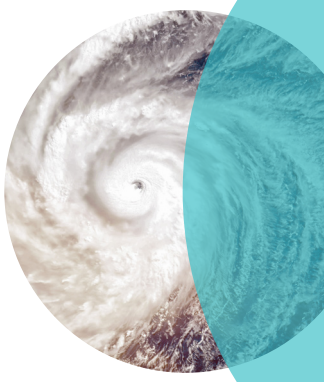
Verisk™

2023 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 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 101 billion compared to an average of less than USD 70 billion over the previous 5-year period. Climate change is often cited as the primary reason for this increase in losses, and, while climate change certainly plays a role, other factors – primarily the year-over-year growth of property exposure and ever-rising replacement values – have a far greater impact in the short term. This rise in exposure values and replacement costs is represented both by continued construction in high-hazard areas as well as high levels of inflation that are driving up repair costs and are only now starting to cool.

Other factors, including the natural inter-year variability in the occurrence of catastrophic events and the impacts of man-made loss drivers, such as social inflation and legal and regulatory changes (particularly in Florida) can also affect the level of global losses in a given time period – though typically to a far lesser degree.

We will focus on the impacts of exposure growth and climate change 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.

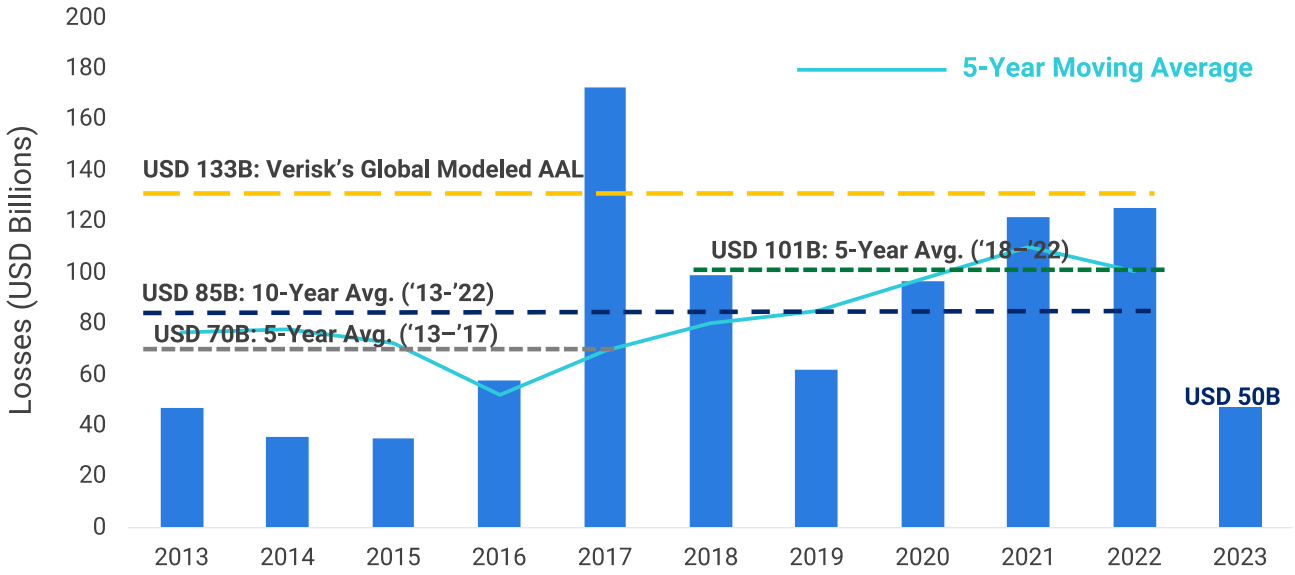

Figure 1. Historical and Average Losses (Source: Swiss Re and Verisk)

[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," "2021 Global Modeled Catastrophe Losses," and "2022 Global Modeled Catastrophe Losses."

[2] Catastrophes in 2017 include major severe thunderstorms across the U.S., HIM events, Mexico earthquakes, and California wildfires.

Evolution of Losses over Time

Figure 1. Historical and Average Losses (Source: Swiss Re and Verisk)**,** above, helps answer that question and put recent years in context. The average losses of the past five years (2018 to 2022) is USD 101 Billion which is significantly more than the average losses (USD 70 Billion) of the previous five years (2013 to 2017). The trend of a 5-year average loss in excess of $100B continues again this year, and may be becoming the new normal. According to the latest analysis using Verisk's models, the global modeled insured average annual loss from natural catastrophes is $133B, meaning the insurance industry should be prepared to experience total insured losses from natural catastrophes well in excess of $100B every year. Please note that this figure represents an increase in the modeled AAL from $123B in 2022 (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 the inclusion of regions and perils for which new models are now available (i.e., Italy flood and Middle East earthquake). In this year's iteration of the global industry EP curve, we have chosen to exclude man-made losses (i.e., losses from terrorism) to focus on the natural perils. Last year, terrorism represented approximately 4% (or $4.6B) of the global annual average loss, so when compared to last year's figure with man-made losses excluded, the global AAL has increased by approximately $15B.

Importantly, the global AAL should be considered the baseline level of losses that can be expected, on average, every year. The global exceedance probability curve generated by Verisk's suite of models provides probabilities on many different levels of loss, with significantly higher losses expected to occur with relatively high frequencies. For example, based on Verisk's calculations, the industry should be prepared that there is a 5% probability (i.e., 1 in 20-year chance) of experiencing a loss of more than $238B each year.

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 catastrophe losses from 2000 to 2022 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, 2000–2022.**).

As part of this analysis, we also calculated the annual worldwide economic losses based on historical percentages of economic losses that have been insured by region and peril. Using this methodology, we estimate that annual economic losses could exceed $400B. This staggering figure highlights the insurance protection gap that exists around the world, as less than one third of those losses would likely be covered by insurance.

The Importance of Up-to-Date Replacement Values and Updated Global Industry Exposures

Now let's discuss each of the factors that have contributed to 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 as well as high levels of inflation that are driving up repair costs. While

reconstruction costs in the U.S. have risen by only 4.3% in the 12-month period from last July[3] as inflation has slowed and the lumber market has stabilized, it's important to note that even a 4.3% increase in exposure value and repair costs per year due to higher inflation would result in a more than 50% increase in losses over a 10-year period. For this reason, it's critically important to regularly reassess your exposures, particularly in times of increased inflation and in the urban and coastal areas that are the most vulnerable to natural hazards. The models rely on accurate property characteristics to produce a realistic projection of potential losses, with an up-to-date replacement value playing a particularly large role in driving modeled losses.

To assist the industry in capturing these updated risks, Verisk updated the industry exposure databases for **all modeled countries** based on the Verisk Global Capital Stock Index[4]. These exposure updates account for more than 90% of the increases in the AAL for the 2023 global exceedance probability curve.

Verisk develops Industry Exposure Indexes using the Verisk Global Capital Stock Index (VGCSI) to reflect recent changes in a country's total industry exposure. The Verisk Global Capital Stock Index is the culmination of internal research on modeling capital stock (physical assets) for more than a decade. The index measures capital stock levels over time and is used to benchmark and reflect changes in value contained in Industry Exposure Databases. More information on the methodology and values used in the the updated Industry Exposure Indexes Using the Verisk Global Capital Stock Index is available on our website.

Accounting for "Secondary Perils"

While the market has in some corners adopted the terminology "secondary perils" to refer to largely non-hurricane and non-earthquake risks, the losses from severe storms and wildfires are, for many portfolios and regions, 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."

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 last five years and can no longer be considered an "attritional peril". So far in 2023, severe thunderstorms have accounted for more than 70% of insured losses, with 8 multi-billion dollar events so far, putting pressure on carriers not prepared for these levels of loss.[5]

Impacts of Climate Change

The other significant factor driving increased catastrophe losses is climate change. The latest IPCC report concludes climate change is impacting 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,

[3] Verisk 360Value Qua rterly Reconstruction Cost Analysis

[4] Global Industry Exposure Indexes Using the Verisk Global Capital Stock Index

[5] Aon - Global Catastrophe Recap: First Half of 2023

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 like 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.

While it can be quite challenging to precisely quantify the impacts of climate change as it applies to individual events, when examined broadly, a few overall trends emerge. 2023 is on track to be the hottest year on record, and the previous eight years were the hottest on record. Heatwaves have plagued the U.S., Europe, and China throughout much of the summer and, while the heatwaves themselves are not responsible for significant insured losses, the warming climate can influence the location, frequency and severity of atmospheric perils. Ocean temperatures are likewise hotter than ever, with the average daily sea surface temperature reaching the highest level ever recorded, with temperatures nearly a full degree (.99°C, 1.78°F) above long term averages this summer. The warm ocean, coupled with the onset of El Niño conditions will likely lead to a higher frequency of extreme weather this year.

For example, this spring saw wildfires raging in Canada, with nearly twice the previous full year's record acreage (71k km^2 in 1995) burned by the end of July (120k km^2). Meanwhile, in the western U.S., 1H wildfire activity was depressed by all of the winter precipitation, with a series of atmospheric rivers channeling nearly double the average rain/snow fall in California from December through March. The wildfire season could turn, however, as the summer heat dries out the new vegetation, setting the stage for a potentially significant wildfire season the second half of the year due to all that new fuel. Entering the 2^{nd} half of the year, Hawaii also experienced deadly and damaging wildfires due to high winds, abundant fuels, and prolonged drought conditions.

The U.S. was not the only region impacted by severe hydrological events, however, as 2023 also delivered two unprecedented events in New Zealand: first, an estimated 9.8" (240 mm) of rain fell on Auckland, followed a week later by cyclone Gabrielle, which devasted the north island and became the costliest cyclone ever in the Southern Hemisphere. Western Europe (France, Italy, and Germany) also experienced significant hail and flood events from powerful storms this spring. While it is difficult to link any of these individual events directly to climate change, the consensus from the simulations produced by climate models is that a warming climate will make the conditions that led to these events more likely in the future.

Tools for Assessing These Impacts

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.

To further help the industry quantify future impacts of climate change, Verisk has also developed climate change projections to illustrate the impact on the U.S. and Caribbean tropical cyclone and U.S. wildfire catalogs at different SSP scenarios and different time horizons. Going beyond these solutions, we've also developed tools that enable companies to modify the models and implement their own view of risk. As more information about the impacts of the changing climate emerges, Verisk's models will continue to incorporate the latest research and our global modeled losses will continue to be updated to reflect this changing risk.

Probabilistic modeling remains the best approach and (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.

Exceedance Probability Metrics

Insured Losses

The global aggregate average annual loss (AAL) and exceedance probability loss metrics for 2023 reflect changes in risk as a result of new models (Italy flood, Middle East earthquake) and updated models (U.S. Hurricane, U.S. MPCI, China Agriculture); they also comprise the updated index factors for all modeled countries.

Global insured AAL and key metrics from the aggregate exceedance probability (EP) curve from 2012–2023 are presented in Table 1.

Table 1. Key insured loss metrics from Verisk's global industry EP curve for all regions and perils[6,7]. (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
2023	133.0	238.2	372.0	452.7

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.

A breakdown of contribution to global AAL by region and key aggregate EP metrics by region appears in Table 2.

[6] From 2012 to 2022, figures included losses from U.S. Terrorism events. As part of the analysis in 2023 and going forward, we have chosen to exclude losses from man-made events to focus on natural catastrophes.

[7] Loss figures from prior years have not been trended to the current year, and instead represent the loss figures generated by Verisk models at the time of the analysis using the set of models available at that time.

Table 2. AAL and EP metrics, by region, based on Verisk's global suite of models, including those introduced or updated in 2023. (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	20.6	69.9	92.7
Europe	17.9	72.7	97.4
Latin America[8]	5.7	52.4	76.6
North America[9]	85.3	313.5	395.9
Oceania	3.5	23.2	35.2
All exposed areas*	133.0	372.0	452.7

* Note that aggregate EP losses are not additive, as noted in the box "Understanding the Exceedance Probability Curve."

Figure 2 shows the contribution to global insured AAL by peril.

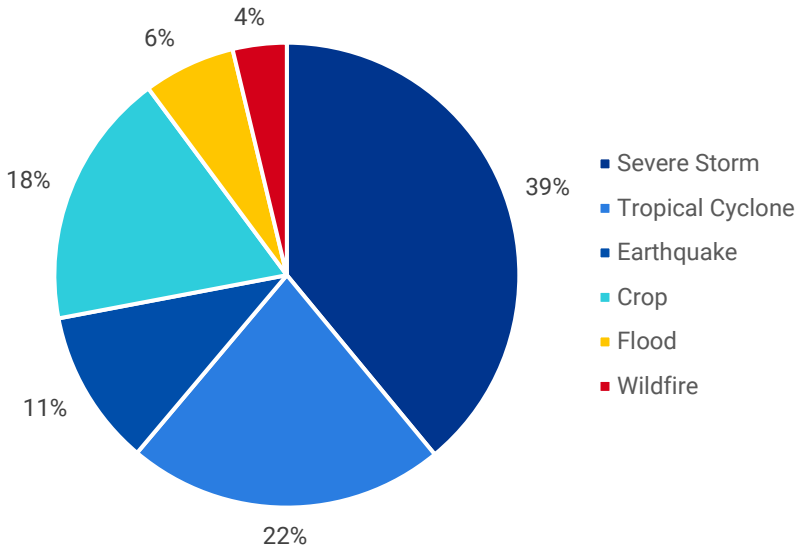

Figure 2. Contribution to global insured AAL by peril for all regions. (Source: Verisk)

It is important to note that AAL represents average expected losses over a long period of time, 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 1 and Figure 2.

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

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

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, AXCO, Lloyd's, and the Insurance Bureau of Canada), Verisk has determined that global insured losses make up less than a third of global economic losses on average, when trended to current dollars. Based on Verisk's modeled global insured AAL, this would correspond to an economic AAL of more than USD 400 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 51% 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	20.6	12%	171.7
Europe	17.9	44%	40.7
Latin America	5.7	24%	23.8
North America	85.3	51%	167.3
Oceania	3.5	53%	6.6
All exposed areas	**133.0**	**32%**	**410.0** (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 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.

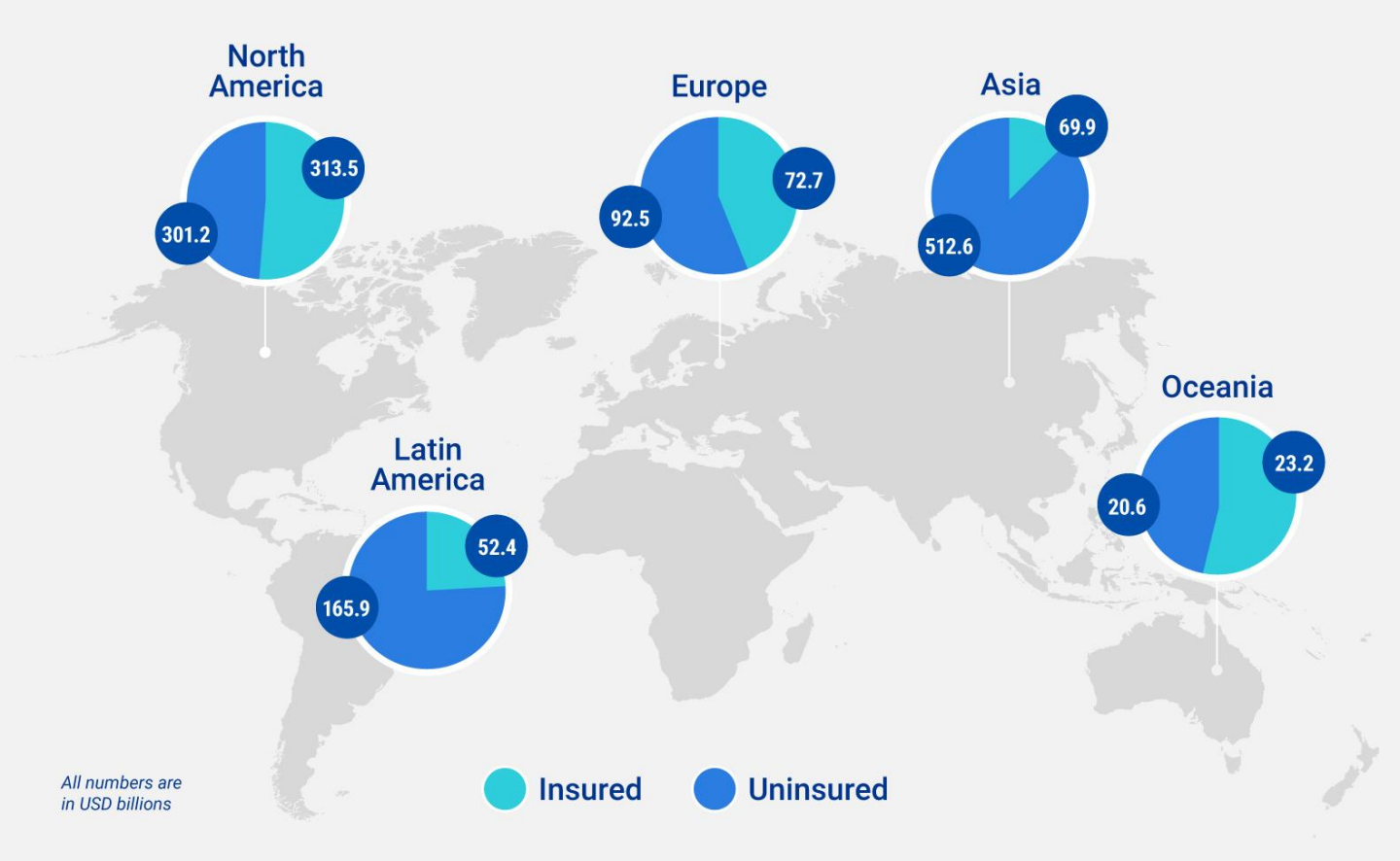

Figure 3. The gap between insured and total economic losses (the sum of insured and uninsured losses), by region, at the 1% exceedance probability (100-year return period) level. (Source: Verisk)

Insured Losses Not Covered by Verisk Models

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 23-year period from 2000 through 2022, as shown in Figure 4.

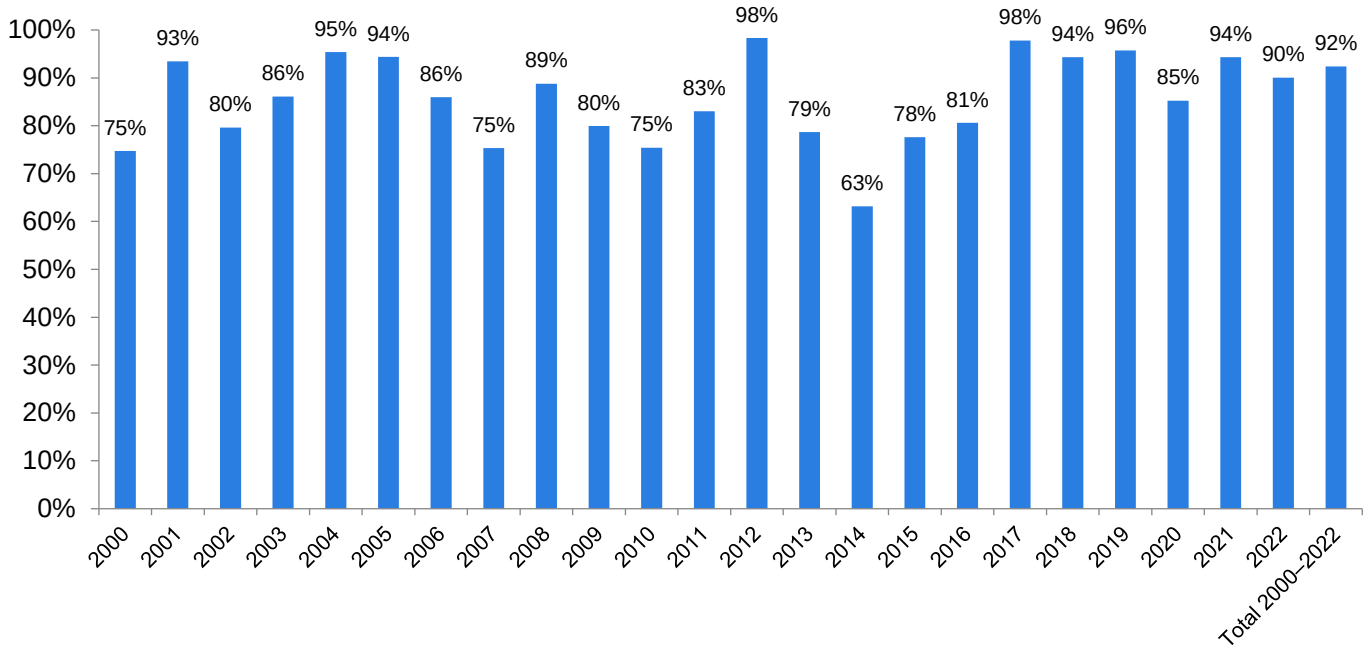

Figure 4. The percentage of reported insured losses covered by Verisk's current suite of models, 2000–2022. (Source: Verisk, Swiss Re, AXCO, Munich Re, PCS, Aon, PERILS)

As indicated in Figure 4, Verisk models covered 90% of the global reported insured losses for 2022. Floods in Australia and South Africa, winter weather and wildfires in Europe accounted for the majority of non-modeled losses.

Managing Your Global Risk

In this paper, we examined how global insured losses have continued to increase after a period of lower than average losses. Two factors are primarily responsible for driving this increase: exposure growth and the related increases in replacement values over time and the impacts of climate change.

To ensure they are ready for this “new normal”, companies can take constructive steps to ensure that they are well prepared for future catastrophes. This can be done primarily by focusing on four key areas:

1.) Ensuring that a complete suite of peril models is run, not just hurricane and earthquake but also including severe thunderstorm, wildfire, and flood.

2.) Ensuring that attributes of as many buildings as possible are accurately captured, including the construction, occupancy and year built, which are primary determinants of how these structures respond to the damaging conditions catastrophes produce.

3.) Ensuring that as many properties as possible are accurately geocoded to represent their actual location within the models. Flood and wildfire are perils that are increasingly important drivers of loss and are particularly sensitive to a properties’ exact location.

4.) Ensuring that books reflect the real, current replacement values of every property. Accounting for both inflation and the rising prices in many of the high risk and high value areas requires frequent and comprehensive reassessments to confirm that outdated information is not being relied upon when assessing risk.

With confidence in the data represented in modeled books and after running the full suite of peril models, much greater confidence in the output of the models can be reached, helping to avoid any unpleasant surprises in the wake of any catatrophic event. Going beyond the standard model output, Verisk has also provided tools to help companies stress test their portfolios so that they can account for the impacts of climate change, demand surge, or social inflation.

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 last five years have been high, averaging $101B per year, they should not be seen as outliers. The Verisk Global AAL is at $133B 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 that they can weather these challenging years without risking their solvency.

As companies 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.