A stormy year

TOPICS Geo Natural catastrophes 2017

Analyses, assessments, positions

NOT IF, BUT HOW

Munich RE

Dear Reader,

2017 was a wake-up call. After a number of relatively benign years, natural disasters in 2017 caused overall losses of US$ 340bn. Insurers had to pay out a record US$ 138bn in losses.

It is crucial that insurers and reinsurers take account of statistically rare loss events in their risk management calculations. One such rare event was the torrential rainfall and severe flooding that Hurricane Harvey brought to the Houston area in August. The series of three powerful hurricanes that struck within the space of just a few weeks – Harvey, Irma and Maria – is also rare but by no means impossible, especially as experts predict that certain types of extreme weather events are likely to become more frequent in the future as a result of climate change. 2017 therefore gave us a foretaste of what we can expect in the future. Once again, significantly less than half the losses were covered by risk transfer solutions.

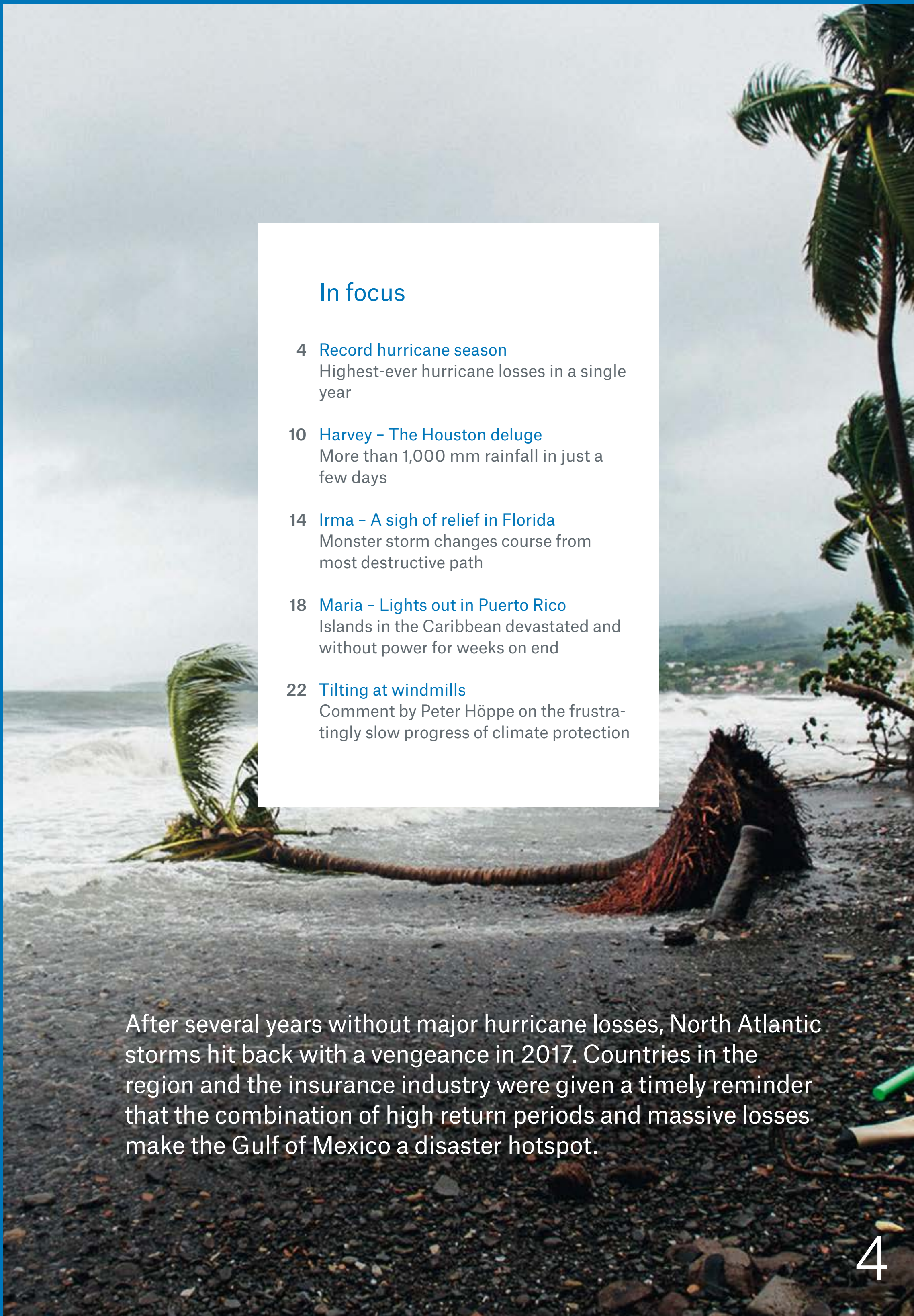
These facts and figures not only highlight the business opportunities available to insurers. They also show the enormous economic challenges that people, companies and public institutions face in tackling the consequences of disasters. Given these circumstances, insurers are almost obliged to develop new covers that better meet clients' needs. The use of data from sensors or satellites and systems incorporating elements of artificial intelligence now make it possible to offer entirely new insurance concepts. One positive effect of such a system is faster payouts by insurers, which help victims to get back on their feet sooner following a disaster. Studies have shown that emerging countries in particular are able to recover more quickly after catastrophes if insurance density is high.

In order to develop new types of cover, we need in-depth knowledge of the risks and how they are changing. Currently top of our agenda is to achieve a better understanding of which regions and weather hazards are already subject to changed risk patterns due to global warming. And we are also looking at ways in which risk prevention can help limit losses.

This latest issue of Topics Geo analyses the natural disasters of 2017 and discusses the conclusions drawn. I hope you find the articles both interesting and informative.

Munich, March 2018

Dr. Torsten Jeworrek
Member of the Munich Re Board of Management
and Chairman of the Reinsurance Committee



In focus

After several years without major hurricane losses, North Atlantic storms hit back with a vengeance in 2017. Countries in the region and the insurance industry were given a timely reminder that the combination of high return periods and massive losses make the Gulf of Mexico a disaster hotspot.

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Catastrophe portraits: Hurricanes were not the only major disasters in 2017. Other weather-related events such as wildfires, frost and floods caused billions of dollars in damage, as did earthquakes. The continued moderate level of insured disaster losses remains a concern, with less than half insured, even in developed countries. The share of insured losses in poorer countries is much lower.

Less than half of the losses insured

US$ 138bn (41%)

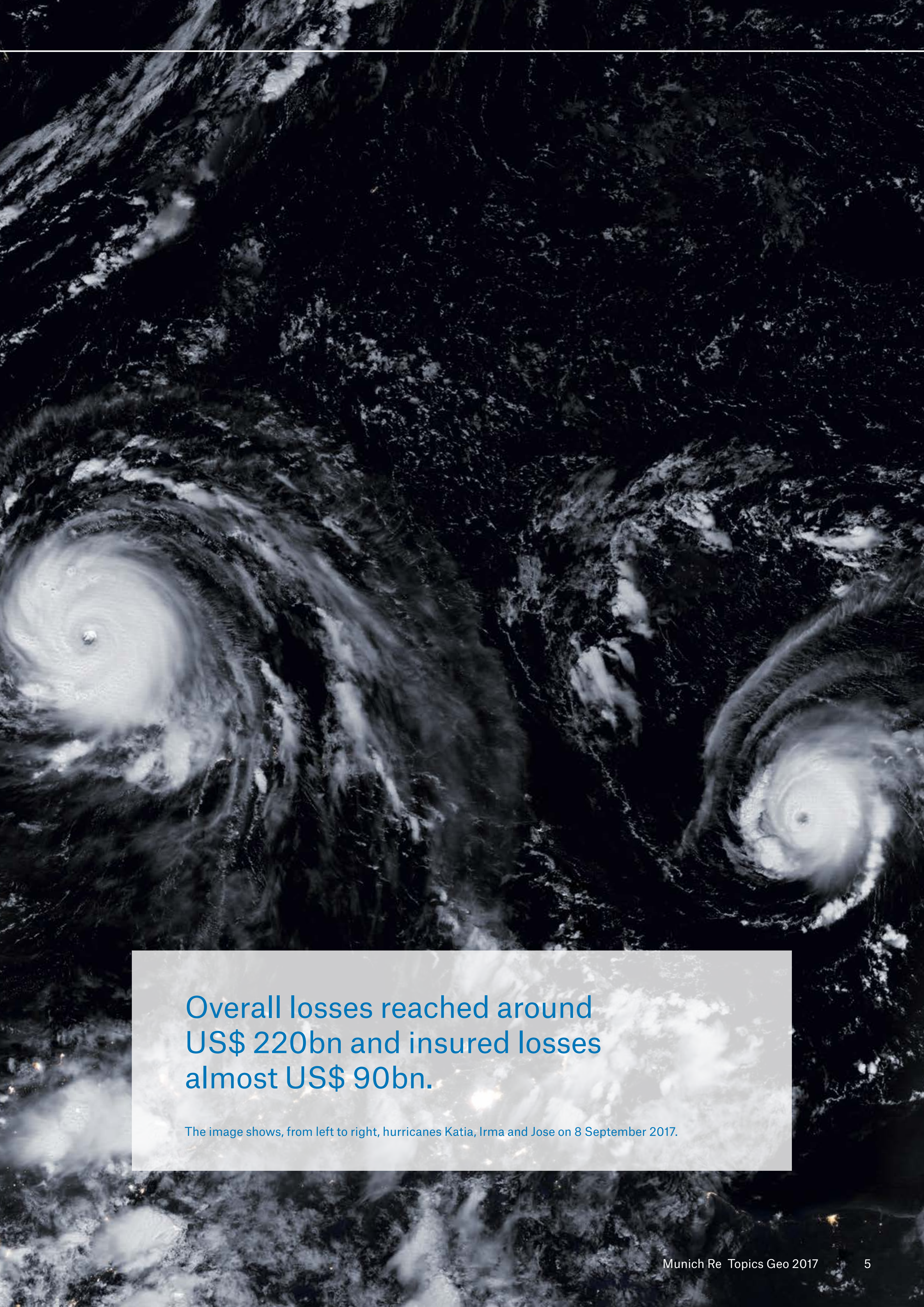
50

NatCatSERVICE and Research: With over 700 loss events, 2017 ranks among the top five years in terms of number of events. Munich Re's NatCatSERVICE tool (http://natcatservice.munichre.com/) contains a wealth of annual and long-term statistics at the touch of a button.

Catastrophe portraits

NatCatSERVICE and Research

Within a span of four weeks, the hurricane trio of Harvey, Irma and Maria made the 2017 hurricane season in the North Atlantic the costliest ever.



Overall losses reached around US$ 220bn and insured losses almost US$ 90bn.

The image shows, from left to right, hurricanes Katia, Irma and Jose on 8 September 2017.

The hurricane season 2017

A cluster of extreme storms

Eberhard Faust and Mark Bove

In terms of original values, the 2017 hurricane losses were higher than in the previous record year of 2005 that included hurricanes Katrina, Rita and Wilma (overall losses US$ 163bn, insured losses US$ 83bn). The question implicitly raised by the events of 2017: What are the causal factors that make a record-breaking loss year?

Only a portion of the 2017 hurricane season was extremely active – the second half of August through early October. During this period, several meteorological preconditions for above-normal activity were met, such as sea surface temperatures in the tropical main development region substantially above average, very low levels of difference in winds at low levels and aloft, an active West African monsoon producing tropical cyclone seedlings, and – last but not least – sufficient moisture levels in the mid to upper troposphere. Given the confluence of such conducive conditions, the season "turned on" and produced a cluster of exceedingly strong storms.

The favourable conditions led to six major hurricanes (cat 3–5) out of an overall ten hurricanes (cat 1–5), and 17 named storms in total. In comparison, note that the period of elevated activity since 1995 averaged 3.4 major hurricanes per year. The Accumulated Cyclone Energy (ACE)released by the storms approximately tied the totals of 2004 and 1995, with only 2005 having been stronger since 1950. All of these high-activity years fall into the period of elevated levels of tropical North Atlantic sea surface temperatures since 1995.

It is noteworthy that major hurricanes Harvey, Irma, and Maria of 2017 all underwent rapid intensification, reached record or near-record intensities, produced record rainfalls and – in the case of Irma – maintained extreme intensity for a record-breaking amount of time.

Similar tracks of Irma and Maria through the Caribbean

A broad spectrum of mechanisms accounted for the widespread destruction stretching from the Texas Gulf coast to Florida to the northeast Caribbean: in the case of Harvey, high pressure blocked the storm's path and reduced its forward speed, resulting in days of torrential rainfall over roughly the same region in eastern Texas and Louisiana.

With the other storms, high winds and storm surge caused most of the damage in the Caribbean and Florida. Due to the similar tracks of Irma and Maria through the Caribbean, some islands were hit twice, with Maria destroying what Irma had left standing.

Many settlements and coastal stretches in the region were severely affected, with some places experiencing significant long-term outages of essential infrastructure such as electricity and communications. These conditions challenged governmental budgets. Specialised labour was needed to carry out repairs, causing a shortage of skilled tradesmen. The time taken to repair these systems further exacerbated damage levels, drove prices up, and triggered an economic downturn and emigration from some locales.

A billboard in Miami is ripped apart by high winds as Hurricane Irma passes

Meteorological conditions definitely had an influence on last year's activity. Although the northern North Atlantic saw a period of remarkable surface cooling between 2014 and 2016, this cooling signal never reached the tropical North Atlantic. Hence, the level of enhanced sea surface temperatures since the onset of the current warm phase in the mid-1990s has remained unabated in the tropics, although the last few hurricane seasons before 2017 were not very active. In fact, the August–October 2017 sea surface temperature anomaly in the main development region of the tropical North Atlantic in 2017 was the third-highest since 1995.

This, together with the other conducive meteorological settings, rendered 2017 another season of the current active era in the tropical Atlantic. This means that high-activity periods reveal a temporal structure of high season-to-season variability with occasional extremely active seasons which are characterised by a cluster of very intense storms. Hence, one of the important outcomes of the 2017 season should be to make sure that the risk models employed by the insurance industry improve their capability to simulate seasonal clusters of strong storms.

Besides the influences from natural multidecadal climate variability such as warm and cold phases, climate change may also have already played a role, most likely regarding the extreme precipitation involved. Current projections of future conditions expect almost unchanged or stagnating overall tropical cyclone numbers in most ocean regions for the mid-21st and end-21st century. By contrast, the frequency of the extreme storms (cat 4–5) is projected to increase in most areas given continued climate change. Also, maximum wind speeds will on average rise a little, and rainfall rates within 100 km of the storm's centre will increase due to higher evaporation rates. Recent research has found that over the last 140 years climate change has significantly increased the probability of extreme three-day rainfall on the Gulf Coast, such as that associated with Harvey (van Oldenborgh et al.: Attribution of extreme rainfall from Hurricane Harvey, Environ. Res. Lett., 12, 2017).

Against the background of these findings and projections, the 2017 season does appear to be a foretaste of the future. We expect there to be a higher frequency of exceptional hurricane seasons like 2004, 2005 and 2017.

Hurricane Harvey

Record-breaking floods inundate Houston

Tobias Ellenrieder

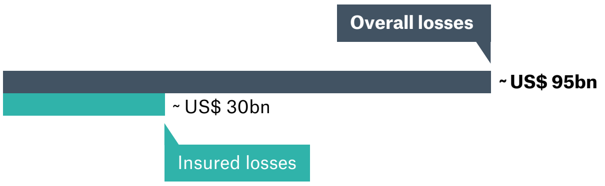
Harvey was the wettest tropical cyclone ever to hit the USA. In parts of Texas, unprecedented flooding occurred. The direct economic losses are likely to be as much as US$ 95bn, which would make Harvey the second-costliest hurricane on record after Katrina. Many private households face a sizeable insurance gap.

Freeways in Houston submerged under water following Hurricane Harvey

The eighth named storm of the 2017 Atlantic hurricane season developed from a tropical wave on 17 August east of Barbados. Harvey traversed the Lesser Antilles as a tropical storm, but weakened to a tropical depression thanks to unfavourable conditions in the Caribbean. After crossing the Yucatán Peninsula, it began to be influenced by a warm-water area in the Bay of Campeche. This had separated from what is known as the "loop current", a warm ocean current between Yucatán and Cuba. The resulting increase in convection quickly fed Harvey with new energy, allowing it to develop to a category 4 hurricane within 48 hours.

The second-costliest tropical cyclone

Hurricane Harvey



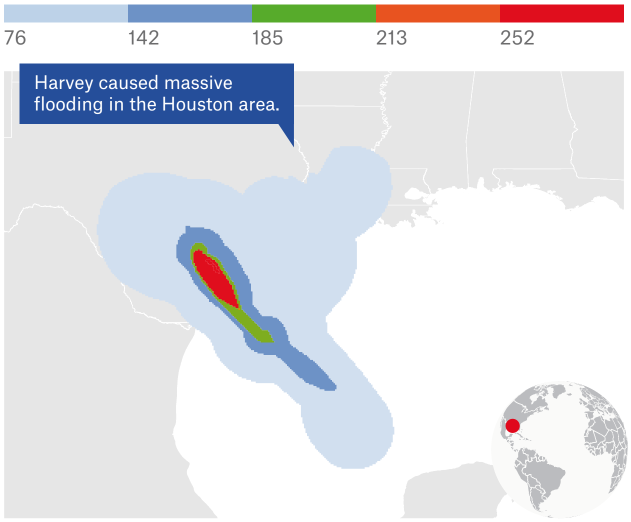
Sources: PCS, Munich Re NatCatSERVICE

On 25 August, Harvey made landfall near Rockport in Texas. The scale of storm damage was relatively low because of the comparatively limited spread of the strongest winds and the sparse population in the landfall region. Also, no particularly strong storm surge was able to build up because of the very rapid development of the storm just before landfall. During its further course, however, the cyclone was sandwiched between two high pressure systems, with the result that its forward progression was brought to a virtual standstill. On 28 August, the centre of Harvey moved back over the sea, before the storm made landfall for a second time on 29 August in Louisiana, after which it weakened rapidly and finally dissipated.

Explosive storm intensification

Hurricane Harvey

Wind speed (gusts) in km/h



Source: Munich Re, based on National Hurricane Center/NOAA

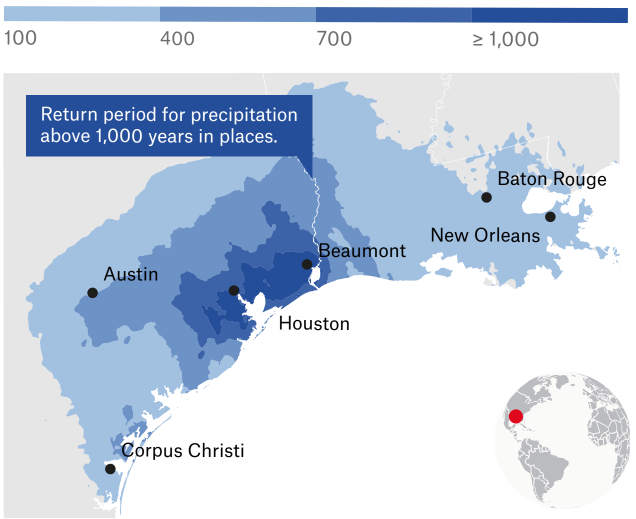
Cyclone with extreme precipitation

Following landfall in Texas, parts of Harvey's circulation remained over the warm waters of the Gulf of Mexico, bringing large quantities of moisture to the mainland. In many parts of southern Texas, the aggregate rainfall exceeded 1,000 mm. The peak value was measured at over 1,500 mm near Beaumont, roughly 120 km east of Houston. But the Lone Star State's largest city also saw rainfall of more than 750 mm over a wide area. This made Harvey the wettest tropical cyclone in the USA since records began. In some cases, the return periods for the quantities of rain experienced were in the 1,000-year range. Much of Harris County recorded rain exceeding the 1-in-100-year amount.

While the amounts of rain were exceptional, the situation was compounded by local conditions. The area of the Texas coast where Harvey hit is extremely flat: there is only a 15–20 metre difference in elevation between Houston and the coast 40 km away at Galveston Bay. The rivers in the district around Houston have only a gentle slope and a low discharge capacity. Houston is also built on alluvial soil, and as the result of groundwater abstraction, the ground there is sinking – by up to 6 cm per year in places.

A very wet storm
Hurricane Harvey

Total precipitation in mm



Source: Munich Re, based on National Hurricane Center/NOAA

All this set the scene for a "perfect rainstorm". In the days after landfall, more than 80 gauge stations around Houston reported flooding, 42 of them severe flooding. Record levels were measured at a large number of river gauges. The floods were exacerbated by the fact that water had to be released from several reservoirs to prevent dams bursting. Approximately 25–30% of Harris County was under water.

Harvey was the second-costliest hurricane after Katrina

The deadly combination of severe and extensive flooding in a highly developed economic region – with 6.6 million residents Houston is the fourth-largest city in the USA – resulted in enormous losses. More than 200,000 homes were damaged or destroyed, and over 250,000 vehicles were damaged. Harvey flooded 800 sewage plants. At least 88 people were killed. Production of oil and gas in the region had to be cut back by about 25%.

With direct losses of US$ 95bn, Harvey is the second-costliest cyclone in US history after Hurricane Katrina in 2005. Texas anticipates costs of US$ 180bn to repair the damage and prevent such disasters in the future. This compares with insured losses of US$ 30bn. Particularly in private households, there is a substantial gap between insured and actual losses.

Insurance cover limited

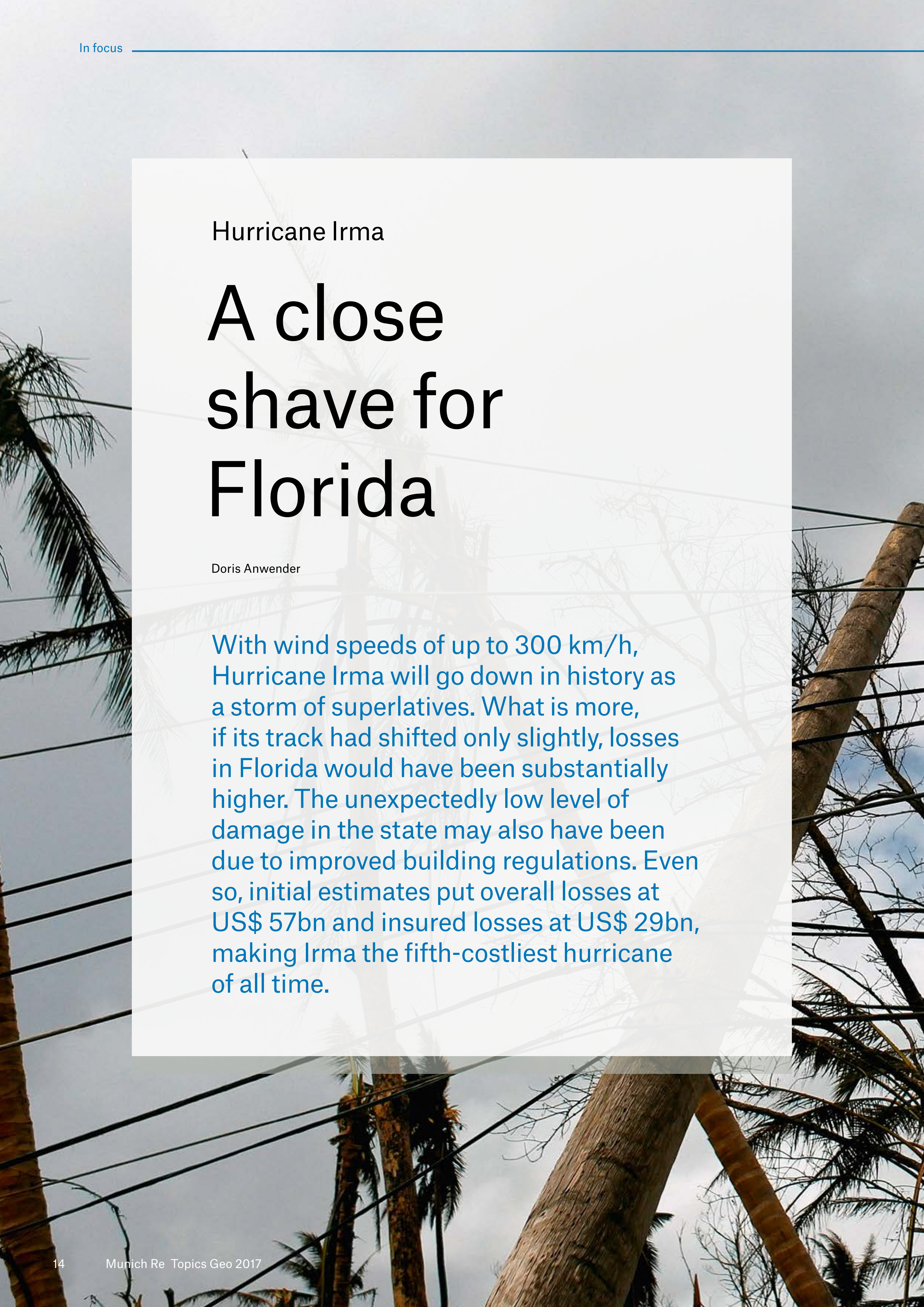
Flooding in the USA is not covered in standard private-residence policies. But this is where the National Flood Insurance Program (NFIP) comes in. It provides private individuals with government insurance cover – albeit with limitations. The programme is only compulsory for properties with a mortgage that are located within a 1-in-100-year flood zone. The premiums are relatively high for what is a limited scope of cover. For example, payments are capped at US$ 250,000 for buildings, and US$ 100,000 for contents, and basements are not covered under the policy.

Due to these somewhat unattractive conditions, the number of NFIP policies has fallen in recent years. In Harris County around Houston, only one in six homeowners has insurance cover for flooding. In addition, the flood zones for which NFIP protection is compulsory relate to river flooding only. But the floods triggered by Harvey mainly affected areas far from any body of water. Lax building regulations did the rest: houses do not have to be built at higher levels, and insufficient consideration was given to the flood risk when planning residential developments. In the course of the construction boom in Houston, large areas have been sealed in the last few years that could otherwise have helped in soaking up and discharging water, thus reducing the flooding hazard.

Better models needed for flood risks

Hurricane Harvey demonstrated once again that floods not only account for a significant proportion of total losses from tropical cyclones, but can actually make up the bulk of such losses. Up until now, these have only played a minor role for the insurance industry in the USA because the risk – where applicable – was covered by the federally run NFIP. This is also reflected in the options for modelling this risk. Numerous solutions and tools delivering an improved risk assessment have only been developed over the last few years. These range from zoning solely for floods that can be used for risk selection and rating, to fully probabilistic models to calculate loss accumulations and reinsurance requirements. However, hurricane models only simulate losses from wind and storm surge – but not flooding losses due to torrential rain. They are thus not suited for mapping the interaction between these three risks. On the other hand, pure flood models generally do not map tropical cyclones, which means that one component of the risk is missing.

If the insurance industry is to expand flood insurance in the USA and tap into the new business potential this will bring, it will need to include flooding in its hurricane models.



Hurricane Irma

A close shave for Florida

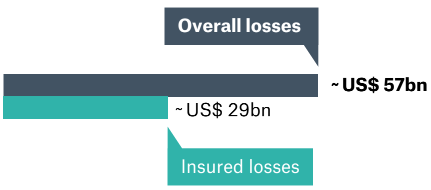
Doris Anwender

With wind speeds of up to 300 km/h, Hurricane Irma will go down in history as a storm of superlatives. What is more, if its track had shifted only slightly, losses in Florida would have been substantially higher. The unexpectedly low level of damage in the state may also have been due to improved building regulations. Even so, initial estimates put overall losses at US$ 57bn and insured losses at US$ 29bn, making Irma the fifth-costliest hurricane of all time.

Scene of destruction in the north of Haiti ahead of Hurricane Irma

Tropical cyclone Irma developed on 28 August 2017 from a tropical wave in the Atlantic that originated in Africa. As it moved west, it intensified with the help of exceptionally warm ocean waters to become a category 5 hurricane on the Saffir-Simpson scale, with peak wind speeds of 300 km/h. Irma thus holds the record for the most powerful cyclone ever measured over the Atlantic, not including the Caribbean and the Gulf of Mexico.

Florida spared the worst
Hurricane Irma



Sources: PCS, Munich Re NatCatSERVICE

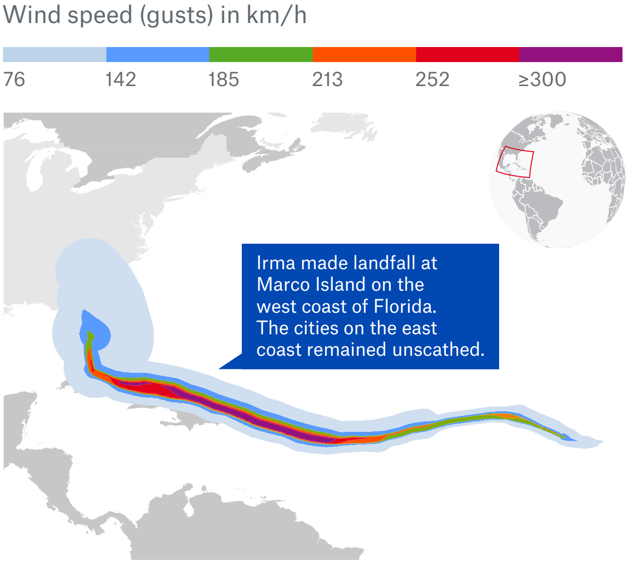
Storm of superlatives

After making initial landfall on 6 September in the Lesser Antilles at peak strength, Irma proceeded to devastate numerous islands in the Caribbean. Later, as it tracked westwards, the storm passed over extremely warm ocean waters with temperatures of up to 34°C. Because of its relatively high forward speed, the storm quickly crossed a large area with high ocean temperatures, helping it to intensify rapidly. Hurricanes that track more slowly restrict their intensity more because they remain longer over sea surfaces that have been mixed by the storm and are thus cooler.

Irma next grazed the coast of Cuba before veering north and hitting the Florida Keys as a category 4 hurricane. Several hours later, when it finally struck Marco Island on the southwest coast of Florida, it had weakened slightly to a category 3 hurricane.

Irma was an unusual storm in many respects. To begin with, its centre, where the highest wind speeds occur around the calm eye, was exceptionally large for such an intense storm. This meant that the path with its maximum speeds was also unusually wide. Furthermore, the hurricane maintained these maximum speeds for more than three consecutive days, then weakened briefly to a category 4, before intensifying again to category 5. As a result, a large number of Caribbean islands were exposed to extreme wind speeds. Owing to the size of the storm over its life cycle, regions like Miami Beach, which under normal circumstances would only have felt the outer edges of the hurricane force winds, were affected by storm surges.

An extreme storm
Hurricane Irma



Source: Munich Re, based on National Hurricane Center/NOAA

Destructive path difficult to predict

The track a hurricane takes is mainly determined by the wind direction in the surrounding area. Irma moved in a westerly direction at the southern edge of a subtropical area of high pressure rotating in a clockwise direction. At the western edge of the high, Irma came under the influence of a trough approaching from the west, whose (counter-clockwise) winds steered it northwards towards Florida.

The predicted track is based on the high and low pressure areas and their projected intensity. Even small deviations can have serious consequences when a cyclone makes landfall on a narrow landmass such as Florida. For example, a cyclone along the east coast of Florida, with the enormous concentration of values in Miami, Cape Canaveral and Jacksonville, could have produced many times the losses of a storm further west. But in the west of Florida there are also sizeable cities like Fort Myers, Naples and Tampa. These centres would potentially be affected by the right, strong-wind side of a cyclone moving over the sea along the west coast. Uncertainty among those responsible for disaster management and among the general population of Florida was correspondingly high.

The actual track the storm finally took was somewhat fortunate in as much as it released its greatest power over the sparsely populated interior of Florida, where it was also cut off from its source of energy, the warm ocean.

Damage and impact

Photos and satellite images showed severe devastation on Barbuda, on the French/Dutch Caribbean island of Saint Martin/Sint Maarten, on Anguilla, and throughout the British Virgin Islands and the two US Virgin Islands of St. Thomas and St. John. Irma's impact was also felt on Puerto Rico, Turks and Caicos, in the Dominican Republic and Haiti, on the southern Bahamas and in Cuba. Even though a strip of the Florida Keys was devastated by the storm and storm surge, there were unexpectedly few reports of damage from the mainland and from most of the Florida Keys. In all probability, this is due to a tightening of building regulations after Hurricane Andrew. In 1992, Andrew made landfall in Florida near Miami as a category 5 hurricane, and moved across the southern part of the state with devastating wind speeds.

Despite the relatively low level of damage, extensive evacuation measures in Florida led to chaotic conditions on the peninsula. Most of the population responded to the official call to evacuate, alarmed by the potentially record-breaking size and intensity of the hurricane, and by media reports on the devastation it had caused on islands in the Caribbean. This led to overcrowded airports, grid-locked roads, long queues at filling stations, fuel shortages, and looting in cities that were virtually deserted.

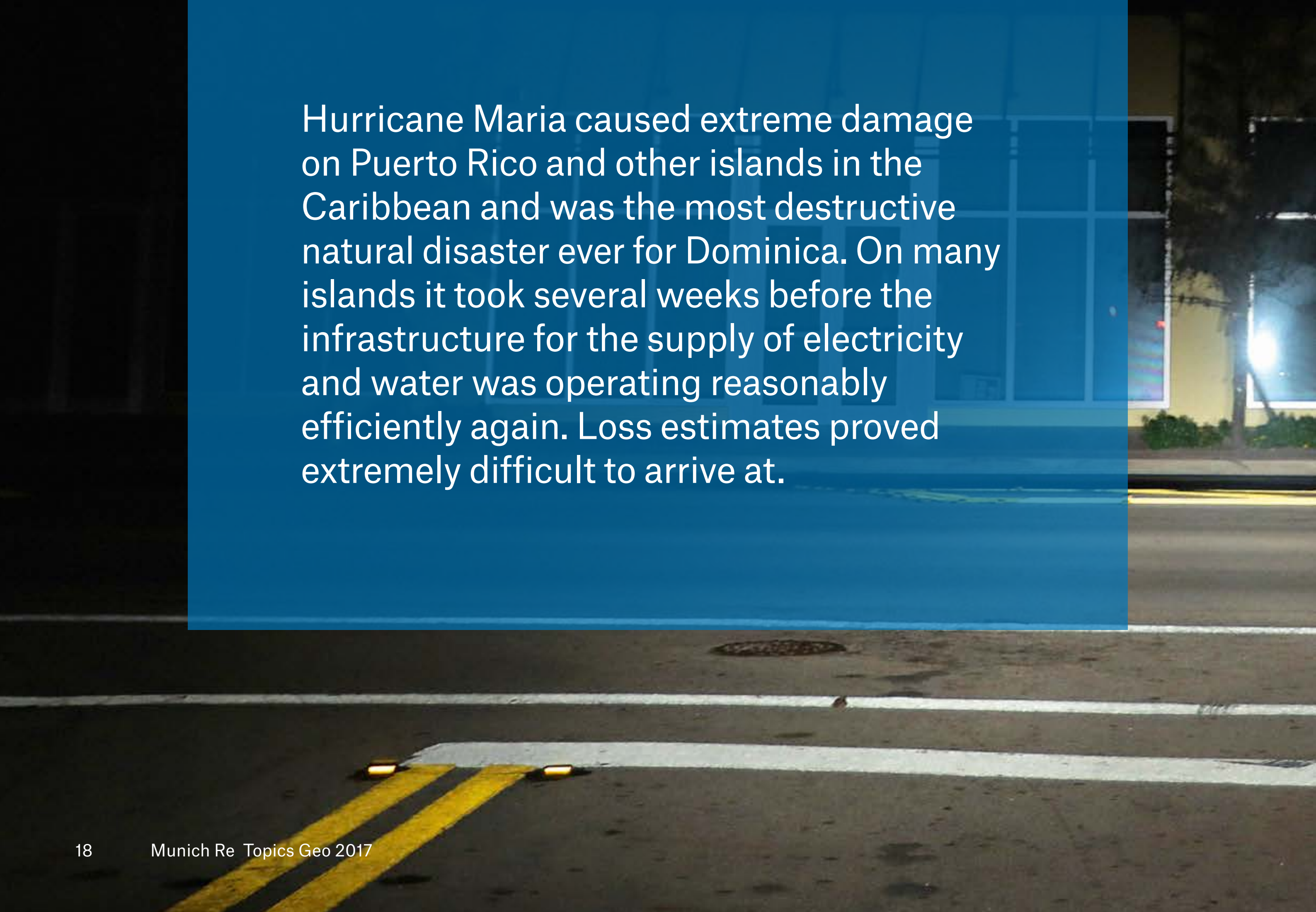
The fact that Irma's landfall in Florida was forecast more than five days in advance reflects the high quality of the weather forecast. But even in the future, it will remain impossible to predict the track of hurricanes precisely, so those responsible for disaster management will need to weigh up whether or not to order an evacuation each time an extreme event occurs. The probabilities of alternative scenarios provided by meteorologists in so-called ensemble forecasts can help decision-making here.

Hurricane Maria

More damage with each passing day

Peter Miesen

Hurricane Maria caused extreme damage on Puerto Rico and other islands in the Caribbean and was the most destructive natural disaster ever for Dominica. On many islands it took several weeks before the infrastructure for the supply of electricity and water was operating reasonably efficiently again. Loss estimates proved extremely difficult to arrive at.

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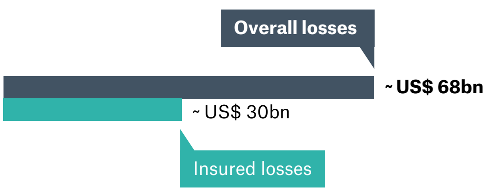
FOR RENT

Bridge in Puerto Rico after Hurricane Maria hit the area in September 2017

The storm system developed on 16 September some 800 km east of Barbados. Within 24 hours it had become a category 1 hurricane moving westwards. In the space of 15 hours over the course of 18 September, the system strengthened to a category 5 storm with wind speeds above 250 km/h, shortly before the eye passed directly over Dominica, leaving catastrophic damage in its wake.

Extreme damage especially in Puerto Rico
Hurricane Maria



Sources: PCS, Munich Re NatCatSERVICE

Compact system with extreme winds

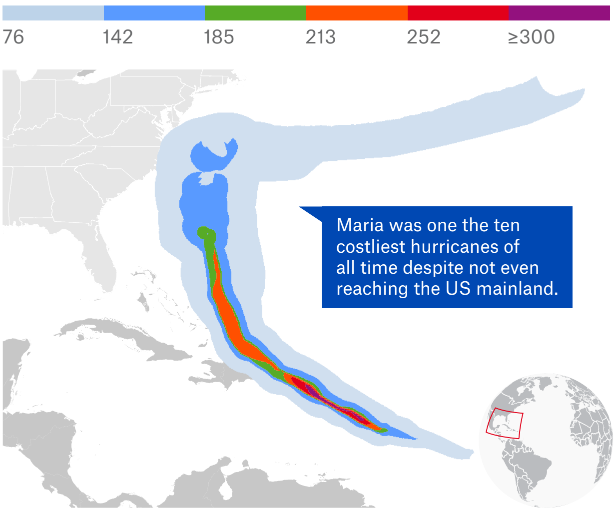
In contrast to the enormous Hurricane Irma, which had devastated the Lesser Antilles somewhat further north only two weeks earlier, Maria was a relatively small but extremely intense system. The highest wind speeds occurred in a ten-kilometre radius around the eye. During its rapid crossing of Dominica, Maria weakened to a category 4 storm. On its continued path, the system touched the southwest regions of Guadeloupe. As the eye of the storm found itself over water again, Maria rapidly returned to a storm of the highest category. On 20 September, as it passed close to St. Croix, the most southerly of the three largest US Virgin Islands and home to roughly 50% of the population, gusts are estimated to have peaked at around 300 km/h. After Irma had struck the islands of St. Thomas and St. John in the northern part of the US Virgin Islands, the last island in the group was now exposed to severe squalls.

At this point, the storm system was already undergoing what is known as an “eyewall replacement cycle”, where a new ring of convective air flow forms outside the centre. This cuts off the inner ring with the highest wind speed from its supply of energy, causing it to dissipate. As a result, the intensity of the system is reduced – for some time at least – while the radius of the highest wind speeds expands. Maria then struck Puerto Rico as a category 4 hurricane on 20 September. The wind field was now large enough to cover almost the entire island.

Maria took less than twelve hours to traverse the island, weakening in the process to a category 2 storm before undergoing renewed intensification over water to category 3. The remnants of the storm caused damage in the Dominican Republic, on the Turks and Caicos Islands, and on some sparsely populated islands in the Bahamas. The storm next tracked over the Atlantic in a north-easterly direction.

Small but very strong
Hurricane Maria

Wind speed (gusts) in km/h



Source: Munich Re, based on National Hurricane Center/NOAA

High level of uncertainty in estimating losses

At between US$ 15bn and US$ 85bn for the entire event, there were significant variations in the estimates for insured market losses that were published in the first few weeks after Maria. This wide range stems from a series of uncertainty factors. A major role in this context is played by the extent and estimation of the wind field and the storm surge area derived from it. Local floods cannot be determined through simulations alone because rain data is much too coarse in terms of spatial and temporal resolution. There is also generally no information on the degree of the soil's saturation. The already soaked soil from Irma's precipitation certainly played a role in the flooding during Maria. Similarly, the terrain models are too coarse for locally differentiated estimates. And lastly, there is little information on where, and to what extent, protective structures such as dykes failed.

Pharmaceutical industry highly concentrated in Puerto Rico

A further source of uncertainties in loss simulations lies in the vulnerability curves used. For example, the storm reached wind speeds on Puerto Rico that were above the ranges validated with loss data. In addition, Puerto Rico in particular involves pharmaceutical industry risks for which there is little loss experience. A large number of American and international pharmaceutical companies have relocated their production facilities to Puerto Rico to take advantage of tax incentives. These ship their products from the island to the US mainland and abroad. In 2016, the island state, which is an unincorporated territory of the USA, exported pharmaceutical and medical products worth US$ 14.5bn, equivalent to more than 72% of Puerto Rico's total exports.

Furthermore, the final extent of Maria's losses, and also that of the other hurricanes of the season, was significantly influenced by what is known as post-loss amplification. For example, as the number of claims increases, so too does the demand for building materials and labour, and thus the costs for these services. This phenomenon was more pronounced in a year like 2017, when several severe hurricanes passed over the region. On the other hand, the economic crisis and the high rate of unemployment on Puerto Rico may avoid a massive increase in labour costs. Put plainly, we can say that, months after Hurricane Maria hit, the loss development is still incomplete.

Consequential losses from destroyed infrastructure

The relatively sluggish aid efforts and the heavily damaged infrastructure had an adverse effect on loss development in Puerto Rico. More than a month after the event, roughly 80% of customers had still not been reconnected to the power grid. But the necessary infrastructure needs to be relatively intact before repairs can even begin. And the longer it takes to commence repairs, the higher the consequential losses that occur, for example from rainwater entering buildings. Not having an electricity supply impacted the entire economy on the island, which led to massive losses from business interruption insurance.

Even by the end of the year, it had not been possible to finally determine the loss amounts from Maria. The estimate for overall losses is around US$ 68bn, with insured losses of around US$ 30bn. It will only be possible to make more precise loss estimates once we can predict how long reconstruction will take. For the future, the events of this hurricane season, and Hurricane Maria in particular, will provide new evidence of the degree to which post-loss amplification can affect the loss amount.

In contrast to the long-lasting loss adjustment process, Hurricane Maria also showed the role insurance can play in financing emergency and recovery operations. CRIFF SPC, an insurance pool that has been operating for the last ten years with the aim of providing Caribbean and Latin American states with prompt financial assistance after hurricanes and earthquakes, announced just days after the storm hit the island that it would pay US$ 19m to the government of Dominica.

Column

Climate protection or tilting at windmills

Professor Peter Höppe,
Former Head of Munich Re's Geo Risks Research/Corporate Climate Centre

Unlike the windmills in Cervantes' classic Don Quixote, the threat of climate change is a real giant to contend with. But, in spite of the urgency and significance of the topic, progress remains far too slow. The Bonn climate summit in November 2017 – though it was constructive and resolved a number of points of detail – has done little to reverse this trend. Two points are especially worthy of mention, however. For the first time ever, cities and regions from around the world were able to actively participate in the negotiations. Secondly, the summit saw the official launch of the InsuResilience Global Partnership, which sees representatives of G20 and V20 countries, civil society, insurers, scientists and academics working together to help make the most vulnerable people more resilient.

The fact is the global temperature continues to rise. After the previous three record-breaking years, 2017 became the warmest non-El Niño year on record. According to the Intergovernmental Panel on Climate Change (IPCC), the increase in temperature that has principally occurred since the second half of the last century is primarily caused by humans and is influencing natural disasters. Following a number of years with low losses, 2017 brought with it a series of devastating hurricanes that reminded us of the incredible damage that natural catastrophes can cause.

But such individual events cannot be definitively attributed to climate change. The research community expects climate change to result in a greater number of very severe storms, even if the actual number of hurricanes does not increase overall. As it were, 2017 has given us a taste of what could be in store for us in the future.

I do not by any means want to trivialise the progress made at previous climate summits. Indeed, great successes achieved include the 1997 Kyoto Protocol with its Framework Convention on Climate Change; the Copenhagen Accord to limit global warming to two degrees; and the 2010 launch of the Loss and Damage work programme with the Green Climate Fund (GCF) in Cancún, which aims to provide non-industrialised countries with support for climate finance and climate change adaptation. Climate insurance can go a long way to helping developing countries in this regard, and the resolution passed at the G7 summit in Elmau in 2015, namely to initiate a project for the insurance of climate risks, aims at just that. By 2020, an additional 400 million people in developing countries are to be given basic insurance cover against weather extremes. The InsuResilience partnership launched in Bonn is the logical next step.

Politicians are now more aware of the acuteness of the problem than ever before, and commitments to reduce emissions have never been so significant. But almost nothing is being done to prevent further climate change. It is true that CO_2 emissions have stagnated over the past few years. But they should have fallen. And it is likely that they actually increased again in 2017. Meanwhile, we continue to argue over how much industrialised countries should assist developing countries in dealing with the effects of climate change. And whether China should be considered a developing or industrialised country. In fact, ten years ago, China overtook the USA as the biggest emitter of greenhouse gases. Yet it is heartening to see that renewable energies are being rolled out very quickly in China, leading to the reduced use of coal there in recent years.

The top priority for the next few years and decades must be for societies around the world to adapt to the now already inevitable impact of climate change. Science offers increasingly precise information about the areas in which climate change is influencing weather extremes. Munich Re, for instance, supports a research project which uses models to investigate the extent to which specific severe weather events have become more probable since pre-industrial times as a result of climate change. Should this research continue to produce good results, measures to prevent and adapt to the effects of climate change can be tailored further to better protect people and goods.

Munich Re's loss statistics also demonstrate the plausibility of climate change already influencing some types of event in a number of regions. By way of example, losses caused by severe thunderstorms in North America and Europe have increased significantly – even after past loss amounts have been adjusted to today's higher values. Given that meteorologists have also observed changes in such weather patterns, it stands to reason that climate change has played a role in the increased losses. Our data also illustrates that prevention works. Protective measures such as flood control for rivers and more stringent building regulations help to reduce losses.

And significant progress has been achieved thanks to innovations in financial risk prevention, for example by way of new coverage concepts. Thanks to insurance, poor island states in the Caribbean now receive millions in payouts no later than two weeks after a hurricane. This money can be used for emergency relief efforts and to rebuild infrastructure. Similar insurance pools to the Caribbean's CCRIF exist in Africa and the Pacific. Munich Re was already thinking along these lines back in 2005 when it founded the "Munich Climate Insurance Initiative" (MCII) think tank. The MCII has been hugely successful: at the Bonn Climate Change Conference, the UNFCCC presented it with the Momentum for Change Award for its microinsurance pilot project in the Caribbean.

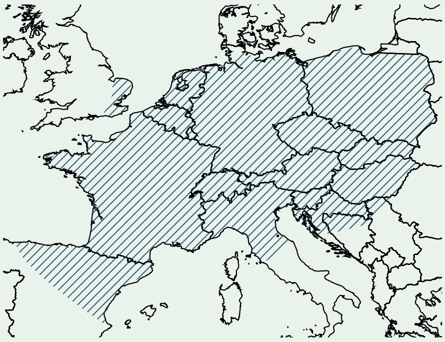
I am optimistic about the future: not about progress in climate protection, as clearly too little is being done, but because I see how people, societies and companies are developing creative solutions to counter the risks of a changing climate. And also because insurers like Munich Re are willing to assume more risk and, in so doing, offer victims of disasters what they need – including financial assistance – to get them back on their feet. Of course, this will not allow us to conquer the scourge of climate change – but it certainly helps us to mitigate its impact.

Spring frost losses and climate change – Not a contradiction in terms

Eberhard Faust and Joachim Herbold

Between 17 April and 10 May 2017, large parts of Europe were hit by a cold snap that brought a series of overnight frosts.

As the budding process was already well advanced due to an exceptionally warm spring, losses reached historic levels – particularly for fruit and wine growers: economic losses are estimated at €3.3bn (US$ 3.6bn), with around €600m (US$ 650m) of this insured.



Spring frost Europe

About
20 countries
affected

Up to **80%**
fruit crop losses

In the second and third ten-day periods of April, and in some cases even over the first ten days of May 2017, western, central, southern and eastern Europe experienced a series of frosty nights, with catastrophic consequences in many places for fruit growing and viticulture. The worst-affected countries were Italy, France, Germany, Poland, Spain and Switzerland. Losses were so high because vegetation was already well advanced following an exceptionally warm spell of weather in March that continued into the early part of April.

For example, the average date of apple flowering in 2017 for Germany as a whole was 20 April, seven days earlier than the average for the period 1992 to 2016. In many parts of Germany, including the Lake Constance fruit-growing region, it even began before 15 April. In the case of cherry trees – whose average flowering date in Germany in 2017 was 6 April – it was as much as twelve days earlier than the long-term average (Fig. 1). The frost had a devastating impact because of the early start of the growing season in many parts of Europe. In the second half of April, it affected the sensitive blossoms, the initial fruiting stages and the first frost-susceptible shoots on vines.

Meteorological conditions

The weather conditions that accounted for the frosty nights are a typical feature of April, and also the reason for the month's proverbial reputation for changeable weather. The corridor of fast-moving upper air flow, also known as the polar front, forms in such a way that the air moves in over central Europe from northwesterly directions near Iceland. This north or northwest pattern frequently occurs if there is high air pressure over the eastern part of the North Atlantic, and lower air pressure over the Baltic and the northwest of Russia. Repeated low pressure areas move along this corridor towards Europe, bringing moist and cold air masses behind their cold fronts from Greenland and Iceland. Occasionally, the high pressure area can extend far over the continent in an easterly direction. The flow then brings dry, cold air to central Europe from high continental latitudes moving in a clockwise direction around the high.

It was precisely this set of weather conditions with its higher probability of overnight frost that dominated from mid-April to the end of the month. There were frosts with temperatures falling below –5°C, in particular from 17 to 24 April, and even into the first ten-day period of May in eastern Europe. The map in Fig. 2 shows the areas that experienced night-time temperatures of –2°C and below in April/May.

High losses in fruit and wine growing

Frost damage to plants comes from intracellular ice formation. The cell walls collapse and the plant mass then dries out. The loss pattern is therefore similar to what is seen after a drought. Agricultural crops are at varying risk from frost in the different phases of growth. They are especially sensitive during flowering and shortly after budding, as was the case with fruit and vines in April 2017 due to the early onset of the growing season. That was why the losses were so exceptionally high in this instance. In Spain, the cold snap also affected cereals, which were already flowering by this date.

Even risk experts were surprised at the geographic extent and scale of the losses (overall losses: €3.3bn, insured losses: approximately €600m). Overall losses were highest in Italy and France, with figures of approximately a billion euros recorded in each country.

Two basic concepts for frost insurance

As frost has always been considered a destructive natural peril for fruit and wine growing and horticulture, preventive measures are widespread. In horticulture, for example, plants are cultivated in greenhouses or under covers, while in fruit growing, frost-protection measures include the use of sprinkler irrigation as well as wind machines or helicopters to mix the air layers. Just how effective these methods prove to be will depend on meteorological conditions, which is precisely why risk transfer is so important in this sector. There are significant differences between one country and the next in terms of insurability and insurance solutions. But essentially there are two basic concepts available for frost insurance:

- indemnity insurance, where hail cover is extended to include frost or other perils
- yield guarantee insurance covering all natural perils

In most countries, the government subsidises insurance premiums, which means that insurance penetration is higher. In Germany, where premiums are not subsidised and frost insurance density is low, individual federal states like Bavaria and Baden-Württemberg have committed to providing aid to farms that have suffered losses – including aid for insurable crops such as wine grapes and strawberries.

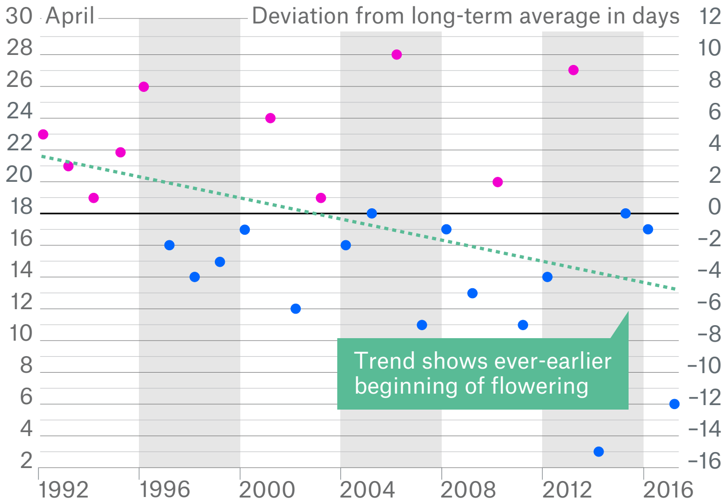
Agricultural losses from the frost events of April/May 2017

	Overall losses	Non-insured losses	Insured losses	Share of insured losses	Most-affected crops
	€m	€m	€m		
Italy	1,040	800	240	23%	Apples, wine grapes, pears, peaches, cherries, plums
France	980	750	230	23%	Wine grapes
Germany	345	330	15	4%	Apples, wine grapes, pears, cherries, plums
Poland	330	328	2	1%	Apples, pears, cherries, plums
Spain	253	181	72	28%	Wine grapes, arable crops, fruit
Switzerland	175	175	–	0%	Wine grapes, fruit
Austria	86	50	36	42%	Apples, wine grapes
Belgium	55	54	1	2%	Apples, pears
Netherlands	26	26	–	0%	Apples
Other affected countries	50	48	2	4%	
Total	3,340	2,742	598	18%	

Source: Munich Re Agro

Fig. 1: Beginning of sweet cherry flowering

Averaged over Germany, 1992–2017

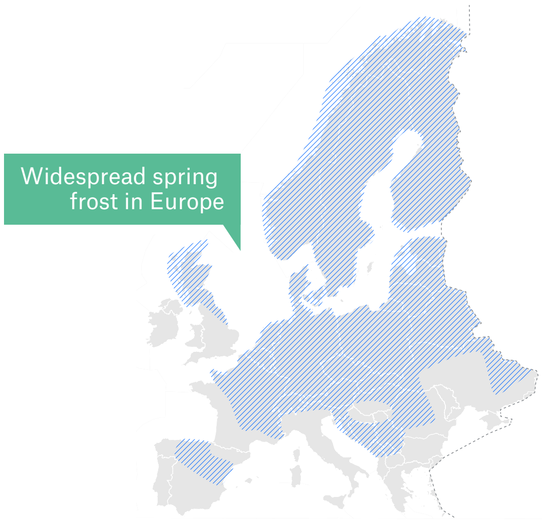


Source: Munich Re, German Meteorological Service, Phenological Statistics, 2017

Fig. 2: Late frost following a warm spring

Large areas of Europe affected

Areas with overnight lows under –2°C,
11 April–10 May 2017



Source: Munich Re, based on JRC MARS Explorer of the European Commission

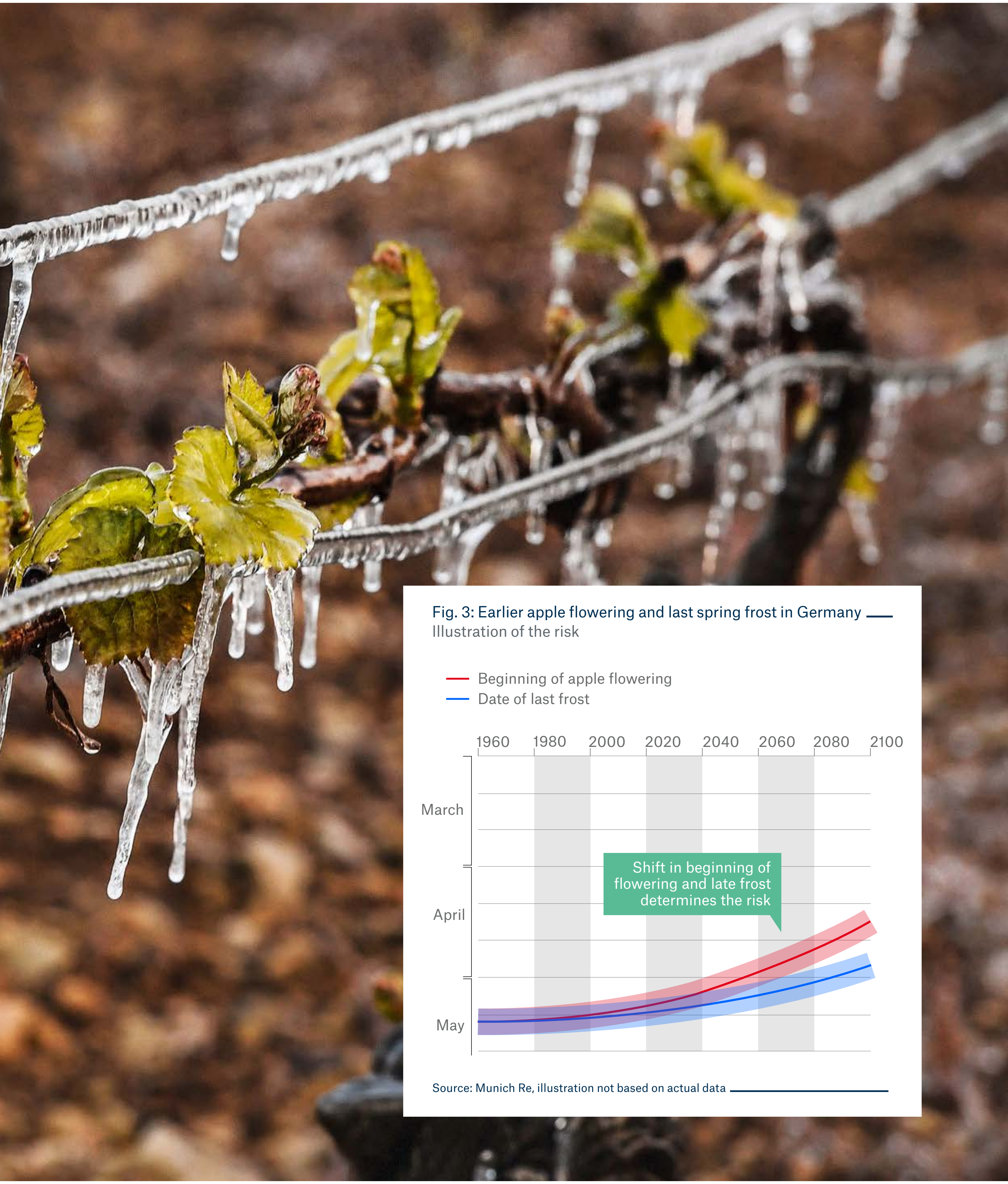


Fig. 3: Earlier apple flowering and last spring frost in Germany
Illustration of the risk

Source: Munich Re, illustration not based on actual data

Late frosts and climate change

There are very clear indications that climate change is bringing forward both the start of the vegetation period and the date of the last spring frost. Whether the spring frost hazard increases or decreases with climate change depends on which of the two occurs earlier. There is thus a race between these two processes: if the vegetation period in any given region begins increasingly earlier compared with the date of the last spring frost, the hazard will increase over the long term. If the opposite is the case, the hazard diminishes.

Because of the different climate zones in Europe, the race between these processes is likely to vary considerably. Whereas the east is more heavily influenced by the continental climate, regions close to the Atlantic coastline in the west enjoy a much milder spring. A study has shown that climate change is likely to significantly reduce the spring frost risk in viticulture in Luxembourg along the River Moselle[1], where the number of years with spring frost between 2021 and 2050 is expected to be 40% lower than in the period 1961 to 1990.

By contrast, a study on fruit-growing regions in Germany[2] concluded that all areas will see an increase in the number of days with spring frost, especially the Lake Constance region, where reduced yields are projected until the end of this century. At the same time, however, only a few preliminary studies have been carried out on this subject, so uncertainty prevails.

1 Molitor et al. (2014): Late frost damage risk for viticulture under future climate conditions: a case study for the Luxembourgish winegrowing region. Journal of Grape and Wine Research, 20, 160–168

2 Chmielewski et al. (2010): Climate change and possible late frost damages to apple trees in Germany. In Matzarakis et al.: Proceedings of the 7th Conference on Biometeorology, 50–56

Outlook

The spring frost in 2017 illustrated the scale that such an event can assume, and just how high losses in fruit growing and viticulture can be. Because the period of vegetation is starting earlier and earlier in the year as a result of climate change, spring frost losses could increase in the future, assuming the last spring frost is not similarly early. It is reasonable to assume that these developments will be highly localised, depending on whether the climate is continental or maritime, and whether a location is at altitude or in a valley.

Regional studies with projections based on climate models are still in short supply and at an early stage of research. However, one first important finding is that the projected decrease in days with spring frost does not in any way imply a reduction in the agricultural spring frost risk for a region. So spring frosts could well result in greater fluctuations in agricultural yields. In addition to preventive measures, such as the use of fleece covers at night, sprinkler irrigation and the deployment of wind machines, it will therefore be essential to supplement risk management in fruit growing and viticulture with crop insurance that covers all natural perils.

Asian floods overshadowed by Houston deluge

Wolfgang Kron

In late August 2017, while the global media's attention was focused on the floods in Houston, people on the other side of the world were experiencing even worse misery from torrential rainfall. An exceptionally powerful monsoon in South Asia claimed the lives of almost 2,700 people and caused severe damage to the region's agriculture.

Each year in late May, the summer monsoon starts at the southern tip of India and spreads northwards. Over the course of the following four months, enormous quantities of rain – roughly three quarters of the annual precipitation – fall on the subcontinent. This rain brings flooding and destruction – and not just in areas that experience extreme rainfall. Normal life also grinds to a halt along the Ganges, Brahmaputra and other rivers, along which huge masses of water roll for hundreds of kilometres down towards the Indian Ocean.

Flood South Asia 2017

2m houses damaged/destroyed
40m people affected

Worst floods for 15 years

The 2017 monsoon was exceptional, both in terms of its duration and impact. In Nepal, the rainy season lasted from 12 June to 16 October, instead of until around 23 September as it normally does. The 127 days made it 20% longer than normal and almost as long as in the record year of 2008 (130 days). On the other hand, the total amount of rain was not exceptional: an average of 1,330 mm of rain fell across all of Nepal, equivalent to 92% of the usual amount.

However, a local and time-resolved analysis presents a different picture. Due to orographic lift, the largest amount of rain falls in regions close to the Himalayas – with extreme temporal variations in intensity. The areas worst affected in 2017 included the Indian provinces of Assam, Uttar Pradesh – India's most densely populated province and home to 220 million people – and Bihar, as well as the Terai plains in Nepal.

Terai is a lowland region between 25 and 100 kilometres wide running for some 800 kilometres along the border with India. It makes up 17% of the area of Nepal, is home to half of the country's population, and includes 53% of the arable land area. In the twelve districts affected, three quarters of the land was under water. According to the United Nations, these were the worst floods for 15 years.

There was also flooding in other regions triggered by torrential rain. Twelve years after the 2005 disaster, the west coast megacity of Mumbai was again hit by floods, with 315 mm of rain falling in the space of twelve hours on 29 August. Even though this was only one third of the 24-hour rainfall experienced on 26 July 2005, the city once again found itself submerged in the floodwaters, which this time extended over a much larger area. Mumbai may now be better equipped to deal with flooding than it was in 2005, but flood alerts are still being issued too late. There are no emergency plans in place and, most importantly, unrestricted and uncontrolled development is taking place on natural drainage paths.

In West Bengal and Bangladesh, the extensive flooding resulted less from local rainfall than from the waters carried down by rivers flowing from the north.

Almost no damage insured

More than 40 million people were affected by the floods in India, Nepal and Bangladesh between the start of June and mid-October. At least 2,670 people died (2,170 in India, 160 in Nepal, 340 in Bangladesh), with dozens of lives being claimed by landslides in the mountains of Nepal.

The bulk of the losses were incurred in the northeastern part of South Asia. Of the overall losses of around US$ 3.5bn, some 2.5bn occurred in India, 600m in Nepal and 350m in Bangladesh. The percentage of insured losses was negligible in all three countries. While these may be small amounts in comparison with the hurricane losses in North America, they affect countries where people's livelihoods are already extremely vulnerable and unstable.

In Nepal, agriculture and livestock farming was badly hit: 40 million hectares of land was flooded and 70,000 domestic and farm animals perished. Virtually nothing was insured. Farmers are generally reluctant to take out insurance, and are also unwilling or unable to make other provisions. A survey carried out by the United Nations in Terai in October 2017 found that only one third of respondents

had made any provision against flood losses, even though 56% had suffered losses in previous years.

In addition, electricity generation from hydropower was severely restricted. Enormous quantities of sediment in the rivers blocked hydro-power intake structures, posing a risk of damage to the turbines. There were also countless bridges damaged and culverts blocked by debris. In the Sauraha Safari Park in the south-west of Nepal, 110 hotels were forced to close. The majority of the small amount of insured losses were at industrial facilities (warehouses), in the construction and engineering sectors, or affected motor vehicles.

In Bangladesh, numerous rivers burst their banks and vast areas of this extremely flat country were inundated. Roads, bridges, railway lines and over 750,000 houses were damaged, with over 100,000 destroyed.

Governments struggle to cope with disaster management

India, Nepal and Bangladesh are among the countries with the highest flood risk. Some 12% of the territory of India (400,000 km^2) is made up of potential flood zones along the banks of rivers, while in Bangladesh three quarters of the country is affected. More than half the population of Nepal lives in the flood zones that make up 20% of the country's total area.

In addition to the direct risk of drowning, there are frequent fatalities from electric shocks, particularly in cities. Wading through heavily polluted water can result in bacterial infections (especially leptospirosis) that are often fatal. House foundations are undermined or weakened to the point where they collapse.

A lack of available options is often the reason that few preventive measures are taken. People do not have enough financial resources, and there is insufficient help from government agencies to identify and implement appropriate solutions. What is more, direct initiatives on the part of the state are rare. Yet it is an undisputed fact that prevention saves money and alleviates suffering and distress. Governments are under an obligation to create at least rudimentary structures (and thereby assume a role model function), on which the population can then build. Institutions like the All India Disaster Mitigation Institute (AIDMI) have long recognised that insurance against flood risks – whether in its traditional form or as microinsurance – makes an invaluable contribution to disaster management. Even if cultural obstacles still exist, there is enormous potential for change. India, for example, has achieved substantial improvements through the introduction of crop insurance.

Increasing resilience

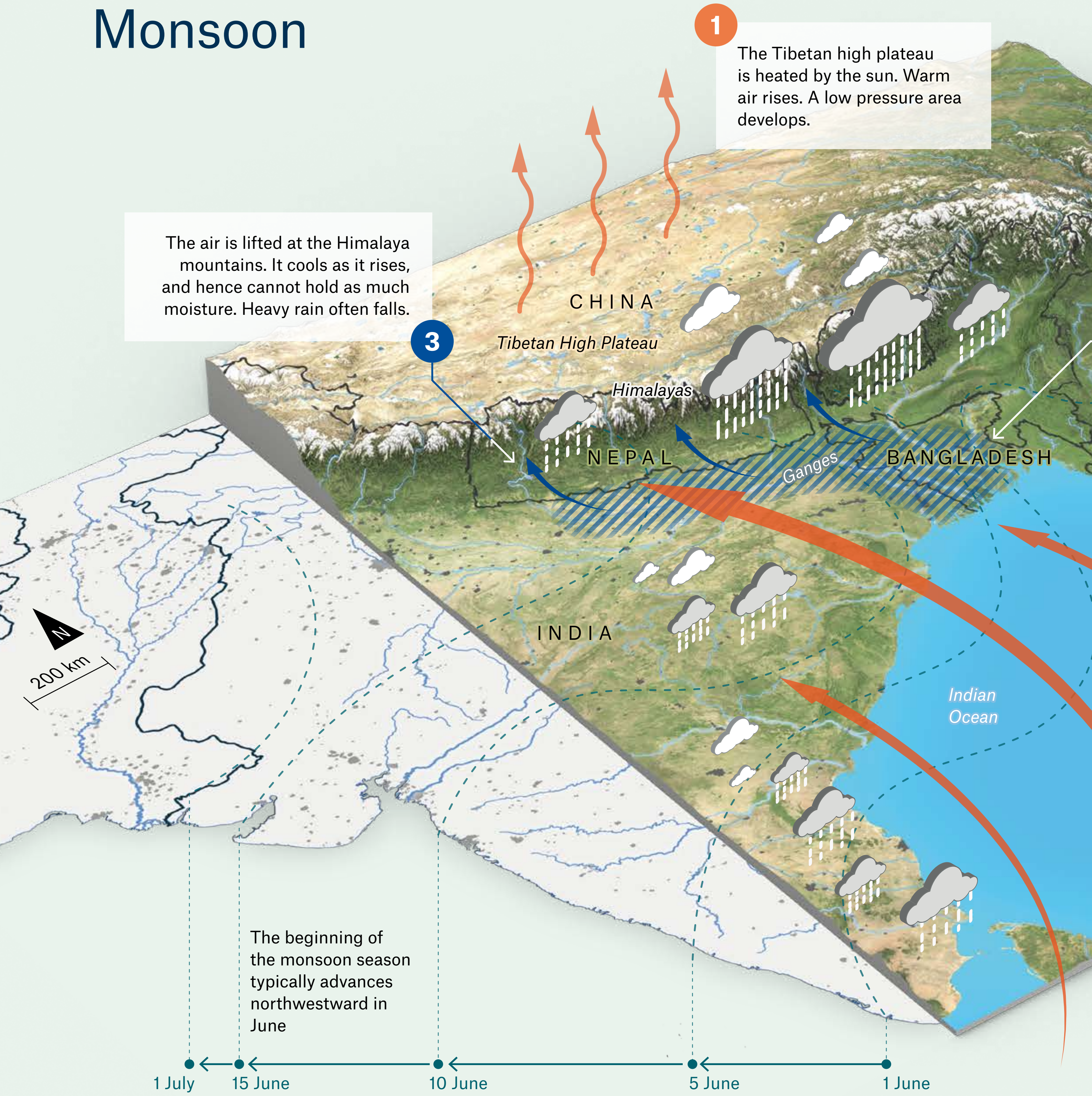
South Asia is representative for the many poorer regions of the world that were hit by flood disasters over the last year. Southern Thailand, Peru, Colombia, Sierra Leone and the Congo were also affected. In absolute terms, losses are often one or two orders of magnitude smaller than in Europe or North America. Yet the impact on people's lives and livelihoods in these poorer countries is generally much more dramatic, given the frequent lack of insurance cover that could otherwise cushion the negative consequences. It has been shown time and again that countries with an effective insurance system against natural hazards are able to return to normal conditions after a disaster much faster than countries without any such protection in place.

Whereas the trail of devastation in the flood regions of Asia and Africa could still be seen weeks and even months after the event, life in Houston had almost returned to normal just a few days after the flooding. Apart from one or two tell-tale signs, it was difficult to find any evidence that large parts of the city had been a metre deep in water a short time before. So the primary goal of the countries affected must be to reduce the vulnerability of their citizens and to make existing systems more robust and resilient.

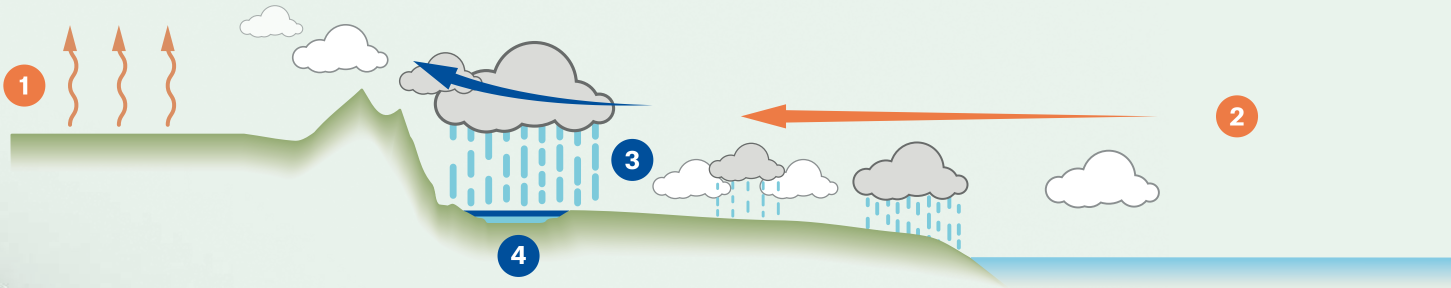
2017 Monsoon South Asia
Flood-affected areas

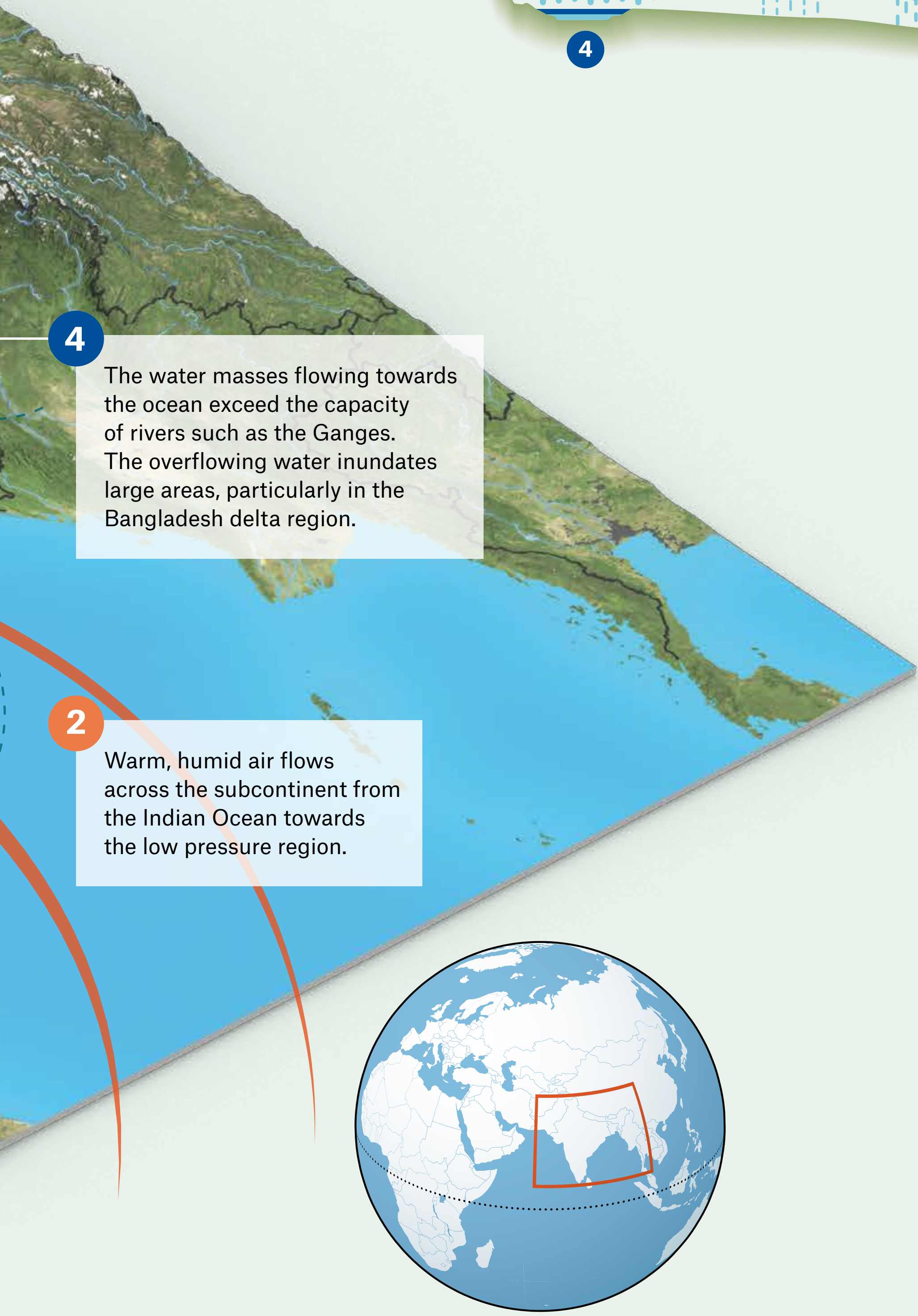
Source: Munich Re based on ReliefWeb

South Asian Monsoon



26.5 metres in one year! Cherrapunji in the northeastern Indian state of Meghalaya holds the world annual precipitation record at 26,461 mm.





The Indian subcontinent is heavily influenced by its monsoon climate. It determines whether entire regions are flooded, yield rich harvests or suffer drought. Hardly anywhere else on earth are boon and bane so close.

During the summer, the land mass warms up more strongly than the ocean, and air circulation commences. The rain front heralding the monsoon season advances northwest during the month of June from the southern tip of India, and retreats again from about the beginning of September. In this period, clouds burst in heavy short precipitation events – sometimes dropping more than 1,000 mm (litres per square metre) in a single day – or pour down continuous rain for days on end. Precipitation is particularly intense on the southern slopes of the Himalayas, where rainfall depths of more than ten metres per year are often measured. Widespread flooding is common, both in the areas where the rain falls and along the large rivers that drain the region.

During the winter monsoon (December to May), cold, dry air from Siberia flows southwards. Practically no rain falls. People in this predominantly agricultural region fear a long rainy season with severe flooding less than a short one which may cause catastrophic drought and famine.

Historically, the Indian monsoon is a climate phenomenon which exhibits little variation in annual precipitation. Over the past 70 years, however, daily extremes of precipitation have shown a significant increase in parts of central India. There is much to indicate that this is a consequence of global warming.

Water and disasters

Questions to Dr. Han Seung-soo

Special Envoy of the Secretary-General of the United Nations for Disaster Risk Reduction and Water, Chair of the UN High-Level Experts and Leaders Panel on Water and Disasters (HELP), Special Adviser of the UN High-Level Panel on Water (HLPW)

Dr. Han, how do you personally rate the importance of water-related risks in today's world?

During the past decade, water-related disasters have not only struck more frequently but have also been more severe, hampering sustainable development by causing political, social, and economic upheaval in many countries. Altogether, water-related disasters, such as floods, droughts, storm surges, cyclones, convective storms and tsunamis, account for 90% of all disasters in terms of the number of people affected. In the year 2017 alone, devastating water-related disasters occurred on nearly every continent. At the same time, drought conditions persist in many parts of the world, including the Horn of Africa. These disasters cause tragic loss of lives and livelihoods, great damage to livestock, and destruction of properties and critical infrastructure.

Damage attributed to a single disaster can sometimes mount up to 15–20% of annual GDP for certain countries. These figures could be even higher if we account for indirect impacts. Moreover, climate change is exacerbating the extremes in hydro-meteorological events. Together with other global drivers under change – population growth, rapid urbanisation, increased asset values – this may result in increased frequencies and even greater impacts of water-related disasters.

The issue of water-related disasters is one of the most important that the international society must address urgently. I would like to stress that these disasters are an underlying issue for most of the Sustainable Development Goals, the SDGs. We need to focus on water-related disaster risk reduction and implement the ambitious goals and targets as agreed in the Sendai Framework, the Paris Agreement and the SDGs to prevent recurrence of tragedies and ensure progress towards the achievement of sustainable development for all.

What was the UN Secretary-General's intention in establishing HELP and HLPW?

HELP was established to assist the international community, governments and stakeholders in mobilising political will and resources, ensuring coordination and collaboration, and implementing effective measures needed to tackle the issues of water and disasters. Since its formation in 2007, the panel has developed an action strategy and is working to contribute towards the achievement of the SDGs, mainly through tackling the issues of water and disasters. Munich Re has been involved in the activities of HELP since its establishment, and I appreciate Munich Re's input and contributions.

The HLPW was co-convened by UN Secretary-General Ban Ki-moon and the President of the World Bank in 2016 with the goal to provide the leadership required to achieve inclusive and collaborative ways of developing and managing water resources and improving water and sanitation-related services. The panel consists of 11 sitting heads of state and government, and one special adviser. The outcome of HLPW's two-year work is a set of documents which includes recommendations to the international community on how to proceed in dealing with pressing water-related issues during the upcoming UN Decade of Action "Water for Sustainable Development".

Thanks to their financial means, highly developed countries can afford to protect themselves. What should poor countries do?

While water-related disasters affect all nations regardless of their development stage, it is the poorest nations and communities that bear the greatest burden. On average, three times as many people die in disasters in low-income countries compared with high-income nations. A vulnerable community hit by a water-related disaster can lose years of development gains in an instant, and require decades to rebuild.

I would like to stress that prevention and resilience efforts pay off, even in developing countries. Investment in water-related disaster risk reduction with a focus on prevention and preparedness, while also ensuring effective emergency response and reconstruction and rehabilitation, is crucial for achieving sustainable development. The countries most affected by disasters are usually the ones least capable of dealing with them. However, the overall benefits of investing in preventive measures will heavily outweigh the initial investment. Early investment in risk reduction will be essential. Investing in prevention needs to be a part of a long-term strategy with continued political support in order to be effective. Furthermore, by providing the legal and administrative systems necessary for effective risk reduction, as well as incorporating disaster resilience into various infrastructure projects, the developing countries can greatly reduce their losses while keeping the costs relatively low.

When devising policies or investing in disaster-risk-reduction projects, the developing countries now have a vast database of knowledge available to them gained from the decades of experience in other parts of the world. Through international cooperation and exchange of knowledge, each country can choose to implement measures proven to be the most effective, and the ones most suitable to the country's specific needs.

Additionally, I believe that when providing aid, the developed countries need to focus more on disaster prevention and preparedness, as most of the official development assistance related to disasters is currently aimed at emergency response and rehabilitation.

In relation to the above, HELP is currently promoting the development of "Principles on Financing and Investment for Water-Related Disaster Risk Reduction", with the aim of providing guidelines for effective investment in DRR to both developing and developed countries. I believe it will prove to be beneficial.

How important is insurance in this context?

Although investing in water-related disaster risk reduction is critical, unexpected disasters could occur at any place or any time. Such disasters could cause tremendous impacts on people's lives and livelihoods. Flood insurance is effective and plays an important role in the speedy rebuilding of daily lives after a disaster.

However, we should note that insurance does not physically reduce the risk of disaster or reduce losses and damage. It is important to utilise insurance in combination with the disaster-risk-reduction measures.

What can be done to increase insurance take-up in less developed regions?

In low-income countries, the percentage of insured losses from natural disasters is almost negligible, whereas that of high-income countries is about 25%. I think increasing insurance take-up in less developed regions is an important challenge.

One of the solutions is introducing weather-related microinsurance. Microinsurance provides low-income households, farmers and businesses with access to post-disaster liquidity, thus securing their livelihoods and providing funds for reconstruction. Since insured households and farms are more creditworthy, microinsurance can also promote investments in productive assets and higher-risk and/or higher-yield crops and can encourage investments in disaster prevention if effectively designed.

It is also important to remove some difficulties which prevent developing countries from adopting natural-disaster insurance. One issue is the technical difficulties of calculating the probabilities of disaster occurrence in countries, which is necessary for reflecting risks in the premiums. Governments in developing countries are rarely equipped with such information. To help governments in these countries acquire insurance systems that assist their disaster-affected people in rebuilding their lives quickly, international communities can offer the technical expertise necessary to define and negotiate the parameters that underpin insurance policies.

You mentioned that the UN Decade of Water for Sustainable Development begins in March 2018. What do you expect to achieve by 2028?

The new Decade will address water-related issues ranging from water supply and sanitation to water-resources management and water-related disaster risk reduction. With more global interest in risk reduction, HELP welcomes the Decade and wishes to contribute to effective utilisation of the Decade to assist in achieving the targets set in the SDGs, the Paris Agreement and the Sendai Framework.

HELP aims to promote and achieve the following with respect to water-related risk reduction:

- Raise awareness of the issue of "water and disasters" at the highest levels by biennially organising the UN Special Thematic Session on Water and Disasters.
- Compile good practices, policies and lessons learned, and publish them as flagship documents on a regular basis.
- Develop, launch and promote the already mentioned "Principles on Financing and Investment" and promote their incorporation in national policies and practices.
- Increase financing and investment, including the use of international funds aimed at climate change mitigation and adaptation, and facilitate the improvement of budget implementation.
- Establish a water-related disaster loss database and set up a quick reporting system on preliminary loss data, including direct and indirect losses, for megadisasters.
- Promote research and development focused on disaster risk reduction, and encourage application of innovative technologies in the field. Facilitate collaboration among research institutions and form alliances.
- Encourage the international community to collect consistent and continuous data on water-related disasters that will assist the development of indicators, and enable governments to set priorities, engage citizens in an inclusive way, and measure progress.

Questions by Wolfgang Kron, Head of Research: Hydrological Hazards, Munich Re, and Adviser to HELP

Mexico City's tragic anniversary

Wilhelm Morales Avilés

On 19 September 2017, a powerful earthquake rocked Mexico exactly 32 years to the day that a similar quake struck the country. Building codes introduced following the 1985 quake proved invaluable, as 95% of the buildings that collapsed or were damaged in 2017 were built before 1985.

As a result of the lessons learned following the 1985 earthquake, a major drill is carried out in Mexico City every year on 19 September. During the drill, the sirens of the seismic alert system sound, and people evacuate buildings in an orderly fashion and proceed to places designated as free or safe zones. This year, the drill started at 11 a.m. Two hours later, the seismic alarms sounded again. But this time it was for real – a 7.1 magnitude earthquake with its epicentre close to Axochiapan on the border between the states of Puebla and Morelos.

Earthquake Mexico

Fatalities in Mexico City
1985: 12,843
2017: 228

Just a few seconds' advance warning

In the country's capital, the alarms went off only 15 seconds before the ground started to shake. The Mexican early warning system is able to give longer warnings of subduction earthquakes originating on the Pacific coast, but not of intraplate earthquakes like the one that occurred that afternoon. Nevertheless, this short notice was sufficient for many people to get outside or to take suitable protection measures inside buildings.

The earthquake caused damage in Mexico City, as well as in other Mexican states. 369 people died. Overall losses amounted to US$ 6bn, of which US$ 2bn were insured. Various sectors incurred significant damage, such as commerce, industry, schools, roads, and water utilities. In terms of economic losses, the worst-affected sector was housing. In the states of Morelos and Puebla, dwellings with vulnerable structures such as unreinforced masonry, buildings made of adobe and many old cultural buildings like churches or convents suffered severe structural damage.

Not since 1985 had Mexico City seen a similar total collapse of buildings and so many people trapped and killed. A large number of fatalities (two thirds of the total) occurred in the city. Most of the severe damage was concentrated in the so-called Transition and Lake zones, as defined in the seismic microzonation of the city (see map on page 41). In similar earthquakes that have hit Mexico City in the last century – i.e. 1957, 1979 and 1985 with magnitudes of 7.6, 7.6 and 8.0 respectively – these areas also suffered the worst damage. How the ground responded to the earthquake obviously played an important part in the damage to buildings.

Almost 95% of the buildings that collapsed or were severely damaged were constructed prior to 1985, which means that they had previously withstood the ground motion caused by the 1985 earthquake. We do not know for sure whether those structures were reinforced after the 1985 quake. Based on the number of collapsed or partially collapsed buildings, it can be said that new buildings (later than 1987) withstood the earthquake well.

The problem of soft storeys

About half of the totally or partially collapsed buildings displayed one of the following features: (1) they had a soft storey, e.g. ground floor columns with little deformation capacity; (2) they were located on corners and thus fundamentally affected by torsion, a rotational movement of the building which the structure has little capacity to withstand; (3) their structural system was based on reinforced concrete columns with flat slabs, without any beams between the columns.

The use of a flat-slab system is limited in earthquake zones in the building codes of some countries, for example in New Zealand. The American Concrete Institute code (ACI 318) places restrictions on the use of flat slabs in areas considered to be highly seismic, such as California. The Mexican code restricts the use of flat slabs through the limitation of the relative horizontal displacement between adjacent storeys. The tolerable displacement is dependent on the storey height. In the 1985 earthquake, many flat-slab buildings had collapsed.

Reduced earthquake risk

This earthquake has shown once again that the existence of an adequate building code and its rigorous enforcement is a key factor in reducing the number of buildings that suffer severe damage or collapse. It should be noted that, compared with 1985, Mexico City and its population showed improved resilience to natural disasters. Features that have influenced this are the existence of seismic alarms, the holding of drills on a regular basis, a public information programme on various aspects of earthquakes, and improved coordination between the different agencies dealing with the risks from natural hazards.

Seismic reinforcement possible but difficult

The practice of using soft storeys in earthquake zones as a construction option to accommodate parking spaces or commercial stores has usually proved highly problematic. Furthermore, the lack of column ductility, i.e. insufficient ability to bend without breaking, has caused dramatic building collapses. Trying to resolve this problem through structural measures is not easy. Strengthening the storey with additional walls of reinforced concrete or with additional steel frames in order to increase rigidity, or through the steel-plate jacketing of columns in order to increase their ductility, are among the structural options used.

The corner buildings that totally collapsed evidently lacked good torsional design. As was also observed in 1985, ignoring the necessary torsional and shear strength of column or wall elements is a serious error. However, collapses are not always due to insufficient structural design. In other cases of severe damage, the absence of supervision during construction, poor quality of materials, a change in the original use of the building, or alteration of the original structure (e.g. removing interior walls) without the additional requisite structural reinforcements could have had an influence. The municipal government of Mexico City was quick to react, launching an initiative in November 2017 to include seismic retrofitting in the building code.

The current Mexico City building code divides the city into three main zones: Hill (I), Transition (II) and Lake (III). Based on the geotechnical characteristics of the different types of soil, Lake is subdivided into four more zones (a, b, c and d). Each zone has a different seismic design spectrum. This spectrum is a graph containing the maximum accelerations for a wide range of building types, which is used to determine the seismic forces that will act on the structure and thus define the seismic design demands. Complementary technical norms for earthquake-resistant design also include maps of fundamental periods (of vibration) of the soil for each zone. In this way, the structural design takes account of seismic microzonation and its effects.

Distribution of severe damage and collapses in Mexico City
during the 1957, 1979, 1985 and 2017 earthquakes

- Severe structural damage from the earthquake on 19.9.2017
- Most-affected area 1985
- Most-affected area 1957
- Most-affected area 1979
- Hill zone
- Transition zone
- Lake zone

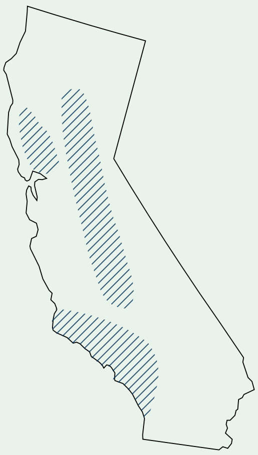
Source: Munich Re, based on Instituto de Ingeniería, UNAM

Rain fuels wildfire risk

Mark Bove

First the north burned, then the south: Two series of devastating wildfires in October and December left behind a trail of destruction in California and losses totalling around 17 billion dollars. Wildfires in California are likely to become more frequent in the future.

The October wildfires broke out in the wine country around Sonoma and the Napa Valley north of San Francisco, leaving unprecedented levels of damage in their wake and surpassing the 1991 Oakland Hills Fire as the worst conflagration in the state's history. In all, over 8,900 structures were destroyed by the fires, over 5,500 of which were from one fire alone – the Tubbs Fire – that obliterated complete neighbourhoods in the city of Santa Rosa. Two months later, Santa Ana winds fuelled a devastating complex of fires around the Los Angeles metropolitan region. Insured losses from the Northern California fires alone are estimated at about US$ 8bn, becoming the largest insured wildfire loss in US history (by far) and a worrisome harbinger of the future of wildfire risk.



Wildfire
California 2017

Overall losses:
US$ 17bn

Insured losses:
US$ 13bn

Background to the fires

After six years of extreme drought in California, the state's warmest and driest period in its recorded history, the winter of 2016–2017 ended the streak of dry weather in dramatic fashion. Northern California saw its wettest winter on record, and flooding forced thousands of people out of their homes. The three-month winter deluge effectively ended the drought in Northern California. Of course, vegetation immediately responded to the much-needed rains, and new grass, chaparral, and other types of vegetation turned the Golden State green for the first time in years. When the deluge finally ended in April, for the next five months the West Coast barely received any additional rainfall. This led all the new vegetative growth to dry out, becoming a massive source of fuel for potential wildfires. Not surprisingly, the return of dry conditions and new fuels helped cause an early start to California's fire season. By the time the peak wildfire season in late September arrived, a near-perfect combination of heat, low humidity and fuels made the state a tinder box. In early October, the National Weather Service put out a "Red Flag Warning" for extreme fire risk in Northern California; in December, similar warnings were given for the Los Angeles region.

Wet-dry cycle increases the wildfire hazard

Large wildfires typically require two meteorological ingredients: dry conditions and high winds. However, as the events of 2017 show us, it does not take years of extreme drought conditions in California to create optimal conditions for wildfires, just a couple of months of dry conditions are sufficient. Furthermore, our changing climate is also making California hotter, which means that the rate of evapotranspiration has increased. In short, dangerous fire conditions return to California faster today than they did in the past.

The second ingredient, high winds, can arise from several different meteorological sources. Most large historical wildfires in California have been associated with so-called Santa Ana or Diablo wind events. These occur when high pressure over the western United States causes dry, easterly winds from inland to be funnelled through mountain passes, causing an increase in velocity.

Wildfires can also take advantage of local terrain and fuel to help create their own winds. As wildfires heat the air around them, the air expands and begins to rise, creating a localised area of low pressure. The low pressure forces air to be sucked in, providing more oxygen for the fire to grow. This, combined with very low humidity and ample fuel, causes fires to grow quickly, lowering the pressure further and ultimately generating winds that exceed gale force. Terrain can help exacerbate this phenomenon as well, as fires tend to race quickly uphill, and hills can funnel winds into a narrow area, increasing velocities and fire spread.

Two major fire outbreaks

The costliest wildfire from the Northern California event, the Tubbs Fire, was ignited around 10 p.m. local time on 8 October near the town of Calistoga. Gusty northeasterly winds of 50–70 km/h caused the fire to spread rapidly, and within hours the fire had reached the northern suburbs of Santa Rosa. The intensity of the Diablo winds continued to increase as the night went on, ultimately reaching speeds of 100 km/h. Evacuations for Santa Rosa and Sonoma County were ordered by local emergency management as the

flames advanced into residential neighbourhoods. Lofted firebrands and embers from the fire crossed over US Highway 101, setting ablaze the Coffey Park neighbourhood, where over 1,300 single-family dwellings were destroyed, as well as several commercial structures. In all, over 5,500 structures were destroyed by the Tubbs Fire, most of them within 24 hours of its ignition, causing – together with some other nearby fires – an estimated insured loss of US$ 7.3bn.

Around the same time on 8 October, the Atlas Fire broke out to the east of Napa. Similar to the Tubbs Fire, the conflagration grew rapidly, ultimately burning an area of 210 km^2. The local terrain and very dry conditions hampered firefighting efforts against the blaze. Although the grape harvest had already been completed for the year, several vineyards in the famous winemaking region suffered heavy destruction to their vines and structures. Although the towns of Napa, Yountville and other farming communities escaped relatively unscathed, the Atlas Fire destroyed 487 buildings and damaged 90 others, in all causing insured losses exceeding US$ 2.4bn.

The Southern California wildfire event started two months later on 4 December, when the Thomas Fire began in a canyon in Ventura County, about 100 km from downtown Los Angeles. The fire grew explosively due to gale-force Santa Ana winds and over the course of the next two

weeks scorched over 1,140 km², becoming the largest wildfire in the state's history and destroying at least 800 buildings. An additional 15,000 structures were at risk from this fire. Other notable fires in this outbreak include the Lilac Fire in San Diego County that destroyed about 200 structures, and the Skirball Fire, which burned six mansions in the enclave of Bel Air. Sadly, the California fires of 2017 claimed a total of 46 lives.

Insurance impacts and underwriting lessons

It is estimated that the Northern California fires of 2017 caused in excess of US$ 10bn in overall economic losses, of which about US$ 8bn was insured, with the Tubbs Fire being the costliest. These fires are the most damaging in the state's history, surpassing the losses caused by the infamous 1991 Oakland Hills Firestorm (US$ 3bn insured loss, US$ 4.5bn overall loss, 2017 values).

Three key factors helped contribute to the loss severity of these events. The first is that the fires impacted several affluent communities with extremely high property values; every structure lost to the fires was essentially a million-dollar claim. Second, the large population and exposure base in the region allowed for extensive smoke damage claims. And third, commercial buildings accounted for almost 20% of the loss from the fires, about double that of past wildfire events. This is due to the impact on businesses in urban Santa Rosa, damage to wineries in Napa County, and the destruction of a hospital complex in Ventura.

The time of day and speed at which many of the fires of 2017 developed illustrates the potential difficulty in protecting homes in fire country. Some residents of Santa Rosa were probably asleep at the time the Tubbs Fire broke out, and did not become aware of the fires until they were on their doorstep. Although private fire services are useful in saving a home, the best preventative measures against wildfires continue to be (1) using flame-retardant construction materials in your home, (2) using native plants in landscaping and planting them a distance from your home, (3) removing vegetative debris from your yard, roof and gutters, and (4) maintaining a defensible perimeter of at least 25–30 metres around your home. However, only if an entire community participates in making their town wildfire-resistant can these measures be truly effective.

The future of the California wildfire risk

In the years following a wildfire, the charred ground is highly prone to erosion. Even moderate rainfall can carry away large masses of topsoil from inclines, initiating mudflows and debris flows. Intense rainfall may destabilise whole hillsides and cause landslides. Tragically, this is exactly what happened just one month after the Thomas Fire on 8 January 2018 in Montecito, where 23 people were killed in a mudslide, and almost 500 homes were damaged, many of them seriously. The increased debris-flow hazard can last up to five years, until vegetation has recovered to its original state.

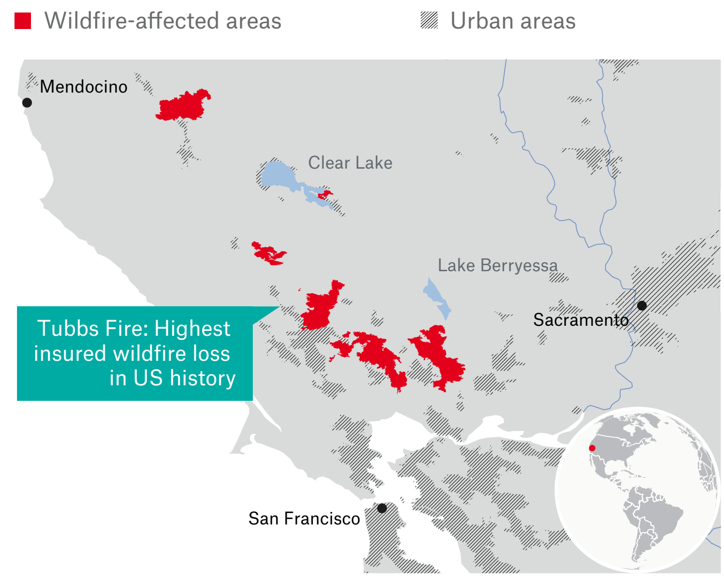
Looking further into the future, insured losses from large wildfires in the American West are expected to continue to increase in frequency and severity. This increase is primarily being driven by continued construction of new homes and businesses within the wildland-urban interface and the rising values of both real and personal property. However, the influence of climate factors on this peril is becoming harder to ignore. Warming temperatures, in part due to anthropogenic influences, are extending the wildfire season, and the prolonged, recent bouts of heat and drought have stressed trees, making them more vulnerable to disease, insects and fires. With neither of these trends likely to change in the coming years, the emphasis must be on improving buildings' resistance to wildfires, and making sure that entire communities take steps to mitigate their collective risk.

Several other countries also ablaze

California was not the only area which incurred colossal insured losses through wildfires in 2017. Globally, 222 people lost their lives in wildfires, 112 in Portugal alone. In Chile, large areas of timber plantations burned down, and fires caused severe property damage in Portugal and South Africa. While the absolute loss figures – Chile US$ 165m, Portugal US$ 270m, South Africa US$ 200m – did not match the billion-dollar losses in California, the affected insurance markets were still seriously hit. These loss events – as well as the unexpected high losses in Fort McMurray, Canada in 2016 (see Topics Geo 2016) – illustrate that wildfire is a peril which must be considered in insurers' pricing and risk management for potentially affected regions.

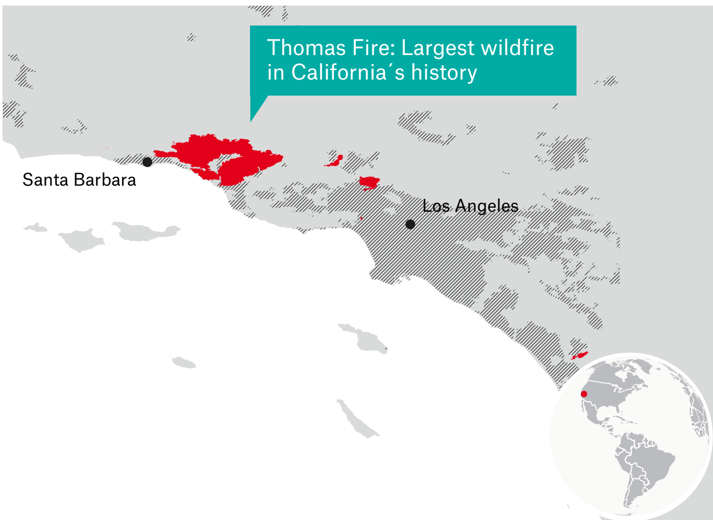
Wildfires in Northern California in October 2017

Wet winter acted as a fire accelerant



Wildfires in Southern California in December 2017

The threat to the wildland-urban interface



Source: Munich Re based on CAL FIRE

Column

Natural disasters and losses: It is the victims who pay the most

Ernst Rauch,
Head of Climate & Public Sector
Business Development

The statistics paint a sad picture of widespread suffering and financial losses that threaten people's very survival. Taken globally, more than half of all losses caused by windstorm, flood and earthquake are paid for by the victims themselves. Two aspects of this situation are particularly alarming: since 1980, it is only rich countries that have seen a tangible narrowing of the insurance gap, not emerging and developing countries. Consequently, it is only rich, industrialised countries where insurers pay a significant proportion of such losses – in 2017 this figure was approximately 46%. The insured share is usually higher when windstorms are involved. In middle- and low-income countries the figure is closer to zero.

Natural disasters affect individuals, businesses and even entire countries. In the vast majority of cases, the injured parties must use their own funds to weather such economic shocks, something that is only possible where there is an adequate level of prosperity. If not, they have to rely on external financing, such as donations from aid campaigns following a major disaster. Studies show that contractually guaranteed insurance benefits can help people get back on their feet faster and more effectively than protracted aid programmes that often take several months to get going. In practice, those relying on public or private donations will struggle to cope with the effects of disasters and as a result often have to take a major hit to their economic well-being.

So what does this mean for the insurance industry, whose added value for society comes from assuming risks and thus helping to stabilise economic growth?

Firstly, in richer countries we need to develop risk transfer products and sales channels that address our clients' requirements and need for information better than they do today. The focus here is on the digitalisation of insurance offers and claims management processes.

And what about in developing and emerging countries? More than anywhere else, the impact of natural disaster losses on the development of prosperity is greatest in financially weak and low-income countries. In such states, there are often no well-functioning insurance markets, and the lion's share of disaster relief comes from donations that are both uncertain and subject to considerable delay.

The most promising way to reduce this obstacle to development is public sector participation at regional or national level, and the forging of partnerships with private risk carriers. Munich Re is helping to consistently build on these approaches by contributing data, expertise and risk capital. We are also conducting an intensive analysis to determine if and where natural hazard risks are changing, for example as a result of climate change, and in what way changes to building standards can reduce losses. This would help to keep natural hazards insurable and premiums affordable, even against the backdrop of long-term adverse risk changes.

I am convinced that success in managing the humanitarian and economic challenges following natural disasters can only be achieved if the public and private sectors pull together. This would also help us to close the insurance gap, which would then become an ever-decreasing obstacle to prosperity.

Hurricanes cause record losses in 2017

The year in figures

Petra Löw

In terms of overall losses, 2017 was the second-costliest year ever for natural disasters. Losses from weather-related disasters broke all previous records.

At US$ 340bn, overall losses in 2017 were far greater even than those in the extreme years of 2005 and 2008. Only the record year of 2011 with losses of US$ 350bn, due mainly to the Tohoku earthquake and floods in Thailand, saw higher loss figures.

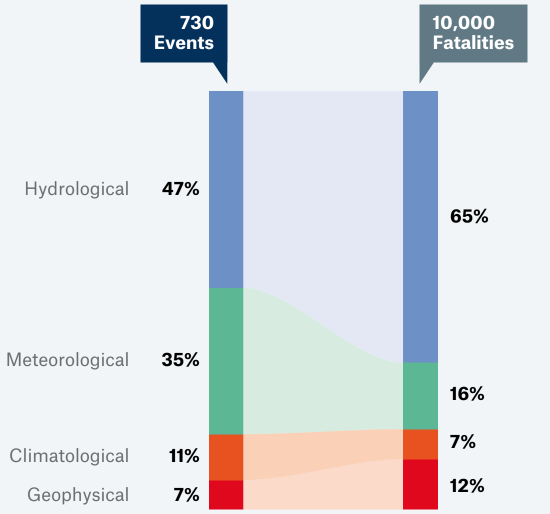
Insured losses in 2017 came to US$ 138bn, the highest annual figure in the period from 1980 to 2017. The Munich Re NatCatSERVICE recorded 730 relevant loss events, which is above the average for the last ten years. The average for the last decade is 605 registered events per year, compared with just 490 for the last 30 years. The event statistics include all relevant loss events, based on different threshold values for property losses according to a country's level of development. The statistics also include all loss events with fatalities.

Losses significantly higher than average

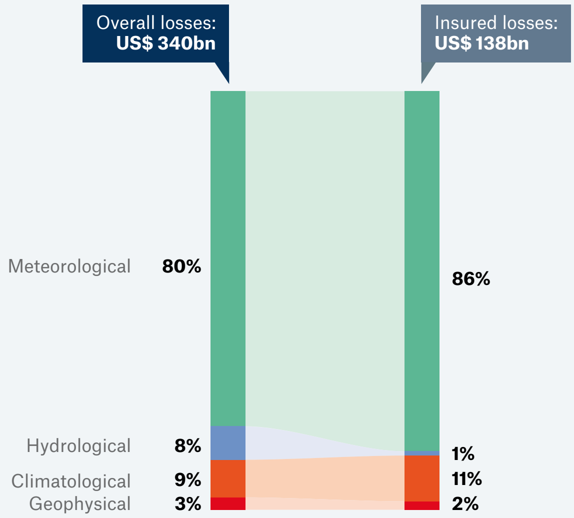
Both overall and insured losses from natural disasters in 2017 were significantly higher than the corresponding averages for the last ten years, which, after adjustment for inflation, amount to US$ 170bn and US$ 49bn respectively.

The hurricane season in the North Atlantic proved particularly costly, accounting for US$ 220bn in overall losses, of which US$ 89bn was insured. There were also two earthquakes in Mexico with a combined loss of over US$ 8bn, and widespread flooding in China which caused losses of more than US$ 6bn. There were severe wildfires in the USA in October and December. Losses from the October fires alone came to US$ 13bn, with the bulk of this amount – US$ 9.8bn – insured. By the end of the year, losses from wildfires were substantially higher.

Natural catastrophes 2017
Percentage distribution

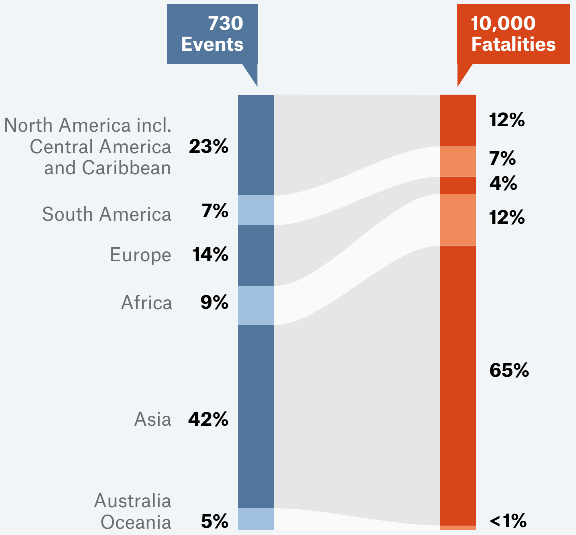


Natural catastrophes 2017
Highest-ever losses from weather catastrophes

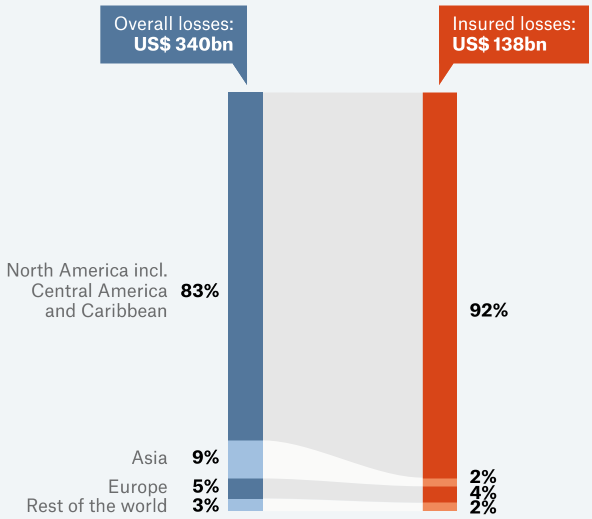


Source: Munich Re NatCatSERVICE

Natural catastrophes 2017
Highest number of fatalities in Asia



Natural catastrophes 2017
Unusually high losses in North America



Source: Munich Re NatCatSERVICE

Roughly 93% of all events worldwide in 2017 were weather-related disasters. The macroeconomic impact was in the region of US$ 330bn, of which some US$ 135bn was insured. This makes 2017 the costliest year ever in terms of global weather disasters.

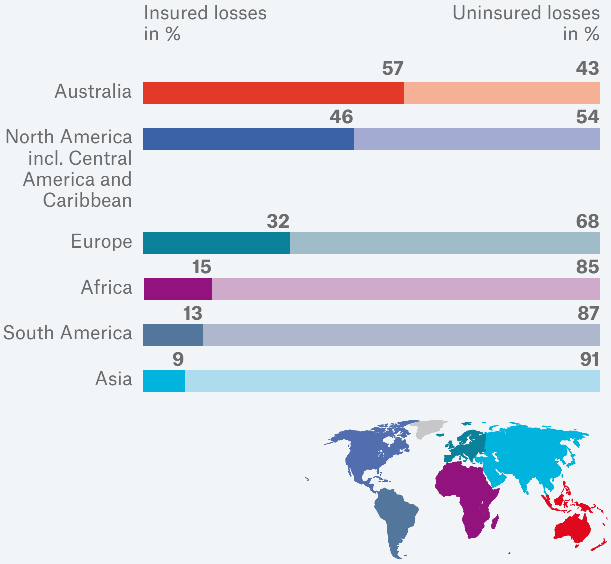
The long-term average for meteorological events since 1980 is around 41% of the overall nat cat claims burden. At 80%, the figure for 2017 represents a significant increase on this average, and the proportion of insured losses is as high as 86%. In contrast, floods and climatological events accounted for 8% and 9% respectively, and geophysical events for 3% of losses.

Number of events

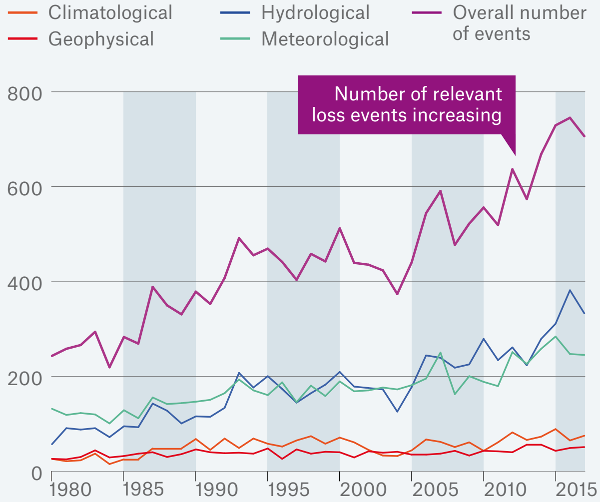
The 2017 distribution of loss events according to the principal peril groups of geophysical, meteorological, hydrological and climatological events showed a trend towards a greater number of floods. This type of hazard, which includes both river flooding and flash floods, accounted for 47% of loss events. The long-term average is around 40%. There were only minor changes in the other hazards, which comprised 53 earthquakes, 255 windstorms, 345 floods and 77 climatological events, such as wildfires, droughts and winter damage.

The 730 events recorded as relevant means that 2017 will join the list of years with the highest number of natural disasters: the 600 mark has been exceeded only five times, all of them in the last six years. A total of 21 events fall into category 4, for especially devastating disasters. Almost two thirds of all the natural disasters registered occurred in North America, the Caribbean, Central America or Asia. This was above the long-term average of 59%.

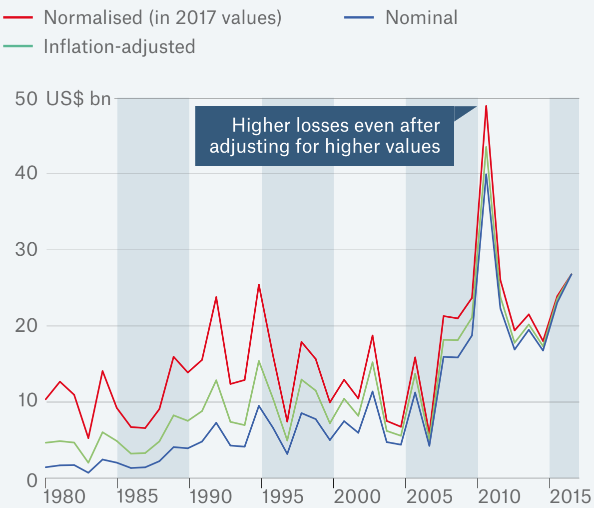
Natural catastrophes 2017
Insurance gap in various regions



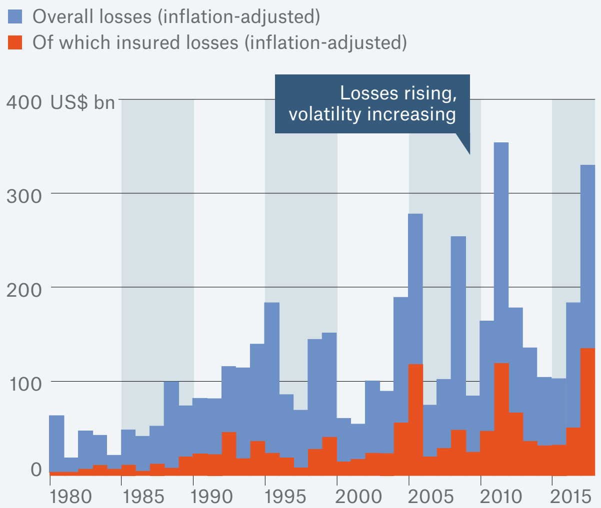
Natural catastrophes 1980–2017
Number of relevant loss events increasing



Thunderstorm losses in the USA 1980–2017
Losses from severe convective storms are increasing



Overall and insured losses 1980–2017
Losses rising, volatility increasing



Source: Munich Re NatCatSERVICE

Losses from natural catastrophes 2017

US$ 340bn

Less than half of the losses insured

US$ 138bn (41%)

Floods in South Asia: a humanitarian disaster

2,700 people killed

Slight increase in the number of fatalities

The number of people worldwide who lost their lives in natural disasters in 2017 was about 10,000, similar to the previous year's figure (9,650). However, compared to earlier periods, the year at least follows the long-term trend towards a reduction in the number of victims. The 10-year average, for example, is approximately 60,000, and the 30-year average 53,000.

Roughly two thirds of the fatalities in 2017 were from natural disasters in Asia, followed by 12% each in Africa and North America, and 4% in Europe.

The deadliest events over the last year were devastating floods in India, Nepal and Bangladesh that were triggered by powerful monsoon rains. Some 2,700 people lost their lives there between June and October. An earthquake in Iran claimed the lives of almost 630 people, while a mudflow killed 500 in Sierra Leone. Once again, a striking feature is that far more people die in natural disasters in emerging and developing countries than in industrialised countries, where protective measures are much more extensive and effective.

Continents

North America (including the Caribbean and Central America)

The continent of North America, including the Caribbean and Central America, accounted for 83% of overall losses and 92% of insured losses worldwide. Approximately 170 events were recorded. There were 15 events that resulted in overall losses of more than US$ 1bn, with much higher losses coming from the major hurricanes Harvey, Irma and Maria. There were also two earthquakes in Mexico, and wildfires and severe weather in the USA. The overall losses from thunderstorms (severe convective storms) came to US$ 25.6bn. Almost three quarters of this was insured.

South America

Between January and March, heavy rain triggered floods and landslides in Peru and Colombia that resulted in billion-dollar losses. Almost 500 people were killed. Chile and Argentina also experienced raging wildfires. Overall losses here totalled more than US$ 600m, of which about US$ 165m was insured.

Europe

In Europe, there were two events that each caused billions in overall economic losses. Mid-April saw the sudden return of winter over Europe, leading to heavy losses in the agricultural sector, particularly in fruit growing. The overall loss came to US$ 3.6bn (€3.3bn), of which less than US$ 650m (€600m) was insured. Dry conditions bringing wildfires and drought to large parts of southern and southeast Europe caused overall losses of US$ 3.8bn (€3.5bn). Only a small proportion of this was insured. In October, Winter storms Herwart and Xavier swept over Germany, Poland and the Czech Republic, causing aggregate economic losses of more than €800m, of which €600 million was insured.

Africa

A mudflow in Sierra Leone was the natural disaster with the second-highest number of fatalities worldwide: roughly 500 people were killed. Two tropical cyclones – Enawo and Dinio – struck Madagascar and southern Africa in February and March. Overall losses of approximately US$ 300m were registered. Only a small proportion was insured. In Ethiopia, Kenya and Somalia, hot weather and no rain between January and September led to drought losses of US$ 950m. In South Africa, two events resulted in significant losses: extensive wildfires and flash floods. The overall loss in each case was several hundred million dollars, of which roughly half was insured.

Asia

Asia accounted for 42% of all events, 65% of all fatalities, 9% of overall losses, and 2% of insured losses. The relative burden for the continent remained moderate because of the enormous loss burden from hurricanes in the North Atlantic and the absence of any extreme loss events in Asia. But even when measured against the absolute amounts, the natural disaster year in Asia was more favourable than average. However, there were still five events that exceeded the US$ 1bn threshold for overall losses. India, Bangladesh and Nepal were hit by severe monsoon rains. The bulk of insured losses were incurred in tropical cyclones that hit Japan, China and the Philippines. Approximately US$ 2.5bn of these losses were insured.

Australia/Oceania

Weather disasters caused an overall loss of US$ 4bn in Australia and Oceania. Insured losses came to US$ 2.3bn. In late March/early April, Cyclone Debbie swept across parts of Australia, costing the country US$ 2.7bn. Of this, US$ 1.4bn was insured. Apart from this loss, the region was largely spared natural disasters in 2017.

The year in pictures

NatCatSERVICE and Research

January to March
Floods: Peru
Overall losses: US$ 3,100m
Insured losses: US$ 380m
Fatalities: 147

28 February–2 March
Tornadoes, severe storms: USA
Overall losses: US$ 1,900m
Insured losses: US$ 1,400m
Fatalities: 4

27 March–6 April
Cyclone Debbie: Australia
Overall losses: US$ 2,700m
Insured losses: US$ 1,400m
Fatalities: 12

22 June–5 July
Floods, landslides: China
Overall losses: US$ 6,000m
Insured losses: US$ 250m
Fatalities: 56

June to October
Floods, landslides: South Asia
Overall losses: US$ 3,500m
Insured losses: minor
Fatalities: 1,787

14 August
Mudflow: Sierra Leone
Overall losses: US$ 30m
Insured losses: minor
Fatalities: 500

19–22 September
Hurricane Maria: Caribbean
Overall losses: US$ 68,000m
Insured losses: US$ 30,000m
Fatalities: 108

19 September
Earthquake: Mexico
Overall losses: US$ 6,000m
Insured losses: US$ 2,000m
Fatalities: 369

8–20 October
Wildfires: USA
Overall losses: US$ 13,000m
Insured losses: US$ 9,800m
Fatalities: 30

1 April
Debris flow: Colombia
Overall losses: US$ 100m
Insured losses: minor
Fatalities: 329

15 April–9 May
Frost: Europe
Overall losses: US$ 3,600m
Insured losses: US$ 650m
Fatalities: none

8–11 May
Hailstorms, severe storms: USA
Overall losses: US$ 3,100m
Insured losses: US$ 2,500m
Fatalities: none

23–27August
Typhoon Hato: China, Vietnam
Overall losses: US$ 3,500m
Insured losses: US$ 800m
Fatalities: 22

25 August–1 September
Hurricane Harvey: USA
Overall losses: US$ 95,000m
Insured losses: US$ 30,000m
Fatalities: 88

6–14 September
Hurricane Irma: USA, Caribbean
Overall losses: US$ 57,000m
Insured losses: US$ 29,000m
Fatalities: 128

15–17 October
Wildfires: Portugal
Overall losses: US$ 500m
Insured losses: US$ 270m
Fatalities: 45

12 November
Earthquake: Iran, Iraq
Overall losses: US$ 750m
Insured losses: US$ 20m
Fatalities: 630

22–24 December
Typhoon Tembin: Philippines
Overall losses: US$ 50m
Insured losses: minor
Fatalities: 168

Source: Munich Re NatCatSERVICE

Climate facts 2017

The warmest non-El Niño year ever

2017 was one of the three warmest years on record. But even more important is the fact that it was the hottest year ever recorded without the warming effect of the natural climate oscillation, El Niño. All 17 years since 2001 rank among the 18 warmest years ever. And in all of this, scientists see a clear signal of climate change.

Eberhard Faust

According to data in January 2018 from the US National Oceanic and Atmospheric Administration (NOAA), the global mean temperature in 2017 over land and sea surfaces exceeded the 20th century average of 13.9°C by 0.84°C. This makes the successive years 2014 to 2017 the four warmest in the measurement series since 1980. Also, 2017 was the third-warmest year, following on from the warmest-ever year of 2016, which was influenced by El Niño. It was also the warmest year without any influence from El Niño, which typically increases the global mean temperature. In this instance, the start of the year saw cool neutral and the end weak La Niña conditions.

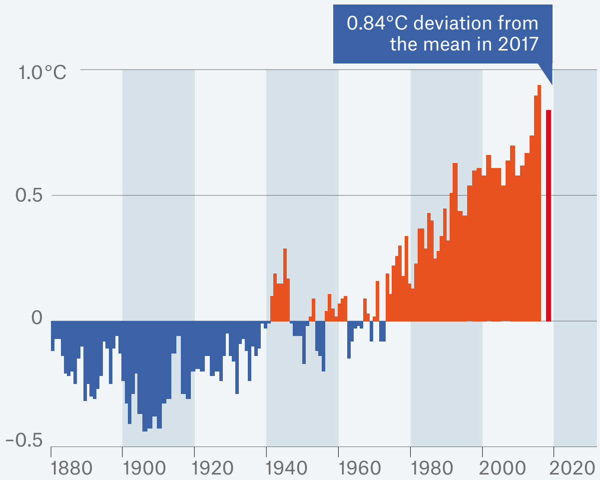
On average, the greatest temperature anomalies occurred in central, northern and eastern parts of Asia, where temperatures during the winter and spring were already much too warm. Russia and China registered record high temperatures in the period January to September. It was also too warm in southern regions of North America and in Alaska – reflecting the significant temperature anomalies in the first and last few months of the year. The USA had its third-warmest year, while California experienced its hottest summer with a heatwave in August/September – thus providing one of the prerequisites for the severe forest fires later in the year.

Other land areas with positive temperature anomalies included eastern Australia, where parts of Queensland and New South Wales experienced their warmest year, with heatwaves in January/February 2017. It was also very warm in western Europe, and in parts of central and southern Europe. This was particularly so in March, then again during periods of extremely hot weather in June/July, and in southern Europe in August as well. Researchers have determined that, as a result of climate change, a hot summer like 2017 has become substantially more probable in the European Mediterranean area in comparison with the start of the 20th century. The probability is currently approximately 10% (World Weather Attribution, 2017).

There were also heatwaves in many other regions: at the start of the year in Argentina and Chile, and later in Pakistan, Iran and Oman, as well as in parts of

Deviation in global mean temperature from the 1901–2000 average

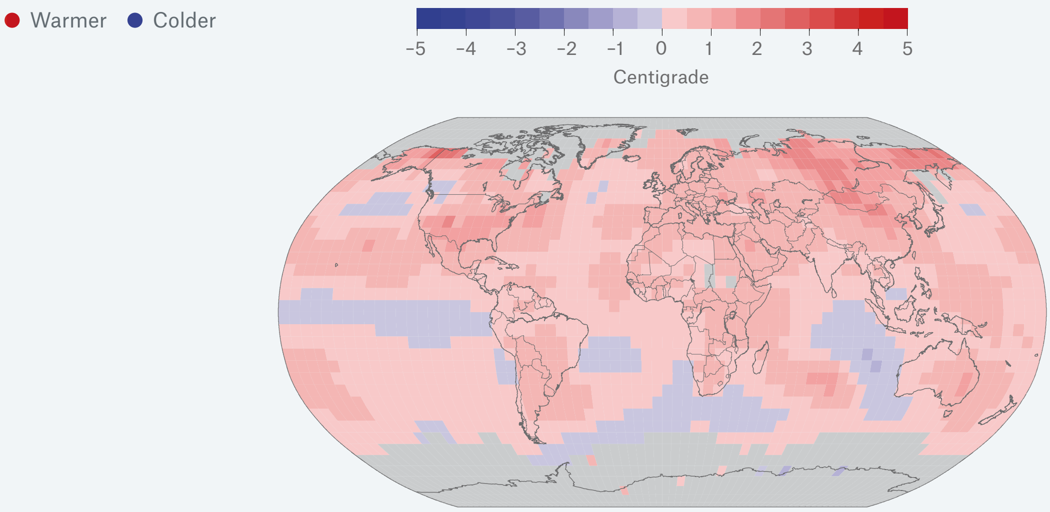
17 of the 18 warmest years were in the period 2001–2017



Source: Munich Re, based on data from the National Centers for Environmental Information/NOAA

Regional deviation of the 2017 annual mean temperature from the 1981–2010 mean

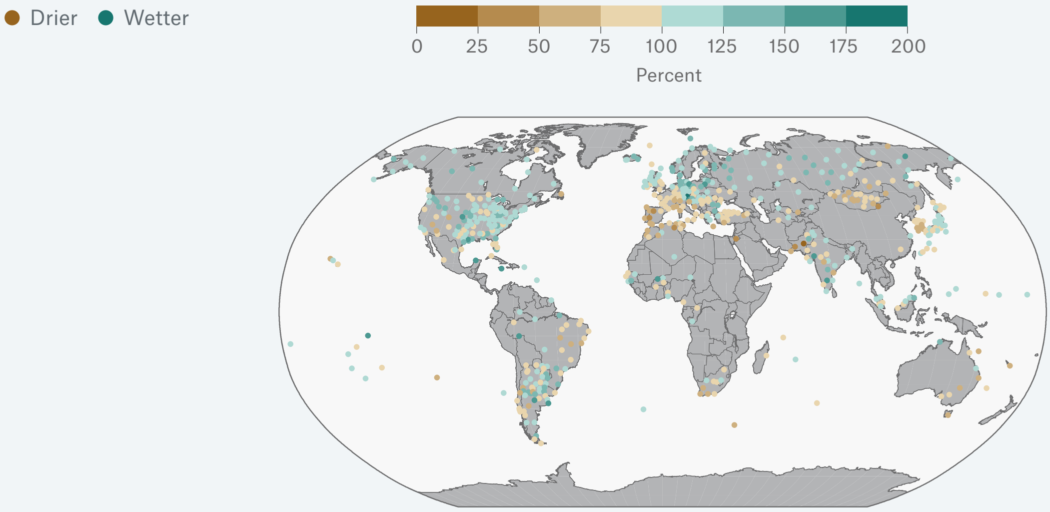
Temperatures were higher than the long-term mean over almost all land surfaces



Source: Munich Re, based on data from the National Centers for Environmental Information/NOAA

Regional deviation of 2017 annual precipitation from the 1961–1990 mean

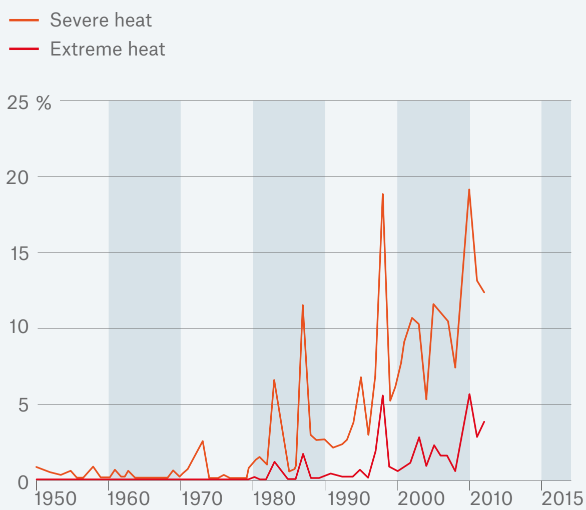
Among the particularly dry regions were parts of Europe, North America and central Asia



Source: Munich Re, based on data from the National Centers for Environmental Information/NOAA

Percentage of land areas affected by severe heat since 1950

More and more regions are being hit by heatwaves



Source: Munich Re, based on data by Coumou & Robinson (2013): Monthly mean temperatures exceeding the long-term average by one standard deviation (severe heat) or two standard deviations (extreme heat).

China. The lower graph on page 60 shows that the global area affected each year by severe and extreme heat events in summer months has been steadily expanding since at least the 1990s. According to information from the World Health Organization, the average number of people annually exposed to heatwaves has increased by 125 million since 2000 (WMO, 2017).

The mean temperature in western Russia over the first ten months was slightly cooler than the 20th century average – the result of negative monthly anomalies in this region and neighbouring areas in the months of April, May, June, July and October. In April especially, western, central and eastern Europe, which had previously experienced unusually warm temperatures, came under the influence of polar and arctic air flows. This resulted in extensive frost damage in large parts of Europe, because the flowering and budding phases in fruit- and wine-growing regions were already well advanced following a warm spring.

In the equatorial Pacific, the first few months of the year saw contrasting sea surface temperatures, with tremendous heat off the coast of Peru and relative cool in more western areas. In February, March and at the start of April, this led to severe and destructive rainfall in northwestern regions of Peru, favoured by extreme humidity from the high rate of evaporation from the sea. The Peruvian weather service spoke of a "coastal El Niño" – an El Niño phase that has not fully developed. In addition, there is some evidence that this equatorial temperature pattern, as a result of teleconnection effects, contributed to an extremely early thunderstorm season in the USA, which caused billions of dollars in damage.

In Europe, the summer months saw an approximate north-south divide in terms of rainfall: in southern Europe from Portugal and Spain to southern France, and especially in Italy and parts of the Balkans, the weather was anomalously dry and generally too hot, contributing to numerous forest fires. In Portugal, the annual rainfall was only 60% of the long-term average, while the period from April to December was the driest since measurements began. Italy experienced the warmest January to August period on record and received just 64% of its normal rainfall. In more northerly regions of Europe, on the other hand, it was for the most part too wet. The north and northeast of Germany, for example, saw exceptionally heavy rainfall, while June in Scotland was the wettest since records began and parts of Scandinavia also experienced unusually wet conditions. The drought of 2016 continued in parts of East Africa, particularly in Somalia, but also in the north of Kenya and the southeast of Ethiopia. The drought in South Africa's Western Cape province intensified.

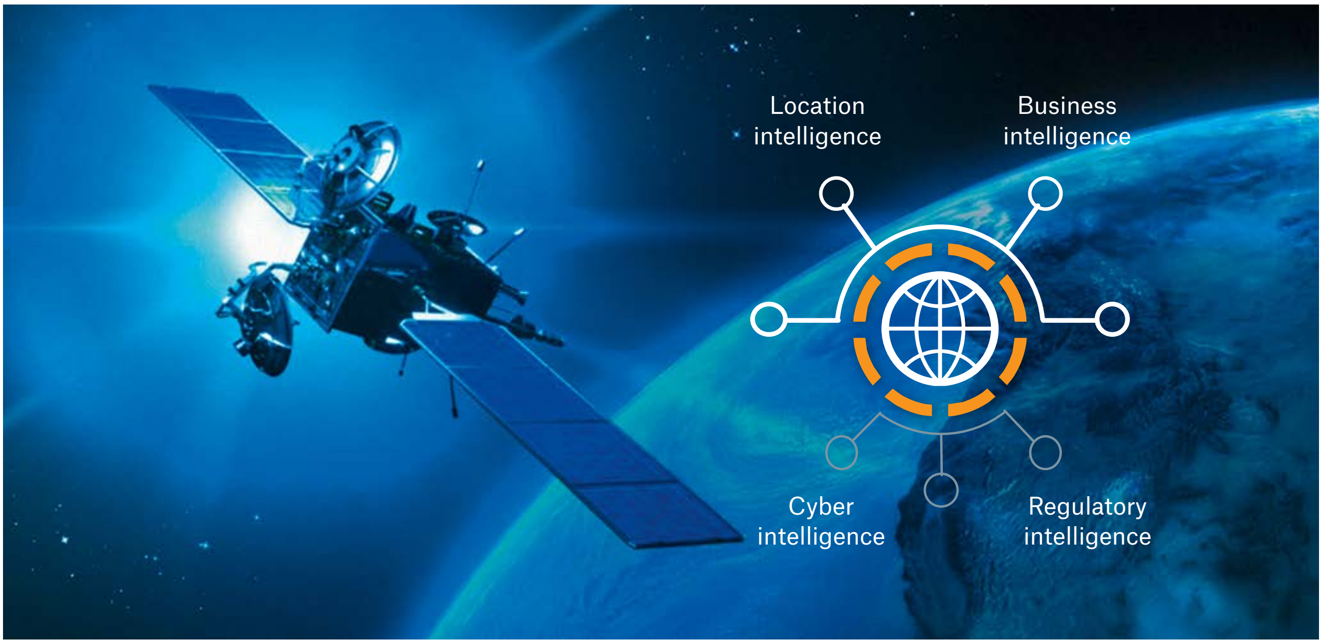
In China, as in the year before, intense precipitation during the East Asian monsoon caused river flooding and damage in June and July in the Yangtze region. The South Asian summer monsoon, which for decades has been bringing increasingly heavy rainfall to places like central India, brought severe regional flooding to India, Nepal and Bangladesh until very late into the monsoon season in September. This season could be perceived as a glimpse into the future of monsoon systems: as climate change progresses further, the IPCC expects a more prolonged monsoon season, with a further increase in the variability and intensity of precipitation, as well as of 5-day rainfall amounts.

The threat to people and the need for increased resilience was highly evident in 2017 against the background of numerous heatwaves, droughts, forest fires and floods, as well as the extremely active hurricane season in the North Atlantic. We can no longer ignore the fact that climate change is the explanation for the clear long-term trend in global average temperature, and is already having or will have an intensified effect on many of these weather extremes.

- World Weather Attribution (2017): Euro-Mediterranean Heat – Summer 2017 (https://wwa.climatecentral.org/analyses/euro-mediterranean-heat-summer-2017/)
- Coumou, D. & Robinson, A. (2013): Historic and future increase in the global land area affected by monthly heat extremes. Environ. Res. Lett. 8(3). doi:10.1088/1748-9326/8/3/034018
- NOAA/NCEI (2018): Global Climate Report – Annual 2017
- WMO (2017): WMO's provisional statement on the state of the climate

Digital solutions for better risk management

Cristof Reinert



In mid-2017, Munich Re established a new business unit, Risk Management Partners. It specialises in developing digital services for risk management and in expanding and integrating existing offerings like NATHAN and M.IN.D. The objective is to offer one-stop intelligent risk solutions to clients from the insurance industry and the public sector, as well as for Fortune 500 companies.

Analysis of geospatial data has long been a standard approach for determining exposure to natural hazards. NATHAN is a good example of this. Over the years, this application has developed into an interactive tool that allows individual portfolio data to be analysed for regional accumulations and new loss patterns, and can provide an exposure and risk score for all locations worldwide.

But modern geodata analysis, in other words the process of collecting and evaluating location-based information, is capable of so much more today. For example, the product M.IN.D., in collaboration with the Mexican disaster fund FONDEN, allows our clients to estimate their financial losses following a natural disaster. Within the newly established unit, specialists from the fields of risk management and IT jointly develop digital solutions with clients that offer a comprehensive view of risks and help companies to identify, evaluate, avoid and reduce the risks they face. The systematic incorporation of real-time data, the link to the Munich Re Data Lake and the development of new algorithms present new opportunities in this context.

The offering will also be expanded to include the topics of location intelligence and business intelligence. Solutions on cyber intelligence and regulatory intelligence are also in the pipeline.

Location intelligence

Applications relating to location intelligence make the work of underwriters and risk managers much easier. The systems can be used at the workplace without the need for major installation work. Maps and satellite images from third-party providers, along with current damage zones and statistics, can be quickly incorporated into an internal application as and when required. Users "compose" their own risk map according to topic and objective.

The solutions developed allow deep insights into risk exposure from natural disasters, so that risks can be predicted more accurately on a global basis. Our clients can select the module that suits them best, depending on the number of risk locations to be analysed, the required levels of user access and integration into their company's own system landscape.

The underlying basis is global hazard data that has been systematically recorded at Munich Re for more than four decades. Location intelligence results from combining this extensive knowledge with in-house risk modelling. The result is an offering comprising global and national risk evaluations, spatial analyses and claims overviews. The application works with high-resolution maps and satellite images. Individual risks can be pinpointed and the surrounding area reviewed. Even entire portfolios can be analysed for their exposure to natural hazards – on request in real time using a web service.

Business intelligence

Unlike location intelligence, business intelligence solutions are more concerned with the broader picture. The focus here is on aspects such as portfolio management, sales management and claims management. Precise loss estimates help to optimise the claims management process. The applications can also help with processing large quantities of data, produce initial loss estimates, identify bogus claims, and visualise geospatial data. A further unique feature of M.IN.D lies in its combination of client-specific, proprietary Munich Re data with data that is publicly available. This information can be individually and flexibly imported into the application and combined to meet the client's special requirements.

The Mexican disaster fund FONDEN is already using M.IN.D to improve its risk management. Using a direct interface to a loss adjuster on the ground, past losses are transferred in real time to a high-performance system, and combined with data on current infrastructure. Exposure can be easily calculated using visual processing and, depending on the risk-bearing capacity, precisely reduced by implementing appropriate measures. For example, communities can be filtered out where the ratio of claims to exposure is exceptionally high. Potential losses can also be estimated at an early stage when a tropical cyclone is approaching the coast.

The FONDEN manager can then use the business intelligence application after a natural disaster to review the processing of a case and identify any bogus claims. A function has also been developed to monitor cat-bond trigger products for hurricanes and earthquakes. Thanks to the intuitive, tangible presentation, the fund manager can see at a glance and in real time whether the trigger has been reached, and to what extent, and whether a payout is likely.

Basis for new kinds of solutions

Location intelligence and business intelligence are just the beginning. Risk Management Partners will continue to refine and expand existing applications. Digitalisation and increasing investment in the field of software as a service are also opening up opportunities for new kinds of solutions, for which cooperation partners in sales and marketing, and partners involved in all aspects of risk management can be brought in. Solutions from Risk Management Partners could also be used in future in the field of corporate risks, for example for site assessments and in supply chain management.

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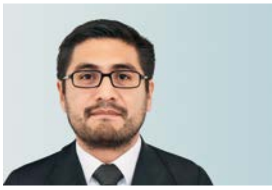

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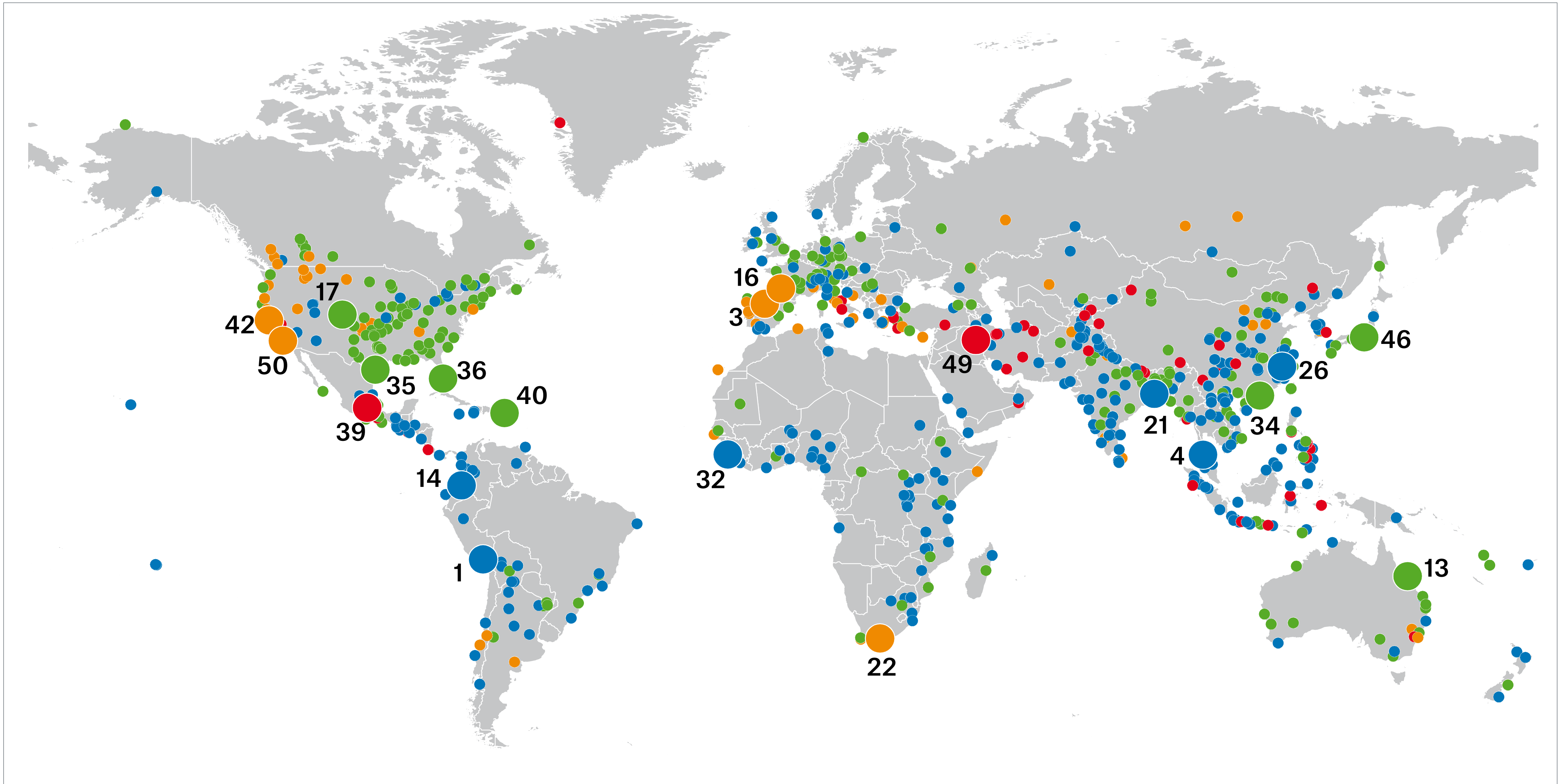
Topics Geo – 50 major loss events 2017

No.	Date	Loss event	Country/Region	Deaths	Overall losses US$ m	Insured losses US$ m	Explanations, descriptions
1	Jan.–Mar.	Floods, landslides	Peru	147	3,100	380	Heavy seasonal rains. Rivers burst their banks. >438,000 homes damaged/destroyed. >1,000 schools, health centres damaged. >500 bridges damaged/destroyed. Displaced/affected: 800,000.
2	Jan.–Sep.	Drought	Ethiopia, Somalia, Kenya, S. Sudan		950		Lack of rain. Losses to agriculture, reduced tea production, lack of fodder, livestock perished. Food, water shortage. Displaced: 766,000 (in Somalia), affected: 28 million.
3	Jan.–Oct.	Drought	Europe (Spain, Italy, Serbia)		3,800	400	Dry conditions, heatwave. Low water levels in rivers, reservoirs. Damage to corn, fruits, vegetables, vineyards, pasture land. Olive, honey production affected. Shortage of livestock forage; milk, cheese production affected.
4	1–30.1.	Floods	Thailand	96	1,000		Heavy rain (610 mm/24 h). >280 homes destroyed, >500,000 homes, shops, >2,200 schools, 3 hospitals, 18 temples, mosques, churches damaged. >340 bridges, roads, highways, railway tracks damaged/flooded. Drinking water supplies disrupted. Rubber plantations damaged, palm oil production hampered. Affected: 1.8 million.
5	1.1.–10.2.	Wildfires	Chile	11	550	165	>120 forest/brushfires, >4,600 km² burnt. >1,600 houses destroyed, >1,000 damaged. 138,000 customers without power. 4 km² of olive production, >2,000 km² of forest plantations burnt. Displaced: >4,000, affected: 4.7 million.
6	12–13.1.	Winter Storm Egon	Europe (France, Germany)	1	400	310	Gusts up to 145 km/h, heavy snowfall. Rail, air traffic affected, weather-related traffic accidents. Houses, cathedral damaged. Trees, power lines downed, 340,000 customers without power. Injured: 50, evacuated: 3,000.
7	4–7.2.	Avalanches	Afghanistan	191			Snowstorms, up to 3 m snowpack. 700 homes destroyed, 260 damaged. Several villages cut off. Injured: 123.
8	6–9.3.	Hailstorms	Australia		490	390	High wind speeds, hail up to 8 cm in diameter. Thousands of homes damaged. Thousands of vehicles damaged. Railways damaged. Trees, power lines downed, 40,000 customers without power.
9	28.2.–2.3.	Tornadoes, severe storms	USA	4	1,900	1,400	Thunderstorms, numerous tornadoes up to EF4, hail up to 7 cm in diameter. Hundreds of homes, mobile homes, commercial buildings damaged/destroyed. Vehicles damaged. Trees, power lines downed.
10	6–9.3.	Severe storms, tornadoes	USA		2,200	1,600	Thunderstorms, tornadoes up to EF3, hail up to 10 cm in diameter. Hundreds of houses, commercial buildings, churches, schools damaged. Airplanes damaged. Hundreds of thousands of customers without power.
11	7–9.3.	Cyclone Enawo, flood	Madagascar	81	200		Cat 4 cyclone. Wind speeds up to 210 km/h, heavy rain (500 mm/48 h). >85,000 houses, >1,800 schools/classrooms, >100 health centres, roads, bridges damaged/destroyed. Displaced: >246,000, affected: >433,000.
12	25–28.3.	Hailstorms, severe storms	USA		2,700	2,000	Thunderstorms, tornadoes up to EF2, wind speeds up to 190 km/h, hail up to 11 cm in diameter, flash floods. Numerous houses, apartment complex, mobile homes, public buildings, shopping mall damaged.
13	27.3.–6.4.	Cyclone Debbie, floods	Australia	12	2,700	1,400	Cat 3 cyclone. Wind speeds up to 195 km/h, gusts up to 260 km/h, torrential rain (up to 1,000 mm/48 h). Thousands of houses, several resorts damaged. Port facilities damaged. Railway tracks, bridges damaged. Trees, communication, power lines downed, 270,000 customers without electricity. Evacuated: >45,000.
14	1.4.	Flash flood, mudslide	Colombia	329	100		Heavy rain (320 mm in a few hours), mudslides. Rivers burst their banks. Parts of Mocoa buried, 4 schools damaged/destroyed. Vehicles damaged. Bridges damaged. Water supply affected. Injured: >360, affected: 45,000.
15	Apr.–Jun.	Heatwave	India	264			Temperatures up to 48°C. Power outages. Water shortages. Heat-related illnesses.
16	15.4.–9.5.	Winter damage, frost	Europe (France, Germany, Italy)		3,600	650	Series of cold spells, low seasonal temperatures (-7°C), heavy snowfall. Some houses damaged. Severe damage to vineyards, fruit crops (apples, stone fruits, berries), vegetables.
17	8–11.5.	Hailstorms, severe storms	USA		3,100	2,500	Thunderstorms, gusts up to 130 km/h, hail up to 7 cm in diameter, heavy rain, flash floods. Numerous buildings, houses, schools, shopping mall damaged, city hall, businesses, streets flooded. Thousands of vehicles damaged.
18	Apr.–Jul.	Drought	China		800		Lack of rain, dry conditions. Water shortages. >5,800 km² of crops affected, livestock perished.
19	24–31.5.	Floods, landslides	Sri Lanka	219	390		Thunderstorms, high wind speeds, heavy seasonal rains (380 mm/24 h), mudslides. >3,000 houses destroyed, >19,900 damaged. Displaced: >80,000, affected: >600,000.
20	Jun.–Sep.	Flood	India	284	250		Heavy seasonal rain (460 mm/24 h), flash floods. Rivers burst their banks. >5,400 dwellings destroyed, >33,000 damaged. Airport damaged. >16,000 head of livestock killed. Evacuated: >112,000, affected: 520,000.
21	Jun.–Oct.	Floods	Bangladesh, India, Nepal	1,787	3,500		Heavy seasonal rains, flash floods, landslides. >2 million houses, educational institutions, businesses, hospitals, government buildings damaged/destroyed. Highways, roads, bridges, railway tracks damaged, airport flooded. >33,000 km² of crops damaged/destroyed. Millions of livestock killed.
22	7-13.6.	Wildfire (Knysna)	South Africa	9	420	200	>1,100 houses, structures, 30 tourism facilities destroyed. Evacuated: 10,000.
23	9–12.6.	Severe storms	USA		2,000	1,500	Thunderstorms, gusts up to 135 km/h, hail, heavy rain. Numerous houses, commercial buildings damaged. Many vehicles damaged. Trees, power lines downed, >110,000 customers without power. Streets flooded.
24	17–22.6.	Wildfires	Portugal	66	200		Two seats of forest fire, 460 km² burnt. Dry conditions, high temperatures (40°C), lightning. >490 houses damaged/destroyed. Vehicles damaged. Roads damaged. Severe damage to forest (eucalyptus, pine). Injured: 254.
25	22–23.6.	Severe storms, hail	Germany	2	740	570	Tornado, thunderstorms, gusts up to 140 km/h, hail up to 8 cm in diameter, heavy rain. Numerous houses damaged. Vehicles damaged. 500 km² of crops (esp. corn), fruits, vegetables, vineyards damaged, livestock killed.
26	22.6.–7.7.	Floods, landslides	China	56	6,000	250	Heavy seasonal rains (Mei-yu). Numerous rivers in South and Central China burst their banks. >417,000 homes damaged/destroyed. 500 km² of crops destroyed, >34,000 km² of farmland hit. Affected: >12 million.
27	26.6.–7.9.	Floods	Pakistan	164			Heavy seasonal rains, thunderstorms, landslides. >440 houses, dwellings destroyed. Vehicles damaged. Injured: 167.
28	5–7.7.	Floods, Tropical Storm Nanmadol	Japan	37	700	140	Heavy rain (545 mm/24 h). Rivers burst their banks. >100 homes, schools destroyed, >870 homes damaged. Vehicles damaged. Highways, roads, bridges damaged. Water supply affected. Injured: 34, evacuated: thousands.
29	27–29.6.	Severe storms, hail, tornado	USA		1,400	1,100	Thunderstorms, EF1 tornado, wind speeds up to 170 km/h, hail up to 7 cm in diameter, heavy rain, flash floods. River burst its banks. Numerous homes, farm buildings damaged. Vehicles damaged.
30	27.7.	Severe storm, hail	Turkey		600	300	Thunderstorm, wind speeds up to 100 km/h, hail up to 9 cm in diameter, heavy rain, flash floods, lightning. >90 houses damaged. 150,000 vehicles, 4 planes damaged. Streets, metro stations flooded.
31	8.8.	Earthquake	China	29	500		M_w 6.5. 100 homes destroyed, >72,500 damaged. Roads damaged. Injured: 525, evacuated: 89,000.
32	14.8.	Mudslide	Sierra Leone	500	30		Heavy rain, flash floods, mudslide. >1,100 dwellings buried/damaged. Displaced: 6,000.
33	16.8.	Landslide	Congo	174			Heavy rain, landslide. 50 dwellings buried. Livestock killed.
34	23-27.8.	Typhoon Hato	China, Vietnam	22	3,500	800	Cat 2 typhoon. Wind speeds up to 160 km/h, gusts up to 210 km/h, floods. >6,500 homes destroyed, 1,550 damaged. Trees, power lines downed, 2.7 million customers without power. Injured: >370, evacuated: 27,000.
35	25.8.–1.9.	Hurricane Harvey, storm surge, floods	USA	88	95,000	30,000	Cat 4 hurricane. Wind speeds up to 215 km/h, heavy rain (>1000 mm/72 h), high waves. 9,000 homes destroyed, >185,000 houses, mobile homes damaged. Chemical factory flooded, explosions. Hundreds of thousands of vehicles damaged/destroyed. Oil, gas industry affected. Trees, communication, power lines downed, >300,000 customers without power. Sewer back-ups, waste water treatment plants damaged. Displaced: 42,000.
36	6–14.9.	Hurricane Irma, storm surge, floods	Caribbean, USA	128	68,000	30,000	Cat 5 hurricane. Wind speeds up to 300 km/h, gusts up to 360 km/h, heavy rain, flash floods, coastal flooding. Tens of thousands of houses, public buildings, businesses damaged/destroyed, numerous hotels, hospitals damaged. Infrastructure damaged. Power plant severely damaged. Yachts, boats damaged. Trees, communication, power lines downed, 16.5 million customers without power. Evacuated: 6.5 million.
37	7.9.	Earthquake	Mexico, Guatemala	98	2,300	400	M_w 8.1, >800 aftershocks. >112,000 homes, several churches, public buildings damaged/destroyed. Roads damaged. Power lines downed, 1.5 million customers without power. Affected: 1.2 million.
38	17–18.9.	Typhoon Talim	Japan	2	500	330	Cat 4 typhoon. Wind speeds up to 160 km/h, heavy rain (120 mm/1 h), landslides. >7,200 homes damaged/destroyed. Vehicles damaged. Rail, air traffic disrupted. Injured: 56, evacuated: >130,000.
39	19.9.	Earthquake	Mexico	369	6,000	2,000	M_w 7.1, aftershocks up to M_w 4.9. 1,500 houses destroyed, 9,500 houses damaged. Textile factory, >20 hospitals, public buildings, schools, historic museum, football stadium damaged. Communication, power lines downed, 4.6 million customers without power. Gas, water mains broken. Injured: 6,000, displaced: 250,000.
40	19–22.9.	Hurricane Maria, floods	Caribbean	108	57,000	29,000	Cat 5 hurricane. Wind speeds up to 260 km/h. Hundreds of thousands of houses damaged/destroyed, hospitals, public buildings, schools, businesses damaged. Canals, roads, bridges, airports, seaports damaged. Power distribution network, communication lines damaged, millions of customers without power.
41	5–6.10.	Winter Storm Xavier	Germany, Poland	9	500	380	High wind speeds, gusts up to 180 km/h. Several houses damaged. Vehicles damaged. Highways, roads, railways blocked. Trees, power lines downed, 810,000 customers without power. Injured: 63, evacuated: 400.
42	8–20.10.	Wildfires (Tubbs, Atlas, Nuns Fires)	USA	30	13,000	9,800	Brush/forest fires. >640 km² burnt. >7,300 structures, businesses, >830 structures damaged. Several wineries destroyed. Communication, power lines downed, 45,000 customers without power.
43	9–10.10.	Flash flood, hail	South Africa	13	320	140	Thunderstorm, hail, heavy rain. Several houses, 5 hospitals, >40 schools, >40 public buildings, sports facilities, automobile factory, >1,000 vehicles, roads, bridges damaged.
44	15–17.10.	Wildfires	Portugal	45	500	270	>440 seats of forest/brush fires, 1,800 km² burnt. Numerous houses, vehicles damaged/destroyed. Injured: 71.
45	16–17.10.	Extratropical Cyclone Ophelia	Ireland, United Kingdom	3	100	75	Remnants of Hurricane Ophelia, wind speeds up to 175 km/h. Several houses, commercial buildings, 40 schools damaged. Railways damaged. Trees, power lines downed, 433,000 customers without power.
46	16-23.10.	Typhoon Lan (Paolo)	Japan, Philippines	17	2,000	1,000	Cat 4 typhoon. Wind speeds up to 180 km/h, heavy rain (800 mm/48 h), flash floods, landslides. 570 houses, public buildings destroyed, >6,700 damaged. Damage to aquacultures and agriculture. Evacuated: >165,000.
47	29.10.	Winter Storm Herwart	Germany, Czech Republic, Austria	8	500	370	Wind speeds up to 145 km/h, heavy rain, flash floods. Houses damaged. Roads, railways damaged. Trees, power lines downed, 390,000 customers without power. Severe losses to forestry.
48	1–6.11.	Typhoon Damrey, floods	Vietnam, Philippines	114	650		Cat 2 typhoon.>3,500 houses destroyed, >300,000 houses, >300 schools, 45 health centres damaged. 7 cargo ships, 1,200 fishing boats sank. 300 km² of farmland flooded. Severe damage to aquacultures. Affected: >4 million.
49	12.11.	Earthquake	Iran, Iraq	630	750	20	M_w 7.3, >230 aftershocks up to M_w 4.9. >15,500 dwellings destroyed, >30,000 damaged. Hospitals, commercial buildings, schools, public buildings damaged/destroyed. Dam damaged. Injured: >12,900, displaced: 72,000.
50	4.12.–31.12.	Wildfire (Thomas Fire)	USA	2	2,200	1,700	Forest/brush fire, >1,140 km² burnt. >1,000 structures, 1 hospital destroyed, 280 structures damaged. 265,000 customers without power. Water supply disrupted. Evacuated: >90,000.

Topics Geo – World map of natural catastrophes 2017

Munich RE



730 loss events, thereof

◯ 20 most significant events in terms of overall or insured losses and/or fatalities

- **Geophysical event:** Earthquake, tsunami, volcanic activity
- **Meteorological event:** Tropical storm, extratropical storm, convective storm, local storm
- **Hydrological event:** Flooding, mass movement
- **Climatological event:** Extreme temperature, drought, wildfire

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