MOODY'S

Insurance Solutions

May, 2026

Hail, straight-line wind, and tornadoes: Using AI property intelligence to uncover hidden insights into regional loss variability for US severe convective storm risk

Table of contents

1. ABSTRACT

Moody's RMS™ Catastrophe Models are designed to assess property-level risk and use building and site details to help improve risk assessment and reduce uncertainty. Insurance submissions typically include primary characteristics such as construction class, occupancy type, year built, and number of stories, but the secondary modifiers that often drive meaningful loss differentiation — such as roof age, roof geometry, cladding material, and tree density — are less commonly present, often incomplete, and sometimes unreliable. When these gaps persist across a portfolio, the consequences may compound, including mispriced risk, misallocated capital, and business decisions that default to broad geographic or class-level assumptions rather than property-level insight.

This data gap matters now more than ever. After several years of rate increases driven by elevated severe convective storm losses and reduced capacity, the property catastrophe market is softening, with rates moderating, capacity returning, and carriers actively seeking growth. In this environment, the ability to distinguish which properties are higher risk and which are lower risk can play an important role in who grows profitably and who accumulates exposure blindly. This paper presents the results of a study in which Moody's analyzed more than 1 million US residential properties, running Moody's RMS™ US Severe Convective Storm HD Model first with primary characteristics only, then with secondary modifiers, all added through AI-powered Exposure Enrichment from Moody's CAPE Property Intelligence.

The results show that when our catastrophe models receive the site-level detail they were designed to use, properties that appeared identical using only primary characteristics separate into distinctly higher- and lower-risk profiles. For severe convective storm risk, two neighboring homes in Aurora, Colorado, in the same ZIP code with the same roof condition diverge sharply: One sees a 62% increase in modeled loss due to wood cladding, an exposed gable roof, and a rooftop solar array, whereas the other sees a 23% decrease thanks to brick veneer, and hip roof. For carriers, this reallocation can have a significant impact on the underwriting strategy. For reinsurers, it reveals whether a cedant's book is composed of well-maintained properties or deteriorating stock — a distinction that is invisible in aggregate metrics. For brokers, it provides objective evidence of portfolio quality that strengthens placement negotiations. Beyond changes in mean modeled loss, Exposure Enrichment reshapes how loss is distributed across individual locations, with implications for portfolio concentration and tail behavior that are not visible in aggregate summaries alone.

“Hail, straight-line wind, and tornadoes: Using AI property intelligence to uncover hidden insights into regional loss variability for US severe convective storm risk” is the first of three white papers. Each white paper delivers professional analysis on how Moody’s Exposure Enrichment influences modeled outcomes, revealing distinct insights into market dynamics and peril risk. Additionally, we present case studies that demonstrate how Exposure Enrichment aids in achieving more precise risk differentiation.

2. INTRODUCTION

2.1 The data gap in catastrophe modeling

At Moody’s, we designed our catastrophe models to assess risk at the individual property level by leveraging detailed building and site characteristics while also accommodating locations with limited building-specific information. However, when secondary modifiers such as roof age, condition, geometry, and material; rooftop equipment; cladding material; and tree density are included in the exposure data, the models can produce even more precise, substantiated loss estimates with reduced uncertainty.

Collecting these attributes through manual inspection is not always possible at the scale required, and site survey data can age quickly. For carriers, this creates a practical problem. Without the data to distinguish between better and worse risks at the property level, business decisions may default to broad geographic or class-level assumptions, and the risk differentiation the models are capable of can remain inaccessible. In practice, secondary modifiers are often captured only for perceived high risk or high value locations, or primarily when they generate mitigation credits. This selective coding leads to inconsistent exposure treatment across the portfolio, introducing bias into modeled results and limiting confidence in location level differentiation — particularly in downstream risk transfer workflows.

2.2 Market context: Why property-level differentiation matters now

The property catastrophe market is at a turning point. After several years of hardening, driven by elevated loss activity, reduced capacity, and corrective rate action, carriers now face a different set of pressures. Rates are changing, capacity is returning, and reinsurance costs have come down. After a relatively benign 2025 loss year, primary carriers have room to grow, and many are actively looking to do so.

In recent years, severe convective storms have emerged as a persistent and costly peril, producing over $45 billion in insured losses annually in the US for three consecutive years. Unlike tail events such as hurricanes or wildfires, severe convective storm losses are geographically widespread, recurring, and driven by hail, straight-line winds, and tornadoes — a single March outbreak in 2025 caused $8 billion-$10 billion in damages across 26 states. This makes refined exposure data particularly important for capturing regional variations in building resilience.

Insurers can capitalize on a softening market by leveraging tools that help deliver greater accuracy and precision in how risk is assessed and compared across the portfolio rather than treating properties that look similar on paper as equivalent in risk. When portfolio analysis relies primarily on standard submission information, meaningful differences within the exposure base can remain hidden, and variation in risk is only visible at broader geographic or vintage levels rather than at the individual property level.

Firms able to evaluate individual properties using observable physical characteristics can assemble portfolios with more favorable underlying risk whereas less discerning approaches allow vulnerabilities to accumulate unnoticed. Over time, these effects can compound at the portfolio scale, with potential impacts to growth strategy, capital efficiency, and how risk concentrates across regions and perils. Solutions that provide objective, up-to-date, property level data may support this shift by allowing for consistent risk assessment across catastrophe modeling, portfolio management, and underwriting workflows, helping carriers pursue disciplined growth while minimizing indiscriminate exposure accumulation.

2.3 Who this paper is for

This paper presents findings relevant to multiple roles across the risk transfer chain:

- **For primary carriers —** The findings demonstrate how enriched property data supports more precise property level evaluation across underwriting and portfolio management workflows at the individual location level, allowing for competitive pricing on well-characterized risks and flagging elevated exposures before binding. That location-level discipline can contribute to a more informed portfolio-level advantage.
- **For reinsurers —** The analysis provides a framework for assessing cedant portfolio quality beyond aggregate metrics. A cedant whose portfolio skews toward well-maintained properties with recently replaced roofs represents a fundamentally different risk than one with older, deteriorated stock, even if their aggregate metrics look similar.

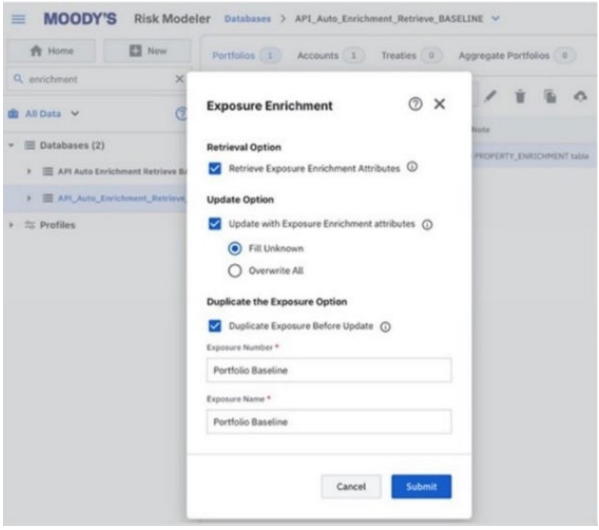
- **For brokers —** Objective, enriched property data moves the conversation from “we believe our book is high quality” to “here is the data that illustrates it.”

Across all these market segments, catastrophe modeling and portfolio analytics teams play an important role in interpreting modeled results. For these users, enriched exposure data improves attribution, stability, and confidence in modeled outcomes by tying loss differentiation to observable building characteristics rather than implicit assumptions.

3. THE SOLUTION: MOODY’S EXPOSURE ENRICHMENT

Moody’s Exposure Enrichment, part of our Enhanced Risk Data solution, leverages artificial intelligence (AI) and aerial imagery to extract relevant property characteristics. These details are then mapped to model-compatible secondary modifiers. Available across Moody’s Intelligent Risk Platform™, it combines Moody’s CAPE Property Intelligence with our catastrophe models to provide the property-level detail that unlocks the differentiation the models were built to deliver with objective, high-resolution data.

Image 1: Exposure Enrichment in Moody’s Risk Modeler™



This alignment supports consistent decision-making across underwriting, portfolio analytics, and risk management teams by driving modeled differentiation via shared, transparent inputs.

The solution delivers three distinct advantages:

- **Flexibility:** Moody’s CAPE-derived property characteristics integrate seamlessly across all locations in a given portfolio, regardless of its size, promoting timely and efficient analysis at portfolio scale. The case study in this paper analyzes 1 million properties across three perils — the kind of scale that manual inspection or survey-based approaches cannot achieve.
- **Data quality:** Moody’s CAPE Property Intelligence derives building and site characteristics from high-resolution aerial imagery, capturing attributes that are objective, current, and independently verifiable. Roof condition, vegetation proximity, cladding type, and structural geometry are observed as they exist today, not as they were recorded at binding or reported by a broker.
- **Alignment across workflows:** Enriched attributes are formally mapped to the secondary modifier inputs that each Moody’s RMS™ model is calibrated to use. This preserves the

integrity of the modeled output and bridges the gap between the data available at the point of underwriting and the data the models need to differentiate risk.

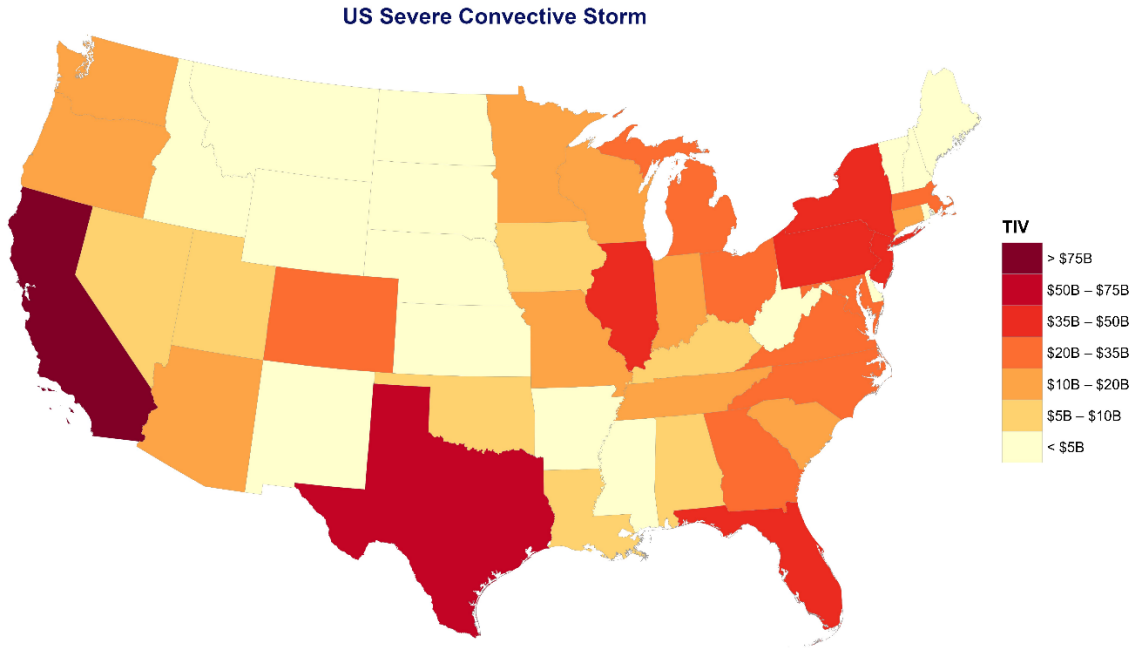
When the model receives the property-level detail it was designed to use, risk differentiation emerges that was previously available in the model's architecture but not accessible without the data.

4. METHODOLOGY

4.1 Dataset and approach

In this white paper, Moody's analyzed more than 1 million US residential properties using Moody's RMS US Severe Convective Storm HD Model. We ran the model with only known primary characteristics — construction class, occupancy type, year built, and number of stories — and then reran them with a combination of key secondary modifiers populated through Exposure Enrichment.

Figure 1: Total insurable value (TIV) of the analyzed US-wide portfolio by state



4.2 Defining material change

In this paper, we define "material change" as a shift of more than 15% in either direction in the modeled average annual loss (AAL) when enriched data is applied. An increase means the model identifies characteristics that place the property above the average assumption of risk, and a decrease means the model identifies characteristics that place it below. Neither direction is inherently good or bad; what matters is that the model can now distinguish between them when previously both properties were treated the same way.

Exposure Enrichment has a distinct impact on each model because the underlying building stock interacts uniquely with each hazard. In every case, the aggregate change conceals a far more consequential reshuffling at the location level — properties where filling in the known unknowns reveals risk that was often previously indistinguishable from neighboring properties.

4.3 Limitations

This study analyzes a portfolio of more than 1 million US residential properties with exposure relevant to all three perils. The results presented here reflect the characteristics of this specific portfolio — the direction and magnitude of impact will vary for any given carrier depending on how their book skews by geography, construction mix, and building age. For stakeholders interested in understanding how Moody's Exposure Enrichment impacts their specific portfolio, Moody's provides the data, model mapping, and analytical support to conduct a tailored analysis available across the Intelligent Risk Platform.

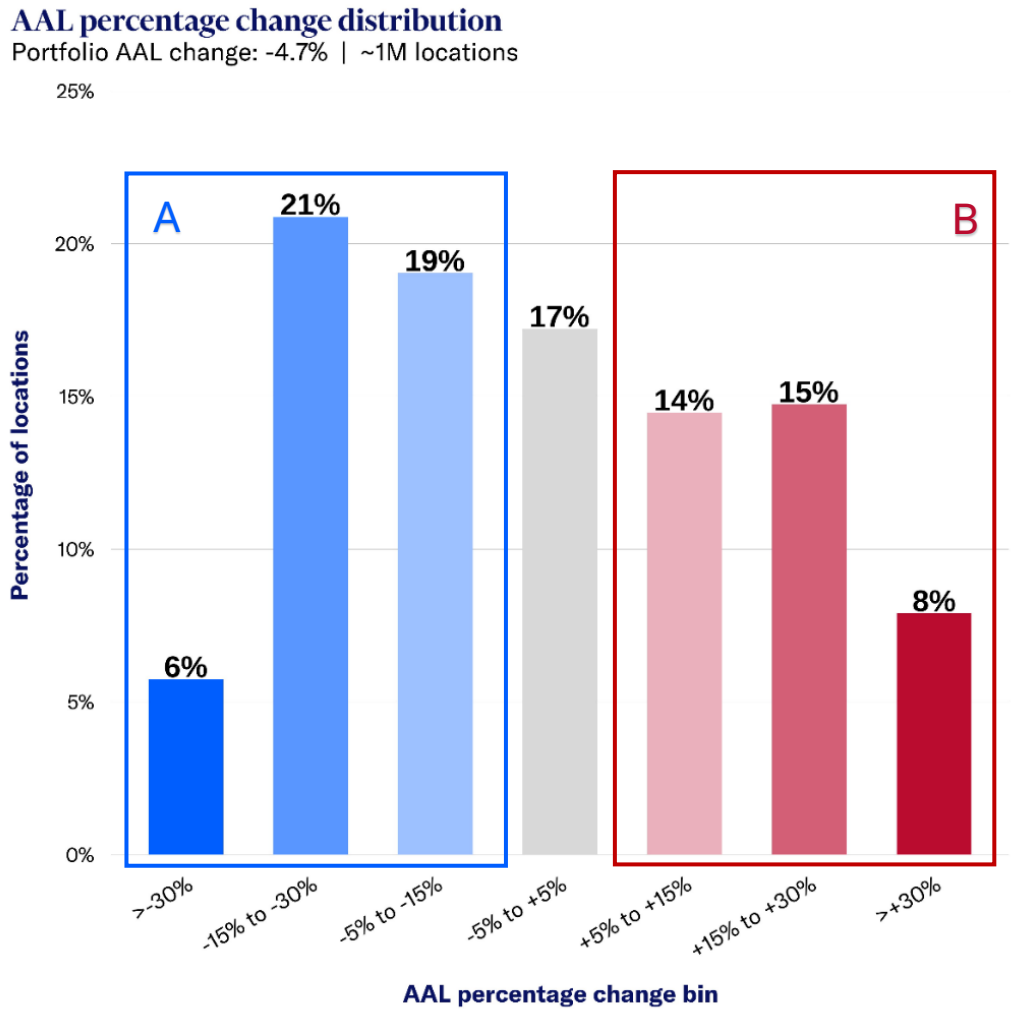
5. KEY FINDING: MOODY'S EXPOSURE ENRICHMENT REVEALS SIGNIFICANT LOCATION-LEVEL DIFFERENTIATION IN US SEVERE CONVECTIVE STORM RISK

5.1.1 Portfolio-level impact

In this study, we selected nine secondary modifiers — roof age, roof maintenance, roof geometry, roof system, cladding system, appurtenant structures, tree density, garaging, and roof equipment — populated through Exposure Enrichment. When applied across the portfolio, enrichment reduces portfolio AAL by 5%, reflecting improved building stock characteristics relative to baseline assumptions, but generally reinforcing the robustness of the peril model for portfolio-level analytics.

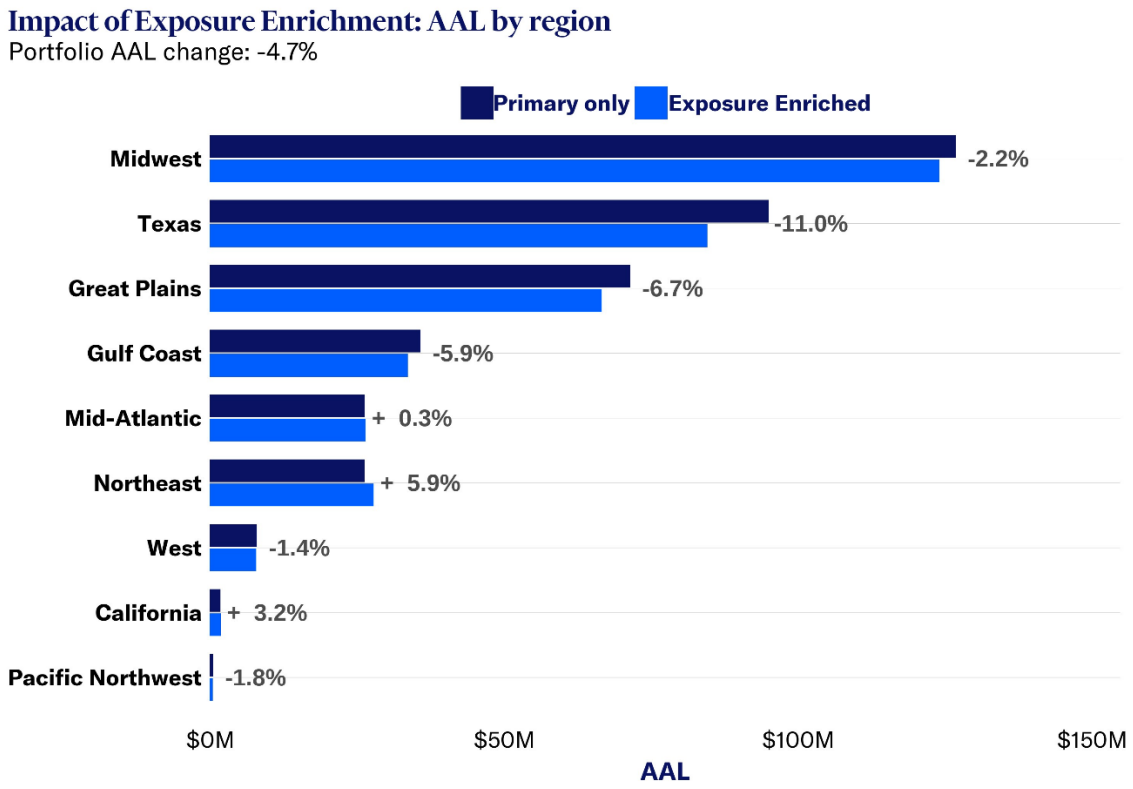
The result is a modest portfolio credit that masks significant repricing at the location level. Nearly half of all locations experience material AAL changes exceeding 15%, with more than 226,000 locations seeing higher risk revealed (Segment B in Figure 2) and over 266,000 seeing lower risk identified (Segment A in Figure 2). As with hurricane results, the aggregate number masks a far larger reshuffling underneath, which matters because it changes how loss concentrates across locations, affecting how risk accumulates across the portfolio. You can learn more about this in our hurricane blog.

Figure 2: Location-level AAL percentage change distribution when incorporating Exposure Enrichment in Moody's RMS US Severe Convective Storm HD Model



5.1.2 Regional drivers: Where repeated hail events shape the building stock in Texas

Figure 3: Exposure Enrichment impact: AAL by region (all perils)

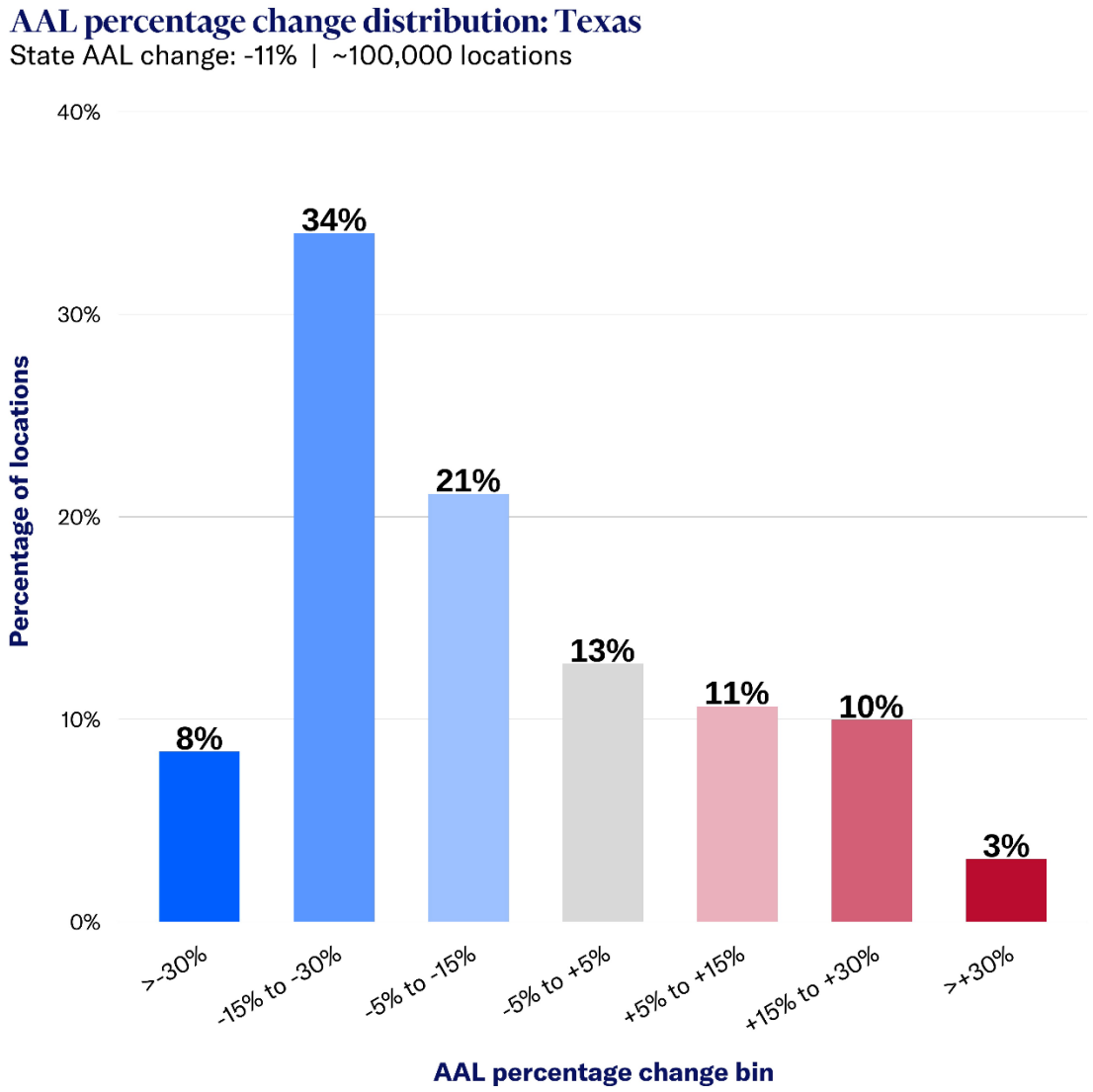


Of all regions, Texas sees the most notable credit after enrichment, with state-level AAL decreasing 11%. In 2023, more than 2 million Texas homes were struck by hail of at least 1 inch in diameter. In fact, the Dallas-Fort Worth area experienced major damaging events in 2012, 2016, and 2019. Years of repeated hail events can lead to replacement of damaged roofs.

Exposure Enrichment captures this trend. In our portfolio, more than two-thirds of locations have excellent roof condition, reflecting roofs recently replaced. Furthermore, the majority of the sampled properties have brick veneer cladding, which is more resistant to hail damage than vinyl siding. Consequently, county-level AAL credits from exposure enhancement for these properties range from 14%-17%.

However, within the same state, locations with older roofs and more vulnerable cladding see the opposite signal. The opportunity lies in distinguishing between locations benefiting from recent rebuilding and those where vulnerability persists.

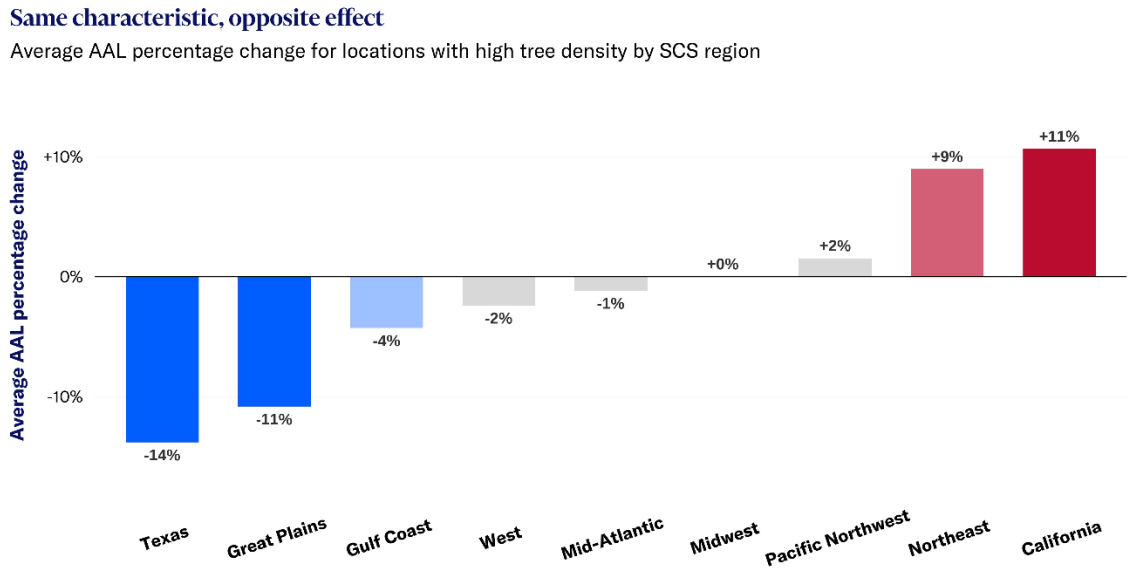
Figure 4: Impact of Exposure Enrichment: Location-level AAL percentage change distribution in Moody's RMS US Severe Convective Storm HD Model (all perils), Texas only



5.1.3 Impact on sub-peril modeling

The US Severe Convective Storm HD Model simultaneously evaluates hail, straight-line wind, and tornado risk. This integrated approach is important because the same physical characteristic can have opposing effects depending on the hazard. Tree density is a clear example: Dense tree cover provides protection from hail but simultaneously creates debris risk for straight-line wind. The models weigh these competing effects against the regional hazard profile, and the results confirm it.

Figure 5: Mean AAL percentage change for locations with high tree risk and high shielding by region



In hail-dominant regions like Texas and the Great Plains, dense tree canopy reduces hail damage, leading to AAL decreases for enriched locations. Conversely, in wind-dominant regions such as the Northeast and California, tree density contributes to debris risks, resulting in AAL increases. These regional differences are evident when filtering enrichment results by tree density (Figure 5) and comparing them with the dominant sub-peril driver by region. Such insights highlight the importance of alignment between enrichment data and model inputs. A generic “tree risk” score applied uniformly would obscure these nuances, whereas enrichment allows for differentiation that reflects how properties perform under specific perils.

5.1.4 Rethinking Home Risk: A case study on roof age vs. year built in Aurora, Colorado

In Aurora, Colorado — located in one of the nation's highest hail-frequency corridors — two three-story homes in the same postal code and with similar floor area diverge by 85 percentage points when enriched data is applied.

Figure 6: Aurora, Colorado — two properties in the same postal code with the same roof condition, 85 percentage points apart after enrichment

Attribute	Location A (+62%)	Location B (-23%)
Year built	2011	1983
Roof geometry	Gable (slope > 6:12)	Hip (slope > 6:12)
Cladding	Wood	Brick veneer
Tree density	Some trees/some shielding	Some trees/some shielding
Roof equipment	Roof-mounted photovoltaic array	No equipment
Roof maintenance	No visible defect	No visible defect

Both properties have adequate roof maintenance. However, Location A has wood cladding, a high-pitch gable roof (more exposed surface area in hail), a roof-mounted photovoltaic array (increases hail damage exposure), and no tree cover. Location B has brick veneer (hail-resistant), a hip roof (lower hail exposure), some tree shielding, and no rooftop equipment.

The year built would suggest the newer home is the better risk, but Exposure Enrichment reveals the opposite: The divergence is driven entirely by secondary modifiers, not by building age or primary characteristics. Without enrichment, these two properties are indistinguishable. A carrier that can see this distinction can price Location B more competitively, with a data-supported rationale, while flagging Location A for potential review.

6. LOOKING AHEAD: ROAD MAP FOR ENHANCED RISK DATA AND EXPOSURE ENRICHMENT

Enhanced Risk Data delivers rich hazard (including but not limited to hurricane, flood, wildfire, and earthquake) and exposure data (Exposure Enrichment that was discussed in this paper) on the Intelligent Risk Platform for both underwriting and portfolio risk management use cases.

Enhanced Risk Data is regularly improved with model updates, new data we extract from aerial imagery and other data sources, and updates to platform applications such as Moody's Risk Modeler™, ExposureIQ™, and UnderwriteIQ™ tools. Today, Exposure Enrichment delivers residential property attributes in the US to enrich secondary modifiers for US severe convective storm and hurricane models. However, we have a busy road map for Exposure Enrichment in Enhanced Risk Data. In the future, the road map has plans for: Exposure Enrichment to cover residential and commercial properties in the US; bring aerial imagery-based enrichment to more cat models like flood and wildfire; and eventually expand from the US to Europe, Canada, Australia, New Zealand, and other geographies.

7. CONCLUSION

7.1 Cross-peril synthesis

Across both Exposure Enrichment white papers, a pattern emerges: The secondary modifiers with the greatest impact on modeled loss — roof age for hurricane and roof condition for severe convective storm — are also the attributes most likely to change over time and most objectively measurable through modern aerial imagery. Roofs age or are replaced. Vegetation grows or is cleared. Cladding deteriorates. As a result, the physical characteristics driving loss today may differ materially from those captured when exposure data was originally collected.

This dynamic creates challenges across portfolio management, catastrophe modeling, and risk management workflows when analyses rely on static exposure data that is infrequently refreshed. When modeled results reflect averages or assumptions that no longer align with current building conditions, it becomes difficult to attribute changes in loss to observable drivers on the ground. This is particularly important for severe convective storm risk, where high frequency, lower severity events may compound small and medium sized losses into material impacts on (re)insurance balance sheets.

Moody's CAPE Property Intelligence helps to address this challenge by deriving current building characteristics from aerial imagery, providing an objective, repeatable view of the building stock as it exists today. By enriching exposure data used in catastrophe modeling and portfolio analysis, this helps provide a more consistent and explainable assessment of risk across workflows, supporting informed portfolio strategy, capital decisions, and underwriting actions within applications on the Moody's Intelligent Risk Platform, such as the ExposureIQ, Risk Modeler, and UnderwriteIQ tools.

7.2 Relevance across the risk transfer chain

The findings in this paper demonstrate that when Moody's RMS Catastrophe Models receive the secondary modifiers they were designed to use, properties that appeared identical under primary only exposure data separate into distinctly higher and lower risk profiles. Crucially, this differentiation is most meaningful when enriched attributes are applied consistently across the full portfolio rather than selectively across a subset of locations. In many existing workflows, secondary modifiers are captured only for perceived high risk or high value locations, or primarily when they generate mitigation credits. This selective coding can bias portfolio results and reduce confidence in the modeled output, particularly in risk transfer discussions.

- **Carriers** can update their underwriting rules using enriched information on underlying physical risk, pricing competitively where enrichment reveals favorable profiles and exercising caution where it does not. Over time, portfolios assembled and actively steered through enrichment informed decisions may exhibit measurably different risk characteristics in terms of concentration, volatility, and resilience.
- **Reinsurers** can benchmark cedant portfolio quality with objective exposure characteristics rather than selective, biased coded modifiers or aggregate metrics alone.

A portfolio enriched systematically across all locations provides a clearer view of underlying vulnerability, concentration, and resilience, supporting greater confidence in cedant submissions and more transparent risk transfer discussions.

- **Brokers** can substantiate portfolio quality with verifiable, enriched data, demonstrating to markets that a book has been objectively characterized.

7.3 Call to action

The findings in this paper are based on a single portfolio of more than 1 million US residential properties. The direction and magnitude of impact will vary depending on each carrier's portfolio composition, geographic footprint, and building stock mix. The patterns identified here represent signals within this specific book, not universal prescriptions.

For industry participants looking to understand how enriched data impacts their own portfolios, Moody's Exposure Enrichment — now available on the Intelligent Risk Platform — can help users enhance residential portfolios, reduce uncertainty, and improve their catastrophe modeling outcomes by leveraging CAPE-enriched property data and formal model mapping.

To discuss a portfolio-specific assessment or learn more about Exposure Enrichment, contact us.