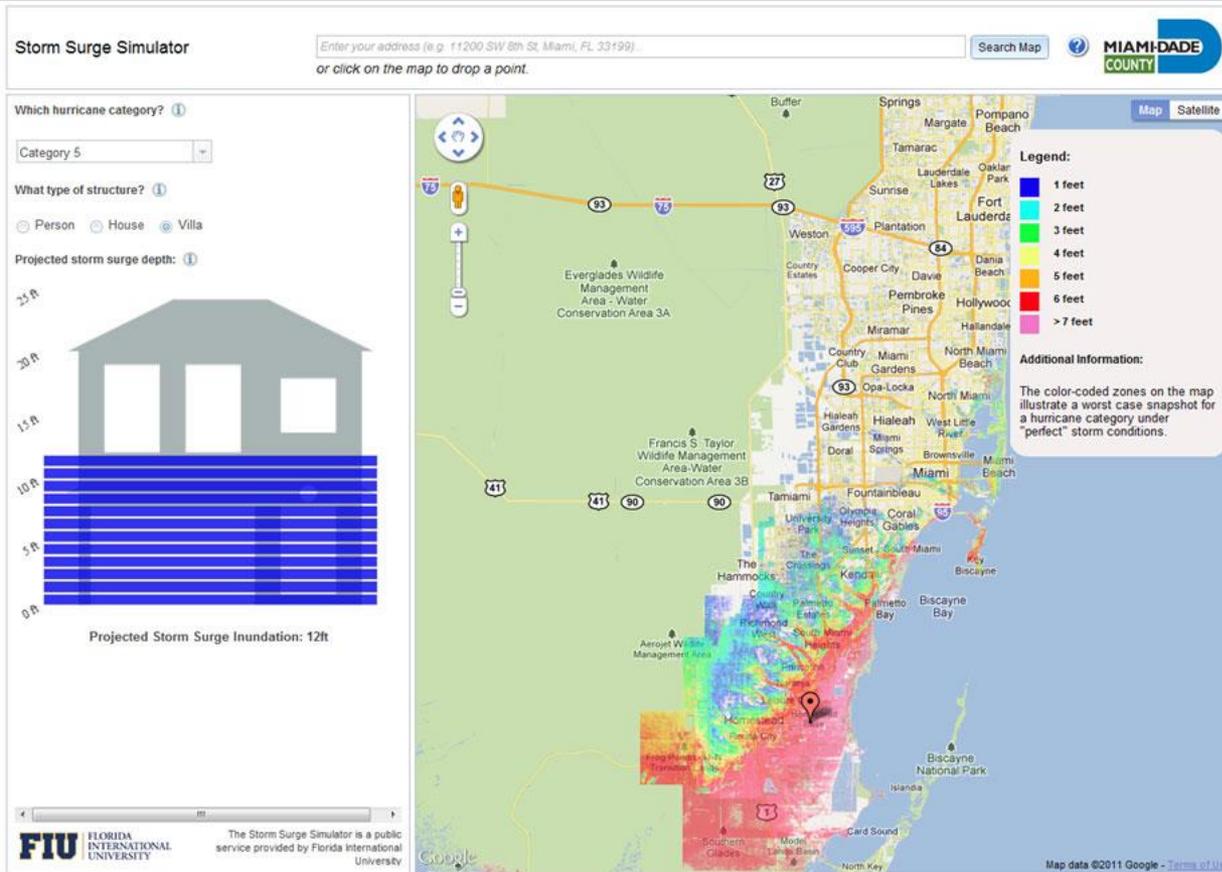
Relationship between forecast and their location needs to be clear



# Personalizing the Hazard



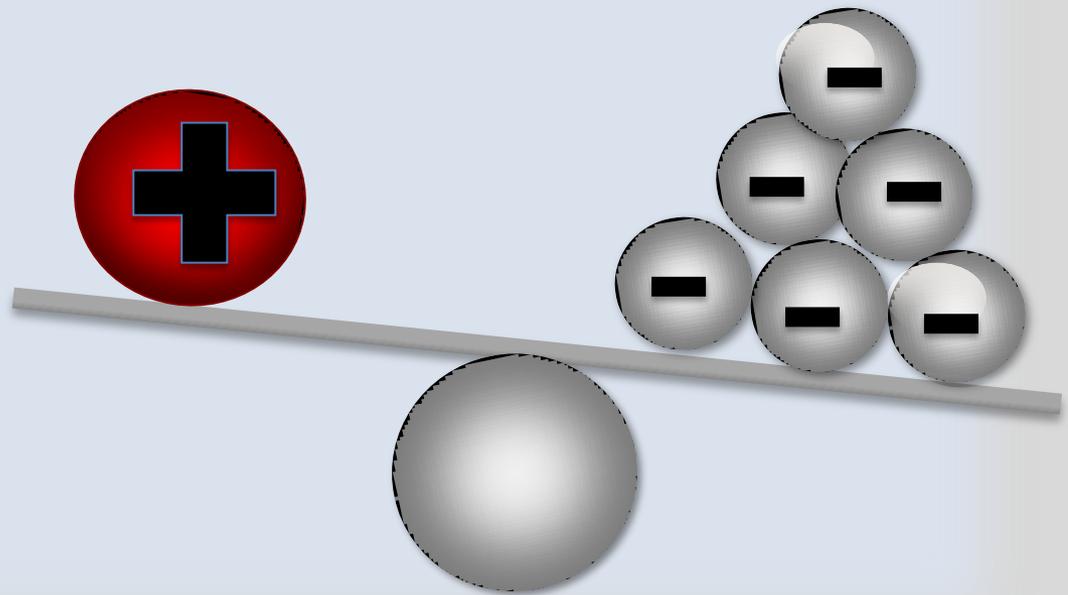
# Personalizing the Hazard



# A Little Bit of Psychology

## *DO I REALLY NEED TO LEAVE?*

Must evoke strong FEELINGS  
to overcome the reasons NOT  
to leave



# Complexities of Personal Safety Decisionmaking

## MIND MAP OF A SURGE ZONE RESIDENT

### COGNITIVE

KNOWLEDGE  
EXPERIENCE

World View  
Personality Traits  
Mental Models

*Sees world as safe or scary*  
*Self efficacy*  
*"Surge is like a flood."*

### SOCIAL

Relationships  
Interactions  
Networks  
*"What are they  
going to do?"*

Evacuate?

### AFFECTIVE

FEELINGS ABOUT:

Hurricanes  
Forecasts  
Home safety  
Travel, Etc.  
RISK

5

**Know What  
To Do**



*Policy Question:*

*Who should be responsible for advising the public about protective actions?*

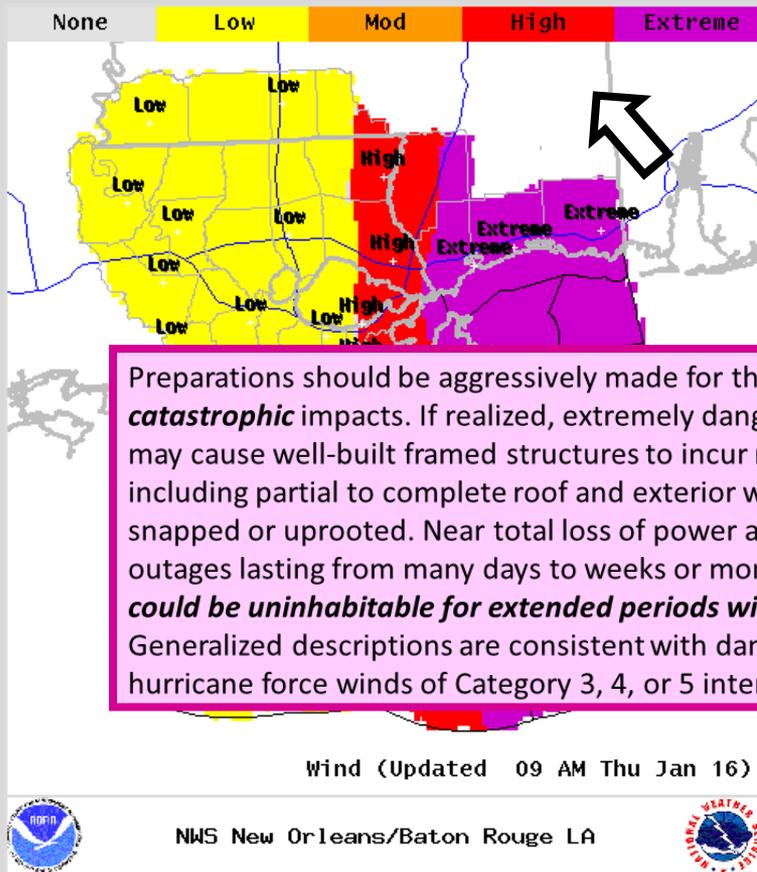
5

**Know What  
To Do**

*Do you agree that weather service forecasters should include Protective Action recommendations to citizens as part of their TC forecasts?*

- A. Strongly agree
- B. Somewhat agree
- C. Somewhat disagree
- D. Not sure

# Example of Proposed NWS Local Impacts and Actions Product



Threat	Potential Impacts to Communities
Extreme	Prepare for the potential of devastating to catastrophic impacts from major hurricane force wind.
High	Prepare for the potential of extensive impacts from hurricane force wind.
Mod	Prepare for the potential of significant impacts from strong tropical storm force wind.
Low	Prepare for the potential of limited impacts from tropical storm force wind.
None	No preparations needed at this time; little to no impacts as wind should remain below tropical storm force.

# RESOURCES?

## Hurricane Katrina - 2005



**Good Forecast**  
56 hours before landfall

## RESOURCES?

# Some Wanted To Leave But Couldn't ....

- Insufficient resources
  - Transportation
  - Cash for gas
  - No place to go

# Steps To Effective Warning Response

**1**

**Understand  
Hazard**

**2**

**Receive and  
Understand  
Message**

**3**

**Perceive  
Risk**

**4**

**Believe It  
Applies**

**5**

**Know What  
To Do**

**RESOURCES?**

**Appropriate Protective Action**

# Social scientists are your friends!

Do people understand TC hazards, such as surge?

Do they understand forecast messages?

Do they understand uncertainty and probabilities?

How do they react to various text and colors?

What factors are associated with risk perception?

Do they recognize their vulnerability?

How much confidence do they have in forecast?

Do they know what the potential impacts and what protective actions to take?

# One Social Science Research Model



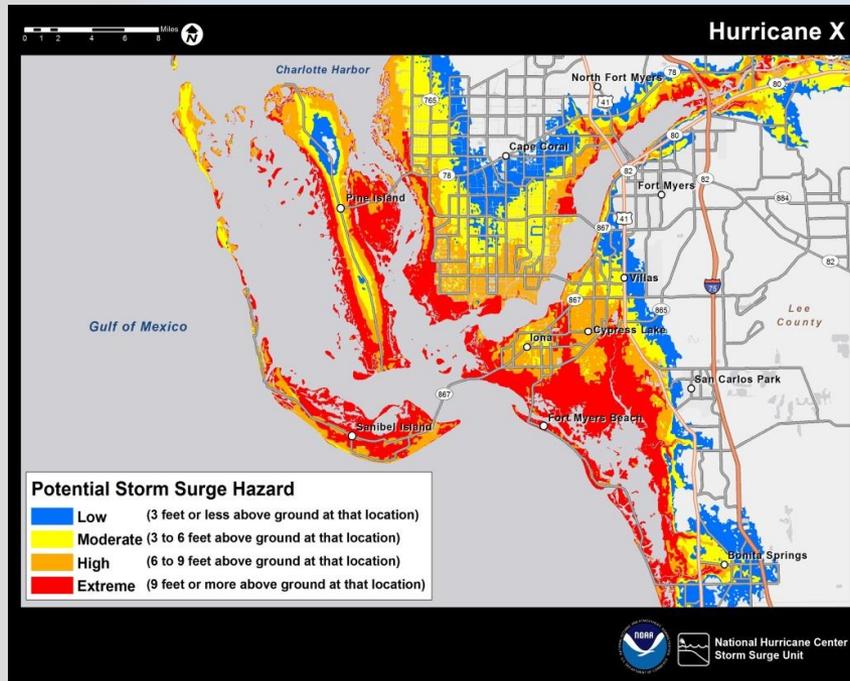
## PRODUCTS:

STORM SURGE  
FLOODING MAP

STORM SURGE  
WARNING

Work completed through Eastern Research Group & National Center for Atmospheric Research and funded by HFIP and NOS Surge Roadmap.

# Storm Surge Map Survey Results



- Preference for this map over solid blue one or graduated blue one
- Problems with using “low” to describe storm surge hazard

## Positive Ratings\*

- Ease of understanding
  - 96% by Media
  - 86% by EMs
  - 77% by Public
  - 90% by WCMs
- Usefulness
  - 94% by Media
  - 84% by EMs
  - 98% by Public
  - 83% by WCMs

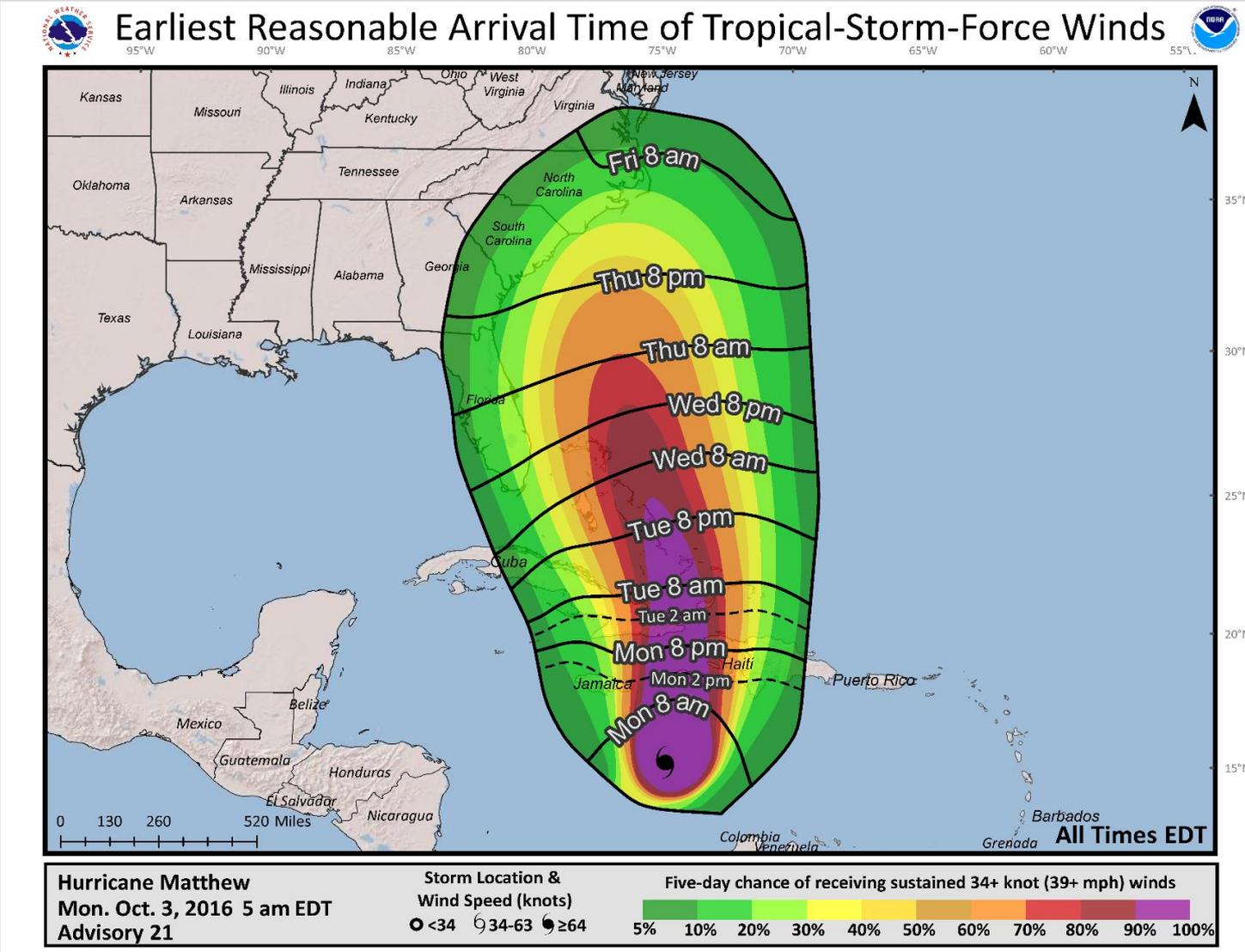
\* Excellent, Very Good or Good

# Other Surge-Related Findings

- Use Above Ground Level datum
  - Describe how derived and what it includes
- Refer to HEIGHT, not depth, when describing levels
  - “1 to 3 feet high”



# Examples of Products Currently Being Developed Using Social Science



# Bottom Line:

- Risk perception and response is very complex
- Forecast only as good as the extent to which it results in appropriate response
- Only scientific way to know how stakeholders interpret and use is to test messages
- Ideal model is an iterative testing process using rigorous social science methodologies during message development with periodic retesting

# Comments or Questions?

[betty@bmorrow.com](mailto:betty@bmorrow.com)

[Robert.Berg@noaa.gov](mailto:Robert.Berg@noaa.gov)