Current status of Seismic Hazard Map in Korea

2011. 11. 25.

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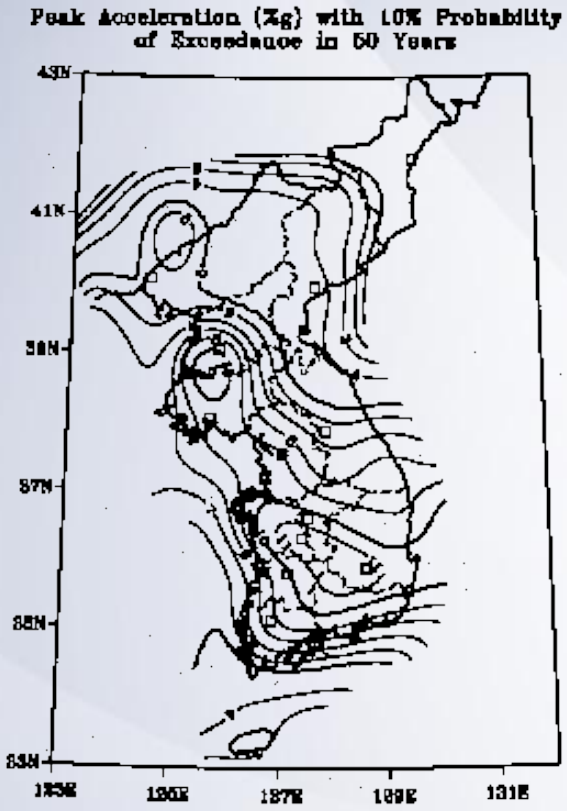
Korea Institute of Geoscience and Mineral Resources (KIGAM)

Background of Korean PSHM

- 1995. 1. 17. Hyogo EQ. (M 6.9)
- 1995. 12. 6. Countermeasure Act for Natural Disaster
- 1997. 12. 1st PSHM made by Ministry of Construction and Transportation (Supported by Earthquake Engineering Society of Korea)
- 2004 Sumatra EQ. (M 9.1), 2005 Pakistan EQ.(M 7.6)
- 2008. 3. 28. Countermeasure Act for Earthquake Disaster
  - Recommendation for renewal of PSHM every 5 years
  - Recommendation for supplying an Active fault map
- 2009. 3. 1. ~ 2012. 8. 31.
  Project Title : "Making an Active fault map and Seismic hazard map"
  - Principal Institute : KIGAM
  - Agency : National Emergency Management Agency (NEMA)

‘97 PSHM



PGA(%g) with 10% probability of exceedence in 50 years

☐ Seismic Source

- Only using Historical & Instrumental Earthquake Catalog
- Without considering the geological & geodetical data
- Without considering the incompleteness of historical earthquake catalog

☐ Path

- Because of no adequate seismic attenuation formula for Korean peninsula,
- Using the attenuation formula of US Eastern region
- Without considering the frequency dependency

☐ Site effect

- Without considering the site effect

Annual objects & contents of PSHM Project

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	1st Year (2009)	2nd Year (2010)	3rd Year(2011)
Annual objects	• Collect whole available seismic data and information • Analysis of the previous research results	• Historical Earthquake Catalog • Collect and sensitivity analysis of input parameters	• Revision of PSHM
Contents	• Analysis the present PSHM • Comparison with the various procedures including foreign countries method to make Korean PSHM • Operation of specialist committee to develop future research direction and contents	• Operation of specialist committee & holding the public hearing to make an unified historical earthquake catalog • Sensitivity analysis of the input parameters for PSHM • Collect & Analysis of the data related to the site amplification	• Preparing the Logic tree & input parameter • Operation of specialist committee & holding the public hearing to make an PSHM • Collect & Analysis of the data related to the site amplification
Product		• Historical & Instrumental Earthquake Catalog	• National PSHM • Site amplification map for 5 metropolitan cities

Procedure for PSHM

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1. PSHM Methodology

- Comparison with various PSHM Methodology

2. Sensitivity Analysis of Input Parameters

- Historical & Instrumental EQ Catalog
- Attenuation Formula
- Intensity-Magnitude Conversion Formula
- Depth, etc

3. Calculation of PSHM

- Applying Logic Tree method & Preparing the basic input data/parameter
- Open consensus-building process
  ; Operation of specialists committee including the variety major
  ; Holing the public hearing

1. PSHM Methodology

KIGAM

☐ Evaluation of the Spatially Smoothed Method

. Criteria for seismic design(II), Ministration of Construction & Transportation, Earthquake Engineering Society of Korea, 1997.

. Peterson, M.D., and others, 2008, United States National Seismic Hazard Maps

. Frankel, A. and others, Documentation for the 2002 Update of the National Seismic Hazard Maps

. Frankel, A. and others, 1996, National Seismic Hazard Maps

☐ Evaluation of the Seismic Zoninig Method

. Cornell, C.A., 1968, Engineering seismic risk analysis

. SSHAC, 1997, Recommendations for PSHM, US Nuclear Regulatory Commission report

. Klugel, 2009, Probabilistic seismic hazard analysis for nuclear power plants

. KOPEC, 2003, Probabilistic seismic hazard analysis for SHINWOLSONG 1&2 nuclear power plant site.

1. PSHM Methodology

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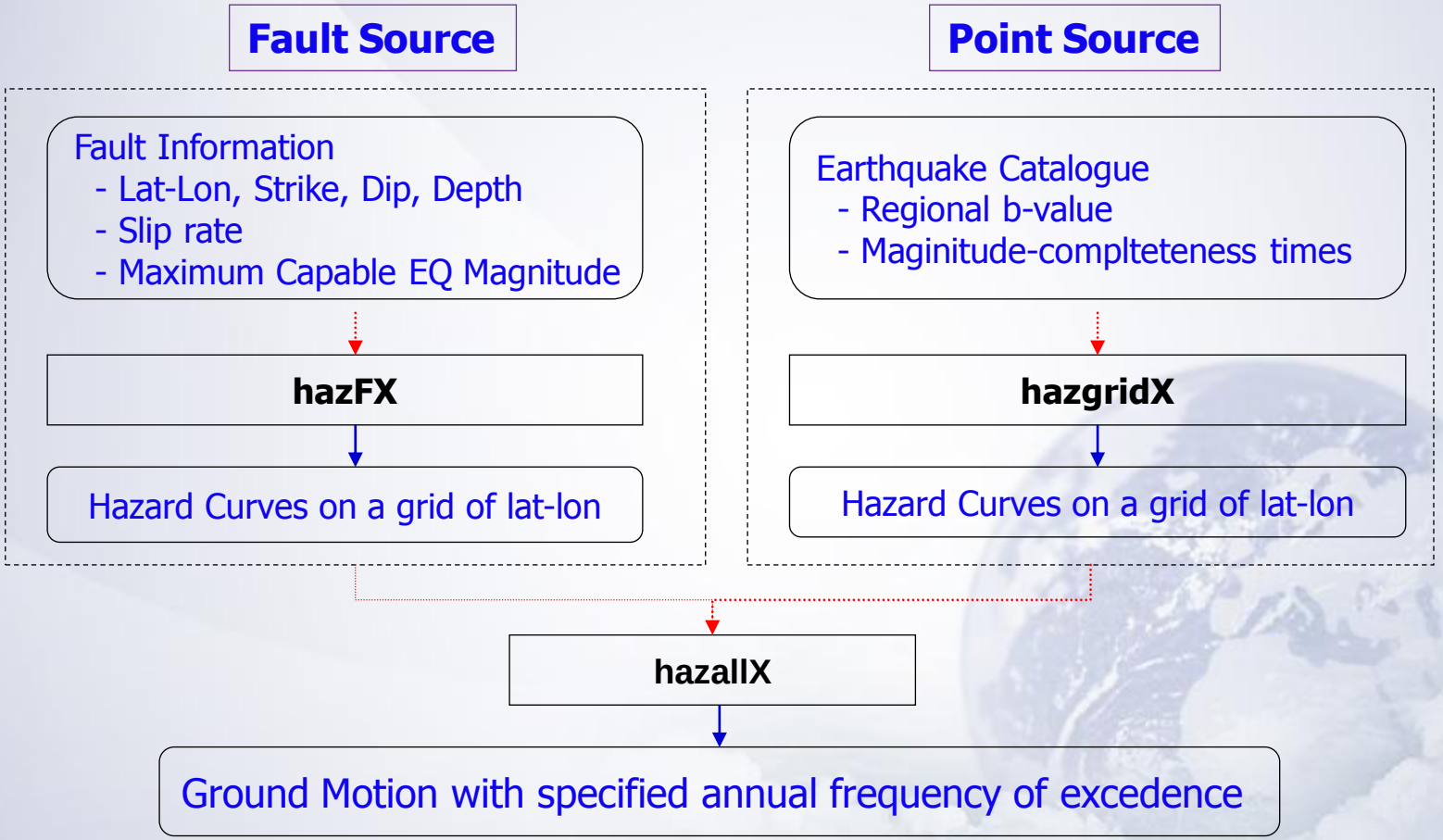
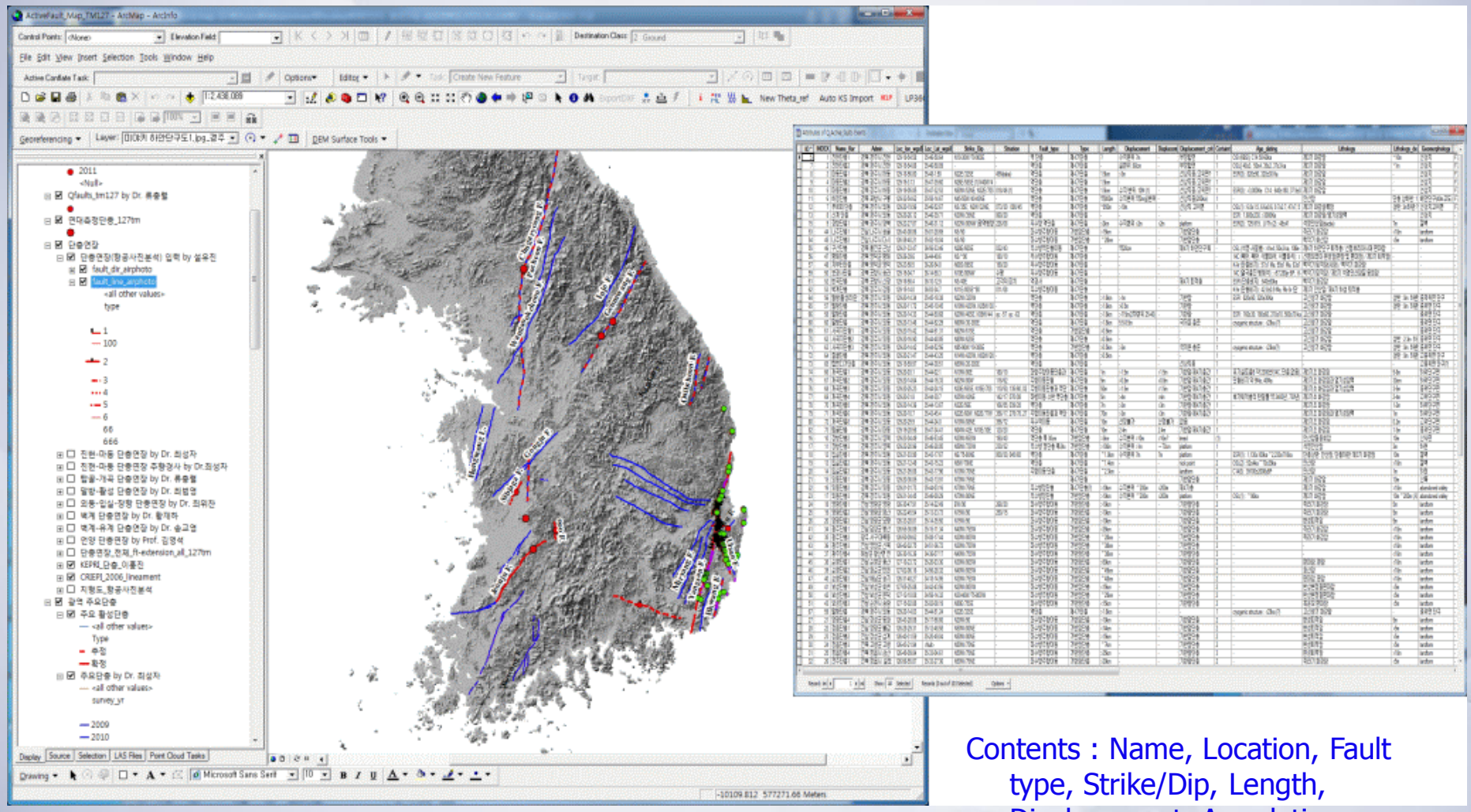
USGS PSHA Method



1. PSHM Methodology

Active Faults D/B

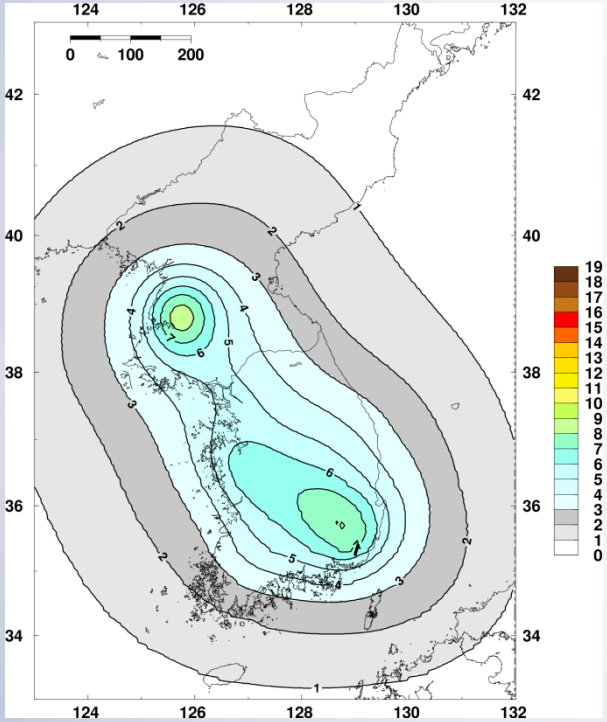


Contents : Name, Location, Fault type, Strike/Dip, Length, Displacement, Age dating, Lithology, etc

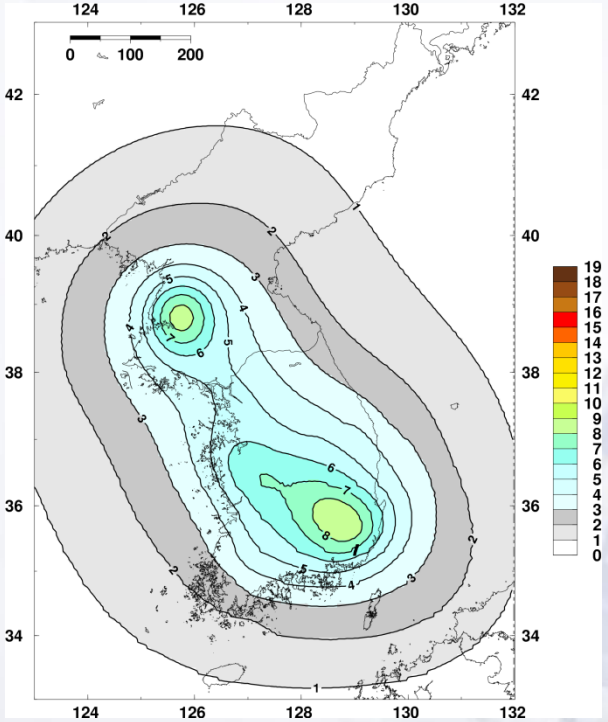
1. PSHM Methodology

Sensitivity Analysis of PSHM using by USGS Method

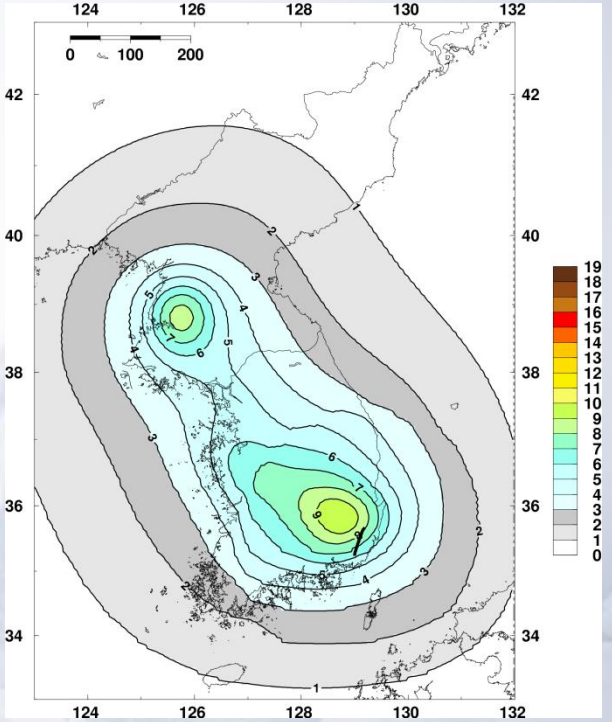
- Slip Rate : 7.0 mm/year



[Length: **10**km, Mmax **: 6.0]**



[Length: **20**km, Mmax **: 6.5]**



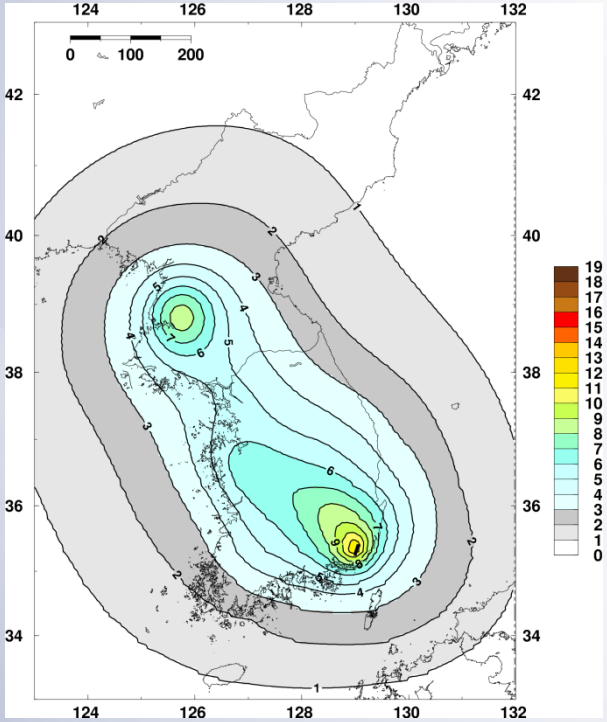
[Length: **50**km, Mmax **: 7.0]**

***PGA[%g] for 50years**

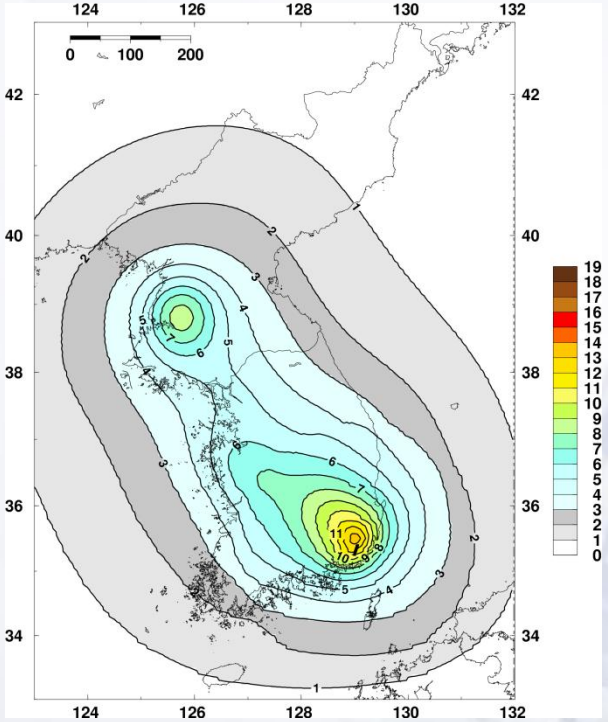
1. PSHM Methodology

Sensitivity Analysis of PSHM using by USGS Method

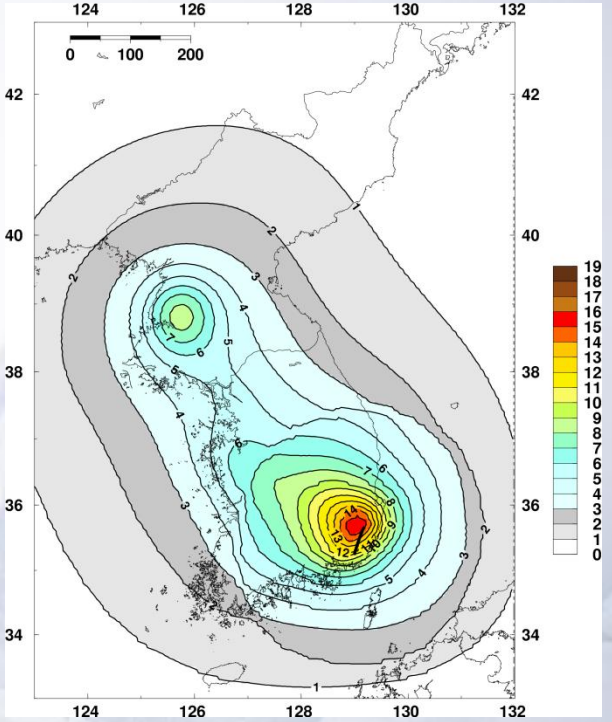
- Slip Rate : 14.0 mm/year



[Length: **10**km, Mmax **: 6.0]**



[Length: **20**km, Mmax **: 6.5]**



[Length: **50**km, Mmax **: 7.0]**

***PGA[%g] for 50years**

2. Input Data/Parameters

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□ USGS(2008)
; combine earthquakes from several (reformatted) source catalogs, choose one preferred record for each event that is listed more than once, and decluster to remove aftershocks and foreshocks

- Western North America(WNA) Catalog
- Central & Eastern North America(CENA) Catalog

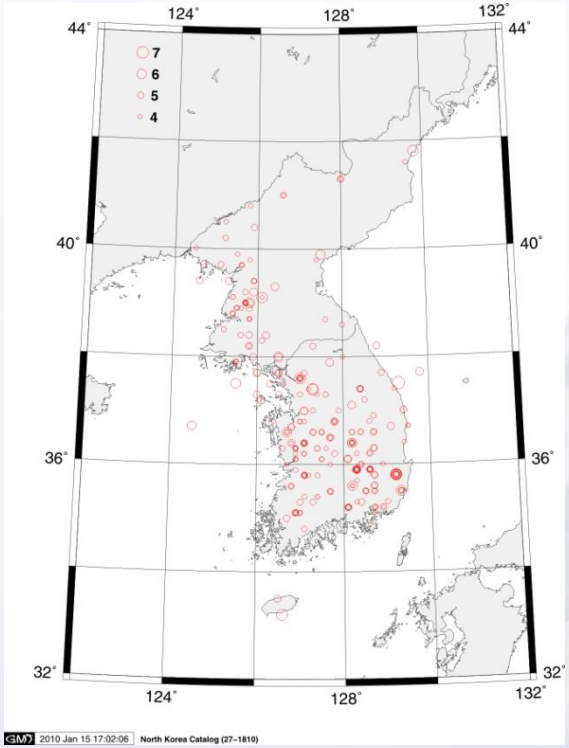
□ Japan NIED(2009)
; Chronological Scientific Tables(自然科學研究機構 國立天文臺 編)

- ~1884 : Tatsuo Usami Catalog(宇佐美龍夫)
- 1885~1925 : Tokuji Utsu(宇津德治)
- 1926~ : JMA

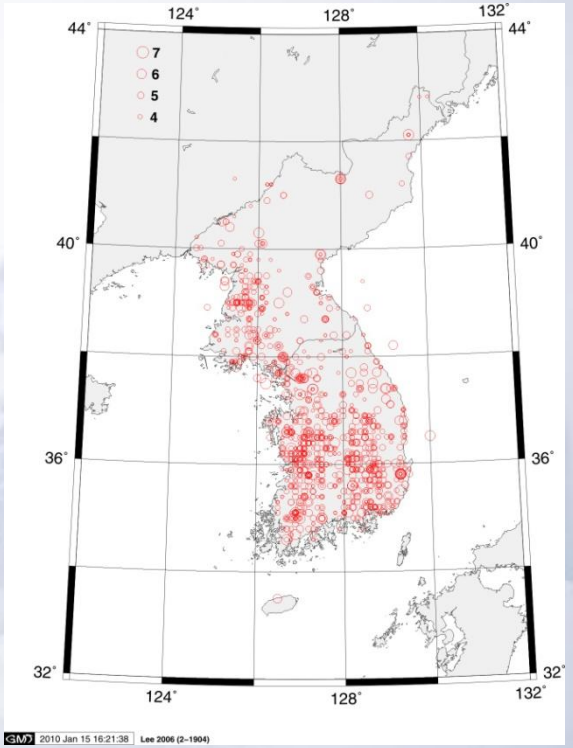
2. Input Data/Parameters

☐ Collection & Analysis of available earthquake list and research results

- 嚴相鎬(1978), 金昭九(1978)
- 鄭鳳一(1981)
- 韓國動力資源研究所(1983)
- 朝鮮地震研究所(1984, 1987)
- 李基和(1985, 1998, 2003, 2005, 2006)
  : 2,186 historical earthquake list
- 慶在福(1989, 2009)
  : 2,113 historicla EQ. List
- 建設交通部(1997)
- 國立防災研究所(1999)
- 原子力安全研究院(2000)



朝鮮地震研究所(1987)

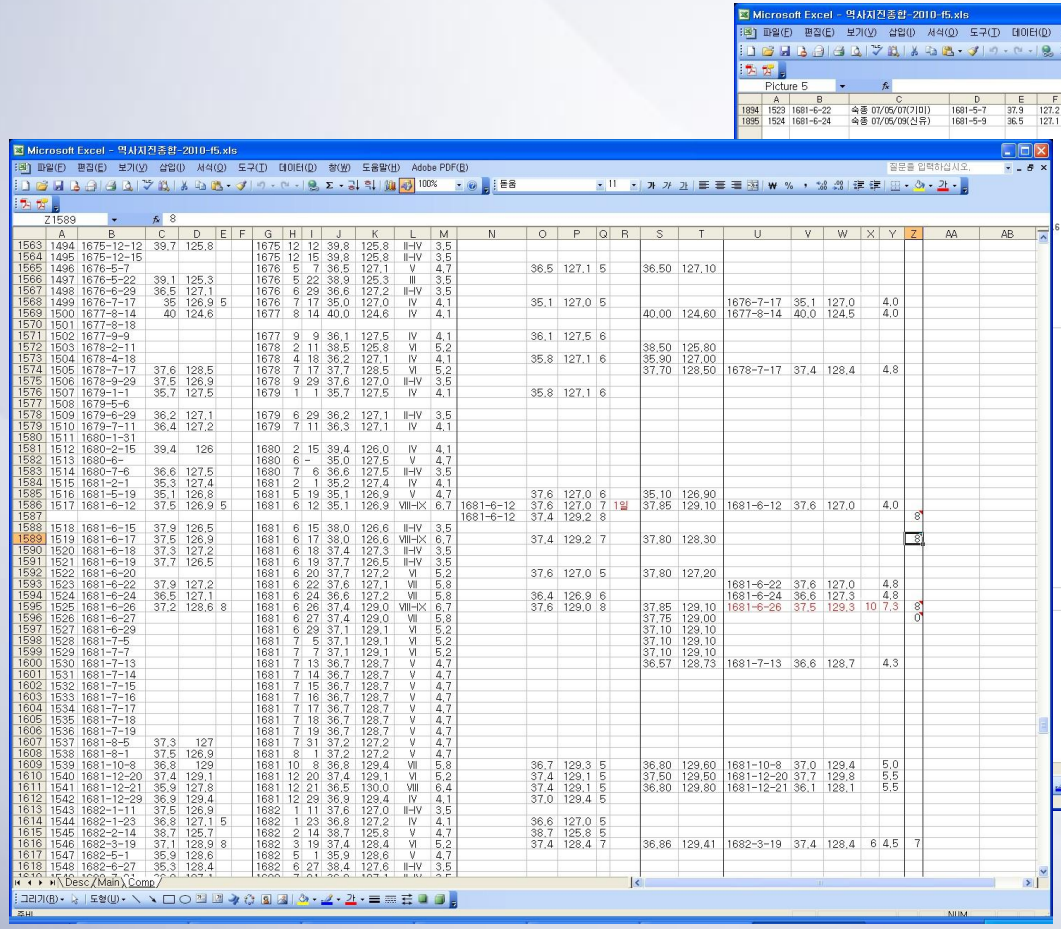


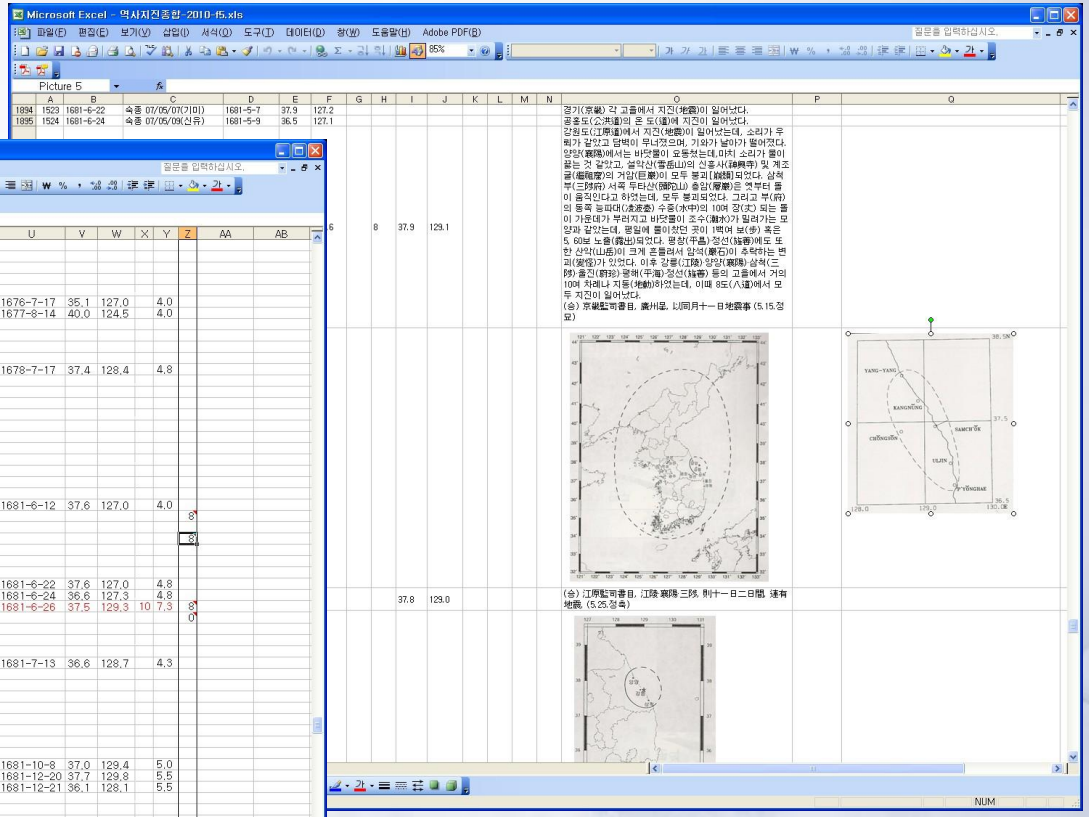
李基和外(2006)

2. Input Data/Parameters

☐ Historical EQ D/B Construction

- Collect all available lists & Publications
- Collect EQ information from National & University D/B related to historical record
- Adjacent countries D/B and List



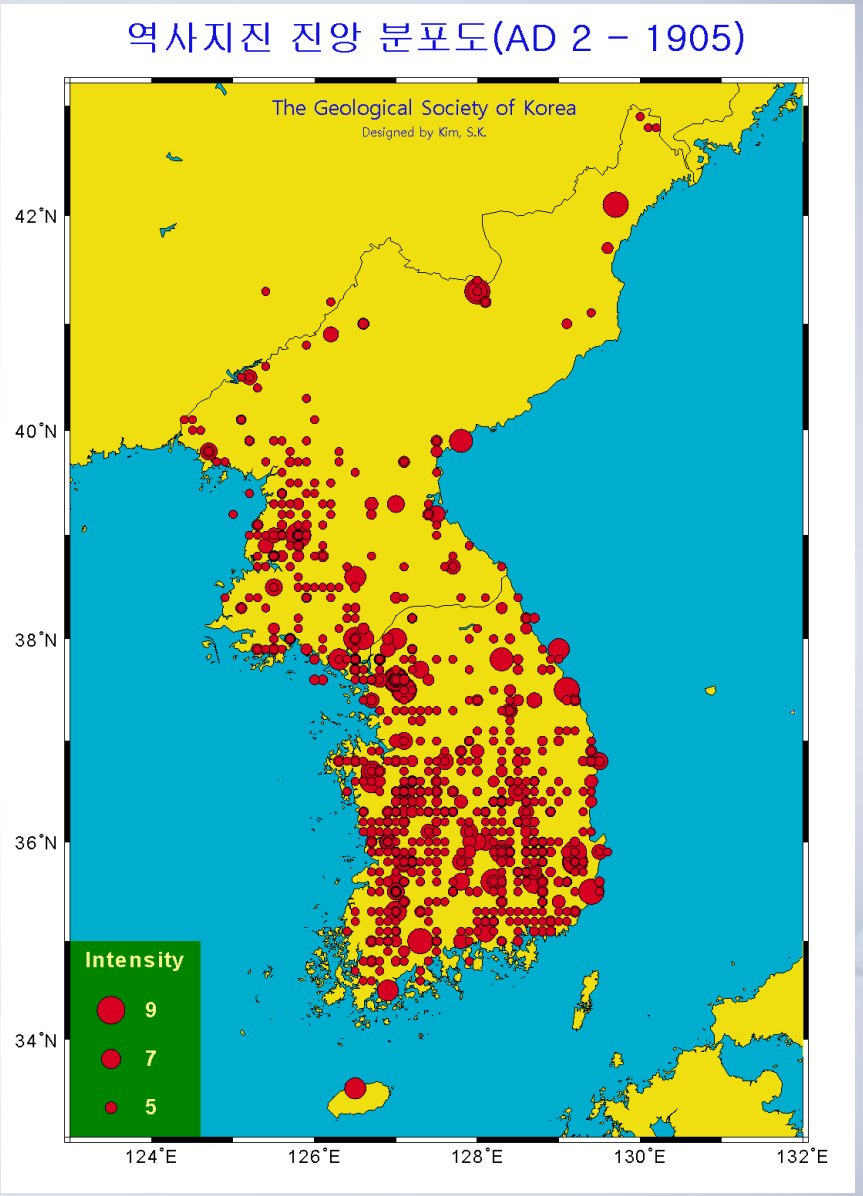


2. Input Data/Parameters

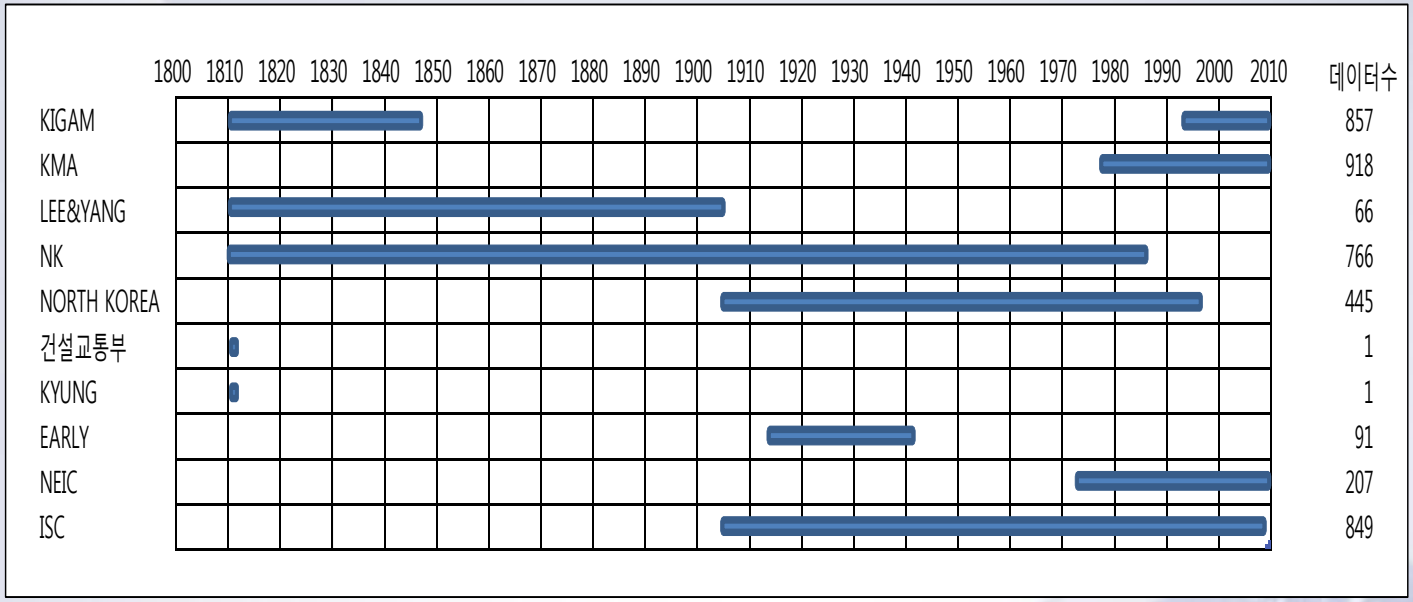
☐ Setup specific criteria for
- Unified Event List
- Epicenter determination
- Intensity determination
  ; Felt-area–Intensity relationship
  ; according to the description for
    Human & Animal
    Building (castle, fortress, house, wall, etc)
    Natural phenomenon (surface rupture, shaking, liquefaction, etc)

☐ Operation of specialist committee
- Confirmation above criterion
- Review the final historical EQ catalog
- Revaluation for the 64 big historical EQ

☐ Holding the public hearing to make an unified(acceptable?) historical earthquake catalog

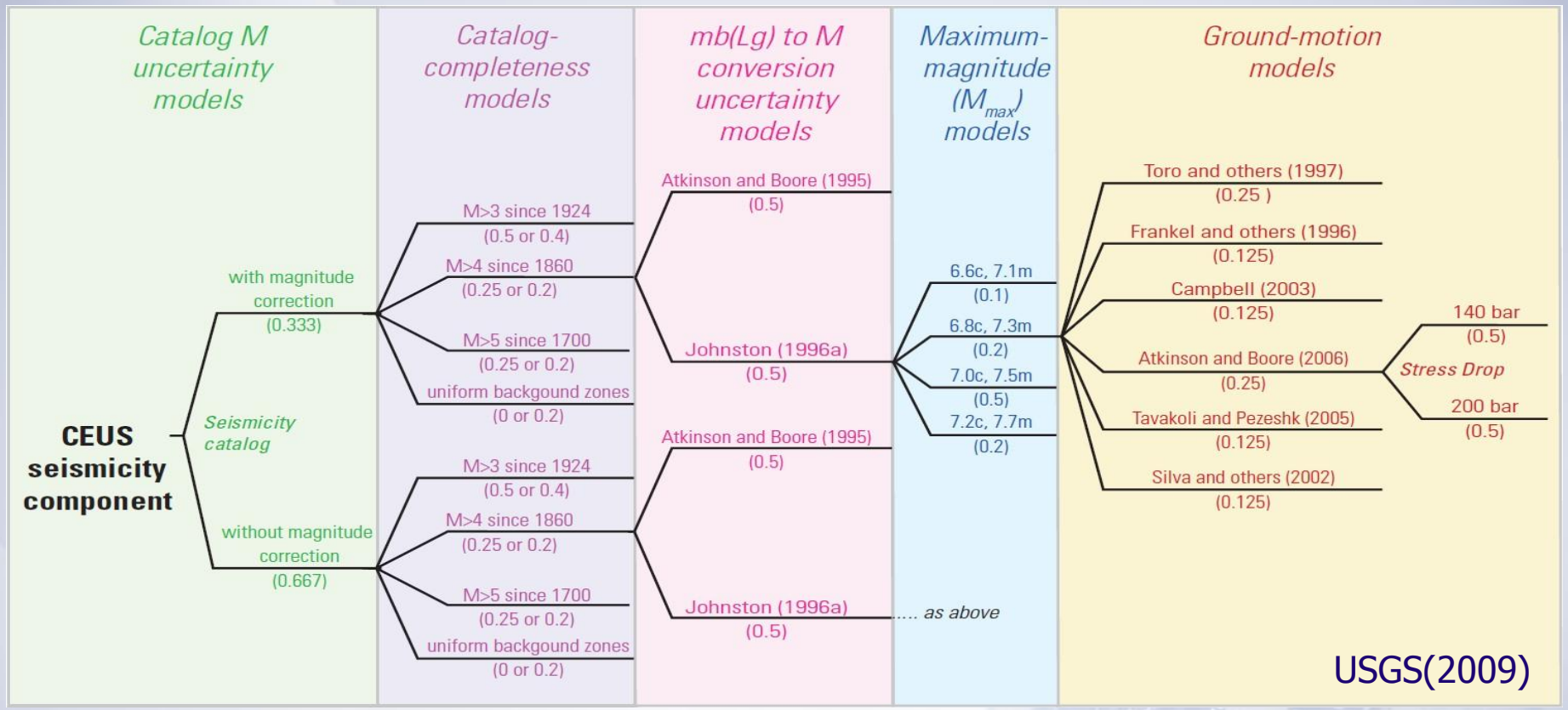


2. Input Data/Parameters



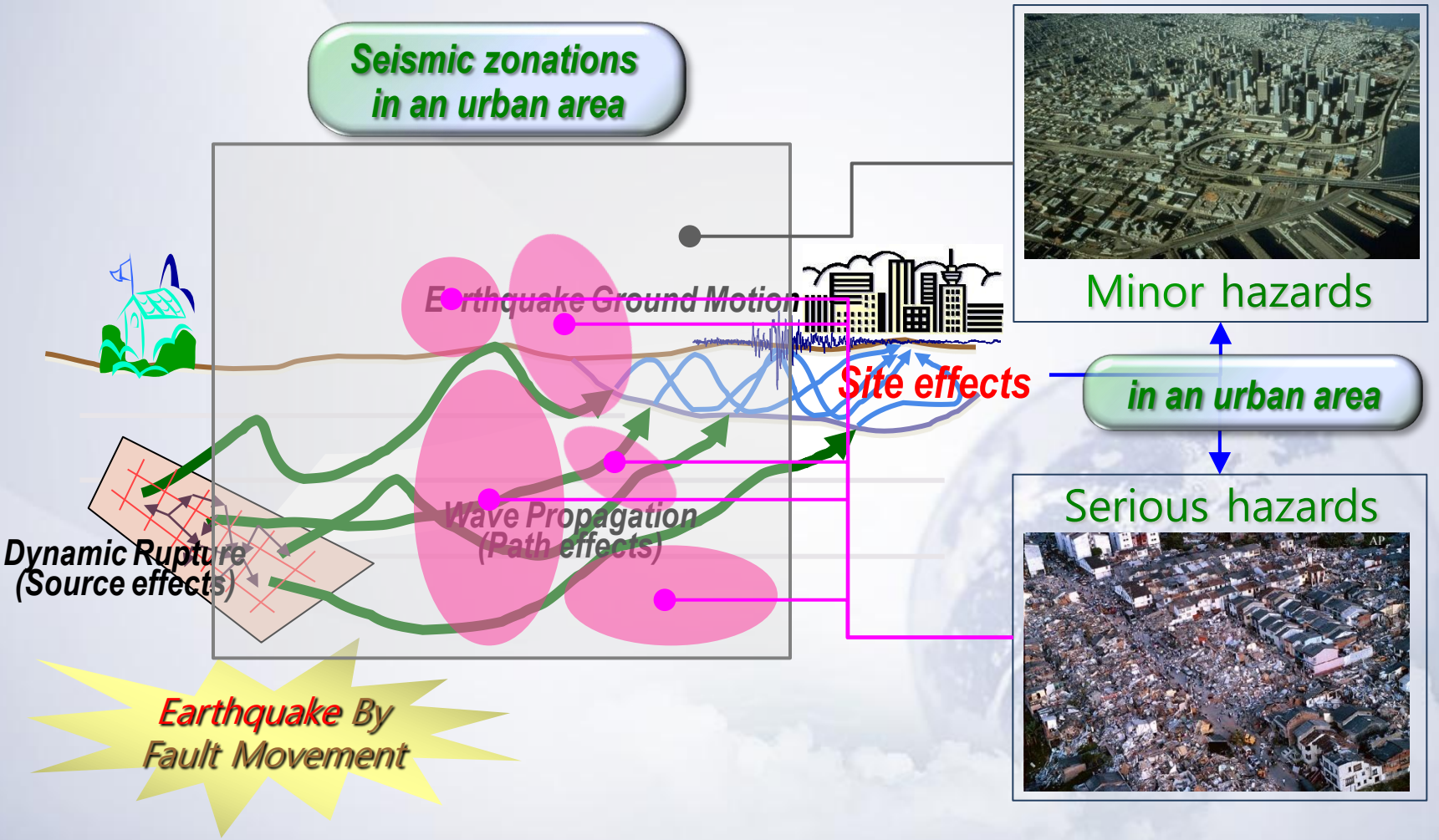
Organization	Duration			No. of Events
KIGAM	02-08	~	2010-11-28	2437
KMA	1978-08-30	~	2010-12-20	918
LEE&YANG	02-08	~	1904-03-23	1928
NK	27-10	~	1985-12-23	1057
NORTH KOREA	1905-08-25	~	1996-11-17	445
Ministry of Construction	27-00	~	1810-01-20	389
KYUNG	27-00	~	1810-02-19	449
EARLY	1913-05-12	~	1941-12-15	91
NEIC	1973-09-10	~	2009-08-10	207
ISC	1905-08-25	~	2009-05-01	849

3. PSHM Calculation



- Construction of specialist committee to conduct the logic tree evaluation, consisted of various major field
- Now, finalizing the logic tree & preparing input data and parameters

4. Site Amplification



4. Site Amplification

Current Site Classification Scheme in Most Codes

– Western Region of US

Soil Profile Type	Generic Description	Average Soil Prop $\overline{Vs}$ (Vs30) (m/s)	Short-Period				Mid-Period			
			Z = 0.11		Z = 0.07		Z =0.11		Z = 0.07	
			C_a	F_a	C_a	F_a	C_v	F_v	C_v	F_v
S_A (Site Class A)	Hard Rock	> 1,500	0.09	0.82	0.05	0.71	0.09	0.82	0.05	0.71
S_B (Site Class B)	Rock	760 - 1,500	0.11	1.00	0.07	1.00	0.11	1.00	0.07	1.00
S_C (Site Class C)	Very Dense and Soft Rock	360 - 760	0.13	1.18	0.08	1.14	0.18	1.64	0.11	1.57
S_D (Site Class D)	Stiff Soil	180 - 360	0.16	1.45	0.11	1.57	0.23	2.09	0.16	2.29
S_E (Site Class E)	Soft Soil	< 180	0.22	2.00	0.17	2.43	0.37	3.36	0.23	3.29
S_F (Site Class F)	Soil Requiring Site-specific Evaluation									

C : Seismic Coefficient
Short Period : 0.1 ~ 0.5 sec,

F : Site Amplification Factor
Mid-Period : 0.4 ~ 2.0 sec

Z : Seismic Zone Factor

4. Site Amplification

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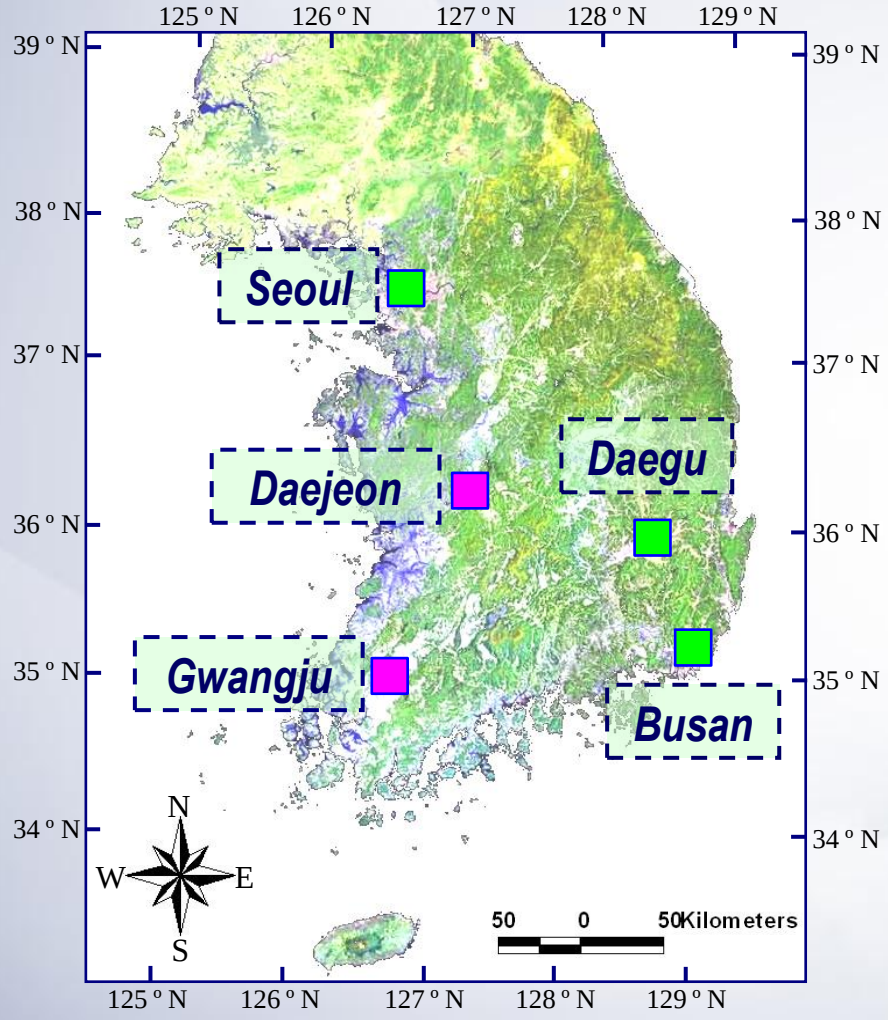
Modification of Site Classification

$$T_G = 4\sum_{i=1}^{n}\frac{D_i}{V_{Si}}$$

Generic Description	Site Class		Criteria		Site Coefficients	
			V_S30 (m/s)	T_G (s)	F_a	F_v
Rock	B		> 760	< 0.06	1.00	1.00
Weathered Rock and Very Stiff Soil	C	C1	> 620	< 0.10	1.28	1.04
		C2	> 520	< 0.14	1.45	1.09
Intermediate Stiff Soil		C3	> 440	< 0.20	1.65	1.13
		C4	> 360	< 0.29	1.90	1.19
Deep Stiff Soil	D	D1	> 320	< 0.38	2.08	1.23
		D2	> 280	< 0.46	2.26	1.29
		D3	> 240	< 0.54	2.48	1.36
		D4	> 180	< 0.62	2.86	1.43
Deep Soft Soil	E		≤ 180	≥ 0.62	1.50	2.00

4. Site Amplification

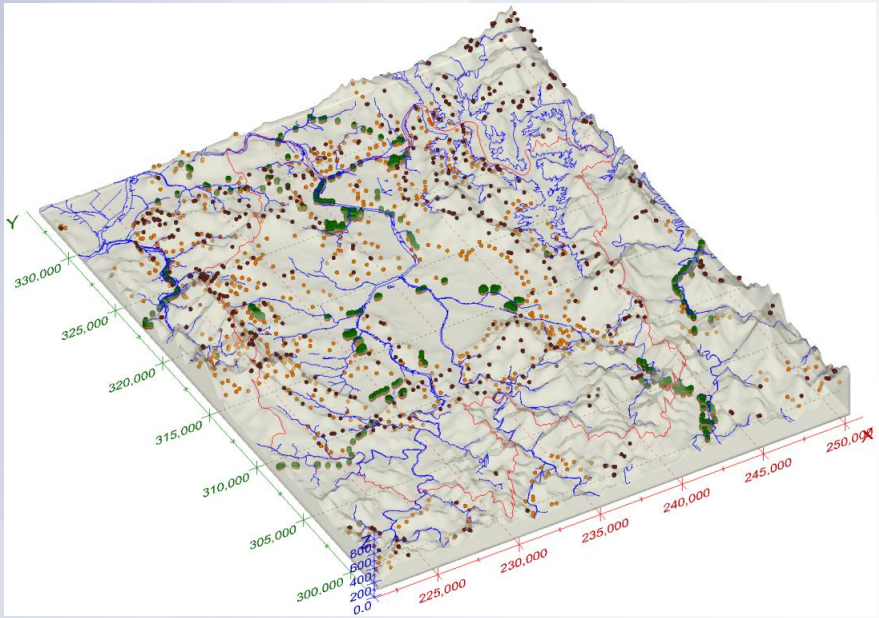
For five metropolitan cities, Seoul, Daejeon, Gwangju, Daegu, Busan

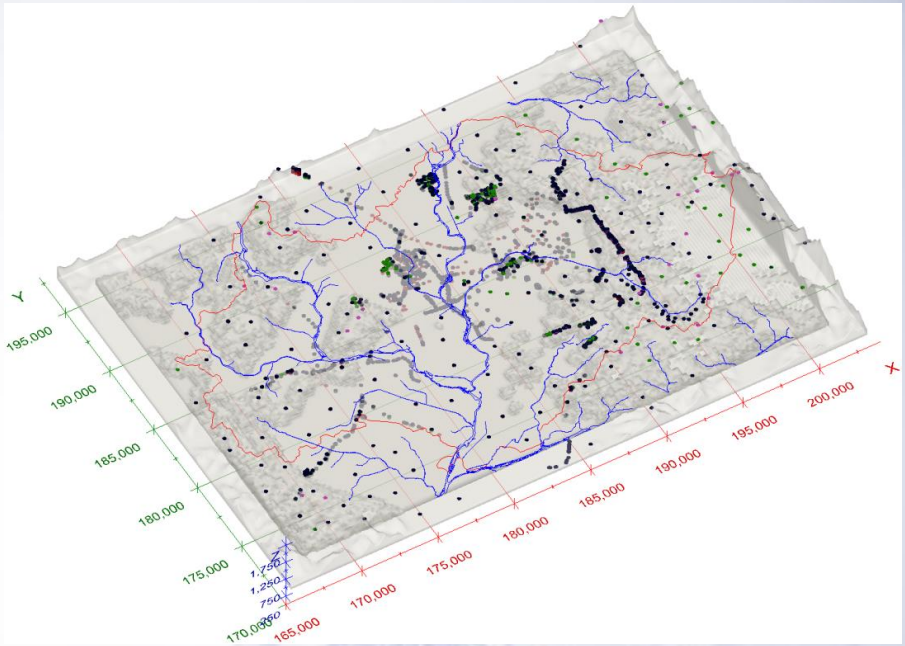


- Building the geotechnical DB composed of the existing borehole drilling data and surface geo-knowledge data
- Implementing the GIS-based geotechnical information system for spatial geotechnical (geo-) layers using the geotechnical DB
- Creating a variety of spatial zoning maps for quantifying the site effects in terms of the site period within GIS-based tools
- Annual Target Area
  - ✓2010 : Daejeon, Gwangju
  - ✓2011 : Seoul, Daegu, Busan

4. Site Amplification

Geotechnical database (2010)





Daejeon : Collecting more than 1,300 existing Borehole drilling data and acquiring about 300 surface goe-knowledge data for each target area

Kwangju : More than 1,900 borehole data and about 300 surface data

4. Site Amplification

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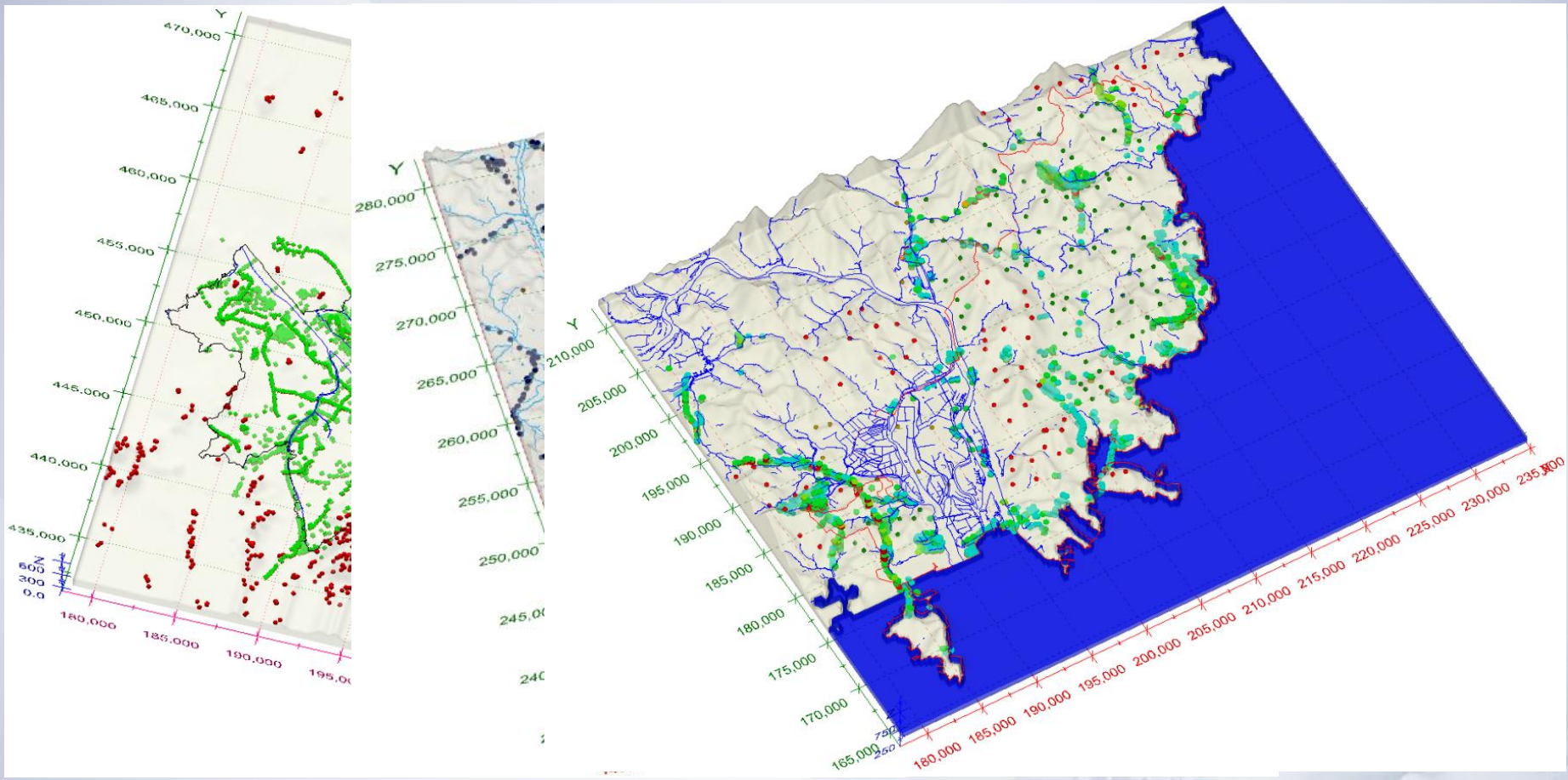
Geotechnical database (2010)

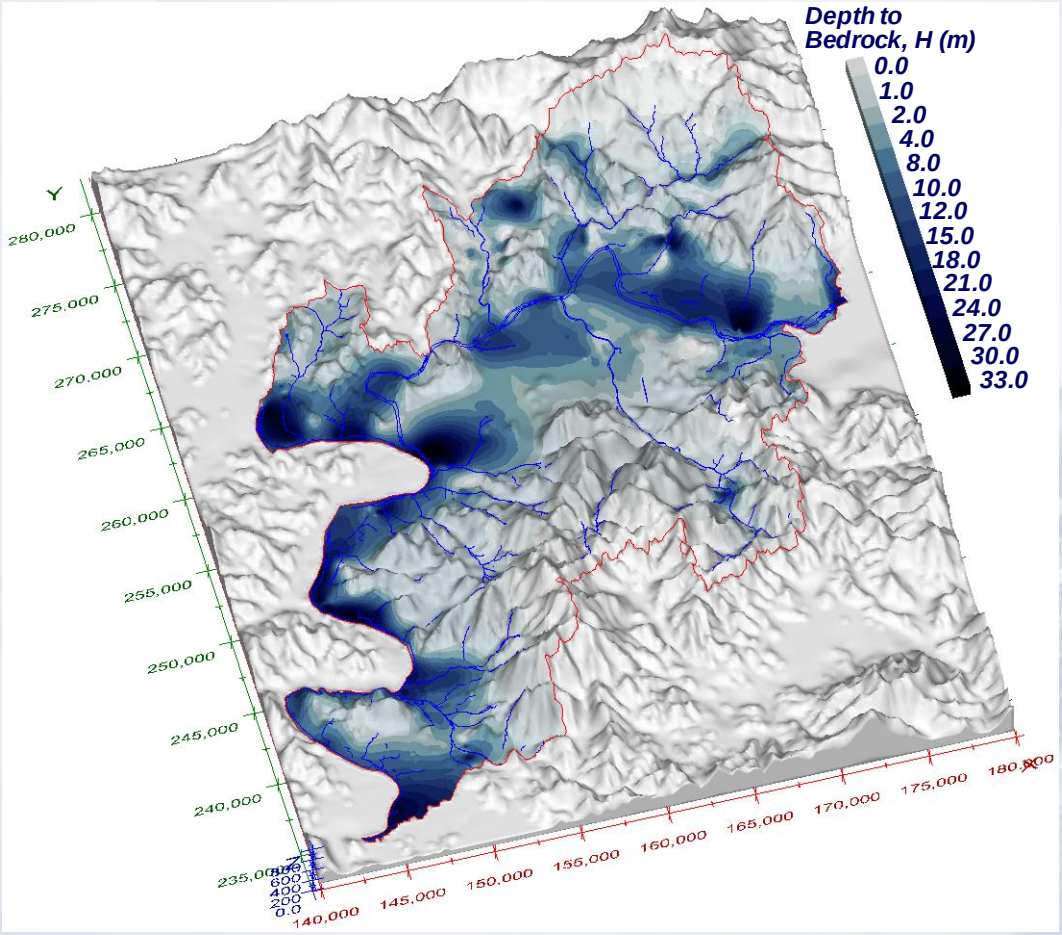


Seoul : More than 10,800 borehole data & about 900 surface data
Daegu : More than 1,800 borehole data and about 300 surface data
Busan : More than 2,900 borehole data and about 200 surface data

4. Site Amplification

Depth to bedrock in Daegu

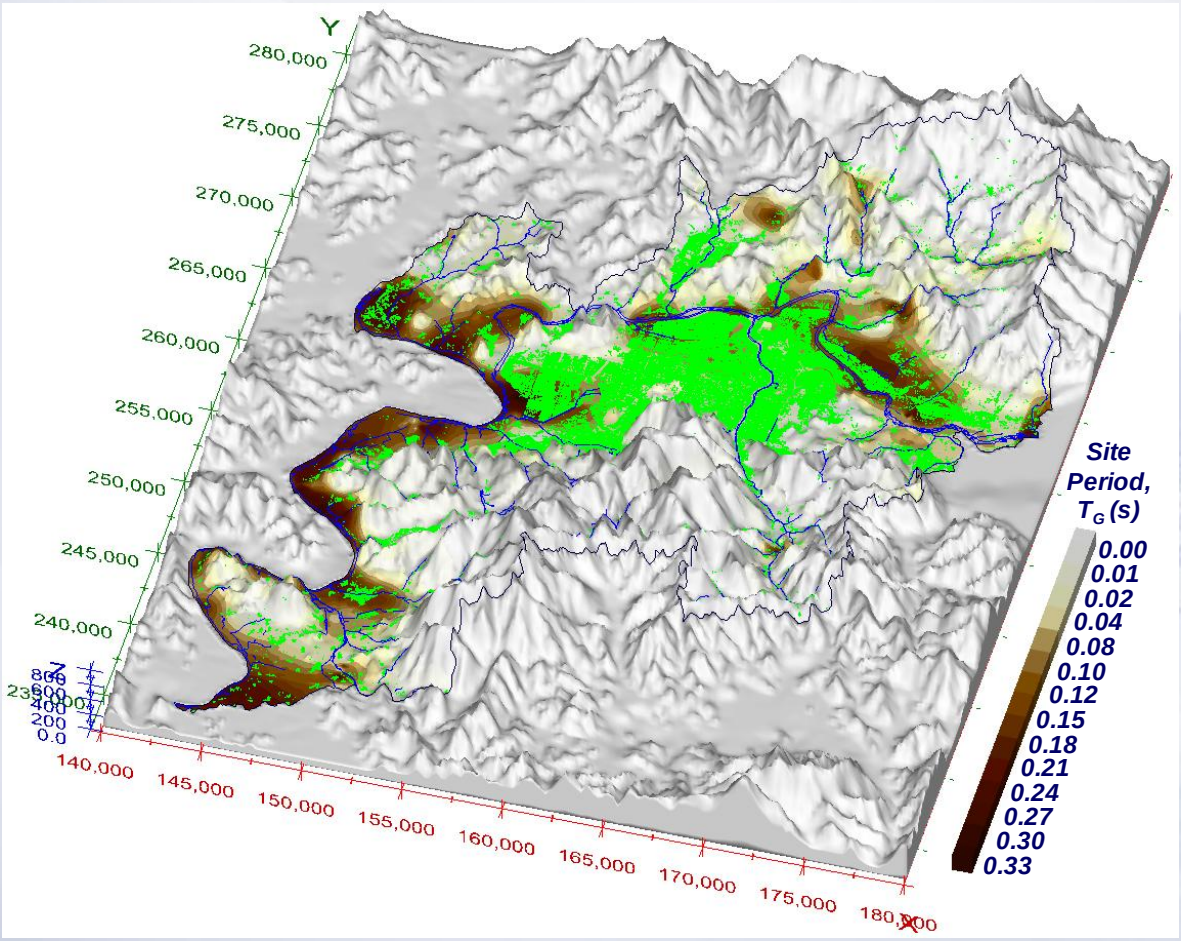
- Maximum depth of deeper than 30m in Daegu basin



4. Site Amplification

Predominant site period in Daegu

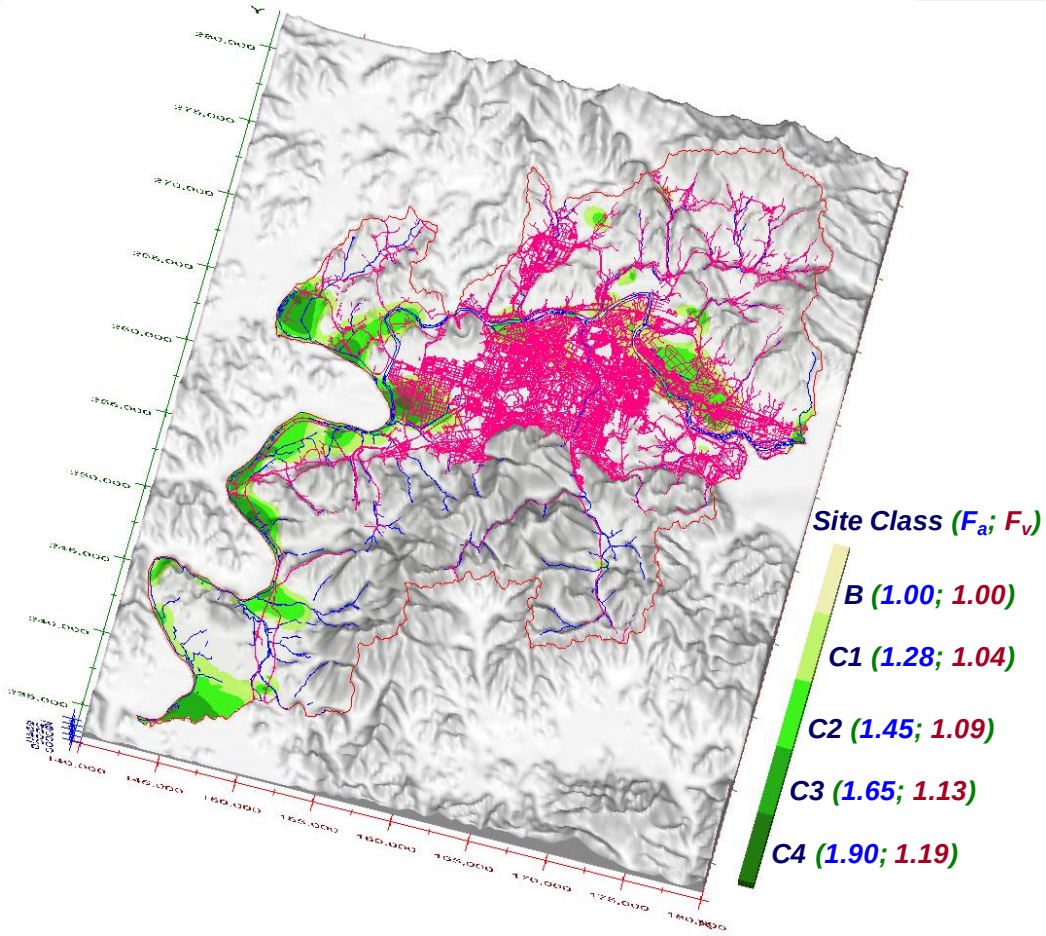
- 0.20 to 0.35 sec in plain and valleys
  (vulnerability for 2 to 4 storied buildings during EQ)
- 100m x 100m Grid



4. Site Amplification

Site classes based on predominant site period in Daegu

- Site classes C(C1 to C4) in plains
- Max 1.90 for Fa and 1.19 for Fv => Significant Seismic amplification



4. Site Amplification

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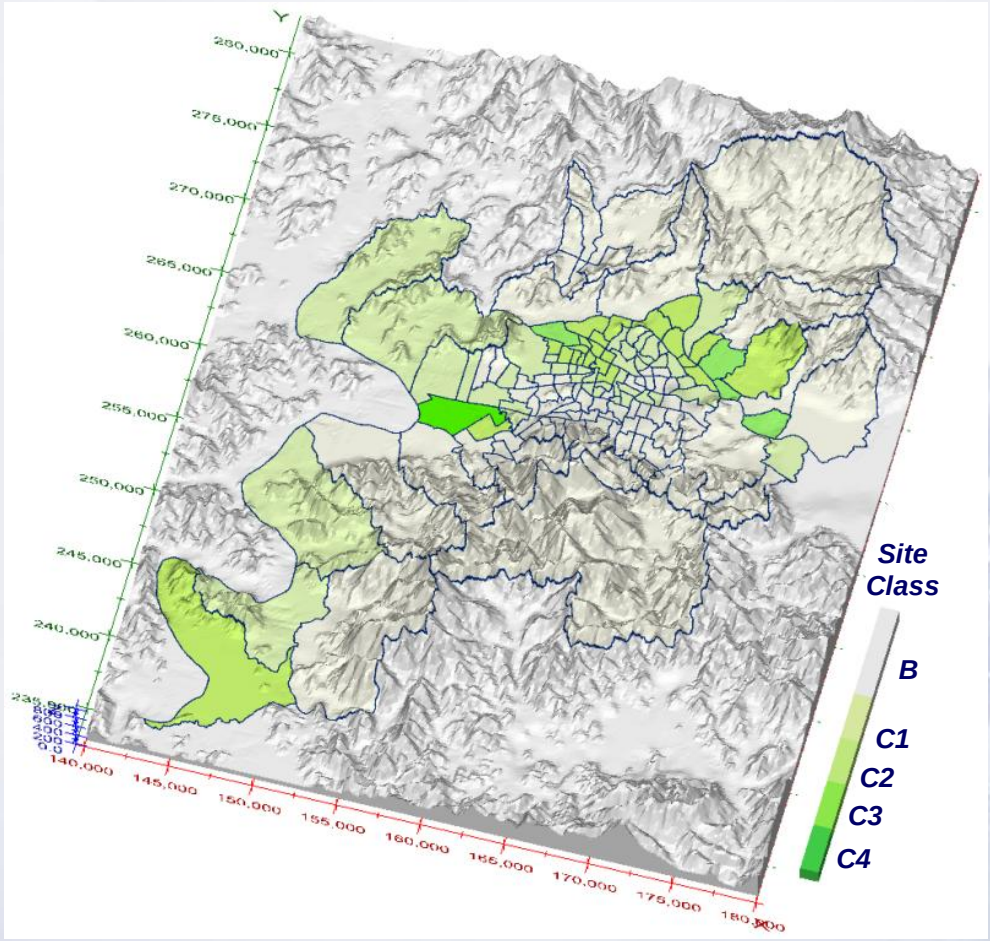
Representative site classes for rapid response in Daegu

- Site classes averaged with administrative sub-unit
- Site classes C(C1 to C4) in most sub-unit => Significant seismic amplification



Final Goal

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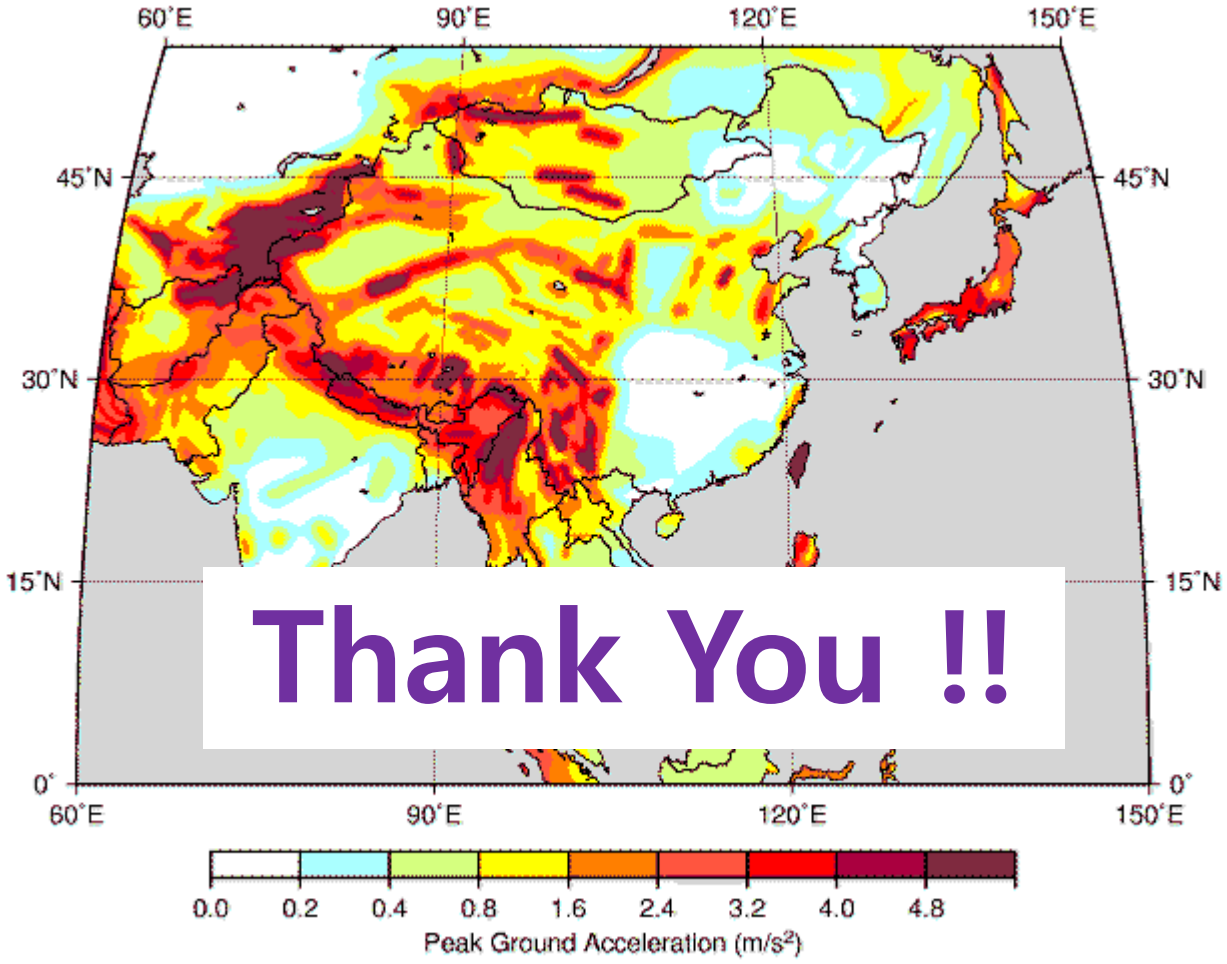
Global Seismic Hazard Assessment Program

– Region 8 Eastern Asia



Thank You !!

http://www.seismo.ethz.ch/static/GSHAP/eastasia/asiafin.gif