Earthquake Risk Modelling

Dr. Dirk Hollnack
GeoRisks Research Group
Munich Reinsurance Company

Münchener Rück
Munich Re Group

Contents

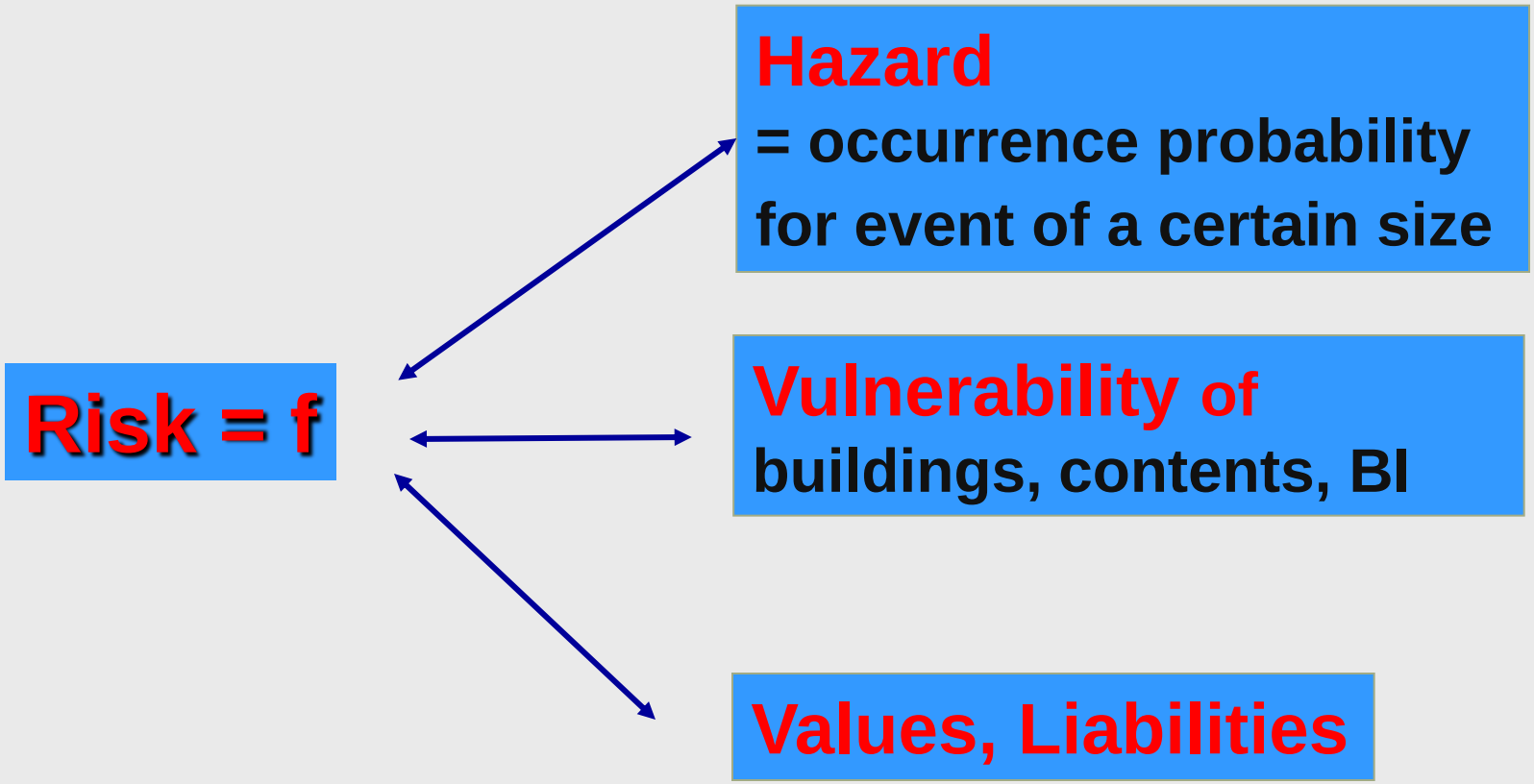
Münchener Rück
Munich Re Group

Principles of Risk Assessment

Münchener Rück
Munich Re Group

Earthquake Risk and its Components

Münchener Rück
Munich Re Group



Natural Catastrophe Modelling

Münchener Rück
Munich Re Group

Why do we use risk models?

- Representation of natural phenomena
  (severity, location, probability)
- Calculate the consequences of these phenomena
- Risk management (preparedness, mitigation)
- Estimate loss potentials

Player in EQ Risk Modelling

Münchener Rück
Munich Re Group

EQ Risk Modelling is done by:

- **Consultants**
- **(Re)Insurances**
- **Brokers**

} **‘Insurance Business’**

- **Geol. surveys and public agencies**
- **Scientific groups/universities**

} **‘Science’ and public**

NatCat Risk Modelling for Insurance Business

Münchener Rück
Munich Re Group

Insurance business uses NatCat risk models since the 80th

Some examples:

- **AIR since 1987**
- **Munich Re since 1987**
- **RMS since 1988**
- **EQECAT since 1994**
- **Benfield since 1999**

EQ Risk Modelling

Münchener Rück
Munich Re Group

Why are university risk models only used for a very limited extend in insurance business?

- **The methodology, resolution and parameters to be used vary with the purpose of risk modelling (i.e. mortality, disaster management, risk reduction, financial risk)**
- **EQ models for insurances have a kind of standard which meets the requirements of the business. Research projects are often designed for a small area (i.e. one city), working on a high resolution and/or are focused on a detailed problem:**
  - **High computational requirements (run-time, memory)**
  - **Results are often difficult to adapt for insurance purposes**

Exposure: What is a “Risk Element”?

Münchener Rück
Munich Re Group

- Building
- Contents
- Machinery & equipment
- Construction sites
- Consequential loss (Business interruption, Advanced loss of profit)
- Vehicles, Life, Arts, Social events (Olympic games, rock concerts), etc

=> Much broader sense than in normally used in EQ Engineering

Insurance Aspects

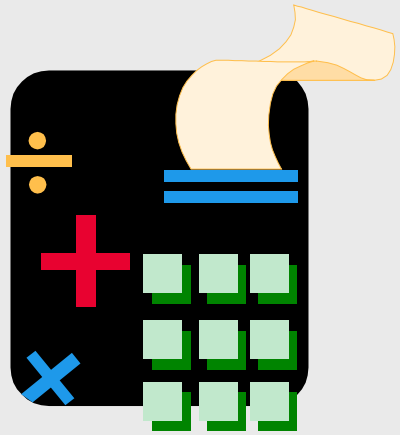
Münchener Rück
Munich Re Group

Average annual loss (AAL)
=> rating – site specific

Probable maximum loss (PML)
=> catastrophe potential - regional scale

An adequate Price and PML must reflect

- **Risk Location - Hazard**
- **Type of Risk - Vulnerability**
- **Insurance Conditions**
- **(Claims Experience)**



Company

Name: [redacted] **Country:** Colombia

Exposure Data

Last user:MUNICH\n045158,last change:22.10.2003 06:31:02

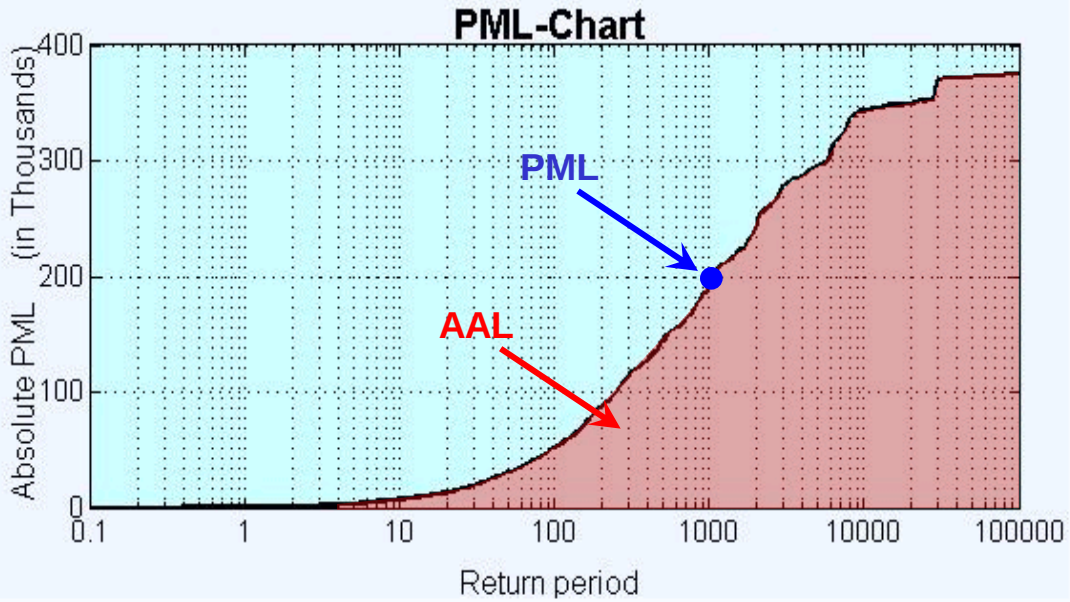
Peril: Earthquake
Geozone Level: CRESTA1
Edition Status: Valid
CPM note:

Country: Colombia
Validity Date: 30.06.2003 00:00:00
Multi location exposure: False

Curve settings

- (•) absolute
- ( ) relative(‰)
- ( ) relative (%)

- (•) return period
- ( ) exceedance freq.



Currency: COP

Maximum Possible Loss: [COP] 375.336,29

Annual Average Loss: [‰] 1,43

Used Sum Insured: [COP] 2.731.188,48

Ignored Sum Insured: [COP] 0,00

Show **Advanced diagnostic information**

EQ Risk Models for Insurances

Münchener Rück
Munich Re Group

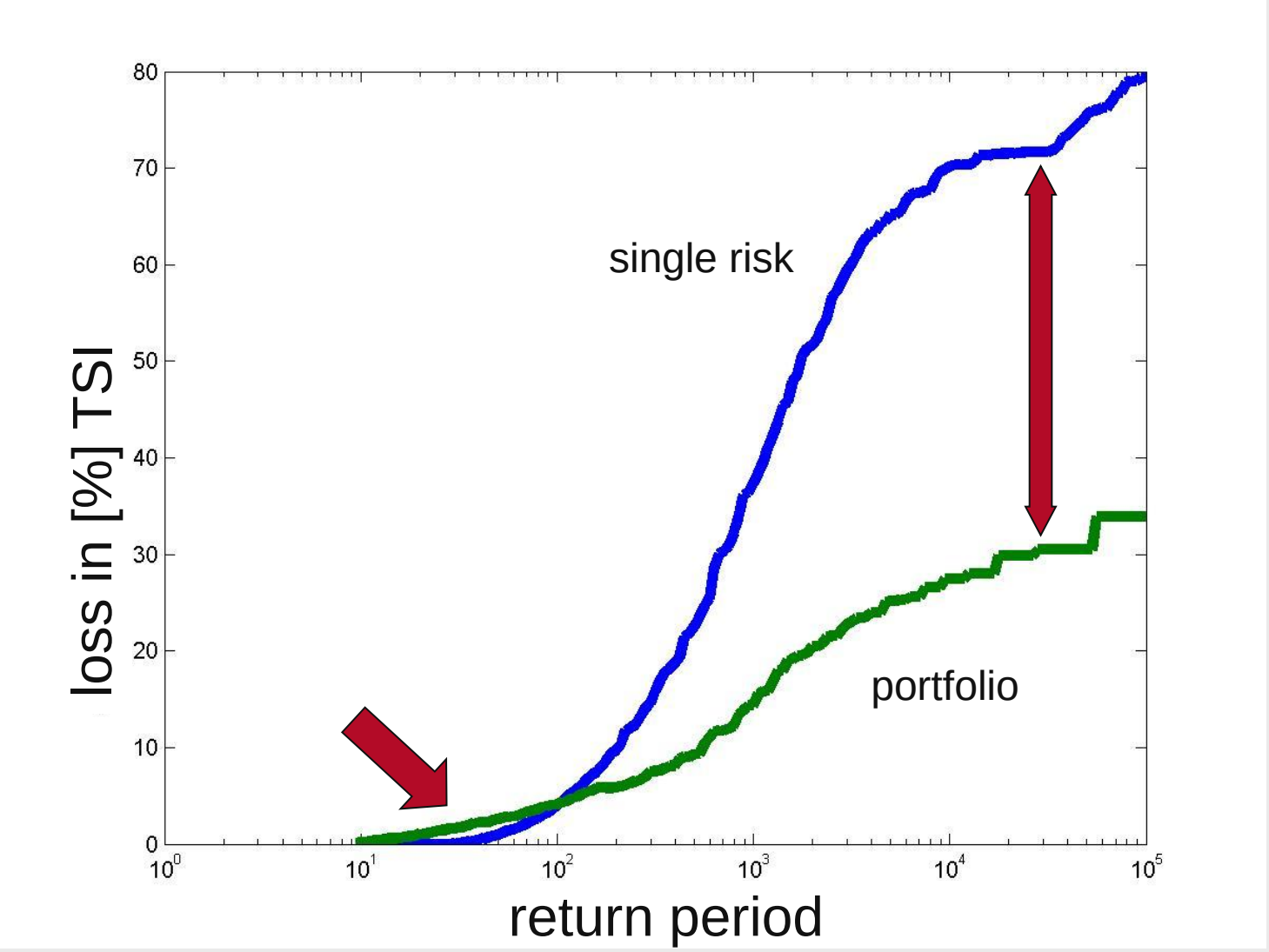
In Principle two different types of contracts which require different modelling methods:

- **Portfolio = large number of risks which are spatially distributed**
- **Facultative = single risk (mainly large industry complexes or buildings)**

Introduction to concepts of loss estimation

Single Risk vs. Portfolio

Münchener Rück
Munich Re Group



Insurance Conditions

Münchener Rück
Munich Re Group

Self-participation

- **Deductibles**
- **Limits**

Hazard Maps

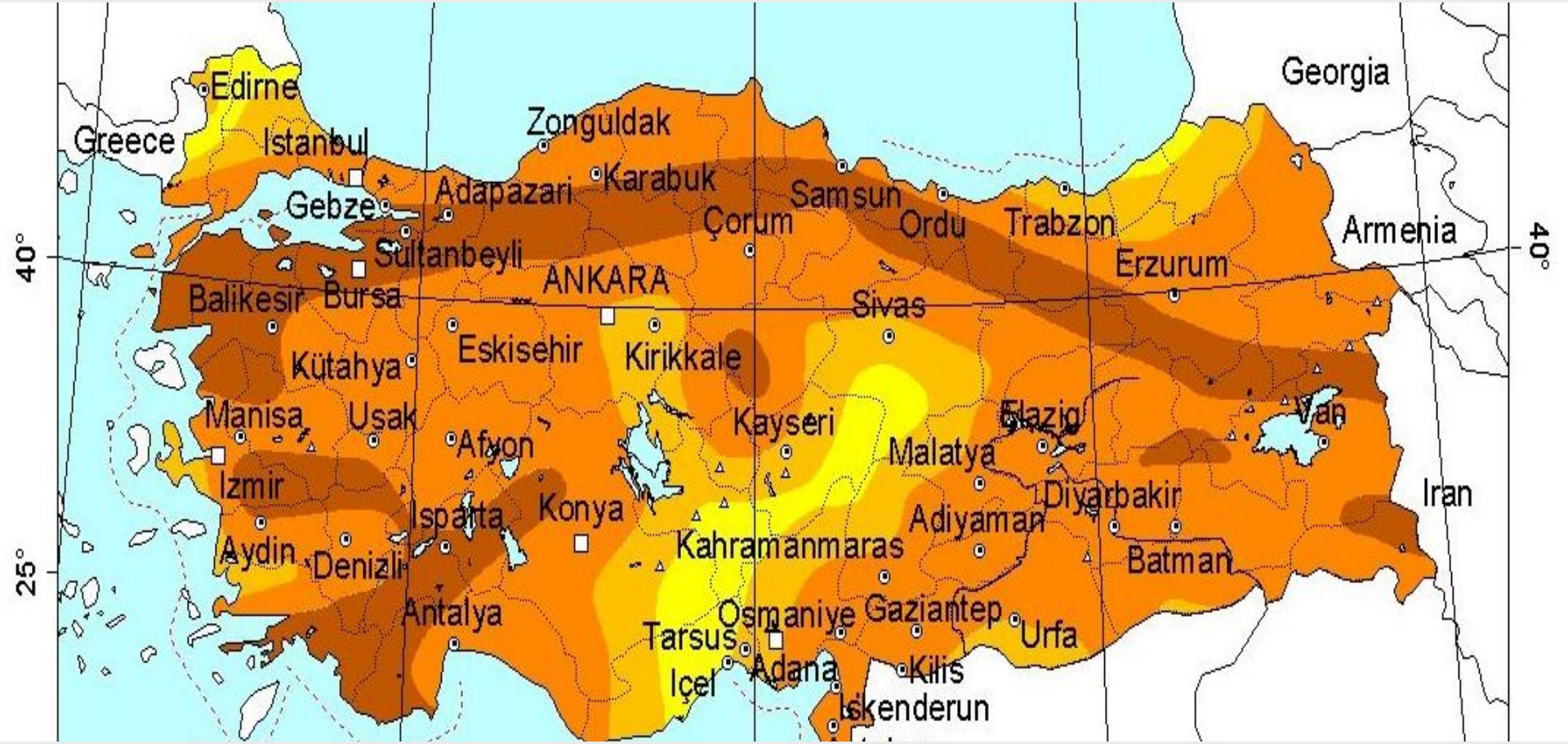
Münchener Rück
Munich Re Group

Hazard Maps

Münchener Rück
Munich Re Group

Nathan- World Map of Natural Hazards

(Maximum Intensity of a 475 years return period)



No information about other return periods

Hazard Map/ Usage

Münchener Rück
Munich Re Group

- Basis of building codes/regulations
- Basis of tariff zones
- Warning signal
- Loss potential estimation
- Comparison of two locations

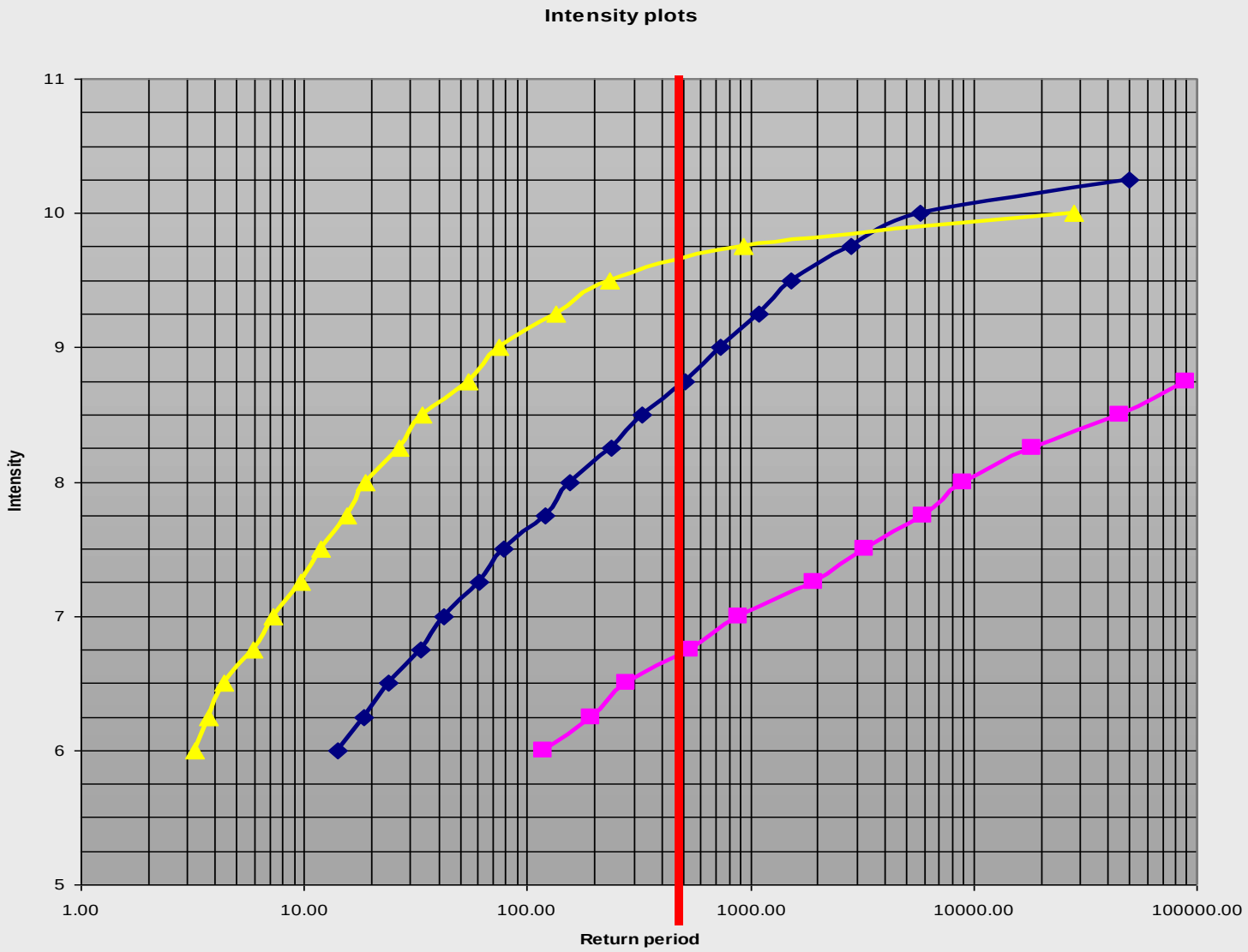
Hazard map/ problems

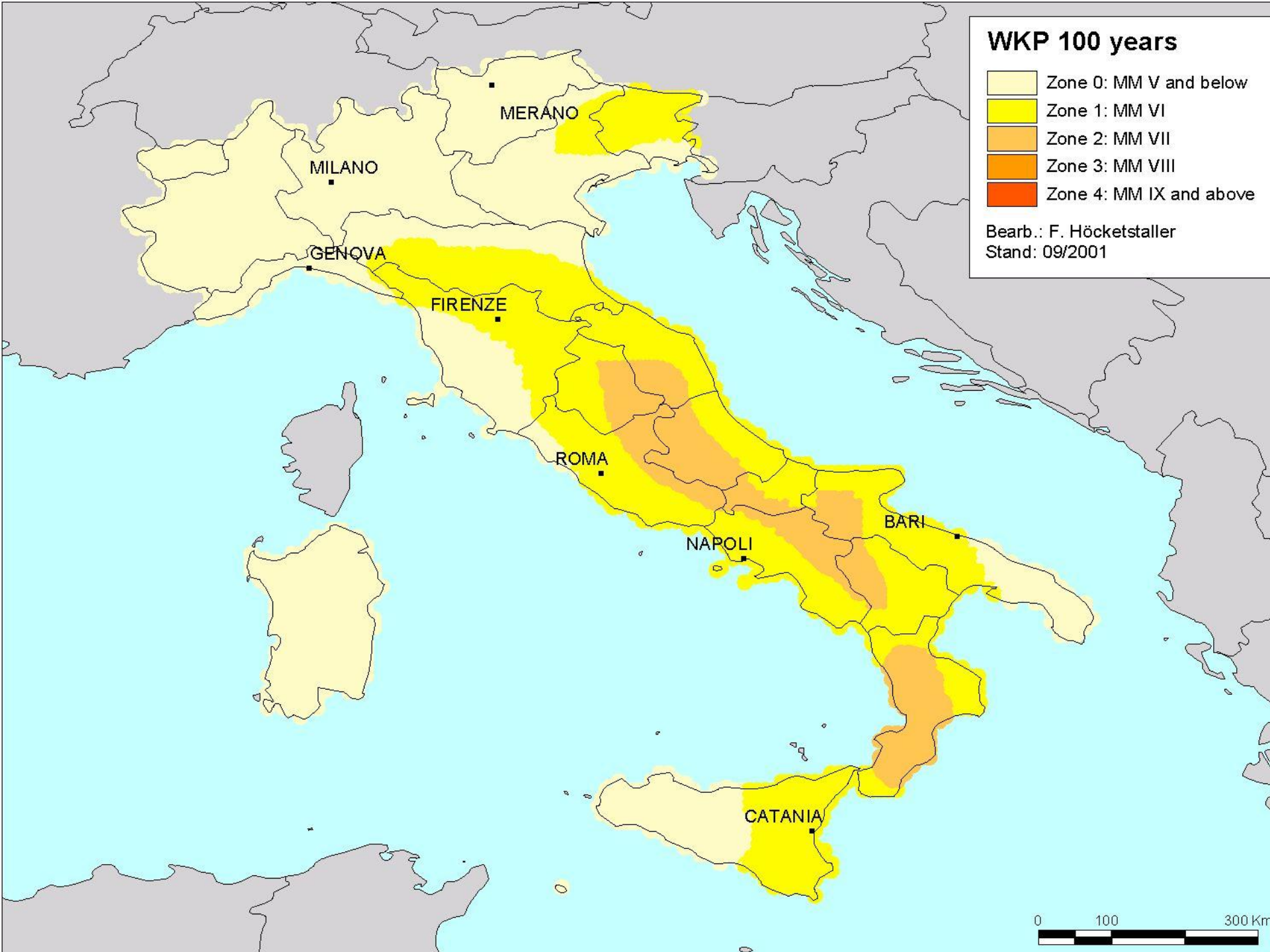
Münchener Rück
Munich Re Group

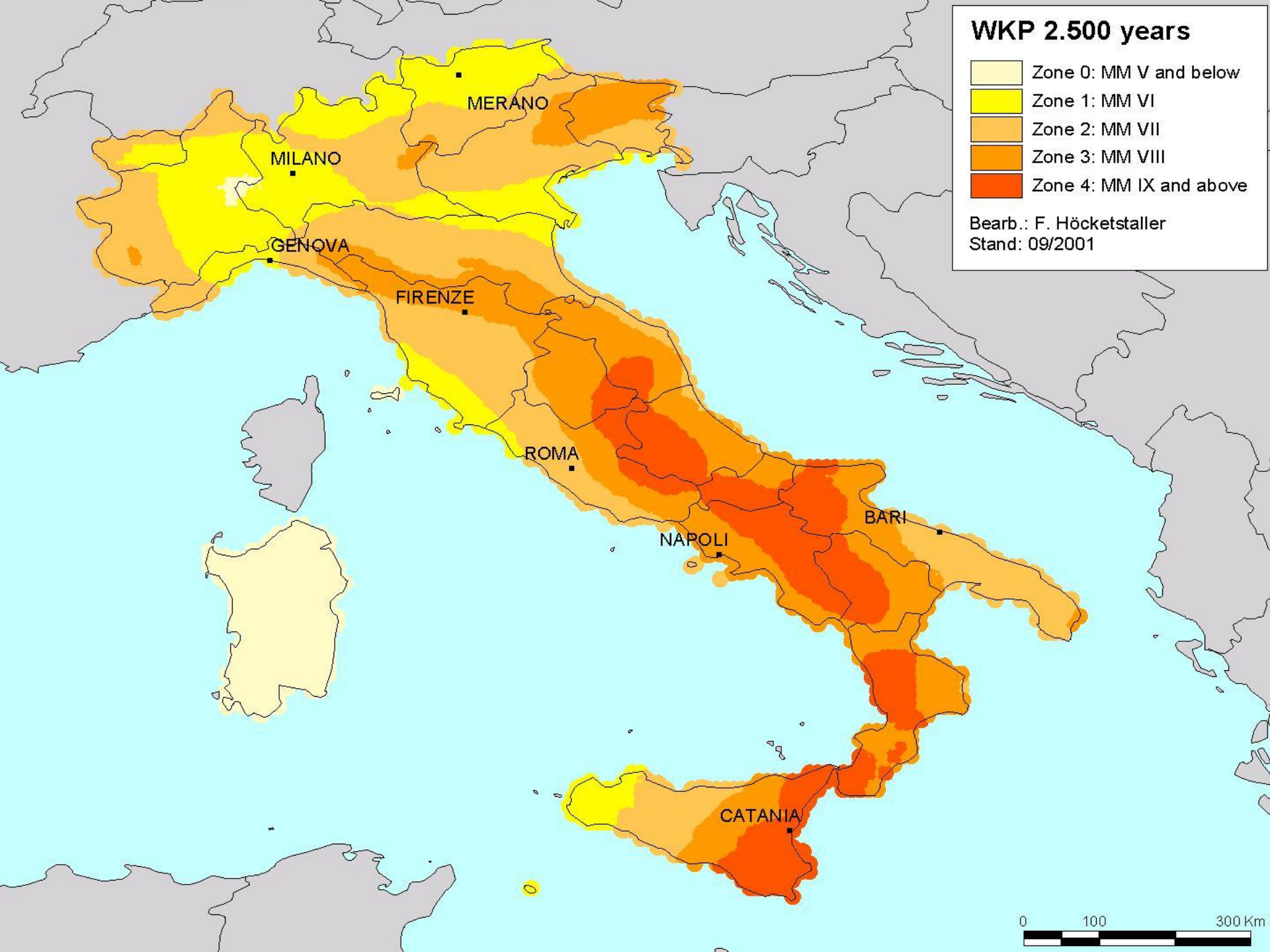
- Affected region not clear
- Verification difficult
- No regional differences inside hazard zones
- Secondary effects not included
- Only for one return period

Hazard at other return periods

Münchener Rück
Munich Re Group




WKP 100 years
Zone 0: MM V and below
Zone 1: MM VI
Zone 2: MM VII
Zone 3: MM VIII
Zone 4: MM IX and above
Bearb.: F. Höcketstaller
Stand: 09/2001
MERANO
MILANO
GENOVA
FIRENZE
ROMA
BARI
NAPOLI
CATANIA
0
100
300 Km


WKP 2.500 years
Zone 0: MM V and below
Zone 1: MM VI
Zone 2: MM VII
Zone 3: MM VIII
Zone 4: MM IX and above
Bearb.: F. Höcketstaller
Stand: 09/2001
MERANO
MILANO
GENOVA
FIRENZE
ROMA
BARI
NAPOLI
CATANIA
0
100
300 Km

Earthquake Scenarios

Münchener Rück
Munich Re Group

Scenario

Münchener Rück
Munich Re Group

What loss potentials can hit me in the case of a natural catastrophe?

Scenario

Münchener Rück
Munich Re Group

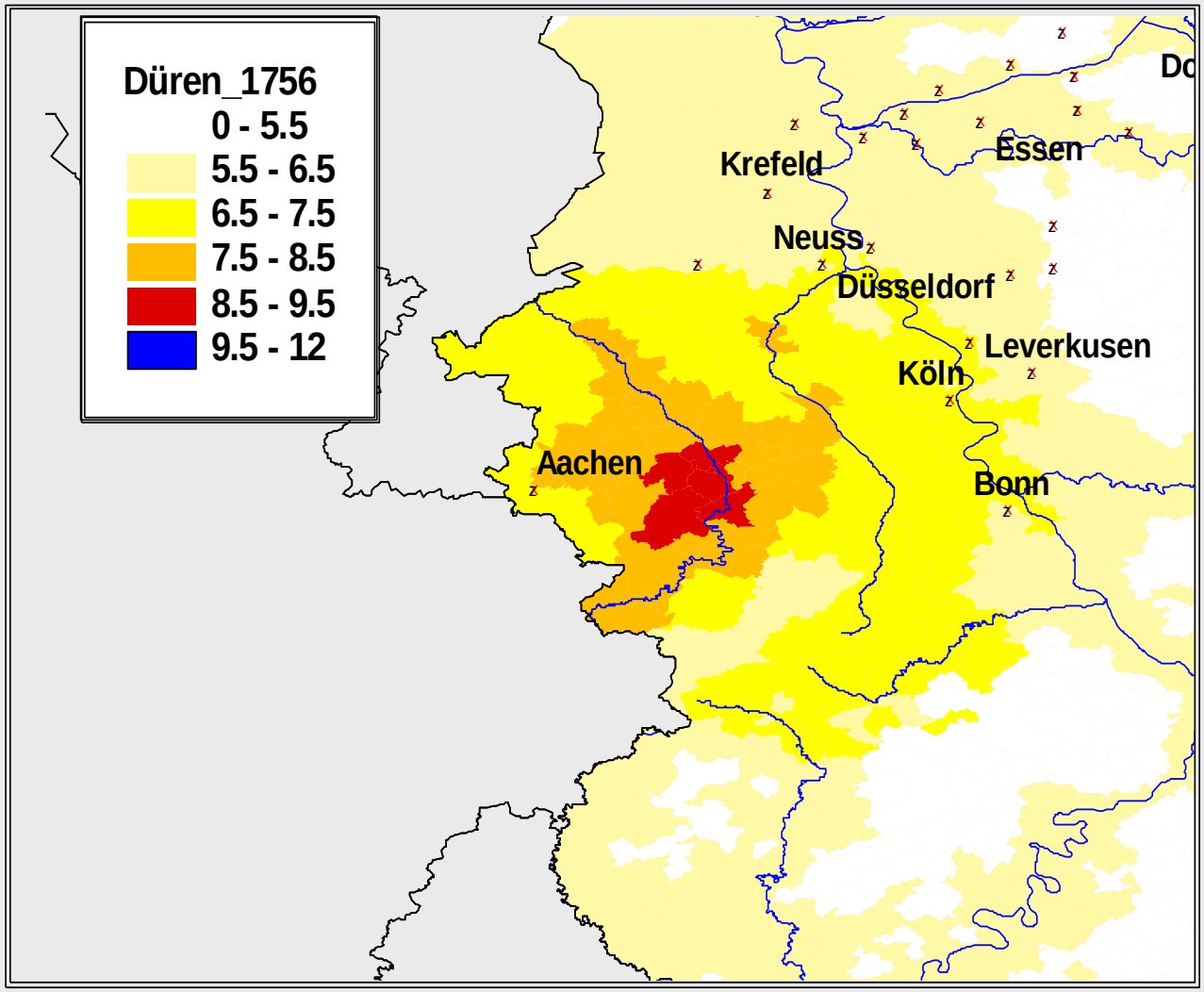
Selection of scenarios

- Historical
- Modified historical
- Theoretical possible (virtual)

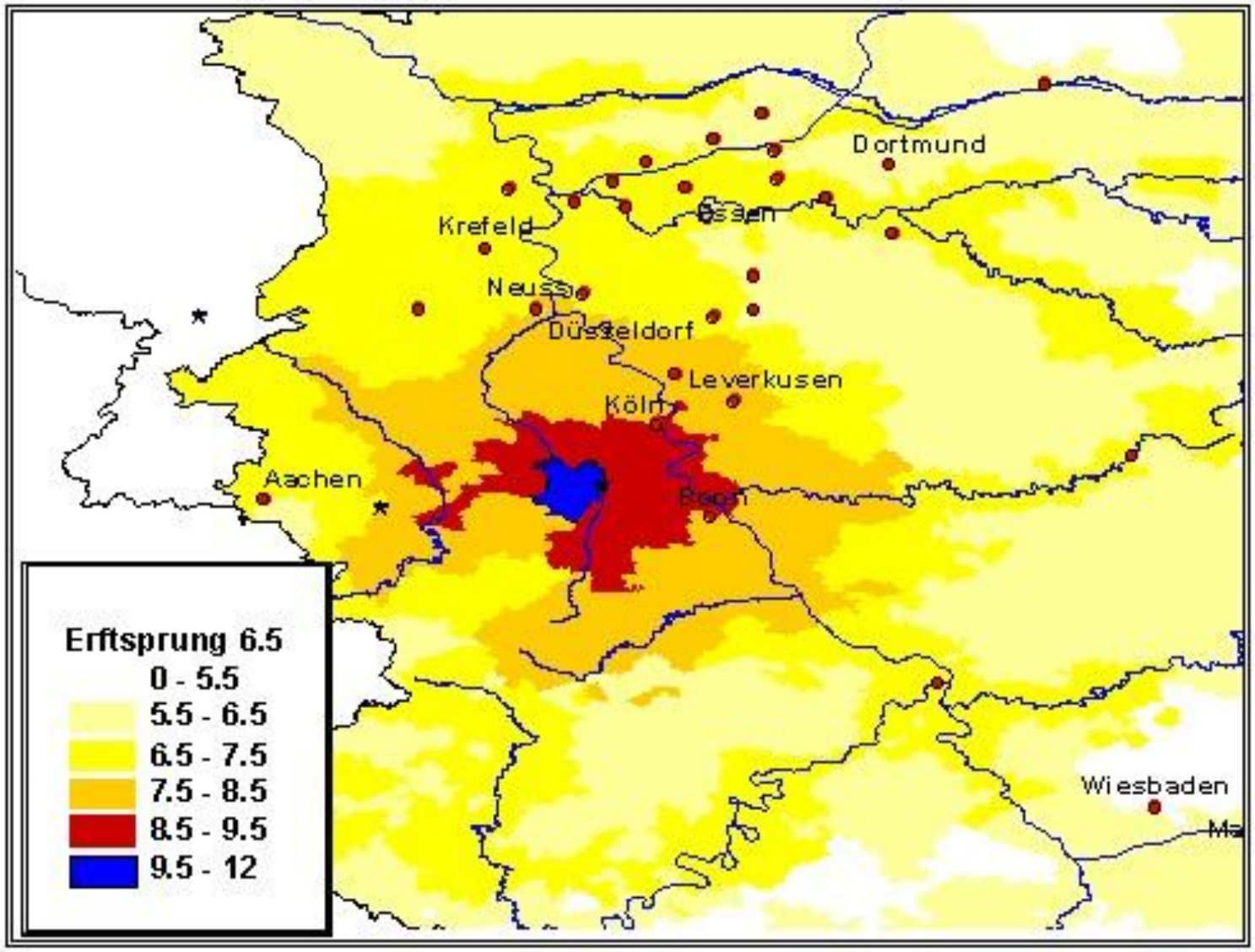
Isoseismal Map / Intensity Scales

Münchener Rück
Munich Re Group

Düren (1756) - M = 6.1



Scenarios – Historical modified



Scenarios/ use

Münchener Rück
Munich Re Group

- As/if calculations
- Comparison to market loss estimates
- Verification of probabilistic models
- Loss potential estimate/ budgets

Scenario / limitations

Münchener Rück
Munich Re Group

Is my Scenario ...

- realistic ?
- adequate ?
- out-dated ?
- a support in determining the premium level ?

Modelling Earthquake Risk

Münchener Rück
Munich Re Group

Probabilistic modelling

Münchener Rück
Munich Re Group

- What are the loss potentials I have to expect for my portfolio?
- How frequent do these losses occur?

Introduction to concepts of loss estimation
Probabilistic modelling

Münchener Rück
Munich Re Group

Principle:

- Generation of large synthetic event sets (thousands to hundreds of thousands)
- Assignment of occurence probabilities
- Calculation of losses
- Calculation of exceedence probabilities
- Calculation of PML curve and technical rate

Probabilistic modelling

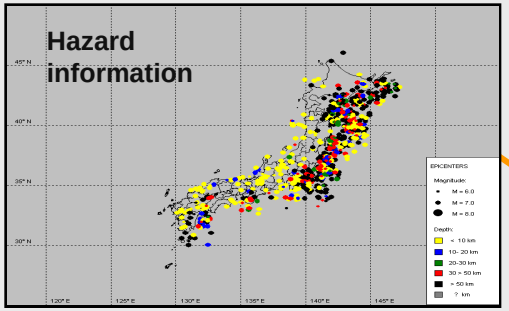
Münchener Rück
Munich Re Group

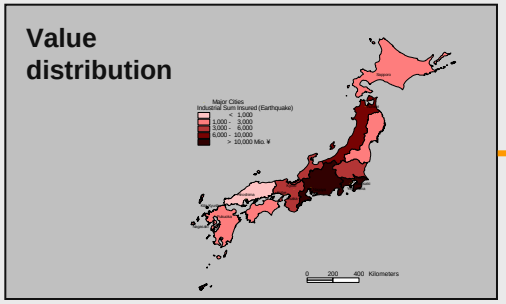
Event simulation is based on:

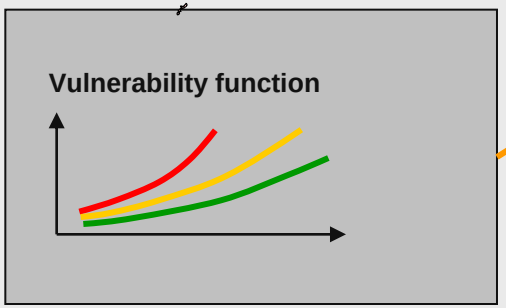
- Measured events
- Historic/ pre-historic events
- Regional characteristics
- Physical framework

The holistic Solution for Risk Assessment: Risk Models

Münchener Rück
Munich Re Group







Scientific input

Individual exposure

Munich Re's loss experience

Set of scenarios

Statistics

Risk curve

Expected loss/ loss occurrence probability

Detailed Risk Information

Münchener Rück
Munich Re Group

Risk models require high resolution data:

- **(GPS) coordinates**
- **Geotechnical information**
- **Building characteristics**
  - **Age**
  - **Height**
  - **Occupancy**
  - **Construction type**

CRESTA – An Insurance Standard

Münchener Rück
Munich Re Group

CRESTA was set up by the insurance industry in 1977 as an independent organisation for the technical management of natural hazard coverage.

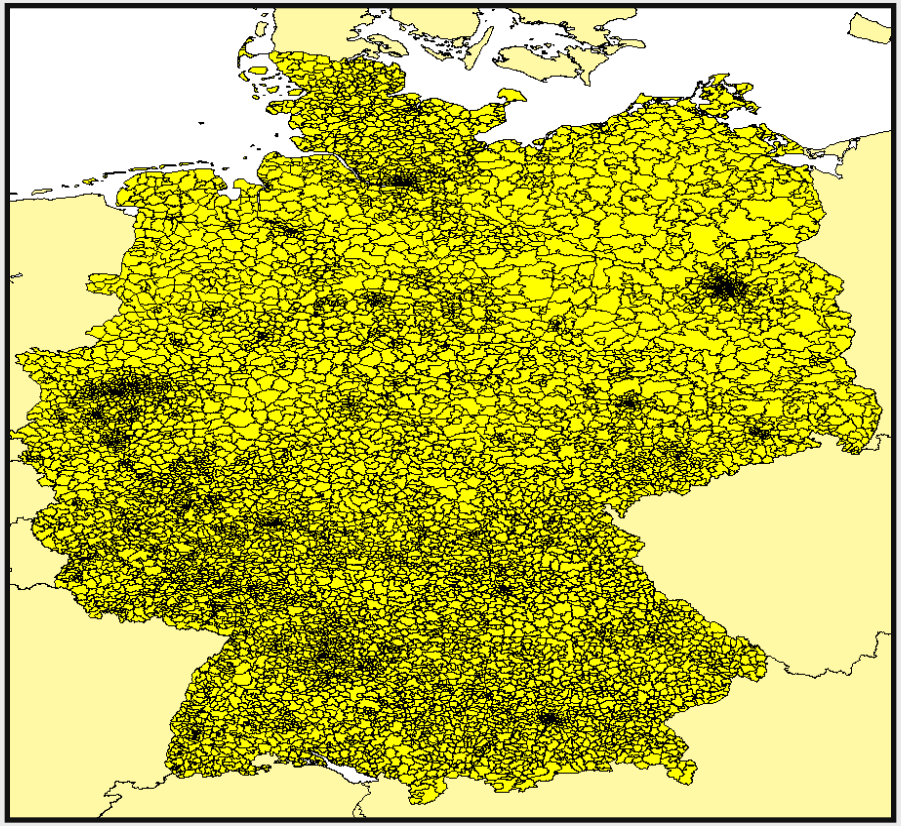
CRESTA's main tasks are:

- Determining country-specific zones for the uniform and detailed reporting of accumulation risk data relating to natural hazards and creating corresponding zonal maps for each country
- Drawing up standardised accumulation risk-recording forms for each country
- Working out a uniform format for the processing and electronic transfer of accumulation risk data between insurance and reinsurance companies

The CRESTA Format

Münchener Rück
Munich Re Group

Germany – 8270 Zones



Greece – 16 Zones

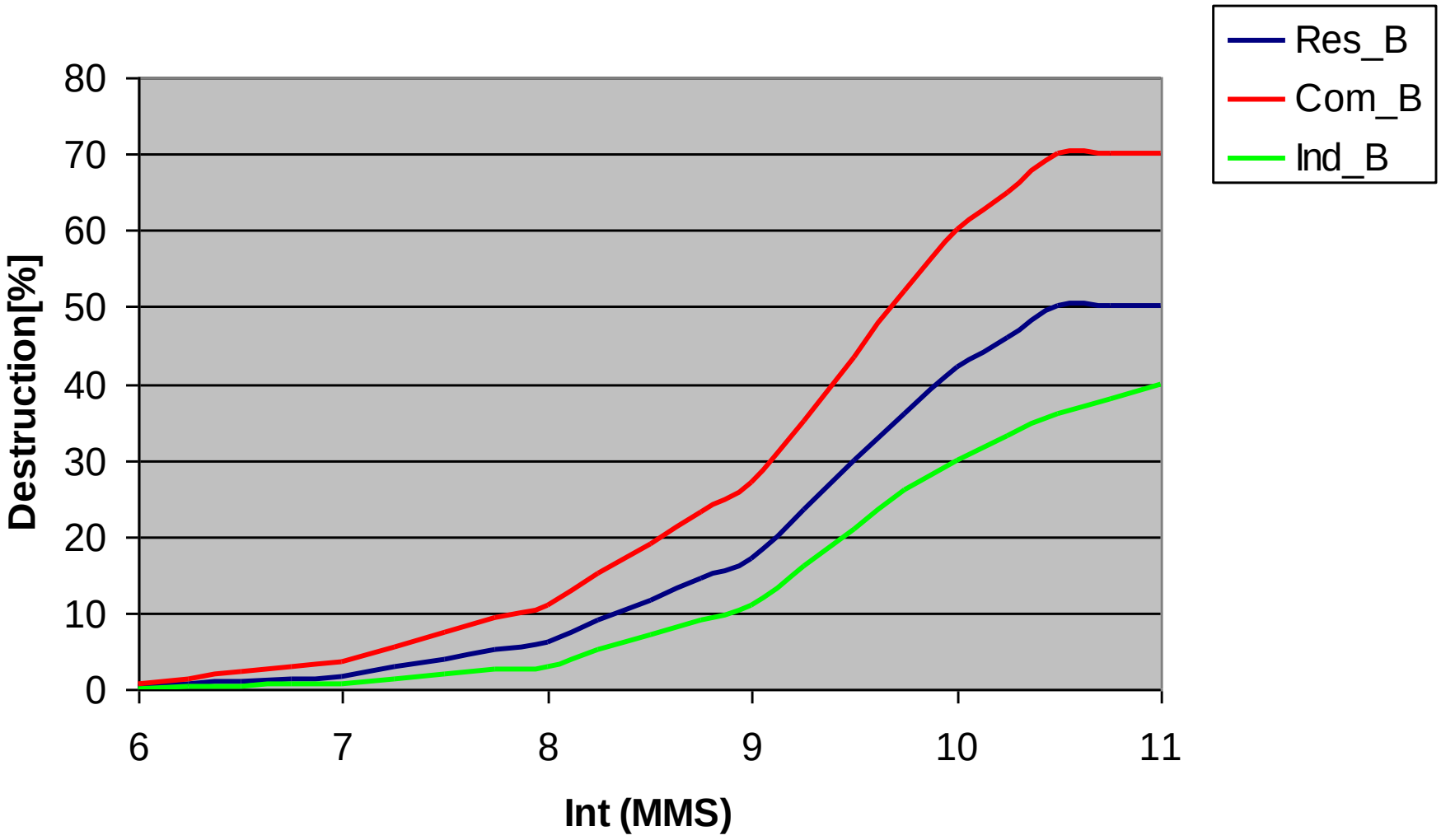
Quality of Input Data

Münchener Rück
Munich Re Group

	Civil/Residential				Commercial				Industrial			
Zonen	Buildings	Contents	BI	B/C/BI	Buildings	Contents	BI	B/C/BI	Buildings	Contents	BI	B/C/BI
1	19,059,000	1,777,993	0	267,219	3,433,837	658,053	69,344	68,181	2,357,407	3,554,544	385,642	12,946
2	89,965,512	10,061,244	0	2,247,123	26,615,501	13,404,683	1,188,438	1,200,682	24,771,456	43,539,058	5,574,650	834,988
3	46,831,599	10,162,430	0	1,900,155	23,509,844	14,714,525	1,858,516	3,212,337	11,058,779	17,386,172	2,263,664	394,079
4	25,210,092	3,116,907	0	1,166,441	16,972,338	7,047,397	978,968	2,354,126	948,737	1,943,135	119,372	137,000
5	37,145,033	4,114,391	0	1,326,791	11,685,506	3,251,542	156,224	1,361,373	4,161,813	8,164,523	508,255	110,644
6	6,118,851	636,884	0	289,540	1,092,442	371,540	35,314	128,361	575,656	1,191,807	159,575	45,744
7	75,464,403	8,797,550	0	7,558,628	26,800,829	16,166,293	1,838,044	6,915,094	28,309,755	59,262,793	9,905,871	5,561,906
8	13,100,955	1,689,061	0	1,483,992	2,336,247	1,502,827	166,488	1,694,816	3,440,600	6,820,629	1,229,880	700,630
9	399,578,306	57,922,315	306,514	53,352,783	145,038,992	75,563,187	14,456,709	28,365,509	69,944,050	123,912,761	22,737,532	9,362,695
10	13,090,075	1,219,452	0	590,951	21,492,631	6,932,666	789,988	5,856,179	1,934,064	3,901,407	429,117	0
11	56,293,282	6,000,802	0	3,627,511	17,143,957	7,132,101	1,080,204	1,943,624	9,124,119	13,951,717	2,137,296	1,442,736
12	21,434,626	2,698,858	0	652,560	3,685,552	3,144,739	333,759	624,015	2,052,238	3,935,882	434,912	16,894
13	26,987,137	2,652,292	0	2,413,157	12,186,718	5,161,222	463,484	1,444,814	3,565,686	6,966,361	980,151	16,948
14	25,795,836	3,918,082	0	1,583,688	26,169,200	9,093,545	1,193,133	4,219,161	6,734,533	14,194,599	1,598,039	69,499
15	11,104,814	2,287,875	54,393	419,643	6,976,208	2,476,777	269,677	725,660	2,527,603	4,956,901	523,404	0
16	16,446,868	2,152,440	0	759,188	27,923,599	11,028,734	1,367,878	757,057	695,255	1,245,379	138,263	201,277
unallocated	5,433,859	688,775	0	0	2,388,355	7,815,275	2,621,209	0	3,660,314	8,757,700	654,693	775,736

Earthquake Risk Modelling at Munich Re

Münchener Rück
Munich Re Group



PML-Curve Construction (I)

Münchener Rück
Munich Re Group

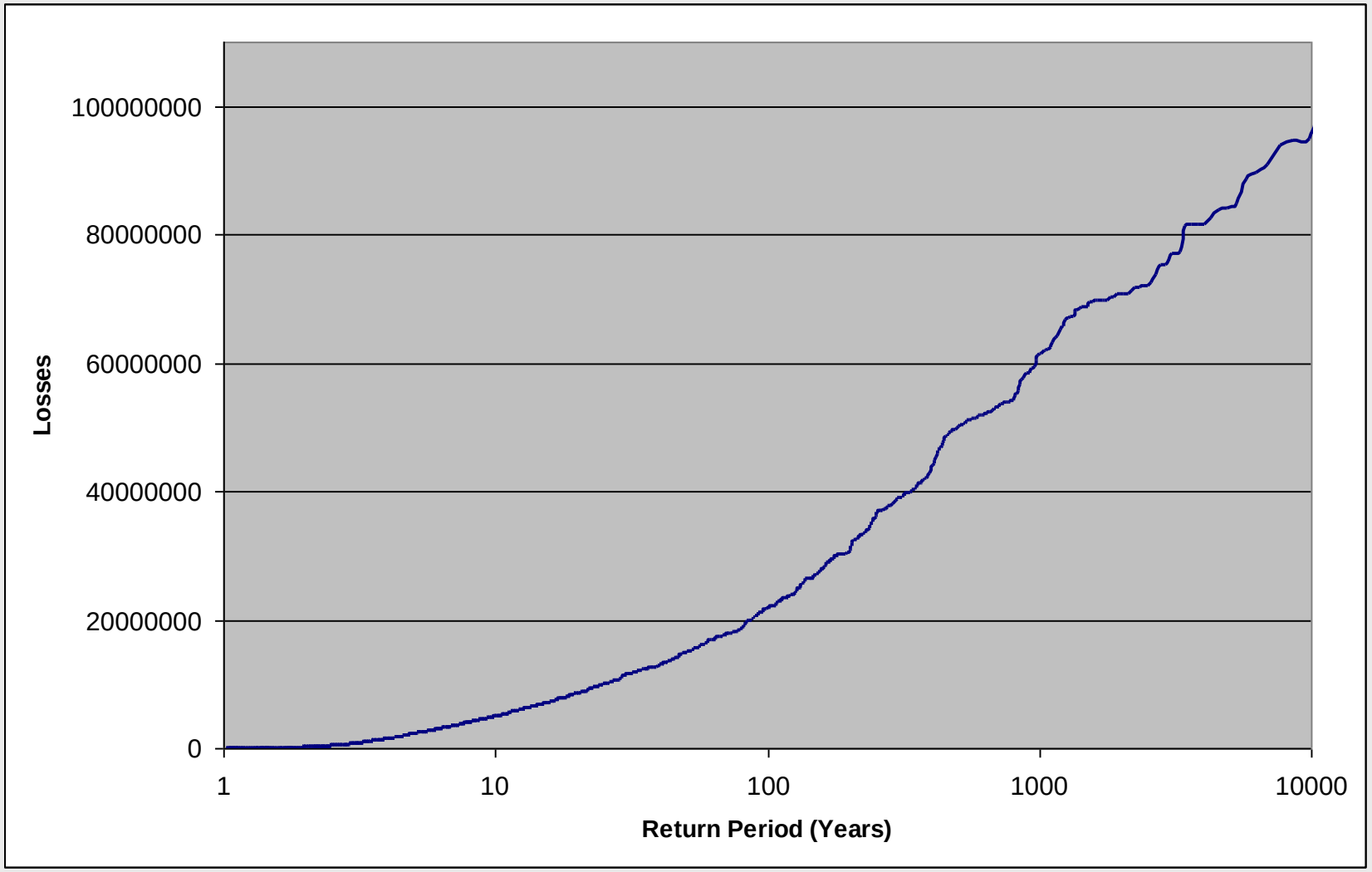
Loss ID	Losses	Probability
71004490111	31880	0.0000250
71004500111	32900	0.0000202
71004510111	65890	0.0000178
71004520111	99899	0.0000157
71004530111	100918	0.0000138
71004540111	136489	0.0000122
71004550111	170498	0.0000108
71007540111	2504	0.0000122
71007550111	3589	0.0000108
71008490111	843	0.0000250
71008500111	1550	0.0000202
71008510111	1550	0.0000178
71008520111	2258	0.0000157
71008530111	4052	0.0000138
71008540111	5898	0.0000122
71008550111	7427	0.0000108
71011510111	1563	0.0000178
71011520111	1563	0.0000157
71011530111	3127	0.0000138
71011540111	4690	0.0000122
71011550111	4690	0.0000108
71012550111	1563	0.0000108
71014530111	18756	0.0000138
71014540111	37512	0.0000122
71014550111	61889	0.0000108
71015480111	9026	0.0000250
71015490111	10253	0.0000250
71015500111	14766	0.0000202
71015510111	20308	0.0000178
71015520111	25852	0.0000157
71015530111	26884	0.0000138
71015540111	38166	0.0000122
71015550111	50223	0.0000108
71016550111	1228	0.0000108
71017490111	620	0.0000250
71017500111	620	0.0000202
71017510111	1139	0.0000178
71017520111	1660	0.0000157
71017530111	1660	0.0000138
71017540111	3496	0.0000122
71017550111	4988	0.0000108
71018540111	620	0.0000122
71018550111	1139	0.0000108
71019500111	1526	0.0000202

Sort by Losses and

cumulate Probabilities

Loss ID	Losses	Probability	Aggreg. Prob.
79075601111	133998352	0.0000001	0.0000001
79074601111	129762193	0.0000001	0.0000003
79055601111	118293935	0.0000001	0.0000004
79073601111	117554340	0.0000001	0.0000006
79054601111	115358800	0.0000001	0.0000007
79035601111	105191113	0.0000001	0.0000009
79015601111	94939435	0.0000001	0.0000010
79072601111	94608504	0.0000001	0.0000012
79071601111	93994622	0.0000001	0.0000013
79053601111	90814195	0.0000001	0.0000015
79034601111	89545358	0.0000001	0.0000016
79019601111	88622112	0.0000001	0.0000017
79033601111	84867325	0.0000001	0.0000019
79052601111	84016389	0.0000001	0.0000020
79017601111	83749481	0.0000001	0.0000022
79018601111	82493940	0.0000001	0.0000023
79051601111	81582667	0.0000001	0.0000025
79069601111	81536053	0.0000001	0.0000026
79005601111	81495306	0.0000001	0.0000028
79070601111	81325784	0.0000001	0.0000029
79016601111	77205819	0.0000001	0.0000030
79002590111	77007852	0.0000002	0.0000032
79003590111	75319716	0.0000002	0.0000034
79020601111	75138043	0.0000001	0.0000036
79014601111	73726959	0.0000001	0.0000037
79021601111	72386374	0.0000001	0.0000039
79037601111	72107042	0.0000001	0.0000040
79006601111	72096580	0.0000001	0.0000041
79027601111	71831104	0.0000001	0.0000043
79025601111	71639091	0.0000001	0.0000044
79031601111	71213075	0.0000001	0.0000046
79038601111	70846538	0.0000001	0.0000047
79046601111	70825182	0.0000001	0.0000049
79007601111	70695378	0.0000001	0.0000050
79049601111	70616009	0.0000001	0.0000052
79050601111	70330444	0.0000001	0.0000053
79048601111	70320559	0.0000001	0.0000054
79008601111	69798792	0.0000001	0.0000056
79045601111	69680677	0.0000001	0.0000057
79068601111	69676089	0.0000001	0.0000059
79001590111	69618605	0.0000002	0.0000061
79028601111	69603323	0.0000001	0.0000062
79026601111	69529242	0.0000001	0.0000064

PML-Curve Construction (II)



Uncertainties in Risk Modelling

Münchener Rück
Munich Re Group

- Event (location, size)
- Intensity (attenuation, directivity)
- Local influence (amplification, frequency)
- Risk information (building quality, location)
- Vulnerability (average damage, distribution)
- Loss (estimation of values, demand surge)

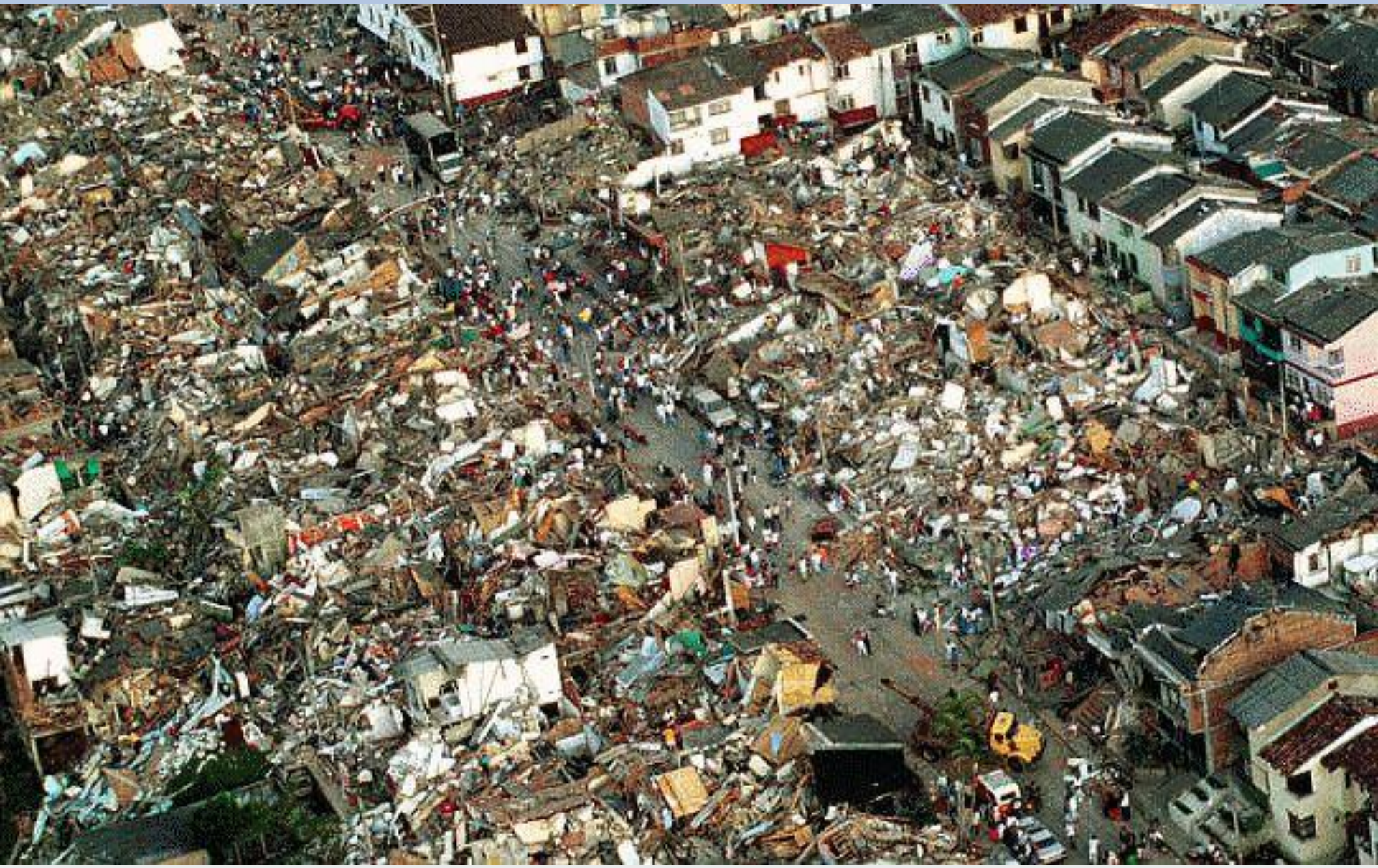
Uncertainties in Risk Modelling

There is a general tendency in modelling to increase the resolution and the number of parameters:

Does this really increase the quality of the models?

Secondary Effects

Münchener Rück
Munich Re Group



Vulnerability: Single Location

Münchener Rück
Munich Re Group

Izmit/Turkey, Aug 17, 1999

Münchener Rück
Munich Re Group

Loss Assessment (Exercises)

Münchener Rück
Munich Re Group

Information required

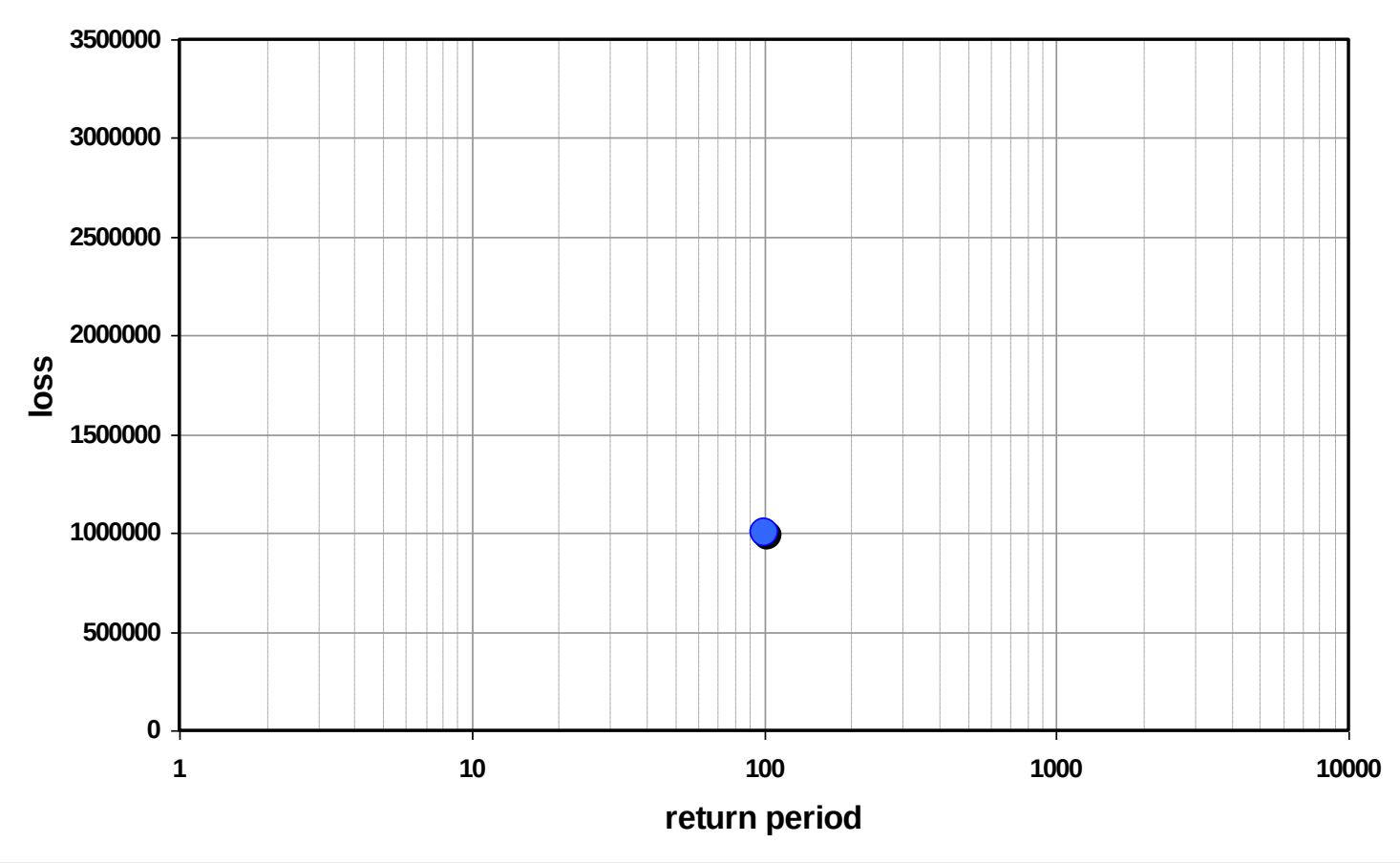
- Location of the risk
- Intensity levels for various return periods
- Type and quality of the risk to estimate the vulnerability
- Value of the risk
- Insurance conditions applied

Estimation of Insurance Rate

Münchener Rück
Munich Re Group

sum of premiums = **sum of loss**

(over a certain time) (over a certain time)

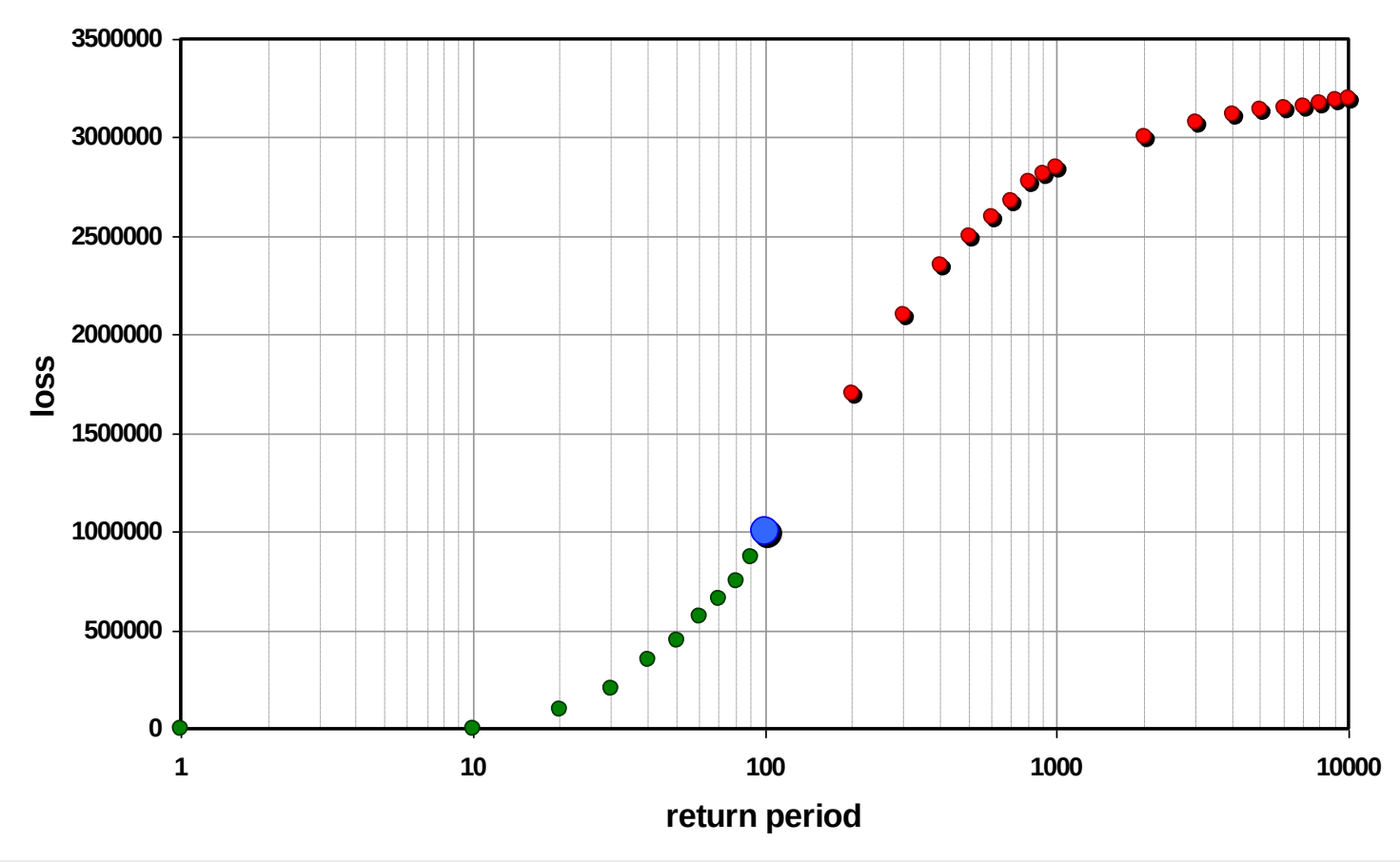


Estimation of Insurance Rate

Münchener Rück
Munich Re Group

sum of premiums = **sum of loss**

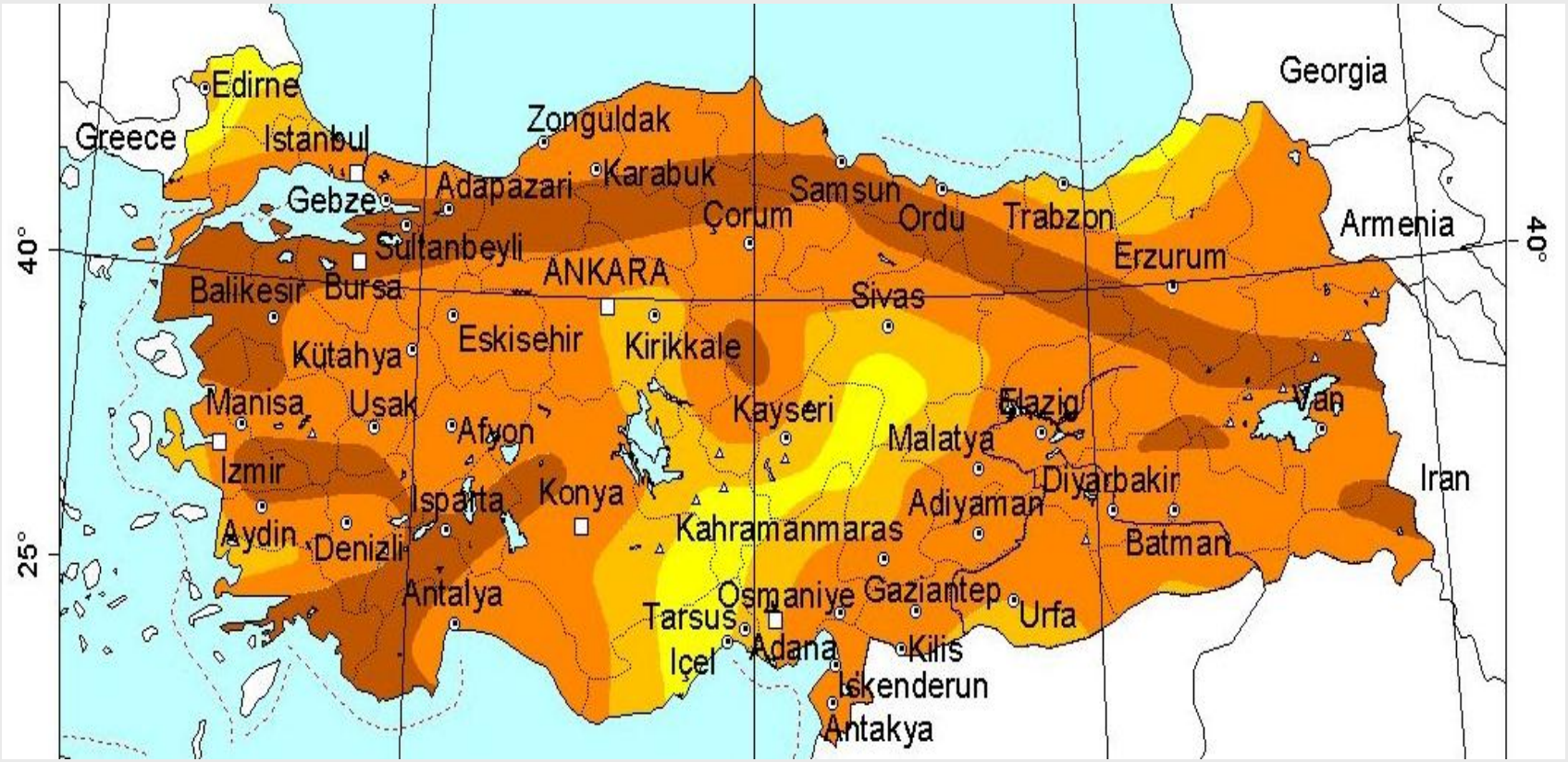
(over a certain time) (over a certain time)



Hazard Maps

Münchener Rück
Munich Re Group

As a rule of Thumb (only for earthquakes):
If the return period for one Intensity is known, a factor of 3-4 can be used to assess the return period for other Intensities



Rate Calculation

Münchener Rück
Munich Re Group

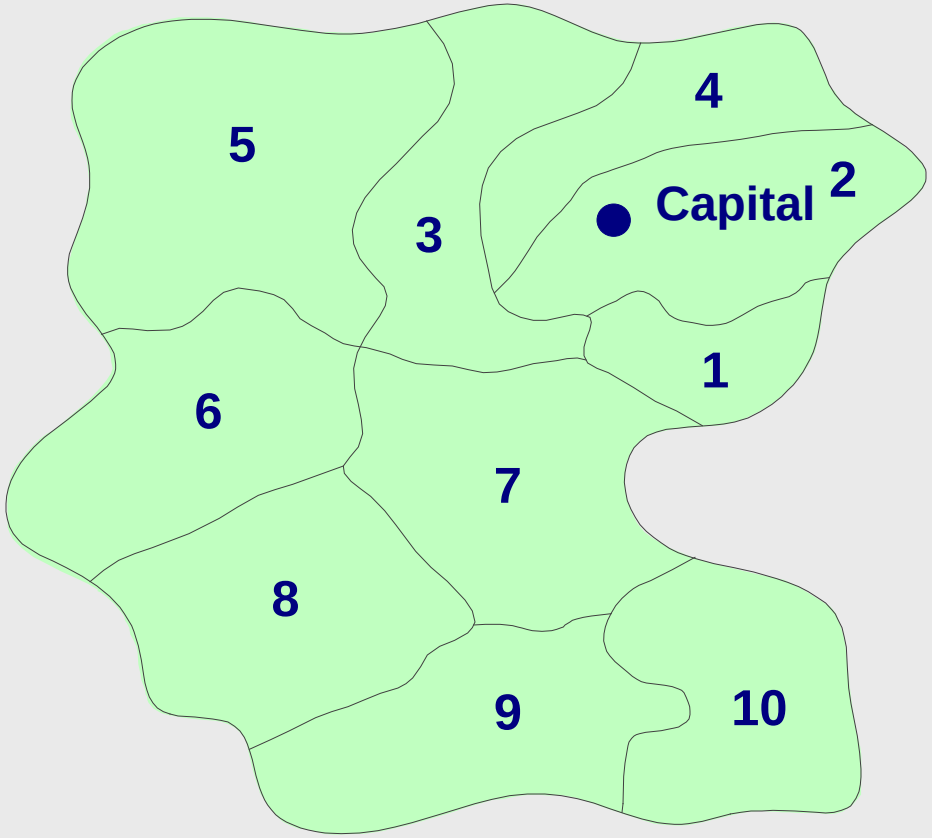
Rate (%) = 1/Return Period(1) * Loss%(1) + 1/Return Period(2) * Loss%(2)
... + 1/Return Period(n) * Loss%(n)

Information required

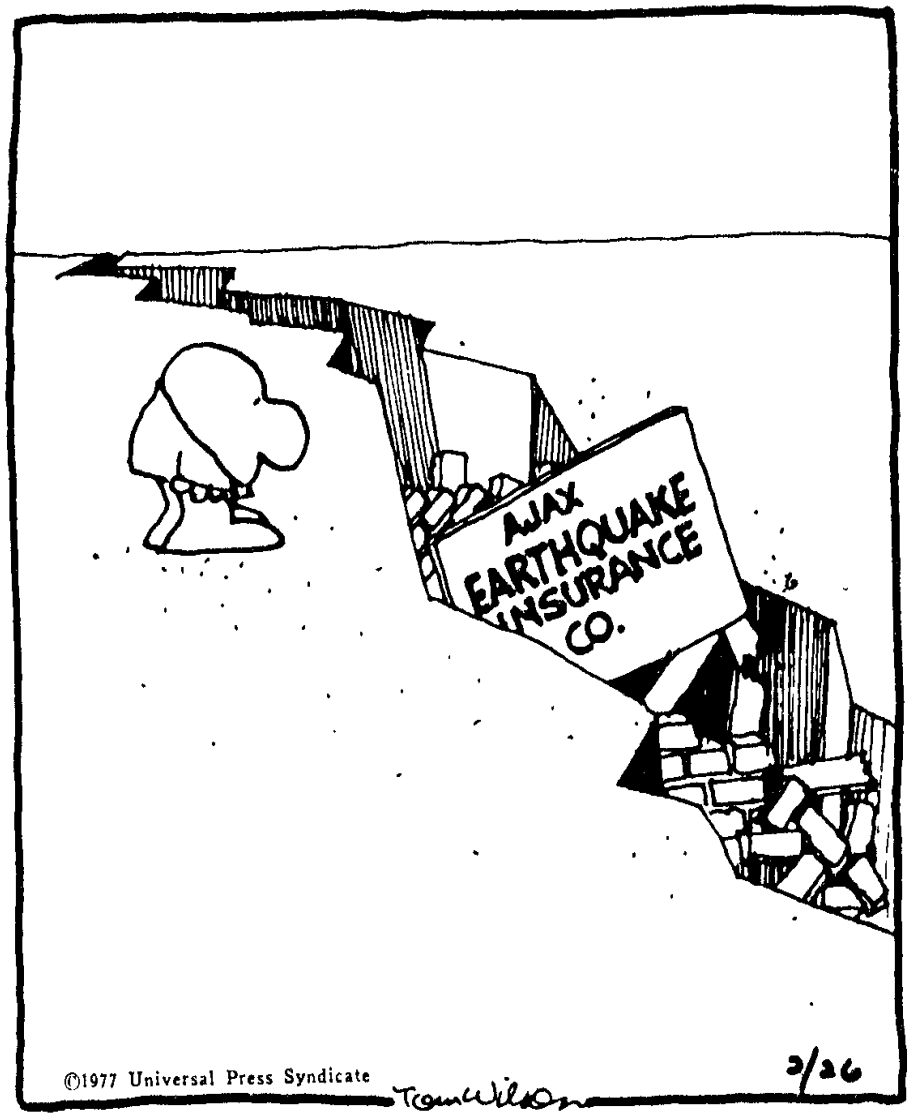
- Geographical distribution of the liabilities (Accumulation assessment zones)
- Risk classes (residential, commercial, industrial)
- Insured interests (building, contents, lop)
- Intensity field of the EQ-scenario
- Vulnerabilities
- Values
- Deductibles applied

Accumulation assessment zones

Example



Definition of zones by either geographical regions or provinces or districts or postal codes



Thank you for your attention!

Dr. Dirk Hollnack
Geophysical/Geological Risks
Geo Risks Research Dept.