Bank of Japan
"Workshop on
Scenario Analysis"

Risk
Management

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Seismic Risk Analysis

OYO RMS Corporation
Takashi Kanemori

東京都港区赤坂3-11-15 赤坂桔梗ビル4階〒107-0052
Tel.03-5575-7189 Fax.03-5575-7197
http://www.oyorms.co.jp/

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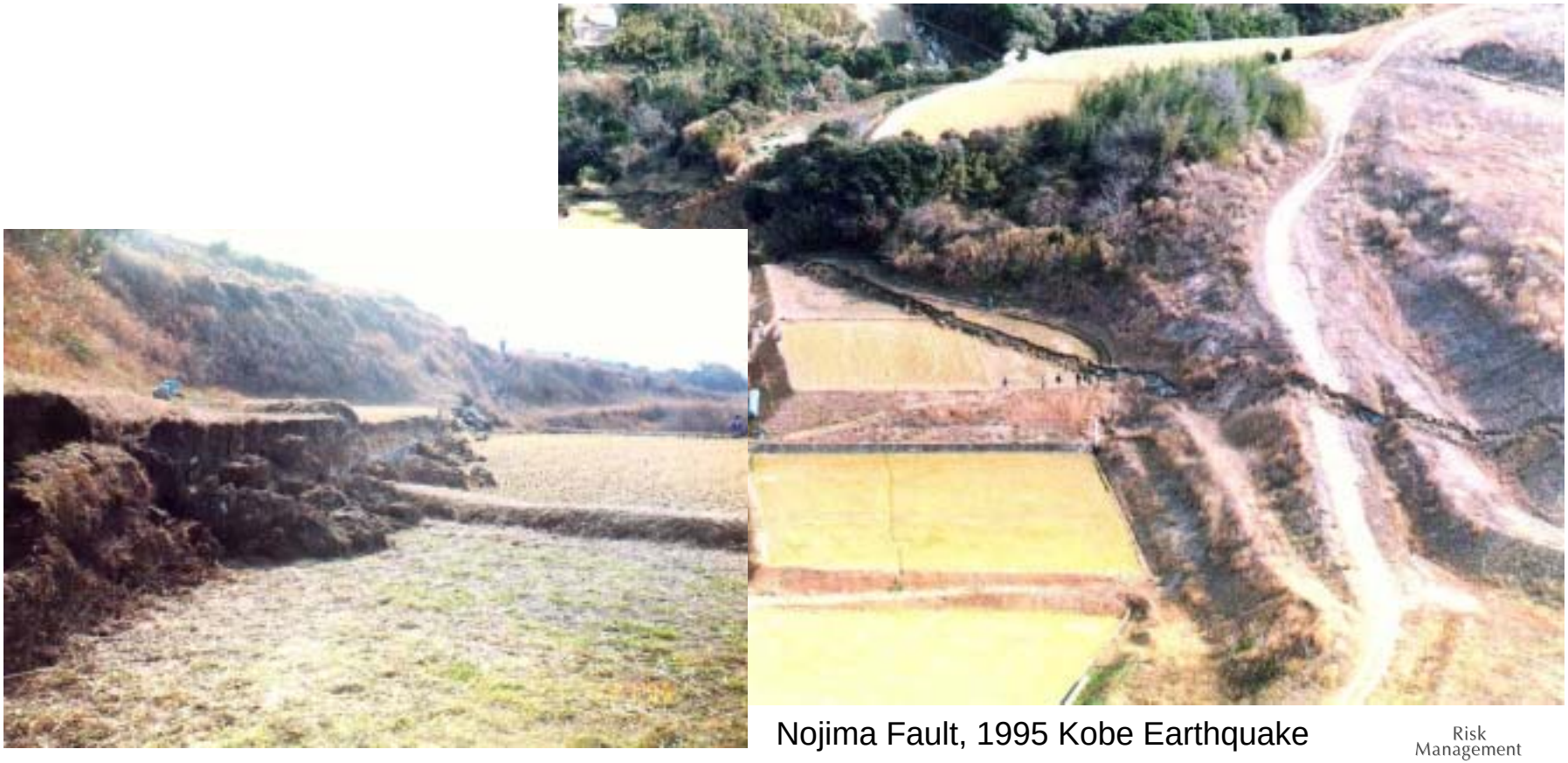
Contents

- How do Earthquakes Occur?
- Quantitative Seismic Risk Analysis
  - Seismic Source Model
  - Model for Assessing Earthquake Motions
  - Model for Loss Estimation
    - Direct Losses of Buildings, Contents, Facilities, etc.
    - Business Interruption Losses
    - Casualty Losses
  - Model for Assessing Risk
    - Event Curves and Risk Curves

How do Earthquakes Occur?



Nojima Fault, 1995 Kobe Earthquake

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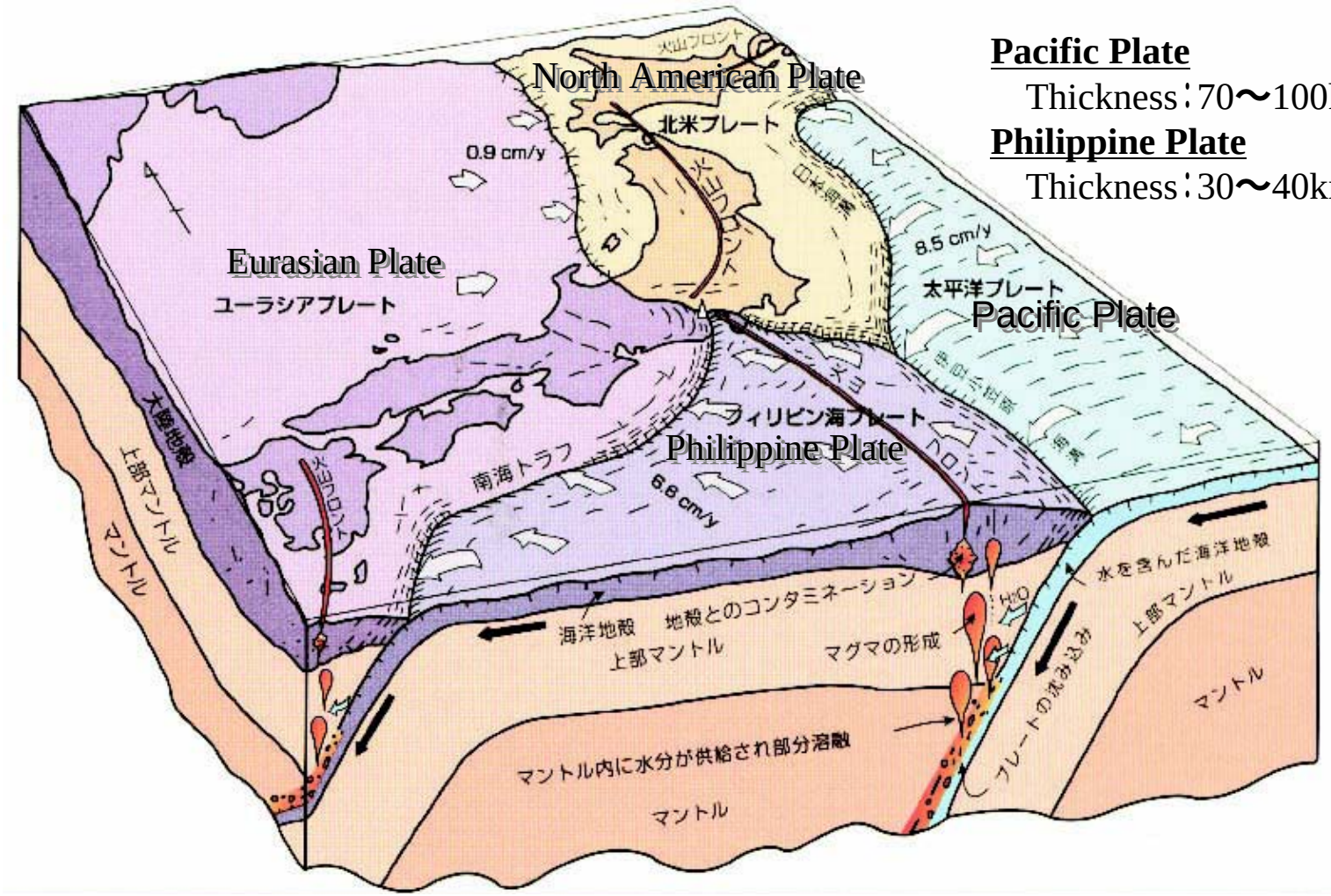
Japan Tectonic Setting



Pacific Plate

Thickness：70～100km

Philippine Plate

Thickness：30～40km

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Two Major Types of Earthquakes in Japan

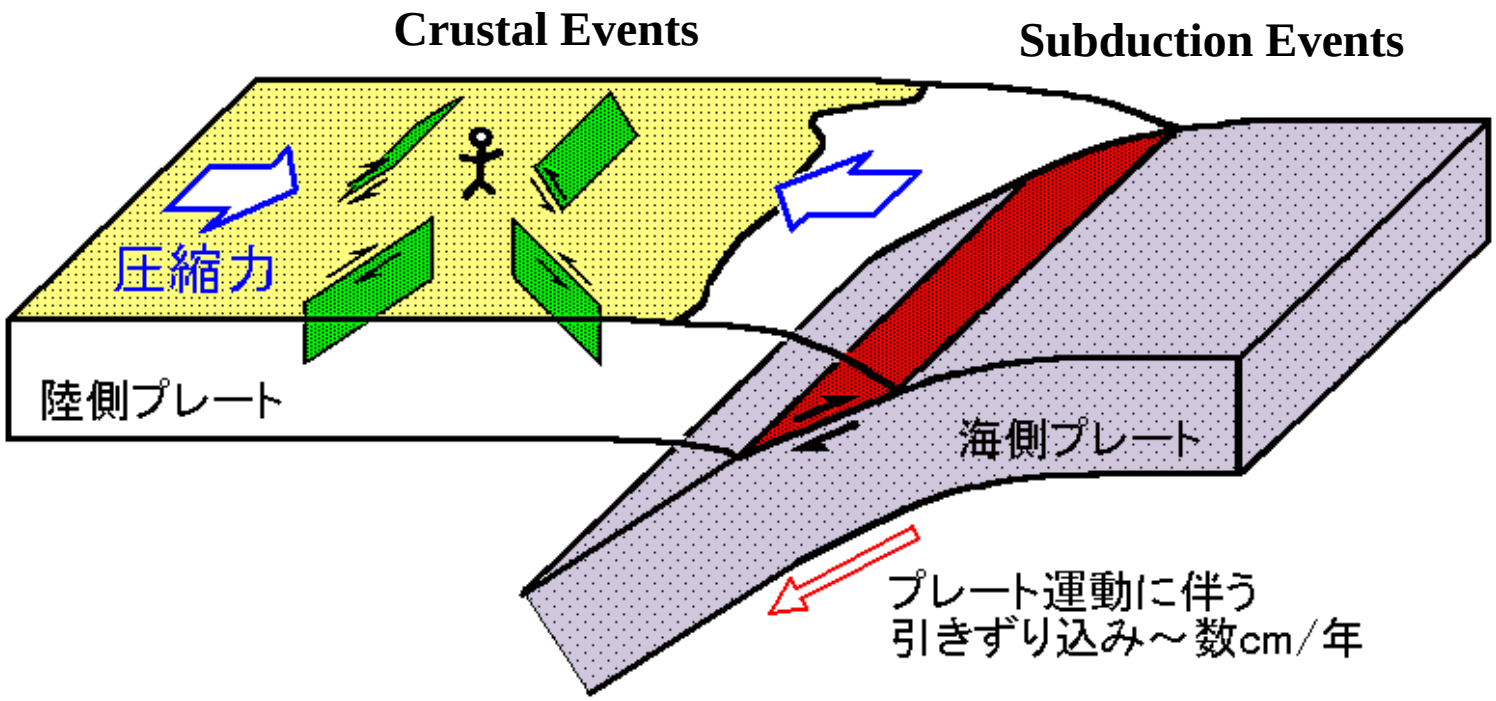
Shallow Crustal Events

- Fault activities in shallow crustal zone caused by release of stress accumulated indirectly with compression force by plate tectonics
- Magnitude is mostly up to sevens
- Repeat Cycle of specific events is several thousands years to several tens thousand years

Subduction Events

- Subduction interface events occur along the surface of contact between the two plates
- Big earthquake over Magnitude 8.0 with 100 to 200 years of repeat cycle

Source: http://www.bosai.go.jp/jindex.html



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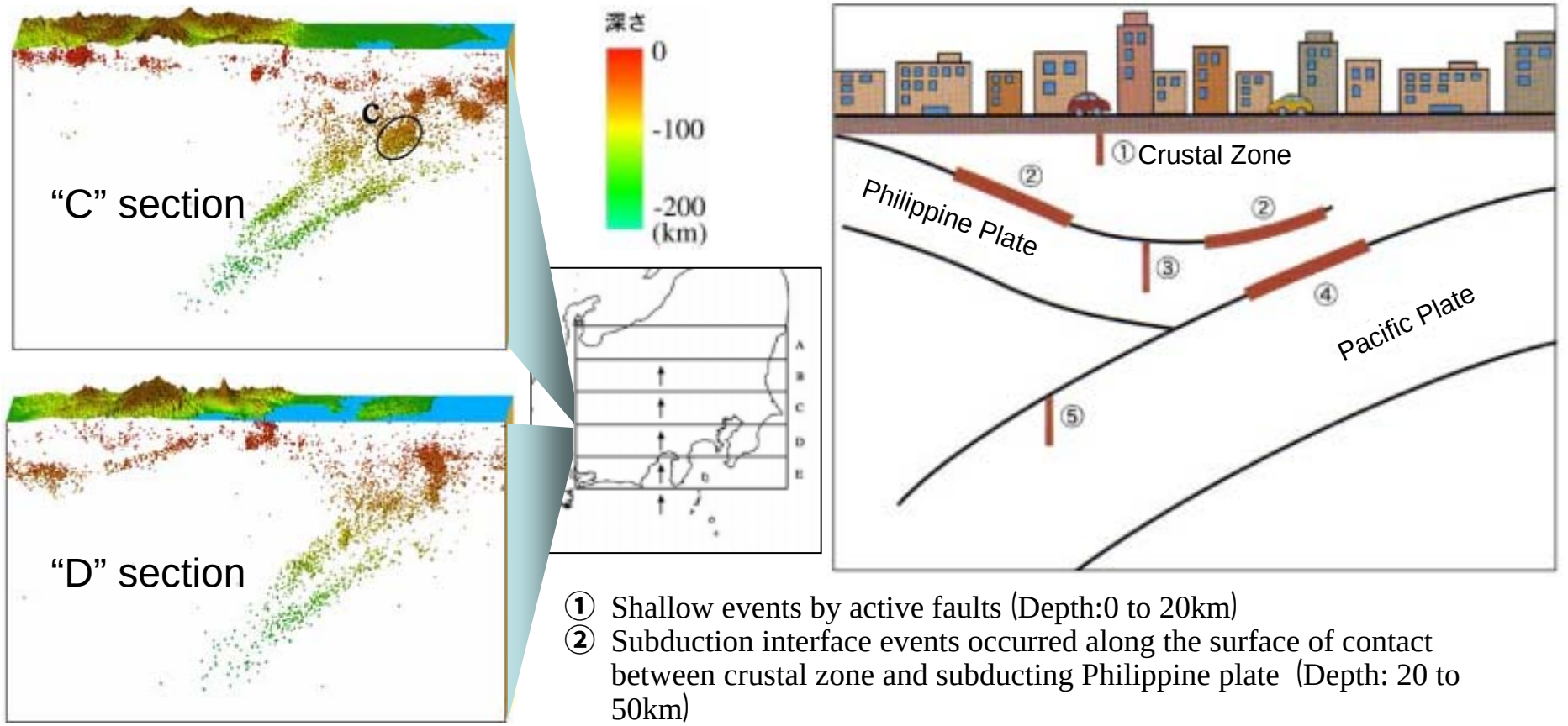
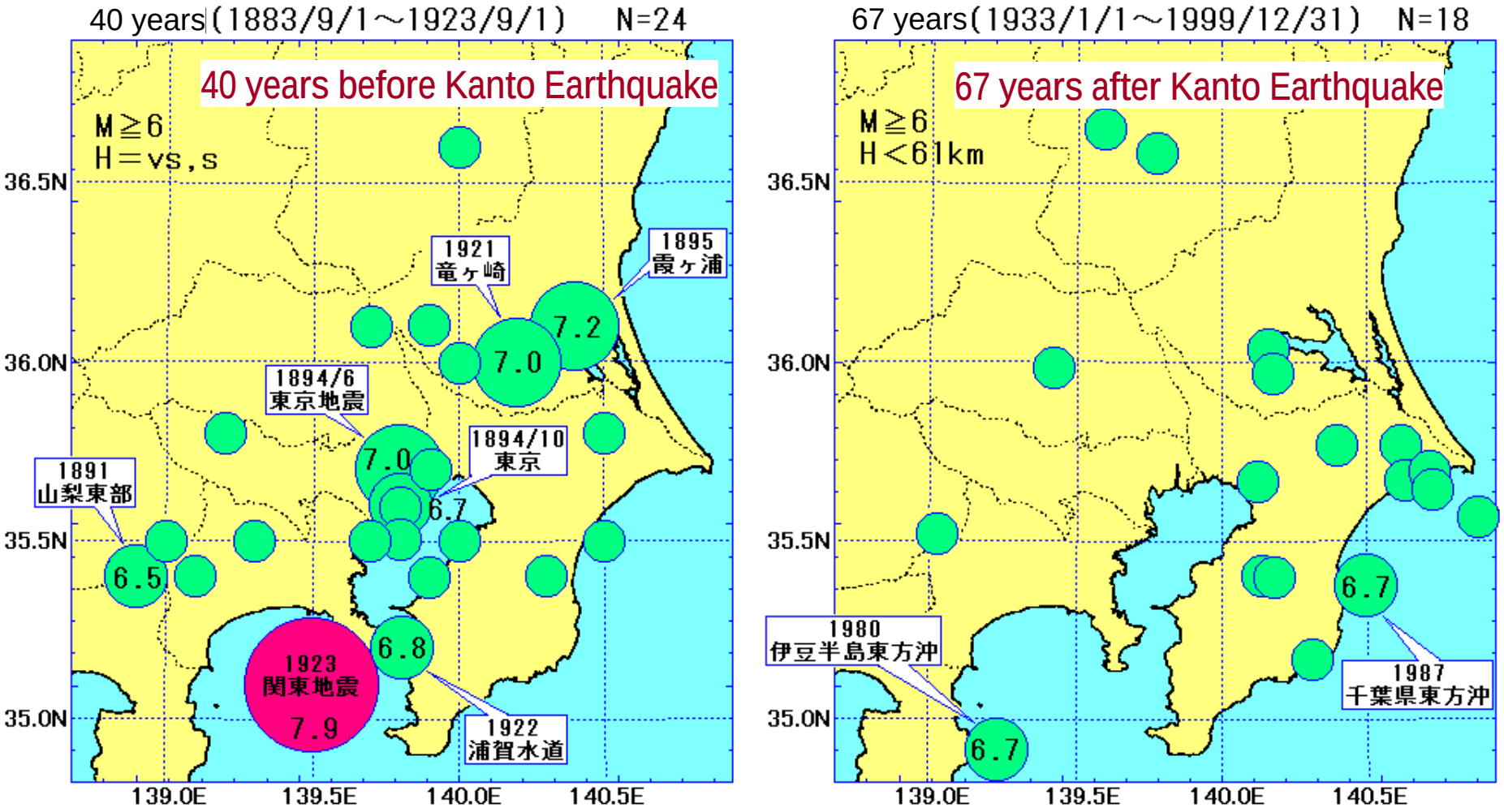
Earthquakes in Kanto Area



① Shallow events by active faults (Depth:0 to 20km)
② Subduction interface events occurred along the surface of contact between crustal zone and subducting Philippine plate (Depth: 20 to 50km)
③ Subduction intraslab events occurred within the subducting slab of Philippine plate (Depth: 20 to 50km)
④ Subduction interface events occurred along the surface of contact between Philippine plate and Pacific plate (Depth: 50 to 100km)
⑤ Subduction intraslab events occurred within the subducting slab of Pacific plate (Depth: 50 to 100km)

Seismic Activity in Kanto Area Becomes Active…

Comparison of seismic activity (M≧6) in Kanto area before and after 1923 Kanto Earthquake (M7.9)



Source: Okada, Yoshimitsu（2001）, http://www.hinet.bosai.go.jp/about_earthquake/part1.htm

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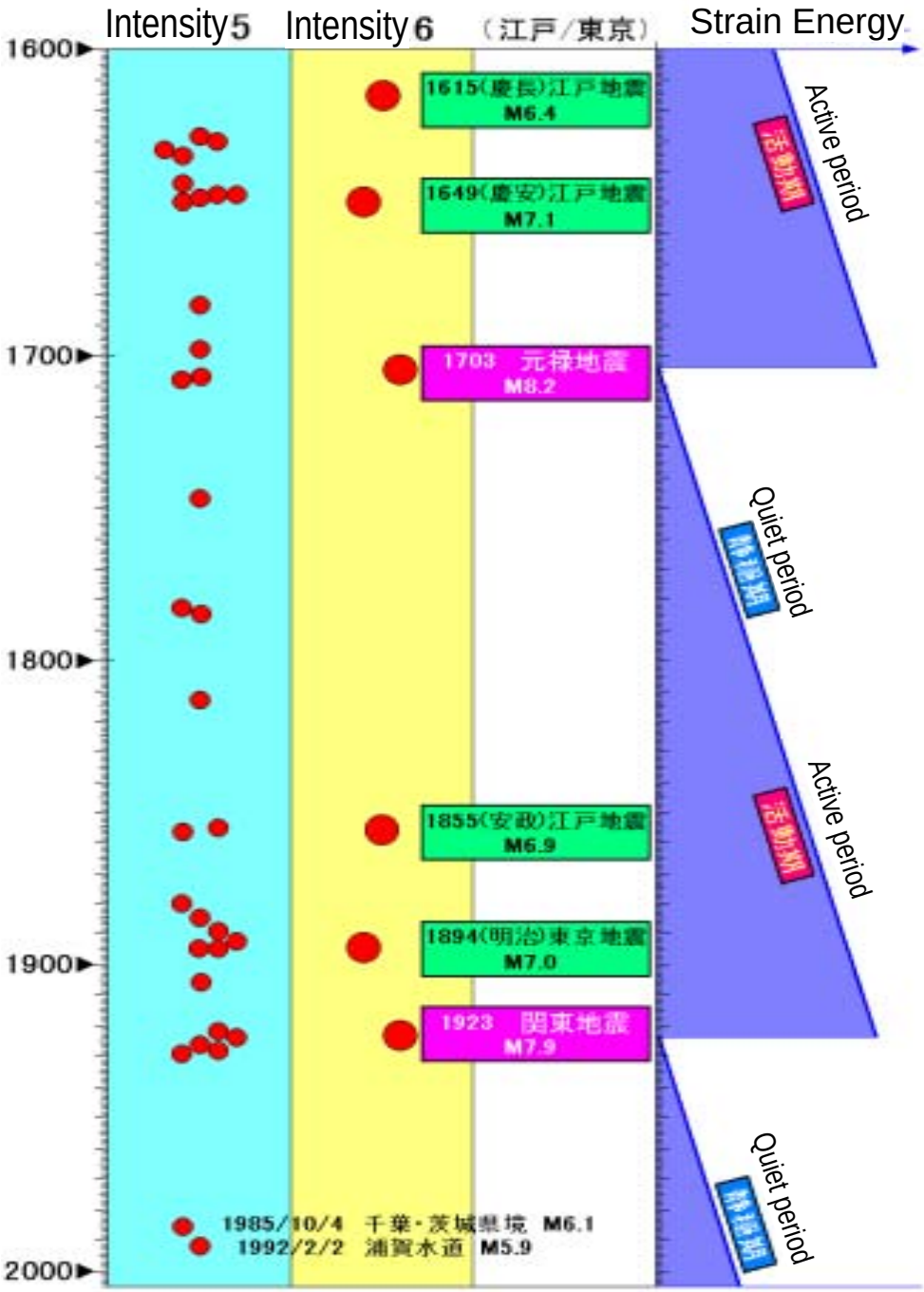

Events with 5 or more of JMA Intensity at Tokyo in the last 400 years

Supposing that return period of Kanto Earthquake is around 200 years, it is considered that the first 100 year is quiet period and the last 100 year is active period. Because only 80 years passed after the 1923 Kanto event, occurrence of the next Kanto event may require another 100 years and the current years will be classified to quiet period. However, regarding “Tokyo Chokka” type earthquake enters a stage which its occurrence should be concerned. Its sign is that there were no earthquake with Intensity 5 in Tokyo area for 50 to 60 years since the great Kanto earthquake but two earthquakes with Intensity 5 have occurred in October, 1985 and February, 1992. Fortunately, these two earthquakes brought only very minor damages because they were deep interslab events in Pacific plate and magnitude were 6s. If source depth was shallower or magnitude was 7s, small damage could be caused.

Soure: Okada, Yoshimitsu (2001)
(http://www.hinet.bosai.go.jp/about_earthquake/part1.htm)

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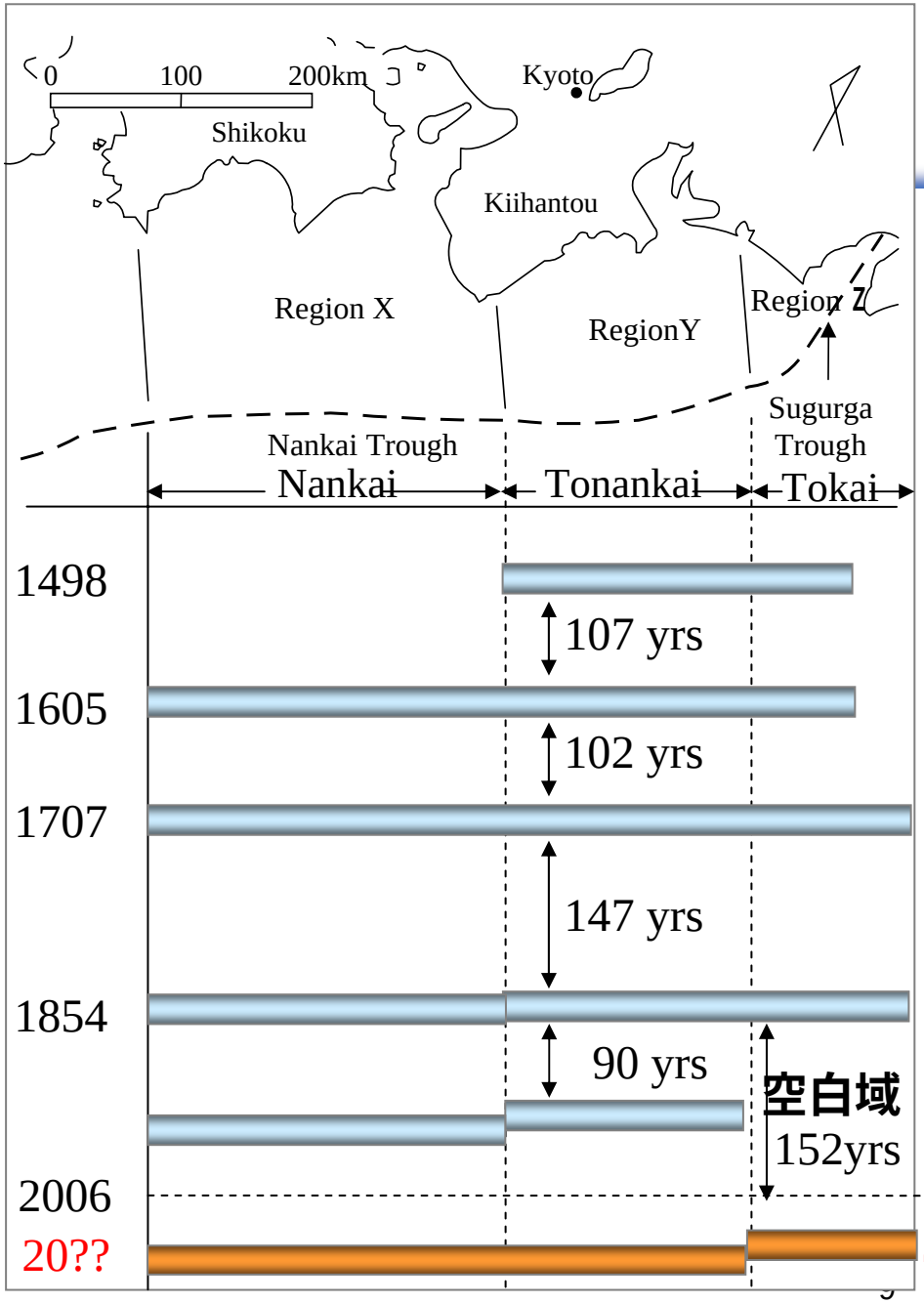
Historical Big Earthquakes and Rupture Zones along Nankai Trough



Sequent Big Earthquakes before/after 1854

1847 M7.4 Zenkoji EQ
1853 M6.7 Odawara
1854 M7.2 Iga Ueno
1855 M7.1 Ansei Edo EQ
1857 M7.2 Iyo Aki
1858 M7.1 Hietsu EQ

09/20 M8.3 Meio Tokai EQ

02/03 M7.9 Keicho EQ

10/28 M8.6 Hoei EQ

12/23 M8.4 Ansei Tokai EQ
12/24 M8.4 Ansei Nankai EQ

12/07 M7.9 Showa Tonankai EQ
12/21 M8.0 Showa Nakai EQ

Tokai EQ ?
Tokai・Tonanaki・Nankai EQ ?

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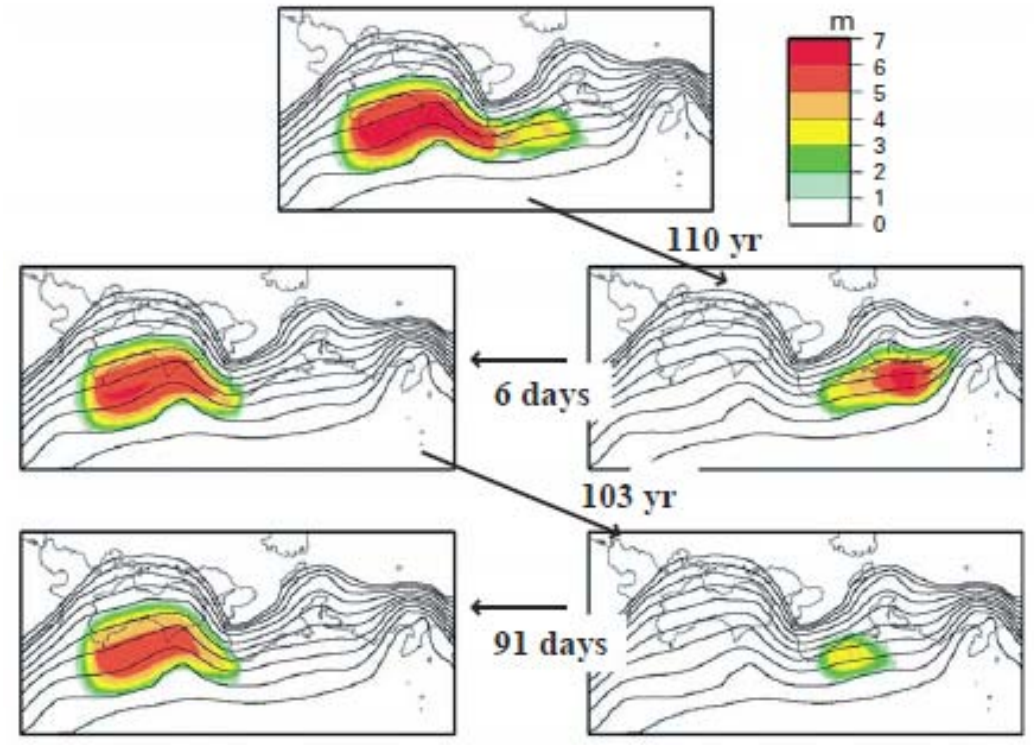
Recent Study

Simulation of plate activities along Nankai Trough



Kazuro Hirahara & others:"Simulation of Earthquake Generation Process in a Complex System of Faults", Annual Report of the Earth Simulator Center April 2004 - March 2005

Lapse Time	Interval	Nankai	Tonankai	Tokai
24.0 yrs	-	●	●	●
135.4 yrs	111.4 yrs		●	
135.5 yrs	26 days	●		
203.7 yrs	95.2 yrs		●	●
203.9 yrs	69 days	●		
343.4 yrs	111.2 yrs	●	●	
453.1 yrs	109.6 yrs		●	●
453.1 yrs	6 days	●		
556.1 yrs	103.0年		●	
556.3 yrs	91 days	●		
667.1 yrs	110.8 yrs	●	●	●

No event only by Tokai rupture zone

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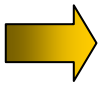
Characteristics of Seismic Risk

- Rate of Occurrence is very low.
  - Data accumulation is not enough to build a model with statistical methodologies.
  - Catastrophic event which has not ever occurred may possibly occur.
- Huge loss can be brought once it occurs.
  - Damage and loss can spread geographically, temporally, socially, economically, etc.
- Large Uncertainty
  - Heterogeneity of earth
  - Unknown characteristics of exposures
  - Difficult to estimate accurate loss amounts.

Seismic Risk of Financial Institute

- ***Direct Damage***
  - Physical Damae: Building, Facilities, Equipment, Furniture, etc.
  - Casualties: Employees, Other business related people
- ***Indirect Damage***
  - Physical Business Interruption
    - Cannot open bank houses
    - Damage/Interruption of banking IT systems
    - Cannot transport cash, notes, checks, etc. (damages of banks, transportation companies, road, etc)
  - Cannot access settlement system (individual bank)
    - Cash flow risk of individual bank
      - ***Settlement and liquidity risk***
        ～ Cash flow failure
    - Invoke credit uneasiness of a bank
      - A run on the bank ＝ ***Rumor risk***
    - Cannot adjust one's position
      - Risk of operational loss ～worsening income statement



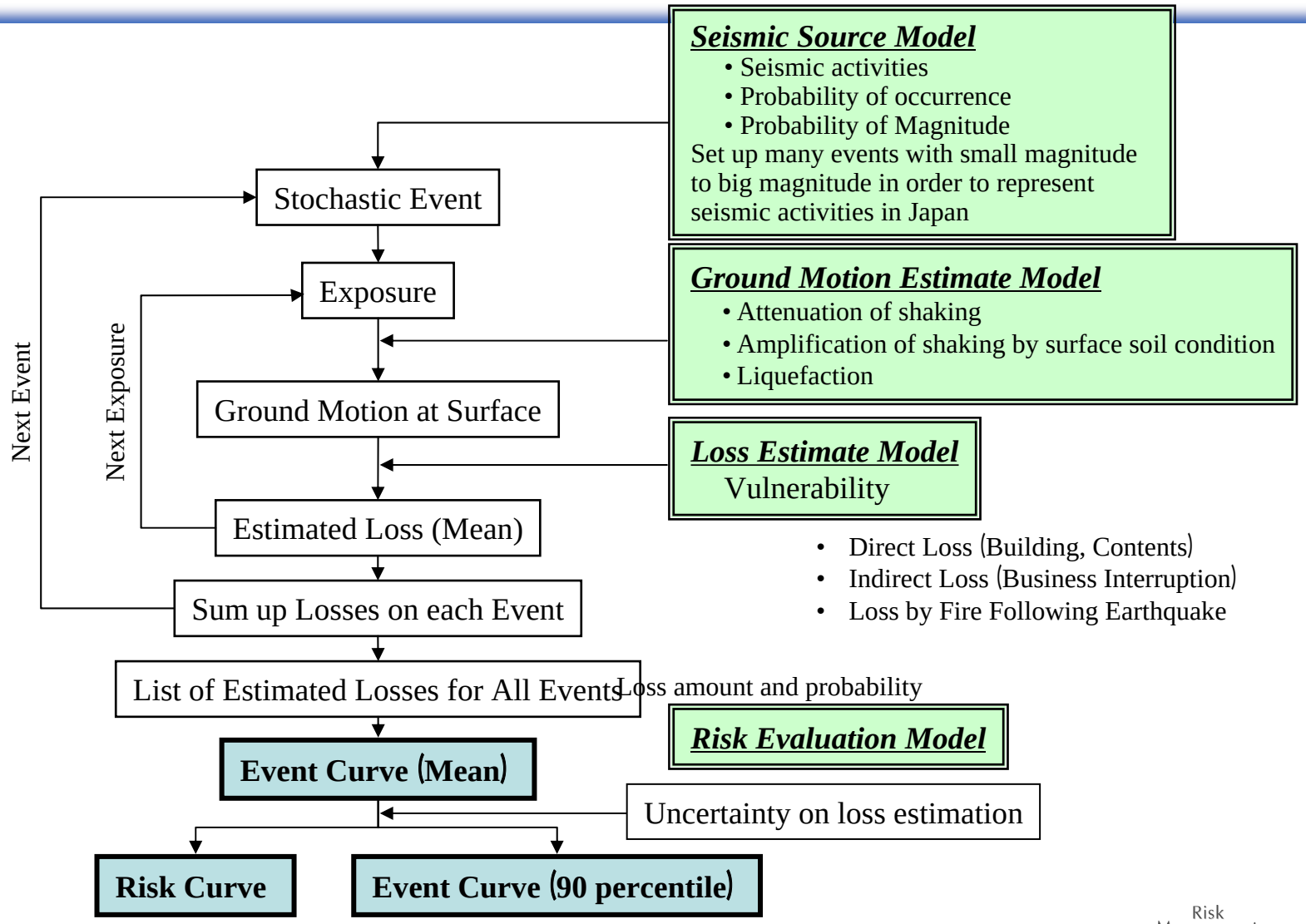
- Infringement of the bank law on duties of operation
  - Penalty
- Delay/Inability of settlement process for customers
  - Trouble to customers Suspension of business transactions of customers with banks Bankrupt of customers
  - ***Credit risk*** on one's loan portfolio

Definition of Operational Risk by Basel II

- "The risk of direct or indirect loss resulting from inadequate or failed internal processes, people and systems or from external events"
- Measurable risk except for credit risk and market risk (excluding rumor risk)
- In addition with direct loss such as physical loss, indirect loss such as cost caused by one mistake is also included.

Quantitative Seismic Risk Analysis

Flow of Seismic Risk Analysis



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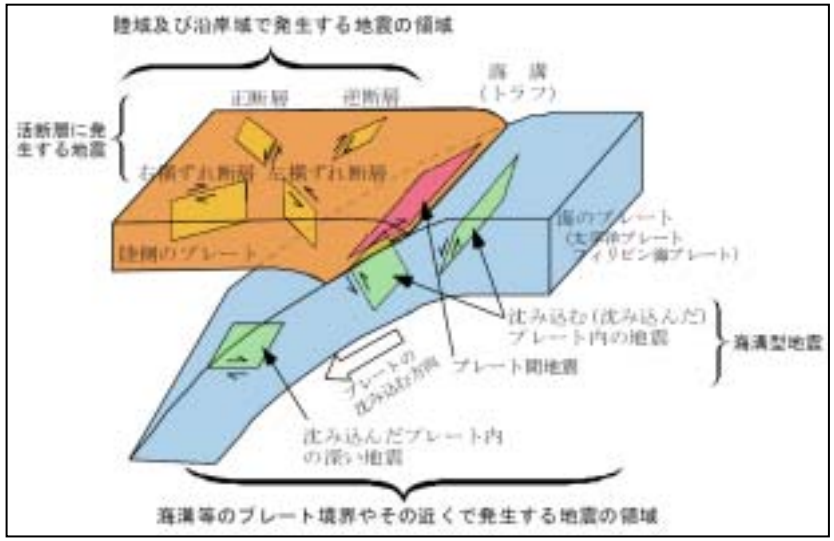
Seismic Source Model

- Build a source model for each type of earthquake
  - Subduction interface source model
    - Subduction interface events occur along the surface of contact between the two plates
    - Ex: Great Kanto EQ, Tokai EQ
  - Sbuduction interaslab source model
    - Subduction intraslab events occur within the subducting slab
    - Ex: Geiyo EQ, Off-shore Kushiro EQ
  - Active fault model
    - Crustal earthquakes occur along known active faults
    - Ex: Nobi EQ, Fukui EQ
  - Background Source Model
    - EQs difficult to know occurrence place in advance
    - Ex: 2005 Fukuoka East Offshore, 2000 Eastern Tottori EQ



- Set up many events of each source model
  - Give annual probability of occurrence to each event

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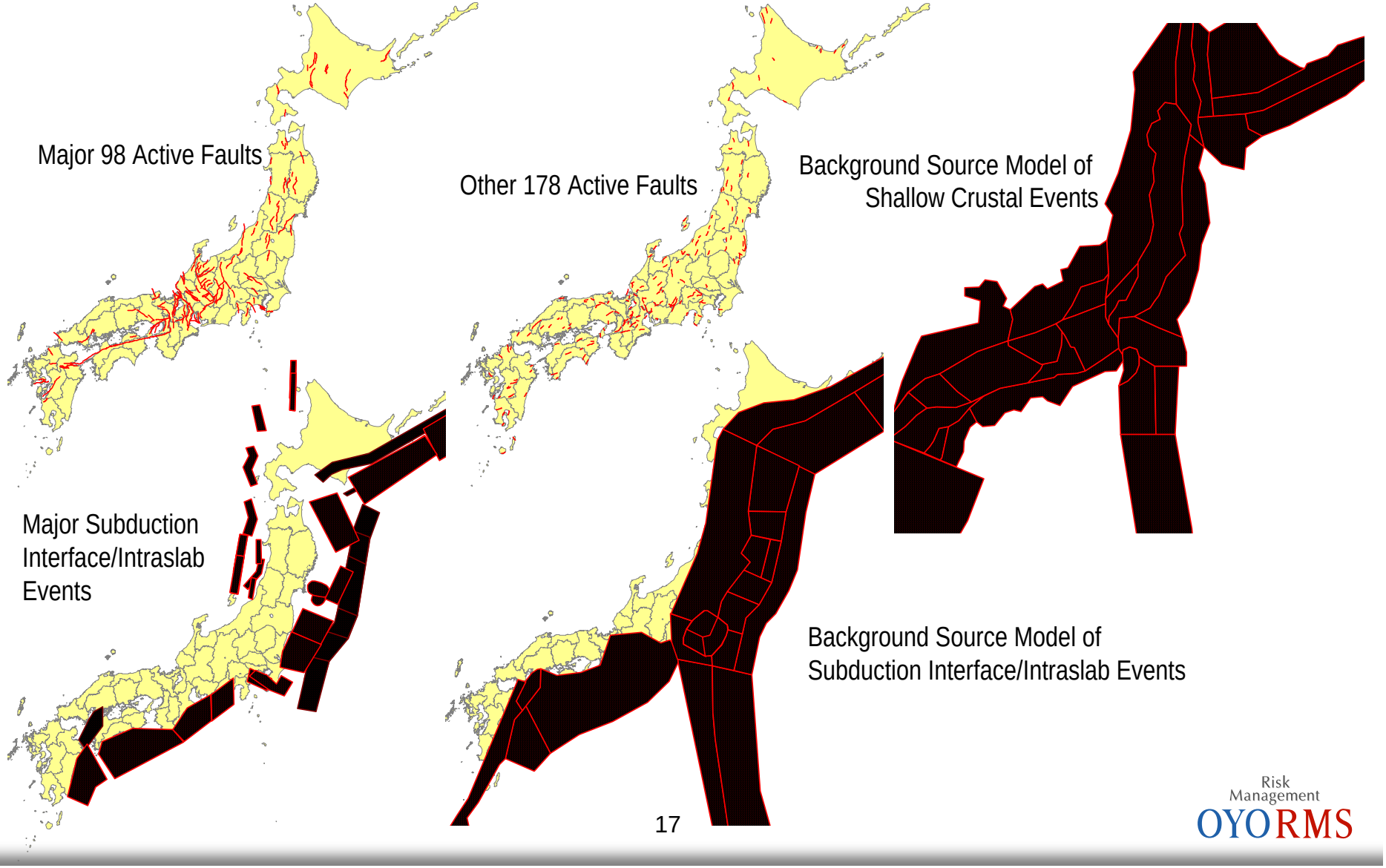
Seismic Source Model



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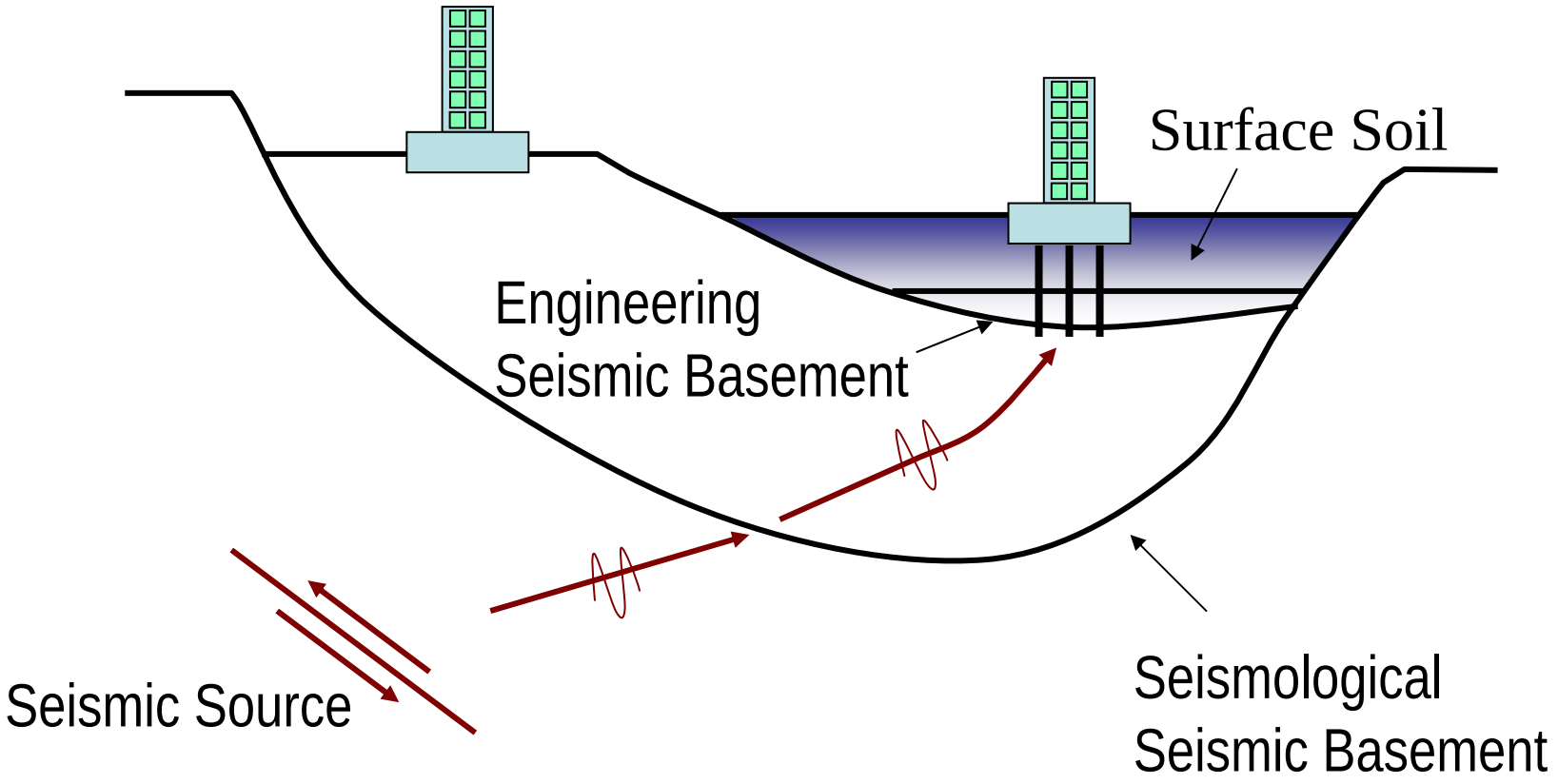
Concept for Estimating Ground Motion



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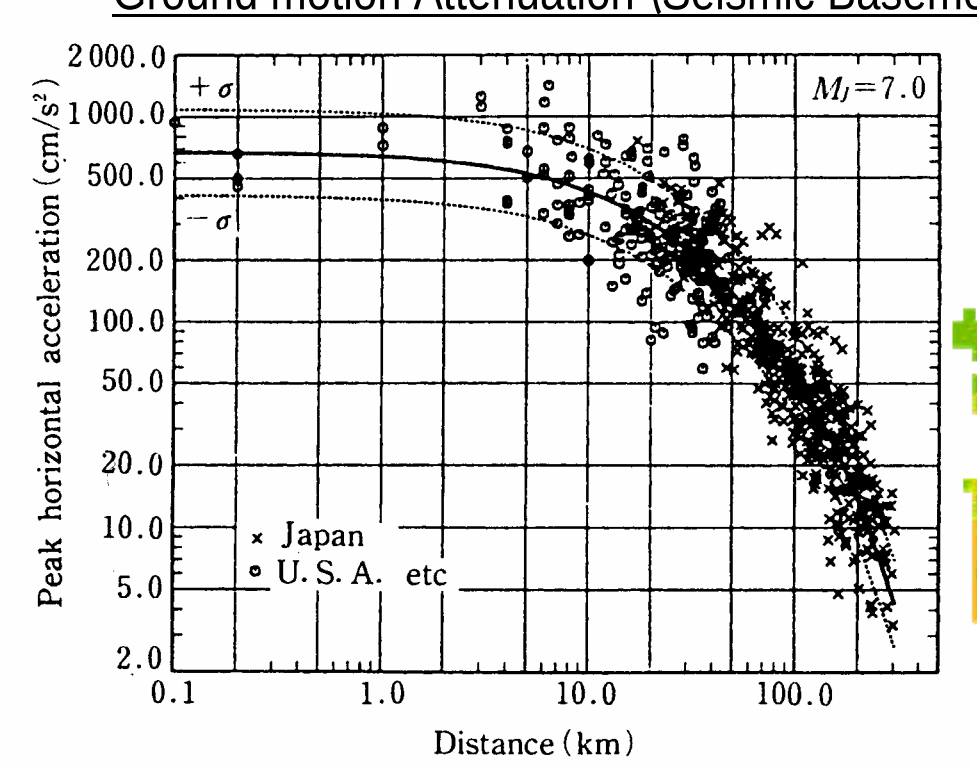
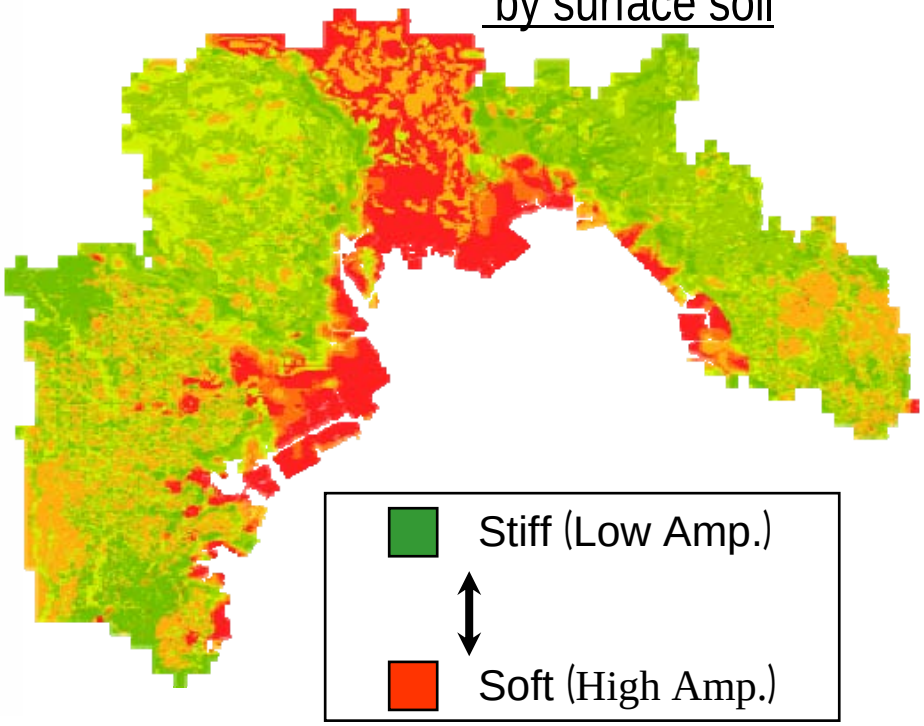
Ground Motion Estimate Model

Ground motion at Surface = Ground motion at seismic basement (M, Δ)
✕Amplification factor by surface soil

Ground motion Attenuation (Seismic Basement)



Amplification of ground motion by surface soil



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