

The hail solution: Weathering a growing storm

Assessing the predictive power of the holistic
CAPE Hail Intelligence Suite





In this report



SECTION 1

Assessing the hail problem in the United States

SECTION 2

Gaps in existing hail risk assessment solutions

SECTION 3

New technologies facilitate holistic hail risk assessment

SECTION 4

The CAPE Hail Intelligence Suite: Product overview

SECTION 5

Study: The predictive power of CAPE's Hail Intelligence Suite

SECTION 6

Use cases and next steps

SECTION 1

Assessing the hail problem in the United States

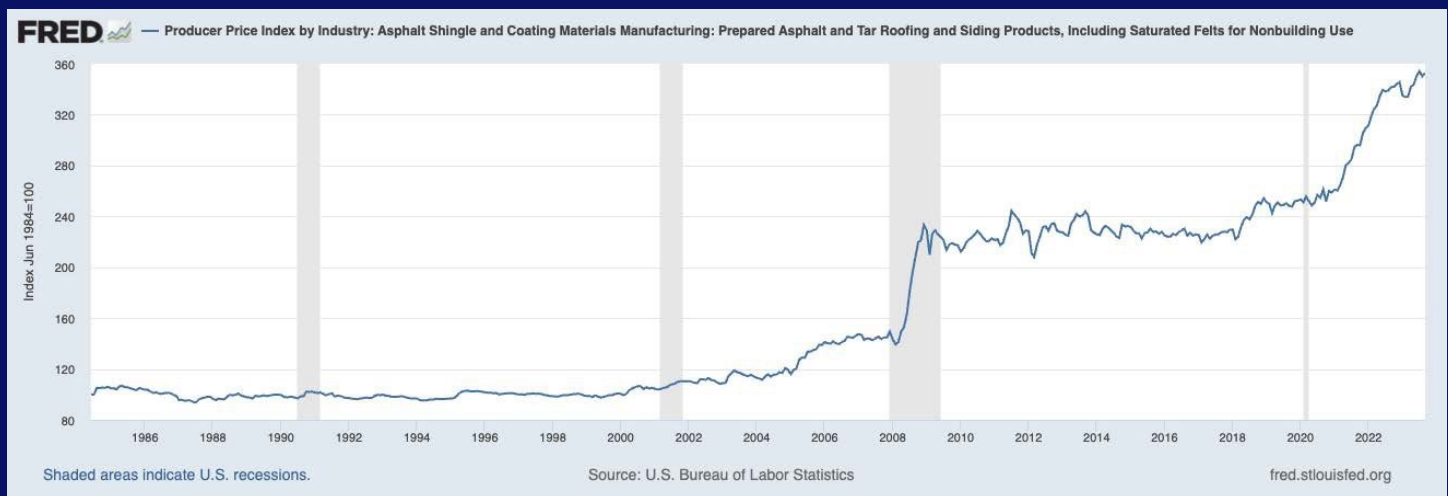
A trifecta of factors has led to ballooning hail losses for the US property insurance industry in recent years, with significant implications on the health of carrier balance sheets. State Farm, for example, reported its hail losses increased by more than \$1 billion (to \$3.5 billion) and roughly 45,000 claims between 2021 and 2022. This figure is expected to grow once again in 2023. The factors driving this trend include exposure growth in the form of more housing construction in areas conducive to hail, increased repair costs, and heightened hailstorm frequency and severity.

Over the past few decades, exposure growth has increased dramatically, especially due to urban sprawl in areas with high hail risk, such as Texas and Colorado, where more properties are affected by severe hailstorms.

According to S&P Global, “Insurance losses are... increasing as more people move into areas vulnerable to hail and thunderstorms. Texas, which accounted for most of the losses during the first half of 2023, saw its population grow 40% over the past 20 years.”

Repair costs have also increased due to changes in housing stock. Homes are increasing in size over time, and the cost of labor and materials has increased due to inflation, COVID-related shortages, and other factors. For example, the Producer Price Index for asphalt shingle manufacturing — just one component of a roof replacement — has tripled in the last 20 years, as shown in Figure 1.

FIGURE 1



Finally, there appear to be signs that hailstorm activity and intensity are increasing over time. In “Trends in United States large hail environments and observations,” *Nature Partner Journals* asserts that “from 1979 to 2017, there has been an increase in days with favorable large hail environments in central and eastern portions of the US.”

Recent years have only added concern: Hail events increased by 17.9% from 2021 to 2022 and then again by 48.1% from 2022 to 2023. Additional research notes that “it is generally anticipated that low-level moisture and convective instability will increase, raising hailstorm likelihood and enabling the formation of larger hailstones; the melting height will rise, enhancing hail melt and increasing the average size of surviving hailstones.”

SECTION 2

Gaps in existing hail risk assessment solutions

Unfortunately, the current set of hail risk assessment solutions has significant gaps when it comes to overcoming some of these challenges.

First, outside of in-person inspections, most property data sources offer no recent and accurate property-specific vulnerability data pertaining to hail. For carriers to reduce their hail losses, it's critical that they understand risk holistically and at the property level; assessing current vulnerability allows carriers to predict a property's propensity to suffer damage and the potential extent of that damage. The advent of geospatial analytics has made this possible at scale for the very first time.

Second, hail-tracking weather solutions do not offer a view into granular and accurate historical hail experience at specific locations. While radar and hail reports are helpful at the county or ZIP code level, they are not precise enough to understand which properties may have been exposed to hail and, just as importantly, the size and intensity of that hail.

UNDERSTANDING THE PROPERTY VULNERABILITY GAP

Extensive research and analysis have demonstrated that specific roof materials and composition and other property factors impact a property's likelihood to suffer damage. In other words, two homes that experience the same hailstorm may have different claim outcomes (both the likelihood of experiencing a claim and the severity of a claim) based on the roof's condition, age, material, size, complexity, and trees that are overhanging and shielding that roof.

Moody's (formerly CAPE Analytics) has shown this in previous research, across both roof condition and roof complexity, size, and tree overhang. The Insurance Institute for Business and Home Safety (IBHS) has also demonstrated this in its research, citing roof features such as its condition, material, slope, and skylights as altering its damageability.



UNDERSTANDING THE WEATHER ANALYTICS AND CLIMATOLOGY GAP

Roofs degrade over time, and weather events can dramatically change the speed at which they degrade. Even frequent, small hailstorms can negatively impact a roof's resilience. According to Moody's internal research, over 25% of homes in hail-prone areas have undetected hail damage that makes those homes twice as likely to suffer a hail claim in the event of a hailstorm. Given the information they have available to them today, many insurance carriers would automatically underwrite and bind these properties. Even if carriers already use imagery-based roof condition to help automate underwriting decisions, this often doesn't include hail damage information. Therefore, a precise understanding of where hailstorms have occurred in the recent past, as well as the severity of those hailstorms, is crucial to bridging the gap in understanding where prior damage may have occurred and where future claims are likely to be filed.

Today, however, all hail risk assessment solutions rely on climatology and historical hail reports to generalize an area's hail hazard and historical experience. Unfortunately, the nature of hail (and certain market dynamics, in the case of hail reports) makes these approaches highly problematic.

→ **Spatial resolution issues:** Climatological and related data often come from weather stations that are unevenly distributed and may not capture localized hail events. As demonstrated by IBHS field research, hailstorms can be highly localized and variable over short distances, so a property could experience severe hail while a nearby weather station reports little-to-no hail activity, or vice versa.

Another frequently used data source is the National Oceanic and Atmospheric Administration's (NOAA) Storm Prediction Center "Storm Reports," which are driven by human reporting of hailstorms. This source is coarse rather than granular and is reflective of population biases rather than a direct reflection of where hail is falling.

- **Temporal resolution issues:** Climatological records are also typically aggregated over longer periods, such as monthly or yearly averages. This can obscure the short-term, intense, and sporadic nature of hailstorms, which can lead to a misrepresentation of location-specific hail impacts. Even raw radar data has a refresh rate of every two to six minutes, depending on the radar system and operating mode, which means significant information is lost in terms of thunderstorm development and where hail may be falling.
- **Lack of detail:** Climatological and raw radar data do not include detailed information about hail size or density, which are crucial factors for assessing the potential damage to a property.
- **Scattered sources of information:** Even if historic hail reports perfectly measured hail experience in every area, which they do not, the sources for this information are scattered across various government agencies and third parties, making it difficult for carriers to efficiently access and use.

Together, these issues vastly reduce the effectiveness of current weather data in assessing where hail falls and its intensity. Given the degree to which hail hazard solutions rely on this form of data, there are significant gaps in overall hail risk assessment today. However, a new generation of weather and hazard solutions are now available that can help overcome these myriad challenges.





SECTION 3

New technologies facilitate holistic hail risk assessment

MOODY'S: IMAGERY-BASED INSIGHTS

Moody's uses a combination of computer vision and machine learning to analyze recent, high-resolution imagery of properties throughout the United States, Canada, and Australia. Moody's focus is on assessing a property's conditional elements and characteristics that have an impact on risk and vulnerability. In the case of peril-aligned risk assessment, this information is then combined with additional analytics, such as next-generation weather and hazard information, to create highly predictive risk scores. Today, Moody's provides more than 70 risk-predictive and recent property attributes derived from aerial and satellite imagery. These attributes are available via API in milliseconds and are currently used by a majority of top property and casualty (P&C) carriers in the United States.

For hail risk specifically, Moody's has developed a number of imagery-derived attributes that predict a property's vulnerability to hail strikes. This includes a home's roof condition, roof material, the number of facets or complexity of a roof, its shape, its size, the protection afforded by trees overhanging the roof, and more. When combined into a machine learning-powered score, these property characteristics are highly predictive of future property damage.

CANOPY WEATHER: FORENSIC WEATHER ANALYTICS

Canopy Weather was founded in 2019 as the first company to bridge the climatology gap and offer deeply granular weather data built for the insurance industry. Canopy Weather has developed an analytics product that tracks and models thunderstorm development every 30 seconds — up to 12 times the granularity of raw radar data. This seamless storm tracking, in combination with additional data sources and expert oversight by a team of meteorologists to oversee the cleanliness of data inputs, provides an exceptional understanding of storm direction, hail core location, wind profiles, and freezing level to determine the trajectory, size, and intensity of hail. This technology allows users to understand hail impacts at the property level for the very first time, with access to historical hail information as well as hail data updated daily.

Now, Moody's and Canopy have combined their respective innovations into a single product, offering one of the most holistic hail assessment solutions available to the property insurance industry.

SECTION 4

The CAPE Hail Intelligence Suite: Product overview

Moody's goal in the creation of this suite of products was to offer carriers a holistic view of hail risk. As our team framed the problem and spoke to insurance carriers with hail exposure, we discovered the need for multiple scores to tackle the various facets of hail risk assessment. These aspects include 1) whether a property has sustained damage from past hailstorms that have degraded its ability to withstand future events, 2) the probability of a future loss being incurred, and 3) the severity of such a loss if it were to occur.

The common component for understanding each of these facets of risk is a property's vulnerability or, in other words, the characteristics that determine a property's susceptibility to sustaining damage in the event of a hailstorm. Given its vulnerability, we can apply different lenses of information to predict different facets of hail risk. By adding a property's past hail experience, we can predict the probability of preexisting hail damage.

By layering in the likelihood of a property experiencing hail or a regional hazard in the future, we can predict the probability of a future hail claim. Lastly, by combining property vulnerability with historical claims trends, we can predict the likely severity of a future hail claim for that specific property.

KEY CONCEPTS & DEFINITIONS

As we delve into the topic of hail risk and possible solutions to fill current gaps, it is important to understand these key concepts:



Hazard frequency is the likelihood that a particular peril will occur in a given area. Sometimes shortened to just "hazard," it can also be differentiated by hazard severity (such as hail size bins).



Property vulnerability is the likelihood that the property will be damaged if a peril occurs. It varies based on the property's characteristics.



Property risk is the likelihood of damage or a claim occurring given the combined impact of hazard and vulnerability.



Property loss severity is the amount of damage (in US dollars) that occurs to a property upon a peril occurring. The difference between loss severity and claim amount is typically the deductible and the actual cash value policy terms.



Property experience is the historical weather activity that has occurred to a particular property. This is separate from a carrier's claims experience.



The following formula presents a heuristic method for how Moody's tracks existing property-level hail damage as well as future risk. Based on this formula, Moody's then set out to build a suite of scores that could accurately satisfy each component.



Property vulnerability



CAPE Hail Risk Rating

<p>Hail Risk Rating overview</p> <p>SCALE 1-10</p>	<p>USE CASE</p> <p>Overall property-specific hail risk</p>	<p>PERCENTAGE OF PROPERTIES WITH EXTREMELY HIGH RISK</p> <p>~15%</p>	<p>CRITICAL FACTORS</p> <p>Hail hazard, structure footprint, roof facet count</p>
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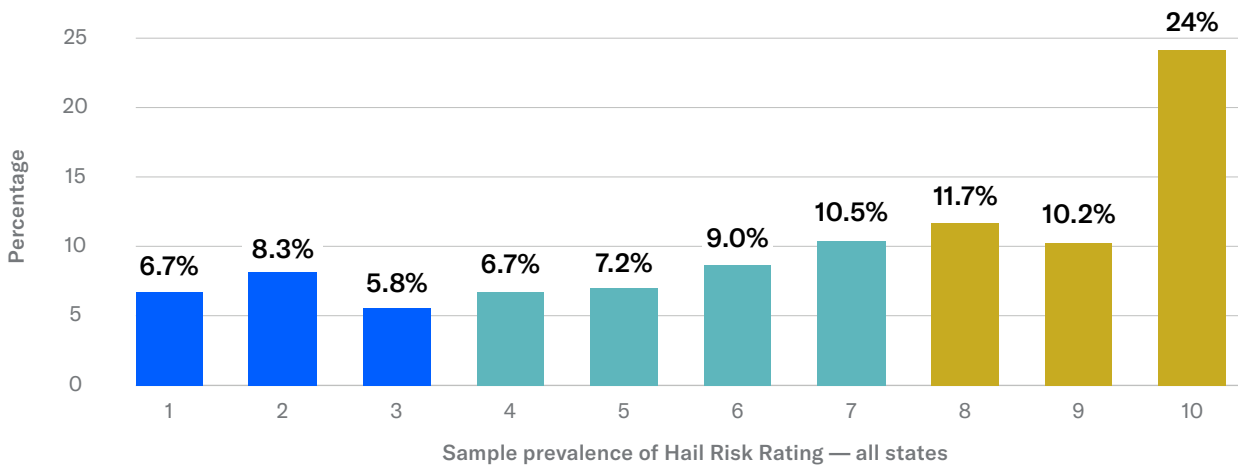
CAPE's Hail Risk Rating is an overall risk score that combines regional hazard and property-specific vulnerability information. This score is presented on a 1-10 scale, with lower numbers signifying higher risk. From a prevalence perspective, more properties are classified as having low risk — nearly 35% of properties receive a score of 9 or 10, the lowest risk categories, while just 15% are given a score of 1 or 2, the highest risk categories. This is due to many states having a lower risk of hail occurring. When focusing only on hail belt states, the prevalence becomes far more evenly distributed.



The components of a Hail Risk Rating are as follows, in order of importance of elements that can increase a property's overall risk:

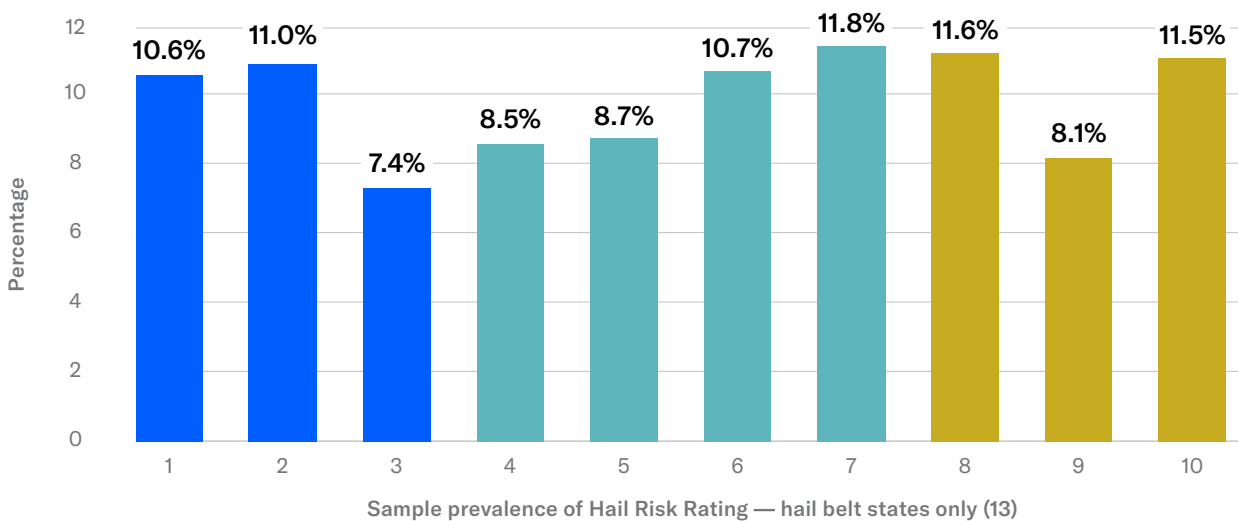
1. Hail event history (hail size and event counts)
2. The property's structure footprint
3. The number of roof facets
4. The roof condition
5. The roof's geometry
6. The roof covering material
7. A lack of trees overhanging the roof

FIGURE 2



Hail Risk Ratings are primarily useful for writing new business. Uses include automatically removing properties with a poor Hail Risk Rating, accelerating the underwriting of properties with a good Hail Risk Rating, or offering mitigation credits or pricing risks in high-hazard areas based on Hail Risk Rating.

FIGURE 3



CAPE Hail Vulnerability Rating

<p>Hail Vulnerability Rating overview</p> <p>SCALE 1-10</p>	<p>USE CASE</p> <p>Property-specific hail vulnerability</p>	<p>PERCENTAGE OF PROPERTIES WITH EXTREMELY HIGH RISK</p> <p>~35%</p>	<p>CRITICAL FACTORS</p> <p>Structure footprint, roof condition, roof facet count</p>	<p>TRANSPARENCY</p> <p>Top three factors driving the score are provided</p>
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CAPE’s Hail Vulnerability Rating is a property-specific susceptibility score based on a property’s current characteristics, which are derived using computer vision applied to recent high-resolution aerial imagery. Like the Hail Risk Rating, this score is presented on a 1-10 score, with lower numbers signifying higher risk. From a prevalence perspective, many properties are classified as having high vulnerability — more than 35% of properties are given a score of 1 or 2, the highest vulnerability categories, whereas approximately 14% receive a score of 9 or 10, the lowest risk categories. Given that property characteristics do not differ significantly between hail and non-hail states, the prevalence of vulnerability scores is similar when focusing only on hail belt states.

FIGURE 4

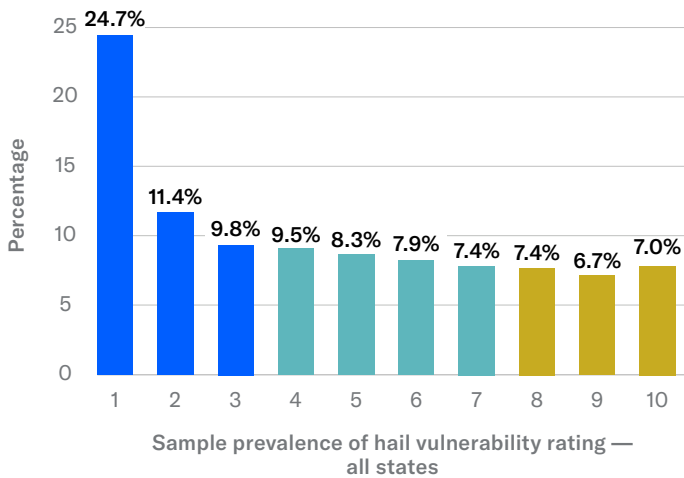
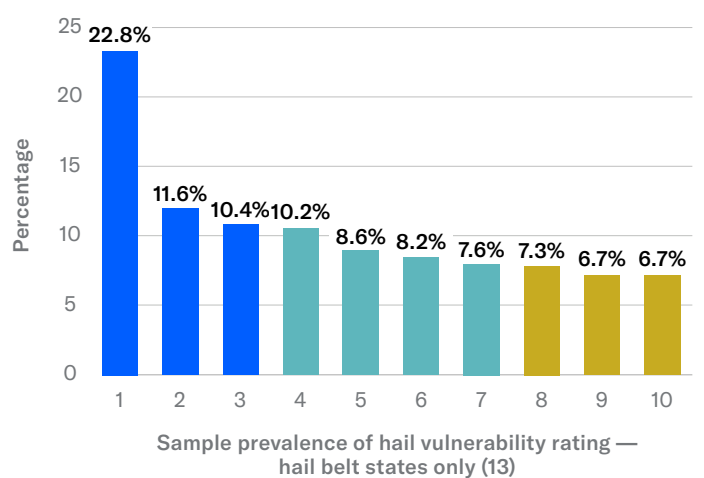


FIGURE 5

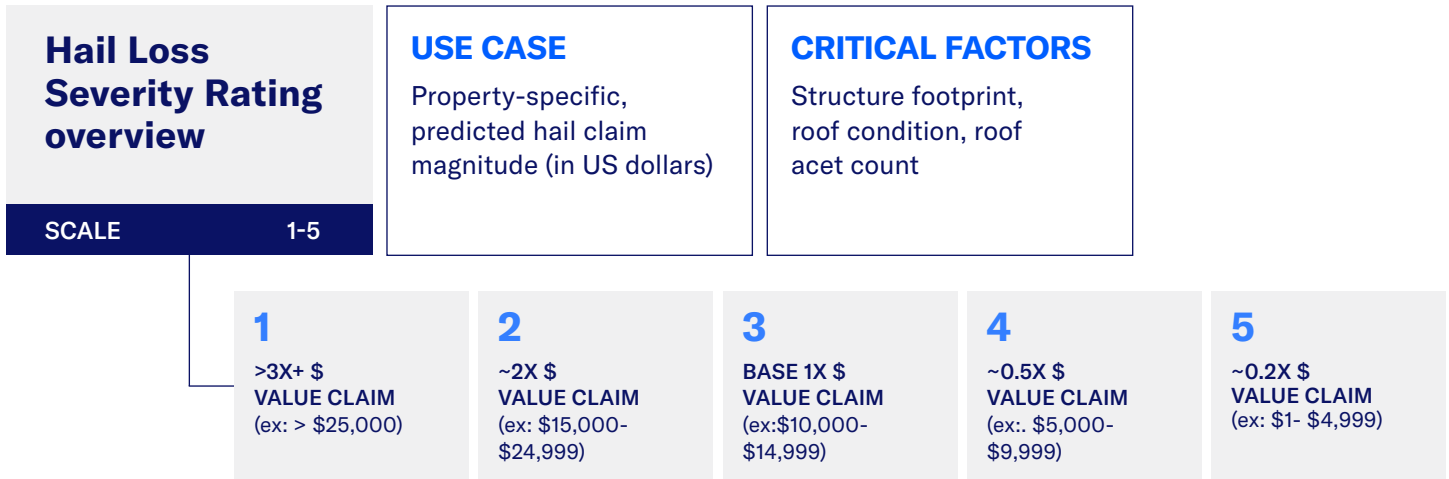


Listed in order of importance of characteristics that can increase the vulnerability of a property, a Hail Vulnerability Rating’s components are:

1. The structure’s footprint
2. The roof’s condition
3. The roof’s facet count
4. A lack of trees overhanging the roof
5. The roof’s covering material
6. The roof’s geometry

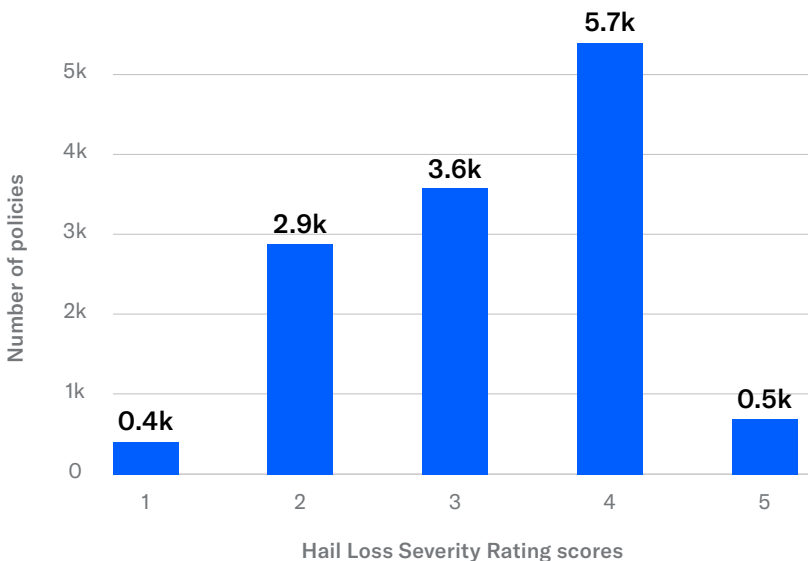
Hail Vulnerability Ratings are useful for both new business and renewals. For new business, uses include automatically removing properties with a poor Hail Vulnerability Rating in high-hail hazard areas, accelerating the underwriting of properties with good Hail Vulnerability Ratings in high-hazard areas, or offering mitigation credits or pricing risks in high-hazard areas based on Hail Vulnerability Ratings. At renewal, carriers can monitor for major year-over-year changes to Hail Vulnerability Ratings and flag those properties for further underwriting review.

CAPE Hail Loss Severity Rating



CAPE’s Hail Loss Severity Rating is an additional property-specific score that predicts the severity of a future claim based on a property’s characteristics relevant to hail. It is important to note that the Hail Loss Severity Rating is a forward-looking score that judges the magnitude of a potential claim should a large hail event occur — it is not meant to reflect a past or current claim. Hail Loss Severity Ratings are scored on a 1-5 scale, with lower numbers indicating higher magnitude claims. For example, a score of 1 denotes a predicted claim severity about three times the average claim, while a score of 5 predicts a claim about one-fifth the average claim severity. Most properties fall within the middle three categories, with 6.5% of properties falling either within the very high or very low loss severity categories.

FIGURE 6



The Hail Loss Severity Rating’s components are as follows, in order of importance:

1. The structure’s footprint
2. The roof’s condition
3. The roof’s facet count
4. A lack of trees overhanging the roof
5. The roof’s covering material
6. The roof’s geometry

Moody’s designed the Hail Loss Severity Rating to help estimate claim severity and for new businesses to incorporate it into pricing to capture additional premium for high-severity properties. The score can also support insurance carriers who seek to estimate potential catastrophic loss prior to an event.

CAPE Hail Experience Rating

<p>Hail Experience Rating overview</p> <p>SCALE 1-3</p>	<p>USE CASE</p> <p>Detect preexisting hail damage</p>	<p>PERCENTAGE OF PROPERTIES WITH EXTREMELY HIGH RISK</p> <p>~25%</p>	<p>CRITICAL FACTORS</p> <p>Number of hail events, maximum hail size, roof material</p>	<p>TRANSPARENCY</p> <p>Delivers the raw number of hail events and maximum hail sizes for the previous two years</p>
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CAPE’s Hail Experience Rating estimates the likelihood that a property has experienced recent hail damage to its roof by characterizing its recent hail exposure using forensic hail data from Canopy Weather and roof material information from CAPE. Unlike the other scores in the Hail Intelligence Suite, the CAPE Hail Experience Rating is a backward-looking score that seeks to bridge the gap between what can be evaluated using imagery and hail damage that may not be visible.

The score is presented on a 1-3 scale, with lower numbers indicating higher hail exposure and likelihood of preexisting damage.

Ingredients for the score include the hail event count in recent years, the maximum hail size for those events, and the roof covering material. The CAPE Hail Experience Rating is optimized to be used for shingle roofs since other materials, such as tile or metal, can better withstand hail damage. As seen in the following chart, most properties in hail-exposed regions have moderate hail experience, while over 25% of properties have seen significant hail in terms of number of events and size of hail. In the next figure, we see how the more granular hailstorm information results in localized swings in average Hail Experience Rating, even within the same hail-exposed metropolitan area.

BRIDGING THE GAP BETWEEN ROOF CONDITION RATING AND INVISIBLE HAIL DAMAGE

Our research at Moody’s shows that 60% of homes with significant recent hailstorm history (meaning multiple events or single events with hail sizes over 1.75 inches) still display good or excellent roof conditions in imagery-based evaluations.

FIGURE 7

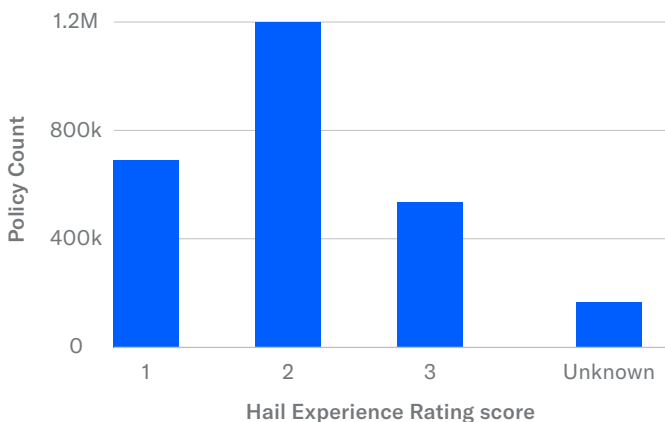
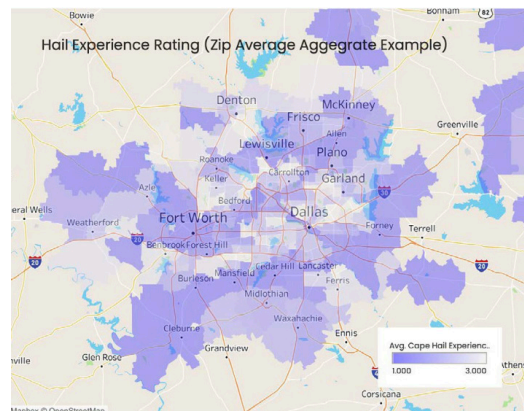


FIGURE 8



SECTION 5

Study: The predictive power of CAPE's Hail Intelligence Suite

METHODOLOGY

Moody's maintains an exposure and loss database provided by insurance carrier partners consisting of more than 20 million exposure records and more than 1 million location-level claims.

The CAPE Hail Intelligence Suite scores were tested against this database to quantify each score's loss impacts as accurately as possible. Contributing partners deliver policy details, including address, structure coverage amount, earned premium, and policy effective dates. They also provided each claim's date, cause of loss, and loss payout amount for analysis. This data is converted into a format consistent across all partners, and duplicates are removed.

This study was conducted with data derived from historical point-in-time imagery and the CAPE Hail Intelligence models. The exposure data was processed in Moody's platform using historical imagery available before the policy effective date for each location.

Hail scores derived from this historical imagery represent the exact data that a carrier would have utilized during the underwriting process for that policy.

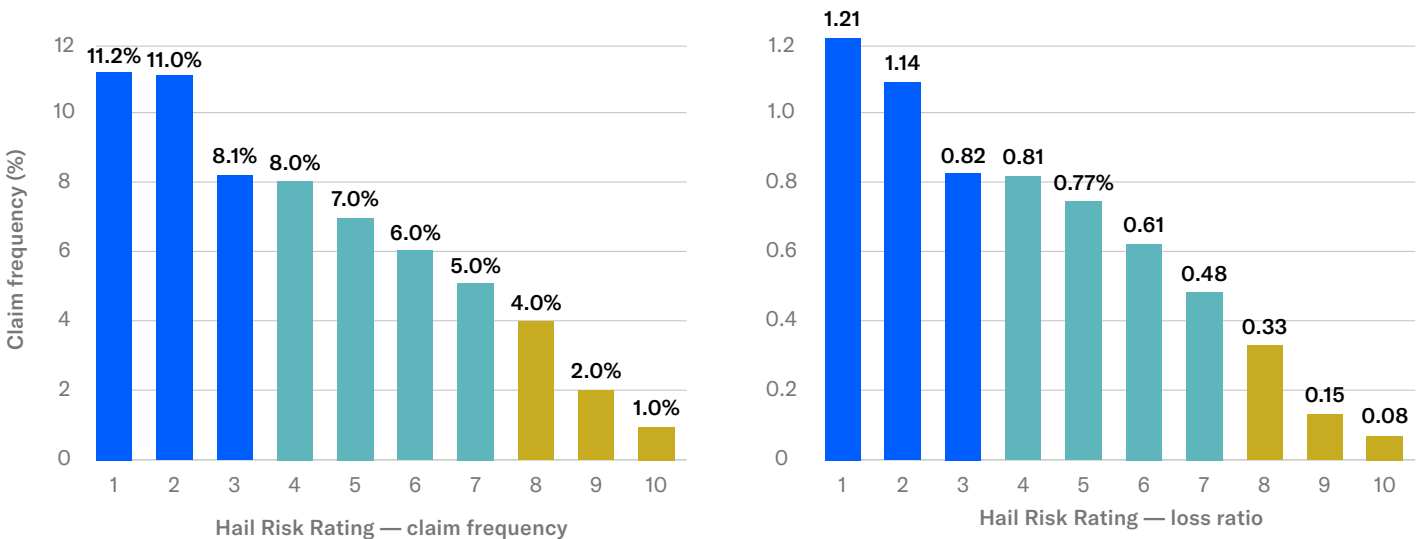
STUDY SAMPLE SIZES

The overall claim experience sample for this study was relegated to states in the hail belt. The 13 states included in this study were Arkansas, Colorado, Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, Oklahoma, South Dakota, Texas, and Wisconsin.

HAIL RISK RATING

Both the claims frequency and loss ratio plots display step decreases with decreasing risk. The splitting power across the range of scores is evident, with scores classified as high risk resulting in four-to-five times the claims frequency and loss ratio as those deemed low risk.

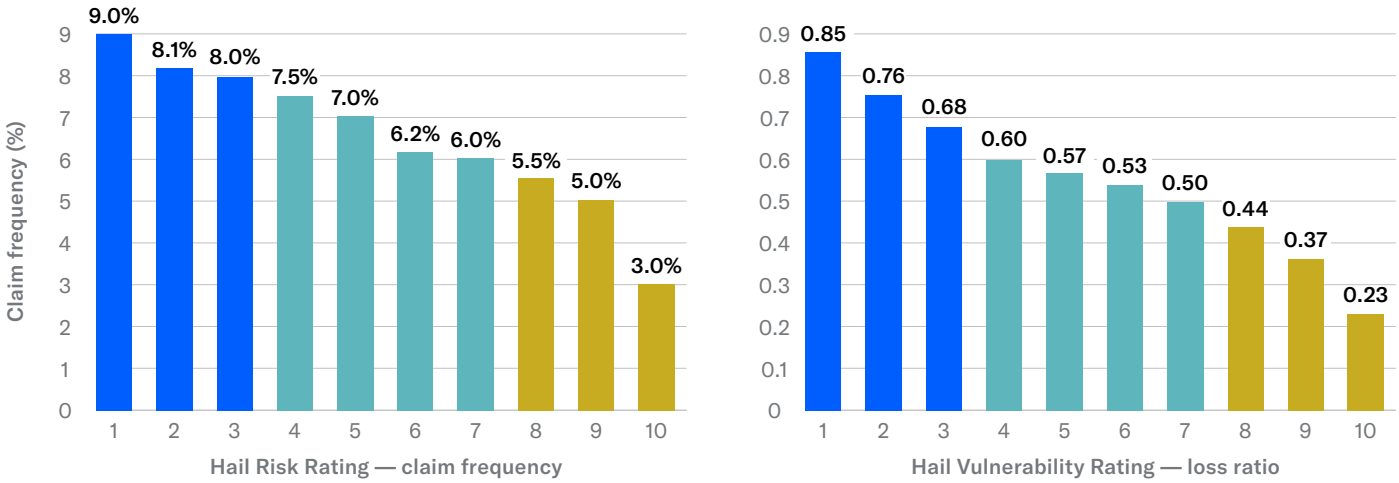
FIGURE 9



HAIL VULNERABILITY RATING

Similar to the Hail Risk Rating, the Hail Vulnerability Rating plots display monotonic decreases with decreasing risk. The impact of property characteristics on the likelihood of a claim is clear: Properties classified as high vulnerability have twice the claims frequency as those deemed low vulnerability.

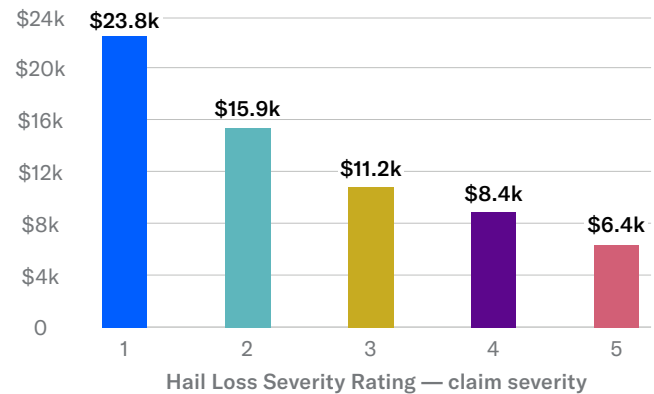
FIGURE 10



HAIL LOSS SEVERITY RATING

Moody’s built the Hail Loss Severity Rating to predict claim severity. Figure 11 shows how a Hail Loss Severity Rating performs, with a step decrease in claim severity for each score. The actual values will depend on a carrier’s book of business, with the dollar amounts as examples for the broad sample set used in this study. This demonstrates how Hail Loss Severity Ratings, in conjunction with Hail Risk Ratings or Hail Vulnerability Ratings, can provide an additional layer of pricing segmentation.

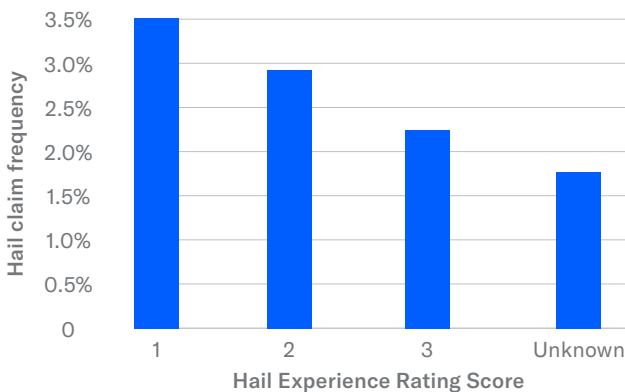
FIGURE 11



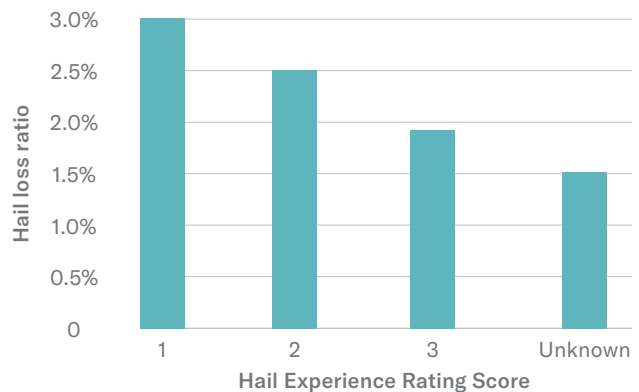
HAIL EXPERIENCE RATING

The Hail Experience Rating demonstrates a monotonic relationship with claims frequency. Properties with a higher frequency and severity of hailstorms in previous years are over 50% more likely to have a future claim due to undetected damage, and these properties represent 60% of the housing stock in hail-prone areas.

FIGURE 12 Hail claim frequency by Hail Experience Rating



Hail Loss Ratio by Hail Experience Rating



Conclusion

SECTION 6

Use cases and next steps

Hail losses are not going away, either in terms of claim frequency or claim severity. Carriers should use all the tools at their disposal to manage risk and bring profitability under control, including better predictive hail analytics in rate-constrained environments.

Improved hail intelligence can better match premium to risk, and aggregated risk information rolled into a single score can be easily incorporated as a factor into existing rating models more quickly than typical years-long large remodels that carriers could undertake internally. It can also power coverage decisions, from whether or not to underwrite a risk at all to whether or not to inspect that risk and whether to allow full coverage options like replacement cost, cosmetic damage, and matching coverage. It can also be used in decisions regarding reducing coverage for a more attractive premium to the customer and better managed, more efficient loss control for the carrier. In these cases, carriers don't have to change their fundamental processes or underwriting guidelines. Better, more easily accessible information will help them more efficiently select which properties to inspect and what coverages to underwrite, saving time and money.

Lastly, better use of hail intelligence tools can assist with reinsurance conversations to show that the carrier is taking active steps to control losses and stay on the cutting edge of risk management. Carriers can use underlying Moody's attributes to inform exposure differentiation in catastrophe modeling solutions, dramatically increasing downstream fidelity of probable maximum loss estimates for severe convective storms and other perils critical to manage weather loss exposure.

In a hard market like the current environment, carriers need to evaluate and use more sophisticated hail intelligence to better match rates and coverage to the growing hail risk. Contact us to learn more about our hail risk solutions.



MOODY'S

**CONTACT MOODY'S TO LEARN MORE:
CAPESALES@MOODYS.COM**

MOODYS.COM/INSURANCESOLUTIONS

**FOR ADDITIONAL RESOURCES OR
INFORMATION, PLEASE REACH OUT
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**ADDITIONAL ROOF CONDITION RATING
RESOURCES INCLUDE PRODUCT OVERVIEWS
FOR FRONTLINE UNDERWRITERS, BEST
PRACTICES FOR CUSTOMER AND AGENT
SUPPORT, RATE FILING DOCUMENTATION,
AND MORE.**