Re: Senate Environment and Communications Committee: Inquiry into recent trends in and preparedness for extreme weather events

Thank you for providing me with the opportunity to review the transcript from the public hearing of the Committee on 11 April.

I also agreed at the time to provide additional material in response to a question from Senator Cameron on the relationship between climate change and losses from natural disasters in Australia.

I would like to refer the Committee to 2 publications which challenge the submissions from Risk Frontiers and the Insurance Council. I have attached the two publications as pdf files.

Nicholls, N., 2011. Comment on “Influence of location, population and climate on building damage and fatalities due to Australian bushfire: 1925-2009”. *Weather, Climate and Society*, **3**, 61-62 (doi: 10.1175/WCAS-D-10-05001.1

Nicholls, N., 2011. Comment on “Have disaster losses increased due to anthropogenic climate change”. *Bull. Amer. Meteorol. Soc.*, **92**, 791 (doi:10.1175/2011BAMS3167.1)

I also refer the committee to the submission by Dr Sandra Schuster to the Committee (submission 49) which directly addresses the question of climate change and insurance losses, and comes to different conclusions than the Insurance Council.

Finally, I would like to refer the Committee to the figure on the bottom opt page 52 of the attached annual report from the NATCAT Service of Munich Re, which shows the marked increase in the number of weather and climate related events globally over the period 1980-2012, compared with the number of geophysical events (earthquakes, tsunamis, etc). This clearly shows a marked increase in weather and climate-related natural disasters over this period.

I hope that this helps to answer the questions from Senator Cameron. I am happy to try to answer any further questions from the Committee.

Prof David Karoly
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CORRESPONDENCE

Comments on "Influence of Location, Population, and Climate on Building Damage and Fatalities due to Australian Bushfire: 1925–2009"

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(Manuscript received and in final form 24 September 2010)

ABSTRACT

The absence of an upward trend in normalized building damage in Australian bushfires may reflect reduced vulnerability (due to improved weather forecasts and other factors) offsetting increases in the frequency or intensity of bushfires.

Crompton et al. (2010) examine trends in bushfire damage in Australia after normalizing historical damage data to take into account increases in building numbers (i.e., to estimate building damage had bushfires in earlier years occurred under the societal conditions of 2008/09). They find no upward trend in normalized damage and therefore conclude that "…there is no discernable evidence that the normalized data are being influenced by climate change due to the emission of greenhouse gases." However, their normalization does not take into account several factors that may have led to a reduction in vulnerability over the period they examined. Each of these factors, in the absence of an upward trend in the intensity or extent of bushfires, might have been expected to result in a decline in the normalized damage from bushfires.

For instance, Crompton et al. (2010) do not factor the increasing urbanization of Australia into their normalization of damage. They normalize the time series of building damage by using changes in the total numbers of buildings across an entire state, without taking into account that the proportion of the state population residing in the capital city has increased substantially over time. In 1958 about 45% of the population of the State of Victoria lived outside the capital city Melbourne. By 2008 this proportion had fallen to about 25%. Presumably this means that, over several decades, the number of buildings outside the capital city has fallen relative to the total numbers of buildings in the state. Apart from those residing on the very fringe of the city, capital city populations (and the houses in which they live) are far less vulnerable to bushfires than are buildings in small towns or isolated communities. The increasing urbanization of southeast Australia over the past 50 years or more might well have led to a decline in the number of buildings damaged by bushfires, unless another factor was operating to offset this decline.

Crompton et al. (2010) also do not take into account possible reductions in vulnerability due to improved building construction and/or regulation. After every major bushfire disaster official enquiries considered what could be done to reduce future vulnerability and recommend actions. As well, individual householders may install systems to reduce bushfire vulnerability (e.g., spray systems to wet houses prior to and during fire attack). Any activities in response to previous bushfire disasters, whether through official changes in building or planning regulations or autonomous actions by householders to reduce building vulnerability, would presumably have led to a decline in bushfire damage, unless the decline in vulnerability was offset by some other factor.

Neither do Crompton et al. (2010) take account of possible reductions in vulnerability due to improved emergency preparations and response, such as improved fire-fighting equipment and management. We should include here the reduced vulnerability that might have resulted from substantial improvements in the skill of weather forecasting over several decades (Nicholls 2001;

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Stern 2008). Such improved forecasts, available with much longer lead times than were possible in the past, could have allowed building owners to prepare more effectively (e.g., by removing fuel from the immediate environs of the building). It seems possible that such systems might have reduced vulnerability, and thus led to a decline in bushfire damage (unless other factors were increasing the threat of bushfire damage).

The above discussion indicates that there are several factors that might have reduced vulnerability to bushfires over the 1925–2009 period examined by Crompton et al. (2010). Any of these factors could have, in the absence of factors increasing the threat of damage, led to a reduction over decades in the damage caused by bushfires. Thus the absence of a decline in normalized damage may reflect an increased threat (perhaps due to a trend toward more frequent or more intense fires) offset by a decrease in vulnerability to fire. Of course, it is feasible that increasing urbanization, improved building/planning standards and techniques, improved emergency planning and response, and improved weather forecasts have not had any success whatsoever in reducing economic vulnerability to bushfires. But until research demonstrates that such decreased vulnerability has not occurred it would be safer to add a caveat to the conclusions of Crompton et al. thus: "...there is no discernable evidence that the normalized data are being influenced by climate change due to the emission of greenhouse gases (*assuming that increasing urbanization, improved building/planning standards and techniques, improved emergency/bushfire planning, equipment and response, and improved weather forecasts have had no effect in reducing economic vulnerability to bushfires*)."

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Comments on "Have disaster losses increased due to anthropogenic climate change?"

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Bouwer (2011) reviewed recent quantitative studies of observed trends in weather-related disaster losses. The studies cited by Bouwer examined observed trends in economic losses that had been adjusted (normalized) "for inflation and changes in exposure and vulnerability that are related to growth in population and wealth" (Bouwer 2011, 40–41). Most of the studies Bouwer examined found no trend toward larger losses, once the losses had been adjusted for changes in exposure. Bouwer concluded, based on this analysis, that although economic losses from weather-related hazards have increased, "anthropogenic climate change so far has not had a significant impact on losses from natural disasters" (Bouwer 2011, p. 43). The observed increased losses arose principally from increases in population and exposure to hazards.

However, Bouwer's (2011) conclusion can only be valid if two other factors potentially affecting losses have not led to reductions in vulnerability. The first of these factors is the possibility that changes in building techniques (perhaps as a result of changing building regulations) may have reduced the vulnerability of structures to weather-related disasters. Few of the studies analyzed by Bouwer consider this possibility (as Bouwer notes). Yet after major disasters, official enquiries often lead to changes to building (and other) regulations that are intended to reduce the vulnerability to disasters. For Bouwer's conclusion to be correct, we must assume that these changes have failed to reduce economic vulnerability to weather-related disasters. If these measures had been successful in reducing vulnerability, then we should have seen a decline in normalized losses in the absence of any increase in either the frequency or intensity of weather-related disasters.

Further, and of more importance, we must also conclude that any improvements in monitoring and forecasting weather hazards have also had no impact on reducing economic losses from weather-related disasters, if Bouwer's (2011) analysis and conclusions are valid. If weather forecasting improvements had reduced vulnerability, then in the absence of a trend in weather-related disasters, we could have expected a decline in normalized economic losses. Of course, if improvements in weather forecasting have led to reduced economic vulnerability to weather-related disasters, then we could conclude, from the absence of a decline in normalized losses, that climate change has led to increases in some forms of weather hazards and losses.

To summarize, only if improvements in weather forecasting and changes in building regulations and techniques have failed to reduce economic vulnerability to weather hazards can we conclude that the absence of an increase in normalized economic losses is evidence that climate change has not increased losses from such hazards. Otherwise, reductions in vulnerability resulting from improvements in weather forecasting and changes in building techniques or regulations may be offsetting increased losses resulting from climate change. The absence of an upward trend in normalized losses may be due to a balance between reduced vulnerability (from improved weather forecasting and building techniques) and increased frequency or intensity of weather hazards. Unless the possibility that vulnerability has decreased can be dismissed, it is premature to conclude that the absence of an upward trend in normalized losses is evidence that anthropogenic climate change has not had an impact on losses from natural disasters. It seems unlikely that increasingly skillful weather forecasting and changes in building regulations and techniques have not had some impact on reducing economic vulnerability to weather-related disasters.

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Reply

—Laurens M. Bouwer
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Nicholls (2011) questions the validity of the main conclusion of my work, that is, that anthropogenic climate change thus far did not have a significant impact on economic losses from natural disasters (Bouwer 2011). His argument is that changes in building techniques and monitoring and forecasting may have reduced the vulnerability to economic damages, thereby balancing a possible increase in either the frequency or intensity of weather hazards. While such effects may certainly play a role, he provides no support that these factors have actually contributed to a substantial reduction in losses over the period of the last decades. Here I will give some reflections on these arguments.

We need not, as Nicholls (2011) argues, dismiss a decrease in vulnerability before we can conclude that anthropogenic climate change has not had an impact on losses from weather disasters. Losses can only have increased due to climate change if there is also an anthropogenic trend of increasing occurrence of the related weather extremes. A human contribution to trends in most large-scale weather-related hazards that were addressed by the studies that I presented, such as extratropical storms and river floods, has, however, not been found (Solomon et al. 2007; Rosenzweig et al. 2007), and for tropical storms it remains uncertain if activity has exceeded natural variability (Knutson et al. 2010). My statement that anthropogenic climate change thus far did not have a significant impact on economic losses from these extremes is therefore robust in my view. I did provide the caveat that for smaller-scale weather extremes for which anthropogenic changes have been established (such as heat waves, droughts, and heavy precipitation events), such impacts may be found, but studies of long time series of damages are rarely available for these extremes.

I agree with Nicholls that it is unlikely that weather forecasts and changes in building regulations have not had any effect on economic vulnerability to natural disasters. The challenge, however, is to find out *how large* the effect on actual economic losses actually has been over longer periods of time. Such quantification would certainly help to support evidence-based policy for vulnerability reduction. However, few quantifications of the avoided losses resulting from vulnerability reduction are available (Benson and Twigg 2004), and economists have resorted to risk modeling or impact-based historic analyses to estimate such benefits (Mechler 2005). Measures for protecting buildings and home content are most often taken after large and rare events, and certainly are not taken everywhere around the world. Government-initiated programs, such as improved building codes in Florida, for instance, have lead to actual reductions in vulnerability to hurricanes only recently (Hallegatte 2008; Pielke et al. 2008). Moreover, direct economic losses from large weather disasters have increased at a rate of about 125% per decade since the 1970s, which is much larger than the average rate of global gross domestic product (GDP) growth (Bouwer et al. 2007). This indicates that a rapid trend of increasing exposure is the main cause for rising losses with urbanization, and an increasing concentration of people and assets along the coasts are the main drivers. Clearly, before vulnerability reduction can turn this trend around, substantial efforts over longer periods of time are needed.

Monitoring and forecasting weather hazards may certainly help to reduce the loss of life. While the number of deaths resulting from floods has apparently increased at a lower rate than economic losses (UN ISDR 2009), it is unsure to what extent forecasting may have reduced economic losses, especially in the largest and most extreme damaging events.

As I have suggested in my article, the match between the loss record normalized for nonclimatic drivers of risk (i.e., changes in exposure and wealth) and the geophysical record of observed weather extremes, such as tropical cyclone landfalls and flood occurrence, provides a good test for the validity of the analysis. Some studies have tested such matches (e.g., Pielke et al. 2008), but more can be done in order to find out the exact causes of variations and trends in disaster losses. Importantly, and as I have pointed out earlier, loss data are far from accurate, which complicates the detection of the relatively subtle signals of anthropogenic climate change and risk reduction. Even if economic losses from certain weather extremes increased, it is unlikely that they would be observed in the loss data, because natural variability and other drivers dominate this loss record, which has high uncertainty ranges. For example, a recent study using climate model results shows that anthropogenic changes in U.S. hurricane losses can be detected only

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after some 260 yr from now, or at the earliest after some 120 yr (Crompton et al. 2011). The first signals of changing weather disaster risks will therefore likely come from geophysical data, not from loss data.

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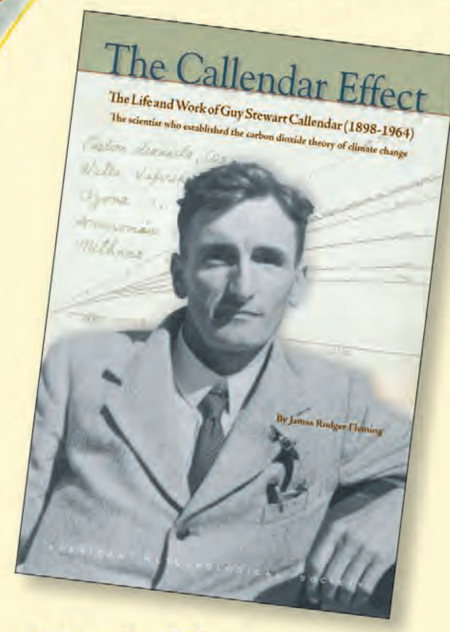

TOPICS GEO

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Analyses, assessments, positions
2013 issue

The great drought

USA experiences the worst drought catastrophe of recent decades. PAGE 16

Hurricane Sandy
Record storm surge along US East Coast

In Focus
Russia – A land of extremes

NatCatSERVICE
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Munich RE

EDITORIAL

Dear Reader,

First Irene then Sandy: the two tropical cyclones struck the northeast coast of the USA in consecutive years. Whilst Irene had caused moderate losses in 2011, Sandy, a late-October storm, graphically demonstrated the destructive power of hurricanes. Sandy ranks alongside Hurricanes Andrew (1992) and Katrina (2005) as one of the costliest storms in terms of insured losses. Power outages lasting several days in some areas also showed just how vulnerable modern society is, despite all the preventive measures.

Overall, the natural catastrophe statistics for 2012 were largely dominated by atmospheric events, with no catastrophic earthquakes. Due to a number of major weather-related catastrophes, including severe tornado outbreaks in the spring and a record drought in the US Midwest, the USA accounted for an exceptionally high proportion of natural catastrophes. However, Russia also experienced unusually hot, dry conditions, and vast tracts of land were devastated by wildfires. In view of climate change, it is to be feared that Russia will be increasingly affected by disastrous natural hazard events. Our "In Focus" section presents an analysis of the situation and explores the consequences for the insurance industry.

There has been a clear upward trend in natural catastrophe losses for some decades now. Topics Geo examines the extent to which this is due to population growth, increased prosperity and other socio-economic factors and the extent to which it is attributable to an increase in the frequency and intensity of natural hazard events. This plays a key role in natural hazard assessment, for instance when calculating loss return periods. Such risk assessments will only provide valid results if data from past events can be classified correctly.

For the first time, Topics Geo includes both the 2012 World Map of Natural Catastrophes and a continent-by-continent breakdown of events recorded in our NatCatSERVICE database since 1980.

I sincerely hope that this issue of Topics Geo will provide useful support for your day-to-day work, and wish you an informative read.

Munich, February 2013

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

NOT IF, BUT HOW

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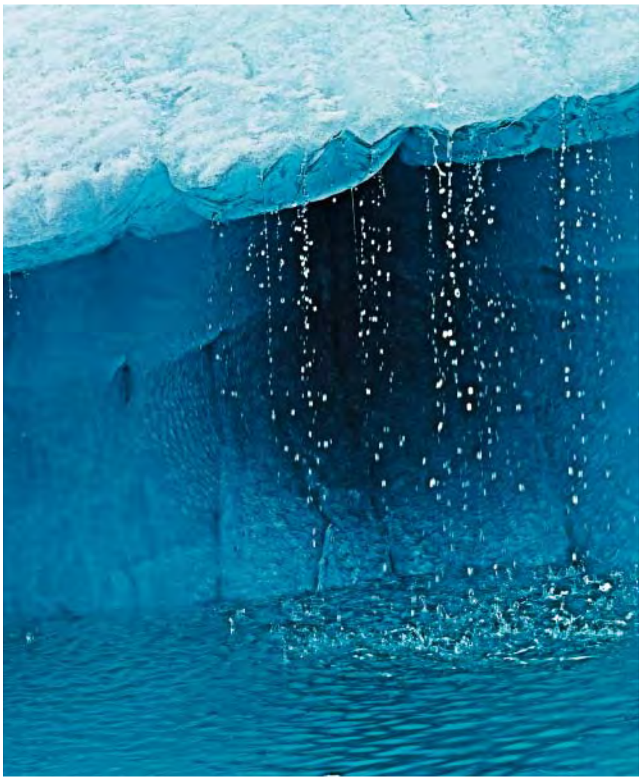

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CLIMATE RISK INDEX

Thailand and Cambodia suffer most

The annual Global Climate Risk Index (CRI) published by Germanwatch shows the extent to which countries have been affected by extreme weather like floods, storms and heatwaves. This is based on Munich Re's NatCatSERVICE database together with demographic and economic data provided by the International Monetary Fund. In 2011, the list was headed by Thailand, Cambodia and Pakistan. In the period between 1991 and 2011, Honduras, Myanmar and Nicaragua ranked highest in terms of losses and fatalities.

>> Further information is available at: **www.germanwatch.org**

DISASTER RESEARCH

Disaster loss data working group formed

IRDR (Integrated Research on Disaster Risk), a programme of the International Council for Science, has set up the DATA (Disaster Loss Data) Working Group. At its first meeting, in October 2012, 12 participants from universities, governments, UN and EU organisations and the insurance industry set the agenda for the next 12 months. The aim is to standardise the terminology and classification of natural disasters so that databases are globally comparable. A further step involves work on an international numbering system for natural catastrophes. This will improve transparency and facilitate data analysis.

>> Further information can be found at: **www.irdrinternational.org**

PUBLICATION

Study on weather risks in the USA and Canada

Weather-related natural catastrophes are increasing at a much faster pace in North America than on any other continent. Our latest study, "Severe weather in North America", analyses different weather phenomena and their consequences. We examine the reasons behind the increase in weather risks, including climate variability and climate change, and recommend risk mitigation and prevention measures designed to deal with extreme events. It is planned to extend the weather risks series to other regions.

>> Details on how to order the study are available at: **www.munichre.com/touch/publications**

News in brief

MCII now in operation: **Munich Climate Insurance Initiative** proposes insurance solutions within the framework of the COP climate negotiations. More information on this and the current pilot project is available at: **www.climate-insurance.org**.

The normalised data recorded in Munich Re's NatCatSERVICE database have been further enhanced with effect from January 2013. Analyses, graphs and statistics are available as free downloads at: **www.munichre.com/touch>>NatCatSERVICE Downloadcenter**

Dr. Anselm Smolka, who is in charge of the section Corporate Underwriting Geo Risks, retires from Munich Re on 30 September 2013. Munich Re's Geo Risks Research Department was built up by Dr. Smolka and Dr. Gerhard Berz, for many years its head. Dr. Smolka was responsible for producing the insurance industry's first probabilistic earthquake risk model in 1987. He will be succeeded by his current deputy, Alexander Allmann, a geophysicist.

CRESTA zones using France as an illustration

Digital CRESTA zone maps are the basis used for natural hazard modelling, accumulation control and mapping. In future, high resolution (see diagram on the right) and low resolution versions will be available.

CRESTA reform promises greater risk transparency

CRESTA, an independent initiative whose main goal is to establish a uniform, global system for the accumulation risk control of natural hazards, was founded some 30 years ago. In 2013, CRESTA's current zoning standard will be overhauled.

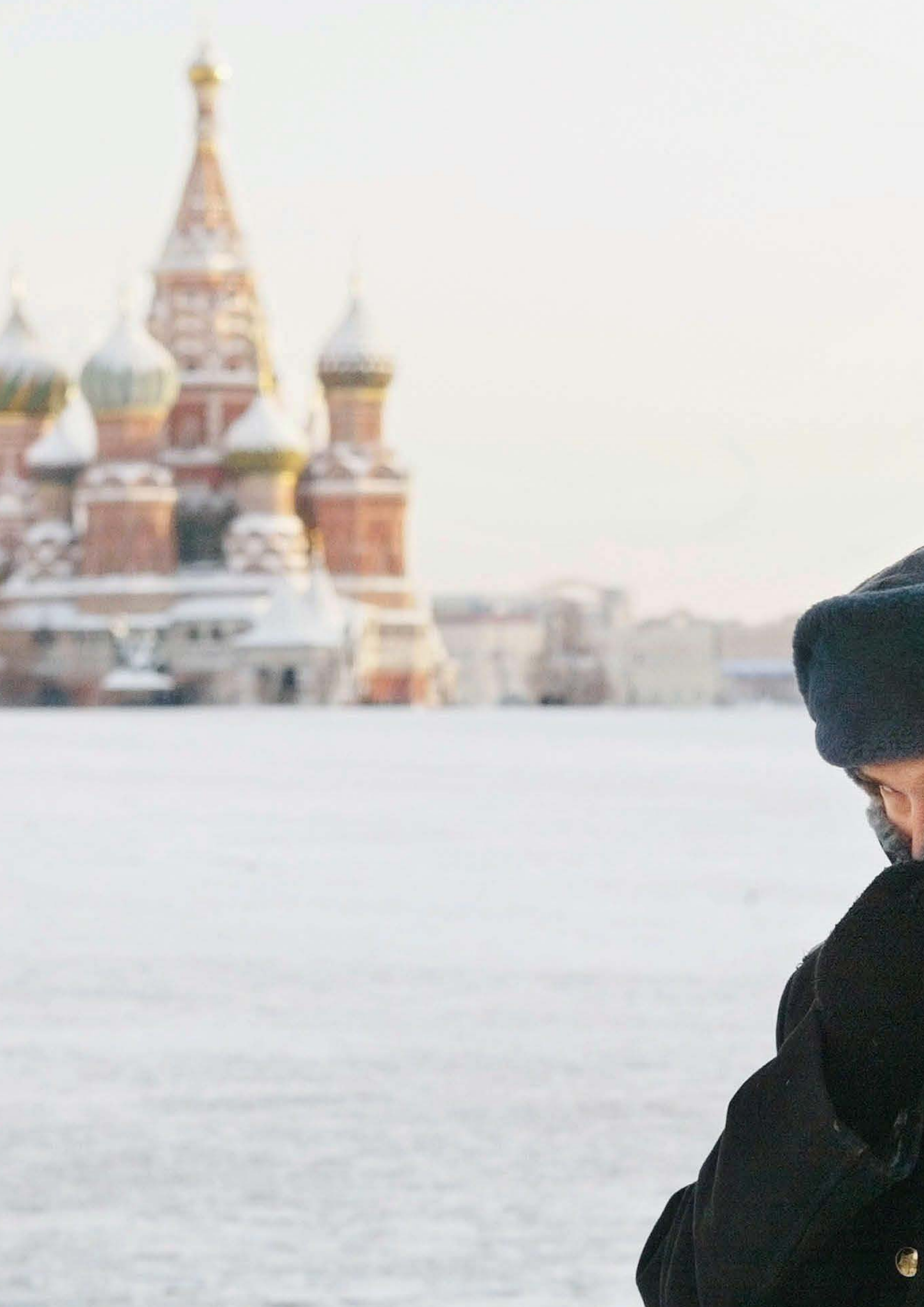
CRESTA zones – the acronym stands for Catastrophe Risk Evaluating and Standardizing Target Accumulations – give primary insurers and reinsurers a system that enables them to transfer aggregated exposure data. Currently, there are zones – and in some cases subzones – for 86 countries.

To give insurers an even better service, CRESTA zones will in future be based on official boundaries rather than perils, since postcodes and administrative zones are generally simpler to use and easily accessible. There will be high resolution and low resolution versions of the CRESTA zones. The high resolution version is designed for data transfer and natural hazard modelling. The low resolution version can be used for accumulation risk control and to visualise aggregated insured values on maps. In addition, a further 49 countries will be added to the database, so that there will be 250,000 high resolution zones worldwide instead of the present 43,000. The official supplier of the special worldwide CRESTA zone maps is GfK GeoMarketing.

To facilitate the changeover to the new system, users will initially be able to access both the new and the old zones, subzones and maps. Conversion tables will be available so that the old zones can be linked with the new ones. Users will still be able to visualise aggregated sums insured per CRESTA zone – in schedule form or in detail – by uploading the ACORD (Association for Cooperative Operations Research and Development) standard table. Another new key function available at no additional cost will allow users to establish CRESTA zones for their insured risks for any given coordinates in just a few short steps.

The task of running the CRESTA secretariat is traditionally performed in alternate years by Munich Re and Swiss Re. In 2013, the secretariat will be headed by Dr. Jürgen Schimetschek, Geo Risks Manager in Munich Re's Corporate Underwriting/Accumulation Risks unit.

>> Further information is available at: **www.cresta.org**



Russian Federation – A land of extremes

Russia is the site of major geological and hydro-meteorological events, weather extremes and other grandiose natural phenomena. Although vast stretches of the country are very thinly populated, natural hazards are a growing challenge for Russian insurance companies and their reinsurers.

Peter Müller

With a land mass extending from the Baltic to the Sea of Japan, and from the Caucasian Mountains to the Arctic glaciers, the country's "vital statistics" are truly impressive: with an area of more than 17 million km^2, the Federation's coastline is more than 37,000 km long, it is crossed by some 120,000 rivers and more than two million lakes dot the landscape. Almost all climate and vegetation zones are found in Russia: the Mediterranean climate, deserts, steppes, tundra, endless ice, permafrost terrain and seemingly never-ending taiga. Major earthquakes, active volcanoes, gale-force winds and severe flooding regularly unleash their destructive forces. Its huge forests also make the Russian Federation an important factor in global climate development.

Jack Frost? Russia covers the full range of climate zones except tropical, but it has a predominantly subarctic and humid continental climate.

Drought causes billions in losses

The statistics of Munich Re's NatCatSERVICE show that, since 1980, roughly 500 natural hazard events have caused macroeconomic losses of US$ 20bn and insured property losses of US$ 760m, both in today's values. Russia captured public attention in the summer of 2010, when the country was ravaged by wildfires during a heatwave and a drought, both worse than any experienced in the past. It is not uncommon for fires to break out in Russia's huge forests. This time, however, toxic smoke covered not only much of the countryside, but also the capital, Moscow. The agricultural sector was badly hit by the drought and farmers experienced considerable production losses. Crops were totally destroyed over an area of around 13 million hectares. The economic loss amounted to several billion US dollars. The government even imposed a ban on cereal exports on account of the disastrous harvest.

Two years on, in 2012, Russia again hit the headlines. This time, wildfires – some caused by arson – raged in the federal districts of the Ural Mountains, Siberia and the Far East, devastating large stretches of land. More major disasters are to be expected in the future. Recent years have already seen a sharp increase in the number of wildfires and wildfire losses. Area-wide forest and peat fires can now be expected roughly every ten years in and around Moscow. A dramatic situation arose even in 2002, when – as in 2010 – the flames nearly reached Moscow's orbital motorway. At the same time, the village of Shiryaevo in the Shatursky District burned down completely. The whole of Moscow was shrouded in smog and visibility was reduced to a mere 50 metres at times.

Ruinous natural calamities on the rise

A completely different kind of disaster occurred on 8 July 2012, when continuous rain and storms caused severe flooding and landslides in Russia's Black Sea region. Thousands of homes were inundated, and 171 people lost their lives. A state of emergency was declared in several towns and cities as railway lines and roads were washed away or rendered impassable. Worst hit was Krymsk, some 1,200 km south of Moscow, where a raging three-metre flood wave fed by the waters of three mountain rivers swept aside everything in its path. The consequences for Krymsk were devastating, with one house in three destroyed by the flood.

The situation is likely to intensify in the future. Russia's Ministry of Civil Defence certainly expects the climate changes observed in Russia in past decades to increase the probability of ruinous natural disasters. Since the devastating wildfires, better technical equipment has been developed to fight catastrophic fires, but major progress is hampered by the sheer size of the territory, uncertainties over who owns the forests, the multifarious interests of lobby groups and the fact that administrative efficiency still has room for improvement.

Insurance market with potential for expansion

Government action is called for following natural catastrophes like that suffered in Krymsk in 2012 because few homeowners are insured against such losses. The insurance products are not yet available and the fact that insurance company branch networks are essentially limited to larger towns and cities also makes life more difficult for potential policyholders. But the situation is gradually changing. For example, the Russian government is considering the reintroduction of obligatory natural hazard insurance for all property owners, as in the Soviet era. At that time, the owners of privately owned individual houses had to purchase state insurance against certain natural hazards, while cover was not obligatory for blocks of flats.

The state's influence has largely been modified to market economy intervention today, although it also intervenes directly. When the state insurance monopoly was dismantled in the early 1990s, a proliferating market emerged, with more than 3,000 insurers jostling for business. The supervisory authorities gradually imposed more stringent capital requirements to stabilise the market, the most recent in January 2012. As a result, many companies closed but the industry's consolidation is by no means complete. Only half of the 600 or so companies currently in the market are expected to remain in operation.

Although a law similar to Germany's Insurance Contract Act (VVG) has been enacted and regulation of the reinsurance market is also liberal, the Russian insurance market still lags behind markets in other former socialist countries in eastern Europe. Political, financial and administrative barriers are still impeding progress. Even now, the two former state insurance companies still play a major role. One has changed its name from Gosstrakh to Rosgosstrakh, while the other – Ingosstrakh – continues to operate under the same name. This can easily give rise to misunderstandings, even among Russian policyholders, because "gos" means state. Indeed, the state has not withdrawn entirely from the insurance industry, and still owns a number of smaller company shareholdings, although they are up for sale. In addition, several of the most important insurers, including SOGAZ, VTB I.C. and Selkhosbank I.C., are run as private companies, in which, however, the state is the major shareholder.

Russia's nascent middle class

With a gross domestic product (GDP) of US$ 1.86tn, Russia ranked ninth in the world in 2011. Despite its economic strength, however, insurance penetration is relatively low. For one thing, even now a large percentage of the population does not own enough property to make insurance worthwhile. At the same time, daunted by a lengthy and frequently turbulent claims settlement process, many people do not see any point in buying a policy. Moreover, many simply lack the financial resources to purchase insurance cover. And the growing numbers of super-rich often dispense with insurance entirely.

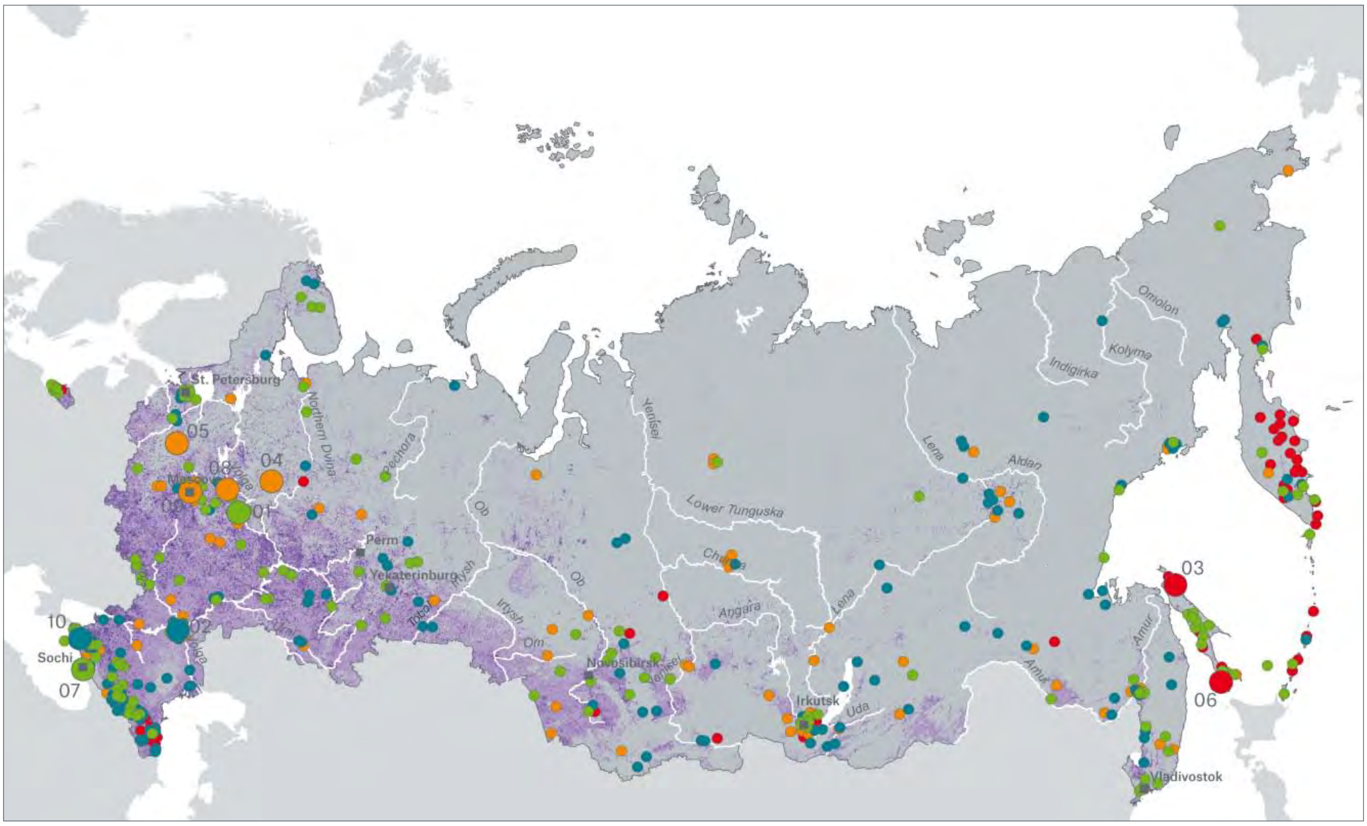
A wealthy middle class with a corresponding need for insurance cover is gradually emerging, mainly in the large conurbations, which offer it greater potential. Roughly three-quarters of Russia's 142 million inhabitants live in cities. In fact, one-quarter lives in the 14 cities with more than one million inhabitants. Moscow, with roughly 12 million inhabitants, and St. Petersburg are the biggest cities. The latter's population recently surpassed five million again, following a wave of emigration in the early 1990s. Unofficially, the population of Moscow is much higher.

The drought and fire catastrophe in 2010 have again raised the question of the function and role of private insurance. Insurance, long considered unnecessary in Russia, is now expected to cover every risk as far as possible. Yet the role of insurance is often misunderstood in this debate. Although it can help to reduce financial burdens, it will never be able to shoulder all economic losses.

To improve market penetration, attention is increasingly focusing on insurers' payment practices, the quality of their products and policyholder satisfaction. However, the government's aim of introducing mandatory natural hazard cover for property owners is the subject of much controversy. The demand for and supply of stand-alone nat cat policies is low but natural hazards are frequently covered under industrial policies (e.g. property, CAR/EAR).

From July to September 2010, much of Russia was caught in the grip of an extreme heatwave and dry conditions. This led to a large number of wildfires and the Moscow region was covered with a dense toxic blanket of smoke. The 30,000 fires caused 130 deaths.

Natural catastrophes and population density in the Russian Federation (1980–2012)



The map shows the population density in Russia together with natural catastrophes documented since 1980. In all, there were some 500 loss-related events with overall losses of US$ 20bn and insured losses of US$ 760m (2012 values). The ten main catastrophes are shown in the table and numbered in order of occurrence.

Source: Munich Re and data from LandScan (2009) TM Population Data Set/UT-Battelle, LLC/U.S. Department of Energy

○ Natural catastrophes
◯ Significant loss events

- Geophysical events (earthquake, volcanic eruption)
- Meteorological events (windstorm)
- Hydrological events (flooding, mass movement)
- Climatological events (temperature extremes, drought, wildfire)

Population density (2009) per km²

- < 1
- 1–9
- 10–49
- 50–199
- ≥ 200

No.	Year	Event	Town/region	Overall losses in US$ m*	Insured losses in US$ m*	Fatalities
1	1984	Tornadoes	Volga region	25	3	400
2	1991	Floods	Volgograd	500	15	
3	1995	Earthquake	Sakhalin	100	5	1,989
4	2002	Wildfires	Esp. Moscow region	500		
5	2006	Cold wave	Esp. Moscow region	400		116
6	2007	Earthquake	Sakhalin	465		4
7	2009	Winter storm, storm surge	Krasnodar, Sochi	60	30	
8	2010	Heatwave, drought, wildfires	Esp. Moscow region	3,600	450	56,130
9	2010	Ice storm	Moscow	60	55	
10	2012	Flash floods	Krasnodar, Krymsk	400	32	172

* Original values

Earthquake hazard in the Russian Federation

Earthquake hazard

- Zone 0: MM V and lower
- Zone 1: MM VI
- Zone 2: MM VII
- Zone 3: MM VIII
- Zone 4: MM IX and higher

Probable maximum intensity (MM: Modified Mercalli Intensity Scale) with a 10% probability of being exceeded in 50 years (corresponds to a return period of 475 years) and average subsoil conditions.

Wildfire hazard in the Russian Federation

Wildfire hazard

- No hazard near water and settlement areas and on soil without vegetation
- Zone 1: Low
- Zone 2: ↓
- Zone 3: ↓
- Zone 4: High

Excluding the effect of wind, fires started deliberately and fire-prevention measures.

According to optimistic forecasts, the Russian Ministry of Finance expects the insurance market to grow strongly in the coming years, with the insurance sector's share of GDP increasing from 1.3% to 5%. Per capita premium income is projected to rise from RUB 5,690 (US$ 190) to RUB 26,770 (US$ 890) by 2020, although how these targets are to be achieved is not clear. In addition to suitable products, more autonomy, better regulation and the planned obligatory covers are expected to stimulate the market.

New agricultural insurance law

The disastrous harvest following the 2010 drought prompted the Russian government to focus on crop insurance. Efforts to revise the existing agricultural insurance law were stepped up in order to achieve agricultural policy objectives, namely self-sufficiency in food production and the exploitation of global export opportunities. Munich Re was actively involved in drafting the new version. The agricultural insurance law lays the foundations for a public-private partnership between the state, the insurance industry and the agricultural sector. The budget needed to support crop insurance is provided by the government. The funds are included in the multi-year agricultural development programme and therefore available in the long term. The same is true of government-aided livestock insurance. Based on the new agricultural insurance law, it will be available from January 2013.

Despite these efforts, however, crop insurance density has not increased (assuming a density of 20% on the basis of insurable acreage), mainly because the insurance industry does not meet the structural and organisational criteria required for the law to be implemented. The investments needed to develop specialty crop insurance have not been forthcoming and there is insufficient know-how to systematically provide a scientifically validated basis for product development, premium calculation and claims settlement. The government knows that the law's practical implementation is not ensured. Further implementation guidelines will have to be drafted – a task which will mainly fall to the National Association of Agricultural Insurers (NAAI). In this respect, the NAAI will have an important coordination function under the agricultural insurance law.

Market crop insurance premium volume, which was around RUB 15bn (US$ 500m) in 2011, is expected to fall in 2012. Crop insurance premiums amounted to only about RUB 7bn (US$ 230m) in the first six months of 2012.

Crop insurance will become more attractive to primary insurers and reinsurers if the public-private partnership develops along the lines of SystemAgro (the sustainable crop insurance programme based on Munich Re's global experience). However, uniform terms of insurance must be established for all market players and the government will have to co-finance insured catastrophe losses. Greater acceptance in Russia's agricultural community would substantially increase insurance density and give farmers an effective risk management tool in the event of further disasters like those of 2010 and 2012. For Russia, this would be a major step towards achievement of its agricultural policy objectives.

Climate change brings opportunities and risks

Until recently, climate change did not loom large in the public mind nor feature particularly in political debate, but the situation is changing as natural catastrophe losses increase. Rising temperatures will lead to more frequent floods, storms and wildfires, while road and rail infrastructure and buildings will also sustain considerable losses as permafrost thaw leads to unstable ground conditions.

On the other hand, climate change will also have positive effects. The Northern Sea Route will one day be commercially viable if the ice cover in the Arctic Ocean is reduced. The melting of the ice caps will also make it easier to drill for raw materials in the Arctic. Russia has already laid claim to the rich oil, gas and ore deposits believed to lie beneath the ice.

Russia entered a new phase of economic development when it became a member of the World Trade Organisation (WTO) in August 2012. Raising the previous limit on foreign shareholdings will also have an impact on the insurance market. Munich Re was represented in Russia in the period 1887/88 to 1914, and played an active part in insuring the monumental Trans-Siberian Railway project. We have had a representative office in Moscow since 1991 and played a pivotal role in developing insurance programmes for new infrastructure, industry and urban development projects. A growing primary insurance market is crucial to further business development. Where natural catastrophes are concerned, Munich Re's positive international natural hazard insurance experience will help the country establish its own sector. Munich Re has acquired a wealth of expertise and will be pleased to assist with the development of viable coverage programmes and rates.

OUR EXPERT

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Facts on climate change in Russia

Jan Eichner and Swenja Surminski

Since all except tropical climate zones are found in Russia, climate change will have a range of consequences. Changes are already evident. Due to its geographic location, with many regions extending into the far north, the temperatures have already risen by more than the global average over the past 100 years.

Russia has a predominantly subarctic, damp continental climate due to the very northerly, polar location of much of Siberia. Permafrost is an important feature. The climate has principally given rise to tundra, taiga and steppe vegetation, with vast forests and extensive grasslands and peat moors. Russia's boreal (mainly birch) forests are the world's largest by acreage and second only to the Brazilian rainforest in terms of CO_2 absorption. Most rivers run from south to north, flowing into the Arctic Ocean and normally freezing over in winter.

In the past 100 years, temperatures in Russia have risen by 1.5°C on average, which is almost twice the global average (0.8°C), even rising by more than 2°C in more northerly regions. The reasons for these major deviations from the global average are complex, one being Russia's geographical location and subarctic continental climate. Due to the cooler temperatures prevailing there, the atmosphere absorbs less water vapour. Supplying energy to the atmosphere generally acts in two ways, increasing both the sensible heat, i.e. air temperature, and the latent heat, i.e. water vapour content. The warmer the air, the more water vapour it can absorb. Since temperatures in Russia are typically lower than in other regions, less atmospheric energy is transformed into latent heat and more into sensible heat, i.e. changes in temperature. This accounts to a large extent for the above-average rise in summer and winter temperatures.

The implications for permafrost regions are considerable. The higher the temperatures in summer, the greater the thaw depth. Thermokarst forms as the permafrost thaws. It is characterised by small lakes, depressions and hummocks caused by ground subsidence. Over the past two decades, some parts of Siberia have subsided by up to 20 cm per year, impacting regional eco-systems, buildings and infrastructure. The stability of roads, power lines, pipelines and railway tracks depends on the stability of the permafrost subsoil. In mountainous regions, landslides may even be triggered as the ground becomes softer. The number of days on which vehicles can cross the tundra on frozen farm tracks and gravel roads has decreased considerably over the decades. Scientists expect this thaw process to continue, leading to a decline in the total permafrost area in the Arctic and subarctic regions.

One dramatic side effect of thermokarst formation is that organic substances, such as rotting plants trapped in the frozen soil for tens of thousands of years, can now thaw. As decomposition resumes, large amounts of carbon dioxide and methane are released, powerful greenhouse gases that further warm the atmosphere.

A positive economic effect expected to result from the reduced Arctic sea ice extent in summer is that the Northern Sea Route will regularly open, giving shipping a shorter route between Europe and Asia while the ice is at its minimum. This will doubtless cut transport costs and permit easier access to mineral and other natural resources. Together with permafrost thaw, however, sea ice retreat is increasing coastal erosion and making it more difficult to plan the investment needed for essential infrastructure like ports and roads.

Although even more directly affected by the rise in temperature, the situation in western and southern Russia is completely different. Extreme heatwaves and droughts, and widespread forest and peat fires have become more frequent and intense, causing serious damage on several occasions in recent years. In the summer of 2010, a heatwave combined with a prolonged drought and poor forest management resulted in devastating wildfires.

For some time now, Russian scientists have observed a change in exposure here – partly due to climate changes. For instance, the average annual number of forest and peat fires and the area affected by fire have more than doubled since 1985. Forecasts project a 50% increase in the number of days with a high wildfire risk in southwestern Russia by 2025. The latest Special Report on Extremes (SREX) by the Intergovernmental Panel on Climate Change (IPCC) also expects further temperature increases in northern Asia. As a result, heat events with a current return period of 20 years will recur every five years by mid-century. A similar pattern can be seen with heavy precipitation (the main cause of flash floods). What are now 20-year extreme events could occur twice as

The Russian Federation's rail network comprises 85,000 km of track and is the longest in the world. It was primarily constructed in the period from 1920 to 1991. Many lines were laid on permafrost, and suffer major damage when the ground thaws and softens, no longer providing firm support.

often in future, and it is no contradiction in terms that the same regions are becoming more arid. Even if total annual precipitation decreases, the probability of extreme cloudbursts can still increase. The desertification of cultivated land is due to increasing aridity in southern Russia. This in turn has repercussions for regional climate, vegetation and water resources – and consequences for agriculture and industry.

Implications for the insurance industry

Even if the complex interactions and uncertainties involved make it impossible to predict exactly how climate change will affect insurance demand, we can at least surmise what factors will lead to a change in demand. Munich Re and the London School of Economics are working on a research project (*Evaluating the Economics of Climate Risks and Opportunities in the Insurance Sector*) which has identified five main determinants of insurance demand within the context of climate change: economic growth, the willingness to pay for insurance, political conditions, the insurability of natural catastrophe risks, and possibilities of adjusting to the impacts of climate change. The base scenario assumes a 7.1% p.a. rise in non-life premium volume in the period from 2010 to 2020. Climate change is expected to have relatively little effect on short- and medium-term growth. In Russia and the other BRIC economies, the annual effect of climate change on income is likely to change by less than 0.4%. This slight but not insignificant effect could intensify, however, if the politicians introduce regulatory mechanisms to counter climate change, such as obligatory insurance, state-subsidised insurance products or the imposition of stricter solvency capital requirements. The same also applies if new business opportunities arise following measures designed to reduce greenhouse gas (GHG) emissions or adapt to climate change. Based on these assumptions, two scenarios can be developed as regards insurance demand in Russia:

Optimistic scenario with a substantial increase in demand

Thanks to decisive action, it will be possible to reduce greenhouse gas emissions so that the costs of climate change will be relatively moderate. The government's proactive adaptation policy and a gradual increase in natural catastrophe risks and losses increases awareness of the advantages of insurance. The government therefore creates a more favourable environment for insurers and reinsurers, and people are more willing to purchase insurance cover. The insurance industry responds favourably to the growing risks and offers products supporting the adaptation process. Confidence in insurers grows and the industry is regarded by the public and the politicians as implicit to a solution to the problems of climate change. A range of adaptation and GHG-reduction measures creates rapid growth in the market for new insurance products.

Pessimistic scenario with little increase in demand
Government measures to reduce the risks of climate change fall short of the mark. Losses increase, adaptation measures and steps to reduce GHG emissions lose momentum. The insurance industry fails to anticipate the full implications of the deterioration in the risk situation and reacts with dramatic price hikes. More and more companies become insolvent, insurers withdraw from some market segments. In some high-risk regions, cover becomes unaffordable and is subsequently no longer available. This has a detrimental effect on the resilience of the local population and on economic development. Public and political confidence in the insurance industry dwindles and the regulatory situation deteriorates. This leads to price regulation and a shift towards more state-sector products in a number of market segments. A more lax global climate policy ultimately leads to a stagnating market for renewable energy cover and a fall-off in demand for GHG-reduction and climate-change-adaptation products. In the medium to long term, global failure to deal with climate change causes increasing economic instability, with higher inflation and lower growth. This adversely affects the insurance market.

Many factors that might cause the pendulum to swing towards either the optimistic or the pessimistic scenario are beyond the insurance industry's control. Nevertheless, a number of factors hinge on the industry's response to the challenges. There are various ways of weighting the trend in favour of the optimistic scenario. They include promoting risk awareness, providing the information needed to keep the climate debate alive, and supporting GHG-reduction and climate-change-adaptation measures. Moreover, changes in the risks must be adequately reflected in underwriting and risk management.

Literature: Nicola Ranger and Swenja Surminski – *A preliminary assessment of the impact of climate change on non-life insurance demand in the BRICS economies*, International Journal of Disaster Risk Reduction.

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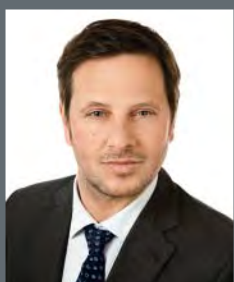

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Drought in the US Midwest

Following the drought in Texas and neighbouring states in 2011, the USA experienced yet another period of extreme dryness in 2012.

Markus Steuer and Maximilian Strobl

2012 was an exceptionally warm year in the USA. In all of the Midwestern states, where most of the main US crops (corn and soybeans) are grown, and many others, the first six months were the warmest since records began in 1895. Above-average temperatures accompanied by increased evaporation rates caused the soil to dry out. In addition, following an abnormally warm and dry 2011/2012 winter, there had been a relatively thin snow cover on the mountains in the spring, so that there was little meltwater to moisten the ground.

From May 2012 onwards, the situation was further aggravated by below-average rainfall in the interior of the country. June and July also failed to bring the abundant rainfall eagerly awaited by farmers, as almost the entire United States came under the influence of high-pressure systems. The resulting drought conditions, which were exacerbated by extremely high temperatures during the warmest July on record since 1895, persisted throughout the subsequent months. The consequences for agriculture were devastating, since weather conditions from June to August play a very important part in the development of corn, soybeans and other crops.

The dryness and heat that prevailed in the US Corn Belt in 2012 primarily affected corn and soybean production. But barge traffic and power production also suffered significant losses.

Based on the Palmer Z Index readings (this index depicts moisture anomalies), a drought of this magnitude in the Primary Corn and Soybean Belt has a return period of 30–35 years. Since 1895, this intensively farmed region had experienced a worse situation only during the Dust Bowl years of 1934 and 1936, and in 1988. Initial model runs by Munich Re assign an agrometeorological return period of 35–45 years to the 2012 drought.

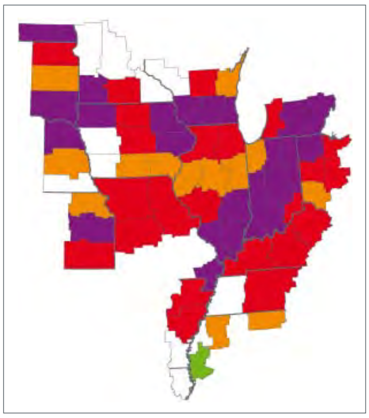
The Palmer Z Index is monthly based and can be used to measure deviations in soil moisture conditions from the long-term average. The duration and geographical extent of very prolonged droughts can be more effectively assessed by the Palmer Drought Severity Index (PDSI), which also takes account of moisture deficits in the preceding months. Based on the PDSI, 39% of the contiguous USA experienced severe or extreme drought in August 2012. This area extended from Nevada to Ohio and from northwestern Texas to North Dakota.

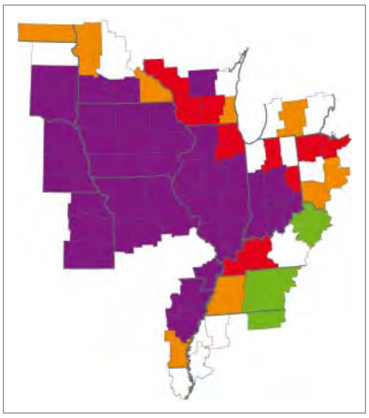
Crop and livestock losses

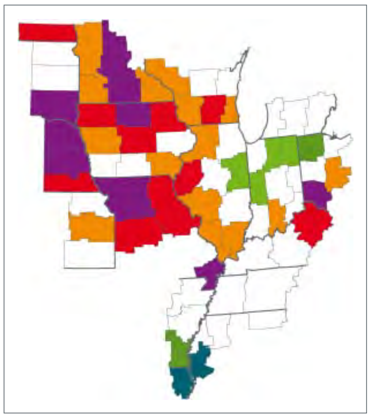
The USA is the world's largest producer of corn and soybeans and also ranks first and second, respectively, in global exports of these products. In 2012, some 40 million hectares (97 million acres) of land were planted to corn and more than 30 million hectares (77 million acres) to soybeans. This corresponds to almost 70% of total grain acreage in the USA. By far the lion's share of these crops is grown in the Primary Corn and Soybean Belt. According to the US Department of Agriculture (USDA) definition, more than 20% of corn and soybeans were rated as being in poor or very poor condition in late June. That share rose to almost 50% (corn) and 40% (soybeans) in July, due to low precipitation and high temperatures. By the time the crops were harvested, the soybean situation had improved slightly, but the condition of the corn crop remained at the same level. Sorghum was affected almost as much as corn.

Prices for crops, especially corn and soybeans, rose considerably in view of the impending losses. Between spring and harvest, the price of soybeans increased by more than 20% and the price of corn by over 30%. Since corn is a very important ingredient in animal feed, livestock producers were particularly hard hit by the higher prices. To make matters worse, between 50% and 60% of the pastures and rangelands were rated as being in poor or very poor condition from July onwards. The price rises also impacted the food processing industry, most of the vegetable oil used for food production being made from soybeans. Soybean meal is also an important source of protein in livestock husbandry and corn is used in the manufacture of industrial products, and primarily ethanol.

Dryness in June, July and August 2012 in the Primary Corn and Soybean Belt


June 2012


July 2012


August 2012

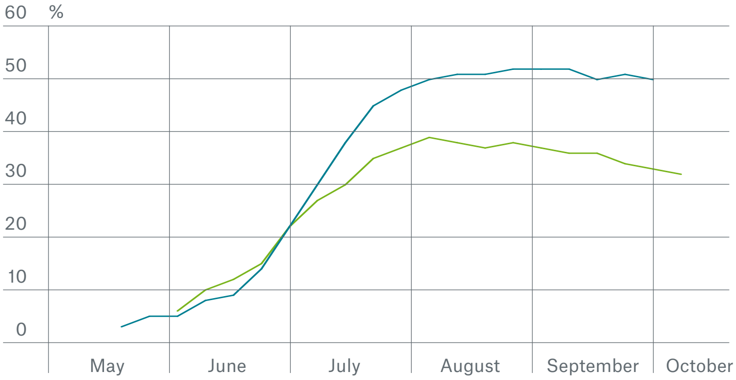
The Palmer Z Index indicates regions in which monthly ground moisture deviates significantly from the long-term average. The rapidly intensifying drought in the Primary Corn and Soybean Belt from June to July was especially devastating for corn because the plants were then at a growth stage particularly crucial to yield.

Palmer Z Index

- Extreme drought (–2.75 or less)
- Severe drought (–2.74 to –2.00)
- Moderate drought (–1.99 to –1.25)
- Normal conditions (–1.24 to 0.99)
- Moderately moist (1.00 to 2.49)
- Very moist (2.50 to 3.49)
- Extremely moist (3.50 or more)

Source: National Climatic Data Center (NCDC), NOAA

Corn and soybeans in poor or very poor condition (2012)



According to the USDA's definition, crops are in poor condition if there is a heavy degree of loss of yield potential. Their condition is deemed to be very poor if there is an extreme degree of loss to yield potential, complete or near crop failure.

— Corn
— Soybeans

Source: National Agricultural Statistics Service (NASS), USDA

As a result of the 2012 drought, stocks of corn and soybeans dropped to historically low levels in the USA and worldwide. Additional production losses due to a continuation of the 2012 conditions would lead to a further deterioration in the supply situation in 2013 and could trigger a drastic rise in food prices throughout the world.

Impact on agriculture in a historical context

During the last severe drought in the Midwest, in 1988, total production of all grains declined by 33% compared with the three-year average. Corn, with a drop of 45%, suffered much more than soybeans (production down by 26%). The overall loss to agriculture totalled US$ 15bn. Farmers were severely hit by the drought, only some 20% of farms and an area of around 23 million hectares (56 million acres) being insured. A total of US$ 1bn was paid in indemnities. The government gave another US$ 4bn in Federal Disaster Assistance.

The 2012 drought proved far costlier for crop insurers, more crops being harvested now than in 1988 and, at the same time, insurance density and total liability covered by crop insurance being much higher. In 2012, farmers had purchased cover for almost 115 million hectares (more than 281 million acres), or 86% of the insurable area. Due to the high exposure and extreme dryness, the losses covered by the public-private multiple peril crop insurance programme will be a record US$ 15–17bn, which translates into a net loss ratio for insurers ranging from around 105% to 135%. In contrast to 1988, many policies link the indemnity not only to yield but also to crop prices paid at harvest time. In this way, the higher prices directly impact the insured losses.

The US crop insurance system is based on a sharing of risks between the private insurance industry and the government. The private insurance industry reported payments higher than at any time in the past, even though the amount of liability is capped by the government.

US droughts since 1900

Period	Main loss area	Overall losses* (US$ m)	Insured losses* (US$ m)	Area percentage (severe to extreme drought)**
1930s Dust Bowl				63% (July 1934)
1951–1956	Great Plains			50% (Sept. 1954)
1988	Midwest	15,000	1,000	36% (July)
2002	Great Plains	10,000	2,000	39% (July)
2011	Texas	8,000	2,400	25% (August)
2012	Midwest	> 20,000	15,000–17,000***	39% (August)

* Losses in agriculture (original values)
** Share of the contiguous USA, based on the Palmer Drought Severity Index
*** Losses covered by the public-private multiple peril crop insurance programme. In average years insured losses are around US$ 9bn.

The table compares the impact of various droughts on agriculture. In terms of duration, intensity and geographical extent, the 1930s series was the severest event. At that time, dust storms caused severe soil erosion in Colorado, Kansas, Oklahoma and Texas, hence the name given to this natural disaster: the Dust Bowl. Overall losses are very hard to quantify, however. It is estimated that US$ 1bn (approx. US$ 16bn in 2012 values) was paid out in governmental aid at that time.

A tough year for farmers and insurers

The drought in the Midwest had severe consequences for farmers. Topics Geo interviewed Derick Warren of Warren Farms and Greg Mills, Chairman of the Crop Insurance and Reinsurance Bureau (CIRB) and President of ADM Crop Risk Services.

***Topics Geo:** The 2012 drought was one of the worst on record for the US agricultural industry. Mr. Warren, your farm grows corn and soybeans in Illinois, a state that suffered extensively under the drought. How did it affect your yields?*

Warren: Up until this last harvest, we'd been averaging about 180 bushels of corn per acre (115 dt/ha) and 55 bushels of soybeans (35 dt/ha). And back in the spring, just a month after planting, it looked like we were going to have our best output ever. The growing conditions were wonderful, and nothing had to be replanted. We were expecting to see as much as 250 bushels of corn per acre (160 dt/ha). But then, in June, it started going steadily downhill. We stopped getting rain and temperatures rose. By 6 July, our soil moisture dropped down to 0%. When it was time, the grain just wouldn't fill the ears, and we had to start aborting kernels. In the end, our corn crop took the biggest hit, with about a 35% loss. Our soybean yields fared better with only about a 10% reduction, thanks to the rain we finally got in August.

Have you experienced a drought of this magnitude before?

Warren: No, nothing close to it. My father has been farming this land for more than 50 years and I started in 1982. Even the drought we had in 1988 didn't destroy as much of our harvest as this one. And until 2012, we never had a problem with alfatoxin either, a toxic fungus that thrives in drought conditions. The corn we did harvest couldn't be stored in our containers; it had to be taken straight to the elevator in town to prevent the risk of contamination.

What makes the 2012 drought so much different than the one in 1988?

Mills: For starters, the 1988 drought was focused more to the north and wasn't nearly as far-reaching. We also didn't see such high temperatures back then. With the 2012 drought, temperatures climbed to around 5° to 15°F (3° to 8°C) higher than normal and lingered. This had an especially devastating affect during the pollination period for corn. On the other hand, many of the crop varieties used today are genetically superior and more drought-resistant than what was planted in 1988. So losses could have been much higher.

Are these genetically modified, drought resistant varieties something your farm uses?

Warren: We've never had the need to plant drought-resistant corn because we've always had enough soil moisture to get us through in this area. But, as it stands right now, we're about 10 inches (25 cm) short of the water we need. So the next few months are critical. Unless we get about one good rain a week or a decent snowfall, we could very well have problems going into the next growing season. If we don't get enough subsoil moisture, it will be another difficult growing season. So, yes, if the drought continues, then it could be something we'd have to look into for the future.

Derick Warren (right) with his son Brody at the family's farm in Illinois. The farm produces mainly corn and soybeans.

Greg Mills, a US crop insurance specialist, is Chairman of the Crop Insurance and Reinsurance Bureau (CIRB) and President of ADM Crop Risk Services.

In the US, the Multiple Peril Crop Insurance (MPCI) programme was created by the government to regulate insurance prices and coverage. It also subsidises farmers' premiums, while still allowing private insurance companies to administer and service the policies. What are the objectives behind this public-private partnership?

Mills: Before the US government created MPCI, a lot of farmers would be completely wiped out after a major natural catastrophe. And, many times, the government would have to go in after the fact and provide emergency relief funds. The objective of MPCI is to give the farmer a backstop in an environment that would otherwise be too risky. And this safety net is increasingly critical in today's agricultural industry; input costs are rising, land is becoming more expensive and the overall risks are higher. Offering farmers yield and revenue protection not only brings a degree of economic security to rural America but also helps stabilise the world's food and biomass energy supplies.

Are American farmers adequately insured to counter the risks and cope with catastrophe?

Mills: About 85% of farmers buy crop insurance under MPCI. MPCI's most efficient coverage is called Revenue Protection. It offers protection against all natural perils and price fluctuations at different guarantee levels. Now, whether they have bought sufficient coverage is another story. But I think that, after this year's drought, we'll see not only a growth in participation but also an increase in coverage levels.

Mr. Warren, your farm is protected under MPCI. What level of coverage do you typically select?

Warren: I've always gone for the full 85% coverage level, and the subsidy helps make it affordable. But my father and I have separate policies. Just one year before the drought hit, I convinced him to increase his coverage as well – a decision we're both thankful for now. I think all farmers should get insured to lock in their revenue. Without it, I'd have lost a considerable amount of income because of the drought. The policy also serves as collateral with my bank, which makes it easier to take out the loans we need for the following year's farming supplies.

Mr. Mills, what was the biggest operational challenge facing the crop insurance industry as a result of the drought?

Mills: The initial administrative processes were a huge hurdle. When you've got, say a million policies and suddenly about 80% have a loss, it's a challenge to get all those claims processed quickly.

How was the crop insurance industry able to handle the increased volume?

Mills: When we started to see how severe the drought could become, some companies began calling up farmers and giving them a heads-up to prepare the necessary documentation. The more organised and prepared a farmer is, the quicker adjusters can assess and process the claim. Technology also plays a pivotal role in how efficiently an insurer can respond. All our loss adjusters at ADM Crop Risk Services are equipped with laptops and smart phones instead of clipboards and pencils. Being able to enter loss information on the spot cut our processing time almost in half.

What was your claims experience like?

Warren: As long as you have your fields separated and your paperwork, like delivery sheets and bin documentation in order, it all runs smoothly. In my case, the adjuster from ADM Crop Risk Services came out and we sat down together to go through all the information. He came up with the number and it was all taken care of right then and there. It took less than 30 days before I received compensation.

What sort of loss ratio are you expecting to be felt in the crop insurance industry?

Mills: I'd say we're looking at a 105% to 120% loss, with some companies facing as much as 130%. And if it wasn't for the August rains that saved a good portion of the soybean crops, it'd be even higher. As part of the MPCI programme, the US government offsets part of the insurers' losses, as do reinsurance companies like Munich Re. But 2012 was still a tough year for many farmers and insurers alike.

The losses to be borne by reinsurers are on a scale normally encountered only after major storms, floods or earthquakes. The 2012 drought showed that, assuming high insurance penetration, private-sector funding of multi-peril crop insurance at current premiums would be economically feasible only in the framework of a public-private partnership. The decisive point in Munich Re's view is that the government's role must not be confined to premium subsidisation, but also include co-financing a substantial share of the catastrophe losses. This is because the main hazards in agriculture are systemic and have wide-scale impact.

Favourable conditions for wildfires

The drought also led to an above-average fire risk in many regions. In Colorado, for instance, June 2012 was the warmest and second driest on record. The Waldo Canyon fire, which raged in the mountains northeast of Colorado Springs in June and July, destroyed almost 350 homes in the wildland-urban interface. This was 2012's most damaging wildfire and the costliest ever in Colorado's history. It resulted in an overall loss estimated at US$ 900m, half of which was insured. The fire was man-made, although it is not clear whether it was caused by arson or carelessness.

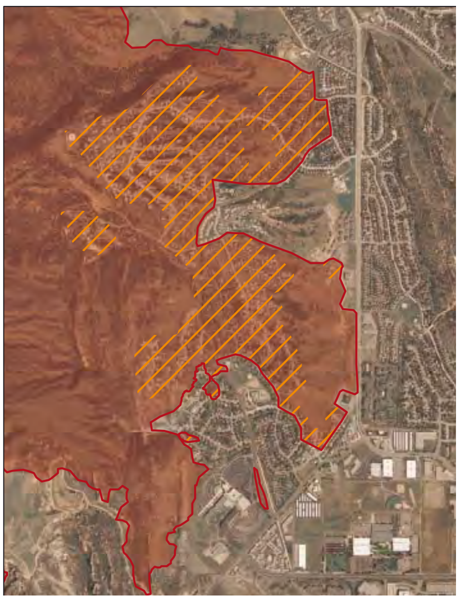
On a nationwide average, the area destroyed in the 2012 wildfire season was the third largest since systematic records began in the 1960s. An above-average number of fires occurred in grasslands and open scrublands. Fire can spread more rapidly in these areas, so that the area affected is on average greater than in the case of forest fires.

Disruption of waterway traffic

Since late spring, navigation had been more difficult on the Mississippi river system due to low water levels. In places, navigable channels had narrowed to such an extent that shipping was held up or able to move one way only. Vessels were no longer able to carry full cargoes and there were numerous groundings. Consequently, fewer goods were transported and there were delays and increased freight costs. Shipping on the Mississippi had already been badly hit by the 1988 drought and the transport of bulk commodities (coal, petroleum and grain) declined by 50% that summer. In several places barge traffic was stopped for four weeks. The industry suffered a loss of at least US$ 200m due to the 20% drop in turnover.

Utility companies cut back production

The drought also affected the power industry in the Midwest. One plant had to be shut down when its cooling water source fell below the plant's intake. At another, output had to be reduced because the cooling water was too warm to be discharged. The eco-system is likely to suffer if the temperature of the river or lake into which the water is discharged exceeds certain limits. The temperature in the cooling pond of a nuclear power plant in Illinois also rose above the permitted 100°F (38°C). Special permission was granted for the plant to continue operating, although the temperature reached 102°F (39°C).



Over 90% of the insured losses from the Waldo Canyon fire were accounted for by personal lines of business, most of the buildings in the area concerned being residential. The photograph shows houses ablaze to the northeast of Colorado Springs. The map indicates the perimeter of the fire in July 2012 (red area) and affected residential areas (hatched).

- Perimeter of the fire in July
- Affected residential areas

Source: Munich Re, based on data from USGS Rocky Mountain Geographic Science Center (perimeter) und ESRI, i-cubed (satellite image)

Risk, Liability & Insurance

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NOT IF, BUT HOW

Munich RE

These examples show that extreme drought can jeopardise the power supply and this can have huge loss potential. In addition to cooling restrictions, a further problem encountered by fossil-fuelled power plants is that coal and petroleum supplies may run out if barge traffic is affected. Hydroelectric power production may also decline due to lack of rainfall.

However, the entire system is subject to stress, not only because less power is generated but also because more power is consumed by cooling and air-conditioning systems during heatwaves. Additional power has to be fed into the system to maintain the balance between generation and consumption. In the event of an imbalance, the point may be reached where some power plants have to be taken out of service to prevent major damage and malfunctions.

In the USA, the additional power required can be met to a certain extent by producing electricity in natural gas plants, which normally only operate at 25% to 50% of their full capacity. If they also have cooling problems or spare capacity is not available in a particular region, power shortages have to be offset between different regions. However, if much of the country is affected by drought for a significant period and several regions are facing the same problems simultaneously, widespread power failures cannot be excluded.

OUR EXPERTS

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Conclusion

The 2012 drought showed that this natural hazard can cause losses in many different sectors. It affected barge traffic and power generation and caused heavy losses due to wildfires, the ignition and spread of which were favoured by the dry conditions. Agriculture was by far the worst hit. The US agricultural insurance system proved its worth and saved the vast majority of farmers from financial distress or even bankruptcy. The agricultural banks did not suffer substantial loan defaults, so that farmers can still avail themselves of low-cost loans. Agricultural loans play an important part in financing ongoing production in the USA. They are used to offset the negative cash flows resulting from the high up-front costs incurred for crops which are harvested and sold at a much later point in time. In addition to these advantages, subsidised premiums have also helped boost acceptance of the crop insurance programme. Around 86% of agriculturally used land was insured in 2012.

This system of providing cover against natural hazards in the US agricultural sector is far more efficient than the state relief generally paid elsewhere following disasters. It ensures that cover and indemnity are tailored to the farmer's individual risk situation, and provides fast claims settlements. However, it also benefits the state because farmers pay much of the premium themselves, whereas aid payments are funded entirely by taxpayers. Public-private partnerships of this type also eliminate the need for a state-run disaster relief infrastructure, this being provided by the private-sector insurance industry.

Munich Re regards the US crop insurance system as an exemplary form of risk management for natural catastrophes in the agricultural sector and a model for other countries. It ensures that production levels quickly return to normal following a natural catastrophe and thus plays an important part in ensuring secure food supplies and preventing major price fluctuations. Based on experience acquired worldwide over many years, Munich Re has analysed the success factors that ensure sustainable crop insurance and given it a name: SystemAgro.

>> Detailed information on SystemAgro can be found on Munich Re's website at: **www.munichre.com/systemagro**

Impact on global food security

Drought – An underestimated natural hazard

Prof. Dr. Peter Höppe, Head of Munich Re's Geo Risks Research/Corporate Climate Centre
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The year 2012 was marked by a series of catastrophic droughts, Munich Re's NatCatSERVICE registering no fewer than 26 loss-related events in all. The main event (with a 40-year return period) was the major drought in the US Midwest, which caused agricultural losses totalling billions of dollars. Meanwhile, Russia, the Ukraine and Kazakhstan, all of which account for a significant proportion of the world's cereal production, also experienced extremely dry conditions. World cereal prices spiralled following disastrous harvests in the regions concerned. According to an analysis by the KfW banking group, prices rose 17% to unprecedented levels in July alone. Some products, such as corn, were subject to even more dramatic increases, prices rising by 25%.

Harvests in agricultural export regions like Texas (USA) and Russia had already been affected by drought in 2011 and 2010. In 2010, Russia experienced unprecedented heat and drought, prompting the government to impose a temporary export ban to safeguard domestic food supplies. The 2011 famine in Somalia was also triggered by a severe drought.

NatCatSERVICE data show a clear long-term trend towards more droughts. The incidence of droughts has doubled from ten loss-related events worldwide in the 1980s to roughly 20 in recent years.

Droughts differ from natural hazards such as storms and earthquakes. They develop gradually and may last months or even years. They are therefore less "spectacular" than tornadoes or flash floods, and less newsworthy and we often become aware of them only when they have caused a famine or a dramatic hike in food prices on world markets. Thus, keeping accurate records of drought data in natural catastrophe databases is a challenge.

"Droughts will be one of the most catastrophic natural hazards in coming decades."

Munich Re sponsored research by a geography Masters student into ways of improving our NatCatSERVICE drought records by basing them on more objective data. Clear criteria were established for determining the duration of an event and the losses. All 500 drought events registered in the database since 1980 have been re-assessed and we now have an even better basis for providing high-quality reports on drought losses and loss trends.

This will be even more crucial in future. In its 2012 report on extreme events (SREX), the Intergovernmental Panel on Climate Change (IPCC) predicted more heatwaves accompanied by droughts in many parts of the world. By mid-century, heatwaves that now have a 20-year return period are likely to occur every two to three years in the US Midwest and central Europe, and as much as every one to two years in Southeast Asia. Thus, droughts will be one of the most catastrophic natural hazards in coming decades, posing a huge threat to world food supplies.

The situation will be further aggravated by the fact that the global population will have grown to some nine to ten billion by mid-century and demand for animal-based foods will increase in countries with rapidly growing wealth, such as China. Agricultural production will have to be stepped up and more land will be needed to meet the growing demand. However, more intensive production will mean the agricultural sector is more susceptible to the increasingly variable weather conditions and similarly to increasing development of farmland in regions ill-suited to agricultural production.

The recent droughts and their implications for food prices are therefore to be seen as precursors of a phenomenon that will be increasingly prevalent in coming decades. Appropriate preventive measures include climate protection, steps to curb population growth, using more resistant types of crop and reducing meat consumption.

Earthquake series in Emilia Romagna, northern Italy

From mid-May to mid-July 2012, the Emilia Romagna region was shaken by a series of earthquakes. Despite the relatively low magnitudes, losses ran into the billions.

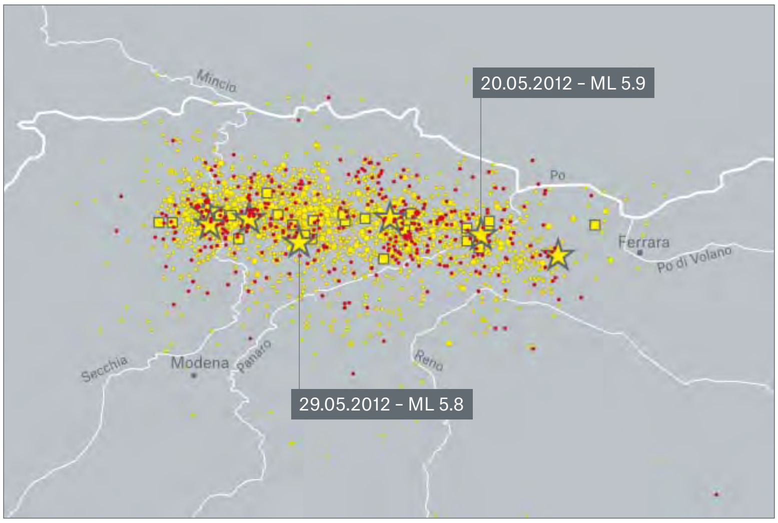
Anselm Smolka and Marco Stupazzini

Seismic activity in the northern foothills of the Apennines is related to continuing orogenic activity that generates northward shear stress. Overall, such activity can be considered moderate, comparable with the regions of stronger activity in central Europe, north of the Alps. The last major damaging earthquake occurred here in 1570, although the epicentre then lay slightly to the east of the area affected in 2012. The series of earthquakes began on 19 May with a number of magnitude-4.1 tremors that culminated in the quakes on 20 May (M=5.9) and 29 May (M=5.8). In all, seven magnitude ≥5 events were registered between 20 May and 20 July 2012, the epicentres moving from east to west. Intensities along an epicentral zone roughly 50 km long reached maximum values of VII–VIII on the European Macroseismic Scale.

Strong ground motions

The acceleration values of the earthquake on 29 May were recorded by three different networks, and the data are of very good quality. The maximum ground acceleration measured by the seismic recording station at Mirandola, closest to the epicentre, was 0.3g in a horizontal direction and 0.9g in a vertical direction. What was particularly striking and very unusual for a relatively low magnitude quake of this nature were the long-period velocity impulses. They are attributable to the directivity of the westward rupture process combined with the highly irregular basement topography beneath the young sediments of the Po Valley. When the observed acceleration spectra are compared with the design spectrum of the current Italian seismic building code, the values measured are found to have a return period of roughly 1,000 years. The value for oscillation periods of more than 1.5 s is prob-

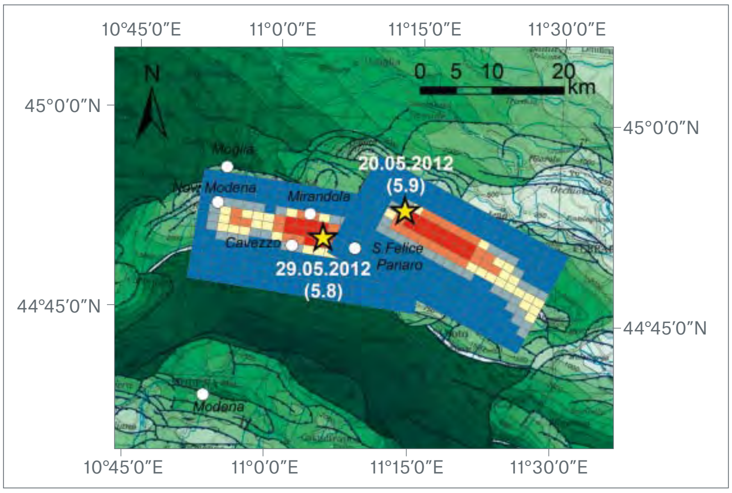
Seismic sequence 19 May–20 July 2012



Epicentres of the earthquake series in the Emilia Romagna region between 19 May and 20 July 2012. The yellow stars represent magnitude ≥5 events.

- ∘ < M. 3.0
- ○ ≥ 3.0–3.9
- □ ≥ 4.0–4.9
- ☆ ≥ 5.0
- ● Events from 19 May–20 June
- ● Events from 21 June–20July

Source: ISIDe Working Group (INGV, 2010), Italian Seismological Instrumental and Parametric Database: http://iside.rm.ingv.it



Rupture planes of the quakes on 20 and 29 May 2012

The diagram indicates the approximate extent of the rupture planes for the quakes on 20 and 29 May. The colour of the smaller squares represents the different displacement amounts.

- High
- ↓
- ↓
- Low

Source: C. Smerzini, personal information, 2012

ably closer to 2,500 years. As is customary, buildings are designed to withstand events with a return period of 475 years.

Seismic building codes in Italy

Italy has had guidelines on earthquake-resistant construction for many decades but their scope and requirements have changed considerably over the years:

- 1927: "Regio decreto": Only applied to the area affected by the Messina/Reggio quake in 1908
- 1974: National building code with special regulations governing earthquake-zone construction
- 1980: Decree of the Ministry for Public Buildings
- 2003: New seismic zoning system
- 2005: Implementation of the zoning system in new construction regulations, mandatory from 2009 onwards

Epicentral parameters of the quakes on 20 and 29 May 2012

	20 May 2012	29 May 2012
Magnitude ML	5.9	5.8
Focal depth (km)	6.3	10.2
Coordinates	44°53′24″N 11°13′48″E	44°51′0N 11°5′10E

A comparison of the situation before and after 2003 (see maps on p. 28) shows that the zones with special earthquake regulations have been considerably extended. Interestingly, Emilia Romagna, where the earthquakes occurred, was not classified as seismically active before 2003.

Losses

The Emilia Romagna quakes form part of the series of earthquake disasters that have occurred throughout the world since the Haiti quake in January 2010, despite their relatively low magnitudes. According to figures published by the Italian Civil Defence Ministry, the overall loss totals €13bn (US$ 16bn), of which roughly €5bn is accounted for by buildings, 25% of which were insured. On a global scale, the building losses sustained in Italy are high because the country has a unique stock of historical buildings, which are extremely prone to earthquake damage. Although the significant losses to historical buildings were not particularly unexpected, many factory buildings were also extensively damaged. This is because most of the industrial buildings were constructed before 2003, i.e. prior to the introduction of a special building code for this earthquake zone.

Insurance aspects

With an estimated cost of €1.3bn (US$ 1.6bn, as at December 2012), the Emilia Romagna quakes produced Italy's highest ever insured earthquake losses. This is surprising, considering that major cities like Modena, Bologna, Ferrara and Mantua were little affected. Although the area where the biggest losses occurred is predominantly rural, all sizeable communities have industrial zones, so that in all several thousand industrial buildings are located here. The main industries are cheese production, including Parmesan and Grana Padana, food processing and medical technology.

Commercial buildings, some of which were completely destroyed, accounted for a significant proportion of the insured losses. Hundreds of thousands of cheeses were lost due to storage racks tipping over. The second major loss item concerns municipal policies for public buildings and covers for water management companies. Public authorities are frequently housed in damage-prone historical buildings, and municipal policies are much more common in this region than in central and southern Italy, for example.

After a somewhat slow start, claims settlement subsequently progressed well. As with other recent quakes, especially Christchurch in New Zealand, the key factors proved to be adequate replacement values and under-insurance clauses, rigorous accumulation control and risk geocoding, and contingency plans for claims settlement following major events. One of the main problems is assessing the restoration value of historical buildings.

The earthquake series in the Emilia Romagna region showed that even moderate quakes have enormous loss potential. A similar situation could also arise in Italy's industrial corridor between Turin and Venice. However there are other regions in central Europe, outside Italy, with similar seismicities and comparable building codes, including the Basle conurbation, southwest Germany, the Lower Rhine Basin and the Vienna Basin.

OUR EXPERTS

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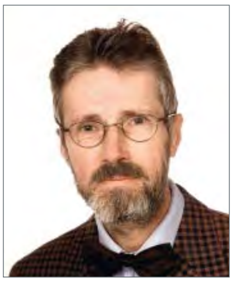

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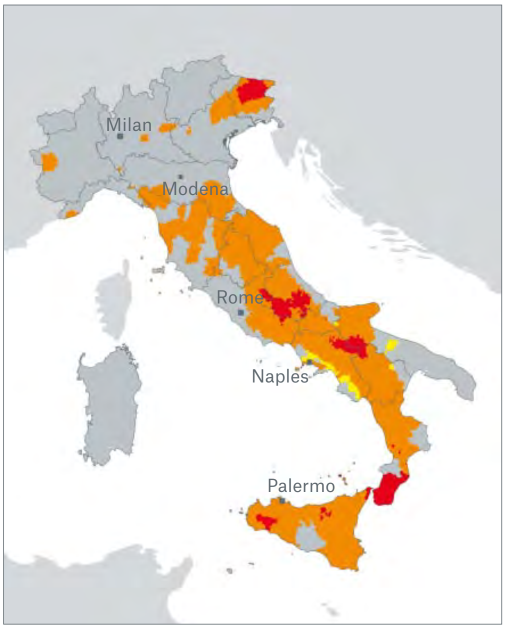
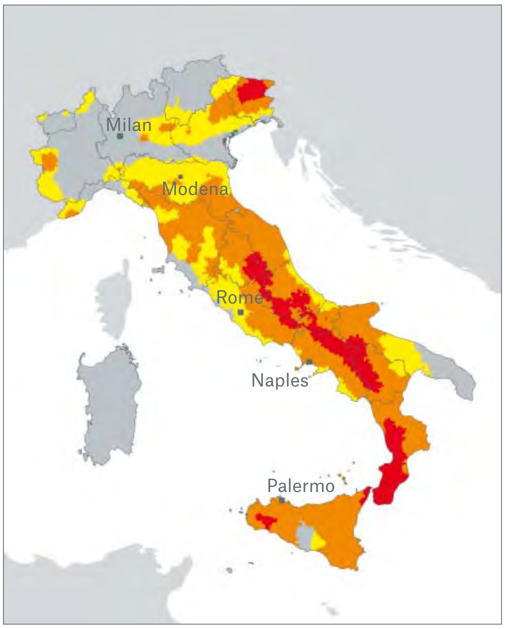
Earthquake zones based on Italian building codes

1980 to 2003



After 2003 onwards



Introduced some decades ago, Italy's guidelines for earthquake-proof construction have since undergone several updates.

1980 to 2003
- Zone 1
- Zone 2
- Zone 3
- No classification

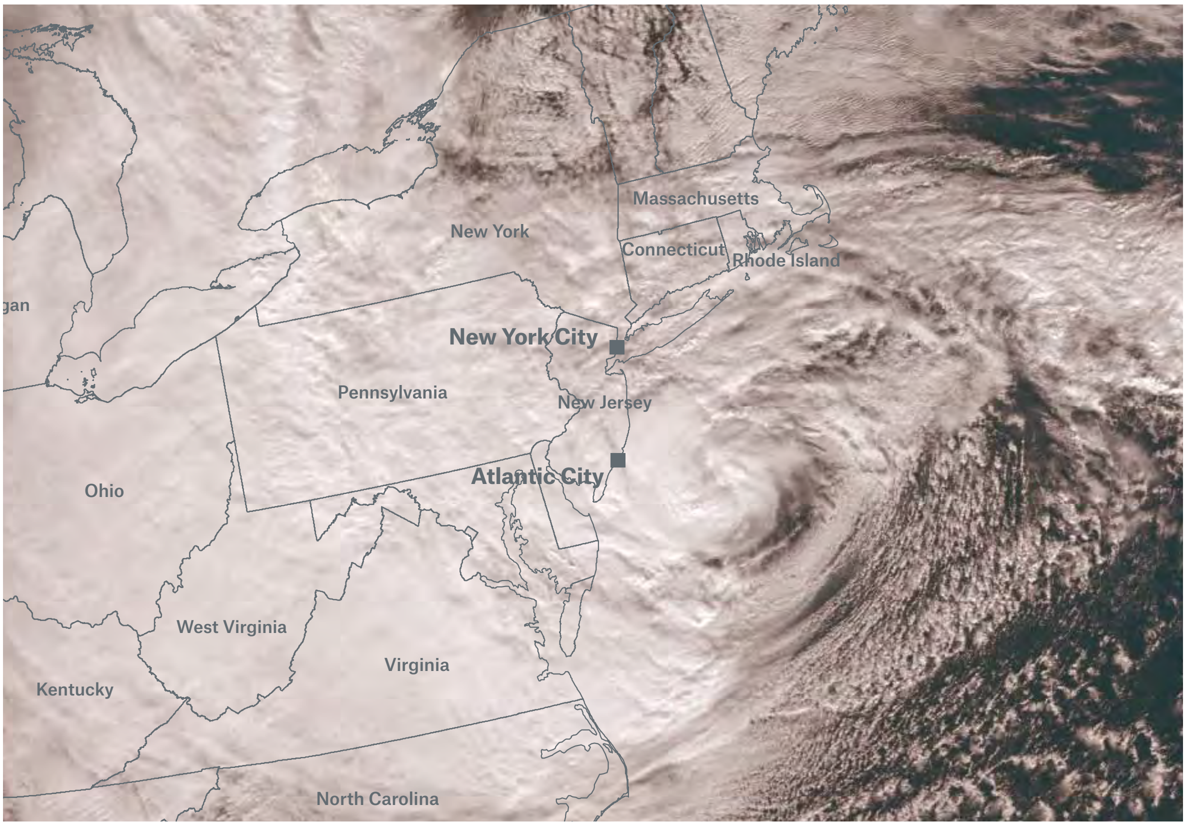
After 2003
- Zone 1
- Zone 2
- Zone 3
- Zone 4

Source: Dipartimento della Protezione Civile, www.protezionecivile.gov.it

The Emilia Romagna region in northern Italy suffered considerable damage in the May 2012 earthquake series. Thousands of buildings, including a number of historical monuments, sustained severe damage. The photograph shows the damaged clock tower in Finale Emilia.

Hurricane Sandy impacts US East Coast

On 29 October, Hurricane Sandy slammed into the New Jersey coastline, leaving behind an unprecedented level of devastation. Sandy was the most destructive hurricane encountered in the northeastern USA since the great storm of 1938.



Hurricane Sandy was an extremely large system – its wind field covered an area of 1.5 million km². Sandy caused losses in 15 US states.

Source: NASA/NOAA/
U.S. Department of Defense

Mark Bove

Hurricane Sandy was the second last hurricane of the 2012 season. It began as Tropical Depression 18 in the central Caribbean on 22 October, then became a tropical storm that strengthened as it moved north, reaching hurricane intensity and passing over Jamaica on 24 October with winds of 130 km/h (80 mph). Sandy then intensified, with sustained winds of 175 km/h (110 mph), before making landfall next morning in Cuba, as a strong category 2 storm on the Saffir-Simpson hurricane damage potential scale. After weakening slightly, the hurricane passed over the Bahamas and then, on 27 October, turned firstly northeast ahead of a strong cold front approaching the eastern United States, and then back to the northwest. Sandy made its final landfall at 8 p.m. local time on 29 October on the North American continent near Atlantic City, New Jersey, with sustained winds of 130 km/h (80 mph).

Meteorological conditions

Among the most unusual aspects of Hurricane Sandy were its northwestward motion before landfall in New Jersey and the vast size of its wind field, which covered an area of 1.5 million km^2 (560,000 square miles). Both features were caused by Sandy interacting with other low-pressure systems, highlighting the impact of extratropical transition.

Over half of all Atlantic tropical cyclones undergo extratropical transition, a process in which a tropical cyclone's structure changes from a warm-core to a cold-core system. Many different factors can influence transition, but typically they involve the tropical storm interacting with a jet stream, extratropical cyclone, or colder, drier air mass. During transition, the previously radially symmetrical tropical cyclone starts to become more asymmetric. The wind field broadens as shear and dry air masses inhibit thunderstorm activity in the tropical cyclone's core. This can trigger the development of warm and cold fronts, helping the storm obtain energy from temperature gradients. In contrast, warm-core tropical cyclones obtain energy when water vapour condenses, releasing latent heat.

Hurricane Sandy went through two distinct periods of extratropical transition, leading it to be dubbed a "Frankenstorm" or "Superstorm" by the US media The first started as Sandy exited Cuba, as shear and dry air from an upper-level low disrupted its core. The storm's wind field broadened substantially, and frontal features started to develop. Sandy began to regain some of its tropical characteristics as it moved north of the Bahamas, away from this low. It then went through another period of extratropical transition as it began to interact with a large area of low pressure over the USA a couple of days later. This time, Sandy completed its transition and became fully extratropical just before landfall. Sandy's two periods of extratropical transition are also probably one of main reasons why the hurricane's wind field grew to near-record size.

The second feature, Sandy's northwestward motion before landfall, was caused by its transition to an extratropical storm and a phenomenon known as the Fujiwhara effect: two low-pressure systems sufficiently close to one another rotate counter-clockwise around each other (in the northern hemisphere), and are slowly drawn together. Occasionally, the two systems merge to form a larger, single circulation. This is what occurred with Sandy in the 24 hours before landfall, as the hurricane and low pressure to its southwest began to interact and rotate around each other, pushing Sandy back to the west before the two systems eventually merged into a very large extratropical cyclone just off the coast of New Jersey.

Comparison with the 1938 Great New England Hurricane

Due to the magnitude of loss, Sandy will inevitably be compared to the Great New England hurricane of 1938. Due to the limited observational data in the 1930s, it is not possible to accurately compare all aspects of the two storms. However, the similarities between the two storms include undergoing extratropical transition, large storm surges that occurred near high tide, similar minimum central pressures, and a large wind field that penetrated deep inland.

Aside from landfall location, the 1938 hurricane was a much more intense storm at landfall than Sandy. If the hurricane of 1938 had occurred today, it would probably cause significantly more damage than Hurricane Sandy. The New England hurricane had reached Saffir-Simpson category 5 intensity while north of the Bahamas and, although it weakened before landfall, its rapid forward motion of 100 km/h (60 mph) limited the amount of weakening and added significantly to the wind speeds on the right-hand side of the storm.

The 1938 New England hurricane was one of the strongest to strike the northeast US coast. Losses were reported in New York State, Rhode Island, Connecticut, Massachusetts and as far north as New Hampshire, Vermont and Maine. The photo shows the scene of devastation left by a ten-metre wave at Island Park.

Although Sandy's winds were less strong than those of the 1938 hurricane, its exceptionally large wind field caused losses in 15 US states. Many boats were destroyed in marinas like this one at Staten Island, New York.

And while extratropical transition had begun to affect the event, it is likely that transition was not complete before landfall. This means that the core of the 1938 hurricane, containing the strongest winds, was largely intact at landfall, whereas Sandy's core had completely collapsed before landfall, resulting in a broader, but generally weaker, wind field.

In the 1938 storm, sustained winds in excess of 200 km/h (120 mph) and gusts above 290 km/h (180 mph) were observed. In Sandy, only a few observing stations had sustained winds above hurricane force, and maximum wind gusts only reached 180 km/h (110 mph). Since wind damage increases exponentially in relationship to wind speed, the 1938 storm was much more potent than Sandy. Similarly, storm surge heights with the 1938 hurricane are estimated to have reached 10 metres (30 feet), about twice the maximum surge heights seen with Sandy.

Nevertheless, some aspects of Sandy had a greater potential to cause large losses. Sandy's landfall was located along the New Jersey and New York coastline, a more densely populated area than Long Island, the location of the 1938 landfall. It also put New York City on the stronger side of the storm's circulation, increasing loss potentials. Sandy's path and large wind field also allowed for a much larger area of coastline to be impacted by surge flooding than during the 1938 storm, especially around the New York Bight, where Sandy's persistent easterly winds funnelled water into New York Harbor and reached record levels. Sandy's extensive wind field produced losses from Indiana to Nova Scotia, a distance of over 1,600 km (1,000 miles), far exceeding the area that sustained damage in the 1938 hurricane.

Loss aspects: Wind

In general, wind damage from Sandy was relatively light but spread across the northeastern USA. Strong gusts, were observed during Sandy at only a few locations along the New Jersey and Long Island coastlines. In these areas, there was loss of roof covering as well as broken windows and subsequent water damage. In Manhattan, the façade of a small building collapsed and a crane on top of a skyscraper under construction was partially toppled. In the Breezy Point neighbourhood of Queens, winds fuelled a residential fire that spread rapidly, destroying 111 homes. Storm surge flooding at the time of the fire also limited the ability of firefighters to contain it.

Further inland, wind speeds were typically not strong enough to cause direct damage to well-built structures. Instead, most wind damage was caused by collapsing branches and power lines that crashed into buildings and vehicles, and also led to widespread power outages. They covered parts of 15 states, including 2.7 million homes and businesses in New Jersey and 2.2 million in New York. Surge flooding was also responsible for some of the outages in New York City and other coastal regions. In some locations, power was not restored for several weeks.

Loss aspects: Storm surge

The combination of Sandy's large wind field, persistent easterly winds, and a high tide at landfall produced a record storm surge in parts of New York, Connecticut, and the New Jersey shore. Surge heights reached 3.5 metres (11.48 feet) above mean sea level at Battery Park in Lower Manhattan, exceeding the previous high water mark set by Hurricane Donna in 1960 by almost 1.3 metres (4 feet). Surge heights also exceeded 3 metres (10 feet) along western sections of Long Island Sound and 4.5 metres (15 feet) at some locations in New Jersey.

The entire length of the Jersey Shore was affected by Sandy's coastal flooding, storm surge and large waves washing over dozens of coastal communities. Thousands of homes and businesses and critical infrastructure were destroyed. In some locations, like the small town of Mantoloking, the storm surge ripped houses from their foundations. Residents here and at other locations had to abandon their homes for weeks.

Dozens of marinas and thousands of boats were also damaged, and the tourist industry was hit. Boardwalks up and down the New Jersey coast were destroyed, and several piers filled with amusement park rides suffered partial or total collapse. Some of the casino resorts in Atlantic City were forced to shut down for several days, resulting in a large loss of revenue. Container ports and vehicle terminal and loading facilities suffered heavy losses, producing the largest ever marine insurance loss: approx. US$ 2.5 to 3bn.

Hurricane Sandy's vast wind field drove powerful water masses onto the coast and coincided with a high tide, producing record sea levels. The map shows the areas affected by Sandy's storm surge.

- Flooded area
- State boundary

Source: PERILS, SERTIT 2012, http://sertit.u-strasbg.fr

Water flowing into New York Harbor caused severe flooding to communities along the Raritan Bay, including Union Beach, Sayreville and Perth Amboy. Further north, the surge flooded the Meadowlands and caused the Hudson River to burst its banks, inundating Jersey City, and Hoboken. Tens of thousands of Hoboken residents were stranded for several days and had no electricity due to flooded electrical substations. Flood waters also poured into the entrances of Port Authority Trans-Hudson (PATH) train stations, flooding a number of platforms and two rail tunnels connecting New Jersey and New York City.

In Manhattan, the Hudson and East Rivers flooded. Large areas of the New York financial district and Battery Park City were affected, as well as significant areas of the Lower East Side, SoHo, Tribeca and Chelsea. Thousands of buildings, ranging from modern skyscrapers to single family homes, sustained water damage as flood waters poured into ground floors and basements, damaging or destroying personal property, insulation and electrical equipment. Over ten million square feet of office space was closed in the financial district alone, forcing companies to relocate their employees until repairs had been carried out and creating the potential for large business interruption losses. The construction site surrounding the World Trade Center complex and art galleries in the neighbourhood of Chelsea were also flooded.

The infrastructure below Manhattan was similarly hard hit. Flood waters poured into subway entrances, inundating five stations and seven rail tunnels that cross under the East River. The surge forced the shutdown of the entire New York subway system for three days. Below 34th street, it remained closed for several more days as water was pumped out and electrical equipment checked for damage. Water also had to be pumped out of the Holland, Brooklyn-Battery, Queens-Midtown and several other road tunnels. Parts of the city's power grid were also damaged as flood waters shorted out substations and underground wiring. Con Edison, the utility provider for New York City, had to cut power to most of Lower Manhattan during the height of the storm to prevent further damage to its systems.

The outer boroughs of Manhattan also sustained heavy flood damage. In Staten Island, the Midland Beach neighbourhood along the island's southeast coast endured some of the most severe flooding, where homes were swept from their foundations by the surge. Coney Island in Brooklyn and the Rockaway Peninsula of Queens were completely inundated, and the runways at John F. Kennedy and LaGuardia airports were submerged for several days, forcing thousands of flight cancellations and snarling US air traffic.

Even coastal areas of Connecticut, New York's neighbouring state, were affected by storm surge as high winds pushed water westward into Long Island Sound.

Loss aspects: Precipitation

Unlike other recent northeastern hurricanes, Sandy did not cause any significant instances of inland flooding due to rainfall. The heaviest precipitation occurred over the Delmarva Peninsula, where rainfall amounts averaged around 18 cm (7 inches), but due to the low-lying, marshy nature of the regions, only isolated incidences of flood damage were reported. Further west, Arctic air caused Sandy's precipitation to fall as snow, creating blizzard conditions in West Virginia and Kentucky. Up to 1 metre (3 feet) of heavy, wet snow accumulated, downing trees and power lines and causing buildings to collapse.

Underwriting aspects

As with all US hurricanes, as a result of Sandy, insurers and reinsurers will examine and, where necessary, revise their underwriting and models, bearing in mind the following points in particular:

Application of hurricane deductibles

In the aftermath of unprecedented losses from Hurricane Andrew in 1992, insurance companies that wrote business in Florida began to institute hurricane deductibles in their policies. Usually expressed as a percentage of the property value, hurricane deductibles are typically several times larger than a standard fire deductible. The implementation of hurricane deductibles accomplished two goals desired by both insurers and state governments. The first was to help reduce the cost of insurance to homeowners by making them pay a larger share of the loss for rare, but potentially severe, hurricane events. The second was to partially mitigate the amount of loss incurred by insurers due to hurricanes, as insured losses from Hurricane Andrew led to the insolvency of 11 insurance companies. Since then, hurricane deductibles have gained wider acceptance by the industry and regulatory agencies and have been implemented by insurers in 18 different hurricane-exposed states.

However, hurricane deductibles have not worked exactly as anticipated by the insurance industry. The first reason for this is that the trigger for a hurricane deductible can be based on many different storm and geographic metrics that can vary by state. Hurricane deductible triggers could be tied to wind speeds, watches and warnings issued by the National Hurricane Center, Saffir-Simpson Scale category, or whether the storm has been "named" by a government agency. In some cases, hurricane deductibles only apply if certain storm criteria are met and the hurricane makes landfall over the state in question.

Furthermore, in some states the department of insurance determines what combination of criteria triggers the hurricane deductible, while other states allow individual insurance companies to determine their own triggers. The different criteria in each state can lead to situations where citizens of one state have to pay hurricane deductibles and citizens of another do not, even if both states experience hurricane-force winds, diminishing their effectiveness.

The second reason why hurricane deductibles have not worked as expected is that state governments may not allow their application in situations where there is uncertainty about a storm's intensity or status as a tropical cyclone at landfall. For example, Hurricane Irene's (2011) intensity dropped below hurricane status just before its transit of New Jersey, New York, and Connecticut. As a result, the governments of these states did not permit the application of hurricane deductibles for this event. In the case of Hurricane Sandy, the National Hurricane Center reported that the storm had become "post-tropical" just prior to landfall in New Jersey. Even though the storm produced hurricane-force winds over the state, Sandy's reclassification enabled New Jersey and other states to prohibit the use of hurricane deductibles for the event.

As seen after Irene and Sandy, state governments will often prevent hurricane deductibles from taking effect in cases where a storm's status as a "hurricane" is uncertain at landfall. However, many insurers and reinsurers typically model hurricane risk using the assumption that hurricane deductibles will be triggered, even in borderline category 1 events or in the case of extratropical transition. Since this is not always the case in reality, it means that actual losses to insurers from events like Irene and Sandy end up being higher than anticipated. In light of this, the insurance industry will probably reconsider the modelling assumptions to reflect the fact the hurricane deductibles may not be applicable for all events.

Flood exposure data and modelling

Although flooding is a major source of insured loss from tropical cyclones, the ability of insurers (and reinsurers in particular) to quantify and assess the amount of flood-exposed risks within a portfolio remains limited. There are two primary reasons why this is the case: the first is the complex mix of public and private insurance in the USA for the peril of flood, and the second is a lack of consistent capturing and reporting of flood exposure data by the industry.

Flood coverage is not normally included in personal lines policies in the USA. Instead, flood insurance offered by the National Flood Insurance Program (NFIP) within participating communities. However, since NFIP coverage for residential buildings is capped at US$ 250,000, much less than the value of many homes, some personal lines writers do offer flood insurance in excess of the NFIP coverage. NFIP flood coverage is also available for small businesses, while private insurers offer flood coverage for various types of commercial and industrial risks.

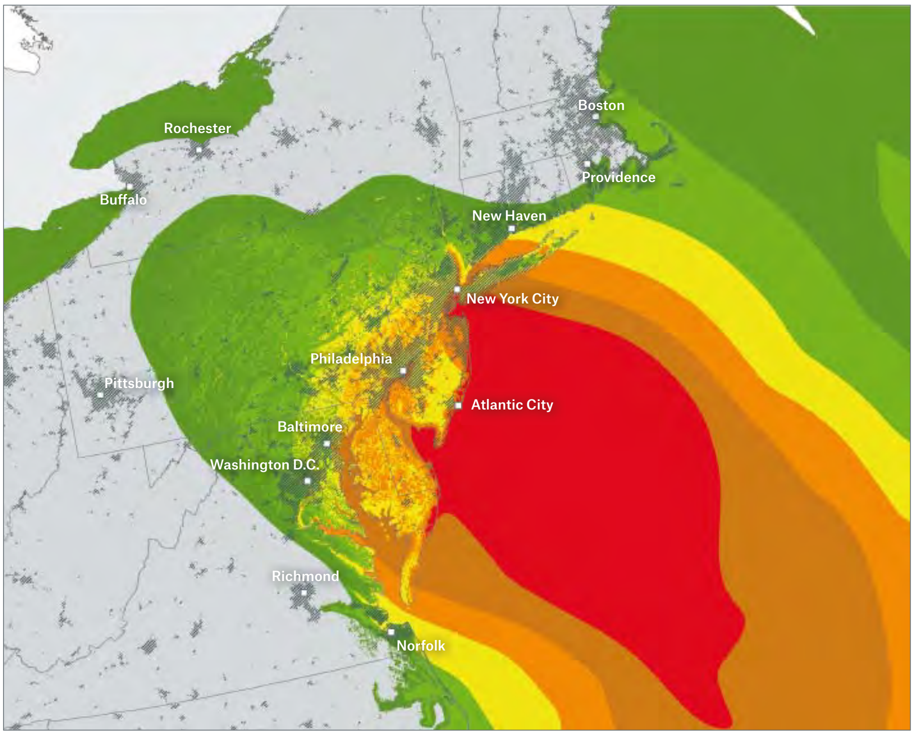
Wind field of Hurricane Sandy

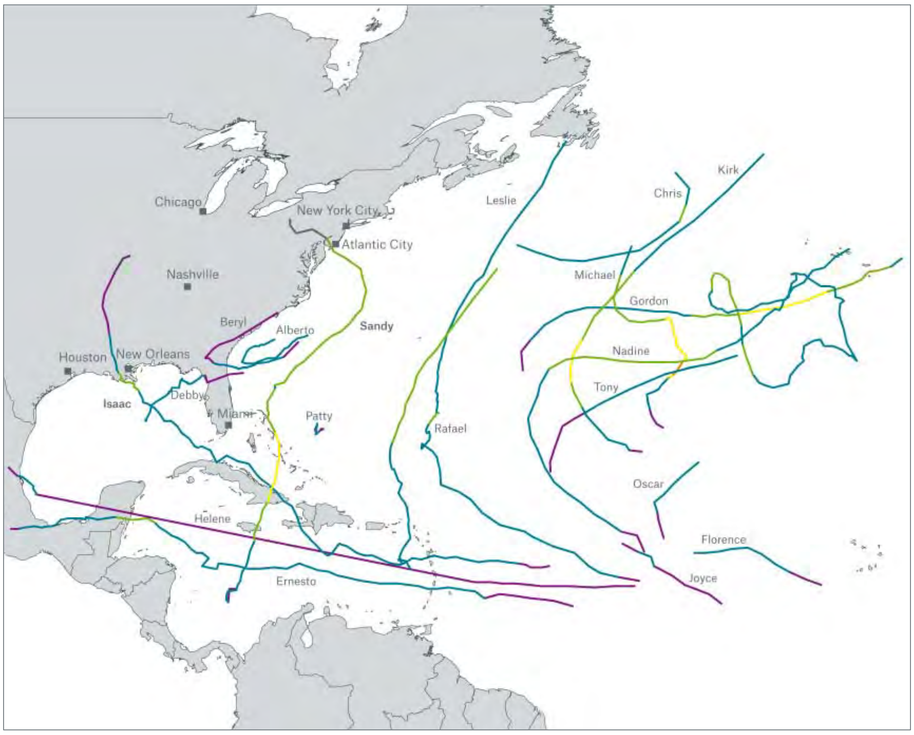
On 29 October 2012, Sandy's huge wind field impacted the US East Coast. It reached Atlantic City, New Jersey, at 8 p.m. local time, with winds of 130 km/h (81 mph).

Gusts (km/h)
- 80–90 (50–56 mph)
- 91–100 (57–62 mph)
- 101–110 (63–68 mph)
- 111–120 (69–74 mph)
- 121–130 (75–80 mph)
- 131–140 (81–86 mph)

Populated areas

Source: Munich Re, based on National Hurricane Center, Hurricane Research Division, National Weather Service





Atlantic tropical storm tracks in 2012

The map shows all North Atlantic tropical storm tracks in 2012. There were 19 tropical storms in all, seven of which made landfall. Storm activity began with Alberto (19 May) and Beryl (26 May) which preceded the official start of the hurricane season, on 1 June.

Wind speeds (km/h, mph)
(SS: Saffir-Simpson Scale)

- Tropical depression (< 63 km/h, < 39mph)
- Tropical storm (63–117 km/h, 39–73mph)
- SS 1 (118–153 km/h, 74–95mph)
- SS 2 (154–177 km/h, 96–110 mph)
- SS 3 (178–209 km/h, 111–129 mph)
- SS 4 (210–249 km/h, 130–156 mph)*
- SS 5 (≥ 250 km/h, ≥ 157 mph)*
- Post-tropical

* No category 4 and 5 wind speeds were recorded on the Saffir-Simpson Scale in 2012.

Source: Unisys

Since only a limited amount of flood insurance in the USA is written by the private sector, the demand for statistical catastrophe models to assess flood risk has historically been much lower than for other perils. Due to low demand and the considerable amount of time and resources required to create such a model, catastrophe model vendors have not developed robust US flooding model tools, particularly for inland flooding. It should be noted that hurricane models have included storm surge flooding for many years, but the modelling of this component has historically been viewed as relatively simplistic in nature compared to the wind component.

All catastrophe models rely on vast amounts of detailed policy data – location, value, construction, deductibles, etc. – to estimate losses. Although, over the past 20 years, insurers have made considerable progress in capturing these data to improve the quality of model output and reduce uncertainty in results, information on flood coverage is often not captured by US insurers. Part of this is due to the fact that there are no models for the peril, so flood-related policy data is often not captured, even in cases where flooding is modelled, such as storm surge. Another limitation is that flood and wind coverage may have different deductibles and limits within the same policy. This is problematic because many hurricane models currently cannot handle different peril-based deductibles and limits. Instead, the models typically use the hurricane deductible for all sources of loss, reducing the accuracy of modelled loss results.

Another important aspect of flood exposure data that should be captured by insurers is how contents are distributed within a building. This is particularly true of larger commercial risks, like high-rise office buildings, where significant amounts of electronic equipment like generators and computer servers are often kept in basements, creating potential for large contents losses from flooding, as seen in the New York financial district during Sandy and in Houston, Texas, following torrential rains from Tropical Storm Allison in 2001.

Due to the lack of high-quality flood exposure data, many insurers and reinsurers are left with great uncertainty as to the amount of flood risk in their portfolios. To reduce this uncertainty, the insurance industry needs to consistently capture flood exposures with greater accuracy and detail to allow for proper actuarial and underwriting analysis. And as flood models for the USA become available over the next couple of years, these detailed flood data, in conjunction with wind policy data, should give insurers a more comprehensive view of hurricane risk to a portfolio and reduce uncertainty in loss results.

Conclusions

Although only a category 1 hurricane before undergoing extratropical transition and making landfall, Sandy shattered loss records for the northeastern USA.

Insured losses, including payments under the National Flood Insurance Program, stand at US$ 30bn (as estimated in February 2013), although this figure could change, since not all claims have been settled. The record losses, despite Sandy being a relatively weak storm, were due to the huge geographic area impacted by its vast wind field, as well as record surge flooding along the heavily populated coasts of New York, New Jersey, and Connecticut. Overall losses are likely to exceed US$ 65bn, making Sandy the second most costly natural disaster in US history, in terms of original dollar loss.

The impacts of Sandy are a much better indication of what a severe hurricane can do to the northeast USA than any other storm in the past 70 years. Although one of the worst natural disasters in the history of New York City and New Jersey, Sandy was far from being a worst-case hurricane scenario for the region. A stronger hurricane, like the 1938 Great New England hurricane that travelled along a similar path to Sandy, would easily cause more severe levels of wind damage and larger storm surges. The lessons learned from Sandy, particularly its storm surge impacts in New York City, should be used to lessen the potential of similar losses from future hurricanes in the region.

OUR EXPERT

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Society and politics

Efforts to mitigate anthropogenic climate change and adjust to its unavoidable impacts constitute an enormous challenge for science and society. Topics Geo highlights the past year's major scientific, political and industrial developments.

Ernst Rauch

Efforts to gain a better understanding of the anthropogenic and natural causes of climate change and its impacts constitute a huge challenge to scientists, civil society, industry and policy makers. Since our current understanding of the physical science basis of global warming was substantially confirmed by climate research in 2012, there have increasingly been calls to formulate socially acceptable and economically viable strategies. However, there has been little evidence of a political will to reduce greenhouse gas emissions. Risk carriers in the private sector and society are faced with the task of establishing their individual exposures and taking appropriate action. Where the insurance sector is concerned, this primarily involves evaluating the portfolio-based risk of change. Increasingly, the technology sector is coming up with proposals for containing climate change. The insurance industry can support this trend by providing innovative risk transfer solutions.

The IPCC Special Report *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (SREX) publishes new scientific analyses of the impact of ongoing warming on extreme weather events and sea levels. Studies show that, in recent years, the rate of sea level rise has been faster than predicted by the models.

SREX: Report on climate change and extreme events

New scientific analyses of the impact of ongoing warming on extreme weather events and sea levels were published in the full version of the IPCC Special Report *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (SREX: http://www.ipcc-wg2.gov/SREX/). Studies show that recent sea level rise has been more rapid than projected in IPCC Fourth Assessment Report models in 2007. Moreover, climate change has already resulted in regional changes in heatwaves, heavy precipitation and other extreme weather events. The SREX Report analyses the future evolution of extreme weather events on the basis of scientific studies and categorises them into region, type of hazard and current research findings.

Increase in greenhouse gas emissions

Provisional estimates indicate that greenhouse gas emissions (CO_2 equivalent) increased by 3% to around 32 gigatonnes in 2012, but this was subject to considerable regional variations. Emissions in the European Union (EU-27), for instance, were roughly 2% lower than in the previous year. With a total reduction of an estimated 17% by 2012 in relation to 1990, the base year, this means that the EU is on target to reach its political goal of a 20% reduction by 2020. The EU has offered to increase this to 30% provided other countries with high CO_2 emission levels also set more ambitious targets.

Doha climate summit: Few tangible results

Since acute financial and economic problems currently dominate the international political agenda, measures to adjust to the consequences of climate change faded into the background at the climate change conference (COP18) held in Qatari capital, Doha, in late 2012. Agreement on global greenhouse gas (GHG) reductions was again deferred. There was little sign of a political will to lead and shape a decisive reaction to the challenges of anthropogenic climate change. The following resolutions were adopted under the Doha Climate Gateway:

- On 1 January 2013, the Kyoto Protocol's second commitment phase, due to end in 2020, began. This involves 37 countries, including all the EU member states. The existing EU goal of a 20% reduction in GHG emissions over the base year 1990 by 2020 was officially adopted.

- The delegates agreed on a timetable for the negotiation process under the umbrella of the UNFCCC (United Nations Framework Convention on Climate Change). It is hoped that this will culminate in a climate change agreement between all countries in 2015.

- Songdo in South Korea was selected as the headquarters of the Green Climate Fund. With US$ 100bn per year in funding from the international community of states by 2020, it will be a key element in the financing of climate mitigation and adaptation projects. What is not clear, however, is whether the industrialised nations will actually deliver on the promises made in 2009.

- Loss analyses and the development of adaptation strategies are to be stepped up within the framework of the Loss and Damage programme launched by UNFCCC to deal with climate change losses in developing countries. Risk transfer mechanisms – and the relevant financing programmes – were explicitly acknowledged to be part of any adaptation strategy. As in previous years, however, the conference failed to pass a detailed resolution on a multinational or global compensation pool for extreme weather losses, even though suitable concepts, based on Munich Climate Insurance Initiative (MCII) proposals, for example, are already available.

On a more positive note, the Doha Climate Gateway will at least ensure that the global climate change negotiating process will continue until 2020. However, it must be pointed out that GHG emissions are still rising steadily throughout the world, despite almost 20 years of climate change summits. The requisite decisions are often deferred and minor advances towards a global agreement on climate protection are all too often nullified by subsequent retreats. Far fewer countries have agreed to the second commitment phase of the Kyoto Protocol, for instance, and they account for only 15% of total global GHG emissions. Without further fine-tuning and critical analysis, the current negotiating concept could ultimately prove counter-productive. On the other hand, there are no ready solutions when it comes to improving the negotiating process. Binding targets for the international community of states can only be reached under United Nations auspices. However, solutions negotiated directly between a smaller group of countries could be the key to a voluntary spearhead movement aimed at achieving a sustainable climate policy.

Industry – Focus on technical solutions

Private-sector climate protection products concentrate on preventing GHG emissions by exploiting renewable energy sources and using heating and cooling technology to make buildings more energy-efficient. The amount of money invested in renewable energy projects worldwide rose from US$ 40bn in 2004 to some US$ 250bn in 2011. Provisional figures indicate that 2012 global investment in this sector is likely to have been on a par with that of the previous year.

Insurance industry – Coverage programmes

The insurance industry is increasingly developing risk transfer products specifically designed to support climate change and GHG adaptation and mitigation. They aim to take account of changing natural catastrophe loss patterns. Reinsurers have offered nat cat frequency covers in response to regional changes in loss frequency for some years now. Innovative renewable energy insurance covers have also been launched. For example, Munich Re's option cover insures photovoltaic system operators against the risk of a solar module manufacturer being unable to discharge its warranty obligations due to insolvency – for instance, following an unexpected fall in output. Such financial protection facilitates the implementation of photovoltaic projects and, without it, bank loans may only be granted on much less favourable terms.

In 2012, Munich Re also became the first insurance group to offer serial loss cover on offshore wind turbines. Under this further addition to its renewable products range, Munich Re meets the cost of repairing or replacing defective turbines or individual components in the event of a loss affecting a series of components in the gear mechanism, rotor or tower, for instance. In addition, the often substantial cost of chartering the necessary purpose-designed ships is covered. The five-year cover also includes the cost of retrofits to systems in which a defective component is incorporated, even though there has been no loss or damage.

The 18th UN climate conference was held at Doha, capital of the Arab emirate of Qatar, from 26 November to 8 December. The photo shows Emir Sheikh Sabah al-Ahmad al-Sabah at the opening ceremony.

Facts, figures, background

The prolonged heatwave and drought that affected vast areas of the USA, record-breaking minimum Arctic sea ice cover during the northern hemisphere's summer months and New York's highest storm surge in over 100 years, triggered by Hurricane Sandy, were the most striking global weather and climate phenomena in 2012.

Eberhard Faust and Ernst Rauch

Provisional figures released by the World Meteorological Organisation (WMO) indicate that 2012 is likely to be among the ten warmest years on record since 1850. As in the period August–December 2011, El Niño Southern Oscillation Index (ENSO) values were negative from January to May 2012. In June, this La Niña phase moved towards more neutral ENSO conditions before subsequently settling on the borderline between neutral and El Niño conditions, with simultaneous warming of the equatorial eastern Pacific off the coast of South America. Thus, on average, 2012 can be regarded as a neutral year.

With regard to worldwide precipitation in 2012 (land-based data only), two regions displayed an extensive and relevant negative deviation from the annual base period (1961–1990) mean, as defined by the US National Oceanic and Atmospheric Administration (NOAA). For several months – and particularly during the growth period – rainfall was well below the long-term average not only in the USA but also in the Mediterranean region as far as the Caspian Sea. Agricultural production of corn and other cereals was primarily affected. Since multiple peril crop insurance is widespread in the USA, this resulted in the highest ever public-private-sector agricultural insurance loss (see article on page 16).

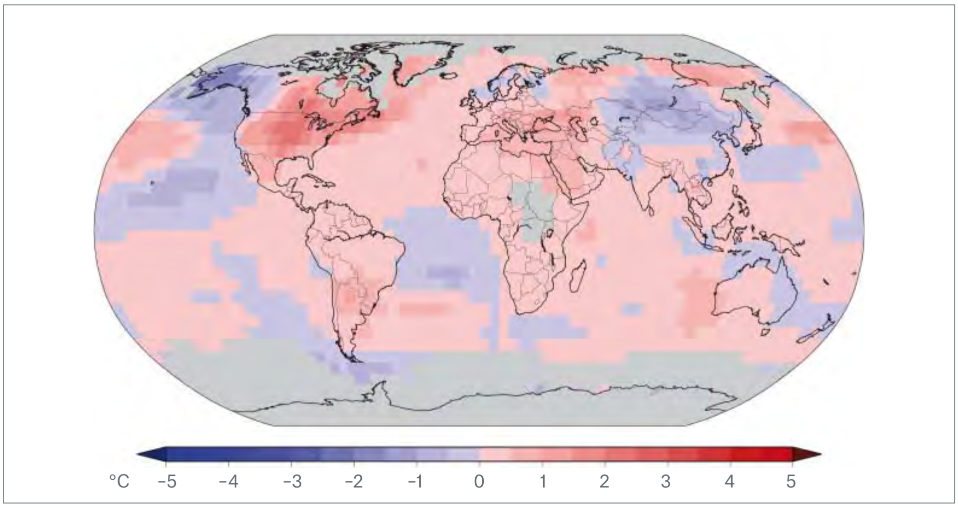
January/February: Strong frost in Europe – Mild temperatures in North America

Due to the negative phase of the Arctic Oscillation (AO) prevailing at the time, much of central and eastern Europe experienced a major cold spell in the last week of January and first two weeks of February. In parts of eastern Europe, the air temperature dropped to –40°C (–40°F), but elsewhere also, including in Germany, temperatures were below –25°C (–13°F) for several days in succession. Rome (Italy) was covered in snow for the first time in 26 years on 4 February. More or less at the time Europe was experiencing severe frost, temperatures in Canada were well above the seasonal average. Also due to the negative AO phase, Winnipeg (Manitoba), for example, recorded its third warmest January and highest January daytime temperature (around +7°C or 45°F) since records began in 1873.

March to September: Heatwave, drought and wildfires in the USA

Much of the USA – and particularly the Midwest Corn Belt – experienced month-long heat and drought in the spring and summer of 2012, causing record US crop insurance claims. From March onwards, the combination of persistent above-average temperatures and below-average precipitation triggered a series of forest and bush fires in the USA and Canada. In the USA alone, 3.7 million hectares (9.2 million acres) were ravaged by flames in the 2012 fire season, the third highest figure since wildfire statistics began in the early 1960s (2006: 4 million hectares/9.9 million acres, 2007: 3.8 million hectares/9.3 million acres). July 2012 was the warmest month ever in the USA and the year as a whole the country's warmest since US records began in 1895.

Regional mean temperature anomalies for 2012 with respect to a 1981–2010 base period

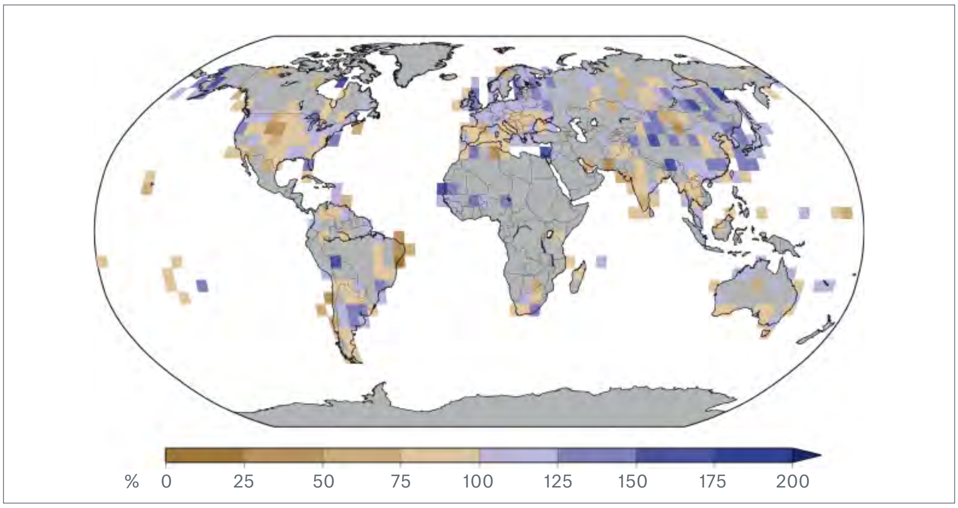


Over much of America, Europe and Africa, 2012 was too warm compared with the reference period. On the other hand, average annual temperatures in Alaska and some parts of Asia were below the long-term average. Globally, 2012 was one of the ten warmest years since 1850.

■ Warmer
■ Cooler

Source: NCDC/NESDIS/NOAA

Regional anomalies in annual precipitation in 2012 with respect to a 1961–1990 base period

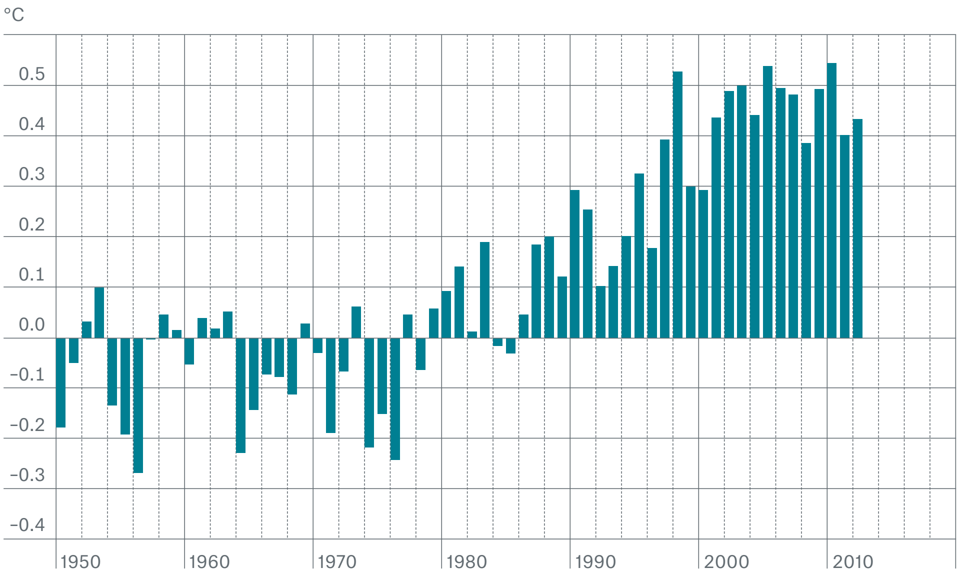


Regional annual precipitation anomalies in 2012 with respect to a 1961–1990 base period. This clearly shows the precipitation deficit over much of the USA.

■ Drier
■ Wetter

Source: NCDC/NESDIS/NOAA

Annual global average temperature anomalies 1950–2012 with respect to a 1961–1990 base period



The ten warmest years in the climate record period 1850–2012 were all subsequent to 1998. The time series starts in 1850. The chart relates to the period from 1950–2012.

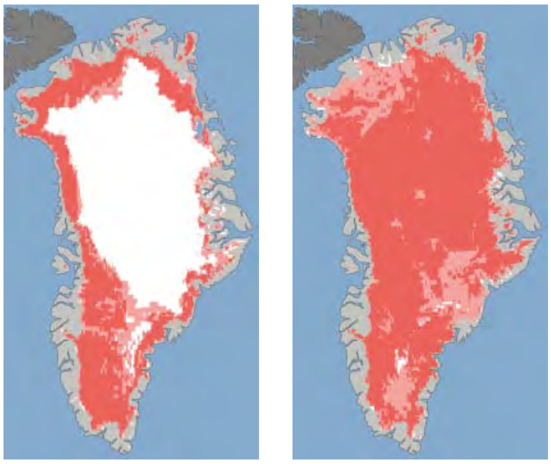
Source: HadCRUT4, Met Office/Climate Research Unit of the University of East Anglia (2013). 2012 is based on HadCRUT4, the update to HadCRUT3

Extent of ice sheet melt in Greenland

Satellite images show the extent of surface melt over Greenland's ice sheet on 8 July 2012 (left) and 12 July 2012 (right). Surfaces are classified as "melt" if at least two satellites detected surface melting. If the data have been detected by only one satellite, the areas concerned are classified as "probable melt".

- Ice/snow free
- Probable melt
- Melt
- Ice and snow

Source: http://www.nasa.gov/topics/earth/features/greenland-melt.html



Scientific assessment

Several years ago, a study by A.L. Westerling et al. (2006) showed that climate change had substantially increased the risk of wildfires of more than 400 ha in the mid-altitude mountain regions of the western USA. A comparison between the periods 1970–1986 and 1987–2003 shows that, during the latter period, fire outbreaks were four times more frequent, the area ravaged by fire was six times larger and the wildfire season was more than half as long again. This is primarily due to higher spring and summer temperatures bringing increasingly early snowmelt, and a growing soil moisture deficit, especially in mountain regions in late summer. According to a projection based on climate models (D.V. Spracklen et al. 2009), the average annual area burned by fire in the western USA will increase by more than 50% over the next 40 years. This does not take account of changes relating to cause of fire, lightning frequency or duration of fire season. The Pacific Northwest and Rocky Mountain regions are likely to be primarily affected, with increases of 80% and 180% respectively. The devastating fires of 2012 thus underline the tendency towards a long-term increase in wildfire risk in populated areas.

With regard to the western USA in particular, wildfire hazard and the observed increase in dry periods can already be causally linked with anthropogenic climate change (T.P. Barnett et al. 2008, G.M. MacDonald et al. 2008). A study based on climate models projects a future increase in heatwaves and associated droughts for the USA as a whole. According to this projection, the threshold value of the hottest season in the reference period 1951–1999 will be exceeded at least seven times over much of the West in the decade from 2030–2039. This will be due to more pronounced high-pressure conditions and substantial soil moisture and precipitation deficits over much of central and eastern USA – i.e. roughly corresponding to the area affected by drought in 2012 – compared with current average summer conditions (N.S. Diffenbaugh and Ashfaq 2010). Thus, 2012 can be interpreted as a year anticipating the projected changes. In North America, the summer drought risk is more likely to increase than decrease in the years to come.

June to July: Heatwave and drought in parts of Russia and Kazakhstan – Exceptionally low temperatures in northern Europe and southern hemisphere

In much of southern Europe and Asia, the summer began with major temperature contrasts: above-average temperatures in northern and western Asia, on the one hand, and cold waves in Sweden and the southern hemisphere, on the other. New record minimum temperatures were set in some places in South Africa, Australia and New Zealand. As in 2010, parts of Russia and Kazakhstan experienced a prolonged drought that caused considerable agricultural losses.

July: Greenland shelf ice at record minimum

Greenland ice melt was the highest since satellite observations began in 1979. While only about 40% of the inland ice cover was affected on 8 July 2012, temperatures of up to 23°C caused 97% of the surface to melt just four days later. Even at the highest elevation of 3,000 metres above sea level, the ice melted on 11 and 12 July. Both observations are unique in the history of systematic recording, which began in 1889. However, scientific analysis of ice cores from the region shows similarly intensive melt events have occurred previously in Greenland.

The exceptionally warm 2012 Arctic summer and rapid melting of the inland ice masses were due to a series of stable high-pressure systems over Greenland between May and July. They led to the formation of heat islands with rising temperatures.

September: Record minimum Arctic/maximum Antarctic sea ice extent

On 16 September 2012, the Arctic sea ice extent measured 3.4 million km², the lowest reading since systematic satellite observations commenced in 1979. As recently as the early 1980s, Arctic sea ice extent was 7–8 million km² during the season when it was at its minimum. This is equivalent to an average decrease in the area covered by ice of 11.3% per decade. During the same period, the maximum annual winter sea ice extent also fell by 2.5% per decade. At roughly 15.3 million km², the figure was about the same in 2012 as in 2010, and more than 2011's record minimum of 14.7 million km².

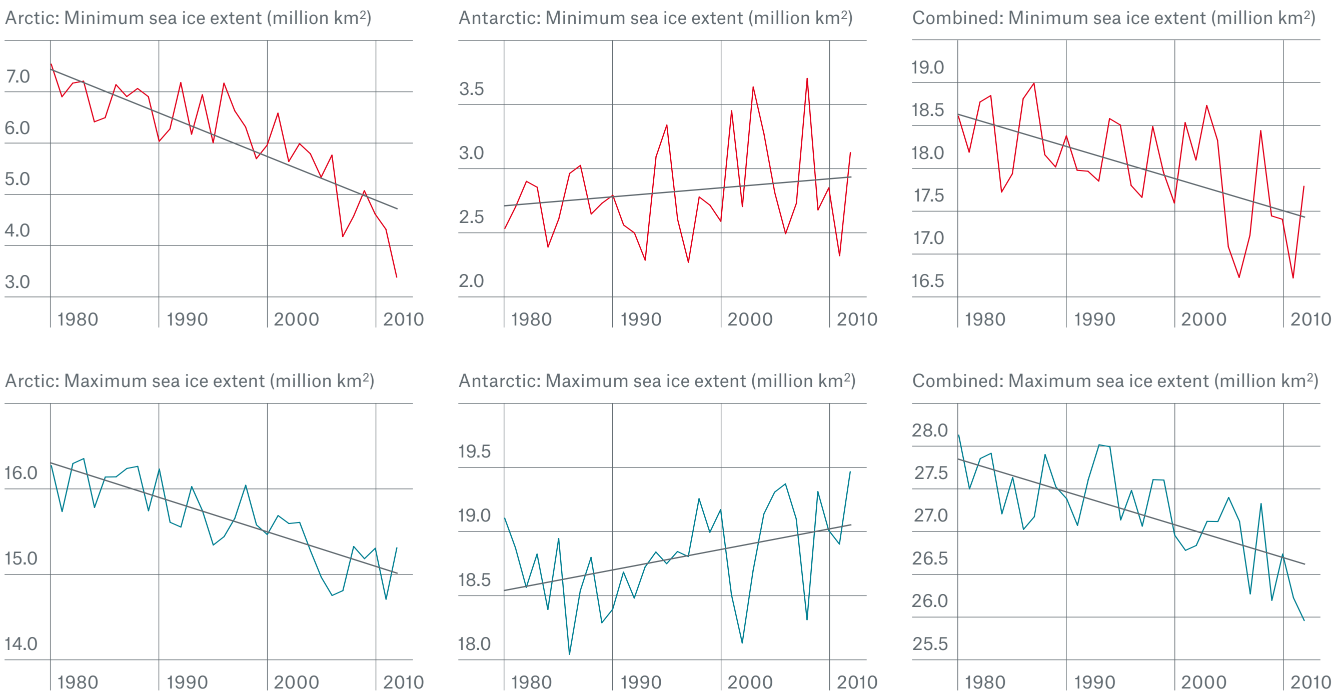
The opposite applied in the southern hemisphere, where both maximum annual Antarctic sea ice extent (excluding inland ice masses) and minimum annual sea ice extent increased between 1979 and 2012. The ice sheet grew by 0.9% per decade during the Antarctic winter. In relation to the trend, the ice sheet increased from around 18.5 million km² in the early 1980s to a maximum of some 19 million km² in September 2012. During the same period, the minimum sea ice extent measured during the Antarctic summer increased by 2.8% per decade from roughly 2.7 million to almost three million km² (trend values). At 3.1 million km², the minimum sea ice extent observed in 2012 was above the trend value and substantially more than the previous year's 2.3 million km².

A closer look at the combined development of Arctic and Antarctic sea ice extent since systematic satellite measurements started shows the following: the annual minimum ice cover (summer months in the respective hemispheres) has declined by 2.0% and annual maximum ice covers (winter months in the respective hemispheres) by 1.4% per decade

Scientific assessment

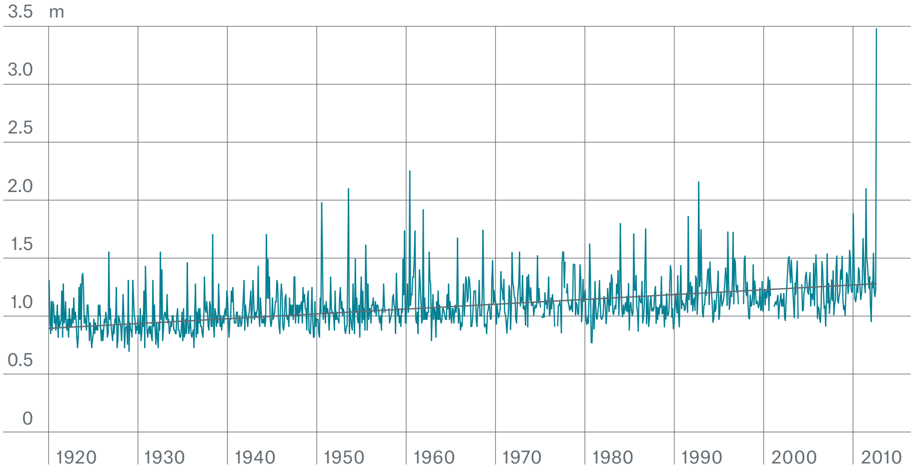
Three records were set in 2012 in the realms of ice and snow: the smallest Arctic sea ice extent in September since the start of the satellite era (3.4 million km²), Greenland's largest surface melting in July since 1889 and the largest sea ice extent ever observed in the Antarctic in September (19.5 million km²). Is there a common climate denominator underlying this trend?

Arctic and Antarctic annual sea ice extent with trend 1980–2012



Annual minimum and maximum Arctic and Antarctic sea ice extent with trend and combined extent of the two polar sea ice sheets. Satellite data have been continuously available since 1979. The data for the combined extent were calculated by totalling the daily ice extent values and may deviate from the annual maximums/minimums.

Source: National Snow and Ice Data Center 2012



Deviation in monthly maximum sea levels in New York (in relation to mean sea level)

The mean sea level recorded at the Battery Park tide gauge, on the southern tip of Manhattan, rose by some 35 cm in the (93-year) period 1920–2012 (an average increase of around 3.8 mm per year).

Source: Center for Operational Oceanographic Products and Services (2012)

A recent study by the Max Planck Institute of Meteorology (D. Notz and Marotzke 2012) investigated the factors behind the significant fall in Arctic sea ice extent during the summer months. Higher carbon dioxide concentrations and the greenhouse effect were identified as being the most probable cause among potential natural and anthropogenic candidates. Researchers also showed that the properties of the upper air flow have changed in the last 30 years as a result of Arctic sea ice melt and self-amplifying temperature rise at higher latitudes. Upper-level air flow follows a wave pattern in the mid-latitudes and governs the sequence of high and low-pressure systems. As a result of the changes, high-pressure systems extend on average much further north in autumn, winter and summer while, at the same time, the west to east flow in the wave structure and weather systems is slowing down. This encourages the development of stable weather conditions with extreme consequences (Francis and Vavrus 2012) such as surface melting over 97% of Greenland in July 2012. This resulted from a series of warm high-pressure systems and the fact that the high-pressure pattern persisted. Ice cores indicate that the last time a similarly record-breaking melt occurred was in 1889. Research also shows that warmer atmospheric conditions over Greenland in summer since 2000 have changed the reflective properties of lower-altitude surfaces by fostering the formation of larger ice grains. The resulting somewhat darker areas absorb more solar energy and heat up more easily, so that more ice melts (J.E. Box et al. 2012).

The winter processes that change the extent of Antarctic sea ice are due to an interaction between continent and ocean. Evidence shows that Antarctica is also getting warmer as a result of climate change, although more slowly than northern regions. The winds around the South Pole are being strengthened by the increasing north-south temperature gradient in the southern hemisphere. Thus, they are tending to blow the sea ice further out into the ocean in some parts of Antarctica and less far in others (P.R. Holland and Kwok 2012). As a result of these changes, overall sea ice extent has increased in recent winters and this year's figure is a record. Climate change is thus also affecting Antarctic sea ice development in the winter months, making it the most likely common denominator behind 2012's various ice and snow records and changes. Since the changes in sea ice extent in the Arctic and Antarctic are attributable to different factors, they cannot be used as an argument against climate change.

October: Record-breaking storm surge in New York due to Hurricane Sandy

Hurricane Sandy was the outstanding loss event of 2012 for the insurance industry. It made landfall in the New York/New Jersey region on the eastern seaboard of the USA in late October, with wind speeds on the borderline between tropical cyclone and hurricane strength. A storm surge of almost 3.5 m above mean sea level was measured at the Battery Park tide gauge at the southern tip of New York's Manhattan Island. Several factors accounted for the height of this storm surge. Firstly, it was due to Sandy's vast size combined with its near-perpendicular landfall. Secondly, there was a full moon, so that landfall coincided with a spring tide. Thirdly, the increase in water level was also due to a steady rise in sea level over a number of decades (roughly 35 cm in 93 years on this gauge).

Scientific assessment

Cyclones that occurred in the distant past can be identified by analysing sediment from salt marshes and lakes near the coast. Such geological analyses have yielded evidence of four major landfalling hurricanes associated with high storm surges in the New York area: in 1693, 1788, 1821 and 1893. The water levels that would have been reached at the southern tip of Manhattan given present-day conditions can be calculated for the last three. This indicates maximum surge heights of roughly 3 m plus a few decimetres above today's mean sea level (Scileppi and Donnelly, 2007). Hurricane Sandy, which occurred in October 2012, was the first storm since these hurricanes to exceed the three-metre mark, with a maximum surge height of almost 3.5 m. A further factor in the case of Sandy was the effect of a 0.5–0.8 m spring tide. Since New York's current flood protection system has a maximum height of 2.5–3 m, the above events would also cause loss or damage today. In the past three centuries, New York has experienced storm surges on this scale at intervals of between 119 and 33 years.

In future, however, events like Sandy, with levels of around 3.5 m, are to be expected far more frequently, according to a recent study into the development of storm surge risks due to climate change, based on climate models (Lin et al., 2012). By the end of the 21st century, this frequency will have increased three- to 33-fold, depending on the model. In addition to the greater intensity and scale of major storms, this increase will primarily be due to sea level rise. In other words, Hurricane Sandy was just a foretaste of what the inhabitants of New York and other parts of the northeast US coast can expect to face more often in the future.

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Most comprehensive nat cat database

In recent decades, natural catastrophe losses have developed in different ways depending on region and hazard. However, in most cases, the trend is clearly upward.

The extent to which the loss trends are due to population growth, increased prosperity and other socioeconomic factors as opposed to increases in the frequency and severity of natural hazard events is of crucial importance in natural hazard risk assessment. A good database is essential so that past loss data can be correctly ranked by order of magnitude. Munich Re's natural catastrophe database, which now contains more than 31,000 entries, is the most comprehensive source of natural catastrophe data in the world. It is the cornerstone that underlies a wide range of information, tools and services in the field of risk management and risk research. In 2012, 905 loss-related events were recorded in the database, considerably exceeding the 820 registered in 2011 and the ten-year average of 800. All natural hazard events that result in property damage or personal injury are recorded in the NatCatSERVICE database. Based on monetary and humanitarian impact, events are attributed to one of several categories, ranging from minor losses to major natural catastrophes.

The latest analyses, charts and statistics are available as free downloads from the Touch Natural Hazards section of our website: www.munichre.com/touch.

In 2012, some 60 earthquakes worldwide caused significant material damage and personal injury. The photograph shows the ruins of a house in Rovereto sulla Secchia, which was destroyed in the series of earthquakes that hit northern Italy in May 2012.

The year in pictures

5 to 6 January
Winter storm Andrea: Europe
Overall losses: US$ 720m
Insured losses: US$ 440m
Fatalities: 5

24 January to 11 February
Floods: Australia
Overall losses: US$ 225m
Insured losses: US$ 140m
Fatalities: 2

2 to 4 March
Severe weather, tornadoes: USA
Overall losses: US$ 5,000m
Insured losses: US$ 2,500m
Fatalities: 41

5 to 8 April
Severe weather: Argentina
Overall losses: US$ 10m
Fatalities: 18

10 to 24 May
Floods: China
Overall losses: US$ 2,500m
Fatalities: 127

20/29 May
Earthquakes: Italy
Overall losses: US$ 16,000m
Insured losses: US$ 1,600m
Fatalities: 18

26 June to 31 July
Floods: Bangladesh
Fatalities: 131

June to September
Drought, heatwave, wildfires: USA
Overall losses: >US$ 20,000m
Insured losses: >US$ 15,000m
Fatalities: 102

July to October
Floods: Nigeria
Overall losses: US$ 500m
Fatalities: 431

8 to 9 August
Typhoon Haikui: China
Overall losses: US$ 1,500m
Insured losses: US$ 230m
Fatalities: 16

11 August
Earthquake: Iran
Overall losses: US$ 500m
Fatalities: 306

24 to 31 August
Hurricane Isaac: Caribbean, USA
Overall losses: US$ 2,000m
Insured losses: US$ 1,220m
Fatalities: 42

3 to 27 September
Floods: Pakistan
Overall losses: US$ 2,500m
Fatalities: 455

7 September
Earthquake: China
Overall losses: US$ 1,000m
Insured losses: US$ 45m
Fatalities: 89

24 to 31 October
Hurricane Sandy: Caribbean, USA
Overall losses: US$ 65,000m
Insured losses: US$ 30,000m
Fatalities: 210

10 to 14 November
Floods: Italy
Overall losses: US$ 15m
Fatalities: 4

11 November
Earthquake: Myanmar
Fatalities: 26

4 to 5 December
Typhoon Bopha: Philippines
Overall losses: US$ 600m
Fatalities: 1,100

The year in figures

Petra Löw, Angelika Wirtz

Following record losses in 2011, 2012 counts as a moderate year. However, overall losses worldwide from 905 events totalled US$ 170bn, which is just above the ten-year average. At US$ 70bn, insured losses were also higher than the ten-year average (US$ 50bn). Fatalities (9,600) were substantially below the ten-year average (106,000).

The worst catastrophe of 2012 was Typhoon Bopha in the Philippines, with more than 1,100 fatalities. The most costly event was Hurricane Sandy, which primarily affected the US states of New Jersey and New York. It caused economic losses of around US$ 65bn and insured losses of US$ 30bn.

Number of events

Of the 905 documented loss events, 840 (93%) were weather-related, i.e. storms, floods and climatological events such as heatwaves, cold waves, droughts and wildfires. The remaining 7% were caused by earthquakes (63 in all) and two volcanic eruptions. This distribution deviates from the 1980–2011 average of 86% weather-related and 14% geophysical events.

On the other hand, the breakdown by continent was approximately in line with the long-term average. The only exception was Africa, where the total of 99 loss events in 2012 was well above the long-term average (56). Most of the natural catastrophes occurred in Asia (334) and America (285). There were 132 in Europe and 54 in Australia.

Fatalities

Of the 9,600 fatalities, almost 30% resulted from only five events:

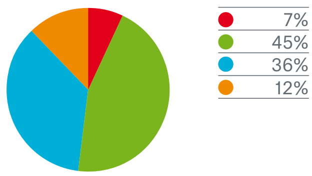
- December: Typhoon Bopha, Philippines, 1,100 fatalities
- January: Cold wave, eastern Europe, 530 fatalities
- September: Floods, Pakistan, 455 fatalities
- July–October: Floods, Nigeria, 431 fatalities
- August: Earthquake, Iran, 306 fatalities

Losses

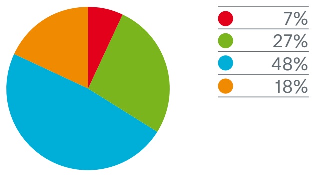
Around two-thirds of the overall losses of US$ 170bn and 89% of the insured losses of US$ 70bn were due to weather-related events in the USA. This was where the five most costly events occurred from an insurance industry perspective.

- October: Hurricane Sandy, USA and Caribbean, US$ 30bn
- June–September: Drought, USA, US$ 15–17bn
- March: Severe weather/tornadoes, USA, US$ 2.5bn
- April: Severe weather/tornadoes, USA, US$ 2.5bn
- June: Severe weather, USA, US$ 2bn

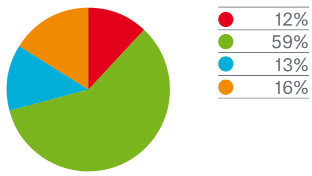
905 events
Percentage distribution worldwide



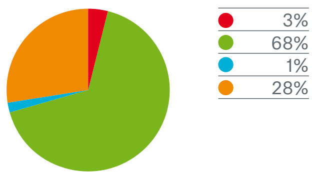
Fatalities: 9,600
Percentage distribution worldwide



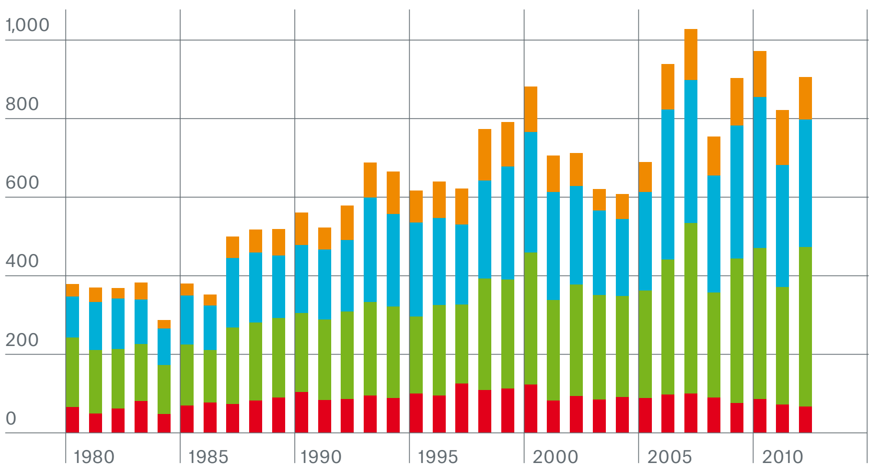
Overall losses: US$ 170bn
Percentage distribution worldwide



Insured losses: US$ 70bn
Percentage distribution worldwide



Number of natural catastrophes 1980–2012



Geophysical events: Earthquake, tsunami, volcanic eruption

Meteorological events: Tropical storm, winter storm, severe weather, hail, tornado, local storm

Hydrological events: River flood, flash flood, storm surge, mass movement (landslide)

Climatological events: Heatwave, cold wave, wildfire, drought

A series of earthquakes in Italy's Emilia Romagna province proved exceptionally expensive. With insured losses of some US$ 1.6bn, this series emerged as the insurance industry's costliest earthquake loss ever in Italy. Overall losses totalled US$ 16bn.

Asia was again hit by major floods in 2012. Torrential rainfall in mid-June caused heavy losses in northeast and southeast China. Insurance claims for Beijing alone were in the order of US$ 150m. The overall loss is estimated to be around US$ 8bn.

Losses in Australia/Oceania were relatively low compared with previous years, with the notable exception of two flood events in Australia: one in Queensland during January and February, and the other in New South Wales during February and March. They resulted in insured losses of US$ 280m and overall losses of around US$ 500m.

A breakdown of the losses between the four main perils reveals a number of substantial deviations from the long-term average. Around 59% of overall losses are attributable to windstorms, compared with the long-term average of 39%. The opposite applies in the case of earthquakes. Earthquakes accounted for 12% of overall losses in 2012, which is only half the 1980–2011 average.

With regard to insured losses, a particularly striking feature in the "climatological events" category is that droughts accounted for a 28% share. This is well above the long-term average of 7%, and was due to the severe drought that primarily afflicted the US Midwest during the summer, causing immense agricultural losses.

Once again, windstorm events accounted for the largest share of insured losses (68%). The loss drivers – Hurricane Sandy in October and a number of tornadoes in the spring – all related to the USA. The most severe tornado outbreak (on 2–4 March) alone caused insured losses of US$ 2.5bn, with Tennessee the worst hit state.

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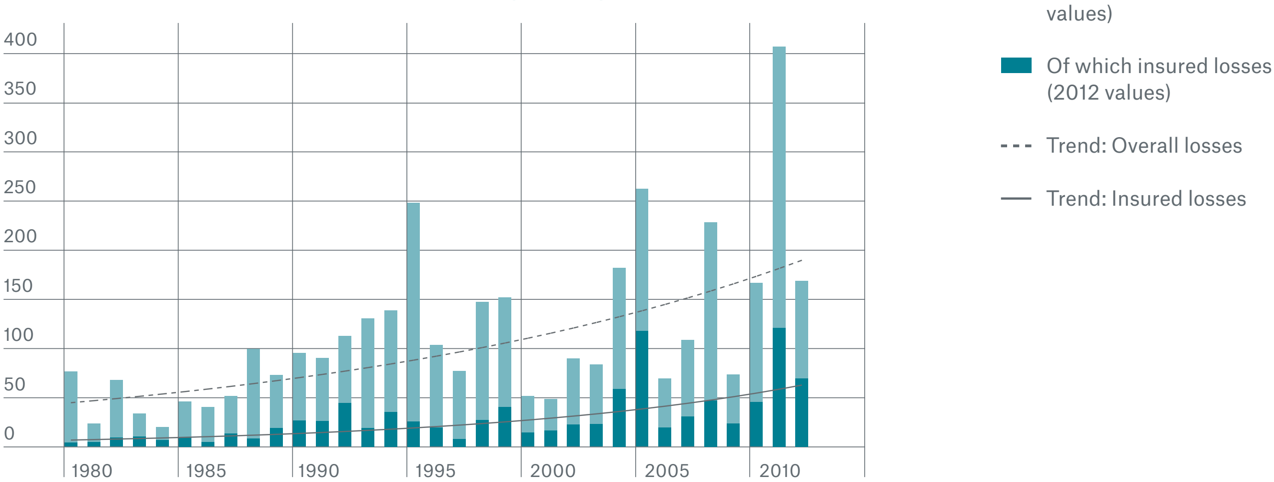
Overall losses and insured losses 1980–2012 (US$ bn)



Natural catastrophes 1980–2012

Breakdown by continents and perils

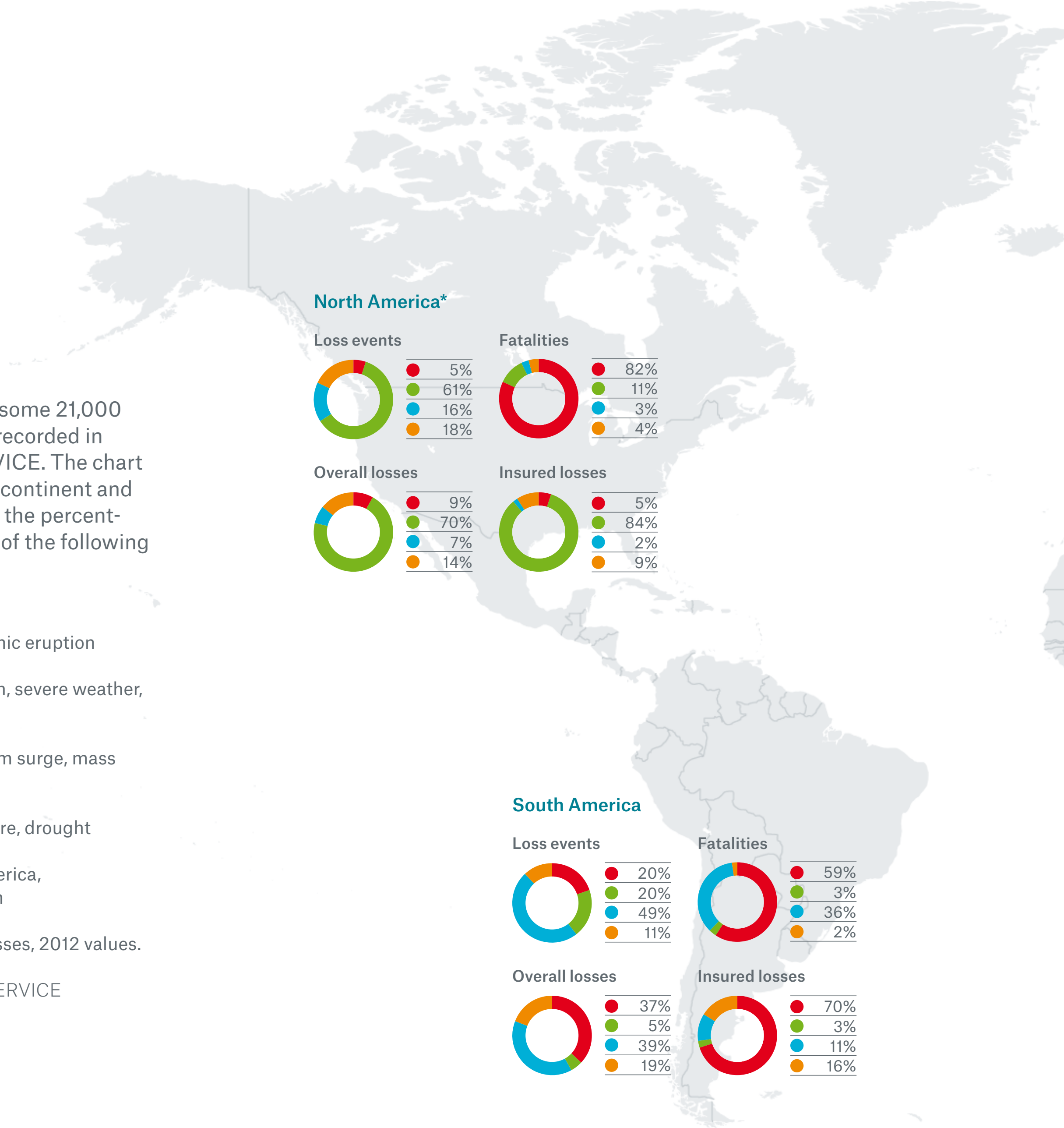
Between 1980 and 2012, some 21,000 loss-related events were recorded in Munich Re's NatCatSERVICE. The chart provides a breakdown by continent and sub-continent and shows the percentages attributable to each of the following main perils:

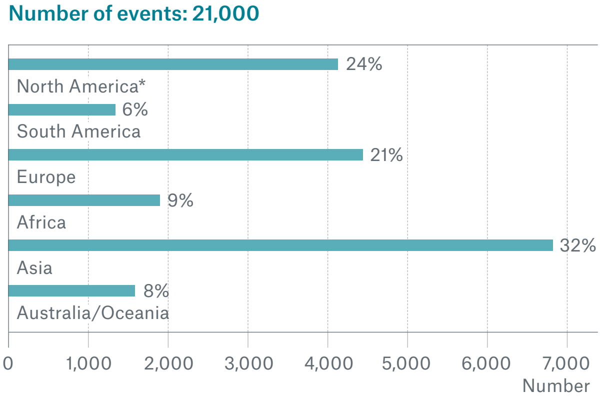
- **Geophysical events:** Earthquake, tsunami, volcanic eruption
- **Meteorological events:** Tropical storm, winter storm, severe weather, hail, tornado, local storm
- **Hydrological events:** River flood, flash flood, storm surge, mass movement (landslide)
- **Climatological events:** Heatwave, cold wave, wildfire, drought

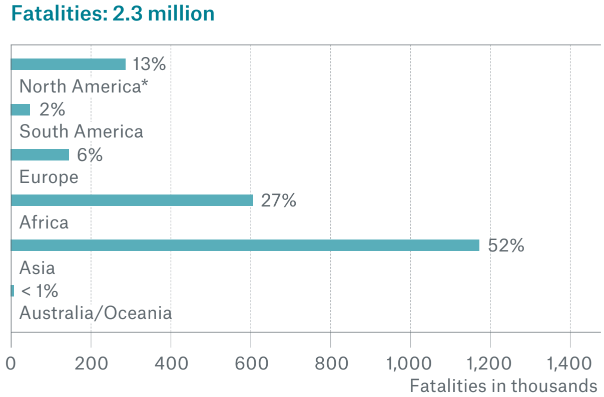
* North America = North America, Central America, Caribbean

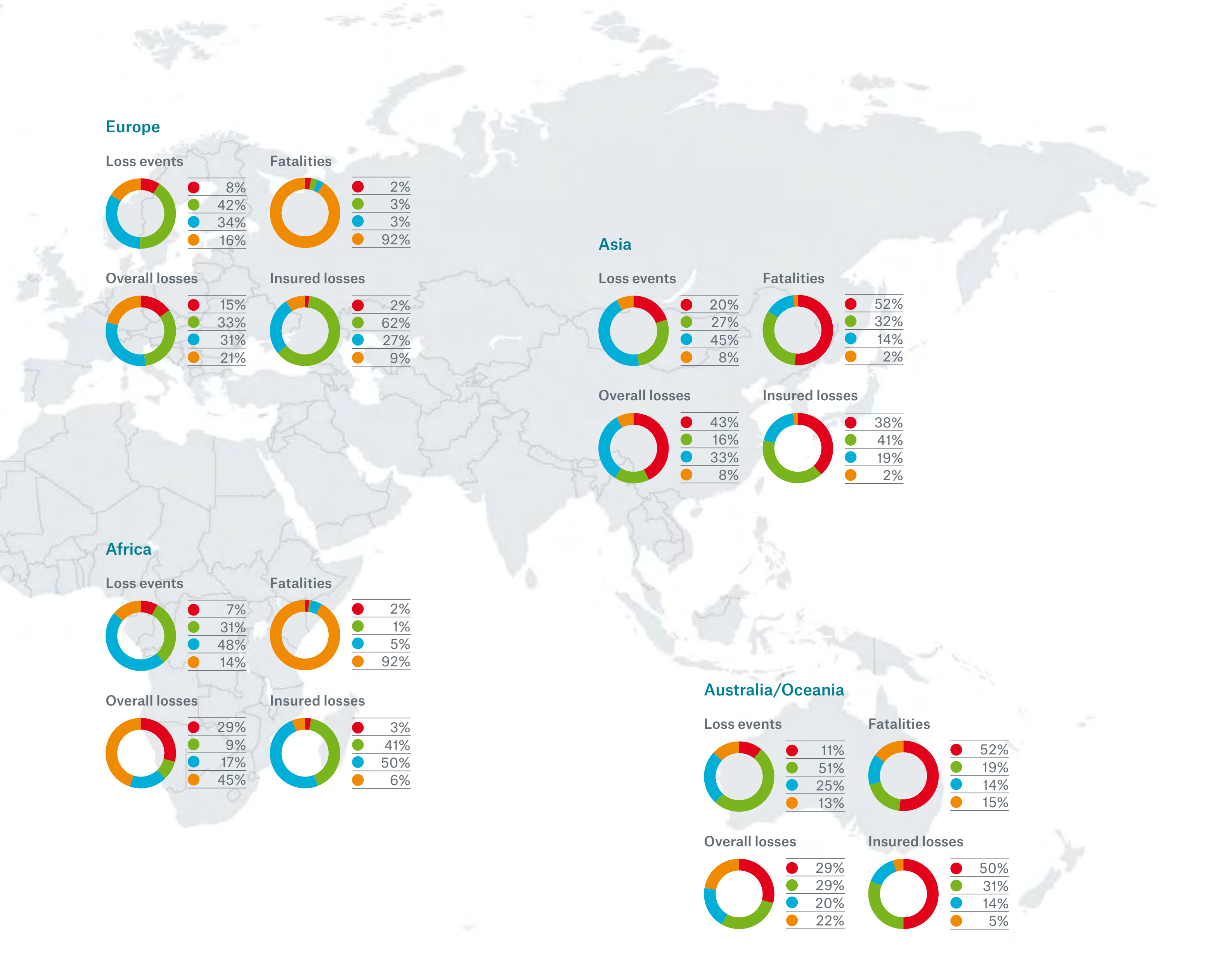
Overall losses and insured losses, 2012 values.

Source: Munich Re, NatCatSERVICE

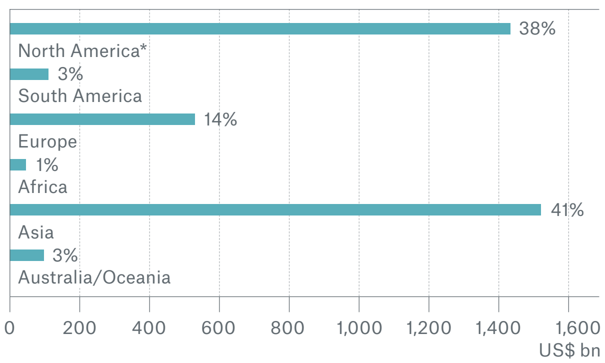




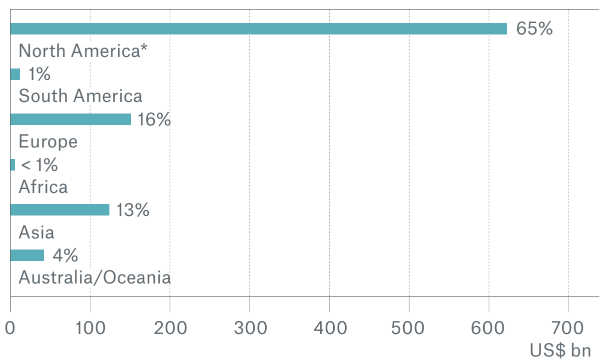




Overall losses: US$ 3,800bn



Insured losses: US$ 970bn



Loss trends – How much would past events cost by today's standards?

In recent decades, natural catastrophe losses have evolved in different ways depending on the region and the hazard. In most cases, it is clear that the trend is upwards, but the factors behind this trend are less clear.

Jan Eichner

We live in an ever-changing world, where circumstances that applied until recently may now be obsolete. This can lead to problems when it comes to nat cat risk assessment, for instance when calculating loss return periods, because such assessments rely on data taken from the past. To be able to compare past and present-day losses, the former would, in theory, have to be repeated under current conditions – which is impossible. We therefore need a standard which enables losses incurred at a given point in time to be set in the current context. Referred to as normalisation, this can only be achieved using proxy data, i.e. approximate indications of how socio-economic values have developed in the course of time.

Risk factors and loss drivers

Risk and the loss amounts potentially associated with it are determined by three factors: the destroyable assets (exposure), their susceptibility to damage (vulnerability) and the intensity and frequency of the natural hazard (hazard). Where insured losses are concerned, exposure also includes insurance penetration. The different factors involved change in the course of time, and usually to different extents, depending on region. Such changes play a major role in any comprehensive risk assessment.

Exposure is closely linked to socio-economic developments such as population growth, wealth, economic growth and the development of natural areas formerly considered, often not without cause, to be waste land. These are factors which increase on average in the course of time, so that the losses also increase.

No clear trend is evident where vulnerability is concerned. On the one hand, building code improvements have been introduced to ensure that roofs are more resistant to storm damage, for instance, and that dams afford protection against specific flood levels. Effective warning systems are another positive development, ensuring speedy deployment of preventive and protective measures. But, on the other hand, vulnerability has also increased due to factors such as the installation of photovoltaic systems on roofs or the use of fragile materials as cladding for façades.

The natural hazards themselves can also change in the course of time but the natural variability commonly referred to as a "whim of nature" is not a matter of mere chance. Atlantic warm and cold phases, for instance, influence hurricane activity on a scale of several years. The same is true of the quasi-periodic ENSO (El Niño, La Niña) phenomenon in the Pacific. As well as influencing Atlantic hurricane activity, ENSO can cause heavy precipitation in South America and affects severe thunderstorm activity over North America. Over long time scales, climate change is also partly responsible for shifts in, and the intensification or even, in some cases, moderation of some natural hazards. Regional climate models and medium-term projections indicate the extent of such changes.

Proxy values and data

To be able to compare past and current losses, one needs to account for inflation and exposure increase over time. Increases in value are positively correlated with population development and values in a given region. Indeed new assets tend to be more readily created in areas that already have an extensive infrastructure. Key macroeconomic data such as national economic output and total income can be used as proxies to reflect such developments. The national figures have to be broken down into local units so that the generally limited dimensions of natural phenomena can be more effectively mapped. Otherwise, the results obtained from normalising individual loss events may be very approximate. However, aggregating a number of events reduces the degree of imprecision, regional overestimates and underestimates virtually balancing each other out.

Miami Beach 1914: Low-risk, despite high hurricane exposure.

Miami Beach 2012: High loss potential due to intense development.

The following data combinations summarise sociological and economic developments. They are now established as proxies of exposure development in normalisation analysis.

Local GDP = GDP per capita* x *Number of people affected

Total economic added value is normally expressed as gross domestic product (GDP) or, less commonly, gross national income (GNI). A proxy for local GDP is obtained by multiplying national GDP per capita by the number of inhabitants within the given region. Other methods divide national GDP into equal-sized cells weighted to reflect the percentage of overall population located in each one. This produces a kind of gross cell product. All the cells located in a region exposed to natural hazards must be added together to obtain a proxy for the region in question.

One of the disadvantages of using GDP data, especially in the western world, is that they now include a substantial proportion of intangible assets (e.g. related to the service sector) that may not be directly affected by natural catastrophes. Normalisation may thus result in a slight but systematic overstatement of past losses.

A far better approximation of actual destructible assets is obtained from estimates relating to building stock and increase in prices and to

Value of local building stock =
Average housing price* x *local building stock

national or regional index of construction and repair costs. The value of the local building stock is the average price of the buildings multiplied by the building stock, and only applies to buildings. It does not take account of the value of contents and vehicles, which may account for a more or less equivalent proportion of the overall amount in the event of a loss.

Although useful for loss normalisation purposes, data of the requisite quality are currently available for just a few industrialised nations and cannot be used for international analyses. Since GDP figures are readily available, they are now accepted for normalisation at global level, despite the inaccuracies involved. More detailed figures are only available for a few regional analyses, primarily in the USA and a number of western European countries.

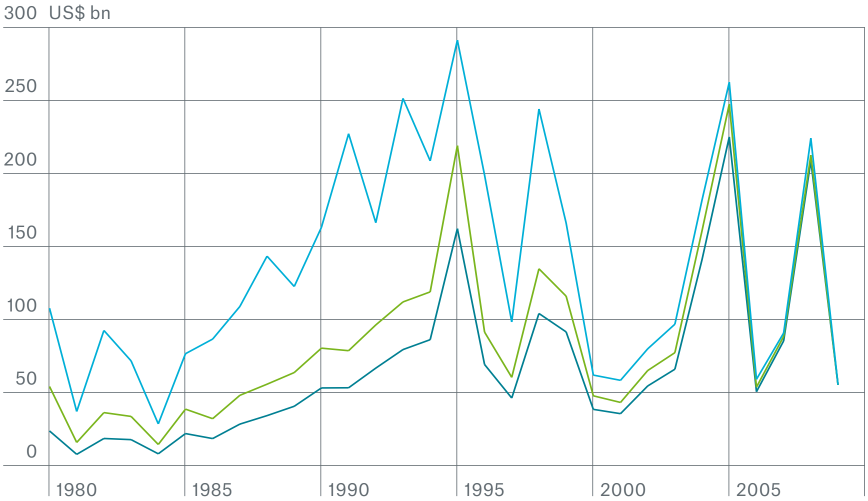
Where precise GDP figures are not available for the country concerned, national income classes can be compiled from World Bank statistics, for example, and a proxy GDP or GNI value calculated by assigning the country to the appropriate class. Although the results may be very approximate in some cases, this method is still better than adjusting loss data for inflation only, for comparison purposes.

Normalisation methods and results

In mathematical terms, normalisation is based on the assumption that the loss and the proxy value develop proportionally and that the quotient of loss value and exposure proxy is constant over time. A formula is then derived for normalised loss at present-day values:

$$\text{Loss today} = \text{Loss in year } X \times \frac{\text{Proxy today}}{\text{Proxy in year } X}$$

Overall economic loss from all natural catastrophes worldwide 1980–2009



The diagram shows global overall nat cat losses since 1980 in original values, adjusted for inflation and normalised on the basis of GDP data.

- Original values
- Adjusted for inflation (2009 values)
- Normalised on the basis of GDP data per country (2009 values)

Source: Diagram based on Fig. 3 in: E. Neumayer and F. Barthel, *Normalizing economic loss from natural disasters: A global analysis,* in Global Environ. Change (2010), Vol. 21 (1), p. 13–24, doi: 10.1016/j.gloenvcha.2010.10.004.

In studies by the Grantham Research Institute of the London School of Economics (LSE) in which loss data from Munich Re's NatCatSERVICE were analysed, the following combination of proxies was chosen to normalise global overall losses in the countries concerned: inflation, gross domestic product per capita and number of people affected by the catastrophe, or:

Proxy = Inflation* x *GDP per capita* x *No. of people affected

One finding established in an LSE analysis into the increase in global nat cat losses is illustrated in the above graph. Due to socio-economic growth, normalising the data has the effect of substantially reducing the trend observed in the case of annual losses in original values. The LSE researchers' cautious linear estimate of the residual trend indicates a mean increase of US$ 1.7bn per year for the past 30 years in present-day values. That is equivalent to an increase of about 50% over the period as a whole. However, the diagram also shows that the trend features phases of greater and lesser loss activity rather than being linear.

A second LSE study analysed insured losses from meteorological and climatological loss events, primarily severe thunderstorms, in the USA. Here, insurance penetration has to be taken into account. The authors of the study use two different methods to compare the effects of different socio-economic proxies on insured losses. The first is based on inflation, insurance penetration, GNI per capita and number of people affected. The second substitutes value of local building stock for the last two values.

Proxy = Inflation* x *GNI per capita* x *No. of people affected* x *Insurance penetration

Proxy = Inflation* x *Building stock value affected* x *Insurance penetration

The results are shown on page 59. Again, the virtually exponential rise in original values is weaker following normalisation. This is also depicted in linear form, both methods resulting in an increase of approximately US$ 750m per year for weather-related events. Even disregarding the outlier Hurricane Katrina in 2005, the trend still indicates an increase of some US$ 450m per year. The increase for severe thunderstorms alone is in the order of US$ 100m per year. The fact that similar results are obtained even though different proxies are used can be taken to indicate the stability of the results.

OUR EXPERT

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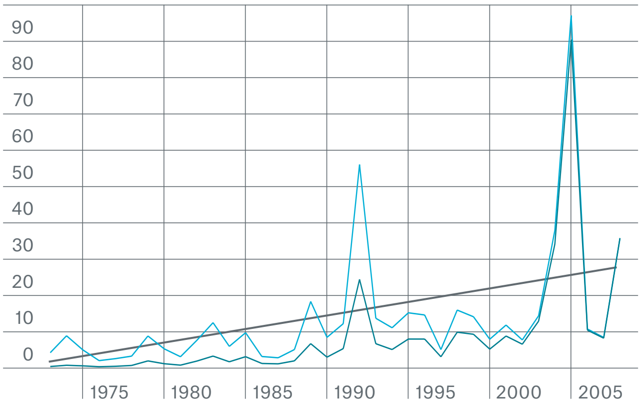
Natural catastrophes in the USA 1973–2009
Insured losses

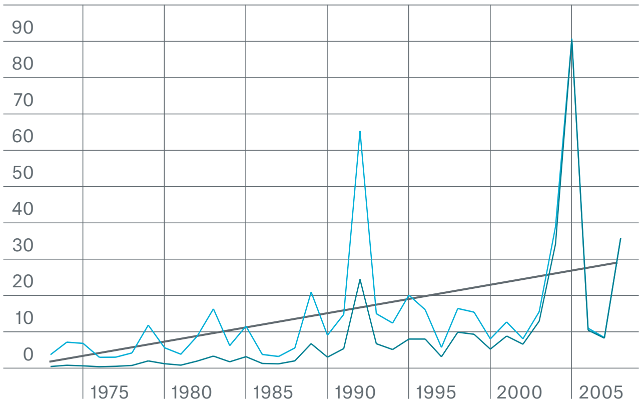
Weather-related events*

Normalised on the basis of income development
100 US$ bn



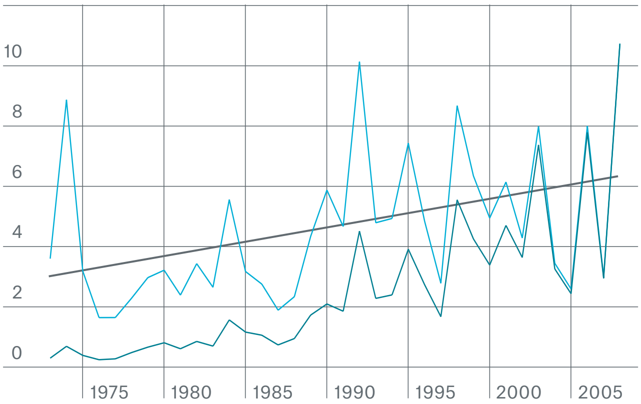
* Weather-related events: Meteorological events (storms), hydrological events (floods) and climatological events (heatwave, cold wave, wildfire, drought)

Normalised on the basis of building stock development
100 US$ bn



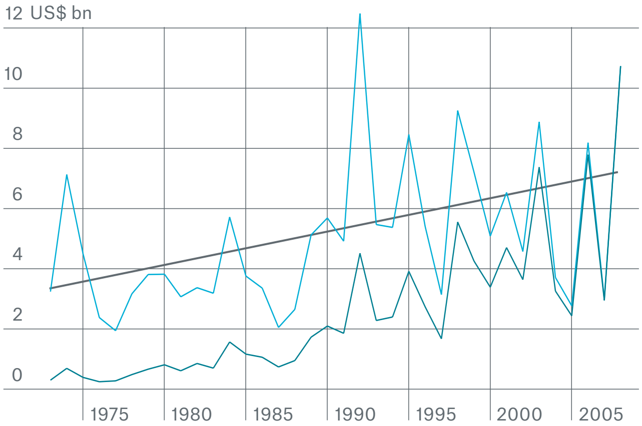
Convective storms**

Normalised on the basis of income development
12 US$ bn



** Convective storms: Severe thunderstorms with flash floods, hail, tornado, lightning

Normalised on the basis of building stock development
12 US$ bn



Insured losses are shown in original values and normalised on the basis of income development (left) and building stock development (right), bearing in mind changes in insurance density.

Source: Based on Fig. 8(a) and (b) in F. Barthel and E. Neumayer, *A trend analysis of normalized insured damage from natural disasters* in Climatic Change (2012) 113: 215–237, DOI 10.1007/s10584-011-0331-2

Conclusion

Once the loss increases have been adjusted to eliminate socio-economic effects, the residual trend can essentially be attributed to changes in vulnerability and in the frequency and intensity of natural hazards. What part the two remaining factors play cannot (yet) be conclusively established. However, if the development is essentially due to changes in the natural hazards, future increases are to be expected as a result of climate change. Munich Re's NatCatSERVICE will also provide normalised loss time series as a standard service from 2013 onwards. The normalisation methods used will be presented in detail in the next issue of Topics Geo.

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Topics Geo – World map of natural catastrophes 2012

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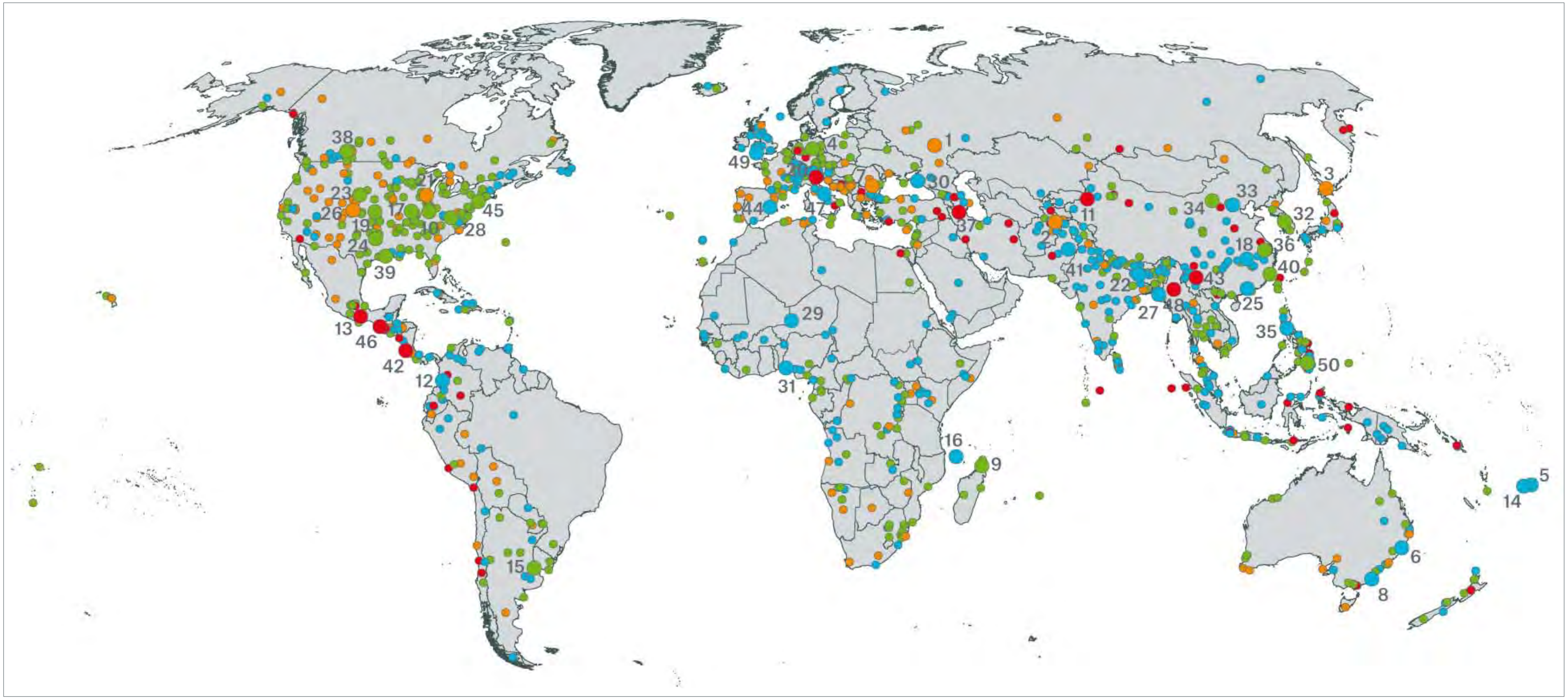

905 natural hazard events, thereof

◯ 50 major events (selection)

- **Geophysical events:** Earthquake, tsunami, volcanic eruption
- **Meteorological events:** Tropical storm, winter storm, severe weather, hail, tornado, local storm
- **Hydrological events:** River flood, flash flood, storm surge, mass movement (landslide)
- **Climatological events:** Heatwave, cold wave, wildfire, drought

Topics Geo – 50 major events in 2012

No.	Date	Loss event	Country/Region	Deaths	Overall losses US$ m	Insured losses US$ m	Explanations, descriptions
1	1.1.–7.2.	Cold wave, winter damage	Russian Federation	215			High wind speeds. Infrastructure and crop losses.
2	January–March	Cold wave, avalanches	Afghanistan	250			Coldest winter for 15 years, heavy snowfall, large avalanches. Areas cut off. Livestock deaths.
3	1.1.–10.2.	Winter damage, snowstorms	Japan	83			Blizzards, gusts up to 130 km/h, avalanches. Bridge collapsed, highways, roads blocked.
4	5.–6.1.	Winter Storm Andrea	Western, northern and eastern Europe	5	720	440	High wind speeds, heavy snowfall (up to 60 cm). Power outages. Property and infrastructure losses.
5	21.–25.1.	Floods, landslides	Fiji	11	20		Tropical depression, heavy rain (400 mm/48h). >50 bridges damaged, 55% of export crop destroyed.
6	24.1.–11.2.	Floods, flash floods	Australia	2	225	140	Torrential rain. Thousands of houses, vehicles damaged. Coal mines affected, cattle losses.
7	25.1.–13.2.	Cold wave, winter damage	Eastern, southern and western Europe	541	850		Snowdrifts up to 8 m, extreme frost and low temperatures (–39°C). River navigation suspended. Pipes burst. Power outages. Livestock losses.
8	24.2.–16.3.	Floods	Australia	2	230	140	Towns cut off. Thousands of houses/vehicles caught in flood waters. Infrastructure and agriculture losses.
9	26.2.–4.3.	Tropical Storm Irina, floods	Madagascar, South Africa, Mozambique	88			Thousands of houses damaged. Bridges, roads damaged. Losses to agriculture.
10	2.–4.3.	Severe storms, tornadoes	USA	41	5,000	2,500	>30 tornadoes up to EF4 (Enhanced Fujita Scale), large hail. Losses to property and industry.
11	9.3.	Earthquake	China		80		M_w 5.8. >8,600 houses damaged or destroyed. Losses to infrastructure.
12	15.3.–1.6	Floods, flash floods	Colombia	55	300		Heavy seasonal rains. >25,000 houses flooded. 5 bridges, 11 aqueducts damaged.
13	20.3.	Earthquake	Mexico	2	320	160	M_w 7.4. >15,000 buildings damaged/destroyed. Communications disrupted, power outages.
14	28.3.–3.4.	Floods, flash floods	Fiji	4	72		Hundreds of houses damaged. Power and water supply disrupted.
15	5.–8.4.	Severe storms	Argentina	18	10		>32,000 houses, many schools and businesses damaged. Power and water supply disrupted.
16	19.4.–13.5.	Floods	Comoros	4	5		Landslides, rockslides. Villages cut off. >9,300 houses damaged or destroyed. Losses to agriculture and livestock.
17	28.–29.4.	Severe storms	USA	1	4,600	2,500	Two waves of supercell thunderstorms, tornadoes, large hail (7cm in diameter). Thousands of houses and businesses damaged or destroyed. >50,000 cars damaged. Power outages.
18	10.–24.5.	Floods, landslides	China	127	2,500		Severe storms, hail. 200,000 houses, hospitals, schools damaged/destroyed. >14,000 km^2 of cropland severely damaged or destroyed.
19	25.–30.5.	Severe storms, hailstorms	USA		3,400	1,700	Thunderstorms, tornadoes, hail (up to 11 cm in diameter). Losses to buildings, industry and agriculture.
20	20.5/29.5.	Earthquakes	Italy	18	16,000	1,600	Series of earthquakes up to M_w 5.9. Major losses to houses and historic buildings. Losses to food industry and infrastructure.
21	June–September	Drought, heatwave	USA	100	20,000	15,000–17,000	Severe lack of rain, extreme temperatures (>40°C). Major crop losses (esp. soybeans and corn). Low water levels in rivers, reservoirs, wells.
22	June–September	Floods, landslides	India	600	150		Heavy monsoon rains. 4,500 villages flooded. Infrastructure damaged. Heavy losses to agriculture fisheries and livestock. More than two million displaced.
23	6.–7.6.	Severe storms, tornadoes	USA		1,400	1,000	Large hail, flash floods. Thousands of houses and vehicles damaged. Losses to infrastructure.
24	11.–13.6.	Severe storms, hailstorms	USA		1,900	950	Hail up to 7cm in diameter. >3,000 houses, 8,000 vehicles damaged. Power outages.
25	20.6.–8.7.	Floods	China	70	800		>100,000 houses damaged or destroyed. Losses to agriculture. More than 160,000 people displaced.
26	23.6.–10.7.	Wildfires	USA	2	600	450	Waldo Canyon fire, gusts up to 95km/h. Hundreds of houses burnt. More than 34,000 people evacuated.
27	26.6.–31.7.	Floods	Bangladesh	131			Torrential rain (400 mm/12h), landslides. >250,000 houses destroyed. Power and communication lines disrupted. Losses to infrastructure.
28	28.6.– 2.7.	Severe storms	USA	18	4,000	2,000	Super derecho. Thousands of houses, mobile homes, businesses, vehicles and boats damaged. >2.4 million without electricity.
29	July–September	Floods	Niger	91			24,000 houses destroyed. Bridges, roads destroyed. Losses to crops and livestock. Outbreak of epidemic diseases.
30	6.–8.7.	Flash floods	Russian Federation	172	400	32	Heavy rain (>300 mm/few hours), tornadoes. Thousands of houses damaged. Major losses to infra-structure.
31	July–December	Floods	Nigeria	431	500		Torrential seasonal rain. 600,000 houses, churches, schools damaged/destroyed. Drinking water supply disrupted. Losses to crops and livestock. Displaced: 2.2 million.
32	18.–29.7.	Tropical Storm Khanun (Enteng)	North and South Korea	89	100		Torrential rain. Tens of thousands of houses flooded or destroyed. Bridges, roads washed away. Losses to agriculture.
33	21.–24.7.	Floods	China	151	8,000	180	200,000 houses damaged or destroyed. 50 bridges, 750 km of roads destroyed. Major losses to agriculture and livestock (170,000 farm animals killed).
34	2.–6.8.	Typhoon Damrey, floods	China	10	370		Torrential rain. Dam collapse. >35,000 houses damaged/destroyed. 240 bridges damaged. Crops destroyed.
35	5.–17.8.	Floods	Philippines	109	70	3	Torrential monsoon rain. >13,000 buildings damaged or destroyed. Financial markets closed. Losses to crops and livestock.
36	8.–9.8.	Typhoon Haikui, floods	China	16	1,500	230	Heavy rain. 40,000 houses damaged or destroyed. Losses to factories. Roads, bridges damaged. Evacuated: >2.1 million,
37	11.8.	Earthquakes	Iran	306	500		Twin earthquakes, up to M_w 6.4. 12,000 houses destroyed. Communications disrupted. Injured: >3,000.
38	12.8.	Hailstorm, severe storm	Canada		1,050	530	Thousands of houses, businesses, vehicles damaged. Trees downed. Power failures.
39	24.–31.8.	Hurricane Isaac	Caribbean, USA	42	2,000	1,220	Category 1 hurricane, heavy rain (500 mm). Buildings, vehicles, boats damaged. Oil platforms, gas production, refineries affected. Losses to agriculture and fisheries.
40	25.–30.8.	Typhoon Bolaven, storm surge	Japan, North and South Korea, China	100	950	450	Torrential rain. Thousands of houses destroyed. Losses to businesses, industry and infrastructure. Major losses to crops and fish farms.
41	3.–27.9.	Floods	Pakistan	455	2,500		>600,000 houses damaged or destroyed. Irrigation systems damaged. Losses to agriculture and livestock. More than 300,000 displaced.
42	5.9.	Earthquake	Costa Rica	2	45	32	M_w 7.6. Hundreds of houses damaged. Losses to infrastructure. Power outages.
43	7.9.	Earthquake	China	89	1,000	45	M_w 5.6. >6,500 houses destroyed, 430,000 damaged.
44	28.9.	Flash floods, tornado	Spain	10	260	130	Villages cut off. Homes, commercial properties damaged. Two bridges destroyed.
45	24.–31.10.	Hurricane Sandy, storm surge	Caribbean, USA, Canada	210	65,000	30,000	Category 2 hurricane. Record storm surge in New York City. Severe flood losses. Major losses to infrastructure. Power supply disrupted, in some cases for weeks.
46	7.11.	Earthquake	Guatemala	44	200		M_w 7.4. Damage recorded in 21 (out of 22) states. >30,000 houses/vehicles damaged/destroyed.
47	10.–14.11.	Floods	Italy	4	15		Rivers burst their banks. Houses, business damaged, vehicles washed away. Bridges destroyed.
48	11.11.	Earthquake	Myanmar	26			M_w 6.8. Hundreds of houses, hospitals, schools, religious buildings, government offices damaged.
49	21.–27.11.	Floods	UK	4	15		Villages cut off. >1,400 houses flooded.
50	4.–5.12.	Typhoon Bopha	Philippines	1,100	600		Torrential rain. >167,000 houses damaged/destroyed. Communication, power and water supply disrupted. Bridges destroyed. 400,000 displaced.

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NOT IF, BUT HOW