THE ECONOMICS OF NATURAL DISASTERS: ***MOVING FROM RISK ASSESSMENT TO RISK REDUCTION***

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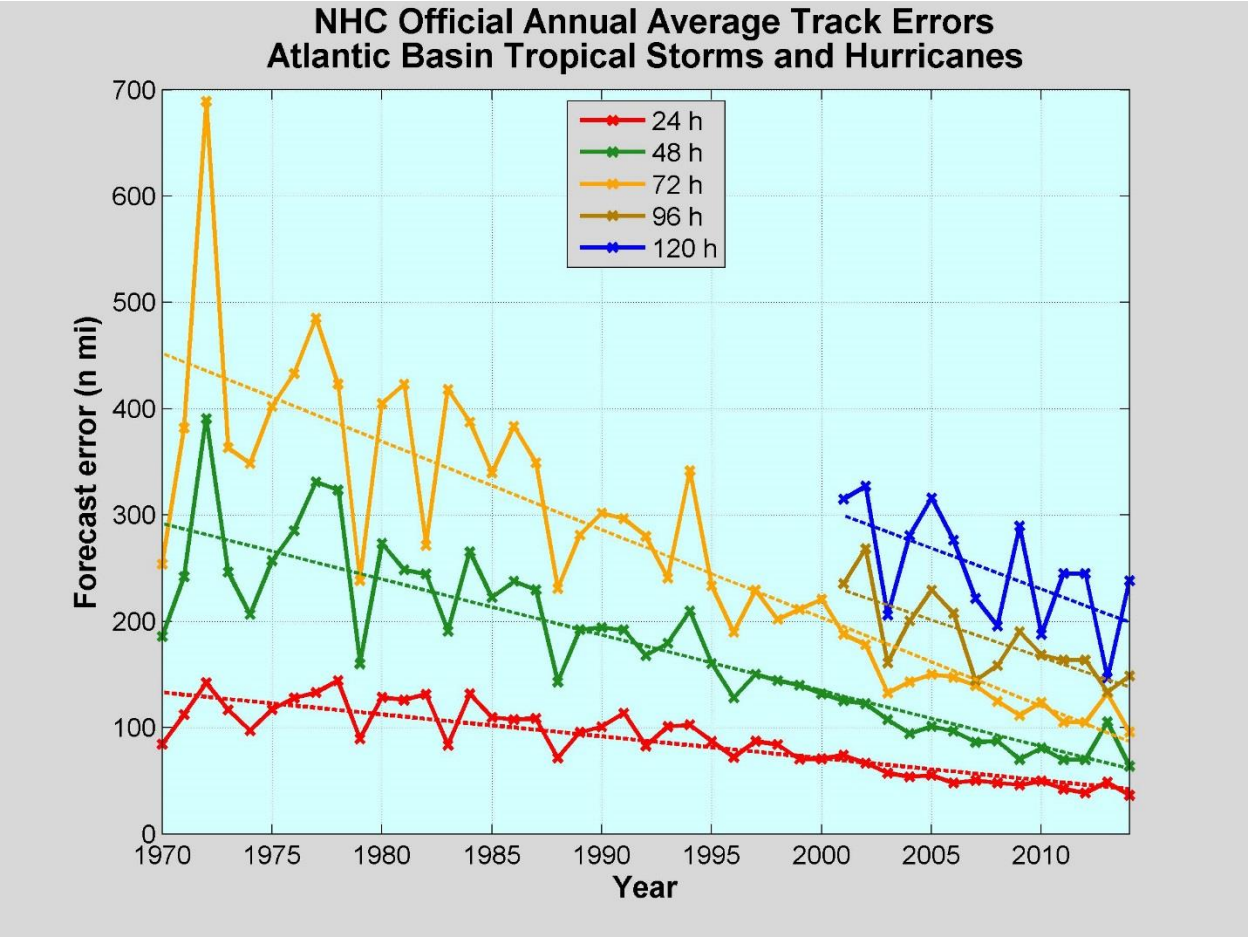
First - let's note the substantial achievements



National Hurricane Center annual average official track errors for Atlantic basin tropical storms and hurricanes for the period 1970-2014, with least-squares trend lines superimposed
(Source:http://www.nhc.noaa.gov/verification/verify5.shtml)

Despite Significant Improvements in Natural Hazard Risk Assessment …

- Upward trend over time in economic losses
- Continued population & exposure growth in high hazard areas
- Increasing vulnerability to disruptions due to interdependencies in economic and social systems
- Underestimation of true total losses

- **Innumerable instances** of inadequate investments in loss reduction measures & poor decision making in natural hazard contexts

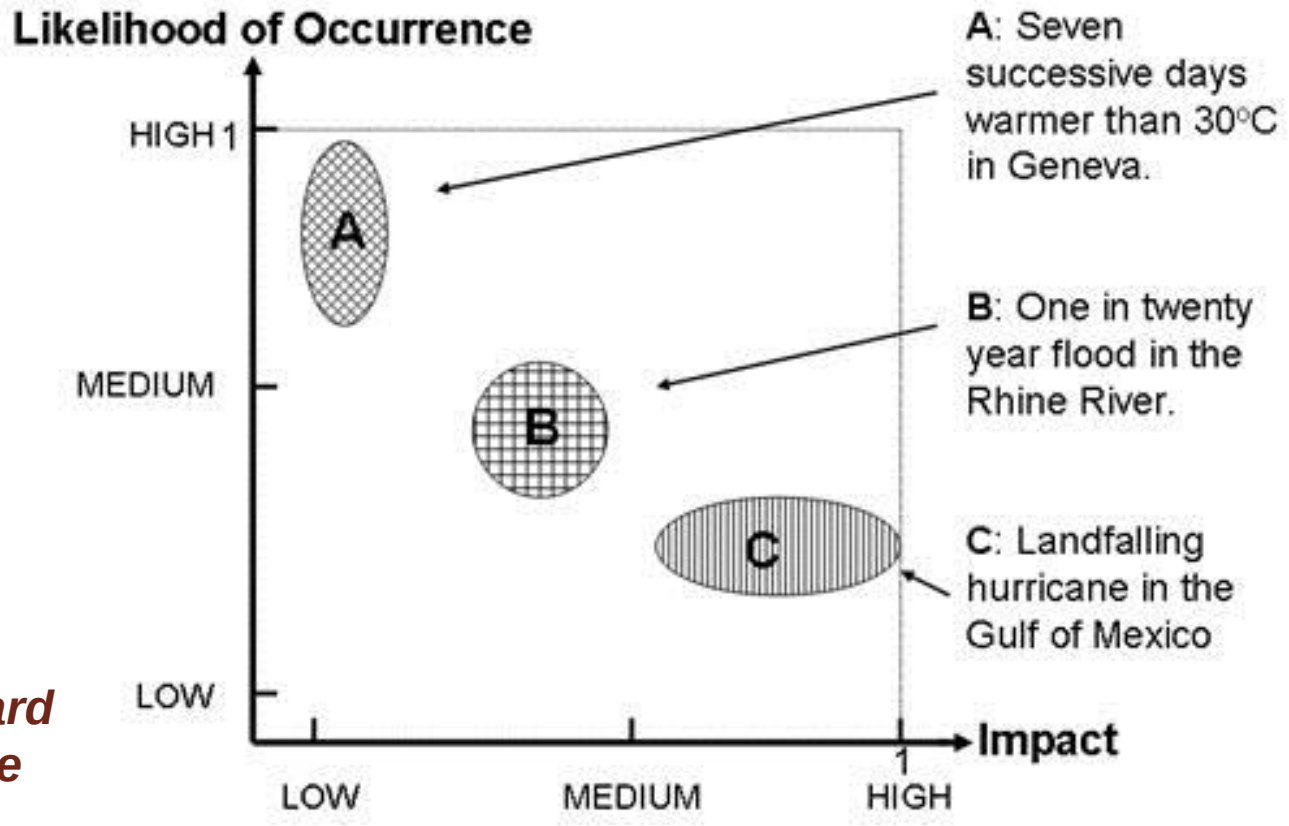
"Experience has shown that a purely technical assessment of risk, however sophisticated and cutting-edge, is by itself unlikely to trigger actions that reduce risk.

Successful risk assessments produce information that is targeted, authoritative, understandable, and usable."

(UNISDR, 2015 pg.148)

This sentiment is becoming more prominent – NRC (2006); NRC (2010); Hirschberg et al. (2011); Morss et al., (2011); NOAA (2015) – amongst a number of others

Risk = Probability *and* Impact

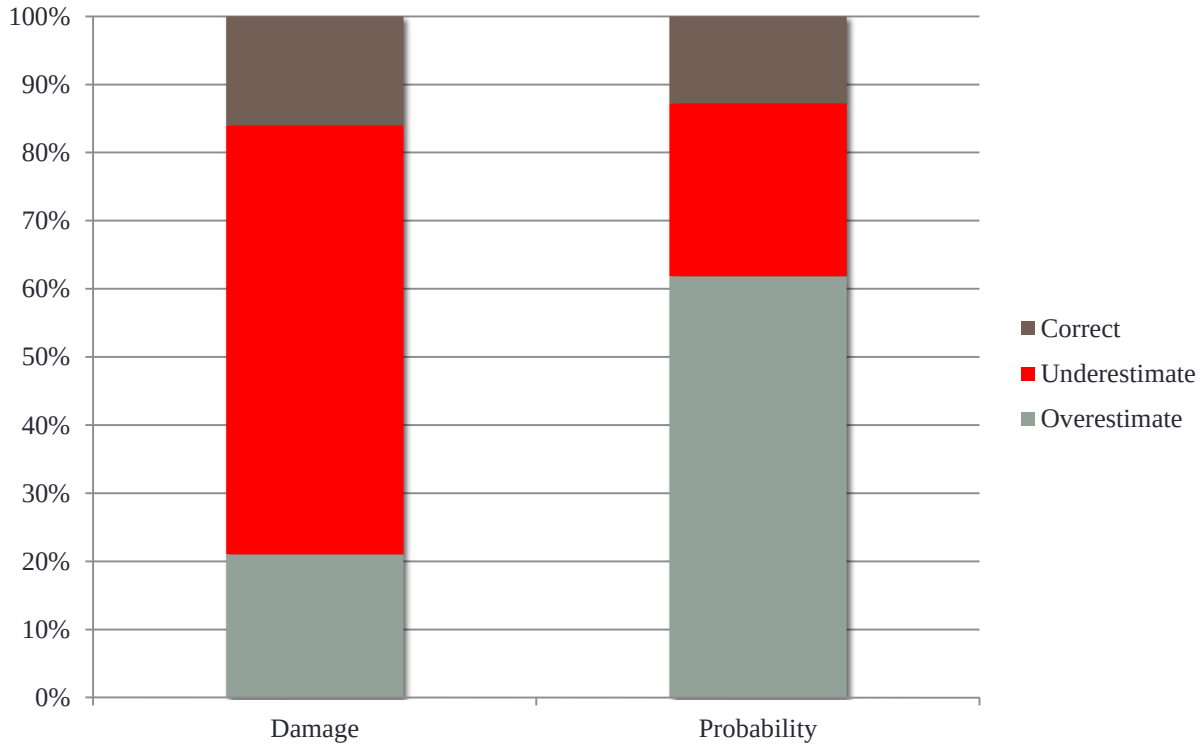


$4.0 billion NOAA 2008 budget => 0.6 percent directed toward social science activities

Natural Hazard Forecast Risk Space.
Figure 3.1 Sourced from Kunreuther and Useem (2010)

Lack of impact knowledge = lack of flood protection in NYC?

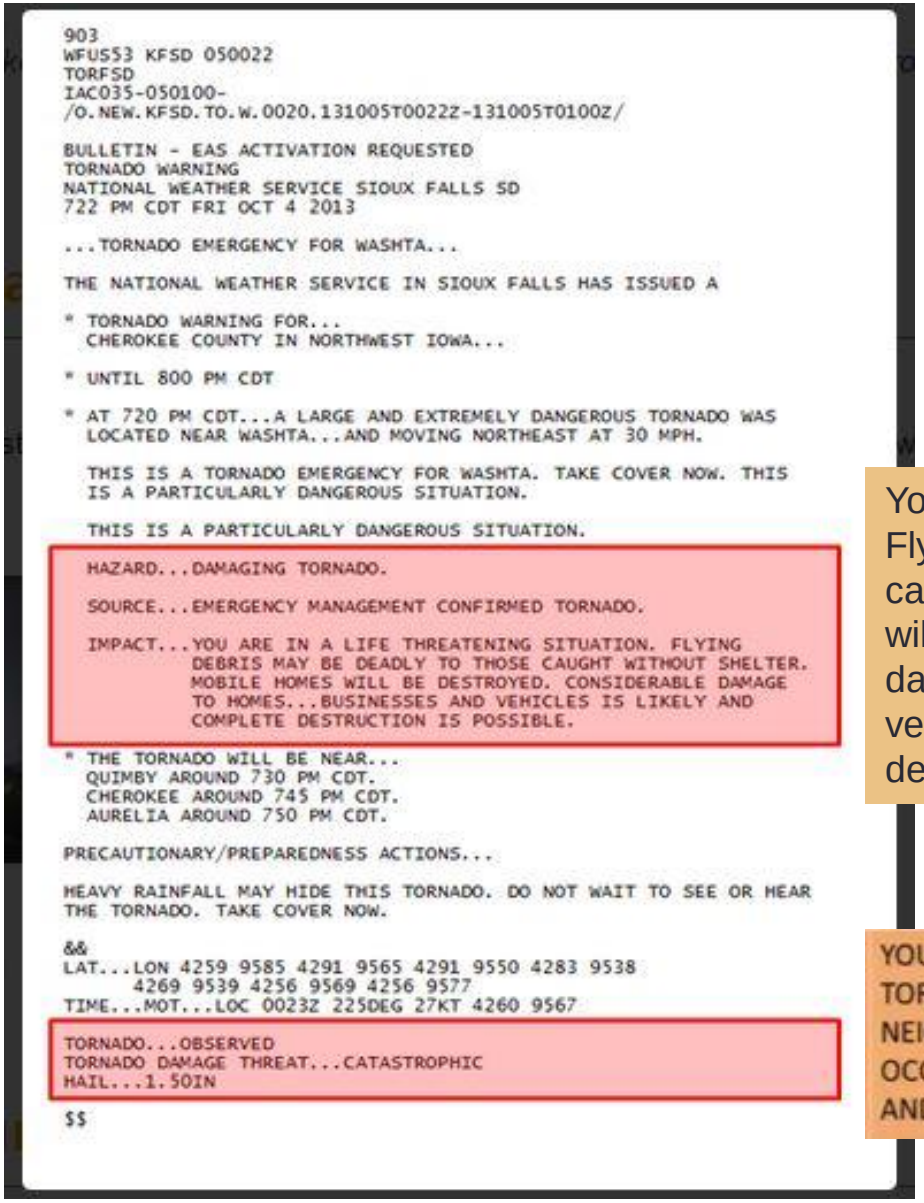
- Botzen et al. (2015) collected flood risk perception data (damage & probability) via a detailed survey in 2013 of more than 1,000 homeowners who all lived in flood-prone areas in NYC.
- Compared responses to catastrophe model objective data



Botzen et al. (2015)

NWS Impact-based Tornado Warnings

Source: NWS 2015 - http://www.weather.gov/impacts/#.Va_h5flViko



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903
WFUS53 KFSD 050022
TORFSD
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BULLETIN - EAS ACTIVATION REQUESTED
TORNADO WARNING
NATIONAL WEATHER SERVICE SIOUX FALLS SD
722 PM CDT FRI OCT 4 2013

...TORNADO EMERGENCY FOR WASHTA...

THE NATIONAL WEATHER SERVICE IN SIOUX FALLS HAS ISSUED A

* TORNADO WARNING FOR...
  CHEROKEE COUNTY IN NORTHWEST IOWA...

* UNTIL 800 PM CDT

* AT 720 PM CDT...A LARGE AND EXTREMELY DANGEROUS TORNADO WAS
  LOCATED NEAR WASHTA...AND MOVING NORTHEAST AT 30 MPH.

  THIS IS A TORNADO EMERGENCY FOR WASHTA. TAKE COVER NOW. THIS
  IS A PARTICULARLY DANGEROUS SITUATION.

  THIS IS A PARTICULARLY DANGEROUS SITUATION.

  HAZARD...DAMAGING TORNADO.

  SOURCE...EMERGENCY MANAGEMENT CONFIRMED TORNADO.

  IMPACT...YOU ARE IN A LIFE THREATENING SITUATION. FLYING
           DEBRIS MAY BE DEADLY TO THOSE CAUGHT WITHOUT SHELTER.
           MOBILE HOMES WILL BE DESTROYED. CONSIDERABLE DAMAGE
           TO HOMES...BUSINESSES AND VEHICLES IS LIKELY AND
           COMPLETE DESTRUCTION IS POSSIBLE.

* THE TORNADO WILL BE NEAR...
  QUIMBY AROUND 730 PM CDT.
  CHEROKEE AROUND 745 PM CDT.
  AURELIA AROUND 750 PM CDT.

PRECAUTIONARY/PREPAREDNESS ACTIONS...

HEAVY RAINFALL MAY HIDE THIS TORNADO. DO NOT WAIT TO SEE OR HEAR
THE TORNADO. TAKE COVER NOW.

&&
LAT...LON 4259 9585 4291 9565 4291 9550 4283 9538
      4269 9539 4256 9569 4256 9577
TIME...MOT...LOC 0023Z 225DEG 27KT 4260 9567

TORNADO...OBSERVED
TORNADO DAMAGE THREAT...CATASTROPHIC
HAIL...1.50IN

$$
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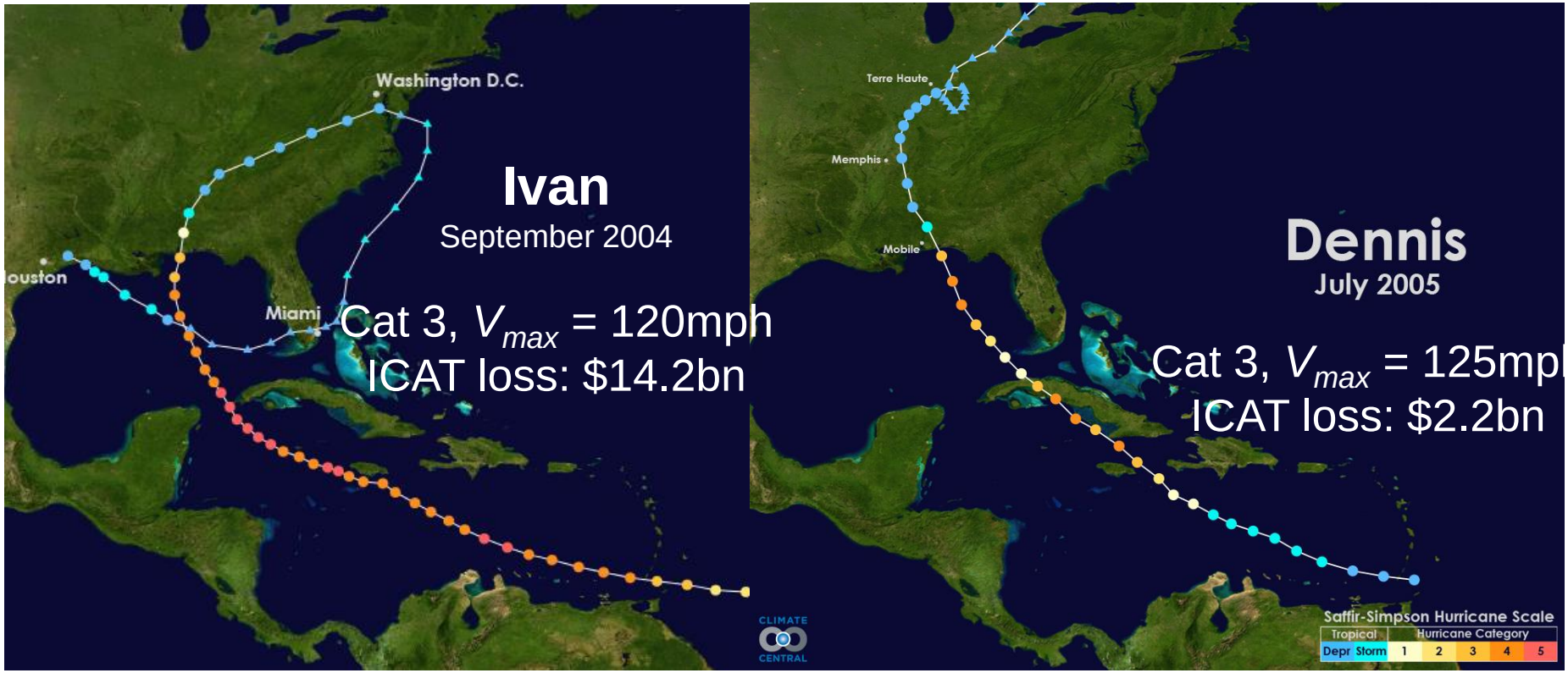
You are in a life threatening situation. Flying debris may be deadly to those caught without shelter. Mobile homes will be destroyed. Considerable damage to homes … businesses and vehicles is likely and complete destruction is possible

YOU COULD BE KILLED IF NOT UNDERGROUND OR IN A TORNADO SHELTER. COMPLETE DESTRUCTION OF NEIGHBORHOODS...BUSINESSES AND VEHICLES WILL OCCUR. FLYING DEBRIS WILL BE DEADLY TO PEOPLE AND ANIMALS.

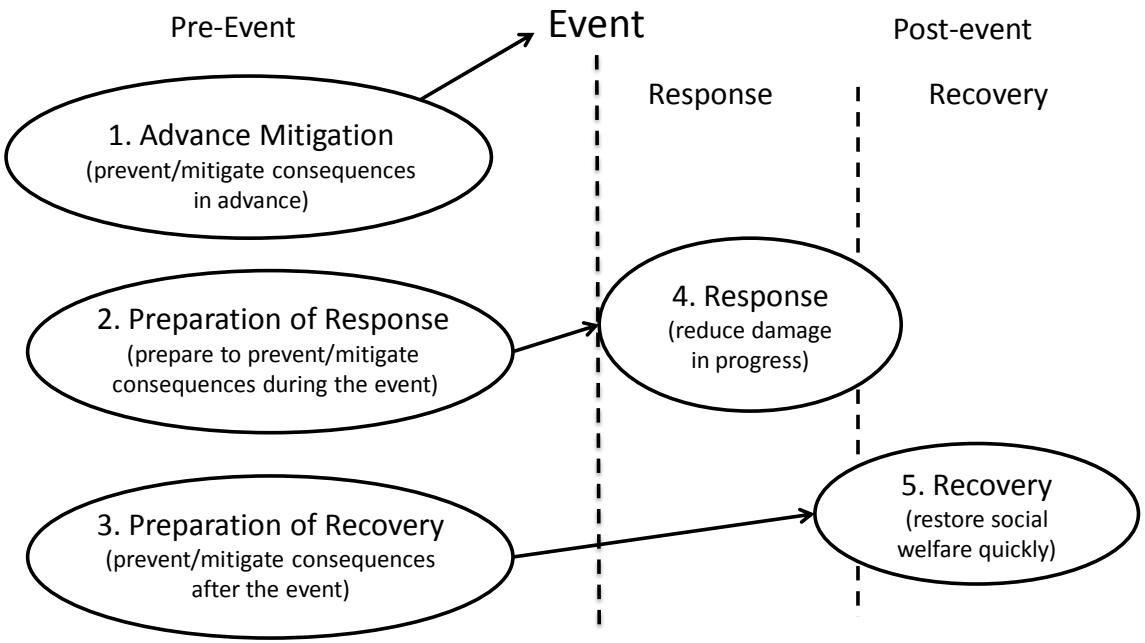
Existing evidence (e.g., Morss and Hayden, 2010) suggests these extreme impacts messages have the potential to lead to more protective action for some but also to simultaneously dissuade others

A multitude of concurrent factors drive hazard event risk => Requires an ***integrated risk assessment***



Czajkowski and Done (2014)

The extent of overall impacts is **not isolated in time** associated only to the event



Overall Timeline of Natural Disaster Risk. Figure 2.2 Sourced from Kunreuther and Useem (2010)

How to extend risk space timescale to allow for optimal total risk reduction efforts?

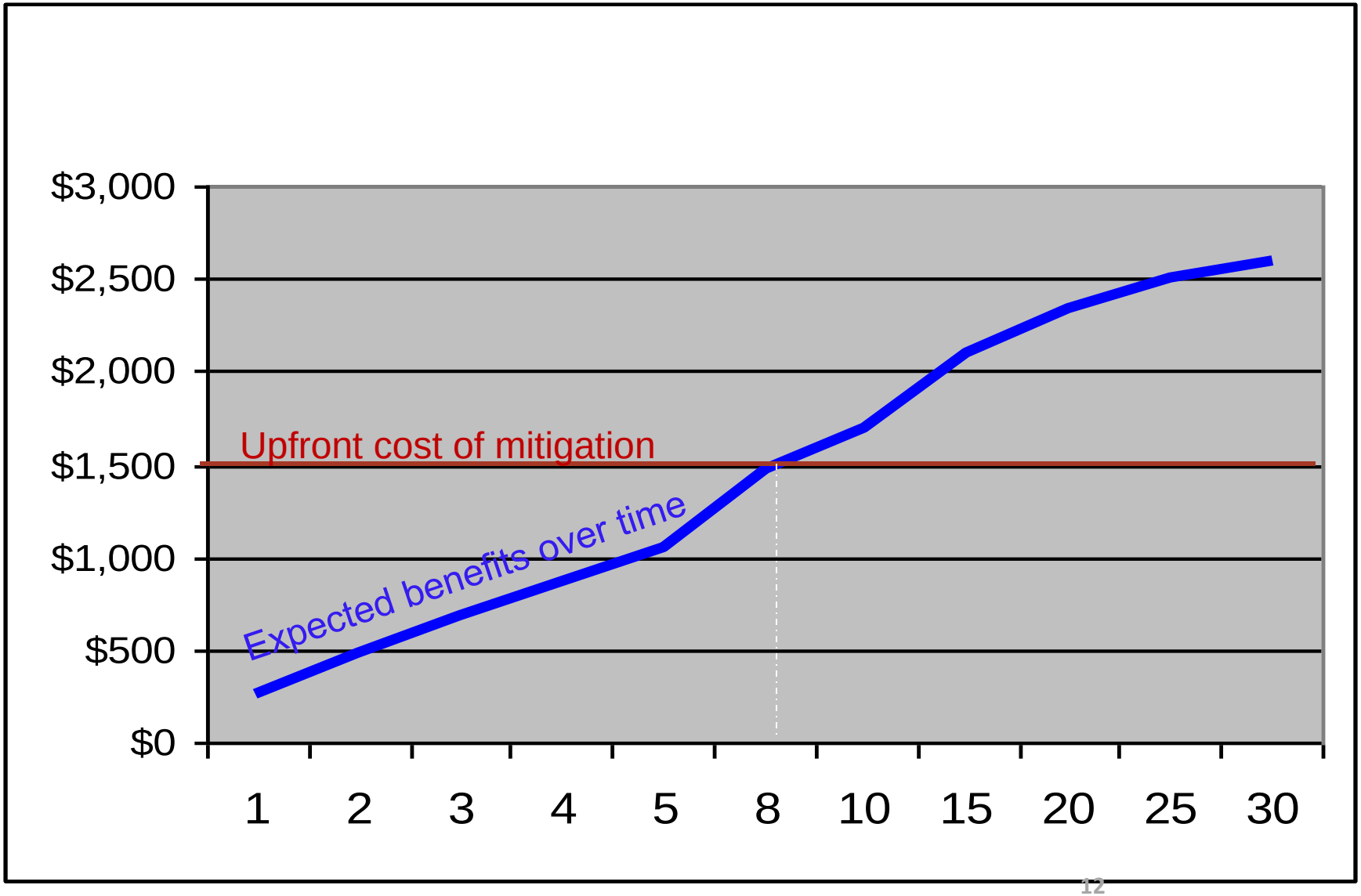
Acting in time – a need to recognize the role of **behavior**

- Behavioral biases in time
  - Pre-event mitigation => costs are immediate and certain whereas benefits are somewhere in the future and uncertain in time and return
  - A number of intertemporal biases would preclude this action

Example:

- Cost of Mitigation: $1,500 to strengthen roof of house
- Nature of Disaster:
  - 1/100 chance of disaster
  - Reduction in loss ($27,500)
- Expected Annual Benefits: $275 (1/100 * $27,500)
- Annual Discount Rate of 10%

Expected Benefit-Cost Analysis of Mitigation (Annual Discount Rate 10%)



Event Decision Making in Natural Hazard Risk Space from an Economic Perspective

Outcome / Action	Landfall Strike (P = 0.3)	Landfall Miss (P = 0.7)	Expected Utility
Stay	-2000	0	(0.3 x -2000) + (0.7 x 0) = -600
Evacuate	1500	-500	(0.3 x 1500) + (0.7 x -500) = 100

But I can't not pay attention. Not with two weather apps and a hurricane tracker app on both my iPhone and iPad that ping when something's stirring out there in the Atlantic. Moments after waking up this week, I reach for my cellphone to stare squinty-eyed at the screen to see what awful prophecies the storm trackers have conjured up that morning.

Then, all day long on my desktop computer, hurricane updates flash through Facebook and Twitter, which get shared and retweeted and amplified on the Internet, building up into a kind of social media crescendo. Never mind that almost all of this stuff is just a variation of the periodic updates coming out of the National Hurricane Center. It's inescapable. It's hypnotic.

It doesn't help one's state of mind that Erika's making an appearance just as we media folks are cranking out 10th anniversary stories on hurricanes Katrina and Wilma, reminding South Floridians that low-rent Category 1 or 2 storms can inflict a lot of misery on a region.

Read more here: http://www.miamiherald.com/news/local/news-columns-blogs/fred-grimm/article32474649.html#storylink=cpy

Event Complexity - a further need to recognize **behavior**

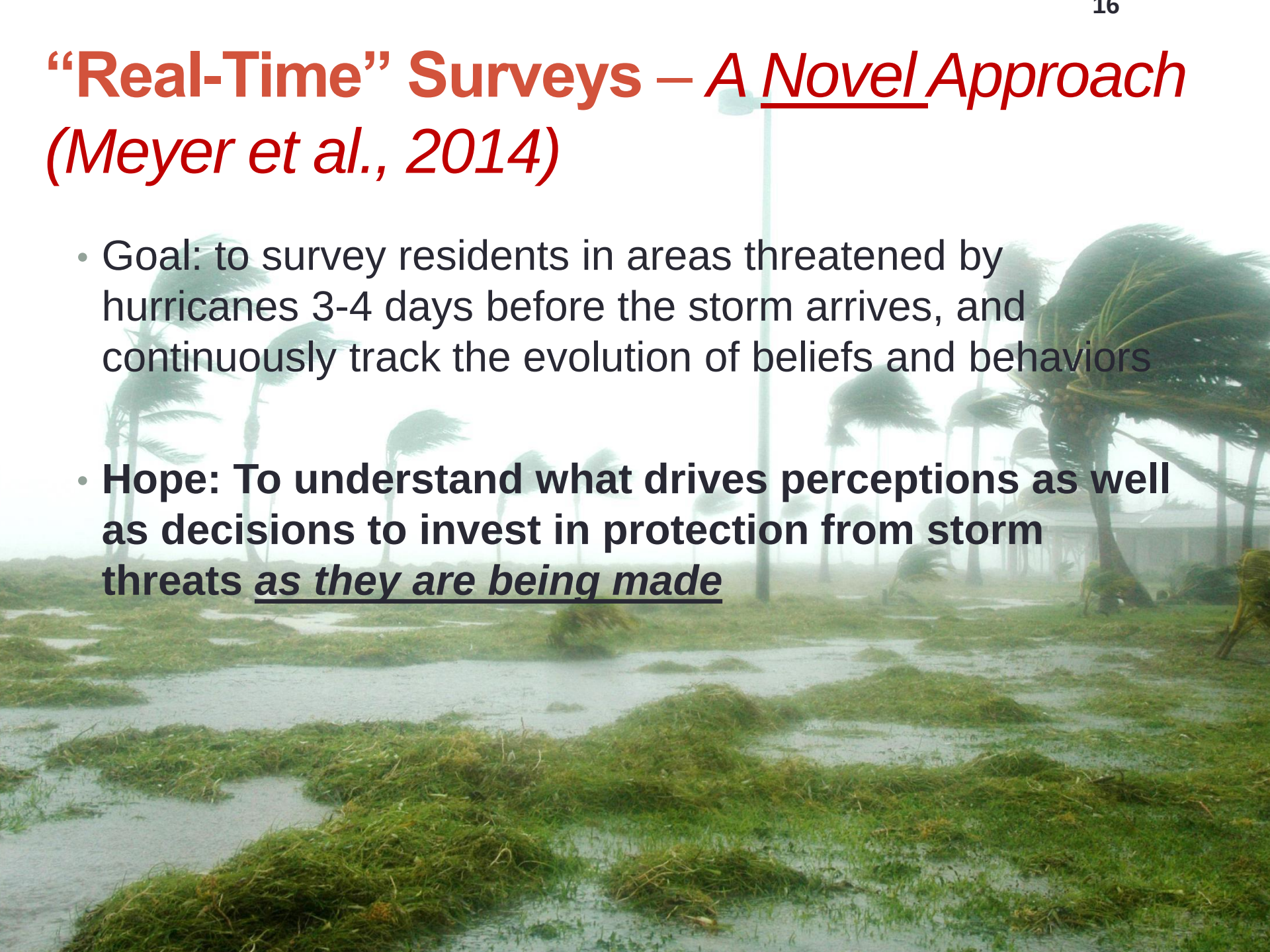
- Natural hazard risk is a complex decision making environment
  - may induce less than “rational behavior”
  - Intuitive (System 1) & Deliberative Thinking (System 2) – Kahneman (2011)
    - System 1 operates automatically and quickly with little or no effort
    - System 2 allocates attention to effortful and intentional mental activities

- Rather a combination of systematic biases coupled with simplified decision rules
  - ***Availability Bias –*** Estimating likelihood of a disaster by its salience
  - ***Threshold Models –*** Failure to take protective measures if perceived likelihood of disaster is below threshold level of concern

"Real-Time" Surveys – *A Novel Approach (Meyer et al., 2014)*

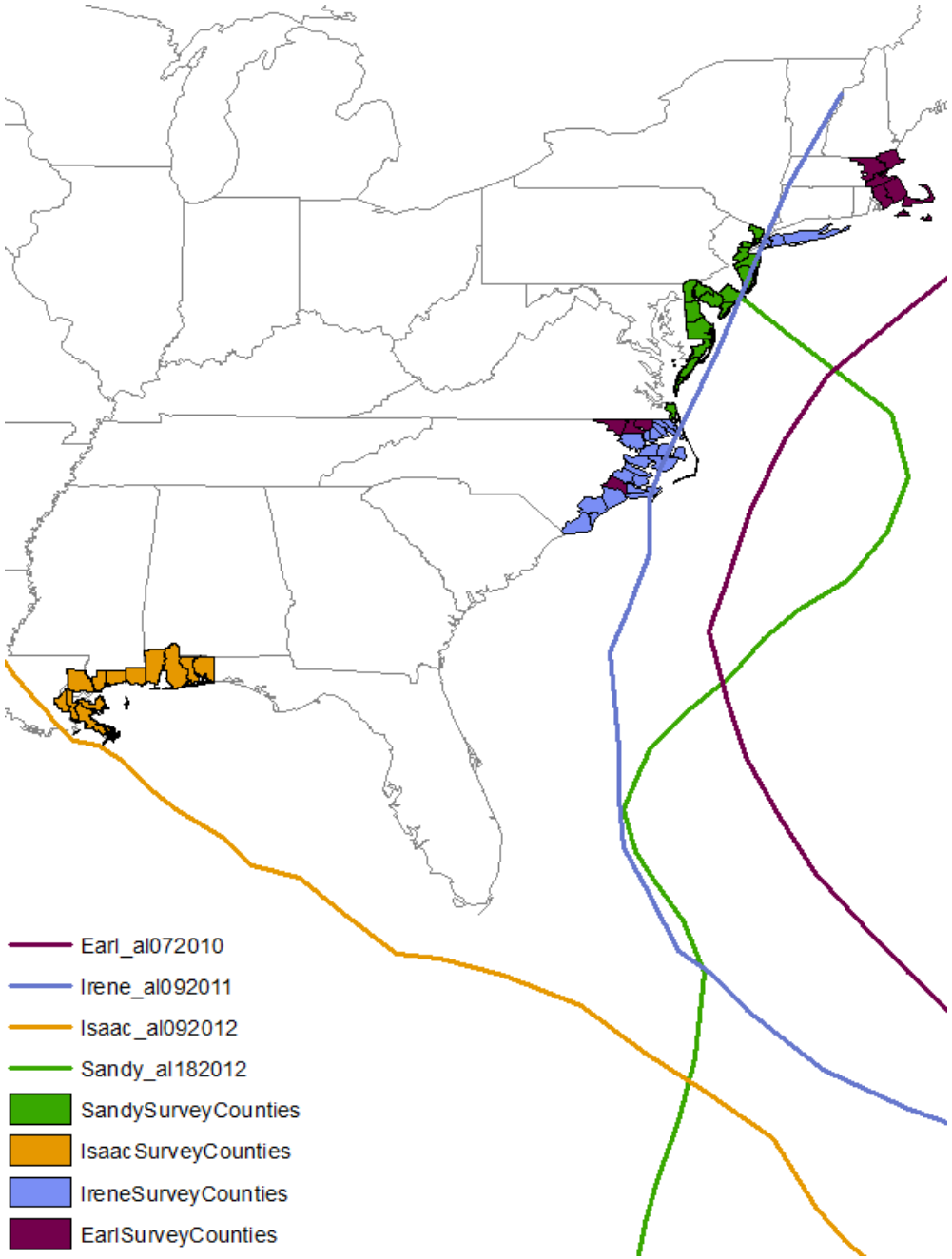
- Goal: to survey residents in areas threatened by hurricanes 3-4 days before the storm arrives, and continuously track the evolution of beliefs and behaviors

- **Hope: To understand what drives perceptions as well as decisions to invest in protection from storm threats *as they are being made***

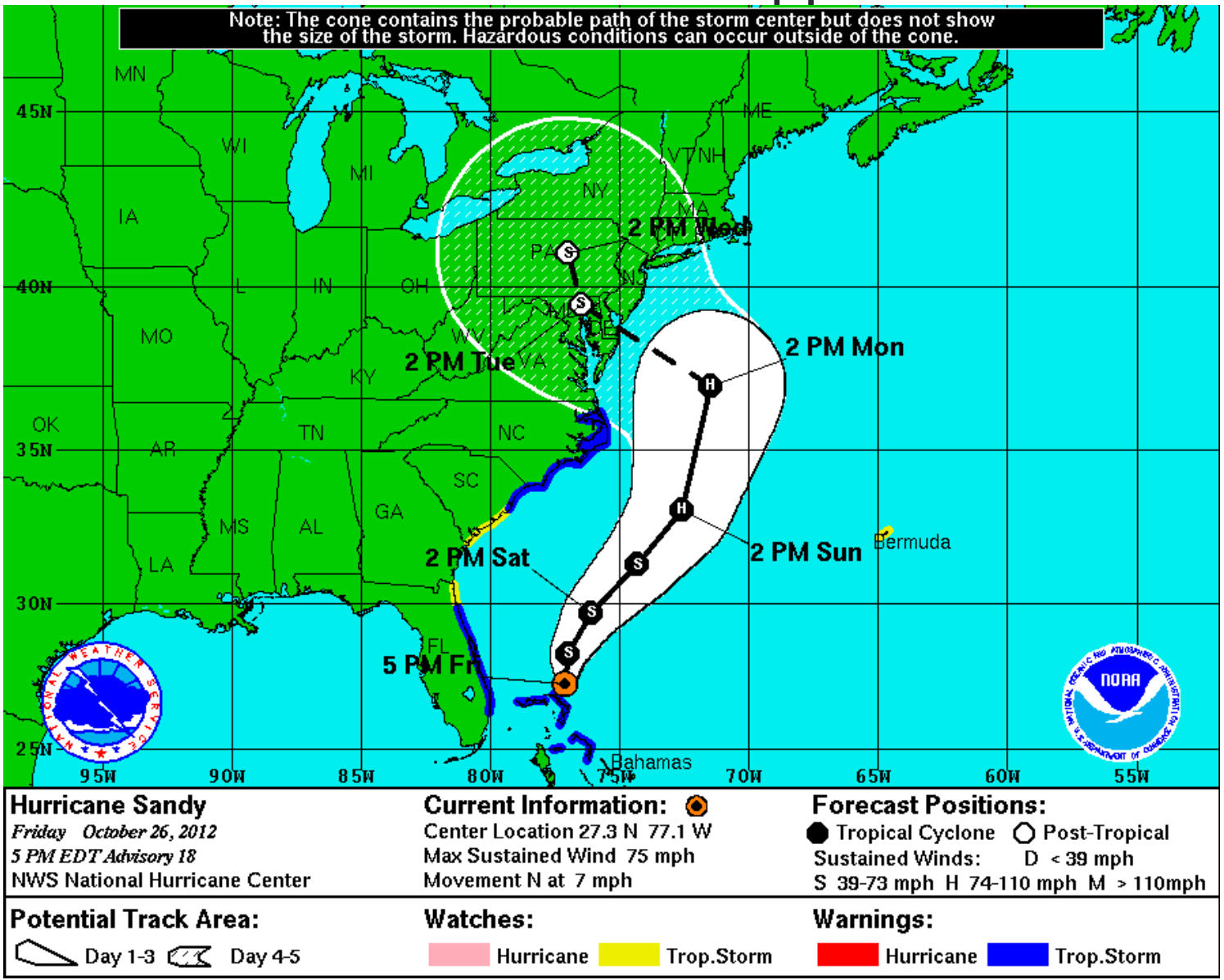


Earl, Irene, Isaac, Sandy: *Natural Experiments in Decision Making*

- All were **mega "media events"**
- Both Irene and Isaac triggered **significant mandatory evacuation orders**
- Wide **variation** in past storm **experience**



Method: Phone surveys, beginning 3 days before each storm made its closest approach - 3 times a day

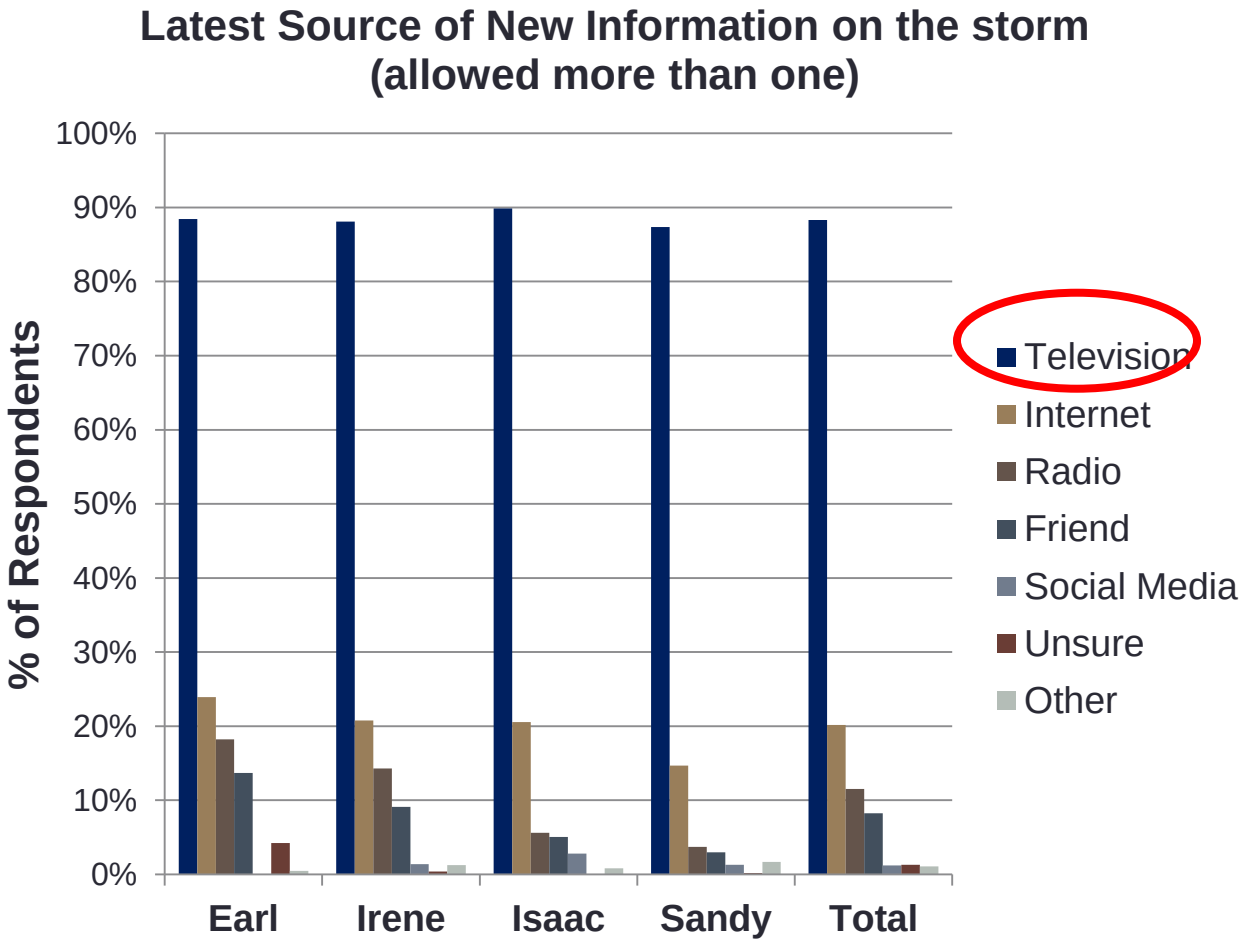


Sandy when interviews were started in VA, MD, DE, and NJ

Survey Information Gathered

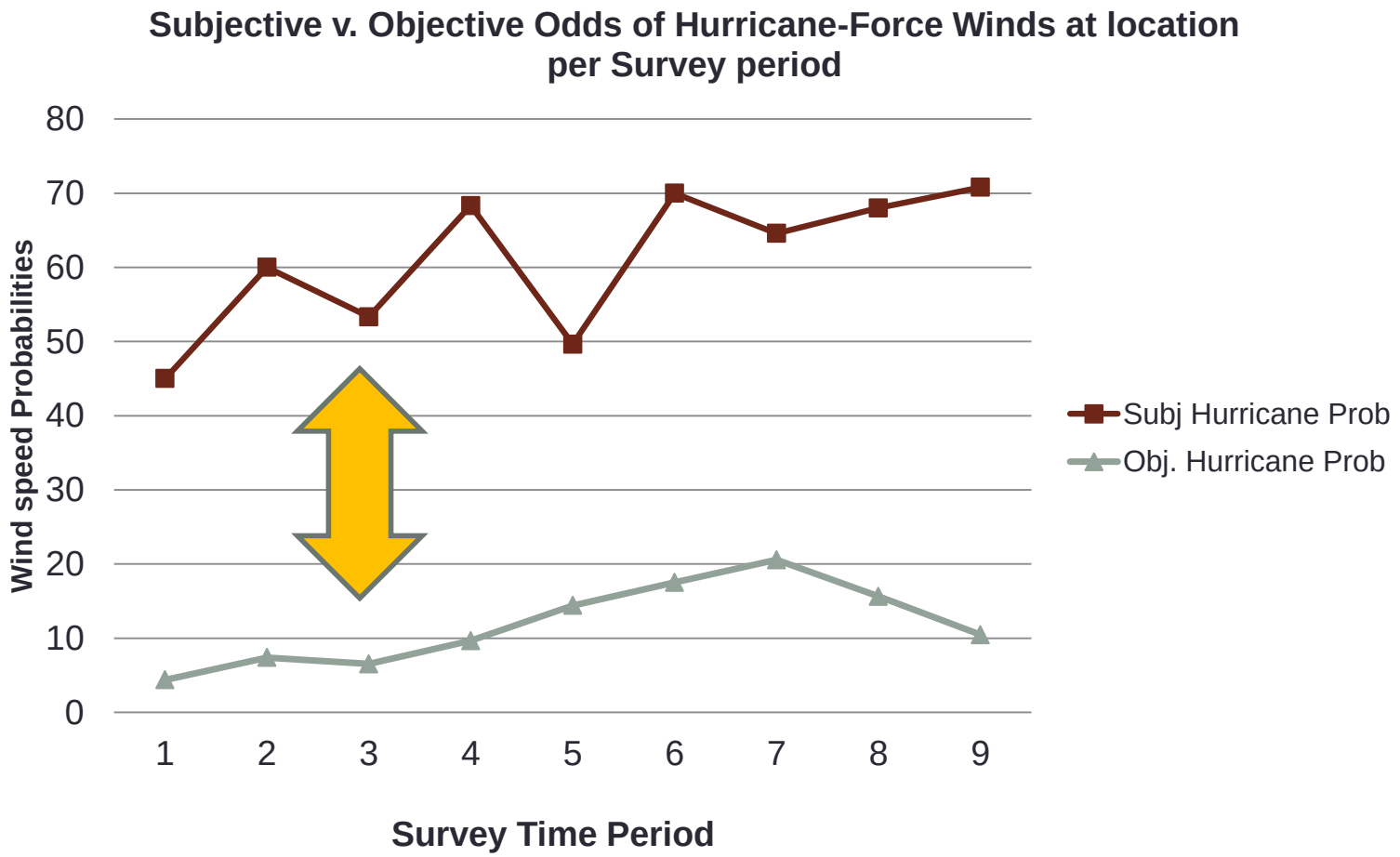
- Information sources and communication
- Beliefs and knowledge about the storm threat *(e.g., odds that home would be hit by hurricane-force winds, degree of worry & feeling of safety, knowledge of warnings)*
- Preparedness actions, mitigation, insurance
- Evacuation actions and reasoning
- Socio-demographics, past storm experience

Don't believe what you've heard about social media: ***Hurricanes are TV events***

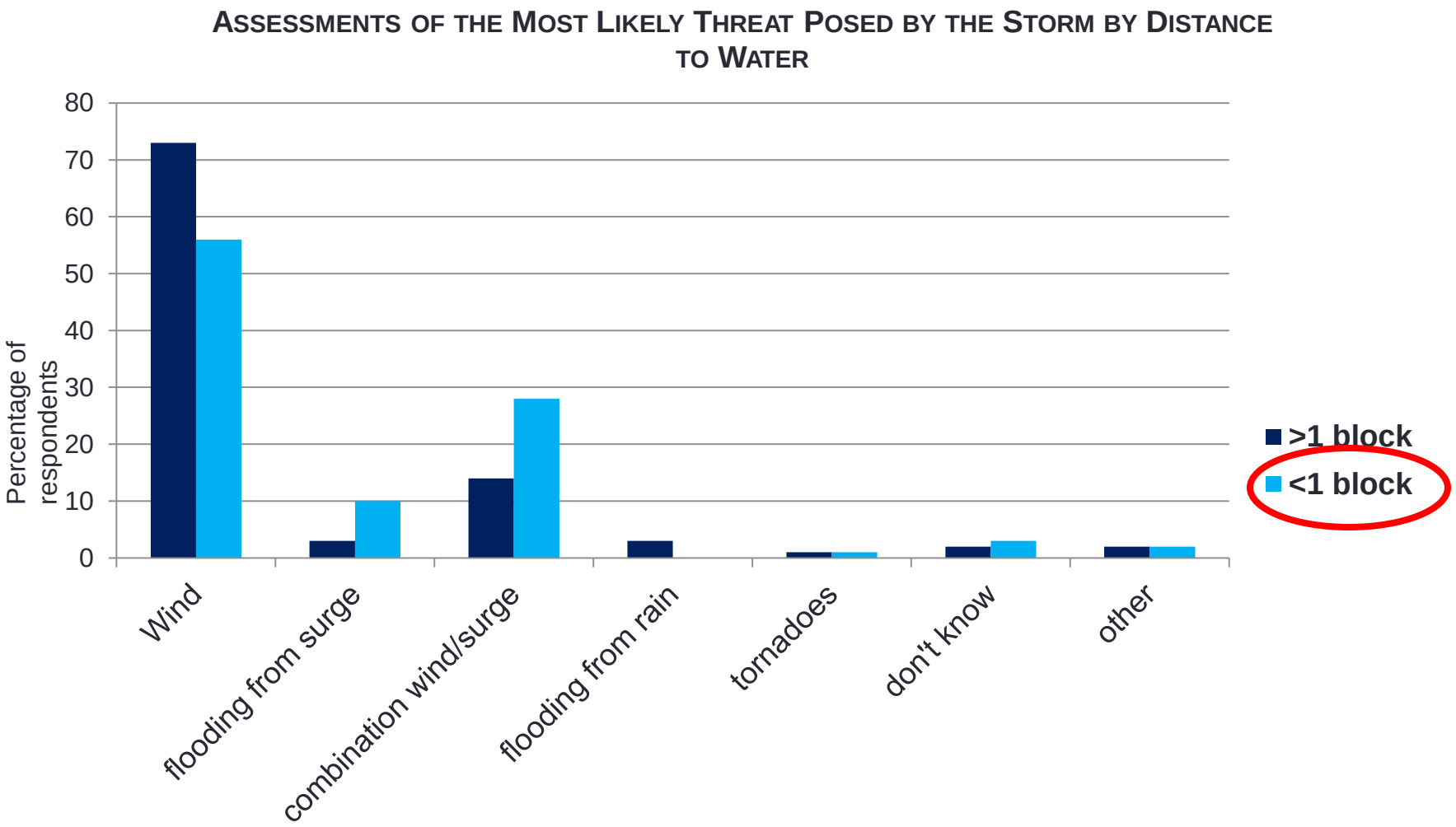


What are people (not) learning from television?

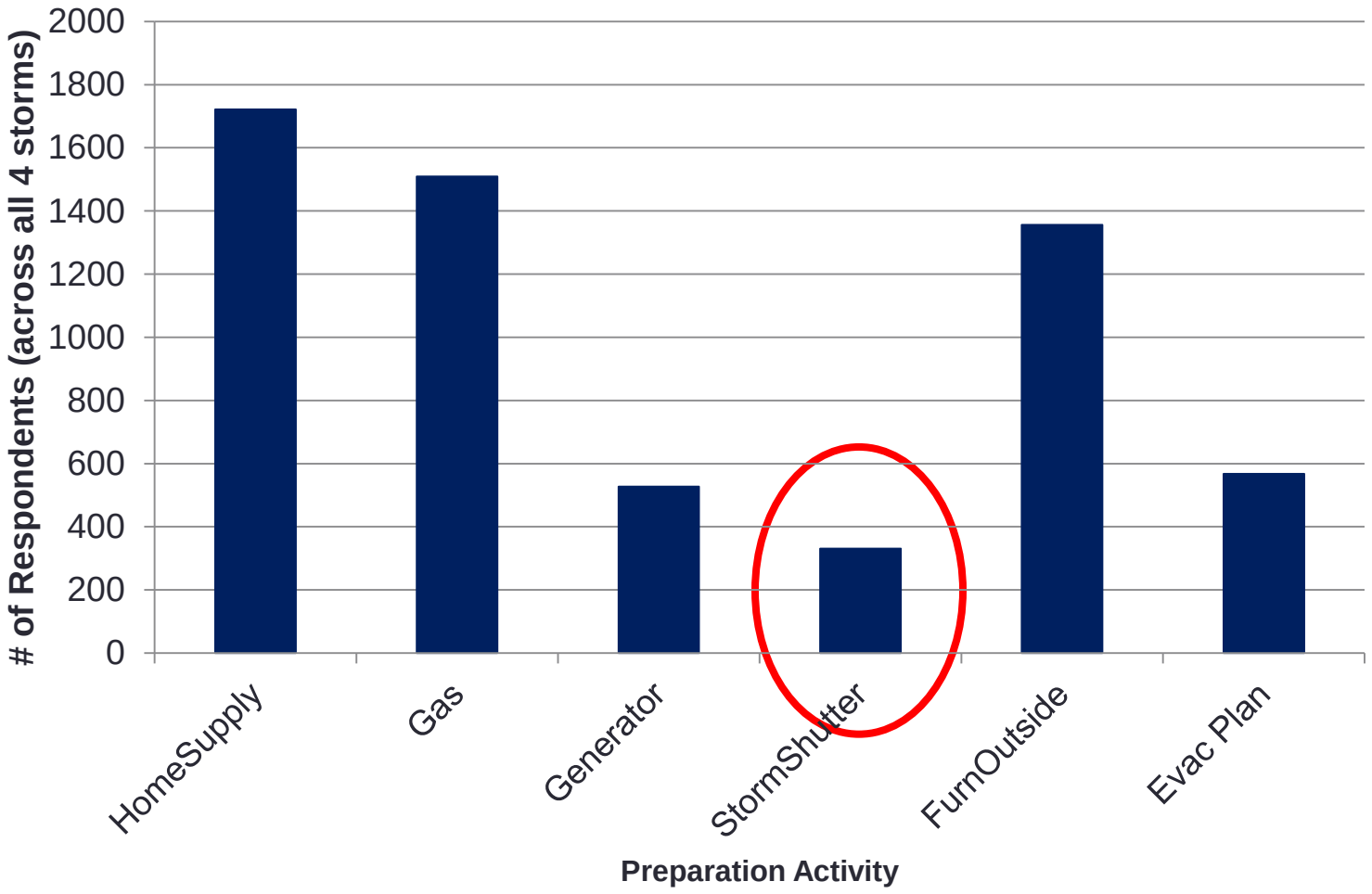
- Gross *over-estimation of the odds of experiencing hurricane-force winds.* *Sandy - NJ*



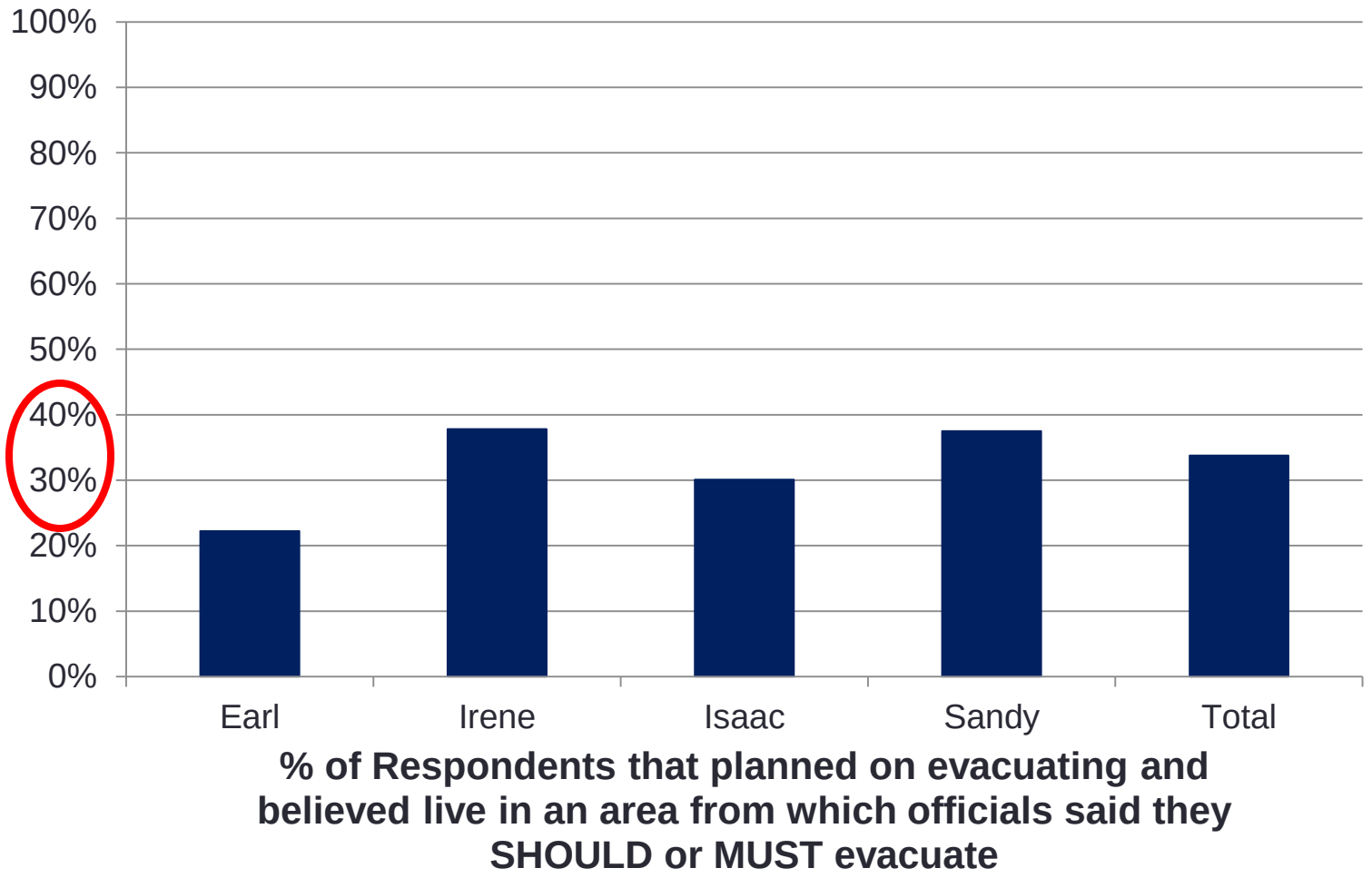
*Poor sense of impacts – Not all that worried (optimistic bias) & **Wind** is the greatest perceived risk even for those on the water in Sandy*



Translation into Different Preventive Actions



Evacuation: *Only 1/3 ordered to evacuate planned to do so*

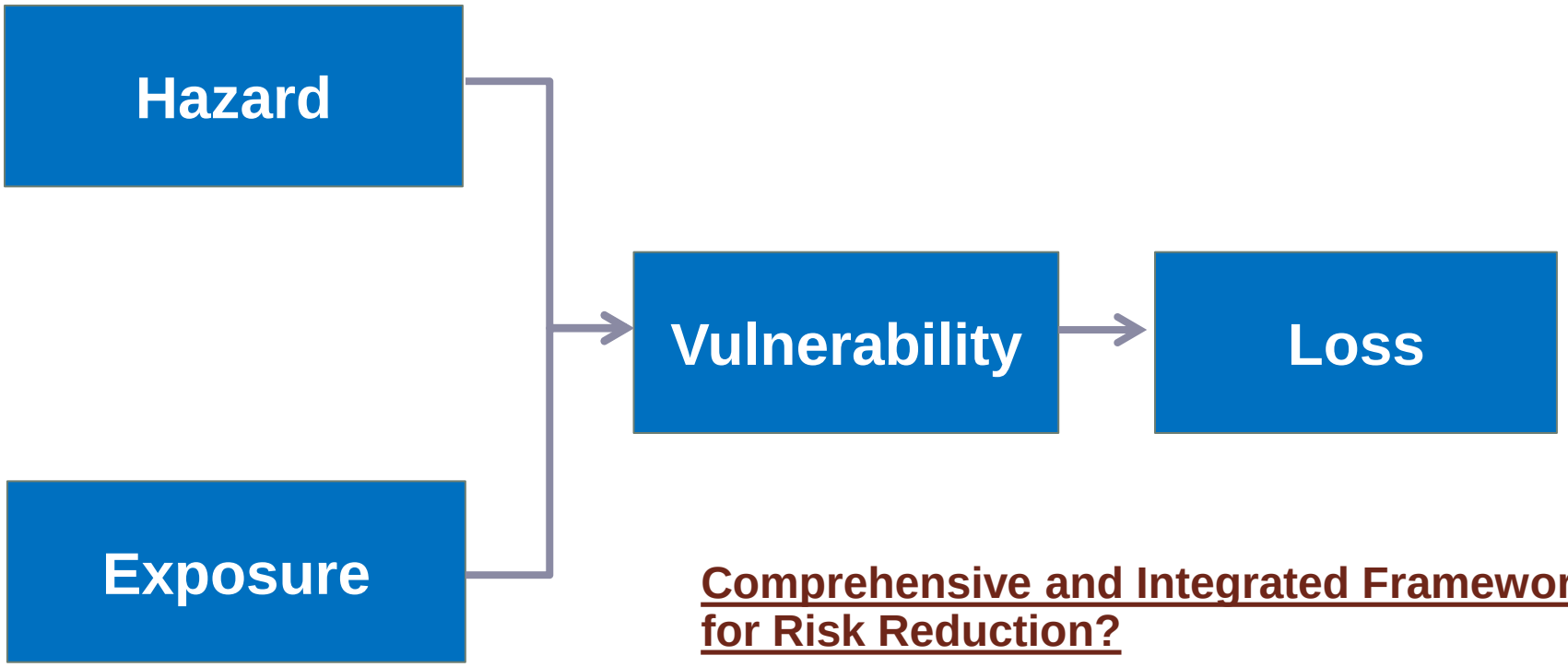


Three years worth of data for four major storms tell similar stories:

- TV driven events with a strong focus on wind impacts
- Overestimation of the probability of being impacted from hurricane force winds, but not that worried about damages from these impacts
- Preparation activities seem to reflect this with light preparation taking place readily, but high-effort preparation activities being more limited
- Limited long-term mitigation activities in-place
- Limited flood insurance in place and high levels of confusion surrounding actual coverage

Does Behavior *Really* Matter? Images from Sandy

Traditional Catastrophic Modeling of Extreme Risks



Comprehensive and Integrated Framework for Risk Reduction?

- ❑ One-way relationships and non-distinguishable time scales
- ❑ Heavy emphasis on the hazard component
- ❑ Role of *Behavior / Risk Perception*
- ❑ Primarily utilized for *industry* purposes

Concluding research recommendations

- Develop warning and forecast products that assess and communicate risk from both probability *and* impact perspective (including the notion of uncertainty).
- Account for the various behavioral biases to have been extensively shown in the socio-economic research literature when designing risk communication tools or incentivizing more proactive preparation/mitigation and/or recovery activities
- Extend the timescale of the risk forecast space into pre-event preparation/mitigation and post-event recovery planning – possibly use stronger sets of decision defaults; i.e., whether one should not prepare
- Extend catastrophe models to include risk perception and behavior components via agent-based modeling techniques
- Integrated modeling across fields including utilizing big data, smart-phone apps, and experimental/simulated settings

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