TRENDS IN NATURAL CATASTROPHES – POTENTIAL ROLE OF CLIMATE CHANGE

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Introduction

For more than 30 years now, Munich Re scientists have been analysing natural hazards throughout the world. The Geo Risks Research department today has a staff of 27, of whom 20 have a natural science degree.

Over the past few years, there have been growing indications that the frequency and intensity of natural catastrophes are being influenced more and more by the unfolding process of climate change. Recent years have been marked by a particular accumulation of weather-related extreme events:

- In the summer of 2002, the hundred-year flood in the Elbe and Danube region (Germany and eastern Europe), caused by a large-scale circulation pattern, which was also behind the extreme summertime precipitation events of 1997 (Odra), 2001 (Vistula), and 2005 (Alpine region)
- In 2003, the 450-year hot summer with excess mortality due to heat affecting more than 35,000 in Europe
- In 2004, a new record of losses caused by hurricanes in one season
- In 2004, the record typhoon season in Japan (ten landfalls)
- In March 2004, the first appearance of a tropical cyclone in the South Atlantic leading to losses in South America (Brazil)
- On 26 July 2005, India's highest precipitation in 24 hours: 944 mm in Mumbai
- In 2005, the largest number of tropical cyclones (27 and 15 hurricanes) in one season in the North Atlantic since recordings began in 1851
- Three of the ten strongest Atlantic hurricanes ever recorded occurred in 2005: the strongest hurricane of all times (Wilma – core pressure: 882 hPa), the fourth-strongest hurricane (Rita), and the sixth-strongest (Katrina) since recordings began
- In 2005, Hurricane Katrina, the costliest single event of all time in absolute terms with over US$ 125bn in overall losses and approx. US$ 60bn in insured losses
- In October 2005, the most northerly and easterly hurricane (Vince), which formed off Madeira
- In November 2005, the first tropical storm to reach the Canary Islands (Delta)
- The 2005 hurricane season in the North Atlantic was marked by an early high activity record and an exceptionally long duration. By the end of July, seven tropical cyclones had already developed, thus topping the previous record of five cyclones by that time. Further on, we saw four cyclones during November and December, the last one being active until 6 January 2006. The extraordinary length of the 2005 hurricane season accords with the long-term observation of an increasing trend in terms of the length of the hurricane season in the North Atlantic (linear trend of 4.8 days/decade since 1915 – Webster and Curry, 2006b).

Munich Re's NatCatSERVICE® database

Munich Re's GEO experts have been researching loss events due to natural hazards around the globe for over 30 years. These losses are documented in the NatCat*SERVICE*® database, which has a record of all natural catastrophes since 1970 (19,000 events). Major historical events (3,000 events since the eruption of Mt. Vesuvius in 79 AD) and all great natural catastrophes back to 1950 have also been included retrospectively.

The reports of events are based on a large number of very different sources and are only entered in the database after thorough review and verification. The possibilities for researching information on natural phenomena throughout the world have improved constantly (Table 1 and Fig. 1). Good descriptions and analyses of major loss events in the past can still be found today, for instance in historical reports. The earliest natural catastrophe recorded in the NatCat*SERVICE*® database is the eruption of Vesuvius in Italy in 79 AD, which was described in precise detail by Pliny the Younger.

Scientific reports

- Annali di geofisica
- BSSA (Seism. Soc. of America)
- Climatic Perspectives
- Disasters in China
- Earthquake and Volcanoes
- Earthquake Spectra
- EERI (EQ Engineering Res. Inst.)
- Hong Kong Observatory
- International Seismological Centre
- Journal of Meteorology
- National Hurricane Center
- Natural Hazard Observer
- Natural Hazards
- NOAA
- PIK (Potsdam Inst. of Climate Impact Research)
- University of Hawaii
- Swiss Earthquake Service
- Transactions Am. Geophys. Union
- USGS (United States Geological Survey)
- World Meteorological Organisation
- Various newsletters and periodicals (e.g. THW German federal disaser relief agency)

NGOs and GOs

- ECLAC
- International Federation of Red Cross and Red Crescent Societies
- OCHA/DHA
- United Nations
- USAID/OFDA
- Others

Weather services

- Fiji Meteorological Service
- German Weather Service
- Monthly Weather Report
- United States Weather Service
- Weekly Climate Bulletin

Insurance industry and news agencies

- 10+ insurance-related (WIR, PCS)
- 5+ news agencies
- Worldwide network of contacts in science, economy etc.
- Proceedings
- Munich Re Branches, 50+ countries
- Claims/Loss reports from clients
- Reports from insurance companies
- Insurance associations worldwide

Tab. 1 Main sources of Munich Re's NatCat*SERVICE*® database

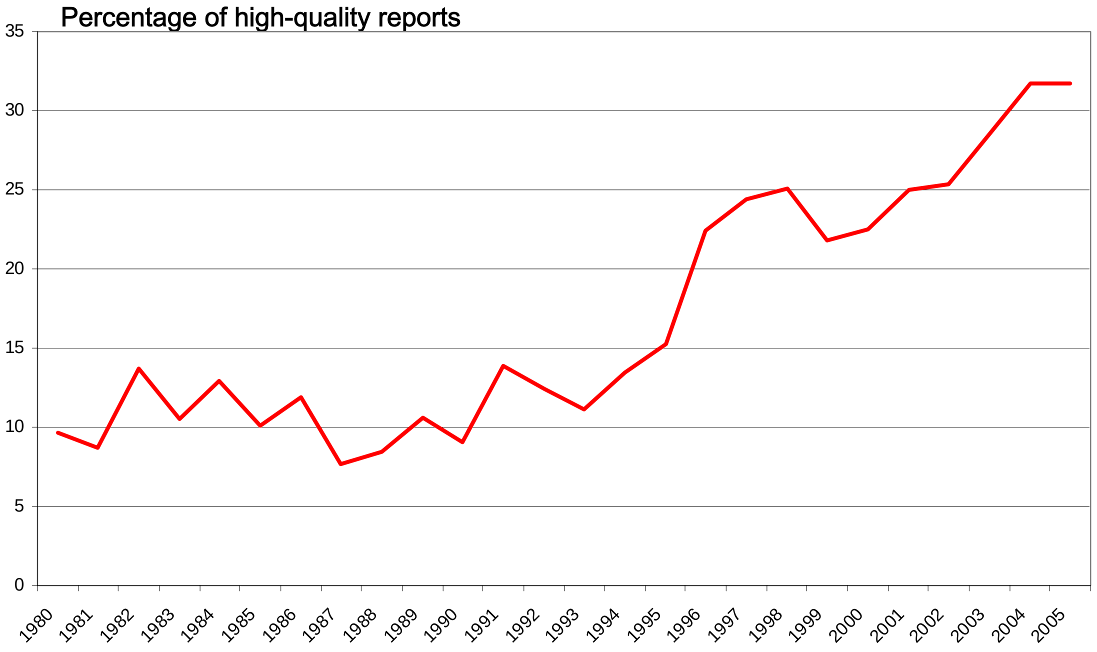


Fig. 1 Percentage of high-quality reporting in relation to all available records over time

The quality of data on natural catastrophe losses is mainly dependent on the level of reporting on natural catastrophes.

Public perception of catastrophes is strongly influenced by reports in the media. As reports on climate change have become more frequent, for example, people have become more aware of weather-related natural catastrophes, and reporting has increased. Reporting is also influenced by distorted information provided by authorities or by the unavailability of information because of intransparent information policies in some countries. In China, for example, the increase in the number of natural catastrophes coincides not only with the growth in population and values but also with the political opening-up of the country since 1980.

However, this does not affect the input of data into Munich Re's NatCat*SERVICE*®, since most of the information used comes from claims reports from insurance companies and insurance associations and is not influenced by reports in the media. Claims reports from insurance companies and insurance associations are based on the losses they have paid out.

Distorted information or intransparent information policies have no effect on NatCat*SERVICE*®'s long-term statistics, as they only relate to so-called great natural catastrophes, on which reporting has always been consistent (e.g. number of great natural catastrophes in China in the 1950s: 4; 1960s: 0; 1970s: 2; 1980s: 4; 1990s: 7; since 2000: none). A graph (Fig. 2b) produced from a current analysis of data records in NatCat*SERVICE*® shows that the loss data on China since the 1980s is of sufficient quality for all natural catastrophes. High-quality data is only available for major natural catastrophes since the 1950s (Munich Re starts with the year 1950 in its classification of catastrophes as major natural catastrophes).

Every data record in our database is given a quality level between 1 and 6 (1 being the highest quality, 6 the lowest) according to the sources used and how good the loss description fits with the loss figures. As a basis for deciding on the quality level, we introduced a decision tree (Fig. 2a and Table 2) to ensure a uniform procedure. First-class sources are information provided by insurance companies and insurance associations, scientific bodies, international organisations (e.g. UN, IFRC, WHO), and some first-class news agencies (e.g. Reuters, dpa). Second-class sources are reliable newspapers and information by brokers. Third-class sources are historical sources and some online information providers.

Our evaluation shows that the records on the largest and most devastating natural catastrophes going back to the 1950s are quality level 1 or 2. The records on smaller events since the 1980s are of sufficient quality for most countries. For some countries like the United States there is a sufficient quality level for a longer time period (Fig. 2c).

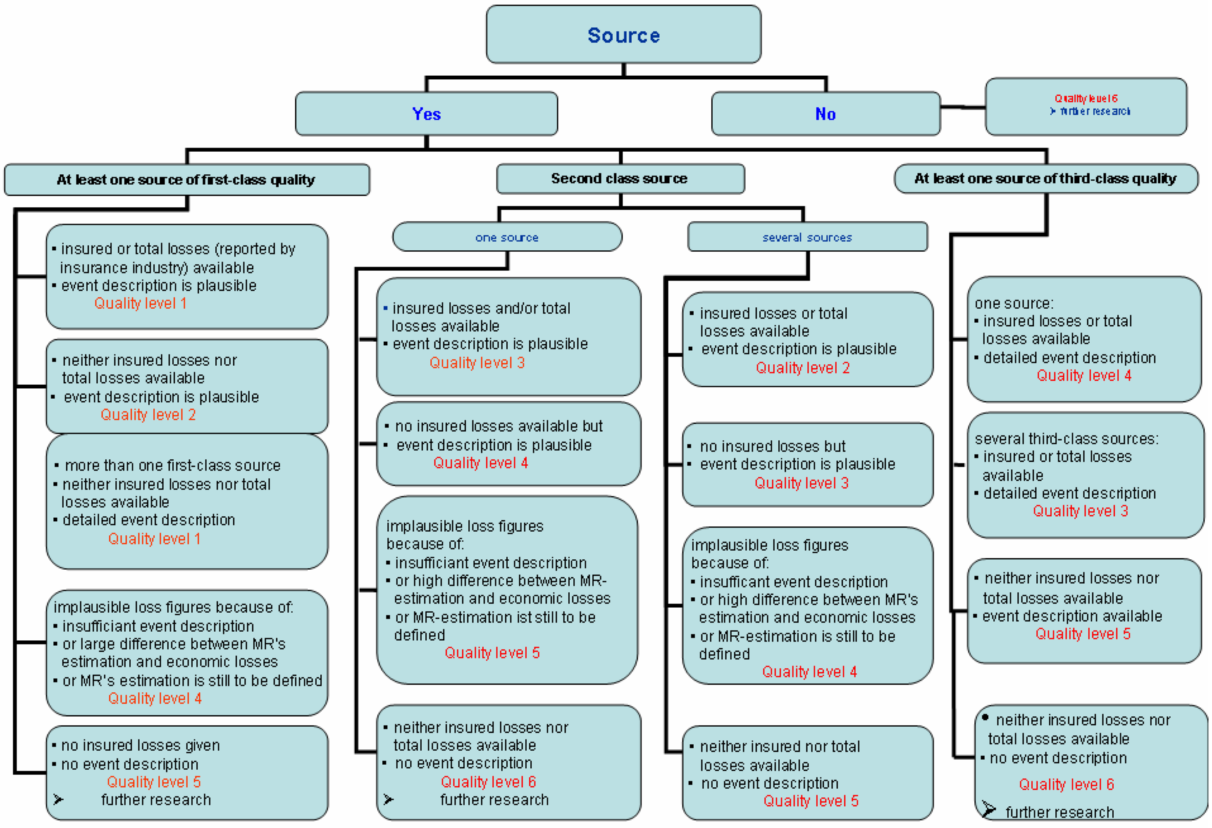


Fig. 2 Decision tree for the classification of data quality

Quality level 1	Loss assessment with very good reporting
Quality level 2	Loss assessment with good reporting
Quality level 3	Loss assessment with satisfactory medium reporting
Quality level 4	Loss assessment with sufficient, brief reporting (loss amount without clear plausibility)
Quality level 5	Loss assessment with faulty, poor reporting (loss amount without plausibility) ➢Dataset (loss assessment) cannot be used for analysis
Quality level 6	Loss assessment with inadequate or missing reporting ➢ Dataset (loss assessment) cannot be used for analysis

Tab. 2 Data quality levels

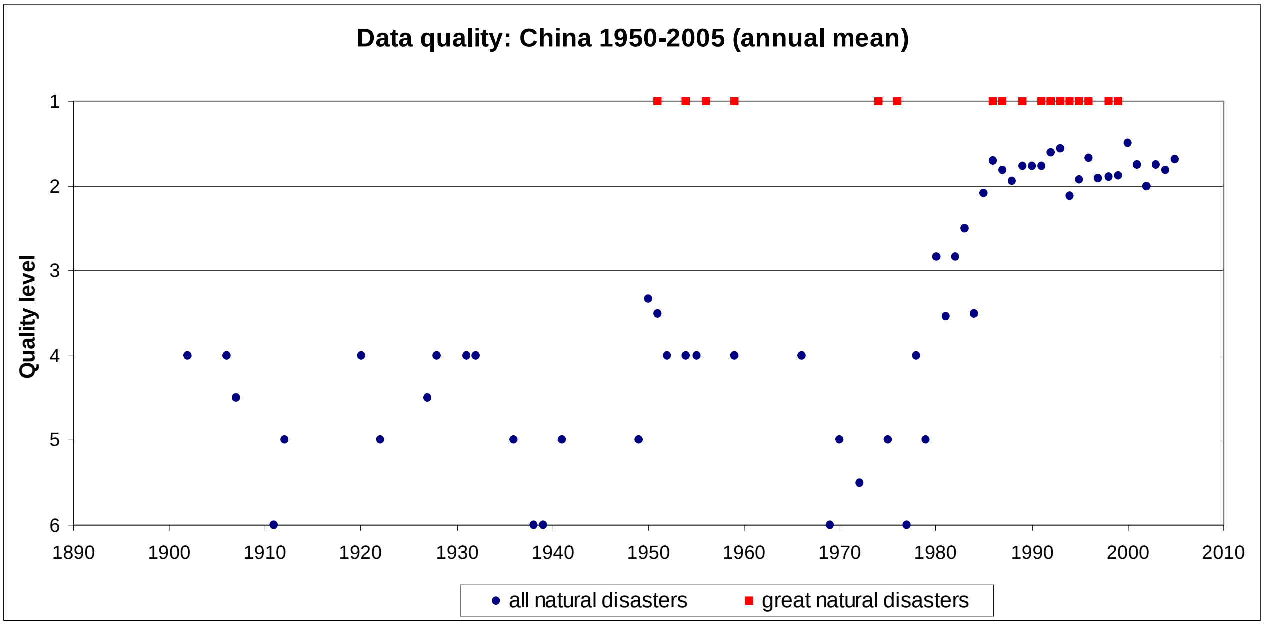


Fig. 2b Quality of data records on natural catastrophes occurring in the P.R. China

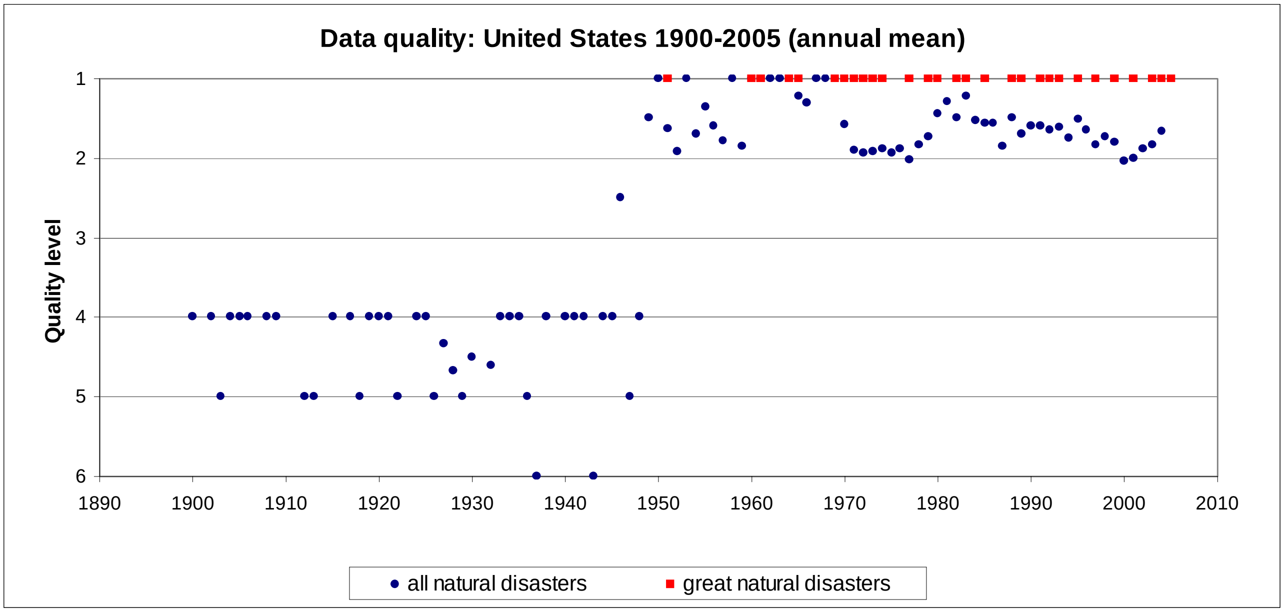


Fig. 2c Quality of data records on natural catastrophes occurring in the United States

In order to be able to perform trend analyses and avoid any distortions of information, all events are assigned to one of seven categories according to their financial and/or humanitarian effects – from pure natural events with a very modest or virtually no economic effect to major natural catastrophes. Our analyses and statistics do not take into account pure natural events (Table 3).

0	Natural event	No property damage (e.g. forest fire with no damage to buildings)			
1	Small-scale loss event	1-9 fatalities and/or hardly any damage			
2	Moderare loss event	10-19 deaths and/or damage to buildings and other property			
			2000-2005	**1990s**	**1980s**
3	Severe catastrophe	20+ fatalities and/or overall losses US$	> 50m	>40m	>25m
4	Major catastrophe	100+ fatalities and/or overall losses US$	> 200m	>160m	>85m
5	Devastating catastrophe	500+ fatalities and/or overall losses US$	> 500m	>400m	>275m
6	Great natural catastrophe *„GREAT disaster“*	Thousands of fatalities, economy severely affected, extreme insured losses (UN definition)			

Tab. 3 Classification of catastrophe size into seven catastrophe categories

Trend analyses of the data show very clearly that natural catastrophes have dramatically increased in number throughout the world and are causing more and more damage. The trend curve of great natural catastrophes (category 6 – thousands of fatalities, billion-dollar losses) worldwide per year reveals an increase from about two at the beginning of the 1950s to a current figure of about seven (Fig. 3).

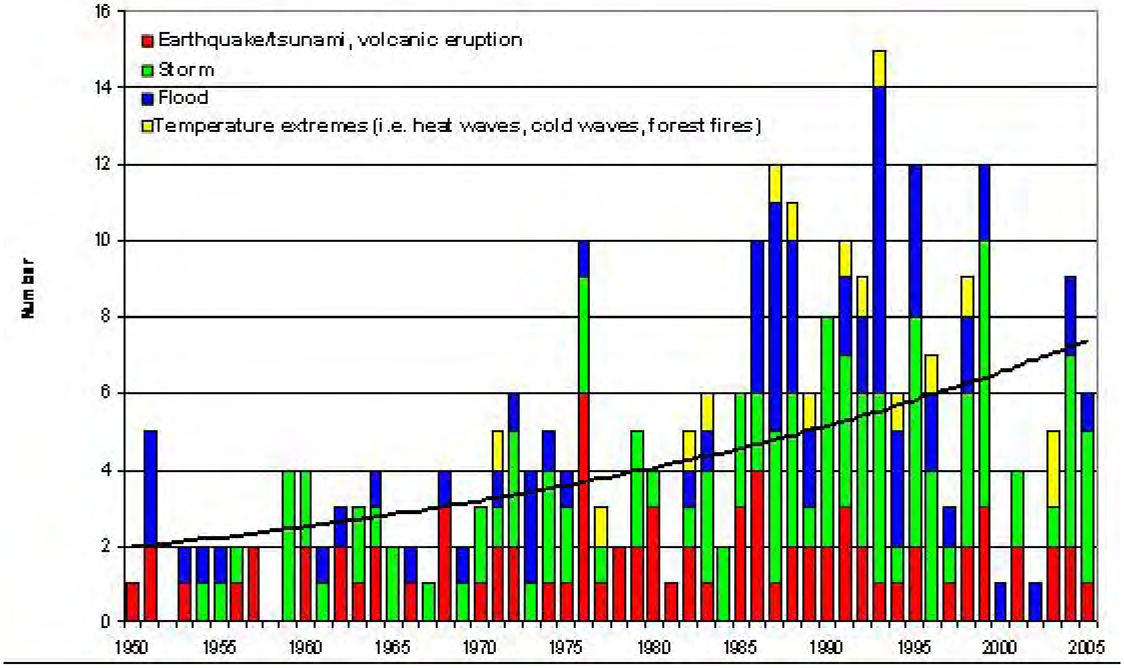


Fig. 3 Great natural catastrophes 1950 – 2005, number of events

In material terms, overall and insured losses from these great natural catastrophes rose even more steeply – to US$ 173bn in overall losses and US$ 83bn in insured losses in the record year of 2005 (Fig. 4). The original overall losses in the year 1995 (Kobe earthquake) were lower compared to 2005 – when adjusted for inflation, however, they exceed the 2005 level by a small amount.

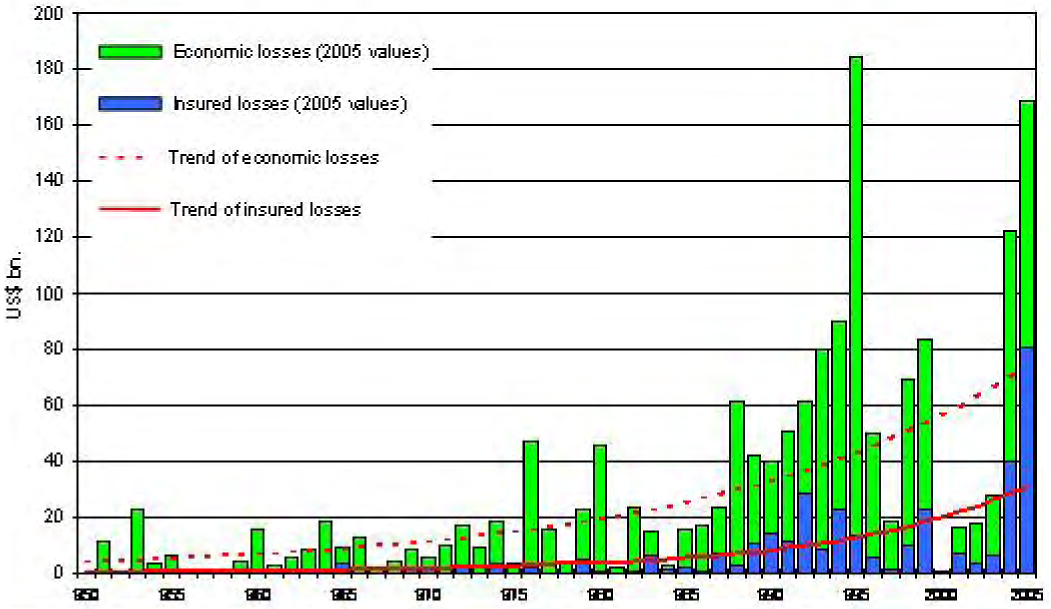


Fig. 4 Great natural catastrophes 1950 – 2005, overall and insured losses

This trend is apparent not only in the events classified as "major natural catastrophes", but also when we analyse all loss events worldwide in catastrophe categories 1 to 6 (Figs. 5 and 6). Similar to the preceding years, major natural catastrophes contribute 78 % to the overall and 88 % to the insured losses.

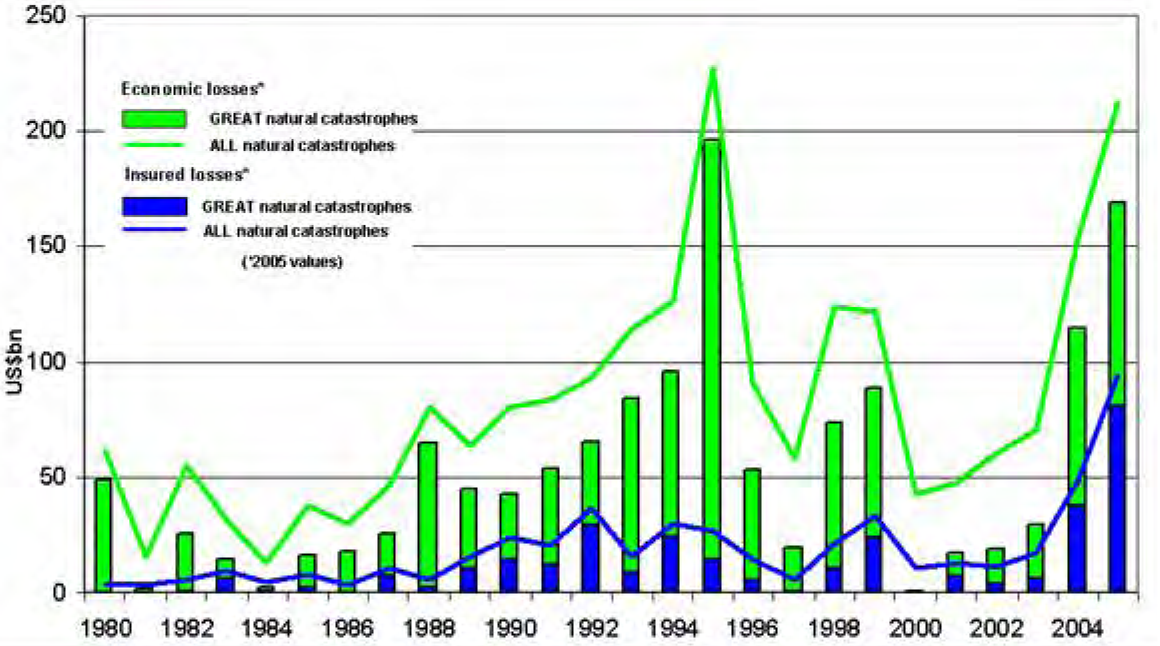


Fig. 5 Natural catastrophes 1980–2005, comparison between great natural catastrophes and all natural disasters worldwide 1980–2005

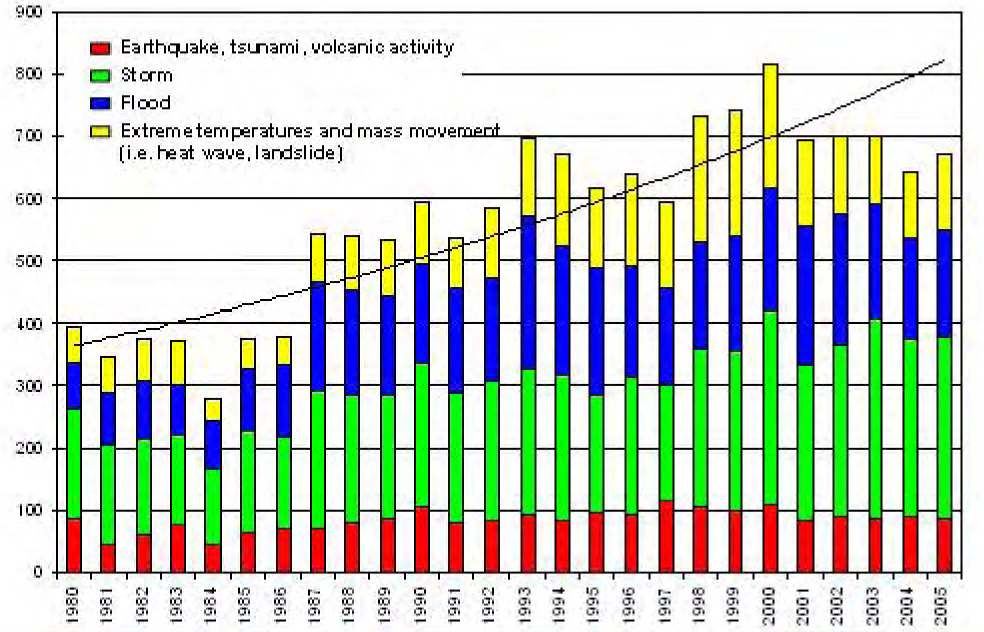


Fig. 6 All natural catastrophes worldwide 1980 – 2005, number of events

The comparison of temporal trends in the numbers of all and major natural catastrophes reveals a much steeper increase in the costly major ones.

The strong rise in losses over time is influenced by population growth, development and industrialisation of highly-exposed regions, elevated vulnerability of modern technologies, and increased insurance cover. As the upward trend in the number of natural catastrophes is mainly due to weather-related events like windstorms and floods and is not apparent in the same way as in the case of events with geophysical causes like earthquakes, tsunamis, and volcanic eruptions, there is some justification for assuming that it is not the result of a reporting bias but of changes in the atmosphere and particularly climate change.

Climate change and changing frequencies and intensities of natural catastrophes

The past few years have provided mounting support for the hypothesis that a changing climate contributes to the positive trend in natural catastrophes over time.

- Analyses of air bubbles trapped in Antarctic ice cores suggest that throughout the past 750,000 years the concentration of carbon dioxide – the most important of the greenhouse gases – has never before been anywhere near the level it has reached today (EPICA community, 2004).
- The last five years (including 2005) rank second to sixth in the table of the warmest years worldwide since 1861. The warmest year to date globally was 1998, in the northern hemisphere 2005 (World Meteorological Organization, 2005).

The third status report of the Intergovernmental Panel on Climate Change (IPCC, 2001) regards the link between global warming and the greater frequency and intensity of extreme weather events as highly significant. The expected increase in global average temperatures by the end of the century – of between 1.4 and 5.8°C, depending on the emission and climate models used – increases the probability of record temperatures enormously. Global warming raises the air's capacity to absorb water vapour and thus the precipitation potentials. Together with stronger convection processes, this leads to more frequent and more extreme intense precipitation events, which are today responsible for the majority of flood losses. The milder winters that are now typical in central Europe also reduce the snow areas over which stable cold high-pressure systems used to act as a barrier to the low-pressure systems coming in from the

Atlantic. Therefore, the barrier is often weak or driven eastwards so that devastating series of winter storms like those in 1990 and 1999 can no longer be considered exceptions. The wind readings at representative German weather stations reveal a clear increase in the number of storm days in the past three decades (at Düsseldorf Airport, for example, this figure has risen from about 20 to 35 a year; Otte, 2000). Although not scientifically confirmed, a trend towards more frequent and more extreme low-pressure systems, i.e. an increase in windstorm activity as such, has been observed in the North Atlantic over the past few decades.

It has been indicated in an increasing number of scientific publications in recent years that there is a connection between climate change and the frequency and intensity of natural catastrophes.

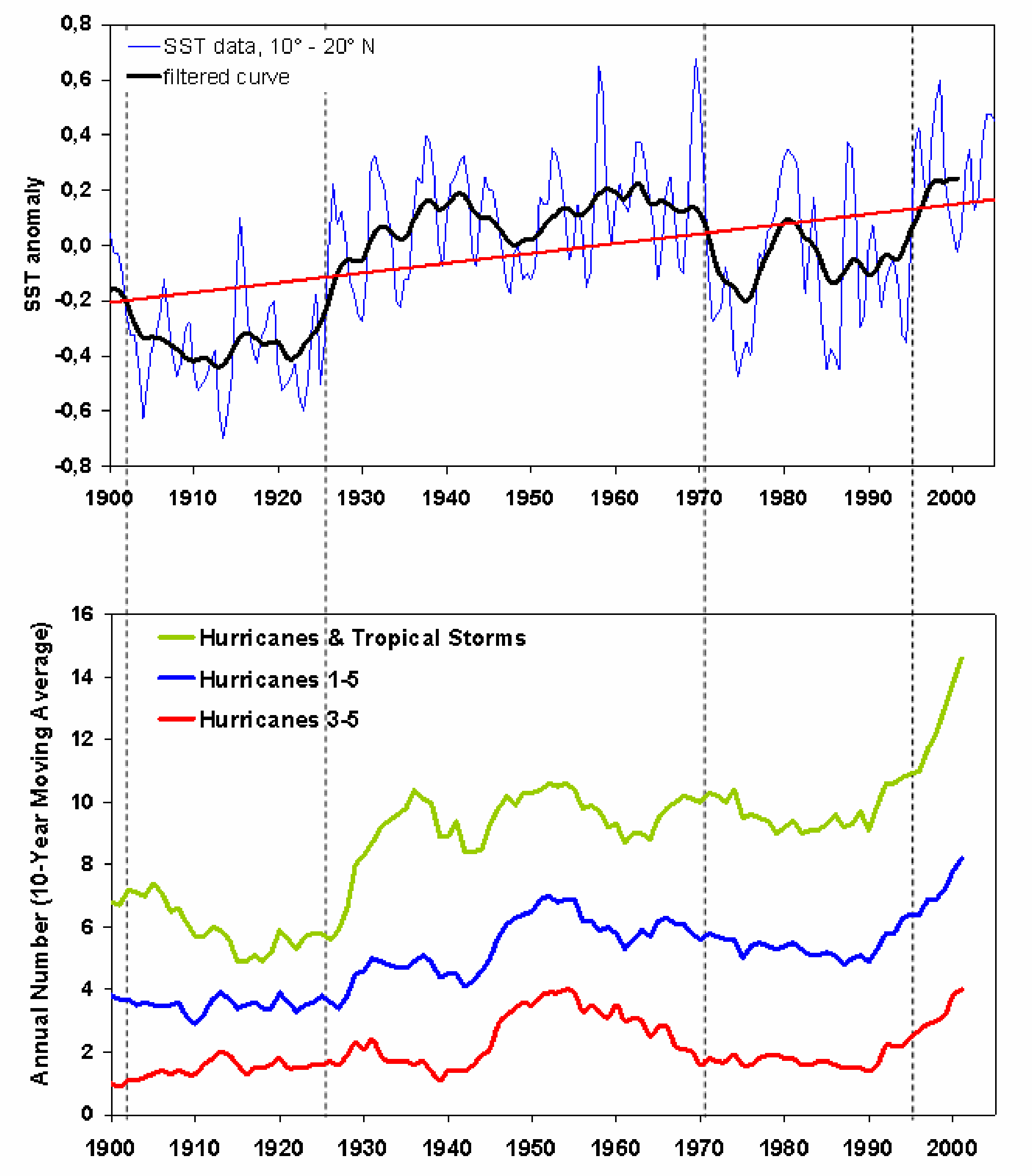
- According to British scientists, it is highly probable (>90%) that the influence of human activity has at least doubled the risk of a heat wave like the one that hit Europe in 2003 (Stott et al., 2004).
- Simulation models of future hurricane activity which factor in climate change show that by 2050 the maximum wind speed of hurricanes will have increased by 0.5 on the Saffir-Simpson Scale and that the associated precipitation volume will have increased by 18% (Knutson and Tuleya, 2004).
- The signal of anthropogenic warming has clearly been detected in a global warming of the world’s oceans. The temperature of the uppermost layers of the world's oceans has increased substantially over the past four decades (Barnett et al., 2005).
- There are strong indications, for instance, that one of the consequences of the increasing sea surface temperature of the tropical Indian Ocean is the ever-increasing drying up of southern Africa due to a zonal circulation (similar to the Walker Circulation). This trend was observed over the second half of the 20th century and has recently been shown to be closely connected with the warmer trend in the Indian Ocean, which is most probably caused by global warming (Hoerling et al., 2006). Increasing drought and famine risks will be among the consequences for the countries affected in southern Africa.

At this point we will go into some detail regarding the tropical cyclone issue in the North Atlantic.

As shown in a study by Barnett et al. 2005, the temperature of the uppermost layers of the world’s oceans has increased substantially over the past four decades. Especially the sea surface temperature of the tropical ocean regions – one of the major factors for development and intensity of tropical cyclones – has risen globally by about 0.5°C since 1970 (Agudelo and Curry, 2004). One might question the relative importance of SSTs and the warmth of the uppermost water layers – as the primary source of energy and moisture – in comparison with other decisive preconditions for TC development such as, for instance, low vertical wind shear in the troposphere or the change in zonal winds with longitude. A new paper studying the period 1970 to 2004 gives strong indications that the clear increasing global trend in Category 4 and 5 hurricanes is directly linked to the long-term trend in tropical SSTs, while the other aspects of the tropical environment, though responsible for short-term variations in hurricane intensity, do not contribute significantly to the global trend of increasing hurricane intensity over time (Hoyos et al., 2006; see also Webster et al., 2006a). Although there is no distinctive trend in the global number of cyclones occurring every year, the percentage of Category 4 and 5 hurricanes has been increasing since 1970 and indeed has more then doubled since then. There has been a steep increase in absolute terms too, from about eight per year at the beginning of the 1970s to eighteen per year in the period 2000 to 2004 (Webster et al., 2005). These findings are corroborated by the tight correlation found by Emanuel between the intensity of TCs in the North Atlantic and West Pacific – as measured by the annual aggregate of wind power release – and SSTs (Emanuel, 2005a; Emanuel, 2005b; cf. Kerr, 2006).

Especially for the North Atlantic, scientific findings over the past few years indicate two factors affecting sea surface temperature and hence hurricane activity variations over time: firstly, there is a multidecadal SST oscillation (Atlantic

Multidecadal Oscillation – AMO) caused by a natural sea current fluctuation and secondly a superimposed long-term warming process most probably caused by climate change – the resulting clear linear warming trend since 1870 amounts to 0.036°C/decade for the tropical North Atlantic (Fig. 7).



Figures 7A and 7B Upper panel (7A): Sea surface temperatures 1900 to 2004 in the tropical North Atlantic 10°–20° N (excluding the area west of 80° W). Anomalies relative to 1961 to 1990. Data taken from Trenberth, 2005. Red line: linear trend; heavy black line: filtered curve.

Lower panel (7B): Ten-year running mean curves for annual numbers of major hurricanes (red), all hurricanes (blue), and all named tropical cyclones (green) in the North Atlantic basin. Data from NOAA and UNISYS.

Independent of human-induced changes, natural cycles make the SST of ocean basins oscillate. In the North Atlantic this phenomenon is described by the "Atlantic Multidecadal Oscillation (AMO)" which in the 20th century showed a periodicity of about 65 years (Knight et al., 2005). The associated cold and warm phases are characterised by a margin of deviation of around 0.5°C in SST, which is about the same range as the presumed climate-change effect. The natural climatic fluctuation is most probably driven by the ocean's large-scale currents (Thermohaline Circulation THC – Knight et al., 2005; Vellinga and Wu, 2004). The current warm AMO phase started in 1995 and is expected to last for another ten to twenty years.

Warm phases produce a distinct increase in hurricane frequency and also more intense storms, whereas cold phases have the opposite effect. In the current warm phase, 4.1 major hurricanes (Saffir-Simpson Categories 3–5) have already occurred per year on average whilst in the previous cold phase this figure was only 1.5 (which means an increase of approx. 170%). Of course, a definite value for the average annual level of activity for the whole warm phase can only be given when this phase has ended and the 11 years of data since 1995 are not that much in comparison with the 45 years of data for the 1926–1970 warm phase. However, these 11 years are all we have at present and there is no reason to believe that they are far from being representative for the whole phase.

A comparison of corresponding AMO phases since 1900 indicates that the natural fluctuation is superimposed by a long-term warming process. This is to be expected from the above-mentioned global SST warming over time. Hence the level of tropical cyclone activity increases from one warm phase to another (Figure 7B). The increase in the number of major hurricanes per year from 2.6 to 4.1 on average from the previous warm phase to the current one means an increase of approx. 60%.

The changes observed for the North Atlantic basin are also reflected in US landfalls (Figure 8). In the case of major hurricanes, the annual average number of landfalls in the US has increased by about 230% from 0.3 to 1.0 compared with the last cold phase (approx. 1971 – 1994) and by about 70% from 0.6 to 1.0 compared with the last warm phase (approx. 1926 – 1970).

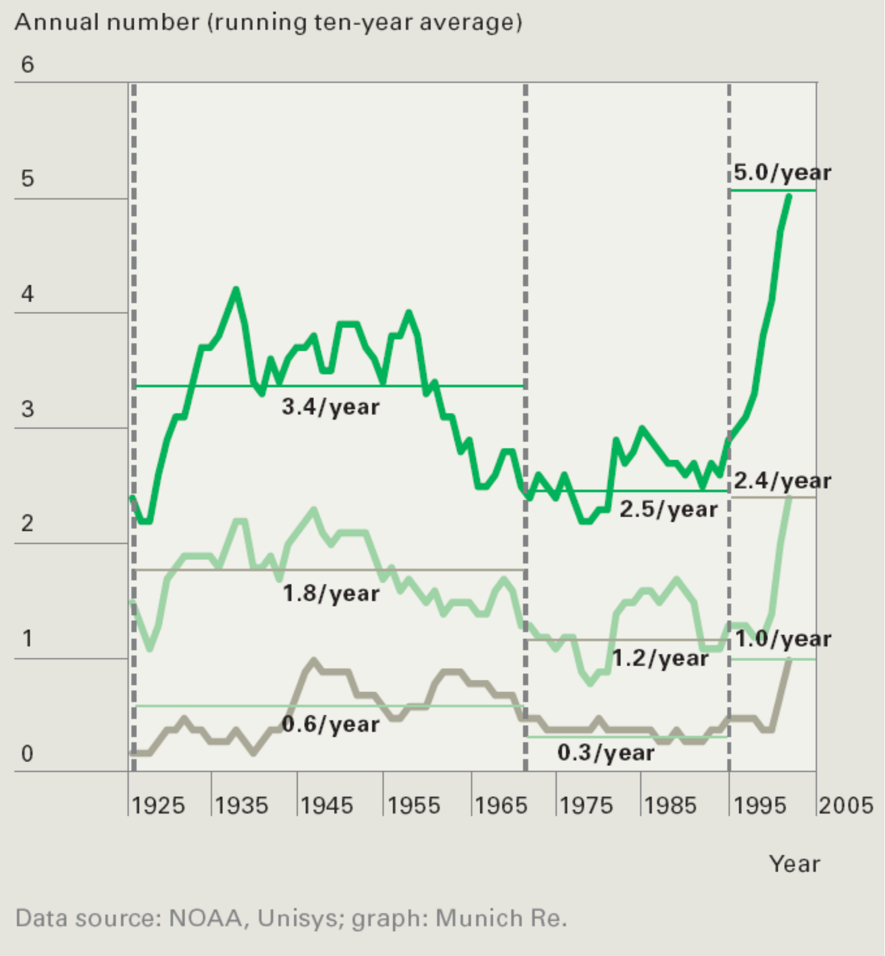


Fig. 8 Annual number of tropical cyclone US landfalls (ten-year running mean) and annual means over climatic phases for major hurricanes (grey curve), all hurricanes (light green curve) and all named tropical cyclones (green curve). Data source: NOAA/Unisys.

The cold/warm phase swing is also reflected in the data relating to losses. As a basis, we took the hurricane loss dataset adjusted to socio-economic conditions as of 2005 by Roger Pielke Jr. We based our analysis on this dataset because it is widely used in scientific contexts (Figure 9), although Pielke's data deviate from the data in Munich Re's MRNatCat*SERVICE*® in some cases.

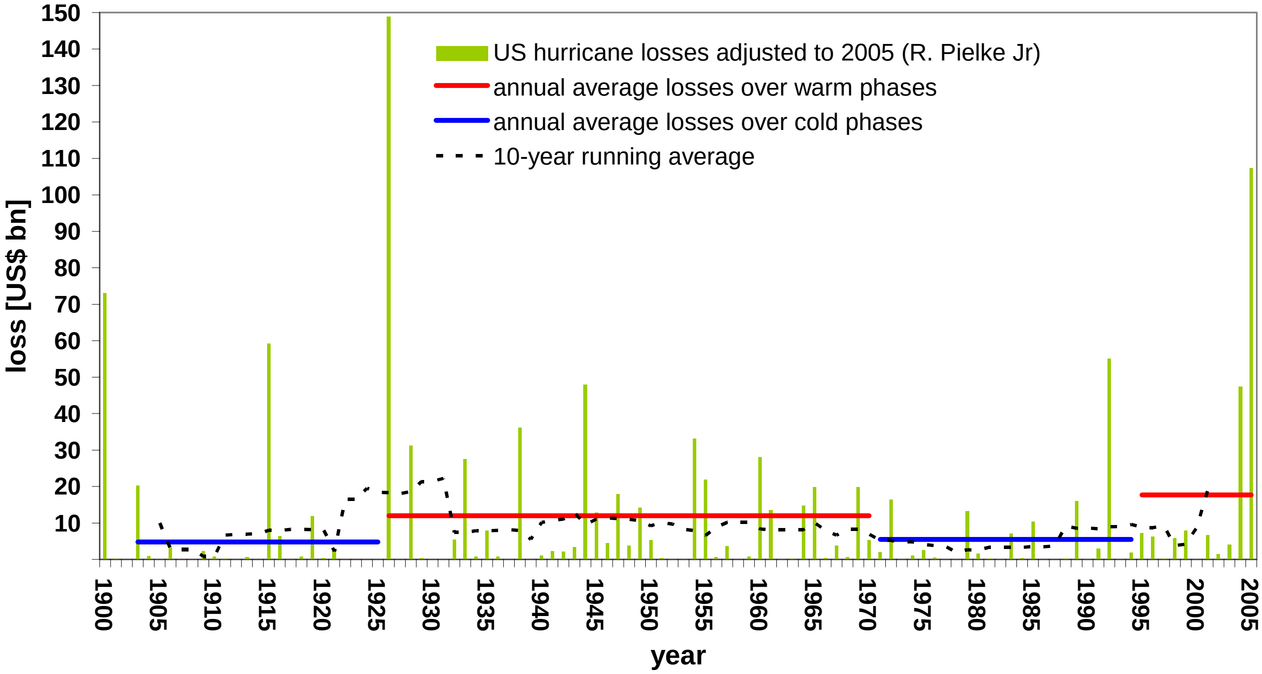


Fig. 9 Historical US hurricane losses adjusted to 2005 socioeconomic conditions (population, wealth, inflation) (green bars) from Pielke, R.A., Jr. (2006). Black dashed line: 10year running average; blue and red lines: annual average losses over cold and warm phases (for definition see the text).

For instance, according to Munich Re's database, economic losses from Katrina 2005 amounted to approx. US$ 120bn whereas Pielke's list gives US$ 80bn for the same event. The swing between cold and warm phases in the Main Development Region of the tropical North Atlantic is clearly indicated in Figure 7A, where we observe sharp changes in the degree of sea surface temperature swings for 1902–1903, and again for 1925–1926, 1970–1971 and finally for

warm phase (n = 56 years)		
mean US$ 13.1 bn	median US$ 3.9 bn	std dev US$ 25.7 bn

cold phase (n = 47 years)		
mean US$ 5.1 bn	median US$ 0.5 bn	std dev US$ 12.2 bn

U-test acc. to
WILCOXON/MANN/WHITNEY:
both loss-frequency distributions and respective median values are different in a statistically significant way (α = 1%).
$(\zeta = 2{,}93 > z_{\alpha=1\%} = 2{,}33)$

Tab. 4 Properties of loss-frequency distributions of annual losses from warm and cold phase years

	cold phase years	**warm phase years**
> US$ 1 bn	19 (of 47) 40%	36 (of 56) 64%
> US$ 5 bn	10 (of 47) 21%	26 (of 56) 46%
> US$ 10 bn	8 (of 47) 17%	17 (of 56) 30%

Tab. 5 Percentages of years exceeding specified annual loss thresholds in warm and cold phases of the 20th century.

1994–1995. These changes define the respective multidecadal cold and warm phases in the 20th century (cold: 1903–1925; 1971–1994; warm: 1926–1970; 1995–present day). We compared the frequency distributions of annual losses in the warm phase years and the cold phase years in the 20th century (Table 4). Median and mean values are much higher in the warm phase distribution and the application of the WILCOXON-MANN-WHITNEY test showed that both distributions and the respective median values are different in a statistically significant way ($\alpha = 1\ \%$). If we look at the exceedance of specified loss thresholds – US$ 1bn, 5bn and 10bn – we find that the percentage of years exceeding these thresholds is much higher in warm phases than in cold phases (Table 5).

If we compare the loss frequency distributions of the two cold phases in the 20th century, we find a higher median value (and mean) in the second cold phase. The difference between the distributions is statistically significant ($\alpha = 10\%$) and can be explained by sea surface temperatures being higher in the second cold phase than in the foregoing one (Table 6). As far as the two consecutive warm phases of the 20th century are concerned, there is only a statistically weak significant difference between the distributions ($\alpha = 20\%$), but median and mean values are nevertheless substantially higher in the second warm phase than in the previous one (Table 7). If we compare consecutive cold (warm) phases in terms of loss exceedance thresholds, we find a higher percentage of years exceeding the US$ 1bn, 5bn and 10bn thresholds in the second cold phase than in the previous one (Table 8). Equally, as far as consecutive warm phases are concerned, we find higher percentages of annual losses exceeding the US$ 1bn and 5bn thresholds in the second phase than in the previous one (Table 9). As to the US$10bn threshold, there is no increase, which is due to only two years (2004 and 2005) covering all the large losses of the current warm phase. Taken together, these findings are a strong indication that climate variations exert a great influence on the distribution of annual losses: warm phase and cold phase years have significantly different loss frequency distributions, with higher mean, median and percentage of years exceeding specified loss levels in the warm phases. Equally, there are strong indications of changing distribution properties between consecutive cold phases (warm phases) in the 20th century, resulting in higher loss frequencies in the second phase characterized by higher sea surface temperatures.

cold phase 1 1903-1925 (n = 23 years)		
mean US$ 4.8 bn	median US$ 0.3 bn	std dev US$ 12.8 bn

cold phase 2 1971 - 1994 (n = 24 years)		
mean US$ 5.5 bn	median US$ 0.7 bn	std dev US$ 11.8 bn

U-test acc. to
WILCOXON/MANN/WHITNEY:
both loss-frequency distributions and respective median values are different in a statistically significant way ($\alpha = 10\%$).
($\zeta = 1{,}511 > z_{\alpha=10\%} = 1{,}282$)

Tab. 6 Properties of loss-frequency distributions of annual losses from consecutive cold phases.

warm phase 1 1926-1970 (n = 45 years)		
mean US$ 12.0 bn	median US$ 3.6 bn	std dev US$ 24.1 bn

warm phase 2 1995 - 2005 (n = 11 years)		
mean US$ 17.7 bn	median US$ 6.3 bn	std dev US$ 32.6 bn

U-test acc. to
WILCOXON/MANN/WHITNEY:
both loss-frequency distributions and respective median values are different in a statistically weak significant way ($\alpha = 20\%$).
($\zeta = 0{,}918 > z_{\alpha=20\%} = 0{,}842$)

Tab. 7 Properties of loss-frequency distributions of annual losses from consecutive warm phases.

	cold phase 1	cold phase 2
> US$ 1 bn	7 (of 23) 30%	12 (of 24) 50%
> US$ 5 bn	4 (of 23) 17%	6 (of 24) 25%
> US$ 10 bn	3 (of 23) 13%	5 (of 24) 21%

Tab. 8 Percentages of years exceeding specified annual loss thresholds in consecutive cold phases of the 20th century.

	warm phase 1	warm phase 2
> US$ 1 bn	27 (of 45) 60%	9 (of 11) 82%
> US$ 5 bn	19 (of 45) 42%	7 (of 11) 64%
> US$ 10 bn	15 (of 45) 33%	2 (of 11) 18%

Tab. 9 Percentages of years exceeding specified annual loss thresholds in consecutive warm phases of the 20th century.

The insurance industry is affected by climate change in a number of ways:

- The greater number and severity of extreme events are increasing the frequency and dimensions of the losses incurred.
- The volatility of losses is growing.
- New types of exposure are developing (e.g. hurricanes in the South and Northeast Atlantic).
- Unprecedented extreme values are being registered (in 2005, the strongest hurricane ever recorded).
- Premium adjustments often lag behind claims developments.

In spite of the unfavourable loss trends, the insurance industry still offers a wide range of covers for natural hazard losses. At the same time, it is endeavouring to encourage loss prevention on the part of its clients. Furthermore, it is making great efforts to control its own loss potentials through the application of modern geo-scientific methods. A quantitative forecast of future climate change's impact on the frequency and intensity of extreme weather events is still a problem.

The insurance industry has great potential for promoting climate protection and thus exerting a positive influence on future losses – by considering climate protection aspects in its products, investments, sponsoring activities, and its communications.

Munich Re will continue to play a leading role in these areas.

Conclusions

The data in Munich Re's NatCat*SERVICE*® clearly show significant trends with ever-increasing numbers of extreme weather events and losses caused by such events during the last decades. There is convincing evidence that climate change is occurring already, affecting not only air temperatures but also sea surface temperatures. A growing number of serious scientific studies provide evidence of causal links between climate change and an intensification of natural catastrophe hazards, such as tropical storms, floods, droughts or heat waves. Especially, we found strong indications that climate variations exert a great influence on the distribution of annual hurricane losses. Taken together, these facts form the basis of our conviction that the increasing losses caused by natural catastrophes are partly a consequence of global warming.

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