HURRICANE RISK INSIGHTS

Prevent Avoidable Losses with Predictive and Actionable Insights

Betterview
by Nearmap

> Property & Casualty (P&C) insurers face an uphill battle when writing policies in regions prone to hurricanes. Due to a lack of sufficient property vulnerability data — and exacerbated by increasing storm activity in recent years — insurance companies have been unable to provide the coverage that their customers depend on, at an affordable premium. This is certainly bad for business, but it also erodes the all-important trust between insurers and their policyholders. Security and peace of mind are the greatest values insurers can provide to their customers; when these are absent, it is time to change existing practices, or else risk serious damage to customer relationships.

Challenges P&C Insurers Face when Underwriting in Hurricane-prone Zones

Existing tools focus exclusively on regional hazard data, not property-level insights, making it hard to make precise underwriting decisions.

Existing hazard data is siloed across different platforms, making it difficult and slow to analyze.

Without transparent property-level vulnerability information, it is difficult for insurers to engage with policyholders to mitigate the risk. This leads to declining coverage, extremely high premiums, and shrinking market share.

Increasing Hurricane Risk in the United States

Hurricanes have long been a source of risk to the United States, with detailed records of hurricane damage available dating back to the 19th century. Since 1851, when the National Oceanographic and Atmospheric Administration (NOAA) began keeping detailed records of hurricane tracks, there have been an average of 17.7 landfalling hurricanes per decade in the United States.[1] In recent years, however, the problem has worsened: Despite the slow start in 2022 hurricane season, NOAA still expects this year to be an "above-normal" season, making it likely to be the third most active season on record.

The Intergovernmental Panel on Climate Change's sixth assessment report found that adverse effects of hurricanes have already increased due to sea level rise, and with increasing coastal development, the country's exposure to these weather events continues to grow as well.[2] Indeed, this increasing risk can already be seen in the financial consequences of hurricanes over just the last few years. In 2016, the Congressional Budget Office estimated the expected annual economic losses caused by hurricane winds and storm-related flooding to be $28 billion — roughly 0.16% of the US economy. By 2019 this estimate had already grown to $54 billion, up to 0.3% of the US economy.[3,4]

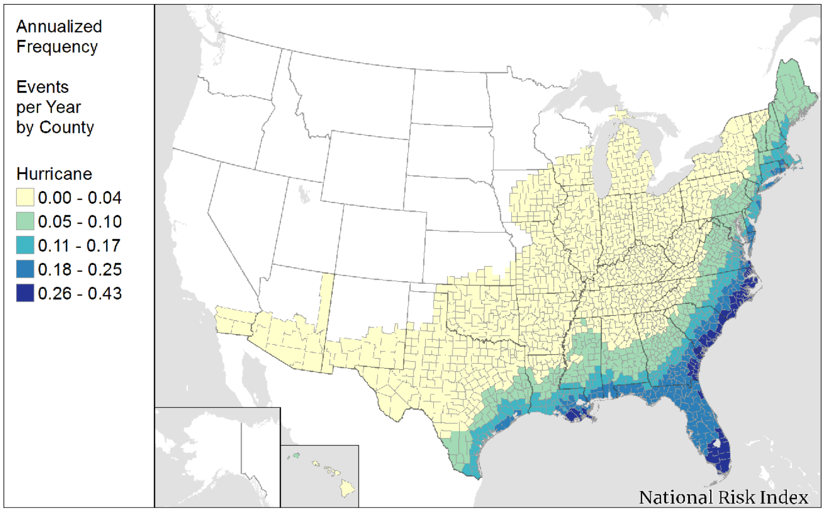


Figure 1: Annualized frequency of hurricane events by county in the United States (FEMA).[5]

Rank	State	Number of major hurricanes 1950-2022
1	Florida	38
2	North Carolina	29
3	Louisiana	28
4	Texas	21
5	Alabama	13
6	South Carolina	11
7	New York	8
8	Mississippi	8
9	Georgia	4
10	Virginia	3

Table 1: Top 10 states by the number of hurricanes recorded since 1950.[6]

Since hurricanes can travel inland for hundreds of miles, and due to their wide wind footprints, large swaths of the United States, not just coastal communities, are exposed to hurricane hazard. The Federal Emergency Management Agency (FEMA) estimates that more than half of the continental United States has a non-zero probability of being impacted by a hurricane (Figure 1). While the majority of the exposed counties have a relatively low likelihood of experiencing a hurricane (up to 0.04 events per year, or one event around every 25 years), the annualized frequency is as high as 0.26-0.43 for some of the higher-risk counties, which roughly translates to being hit by a hurricane every 2 to 4 years.[5]

The increased hurricane risk in the United States has become a challenging issue for P&C insurers, especially in the coastal states. It is ever critical for underwriters to get ahead of this hurricane risk and understand it thoroughly to predict and prevent losses.

Get a Complete Picture of Hurricane Risk

Regional Hazard x Property-level Vulnerability = Risk

Insurance companies rely on accurate, consistent, and complete measures of catastrophe risk in order to appropriately price, underwrite properties, and assess their exposure. The catastrophe risk is determined by two complementary factors: hazard and vulnerability.

Hazard is the probability of the peril in question (hurricane, wildfire, etc.) occurring in a particular area and also the expected intensity if it occurs. For example, a hurricane hazard model estimates the likelihood of different levels of hurricane wind speeds impacting a given area based on past hurricane activity, observed wind speed data, and physics-based models. This means that two identical buildings, one in Louisiana and the other in California, have different hazard levels with different likelihoods of exposure to hurricanes.

Vulnerability, on the other hand, is an asset's level of susceptibility to damage or loss for a specific peril. This means vulnerability is not related to location but is a derivative of the characteristics of the exposed asset. Hence, the two identical buildings in Louisiana and California could have the same vulnerability when exposed to winds, despite their locations having different levels of hazard. The building in Louisiana has a much higher overall hurricane risk than the one in California.

This interplay between hazard and vulnerability in determining overall hurricane risk is demonstrated in Table 2. Risk in a high hazard area can be mitigated by having well-protected building structures that are less susceptible to hurricane damage. Risk in a low hazard area is elevated for properties that are particularly vulnerable to these low probability but high-intensity events.

In this context, it is crucial for insurance companies to have an accurate understanding of both hazard and vulnerability to get a complete picture of hurricane risk, in order to appropriately price and underwrite existing and new policies.

	Low Hazard *(e.g. California)*	**High Hazard** (e.g. *Louisiana)*
Low Vulnerability *Reinforced concrete factory building*	**LOW** HURRICANE RISK	**SOME** HURRICANE RISK
High Vulnerability *Wood frame single-story home*	**SOME** HURRICANE RISK	**HIGH** HURRICANE RISK

Table 2: Hazard vulnerability matrix for determining overall hurricane risk.

Hurricane Vulnerability Modeling

The main building blocks of a catastrophe model are mathematical representations of hazard and vulnerability. Hurricane hazard modeling is relatively advanced thanks to the wealth of available weather data, the advanced state of meteorology and atmospheric sciences, ongoing publicly funded research on hurricanes, and models to analyze different related societal needs (e.g., robust weather prediction and emergency preparedness). On the other hand, hurricane vulnerability modeling has historically faced more challenges owing to the vast uncertainty of damage outcomes, the influence of human behaviors on claims outcomes, and most importantly, the lack of available data like current conditions of a building, state and coverage of maladies on the roof, and current state of vegetation in the vicinity of the building. As such, vulnerability tends to be the weaker link in a hurricane risk model.

There are typically two approaches to modeling hurricane vulnerability: actuarial (claims-based) or engineering (physics-based). Actuarial models derive the statistical relationships between building characteristics and historical claims or damage outcomes. Engineering models instead link building characteristics to damage outcomes through modeling the physics of the structure itself based on engineering principles (Figure 2). Both methodologies have their merits but are challenging to execute for different reasons.

Actuarial models are limited by the availability of large, high-quality claims datasets. There are also human behaviors that influence the claims outcome, specifically fraudulent claims that lead to inaccurate damage correlations. The National Insurance Crime Bureau (NICB) estimates fraud adds up to 10% of the overall claims payout after a disaster.[7]

Engineering models are at risk of yielding inaccurate results if they do not fully account for physical dynamics. It is often impractical, too complex, or too costly to model the underlying physics correctly, therefore, a simplified and approximated model may be used. These models are limited to certain structure types, leading to an incomplete picture of risk — particularly for structure types not represented in the underlying data. This last point leads to a situation in the industry where very few structure types have been studied relative to the vast set of structure types that exist in insurance companies' portfolios.

The industry standard for hurricane vulnerability modeling is to represent structures based on their four primary characteristics: occupancy type, construction material, number of stories, and year built. Intuitively, this makes sense — buildings constructed of different materials or of different heights are likely to behave differently under the same wind loads. However, even when considering all four primary characteristics, there is still a considerable amount of variability and uncertainty in hurricane damage outcomes.[8] This is due in part to the unmodeled effects of other parameters that influence vulnerability but are not included in the four primary characteristics, such as roof condition, roof shape, and roof material. While commercial catastrophe models do allow for these and other additional inputs (so-called "secondary modifiers"), these data points are typically difficult to ascertain and therefore frequently not available for insurance companies.

This is where Betterview's technology comes in. By leveraging computer vision, aerial imagery of properties, and predictive analytics on historical hurricane data,

Figure 2: IBHS is one of the research institutes that recreates buildings to test them against high perils side by side and study the differences. Image courtesy of IBHS.org

Betterview uses a mix of both actuarial and engineering models to surface the important factors that impact property vulnerability in an automated and systematic fashion. Through the Betterview Hurricane Risk Insights which include the Hurricane Vulnerability Score, we offer insurance companies a more accurate, comprehensive, and actionable view of property vulnerability to hurricanes, and therefore hurricane risk, than was previously possible.

How does Betterview Measure Property Vulnerability

To explore the impact of these secondary modifiers (roof condition, roof shape, roof material, defensible space, etc.) on property vulnerability to hurricane-force winds, Betterview studied how such factors affect hurricane vulnerability by measuring the relationship between pre-hurricane conditions and post-hurricane damage. The primary area selected for the study was Lake Charles, Louisiana, which was hit by Hurricane Laura in 2020. Hurricane Laura was a destructive and deadly Category 4 hurricane that hit the Gulf Coast of the United States in August 2020 and caused more than $19 billion dollars in damage.[9]

For this white paper and as part of Betterview's hurricane vulnerability model, we created a dataset of over 72,000 structures across 65,000 parcels within Lake Charles using our proprietary computer vision and aerial imagery taken before and after the hurricane. The extent of the study area is shown in Figure 3, along with the track of Hurricane Laura.

For each building included in the study, we generated two sets of data points:

- **Pre-storm condition**: Conditions of the structure and on the surrounding parcel *prior to the event*
- **Post-storm damage**: Conditions of the structure and on the surrounding parcel *immediately after the hurricane*

The pre-storm condition data includes all of Betterview's computer vision detections based on imagery from November 2019, including roof shape and material, roof maladies such as staining, ponding, and rust, and other features such as the presence of a swimming pool, tree overhang, parcel vegetation coverage, and solar panels. Post-storm damage was analyzed using these same computer vision models on images taken in August 2020, within 2 days after Hurricane Laura hit Lake Charles.

The distribution of damage post-Laura shown in Figure 4 suggests that the damage was more severe and wide-spread in the areas south and east of the Calcasieu River than in the areas north and west.

Several factors could be at play here. It's possible that higher wind forces impacted the structures in the southeast (i.e., higher hazard), or that certain characteristics of the structures in the southeast made them more susceptible to damage (i.e., higher property-level vulnerability) — or a combination of the two.

Wind speed experienced by the structure is commonly understood to be one of the main drivers of hurricane damage (higher wind speeds will create a greater force on

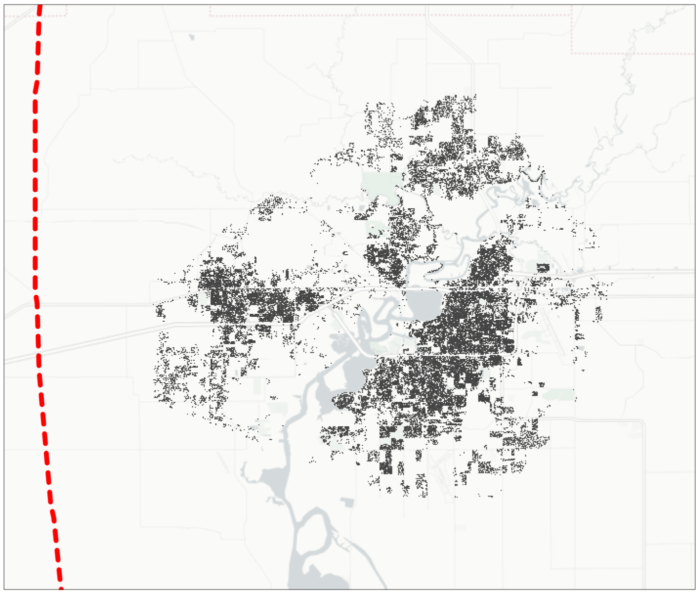


Figure 3: 72,000 structures in Lake Charles, LA included in Betterview's hurricane damage study. Each structure is shown with a black dot on the map above, and Hurricane Laura's track is shown with the dashed red line to the west of the city.

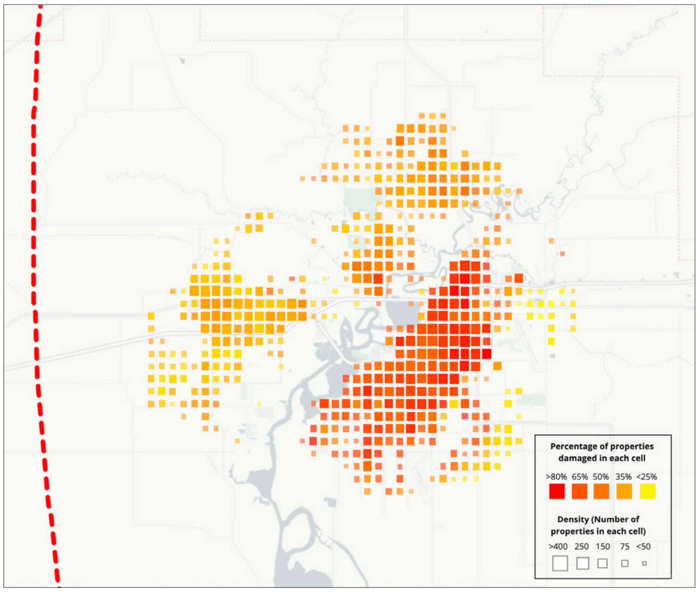


Figure 4: Distribution of property damages in Lake Charles after Hurricane Laura, August 2020. The Hurricane Laura track is shown with the red dashed line to the west of Lake Charles.

a structure, leading to greater damage). However, if this was the case in Lake Charles, one would expect to see greater damage closer to the hurricane centerline and less damage further away. As shown in Figure 4, Lake Charles defied this expectation and indicated there were other factors contributed to the damage distribution.

Influence of Wind Speed & Roof Characteristics on Hurricane Damage

To validate the hypothesis that factors other than wind speed correlated with damage, we conducted a study of another similar event. Hurricane Michael was a destructive Category 5 hurricane that made landfall in Panama City, FL in October 2018 and left more than $25B in damage in its wake.[10] For the purpose of this study, the null hypothesis is that wind speed is the sole determinant of damage. To satisfy this null hypothesis, the percentage of properties that are damaged should be correlated with the wind speed experienced. Using distance from the hurricane centerline as a proxy for wind speed[11], we narrowed the study area to a segment of land perpendicular to Hurricane Michael's track, containing properties up to 100 miles away from the centerline. The transect extends 20 miles parallel to the track, resulting in a 200 x 20 mile area perpendicular to Hurricane Michael's path (Figure 5).

To normalize for the variation in building density across the transect, the area was divided into 30 sub-areas and 200 random properties were selected from each sub-area for the study (Figure 6).

Using Betterview's computer vision models to analyze aerial imagery from immediately after the hurricane, we determined whether each property was damaged. Figure 7 shows the percentage of properties that showed signs of damage within each subarea (i.e., at different distances from Michael's centerline).

Figure 7 shows that the properties to the right of the hurricane experienced slightly more damage than those on the left, which is in line with the asymmetrical nature of hurricanes in the northern hemisphere — hurricane winds rotate counter-clockwise and therefore are amplified on the right side of the track when in the same direction as the track's movement[12]. However, in this study of Hurricane Michael, there is no statistically significant indication that proximity to the hurricane centerline, and thereby the wind speed experienced by a building, is a strong influential factor to the damage. Indeed, there must be other local characteristics such as building features that influence the likelihood of damage.

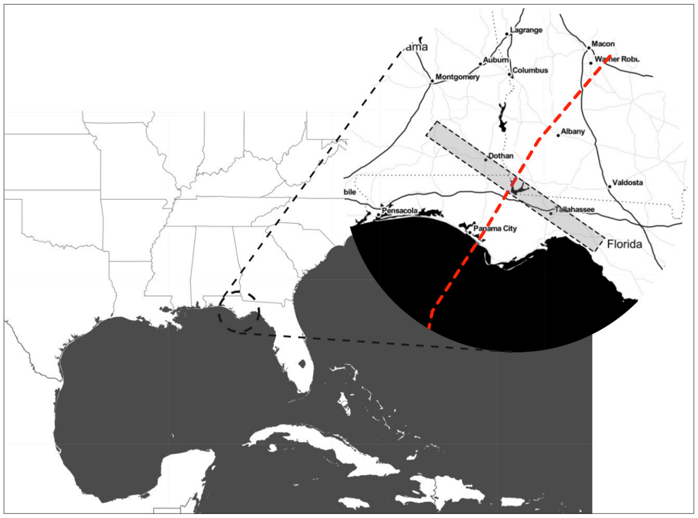


Figure 5: Study area for Hurricane Michael transect study. The gray dotted rectangle is the 200 x 20 mile transect area; the red dashed line is Hurricane Michael's track.

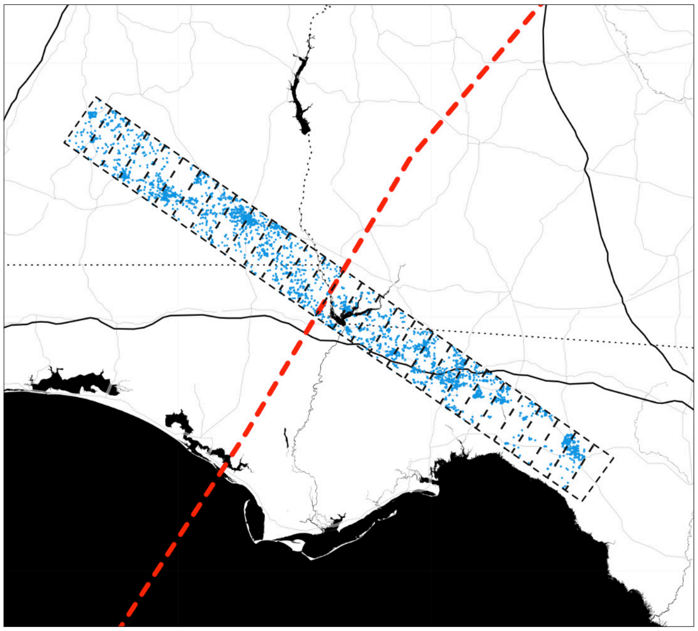


Figure 6: Properties randomly selected in each sub-area for the Hurricane Michael transect study. The Hurricane Michael track is shown with the red dashed line.

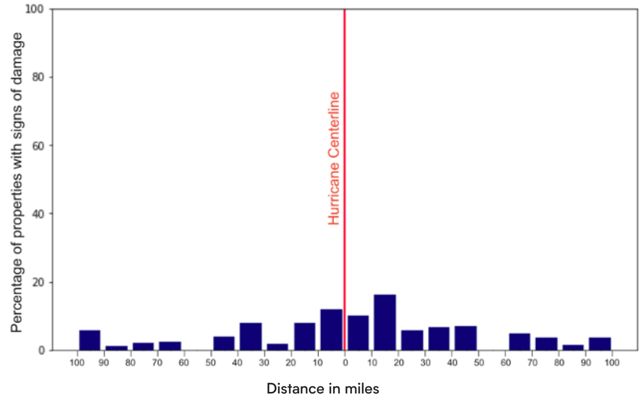


Figure 7: Percentage of damaged properties as a function of distance to Hurricane Michael's centerline

Figure 8: Side-by-side homes in Lake Charles, LA. Top Image: observed on November 3rd, 2019. Yellow polygons indicate staining on the roof, green polygons indicate tree overhang, blue polygon indicates yard debris. Bottom image: observed on August 27th, 2020, a few days after Hurricane Laura.

Figure 9: Side-by-side homes in Lake Charles, LA. Top image: observed on November 3rd, 2019. Yellow polygons indicate staining, green polygons indicate tree overhang. Bottom image: observed on August 27th, 2020, a few days after Hurricane Laura.

Betterview Detections Predict Wind Damage

These studies of Hurricanes Laura and Michael both demonstrate that building characteristics play a non-negligible role in hurricane vulnerability (relative to wind speed), our subsequent analysis focused on quantifying the relationships between the individual characteristics Betterview detects and the property's vulnerability to hurricane damage.

A qualitative image review suggests a clear relationship between these conditions pre-hurricane and damage outcomes post-hurricane. Consider the following examples.

Example 1: Staining

Figure 8 shows two side-by-side homes in Lake Charles, Louisiana. In November 2019, a notable portion of the roof of the property on the right was detected as stained, while the roof of the property on the left did not have any staining detected. After Hurricane Laura, the property on the left came out unscathed, whereas the property on the right, the stained one, lost many shingles that likely led to an entire roof replacement.

Example 2: Roof Material

In the other example (Figure 9), the two side-by-side roofs are made of different materials. On the left is a metal panel roof, and on the right is an asphalt shingle roof (which is slightly stained). After Hurricane Laura, the roof on the right had many of its shingles damaged or fully removed, whereas the roof on the left came out relatively unscathed.

Figure 10 shows three examples of our detections. Each of the maps shows the distribution of the corresponding detection across the study area — Staining on roof, Roof Material (asphalt shingles), and Overhang. In all three cases, the visual pattern of the detection distribution matches the damage distribution in Hurricane Laura — detections were concentrated in the southeast area, as was the damage.

Through analyzing the correlations of Betterview's detections, we found strong evidence that many of the features and conditions Betterview detects with computer vision prior to a hurricane are predictive of whether a structure will be damaged by a hurricane.

These correlations are especially powerful because not only do they provide a better picture of overall hurricane

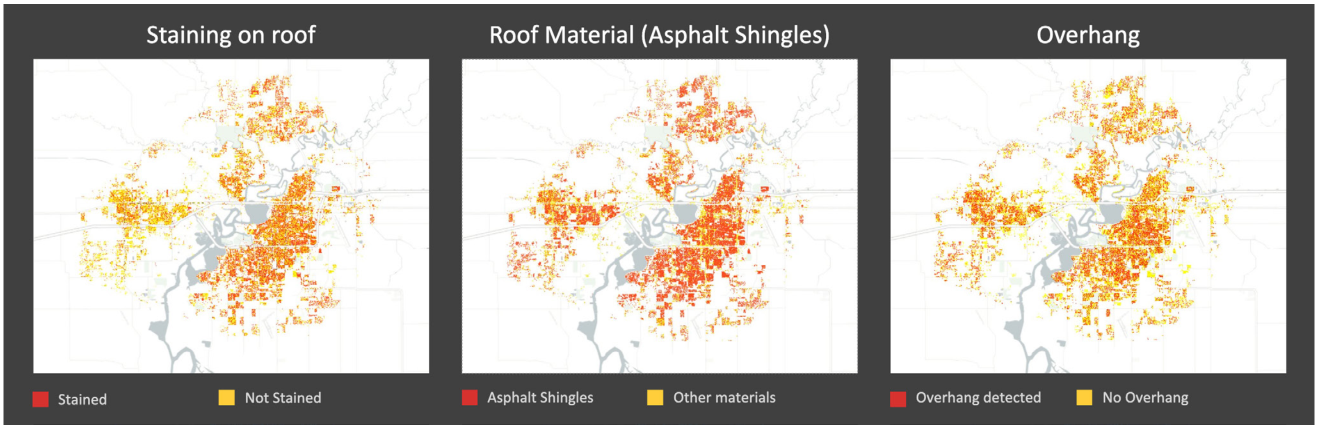


Figure 10: Distribution of roofs where Betterview has detected Staining, Asphalt Shingles, and Overhang

risk; they also allow insurers to transform their mindset from *Repair & Replace* to ***Predict & Prevent***. Insurers can proactively alert policyholders whose properties are more vulnerable to hurricane damage, allowing them to take risk mitigation actions before disaster strikes. This is a win for all parties involved: insurers may avoid paying out large claims, and the insured can rest easier during hurricane season, knowing that their level of risk is being actively monitored and managed.

Tying It All Together — The Betterview Hurricane Vulnerability Score

By combining the insights from the analysis performed for this study, we trained a machine learning model to predict post-hurricane damage based on the most predictive conditions and features that are observed pre-hurricane. The result, the **Betterview Hurricane Vulnerability Score**, is a highly predictive and easy-to-understand index from 1-5 that provides a significant lift in predicting how likely a structure is to be damaged if exposed to hurricane-force winds.

Each structure is assigned a score from 1 to 5, where 1 indicates the highest likelihood of being damaged; 5 indicates the lowest likelihood of being damaged. The Hurricane Vulnerability Score is designed such that structures with a score of 3 have an average probability of being damaged.

As shown on the left in Figure 11, buildings with a Hurricane Vulnerability Score of 1 are roughly 1.5 times more likely to be damaged when exposed to hurricane-force winds than buildings with a score of 3. On the other hand, buildings with a score of 5 are less than half as likely as average to experience damage in that same event.

The graph on the right in Figure 11 shows the distribution of properties in different score bands. It shows a good amount of properties in each score band, meaning the conclusion we drew above was statistically meaningful.

Transparency is a core value at Betterview, and it underlies everything we do when identifying and managing real

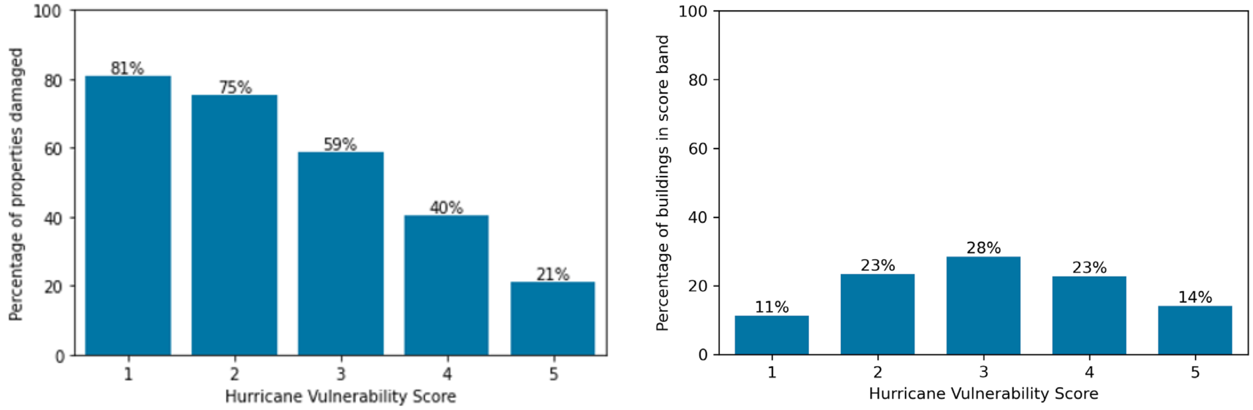
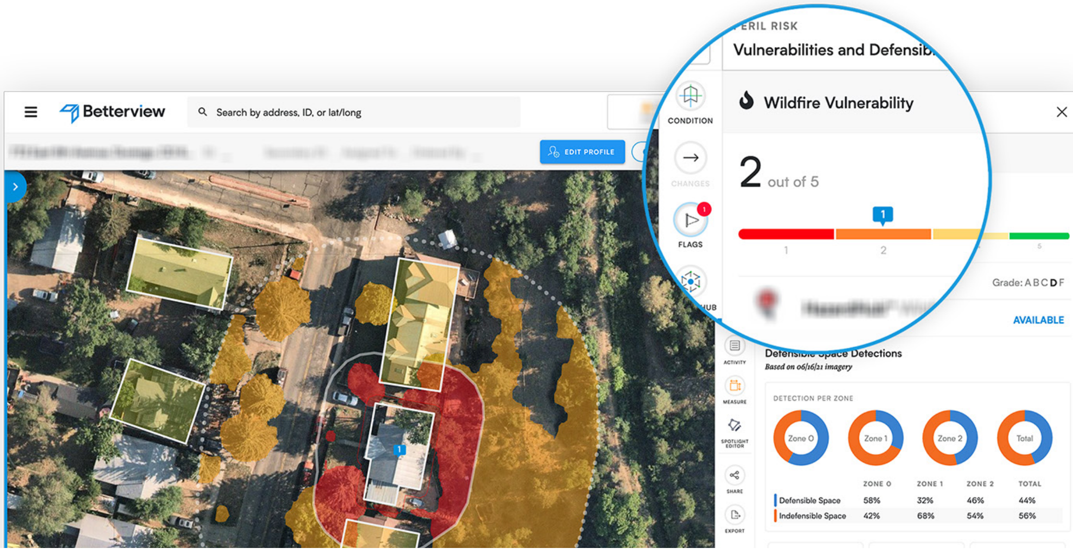


Figure 11: Left: Damage likelihood as a function of Hurricane Vulnerability Score based on a holdout set from the Hurricane Laura study.
Right: Distribution of properties by Hurricane Vulnerability Score in the holdout set.



property risk. We do not simply offer a numerical risk score with a black box around contributing factors. Instead, we show underwriters exactly which property attributes led to a specific score. Attributes that we show include roof shape, roof material, roof conditions such as missing shingles, staining, defensible space, and more real risk drivers. Thanks to this transparency, you can proactively inform your policyholders of steps they can take to mitigate risk, such as making necessary roof repairs or clearing overhung trees before a hurricane season.

Prevent Avoidable Losses & Protect More Homes & Businesses

A good measure of hurricane risk requires a measurement of the hazard impacting the location and the vulnerability of the exposed asset. You can access both critical data points within a single platform through the **Betterview Hurricane Risk Insights**:

- Hazard - third-party hazard modeling vendors via PartnerHub, the third-party data marketplace on the Betterview platform. PartnerHub includes numerous industry-standard datasets relevant to hurricane risk, including the Hurricane Score from HazardHub and the FEMA Risk Index.
- Vulnerability — Betterview Hurricane Vulnerability Score that includes roof conditions, roof materials, defensible space, and more.

The combination of the two complementary data points allows insurance carriers to flag buildings based not only on how prone their location is to hurricanes, but also on how susceptible they are to experiencing a loss if a hurricane actually strikes. The power from these data points is unlocked through their combination. By leveraging only one, insurance companies miss out on important aspects of catastrophe risk when pricing and underwriting. By excluding vulnerability and focusing exclusively on hurricane hazard, insurers may opt not to write policies for structures that have mitigated hurricane risk through reduced vulnerability, thereby potentially missing out on good risks. Conversely, by excluding hurricane hazard and only considering vulnerability, insurance companies may over-index on some features of the property that are only relevant when the property is exposed to hurricane, thereby also missing out on business opportunities.

The presence of both property-level vulnerability insights and regional hazard data gives Betterview users a complete and actionable view of hurricane risk. Faced with worsening storm seasons, there is no question that insurers need this evolved approach to risk management. The Hurricane Risk Insights from Betterview allows you to streamline underwriting efficiency, reduce avoidable losses, and improve communication with the insured. More than that, this new feature empowers you to shift the mindset from Repair & Replace to Predict & Prevent.

Imagine if the insurer of the home on the right in the earlier example (Figure 8) could have stepped in and alerted the homeowner of the vulnerability, suggested roof repair or trimming of the tree overhung, avoid massive disruption, loss, and pain, and be the hero to help minimize the impact? You can be that hero.

Instead of waiting for disaster to strike and scrambling to recover afterward, you can proactively manage future risks. With better tools and complete insights, you can keep homes, businesses, and communities safe during hurricane season. Schedule a demo with us now to experience the power of predict and prevent!

SCHEDULE A DEMO

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Shiva works with the Data Science team to quantify the value of Betterview's data, extract and visualize the stories that the data tells, and conduct studies to discover additional avenues of exploration for the insurance industry. She is heavily involved in developing the data models for the Betterview Hurricane Vulnerability Score and CAT Response System. Shiva received her master's degree at the University of Texas at Austin, and is an alumna of the University of Tehran.

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