TOPICS GEO

Natural catastrophes 2013
Analyses, assessments, positions
2014 issue

After the floods

Heavy rainfall in central Europe caused record floods. There was also flooding in many other regions of the world. PAGE 16

Typhoon Haiyan
Superstorm devastates the Philippines

Meteorite impact
Russia gets a warning shot

Climate change
No end in sight

Munich RE

EDITORIAL

Dear Reader,

For the insurance industry, 2013 was a below-average year in terms of natural hazard losses. There were no major earthquakes, and hurricane activity in North America was a long way below the long-term average. Apart from two landfalls in Mexico, there were no major losses in the Americas. However, it was a quite different situation on the other side of the world, where Typhoon Haiyan caused the year's biggest catastrophe. The storm surge in the Philippines claimed thousands of lives and devastated vast areas.

It is fair to say that 2013 was dominated by water-related events, with extensive flooding on nearly all continents. Perhaps somewhat surprisingly, the largest insured loss occurred in Germany, where the hailstorms in late July cost the insurance industry US$ 3.7bn (€2.8bn) in just 48 hours. The meteorite impact in Chelyabinsk, Siberia, was an unusual event and showed that the insurance industry needs to consider even the "most exotic" of hazards.

Although 2013 was relatively quiet compared to previous years, we should be wary of drawing hasty conclusions. There will always be years in which losses are at the lower end of the scale.

I hope that you find this issue of Topics Geo of practical use in your day-to-day work and that it offers you interesting insights beyond your own field of responsibility. I wish you an interesting read.

Munich, March 2014

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

NOT IF, BUT HOW

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LOSS DATA

Information online from NATHAN

Via NATHAN Online, Munich Re's business partners can access statistics and information on the most significant natural catastrophes since 1980. The loss data complement hazard information and permit better management of natural hazard risks. Historical data often make it possible to draw conclusions regarding return periods and loss potentials of major events.

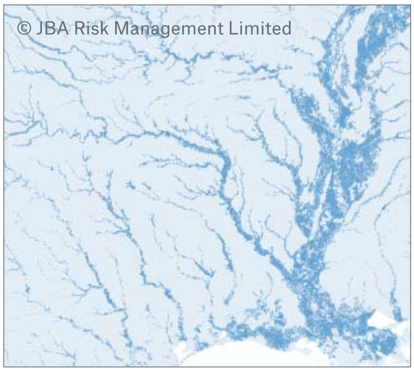
>> More information is available at:
Munich Re Connect: https://nathan.munichre.com

MCII

Weather index insurance launched in the Caribbean

Mid-2013 saw the market launch in Saint Lucia (and subsequently in Jamaica and Grenada) of the "Livelihood Protection Policy" (LPP), developed by the Munich Climate Insurance Initiative (MCII) together with the Caribbean Catastrophe Risk Insurance Facility (CCRIF) and the microinsurance consultant, MicroEnsure. The idea behind this product is that insurance cover is triggered if specific meteorological parameters exceed defined limits (weather index insurance). This means prompt payouts following weather events without complex claims settlement.

>> More information is available at:
www.climate-insurance.org



HAZARD ZONES

New global flood zones

The flood zones in NATHAN Risk Suite will in future be based on a digital terrain model with a resolution of 30 metres. Thus far, a resolution of 100 metres was considered to be the benchmark for global natural hazard studies. The zones represent events with return periods of 100 or 500 years. The high-resolution version will initially be available for North and Central America and for the Caribbean. It will then gradually be made available for other regions as well.

>> More information is available at:
Munich Re Connect: https://nathan.munichre.com

News in brief

Project Risk Rating
Munich Re and TÜV Süd have joined forces to develop a new rating system. Project Risk Rating (PRR) enables project participants to benefit from the combination of TÜV SÜD's extensive technical know-how and Munich Re's wide-ranging risk knowledge, especially in the field of natural hazards. The various subject areas are processed by the relevant experts at both companies. The basis of the ratings is a modular system of individual risk components reflecting an investment project's main risks. These components take account of macroeconomic, technical, ecological and contractual aspects of the project.

Weather risks
In late 2013, Munich Re acquired the business unit for weather risks RenRe Energy Advisors Ltd. (REAL) belonging to the reinsurer Renaissance Re Holdings Ltd., Bermuda. The team of experts at REAL has been handling weather risks for more than 16 years and is one of the leaders in this market segment.

New forms of risk transfer
Munich Re and the International Finance Corporation (IFC), a member of the World Bank Group, have struck an agreement on an innovative form of risk transfer. IFC will provide Munich Re with capacity of up to US$ 100m with the objective of supporting infrastructure projects in Latin America.

Severe weather publication series

Almost all regions of the world have suffered extreme weather events in recent years. The development of built-up areas, especially in highly hazard-prone regions like coasts or mountains, has skyrocketed in the past decades. Despite protection measures, vulnerability has not been reduced in general. Climatic changes are discernible in most areas and already certain in some. Hence, the consequences of weather events are on the rise throughout the world, and the risks associated with them are changing faster and faster. *Severe weather in North America: Perils • Risks • Insurance* was the first issue of a new Munich Re publication series that deals with this topic for a certain region comprehensively and in depth. Published in 2012, it was followed in November 2013 by a report on Eastern Asia.

Changing weather risks not only affect society in general but also have a huge impact on the insurance industry, which needs to find adequate responses in the form of innovative insurance solutions. In order to support this process, various experts from different units at Munich Re and a number of renowned guest authors shed light on the basic concepts and physical principles behind natural hazard phenomena, explain their occurrence and impact, and analyse resulting loss events. They describe the underlying factors of changing risk, including climate variability and climate change. Munich Re's scientists are at the forefront of the latest research, and work in close contact and cooperation with scientists from all relevant fields. The books also give advice on risk reduction and on how to prepare for and deal with extreme events. Implications are drawn for the respective insurance markets based on the findings presented.

The publications are organised in three main chapters. In *Perils*, different hazards are discussed, weather phenomena explained, and consequences, significant historical loss events, methods of risk mitigation and insurance issues addressed. *Risks* looks at the various aspects that influence risk, among them natural climatic variability and climate change.

In *Insurance*, the availability and structure of insurance for personal and commercial lines are discussed and other insurance products described. The main message is the need for an alliance between homeowners, businesses, scientists and researchers, government at all levels and the insurance industry in order to prevent and mitigate the effects of extraordinary events. All those involved need to develop a greater awareness of the increasing risks in exposed regions and understand how to prepare for catastrophes.

>> For more information visit:
www.munichre.com/en/weather-asia
www.munichre.com/en/weather-north-america

Super typhoon wreaks havoc on the Philippines

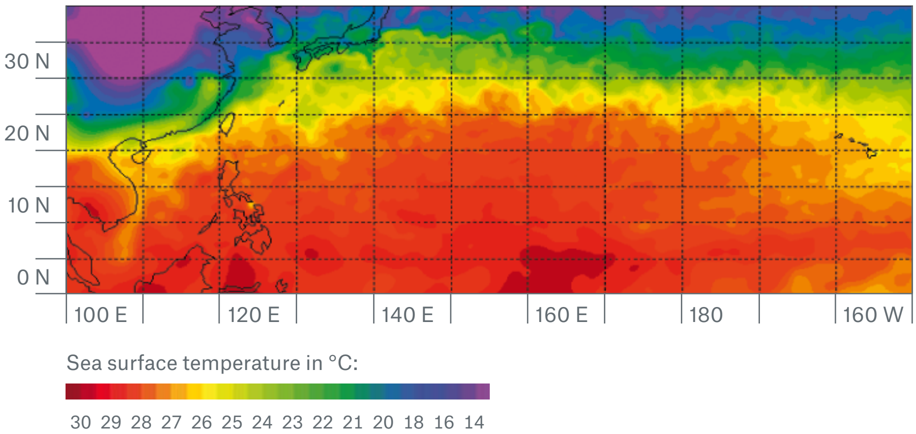
In November, what is assumed to be the strongest tropical cyclone ever to hit land resulted in enormous loss of life and damage in Southeast Asia, in particular across the Philippines. Super Typhoon Haiyan reached wind speeds of well over 300 km/h, with gusts of up to 380 km/h.

Doris Anwender and Eberhard Faust

The 2013 typhoon season was noticeably stronger than in previous years, with nine landfalls at typhoon strength compared to between five and nine annually in the years 2008 to 2012. The strongest of these landfalls and probably the strongest ever recorded tropical cyclone landfall struck the Philippines on 7 November. This super typhoon was known locally as Yolanda and worldwide as Haiyan.

Typhoon Haiyan originated about 100 km east of Pohnpei, the main island of Micronesia. On the night of 3 November, what was initially a tropical depression developed into a tropical storm that reached typhoon status the next day. From the early evening of 5 November on, Haiyan quickly became much stronger, with wind speeds increasing by at least 80 km/h over a 24-hour period. During this time the typhoon's central pressure decreased from about 970 to 905 hPa. On 6 November, Haiyan was classified a typhoon equivalent to a Category 5 hurricane on the Saffir-Simpson Hurricane Scale.

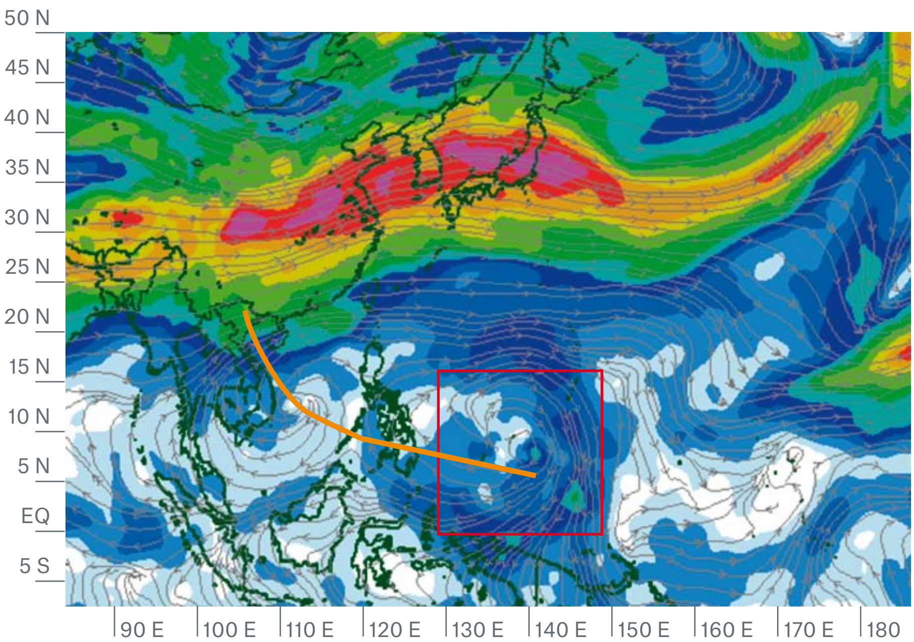
The eastern coast of Leyte Island was hit by a storm surge of up to six metres in height, leaving death and destruction in its wake.



Sea surface temperatures

Distribution of sea surface temperatures in the tropical and subtropical Western North Pacific on 6 November 2013. Sea surface temperatures close to the landfall position were 28–29°C.

Source: NOAA/PMEL, Pacific Marine Environmental Laboratory



Vertical wind shear

The difference in strength and direction between winds at 11 km and at 1.5 km altitude, i.e. the vertical wind shear, was relatively small on 6 November in the region of Typhoon Haiyan (red square).

Vertical wind shear in knots
(1 knot = 1.852 km/h):

>60	30–25
60–55	25–20
55–50	20–15
50–45	15–10
45–40	10– 5
40–35	<5
35–30	

Storm track Haiyan

Source: U.S. Naval Research Laboratory, Marine Meteorology Division, Monterey, California

Typhoons draw the energy for the generation of their winds from the warm ocean. Typically, as a tropical storm develops, its winds stir up deeper, cooler ocean water, which then limits the typhoon's strength. An atypically thick subsurface ocean layer with temperatures above 26°C thus favoured the strong intensification of Haiyan. However, the sea surface temperatures of about 28°C in the area of Haiyan's intensification were not abnormally high for this region and time of year.

Probably the most important factor that contributed to Haiyan's enormous strength was the very small difference in strength and direction between the winds close to the surface and those aloft. This is known as vertical wind shear. The highly symmetric ring of upper-level clouds seen in the satellite imagery illustrates the strong divergence in the upper part of the typhoon.

Haiyan reached its maximum intensity on 7 November in the early evening, with one-minute maximum sustained wind speeds of 314 km/h, gusting at 379 km/h (Joint Typhoon Warning Center, JTWC). The minimum central pressure sank to values between 862 hPa (Japan Meteorological Agency, JMA) and 884 hPa (JTWC). At 20.40 UTC Haiyan made landfall on the southern tip of the Philippine island of Samar close to Guiuan as a Category 5 typhoon. The record wind speeds and central pressure values at landfall made Haiyan probably the most intense tropical cyclone ever observed to hit land.

During its passage over the Philippine islands, where Haiyan made several landfalls, the typhoon maintained its strength and was classified a Category 5 tropical cyclone. On the following day Haiyan weakened continuously to a Category 3 typhoon, when it was northwest of the Philippine island of Palawan in

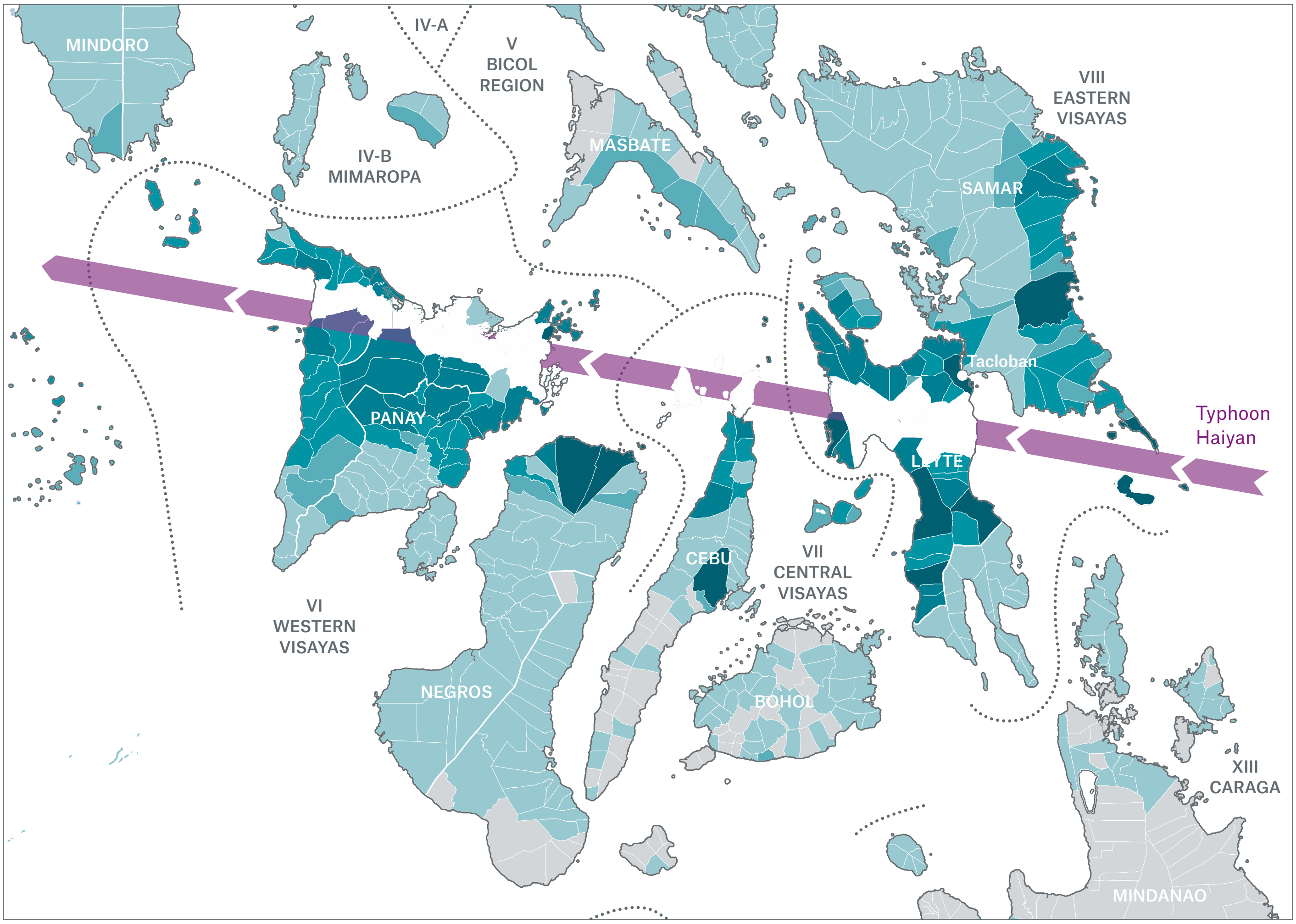
Several large vessels were washed ashore by strong waves. The Eva Jocelyn sits 500 m inland on top of destroyed homes in Tacloban City, Leyte Province.

the South China Sea. Haiyan continued moving towards the northwest and made its final landfall as a Category 1 typhoon between 10 and 11 November in northern Vietnam near Hai Phong.

Most damage caused by storm surge

While only minor damage was reported in Taiwan, China and Vietnam with 34 deaths, Haiyan caused enormous destruction in the Philippines, where it made six landfalls in total. During the typhoon's first and second landfall on Samar island and the island of Leyte, a storm surge height of up to six metres extending one kilometre inland was reached. In spite of the typhoon's extreme wind speeds, the worst part of the destruction was caused by the storm surge. Furthermore, Typhoon Haiyan brought extensive rainfall to the region. Large areas reported rainfall amounts of 50 to 100 mm. Surigao experienced the greatest amount of rainfall measured at rain gauges, with a peak of 248 mm in 24 hours. As much as 500 mm of rain fell in the central Philippines from 6 to 12 November according to TRMM satellite rain estimates.

Some 70% to 80% of the houses on the island of Leyte were destroyed, with the low-lying areas of Tacloban City worst affected. The terminal buildings of Tacloban Airport were destroyed, along with almost all of Tacloban's infrastructure. Over 20,000 houses in the city were damaged, with a large part of them totally destroyed. Ships were washed inland, cars piled up and trees collapsed. The heavy rainfall triggered mudslides, damaging both houses and infrastructure alike. Numerous towns and villages on Samar and Leyte had no power for a month.



Houses damaged by Typhoon Haiyan

Super Typhoon Haiyan made several landfalls while moving over the Philippines, leaving a trail of destruction. The map shows how many houses were reported damaged in the affected municipalities.

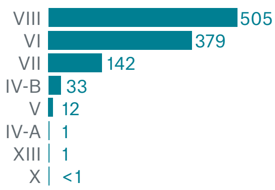
Houses damaged

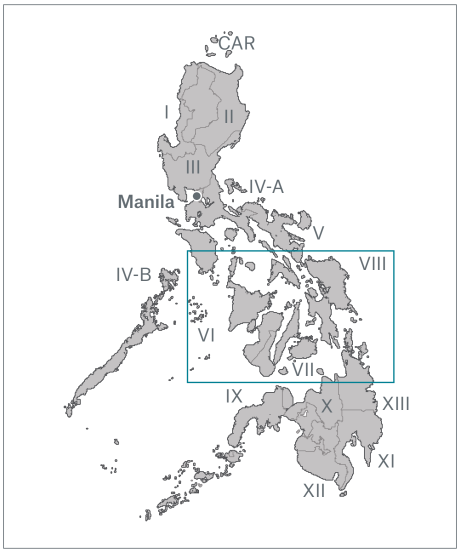
- >10,000
- 5,000–10,000
- 2,000–5,000
- 1,000–2,000
- <1,000
- No data

Source: United Nations Office for the Coordination of Humanitarian Affairs, as at 18 November 2013

1.1 million
houses damaged

Number of damaged houses by region (in thousands)





According to the National Disaster Risk Reduction and Management Council (NDRRMC), the typhoon caused more than 6,000 fatalities. About 27,000 people were injured and almost 1,700 are missing. More than four million people were forced to leave their homes. Roughly 600,000 houses were destroyed, with an estimated additional 600,000 partially damaged. In total, about 17 million people were affected by the disaster.

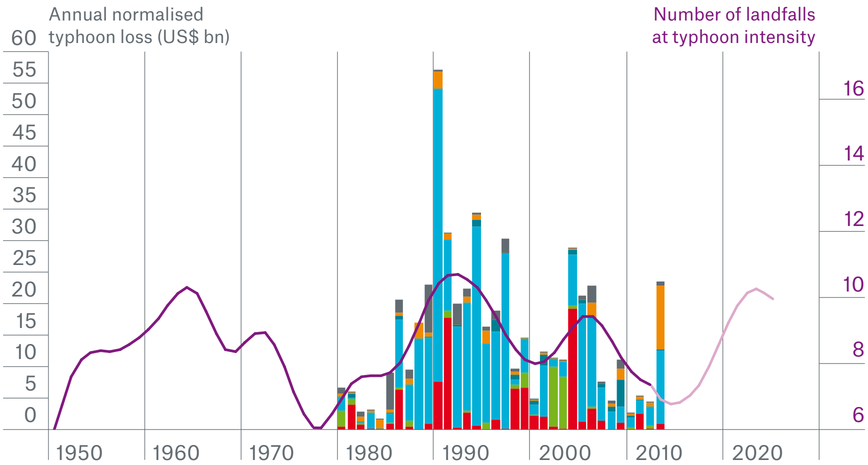
Aid relief only gradually reached the worst-affected areas. People suffered not only from power outages and a breakdown of the communications infrastructure, but crucially from shortages of food, water and medical supplies. Serious damage to the public infrastructure, roads and railways buried by masses of debris and mud, and badly damaged transportation systems strongly hindered access of disaster relief organisations to affected areas. Partially destroyed properties worsened, and without public order, medical care, food and water, people's despair drove them to extremes. Severe and chaotic social conditions, including criminal acts by escaped prisoners in Tacloban and other places, compounded the natural disaster by adding a social component to it, as terrifying rumours of complete disorder circulated.

As a consequence, thousands tried to escape on evacuation planes from the central Philippines, especially from Tacloban. Due to safety concerns, many relief agencies avoided the Tacloban region and some United Nations staff were ordered back from the area, which one BBC correspondent called a "war zone". As a consequence of the widespread desperation and fight for survival, looting took place in several areas, further increasing property losses and social disorder. Philippine military forces entered Tacloban City one week after Haiyan's landfall to prevent looting and restore some basic order. Overall, direct losses in the Philippines are estimated to have reached US$ 9.7bn, while the insured portion is estimated to be around 7% of this sum, or US$ 700m, as the private insurance market there is still not strongly developed.

Disaster economics

The disaster brought about by Typhoon Haiyan is another example of the large loss amplification mechanism, a term coined in the aftermath of Hurricane Katrina. Big disasters such as major tropical cyclone landfalls can release secondary catastrophes such as prolonged periods of non-accessibility to affected places due to infrastructure destruction. A stronger regional downturn due to genuine social chaos and damaging rumours of anarchy and lawlessness was a consequence on the Philippines. This led in turn to a population drain and migration flows into big cities such as Cebu or Manila, especially of young people and skilled workers. As a consequence, initial recovery was slowed down.

Long-term pattern of typhoon landfalls and losses



Bars indicate the time series of normalised direct typhoon losses in Eastern Asia beginning in 1980, and split into regional contributions.

- Southeast Asia
- Philippines
- Taiwan
- China
- South Korea
- Japan
- Landfalls at typhoon intensity (smoothed)
- Fictive landfalls at typhoon intensity

Source: Munich Re, 2013. Typhoon landfall data according to Weinkle, J., R. Maue and R. Pielke, Jr. (2012): Historical global tropical cyclone landfalls. Journal of Climate, 25, 4729–4735

In the Philippines, insurance has only a limited share of private risk financing – accordingly, the private insurance market is relatively small. Instead of ex ante risk financing, households and private enterprises face disaster losses as a huge burden ex post, hitting the regional economy and leaving countries like the Philippines dependent on donors and credit-based governmental recovery programmes. Recent macro-economic analysis has demonstrated that emerging countries with only very small private insurance markets are affected by stagnation of output and enhanced governmental deficit in the aftermath of disasters – in contrast to countries with developed insurance markets (see next page). The latter can shoulder part of the disaster costs and facilitate accelerated recovery.

Increase in severe typhoon activity

Apart from the number of landfalls at typhoon strength in 2013, other parameters also reflect somewhat enhanced activity compared to the last few years. In 2013, 16 typhoons were recorded in the Western North Pacific basin – one more than the annual maximum of 15 typhoons recorded in the previous seven years. Including named storms below typhoon strength, 29 tropical cyclones (TC) were observed, which tallies with the long-term average of 26.1 (1965–2012) and nearly equals the level of 30 TCs last observed in 2004. Regarding basin-wide activity, 2013 cannot be termed a particularly strong year. The 16 recorded typhoons closely match the long-term mean of 16.3 (1965–2012). Over the same period, an average of 3.9 super typhoons (at least 240 km/h) occurred per year, hence the five super typhoons of 2013 reflect slightly enhanced severe typhoon activity.

As was recently demonstrated in Munich Re's publication *Severe weather in Eastern Asia*, there are indications of the existence of a multi-decade typhoon oscillation in the Western North Pacific basin, translating into multi-decade loss variability. Most interesting is the fact that higher levels of landfalls at typhoon strength correlate well with higher levels of normalised typhoon losses from all of Eastern Asia, according to data available since 1980. This is shown by the diagram on the previous page, in which the typhoon landfall data are shown as a curve smoothed by a low-pass filter.

Although the 2013 season was somewhat stronger than the preceding seasons, data from a single season are not enough to surmise a robust rise in activity. Another five years or so of monitoring will be necessary to confirm a switch of phases. The 2013 season might be a first indicator of the expected upswing, given that the occurrence of five super typhoons in one season is a rare event during quiet periods. If we start from the period of the oscillation in landfalls at typhoon intensity observed since 1950 and assume a continuation of this period (which need not be the case), we would end up with the scenario of a new relative maximum in the 2020s.

In such a scenario, China, Japan, South Korea and the Philippines would be the main contributors to losses. China is particularly prominent due to the enormous length of its coastline and the rapid build-up of exposure over recent decades. Hence, in addition to the rise in destructible wealth due to the strong economic growth of the region, the scenario of an upswing in typhoon activity would strongly contribute to the future vulnerability of Eastern Asia.

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Insurance against natural catastrophes is essential, particularly in developing and emerging economies

It is precisely because natural catastrophes present such a threat to the economies of developing and emerging countries that insurance provides such effective protection for these nations' economic development. This is borne out by the results of research analysing loss history over the past decades.

Hans-Jörg Beilharz, Benedikt Rauch and Christina Wallner

Inflation-adjusted figures in Munich Re's NatCatSERVICE database show a clear trend: direct overall economic and insured losses from natural catastrophes have increased during recent decades. One important reason for this is the rapid economic growth in many developing and emerging countries. But urbanisation of seriously exposed coastal and river regions as well as more frequent severe weather events have also contributed to this development.

Economic consequences of natural catastrophes

It is the countries with lower per-capita income which must usually overcome larger economic losses from natural catastrophes relative to their overall economic strength than countries with higher per-capita income. Therefore, emerging economies often lack the financial resources needed for the prevention of catastrophes and for disaster relief. The Indian Ocean tsunami of December 2004, which alone killed 220,000 people, caused direct overall economic losses of more than US$ 11bn.

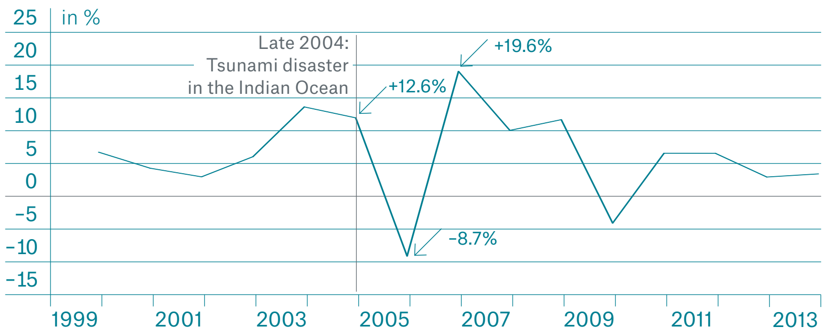
Even more costly were the 2010 earthquake and tsunami in Chile, with overall losses of US$ 30bn (which equates to 14% of the country's GDP) and the flooding in Thailand in 2011 (US$ 43bn or 12% of GDP). 65 of Thailand's 77 provinces were affected by the flood, hundreds of thousands of homes, a huge amount of agricultural land and important industrial areas were flooded.

Indirect losses from natural catastrophes such as delays or interruptions to production must be added to these figures. The result was that during the most serious phase of the floods in the fourth quarter of 2011, Thailand's GDP shrank by 2.5% compared with the previous quarter. The World Bank has also calculated that indirect losses from typhoons reduce GDP growth in the Philippines every year by 0.8 percentage points. Negative indirect effects are also evident in other important macroeconomic parameters such as government debt or external trade. In Chile, for example, debt rose by around 70% in 2010, the earthquake year, and the balance of trade collapsed. In a comprehensive study undertaken in 2011, Martin Melecky and Claudio Raddatz of the World Bank provided evidence of a statistically significant deviation from the historical trend of the per-capita government debt in emerging economies after "major" natural catastrophes. According to this study, there was a significant increase in the debt burden of almost 30% within five years.

Growth and reconstruction

It is often assumed that natural catastrophes (notwithstanding the tragic human consequences) can have a positive effect on an economy because reconstruction acts as an economic stimulus. New production facilities and infrastructure are generally of better quality than the old assets that were destroyed. Several examples of this can be found. Thailand experienced a strong upswing in the year after the floods. After the tsunami at the end of 2004, the economy of the Maldives shrank by 8.7% in 2005. However, it then grew by a massive 19.6% in 2006 – its strongest growth in more than 20 years. But we must remember that the above-average

Tsunami hits growth in the Maldives



After the tsunami late 2004, the economy collapsed in 2005. The recovery in 2006 may also be due to reconstruction programmes.

— Real GDP growth in % compared with previous year

Source: IHS Global Insight

growth is due, at least in part, to the low comparison base caused by the catastrophe and that improved figures should be expected for this very reason.

No offsetting effects

Empirical evidence suggests that, on average, the indirect positive effects on wealth cannot offset the indirect losses of all countries and natural catastrophes. With the aid of the Munich Re NatcatSERVICE database, Goetz von Peter et al. demonstrated this in 2012 for "major, devastating and great" natural catastrophes (over 100 dead or US$ 250m direct losses after adjustment for inflation). They found a statistically significant GDP reduction of almost 4% after five years when compared with catastrophe-free GDP development. Furthermore, developing and emerging economies are faced with substantially larger overall losses on average (direct and indirect) in relation to GDP than wealthy industrialised countries.

The results of scientific studies provide clear evidence of the appreciable positive role played by efficient financial and insurance markets. If adequate insurance cover is in place, this can mitigate the catastrophic impact of natural events in at least two respects. Firstly, insurance cover has a preventive effect – for example, through the way in which policy terms and conditions are formulated or by providing information. Insurance premiums provide signals which play a particularly important role in creating this preventive effect. They allocate a price to the risk to be insured, thereby increasing the incentive to lower this price by taking measures to minimise the risk. Secondly, insurance helps to provide prompt financial relief by means of rapid payouts, which in turn help to limit indirect losses, for example because factories can be reconstructed without delay.

More recent studies show that given two countries with identical per-capita income, the country with higher insurance cover will be better able to withstand natural catastrophes. The studies focus on natural catastrophes above a certain severity or scale. Each one uses a different analysis method, yet all come to the same conclusion – independent of other factors such as prosperity, institutional strength and social homogeneity, insurance has a statistically demonstrable positive effect. This applies not only to the individuals who are insured but also to the economy as a whole. Similarly, the higher the insurance cover against natural catastrophes, the lower the anticipated government debt, external trade deficit and macroeconomic impact.

Loss-mitigating effect

The presumption that emerging economies particularly benefit from additional insurance cover is strongly supported by a study undertaken by Englmaier and Stowasser (2013). Munich Re Economic Research was closely involved in this project. Based on the estimates of the two authors, the greatest loss-minimising effects are most evident in countries with "average" insurance penetration, as is often the case in emerging economies. However, the additional benefits of insurance cover in developing economies should not be forgotten, either. For example, the mandatory loss prevention measures stipulated in insurance contracts alone can significantly reduce fatalities.

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Typhoon Haiyan

Poor countries again bear the brunt of the damage

Climate expert Prof. Peter Höppe, Head of Munich Re's Geo Risks Research/Corporate Climate Centre
phoeppe@munichre.com

Typhoon Haiyan, which cost the lives of more than 6,000 people, was the natural catastrophe with the highest death toll in 2013 – and once again it was a developing country, this time the Philippines, that claimed this sad record.

Of the 20,500 people in the world who lost their lives in natural catastrophes, 83% were in the two lowest-income country groups. Even though the material losses from Typhoon Haiyan appear low at approximately US$ 10bn (Hurricane Katrina alone caused over US$ 125bn of direct losses in the USA in 2005), they made a deep dent in the Philippine economy. Property valued at around 4% of the country's GDP was destroyed. Only about 7% of the losses were insured and the balance cannot be recovered without placing a huge additional burden on the country's population or the national budget. This will weigh heavily on the Philippine economy for years to come.

By contrast, take the example of the hailstorms which moved across Germany in the summer of 2013. Although they caused overall damage of US$ 4.8bn, making them the world's most destructive hail event to date, they had no significant consequences for the German economy. Almost 80% of the losses were insured; the remaining part, totalling approximately US$ 1bn, represents only 0.03% of the German GDP.

Poor and rich countries differ from one another not only in the extent to which they are affected by natural catastrophes but also in the extent to which they undertake loss prevention. As developing countries simply do not have the means for such measures, they are, relatively speaking, always more susceptible to natural catastrophes than rich countries. Worse still, the storm surge caused by Typhoon Haiyan proved to be particularly devastating, as not only were there no protective measures such as dykes but in many places large areas of mangrove forests had been uprooted to make way for shrimp farms in the absence of other sources of income.

> "As it is simply not financially viable to prevent all damage, greater focus should be placed on insurance solutions."

By contrast, many rich countries have been able to reduce their vulnerability to storm surges and floods through major investment. Winter Storm Xaver, whose storm surge hit Hamburg in December 2013, demonstrated the success of these measures. Although the water rose almost half a metre higher than during the catastrophic floods of 1962, this time there was no damage to speak of. The investments in flood protection since the 1960s costing about €2bn in total have already paid for themselves several times over.

How can the poorer countries be helped? First of all, it would be necessary to take more measures to prevent major damage from occurring. A large part of development aid should be used specifically for this purpose, with the primary focus on measures to protect human life. As it is simply not financially viable to prevent all damage, greater focus should be placed on insurance solutions. Industrial countries could at least provide the seed capital for the development of appropriate systems. These types of insurance demonstrably produce a stabilising effect as rapid claims payments after a catastrophe help to avoid secondary losses. The "Warsaw International Mechanism" agreed at the World Climate Summit in December 2013 could also make a contribution to insurance solutions in the medium term. Using this mechanism, it would be possible to make money and expertise available to the developing world so that it can better overcome the burgeoning losses from the growing number of extreme weather events ("loss and damage").

Not least because of their responsibility for climate change, industrial countries must support preventive measures and ex post risk management by providing insurance for poor countries. More stable conditions in the countries affected should in any case also bring benefits to the donor countries over the long term.

Floods in central Europe

Continuous heavy rain at the end of May and beginning of June 2013 in many parts of central Europe caused serious flooding. It was widespread in the south and east of Germany but the Czech Republic and Austria were also seriously affected.

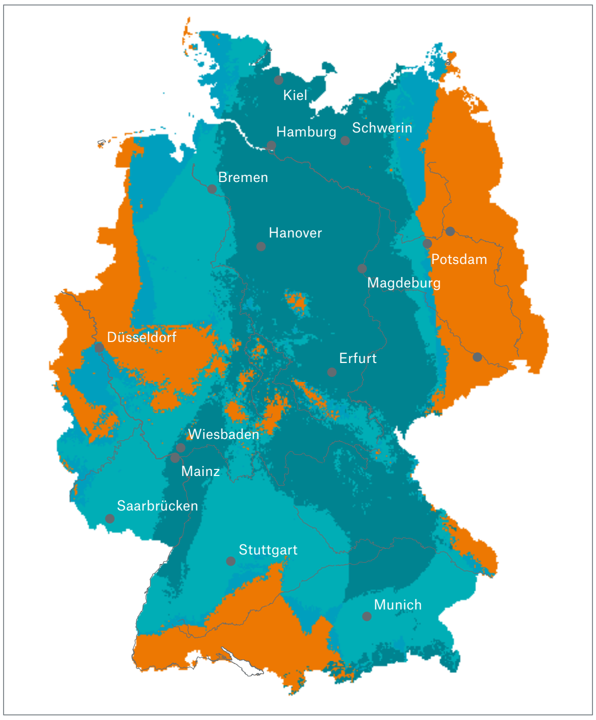
Tobias Ellenrieder and Alfons Maier

A very wet May 2013 with rainfall well above the long-term average meant that the ground could scarcely absorb any more rain. In some regions the highest soil moisture content for over 50 years was recorded. In May, 178% of the long-term monthly precipitation fell across the whole of Germany, the second highest level since records began in 1881. At the end of the month, an upper-atmosphere low-pressure zone moved slowly eastwards and attracted a continuous stream of moist subtropical air to central Europe from south-east Europe, spread in a wide arc. Along with a strong northerly airstream, these air masses triggered very heavy rain on the northern slopes of the Central German Uplands and the Alps. Some areas experienced a total of over 400 mm of rain within a few days.

As the ground was already saturated with water, the additional rain soon found its way into the rivers. In a first stage, smaller tributaries overflowed their banks before flood waves developed in major rivers such as the Danube and the Elbe. While there was only moderate flooding in the southwest of Germany along the Neckar, Mosel and Rhine, the authorities in parts of southern Bavaria and Austria declared a full-scale emergency. In Upper Bavaria, parts of the city of Rosenheim, which lies at the confluence of the Mangfall and Inn, had to be evacuated after embankments were breached.

Fischerdorf on the Danube suffered more than most places from the flooding, with many buildings submerged under water after a dyke collapsed.

Extreme soil moisture values on 26 May 2013



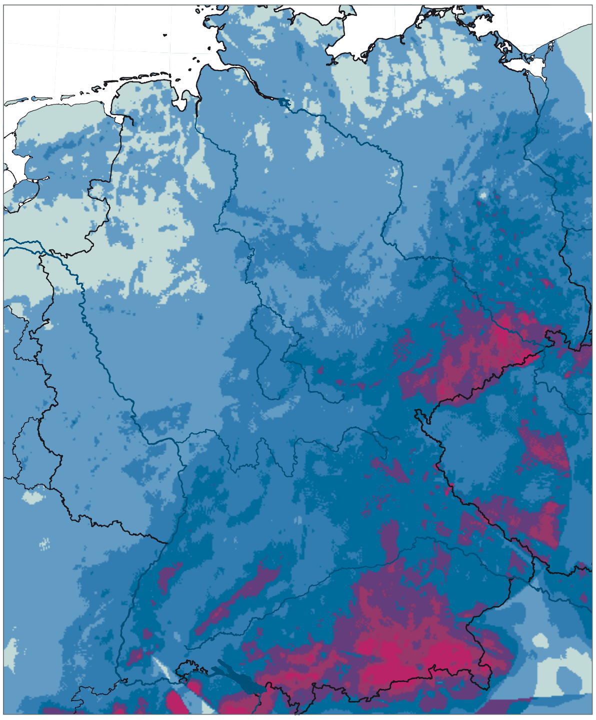
- Highest soil moisture level exceeded
- Second highest soil moisture level exceeded
- Third highest soil moisture level exceeded
- No maximum exceeded

Source: German Weather Service/Agrometeorology

Thousands of houses between Regensburg and Passau were under water, and the inhabitants of Deggendorf and surrounding areas had to battle with severe flooding. In Passau, where the Danube, Inn and Ilz meet, the water level reached 12.89 m – a level that has not been recorded since 1501. Large parts of the Old City were under water.

Eastern Germany, particularly the states of Saxony, Saxony-Anhalt and Thuringia, was also severely affected. Smaller rivers flooded towns and villages, for example Zwickau and Chemnitz. In Meissen, the Elbe breached its flood walls in the night of 3 to 4 June. In Dresden, the river reached a peak of 8.75 m, which corresponds to a discharge of 4,370 m^3/s. However, at this level it was well under the record established in August 2002 (a level of 9.40 m and a discharge of > 4,500 m^3/s). The fact that the historic centre of Dresden was largely spared in 2013 was also due to improved flood protection. Because, unlike 2002, the flow of the Elbe was not relieved by overflowing its banks and by breaches in its dykes, this time a major flood wave propagated downstream. Many measurements in Saxony-Anhalt recorded water levels higher than in 2002, and in Magdeburg the Elbe even reached a new record of 7.48 m.

Precipitation levels in central Europe from 27 May to 2 June



- 0–10 mm
- 10–50 mm
- 50–90 mm
- 90–130 mm
- 130–170 mm
- 170–210 mm
- >210 mm

Source: German Weather Service/Hydrometeorology

In spite of very heavy rains, Switzerland experienced only localised flooding. The protective measures taken after the experiences of 2005 and 2007 clearly prevented anything worse. Occasional debris flows were experienced.

Local flooding and mudslides also occurred in Austria, mainly in the states of Tyrol and Salzburg. Extremely high water levels were measured in the larger rivers such as the Inn. In Upper and Lower Austria, the Danube flooded many areas. Originating in Passau, the flood hit Schärding, Melk and Linz. The flood waters reached levels which are only expected about every 100 years on average. In Vienna, some of the flood water was diverted into the "New Danube" relief channel, making it possible to restrict the flooding to a few streets.

In the Czech Republic, it was mainly the western parts of the country that were affected by the floods. Flood warnings were issued for 400 towns and cities, and at least 11 people lost their lives. In Prague, the Vltava reached a critical level but the discharge of 3,000 m^3/s was less than during the disastrous floods of 2002 when almost 5,000 m^3/s were measured. On the Elbe, parts of the industrial city of Ústí nad Labem were flooded.

Oversimplistic explanations

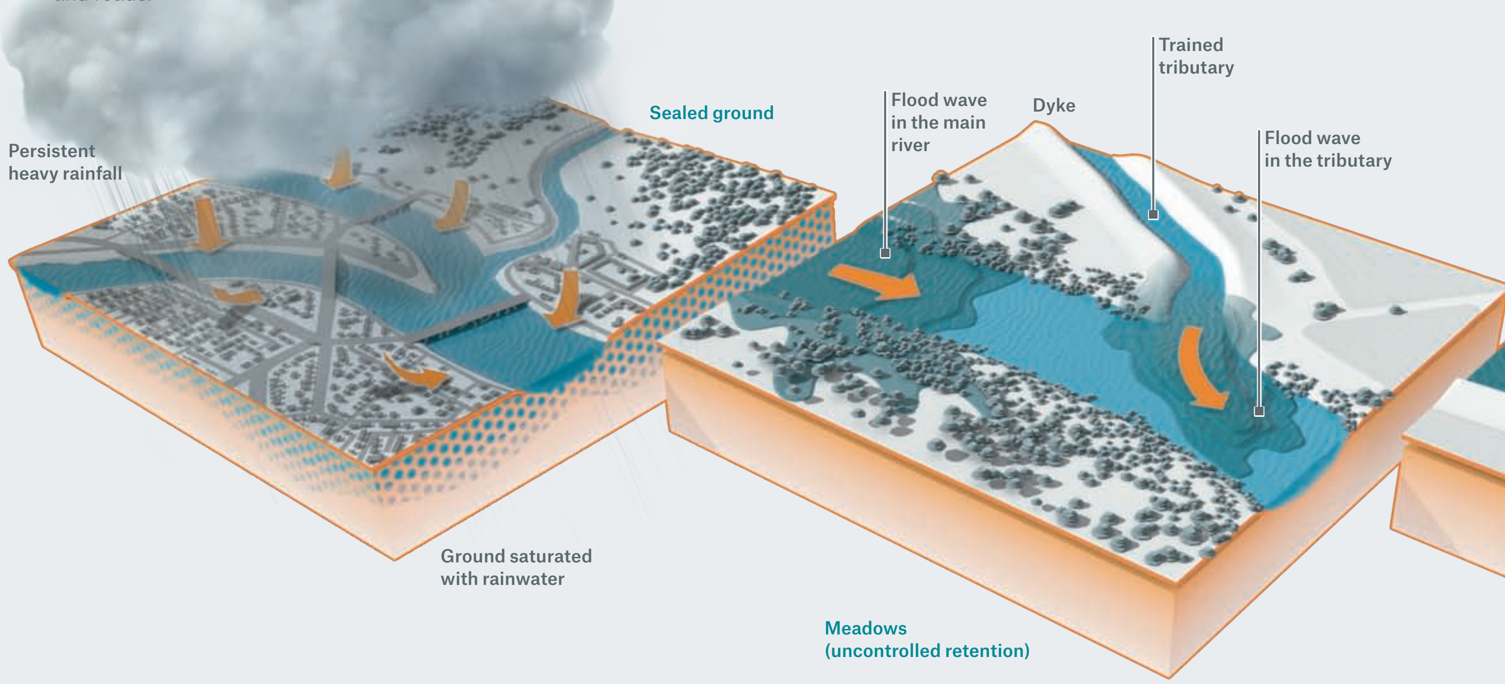
Many observers are often quick to allot blame or suggest simple solutions after floods. When doing so, they are happy to generalise about the effect of various influencing factors and remedial measures and normally overestimate their impact. Flood management is complex and must be customised to each specific situation. One particular measure can be very efficient in one case but practically ineffective in another. Here are three particularly widespread misconceptions:

Misconception 1

A major cause of extreme flood events is the sealing of the ground as the result of the construction of houses and roads.

Misconception 2

Relocating dykes and river restoration prevent floods; canalised rivers exacerbate floods.



Fact 1

Sealing makes almost no difference in large-scale events. The ability of the ground to store water is often exhausted after heavy precipitation with the result that rain flows directly into rivers and lakes from natural areas. However, sealing often plays a decisive role in cases involving torrential rain in localised urban areas.

Fact 2

River restoration can be helpful but its effects are very limited in an extreme flood. The primary objective of flood management is to cap the discharge peak. But in cases where the flow is uncontrolled, the flood plains often fill at the beginning of the flood wave and are not available when things get serious. However, delaying the time of the discharge peak helps flood defence.

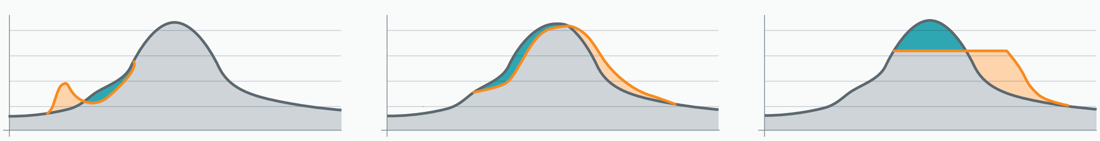
The discharge peak from the main river and the tributary should not coincide. But this can happen irrespective of whether a river has been canalised or follows its natural course, as the path the precipitation follows plays a role.

Flood management measures can crucially change the flood hydrograph. What counts is that the height of the flood peak is as low as possible.

1 Impact of sealing

2 Impact of uncontrolled retention (meadows)

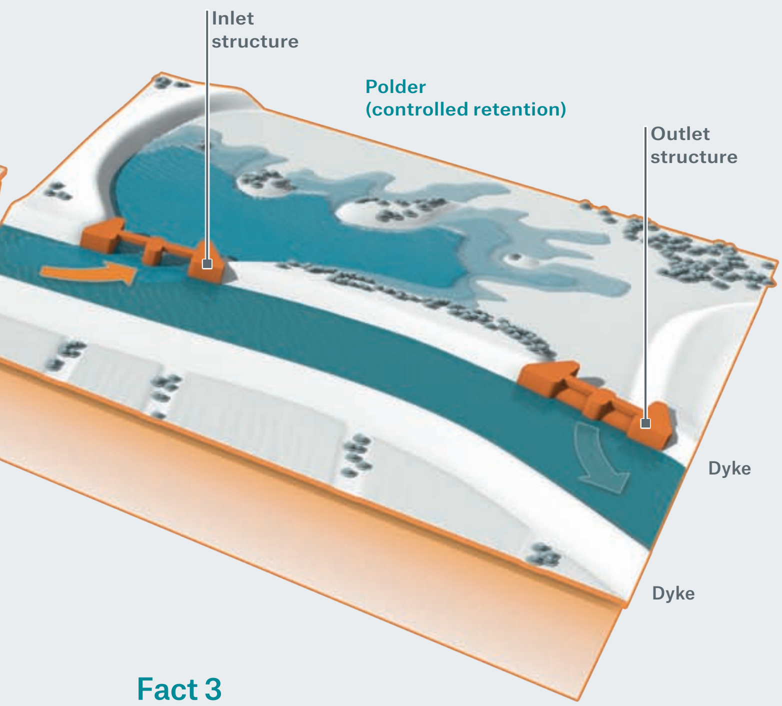
3 Impact of controlled retention (polders, dams)



Key: Original flood wave — Modified flood wave — Shift in volume due to impact factor

Misconception 3

Artificial polders destroy the river environment and restrict agricultural use of the land.



Fact 3

Controlled retention using retention basins or by means of polders (i.e. the lateral diversion of the water) is the most efficient way of influencing a flood wave. However, this requires reliable and accurate forecasting. Retention is controlled so that the volume of the retention area is optimally used for capping the flood peak. Polders which are intended for large events can be used for agricultural purposes (grassland) and are only rarely flooded (for example, every 20 years on average). If appropriate compensation is paid, all parties involved can benefit.

Source: Munich Re

In Poland the southwest of the country was affected by the flooding. But evacuations were only reported from some rural areas. The damage was also limited in Slovakia, although the Danube reached a maximum discharge rate of 10,530 m^3/s in Bratislava. As the flood moved on from Slovakia, it finally reached Hungary, flooding places such as Györ and Esztergom. The highest level in Budapest (8.91 m) was reached on 9 June. Although this water level was 30 cm higher than the previous record set in 2006 (and 40 cm higher than in 2002), damage here was moderate. The flood control measures on the Danube are designed to cope with water levels of up to 9.30 m. However, rising groundwater and overflows from sewers did cause local flooding.

Comparison with earlier events

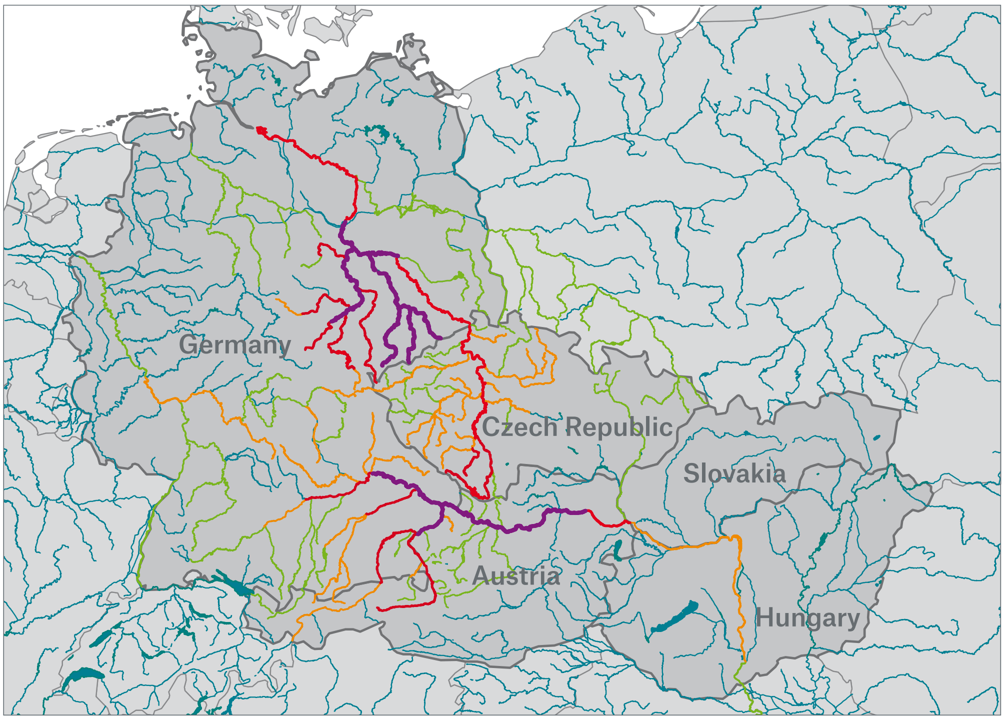
After the flooding of 1954 and 2002, the 2013 flood was the third most serious event in the last 60 years to affect the catchment areas of the Danube and Elbe at the same time. However, closer examination reveals some differences. For example, the discharges measured on the Danube this time were generally higher than in 2002 and 1954. And while in 2002 the flood wave was mainly fed by flows from rivers in its headwaters (the Iller and Lech) and in 1954 the eastern tributaries of the Danube (the Isar, Inn and Naab) contributed major volumes of water, in 2013 almost all the German tributaries of the Danube contributed to the flood wave. Further downstream too, in Austria, Slovakia and Hungary, the water levels were significantly higher than in 2002. On the other hand, many tributaries did not experience severe floods on this occasion.

The flood on the Elbe, which originated in the Czech Republic, was lower than in 2002. However, in 2013 the catchment area of the Saale was also affected. As a result of the meeting of the flood waves on the Elbe, Mulde and Saale, water levels in the Elbe downstream of its confluence with the Saale were significantly higher than in 2002.

Impact and losses

According to information from the Center for Disaster Management and Risk Reduction Technology (CEDIM), from a hydrological viewpoint the flooding in Germany significantly exceeded the events of 1954 and 2002 with regard to severity and extent. Almost 50% of the German river network experienced flooding with a return period of more than five years.

Intensity of flooding on the rivers of central Europe



The severity of flooding is calculated from the level/return period of the discharge peak and the duration of the event.

– Not affected
– Moderately affected
– Seriously affected
– Very seriously affected
– Extremely affected

Source: CEDIM, Munich Re

In central Europe the flooding caused an overall economic loss of €11.7bn, €10bn of which was in Germany alone. Twenty-five people lost their lives. In this respect, the 2013 floods were less damaging than those of 2002, which cost the lives of 39 people and caused damage amounting to €17bn (original values, not adjusted for inflation). This is partly due to differences in the characteristics of the flood. The lower intensity of the rain in the Elbe catchment area in 2013 triggered fewer flash floods and therefore less damage to the infrastructure, for example from scouring of roads and railways. A further factor was the improved system of flood protection with new or reinforced dykes. For example, the mobile flood barriers in Prague, Dresden, Bratislava and Budapest were able to withstand the water.

Insured losses amounted to approximately €2.4bn, €1.8bn of which were in Germany, €235m in Austria and €300m in the Czech Republic. Insured losses in Switzerland are reported to be CHF 45m and approximately €3.5m in the other countries affected by the floods. Insured losses were therefore lower than in 2002. The Czech Republic and Austria benefited from the fact that a smaller area was flooded in 2013 and that, particularly in the Czech Republic, new insurance policies introduced after 2002 with lower limits restricted individual losses.

Although insured losses in Germany (€1.8bn) were similar to those in 2002, the cost to the insurance industry was less after adjusting for inflation. As well as the different characteristics of the floods of 2002 and 2013, improved flood defences and other measures to reduce damage also contributed to the lower loss figures.

The risk management approach taken by the Dresden water utility demonstrates how important it is to learn from the lessons of earlier events: after the floods of 2002, structural, technical and organisational changes were made. Thanks to the rapid formation of a crisis management team, effective communication with all concerned and improved flood protection measures at crucial facilities (buoyancy prevention and protection of power supplies), damage in 2013 was only about one-quarter that of 2002. In addition, it proved possible to reduce the business interruption period of one water treatment plant from the 160 days of 2002 to only 18 days in 2013.

Housing companies were also better prepared for floods. After suffering serious damage in underground car parks and electrical operating systems in 2002, the owners of three apartment blocks developed an alarm plan. Systematic implementation of this plan reduced damage by 50% – at a comparable flood level.

Even if natural hazard insurance, which comes into play in the event of floods, is now more widespread in Germany than in 2002, average penetration across the country is still only 33% – with major regional differences. Although about 40% of homeowners in Saxony, Saxony-Anhalt and Thuringia are insured against flood risks, the proportion in Bavaria is 21% and in Lower Saxony only 13%. In many cases, the costs were borne by the people themselves or paid by public assistance programmes. This once again prompted debates about the introduction of obligatory natural hazards cover.

Loss potential and loss prevention

The best strategy to avoid flood damage is, in the first instance, not to build in areas prone to flooding. But where this simple fact has been ignored, the risk of damage can be reduced in three stages: by diverting the water into flood polders, retention areas or flood control basins, through defensive measures (backwater gates, the protection of windows and doors) and by controlled admission (flooding a building).

Much of the damage occurs in high-risk areas. In such cases, hazard maps can make a significant contribution to increasing risk awareness. After a flood, rebuilding should also pay much closer attention to flood protection.

The creation of an alarm plan has proved its value once again. It enables suitable preparations to be made and action to be taken as part of an overall concept. At the same time, the precautions should be regularly tested and exercises held.

In addition, structural and technical changes to buildings can prevent or reduce damage. For example, building installations could be located in parts of the building which floods cannot reach, interior fittings and finishes could be designed to be water resistant, building apertures and entrances could be better protected. In areas prone to flooding, insurance cover could be made contingent upon the existence of such precautions. The insurance industry with its expert knowledge is an ideal partner to discuss ways and means of reducing flood risks.

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2013 – The year of floods

It wasn't just central Europe that found itself submerged under water last year. Many other parts of the world also experienced major flooding. Rarely has this natural hazard so dominated the annual statistics as in 2013.

Wolfgang Kron

Virtually all types and causes of flooding were to be found among the major events: sudden local flash floods, torrential rainfall lasting several days in mountainous areas, rain combined with snowmelt, long-lasting river flooding over large areas as well as destructive storm surges associated with tropical cyclones. The summary which follows contains a selection of the most significant events.

January: Australia and Indonesia

In what has almost become an annual event, the year began with floods in Queensland and on Java. While the state of Queensland escaped more lightly than in previous years, unusually heavy seasonal rainfall affected the region around Jakarta as rarely before. Rivers broke their banks and a major dyke breach caused losses amounting to US$ 3bn. About 10% of this was covered by insurance. More than 100,000 houses were damaged or destroyed and 47 people lost their lives.

June: Uttarakhand/India

In May and June of every year Hindu pilgrims make their way through the valleys of the Himalayas in the Indian state of Uttarakhand to visit holy places such as the temple in the city of Kedarnath. More than 100,000 people were on the move in June 2013. They were hit by the most violent monsoon rains for 80 years, which had arrived unexpectedly early and without warning. Torrential rain fell for 50 hours; some places recorded a total of over 500 mm of rain. The flood waters transformed narrow gorges into raging torrents, caused hillsides to collapse, washed roads, bridges and buildings away – along with hundreds of people. Tens of thousands of pilgrims were stranded for several days in cold and wet conditions, surrounded by swirling mountain streams, freezing and hungry. Not even helicopters could fly in these adverse conditions, with the result that survivors could only be rescued several days later.

Stranded pilgrims in Uttarakhand wait to be evacuated.

Many spoke of a "Himalayan tsunami". But the disaster was also caused by the careless or illegal construction of roads and villages. It claimed the lives of over 5,500 people, making it the natural catastrophe in 2013 with the second highest cost to human life after Typhoon Haiyan.

June/July: Alberta and Ontario/Canada

Three days of unbroken torrential rain triggered what were probably the most serious floods ever experienced in the history of the Province of Alberta in western Canada. Rivers overflowed their banks, washed away roads and bridges, flooded houses and transformed streets into mud-brown torrents. The flooding was made worse by the already high level of ground moisture when the rain began. The snowmelt had already started and considerable quantities of snow still remained. Rain on snow, a situation which arises only rarely in Alberta, caused river levels to rise rapidly. The flow rate of the Bow River increased tenfold over a very short period – which proved to be calamitous for the million-strong city of Calgary and Medicine Hat in the south of the province. The water was several metres deep in downtown Calgary, in the Saddledome ice hockey stadium and in the grounds of the world-famous Calgary Stampede. Some of the animals in the zoo had to be evacuated. Losses totalled almost US$ 6bn, of which about US$ 1.6bn were insured. It was Canada's most costly natural catastrophe to date. Only two weeks later Canada experienced floods again, but this time in and around Toronto. Storms with flash flooding caused an overall loss of US$ 1.6bn and insured losses of almost US$ 1bn.

August/September: Russia and northeast China

The city of Khabarovsk in eastern Siberia lies on the Amur, the river which marks the border with China, where it is called the Heilongjiang. After the most serious flooding for decades, the city was in the news for several days. The floods affected not only Siberia, but extended across the whole of northeastern China, where the damage was even greater. Agriculture was particularly hard hit in the river basins of the Liao and Songhua and their tributaries. Of the overall losses of about US$ 4bn, 1bn occurred in Russia and 3bn in China. Apart from covered agricultural losses of US$ 400m, only a very small part was insured in either country.

September: Colorado/USA

An almost stationary area of low pressure over the Great Plains drew moist air from the south along a corridor towards the Rocky Mountains for one week. In some areas, the continuous rain on the slopes of the mountains totalled more than 500 mm. The water flooded downhill through canyons, often directly into inhabited areas and in some cases dug entirely new channels for itself. It soon reached the plain and flooded large areas of agricultural land, particularly along the South Platte River. Over 100,000 litres of oil polluted the water after several storage sites were flooded. The authorities declared a state of emergency in 17 counties along an area extending for 300 kilometres. Overall losses amounted to approximately US$ 1.5bn. It will cost about half a billion dollars just to repair the 120 bridges and 800 kilometres of roads affected. The rest of the losses result from some 20,000 houses which were damaged or destroyed, as well as from damage to commercial and public buildings, mobile homes and cars. Losses amounting to US$ 155m were covered by private insurance, and just under US$ 10m by the National Flood Insurance Program. Nine people were killed.

September: Pacific coast and Gulf of Mexico coast

Unlike the USA, Mexico was not spared by tropical cyclones in 2013. Atlantic hurricane Ingrid and Pacific hurricane Manuel approached the country in a pincer movement in September. Within ten days up to 1,000 mm of rain fell in almost all coastal areas. The tourist centres of Acapulco and Culiacán on the Pacific and the state of Veracruz on the Gulf of Mexico were particularly hard hit. Tens of thousands of people were cut off for several days in Acapulco after landslides

Portable buildings piled up by flood waters.

and scouring made roads in and out of the city unpassable, and some airports were inundated. 13,500 houses were flooded and 157 people died, many of them in landslides. The insured loss came to almost US$ 1bn, about one-sixth of the overall loss.

November: Sardinia/Italy

On 19 November Sardinia fell victim to an unusually violent storm front ("Cleopatra"). Over 300 mm of rain fell in just a few hours. Water transformed streams, ditches and roads into raging torrents that carried away houses and cars and flooded cellars. Sixteen people were killed in the flash floods.

December: Storm surge in the North Sea

The good news: Although Winter Storm "Xaver" caused a severe storm surge on the German North Sea coast at the beginning of December, there was almost no damage. And this in spite of the fact that the surge peaked at a level 39 cm higher than in the catastrophic floods of 1962 – the second highest level since records began. The improvements to flood protection over the last 60 years prevented anything worse and paid off in the true sense of the word.

OUR EXPERT

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Record losses from hail

Hailstones larger than golf balls caused severe damage in parts of Germany in late July/early August 2013. According to the German Insurance Association (GDV), chipped façades, shattered glass and dented cars caused by the German hail season cost the insurers €4bn – a new record.

The different coloured tarpaulins covering broken roof tiles provided an unwelcome splash of colour in the Tübingen-Reutlingen area of Germany. In some places, 90% of the buildings were damaged.

Peter Miesen and Alfons Maier

Hailstorms can be delineated quite well, both spatially and temporally, by focusing on events with hailstone sizes upwards of 4 cm. Structural damage can be expected beyond this threshold value. This is what occurred on 27 July in North Rhine-Westphalia and Lower Saxony, where storms primarily affected regions along a line from northeast of the Ruhr area to Wolfsburg with hailstones of up to 8 cm. On 28 July, hailstones as large as 10 cm in diameter fell along a line from Villingen-Schwenningen to Schwäbisch Hall in Baden-Württemberg. During another event on 6 August, Baden-Württemberg, Saxony and Bavaria were hit by hailstorms. A hailstone with a diameter of 14 cm, a size never before recorded in Germany, was found at Undingen, a town near Reutlingen. The world record is held by a hailstone from the USA (Vivian, South Dakota), which had a diameter of 20 cm and fell on 23 July 2010.

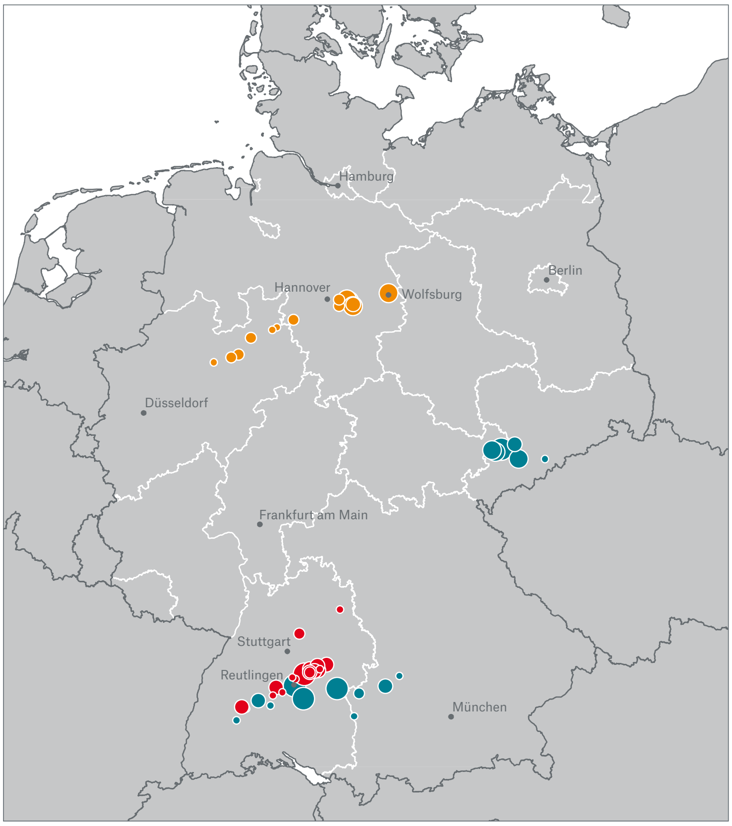
Ideal weather conditions for thunderstorms

A persistent trough over the eastern Atlantic, which was responsible for the weather in western Europe in late July, was the cause of the storms. In other words, ideal conditions existed for the development of severe thunderstorms, without a particular event being attributable to a particular area of low pressure. Rather, several mesoscale convective systems (MCS) were formed on 27 July due to small disturbances within the warm and humid southwestern flow. Embedded in these MCS were supercells (mesocyclones) which triggered the extreme hailstorms, downbursts and heavy rainfall.

The MCS of 27 July moved to western Germany and was responsible for hail damage in the north. In the afternoon of 28 July in Baden-Württemberg, a squall line appeared with its embedded supercell, as is often the case, before the actual front (cold front from the low-pressure system Andreas) along what is known as a convergence line. The event on 6 August strongly resembled the thunderstorm at the end of July because of the trough situation.

High level of damage in densely populated areas

According to the GDV, last year's violent hailstorms caused overall losses of over €4bn. Of this figure, approximately €1bn is attributable to motor insurance. There were nearly a million property insurance claims for damage to residential and commercial buildings and their contents amounting to €3.1bn. The high level of damage is owed to two factors: the extraordinary size of the hailstones and the passage of the hailstorms over densely populated areas.



Severe storms in Germany on 27/28 July and 6 August 2013

Storms producing hailstones measuring over 4 cm in diameter on 27/28 July and 6 August.

Source: Munich Re, based on data from ESSL

○ 4–5 cm
○ 5–6 cm
○ 6–7 cm
○ 7–8 cm
○ 8–12 cm

● 27 July 2013
● 28 July 2013
● 6 August 2013

Typical damage to buildings, particularly older structures, consisted of shattered or broken roof tiles, through which rainwater leaked into buildings. This proved to be particularly damaging in Baden-Württemberg on 29 July, one day after the heavy storms, when extensive rain fell in the area. The Stuttgart-Echterdingen weather station registered 30 mm of rain, the second largest amount to fall on a single day in 12 months.

Also, solar installations, both solar thermal and photovoltaic, generally failed to withstand the heavy hail, as their modules are not designed to cope with hailstones 8 cm or more in diameter.

Rapid response helps reduce hail damage

As Head of the Claims Department at SV SparkassenVersicherung, Peter Philipp has been advancing the development of customer-oriented claims management for many years. Two severe hailstorms enabled his team to demonstrate the importance of proactive planning.

Munich Re: Mr. Philipp, hail events in 2013 produced a record insured loss of €4bn. As the leading insurer of buildings in one of the affected regions, how do you classify the events?

Philipp: The hailstorm in late July 2013 was an extraordinary event. Hailstones, some as large as tennis balls, flew almost horizontally while the storm raged, smashing window panes and shutters across the region. Afterwards, some houses looked as if they had been hit by artillery. SparkassenVersicherung had to process over 70,000 claims immediately after the hailstorm, mostly in Baden-Württemberg. On 6 August, we had over 15,000 more claims due to a second storm.

What is your primary focus after such massive claims?

The most important thing after such a storm is to inspect the damage as soon as possible, so that we can arrive at a settlement quickly. We immediately sent out 300 adjusters and experts following the hailstorm. They worked non-stop, even over the weekends. After the first week, we had already assessed the damage in 33,000 cases and half of the claims were being processed.

Were you prepared for such a large number of claims?

The greatest challenge with such mass losses was setting priorities. We also had to offer our customers the best-possible support, so that the damage could be repaired as quickly as possible, even though it was the summer holiday season. We decided to inspect all claims over €3,000 and were able to accomplish this.

What exactly does hail damage assessment involve?

The experts look at what, exactly, has been damaged: bricks, façades, insulation or household items, and in commercial or industrial buildings, they inspect technical and commercial installations. Loss of revenue is also considered. And then our people immediately ascertain whether losses can be minimised, whether repair is possible, or whether something needs to be replaced completely. At the end of the assessment, they calculate what the damage will cost and discuss this with the client.

When do the clients receive payment?

Our pledge has always been: “Inspection plus one day.” In other words, the client receives payment one day after the inspection. If it was not possible to assess all the damage in that time, we arranged for a partial payment to be made. Where the losses were fairly straightforward, the clients received full payment immediately.

Have you heard from your clients regarding their level of satisfaction with the handling of claims?

Our claims handling was greatly appreciated by both clients and our sales partners. We had already finalised settlement for half of the claims by the end of 2013. Claims payments at that point were already in excess of €300m. Because we conducted so many inspections and settled quickly and because we provided additional hands-on support through specialist companies, we were able to achieve several positive results. A comparison with claims levels after similar severe hail events shows that we achieved savings of approximately one-third. Nevertheless, the hailstorms in late July proved to be the costliest natural hazard event in our company’s history.

Building façades with exterior insulation finishing systems (EIFS) also proved to be vulnerable. In these cases, the finishing coat is applied considerably thinner than in older façades, reducing resistance to hail. The impact of hailstones can knock the plaster off right down to the reinforcement fabric. Due to the increasing shift to renewable energies, this type of damage, and of course damage to solar installations, will become more common in the future.

As certain parts of the building, such as solar installations, are increasingly susceptible to damage, these are now being tested far more thoroughly. With this in mind, the insurance industry also supports the Research Center of the Insurance Institute for Business & Home Safety (IBHS) in South Carolina, USA. Impressive footage of some tests can be found on the website www.disastersafety.org.

The hailstorms that hit Germany also placed a huge burden on marine and motor insurers. For example, those significantly affected by the storms included not only a great number of car dealerships, but also some large storage sites for automotive manufacturers. The hail battered auto bodies and shattered windshields. In Wolfsburg, more than 10,000 vehicles were damaged at the premises of one automobile manufacturer alone. A tent city was specifically set up in order to inspect the vehicles. Several thousand vehicles at storage yards near Zwickau were also affected.

The extent of damage that hail can cause was demonstrated at the end of July at a storage yard in France, where hail smashed the windows of approximately 70% of the parked vehicles, letting in water. This drove up the cost of repairs substantially due to electrical damage, and consequently about 80% were write-offs.

Newer, well-insulated façades with a thin finishing coat proved to be very susceptible to hail damage.

Given the large number of losses involved, insurers' claims management departments faced a huge challenge. But their contingency plans for handling mass losses proved up to the task. Losses were settled quickly and payments promptly made. Roofing and scaffolding companies from all over Germany were used for the repair work. The claims departments of insurance companies were able to demonstrate their skill and efficiency in the aftermath of this extreme event. Not only were insureds helped quickly, but the coordination and use of service providers also went very smoothly.

OUR EXPERTS

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A quiet year for hurricanes and tornadoes

Over the past decade, large weather catastrophes have repeatedly battered the central and eastern United States. Following multiple hurricane landfalls in 2004, 2005 and 2008, Hurricane Sandy in 2012, plus unprecedented tornado outbreaks in 2008 and 2011, it was a relief to many that 2013 was a relatively quiet year. But why was it so quiet?

Andrew Moore and Mark Bove

The 2013 North Atlantic hurricane season was one of the least active in recent memory, with 13 named storms, two Saffir-Simpson Category 1 hurricanes, and no major hurricanes (Categories 3–5). Activity levels were roughly 30% of normal, based upon the Accumulated Cyclone Energy (ACE) Index, which is a measure of the duration and intensity of every tropical cyclone in a year. Although the number of storms that formed was slightly above the long-term average, most encountered unfavourable atmospheric conditions causing them to be short-lived and remain weak.

The Atlantic did not see a hurricane until the eighth storm of the year, and Humberto's classification as a hurricane at 9 a.m. GMT on 11 September was just three hours shy of setting a record for the latest date for a first hurricane formation. The hurricane count of two was the lowest since 1982, and the maximum intensity achieved by any storm during the season was just 75 knots, the lowest since 1968. The 2013 hurricane season was also the first since 1994 in which no major hurricanes formed in the basin. The inactive hurricane season extended the streak of no major hurricane landfalls in the United States to eight years – the greatest gap since records were first kept in 1878.

Pre-season forecasts anticipated a much more active season, as low levels of wind shear were expected due to neutral ENSO conditions in the Pacific, and warmer than normal sea surface temperatures were foreseen for the tropical Atlantic. While wind shear did remain below normal in the central Atlantic, which favours tropical cyclone development, it was higher than normal in the Caribbean and the Gulf of Mexico, curtailing storm development in these regions. Sea surface temperatures were also warmer than normal, as forecasted, and were not a negative factor on the season's activity levels. Instead, it was other atmospheric factors present in 2013 that hindered tropical cyclone development, and most of these are currently only predictable a few weeks in advance.

Why were there so few hurricanes?

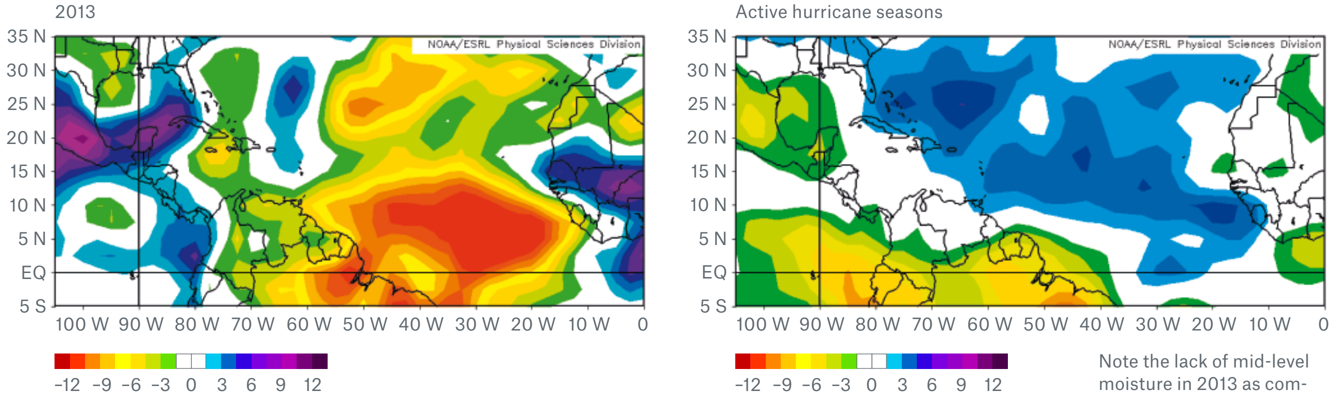
Hurricanes need a moist environment that allows a continuous inflow of moist air at the surface, enabling them to pull in large amounts of energy from the surrounding ocean to fuel convection that acts as the hurricane's engine. A dry environment causes evaporation and cooling, leaving cool air to sink to the surface, effectively choking off the hurricane's energy source.

The 2013 storm season in comparison

Metric	Named tropical storms	Hurricanes	Major hurricanes (Categories 3–5)	ACE index
Long-term average (1950–2012)	11.6	6.3	2.7	103
Recent active era (1995–2012)	15.2	8	3.7	139
2008 season	16	8	5	144
2009 season	9	3	2	51
2010 season	19	12	5	165
2011 season	19	7	4	125
2012 season	19	10	2	133
2013 season	13	2	0	33

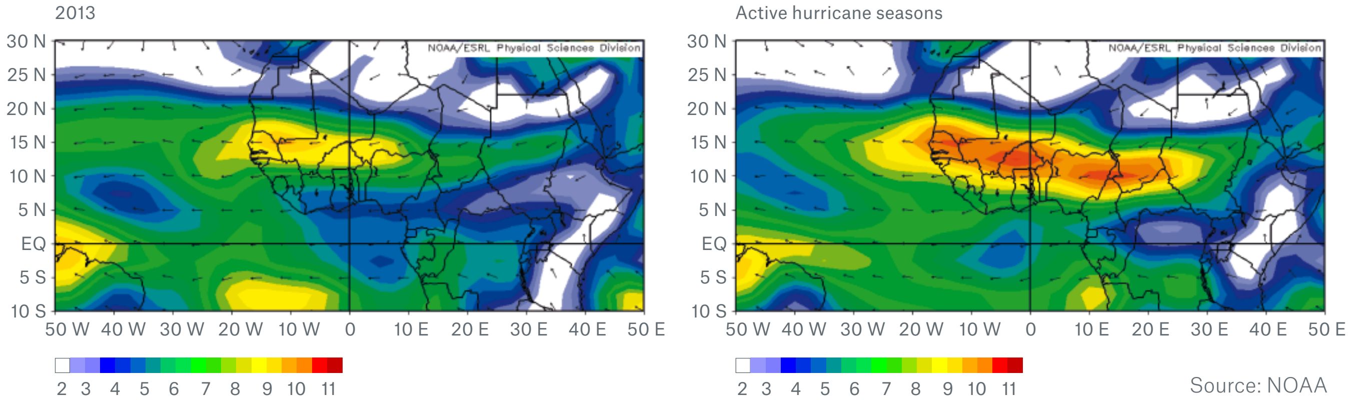
Comparison of 2013 Atlantic hurricane season activity with the previous five years and two historical averages. While the number of named storms in 2013 was between the long-term and recent active era averages, the number of hurricanes and major hurricanes was far below normal.

Relative humidity (RH) anomalies during the period August–October at 500 hPa (about 5,000 m aloft) for 2013 (left) and active hurricane seasons (right)



Note the lack of mid-level moisture in 2013 as compared to active years.

Intensity of the African Easterly Jet (AEJ) during the period August–October 2013 (left) and active hurricane seasons (right)
The AEJ was about 2–4 m/s weaker during the peak of the 2013 season, reducing the vorticity (spin) imparted to tropical waves and inhibiting potential development.



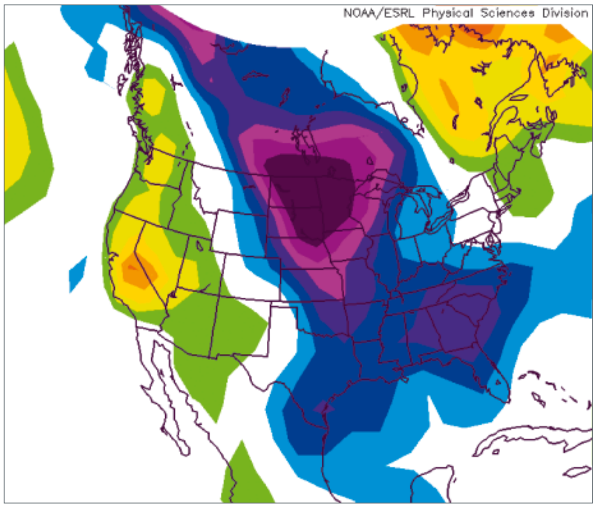
Source: NOAA

A combination of dry air flowing into the region and sinking air at upper levels created extremely dry conditions over the tropical Atlantic during the peak of the 2013 hurricane season, and is believed to be the primary reason for the quiet hurricane season. At the surface, abnormally strong high pressure off the coast of Spain drove dry continental European and Saharan air south into the tropical Atlantic. This also forced the Inter-Tropical Convergence Zone to move farther south than normal, limiting the flow of moisture across the equator into nascent tropical waves that act as the initial stages for hurricane formation as they emerge off Africa. At higher levels in the atmosphere, a pattern of convergent winds persisted throughout much of the season, causing a strong sinking motion and atmospheric drying due to adiabatic heating. Typically, upper-level patterns of convergence would be transitory, and would occasionally be replaced by a diverging flow allowing for rising air that favours hurricane development. Preliminary indications from additional research show that warm ocean anomalies near Southeast Asia may have been a contributing factor.

Another likely contributor to the lack of hurricanes was a weaker than normal African Easterly Jet (AEJ) that provides tropical waves off the African coast with vorticity, or spin. This east-to-west jet is driven by strong temperature differences between the hot Sahara Desert and relatively cool waters in the Gulf of Guinea. More than 80% of the major hurricanes that form in the Atlantic originate from tropical waves that emerge from Africa. But during the peak of the 2013 hurricane season, the AEJ was reduced by 2–4 m/s against average levels, thereby providing less spin for tropical cyclone formation.

An inactive spring tornado season

The United States also experienced its lowest tornado count in over two decades in 2013, with the final official tally from NOAA's Storm Prediction Center reporting only 898 nationwide. Available preliminary counts for hail and straight-line winds were also below a 2005–2012 average, though the tornado counts showed the greatest deviation from average of the three perils. Comparing the 2013 daily cumulative tornado count to the 2003–2012 average reveals that the months of March, April, and May, a period that typically accounts for about half of the year's tornadoes, saw about 260 fewer tornadoes than average in 2013, leading to the lowest tornado count since 1989.



Cold spell

March to May 2013 anomalies for surface temperature showing cooler than normal conditions across much of the eastern United States.

-3 -2 -1 0 1 2 3

Source: NOAA

The lack of tornado activity during the spring was in part due to a strong high pressure anchored over the northeast Pacific Ocean, which forced the polar jet stream much farther north than normal into Alaska before diving southward across the eastern United States. This pattern allowed cool Arctic air masses to dive south over the central United States, keeping the atmosphere stable. Further, this pattern also kept warm, humid tropical air from moving inland from the Gulf of Mexico, limiting the availability of heat and moisture required for severe thunderstorms to develop. In contrast, the three busiest recent years for tornado activity (2004, 2008, 2011) saw a spring jet stream pattern that dove south over the Rocky Mountains before turning back north across the Central Plains and the eastern US. This pattern, often associated with La Niña conditions, allowed warm, unstable tropical air to move into the central US and spur the development of severe thunderstorms. The quiet tornado season of 2013 corresponded well to a neutral ENSO year.

Key events

There were four severe thunderstorm outbreaks in 2013 that caused over US$ 1bn in insured losses, generating more than half of the year's total. The first event, on 18 March, produced ten tornadoes and caused baseball-sized hail in several cities across the Deep South, resulting in an estimated US$ 1.6bn in insured losses, due mainly to hail damage. The fourth event was the largest tornado outbreak ever observed in November, with an estimate of 75 tornadoes touching down in Illinois and the Ohio River Valley, causing widespread damage.

Most notable were the second and third events of the season, which occurred in late May over the central United States. During this period, several disturbances moved along a stalled frontal boundary over the region, triggering repeated rounds of severe thunderstorms over a two-week period. Although damaging storms occurred from Texas to Michigan, the strongest storms were located in and around Oklahoma. On 20 May, an EF5 tornado roared through the towns of Newcastle and Moore, Oklahoma, becoming the fourth significant tornado (rated EF2 or higher) to impact these communities since 1999. The tornado devastated large sections of both communities, destroying over 1,000 homes and heavily damaging the local medical centre and two elementary schools. The Moore tornado alone killed 26 people and injured nearly 400, leaving behind almost US$ 2bn in overall damage.

Almost two weeks later, a second round of severe weather caused a tornado to form just west of the town of El Reno, Oklahoma. Once on the ground, the tornado grew to 4.2 km (2.6 miles) in width, the widest tornado ever observed. Fortunately, this EF3 tornado moved over mostly open terrain, limiting property damage. However, due to the tornado's size and erratic movement, three storm chasers perished when they were overtaken by the storm. In all, the late May thunderstorm outbreaks in the central US caused insured losses in excess of US$ 3.2bn.

Insurance and underwriting aspects

Insured losses in the US due to thunderstorm events in 2013 are currently estimated at US$ 10.5bn. This amount is about US$ 4bn lower than the 2008–2012 average of US$ 14.8bn. The current average is almost US$ 8bn higher than a decade ago and over seven times higher than the 1980–1984 average.

Socio-economic factors continue to be the primary drivers of increasing thunderstorm losses. The southward shift of the US population over the past 50 years has led to rapid growth in vulnerable regions, which has increased the probability that more people could be impacted by an event. Property values and building prices continue to increase, and building codes in many thunderstorm-prone regions are inadequate. Additionally, recent research indicates that changing climate conditions have already increased the variability and frequency of severe thunderstorms and will continue to do so in the coming decades as a warmer, moister atmosphere could lead to greater convective potential in thunderstorms (see the article on thunderstorm losses on page 46).

Hail is the cause of most thunderstorm-related losses, so even seasons with low levels of tornado activity, such as 2013, can still produce billions of dollars in insured losses. However, hail damage can easily be mitigated through use of proper building materials, such as impact-resistant shingles, siding, and windows. Adequate building techniques, such as hurricane straps on roof-to-wall connections, can also reduce the risk of wind damage to a building, but they cannot completely protect a building from a powerful tornado.

Managing thunderstorm risk for a portfolio of property risks remains quite challenging. Altering policy terms, such as the implementation of hail deductibles, may lead to a reduction in incurred losses, but does not address the issue of risk accumulation. Monitoring exposure accumulations within small geographic areas and diversifying your portfolio with several types of property risks remains one of the most effective ways to limit potential losses from a severe thunderstorm outbreak. This type of geographic control, if implemented across an entire portfolio, may reduce the accumulation of losses from larger outbreaks as well as the impact of a single, severe tornado or a hail swath.

OUR EXPERTS

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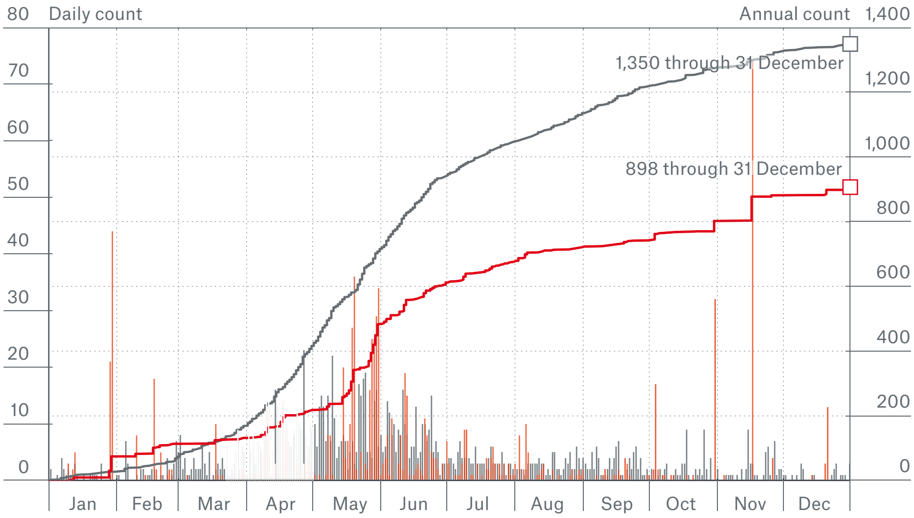


Daily tornado count and cumulative frequency

The annual cumulative frequency curve of daily tornado reports in the year 2013 evolved at levels substantially below the average curve over the period 2003–2012. Daily and annual averages are based on preliminary local storm reports.

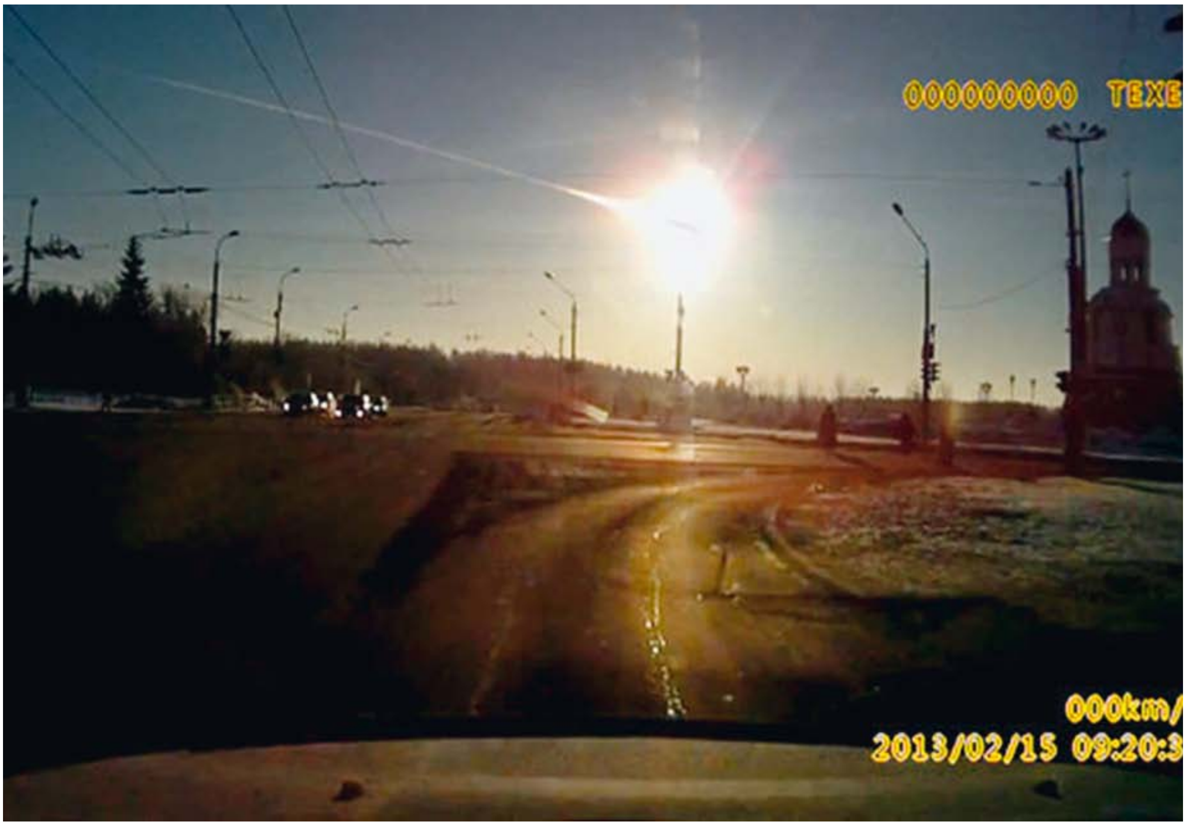
— Average annual cumulative frequency (2003–2012)
— 2013 cumulative frequency

■ Average daily count (2003–2012)
■ 2013 daily count

Source: NOAA, National Weather Service, Storm Prediction Center

Meteor over Chelyabinsk

On the morning of 15 February 2013, a bright light appeared in the sky over the Russian city of Chelyabinsk. A short time later a loud explosion occurred which shattered hundreds of thousands of windows and caused losses in the millions. It transpired that a meteoroid weighing thousands of tonnes had exploded as it entered the atmosphere.



The Chelyabinsk event on a cold, clear winter's morning was captured on numerous cameras and mobile phones, making it the best-documented meteorite impact of all time. Meteoroids only become meteorites when they strike Earth.

Jan Eichner

At 9.20 a.m. local time, a roughly 17-m-wide object entered the Earth's atmosphere at a shallow angle near the million-plus Russian city of Chelyabinsk in the southern Urals region. The object approached from the southeast at a speed of 18.5 km/s. With an estimated weight of more than 12,000 t, the bolide exploded with a force equivalent to 500 kilotonnes of TNT (equivalent to the explosive force of 30 Hiroshima bombs) at a height of roughly 25 km. The flash of light released by the explosion was 30 times brighter than the sun at peak brightness.

Curious as to what was glowing in the sky, many people ran to their windows or out onto the streets. It took about three minutes for the shock wave to reach the city of Chelyabinsk from the point of explosion 60 km away. Countless windows shattered and injured people. The event, particularly the trail of light and the explosion, was captured on numerous cameras and mobile telephones, and the news rapidly spread on the internet, making this the best-documented meteorite impact of all time.

Loss pattern

Despite the long distance involved, the shock wave was so strong that it shattered windows and caused structural damage to 7,000 buildings, even causing the roof of one factory to cave in. Most of the 1,500 people injured suffered cuts; more than 40 people required in-patient treatment in hospital. No fatalities were reported. The low temperatures in Chelyabinsk that season – the thermometer dropped to –15°C in the nights following the strike – led to further losses. For example, water pipes froze in residential buildings with shattered windows.

Scientific analysis

Immediately after the event, millimetre- to fist-sized fragments of the meteorite were found near Lake Chebarkul. In mid-October 2013, eight months after the impact, divers recovered a piece weighing over 600 kg from the bottom of the lake. On impact, it had made a hole 6 to 7 m in diameter in the ice. Analyses showed that the meteoroid was from the group of "ordinary chondrites", the most abundant type of meteoroid in our solar system originating from the asteroid belt.

Historical classification

In view of its characteristics, this so-called "air burst" can clearly be classified as a minor "Tunguska event", in reference to the impact event of 1908, when a meteoroid or comet with a presumed diameter of 40 to 70 m exploded shortly before impact at an altitude of 8 to 10 km above the Tunguska region in Siberia. The energy of that blast was 1,000 times greater than that of the bomb dropped on Hiroshima, and uprooted 80 million trees in a 30 km radius.

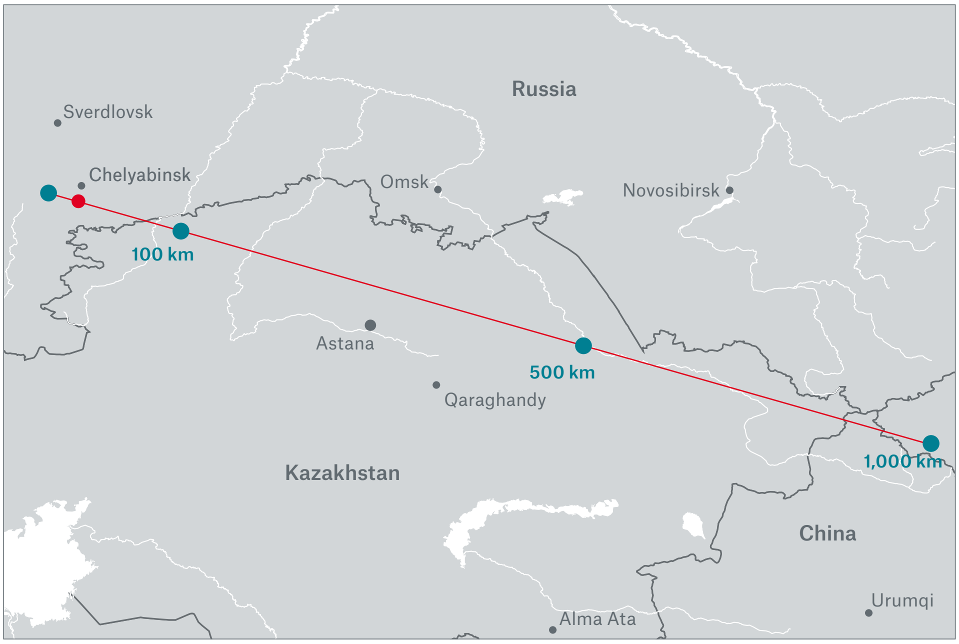
Taking inaccuracies into account, it is estimated that events like the Chelyabinsk meteorite occur every 40 to 100 years, although there are indications that the likelihood of recurrence is more in the 40-year range. The explosive force was several orders of magnitude lower than that of the Tunguska event, but still comparable to that of the Curuçá impact in Brazil in 1930, and somewhat stronger than the event near Prince Edward Island (some 1,000 miles to the south of South Africa) recorded infrasonically in 1963.

Insurance relevance

The property damage (mostly broken glass, but also several cases of structural building damage) is estimated at over 1 billion rubles (US$ 35m). It was of no major significance to the international insurance industry, in part because Russian homeowners' insurance is not reinsured. The cost of treating the injured was covered by Russia's national insurance scheme.

Meteorite strikes can impact a variety of policies. All risks policies offer complete coverage for damage due to impact, shock wave and fire. Named perils policies usually cover fire damage in full, but not damage due to impact and shock wave. In contrast, natural hazards insurance policies typically offer no coverage for meteorite strikes. Fire insurance for residential buildings encompasses fire damage, including that resulting from meteorite explosions or strikes. In extended commercial insurance, there is no coverage for impact damage as long as this was not explicitly agreed upon. In the motor own damage insurance segment, fire and broken glass are covered, whereas "stone-chipping" may be excluded. Traffic accidents resulting from a strike are covered under motor liability and fully comprehensive insurance. Life and disability insurance policies similarly include such coverage. Cancellation-of-events insurance may also become relevant in the case of meteorite strikes, although these policies are limited to any losses in earnings and not to property damage.

Trajectory of the Chelyabinsk meteoroid



Trajectory of the meteoroid on 15 February 2013. The blue numbers mark the altitude above the Earth's surface. Entry into the Earth's atmosphere occurred near the border between Kazakhstan and Russia.

● Location of explosion

Source: NASA-NEO Program

General hazard situation

Impacts by large asteroids are very rare. Although the principle of "the smaller, the more frequent" generally applies, objects with a diameter of less than 20 m usually have no chance of penetrating the Earth's atmosphere or causing any major damage on the ground. The graph on page 37 shows the relationship between the frequency of meteorite impact events and the kinetic energy released, according to the latest research. Minor events leave no trace or damage (at most on satellites or space stations). In contrast, the impact of an object roughly 1 km in diameter would be so serious that in addition to severe local devastation, global consequences would have to be expected (dust clouds with subsequent freezing temperatures even in summer, destruction of the ozone layer).

On 15 February 2013, i.e. on the same day as the Chelyabinsk event, a roughly 40 m asteroid designated 2012 DA14 passed the Earth at a distance of only 27,000 km. That is less than one-tenth the distance between the Earth and the Moon and closer than the orbit of geostationary satellites. Regardless of the Chelyabinsk event, this fact caused quite a media stir, and not just in specialist publications. However, reconstructions of the trajectories have ruled out any relationship between the Chelyabinsk meteorite and 2012 DA14, which also originates from the asteroid belt. The former was not a companion or fragment of 2012 DA14, as is sometimes the case with asteroids.

The last time the Earth barely missed a severe collision was on 23 March 1989, when a 300 m object designated 1989FC (Asclepius) missed the Earth by approximately 700,000 km, equal to twice the Moon's orbital radius. The distance involved may not appear critical, but in terms of time, the asteroid missed the Earth by only six hours, because it had exactly crossed the Earth's orbit.

Evaluation of the risk

Meteorite strikes are extremely rare but very real threats to the Earth. If the holistic risk assessment (Risk = Hazard x Vulnerability x Exposed Assets) is divided into its individual factors, the following assessment results:

On the hazard side, no increased or acute threat exists at this time. However, the limits of predictability must be taken into consideration: although over 90% of the potentially dangerous asteroids have now been documented (those that could pass very close to the Earth on their trajectories), trajectory prediction is subject to continuous minor changes that can lead to major deviations over many years. Another restriction on predictability relates to comets. They usually come from the outer regions of the solar system and, on account of their elliptical orbits, are out of direct observational range for the longest time (decades to centuries), meaning that most objects have not yet been discovered.

Should an asteroid or comet strike the Earth, the consequences in the case of objects ranging in size from 30 to 500 m in diameter (depending on the chemical composition) would be similar to those of a classic natural disaster, such as a tsunami, windstorm, earthquake or volcanic eruption, albeit in their extreme forms.

With regard to vulnerability, all precautionary measures taken on Earth are largely useless in view of the tremendous energies involved. Potential defence strategies and technologies are limited almost entirely to the space technology sector, but must first be developed and tested. Based on an extrapolation of previous investment and development progress, it is likely to be several decades before an effective technology for meteorite defence is available and tested. The liability aspects involved are as yet unclarified. Which nation (or group of nations) considers itself to be technically responsible for implementing a defence strategy, even if the impact is not a direct threat to its own territory according to predictions? What if the defence strategy fails and ultimately only shifts the location of impact?

On account of the diverse possible manifestations of the hazard, virtually all lines of established insurance policies (all risks, fire, motor own damage, life, etc.) would be affected. If a meteorite were to strike an urban region, an extreme event would be inevitable. However, the probability of this occurring remains several orders of magnitude smaller than that of major losses caused by other natural disasters, such as windstorms or earthquakes.

OUR EXPERT

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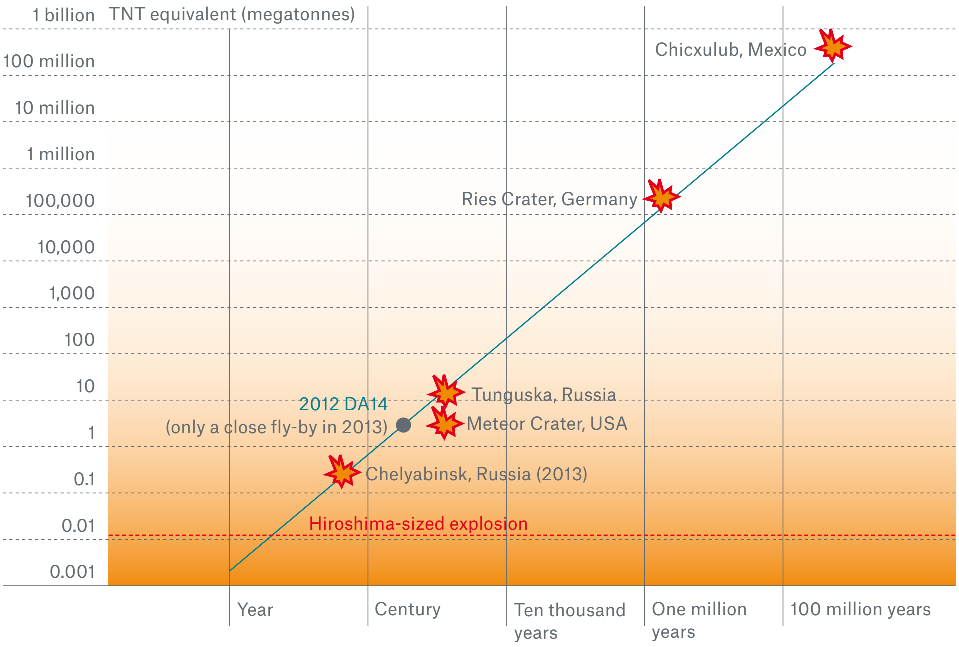
Rocks from space – Energy of impact events



Relationship between the occurrence frequency of meteorite impacts and the released energy. The Chelyabinsk air burst was classified in this diagram by GEO/CCC.

Source: NASA

Is climate change coming to an end?

The moderate rise in global temperatures in recent years might suggest that climate change is coming to an end. However, the latest findings indicate that the slower rise is due to non-permanent phenomena. The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5) expects stronger warming to resume in the long term.

Eberhard Faust

Global warming has significantly slowed in the last 15 years. Between 1998 and 2012, the mean global temperature increased by only 0.04°C per decade, only about one-third of the rise (0.11°C per decade) observed in the period from 1951 to 2012. However, the increase in the concentration of greenhouse gases in the atmosphere has continued unabated. One might be tempted to conclude that climate change is coming to an end.

But the first part of the Fifth IPCC Assessment Report (IPCC AR5) devoted to scientific knowledge of climate change and published in September 2013 comes to a different conclusion. According to this report, there have always been phases during which the mean global temperature has barely increased. This phenomenon also occurred in climate models simulating the climate change that has already taken place.

Heavy precipitation is increasing in the temperate latitudes and humid tropics as a result of climate change.

Changes in extreme events

Phenomenon and direction of trend	Assessment that changes occurred (typically since 1950 unless otherwise indicated)	Assessment of a human contribution to observed changes	Likelihood of further changes 2016 to 2035	2081 to 2100
Warmer and/or fewer cold days and nights over most land areas	Very likely	Very likely	Very likely	Virtually certain
Warmer and/or more frequent hot days and nights over most land areas	Very likely	Very likely	Very likely	Virtually certain
Warm spells/heat-waves. Frequency and/or duration increase over most land areas	Medium confidence on a global scale. Likely in large parts of Europe, Asia and Australia	Likely	Not formally assessed	Very likely
Heavy precipitation events. Increase in the frequency, intensity, and/or amount of heavy precipitation	Likely more land areas with increases. Very likely, especially in central North America	Medium confidence	Likely over many land areas	Very likely over most of the mid-latitude land masses and over wet tropical regions
Increases in intensity and/or duration of drought	Low confidence on a global scale. Likely changes in some regions	Low confidence	Low confidence	Likely on a regional to global scale
Increases in intense tropical cyclone activity	Low confidence in long term (centennial) changes. Virtually certain in North Atlantic since 1970	Low confidence	Low confidence	More likely than not in the Western North Pacific and North Atlan-tic
Increased incidence and/or magnitude of extreme high sea level	Likely (since 1970)	Likely	Likely	Very likely

One reason for the occasional occurrence of a subdued rise in temperature is the natural climate variation associated with the Pacific Ocean, the "Interdecadal Pacific Oscillation (IPO)", which has periods spanning decades. In the negative phase of the IPO, as has been observed since the end of the 1990s, an increased proportion of the additional thermal energy enters the ocean compared with the amount entering during the positive phases; this is why the temperature increase in the atmosphere weakens. Some climate models initialised with observations from the end of the 1990s (just before the IPO phase change) therefore also indicate a lesser increase in the mean global temperature since 1998 than models without this initialising.

As well as climate variability in the Pacific, IPCC AR5 also states that reduced solar irradiation is a further reason for the slower rise in temperature. On the one hand, radiation intensity has slightly declined between the solar maximum in 2000 and the solar minimum in 2009. And on the other hand, minor volcanic eruptions have increased the content of stratospheric aerosol since 2000, which has further reduced irradiation.

When viewed over the long term, i.e. over the period 1951 to 2012, the ensemble of new climate models used for the report reproduces the actual warming trend quite well. It is therefore safe to assume that climate change is not at an end and that the recent decline in the rate of temperature increase does not mean the models are flawed. As all the factors which are currently slowing the rise in temperature are in principle reversible, the report anticipates a further stronger warming trend over the long term.

Based on a large number of observations and modelling results, the latest IPCC report indicates that it is extremely likely that mankind is responsible for more than half of the increase in the global mean temperature since 1951. The extent of the Arctic sea ice, the spring snow cover in the northern hemisphere, the masses of the inland glaciers and the near-surface permafrost will all continuously decline to the extent that greenhouse gas concentrations increase. IPCC AR5 also offers a pessimistic projection with regard to sea levels. In the worst case, a maximum rise of 82 cm up to the period 2081–2100 compared with the period 1986–2005 is now considered possible. The corresponding figure in the previous report was only 59 cm. Human settlements and infrastructure close to the coast are therefore increasingly exposed. In particular, storm surges can reach ever greater heights. The expectation for future monsoon systems is that they will last longer, have weaker circulation, and produce more extreme rainfall.

According to IPCC AR5, climate change is also likely to cause an increase in extreme weather events over the long term. In particular, heavy precipitation will increase in the mid-latitudes and humid tropics. Some regions will also have more heatwaves, droughts and severe storms. The severity of tropical cyclones will also increase. It has now been possible to improve the regional delineation of some observations and projections, and the uncertainties are presented in clear terms. As a result, climate change is likely to exacerbate the risk situation in many regions of the world.

Part 2 of the IPCC AR5 report on the impact of climate change on socio-economic sectors and regions was published in March 2014 and Part 3 on measures to mitigate climate change will follow at a later date.

OUR EXPERT

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IPCC 2013: Working Group I Contribution to the IPCC Fifth Assessment Report, Technical Summary, Climate Change 2013: The Physical Science Basis (http://www.ipcc.ch/report/ar5/wg1/)

Facts, figures and background

For weather and climate researchers, 2013 was marked by prolonged wet weather conditions and temperature extremes. The Antarctic sea ice extent set a new record for the second year in succession.

Ernst Rauch and Eberhard Faust

According to preliminary data issued by the World Meteorological Organization (WMO), 2013, like the preceding year, was among the ten warmest years since 1850. The mean global temperature was about 0.5°C above the 30-year reference period (1961–1990) defined by the WMO and therefore close to the mean value of the ten warmest years. While it was clearly excessively warm in large parts of northern and eastern Europe, central and east Asia, Australia and in parts of Brazil, it was only cooler than the reference period in a few areas such as Canada and northern Russia. However, when viewed on a month-by-month basis, a very differentiated picture emerges: pronounced regional summer heatwaves in many Asian countries and in Australia contrasted with massive outbreaks of cold polar air during the northern winter and spring across large parts of Europe and eastern North America.

Global precipitation (restricted to land-based data) was generally lower than in the reference period (1961–1990) defined by the US Weather Service, NOAA. This was particularly true for parts of Australia, the western US and Brazil. More relevant – also because of their impact on the overall claims costs of the insurance industry – were the sustained periods of rain in some regions, which brought severe flooding. Europe, western Canada and the border area between Russia and China were particularly affected.

The El Niño/Southern Oscillation Index (ENSO index) remained neutral throughout 2013. This underlying weather phenomenon, which depends on fluctuations in the surface temperature of the equatorial Pacific Ocean, therefore had no relevant influence on weather patterns and weather extremes.

The global sea level reached a new record in 2013. The rise of approximately 3 mm per year observed between 2001 and 2010 was almost twice the secular trend of 1.6 mm per year in the 20th century.

Cold spells in the north

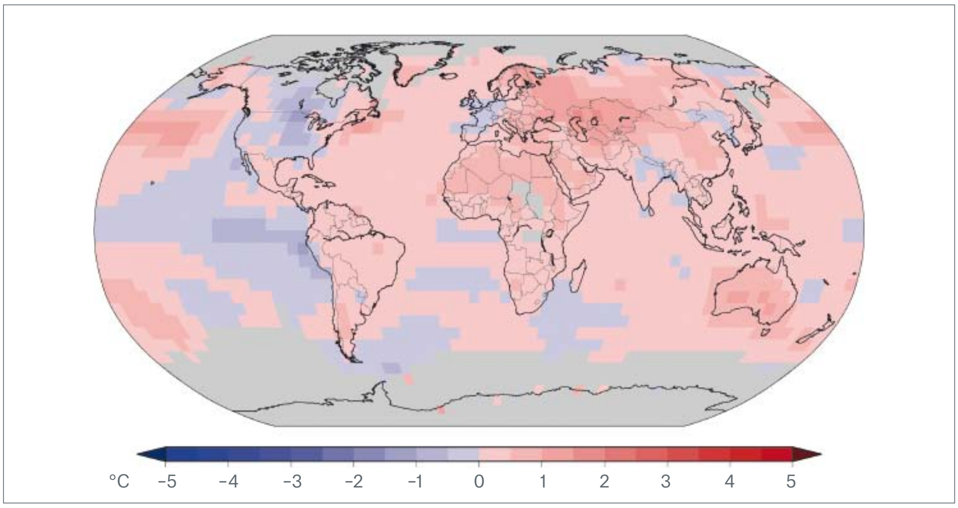
Mild temperatures predominated in large parts of Europe at the beginning of the year, breaking records in the northeast of Iceland. But in the course of January, weather conditions changed completely. The persistent flow of cold polar air, which lasted into March, resulted in one of the most intense cold spells in central Europe and Russia for many decades. Temperatures were up to 10°C below the long-term average. In many parts of Russia, March was colder than February. In North America cold air from the Arctic held the eastern part of the continent firmly in its grip right into April.

By contrast, Australia began the year with one of the most intense heatwaves in recent memory. In January, the highest ever nationwide average daytime temperature of 40.3°C was recorded; Sydney and Hobart reached new records of 41.8 and 45.8°C respectively. The plateau in the northeast of Brazil suffered the worst drought for 50 years. Crop failures and shortfalls in hydroelectric power supplies produced economic losses costing billions.

Is the loss of sea ice promoting cold advection?

The cold in late winter and early spring in the mid-latitudes of the northern hemisphere was caused by a negative phase in what is called the Arctic Oscillation. During these phases, there are comparatively small differences in temperature and air pressure between the Arctic and the more southerly latitudes, resulting in weak westerly winds. For Europe this means, for example, that there are only slight differences in temperature and air pressure between the subtropical high-pressure area in the south of the eastern North Atlantic and the low-pressure area around Iceland. Mild air masses which have been warmed by the Atlantic do not reach the continent in these circumstances and cold conditions can develop there. In North America, the area of this type of polar outbreak stretches over the central and eastern parts of the con-

Temperature anomalies, Jan–Dec 2013 (with respect to a 1981–2010 base period)

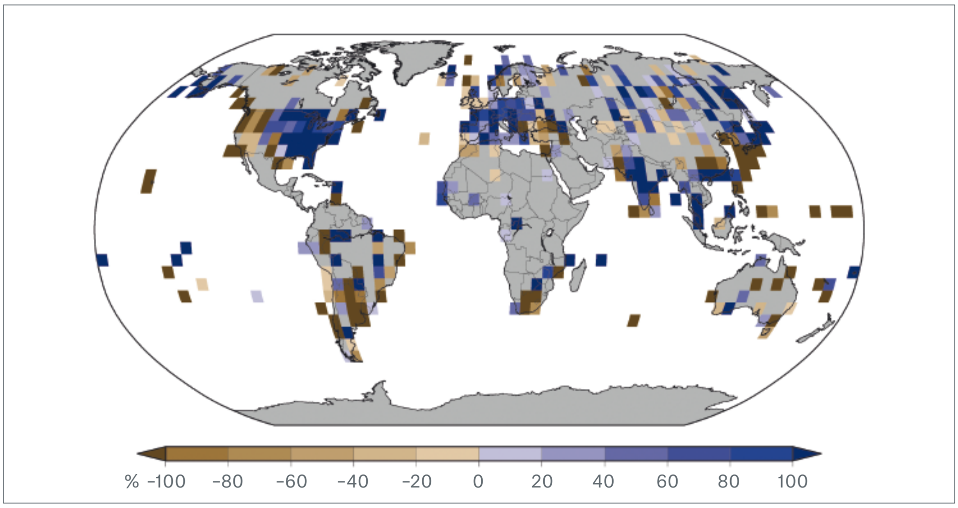


In 2013, northern and eastern Europe, central Asia and Australia in particular were warmer than the reference period, while the annual mean temperature in the eastern US and Canada was below the long-term mean. In global terms, 2013 is among the ten warmest years since 1850.

■ Warmer
■ Cooler

Source: NCDC/NESDIS/NOAA

Precipitation anomalies, Jan–Dec 2013 (with respect to a 1961–1990 base period)

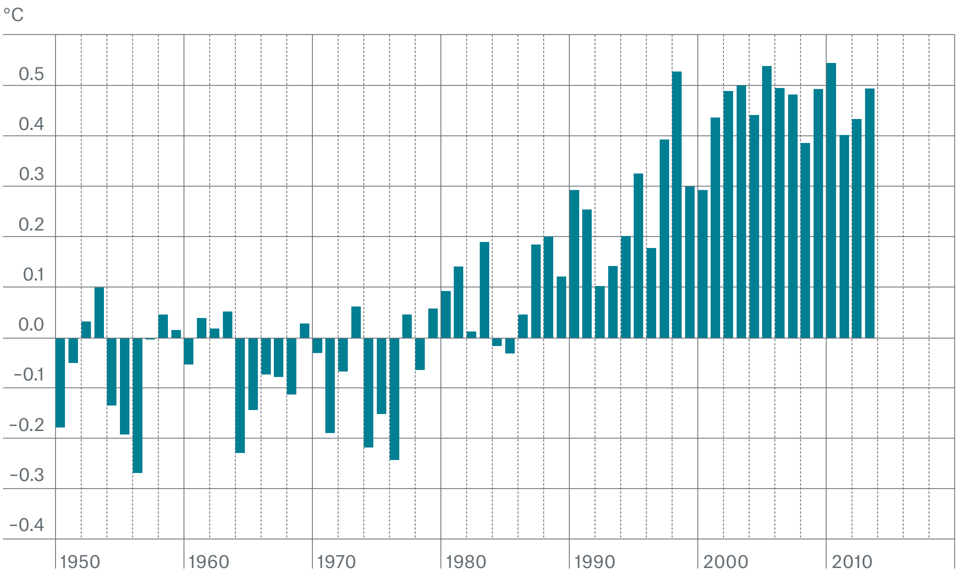


Regional anomalies of total annual precipitation in 2013 in comparison with the reference period 1961–1990. Note the above-average wet conditions in Europe and the eastern US.

■ Drier
■ Wetter

Source: NCDC/NESDIS/NOAA

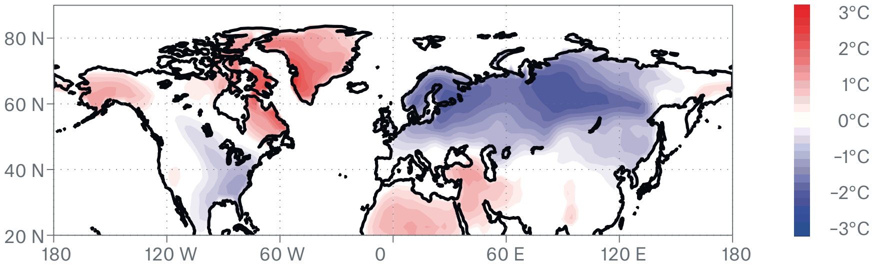
Annual variations of the global annual mean temperatures in the period 1950 to 2013 compared with the 1961 to 1990 mean



The ten warmest years in the observation period 1850 to 2013 were all after 1998. The time series commences in 1850; the period 1950 to 2013 is shown here.

Source: HadCRUT4, Met Office/ Climate Research Unit of the University of East Anglia (2014).

Change in winter temperatures based on the Arctic Oscillation Index



If the Arctic Oscillation Index decreases by a standard deviation, the mean temperature from December to February changes as shown in the graph. The cooling in large parts of Europe, northern Asia and the eastern part of North America is clearly shown.

Source: Cohen et al Environ. Res. Lett. 7 (2012) 014007. CC BY-NC-SA.

tinent, as in the late winter of 2013. Some research groups suspect that the polar outbreaks are linked to the dwindling sea ice in the Arctic Ocean. They have discovered that the probability of weather patterns of this nature with inland cold spells during the continental winter increases as the ice cover decreases in the Arctic. This results in an intensification of the Siberian high-pressure area during the autumn, which in turn influences the regime of the atmospheric circulation into the winter months (see Cohen et al., 2012). However, the physical mechanisms behind this interrelation are not yet adequately understood.

Severe flooding in central Europe

In Russia, the unusually cold weather suddenly shifted to extraordinarily warm weather in April, with positive regional temperature deviations of up to 9°C compared with the long-term average. It was also very warm at the beginning of the Australian autumn. At the end of May/beginning of June, a trough of low pressure developed over central Europe, channelling warm, damp air round the Alps. The violent precipitation, which in places reached 400 litres per square metre in the space of a few days, led to the most costly natural disaster of the year in terms of overall economic losses. In southwestern Asia, the monsoon broke very early in June and caused the most severe flooding of the last 50 years in the border regions of India and Pakistan.

Record ice in the Antarctic

Both the northern summer and the southern winter were marked by extensive warm periods with temperature anomalies of up to 5°C compared with the NASA reference period of 1981 to 2010. Central and eastern Europe, western North America and Australia were particularly affected. In stark contrast to this was the extension of the sea ice in the Antarctic, which set a new record for the second time in a row. The maximum surface area of 19.5 million km^2 measured by satellites was 2.6% over the mean level of the reference period. At the North Pole, the melting of the ice cap was less pronounced than in recent years. While its minimum level of 3.4 million km^2 set a new record low in 2012, the melting process in 2013 stopped in September at 5.1 million km^2. But this was still approximately 18% (1.1 million km^2) less than the average of the reference period 1981 to 2010.

Sustained, intense rain between the end of July and the middle of August in the border region between China and Russia led to extensive floods, particularly in the catchment area of the Amur River, which reached new record levels.

Weather becoming more persistent

Stationary high- and low-pressure systems triggered a series of extreme weather events in 2013. Persistent troughs of low pressure with high precipitation activity were responsible for the floods in central Europe and on the Russian/Chinese border. During the time of the trough over central Europe, a persistent high-pressure zone formed further to the east in Russia and Scandinavia, which caused a prolonged heatwave.

According to the findings of the latest research, these persistent weather patterns could be linked to the warming of the high latitudes as a consequence of climate change. A meandering band of strong winds at high altitudes which encircles the Earth in a wave-like pattern normally determines the arrangement and movement (normally from west to east) of the large high- and low-pressure areas in the mid-latitudes. Analysis of past extreme summer events (US heatwave in 2011; European floods in 2002) has revealed evidence of a resonant reinforcement of a stationary occurrence of this wave structure with particularly large amplitudes. The resultant intense high- and low-pressure areas therefore increased their regional impact due to their extreme persistence. The basic conditions for a stationary wave structure capable of determining weather conditions described by research scientists occurred twice as frequently in the period 2002 to 2012 as in the periods 1991 to 2001 and 1980 to 1990. A correlation with the reduced temperature difference between the higher and lower latitudes as a result of climate change is assumed (Petoukhov et al., 2013) but has not been conclusively proved. Future research projects must explain the extent to which climate change promotes the formation of stationary wave structures.

Low-energy tropical cyclones

The figure of 86 tropical cyclones observed worldwide in 2013 is in line with the long-term average (1981–2010 average 89). In the North Atlantic, the number of 13 named tropical storms was below the average for the warm phase of the "Atlantic Multidecadal Oscillation", which has predominated since 1995 (average since 1995: 15). What was more striking was the low energy of the storms: the "Accumulated Cyclone Energy" (ACE), which is determined by the intensity and duration of the storms, was only about 30% of the long-term average.

On the other hand, rather more than the usual number of cyclones occurred in the northwest Pacific. One of them, Super Typhoon Haiyan, which struck the southern Philippines with wind speeds far exceeding 300 km/h in places, caused the greatest human catastrophe of the year. A detailed description can be found starting on page 6 under the heading "In Focus".

OUR EXPERTS

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FK7-B7L

Variability of severe thunderstorm losses on the rise

Over the past decades, the variability of normalised annual losses from severe thunderstorms in the US has increased. According to a recent study, climatic changes are the principal reason for this.

Eberhard Faust

In 2011, outbreaks of severe thunderstorms in the US caused losses totalling US$ 47bn, of which US$ 26bn were insured. This corresponds roughly to the extent of damage from Hurricane Sandy. Even 2013, a year with relatively few storms, experienced the sporadic occurrence of severe events. In May, multiple violent tornadoes swept through Oklahoma City (Moore, El Reno), and in November there was an outbreak of 75 tornadoes in the northeast of the country, which was highly unusual for that time of year.

In light of these developments, the question arises as to what extent the number of severe thunderstorms and their associated damage have changed over the past decades in the US. A study published in the October 2013 issue of the American Meteorological Society's journal, *Weather, Climate, and Society*, provides some insights. Authors from Munich Re and the Institute of Atmospheric Physics at the German Aerospace Centre (DLR) collaborated on this study to combine meteorological observations with loss data from Munich Re's NatCatSERVICE.

The loss potential of severe thunderstorms with hail, heavy rainfall, tornadoes and wind gusts is enormous.

The study covered severe thunderstorm events in an area east of the Rocky Mountains (109°W) which occurred between March and September in the period from 1970 to 2009. In order to account for the fact that higher destructible values exist today than 40 years ago, the authors normalised all losses occurring since 1970 to the level of destructible values at the end of the study period. This "pre-treatment" of the data ensures that any changes in the loss data during the study period will not be based merely on an increase in values.

The study focuses on events with a normalised overall loss of at least US$ 250m or with insured losses of at least US$ 150m. This relatively high threshold value is reached only by large-scale events that generally affect several states. Consequently, these events have been sufficiently extended to ensure a high probability of event detection from the very beginning of the study period. The events selected in this way account for 80% of losses between 1970 and 2009.

The study shows an increasing variability in the normalised total and insured losses over time. Measured in terms of the standard deviation, this variability in the normalised overall losses during the period from 1990 to 2009 is higher than for 1970 to 1989 by a factor of 1.4. The average loss is actually twice as high.

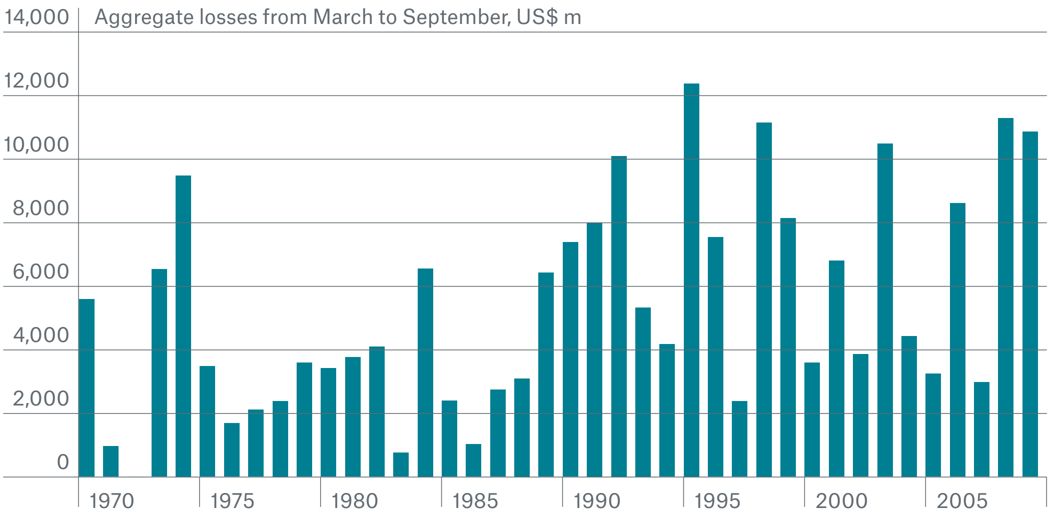
Potential for severe thunderstorms increasing

These changes in normalised losses are associated with changes in thunderstorm severity potential, which was derived from meteorological observation data. Both the convective storm energy potentially available in the atmosphere and the wind changes with height (vertical wind shear) are important prerequisites for the development of severe thunderstorms. Accordingly, they are factored into the definition of thunderstorm severity potential. The similar pattern of variation for severe thunderstorm potential and damage index is particularly apparent when the annual fluctuations are smoothed out with a moving average, making it possible to focus on the longer-term variability during the study period.

This smoothed-out representation indicates that the long-term changes in losses are clearly based on an altered meteorological severe thunderstorm potential and thus on a changing climate. Initially, it is still unclear whether this is natural climatic variability or anthropogenic climate change. More recent, model-based studies on changes in severe thunderstorms in the US demonstrate that, in particular, the potentially available storm energy is increasing during the course of climate change, as the moisture content in the lower atmosphere is increasing (Trapp et al., 2009).

According to climate-model studies, the latter phenomenon, which has been measurable for the past 40 years, is likely attributable to anthropogenic climate change (Willett et al., 2010). The current study on severe thunderstorm damage also shows that the potentially available storm energy has clearly increased (over a high threshold) during the past decades. Thus, the results of the study are consistent with the findings on anthropogenic climate change.

Normalised direct losses caused by US thunderstorms for events exceeding US$ 250m in damage



Annual aggregate losses from thunderstorms in the US exceeding an event threshold of US$ 250m after normalisation. Study area east of 109°W from March to September, 1970–2009.

Source: Munich Re

Better protection for buildings

Impacts on building standards are among the consequences which have arisen for the insurance industry as a result of the increasing variability of severe thunderstorm damage. The damage potential from squalls can be reduced substantially if building doors open outwards instead of inwards, if windows are able to withstand strong winds and airborne debris, or if reinforced garage doors are installed, to name just a few examples. Hail-resistant roofs and façades also considerably reduce the potential for damage. Government information campaigns should educate the public about the perils involved. In terms of managing the underwriting risk, higher priority must be given to accumulation assessment in future.

OUR EXPERT

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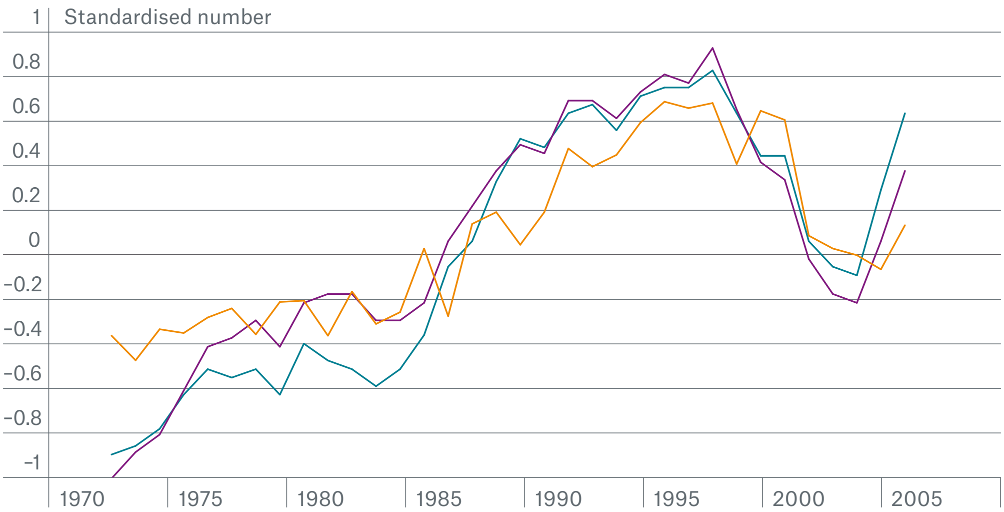
Hail, a by-product of severe thunderstorms, can cause significant property damage.

Trapp, R.J., Diffenbaugh, N.S. and Gluhovsky, A., 2009: Transient response of severe thunderstorm forcing to elevated greenhouse gas concentrations. Geophysical Research Letters, 36

Willett, K.M., Jones, P.D., Thorne, P.W. and Gillett, N.P., 2010: A comparison of large scale changes in surface humidity over land in observations and CMIP3 general circulation models. Environmental Research Letters, 5

Severe thunderstorm potential in line with associated normalised losses in the US



Annual total of severe thunderstorm-related losses > US$ 250m (normalised according to GDP)
Annual total of severe thunderstorm-related losses > US$ 250m (normalised according to building stock)
Number of threshold value exceedances of thunderstorm severity potential

Annual total of losses due to severe thunderstorms in the US from damage amounting to at least US$ 250m after normalisation based on a) gross domestic product and b) existing buildings, compared with the number of threshold value exceedances of a meteorological parameter representing the severe thunderstorm potential.

Source: Sander et al., 2013: Rising variability in thunderstorm-related U.S. losses as a reflection of changes in large-scale thunderstorm forcing, WCAS 5, 317–331

Lessons learnt from two earthquake clusters

Temporally clustered earthquake sequences in combination with secondary effects can pose a major threat. Important lessons were learnt from two recent earthquakes: New Zealand 2010–2011 and Italy in May 2012.

Marco Stupazzini

The common perception of a major earthquake is that it is an isolated, individual event. However, recent experience in New Zealand and Italy proves that a sequence of earthquakes and their secondary effects pose a major threat and present additional challenges.

Christchurch, New Zealand

Nobody anticipated that the magnitude 7.1 Darfield earthquake of 4 September 2010, with its epicentre on the previously unidentified Greendale fault 40 km west of Christchurch, would mark the beginning of an earthquake sequence culminating in the magnitude 6.2 Lyttelton earthquake of 22 February 2011 that destroyed the city centre of Christchurch. The so-called Canterbury earthquake sequence, and in particular the Lyttelton quake, raised many questions and subjected the world's oldest public earthquake insurance scheme – New Zealand's Earthquake Commission – as well as the entire insurance market to a stern test. The earthquake activated an old geological structure which had probably last been active more than 5,000 years ago. Most of the 185 victims perished in two collapsed buildings. But the amount of total material losses was staggering for a city of this size, with some US$ 30bn (mainly insured) losses to date.

Emilia-Romagna, Italy

The previous major earthquake in the Emilia-Romagna region of Italy, the Ferrara earthquake, occurred in 1570. The new series of earthquakes began on 19 May 2012 with a number of magnitude 4.1 tremors, culminating in the quakes on 20 May (magnitude 5.9) and 29 May (magnitude 5.8). With an estimated insured cost of €1.3bn, the quakes produced Italy's largest ever insured earthquake losses. This is surprising, considering that major cities like Modena and Bologna were little affected. Although the biggest losses occurred in predominantly rural areas, all sizeable communities have industrial zones, with several thousand industrial buildings.

So, what are the lessons we can learn? Without claiming completeness, some of the pertinent issues are listed below.

Risk identification

Maps like the Munich Re World Map of Natural Hazards provide a good template for recording hazards. They tend to focus, however, on main hazards such as ground shaking for earthquakes, or wind speed for windstorms. Recent events have clearly illustrated how important concomitant effects such as ground failure, liquefaction and tsunami are for earthquakes.

Risk evaluation

In the area of risk evaluation, there are a number of issues that need to be looked at.

Secondary effects (e.g. directivity) require more effort to be invested in probabilistic risk models. The more effects that are included, the higher the uncertainty of the results.

Temporal seismic hazard change: Two effects play over different timescales. In the long term earthquake cycles and in the short term transient hazard changes due to stress transfers can affect seismicity and trigger aftershocks. Figuring out how risk temporarily changes after significant events is becoming more important.

Clustering: Earthquake clustering is a related problem, as the Canterbury earthquake sequence highlighted. Problems from such sequences start with risk assessment.

Post-loss amplification (PLA): This has nothing to do with physical risk, but with resilience and the sociopolitical dimension of disasters.



The Torre dei Modenesi, built 800 years ago in the Italian town of Finale, before the earthquake of 20 May 2012 and after.

Risk control

Other lessons learnt concern the area of risk control. They are:

Loss prevention: In recent events, non-structural losses have played a paramount role; avoiding collapse and ensuing loss of life is achievable through modern building codes. However, overall the time has come to introduce broad-based loss control features into building regulations.

Risk-adequate price: Some large disasters have shown that pre-disaster prices were inadequate, as important price drivers were underestimated (i.e. new building practices, underinsurance, PLA in general). The Canterbury earthquake sequence will consume about 20 years of the 2011 property premium, including non-earthquake coverage for the whole of New Zealand.

Accumulation control: Disasters may reveal deficiencies in the exposure data, especially for policies in which several locations are covered under one policy, and the full sum insured is listed under the headquarters' location.

Self-participation: The Canterbury earthquakes provided a textbook example of the efficiency of deductibles or the lack thereof. A deductible that is too low fails to serve the two principal goals of self-participation: the number of claims remain unreduced and there are no incentives for loss prevention measures.

Policy wording: Two elements have to be considered, *event definition* and *sum insured*. While careful wording in terms of *event definition* helps to avoid unpleasant surprises, it cannot solve the problem of apportionment to specific events in event sequences, a process that is always arbitrary and usually extremely difficult to verify. The *sum insured* is most commonly stipulated as the replacement value. But what does this mean? Reinstatement to the pre-event condition? Are post-disaster code upgrades included? What about the replacement value of heritage buildings? Those issues should be clearly addressed through the wording.

Claims settlement: The key to an efficient loss adjustment process is to have contingency plans that guarantee access to a sufficient number of professional loss adjusters.

Conclusion

Despite the enormous progress made over many years, recent events have shown some deficiencies in different fields. In hazard assessment, secondary perils and temporal hazard changes have to be addressed. Regarding vulnerability, controlling structural and non-structural losses is gaining more and more significance. Finally, risk management has to take account of event clusters.

OUR EXPERT

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Global Earthquake Model nears launch

The Global Earthquake Model – GEM – is the world's first ever standardised model for assessing earthquake risks. Scientists from around the world have been developing the bases for this model for five years. And now the practical test phase is starting.

Alexander Allmann

For years, geoscientists have been calling for a globally unified calculation model for analysing earthquake risks. Risk researchers in threatened and, above all, poorer regions without their own risk model have no access to data and calculation tools that would allow them to implement preventive measures, define building codes or develop contingency plans. Industrial nations and insurers with worldwide operations also lack a system that is standardised worldwide. Regional comparisons are difficult and loss potential cannot always be calculated exactly – a situation that also places considerable constraints on insurability in earthquake-prone regions.

In response to this, the OECD's Global Science Forum launched a project in 2007 with the objective of establishing a global standard for the collection of risk-relevant data on earthquake exposure: the Global Earthquake Model, or GEM.

The founding members were Jochen Zschau, Seismic Risk Expert at the German Research Centre for Geosciences in Potsdam, Ross Stein, Geophysicist for the U.S. Geological Survey (USGS), Domenico Giardini of the Swiss Federal Institute of Technology in Zurich (ETHZ) and Anselm Smolka, Head of Geo Risks in Corporate Underwriting at Munich Re until September 2013 and General Secretary of GEM since the beginning of the year. Starting out with just four members, the project has grown and today more than 500 scientists are working on the global risk model.

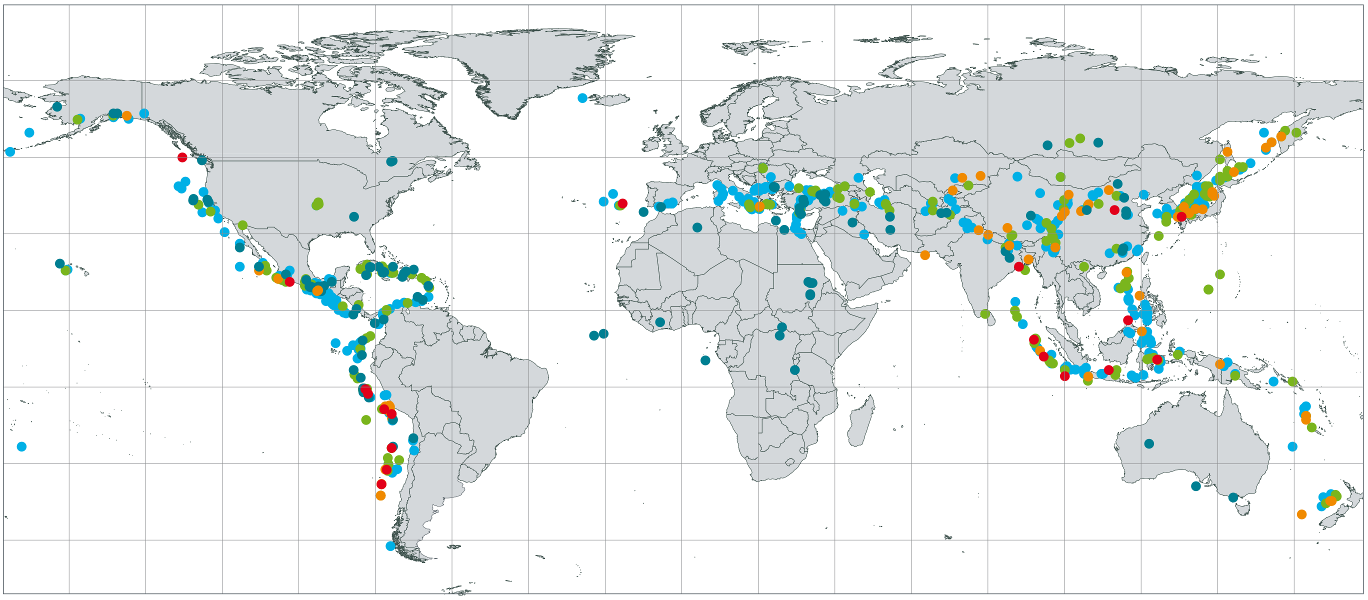
GEM to become the global standard

At the very heart of GEM is OpenQuake, an open source platform supplying the various modules for the globally standardised calculation of earthquake risks. The economic independence of OpenQuake, its open software architecture and free access for anyone who wishes to use the data for non-commercial purposes are all geared towards establishing the project as the worldwide standard.

"With GEM and the OpenQuake platform, we primarily hope to promote risk awareness in less-developed nations. At the same time, we want to improve the insurability of earthquake risks, also in severely affected risk regions," explains Anselm Smolka, describing the underlying principle of the project.

However, GEM can also be used at a commercial level. To do so, companies such as risk consultants or insurers must become official sponsors.

Podium discussion on GEM with Anselm Smolka (left), Haruo Hayashi (Kyoto University) and Mary Comerio (UC Berkeley) at the World Conference on Earthquake Engineering in Lisbon, 2012.



Historical Earthquake Catalogue 1000–1903

One of the first tasks GEM tackled was to develop a Global Historical Earthquake Catalogue (GHEC). The map shows earthquakes in the period from 1000 to 1903.

Source: Munich Re, based on data from GEM

Magnitude

- ≥ 8.5
- 8.0–8.4
- 7.5–7.9
- 7.0–7.4
- <7.0

"Reinsurers expect GEM to provide greater risk transparency worldwide. This will enable them to improve the spread of risks and also to offer more cover in heavily threatened regions," said Smolka. Since its launch, Munich Re has supported the project financially and has provided staff. Eight of our geo-risk experts are currently involved in GEM projects. The first calculation modules have been online since July 2013.

After more than five years of development work, GEM is now nearing a decisive milestone. OpenQuake entered the test phase with a total of ten global calculation modules at the end of 2013. The platform will be officially accessible for non-commercial use at the end of 2014.

Regional projects in progress

OpenQuake forms the framework on which the regional projects can be based. It is the regional projects that will make GEM a practical tool. Risk calculations will then be performed at local level based on the methodology and standards of the global modules and the results made available. For Europe, for instance, the results of SHARE (Seismic Hazard Harmonization in Europe) were already published in mid-2013. The development of EMME (Eastern Mediterranean Middle East) has also been concluded for the region extending from Turkey to Pakistan. Further regional projects for Latin America, Central and Southeast Asia, Africa and the Caribbean have been initiated.

GEM II is ready to roll: the first project phase was wrapped up when the results from the ten global components were presented at the end of 2013. The test phase and official launch of OpenQuake at the end of 2014 already form part of GEM II, which is planned to run until 2018. The core objectives of this second phase are to develop the regional projects and expand OpenQuake for assessing the risk of consequential hazards such as tsunamis.

At least €15m will be needed for the second phase. Munich Re will continue to support the project and has already pledged funding of €1m.

OUR EXPERT

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The relevance of disaggregation in risk models

Modelling natural hazards in property insurance requires liability data with a high spatial resolution. However, if such data are only available aggregated for complete zones, they must be intelligently redistributed on the basis of certain assumptions.

Jutta Schmieder

In this day and age, we really should have the exact address of all risk locations available. However, this is not always the case. If only the rough geographical location of an insured risk is known, then “disaggregation” can help. Disaggregation breaks down the data for an aggregated zone level to a higher spatial resolution, i.e. to locations at which the liability risks are likely to be.

At Munich Re, this method is used in the appraisal of natural hazards in property business when only spatially aggregated liability data are available, instead of liability data for a precise locality. Depending on the class of business, different methods are employed to approximate reality. Industrial risks are distributed across industrial locations, commercial risks across business centres and commercial areas, and residential property liability risks across areas with residential use.

Why is such an approach advisable? The extensive flooding in Thailand in 2011 highlighted, not for the first time, the immense impact of spatial risk distribution on the accuracy of loss estimates. At the time of the event, a large proportion of the insured industrial values were only available as an overall total for the country.

It makes a difference whether these amounts are evenly distributed across an area for further analysis, or whether the industrial risks can be concentrated on specific industrial sites. Industrial parks are frequently located in the vicinity of rivers and consequently exposed to an above-average risk of flooding.

Portfolio data are disaggregated in natural hazard models as soon as the hazard components, such as flooded areas or storm footprints, are available in a more detailed resolution. This is because the actual differences in the risk parameters can only be mapped onto the relevant spaces if liability data and modelling parameters are available at the same spatial level.

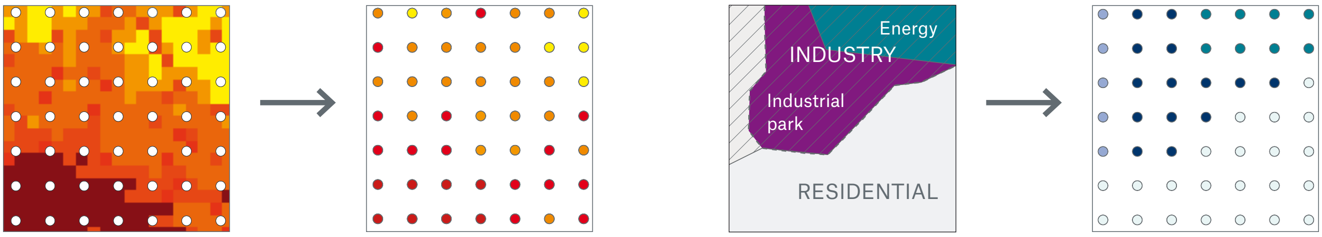
If market players are unable to provide the requisite accuracy of liability data, Munich Re’s natural hazard models use intelligent redistribution schemes in order to obtain the best-possible modelling results on the basis of the underlying data. To achieve this, all aggregated liability data are redistributed on high-resolution computational grids, i.e. the modelling points. These points are configured in such a way that they map all relevant fluctuations – including local variations – in the modelling parameters, such as variability in hazard. They also ensure good performance on the part of the model. Depending on country and hazard type, the spacing between the modelling points usually ranges from approximately 50 metres, e.g. for localised flooding, to one kilometre, e.g. for large-scale winter storms.

How does disaggregation work in detail? To be able to map the liability data as realistically as possible, value distributions must first be generated individually for the respective lines of business. For residential property, liability is customarily distributed according to population density, possibly in combination with economic indicators such as GDP or purchasing power.

This approach makes no sense for industrial and commercial risks. For these risks, a variety of data sources have to be processed and combined. Possible indicators for the distribution of commercial and industrial risks can be extracted from land-use information, from business databases, from address data or from other statistical information such as the value added by each industrial park or region.

Publicly accessible sources are frequently inadequate. Consequently, Munich Re has collected and processed additional detailed information on industries from numerous databases, maps, satellite imagery and the homepages of industrial parks. The Munich Re Industry Location Database (ILD) is a global loca-

Example of the creation of value distributions (the darker the colour, the higher the value)



Indicator: Population density

Value distribution for residential property liabilities at the modelling points

Various indicators for industrial risks

Value distribution for industrial liabilities at the modelling points

tion database for a variety of industries such as automotive, chemical, electronics, etc.; the Munich Re Critical Infrastructure Database (CID) combines location data with infrastructure risks. These databases are continually checked and added to in order to achieve up-to-date global coverage.

Exactly which basic data are available depends on the respective market. Collecting and processing them always involves laborious research work. The evaluation methodology must also be individually adapted according to data availability.

The next step involves combining the basic data logically so that a high-resolution value distribution per line of business can be produced as an interim result. Subsequently, zone-specific weightings can be calculated for the individual modelling points on the basis of the value distribution now available. Based on these weightings, the sums insured can then be broken down for a specific zone during the modelling process, allowing realistic spatial disaggregation of aggregated portfolio data.

It is important to remember, however, that these data and the corresponding methodology can only approximate the actual spatial location of the insured objects and therefore do not necessarily reflect the real distribution. Even if an optimum data basis is available, the distribution will always correspond to the market average. This impacts large zones in particular: individual liability accumulations, e.g. of regional insurers writing business on a limited basis, cannot be identified. Instead, they are spread across the entire zone, according to the market average.

This problem can only be circumvented by collecting liability data for each location in a detailed way from the outset. Customer-specific liability distributions and individual modelling results that best reflect reality can then be obtained.

OUR EXPERT

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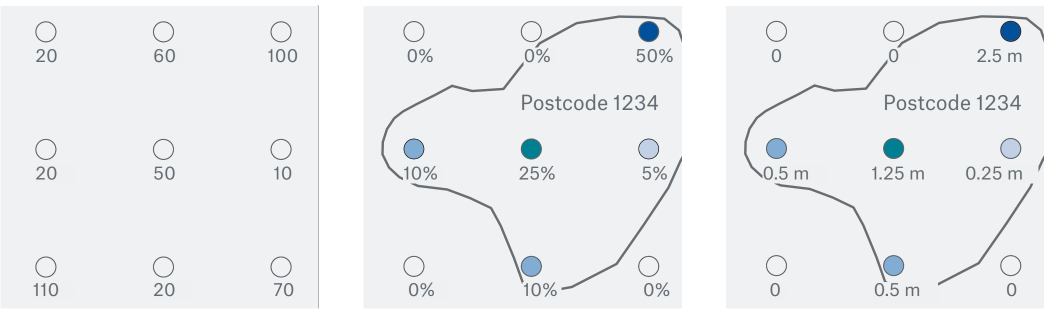
Distribution of aggregated values according to weighting



Value distribution per modelling point

Example postcode 1234: Deriving the percentage rates within the zone

Distribution of the sum insured of €5m within the zone

The year in pictures

15 to 22 January
Floods: Indonesia
Overall losses: US$ 3,000m
Insured losses: US$ 300m
Fatalities: 47

15 February
Meteorite impact: Russian Federation
Overall losses: US$ 35m

22 March
Tornadoes: Bangladesh
Fatalities: 38

20 April
Earthquake: China
Overall losses: US$ 6,800m
Insured losses: US$ 23m
Fatalities: 196

18 to 22 May
Severe weather, tornadoes: USA
Overall losses: US$ 3,000m
Insured losses: US$ 1,800m
Fatalities: 28

30 May to 19 June
Floods: Central Europe
Overall losses: US$ 15,200m
Insured losses: US$ 3,100m
Fatalities: 25

14 to 30 June
Floods, flash floods: India
Overall losses: US$ 1,500m
Insured losses: US$ 600m
Fatalities: 5,500

19 to 24 June
Floods, severe storms: Canada
Overall losses: US$ 5,700m
Insured losses: US$ 1,650m
Fatalities: 4

July
Heatwave: United Kingdom
Fatalities: 760

27 to 28 July
Hailstorms: Germany
Overall losses: US$ 4,800m
Insured losses: US$ 3,700m

7 August to 20 September
Floods: China, Russian Federation
Overall losses: US$ 4,000m
Insured losses: US$ 550m
Fatalities: 170

12 to 21 September
Hurricanes Ingrid and Manuel: Mexico
Overall losses: US$ 5,800m
Insured losses: US$ 950m
Fatalities: 139

21 to 26 September
Typhoon Usagi: China, Philippines, Taiwan
Overall losses: US$ 3,000m
Insured losses: US$ 75m
Fatalities: 36

15 October
Earthquake: Philippines
Overall losses: US$ 90m
Fatalities: 222

27 to 30 October
Winter Storm Christian (St. Jude): Europe
Overall losses: US$ 2,150m
Insured losses: US$ 1,550m
Fatalities: 17

8 to 12 November
Typhoon Haiyan: Philippines, Vietnam, China, Taiwan
Overall losses: US$ 10,500m
Insured losses: US$ 700m
Fatalities: 6,235

18 to 20 November
Flash floods: Italy
Overall losses: US$ 780m
Fatalities: 16

5 to 7 December
Winter Storm Xaver: Western Europe
Overall losses: US$ 1,700m
Insured losses: US$ 970m
Fatalities: 12

The year in figures

Petra Löw

In 2013, the NatCatSERVICE registered 890 loss events worldwide with overall losses of US$ 135bn and insured losses of US$ 35bn. These figures mean that 2013, like 2012, can be described as a relatively moderate year. The number of events in 2013 was lower than in 2012 (920) but still exceeded the ten-year (790) and 30-year (630) average.

Aggregate losses suffered by economies across the world as a result of natural catastrophes were well below the ten-year average and also failed to approach the US$ 175bn of the previous year. Insured losses were at the same level as in the last ten years but also remained below 2012 figures.

At about 20,500, the number of fatalities was twice that of 2012 but still well below the ten-year average of over 100,000.

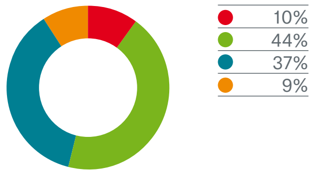
Number of events

Of the total of 890 loss events, 90% fell into the category of weather-related natural catastrophes and 10% were of a geophysical nature. There was also an extraterrestrial event in the form of a meteorite strike in Russia. The percentage distribution of the main perils within the geophysical, meteorological, hydrological and climatological fields is roughly in line with the average of the past 30 years, albeit with slight deviations. Events such as heatwaves, cold spells, droughts and forest fires were less frequent at 9% (instead of 13%), as were geophysical events with 10% (instead of 13%). However, the figures for windstorms and floods were slightly higher at 5% and 2% respectively.

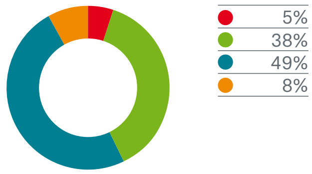
An examination of the distribution of loss events by continent reveals that America, Africa and Australia all maintained their long-term average, with figures of 32% for America and 8% each for the other two. On the other hand, Europe experienced 6% fewer loss events while Asia recorded a plus of 5%.

The Munich Re NatCatSERVICE database subdivides the events of a year into catastrophe categories according to their monetary and humanitarian impact. We extensively revised this categorisation in 2013. The previous six-level classification has been reduced to four levels and

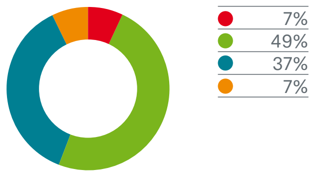
Events: 890
Percentage distribution worldwide



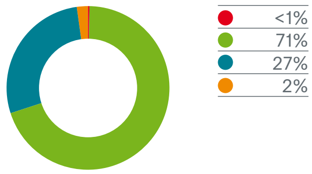
Fatalities: 20,500
Percentage distribution worldwide



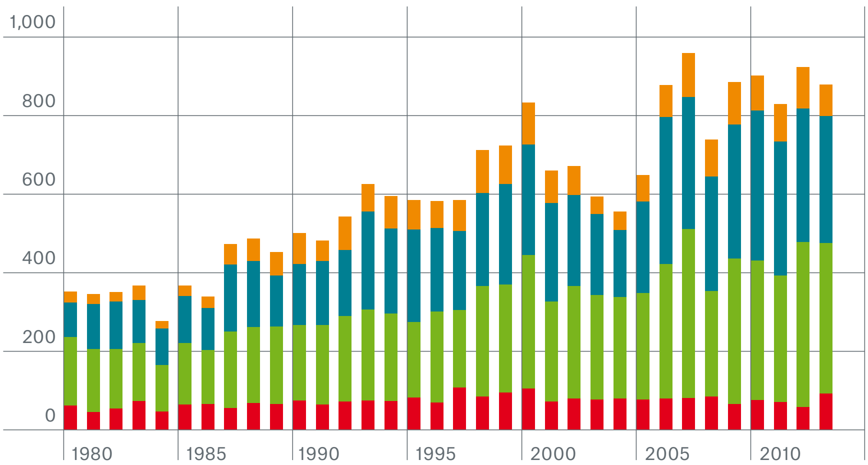
Overall losses: US$ 135bn
Percentage distribution worldwide



Insured losses: US$ 35bn
Percentage distribution worldwide



Number of loss events 1980–2013



Geophysical events: Earthquake, tsunami, volcanic eruption

Meteorological events: Tropical storm, extratropical storm, convective storm, local storm

Hydrological events: Flooding, mass movement

Climatological events: Extreme temperatures, drought, wildfire

Source: Munich Re

is now based on country-specific threshold values. This means that events can now be compared more objectively with each other, irrespective of specific developments in individual countries.

Fatalities

Two natural catastrophes alone accounted for 56% of the 20,500 fatalities across the world. In June, heavy monsoon rain triggered destructive flash floods and widespread flooding in India, causing the deaths of 5,500 people. In November, Typhoon Haiyan hit the Philippines, China and Vietnam. The Philippine islands of Leyte and Samar were devastated and over 6,200 people lost their lives.

Two heatwaves were also among the most deadly events of 2013. Between April and June, over 550 died in India as a result of the heat. In July, temperatures in the UK rose to over 33.5°C for several days; the deaths of 760 people were linked to the hot weather. The death toll in Pakistan following an earthquake reached approximately 400 and a further quake in the Philippines cost the lives of over 200 people.

Losses

A breakdown of the aggregate losses of US$ 135bn between the four main perils reveals some substantial deviations from the long-term average. 49% of aggregate losses in 2013 were attributable to windstorms (1980–2012: 40%) and 37% to floods (1980–2012: 22%). Asia accounted for almost half of all overall economic losses in 2013. Chief among the causes of these losses were Typhoons Haiyan and Fitow as well as earthquakes, floods and droughts in China.

The events producing the greatest economic losses in 2013 were the floods in May and June in central and eastern Europe, which cost US$ 15bn, followed by Typhoon Haiyan in Southeast Asia in November, which cost more than US$ 10bn. The earthquake in China in April caused losses of US$ 6.8bn, the floods in Canada in June cost US$ 5.7bn and Typhoon Fitow, which hit China and Japan in October, caused damage totalling US$ 5bn.

The insured losses of US$ 35bn were caused primarily by floods and hail in central Europe and by severe thunderstorms and floods in North America. The hailstorms in Germany were the costliest event for the insurance industry worldwide, with a total claims bill of US$ 3.7bn.

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OUR EXPERT

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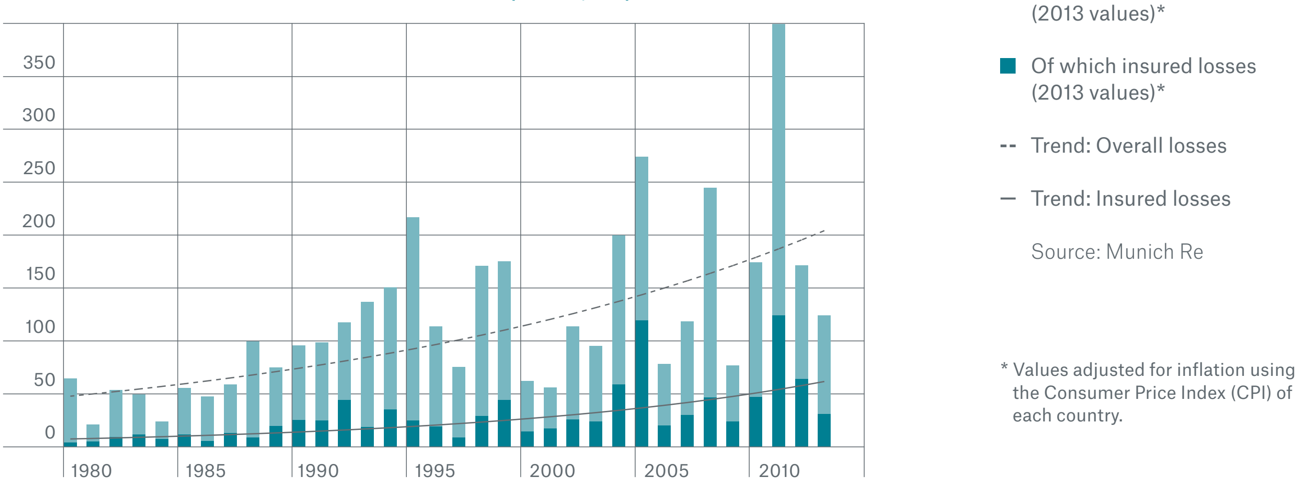
Overall losses and insured losses 1980–2013 (in US$ bn)



* Values adjusted for inflation using the Consumer Price Index (CPI) of each country.

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Topics Geo – 50 major loss events in 2013

No.	Date	Loss event	Country/Region	Deaths	Overall losses US$ m	Insured losses US$ m	Explanations, descriptions
1	January–April	Floods	Zimbabwe, Mozambique	269			Persistent heavy rain. >630 schools damaged. >6,260 homes, bridges, roads destroyed.
2	1.–20.1.	Cold wave, winter damage	Mexico, USA	30			Low temperatures, snowstorms, frost. Water pipes burst, casino affected. Losses to agriculture.
3	15.–22.1.	Floods	Indonesia	47	3,000	300	Heavy seasonal rains. 80 villages flooded. Health facilities damaged. Losses to industry, infrastructure.
4	21.–31.1.	Floods	Australia	6	2,000	1,000	Torrential rain (570 mm/24 h). Houses, roads damaged. Coal mines affected. Losses to crops, livestock.
5	6.2.	Earthquake, tsunami	Solomon Islands	10			M_w 8.0, aftershocks. Tsunami wave (up to 1 m) reached about 500 m inland. Numerous fishing boats and houses destroyed. Airport flooded. Power lines downed. Water supply affected.
6	15.2.	Meteorite impact	Russian Federation		35		Massive explosion of meteorite (estimated 17 m in diameter, 10,000 t), air burst, shock wave. >7,400 buildings damaged. Communication, power lines downed. Injured: >1,100.
7	Mar.–June	Floods	Colombia	3	150		Heavy seasonal rains, landslides. Losses to property, infrastructure and agriculture.
8	18.–19.3.	Severe storm	USA	2	2,200	1,600	Thunderstorms, tornadoes, large hail (7 cm in diameter). Hundreds of buildings and vehicles damaged. Flights cancelled.
9	22.3.	Tornadoes	Bangladesh	38			Severe storms, hailstorms. Homes and vehicles destroyed. Rail, road traffic and agriculture affected.
10	April–June	Heatwave	India	557			High temperatures up to 46°C for several weeks.
11	2.–4.4.	Flash floods	Argentina	70	500		Torrential rain (300 mm/2 h). Thousands of houses, vehicles damaged. Roads, railway tracks flooded. Trees, power lines downed. 250,000 without electricity.
12	9.4.	Earthquake	Iran	42			M_w 6.3. 92 villages affected. >3,100 houses destroyed. Communication lines disrupted. Injured: 1,100.
13	20.4.	Earthquake	China	196	6,800	23	M_w 6.6. >700,000 houses destroyed/damaged, hospitals, schools, dams, reservoirs, 450 bridges, roads and gas pipes damaged. Power outages. Displaced/evacuated: >237,600, affected: 2 million.
14	20.4	Severe storm	New Zealand		60	40	Severe thunderstorms, small tornado. 1,500 houses, buildings, stadiums, businesses damaged. Trees downed. Losses to agriculture and infrastructure.
15	29.4.–2.5.	Flash floods	Saudi Arabia	24			Heavy rain. Dam collapsed, plains flooded. Houses, farms damaged/destroyed. Affected: >900.
16	18.–22.5.	Severe storms, tornadoes	USA	28	3,100	1,800	EF5 tornado (Enhanced Fujita Scale) in Moore, Oklahoma, >70 tornadoes. >20,000 homes, theatre, schools, health centres, natural gas lines and thousands of vehicles damaged/destroyed.
17	22.5.	Flash floods	Bahamas		45	15	Thunderstorms, torrential rain. Damage to property and infrastructure. Sewerage systems overflowed.
18	28.–31.5.	Severe storms, hailstorms, tornadoes	USA	20	2,100	1,425	EF3 tornado (Enhanced Fujita scale) in El Reno, Oklahoma, hail (7 cm in diameter). Heavy losses to property and businesses. Campus buildings (Technology Center, Oklahoma) damaged/destroyed.
19	30.5.–19.6.	Floods	Western and eastern Europe	25	15,200	3,100	>60 rivers burst their banks (esp. Danube, Inn, Elbe). Numerous towns flooded. Thousands of houses, vehicles damaged/destroyed. Damage to infrastructure. Losses to agriculture. Evacuated: 73,500.
20	14.–30.6.	Floods, flash floods	India	5,500	1,500	600	Torrential monsoon rains. Heavy losses to property, businesses, schools, health centres, hydroelectric power stations, infrastructure, agriculture and fishery. Evacuated: 115,000.
21	15.–30.6.	Floods	Nepal	50			Heavy monsoon rains, mudslides. Losses to homes and livestock. Displaced: >1,300 families.
22	18.–19.6.	Severe storms, flash floods	France, Spain	3	690	360	Thunderstorms, hail, heavy rain. Several houses, >30 hotel buildings, churches, businesses, cars damaged. Roads blocked. Power lines downed. Severe damage to vineyards (due to hail).
23	19.–24.6.	Floods, severe storms	Canada	4	5,700	1,650	Severe thunderstorms, 70 sinkholes. Buildings, infrastructure, Calgary Stampede area flooded. Train derailed. 2 pipelines closed. 30,000 customers without electricity. Evacuated: 100,000.
24	July	Heatwave	UK	760			High temperature (33.5°C). Train tracks, signalling affected. Injured: 10.
25	July–August	Cold wave/winter damage	South America	80			Low temperature, heavy snowfall, frost. Agriculture, livestock affected.
26	2.7.	Earthquake	Indonesia	42	130		M_w 6.1. >20,400 houses, health centre, school, mosque, roads, bridges damaged. 2 mobile water tanks destroyed.
27	8.–9.7.	Flash floods, severe storms	Canada		1,600	920	Rainstorm, thunderstorm, heavy rain (106 mm/3 h). Damage to private and commercial property. Rail, road traffic affected, air traffic suspended. Power outages.
28	19.7.	Severe storms	Canada	1	400	195	High wind speeds, hail, torrential rain, flash floods. Hundreds of houses, vehicles damaged. Trees, power lines downed. Injured: 8.
29	21.7.	Earthquake	China	95	1,000		M_w 5.9, aftershocks, landslides, rockslides. 8 towns affected. Evacuated/displaced: >220,000.
30	27.–28.7.	Hailstorms, severe storms	Germany		4,800	3,700	Thunderstorms, high wind speeds, hail (6 cm in diameter). Tens of thousands of buildings damaged, basements flooded. Road, rail traffic affected. Crops, harvest destroyed.
31	Aug.–Sept.	Floods	South Sudan	98			Heavy persistent rain, thunderstorms, lightning. >85,000 houses, schools, roads damaged/destroyed.
32	1.8.–12.9.	Floods	Pakistan	234	1,500		Heavy monsoon rains. >7,800 villages flooded. >5,800 km² of crops damaged, livestock killed.
33	7.8.–20.9.	Floods	China, Russian Federation	170	4,000	550	Torrential rain. Rivers burst their banks. 229,000 houses flooded. 1,600 km of roads, >170 bridges damaged/destroyed. >26,000 km² of farmland damaged. Evacuated: hundreds of thousands.
34	Sept.	Frost, cold wave	Chile		1,000		Low temperatures (worst September frost in 84 years). Severe damage to vineyards, crops, fruits.
35	9.–16.9.	Floods, flash floods	USA	9	1,500	160	Torrential rain (244 mm/36 h), mudslides, rockfall. Dams, canal burst. >19,400 houses, >200 businesses, buildings damaged/destroyed. Oil spill, gas leaks. Evacuated: 12,000.
36	12.–21.9.	Hurricane Ingrid & Manuel	Mexico	139	5,800	950	Numerous villages flooded, >40,000 houses damaged/destroyed. Severe damage to infrastructure, airport in Acapulco closed. Power outages. >5,300 km² of cropland affected. Displaced: >75,000.
37	16.9.–16.10.	Floods	Cambodia	168	500		Numerous buildings damaged/destroyed. Farmland affected, livestock killed. Evacuated: >60,600.
38	21.–25.9.	Severe storm, tornado	Brazil, Paraguay	4	125		Thunderstorms, hailstorms, tornado, flash floods. >27,000 houses, 100 schools damaged, businesses destroyed (due to tornado). Silos, farm equipment destroyed, crop damage.
39	21.–26.9.	Typhoon Usagi, floods	China, Philippines, Taiwan	36	3,000	75	Category 5 super typhoon, landfall in China as a Category 2 typhoon. Severe damage to property and agriculture. Roads flooded, train, air traffic disrupted, maritime shipping affected. Stock market closed.
40	24.–28.9.	Earthquakes (series)	Pakistan	400			M_w 7.7. Aftershocks up to M_w 6.8. >46,000 mud-brick houses damaged/destroyed.
41	5.–9.10.	Typhoon Fitow (Quedan), floods	China, Japan	12	5,000	750	Category 2 typhoon, dams breached. Thousands of houses, cars damaged/destroyed. Train, road, air traffic affected. Crops damaged. 11 million people without electricity. Evacuated: >1 million.
42	15.10.	Earthquake	Philippines	222	90		M_w 7.1. >72,000 houses damaged/destroyed. Government buildings, seaports, hospitals, historic churches damaged. Roads, >40 bridges damaged.
43	16.–29.10.	Wildfires	Australia	2	270	170	>100 seats of bushfires, >1,200 km² burnt. >200 houses destroyed, >100 damaged. Dozens of cars destroyed. Air traffic disrupted. Schools closed. Evacuated: thousands.
44	27.–30.10.	Winter Storm Christian (St. Jude)	Northern, western and eastern Europe	17	2,150	1,550	High wind speeds, heavy rain, storm surge, waves up to 7.5 m. Hundreds of thousands of houses without electricity. Telecommunications cut off. Rail, air, road traffic, maritime shipping disrupted.
45	8.–12.11.	Typhoon Haiyan	Philippines, Vietnam, China	6,235	10,500	700	Peak gusts up to 380 km/h. >1.1 million houses damaged/destroyed. 80% of Tacloban City destroyed. Major losses to infrastructure, agriculture. Water, food shortages. Missing: >1,700, evacuated/displaced: >4.9 million.
46	10.–15.11.	Tropical Cyclone Three, flash floods	Somalia	162			Heavy rain, storm surge, flash floods, rivers burst their banks. Whole villages swept away, numerous houses destroyed. Losses to infrastructure and livestock. State of emergency declared.
47	18.–20.11.	Flash floods	Italy	16	780		Low-Pressure Area "Cleopatra". Whole villages inundated. Major losses to property, infrastructure, cattle. Dykes breached. State of emergency declared.
48	December	Flash floods, thunderstorm	Brazil	64			Heavy rain, thunderstorm, flash floods, landslides. Hundreds of houses, businesses, cars damaged/destroyed. Damage to infrastructure. Evacuated/displaced: >70,000.
49	5.–7.12.	Winter Storm Xaver	Northern, western and eastern Europe	12	1,700	970	High wind speeds, storm surge. Roofs torn off houses. Flooding in several cities and towns close to the sea, thousands of buildings inundated. Rail, air, ferry traffic disrupted, bridges closed.
50	11.–16.12.	Winter/Snow Storm Alexa, flash floods	West Asia and Middle East	30	420	290	Heavy rain/snowfall, storm surge. Thousands of houses flooded/destroyed. Numerous traffic accidents. Air, bus, rail traffic disrupted. Water supply, sewerage, telecommunications services affected. Severe losses to agriculture.

Topics Geo – World map of natural catastrophes 2013

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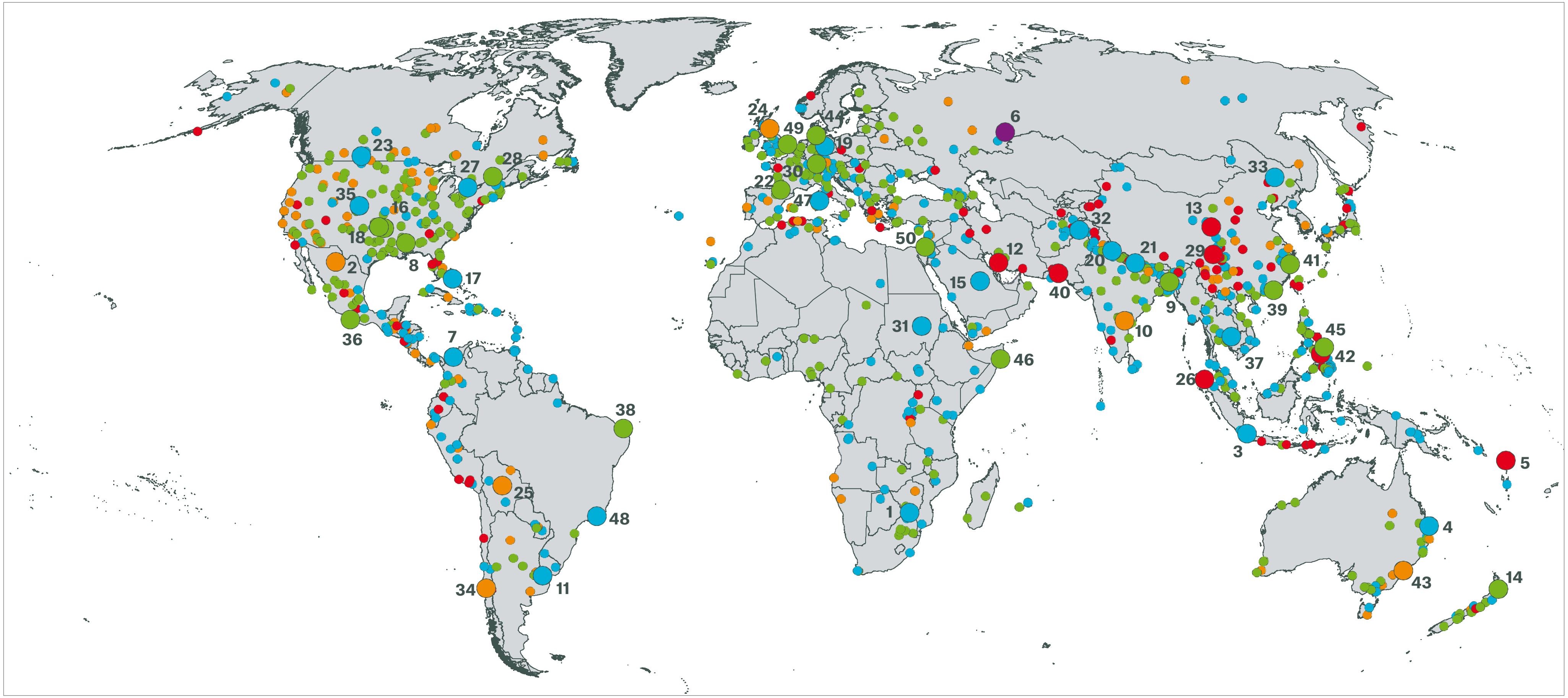

890 natural hazard events, thereof

50 major events (selection)

- **Geophysical events:** Earthquake, tsunami, volcanic eruption
- **Meteorological events:** Tropical storm, extratropical storm, convective storm, local storm
- **Hydrological events:** Flooding, mass movement
- **Climatological events:** Extreme temperatures, drought, wildfire
- **Extraterrestrial events:** Meteorite impact

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