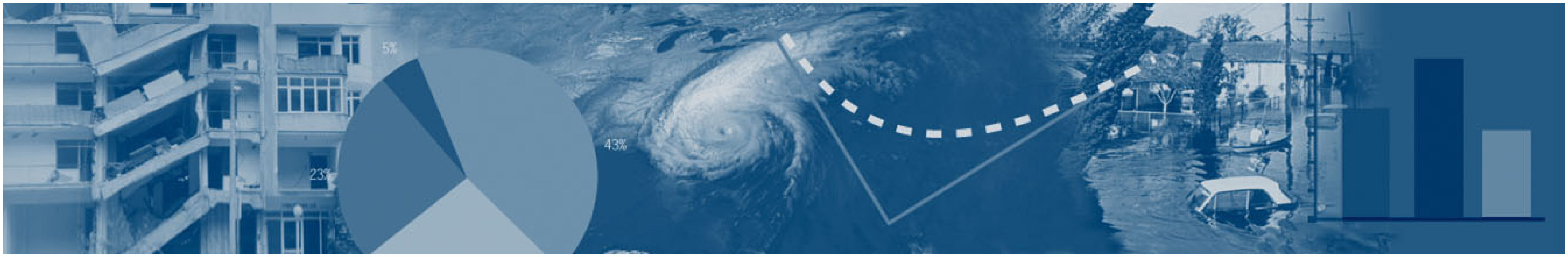

Lessons Learned from 2008: Hurricane Ike

Session: Lessons of the 2008 Cat Season

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Risk Management Solutions

Bringing Science to the Art of Underwriting™

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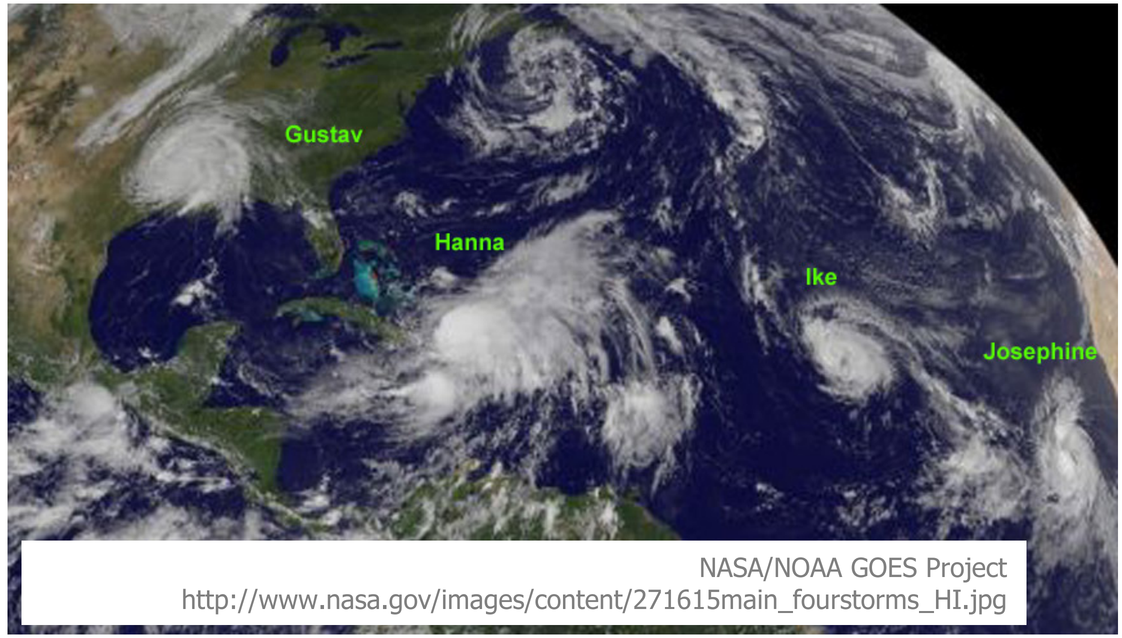
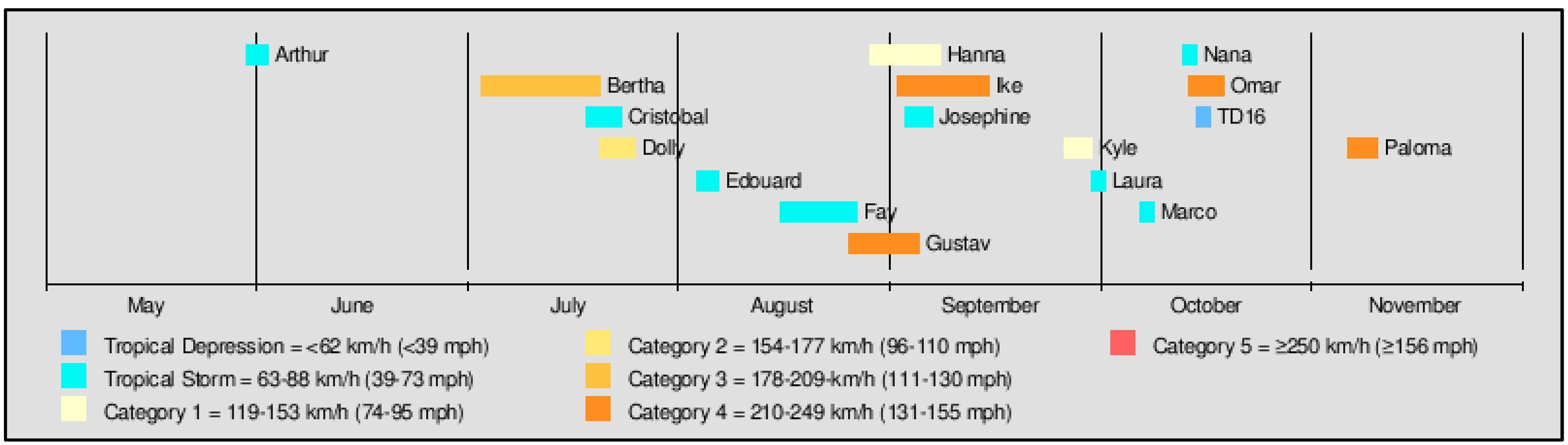
2008 Hurricane Season

- Fourth highest number of named storms in history
- A major hurricane existed in the North Atlantic for five consecutive months
- A record six consecutive named storms struck the U.S.

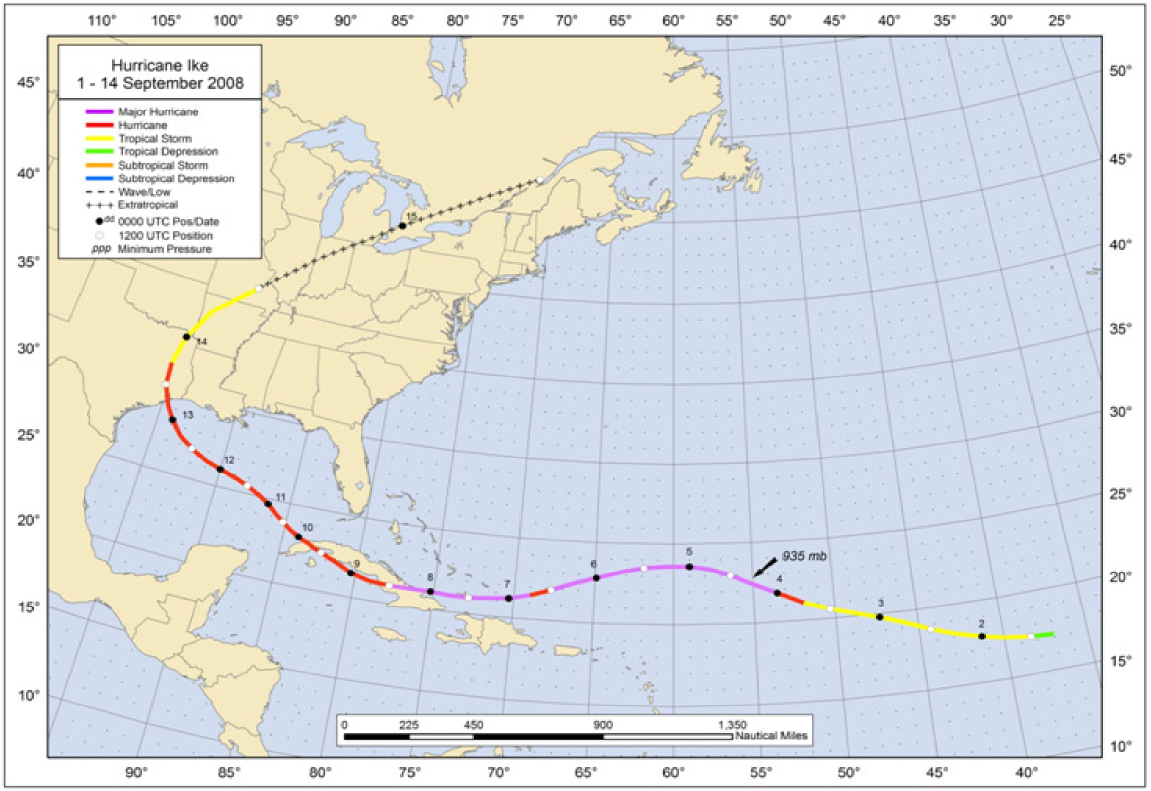


NASA/NOAA GOES Project
http://www.nasa.gov/images/content/271615main_fourstorms_HI.jpg



Hurricane Ike

- One of the most destructive storms to make landfall in U.S. history
- Ike merged with an extra-tropical storm resulting in tropical storm force winds as far north as Canada and significant damage to the Ohio Valley
- Hurricane Ike could be Ohio's most costly natural disaster ever



Hurricane Ike
Duration: September 1st – September 14
Intensity: 145 mph (230 km/h) (1-min), 935 mbar (hPa)
Saffir-Simpson Category: 4

Key Features of Hurricane Ike

- Losses from Ike rapidly escalated in a way that surprised even insurers and claims managers on the ground
- Glancing blow (left hand side of the track) on the #1 concentration of near coastal industrial & commercial risk in the hurricane states
  - Caused the most protracted power outages of any hurricane
  - More than 100,000 properties were flooded by surge
  - Compounding of loss causes
- Large proportion of all the losses in Harris County (Houston) with windspeeds 60-90mph
  - High sensitivity to low windspeed vulnerabilities
- Combined with inherent uncertainties in post-event modeling:
  - A lack of recorded windspeed data over the heavily exposed Houston area

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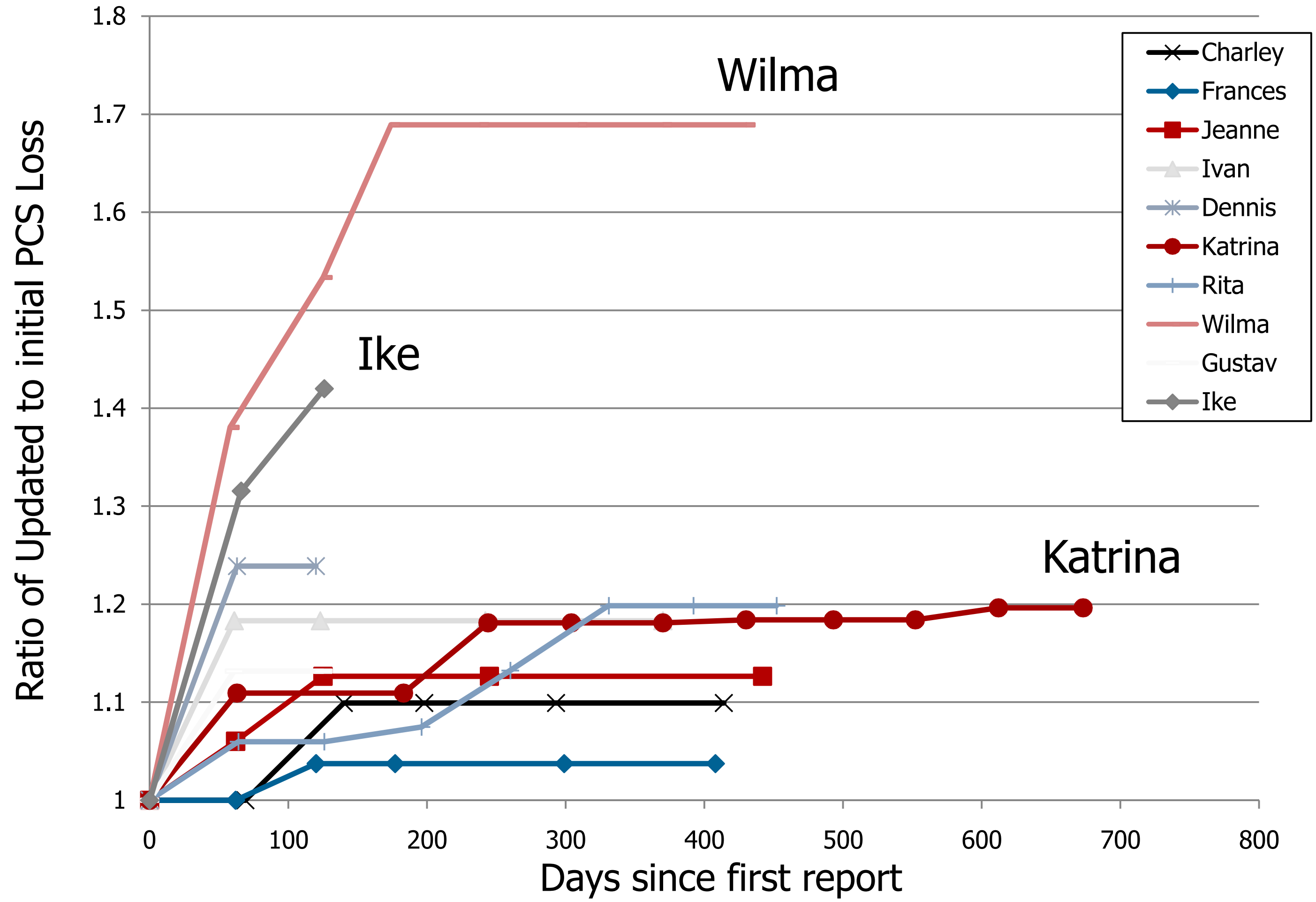
The Escalating Losses

Losses from Ike Escalated More than Most Other Storms



PCS usually predicts the loss quite well, their initial estimate is typically within 20% of their final estimate. Ike and Wilma are different

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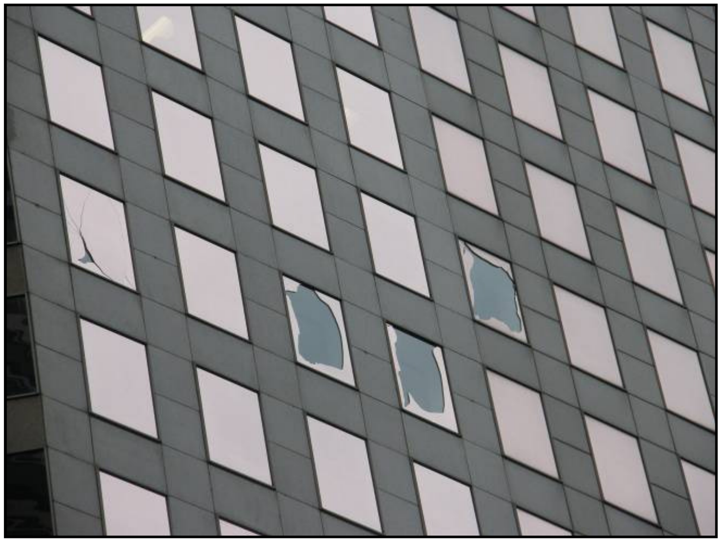
Why have Ike's Losses Escalated?

- Moderate windspeeds impacting a major urban area
  - Majority of losses are not visible externally: People take time to discover the extent of damages?
- Overlap of evacuation, surge, power outage and wind causing complex claiming

Houston residential



Houston downtown high-rise

How Does Size Relate to Severity?

- Ike was the biggest Cat 2 or greater Atlantic hurricane for 20 years
  - But not the biggest ever – or biggest in stochastic events sets.
- Non-linearities related to size include:
  - Larger storms generate higher waves relative to windspeeds
  - Larger storms are slower to fill once they hit land
  - Higher levels of rainfall relative to forward speed
  - Much larger volume of tropical air than is typical - with a greater potential for re-intensification to the north?

Offshore

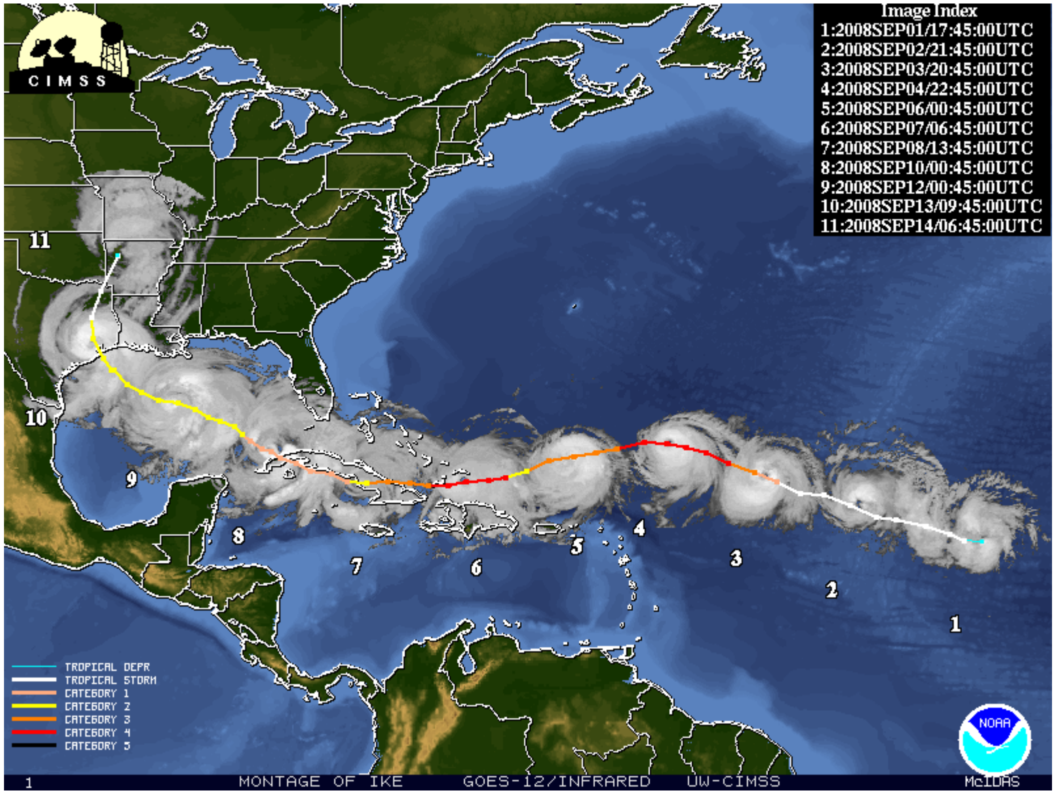
Impacts in the Caribbean

- Tracked over the Turks Islands as a category 4 hurricane, Tuesday, Sept. 9
- Max sustained winds ~135 mph RMax ~ 22 miles
- Storm surge up to 18 feet
- Severe and widespread damage Grand Turk, Salt Cay and South Caicos
- 90% of roofs damaged, with approximately 20% destroyed

Brennan Linsley/AP Photo

The Expansion of Ike in the Gulf

- Ike's inner core disrupted after its interaction with Cuba - weakened to cat 1
- RMax expanded to **90 miles** on Sep 10
- Largest Cat 2+ in the Atlantic for 20 years



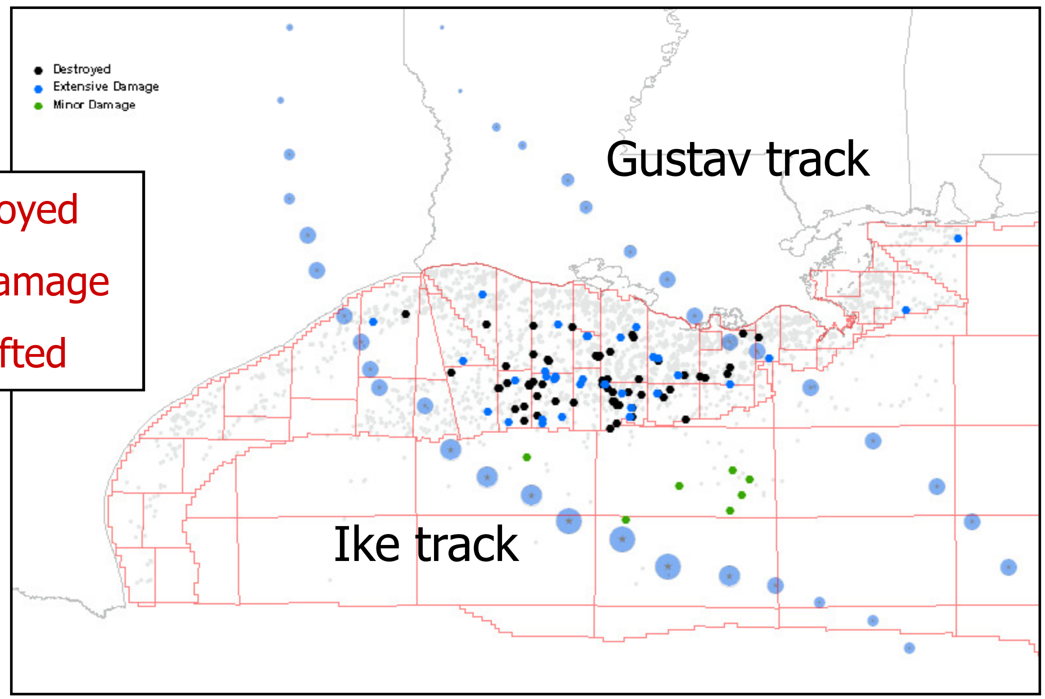
Gustav & Ike Offshore Damage Observations

- Extensive damage to the right hand side of Ike's track: Expected as the strongest winds in a hurricane are located on the right hand side
- However, also damage close to the Gustav track.
- Very difficult to separate the two as there wasn't time to check all the platforms for damage before they had to be evacuated again.

60 Platforms, 3 Jackups Destroyed

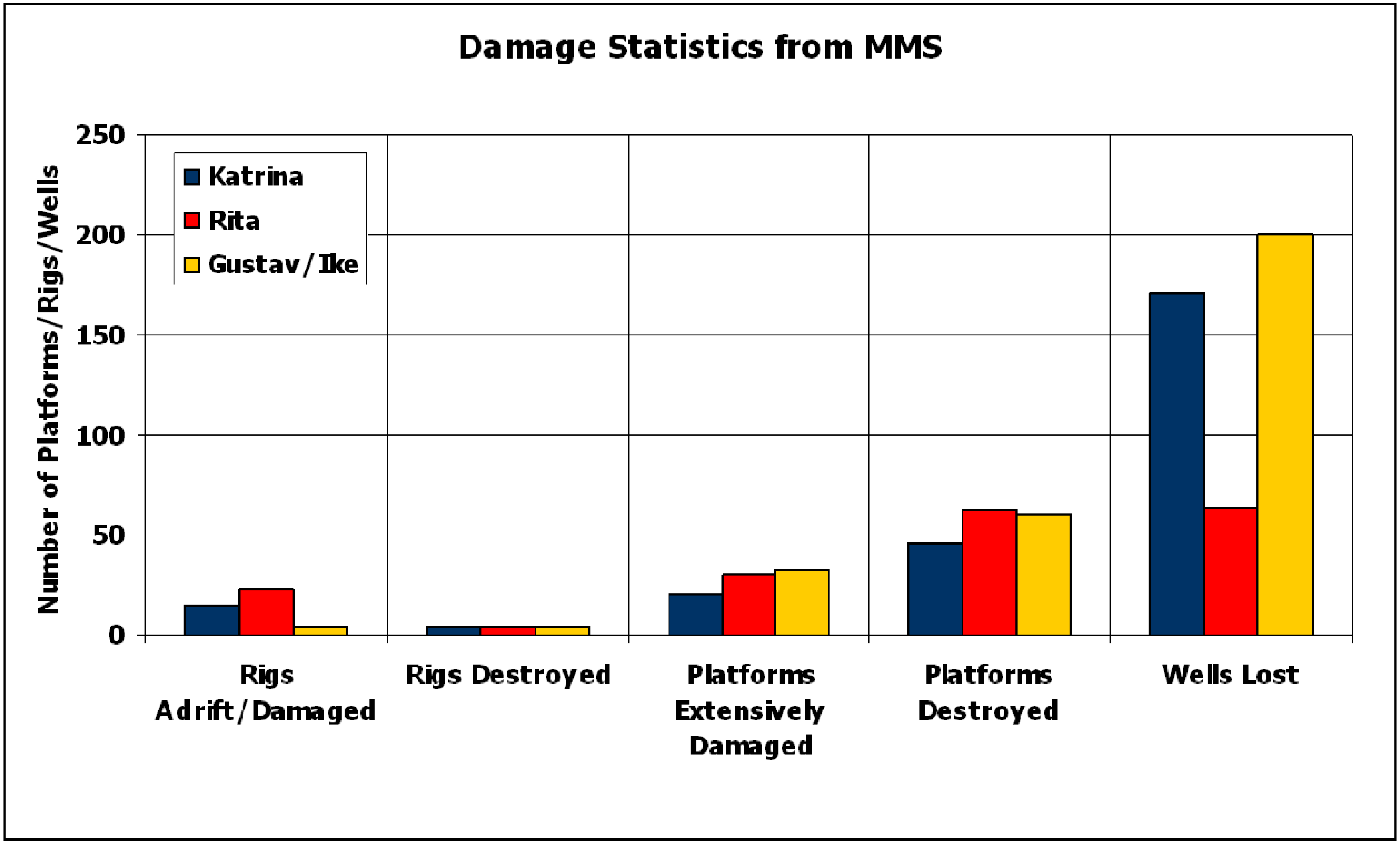
32 Platforms with extensive damage

4 SEMIs lost moorings and drifted



Gustav & Ike – Comparison to 2005

Damage from Ike is commensurate with the much stronger storms of 2005

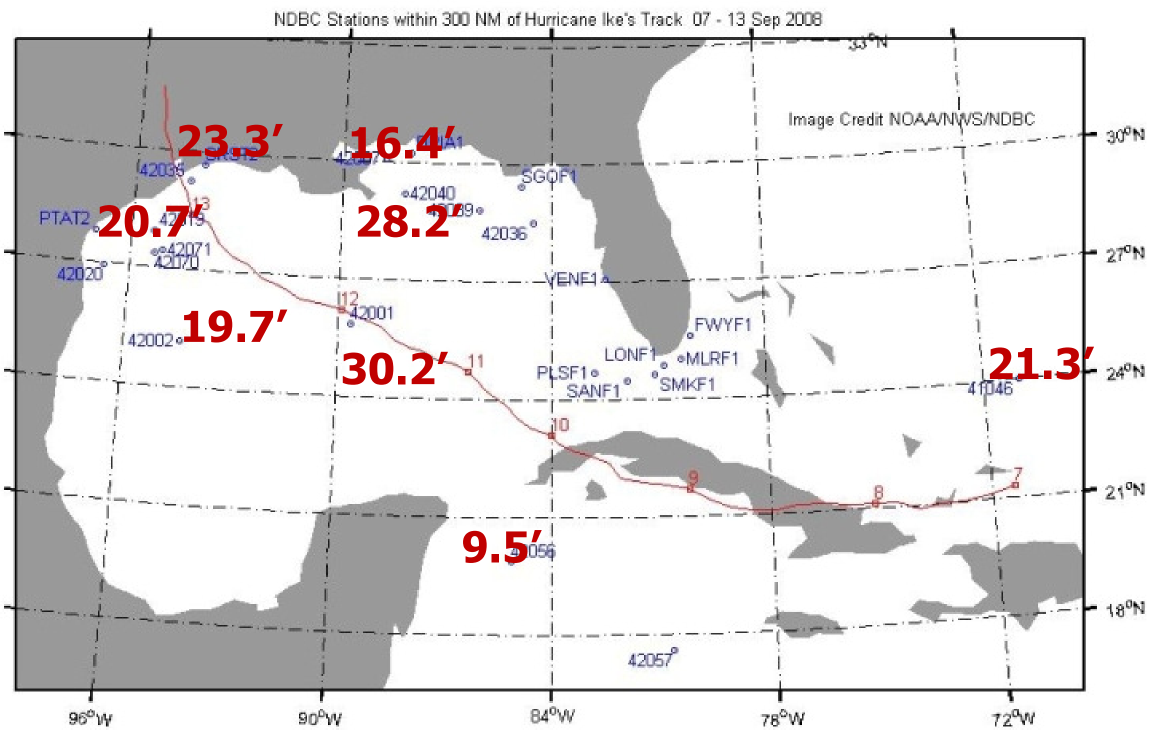


* Rigs destroyed include platform rigs and jackups

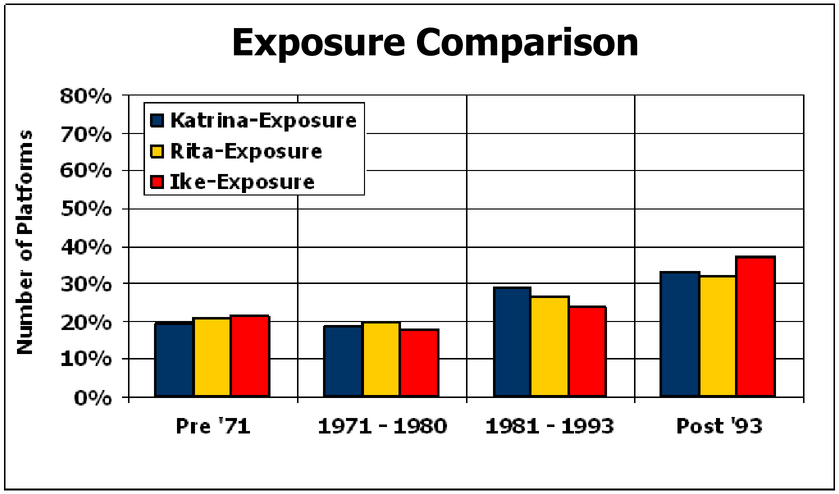
* Platforms destroyed include Caissons/Fixed platforms except Typhoon MTLP in Rita

Disproportionately High Waves?

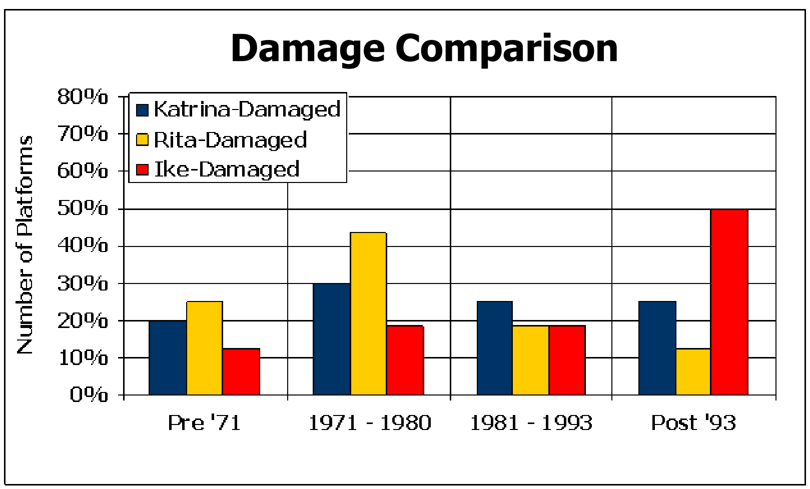
- Few recordings of wave heights in the Gulf
- New dynamical Storm Surge models tell us that wave heights were much greater than typical for a cat 2 storm - because of Ike's large size
- Waves known as principle component of offshore damage

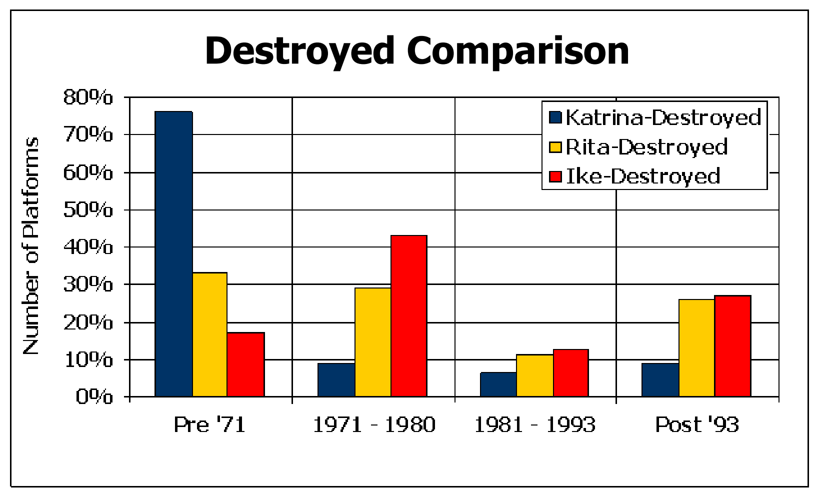


What Types of Platforms Were Destroyed?



- Exposure in the 3 storms similar in terms of age of platforms affected: about 30% platforms affected in each storm are post 93
- Newer platforms more damaged by Gustav/Ike than the 05 storms: 50% of the platforms damaged in Ike were post 93, compared to only 20% of the platforms damaged in Katrina





Offshore Lessons to be Learned

- The large diameter of Ike meant that waves were much higher relative to windspeeds
  - Improvements in dynamical wave modeling expected in future model versions (not captured today, even in SLOSH)
- Following soon after Gustav (before damages had been assessed) damages likely to have been compounded in the two storms
  - Claiming practices and allocation between storms in loss modeling is area of ongoing research
- Unexpected failure of newer platforms ??
  - Claims analysis underway
- A few toppled platforms with 10+ wells have caused significant OEE that are driving the total loss for Gustav/Ike

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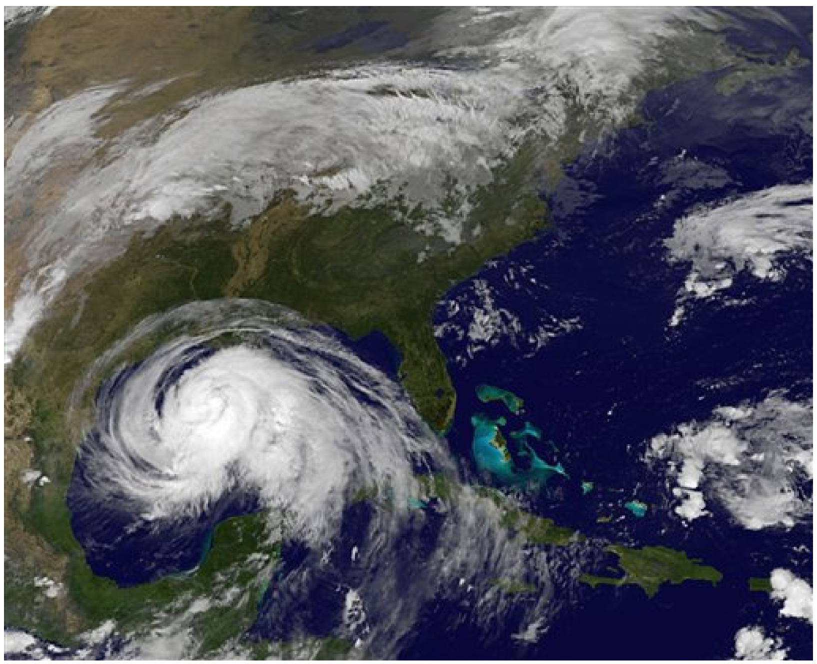
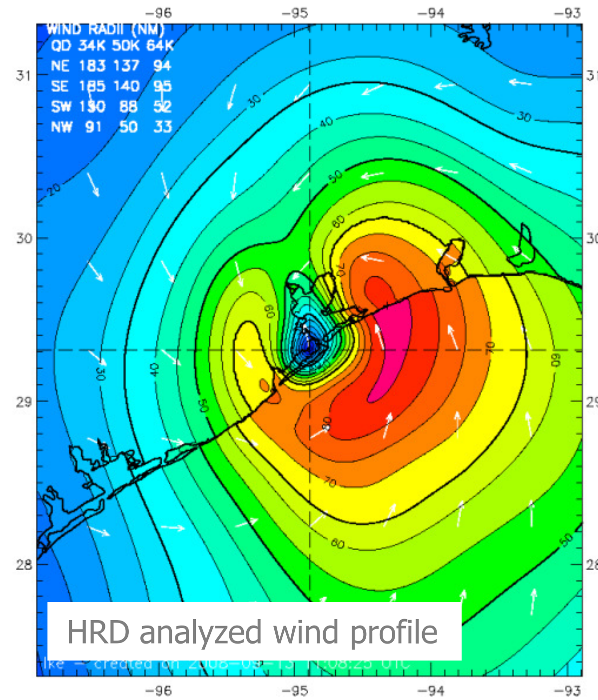
Ike’s Onshore Windfield

Landfall on Saturday Sep 13 2.10 am CDT

- Eye came onshore at Galveston: Shrunk in size RMax 39 - 44 miles
- Estimated maximum sustained winds 110mph, Central pressure 952mb (CAT 2)
- Strongest winds located 51 miles to the east: east Galveston Bay
- Weakened slowly, still a CAT-1 8 hours after landfall as it tracked over Houston
- Storm surge heights 9-11 feet above normal along much of the Texas coast





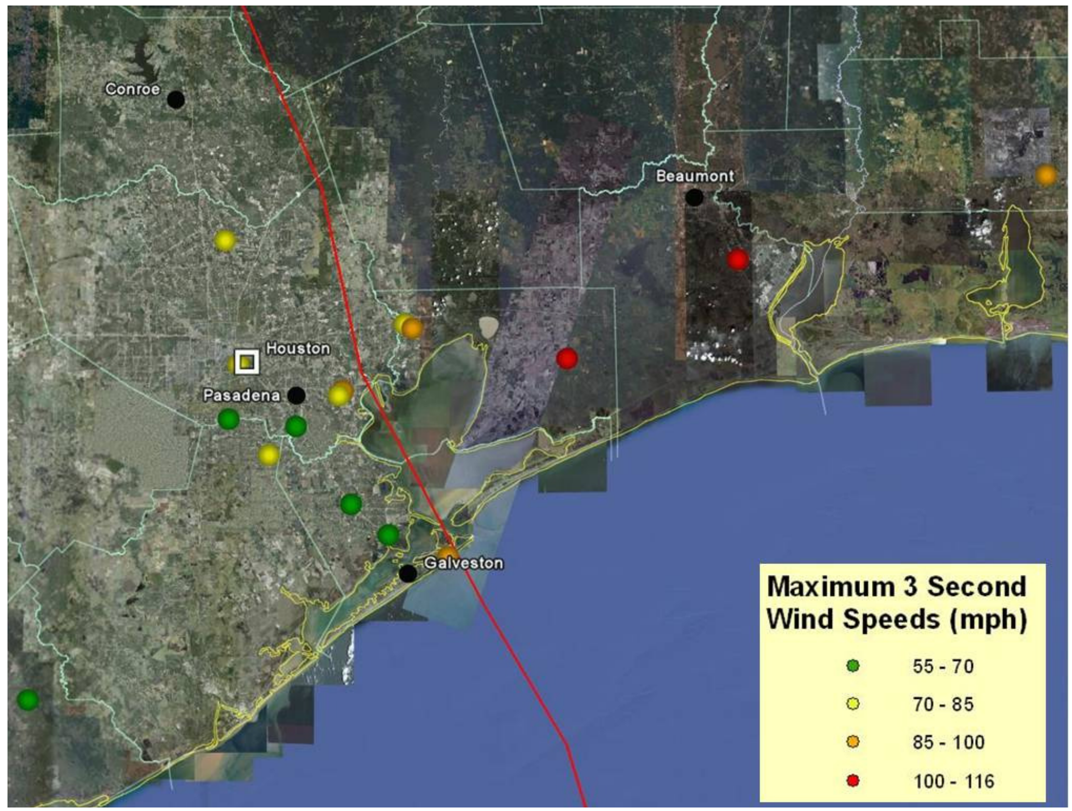
HRD analyzed wind profile

What Did We Know About Ike?

- Almost all NWS wind speed recorders failed to record peak windspeeds
- RMS funded 5 FCMP towers, 7 WeatherFlow observations offer key insights
- So, what were Ike's winds over Houston?

Typical WeatherFlow® weather station

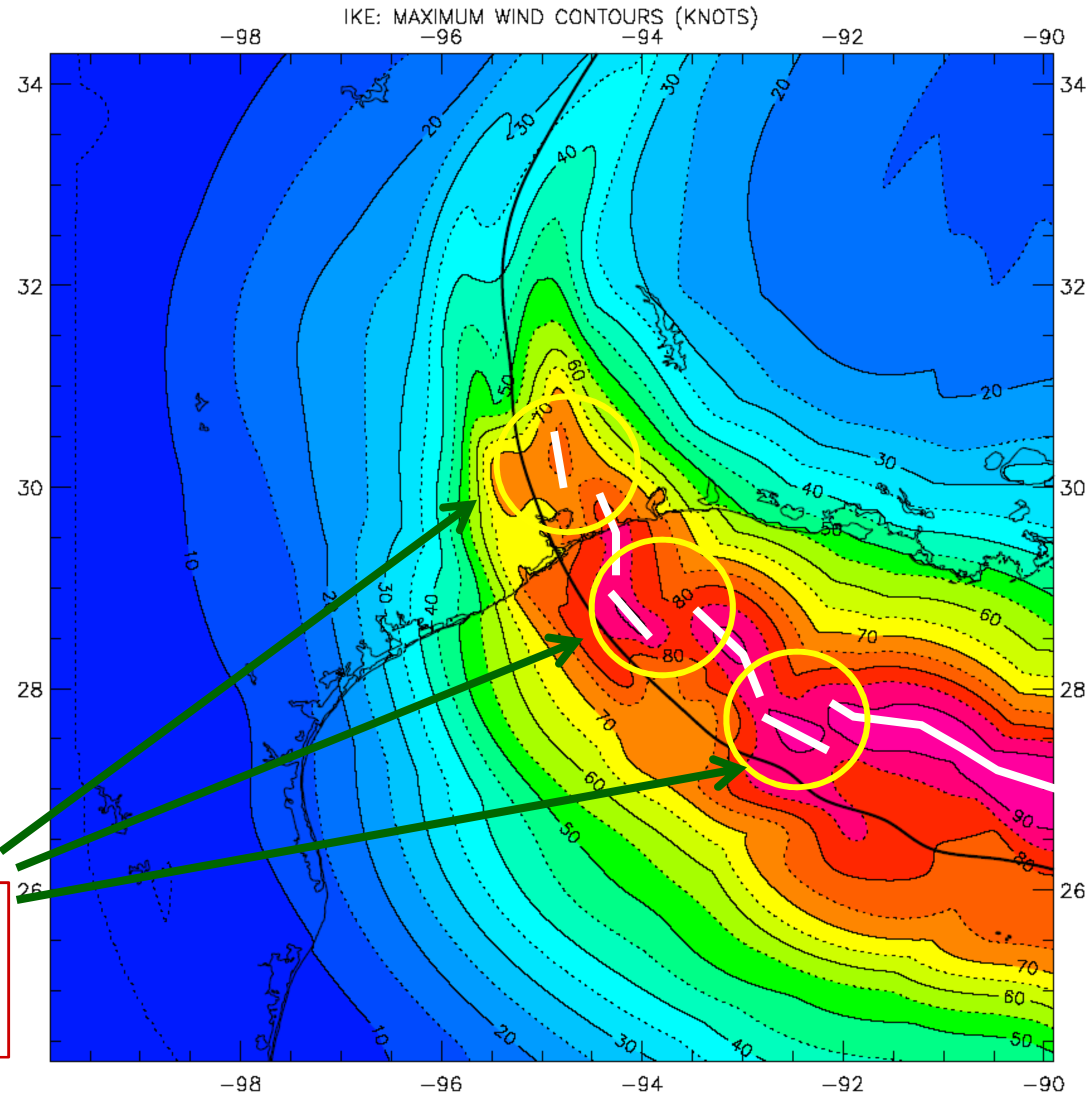
Typical weatherflow station



Weatherflow and FCMP observations

Windfield Reconstruction Challenges for Ike: Rapid Eyewall Replacement Cycles

- Rapid eyewall replacement cycles evident before and after landfall
- Contraction of eyewall increases winds
- And winds move to the left
  - Looks like a final eyewall contraction happened after landfall as Ike passed Houston: bringing a burst of higher winds over Harris county

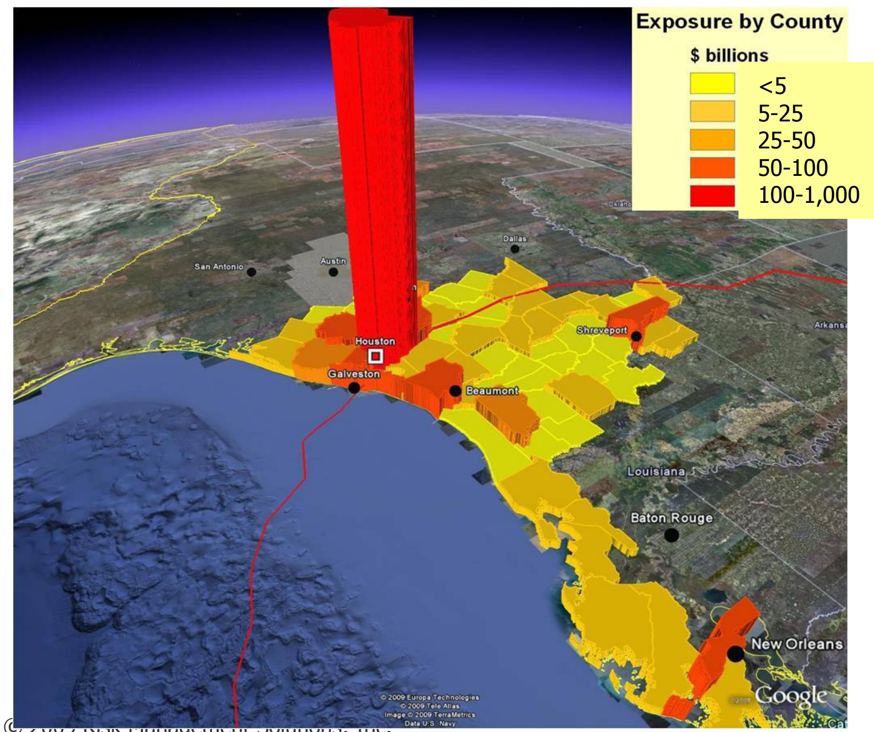


As a new smaller eyewall develops, high winds also move to the left of the track

Critical for HU Ike Because:

- The larger the proportion of the loss that comes from low hazard levels the greater the sensitivity in loss reconstruction
  - Vulnerability curves are steep at relatively low hazard levels
- Also, uncertainty in vulnerability is higher at low windspeeds

High Concentration of Exposure in Harris County



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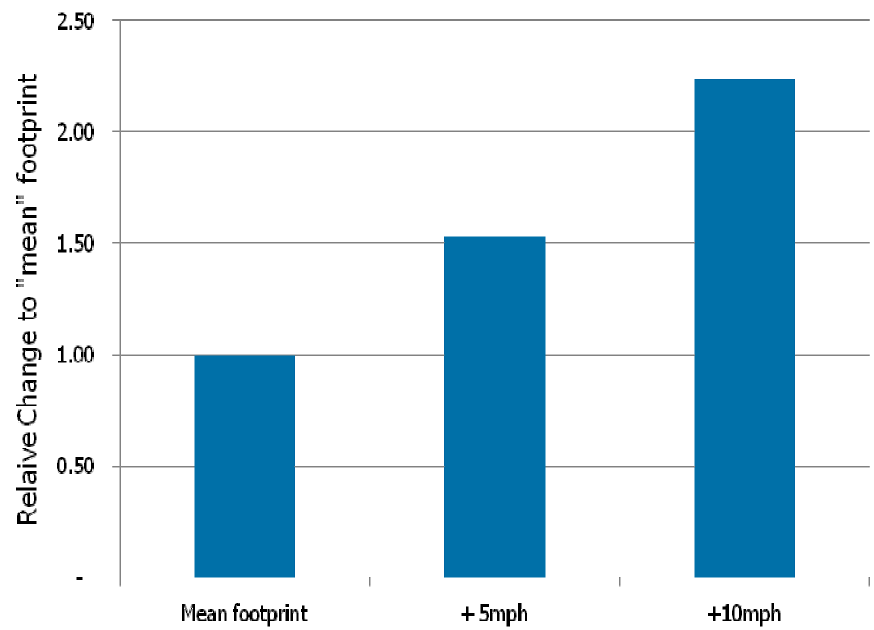
Low windspeed event = high sensitivity in loss estimates



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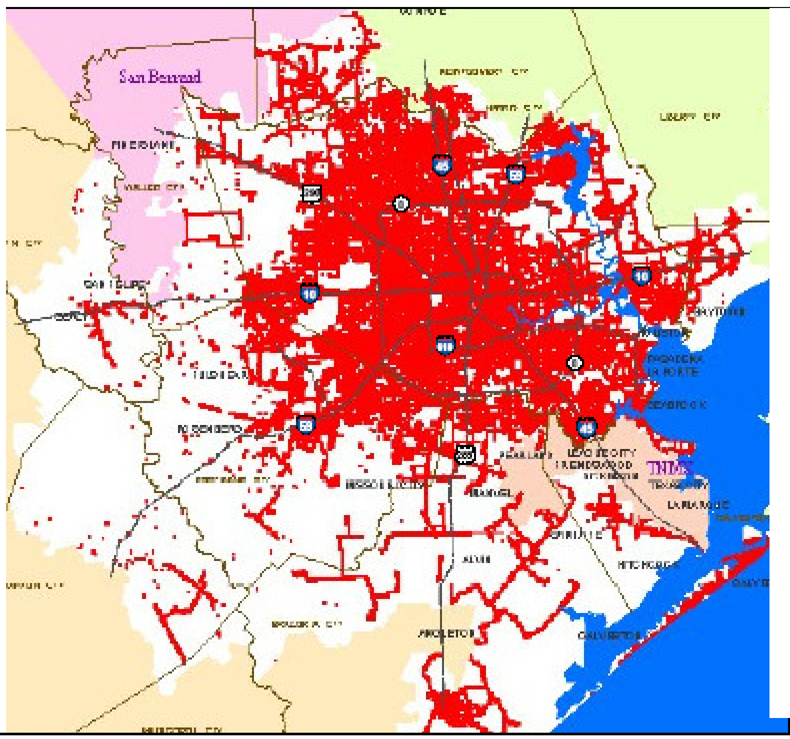
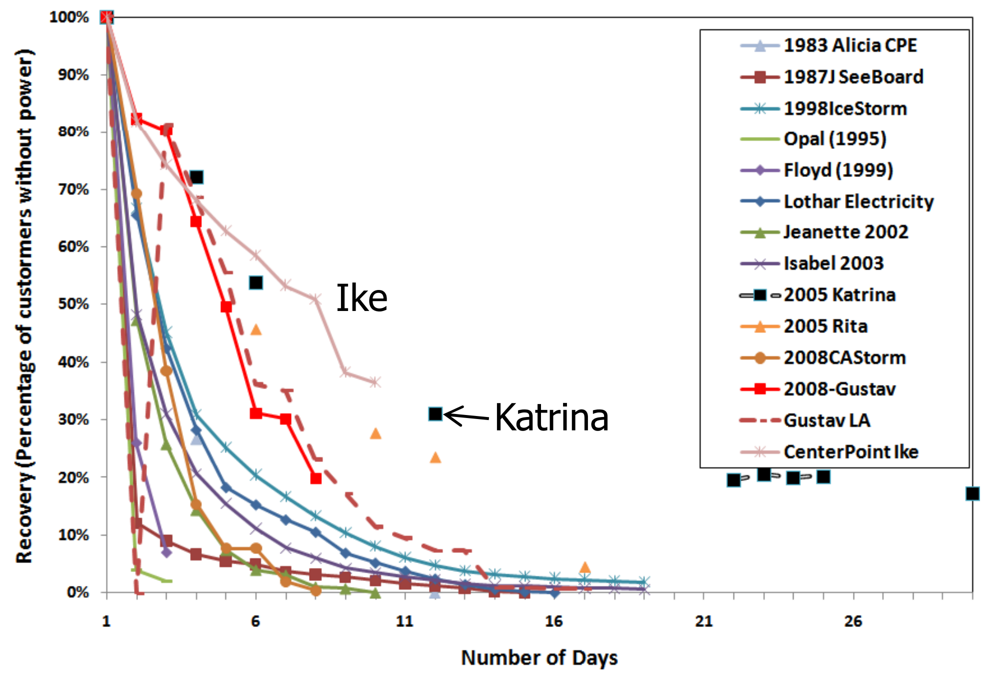
Power Outages and Storm Surge

Extensive Power Outages

- The degree of damage to the Houston region power infrastructure was surprisingly high for a cat 2 hurricane
- Unusual to have such long lasting outages in a major city
- Reconnection rates slower than Katrina even though Katrina exacerbated by New Orleans flooding and loss of oil supplies insights

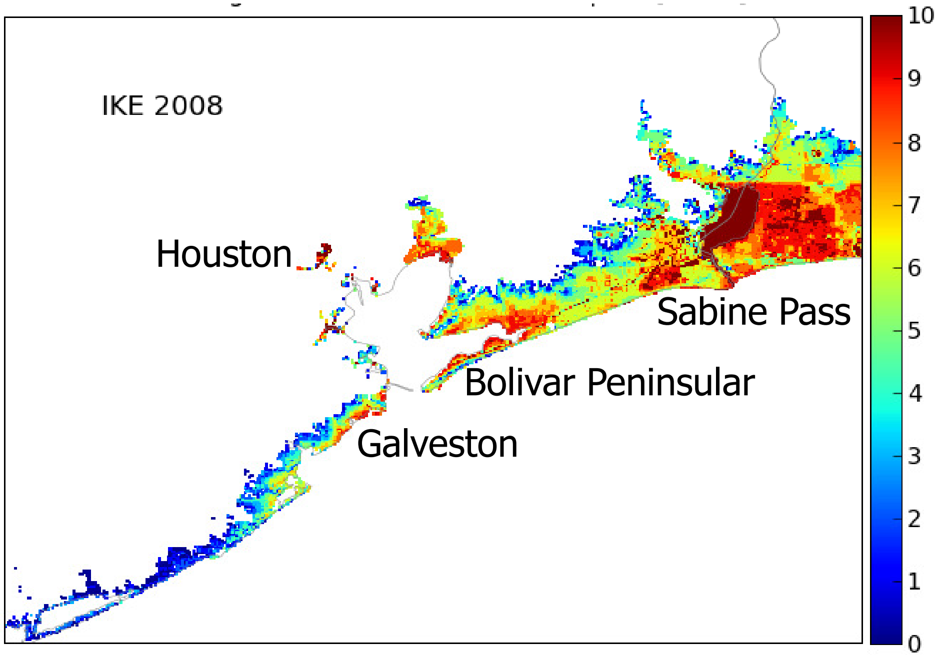


2.1 Million Customers without power, 13 Sept, 11 a.m.



Extensive 10ft+ surge

- 100,000+ properties damaged/destroyed along the coastline
- Leakage of loss into wind policies for destroyed properties ??
- Network BI impacts from uninsured flood damaged properties on wind policies

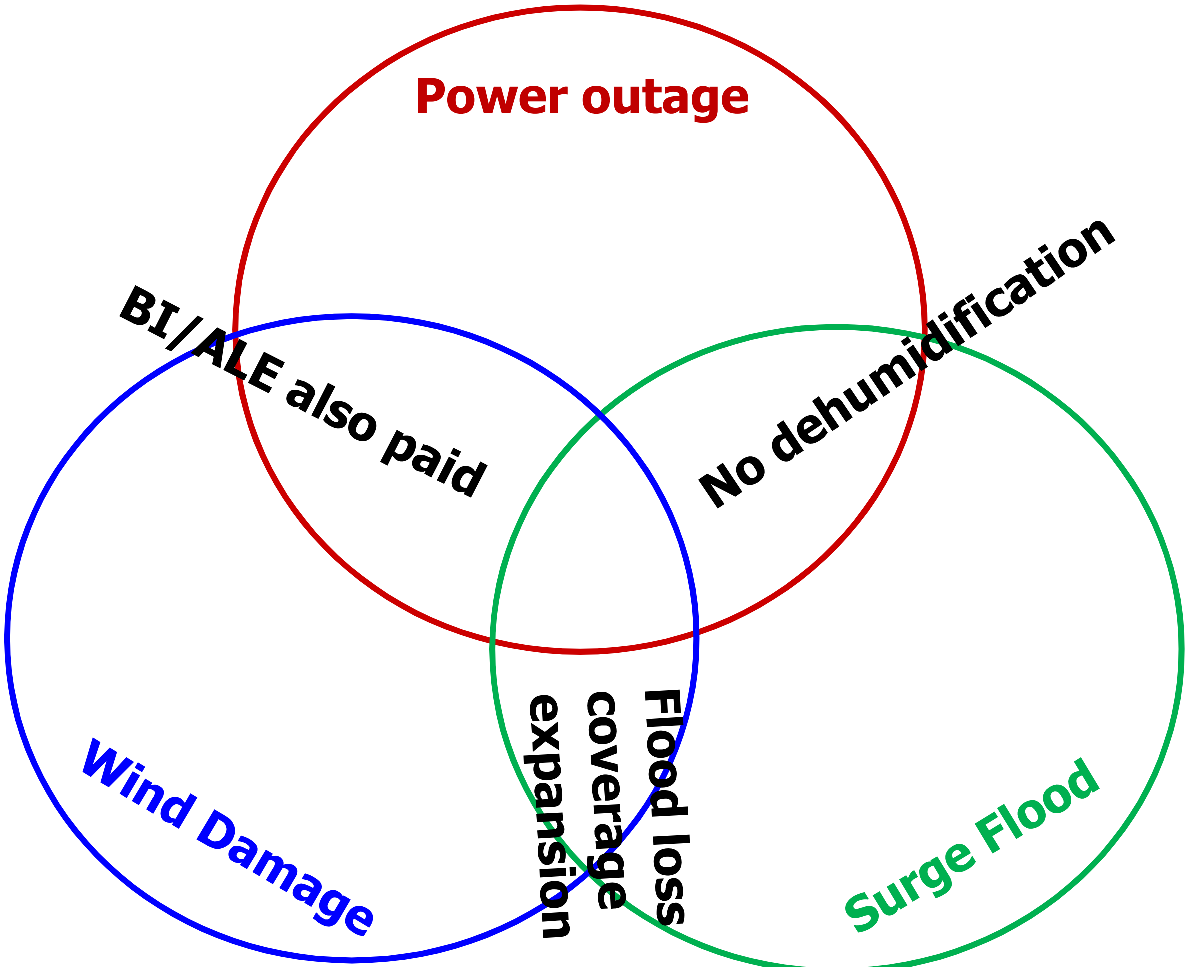


Modeled Storm Surge Footprint

David J. Phillip – Pool/Getty Images

Claiming at the intersection of the perils

- Losses escalate when power outages, flood damage and wind damage intersect, particularly in a major urban area

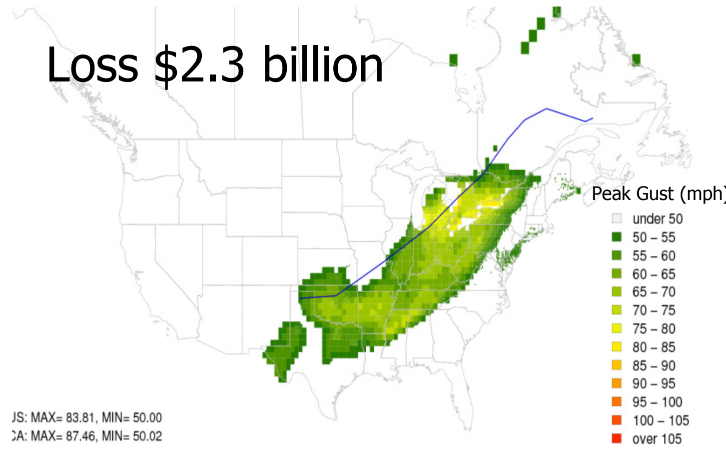


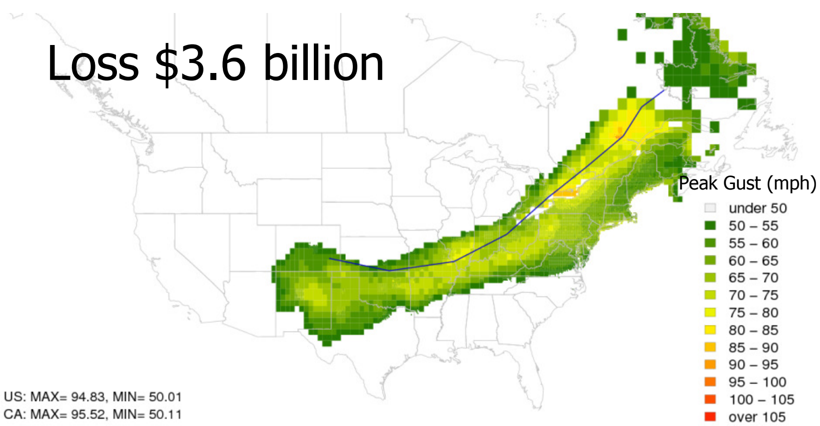
Inland Reintensification

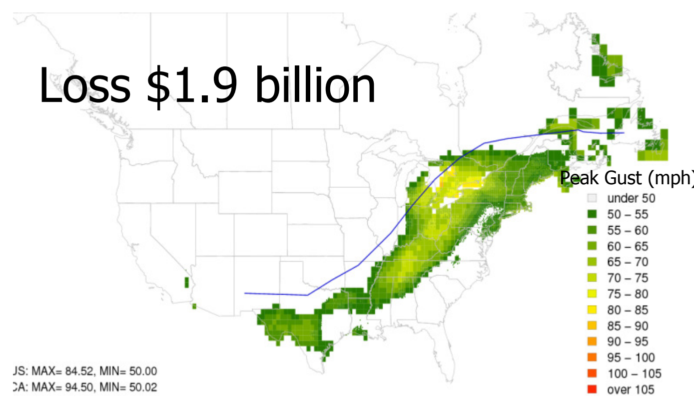
Remains of Ike Combined With an Extratropical System Inland

- NHC: “The post-tropical remnant low of Ike produced strong wind gusts as it moved across the Ohio Valley into southeastern Canada Wind gusts to hurricane force were reported at Louisville, Kentucky, and Cincinnati, Columbus, and Wilmington, Ohio. “
- Similar to how winterstorms form
- How frequently can this occur?

Similar storm footprint events from Winterstorm Model







New Learning From Claims Data

Post 2008: Claims Analysis Initiative

- RMS is again pursuing a major claims research program, as with after all major cat events
- Working with the industry across all LOBs
- Talking with claims handlers, loss adjustors etc

Residential

Commercial/ Industrial

Flood and wind

Detailed Forensics into Claims Escalation

- **Quality of construction** (likely due to a lack of building code enforcement):
- Issues with **valuation** (under insurance)
- **Code Upgrade Requirements** - ongoing debate about who is responsible for the additional cost of repair due to the required upgrade (insured vs. insurer)
- **Claims inflation:** e.g. reported instances of whole roof's getting tarped for repair with only a small area in need of repair
- **Coverage expansion** and vulnerability deterioration due to extended power outages, particularly for large commercial and industrial properties
- **Wind/Water** damage and allocation in claims handling
- Role of **public loss adjustors**
- Influence of **data coding**: applying data quality indexes

Learning from Catastrophes

- There is always something to learn from major cat events, and Ike was no exception - each major catastrophe provides important new insights.

- Losses from Ike rapidly escalated in a way that surprised even insurers and claims managers on the ground

- Key lessons to be learned from Ike
  - Impacts of extended power outages, flood damage and wind damage on escalating claims
  - Non-linearities related to size of storms – particularly on offshore losses
  - Sensitivity to low windspeed vulnerabilities
  - Claiming behaviour