ACTUARIAL STANDARDS BOARD

● **EXPOSURE DRAFT** ●

Proposed Revision of
Actuarial Standard
of Practice
No. 39

Treatment of Catastrophe or Extreme Event Losses in Future Cost Estimates for Property/Casualty Risk Transfer and Risk Retention

Comment Deadline:
May 1, 2025

Developed by the
ASOP No. 39 Task Force of the
Casualty Committee of the
Actuarial Standards Board

Approved for Exposure by the
Actuarial Standards Board
December 2024

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APPENDIX

December 2024

TO: Members of Actuarial Organizations Governed by the Standards of Practice of the Actuarial Standards Board and Other Persons Interested in the Treatment of Catastrophe or Extreme Event Losses in Property/Casualty Risk Transfer and Risk Retention

FROM: Actuarial Standards Board (ASB)

SUBJ: Actuarial Standard of Practice (ASOP) No. 39

This document contains the exposure draft of ASOP No. 39, *Treatment of Catastrophe or Extreme Event Losses in Future Cost Estimates for Property/Casualty Risk Transfer and Risk Retention*. Please review this exposure draft and give the ASB the benefit of your comments and suggestions. Each comment letter received by the comment deadline will receive consideration by the drafting committee and the ASB.

The ASB appreciates comments and suggestions on all areas of this proposed standard. The ASB requests comments be provided using the Comments Template that can be found here and submitted electronically to **comments@actuary.org**. Include the phrase ["ASOP No. 39 COMMENTS"] in the subject line of your message. Also, please indicate in the template whether your comments are being submitted on your own behalf or on behalf of a company.

The ASB posts all signed comments received on its website to encourage transparency and dialogue. Comments received after the deadline may not be considered. Anonymous comments will not be considered by the ASB nor posted on the website. Comments will be posted in the order that they are received. The ASB disclaims any responsibility for the content of the comments, which are solely the responsibility of those who submit them.

For more information on the exposure process, please see the ASB Procedures Manual.

Deadline for receipt of comments: **May 1, 2025**

History of the Standard

Many property/casualty insurance products are, by their nature, subject to large aggregate losses resulting from relatively infrequent events or natural phenomena, i.e., from catastrophes or extreme events. These losses can cause extreme volatility in historical insurance data and generally require separate and different treatment from other losses in ratemaking methodologies and other actuarial analysis. Historically, the most common method was to calculate the ratio of actual catastrophe losses to non-catastrophe losses over a longer experience period and apply that ratio to expected non-catastrophe losses in the ratemaking formula.

In 1992 and 1994, two events occurred that changed the actuarial profession's view of catastrophe losses. The Hurricane Andrew and Northridge Earthquake catastrophes clearly demonstrated the limitations of relying exclusively on historical insurance data in estimating the financial impact of potential future events. In addition, property/casualty insurers (including self-insurers) and their actuaries began to focus on the impact that large individual events or sequences of events could have on the insurers' solvency, cash flow, and earnings.

The ASB adopted ASOP No. 39, *Treatment of Catastrophe Losses in Property/Casualty Insurance Ratemaking*, in 2000 to provide guidance to actuaries in evaluating catastrophe exposure and in determining a provision for catastrophe or extreme event losses and loss adjustment expenses in property/casualty insurance ratemaking.

Since this ASOP was adopted, there have been many developments in ratemaking and modeling that are not adequately addressed in the current standard. Actuarial practice has evolved to such an extent that the guidance in the standard is no longer broad enough. The current standard is also limited in scope because it does not adequately address 1) events that impact casualty insurance or multiple insurance lines, or 2) other events that the industry now faces, such as cyber-attacks, terrorism, and the effects of climate change. In addition, the current standard focuses on the use of historical data as the default, but this is no longer an accurate description of the current practice in estimating future catastrophe cost components. The ASB therefore approved a proposal to update ASOP No. 39 in 2021. The standard is also being updated to recognize ASOP No. 53, *Estimating Future Costs for Prospective Property/Casualty Risk Transfer and Risk Retention*, and ASOP No. 56, *Modeling*, as well as changes to ASOP No. 38, *Catastrophe Modeling (For All Practice Areas)*.

Notable Changes from the Existing Standard

Notable changes from the existing standard are summarized below. Notable changes do not include changes made to improve readability, clarity, or consistency.

1. In section 1.2, the scope has been broadened to include both catastrophes and extreme events. In addition, the standard applies to actuarial services beyond ratemaking.

2. Guidance has been expanded for casualty coverages in section 3.6.

3. Guidance has been expanded for catastrophe models and scenario analysis.

4. Guidance has been expanded to include potential changes to the future risk environment, such as future climate change impacts.

5. In section 3.4.1.3, guidance on adjustment of historical insurance data has been enhanced.

6. In section 3.11, guidance on reasonableness has been added.

7. In section 3.12, guidance on relying on another party has been added.

8. In section 3.13, guidance on documentation has been updated.

9. In section 4, disclosures have been updated to reflect the changes made in section 3.

Request for Comments

The ASB appreciates comments and suggestions on all areas of this proposed standard submitted through the Comments Template. Rationale and recommended wording for any suggested changes would be helpful.

In addition, the ASB would like to draw the readers' attention to the following questions:

1. Does this exposure draft overlook any significant approaches to estimating future costs of catastrophes or extreme events? If so, please explain.

2. Is the guidance regarding scenario analysis clear and sufficient? If not, please explain.

3. Is the guidance regarding reasonableness clear and sufficient? If not, please explain.

The ASB voted in December 2024 to approve this exposure draft.

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The Actuarial Standards Board (ASB) sets standards for appropriate actuarial practice in the United States through the development and promulgation of Actuarial Standards of Practice (ASOPs). These ASOPs describe the procedures an actuary should follow when performing actuarial services and identify what the actuary should disclose when communicating the results of those services.

EXPOSURE DRAFT—December 2024

PROPOSED REVISION OF
ACTUARIAL STANDARD OF PRACTICE NO. 39

TREATMENT OF CATASTROPHE OR EXTREME EVENT LOSSES IN FUTURE COST ESTIMATES FOR PROPERTY/CASUALTY RISK TRANSFER AND RISK RETENTION

STANDARD OF PRACTICE

Section 1. Purpose, Scope, Cross References, and Effective Date

1.1 Purpose—This actuarial standard of practice (ASOP or standard) provides guidance to actuaries when performing actuarial services with respect to analyzing, determining, or reviewing future cost estimates for **catastrophe** or **extreme event** losses and loss adjustment expenses for property/casualty risk transfer or risk retention.

1.2 Scope—This standard applies to actuaries when performing actuarial services with respect to analyzing, determining, or reviewing future cost estimates for **catastrophe** or **extreme event** losses and loss adjustment expenses for property/casualty risk transfer or risk retention. For example, this standard applies when actuaries are developing future cost estimates underlying product prices for direct insurance and reinsurance; estimating funding requirements for self-insured programs and captives; reviewing financial reports for internal or external use; conducting analyses of capital requirements, capital adequacy, and stress testing; and estimating various risk metrics, such as average annual losses, risk loads, and return period loss estimates.

If the actuary is performing actuarial services that involve reviewing future cost estimates for **catastrophe** or **extreme event** losses and loss adjustment expenses for property/casualty risk transfer or risk retention, the actuary should use the guidance in this ASOP to the extent practicable within the scope of the actuary's assignment.

If the actuary determines that the guidance in this standard conflicts with an ASOP that applies to all practice areas, this standard governs.

If a conflict exists between this standard and applicable law (statutes, regulations, and other legally binding authority), the actuary should comply with applicable law. If the actuary departs from the guidance set forth in this standard in order to comply with applicable law, or for any other reason the actuary deems appropriate, the actuary should refer to section 4.

1.3 Cross References—When this standard refers to the provisions of other documents, the reference includes the referenced document as it may be amended or restated in the future, and any successor to it, by whatever name called. If the amended or restated document

differs materially from the originally referenced document, the actuary should follow the guidance in this standard to the extent it is applicable and appropriate.

1.4 Effective Date—This standard is effective for actuarial services performed on or after four months after adoption by the Actuarial Standards Board.

Section 2. Definitions

The terms below are defined for use in this standard and appear in bold throughout the ASOP. The actuary should also refer to ASOP No. 1, *Introductory Actuarial Standard of Practice*, for definitions and discussions of common terms, which do not appear in bold in this standard.

2.1 Catastrophe—An **extreme event** that exceeds a predetermined threshold specified by an individual insurer/reinsurer or by an industry organization (e.g., Property Claims Services, also known as PCS) such as total economic loss, total insured loss, number of casualties, or losses from an event commencing over a stated number of consecutive hours.

2.2 Catastrophe Model—A model of low-frequency events with high-severity or widespread potential effects. **Catastrophe models** may be used to explain a system, study effects of different components, or derive estimates.

2.3 Compound Events—Individual events that interact to yield outcomes that differ from what would be expected if they occurred with full independence.

2.4 Extreme Event—A low-frequency event with high-severity or widespread potential effects that causes unusually large aggregate losses and that could distort the historical experience. An **extreme event** may exhibit contagion, which is a lack of independence between the occurrence of losses among different entities.

2.5 Scenario Analysis—A process for assessing the impact of one possible event or several simultaneously or sequentially occurring possible events. **Scenario analysis** is often used when historical data is insufficient or a reliable **catastrophe model** is unavailable. **Scenario analysis** may include a narrative description or numerical calculations.

Section 3. Analysis of Issues and Recommended Practices

3.1 Overview—When performing actuarial services involving future cost estimates for **catastrophe** or **extreme event** losses and loss adjustment expenses for property/casualty risk transfer or risk retention the actuary may estimate future costs for such types of events using any appropriate methods that utilize historical data, output from one or more **catastrophe models**, **scenario analysis**, or a combination thereof, subject to the guidance set forth below.

3.2 Identification of Potential Catastrophes or Extreme Events—The actuary should take reasonable steps to identify the perils or events that may produce **catastrophe** or **extreme event** losses.

The terms "**catastrophe**" and "**extreme event**" have different meanings in different contexts and may be dictated or imposed by an outside entity. The actuary should use terms and meanings that are appropriate for the actuary's assignment.

3.3 Identification and Attribution of Historical Catastrophe or Extreme Event Losses—The actuary should identify, where practicable, the **catastrophe** or **extreme event** losses in historical insurance data. When doing so, the actuary should take into account how accurately these losses can be identified and the extent to which they may have a material impact on the results of the analysis.

When attributing losses to a **catastrophe** or **extreme event**, the actuary should do the following:

a. use criteria tailored to and consistently applied to the coverage and type of event, risk classifications, and historical periods.

b. make appropriate adjustments when the criteria result in a material inconsistency in how **catastrophes** or **extreme event** losses are identified in the historical data.

3.4 Use of Data and Models—The actuary may use historical insurance data, non-insurance data, or **catastrophe models** as described in the sections below. When using historical data, the actuary should refer to ASOP No. 13, *Trending Procedures*, and No. 23, *Data Quality*.

3.4.1 Use of Historical Insurance Data—Sources of historical insurance data include data and information from self-insureds, insurance companies, reinsurers, and governmental entities such as a state fund. When using historical insurance data, the actuary should follow the guidance below.

3.4.1.1 Applicability of Historical Insurance Data—The actuary should assess the extent to which the exposures that generated the historical data are applicable to the future period, taking into account changes in coverages and provisions, applicable law, building codes, geographic representation, concentration, and other relevant factors.

3.4.1.2 Evaluating Credibility of Historical Insurance Data—The actuary should consider comparing historical insurance data to non-insurance data and **catastrophe models** to evaluate the extent to which the available historical insurance data fully represent the long-term frequency and severity of the perils or events identified in section 3.1 that may produce the **catastrophe** or **extreme event** losses. The actuary should also refer to ASOP No. 25, *Credibility Procedures.*

3.4.1.3 Adjustment of Historical Insurance Data to Reflect Future Conditions—The actuary should consider adjusting the historical insurance data to reflect the environment expected to exist in the period for which the actuary is estimating the future costs, taking into account the following:

a. exposure to loss (including coverage differences, the underlying portfolio of insured risks and the associated values, insured limits, and deductibles);

b. population shifts;

c. claim cost inflation;

d. wealth effect (the increase in the amenities included in, and the average size of, a home or other building);

e. economic distortions occurring when past data were collected, such as the supply chain problems that occurred during the COVID-19 pandemic;

f. noneconomic distortions such as claimant behavior, changes in applicable law, building codes and the enforcement of these codes, and building practices that would impact coverage or claim settlement;

g. emerging technology; and

h. other relevant factors.

The actuary should also refer to ASOP No. 53, *Estimating Future Costs for Prospective Property/Casualty Risk Transfer and Risk Retention*, regarding additional changes that may suggest the need for adjustments.

3.4.1.4 Stability vs. Responsiveness of Outcomes Based on Historical Insurance Data—The actuary should take into account the extent to which the future cost estimates for **catastrophe** or **extreme event** losses would change if the analyses were to be carried out using different historical experience periods. If, in the actuary's professional judgment, the future cost estimation procedure is too sensitive to the inclusion or exclusion of an individual **catastrophe** or **extreme event**, or sets of years, the actuary should consider modifying the future cost estimation procedure to reduce such sensitivity.

3.4.1.5 Differing Trends in Loss Data—Historical insurance data used to estimate future **catastrophe** or **extreme event** losses will often extend over much longer time periods than data used in most other applications; thus, the effect of small differences in annual trend rates will be magnified. The actuary should take into account the potential for **catastrophe** or **extreme event** losses to trend at a rate materially different from the other losses and reflect such differences in the trend assumptions and methods as appropriate.

When trending prior years to current levels, the actuary may consider relevant indices from non-insurance sources, such as the U.S. bureaus of Economic Analysis, Labor Statistics, and Census.

3.4.1.6 Differing Development in Loss Data—Traditional actuarial loss development techniques may not be appropriate for **catastrophe** or **extreme event** losses. The actuary should take into account the potential for **catastrophe** or **extreme event** losses to emerge differently from the other losses and reflect such differences in the development assumptions and methods as appropriate.

3.4.2 Use of Non-Insurance Data—Various organizations publish data relevant to **catastrophes** and **extreme events**. For example, the federal government publishes census and other data related to inflation, changes in exposure, population shifts, or other data relevant to assessing changes in exposure to **catastrophes** and **extreme events** losses. Additional data is also collected on economic losses from **catastrophes** or **extreme events** or historical patterns of cyber data breaches. When using non-insurance data, the actuary should follow the guidance for historical insurance data in section 3.4.1, as applicable.

3.4.3 Use of Catastrophe Model Output—If, after considering the items contained in section 3.3.1 and 3.3.2, the actuary believes that the available historical data do not sufficiently represent the exposure to **catastrophe** or **extreme event** losses, the actuary should consider using **catastrophe model** output to improve future cost estimates for **catastrophes** or **extreme events**. The actuary should also refer to ASOP No. 38, *Catastrophe Modeling (for All Practice Areas).*

3.4.4 Blending of Historical Data and Catastrophe Model Output—The actuary may blend historical experience with **catastrophe model** output when, in the actuary's judgment, it is reasonable to do so. For example, the actuary may use an approach comparable to a basic and excess actuarial methodology, where historical experience is used to derive the basic portion of the future cost estimates and an excess expected loss load derived from a **catastrophe model** is applied above the level chosen for capping the experience.

3.5 Incorporation of Loss Adjustment Expenses—The actuary should develop a reasonable estimate of prospective loss adjustment expense for **catastrophe** or **extreme event** losses.

When doing so, the actuary should take into account that the relationship of loss adjustment expense to loss can be significantly different for **catastrophe** and **extreme event** losses than for other losses.

3.6 Additional Considerations for Casualty Coverages—When developing cost estimates for casualty **catastrophes** and **extreme events**, the actuary may use methods other than those described in section 3.3, such as **scenario analysis**, in light of the following challenges:

a. Industry data may exclude relevant losses not covered by insurance in the historical periods.

b. Mass tort losses are difficult to predict given their dependence on changing legal interpretation and legislative issues.

c. Casualty **catastrophe models** in early stages of development may not provide reliable estimates.

d. Casualty claims may be reported after long latency periods.

e. Unanticipated risks may emerge after a coverage commitment.

3.7 Considerations when Evaluating Models—When choosing a **catastrophe model**, the actuary should refer to ASOP No. 38 and ASOP No. 56, *Modeling*. If models for a particular peril or event are, in the actuary's professional judgment, not mature, then the actuary should consider reviewing the results of more than one model or using a deterministic **scenario analysis** to get better insight into possible future outcomes. The actuary should take into account the following, if applicable:

a. whether the model's output is relevant for the whole portfolio, coverages, and perils or events, or just a segment;

b. the extent to which models and experience are relevant if a peril or type of event is rapidly changing (such as cyber risk, climate change, or terrorism); and

c. the impact of emerging technology.

The actuary may review and discuss the issues, scenarios, and results of blending various approaches with experienced professionals in other relevant areas to gain additional insight.

3.8 Costs Not Considered in Catastrophe Models—When using a **catastrophe model** to develop the future cost estimates, the actuary should assess whether the model output fully reflects the costs included in the coverage associated with the future cost estimates. If the actuary identifies costs that are not reflected in model output, the actuary should consider separately estimating such costs.

3.9 Compound Events—The actuary should consider adjusting the future cost estimate for the possibility of **compound events**, if reasonable and appropriate given the intended purpose of the future cost estimate.

3.10 Impact of Broader Economic Forces—The actuary should take into account whether future costs for **catastrophes** or **extreme events** might be affected by broader economic forces such as demand surge caused by temporary supply and demand imbalances triggered by a **catastrophe** or **extreme event**.

3.11 Reasonableness—The actuary should be satisfied that the future cost estimates reflect a reasonable frequency and severity distribution of **catastrophes** and **extreme events**.

3.12 Reliance on Another Party—When relying on another party and thereby disclaiming responsibility for

a. data and other information relevant to the use of data, the actuary should refer to ASOP No. 23.

b. a model, the actuary should refer to ASOP No. 56.

c. a **catastrophe model**, the actuary should refer to ASOP No. 38.

d. assumptions or methods prescribed by another party, the actuary should review the assumptions or methods for reasonableness and consistency to the extent practicable and appropriate within the scope of the actuary's assignment.

e. assumptions or methods not prescribed by another party, or for any other item not addressed above, the actuary should review the items for reasonableness and consistency to the extent practicable and appropriate within the scope of the actuary's assignment. In addition, the actuary should be reasonably satisfied that the reliance is appropriate, taking into account the following, as applicable:

1. when the other party is an actuary, whether the actuary knows that the other party is appropriately qualified and has followed applicable ASOPs;

2. whether the actuary knows that the other party has expertise in the applicable field;

3. whether the actuary knows the other party's stated purpose for the item and the extent to which it is consistent with the actuary's intended purpose; and

4. whether the actuary knows of differences of opinion within the other party's field of expertise that are material to the actuary's use of the item.

3.13 Documentation—The actuary should consider preparing and retaining documentation to support compliance with the requirements of section 3 and the disclosure requirements of

section 4. If preparing documentation, the actuary should consider preparing documentation in a form such that another actuary qualified in the same practice area could assess the reasonableness of the actuary's work. The amount, form, and detail of the documentation should be based on the professional judgment of the actuary and may vary with the complexity and purpose of the actuarial services. In addition, the actuary should refer to ASOP No. 41, *Actuarial Communications*, for guidance related to the retention of file material other than that which is to be disclosed under section 4.

Section 4. Communications and Disclosures

4.1 Required Disclosures in an Actuarial Report—When issuing an actuarial report, the actuary should refer to ASOP Nos. 13, 23, 25, 38, 41, 53, and 56. In addition, the actuary should disclose the following in such actuarial reports:

a. any perils or events identified by the actuary that may produce **catastrophe** or **extreme event** losses (section 3.2);

b. the terms used by the actuary for **catastrophes** or **extreme events** and their meaning, including the criteria used to attribute losses to such events (see sections 3.2 and 3.3);

c. a description of analyses used to evaluate the applicability and credibility of historical data, as well as the experience period utilized (see section 3.4.1.1 and 3.4.1.2);

d. a description of the methods and assumptions used to

   i. incorporate historical insurance data, non-insurance data, and **catastrophe model** output in the future cost estimate (see sections 3.4 and 3.7);

   ii. incorporate loss adjustment expenses in the future cost estimate (see section 3.5);

   iii. produce any **scenario analysis** (see section 3.6 and 3.7);

e. any other methods used to estimate future costs for casualty coverages (see section 3.6);

f. assumptions and methods used to estimate any costs not reflected in **catastrophe models** being used (see section 3.8);

g. any costs identified by the actuary that have not been included in the future cost estimate (see section 3.8);

h. any adjustment made for **compound events** (see section 3.9);

i. any impact of broader economic forces considered (see section 3.10); and

j. the extent of any reliance on information provided by another party (section 3.12).

4.2 Additional Disclosures in an Actuarial Report—The actuary also should include disclosures in an actuarial report in accordance with ASOP No. 41 for any of the following circumstances:

a. if any material assumption or method was prescribed by applicable law;

b. if the actuary states reliance on other sources and thereby disclaims responsibility for any material assumption or method selected by a party other than the actuary; or

c. if in the actuary's professional judgment, the actuary has deviated materially from the guidance of this standard.

4.3 Confidential Information—Nothing in this standard is intended to require the actuary to disclose confidential information.

Appendix

Background and Current Practices

Historical Procedures

Prior to Hurricanes Hugo (1989) and Andrew (1992), the predominant ratemaking procedures used by primary property insurers to determine a catastrophe provision involved calculating the long-term ratio of such losses to non-catastrophe losses over a twenty- to thirty-year span. Property catastrophes were identified by an industry-dollar or loss-ratio threshold and were typically restricted to weather-related perils such as hurricanes, tornadoes, or snowstorms. Other property catastrophes such as floods and earthquakes were usually covered by optional coverages or separate policies.

Provisions for casualty-related catastrophes were typically included implicitly in primary insurers' rates, possibly using a contingency provision.

Primary insurers used ceded reinsurance to manage various exposures beyond the insurer's risk tolerance. Reinsurers used a combination of methods to price property catastrophe reinsurance or casualty excess-of-loss reinsurance, including historical data, expert judgment, learnings from similar events in the past, and experience and exposure rating techniques. Final prices were often expressed as ratios to a cedant's primary exposure or premium within the subject business of a treaty or facultative placement.

Regulatory and rating agency surplus requirements for U.S. insurers were a function of written premium, with no explicit recognition that catastrophe-exposed insurers required more capital compared to others with minimal catastrophe exposure. Furthermore, a catastrophe-exposed insurer with inadequate rates or underestimated unpaid claims reserves appeared to be better capitalized than a similar insurer with sufficient rates or reasonable carried reserves.

Issues

Property—In the late 1980s and early 1990s, property catastrophes produced aggregate losses exceeding previously expected possibilities, leading to several insurer and reinsurer insolvencies. Events such as hurricanes Hugo and Andrew, California earthquakes near San Francisco and Northridge, the Oakland Hills wildfire, and a major flood in the Midwest caused unanticipated levels of loss and prompted recognition of rate inadequacy. In addition, population movements, increasing exposure concentration, and variations in adherence to building codes produced changes in exposure that had not been taken into account by historical procedures. The resulting higher historical losses led to rapid rate increases, capacity shortages, and other market disruptions.

This situation triggered a drive to improve risk assessment tools and sources of capital in the early 1990s, giving rise to the development of property catastrophe models. Property catastrophe models became more mature after enhancements, validation efforts, reinsurers' insistence on the

quality of cedants' exposure data, and some state-level regulatory or legislative scrutiny. The use of catastrophe models to support rates for catastrophic property perils or events instead of relying solely on historical insurance data has become more widely accepted. Many U.S. regulators now expect property/casualty insurers to use property catastrophe model output when monitoring their exposure accumulations compared to their desired risk profiles and when evaluating their capital adequacy.

Casualty—In the mid-1980s, recognition of accumulated asbestos and environmental liabilities exacerbated a sharp turn from soft to hard U.S. casualty market conditions. Recognition of asbestos and environmental unpaid claims liabilities produced insolvencies and prompted reinsurers (and primary insurers) to implement new exclusions or change occurrence coverage to claims-made coverage in the most affected commercial lines segments. This shifted the balance of incentives for large accounts in those markets toward risk mitigation or loss prevention and limited risk transfer using non-admitted excess and surplus lines markets. Casualty catastrophes and extreme events are manifested in legal, socio-economic, and environmental factors rather than physical properties. Liability may be incurred long before claims are reported, and loss development may span years or decades. Liability often does not occur in well-defined geographic areas and tends to be non-recurring, unlike losses for natural catastrophes or extreme events.

Emerging Risks—Other issues such as terrorism exemplified by the 9/11 World Trade Center attack and wildfires have emerged that make assessment of catastrophe and extreme event exposure more difficult. Technological advances in the 21st century have led to risks not previously contemplated, such as cyber risk. Likewise, the recent advances in artificial intelligence may introduce additional sources of emerging liability catastrophe risk.

Finally, climate change has been a source of increased focus in the 21st century and is believed to have increased the variability in frequency and severity of natural catastrophes or extreme events, as was found in the review of long-term historical data underlying the Actuary's Climate Index (ACI). Climate change impacts may require reliance on additional or new types of data, climate studies, scenario analysis, or climate models from global organizations (e.g., Intergovernmental Panel on Climate Change), academic institutions, catastrophe modeling organizations, or climate scientists.

Evolution of Tools—In response to the need for better tools to understand exposure to catastrophe or extreme events losses, the quality and granularity of data has significantly improved. This, combined with rapid advances in computational power, has resulted in catastrophe simulation models being widely used by actuaries in many practice areas for risk management, ratemaking, and pricing analyses. The use of catastrophe models in the United States, which initially focused on the hurricane and earthquake perils, has steadily expanded to other key perils and events such as severe convective storm, winter storm, wildfire, flood, terrorism, and initial versions of cyber catastrophe models.

The growth of catastrophe models has not obviated the need to perform actuarial analyses of loss experience. The review of historical insurance and non-insurance data continues to be important, given the varying levels of model maturity, and in some cases, model results that are unreliable

or not fit-for-purpose. For example, catastrophe loss experience can be used for a variety of purposes, including validating catastrophe model assumptions, comparing model output to indications based on adjusted historical data, adjusting model assumptions or output metrics, or blending with model output to improve expected loss estimates. Using long-term historical data requires adjusting historical data to reflect expected conditions including exposure changes, population shifts, claim cost inflation, economic and noneconomic distortions, changes in applicable law, and changing climate conditions.