



مروری بر برخی مطالعات انجام شده

بعد از زلزله بهم

سیستم هشدار سریع زلزله

*Earthquake Early Warning Systems  
(EEWS)*

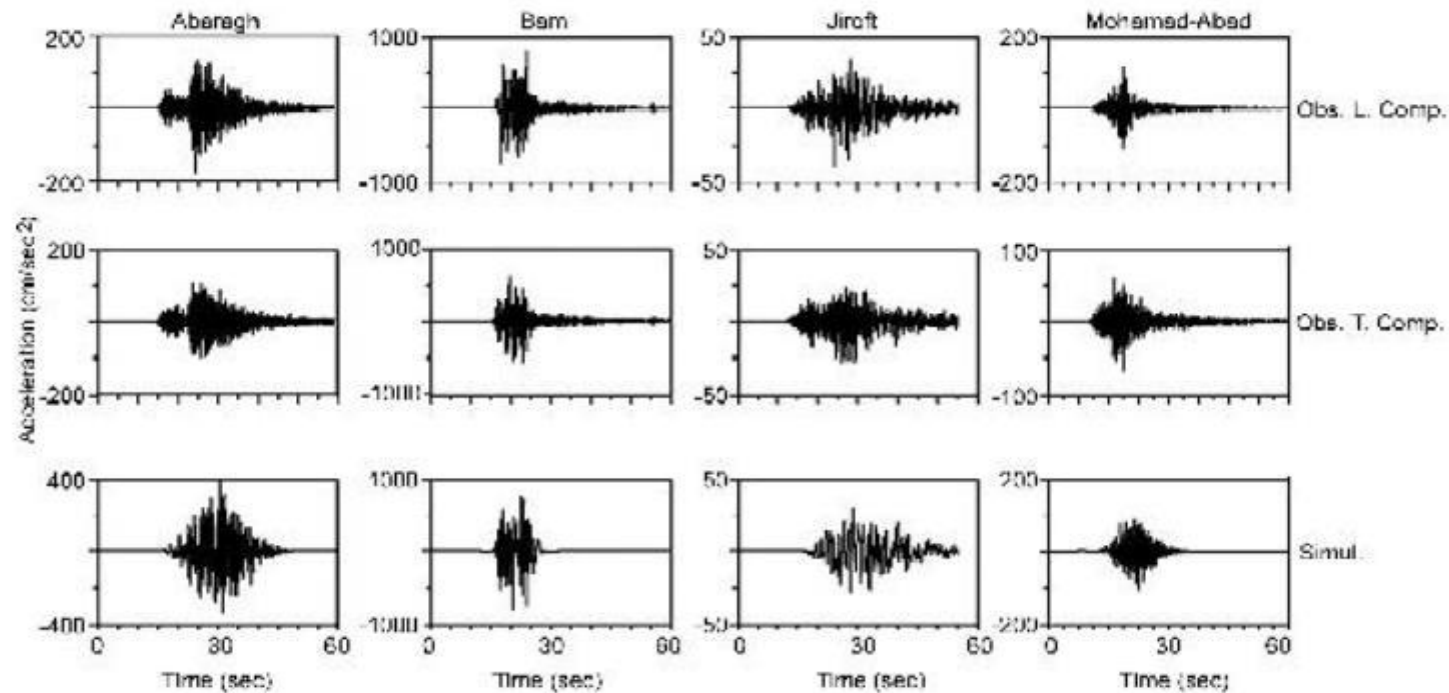


# A Study of the Strong Ground Motions of 26 December 2003 Bam Earthquake: Mw6.5

*Mehdi Zaré and Hossein Hamzehloo*

Seismologist Research Center, International Institute of Earthquake Engineering  
and Seismology (IIEES), Tehran, Iran, email: mzare@iiees.ac.ir

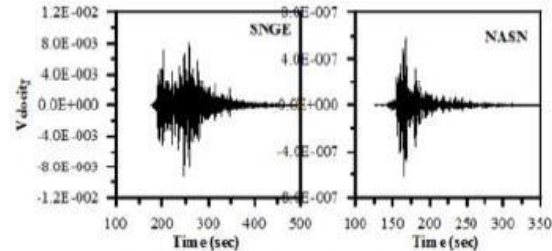
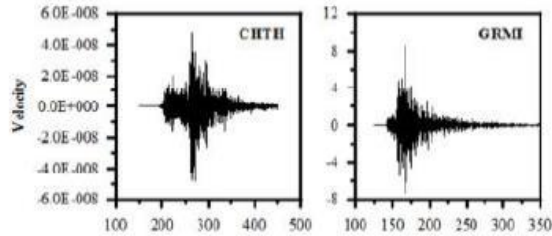
*A Study of the Strong Ground Motions of 26 December 2003 Bam Earthquake: Mw6.5*



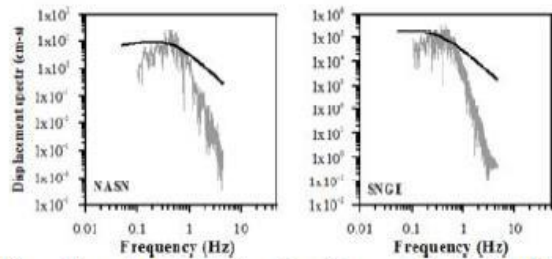
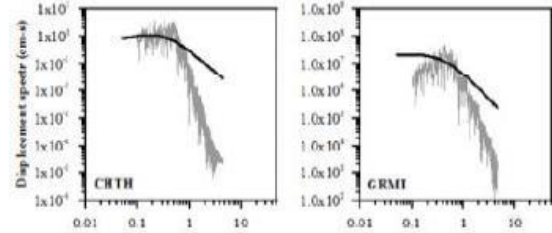
**Figure 41.** The observed horizontal acceleration and simulated records for model M3 based on analysis of SH-wave strong ground motion.

# برگردان امواج حجمی (SH) به منظور تعیین سازوکار زمین‌لرزه‌ها با استفاده از داده‌های باند پهن و محلی

پردازش داده‌ها یا روش SH



شکل (۱-۳): مولفه SH برای زمینلرزه دوم اهر-ورزقان.



شکل (۱۱-۳): طیف منال چشمه برون و مشاهده شده برای زمینلرزه دوم اهر-ورزقان به روش SH.

مجری پروژه:

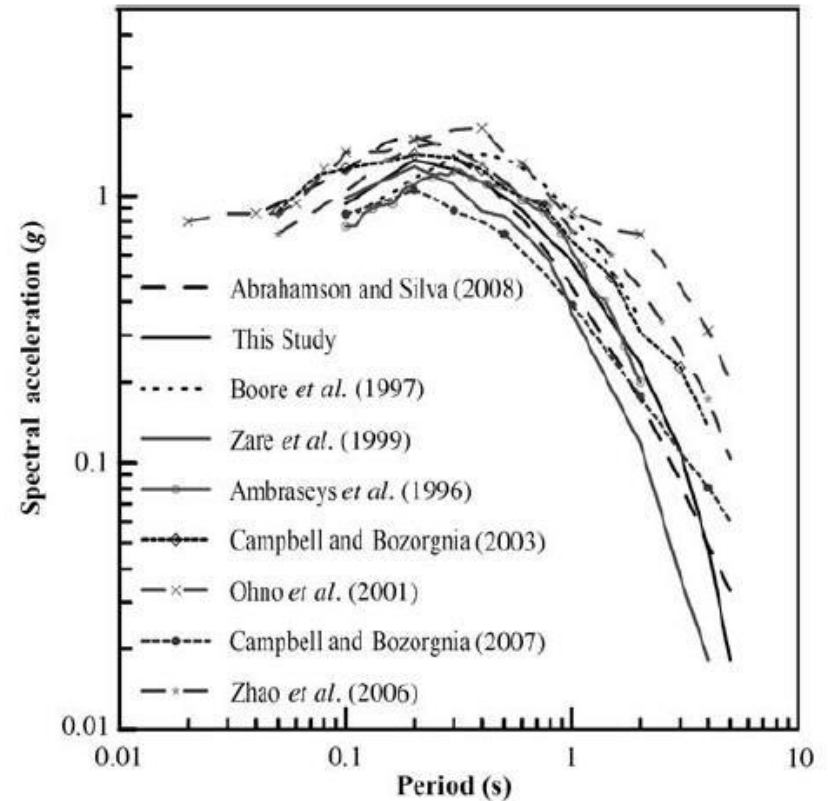
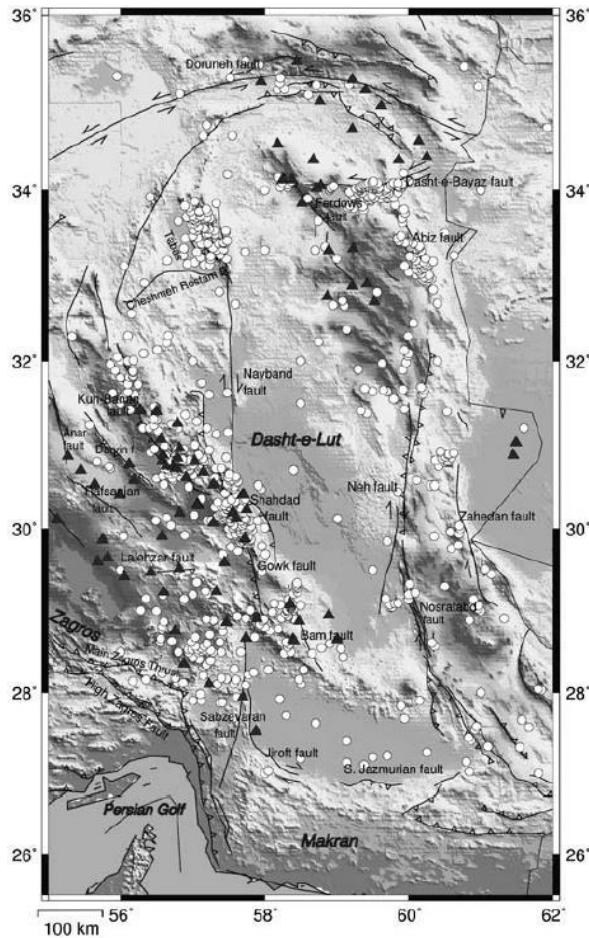
حسین حمزه‌لو



# Ground-Motion Attenuation Relationship for East Central Iran

by Hosseyn Hamzehloo and Majid Mahood

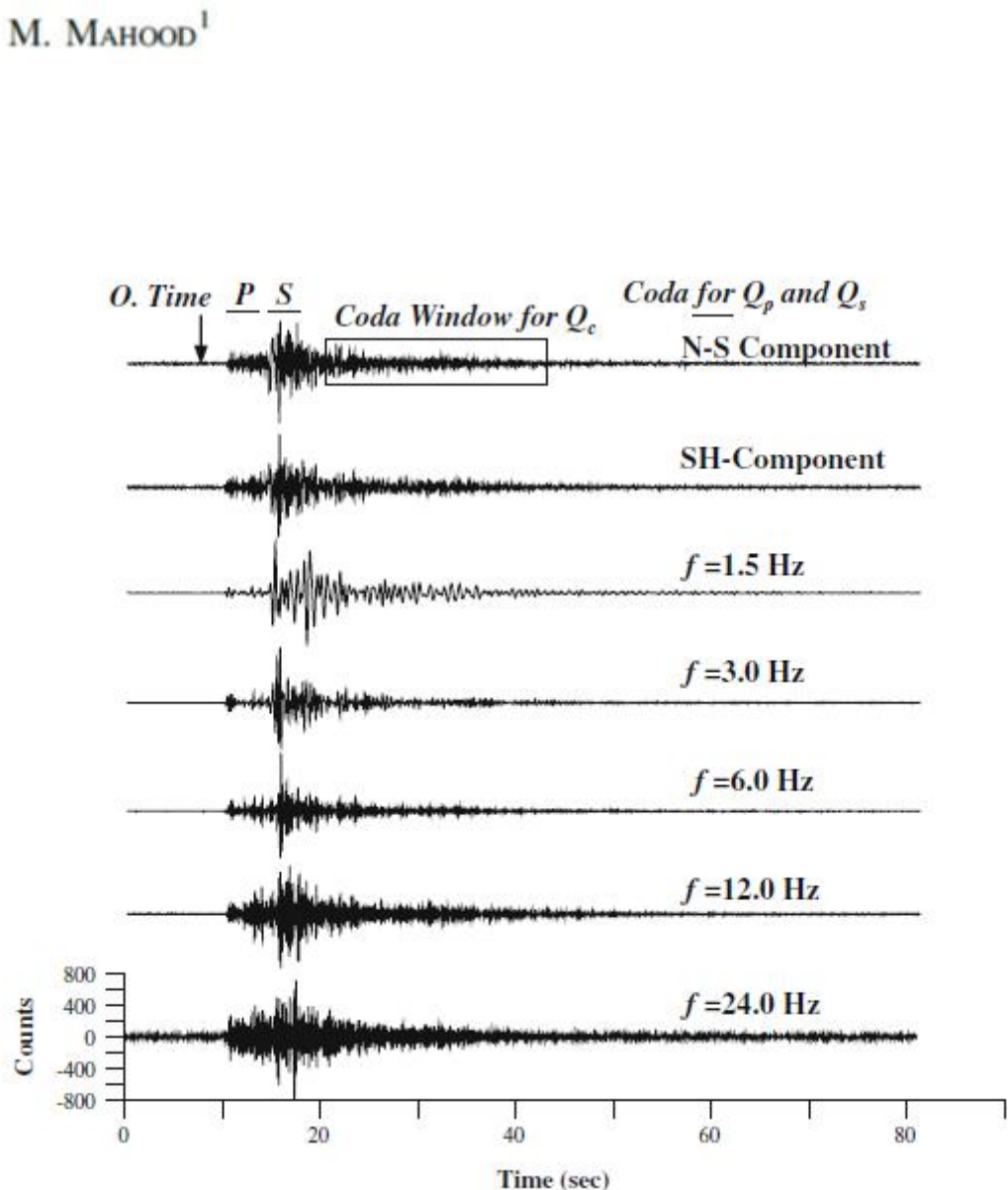
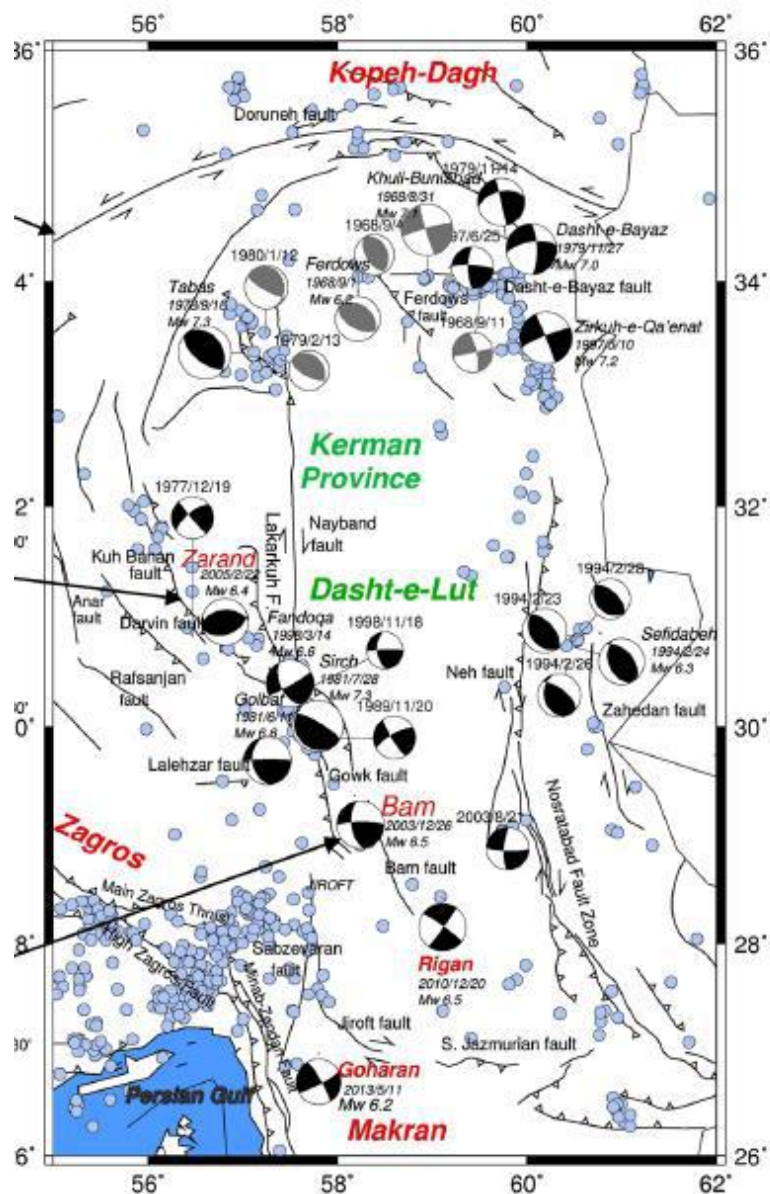
H. Hamzehloo and M. Mahood



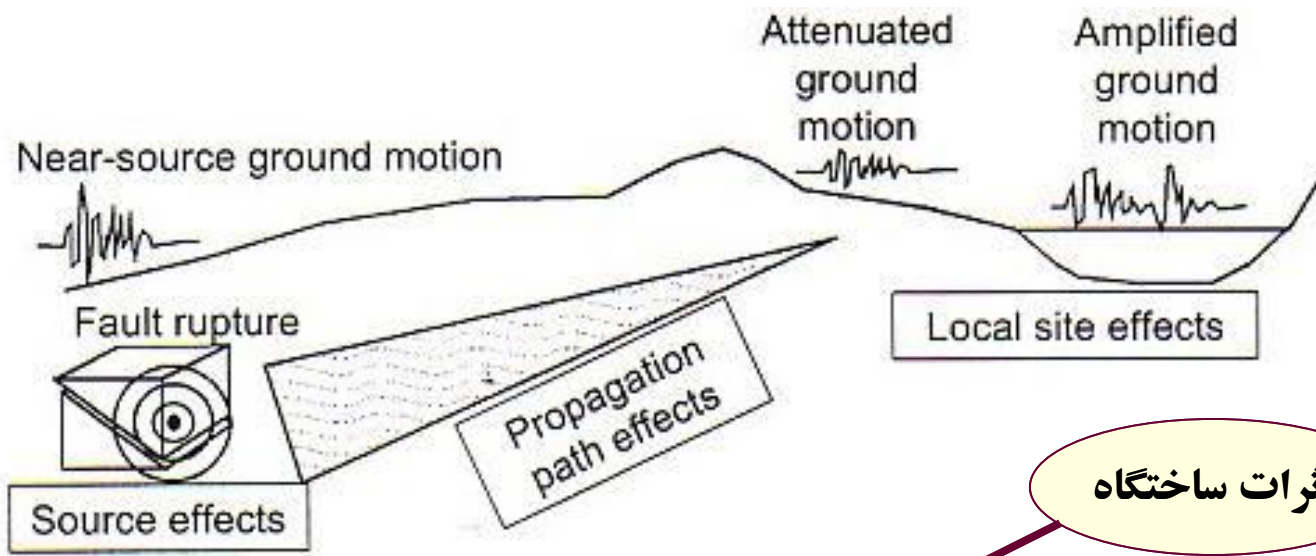
**Figure 1.** Distribution of earthquakes from 1978 to 2008 (circles) and the BHRC strong ground-motion stations (triangles).

# Attenuation of High-Frequency Seismic Waves in Eastern Iran

M. MAHOOD<sup>1</sup>



# اثرات محیط بر انتشار امواج لرزه‌ای



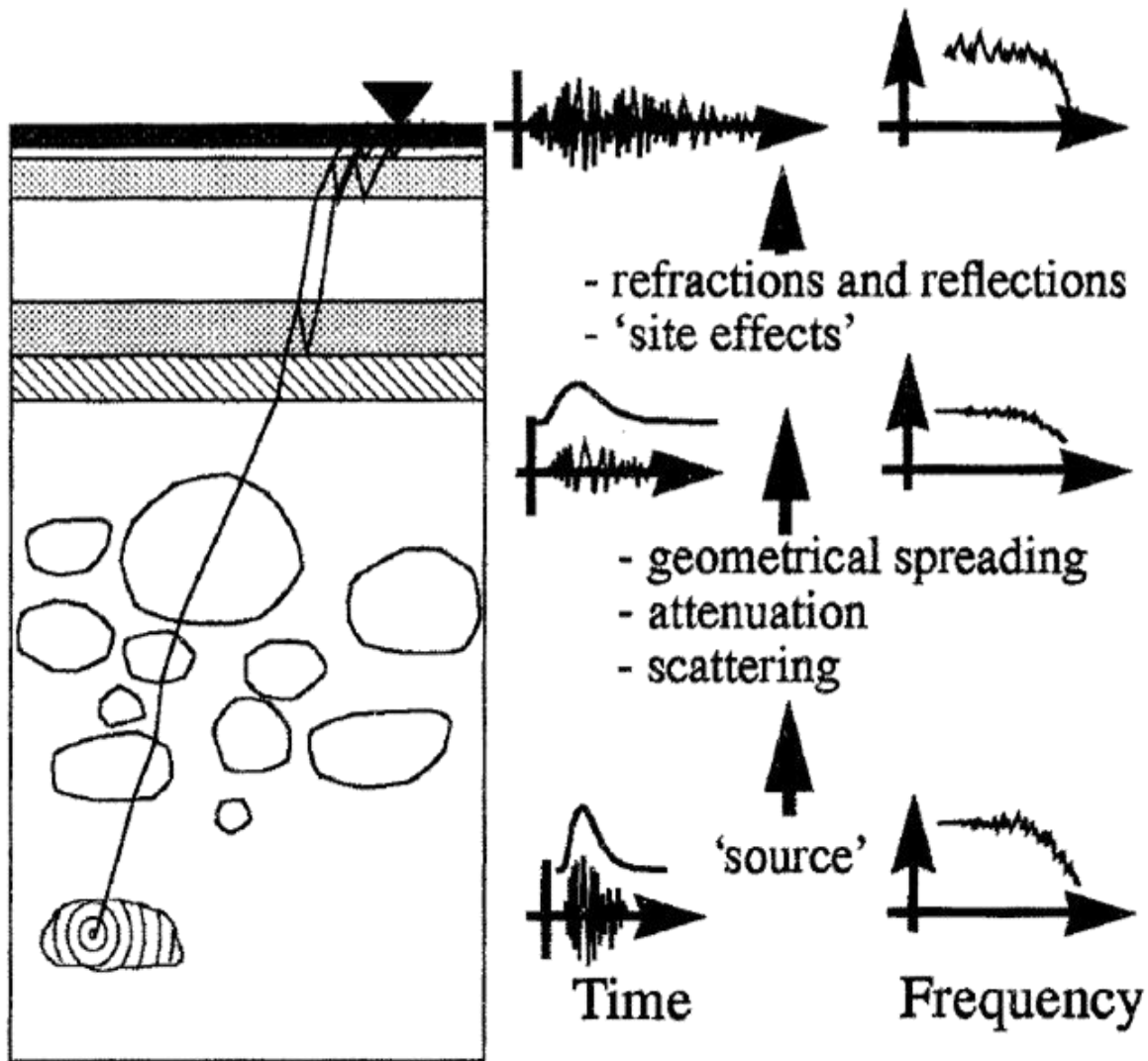
$$U(t) = S(t) * p(t) * Z(t) * I(t)$$

سری زمانی ثبت شده

اثرات چشمه

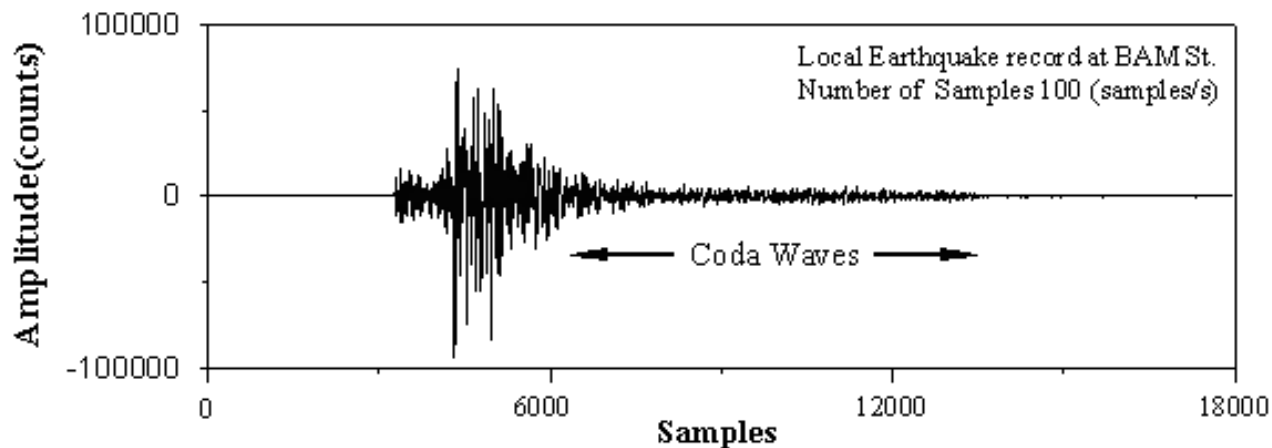
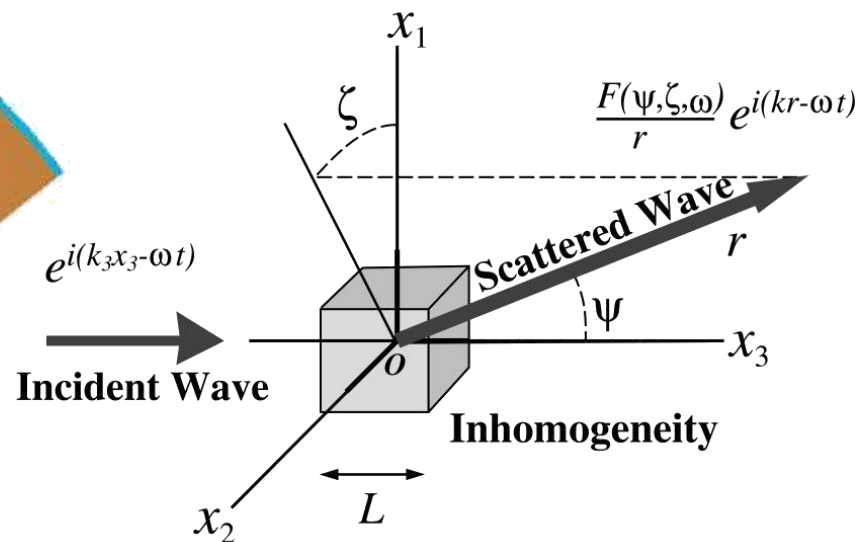
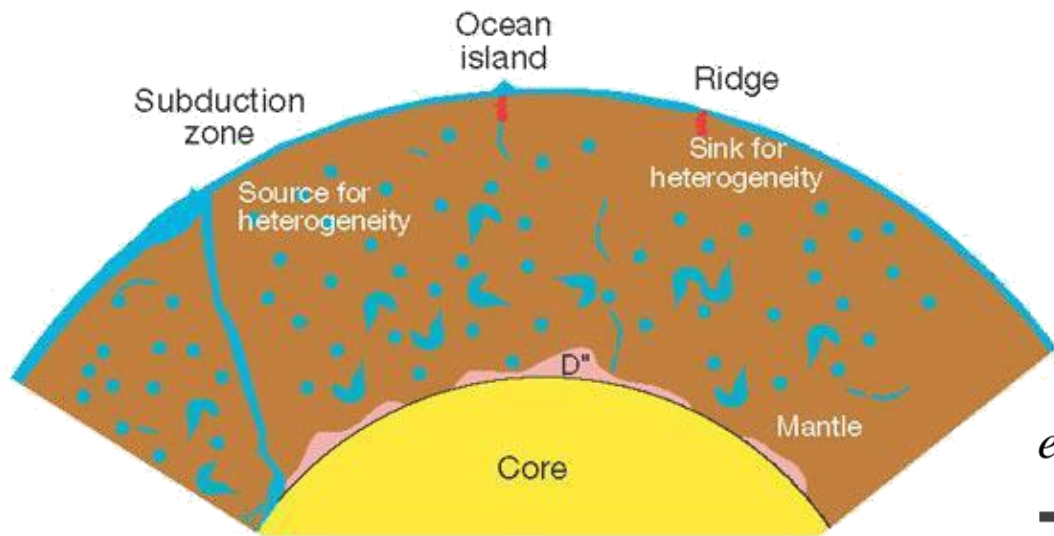
اثرات مسیر

اثرات دستگاه



تغییرات اعمال شده بر روی امواج لرزه ای از  
 چشمه تا سطح زمین (ساتو و فلر ۱۹۹۸)

# امواج کدا واضحترین و ساده ترین نشانه وجود ناهمگنی های تصادفی و نامنظم درون زمین هستند.





# Estimation of coda wave attenuation in East Central Iran

M. Ma'hood · H. Hamzehloo

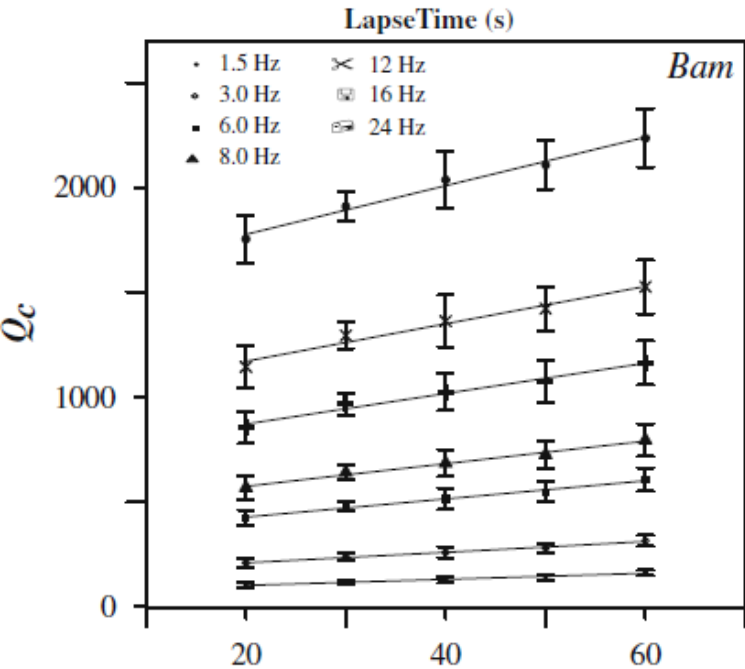
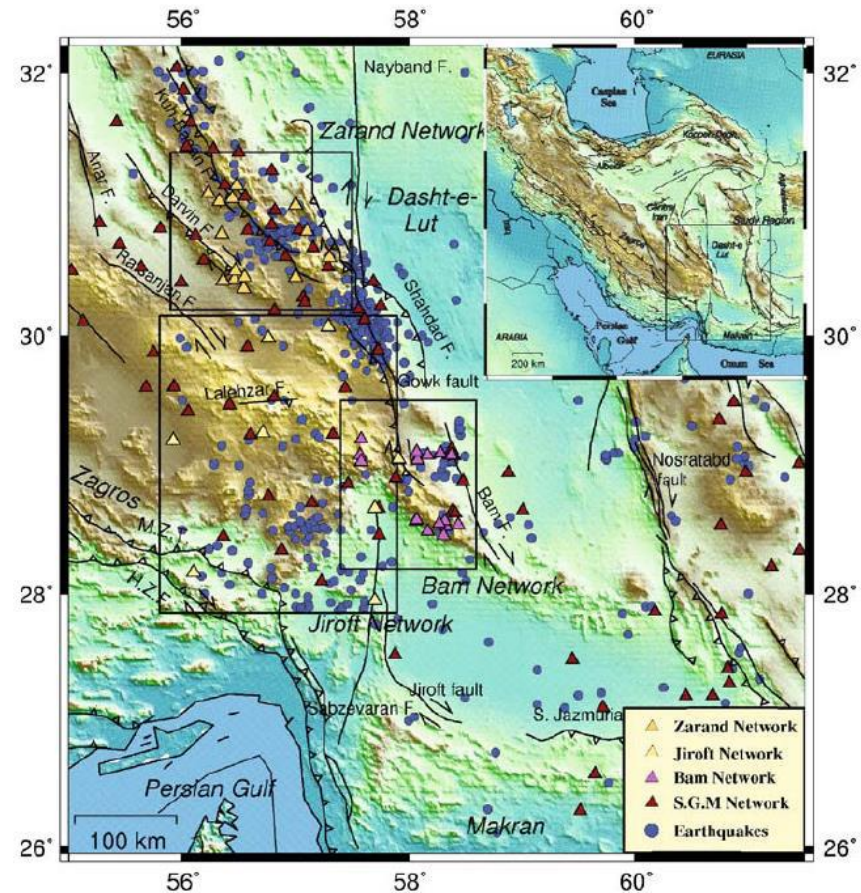


Fig. 1 Seismicity of east central Iran (circles) and the regional strong ground motion (SGM) network. Rectangles are the area of three local networks for Zarand, Bam, and Jiroft networks



**A ground-motion predictive model for Iran and Turkey for  
horizontal PGA, PGV and 5%-damped response spectrum:**

**Investigation of possible regional effects**

Özkan Kale, Sinan Akkar, Anooshiravan Ansari and Hossein Hamzehloo

J Seismol  
DOI 10.1007/s10950-009-9159-x

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ORIGINAL ARTICLE

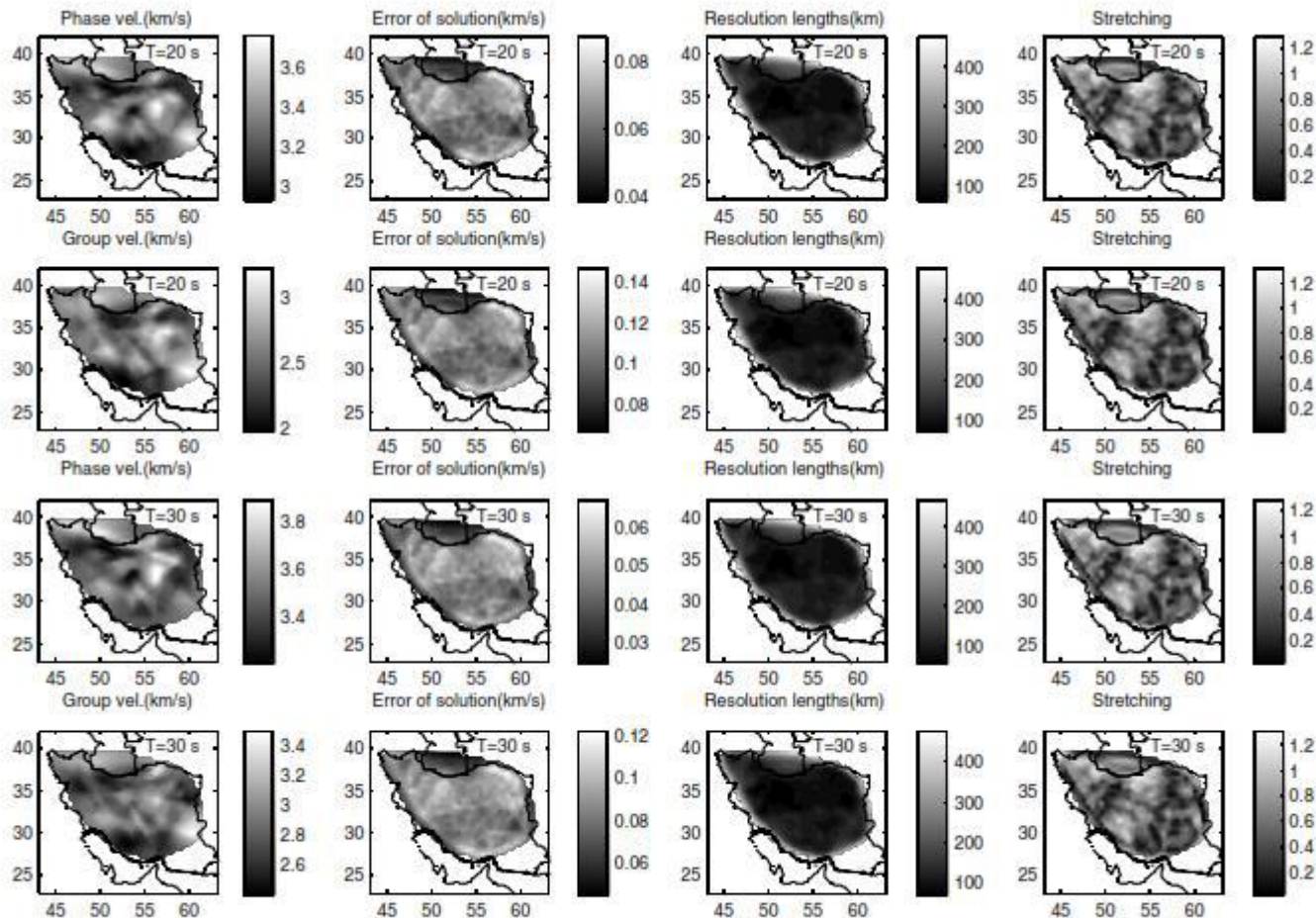
**Modeling the strong ground motion and rupture  
characteristics of the March 31, 2006, Darb-e-Astane  
earthquake, Iran, using a hybrid of near-field SH-wave  
and empirical Green's function method**

**H. Hamzehloo · H. Rahimi · I. Sarkar ·  
M. Mahood · H. Mirzaei Alavijeh · E. Farzanegan**

Received: 3 September 2008 / Accepted: 12 March 2009  
© Springer Science + Business Media B.V. 2009

## Shear-Wave Velocity Tomography of the Lithosphere–Asthenosphere System beneath the Iranian Plateau

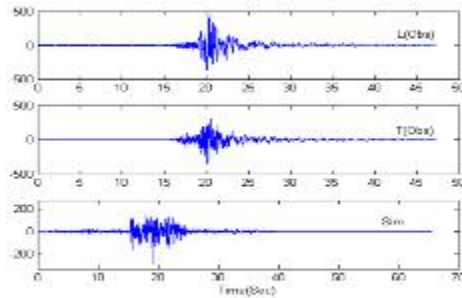
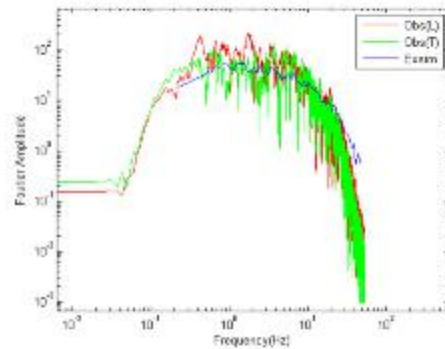
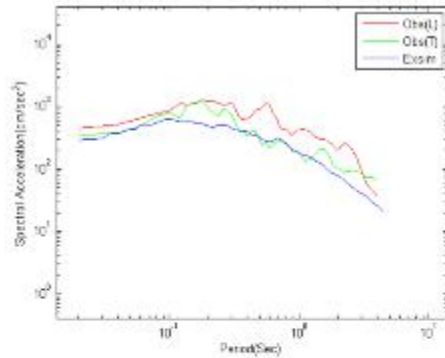
by H. Rahimi, H. Hamzehloo, F. Vaccari, and G. F. Panza



**Figure 5.** Rayleigh-wave group and phase velocity tomography maps, with resolution lengths and stretching parameter at 20 and 30 s periods.

## شبیه‌سازی جنبش نیرومند زمین برای زمین‌لرزه اول ۲۱ مرداد ۱۳۹۱ اهر-ورزقان، شمال غرب ایران به روش کاتوره‌ای گسل محدود

مجید معهود<sup>۱</sup>، نقیسه اکبرزاده<sup>۲</sup> و حسین حمزه‌لو<sup>۳</sup>



شکل ۶. نمایش طیف فوریه، طیف پاسخ و تاریخچه زمانی مؤلفه‌های

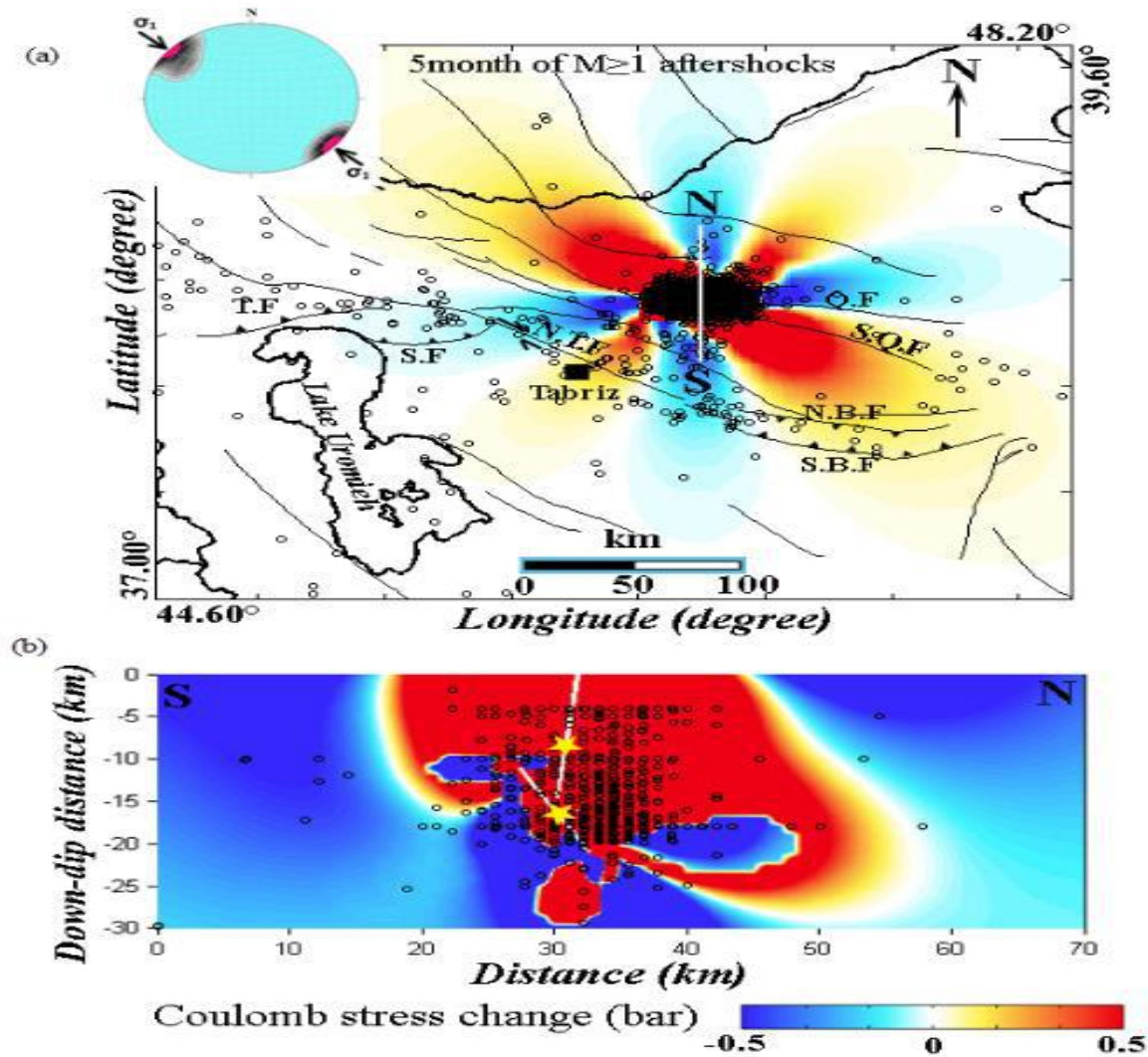
افقی نگاشت‌های مشاهده‌ای و شبیه‌سازی شده با کیفیت A

زمین‌لرزه اول ۲۱ مرداد ۱۳۹۱ اهر-ورزقان در ایستگاه ورزقان.

# Coulomb Stress Changes in the NW of Iran due to the twin 2012 Ahar- Varzaghan Earthquakes

By Behnam Maleki Asayesh<sup>1</sup>, Hosseyn Hamzehloo<sup>1\*</sup>, Hamid Zafarani<sup>1</sup>

<sup>1</sup> International Institute of Earthquake Engineering and Seismology, Tehran, I. R. Iran.



# Coda wave attenuation's dependency on Lapse time and frequency in west of Iran plateau using local earthquakes

Rouhollah Amiri Fard<sup>1</sup>, Gholam Javan-Doloei<sup>\*,1</sup>, Mohsen Farrokhi<sup>2</sup>, Habib Rahimi<sup>3</sup>, Majid Mahood<sup>1</sup>

(<sup>1</sup>) International Institute of Earthquake Engineering and Seismology, Postal Code: 1953714453 Tehran, I.R. IRAN

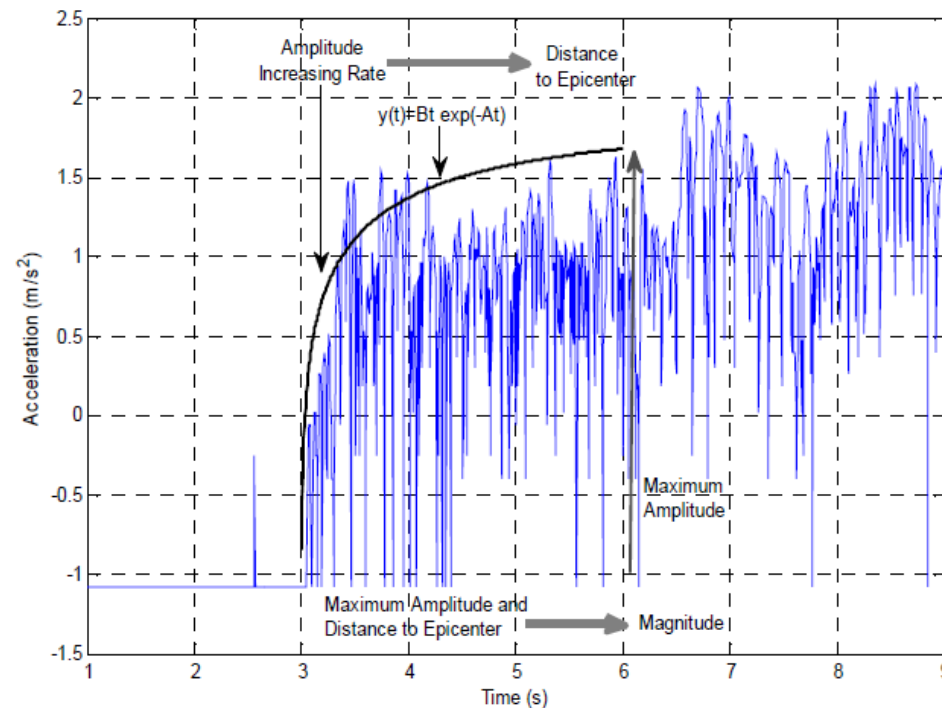
(<sup>2</sup>) Dept. of Physics, University of Hormozgan, Bandar Abbas, Iran

(<sup>3</sup>) Institute of Geophysics, University of Tehran, Tehran, Iran

## Prediction of Magnitude and Epicentral Distance from a Single Seismic Record: A Case Study of the Ahar-Varzaghan Earthquake

Majid Mahood\*, Mohammad Mokhtari, Hamid Zafarani

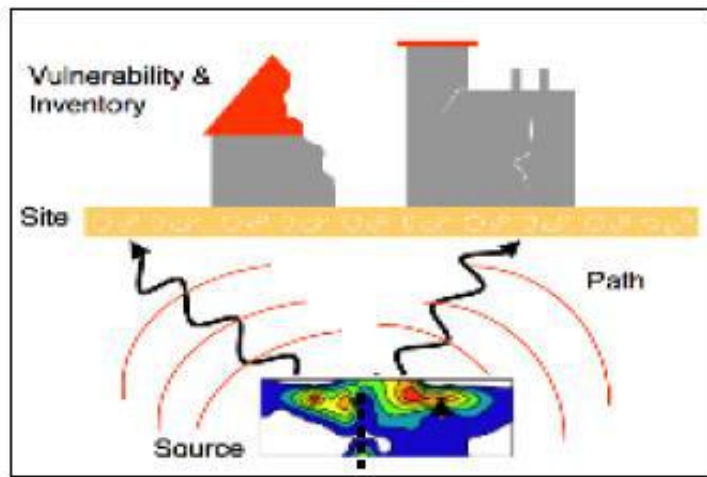
Earthquake Prediction Center, International Institute of Earthquake Engineering and Seismology, Tehran, Iran



# The different time scales of the earthquake process

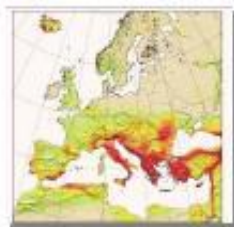
## *Real Time Seismology*

From an original figure of Tom Jordan redrawn by Stefan Wiemer



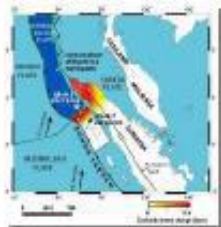
REAL-TIME SEISMOLOGY

Earthquake



Long-term  
Hazard  
Mapping

decades



Long-Term  
Forecasting

years



Short-Term  
Forecasting  
& Prediction

days



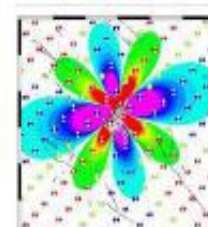
Early  
Warning

seconds



ShakeMaps  
& Rapid Loss  
Assessment

minutes



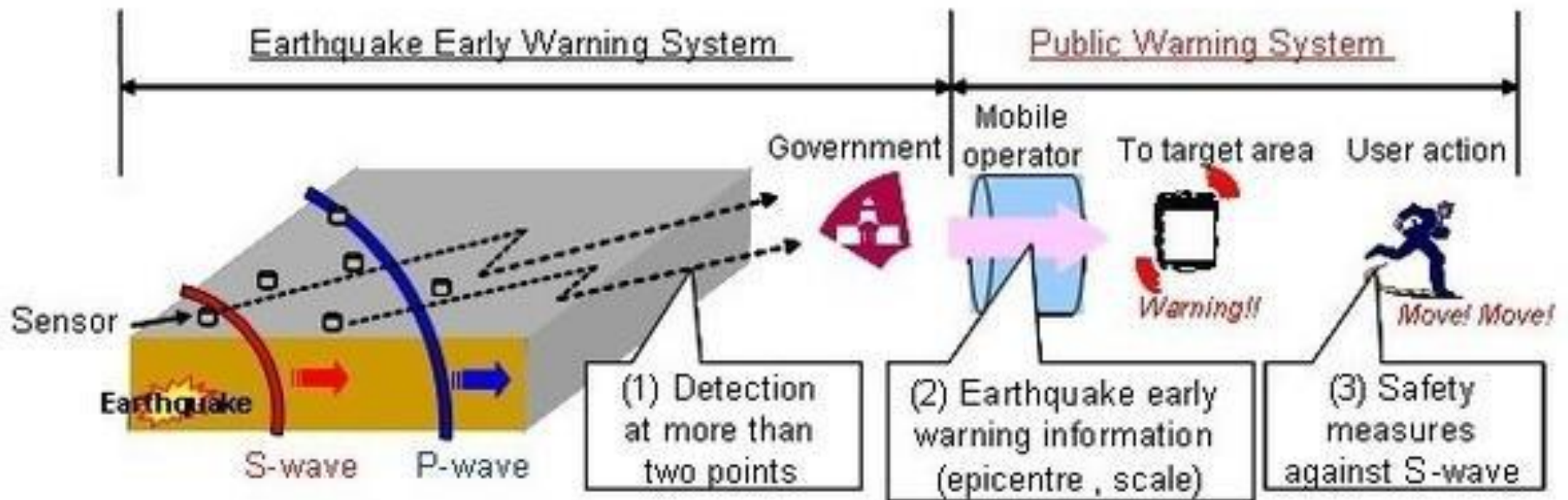
Aftershock  
Hazard

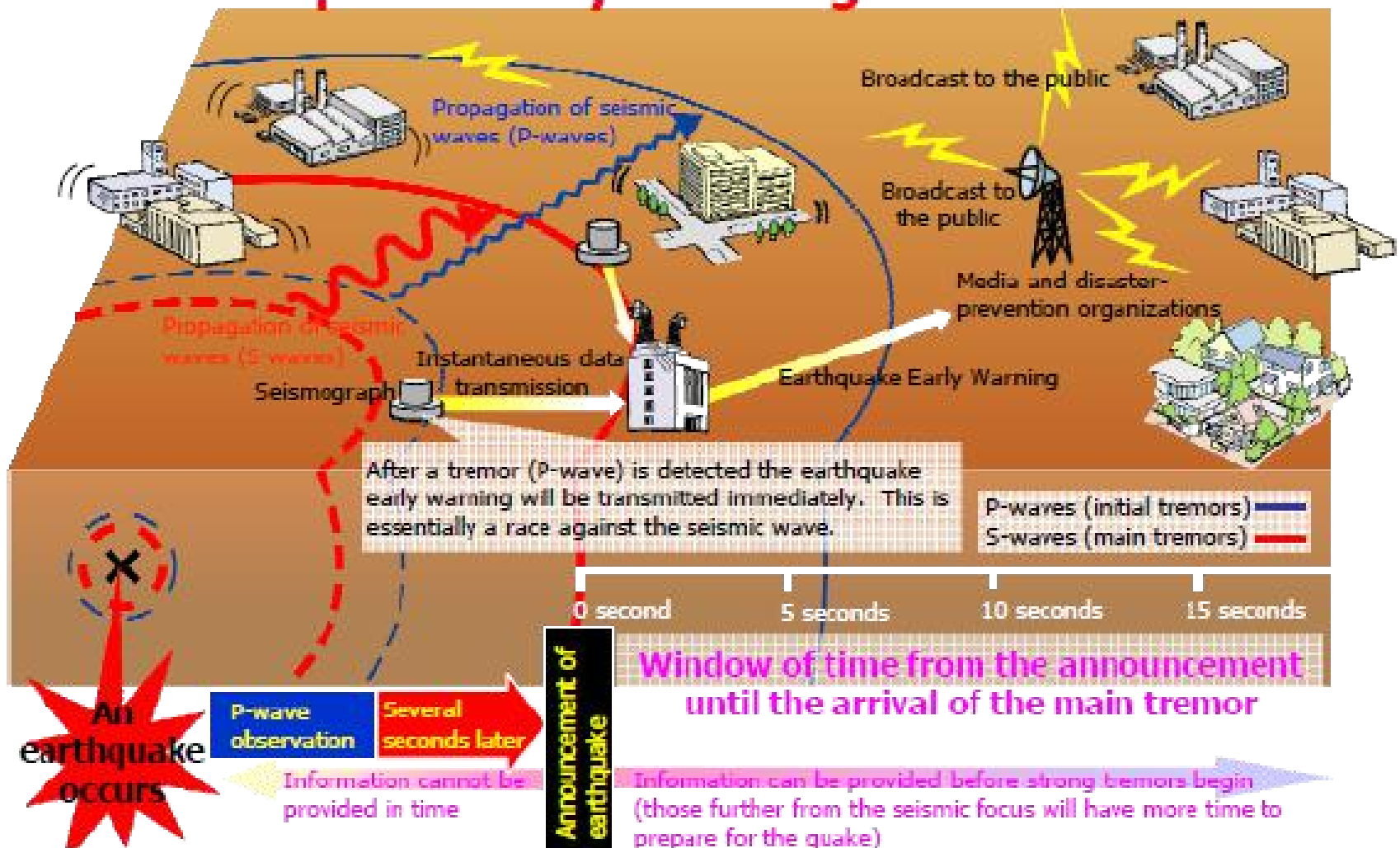
days/  
months



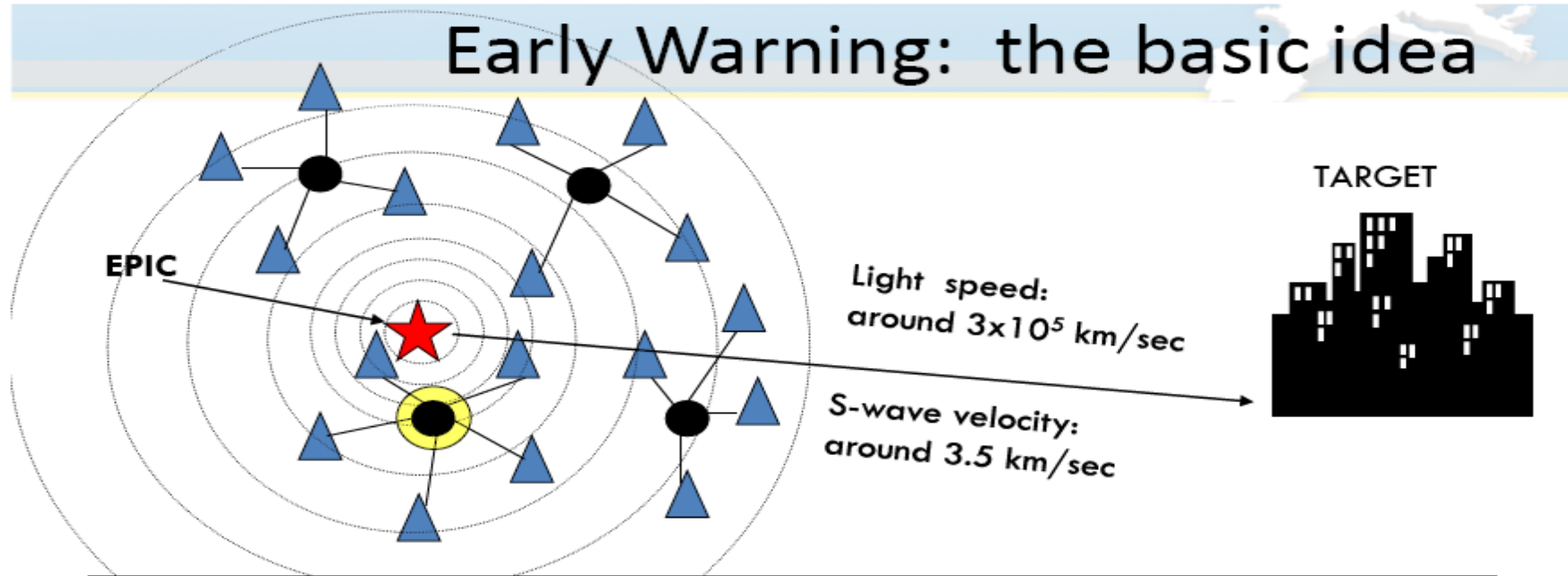


- Earthquake Early Warning System
- Early Response System
- Rapid Damage Estimate





# Early Warning: the basic idea



- Based on the difference between the propagation velocity of the seismic waves in the undersoil and that of the analogue (digital) signals transmitted by radio (or cable)

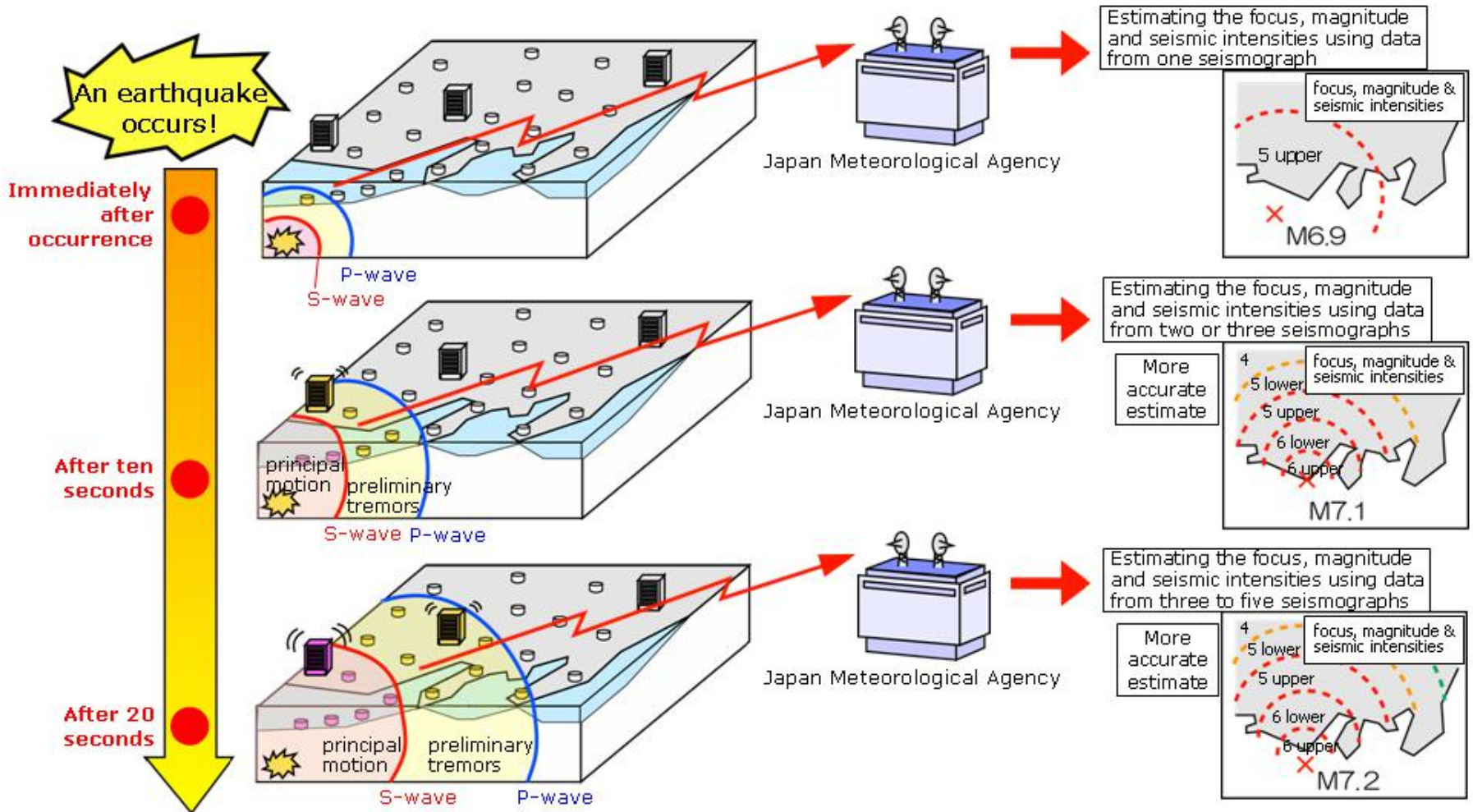


## • Speedness

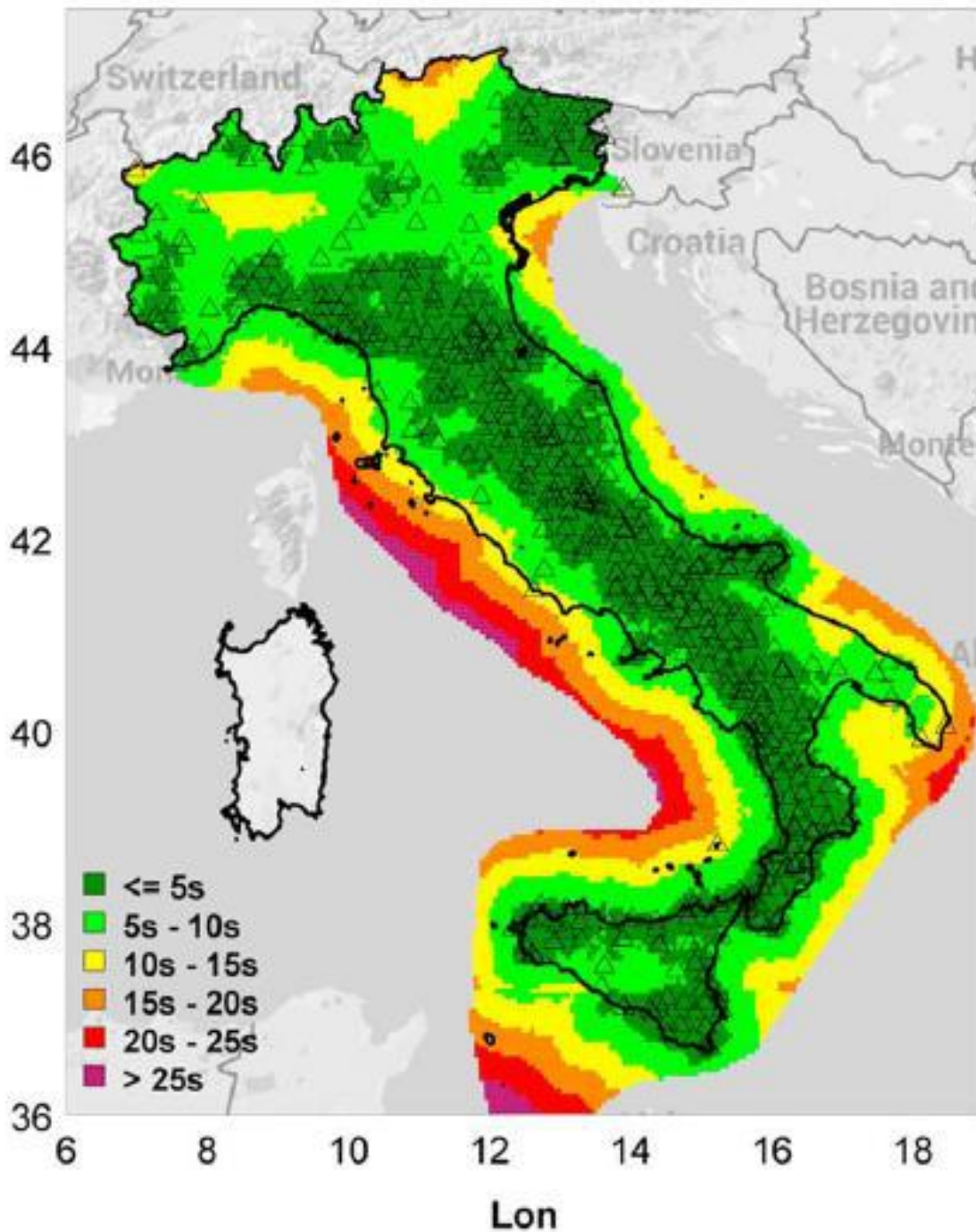
Fast data transmission & computing, small latency time

*Predict the Magnitude and Epicentral distance to estimate the ground shaking at a given target* (Satriano et al., 2010)

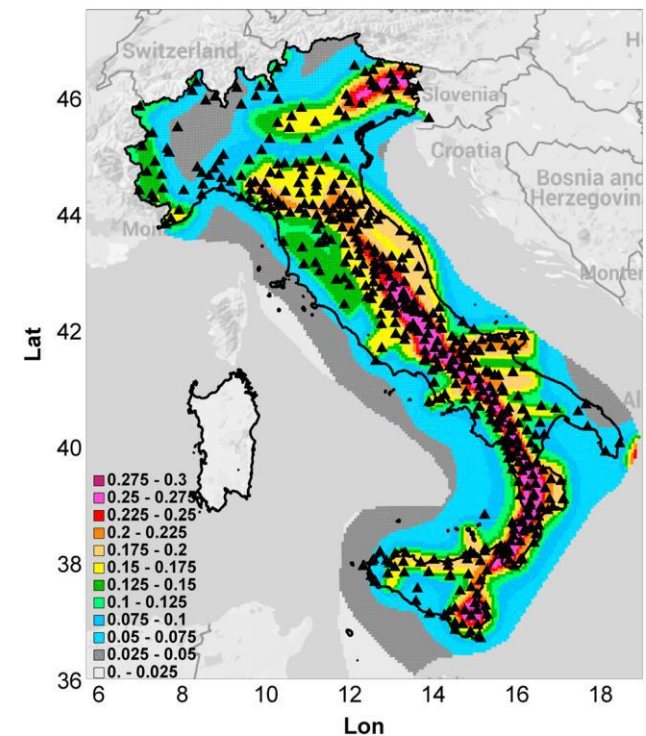
# با افزایش تعداد سنسورها دقت محاسبات بالا می رود

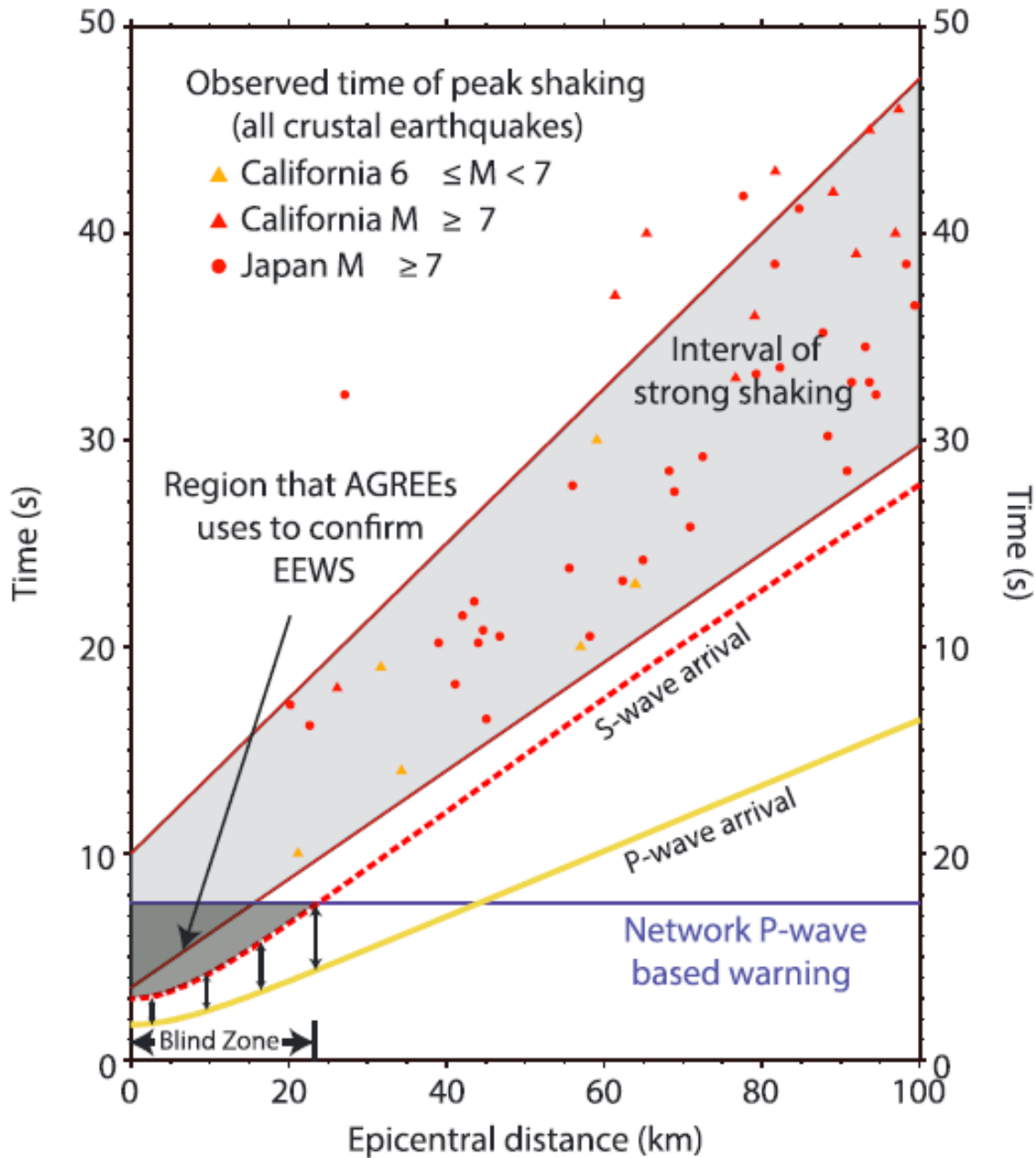


Lat



The Feasibility of *a nationwide earthquake early warning system in Italy*



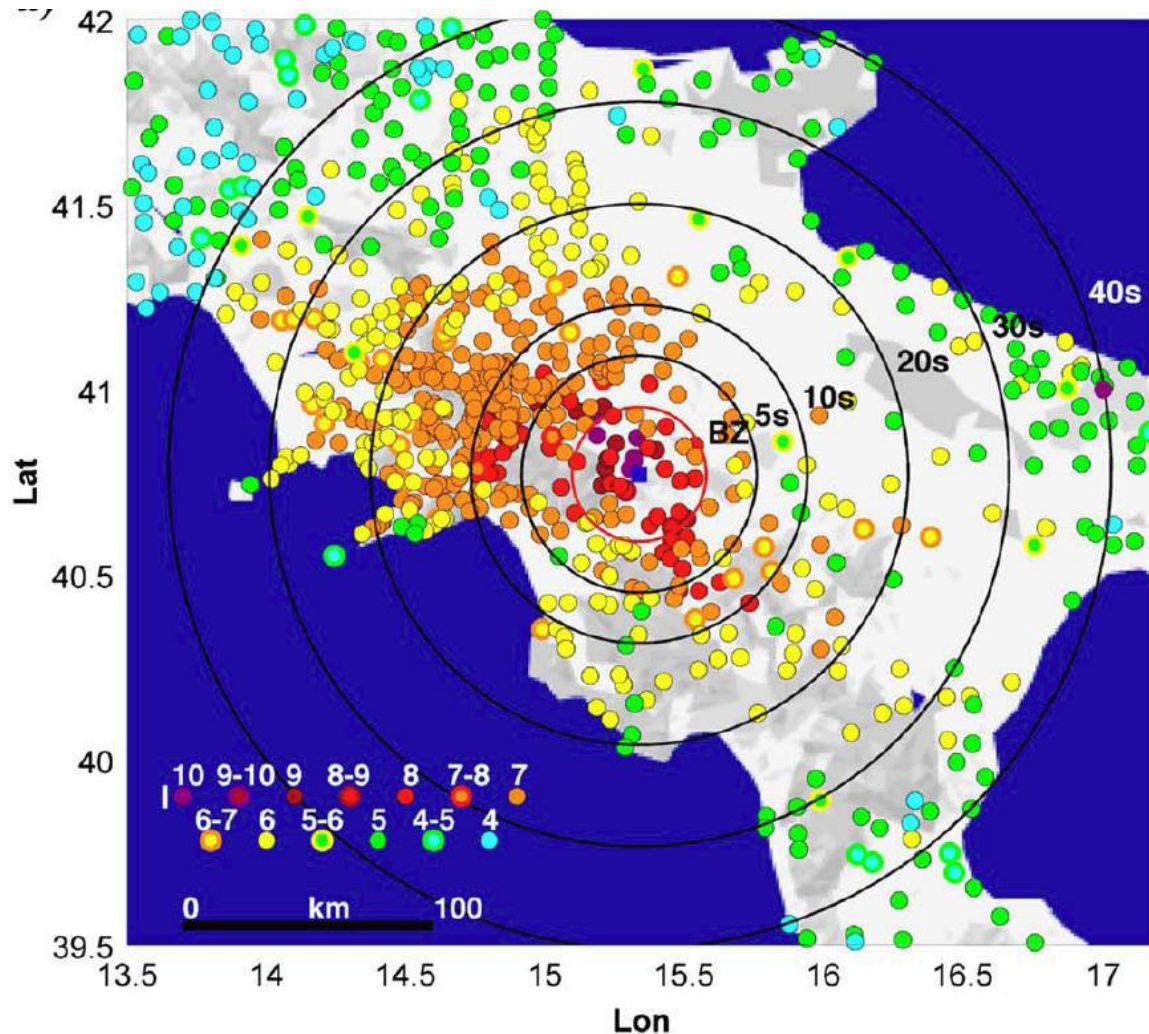


- Station: 32 km
- P-time : 5.6 s
- Cal time : 2 s
- blue horizontal line at 7.6 s is the warning of regional

- **Blind Zone:** an area where S wave and/or strong shaking has already reached is  $\sim 23$  km from the epicenter at this time (Kuyuk et al., 2015)

# Macroseismic intensity of the 23 November 1980 Irpinia Earthquake (Mw 6.9)

Epicenter (blue square), the circles indicate the BZ (red line) and distribution of Lead Time (i.e., 5, 10, 20, 30, and 40 s, black line).

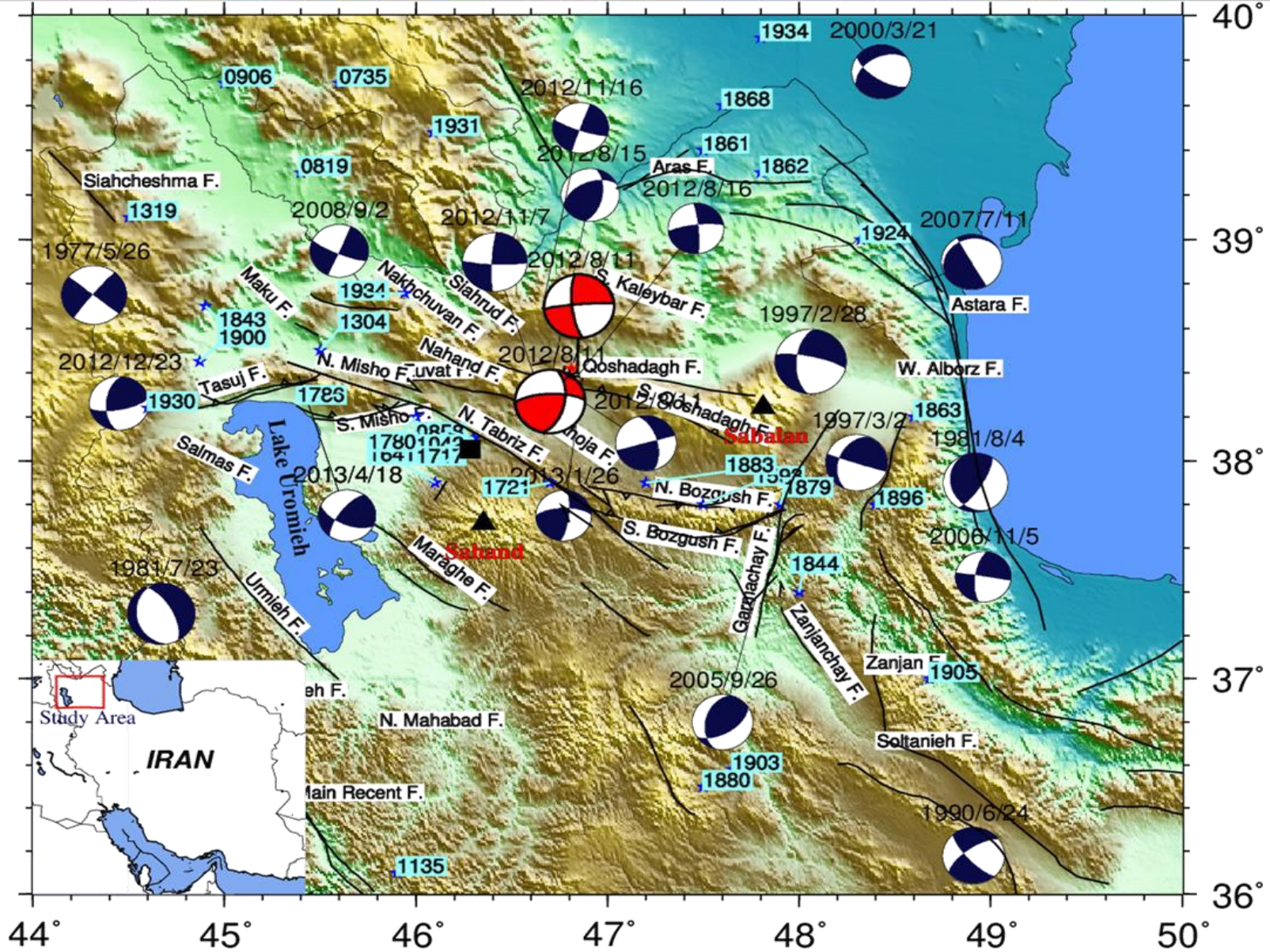


“seismic alert” blaring from speakers in schools and parks. It means an earthquake is rumbling up from the Pacific coast, and you have 60 to 90 seconds to get someplace safe.



The subduction zones that produce the quakes are along the Pacific coast, more than 200 miles away from the city.

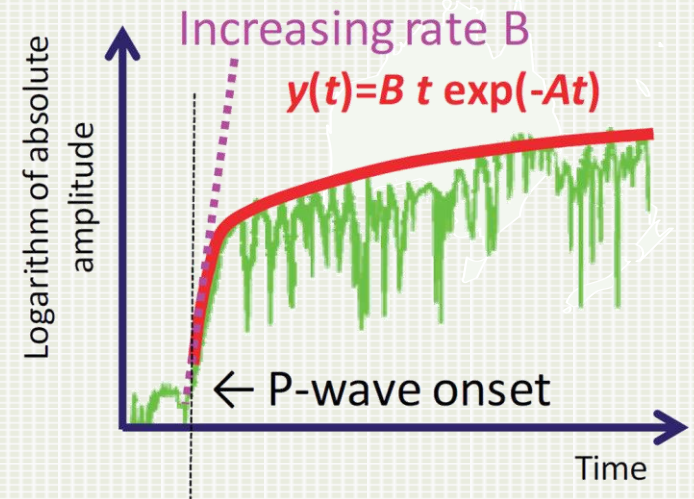




An overview of NW-Iran, destructive and historical events, location of the Ahar-Varzeghan earthquakes

# Introduction

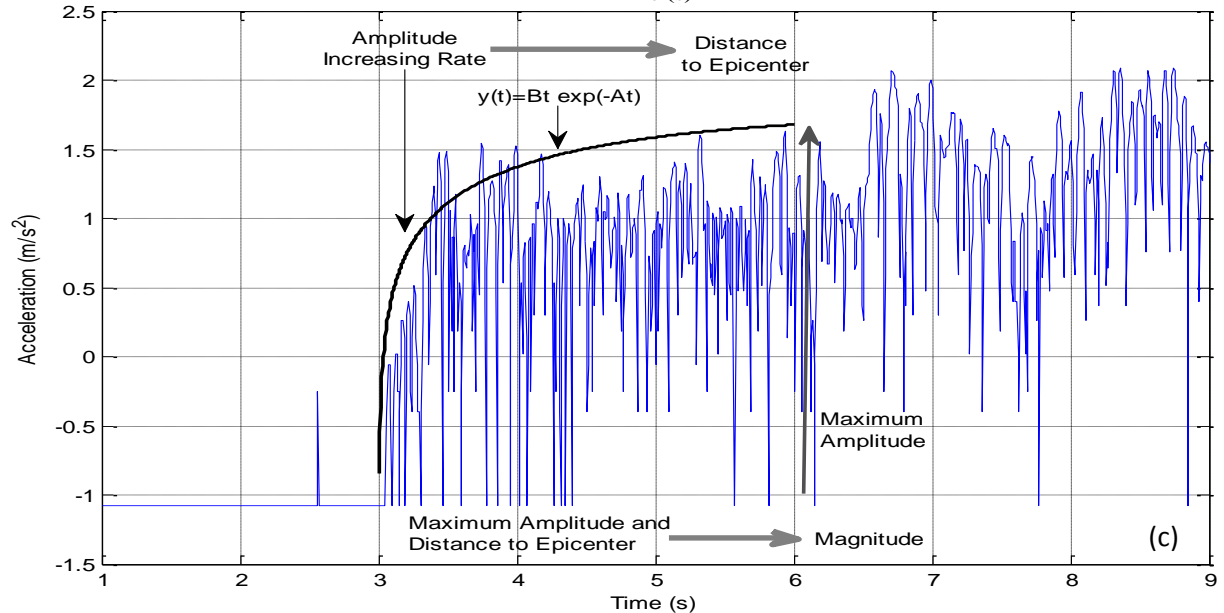
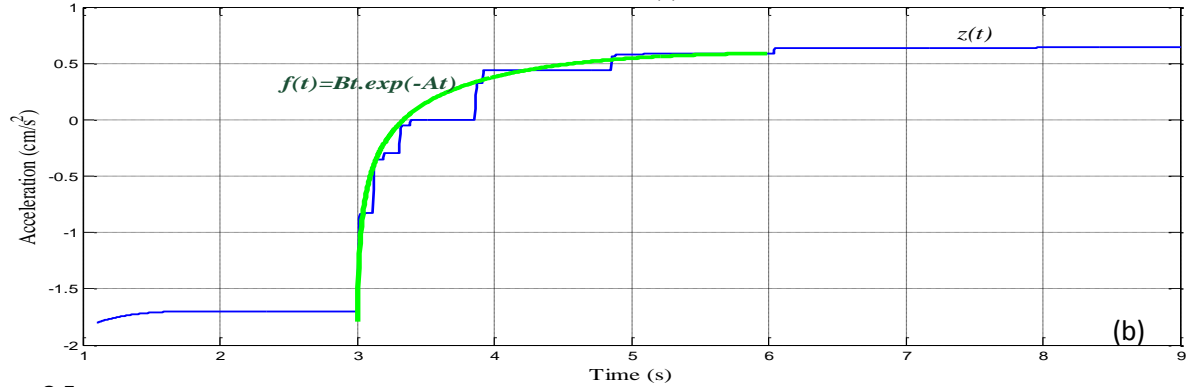
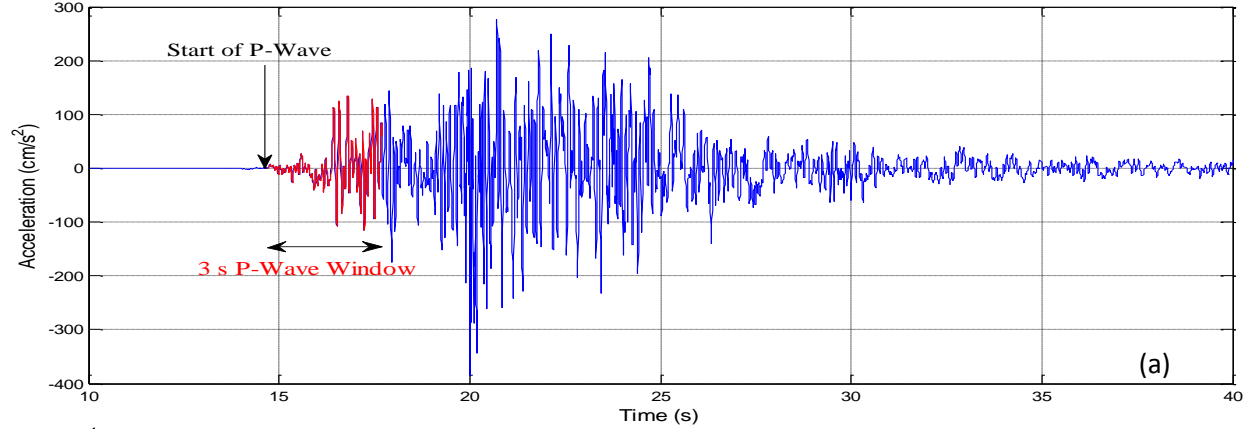
- Odaka *et al.* (2003) presented a novel method of estimating the magnitude and epicentral distance from a single seismic record in a short amount of time, say, a few seconds after the *P*-wave arrival.
- This method is called the B- $\Delta$  method.

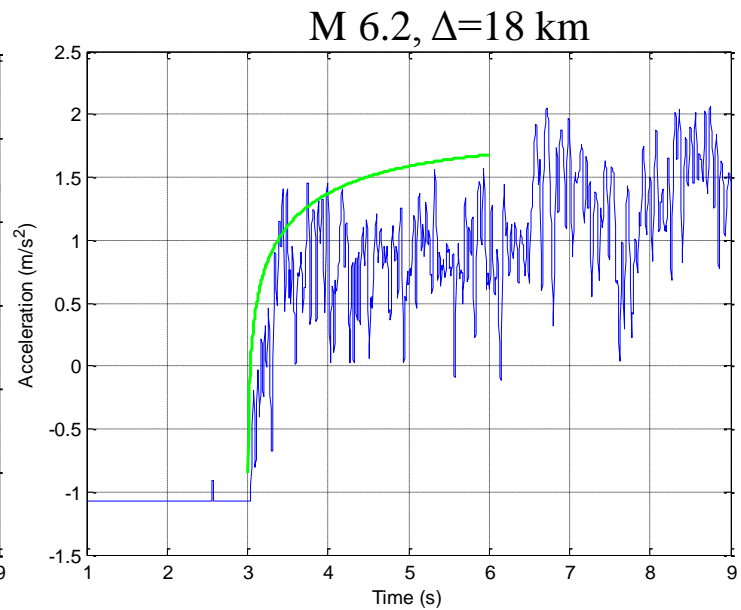
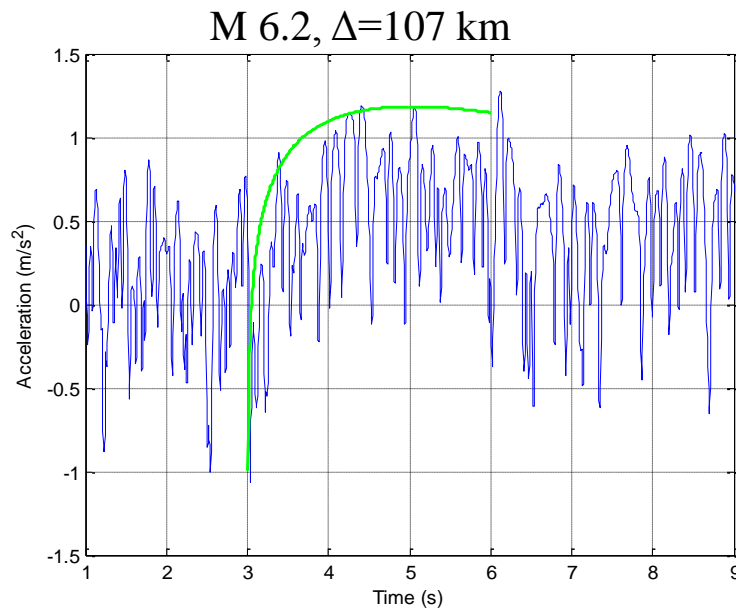


مولفه عمودی  
شایبناگشت ثبت  
شده از زلزله اول  
اھر

شروع موج  $P$   
مشخص شده  
است. در شکل  
پایین لگاریتم  
قدر مطلق دامنه  
پنججریه زمانی ۳  
ثانیه انتخاب شده

به همراه منحنی  
برازش شده با  
رابطه  
 $Y=Bt*exp(-At)$   
به نمایش درآمده  
است

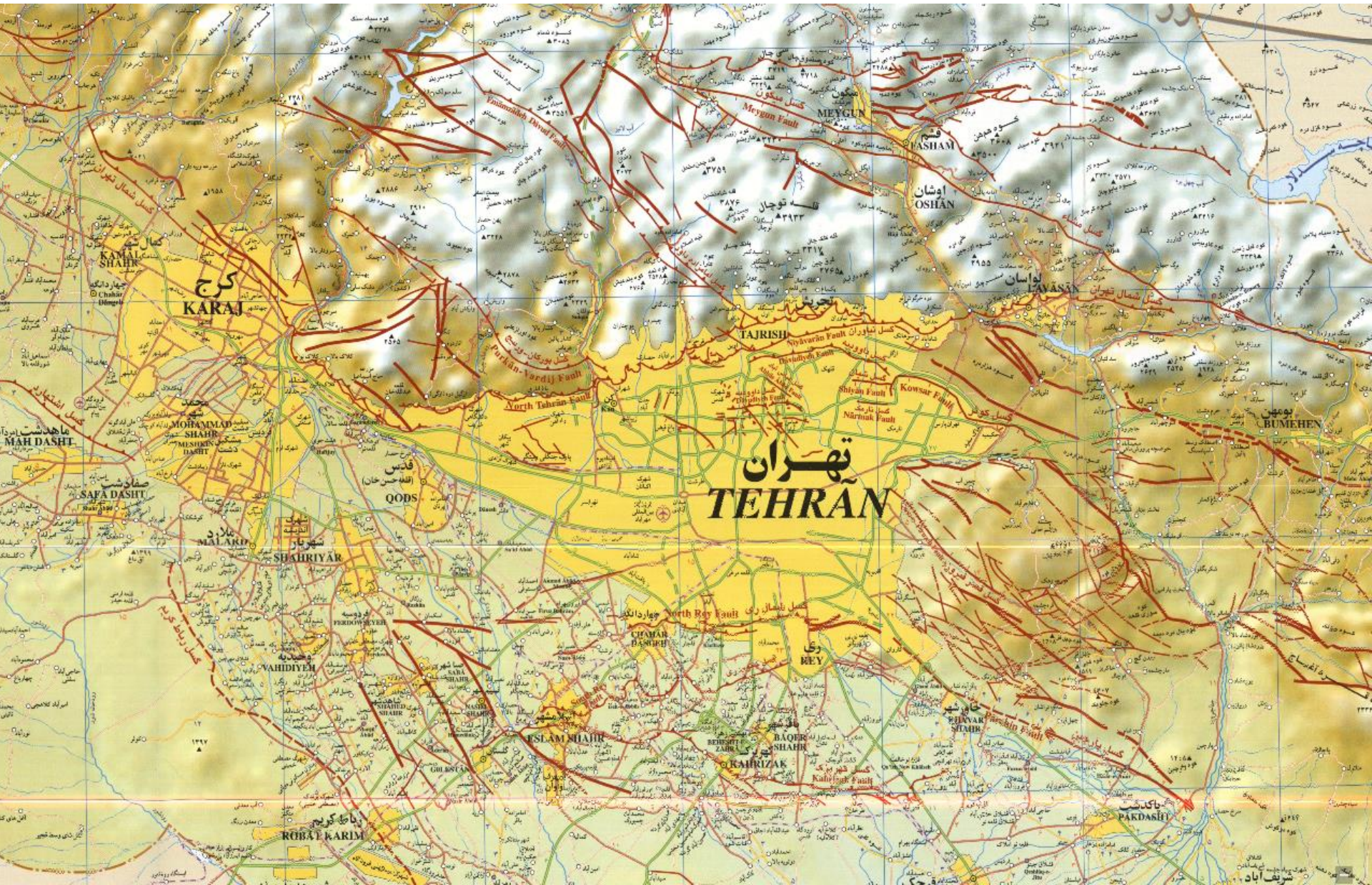




مقایسه بین دو نگاشت ثبت شده با شکل متفاوت از زلزله اهر ورزقان در فواصل کانونی مختلف نمودار سبز رنگ منحنی برازش شده با رابطه  $Bt.exp(-At)$  می باشد

We considered  $V_p=6.5$  km/s and  $V_s=3.5$  km/s. For Sarpol-e Zahab station ( $\Delta = 39$  km) P-time is 6 s and calculation time is 4 s. We need 10 s for warning time whereas S arrival time is 11.2 s, then we have only 1.2 s time for the decision to alarm. Blind Zone, an area where S-wave and/or strong shaking has already reached, is  $\sim 35$  km from the epicenter at this time. For the stations near the epicenter, we will have more time to alarm and therefore small blind zone. For very near stations, there is not enough time to record 3 s initial part of P-wave and S-waves arrive before 3 s.

# موقعیت گسل‌های تهران



- اجرای سیستم‌های هشدار سریع زلزله در کشور زلزله‌خیز ایران، نواحی زاگرس، آذربایجان، البرز و مخصوصاً تهران و شهرهای بزرگ به دلایل زیر از اهمیت بالایی برخوردار هستند: وجود گسل‌های فراوان،
  - زمین‌لرزه‌های تاریخی و دستگاهی،
  - گسترش روند شهرنشینی و تمرکز جمعیت،
  - شریان‌های حیاتی آسیب پذیر،
  - شبکه توزیع گاز گسترده، گسترش خطوط ارتباطی مانند مترو،
  - وجود شهرک‌های صنعتی.
- امید است با رشد سریع ارتباطات و الگوریتم‌های انتقال داده بتوان با استفاده از تکنولوژی‌های جدید از خسارات ناشی از زلزله‌های آینده در نواحی مختلف کشور کاست.

**با تشکر**