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Third Workshop on 3D Modelling of Seismic Waves Generation Propagation and their Inversion

4 - 15 November 1996

Seismic Risk in Intraplate Areas

II

Hazard, Risk and Policies

H. Bungum

NORSAR, Norway

Seismic Risk in Intraplate Areas

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Hazard, Risk and Policies

by

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NORSAR, Norway

Seismic Risk

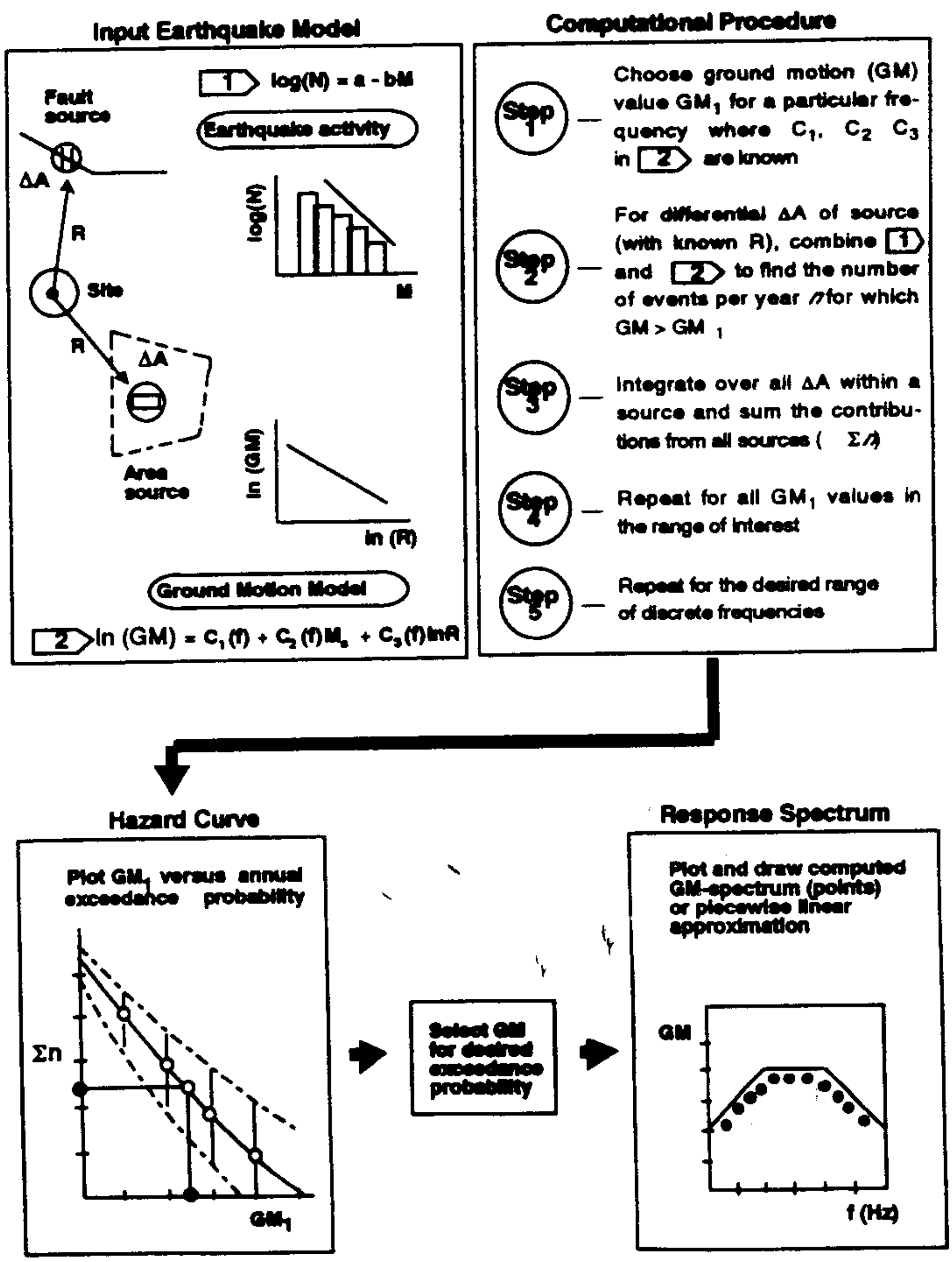
Risk = Hazard x Vulnerability

where

- **Hazard is connected to the probability for some ground motion from earthquakes**

- **Vulnerability reflects the degree of exposure to the seismic hazards**

Probabilistic method



Methods: Pros and Cons

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Deterministic Analysis

Pro: Simple, tracable

Con: Uncertainties are not removed
by ignoring them

Probabilistic Analysis

Pro: Uses more information and accounts
for uncertainties

Con: Complicated to use and to trace,
often unstable

Sources of Uncertainties

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1. Source Effects

* Spatio-temporal distributions as well as source models and their scaling relations and rupture characteristics.

2. Path Effects

* Strong motion attenuation models. For Norway, spectral attenuation models have been developed based on a combination of data from local low- and medium sized events, semi-theoretical methods (stochastic predictions), and strong motion data and models borrowed from tectonicallt comparable regions.

3. Site Effects

* Often covered through special geotechnical analysis based on detailed site information and an estimate of the expected ground motion at 'bedrock outcrop' level

1. Randomness (aliatory)

Covers random occurrences in nature that we cannot expect to predict (reduce) with additional data and better models

* Magnitude and location of the next earthquake on a fault
* Ground motion characteristics resulting from details of the fault rupture process

The seismic hazard curve is produces by integrating over these random occurrences

2. Uncertainty (epistemic)

Describes lack of knowledge about appropriate models or parameters used in characterizing natural phenomena (random occurrences)

* Magnitude distributions and their parameters
* Mean strong motion attenuation relations
* Maximum magnitude

These uncertainties can in principle be reduced and are handled by producing multiple hazard curves

Logic Tree Approach

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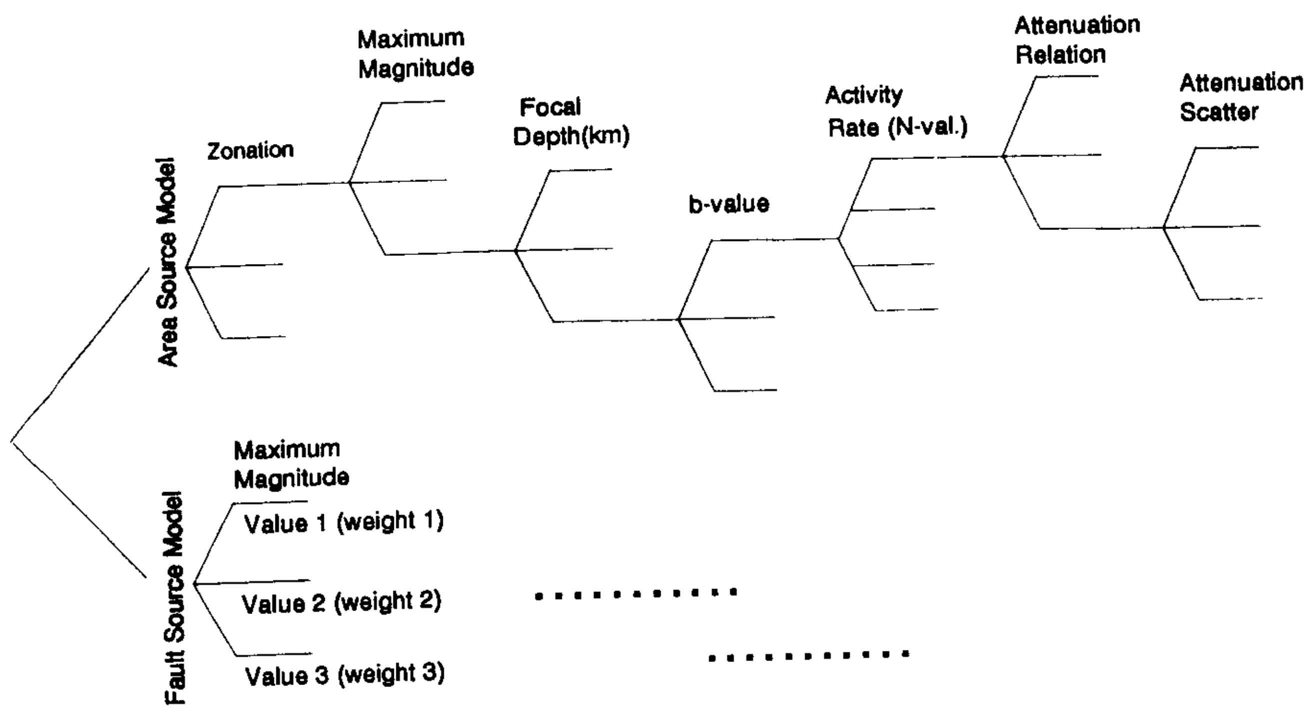


Quantifying Uncertainties:

* Judgements and documentation must be justified scientifically

* diversity among experts must be resolved if caused by misunderstandings

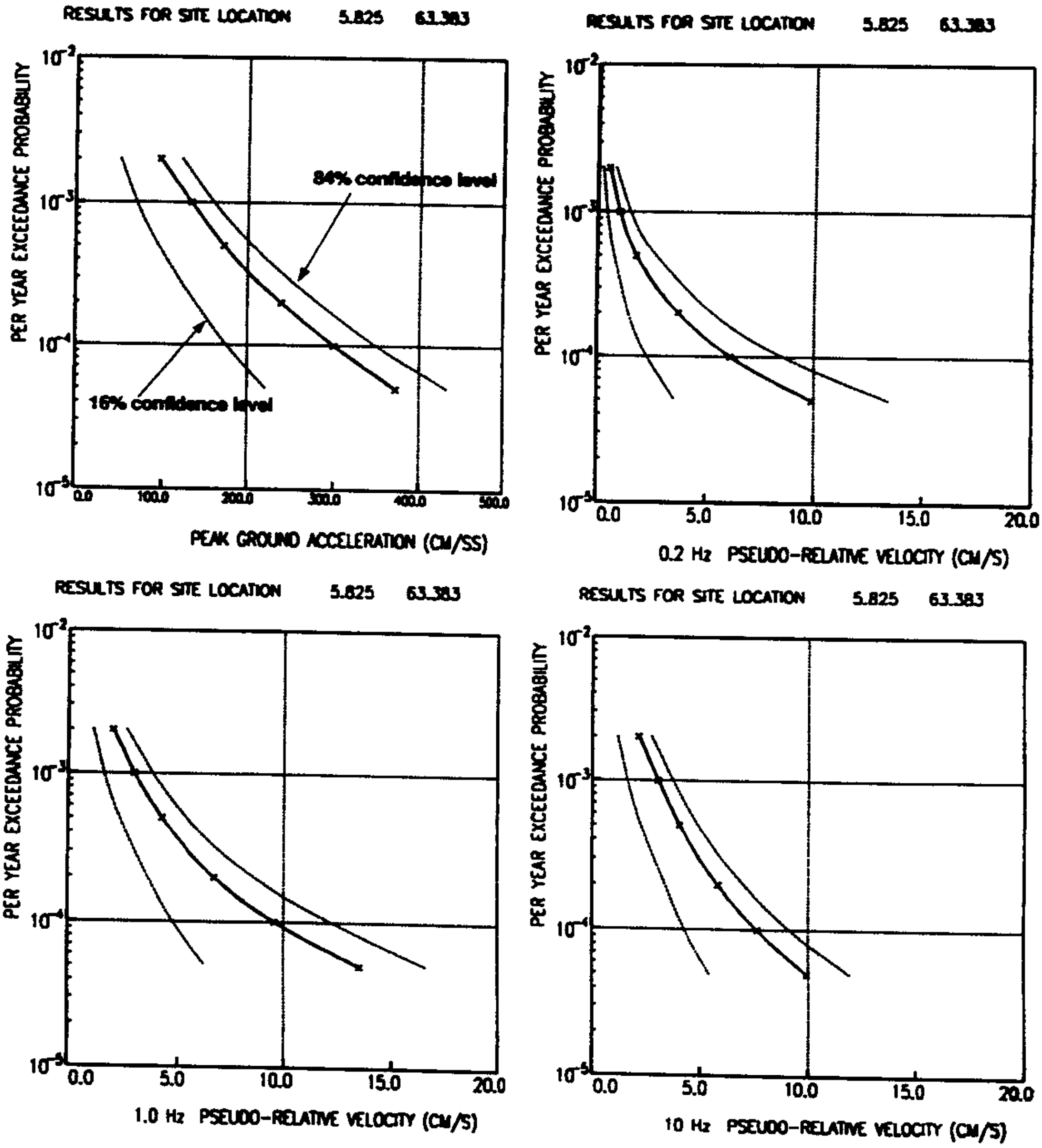
* the earth scientists themselves must take part in developing the procedures for quantifying and documenting expert opinions

Also:

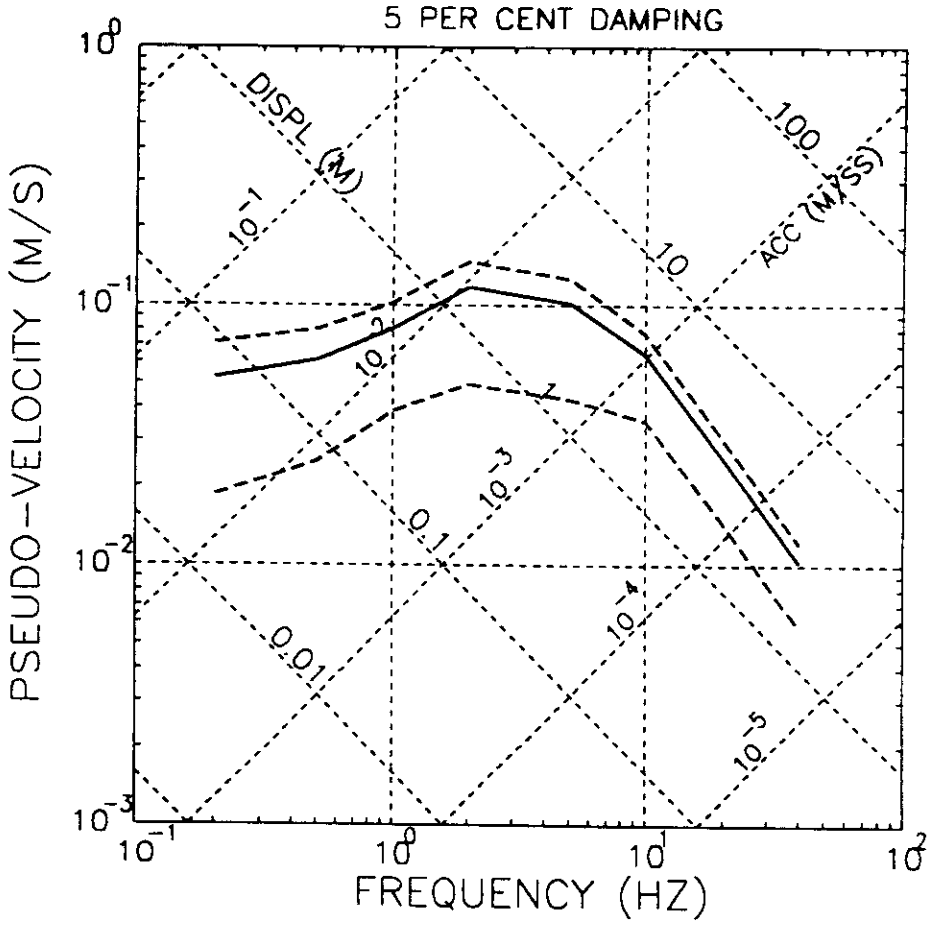
* defendability of methodology and results is essential

* use of expert teams is not neccessary but it may be desirable

Hazard Curves - Uncertainties NORSAR



Design Spectra - Uncertainties



Earthquakes 1965-1995, M>3

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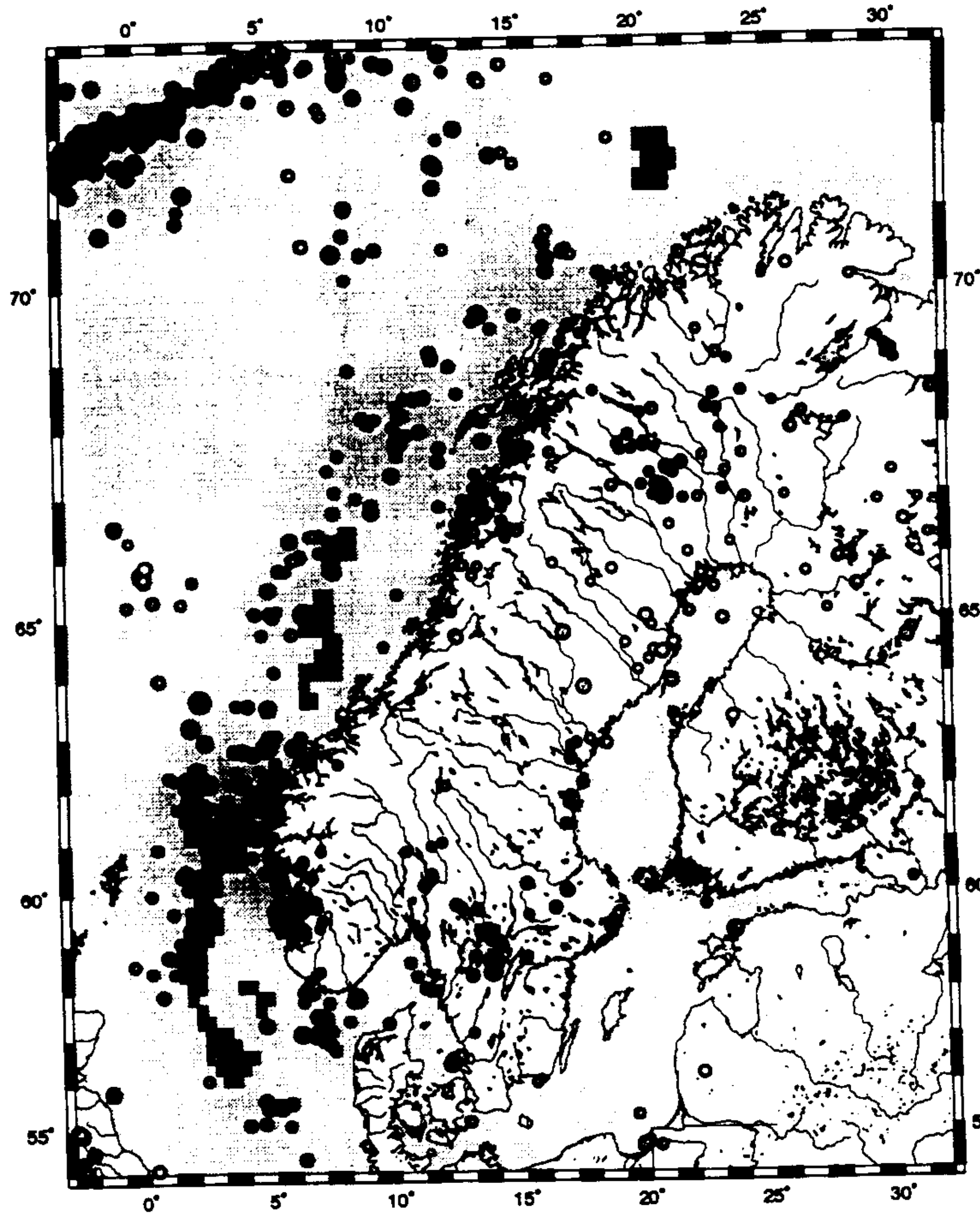

Logic Tree Model

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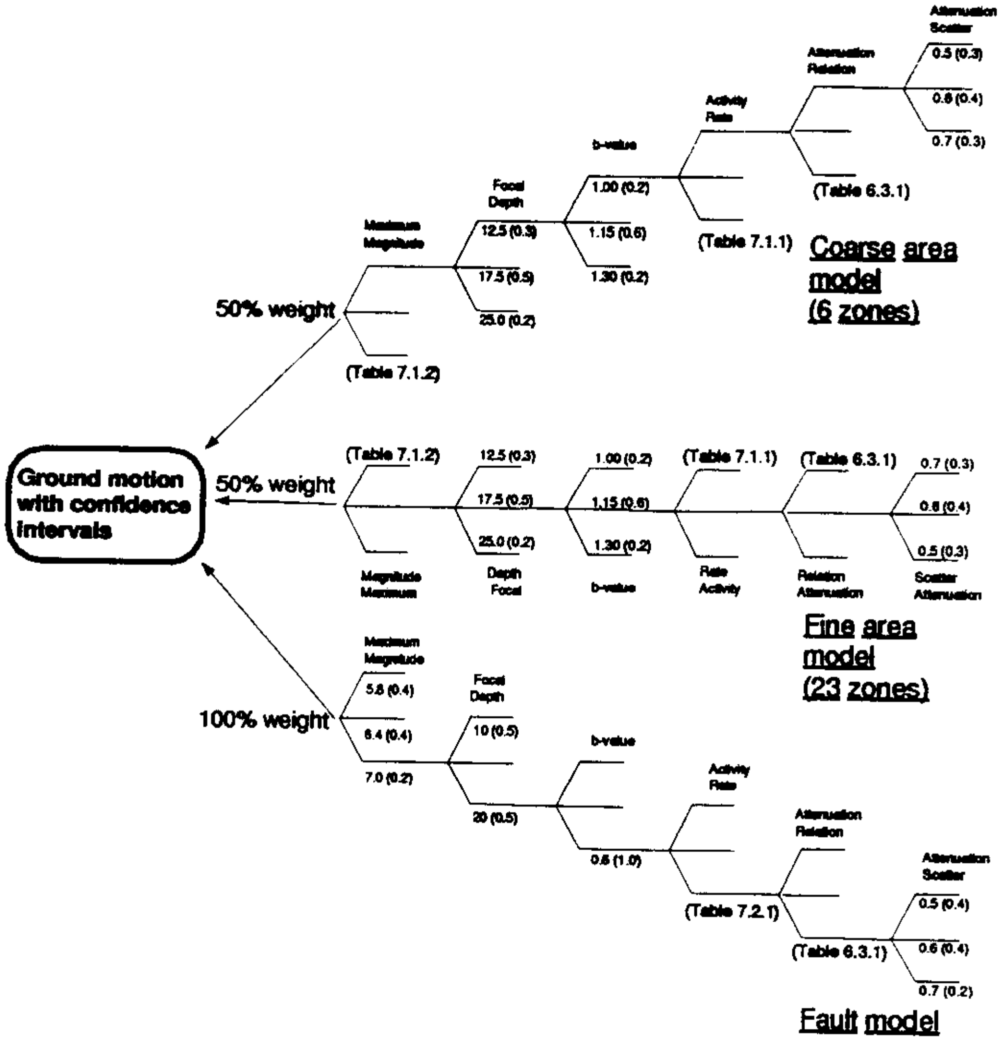

Earthquake Occurrence Models NORSAR

Conventional Approach

* Regions (area zones) with some well defined (not necessarily log-linear) magnitude- frequency distribution, with a lower bound and a maximum magnitude (could also include so called 'characteristic' models).

Alternative Approach

* Independent distributions and source zonations for small/ intermediate and larger earthquakes, reflecting the larger uncertainties for the latter ones both in terms of location and return time.

* Global studies shows for example that passive margins and abandoned rifts are intraplate regions with higher occurrence probabilities but very long return times, and local catalogs may not be very useful in defining occurrence models for these rare events.

* Will be considered in a new seismic zonation for Norway.

* Kernel Estimation Method (Woo)

Kernel Estimation Method

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Problems with area zones:

* The uniform seismicity assumption within each zone and the zone geometries and both in conflict with the fractal spatial distribution of seismicity.

* The zonation ignores the different spatial distributions and correlations of different-sized earthquakes.

Solution:

* Statistically based kernel estimation of the activity rate density inferred from the regional catalog.

* The form of kernel is goverened by the concepts of fractal geometry and self-organized criticality, with the bandwith scaling according to magnitude.

* The kernel estimation methodology makes provisions for moderate earthquakes to cluster spatially, while larger earth-quakes may migrate over sizeable distances.

(Gordon Woo: BSSA, 86, 353-362)

Øygarden Seismicity

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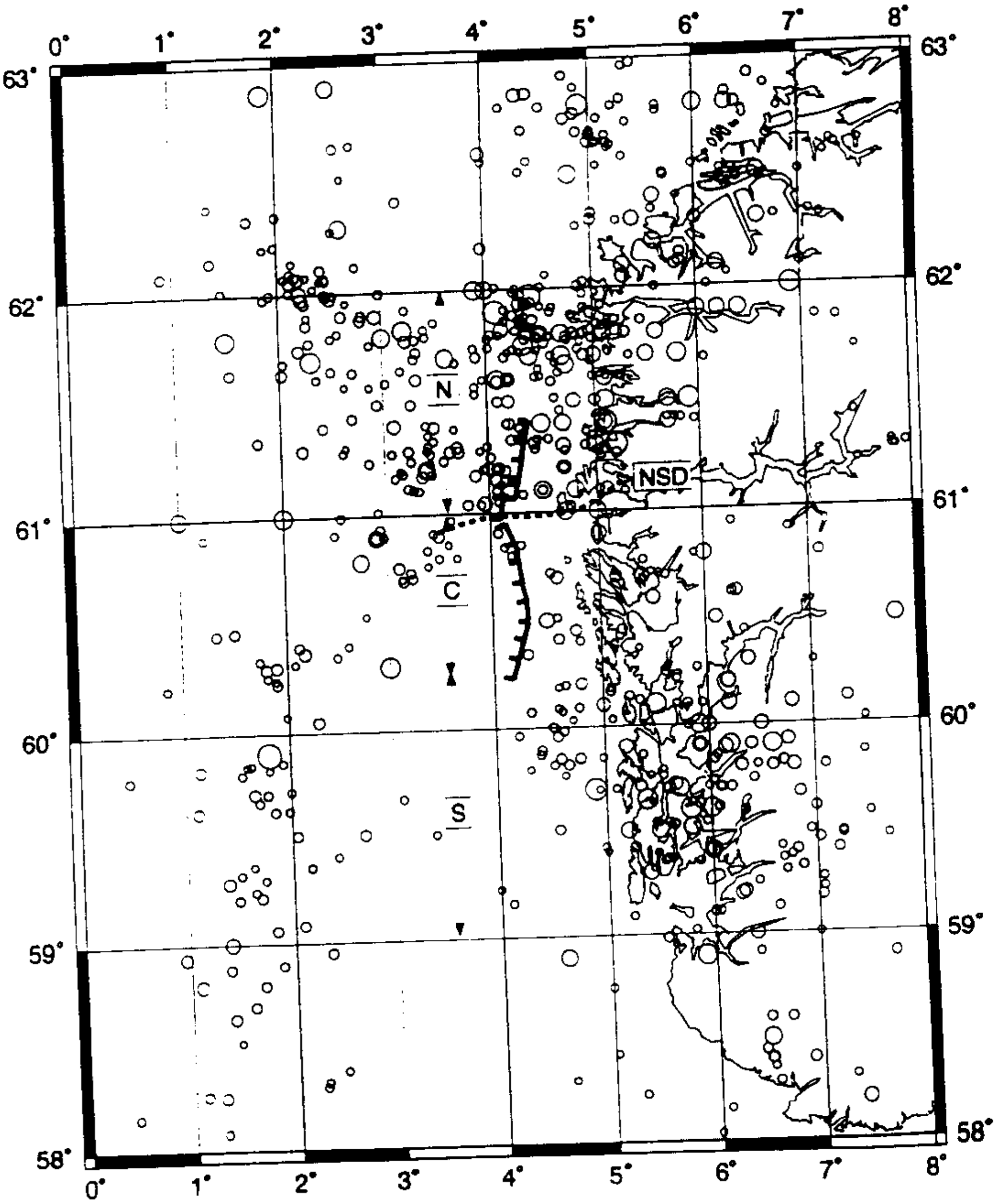
Ms > 2.5



Results

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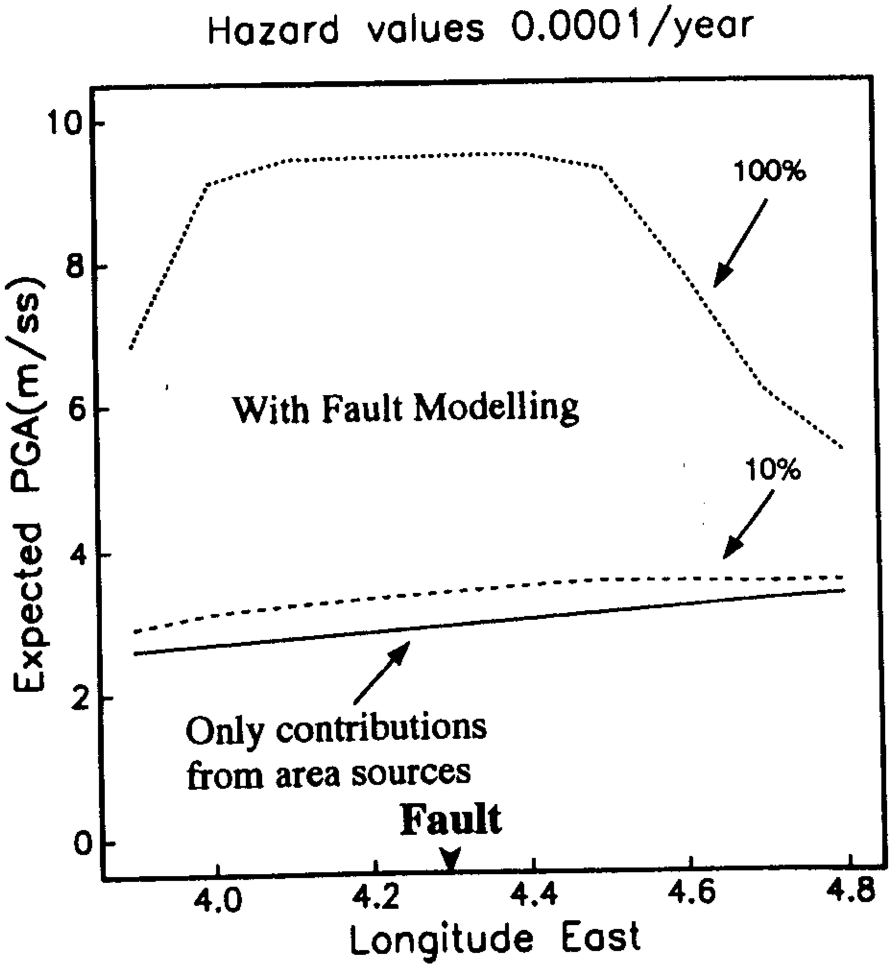

Design Spectra, 100 yrs

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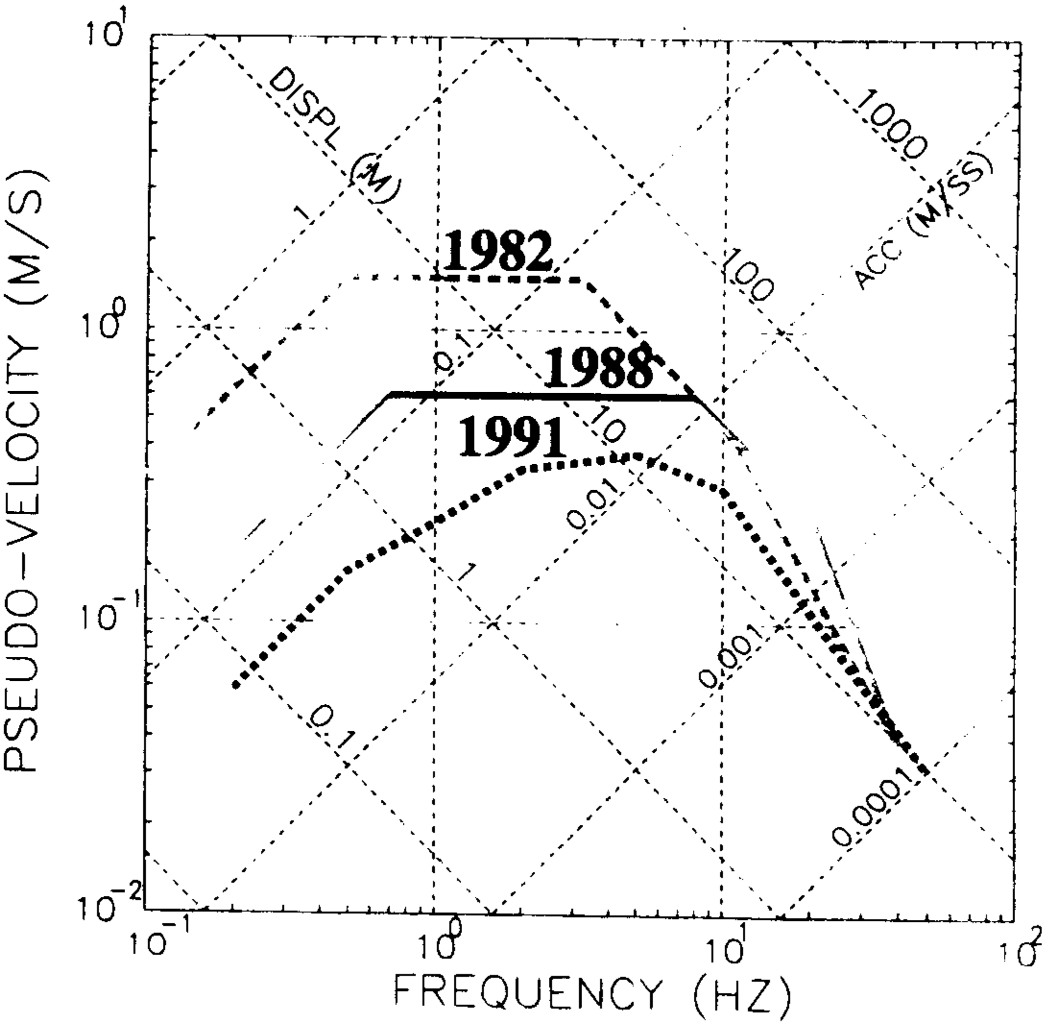
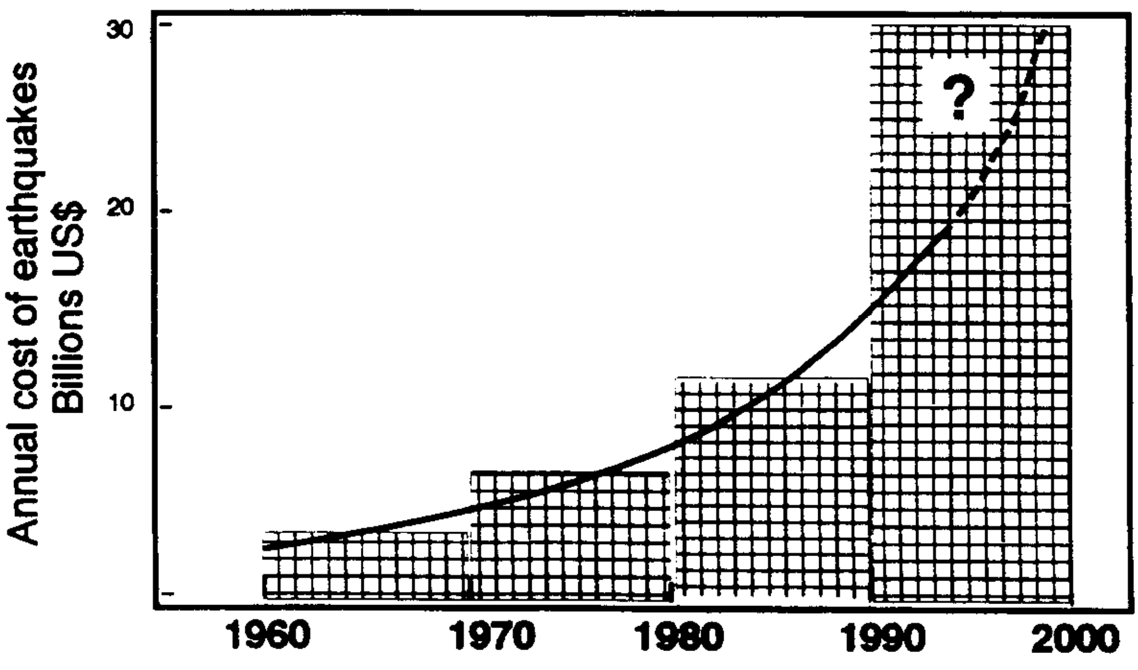


Economic loss



Why is vulnerability increasing?

- Increase in building density and infrastructure
- Inappropriate use of traditional building techniques
- Precautionary measures weakly implemented and enforced
- Inadequate public education

However:

- International programmes are not enough

- Strong national programs are also needed:

  - Political support essential
  - Implementation also on regional and local levels
  - Discussion of acceptable risk
  - Balanced use of resources

Earthquake hazard mitigation advances:

- Improved monitoring and understanding of earthquake processes
- Improved integration of geological and seismological data
- Increased awareness and understanding of secondary effects
- Improved building codes and land use regulations
- Better public preparedness

Future directions to go:

- **Improved earthquake resistant design and construction; retrofitting**
- **Closer interaction between disciplines**
- **Better communication between specialists, political authorities, and the public**

- **A large array of measures should be implemented at different levels**

- **Political committment needed**

- **Efficient measures are not always expensive**

- **Large future earthquakes are inevitable, but large earthquake disasters are not!**

- **<u>Knowledge is not the main limiting factor!</u>**

NAD classification

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CATEGORY	STRUCTURES	IMPORTANCE FACTOR	RET PERIOD (YEARS)
I OR STRICTER	NUCLEAR REACTORS, STORAGE FOR RADIOACTIVE WASTE, DAMS, ONSHORE OIL AND GAS FACILITIES		MORE TH 2,000
I	HOSPITALS, FIRE STATIONS, POWER PLANTS, WATER SUPPLY, ESPECIALLY LARGE BRIDGES	1.8	2,000
II	RAILWAY AND ROAD BRIDGES, TOWERS, CHIMNEYS, MASTS, TANKS, SILOS, HARBOURS, CRANES, MAIN LIFELINES, BUILDINGS AND STRUCTURES FOR LARGE NUMBER OF PEOPLE	1.4	1,000
III	HOUSES UP TO TWO STORIES, QUAYS, AGRICULTURAL STRUCTURES, FISHERY HARBOURS, LOCAL LIFELINES, EXCAVATIONS AND EMBANKMENTS	1.0	475
IV	ONE STOREY STOREHOUSES, SMALL GARAGES, BOATHOUSES, FOUNDATIONS	0.7	200

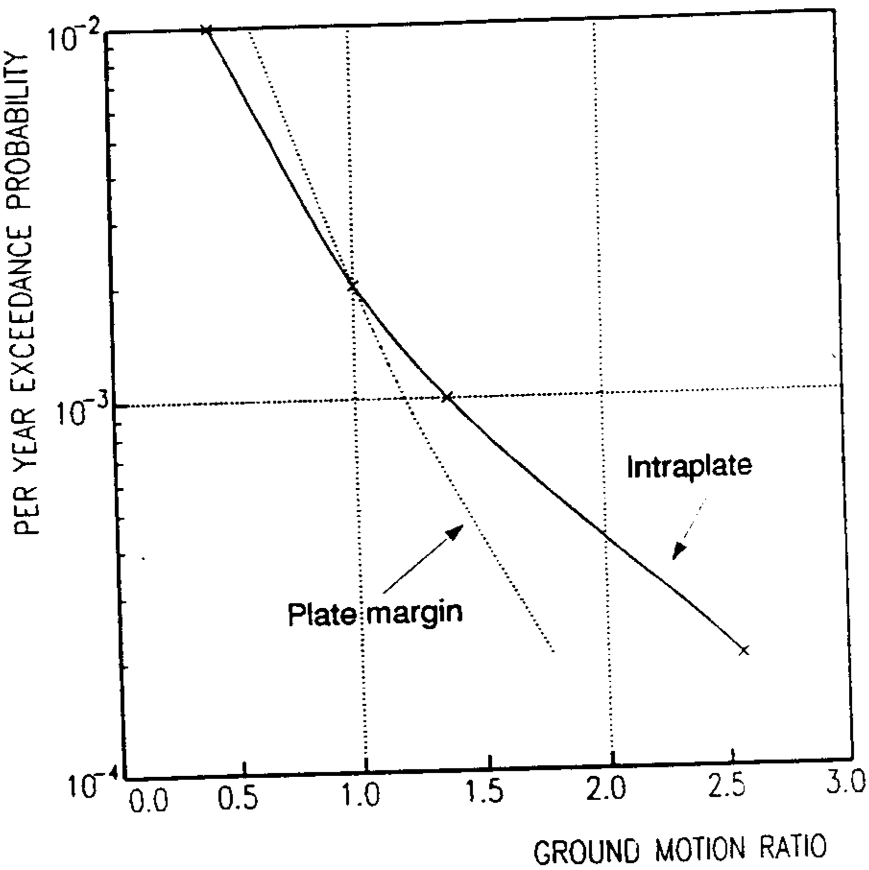

Figure 1. Average ground motion ratios as taken from the last row in Table 1, plotted against annual exceedance probability (inverse of return period) for intraplate (Norway) and plate margin (southern Europe) areas, respectively.