9th Year · 2002

Natural catastrophes in 2001 / Major engineering and fire catastrophes in 2001 / Trends of great natural catastrophes since 1950 / The insurance industry's billion-dollar loss list / The Gujarat earthquake / "Wet" storms – Flood losses dominate / Loss potentials – Known/unidentified? / Meteorites – An underestimated accumulation risk? / Climate negotiations 2001 / Geoscientists at American Re

topics

ANNUAL REVIEW: NATURAL CATASTROPHES 2001

Münchener Rück
Munich Re Group

Cover picture:
01 Floods in Houston, Texas, following massive rainfall from Tropical Storm Allison in June 2001. More than 100,000 cars were swamped by this "wet" storm of historical dimensions.

Left:
02 The earthquake in Gujarat, India, on 26th January 2001. This multi-storey residential building in Ahmadabad was a total loss.

Natural catastrophes in 2001 Review of the year

01

As far as catastrophes in general are concerned, the year 2001 was overshadowed by 11th September. The losses from this awful terrorist act far exceed the total cost of the year's natural catastrophes. Experts at Munich Re have calculated all the relevant loss scenarios for the major natural catastrophes that may occur in the world. Some of them are distinctly larger than the WTC loss. The highest losses recorded to date, namely Hurricane Andrew (Florida, 1992, with economic losses of US$ 30bn and insured losses of US$ 17bn) and the Northridge earthquake (California, 1994, with economic losses of US$ 44bn and insured losses of US$ 15.3bn), can only be regarded as grazing shots and should be taken as a warning. Andrew did not touch Miami or New Orleans, and the Northridge earthquake only affected the periphery of Los Angeles. Direct hits in these areas would have caused much greater losses. The subject of unidentified loss potentials from natural catastrophes is discussed in a special article in this publication.

As far as natural catastrophes are concerned, 2001 may be regarded as an average year altogether, following a year of record losses in 1999 and a year of exceptionally few losses in 2000. Nevertheless, at least 25,000 people were killed in 2001 (previous year: 10,000), more than half of them being victims of one single event, the earthquake that hit Gujarat in India on 26th January. The number of loss events recorded in 2001 came to around 700, which was above the long-term average (650) but far below the record (850) set in the year 2000. At approx. US$ 36bn, economic losses exceeded the 2000 figure (US$ 30bn). At approx. US$ 11.5bn, insured losses increased even more in comparison with the previous year (US$ 7.5bn). The most expensive natural catastrophe for the insurance industry (US$ 3.5bn) was Tropical Storm Allison, which hit the southern United States in June, causing major floods and an overall loss of around US$ 6bn.

Altogether there were four great natural catastrophes last year: the earthquakes in El Salvador and India (cf. this year's catastrophe portrait), the hailstorm in Kansas City, which set a new record in terms of losses from a severe storm, and Tropical Storm Allison (cf. the special article on "wet" storms).

Earthquakes

At the beginning of the year, on 13th January, an earthquake with a magnitude of 7.7 in El Salvador caused numerous landslides, beneath which hundreds of people were buried; the death toll came to 845.

Just two weeks later the earth was shaken again – by an earthquake with a magnitude of 7.7 in the densely populated northwest of India. In the Gujarat region numerous towns and villages within a radius of several hundred kilometres from the epicentre were flattened. A figure of 14,000 deaths has been confirmed, but many more people are feared to have been killed.

There was a stir in the United States at the end of February when Seattle was shaken by the severest earthquake in 50 years (with a magnitude of 6.8). Numerous large industrial enterprises along the northwest coast were also affected. The insurance industry paid more than 10,000 claims with an overall volume of roughly US$ 300m.

Altogether there were 80 earthquake losses around the globe, putting a burden of about US$ 9bn on the economies of the countries concerned; about a tenth of that amount was insured.

Windstorms

Windstorms and floods again had the greatest impact on the overall balance, accounting for more than two-thirds of all the events (480). They were also responsible for 92% of the insured losses caused by natural catastrophes and in this respect too were again absolutely dominant.

In June Tropical Storm Allison caused serious flooding in the southern United States – primarily in Texas. Rain falling for days on end led to chaotic conditions, especially in Houston. A total of more than 100,000 cars sank in the floods. With wind speeds of only 95 km/h, Allison was not classed as a hurricane (beginning at 118 km/h) but goes down in history as the costliest non-hurricane of all time.

The hurricane season was marked by above-average activity, with 15 named tropical storms including nine hurricanes in the North Atlantic and the Caribbean, but this did not result in extreme losses.

In the Far East, on the other hand, a series of large typhoons (including Nari, Pabuk, and Chebi) caused new record losses. In fact Taiwan was the target of typhoons several times. Typhoon Nari, which swept over Taipei in September, is the costliest windstorm catastrophe to date in the country's insurance history with insured losses of approx. US$ 500m. Parts of the capital's underground railway system were under water for weeks; the stock exchange and important trading centres had to stay closed for several days.

In Kansas City the largest hail loss of all time was reported. Tens of thousands of roofs and cars were damaged by hailstones, some almost as big as tennis balls. The hailstorm was part of a huge storm system that sped over large parts of the United States in April. The insurance industry paid a total of almost US$ 2bn in claims.

There were many severe storms and hailstorms in Europe too. A hailstorm in Bavaria on 3rd August, for instance, generated insured losses amounting to several hundred million dollars.

Floods

In contrast to 2000, which could be called a year of floods, 2001 was not severely affected by this natural hazard. All the same there were some events that were of major regional significance. In France large areas of land along the Somme were under water for weeks on end (April). In Siberia ice jam floods devastated numerous villages and towns (May). In southeast Poland days and days of rain caused major damage particularly in the agricultural sector (July). In Algeria flash floods tore people and cars along with them and claimed more than 700 victims (November).

Other events

Heat waves, droughts, and forest fires affected many countries of the world. Iran and some provinces in China suffered from months of drought (lasting from March to November in both cases); numerous forest fires raged in southeast Australia, forging into the outskirts of Sydney towards the end of the year and burning down about 150 houses.

Climate change

According to the World Meteorological Organization (WMO), 2001 was – after 1998 – the second-warmest year since systematic temperature measurements began around 160 years ago, making it the 23rd year in succession to exceed the average temperature for the period 1961–1990. It thus appears more urgent than ever to take the important first step towards global climate protection and ratify the Kyoto Protocol. The course was set for this by the 7th world climate conference in Marrakesh in November (cf. the special article on the climate negotiations).

Outlook

After the series of gigantic loss events in the 1990s and the record loss year of 1999, natural catastrophes "took a breather" in 2001, which was particularly important for the insurance industry that year. An extreme burden from the realm of natural catastrophes in addition to the WTC loss would have put a much greater strain on the capacity of the international insurance industry. But this breathing space should on no account be taken as an occasion for paying less heed to natural hazards. The dramatic upward trend in natural catastrophes that we have been observing for decades and the causes of this trend will almost inevitably lead to us being confronted sooner or later with new loss records, for which we must prepare ourselves as early and as well as possible.

03 Hurricane Iris, which sped over Belize in October 2001 at peak wind speeds of 225 km/h, destroyed 60 villages and left behind a trail of devastation. Faulty construction in hurricane-prone areas – in this case insufficient anchoring devices – is often responsible for extreme storm damage. This picture was taken in Placencia, 130 km south of Belmopan, the capital.

Pictures of the year

In May ice jam on the Lena and other rivers led to the worst floods in 100 years. Major transportation routes were blocked in numerous East Siberian towns.

In April, under the strain of weeks and weeks of rain and melt water, the dams on the upper reaches of the Mississippi were near bursting. The flood wave was so high that even the good protection measures taken by those along the river in response to the early warning that was issued were of no avail. This picture shows the hopeless struggle with the masses of water in Port Byron, Illinois. Altogether, more than 1,500 houses and numerous businesses in four states were flooded in the catastrophe.

Tall structures like transmission masts, towers, and churches are particularly at risk during storms because the wind forces increase significantly with the height due to the lack of ground friction. This church tower was blown over by severe gusts during the severe storms that hit the United States in April and generated the highest insured storm loss of all time (US$ 1.9bn) in Kansas City.

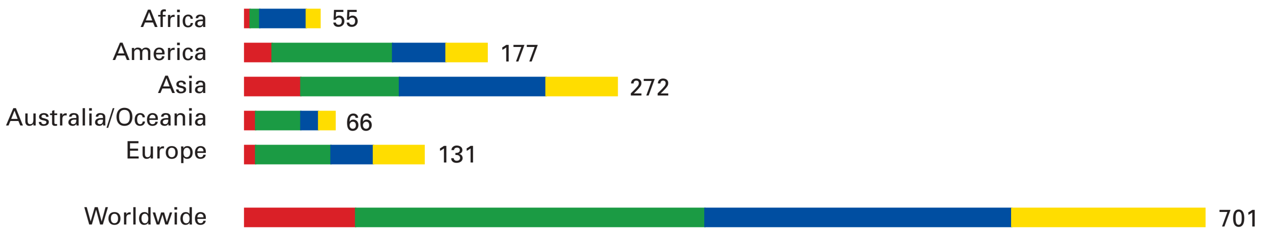
The eruption of Mt. Etna in Sicily was a cause of major concern almost all summer long. For weeks glowing masses of lava poured down the slopes, destroying lift facilities one after the other and a hotel. The surge of fire was so huge that it could even be seen from outer space. This satellite image shows thick clouds of smoke advancing across the Mediterranean.

On 3rd August, after a long heat wave, numerous severe storms hit southern Germany, Poland, and the Czech Republic. Tremendous downpours, hailstones the size of golf balls, storm gusts, and fires caused by lightning strokes generated losses amounting to over US$ 300m. This is a picture of a burning farmhouse near Traunstein in Bavaria.

There was above-average hurricane activity in the North Atlantic. Hurricane Michelle at the beginning of November was the eighth of the season and its large wind field affected nearly all of the islands in the Caribbean. In Cuba, where numerous built-up areas and industrial facilities were devastated, Michelle was the strongest cyclone in 60 years with wind speeds of over 200 km/h. This is a picture of a demolished sugar factory near Jagüey Grande in the centre of the island.

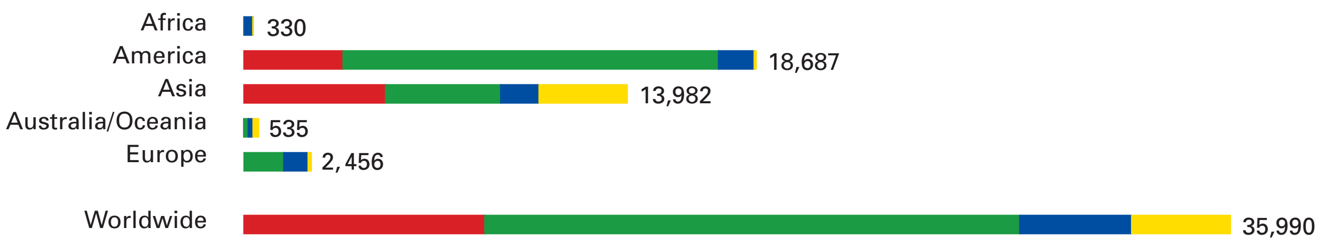
Statistics of natural catastrophes in 2001

Number of loss events



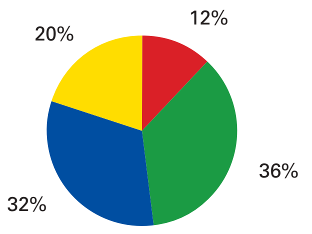
Number of fatalities

Economic losses (US$ m)

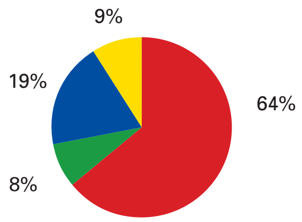


Insured losses (US$ m)

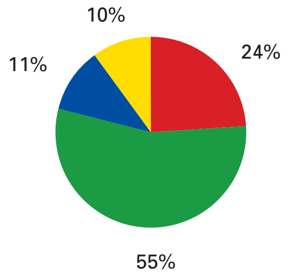
700 loss events



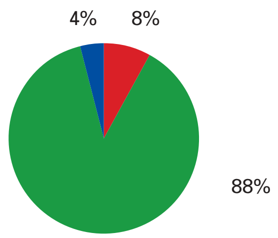
25,000 fatalities



Economic losses: US$ 36bn



Insured losses: US$ 11.5bn



- Earthquake, volcanic eruption
- Windstorm
- Flood
- Others

Percentage distribution worldwide

Major engineering and fire catastrophes in 2001

02

In the year 2001 engineering and fire catastrophes reached hitherto unknown dimensions – on account of the terrorist attack on 11th September.

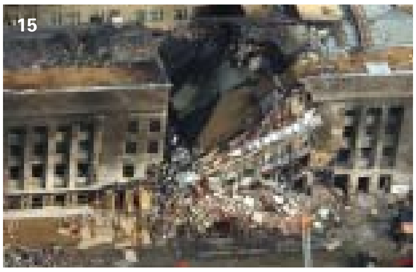
28th February, Great Britain
Road accident causes railway disaster.

15th March, Brazil
Oil rig sinks after explosions.

July, September, December, worldwide
Computer viruses.

25th July, Sri Lanka
Aircraft damaged during rebel attack.

11th September, United States
Terrorist attack.



11th September, United States
Terrorist attack.

21st September, France
Explosion at a petrochemical plant.

24th October, Switzerland
Tunnel fire.

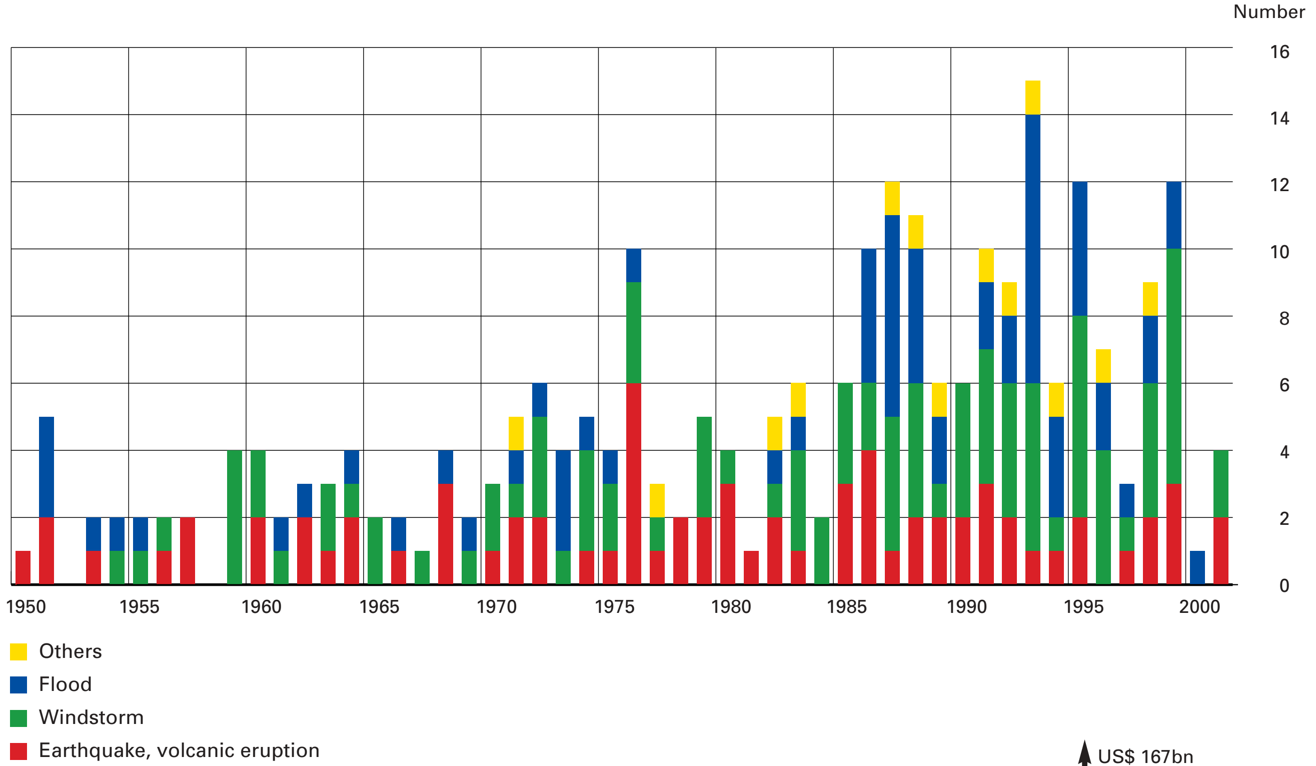
12th November, United States
Air crash in New York.

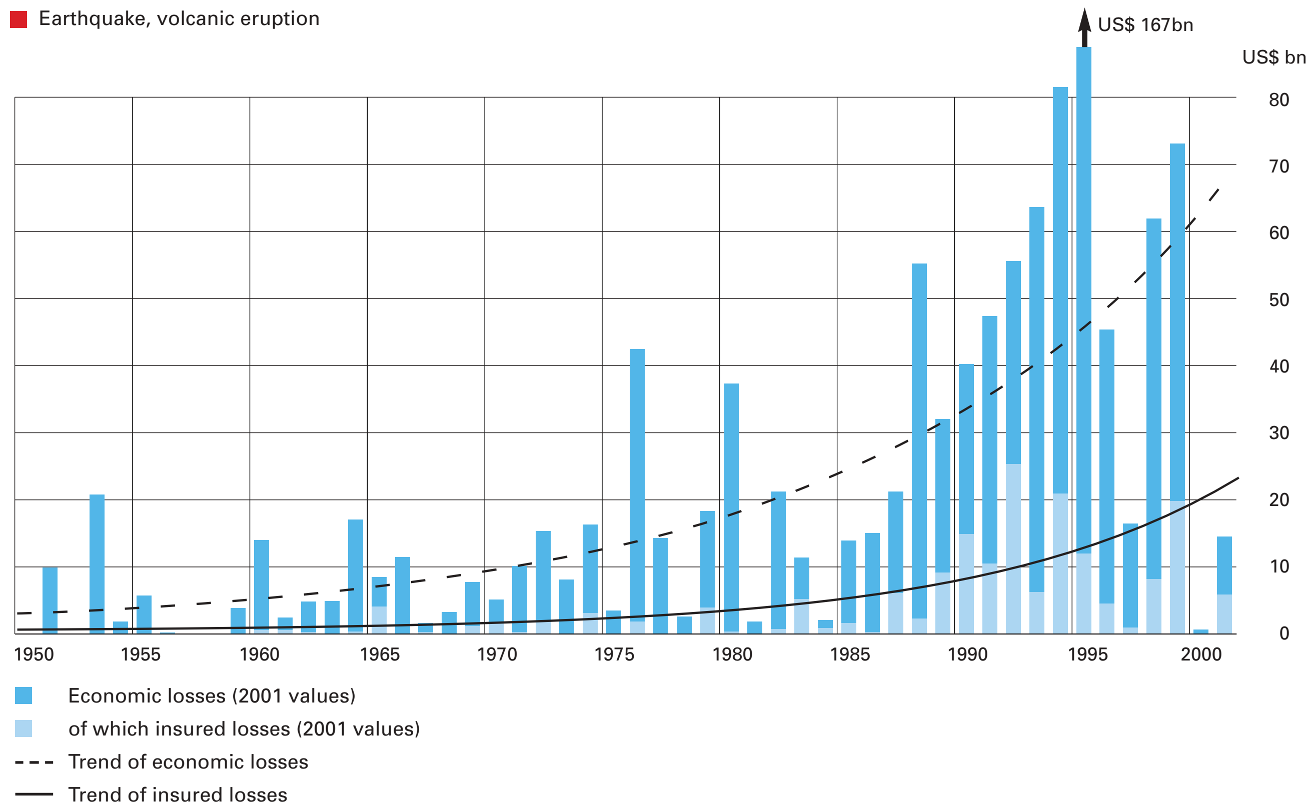
Date	Region	Description of loss
28.2	**Great Britain,** Selby	**Road accident causes railway disaster** A vehicle that had come off the road ran down the embankment and onto the railway lines, where it was hit by an Intercity train approaching at high speed. The train derailed and shortly afterwards collided with a goods train coming the other way. 13 people were killed; the insured loss came to about US$ 70m.
15.3	**Brazil**	**Oil rig sinks after explosions** Five days after being hit by a series of explosions, P-36, the largest floating oil rig in the world, sank off the Brazilian coast. About 1.2 million litres of diesel oil and 300,000 litres of crude were stored on board the oil rig and spilled out into the Atlantic. Eleven workers were killed in the accident; the insured loss came to about US$ 500m.
July, September, December	**Worldwide**	**Computer viruses** Computer viruses and worms take advantage of security gaps in operating systems and Internet servers and then spread with extreme speed around the globe. Computer networks are crippled and electronic communications are seriously disrupted. The cost of removing the damage is considerable. The most aggressive destroyers in 2001 were viruses called Code Red, Nimda, and Goner.
25.7	**Sri Lanka,** Colombo	**Aircraft damaged during rebel attack** During an attack by Tamil underground fighters at an air force base near Colombo International Airport 14 aircraft were damaged or destroyed. The attack cost the lives of 18 people and resulted in an overall loss of at least US$ 300m.
11.9	**United States,** New York, Washington, Pittsburgh	**Terrorist attack** The attack on the World Trade Center in New York and the Pentagon in Washington cost the lives of more than 3,000 people from 80 countries (including the air crash in Pittsburgh).
21.9	**France,** Toulouse	**Explosion at a petrochemical plant** On the outskirts of Toulouse in the south of France, a petrochemical plant belonging to TotalFinaElf exploded. 29 people were killed, 2,500 were injured. The overall loss came to about US$ 1.8bn.
24.10	**Switzerland,** Gotthard Tunnel	**Tunnel fire** In the Gotthard road tunnel two lorries crashed head-on and went up in flames. The two vehicles exploded, bringing down the roof of the tunnel over a length of 100 m. At least eleven people died in the inferno. An estimated US$ 6m will be required to restore the tunnel.
12.11	**United States,** New York	**Air crash in New York** Shortly after taking off from JFK Airport a passenger aircraft belonging to American Airlines crashed onto the borough of Queens. Numerous houses went up in flames. None of the 260 people on board survived the crash. The aircraft's hull value was around US$ 45m; third party liability claims are estimated to reach a total of US$ 700m.

19 A landslide after the earthquake in El Salvador on 13th January 2001. In Santa Tecla (photo) 500 houses were buried, and 800 people were reported missing. The devastating quake triggered more than 10,000 landslides and damaged about 200,000 houses.

Great natural catastrophes 03

Great natural catastrophes with trends





Long-term statistics 1950–2001

Decade	1950–1959	1960–1969	1970–1979	1980–1989	1990–1999	Last 10 years
Number	20	27	47	63	89	78
Economic losses	42.2	75.7	136.1	211.3	652.3	579.9
Insured losses	–	**7.2**	**12.4**	**26.4**	**123.2**	**103.7**

Factor	80s:60s	90s:60s	Last 10:60s
Number	2.3	3.3	2.9
Economic losses	2.8	8.6	7.7
Insured losses	**3.6**	**17.0**	**14.3**

Losses in US$ bn (2001 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 four events met these criteria (cf. World Map 2001 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 tables allow a comparison of the aggregate loss figures of recent decades. Comparing the last ten years with the 1960s makes the dramatic increase in natural catastrophes particularly clear. This applies both to the number of events and to the extent of the losses incurred.

NatCat*SERVICE* information The insurance industry's billion-dollar loss list

04

In this NatCat*SERVICE* information we list all the natural catastrophe losses that have cost the insurance industry more than US$ 1bn (in original values). This loss amount has always represented a distinctive threshold for the insurance industry. Insured losses are a particularly suitable basis for analyses as they can be established precisely. Economic losses on the other hand can never be calculated exactly as they are determined in various ways, depending on the definition applied in each case, and are seldom fully and reliably established (cf. the article in topics Annual Review: Natural Catastrophes 2000). Although inflation has not been taken into account in the values shown here, the analysis of billion-dollar losses permits us to draw interesting conclusions:

– Hurricane Alicia in 1983 was the first event to go down in the statistics as a billion-dollar loss. Altogether there were only three of these gigantic losses in the 1980s. In terms of insurance they were really exceptional events that marked the transition to new dimensions.

– Between 1987 (beginning with the 87J gale in England) and 1992 (Hurricane Andrew) new loss records were set every year, regardless of where in the world the forces of nature raged. Towards the end of the last century the loss situation deteriorated again quite drastically, and a new record was set in 1999 with seven events of this size.

– Although almost every continent appears somewhere in this list, it is clearly dominated by America and Europe. This is because of the enormous concentrations of values and the high insurance density in these two regions. They accounted for 78% of the global non-life premium (total of premiums for property insurances) in 2001.

– Looking at the billion-dollar loss statistics by type of event, we are struck by the enormous strain from meteorological catastrophes (windstorms, hail). But the two earthquakes in the list are also remarkable: Kobe (1995) was the most expensive natural catastrophe of all time (economic losses); Northridge (1994) is to be found in the very supreme group of insured losses. On account of the low insurance density globally, floods are not particularly conspicuous. As far as the other events are concerned, which include winter damage, frost, drought, and forest fires, it is only forest fires that play any role at all, and a subordinate one at that. Although devastating forest fires (like those recently in the United States and Australia) rage every year, the size of the monetary losses depends on the extent to which buildings are destroyed. The Oakland fire in California in 1991, for instance, was a major loss because it affected a region in which numerous luxury villas had been built.

– Since 1983 there have been 34 natural catastrophes with insured losses of at least US$ 1bn, and 32 of them had atmospheric causes. On account of the increase in population density in exposed areas throughout the world, the associated concentrations of values, and climate change, which will bring even more frequent and more intensive weather catastrophes in the future, it must be feared that the billion-dollar loss list will continue to grow rapidly.

Insured losses of US$ 1bn and above

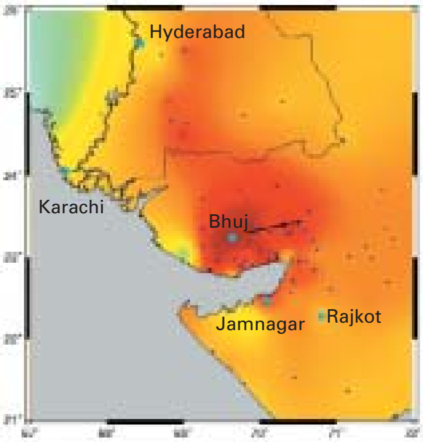
Rank*	Year	Event	Region	Insured losses** (US$ m)	Economic losses** (US$ m)
27	1983	Hurricane Alicia	USA	1,275	3,000
10	1987	Winter storm	Western Europe	3,100	3,700
6	1989	Hurricane Hugo	Caribbean, USA	4,500	9,000
5	1990	Winter Storm Daria	Europe	5,100	6,800
26	1990	Winter Storm Herta	Europe	1,300	1,950
15	1990	Winter Storm Vivian	Europe	2,100	3,250
25	1990	Winter Storm Wiebke	Europe	1,300	2,250
4	1991	Typhoon Mireille	Japan	5,400	10,000
18	1991	Oakland forest fire	USA	1,750	2,000
1	1992	Hurricane Andrew	USA	17,000	30,000
20	1992	Hurricane Iniki	Hawaii	1,650	3,000
19	1993	Snow storm	USA	1,750	5,000
33	1993	Flood	USA	1,000	16,000
2	1994	Earthquake	USA	15,300	44,000
11	1995	Earthquake	Japan	3,000	100,000
29	1995	Hail	USA	1,135	2,000
22	1995	Hurricane Luis	Caribbean	1,500	2,500
16	1995	Hurricane Opal	USA	2,100	3,000
21	1996	Hurricane Fran	USA	1,600	5,200
28	1998	Ice storm	Canada, USA	1,200	2,500
34	1998	Floods	China	1,000	30,000
24	1998	Hail, severe storm	USA	1,350	1,800
7	1998	Hurricane Georges	Caribbean, USA	4,000	10,000
30	1999	Hail storm	Australia	1,100	1,500
23	1999	Tornadoes	USA	1,485	2,000
14	1999	Hurricane Floyd	USA	2,200	4,500
8	1999	Typhoon Bart	Japan	3,500	5,000
13	1999	Winter Storm Anatol	Europe	2,350	2,900
3	1999	Winter Storm Lothar	Europe	5,900	11,500
12	1999	Winter Storm Martin	Europe	2,500	4,000
32	2000	Typhoon Saomai	Japan	1,050	1,500
31	2000	Floods	Great Britain	1,090	1,500
17	2001	Hail, severe storm	USA	1,900	2,500
9	2001	Tropical Storm Allison	USA	3,500	6,000

* Ranked by insured losses
** Original losses, inflation not taken into account

20 A row of houses in Bhuj after the earthquake on 26th January 2001.

Catastrophe portrait
The Gujarat earthquake in India

05



Descriptive term	Damage	Intensity
Imperceptible	None	I
Very slight–slight	None	II–III
Moderate	None	IV
Rather strong	Fallling objects	V
Strong	Slight damage to buildings	VI
Very strong	Moderate damage to buildings	VII
Destructive	Severe damage to buildings	VIII
Devastating	Widespread damage to buildings	IX
Annihilating – Disaster – Major disaster	Widespread destruction of buildings	X+

The intensity distribution map for the Gujarat quake clearly shows the huge area of the damage zone.

The new millennium was expected to be completely under the sign of technological progress, but it was only 26 days old when nature struck with all its might in India, sometimes called a "high-tech developing country". On 26th January 2001, the earth shook in Gujarat State, in the northwest of the subcontinent. It was not the first time that the earth had shaken in India, but the humanitarian and economic dimensions of this catastrophe were unique even in this country where natural catastrophes are more or less regular events.

Scientific aspects, characteristics of the quake

The severe earthquake with a magnitude of M_w 7.7 occurred at 8:45 local time in the Kachchh region of the Indian state of Gujarat. The epicentre was to the north of Bhachau, a town with a population of 60,000 situated some 220 km west of Ahmadabad (India) and 290 km southeast of Hyderabad (Pakistan). According to the US Geological Survey the focal depth was approx. 23 km.

The occurrence of earthquakes in India is neither surprising nor unusual – particularly in the suture zone between India and Eurasia, a line that is drawn by the Himalayas. A large number of earthquakes have occurred there in the past, of which there are also historical records. The reason for the particularly high frequency of earthquakes in this region is the northward drift of the Indian subcontinent at a speed of approx. 5 cm a year. In the process, India is being forced under the Eurasian plate. That is also why the Himalayas have folded up on this subduction zone to a height far exceeding 8,000 m.

The Gujarat quake, however, did not occur on this plate boundary. Its epicentre was inside the Indian continental plate, making it what is called an intracontinental quake. Comparatively few have been identified so far in the world. A situation similar to that in Gujarat is also to be found, for instance, in the New Madrid zone of the US Midwest, which is inside the North American continental plate. In 1811 and 1812 this region was hit by a series of earthquakes with magnitudes similar to that reached in the Gujarat quake. This similarity is of great interest both from the scientific point of view and with regard to estimating future loss potentials for the US Midwest region. The cause of the earthquake in the Kachchh region is not yet understood in detail, but as in the US Midwest the suspicion is that the faults of an old rift are being reactivated by the current north-south tectonic pressure zone.

One major feature of this quake is that it was still felt strongly even very large distances from the epicentre and that high intensities were observed locally with corresponding loss patterns. There was significant damage in the town of Hazira, for instance, some 400 km from the hypocentre. The reason for this wide spread of intensity is to be found in the minimal attenuation characteristics of India's continental crust. India is an ancient craton. The rock strata found there are as much as four billion years old and these conduct earthquake waves particularly well because of their density. The combination with overlying sedimentary basins causing amplification of ground motion was responsible for the unusual intensity pattern.

With a magnitude of 7.7 this was the strongest quake in this part of India for almost 200 years. The last severe earthquake occurred here in 1819 and is said to have had a similarly high magnitude. It resulted in a death toll of about 1,500.

Losses

The state of Gujarat in the west of India has a total area of 195,000 km^2, making it just a little smaller than Great Britain. Approx. 41 million people live in Gujarat, one of the economically thriving states of India and the second most industrialized. The earthquake also hit the state capital of Ahmadabad (with about 4.5 million inhabitants) some 960 km southwest of New Delhi. It is particularly famous because Mahatma Ghandi lived and worked there for many years. Gujarat has approx. 1,600 medium to large industrial enterprises and approx. 200,000 small firms. The main sectors are agriculture and textiles.

The effects:

– Even today it is unclear how many victims the earthquake really claimed. An official figure published by the government states a death toll of 17,122, a figure that has since been reduced to 14,000. However, the number of fatalities is likely to have been much higher.
– The economic loss is US$ 4.5bn, with insured losses in the range of US$ 100m.
– Prior to the Gujarat catastrophe, the most severe quake in India was the Khillari quake (Central India), which occurred in 1993. The loss amount was US$ 280m, equivalent to about only 6% of the loss generated by the Gujarat earthquake. The largest economic loss from a natural hazard event also dates back to 1993, when floods caused losses amounting to about US$ 7bn.

Damage to houses and small industry

Generally speaking, there are major differences in building fabric between rural and urban areas.

– The building stock in the villages and in the poor-looking areas on the periphery of the larger towns and cities is dominated by very simply built houses of burnt or unburnt clay bricks. Even if any material is used to hold the bricks together, it is often of poor quality. Therefore, dynamic stress, like that exerted by an earthquake, quickly results in the partial or total collapse of such structures, as they have neither the shear strength nor the tensile strength to cope with the forces and moments occurring in an earthquake.
– In the towns the preferred style of building for two- to four-storey houses is a combination of reinforced steel-frame structures with brick-filled walls. The majority of these structures also proved to be of inadequate design to cope with the stresses that occurred.

– It was frequently found that the reinforcements in the load-bearing columns were too far apart and that the ties were inadequate. Typical loss profiles in this type of building were the “soft storey” and “pancake” effects, involving the total collapse of one or all of the storeys due to insufficient load-bearing capacity under dynamic stress.

The Gujarat quake on 26th January 2001 devastated an area of several thousand square kilometres. The infrastructure was destroyed, important transportation routes were made impassable. Besides industrial and commercial buildings, innumerable houses were flattened. According to official sources, at least 14,000 people were killed. This photo shows the remains of a temple in Bhachau.

Particularly noticeable was the fact that severe damage was also recorded in Ahmadabad, almost 220 km from the epicentre (and even in the more distant Hyderabad in Pakistan). This mainly involved the partial or complete collapse of multi-storey apartment buildings. About 70 buildings were affected altogether. These instances of collapse were not registered in a concentrated area, suggesting that they were due to an ill-fated combination of deficiencies in the design or construction and poor subsoil conditions. Large parts of Ahmadabad are located on a river bed that was filled with old sediment. It cannot be ruled out that a certain role was played by the Mexico City Effect, which gets its name from the 1985 earthquake in Mexico, i.e. a double resonance coupling between the resonance frequency of the affected buildings and the soft sediments below and the incoming quake waves. This results in the resonance of the building being amplified more and more until the dynamic stress is so great that the loadbearing parts fail. Nevertheless, in view of the fact that – according to statements made by experts on the spot – the damaged residential complexes were no more than eight to ten years old, the building fabric is to be considered very deficient.

Damage to industrial plants

In Gujarat there are many large industrial plants, especially refineries and industrial ports (Gujarat Chemical Port, Kandla Port, etc.). Their building standards appear to be much better than in the case of residential buildings and in the small and medium industrial sector. Large enterprises like Reliance Oil, which operates the largest refinery in the Asian region in Jamnagar (approx. 100 km south of the epicentre), or Indian Oil escaped with relatively few property and business interruption losses. This must be seen in relation to the overall value of these plants, however, because in absolute terms the industrial losses accounted for a substantial share of the overall loss.

Conclusion

The quake of 26th January 2001 had devastating effects on the Gujarat region. Besides the strength of the earthquake itself (M_w 7.7) the following factors influenced the loss profile and the extent of the catastrophe:

1 Generally speaking, the building stock is to be considered particularly vulnerable. The quake thus also drew attention to the enormous loss potential for such large conurbations as Mumbai, Delhi, and Kolkata. This is all the more worrying in that several "seismic gaps", i.e. areas of elevated earthquake probability, are suspected to be on the southern edge of the Himalayas, where an earthquake would hit the densely populated Ganges plain.

2 Large industrial plants are usually well built, representing a positive exception in the general loss profile. Otherwise, there is little or no adherence to the building codes. This was reflected in the collapse of high-rise buildings in both Bhuj and Ahmadabad, where some multi-storey buildings were built on a subsoil that would not be permitted in the building code. An example of this is the collapsed part of the Mansi residential complex in Ahmadabad, which also contained an unauthorized swimming pool on the 10th floor.

3 The subsoil exerted a strong influence on the intensity amplification. For this reason and because of the high conductibility of the earth's crust in the quake area, there were high intensities even at a great distance from the hypocentre. This makes the quake an interesting model for an earthquake in the US Midwest. Particularly remarkable is the unusual vulnerability of relatively new multi-storey buildings, as observed above all in Ahmadabad (see above). In this connection a kind of Mexico City Effect may well have played a part in combination with the poor building stock.

22 Typhoon Nari, September 2001. A ruined railway bridge with demolished containers in Keelung in the north of Taiwan.

"Wet" storms
Flood losses dominate

06

– Japan, September 2000: Typhoon Saomai, insured loss: US$ 1.0bn, flood losses: > 90%
– Great Britain, October–November 2000: winter storms, torrential rain, insured loss: US$ 1.1bn, flood losses: > 90%
– United States, June 2001: Tropical Cyclone Allison, insured loss: US$ 3.5bn, flood losses: > 95%
– Taiwan, September 2001: Typhoon Nari, insured loss: US$ 500m, flood losses: > 95%

The equation appears to be quite simple: “storms = wind damage”. And even today it serves as the basis of virtually all risk models and rating systems for calculating the risk premium for insurance protection. Additional damage caused by rain water penetrating the damaged shell of the building is included as “secondary damage”, but the possibility that storms are also capable of causing catastrophic floods is often ignored.

America: Historic floods caused by tropical cyclones almost forgotten
Asia: Windstorm and flood insurance still in its infancy
Europe: Focus on coastal flooding caused by storm surges

The series of storms in Europe in 1990, Typhoon Mireille in Japan in 1991, and Hurricane Andrew in the United States in 1992 were the major triggers for the development of mathematically/scientifically-based simulation methods for modelling the potential burden to be borne by the insurance industry as a result of windstorm events. The goal of these models is always a state-of-the-art calculation of loss accumulations and risk premiums for individual portfolios.

But what is the state of the art that model developers and risk managers have generally used as their reference in recent years? The events at the beginning of the 1990s were the first to deliver comprehensive data in electronic form – which could thus be analysed in detail – on the connection between the intensity of storms and the losses to be expected. However, Daria, Vivian, Wiebke, and the other European winter storms of 1990 were relatively “dry” storms, as were Mireille and Andrew; the damage caused by torrential rain and floods was of minor significance. The basis for the loss experience that flowed into the risk models was therefore limited in essence to pure windstorm losses (a qualification to which model developers also repeatedly drew attention).

Furthermore, many risk managers have almost forgotten the major windstorm catastrophes in which the primary cause of loss was floods resulting from torrential rain. The United States’ most extreme hurricane catastrophe in terms of the number of deaths occurred over a hundred years ago in 1900, when over 8,000 people fell victim to a hurricane in the city of Galveston (south of Houston) in Texas. The main causes of this catastrophe were a storm surge and floods along the coast. (By way of comparison, the earthquake that rocked San Francisco in 1906 claimed the lives of 3,000 people.) Hurricane Andrew in 1992 – still the most expensive natural catastrophe of all time for the insurance industry with an insured loss of US$ 17bn – was a relatively “dry” cyclone. Perhaps this event also contributed to the fact that the flood hazard emanating from tropical cyclones was given so little attention until June 2001 when Tropical Storm Allison set a new record with an insured loss of almost US$ 3.5bn that was almost exclusively made up of flood losses.

23

The torrential rain from Typhoon Nari flooded industrial facilities like this steel works. Severe damage was inflicted on machines and goods. Many companies were only able to resume work after extensive clean-up operations.

24

An underground station in Taipei. Power failures and the insufficient capacity of the pumps that had been installed led to some underground stations being completely flooded. Train services were limited for weeks on end.

Tropical Storm Allison caused an unprecedented insured flood loss in the United States of US$ 3.5bn. On 11th June Allison faded to below gale force (< 63 km/h) over Louisiana. The track indicated here describes the path taken by the residual low-pressure area from this point on.

Tropical Storm Allison, June 2001

Allison was the first tropical storm of the 2001 hurricane season in the North Atlantic. With wind speeds of below 100 km/h the centre of the storm passed directly over the city of Houston. More than 720 mm of rain (equivalent to three-quarters of the annual rainfall in Munich) fell in 12 hours. Losing speed, Allison then crossed over parts of New Orleans (120 mm of rain in 24 hours) before shifting towards northern Florida and on to the East Coast. Even in Connecticut up to 170 mm of rain was measured locally.

With insured (flood) losses of US$ 3.5bn – over US$ 1bn of which was covered by the National Flood Insurance Program (NFIP) – Allison was the most expensive “wet” tropical storm to date worldwide. The fact that the insurance industry came away with no more than a “black eye” is revealed by the enormous volumes of rain that fell all along the windstorm area’s track over land. Houston was the only large city to be hit directly, but nonetheless this region accounted for almost US$ 3bn of the insured loss. The loss total might easily have been much higher if one of the conurbations on the East Coast had been hit directly as well.

Taiwan was hit by a tropical cyclone in 2001 too, and this caused unexpectedly high flood losses. Though almost ignored by the media, Typhoon Nari was the most expensive typhoon to date for the insurance industry in Taiwan. With insured losses of US$ 500m the financial dimensions of this catastrophe were close on the heels of the loss from the Chichi earthquake of 1999 (2,500 fatalities and an insured loss of US$ 750m).

One year previously, in September 2000, Japan had been hit by a “wet” typhoon. With record rainfalls of up to 540 mm in 24 hours in some parts of the country Typhoon Saomai was responsible for the worst floods for decades. Although Typhoon Saomai appears as a “non-event” in all typhoon loss simulation programs on account of the relatively low wind speeds, the insurance industry had to pay out a good US$ 1bn in flood losses.

In many Asian countries cover for windstorm and flood losses has only been common in mass business in the last few years (in Japan, for example, since the mid-1980s). Therefore, a simple extrapolation based on past losses (burning cost) and today’s liability circumstances often leads to the loss potentials being underestimated.

The track of Typhoon Nari, which in mid-September 2001 produced the worst flooding for years in the Taiwanese capital of Taipei. When it hit land for the second time – north of Hong Kong – intense and persistent rainfall produced further flooding and landslides.

Typhoon Nari, September 2001

The meteorological profile of Nari over Taiwan is quite similar to that of Allison.

– By the time Nari hit land northwest of Taipei it had weakened considerably, falling from hurricane force (wind speeds > 118 km/h) to gale force with wind speeds of around 100 km/h; even lower intensities were registered in Taipei.
– In the north of Taiwan precipitation exceeded 800 mm in 24 hours. The values recorded at many measuring stations were the highest since meteorological recordings began (around 1930).
– The windstorm losses were minimal, but the flood losses catastrophic:
  · The death toll was 93.
  · Almost all of the central part of Taipei was under water for days (the underground main railway station and some subway stations for weeks).
  · The overall economic loss was just under US$ 1bn, and (with a population in Taiwan of 22 million) the insured loss was US$ 500m.

The fact that extratropical low-pressure systems and storms can lead to severe floods was last demonstrated in the autumn of 2000 by a series of events in Great Britain. In October and November that year they presented the country with the worst river flooding since 1947; the insured loss (almost entirely from water damage) was just under US$ 1.1bn. Here too the position until recently was such that storm models only considered direct windstorm losses and accumulation considerations were often dominated by studies of the storm surge loss potential along the coastal regions. It is only in recent years that reinsurers and commercial consultants have begun developing models that facilitate a systematic estimate of accumulation losses and risk premiums from inland floods caused by "wet" storms.

25

In the case of commercial risks, the damage that floods inflict on stored goods and furnishings may far exceed the damage to buildings.

Winter storms and floods in Great Britain in October and November 2000

September had already brought heavy rainfall to England and parts of Wales, causing water levels to rise in many rivers. In mid-October two low-pressure systems (Imke and Heidrun) brought further heavy rain, followed by the first cases of flooding in the counties of East and West Sussex, Kent, Devon, and Hampshire. The flood situation had just begun to improve when on 28th October a tornado swept through the town of Bognor Regis on the south coast of England – a vanguard, so to speak, of the extreme weather events to follow. On 29th October a further intense low-pressure system (Oratia) formed over the Atlantic south of Greenland. It brought wind speeds of up to 160 km/h over England and Wales, with as much as 50 mm of rain falling in 12 hours in some places. This caused floods in many parts of Great Britain which in terms of their expanse and intensity were comparable with the historic events of 1947. On 6th November the next storm of the autumn (Rebekka) brought more than 20 mm of rain in 24 hours; this time it was not only areas in the southwest and southeast of Great Britain that were hit by floods but also Ireland and the northwest. (See also the catastrophe portrait “Autumn floods in Great Britain“ in topics Annual Review: Natural Catastrophes 2000.)

Climate change: Storms are becoming potentially rainier

“Wet” storms are not a new phenomenon. The hurricane catastrophe in Galveston in 1900 mentioned at the beginning was a “wet” storm as was, for example, Typhoon Vera (Isewan) in 1959, one of the greatest flood and storm surge events of the 20th century in Japan, with over 5,000 killed and 360,000 buildings destroyed by the masses of water.

The effects of climate change on windstorm events worldwide are still a matter of controversial discussion, even on scientific committees. Even the computer models used today do not permit climate modellers and meteorologists a reliable quantitative view into the future, as the birth and course of windstorms are extremely complex, dynamic processes in both spatial and temporal terms. There is no categorical scientific proof of an increase in windstorm frequency and intensity, for instance, even if such an increase is considered very possible.

There is more empirical support, on the other hand, for the forecasts made by climatologists on the future development of intense precipitation events. As the atmosphere becomes warmer throughout the world, it can absorb more water vapour, leading to a general increase in humidity. As a result, more water is stored in the cloud vortexes of the low-pressure systems of extratropical storms and tropical cyclones. The probability that storms will be accompanied by extreme precipitation increases. There is already proof of an increase in precipitation – and extreme precipitation – in many regions of the earth, e.g. in Europe and the United States.

Conclusion: Adjustments are needed in the insurance industry

Windstorm risk modelling and underwriting have in recent years concentrated on potential losses arising from the direct effects of the wind, and the consideration of "secondary perils" like flood has involved at most the application of standardized loadings.

What are the conclusions that the insurance industry must draw from these "wet" – and in terms of their loss potentials often underestimated – storms, and what significance do the forecasts made by climate researchers have as far as the risk of change from the windstorm hazard is concerned?

– Extending windstorm risk analyses (accumulation PML and risk premium pricing) by means of a more holistic observation that takes flood losses into consideration. This may be achieved by new methods in risk modelling – e.g. by amalgamating windstorm and flood models.
– Prospective consideration of scientific studies on the expected effects of global warming. The general increase in precipitation in the moderate latitudes during the winter half-year is now accepted as scientifically substantiated. Individual winter storms will accordingly become "moister", i.e. rainier. This is a fact that will influence windstorm losses in general and have a very significant effect on individual losses.

26

The drivers of these trucks in the middle of the road near Houston were caught unawares by the flash floods triggered by Allison. This example shows that when events occur suddenly, it is often impossible to take loss minimization measures.

Loss potentials Known/unidentified?

07

27 An example of unexpected losses is provided by the failure of the middle storeys of numerous buildings in the centre of Kobe during the 1995 earthquake. This picture shows the old part of Kobe City Hall; the high-rise building added in the 1980s suffered no damage.

28 At this location, in the centre of the island, the strength of the 1999 Taiwan quake (M = 7.7) came as a surprise to the experts. The probability of an event on the fault, which runs straight through the middle of the destroyed building, had been estimated to be once in 10,000–100,000 years.

Since the mid-1970s international reinsurers have increasingly been looking into the loss potentials arising from great natural catastrophes. But it was a man-made event that suddenly generated awareness of the associated problems: the terrorist attack of 11th September 2001. While turning the spotlight on unidentified loss scenarios in a quite unexpected and brutal manner, it also showed that – over and beyond the usual probability considerations – even worst case events are not to be excluded from the underwriters' view.

Unexpected loss events: past examples

Indirectly, of course, all accumulation risks – indeed all risks whatsoever – may be attributed to human activity, because if people or values were not exposed, there would be no loss of any relevance for the people or the economy. And the problem of unidentified or underestimated accumulation loss potentials, which manifested itself in such an extreme way in the WTC attack, is a problem that is also encountered in the insurance of natural hazards – in spite of the fact that it is now over 25 years since a control of the insured liabilities ("accumulation control") was initiated. The introduction of such a control was prompted above all by the earthquake in Managua, Nicaragua, in the year 1972. At that time it came as a shock to the insurance industry that an earthquake in a small Third World country could generate an insured loss of US$ 80m, which was to be carried almost exclusively by the international reinsurance market. There was a similar shock exactly two years later when Cyclone Tracy generated an inconceivable insured loss of over US$ 200m in the small North Australian town of Darwin. And there are too many potential catastrophe scenarios from the various natural hazards in the world to be immune to further surprises. The Managua and Darwin shocks have been followed by further shock events since 1972: as in 1989, when an earthquake generated an insured loss of US$ 670m in Newcastle, a town of medium size to the north of Sydney, Australia, and in 1994, when the Northridge quake in the northwest of Los Angeles caused an insured loss of US$ 15.3bn. These last two examples were earthquakes. But there has been no lack of meteorological catastrophe surprises either, beginning with the 1984 Munich hailstorm, then Typhoon No. 19 (Mireille) in Japan in 1991, and finally the 1999 winter storms, Anatol in Denmark and Lothar in France.

The surprise element: the causes

The element of surprise may have quite different and sometimes overlapping causes, as the following list shows.

Scientific:
– the “chance” occurrence of an event that is extremely rare in statistical terms (e.g. an earthquake with a long return period, such as the 1999 Taiwan quake with an estimated return period of 10,000–100,000 years)
– the occurrence of a hazard that is minor in statistical terms (e.g. volcanic eruption, meteorite impact)
– the underestimation of a certain type of hazard (e.g. severe storm, hail, snow catastrophe, heat wave)
– an unexpected chain of cause and effect (e.g. the flood wave in Longarone following a landslide into a reservoir, 1963)

Loss-related:
– structural (resonance) effects and deficiencies (e.g. the earthquakes in Mexico, 1985, and Kobe, 1995)
– underestimation of contents losses in the broadest sense (machines, processing plants, etc.)
– exploding repair costs following a major event
– unexpected loss mechanism and consequential losses (e.g. release of toxic substances from warehouses or production plants)
– unexpected business interruption losses and loss of income as a result of many different complex effects of breakdowns in the infrastructure (traffic, energy, water, communications, etc.) as in the case of Kobe, 1995, and Taiwan, 1999
– global chains of cause and effect, even including effects on the capital markets in the case of mega events
– significant drop in the price of investments (assets) in addition to the burden from reinsurance (liabilities)

Insurance-related:
– underestimation of the insurance density (e.g. Northridge, 1994)
– underestimation of the loss potentials from special insurance products (e.g. coverage of outside facilities and earthquake sprinkler leakage: Northridge, 1994)
– too broad a scope of cover or insufficient exclusions (e.g. suppliers’ risks or business interruption cover without the proviso of the affected object suffering a property loss: Taiwan earthquake, 1999; inclusion of fire following earthquake in standard fire covers as is customary in North America)
– deficits in claims settlement due to excessive numbers of claims (e.g. Northridge, 1994, and European winter storms, 1990)
– unexpected losses from non-property lines of business (e.g. Kobe, 1995)

IBNR (incurred but not reported) losses are a special category, of which the following are examples:
– the long-term damaging effects of corrosive gases as a result of a volcanic eruption (Montserrat, 1995–97)
– not immediately visible and thus not initially discovered damage to steel-frame high-rise buildings (Northridge earthquake, 1994)
– large numbers of late claims for minor damage (again Northridge, 1994)

These insurance-related criteria apply, of course, to man-made and technological catastrophes too, e.g. to the WTC event in non-property lines of business, with life, health, and personal accident insurances accounting for an extremely large share of the insured loss, a fact that is certainly to be considered with regard to large earthquake catastrophes in correspondingly developed insurance markets.

In many a case the actual extent of loss will only become evident weeks, months, or even years after the event. The gravest example of this is still the Northridge earthquake (cf. chart: Development of insured losses). In this case the overall loss increased within the space of 12 months from an originally estimated US$ 1–2bn to US$ 10.4bn, a figure that was finally raised again to its current position of US$ 15.3bn in 1998. Incidentally, the belatedly discovered damage to the steel-frame buildings played a relatively minor role compared with the huge number of claims that were reported extremely late. There are a number of examples that may be quoted in the windstorm sector. Typhoon Bart, which hit Japan in September 1999 was – at US$ 3.5bn – the largest insured loss of the year but was completely overshadowed in the media by the much more spectacular earthquake in Turkey. And in 2001 there were two such events: the hailstorm in Kansas City, which, after being long neglected by the media and even by the insurance industry, has since advanced to become the largest severe storm loss in insurance history at US$ 1.9bn, and Typhoon Nari in Taiwan, which in September 2001 generated an insured loss as large as the Chichi earthquake of 1999 but was eclipsed in the media by the WTC attack.

Transparency – essential for successful risk management

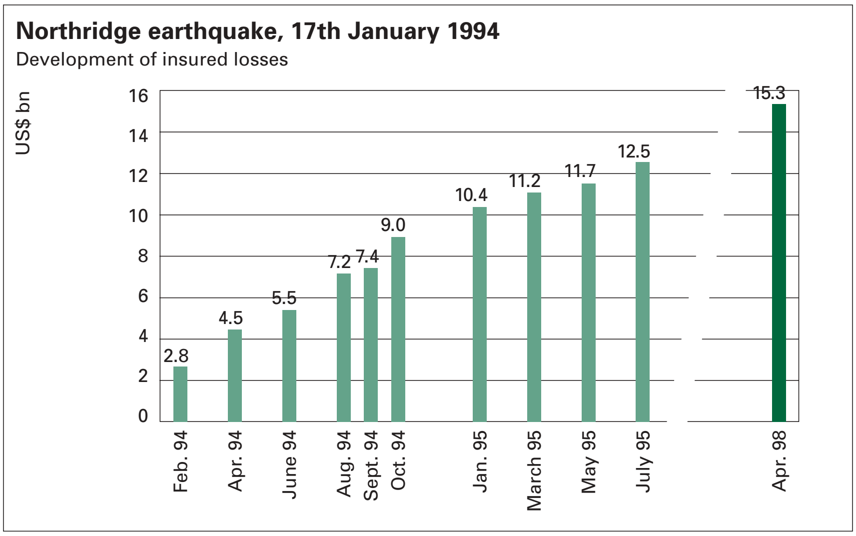
Because of the convoluted chains of cause and effect between natural events and their consequential losses it will never be possible to completely eradicate the uncertainties that exist with regard to unidentified or underestimated loss scenarios in the sector of natural hazards. Nevertheless, striving to achieve this ideal is in itself an indispensable step towards calculating realistic probabilities of ruin and minimizing the overall risk from the insured business, particularly where (insurance) companies with worldwide operations are concerned. The keyword for eliminating "bare patches" on the "risk landscape" is transparency with regard to all of the elements discussed here.

- Knowledge of locally significant catastrophe hazards and the degree of exposure
  Munich Re's natural hazard information system NATHAN (Natural Hazard Assessment Network) represents a crucial step in this direction. In terms of catastrophe scenarios it should be mentioned that rare types of event like volcanic eruption have hardly been examined to date. The only exception is an estimate of the overall economic loss for Naples, which comes to about US$ 40bn. Auckland in New Zealand is possibly the most significant case as far as underwriting is concerned, being located in the centre of an active volcanic area with almost total market penetration. The latest investigations put the return period of an eruption in the 1,500 year range. We refer you to the article on the subject of meteorites.
- Knowledge of the liability situation in all the relevant lines of business with an appropriate degree of detail in terms of the spatial resolution and the types of risk covered
  The desirable transparency and quality of accumulation reports is only seldom attained and needs constant improvement even in the fire sector, the line of business which may be assumed to account for the lion's share of losses caused by natural catastrophes. This applies even more to lines of business like engineering, marine, and aviation – and above all to insurances of the person (life, health, workers' compensation). Calculating the accumulation PMLs for these lines also makes special demands in terms of the method adopted, particularly in the case of non-stationary risks.
- Knowledge of the terms and conditions of insurance, especially the scope of cover and the limits of liability
  Of particular significance in this respect is firstly the automatic inclusion of what are called "allied perils", which may effectively represent a high accumulation loss potential. This applies namely to markets under Anglo-Saxon influence (e.g. Australia with the real-life example of the Newcastle earthquake in 1989 and a substantial accumulation loss potential from earthquake in the Greater Sydney area – analogous to South Africa with Johannesburg being the main accumulation area as regards severe storm and earthquake – as well as Singapore, which could easily be hit today by – historically validated – long-distance quakes of high magnitudes). The second important aspect is the inclusion of fire following earthquake in standard fire covers. In conjunction with a low market penetration of earthquake cover (as in eastern Canada) this results in the earthquake PML being distorted in extreme cases and becoming an – unnoticed – fire PML. The third aspect is the exact scope of cover under BI policies, in particular the cover of possible suppliers' risks, which may lead to the effects of what are in fact only local events being "globalized".

– Knowledge of the vulnerability of the insured portfolio
The great hurdle in this connection is either the lack of useful loss data as such or the discrepancy between detailed loss data and aggregated liability data in terms of the spatial resolution or the types of risk involved. Even when the loss data are excellent, this discrepancy does not permit the derivation of average loss rates including policies that are not affected. As to the losses themselves, however, the statistical documentation of such important earthquakes as Japan in 1995 and Taiwan in 1999, which would be so important for the assessment of industrial risks, is inadequate. Theoretical methods of loss assessment, including, for example, the superimposition of structures' stress and capacity curves, can only partially replace empirical processes, particularly if only aggregated portfolio data are available.

Conclusions

The most extensive possible identification of unknown loss potentials calls for a rigorous interdisciplinary application and collation of scientific, engineering, and underwriting specialist knowledge. Worst-case scenarios should not be generally excluded from such an integrated view either. Only on this basis will it be possible to produce a more or less complete "risk map" and take appropriate precautions for gigantic loss events, both natural and man-made.



Sources: Insurance Information Institute, ISO/PCS reports; Munich Re NatCat*SERVICE*

Development of the Northridge loss: Six months after the event less than half – and a year later only two-thirds – of the ultimate loss was known. Note the significant adjustment more than four years after the quake. In this respect then natural catastrophes may also assume the features of long-tail losses.

In this connection it should be mentioned that the return periods observed for individual accumulation scenarios – of 1,000 years, for example, or even less – conjure up a picture of false security. There are two reasons for this, the first being on account of the many different possible scenarios that substantially increase the overall probability of corresponding losses, and secondly because insurance markets should also be able to cope with statistical "outliers" with much higher losses and a lower occurrence probability.

Meteorites (Another) underestimated accumulation risk?

08

"Too improbable", "too catastrophic", "probably not insured ", "irrelevant to the insurance industry": all these are answers the majority of risk managers in the insurance industry might have given if they had been asked about the risk of accumulation from meteorite impact – at least before the terrorists attack of 11th September 2001, which generally resulted in a radical reconsideration of loss potentials.

A technically sound, all-embracing, and reliable assessment of the probability of material from outer space hitting the earth and the extent of damage this would cause is still a very difficult matter because of our limited knowledge of these potentially threatening extraterrestrial objects and the inadequate transparency of insurers' liabilities. Nevertheless, analyses of the hazard and the scope of cover give some indication of the accumulation risks that exist. The mere processes of estimating the magnitude of loss potentials and then approximating the occurrence probabilities are capable of revealing the preparedness measures that may be necessary or, in the most favourable case, of providing a more solid foundation for the feeling of "not having done anything wrong".

The scientific analysis of the meteorite impact risk must first address the sources of bombardment from space:

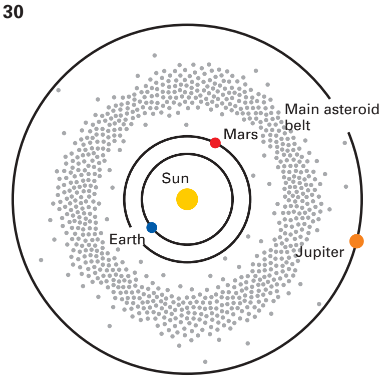
– **Comets**
On account of their bright appearance, comets are the most familiar objects in the night sky apart from the stars. They have a hard nucleus comprising various types of ice (frozen water accounting for about 80%, with smaller quantities of frozen carbon monoxide and carbon dioxide and methane ice) and particles of rock and dust. They are aptly described as "dirty snowballs". As they approach the sun, the ice begins to evaporate, forming what is called the coma, a cloud of gas and dust. Even closer to the sun they develop an often clearly visible tail of dust and plasma (shining electrons and ions). The particles of dust and the small stones may be seen in the form of bright meteors (shooting stars) when the earth crosses the comets' track and they burn up in the earth's atmosphere.

– **Asteroids**
It was not until the 19th century that astronomers searching for a planet between Mars and Jupiter discovered "curious small bodies" in the solar system. The first of these planetoids, also known as minor planets or most commonly asteroids, was discovered in 1801 from a point in Sicily and was given the name Ceres after the Roman goddess of agriculture.

With a diameter of 948 km Ceres is still the largest known asteroid even today. In the meantime astronomers have discovered almost 150,000 asteroids and have determined the orbits of about 30,000 of them. They are to be found above all in relatively circular orbits between Mars and Jupiter in what is known as the main asteroid belt.

In 1932 a small asteroid was observed flying outside the main belt on an elongated ellipsis and coming dangerously close to the earth. Since then about 1,500 of these near-earth asteroids (NEAs) have been discovered, including 500 so-called "killer asteroids" with a diameter of more than a kilometre. All asteroids have one thing in common: on their way around the sun they cross the orbit of at least one planet – including the earth – and can change their orbits under the influence of the gravitational pull of the sun and other planets and as a result of colliding with other asteroids. The "end of life" for the majority of asteroids is known too: impact on one of the planets in our solar system (including the earth) or on the sun.

30



The inner solar system with the planet Jupiter. Between the orbits of Mars and Jupiter is the main asteroid belt, in which about 150,000 asteroids circle the sun. The greatest risk of impact for the earth comes from objects that are even further inside the solar system.

29 The comet Hale-Bopp over the Bulgarian town of Varna on 11th March 1997. Just a few days later, on 22nd March 1997, Hale-Bopp reached its nearest point to Earth at a distance of almost 200,000,000 km.


31

The heaviest single meteorite ever found on earth was discovered at Hoba (Namibia) in 1920. This object is mainly of iron and weighs around 60 tonnes.


32

It was not until 20 years after the Tunguska event in 1908 that the first expedition went into the area of this meteorite crash, the most significant of the 20th century, but the destruction in the forests is still clear to see. The trees' direction of fall radiates from the centre of the impact.

– **Space rubbish**
In addition to these natural objects circling the sun there is also a great deal of space rubbish (old satellites, rocket stages, waste from space stations) in near-earth orbits. In order to dispose of these products of technology, they are usually taken to an orbit in which they move away from the earth under their own volition. If this is not possible (because they do not have or no longer have any power) a controlled crash may be a wise and technically feasible loss prevention measure, and this was the solution chosen in the case of MIR, the Russian space station, in the spring of 2001.

Threat/exposure

Every day about 100 tonnes of dust and small stones reaches the earth's atmosphere from space. Most of these particles burn up in the atmosphere and are seen as shooting stars; the rest are so strongly decelerated that they reach the ground at a relatively low speed. Only larger objects (with a diameter of several metres) are able to survive their flight through the earth's atmosphere largely intact; then they hit the earth with a wide range of effects – including damage of epochal dimensions.

– Direct effects of impact (without any major heat or shock wave)
It is only when meteorites have a diameter of no more than a few metres that the damage is limited to the direct effects of the impact. The extent of damage is not widespread, but personal injury and property damage may be severe (including the total destruction of buildings).

– Pressure/shock wave (usually forming a crater formed when the object hits the earth)
Large projectiles always push a wave of (air) pressure ahead of them. The loss area will then be many times larger than the diameter of the descending object. One of the most well-known events of the more recent past is the crash of a 30-m to 60-m meteorite over Siberia on 30th June 1908. It exploded at a height of 6 to 8 km over the Tunguska region, and the shock wave either disbranched or felled all the trees in an area of forest measuring approx. 2,200 km² (equivalent to the areas of Berlin, Moscow, and London added together).

About 40 years later (1947) a much smaller meteorite of iron burst in the air over the Sikhote Alin mountains (also in Russia) and created about 120 small craters with diameters of up to 30 m.

– Heat wave
When entering the earth's atmosphere, all celestial bodies heat up as a result of friction with the atmosphere. As a result they radiate heat. The compressed air in the pressure wave heats up too. The resulting heat wave may lead to buildings catching fire that were not directly affected by the impact or the pressure wave.

– Sea wave
When a large meteorite crashes into the sea – the probability of the oceans being hit is 71%, equivalent to their share of the earth's surface – the pressure wave and the impact may cause sea waves similar to tsunamis after seaquakes. Although no damage is caused where the celestial body hits the ocean, the area in which flood damage may occur as a result extends to a large proportion of distant coastal regions.

– Earthquake
Although this aspect has not been sufficiently investigated, the possibility of an earthquake being "artificially" triggered by the impact of a celestial body cannot be ruled out. However, computer models show that it is only when very large meteorites with a diameter of more than 1 km impact the earth that a shock wave is created which is capable of running through the globe and being registered throughout the world as an earthquake.

– Climate change ("nuclear winter")
The effects of bodies with a diameter of more than 1 km may well take on epochal proportions due to other kinds of interaction with the earth and its atmosphere. When passing through the earth's atmosphere, such "global killers" create a shock wave travelling at supersonic speed. The body explodes on impact with the earth's surface, and both it and the impact site evaporate, this being the main cause of the subsequent global catastrophe. Widespread fire storms are caused by the overheated air and destroy a large proportion of the surrounding biomass. Within seconds a crater is formed, some twenty times as big as the meteorite itself. The rising rock vapour reaches into the stratosphere, spreading over the entire planet and "darkening" the sun. Temperatures on the earth's surface drop because of the lower irradiation levels, and throughout the world it is winter (like in the "nuclear winter" that could be caused by large nuclear explosions). It may take months or even years for the dust particles to be gradually washed out of the atmosphere or drawn down to the ground by gravity. Besides the temperature, photosynthesis is also reduced. On the other hand, the lower oxygen content (and consequently the higher carbon dioxide content) in the air reinforces the greenhouse effect in the atmosphere. The coincidence of impact winter and greenhouse effect may result in a massive change in the global hydrological cycle (evaporation – precipitation – evaporation).

Further damage is caused by acid rain. As the body passes through the atmosphere, large amounts of air molecules are ionized. The resulting precipitation has a high concentration of nitrogen (nitrous acid), which is enhanced by other impact-induced interaction with the air (fusion, rock vapour), and changes all the surface water into a corrosive acidic fluid. The nitrous oxides remaining in the atmosphere destroy the ozone layer, which protects the earth against UV radiation.

The Barringer crater in Arizona, United States. The desert climate preserved the 50,000 year old crater so well that it suffered hardly any erosion. It is about 1,200 m in diameter.

A Russian postage stamp issued in 1957 to mark the tenth anniversary of the Sikhote meteorite crash (1947). The illustration is based on an eye-witness account by the artist P.I. Medvedev, who saw the crash from the town of Iman.

– Scientists are now convinced that this is a scenario that took place about 65 million years ago – on the threshold between the Cretaceous Age and the Tertiary Age. It was triggered by the impact of a meteorite with a diameter of probably 10 km in what is now Mexico. It was not until after 1990 that the submarine crater of Chicxulub off the Yucatan Peninsula revealed the extraterrestrial cause of the global extinction of animals (including the dinosaurs).

The underwriting aspects, i.e. in particular the types of cover for the results of impact under the common property insurance concepts, may be summarized as follows:

Direct effects of impact

Especially in the case of small meteorites, it is only the direct impact that has destructive effects. As to the question of insurance cover, a distinction must be made between all risks and named perils policies:

– All risks covers
The customary terms and conditions do not specify any exclusion of meteorite impact; as a rule, therefore, insurance protection exists.
– Named perils covers
The policy wording must be examined very carefully. Insurance policies in Anglo-Saxon markets often refer to "loss, destruction or damage directly caused by pressure waves resulting from any aircraft or other flying object travelling at or above the speed of sound ...". Such a wording would

35

The Leonid meteor shower over Jordan on 18th November 1999. The traces of light come from particles of the comet Temple-Tuttle, which orbits the sun on an elongated ellipse every 33 years. The Leonid shower is named after the constellation of Leo, from which the meteor particles appear to come (in fact they fall parallel to the track of the comet). Meteor showers represent a hazard to space vehicles and satellites that is not to be neglected.

suggest that meteorite crashes are covered. Other policies make a distinction between manned and unmanned aircraft in the cover they provide, which would make it necessary to look into whether a meteorite could be conceived to be an unmanned aircraft. Within the scope of this article it is not possible to enter into a full discussion of all the aspects that need to be considered, but we would draw the reader's attention to the following questions:

- Do "unmanned flying objects" have to be manufactured or could they be of natural origin?
- Do " flying objects" have to have a ballistic or aerodynamic trajectory or could a body be called a flying object if it fell down without being guided?
- Supplementary descriptions like "aircraft, its parts or cargo" would suggest that the user of such a wording wanted to describe an object that can be loaded with goods. This would clearly rule out meteorites.

Fire

If a fire results from a meteorite impact, this is usually covered under all the common named perils policies. The same applies to all risks covers. Fire is one of the main insured perils and there are practically no exclusions for meteorite impact.

Explosion

If a meteorite hits the earth's surface or bursts in the atmosphere, this may be viewed as an explosion. If one concurs with this view, one will approach the issue of cover in the same way as when classifying the phenomenon under the aspect of fire, i.e. that insurance protection is given under named perils and all risks policies as long as the peril is not expressly excluded.

Sea wave and earthquake

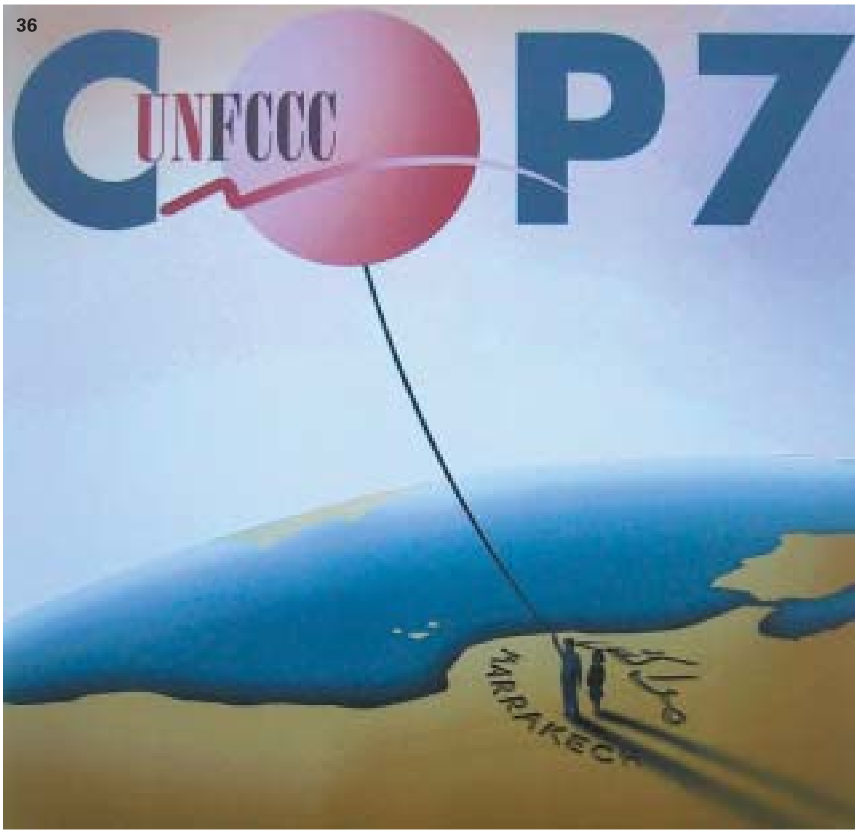
As described above, meteorites can trigger sea waves and even earthquakes. There is no general answer to the question of cover for these consequences of impact. These perils are not standard components of named perils and occasionally they are excluded or limited in all risks policies. Insofar as cover is expressly given (in the case of named perils) or no exclusion of earthquake or sea wave (tsunami) has been agreed upon (in the case of all risks policies), it must be assumed that these effects of a meteorite impact are insured.

Conclusion

With the exception of pure impact and pressure wave losses, the destructive results of meteorite impact are by and large included in the scope of cover of the terms and conditions of insurance generally used throughout the world. The occurrence probability is very low, it is true. Nevertheless, if a densely populated area were directly hit by a meteorite or by a sea wave after a meteorite crash, this could result in a loss accumulation of previously unknown dimensions. The insurance industry must consider whether, in the light of this substantial threat, it is equipped to deal with such a scenario – which is to be doubted. Simply pointing to the presumable rarity of such events should no longer suffice in the light of recent experience.

After all, there were around 100 documented meteorite crashes on earth between 1900 and 2001; the biggest of these was the Tunguska event in 1908, which affected an area measuring 2,200 km^2.

Climate negotiations 2001 The struggle over the Kyoto Protocol 09



The official poster for COP7, the world climate summit hosted by Marrakesh in November 2001 (UNFCCC: United Nations Framework Convention on Climate Change).

It was tough going in November at the seventh world climate summit in Marrakesh (Conference of the Parties/COP7), but the outcome of the negotiations was positive. The Kyoto Protocol, the important first step towards global climate protection, was ready for signing at last.

It had been a tense and difficult affair. Two world climate summit meetings were needed in 2001 to negotiate the fate of the Kyoto Protocol. After the failure of COP6 in The Hague the previous November (cf. topics Annual Review: Natural Catastrophes 2000) the delegates came together in July to rework the disputed points in the protocol in such a way that they could be accepted by all the parties to the treaty worldwide. In the wake of President Bush's official announcement in the spring of 2001 that the United States would withdraw from the negotiations until further notice, it was particularly important for countries like Australia, Japan, Canada, and Russia to come up with arrangements that would facilitate a consensus. The contribution each individual country makes towards the Kyoto process will be decisive for its success. The climate protection protocol drawn up in Kyoto, Japan, in 1997 states that by 2012 the largest industrialized countries numbering almost 40 should reduce their emissions of greenhouse gases by an average of 5.2% in comparison with their 1990 values. For this protocol to become binding under international law, it has to be signed by 55 countries that account for at least 55% of the greenhouse gas emissions in industrialized countries.

The follow-up summit in Bonn (COP6b) in July 2001

The interim round of negotiations in Bonn addressed a number of major points that had not been settled at COP6 like the counting of CO_2 sinks. Another outstanding point was the question as to what should happen if individual countries failed to meet the reduction targets (Compliance Regime). As it turned out, however, a solution to this problem was not found in Bonn either. Nevertheless, this follow-up summit was regarded as a success. The most important results were:

Poorer countries can receive money from funds for environmental and climate-friendly measures.

These countries have no obligations to meet as far as climate protection is concerned – at least not before 2012. This means that the reductions in emissions must be achieved by the industrialized countries alone, the argument being that at the end of the day these are the countries which are mainly responsible for man-made climate change.

The protocol stipulates that nuclear energy can no longer be traded for emission reductions. Supporting the development of nuclear energy was considered unacceptable until such central issues as the disposal of radioactive waste have been solved.

Forest areas and certain agricultural methods may be counted in the future and will be recognized as CO_2-absorbing measures, or "CO_2 sinks" as they are called. This new ruling is of particular advantage to countries with an abundance of forests because it will help them to meet the reduction targets set in the Kyoto Protocol. Against the backdrop of a further increase in CO_2 emissions since 1990 in nearly all countries of the world (the exceptions being the United Kingdom, Germany, and Luxembourg) it is clear that this ruling will be a major help to many countries. It also means that, on the basis of new calculations, countries with huge areas of forest like Russia (Kyoto target: +/-0%) and Canada (Kyoto target: -6%) will even be able to increase their emissions considerably (Russia: approx. +4%; Canada: approx. +5%).

Climate experts and environmental groups criticize the inclusion of forests and green areas, arguing that it will lead to the reduction targets being lowered globally by more than 5% to below 2%. The general mood at the end of the follow-up summit in Bonn was nevertheless positive since it did achieve the ultimate aim of keeping the Kyoto process going. Without the compromises that were made, a continuation of the conferences between the treaty countries would have been more than uncertain.

The climate summit in Marrakesh (COP7) in November 2001

The main gist of the comments expressed at the end of the Marrakesh negotiations was that although the meagre results would hardly help the climate, the Kyoto Protocol, which was considered an important signal, was at long last ratifiable. It took marathon negotiations to reach a consensus on the central problems:

The details of the much-discussed CO_2 sinks were settled and made binding.

A solution to the question of control mechanisms and sanctions was found. Countries that do not meet their obligations (CO_2 reductions) will face sanctions. If, for instance, the agreed targets are not met in one period, even higher CO_2 savings will be required in the next.

Prospects

With around 170 countries agreeing to an extensive catalogue of measures, the Kyoto Protocol is now ready for implementation – even without the United States, which in 1990 accounted for about 36% of CO_2 emissions in industrialized countries. Climate change is no longer disputed by George W. Bush – as he announced in June 2001 in the light of a study carried out by the National Academy of Sciences (NAS) at the request of the Bush administration. Nevertheless, there is little likelihood of the United States rejoining the Kyoto process.

Important key countries like Japan, Russia, and the EU members are now prepared to ratify the protocol. Some countries, including the EU member states, have already launched the process. This means that systems can at last be set up for cross-border emissions trading.

The new framework will probably encourage large sections of the economy to save energy or use it more efficiently. If it emerges that climate-friendly development creates market opportunities and jobs, this could even lead to a boom in climate protection.

All the same, it will obviously not be easy to meet all the targets in the very near future, with CO_2 emissions having increased by a further 8% since 1990.

Underwriting strategies

One thing we must be aware of is that even if the Kyoto Protocol is implemented in full, the emission of greenhouse gases will result in our having to contend with the effects of climate change for decades to come in the form of more frequent and more intensive natural catastrophes. Since they carry the main burden of the losses from weather-related natural catastrophes, reinsurers must therefore consider whether their current underwriting strategy will be commensurate with the developments. In view of the loss trends that are observable their past practice of retrospective underwriting – which involves calculating premiums from historical claims development – inevitably leads to premiums lagging behind and hence results in losses. The insurance industry must think about how risk-commensurate fluctuation loadings can be calculated for the risk of change inherent in climate change and must at long last adopt a policy of adequate prospective underwriting.

Geoscientists at American Re Our partners in North America

10

American Re is one of the market's three leading reinsurers in the non-life sector on the American continent. In 1996 it became a member of the Munich Re Group, and since then we have been working with our colleagues there in the Catastrophe Management Group (CMG), which covers the following areas for the United States:

– Catastrophe and loss modelling, loss investigations after major events
– Analysis and optimization of reinsurance programmes, development of tailor-made reinsurance solutions for clients
– Consulting services and support in specialist questions that relate to the wide spectrum of natural hazards

The tasks performed by the geoscientists at American Re include analysing natural hazard events. This satellite image shows Hurricane Michelle off the south coast of the United States (November 2001).

The CMG team was reinforced in recent years by two scientists:

– Mark Bove is a meteorologist and has for a number of years been conducting research into climate change with special emphasis on the ENSO phenomenon, because the alarming effects of El Niño and La Niña in North and South America are subjects to which the insurance industry is giving increasing attention. Mark Bove is also an expert on natural hazard modelling and special issues such as weather derivatives.

– Hjörtur Thrainsson is a structural engineer focusing on seismology. During his long years of research in California he acquired specialist knowledge in the field of the damaging effects of earthquake on buildings and is acclaimed in the United States as a recognized expert. Hjörtur Thrainsson is also intensively concerned with risk modelling.

Both of these experts work together with us on various research projects and make a valuable contribution to our work, which is supported by their intimacy with the market and their good contacts in scientific committees in the United States.

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