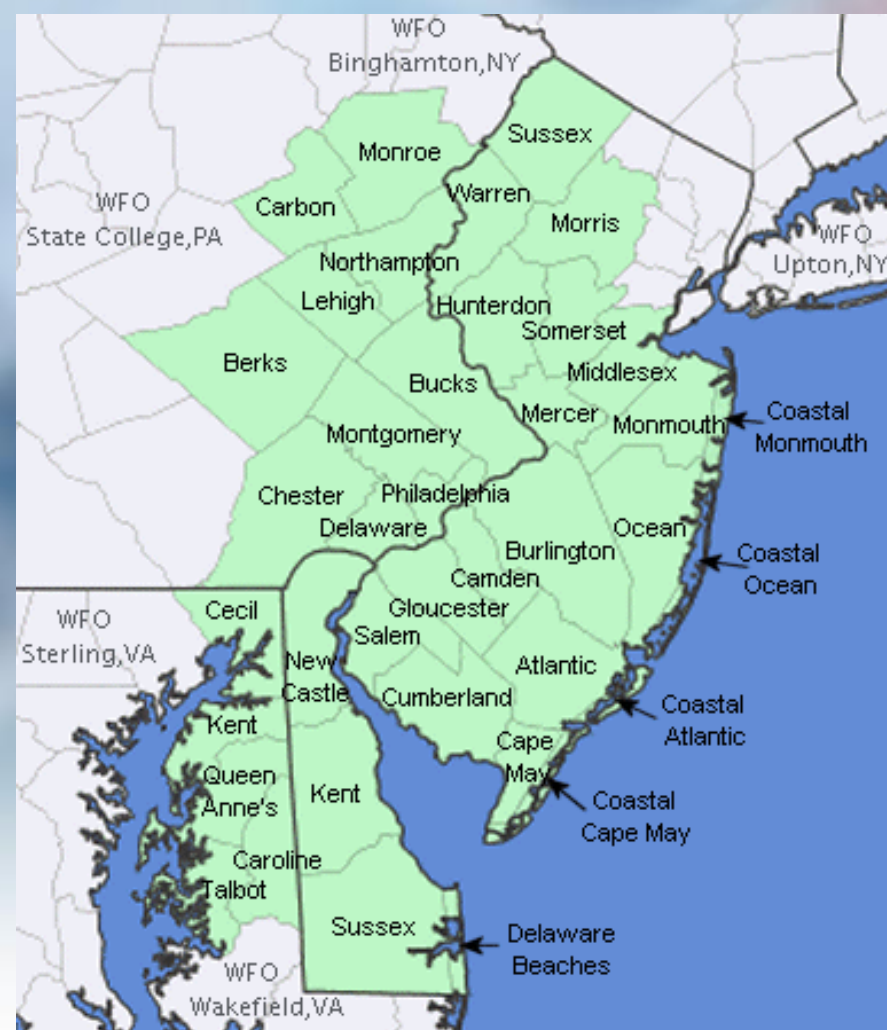


A satellite image of a large, well-defined hurricane or tropical storm system over the ocean. The storm's eye is visible in the center, surrounded by dense, swirling cloud bands. The surrounding ocean surface shows some texture and color variations, possibly due to wind speed or depth. The overall scene is in shades of blue, white, and grey.

**Reflections on Sandy:  
Understanding What Just Happened &  
Where Do We Go From Here?**

**Gary Szatkowski  
National Weather Service  
Philadelphia/Mount Holly, NJ Office  
gary.szatkowski@noaa.gov  
609-261-6602 x222**

# National Weather Service – Mount Holly NJ



- The area we serve is shaded in green
- 34 counties in four states
- Over 11 million people
- We issue weather, water & climate forecasts & warnings for the protection of life & property, and to enhance the national economy.



# Sandy – what happened



# Performance

- NWS Mount Holly began issuing briefing packages on Tuesday, October 23<sup>rd</sup>
- Weather watches were issued +/- 55 hours before event.
- Weather warnings issued +/- 40 hours before event
- Partner performance – excellent media coverage



# Recognition



- NWS Mount Holly (including me) recognized as “Hurricane Sandy Hero” by Newark Star-Ledger



# Partner performance

- Excellent leadership by Governors of New Jersey & Delaware
  - They called evacuations when they needed to
- Excellent communication by state, county & local emergency managers
  - They said and did the right things.
  - Messaging was consistent all through the run-up to the event.



# How were the results?

- Let's look briefly at the physical results
- Then spend some time talking about the other results.



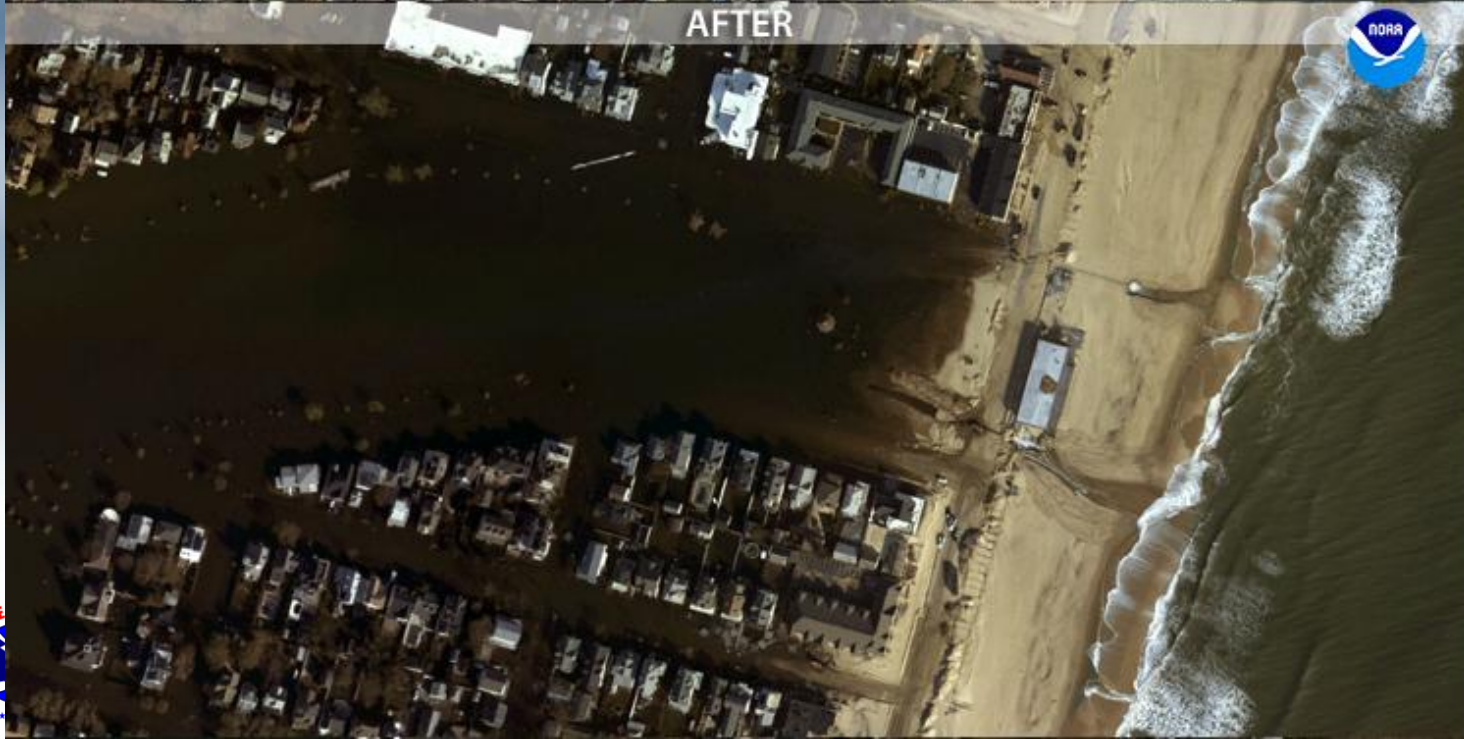
# Atlantic City





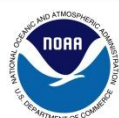


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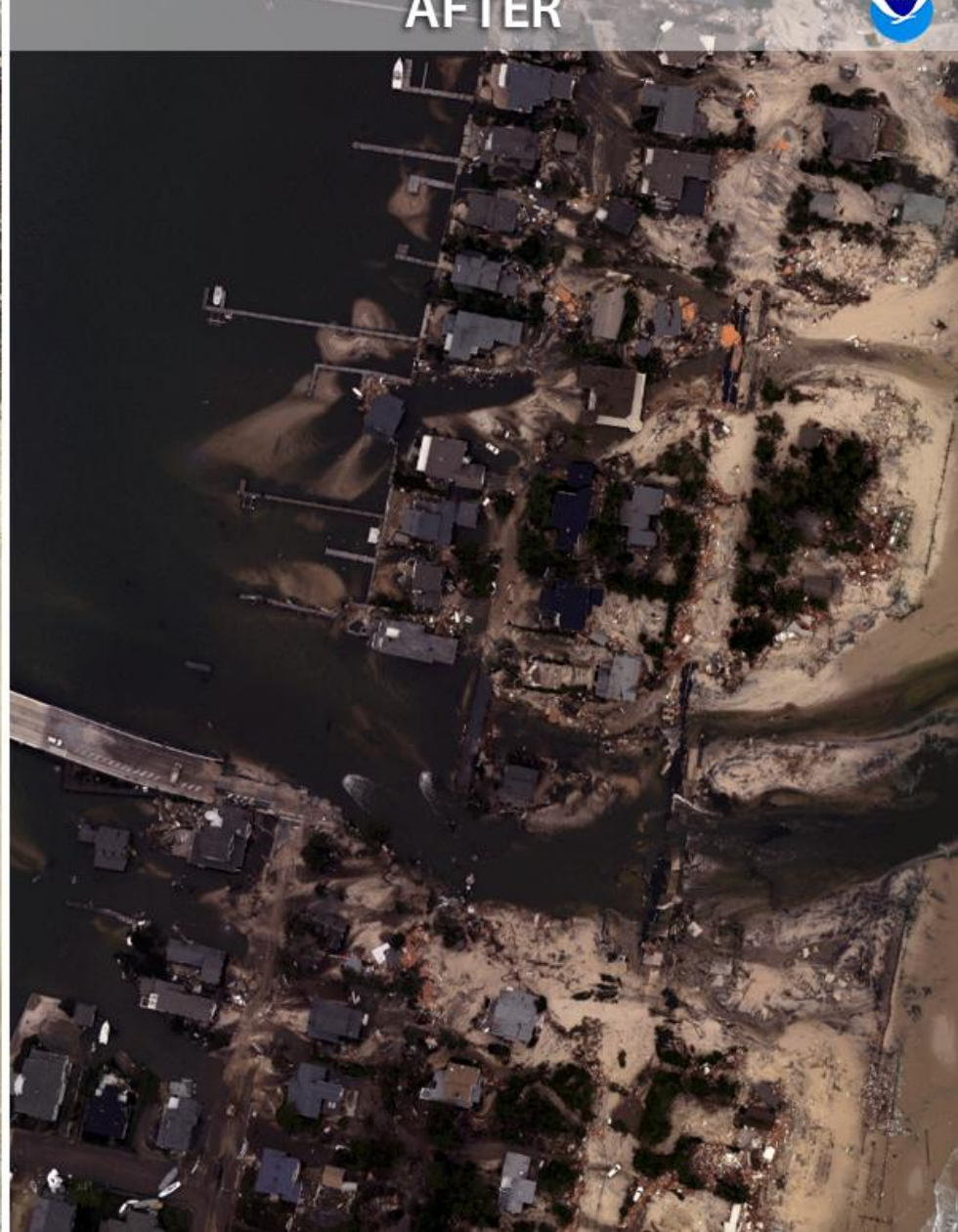




AFTER



Weather Service  
Mt. Holly



# Mantoloking – Barrier Island Breach!



# Normandy Beach, NJ

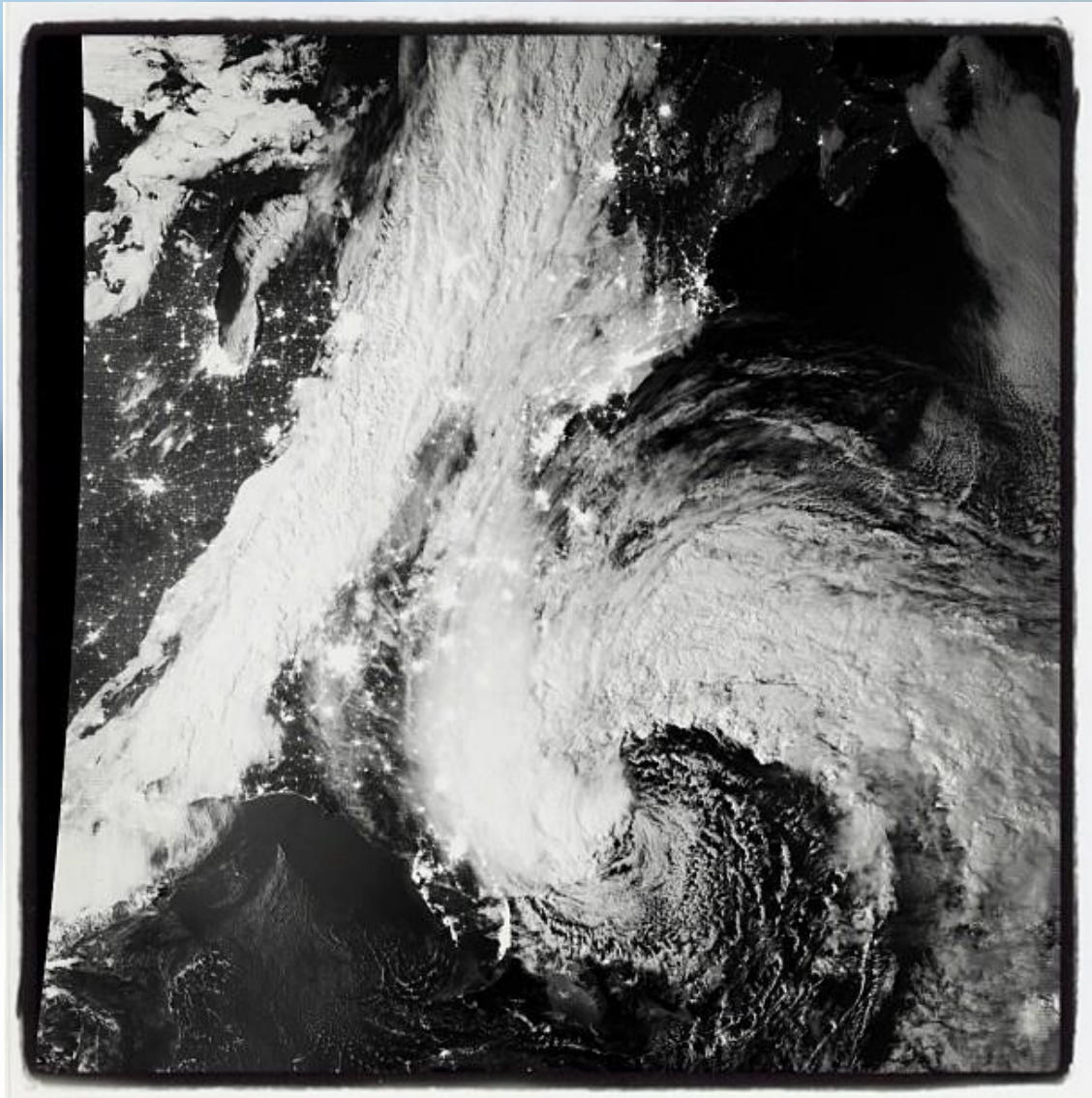


# Summary slide of Sandy impacts

- 253 deaths total
  - 131 in the United States, 104 in Haiti, 11 in Cuba, 2 in Bahamas, 2 in Canada, 2 in Dominican Republic, 1 in Jamaica
- \$65+ billion in damages
  - \$63 billion in United States
- All figures are still under review.



# Hurricane Sandy



National Weather Service  
Philadelphia/Mt. Holly

# Sandy – Where do we go from here

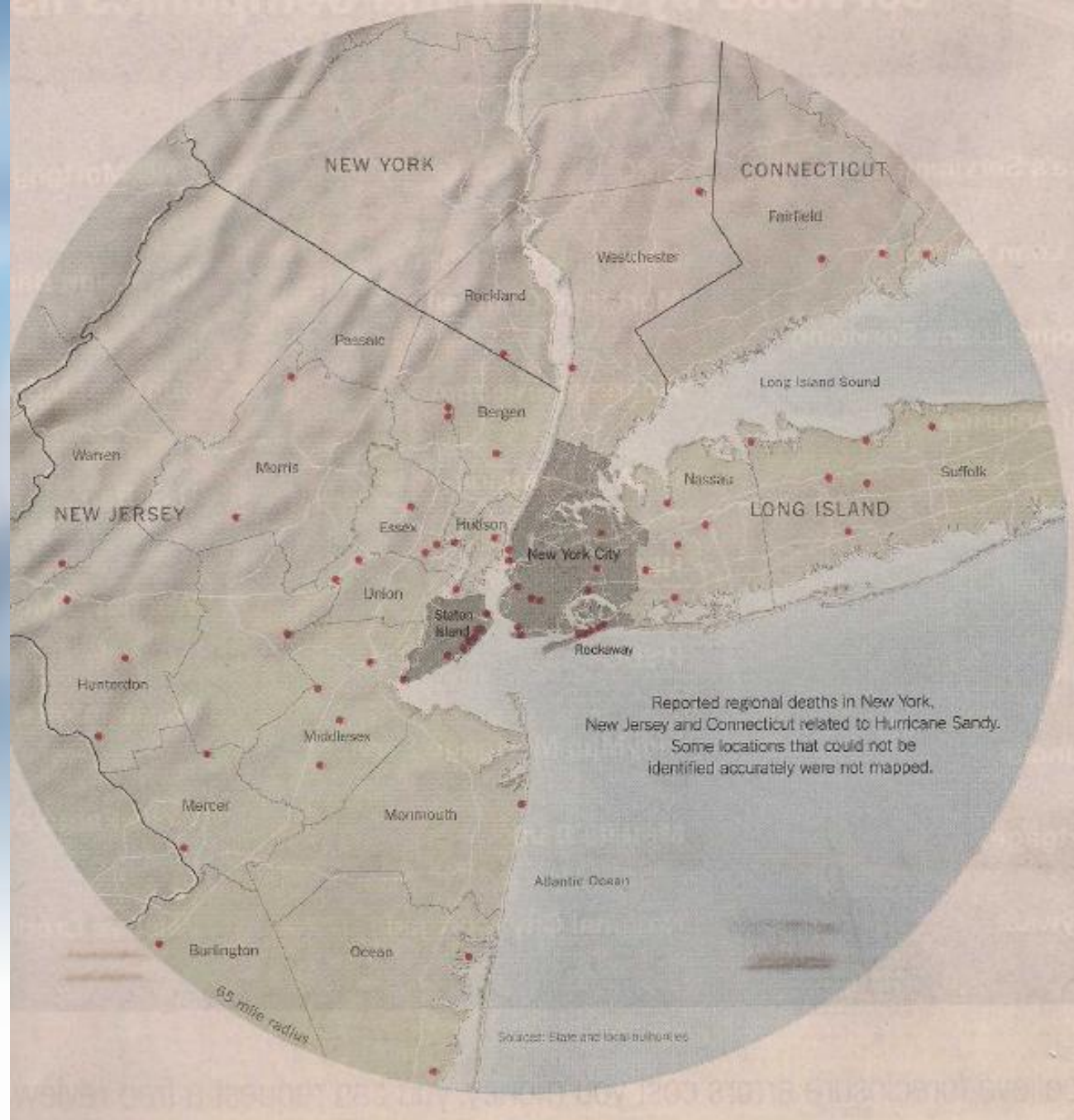
- Photo on previous page was a nighttime image that looks as clear as our old visible satellite imagery
- Our technical tools are outstripping our ability to get people to understand what they need to do





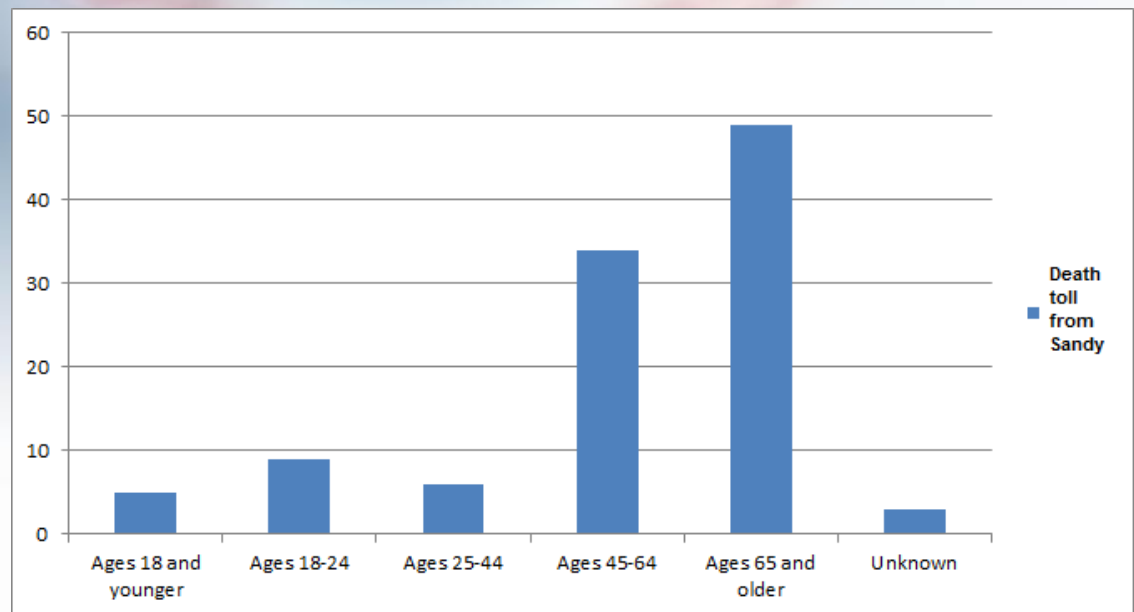
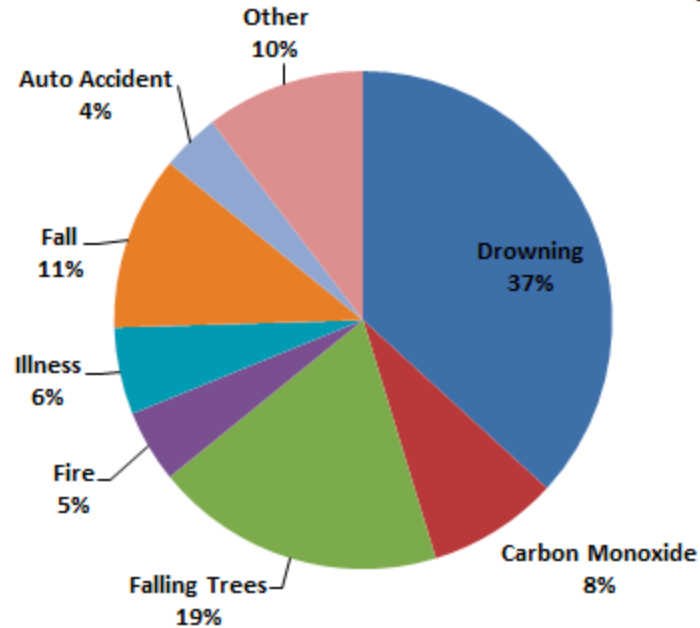
# Fatalities

- Any fatality is one too many.
- But we have fatality hotspots from coastal flooding
- Why?
- Graphic courtesy NY Times



- Analysis of fatalities in the United States

Causes of Sandy Deaths



# Decisions made Saturday before Sandy landfall on Monday

- NJ Governor quotes – Saturday morning declares State of Emergency and **mandatory evacuations**: “We are looking at hurricane force winds. **It is simply unsafe for people to be there [evacuation zones].**”
- NYC Mayor quotes – Saturday afternoon press conference explaining why **no evacuations are being ordered**: “We're making that decision based on the nature of this storm. Although we're expecting a large surge of water, it is not expected to be a tropical storm or a hurricane-type surge,” he said. “**With this storm we'll likely see a slow pileup of water**, rather than a sudden surge, which is what you would expect from a hurricane and which we saw with Irene 14 months ago.”



# Things to focus on regarding coastal flooding for the Atlantic Coast, lower Delaware Bay & Raritan Bay

- We are now completing our third high tide cycle with Hurricane Sandy. This high tide cycle was very destructive with major to record coastal flooding occurring.
- The next high tide cycle will be even worse along the Atlantic Coast where Sandy comes ashore as well as points further north. The Atlantic Coast of New Jersey and the Raritan Bay will see even higher coastal flooding on this evening's high tide, at record levels. Any shift of the storm track further south will bring higher coastal flooding levels to the Atlantic Coast of Delaware and the Delaware Bay.
- Dangerous wave action will combine with the coastal flooding. 12 to 20 foot breakers will occur in the surf zone for the remainder of today and into tonight.
- **The barrier islands will be cut off from the mainland. Breaches in the barrier islands will likely occur during this evening's high tide, as the center of Sandy approaches.**
- **Water is the most life threatening aspect of this storm. Hurricane Sandy is already the deadliest hurricane of the 2012 season. Please respect its power and heed the advice of local and state officials regarding any evacuations.**



# Barrier island breach! – Mantoloking NJ



# Exclusive: New Jersey railway put trains in Sandy flood zone despite warnings

Sat, Nov 17 2012

By Janet Roberts and Ryan McNeill and Robin Respaut

NEW YORK (Reuters) - New Jersey Transit's struggle to recover from Superstorm Sandy is being compounded by a pre-storm decision to park much of its equipment in two rail yards that forecasters predicted would flood, a move that resulted in damage to one-third of its locomotives and a quarter of its passenger cars.

That damage is likely to cost tens of millions of dollars and take many months to repair, a Reuters examination has found.

The Garden State's commuter railway parked critical equipment - including much of its newest and most expensive stock - at its low-lying main rail yard in Kearny just before the hurricane. It did so even though forecasters had released maps showing the wetland-surrounded area likely would be under water when Sandy's expected record storm surge hit. Other equipment was parked at its Hoboken terminal and rail yard, where flooding also was predicted and which has flooded before.

Among the damaged equipment: nine dual-powered locomotive engines and 84 multi-level rail cars purchased over the past six years at a cost of about \$385 million.



- In extreme events, experience fails.
- NJ Transit put equipment valued \$385 million in a location that **did not flood during Hurricane Floyd & Hurricane Irene**
- Kearny, NJ – 9 feet above MSL vs. storm tide 12-15 feet



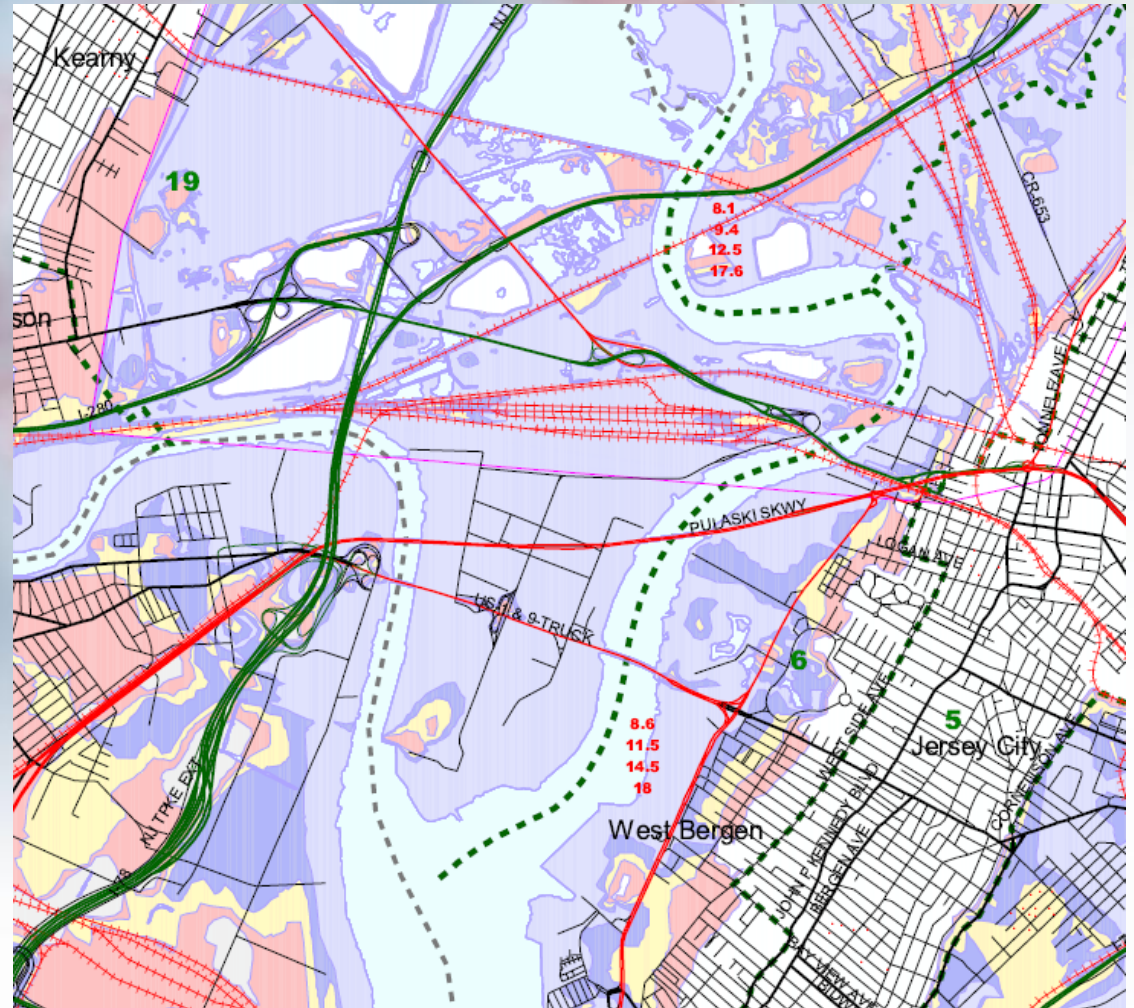
# Are we learning?

- Philadelphia Inquirer 12/04/2012 - Statement by NJ Transit Director – “...projections from the NWS forecast at the time the system shutdown called for only a 10 to 20 percent chance of flooding at the [Kearny] railyards.”
  - If you follow @GarySzatkowski on Twitter, you saw my reaction.
- Statement by ex-NJ Transit chief of staff in opinion piece explaining why NJ Transit should not be criticized.
- NorthJersey.com 12/04/2012 opinion piece – “Weather forecasting” not an “exact science”
- NJ.com 12/05/2012 opinion piece – Sandy “weather forecast was wrong.”
- Why is this being said?
- NJ Transit has to testify before US Senate on 12/06/2012 on loss of rail cars
- NJ Transit has to testify before NJ Assembly on 12/10/2012 on loss of rail cars.
  - NJ Transit testimony stressed listening & use of NWS information in the run-up to Sandy.
  - NJ Transit railyards which flooded were considered ‘not in flood zone’.



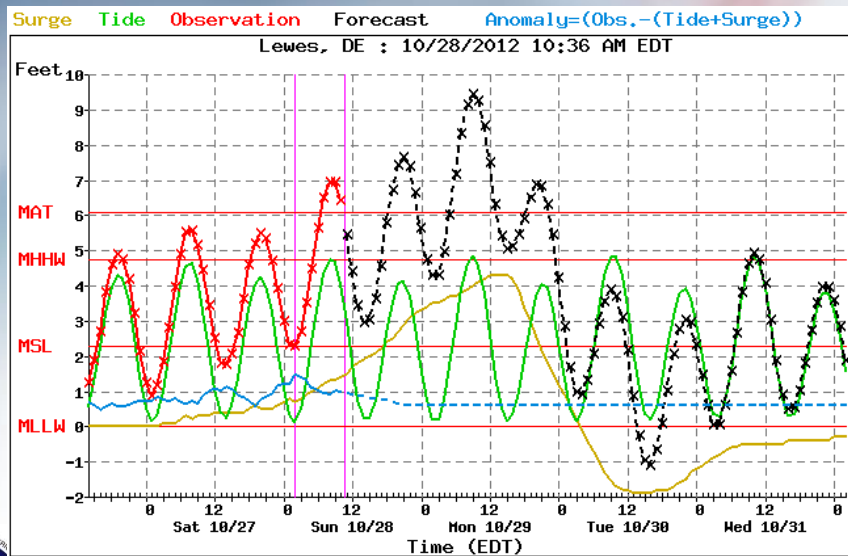
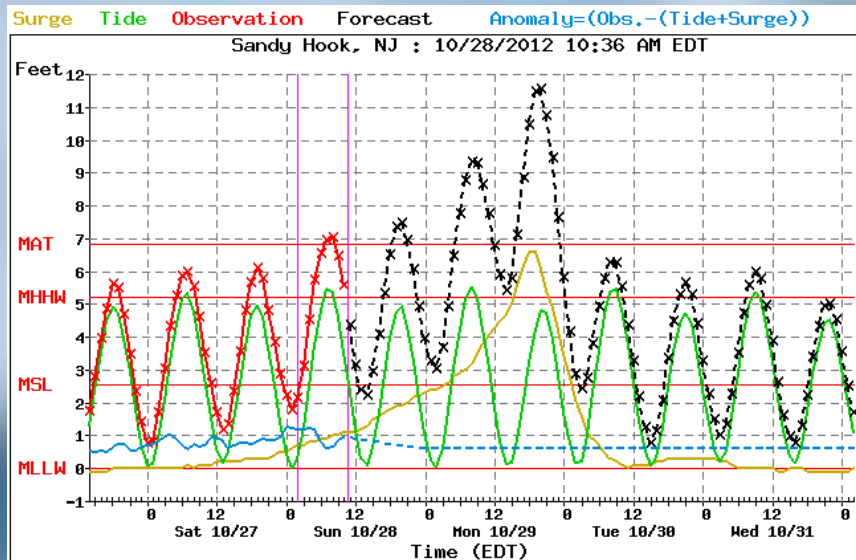
# USACE map 2010

- Light gray shading floods with Category I storm surge – 6 to 9 feet.





# Coastal flooding tools



- Major coastal flooding is expected based on the current track forecast. **Record coastal flooding is likely.**
- A 12 to 15 foot storm tide (surge + astronomical tide) is possible in the Raritan Bay. This would produce record coastal flooding.
- A 10 to 12 foot storm tide is possible along the Atlantic Coast & the Delaware Bay. This would result in record coastal flooding in many locations.
- A 3 to 5 foot storm tide (surge + astronomical tide) is possible in the Chesapeake Bay based on where the storm center comes ashore. This would produce moderate coastal flooding.

# Storm surge forecast from NHC issued 1100 AM Sunday October 28th

- Maximum surge forecast for Monday night

NC NORTH OF SURF CITY INCLUDING PAMLICO/ALBEMARLE SOUNDS...4 TO 6 FT  
SE VA AND DELMARVA INCLUDING LOWER CHESAPEAKE BAY...2 TO 4 FT  
UPPER AND MIDDLE CHESAPEAKE BAY...1 TO 3 FT  
LONG ISLAND SOUND...RARITAN BAY...AND NEW YORK HARBOR...6 TO 11 FT  
ELSEWHERE FROM OCEAN CITY MD TO THE CT/RI BORDER...4 TO 8 FT  
CT/RI BORDER TO THE SOUTH SHORE OF CAPE COD INCLUDING BUZZARDS  
BAY AND NARRAGANSETT BAY...3 TO 6 FT



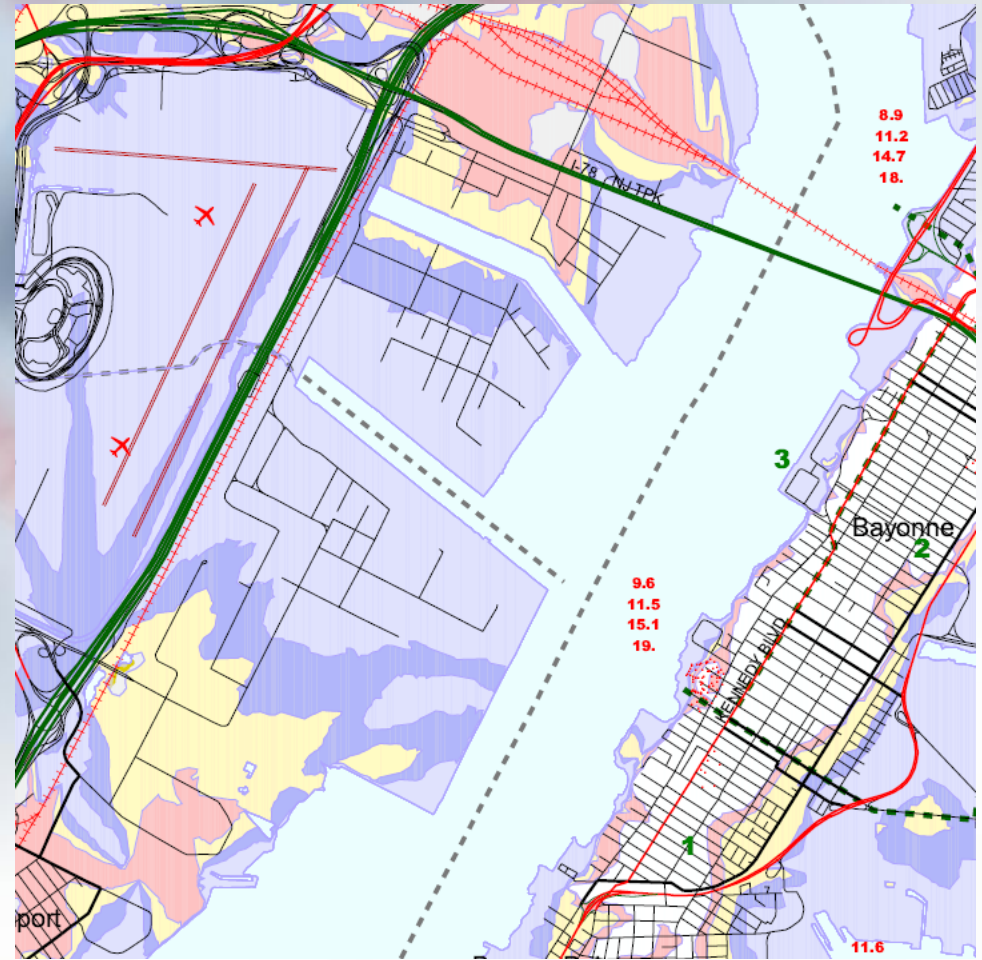
# Port Authority NY/NJ

- “No one believed there could be a 13-foot storm surge ever in this port and there was,” said retired Rear Admiral Rick Larrabee, director of Port Commerce for the Port Authority of New York and New Jersey. “I talked to people **who have worked here for 30 years** who said they never feared for their lives but they did that night.”
- What they actually got was about an 8 to 10 foot storm surge.
- Forecast surge on Saturday – 4 to 8 feet for Mon
- Forecast surge on Sunday – 6 to 11 feet on Mon
- The price for this decision-making:
  - Larrabee said the storm surge enveloped 14,000 new cars on the docks on the New Jersey side of the Hudson, incapacitated 40 percent of the 50 gargantuan cargo cranes that stand several stories high and took out 2,500 trucks critical to moving freight off the docks.

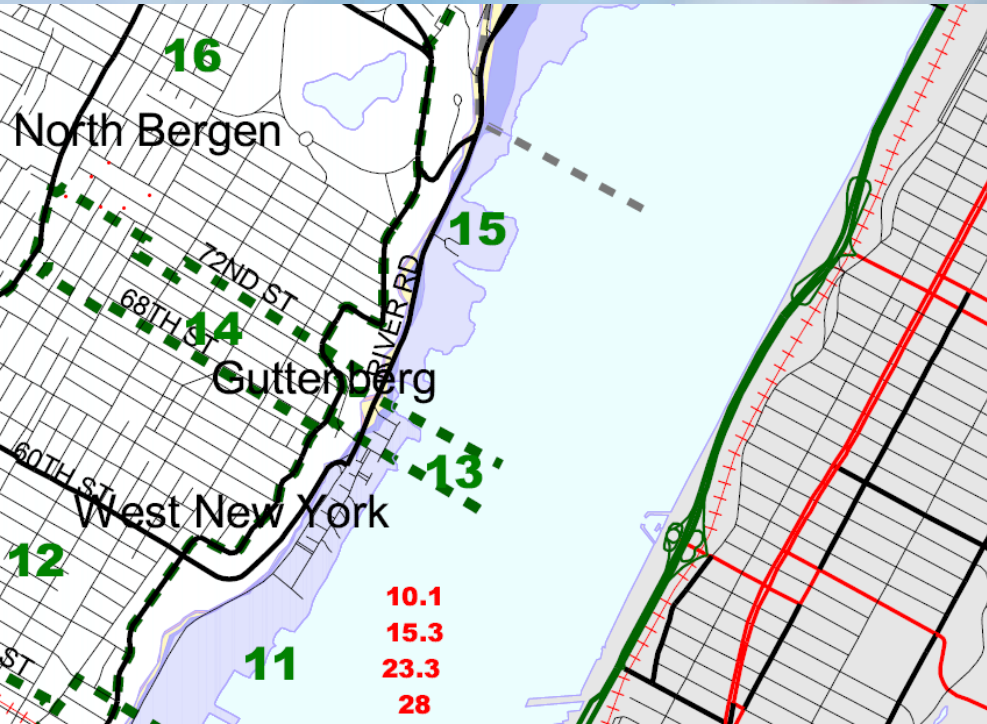


# USACE map 2010

- Light gray shading floods with Category I storm surge – 6 to 10 feet.



# Palisades Medical Center



- **Did not evacuate during Sandy** until flooding began at their facility & they lost emergency power; despite forecast of 6 to 11 feet storm surge.
- The Medical Center was able to evacuate 83 patients to Hackensack Medical Center, including 13 that were on life support, according to township spokesman Swibinski. The effort was coordinated by the North Bergen Police Department along with EMS and McCabe ambulance – NJ.com report
- **Did evacuate for Hurricane Irene;** water got into their parking lot but did not flood the facility at that time, experienced storm surge of 4 to 5 feet.
- Experience issue? Other factors?

# Sandy's Deathtrap | Storm claimed 10 lives in one flood-prone spot

○ Locations where Sandy victims were found FEMA flood risk category: ■ High ■ Moderate



# Wall Street Journal article

- Fearing a flood, Mr. Bediner drove his family out of Midland Beach at about noon on Monday. Many of his neighbors stayed. As wind and rain intensified on Monday afternoon, the mood in the neighborhood was still upbeat. "We were out there joking, saying, '**They hyped Irene so much, and what'd we get? A little water,**' " recalled Laura Gatti. About three-quarters of her immediate neighbors decided to weather the storm in their homes. **Many recalled that Tropical Storm Irene in 2011 had turned out to be less fierce than predicted,** and some worried about looting if they left.



# Dune or not to Dune – that is the question

- Philadelphia Inquirer 12/03/2012
  - Showdown at the Shore: More dunes or fewer?  
And who pays?





# Sandy – Where do we go from here

- These are not hard science issues
- These are not labeling issues
  - Was it a hurricane when it made landfall? Or not?
  - Should hurricane warnings have been in place?
  - NJ Transit made decisions based on previous **hurricane** experience
  - So did the people who died in Staten Island (WSJ report)
- These are social science issues
  - Because we have gotten so good at the hard science



# Wharton report – November 2012

- Report itself – questioning seems biased against NWS decision-making process for Sandy. Refers to warnings we did issue as a ‘cacophony’.
- Bad news – almost endless.
  - Problems with risk messaging
  - Problems with risk assessment
  - Problems with actions taken in response to perceived risk.



# Problems with risk messaging

- Report suggests that lack of hurricane warnings vs. ‘cacophony’ of other type of warnings (coastal flood, high wind, etc.) produced confusion about exact threat they faced.
- My thoughts – I’m not completely buying this, & survey seems to be fishing for this result.
- People clearly knew ‘something’ was coming and it posed some type of hazard.



# Problems with risk assessment

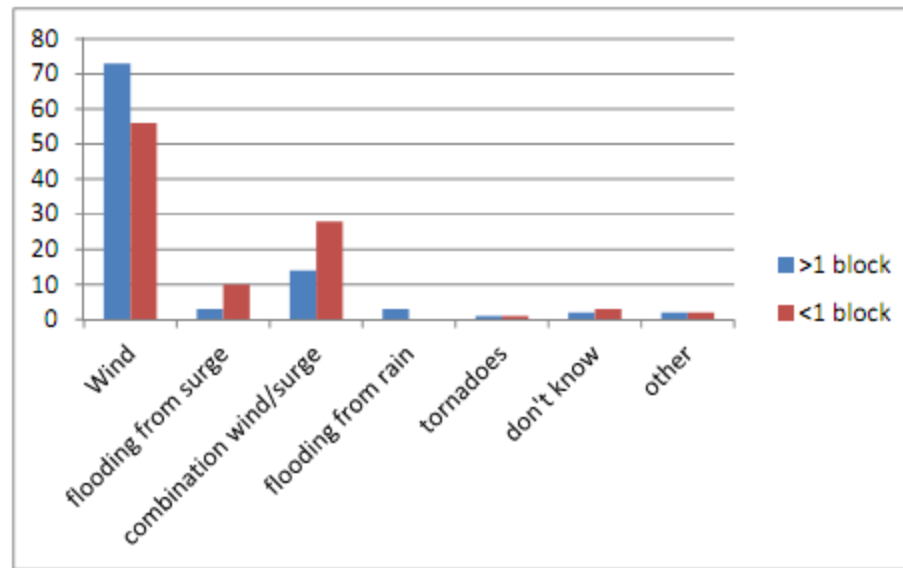


FIGURE 8: ASSESSMENTS OF THE MOST LIKELY THREAT POSED BY THE STORM BY DISTANCE TO WATER

- Even residents who lived within a block of the water—where flooding would have been the largest threat posed by the storm—saw the greatest threat posed by Sandy as coming from winds, not water.
- Look at the numbers regarding ‘flooding from rainfall’!
- My thoughts – These results are based on experience. The damage most widely seen is ‘wind’.

# Problems with risk assessment

- 76% of survey had ‘experienced’ living through a hurricane
- Of those who experienced Irene, only 37% reported suffering any damage from the storm.
- My observation – if you haven’t experienced damage or other significant problems (prolonged power outage), you haven’t experienced a hurricane



# Problems with actions taken based on perceived risk

- If you can't 'envision' it, you probably aren't prepared to deal with it.
- If you don't see storm surge as a big risk (even if you can see the ocean), you are at substantial risk to not make a good decision.
- In the absence of the ability to 'envision', we substitute 'experience' (e.g., the railyard hasn't flooded during previous 'hurricanes')



# Story about person & co-workers

- Person works in small store in mid-town Manhattan
- Person didn't experience Hurricane Irene; co-workers did.
- Asked what to expect with Sandy, was told:
  - You get one to two days off
  - Some wind; some rain.
  - Power may go off.
  - May want to pick up some water, a bottle of wine.
  - My conclusion: It's a snow day, expect change the snow to wind & rain.
- Why would they say this?
  - Because they 'experienced' Hurricane Irene, and this is what happened.
- This is the challenge. Until you can understand what will likely happen, you cannot be prepared.



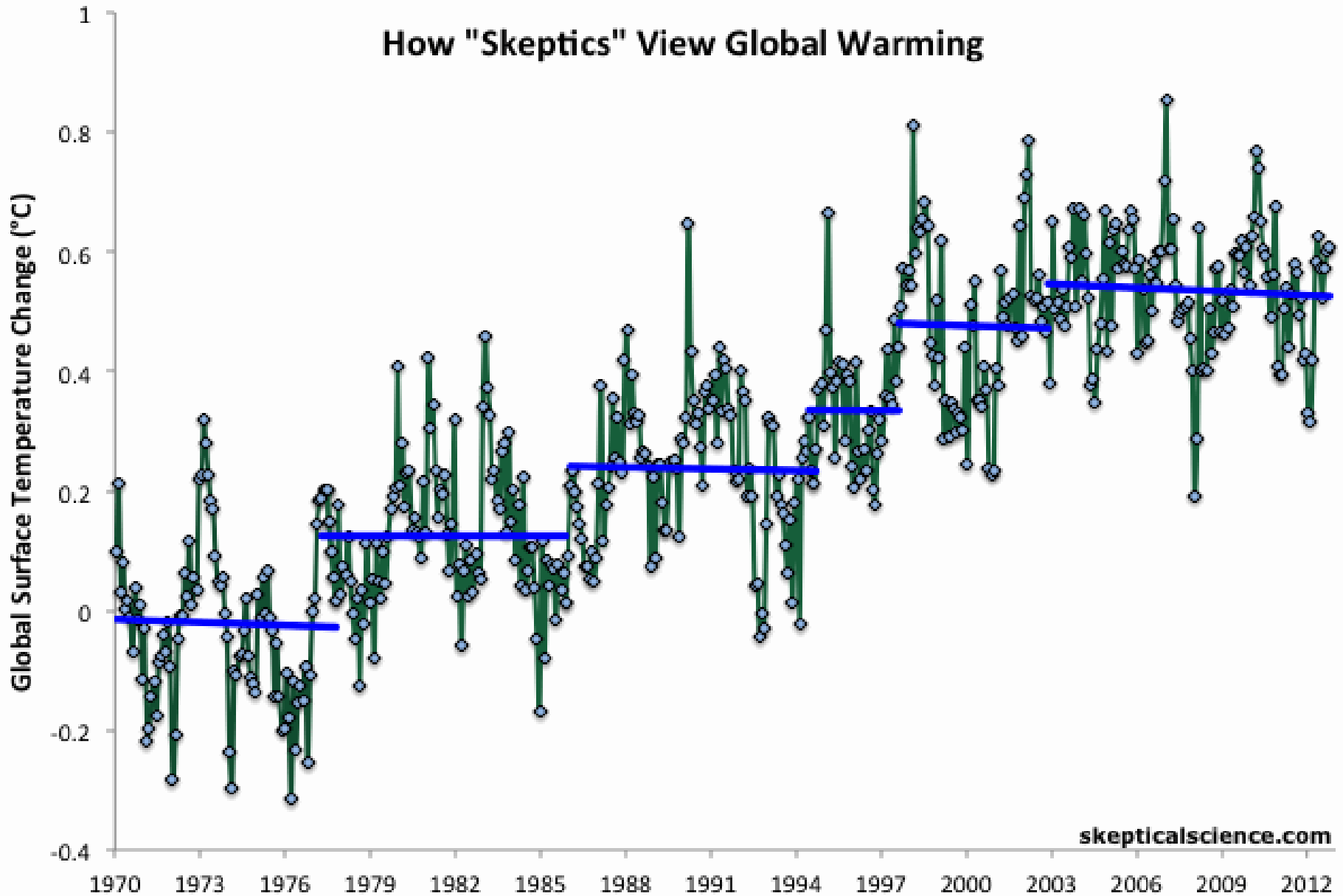
# Factoring In Climate Change

- Did climate change make Sandy worse?
  - Sure it did. Sea level is rising, and coastal flooding was worse as a result.
- Did climate change cause Hurricane Sandy?
  - No, of course not. We have a long history of Hurricanes
- Will climate change cause more storms like Sandy?
  - Possibly.

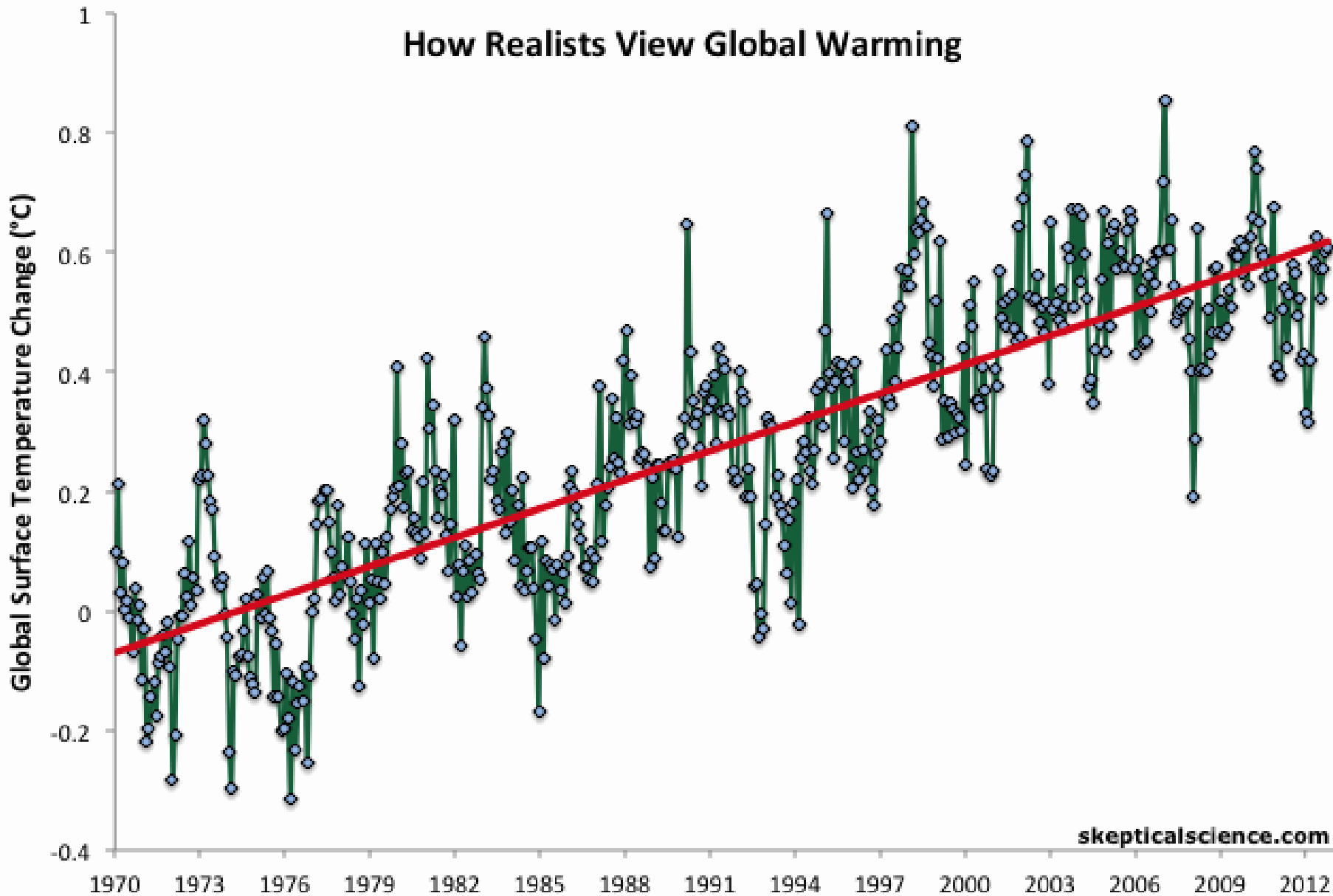




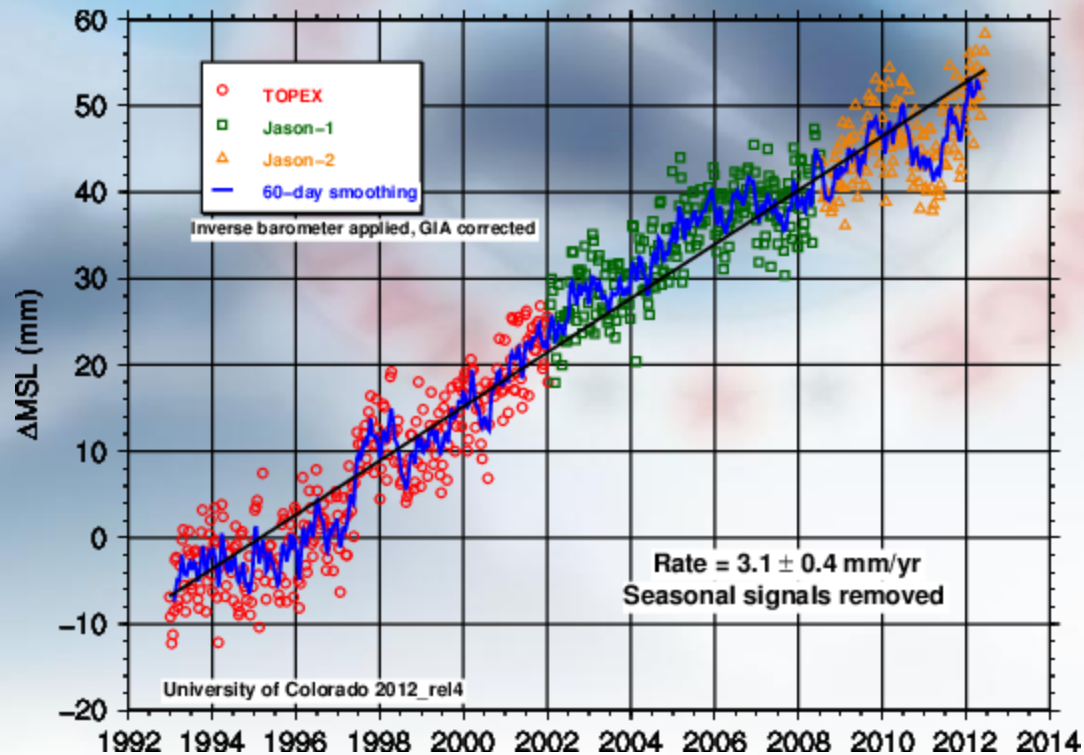
# How "Skeptics" View Global Warming



# How Realists View Global Warming



# Sea level continues to rise

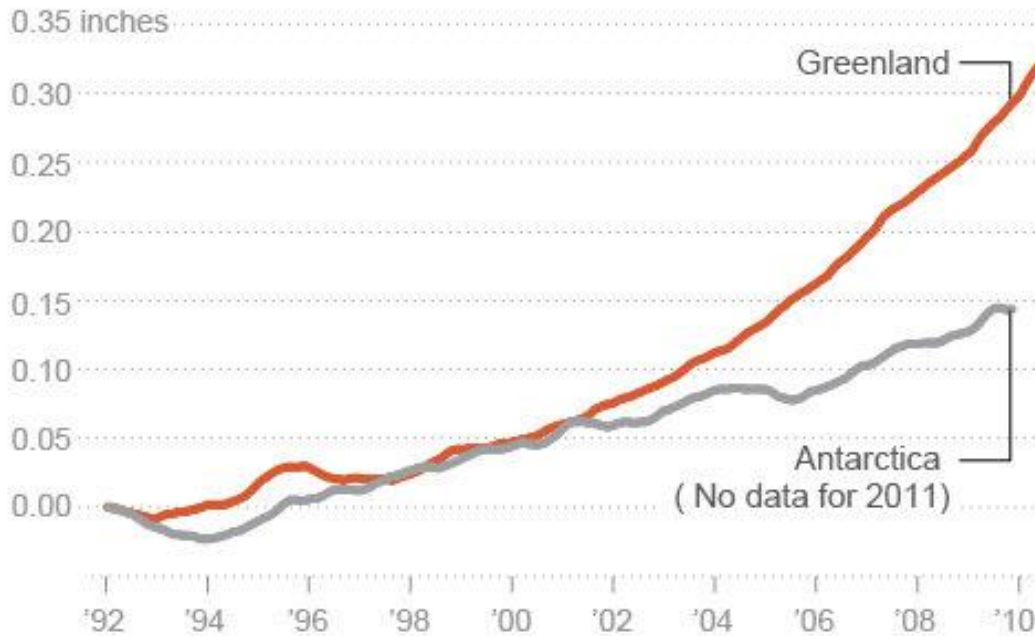


# Greenland will contribute more to sea level rise in the future

## Ice melt contributes to sea level rise

Greenland and Antarctica ice sheets are melting at an accelerating pace causing seas globally to rise.

### Ice sheet contribution to global sea levels

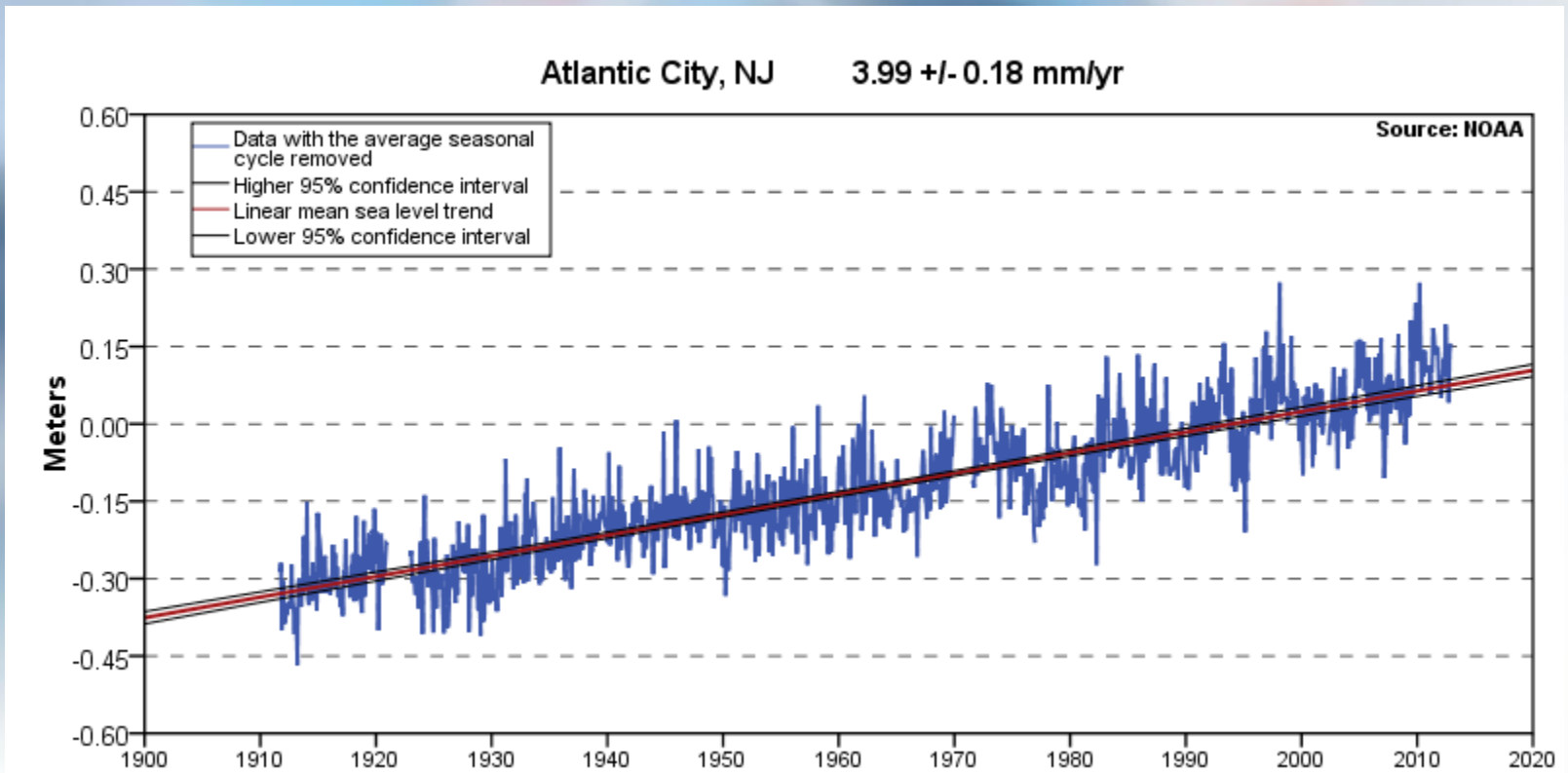


SOURCES: University of Leeds/UCL/ESA/NASA

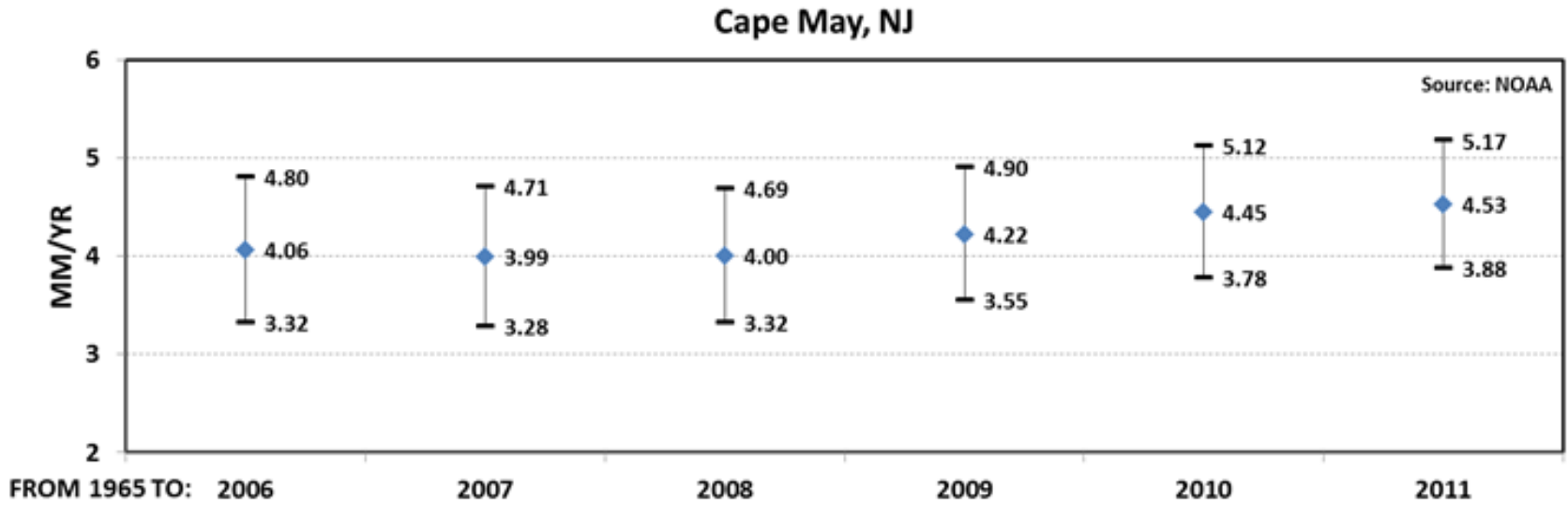
AP



# Atlantic City – rising more than 1 foot per 100 years



# Cape May NJ – sea level rise accelerating



# The problem

- When we lack vision, or exceed our ability to envision an extreme possibility, we fall back on ‘experience’
  - This tendency to favor ‘experience’ limits us to things which can be seen and understood over an average human’s adult life span – roughly 50 years.
  - Bad news if you’re facing a 100 year or 500 year storm
- This problem is exacerbated when climate changes ‘extreme’ weather
  - e.g., sea level is higher, or heavy rainfall more likely.



# The problem – long term

- In the long term, we as a species will have to discuss/decide what kind of world we want 100 years from now.
- Climate change is driven primarily by greenhouse gas emissions.
- We have to decide what tradeoffs we want to make.
- And that is all I'm going to say about that, for that is a political leadership challenge.





# The problem – short term

- The problem in the short term (5 to 50 years) is that we have already built into the system the changes we are going to see
- The planet is NOT in equilibrium.
- If we ceased emitting greenhouse gases right this minute, the planet would still get warmer, seas would continue to rise.
  - Why? Because we are NOT in equilibrium.
- Automobile analogy
  - Press harder on accelerator, you go faster,
  - Press less on the accelerator, you go slower.
  - Take foot off the gas, you will keep rolling for awhile before coming to a stop.
  - In all scenarios, you are not where you started.
  - Climate will change, the only question is how much?



# The problem – short term

- So, no matter what we do, climate will change over the next 50 years.
  - Warmer temperatures, rising sea level, etc.
- The ability for our ‘experience’ to mislead us will continue to grow.



# Sandy – Where do we go from here

- A ray of hope – our ability to forecast the weather in the next 7 to 10 day time range will continue to improve, enhancing our **potential** ability to respond to all weather threats.
- It is clear to me that the value of our weather forecasts has improved to such a degree that the bigger problem has become getting people to understand the impacts of a weather forecast.
- We have a lot of hard work ahead of us in getting people to understand and fully leverage the information available to them when dealing with very low frequency, very high impact natural hazard events.
  - Perhaps a model – children & crossing a street
- Most importantly, we have been reminded by Mother Nature that the world is a dangerous place. During Hurricane Sandy, some paid a terrible price for us to re-learn this truth. For their sake & ours, let's not ever forget it.



# Questions? Comments?

