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Natural catastrophes and man-made disasters in 2018: "secondary" perils on the frontline

Executive summary

Insured losses from catastrophes in 2018 were USD 85 billion, the fourth highest for a single year, and above the annual average of the previous 10 years of USD 71 billion.

The catastrophe experience of 2018 reaffirms that the loss impact of secondary peril events is anything but "secondary". Total economic losses from natural catastrophes and man-made disasters in 2018 were USD 165 billion. Insurance covered USD 85 billion of those losses, the fourth highest one-year aggregate industry pay-out ever, and above the previous 10-year annual average of USD 71 billion. Of last year's insured losses, USD 76 billion were due to natural catastrophes and of those, more than 60% of claims were to help populations impacted by secondary peril events. Tragically, 13 500 people lost their lives in all catastrophes last year.

There has been a trend of rising losses from secondary and secondary-effect perils, and we expect this to continue.

Secondary perils can be independent small to mid-sized events, or secondary effects of a primary peril. Their associated losses have been rising due to rapid development in areas exposed to severe weather conditions. We expect this trend to continue given ongoing urbanisation, growth in concentration of assets in exposed areas, and long-term climate change projections. The world is getting warmer, leading to more occurrence of extreme weather conditions and associated secondary perils (eg, drought and wildfires) and secondary-effect peril events (eg, torrential rains, storm surge-induced flooding). The single biggest natural catastrophe insurance loss-event of 2018 was Camp Fire in California (USD 12 billion), a "secondary" peril.

The natural catastrophe losses for 2017 and 2018 combined were USD 219 billion, the highest ever over a two-year period.

Indicative of a growing trend, the combined insured losses for 2017 and 2018 resulting from natural catastrophes were USD 219 billion, the highest ever for a two-year period, with more than half due to secondary and secondary-effect peril events. Stakeholders in building resilience – including insurers – are well advised to pay more attention to the growing risk these perils present. The global all-catastrophe protection gap of the past two years combined was also impressively large at USD 280 billion, and more than half of that resulted from independent secondary and secondary-effect peril events.

The industry is well capitalised to deal with these losses, but underinsurance remains a theme across the advanced and emerging markets.

The paradox is that the insurance industry is well capitalised to absorb this risk. According to Swiss Re estimates, total capital in the non-life re/insurance market (including alternative capital) was more than USD 2 trillion at the end of 2018. Main explanations for the underinsurance are lack of consumer risk awareness and poor understanding of catastrophe insurance covers, and on occasion hesitation to provide cover where risk assessment is uncertain. Given their unique features such as being highly localised, modelling secondary peril risks can be difficult, more so than for peak peril losses where the industry has tended to focus.

Insurers need to improve their risk modelling capabilities for secondary perils, and develop a greater product range.

The existing protection gap is an opportunity for the insurance industry to both grow and to help more of the global population be better prepared to manage the financial hardship that disaster events can inflict. This includes fostering consumer awareness, and developing a greater product range and targeted distribution for catastrophe covers. In the face of rising losses from secondary and secondary-effect peril events, by leveraging latest technologies insurers can focus more on developing appropriately regionalised models to assess the risk posed by the perils, the variables of which will likely be in a continual state of flux due to ongoing land-use changes and greater occurrence of extreme weather events.

Also, with a more conducive regulatory environment, insurers would be able to contribute much more to global resilience by investing in infrastructure.

Insurance's main value proposition is to absorb and manage risk. Re/insurers can also build socio-economic resilience through their investment activities, in particular by being able to invest more in long-term infrastructure projects. There are many examples of disaster mitigating defences having been strengthened as part of reconstruction efforts after a catastrophic event. With a more conducive investment and regulatory environment, insurers can play a much more effective role in ex-ante preparation. According to Swiss Re Institute estimates, global re/insurance assets amount to approximately USD 30 trillion. Even a small part of this could unlock a significant amount of capital for deployment into long-term resilience-building infrastructure projects. In addition, public private partnerships in infrastructure would bring additional benefits of reducing the burden of project costs on governments and develop a broader culture of effective risk-sharing.

Catastrophes in 2018: global overview

Insured losses from catastrophe events globally were USD 85 billion in 2018, the fourth highest on *sigma* records. More than half of the total was the accumulation of losses from smaller and mid-sized secondary natural catastrophes. The total was well below the peak loss years of 2017, 2011 and 2005, reflecting the absence of mega-loss generating events. The combined insurance pay outs for natural catastrophe events in 2017 and 2018 were USD 219 billion, the highest ever for a consecutive two-year period.

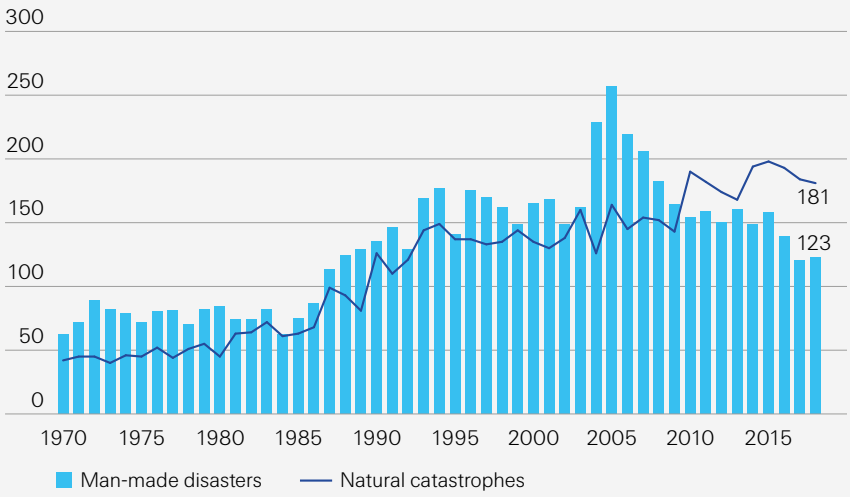
Facts and figures

There were 181 natural catastrophes in 2018.

Number of events: 304

There were 304 catastrophe events in 2018, the same as in 2017.[1] Of those 181 were natural catastrophes (184 in 2017), and 123 were man-made disasters.

Figure 1
Number of catastrophe events, 1970–2018



Source: Swiss Re Institute

[1] The number of catastrophes according to *sigma* loss criteria. See Appendix for full details.

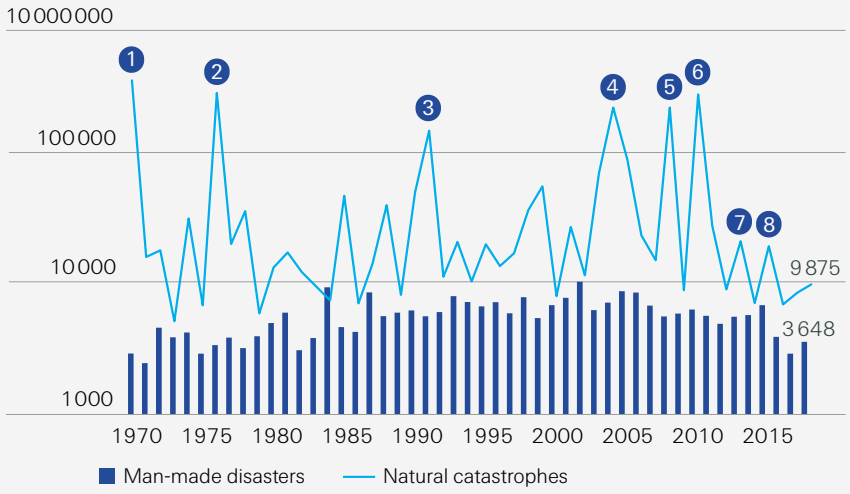
Natural disasters claimed more than 9 800 victims last year.

Number of victims: more than 13 500

Worldwide more than 13 500 people died or went missing in disaster events in 2018, one of the lowest totals in a single year on *sigma* records. Natural catastrophes claimed more than 9 800 victims, and man-made disasters resulted in roughly 3 600 deaths, up from around 3 000 in 2017.

Figure 2
Number of victims, 1970–2018

1. 1970: Bangladesh storm
2. 1976: Tangshan earthquake, China
3. 1991: Cyclone Gorky, Bangladesh
4. 2004: Indian Ocean earthquake and tsunami
5. 2008: Cyclone Nargis, Myanmar
6. 2010: Haiti earthquake
7. 2013: Typhoon Haiyan, Philippines
8. 2015: Earthquake in Nepal



Note: Scale is logarithmic: the number of victims increases tenfold per band.
Source: Swiss Re Institute

Economic losses from natural catastrophe events were about USD 155 billion.

Total economic losses: USD 165 billion

Total economic losses from disasters across the world were an estimated USD 165 billion in 2018, with around USD 155 billion resulting from natural catastrophes and the remainder from man-made events. The total was less than half that experienced in 2017 (USD 350 billion), and was below the inflation-adjusted average of USD 220 billion of the previous 10 years. Last year's lower losses reflect the absence of a very large event occurrence. Catastrophe losses in 2018 were 0.19% of global gross domestic product (GDP), below the 10-year average of 0.28%.

Table 1
Economic losses by region, in USD billion and % of global GDP, 2018

Regions	in USD bn	in % of GDP
North America	80	0.36%
Latin America & Caribbean	5	0.08%
Europe	21	0.09%
Africa	1	0.06%
Asia	55	0.18%
Oceania/Australia	2	0.14%
Seas/space	1	0.00%
Total	**165**	
World total		0.19%
10-year average*	220	0.28%

*inflation adjusted

Source: Swiss Re Institute

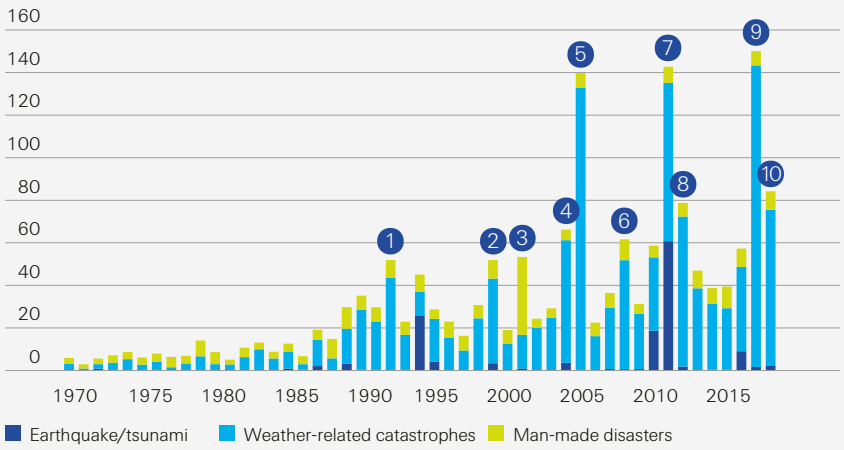
All disaster-related insured losses in 2018 were the fourth highest on sigma records.

Insured losses: USD 85 billion

Insurance covered about half (USD 85 billion) of the economic losses resulting from natural and man-made catastrophes in 2018, the fourth highest one-year total on *sigma* records. Insurance payouts were down from USD 150 billion in 2017, but above the inflation-adjusted annual average of the previous 10-years (USD 71 billion). Of last year's insured losses, USD 76 billion were claims resulting from natural catastrophes, above the previous 10-year annual average (USD 63 billion). Man-made disaster-related insurance claims were close to USD 9 billion, up from USD 7 billion in 2017. Natural catastrophe-associated insured losses were 0.09% of world GDP in 2018 and 4.3% of global property direct premiums written (DPW), above the respective 10-year annual averages of 0.08% and 3.9%. Insured losses from natural catastrophes and man-made disasters were 0.1% of GDP and 4.8% of DPW.

Figure 3
Insured catastrophe losses, 1970–2018 (USD billion, in 2018 prices)

1. Hurricane Andrew
2. Winter Storm Lothar
3. WTC
4. Hurricanes Ivan, Charley, Frances
5. Hurricanes Katrina, Rita, Wilma
6. Hurricanes Ike, Gustav
7. Japan, NZ earthquakes, Thailand flood
8. Hurricane Sandy
9. Hurricanes Harvey, Irma, Maria
10. Camp Fire, Typhoon Jebi



Source: Swiss Re Institute

By region, insured losses were highest in North America in 2018.

Regional loss overview

Mother Nature fired from all directions in 2018, unleashing severe weather events and earthquakes across many regions. Tropical cyclones caused the highest insured losses. By region, the losses were highest in North America (around USD 53 billion), mostly coming from wildfires, thunderstorms and hurricanes. Asia, in particular Japan, was also hit by tropical cyclones and floods. Record heavy rains, a succession of typhoons and earthquakes hit the country, together resulting in insured losses of USD 17 billion. The aggregate EUR 8 billion (around USD 9 billion) in insured losses in Europe resulted different perils, including windstorms, flooding, cold/frost and, at the other end of the temperature scale, a summer heat wave.

Table 2
Number of events, victims, economic and insured losses by region, 2018

				Insured losses		Economic losses	
Region	**Number**	**Victims**	**in %**	**in USD bn**	**in %**	**in USD bn**	**in %**
North America	68	329	2.4%	52.9	62.5%	80.5	48.8%
Latin America & Caribbean	20	959	7.1%	1.3	1.5%	4.9	2.9%
Europe	44	676	5.0%	7.7	9.1%	20.7	12.5%
Africa	53	2488	18.4%	0.2	0.2%	1.3	0.8%
Asia	104	8823	65.2%	20.4	24.0%	54.7	33.2%
Oceania/Australia	9	216	1.6%	1.6	1.9%	2.3	1.4%
Seas / Space	6	32	0.2%	0.6	0.7%	0.7	0.4%
World	**304**	**13523**	**100.0%**	**85**	**100.0%**	**165**	**100.0%**

Note: some percentages may not add up to 100 due to rounding.
Source: Swiss Re Institute

A wildfire in California was the single costliest insurance event of the year.

Costliest insurance events of the year

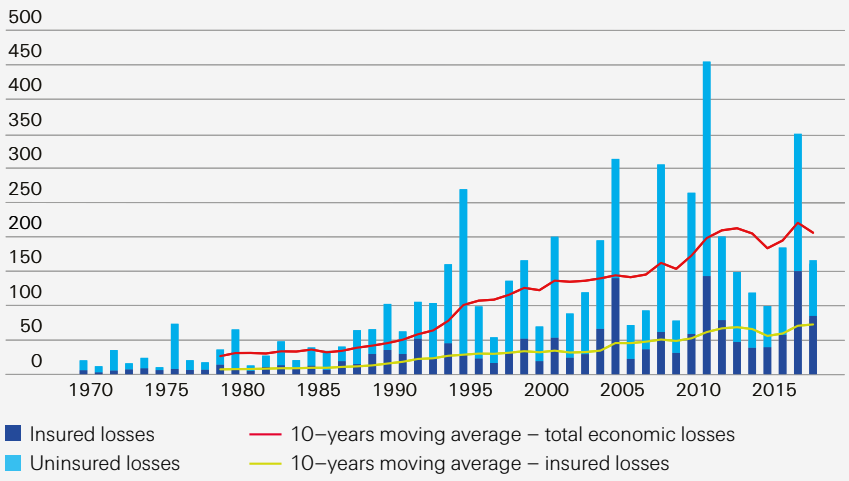
Camp Fire in California in November was the world's costliest event of the year, resulting in insured losses of USD 12 billion. Next were Hurricane Michael in the US, and Typhoon Jebi in Japan. Seventeen single events triggered insured losses of USD 1 billion or more last year, the same as in 2017.

Global catastrophe protection gap: USD 80 billion

Last year's protection gap was less than half that of 2017.

Figure 4 shows the difference between economic and insured losses over time, the insurance protection gap. It is the financial loss generated by catastrophes not covered by insurance. In 2018, the global protection gap was around USD 80 billion, down from USD 199 billion in peak-loss year 2017. The rate of growth of economic losses has been slightly above the growth of insured losses over the last 27 years. In terms of 10-year rolling averages, economic losses grew by 5% between 1992 and 2018, and insured losses by 4.7%.

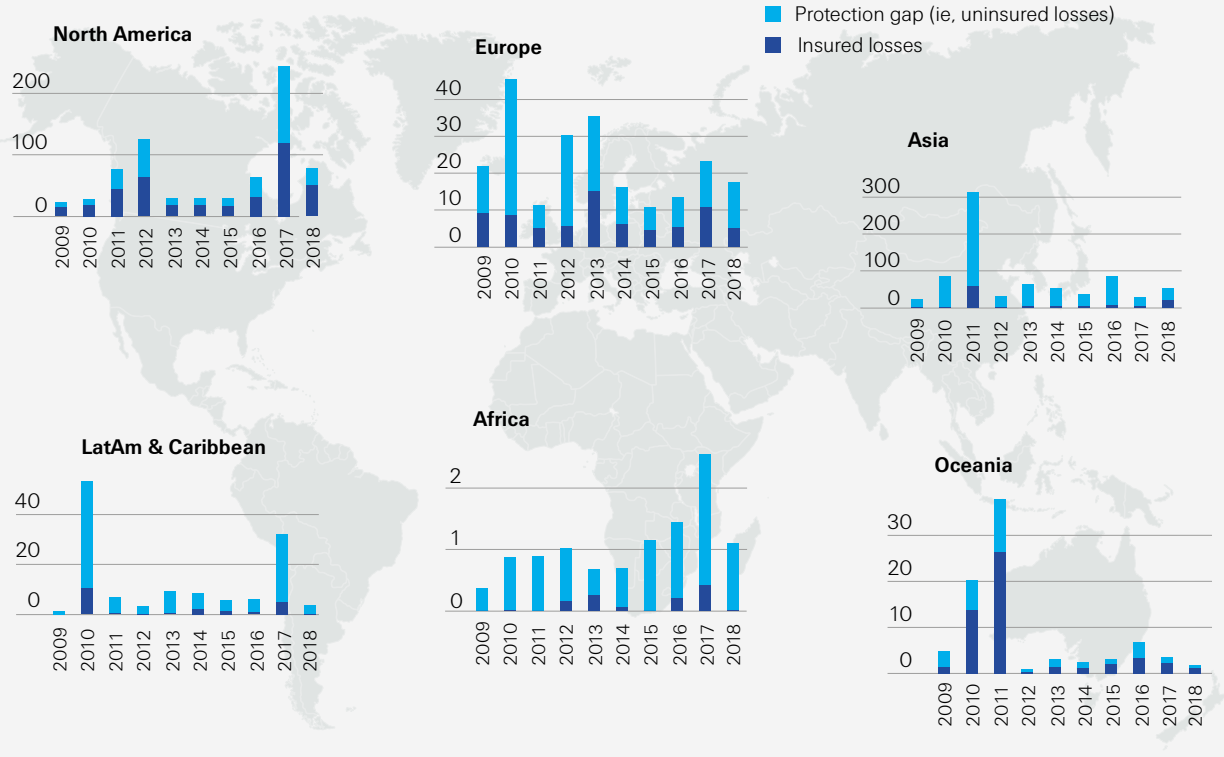
Figure 4
Insured vs uninsured losses, 1970–2018, in USD billion at 2018 prices



Economic losses = insured + uninsured losses
Source: Swiss Re Institute

Figure 5 below shows the development of the natural catastrophe protection gap by region in 2018, and over the last 10 years.

Figure 5
Natural catastrophe protection gap by region 2009–2018, in USD billion (in 2018 prices)



Source: Swiss Re Institute

Top 5 observations from 2018

1. The accumulation of insured losses from secondary-peril disaster events helped make 2018 the fourth costliest year for the industry ever.

2. Another number 4: according to preliminary estimates, 2018 was the fourth warmest year on record.[2]

3. High temperatures brought prolonged dry conditions. Insured losses from wildfires reached a new high for a second year running. The summer heat wave also led to severe drought conditions in central and northern Europe.

4. Other secondary perils of note in 2018 were precipitation-induced flooding. Hurricane Florence brought record rainfalls in both the Carolinas.

5. The combined insured losses from natural catastrophe events in 2017 and 2018 were USD 219 billion, the highest ever for a consecutive two-year period. The previous two-year high (in 2018 prices) was 2011–2012, at USD 207 billion.

[2] *The State of the Global Climate in 2018*, *World Meteorological Organisation*, 29 November 2018 https://public.wmo.int/en/our-mandate/climate/wmo-statement-state-of-global-climate

Another benchmark year for secondary perils

Last year, insured losses from natural catastrophes and made-disasters were USD 85 billion, the fourth highest total in a single year. More than half resulted from secondary natural catastrophe perils. Warm temperatures and dry conditions led to large wildfire spread and drought, but there were also record-setting precipitation events. With urbanisation and associated growth in asset concentration in exposed areas, and also long-term climate change projections, we expect the trend of growing losses from secondary perils to continue. Insurers need to develop their modelling capabilities to better assess the risk that these perils pose.

Secondary perils: don't be fooled by the name

Small and mid-sized loss events pushed up the cost of disasters last year.

The natural catastrophe theme of 2018 was occurrence of many small and mid-sized secondary peril events across the world. One cannot underplay the impact of these, not the loss of life nor hardship (including financial) inflicted. There were no mega disaster events last year in terms of resulting financial losses. Even without, however, the combined insured losses of all natural catastrophe events alone mounted to USD 76 billion. More than half of those losses stemmed from secondary peril events.

The largest insured losses resulted from secondary perils.

Absent a formal definition, industry practice has been to consider secondary perils as high-frequency (ie, occur more frequently than primary peril events such as earthquakes and hurricanes), low-to-medium severity loss events (relative to losses resulting from primary perils). Secondary perils can happen on an independent basis, such as river floods, flash floods, thunderstorms (hailstorms, tornadoes and straight-line winds), snow and ice storms, drought and wildfire outbreaks. Often the events appear as secondary effects of primary perils. For instance in 2012, many of the losses associated with Hurricane Sandy (primary peril) resulted from a massive storm surge triggered by the storm. Other secondary effect perils include torrential rainfalls associated with tropical cyclones, tsunamis and landslides.

Table 3
Defining primary and secondary perils

Primary perils	Peak perils with known severe loss potential for the insurance industry. Traditionally well-monitored risks in developed re/insurance markets.	Examples: tropical cyclones, earthquakes, winter storms in Europe.
Secondary perils	Independent secondary perils. Often not modelled and receive little monitoring by the industry.	Prominent examples: river floods, flash floods, torrential rainfall, landslides, thunderstorms, winter storms outside Europe, snow and ice storms, drought and wildfire outbreaks.
	Secondary-effect of a primary peril: not always well-captured in primary perils modelling, not in proportion to their severity potential.	Prominent examples: hurricane-induced precipitation, storm surges, tsunamis, liquefaction and fire following earthquakes.

Source: Swiss Re Institute

In peak loss years, primary perils are responsible for most damage.

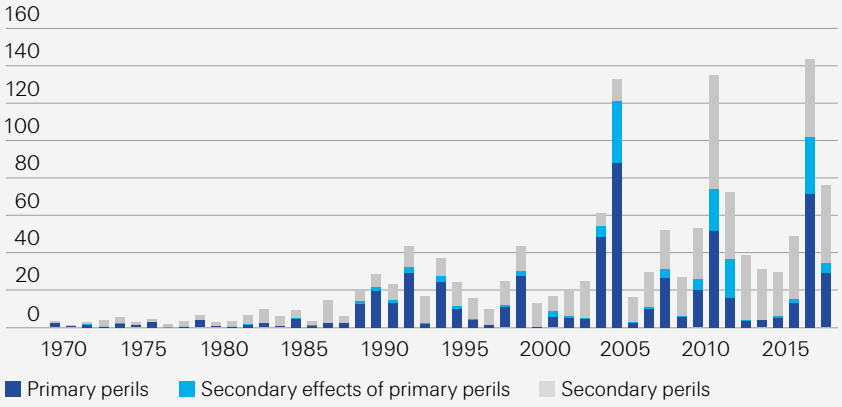
Since 1970, the peak catastrophe insurance loss years were 2005, 2011 and 2017 (see Figure 4). In each of these, primary perils made up the bulk of the annual losses: in 2005, the cluster Hurricanes Katrina, Wilma and Rita; in 2011, devastating earthquakes in Japan and New Zealand; and in 2017, the quick-succession cluster Hurricanes Harvey, Irma and Maria, which alone resulted in insured losses (including the secondary-peril effects of primary perils) of close to USD 94 billion (inflation adjusted).

Another benchmark year for secondary perils

However, over time secondary perils have been driving a growing share of catastrophe related insurance claims.

In 2018, according to *sigma* data close to 62% of all natural catastrophe-related (ie, excluding man-made disaster) insurance claims came as a result of losses inflicted by secondary perils, once we include secondary effects of primary perils. On this theme, Figure 6 reveals other takeaways also: (1) generally, the component of secondary peril-associated losses has been increasing over time; and (2) in peak loss years specifically, secondary and secondary-effect perils make a major contribution to overall losses. For example, in 2017 around 50% of the total insurance pay outs for natural catastrophes were compensation for losses resulting from secondary peril events and secondary effects of primary perils. The secondary-effect peril torrential rainfalls after Hurricane Harvey led to widespread flooding in Houston and North Carolina, a main component of the year's total insured losses. And in 2011, the tsunami that caused about 25% of the overall losses in Japan on 11 March was triggered by the huge magnitude 9 earthquake that struck earlier that same day.

Figure 6
Split of primary and secondary peril insured losses since 1970 (USD billion, in 2018 prices)

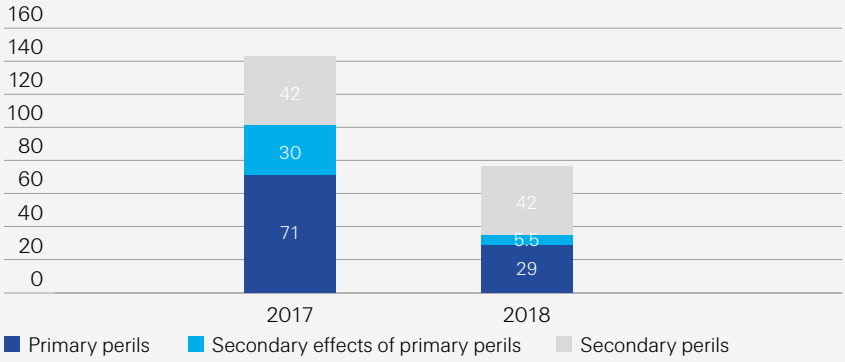


Source: Swiss Re Institute

The secondary effects of primary perils also add to the losses.

In each of 2017 and 2018, secondary and secondary-effect perils accounted for more than half of the total natural catastrophe insured losses for the respective years (see Figure 7). This contributed to the accumulation of all natural catastrophe related insurance pay outs to USD 219 billion, the highest level ever for a two-year consecutive period. The influence of secondary perils is of growing importance in the estimation of the losses for the insurance industry and its sustainability. Industry dialogue around natural catastrophe insurance has centred on peak perils where capital and solvency are dominant factors. Looking ahead and taking climate and land-use trends into account, in our view insurers should pay more attention to the growing share of losses coming from secondary perils as these will increasingly impact earning volatility.

Figure 7
Split of primary, secondary and secondary-effect natural catastrophe insured losses in 2017 and 2018 (USD billion, in 2018 prices)



Source: Swiss Re Institute

The world is getting warmer

Warmer air means more precipitation...

2018 was another hot year. According to the preliminary estimates from the World Meteorological Organization, it is on course to become the fourth warmest year on record, meaning all of the last four years (2015, 2016, 2017 and 2018) were the warmest ever.[3] Twenty of the warmest years since measurements began were within the last 22. Large losses from secondary perils have tended to be water-related. As such, they are susceptible to the effects of the warmer temperatures coming with changing climate.[4] According to the Clausius-Clapeyron equation, the water-holding capacity of the atmosphere increases by about 7% for every 1°C rise in temperature. Hence, higher temperatures imply more precipitation potential. As of yet, there is not enough evidence to determine causality but arguably, rising sea levels as a result melting ice caps, for example, may have contributed to the severity of the storm surge that followed Hurricane Sandy in 2012. Climate projections also point to increasing severity of precipitation associated with tropical cyclones. This could help explain the intensity of the torrential rainfalls that came with Hurricane Harvey in 2017 and Hurricane Florence in 2018.

...and more heatwaves, drought and wildfires.

Warmer temperatures may also be contributing to heat-event driven losses, as suggested by main loss-making catastrophes of the last two years. Warmer temperatures are creating drier surface conditions and increasing the risk of wildfire outbreaks, and drought. With respect to the former, in 2018 total insured losses from wildfires globally were USD 17 billion, a new record. In the absence of main primary peril events, Camp Fire in California was the biggest loss-making event of the year, calling into question the industry's consideration of wildfire as a secondary peril.

[3] *Global warming* of 1.5°C, IPCC, 2018, https://www.ipcc.ch/sr15/. A special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global actions on climate change, sustainable development, and efforts to eradicate poverty.

[4] "On Fire: July was California's Hottest Month Ever Recorded", *Washington Post*, 9 August 2018, https://www.washingtonpost.com/news/capital-weather-gang/wp/2018/08/09/on-fire-july-was-californias-hottest-month-ever-recorded/

California burning, again

The 2018 fire season was the deadliest and most destructive in California.

Last year was the most deadly and destructive wildfire season in California, with record insurance losses. July was the hottest month ever recorded, fuelling a series of wildfires, including the Carr and Mendocino Complex Fires in the north.[5] The Carr Fire was sparked by mechanical failure of a vehicle, burning nearly 230 000 acres over roughly five weeks, and destroying more than 1 600 structures.[6] A few days later, the Mendocino Complex Fire began not far to the south. Prolonged windy and dry conditions allowed burning for nearly two months over 459 000 acres, the most expansive ever recorded in California. The number of acres burned dwarfs the previous record: nearly 282 000 acres in the Thomas Fire of 2017.[7]

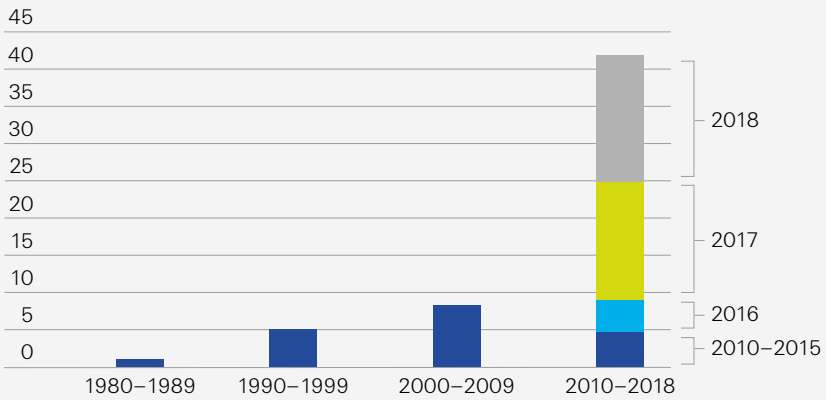
Camp Fire in November resulted in insurance losses of USD 12 billion, the largest ever experienced.

In November came Camp Fire in northern California, killing 86 people and burning more than 18 800 structures in Butte County over 17 days. This was the deadliest and most destructive single fire event in the state's history. Dry conifer fuels, low humidity and high winds allowed the fire to spread across more than 70 000 acres within 24 hours of ignition. As of February 2019, total insured losses from the Camp Fire were estimated to be USD 12 billion, the highest ever. Just hours after the Camp Fire started, the Woolsey Fire broke out in southern California. In the dry chaparral landscape, warm weather and high winds, 35 000 acres burned within 24 hours. Smaller in scale than the Camp Fire, Woolsey received the media spotlight due to the many high value homes impacted in Los Angeles and Ventura Counties.

Insured losses from wildfire events have increased dramatically in the past three years.

The 2018 experience across California was the third consecutive year of devastating wildfire activity in the state. Figure 8 depicts the notable increase in fire-associated insured losses since 1980, of which more than 70% came in the last three years alone. According to *sigma* data, six of the 10 largest-ever insured loss totals from fire events across the world occurred in the past three years, and five in the past two.

Figure 8
Global insured losses from wildfires since 1980 by decade (USD billion, in 2018 prices)



Source: Swiss Re Institute

[5] *Carr Fire Incident Update*, Cal Fire, 28 February 2019, http://cdfdata.fire.ca.gov/admin8327985/cdf/images/incidentfile2164_4121.pdf
[6] *Thomas Fire, Cal Fire*, 3 January 2019, http://cdfdata.fire.ca.gov/incidents/incidents_details_info?incident_id=1922
[7] *Camp Fire, Cal Fire*, 4 January 2019, http://cdfdata.fire.ca.gov/incidents/incidents_details_info?incident_id=2277

Development in the wildland-urban interface environment is putting more assets and people at risk…

Several factors have combined to fuel the larger and more deadly fires in California. A key factor is a change in underlying exposures, marked by growth in populations and properties in the wildland-urban interface (WUI). The WUI refers to regions where structures are built adjacent to or within undeveloped natural area. Once a fire gets going in the WUI, it can spread quickly and be difficult to suppress. Since 1990, around 60% of new homes in the US have been built in WUI land.[8] It is not entirely surprising that most structures lost in last year's California fires were in the WUI.

…and greater accumulation of flammable biomass is leading to increasing wildfire activity.

Another factor is an increase in natural fuels (biomass) and conditions conducive to wildfire. In December 2017, the USDA Forest Service estimated that the total number of dead trees in California due to drought and bark beetles was 129 million across 8.9 million acres.[9] Further, some say wildfire risk in the US has been exacerbated by fire suppression activities, such as fighting fires that pose relatively low risk to people and properties. As a result, fewer fuels have been allowed to burn and more biomass has accumulated over time, which has increased the risk of large, uncontrollable wildfires.

Drought in 2018: high losses from another heat-related secondary peril

Many regions experience acute water shortages in 2018.

The high temperatures of 2018 combined with rainfall deficits had severe repercussions on water resources and in agriculture around the world. The Cape Town Province of South Africa experienced acute water shortages in the first half of 2018 following low rainfall of the previous years.[10] In Argentina, soy production was also severely affected by dry conditions[11] and in Australia, there was drought across eastern states, particular New South Wales in the second half of the year.[12]

The summer of 2018 was one of the warmest and driest ever experienced in northern Europe.

The heat and lack of rainfall were particularly devastating for farmers in Europe, who suffered severe drought throughout the summer. The summer of 2018 was one of prolonged high temperatures, with well-above mercury readings starting in April, alongside a dramatic increase in precipitation deficits. The July to September period was one of the warmest and driest of the past 70 years, and resulted in large agriculture sector losses across France, Benelux, Germany and Poland.

[8] *Wildfire, Wildlands, and People: Understanding and Preparing for Wildfire in the Wildland Urban Interface*, United States Department of Agriculture, January 2013, https://www.fs.fed.us/openspace/fote/reports/GTR-299.pdf

[9] USDA Forest Service, 12 December 2017, see https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd566303.pdf

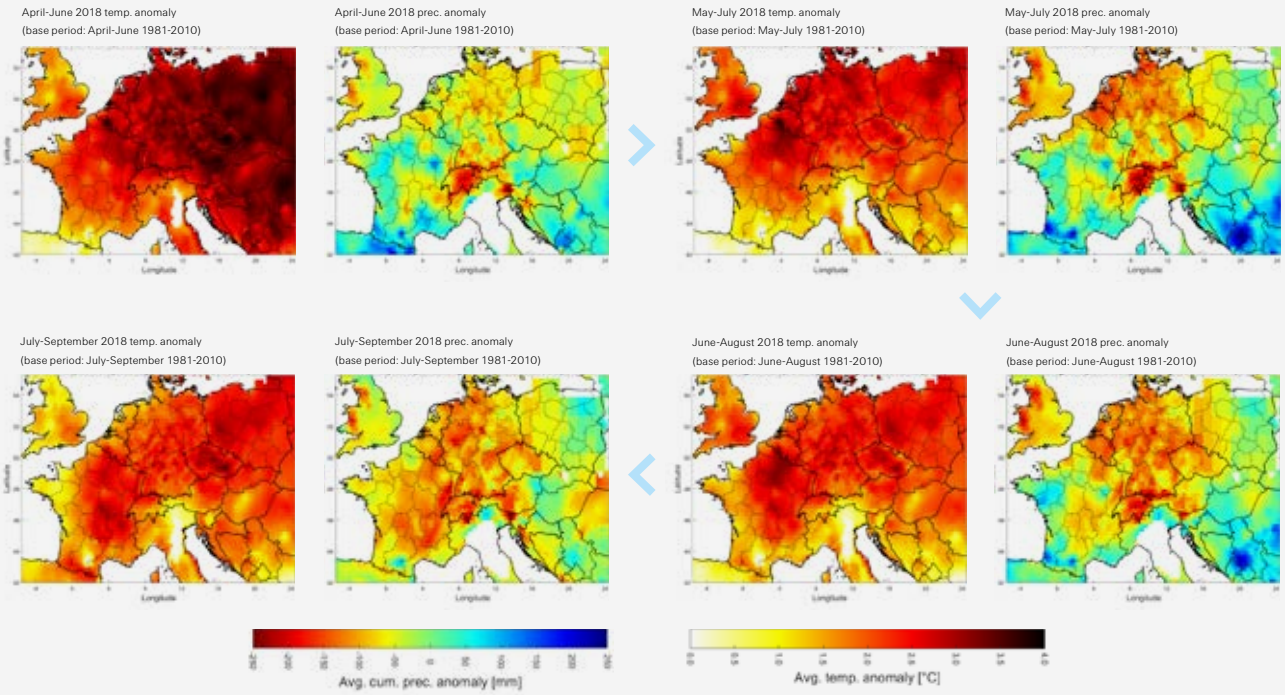
[10] "Cape Town drought declared a national disaster", *bbc.com*, 13 February 2018, https://www.bbc.com/news/world-africa-43047833

[11] "Argentina soybean production forecast down 13%", *worldgrain.com*, 14 March 2018, https://www.world-grain.com/articles/9536-argentina-soybean-production-forecast-down-13

[12] "Australia's 2018 in weather; drought, heat and fire", *The Conversation*, 9 January 2019, http://theconversation.com/australias-2018-in-weather-drought-heat-and-fire-109575

Another benchmark year for secondary perils

Figure 9
Development of temperature (temp) and precipitation (prec) anomalies in April-September 2018 in Europe, relative to a 1981–2010 base period



Note: precipitation anomalies for Italy are not available.

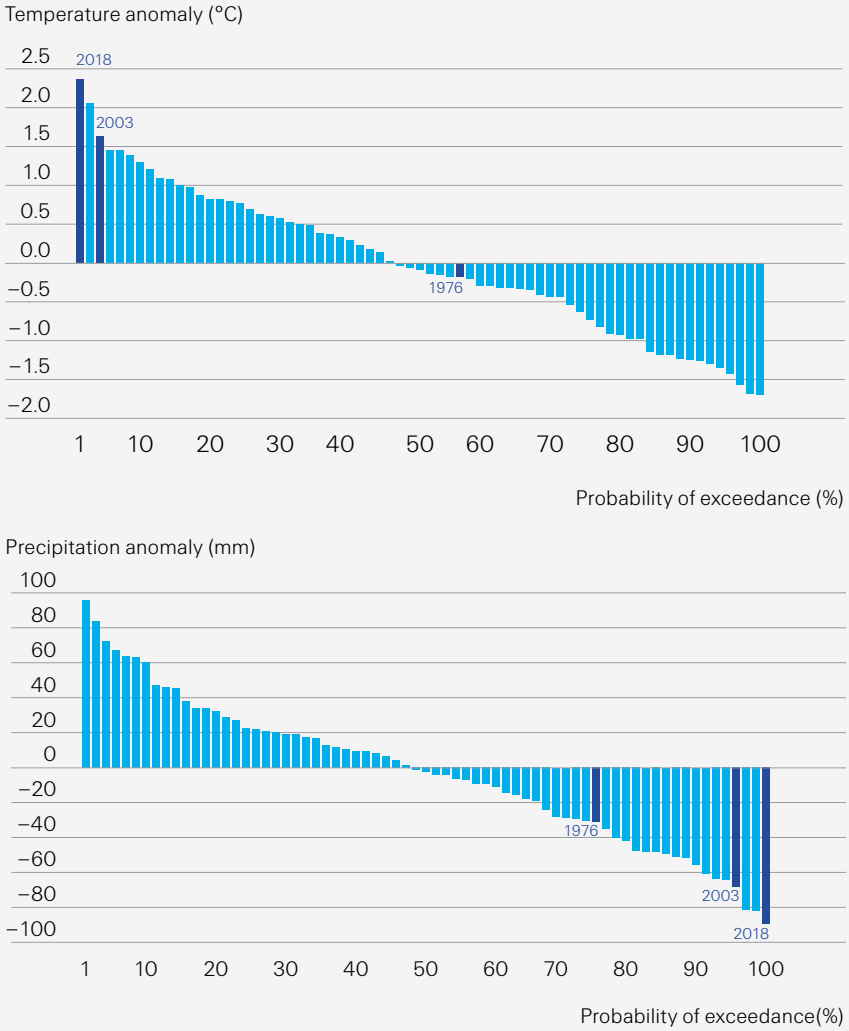
Source: Swiss Re analysis based on E-OBS dataset from the EU-FP6 project ENSEMBLES (http://ensembles-eu.metoffice.com) and the data providers in the ECA&D project (http://www.ecad.eu).

The ensuing drought was exceptional on account of severity and duration.

For the sake of perspective, while the record peak temperatures of the 2003 summer were not reached in 2018, the long duration of above-average temperatures caused the aggregate temperature anomaly for the whole summer to be much more severe. And, while the precipitation deficit last year was not as extreme as in the record year of 1976, the aggregate summer temperatures in 2018 were much higher than in 1976, aggravating the effects of the lack of precipitation. Figure 10 shows the return periods[13] of precipitation and also temperature anomalies in northern Europe for the years 1950–2018, measured by deviation from the mean value. As indicated, the late summer deviations for both precipitation and temperatures were most extreme in 2018.

[13] A statistical measurement of the average time of recurrence of a natural catastrophe event.

Figure 10
Return periods of temperature anomalies for Germany, Netherlands, Belgium, France and Poland; and precipitation for Germany, Netherlands, Belgium and France



Note: precipitations excludes Poland
Source: Swiss Re analysis, based on E-OBS dataset from the EU-FP6 project ENSEMBLES (*http://ensembles-eu.metoffice.com*) and data from the ECA&D project (*http://www.ecad.eu*)

The prolonged warm and dry weather conditions affected the development of many crops.

The drought protection gap in Europe

The long drought and heat severely affected the development of many crops in Europe, including wheat, barley, corn and grassland for feed production. The physiological development of wheat and barley was accelerated, whereas their grain filling and flowering stages were impaired by the climatic conditions.[14,15] The grains were small and their protein content was low due to accelerated ripening. Farmers were faced with both lower quantity of crop produce, and poor quality.[16]

[14] Fahad, Shah et al. "Crop Production under Drought and Heat Stress: Plant Responses and Management Options" *Frontiers in Plant Science*, vol. 8 1147. 29 June 2017, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5489704/
[15] "Dürre führt zu erheblichen Ernteausfällen", *Deutscher Bauernverband*, July, 2018 https://www.bauernverband.de/duerre-fuehrt-zu-erheblichen-ernteausfaellen
[16] "French Wheat Battered by Weather Worries, New Competition," *Gro Intelligence*, September, 2018 https://gro-intelligence.com/insights/french-wheat-battered-by-weather-worries-new-competition

Another benchmark year for secondary perils

Most drought-related losses were uninsured...

According to Swiss Re Institute estimates, the combined resulting economic losses in agriculture across Germany, France and Poland were close to EUR 6 billion (USD 6.9 billion). Most were shouldered by the farmers themselves as only a small part was insured.[17,18,19] In Germany, total economic losses for farmers were an estimated EUR 3 billion of which only EUR 5 million were covered by insurance. In France, economic losses associated with grassland feed production were around EUR 1.5 billion of which only EUR 11.6 million were insured. The poor corn yield led to economic losses of EUR 650 million), and insured losses of EUR 195 million. In Poland, the ministry of agriculture estimated total economic damage from drought at EUR 0.8 billion. Combined, the insured losses across the three countries reached an estimated EUR 269 million (USD 308 million), just 4% of the total.

...in some countries more than in others.

Low uptake of private sector agriculture insurance in the said countries can be explained by high premiums, high deductibles and, importantly, a mismatch of insurance products available and actual need requirements. Hail and multi-peril crop insurance (MPCI) is the most commonly available type of cover. In Germany, MPCI covering drought constituted only EUR 1 million of the market's total crop premium volumes in 2018; the other EUR 200 million were hail insurance premiums. France has a more diverse insurance offering: about 50% of arable surface is covered against hail, 25–30% of the arable surface is covered through the MPCI (all climatic perils), but only 2% of grassland benefits from MPCI cover (in the form of index solutions). To put things into perspective, 50% of the agriculture surface is arable land, and 50% is for livestock. In Poland, standard crop insurance policies similar to MPCI do not cover drought as a peril. As a result, none of last year's drought-associated crop losses were covered by the overall crop insurance premium volumes of EUR 150 million.

Table 4
Drought related losses and government aid for select countries

EUR bn	Economic losses	Insured losses	Governmental support
Poland	0.8	0	0.35
Germany	3	0.005	0.34
France	2.2	0.264	0.6
Belgium	N/A	N/A	0.055
Netherlands	N/A	N/A	0
Total	**6**	**0.269**	**1.345**

Note: Losses for France are estimated
Source: Swiss Re Institute

Insurance can make drought-stricken farms more resilient.

The European Union's Common Agriculture Policy (CAP) states that the agriculture sector should become more market oriented. The onus is on farmers to manage periods of crop price volatility, increasing pressure on their income, even more so in the event of a natural catastrophe like drought.[20] Insurance is an effective tool to deal with the economic downside associated with weather-related events. The challenge for policy makers and insurers alike is to incentivise and generate more uptake of agriculture risk protection solutions (see *State aid helps, but is it enough?*).

[17] "Crop failure and bankruptcy threaten farmers as drought grips Europe," *The Guardian*, July, 2018 https://www.theguardian.com/environment/2018/jul/20/crop-failure-and-bankruptcy-threaten-farmers-as-drought-grips-europe
[18] "Drought in Europe Summer 2018: Crisis Management in an orderly Chaos," *Farm Europe*, October 2018 https://www.farm-europe.eu/blog-en/drought-in-europe-summer-2018-crisis-management-in-an-orderly-chaos/
[19] "2018 harvest shows significant falls in production of wheat and barley," *Farminguk*, October, 2018 https://www.farminguk.com/News/2018-harvest-shows-significant-falls-in-production-of-wheat-and-barley_50579.html
[20] *Risk Management schemes in EU agriculture – Dealing with risk and volatility*, European Commission, September 2017, https://ec.europa.eu/agriculture/sites/agriculture/files/markets-and-prices/market-briefs/pdf/12_en.pdf

State aid helps, but is it enough?

Insurance premiums subsidies for farmers differ among the EU member states...

Europe's agricultural policy is centrally regulated by the CAP, which provides member states with a framework of obligatory and optional policy measures.[21] The CAP budget for 2014–2020 is around EUR 410 billion, of which the largest part is for yearly direct payments to farmers. EUR 2.2 billion is allocated to subsidies for agricultural insurance premiums across the member states.[22] The incentive for farmers to purchase crop insurance is strongly linked to the level of income support and also member states' specific policies with respect to subsidies for insurance premiums, as a means to stabilize farm income. According to Article 37 of the Rural Development Regulation of the European Union and within the framework of the CAP, member states can allocate part of their budget to subsidise insurance premiums by up to 65%, on condition of a loss threshold of 30% of average annual production. France, the Netherlands and Poland make use of this facility. Germany and Belgium, however, offer their farmers no such subsides.[23,24]

...as does the degree of other government support

In the wake of the 2018 drought, the European Commission implemented several measures such as advanced pay outs of yearly direct payments and exemption from certain environmental measures to help farmers manage their losses. Some countries also initiated reforms to help farmers manage their losses. However, the responses have not been uniform nor universally supportive. In Germany, for instance, the government promised EUR 340 million in aid following a request from the farmer's association for support of EUR 1 billion.[25] The aid came with the condition that the ex-post support goes only to those farmers who can prove they suffered financial distress. By the end of 2018, only about EUR 40 million of the compensation had been paid out.[26,27,28] The government in Poland meanwhile, helped farmers with ad-hoc state aid amounting EUR 350 million.

In Belgium, the 2018 drought was declared a disaster; in the Netherlands it was not.

In Belgium, the drought was declared a disaster and the government set up a support fund of EUR 55 million. Farmers need to apply to receive the money (maximum budget per farmer: EUR 62 400, and by the end of last year, approximately 2 000 claims had been submitted. In the Netherlands, on the other hand, the drought was deemed a 1-in-20 year event, rather than a disaster. The expectation was that farmers manage their losses with in-place risk management measures and commercial MPCI covers. France has the "Fonds national de gestion des risques en agriculture" (FNGRA) to support farmers after a severe natural catastrophe event.[29] Drought-affected administrative regions have to apply for ex-post aid and are evaluated by the National Agricultural Risk Management Committee (CNGRA). The last applications for aid following last year's drought were anticipated to be submitted by January/ February 2019.[30] It is not clear how much will be paid out. In the case of the 2003 drought, the FNGRA disbursed about EUR 600 million in total compensation.

[21] A.R. Rota, Master Thesis: *Influence of the European CAP Reform on the Agricultural Insurance Sector*, ETHZ, 2015.
[22] European Commission, September 2017, op. cit.
[23] A. R. Rota, op. cit.
[24] European Commission, September 2017, op. cit.
[25] "Sécheresse: l'agriculture gravement touchée dans trois départements sur quatre", *L'Info Durable*, October 2018 https://www.linfodurable.fr/secheresse-lagriculture-gravement-touchee-dans-trois-departements-sur-quatre-7228
[26] "Drought in Europe in Summer 2018: Crisis Management in Orderly Chaos", *Farm Europe*, 2 October 2018, https://www.farm-europe.eu/blog-en/drought-in-europe-summer-2018-crisis-management-in-an-orderly-chaos/
[27] Client Meeting Information (21 November 2018), between Swiss Re and GDV Gesamtverband der Deutschen Versicherungswirtschaft e.V, Expert Agri insurance Germany
[28] "Drought Has Europe's Farmers Fearing Crop Failures and Bankruptcies," *The Weather Channel*, August 2018 https://weather.com/news/news/2018-08-02-drought-crop-failures-europe-farmers
[29] A. R. Rota, op. cit.
[30] "Sécheresse : le Gouvernement vient en aide aux agriculteurs", *Alim'agri*, October 2018 https://agriculture.gouv.fr/secheresse-le-gouvernement-vient-en-aide-aux-agriculteurs

A well-functioning agricultural insurance market in Europe is needed, as a complement to state aid.

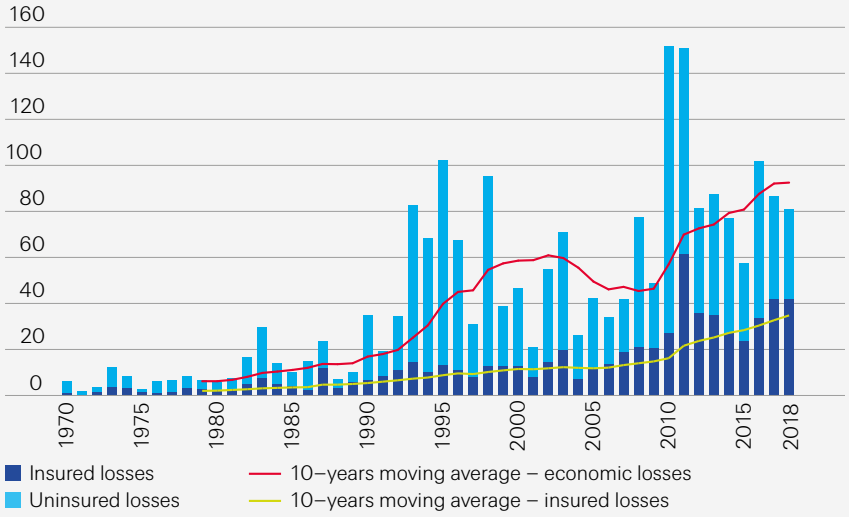
State aid does provide farmers who suffer crop losses with some financial relief. Often, however, the aid comes with difficult eligibility criteria, further supporting the cause for the development of a well-functioning agricultural insurance market in Europe. This will become increasingly important as temperatures continue to rise, likely leading to more frequent occurrence of heat waves and drought.

The secondary peril protection gap

Only half of last year's secondary peril losses were insured.

Last year, total economic losses from secondary perils (excluding the secondary peril effects) were USD 81 billion, of which around half was insured. The secondary-peril protection gap, therefore, was around USD 39 billion. Underinsurance against secondary perils is nothing new. As Figure 11 shows, the secondary peril protection gap has been on a consistently widening trajectory since 1990.

Figure 11
Insured, uninsured losses from secondary perils (excluding secondary peril effects), in USD billion at 2018 prices



Source: Swiss Re Institute

Warmer and drier weather conditions have raised the risk of drought and wildfire occurrence.

With warming temperatures, is climate change a factor?

There is not enough evidence to conclude that warming climates alone are responsible for the rising uninsured losses from secondary (and primary) peril events since 1990. The increased frequency and severity of warm and dry conditions of recent years have been conducive to heightening the risk of wildfires and drought occurrence. In the case of wildfire, it is a self-perpetuating cycle: the fires themselves exacerbate climate change, as the combustion of trees, plants and grasses releases greenhouse gases into the atmosphere.

We expect extreme weather events to become more common place; with urbanisation and asset growth in exposed area, losses will likely continue to rise also.

With climate change, we expect that wildfires and drought will occur more frequently, and that tropical cyclones will possibly be more intense. However, climate change itself is not the sole cause of huge resulting losses. Rather, it is the impact of population growth and urbanisation. Weather and other events only become catastrophes when they hit densely populated areas.[31] For example, in the last 20 years, urbanisation in Asia has happened at break-neck speed, often on coastlines. As a result, today the likelihood of a tropical storm striking a large conurbation in Asia has increased manifold (eg, on China's coastline). The probability of heavy losses,

[31] According to United Nation, today 55% of the world's population lives in urban areas. That is expected to increase to 68% by 2050, with close to 90% of the increase taking place in Asia and Africa.

given growing concentrations of economic assets in densely populated towns and cities, has likewise multiplied.

Urbanisation is reducing the venues for water discharge exacerbating the impact of heavy rains.

In the event of torrential rainfall, rapid urbanisation reduces avenues for water discharge and can lead to heavy flooding. Such was the case in Mumbai in 2005, when flooding after heavy rains resulted in one of the largest insurance loss events ever experienced in India (USD 0.9 billion, according to *sigma* data). Similarly, the massive flooding and losses in Houston in 2017 due to the secondary-effect peril torrential downpours brought by Hurricane Harvey. In each of the previous two years, the Houston metropolitan area suffered major rain-induced flood events, with associated insured losses of USD 1.1 billion in 2016, and USD 1.6 billion in 2015. The city has become vulnerable to flooding on account of the spread of suburban sprawl across the area's flood plains over the last 15 years. The ever-expanding area of paved surfaces in these areas means that rainwater runs and rises along hard surfaces rather than be absorbed in the ground.

Impact on the insurance industry

Insurers needs to pay more attention to secondary perils.

Insurance pricing for catastrophe risks is mostly influenced by the loss impact of primary (particularly mega-sized) perils. However, as the experience of 2018 shows, insured losses from secondary events can also mount to high levels. With increasing population densities, wealth concentration and coastal exposures, insurers need to respond to what has developed into a more constant flow of small and medium-sized catastrophe events. As with Camp Fire last year, we expect that secondary perils (including river and storm surge floods) will, more and more, rank among the top-loss making events in any one year, and that this will happen sooner rather than later.

Above all in terms of enhanced risk assessment.

This means re/insurers need to develop enhanced methods of risk measuring, monitoring and modelling to manage a different kind of natural perils result volatility: one that is more frequency than severity driven, but with a strong underlying trend increase in both frequency and severity due to environmental and societal changes, particularly urbanisation (see *Complexity in risk assessment and lack of robust tools*). Failure to afford due recognition to these loss events and their underlying growth trend will over time risk facilitating increasingly more pronounced market dislocation.

This will be important for insurance-sector profitability over the long term.

In the last decade, the industry has generated dependency on increasingly sophisticated probabilistic loss models available for major primary perils such as earthquakes. However, the ability to make accurate loss estimates for sustainable profitability is not solely based around the ability to use the available models. In our view, the to-date non-modelled secondary perils are of growing importance in loss estimates, also with a view to ensuring the sustainability of the insurance industry.

Modelling secondary peril risk is harder than primary...

Complexity in risk assessment and lack of robust tools

With a few exceptions (eg, flood risk models in US), insurers have tended to focus on primary peak loss-generating perils such as hurricanes in the North Atlantic. The discipline of secondary peril risk modelling has not been afforded the same priority. Also, it is more complex:

- The areas vulnerable to primary perils are generally well-defined (eg, near seismic fault lines (earthquakes) and coastal areas (tropical cyclones)). Many secondary perils, on the other hand, can happen anywhere (eg, heavy precipitation in large urban centres far inland or away from river plains).
- While primary perils typically affect large areas in a relatively homogeneous way, many secondary perils are highly localized (eg, hailstorms). An enormous amount of data and computational power is required to model the probability of a peril affecting the same area more than once.
- Many secondary perils can also be influenced by unpredictable human intervention. The scale of wildfires for example, are impacted by human prevention, ignition (eg, the mechanical failure of a vehicle that set off the Carr Fire as described above), containment and suppression activities. Further, while there is a high level of scientific understanding of the atmospheric and land conditions conducive to wildfire growth, spread and sustainability, it is difficult to translate smoke/ember emissions, dispersion and accumulation into a loss value.

...which has led to lack of associated insurance products.

These considerations help explain in some cases a lack of relevant insurance solutions and in others (such as crop insurance covers in European countries), a mismatch between the design of available covers and consumer requirements. To overcome such issues and help narrow existing protection gaps, the insurance industry needs to better understand and include high-frequency secondary perils in their claims monitoring, risk assessment, pricing and management activities.

Capacity plentiful, and insurance opportunities too

Total non-life re/insurance capacity (including alternative capital) was more than USD 2 trillion at the end of last year, according to Swiss Re estimates. The accumulated insured losses from natural catastrophes in 2017 and 2018 were USD 219 billion. The combined protection gap for the two years, meanwhile, was USD 280 billion, indicating widespread underinsurance. This presents an opportunity for the insurance industry to greater fulfil its utility to society as absorber of risk. Insurers can also help build socio-economic resilience through their long-term investment activities, particularly if able to invest more in infrastructure projects.

Industry capacity

The insurance industry is well prepared to manage extreme events.

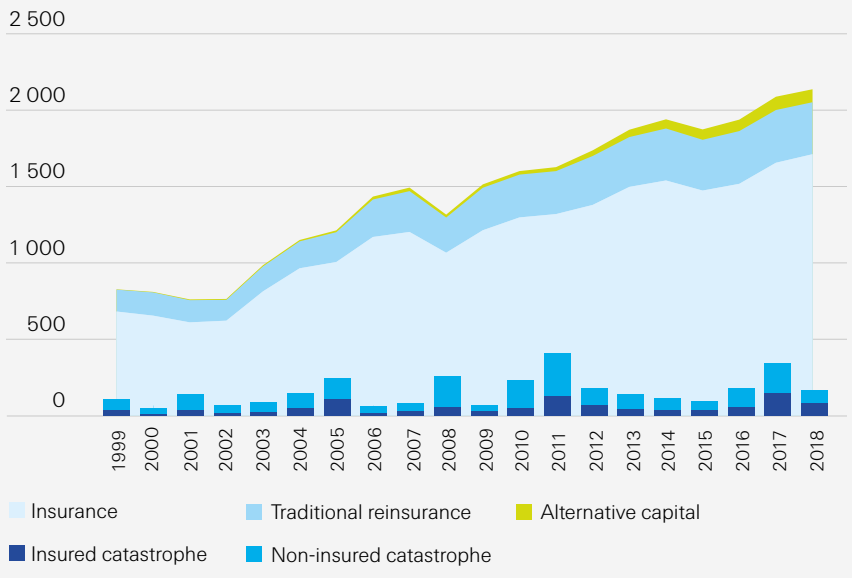
The re/insurance industry is well capitalised to cope with the losses arising from extreme events. Industry capital has been growing and far outstrips the level of catastrophe losses. In most years, supply-side capacity has not been a constraint to catastrophe risk coverage,[32] and limitations in the supply of insurance for certain risks have been successfully overcome whenever they occurred. Examples are the market disruptions caused by Hurricane Andrew (1992) and Hurricane Katrina (2005). Low barriers to entry for capital to enter the natural catastrophe reinsurance market facilitated the swift replenishment after each disruption. Furthermore, both events were followed by significant improvements in risk modelling and waves of new and alternative capital entering the market.

Capacity breakdown

The total capital base was more than USD 2 trillion at the end of 2018.

The total capital base of the non-life insurance industry has increased steadily over time, averaging 5.7% per annum growth from 1999 to more than USD 2 trillion by the end of 2018, according to Swiss Re estimates. Most (80%) of the capital comes from primary insurers, with reinsurance contributing 16% and alternative capital (AC) the remaining 4% (see Figure 12).

Figure 12
The development of the global non-life re/insurance capital, and the size of insured and uninsured losses since 1999 (in USD billion)



[32] T. Holzheu, G. Turner "The Natural Catastrophe Protection Gap: Measurement, root causes and ways of addressing underinsurance for extreme events", *Geneva Papers on Risk and Insurance – Issues and Practices*, January 2018.

Capacity plentiful, and insurance opportunities too

AC has made a significant contribution to total reinsurance capacity.

A prominent development since 2011 has been the influx of AC into the market. The main benefit of AC is to increase insurance capacity and the securitisation of risks. Initially, after the global financial crisis of 2008–09, AC remained a niche area. Soon after, institutional investors became increasingly aware that insurance-linked securities (ILS) offered diversification benefits and attractive returns relative to similarly-rated corporate bonds, and cat risks matured into a separate asset class.

AC has well coped with the record losses of the last two years...

According to Swiss Re estimates, the level of AC in the market had grown to around 25% of total property cat risk supply in 2018. Before 2017, some analysts doubted that AC capacity would remain active after a large natural catastrophe shock. However, the ILS market remained liquid throughout 2017, in spite of the huge losses racked up by Hurricanes Harvey, Irma and Maria, and investor capital was more than replenished. A mix of both established and opportunistic new investors contributed to the segment's continued growth into 2018. Spread increases in the ILS market and traditional reinsurance pricing in January and through 2018 were disappointing, but remained attractive relative to similarly rated high-yield corporate bonds.

...but there are signs that investor appetite for AC has waned slightly.

All told, we observe that the appetite of investors in the AC segment to take on new risks did wane slightly over 2018. The reasons were disappointing price increases, gradually escalating loss numbers (loss creep) from Hurricane Irma and other catastrophes in 2017, and the record losses from wildfires in California. Additionally, spread widening in the high-yield corporate bond segment might also have decreased the relative attractiveness of AC. These factor prevented some ILS funds from rolling over their investments into new ventures for the 2018 catastrophe season. Initial indications from the January 2019 renewals go further to suggest a reduced risk appetite on the part of institutional investors, driven by the losses and by prices which remained broadly flat at the January 2019 renewals.[33]

Nevertheless, AC is here to stay.

On a longer-term view, however, we believe that AC is here to stay. It has matured into an integral player in the growing market for catastrophe risks. Re/insurance demand will rise faster than economic growth due to dynamic industrial growth and urbanisation in emerging markets, and also as the increasing value of assets located near coastal areas in mature markets, which are often vulnerable to natural hazards.

The catastrophe losses in 2018 were 18% of the global property premiums.

Two-years accumulated losses the highest ever: who's paying?

The combined insured losses from natural catastrophes in 2017 and 2018 were USD 219 billion (on an inflation-adjusted basis), the highest two-year accumulation ever. The re/insurance industry stepped up its contribution to the financing of these losses. Claims for natural catastrophe-associated losses accounted for 6.7% and 3.6% of global non-life insurance industry capital in 2017 and 2018, respectively. That's compared to around 2% of sector capital in a "normal" year.

Table 5
Natural catastrophe losses (not inflation adjusted)

	Losses (USD billion)	% of capital	% of property premiums
2017	140	6.7%	36.8%
2018	76	3.6%	18.6%
20-year median		2.2%	11.1%

Note: non-life re/insurance industry capital is the sum of primary insurance, traditional reinsurance and alternative capital. Numbers in this table are not-inflation adjusted
Source: Swiss Re Institute

[33] *Sharpening Focus Through Adaptation, Reinsurance Renewal*, Guy Carpenter, January 2019..

AC made a significant contribution to the loss payments for the first time,

The insured losses of the past two years were shared between primary insurers active in the affected areas, and the (international) reinsurance industry. For the first time, the AC sector has also made a significant contribution to the loss payments. According to Swiss Re estimates, AC accounted for about 25-30% of the insured losses resulting from the 2017 North Atlantic hurricane season, for example.

AC brings the added benefit of ease of entry to the market, which helps smooth cycle volatility.

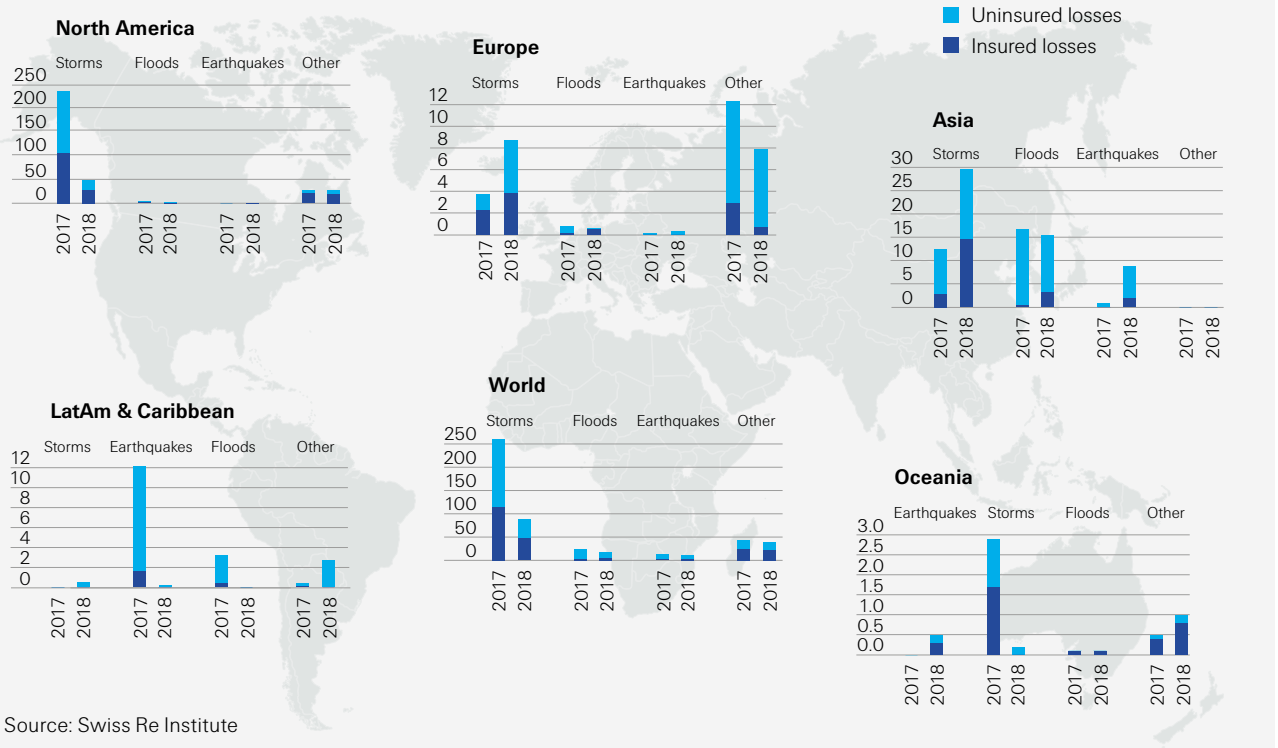
The losses of the past two years were high and well absorbed by the strongly capitalized re/insurance market, highlighting the utility of the industry as a main line of defence in building resilience. AC is a new source of supply, particularly in the reinsurance property catastrophe risk market. A benefit of AC is the increased ease at which capital can enter the market. This will help curb the volatility of the reinsurance underwriting cycle, making for an overall more stable insurance market.

Why is there an insurance protection gap?

Underinsurance of catastrophe risk remains a global problem.

In spite of the ample availability of risk capital in the market, underinsurance for natural catastrophe events remains widespread across the world. The frequency and severity of losses resulting from catastrophe events have increased over time, and the resulting economic and insured losses have grown on average by around 5% annually since 1999. Last year, the economic losses from natural catastrophe were USD 155 billion, and insured losses USD 76 billion, leaving a protection gap of around USD 80 billion. For 2017 and 2018 together, the economic loss total from natural disaster events was USD 497 billion, and the insured loss total USD 219 billion,[34] representing the highest level of associated insurance pay outs over a two-period ever. Nevertheless, the combined natural catastrophe protection gap for the two years was also large, at USD 280 billion.

Figure 13
Insured vs uninsured losses by peril and region in 2017 and 2018 (USD billion, in 2018 prices)



Source: Swiss Re Institute

[34] In Table 5, the value for 2017 insured losses (USD 140 billion) is stated in 2017 prices. At 2018 prices, the value would be USD 143 billion, making for the two year insured loss total of USD 219 billion.

Challenges and insurance opportunities

The protection gap is typically higher in emerging markets.

The share of uninsured catastrophe losses varies by region. It is typically higher in developing countries where infrastructure construction and implementation of catastrophe risk mitigation measures do not keep pace with economic growth. However, there are areas of underinsurance in advanced countries too, even in those with known medium to high exposure to certain hazards. One example is the low insurance penetration among private households to seismic risk in earthquake-prone Italy. Similarly, while commercial property tends to be better-protected than residential, often small and medium enterprises (SMEs) have large exposure gaps, in spite of the existence of well-established insurance markets in their home country. For instance, last year many SMEs in Japan, which make up 99% of the country's industrial and commercial base, suffered large uninsured losses as a result of the spate of disasters that hit that country. Following the disasters, in November the Small and Medium Enterprise Agency set up the SME Resilience Study Group with the aim of fostering the resilience also through risk finance to generate higher insurance penetration.[35] The agency considers penetration "not necessarily sufficient," quoting a survey by the Research Institute of Economy, Trade and Industry which set the take up rate within the SMEs at 47%.[36]

A new approach to risk modelling, making use of new technologies, is needed if the pooling mechanism of insurance is to become more effective.

The global re/insurance industry has ample capacity to underwrite primary and secondary natural catastrophe risks. The insurance pooling mechanism allows for the diversification of those risks across populations and regions. The global nature of re/insurance markets allows for risk diversification across borders, reducing the amount of loss absorbed locally.[37] But while relying on historical loss experience has sufficed in the past, this may not be the case in a world of increased urbanisation and changing climates. In order to capture the frequency, severity and the growing risk associated with these perils, insurers need to take a new approach, including making more use of technology (eg, satellite imagery, social media data) to develop more robust and efficient modelling tools that capture trends and environmental changes more in real time than in hindsight (See *Solution example: tackling the US flood protection gap*).

Secondary perils' insurance could be easier to sell than comprehensive natural catastrophe insurance.

It is hard to incentivise an individual to buy insurance protection for rare perils like earthquakes, which are perceived as very remote. However, perils related to extreme weather, also including windstorms and floods, can be an opportunity to close the protection gap where the relatively frequent nature of these perils better aligns with the time horizon of an individual and a policy maker. Secondary perils' insurance (eg, cover for heavy precipitation, landslides) could provide a first crucial step to incentivise customers to realise the value of insurance and later buy comprehensive natural catastrophe insurance addressing more remote perils. This will help develop an insurance culture in less-mature markets.

Swiss Re has developed a series of solutions for secondary perils.

Swiss Re has supported many insurance solutions covering secondary perils (eg, excess rainfall (from hurricanes) cover in addition to wind damage for Caribbean Catastrophe Risk Insurance Facility (CCRIF), and more recently landslide cover for Mao County in China. And, to meet increased demand for tailored reinsurance programs, new methods and tools to assess frequency rather than severity risks, are required. Robust risk assessment will be critical in developing new products to cover frequency risks and steer more efficient use of insurance capital.

[35] The Small and Medium Enterprise Agency, available in Japanese only. See http://www.chusho.meti.go.jp/keiei/antei/2018/181121kyoujin04.pdf

[36] Ibid.

[37] *The Contribution of Reinsurance Markets to Managing Catastrophe Risks*, OECD, 2018 https://www.oecd.org/finance/the-contribution-of-reinsurance-markets-to-managing-catastrophe-risk.pdf

Solution example: the US flood gap and the private market's role

Flood risk in the US has remained traditionally uninsured.

According to Swiss Re's proprietary in-house catastrophe models, economic losses from flood events in the US will amount to USD 15 billion annually. Of these only USD 5 billion are insured, leaving an annual protection gap of USD 10 billion. The US is subject to many flood-generating perils given the vastness of its territories and diversity of its climatic regions. Yet, only one in six homes in the US has flood insurance. Many Americans think they don't need it, others assume their homeowner's policy covers flood, and others think cover is too expensive.

Today flood risk modelling is well developed...

Other factors make matters worse: torrential rainfalls, rising sea levels, more severe storms and storm surges, plus increased residential and commercial development in flood-prone areas. Until recently there has been little appetite on the part of insurers to cover US flood risks. However, advancements in technology are changing that and have sparked first steps in the development of a private flood insurance market.

...allowing the possibility to devise innovative retail insurance solutions.

A generation ago, the industry was limited in its ability to assess the true flood risk for a location. Even when using the National Flood Insurance Program's (NFIP) flood maps, it was not possible to distinguish the stark differences in risk even within the same flood zone. Today, fully probabilistic US flood models — combining detailed hazard vulnerability, value distribution and insurance conditions — deliver accurate information in real time, allowing insurers to rate the risk on individual exposures and unique characteristics. With Swiss Re's retail flood toolkit, insurers in the US can provide customised flood risk protection solutions for both the household and commercial sectors. The toolkit provides the means to evaluate and price flood risk, and simplifies the terms of cover, creating value for property owners in doing so.

Insights from behavioural economics can help

Lack of risk awareness remains a root cause of underinsurance...

Some of the root causes of underinsurance lie on the demand side, and insurers can gain valuable insights into consumer buying habits from behavioural economics. The reasons for underinsurance are many, including lack of consumer knowledge about insurance products and their availability, and also lack of risk awareness. Traditional economics assumes people are rational with perfect information and choose the option that maximises their net utility. However, in reality humans are often irrational, with hidden biases. This can be very relevant when it comes to insurance purchase decisions. Insurance is an abstract product, and uptake relies heavily on trust in the insurance company to pay potential claims. Catastrophe insurance adds an additional layer of bias complexity. Most people do not have first-hand experience of a catastrophe event and related losses.

...particularly for high severity, low frequency perils.

The "availability bias" is an important factor. We typically estimate the likelihood of something happening based on how quickly we can come up with examples and recent cases. If the locality in which we live has not experienced a flood in the past 10 years, we will not necessarily appreciate the need to purchase flood insurance. A second problem is that the memory of an event can quickly fade. One study in the US found that there was an increase in uptake of insurance directly after a flood, and the increased level remained statistically significant for nine years after.[38] Further out, the take-up rate was as if the flood had never occurred. Behavioural economics is an active field of research in insurance. A sound understanding of consumer preferences, buying patterns and risk awareness can inform product design and pricing across all lines of business, including for natural catastrophe covers.

[38] J. Gallagher, *Learning about an Infrequent Event: Evidence from Flood Insurance Take-Up in the United States*, Case Western Reserve University - Weatherhead School of Management, 31 October 2013, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3078097

The role of insurance in building resilient infrastructure

Addressing the protection gap requires public private partnerships.

Narrowing the natural catastrophe protection gap requires not only increasing the insured portion of the losses, but also reducing expected economic losses. This requires a combined response from the public and private sectors. In the past, public private partnerships (PPPs) have been successful in finding solutions to mitigate disaster risk. For example, in the UK insurers have provided cover to homes in high-risk flood areas, in exchange for the government investing in flood protection measures. More recently, starting in 2017, policy makers in Italy introduced tax incentives to encourage uptake of earthquake insurance and anti-seismic retrofitting of homes. We welcome these moves (see additional "Special *sigma* 2/2019 feature: L'Aquila, 10 year on").

The road to a resilient future is to limit future losses.

High-quality, robust infrastructure progresses economic development and also societal resilience. There are many examples of where disaster mitigating defences have been strengthened (or built) after occurrence of a catastrophic event. For instance, flood defences built after the catastrophic floods along the Yangtze River basin in China in 1998 helped curtail the economic losses of a similar potential catastrophic recurrence in 2016. More can be done through PPPs on an ex-ante basis, however, to protect population centres, particularly those vulnerable to growing frequency of severe weather events, with the building of risk mitigating infrastructure. And here, in their capacity as long-term investors, insurers can contribute an important financing element.

Insurers can deploy a higher amount of capital in long-term resilience building infrastructure projects.

PPPs in infrastructure bring several benefits. For example (1) global private-sector re/insurance assets amount to approximately USD 30 trillion.[39] Even a low single-digit increase could unlock a significant amount of capital for deployment into infrastructure projects, helping governments shoulder the costs amid tight fiscal space and also increasing overall economic resilience. Privately-financed infrastructure investments boost economic growth and lower production costs for firms. At the same time, well-developed private markets with diverse, long-term financing channels for, among others, infrastructure investment, benefit overall financial stability and economy resilience at large;[40] (2) on average PPPs lead to project efficiency gains and contribute to effective risk-sharing: and (3) in a world of still historically very low yields, infrastructure projects can provide an attractive return for long-term investors.

However, the scaling up of investments in critical infrastructure is being held back by the lack of clear asset classes and standards.

Despite their advantages, infrastructure PPPs are not commonplace. Generally, infrastructure projects remain opaque and hard-to-access for institutional investors, including insurers. A lack of standardized debt financial documentation and reporting templates, and also of harmonised dispute resolution regimes, means investor "rights" in infrastructure projects are often weak. What further complicates the mix: infrastructure assets are illiquid, constraining the ability of long-term investors to deploy a significant chunk of their capital into the asset class.

Regulatory clarity would also stimulate investments in infrastructure.

To develop a dynamic infrastructure PPP sector, there needs to be a more conducive investment environment. Best practices designed jointly by the public and private sector would need to be universally applied. In this regard, a benchmark PPP transaction showcasing best practices would set a positive precedent and guide future transaction activity. Crucially, the regulatory framework matters: it should be clear, consistent and harmonised to effectively mobilise long-term investor capital.

[39] According to Swiss Re Institute estimates.

[40] *Infrastructure Investment: It Matters*, Swiss Re and Institute of International Finance, 2004, https://www.swissre.com/dam/jcr:513b66a1-0ea5-485a-8ef8-eaaec27b6749/Infrastructure_Investment_IIF.pdf

Encouragingly, there seems to be political will to implement changes.

Encouragingly, the political path for infrastructure to become tradable and for more PPPs to take effect, appears promising. For example, the G20 Eminent Persons Group report highlights the need for a tradable infrastructure asset class.[41] The same report makes several tangible suggestions, including leveraging Multilateral Development Banks' (MDBs) balance sheet to de-risk projects. Alternatively, MDBs could also pool individual projects and market them to long-term investors, freeing up the space for infrastructure lending on their balance sheets. The European Financial Services Roundtable, a consortium of major European re/insurance companies and banks has also proposed a template for "best practice" financial documentation.[42]

[41] *Making the Global Financial System Work For All*, Global Financial Governance, 2018, https://www.globalfinancialgovernance.org/report-of-the-g20-epg-on-gfg/

[42] *Facilitating European Infrastructure Investment*, European Financial Services Round Table, 2018, http://www.efr.be/documents/news/117.1.%20Updated%20EFR%20paper%20on%20Infrastructure.pdf

Conclusion

More than half of last year's insurance losses resulted from secondary perils.

Last year provided no respite for the global re/insurance industry, even with the absence of mega-loss generating primary peril catastrophe events. Total insured losses from natural catastrophe and man-made disasters of USD 85 billion were the fourth highest for a single year ever, according to *sigma* records. And more than half of the losses were the result of natural catastrophe secondary peril events, including droughts, wildfires and precipitation-induced flooding.

We expect secondary peril-associated losses to continue to grow...

Traditionally, insurers' risk monitoring efforts (and also loss accumulation) have focused on peak risks such as hurricanes in the North Atlantic, earthquakes and winter storms in Europe. We expect that the share of secondary perils, both as stand-alone events and secondary effects of a primary peril, in overall natural catastrophe losses will continue to grow. This is mainly due to rapid urbanisation and associated higher concentrations of assets in areas exposed to extreme weather conditions, and also in anticipation of warmer and drier weather.

... because more frequent occurrence of flooding, drought and wildfire events due to warming temperatures is a reality in many parts of the world.

Compared to two decades ago, the potential for large losses due to extreme weather affecting densely populated and still-expanding urban areas has increased significantly. We also expect the trend of rising losses from secondary perils to accelerate, on account of further rapid urbanisation in areas exposed to flooding (such as cities in coast lines or in former flood plains) and fire risk (wildland-urban interface), and with acknowledgement of long-term climate change projections. While the probability outlook for more extreme catastrophes like hurricanes due to climate change remains uncertain, more extreme weather conditions and more frequent occurrence of resulting secondary peril flooding, drought and wildfire is a reality in many places across the world.

The re/insurance sector has plenty of capital to absorb these growing exposures and needs to focus more on understanding them.

The insurance industry needs to understand and help society tackle these risks. In 2017 and 2018, insurance claims for losses arising from natural catastrophe events were USD 219 billion. There is plenty more risk absorbing capacity to go round. For more effective use of this capital, re/insurers should more actively include high-frequency secondary perils in their claims monitoring, risk assessment, pricing and management activities. They should also focus on fostering consumer risk awareness, and developing product availability and targeted distribution.

Insurers can also improve global resilience through their long-term investment activities.

The role of the public sector is also important in disaster risk management. Here insurers can contribute too, by providing intelligence to public bodies. This knowledge can inform public policy strategy around the development of risk mitigating measures to minimise financial, as well as loss of life due to disaster events. Importantly, with a more conducive regulatory environment, insurers can also help build resilience through their investment activities, in particular in long-term infrastructure projects.

Appendix

Terms and selection criteria

A natural catastrophe is caused by natural forces.

Natural catastrophes

The term "natural catastrophe" refers to an event caused by natural forces. Such an event generally results in a large number of individual losses involving many insurance policies. The scale of the losses resulting from a catastrophe depends not only on the severity of the natural forces concerned, but also on man-made factors, such as building design or the efficiency of disaster control in the afflicted region. *sigma* sub-divides natural catastrophes into the following categories: floods, storms, earthquakes, droughts/forest fires/heat waves, cold waves/frost, hail, tsunamis, and other natural catastrophes.

A man-made or technical disaster is triggered by human activities.

Man-made disasters

This study categorises major events associated with human activities as "man-made" or "technical" disasters. Generally, a large object in a very limited space is affected, which is covered by a small number of insurance policies. War, civil war, and war-like events are excluded. *sigma* subdivides man-made disasters into the following categories: major fires and explosions, aviation and space disasters, shipping disasters, rail disasters, mining accidents, collapse of buildings/bridges, and miscellaneous (including terrorism).

Losses due to property damage and business interruption that are directly attributable to major events are included in this study.

Economic losses

For the purposes of the present *sigma* study, economic losses are all the financial losses directly attributable to a major event, ie damage to buildings, infrastructure, vehicles etc. The term also includes losses due to business interruption as a direct consequence of the property damage. Insured losses are gross of any reinsurance, be it provided by commercial or government schemes. A figure identified as "total damage" or "economic loss" includes all damage, insured and uninsured. Total loss figures do not include indirect financial losses – ie loss of earnings by suppliers due to disabled businesses, estimated shortfalls in GDP and non-economic losses, such as loss of reputation or impaired quality of life.

The amount of the economic losses is a general indication only.

Generally, total (or economic) losses are estimated and communicated in very different ways. As a result, they are not directly comparable and should be seen only as an indication of the general order of magnitude.

Insured losses

"Losses" refer to all insured losses except liability. Leaving aside liability losses, on one hand, allows a relatively swift assessment of the insurance year; on the other hand, however, it tends to understate the cost of man-made disasters. Life insurance losses are also not included.

NFIP flood damage in the US

The *sigma* catastrophe database also includes flood damage covered by the National Flood Insurance Program (NFIP) in the US, provided that it fulfils the *sigma* selection criteria.

sigma has been publishing tables listing major losses since 1970. Thresholds with respect to casualties – the number of dead, missing, severely injured, and homeless – also make it possible to tabulate events in regions where the insurance penetration is below average.

Thresholds for insured losses and casualties in 2018

For the 2018 reporting year, the lower loss thresholds were set as follows:

Insured losses (claims):		
	Maritime disasters	USD 20.8 million
	Aviation	USD 41.7 million
	Other losses	USD 51.8 million
or	Total economic losses:	USD 103.5 million
or	Casualties	
	Dead or missing	20
	Injured	50
	Homeless	2000

Losses are determined using year-end exchange rates and are then adjusted for inflation.

Adjustment for inflation, changes to published data, information

sigma converts all losses for the occurrence year not given in USD into USD using the end-of-year exchange rate. To adjust for inflation, these USD values are extrapolated using the US consumer price index to give current (2018) values.

This can be illustrated by examining the insured property losses arising from the floods which occurred in the UK between 29 October and 10 November 2000:

Insured loss at 2000 prices: USD 1046.5 million

Insured loss at 2018 prices: USD 1526.1 million

Alternatively, were one to adjust the losses in the original currency (GBP) for inflation and then convert them to USD using the current exchange rate, one would end up with an insured loss at 2018 prices of USD 1 302.4 million, 15% less than with the standard *sigma* method. The reason for the difference is that the value of the GBP declined by almost 15% against the USD in the period 2000–2018. The difference in inflation between the US (45.8%) and the UK (45.7%) over the same period was negligible.

Figure 14
Alternative methods of adjusting for inflation, by comparison

Floods UK	Exchange rate			US inflation
29 October–10 November 2000	GBPmn	USD/GBP	USDmn	USDmn
Original loss	700.0	1.495	1046.5	1046.5
Level of consumer price index 2000	72.7			100.0
Level of consumer price index 2018	105.9			145.8
Inflation factor	1.457			1.458
Adjusted for inflation to 2018	1020.0	1.277	**1302.4**	**1526.1**
Comparison			85%	100%

Source: Swiss Re Institute

Changes to loss amounts of previously published events are updated in the *sigma* database.

If changes to the loss amounts of previously published events become known, *sigma* takes these into account in its database, but Swiss Re is under no obligation to publicly revise or update this *sigma* study.

Newspapers, direct insurance and reinsurance periodicals, specialist publications and other reports are used to compile this study.

Sources

Information is collected from newspapers, direct insurance and reinsurance periodicals, specialist publications (in printed or electronic form) and reports from insurers and reinsurers. In no event shall Swiss Re be liable for any loss or damage arising in connection with the use of this information (see the copyright information on the backpage).

Exchange rate used[43], national currency per USD

Country	Currency	Exchange rate, end 2018
Australia	AUD	1.4205
Canada	CAD	1.3652
Switzerland	CHF	0.9853
China	CNY	6.8776
Eurozone	EUR	0.8746
United Kingdom	GBP	0.7851
Indonesia	IDR	14430.0144
India	INR	69.4444
Japan	JPY	109.7815
Kenya	KES	101.8600
Laos	LAK	8551.3939
Sri Lanka	LKR	181.8182
Madagascar	MGA	3540.7004
New Zealand	NZD	1.4910
Oman	OMR	0.3850
Philippines	PHP	52.5210
Sweden	SEK	8.8652
Tonga	TOP	2.3321
US	USD	1.0000
Vietnam	VND	23201.8561

[43] The losses for 2018 were converted to USD using these exchange rates. No losses in any other currencies were reported

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