# How to use Probabilistic Seismic Hazard Analysis, PSHA, Map ?

## - from user's point of view -

如何使用概率地震危險性分析, PSHA, 圖？

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OYORMS Corporation

# Company Profile / self-introduction

OYO RMS

- Earthquake risk analysis for companies and real estate
- Natural hazard analysis and simulation
- Development of natural disaster risk model

OYO 応用地質

- Japan's leading geotechnical engineering firm
- Disaster management / Environment / Social infrastructure / Energy / Instrument

RMS®

- World's leading natural catastrophe modeling company
- Funded in 1989 at Stanford University, USA

# Agenda

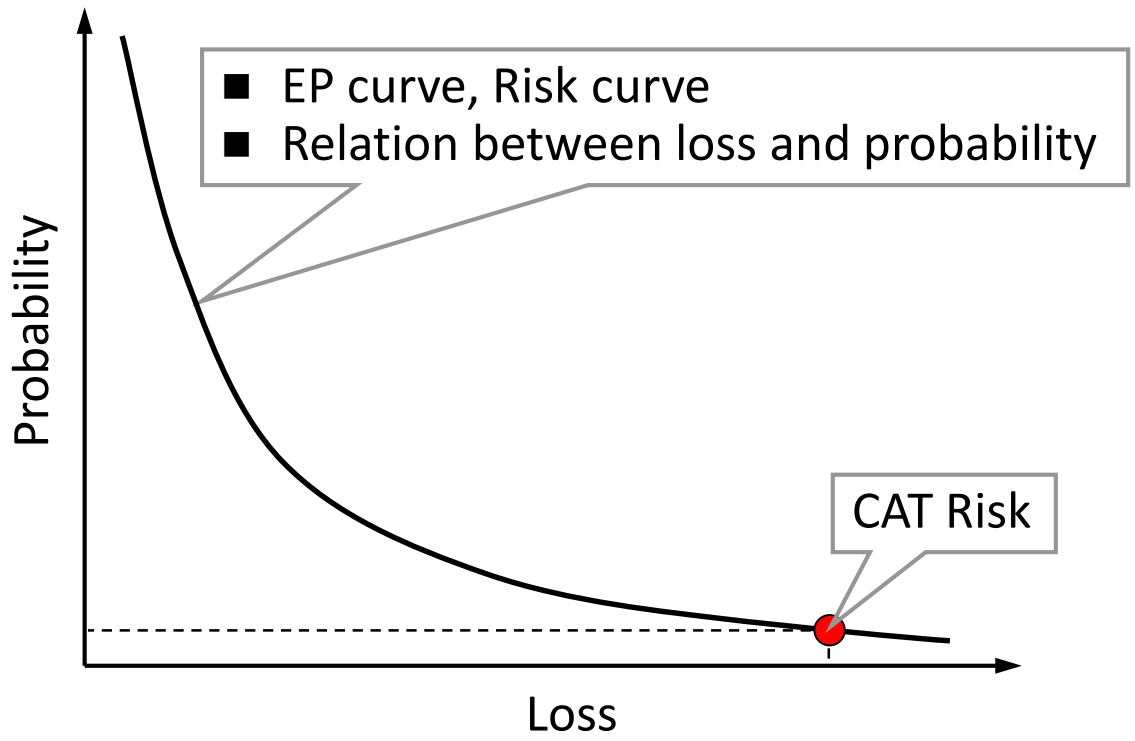
- What is risk and risk management?
- How is PSHA map used in the insurance industry?
- How is PSHA map used for the seismic design in Japan?
- Which seismic motion strength index is desirable for PSHA?
- What is easy-to-understand expression for the users?

# What is risk and risk management?

# What is Risk?　什麼是風險？

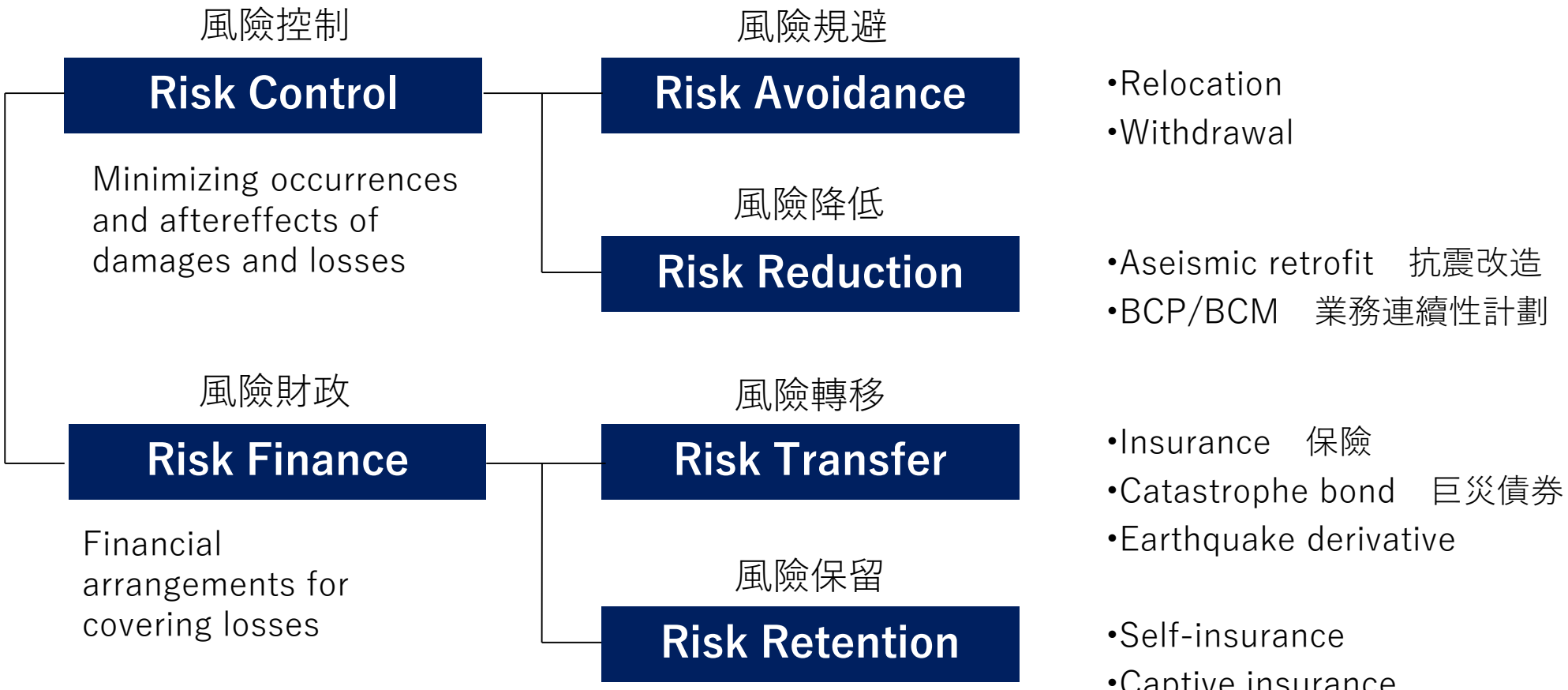
- **Concept of Risk**
  - Negative impact　負面影響　: Damage, Loss, …
  - Occurrence probability　發生概率　: Cyclic, Return period
  - Uncertainty　不確定　: Variance

- **What is CAT Risk?**
  - **Cat**astrophe Risk　浩劫風險
  - Low probability but big impact



# What is Risk Management ？　什麼是風險管理 ？

"Risk management" is the process of protecting assets, earning, debt, and human resources of the company with maximum effects and minimum costs.



# How is PSHA map used in the insurance industry?

# Flow of earthquake risk analysis

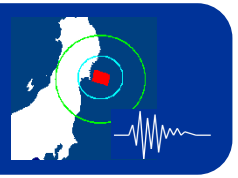
Pick up all possible earthquake scenarios

Calculate for all scenarios

**Source model**

Magnitude, occurrence probability and location/shape of the earthquakes

**Earthquake ground motion prediction**



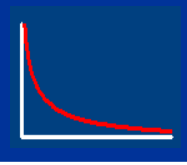
・Source distance
・Ground condition (amplification, liquefaction)

**Loss prediction**

・Replacement cost of properties
・Vulnerability
・Relation between loss and recovery days

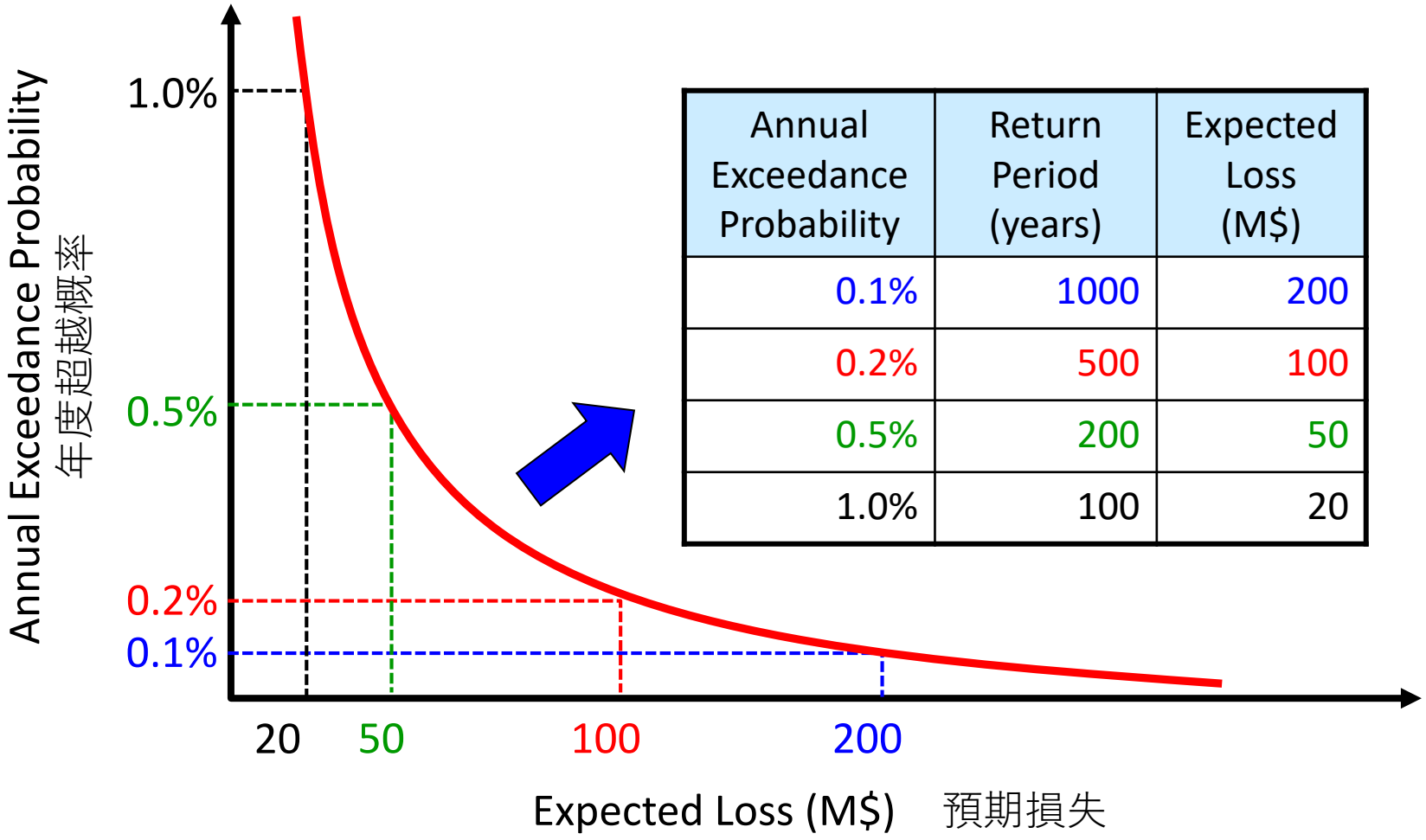
Add all the losses considering occurrence probability of the earthquakes

**Risk calculation**



Relation between Loss and Probability

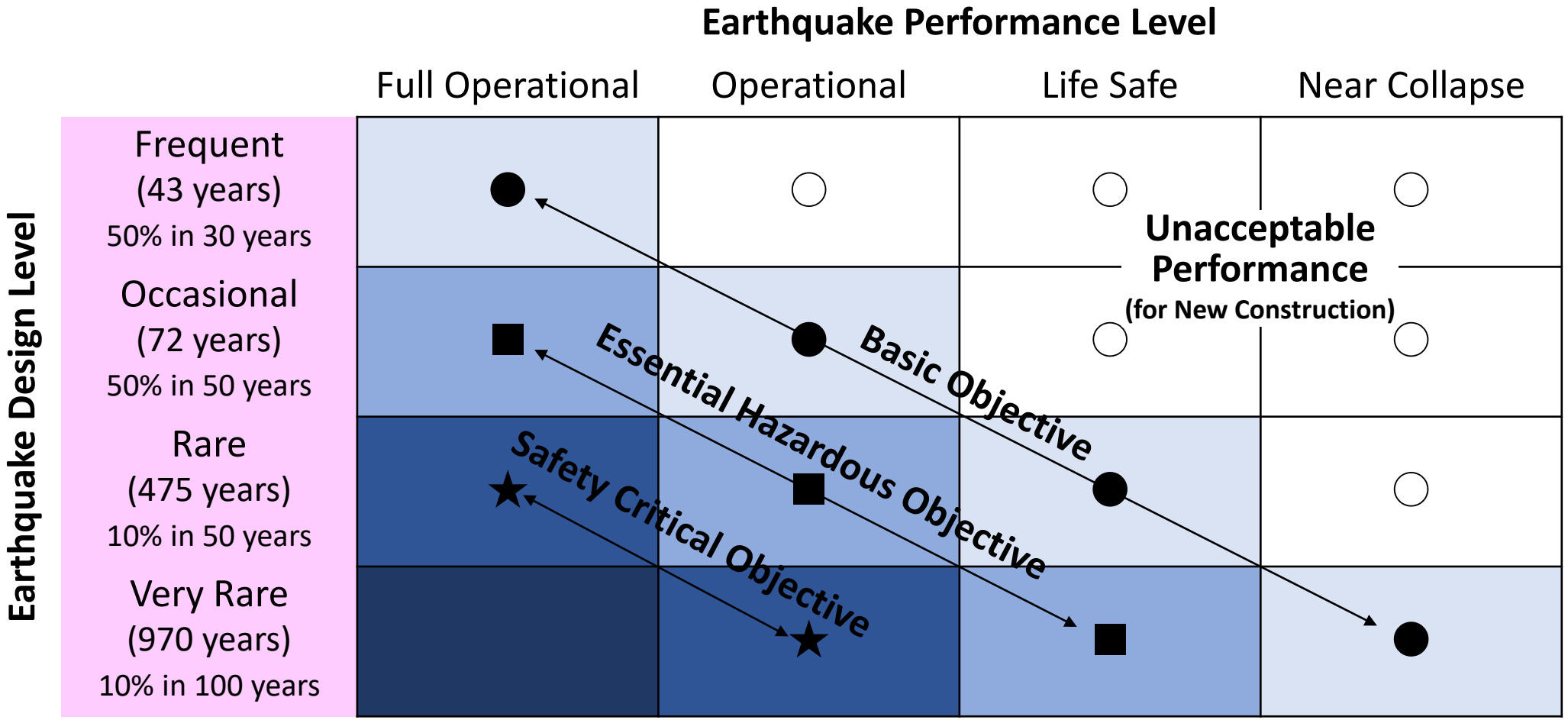
# Result of Risk Analysis / Relation between loss and probability




| Annual Exceedance Probability | Return Period (years) | Expected Loss (M$) |
|---|---|---|
| 0.1% | 1000 | 200 |
| 0.2% | 500 | 100 |
| 0.5% | 200 | 50 |
| 1.0% | 100 | 20 |

# How is PSHA map used for the seismic design in Japan?

# Performance-based seismic design



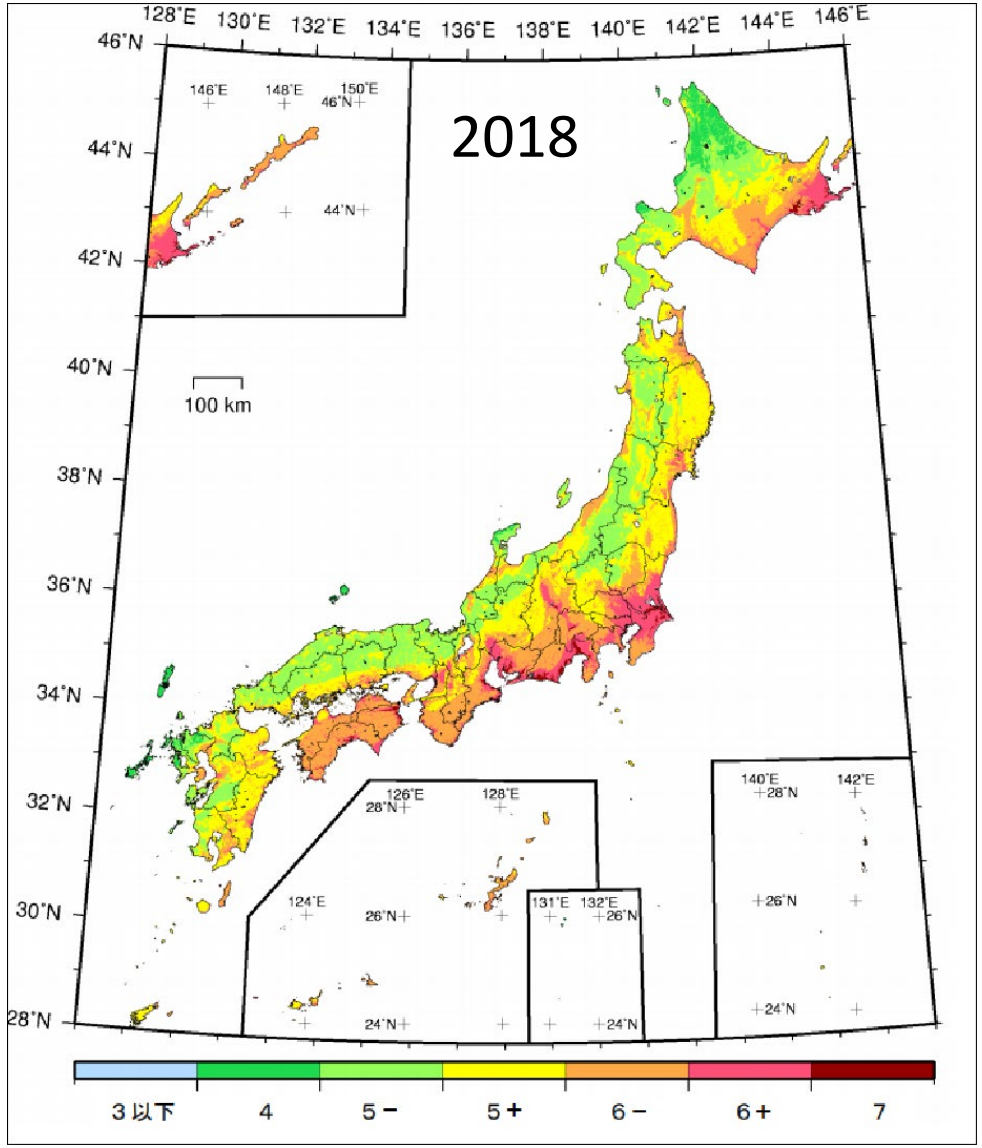

**Recommended performance objectives for buildings (Vision 2000)**

SEAOC Vision 2000 Committee (1995). Performance-based seismic engineering of buildings

# Design seismic motion and expected performance in Japan

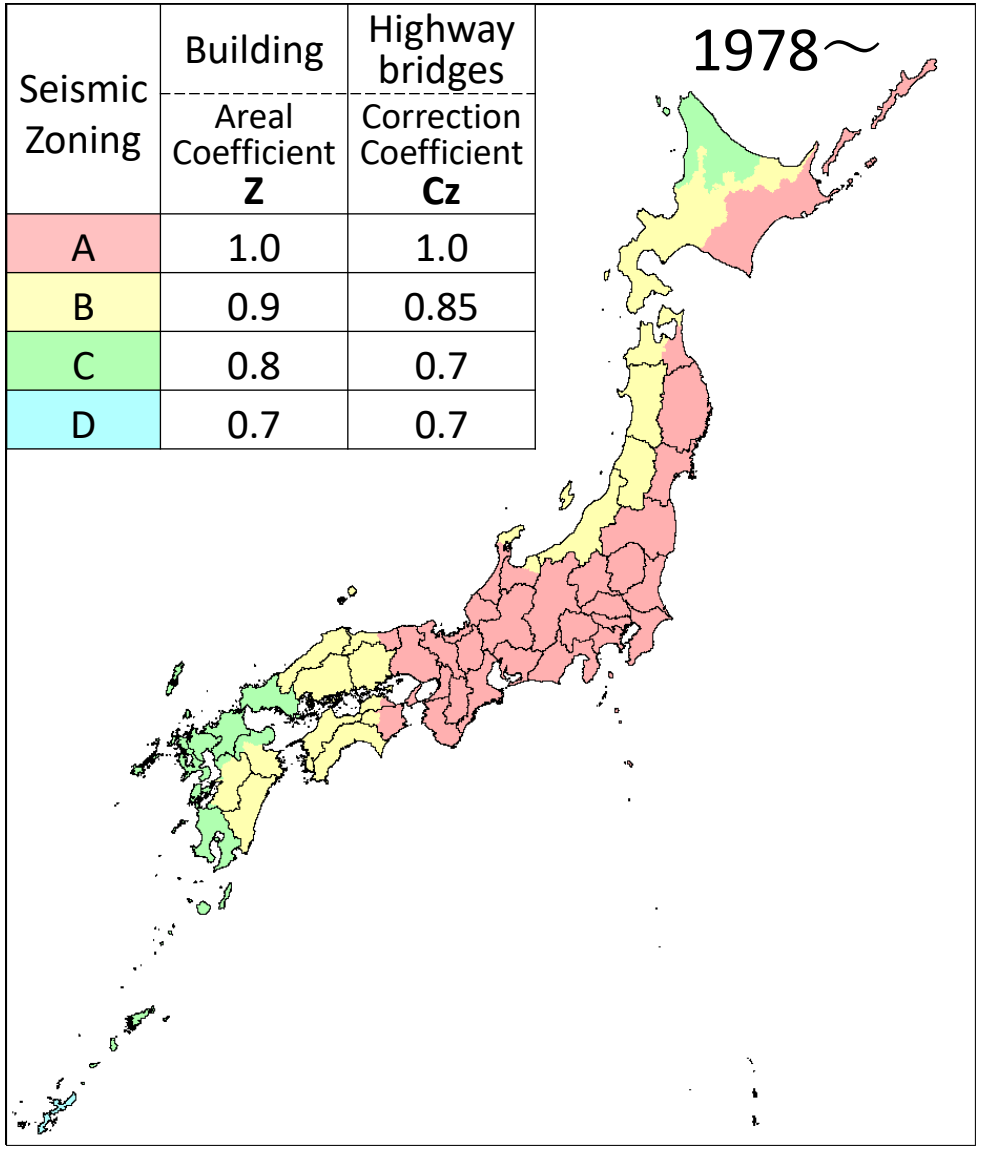
| Document | ***Building Standards Act*** | ***Specifications for highway bridges*** | |
|---|---|---|---|
| Legislation | 1981 | 2002 | |
| Seismic load | base shear coefficient ($C_0$) | acceleration response spectrum (Sa) | |
| Lower level | Primary design | Level 1 | |
| Design seismic motion level | ● low occurrence probability<br>● middle class load<br>● $C_0$ >= 0.2 - 0.3<br>☐ allowable stress design | ● high occurrence probability during service<br>● middle class earthquake, conventional level<br>● Sa = 200 - 300 gal (T=1 sec) | |
| Performance level | no damage in main structure | operational | |
| Higher level | Secondary design | Level 2 | |
| Design seismic motion level | ● very low occurrence probability<br>● the largest class load<br>● $C_0$ >= 1.0<br>☐ calculation of lateral load carrying capacity | Type I | ● low occurrence probability<br>● large subduction earthquake (Kanto EQ)<br>● Sa = 700 - 1000 gal (T = 1 sec) |
| | | Type II | ● very low occurrence probability<br>● inland earthquake (Kobe EQ)<br>● Sa = 1500 - 2000 gal (T = 1 sec) |
| Performance Level | no collapse | short time recovery / non-fatal damage | |

# PSHA map and seismic zoning for structural design




JMA Intensity for 10% occurrence probability in 50 years

| Seismic Zoning | Building | Highway bridges |
|---|---|---|
| | Areal Coefficient **Z** | Correction Coefficient **Cz** |
| A | 1.0 | 1.0 |
| B | 0.9 | 0.85 |
| C | 0.8 | 0.7 |
| D | 0.7 | 0.7 |




Seismic zoning for structural design

# Which seismic motion strength index is desirable for PSHA?

# Which seismic motion strength index is desirable for PSHA?

- Many indices: PGA, PGV, seismic intensity(MMI, JMA), SI, Sa(t), etc.
- For users, the desirable index is what can explain structural damage and social impact caused by the seismic motion.
- However, it is not clear which index is best fit for fragility/vulnerability function. Why?
- One reason is the seismic motion at the damaged structure location is usually unknown, though damage or loss of the structures can be investigated after the earthquake.
- But, it is not so easy to install seismometer in all structures.
- So we tried to predict the seismic motion at any location as accurately as possible from the observed data for developing better fragility/vulnerability function.

# Methodology for spatial interpolation of seismic motion

**STEP-1:** Calculate seismic motion strength index from the observed waveforms

- PGA, PGV, JMA Intensity, SI, and Sa (0.05 to 10 sec)

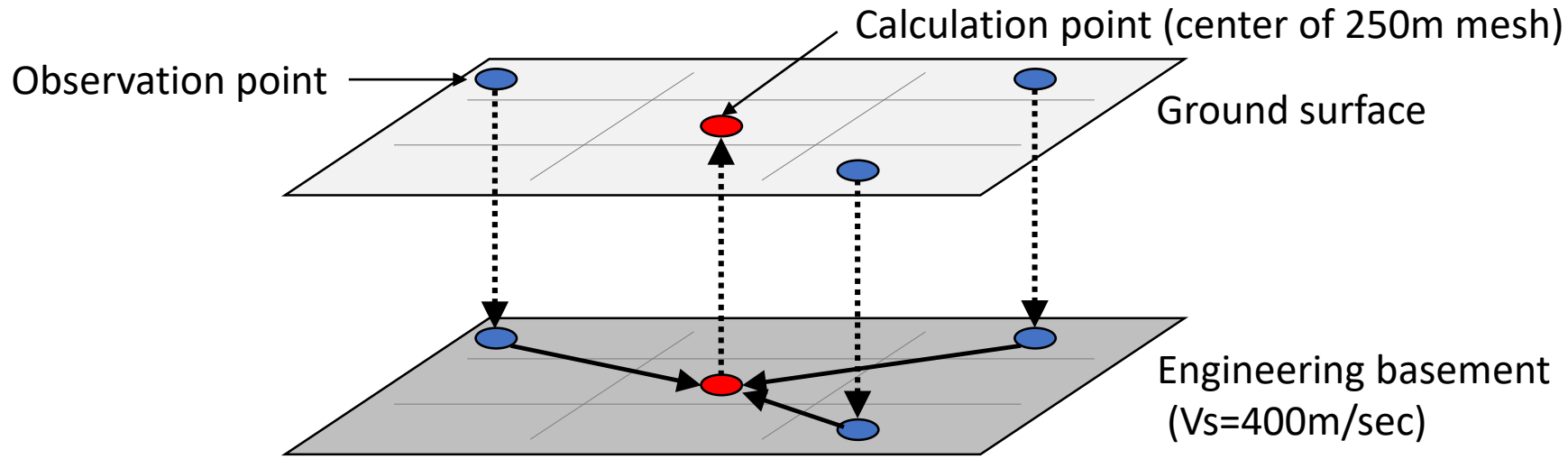
**STEP-2:** Calculate the index on the engineering basement (Vs=400 m/sec)

- Use non-liner amplification factor of the subsurface ground (AVS30)

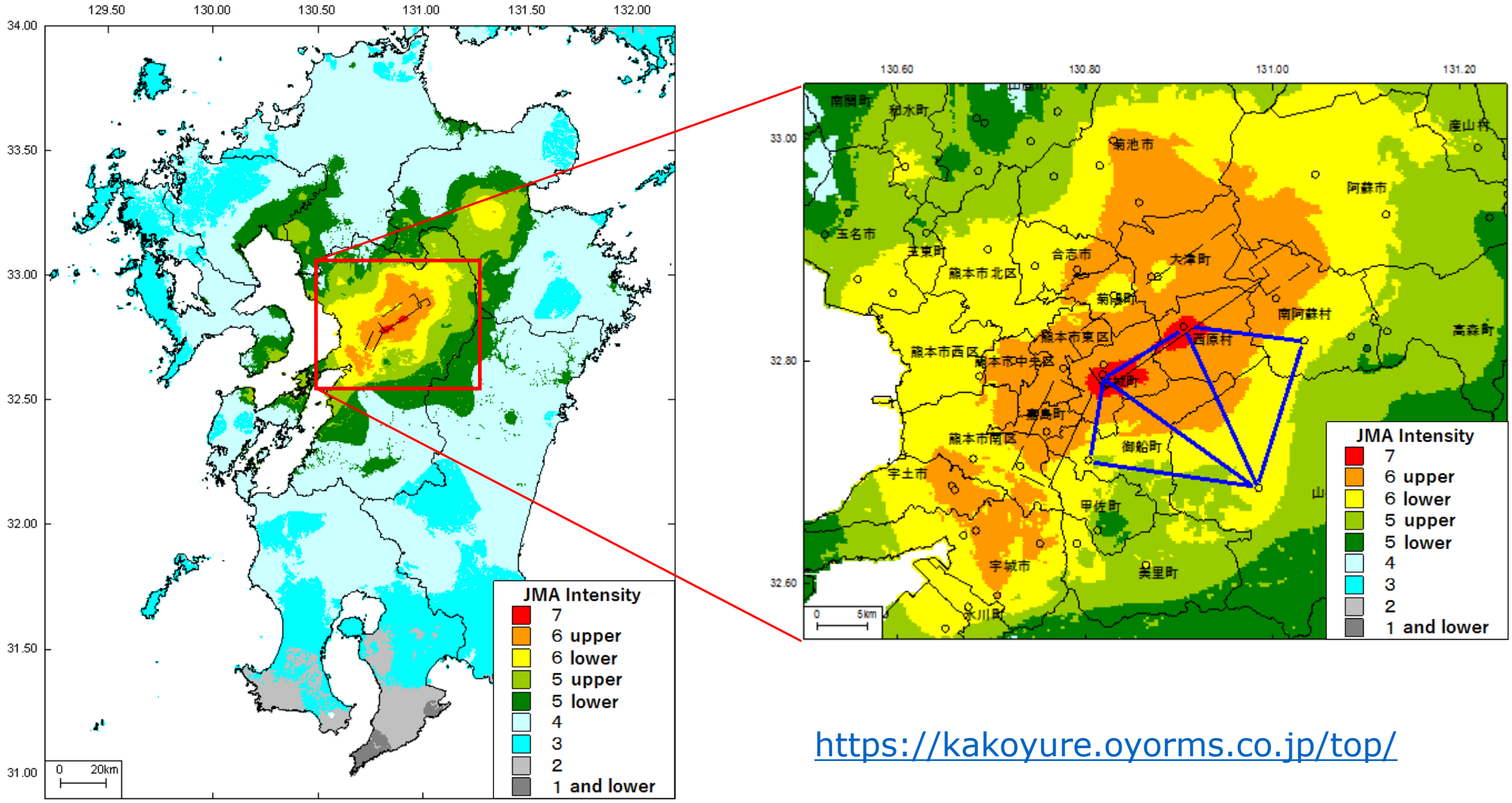
**STEP-3:** Spatial interpolation on the engineering basement (center of mesh)

- Simple Kriging method: Consider attenuation trend from the fault model

**STEP-4:** Calculate seismic index on the ground surface



# Spatial interpolation result of Kumamoto earthquake

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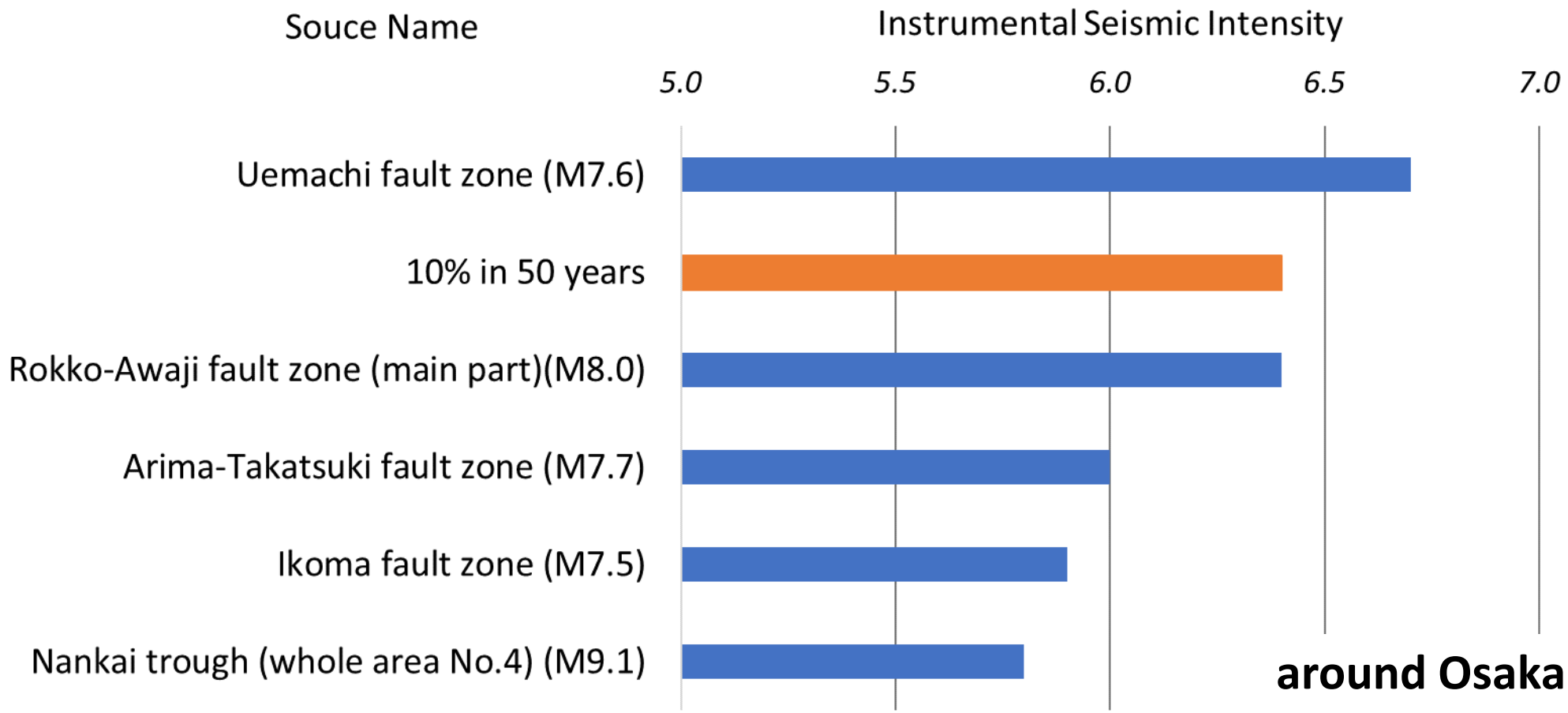
# What is an easy-to-understand expression?

# Risk management at various levels

| Scale | Organization | Purpose of use | Risk management |
|---|---|---|---|
| Global | Reinsurance company | Portfolio management | Probabilistic risk<br>Portfolio risk<br>Risk finance |
| ↕ | Multinational company | Supply chain management | |
| Country-wide | National government | Security and lives of citizens | |
| ↕ | Insurance company | Ceded reinsurance | |
| | Country-wide company | Supply chain management | |
| Regional | Lifeline company | Early recovery, BCP/BCM | Scenario risk<br>Risk control |
| ↕ | Railway company | Early recovery, BCP/BCM | |
| | Highway company | Early recovery, BCP/BCM | |
| Local | Local government: City, Town | Protection of residents | |
| ↕ | Hospital, fire station | Maintain operation | |
| | Local company | Business continuity, survival | |
| Location | Resident | Maintaining life and living | |

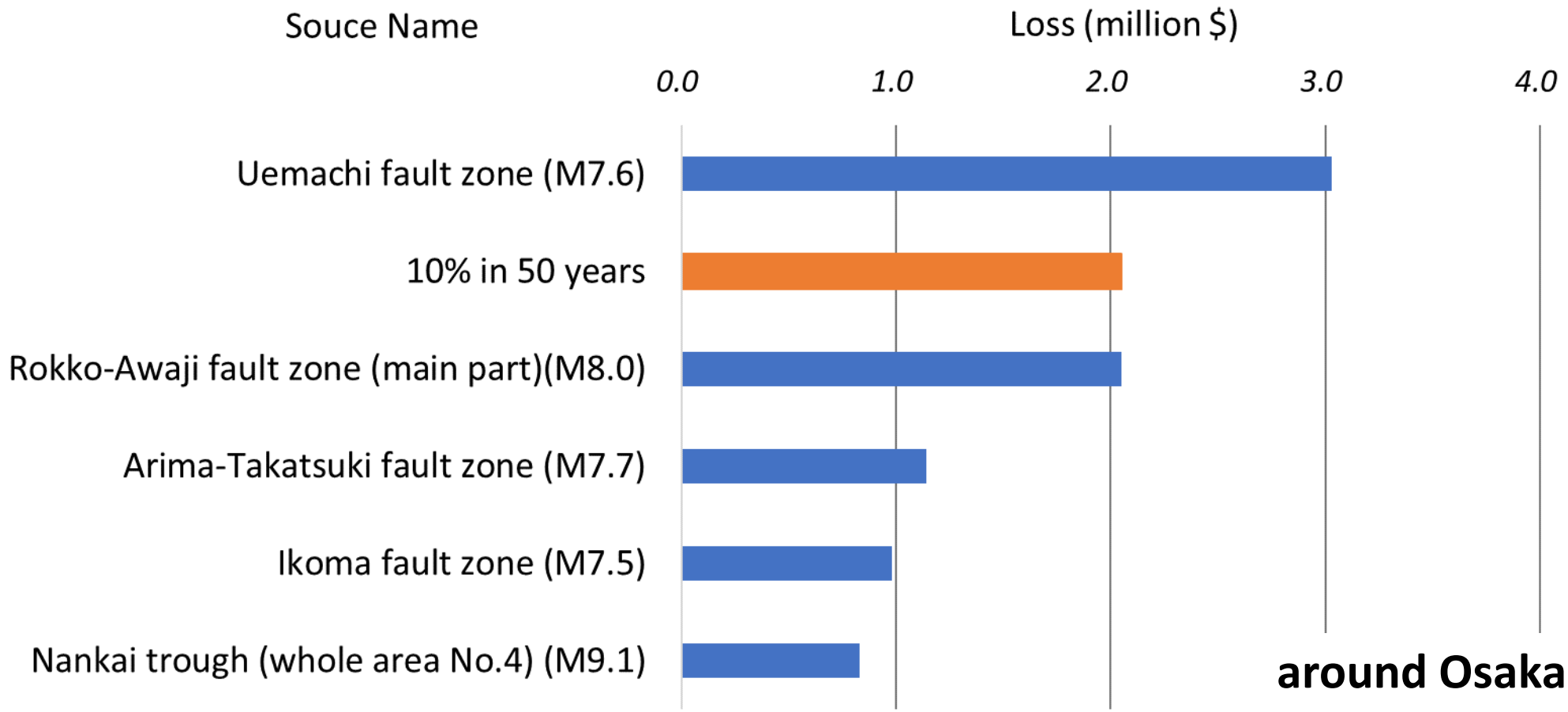
# What is an easy-to-understand expression? (example-1)

- **Comparison**
  - seismic intensity of the top 5 earthquakes and probabilistic assessment



# What is an easy-to-understand expression? (example-2)

- **Familiar expression for the users**
  - Extent of damage and/or loss



# Thank you! 謝謝你的關注！

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