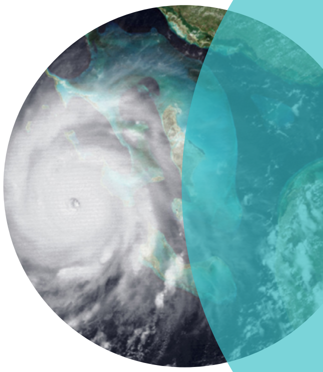
2022 WHITEPAPER

Global Modeled Catastrophe Losses



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Introduction

Every year since 2012, Verisk has published a report on extreme event risk from a global perspective.[1] This global risk profile is assessed by way of Verisk's global industry exceedance probability (EP) curve, which puts into context years with high insured losses such as 2011 and 2017.[2] The value of the insights contained in this analysis has never been greater given the current challenges the global (re)insurance industry faces in addressing recent catastrophe losses. Over the past 5 years, actual insured losses from natural catastrophes have averaged USD 100 billion, compared with an average of less than USD 50 billion over the previous 5-year period. Although many public statements have been made attributing this increase primarily to climate change, our analysis indicates that a number of factors contribute to this doubling of the most recent 5-year average loss over the previous 5-year period. These factors are (in order of importance):

1. A rise in exposure values and replacement costs, represented both by continued construction in high-hazard areas and by high levels of inflation that are driving up repair and rebuild costs
2. The natural variability that comes from selecting any five-year sample of natural catastrophe experience
3. The effects of climate change on different atmospheric perils
4. The impacts of man-made loss drivers, such as social inflation and legal and regulatory factors

We will discuss each of these factors in more detail below, but first we will answer whether models have well represented the scale of global losses and whether these recent years are truly outliers.

[1] "Taking a Comprehensive View of Catastrophe Risk Worldwide: AIR's Global Exceedance Probability Curve," "AIR's 2013 Global Exceedance Probability Curve,", "AIR's 2014 Global Exceedance Probability Curve," "2015 Global Modeled Catastrophe Losses," "2016 Global Modeled Catastrophe Losses," "2017 Global Modeled Catastrophe Losses," "2018 Global Modeled Catastrophe Losses," "2019 Global Modeled Catastrophe Losses," "2020 Global Modeled Catastrophe Losses," and "2021 Global Modleed Catastrophe Losses."

[2] Catastrophes in 2011 include the Tohoku earthquake in Japan, major severe thunderstorms across the United States, earthquakes in New Zealand, and floods in Thailand; catastrophes in 2017 include major severe thunderstorms across the United States, Harvey, Irma, and Maria storms, Mexico earthquakes, and California wildfires.

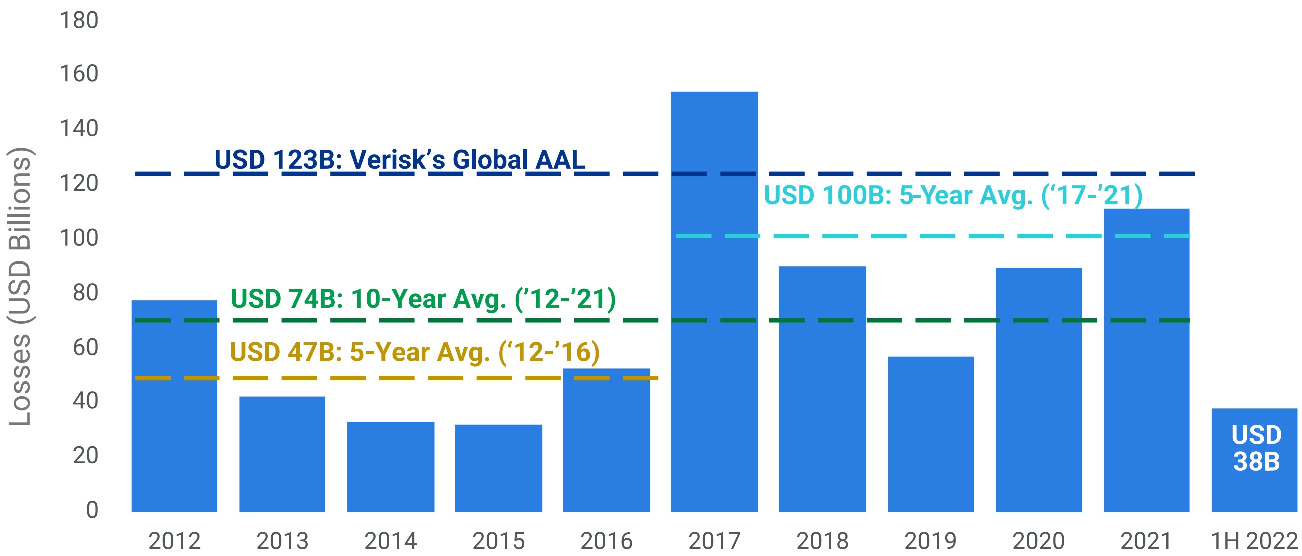

Figure 1. Historical and Average Losses (Source: Swiss Re and Verisk)

Figure 1. Historical and Average Losses, above, helps answer that question and put recent years in context. The average loss over the past five years (2017 to 2021) is USD 100 billion, which is more than double the average loss (USD 47 billion) of the previous five years (2012 to 2016). However, a 5-year average loss exceeding USD 100 billion should not be a surprise. According to the latest analysis using Verisk's models released in June 2022 and a global suite of industry exposure data as of December 31, 2021, the global modeled insured average annual loss (AAL) is USD 123 billion, meaning the insurance industry should be prepared to experience total insured losses from natural catastrophes well in excess of USD 100 billion every year. Please note that this figure represents an increase in the modeled AAL from USD 106 billion in 2021 (See **Table 1. Key insured loss metrics from Verisk's global industry EP curve for all regions and perils**. (Source: Verisk)). This rise reflects both increases in the numbers and values of insured properties in areas of high hazard and significant enhancements to the Verisk U.S. Severe Thunderstorm Model that better represent a near-present climate view of risk.

Whether the industry is enjoying good times or weathering bad times, both of these 5-year periods illustrate the importance of using models and taking a longer-term view. Short-term samples can often skew future expectations high (or low), so instead of relying primarily on recent experience, (re)insurers should instead look to Verisk's global suite of models to get a realistic assessment of what to expect on average over a longer time horizon. Indeed, over 90% of insured natural catastrophe losses from 2000 to 2021 have been modeled by Verisk's global suite of models (See **Figure 4. The percentage of reported insured losses covered by Verisk's current suite of models, 2000–2021.** (Source: Verisk, Swiss Re, AXCO, Munich Re, PCS, Aon Benfield, PERILS)).

Several factors have contributed to the recent increases in natural catastrophe losses. The first and most significant is the rise in exposure values and replacement costs, represented both by continued construction in high-hazard areas and by high levels of inflation that are driving up repair costs. It's important to note that a typical 5% increase in exposure value and repair costs per year would result in a more than 60% increase in losses over a 10-year period. For this reason, it's important to regularly reassess your exposure data quality across all geographic regions. The models rely on accurate property characteristics to produce a realistic projection of potential losses, with up-to-date replacement values playing a particularly large role in driving modeled losses.

To assist the industry in capturing these updated risks, Verisk each year updates the industry exposure databases (IEDs) for a selected set of countries[3]. In between these full refreshes, Verisk also releases index factors to gross up our existing IEDs to account for these changes over time. These exposure updates account for nearly 60% of the increases in the modeled AAL for the 2022 global exceedance probability curve.

The second most significant factor driving increased catastrophe losses is the uncertainty and natural variability associated with global catastrophe losses. The current 5-year actual loss period has immediately followed a 10-year hurricane drought in the United States, and while several notable hurricanes have affected the United States since 2017, the industry has not experienced a single, large event exceeding USD 50 billion. Verisk's modeling suggests there is a more than 40% chance of experiencing a 5-year average loss exceeding USD 100 billion, so again this is not a rare occurrence. And while the market has increasingly used the terminology "secondary perils" to refer to non-hurricane and non-earthquake risk, the losses from severe storms and wildfires are, to the contrary, primary and significant. All catastrophes contribute to losses, whether they are a single major event, an aggregation of smaller ones, or a combination of the two. While some perils are responsible for far greater losses than others, these losses are all part of a spectrum, and Verisk does not categorize perils as "primary" or "secondary."

While Swiss Re Institute's annual *sigma* review attributes more than 70% of the insured losses from 2021 to "secondary perils" (i.e., perils outside of hurricane and earthquake), losses from the perils of flood, severe thunderstorm, and wildfire are well covered by Verisk models, and in many cases, models for these perils have been in place for a decade or more. Accounting for the losses from these perils should be standard practice for (re)insurers, especially as they account for a larger proportion of the overall annual losses, due to the combination of more frequent events and more valuable properties at risk. Severe thunderstorms, in particular, have been responsible for a growing proportion of the losses over the past five years, and in fact now are the largest contributing peril to global modeled average annual loss. To ensure we are properly capturing this risk, Verisk released a comprehensively updated Severe Thunderstorm Model for the United States that features the most robust set of events ever captured by a model and produces losses that reflect this increased risk.[4]

The third most significant factor driving increased catastrophe losses is climate change. The latest report from the Intergovernmental Panel on Climate Change (IPCC) concludes climate change is affecting all perils to varying degrees. This is supported by the tremendous body of scientific research that utilizes the 6th generation of climate models (CMIP6). From a scientific point of view, we have higher levels of confidence in perils that are directly tied to changes in temperature and the hydrological cycle of a region. Therefore, perils such as floods, droughts, wildfire, and sea level rise (and therefore storm surge) are becoming more severe, and the observational data corroborates the science. For other perils, the contribution of climate change is harder to quantify, especially on shorter time scales. However, we are diligently working to combine the science of climate change and the trends in historical data to ensure our models are climate-ready and reflect the near-present climate risk.

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[3] The following countries or regions have received full IED updates since 2017: the U.S. [twice], Japan [twice], Europe [incl. 29 countries], Caribbean [incl. 29 countries], Australia, and New Zealand.

[4] Beyond the nearly 60% of the increase in the global AAL this year due to exposure changes, the remainder is due to updated models, including the U.S. severe thunderstorm model.

To help organizations better understand the impacts of climate change, Verisk has formed the Verisk Climate Advisory Council. The ongoing research by the experts on this council will help ensure that Verisk is well-informed on the latest climate change research and analyses to help drive its development of industry-leading products and services.

As that science on climate change continues to develop, it's important to note that Verisk's current probabilistic atmospheric peril models represent the near-term climate on a 0- to 10-year time frame. These models take the changing climate into account by considering not just the historical record but also by looking at trends over time and using that information to inform the underlying hazard assumptions in the models themselves. Over the past three years, we have made these assumptions explicit by including climate change chapters in the model documentation for all of Verisk's atmospheric peril models.

A fourth factor contributing to increased catastrophe losses is the impacts of man-made loss drivers such as social inflation and legal/regulatory changes. "Social inflation" is generally defined as the "rising costs of insurance claims" due to a variety of societal factors including, but not limited to[5]:

- More liberal treatment of claims
- Societal shifts and a changing view of the social responsibility of large corporations
- Claims fraud and abuse of the assignment of benefits clause in some policies

While the particular causes of social inflation may be up for debate, many insurance professionals regard it as an emerging insurance risk that is significantly affecting and could continue to affect the overall industry loss experience. Because social inflation occurs post-event and depends on a variety of societal factors, it can be very difficult for models to accurately capture this phenomenon. While social inflation may be an ongoing trend, there is no single occurrence or triggering event that can capture the impact of social inflation. As a result, social inflation remains difficult to quantify, and we acknowledge (re)insurers may need to adjust the output from the models to account for social inflation for select perils and regions known to be impacted by the phenomenon. We continue to investigate other ways to help the industry account for and quantify this very real and pressing risk.

We at Verisk have full confidence in the probabilistic modeling approach and strongly believe (re)insurers should continue to rely on the models to provide a stable view of global risk, while at the same time accounting for the impacts of climate change, continued exposure growth and the increased role of perils beyond tropical cyclones and earthquakes.

[5] For more on social inflation and its impacts, see for example, articles by III, the Geneva Association and the International Risk Management Institute.

Exceedance Probability Metrics

Insured Losses

The global aggregate AAL and exceedance probability loss metrics for 2022 reflect changes in risk as a result of updated models (U.S. Severe Thunderstorm, U.S. Crop Hail); they also comprise the updated index factors for the United States, Canada, Mexico, Australia, New Zealand, Central America (7 countries), India, and Southeast Asia (9 countries/territories).

Global insured AAL and key metrics from the aggregate exceedance probability (EP) curve from 2012–2022 are presented in **Table 1**.

Table 1. Key insured loss metrics from Verisk's global industry EP curve for all regions and perils. (Source: Verisk)

Year	AAL (USD Billions)	Aggregate EP Loss (USD Billions)		
		5.0% (20-year return period)	1.0% (100-year return period)	0.4% (250-year return period)
2012	59.3	-	205.9	265.1
2013	67.4	-	219.4	289.1
2014	72.6	-	231.5	292.5
2015	74.4	-	232.8	304.8
2016	80.0	-	252.9	325.3
2017	78.7	-	246.9	325.3
2018	85.7	-	270.9	341.9
2019	91.8	-	288.2	366.2
2020	99.6	192.5	301.1	376.3
2021	106.3	203.4	320.5	397.0
2022	123.3	224.3	345.0	441.4

Average annual insured losses and the metrics from the aggregate insured EP curve—for all regions and perils modeled by Verisk—have generally increased since the first white paper was published in 2012. This is expected; the rise reflects both increases in the numbers and values of insured properties in areas of high hazard and the inclusion of regions and perils for which new models are now available. This year, however, we saw slight decreases across the board in Europe, Asia, and Latin America. While our models for these regions are unchanged, we saw significant changes to the exchange rates between local currencies and the U.S. dollar, the currency we use to report global losses. As the euro, the yen, the pound, and multiple peso currencies all fell in relation to the dollar, losses in those regions naturally decreased as well. The increases observed in North America and Oceania were driven by updates to the industry exposures, with North America receiving a substantial additional increase as a result of the updates and enhancements to the U.S. Severe Thunderstorm Model.

A breakdown of contribution to global AAL by region and key aggregate EP metrics by region appears in **Table 2.** AAL and EP metrics, by region, based on Verisk's global suite of models, including those introduced or updated in 2022. (Source: Verisk).

Table 2. AAL and EP metrics, by region, based on Verisk's global suite of models, including those introduced or updated in 2022. (Source: Verisk)

Region	AAL (USD Billion)	Aggregate EP Loss (USD Billion)	
		1.0% (100-year return period)	0.4% (250-year return period)
	Insured	Insured	Insured
Asia	18.5	70.8	93.8
Europe	15.6	64.6	84.2
Latin America[6]	5.4	45.0	62.6
North America[7]	80.6	293.0	378.1
Oceania	3.2	21.5	33.1
All exposed areas*	123.3	345.0	441.4

* Note that aggregate EP losses are not additive.

Figure 2. Contribution to global insured AAL by peril for all regions. (Source: Verisk) shows the contribution to global insured AAL by peril.

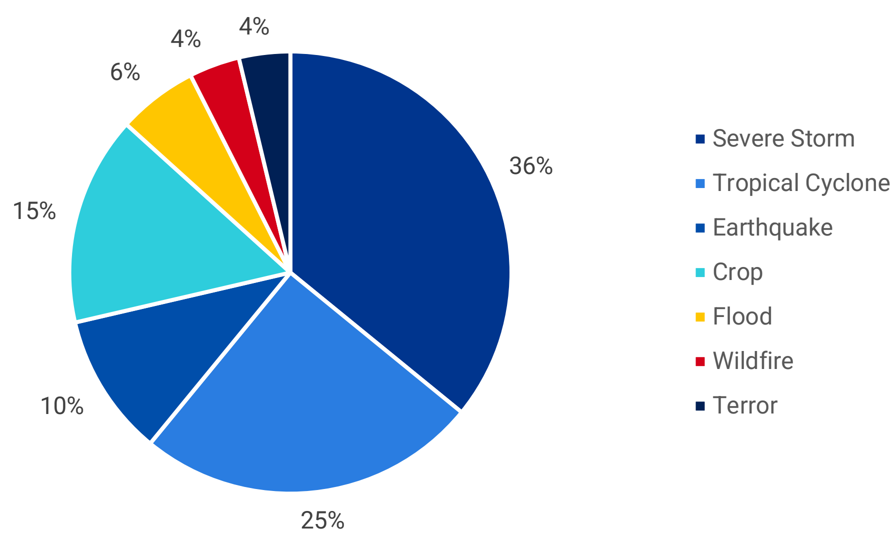

Figure 2. Contribution to global insured AAL by peril for all regions. (Source: Verisk)

[6] Includes the Caribbean, Central America, and South America

[7] Includes Canada, the United States, Bermuda, and Mexico

It is important to note that AAL represents average expected losses over a long period, not what would be expected in any given year. As reflected in Verisk's stochastic catalogs, global aggregate losses in any given year may comprise a few large loss events in peak regions or lower losses from multiple perils across multiple regions; what is certain is that they are unlikely to look like the long-term AAL breakdowns shown in **Figure 2.** Contribution to global insured AAL by peril for all regions. (Source: Verisk)

Economic Losses

Global economic losses include insured losses and uninsured sources, which may include properties with no insurance, infrastructure, and lost economic productivity. Comparing insured losses with reported economic loss estimates for natural disasters since 1990 (as reported by Swiss Re, Munich Re, Aon Benfield, AXCO, Lloyd's, and the Insurance Bureau of Canada), Verisk has determined that global insured losses make up about a quarter of global economic losses on average, when trended to 2020 dollars. Based on Verisk's modeled global insured AAL, this would correspond to an economic AAL of more than USD 370 billion.

On a regional basis, the percentage of economic loss from natural disasters that is insured varies considerably (**Table 3**). In North America, for example, about 50% of the economic loss from natural disasters is insured, while in Asia and Latin America, insured losses account for only about 12% and 24% of economic losses, respectively, reflecting the very low insurance penetration in these regions. The portion of economic losses that is insured also varies significantly by peril.

Table 3. Insured and economic AAL by region* (Source: Verisk)

Region	Insured AAL (USD Billion)	Percentage of Economic Losses Estimated to Be Insured	Economic AAL (USD Billion)
Asia	18.5	12%	150.0
Europe	15.6	44%	35.9
Latin America	5.4	24%	22.5
North America	80.6	51%	159.6
Oceania	3.2	53%	6.0
All exposed areas	**123.3**	**37%**	**374.0** (sum of regional losses)

*Note that there is considerable uncertainty in the estimated percentage of economic losses that is insured, which partly stems from uncertainty in reported economic losses for actual catastrophes.

The sizable difference between insured and economic losses—the protection gap—represents the cost of catastrophes to society, much of which is ultimately borne by governments. Increasing insurance penetration can ease much of the burden, while providing profitable growth opportunities for the insurance industry. In situations where insurance is not feasible or cannot be offered at an affordable price, catastrophe modeling can be used to inform emergency management, hazard mitigation, public disaster financing, risk pooling, and other government-led risk- and loss-mitigation initiatives to enhance global resilience.

Using the same techniques that were used to quantify the protection gap on an AAL basis, the insured and economic losses for each region at the 1% exceedance probability (the 100-year return period) can be calculated. The difference between economic and insured losses—the uninsured losses—includes all of the potential losses to uninsured properties and, in addition, losses that extend beyond the models' scope, including estimates of damage to roads, bridges, railways, and sewers, as well as the global electrical and telecommunications networks and other infrastructure (**Figure 3**). Looking at this metric reinforces the need for additional risk financing solutions.

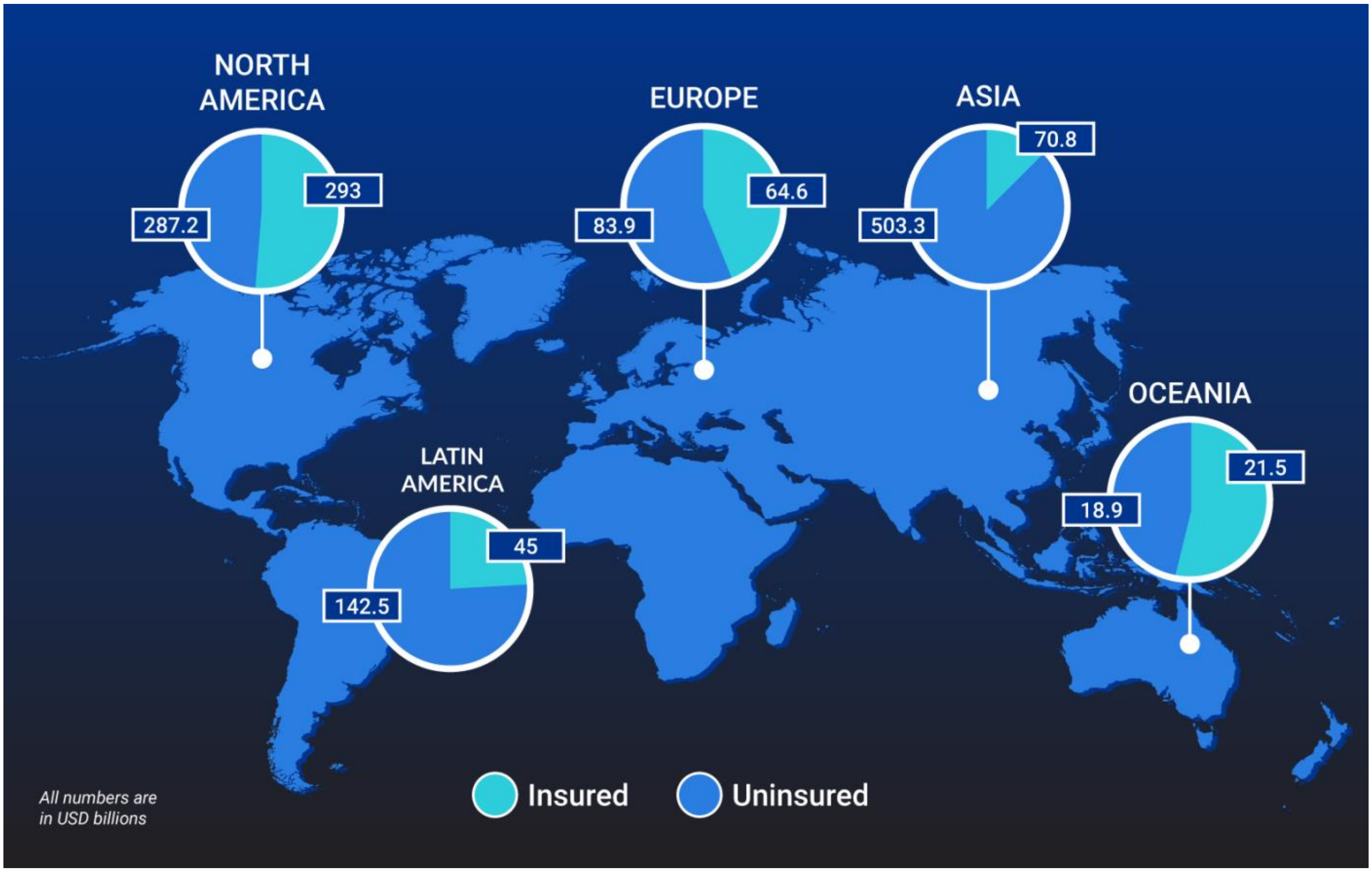

Figure 3. The gap between insured and total economic losses (the sum of insured and uninsured losses), by region, at the 1% exceedance probability (100-year return period) level. (Source: Verisk)

Non-Modeled Sources of Insured Loss

Industry insured losses can and do occur from perils and in regions that Verisk does not currently model. Those losses are therefore not included in Verisk's global insured estimates. (See "Verisk Models by Peril and Region" for a comprehensive listing of Verisk's model coverage.) If all losses could be modeled and included in Verisk's calculations, the aggregate insured loss figures at given EPs would be slightly higher; likewise, the EPs associated with given loss figures would be slightly higher.

Verisk's current suite of models—which covers perils in more than 110 countries—captures catastrophe events responsible for 92% of worldwide insured losses for the 21-year period from 2000 through 2021, as shown in **Figure 4**.

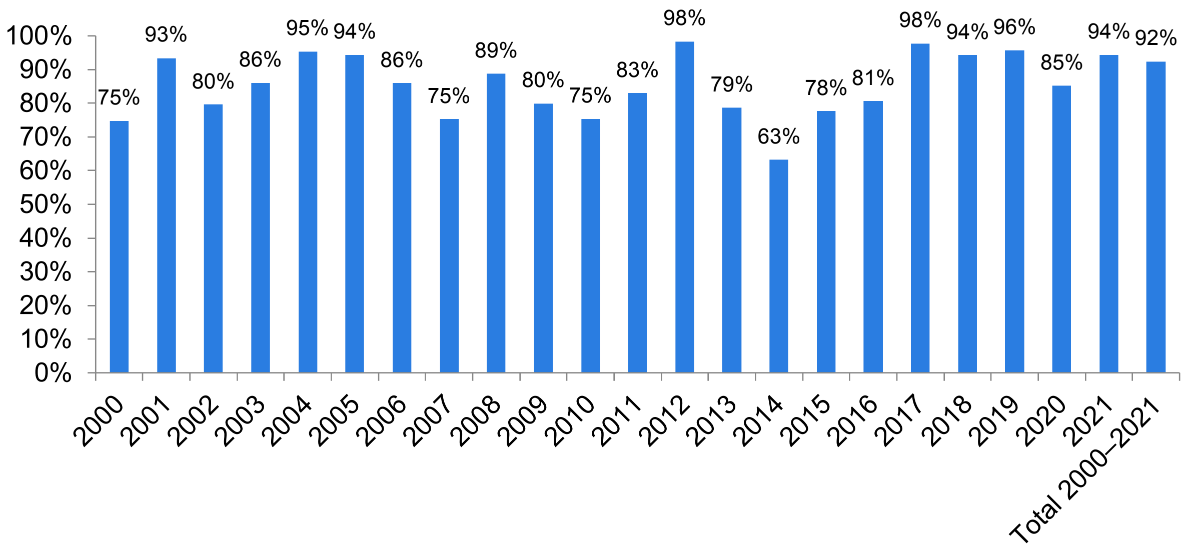

Figure 4. The percentage of reported insured losses covered by Verisk's current suite of models, 2000–2021. (Source: Verisk, Swiss Re, AXCO, Munich Re, PCS, Aon Benfield, PERILS)

As indicated in **Figure 4**, Verisk models covered 94% of the global reported insured losses for 2021. Floods in China and India, winter weather and wildfires in Europe, a prolonged drought in the United States, and weak (i.e., non-hurricane) tropical cyclones in the U.S. accounted for the majority of non-modeled losses.

Managing Your Global Risk

In this paper, we examined how global insured losses have increased over the past five years and sought to explain this increase as a combination of four factors: exposure growth and the related increases in replacement values over time, the natural variability of catastrophic events, the impacts of climate change, and man-made loss drivers, including social inflation.

While it's not possible to control the year-to-year variability of catastrophes, companies can take constructive steps to ensure they are well prepared for future catastrophes. This can be done primarily by focusing on four key areas:

1.) Ensuring that you run the complete suite of peril models that impact your portfolio, not just hurricane and earthquake but also including severe thunderstorm, wildfire, and flood.

2.) Ensuring your books reflect the real, current replacement values of every property. Accounting for inflation in many of the high-risk and high-value areas requires frequent and comprehensive reassessments to confirm that you aren't relying on outdated information when assessing your risk.

3.) Ensuring your properties are accurately geocoded to represent their actual location within the models. Flood and wildfire perils are increasingly important drivers of loss and are particularly sensitive to a property's exact location.

4.) Ensuring you've accurately captured the attributes of each building, including the construction, occupancy, and year built, which are primary determinants of how these structures respond to the damaging conditions catastrophes produce.

Once you have confidence in the data represented in your book and that you've run the full suite of models for perils to which you are exposed, you can have much more confidence in the output of the models helping to avoid any unpleasant surprises in the wake of an event. Additionally, while the models capture a significant majority of the risk, there are still non-modeled sources of loss that should be accounted for when assessing the overall impact of catastrophic events. Losses from non-modeled sub-perils, loss adjustment expenses, legal or regulatory practices that affect how losses are paid, hazardous waste cleanup, and losses resulting from the compromise of existing defenses are just a few areas not accounted for by the models. Consult our model documentation for a complete listing of what is (and what is not) covered by our models so that your organization can be better prepared for any additional losses.

Verisk's global suite of catastrophe models help put the losses the industry has experienced over the past few years into context. While actual insured losses over the past five years have appeared high, averaging USD 100 billion per year, they should not be seen as outliers. The Verisk Global AAL is at USD 123 billion and represents well the scale of recent losses. With this information, companies can prepare for large loss years and truly own their risk with confidence so they can weather these challenging years without risking their solvency.

As (re)insurers continue to understand and manage these losses, the models and the global EP curves they generate can give companies the information they need to benchmark their own potential losses and manage their catastrophe risk with confidence around the world.

About Verisk

Verisk (Nasdaq: VRSK) provides data-driven analytic insights and solutions for the insurance and energy industries. Through advanced data analytics, software, scientific research and deep industry knowledge, Verisk empowers customers to strengthen operating efficiency, improve underwriting and claims outcomes, combat fraud and make informed decisions about global issues, including climate change and extreme events as well as political and ESG topics. With offices in more than 30 countries, Verisk consistently earns certification by Great Place to Work and fosters an inclusive culture where all team members feel they belong. For more, visit Verisk.com and the Verisk Newsroom.