CAS RESEARCH PAPER

DEVELOPING RATES FOR THE SEVERE CONVECTIVE STORM PERIL IN PROPERTY INSURANCE

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1. Introduction

(Re)insurance industry conversations and trade publications have increasingly focused on the rising cost of severe convective storms (SCSs) as the number of billion-dollar events has risen markedly in recent years. While such events may have caught some in the industry by surprise, these storms, characterized by the presence of the sub-perils of hail, tornado, and/or straight-line winds at the time of property damage, have always occurred frequently in nature, albeit at a smaller scale.

For some insurers with concentrations of insured value in high-hazard regions, SCSs have become an existential threat – depleting capital at alarming rates. For others, SCSs present a persistent earnings challenge, as they struggle to achieve rate increases commensurate with the rising cost of the peril. Regardless, most property insurers are attempting to understand and manage losses from SCSs with increasing rigor.

While insurance professionals look to their own portfolios' loss experience, their view of SCS risk may be supplemented by commercially available catastrophe modeling output and other publicly available information. Fortunately, many external sources of data and research exist to support their understanding of the frequency and severity of weather events that must be present for these losses to occur, characteristics that make individual structures more susceptible to loss, and economic and societal trends that drive the average cost of these claims.

This paper will explore techniques currently being employed in the industry to adequately develop rates for SCSs in property insurance, including these external data sources and how they may be incorporated into existing ratemaking practices for actuaries.

2. Definition of Terms

Amount of insurance: In property insurance, this value is used to calculate the premium to insure the building. Property insurers use expert-provided estimates to approximate the replacement value of a building at policy inception. Many property insurers apply an annual increase to this amount of insurance to reflect the influence of inflation on replacement values.

Amount of insurance years: A monetary value, for example $1,000, of building coverage in force in a portfolio for one year. When an exposure is in force for less than a full year, the amount of insurance for the exposure is prorated based on the percentage of the year that the exposure was insured.

Annual aggregate treaty: A property-casualty reinsurance structure that allows the cedent to recover losses accumulated over an annual period rather than losses from a single event.

Attachment point: The dollar value where reinsurance coverage begins for a cedent. It can be considered synonymous with *self-insured retention* but applied in the context of reinsurance coverage.

Cedent: The party in a reinsurance transaction that pays a reinsurance premium in exchange for the ability to cede losses to another party (the *assumer* or *reinsurer*).

Depreciated value: The value of an asset after accounting for depreciation of the asset over time. As applied in property insurance, depreciation usually occurs as the result of wear and tear or age of the asset.

Derecho: A fast-moving, long-lived straight-line windstorm, classified by wind gusts of at least 58 miles per hour along most of the storm's path and a damage swath extending more than 240 miles in length.

Replacement value: The actual cost to replace an insured building with similar kind and quality after a total loss such as a fire or collapse.

Representative Concentration Pathways (RCPs): Climate change scenarios that project future greenhouse gas concentrations in the atmosphere, formally adopted by the Intergovernmental Panel on Climate Change. In this paper, we discuss findings from RCP 4.5 and RCP 8.5, which represent an intermediate scenario and a worst-case scenario, respectively.

Verisk Property Claims Service (PCS) identified catastrophe: When Verisk believes that an event is likely to cause more than $25 million of damage in the U.S. and affect a significant number of policyholders and insurers, Verisk's PCS assigns a catastrophe number and declares perils (e.g., hurricane or tornado) associated with the event. Insurers voluntarily submit claim counts and loss estimates by line of business (i.e., personal property, vehicle, or commercial property), state, and county. Verisk PCS issues at least one catastrophe bulletin that estimates the entire industry's losses stemming from the catastrophe. (For more information, visit www.verisk.com.)

Note: Throughout this document, the following terms are used interchangeably to refer to SCSs: *severe thunderstorms*, *convective storms*, and *thunderstorms*.

3. SCSs: Understanding the Peril

As prevalent and persistent natural hazards, SCSs are characterized by their potential to produce damaging winds, hail, and tornadoes. While heavy rainfall and lightning are also associated with thunderstorms of this variety, they do not have a significant impact on insured losses and therefore will not be addressed within this paper. SCSs pose substantial risks to life, property, and infrastructure, thereby playing a significant role in both insurance and reinsurance transactions.

While convective thunderstorms can occur in many places around the world, their prevalence in North America, and particularly the U.S., can be attributed to factors unique to the region, including its geography and topography; its proximity to a source of warm, moist air from the Gulf of Mexico; and the overall land surface and terrain, among others. Collectively, the U.S. offers the perfect confluence of the necessary ingredients for severe thunderstorms, allowing for this peril to occur routinely. Therefore, SCSs can be largely characterized as high-frequency catastrophes, especially relative to hurricanes and earthquakes given that SCS events frequently meet the threshold of the PCS definition of *natural catastrophe events*.

While severe thunderstorms can occur at any time during the calendar year, peak severe weather season for the U.S. is generally considered to be spring, March through May. However, SCS sub-perils tend to peak at different times of the year, with tornado being the earliest, followed by hail, and then straight-line wind, which peaks during summer months. In addition to higher periods of activity in the spring and early summer months across the entire U.S., parts of the Southeast experience a secondary season in the autumn, usually between November and December.

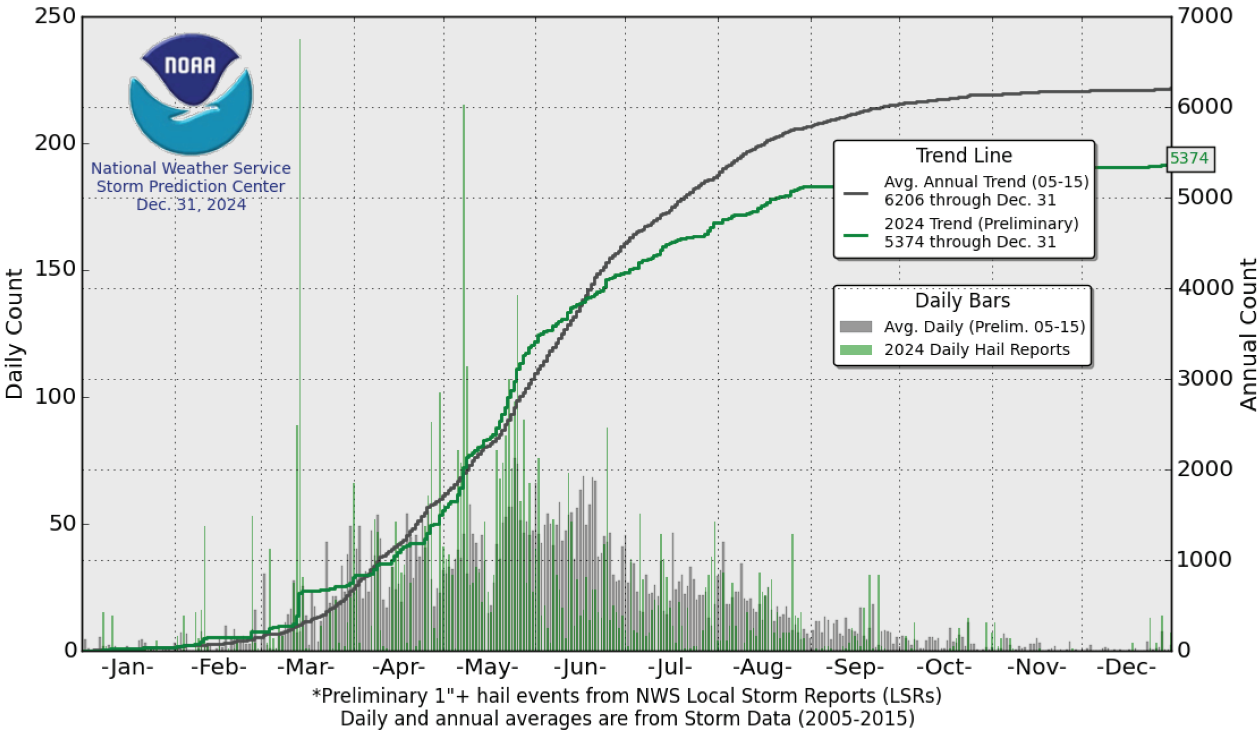
During the spring months, temperature contrasts between cold and warm air boundaries set the stage for thunderstorm production. Compounded by more sunlight for the Northern Hemisphere as seasons change, the positioning of the jet stream, and moisture being fed in from the Gulf of Mexico, this time of year can see thunderstorm activity at a very high frequency.

Figure 1 shows the daily count of U.S. hail reports for 2024, with daily bars and a cumulative trend line (green) relative to a longer-term average from 2005 to 2015 averages (gray). Note the bell-shaped curve of the daily bars in gray that peaks in May and June, which represents the most active time for hail in the U.S. Of note, 2024 ran slightly below the 2005–2015 average for hail frequency but followed the same seasonal pattern. This seasonality differs for tornado and straight-line wind reports.

Severe thunderstorms regularly impact the central and eastern U.S. on an average annual basis. As seen in Figure 2, the central plains serve as a hotspot for severe weather, with the highest frequency of events occurring there, and minimal activity is observed west of the Rockies due to the lack of necessary ingredients for convective thunderstorm development. Despite certain regions or geographies being more prone to severe weather activity, the exact location of a storm or a feature within a storm, such as a hail swath, a wind gust, or even a tornado, occurs with a high degree of randomness.

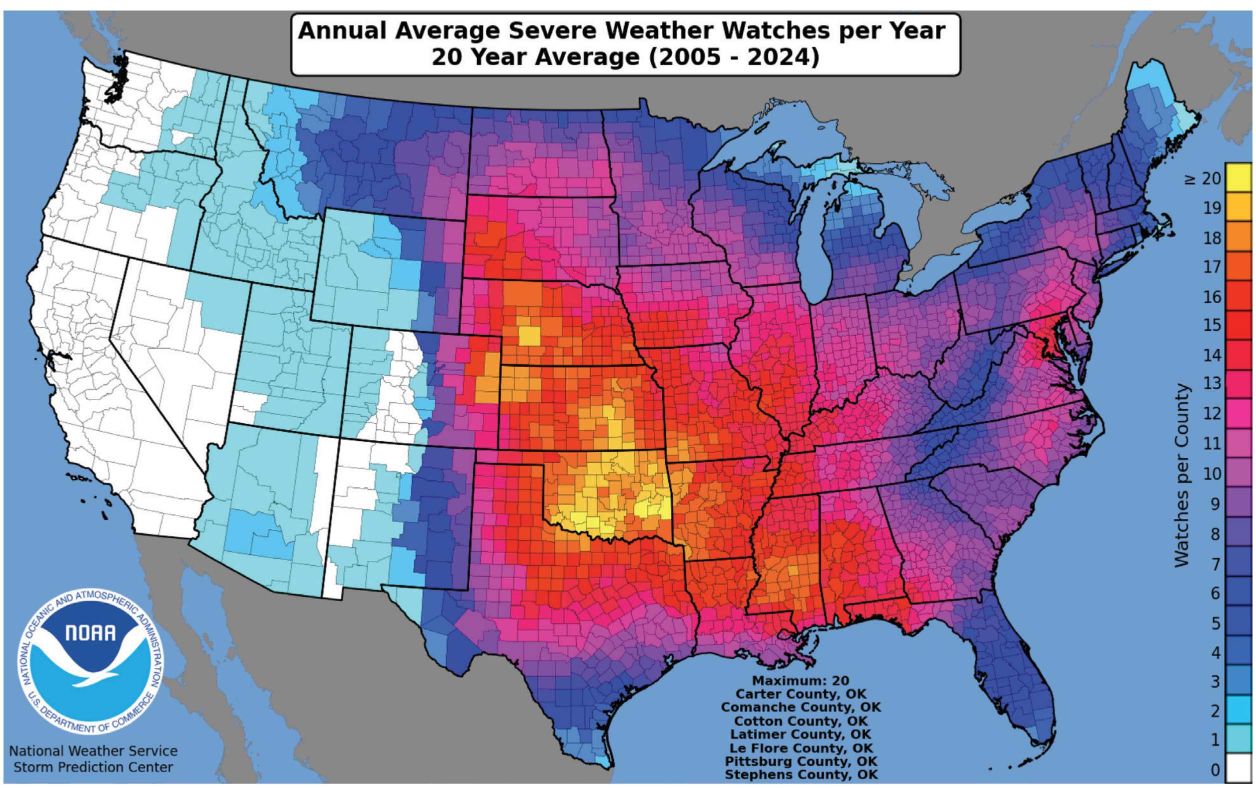
Noting the challenges and local variation associated with SCSs, the geographic scale of specific events is complex. While severe thunderstorms are highly local phenomena, forecasting and predicting storms at this level of granularity is challenging. When forecasting the potential for severe weather, the exact location of storm formation is highly uncertain; forecasting is generally performed at a regional or subregional scale. Therefore, when aiming

Figure 1. U.S. Hail Reports: Daily count and running annual trend



Source: National Weather Service Storm Prediction Center (March 17, 2025).

Figure 2. Annual average severe weather watches per year (2005–2024)



Source: National Weather Service Storm Prediction Center (March 17, 2025).

to aggregate carrier SCS losses or examine hazard in aggregate, address or location level is not appropriate. Viewing the hazard through a less granular lens – such as a census block, county, or large grid system – is a more suitable approach.

SCS losses are driven by three primary sub-perils: hail, straight-line winds, and tornado, either on an individual basis or in combination with one another. Each sub-peril has its own unique challenges and characteristics when it comes to understanding the relationship with claims activity:

- Hail stones can drastically vary in size, ranging from ¼ inch (pea size) all the way to 4½ inches (softball size). In extreme cases, hail can form in excess of 7 inches in diameter – the largest hailstone on record measured 8 inches in diameter and fell in Vivian, South Dakota, in 2010. Given this vast size distribution, as well as other factors such as density of hailstones and uniformity (or nonuniformity) of hail swaths, translating the impact of hail to insurance claims is a complicated exercise. Hail tends to be more capable of causing damage to auto and residential property relative to commercial and industrial property, and losses can be significant in aggregate. Impacts from hailstones to roofs and siding of residential homes are common, and compounding hailstorms over time can significantly affect roof integrity. Of note, research from the Insurance Institute for Business & Home Safety (IBHS) has shown that the continued impact of even small hail can significantly degrade the life span of a roof. Certain characteristics of properties such as roof age, roof material, and siding type can be integral in assessing the potential impact of hail.
- Damaging straight-line winds can occur in a variety of forms, including a downburst, a gust front, or in extreme cases, a derecho. Straight-line winds are the most frequent cause of downed trees and power lines, which can lead to significant property damage and prolonged power outages. Severe straight-line winds can cause structural damage to compromised or vulnerable structures.
- Tornadoes occur with less frequency than the aforementioned sub-perils but are the most extreme and damaging sub-peril associated with SCSs. Often packing wind speeds over 100 miles per hour, tornadic winds rotate around a core and can cause catastrophic structural damage, even to reinforced and well-engineered buildings. It has been recently demonstrated, however, that newer homes built to a more resilient code can be significantly less damageable than older homes.

4. An Evolving SCS Landscape

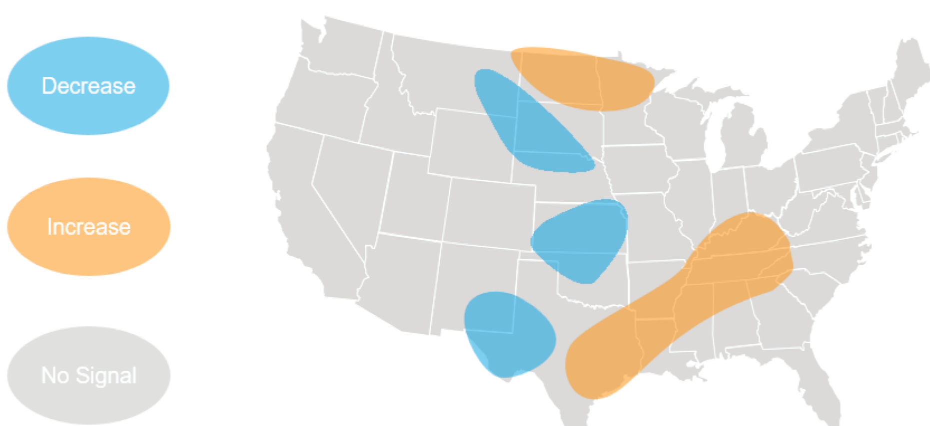
4.1. Hazard Changes

While it is crucial to understand the current severe thunderstorm risk landscape and how the hazard has evolved over time, it is becoming ever more apparent that future shifts from a changing climate are critical to informing views of the hazard and therefore applications to ratemaking. An uptick in losses across the insurance industry from SCSs, driven in part by changes to the hazard, has resulted in carriers needing to develop an understanding not only of these changes to the evolving risk landscape but also the uncertainty surrounding the changes, particularly when considering human-induced climate change.

Observed and projected changes to SCS hazard are not one-size-fits-all. Potential changes at the sub-peril level differ from one another regarding frequency, severity, volatility, and even temporality. These changes have varying implications for the insurance industry.

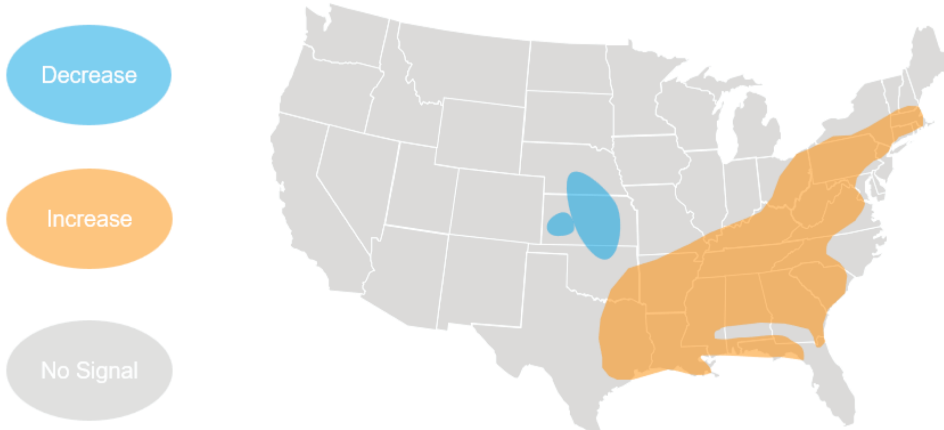
- *Hail:* Researchers often use the Significant Hail Parameter (SHIP) to assess severe thunderstorm environments for production of large hail (2 or more inches). SHIP was originally developed for operational forecasting purposes but has since been leveraged in academic studies.
  - Over the last four decades, SHIP values have increased across most areas east of the Rockies, which is indicative of a higher potential for days when the environment can support large hail. The highest increases over the last 40 years are observed throughout the central U.S. Minor decreases are present along the front range of the Rockies.
  - As shown in Figure 3, future climate scenarios that leverage the RCP 4.5 scenario result in an increase in the number of days where the environment could support large hail in areas of eastern Texas, the mid-South, and south-central Canada.
  - Conversely, decreases in the SHIP parameter were observed in the aforementioned scenario in parts of western Texas and the central Great Plains.
- *Tornado:* Like hail, researchers use the Significant Tornado Parameter to analyze when significant tornadoes (EF2 or stronger) can be generated.
  - Over the last four decades, a strong spatial shift has been observed with respect to favorable environments for tornadoes, with a bull's-eye over the Deep South, centered over Arkansas, Mississippi, and Alabama. The largest decreases are seen in central and eastern Texas.
  - As shown in Figure 4, in the RCP 4.5 scenario, findings suggest an increase in environments favorable for significant tornado production in the mid-South, Southeast, mid-Atlantic, and parts of the Northeast.

Figure 3. Expected changes in severe hail days between 2025 and 2050 based on RCP 4.5



Source: Guy Carpenter and Northern Illinois University.

Figure 4. Expected changes in tornado days between 2025 and 2050 based on RCP 4.5



Source: Guy Carpenter and Northern Illinois University.

  - Decreases corresponding to the above study could suggest slight decreases in the number of annual tornado days over parts of the central Great Plains and parts of the upper Mississippi Valley.

- *Straight-line wind:* Straight-line wind carries the highest uncertainty regarding potential changes among the three sub-perils. However, recent publications focused on this sub-peril suggest potential increases in the overall occurrence rates of derechos and changes to the temporal component of derechos in future climate scenarios, as well as overall intensification of straight-line winds.

4.2. Population and Demographic Changes

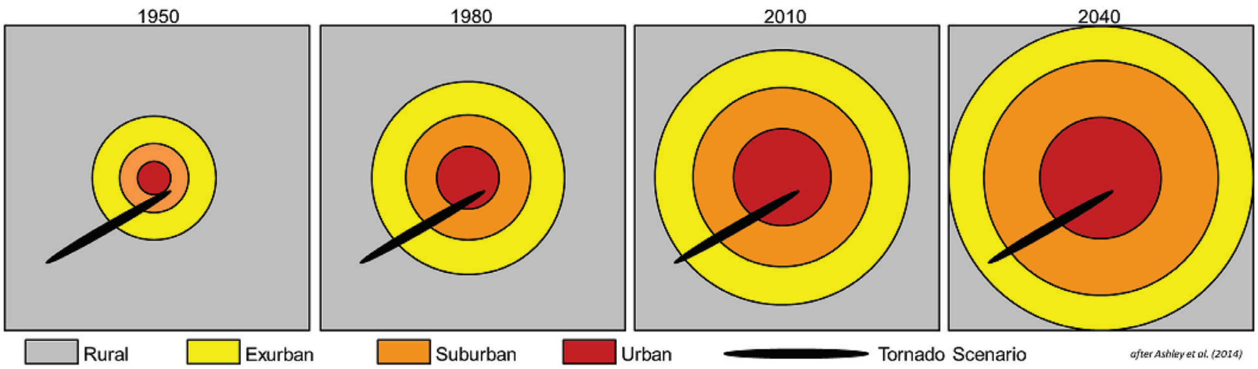
While changes to the climate and hazard landscape drive headlines of loss escalation, additional factors such as population and demographic changes play a role as well in the increasing impact potential of such events.

4.2.1. The Expanding Bull's-Eye Effect

Originally published by Walker S. Ashley and colleagues (2014), the "expanding bull's-eye effect" model, illustrated in Figure 5, shows how population growth and spread lead to increases in the costs associated with natural disasters. Put simply, the more things in harm's way, the more likely for more of those things to be damaged and thereby drive costs higher. Fundamentally, the expanding bull's-eye effect holds hazard constant; even if the frequency and severity of natural disasters did not change, the level of impact and cost to rebuild would, solely due to demographic changes.

Observed and predicted changes in weather patterns, as well as changes in population and demographics, present significant challenges and opportunities for the insurance industry. A holistic ratemaking approach that integrates these changes is essential for accurately assessing risk. As climate conditions continue to evolve, insurers must remain vigilant and adaptable, leveraging data and insights to navigate the complexities of a changing risk landscape.

Figure 5. A conceptual model of the expanding bull's-eye effect



Source: Ashley et al. (2014, 191). © American Meteorological Society. Used with permission.

5. SCS Peril and Catastrophe Models

Several procedures to develop rates inclusive of catastrophe losses in property insurance require well-calibrated, well-validated catastrophe models to apply those procedures to developing rates.

Actuarial Standards of Practice (ASOP) No. 38, Catastrophe Modeling (for All Practice Areas), defines a *catastrophe model* as

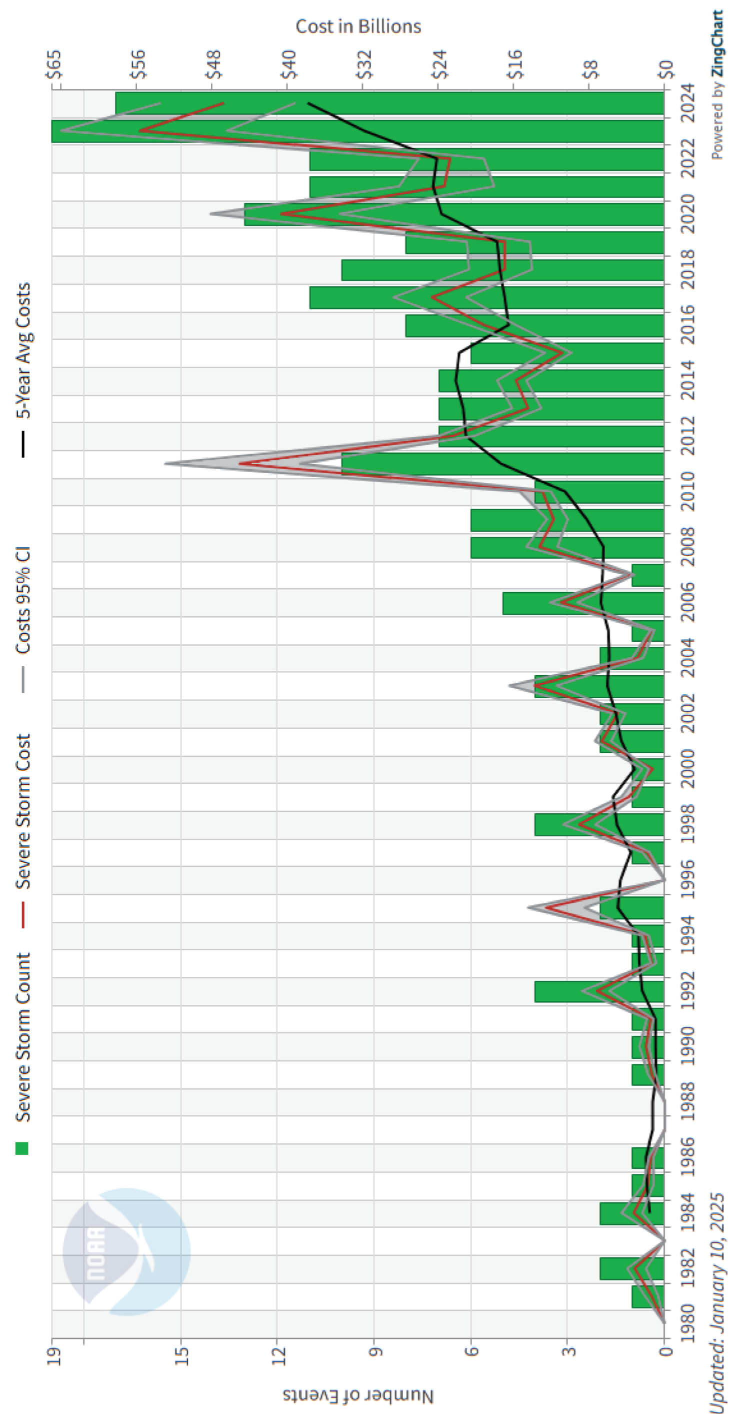
> A representation of relationships among events based on statistical, financial, economic, or mathematical concepts and equations used to explain a system, to study the effects of different components, and to derive estimates based upon the future occurrences of large-scale, low-frequency, high-severity events such as hurricanes, earthquakes, tornados, terrorist acts, and pandemics.

Catastrophe models for the natural perils of hurricane, earthquake, and fire following earthquake have long been used to understand the potential losses from these perils by the (re)insurance market. In contrast, catastrophe models for SCSs have not yet received the same acceptance and are often viewed as less robust.

ASOP No. 38 poses many considerations to actuaries about using catastrophe models in their work. Specific to catastrophe models for the SCS peril, the authors would hypothesize that (re)insurance market acceptance of these models has been lackluster for the following reasons:

1. *Appropriate validation:* As of this paper's writing, average annual loss estimates produced by SCS models fall significantly short of recent years' industry losses, noting some improvement in the most recent model versions.
2. *Applicability of historical data:* The most recent version of commercially available catastrophe models for SCSs are calibrated with data only through 2018, omitting the most active loss years for the U.S. property insurance industry (as shown in Figure 6).

Figure 6. U.S. billion-dollar disaster events, 1980–2024, CPI-Adjusted



Source: NOAA National Centers for Environmental Information (2025).

Even with more recent relevant data, SCSs pose unique challenges to developers of catastrophe models; these events occur frequently, but their damage swaths can vary significantly by both event and sub-peril. While a storm may be vast, extreme conditions that cause property damage can be very localized – sometimes spanning only a few hundred feet. For this and other reasons, losses stemming from SCSs are not universally captured with a PCS event designation since they could easily fall below PCS's reporting threshold. This makes accurate loss estimation of less severe but more frequent ("low-return-period") events very challenging to calibrate. It likely necessitates a greater number and variety of low-severity events within a catastrophe modeling event set.

Model developers have overcome unique challenges posed by other natural perils, and they are sure to do so as the demand for better loss estimates for SCSs continues to increase. Actuaries should continue to evaluate new versions of SCS catastrophe models and reflect on the appropriate use consistent with ASOP No. 38 and ASOP No. 39, Treatment of Catastrophe Losses in Property/Casualty Insurance Ratemaking.

6. Common Approaches to Developing Property Insurance Rates Inclusive of the SCS Peril

Actuarial approaches for developing property insurance rates inclusive of SCS losses vary greatly across carriers but fundamentally fall into four types. The actuary selects an approach considering the size and stability of the insured portfolio, access to reliable current and historical insured portfolio and claims data, and available catastrophe modeling expertise.

The first approach uses a **catastrophe adjustment factor to non-catastrophe projected loss costs** per some measure of exposure, such as amount of insurance years or earned house years. The catastrophe adjustment factor is usually a long-term average, 10 years or more, of the ratio of catastrophe to non-catastrophe losses experienced by the insurer. Where an insurer relies upon a catastrophe model for estimating hurricane or earthquake loss costs, both the catastrophe and non-catastrophe loss costs are calculated with the insurer's own experience for those modeled perils removed.

While this approach would normally be appropriate for insurers with many years of loss experience and a relatively constant mix of business, it is suboptimal for developing rates for SCSs because the definition of *catastrophe* is murkier for SCSs and the ratio of catastrophe to non-catastrophe losses is unlikely to remain constant over time.

The second approach removes the insurer's own loss experience for SCSs and uses an **average annual loss (AAL) estimate derived from an SCS catastrophe model** based on the insurer's current portfolio. Insurers using this approach compare their actual historical SCS losses to the catastrophe model–estimated AAL for the insured portfolio. Insurers frequently scale the catastrophe-modeled AAL for the current portfolio based on an average of the historical difference between the modeled estimate and their actual losses – sometimes decreasing but usually increasing estimates for their portfolio. The scaled SCS AAL is then used to support the loss estimate for the future period. (See Table 1 for an example.)

Table 1. Example of scaling SCS catastrophe model average annual loss estimates

(1) Year	(2) Model 1 AAL for SCS	(3) Model 2 AAL for SCS	(4) Blended AAL for SCS	(5) Actual Loss for SCS	(6) Scaling Factor
2014	$ 55,637,890	$ 83,214,748	$ 69,426,319	$ 98,590,313	1.42
2015	$ 66,359,754	$ 99,250,892	$ 82,805,323	$ 79,237,176	0.96
2016	$ 69,665,754	$ 104,195,508	$ 86,930,631	$ 77,577,010	0.89
2017	$ 73,429,466	$ 109,824,699	$ 91,627,082	$ 103,115,013	1.13
2018	$ 78,545,322	$ 117,476,224	$ 98,010,773	$ 86,800,159	0.89
2019	$ 82,566,831	$ 123,490,988	$ 103,028,909	$ 142,702,289	1.39
2020	$ 85,558,861	$ 127,966,014	$ 106,762,437	$ 115,247,261	1.08
2021	$ 86,902,751	$ 129,976,003	$ 108,439,377	$ 115,794,660	1.07
2022	$ 87,095,346	$ 130,264,057	$ 108,679,701	$ 235,157,991	2.16
2023	$ 107,508,878	$ 160,795,533	$ 134,152,205	$ 184,603,954	1.38
	10-YR Avg Scaling Factor	1.24			
	2025 Blended SCS AAL	$ 131,267,803			
	2025 Scaled SCS AAL	$ 162,149,859			

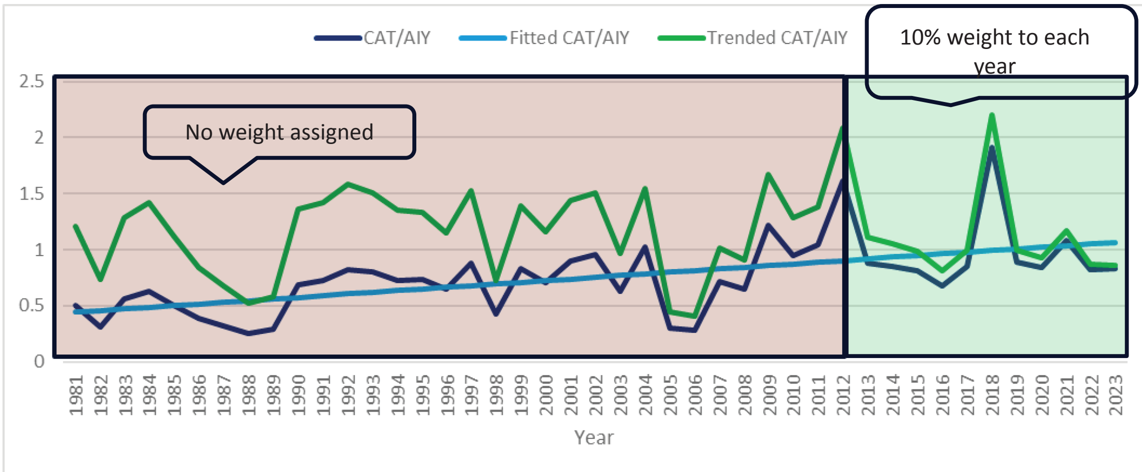
(4) = ((2) x (3)) / 2
(6) = (5) / (4)

To appropriately employ this method, actuaries must run their historical exposures through the current version and settings of the SCS catastrophe model being used. Good recordkeeping of the historical exposures' geocoding, insured values, and property characteristics are critical for this procedure's success. Also, accurate coding of losses by cause is necessary for appropriate comparison of SCS-modeled losses to actual losses caused by hail, tornado, and straight-line wind.

The third approach is described by ASOP No. 39 as developing **catastrophe losses to amount of insurance years**. This procedure is explained in detail by David H. Hays and W. Scott Farris (1990). The procedure separates PCS catastrophe losses into hurricane and non-hurricane components. A long-term ratio of non-hurricane PCS catastrophe losses to amount of insurance years is then calculated and applied to the expected amount of insurance years for which rates are being developed.

To account for the rapidly increasing contribution of SCS losses to total loss costs, carriers commonly adjust the ratio derived from the simple calculation above. First, carriers will *trend* the calculated ratio of non-hurricane PCS catastrophe losses to amount

Figure 7. Example of trending and adjusting experience period for the catastrophe loss to amount of insurance years method



CAT = Catastrophe Loss
AIY = Amount of Insurance Year

of insurance years. Second, carriers will *adjust the experience period* used to calculate the ratio of non-hurricane PCS catastrophe losses to amount of insurance years, either weighting more recent years' experience more heavily or shortening the experience period. (See Figure 7 for an example.)

According to Hays and Farris, "Amount of Insurance Years appears to be an appropriate base for the measurement of exposure to catastrophe loss *assuming no significant changes in the average relationship of [amount of] insurance to replacement values*" (1990, 567, emphasis added). During times of sudden changes in inflation rates, such as the post-COVID economic environment, the ratio of amount of insurance to replacement values may not be constant. For this reason, actuaries relying on any approach that uses amount of insurance should carefully examine the factor by which they have adjusted the amount of insurance and continue to do so annually.

In a fourth approach, the actuary uses selections of SCS claim frequency and SCS claim severity to determine **SCS pure premium per amount of insurance year**, where

- frequency of SCS losses is claim counts divided by the amount of insurance years during the measurement period, and
- trended average severity of capped SCS losses is the sum of all trended SCS losses (individually capped at a predetermined amount) divided by the number of SCS claim counts.

This SCS pure premium per amount of insurance years is multiplied by the expected amount of insurance years for the portfolio and used to support the loss estimate for the future period.

Insurers with smaller portfolios may find this approach challenging as both frequency and average capped severity from SCSs may vary greatly from year to year. This approach is best suited for the industry's largest personal property insurers, who are more likely to achieve 100% credibility with just a few years of data.

Regardless of the approach chosen to estimate future SCS costs to a portfolio, carriers frequently adjust their prior years' data to adequately reflect their current mix of business. These adjustments are usually opaque in rate filing documents, but they are based on changes to the geographic concentration of risks and the mix of business (e.g., construction materials, settlement method, or deductibles) that are known to influence the SCS cost of an insured property. Carriers may also rely on predictive modeling to account for varying distributions in geographic and insured structure characteristics across time. (See Section 8 for additional discussion.)

7. Contingency Provision

In recognition that existing procedures may not be adequate for ratemaking for catastrophe risks, the final words from ASOP No. 39, Appendix 1, are as follows: "All of these procedures may or may not be supplemented with a risk load calculated in accordance with ASOP No. 30, Treatment of Profit and Contingency Provisions and the Cost of Capital in Property/Casualty Insurance Ratemaking."

ASOP No. 30 defines *contingency provision* as "a provision for the expected differences, if any, between the estimated costs and the average actual costs, that cannot be eliminated by changes in other components of the ratemaking process." It goes on to state that "while the estimated costs are intended to equal average actual costs over time, differences between estimated and actual costs of the risk transfer are to be expected in any given year. If a difference persists, the difference should be reflected in the ratemaking calculations as a contingency provision."

Since many carriers have struggled to achieve rate adequacy in property lines, a contingency provision, separate and distinct from the profit provision, may be reasonable and necessary to adequately develop rates for this line, in part due to the volatility of SCS loss costs over time.

ASOP No. 30 cites the development of the contingency provision using "methods that measure differences between expected and actual costs." To do so, the actuary compares the actual costs to the estimated costs derived from the ratemaking process over a long period of time.

This contingency provision may account for inaccuracy in predicting expected costs stemming from any of the following areas:

- *Historical data:* Reliance on historical data can be challenging due to limited volume of experience and other factors, including changes in the ratio of amount of insurance to replacement values, claims handling practices, portfolio composition, and shifting policyholder attitudes toward available insurance protection.

- *Modeling techniques:* If actuaries rely on external vendor models as a complement to historical SCS experience, there may be inherent uncertainty in the modeling form or output.
- *Climate change:* Climate change has affected and is likely to continue to affect the frequency and intensity of hail, wind, and tornado events.
- *Market factors:* Factors arising from the legislative, judicial, regulatory, and social environments, such as regulations surrounding maximum claim settlement periods before punitive action and other consumer protection regulations, may cause actual costs to deviate significantly from expected costs.

8. Additional Insights on Managing SCS Losses in Property Insurance

Given the significant increase in insured losses stemming from SCSs, carriers continue to closely study the factors contributing to these losses. These studies have resulted in the adjustment of historical exposures and/or loss experience used in the indication to reflect the current portfolio, the creation of underwriting rules (e.g., risk eligibility), and the employment of complex segmentation used to price specific risks.

8.1. Location and Concentration of Exposures

As described previously, the science of meteorology has determined that atmospheric, environmental, and topographic characteristics will cause specific geo-units to experience these SCS weather phenomena differently. As a result, combining relevant weather hazard data with the physical location of historical and expected insured exposures is key to understanding whether SCS loss costs will behave similarly to historical experience or diverge from historical trends. (Examples of relevant weather hazard data are discussed in Section 9.)

In some instances, an insurer may have little or no historical loss exposure in a specific location in its own portfolio – having not yet established distribution or underwriting appetite in that location. Fortunately, publicly available data exists such that, for example, the frequency and intensity of SCS weather activity in that location may be studied. The insurer may then use SCS loss observations from locations with similar hazard frequency and intensity and apply loss assumptions from those locations to the portfolio expected in the new location. In other words, insurers may use weather data about severe thunderstorm events as a complement of credibility to their own loss experience.

In other instances, an insurer may choose to set underwriting rules based on geographic concentration of insured value (e.g., maximum insured value of $50 million within any 2-kilometer circle). The maximum concentration of insured value may be influenced by the relative hazard risk at that location and the maximum amount of capital the insurer is willing to put at risk by any single event.

8.2. Structural Property Characteristics

The IBHS has published many studies on the physical characteristics of structures that make them more (or less) susceptible to hail and wind damage (IBHS 2025). Exterior construction materials (e.g., roofing and siding materials), roof shape, roof condition, roof size, property square footage, number of stories, and year of construction should all be studied for their influence on SCS loss costs in homeowners' insurance. For commercial structures, occupancy and class code may also reveal themselves to be meaningful.

Insurance companies in some regions have nonrenewed significant portions of their portfolio – sometimes pushing the properties most vulnerable to SCS hazard into the insurance market to quote. Careful monitoring of structure vulnerability may cause an actuary to adjust historical loss experience to better reflect current portfolio characteristics. For this and other purposes, aerial imagery vendors may be used to supplement the insurer's understanding of the insured structures.

8.3. Terms and Conditions of Coverage

To counteract rising loss costs for insurance companies and resulting premiums for insureds, the average policyholder has less coverage for SCS losses today than in the past. Many insurers have implemented sublimits or exclusions for cosmetic and/or nonstructural damage to roofs and siding, or loss settlement for roof claims that take into consideration the depreciated value of the insured roof. Developing rates for SCSs in property insurance should consider such terms and conditions.

8.4. Deductibles

As previously discussed, insurers commonly adjust the amount of insurance provided by a property policy at each renewal to account for inflationary factors that affect the cost to repair or rebuild an insured structure. If deductibles are not adjusted to maintain a consistent ratio of deductible to amount of insurance, insurance companies will bear a larger portion of the loss, resulting in a higher future severity trend compared with the historical severity trend.

9. Data Sources to Understand Weather Hazards

As SCS losses cannot occur without a hail, tornado, or straight-line wind weather event, it is useful to study the patterns at insured locations of both the historical and future portfolios. Fortunately, public data on these topics is rich and easily accessible.

The National Weather Service (NWS) holds primary responsibility for all weather-related matters in the U.S. The mission of the NWS is to "provide weather, water, and climate data, forecasts, warnings, and impact-based decision support services for the protection of life and property and enhancement of the national economy" (NWS 2025). In doing so, the NWS, via entities such as the Storm Prediction Center (SPC) and 122 different Weather Forecast Offices (WFOs), issues and archives location-specific data that can be leveraged for applications such as that considered in this paper.

9.1. Local Storm Reports

Local Storm Reports (LSRs) represent information related to sightings of hail or tornadoes, downed power lines, uprooted trees, and other evidence of severe thunderstorm conditions. These reports are informed by a variety of sources, including but not limited to storm chasers or spotters, government officials, radio and TV stations, and public citizens, and are recorded by local WFOs. They are then collected and aggregated by the SPC and ultimately provide information such as the location of the event, its magnitude, and the date and time of occurrence.

When evaluating trends in LSRs, one must consider the population bias present in this reporting method. In the context of LSRs, *population bias* refers to the tendency for reports to be not only concentrated in heavily populated areas, but also for SCSs to be seen and reported by fewer people in sparsely populated areas, despite events that may occur. Leveraging this data alone could create a misrepresentative picture of severe weather activity, and therefore evaluating hail-, wind-, or tornado-producing *days* rather than individual *reports* of hail, wind, or tornado may be an effective way to decrease the impact that current demographics and changes in population have within the current reporting framework.

9.2. Weather Watches and Warnings

NWS issues a variety of watches and warnings ahead of or during specific weather events or conditions. These watches and warnings contain key temporal and spatial information about the event and are particularly useful because they do not require an individual to report sighting of a weather phenomenon. Watch and warning polygons can be accessed in shapefile form so that they may be ingested by geospatial software and overlaid onto a carrier's definition of territory.

Particularly relevant to SCSs, severe thunderstorm warnings and tornado warnings have a direct correlation with observed weather hazards. A severe thunderstorm warning polygon is issued based on physical observations of the atmosphere and radar indications in which meteorologists have determined it likely that a storm can produce at least 1-inch hail stones, wind gusts of at least 58 miles per hour, or a tornado. A tornado warning polygon is issued when a tornado has been observed or indicated by radar.

Advancements in technology over the last 10 to 15 years have led to improvements in warning lead time and better accuracy overall of warnings. Dual-polarization (dual-pol) radar is a radar system that takes a three-dimensional scan of the atmosphere, as compared with the traditional, older radar systems that performed only two-dimensional scans. The NWS began its transition to dual-pol radar in the early 2010s and has since upgraded all radar systems to the newer version. These systems ultimately give forecasters better estimates of the size, shape, and type of targets, thus leading to better warning issuance and improved radar detection of storms.

9.3. Particularly Dangerous Situation

While rare, a Particularly Dangerous Situation (PDS) Watch is issued by the NWS when there is an increased risk of severe weather and loss of life, indicative of an extremely severe weather condition present. PDSs can be issued when long-lived, violent tornadoes are possible or when intense convective straight-line windstorms are possible. PDSs represent an increased potential in event severity.

9.4. Next Generation Weather Radar

This high-resolution radar, commonly referred to as NEXRAD, is freely available through the National Centers for Environmental Information within the National Oceanic and Atmospheric Administration. Radar data spanning back to 1995 can be downloaded from the NWS site. This data can be crucial for studying past weather patterns, including identifying storm generation and tracks, evaluating seasonal and geographical patterns, and benchmarking or calibrating to historical events.

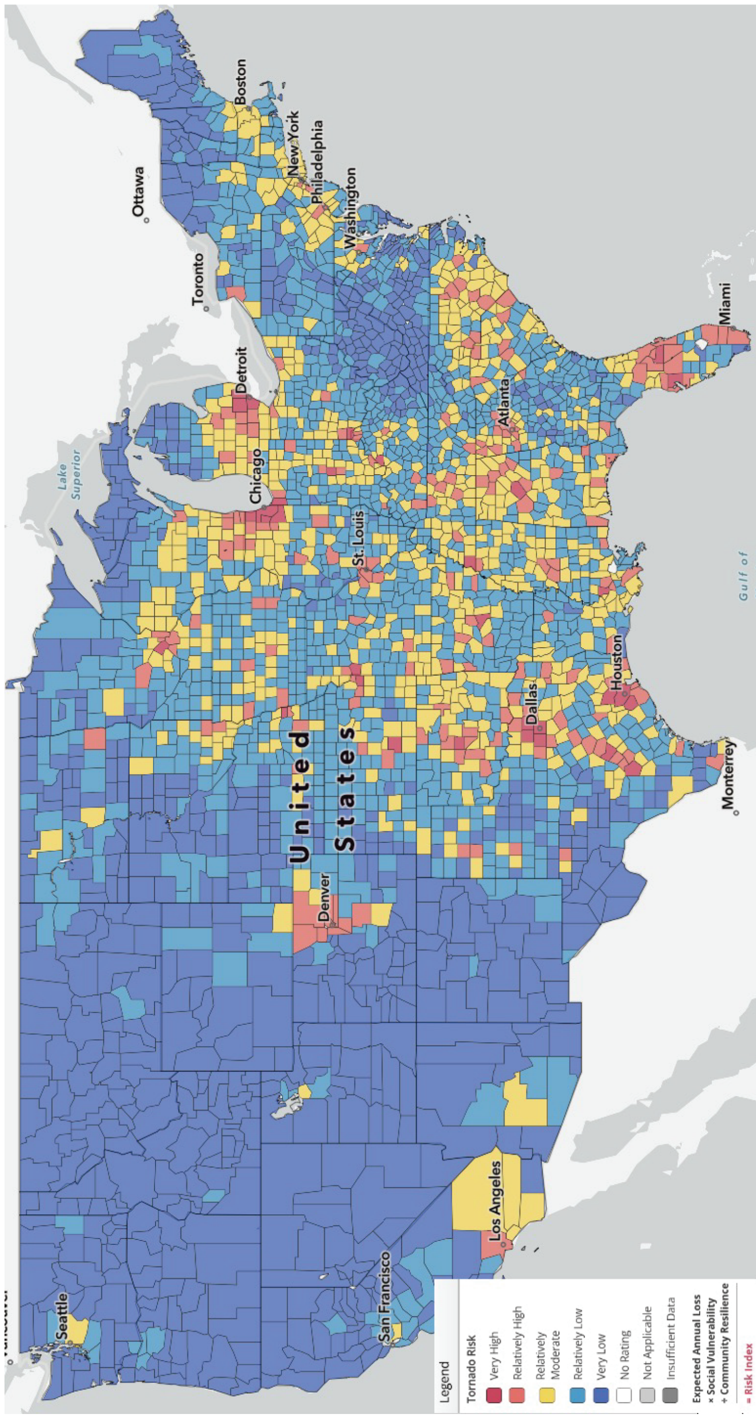
9.5. Additional Data Sources

While not always freely and publicly available or housed by the NWS, other data sources, such as event footprints and simulations, findings from peer-reviewed and published academic literature, and historical weather reanalysis data, can also be viable sources for assessing weather frequency and severity. Additionally, climate model data can be leveraged to assess future weather environments. Finally, indexed views of weather and climate, two of which are highlighted below, can offer an additional viewpoint in evaluating weather patterns.

National Risk Index: Developed by the Federal Emergency Management Agency, the National Risk Index is a baseline risk measurement for every U.S. county and census tract, considering 18 different natural hazards. The index is computed by accounting for an expected annual loss, social vulnerability, and community resilience. This product is interactive and can be downloaded and filtered by hazard, as the example, for tornado risk, shown in Figure 8.

Actuaries Climate Index (ACI): Developed by a group of actuarial societies, academies, and institutes, the ACI was created to show the economic impact of climate risk and how that may change over time. The index consists of six components: temperature frequency at two percentiles, extreme rainfall, dry periods, extreme winds, and sea level.

Figure 8. County view for the tornado hazard according to the National Risk Index



Source: FEMA (March 18, 2025).

10. Conclusion

SCSs represent a significant and evolving risk to life, property, and infrastructure across the U.S. Their high frequency and potential for catastrophic damage necessitate a comprehensive understanding of the weather events that must be present for these losses to occur, characteristics that make individual structures more susceptible to loss, and economic and societal trends that drive the average cost of these claims. As climate change continues to alter weather patterns and demographic shifts increase exposure to these hazards, the insurance industry must adapt its risk assessment and ratemaking strategies.

The complexity of SCS events, characterized by their localized nature and unpredictable behavior, underscores the need for robust catastrophe models and innovative actuarial approaches. By leveraging historical data, advanced modeling techniques, and a thorough analysis of structure vulnerability, insurers can better navigate the challenges posed by SCSs and ensure adequate premiums are collected to compensate for the increasing loss cost. As the landscape of severe weather continues to evolve, ongoing vigilance and adaptability will be essential for effectively managing the risks associated with SCSs.

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