AIR WORLDWIDE

Webinar: The Impact of Hurricanes Harvey and Irma on the U.S. Mainland

Q&A Response Document

➢ Meteorology and Climate

Were there any early-season or prior-season significantly predictive features?
The atmospheric flow that caused Harvey (or any storm) to take the track it did cannot typically be predicted more than around 10-14 days prior. There are some large-scale pressure and wind patterns that result from specific time-varying phenomena, such as the North Atlantic Oscillation, but these variations can go back and forth over weekly to monthly periods. Therefore, there is currently no way to predict Harvey-like events with any reasonable accuracy prior to a season.

Regarding climate change, I believe NOAA has said that one storm season or even one storm cannot establish such a phenomenon. What is your view of this?
We agree with this assessment.

Will we see more intense hurricanes over the next few years, or was this an anomaly?
It is generally agreed that we have been in a period of enhanced activity since around 1995. This of course varies from season to season. Over the last five years or so we have experienced a period of relatively lower activity, and some suggested that this signaled a return to less tropical activity, as observed in the late 1960s through the early 1990s. Activity this year has caused many to question this suggestion, and based on the factors believed to lead to enhanced activity (e.g., Atlantic sea surface temperatures), there is no indication that we are out of this active period. In general, we should therefore expect relatively active seasons to continue, subject to typical inter-seasonal variations.

With events like Harvey (and Matthew last year), how significant do you anticipate hurricane-induced precipitation flood to be going forward? Or are these types of events rare in nature with respect to this sub-peril being the primary driver of loss?
From a purely hazard perspective, there is currently no strong indication either way that we will see significantly more precipitation flooding from hurricanes in the future. There is a physical relationship between the air temperature and the amount of water vapor the air can hold, so some climate simulations have suggested that we might generally see more rainfall as the planet warms, but currently no clear observational evidence exists. Harvey's large amount of rainfall had more to do with the storm

motion stalling in southeast Texas; this is not all that unusual, as tropical cyclones often stall when the atmospheric steering currents become weak, but unfortunately it occurred in a particularly vulnerable location. Independent of the hazard is the issue of poor planning and urban sprawl, which in Harvey's case certainly exacerbated the problem.

How does AIR differentiate inland flood from storm surge in their model?
In the existing suite of AIR models, inland flooding and flooding due to storm surge are modeled independently using the AIR U.S. inland flood model and U.S. hurricane model, respectively. The interaction between the two processes is not modeled.

How does the model handle the non-surge flood portion of the events?
For Harvey, the AIR U.S. inland flood model was used to model the non-surge portion of the hazard for the ALERT™ full loss posting. In the AIR U.S. hurricane model, non-surge flood (i.e., inland precipitation-induced flooding) is not currently modeled. Future U.S. hurricane model updates will contain the inland flooding sub-peril.

How does AIR model the pluvial flood footprint for Harvey considering AIR's U.S. flood model is a 1-dimensional riverine model?
As a matter of fact, both riverine and pluvial flooding are modeled by the AIR U.S. inland flood model. The *riverine* flood extents are modeled based on a 1-dimensional water surface profile estimation method, followed by a 2-dimensional flood mapping approach. The impact of *pluvial* (or non-riverine) flooding and consequential losses are estimated based on a statistical approach that incorporates relative elevation and rainfall excess as the bivariate proxies of the flood intensity. As the pluvial flood model component is statistical in nature, no spatial flood footprint map is provided as an explicit output by the model. The spatial coverage of locations incurring losses due to the pluvial component implicitly represents the extent of the pluvial flood.

Why do we see so much storm surge near Jacksonville from Irma while little is seen on the rest of the East Coast?
Several factors likely contributed to Jacksonville being more impacted than farther south: first, the larger wind field and resulting fetch and duration forced more water into the estuaries in North Florida; second, the already large amount of rain that had fallen in the area (upwards of a foot in some locations) contributed to the surge

inundation; third the onshore wind prevented this rain from draining before the surge arrived.

Is the storm surge completely a result of the wind component of the storm or is it also related to the internal pressure or other aspects of the hurricane?

Wind is certainly an important component to modeling storm surge, and the size of the wind field is just as important as the intensity/maximum winds. Additional factors that control the impact of surge are the speed of the storm, the angle at which the storm crosses the coastline, and the local bathymetry (i.e., the shape of the ocean floor near the coast). The pressure of the storm (aside from the relationship between pressure and wind) has a comparatively small impact on the surge. This so-called inverse-barometer accounts for only a few percent of the sea-level rise in the strongest of storms.

Is it possible to expand on why Irma's wind field expanded so much as it headed north? Anything we can learn for the future?

While this increase in Irma's size appeared to be rather abrupt, both theory and observations show that as tropical cyclones increase in latitude (i.e., travel north), the storm size typically increases. AIR's model takes this into account.

Could you discuss the blocking high and what caused this to be coupled with the weak vertical wind shear and high sea surface temperatures? Are teleconnections such as El Nino likely to play a role in this?

The juxtaposition of the blocking high that resulted in Harvey stalling with the generally supportive conditions for Harvey's intensification are not likely a result of some discernable phenomenon. There are numerous historical analogs for Harvey of tropical cyclones stalling, looping, reversing direction, etc., due to the atmospheric steering flow pattern. Harvey unfortunately happened to stall in a particularly vulnerable location.

Which potential climate change impacts are being included within the AIR North Atlantic TC model?

Changes in hurricane activity due to climate variability is implicitly covered in AIR's U.S. hurricane model because we model from the historical record, which spans several climate states. We do not yet explicitly model the climate influence on activity, but this is being researched for future model releases.

Although there is not yet scientific consensus on how anthropogenically-driven climate changes will influence hurricane activity from a physical standpoint, we continue to monitor scientific literature and data for scientifically and statistically robust signals.

➢ Vulnerability

What is the biggest factor impacting the non-homogeneous nature of residential wood frame damage?
The wide variability in the residential wood frame building inventory in terms of size, roof geometry, roof shape, roof cover, level of opening protection, and foundation type is what makes them non-homogenous.

Were there any notable examples of building types that performed significantly better or worse than expected (modeled)?
When it comes to wind, non-engineered building types constructed with wood or masonry tend to suffer more damage compared to their engineered counterparts constructed using concrete and steel. Manufactured homes (colloquially referred to as mobile homes) are exceptionally bad performers when it comes to wind and storm surge.

Among commercial building types, gas stations are one of the most vulnerable structures, along with buildings that have light metal panels that form their walls or roofs. Buildings with unprotected or partially protected openings, unbraced gable end walls, or insufficient anchorage among components, such as roof cover to roof deck, roof deck to roof system, roof system to walls, walls to foundation, also tend to sustain more damage.

When it comes to storm surge, foundation type, elevation of the first floor in the building, and location of service equipment are the primary determinants of damage. Slab foundations tend to perform the worst, and again, so do manufactured homes. Buildings and service equipment that are elevated sufficiently usually perform well against storm surge.

What does opening protection mean?
Building codes require structures in windborne-debris regions to protect openings such as doors and windows through the installation of shutters or impact-resistant glass. These protective measures safeguard the building envelope from breach due to debris

and prevent any failures that could arise from internal pressurization of the building envelope.

Would the internal pressurization be alleviated by keeping all windows and doors open?
No, opening any windows or doors during a hurricane can lead to extensive damage. All windows and doors should be shut tightly to prevent any wind from entering the home. This article from the Insurance Institute for Business and Home Safety addresses this issue.

What is the relative cost of each of these types of roofs: metal, shingle, tile?
From an initial installation standpoint, an asphalt-shingled roof is much less expensive—by about 50%—than a metal roof. However, when we look at a life cycle cost assessment, the decreased maintenance and energy cost are what makes metal roofs more appealing. This page examines the cost of various roofing materials from an initial investment and long-term perspective.

Would you say that clay tile roofs were equivalent to composite shingle or worse?
The answer depends on the age of the roof cover material and the composition of the composite shingles: asphalt vs. concrete. Composite asphalt shingles that predate building code test standards are generally more vulnerable to wind than tiles. Tiles and asphalt shingles that are compliant with current hurricane-rated test standards generally perform similarly. Composite concrete roof cover performs similar to tiles with respect to wind vulnerability.

For industrial buildings, you mentioned extensive metal roof damage, but don't metal roofs perform well for residential structures?
Industrial and residential structures have significantly different metal roof structures leading to this damage discrepancy. While residential buildings tend to have corrugated sheet metal, standing-seam metal panels or metal shingles, the industrial metal roofs we discussed in the webinar are primarily composed of metal panels. The overall roof system itself (consisting of metal panels, connections, and decking) is very different. Residential structures have wood or masonry walls and a roof system consisting of trusses, decking, and metal panels connected to the decking using screws or ring shank nails. Industrial buildings, by contrast, tend to have a main frame made with steel members, with the roofs and walls made of steel or metal sandwich

panels connected to the purlins by nails. Some industrial buildings can also have masonry or concrete walls. The gauge of these panels and the relatively larger dimension and spacing are what make them subject to higher wind loads and pressures.

Can roof tie-downs be changed affordably to mitigate roof damage?
We think so. These are very affordable and extremely effective in making sure that the roof system is intact and does not fly away.

What makes the soffits on homes with metal roofs more susceptible to damage?
Soffits in general are highly susceptible components, irrespective of the type of roof cover used. Though asphalt shingles and clay tile roofs were more significantly damaged compared to metal roofs, the soffits were damaged in all cases. In the case of a metal roof, while the metal panels themselves could withstand the suction pressures from wind acting on them, the soffits were blown out because of their lower resistance to the same pressures.

Do the updated building codes require reinforcement of roof beams to the house?
The majority of residential single- and multi-family housing is wood and masonry construction, both of which have wooden roof systems. As such, reinforcement of roof beams is not applicable. It is more relevant when we look at reinforced concrete construction with concrete roofs that are either poured monolithically with the walls or made up of precast concrete panels.

Within this structure type, roof joists are indeed fortified to carry additional loads. This is typically done by adding additional joists in between two existing joists to reduce the spacing between them, or reinforcing the existing joists with additional pieces of wood, along with glue and screws, to convert them to I-joists. In high-wind areas, where structures are generally designed to withstand 3-second gusts in excess of 110 mph, additional metal connectors might be necessary between the roof system and the walls to reinforce the structure against high-suction pressures from winds.

Could you comment on Exterior Insulation and Finish System (EIFS) performance? Did you notice any improvement in newer installations and those with DensGlass?
Given that a lot of the structures with significant wind damage were residential, EIFS performance was not necessarily in our objectives. We will keep you informed in case we gain additional insight into this aspect in the future.

Which counties/areas had the laxest enforcement of building codes?
Regarding only regions affected by hurricanes Harvey and Irma in Texas and Florida, respectively, Florida had superior enforcement. In Texas, the coastal counties generally have better enforcement than inland counties. This assertion is supported by data from Verisk's Building Code Effectiveness and Grading Schedule (BCEGS), the Insurance Institute of Business and Home Safety's (IBHS) Rating the States reports, and AIR's own research.

Are there any indications that code enforcement differentiated loss?
We have seen in the past that areas with better code adoption and enforcement practices fare better when it comes to hurricanes. This was gleaned primarily by looking at claims data from several insurance companies for past hurricanes. We have yet to receive claims data for the 2017 hurricanes, but this is something we will look at when we do receive them.

How did the year a structure was built impact wind damage from Hurricane Irma?
On average, buildings built after 2001 in Florida should fare better when compared to buildings built prior to 2001. The significance of 2001 lies with the adoption of the first edition of the Florida Building Code. When we look at the pre-2001 time frame, buildings built between 1995 and 2001 should fare better than those built before 1995. Learnings from 1992's Hurricane Andrew were incorporated into Florida's building code in 1995. As always, uncertainty exists across all these time bands depending on the adoption and enforcement of building codes.

What building regulations will change as a result of this wind season?
Changing building codes is a politically charged process, and what can be even more political is their adoption and enforcement. We at AIR are waiting to see what the 2017 hurricane season means in terms of building code requirements and changes. We anticipate that this process would take a few years.

From your survey, can you identify or tell the differences between wind loss and water loss, given some insurance doesn't cover water damage (flood)?
Our damage surveys are geared toward understanding damage mechanisms and patterns among different structures. We use these surveys to understand which components of buildings are damaged and the extent of the damage; common damage themes in residential vs. commercial buildings; the impact of construction type; and the relative performance of different secondary features such as roof cover and foundation

type. When we look at structures that are impacted by both wind and flooding, we can look at damaged components and assign them to wind vs. water. However, we typically don't have the claims/losses handy when we go out on these surveys to then try and split them out as wind vs. flood.

Regarding flood damage to autos, did your damage survey give a sense of how many autos left the areas through evacuation versus the proportion that were left and subject to flood damage?
Our damage surveys did not look at damage to automobiles in the context of correlating them with evacuation in the affected areas.

➢ Losses

What evidence is there thus far of demand surge?
AIR published several blog posts examining demand surge in the 2017 hurricane season in general and specifically for the individual hurricanes:

- What Demand Surge Might Look Like in This Year's Hurricane Season
- How Will Loss Adjustment Expenses React to Hurricane Irma?
- Why Puerto Rico Needs More Loss Adjusters Now

Is there any consideration to include loss of life and the economic impact on the life insurance LOB?
AIR will not be releasing information on the impact to the life insurance LOB.

What is the current AIR view of private insured loss from Hurricane Harvey (including flood)?
Our estimate of industry insured losses is in excess of $10 billion. More details, including what factors these estimates do and do not include, are available on our ALERT posting for Hurricane Harvey.

Are there any insights or estimates on an industry return period?

- Irma United States (Wind and Surge)
    - U.S. ≈ 10 years
    - FL ≈ 18 years
    - Alabama, Florida, Georgia, South Carolina (impacted states) ≈ 17 years
- Hurricane Harvey (Wind and Surge)

  - U.S. ≈ 2 years
  - Texas ≈ 8 years

Can you expand on the differential between FLOIR estimated loss of $5bn and AIR estimated of $25-35bn for Hurricane Irma?
The Florida Office of Insurance Regulation (FLOIR) is not estimating losses from Hurricane Irma, rather they are reporting claims that have already been filed. The FLOIR's estimate is "aggregate information … compiled from claims data filed by insurers." As a result, it is constantly evolving as new claims come in. Through November 13, their reported claims stood at more than USD 5.8 billion. The FLOIR will update its claims data next on Dec. 14, and we expect that number to continue to increase as more people return to parts of Florida, particularly the Keys, which experienced the most significant degree of damage. For an additional source of context, reported losses from PCS for Florida thus far are significantly higher than the claims data being reported by the FLOIR.

AIR's loss estimates, on the other hand, are intended to be a more comprehensive figure that accounts for all insured losses that could be attributable to Irma. Please visit our ALERT posting for Hurricane Irma for details on what our loss estimates do and do not include.

Do you have any indication of how these losses might affect the reinsurance market?
It is a bit early to tell the true impact of the 2017 hurricane season on the reinsurance market. Currently, the reinsurance market is soft (low rates, high limits, flexible contracts), but there are differing views on whether this season will harden the market or not. In addition to the 2017 hurricane season, we also need to consider the two earthquakes in Mexico and the wildfires in California this year. The insurance and reinsurance industry will see the true impact of their underwriting guidelines this year with the multiple events across multiple regions and perils.

➢ General

Why was Puerto Rico not discussed?
The topic of this webinar was specifically to look at the impact of Hurricanes Harvey and Irma on mainland U.S. The impact of Hurricanes Irma and Maria on the Caribbean will be discussed as part of another webinar in December. Details will follow soon.