10th year · 2003

Natural catastrophes in 2002 | Major engineering and fire catastrophes in 2002 | Trends of great natural catastrophes since 1950 | The summer floods in Europe – A millennium flood? | A natural hazard index for megacities | Does geographical underwriting improve risk management?

topics

ANNUAL REVIEW: NATURAL CATASTROPHES 2002

Münchener Rück
Munich Re Group


Landeshauptstadt
Dresden

Cover picture:
01 The flooding of Dresden's main station in August 2002. The great summer floods that hit numerous countries of central Europe were of historic dimensions in many regions.

Left:
02 Dresden boundary sign in deep water.

Natural catastrophes in 2002 Review of the year

01

The year 2002 was marked by numerous severe storms and floods. In Europe there was a thousand-year flood, of the sort that we have not seen since the Middle Ages. Records were broken throughout the world in numerous weather events. Around the Pacific a number of weather extremes are an indication of a new El Niño event, which is expected to peak in 2003.

Loss figures

Throughout the world some 11,000 people were killed in natural catastrophes (previous year 25,000); just under half of these were the victims of floods. The number of loss events was around 700 and thus above the long-term annual average (650). Economic losses came to some US$ 55bn (2001: US$ 35bn), with insured losses accounting for almost US$ 13bn (previous year: US$ 11.5bn).

The outstanding events were the major floods on the Elbe, Vltava, Danube, and their tributaries in August. They caused economic losses of about US$ 18.5bn throughout Europe, of which more than US$ 3bn was insured. Other significant catastrophe events included the tornado outbreaks in the United States in April and November and Jeanett, the winter storm that hit the whole of western and central Europe at the end of October.

Storms and floods

Windstorms and floods are at the top of the year's list of natural catastrophes with just under 500 events (previous year: 450) and also dominate the insurers' claims burdens (99% of the insured natural catastrophe losses; previous year: 92%).

- Tropical cyclones hit South Korea, Japan, La Réunion, Mexico, and the United States. Typhoon Rusa destroyed 650 ships and boats in Korea at the beginning of September and caused severe damage to the country's fish farms. Typhoon Higos, which raged over the western Pacific at the beginning of October, was one of the strongest typhoons of recent years. Luckily, its intensity decreased markedly before it arrived in Japan and therefore, after setting course for the capital Tokyo, caused relatively little damage there. In September and early October Hurricanes Lili and Isidore damaged numerous offshore oil rigs in the Caribbean. Fortunately, the force of these two storms weakened considerably before they reached the coast.

- There was a spectacular series of tornadoes in the United States at the end of April, when more than 30 tornadoes sped across the Midwest and the East at speeds of 300 km/h (F5 tornadoes). Thousands of houses, cars, businesses, and freight trains were badly affected. Insurers were faced with a bill of US$ 1.6bn, the most expensive tornado loss of all time. The Midwest was hit by another series of tornadoes in November, which generated extensive damage (90 tornadoes, 35 fatal victims).

- Prolonged sand and dust storms with exceptionally high concentrations of dust covered large areas of eastern Asia in the spring. In Siberia, Mongolia, Korea, and China, more than half of the country in each case was hit by the storms.

- At the end of October, a winter storm christened Jeanett battered almost the entire area of western and central Europe and will probably cost the insurers around US$ 1.5bn. Insurers in Germany alone are likely to have a bill of more than US$ 1bn to pay out. Similar dimensions have only ever been reached in Germany by Daria, Vivian, and Wiebke, the gales which each caused insured losses of around US$ 600m at the beginning of 1990.

2002 – A year of rainfall extremes

Not only the typhoons in Asia, but also numerous severe storms in other parts of the world led to new rainfall records, causing numerous regional and supraregional floods. Examples from Europe show that some of the events were caused by historical extreme precipitation.

- In August, Majorca was swamped by 224 mm (= l/m^2) of rain in just three hours, which triggered numerous flash floods, landslides, and debris flows.

- In large parts of Europe there were copious falls of torrential rain in the summer months of July to September, which caused many a river to burst its banks (cf. the articles beginning on pages 16 and 26). On 12 August in Dresden, for example, 158 mm of rain fell in just 24 hours, more than twice as much as had ever been recorded there. At the beginning of August, a dramatic flash flood in a holiday village in southern Russia tore more than 100 people to their deaths.

– On 8/9 September in the Rhône valley 670 mm of rain fell in just 36 hours; this is far more than half the normal annual rainfall. There was major damage in villages and vineyards around the city of Orange in southern France as a result.

In other parts of the world, such as Australia and the United States, on the other hand, there were month-long droughts and heat waves, which caused severe damage to agriculture and devastating forest fires.

Volcanic eruptions and earthquakes

Throughout the world there were about 70 loss-producing earthquakes and 20 major volcanic eruptions, generating economic losses of around US$ 1.2bn, but insured losses of only US$ 11m. Some examples:

– At the beginning of the year, the Nyiragongo volcano in the border area between the Democratic Republic of Congo and Rwanda erupted; thousands of people had to flee from the streams of lava that were burying entire settlements below them. Mt. Etna on Sicily did not come to rest in 2002 either, spewing out fire and ashes for weeks on end in the autumn. At the end of the year another of Italy’s volcanoes became active again, Stromboli. As yet, however, it has not caused any major damage.

– The most severe earthquakes happened in Afghanistan. At the end of March more than 2,000 people were killed in a series of tremors in the Hindu Kush mountains in the north-east of the country.

– On 31 October an earthquake of medium strength caused a school to collapse in Molise in central Italy. This generated heated debates. Many people would have been still alive today if the quality of the building had corresponded to the earthquake hazard in that area, which was after all no unknown factor.

– The strongest earthquake of the past year happened on 3 November in Alaska and caused concern among scientists. Its magnitude there reached the unusual reading of 7.9 on the Richter Scale. As the epicentral area was in a hardly populated region, the losses were not very extensive.

Prospects

The weather extremes and loss events of the past year underline the fact that we must continue to take the effects of climate change very seriously.

2002 was, along with 1998, the warmest year since global temperature readings began – evidence of the unbroken trend of global warming.

It remains to be hoped that the Kyoto Protocol, which was designed to help curb this warming process, will finally come into force in 2003 (cf. our report on page 46).

There are fears that 2003 will confirm forecasts of a new El Niño event. Although temperature and pressure conditions in the equatorial El Niño regions of the Pacific area were not very pronounced at the end of the year, numerous typical circumstances were already indicating that this natural climate fluctuation was beginning: heavy droughts in Australia, floods and severe storms on the Pacific coast of the United States, heavy snowstorms in the Midwest and on the East Coast, etc.

Also, the trends that were observed last year again confirm the fear that Munich Re has expressed on repeated occasions: that the insurance industry must be prepared to face quite new loss dimensions in terms of natural catastrophes because the loss trends will continue to grow worse. Nevertheless, capacity, service, and first-class reinsurance protection will continue to be available, as long as the terms and conditions take all risk factors into account, e.g. the increase in weather-related extreme events, growing urbanisation (cf. the article beginning on page 32), and the increasing concentrations of values.

03 In Australia the year 2002 was marked by periods of drought and huge forest fires. From July until November agriculture alone suffered losses exceeding US$ 2bn. The worst bush fires occurred in the area around Sydney at the end of the year. Thousands of fire-fighters and inhabitants tried to save the houses from the flames.

Pictures of the year

04

04 At the end of March, a 7.1 earthquake shook the capital of Taiwan. This is a photo of the construction site of the Taipei Financial Center, which will become the world's highest skyscraper. A crane on the 56th floor of this steel-frame structure came loose and plunged down to the ground. Five people were killed, the insured loss came to US$ 10m.

05 In China, extreme rainfalls and floods lasting for weeks in the summer destroyed more than 280,000 houses, agricultural land, and infrastructural facilities. 600,000 people had to be evacuated. The poor inhabitants, who are often forced to live on the fringes of large cities, were hit particularly badly. This is a photo of Wuhan on the Yangtse.

06 At the end of August, Rusa, one of the strongest typhoons in the history of Korea, sped across the Yellow Sea with wind speeds of 200 km/h. This violent cyclone destroyed 645 boats and caused massive damage to harbour facilities. Many towns and villages were devastated too. The property damage came to US$ 4.9bn, of which US$ 170m was insured.

05

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07 The first winter storm of the year, Jeanett, caused enormous damage in many countries of Europe. In Germany, Jeanett could become the costliest insured windstorm loss of all times (insured losses up to US$ 1bn.) This is a wind turbine in northern Germany that was buckled by the storm.

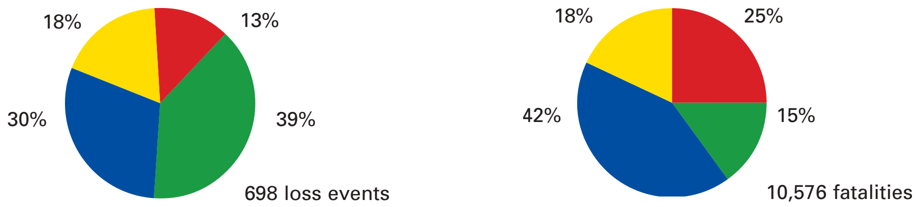
08 In the United States, the Midwest is repeatedly hit by whole series of tornadoes. In two tornado outbreaks in April and November, more than a hundred cyclones tore over the country, leaving a trail of destruction behind them. Thousands of houses, cars, and pylons were destroyed. In the spring alone, insurers had more than 600.000 claims to deal with. This is a picture of a tornado in the area of La Plata in April.

09 In January 250,000 people had to leave their villages in the Democratic Republic of Congo when the Nyiragongo volcano erupted. Streams of lava poured through 14 villages and destroyed the people's belongings. 50 people were killed when a petrol station exploded.

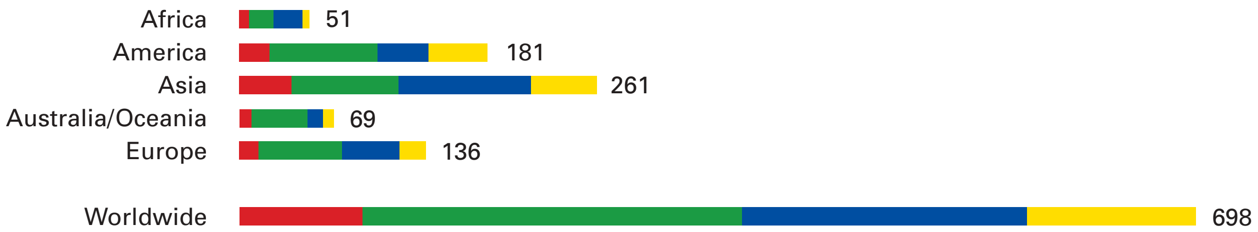
Statistics of natural catastrophes in 2002

Loss events and fatalities

Percentage distribution worldwide

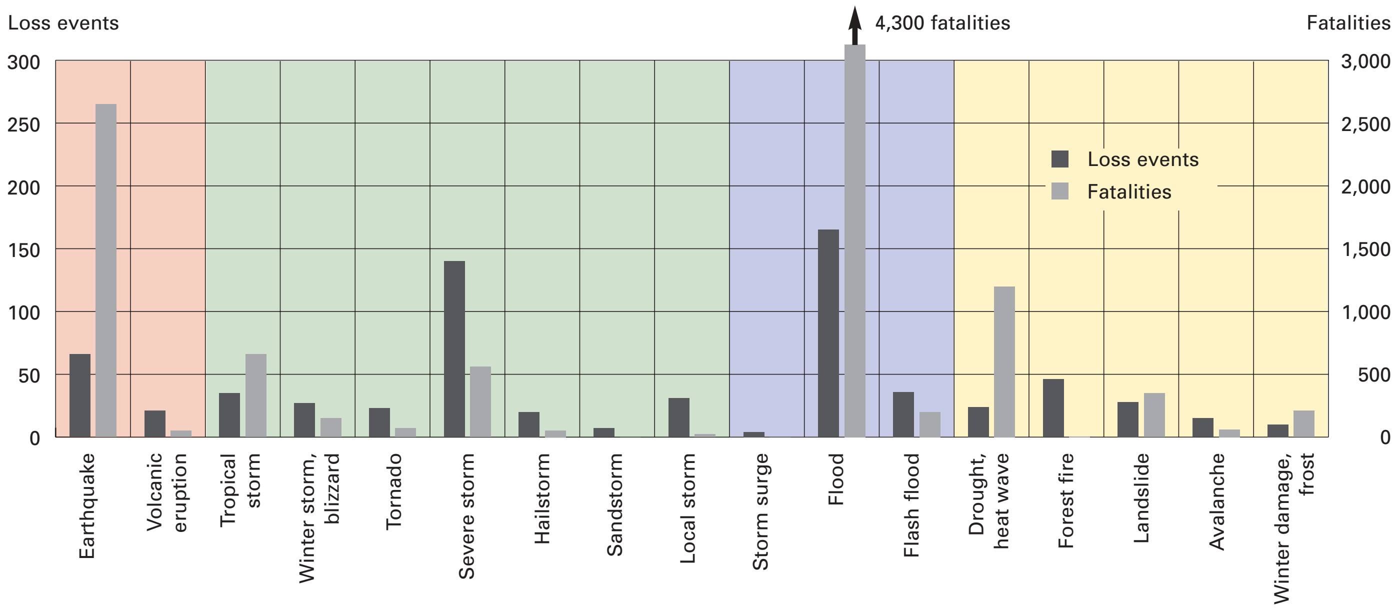


Number of loss events



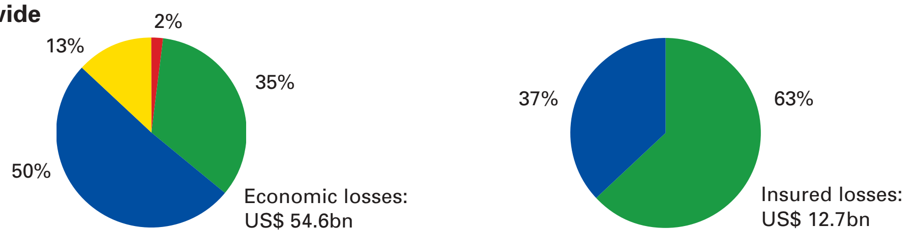
Number of fatalities

Breakdown by type of event

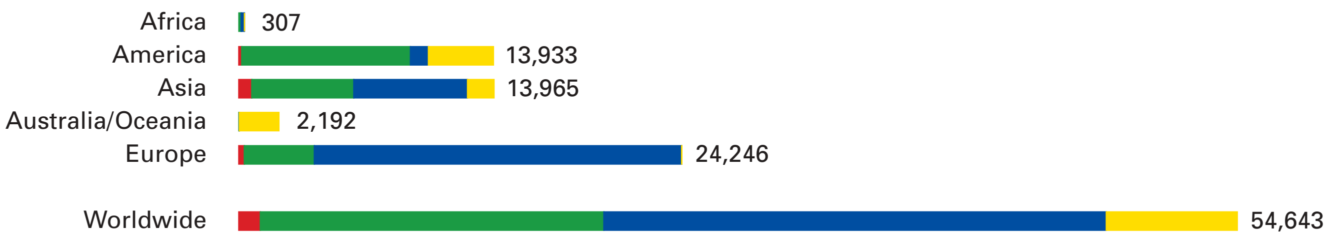


Economic and insured losses

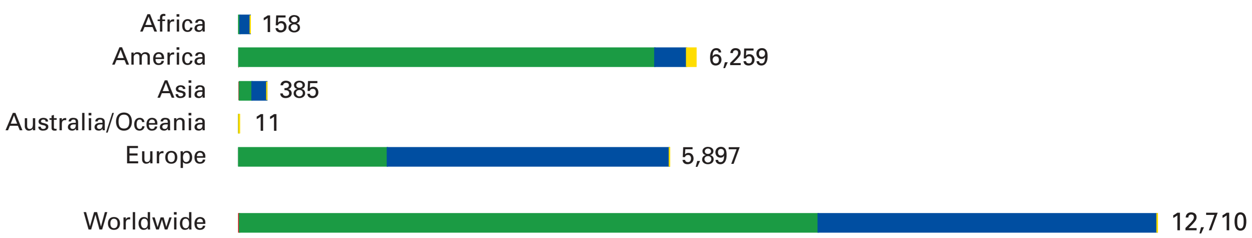
Percentage distribution worldwide



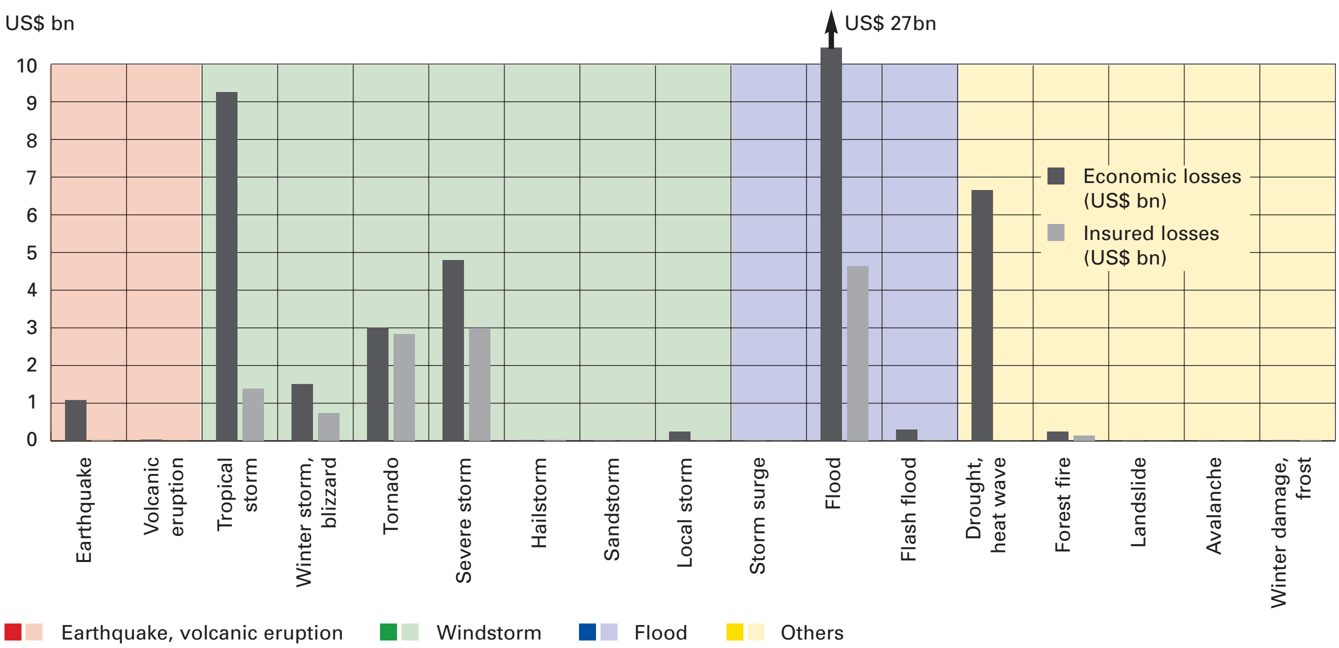
Economic losses (US$ m)



Insured losses (US$ m)



Breakdown by type of event



Major engineering and fire catastrophes in 2002

02

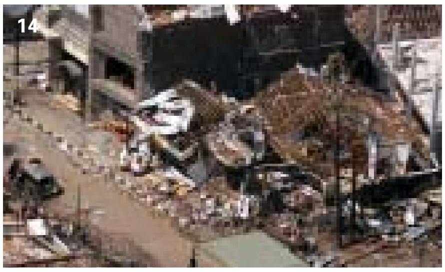
In the year 2002 there were a large number of spectacular engineering and fire catastrophes. A few of the most significant losses are presented on these two pages.

31 January, Kuwait
Explosion at oil production plant

7 May, Tunisia
Plane crash on approach to runway

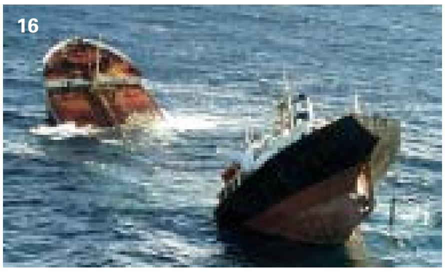
25 May, Taiwan
Plane crash

2 July, Germany
Midair collision over Lake Constance



12 October, Indonesia
Terrorist attack on nightclub

11 November, Indian Ocean
Explosion on container vessel



19 November, Atlantic coast of Spain
Tanker accident

11 December, French Guyana
Unsuccessful launching of Ariane 5

14 December, English Channel
Collision between a car carrier and a freighter

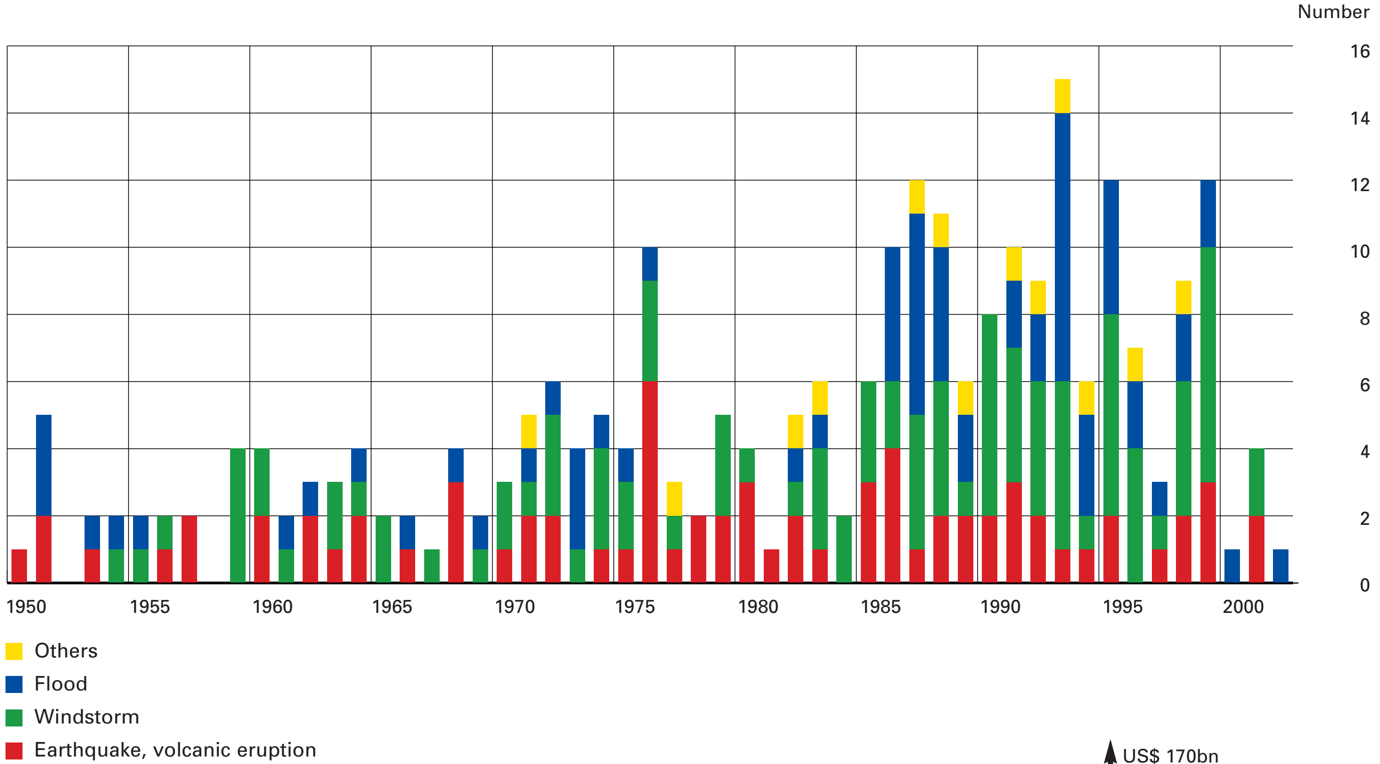
Date	Region	Description of loss
31 January	**Kuwait,** Al-Rudatayn	**Explosion at oil production plant** A leak in a main production line led to a massive explosion at an oilfield near the border to Iraq. Four workers were killed, 19 injured. Oil production on four oil fields had to be stopped temporarily. The insured business interruption losses and property damage came to a total of US$ 165m.
7 May	**Tunisia,** Tunis	**Plane crash on approach to runway** On its approach to Tunis airport, a Boeing 737 with 63 people on board crashed into a hill. 15 people were killed. The aircraft had a hull value of US$ 22m, the liability losses are estimated to total US$ 8.5m.
25 May	**Taiwan,** Penghu Island	**Plane crash** 45 minutes after taking off for Hong Kong, a Boeing 747 broke into four pieces and crashed into the sea off Penghu Island. 225 people were killed. The hull loss came to US$ 20m.
2 July	**Germany,** Überlingen	**Midair collision over Lake Constance** 71 people died when a Russian passenger jet and a cargo plane collided at night. Numerous pieces of debris crashed into a built-up area. The hull losses of the two planes are quoted at just under US$ 40m.
12 October	**Indonesia,** Bali	**Terrorist attack on nightclub** 191 people were killed in the bombing of a nightclub in Kuta Beach. Hundreds were injured. The club, which was mainly used by tourists, and neighbouring buildings were completely devastated in this terrorist attack, the worst in the history of Indonesia.
11 November	**Indian Ocean**	**Explosion on container vessel** On its journey from Singapore to Hamburg, the Hanjin Pennsylvania was rocked by an explosion in the hold. Fire-fighting was hampered by further explosions, so that the fire was able to spread throughout the cargo vessel with its 3,500 containers. The Hanjin Pennsylvania's hull value alone is US$ 42m.
19 November	**Atlantic coast of Spain**	**Tanker accident** The oil tanker Prestige was loaded with 77,000 tonnes of fuel oil when it broke in two some 250 km off the north-west coast of Spain. Oil poured into the sea for a matter of weeks, causing pollution along the Atlantic coastline of Spain, Portugal, and France. Fears are that this will be the worst environmental disaster ever in European waters. Three years before, devastating oil pollution had been caused by the 14,000 tonnes of oil that poured out of the oil tanker Erika off the coast of Brittany.
11 December	**French Guyana**	**Unsuccessful launching of Ariane 5** The Ariane 5 launch vehicle carrying two telecommunications satellites veered off course three minutes after lift-off and had to be destroyed by ground control. The overall loss is estimated to be US$ 600m. The first attempt on 28 November had been aborted because of a sensor problem.
14 December	**English Channel**	**Collision between a car carrier and a freighter** Two large cargo vessels, the Tricolor and the Kariba, collided in thick fog 50 km east of Ramsgate in England. The Tricolor, which sank after the collision, was carrying 77 tractors and almost 3,000 new cars. The insured loss of the cargo amounts to about US$ 100m.

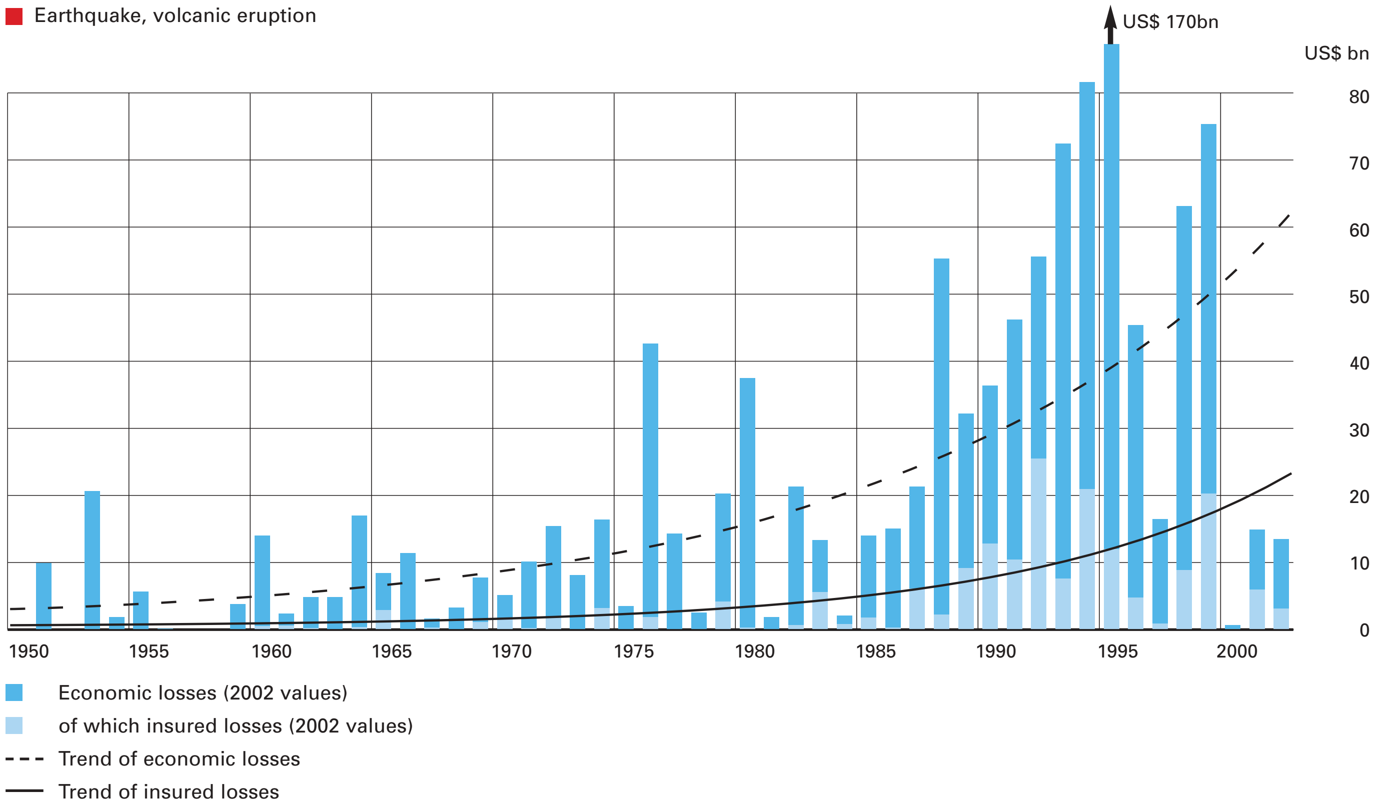
19 The usually small and peaceful Müglitz in Saxony washed nine houses into its raging torrents in Weesenstein. This picture shows a family that had to sit for more than ten hours on the meagre remains of their home and wait for help from the air.

Great natural catastrophes

03

Great natural catastrophes with trends





Long-term statistics 1950–2002

Decade	**1950–1959**	**1960–1969**	**1970–1979**	**1980–1989**	**1990–1999**	**Last 10 years**
Number	20	27	47	63	91	70
Economic losses	42.1	75.5	138.4	213.9	659.9	550.9
Insured losses	**–**	**6.1**	**12.9**	**27.0**	**124.0**	**84.5**

Factor	**80s:60s**	**90s:60s**	**Last 10:60s**
Number	2.3	3.4	2.6
Economic losses	2.8	8.7	7.3
Insured losses	**4.4**	**20.4**	**13.9**

Losses in US$ bn (2002 values)

Definition of great natural catastrophes: Natural catastrophes are classed as great if the ability of the region to help itself is distinctly overtaxed, making interregional or international assistance necessary. This is usually the case when thousands of people are killed, hundreds of thousands are made homeless, or when a country suffers substantial economic losses, depending on the economic circumstances generally prevailing in that country.

The two charts on the left present the losses caused by great natural catastrophes since 1950. A total of 700 loss events due to natural hazards were registered last year and from these we have selected the "great" natural catastrophes on the basis of the above definition. Last year only one event met these criteria: the August floods in Europe (cf. our Catastrophe Portrait and the World Map 2002 insert).

The upper chart shows for each year the number of events defined as great natural catastrophes, divided up by type of event. The lower chart presents the economic losses and insured losses – adjusted to present values. The trend curves verify the increase in catastrophe losses since 1950. The low losses incurred over the past three years do not represent a change in the trend. 2002 was a further year in which there were happily only a few gigantic catastrophes. Tropical cyclones with enormous loss potentials fortunately weakened before they hit heavily populated coasts or megacities.

The tables allow a comparison of the aggregate loss figures of recent decades. Comparing the last ten years with the 1960s makes the increase in natural catastrophes particularly clear. This applies both to the number of events and to the extent of the losses incurred.

20 The summer floods described in the following articles were the largest flood catastrophe in central Europe for many centuries. The water levels of the Danube, Vltava, Elbe, and their tributaries broke all previous records. This photo was taken in Dresden, which was last flooded in 1845.

Catastrophe portrait
The summer floods in Europe – A millennium flood?

04

The massive falls of rain at the beginning of August turned small rivers and brooks into raging torrents. Many houses that had been built too near the water were destroyed. The development of areas near rivers is one of the main reasons for the dramatic increase in flood losses in Europe.

In central Europe, the year 2002 will remain etched in people's memories as the year of catastrophic floods in the catchment of the Elbe. But one thing could be easily forgotten: although the Elbe area was the region most badly affected, there was massive flooding in many other regions of Europe too, with many parts of the Danube catchment suffering their worst floods for years. In June three people in Diedorf (western Bavaria) drowned in flash floods following severe thunderstorms; at the beginning of August well over 100 people were killed by sudden floodwaters raging down to the Russian Black Sea coast; at the end of August rainfall records were broken in the South of France (650mm in 24 hours in Anduze in the southern Rhône valley); and in November many places in northern Italy were submerged after incessant rainfall for several days.

The Elbe flood was one of the worst flood catastrophes in central Europe since the Middle Ages. It is comparable with the great storm surges of the North Sea and the millennium flood in the infamous flood year of 1342, when – likewise in August – flood stages were reached on virtually all major rivers in Europe between the North Sea and the Mediterranean. The events of August 2002 have since been widely discussed in numerous scientific publications and in the media. This article will therefore only briefly sketch out the sequence of events and will concentrate instead on important background factors, interrelationships, and consequences.

The meteorological situation – The two lows Hanne and Ilse

Whenever speaking of the flood catastrophe in August, it is important to bear in mind that this was not just one single event. The floods did not occur in the various regions simultaneously and they were not triggered by one single meteorological event. It was in fact two low-pressure systems, christened Hanne and Ilse by the Berlin Meteorological Institute, that were mainly responsible for the catastrophe. The two systems started near Ireland within about four days of each other and then moved in the direction of eastern central Europe.

Between 4 and 7 August, Hanne remained almost stationary over the southern North Sea and for several days attracted moisture from warm air coming from the Mediterranean area in the south, which, on contact with the colder air masses in the north over Austria, Bohemia, and parts of Bavaria, was released in the form of torrential rain. The daily precipitation depths of up to 150 mm were in some cases higher than the average totals for the month of August. On 8 August the band of torrential rain swung northwest, with extreme rainfall in northern Germany (e.g. 80 mm in 6 hours in Bremerhaven). Hanne also triggered a secondary low over the Adriatic, which moved eastwards across the Balkans and caused floods in Slovakia, Hungary, Bulgaria, Romania, Moldova, Ukraine, and Russia.

The second low, Ilse, moved southwards around the western ridge of the Alps, stocked up with enormous volumes of water vapour over the Gulf of Genoa, then turned to the north on

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Thousands of helpers tried for days in Austria, the Czech Republic, and Germany to keep the flood waters under control. In many places, however, they had to give up the fight in the face of overwhelming masses of water.

the Vb track, and on 11 August triggered the Elbe floods. When it reached Poland on 12 August, a northerly air flow came up behind it, which further intensified the precipitation as a result of orographic lifting on the Erz Mountains. The same day, Zinnwald in Saxony recorded 312 mm of rain, a level that exceeded the previous record for 24-hour rainfall in Germany by 20%. The 158 mm that fell at the Dresden weather station was more than twice the previous highest figure recorded there in a time series of well over 100 years.

Although Vb weather conditions are not always associated with heavy rain, they are infamous triggers of catastrophic floods. The Odra floods in 1997 – and likewise the Whitsun floods that hit Bavaria in 1999 – were the result of such weather conditions, which occur on average about three to four times a year especially in the summer months. The typical feature of Vb weather conditions is that warm and moist air masses from the Mediterranean region are drawn northwards in an easterly direction around the Alps and then make contact with cooler air coming from the west and north. This often results in a stationary low-pressure trough, whose precipitation is usually intensified by moist air building up and rising on the north side of the Alps or the low mountain ranges in central Europe.

Loss overview

Using the term "Elbe Flood" for the floods in August is really misleading because only a fraction of the losses were actually incurred in the Elbe valley itself. The devastation was at its greatest on the Elbe's tributaries, where small brooks often turned into raging torrents in the shortest of time. The floodwaters of the Mulde were up to 4 m high in Grimma; the little town of Weesenstein was destroyed by the Müglitz; and even the water that surged through Dresden's central railway station had nothing to do with the floodwaters of the Elbe itself but came from the Weisseritz. The 100-year discharge of this small river was actually 350 m^3/s, but as it approached Dresden, the peak discharge was 600 m^3/s. The Weisseritz, which flows through parts of the city underground nowadays, was unable to cope with these masses of water. The overflowing water returned to its old course – in which now stands Dresden's main station.

The two low-pressure vortices and their secondary lows affected many countries in western, central, eastern Europe, and parts of southern Europe. The floods were the most expensive natural catastrophe in the history of Germany, but there were catastrophic losses in the Czech Republic and Austria too; substantial losses were also incurred in Italy, Switzerland, Slovakia, Hungary, Romania, and Russia. Other countries with notable losses were Great Britain, the Netherlands, Spain, Poland, Moldova, and Ukraine.

Losses in the three countries most severely affected
Estimates as at 31 December 2002; in €bn

	Economic	Insured
Germany*	9.2	1.8
Czech Republic*	3.0	0.9
Austria*	3.0	0.4

* The overall loss from all flood events in central Europe (all countries affected) in August came to €18.5bn, of which €3.1bn was insured.

As far as the insured losses are concerned the figures have had to be adjusted upwards again and again. It is now assumed that the three insurance markets will have to contend with payments clearly exceeding €3bn.

Impact on the insurance industry

In the case of floods, unlike windstorm, the proportion of losses that are insured is usually relatively low.

- The majority of the losses involve public facilities like roads, railway lines, dykes, riverbeds, and bridges, and other infrastructural installations (e.g. water supply and sanitation).

- The proportion of insured losses in the Czech Republic was approx. 30% and thus much higher than in Germany (approx. 20%) despite the fact that the floods mainly affected regions in the eastern part of Germany where there is still likely to be quite a lot of insurance cover for natural hazards. Prior to German reunification, almost all householders had taken out state insurance against flood and other natural hazards. In the 1990s, the number of people that bought this cover steadily declined as the risk of flooding was largely taken too lightly. In many places, people were not willing to pay the premiums for what was in fact a relatively inexpensive natural hazard cover. In the Czech Republic, on the other hand, there had been an increase in demand for insurance following the great floods on the Odra and Morava in the summer of 1997.

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The flood waters on the Vltava were so strong that a number of inland water transport vessels in the Czech Republic had to be blown up with explosives to prevent them from damaging or even destroying bridges.

– In order to assess the accumulation risks, it is essential to consider the distinction – or overlap – between individual loss events in temporal and spatial terms. In the flood catastrophe in August there was a clear distinction between two events in meteorological terms. It was only in Austria and the Czech Republic that there were temporal overlaps. And once again there was a demonstration of just how problematical the definition of one event can be in the case of floods. In Bohemia, the ground was already so saturated by the heavy rain (already causing substantial flood damage) generated by Hanne that it could not absorb the extreme amounts subsequently brought by Ilse, which therefore ran off directly into the water courses. The flood wave in the Elbe was actually a result of these circumstances too and was generated above all by the water coming from the Vltava, i.e. from the Czech Republic.

– In Germany and its neighbouring countries, international insurers in particular must now consider even more closely than before if and to what extent worst-case scenario floods may occur simultaneously in the catchments of the major central European rivers like the Rhine,

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The clogging of bridges with wood and other floating debris is a constant cause of overflows. This is a picture of a railway bridge in Austria which was unable to withstand the forces of the water.

Danube, and Elbe. The latest floods proved that large loss accumulations are possible in Europe. An event like that of 1342 would be a major challenge for insurers nowadays.

– On account of the considerable accumulation potential involved in providing insurance and reinsurance protection against flood losses, it is crucial that the prices are commensurate with the risk. It is important to consider the following: the frequency or return periods of events, the location and hence the exposure of insured objects, and product segmentation (private/industrial, building/contents). It is essential to include adequate deductibles in the pricing. They encourage policyholders to prevent losses and they reduce the considerable work involved in the administration of minor losses.

– The problem of frequent floods can only be solved by a risk partnership between the state (dyke protection, land use regulations, etc.), the insurance industry (compensation for some of the losses, support for quick repairs, etc.), and the general public (development of risk awareness, private loss prevention through efforts on insured property). Insurers are working on new approaches to solving the question of how to provide the best possible solution for everyone affected, including those with high exposure. In Germany, the basic parameters and individual circumstances are currently being examined in detail.

Is man to blame?

In August, central Europe experienced its worst floods for centuries. Nevertheless, floods of these dimensions occurred in the past and they will occur in the future as well. Their causes are the subject of heated discussion. They are repeatedly attributed to sealing, river regulation, and the disappearance of natural flood retention areas. General and in part one-sided allegations do not bear critical examination. The causes are much more complicated. The following aspects all play a central role:

- A major proportion of the losses are due to a lack of care or awareness in the use of areas exposed to flooding. In this respect, mistakes have regularly been made and will continue to be made by owners and those responsible for communal planning.

- Flood control measures (dykes, flood detention basins) are always designed to cope with what is called a design event, a flood discharge based on a statistical occurrence or exceedance probability of typically once in 100 years. Situations in which the design event is exceeded (meaning, for example, a 200-year event) are encountered many times each year, and this applies to Germany too, but they are frequently no more than local or small-scale events. The Elbe floods were on such a large scale and so extreme, however, that normal dyke protection would not have been adequate.

- River restoration measures make sense and are very welcome; but their effectiveness in extreme cases is often overestimated or misrepresented. As a rule, they are incapable of preventing really catastrophic floods and in many cases will not even bring about any significant reduction. The volumes of water that amass in extreme events are simply too huge.

It is essential to note that the increase in flood damage in recent years and decades has been due by and large to the boom in the development of areas near bodies of water. Flood experts – including in particular those from the insurance industry – have for years been drawing attention to the dangers that ensue when the conversion of flood plains into housing and industrial areas is pursued to excess, and when the construction of dykes make the people that live and work there feel overly safe from major floods. The dangers persist even if in the course of time recurrent improvements have been made in forecasting, early-warning, and flood control facilities. There is a residual risk – which in fact is increasing in absolute terms.

Is climate change to blame?

Although it is very difficult to supply statistical proof of a significant upward trend as far as extreme weather conditions in Germany are concerned, there is no denying the fact that if the temperature rises, the atmosphere can absorb more water vapour, and this always results in larger amounts of rain. At the same time, the scientific community is now broadly in agreement that the observed global increase in temperature of some 0.7°C in the last one hundred years is largely attributable to human activity. Nevertheless, we are still at the beginning of a truly menacing development involving a global temperature increase this century of probably as much as 6°C. For this reason, the resulting costs – particularly those generated by weather catastrophes – will rise dramatically and put an enormous strain on national economies and insurance industries. The severe storms and rainfall in the summer of 2002 may be taken as a further indication that in a warmer climate it is necessary to reckon with an increase in extreme events. Munich Re will continue to meet these increasing challenges. First-class reinsurance protection and service will only be available, however, at prices and conditions that take account of the global increase in weather-related extreme events and the concentration of values. It will also be very important to introduce substantial deductibles.

The planning of future flood control facilities will have to take into account the fact that the situation has been exacerbated by climate change. Different temperature and precipitation conditions probably lead to the return periods of floods becoming dramatically shorter. Events that in the past occurred on average once in a hundred years could become ten-year events in the future. The use of optimised regional climate models and improved hydrological analyses may be expected to provide for greater certainty, which is essential for all designs of flood control structures.

Can the effects of floods be reduced?

There is no denying that measures like surface sealing and river training and anthropogenic climate change can intensify floods. The influences that have been identified as being negative must be quickly reduced. But – with or without significant human intervention – extreme flood situations will continue to occur. This makes it all the more important to make optimum use of the opportunities already presented by disaster reduction, particularly in terms of land use management.

This means giving flood safety a higher priority than other aspects. Local interests must take second place to an integrated catchment-based management of water and other resources which embraces all interests in the assessment. Advantages that any one community or resident located beside a river may derive from particular measures should not burden society as a whole, be it in the form of state aid or private (compulsory) insurance. As it will not be possible to avoid building in risk zones completely even in the future and as, above all, settlements cannot be moved lock, stock, and barrel, technological flood control measures will continue to play an important role.

Another aspect that will be of central significance, however, is optimum preparation for catastrophe situations. This involves in particular establishing early-warning systems and setting up an emergency plan that works. Much loss and suffering could have been avoided if the instruments of disaster reduction had been implemented. For many years these have been called for by numerous initiatives that promote disaster management like the International Strategy for Disaster Reduction (ISDR) and the German Committee for Disaster Reduction (DKKV). The insurance industry should continue to give these endeavours its pinpointed support and make them its own.

Zoning system for flood, backwater, and heavy rain (ZÜRS)

The new zoning system for flood, backwater, and heavy rain launched in 2001 by the German insurance industry divides the whole of Germany into zones corresponding to three levels of exposure to river flooding. The August floods put it to the test.

ZÜRS is based on a statistical analysis of peak discharges taken for long-term measurements throughout Germany (at 322 gauges). With the results of this analysis, the extreme values of the discharges for specified return periods, were calculated for every river section (regionalisation). Flood-prone areas were then computed from the discharges using a hydraulic model. Finally, the water authorities of the various German states checked these results for plausibility, incorporating among other things the effectiveness of protection systems (dykes, flood detention basins, etc.).

ZÜRS distinguishes between the following three exposure zones:
- Zone I (“low exposure”): areas which are flooded on average less than once in 50 years
- Zone II (“moderate exposure”): areas which are flooded on average between once in 10 and once in 50 years
- Zone III (“high exposure”): areas which are flooded on average at least once in 10 years (objects in this zone only insurable after special examination)

Definitions

The occurrence/exceedance probability denotes the probability that a certain (e.g. discharge) value will be reached/exceeded in any one year.

The return period denotes the **mean** interval between two events of the same intensity and is the inverse of the occurrence probability.

ZÜRS came in for some criticism after the Elbe floods, even in insurance circles: "ZÜRS has failed and must be revised, because many of the flooded areas were in Zone I and were thus not classified as exposed." This conclusion indicates that the concept behind ZÜRS had been partly misinterpreted. As many rivers were subject to floods with a return period far in excess of 100 years, many risks in Zone I were also affected. An initial estimate suggested that in Dresden, for example, about half of the flooded – and developed – area was in Zone I. One single event – even one as large as the flooding in August – may influence the frequency analysis at some of the affected gauges, but it will have next to no impact on the overall picture. This means that ZÜRS does not require a general overhaul.

It should be noted that ZÜRS does not make any distinction as far as flash floods are concerned but regards the exposure in all zones to be the same (which is certainly justifiable from a scientific point of view). Inundation caused by flash floods, i.e. by the overflow of small brooks, which are not contained in the approx. 55,000 kilometres of river considered by ZÜRS, accounted for a major share of the losses in southern Bavaria and the Erz Mountains. This again underlines the fact that this type of flood should on no account be underestimated.

Of course, the latest flood losses are brought into play in order to identify any local deficiencies that ZÜRS may exhibit at one place or another. Even if this system cannot be accurate down to the smallest detail, it must be said that in creating this system the German insurance industry has produced an evaluation tool, the like of which is not available on such a scale in any other country. The hope is that it will come to be used even more intensively for underwriting purposes.

At the time of writing ZÜRS can only be employed for primary insurance purposes. Reinsurers, on the other hand, need additional knowledge on accumulation risks. For some years now, Munich Re has been using a model based on the same hydrological and hydraulic principles as ZÜRS. It can be employed to estimate accumulation loss potentials for floods in Germany. Together with other reinsurers we have commissioned further work on ZÜRS, involving enhancements that are crucial to accumulation assessment. By establishing an additional Zone 0 for a return period of 200 years, it should be possible to produce improved analyses of extreme events in terms of accumulation.

In October 2003 Bonn will host the Second International Conference on Early Warning (EWC II). This event was initiated by the national and international networks of disaster reduction and the various fields of science involved, and it is expected to generate new impulses as far as early-warning and the organisational preparations for natural catastrophes in Germany and Europe are concerned.

NatCat*SERVICE* information Economic consequences of the August floods in Germany – A review

05

Numerous historical buildings and museums were underwater in Dresden. The world-famous Semper Opera House and the Zwinger (photo) could not be defended despite colossal efforts on the part of hundreds of helpers. The art treasures in museums are often not insured, as many local authorities cannot afford the insurance premiums.

Introduction

The insured losses generated by the August floods are ample (cf. Catastrophe Portrait of the Year, page 16); the economic losses are even more substantial, but it is very difficult to measure them exactly. The extent of losses that are insured can be quantified with increasing accuracy because they are reported to insurance companies by policyholders when a natural catastrophe occurs. Measuring the economic losses, on the other hand, soon reaches its limits in the face of the great human suffering involved – dead and injured people cannot be counted as a loss in euros or any other currency.

Of course, every natural catastrophe has an impact on the economy as a whole – and economists are called on to quantify this effect. In an earlier issue of topics we described in detail the basic difficulties of measuring the economic losses caused by a natural catastrophe (cf. topics 2000, page 16 ff.).

Estimates from various sources

Shortly after the flood catastrophe in particular the media and political circles were quoting the most varied of figures for the total economic loss. For Germany these ranged from about €5bn to way over €20bn. The Hamburg economic research institute HWWA, for example, initially reckoned with €15bn, and at the end of September the federal government even quoted a sum of at least €22.6bn.

All in all, the estimates of the flood losses followed a pattern often encountered in connection with catastrophes. As long as the extent of the damage is not sufficiently evident or as long as the catastrophe has not come to an end, loss estimates tend to be on the reserved side. This initial stage is followed by a wave of corrections, which often lead to much higher estimates, for one thing because they are politically instrumentalised. After the floodwaters have receded and public interest has waned, the loss forecasts are revised downwards again.

At the beginning of November 2002 the German government issued provisional figures – based on information from the federal states – which put the overall loss from the flood catastrophe in Germany as a whole at around €9.2bn – i.e. much lower than at the end of September. This latest picture includes infrastructural damage to federal property (railway facilities, highways, dams and embankments, etc.) of around €1.6bn. The distribution of losses among the various regions is very uneven, as Fig. 1 shows: Saxony has to carry by far the largest share of the flood losses at around €6bn.

Private households, trade and industry, and the state were impacted in varying degrees by flood losses; Fig. 2 shows the distribution by type of loss. Losses affecting the public infrastructure came to around €3.4bn, but trade and industry and private households also had an immense burden to carry from the flood catastrophe. The "other losses" include the damage to cultural facilities like the Semper Opera House in Dresden, where the loss came to almost €27m.

Systematic recording of economic losses

The term "economic loss" is often used as a catch-all for the entire range of losses generated by a natural catastrophe, but when economic losses are measured, the type of loss under observation must always be defined exactly; double counting in particular is to be avoided (cf. topics 2000, page 16 ff.) .

A distinction must be made between the following effects of natural catastrophes:

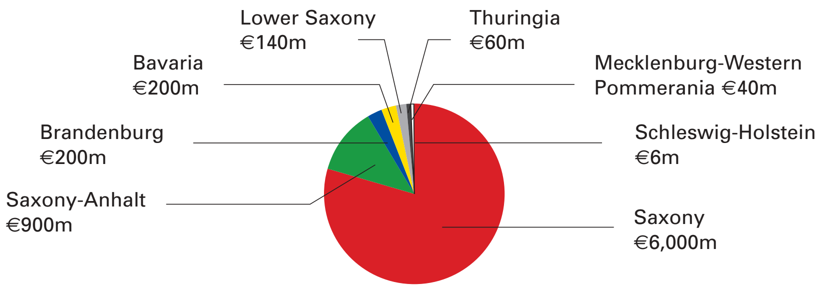
– Effects on the production potential (stock effect)
– Effects on the gross domestic product (GDP: the value of all goods and services produced in a country or region in a certain period) of the affected country (flow effect).

The loss estimates described above are mainly based on the effects on the production potential.

Effects on the production potential

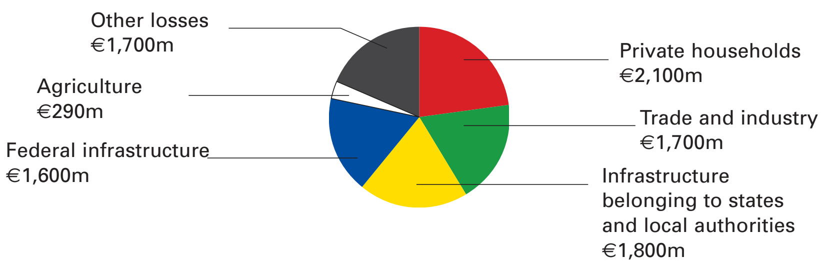
The evidently most immediate effect of a natural catastrophe is that all

Losses in the affected federal states (total: approx. €7,600m)*



*not including damage to state facilities
Source: Federal government (as at 6.11.02)

Breakdown of losses by type



Source: Federal government (as at 6.11.02) kinds of property stocks are damaged and destroyed, particularly the production potential.

– **(Public) infrastructure**
Roads and other thoroughfares, electricity and energy supply systems, telecommunication facilities, and so on make a direct contribution to value creation as factors of production. Accordingly, damage to the infrastructure reduces the production potential of the economy, from which that economy's value creation is ultimately derived. In the case of the floods in August, it is the damage to transport infrastructure that is most relevant. The floods damaged or destroyed at least 180 bridges, 740 km of roads, 94 railway bridges, and 400 km of track, as well as hydraulic structures and canals. As mentioned above, these losses amount to about €3.4bn all told. Added to these come the losses involving damage to the telephone network, estimated at an additional €100m.

– **Buildings and industrial facilities**
Damage and destruction to buildings and industrial facilities directly impair the production potential. The loss generated by the floods may be determined by way of the reinvestments that are needed to re-establish the state that existed before the floods. The official estimates published by the government and the federal states quote a figure of €1.7bn for trade and industry. This amount is likely to stem mainly from the damage to buildings and production facilities.

Effects on gross domestic product

There are three significant effects in this respect:

– As the floods impair the production potential and firms cannot maintain production on account of the destruction of buildings and machines, the gross domestic product declines in the region affected as a direct result (short-term effect).
– At the same time, there are also effects on other regions that are only indirectly affected (indirect effects); they are not necessarily negative effects – the gross domestic product may even increase there, e.g. because firms can take over orders. This means that there are regional distribution effects.
– Added to this comes a temporary negative effect, which in the case of the floods in August was not insubstantial: many people were unable to reach their place of work because road and rail links were closed or because they were occupied with rescue operations and loss minimisation efforts. In addition, the power supply was temporarily interrupted.

All three effects have an impact on GDP in the current year.

Effects on GDP in 2002

The floods did not have much effect on GDP in Germany as a whole, but in the affected federal states – especially Saxony and Saxony-Anhalt – the effects were quite perceptible. The Institute for Economic Research in Halle estimated that GDP in Germany fell by about €1bn on account of the flood losses or by 0.05% of GDP in 2001.

Example of a short-term estimate of lost production using the number of persons affected:

– According to the federal government, a total of 337,676 people were affected in Germany by the floods, mainly in eastern Germany. In the new federal states (not including Berlin) the per-capita GDP in 2001 was €16,514.

– Assuming that the loss event lasted for one month and that the value creation of the people affected was nil during this period, the corresponding calculation (337,676 x 16,514 x 1/12) results in a negative effect on GDP in Germany of €465m. This corresponds to 0.023% of Germany's total GDP in 2001. While the effect for Germany as a whole is relatively small, the flood catastrophe makes itself much more distinctly discernible in this model at state level in Saxony-Anhalt and Saxony, amounting to over 0.3% of GDP in both cases.

Before the corresponding official statistics become available, we at Munich Re endeavour to estimate the economic loss with the help of model calculations. The very simplified (representative) model presented in the box above only considers the short-term impact on GDP in the affected regions; in other words, it does not consider indirect effects in other regions, which, as mentioned, may well turn out to be positive.

Other more complex models we have performed lead to even higher results, but we assume that Germany's GDP

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State buildings and infrastructure are often not insured. In principle cover is available for railway tracks (CECR: civil engineering completed risks), but many countries do not take advantage of it. In the great summer floods many railway lines in the Czech Republic, Austria, and Germany were badly damaged.

in 2002 actually declined on account of the floods by less than €1bn, i.e. by much less than 0.1%. The loss is more significant, however, in Saxony (less than 1% of GDP) and in Saxony-Anhalt (less than 0.5% of GDP).

As the provisional figures for GDP at state level in 2002 published in the official statistics at the beginning of February 2003 cannot be used as a basis for a quarterly analysis, it is impossible to draw any definite conclusions as to what effects the floods had on GDP in the states affected. Given real GDP growth in 2002 of +0.1% in Saxony and +0.5% in Saxony-Anhalt – compared with +0.2% in Germany as a whole – it appears that other, in part opposing factors play a role.

Effects on GDP in 2003/2004

For the years 2002 to 2004 it is to be expected that as a result of the flood catastrophe investments in repairs and restoration work will far exceed €10bn. These investments are being financed by public funds (totalling €9.2bn, see table on page 30), private insurance claims payments, and additional private funds.

This expenditure is likely to produce a **noticeable increase in growth** at least in eastern Germany. In the medium term, incoming orders and production are likely to increase especially in

Aid for financing the losses caused by the flood catastrophe of August 2002 (€bn)

	Total	Federal government	States and local authorities	European Union
"Aufbauhilfe" – A special federal rebuilding fund				
Income				
Postponement of second stage of tax reform by one year to 2004	5.77	2.62	3.15	
Temporary increase (2003) of corporate income tax by 1.5 percentage points to 26.5%[1]	0.79	0.42	0.37	
Additional financing for the year 2003	0.54	0.47	0.07	
Total	**7.10**	**3.51**	**3.59**	
Expenditure				
Financial aid for affected private households and companies	1.99	1.02	0.97	
Reinstatement of infrastructure owned by the federal states and local authorities	1.95	1.05	0.90	
Reinstatement of infrastructure owned by the federal government	0.97	0.97	–	
Reserve	0.47	0.47	–	
Aid programmes of the federal states	1.72	–	1.72	
Total	**7.10**	**3.51**	**3.59**	
Other financing measures				
Restructuring of federal transportation budget[2]	1.00	1.00	–	–
Immediate measures	0.50	0.50	–	–
Resources from EU structural funds	0.60	–	–	0.60
Total financial aid	**9.20**	**5.01**	**3.59**	**0.60**

[1] Including solidarity surcharge for the valuation year 2003
[2] In favour of the transportation infrastructure of the affected states
Source: German Council of Economic Experts, Federal Ministry of Finance

construction, although some of the public funds would doubtlessly have been spent on investments even if the flood catastrophe had not occurred.

One negative aspect is the **financing** of public projects, however, particularly as the next stage in the tax reform has been postponed. In their autumn report, however, the leading German economic research institutes assume that on balance there will still be a positive effect on demand of around €8.5bn. This corresponds to about 0.4% of GDP in Germany in 2002. The additional demand will be spread over the years 2002 to 2004 but is likely to be at its strongest in 2003.

All in all, there will certainly be perceptible regional **distribution effects** between the federal states. As state development aid is geared to the geographical distribution of flood losses, around 75% of the public funds – about €7bn – is likely to be allocated to Saxony and Saxony-Anhalt. This is roughly 6% of GDP in these two states in 2002. Therefore, the positive effect ought to be strongest in these federal states, even if the demand is not met entirely by local companies.

Prospects and conclusions: A boost to modernisation is possible in the long term

More than that, it is impossible to say at present what the long-term macroeconomic effects of the floods will be.

The experience of other countries that have been hit by natural catastrophes suggests that the long-term development of economic growth after a natural catastrophe is often much less favourable than it would have been if the catastrophe had not occurred; but

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The loss potential at trading estates is very high as a rule, because department stores, DIY shops, and warehouses stand shoulder to shoulder. This photo was taken at a trading estate on the Elbe that was flooded in the summer.

there is always a question mark against such comparisons as to the methodology adopted (cf. topics 2000, page 16 ff.). One thing is certain, however: the negative effects are much less pronounced especially when the region is part of a larger state structure and there is a rapid flow of public and private aid and, given the requisite private insurance density, claims payments. To some extent the modernisation of production facilities and infrastructure that is triggered by investments and rebuilding efforts produces a positive impulse for growth in the long term (modernisation surge).

As far as we can see, there is much to suggest that such an effect will be witnessed in the federal states that were hit by the hundred-year flood. In that case this catastrophe, which caused immeasurable human suffering and high insured losses, will not have any negative macroeconomic consequences for the affected areas at least in the long term. Finally, this catastrophe event shows again the positive effect that a strong and functioning private insurance industry has on the economy as a whole.

28 Around the globe, huge loss potentials develop in the narrowest of space in megacities, because millions of people and values are concentrated there. These agglomerations are often built in exposed areas or they expand into such areas. This is a photo of a shopping mall in Shanghai.

A natural hazard index for megacities

06

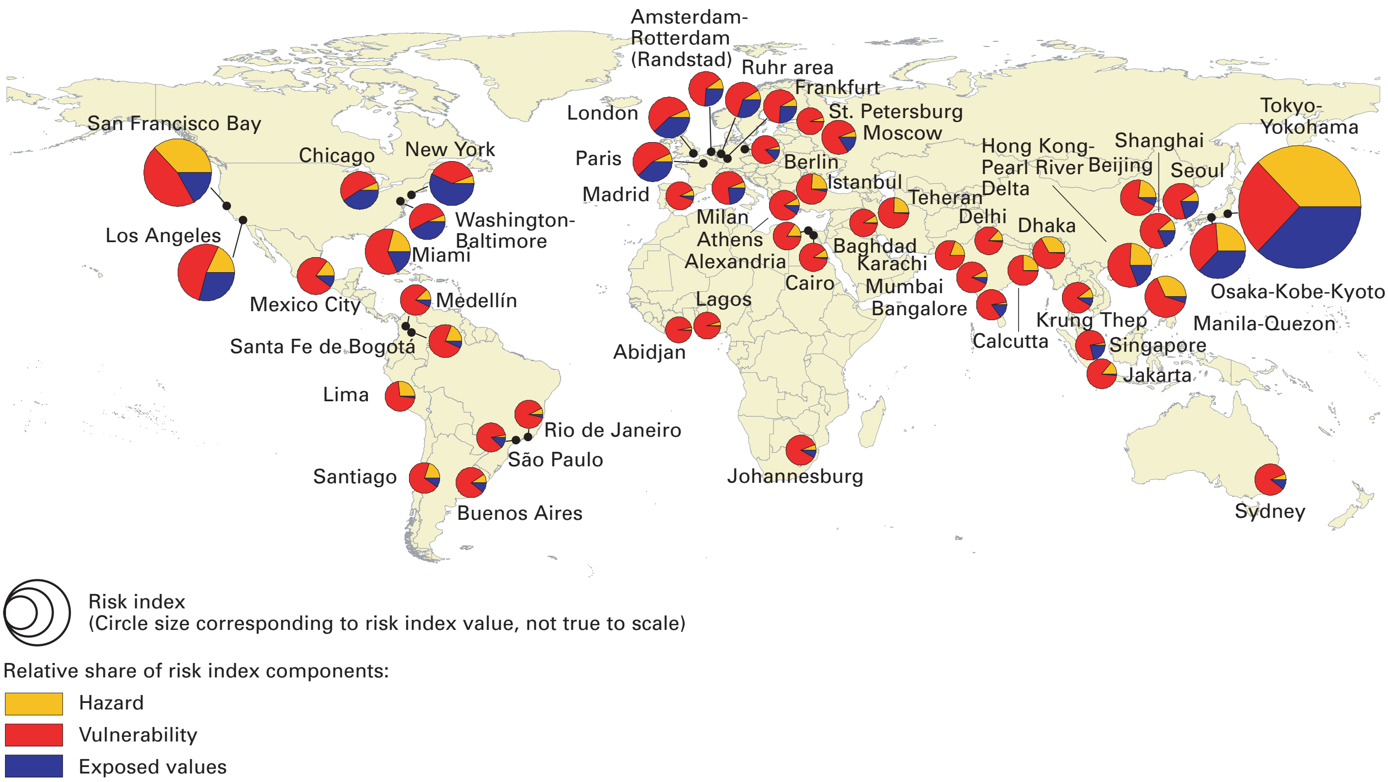
1 The purpose behind a hazard index for megacities

The statistics show that, even when adjusted for inflation, the losses caused by natural catastrophes have been increasing dramatically and at an ever-quickening pace in the period since 1950 (cf. page 14). One of the main reasons for this is the concentration of people and property values in urban centres, a concentration that is most pronounced in the megacities. This increase in losses is attended and accelerated by growing economic integration on a global scale. The outcome of this globalisation is that the effects of a catastrophe event may reverberate around the world. This was illustrated vividly by the attack on the WTC – with a dimension of loss comparable with that of major natural catastrophe scenarios.

The 20 strongest megacities in economic terms account for 27% (and rising) of global gross national product. The global loss potential from natural catastrophes is dominated more and more by the megacities. A real example: Los Angeles and Osaka may only have been brushed by the earthquakes in 1994 and 1995 respectively, but these two events were largely responsible for the magnitude of losses in these two years, with the highest loss totals in recent decades. The insurance industry is exposed to this development to an even greater degree than the economy as a whole because the insurance density in urban areas is usually much higher than in areas of a rural nature. Given this backdrop, a collation and comparison of the risk in conurbations incorporating all natural hazards across the board is certainly of great interest. Such an examination also makes it

Megacity*	Population* (millions)	Total risk index	Risk index components		
			Hazard	Vulnerability	Exposed values
Tokyo-Yokohama	34.9	710	10.0	7.1	10.0
San Francisco Bay	7.3	167	6.7	8.3	3.0
Los Angeles	16.8	100	2.7	8.2	4.5
Osaka-Kobe-Kyoto	18.0	92	3.6	5.0	5.0
Miami	4.1	45	2.7	7.7	2.2
New York	21.6	42	0.9	5.5	8.3
Hong Kong-Pearl River Delta	14.0	41	2.8	6.6	2.2
Manila-Quezon	14.2	31	4.8	9.5	0.7
London	12.1	30	0.9	7.1	4.8
Paris	11.0	25	0.8	6.6	4.6
Chicago	9.4	20	0.8	5.6	4.4
Mexico City	25.8	19	1.8	8.9	1.2
Washington-Baltimore	7.9	16	0.6	5.4	4.4
Beijing	13.2	15	2.7	8.1	0.7
Seoul	21.2	15	0.9	7.2	2.2
Ruhr area	9.6	14	0.9	5.8	2.8
Shanghai	14.2	13	1.1	7.0	1.7
Amsterdam-Rotterdam (Randstad)	8.0	12	0.9	5.6	2.3
Moscow	13.2	11	0.7	8.7	1.8
Frankfurt am Main	5.0	9.5	0.7	5.9	2.3
Milan	4.0	8.9	0.6	6.7	2.2
Santa Fe de Bogotá	7.7	8.8	1.9	7.3	0.6
Dhaka	11.3	7.3	4.8	9.6	0.2
Sydney	5.0	6.0	0.6	9.1	1.1
Mumbai	18.2	5.1	0.8	8.6	0.7
Krung Thep (Bangkok)	10.3	5.0	0.9	7.4	0.8
Santiago	5.5	4.9	1.5	5.2	0.7
Medellín	4.0	4.8	1.1	7.2	0.6
Istanbul	16.0	4.8	2.4	7.2	0.3
Teheran	14.0	4.7	3.0	9.4	0.2
Bangalore	8.0	4.5	0.3	8.4	1.6
Calcutta	15.9	4.2	3.2	9.5	0.1
Buenos Aires	13.7	4.2	0.7	6.3	0.9
Johannesburg	7.5	3.9	0.6	8.2	0.7
Lima	9.0	3.7	2.8	7.3	0.2
Athens	4.0	3.7	0.7	6.9	0.8
Jakarta	17.1	3.6	1.7	9.9	0.2
Singapore	4.0	3.5	0.3	7.1	1.9
Karachi	12.3	3.1	2.3	10.0	0.1
São Paulo	20.3	2.5	0.3	8.0	1.1
Rio de Janeiro	12.3	1.8	0.6	8.2	0.4
Berlin	4.2	1.8	0.3	5.9	0.9
Cairo	16.5	1.8	0.9	8.7	0.2
Madrid	5.2	1.5	0.5	6.7	0.4
Delhi	17.2	1.5	1.2	7.8	0.2
Alexandria	5.0	1.4	1.4	7.5	0.1
Baghdad	8.0	1.3	0.9	9.2	0.1
St. Petersburg	6.0	0.7	0.5	8.7	0.1
Lagos	13.5	0.7	0.5	9.4	0.1
Abidjan	3.9	0.3	0.3	8.7	0.1

*Relates to the entire agglomeration in each case (i.e. includes adjacent towns and cities)



possible to analyse the influence of the various risk factors on the overall risk.

But how can the risk of different megacities be compared? In the following we present, as a first step, a natural hazard index for the 50 most important megacities. This index differs from previous work on this subject in two ways. Firstly, it adopts an absolute approach, i.e. the aim is to establish not only a relative classification but also a relation to at least the order of magnitude of the absolute loss potential. Secondly, it is the first index that considers all the relevant natural hazards at once. As soon as data of the required quality are available, it can be converted into an absolute index, which directly reflects a megacity's loss potential. The study presented here must still be considered an approximate solution.

2 Objectives and structure of the index

The version of the index presented here is geared to the risk of material losses, without including the insurance density or the insurance terms and conditions, which vary by region and hazard. However, its modular structure means that the index can be adapted without any difficulty either for underwriting purposes or for more general contexts by selecting other appropriate indicators. As the index is intended to be a measure of loss potential, it embraces the three components of the risk formula: hazard, vulnerability, and exposed values. The hazards considered in the calculation were earthquake, windstorm, and flood as the main hazards, and volcanic eruption, bush fires, and winter damage (frost) as the most important secondary hazards.

The three main components mentioned above comprise in turn several sub-components, which will be described in some detail in the following sections. Many of the selected components or indirect indicators were initially allocated to classes numbering as a rule four or five. Bearing in mind the desired absolute measure of risk, these classes are then to be fed, whenever possible, with absolute values that reflect the influence on the risk. These generally involve exponential or potential functions. (Windstorm hazard classes, for example, are defined on the basis of peak wind speeds, the corresponding loss increasing by wind speed to the

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The gigantic traffic problems in megacities present planners with a particular challenge which can often only be solved with remarkable structures. Bridges and flyovers are also extremely susceptible to damage, as the earthquake catastrophes in Kobe (1995) and Los Angeles (1994) have shown.

power of four). The use of absolute quantities is also the precondition for objectifying the weighting of the individual components when combining them to form indices and sub-indices. In a final step the subcomponents are standardised and combined with one another.

3 Representation of the index components

3.1 Hazard

As far as the exposure to hazard is concerned, the various natural hazards are best weighted objectively by allocating average annual losses (AAL). These can then be added together without difficulty. In addition to the AAL, a catastrophe loss with a low occurrence probability should also be considered as a second component. This is geared to the uniform basis of a 1,000-year loss (probable maximum loss = PML). The values are allocated to the various hazard classes on the assumption of equal vulnerability. Vulnerability comes into play as a separate component (see below).

3.1.1 Earthquake

The quantity used as a starting point is the earthquake zone in Munich Re's World Map of Natural Hazards. The earthquake zone stands for the intensity of ground motion that is to be expected on average once in 475 years without considering secondary effects. The zone value was therefore modified for the following secondary effects:

– Change in the vibration intensity (in accordance with the subsoil conditions)
– Liquefaction (softening of the subsoil)
– Tsunami (sea wave triggered by an earthquake)
– Fire following earthquake

However spectacular their manifestation may sometimes be, these effects generally only occur in small parts of urban areas, so that the largest weight of the index is in the original shaking intensity. In a further step, AALs and PMLs were calculated on the basis of the modified zone values using worldwide loss statistics.

3.1.2 Windstorm

Unlike earthquake, there are various kinds of windstorm that need to be observed:

– Tropical storms
– Extratropical storms
– Local storms (e.g. tornadoes, hailstorms)

For tropical storms we again used the original classes in the World Map of Natural Hazards. The criterion for classification is the storm strength on the 5-stage Saffir-Simpson Scale that is to be expected once in 100 years, this being ultimately the wind speed. Extratropical storms were classified in the same way, but the number of classes is reduced from five to three because of the wind speeds being lower than in the case of tropical storms. In order to obtain a better degree of grading, intermediate values were allocated in some cases rather than whole-number values. In the case of local storms, other factors (such as hailfall, driving rain) also play a role besides wind speed, so that the hazard is much more difficult to classify in quantitative terms. For this reason a purely qualitative basis was used in the attempt to derive classes that plausibly reflect the hazard. Storm surge (the accompanying effect for tropical and extratropical storms) is considered in connection with flood. As in the case of earthquake, AALs and PMLs were then allocated to the zones. The AALs for the various windstorm phenomena were added together, whereas in the case of the PMLs the highest was selected in each case.

3.1.3 Flood

As in the case of windstorm, there are different forms of manifestation to be considered:

– River flooding
– Flash flood/torrential rain
– Storm surge

As flood is not shown on the World Map of Natural Hazards because of the small size of the exposed areas, the classifications were developed specially for this index. The initial classification is qualitative and could be refined considerably by recording the corresponding detailed data. In the allocation of AALs and PMLs it was important to consider that the affected urban areas are comparatively small as a rule. The same procedure was adopted for the flood index as for windstorm.

3.1.4 Other hazards

Volcanic eruption, bush fire, and frost were considered relevant for this index. On the bottom line, however, these hazards only make a small contribution to the total hazard. The allocation of AALs and PMLs and the production of the overall index were performed in the same way as with the other hazards.

3.1.5 Total exposure to hazard

The total hazard is derived in the following steps:

- Adding the AAL values for the individual hazards
- Selecting the highest PML value for all hazards
- Weighting the AAL total at 80% and the highest PML at 20%, then adding the two values

The weighting of AALs and PMLs is subjective but may be adjusted for each respective use.

3.2 Vulnerability

3.2.1 Selection of the components

In order to determine the index for vulnerability, three main components were examined; two of them are related to hazard, the third is of a general nature:

Hazard-related components:
- Vulnerability specific to the building class, i.e. the vulnerability of the predominant form of residential construction to the various hazards. For commercial and industrial risks a similar type of construction (but not quality, see below) was assumed throughout the world.
- Standard of preparedness/safeguards, likewise broken down by hazard. This includes, for example, building regulations and town and country planning in respect of specific hazards, flood protection.

The general components consider, on the one hand, the general quality of construction and, on the other, building density. The greater the density, the greater the risk.

3.2.2 Calculation of the vulnerability index

Vulnerability, preparedness, and quality of construction are broken down into four classes, “very good”, “good”, “average”, and “below average”. Population density was used as the indicator for building density; to derive the index, a range of percentage losses to be expected was allocated to the classes. This is an expression of the degree to which the loss varies for the respective criterion when all other criteria remain unchanged. The building density is considered in the form of original values, standardised to a range of 0 to 4.

In order to calculate the total vulnerability index, the three main components were each given the same weighting. In the components themselves, the four hazard-related subcomponents were also given the same weighting. Of the two general subcomponents the quality of construction has a weighting of 3 and the building density a weighting of 1. The total index is then derived by simply adding the weighted individual components. On account of the sometimes poor quality of the available data, the weightings here are less objective than in the case of the hazard, but they still appear plausible on the whole.

3.3 Exposed values

As the derivation of genuine value inventories was beyond the scope of this pilot study, various indicators were defined for the “total value” of an urban area in the form of a relative grading. These are:

- Material values:
  - Average value of household (for residential buildings)
  - Gross domestic product (for commercial/industrial buildings)
- Value in the overall context
  - Global economic significance

The average values of households were derived on the basis of an average relation between values of households and gross domestic product for the federal states in the USA and Germany. The relations between the values seem to fit both in the large regions themselves and in a comparison of the regions. The gross domestic product was largely derived from city statistics; otherwise it was calculated on the basis of the share in the population.

The global significance – graded in four classes from very high to low – reflects the role of the individual urban area in the global economic network. The original class value was not included in the index, but the class value to the power of 2.5. This means, for instance, that Tokyo has a 32-fold weighting compared with Abidjan. In the calculation of the total value index all three subcomponents are added together with the same weighting.

4 Calculating the total risk index

In order to produce a total index from the three main components of hazard, vulnerability, and exposed values, these must be standardised. For this purpose, the maximum values were first set to 10 and the other values were then calculated proportionally.

The second step is combining the components. For this there are three possibilities:

– Adding the main components (as with the subcomponents)
– Multiplying the main components
– Multiplying hazard and vulnerability for each individual hazard, then combining the product with the exposed values

As far as the – subjective – plausibility of the results is concerned, the first of these three options proves to be the least suitable. The other two options lead to similar results; for the purposes of representation, direct multiplication of the main components is preferable. Implicitly, the three main components are weighted equally in all processes.

5 Discussion of the results

As was to be expected, Greater Tokyo, with its combination of high hazard and peak position in terms of exposed values, leads the field by a wide margin. All in all, the index is heavily influenced by the exposed values and not quite so much by the hazard, whereas vulnerability only plays a secondary role. This may seem surprising at first, but it does reflect the fact that there is a much broader spread in values and hazard than in vulnerability. Accordingly, there is only one megacity from the Third World in the first ten, namely Manila on account of its high hazard. And some cities with a comparatively low hazard like New York, Paris, and London also came very high up in the ratings because of their considerable concentrations of values.

Regardless of all the limitations and the inexactness of the underlying values, the index presented here supplies a realistic comparison between the loss potentials of various megacities. If corresponding data on the insurance density or direct information on the exposed liability are available, statements can be made on the insured loss potential. Although they are no substitute for the results of comprehensive individual risk models, they can provide a usable initial indication particularly for areas where no such models are available or where markets are just in the process of developing.

6 Prospects

The natural hazard index for megacities presented here is to be seen as a basis for discussion rather than as a completed piece of work. Many of the assumptions made here, particularly with regard to vulnerability, need to be confirmed and objectified by pinpointed surveys, like those performed as part of the RADIUS project (Risk Assessment Tools for Diagnosis of Urban Seismic Disasters) and continued in its successor GESI (Global Earthquake Safety Initiative). As far as hazard is concerned, one very weak spot is flood. For a truly sound assessment, much more detailed data are needed for this hazard than were available for use in this pilot study. As far as the total hazard is concerned, earthquake plays a surprisingly important role, which requires more detailed examination. There is further need for research with regard to the analysis of, in particular, the main components of the index, with the aim of objectifying their weighting.

Generally speaking, this method can be developed as required and applied to smaller towns or even entire countries.

Getting to the "point" – Does geographical underwriting improve risk management? 07

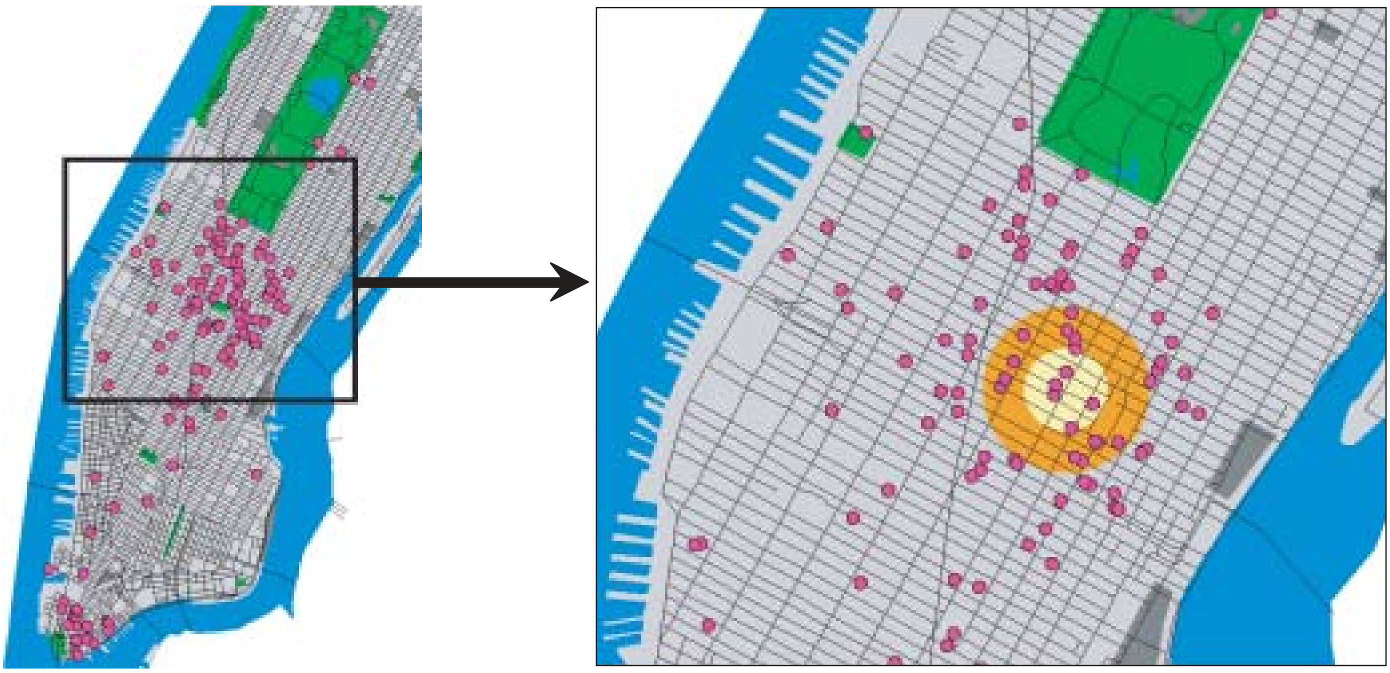
The insurance industry is constantly seeking new ways of improving the analysis and control of its risk exposures, and this is especially the case since 11 September 2001. However, it is not only man-made perils and the growing threat from terrorism that call for enhanced risk management but also natural catastrophe trends, which are continually worsening.

The ability to manage catastrophe risks depends very much on the degree of familiarity with the risk situation, the risk concentration, and the lines of business involved in a certain area. In order to assess the overall risk better and to control or optimise the exposures, insurers and reinsurers must be in a position to give a competent answer to the question, "Where are the risks?". Geographical underwriting is a promising solution since the markedly different risk situation now confronting the industry makes a detailed spatial observation of risks indispensable.

New challenges for the insurance industry

Recent experience with major catastrophes (winter storms like Lothar in 1999, the terrorist attack on the World Trade Center in 2001, the explosion at a fertiliser plant in Toulouse in 2001, the floods in central Europe in 2002) shows that great effort is required to assess and analyse complex catastrophe events. Only when this has been done is it possible to draw a comprehensive picture of the loss and to make the first stable estimates. This is due first and foremost to the complexity of the contractual arrangements, the different lines of business affected, and the individual nature of loss adjustment locally. It also becomes clear, however, that the corresponding figures would be available much quicker if information on the geographical situation were used. For this purpose, however, it would be necessary to know in advance exactly how the exposures were distributed.

Already today geographical (spatial) data on the risk situation are incorporated in the underwriting process (pricing, budget and accumulation



Portfolio analysis and scenario generation in Manhattan (New York)
Geocoding on an address basis draws a very exact picture of possible focuses of exposure. Various scenarios can be used in order to identify very critical areas and thus improve risk management. Since various lines of business can be considered at one time, this also gives rise to new analytical opportunities.

Left:
30 This one-metre-resolution satellite image of Lower Manhattan in New York was collected on 12 September 2001 by Space Imaging's IKONOS satellite. The image shows an area of white and grey-coloured dust and smoke at the location where the towers of the World Trade Center once stood. In this perspective, the enormous concentration of high-rises and the risk potential becomes obvious (Space Imaging, 2001).

control), but it is often stored in "coarse" or heavily aggregated form. In the field of natural hazards, for instance, portfolio exposures are exchanged and analysed using the so-called CRESTA zones, which are mainly based on postal areas or administrative units. These exposures can be used, for instance, to determine the accumulation risk affecting insurers and reinsurers. It has been found, however, that flood models, for instance, call for spatial data with a higher resolution, because completely different risk assessments can be generated, depending on whether a risk is 50 m from a river or 100 m.

Accurate input data are also required when assessing business interruption and workers' compensation insurances in connection with catastrophe events; and when creating models for terrorist scenarios in urban areas they are even indispensable.

Geographical underwriting

Geographical underwriting means in principle that the geographical situation of insured property is stored in a database and actively used.

The process of geocoding (= georeferencing the risk) uses the information on the situation of the insured property (e.g. location or address) and converts it into geographical coordinates (longitude and latitude). This means that every item of property throughout the world is accessible by means of its spatial relationships within a coordinate system. This basic principle of analysing information using geographical information systems (GIS) has been applied successfully at Munich Re for many years with a view to analysing natural hazards and natural catastrophes.

As treaty and facultative business – primarily in the non-life sector – need to be examined simultaneously, it is important to be able to combine different spatial resolutions with each other.

Technically speaking, high resolutions (addresses) involve processing precise coordinates, whereas the lower resolutions (e.g. postcodes) are defined on the basis of the respective centroid or focus of exposure.

An advantage is the increasing availability of exact client data in digital form, as this is an excellent basis for an exact geocoding process at address level.

What can the industry do?

Many insurance companies have now realised that in the future their risk managers will have to know the situation of the risks if they want to analyse small-scale or spatially concentrated exposures (e.g. hazardous industrial facilities, potential targets of terrorism).

Geocoding of risks

Such analyses are only possible when large numbers of risks with geographical coordinates (based on the risk addresses) are stored in the portfolio management systems. There are a number of hurdles that still have to be overcome first:

– In many lines of business, risks are written on the basis of large rating zones (e.g. Florida, Dade County). It would better to store the exact address and then convert it into geographical coordinates. This is the only way to make sure that small-scale loss potentials can be recorded as well and calculated in the form of scenarios.

– A further problem arises when numerous individual risks are drawn together in one treaty (multiple locations). In such cases an attempt should be made without fail to identify and geocode at least the most important individual locations.

– In many companies there are several portfolio management databases. Taking advantage of the geographical view, portfolios can be combined and analysed as required. And even if not all the policies are recorded with the highest resolution (address), it is still much easier to perform a cross-cutting assessment of the risk situation in the company or division as a whole.

The additional work and expense involved in recording and cleaning up geocoded data is not inconsiderable; but it can be reduced to a reasonable level by using tried and tested tools. Particularly in the treaty sector, it is important to weigh up the benefit of recording and storing detailed situation data against the work this involves. Ideally the company IT department will make support tools available that do not interfere with the actual underwriting process.

Benefits for underwriting processes

Geographical underwriting primarily supports the work processes of underwriting and risk management in non-life business. The following positive effects may be ascertained:

Address	City	Zip code	Client	Sum insured	Latitude	Longitude	Quality
106 East 42nd St.	New York	10017	Client A	10,000,000	40.751654	–73.977492	Block
995 Fifth Ave.	New York	10028	Client A	10,000,000	40.778026	–73.963359	Block
111 Broadway	**New York**	**10006**	**Client A**	**25,000,000**	**40.707619**	**–74.012248**	**Block**
405 Lexington Ave.	New York	10174	Client B	10,000,000	40.751677	–73.976098	Block
1335 Ave. of the Americas	New York	10019	Client A	10,000,000	40.762245	–73.979228	Block
625 8th Avenue	New York	10018	Client A	25,000,000	40.756162	–73.991065	Block

Geocoding methods
In the most exact form of geocoding, geographical coordinates (longitude and latitude) are calculated and stored on the basis of address data (city, street, postcode).

– Cross-line and group-wide analysis of all a company's exposures in a selected region:

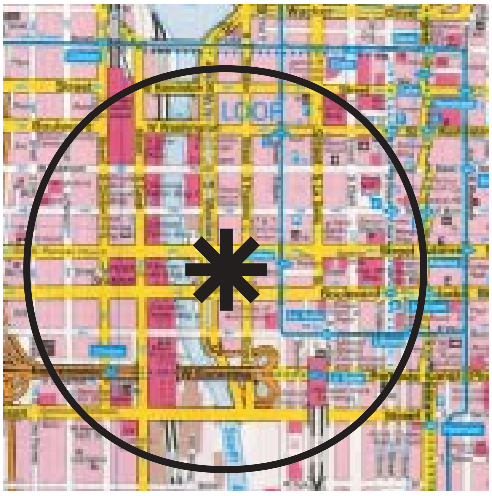
Whether market analysis (geomarketing), loss potential, or loss estimate – regardless of the region observed, all underwriting data for the risk management strategy are available quickly and efficiently using the common spatial relationship.

– Support for budget and accumulation controls

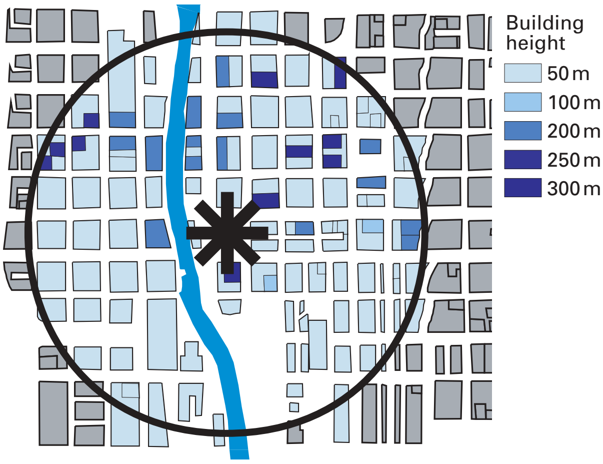
The familiar CRESTA zonings for natural hazards have proved their value. In order to make the risk map even more transparent, however, the zonings must be extended and refined. The improved CRESTAPlus format accounts for this and makes it possible to identify new focuses of accumulation.

– Visualising the spatial spread of risks

Representing and visualising risk locations makes analysis, assessment, and transparent advice easier in many cases. The information that was previously imparted by coloured pins stuck on the map can now be visualised on the screen elegantly and flexibly to suit the user's own individual needs.



Sears Tower and surroundings



Modelling of catastrophe scenarios
The example of Sears Tower in Chicago shows what modelling opportunities already exist today. The height of a building and the number of storeys may be used to derive the number of employees in a building or area. Various scenarios permit conclusions to be drawn on the loss potential in the loss area.

– Scenario modelling

As new types of risk are emerging (e.g. terrorism), very exact observations in time and space are required to come to terms with this risk of change. Highly exposed objects or hazardous installations (hot spots) may be examined with the focus on their surroundings; hence the exposure accumulation within a 5-km radius of a chemical plant, for instance, can be specified without any difficulty at all. Hitherto unidentified or underestimated loss scenarios can be identified and simulated in much more detail, with much greater precision, and much faster.

– Equitable pricing

Optimised pricing – as a result of spatially improved data – makes it possible in many cases to reduce the risk and the safety loadings that are required; often, if detailed data are not available, cautious assumptions must be applied. The position of individual products in the market can thus be altogether improved.

– Allocation of insurance capacity

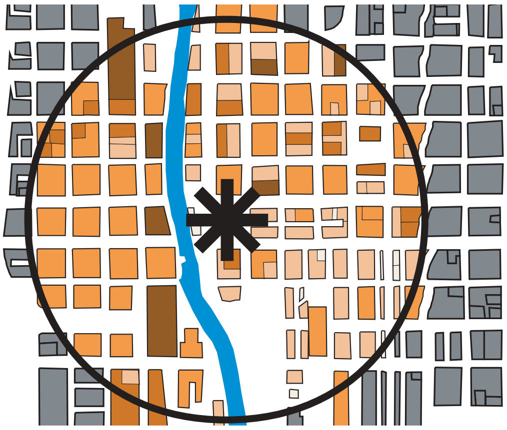
One aspect that is closely connected with budget and accumulation considerations is the aim of placing the allocated risk capital to best effect or possibly of limiting it. In this respect, the method presented here also offers new approaches because there may well be potential for development and expansion in identified high-risk zones if the portfolio is known in detail.

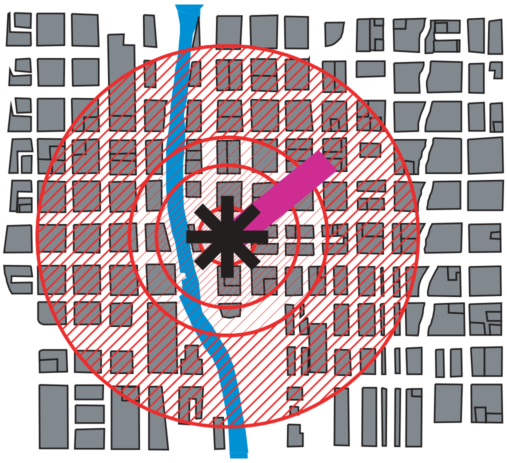
– Assessment of real estate

The security presented by real estate plays a major role in the financial services sector. For this reason it is thoroughly reasonable to examine this form of investment in terms of its risk exposure and any possible precarious focuses of concentration.

Conclusion

The latest major catastrophes have brought home just how extensive the field of tension can be between yield and risk and between profitability and





huge losses. Only professional risk management and experienced risk managers can control the overall risk safely.

Geographical underwriting is an important new tool, which can be used to better assess premium requirements and the risk of losses in non-life and accident insurance. Munich Re is vigorously pursuing the development and implementation of such projects. More and more primary insurers are also recognising the added value it can generate, added value which improves risk management within the industry as a whole. Consultants are using these techniques on a large scale too as a basis for their numerous modelling tools.

The additional work that this entails for the individual company is fully justifiable, as geoinformatics has undergone an incredibly steep upward development in recent years and is now on the market with a number of flexible, user-friendly applications and services.

At present there are only a handful of companies (primarily in the English-speaking world) that are exploiting the great potential of this tool. Nevertheless, it is already clear that in just a few years' time this modern facility will be in routine use in all markets, as a means of improving risk management in the long term.

2002 – A year of summit meetings Protection of environment and climate remain on the agenda

08

In his speech at the eighth climate summit, COP 8, the Prime Minister of India said that the industrialised countries must take steps soon to protect the climate.

Although topics like economic crises, political tension, and terrorism dominated the headlines in 2002, the environment and the climate were not forgotten either. Numerous severe storms, droughts, and floods on all continents of the world served as powerful reminders of just how massive losses caused by extreme weather conditions can be. At the same time, accidents and environmental catastrophes attracted great attention and inflicted much sorrow, as in the autumn when the tanker Prestige sank in the Atlantic.

Environmental and climate protectionists had placed great hopes in 2002. This was the year in which the second World Summit on Sustainable Development (WSSD) was to begin in Johannesburg at the end of August – ten years after the first global conference on the environment in Rio de Janeiro and therefore called “Rio + 10”. In October the states that had signed the Rio Framework Convention on Climate Change in 1992 met for their annual negotiations (Conference of the Parties, COP 8), this time in New Delhi. Neither of these two major events produced any landmark results. Nevertheless, some progress is being made in the cause of environmental and climate protection.

The World Summit in Johannesburg

Seen in the context of what are really pressing global challenges, the results of the World Summit must be considered disappointing. The most important resolution taken in Johannesburg was to halve, by 2015, the number of people in the world that have no access to clean drinking water or basic sanitation. This is an important decision, affecting as it does more than two billion people on earth. "Water" has thus been confirmed as one of the crucial issues of the future. Less success was achieved in the endeavours to more strongly promote renewable energy sources; but at least a major UN Conference is to be held on this issue. In addition, climate protection was identified by numerous heads of state as one of the leading environmental problems of our time. Happily, Russia and Canada finally announced their intention to ratify the Kyoto Protocol, which is to reduce global CO_2 emissions over the coming years and decades. Canada has already fulfilled this commitment, and ratification by the Russian parliament is expected in 2003.

The climate summit in New Delhi

The declaration published after what was in New Delhi the eighth round of negotiations cannot be called a milestone in climate protection. The paper reaffirms that the industrial countries named in the Kyoto Protocol must fulfil the obligations as agreed. The host country made it clear that the threshold and developing countries would not be able to become more strongly involved until 2012 at the earliest, viz. when the second commitment period begins. All the same, on the fringe of the negotiations, Brazil, India, and China acknowledged their important role in global climate protection and signalled more active involvement. Although the United States has now recognised man-made global warming as a fact, it still refuses to support the Kyoto process. What is more, it attempted to gain the support of other countries at COP 8 for its own alternatives to the Kyoto Protocol. Considering the fact that CO_2 emissions have been rising in nearly every country in the world, it is easy to imagine that the alternative strategies proposed by the United States, which are primarily geared to voluntary agreements, are becoming more attractive for many countries. The year 2003 is therefore likely to be very important as far as further developments are concerned. If Russia ratifies the Kyoto Protocol, the targets stipulated therein will become binding under international law. If the ratification process continues to drag on, however, this could strengthen the Protocol's opponents and lead to the failure of the Kyoto process. This would mean that the great opportunity to introduce initial global climate protection measures would be lost.

The role of financial services providers – Insuring the Kyoto mechanisms

The financial sector – banks and insurers – recently declared in New Delhi that it would continue to support the Kyoto process and act as a competent partner in promoting the so-called flexibility mechanisms. These include emissions trading (ET), the Clean Development Mechanism (CDM), and Joint Implementation (JI) of projects between industrial countries, each of these mechanisms having the goal of reducing CO_2

Small meetings on the fringe of the summit proper often bring important results. In New Delhi, Brazil, India, and China agreed that they would soon investigate how they could take on more obligations in the cause of climate protection.

emissions. CDM and JI projects are mainly devoted to the transfer of technology (such as installing a wind farm in a developing country with distinct CO_2 savings). The efficiency of the majority of these projects can easily be insured using traditional methods (see below). As the absorption of CO_2 in forest or agricultural crops may also be counted under the Kyoto Protocol, there are opportunities for insurance in the agricultural sector too.

The range of business options that can be offered by the insurance industry extends far beyond the pure financial assistance more common in the realms of banking. Possible insurance products include the following:

- Traditional forms of cover (e.g. marine, erection all risks)
- Business interruption insurances: compensation when the expected CO_2 reductions cannot be achieved because a certain plant is at a standstill
- Various forms of credit insurance (insolvency covers, etc.)
- Agricultural insurances (carbon crop insurance): cover for successful reforestation and agricultural projects aimed at absorbing CO_2

Banks and insurers also make it clear, however, that active participation is linked to various conditions like sound markets. The main condition is a global consensus on Kyoto with binding laws and regulations. Importance is attached to the following:

- Long-term validity of commitment agreements
- Clearly defined sanctions which will apply if the Kyoto targets are not met (compliance regime)
- Political and economic stability in the partner countries as a basis for sustainable business relations

Well-structured insurance portfolios can only be built up if large numbers of CDM and JI projects are carried out with a wide geographical spread. Also, relatively long coverage periods – of several years at least – are prerequisite to financial compensation in the event of losses occurring.

Emissions trading is on its way

In December 2002 the EU environment ministers agreed that, regardless of the fate of the Kyoto Protocol, a European trading system in emission certificates would be introduced as of 2005. This is an important stimulus for investments in climate protection. According to EU estimates, several thousand firms (4,000–5,000 industrial facilities) are likely to take part – more than half of them in Germany. Emissions trading in Europe is likely to develop into a market of economic significance in the years to come.

2002 – The second warmest year

2002 was the second warmest year on record – just behind 1998. The ten warmest years since 1860 have all been registered since 1987, nine of them since 1990. The warming of the atmosphere has accelerated dramatically in the last 25 years (by a factor of three compared with the development last century). There is no sign of any change in the trend. In fact, it is to be feared that the negative effects of climate change will become more and more pronounced, manifesting themselves especially in the form of extreme weather situations. The past year of natural catastrophes has again given an idea of what to expect. Emissions trading will reward energy-conscious development and encourage innovations. Renewable sources of energy and energy efficiency systems are sure to profit. That is important because, in view of the temperature developments in the atmosphere, swift action is urgently required.

33 Mt. Etna, Italy, erupts.

Picture sources

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