Weather, Climate & Catastrophe Insight

2019 Annual Report

Empower Results®

Table of Contents

Executive Summary

2019: Major humanitarian impacts; manageable financial costs

Economic losses
USD232 billion
3% below average (21st Century)

Insured losses
USD71 billion
6% above average (21st Century)

Two costliest insurance events occurred in Japan

409
total natural disaster events

51%
of **global insured losses** were recorded in the United States

69%
global protection gap

41
billion-dollar economic loss events

12
billion-dollar insured loss events

10+ million hectares
Area burned by wildfires in Russia

18.6+ million hectares
Area burned by wildfires in Australia

1,750
fatalities from the Indian monsoon floods – the deadliest disaster of 2019

2 million people
displaced in Africa following Cyclones Idai & Kenneth

185 mph (295 kph)
Hurricane Dorian landfall in The Bahamas; tied with the 1935 Labor Day Hurricane as the strongest landfalling storm on record in the Atlantic Ocean

+0.95°C (1.71°F)
Above the 20th Century Average
Second warmest year on record for land & ocean temperatures since 1851

New all-time temperature record set
46.0°C (114.8°F) in France
42.6°C (108.7°F) in Germany

15.71 inches (399 millimeters)
Wettest January to May U.S. rainfall average on record since 1895

Along with this report, we continue to welcome readers to access current and historical natural catastrophe data and event analysis on Impact Forecasting's Catastrophe Insight website: **http://catastropheinsight.aon.com**

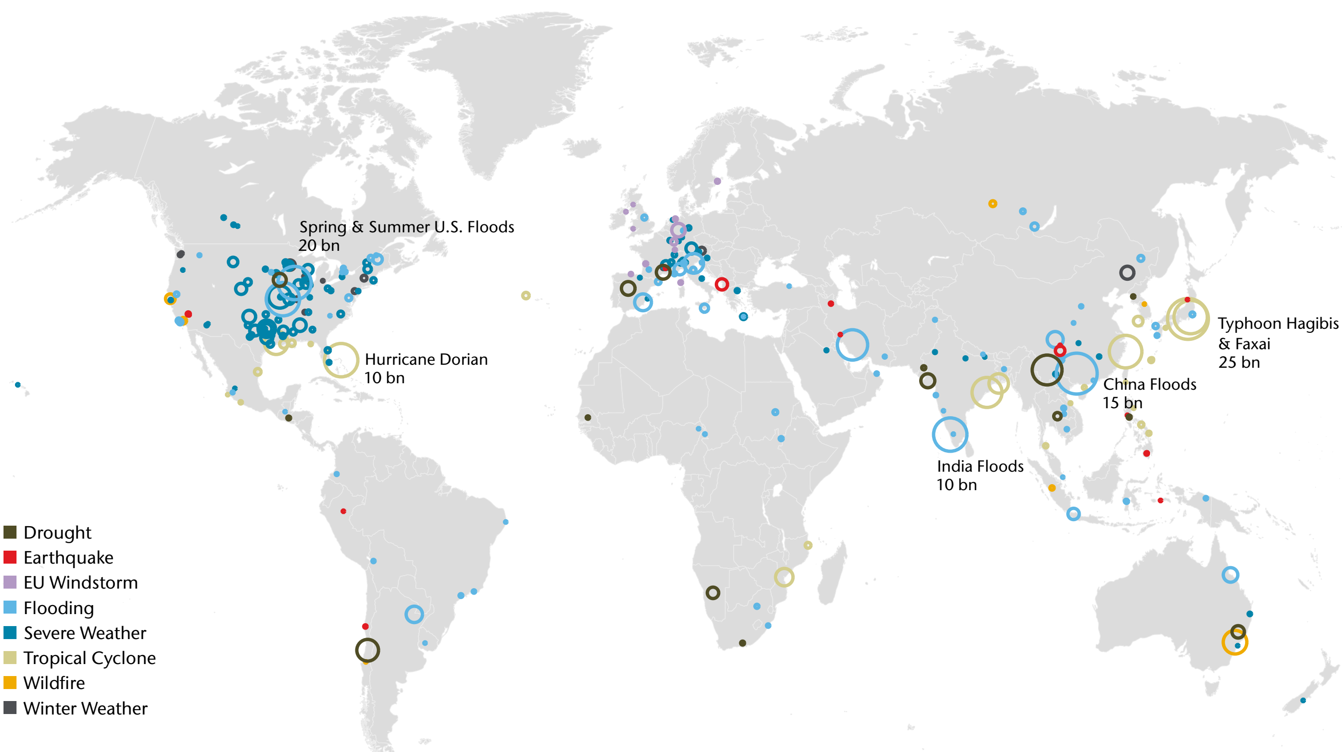
2019 Natural Disaster Events & Loss Trends

Global Economic Losses

Exhibit 1: Top 10 Global Economic Loss Events

Date(s)	Event	Location	Deaths	Economic Loss (USD billions)	Insured Loss (USD billions)
October 6-12	Typhoon Hagibis	Japan	99	15.0	9.0
June - August	Monsoon Floods	China	300	15.0	0.7
September 7-9	Typhoon Faxai	Japan	3	10.0	6.0
May – July	Mississippi Basin Floods	United States	0	10.0	4.0
Aug 25 – Sep 7	Hurricane Dorian	Bahamas, Caribbean, US, Canada	83	10.0	3.5
March 12-31	Missouri Basin Floods	United States	10	10.0	2.5
June – October	Monsoon Floods	India	1,750	10.0	0.2
August 6-13	Typhoon Lekima	China, Philippines, Japan	101	9.5	0.8
March - April	Flooding	Iran	77	8.3	0.2
May 2-5	Cyclone Fani	India, Bangladesh	81	8.1	0.5
			All Other Events	126 billion	44 billion
			Totals	**232 billion[1]**	**71 billion[1,2]**

Exhibit 2: Significant 2019 Economic Loss Events[3]



[1] Subject to change as loss estimates are further developed
[2] Includes losses sustained by private insurers and government-sponsored programs
[3] Based on events that incurred economic loss equal to or greater than USD50 million. Position of an event is determined by the most affected administrative unit or epicenter.

Direct economic losses and damage from natural disasters in 2019 were estimated at USD232 billion. This was reduced from recent elevated levels in 2016, 2017 and 2018. The USD232 billion was 3 percent lower than the average (USD239 billion) and 5 percent lower than the median (USD243 billion) during the 21st Century. The economic losses were a further 20 percent lower than the average and 12 percent lower than the median of the past decade (2009-2018).

In terms of economic losses resulting solely from weather disasters – which are defined as events caused by atmospheric-driven scenarios – the global total was USD229 billion, which was 17 percent higher than the 21st Century average and 28 percent above the median. 2019 was the 8th costliest year in terms of weather-related natural disasters after adjusting for inflation.

The costliest individual peril was inland flooding at nearly USD82 billion. It was closely preceded by tropical cyclone (USD68 billion). Five of the top 10 costliest disasters of 2019 were flood-related: spring and summer flooding in the United States, separate seasonal monsoon floods in China and India, and a major flood event in Iran. Those five events alone accounted for more than USD53 billion in direct economic impact.

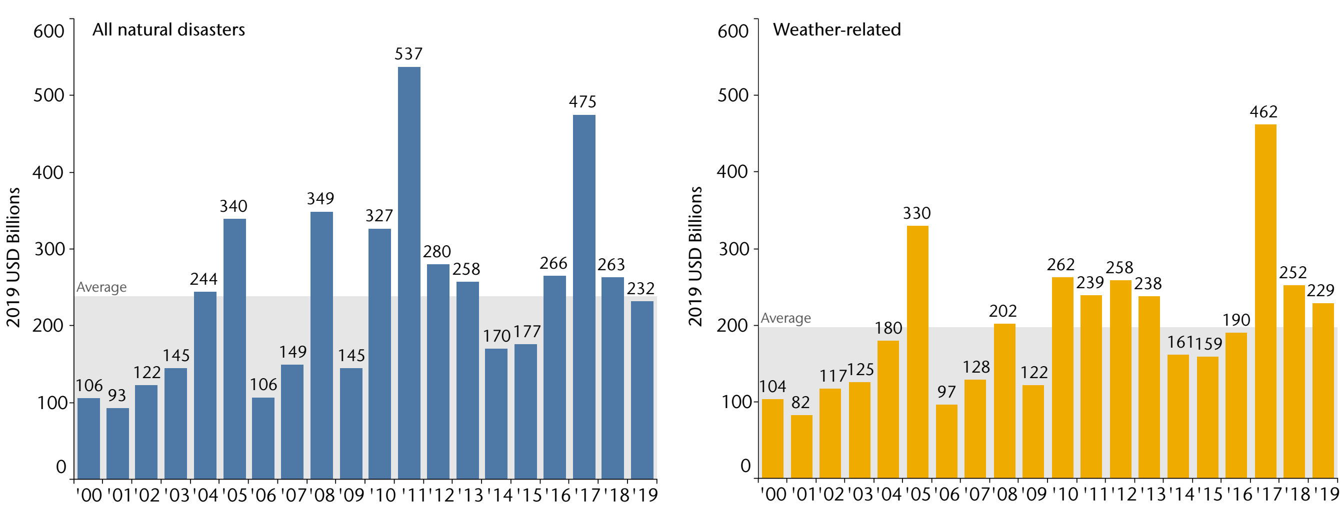
Three costly tropical cyclone events also occurred, each of which resulted in a minimal USD10 billion economic cost: Typhoons Hagibis and Faxai in Japan; and Hurricane Dorian in North America, with a majority of losses occurring in The Bahamas. Typhoon Lekima in China resulted in a loss of USD9.5 billion. Additional major events included destructive tropical cyclones in the Indian Ocean Basin – Cyclones Fani, Idai and Bulbul (Matmo), which collectively contributed to the global economic toll by more than USD14 billion. Due to many structures being poorly built in these areas, and limited insurance coverage, the affected regions suffered a heavy humanitarian impact.

Severe convective storms were also noteworthy as global thunderstorm-related damage topped USD30 billion for the tenth consecutive year. This remains one of the most consistent loss drivers on an annual basis, with much of the loss coming from events in the United States.

The only other peril with aggregate damage above USD10 billion was drought, which was actually below the average since 2010. Earthquakes were again not a predominant loss driver, as the costliest earthquakes of 2019 occurred outside of the Pacific Ring of Fire Region. The costliest and deadliest tremor occurred in Albania in November.

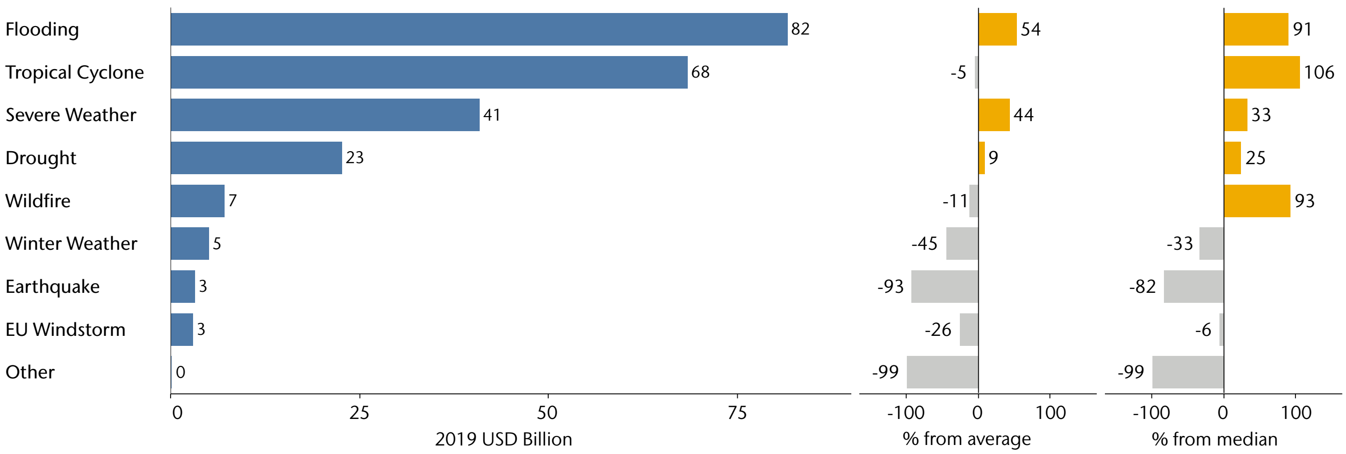
The economic and insured loss estimates in this document are up to date as of January 2020. As new data is obtained and loss development occurs, this may result in future adjustments of individual event and/or overall annual loss totals. Reanalysis is a common research methodology to ensure that the most accurate and realistic views of events are cataloged for meaningful natural disaster loss analysis. Also, please note that in some cases data has been rounded, and this may result in some regional or peril totals being slightly different from overall aggregate listings.

Exhibit 3: Global Economic Losses



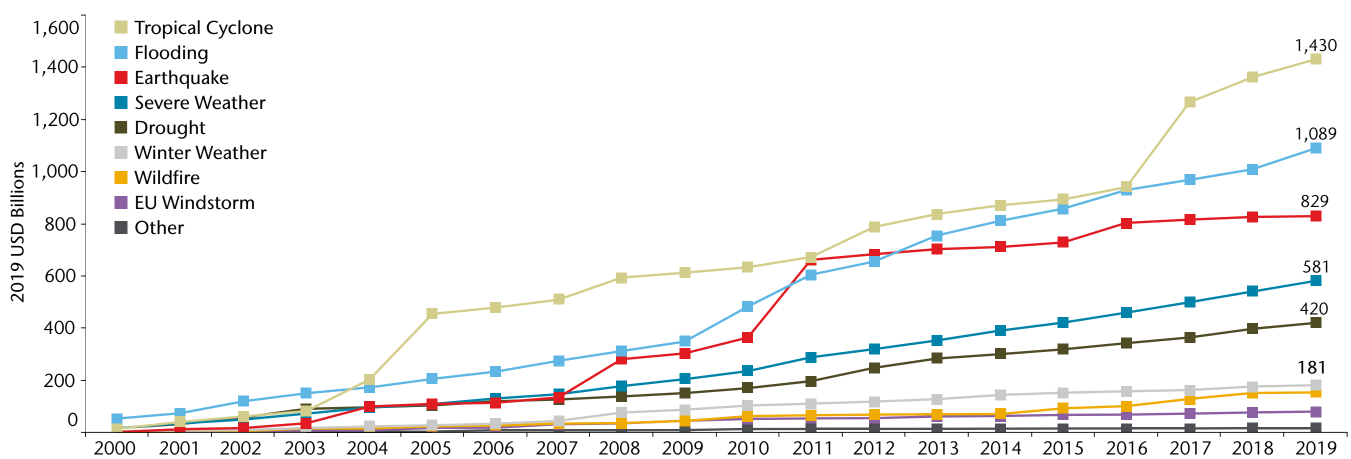
At USD82 billion, the inland flood peril was the costliest of 2019, and its highest year since 2013. Other expensive perils included tropical cyclone, severe weather, drought and wildfire; all of which generated losses above the median. All other perils were notably below long-term mean and median values (since 2000).

Exhibit 4: 2019 Global Economic Losses by Peril



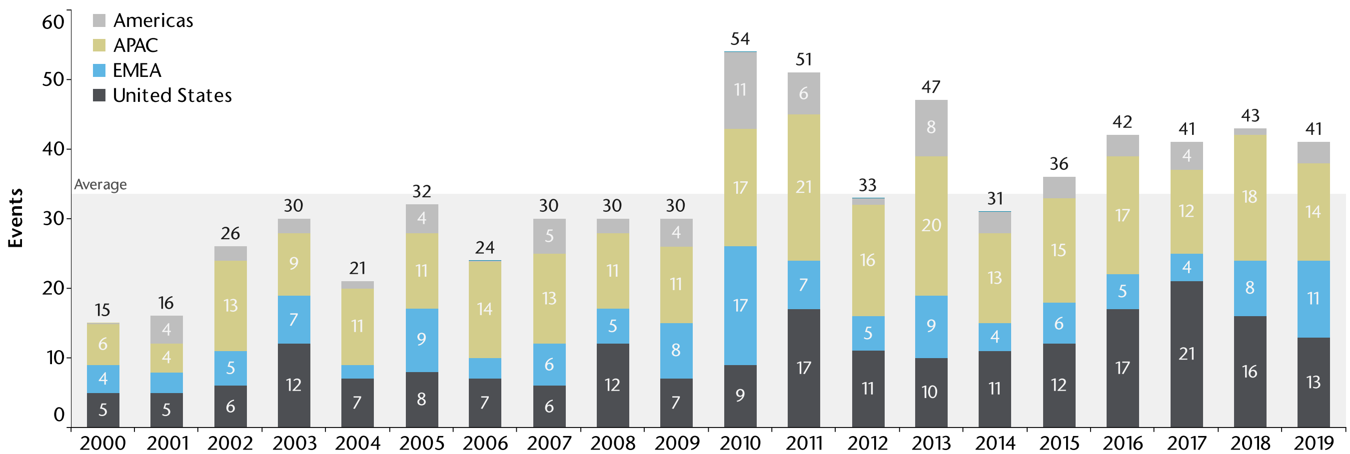
The costliest global peril around the world since 2000 has been tropical cyclone. This has largely been driven by extreme loss years in 2018, 2017, 2012, 2005, and 2004, which account for nearly USD909 billion of the USD1.43 trillion total alone. Similarly, earthquake ranks third with very costly years such as 2011 and 2008, but also very low years, such as 2019. Both perils are often driven by extreme annual volatility. Other perils have shown a steadier rate of increase, which suggests consistency during the past 20 years.

Exhibit 5: Cumulative Economic Loss by Peril



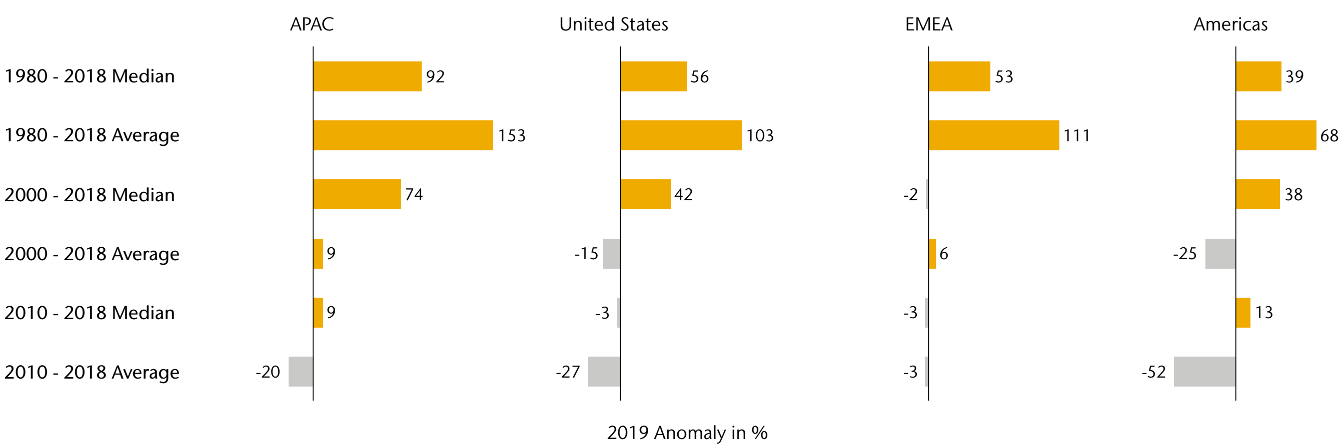
There were 41 individual billion-dollar natural disaster events in 2019, which was below the average of 33 events dating to 2000 and "below" the total of 43 such events recorded in 2018. All but one of the natural disaster events were weather-related. The 40 separate billion-dollar weather disasters were above the 30 recorded on average since 2000, and slightly higher than the 37 on average in the past decade. *Please note that Hurricane Dorian caused billion-dollar losses in both United States and Americas regions.*

Exhibit 6: Global Billion-Dollar Economic Loss Events



Note: Exhibit 6 includes events which reached the billion-dollar-plus (USD) threshold after an inflation-adjustment based on the 2019 U.S. Consumer Price Index.

Exhibit 7: 2019 Economic Loss Historical Comparison

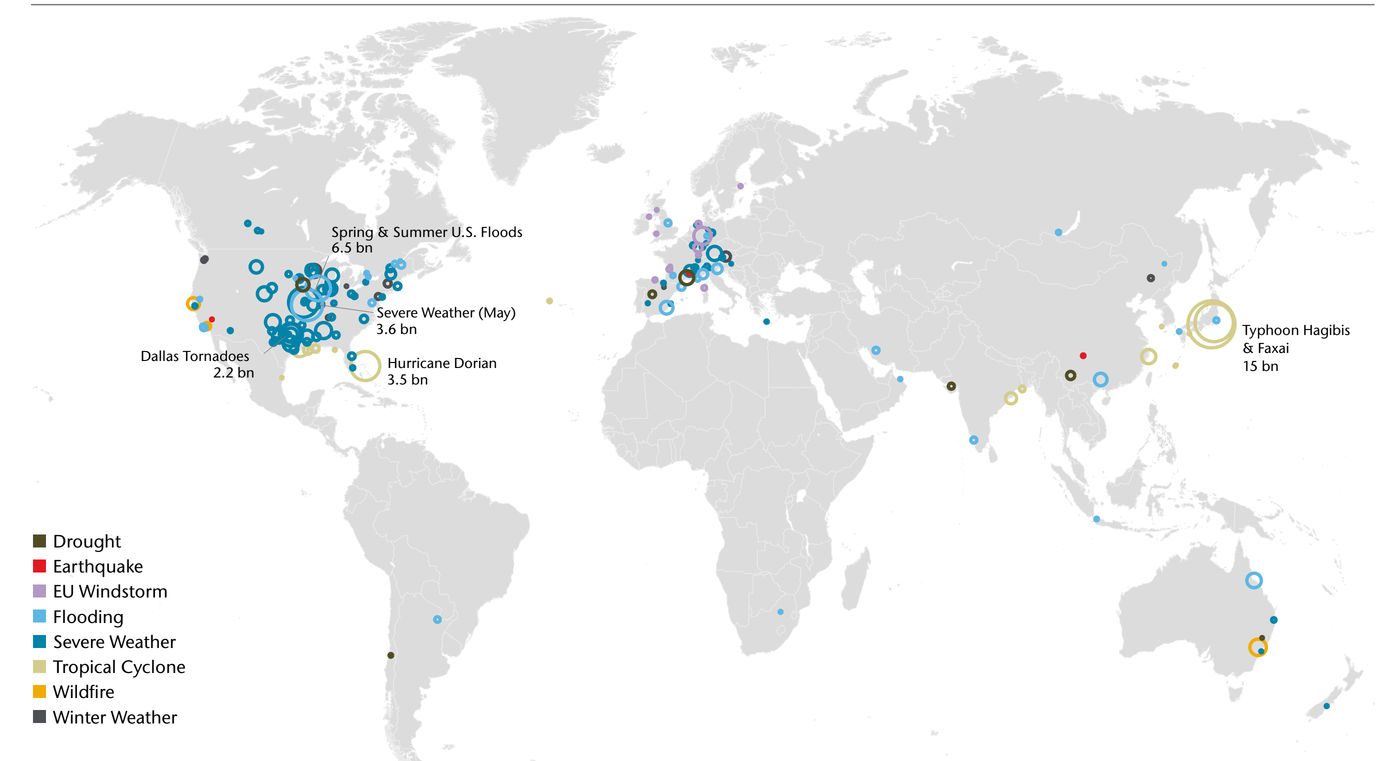


Global Insured Losses

Exhibit 8: Top 10 Global Insured Loss Events

Date(s)	Event	Location	Deaths	Economic Loss (USD billions)	Insured Loss (USD billions)
October 6-12	Typhoon Hagibis	Japan	99	15.0	9.0
September 7-9	Typhoon Faxai	Japan	3	10.0	6.0
May – July	Mississippi Basin Floods	United States	0	10.0	4.0
May 27-30	Severe Weather	United States	0	4.5	3.6
Aug 25 – Sep 7	Hurricane Dorian	Bahamas, Caribbean, US, Canada	83	10.0	3.5
March 12-31	Missouri Basin Floods	United States	10	10.0	2.5
October 20-21	Dallas Tornadoes	United States	4	2.8	2.2
March 23-25	Severe Weather	United States	0	1.8	1.4
March 10-11	Windstorm Eberhard	Western & Central Europe	2	1.6	1.2
September 17-22	Tropical Storm Imelda	United States	5	5.0	1.2
			All Other Events	161 billion	36 billion
			Totals	**232 billion[1]**	**71 billion[1,2]**

Exhibit 9: Significant 2019 Insured Loss Events[3]



[1] Subject to change as loss estimates are further developed
[2] Includes losses sustained by private insurers and government-sponsored programs
[3] Based on events that incurred insured loss equal to or greater than than USD25 million. Position of an event is determined by the most affected administrative unit or epicenter.

Insured losses from natural disasters in 2019 reached USD71 billion and were significantly lower than the record USD157 billion in 2017 and USD100 billion in 2018. This marked the first time on record for back-to-back years with insured catastrophe losses topping USD100 billion. However, despite the major reduction in 2019, payouts from public and private insurance entities were higher than both the 21st Century average (USD67 billion) and median (USD59 billion). Incurred losses were lower than the 10-year average and above the median.

Weather-related incidents drove virtually all of the insured natural disaster losses in 2019. This was due to a relatively subdued year for earthquake and tsunami occurrences that did not impact areas with widespread insurance take-up for the peril. All but USD265 million of the year's insurance losses were due to weather events. The cumulative tally well exceeded both the median and average values for the 21st Century.

The protection gap, which is the portion of economic losses not covered by insurance, was the fifth lowest since 2000 at 69 percent. The global protection gap was nevertheless higher than in 2018 (62 percent), as many of the costliest events occurred in regions where insurance penetration is generally lower, such as China, India and Iran. The United States accounted for 51 percent of insured payouts in 2019. In the past decade, the U.S. represented 53 percent of global payouts.

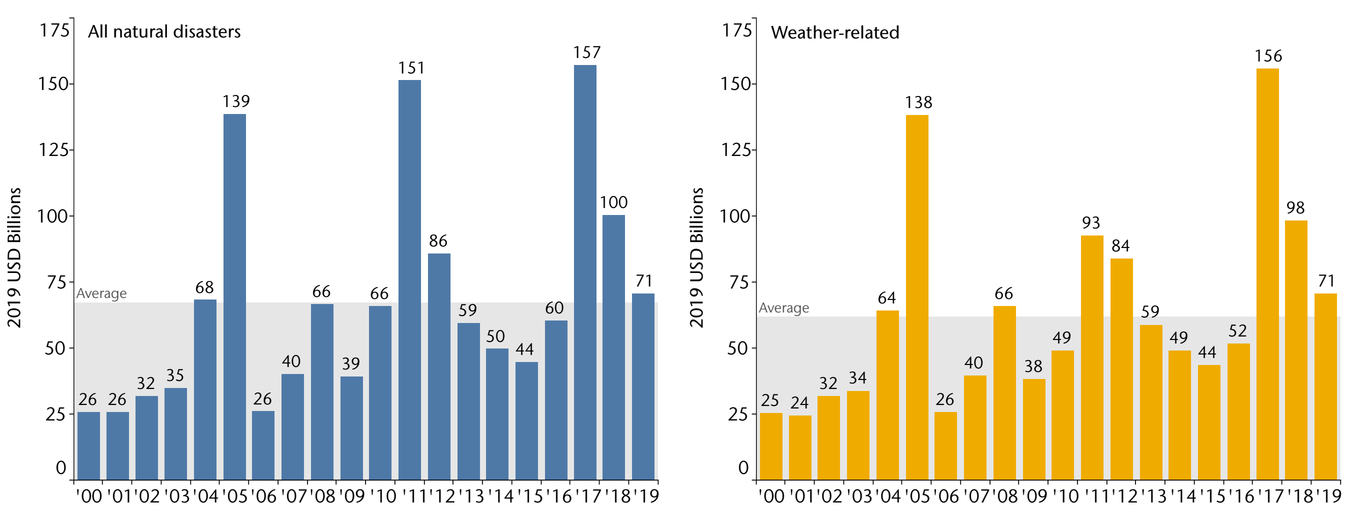
Despite a slim majority of global insured losses occurring in the U.S., for the first time on record, the two costliest insured events of the year occurred in Japan. Consecutive strong typhoon events – Faxai in September and Hagibis in October – each rendered substantial damage in densely populated areas, including the greater Tokyo metro and Chiba Prefecture, due to high winds and exceptional inland flooding. The combined insured loss was tentatively estimated at USD15 billion, though it was expected that a firmer view and by-event breakout of final insured payouts will not appear until Q2 2020. Hagibis and Faxai occurred as the local market was still coping from the record-breaking industry impact of Typhoon Jebi in 2018.

The costliest peril in 2019 for insurers was severe convective storm (SCS). This only further underlined the growing prominence of this type of catastrophe for insurers. 2019 marked the fourth consecutive year of SCS payouts topping USD20 billion globally. As the case in most years, this total was mainly driven by costly hail and wind outbreaks in the U.S.

After driving exceptional insured losses in 2017 and 2018, the wildfire peril was again elevated in 2019 – but substantially less than the previous two years. Two notable fires in California caused roughly USD900 million in payouts. Historic bushfires in Australia from November 2019 into January 2020 were set to become the country's most expensive on record.

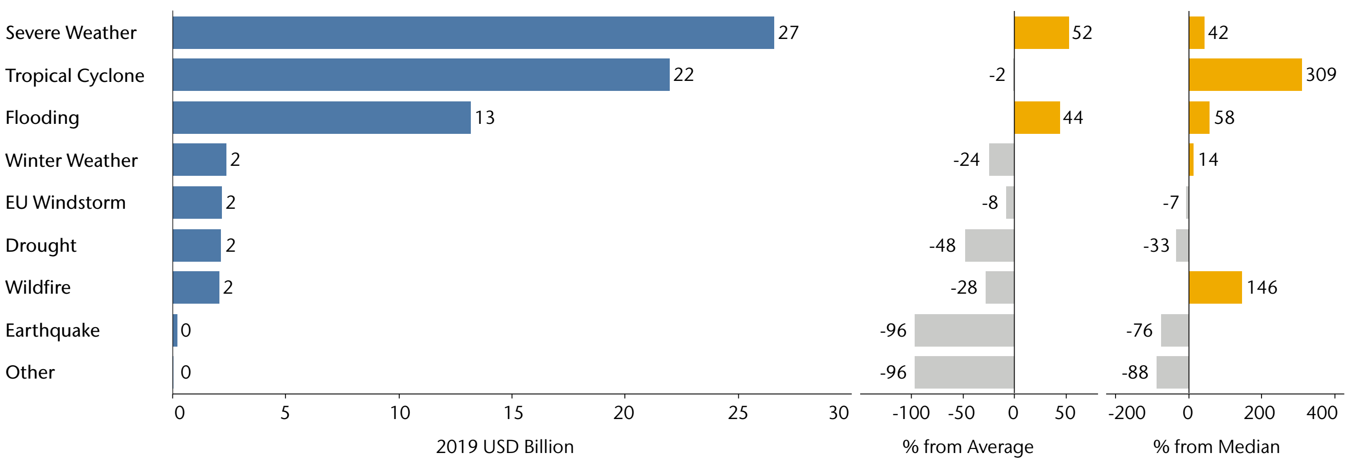
To read more regarding available re/insurance industry capital and the health of the overall market, please refer to Aon's Reinsurance Market Outlook.

Exhibit 10: Global Insured Losses



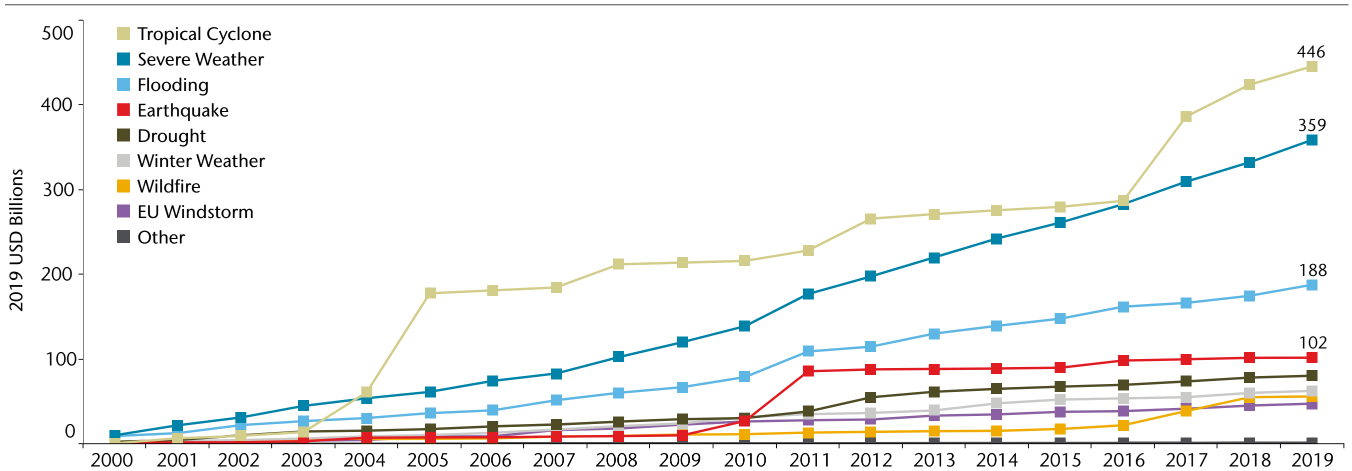
The costliest peril for public and private insurance entities in 2019 was severe weather, closely followed by tropical cyclone. All perils except severe weather, tropical cyclone and flooding generated insured losses that were below the long-term average values since 2000.

Exhibit 11: 2019 Global Insured Losses by Peril



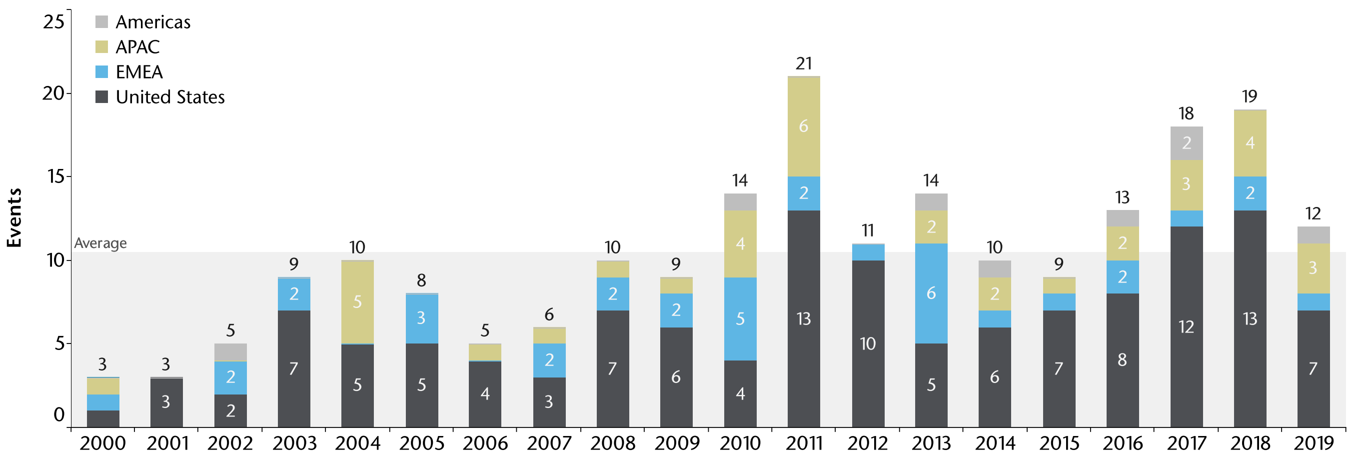
The tropical cyclone peril remained the costliest in the 21st Century. To provide perspective on the heightened activity of 2017, 2018, and 2019, the aggregated payouts from those years account for 36 percent of the last 20 years' worth of payouts for the peril, and 12 percent of all payouts for all perils since 2000. Losses from severe convective storms ranked second and showed a consistent rate of increase at an accelerated pace during the last 20 years. Wildfire, until recently a relatively insignificant annual loss driver for the industry, gained prominence after record-breaking losses in 2017 and 2018.

Exhibit 12: Cumulative Insured Loss by Peril



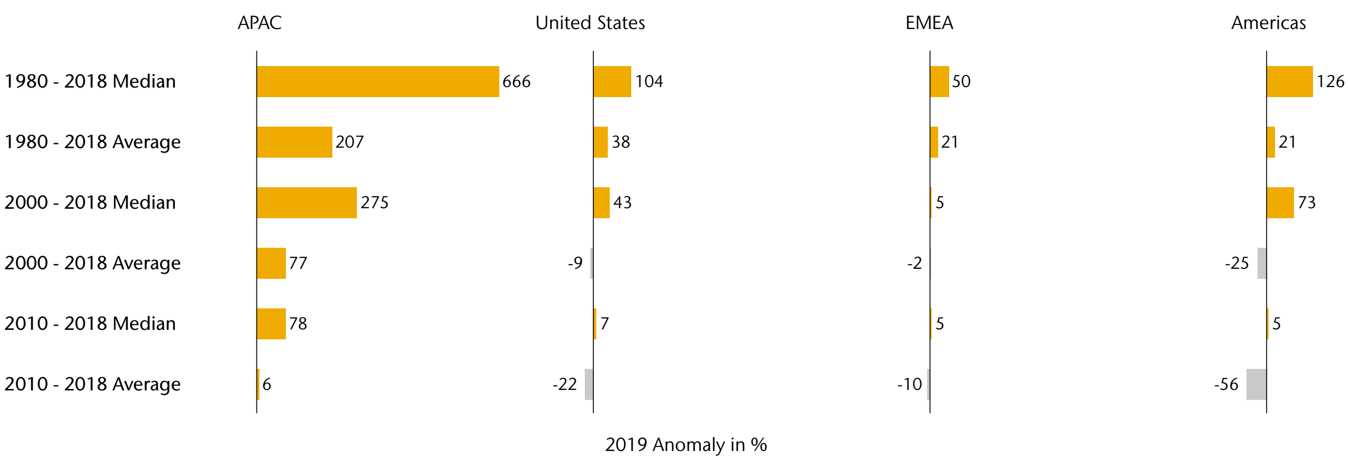
There were 12 individual billion-dollar natural disaster events in 2019, which was above the average of 10 dating to 2000 and lower than the 19 events that occurred in 2018. Four of these events were severe weather outbreaks in the United States, four were tropical cyclones, two were flooding events in the United States, one was Windstorm Eberhard in Europe, and the billion-dollar mark was also exceeded by the exceptional bushfires in Australia.

Exhibit 13: Global Billion-Dollar Insured Loss Events



Note: Exhibit 13 includes events which reached the billion-dollar-plus (USD) threshold after being adjusted for inflation based on the 2019 U.S. Consumer Price Index.

Exhibit 14: 2019 Insured Loss Historical Comparison



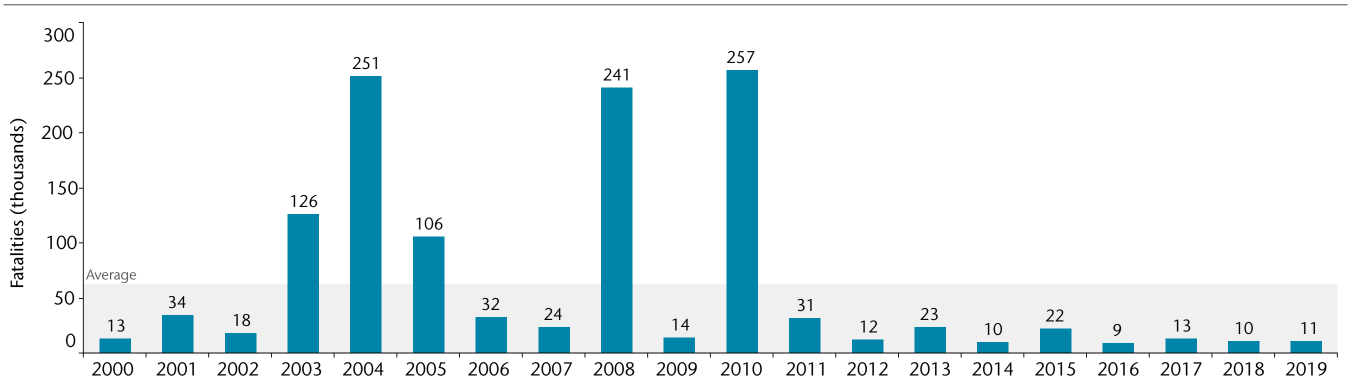
Global Fatalities

Exhibit 15: Top 10 Human Fatality Events

Date(s)	Event	Location	Deaths	Economic Loss (USD)
June - October	India Monsoon Floods	India	1,750	10 billion
March 4-17	Cyclone Idai	Southern Africa	1,303	2.7 billion
June - July	China Seasonal Flooding	China	300	15 billion
October - December	East Africa Floods	East Africa	216	140 million
July 9-31	Flooding	Bangladesh	210	75 million
March 16-18	Flooding	Indonesia	194	103 million
April 15-17	Severe Weather	India, Pakistan, Afghanistan	146	75 million
July - August	Flooding	Pakistan	143	75 million
October	Central Africa Floods	Central Africa	118	60 million
July - August	Flooding	Nepal	118	50 million
		All Other Events	~6,500	204 billion
		Totals	**~11,000**	**232 billion**

More than 10,000 people lost their lives to natural disasters in 2019. For the ninth consecutive year, the annual total was below the 21st-Century average and ranked among the 10 years with the lowest disaster-related fatality totals since 1950. Approximately 59 percent of fatalities occurred in the Asia-Pacific region and 36 percent in Europe, Middle East & Africa. The deadliest disaster of 2019 was prolonged monsoonal flooding in India, which resulted in death of at least 1,750 people. Cyclone Idai, with destructive landfall in Mozambique and additional effects in the wider region of Southern Africa, claimed at least 1,303 lives. It is worth noting that there remains uncertainty surrounding the death toll of Hurricane Dorian. The official toll is listed at 83, though hundreds of residents in the Bahamas were suspected to have died after being swept into the ocean. The deadliest earthquake of 2019 was the magnitude-6.4 tremor in Albania with 52 fatalities, which occurred in November. The peril saw the lowest fatality total since 2000.

Exhibit 16: Global Human Fatalities



Natural Disasters Defined and Total Events

An event must meet at least one of the following criteria to be classified as a natural disaster:

- Economic Loss: USD50 million
- Insured Loss: USD25 million
- Fatalities: 10
- Injured: 50
- Homes and Structures Damaged or Filed Claims: 2,000

Based on the noted criteria above, there were at least 409 individual natural disaster events in 2019, which was above the average (374) and median (375) since 2000. As typically anticipated, the most number of disaster events occurred during the second (104) and third (123) quarters. APAC retained the highest number, which is expected given Asia's expansive landmass and susceptibility of natural disaster events.

Exhibit 17: Total Natural Disaster Events

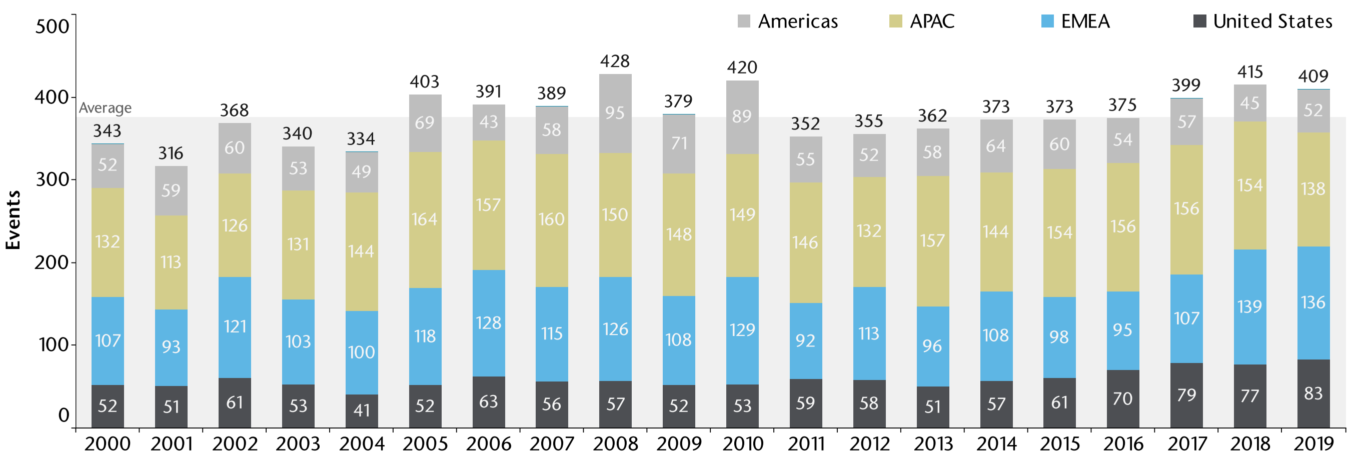
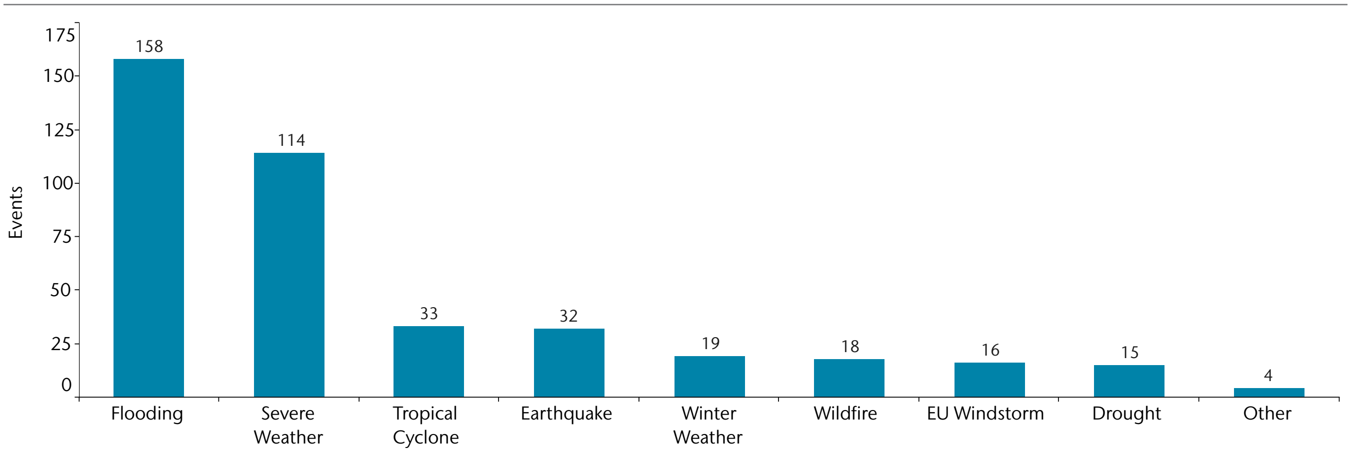


Exhibit 18: Total Natural Disaster Events by Peril in 2019



2010-2019: The Globe's Costliest Decade

Earthquakes. Tsunamis. Tropical cyclones. Severe Convective Storms. Inland flooding. Wildfires. Droughts. Extreme heat. Extreme cold. The 2010-2019 period featured record-breaking instances for each of those individual perils. The following will highlight the past decade of natural disasters and some important advances made in understanding these events.

Economic Loss

The decadal period from 2010-2019 marked the costliest in the modern record for global natural disasters on a nominal and inflation-adjusted basis. Total direct economic damage and losses tallied USD2.98 trillion. This was USD1.1 trillion higher than the previous decade (2000-2009); USD1.8 trillion. Asia-Pacific (APAC) accounted for USD1.3 trillion – or 44 percent – of the decadal total as catastrophic earthquake, tsunami, inland flood, and tropical cyclone events were recorded. The United States was second at USD906 billion following a series of significant hurricane landfalls and severe convective storm outbreaks. EMEA was third with USD396 billion and the Americas (Non-U.S.) was fourth with USD377 billion.

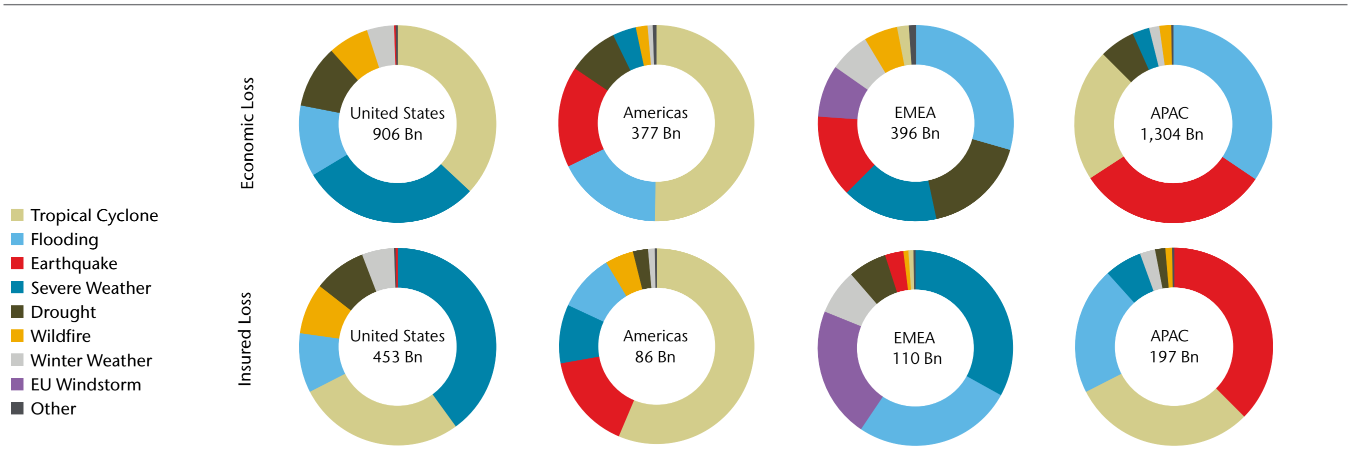
Many countries globally registered an event that resulted in their costliest economic natural disasters on record. A selection of such countries or territories include Japan, Thailand, Puerto Rico, Mozambique, Chile, Haiti, New Zealand, Nepal, and Brazil. The economic costs were almost certainly enhanced by a combination of more intense weather events, increased vulnerable exposure and population in the path of the event footprint, and elevated direct business interruption impacts due to greater supply chain dependency within a globalized economy.

Insured Loss

Record economic losses also equated to record payouts by the re/insurance industry. Private and public insurance entities paid out USD845 billion during the decade. The U.S. accounted for USD453 billion of that total alone; or 54 percent. This only reinforced that the U.S. remains the most mature property and casualty market in the world, and one of the most natural disaster-prone regions on the planet. In APAC, the top 10 insured loss events (USD120 billion) accounted for 61 percent of the region's entire decade total.

The decade also further highlighted the significant protection gap that persists in developing and emerging countries. The protection gap is the portion of economic damage not covered by insurance. No part of the world was more vulnerable to this topic than in Asia, where just 12 percent of economic losses – USD152 billion out of USD1.24 trillion – were covered by insurance. In addition to Asia, there remain major protection gap issues across Latin America and Africa as most of these countries have insurance take-up rates in the low single-digits. This means that, in most major disaster events, virtually all losses are uninsured and local populations are entirely dependent on financial support from the federal government or international aid agencies for recovery. The development of new insurance schemes, such as parametric insurance, insurance risk pools, or catastrophe bonds, will be important new ways to improve risk mitigation in the most vulnerable areas.

Exhibit 19: Economic & Insured Loss Breakout by Peril (2010-2019)



Decadal Loss Trends

The past decade provided some significant shifts in catastrophe loss trends – both regionally and on a by-peril basis. Starting on a regional level, each of the four primary regions of the globe established a new decadal record for most aggregate catastrophe losses on an inflation-adjusted basis. (For this analysis, inflation-adjusted losses are used to highlight actual incurred losses in today's dollars; as opposed to a normalized technique to assume hypothetical event cost occurrence with today's population, exposure, and wealth.)

When comparing losses of the 2000s versus the 2010s, the most considerable uptick occurred in the Americas; notably the Caribbean. The region registered a 192 percent increase in economic costs from natural perils in the 2010s compared to the 2000s. This was largely driven by the historic Atlantic hurricane season of 2017 and Hurricane Dorian in 2019. Asia-Pacific also saw a major uptick in financial impact, with costs showing a 96 percent increase when comparing back-to-back decades. The region became the first to ever record more than USD1.0 trillion in damage during a 10-year period. The United States (+36 percent) and EMEA (+19percent) also showed decadal growth.

The increases on a regional basis follow similar, steady loss growth that has annually occurred since 1950. Catastrophe losses have grown by +4.2 percent annually above the rate of inflation since 1950. Perhaps surprisingly, the United States has shown the least rate of growth during this timeframe at +3.5 percent. APAC leads at +5.9 percent, followed by EMEA at +4.8 percent and the Americas at +3.8 percent. The regional differences can be attributed to improvements in data availability in recent decades, costlier and more frequent major disaster occurrences, and increased vulnerable assets.

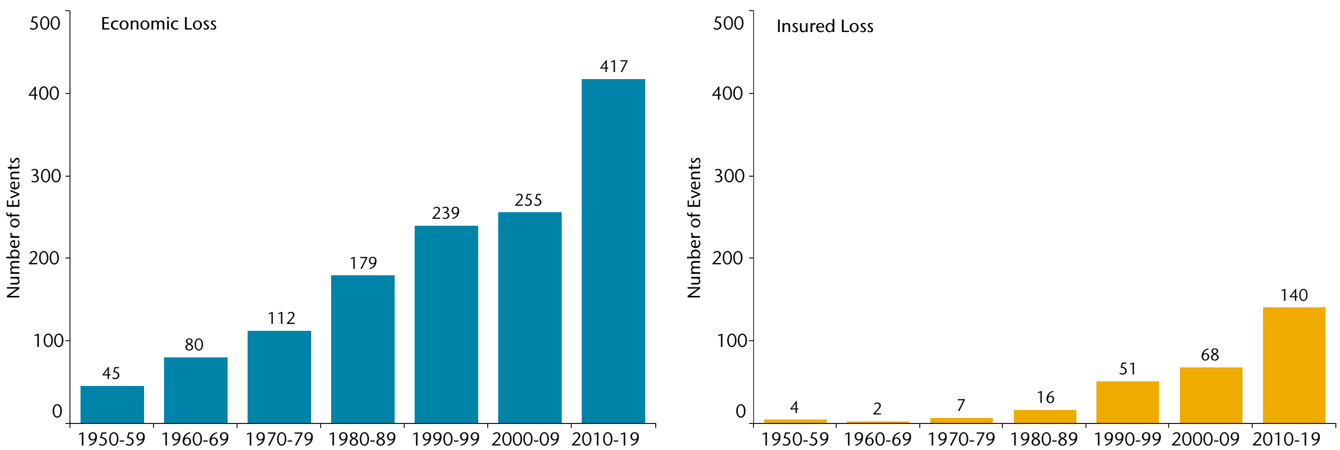
With insurance becoming much more globally utilized since 1980, a slightly shorter timescale is used to identify the annual rate of growth. Unsurprisingly, it has grown at an expedited and faster rate of growth than economic losses at +6.5 percent above the rate of inflation. The steady increase in global insurance premium and take-up remain the primary drivers of this uptick. Regional increases include APAC at +11.8 percent, Americas at +7.7 percent, United States at +6.1 percent, and EMEA at +5.8 percent. As more developing and emerging markets across Asia and Latin America develop new insurance programs and schemes, it makes sense that these areas have shown the highest rates of growth.

On a by-peril basis, tropical cyclone and inland flood were the globe's two costliest perils of the decade. Unsurprisingly, these perils showed significant annual volatility as various atmospheric and oceanic conditions – such as ENSO phase – can often impact event frequency and location. The most consistent peril remains severe convective storm. Of the four perils since 1980 which have caused at least USD750 billion in combined economic losses, severe convective storms had the least standard deviation at USD11 billion. The other four were much higher: tropical cyclone (USD63 billion), earthquake (USD58 billion), and flooding (USD28 billion).

What's Next for Loss Trends in the 2020s

Of course it is impossible to know precisely what the next decade will bring. If loss trends are a guide, however, then it is expected that there will continue to be larger and costlier events on a global scale. Much of this increase will be directly tied to further population migration and exposure growth patterns to coastal and inland areas which have long been identified as highly vulnerable to natural peril risk. Scientific research continues to indicate that climate change effects will grow more obvious as sea level rise persists at an accelerated rate and more individual weather events will show signs of climate change influence. Climate change event attribution will remain one of the biggest questions to be answered.

Exhibit 20: Billion-Dollar Disasters per Decade; Adjusted to 2019 USD



Humanitarian Impacts

While much focus is on the financial side of natural disasters, perhaps the most important incurred impacts from these events involves the people whose lives are forever altered. Regardless of country or region, the widespread breadth of spatial coverage by large tropical cyclones, earthquakes, floods, tornadoes, or droughts can leave devastating damage to physical property, land, or life itself.

The decade saw one of the deadliest catastrophe events and resultant humanitarian crisis in decades: the January 12, 2010 M7.0 Haiti Earthquake. Unofficial death toll estimates ranged from 160,000 to 316,000 as extensive damage occurred to virtually every structure in the capital of Port-au-Prince and surrounding cities. A decade later and the country still has a long way to go for a full recovery. Similar humanitarian crises were noted in Mozambique following the 2019 landfall of Cyclone Idai; in Japan following a historic tsunami from the M9.1 Tohoku earthquake in March 2011, including the most severe nuclear reactor disaster since Chernobyl in 1986; in the Philippines following Typhoon Haiyan in 2013; in Nepal following a M7.8 earthquake in April 2015; and severe drought conditions across Africa and the Middle East during the decade which resulted in food insecurity.

Data Availability

The decade also proved important in the advancement of data availability in the weather and climate realm. Internationally renowned agencies such as the World Meteorological Organization (WMO), National Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey (USGS), and various academic institutions all achieved great successes in making available more satellite, instrument-based, and/or modeled datasets. Such information is critical as progress is further made in better understanding the background science of how, when, and why natural perils occur. As technology further improves and computational power increases, the granularity of modeled datasets will only grow more defined. This should improve the ability to better predict future risks.

Climate Change

There was perhaps no topic that became more engrained into the global social fabric during the past decade than climate change. The most notable development occurred in December 2015, when nearly every country in the world signed the Paris Climate Agreement. This was achieved at the United Nations Framework Convention on Climate Change that sought to minimize future growth of greenhouse gas emissions and halt the growth of global average temperatures to below 1.5°C by the second half of the 21st Century and improve mitigation, adaptation, and finance practices.

Financial institutions became more involved in the subject during the latter half of the decade. This was led by the 2015 Task Force on Climate-Related Financial Disclosures (TCFD) initiative that sought to improve transparency around how climate change may affect company financial statements and investments. Other more localized initiatives on a country level were seen in Europe and Asia. One such example was the Prudential Regulation Authority (PRA) by the Bank of England that required banks and insurers to implement stress tests by considering how future climate change scenarios could affect their balance sheets.

Climate change additionally changed the conversation on future real estate investment and infrastructure spending. With the expectation of greater sea level rise and more impactful weather-related events, companies and governments were forced to start addressing ways to retrofit already-built structures and make tough decisions on the livability of some locations. Risk mitigation and resilience became important topics as the calendar turned to 2020.

Exhibit 21: Costliest Natural Disasters of the Decade (2010-2019)

Event (Year)	Economic Loss
Tohoku EQ & Tsunami (2011)	269 billion
Hurricane Harvey (2017)	130 billion
Hurricane Maria (2017)	93 billion
Hurricane Sandy (2012)	85 billion
Hurricane Irma (2017)	78 billion
Thailand Floods (2011)	51 billion
Yangtze River Basin Floods (2010)	41 billion
Kumamoto Earthquakes (2016)	41 billion
United States Drought (2012)	37 billion
Chile Earthquake (2010)	35 billion

Event (Year)	Insured Loss
Tohoku EQ & Tsunami (2011)	40 billion
Hurricane Sandy (2012)	33 billion
Hurricane Irma (2017)	33 billion
Hurricane Harvey (2017)	31 billion
Hurricane Maria (2017)	31 billion
Thailand Floods (2011)	18 billion
United States Drought (2012)	16 billion
Christchurch Earthquake (Feb. 22, 2011)	16 billion
Typhoon Jebi (2018)	13 billion
Hurricane Michael (2018)	13 billion

All values inflation-adjusted to 2019 USD

2019 Natural Peril Review

Focus Topic: Tropical Cyclone

Above Average Activity in 2019

2019 marked the third consecutive year with several notable and costly tropical cyclone landfalls. From a financial standpoint, the costliest events were Typhoon Hagibis (Japan), Typhoon Faxai (Japan), Hurricane Dorian (Bahamas), Typhoon Lekima (China), Cyclone Fani (India), and Tropical Storm Imelda (United States). Collectively, these six storms alone combined to cause nearly USD58 billion in economic damage. Perhaps most notable was the fact that Japan faced its second consecutive year of substantial typhoon-related insurance payouts, with Hagibis and Faxai resulting in nearly USD15 billion in payouts alone. Dorian became the costliest natural disaster on record in the Bahamas – economic losses estimated at nearly USD8 billion – and also the local insurance industry's most expensive event with payouts topping USD2.5 billion.

From a humanitarian perspective, Mozambique faced a severe crisis following back-to-back landfalls from Cyclone Idai and Cyclone Kenneth. Nearly two million people were left displaced across the country as a multi-year rebuilding process was anticipated.

Overall tropical cyclone activity – as seen in Exhibit 22 below – was above normal based on the number of named storms, hurricanes (Category 1+), and major hurricanes (Category 3+) in comparison with the climatological average from 1981-2010. The categorical scale used is the Saffir-Simpson Hurricane Wind Scale. There were 98 named storms, including 71 in the Northern Hemisphere, of which 52 strengthened into hurricanes (1-minute sustained average winds of 74 mph (119 kph) or greater). Thirty-three of those storms intensified into major hurricanes (1-minute sustained winds of 111 mph (179 kph) or greater).

As typically expected, the most active basin was the Western Pacific with 16 hurricane-equivalent storms. Six such storms, equal to a normal year, were recorded in the Atlantic. The other basins included: South Indian (13), East Pacific (7), North Indian (6), and South Pacific (4). Major hurricane-equivalent storms (Category 3+) were normal across the Northern Hemisphere, and slightly above normal in the Southern Hemisphere.

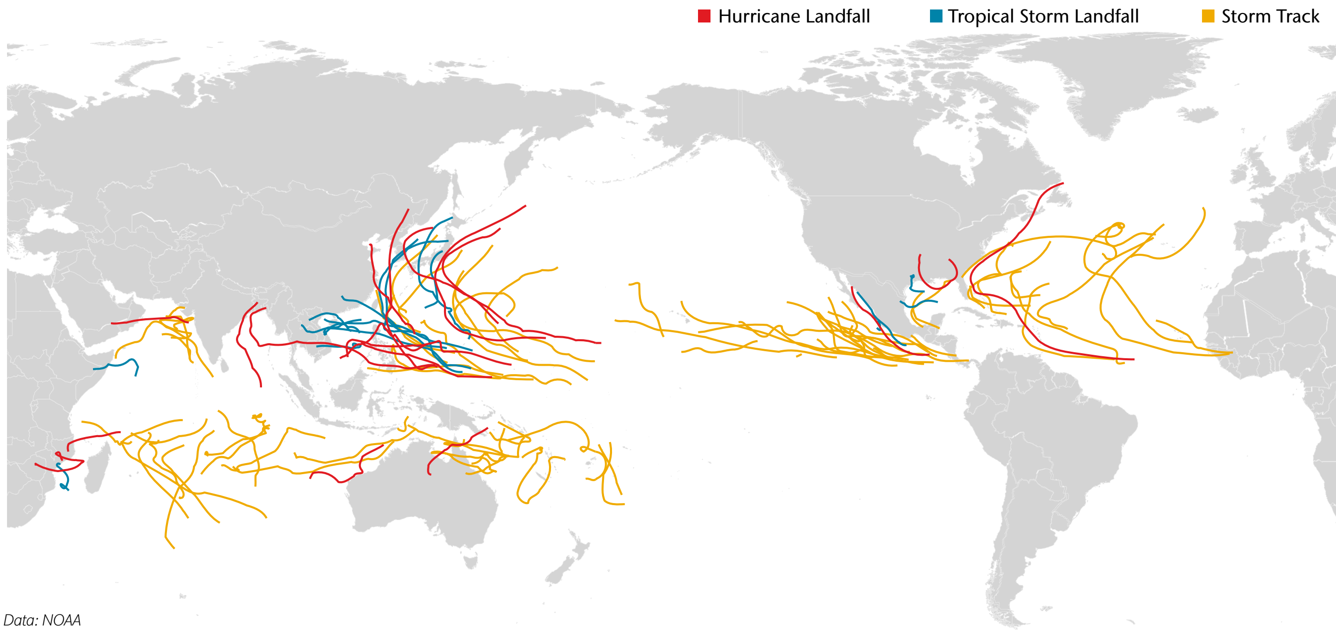
In terms of the Accumulated Cyclone Energy (ACE), the global average for 2019 was 843.3; higher than the climatological average of 769.9. ACE is a measure that helps indicate how active individual storms or entire seasons have been. It uses an approximation of wind energy based on the intensity and duration of storms across a six-hour time interval.

Exhibit 22: 2019 Global Tropical Cyclone Activity by Basin*

Basin	Named Storms	Hurricanes	Major Hurricanes	ACE
Atlantic	18 (12)	6 (6)	3 (3)	129.8 (105.6)
East Pacific	19 (17)	7 (9)	4 (4)	97.5 (132.1)
West Pacific	27 (26)	16 (17)	11 (9)	269.4 (307.3)
North Indian	7 (5)	6 (2)	3 (1)	88.6 (19.1)
Northern Hemisphere	*71 (59)*	*35 (34)*	*21 (17)*	*585.3 (564.1)*
South Pacific	9 (10)	4 (5)	1 (2)	53.6 (71.0)
South Indian	18 (16)	13 (9)	11 (4)	204.4 (134.7)
Southern Hemisphere	*27 (26)*	*17 (14)*	*12 (7)*	*258.0 (205.9)*
Global	**98 (86)**	**52 (47)**	**33 (23)**	**843.3 (769.9)**

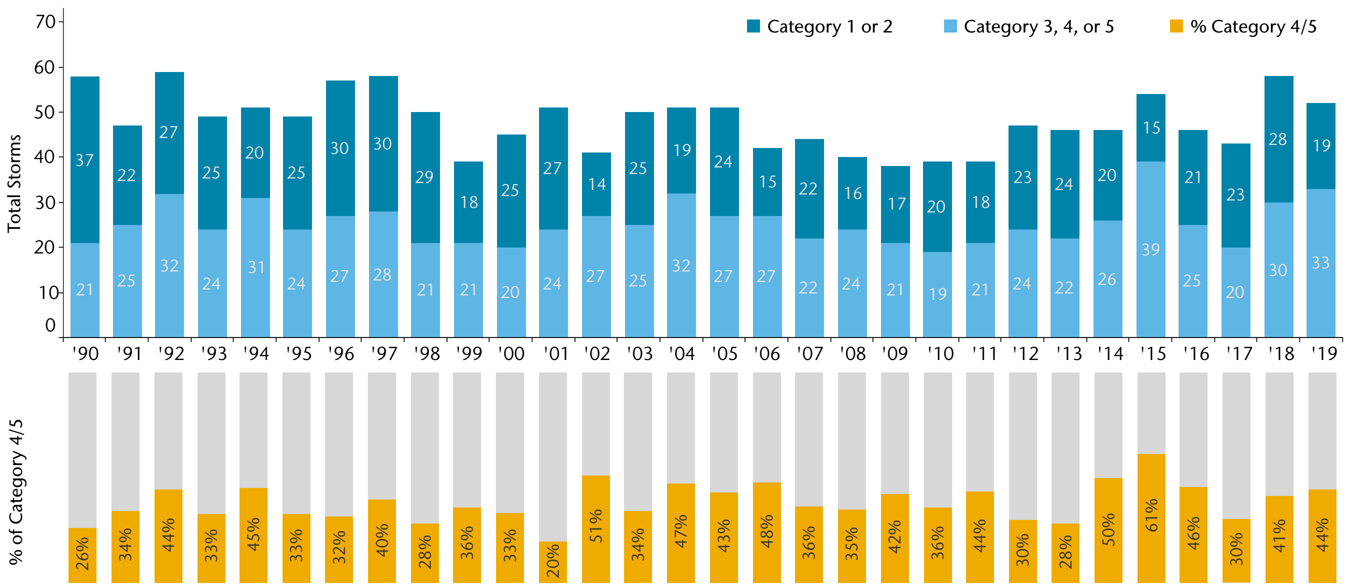
**Data in parenthesis is the 1981-2010 climatological average. The 2019 Southern Hemisphere season ran from July 1, 2018 to June 30, 2019.*
Source: National Hurricane Center; Joint Typhoon Warning Center; Colorado State University

Exhibit 23: 2019 Global Tropical Cyclone Track Map



Data: NOAA

Exhibit 24: Global Tropical Cyclone Trends



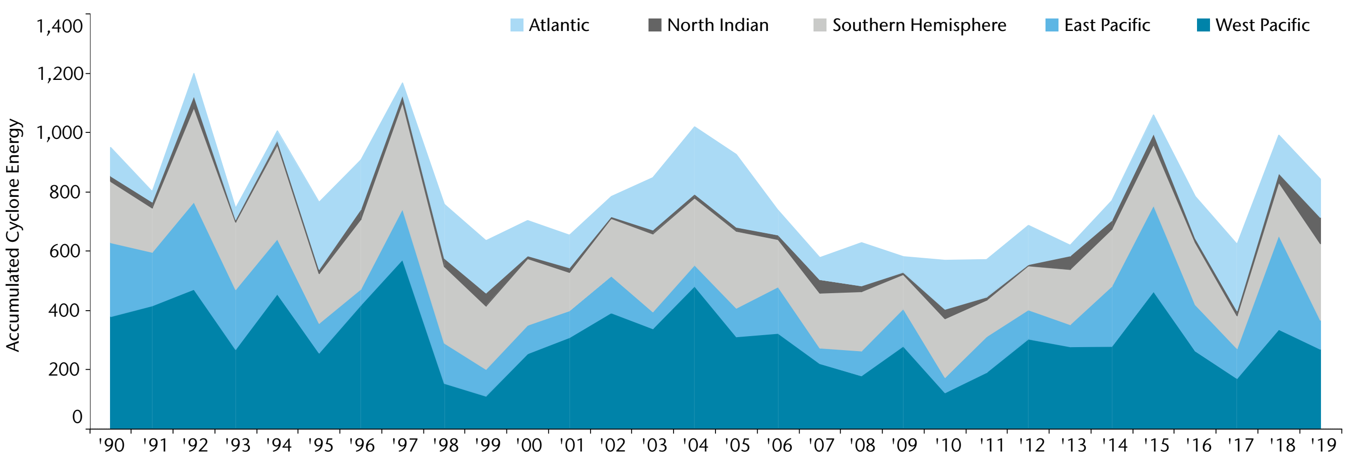
Data: NOAA

Accumulated Cyclone Energy

The global ACE values, as previously noted, were above the climatological norm in 2019. This marked the second consecutive year of higher-than-normal ACE values. Despite this recent uptick, the general trend of ACE values since 1990 has actually been largely flat; a negative 0.91 percent annual rate of growth. This suggests that overall seasons have not shown any statistically significant change as the overall frequency of storms on a per-year basis has not changed much.

However, when viewing individual storms, a different pattern continues to emerge. This is also where a climate change influence is becoming more apparent. As warmer oceanic and atmospheric conditions become conducive for more instances of rapid intensification cycles and/or storms maintaining maximum intensity for longer periods of time, it is expected that the storms which do develop have the potential to be larger, more intense, and pose a greater risk to coastal and inland vulnerabilities. The past three decades has resulted in an increasing percentage of hurricanes becoming high-end, Category 4 or 5 storms. The decadal breakout includes: 1990-99 (35 percent); 2000-09 (39 percent); 2010-19 (41 percent).

Exhibit 25: Global Accumulated Cyclone Energy (ACE)



Data: NOAA

2019 Notable Tropical Cyclone Seasonal Records

- Hurricane Dorian: 185 mph (295 kph) winds at landfall in the Bahamas; tied with the 1935 Labor Day Hurricane as the strongest Atlantic Ocean hurricane landfall on record; spent 27 hours at Category 5 intensity while affecting the Bahamas, the longest such occurrence on record
- Hurricane Lorenzo became the easternmost Category 5 on record in the Atlantic Ocean
- Hurricane Pablo was the farthest east and second farthest north hurricane in the Atlantic Ocean
- Tropical Storm Pabuk became the earliest forming storm on record in the Western Pacific Ocean
- Typhoon Wutip became the first Category 5 super typhoon and strongest tropical cyclone on record in the Northern Hemisphere during the month of February
- 2019 marked the highest year for ACE in the North Indian Ocean on record
- Cyclone Idai became the costliest cyclone in South West Indian Ocean basin
- Cyclone Kenneth became the strongest storm to make landfall in Mozambique on record

Global Landfall Trends

There were at least 18 official hurricane-equivalent landfalls around the globe during the 2019 season. This was one more than the 1990-2018 average. The West Pacific recorded eight such landfalls, with the most notable being typhoons Hagibis, Faxai, and Lekima. Four Category 1+ storms came ashore during the official 2019 Southern Hemisphere season, and three were recorded in the North Indian – the second year in a row and tied for the most since at least 1990. Only two hurricanes made landfall in the Atlantic, but Dorian struck the Bahamas as one of the strongest tropical cyclones in the official global record. Of the 16 hurricanes that made landfall in 2019, six were equivalent to Category 3 or stronger: Dorian, Kammuri, Kenneth, Fani, Trevor, and Phanfone. This was equal to the 1990-2018 average.

Please note that 1990 is generally considered the first year when global tropical cyclone data are best verified in every basin. Data from the Southern Hemisphere prior to 1990 is still subject to future reanalysis by official tropical cyclone agencies.

Exhibit 26: Global Tropical Cyclone Landfalls (Category 1+)

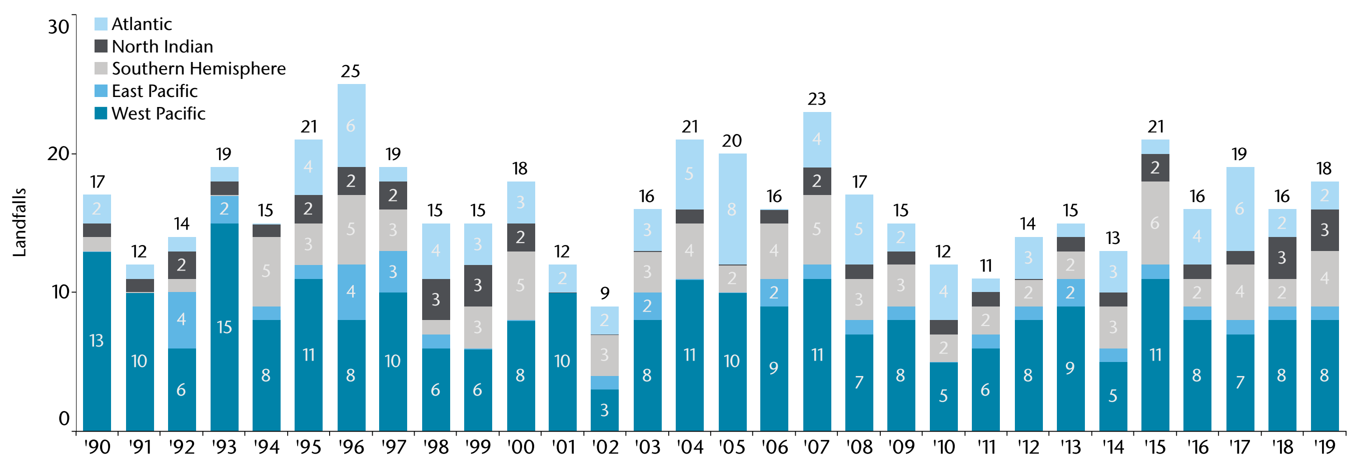
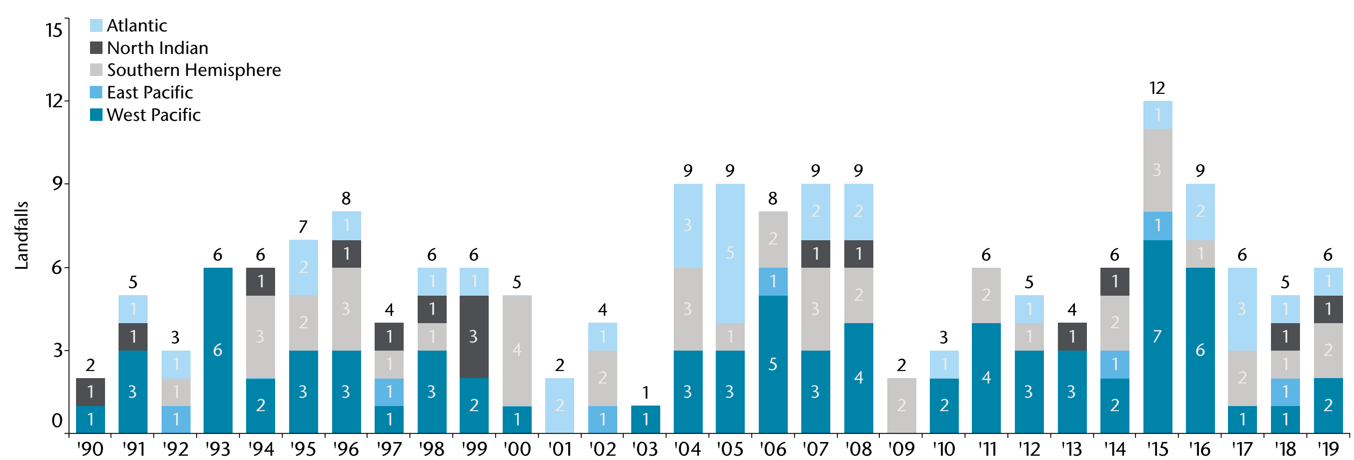


Exhibit 27: Global Tropical Cyclone Landfalls (Category 3+)



A humanitarian perspective

Trevor Riggen; *American Red Cross*

2019 was a year full of extreme and costly weather events—resulting in a string of disasters, ranging from wildfires in California, to Hurricane Dorian which ravaged islands in the Bahamas, to record-breaking flood impacts across the Central U.S.

With an increased level of disaster risk and occurrence, the overall landscape of natural disaster preparedness and response continues to expand on a global scale.

As a result, demand for our services is increasing. In 2014, the Red Cross was initiating a major domestic disaster response approximately every 34 days. Today, we are responding to significant disasters about every two weeks.

These upsurges—potentially our new normal—coupled with our organization's increased disaster response cadence, require us to be as effective, nimble and responsive as possible—especially during the critical post-disaster hours and days.

Whether it is a big disaster, like a hurricane or flood, or an "everyday disaster" like a home fire, we need to be ready to immediately scale to where the needs are, and directly assign our best resources to address those needs.

For any disaster, access to information is critical for those responding. In the U.S., the state-of-the-art disaster management system for the Red Cross, RC View, leverages the latest in GIS technology to source and display real-time service delivery data, as well as visualize damage and the needs of communities—enabling us to better allocate resources, accelerate relief and streamline operations.

Internationally, many remote communities are missing from maps that responders use to deliver lifesaving aid. To get relief into people's hands more quickly, we use virtual volunteers to map high-risk areas. The resulting digital maps help expedite the delivery of emergency supplies, determine where help is needed most, and even track the spread of diseases like Ebola.

At the same time, we want to empower people with the knowledge and resources they need to make them ready for and more resilient in the face of these emergencies – so we have put preparedness in people's pockets by developing an innovative series of emergency preparedness mobile apps—including first aid and early warning apps customized to local communities around the globe.

I am truly proud of the work we are doing to revolutionize our service delivery and help make communities safer, but I am even more grateful for the support we get from our generous volunteers, community partners and philanthropic donors – like Aon – who stand alongside us to ensure we can innovate and better support the needs of people impacted by disasters.

Focus Topic: Flooding

U.S.: Importance of Crop Insurance

In a year marked by several large flood events around the world, the most financially expensive and impactful to agriculture was incurred in the United States. An exceptionally wet stretch from January to May – which was the wettest period on record in the contiguous U.S. since reliable data began in 1895 – led to multiple bouts of significant and damaging flooding across parts of the Plains, Midwest, and the Mississippi Valley. Exhibit 28 provides a county-level analysis of January-May rainfall totals as a percentage of the 20th century average. The excessive precipitation is exceedingly evident in the Plains, Midwest, Mississippi Valley, and parts of the West.

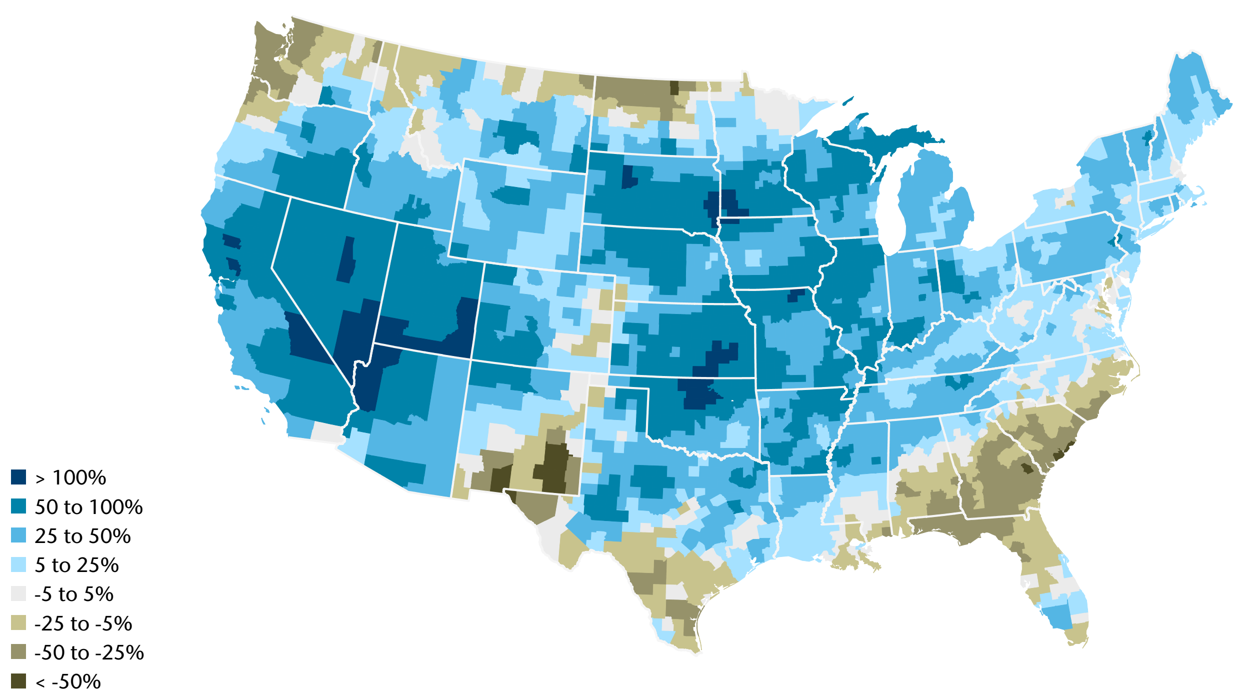
The first wave of flooding occurred during March 2019 after numerous rivers and streams throughout the Missouri River Basin resulted in extensive damage to physical property, infrastructure, and agriculture in South Dakota, North Dakota, Minnesota, Nebraska, Iowa, and Missouri. The second wave of flooding was noted from May through July. An even more expansive area of the Midwest and Southeast was impacted; notably within the Mississippi, Arkansas, and Ohio River Basins.

Major inundation to property and agriculture was cited in the hardest-hit states of Illinois, Ohio, Michigan, Indiana, Arkansas, Missouri, and Wisconsin. Many river gauge locations set all-time record high crests; surpassing previous records set in 1993, 2008, and 2011. Some areas cited river levels at major flood stage for more than 100 consecutive days.

Additional notable, and impactful, flooding was cited in California during the first quarter of 2019 following a series of strong Atmospheric River events that resulted in well-above normal precipitation. Flash flooding led to mudslides and debris flows in areas which had been recovering from major wildfire events during 2017 and 2018. Further flooding due to elevated rainfall was also recorded across the Central and Eastern United States during the late summer and fall months that only exacerbated crop impacts.

The total combined economic cost from U.S. flood events was estimated at nearly USD24 billion. This is the second-costliest year for non-tropical cyclone-related flooding in the U.S. on record; only behind 1993 (USD40 billion).

Exhibit 28: U.S. 2019 Spring Precipitation Anomaly against 21st-Century average



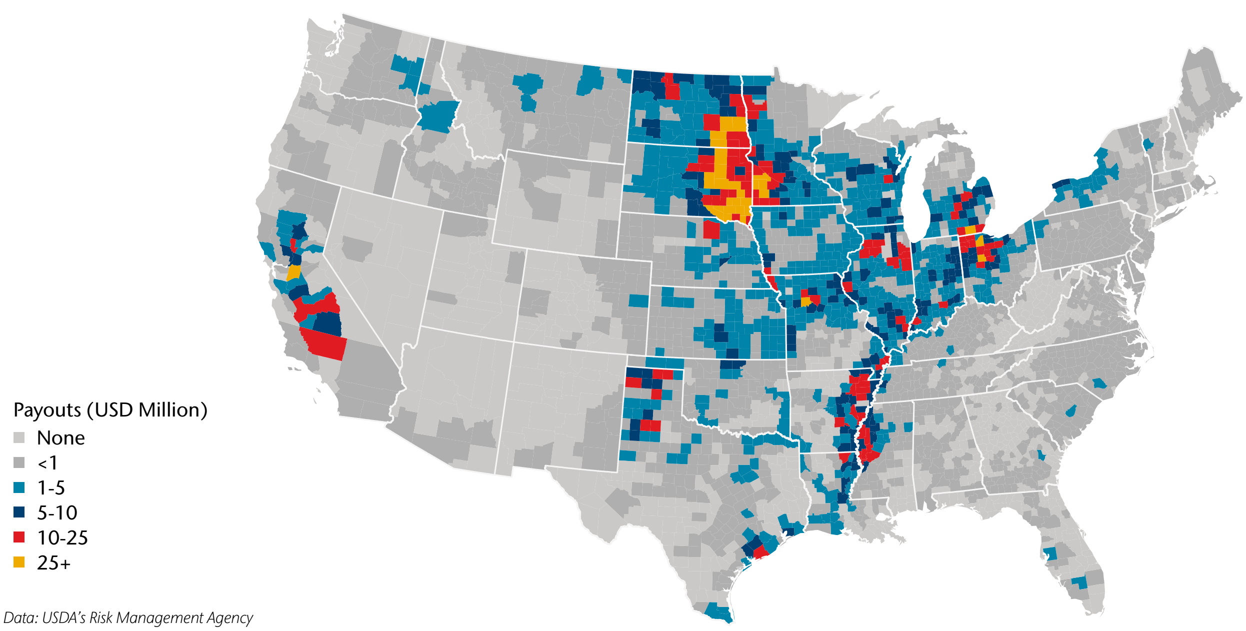
Data: NOAA

2019 also marked the most expensive year on record for the flood peril for the USDA's Risk Management Agency crop insurance program. More than USD6 billion in flood and excess moisture-related payouts were made to policyholders. This was nearly USD2 billion more than the previous high of USD4.3 billion in 2011. The agricultural and crop-related flood losses were most prolific across the Plains, Midwest, and the Mississippi Party. As seen in Exhibit 29 the payouts were most pronounced in South Dakota, North Dakota, Minnesota, Illinois, Ohio, Indiana, and Texas. The payouts resulted from excessive soil moisture that inhibited many farms from being able to plant their crops on time.

Weather-related incidents resulted in 19 million acres (7.7 million hectares) of crops not being planted in 2019; the most since the U.S. Department of Agriculture began measuring the statistic in 2007. Major reductions in harvests of peak crops such as corn, soybeans, and wheat were noted throughout the Plains and Midwest. In Iowa, the floods resulted in 400 farmers offering to sell 41,000 acres (16,592 hectares) of cropland to the U.S. government and take it out of production to solely serve as a flood plain.

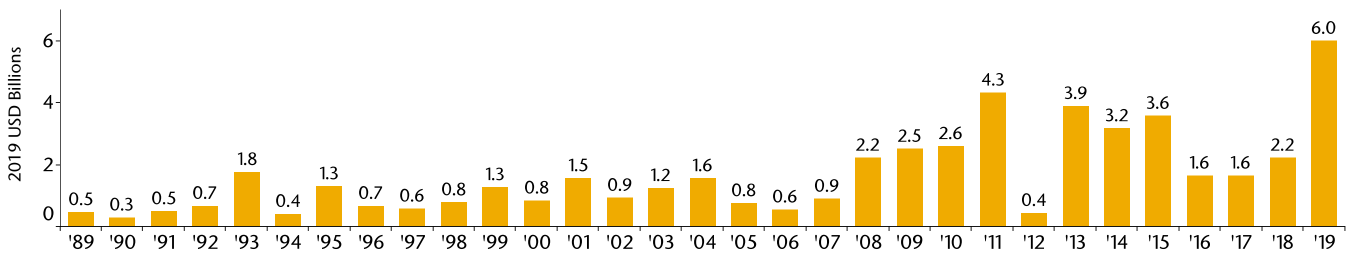
Further flood impacts were incurred to farming equipment, structures, and storage bins of already harvested crops. Those economic costs, and in many instances uninsured, totaled into the billions of dollars. The 2019 floods were exacerbated by substantial damage to the U.S. Army Corps of Engineers' levee system; including more than 50 damaged levees alone along the Missouri River. This will undoubtedly lead to conversations around future farming in flood plains given continued trends of heavier precipitation events leading to greater stresses on already weakened crop infrastructure.

Exhibit 29: U.S. 2019 Flood-Related Crop Insurance Payments



Data: USDA's Risk Management Agency

Exhibit 30: United States Flood-Related Crop Insurance Payments



Data: USDA's Risk Management Agency

Southern Europe: From Drought to Floods

Europe experienced generally a modest year for natural disasters, though some regions of the continent were affected by contrasting conditions from drought to flood. The months of June and July were marked by exceptional heatwaves that set historical temperature records in several European countries, including Germany and France. However, the drought situation was milder than it was in 2018, thanks to increased precipitation.

Flooding – both inland and coastal – became much more significant during the Autumn months. Above-normal precipitation totals were recorded in multiple European regions; notably across southern Europe. A series of major flood events occurred in Italy, eastern Spain, southern France, and elsewhere on the continent from September to early December that combined to result in significant economic and insured costs.

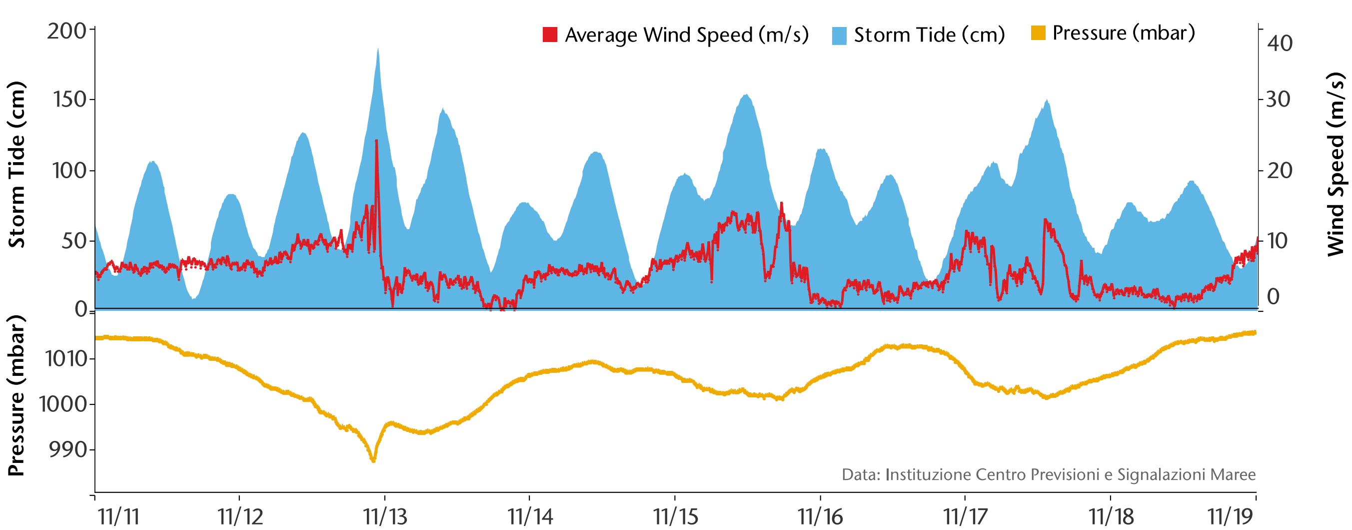
The first major flooding event in mid-September 11-15 was caused by a cut-off area of low pressure that was located over the Iberian Peninsula. The meteorological term used in Spain for such patterns is DANA, translated as "Isolated depressions at high levels". This is a further specification of a more general term "cut-off low", which sometimes refers to any type of a low-pressure area isolated from the general zonal circulation. DANAs acquire closed cyclonic circulation in medium and high levels, usually at approximately 300 to 500 millibars.

The most significant event in Italy occurred in mid-November because of several low-pressure systems that originated in the western Mediterranean. These moisture-laden systems brought significant amounts of precipitation to Italy and the Alpine region. Rain and/or snow totals were locally exacerbated by an orographic effect, particularly in the southern part of the Alps. As seen in Exhibit 31, Venice suffered its worst tidal flooding in 53 years during *acqua alta*, or "high water", a phenomenon that can occur during such cyclonic situations, which can result in strong Scirocco winds. The floods were enhanced by low pressure, an onshore wind flow, high tide, land subsidence, and continued effects of sea level rise.

A third type of event that caused significant floods in southern Europe was a "Mediterranean episode" a phenomenon that brings intense storm systems to southern France, usually three to six times a year and mostly during the autumn months. The sea is still warm during this time of the year and water evaporates. If there is a low-pressure system over Western Europe, a mass of moist, warm air is pulled from the Mediterranean Sea northwards and the moisture is released over mountain ranges in high intensity in a span of a few days. There were two notable episodes in France in 2019, on November 22-23 and on December 1-2. These floods resulted in hundreds of millions (EUR) worth of insurance payouts alone.

For the first time in four years, flooding ranked as the costliest natural peril in Europe, with economic losses estimated at more than USD9.4 billion.

Exhibit 31: Storm Tide & Meteorological Conditions in Venice in mid-November 2019



Indian Ocean Dipole and its role in Africa & Asia-Pacific

An important climatological phenomenon called the Indian Ocean Dipole (IOD) was a direct driver of significant weather-related impacts across parts of Africa, Asia, and Oceania during 2019. These impacts ranged from flooding to record heat to drought to wildfires. As a background, the IOD is represented by the anomalous temperature gradient between tropical western Indian Ocean (50°E-70°E and 10°S-10°N) and tropical eastern Indian Ocean (90°E-110°E and 10°S-0°N). The strength of the IOD event is determined by the difference in sea surface temperatures in the tropical western and eastern Indian Ocean. A positive IOD phase occurs when sea surface temperature near the Horn of Africa are warmer than average with cooler than average sea surface temperatures in the eastern Indian Ocean. This type of phase was present in 2019.

During a positive phase of the IOD, increased precipitation and convective activity occurs in East Africa, while cooler than normal conditions affect parts of Southeast Asia. Additional effects include a typical severe reduction in precipitation across Australia that allows for above-average temperatures given a wavier jet stream with more blocking ridges of high pressure during the winter and spring months.

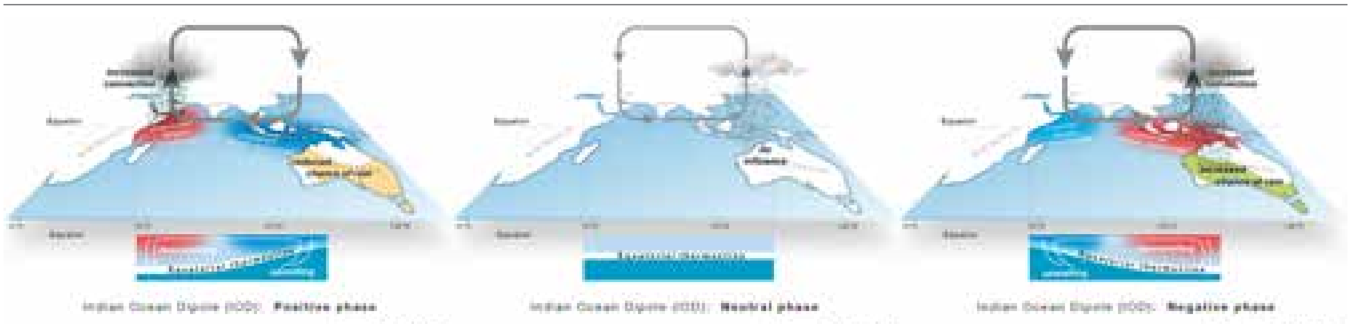
The strongest positive phase of the IOD since at least 2001 – when the Australian Bureau of Meteorology first began maintaining statistics – was recorded during the months of October and November. Unusually warm waters off the coast of East Africa resulted in higher evaporation from the Indian Ocean and led to substantial and persistent rainfall into December that prompted major inland flooding in more than a dozen countries. Hundreds of fatalities were recorded in the hardest-hit areas of Kenya, Uganda, Democratic Republic of the Congo, Tanzania, Burundi, Ethiopia, and Somalia as flash floods overwhelmed porous infrastructure unable to handle such volumes of water.

In Asia, the positive IOD signal was likely a trigger in the seasonal monsoon winds withdrawing at a later timeframe than normal: October 9 as opposed to September 1. The delayed withdrawal was the latest on record – surpassing the previous record of October 1 in 1961. This extension of the monsoon coincided with its initial late arrival in June. During the 2019 season, India cited an average rainfall of more than 10 percent higher than the climatological average. These rains prompted substantial flooding that resulted in more than 1,750 deaths and nationwide economic damage to property, agriculture, and infrastructure of more than USD10 billion.

Academic studies have shown that a strong positive IOD signal can also result in drier and hotter summer conditions in Japan, the Korean Peninsula, and Eastern China. This was true in 2019. In parts of Eastern China, for example, a 60 percent reduction in rainfall from August to October led to severe drought conditions in the Yangtze River Basin. This included the provincial regions of Anhui, Fujian, Jiangxi, Henan, Hubei, and Hunan. Combined drought costs neared USD8 billion. Severe drought conditions were also reported in North Korea; thought to be the country's worst in decades.

Perhaps no other region outside of East Africa was impacted more by the positive IOD than Australia. As noted previously, cooler than average temperatures in the eastern half of the Indian Ocean can influence exceptionally dry conditions in Australia. This often leads the country to become susceptible to a significant bushfire threat. The 2019 spring and early winter months (September to December) marked Australia's driest in 120 years. In eastern Australia, bushfire season began much earlier than usual and became one of the most significant in terms of spatial area burned. On December 18, the country recorded its hottest national average temperature on record: 41.9°C (107.4°F). The exceptional heat would also help fuel further exceptional bushfires across the country. See the wildfire section for additional details.

Exhibit 32: Phases of the Indian Ocean Dipole



Focus Topic: Severe Weather

Hail: The Leading Cause of SCS Loss

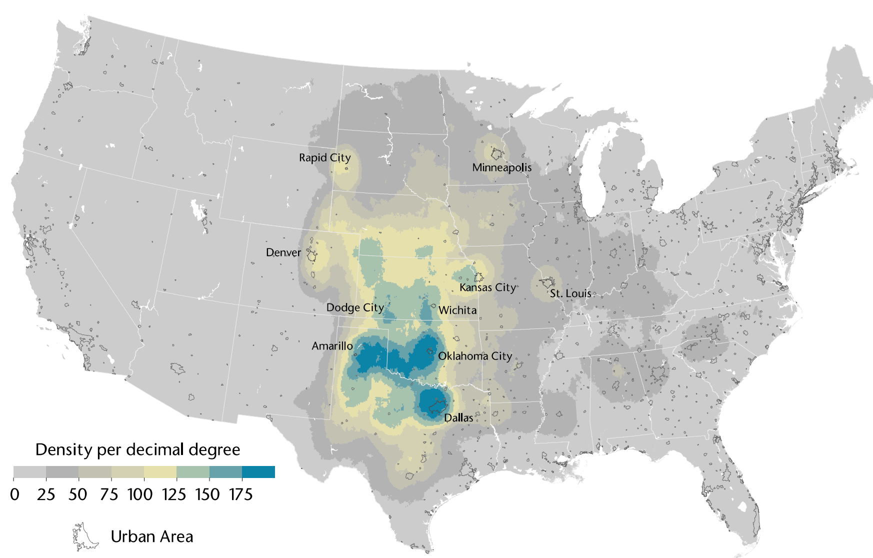
Severe convective storms (SCS) persisted as a significant driver of global natural disaster losses during 2019; particularly in the U.S. As has been the case in every year since 2008, thunderstorms generating tornadoes, large hail, and damaging straight-line winds resulted in public and private insurance payments that again topped USD10 billion. The U.S. unofficially recorded 1,520 tornadoes during the year; its highest number of tornado touchdowns since 2011 (1,691). NOAA's Storm Prediction Center also confirmed no fewer than 36 tornadoes rated EF3 or EF4. This was also the highest annual total of EF3+ twisters in the modern record since the historic 2011 season recorded 84 such events. (The 1974 season noted a remarkable 131 F3+ tornadoes, including 7 rated F5 during the Super Outbreak on April 3/4.) The U.S. has not recorded an EF5 twister since May 2013; the longest such streak since NOAA began keeping tornado statistics in 1955. Twelve killer tornadoes left at least 41 people dead. The most notable outbreak occurred during a two-week stretch in May in which more than 300 tornadoes touched down, including two rated EF4 (Dayton, Ohio and Linwood, Kansas).

Despite the elevated number of tornadoes in 2019, the leading driver of a majority of thunderstorm damage costs were again due to large hail. Hail swaths were particularly damaging in the traditional hail belts of the U.S., including Colorado, Texas, Oklahoma, South Dakota, Kansas, and Nebraska. Large hail was also damaging in Central Florida, where hail larger than golf balls struck Brevard County.

An increasingly asked question within the insurance world is whether the U.S. – and elsewhere around the globe – has entered a "new normal" phase with more and/or larger hail events. Based on the volume of annual claims filed in the past 12 years, it is safe to assume that the financial costs associated with hail have entered a new normal. With an assumption that hail accounts for 50 to 80 percent of thunderstorm-related payouts in any given year, this means hail payouts have ranged from USD8 to 14 billion in the past decade alone. In terms of the frequency of large hail reports into NOAA – defined as 2-inches or larger in diameter – the data and science remain unsettled. In the Doppler radar era since 1990, large hail reports have shown a slightly greater than 2 percent annual rate of growth. This suggests that the increase could potentially be tied to increased frequency of events per storm outbreak and/or better reporting.

Hail reports do show urbanized bias. In Exhibit 33, a heatmap was created which shows the highest concentration areas of large hail in NOAA's Storm Prediction Center database. It is clear to find peaks of storm reports in areas with larger – and growing – population centers.

Exhibit 33: Density of Large Hail Reports in the United States (1955-2019)



Data: NOAA

What is Driving Increased Hail Losses?

The dominant driver of hail-related financial costs is the United States. Annual hail-related insured losses in the U.S. have roughly averaged between USD8-14 billion per year in the last decade alone. Additional hail payouts in other parts of the globe – including hail-prone areas in Germany, France, Italy, Australia, Canada, China, India, and South Africa – also reach into the multiple billions (USD) annually as hail swaths can often cause considerable damage to property, vehicles, and agriculture. As damage costs continue to grow, there are further questions as to what is driving these increased losses.

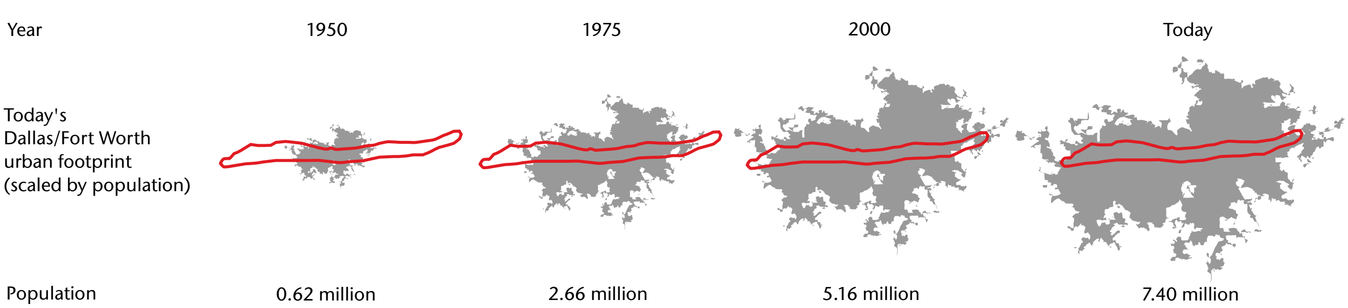
As noted in the previous section, the United States has seen a gradual uptick in the number of large hail reports (2 inches or larger) since 1990. While the increase in raw reports is in fact statistically significant, it is not yet conclusive that factors such as climate change are the only driver/cause in this increase. Recent studies on the topic – such as Tang, Gensini, Homeyer (2019) – suggest that while there has not been any appreciable increase in the overall number of hail days, there may be evidence that anthropogenic warming could be leading to a shift of more days and locations with favorable atmospheric conditions that are more conducive to large hail occurrences. Such conclusions are also becoming more apparent in areas in the world beyond the U.S.; notably in Europe and Australia.

The question, however, remains around the monetary costs associated with the sub-peril itself. Instances of severe convective storms are well documented throughout many decades, but not with the financial toll as seen in the past 25 years. Perhaps the most obvious explanation is not entirely on the science, but directly in conjunction with socioeconomic patterns. The World Bank cites that in 1960, more than 60 percent of the global population lived in a rural setting. In 2018, that percentage was down to 45 percent. This means that increased urbanization and an expansion of city centers given urban sprawl has led to more people per square kilometer of land area. In fact, the World Bank cites a doubling of population density from 24 in 1961 to 59 in 2018.

An important 2014 study by Ashley, et al. introduced the concept of the "expanding bullseye". This focused on the fact that not only is the population of some major cities growing at a rapid pace, but the urban metro area footprint has also expanded. Such a reality is a significant component to loss potential; especially in areas of world which are particularly exposed to natural peril risk, including hail. When analyzing some of the most hail-exposed and fastest-growing urban areas of the world – Dallas / Fort Worth, Texas (U.S.); Denver, Colorado (U.S.); Sydney, Australia; Brisbane, Australia – the one common theme is the physical growth of the metro area.

Exhibit 34 below provides a hypothetical example a singular hail swath overlaid on top of the Dallas /Fort Worth metro area footprint in 25-year time increments since 1950. The exhibit clearly shows that the same hail swath would be tracking over a substantially higher concentration of exposure between 1950 and today. Thus, the loss potential is much higher today as more physical property is at risk of being damaged. Any enhancement of climate change-related shifts in hail occurrence, combined with urban spatial expansion, inevitably leads to an assumption of greater future losses.

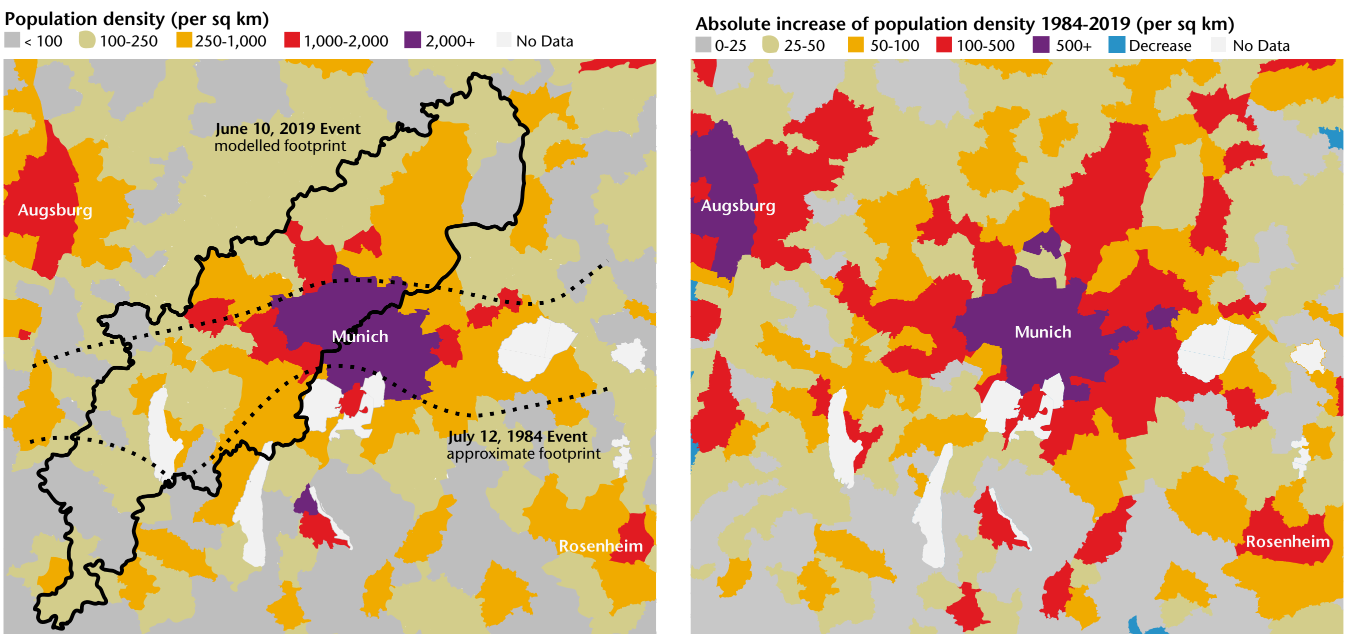
Exhibit 34: Expansion of Urban Footprint with Hypothetical Hail Swath



But what about metro areas which have not yet seen or implemented urban sprawl initiatives, but the population continues to grow? One such example is in Munich, Germany. Following World War II, city planners developed multiple strategies to keep Munich's urban footprint within small, yet efficient, spatial outline to ensure healthy growth via increased population density. While this runs contrary to the "expanding bullseye" theme, it does dramatically increase the risk of loss potential if a hail swath were to inevitably track over the city. Munich has the highest population density in Germany at 4,500 people per square kilometer (12,000 people per square mile).

On June 10, 2019, northwestern outskirts of Munich and the wider region were hit by a notable hail event, causing approximately EUR650 million (USD725 million) of insured losses. The hail swath offers a comparison with one of the most significant hail events in Europe, which occurred in July 1984 and directly impacted the city of Munich, as shown on the Exhibit 35 (approximated based on Höller & Reinhardt, 1985). Insured losses adjusted to today's dollars using a simple inflation adjustment would be equal to USD1.4 billion. In the 35 years since that historic event, the population density in Munich has increased by 600 people per square kilometer, with residential, commercial and industrial exposure showing significant growth. Should a repeat of the 1984 event occur today, the resulting losses would be substantially higher.

Exhibit 35: Population Density in Munich Region and hail swaths of 2019, 1984



Data: Bundesamt für Kartographie und Geodäsie

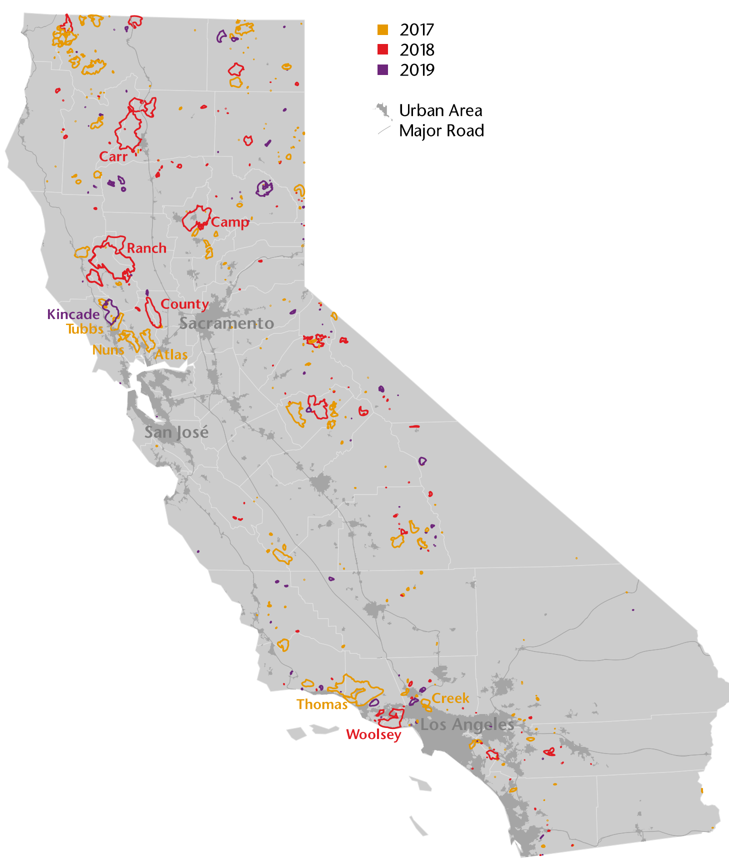
Focus Topic: Wildfire

California: New Strategies in Place

Following back-to-back exceptional years for the wildfire peril in California, there was considerable concern about whether a third consecutive year of highly elevated damage and costs would occur in 2019. While several large and impactful fires were ignited across northern and southern sections of the state – which resulted in hundreds of thousands of residential evacuations – the overall scale of damage was significantly less than what was incurred in 2017 and 2018. The Kincade Fire was the most damaging event, destroying 374 structures (including many single-family homes) in Sonoma County. In total, CalFire identified 732 destroyed structures during the season. This was significantly reduced from the minimum of 23,000 structures destroyed in 2018 and the nearly 10,000 in 2017. Total combined insured losses from the 2019 California wildfires totaled roughly USD900 million. This compared to the historic payouts in 2017 and 2018 (USD16 billion).

Perhaps most notable during the 2019 California wildfire season was the introduction of scheduled intentional power outages by utility companies when fire weather conditions were forecast. This was meant to minimize or eliminate ignition risk from downed powerlines. The outages resulted in millions of customers losing electricity, and in some instances for several days that led to unintended consequences. The state of California continued to develop schemes to protect utility companies and consumers in the advent of future wildfire events. The state legislature passed a bill which created a USD21 billion state-run insurance pool that was meant to act as a cushion for utility companies against future wildfire claims. Legislation was also passed that imposed a one-year moratorium on dropping insurance policies in areas recently affected by wildfires.

Exhibit 36: California Wildfire Perimeters (2017-2019)



Data: GeoMAC

Historic Bushfires in Australia

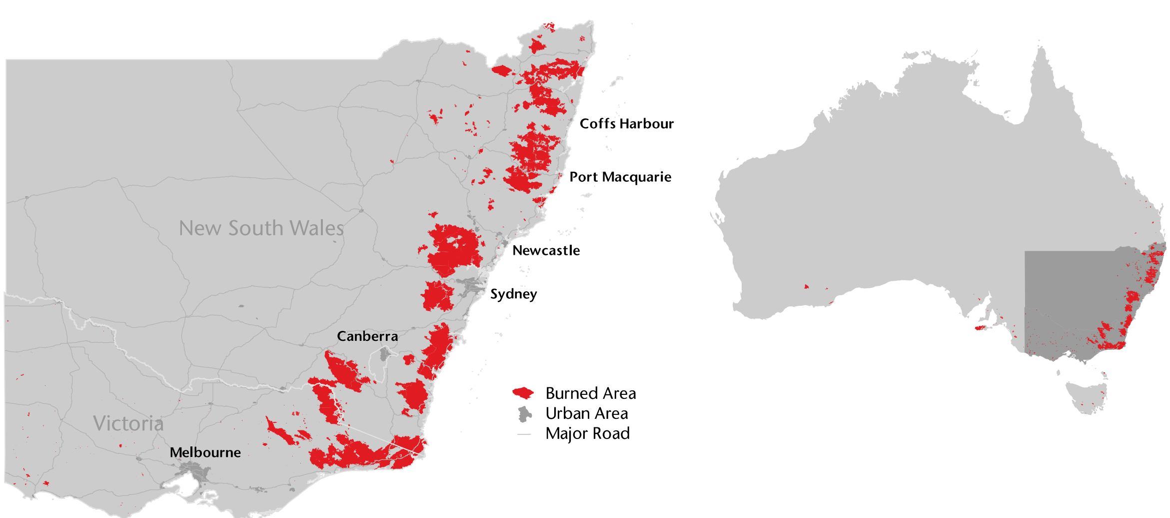
Outside the U.S., there was perhaps no other region of the world which encountered more calamitous wildfire and dangerous heatwave conditions than Australia. As previously highlighted in the Flooding section, the country was heavily affected by the anomalously strong positive IOD event. This resulted in the driest stretch of September to December in at least 120 years, and also coincided with extremely warm temperatures that included Australia's hottest average max temperature day on record: 41.9°C (107.4°F) on December 18, 2019. The lack of precipitation, record heat, and windy conditions set the stage for an early – and extended – bushfire season.

The first outbreak of fires for the 2019/20 season was noted in New South Wales and Queensland during early September as dozens of homes and other structures were damaged or destroyed. Further fires were ignited in early October across northern New South Wales in the Rappville area that destroyed nearly 50 homes and resulted in two casualties. The Insurance Council of Australia (ICA) declared an insurance catastrophe for both outbreaks.

However, the most catastrophic bushfire occurrences stretched from November 8 through the end of calendar year 2019. Fueled by record temperatures and a lack of rainfall, thousands of fires were ignited in New South Wales, Queensland, South Australia, Victoria, Tasmania, and Western Australia. The most prolific fires were in New South Wales, where at least 20 people were killed. The Rural Fire Service (RFS) in NSW noted as of January 2020 that bushfires had destroyed 2,176 homes and damaged another 850. An even higher number of outbuildings or public facilities had been damaged (1,839) or destroyed (4,750). Despite the high volume of structures affected, firefighters had done an outstanding job in saving an even higher number of buildings: 13,029 homes, 11,453 outbuildings, and 1,305 public facilities. Overall, bushfires in New South Wales had charred across 5.2 million hectares (12.8 million acres) of land. This included the Gospers Mountain Fire that burned more than 512,000 hectares (1.27 million acres) and became the largest fire on record in Australia. Beyond the physical burning, the large blazes created enormous plumes of smoke that engulfed many urbanized areas along the eastern NSW coast – including in the greater Sydney metro region. Thick smoke shrouded most of the region as hospitals reported a significant increase in the number of emergency room visits due to heat exhaustion and respiratory problems.

By January 2020, bushfires had burned at least 18.6 million hectares (46.0 million acres) of land. This already made the 2019/20 season one of the most significant on record in the country. The total economic cost of the fires reached well into the hundreds of millions (AUD). The ICA cited that a minimum of 16,380 claims had been filed from the November, December, and January fires alone with insured losses exceeding AUD1.41 billion (USD970 million) as claimed continued to be filed. This ensured that the 2019/20 bushfire season will be one of the costliest, if not most expensive, on record in Australia.

Exhibit 37: Australia Bushfires of 2019



Noted as of January 2020

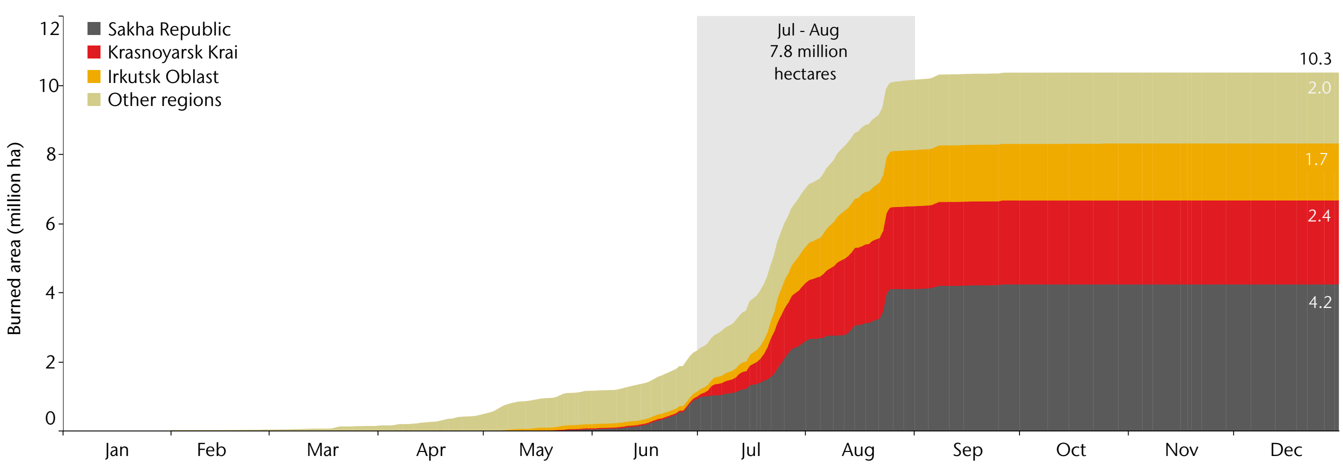
Economic vs. Environmental Impact

Several regions of the globe saw vast stretches of land burned by raging wildfires during 2019, whether it was due to man-made activity, climatological factors or a combination of both. Beside the densely populated areas in California and Australia, the most prominent fires impacted the Amazon, parts of Indonesia, and Eastern Russia.

As an example, nearly 8 million hectares (19.8 million acres) of woodland was destroyed in the Siberian and the Far East federal districts of Russia in July and August alone. According to official governmental data, the extent of land burned by forest fires throughout 2019 exceeded 10.3 million hectares (25.5 million acres). Unlike the fires in California, the Russian fires occurred largely in sparsely populated and remote areas without endangering significant property exposure. Despite burning a vast expanse of land, local officials estimated the total economic damage at only RUB19 billion (USD305 million), while the impact on insurance was negligible. However, the 2019 Russian wildfire season highlighted other issues, such as health impacts due to exposure to fire-induced air pollution or environmental impacts. The amount of carbon dioxide and other greenhouse gases released to the atmosphere, along with large amounts of pollutants, highlighted a notable role of large-scale fires in climate and air-quality in regions thousands of kilometers away.

The dramatic speed of fire progression in remote areas of Russia, along with lack of resources and low danger of property damage, caused authorities to abandon plans to even try to extinguish the fires. Fires with total extent of millions of hectares were thus left unfought.

Exhibit 38: Area burned by forest fires in Russia in 2019



Data: Aerial Forest Protection Service (Russia)

Focus Topic: Additional Perils

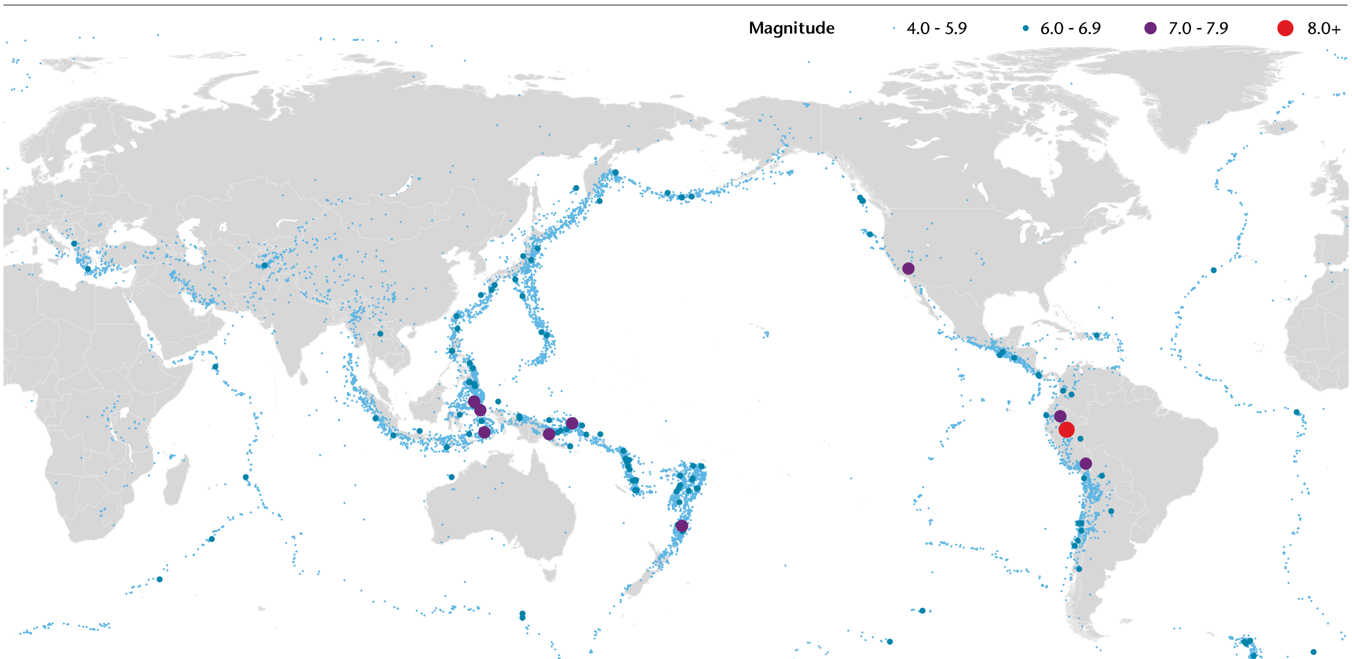
Additional perils which had notable events in 2019 included earthquake. The deadliest and costliest tremor of the year was in Albania when a magnitude-6.4 struck the northwest city of Durrës on November 26 and left at least 52 people dead. This marked Albania's deadliest earthquake in 99 years, and the strongest since a magnitude-6.9 struck in April 1979. Economic damage was estimated at upwards of USD1.0 billion. In the U.S., a series of strong earthquakes struck California in early July. The strongest – registered by the USGS as magnitude-7.1 – was noted near the town of Ridgecrest. Given the largely rural area of California which the earthquake sequence struck (M6.4, M5.4, M7.1), the scope of damage was largely limited. The magnitude-5.8 event in China's Sichuan province on June 17 damaged more than 150,000 structures and caused an estimated USD815 million in financial loss.

The European windstorm season during the calendar year 2019 was another relatively benign one from a damage and financial cost perspective. The only billion-dollar event of the year was March's Windstorm Eberhard, which resulted in USD1.2 billion in insured payouts. The only other storm which reached into the hundreds of millions (USD) for insurers was Windstorm Freya (USD300 million).

Winter weather-related costs were also relatively negligible on a global level in 2019. The most notable winter weather event was tied to a particularly strong instance of the Polar Vortex which engulfed North America in late January and early February. Total economic losses were just under USD1 billion; primarily associated with broken pipes and crop impacts. In Europe, heavy prolonged periods of snowfall and cold temperatures in early January led to considerable insurance claims in Austria, Germany, Czech Republic, Slovakia, and Poland. Payouts topped USD300 million.

In a year dominated by elevated flood losses, there were also notable impacts resulting from the drought peril. Parts of China incurred more than USD6 billion in economic damage to its agricultural sector. A large swath of Africa also endured a severe shortage of precipitation, despite many areas recording major flooding, which also led to agricultural costs reaching well into the hundreds of millions (USD). Record heat and lack of rainfall also led to crop losses topping USD1 billion in Africa. The United States incurred its lowest drought-related damage – roughly USD1.5 billion – since at least 1997. As a reminder, 2010 was the last year to not record at least USD1 billion in direct financial losses due to the peril.

Exhibit 39: Global Earthquake Activity in 2019



Data: USGS

Assessing the financial impact of climate-related risks

Tim Manuel & Ahmed Ali, *Aon*

The discussion about how climate risk affects the financial sector has gained significant momentum in recent years.

Financial regulators in the UK, France, Japan, Singapore, Hong Kong, Canada and beyond are looking seriously at the effects of climate change on financial stability, building on the work of the Financial Stability Board's Taskforce on Climate Related Financial Disclosures (TCFD). In April 2019, the UK's Prudential Regulation Authority became the first regulator to issue a supervisory statement setting out its expectations concerning banks and insurers' approach to managing the financial risks associated with climate change. Shortly thereafter, the ACPR, France's financial regulator, announced its intention to include climate risks in its stress tests of banks and insurers and the European Central Bank is actively considering doing the same. Finally, in December 2019, the Bank of England published a discussion paper which sets out its proposals for stress testing the financial stability implications of climate change. The exercise – to be conducted in 2021 – will test the resilience of the UK's largest banks and insurers to the physical and transition risks associated with three distinct climate scenarios.

This steadily increasing regulatory focus highlights the need for financial institutions to have a robust climate change strategy which quantifies the potential impact of climate-related risks on assets and liabilities, while demonstrating how they will manage these risks. Given the uncertainty around the future path of emissions and their associated economic and financial impacts, scenarios – data-driven narratives about the future – can be used to drive better decisions today. They can help investors assess the potential range of impacts from physical and transition sources of risk to enhance strategic decision-making.

The case of real estate and infrastructure

While every asset class is exposed to climate risk to some degree, real assets, such as real estate and infrastructure, provide a vivid illustration of the hazards that lie ahead.

As the intensity of weather events continues to bring greater risk of even more damaging impacts, the risks to geographically vulnerable areas become particularly acute. Ratings agency S&P raised this issue in 2018 when it reported that the average impact of weather events on corporate earnings was 6% for companies that reported it[1]. To take one recent example, Hurricane Harvey alone damaged more than 200,000 homes and resulted in direct economic losses of $125 billion, forcing several real estate investment trusts to book hurricane-related charges. More broadly, a recent study[2] found that properties exposed to sea level rises are selling at an average discount of 7% relative to comparable but less-exposed properties in the United States, highlighting the longer-term impact of climate-related risks on asset prices.

Extreme weather events also pose both acute and chronic physical risks to infrastructure investments: in the worst case, an extreme weather event may cause damage that results in catastrophic failure and a dramatic reduction in the lifespan of infrastructure assets. In 2012, for example, Hurricane Sandy knocked out a large part of Verizon's power systems, contributing to a $4.2 billion quarterly loss despite adding customers over the period. Less perceptible, but equally important, is the impact of gradual climatic shifts. To take one example, reduced river flow impacts the operability and profitability of hydropower facilities and can lead to significant asset write-downs. Identifying and integrating these risks is a critical part of the risk management process.

Given the scale, scope and interrelatedness of the risks, it is incumbent on asset owners to assess and plan for climate change.

[1] *S&P Global Ratings, The Effects of Weather Events on Corporate Earnings are Gathering Force (2018).*
[2] *Bernstein et al., Disaster on the Horizon: The Price Effect of Sea Level Rise (2018). Journal of Financial Economics (JFE), forthcoming.*

2019 Climate Review

Global Temperatures & ENSO

2019 became the second-warmest year on record dating to 1880. Preliminary official data from the National Centers for Environmental Information (NCEI), formerly known as the National Climactic Data Center (NCDC), indicated that 2019 was 0.95°C (1.71°F) warmer than the historical norm. It was also the 43rd consecutive year of above average global land and sea surface temperatures. Temperature anomalies are compared against NCEI's 20th Century average (1901-2000).

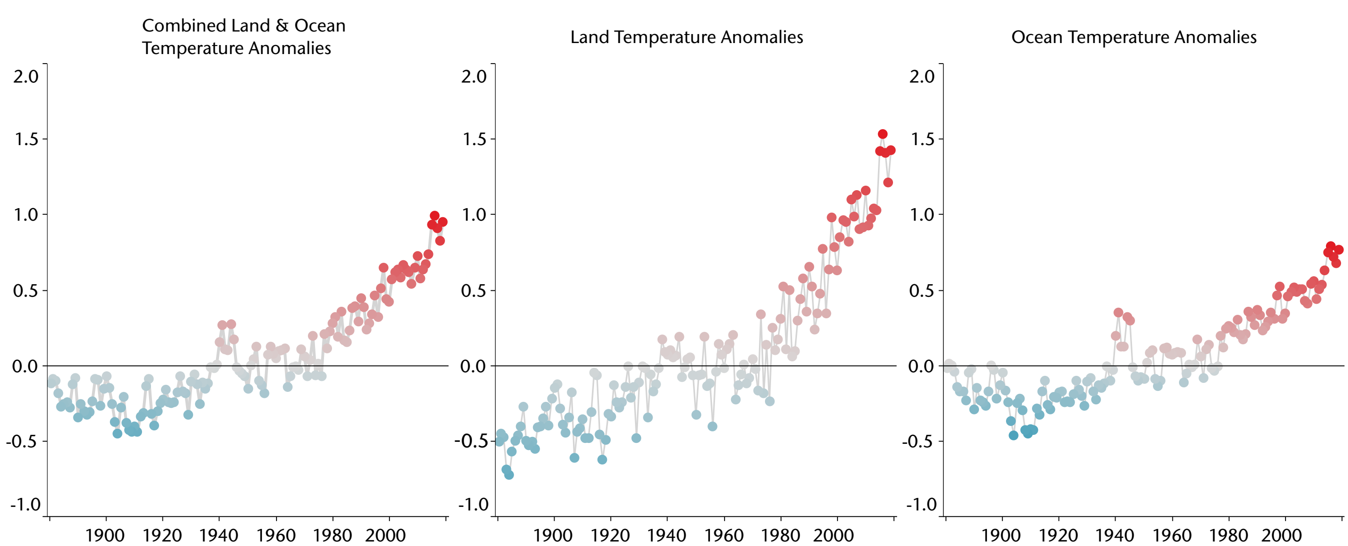
It is worth noting that each of the five warmest years on record have occurred in the past five years: 2016, 2019, 2015, 2017, and 2018. Perhaps even more striking is that 19 out of the 20 warmest years have been registered since 2001; the lone exception being 1998 when the globe encountered one of the strongest El Niño events on record. Eight of the top 10 warmest years also occurred in the last decade (2010-2019). An additional point of perspective is recognizing that the warmest year on record in 2016 at 0.99°C (1.78°F) is much more anomalous than the coldest year on record in 1904 at -0.46°C (-0.83°F).

To provide further context of the longevity of the earth's warming streak, the last below-average year for the globe occurred in 1976. At that time, global temperatures registered 0.07°C (0.13°F) below the long-term average. The last individual month to be below average was December 1984 at -0.08°C (-0.15°F) lower. As of December 2019, that marked 420 consecutive months with above average temperatures.

When viewing the temperature trends individually – land and ocean – since the last below average combined year in 1976, the rates of growth are pronounced. Land temperatures have shown a +5.3 percent uptick; while ocean temperatures have grown by +3.3 percent. The combined land and ocean increase is +3.9 percent. This is due to oceans having a larger spatial extent than land.

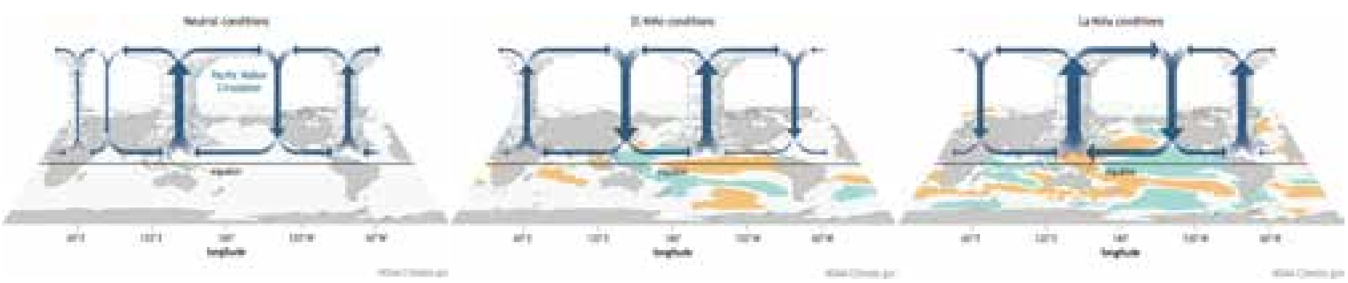
Analyzing global temperature anomaly trends is important to track changes in climate. A temperature anomaly is simply the difference of an absolute (measured) temperature versus its longer-term average for that location and date. All major agencies that independently measure global temperatures use a combination of surface and satellite observations have each concluded that the Earth continues to get warmer. Some of these agencies include NOAA, NASA, the UK Met Office, and the Japan Meteorological Agency.

Exhibit 40: Global Land and Ocean Temperature Anomalies: 1880-2019



Data: NOAA

Exhibit 41: Phases of the El Niño/Southern Oscillation (ENSO)



Various ocean oscillations influence the amount of warming or cooling that takes place in a given year. The El Niño/Southern Oscillation (ENSO) is a warming or cooling cycle of the waters across the central and eastern Pacific, leading to a drastic change in the orientation of the upper atmospheric storm track. Warming periods are noted as El Niño cycles, while cooling periods are known as La Niña cycles. The Niño-3.4 Index, which measures the temperature of the ocean waters in the central Pacific, is used to determine ENSO phases/cycles.

According to data from the National Oceanic and Atmospheric Administration's (NOAA) Climate Prediction Center (CPC), 2019 was a year initially marked by a moderate El Niño episode before transitioning to the boreal – Northern Hemisphere – summer. Most of the year saw sea surface anomalies in the equatorial Pacific Ocean between +0.1°C and +0.5°C; which meets the criteria for ENSO-neutral conditions. By the end of the year, these ENSO-neutral conditions persisted. NOAA announced that warming waters in the Pacific Ocean highlighted the likelihood of an El Niño. For 2020, initial projections by NOAA and the International Research Institute for Climate and Society (IRI) at Columbia University suggested that neutral ENSO conditions would persist through the first half of the new year.

Please note that to be considered in an ENSO phase, NOAA requires a five consecutive, three-month running mean of sea surface temperature anomalies in the Niño-3.4 Region to be +0.5°C (El Niño) or -0.5°C (La Niña). The exhibit below highlights NOAA-defined ENSO calendar years in which these conditions were met.

Exhibit 42: ENSO Years Since 1900

El Niño | La Niña | Neutral

1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010
1901	1911	1921	1931	1941	1951	1961	1971	1981	1991	2001	2011
1902	1912	1922	1932	1942	1952	1962	1972	1982	1992	2002	2012
1903	1913	1923	1933	1943	1953	1963	1973	1983	1993	2003	2013
1904	1914	1924	1934	1944	1954	1964	1974	1984	1994	2004	2014
1905	1915	1925	1935	1945	1955	1965	1975	1985	1995	2005	2015
1906	1916	1926	1936	1946	1956	1966	1976	1986	1996	2006	2016
1907	1917	1927	1937	1947	1957	1967	1977	1987	1997	2007	2017
1908	1918	1928	1938	1948	1958	1968	1978	1988	1998	2008	2018
1909	1919	1929	1939	1949	1959	1969	1979	1989	1999	2009	2019

Global Carbon Dioxide

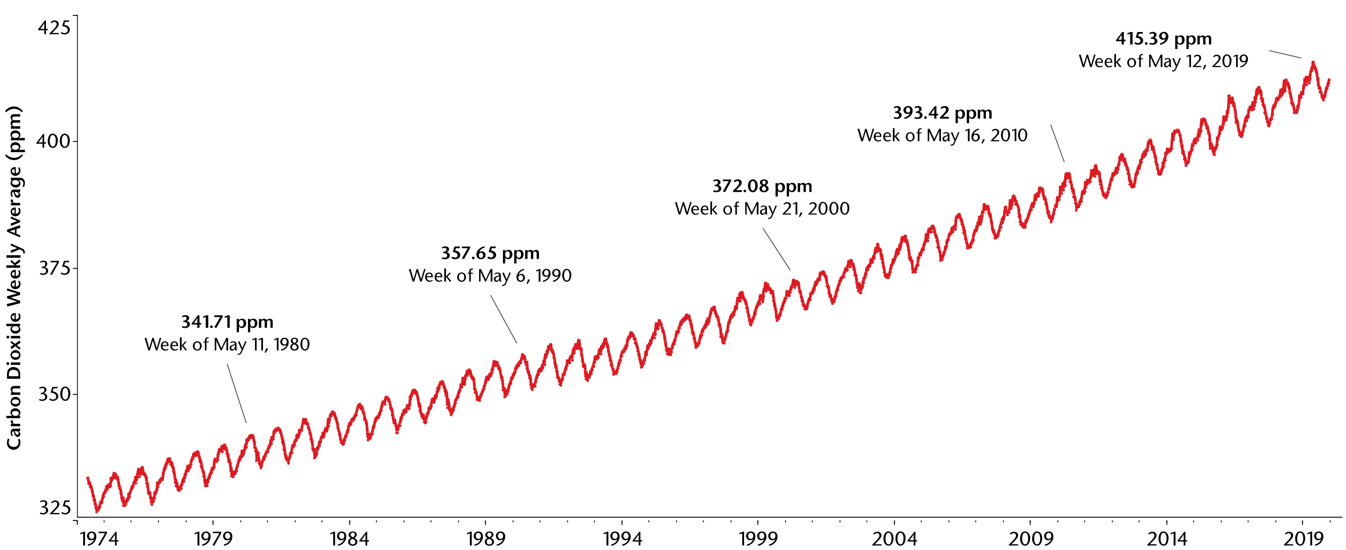
According to the data provided by the National Oceanic and Atmospheric Administration's (NOAA) Earth System Research Laboratory (ESRL), global carbon dioxide (CO2) levels averaged more than 411 Parts Per Million (PPM) for the first time in the modern record in 2019. Monthly average concentrations on Mauna Loa Observatory in May peaked at more than 415 ppm. Similarly, the concentrations did not fall below 408 ppm in any month for the first time, again, in the modern record.

Atmospheric CO2 levels have a scientifically-proven correlation with global temperature, supported by data from ice cores and the geological record. Concentrations annually peak in May as plants begin to grow in the Northern Hemisphere with the arrival of spring. After peaking, a gradual decline occurs during the month of September as the growing season draws to a close.

CO2 is just one of several atmospheric gases that contribute to the "greenhouse effect"; others include water vapor, methane, nitrous oxide, and chlorofluorocarbons (CFCs). However, carbon dioxide is universally considered the largest contributor to the effect—currently 63 percent.

It is worth noting that the annual rate of growth in CO2 concentration has been increasing for many decades. The annual mean rate of growth of CO2 in a given year is the difference in concentration between the end of December and the start of January of that year. If used as an average for the globe, it would represent the sum of all CO2 added to, and removed from, the atmosphere during the year by human activities and by natural processes. NOAA also applies a 4-month interpolating technique to account for month-to-month variability, which might be caused by weather patterns.

Exhibit 43: Average Atmospheric CO2 Concentrations



Data: NOAA

Arctic Sea Ice

The well-documented decline of Arctic sea ice extent and volume results in important climatic feedback mechanisms that affect global circulation patterns. Surface air temperatures in the Arctic region have been increasing at a rate twice as high as the global value, with far-reaching impacts for the entire Arctic ecosystem. Some of these impacts include a reduction in natural habitats, but also increased accessibility of the Arctic Ocean for shipping.

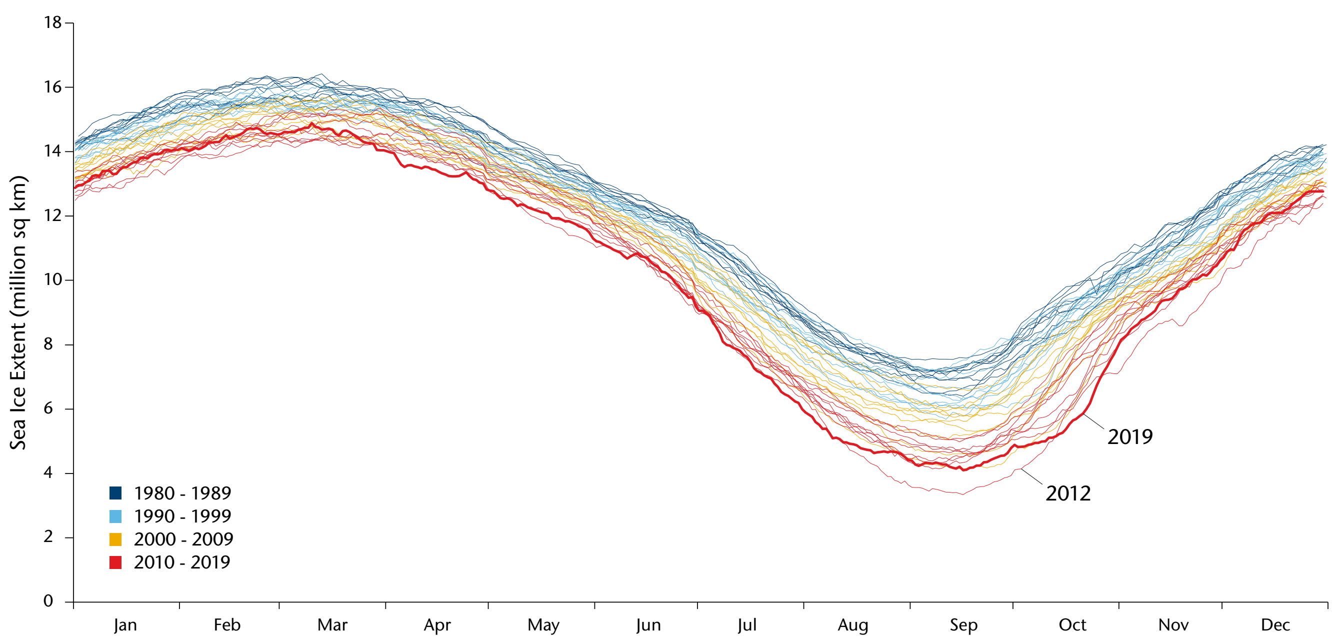
The minimum extent of Arctic sea ice was tied with 2007 and 2016 for the second lowest since modern satellite record began in the late 1970s. An analysis of satellite data by NASA and the National Snow and Ice Data Center (NSIDC) shows that the 2019 minimum extent, which was likely reached on September 18, measured 4.15 million square kilometers (1.60 million square miles). September extent in 2019 was the third lowest on record and averaged at 2.09 million square kilometers (807,000 square miles) below the 1981-2010 mean.

The summer months were generally characterized by high pressure over Greenland and parts of the Arctic Ocean, with frequent advection from the south along the longitudes of Siberia and Alaska. The speed of the seasonal decline in July and August was particularly high and similar to the record year of 2012. Daily minimum records were set throughout July and early August. Extensive open water remained in the Chukchi and Beaufort Seas and in Baffin Bay towards the end of the year.

April, July and October 2019 had the lowest average monthly extents on satellite record, while May, June, August and November the second lowest. The recently released data included in the IPCC "Special Report on the Ocean and Cryosphere in a Changing Climate" shows high confidence that the Arctic sea ice cover will continue to shrink during the 21st Century.

While an important metric, sea ice extent does not tell the complete story of the health of the Arctic and Antarctic circles. Age and depth of sea ice is a critical component to this type of analysis. Younger and thinner ice permits more heat to escape into the atmosphere. This in turn causes Arctic and Antarctic air and sea surface temperatures to warm. Analyses show that average age of Arctic ice has significantly decreased in last decades.

Exhibit 44: Arctic Sea Ice Extent: 1980-2019



Fetterer, F., K. Knowles, W. Meier, M. Savoie, and A. K. Windnagel. 2017, updated daily. Sea Ice Index, Version 3. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. doi: https://doi.org/10.7265/N5K072F8. [1/5/2020].

2019 Global Catastrophe Review

United States

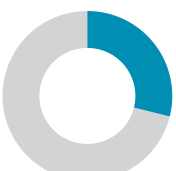
Exhibit 45: Top 5 Most Significant Events in the United States

Timeframe	Event	Location	Deaths	Economic Loss (USD)	Insured Loss (USD)
Spring/Summer	Mississippi Basin Floods	Midwest, Plains, Southeast	0	10 billion	4.0 billion
March	Missouri Basin Floods	Plains, Midwest	10	10 billion	2.5 billion
September	Tropical Storm Imelda	Plains, Midwest	5	5.0 billion	1.2 billion
May 27-30	Severe Weather	Rockies, Plains, Midwest	0	4.5 billion	3.6 billion
Oct/Nov	Kincade Fire	California	0	825 million	575 million
		All Other Events	~202	39 billion	24 billion
		Totals	**~217**	**68 billion[1]**	**36 billion[1,2]**

[1] Subject to change as loss estimates are further developed
[2] Includes losses sustained by private insurers and government-sponsored programs

68 bn — **Total Economic Losses (USD)** 15% below average since 2000

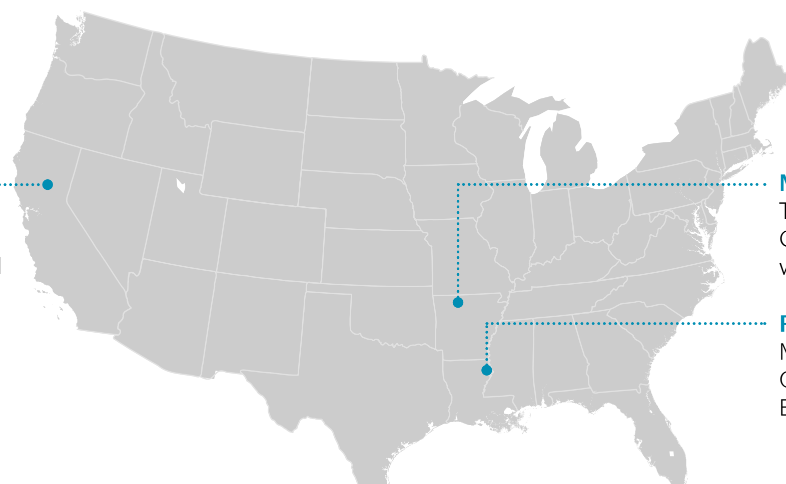
36 bn — **Total Insured Losses (USD)** 9% below average since 2000



29% Portion of Global Economic Losses

51% Portion of Global Insured Losses

53% Portion of losses covered by insurance



Kincade Fire
Most destructive California wildfire
374 structures destroyed

May 27-30 outbreak
Tornado, Hail & Wind
Costliest insured SCS event with USD3.6 billion loss

Riverine Flooding
Mississippi, Missouri, Arkansas, Ohio River Basins
Economic Loss USD20 billion

58.1°F / 14.5°C
Average temperature in July in the state of Alaska: Warmest month on record

1,520+
Unofficial number of U.S. tornadoes in 2019; Most since 2011

37.68 in / 957 mm
June 2018 to May 2019 average rainfall in the contiguous U.S.; wettest 12 months dating to 1895

Economic and insured losses derived from natural catastrophes in the U.S. were substantially reduced from high-cost years in 2017 and 2018. The overall economic total was an estimated USD68 billion, of which USD36 billion was covered by public and private insurers. When compared to annual data from 2000-2018, economic losses in 2019 were 15 percent below the average (USD79 billion), though 43 percent higher than the median (USD47 billion). Insured losses were 9 percent lower than average (USD40 billion) and 43 percent higher than the median (USD25 billion).

Despite not incurring a major singular catastrophe which caused more than USD25 billion in economic damage, the U.S. was impacted by several significant events which had wide-ranging effects. Following the wettest 12-month stretch in the contiguous U.S. on record dating to 1895 – from June 2018 to May 2019 – there was catastrophic river flooding across the Mississippi River watershed. The first major wave of floods occurred in March in along the Missouri River in the Upper Plains and Midwest. The second, and even more impactful, event occurred from May to July along the Mississippi, Arkansas, Ohio, and Missouri Rivers from the Dakotas to Arkansas. The two events combined to cause more than USD20 billion in economic damage; subject to change. Payouts via the USDA's Risk Management Agency crop insurance program due to flooding or excessive moisture was poised to top USD6 billion.

While the U.S. endured two hurricane landfalls – Barry (Louisiana) in July and Dorian (North Carolina) in September – the most noteworthy tropical cyclone was Tropical Storm Imelda. That storm came ashore near Freeport, Texas in mid-September and produced prolific rainfall. Imelda became the fifth-wettest tropical cyclone on record in the Lower 48, and the fourth-wettest tropical cyclone in the state of Texas. Flooding from the system caused impacts in many areas previously damaged by Hurricane Harvey in 2017. Total economic damage was minimally estimated at USD3.5 billion.

The costliest peril – as it has been for 12 of the last 20 years – was severe weather. A notable uptick in the number of tornadoes, unofficially estimated at more than 1,500, marked the most in the country since 2011. No fewer than 36 EF3 or EF4 tornadoes were confirmed. The three EF4 tornadoes were noted in Beauregard, Alabama; Dayton, Ohio; and Golden City, Missouri. Catastrophic damage was noted in portions of each of those communities. An EF3 tornado tracked through North Dallas, Texas in October, which led to significant damage to property and vehicles. While tornado losses were elevated in 2019, the primary driver of thunderstorm-related costs were again tied to hail. Major hail damage was again cited in parts of Texas, Colorado, Nebraska, Oklahoma, and South Dakota. With expanding urban centers in some of the most hail-prone areas in the U.S. – including Dallas / Fort Worth, Texas and Denver, Colorado – thunderstorm-related damage costs have continued to rise. The insurance industry has now paid out more than USD10 billion from the peril in every year since 2008; marking the assumption of a "new normal" of high costs.

Following two record-breaking years of wildfire damage and losses in California, there were elevated concerns of a third consecutive year of major impacts. While the year was marked by a series of significant fire events that prompted the evacuation of millions of residents in northern and southern California, the overall scope of damage was much reduced from 2017 and 2018. The two most impactful fires – the Kincade and Saddle Ridge fires – combined to cost insurers more than USD800 million. This compares to the USD32 billion from the events of 2017 and 2018.

Other events included a major instance of the Polar Vortex which engulfed much of the country at the end of January into early February. Daily record low temperatures were established throughout the Plains, Midwest, and Northeast; including -23°F (-51°C) at Chicago, Illinois' O'Hare International Airport on January 30. Total economic costs largely tied to burst pipes and snapped trees/powerlines were estimated at USD950 million. In California, the strongest earthquakes in 20 years struck the state on July 4/5. The magnitude-7.1 tremor had an epicenter near the town of Ridgecrest. Damage was much less than initially feared due to the epicenter being in a largely rural part of the state. Annual drought losses in the U.S. were estimated at roughly USD1 billion; the lowest since 2010. This was unsurprising given the catastrophic flood situation in the Plains/Midwest.

Once in a lifetime: what made Hurricane Dorian unique

Paul Cutbush, *Head of Analytics – Canada and Caribbean at Aon's Reinsurance Solutions business*

Hurricane Dorian's devastating impact on The Bahamas in 2019 was nothing like the Caribbean insurance market had ever experienced. While the geographical extent of this Category 5 event was limited mainly to the islands of Abaco and Grand Bahamas, the record-setting landfall intensity and highly unusual storm path and trajectory – in combination with its extensive damage footprint – was so shocking that it reignited debate on whether the Saffir-Simpson Hurricane Wind Scale should be amended to add further categorization that would include such upper-echelon events.

Moreover, following the lower intensity yet far more devastating insured losses from Irma and Maria's "September Double Whammy" of 2017, many questioned the impact on re/insurer appetite and rates going forward.

Once the challenging recovery had started, the unique circumstances of Dorian started to come to light. After such a calamitous storm, it is normal for Caribbean property and casualty insurance professionals to instinctively ask themselves about the normal recurrence of such a hurricane. Estimates vary with international reinsurers vindicating much shorter return periods than those interpreted by local Caribbean insurers to support higher catastrophe rates at the following renewal.

Previous Category 5 storms have been in the three-digit range, i.e. 150 years, 250 years, etc. However, Dorian was the longest-stalling Category 5 hurricane since 1851 (when record keeping began). It maintained peak intensity for nearly 12 hours while impacting the two islands and stayed at Category 5 intensity for nearly 30 hours. Such storm behavior differentiates Dorian as an extreme tail storm associated with a recurrence that goes well into the four-digit or possibly five-digit return period realm.

The Bahamas has some of the strongest wind building codes in the Caribbean which are on par with those of Southern Florida, allowing structures to withstand sustained winds in the 165 mph to 185 mph range. Under such stringent standards, there is a confidence that Category 5 storms will behave as they have historically with high-level sustained winds being short-term events that eventually subside over areas like Grand Bahamas and Abaco. This is due to either the storm continuing to move along its trajected path or due to the natural slowing of winds caused by friction when landfall is made.

With neither of these natural phenomena occurring during Dorian, the likelihood of seeing a repeat event like this again in our lifetimes is likely very low. As such, unlike the effects of Irma and Maria, Dorian is not a similar-case event where insurers or reinsurers should question changing their view of hurricane risk in the Caribbean.

Americas (Non-U.S.)

Exhibit 46: Top 5 Most Significant Events in the Americas (Non-U.S.)

Timeframe	Event	Location	Deaths	Economic Loss (USD)	Insured Loss (USD)
September	Hurricane Dorian	Bahamas, Caribbean, Canada	73[3]	8.0 billion	2.5 billion
January	Flooding	Argentina, Uruguay	0	2.4 billion	125 million
April / May	Flooding	Canada	0	800 million	210 million
September	Tropical Storm Fernand	Mexico	1	383 million	25 million
Annual	Drought	Chile, South America	N/A	4.0 billion	50 million
		All Other Events	~195	3.4 billion	1.1 billion
		Totals	**~269**	**19 billion[1]**	**4.0 billion[1,2]**

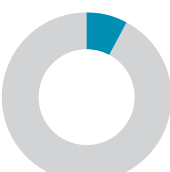
[1] Subject to change as loss estimates are further developed
[2] Includes losses sustained by private insurers and government-sponsored programs
[3] Unofficial death toll from Hurricane Dorian was well into the hundreds

19 bn

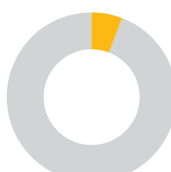
Total Economic Losses (USD)
25% below average since 2000

4 bn

Total Insured Losses (USD)
25% below average since 2000



8%
Portion of Global Economic Losses



6%
Portion of Global Insured Losses

21%
Portion of losses covered by insurance

St. Lawrence, Ottawa & St. John River Floods
Top Canada Event
Insured Loss USD210 million

Hurricane Dorian in The Bahamas
Costliest & Deadliest Event
Economic Loss USD8.0 billion
Insured Loss USD2.5 billion
73 official fatalities; hundreds more presumed dead

Parana Floods
Top South America Event
Argentina & Uruguay
Economic Loss USD2.4 billion

32.5°C / 90.5°F
Porvenir, Chile on Feb 4; Most southerly 90-degree reading ever recorded

8.0
Magnitude of the world's strongest earthquake of 2019 recorded near Loreto, Peru

113.7m a.s.l.
Ottawa River in Pembroke, Canada in May; breaking a 59-year record

Economic and insured losses from natural catastrophes in the Americas were higher than those in 2018, but still substantially less than the record year in 2017. The overall economic total was listed at roughly USD19 billion. For comparison, the economic cost of the 2017 events was nearly USD150 billion following hurricanes Irma and Maria. Of the USD19 billion economic toll in 2019, just USD4 billion was covered by public and private insurance entities. Based on annual data from 2000 to 2018, economic losses in 2019 were 26 percent lower than average (USD26 billion) and 19 percent higher compared to the 21st Century median (USD16 billion). Insured losses were 25 percent below the average (USD5.3 billion), but 73 percent higher than the median (USD2.3 billion).

The most newsworthy and impactful event across the Americas in 2019 was without question Hurricane Dorian. The Category 5 storm made multiple landfalls in The Bahamas as a 185 mph (295 kph) storm; tying with the 1935 Labor Day Hurricane as the strongest landfalling storm on record in the Atlantic Ocean. Catastrophic damage was incurred to Great Abaco and Grand Bahama islands, as Dorian maintained Category 5 intensity for 27 consecutive hours while meandering over land. This resulted in overwhelming damage due to storm surge, winds gusting to 200 mph (320 kph), and flash flooding. Despite the Bahamas having some of the strongest building codes and requirements in the Caribbean, the persistent intensity of Category 5 winds and surge wore down even the best-built structures. Total economic damage in the Bahamas was tentatively estimated at USD8 billion; with insured losses poised to approach USD2.5 billion. This marked the costliest natural disaster on record in The Bahamas.

Dorian would later make landfall in Nova Scotia, Canada in September as a Category 2-equivalent, post-tropical cyclone with 100 mph (160 kph) winds. The storm's high winds and heavy rains led to widespread damage that was tallied at more than USD200 million.

Canada endured another active year, beyond the impacts of Dorian, as total insured losses from natural catastrophes topped USD1.1 billion. The costliest event of 2019 was a prolonged flood event along the St. Lawrence, Ottawa, and St. John rivers that inundated thousands of homes in parts of Quebec, Ontario, and New Brunswick. Insured losses surpassed USD210 million alone, as low insurance penetration for the flood peril ensured that the overall economic cost was much higher. Additional events during the year – including a notable hailstorm in Edmonton in August and other regional flood events across central and eastern Canada – led to hundreds of millions (USD) of additional economic damage.

Flooding was a major driver of damage and financial loss in South America during 2019; largely driven by an early year continuation of El Niño. This was especially true in Argentina during January. Extensive flooding inundated vast areas of cropland in the lowlands Pampas region. Record rainfall was cited during the stretch, including a new 24-hour rainfall record of 224 millimeters (8.81 inches) at Resistencia, Argentina on January 8; breaking a previous record set in January 1994. Many other areas cited monthly rainfall totals running four times higher than normal. The Argentina flood damage was estimated at upwards of USD2.3 billion. Other notable South American floods during the year were cited in parts of Uruguay, Brazil, and Colombia.

In Mexico, the most expensive disaster of the year followed landfall of Tropical Fernand in September. The storm made landfall in Tamaulipas state before dissipating and its remnants bringing torrential rains to neighboring states of Coahulia, Nuevo Leon, and San Luis Potosi. Total economic damage was estimated at USD383 million. Seasonal flooding brought further impacts to the country and led to dozens of fatalities. Tropical Storm Narda (September) and Hurricane Lorena (September) also made landfall in Mexico, though overall impacts were not as substantially as initially feared.

Elsewhere, the world's strongest earthquake of 2019 was recorded in Peru on May 26. The magnitude-8.0 tremor only caused minor damage due to it occurring in a fairly rural part of the country and at a deep depth. Hurricane Humberto grazed Bermuda in September and brought hurricane-force winds across the tiny island, though damage was largely minimal and isolated to downed tree branches. Large wildfires in Brazil's Amazon region, which were intentionally set due to deforestation practices, proved concerning as the Amazon rainforest remains one of the world's most important natural mitigators of global warming by storing carbon dioxide.

EMEA (Europe, Middle East & Africa)

Exhibit 47: Top 5 Most Significant Events in EMEA

Timeframe	Event	Location	Deaths	Economic Loss (USD)	Insured Loss (USD)
March 4-17	Cyclone Idai	Southern Africa	1,303	2.7 billion	10 million
March 10-11	Windstorm Eberhard	Western & Central Europe	2	1.6 billion	1.2 billion
March – April	Iran Floods	Iran	77	8.3 billion	150 million
September 11-15	Flooding	Spain	7	2.5 billion	655 million
June 10-12	Severe Weather	Central Europe	0	1.1 billion	815 million
		All Other Events	~2,950	22 billion	7.2 billion
		Totals	**~4,340**	**39 billion[1]**	**10 billion[1,2]**

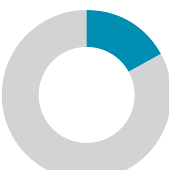
[1] Subject to change as loss estimates are further developed
[2] Includes losses sustained by private insurers and government-sponsored programs

39 bn

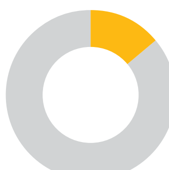
Total Economic Losses (USD)
6% above average since 2000

10 bn

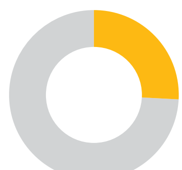
Total Insured Losses (USD)
Equal to average since 2000



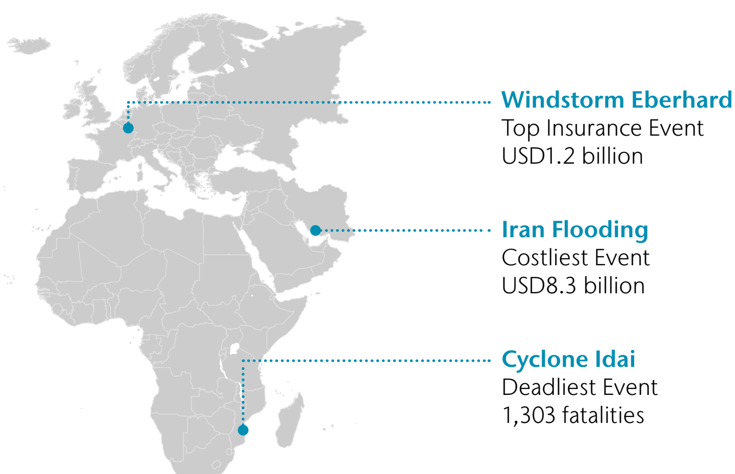
17%
Portion of Global Economic Losses



14%
Portion of Global Insured Losses



26%
Portion of losses covered by insurance



46.0°C / 114.8°F
Record high temperature reached in France on June 28

140 mph
Cyclone Kenneth strongest landfall on record in Mozambique

45 million
People in 16 African nations with food insecurity due to record drought

Overall economic losses that were caused by natural catastrophes in Europe, Middle East, and Africa in 2019 were slightly higher when compared against losses from this century. Total aggregated losses were preliminarily estimated at more than USD39 billion, which is 6 percent above the average of years 2000-2018 (USD36 billion) on an inflation-adjusted basis. It was 6 percent lower when just looking at the last decade (USD41 billion). When viewing the 2019 economic costs with the median of the same periods, it indicates a downturn of 2 percent (USD39 billion) and 6 percent (USD41 billion), respectively.

Similarly, to the previous year, the region was marked by a lack of financially significant earthquakes, with the peril incurring less than four percent of the total economic loss in EMEA. This is the third consecutive year with earthquake losses lower than USD2 billion. In 2016, major tremors in Italy resulted in nearly USD27 billion in damage. Focusing solely on weather-related costs, EMEA saw above-average losses compared to normal; 18 percent above the average since 2000 and 11 percent above the decadal average.

Insurers in EMEA recorded aggregated losses of USD10 billion, which was roughly equal to the average since 2000. Comparing the total with the median value shows 2019 was higher by 5 percent. If only the last 10 years are considered, insured losses showed a 2 percent decline against the average value and nearly flat against the median.

Perhaps somewhat surprising, the two costliest events in EMEA did not occur in Europe. The most expensive was a significant, multi-week flooding event in Iran that occurred from mid-March to early April. The floods impacted 25 individual provinces and more than 4,400 villages, while also causing major damage to regional infrastructure and agriculture. Nearly 80 people were killed. Local officials cited the damage at up to IRR350 trillion – which converted to USD8.3 billion at the time of occurrence using the global free market currency conversion, or USD2.6 billion if using the unofficial local Tehran conversion.

The most substantial humanitarian crisis of 2019 occurred in Mozambique following successive cyclone landfalls in March and April. The most destructive was Cyclone Idai, which made landfall as a high-end Category 2 storm and produced exceptional storm surge and inland flooding near the city of Beira. More than 300,000 homes were destroyed. and 1,303 people were killed. Total economic losses were listed by the World Bank at USD2 billion. Cyclone Kenneth would later strike a few weeks later as a Category 4 storm; the strongest cyclone on record to come ashore in Mozambique. The storm combined with Idai to leave nearly 2 million people directly impacted and facing food insecurity and/or lack of shelter.

In Europe, the continent faced several high-cost flood events that accounted for more than half of EMEA's economic losses in 2019. Parts of Spain, France, and Italy were among the hardest-hit. Italy was particularly affected in November as the combination of a Mediterranean low, sea level rise, and heavy rains prompted major flooding in Venice and elsewhere. Cost of the autumn flooding was estimated by the Italian government at USD5.0 billion. Spain similarly endured major flooding during September that caused more than USD2.5 billion in damage. Flood-related insurance payments during November and December alone in France were expected to top USD430 million.

Perhaps Europe's most meteorologically significant event of the year was a recurring dome of exceptional heat that engulfed much of the continent in June and July. Numerous countries established new all-time national record high temperatures, including 46.0°C (114.6°F) at Vérargues, France. In fact, at least 12 official stations in France beat or tied the previous French national heat record of 44.1°C (111.4°F).

Other notable events in EMEA in 2019 included Windstorm Eberhard, which was the lone event in Europe to surpass USD1 billion in insured losses during the year after tracking across Western and Central Europe in March. The globe's deadliest earthquake occurred in Albania on November 26. The M6.4 tremor left at least 52 people dead. Despite much of Eastern Africa enduring major flooding during the second half of 2019 – which left hundreds of people dead – Southern Africa continued to endure a severe rainfall deficit. At least 16 countries, accounting for 45 million people, were said to be food insecure.

APAC (Asia & Oceania)

Exhibit 48: Top 5 Most Significant Events in APAC

Timeframe	Event	Location	Deaths	Economic Loss (USD)	Insured Loss (USD)
October	Typhoon Hagibis	Japan	99	15 billion	9.0 billion
Summer	Flooding	China	300	15 billion	650 million
Summer/Fall	Flooding	India	1,750	10 billion	150 million
September	Typhoon Faxai	Japan	3	10 billion	6.0 billion
November - January (2020)	Bushfires	Australia	29	~5.0 billion	~1.1 billion
		All Other Events	~3,640	52 billion	4.1 billion
		Totals	**~5,820**	**107 billion**	**21 billion**

[1] Subject to change as loss estimates are further developed
[2] Includes losses sustained by private insurers and government-sponsored programs

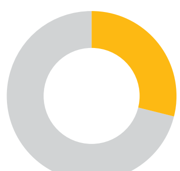
107 bn

Total Economic Losses (USD)
9% above average since 2000

21 bn

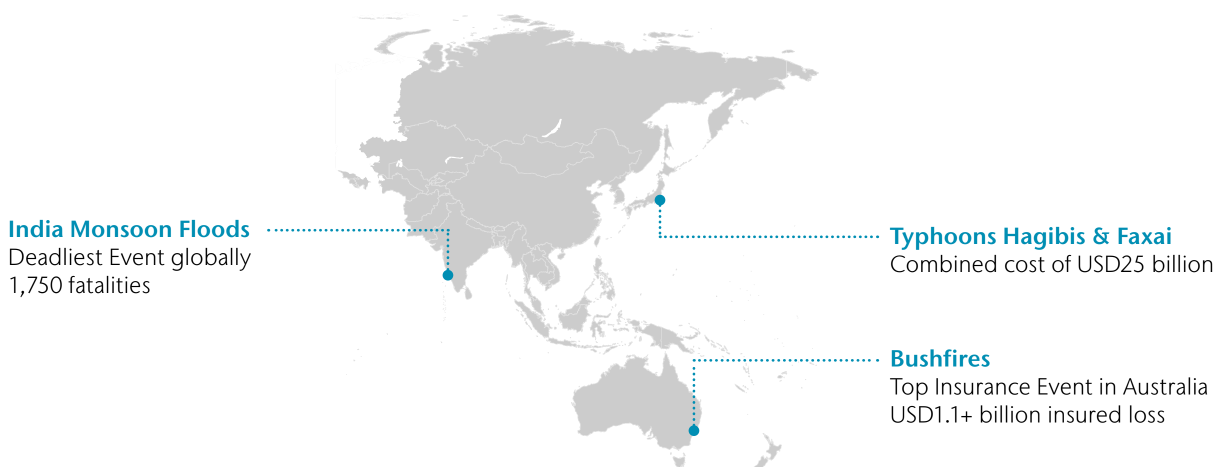
Total Insured Losses (USD)
77% above average since 2000

46%
Portion of Global Economic Losses



29%
Portion of Global Insured Losses

19%
Portion of losses covered by insurance



41.9°C / 107.4°F
nationwide Australia record of average daily temperature set on December 18

922.5 mm / 36.31 inch
24-hour national rainfall record in Hakone, Japan following TY Hagibis landfall

1,800 km / 1,118 miles
Distance traveled overland by Tropical Storm Matmo before entering the Adaman Sea

Asia-Pacific had an active, but not overly unexpected year for natural disasters in 2019 given the large spatial extent and its propensity for much activity. The overall economic total was listed at roughly USD107 billion, marking the fifth time in the 2010s for the region crossing the USD100 billion threshold. Of the economic losses, just USD21 billion was covered by public and private insurance entities. This again highlights the large protection gap as approximately 8 in 10 disaster losses were left uninsured. Based on annual data from 2000 to 2018, economic losses in 2019 were 9 percent above than average (USD98 billion), and 74 percent higher compared to the 21st Century median (USD61 billion). Insured losses were 78 percent above the average (USD12 billion), and 275 percent higher than the median (USD5.5 billion).

For the second year in a row, Japan was the dominant driver of natural catastrophe losses in APAC. The country was again impacted by back-to-back typhoon events – Faxai in September and Hagibis in October – which resulted in considerable and widespread damage. The estimated combined insured loss for the two storms was USD15 billion; USD9 billion for Hagibis and USD6 billion for Faxai. The primary reason for the elevated payouts was each storm tracking through a highly urbanized area; notably the Tokyo metro region and neighboring Chiba prefecture. However, there remains ample uncertainty as to how the final claims payouts may settle as local insurers continue to assess. It was expected that a much clearer view of the 2019 Japan typhoon losses will emerge by Q2 2020 as companies report their annual filings ahead of the April 1 renewal period. The country was also affected by a notable heavy rain and flooding event in late October that also affected Chiba and Fukushima prefectures.

Beyond typhoon activity in Japan, there was perhaps no other country more impacted by tropical cyclones in Asia than the Philippines. Two late-season events – typhoons Kammuri and Phanfone – combined to damage or destroy at least 1 million homes and other structures across Luzon and Visayas. The storms were so impactful that the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA) noted that the local names of each storm (Tisoy and Ursula) would be retired. The Philippines were also heavily affected by a series of strong earthquakes in 2019. At least five notable tremors – ranging from magnitude 5.8 to 6.8 – struck Mindanao between July and December. Dozens of people were killed dead and tens of thousands of homes damaged. Other notable typhoon events in 2019 included August's Typhoon Lekima becoming one of the costliest tropical cyclones on record in China at USD9.5 billion, and Cyclone Fani's May landfall in India that caused an estimated USD8.1 billion in damage.

An active year for seasonal monsoon flooding resulted in major damage and fatalities across the Asian continent in 2019. Under the likely influence of an unusually strong Indian Ocean Dipole event (as discussed in greater detail earlier in this report), monsoon rains led to a combined USD25 billion in damage in China (USD15 billion) and India (USD10 billion) alone. The floods were deadly in India, as raging water and landslides resulted in at least 1,750 fatalities. At the end of December 2019 and into January 2020, seasonal rains prompted some of the worst floods in years in Jakarta, Indonesia. More than 68 people were killed, and economic losses topped USD1.1 billion.

Australia recorded one of its most notable years for weather disasters; including some events which were enhanced by increased climate change influence. The year was initially highlighted by record flooding that inundated the far Northern Queensland community of Townsville in February. Nearly 31,000 insurance claims were filed, with payouts topping USD880 million. The most significant event, however, was the ongoing intense multi-year drought and record-setting spring and summer heat which led to conditions able to ignite destructive bushfires in New South Wales, Queensland, Victoria, and South Australia. More than two-dozen people were killed, 18.2 million hectares (45 million acres) burned, and more than 2,779 homes destroyed. The fires, which began in early November 2019 and extended into January 2020, were poised to be the costliest for Australian insurers since the historic bushfire season of 2009. The total economic cost was expected to exceed AUD5 billion. The Insurance Council of Australia declared at least six different events to be insurance catastrophes during the 2019 calendar year.

Other notable wildfire events in APAC included in Indonesia and Eastern Russia. In some cases, the fires were ignited due to human activity but burned vast areas of land.

Record typhoon losses create new learning opportunities for Japanese insurers

Oriol Gaspa, *Head of Analytics – Japan at Aon's Reinsurance Solutions business*

The 2018 and 2019 Northwest Pacific Typhoon seasons resulted in Japan experiencing some of the costliest typhoon-induced insured losses on record. Current estimates for Jebi, Hagibis and Faxai rank them the first, second and fourth largest storm-related catastrophic losses in Japan when compared with estimates from the General Insurance Association of Japan. 2018's Trami was another event which additionally resulted in a multi-billion-dollar payout for insurers.

Although Jebi is the largest loss in record, Japanese insurance companies' reinsurance programs worked effectively. Japanese companies have been using a wide variety of risk modelling tools for a long time, boosting their understanding of typhoon risk and its financial impact in Japan. This risk management maturity has led to the current adequate reinsurance limits purchase.

Jebi and Hagibis have shown two unique features.

- Firstly, Jebi is the first major hurricane-equivalent (Category 3 or stronger) to have a direct hit on a large Japanese metropolis (Osaka). It is possible that high winds combined with a landscape of skyscrapers and wide streets caused unforeseen localized effects, increasing the experienced wind gusts relatively compared to the same typhoon passing over less urban areas. This process around skyscrapers is known as the Venturi Effect, when winds flow through a constricted passage resultingly in higher speeds.
- Secondly, Hagibis, which showed much lower intensity wind gusts than Jebi, produced an extraordinary amount of rainfall with some areas accumulating more than 1m of precipitation in 24h. According to reports by Japanese broadcaster NKH on October 15, 2019, Hagibis caused more than 90 levee breaches following unpreceded levels of rainfall and flooding. These however were within expectation of the risk levels set by the government risk mitigation strategy and flood maps.

Vendor modeling companies have struggled to provide consistently reliable post loss estimates, creating uncertainty in the market. In response, Aon developed an alternative tool that combines real time measurements from the Japan Meteorological Agency (JMA) stations with damage curves from Aon's Impact Forecasting team that have been built with local data. This new tool helps to pinpoint the total number of buildings damaged hours after an event occurrence to develop reliable claims estimates and help insurers reach more informed decisions during challenging times.

Outputs and benchmarking of the claims and loss estimates are also used to test Impact Forecasting's new Japan typhoon model, taking into account what has been learned (and still learning) from these recent storms (Jebi, Trami, Hagibis, Faxai).

Concluding Remarks

Following two costly back-to-back years for natural disasters in 2017 and 2018, industry sensitivity to loss experience in 2019 was heightened. While there was no singular "mega" event which prompted individual economic damage costs beyond USD25 billion, nor above USD15 billion for the insurance industry, there were several moderately large events which aggregated to become notable for local governments and/or the re/insurance industry. These included events such as Typhoon Hagibis, Typhoon Faxai, Hurricane Dorian, multiple U.S. inland floods, severe convective storm outbreaks, bushfires in Australia, and seasonal monsoon flooding in Asia.

Strong capitalization has allowed the re/insurance industry to comfortably manage recent major loss experience.

What is already shifting is the view of individual perils and their associated risks, as there are increasingly multi-peril impacts within a single event. A prime example would be a landfalling tropical cyclone that not only has coastal impact, but additionally produces extensive inland damage due to flooding, severe convective storms, and synoptic winds. There also remains the continued challenges around the topic of protection gap. With more than 90 percent of catastrophe losses being uninsured in parts of disaster-prone Asia, Latin America, or Africa, this is forcing new conversations on how insurance, government, and other sectors seek to mitigate or minimize natural peril risk. This may include the development of new insurance schemes such as parametric-based policies or broader catastrophe bonds that can stretch across an entire region, as opposed to a singular market.

As socioeconomic patterns (population and exposure) further combine with scientific factors such as climate change or extreme weather variability, the potential financial costs at play are only going to increase. The most "buzzworthy" topics in 2019 surrounded resilience and how private sector groups are incorporating new technologies via artificial intelligence to create new solutions that solve problems before they occur.

How this Report Can Help

The annual "Weather, Climate, and Catastrophe Insight" report is written for many different sectors. We hope that the wealth of qualitative and quantitative information in this main document, and the accompanying data in the below Appendix, will be absorbed and utilized by the insurance industry, government agencies, risk managers, emergency management, climate science, academia, and other sectors to better understand and put into context the increasingly volatile world of natural disasters.

Some takeaways from this report include:

- Identification of catastrophe loss trends on a global and regional scale
- Data-driven analysis highlighting vulnerable locales from specific perils
- Modernizing and implementing stringent building code requirements
- Developing public and private risk mitigation solutions to reduce vulnerabilities
- Introduce insurance strategies to close the global protection gap
- Climate change influence more identifiable as extreme weather events impact greater exposure centers
- Communication of risk and uncertainty remains a challenging, yet vital component of resilience planning
- Integration of cross-sector solutions that incorporates ideas from government, academic, and the private sector

Appendix A: 2019 Global Disasters

United States

Date	Event	Location	Deaths	Structures/Claims	Economic Loss (USD)
01/01-12/31	Drought	Nationwide	N/A	N/A	1.5+ billion
01/05-01/06	Winter Weather	West	0	7,500+	125+ million
01/11-01/14	Winter Weather	Plains, Midwest, Mid-Atlantic	13	Thousands	200+ million
01/16-01/18	Winter Weather	West	5	12,000+	275+ million
01/18-01/24	Winter Weather	Midwest, Northeast	10	22,000+	300+ million
01/29-02/01	Winter Weather	Midwest, Northeast, Southeast	22	45,000+	950+ million
02/01-02/03	Flooding	California	0	11,000+	250+ million
02/05-02/06	Winter Weather	Plains, Midwest	3	7,500+	50+ million
02/06-02/08	Winter Weather	Plains, Midwest, Southeast	1	5,000+	60+ million
02/08-02/15	Winter Weather	West, Plains, Midwest, Northeast	2	10,000+	100+ million
02/10	Severe Weather	Hawaii	1	2,000	50+ million
02/18-02/21	Winter Weather	Northern Plains, Southeast	3	10,000+	125+ million
02/22-02/26	Severe Weather	Central/Eastern U.S.	4	175,000+	1.4+ billion
02/26-02/28	Flooding	California	1	6,000+	175+ million
03/03-03/04	Severe Weather	Southeast, Mid-Atlantic, Northeast	23	15,000+	190+ million
03/08-03/09	Severe Weather	Plains, Midwest, Southeast	1	10,000+	100+ million
03/12-03/17	Severe Weather	Plains, Midwest, Southeast	5	125,000+	1.0+ billion
03/12-03/31	Flooding	Central U.S.	10	25,000+	10+ billion
03/23-03/25	Severe Weather	Plains, Midwest	0	110,000+	1.8+ billion
03/27	Severe Weather	Florida	0	22,000+	230+ million
04/04-04/07	Flooding	Northwest	0	5,000+	75+ million
04/05-04/08	Severe Weather	Plains, Southeast	0	25,000+	250+ million
04/10-04/12	Winter Weather	Rockies, Plains, Midwest, Southeast	0	15,000+	150+ million
04/12-04/15	Severe Weather	Plains, Southeast, Midwest, Northeast	9	100,000+	1.3+ billion
04/17-04/19	Severe Weather	Plains, Southeast, Midwest	4	40,000+	350+ million
04/23-04/25	Severe Weather	Plains, Southeast	5	60,000+	850+ million
04/30-05/02	Severe Weather	Plains, Midwest, Southeast	5	35,000+	750+ million
05/01-07/31	Flooding	Central & Eastern U.S.	0	Thousands	10+ billion
05/04-05/10	Severe Weather	Plains, Midwest, Southeast	1	90,000+	1.5+ billion
05/13	Severe Weather	North Carolina	0	20,000+	290+ million
05/16-05/17	Severe Weather	Plains, Midwest	0	60,000+	1.0+ billion
05/17-05/19	Severe Weather	Plains, Midwest, Southeast	0	15,000+	200+ million
05/20-05/23	Severe Weather	Plains, Midwest, Southeast, Northeast	9	45,000+	980+ million
05/24-05/26	Severe Weather	Rockies, Plains, Midwest, Northeast	0	15,000+	150+ million
05/27-05/30	Severe Weather	Rockies, Plains, Midwest, Southeast	0	280,000+	4.5+ billion
06/01-06/06	Severe Weather	Rockies, Plains, Midwest, Northeast	1	20,000+	375+ million
06/08-06/09	Flooding	Southeast	3	2,000+	50+ million
06/08-06/10	Severe Weather	Rockies, Plains, Southeast	3	62,000+	900+ million

United States *(continued)*

Date	Event	Location	Deaths	Structures/Claims	Economic Loss (USD)
06/15-06/16	Severe Weather	Midwest, Mid-Atlantic	0	7,500+	100+ million
06/16-06/17	Severe Weather	Texas	0	17,500+	200+ million
06/18-06/20	Severe Weather	Plains, Southeast, Mid-Atlantic	1	25,000+	200+ million
06/21-06/22	Severe Weather	Plains, Midwest, Southeast	3	20,000+	175+ million
06/23-06/24	Severe Weather	Plains	0	22,000+	235+ million
06/29-06/30	Severe Weather	Northeast, Mid-Atlantic	2	7,500+	100+ million
06/29-06/30	Severe Weather	Plains, Midwest	1	10,000+	100+ million
07/02-07/04	Severe Weather	Plains, Midwest, Northeast	0	10,000+	140+ million
07/04-07/05	Earthquake(s)	California	0	5,000+	200+ million
07/04-07/05	Severe Weather	Rockies, Plains	0	70,000+	1.1+ billion
07/07-07/08	Flooding	Maryland, Washington D.C., Virginia	0	12,000+	325+ million
07/13-07/17	Hurricane Barry	Southeast, Midwest, Northeast	0	50,000+	630+ million
07/17-07/18	Severe Weather	Rockies, Midwest	0	25,000+	260+ million
07/19-07/23	Severe Weather	Midwest, Northeast, Mid-Atlantic	2	82,000+	925+ million
07/26-07/30	Severe Weather	Midwest, Northeast	0	20,000+	235+ million
08/04-08/05	Severe Weather	Midwest	0	45,000+	790+ million
08/06-08/07	Severe Weather	Plains, Midwest	0	12,000+	140+ million
08/06	Severe Weather	Northwest	0	2,000+	50+ million
08/10-08/11	Severe Weather	Rockies, Plains	0	40,000+	780+ million
08/13-08/16	Severe Weather	Rockies, Plains, Midwest	0	35,000+	415+ million
08/17-08/18	Severe Weather	Midwest, Northeast	0	15,000+	120+ million
08/25-08/26	Severe Weather	Rockies, Plains, Midwest, Southeast	0	25,000+	250+ million
09/04-09/06	Hurricane Dorian	Southeast, Mid-Atlantic	9	50,000+	1.6+ billion
09/10-09/12	Severe Weather	Rockies, Plains, Midwest	0	20,000+	310+ million
09/12-09/16	Flooding	South Dakota	0	7,500+	100+ million
09/17-09/20	Tropical Storm Imelda	Plains, Southeast	1	75,000+	5.0+ billion
09/23	Flooding	Arizona	0	5,000+	50+ million
09/27-09/28	Severe Weather	Plains, Midwest	0	15,000+	150+ million
10/10-10/17	Wildfire (Saddle Ridge)	California	3	5,000+	375+ million
10/16-10/17	Severe Weather	Mid-Atlantic, Northeast	0	35,000+	245+ million
10/18-10/20	Tropical Storm Nestor	Southeast	0	10,000+	100+ million
10/20-10/21	Severe Weather	Plains, Southeast	4	66,000+	2.75+ billion
10/23-10/31	Wildfire (Kincade)	California	0	17,500+	825+ million
10/24-10/31	Wildfire (Tick)	California	0	Hundreds	50+ million
10/26-10/28	Tropical Storm Olga	Southeast	1	35,000+	400+ million
10/26-10/31	Severe Weather	California	1	11,000+	100+ million
10/31-11/01	Severe Weather	Mid-Atlantic, Northeast	3	60,000+	500+ million
11/12-11/15	Winter Weather	Plains, Midwest, Southeast, Northeast	11	10,000+	50+ million

United States *(continued)*

Date	Event	Location	Deaths	Structures/Claims	Economic Loss (USD)
11/19-11/21	Severe Weather	Arizona	0	8,000+	90+ million
11/25-11/28	Winter Weather	West, Plains, Midwest, Southeast	1	20,000	190+ million
11/27-12/03	Winter Weather	West, Plains, Midwest, Northeast	8	17,500+	200+ million
12/15-12/18	Severe Weather	Central, Eastern	18	15,000+	235+ million
12/21-12/24	Severe Weather	Southeast	0	10,000+	125+ million
12/28-21/31	Severe Weather	Plains, Midwest, Southeast, Northeast	2	10,000+	100+ million

Remainder of North America (Non-U.S.)

Date	Event	Location	Deaths	Structures/Claims	Economic Loss (USD)
01/24-01/25	Flooding	Canada	0	3,750+	68+ million
01/27	Severe Weather	Cuba	4	1,000+	25+ million
02/03-02/05	Flooding	Canada	0	5,500+	145+ million
02/24-02/25	Winter Weather	Canada	0	8,500+	115+ million
03/09-03/11	Flooding	Canada	0	6,500+	130+ million
03/13-03/16	Flooding	Canada	0	11,000+	240+ million
04/16-05/14	Flooding	Canada	1	17,000+	800+ million
03/01-06/06	Wildfire	Canada	0	1,500+	35+ million
06/02	Severe Weather	Canada	0	2,000+	25+ million
06/02	Flooding	Mexico	7	2,500+	75+ million
01/01-12/31	Drought	Central America	N/A	N/A	127+ million
06/27-06/29	Severe Weather	El Salvador	0	Hundreds	30+ million
06/27-06/29	Flooding	Canada	0	3,500+	30+ million
06/30	Severe Weather	Mexico	0	5,000+	50+ million
07/06-07/10	Severe Weather	Canada	0	2,500+	25+ million
07/13-07/15	Severe Weather	Canada	0	5,500+	50+ million
07/17	Flooding	Canada	0	2,000+	75+ million
07/30-07/31	Severe Weather	Canada	0	7,500+	110+ million
07/31-08/01	Severe Weather	Canada	0	2,000+	25+ million
08/02	Severe Weather	Canada	0	13,000+	110+ million
08/06	Flooding	Canada	0	2,000+	25+ million
08/31-09/07	Hurricane Dorian	Caribbean, Bahamas, Canada	74*	68,000+	8.4+ billion
09/05-09/06	Tropical Storm Fernand	Mexico	1	10,000+	385+ million
09/19-09/20	Hurricane Humberto	Bermuda	0	2,000+	25+ million
09/19-09/22	Hurricane Lorena	Mexico	1	5,000+	50+ million
09/29-10/01	Tropical Storm Narda	Mexico	6	2,000+	100+ million
09/30-10/01	Severe Weather	Canada	0	2,500+	35+ million
10/01-10/31	Flooding	Guatemala	2	3,000+	50+ million
10/10-10/12	Winter Weather	Canada	0	2,500+	40+ million
10/31-11/02	Severe Weather	Canada	1	40,000+	305+ million

South America

Date	Event	Location	Deaths	Structures/Claims	Economic Loss (USD)
01/01-12/31	Drought	Chile	N/A	N/A	2.0+ billion
01/01-12/31	Drought	Uruguay	N/A	N/A	1.1+ billion
01/01-12/31	Drought	Paraguay	N/A	N/A	660+ million
01/01-12/31	Drought	Bolivia	N/A	N/A	300+ million
01/01-12/31	Drought	Argentina	N/A	N/A	125+ million
01/01-12/31	Drought	Colombia	N/A	N/A	50+ million
01/01-01/20	Flooding	Argentina, Uruguay	5	Thousands	2.3+ billion
01/19	Earthquake	Chile	2	1,000+	100+ million
01/27	Flooding	Peru	15	100+	Negligible
02/01-02/10	Flooding	Chile	6	5,700+	90+ million
02/01-02/10	Wildfire	Chile	2	56+	50+ million
02/02-02/05	Flooding	Bolivia	23	1,600+	Unknown
02/07-02/10	Flooding	Peru	10	Dozens	Unknown
02/22	Flooding	Colombia	0	4,000+	25+ million
03/10-03/12	Flooding	Brazil	13	7,500+	125+ million
03/15-04/05	Flooding	Paraguay	5	8,500+	25+ million
03/19-04/01	Flooding	Peru	0	2,000+	15+ million
04/01/04/08	Flooding	Colombia	10	40+	Millions
04/08-04/09	Flooding	Brazil	10	7,500+	100+ million
04/20-04/22	Flooding	Colombia	30	10,000+	75+ million
05/26	Earthquake	Peru	2	2,000+	50+ million
06/13	Flooding	Brazil	7	2,500+	50+ million
06/15-06/16	Flooding	Uruguay	0	3,000+	50+ million
10/27-11/15	Flooding	Colombia	20	4,650+	25+ million
11/12-11/15	Flooding	Colombia	1	2,000+	Millions
12/23-12/24	Wildfire	Chile	0	250+	Millions
12/26	Flooding	Colombia	18	2,000+	15+ million

Europe

Date	Event	Location	Deaths	Structures/Claims	Economic Loss (USD)
01/01-01/02	Windstorm Alfrida	Northern Europe	0	15,000+	145+ million
01/01-01/14	Winter Weather	Central Europe	26	Thousands	440+ million
01/10-01/12	Winter Weather	Spain	0	Hundreds	30+ million
01/14	Windstorm Florenz	Central Europe	0	2,500+	Millions
01/22-01/24	Flooding	Spain	4	3,700+	45+ million
01/29	Windstorm Gabriel	France	0	8,100+	40+ million
02/02-02/04	Flooding	Slovenia, Italy	0	Thousands	80+ million
02/08-02/09	Windstorm Erik	United Kingdom, Ireland	1	15,000+	55+ million

Europe *(continued)*

Date	Event	Location	Deaths	Structures/Claims	Economic Loss (USD)
02/10-02/11	Windstorm Isaias	France, Germany	0	15,000+	90+ million
02/14-02/17	Windstorm Julia	Norway, Sweden	0	2,000+	15+ million
02/23-02/26	Severe Weather	Italy, Greece, Malta, Croatia	8	20,000+	296+ million
03/01-06/30	Drought	Spain	N/A	Thousands	1.7+ billion
03/03-03/05	Windstorm Freya	Central & Western Europe	2	225,000+	375+ million
03/10	Windstorm Eberhard	Central & Western Europe	2	711,000+	1.6+ billion
03/11-03/12	Windstorm Gareth	United Kingdom	0	5,000+	50+ million
03/25-03/26	Severe Weather	Italy	0	5,000+	50+ million
04/06	Flooding	Greece	0	2,500+	50+ million
04/06	Severe Weather	Spain	0	Hundreds	45+ million
04/18-04/23	Severe Weather	Spain	0	15,000+	55+ million
05/06	Winter Weather	Spain	0	14,000+	10+ million
05/11-05/14	Flooding	Italy, Croatia, Bosnia	0	3,050+	274+ million
05/20-05/22	Flooding	Central Europe	0	Thousands	130+ million
06/01-06/03	Flooding	Serbia, Bosnia & Herzegovina	0	2,000+	30+ million
06/04-06/05	Severe Weather	Netherlands, Germany	0	12,500+	45+ million
06/07-06/08	Windstorm Miguel	France, Belgium	5	10,000+	20+ million
06/10-06/12	Severe Weather	Central Europe	0	255,000+	1.1+ billion
06/15-06/16	Severe Weather	Western & Central Europe	2	50,000+	698+ million
06/19	Severe Weather	Sweden	0	7,000+	13+ million
06/20-06/22	Severe Weather	Switzerland, Italy, Poland	1	2,300+	180+ million
06/27-08/31	Drought, Heatwave	Western & Central Europe	N/A	N/A	1.7+ billion
06/27	Severe Weather	Slovakia, Hungary, Austria, Romania	0	25,000+	30+ million
07/01-07/03	Severe Weather	Western & Central Europe	1	21,000+	255+ million
07/07-07/08	Severe Weather	Slovenia, Croatia, Hungary, Slovakia	0	Thousands	106+ million
07/08	Severe Weather	Spain	1	10,000+	65+ million
07/09-07/10	Severe Weather	Italy	1	10,000+	100+ million
07/10	Severe Weather	Greece	7	Hundreds	Millions
07/11-07/12	Severe Weather	Germany	0	Thousands	110+ million
07/19	Earthquake	Greece	0	3,200	30+ million
07/20-07/21	Severe Weather	Western and Central Europe	0	Thousands	155+ million
07/27-07/29	Severe Weather	Central Europe	3	Thousands	155+ million
08/02	Severe Weather	Italy	0	Thousands	110+ million
08/06-08/07	Severe Weather	Western and Central Europe	0	2,000+	210+ million
08/09	Severe Weather	Luxembourg, Western Europe	0	2,500+	145+ million
08/12-08/13	Severe Weather	Italy, Hungary, Poland	0	9,000+	180+ million
08/18	Severe Weather	Germany, France	0	7,000+	75+ million
08/20-08/21	Severe Weather	Spain	0	2,000+	Millions

Europe *(continued)*

Date	Event	Location	Deaths	Structures/Claims	Economic Loss (USD)
08/22	Severe Weather	Poland, Slovakia	5	N/A	N/A
08/26-08/28	Severe Weather	Spain	0	3,000+	30+ million
09/11-09/15	Flooding	Spain	7	70,000+	2.5+ billion
09/17	Severe Weather	Germany	0	4,000+	Millions
09/21	Earthquake	Albania	0	1,500+	45+ million
09/29-09/30	Windstorm Mortimer	Germany, Poland, Czech Republic	3	16,700+	145+ million
10/02	Hurricane Lorenzo	Portugal	0	Thousands	365+ million
10/03-10/04	Severe Weather	Greece	0	2,000+	15+ million
10/21	Severe Weather	Italy	1	2,000+	90+ million
10/22-10/24	Flooding	Spain, France	9	75,000+	280+ million
10/24-10/26	Flooding	Italy	1	1,000+	590+ million
11/02-11/03	Windstorm Amélie	France, Spain, Italy	0	27,000+	140+ million
11/07-11/11	Flooding	England	1	4,000+	225+ million
11/11	Earthquake	France	0	900+	55+ million
11/11-11/19	Flooding	Italy, Austria	3	5,500+	3.5+ billion
11/14	Winter Weather	France	0	Thousands	110+ million
11/21-11/24	Flooding	France, Italy	9	40,000+	1.2+ billion
11/26	Earthquake	Albania	52	14,000+	1.1+ billion
11/30-12/02	Flooding	France	4	20,000+	170+ million
12/08-12/09	Windstorm Atiyah	Ireland, United Kingdom	0	Hundreds	52+ million
12/15-12/17	Flooding	France	3	10,000+	100+ million
12/19-12/20	Windstorm Elsa	Portugal, Spain, France	8	Thousands	96+ million
12/21-12/22	Windstorm Fabien	Portugal, Spain, France	0	Thousands	120+ million

Middle East

Date	Event	Location	Deaths	Structures/Claims	Economic Loss (USD)
01/06	Earthquake	Iran	0	2,000+	25+ million
01/24-01/26	Severe Weather	Turkey	2	2,000+	20+ million
01/27-01/29	Flooding	Saudi Arabia	12	2,000+	25+ million
03/09-03/10	Flooding	Iran	0	Hundreds	80+ million
03/17-04/09	Flooding	Iran	77	10,000+	8.3+ billion*
03/24-03/29	Flooding	Iraq, Syria	10	1,000+	10+ million
04/29	Other	Iraq	5	Unknown	Unknown
05/17-05/27	Flooding	Oman, Yemen, UAE, Saudi Arabia	7	5,000+	100+ million
06/07-06/09	Flooding	Yemen	3	5,000+	Millions
06/09	Flooding	Turkey	3	2,000+	15+ million
07/08	Earthquake	Iran	1	2,000+	50+ million
07/17	Flooding	Turkey	7	2,160+	25+ million

Middle East *(continued)*

Date	Event	Location	Deaths	Structures/Claims	Economic Loss (USD)
07/31-08/06	Flooding	Yemen	12	2,500+	Unknown
08/17	Flooding	Turkey	1	5,000+	25+ million
08/23-08/24	Flooding	Turkey	0	Hundreds	50+ million
09/24	Cyclone Hikaa	Oman	14	Hundreds	Millions
09/26	Earthquake	Turkey	1	10,000+	14+ million
10/13-10/15	Wildfire	Lebanon, Syria	1	2,000+	Millions
10/27	Severe Weather	Saudi Arabia	7	5,000+	75+ million
11/08	Earthquake	Iran	7	4,500+	90+ million

**Global free market currency conversion; unofficial local free market conversion cost is USD2.6 billion*

Africa

Date	Event	Location	Deaths	Structures/Claims	Economic Loss (USD)
01/01-01/31	Flooding	Mozambique	18	2,000+	Millions
01/01-12/31	Drought	Zimbabwe	N/A	N/A	293+ million
01/01-6/30	Drought	Senegal	N/A	N/A	100+ million
01/01-12/31	Drought	South Africa	N/A	N/A	135+ million
01/01-12/31	Drought	Angola	N/A	N/A	600+ million
01/01-12/31	Drought	Botswana	N/A	N/A	90+ million
01/01-12/31	Drought	Lesotho	N/A	N/A	83+ million
01/01-12/31	Drought	Zambia	N/A	N/A	50+ million
01/01-12/31	Drought	Namibia	N/A	N/A	40+ million
01/17-01/21	Flooding	Burundi	10	Hundreds	Unknown
01/22-01/24	Tropical Storm Eketsang	Madagascar	27	Unknown	Unknown
02/12-02/18	Flooding	Zimbabwe	26	Unknown	Unknown
03/04-03/22	Cyclone Idai	Southern Africa	1,303	310,000+	2.7+ billion
03/10-03/12	Flooding	South Africa	10	Hundreds	5+ million
03/16-03/19	Flooding	Angola	27	1,000+	Millions
04/22-04/24	Flooding	South Africa	87	7,500+	100+ million
04/23	Flooding	Uganda	17	Unknown	Unknown
04/24-04/26	Cyclone Kenneth	Comoros, Mozambique	52	53,000+	300+ million
05/06	Wildfire	South Sudan	48	138	Unknown
05/15-18	Flooding	Mali, Guinea	21	Hundreds	Millions
05/30-06/01	Flooding	Ghana	13	Hundreds	Millions
06/03	Flooding	Libya	4	2,000+	5+ million
06/04-06/08	Flooding	Uganda	6	Thousands	Unknown
06/05-06/10	Flooding	South Sudan	3	11,000+	15+ million
07/24	Landslide	Morocco	15	N/A	N/A
08/01-08/31	Flooding	Sudan	59	48,800+	200+ million

Africa *(continued)*

Date	Event	Location	Deaths	Structures/Claims	Economic Loss (USD)
08/11-08/12	Flooding	Ethiopia	0	6,650+	5+ million
08/20-08/25	Flooding	Nigeria	12	11,300+	50+ million
08/24-08/27	Flooding	Mali	0	2,000+	15+ million
08/26-08/27	Flooding	Mauritania	0	4,200+	5+ million
8/24-09/15	Flooding	Niger	57	16,500+	25+ million
09/08	Flooding	Morocco	17	Negligible	Negligible
09/11-09/18	Flooding	Algeria	7	2,000+	Unknown
10/01-10/31	Flooding	West Africa	33	21,000+	25+ million
10/01-11/30	Flooding	East Africa	284	50,000+	140+ million
10/01-12/15	Flooding	Central Africa	180	105,000+	105+ million
10/28	Flooding	Cameroon	73	Negligible	Negligible
11/11-11/12	Severe Weather	South Africa	12	Dozens	10+ million
12/02-12/11	Flooding	South Africa	2	5,000+	140+ million
12/03-12/07	Flooding	Uganda	30	2,000+	Unknown
12/04-12/05	Flooding	Burundi	38	Unknown	Unknown
12/07	Flooding	Uganda	22	1,000+	Unknown
12/09	Cyclone Belna	Madagascar	9	4,500+	25+ million
12/21	Flooding	Burundi	14	220+	Unknown
12/25	Flooding	Rwanda	12	115+	Unknown

Asia

Date	Event	Location	Deaths	Structures/Claims	Economic Loss (USD)
01/01-12/31	Drought	India	N/A	N/A	1.75+ billion
01/01-12/31	Drought	China	N/A	N/A	8.0+ billion
01/01-12/31	Drought	Pakistan	N/A	N/A	150+ million
01/01-12/31	Drought	North Korea	N/A	N/A	100+ million
01/01-04/30	Winter Weather	China	3	N/A	235+ million
01/01-03/31	Flooding	China	0	2,500+	40+ million
01/03-01/05	Tropical Storm Pabuk	Thailand, Vietnam, Malaysia	10	5,000+	157+ million
01/06	Flooding	Afghanistan	30	0	Negligible
01/21-02/01	Flooding	Indonesia	85	23,000+	98+ million
02/17-02/18	Severe Weather	Vietnam	0	3,625+	Unknown
02/20-02/21	Flooding	Pakistan	26	Hundreds	Millions
02/24-02/25	Earthquake	China	2	11,000+	35+ million
03/01-06/30	Drought	Philippines	N/A	N/A	154+ million
03/01-03/04	Flooding	Afghanistan	68	4,000+	Unknown
03/01-03/07	Flooding	Pakistan	31	2,700+	Unknown
03/07-03/10	Flooding	Indonesia	8	Dozens	Unknown

Asia *(continued)*

Date	Event	Location	Deaths	Structures/Claims	Economic Loss (USD)
03/15	Flooding	China	20	100+	3.0+ million
03/16-03/18	Flooding	Indonesia	194	3,000+	103+ million
03/17	Earthquake	Indonesia	9	4,000+	25+ million
03/18	Flooding	Afghanistan	13	Dozens	Unknown
03/19-03/22	Severe Weather	China	9	24,000+	100+ million
03/29-03/30	Flooding	Afghanistan	45	13,000+	10s of Millions
03/30-04/09	Wildfire	China	31	N/A	N/A
03/31	Severe Weather	Nepal, India	35	2,400+	50+ million
03/31	Severe Weather	Bangladesh	15	Hundreds	25+ million
04/04-04/05	Wildfire	South Korea	2	2,000+	50+ million
04/09	Flooding	India	1	8,300+	Unknown
04/09	Severe Weather	Pakistan	8	Dozens	Unknown
04/11-04/12	Flooding	China	11	2,000+	50+ million
04/13-04/14	Flooding	Pakistan	20	4,200+	Millions
04/15-04/17	Severe Weather	Afghanistan, Pakistan, India	146	12,500+	75+ million
04/19-04/20	Wildfire	Russia	0	118+	20+ million
04/22-04/23	Severe Weather	Myanmar	8	7,500+	10+ million
04/22-04/22	Earthquake	Philippines	21	5,100+	50+ million
04/25-04/27	Flooding	Indonesia	44	2,000+	15+ million
05/01-07/31	Drought	Thailand	N/A	N/A	490+ million
05/03-05/05	Cyclone Fani	India, Bangladesh	89	Thousands	8.1+ billion
05/20-05/24	Flooding	Thailand	1	4,009+	Millions
05/22-05/25	Flooding	Afghanistan	24	1,000+	Millions
05/31-06/17	Heatwave	India	210	N/A	Unknown
06/01-10/05	Flooding	India	1,750	200,000+	10+ billion
06/01-06/03	Severe Weather	India	10	Hundreds	Unknown
06/01-06/30	Flooding	Indonesia	2	75,047+	141+ million
06/01-09/01	Flooding	China	300	300,000+	15+ billion
06/06-06/14	Severe Weather	India	50	10,000+	75+ million
06/15-06/16	Flooding	Mongolia	12	5,000+	25+ million
06/17	Earthquake	China	13	156,000+	815+ million
06/18	Earthquake	Japan	0	12,000+	50+ million
06/22-06/27	Severe Weather	Nepal, India	53	Unknown	25+ million
06/27-07/03	Flooding	Russia	26	10,900+	460+ million
06/28-07/04	Flooding	India	77	25,000+	100+ million
06/29-07/04	Flooding	Japan	2	1,000+	125+ million
07/01-08/31	Wildfire	Russia	0	2,000+	300+ million
07/01-08/31	Heatwave	Japan	162	N/A	N/A

Asia *(continued)*

Date	Event	Location	Deaths	Structures/Claims	Economic Loss (USD)
07/01-08/23	Flooding	Pakistan	143	4,000+	75+ million
07/01-08/14	Flooding	Myanmar	115	4,000+	Millions
07/03	Severe Weather	China	6	15,000+	145+ million
07/09-07/31	Flooding	Bangladesh	210	584,000+	75+ million
07/11-07/14	Flooding	Nepal	118	15,000+	50+ million
07/12-07/14	Severe Weather	Bangladesh	18	10,000+	25+ million
07/12	Earthquake	Philippines	0	2,514+	Unknown
07/14	Earthquake	Indonesia	14	2,914+	20+ million
07/15	Flooding	Pakistan	28	500+	Unknown
07/15-07/19	Flooding	Indonesia	1	2,000+	Unknown
07/18-07/23	Flooding	Sri Lanka	9	3,600+	25+ million
07/19	Earthquake	Philippines	0	1,900+	Unknown
07/23	Flooding	China	52	21+	276+ million
07/23	Flooding	Nepal	13	Unknown	Negligible
07/25-07/31	Flooding	Russia	0	3,000+	180+ million
07/26	Earthquake	Philippines	9	1,000+	15+ million
07/29-08/01	Flooding	China	0	2,500+	315+ million
07/29	Flooding	Pakistan	16	Dozens	Unknown
08/01-08/08	Tropical Storm Wipha	China, Vietnam	33	8,500+	143+ million
08/02	Earthquake	Indonesia	6	1,000+	10+ million
08/04-08/09	Severe Weather	China	33	2,000+	65+ million
08/08-08/10	Flooding	Vietnam	10	12,000+	10+ million
08/09-08/11	Typhoon Lekima	China, Philippines, Japan	101	150,600+	9.5+ billion
08/09-08/11	Flooding	Pakistan	38	1,000+	Unknown
08/15-08/16	Typhoon Krosa	Japan	3	2,000+	75+ million
08/16-08/20	Flooding	Pakistan	16	Hundreds	Unknown
08/18-08/21	Flooding	China	45	2,200+	2.3+ billion
08/20-09/23	Flooding	Laos	14	30,000+	140+ million
08/24-08/25	Tropical Storm Bailu	Taiwan, China, Philippines	3	11,200+	60+ million
08/27-08/30	Tropical Storm Podul	Philippines, Vietnam	18	7,500+	60+ million
08/27-08/29	Flooding	Japan	3	2,000+	250+ million
08/28-08/31	Flooding	Russia	0	5,000+	34 million
08/31-10/02	Flooding	Cambodia	16	50,000+	100+ million
09/02-09/12	Tropical Storm Kajiki	Laos, Vietnam, Cambodia	40	10,000+	75+ million
09/05-09/08	Typhoon Lingling	Japan, China, Korea	8	12,750+	211 million
09/08	Earthquake	China	1	10,000+	50+ million
09/08-09/09	Typhoon Faxai	Japan	3	185,000+	10+ billion
09/08-09/19	Flooding	Thailand	33	5,000+	75+ million

Asia *(continued)*

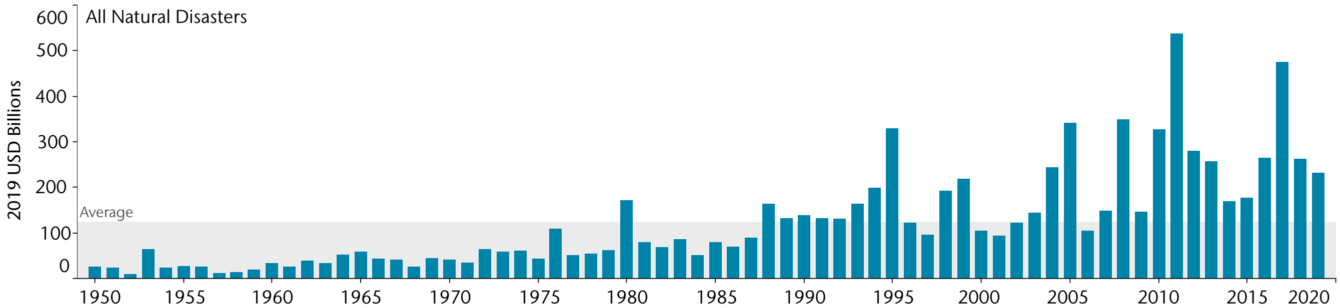
Date	Event	Location	Deaths	Structures/Claims	Economic Loss (USD)
09/09-09/20	Flooding	China	0	Hundreds	57+ million
09/21-09/22	Tropical Storm Tapah	Japan, Korean Peninsula	2	6,000+	85+ million
09/23-09/25	Flooding	Sri Lanka	1	2,000+	25+ million
09/24	Earthquake	Pakistan	40	5,700+	20+ million
09/25	Earthquake	Indonesia	41	6,700+	50+ million
09/30-10/03	Flooding	Pakistan	8	Unknown	Unknown
10/01-10/02	Typhoon Mitag	China, Taiwan, Korean Peninsula	17	6,000+	835+ million
10/02	Earthquake	China	0	7,800+	10 million
10/06-10/12	Typhoon Hagibis	Japan	99	275,000+	15+ billion
10/15-10/23	Flooding	Vietnam	4	5,200+	15+ million
10/15-10/25	Flooding	China	14	Thousands	90+ million
10/16	Earthquake	Philippines	7	7,089+	25+ million
10/19-10/22	Flooding	India	12	5,500+	50+ million
10/22-10/27	Flooding	Indonesia	0	2,000+	Millions
10/24-10/26	Flooding	Japan	11	2,500+	200+ million
10/28	Earthquake	China	0	7,300+	10 million
10/29-10/29	Earthquake	Philippines	24	34,482+	100+ million
10/29-11/01	Tropical Storm Matmo	Vietnam	1	2,493+	Millions
10/31-10/31	Earthquake	Philippines	10	5,697+	50+ million
11/01-11/30	Winter Weather	China	0	6,000+	10+ million
11/01-12/31	Winter Weather	Bangladesh	50	Unknown	Unknown
11/08-11/11	Cyclone Matmo (Bulbul)	India, Bangladesh	72	210,000+	3.4+ billion
11/08-11/10	Tropical Storm Nakri	Philippines, Vietnam	19	Hundreds	41+ million
11/27-12/02	Flooding	Malaysia	3	Hundreds	Unknown
11/29-12/02	Severe Weather	Sri Lanka	6	Hundreds	Unknown
11/29-12/02	Flooding	India	27	5,000+	Millions
12/02-12/04	Typhoon Kammuri	Philippines	17	561,500+	110+ million
12/02-12/31	Flooding	Sri Lanka	24	2,000+	25+ million
12/12-12/17	Flooding	Indonesia	14	5,500+	20+ million
12/15	Earthquake	Philippines	14	45,800+	100+ millions
12/19-12/21	Flooding	Indonesia	6	9,000+	15+ million
12/24-12/25	Typhoon Phanfone	Philippines	59	531,300+	125+ million
12/31-01/03	Flooding	Indonesia	30	50,000+	1.15+ billion

Oceania (Australia, New Zealand, and the South Pacific Islands)

Date	Event	Location	Deaths	Structures/Claims	Economic Loss (USD)
01/01-12/31	Drought	Australia	N/A	N/A	1.4+ billion
01/28-02/07	Flooding	Australia	3	30,000+	1.9+ billion
03/01-03/20	Wildfire	Australia	0	432+	40+ million
03/24-03/25	Flooding	New Zealand	1	2,000+	15+ million
04/15-04/15	Flooding	Papua New Guinea	12	Dozens	Unknown
09/05-10/10	Wildfire	Australia	2	725+	55+ million
11/08-12/31	Wildfires	Australia	29	13,750+	5.0+ billion
11/17	Severe Weather	Australia	0	15,870+	100+ million
11/17-11/20	Severe Weather	New Zealand	0	12,000+	50+ million
11/26	Severe Weather	Australia	0	2,500+	50+ million
12/09	Volcano	New Zealand	20	N/A	N/A

Appendix B: Long-term Natural Disaster Trends

Exhibit 49: Global Economic Losses from natural disasters since 1950



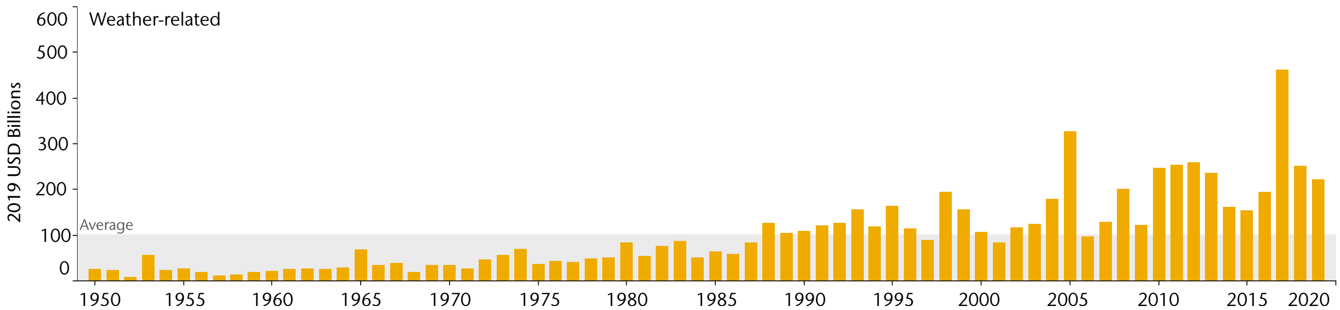


Exhibit 50: Cumulative Global Economic Losses by peril since 1950

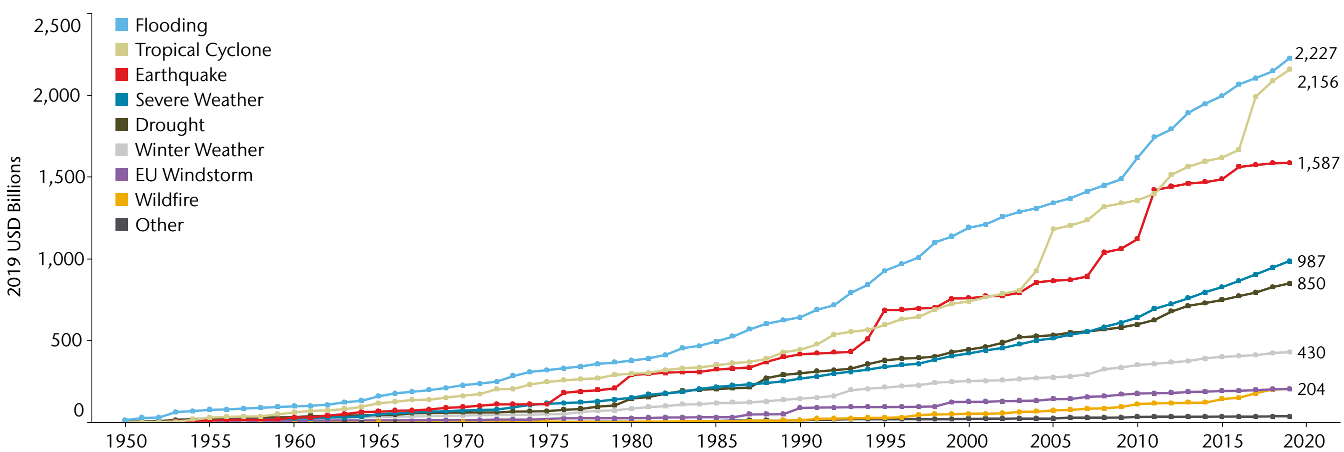


Exhibit 51: Global Insured Losses from natural disasters since 1950

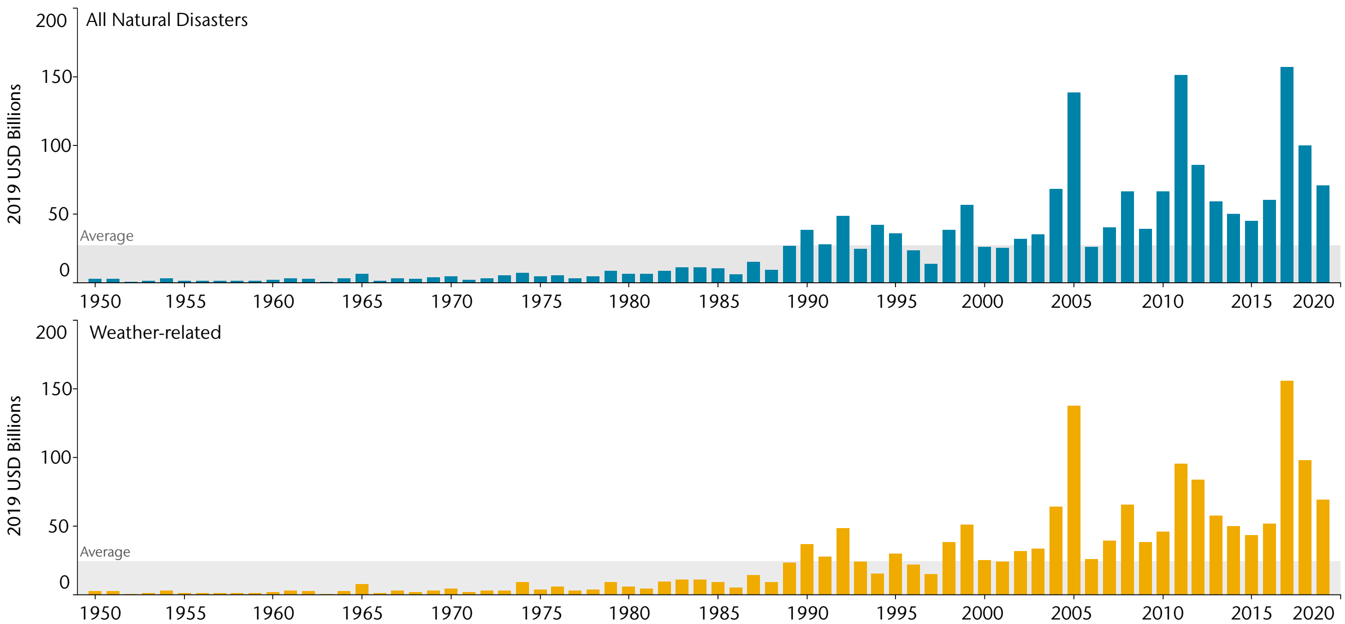
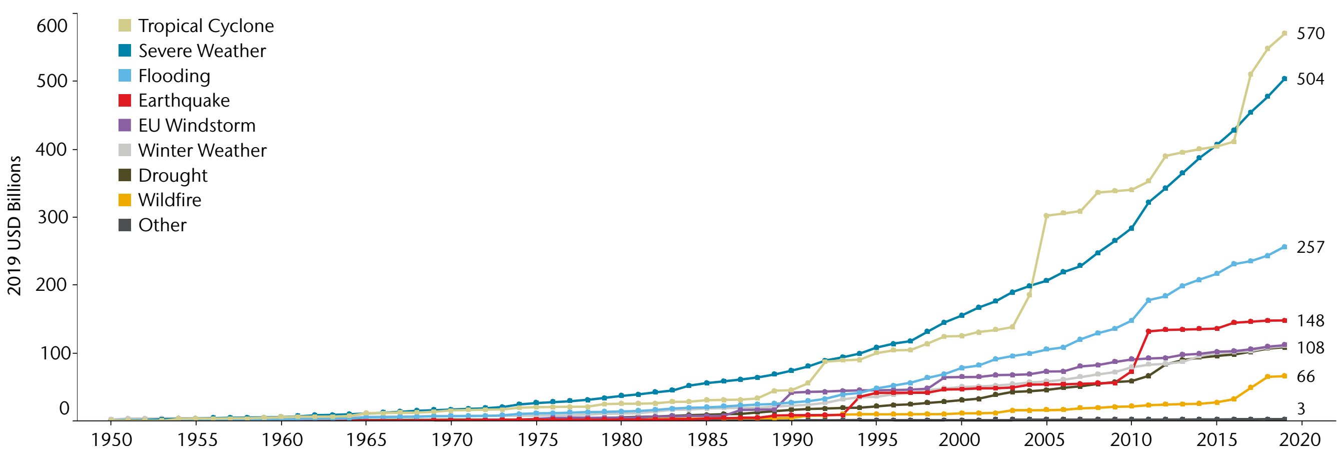


Exhibit 52: Cumulative Global Insured Losses by peril since 1950



Appendix C: Historical Natural Disaster Events

The following tables provide a look at specific global natural disaster events since 1900. (Please note that the adjusted for inflation (2019 USD) totals were converted using the U.S. Consumer Price Index (CPI). Insured losses include those sustained by private industry and government entities such as the U.S. National Flood Insurance Program (NFIP). Inflation-adjusted losses are used since they represent actual incurred costs in today's dollars. Normalized values, while very valuable for analyzing historical scenarios using today's population, exposure, and wealth, are hypothetical. Please note that some of these values have been rounded to the nearest whole number.

For additional top 10 lists, please visit **http://catastropheinsight.aon.com.**

Exhibit 53: Top 10 Costliest Global Economic Loss Events (1900-2019)

Date	Event	Location	Economic Loss[1] Actual (USD)	Economic Loss[2] (2019 USD)
March 11, 2011	Tohoku EQ/Tsunami	Japan	235 billion	269 billion
January 16, 1995	Great Hanshin EQ	Japan	103 billion	174 billion
August 2005	Hurricane Katrina	United States	125 billion	163 billion
May 12, 2008	Sichuan Earthquake	China	122 billion	144 billion
August 2017	Hurricane Harvey	United States	125 billion	130 billion
September 2017	Hurricane Maria	Puerto Rico, Caribbean	90 billion	93 billion
October 2012	Hurricane Sandy	U.S., Caribbean, Canada	77 billion	85 billion
September 2017	Hurricane Irma	U.S., Caribbean	75 billion	78 billion
January 17, 1994	Northridge EQ	United States	44 billion	77 billion
November 23, 1980	Irpinia EQ	Italy	20 billion	60 billion

[1] Economic loss include those sustained from direct damage, plus additional directly attributable event costs
[2] Adjusted using U.S. Consumer Price Index (CPI)

Exhibit 54: Top 10 Costliest Global Insured Loss Events (1900-2019)

Date	Event	Location	Insured Loss[1] Actual (USD)	Insured Loss[2] (2019 USD)
August 2005	Hurricane Katrina	United States	65 billion	85 billion
March 11, 2011	Tohoku EQ/ Tsunami	Japan	35 billion	40 billion
October 2012	Hurricane Sandy	United States	30 billion	33 billion
September 2017	Hurricane Irma	U.S, Caribbean	32 billion	33 billion
August 2017	Hurricane Harvey	United States	30 billion	31 billion
September 2017	Hurricane Maria	Puerto Rico, Caribbean	30 billion	31 billion
August 1992	Hurricane Andrew	U.S., Bahamas	16 billion	29 billion
January 17, 1994	Northridge EQ	United States	15 billion	27 billion
September 2008	Hurricane Ike	U.S., Caribbean	18 billion	21 billion
June-December 2011	Thailand Floods	Thailand	16 billion	18 billion

[1] Losses sustained by private insurers and government-sponsored programs
[2] Adjusted using U.S. Consumer Price Index (CPI)

Exhibit 55: Top 10 Costliest Tropical Cyclones: Economic Loss (1900-2019)

Date	Event	Location	Economic Loss[1] Actual (USD)	Economic Loss[2] (2019 USD)
August 2005	Hurricane Katrina	United States	125 billion	163 billion
August 2017	Hurricane Harvey	United States	125 billion	130 billion
September 2017	Hurricane Maria	U.S., Caribbean	90 billion	93 billion
October 2012	Hurricane Sandy	U.S., Caribbean, Canada	77 billion	85 billion
September 2017	Hurricane Irma	U.S., Caribbean	75 billion	78 billion
August 1992	Hurricane Andrew	U.S., Bahamas	27 billion	49 billion
September 2008	Hurricane Ike	U.S., Caribbean	38 billion	45 billion
September 2004	Hurricane Ivan	U.S., Caribbean	27 billion	37 billion
October 2005	Hurricane Wilma	U.S., Caribbean	28 billion	35 billion
September 1989	Hurricane Hugo	U.S., Caribbean	13 billion	26 billion

[1] Economic loss include those sustained from direct damage, plus additional directly attributable event costs
[2] Adjusted using U.S. Consumer Price Index (CPI)

Exhibit 56: Top 10 Costliest Tropical Cyclones: Insured Loss (1900-2019)

Date	Event	Location	Insured Loss[1] Actual (USD)	Insured Loss[2] (2019 USD)
August 2005	Hurricane Katrina	United States	65 billion	85 billion
October 2012	Hurricane Sandy	U.S., Caribbean, Canada	30 billion	33 billion
September 2017	Hurricane Irma	U.S., Caribbean	32 billion	33 billion
August 2017	Hurricane Harvey	United States	30 billion	31 billion
September 2017	Hurricane Maria	Caribbean, U.S.	30 billion	31 billion
August 1992	Hurricane Andrew	U.S., Bahamas	16 billion	29 billion
September 2008	Hurricane Ike	U.S., Caribbean	18 billion	21 billion
October 2005	Hurricane Wilma	U.S., Caribbean	13 billion	16 billion
September 2004	Hurricane Ivan	U.S., Caribbean	11 billion	14 billion
September 2018	Typhoon Jebi	Japan	13 billion	13 billion

[1] Losses sustained by private insurers and government-sponsored programs
[2] Adjusted using U.S. Consumer Price Index (CPI)

Exhibit 57: Top 10 Costliest Floods: Economic Loss (1900-2019)

Date	Event	Location	Economic Loss[1] Actual (USD)	Economic Loss[2] (2019 USD)
July-December 2011	Thailand Floods	Thailand	45 billion	51 billion
June-September 1998	Yangtze River Floods	China	31 billion	49 billion
July-August 2010	Yangtze River Floods	China	35 billion	41 billion
June-August 1993	Mississippi Floods	United States	21 billion	37 billion
June-August 1953	Japan Floods	Japan	3.2 billion	31 billion
May-August 2016	Yangtze River Floods	China	28 billion	30 billion
August-September 2013	Amur Basin Floods	Russia, China	24 billion	26 billion
May-September 1991	Yangtze River Floods	China	14 billion	26 billion
July 1995	North Korea Floods	North Korea	15 billion	25 billion
May-August 1995	Yangtze River Floods	China	14 billion	24 billion

[1] Losses sustained by private insurers and government-sponsored programs
[2] Adjusted using U.S. Consumer Price Index (CPI)

Exhibit 58: Top 10 Costliest Earthquakes: Economic Loss (1900-2019)

Date	Event	Location	Economic Loss[1] Actual (USD)	Economic Loss[2] (2019 USD)
March 11, 2011	Tohoku EQ/Tsunami	Japan	235 billion	269 billion
January 16, 1995	Great Hanshin EQ	Japan	103 billion	174 billion
May 12, 2008	Sichuan Earthquake	China	122 billion	143 billion
January 17, 1994	Northridge EQ	United States	44 billion	77 billion
November 23, 1980	Irpinia EQ	Italy	20 billion	60 billion
April 14, 2016	Kumamoto EQ	Japan	38 billion	41 billion
October 23, 2004	Chuetsu EQ	Japan	28 billion	37 billion
February 27, 2010	Chile EQ	Chile	30 billion	35 billion
December 7, 1988	Armenian EQ	Armenia (Present Day)	16 billion	34 billion
July 27, 1976	Tangshan EQ	China	5.6 billion	25 billion

[1] Losses sustained by private insurers and government-sponsored programs
[2] Adjusted using U.S. Consumer Price Index (CPI)

Exhibit 59: Top 10 Costliest Individual Wildfires: Insured Loss (1900-2019)

Date	Event	Location	Insured Loss[1] Actual (USD)	Insured Loss[2] (2019 USD)
November 2018	Camp Fire	United States	10 billion	10 billion
October 2017	Tubbs Fire	United States	8.7 billion	9.0 billion
November 2018	Woolsey Fire	United States	4.2 billion	4.3 billion
October 1991	Oakland (Tunnel) Fire	United States	1.7 billion	3.2 billion
October 2017	Atlas Fire	United States	3.0 billion	3.1 billion
May 2016	Horse Creek Fire	Canada	2.9 billion	3.0 billion
December 2017	Thomas Fire	United States	2.3 billion	2.3 billion
October 2007	Witch Fire	United States	1.6 billion	2.0 billion
October 2003	Cedar Fire	United States	1.1 billion	1.5 billion
October 2003	Old Fire	United States	975 million	1.3 billion

[1] Losses sustained by private insurers and government-sponsored programs
[2] Adjusted using U.S. Consumer Price Index (CPI)

Exhibit 60: Top 10 Global Human Fatality Events in the Modern Era (1950-2019)

Date	Event	Location	Economic Loss[1] Actual (USD)	Insured Loss[2] (2019 USD)	Fatalities
November 12, 1970	Cyclone Bhola	Bangladesh	86 million	N/A	300,000
July 27, 1976	Tangshan EQ	China	5.6 billion	N/A	242,769
July 30, 1975	Super Typhoon Nina	Taiwan, China	1.2 billion	N/A	230,000
December 26, 2004	Indian Ocean EQ/Tsunami	Indian Ocean Basin	14 billion	3 billion	227,899
January 12, 2010	Port-au-Prince EQ	Haiti	8.0 billion	200 million	160,000
April 1991	Cyclone Gorky	Bangladesh	1.8 billion	100 million	139,000
May 2008	Cyclone Nargis	Myanmar	12.9 billion	N/A	138,366
August 1971	Vietnam Floods	Vietnam	N/A	N/A	100,000
October 8, 2005	Kashmir EQ	Pakistan	6.7 billion	50 million	88,000
May 12, 2008	Sichuan EQ	China	122 billion	366 million	87,652

[1] Economic loss include those sustained from direct damage, plus additional directly attributable event costs
[2] Adjusted using U.S. Consumer Price Index (CPI)

Appendix D: Tropical Cyclone Activity & Landfalls

The following shows tropical cyclone activity and landfalls by basin. Note that data for the Atlantic and Western Pacific Basins in this section extend to 1950 given the level of quality data as provided by NOAA's IBTrACS historical tropical cyclone database. All other basins include data to 1980.

Atlantic Ocean Basin

Exhibit 61: Atlantic Basin Tropical Cyclone Activity

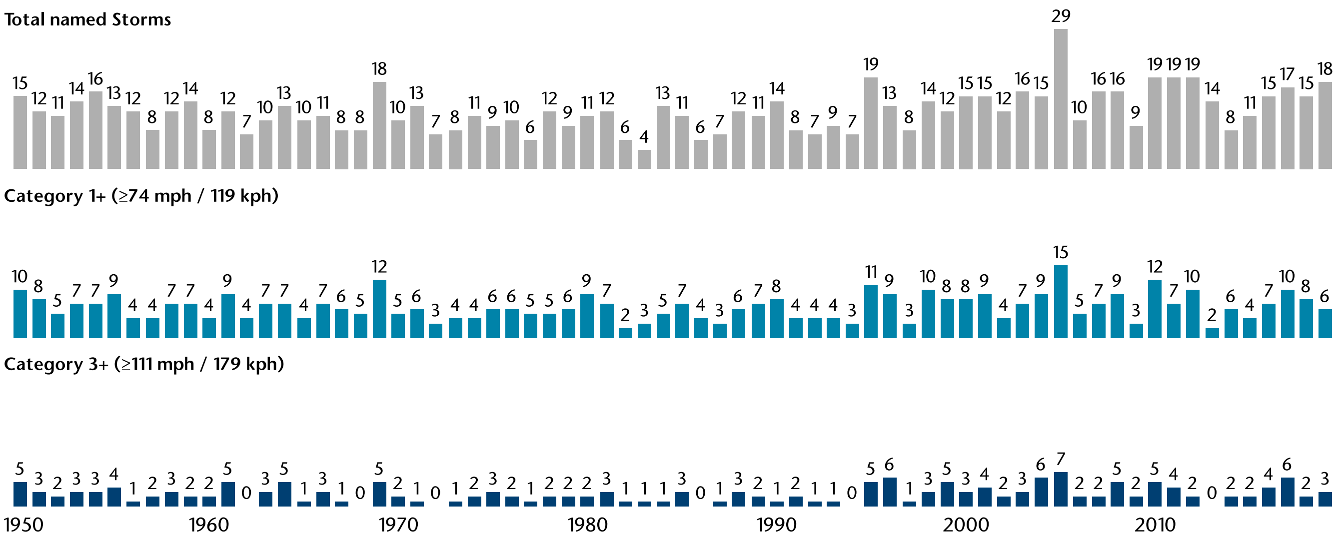


Exhibit 62: Atlantic Basin Hurricane & Major Hurricane Landfalls

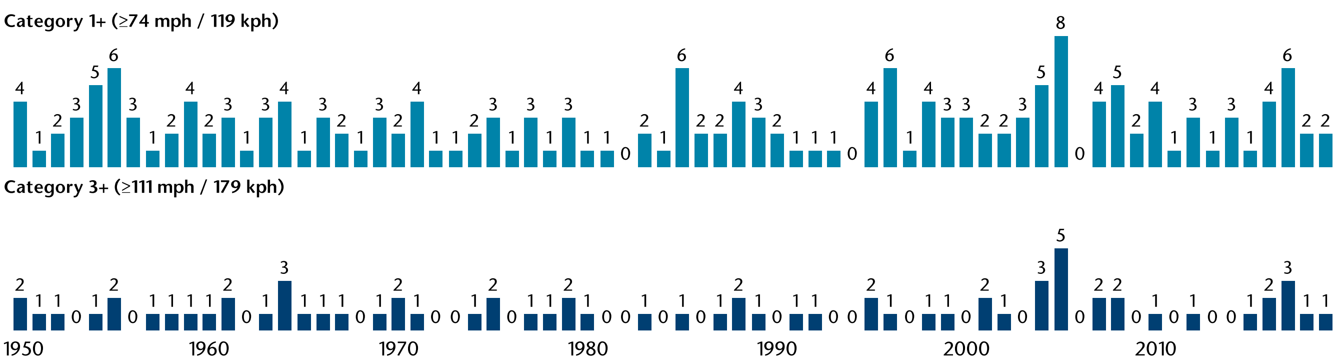


Exhibit 63: United States Hurricane & Major Hurricane Landfalls

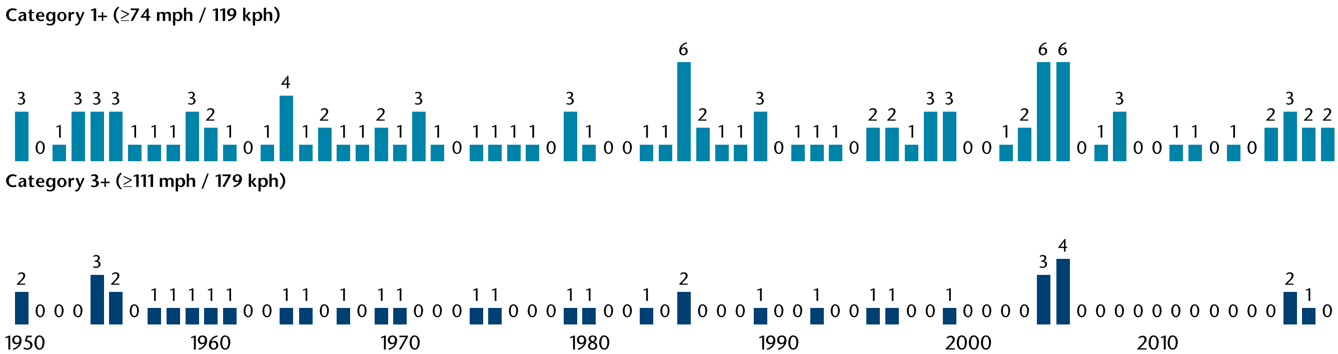
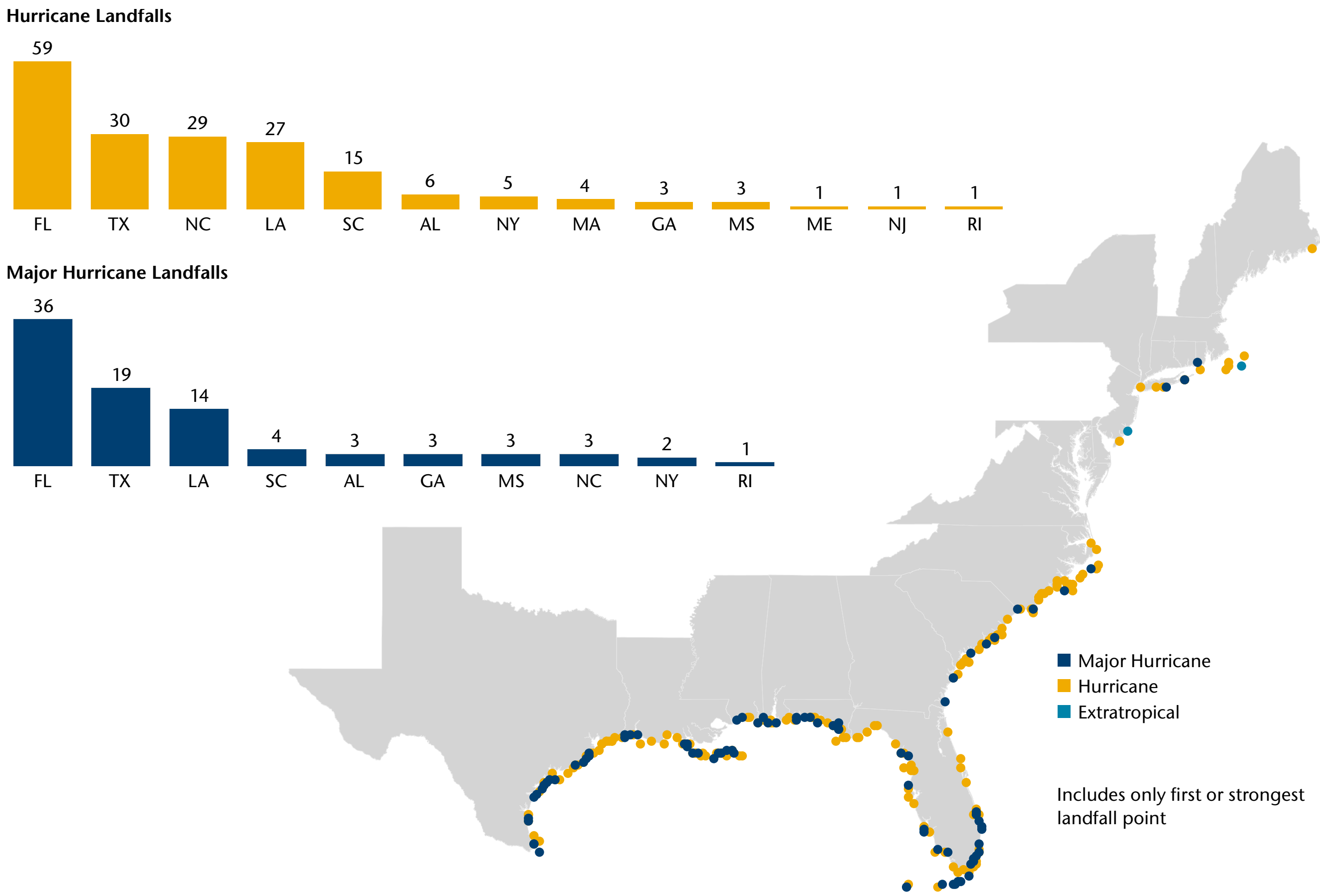


Exhibit 64: United States Hurricane & Major Hurricane Landfall Map



Eastern Pacific Ocean Basin

Exhibit 65: Eastern & Central Pacific Basin Tropical Cyclone Activity

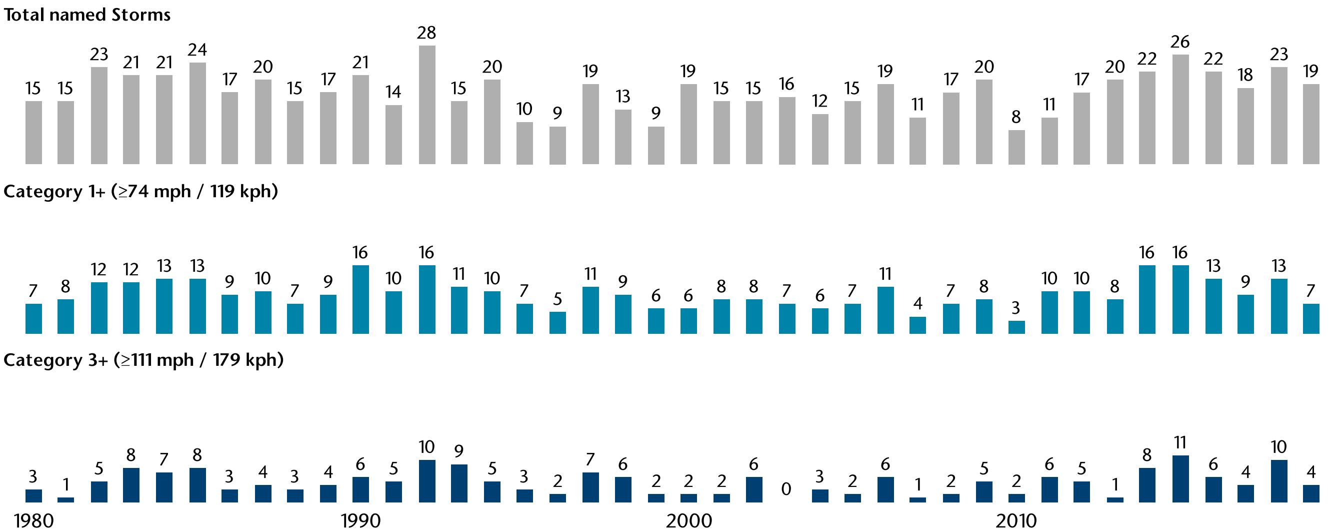
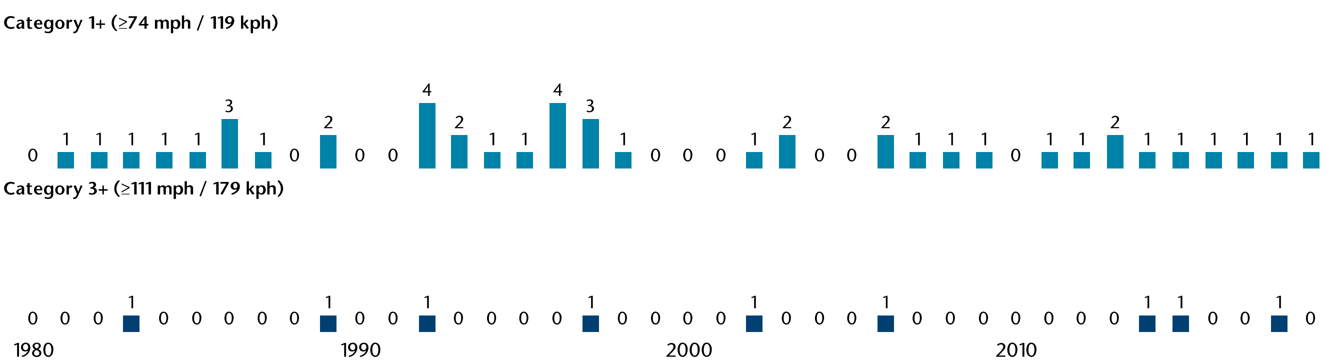


Exhibit 89: Eastern & Central Pacific Basin Hurricane & Major Hurricane Landfalls



Western Pacific Ocean Basin

Exhibit 67: Western Pacific Basin Tropical Cyclone Activity

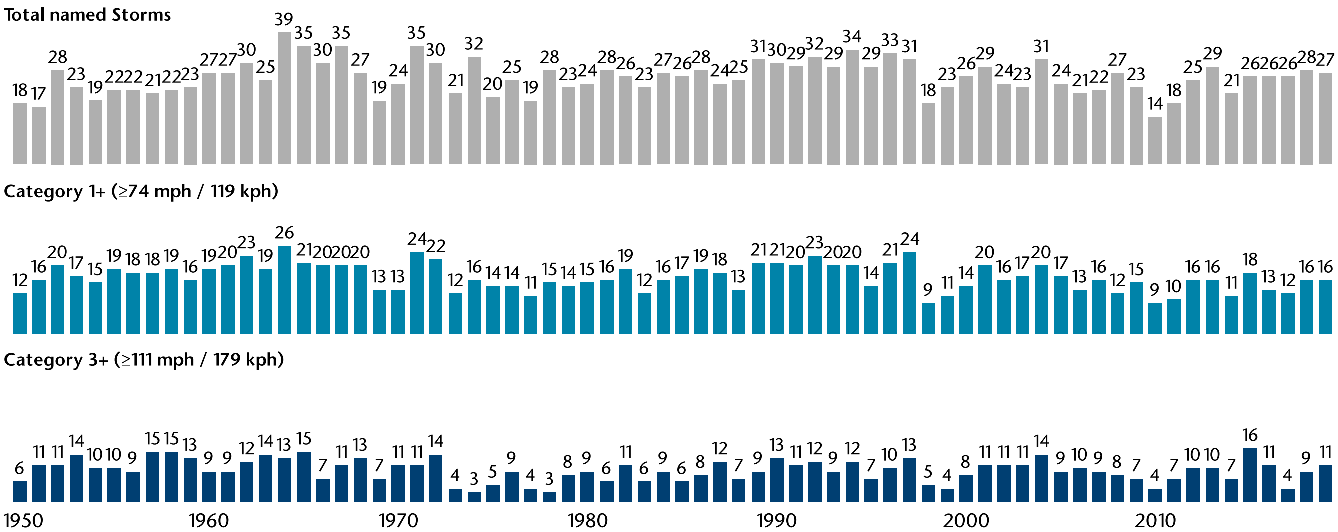
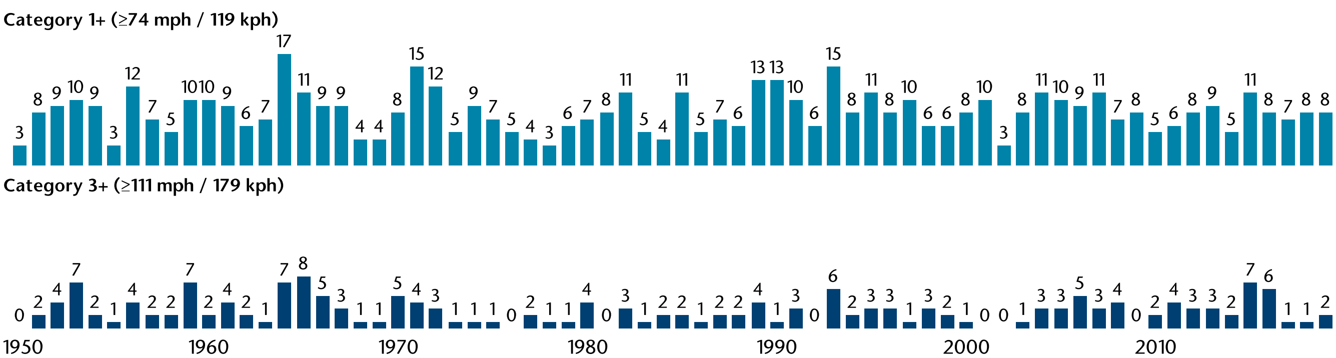


Exhibit 68: Western Pacific Basin Typhoon Landfalls



North Indian Ocean Basin

Exhibit 69: North Indian Basin Tropical Cyclone Activity

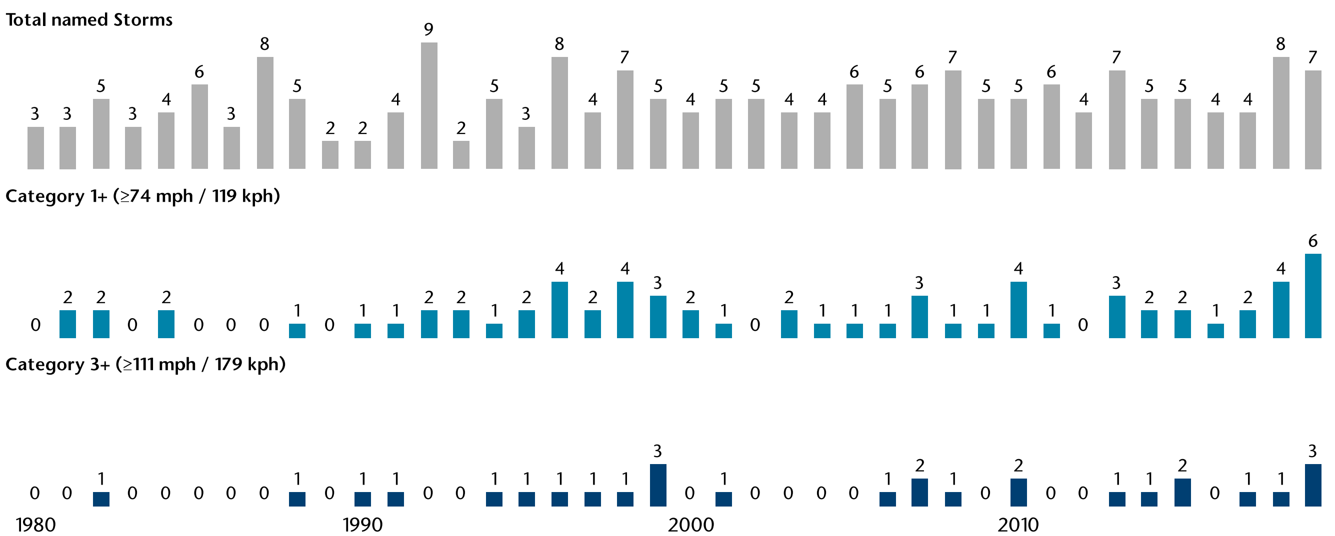
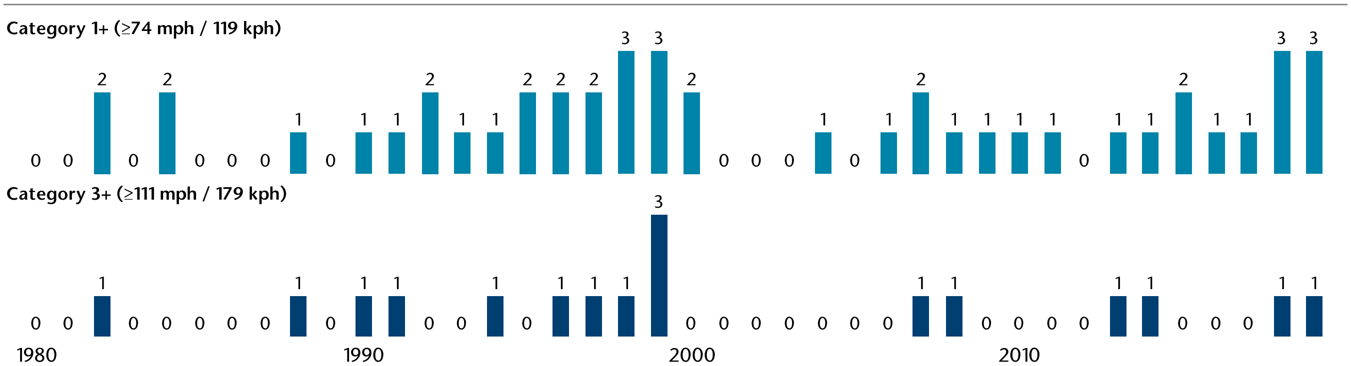


Exhibit 70: North Indian Basin Tropical Cyclone Landfalls



Southern Hemisphere

Exhibit 71: Southern Hemisphere Tropical Cyclone Activity

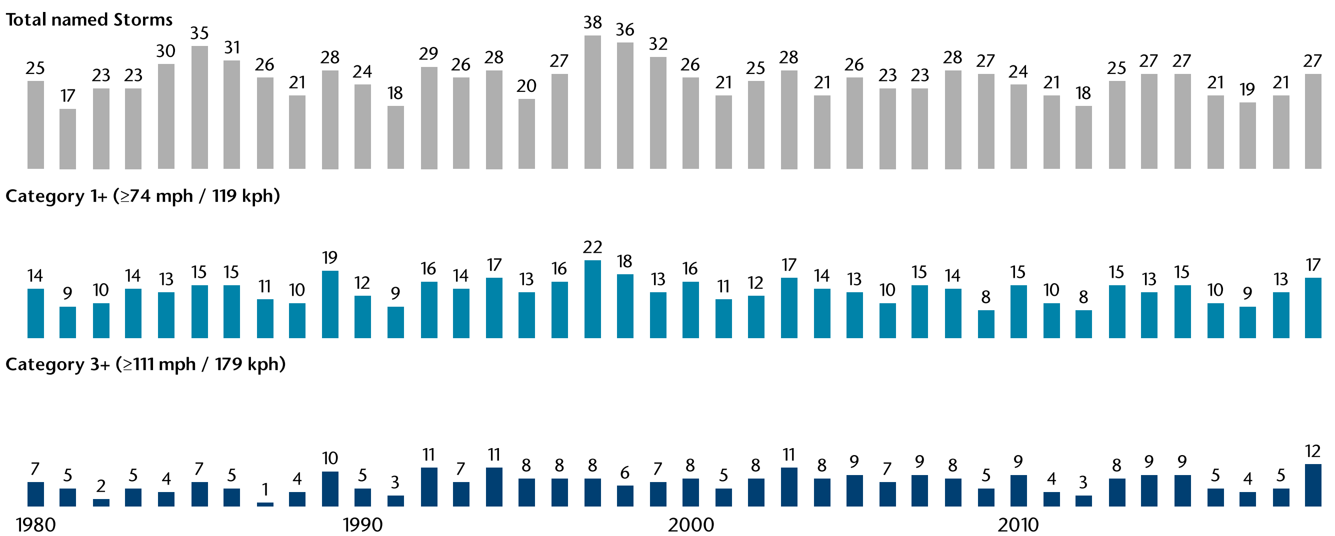
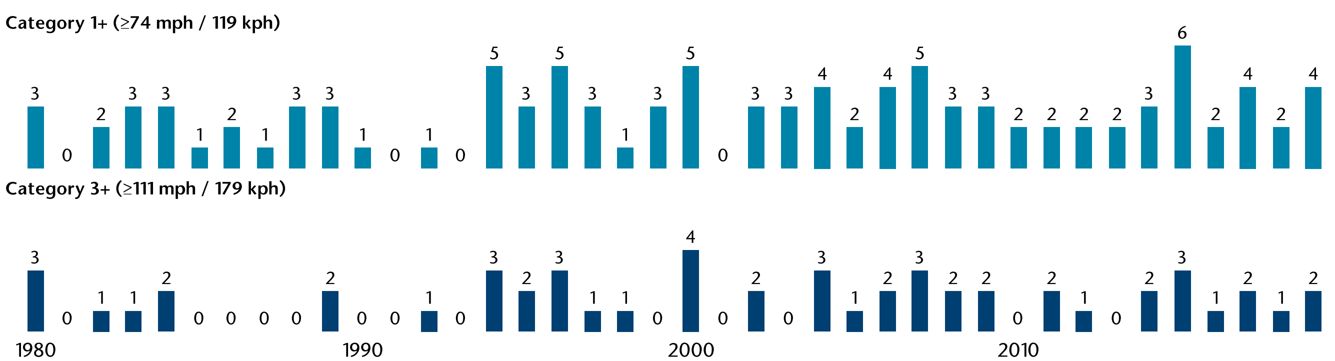


Exhibit 72: Southern Hemisphere Tropical Cyclone Landfalls



Appendix E: United States Severe Weather Data

Given the increased cost of severe weather-related damage in the United States during the past decade for insurers, the following is a breakout of tornadoes, tornado fatalities, large hail (2.0" or larger), and damaging straight-line winds (75 mph or greater). The data comes via NOAA's Storm Prediction Center. Please note that data prior to 1990 are often considered incomplete given a lack of reporting. *The implementation of Doppler radar, greater social awareness and increased reporting has led to more accurate datasets in the last 30 years.* Data from 2019 is to be considered preliminary.

Exhibit 73: U.S. Tornadoes

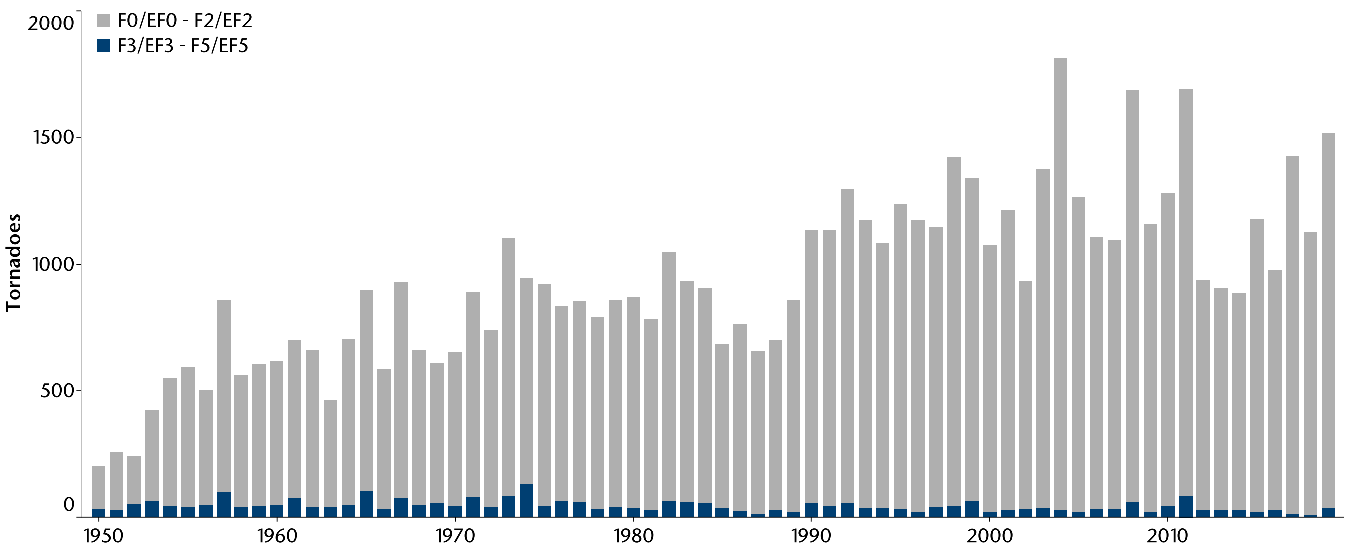


Exhibit 74: U.S. Tornado (F3/EF3+)

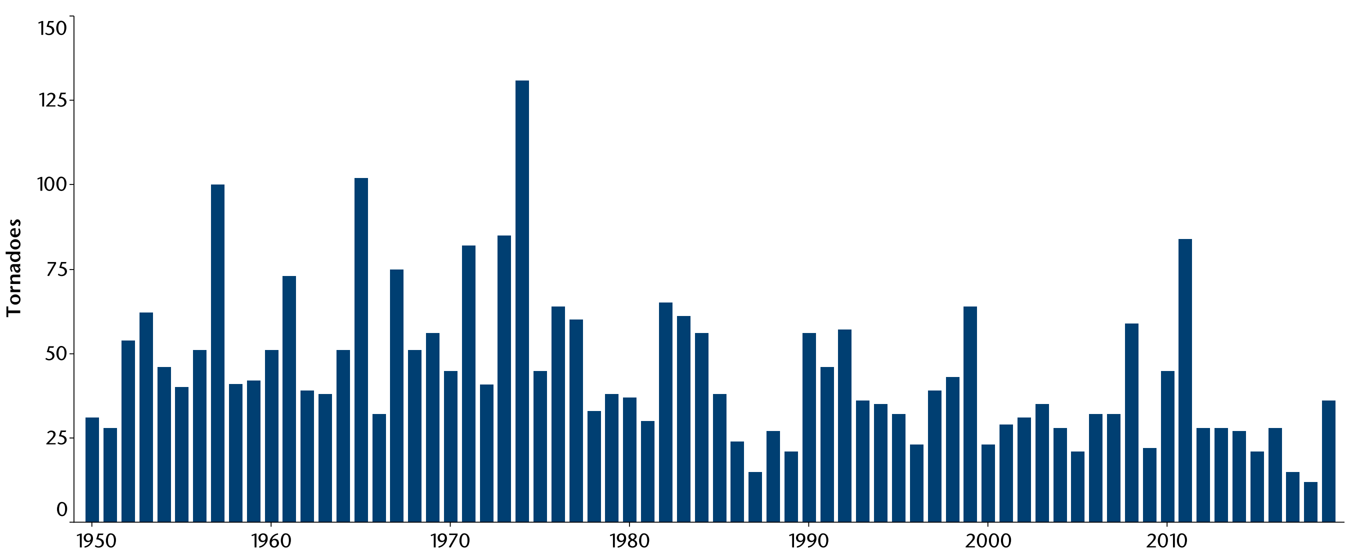


Exhibit 75: U.S. Large Hail Reports (2.0” or Larger)

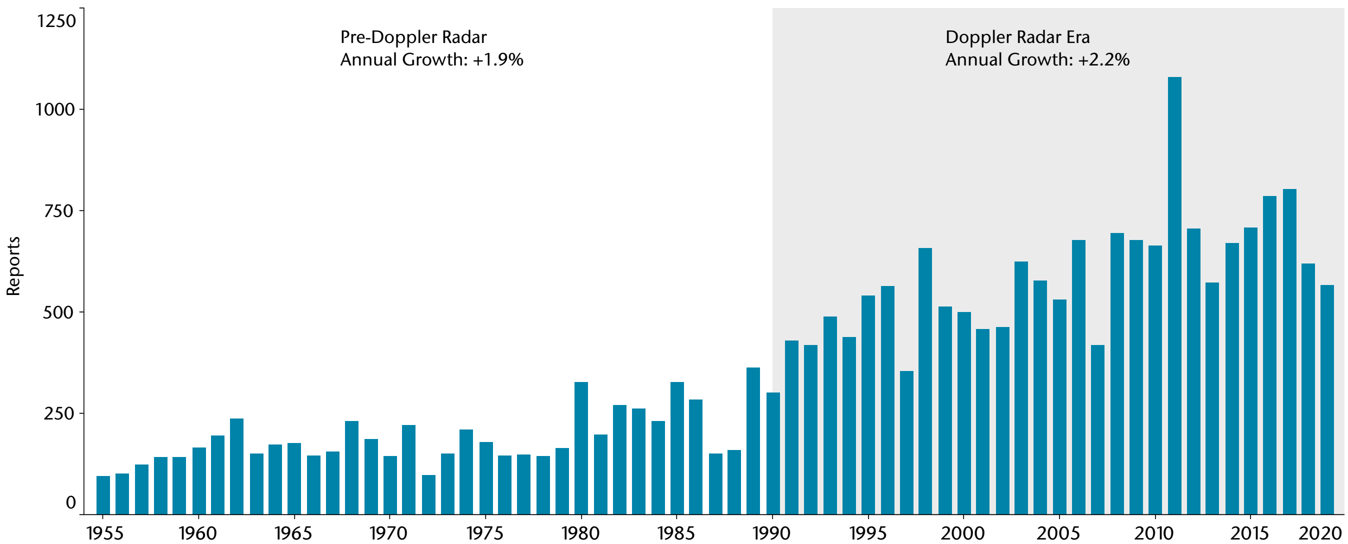
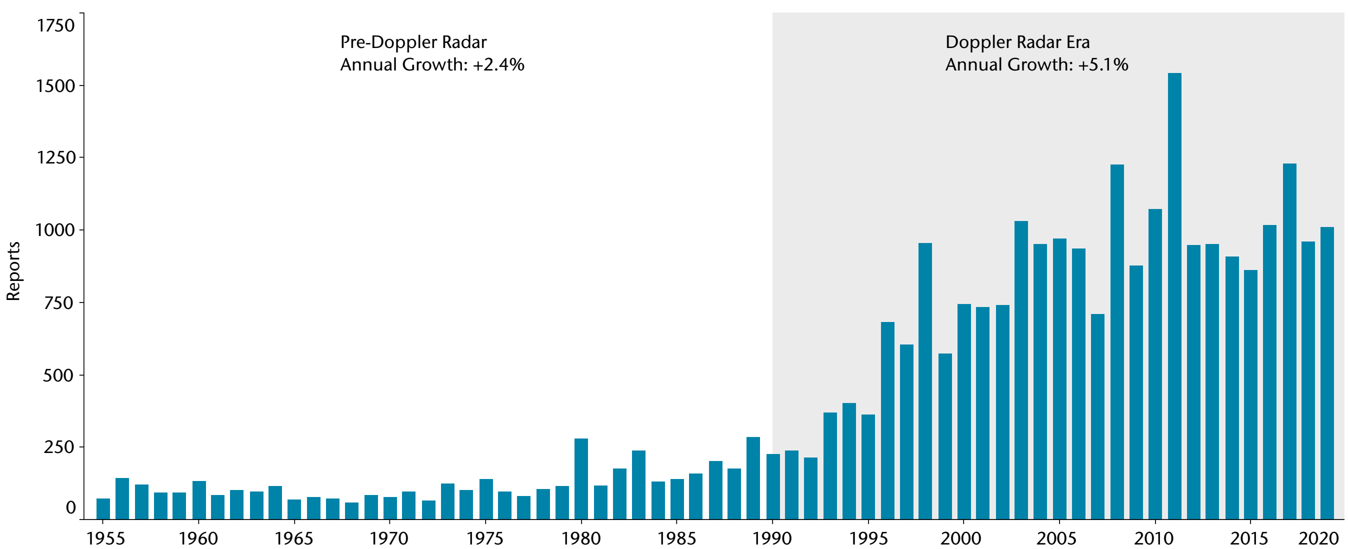


Exhibit 76: U.S. Damaging Wind Reports (75 mph or Greater)



Appendix F: Global Earthquakes

Based on historical data from the United States Geological Survey, there were at least 143 earthquakes in 2019 with magnitudes of 6.0 or greater. Overall earthquake activity does not often show large fluctuations on an annual basis. This is especially true given the extensive network of global seismograph stations that has led to an improved and more robust dataset in recent decades.

Exhibit 77: Global Earthquakes (M6.0+)

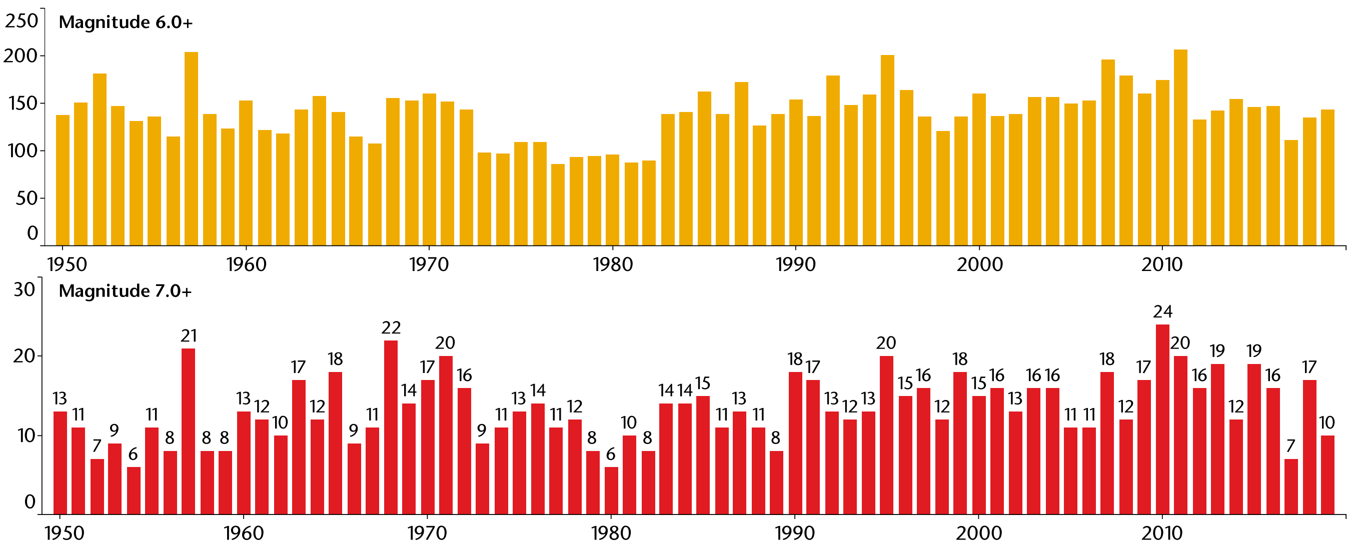
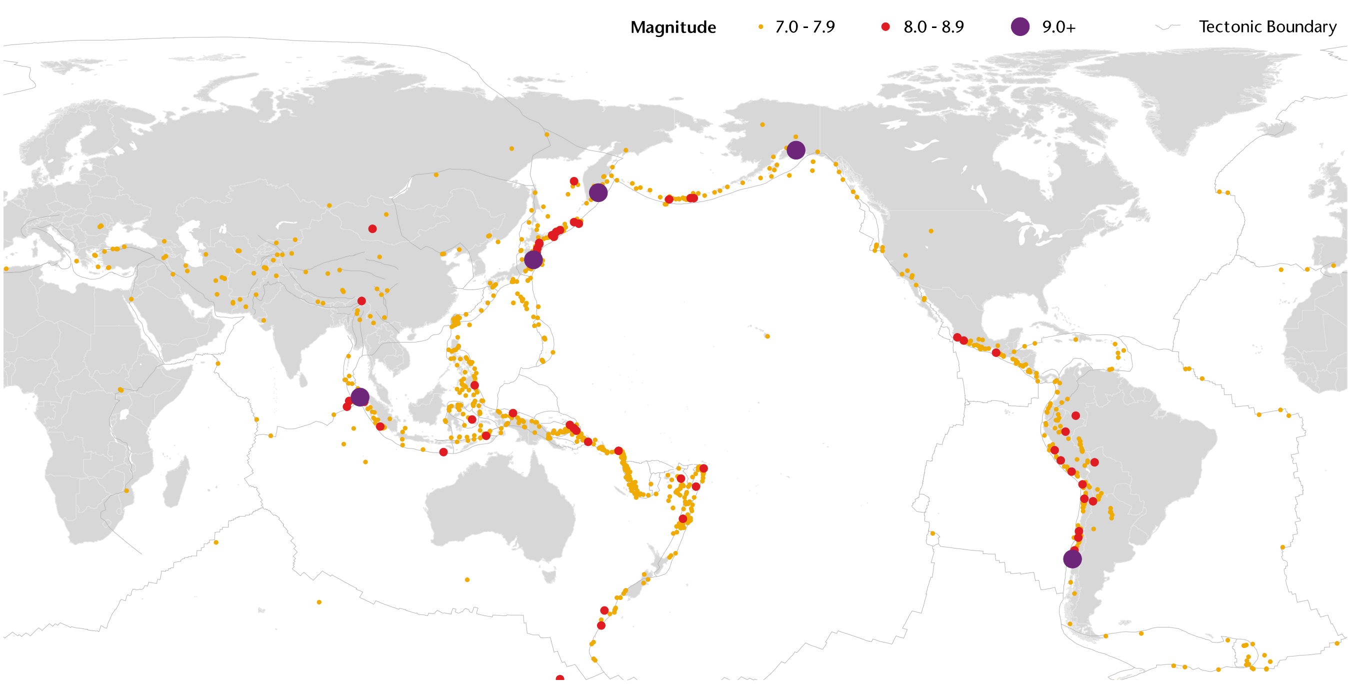


Exhibit 78: Global Earthquake Map; M7.0+ (1950-2019)



Appendix G: United States & Europe Wildfire Data

The following wildfire data in the United States is provided from the National Interagency Fire Center (NIFC), which began compiling statistics under their current methodology in 1983. Previous data was collected by the National Interagency Coordination Center (NICC) from 1960 to 1982 but used a different methodology. **It is not advised to compare pre-1983 data to post-1983 data given these different data collection methods.** The European data comes via the European Forest Fire Information System (EFFIS), which is maintained by the European Union's Copernicus group.

Exhibit 79: United States Wildfire Acres Burned & Acres Burned per Fire

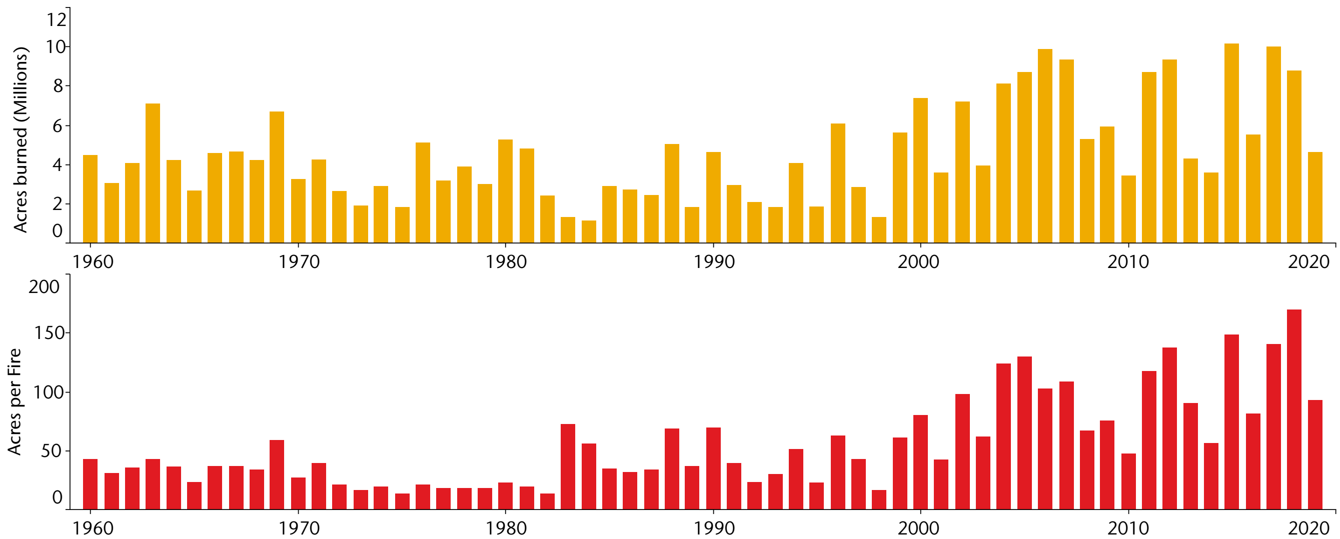
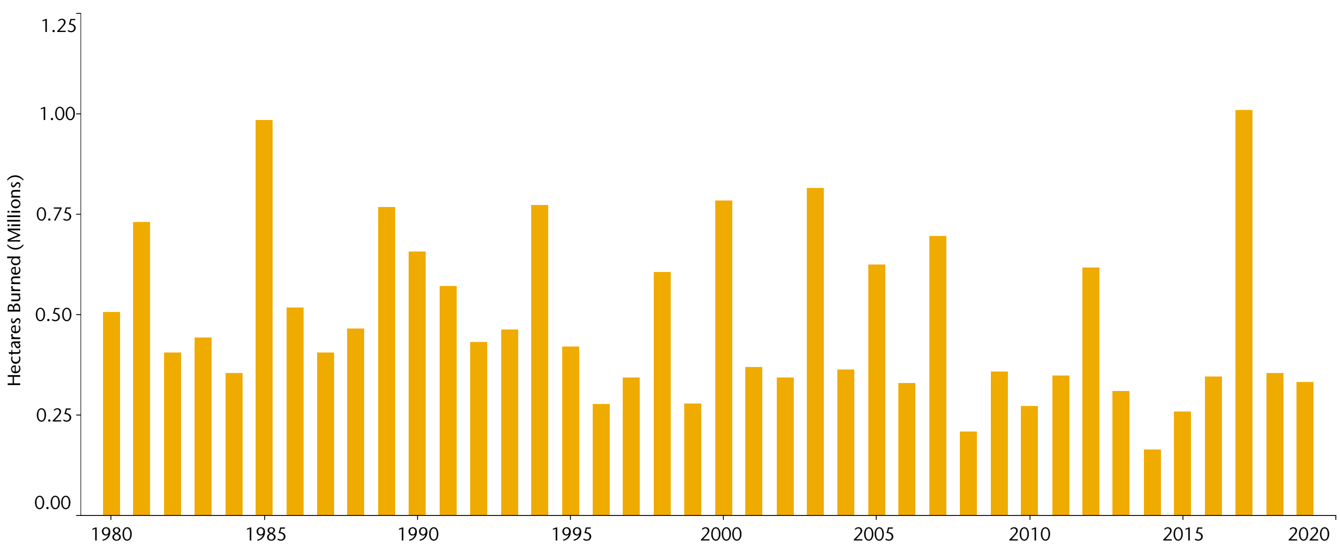
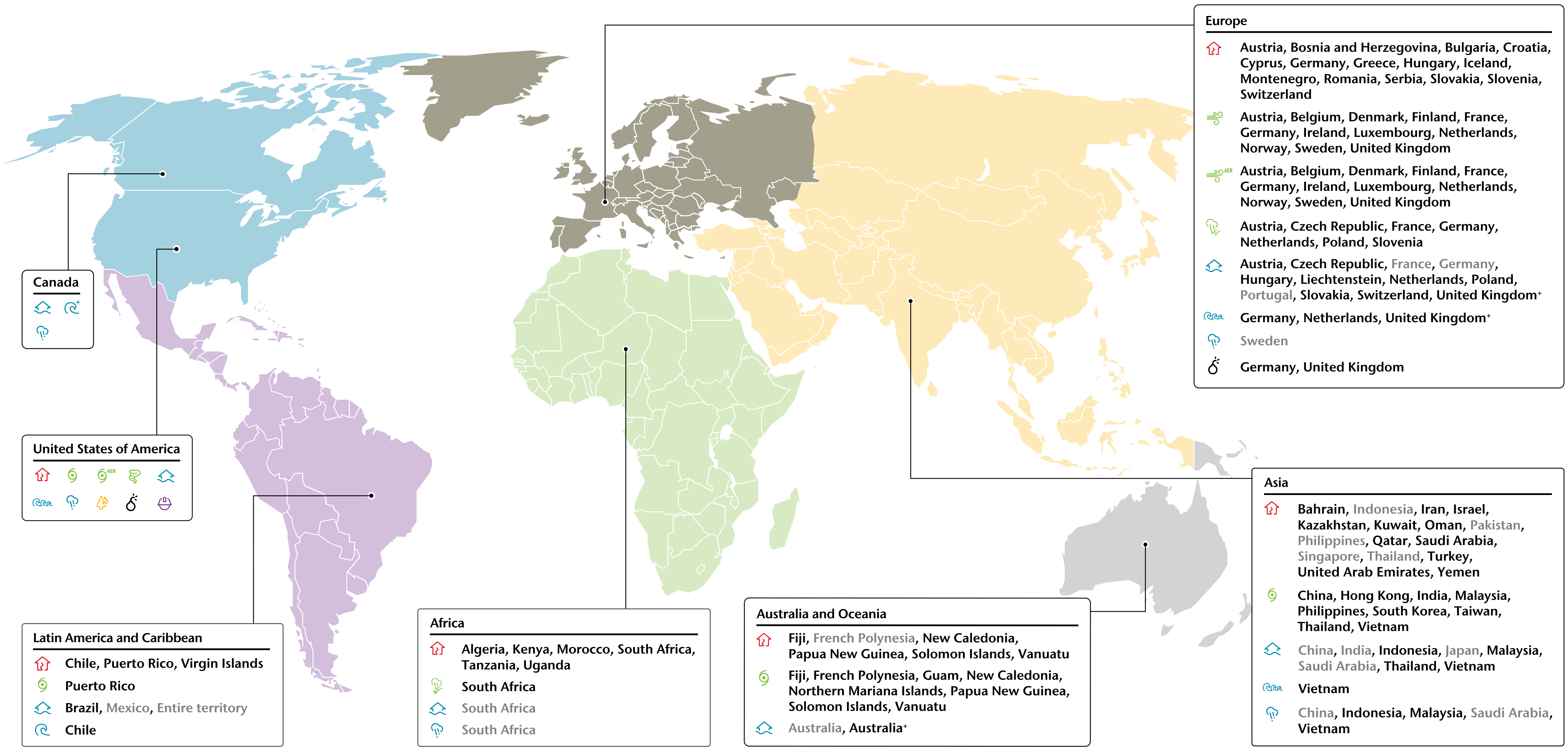


Exhibit 80: Area burned by Forest Fires in the European Union



Impact Forecasting Model Coverage Map



Additional Report Details

TD = Tropical Depression, TS = Tropical Storm, HU = Hurricane, TY = Typhoon, STY = Super Typhoon, CY = Cyclone

Fatality estimates as reported by public news media sources and official government agencies.

Structures defined as any building — including barns, outbuildings, mobile homes, single or multiple family dwellings, and commercial facilities — that is damaged or destroyed by winds, earthquakes, hail, flood, tornadoes, hurricanes or any other natural-occurring phenomenon. Claims defined as the number of claims (which could be a combination of homeowners, commercial, auto and others) reported by various insurance companies through press releases or various public media outlets.

Damage estimates are obtained from various public media sources, including news websites, publications from insurance companies, financial institution press releases and official government agencies. Economic loss totals include any available insured loss estimates, which can be found in the corresponding event text.

This report use publicly available data from the internet and other sources. Impact Forecasting® summarizes this publicly available

information for the convenience of those individuals who have contacted Impact Forecasting® and expressed an interest in natural catastrophes of various types. To find out more about Impact Forecasting or to sign up for the Cat Reports, visit Impact Forecasting's webpage at www.impactforecasting.com.

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Notes

Notes

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About Impact Forecasting

Impact Forecasting is a catastrophe model development center of excellence within Aon whose seismologists, meteorologists, hydrologists, engineers, mathematicians, GIS experts, finance, risk management and insurance professionals analyze the financial implications of natural and man-made catastrophes around the world. Impact Forecasting's experts develop software tools and models that help clients understand underlying risks from hurricanes, tornadoes, earthquakes, floods, wildfires and terrorist attacks on property, casualty and crop insurers and reinsurers. Impact Forecasting is the only catastrophe model development firm integrated into a reinsurance intermediary. To find out more about Impact Forecasting®, visit www.impactforecasting.com.

About Aon

Aon plc (NYSE:AON) is a leading global professional services firm providing a broad range of risk, retirement and health solutions. Our 50,000 colleagues in 120 countries empower results for clients by using proprietary data and analytics to deliver insights that reduce volatility and improve performance.

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