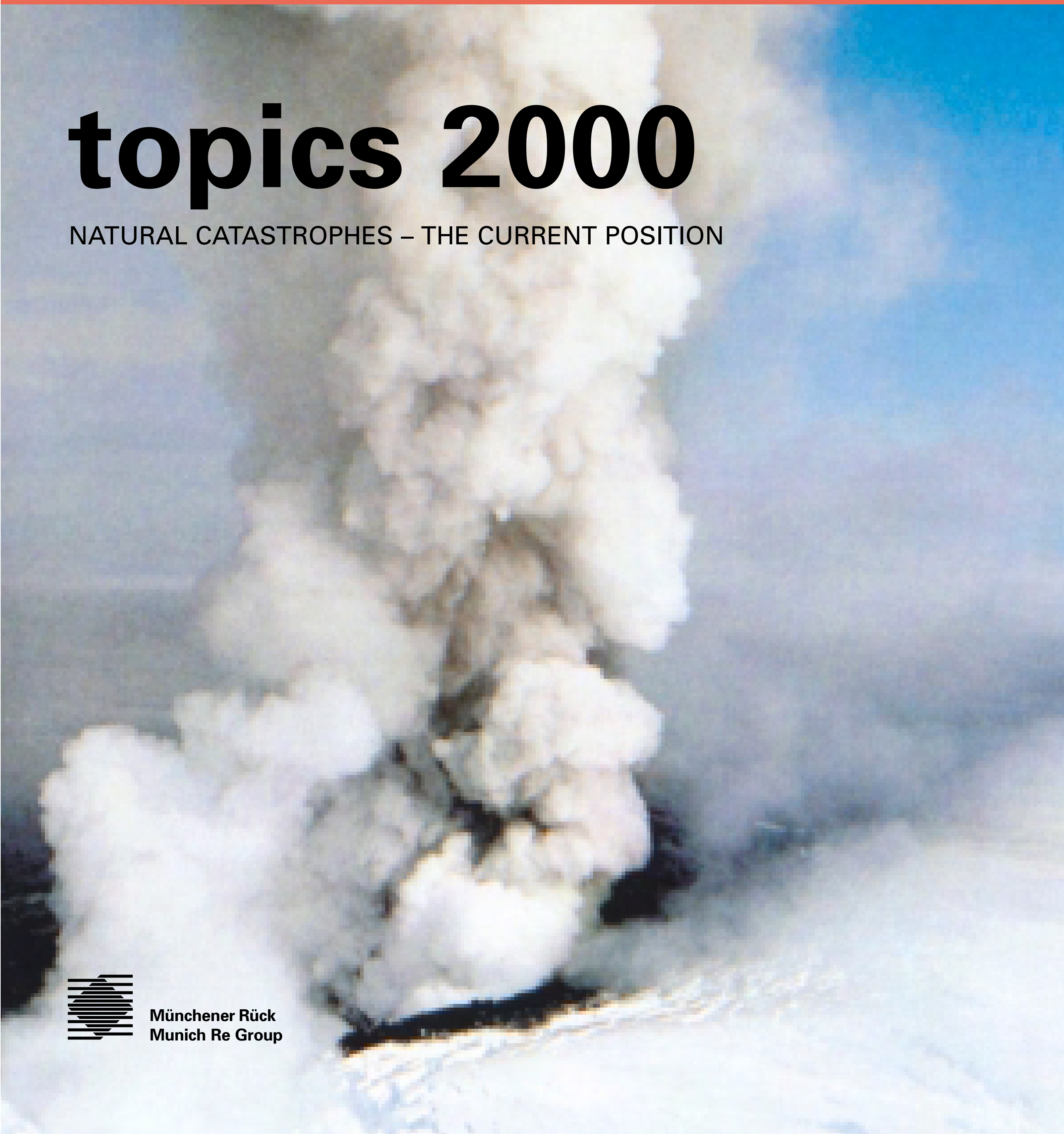
Special millennium issue

The great natural catastrophes of the 2nd millennium and the 20th century | Population development and urban growth | The vulnerability of modern societies to catastrophes | Changes in climate and environment | From the fire map to hurricane real-time simulation

topics 2000

NATURAL CATASTROPHES – THE CURRENT POSITION



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Contents

Editorial

At the end of a century – and now at the end of a millennium – it is appropriate but also essential to look back upon the events and developments of the past and to see what lessons and prognoses can be derived from them for the future. Of course, the situation we are in resembles that of a driver who approaches a wall of fog and, having only a vague impression of the stretch in front of him, looks into the rear mirror in an attempt to see in the clear view of the road behind some indication of what lies ahead. Let us hope that in adopting this approach, we are not on collision course with disaster.

For the stretch of road we are on is a dangerous one. The obstacles come in the form of natural catastrophes that are constantly growing in size and are occurring at ever-diminishing intervals and there are some drivers on this earth that, instead of stepping on the brake, are putting their foot down firmly on the accelerator – and are even taking on more passengers at the same time.

But the only thing we can do is place our trust in a certain continuity of development and use the knowledge we have gained from the recent past as a basis for extrapolating the future. As far as the subject of natural catastrophes is concerned, it is helpful for us that some of the main factors in the trend towards dramatic increases observed in recent decades, such as population growth and urbanization, are in fact developing at an extremely constant rate which is not expected to undergo any rapid change in the near future. Other factors, on the other hand, like the vulnerability of infrastructures, insurance density, and also environmental and climatic influences may well change abruptly and could "catch us on the wrong foot". This makes it all the more important for us to become aware of the potential range of fluctuations in our prognoses, i.e. the probability of error, and to take precautions for dealing with potential surprises and extreme variations.

One thing is certain: precise forecasting of major natural catastrophes years in advance with details of the size and location and the exact date is not to be

The Geoscience Research Group

01

expected in the foreseeable future. The intention we pursued in writing this special publication was therefore to draw together the most important aspects of catastrophe accumulation in a collection of essays written by the experts responsible for the various areas in Munich Re's Geoscience Research Group and to provide a detailed overall impression of the catastrophe hazard past and future.

We have also attached particular importance to a thorough compilation and documentation of major natural catastrophes in the last one hundred and, wherever possible, the last one thousand years, in order to present a complete picture of the entire range of extreme natural events in the various regions of the world and of their damaging effects. An even higher degree of accuracy has been attained in our compilation of information on major catastrophes in the last 50 years, thus permitting a reliable analysis of trends and – finally – in our collection and analysis of all the information that is available on loss events caused by natural hazards anywhere in the world in the last 15 years, which represents the pinnacle of our endeavours towards a complete analysis of losses by type of hazard and by country. All in all we hope to present our clients and readers with a uniquely comprehensive discussion of a subject we are convinced will be a greater challenge to mankind's identity and sense of responsibility in the 3rd millennium than almost any other. The insurance industry will be confronted with immense tasks and it will only be able to master them if it identifies future developments at an early stage and devises innovative and prospective solutions for them.

This special issue is the latest in our long-running series of annual reviews of natural catastrophes and covers the events that occurred up until the end of October 1999. In the future, too, we will inform you each year – in this new layout – about current developments and interesting topics.

Dr. rer. nat. Gerhard Berz

NATURAL CATASTROPHES ON THE VERGE OF THE NEXT MILLENNIUM: ARE THE LOSSES CONTINUING TO INCREASE?

Natural catastrophe statistics

IN THE PAST ONE HUNDRED YEARS, MORE THAN 50,000 NATURAL CATASTROPHES OCCURRED THROUGHOUT THE WORLD AND CLAIMED THE LIVES OF OVER FOUR MILLION PEOPLE. AND THIS FIGURE DOES NOT EVEN INCLUDE THE DROUGHTS AND FAMINES THAT CAUSED SUFFERING TO MANY MORE MILLIONS.

Munich Re's Geoscience Research Group has been collecting and analysing information on natural catastrophes throughout the world for more than 25 years. A central element in this catalogue of data, which goes far back into history, is the **NatCat*SERVICE* database,** in which losses due to natural hazards have been systematically recorded since the mid-1980s.

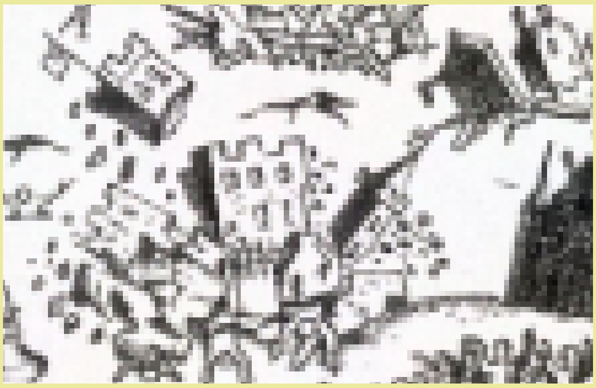
In this special issue in our series of annual catastrophe reviews we take the changeover to the new millennium as an opportunity to trace **the history of catastrophes over the past one thousand years** and at the same time to examine the last decades in the greatest possible depth with a view also to highlighting recognizable trends. It stands to reason that as far as the historical events are concerned, we can only turn the spotlight on a few of the really huge catastrophes. It is inevitable too that in our review of the last millennium we focus on the number of fatalities (page 10).

Evaluations on a quantitative monetary basis and examinations of trends, on the other hand, really only make sense from the middle of the 20th century onwards. In this publication we present two different analyses: The first covers all **the loss events we have registered since 1985** broken down by continent and type of event. This provides a global view of everything that has happened (page 64). The second, our trend analysis, is restricted to **great natural catastrophes** since 1950, because an examination of all the loss events in this period would inevitably include the minor ones as well and would consequently show an increase that is purely due to the proliferation of data available.

In this context, 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. **Great natural catastrophes can be analysed very well in retrospect** because even records that go back several decades can still be investigated today. And this is why trend analyses make so much sense in this connection (page 40).

A list of the **largest loss events in insurance history** rounds off the statistical section (page 44).

1000-1899

Major natural catastrophes from the 11th to the 19th century

■ Fatalities

< 1,000,000 fatalities

< 500,000 fatalities

< 200,000 fatalities

< 80,000 fatalities

21.8.1042
Syria,
Palmyra
Earthquake
■ **50,000**

< 50,000 fatalities

17.9.1303
China,
Linfen
Earthquake
■ **200,000**

January 1281
The Netherlands,
IJsselmeer
Storm surge
■ **80,000**

27.9.1290
China,
Shangtou
Earthquake
■ **100,000**

January 1362
Germany,
North Sea
Storm surge "Grosse Manndränke"
■ **100,000**

November 1421
The Netherlands,
IJsselmeer
Storm surge
■ **100,000**

1268
Turkey,
Cilicia
Earthquake
■ **60,000**

December 1287
Germany,
North Sea
Storm surge
■ **50,000**

20.5.1202
srael.
Lebanon.
Jordan.
Syria
Earthquake
30,000

23.1.1556

China,
Shaanxi
Earthquake
■ **830,000**

25.10.1622

China,
Anxiang
Earthquake
■ **150,000**

25.7.1668

China,
Shandong
Earthquake
■ **50,000**

20.9.1498

Japan,
Tokai
Earthquake
■ **41,000**

26.1.1531

Portugal,
Lisbon
Earthquake
■ **30,000**

14.1.1668

Azerbaijan,
Shemakha
Earthquake
■ **10,000**

1887
China,
Henan
Flood
■ **900,000**

7.10.1737
India,
Calcutta
Cyclone
■ **300,000**

12.9.1850
China,
Sichuan
Earthquake
■ **300,000**

October 1876
Bangladesh,
Bakarganj
Cyclone
■ **215,000**

8.10.1881
Vietnam,
Haiphong
Typhoon
■ **300,000**

30.11.1731
China,
Beijing area
Earthquake
■ **100,000**

1852
China,
Henan
Flood
■ **100,000**

June 1882
India,
Mumbai
Cyclone
■ **100,000**

11.1.1693
Italy,
Catania
Earthquake
■ **60,000**

3.1.1739
China,
Ningxia,
Yinchuan
Earthquake
■ **50,000**

8.1.1780
Iran,
Tabriz
Earthquake
■ **50,000**

4.5–15.7.1815
Indonesia
Eruption of
Tambora
■ **56,000**

June 1822
Bangladesh,
Bakarganj
Cyclone
■ **50,000**

5.10.1864
India,
Calcutta
Cyclone
■ **50,000**

26.4.1721
Iran,
Tabriz
Earthquake
■ **40,000**

1.11.1755
Portugal,
Lisbon
Earthquake
■ **30,000**

October 1780
West Indies:
Barbados,
Guadeloupe,
Martinique
Hurricane
■ **24,000**

20.5–28.8.1883
Indonesia,
Java, Sumatra
Eruption of
Krakatoa,
tsunami
■ **36,400**

02
Even today earthquakes are still considered to be the most terrifying of natural events because of the feeling of impotence and absolute helplessness they engender among victims. In past times earthquakes were frequently ascribed to the wrath of the gods. This drawing depicts a scene from ancient Japan, where victims confront the catfish (namazu), considered responsible in this country for destructive earthquakes, with anger and resentment.

03
This contemporary engraving from Jamaica shows the destruction of Port Royal. Today it is known that this settlement was built on massive gravel and sandstone sediments, which was the main cause of the total devastation following an earthquake in 1692.


03


04


05

04

The top-left picture shows the destruction of Lisbon after the major earthquake of 1755. Over 30,000 lives were lost as a result of buildings collapsing, conflagrations, and tidal waves, which were referred to as the "the great plagues" in those days. On the basis of present-day calculations, the earthquake reached an historic magnitude of 8.75 on the Richter scale.

05

This historical illustration of the German North Sea coast bears impressive witness to the huge destructive power of the sea. In February 1164, at a time when storm surge protection was practically unknown, some 20,000 people perished in the Julian Flood. The "Grosse Manndränke" of January 1362 is reputed to have claimed the lives of no fewer than 100,000 people.

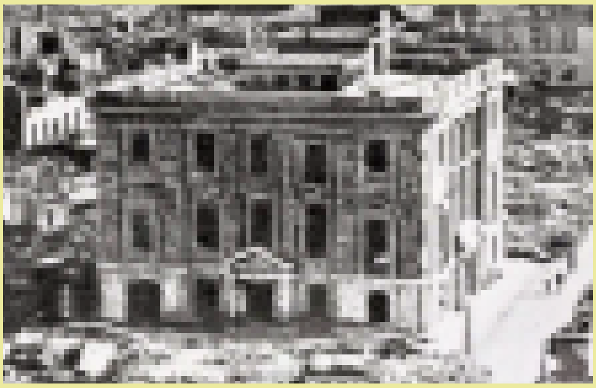
06

The eruption of Tambora on Sunda in Indonesia in 1815 blasted so much gas and ash into the atmosphere that it caused a worldwide "summer without any sun". Krakatoa (1883) generated large tsunamis which cost thousands of lives.

07

Mt. Vesuvius in the Gulf of Naples erupted not only in antiquity when the cities of Pompeii and Herculaneum were buried under lava, debris, and ash. Several outbreaks in the last thousand years kept this region in suspense time and again. The "year-long" eruption of 1632 claimed the lives of around 3,500 people.

1900-
1999



Major natural catastrophes in the 20th century*

■ Fatalities
■ Economic loss in US$ m

* not including drought

< 500,000 fatalities

16.12.1920
China, Gansu
Earthquake
■ **235,000**
■ **25**

< 100,000 fatalities

28.12.1908
Italy,
Messina
Earthquake
■ **85,926**
■ **116**

13.1.1915
Italien,
Avezzano
Earthquake
■ **32,610**
■ **25**

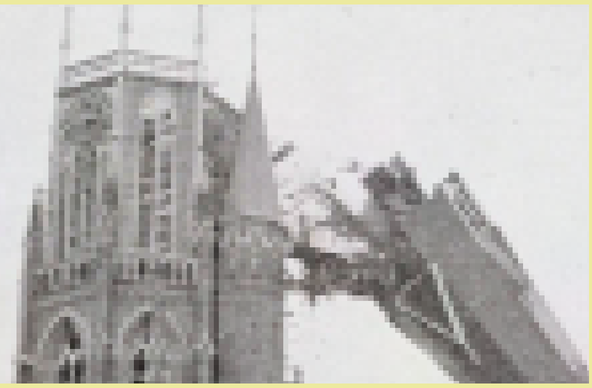
< 15,000 fatalities

8.9.1900
USA, TX,
Galveston
Hurricane
■ **6,000**
■ **30**

< 5,000 fatalities

18.4.1906
USA,
San Francisco
Earthquake
■ **3,000**
■ **524**

< 100 fatalities



1.9.1923

Japan, Tokyo,
Yokohama
Earthquake
142,800
2,800

July–August 1931

China,
Yangtzekiang
Flood
■ **140,000**

30.5.1935

Pakistan,
Quetta
Earthquake
■ **35,000**
■ **25**

25.1.1939

Chile,
Concepción
Earthquake
■ **28,000**
■ **100**

26.12.1939

Turkey,
Erzincan
Earthquake
■ **32,740**
■ **20**

16.10.1942

Bangladesh,
India
Cyclone
■ **61,000**

10–22.9.1938

USA,
New England states
Hurricane
■ **600**
■ **300**

12.1.1970

Bangladesh,
Chittagong, Khulna
Cyclone,
Storm surge
■ **300,000**
■ **63**

August 1954

China,
Dongting area
Flood

■ **40,000**

31.5.1970

Peru,
Chimbote
Earthquake, landslide
■ **67,000**
■ **550**

26–27.9.1959

Japan,
Honshu
Typhoon Vera (Isewan)
■ **5,100**
■ **600**

29.2.1960

Morocco,
Agadir
Earthquake
■ **12,000**
■ **120**

February 1953

The Netherlands.
UK
Storm surge
■ **1,932**
■ **3,000**

7–12.9.1965

USA, FL, LA
Hurricane Betsy
■ **75**
■ **1,420**

27/28.7.1976
China,
Tangshan
Earthquake
■ (magenta) **290,000**
■ (blue) **5,600**

29–30.4.1991
Bangladesh
Cyclone Gorky,
Storm surge
■ (magenta) **139,000**
■ (blue) **3,000**

4.2.1976
Guatemala,
Guatemala City
Earthquake
■ (magenta) **22,084**
■ (blue) **1,100**

13–14.11.1985
Columbia,
Armero
Eruption of
Mt. Nevado
del Ruiz, lahar
■ (magenta) **24,740**
■ (blue) **230**

7.12.1988
Armenia,
Spitak
Earthquake
■ (magenta) **25,000**
■ (blue) **14,000**

17.8.1999
Turkey,
Koaceli, Izmit
Earthquake
■ (magenta) **> 17,000**
■ (blue) **> 13,000**

19.9.1985
Mexico,
Mexico City
Earthquake
■ (magenta) **10,000**
■ (blue) **4,000**

30.9.1993
India,
Maharashtra,
Khillari
Earthquake
■ (magenta) **9,475**
■ (blue) **280**

17.1.1995
Japan, Kobe
(Great Hanshin)
Earthquake
■ (magenta) **6,348**
■ (blue) **> 100,000**

25.10–8.11.1998
Honduras.
Nicaragua
Hurricane Mitch
■ (magenta) **9,200**
■ (blue) **5,500**

9–17.9.1988
USA.
Caribbean,
Central America
Hurricane
Gilbert
■ (magenta) **355**
■ (blue) **3,000**

25.1–1.3.1990
Western Europe
Winter storms
■ (magenta) **230**
■ (blue) **14,800**

May–Sept. 1998
China,
Yangtzekiang,
Songhua
Flood
■ (magenta) **3,650**
■ (blue) **30,000**

20.9.1999
Taiwan,
Taichung
Earthquake
■ (magenta) **2,400**
■ (blue) **> 11,000**

2–4.1.1976
Central and
Western Europe
Capella gale
■ (magenta) **82**
■ (blue) **1,300**

17.10.1989
USA, CA,
San Francisco
(Loma Prieta)
Earthquake
■ (magenta) **68**
■ (blue) **6,000**

26–28.9.1991
Japan,
Kyushu,
Hokkaido
Typhoon
Mireille (No. 19)
■ (magenta) **62**
■ (blue) **6,000**

23–27.8.1992
USA,
FL, LA
Hurricane
Andrew
■ (magenta) **62**
■ (blue) **30,000**

17.1.1994
USA, CA,
Los Angeles
(Northridge)
Earthquake
■ (magenta) **61**
■ (blue) **44,000**

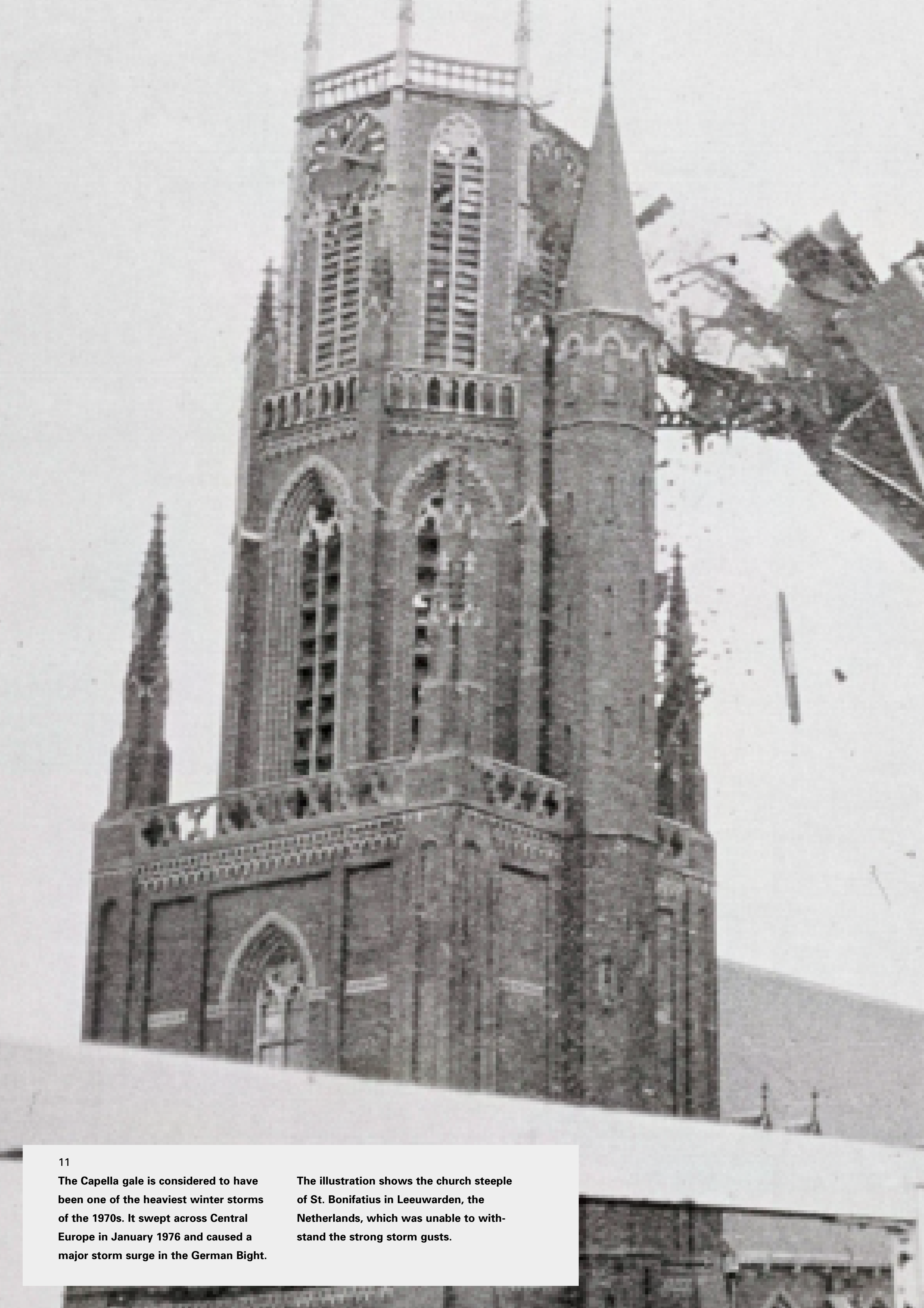
08
An earthquake measuring 8.3 on the Richter scale rudely awoke San Franciscans on the morning of 18th April 1906. The subsequent hours and days were a nightmare. 30,000 buildings collapsed or burned down in the ensuing huge conflagration, which cost the lives of more than 3,000 people.

09
The great Kanto earthquake of 1923 devastated large parts of Tokyo and Yokohama. There were 140,000 fatalities, and the loss to the economy as a whole was in the region of US$ 2.8bn. Due to the enormous growth of these metropolitan areas since then, an earthquake of equivalent magnitude would be likely to cause a loss that could be up to one thousand times larger.

10
It is now already 35 years since Hurricane Betsy, which devastated parts of Florida and Louisiana in September 1965, demonstrated the enormous loss potential of windstorm events. The hurricane followed a similar path to that taken later by Hurricane Andrew (1992) and caused losses to the economy amounting to US$ 1.4bn, which was an absolute peak figure in the sixties. Even at that time, around half of the losses were insured.

09

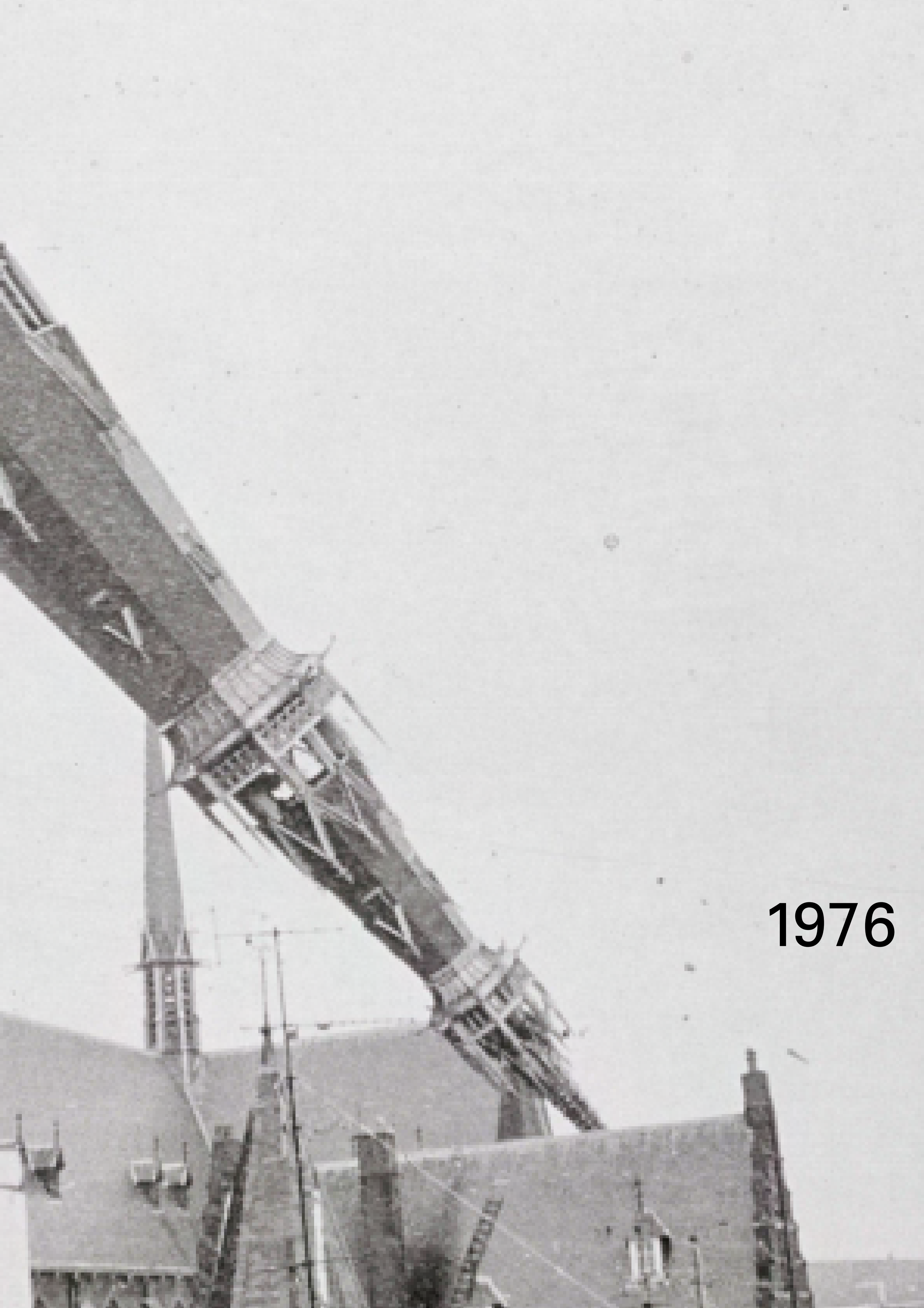
10



11

The Capella gale is considered to have been one of the heaviest winter storms of the 1970s. It swept across Central Europe in January 1976 and caused a major storm surge in the German Bight.

The illustration shows the church steeple of St. Bonifatius in Leeuwarden, the Netherlands, which was unable to withstand the strong storm gusts.


1976

12

In September 1988 Hurricane Gilbert set a record with a pressure of only 888 hPa at its centre and was one of the strongest cyclones in the 20th century. It caused enormous damage in the Caribbean and devastated tourist centres in Yucatán, Mexico. The photo of wrecked hotels in Cancún shows impressively that the intensive development of the tourist industry in exposed regions of the world is one factor in the marked increase in losses due to natural catastrophes.

13

Florida is regularly hit by tropical cyclones. Hurricane Andrew, which swept through Dade County at speeds of 280 km/h, generated a new dimension of loss in August 1992 (see also page 61). One of the main reasons for the dramatic extent of the losses (62 fatalities, economic losses totalling US$ 30bn, insured losses of US$ 17bn) was the inadequate protection of the dwellings (simple wooden constructions, mobile homes, etc.) although the country has the most stringent building regulations in the world as far as windload is concerned.

14

The earthquake which devastated the Japanese port of Kobe on 17th January 1995 was the most expensive natural catastrophe of the 2nd millennium with losses to the economy exceeding US$ 100bn. A total of 6,350 people lost their lives, and more than 300,000 were made homeless. The earthquake made it fright eningly clear that natural catastrophes can seriously disrupt economic and private life for several months on end in highly developed industrial societies too.

1995

1997

15

Tornadoes occur throughout the middle latitudes but the greatest losses occur regularly in the Midwest of the United States. In the late 1990s, even major metropolitan areas such as Oklahoma City and Salt Lake City were affected. This picture shows a tornado which caused considerable anxiety in Miami on 12th May 1997.


Barnett Bank


1998

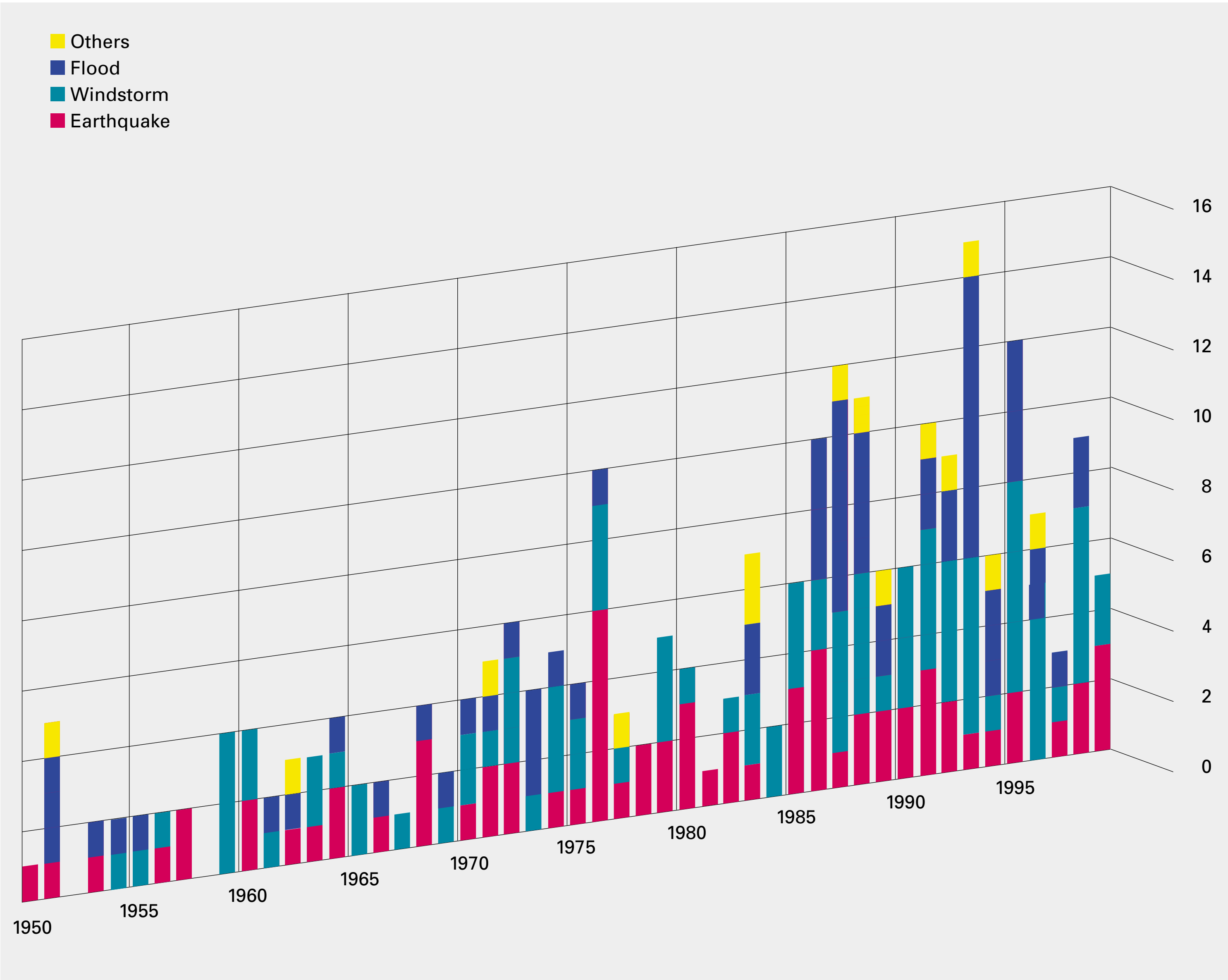
16
The last decade of the 20th century was marked by several gigantic floods in central and southern China. Despite the untiring efforts to erect flood defences, the losses generated by the hundred-year flood in 1998 ran to US$ 30bn.

17
Mitch, one of the most powerful hurricanes this century with wind speeds of over 300 km/h and extremely heavy downpours (625 mm in 24 hours), wreaked havoc in Central America, leaving in its wake the tragic toll of 9,200 dead and thousands suffering the effects of epidemics. The massive damage to the infrastructure, especially in Honduras, Nicaragua, and El Salvador, will put back economic development in the countries affected by years.

18
A severe earthquake in the western part of Turkey in 1999 razed large parts of Gölcück and Izmit to the ground. The picture clearly shows that building construction plays a key role in terms of the damage caused in earthquakes. In the western part of Turkey, the use of inferior construction materials was responsible for almost all of the cases in which buildings collapsed. Had the Turkish building codes been strictly observed, loss of life could have been avoided in most cases.

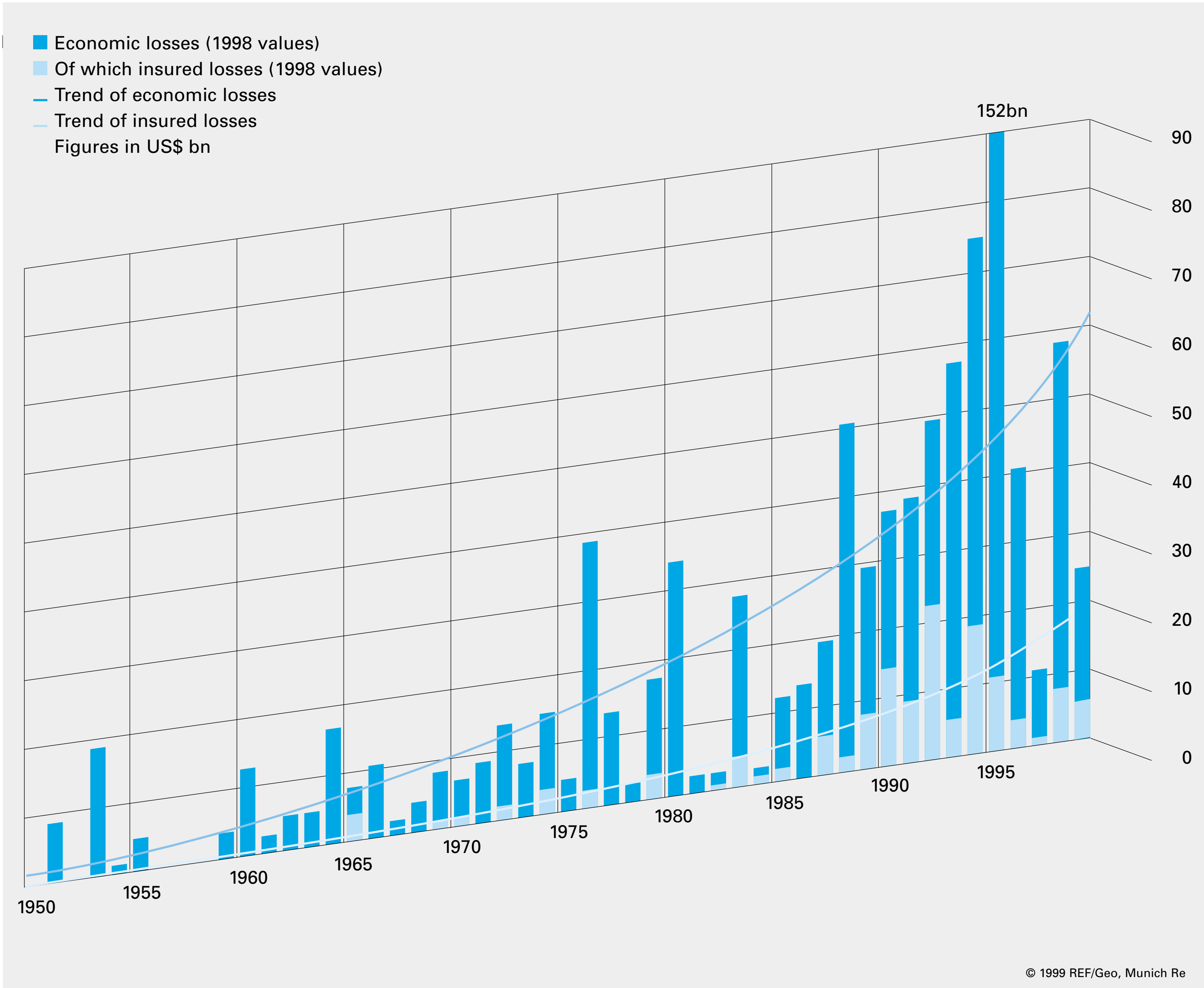
Great natural catastrophes 1950–1999: economic and insured losses with trends

These two charts show the development of losses due to great natural catastrophes since 1950. The chart on the left indicates for each year the number broken down by type of event. The chart on the right indicates economic and insured losses, projected to today's values. The trend curves document the worrying rise in catastrophe losses at the turn of the century.



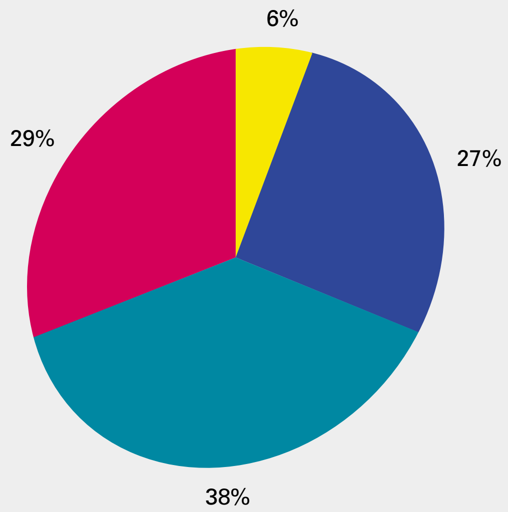
Definition of great natural catastrophes

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.



Great natural catastrophes 1950–1999

- Others
- Flood
- Windstorm
- Earthquake



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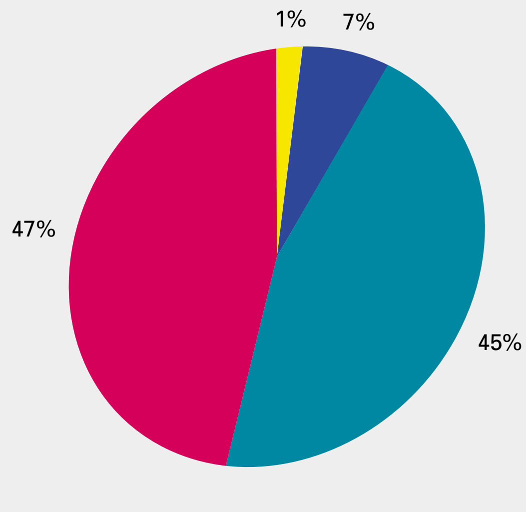
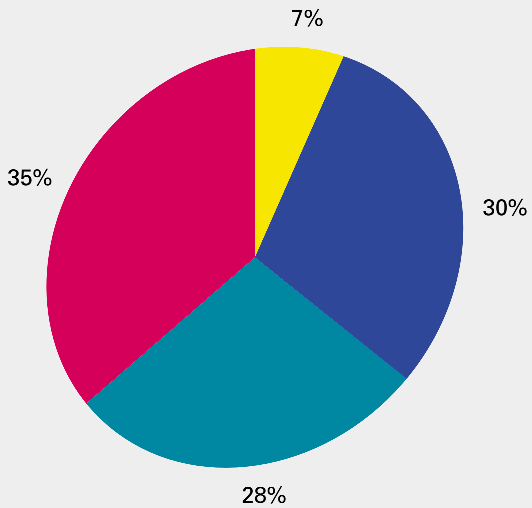
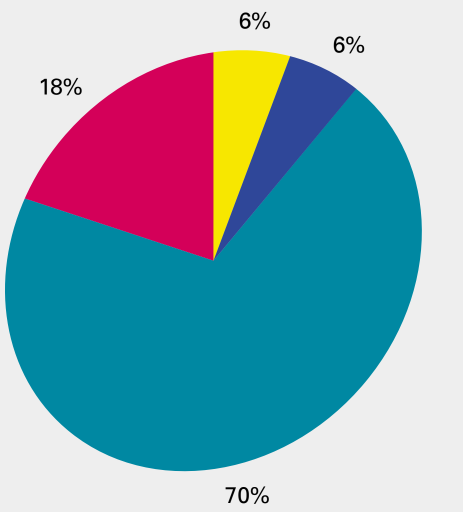


Fatalities: 1.4 million



Economic losses:
US$ 960bn



Insured losses:
US$ 141bn

Comparison of decades 1950–1999

	Decade 1950–1959	Decade 1960–1969	Decade 1970–1979	Decade 1980–1989	Decade 1990–1999
Number	20	27	47	63	82
Economic losses	38.5	69.0	124.2	192.9	535.8
Insured losses	0/unknown	6.6	11.3	23.9	98.8

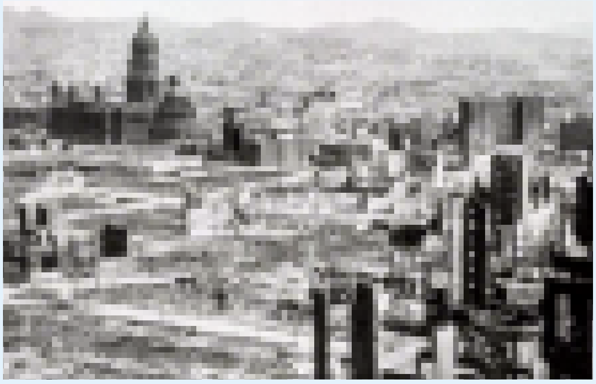
	Factor 90s:80s	Factor 90s:70s	Factor 90s:60s	Factor 90s:50s
Number	1.3	1.7	3.0	4.1
Economic losses	2.8	4.3	7.8	13.9
Insured losses	4.1	8.7	15.0	–

Great natural catastrophes 1950–1999
Losses in US$ bn (1998 values)

THERE WERE ABOUT 250 GREAT NATURAL CATASTROPHES IN THE SECOND HALF OF THE 20TH CENTURY ALONE.

The pie charts show the percentage distribution of great catastrophes broken down by type of event. In the second half of the 20th century, some 250 great natural catastrophes (as defined on page 41) claimed the lives of around 1.4 million people, mostly as a result of windstorms or major flooding (around 90% in total). Economic losses are due in more or less equal degrees to the main hazards of earthquake, windstorm, and flooding (35%, 28%, 30%); other events (drought, forest fire, frost, etc.) carry less weight (7%). As far as insured losses are concerned, windstorm clearly dominates with 70% since coverage for this natural hazard is the most widespread in global terms. The table allows a comparison of the condensed figures of recent decades. A comparison of the figures for the 1990s and those of earlier decades shows the dramatic increase in natural catastrophes in that period. This applies both to the number of events and to the extent of losses. Owing to the global increase in the concentration of values and insurance density, both economic and insured losses have risen at a much higher rate than expected. A reversal of this trend is not in sight.

1900-1999



Major natural catastrophes in insurance history

- Fatalities
- Economic loss in US$ m (original loss)
- Insured losses in US$ m (original losses)

< 20,000
US$ m insured losses

< 15,000m

< 5,000m

< 2,000m

< 1,000m

18.4.1906
USA, CA,
San Francisco
Earthquake
- **3,000**
- **524**
- **180**

1.9.1923
Japan, Tokyo
Earthquake
- **142,807**
- **2,800**
- **590**

7–12.9.1965

USA, FL, LA
Hurricane Betsy

- **75**
- **1,420**
- **715**

23.10.1972

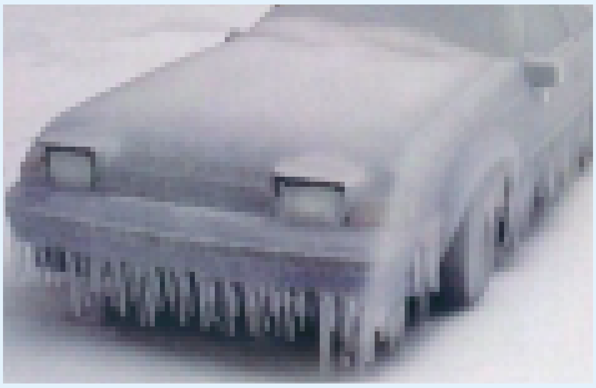
Nicaragua, Managua
Earthquake

- **11,000**
- **800**
- **100**

2–5.4.1974

USA
Tornadoes

- **320**
- **1,000**
- **430**



23–27.8.1992
USA, FL, LA
Hurricane
Andrew
62
30,000
17,000

17.1.1994
USA, CA,
Los Angeles
(Northridge)
Earthquake
61
44,000
15,300

25.1–1.3.1990
Central Europe
Winter storms
230
14,800
10,200

26–28.9.1991
Japan,
Kyushu, Hokkaido
Typhoon Mireille
(No. 19)
62
6,000
5,200

15/16.10.1987
UK.
France
Winter-
storm 87J
17
3,700
3,100

14–22.9.1989
Caribbean.
USA
Hurricane Hugo
86
9,000
4,500

17.1.1995
Japan,
Kobe
(Great Hanshin)
Earthquake
6,348
100,000
3,000

20–30.9.1998
Caribbean.
USA
Hurricane Georges
4,000
10,000
3,400

17–20.8.1983
USA, TX
Hurricane Alicia
21
2,000
1,275

21–22.10.1991
USA, CA,
Oakland
Forest fire
25
2,000
1,750

4–10.1.1998
Canada.
USA
Ice storm
45
2,500
1,150

15.5.1998
USA, MN
Hailstorm
1,500
1,305

3–7.5.1999
USA, OK, TN
Tornadoes
51
2,000
1,485

25.12.1974
Australia,
Darwin
Cyclone Tracy
65
800
235

2–4.1.1976
Central and
Western Europe
Capella gale
82
1,300
508

12.7.1984
Germany,
Munich
Hailstorm
950
480

9–17.9.1988
USA.
Caribbean.
Central America
Hurricane Gilbert
355
3,000
800

28.12.1989
Australia,
Newcastle
Earthquake
13
1,200
670

5.7–10.8.1997
Eastern and
Central Europe
Flood
110
5,900
795

14.4.1999
Australia,
Sydney
Hailstorm
1
1,500
960

19

20

19
The San Francisco earthquake of 1906 generated insured losses of US$ 180m. Measured in terms of the ratio of loss to premium volume, this is the most expensive catastrophe loss Munich Re has ever experienced in its entire history, which goes back to 1880.

20
Cyclone Tracy, which hit Darwin in the northeast of Australia at Christmas in 1974, brought with it a surprise for the insurance industry. Although the region was only relatively sparsely populated – Darwin only had around 40,000 inhabitants at that time – insured losses came to no less than US$ 235m.

21
The Munich hailstorm on 12th July 1984 revealed the enormous loss potential of such natural events in comparatively small areas. Facades, roofs, and windows were the target of hailstones the size of tennis balls. 240,000 cars were damaged, some of them severely. About half of the economic loss amounting to US$ 950m. (at that time DM 3bn) was borne by the insurance industry.

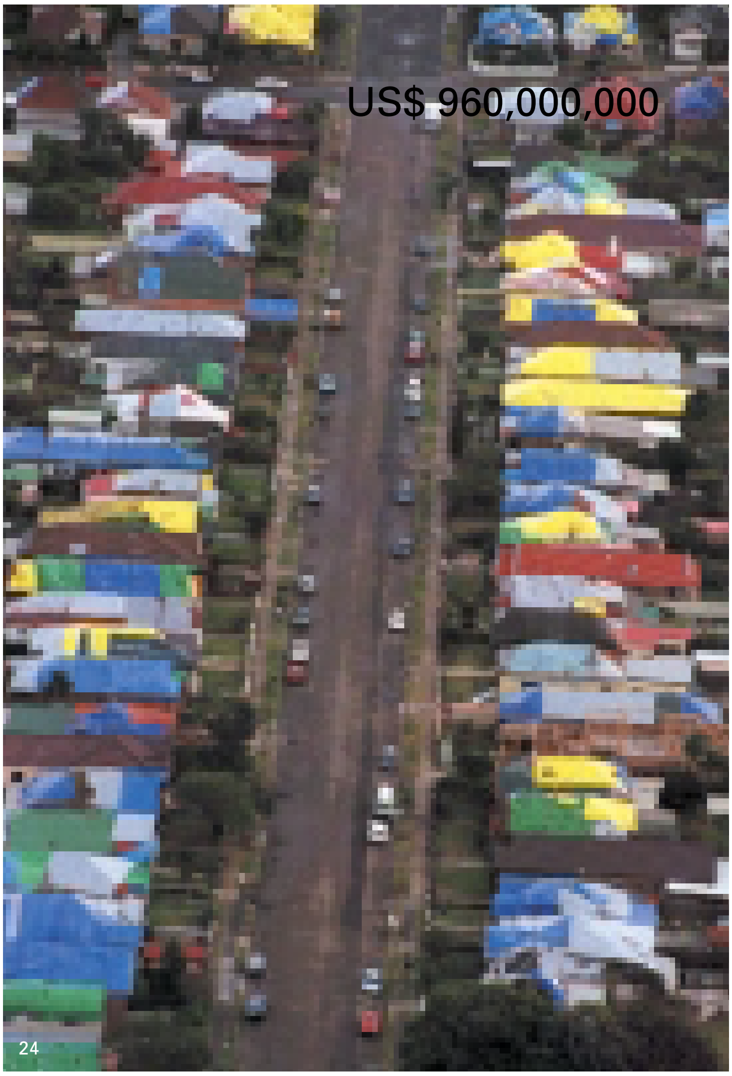
21

US$ 795,000,000

The extreme summer floods in 1997 on the Morava and Odra presented the young insurance markets of Poland and the Czech Republic with an immense task. US$ 760m (out of a total of US$ 795m) had to be paid out in claims. The two markets settled them in a professional manner and mastered this enormous challenge with great bravura.


0829

US$ 800,000,000



23
As Hurricane Gilbert (see also page 32) cut its way through the Caribbean, it tossed aircraft through the air like toys. Jamaica was hardest hit with peak gusts reaching over 320 km/h. Half of the houses were badly damaged or destroyed and agriculture was completely devastated. The local insurance market got off lightly, however, since 98% of the insured losses of US$ 720m were borne by the reinsurance industry.

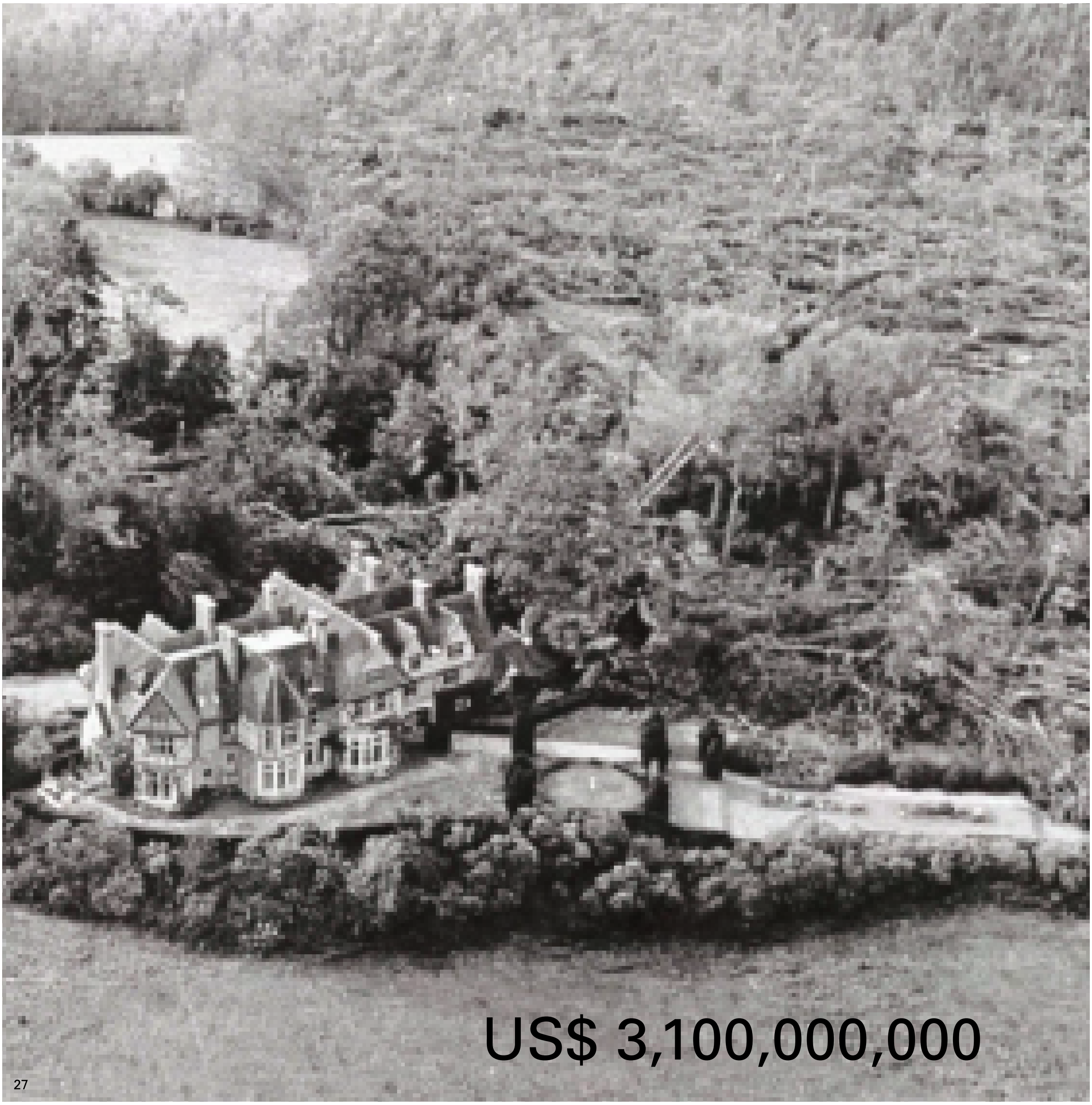
24
This is a picture of a Sydney street following the hailstorm of 14th April 1999. A total of 32,000 houses and 40,000 cars were damaged. 23 aircraft, including large passenger planes, were badly affected. Insured losses were around the US$ 1bn mark.

25
Tornadoes, which are encountered most profusely in the United States, put a heavy strain on the insurance industry each year. In the 1990s, at least one tornado struck every year, causing insured losses of between a quarter and half a billion US dollars. This picture shows the path of destruction through Oklahoma City, which suffered a direct hit on 3rd May 1999. Almost 50 lives were lost as a result.

26

In January 1998 an ice storm covered an area of almost 800,000 km² in Canada and the northeast of the United States with a layer of ice up to 10 cm thick. At first it only affected overhead utility lines, but later public life in the affected region almost completely came to a halt. The insurance industry felt the effects too. The ice storm of Canada caused losses of almost one billion dollars and is thus the most expensive catastrophe to date in the history of the Canadian insurance industry. In the United States, the insured losses amounted to US$ 200m.


US$ 1,150,000,000



27

In October 1987 a winter storm of historic dimensions swept over Central Europe, causing losses on a scale that only tropical cyclones had previously been thought capable of generating. In the UK alone, 15 million trees were uprooted. Economic losses in all of the countries affected ran to US$ 3.7bn, of which 85% was insured.

28

Hurricane Georges, which hit Puerto Rico, Hispaniola, Cuba, and finally Florida and Mississippi in September 1998, set a new loss record in the Caribbean for the insurance industry. The economic loss totalled US$ 10bn; 4,000 people died, most of them following an accident involving a dam in the Dominican Republic.

29

This is a picture of the damage at a huge tank farm on one of the Caribbean islands which was caused by Hurricane Hugo in September 1989. The hurricane swept over Martinique, the Lesser Antilles, and Puerto Rico, finally reaching the coast of South Carolina after nine days. Insured losses amounted to US$ 4.5bn, which was at that time a very gloomy record figure, but one that was to be far exceeded in the years that followed.


US$ 3,400,000,000
28


US$ 4,500,000,000
29

US$ 15,300,000,000

30

On 17th January 1994 the earth shook in the north of Greater Los Angeles. 115,000 houses were damaged, numerous highways, bridges, and utility lines were destroyed. Although underwriting is relatively restrictive in California because of the high exposure, insurers received about 430,000 claims. Payments of US$ 15.3bn made Northridge the most expensive insured earthquake loss of the 20th century.

31

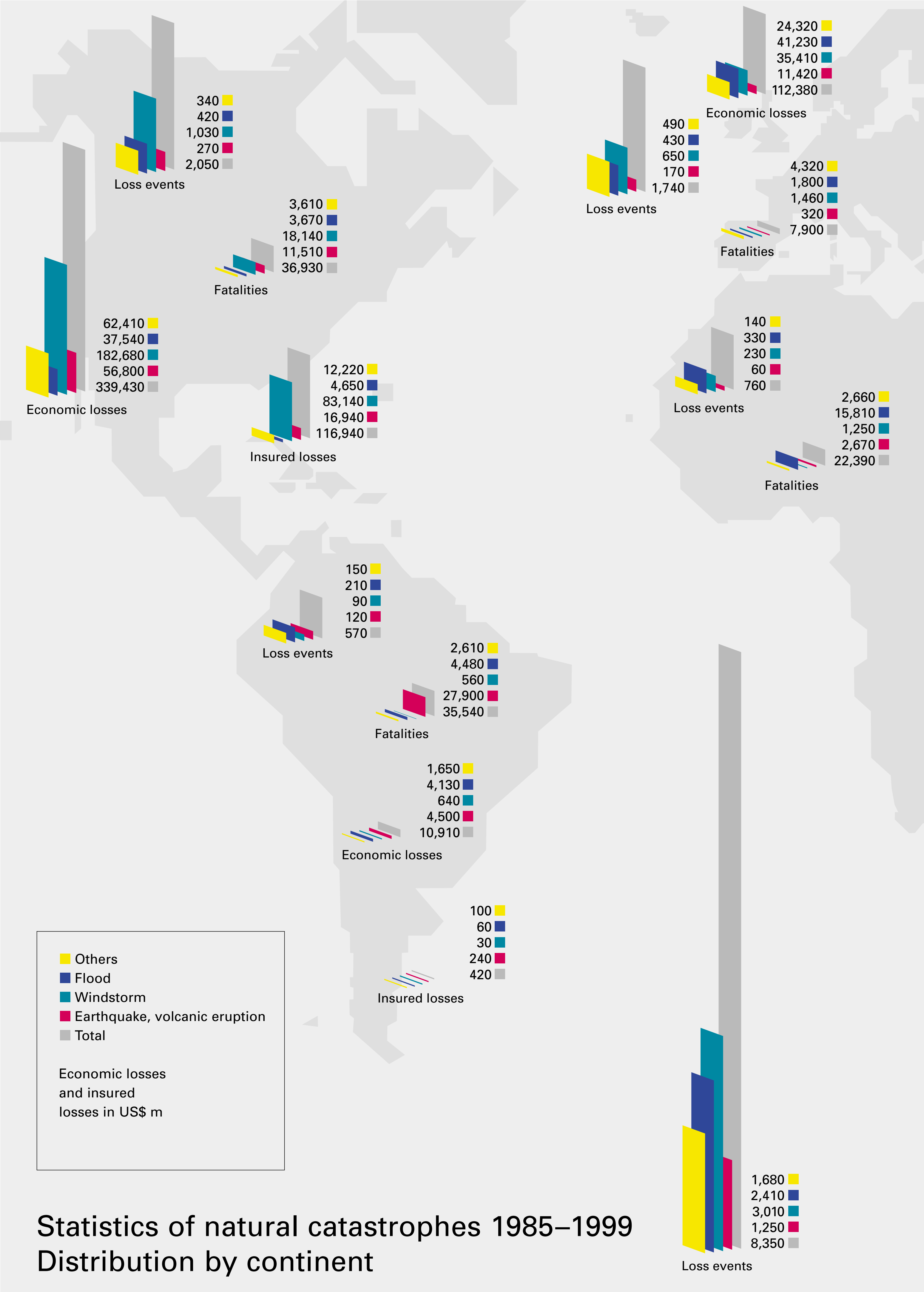
Hurricane Andrew, which devastated the southern tip of Florida and parts of Louisiana in August 1992, is the most expensive natural catastrophe to date in history of insurance with insured losses amounting to US$ 17bn. But even then the insurers were lucky. If the track of the hurricane had been just 50 km to the north, the loss could easily have been three to five times as high.

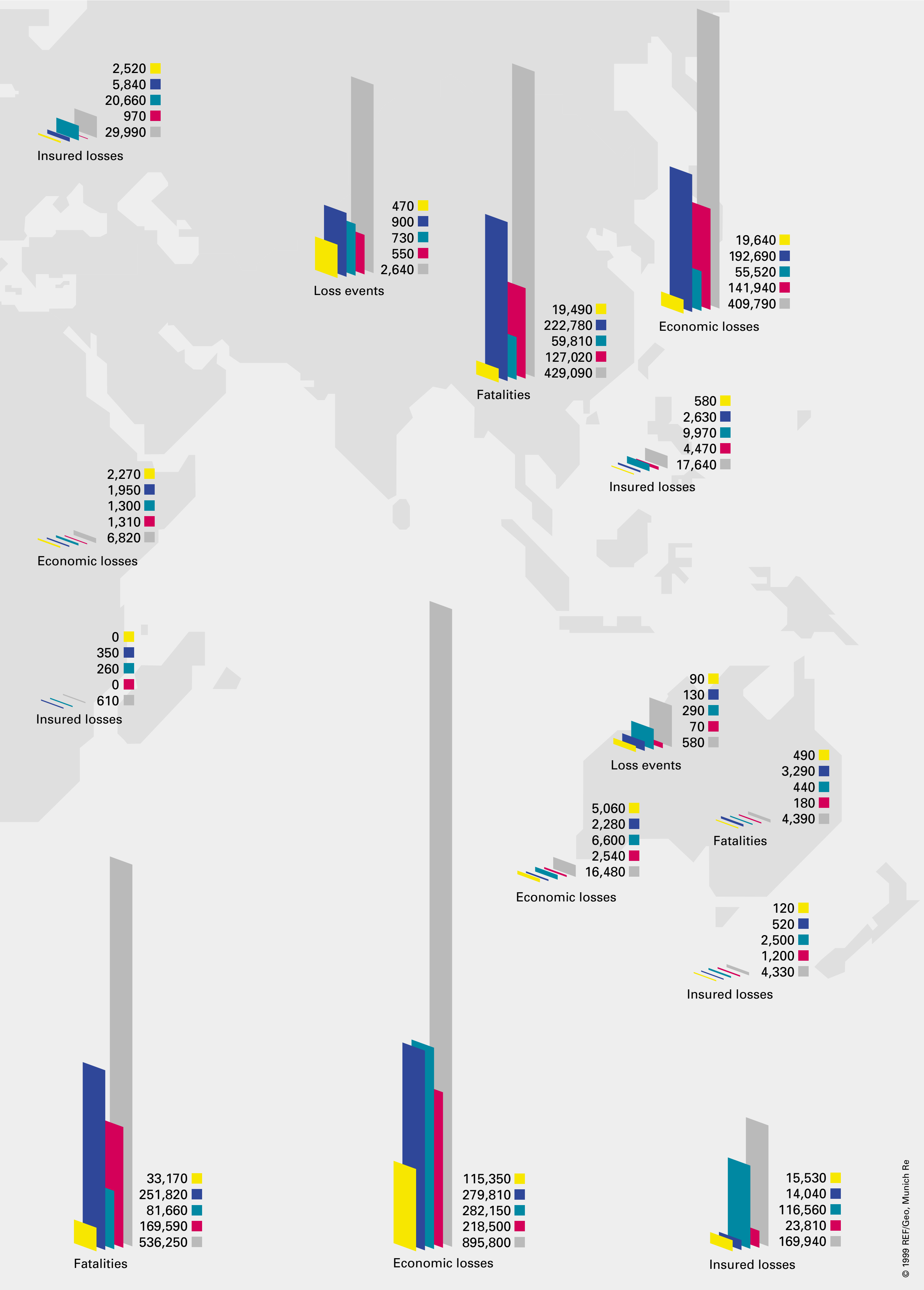
Compiling catastrophe data. Munich Re's Geoscientific Research Group has been systematically collecting and analysing information on natural catastrophes from around the world for 25 years. As far as major natural catastrophes are concerned, which we dealt with in the first section of this publication, it is relatively easy to investigate well-documented information even today. As shown on pages 40 to 43, these so-called **great natural catastrophes** generally account for half of the overall loss on average. The large number of small and moderate events roughly doubles the extent of loss. The possibilities of gathering global information on natural catastrophes have constantly improved in recent years. This has to do with the changes in the media world and the development of new media, such as the Internet. Since around the middle of the 1980s, the volume of information has gradually increased, leading to an ever-broadening data basis. In the past fifteen years we have recorded between 500 and 700 natural catastrophes every year. The late 1980s and early 1990s bear the marks of individual events with extremely large losses, while the end of the 20th century is characterized by an increase in the number of events, on the one hand because people and values are affected more and more frequently by natural events and on the other because the information on "hits" is increasing.

The reports of loss events that we record are first checked several times and verified. Only then is the data entered and subsequently updated in the **NatCat*SERVICE*** database (NatCat*SERVICE* because our clients have access to it, cf. the section on service products on page 120). The entries are based on data from a variety of sources, such as online information services (e.g. REUTERS Insurance Briefing, information bulletins issued by the International Red Cross, catastrophe reports published by the United Nations), insurance journals (Lloyd's List, World Insurance Report, etc.), and other primary sources. **Our worldwide contacts over the decades** with scientists, official agencies, and institutes that are concerned regionally or internationally with the subject of natural hazards are as important a source of information for us as conferences, workshops, and expert opinions. Technical literature and essays, studies and scientific reports in specialist journals, and conference papers are also evaluated. Finally, our clients in more than 150 countries, our subsidiaries, engineering offices, branch offices, service companies, and liaison offices send us loss advices and reports on natural events, from which we glean the data to be entered in our database.

On the following pages we present the worldwide distribution of all events recorded since 1985, broken down by the number of catastrophes, number of fatalities, economic losses, and insured losses. It is noticeable that the **distribution of population and the exposure situation in each continent are decisive factors** as far as the frequency and extent of natural catastrophes are concerned. America and Asia (high exposure, dense population) clearly dominate the picture. Africa and Australia are less significant: Australia primarily because of the relatively low population density, Africa on account of the generally low exposure.

Statistics of natural catastrophes 1985–1999
Distribution by continent



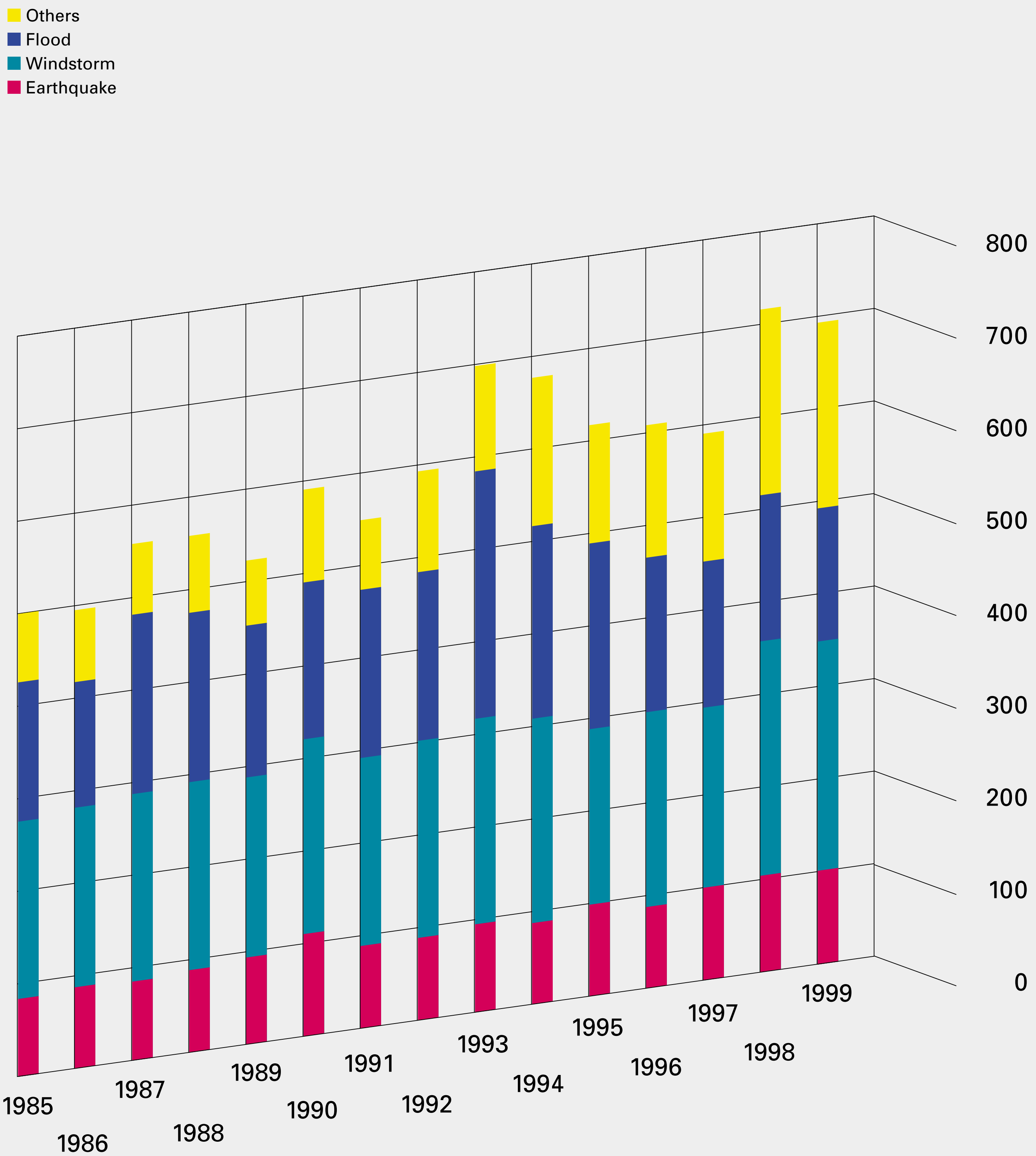


2,520
5,840
20,660
970
29,990
Insured losses
470
900
730
550
2,640
Loss events
19,490
222,780
59,810
127,020
429,090
Fatalities
19,640
192,690
55,520
141,940
409,790
Economic losses
580
2,630
9,970
4,470
17,640
Insured losses
2,270
1,950
1,300
1,310
6,820
Economic losses
0
350
260
0
610
Insured losses
90
130
290
70
580
Loss events
490
3,290
440
180
4,390
Fatalities
5,060
2,280
6,600
2,540
16,480
Economic losses
120
520
2,500
1,200
4,330
Insured losses
33,170
251,820
81,660
169,590
536,250
Fatalities
115,350
279,810
282,150
218,500
895,800
Economic losses
15,530
14,040
116,560
23,810
169,940
Insured losses

Number of natural catastrophes worldwide 1985–1999

This chart shows the number of events broken down by type of event and reveals an upward trend. The catastrophes caused by extreme weather events like windstorms, floods, landslides, cold spells, and forest fires are unmistakably predominant, whereas the geological catastrophes like earthquake and volcanic eruptions are remarkably constant.

IN THE PAST FIFTEEN YEARS WE HAVE RECORDED BETWEEN 500 AND 700 NATURAL CATASTROPHES EVERY YEAR.
THE LATE EIGHTIES AND EARLY NINETIES WERE MARKED BY INDIVIDUAL EVENTS WITH EXTREMELY LARGE LOSSES.


Others
Flood
Windstorm
Earthquake
800
700
600
500
400
300
200
100
0
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999

Special section, services, tables

THROUGHOUT ITS HISTORY, MUNICH RE HAS DEVELOPED TAILOR-MADE SERVICES AND INSURANCE PRODUCTS FOR ITS CLIENTS AND HAS WRITTEN NUMEROUS SPECIALIST PUBLICATIONS

From the fire map to hurricane real-time simulation – a contribution to the development of risk modelling

The fact that the insurance industry needs to have an accurate overview of hazard sources and risk locations for the purposes of underwriting, rating, accumulation control, and marketing is already illustrated by early examples. The experience gained from the devastating fire in New York in 1835 was used to produce the first insurance maps for fire underwriting around 1850. In England, too, hand-drawn plans were used for this purpose from 1885 onwards. These maps showed construction types and materials, the storage of combustible materials, and the extinguishing equipment available, with the aim of easing the job of risk assessment and premium calculation for underwriters.

The realization that neither the forces of nature nor the forces of the market can be deactivated and the evident increase in catastrophe losses led to a turbulent development of catastrophe models designed for the insurance industry beginning in around 1985. Besides windstorm models it was in particular earthquake models that were intended to improve technical underwriting in exposed regions.

Whereas purely statistical or deterministic approaches were at first predominant, the current trend in modelling development is going strongly in the direction of an integrated spatial form of processing, analysis, and representation.

These innovations are largely based on technical developments in information processing, particularly in the field of geographical information systems (GIS). GIS technology makes it possible to overlay underwriting, geoscientific, and cartographic data, using the characteristic of the common spatial reference. For use in marketing, these data can be supplemented with sociodemographic data (e.g. buying power, car ownership, lifestyle of population groups) to refine the models.

These developments are supported by the improved availability and quality of historical databases (e.g. earthquake and hurricane catalogues) and the optimized opportunities for access to this information in a world of global networks.

Besides a number of scientific research institutes, it was in particular the leading reinsurers that were a driving force in the creation of catastrophe models. Munich Re's Geoscience Research Group began using modern earthquake models as early as 1987 and windstorm models in 1990. These were made available to our clients as a complimentary service even before there was any wide range of commercial catastrophe models that can be had in return for a licence fee. Nowadays commercial vendors and consulting firms play an important role too, and it is no longer just the reinsurers that use these tools for portfolio analysis and risk management but to an increasing degree insurers too. The models that are available on the market provide quite plausible results when seen in isolation, but these results may vary considerably from one model to the next and understandably cause some irritation on the part of clients. What is the reason for the differences in results? In all cases, the basis of calculations is the data that has been input, the quality and plausibility of which must be examined very critically and verified. The mathematical, statistical part is the real heart of the model and is therefore set up as a kind of "black box" in many commercial models. Its contents are not accessed by the user or only in part, which makes it that much more difficult to interpret the results. Even in the final stage of modelling, when loss ratios are applied as a function of the size of an event (wind speed, earthquake intensity, water level), there may still be considerable differences. This is because of the different loss experience and loss evaluation of those developing the models.

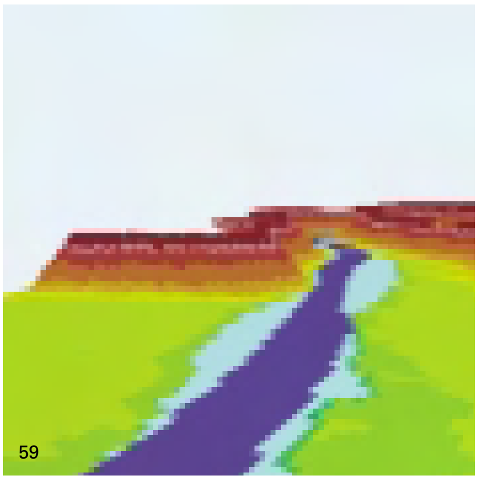
Generally speaking, simply taking the results of models and applying them to insurance business without further investigation is a practice to be warned against. For this reason Munich Re offers its clients a package of services (MRcatPML*SERVICE*), consisting in the scientific analysis of client portfolios using products we have developed ourselves (accumulation loss potential analysis) supplemented by consultancy discussions with the clients themselves. These discussions can go into detail about specific features of the individual portfolio, differences between this and other products, and the accuracy of the models and the interpretation of results. This complimentary service supports our clients in the development of a tailor-made reinsurance construction.

Future developments will concentrate on improving the quality of the input data and refining the expected loss susceptibility of various types of occupancy. In addition, the spatial resolution of the models will undergo distinct improvement. Analyses in Germany, for instance, used to be carried out on the basis of two-digit postal regions, whereas today five-digit postal codes are used. In the future, it will be feasible to carry out analyses of treaty business that are based on the data and addresses of individual clients. American insurers have already made a start in this direction. The use of models with a high spatial resolution will enable us to analyse other natural hazards like flood or hail with even greater precision.

Exact elevation data in 3-dimensional models and the incorporation of a temporal component will make even more detailed analyses and more complex simulations possible.

58–62
The use of risk models for underwriting and risk management is becoming increasingly important. The spatial linking and analysis of underwriting, geoscientific, and cartographic information produce models that are increasingly precise and realistic.


58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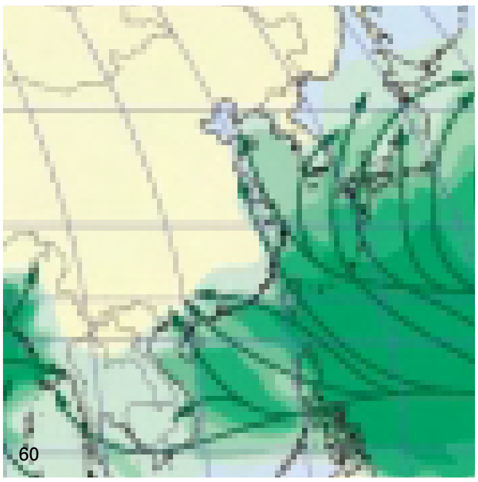
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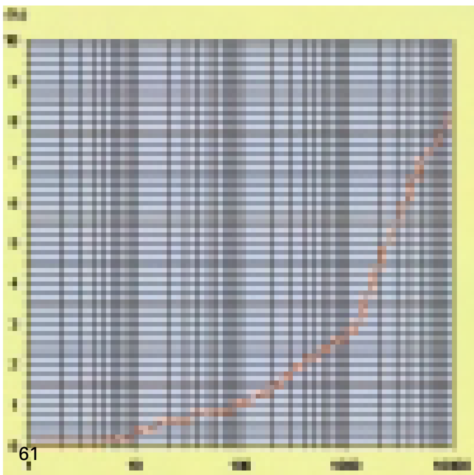
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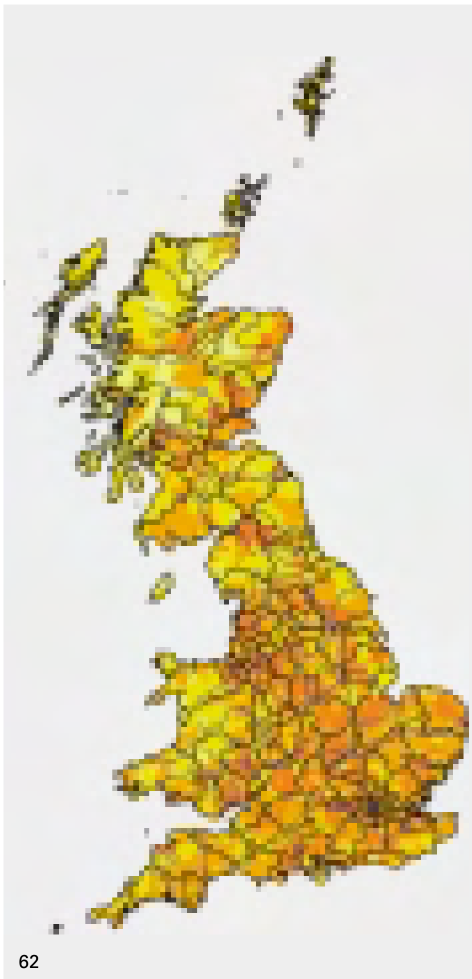
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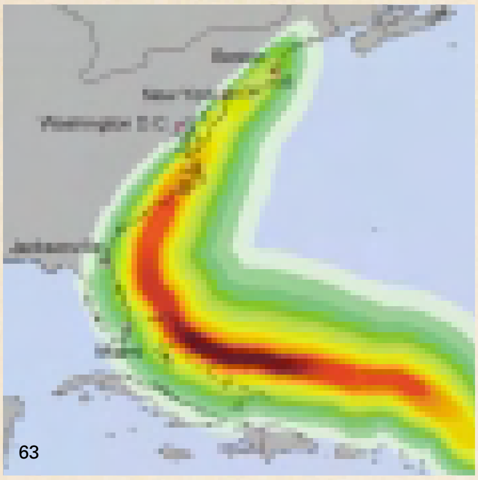
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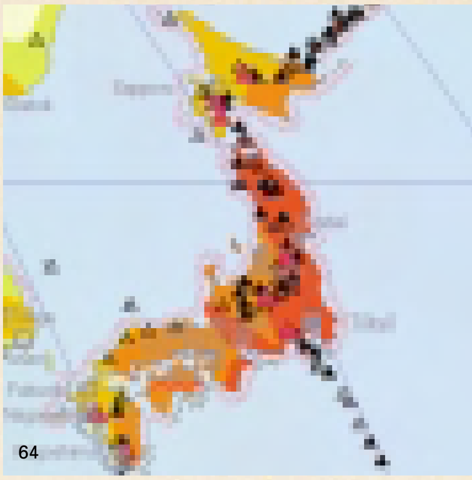
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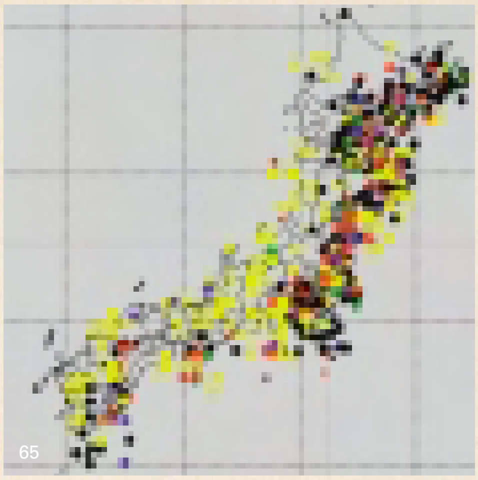
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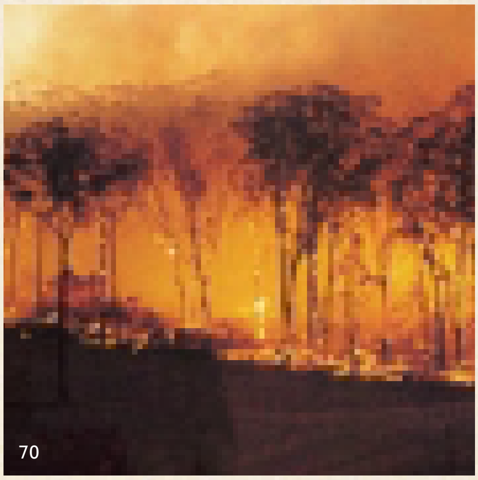
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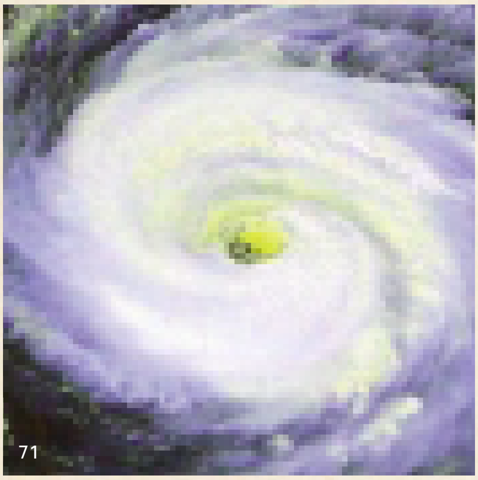
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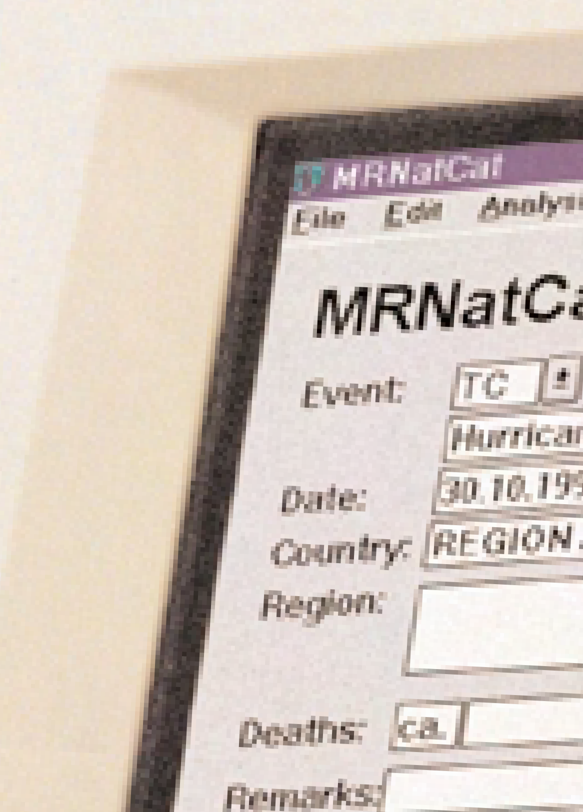

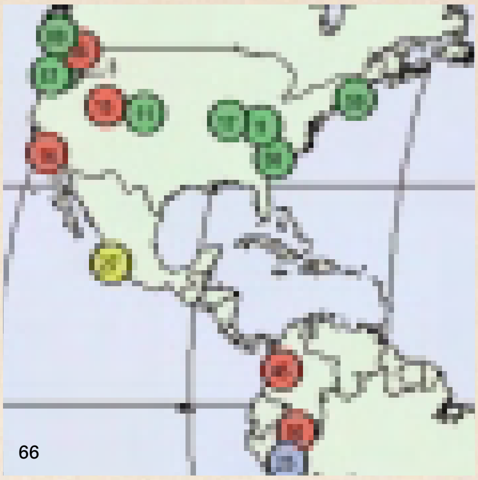
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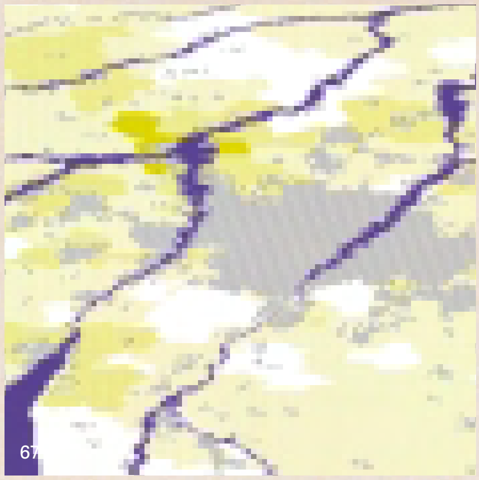
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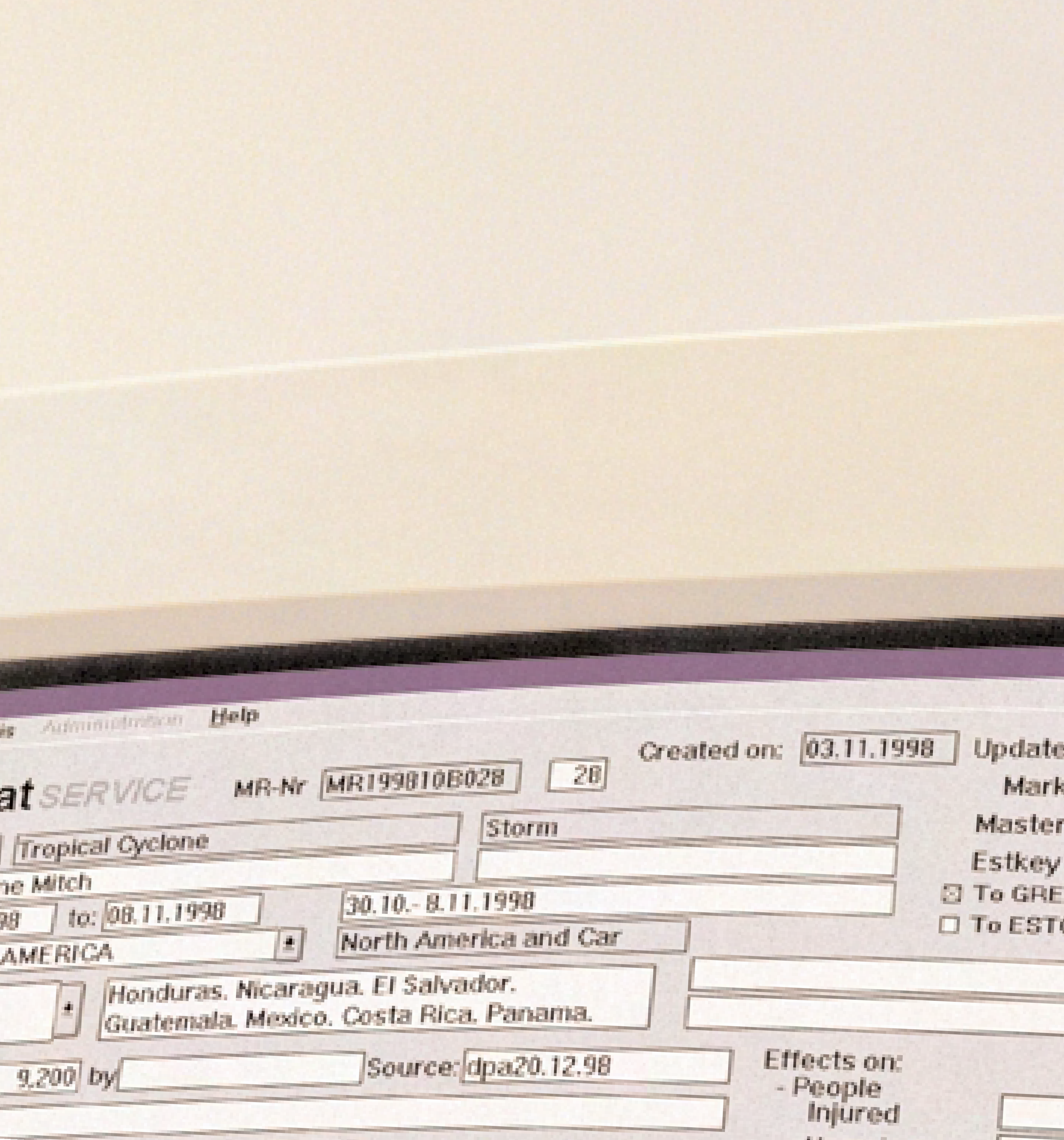
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28
Mark
Tropical Cyclone
Storm
Master
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ne Mitch
to: 08.11.1998
30.10.- 8.11.1998
To GRE
To EST
AMERICA
North America and Car
Honduras, Nicaragua, El Salvador,
Guatemala, Mexico, Costa Rica, Panama,
9,200
by
Source: dpa20.12.98
Effects on:
- People
Injured

Munich Re's service products

Munich Re has always been a client-oriented partner in the national and international insurance industry. And it was to support the technical analysis of natural hazard covers that we set up a geoscientific research team in the early 1970s. The Geoscience Research Group now comprises scientists from almost all specialist fields: from meteorology and climatology to seismology, geology, geophysics, and geography, down to hydrology, and experts in geographical information systems (GIS).

In this way, we can give our clients support in questions about underwriting but also provide them with information and consultation services on historical and feasible future losses from natural catastrophes.

MRNatCat*SERVICE*. The NatCat*SERVICE* database (see also pages 62–63) can be used both to document the extent and intensity of individual natural loss events in various regions of the world and for regional and global exposure analyses and cautious trend studies.

Clients that use the MRNatCat*SERVICE* receive a brief and precise description of each event and important supplementary information:

- Loss lists
  by country or event type in tabular form. These are used to obtain a quick overview of recent loss history and to make a preliminary appraisal of a specific region's exposure.

- Expert opinions
  on specific events, which are analysed in terms of their occurrence probability (return period) and loss size (for example, in comparison with other catastrophes).

Our clients can keep themselves up to date about the events of recent months either by contacting Munich Re direct or by accessing Reuters Insurance Briefing (RIB), a comprehensive on-line information service provided by the news agency Reuters. Brief reports can be called up under "NatCat" (as a source or as a search string).

MRCatPML*SERVICE*. Under this product name, Munich Re produces accumulation loss potential analyses for earthquake, windstorm, and flood on the basis of information on liabilities (CRESTA system) broken down by geographical area and risk category. These PML investigations determine the maximum losses that are to be expected. Individual historical or hypothetical catastrophe scenarios can be simulated as desired by the client and their effects on individual portfolios can be estimated (deterministic analysis). Probabilistic evaluations are also possible. In such cases, we calculate loss occurrence probabilities for specific liability situations with the aid of own simulation models. Our clients are supported in the development of tailor-made reinsurance constructions by the MRCatPML*SERVICE*.

There follows a short introduction to the risk programs that are used in MRCatPML*SERVICE*. These programs are already available for a large number of countries (although MRFlood is only used for general property business in Germany).

MRQuake (Earthquake risk). This program, which was first produced in 1987, is continually adjusted to be in line with the current state of earthquake research and provides a probabilistic analysis of any insured portfolio. It includes the most important exposed countries in the world.

MRStorm (Windstorm risk). By analogy, the MR windstorm risk software has been developed for carrying out loss accumulation analyses of windstorm portfolios in Germany. The simulation model is based on the extensive loss evaluations of historical windstorms and meteorological studies undertaken by Munich Re's Geoscience Research Group in the wake of the series of winter storms in 1990 (extracts of these are published, for instance, in our exposé "Winter storms in Europe in 1990"). With the windstorm risk model, as-if loss potentials from historical and freely definable windstorm events can be calculated as well as loss occurrence probabilities as a result of simulating a large number of windstorms with different return periods.

MRFlood (Flood risk). The new flood program for Germany is based on state-of-the-art GIS technology. The accumulation loss potentials from river floods are calculated for specific insured portfolios on the basis of flood scenarios. The main item of the results, which are presented as in the case of the earthquake and windstorm analyses in a compact brochure, is a PML curve (maximum losses for various occurrence probabilities). It serves as an aid in budget control and in ascertaining reinsurance requirements. Also, foci of accumulation are visualized by the cartographic representation of the individual distributions of liabilities.

Major natural catastrophes from the 11th to the 19th century

Date	Year	Country and region	Event	Fatalities
21.8	1042	Syria, Palmyra	Earthquake	50,000
20.5	1202	Israel. Lebanon. Jordan. Syria	Earthquake	30,000
	1268	Turkey, Cilicia	Earthquake	60,000
January	1281	The Netherlands, IJsselmeer	Storm surge	80,000
December	1287	Germany, North Sea	Storm surge	50,000
27.9	1290	China, Shangtou	Earthquake	100,000
17.9	1303	China, Linfen	Earthquake	200,000
January	1362	Germany, North Sea	Storm surge "Grosse Manndränke"	100,000
November	1421	The Netherlands, IJsselmeer	Storm surge	100,000
20.9	1498	Japan, Tokai	Earthquake	41,000
26.1	1531	Portugal, Lisbon	Earthquake	30,000
23.1	1556	China, Shaanxi	Earthquake	830,000
25.10	1622	China, Anxiang	Earthquake	150,000
14.1	1668	Azerbaijan, Shemakha	Earthquake	10,000
25.7	1668	China, Shandong	Earthquake	50,000
11.1	1693	Italy, Catania	Earthquake	60,000
26.4	1721	Iran, Tabriz	Earthquake	40,000
30.11	1731	China, Beijing area	Earthquake	100,000
7.10	1737	India, Calcutta	Cyclone	300,000
3.1	1739	China, Ningxia, Yinchuan	Earthquake	50,000
1.11	1755	Portugal, Lisbon	Earthquake	30,000
8.1	1780	Iran, Tabriz	Earthquake	50,000
October	1780	West Indies: Barbados, Guadeloupe, Martinique	Hurricane	24,000
4.5–15.7	1815	Indonesia	Eruption of Tambora	56,000
June	1822	Bangladesh, Bakarganj	Cyclone	50,000
12.9	1850	China, Sichuan	Earthquake	300,000
	1852	China, Henan	Flood	100,000
5.10	1864	India, Calcutta	Cyclone	50,000
October	1876	Bangladesh, Bakarganj	Cyclone	215,000
8.10	1881	Vietnam, Haiphong	Typhoon	300,000
June	1882	India, Mumbai	Cyclone	100,000
20.5–28.8	1883	Indonesia, Java, Sumatra	Eruption of Krakatoa, tsunami	36,400
	1887	China, Henan	Flood	900,000

Major natural catastrophes in the 20th century*

Date	Year	Country and region	Event	Fatalities	Economic loss	Insured losses
8.9	1900	USA, TX, Galveston	Hurricane	6,000	30	
18.4	1906	USA, San Francisco	Earthquake	3,000	524	180
28.12	1908	Italy, Messina	Earthquake	85,926	116	
13.1	1915	Italy, Avezzano	Earthquake	32,610	25	
16.12	1920	China, Gansu	Earthquake	235,000	25	
1.9	1923	Japan, Tokyo, Yokohama	Earthquake	142,800	2,800	590
July–August	1931	China, Yangtzekiang	Flood	140,000		
30.5	1935	Pakistan, Quetta	Earthquake	35,000	25	
10–22.9	1938	USA, New England states	Hurricane	600	300	
25.1	1939	Chile, Concepción	Earthquake	28,000	100	
26.12	1939	Turkey, Erzincan	Earthquake	32,740	20	
16.10	1942	Bangladesh. India	Cyclone	61,000		
February	1953	The Netherlands. UK	Storm surge	1,932	3,000	
August	1954	China, Dongting area	Flood	40,000		
26/27.9	1959	Japan, Honshu	Typhoon Vera (Isewan)	5,100	600	
29.2	1960	Morocco, Agadir	Earthquake	12,000	120	
7–12.9	1965	USA, FL, LA	Hurricane Betsy	75	1,420	715
12.11	1970	Bangladesh, Chittagong, Khulna	Cyclone, storm surge	300,000	63	
31.5	1970	Peru, Chimbote	Earthquake, landslide	67,000	550	14
2–4.1	1976	Central and Western Europe	Capella gale	82	1,300	508
4.2	1976	Guatemala, Guatemala City	Earthquake	22,084	1,100	55
27/28.7	1976	China, Tangshan	Earthquake	290,000	5,600	
19.9	1985	Mexico, Mexico City	Earthquake	10,000	4,000	275
13/14.11	1985	Columbia, Armero	Eruption of Mt. Nevado del Ruiz, lahar	24,740	230	
9–17.9	1988	USA. Caribbean. Central America	Hurricane Gilbert	355	3,000	800
7.12	1988	Armenia, Spitak	Earthquake	25,000	14,000	
17.10	1989	USA, CA, San Francisco (Loma Prieta)	Earthquake	68	6,000	950
25.1–1.3	1990	Western Europe	Winter storms	230	14,800	10,200
29/30.4	1991	Bangladesh	Cyclone Gorky, storm surge	139,000	3,000	100
26–28.9	1991	Japan, Kyushu, Hokkaido	Typhoon Mireille (No. 19)	62	6,000	5,200
23–27.8	1992	USA, FL, LA	Hurricane Andrew	62	30,000	17,000
30.9	1993	India, Maharashtra, Khillari	Earthquake	9,475	280	
17.1	1994	USA, CA, Los Angeles (Northridge)	Earthquake	61	44,000	15,300
17.1	1995	Japan, Kobe (Great Hanshin)	Earthquake	6,348	> 100,000	3,000
May–Sept.	1998	China, Yangtzekiang, Songhua	Flood	3,650	30,000	1,000
25.10–8.11	1998	Honduras. Nicaragua	Hurricane Mitch	9,200	5,500	150
17.8	1999	Turkey, Izmit, Koaceli	Earthquake	> 17,000	> 13,000	1,000
20.9	1999	Taiwan, Taichung	Earthquake	2,400	> 11,000	> 850

Economic loss in US$ m

* not including drought

Selected major natural catastrophes in insurance history

Date	Year	Country and region	Event	Fatalities	Economic loss	Insured losses
18.4	1906	USA, CA, San Francisco	Earthquake	3,000	524	180
1.9	1923	Japan, Tokyo	Earthquake	142,807	2,800	590
7–12.9	1965	USA, FL, LA	Hurricane Betsy	75	1,420	715
23.10	1972	Nicaragua, Managua	Earthquake	11,000	800	100
2–5.4	1974	USA	Tornadoes	320	1,000	430
25.12	1974	Australia, Darwin	Cyclone Tracy	65	800	235
2–4.1	1976	Central and Western Europe	Capella gale	82	1,300	508
17–20.8	1983	USA, TX	Hurricane Alicia	21	2,000	1,275
12.7	1984	Germany, Munich	Hailstorm		950	480
15/16.10	1987	UK. France	Winter storm 87J	17	3,700	3,100
9–17.9	1988	USA. Caribbean. Central America	Hurricane Gilbert	355	3,000	800
14–22.9	1989	Caribbean. USA	Hurricane Hugo	86	9,000	4,500
28.12	1989	Australia, Newcastle	Earthquake	13	1,200	670
25.1–1.3	1990	Western Europe	Winter storms	230	14,800	10,200
26–28.9	1991	Japan, Kyushu, Hokkaido	Typhoon Mireille (No. 19)	62	6,000	5,200
21/22.10	1991	USA, CA, Oakland	Forest fire	25	2,000	1,750
23–27.8	1992	USA, FL, LA	Hurricane Andrew	62	30,000	17,000
17.1	1994	USA, CA, Los Angeles (Northridge)	Earthquake	61	44,000	15,300
17.1	1995	Japan, Kobe (Great Hanshin)	Earthquake	6,348	100,000	3,000
5.7–10.8	1997	Eastern and Central Europe	Flood	110	5,900	795
4–10.1	1998	Canada. USA	Ice storm	45	2,500	1,150
15.5	1998	USA, MN	Hailstorm		1,500	1,305
20–30.9	1998	Caribbean. USA	Hurricane Georges	4,000	10,000	3,400
14.4	1999	Australia, Sydney	Hailstorm	1	1,500	960
3–7.5	1999	USA, OK, TN	Tornadoes	51	2,000	1,485

Economic loss in US$ m

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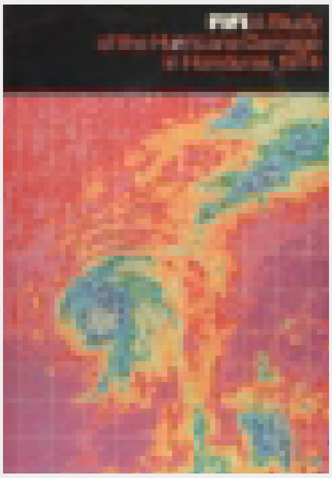



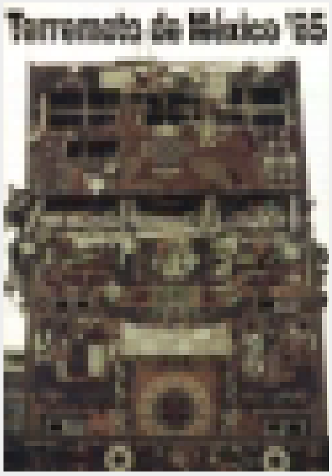


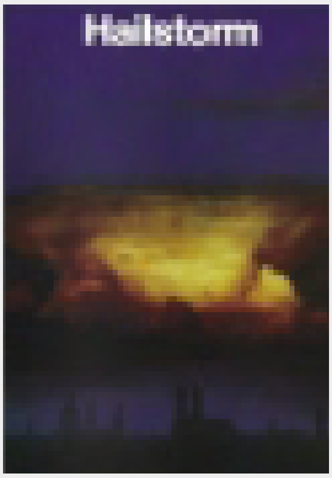


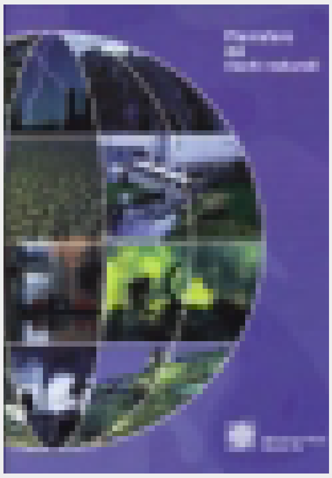
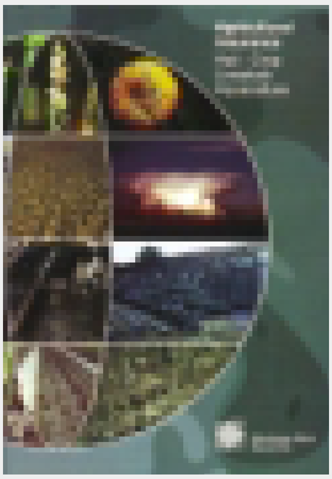
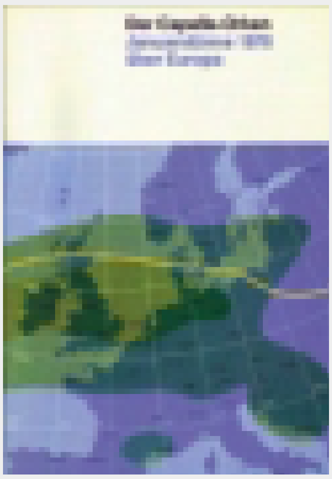
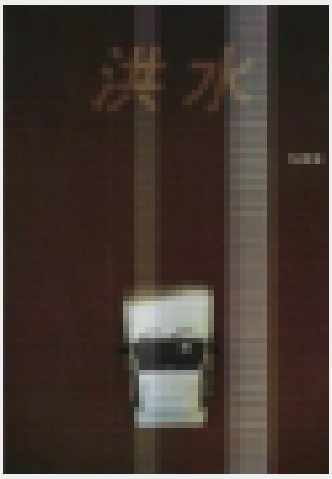

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