Quantification of Earthquake Risk and Application for Insurance Portfolio Management

Shumpei Okada, Tokio Marine & Nichido Fire Insurance Co., Ltd.
Yoshiaki Ogane, Tokio Marine & Nichido Risk Consulting Co., Ltd.

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   - Aggregation

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1. Risk Quantification in Insurance Business

2. Risk Quantification Methods
   - Natural Catastrophes (Example: Earthquake)
   - Other Risks
   - Aggregation

3. Issues to Be Solved

Quick Summary of TMNF

- Established: 1879
- Net Premium Written: JPY 1,904 Bil
  / USD 18.49 Bil
- Market Share: 24.89%
- Assets: JPY 9,077 Bil
  / USD 88.13 Bil
- Rating Information:
  S&P AA-
  A.M. Best A++
  Moody's Aa2

The above figures are the total of Tokio Marine and Nichido Fire as of and for the fiscal year ended March 31, 2004

Quick Summary of TMNF

- Always leads industry in employing new technologies
  - Financial
    - Asset liability management
    - Risk based pricing for corporate loans and other credit products
    - Value at Risk/Credit VaR
  - Product Development/Management
    - Insurance-risk linked derivatives (Weather, Typhoon, EQ, etc.)
    - Quantified pricing/management of natural catastrophic risks
    - First issue of catastrophic bond in Japan
    - Re-insurance/retention management based on DFA
  - Corporate
    - Operational risk quantification
    - Capital management based on enterprise-wide risk evaluation

Risk Exposures

- Underwriting
- Financial

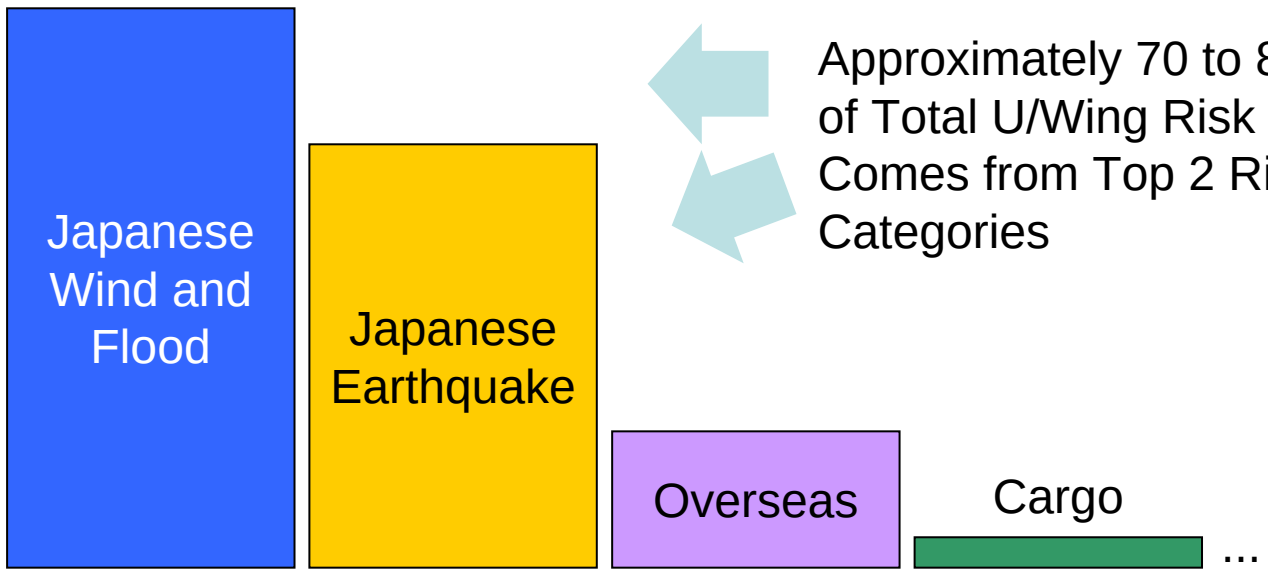
Core Business Risks
= Intended Sources of Return

- Operational
- Legal
- Liquidity
- Natural Disastrous
- Criminal
- Reputation
- System
- ...

Non-Core Risks
= No Return is Expected
by Taking These Risks

Within Underwriting Risks ...

- Japanese Wind/Flood and Japanese EQ, are major components of total underwriting risk
  - Most P&C insurance companies are in the similar shape, though may vary due to the re-insurance arrangements



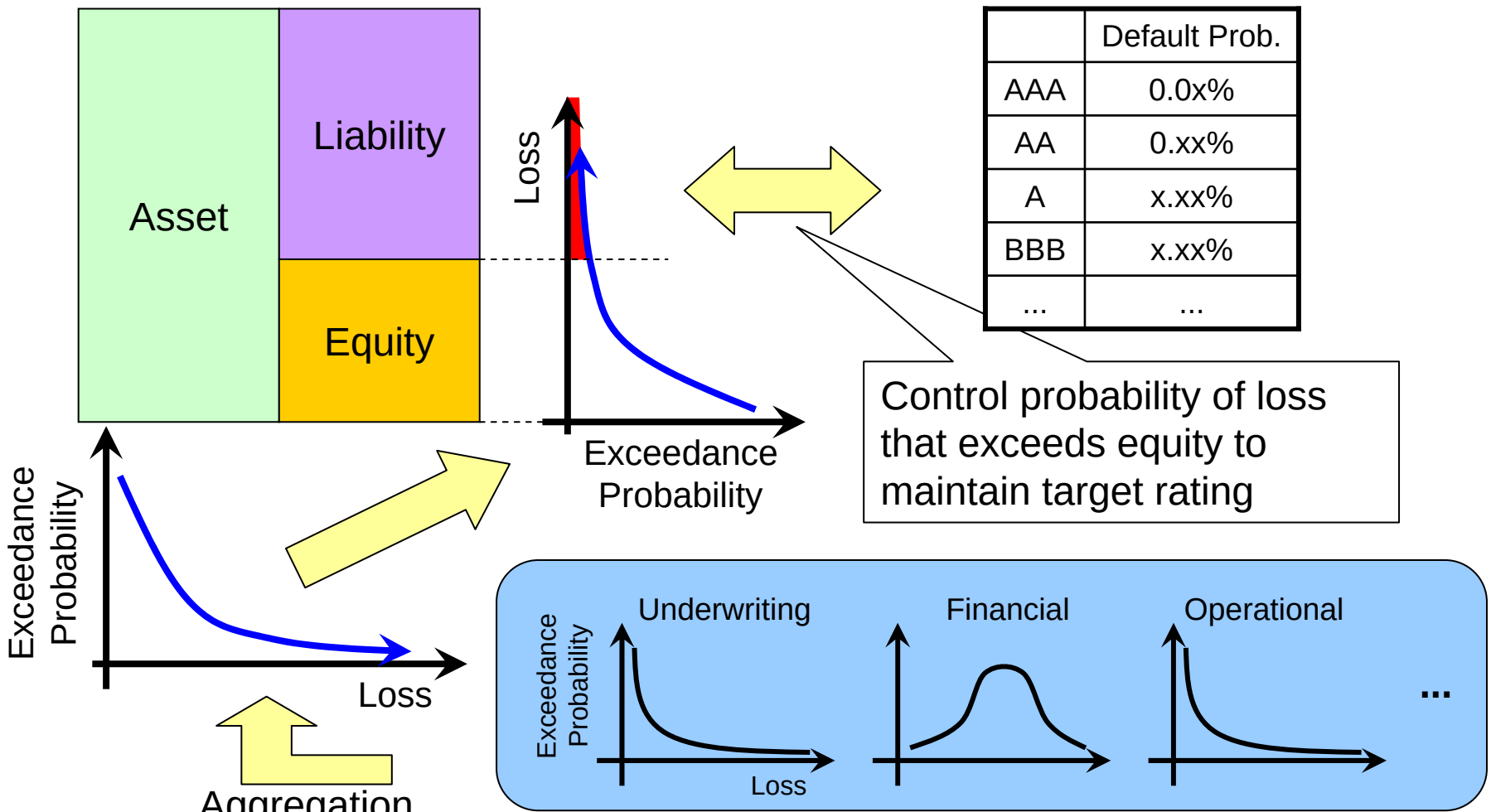
Management of Insurance Business

- Core business risks, together with non-core risks, have to be controlled so that the insurance company would not default
  - Equity plays as a buffer when a catastrophic risk realizes
  - Without sufficient equity, an insurance company cannot stay in the market

- Expected return on equity has to exceed the shareholders' requirement
  - On the contrary, excessive risk premium results in loss of deals/market share

Control of Total Risk

- Example: Balance Sheet Approach



Quantifying Underwriting Risks

- To manage risk portfolio appropriately, accurate estimation of risk is highly required
  - Pricing
  - Risk management/Re-insurance arrangement

- Two methods are available to quantify underwriting risks
  - For risks with high frequency, actuarial/mathematical approach can be applied
  - For low frequency risks, such as EQ or Typhoon, we employ engineering approach to estimate

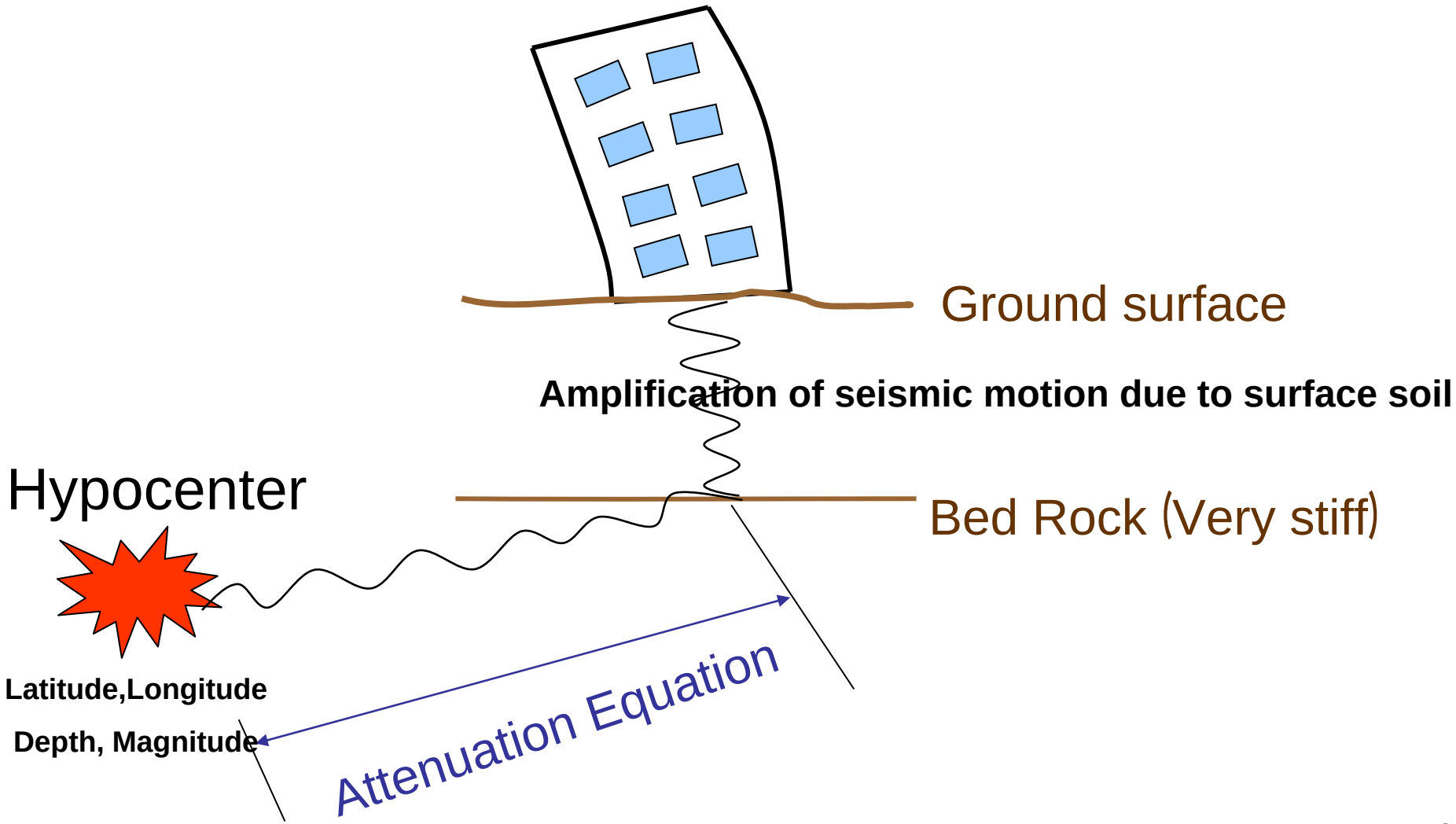
1. Risk Quantification in Insurance Business

2. Risk Quantification Methods

- **Natural Catastrophes (Example: Earthquake)**
- Other Risks
- Aggregation

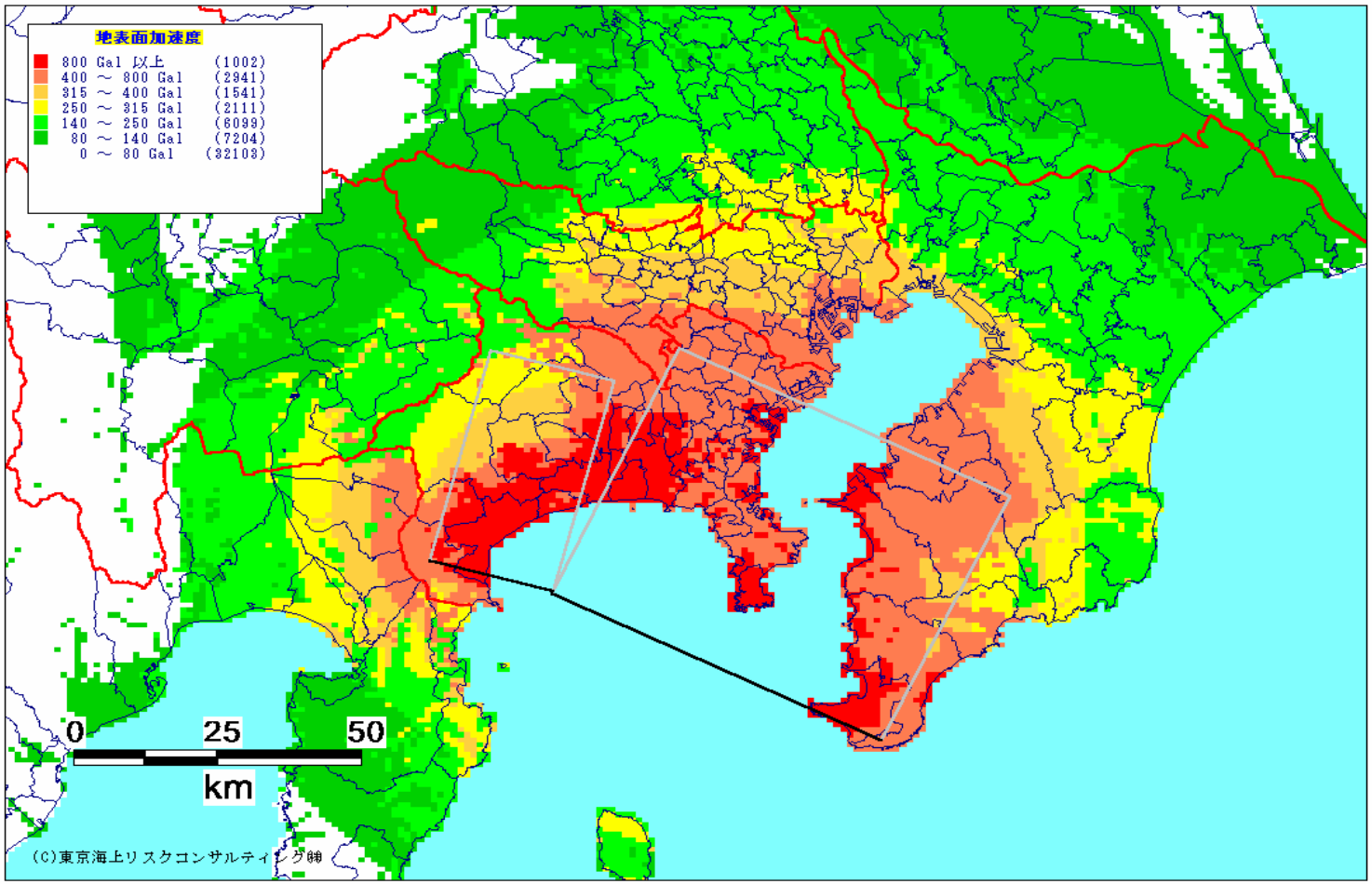
3. Issues to Be Solved

How the Seismic Motion Goes?



Distribution of Seismic Intensity

- Great Kanto Earthquake (M7.9, 1923)



Outline of Quantifying EQ Risk

Hazard Component

- Hypothetical EQ Generation
  (Lat, Lon, Depth, M)
- PGA Calculation

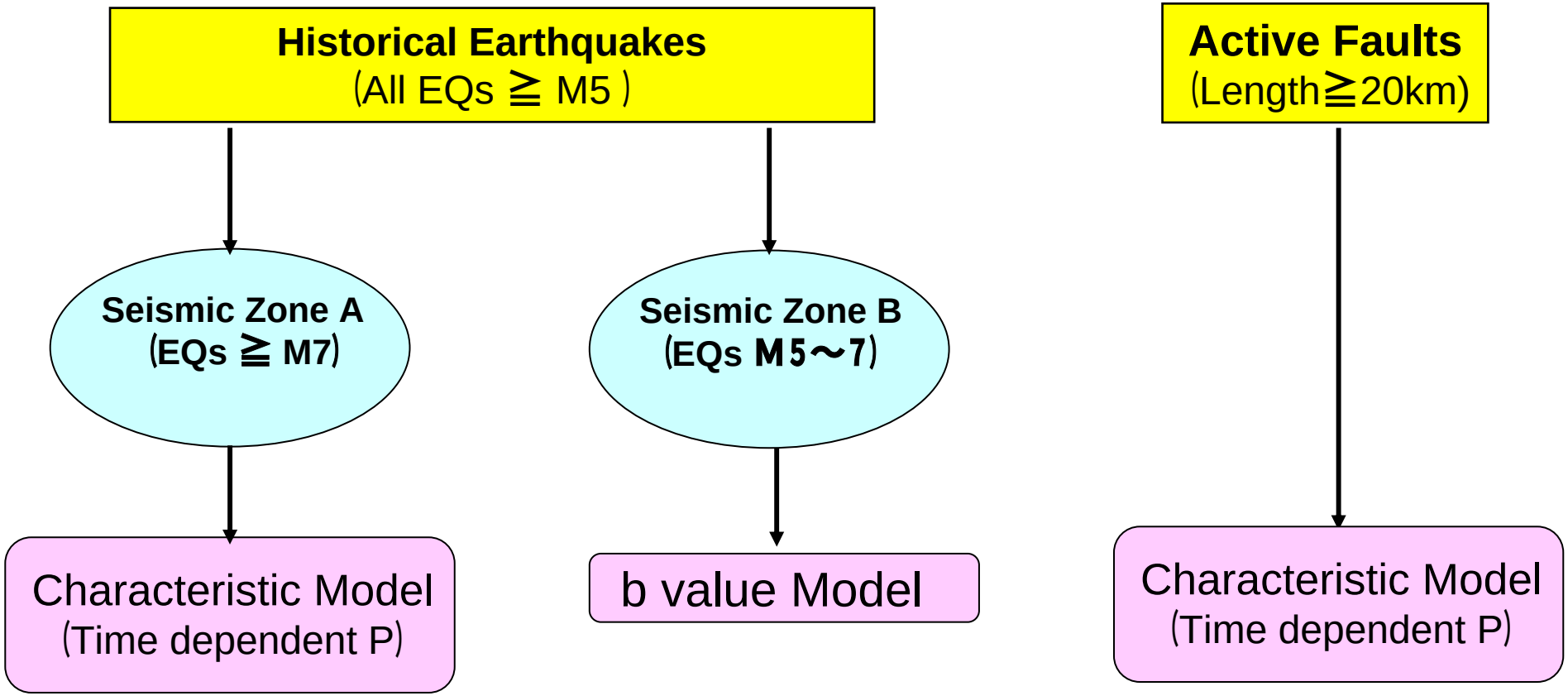
Damage and Loss Component

- Damage Functions
  (Damage Ratio vs PGA)
- Policy Conditions
- Loss Calculation

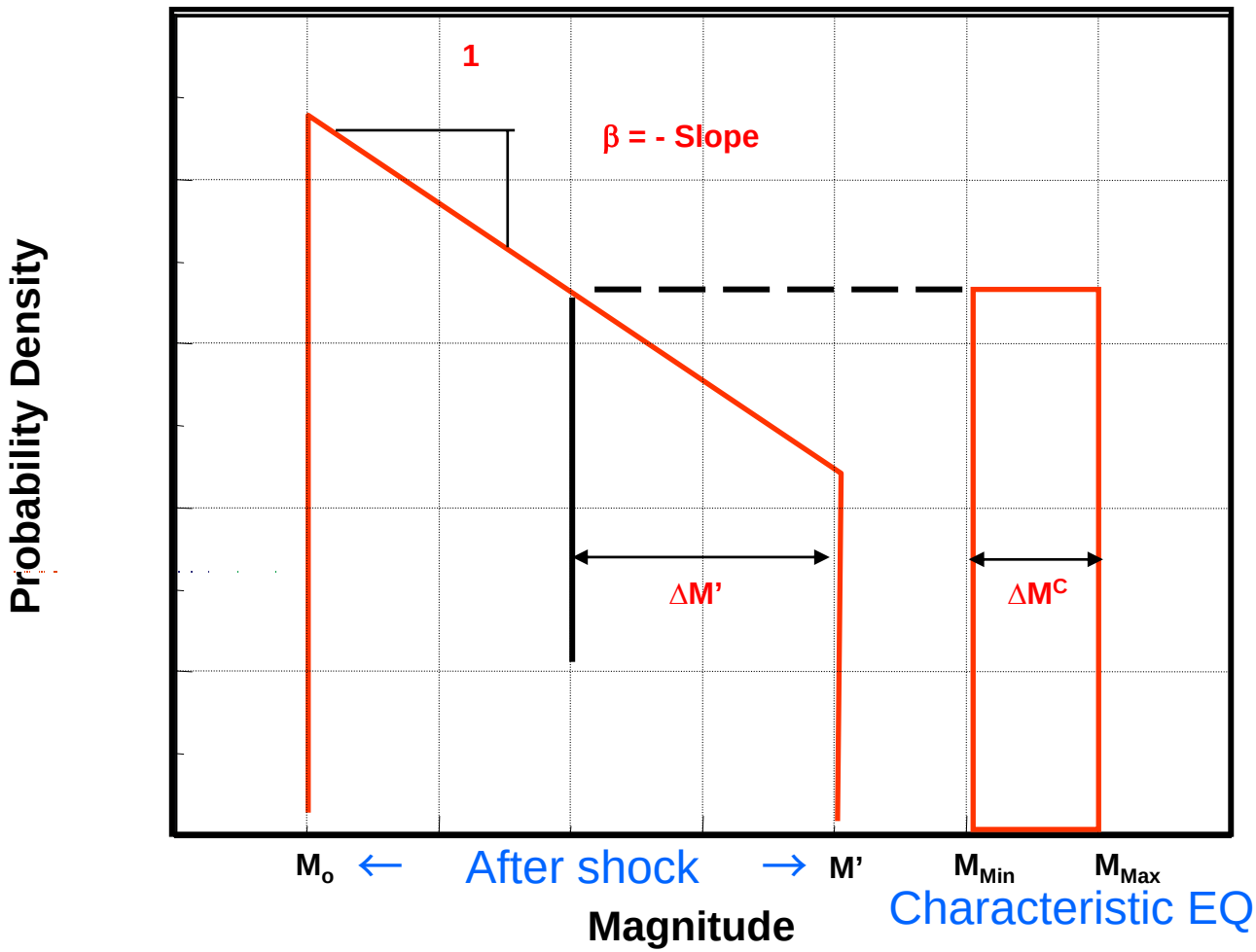
Seismic Risk Curve Drawing

Exceedance Probability / Estimated Loss

Seismic Zones

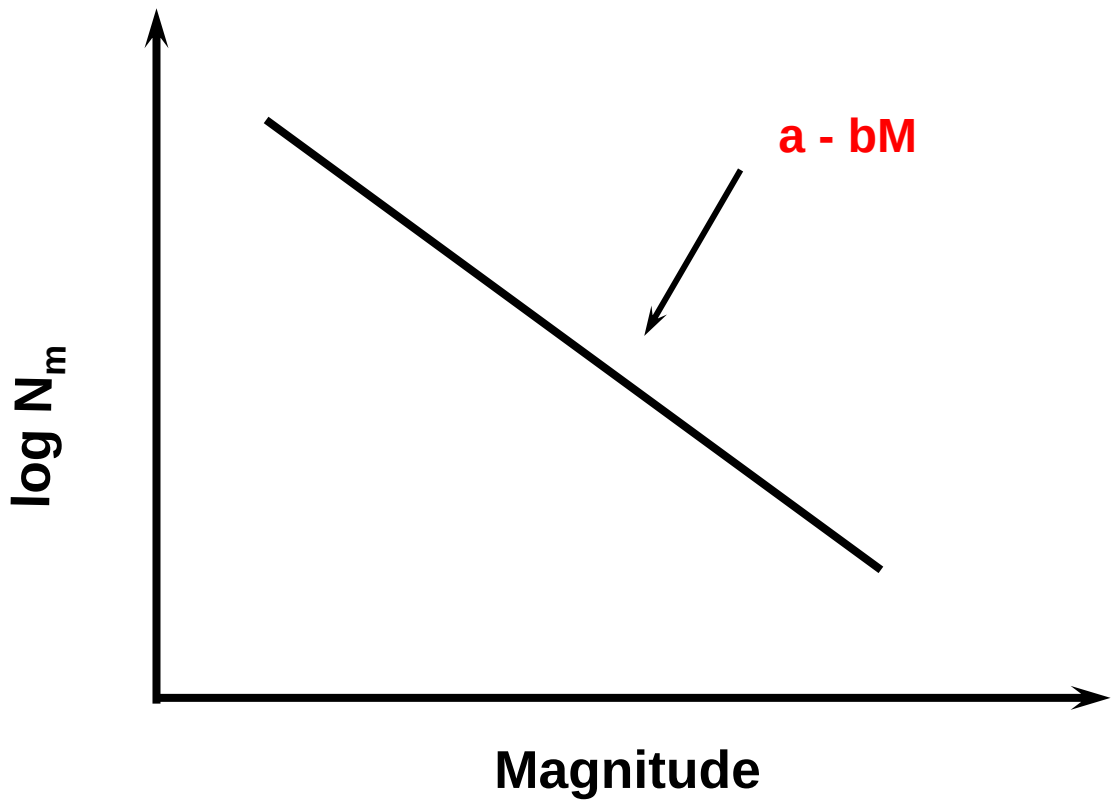


Characteristic EQ Model



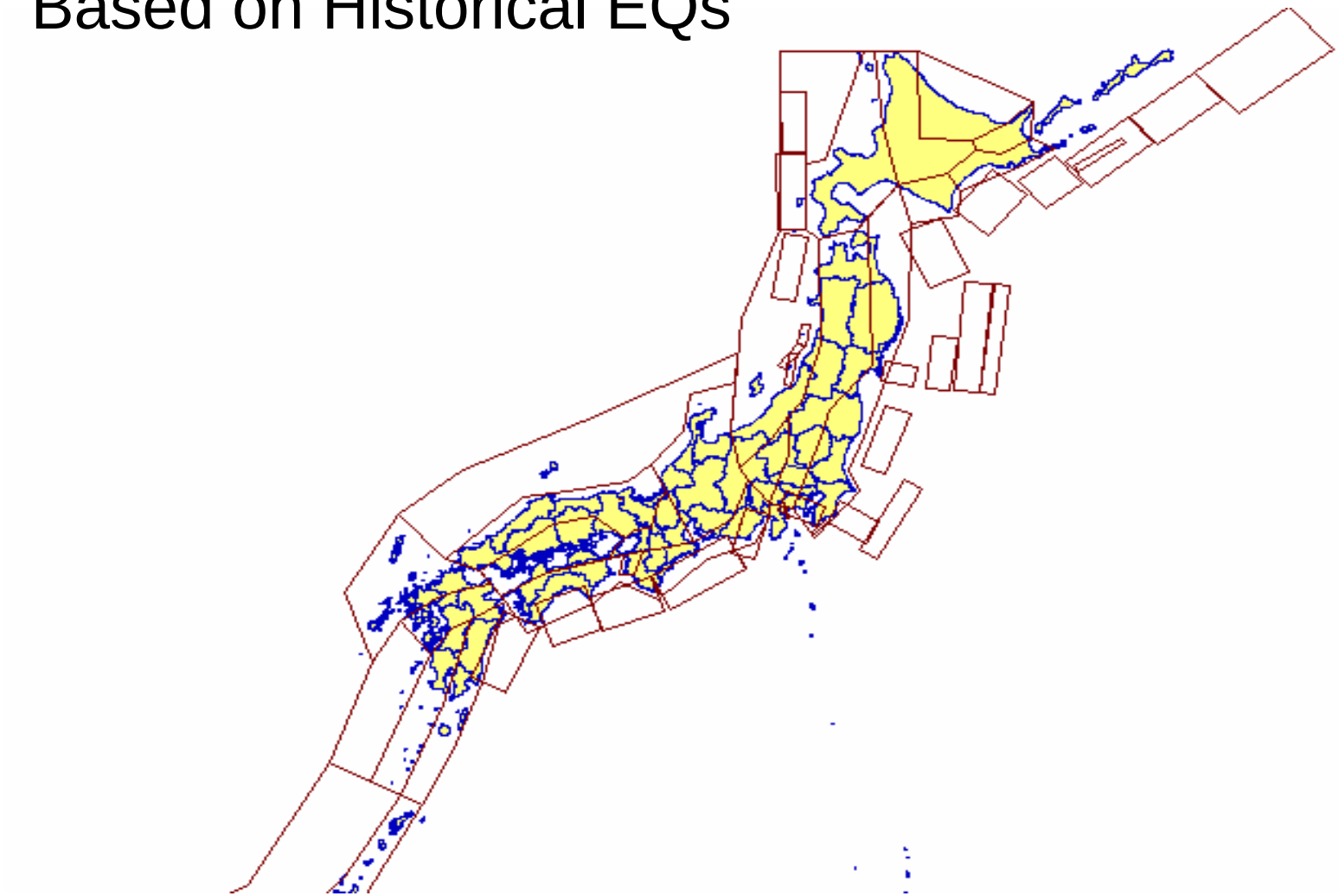
b-Value Model

- Gutenberg Richter Equation



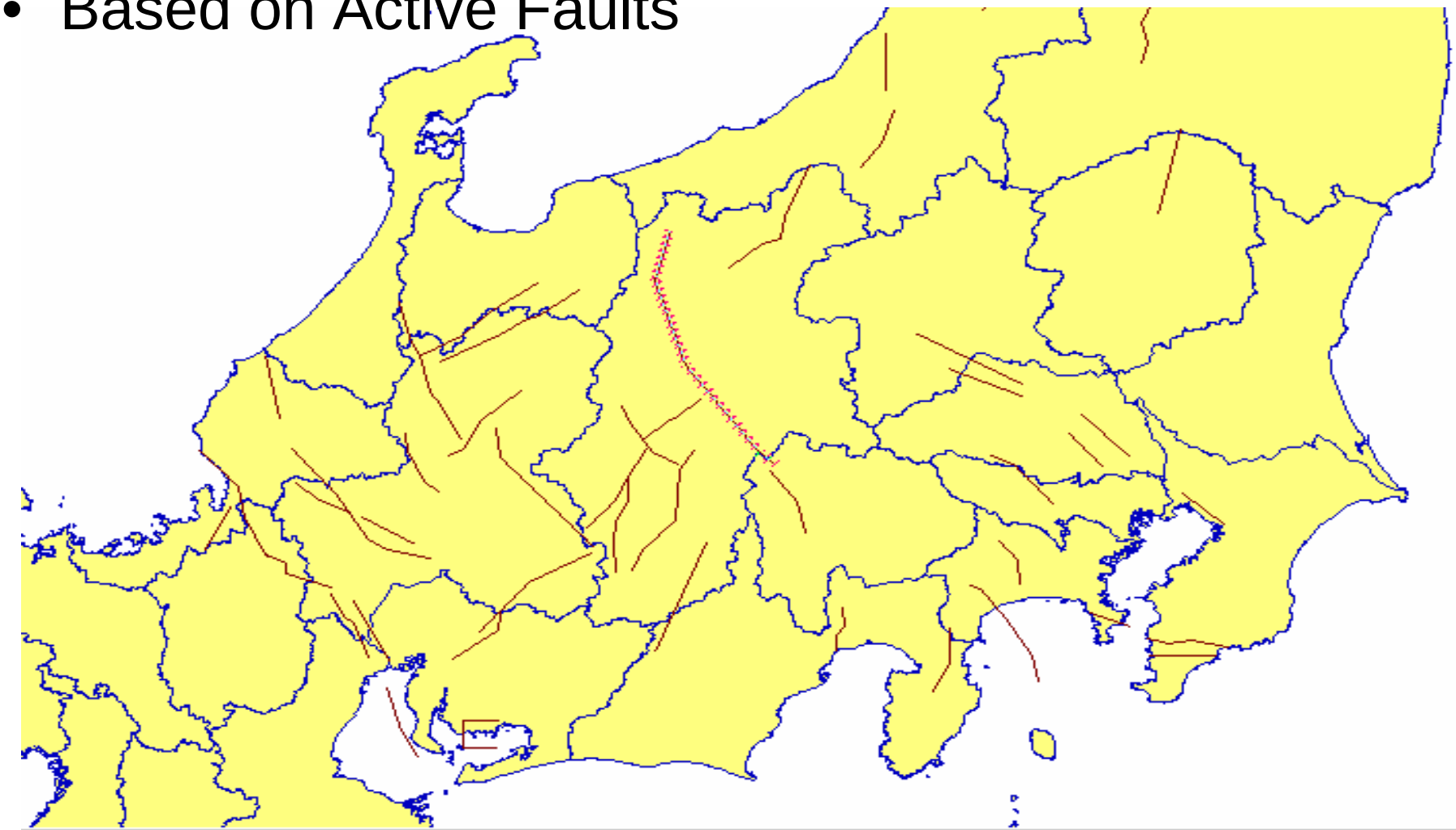
Seismic Zones

- Based on Historical EQs



Seismic Zones

- Based on Active Faults



Time Dependency (1/2)

- Great Kanto EQ (M7.9)

  Occurred in 1923

  Elapsed Time 82 Years as of 2005

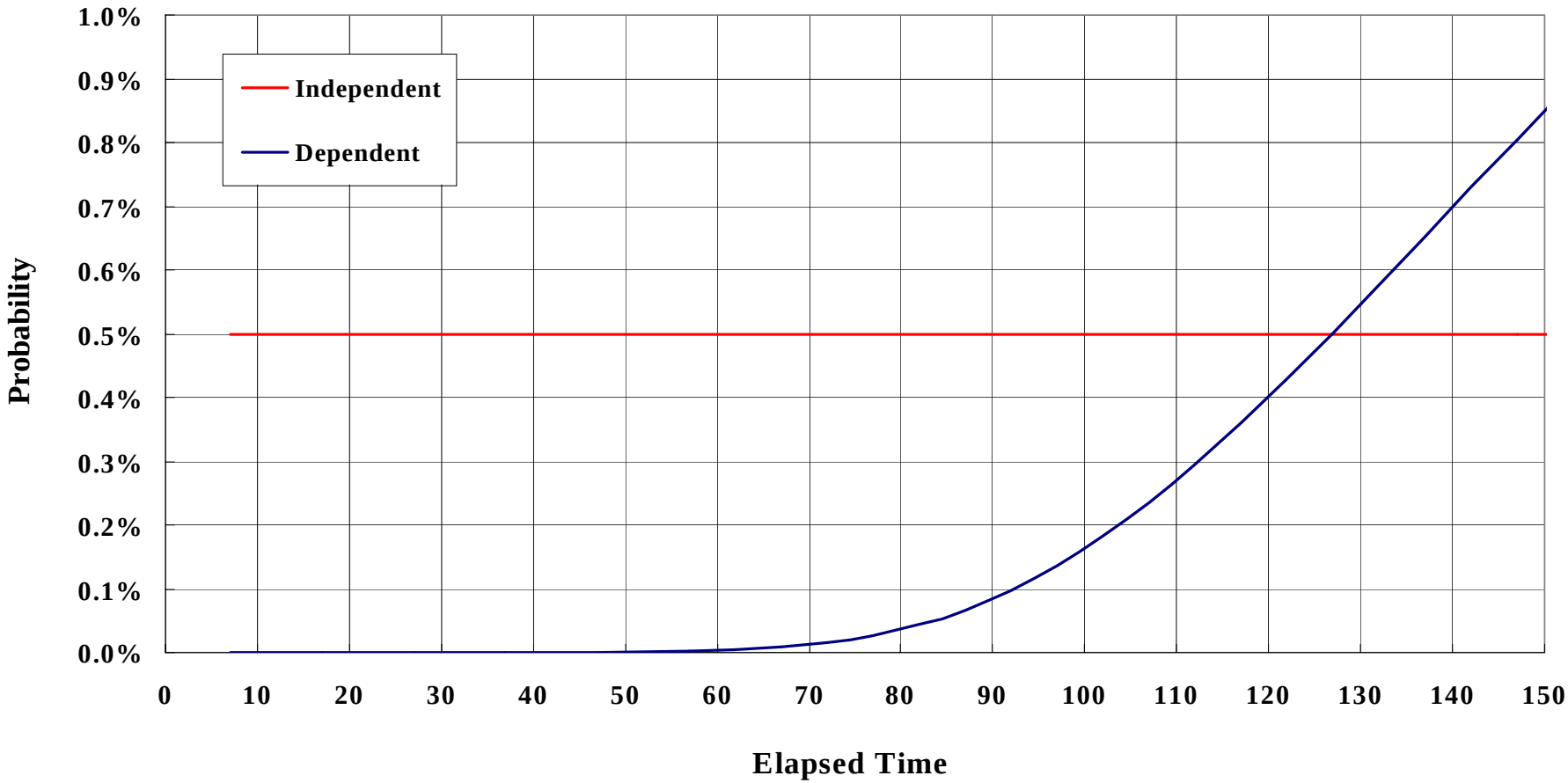
  Average Recurrence Period 200 Years

  ↓

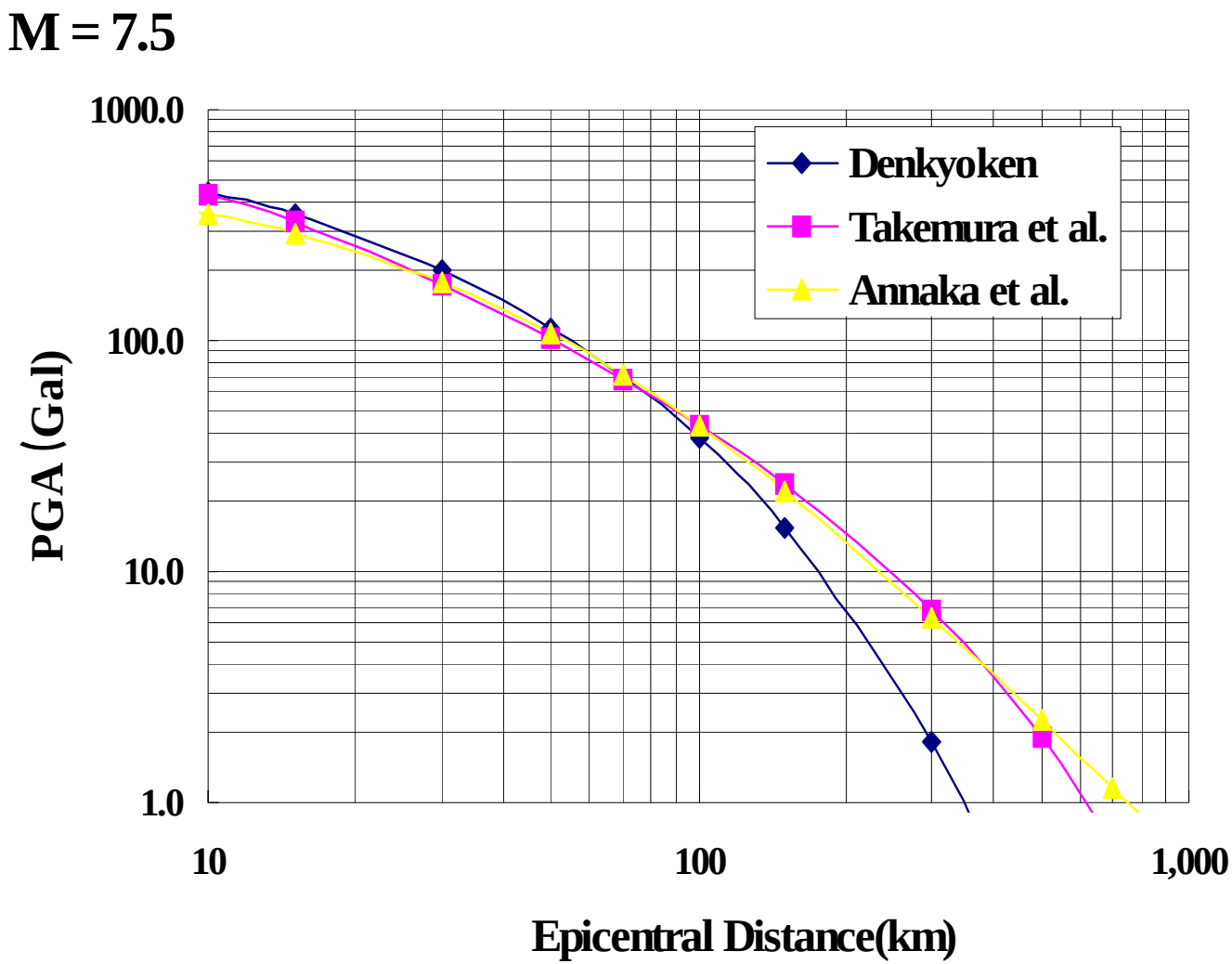
  Probability of Occurrence

  Gets Higher as Time Goes

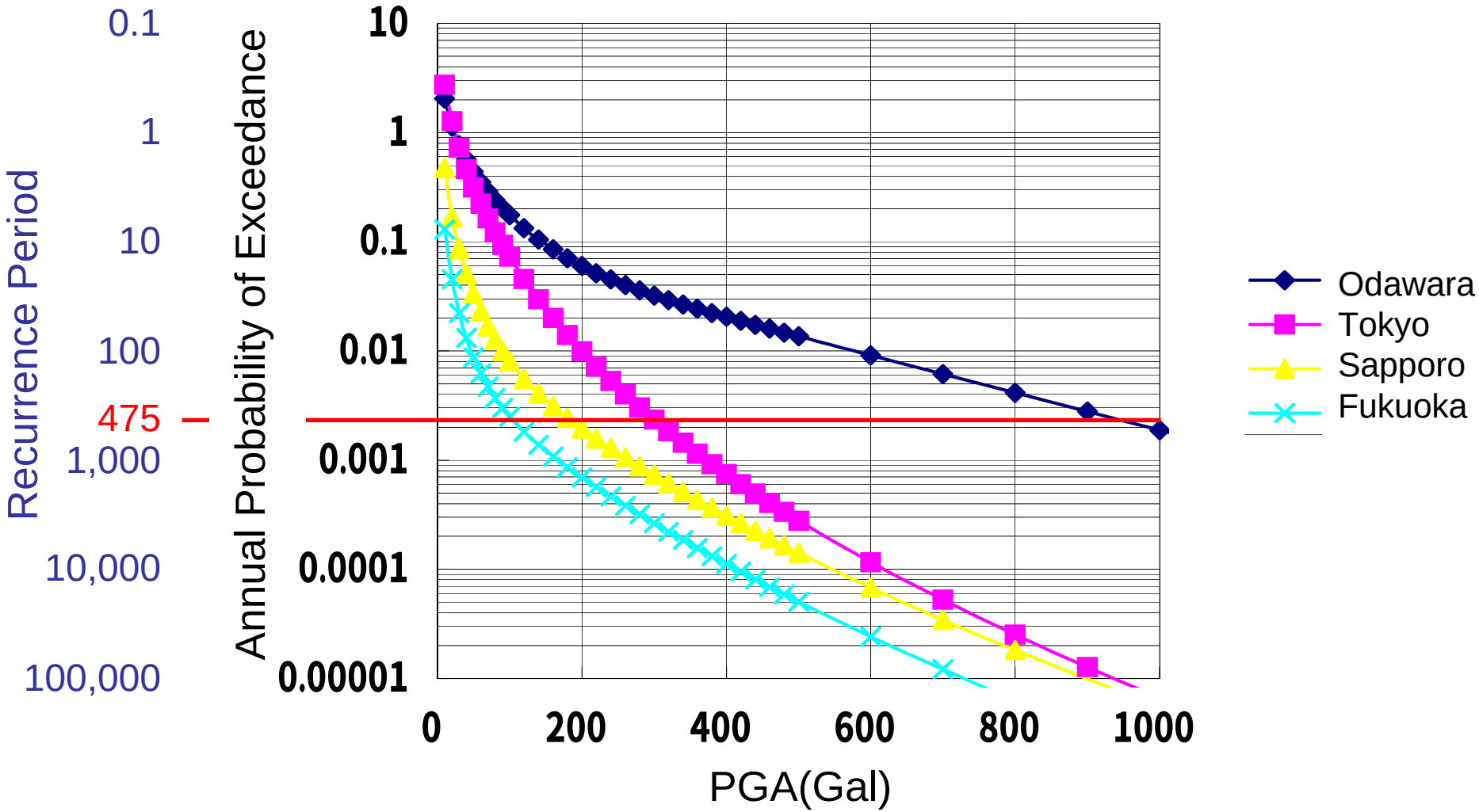
Time Dependency (2/2)



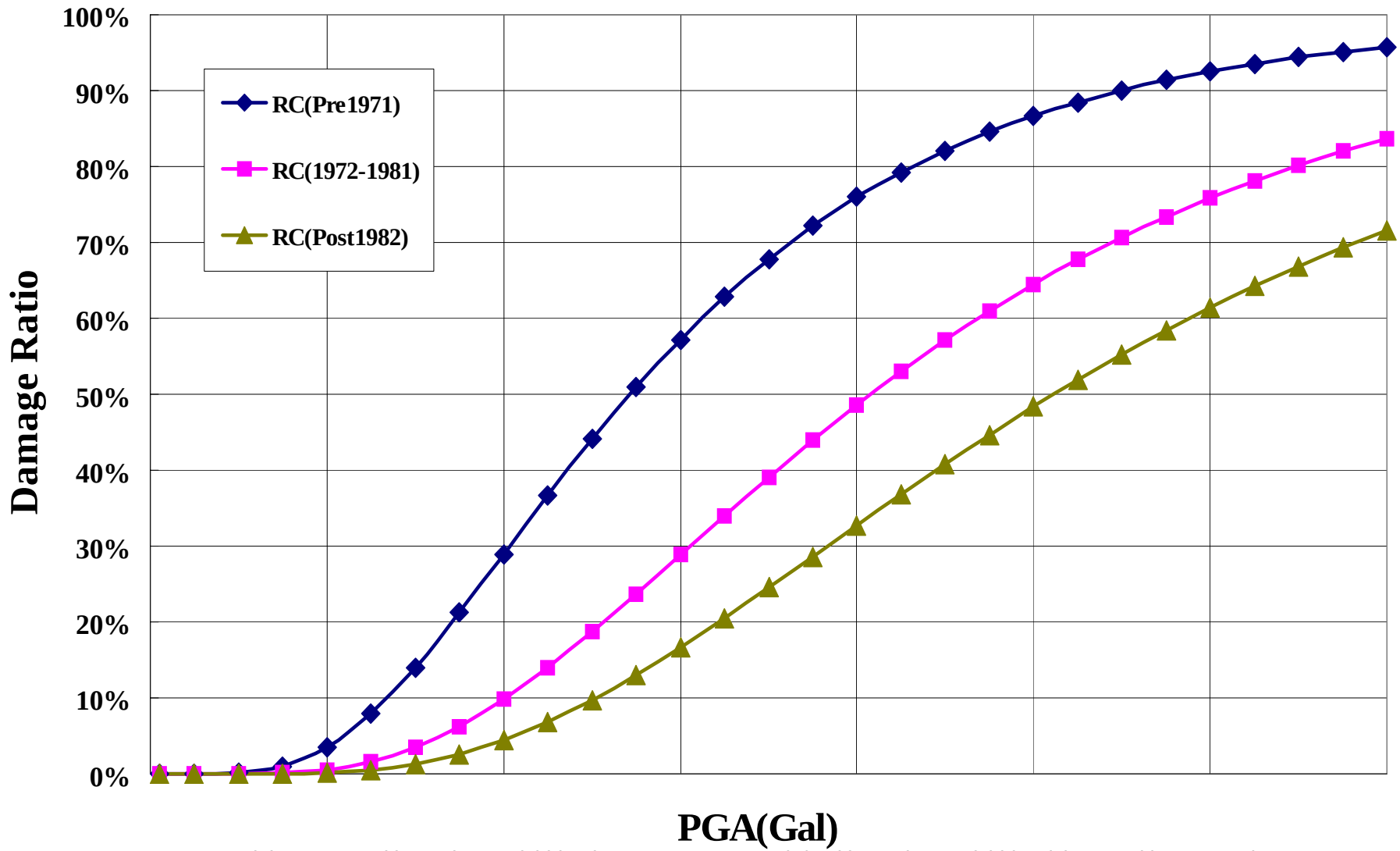
Attenuation Equations

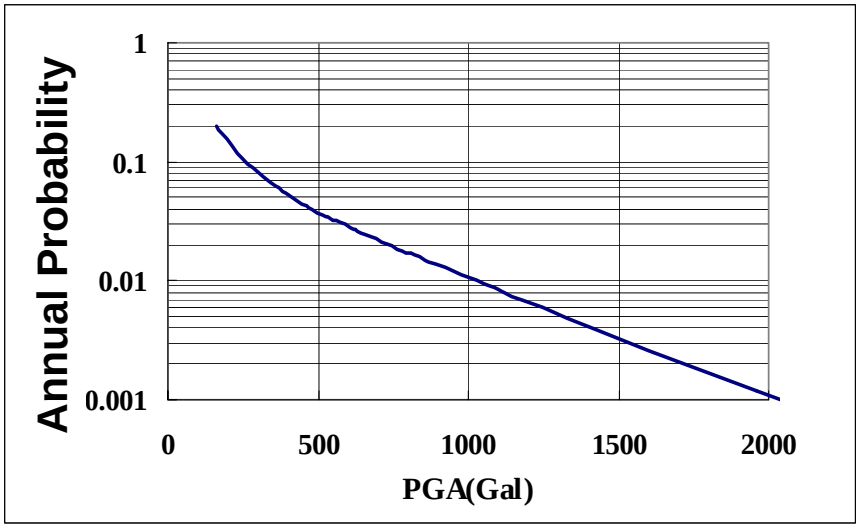


Seismic Hazard Curve



Seismic Damage Functions





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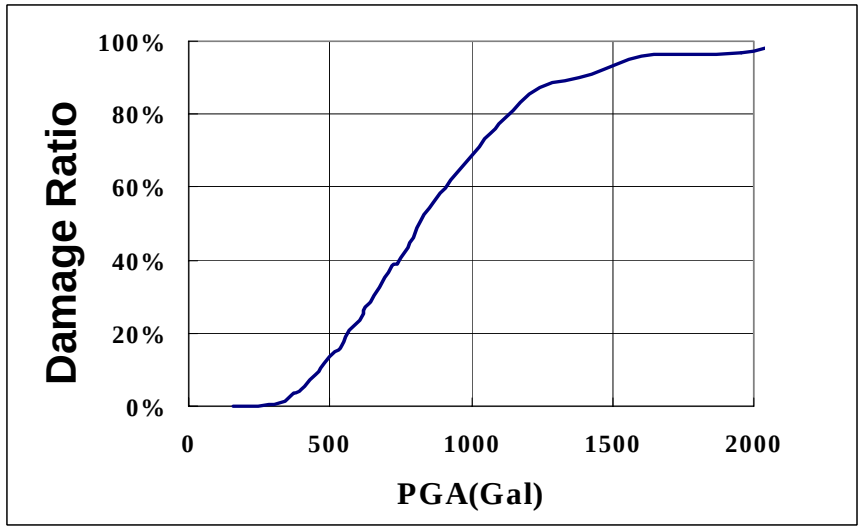
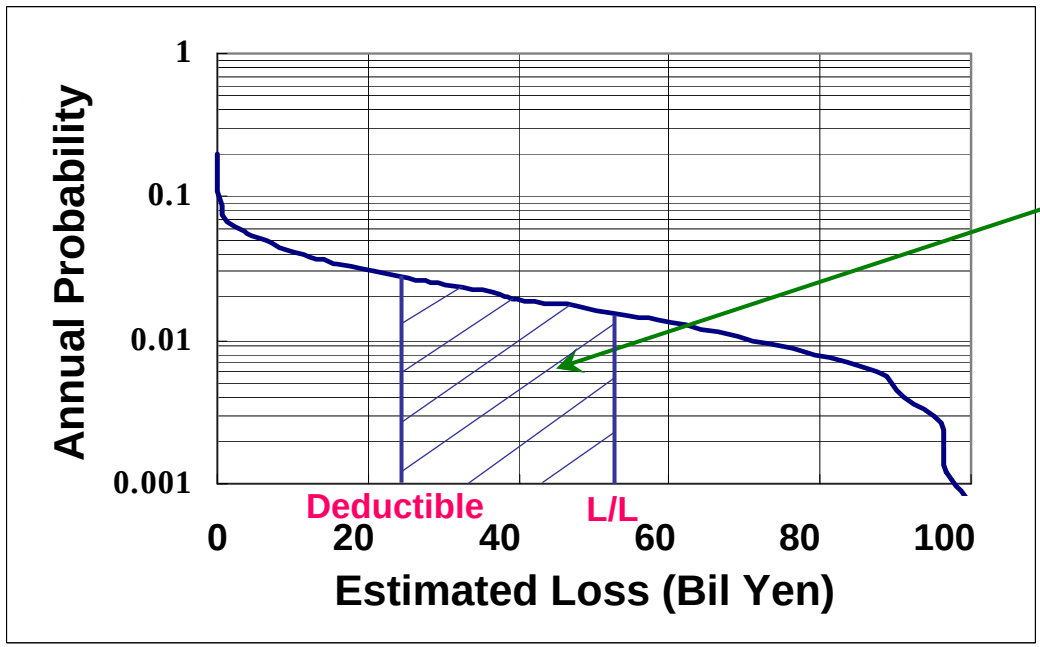


Seismic Damage Function



Seismic Risk Curve

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2. Risk Quantification Methods

- Natural Catastrophes (Example: Earthquake)
- **Other Risks**
- Aggregation

3. Issues to Be Solved

Non Natural Catastrophic Risks (1/2)

- Using historical claim data, frequency curves and damageability curves are estimated by risk categories
  - Categorization is the key
    - Geography, Industry, etc.
  - Distribution curves typically applied are:
    - Frequency: Poisson, Negative-binomial, etc.
    - Damageability: Log-normal, Pareto, etc.
  - Risk factors may be included in fitting curves
    - Exposure size, Months, etc.

Non Natural Catastrophic Risks (2/2)

- With estimated F and D curves, Monte Carlo simulation is applied for portfolio

```
For i = 1 to NumTrial
    For j = 1 to NumPolicies
    x = PoissonRandNumGeneration(Lambda(j))
        For k = 1 to x
            Damage(i, j, k) _
               = LogNormRandNumGeneration(Mu(j), Sigma(j))
            Loss(i, j, k) _
               = Min(Limit(j), Max(0, Damage(i, j, k) - Deductible(j)))
            TotalLoss(i) = TotalLoss(i) + Loss(i, j, k)
        Next k
    Next j
Next i
```

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3. Issues to Be Solved

Correlation Consideration (1/2)

- As for natural catastrophic risks, correlations are considered at event level
  - A simulated EQ results in simultaneous payment in policies affected

- As for non-cat risks, no correlation is considered among policies as long as there are no serious geographical accumulation of exposures

Correlation Consideration (2/2)

- Among risk categories, no correlation is usually assumed in aggregation
  - Common sense tells no correlation between EQ and Wind, for example
  - When conservative estimation is required, certain correlation might be applied, though not logical/observable

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Issues to Be Solved

- Data
  - Natural catastrophic risks
    - Are there unknown active faults exists or not?
  - Non natural catastrophic risks
    - Some risks do not have enough historical payment data
  - ...
- Unknown factors
  - Effect of global warming
  - Change in legal system
  - ...

Contacts

- Shumpei Okada
  shumpei.okada@tmnf.jp

- Yoshiaki Ogane
  y.oogane@tokiorisk.co.jp