AIR’s 2014 Global Exceedance Probability Curve

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The AIR Institute’s
Certified Catastrophe
Modeler Program

AIR WORLDWIDE®

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Executive Summary

Since 2012, AIR Worldwide (AIR) has published an annual white paper discussing how AIR's global industry exceedance probability (EP) curve can be used to obtain a comprehensive and meaningful view of potential losses and to put into context years with high insured losses (such as 2011).[1] This paper, the 2014 update, bases its global loss metrics on AIR's latest suite of global models, including new models and updates released during 2014, as well as updated industry exposure databases (IEDs).

As with the 2012 and 2013 white papers, this paper presents two global insured loss scenarios around the 1% aggregate EP (the 100-year return period) to illustrate the wide variety of perils and regions that can combine to produces losses at a given EP level. In this paper's scenarios, losses in one of the modeled years are dominated by a major earthquake that strikes just outside Montreal, Quebec; in the other modeled year, losses are dominated by a major hurricane making landfall just north of Miami, Florida.

AIR is uniquely qualified to provide global insurers and reinsurers with the insightful view of risk presented in this paper for the following reasons:

- AIR develops and maintains a detailed IED—including counts, replacement values, and physical attributes of insurable properties—for each modeled country. These IEDs serve as the foundation for all modeled industry insured loss estimates and make the generation of a global industry EP curve a straightforward task.
- AIR's simulation approach to generating the stochastic catalogs included in its models enables model users to determine the probability of various levels of loss for years with multiple catastrophic events, across multiple perils and multiple regions.
- AIR models the risk from natural catastrophes and other perils (including pandemics and terrorism) in more than 90 countries, affording AIR a truly global perspective.[2]

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[1] Previous EP curve papers: "Taking a Comprehensive View of Catastrophe Risk Worldwide: AIR's Global Exceedance Probability Curve" (2012) and "AIR's 2013 Global Exceedance Probability Curve" (2013).

[2] Because of the unique catalog architecture of the AIR pandemic model, pandemic losses were excluded from the analyses in this paper.

Industry Exposure Databases Give AIR Unique Global Risk Insight

AIR builds its industry exposure databases (IEDs) from the bottom up, compiling detailed data about risk counts, structure attributes (parameters that greatly influence the ability to withstand high winds, ground motion, and flood depth), and replacement values, as well as information on standard policy terms and conditions. AIR then validates key attributes of the database through a top-down approach, using aggregate data from multiple additional sources. Coupling these approaches results in aggregated industrywide IEDs that are both objective and robust.

High-resolution IEDs for every modeled country—and a straightforward and intuitive catalog-generation process—enable AIR to provide insight into different levels of loss from catastrophes on a global scale. *AIR is the only modeling company with this capability.*

Average annual insured losses (AALs) and the metrics from the aggregate insured EP curve—modeled by AIR for all regions and perils—have increased steadily since the 2012 white paper. This is expected; the rise reflects both increases in the numbers and values of insured properties in areas of high hazard risk and the availability of new models for regions and perils previously not modeled.

Industry insured losses can and do occur from perils and in regions for which AIR does not yet provide models, and those losses are not included in AIR's global estimates. AIR, however, is committed to continually expanding model coverage and is engaged in an aggressive model development program.

Exceedance Probability Metrics

The modeled global insured average annual loss (AAL) and the selected exceedance probability metrics for 2014 include metrics based on a new model introduced this year (the U.S. crop hail model) and reflect changes in risk as a result of updated models (the Canada earthquake model, the U.S. earthquake and severe thunderstorm models, and the China crop model), as well as updates to AIR's industry exposure databases for the U.S. and Canada.

AIR also introduced a fully probabilistic inland flood model for the United States in 2014. Results from that model have been excluded from the insured loss metrics presented in this paper because of the high uncertainty in insurance take-up rates (see the box "U.S. Inland Flood: Modeling for an Emerging Market" for more information).

U.S. Inland Flood—Modeling for an Emerging Market

At any given time, a storm with the potential to produce flooding is occurring somewhere over the contiguous United States. Thousands of towns and cities are located on floodplains, but many areas far from these low-lying river valleys are also susceptible to flood damage and loss. The AIR Inland Flood Model for the United States, introduced in 2014, provides companies with the most detailed probabilistic view of risk available for assessing and managing inland flood losses at high resolution, for locations on and off the many and varied floodplains across the country.

According to the AIR model, the U.S. experiences, on average, *ground-up* flood losses of USD 28 billion annually. This figure is expected to grow with continued development, ongoing increases in property value, and more extreme wet-weather events. For the analyses in this document, model results from the AIR Inland Flood Model for the United States were not incorporated in the average annual *insured* loss and exceedance probability calculations because reliable information on U.S. flood insurance take-up rates in the private sector simply is not available. We will consider including results from the AIR U.S. inland model in future white papers as our flood take-up rate information improves.

With the release of the AIR U.S. inland flood model, risk managers are now able to account for the many complexities that affect flood risk and understand the severity, frequency, and location of potential flood events both on and off the floodplain. Opportunities for profitable growth are there for the taking, and it is our hope that the model will drive innovation in flood insurance products offered in the private market and that take-up rates for flood insurance—relatively low at present—will rise to meet the clear needs of home and business owners to protect their properties.

Global AAL and key metrics from the aggregate exceedance probability (EP) curve from 2012–2014 are presented in Table 1.

Table 1. Key loss metrics from AIR's global industry EP curve for all regions and all perils. EP metrics can be expected to increase every year due to increases in insured properties and new models. (Source: AIR)

Year	AAL (USD Billion)	Aggregate EP Loss (USD Billion)	
		1.00% (100-year return period)	0.40% (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

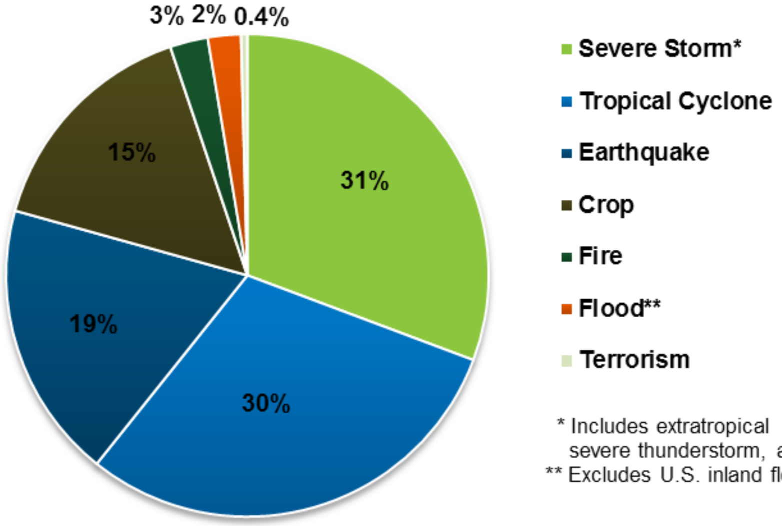
A breakdown of contribution to global AAL by region and key aggregate EP metrics by region appears in Table 2.

Table 2. AAL and EP metrics, by region, based on AIR's global suite of models, including those introduced or updated in 2014. (Source: AIR)

Region	AAL (USD Billion)	Aggregate EP Loss (USD Billion)	
		1.00% (100-year return period)	0.40% (250-year return period)
Asia	11.6	60.0	91.0
Europe	10.7	68.6	102.7
Latin America (Mexico, the Caribbean, Central America, South America)	6.6	50.8	67.6
North America (Canada, the United States, Bermuda)	42.0	188.7	249.8
Oceania	1.7	22.0	39.5
All exposed areas	**72.6**	**231.5***	**292.5***

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

Figure 1 indicates the contribution to global AAL from each modeled peril.



* Includes extratropical cyclone, severe thunderstorm, and winter storm.
** Excludes U.S. inland flood.

Figure 1. Contribution to global insured AAL by peril for all regions. (Source: AIR)

Understanding the Exceedance Probability Curve

To meet the diverse needs of model users, AIR's catastrophe models provide a wide range of modeled loss output. One of the most commonly used outputs is a distribution of potential losses with the associated probabilities of exceedance. These *exceedance probability* (EP) curves—which can be specific to peril, region, or line of business—quantify the risk profile for whole portfolios or individual risks and can be used to inform a variety of risk management decisions.

Understanding how AIR develops its stochastic catalogs of simulated events helps one understand how the EP curves are generated. To create a stochastic catalog for a given peril, scientists first gather information on historical events from a comprehensive range of sources. This data is then used to infer what can happen in the future; that is, to indicate where and how frequently certain types of events are likely to occur and how large or severe the events are likely to be. A 10,000-year hurricane catalog, for example, contains 10,000 potential scenarios for tropical cyclone activity in an upcoming year. Importantly, although the simulated events have their basis in historical data, they extend beyond the scope of past recorded experience to provide the full spectrum of future potential catastrophe events.

To generate the EP curves, first an AIR catalog is run against the portfolio of exposures. Next, the loss for each event in each modeled year is calculated. (Some modeled years will have multiple events, some a single event, and some no events.) Then modeled years are ranked from highest loss to lowest loss, based on loss figures calculated for either *occurrence* loss (based on the largest event loss within each modeled year) or *aggregate* loss (based on the sum of all event losses of each modeled year).

Finally, EPs corresponding to each loss—occurrence or aggregate—are calculated by dividing the rank of the loss year by the number of years in the catalog. Thus for a 10,000-year catalog, the top-ranked (highest loss) event would have an EP of 0.0001 (1/10,000) or 0.01%, the 40th-ranked event an EP of 0.004 (40/10,000) or 0.40%, the 100th-ranked event an EP of 0.01 (100/10,000) or 1.00%. The return period for a loss level equals the inverse of EP: EPs of 0.01%, 0.40%, and 1.00%, for example, correspond to 10,000-, 250-, and 100-year return periods.

Model users should keep in mind that EP metrics provide the probability of a certain *size* loss, not the probability that a specific *event* or *events* will occur. Also, the probability of an event or events occurring exactly as modeled (or the exact recurrence of a historical event) is virtually zero, although a wide range of event scenarios may cause a similar level of loss.

Average annual losses (AALs) for exposed areas—such as the regions listed in Table 2—can be summed because the region figures were calculated by averaging losses across all modeled years. Aggregate EP losses are not additive and thus—again referring to Table 2—do not equal the sums of the regional aggregated EPs.

To read more about how exceedance probability curves are constructed and how they should be interpreted, see the articles "Modeling Fundamentals: What Is AAL?" and "Modeling Fundamentals: Combining Loss Metrics."

Global Industry Insured Loss Scenarios Around the 1% Exceedance Probability

Understanding years with large aggregate industry insured loss helps companies evaluate alternative reinsurance options and better own their risk. Quantifying losses at various EP levels is an important step in evaluating large loss years, but companies should also keep in mind that quite varied catastrophic event scenarios—different perils in different regions—can produce similar EP loss levels in any given year.

The following two scenarios describe different possible combinations of natural catastrophes worldwide producing losses near the current 1.00% aggregate EP loss for 2014, USD 231.5 billion. (See the box "AIR Loss Estimates" on page 12 for what modeled losses include.) Each scenario represents a single year ID across all of AIR's 10,000-year catalogs.

Aggregate Loss Scenario 1—Canada Earthquake Losses Dominate

Earthquake losses make up 77% of the USD 228.9 billion total global insured loss in this ~1% EP modeled year. North America—with losses from crop, fire, severe storm, and tropical cyclone damage, in addition to earthquake—experienced the highest insured loss total of the five regions, at USD 151.7 billion (66% of the global insured loss total). Europe—damaged by earthquake, flood, and severe storm—was the second most heavily impacted region, with USD 61.5 billion (27%). See Figure 2 for a breakdown of losses by region and peril.

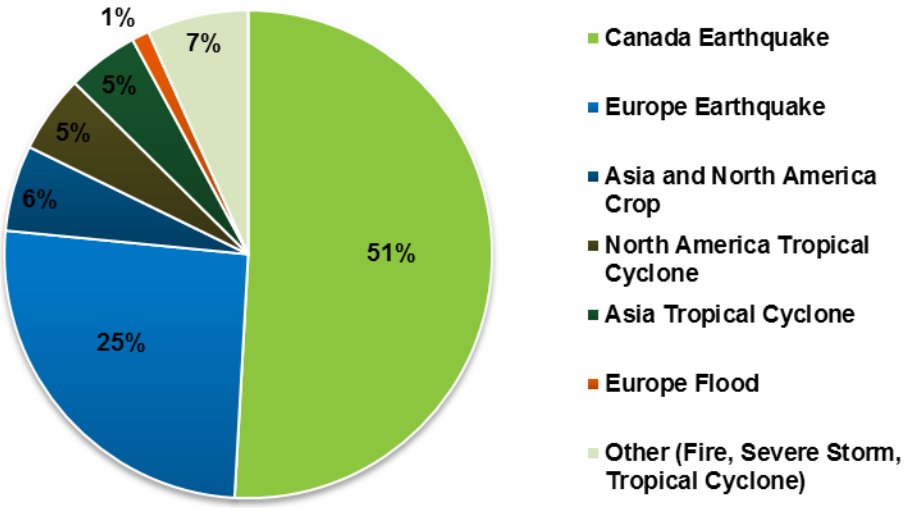


Figure 2. Breakdown of total global insured loss for Aggregate Loss Scenario 1. (Source: AIR)

Table 3 lists the 10 highest loss-producing events in Aggregate Loss Scenario 1, which make up USD 208.6 billion of the USD 228.9 total for the year. A single North America earthquake—an M6.7 earthquake that strikes just 7 miles outside downtown Montreal and damages properties in parts of Ontario and Quebec provinces in

Canada, as well as parts of New York and Vermont in the United States—accounts for USD 115.3 billion, fully 50% of the global insured loss total for all perils. The second-largest loss event, an M7.8 earthquake that occurs less than 40 miles from Istanbul and severely impacts Turkey, Greece, and Bulgaria, results in insured losses of USD 57.8 billion—25% of the global insured loss total.

Table 3. Top 10 loss-producing events in Aggregate Loss Scenario 1. (Source: AIR)

Event	Insured Loss (USD Billion)
M6.7 Canada Earthquake (Ontario,Quebec, New York, Vermont)	115.3
M7.8 Europe Earthquake (Turkey, Greece, Bulgaria)	57.8
Category 3 North America Hurricane (Louisiana, Mississippi,Texas)	9.9
Category 4 Asia Typhoon (Japan, South Korea)	9.5
North America Crop Loss (Kansas, Minnesota, Missouri, Nebraska, South Dakota)	9.1
North America Severe Thunderstorm (Arkansas, Illinois, Kansas, Michigan, Ohio)	2.0
Europe Flood (Germany)	1.3
North America Severe Thunderstorm (Michigan, Minnesota, New Jersey, Pennsylvania, Washington)	1.3
Asia Crop Loss (China)	1.2
Europe Flood (Germany)	1.2

Aggregate Loss Scenario 1 corresponds to Year 1827 in AIR's 10,000-year catalogs, implemented in Version 16.0 of CATRADER® and Version 2.0 of Touchstone®.

Aggregate Loss Scenario 2—Tropical Storm Devastation in Florida and the Caribbean

As Figure 3 dramatically reveals, one type of event—North America tropical cyclone—resulted in 80% of the total global insured losses for this ~1% EP modeled year: USD 189.2 billion of USD 235.1 billion.

The second- and third-largest loss categories—North America severe storm (USD 13.6 billion, 6% of global insured losses) and North America crop losses (USD 9.0 billion, 4%)—plus other much smaller North America losses from earthquake and terrorism, brought the total North America losses for the year to USD 214.2 billion, a full 91% of global insured losses.

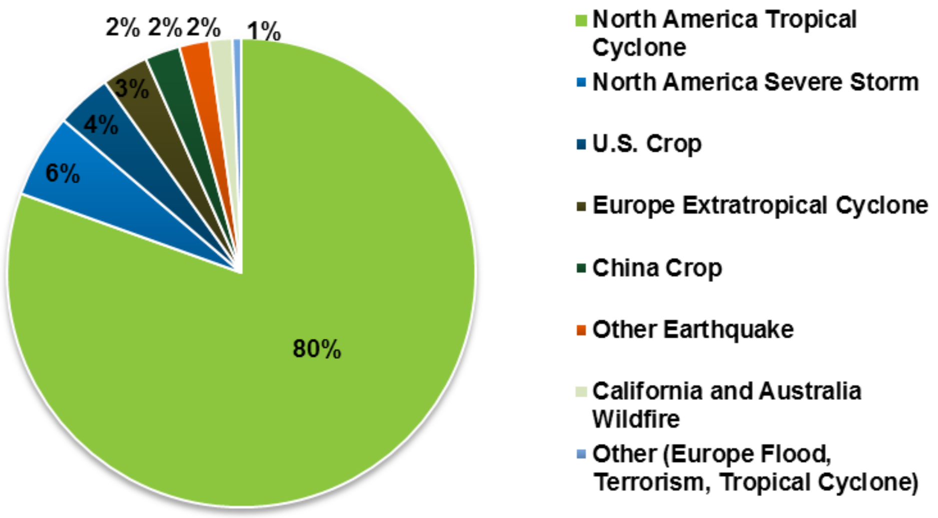


Figure 3. Percentage of total global insured loss by region and peril for Aggregate Loss Scenario 2. (Source: AIR)

Table 4 lists the 10 highest loss-producing events in Aggregate Loss Scenario 2, which make up USD 207.7 billion of the USD 235.1 billion total for the year. The top loss-causing event is a devastating Category 4 hurricane that made landfall just north of Miami in Broward County, Florida—one of the most highly concentrated areas of coastal exposure in the U.S.—and also impacted the U.S. Virgin Islands, Puerto Rico, and the Bahamas, resulting in USD 121.8 billion in insured losses, almost 52% of the total global insured losses. Three crop loss events and three severe storm events appear in this listing, although even totaled they are just a small portion of the overall losses. As expected, hurricanes in North America are the predominant driver of loss.

Table 4. Top 10 loss-producing events in Aggregate Loss Scenario 2. (Source: AIR)

Event	Insured Loss (USD Billion)
Category 4 North America Hurricane (Florida, U.S. Virgin Islands, Puerto Rico, the Bahamas)	121.8
Category 1 North America Hurricane (Florida, Georgia, South Carolina, Cuba)	35.6
Category 4 North America Hurricane (Georgia, South Carolina, North Carolina)	29.8
North America Crop Loss (Minnesota, Missouri, Nebraska, South Dakota, Wisconsin)	9.0
Europe Severe Storm (Norway, Sweden, Poland, Lithuania, Latvia)	2.9
Asia Crop Loss (China)	2.2
North America Severe Thunderstorm (Arkansas, Louisiana, North Carolina, South Carolina, Texas)	2.0
Europe Severe Storm (Germany, the Netherlands, Denmark, Belgium, France)	1.8
Asia Crop Loss (China)	1.4
Europe Earthquake (Turkey)	1.2

Aggregate Loss Scenario 2 corresponds to Year 5431 in AIR's 10,000-year catalogs, implemented in Version 16.0 of CATRADER and Version 2.0 of Touchstone.

AIR Loss Estimates

AIR modeled insured loss estimates reflect damage from the perils and in the regions modeled by AIR (see complete list of model coverage here). AIR loss estimates typically include:

- Insured physical damage to property (residential, commercial, industrial, auto)—both structures and their contents
- Time element coverage—additional living expenses for residential properties and business interruption for commercial properties

For comprehensive information on what AIR's loss estimates do and do not reflect, refer to the model documentation available on the AIR Client Portal.

Non-Modeled Sources of Loss

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

AIR's existing suite of models in 2014—which cover perils in more than 90 countries—captured events impacting over 88% of worldwide insured losses for the 14-year period from 2000 through 2013, as shown in Figure 4.

Figure 4. The percentage of reported insured losses covered by AIR's current suite of models, 2000-2013. (Source: AIR, Swiss Re, AXCO, Munich Re)

As indicated in Figure 4, AIR models covered 78% of the global reported insured losses for 2013. Significant non-modeled losses during 2013 included flood events in Canada and Australia, and a devastating USD 3.7 billion hailstorm in Germany.

To better serve the needs of the industry, AIR continues to expand into previously non-modeled regions and perils through an ambitious model development program. AIR also provides modeling tools that can help companies understand the risk from non-modeled sources of loss. Using Touchstone's Geospatial Analytics Module, for example, companies can analyze accumulations of risk anywhere in the world. Users can import hazard footprints and assign custom damage ratios to calculate not only concentrations of risk counts and replacement values but also exposed limits after accounting for policy terms (including deductibles, layers, limits, and reinsurance treaties). This Touchstone feature helps organizations achieve an integrated view of enterprisewide exposure to catastrophe risk and evaluate where to grow or retract business.

In addition, AIR's probabilistic flood hazard maps are available as spatial layers for use in the Touchstone Geospatial Analytics Module. Currently available for China and Thailand (and Brazil in 2015), AIR's flood hazard maps enable a sophisticated understanding of the threat posed by complex river networks by helping manage accumulations, determine whether a risk meets underwriting guidelines, and develop effective portfolio management and risk transfer strategies.

Touchstone users also have the flexibility to modify modeled losses by line of business, region, or peril to account for non-modeled sources of losses.

Conclusion: The Importance of a Global View

Since catastrophe risk can threaten a company's financial well-being, companies operating on a world stage need to understand their risk *across* global exposures to ensure they have sufficient capital to survive years of very high loss. Understanding—owning—this risk requires knowing both the likelihood of high-loss years and the diversity of events that could produce such losses. In addition, companies with global exposures and an expanding global reach should prepare for the possibility that future catastrophes will produce losses exceeding any historical amounts.

Companies that evaluate loss on a global scale, rather than regionally or even nationally, should always look at more than one peril (or one region) to assess the risk at a given exceedance probability (EP). If a company considered only its worst single peril, it could severely understate risk at a given EP, since for a given modeled year losses from a combination of other events (different perils in different regions) likely would equal or exceed the worst single peril. As discussed in the "Understanding the Exceedance Probability Curve" box on page 8, EP curves can be developed for both occurrence (based on the largest loss event in each catalog year) and aggregate (based on the sum of all loss events in each catalog year). Aggregate EP is a far better measure of portfolio risk.

With the insight provided by AIR's global suite of models, companies can pursue profitable growth in a market that is ever more connected, and amid regulatory environments that are ever more rigorous. The ability to take a comprehensive, global view can give insurers and reinsurers greater confidence that the risk they have assumed is risk they can afford to take. The global EP curves generated with AIR software give companies the knowledge with which to benchmark and manage natural catastrophe risk in more than 90 countries around the globe.

About AIR Worldwide

AIR Worldwide (AIR) is the scientific leader and most respected provider of risk modeling software and consulting services. AIR founded the catastrophe modeling industry in 1987 and today models the risk from natural catastrophes and terrorism in more than 90 countries. More than 400 insurance, reinsurance, financial, corporate, and government clients rely on AIR software and services for catastrophe risk management, insurance-linked securities, detailed site-specific wind and seismic engineering analyses, and agricultural risk management. AIR, a Verisk Analytics (Nasdaq:VRSK) business, is headquartered in Boston with additional offices in North America, Europe, and Asia.

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