Impact of increasing Natural Hazards on Engineering Insurance

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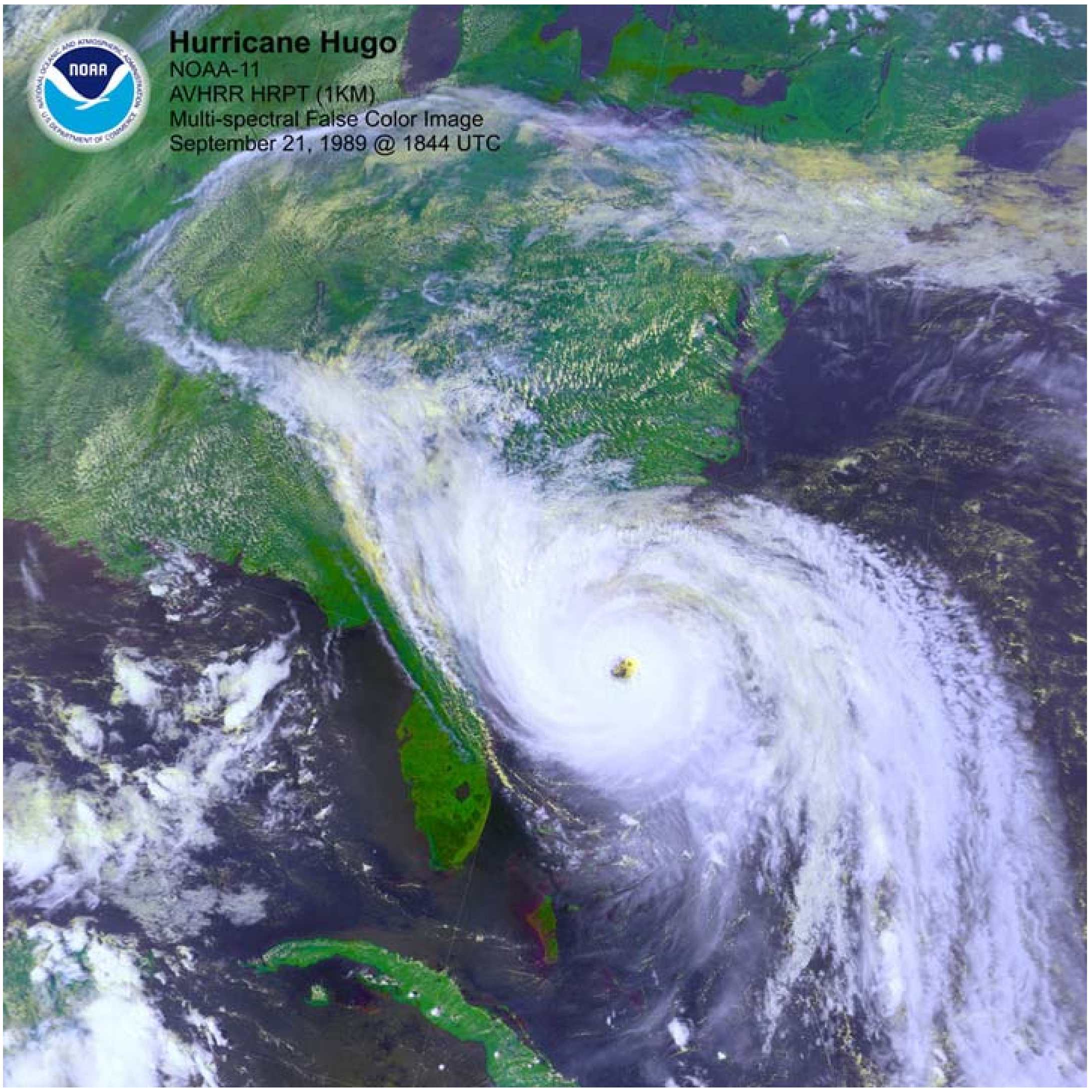

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Excecutive Summary

In conclusion, we can state that the question discussed under this heading cannot be answered unequivocally. First of all, there is a lack of sufficiently significant data and statistics which would be required to prove conclusively an increasing impact of natural hazards on Engineering insurance. Individual statistics reveal a growing impact. Basic data, however, do not provide enough details in order to conclude in how far an impact on Engineering insurance can be quantified. It is undoubted, however, that an impact exists which will be even significantly intensified by future developments (global warming, exposed values).
Additionally, enquiries carried out in preparation for this paper have shown that major efforts need to be undertaken in order to model impacts of natural hazards on insured values. These models work exclusively with elaborately generated assumptions, which can differ from model to model. This leads to the fact that the results can also vary dramatically depending on the input. For the area of Engineering insurance these models have not yet been established to the same extent as in the area of property insurance.
Due to these uncertainties, technical underwriting and risk assessment gain an increasing importance in controlling possible impacts of increasing natural hazards on Engineering insurance.

1 Increasing Natural Hazards?

1.1 Development of Losses caused by Events of Nature

Influenced by the public discussion about global climate changes and by impressive media coverage of occurring natural disasters, insurance industries all over the world suspect that the number of losses caused by events of nature has increased in recent decades and fear similar developments in the future.

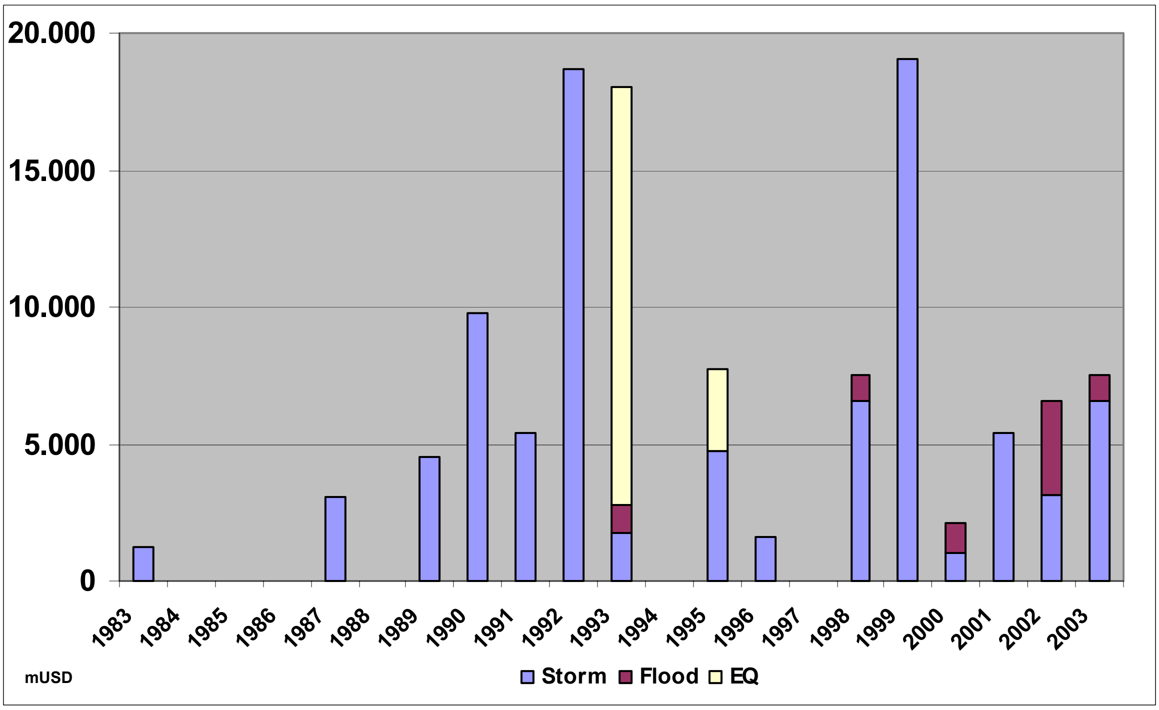
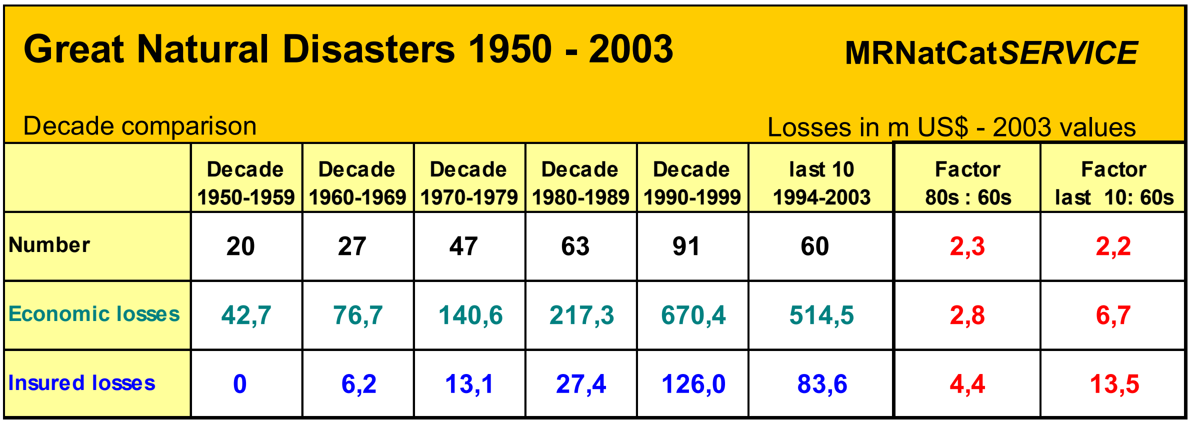


Fig. 1: Events of Nature: Total Amount of Insured Losses with an insured loss of more than US$ 1 bn [© Munich Re GeoRisks Research]

Losses caused by natural disasters have reached a dramatic extent especially in recent years and especially in the insurance industry. Fig. 1 shows all natural disasters in recent decades which caused costs of more than 1 billion US dollars for the insurance industry.

Before 1987, only one single event had reached such an amount of insured loss: hurricane “Alicia”. Since 1987, however, a total number of 41 such events have occurred, 27 of which occurred in the 1990s and again another 12 since 2000! Among these, the absolute front-runner is hurricane “Andrew” with an insured loss of 17 billion dollars, which might have been even several times higher if “Andrew” - instead of landing a “double miss” by moving about 50 km/150 km past Miami and New Orleans – had hit twice in the bull’s eye. Not much different was the earthquake in California in 1994 which also affected the Greater Los Angeles area only marginally and therefore, despite an insured loss of more than 15 billion dollars can only be seen as a „warning shot“ or at best as a “grazing shot“. The same is true for the earthquake in Kobe (Japan) in 1995. These two earthquakes are the only disasters in the list which were not caused by changes in the atmosphere.



Great Natural Disasters 1950 - 2003 **MRNatCat*SERVICE***

Decade comparison

Losses in m US$ - 2003 values

	Decade 1950-1959	Decade 1960-1969	Decade 1970-1979	Decade 1980-1989	Decade 1990-1999	last 10 1994-2003	Factor 80s : 60s	Factor last 10: 60s
Number	20	27	47	63	91	60	2,3	2,2
Economic losses	42,7	76,7	140,6	217,3	670,4	514,5	2,8	6,7
Insured losses	0	6,2	13,1	27,4	126,0	83,6	4,4	13,5

Fig. 2: Great Natural Disasters 1950 – 2003 [© Munich Re GeoRisk Research]

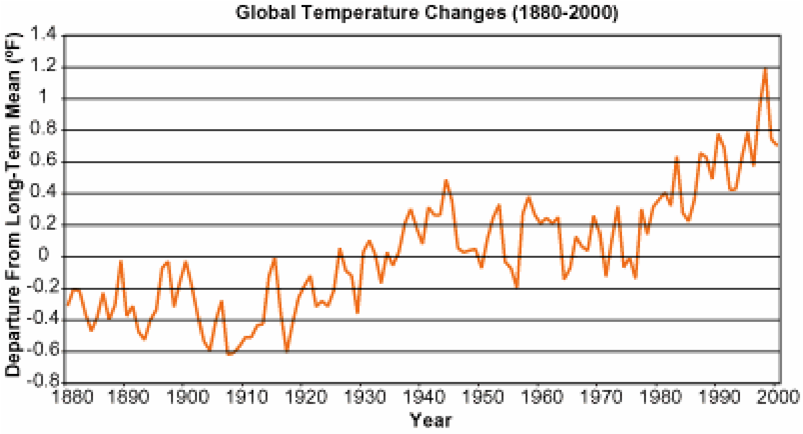
The development since 1950 (Fig. 2) significantly shows the dramatic increase in recent years’ losses caused by natural disasters. This development implies that annual losses in the range of 100 billion dollars (current value) will become the norm only in a few years time.
The inflation-adjusted increase compared to the 1960s which had been three times as high for economic losses and four times as high for insured losses in the 1980s, has in the meantime – that is in the last 10 years – rocketed to a seven times higher or even 14 times higher rate (Tab. 2). These figures refer to the so-called „big“ natural disasters, other basic losses of which Munich Re counts 600-850 annually worldwide, increase the total loss volume on average to approximately double the amount (Munich Re, 2004).
Additional observations which would be desirable in order to put the events into perspective and which would allow to draw conclusions from the causes of assumed and assessed developments are almost completely missing. In order to explain this extremely unsatisfactory situation judged from a scientific point of view, we have to refer to the fact that sufficiently tested data from the past are not available and that reliable comparative statistical data are largely non-existent.
Serious climate research, for example, conceals by no means that a comparative assessment according to defined criteria of frequency and intensity of classified natural disasters with past incidences is impossible for the mere reason that observation periods of sufficient length do not exist.

When an objective quantification of the after-effects of such incidences is sought, the additional problem of missing reference parameters becomes apparent. Increased losses as a result of the occurrence of certain natural events are not necessarily only the result of a growing intensity of today's events compared to similar events in the past. An equally qualifying and quantifying observation of the development of natural disasters rather requires taking numerous additional influencing factors into account including economic developments just as much as technical and socio-cultural changes. The following issues, for example, have to be considered as potential influencing factors:

- An increase in value in the insured object exposed to a natural hazard – e.g. it does not really have to be surprising if a loss at a building of a certain construction assessed after an earthquake is doubled by the fact that construction costs have also become twice as high in the observed period.
- Extension of settlement areas due to population growth and/or economic use of buildings exposed to natural hazards. In a realistic consideration, it can hardly be astonishing if no or perhaps only insignificant damage effects of any Tsunami-incidences are known in accordingly endangered coastal areas.
- Changing communication behaviour and extended communication opportunities compared to the past – Possibly no-one noticed a particular incidence in the past because the area had not been inhabited? Perhaps the actually existing inhabitants simply had no means to inform distant populations about the incidence and its effects? Would possible receivers of such news be at all interested to learn what happened in areas which they never – not even on holiday – set foot on?

Reduced to the scientific facts currently seen as largely reliable, the present situation of the development of natural hazards can be summarized as follows:

Since the mid-70s of the last century, an increasing number of positive changes from the long-term average of the earth surface temperature showing an uneven regional distributing can be stated. However, it is not known whether this temperature change is a result of natural cyclical changes or occurs in connection with the modern use of available resources (1).



Source: U.S. National Climatic Data Center, 2001

Fig. 3: Global annual mean surface air temperature change 1880 – 2000
Deviation from Long Term mean Temperature

The Third Assessment Report of the Intergovernmental Panel on Climate Change (2001) attaches special importance to the connection between global warming and the frequency or intensity of extreme atmospheric events. In fact, analysis of observation series as well as model calculations deliver numerous hints that the occurrence probability for extreme values of different meteorological parameters has already considerably changed and will continue to do so.

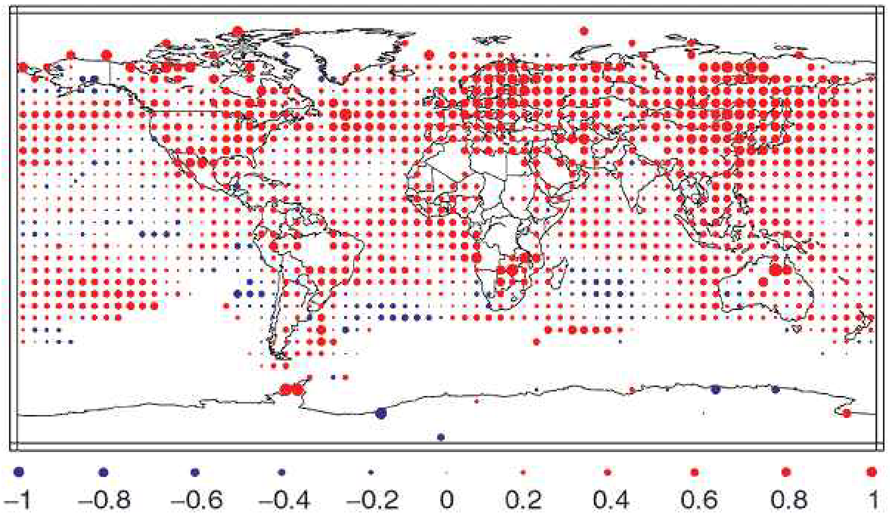


Fig. 4: Trends of Surface-temperature in °C/Decade 1975 – 2000
Trend is characterised by diameter of dots (green: decreasing, red: increasing
[Third Assessment Report of IPCC 2001]

Additionally, with the individual consequences of occurring extremes (e.g. increased water vapour content of the air, major temperature differences within the atmosphere), changes in the relevant primary intensities (e.g. amount of precipitation, wind velocity) of certain natural phenomena – especially storm and intense rainfall – must be expected at the place of occurrence (2).

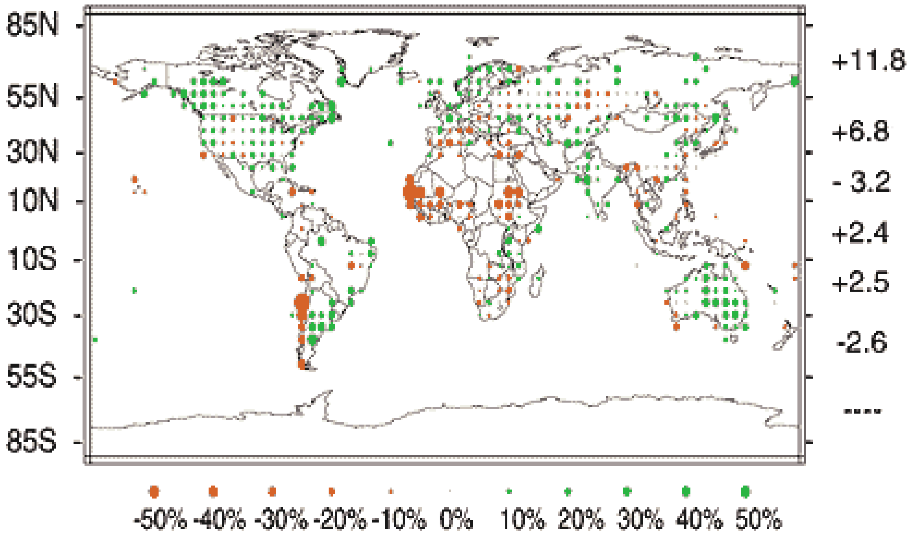


Fig. 5: Trends of Precipitation in % of mean value 1900 – 1999
Trend is characterised by diameter of dots; (green: increasing; red: decreasing)
[Third Assessment Report of IPCC 2001]

In absolute figures, an increase in the secondary effects (losses) of the occurred natural events compared to existing values of the past can be stated. Quantification of the financial consequences of these events - cumulated over a limited observation period - shows an increase in the economic as well as in the insured losses. Such a uniform development of economic and insured losses is to be expected since the latter represents with high probability a correlating subset.

The relative development of loss effects in comparison to past periods is completely unknown under economic aspects as well as under insurance related aspect. Neither are possible causes and cause constellations which determine or influence these developments comprehensively clarified.

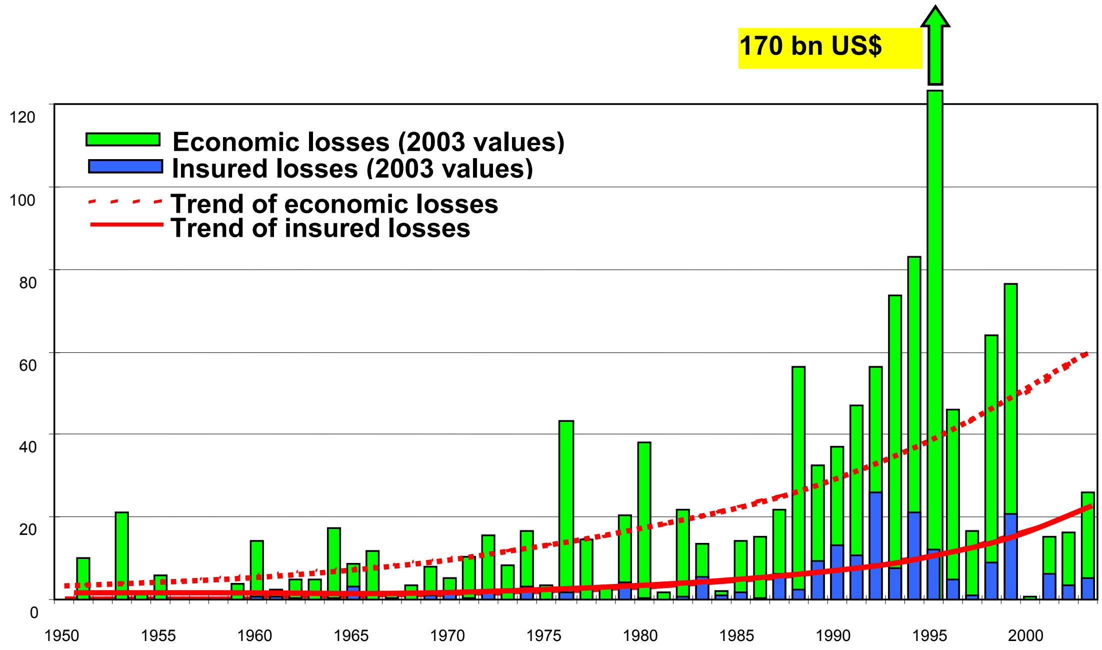
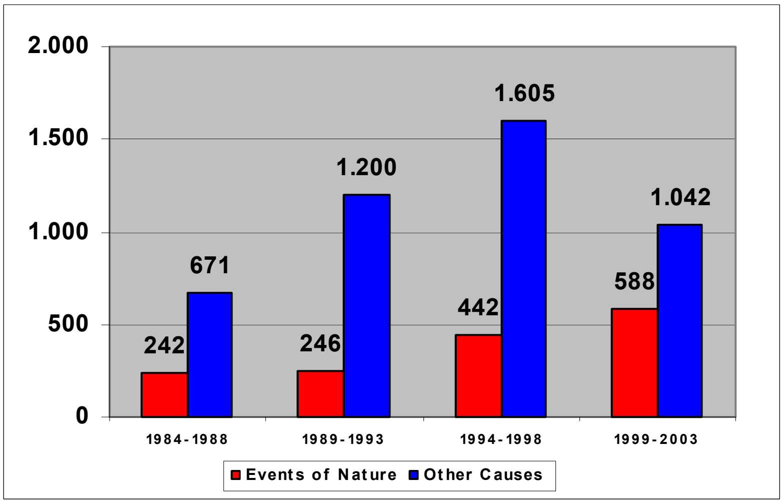


Fig. 6: Great Natural Catastrophes 1950 – 2003
[2003 GeoRisks Research Dept. Munich Re]

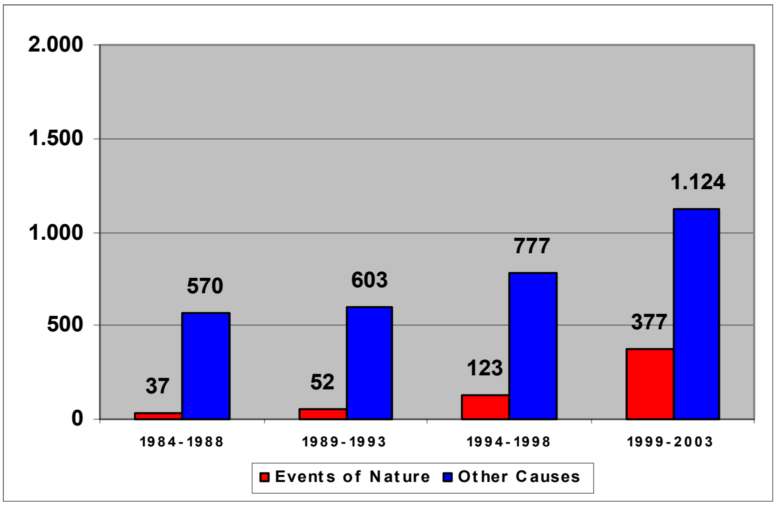
2 The Importance of Cat. Nat. Losses for Engineering Insurance

The above-mentioned problems in the qualified and relative observation of natural hazards are also unrestrictedly true for the area of Engineering insurance. Therefore, the percentage of natural hazards of the total losses within definable portfolios and definable periods of time has been determined within the framework of this paper instead. In this context, a correlation between the individual loss developments during a specific period of time can be established. National and international statistics used here are not generally significant, since such considerations almost exclusively reflect only the impact of natural hazards on the portfolios of individual companies or individual markets. Additionally, it has to be taken into account that further parameters, such as, for example, increasing deductibles customary in a particular market, cession of Cat. Nat. risks into national pool solutions as well as individual underwriting policies have a considerable influence on the available results which cannot be fully quantified. Corresponding surveys carried out by individual market participants show the following results:



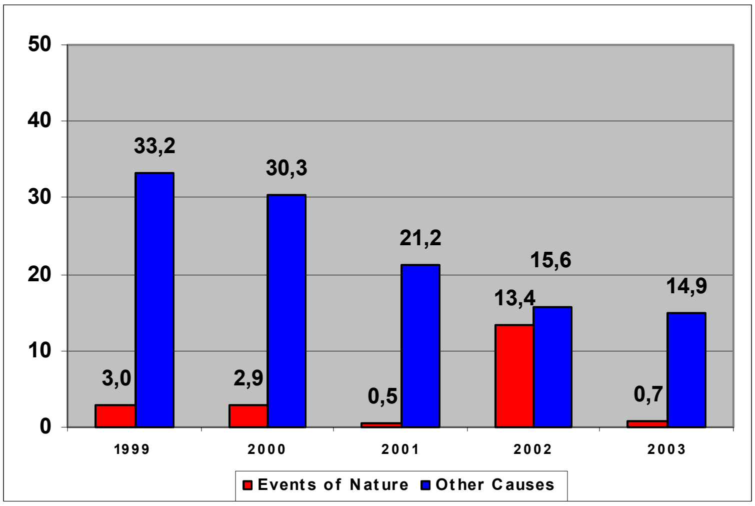
	Total amount of loss	% of events of nature
1984 -1988	€ 914m	26,5 %
1989 -1993	€ 1,446m	17,0 %
1994 -1998	€ 2,046m	21,6 %
1999 -2003	€ 1,630m	36,1 %

Fig. 7: Losses caused by events of nature in an EAR/CAR-Portfolio of an international reinsurer (all figures in million €)



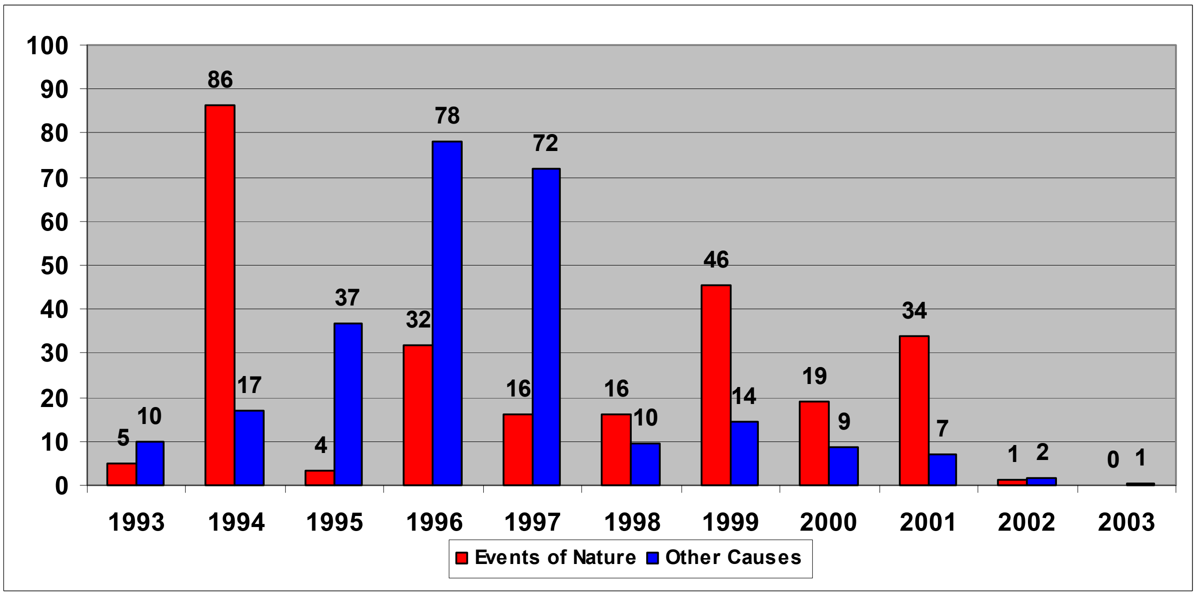
	Total amount of loss	% of events of nature
1984 -1988	$ 607m	6,9%
1989 -1993	$ 655m	8,5%
1994 -1998	$ 899m	14,2%
1999 -2003	$ 1,501m	26,1 %

Fig. 8: Losses caused by events of nature in an Engineering-Portfolio of an insurer with an international portfolio (all figures in million USD)



	Total amount of loss	% of events of nature
1999	€ 36,2m	8,3 %
2000	€ 33,2m	8,7 %
2001	€ 21,8m	2,1 %
2002	€ 29,1m	46,4 %
2003	€ 15,6m	4,3 %

Fig. 9: Losses caused by events of nature in an EAR/CAR-Portfolio of an insurer with a German portfolio (all figures in million €)



	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total amount of loss ($m)	15	103	40	110	88	26	60	28	41	3	1
% of events of nature	34%	83%	9%	29%	18%	63%	76%	69%	83%	47%	0%

Fig. 10: Losses caused by events of nature in the EAR/CAR-Portfolio of Taiwan (all figures in million USD)

⇨ The percentage of losses caused by events of nature of the total losses of individual portfolios/portfolio segments in Engineering insurance is in the range of 10% for European countries. If we look at worldwide portfolios, the percentage of losses caused by natural hazards increases to about 30%. In extreme cases this rate was as high as 75% (Taiwan).

In the general tendency, the data presented above reveal an increase in the percentage of losses caused by natural hazards in the total amount of loss.

⇨ In this context, individual events of nature have a significant impact on the losses within specific portfolios which, however, is frequently expressed in a considerably increased percentage of natural hazards in the total amount of loss. This does not necessarily lead to an increase in the total amount of loss of the respective portfolio in excess of the expectation tolerance limits. Only relatively small portfolios in regionally restricted areas which are highly exposed to natural hazards form exceptions to this rule.

Statistics used in the preparation of this paper are based on different regions and periods of time as well as on different portfolio compositions and therefore cannot be easily reduced to the common denominator so that general conclusions could be drawn.

3 Aspects of Insurance

3.1 Reactions to natural hazard development required by the Insurance industry

Insurance companies play an important role in private, business and public risk provisioning and as such mainly aim at minimising the risk of an insurance holder's financial collapse. This is also true – and especially so for countries with high exposure – for natural hazards with their comparatively high loss potential.
In order to continue to meet this requirement against the backdrop of the discussed natural hazard development, it could be considered the original task of the insurance industry to develop instruments which – when applied correctly and selectively - allow for a limitation and control of disaster risks. The following measures are taken as examples:

- Selective provision of coverage taking into account the accumulation risk
- Risk-adequate prices and deductibles depending on the individual hazard and on the accumulation risk
- Portfolio diversification and portfolio management
- Re-insurance
- Risk management
- Reserve policy

Measures which aim at creating risk collectives of a sufficient size and of a sufficient regional diversification are of special importance. They serve the purpose of improving the prospect of a sufficient funding of accumulation-type losses. Furthermore, measures to build up sufficient reserves are important to allow for an alternative or complementary balance of risks over a period of time.

Pool insurance solutions form an option in which the mentioned measures are already partially put into practice. They exist on a national level, e.g. in Switzerland, France and Spain and in some other countries. The principle of such solutions consists in the enlargement of the risk bearing and, if necessary, financing collective of individual risks and in a simultaneous diversification regarding the insured hazards and differently exposed locations.

Mostly independent of the question whether individual solutions are adopted or whether insurance pools are created and besides achieving a sufficient overall budget (premium and reserves) profound knowledge of individual risks and a reliable estimate of the existing accumulation risks is indispensable for the insurance industry in order to continue to meet the demands placed on it. Thus, reliable methods for assessing and controlling the accumulation risk have to be put into practice in addition to qualified individual risk management and underwriting.

3.2 Aspects of Accumulation Control in Engineering Insurance

Accumulation control for different coverage in Engineering insurance is based on the same principles as in other property insurance types. Some coverage specific particularities, however, have to be taken into account and are briefly presented in the following:

Machinery Breakdown

Fig. 11: Power plant after Flood

The scope of coverage regarding natural hazards differs largely in the different markets and also depends on the type of insured property (stationary or mobile). If natural hazards are covered, the insured values and, in the case of stationary machinery their location is normally known.

We have to consider, however, that sometimes only individual plants may be insured and that they may be vulnerable to individual natural hazards in different ways depending on their location. Machinery on the 2nd floor is less prone to floods than machinery on ground floor. Transferring the considerations for property insurance to Engineering insurance may thus be misleading. Non-stationary risks present another problem: sometimes an equipment park (construction equipment or rolling stock) is insured but the insurer does not or only temporarily know the exact whereabouts of the insured equipment. With major EAR or CAR projects, the value of the insured equipment being used at the construction site can amount to several m€.

Electronic Equipment

On principal, the same is true for Electronic equipment insurance as for Machinery breakdown insurance of stationary equipment. Values and locations are usually known or the corresponding information can be requested from the insurance holder, if necessary. Again, location plays the decisive role in determining potential exposure.

MB/EE and Business Interruption

Since business interruptions resulting from damage at stationary equipment can be clearly assessed, effects of natural hazards can be predicted in this area with a corresponding reliability (accuracy) and in an analogous way as for all other hazards.

A particular problem exists – as in property coverage – only with mobile plants and equipment. Loss potential of business interruption coverage cannot be assigned to a definable location and therefore has to be attributed to different regional hazard zones and/or to different scenarios.

Engineering All Risks/Construction All Risks

With EAR/CAR policies, the different locations are usually known to the insurer, open cover and master agreements being the only exceptions. A generally occurring problem, however, consists in the fact that the value at risk changes during the erection period.
Fig. 13 shows the value at risk of a 950 MW power plant during the erection period of 5 years. Here, the insurer, together with the insured, has to determine the development of the insured values during the erection period. For accumulation control, values at risk have to be revised periodically in order to represent the construction progress in a mathematical formula (e.g. step function or proportional to the construction period).

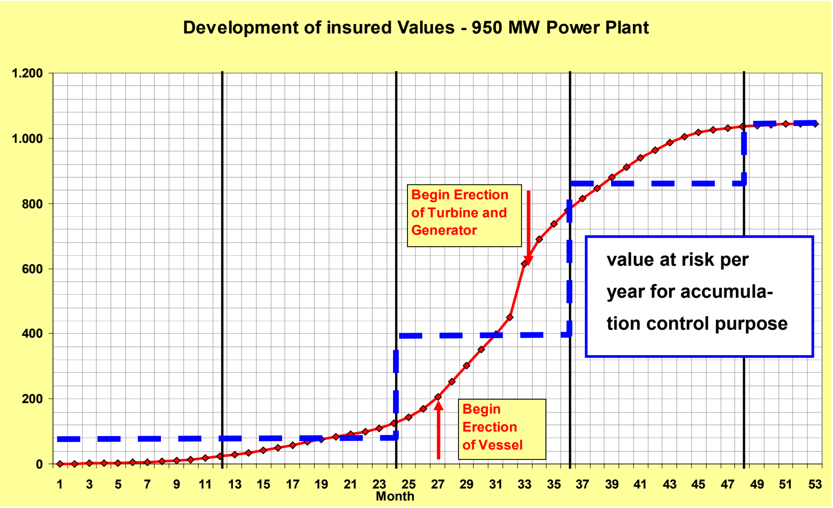


Fig. 12: Development of Insured Values during Erection

Different vulnerabilities to different natural hazards may occur in the course of the construction works depending on the type of plant being built. It is, however, not reasonable to acquire such data in an accumulation control system, since corresponding exposure curves would be required for which up to now any experience is missing (see chapter 4.3.4, vulnerability)

It is even more difficult to integrate risks showing track or surface area aspects such as, for example, the construction of the high speed rail between Cologne and Frankfurt in Germany With a construction time of 7 years the construction sum amounted to over € 6 billion. During construction, the railway line was only in a few areas threatened by conventional natural hazards such as storms or floods. The 30 tunnels with an overall length of 47 km posed a much bigger problem. Here, land slides actually had to be expected, for which no standard calculation formula exists.

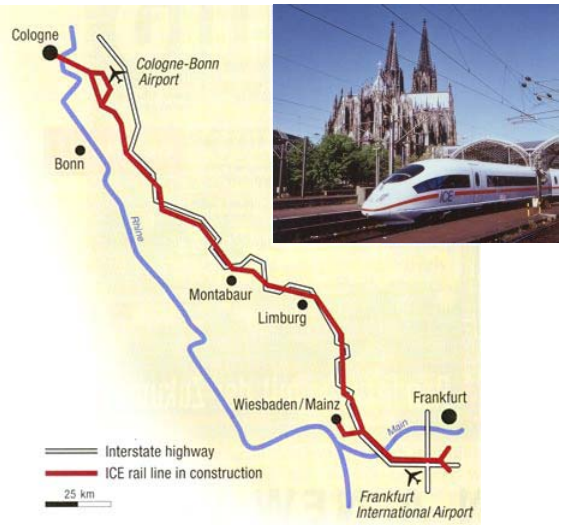


Fig. 13: High-Speed-Rail Cologne/Frankfurt

Fig. 14: Tank farm after windstorm [© MR]

In the case of master agreements (open policy) where the insurer is not informed about individual projects within a certain limit, the distribution of the insurance sum to individual sites presents an additional problem. This situation can be coped with by appropriate contract design (insured sum limits for individual risks or natural hazards in exposed regions).

Furthermore, we have to consider the fact that with coverage for major EAR/CAR projects Cat.Nat capacities have to be determined very early for a point in time in the distant future. When the contract is concluded the insurer may not yet know the possible development of the exposure to natural hazards but still has to provide capacities for a long period thus tying up risk capital.

Civil Engineering Completed Risks (CECR)

After completion of infrastructure projects similar problems occur when track and surface area risks have to be transferred into property coverage. The value of the insured objects stretches across a wide area and geo-coding requires major efforts. If a considerable insurance sum is for example distributed based on the 2-digit CRESTA zones, unrealistically high values would be included in the modelling. So far, no methods for creating corresponding exposure curves for such risks have been established.

EAR/CAR and ALoP/DSU

Assessing loss potential for AloP/DSU generally poses a problem for the insurer regardless of the occuring hazards. It leads to capacity lockup right from the start of coverage since a loss caused by natural hazards can result - just as any other loss - in ALoP/DSU coverage at any time during construction. Within the framework of accumulation control of natural hazards, the insurer thus has to allow for the full sum insured under this coverage at any time during construction.

4 Modelling the disaster – a complex process

4.1 The Problem

Despite the significant increase in the number of losses caused by natural disasters in recent years, earthquakes, storms and floods represent “rare events“ for insurance companies in a statistical sense - especially for the risk assessment of regionally restricted portfolios. Thus, traditional underwriting principles come up against limiting factors. Two central questions before accepting risk coverage are:

- ⇨ How much is the technical premium rate?
- ⇨ How much is the “PML“ amount?

Historical loss collectives are usually not comprehensive enough for burning cost calculations. In most cases, very large losses are completely missing: on the one hand, major or even epoch-making natural disasters often have return periods of several hundred or thousand or more years. On the other hand, coverage conditions in the insurance industry have seen a constant change in the past.

Mathematical-statistical loss models lead to similar problems. Here, the attempt is made to predict future losses (PMLs) by using statistical loss distributions created on the basis of historical data. In these procedures, the limited quantity of input information (losses from the past) as well as the lack of plausible explanations of the results from a natural-scientific point-of-view (seismological, meteorological and hydrological) also results in great uncertainties.

After all, purely statistical modelling procedures potentially lag behind the actual loss development in a changing risk situation e.g. due to global climate change.

In the past when computers had not been invented, underwriters placed pins on a map, showing the location of their risks. As fire and lightning were the only insurable perils, this tracking method could restrict the companies’ exposure for example in a specific street or city. When windstorm coverage and coverage for other natural hazards were introduced, pin mapping was an expensive process and insurers dismissed natural hazards as random events.

Hurricane Hugo (insured losses: US$ 4.5 bn) and the Loma Pieta Earthquake in 1989 (insured losses: US$ 1.5 bn), hurricane Andrews in 1992 (insured losses: US$ 17,0 bn) and the Northridge Earthquake in 1994 (insured losses: US$ 15 bn) changed the insurance industry’s view of natural catastrophes and its possible impact on the insurers portfolio. These large catastrophes brought catastrophe modelling to the forefront and became a new paradigm for insurance companies with books of business in catastrophe prone areas. Especially the Bermuda Reinsurance Market which was formed in the aftermath of hurricane Andrew had a focus on catastrophe risk and began using catastrophe modelling to obtain a more detailed view on the exposure of a limited capacity.

4.2 Natural Hazards - Random occurrences or predictable disaster?

The condition precedent to the insurability of natural hazards is the randomness of natural hazards. If it were possible to predict who or which industrial facility would be affected by a loss event, insurance coverage against losses from natural hazards would no longer be available.

If we look at the most powerful natural hazards which generate the highest event losses

⇨ earthquake
⇨ hurricane, windstorm
⇨ flood, inundation
⇨ (tornados)

we can state the following findings:

Earthquake:

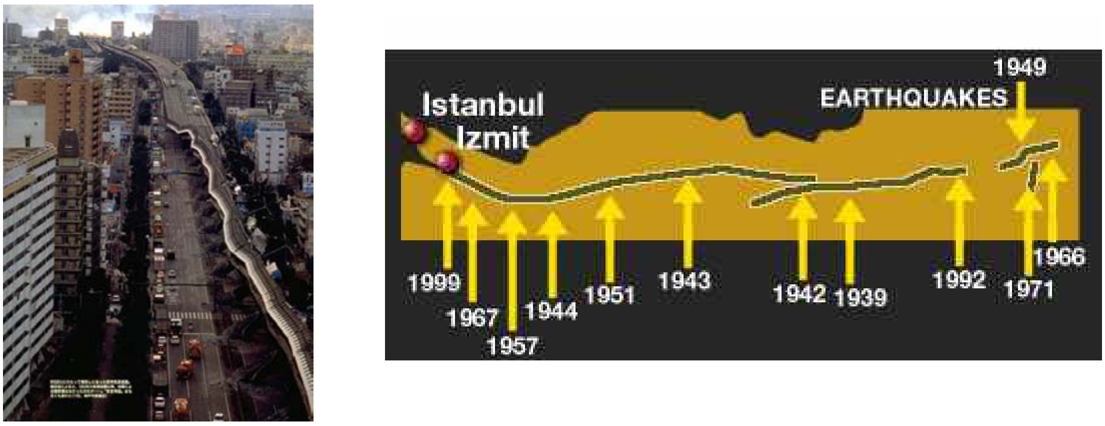


Fig 15: a: Damage caused by the 1995 Kobe Earthquake [USGS.org]
b: The North Anatolian Fault [cnn.com]

It is known that in the area around the Japanese city of Kobe was a high risk of earthquake, but no one had a premonition of the catastrophic earthquake which hit Kobe in January 1995.

The seismic activity and the westward progression of earthquakes towards Istanbul along the North Anatolian Fault have been well-known for many decades. Nevertheless time and location of the Izmit earthquake of August 17, 1999 were not predictable (Fig a and b)!

Although research in predictability of earthquakes is enormous, it will remain impossible in the near future to anticipate where **and when** a quake will strike. Normally, there is no possibility to protect property or inventory against the impact of an earthquake. In some earthquake-prone countries, however, special building codes have been issued to protect lives.

Hurricane, Windstorm

Despite advanced warning, hurricanes like “Mitch” and “Andrews” in the Caribbean or extratropical cyclones like “Lothar” in Western Europe caused high death toll and a high amount of property damage. Because of the uncertain perception of the possible track, the time for predicting these events is a few days only and the possibility of protection is minimal.

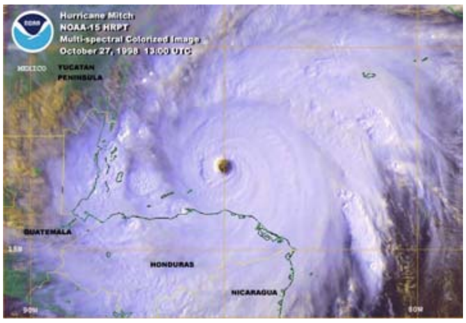


Fig: 16: Hurricane Mitch 1998 [NOAA]

Flood, Inundation

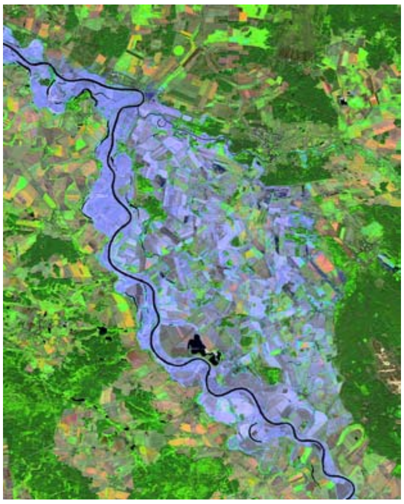


Fig: 17: River Elbe Flood of 2002 [DLR/Eurimage]

In 1993 the flooding of the Mississippi caused an economic damage of more than 18 billion USD and the River Elbe Flood in Germany in 2002 obtained a total economic loss of around € 9.0b and an insured loss of about € 1.6b.

Among all natural hazards, flooding affects the most number of people worldwide. One of the phenomena for example that influences flooding is El Nino. The available data provide the predictability of El Nino effects in individual regions but limit insuring property. As mentioned above large river floods can cause extreme economic losses due to their great spatial extent. However, also flash floods which can occur nearly everywhere are able to cause large damage in small areas.

Only for river flooding is the time for prediction long enough to take protection measures which offer the possibility to reduce or even avoid flood damage.

Tornados

The most exposed region for Tornados is the Mid-West of the United States where around 800 tornados are reported per year. The last major outbreak of a series of severe tornados occurred in May 2003 in Oklahoma and Kansas causing deaths and major losses.

Compared to other natural hazards the impact of tornados is normally moderate, the problem being rather the frequency of occurrence in specific regions. During the last years more severe F4 to F5 (Fujita scale) tornados were reported resulting in heavy damage.

Fig: 18: Autotomobile plant hit by a tornado in May 2003 [The Daily Oklahoma]

The forecasting of tornados is very limited. Weather conditions like supercells can produce tornados but the prediction of the severity and the track is uncertain.
Tornado warnings are normally issued minutes before the tornado strikes and many of the warnings are false alarms.

Conclusion

Natural catastrophes occur at random. The possibility for predicting impacts, time, location and track or footprint of an occurrence is very limited and the time for forecasting an event varies between minutes and several days or is nearly impossible as e.g. for earthquakes.

Standard actuarial systems which require substantial historical loss data are uneligible to predict the estimated losses from natural catastrophes. Up to now, it is impossible to base underwriting and pricing decisions on historical loss data because earthquakes, severe windstorm and flood events etc. are relatively rare and more seldom in a specific region. Therefore, the insurance industry faces two alternatives:

- ⇨ To declare losses resulting from natural hazards as partially or totally uninsurable or
- ⇨ To support experts' efforts to compile the necessary data bases, to develop the required instruments to calculate the relationship between the amount of losses and the probability of occurrence and to develop reliable instruments to control and manage the specific exposure of natural event losses.

In recent years, sophisticated catastrophe models were introduced in the insurance industry which try to simulate the physical characteristics of natural catastrophes and the possible impact on a given portfolio or a single large risk.

This approach to the possible influence of natural hazards should also become more common in Engineering Insurance especially with respect to large EAR and CAR risks.

4.3 Modelling losses caused by natural catastrophes

4.3.1 How Do Catastrophe Models Work?

Catastrophe risk modelling has come a long way. They were first introduced in the 1980s and have now become a standard for any CAT reinsurer and primary insurer in the market.

Hurricane Andrew with insured losses of USD 18 billion, the three major winter storms in Europe in 1999 – Anatol, Lothar and Martin – with insured losses of together 10 billion USD led to a CAT model breakthrough.

There are two different models to assess the loss potential of a portfolio:

- ⇨ the deterministic and the
- ⇨ probabilistic model

Deterministic models simulate an individual natural catastrophe scenario. These models look back to large historical events and apply these events to the distribution of the presently existing portfolio. Deterministic models have the disadvantage that they allow only the calculation of the resulting "as-if" loss for a single, extreme risk or portfolio of a historical or future event. They do not take all the other events into consideration which may occur and the annual average loss of a portfolio or the frequency of occurrence cannot be calculated or remains uncertain. Therefore, deterministic loss models are only suitable to calculate a worst case scenario or to calculate the loss amount of a historical event by using today's measures.

To avoid this uncertainty, probabilistic models have been established to assess hazards of the highest risks earthquake, tropical and extratropical cyclones and – most recently - floods.

Probabilistic models simulate the possible events for a specific hazard which may occur in thousands or even ten thousands of years. The model is based on the estimation of the return period for a large number of possible earthquakes, windstorms or inundation/flood in the investigated area. In the model, a representative list of events which is deviated from historical events and their extrapolation to events with a very long return period is generated. The results show the relationship between the possible loss potential and the return period.

These models are even more complex and need a huge amount of data for the simulation as there are for example the following fundamental components:

- ⇨ intensity and frequency of the analyzed hazard in determined locations, deviated from past events (event generation)
- ⇨ characteristics of individual location determined (topographic information)
- ⇨ number and geographical location (geocoding) of the insured facilities, building/object characteristic, occupancy, regional building design and specific building codes in natural hazard prone areas, etc and the insured values (risk assessment)
- ⇨ the probable number and extent of damage in respect to a given hazard intensity (vulnerability)
- ⇨ what percentage of the loss is insured (policy conditions)

These data are then combined in a highly sophisticated model – the principal modules are shown in Fig: 20 - to estimate a potential loss with respect to the return period.

A method developed by Cornell in 1968 represents the state-of-the-art in earthquake modelling. Up to now, only a few components have been modified. For probabilistic modelling processes for windstorm and inundation/flood there is no generally accepted method. The available models (developed commercially or by reinsurers) differ more or less in the method of modelling and in the results of the simulation.

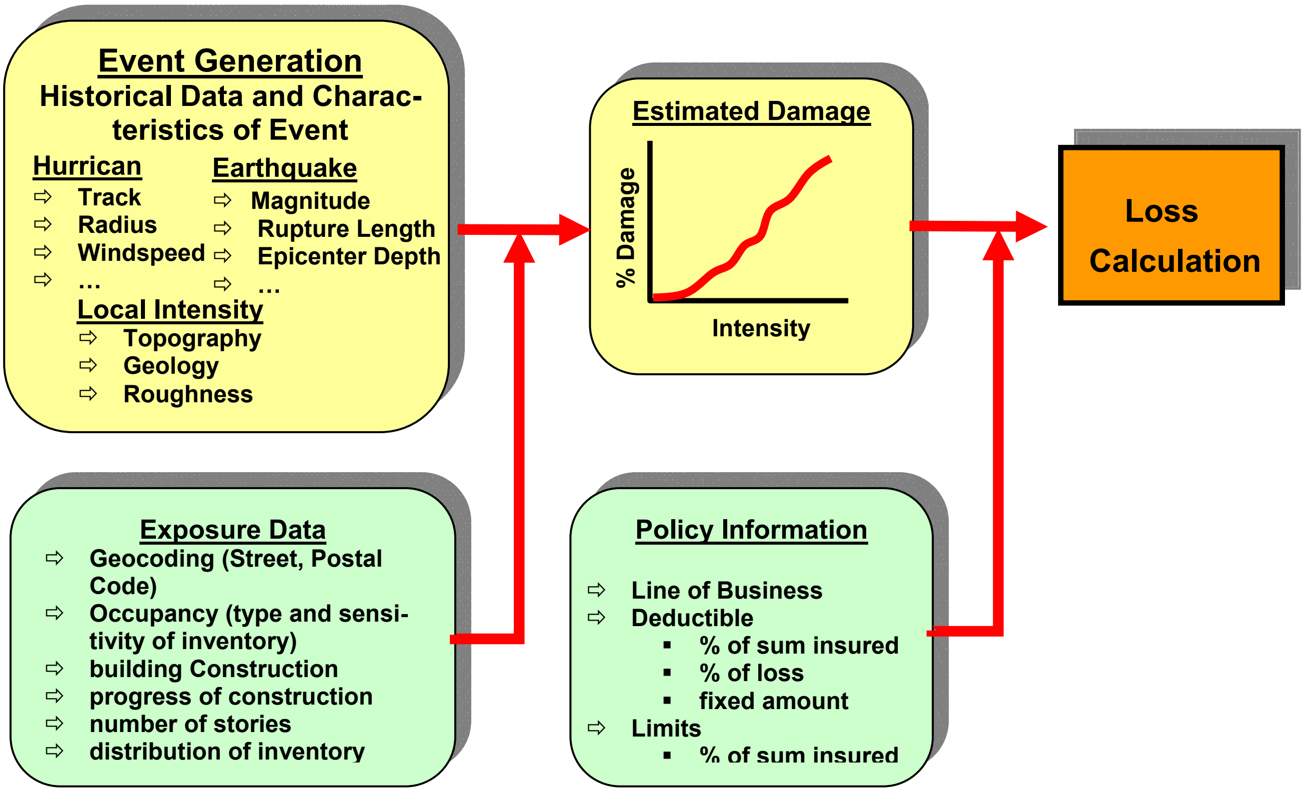


Fig: 19: Main Components of a Catastrophe Model

4.3.2 Event Generation

Tropical and Extratropical Cyclones

The characteristics of tropical and extratropical cyclons are as follows:

	Tropical cyclones	**Extratropical Cyclones**
Diameter of atmospheric system	500 – 2,000 km	1,000 – 3,000 km
Diameter of hurricane force winds	100 – 200 km	Up to 1,000 km
Length of track	5,000 – 15,000 km	2,000 – 5,000
Live span	5 – 15 days	2 – 5 days
Speed of movement	10 – 50 km/h	20 – 50 km/h
Maximum wind speed	300 – 400 km/h	Up to 250 km/h

As mentioned earlier, a catastrophe model tries to anticipate the likelihood and the severity of events. Catastrophe models simulate thousands of potential events to represent the entire spectrum of possible storm tracks, including extreme events occurring in a specific time period (model years). Therefore, cyclone activity is simulated on the basis of historical statistical data of tropical cyclones that have occurred in the North Atlantic over the past hundred years.

In generating the event set, the paths of historical cyclones are varied by using a mathematical simulation process (Monte Carlo process). With this process, cyclones are generated which have not yet occurred but may occur in the future. Also the physical factors:

- pressure
- size (radius of wind field)
- forward speed
- track and landfall location
- wind speed

as well as the influence of atmospheric conditions such as high and low pressure areas and the jet stream are taken into account.

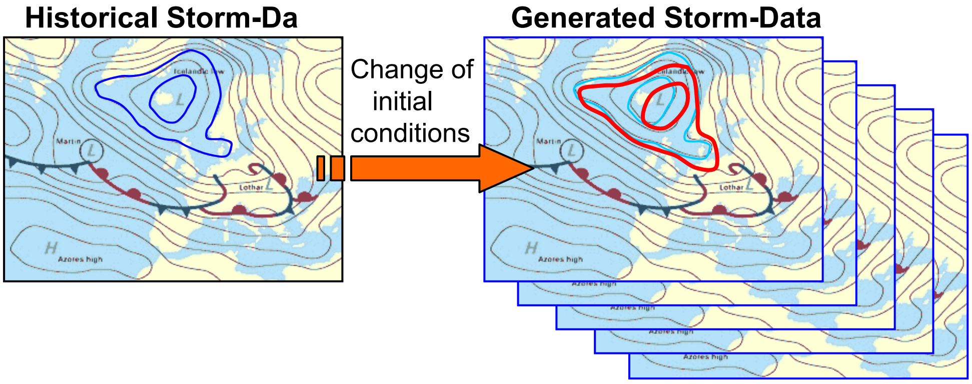


Fig: 20: Initial historical meteorological storm data and potential storm data generated by varying the initial conditions

Changes in these initial conditions generate other cyclones which can be quite different in effect. If the initial conditions of historical cyclones are perturbed by small amounts a very large set of potential atmospheric conditions, cyclones and windstorms can be simulated (See Fig: 21).

With this data the possible combination of intensity, storm path and temporal development can be described (See Fig: 22).

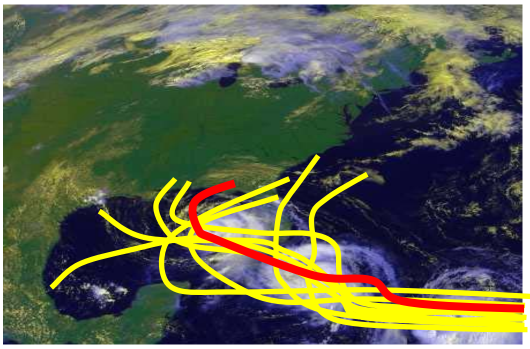


Fig: 21: Example of the path of a historical mothercyclone and derived potential cyclones

The next part of generating the event set is the simulation of the surface wind speed which is the most important factor for the extent of the damage. To calculate these wind fields differential equations are applied to meteorological data. Surface and topographical information at a very detailed level of geographical resolution is also taken into account.

Especially for modelling extratropical cyclones Numerical Weather Prediction (NWP) techniques are used to produce a more realistic output. NWP models use global environmental data such as sea surface temperatures, wind speed and pressure in conjunction with known physical laws to model the evolution of circulation patterns in three-dimensional space. These models can capture the evolution of a storm due to small changes in the initial conditions of the atmosphere.

The models contain normally several ten thousand unique stochastic storm events, covering the whole population of possible storms - storms of minimal intensity just as much as storms of moderate intensity - which cause little damage but also storms of low probability and extreme intensity. Each real storm is used to calibrate the models by using the meteorological data and the loss experience.

It is easy to imagine that the procedure to generate the event set in the different models is very time-consuming and requires highly sophisticated computer systems and performance.

Commercially available storm models have one thing in common: they are all based on data from the past. Changes in storm hazards due to the assumed climate changes have not yet been taken into account. Even if research has not come to final results there is ample evidence - at least regionally - pointing to a discernable change in storm activity.

For the insurance industry, the quantification of the resulting potential risks of change represents one of the biggest challenges in the creation of the next generation of storm models.

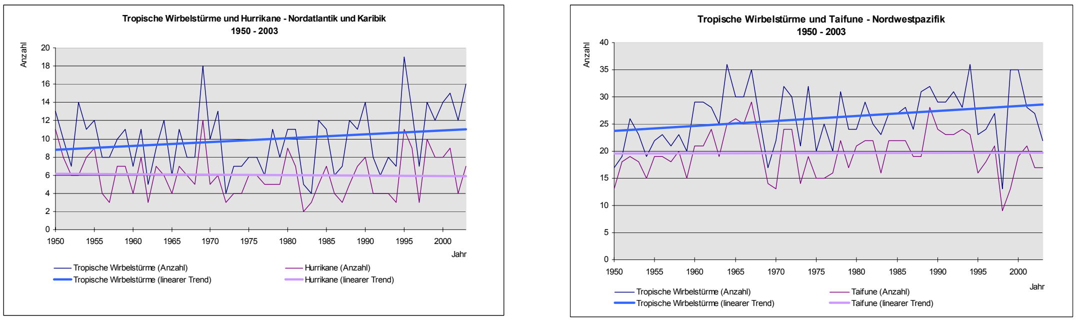


Fig 22: a) No. of tropical cyclones (blue) and hurricanes (red) in the Atlantic Ocean per year between 1950-2003
b) No. of tropical cyclones (blue) and hurricanes (red) in the Northwest Pacific Ocean per year between 1950-2003

Earthquake

To generate the event generations which are used in probabilistic earthquake models, information about historical earthquakes in faults and in background sources are taken into consideration. The activity rates for earthquakes along faults are related to the slip rate (how fast one side of the fault slides past the other side). The faster the fault slips, the more likely the fault is to generate earthquakes. The length or area of the fault rupture is used to determine an expected magnitude of the fault.
Earthquake catalogues for specific magnitudes are used to describe where future large earthquakes may occur.

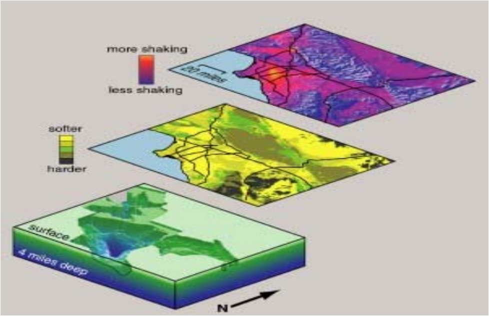


Fig: 23: Geologic factors affecting earthquake shaking
[Geotimes Magazine]

The models use the latest available information on high-resolution geotechnical data and source geometry – for the US for example from the USGS, US Geological Survey. In Fig: 24 the most important geological factors are shown which affect the level of shaking experienced in earthquakes. The first layer shows the depth of sedimentary basins (Los Angeles area), the middle layer shows the softness of near-surface rocks and sediments. The top layer combines this information to predict the total amplification expected in future earthquakes. In this way the full three-dimensional character of known faults and subduction zones is modelled. The modelled events are calibrated by using the ground motion research following the latest earthquakes.

Another point that has to be taken into consideration is the fire following earthquake problem. Large earthquakes that strike urbanized areas can cause multiple fires, generating additional substantial losses. High resolution data on local building material, area and occupancy (see portfolio assessment) have to be combined with the expected severity of a potential earthquake and other information about local conditions to determine sources of fire ignition and the potential losses due to fire following earthquake.

The event set of the RMS-Model for western U.S. Earthquake, for example, contains more than 42,000 simulated earthquake events which represent a broad range of potential losses and include a rich sample of intensive events that reflect the uncertainty in the characteristic magnitude of faults in the western U.S.

River-Flood

Since many different phenomena influence the impact of potential river-floods the modelling of these events is a highly complex process. For a long time, it was considered impossible to generate reliable estimates for these risks and the underlying basic assumptions have not been scientifically proven.

Topographical factors and a large number of physical effects influence the development of a flood event, regulation of river flows through human intervention alters river behaviour, rainfall run-off and flood risk. The following points are involved in the process of generating the event set and the risk estimate:

- ⇨ Local topographic situation and data concerning soil conditions
- ⇨ Density of building development and demographic data
- ⇨ Gauge-levels and meteorological precipitation data
- ⇨ High resolution digital terrain data
- ⇨ Description and mapping (affected areas, insured and economic losses) of historical events from different sources
- ⇨ Flood protection systems (dams, dikes, mobile protection systems retention areas can prevent frequent damage, but may intensify rare events)
- ⇨ Size of the river drainage area (reaction of the river to different precipitation patterns)
- ⇨ Seasonal behaviour (summer, winter)


Fig: 24: Vienna about 1785

Long lasting series of drainage and water level measurements are combined with the above mentioned data and in conjunction with Monte Carlo techniques thousands of new hydrological events are generated. With these events and by using hydrodynamic simulation software the flooded areas of each of these events are calculated.

Flood PML models consider only river floods. Flash floods after torrential rain are not included on account of the fact that they occur locally and therefore play a subordinate role in accumulation considerations. At present, floods caused by storm surges are not considered either since they are not insurable in specific countries or because of their gigantic loss potential.

4.3.3 Exposure Data

Portfolio analysis and risk assessment

Engineering insurance covers - just as much as other property insurance covers - are preliminary designed to cover losses from hazards where a single risk or industrial facility is affected. The maximum possible loss is determined by the total insured value of the single risk and the loss burden of balanced portfolios shows only minor fluctuations. In connection with an adequate portfolio control and portfolio management, traditional risk assessment instruments like site visits can limit the exposure of the insurer. Catastrophic natural hazards cause losses in a wide-spread geographical area with many individual risks involved. As a consequence of the possible cumulative effects of natural events, risk assessment methods preliminary focused on a single risk only have a very limited or even no efficiency for estimating and controlling the total portfolio exposure of the insurers. To ensure the necessary portfolio control and management, specific additional measures for risk assessment of natural hazards have to be developed.

For risk assessment of the impact of natural hazards special circumstances and factors have to be taken into consideration. One of these factors is the geographical location of an insured risk.

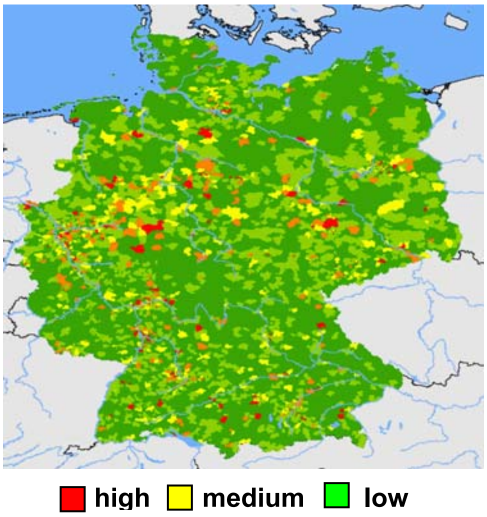


Fig: 25: TIV´s accumulated by 2-digit Post Code for a German portfolio

Depending on the extent of coverage for e.g. MB insurance purposes, the location of the risk might not be the most important factor as far as the risk assessment is concerned.

This is quite different when one or more natural hazards are covered. First of all, the natural hazard to be expected at the location of the risk may become the relevant event for the individual PML to be estimated. Moreover or in addition, a possible effect of natural events has to be considered cumulatively when natural hazards are covered in a greater number of policies. In this case the location and the geographical distribution of risks become crucial components in the process.

Detailed knowledge of the location and the allocation of the total insured value (TIV) with respect to every single location is the key demand for reflecting on modelling the estimated loss burden from natural hazards for a portfolio (See also 4.1 Portfolio Analysis). The allocation of the TIV by 2-digit Post Code (see Fig:26) gives only an overview where the TSI per postal code comes up to peaks and where potentially the largest exposure to a specific natural hazard, e.g. flood may be located.

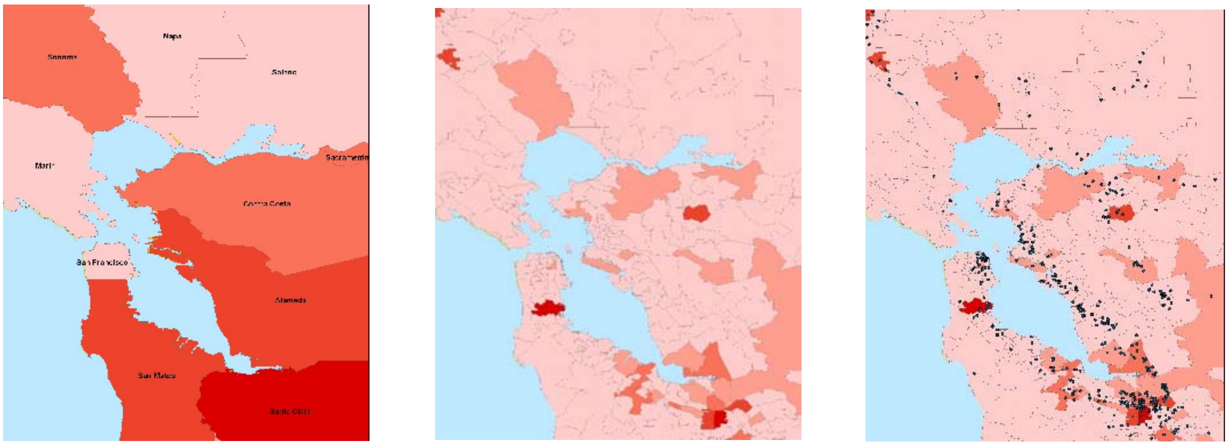
Accuracy of these location data can be increased and will probably meet all future demands.

One example of an electronic standard for reporting natural hazard risk information on an international basis is published by the independent organisation CRESTA. It was set up by the insurance industry in 1977 to establish a uniform system for the accumulation risk control of natural hazards (http://www.cresta.org). This type of data gives a rough overview on the possible exposure but a more detailed view on the distribution of locations and coverage information is necessary. In different insurance markets a trend defining locations more precisely with addresses or postcodes is coming up. This geographical information is needed for modelling inundation or flood losses.

Geographical Information Systems (GIS) are the common utilities to achieve this. With such systems the position of each insured object with the corresponding insurance data can be precisely registered (geocoding, assigning latitude and longitude to a risk location) and the relationship between different objects can be analysed. At present, the data have a high level of coverage particularly in the important industrial countries. These countries are mainly the core markets in the industrial sector. The United States and Europe are very well covered and will soon be joined by the Asian markets. For other markets only GPS-data (Global Positioning System) can provide the insurer and reinsurer with the data needed.

The starting point for a future-oriented control and optimisation of portfolios with regard to natural hazards and man-made risks is to identify as precisely as possible the geographical location of the risks concerned (georeferencing; for additional information see also: Munich Re, Topics 2002 - Annual Review of Natural Catastrophes; “Getting the point” – Does geographical underwriting improve risk management).

The geocoding of portfolios of liabilities and losses makes it possible to produce analyses and computer models in accordance with the geographical underwriting method. Geocoding may be performed using various levels of detail (addresses, municipalities, postcodes) (Fig. 27). In view of the precision and quality required in the future, coarse geocoding, e.g. at country or state level, is no longer sufficient. The spatial definition (risk allocation) on the basis of CRESTA zones often used today in property insurance must be refined and made more transparent for important core markets and risk types.



3-digit postcode

5-digit postcode

addresses/georeferencing

Fig. 26: Risk allocation with varying levels of detail

Using a simulated portfolio as an example, the input datasets (e.g. liabilities) are visualised in various resolutions. The different colour intensities reflect the different liability concentrations. The address level gives an idea of how much better analyses can be if this level of resolution can be attained. Switching from county or 2-digit postcodes to data based on specific addresses increases a portfolio's transparency quite considerably.

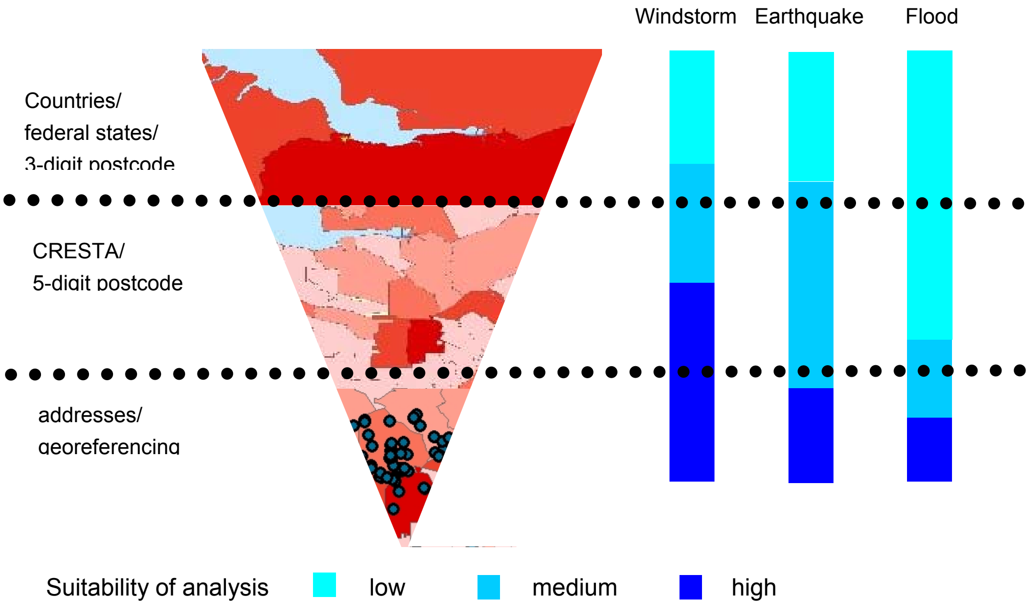


Fig. 27: Levels of detail and their suitability for computer modelling and simulation [Munich Re]

Ideally, as much liability information as possible should be available with a high geographical resolution. It is then possible to aggregate to the most suitable level of detail, depending on the issues and objectives involved. This only functions from a lower to a higher level, however, e.g. from addresses (individual coordinates) to the next aggregation level upwards (postcodes, countries).

The level of detail required in the geocoding process depends on the hazard for which the risk exposure is being examined. Given the modelling and simulation programs available nowadays, a distinction can be made between three levels of spatial detail (resolutions):

Coarse: Data with a coarse resolution usually only relate to regions, countries, federal states, or very large postcode units. Such a resolution may be used for large-scale hazards or scenarios (e.g. the effects of climate change, environmental influences) but it is of limited value as far as many other (natural) hazards are concerned.

Medium: If data of medium quality are available – precise postal units, municipalities, and local authority boundaries – it is possible to produce quite realistic analyses for certain natural hazards like windstorm or earthquake. The majority of CRESTA zones are based on this classification.

Fine: If the focus of the hazards to be analysed is on small areas (as is the case with terrorist attacks and industrial accidents, for example) or if the question as to whether damage occurs or not depends on a difference of only a few metres (floods, hail), it will be necessary to work with more detailed geodata. This means the kind of information provided by individual addresses and GPS (Global Positioning System), which yield exact results down to a few metres.

In order to calculate and analyse the PML (probable maximum loss) in areas prone to natural hazards, it is a great advantage to have exact knowledge of the risk (risk situation). How strong an impact the level of detail may have on the PML calculation will depend on the composition and spread of the portfolio in the area analysed. In the example in Fig. 29 the PML derived from the postcode calculation (red line) is almost one-third higher than the address-based PML (blue line).

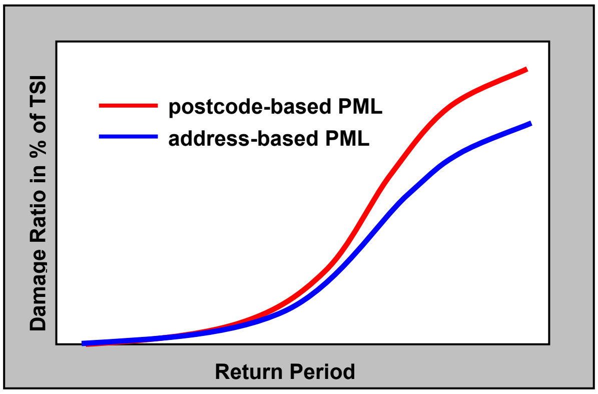


Fig. 28: Level of detail and possible effect on PML

Many portfolios contain multi-location policieswhich are difficult to identify and to analyse exactly. These often involve housing associations or chains of companies, where the address quoted only refers to the headquarters while the policy actually includes many other risks at different locations as well. This can lead to a situation in which existing exposures are not identified or are incorrectly evaluated. This may prove to be a drawback both for insurers and for reinsurers.

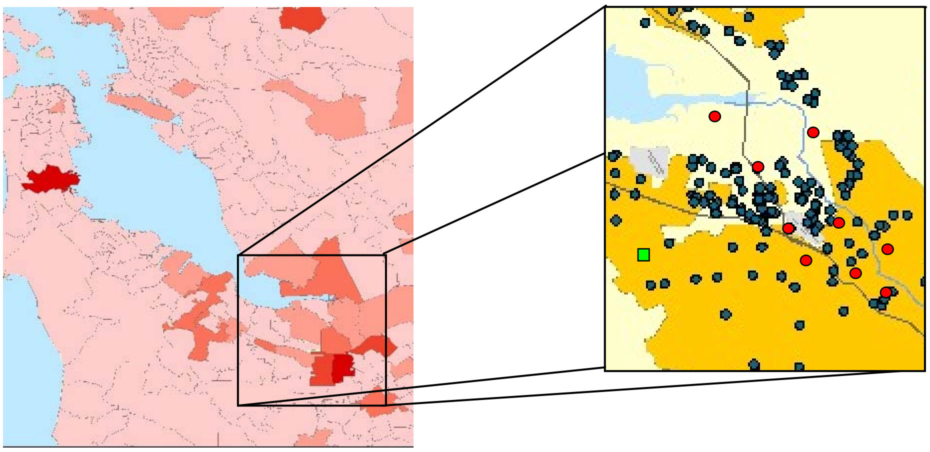


Fig. 29: The multi-location problem (overview and detail; green: address of the multi-location policy; red: actual location of the risks) [Munich Re]

In the example of a multi-location risk (see Fig.30), the known situation (green dot) would possibly not lead one to expect an exposure to natural hazards (e.g. flood or earthquake). If all the individual risks subsumed under this policy are observed, however, it turns out that a not inconsiderable number of these individual risks are potentially highly exposed. This frequently encountered problem can be solved if all the individual risks collected together in one package policy are available with their address and the corresponding indemnity limit.

All required information should be put into a standardised spreadsheet which forms the basis for the geocoding system.The key question for insurers and reinsurers is:

How great is the loss potential arising from possible major natural disasters? On the basis of the above mentioned data, this question can only be answered by the described sophisticated scientific models which try to simulate natural catastrophe losses expected in reality.

Besides the geographical information, additional data concerning the characteristics of the individual property are required:

- ⇨ client segment (commercial, industry)
- ⇨ building construction
- ⇨ occupancy, type and sensitivity of inventory
- ⇨ quality of building, age
- ⇨ number of stories
- ⇨ distribution of property over stories

It is important to note that in the presented data for the distribution of insured property the replacement value should always be used and not the sum insured or the insured limit for natural hazards. Otherwise the load of the sum insured or the limit could not be calculated.

4.3.4 Vulnerability

Fig. 30: Damage by Kobe-Earthquake 1995 [UNESCO.org]

Vulnerability is used to express the degree of damage to a specific insured property or a portfolio of insured objects by a certain natural hazard intensity. The intensity of natural hazards can be defined in terms of wind speed, the damage to buildings resulting from ground motion or the depth of flood waters. When natural catastrophes strike, it becomes evident that the degree of damage can vary in a large range although the intensity of varying events is the same. The damage to a building depends on its age, construction or height. Also the damage to the content may depend on the reaction of content e.g. regarding wetness or the sensitivity of an industrial facility or its content to natural hazards. A refinery for example is more sensitive to flood or earthquake than to windstorm and a new bridge is possibly threatened by flood, windstorm or earthquake during the construction period.
It is obvious that it is not possible to analyse the individual characteristic of each insured object in detail. Therefore, different production processes in connection with the types of content or building are grouped into classes of similar characteristics (occupancy codes).

From loss experiences, engineering studies und investigations into the possible damage to different kinds of property or different types of construction of buildings with respect to the analysed natural hazard, mathematical functions are developed which describe the response of different property to the intensity to which they are exposed by a given hazard. The results of these calculations are the vulnerability curves or damage functions which show the relation between the probability of occurrence and the damage ratio (different loss amounts at the same intensity) as well as the relation between the intensity and the mean damage ratio (See Fig: 32); ratio of the total loss amount of all insured objects, including loss-free insured objects).

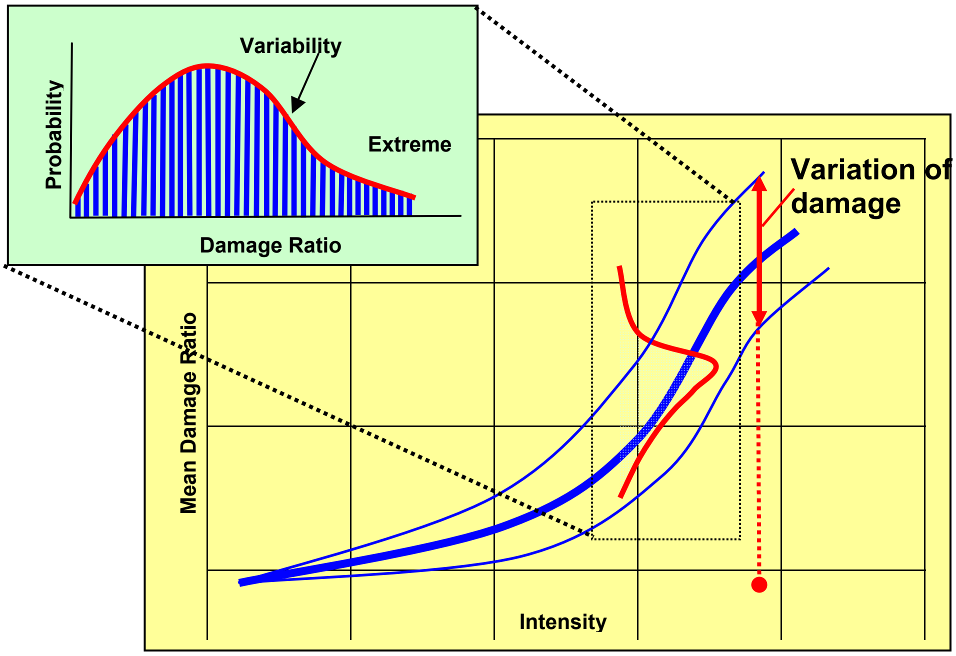


Fig. 31: Derivation of Vulnerability Curves

Industrial facilities consist of many different complexes and processes and the success of an operation depends on the performance of its critical components. The vulnerability varies between the insurance lines (engineering, property), client segments (commercial, industry) and the insured objects (building, content or occupancy [type of machinery, electronic components, clean room technique vs. chemical processing], business interruption).

To reflect the various parts of a portfolio, separate vulnerability functions have to be developed for buildings and contents for every critical component of each industrial facility occupancy. The vulnerability of different types of buildings can influence the vulnerability of the content which is for example insured against MB. Therefore, parameters influencing the vulnerability must be taken into consideration:

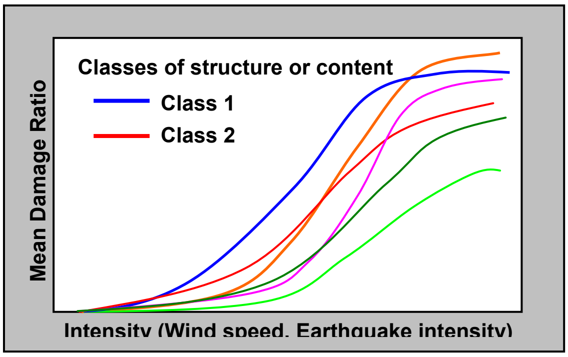


Fig. 32: Component level vulnerability functions

- ⇨ design of structure (building codes)
- ⇨ construction material
- ⇨ shape and proportion of building
- ⇨ roofs, facades

The result is a large set of individual vulnerability functions for the different structures and contents within a specific occupancy (Fig: 33).
The vulnerability curves of the different occupancies and critical components on the component level then have to be weighted according to their relative values to arrive at the overall building and content vulnerability.

If there are country-specific building code requirements e.g. seismic building codes in Japan, region specific vulnerability functions are developed to take local construction practise into account.

4.3.5 Policy Information

The insurance conditions provide important information about the proportion of the insured loss. Insurer use deductibles to restrict the amount the re/insurer has to pay in the event of a loss and to reduce the administration effort by avoiding the need to adjust a large number of minor claims.

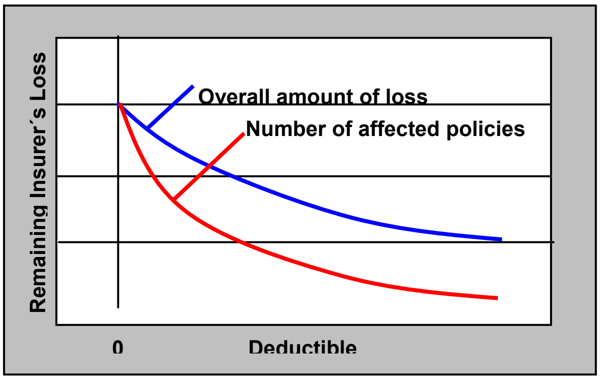


Fig. 33: Influence of deductibles to loss burden and number of losses

Natural hazard-events result in a huge number of individual losses which need to be processed. This number of losses and the loss burden can be reduced by applying deductibles to the policy. The deductible reduces the often disproportionally large administrative effort of an insurer who is faced with a mass of small claims, especially in a more private-lines orientated portfolio.

Policy conditions vary with respect to the market, the type of natural hazard or the insured object. Most commonly, we will find the following conditions applied to the sum of all insured interests in various locations or to an individual insurance cover (building, machinery, single or multi locations) or to different insured interests at the same location (machinery, business interruption, ALoP):

Deductibles and limits by policy, location, region

- ⇨ Percentage of the sum insured
- ⇨ Percentage of the loss
- ⇨ Fixed amount
- ⇨ Franchise

Other additional specific conditions may apply like annual loss limits or specific limits per location or hazard (e.g. Japan quake, California quake).

It is obvious that the policy conditions may have a major impact on the insured loss and it is important to evaluate this data correctly for this part of the modelling process.

4.3.6 Loss Calculation

The basic principle of Cat. Nat. modelling consists in a combination of the parameters “exposure data”, “vulnerability” and “hazard”.

Risk = f (hazard, vulnerability, exposed values)

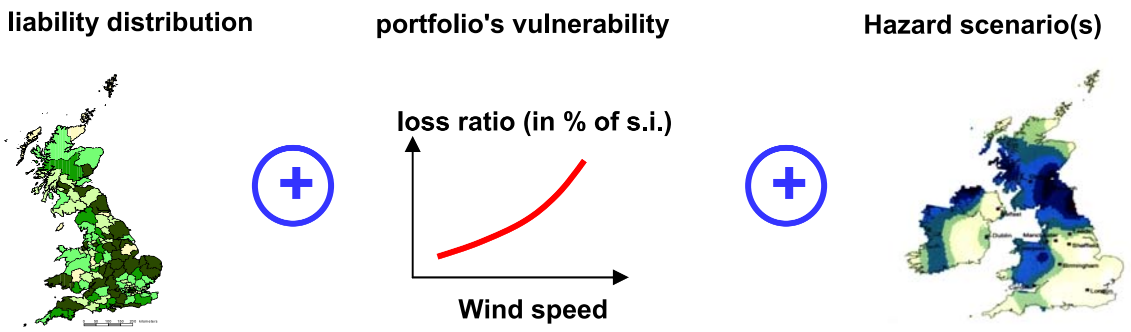


Fig. 34: Basic principle of risk modelling [MR NatCat Service]

The model works like a time-lapse film by applying the event set – representing a period of several hundred years to the insured portfolio. For each of these events, an event loss is calculated. In this way, a list of all expected event losses for the investigated portfolio is generated (Fig:).

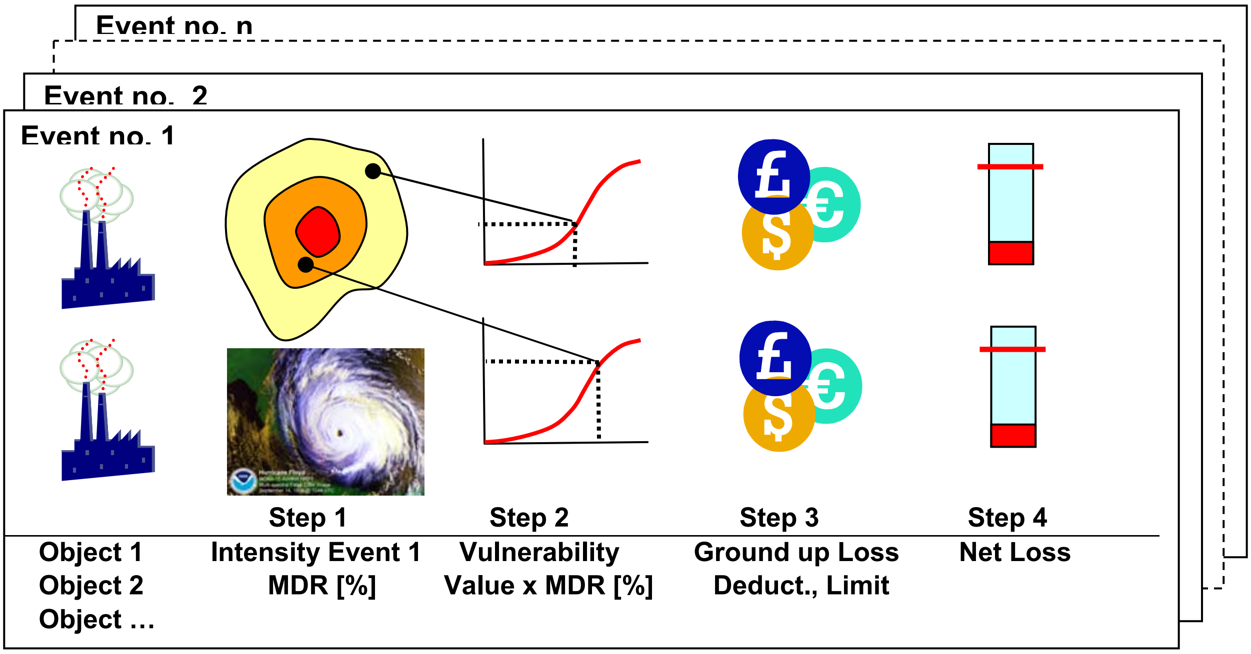


Fig. 35: Loss Modelling Process [Swiss Re]

Step 1: The event set – representing hundreds of modeled years - generates the intensity for event no. 1 and the insured objects (locations)

Step 2: The vulnerability function shows the mean damage ratio (MDR) the intensity of

event 1 will generate in the insured objects
e.g. 5 % for object 1 and 50 % for object 2

Step 3: The ground up loss is calculated by multiplying the mean damage ratio and the value of the insured objects
Object 1: $ 6,0 m x 5% = $ 300,000; Object 2: $ 25m x 50 % = $ 12.5m)

Step 4: The net loss of event 1 and object 1 is calculated by applying the policy conditions to the ground up loss
Object 1: $ 300,000 – $ 5,000 = $ 295,000;
Object 2: $ 12.5m, policy limit of $ 10m applies = $ 10m

Step 5: Steps 1 to 4 are performed on all insured objects of the portfolio. The sum of all losses produces the total loss from event loss no. 1
Event 1: $ 295,000 + $ 10m + ….. = Event loss from event no. 1 ($ 77,5m)

Step 6: Steps 1 to 5 are performed on all other events in the event set, producing a list of all event losses

Event Losses in million $ from Event no…										
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**…**
124.5	**98.7**	**131.6**	**38,6**	**83.7**	**127.6**	**6,7**	**118.7**	**65,1**	**110.6**	**…**

This list allows the insurer to calculate the statistically expected annual loss which can arise from the portfolio with respect to the modelled hazard.
If the event set is for example generated for 250 model years, a loss frequency curve can be created, assessing the extreme event losses. From the event list the relation between loss amount and loss frequency can be derived:

- a loss of more than $ 130m (No. 3) will occur once within the modelled period of 250 Years or 0.004 per year
- a loss of $ 127.6m or more will occur twice in 250 years (No. 3 and 6) or 0.008 per year (once in 125 years)
- a loss of $ 124.5m or more will occur three times in 250 years (No. 1, 3 and 6) or 0.012 per year (once in 83 years)
- a loss of $ 110.6m or more will occur five times in 250 years (No. 1, 3, 6, 8 and 10) or 0.02 per year (once in 50 years)

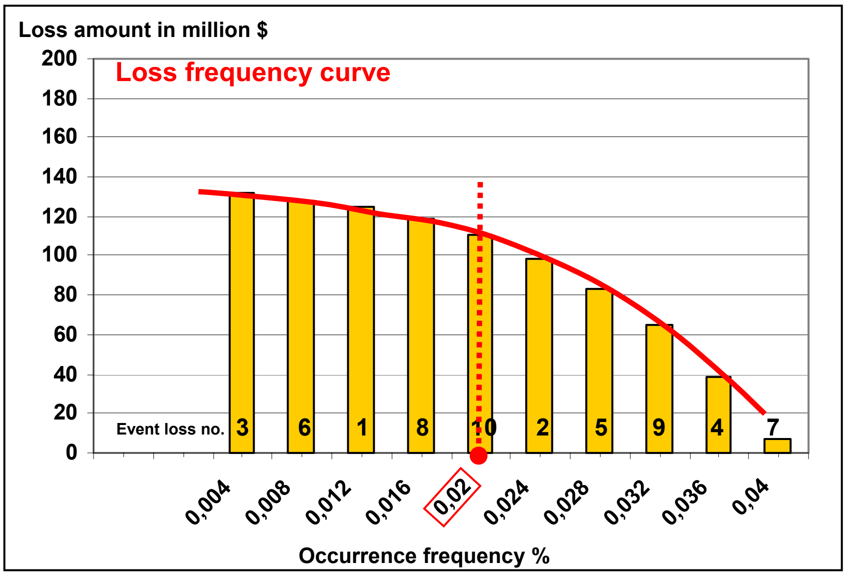


Fig. 36: Loss frequency curve of the event losses of the example

The largest modelled event losses give an idea of the loss amount the insurer can be liable to cover in the event of an extreme catastrophe scenario. In this example the maximum loss from the portolio that can occurr in 50 years is about $ 110m (event no. 10, occurrence frequency 0,02%).

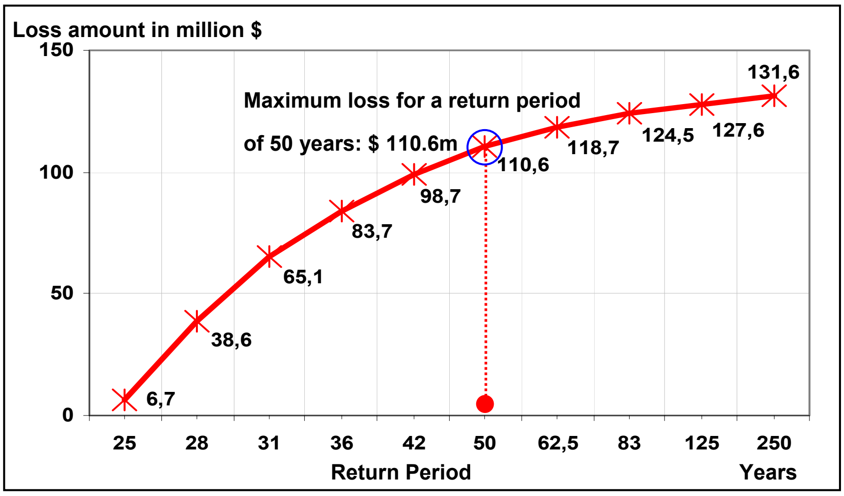


Fig. 37: Maximum loss by return period

The expected total amount of losses from this portfolio within 50 years is the sum of the losses no. 10, 2, 5, 9, 4 and 7 which equals $ 403.4m or $ 1.6m per year ($ 403,4m : 250 model years).

These figures provide the insurer with detailed information about the exposure of his portfolio and its distribution by region or country. From the results of the modelling process the requirements for premium rates and the structure of reinsurance facilities can be derived.

4.4 Modelling the nature?

In the discussion of the results of the different natural hazard models, the uncertainty of the models has to be taken into consideration. Currently available models are a simplified representation of reality. We do not know exactly whether the event set gives a representative picture of the hazard. On the other hand, the event loss can vary a lot depending on the time of occurrence.

The connection between climate, extreme events and amount of losses is extremely complex and linked to socio-economic factors e.g. urbanization in vulnerable areas and the increasing number of industrial facilities in developing countries.

Most of the models discussed use data of historical events to generate the event set. In many cases these data are scarce, inconsistent and of varying quality. Collection of these data was sporadic and they are only available for limited geographical areas because atmospheric data was typically collected around centres of population. Old data do not take the predicted climate changes into consideration.

Especially the consequences of the anticipated climate change are normally not taken into account in the methods to generate the event sets. However, there is one exception: the idea to implement Numerical Weather Prediction (NWP) in the process of modelling the specific atmospheric conditions for the model to simulate extratropical cyclones.

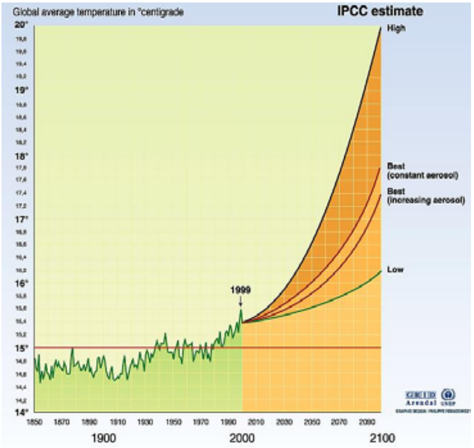


Fig. 38: Projected changes in global temperature [IPCC 2001]

Assumptions concerning the future development of the global temperature change or the sea level rise are quite uncertain (see Fig: 38). Understanding of the impact of different parameters on future development is relatively limited and has to be improved. Climate variations and change caused by external forcings (e.g. increasing emission of green-house gases) may be partly predictable particularly on the larger continental and global, spatial scale. The ability to predict future development of man-made climate change is limited because one can not accurately predict population change, economic change or technological change. In practise, scientists have to rely on carefully constructed scenarios and determine climate projections on the basis of such scenarios.

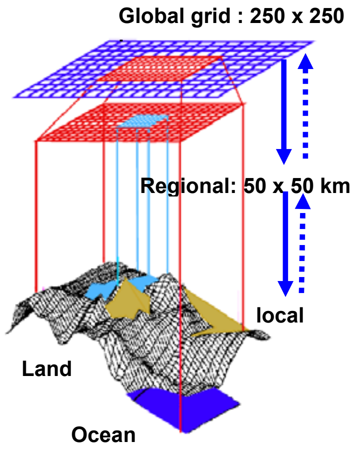


Fig. 39: Grid for Climate Models [IPCC, 2001]

On a global scale with a grid of 250 x 250 km climate, inhomogeneities and circulations are dominated by general circulation processes and interactions. Statistical downscaling from general and global processes to regional (grid: 50 x 50 km) or even local scales is a very complex transaction and additional assumptions have to be made. Examples of regional and local scale forcings are those due to complex topography, land-use characteristics, inland bodies of water, land-ocean contrasts, atmospheric aerosols, etc. The difficulty of simulating regional climate and climate change is therefore evident and an interdisciplinary and multi-scale approach is necessary for a full understanding of regional climate change processes. The results of regional or local climate models have to give a feed-back to the global climate model in order to reflect interactions and dependencies.

There are several levels of uncertainty in the generation of regional or local climate change information:

- ⇨ alternative scenarios of future emission and their influence on the climate
- ⇨ simulation of the climate response for a given scenario
- ⇨ incomplete knowledge and/or representation of physical processes
- ⇨ simplifications and assumptions in the models or approaches
- ⇨ statistical downscaling methods
- ⇨ lack of good quality high-resolution observed data

To manage these uncertainties and to enhance the predicticability of future climate and weather trends, great efforts have to be undertaken in the near future.

In recent years, the techniques to model and predict future climate development have been significantly improved. Since weather-related events are perceived to be linked to climate change, the actuarial uncertainty in risk assessment will increase.

4.5 Conclusion

Natural hazards can cause extreme losses for the insurance industry. They occur at random and their predictability is limited and protection measures are often insufficient. Insurers have to calculate their potential losses from natural hazards, the adequate premium and the required reinsurance structure. The expected risks of change (e.g. due to climate change) are very likely to lead to an increase in natural catastrophes and extreme events. Experience gained in the past is therefore of limited value as an indicator for the future. For this reason, proactive underwriting is required in which the probable higher losses of the future are appropriately considered.

Newly-developed Cat. Nat. models can provide more security in estimating the exposure of a single risk or a entire portfolio. The problems in predicting future climate change and weather trends have not been solved yet and the assumptions which have been made when designing the model basics are in some way approximations to the reality. However, it is an opportunity for insurers to use Cat.Nat. models for exposure assessment.

If such models are applied it should be noted that a huge quantity of data is needed and that these data are not always available in the required resolution (in which storey of a building is the technical inventory located?). The results of the modelling process should be critically evaluated. On the other hand, a systematic survey of the exposed portfolio gives the insurer more security with expectations concerning weather-related events.

The presented procedures for modelling natural hazard loss expectations were developed for the area of property insurance. With relatively small changes they can also apply to MB and EEL insurance. Using them in the EAR/CAR field is more problematic: on the one hand, risks which spread over several zones have to be taken into account. On the other hand, risks have to be considered whose value development and vulnerability can dramatically vary during the construction period.

5 Consequences of facts - How can the Engineering Insurance Industry manage Natural Hazard Risk?

Losses in Engineering insurance have been significantly less influenced by events of nature than it was true for other property insurance lines of business. This situation is explained - among other things - by the following facts:

⇨ Natural hazards are - depending on the market and/or coverage - not or only partly insured in Machinery breakdown and Electrical equipment insurance

⇨ Low market penetration in comparison to property insurance and resulting lower accumulation risk in case of loss

⇨ Comparatively detailed technical engineering underwriting with the resulting advantage of an exact knowledge of individual occurrences and an intensified consideration of hazards with low occurrence probability

⇨ A diversified underwriting aiming at a broad risk distribution rather than at a high individual risk exposure due to the predominant frequency loss character and the associated basic claims burden in numerous Engineering insurance covers

⇨ Partly, risk specific international business (project coverage) resulting necessarily in a regional diversification of the insurer's respective portfolios

Where significant losses caused by natural disasters can be identified for past periods in Engineering insurance, they refer mainly to locally insufficient diversified portfolios in regions especially exposed to natural hazards.

These findings which are undoubtedly true must not hide the fact that the underlying data base is currently still very limited. Reasons for this are presumably shortcomings in systematics as well as insufficiencies in statistical records exclusively referring to Engineering insurance. The following facts – among other things - can be mentioned as systematic shortcomings in the existing statistics on the effects of natural hazards which basically apply to all property insurance lines of business:

- ⇨ Up to now, data on the distribution of insurance sums have not been continuously recorded.
- ⇨ Tools for assessing changes in the insured values over a given period of time are not known in a sufficiently accurate way. Hence there is no possibility to recognize effects of increasing values in specific regions and to include them in the assessment.
- ⇨ Available statistics generally refer to specific regions and portfolios. The resulting data reflect only a small section of the overall situation.
- ⇨ Changes in the value concentration and in the insured values in certain regions are not known. Significant changes in the values on the whole and in the insured values may occur. Statistics may be influenced by the behaviour of direct insurance and reinsurance markets in individual regions.
- ⇨ There is only restricted availability of information on deductibles and limits which, however, may considerably impact statistical statements.
- ⇨ The long-term structures, composition and changes of portfolios underlying certain analysis are unknown. Thus statistics could reflect changes in underwriting policy or the data could show a weaker or stronger influence of natural hazards depending on locally limited portfolios.

Especially in Engineering insurance additional circumstances further restrict the informational value of statistics being currently produced:

- ⇨ Natural disasters were not equally in the focus of Engineering insurance as for example in Property insurance. This was influenced by the fact that there had obviously been relatively little effect of events of nature on the insurers' total claims burden compared to other lines of business. Existing claims information thus frequently reveals an insufficient claims code in this respect.
- ⇨ Depending on the conditions in different markets, individual coverage (MB, EE) is attributed - either completely or with regard to individual hazards - to different insurance lines of business rendering the compilation of overall market statistics more difficult or even impossible.

Despite the diagnosed shortcomings of currently available statistical material, existing data already reveal that natural hazards could have a considerable influence on loss development in engineering insurance (see chapter 2). Growing exposure and the relating danger of increased losses caused by natural hazards is quite likely in Engineering insurance just as much as it is in other property insurance. This forecast has to take into account that loss development in the area of natural hazards will also be influenced to a considerable extent by the fact that higher value concentrations develop in endangered regions. For reasons of an optimised economic use, there may be e.g. an increased building activity along coastal lines and river banks or large objects being built in earthquake-prone areas. These developments will automatically lead to a significantly stronger exposure of locally limited portfolios in endangered regions compared to regionally diversified portfolios containing risks from exposed and non-exposed areas. Additionally, with locally restricted portfolios it is generally impossible for the insurer to fund the potential loss expectation at short notice.

Insurers need to aim at the following targets:

- ⇨ Assess developments
- ⇨ Quantify effects in a reliable way
- ⇨ Deduce reliable forecasts for the future

To do so, improving the quality of statistical data is a prerequisite. Improvements in the content (e.g. claims coding) are as much required as conceptual amendments (e.g. exposed values at risk within the insurance period).

Furthermore, similar necessities for improvement arise regarding the presently generally applied procedures for modelling the effects of natural hazards on Engineering risks and portfolios. It is true that the existing models and simulations are applicable for individual Engineering lines of business (namely MB and EE for stationary risks) with identical informational precision and reliability as for Property insurance, but particularities of other Engineering lines of business are not or only insufficiently taken into account.

This is especially true for the area of Erection All Risks (EAR) and Contractors All Risks (CAR) where the portfolio - in contrast to Property insurance – consists of a relatively small number of risks with high values and not of a multitude of objects in the observed zones.

Furthermore, we have to consider the fact that the insured values in EAR/CAR projects build up in an accumulative way over a longer period. Vulnerability to natural hazards, however, may vary dramatically during the construction period. In addition, vulnerability curves for specific similar risks form the basis for calculations in all applied models. Since EAR/CAR portfolios contain at any time a wide variety of different objects (office buildings, petrochemical plants, tunnels, dams, etc.) in different construction phases, a division into similar risks of almost identical vulnerability to natural hazards is very difficult. Only if sufficiently meaningful statistical information will be available, will we be able to clarify, in how far individual risk groups can be classified in the future in order to use this data as a basis to determine higher vulnerabilities to certain natural perils by means of loading (% of values at risk on site). For want of such findings and without statistically reliable methods insurers can only consider natural hazards for individual risks during construction periods within the framework of their risk management accordingly and assess them with regard to their current loss potentials.

6 General conclusions

A number of well-founded studies have shown that an increase in the number of major events of nature is to be expected. Surveys carried out by renowned reinsurers have revealed an increase in economic and especially in insured losses.

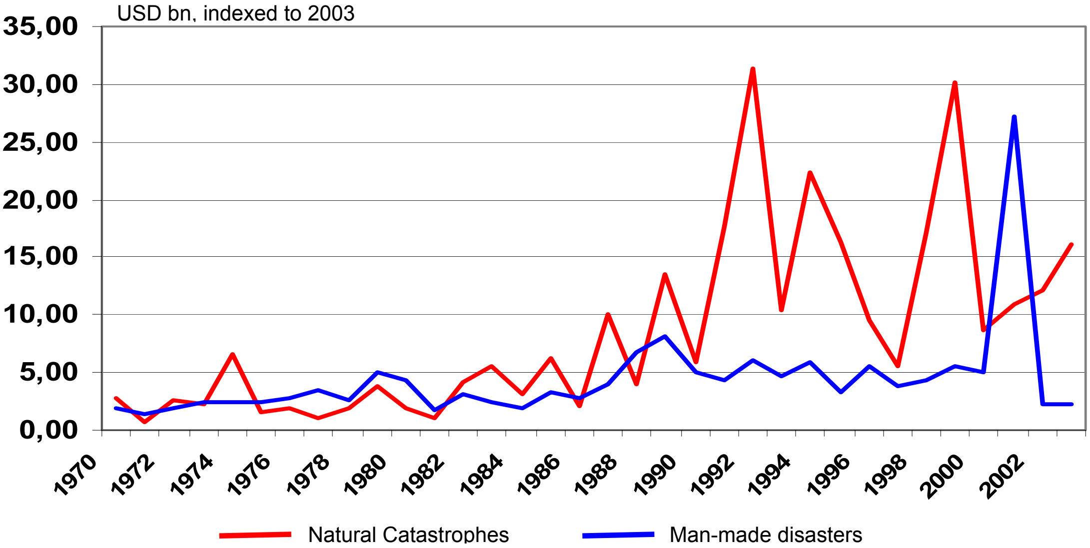


Fig. 40: Insured losses 1970 – 2003 [Swiss Re, Economic Research and Consulting [Sigma 1/2004]

While man-made disasters reveal a moderate increase in losses without any distinct peaks, the trend for natural catastrophes clearly points upwards showing significant amplitudes over the last years due to peak losses (hurricane Andrews 1992; Northridge earthquake 1994; hurricane Mireille 1991; winter storms in Europe 1999).

This trend becomes even more significant if we also take those economic losses into account which are not insured at the time of the event.

There is ample evidence that the trend towards large scale losses of several billions will continue even if the effects of a potential climate change on the frequency and intensity of events of nature cannot be reliably predicted today. However, for

- ⇨ more intensive precipitation events
- ⇨ the increase in tropical cyclone peak wind intensities and
- ⇨ the increased intensity of mid-latitude storms

higher probability has to be assumed [IPCC Third Assessment Report – Climate Change 2001].

The rise in insured losses since 1970 can be explained by economic, demographic and geographical factors. Specifically in industrialised countries, there was a demonstrable and rapid rise during this period in insured values, such as residential, industrial and office buildings. In addition, exposed areas like costal regions, or river and lake floodplains, were claimed for constructions or saw their population density grow.

Greater vulnerability to losses is to be expected against the backdrop of a potential shift in climate zones caused by climate change. Certain regions could be affected by natural events presently known only to impact extreme regions. As infrastructure has not been adapted to withstand these new conditions, it may be that the high catastrophe losses of recent years were also the result of higher vulnerability [Swiss Re, Sigma 1/2004].

Concerns for Engineering lines of business

The observed trend will also have an impact on Engineering insurance. Currently, clear statements concerning trends in loss development and the underlying causes cannot be deduced due to missing or inconsistent data. Insurers, however, have to deal with the present development and its consequences within the framework of Engineering lines of business:

- ⇨ Along the lines of other property insurance, Engineering insurance, too, shows an increase – in absolute figures - in losses caused by natural events.
- ⇨ At the same time, we can state that the percentage of losses caused by natural events of total losses reveals an upward trend in the observed lines of business.

These observations directly correlate with reliable scientific findings of an increase in the frequency of extreme but usually locally limited events of nature. Their primary intensities, however, show an increase compared to similar events in the past. Up to date knowledge indicates that the decisive question will not be if and when we will finally be able to prove man-made climate changes; but rather the question if the climate data or climate model calculations can provide an informative basis for a reasonable estimate of future changes and for developing appropriate adjustment and defence strategies in due time. The risk of error will remain high for the time being. Thus it is all the more important that the strategies are flexible and are assessed with regard to the losses which are to be avoided.

Consequences for Engineering insurers resulting in the near future from the available facts and findings are obvious:

- ⇨ Relevant natural hazards increasingly have to be taken into account within the framework of individual risk assessment despite their comparatively low probability
- ⇨ Within the framework of risk management, preventive measures to limit the effects of occurring natural hazards have to be put into practice or have to be demanded.
- ⇨ Underwriting needs to focus on achieving broad risk distribution and extensive regional diversification of portfolios. On the other hand, high exposures of individual risks should be avoided.
- ⇨ If sufficient risk distribution and diversification of individual portfolios is impossible due to regional restrictions of business activities or for other reasons, suitable strategies for establishing reserves have to be developed. These strategies complement the primary aim of a risk balance in the collective by a risk balance over time.

These and similar measures alone are certainly not sufficient to cope with the future risk development of losses caused by events of nature.

With the presently available findings we cannot assess the development of the natural hazard risk in Engineering insurance. Today, a reliable identification of the causes of risk increases which must be assumed or at least cannot be excluded is even less feasible. Without a precise knowledge of the causes, however, it is impossible to develop appropriate counter-measures which would also in future guarantee a consistent demand-orientated insurance protection at risk-adequate prices and terms and conditions.

The first and most important step in this direction certainly consists in dramatically improving the information basis for all insurance lines of business covering losses caused by events of nature as quickly as possible. Absolute statements concerning the development of losses resulting from natural hazards alone are completely useless. In the worst case, they may even lead to false conclusions and contra-productive reactions. Rather do we need observations which put things into perspective, by, e.g. comparing costs of natural hazards with suitable reference parameters (value exposure, exposure development, development of insurance density).

To have the indispensable accumulation records and control also for Engineering insurance risks definitely represents a step forward in improving data quality and statistical information resulting from it. In the field of Engineering insurance, however, it is also especially important to broaden the models and simulations used in accumulation control according to requirements. Contrary to coverage in MB and EE for which standard models provide statements of the same quality as for property insurance, well-founded engineer-technical extensions are imperative for project coverage. This refers mainly to vulnerability due to events of nature of objects insured under EAR/CAR coverage during the different construction periods.

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