Seismic Attenuation in the Korean Peninsula

Seismic Parameters for Prediction of Strong Ground Motions in Korea

Tae-Seob Kang[1], Nam-Dae Jo[2] & Chang-Eob Baag[3]

[1]Department of Earth Environmental Sciences, Pukyong National University, Korea
[2]Daewoo International Corporation, Korea
[3]School of Earth and Environmental Sciences, Seoul National University, Korea

Contents

1. Basic Definition on <u>Earthquake Ground Motions</u>

2. Efficient Procedure for <u>Estimation of Seismic Parameters</u> for Ground Motions

1. Basic Definition on Earthquake Ground Motions

“By Any Other Name”

- Attenuation laws (Europe)
- Attenuation relations (U.S. Engineers)
- Attenuation relationships (U.S. Engineers)
- Attenuation equations
- Ground motion relations (U.S. Seismologists)
- Ground motion prediction relations
- Ground motion prediction equations
- Ground motion estimation equations

Definition

"An attenuation law is a mathematical equation or engineering model that relates a strong-motion parameter to one or more parameters of the earthquake source, wave propagation path, and local site conditions"

Methods of Development

- Empirical methods
  - Derived from strong-motion recordings
- Hybrid empirical methods
  - Derived by modifying empirical attenuation laws in one region to use in another region based on seismological transfer functions usually derived using stochastic methods (see below)
- Stochastic methods
  - Derived from stochastic ground-motion simulations and simple seismological models
- Theoretical methods
  - Derived from kinematic and dynamic ground-motion simulations and rigorous seismological models

Basic Functional Form

$$\log Y = c_1 + c_2 M - c_3 \log R - c_4 R + \varepsilon_a + \varepsilon_e$$

where,

- $\log Y$ = log of strong-motion parameter
- M = earthquake magnitude or $f(M)$
- R = source-to-site distance or $f(R,M)$
- ε_a = aleatory uncertainty
- ε_e = epistemic uncertainty
- c_i = model coefficients

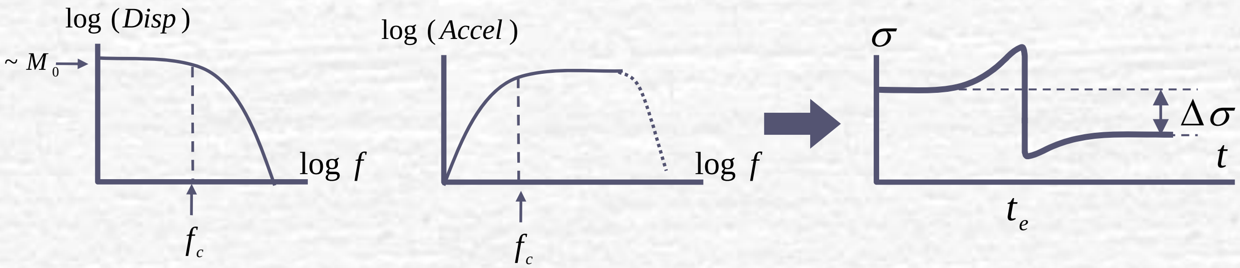
Common Parameters

- Ground-motion measure
- Earthquake magnitude
- Source-to-site distance
- Finite faulting effects
- Local site conditions
- Stress drop
- Hanging-wall effects
- Tectonic environment

2. Efficient Procedure for Estimation of Seismic Parameters for Ground Motions

Seismic parameters for computation of ground motions

- Source parameters
  - Seismic moment (M_0), Corner frequency (f_c), Stress drop ($\Delta\sigma$)



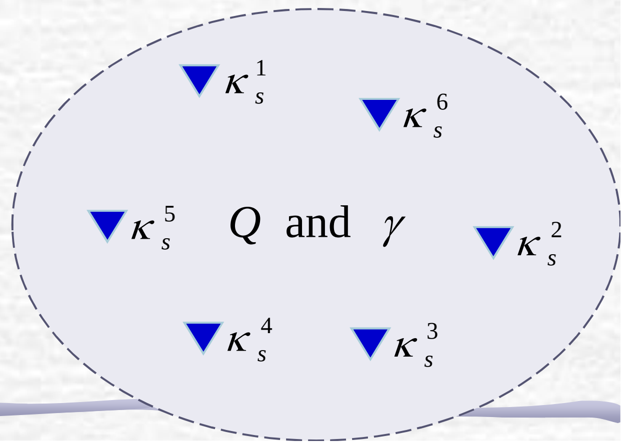
- Propagation constants
  - Quality factor Q (κ_q), site-dependent κ_s, Geometrical spreading $R^{-\gamma}$

$$A(f, R) \propto e^{-\pi\kappa f} \cdot R^{-\gamma}$$

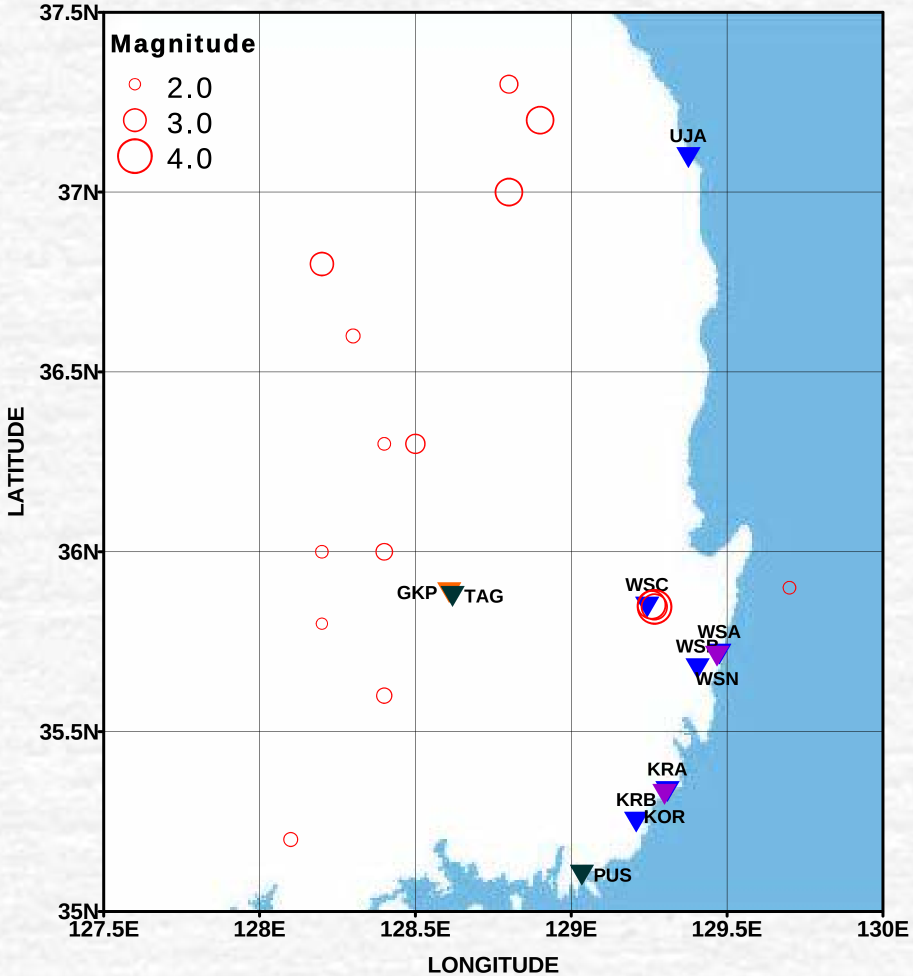
$$\kappa = \kappa_q R + \kappa_s$$

site-specific parameter

regional parameter (~ Q)

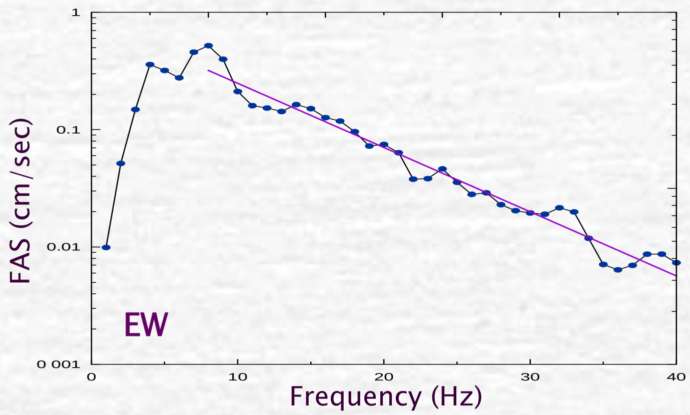


κ–values from acceleration spectrum



Fourier Amplitude Spectrum of Acceleration

1999/06/02 KRA station R = 58.0 km

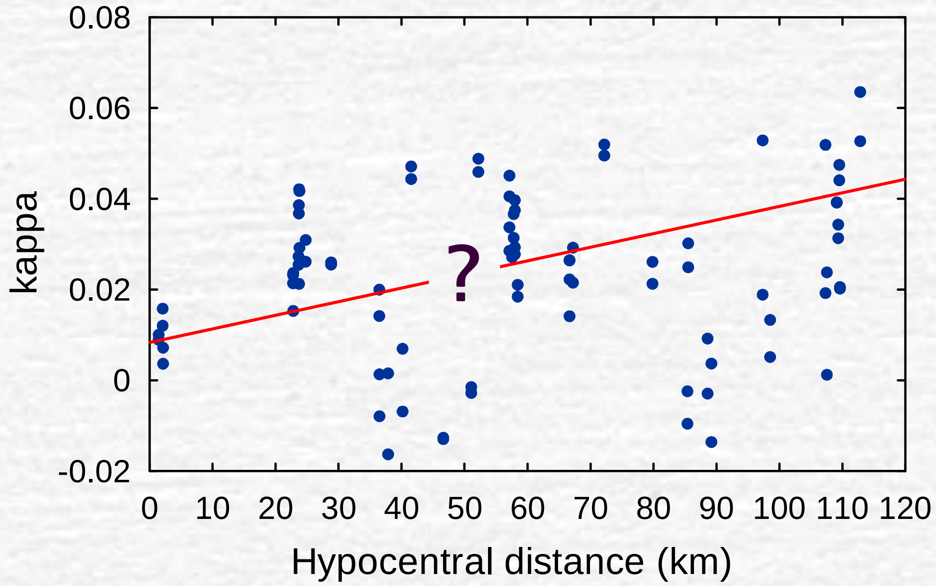


$$\text{Log(FAS)} = -0.126045\ f - 0.132014$$

$$-\pi\kappa f$$

$$\kappa_{R=58km}^{KRA} = 0.0401$$

Linear curve fitting for $\kappa = \kappa_s + \kappa_q R$



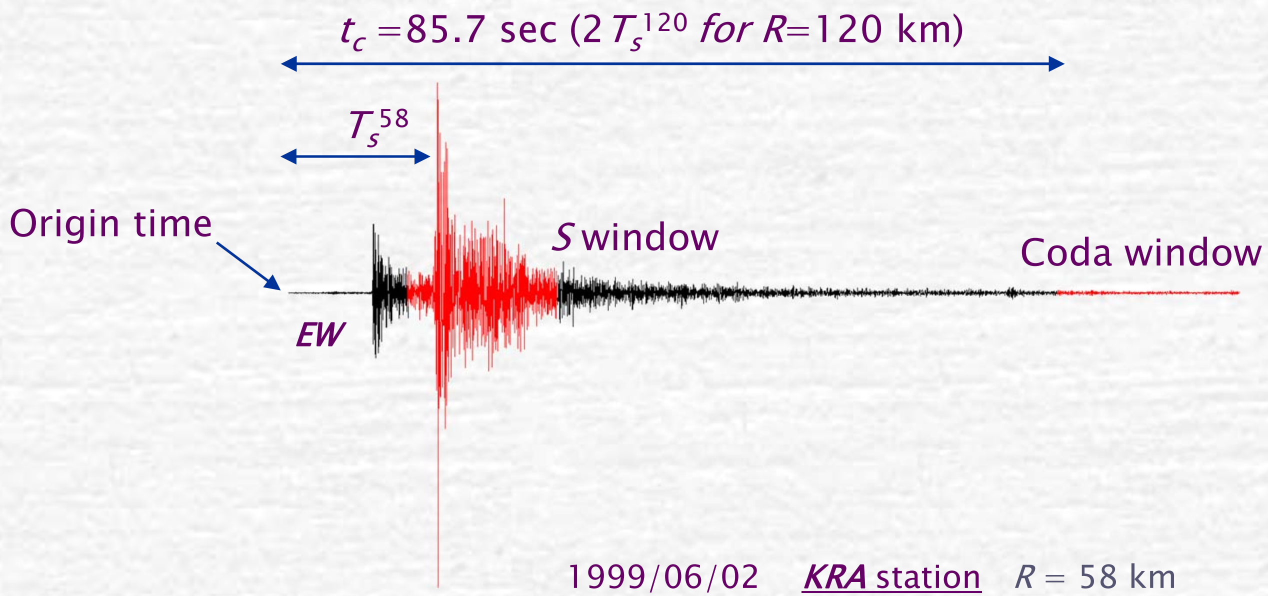
κ–value; May be seriously influenced by the site effect

→ Need to propose a new procedure for κ_s and κ_q

Computation of site-dependent κ

1st STEP: computation of site independent value κ_q (or Q)

Using coda normalization method (Frankel, 1990) or others



1999/06/02 *KRA* station R = 58 km

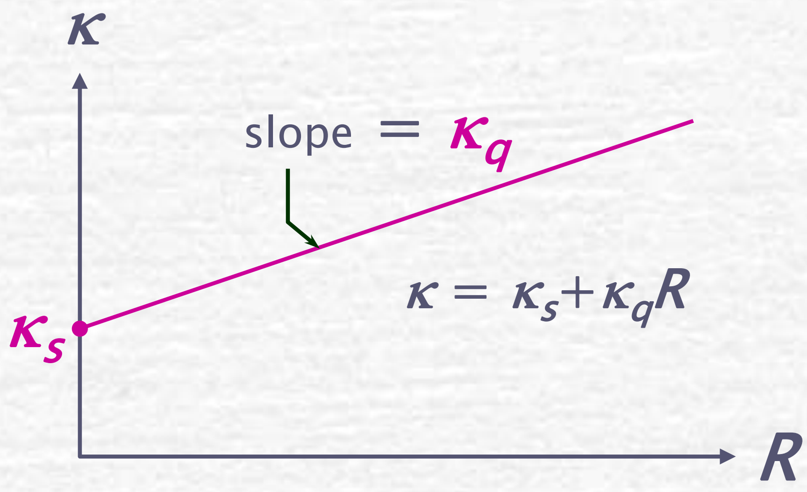
Result of inversion for Q and γ

$\gamma = 0.7649$

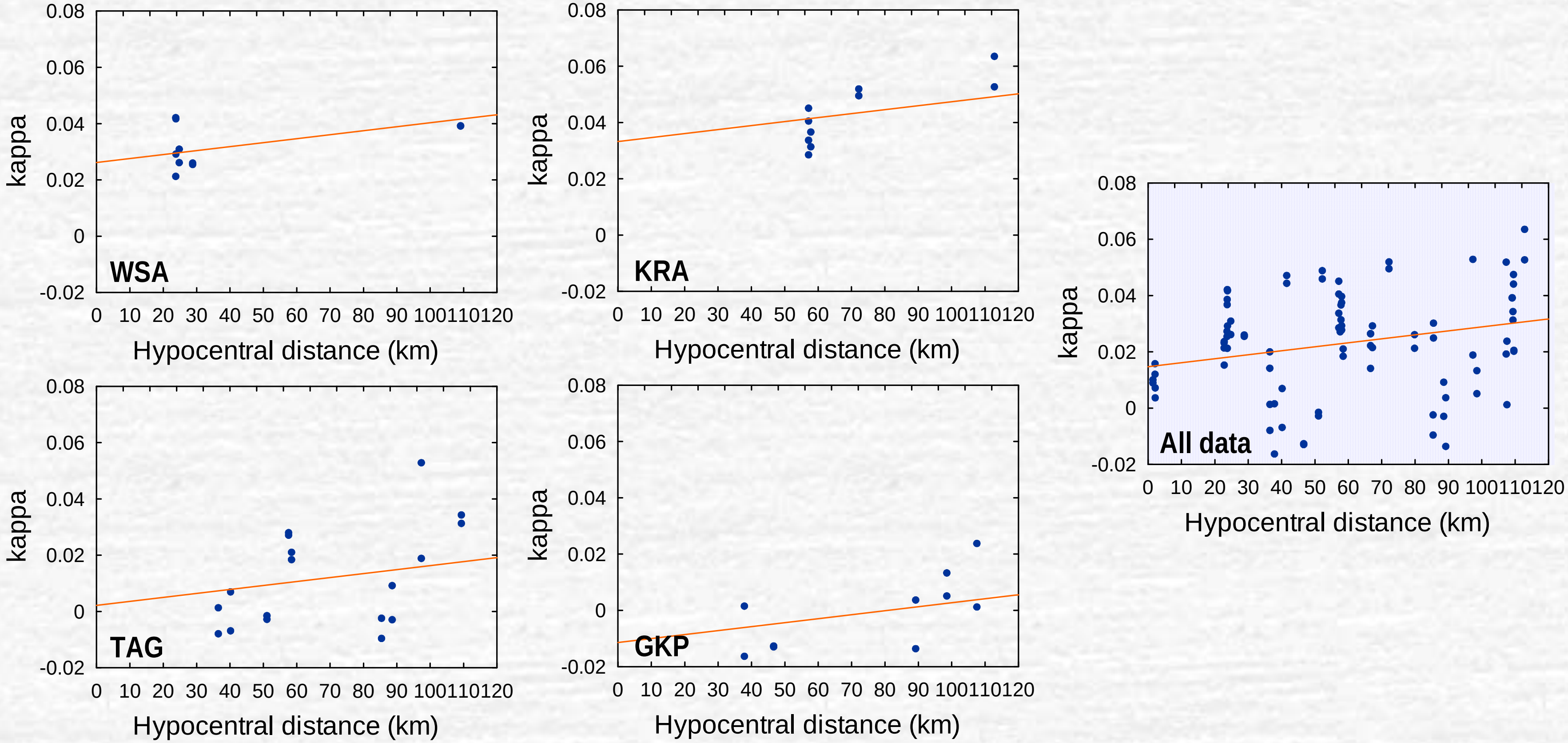
$Q = 2022.58$

$\Leftrightarrow \kappa_q = 0.0001413$

; slope in κ–R relation
is obtained

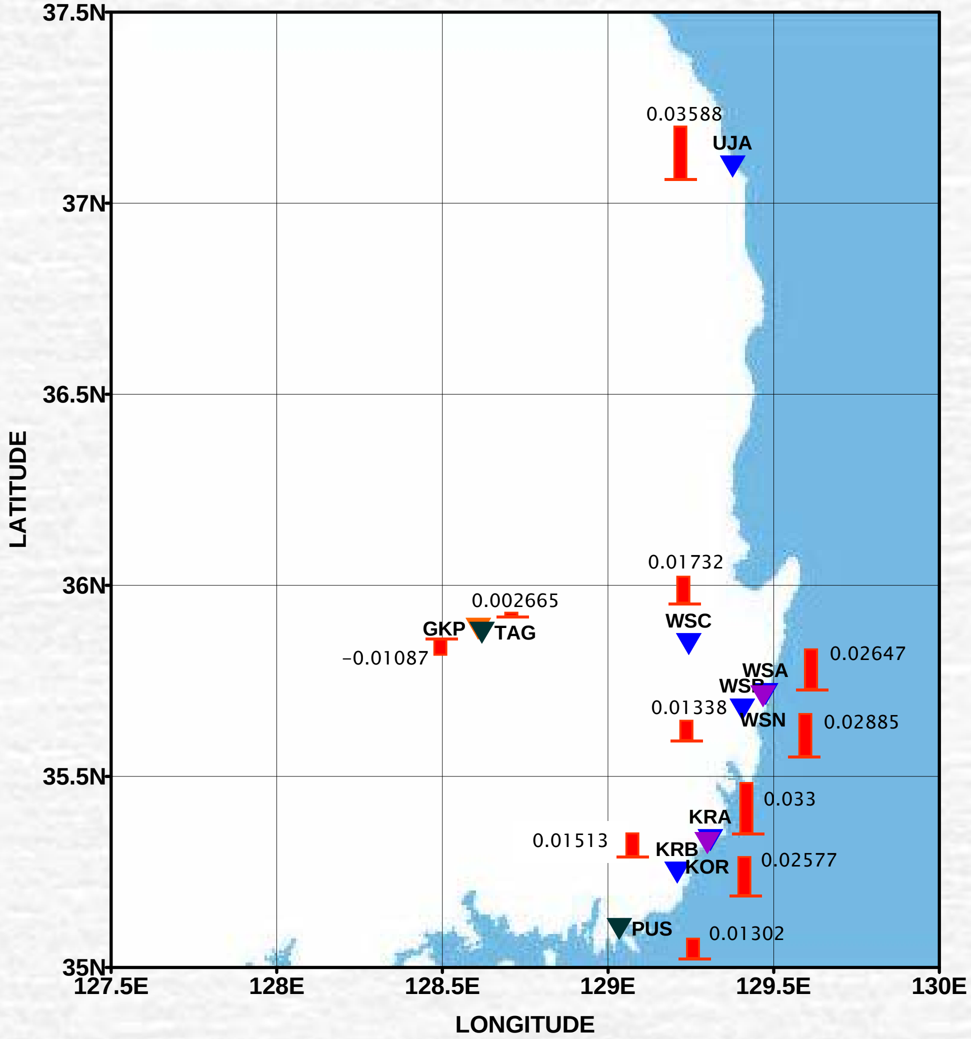


2^{nd} STEP : computation of κ_s for each site using given κ_q value

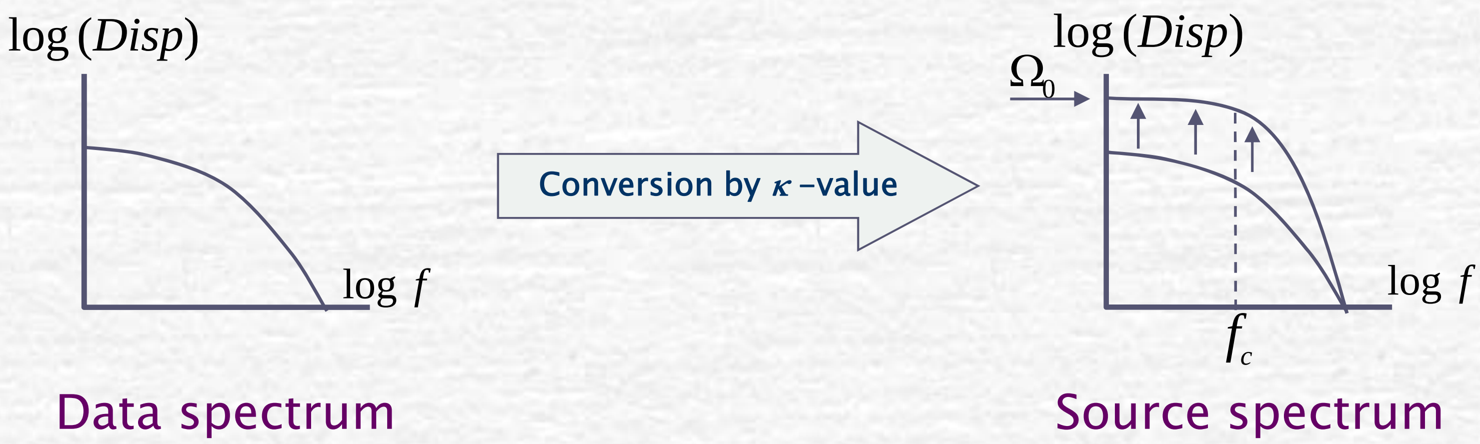


Station	WSA	WSB	WSC	WSN	KRA	KRB	KOR	UJA	TAG	GKP	PUS
κ_s	0.02647	0.01337	0.01732	0.02885	0.03300	0.01513	0.02577	0.03588	0.002665	-0.01087	0.01302

Site-dependent κ_s values



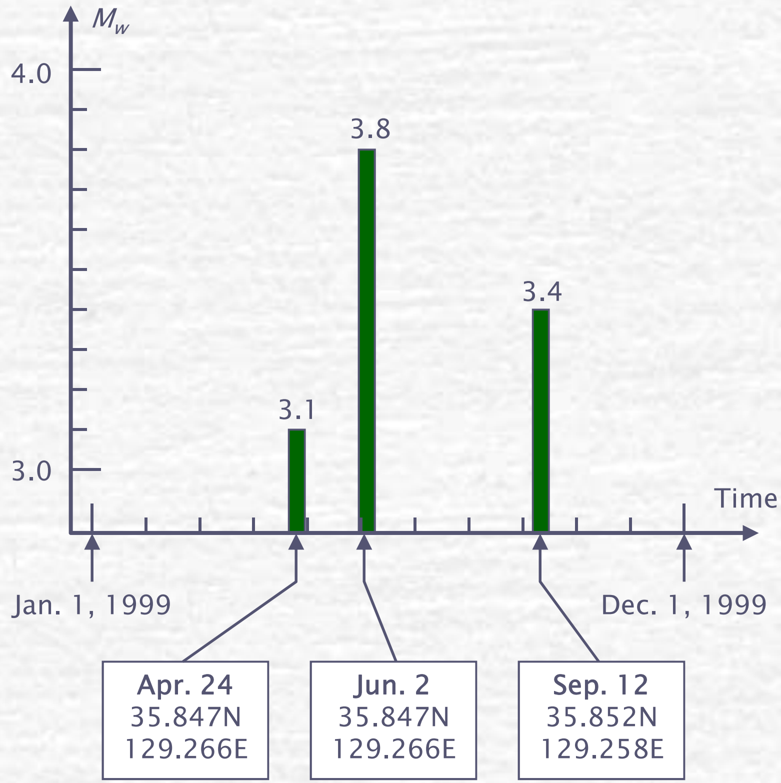
Brune's stress drop

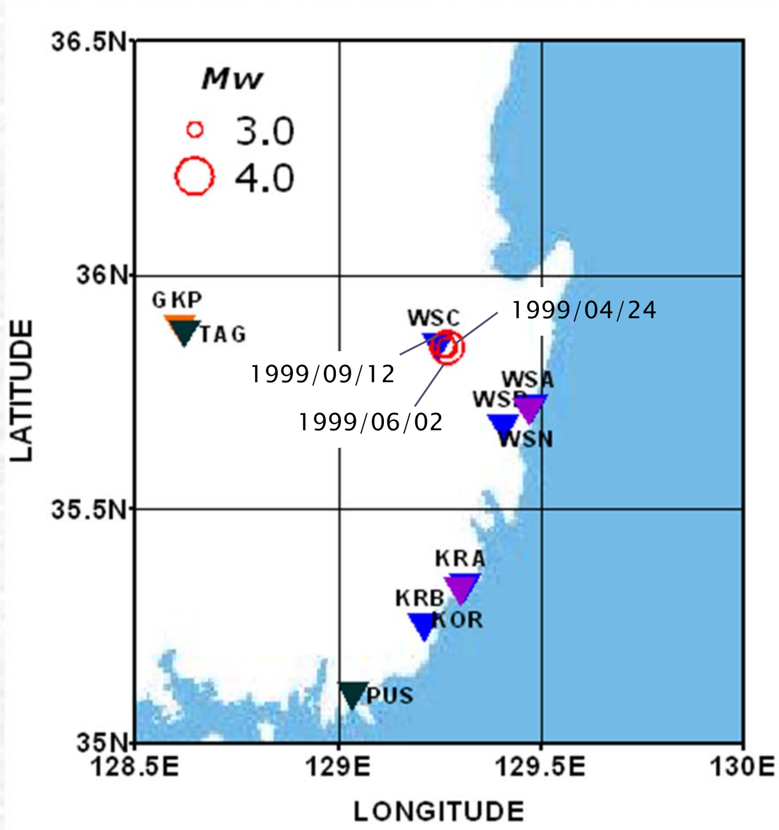


- Stress drop ($\Delta\sigma$) is obtained from
  - Low frequency spectral value (Ω_0)
  - Corner frequency (f_c)

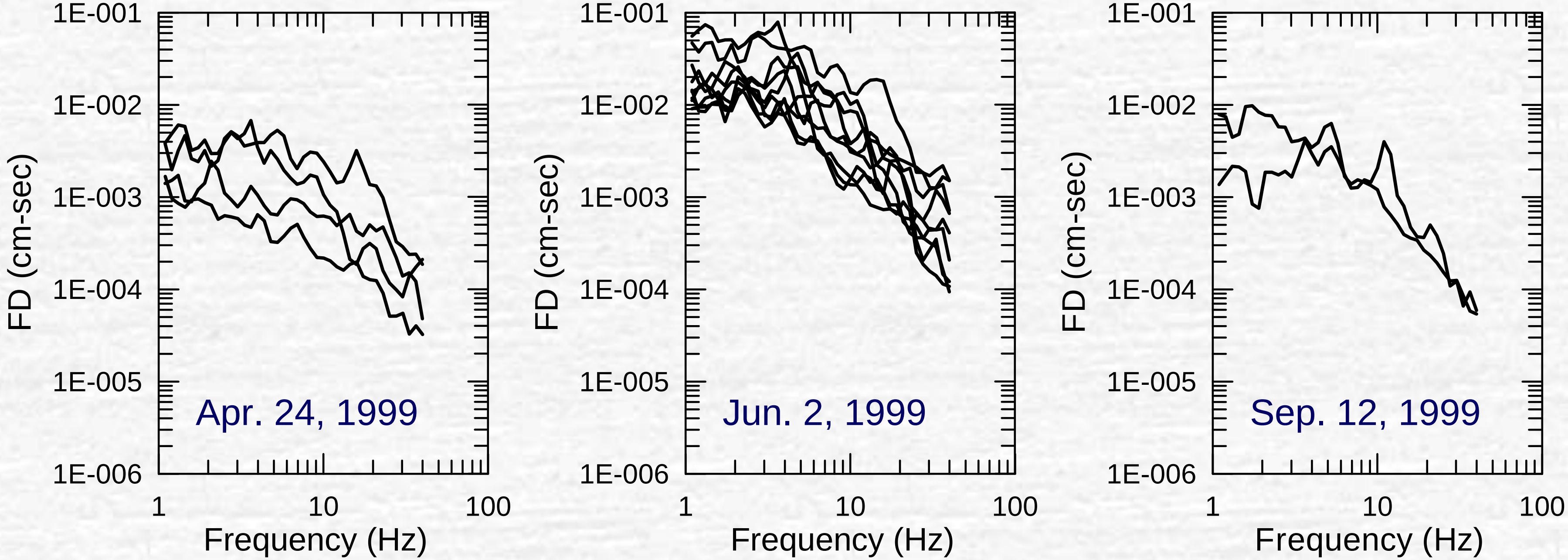
1999 Gyeongju Earthquakes, Korea

- Three small-to-medium-sized earthquakes at almost the same location

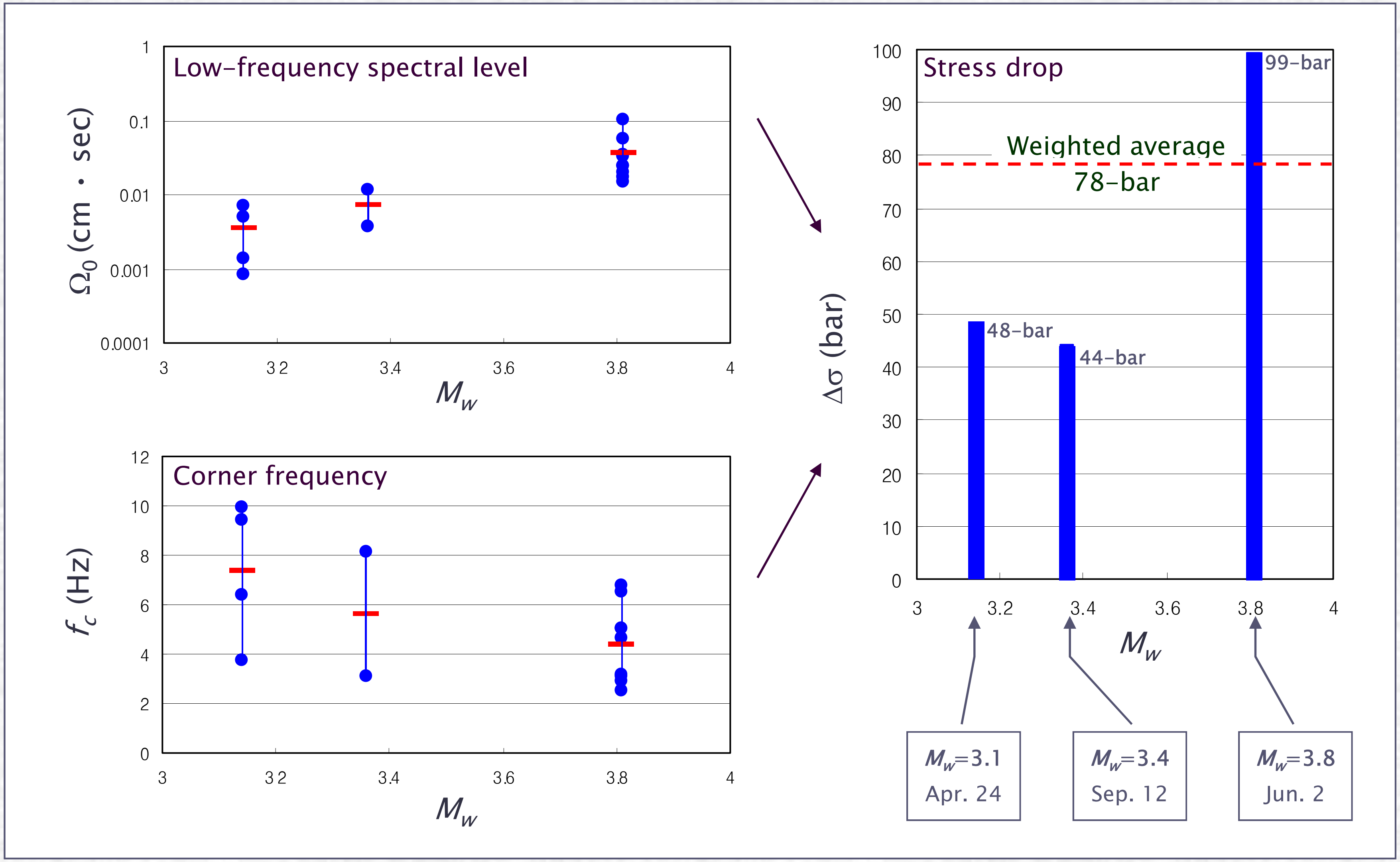




Computed source spectrum (smoothed)



Computed source parameters



Conclusion

Proposed methods and procedures for estimation of site-dependent ground motions can be efficiently used in the low and moderate seismicity regions.