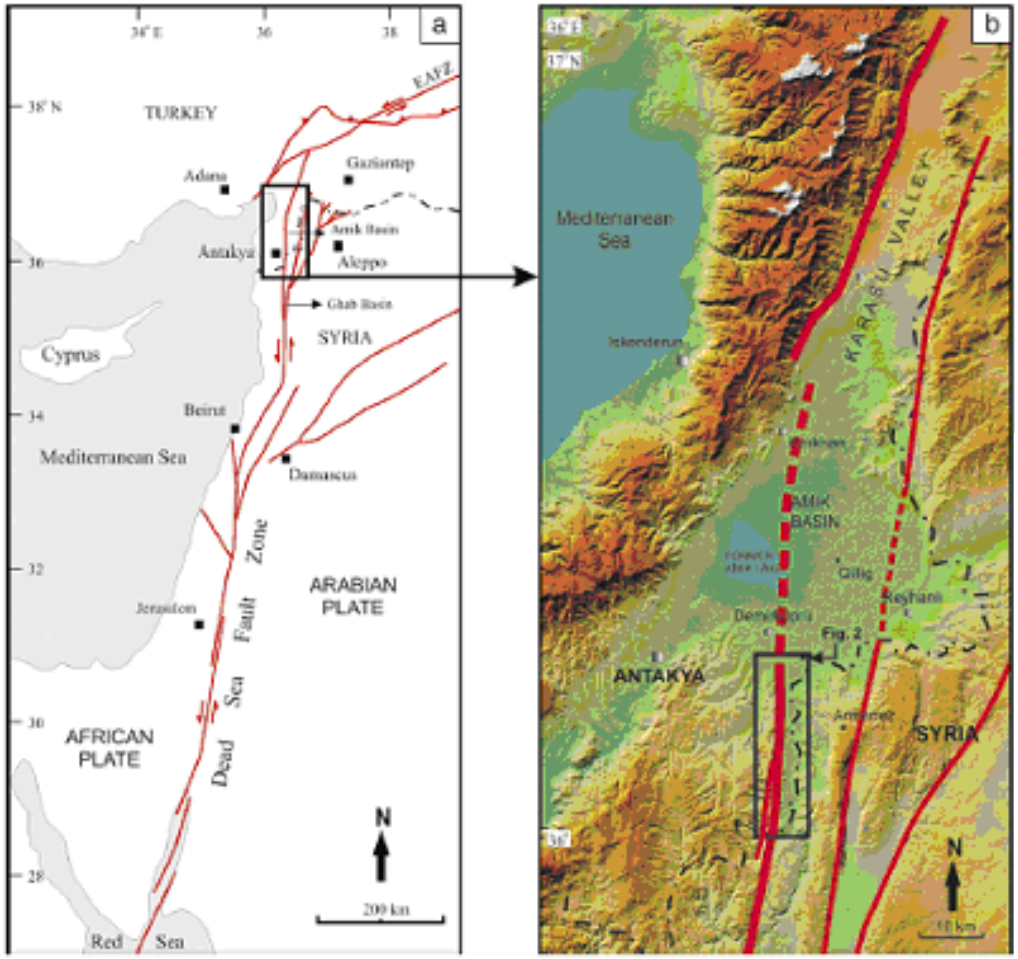
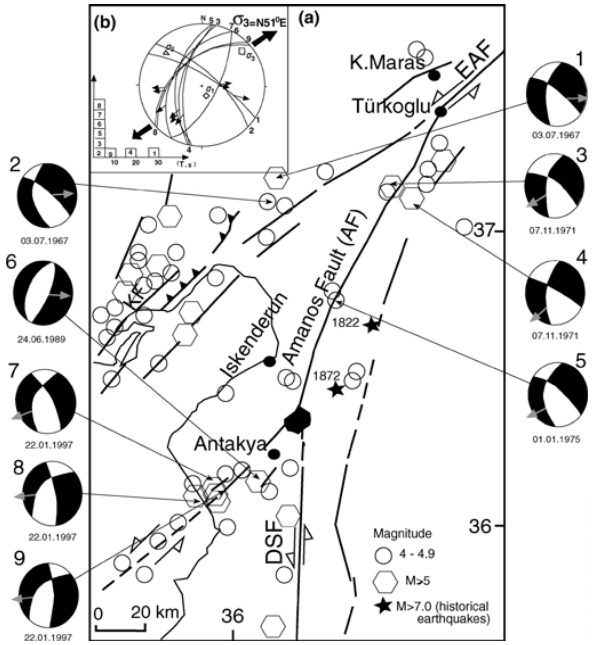
Strong Ground Motion in Antakya: From Observation to Simulation

Eser Çaktı, Oğuz Özel, Murat Bikçe, Cemal Geneş,
Selçuk Kaçın, Erdal Şafak, Semir Över, Mustafa Erdik
Boğaziçi University, Mustafa Kemal University, İstanbul University

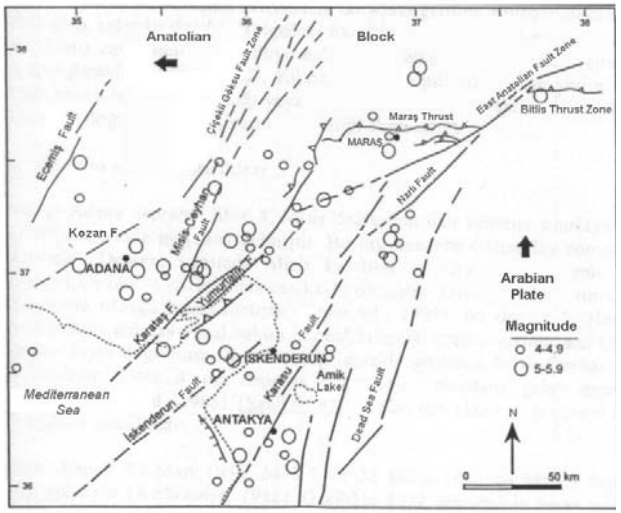
Seismotectonics



from Akyuz et al.,2006

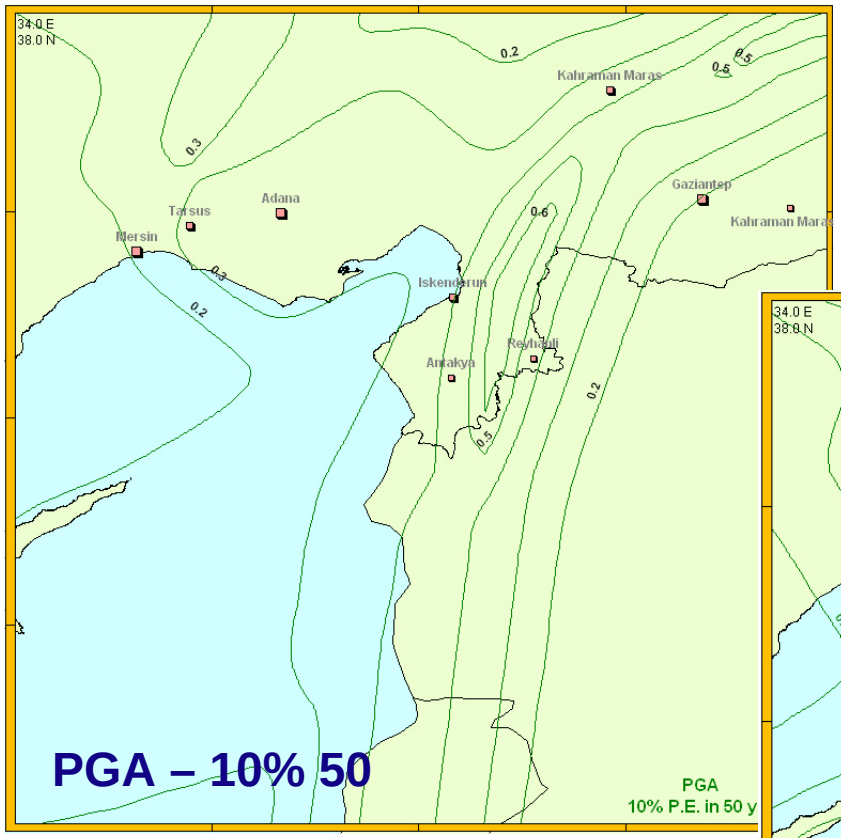


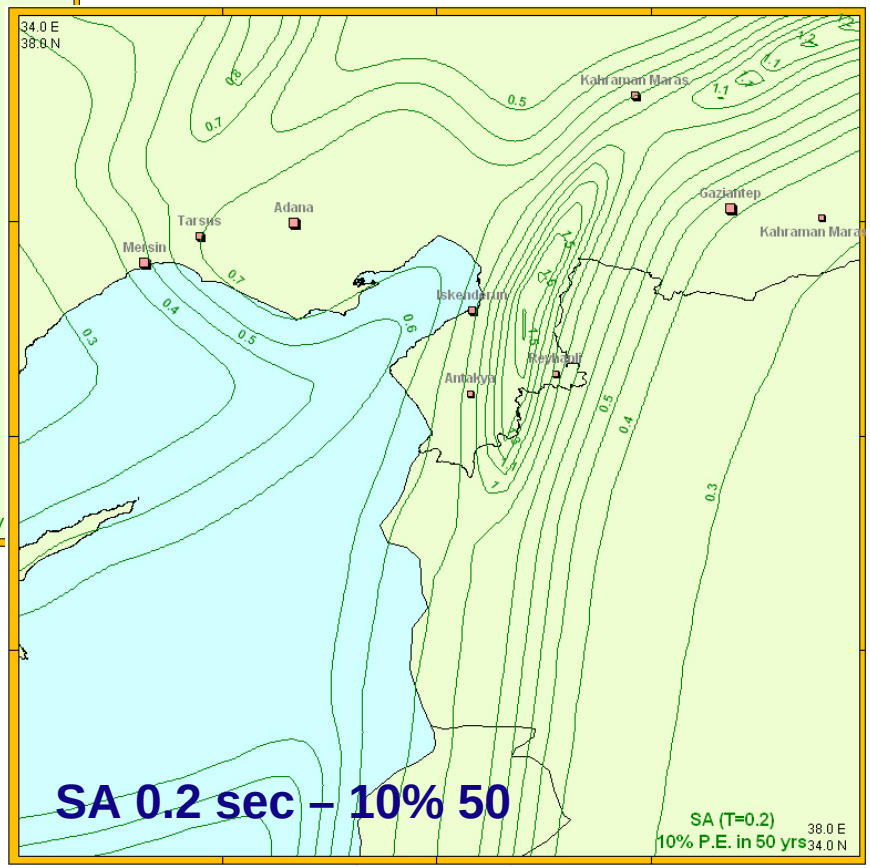
from Over et al., 2002



from Barka et al.1999,
modified from Gülen et al., 1988

Earthquake Hazard





Site independent

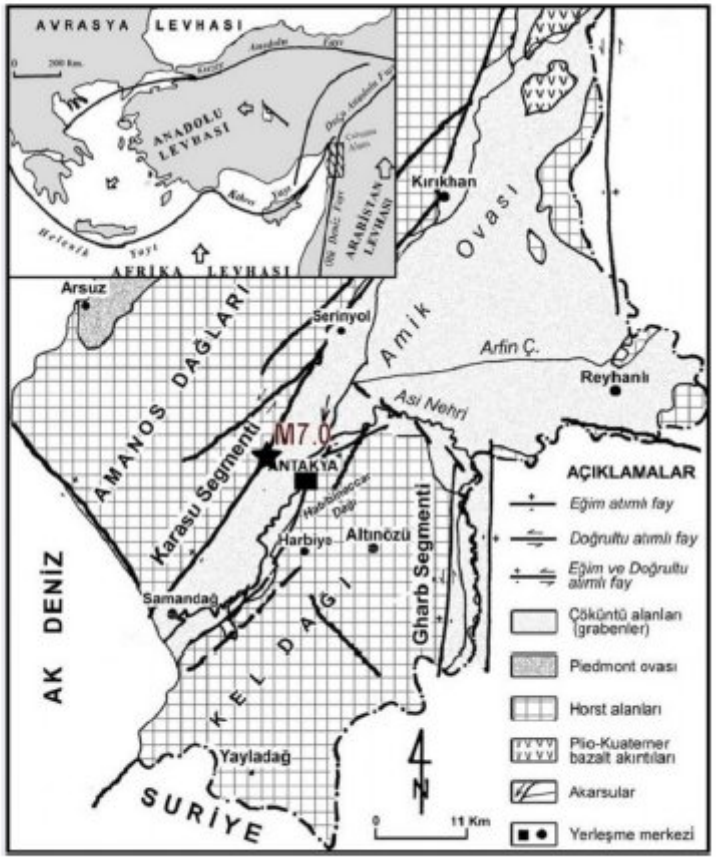
on average x1.5 increase on these values if site dependency is considered

from Demircioğlu et al, 2009

Earthquake Loss Estimation, *Level 1*

ELER Loss Estimation
ELER Kayıp Tahmini **Case: *Antakya M7***

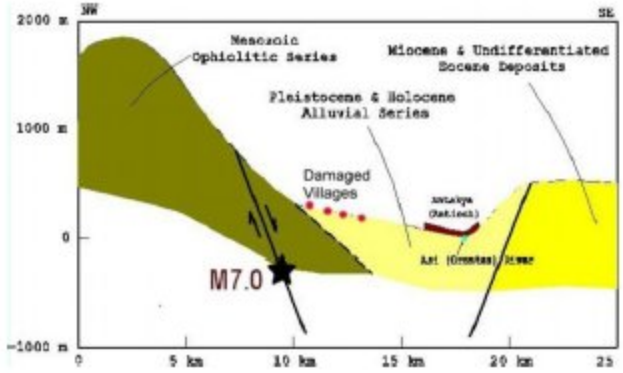
Fault rupture: 40 km (Coppersmith & Wells) Strike Slip



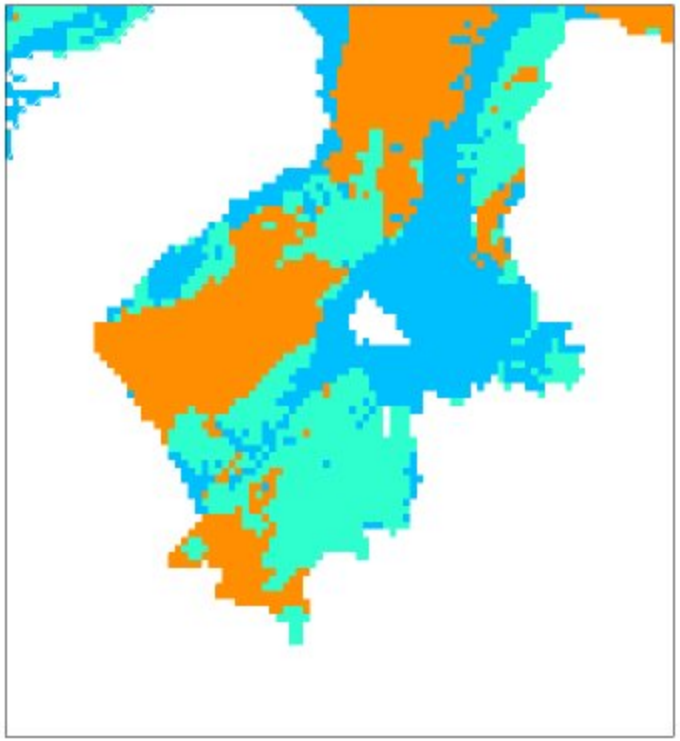
General Site Conditions

ELER Loss Estimation
Case: *Antakya M7*

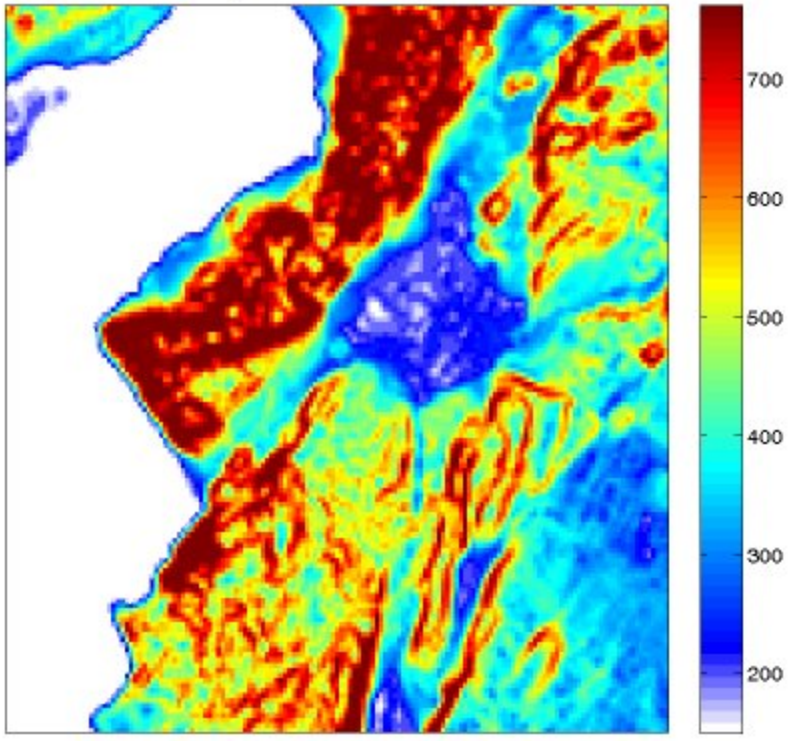
***Site Condition**: Geoteknik Yapı* Vs30 maps



QTM Based



Slope Based (USGS)



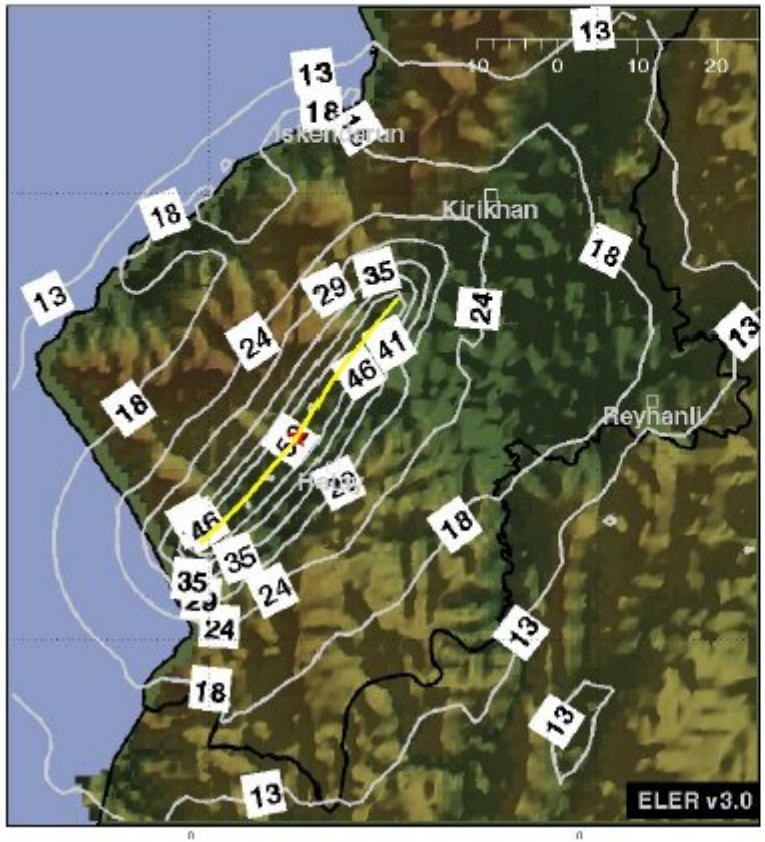
Earthquake Hazard

ELER Loss Estimation
Case: *Antakya M7*

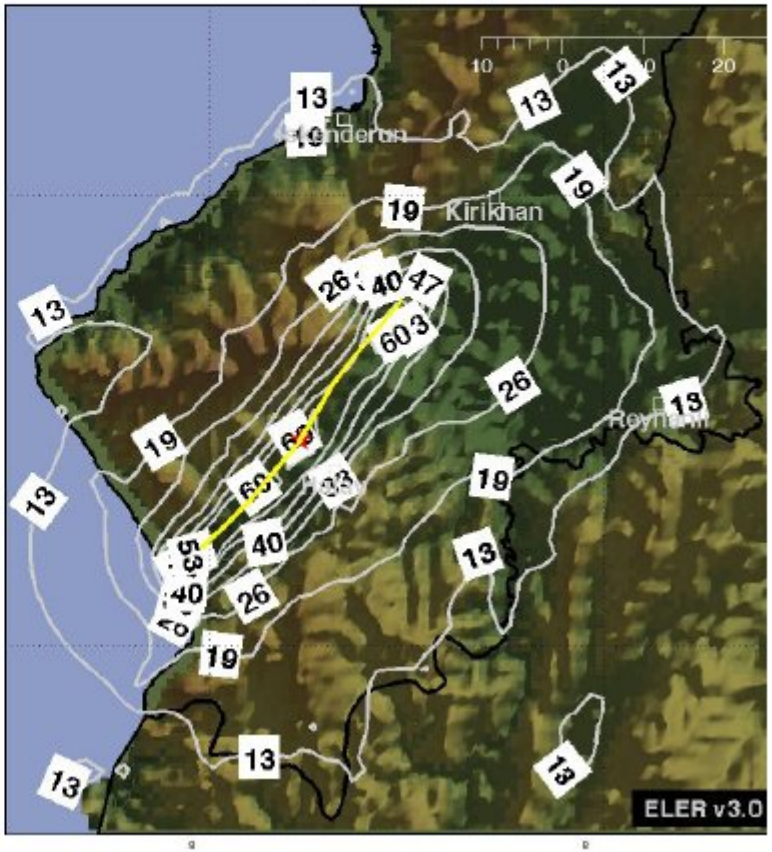
GMPE:Boore & Atkinson 2008, calculated directly at surface using slope-based Vs30 (USGS)

Ground Motion: PGA & PGV Pik İvme ve Hız Dağılımı

M7 Depth= 5.4 Lat= 36.2285 Lon= 36.1164
Map of: PGA (%g)



M7 Depth= 5.4 Lat= 36.2285 Lon= 36.1164
Map of: PGV (cm/s)

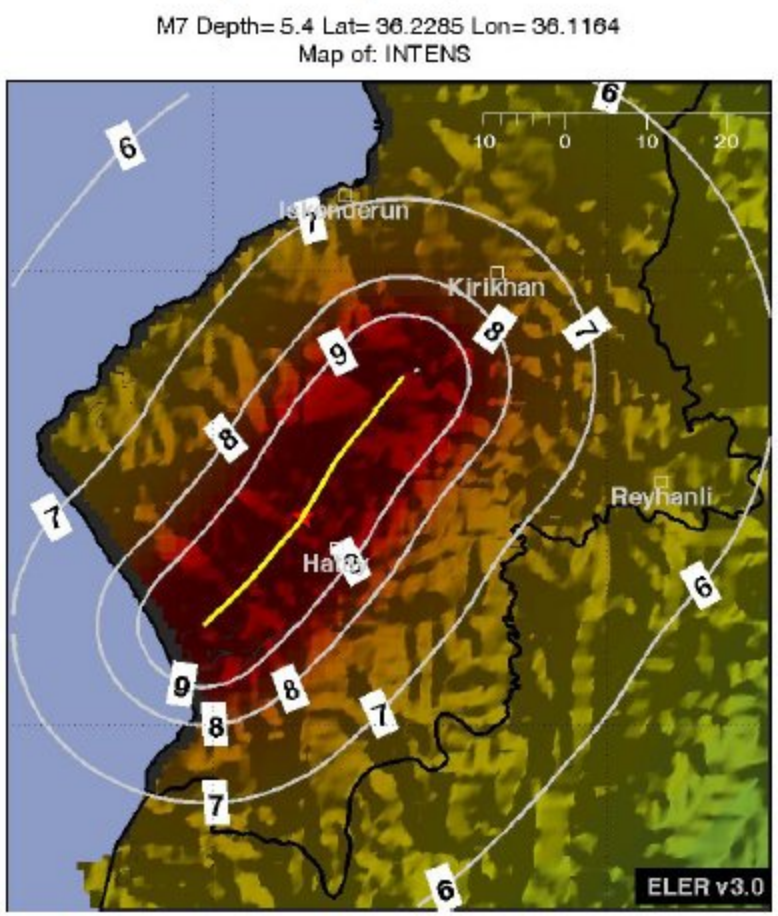


Earthquake Intensities

ELER Loss Estimation
Case: *Antakya M7*

Şiddet Dağılımı

Intensity: Sesetyan (function of source distance R)



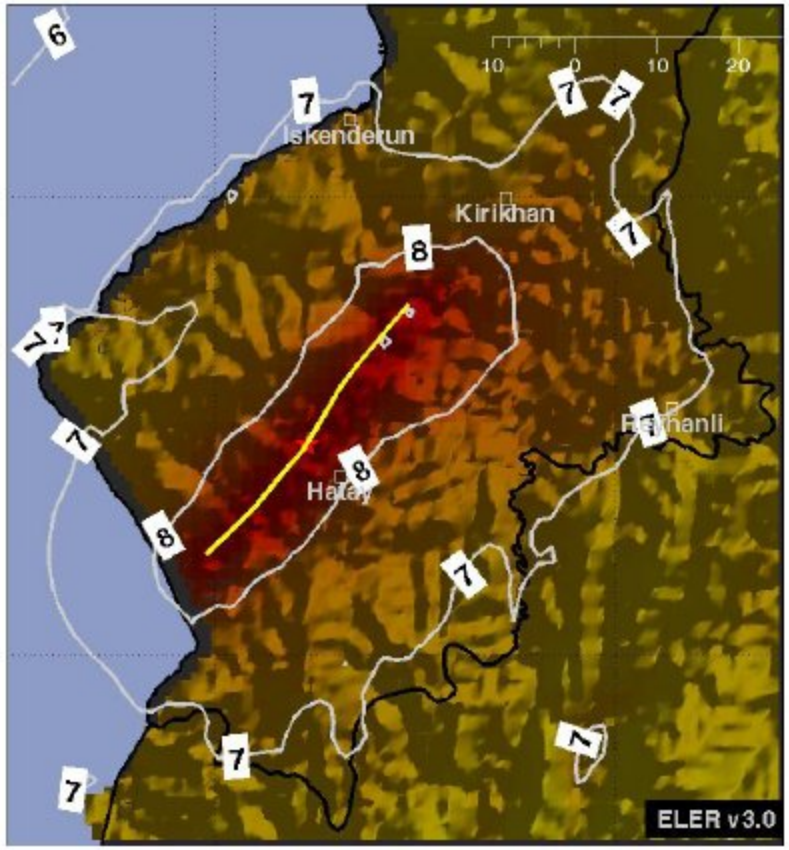
Earthquake Intensities

ELER Loss Estimation
Case: *Antakya M7*

Şiddet Dağılımı

Intensity: Atkinson & Kaka (function of PGV)

M7 Depth= 5.4 Lat= 36.2285 Lon= 36.1164
Map of: INTENS

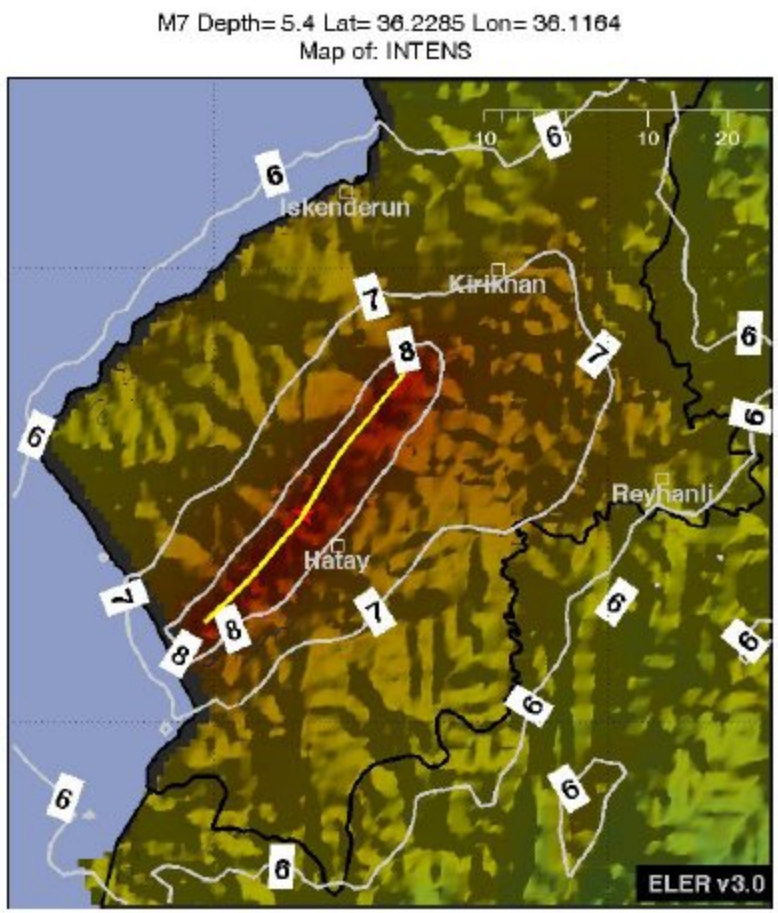


Earthquake Intensities

ELER Loss Estimation
Case: *Antakya M7*

Şiddet Dağılımı

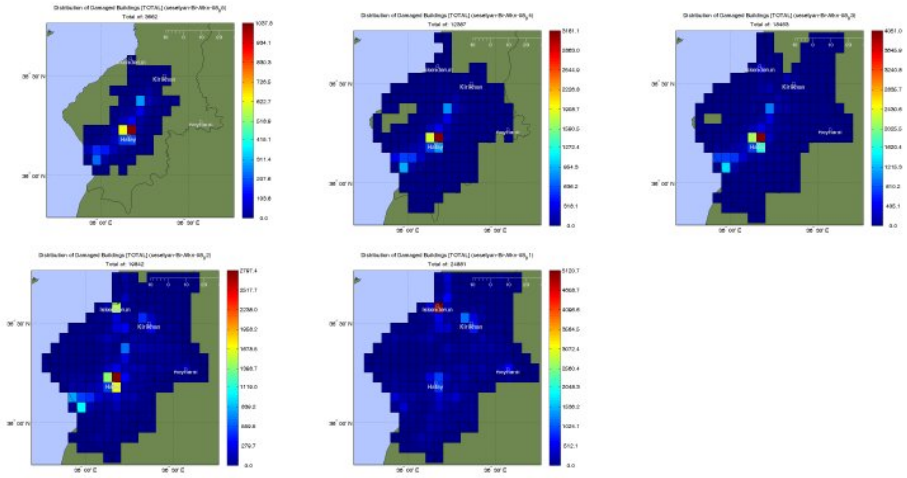
Intensity: Wald (function of PGV & PGA)



ELER Loss Estimation
Case: *Antakya M7*

Bina Hasar Tahmini

Level 1: Damage Distributions (Sesetyan)

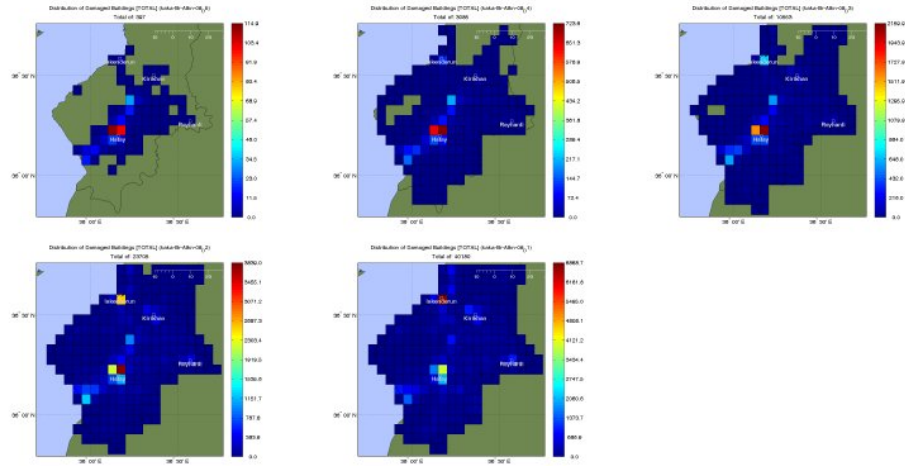


Building Damage

ELER Loss Estimation
Case: *Antakya M7*

Bina Hasar Tahmini

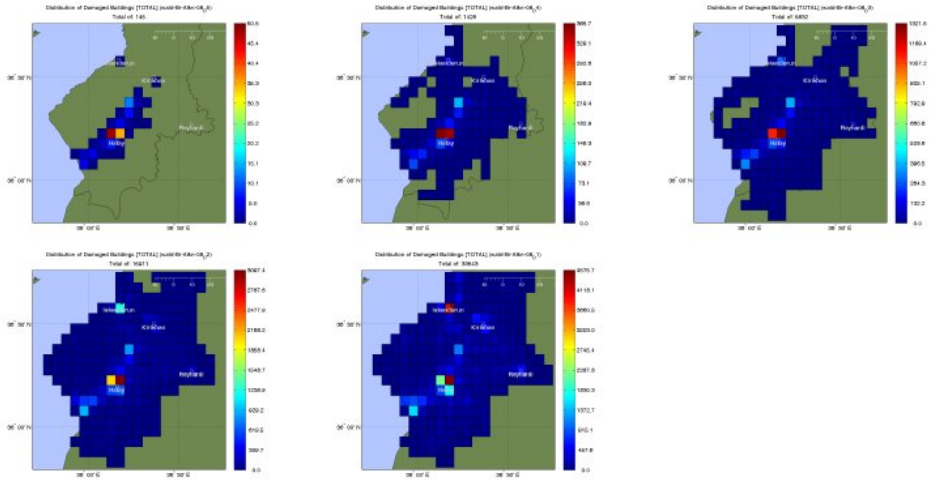
Level 1: Damage Distributions (Atkinson & Kaka)



ELER Loss Estimation
Case: *Antakya M7*

Bina Hasar Tahmini

Level 1: Damage Distributions (Wald)

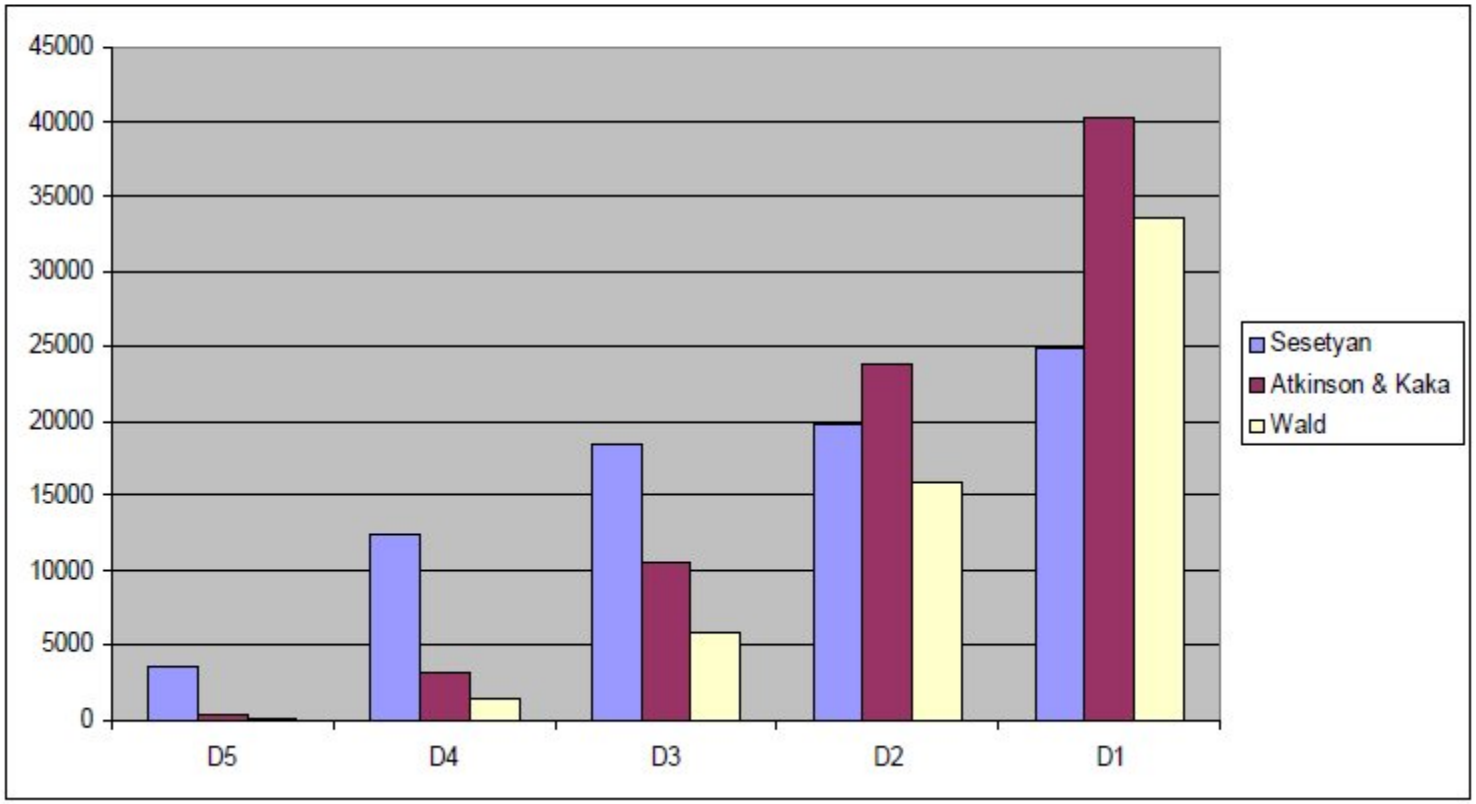


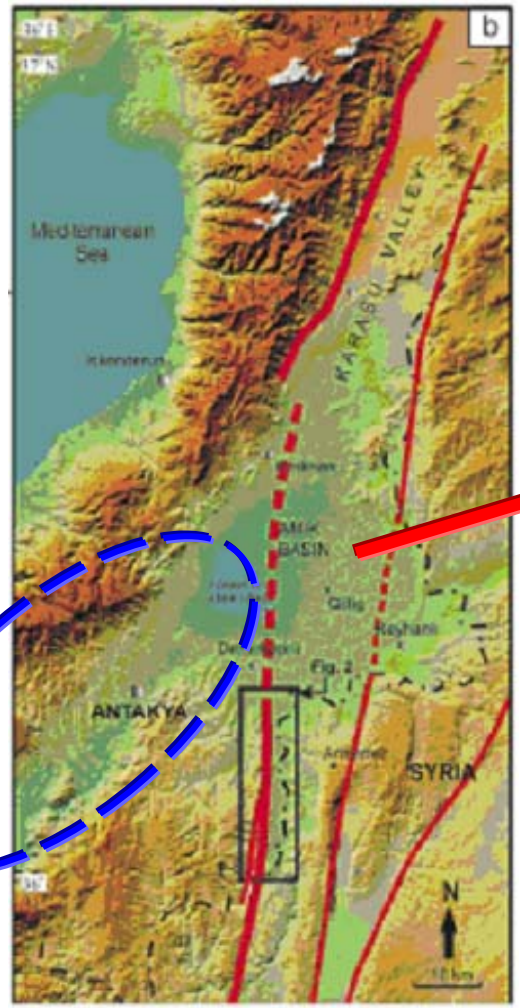
Building Damage

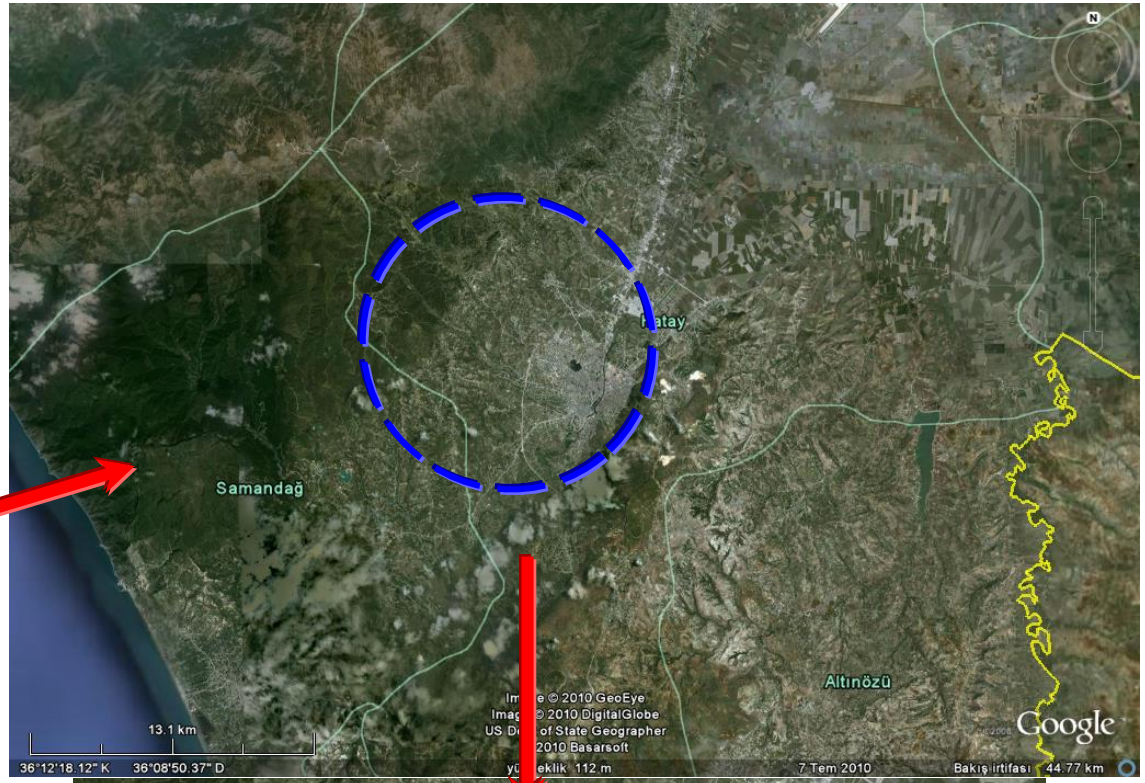
ELER Loss Estimation
Case: *Antakya M7*

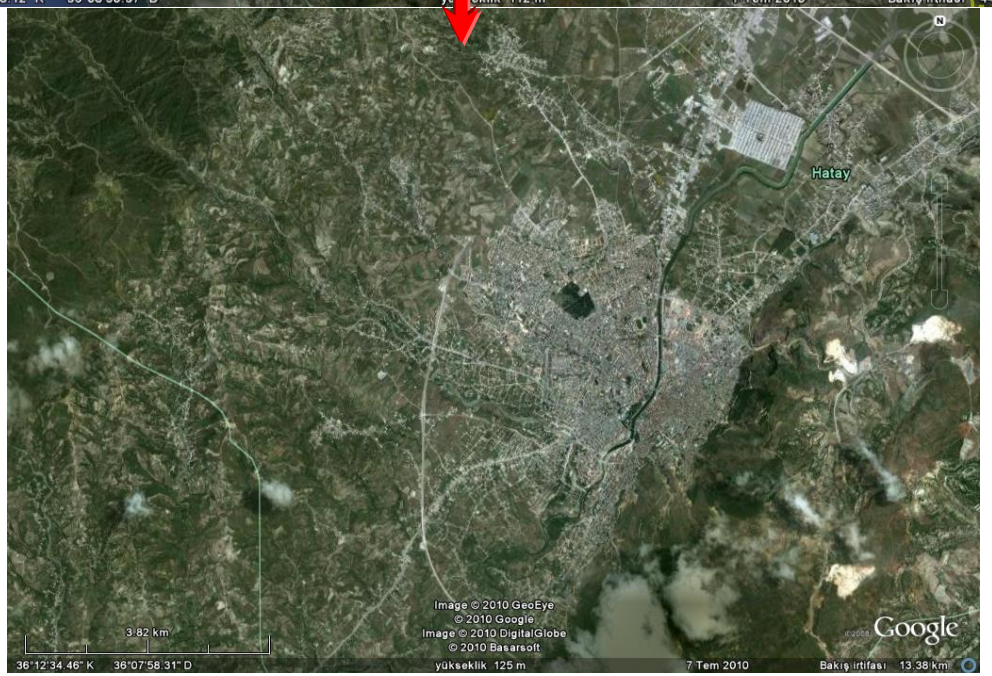
Bina Hasar Tahmini

Level 1: Damage Estimations

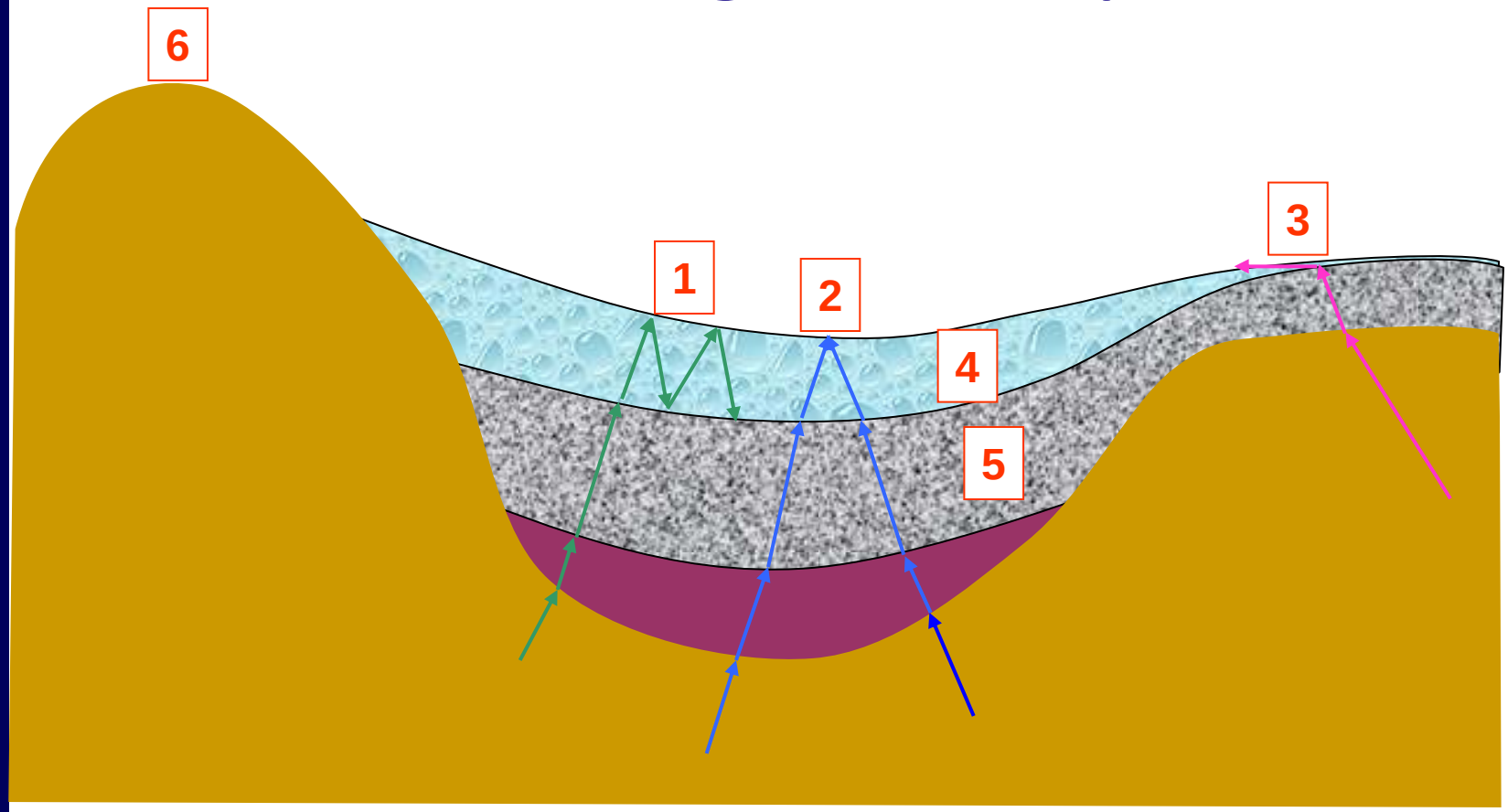



b
Mediterranean Sea
KARASU VALLEY
BASIN
Reyhanlı
ANTAKYA
SYRIA
N


Samandağ
Altınözü
13.1 km
36°12'18.12" K 36°08'50.37" D
7 Tem 2010
Bakış irtifası 44.77 km
Google

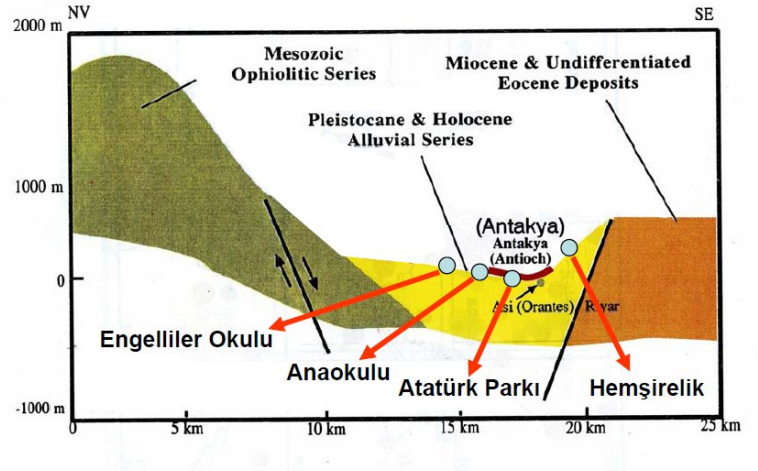

Hatay
3.82 km
Image © 2010 GeoEye
© 2010 Google
Image © 2010 DigitalGlobe
© 2010 Basarsoft
36°12'34.46" K 36°07'58.31" D
yükseklik 125 m
7 Tem 2010
Bakış irtifası 13.38 km
Google

Factors affecting site amplification



1- Resonances due to impedance contrasts
2- Focusing due to subsurface topography
3- Body waves converted to surface waves
4- Water content
5- Randomness of the medium
6- Surface topography


23_4 Hürriyet İşitme Engelliler İlköğretim Okulu Bahçesindeki Küçük Yapı
19_1 Hayrettin Ozkan İlkogretim Anaokulu Binasi
Hatay
15_6 kapali spor salonu yaşama sevinci kulup binasi
Antakya
36_4 Antakya Sosyal Yardımlaşma ve Dayanışma Vakfı
36_2 MKÜ Hemşirelik MYO Güvenlik Klübesi
41_3 Su Pompa B
Turunçlu
Aşağıokçular
Image © 2008 DigitalGlobe
© 2008 Europa Technologies
Image © 2008 GeoEye
Google
Yükseklik 180 m
14 Mayıs 2003
Bakış irtifası 5.12 km


NV
SE
2000 m
1000 m
0
-1000 m
Mesozoic
Ophiolitic Series
Miocene & Undifferentiated
Eocene Deposits
Pleistocane & Holocene
Alluvial Series
(Antakya)
Antakya
(Antioch)
Asi (Orantes) River
Engelliler Okulu
Anaokulu
Atatürk Parkı
Hemşirelik
0
5 km
10 km
15 km
20 km
25 km

Antakya Basin
Strong Ground Motion System

is set up to

- monitor the earthquake response of the Antakya Basin.
- improve our understanding of basin response
- help to determine the effects of local and regional earthquakes on the urban environment of Antakya
- contribute to earthquake risk assessment of the city

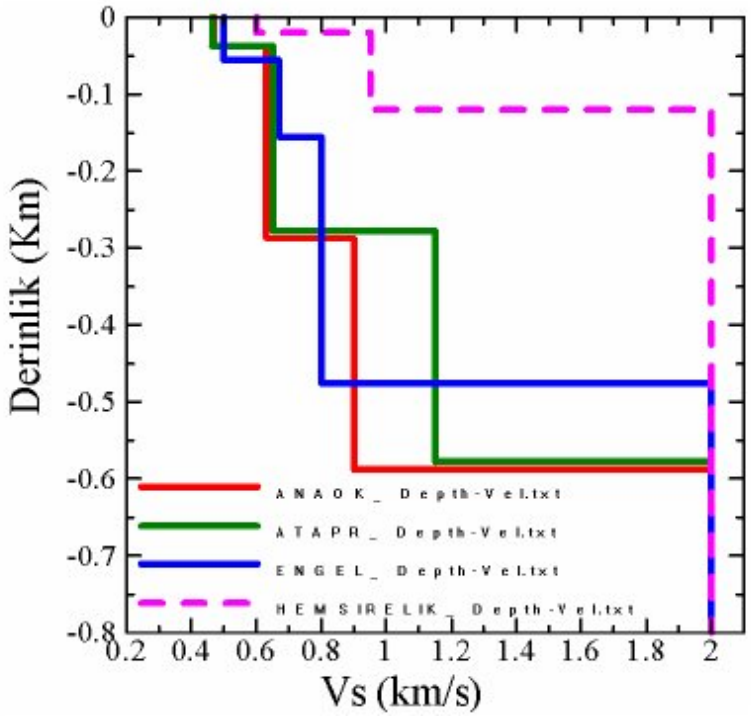
- The soil properties beneath the strong motion stations (S-Wave velocity structure and dominant soil frequency) are determined by array measurements
- The strong motion monitoring system consists of six instruments installed in small buildings.
- The stations form a straight line along the short axis of Antakya basin passing through the city center.
- They are equipped with acceleration sensors, GPS and communication units.
- Currently the stations operate in trigger-mode.
- We are in contact with GSM operators to enable For real time data transmission
- The system is the first monitoring installment in Turkey dedicated to understanding basin effects.

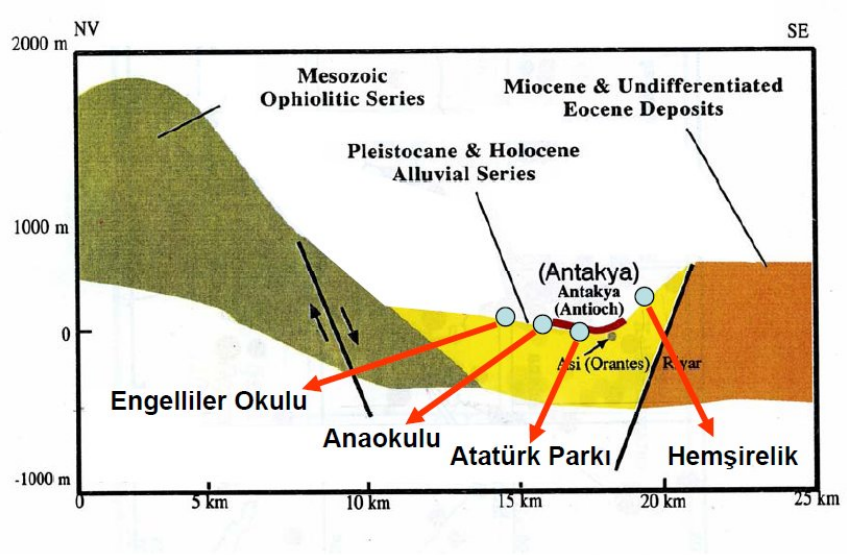
ALETLERİN YERLEŞTİRİLDİĞİ İSTASYONLAR				
Sıra No (Kod No)	**Koordinatlar**	**Seçilen İstasyon Yeri**	**İstasyon Adresi**	**Bağlı Olduğu Kurum**
1 (41_3)	36°11'714"K 36°10'174"E	Antakya Su Pompa Binası	Havuzlar Mah. İzmir Caddesi Başlangıcı	Antakya Belediyesi
2 (36_2)	36°11'682"K 36°09'952"E	MKÜ Hemşirelik MYO Güvenlik Klübesi	Bağrıyanık Mah. Hastane Cad.	Mustafa Kemal Üniversitesi Rektörlüğü
3 (36_4)	36°11'890"K 36°09'655"E	Antakya Sosyal Yardımlaşma ve Dayanışma Vakfı	Güllü Bahçe Mah. Silahlı Kuvvetler Cad.	Hatay Valiliği
4 (15_6)	36°11'994"K 36°09'303"E	Kapalı Sapor Salonu, Antakya Yaşama Sevinci Spor Klüp Binası	Cumhuriyet Mah. Gündüz Cad.	Hatay Beden Terbiyesi Gençlik ve Spor İl Müdürlüğü
5 (19_1)	36°12'303"K 36°08'794"E	Saray Kent 125. YIL Anaokulu Binası	Gazi Mah. Adnan Menderes Cad.	Milli Eğitim Müdürlüğü
6 (23_4)	36°12'594"K 36°08'132"E	Hürriyet İşitme Engelliler İlköğretim Okulu Bahçesindeki Küçük Yapı	Esentepe Mah. 30. Sok.	Milli Eğitim Müdürlüğü

Şekil 5.16. İstasyon 5'in önden görünüşü

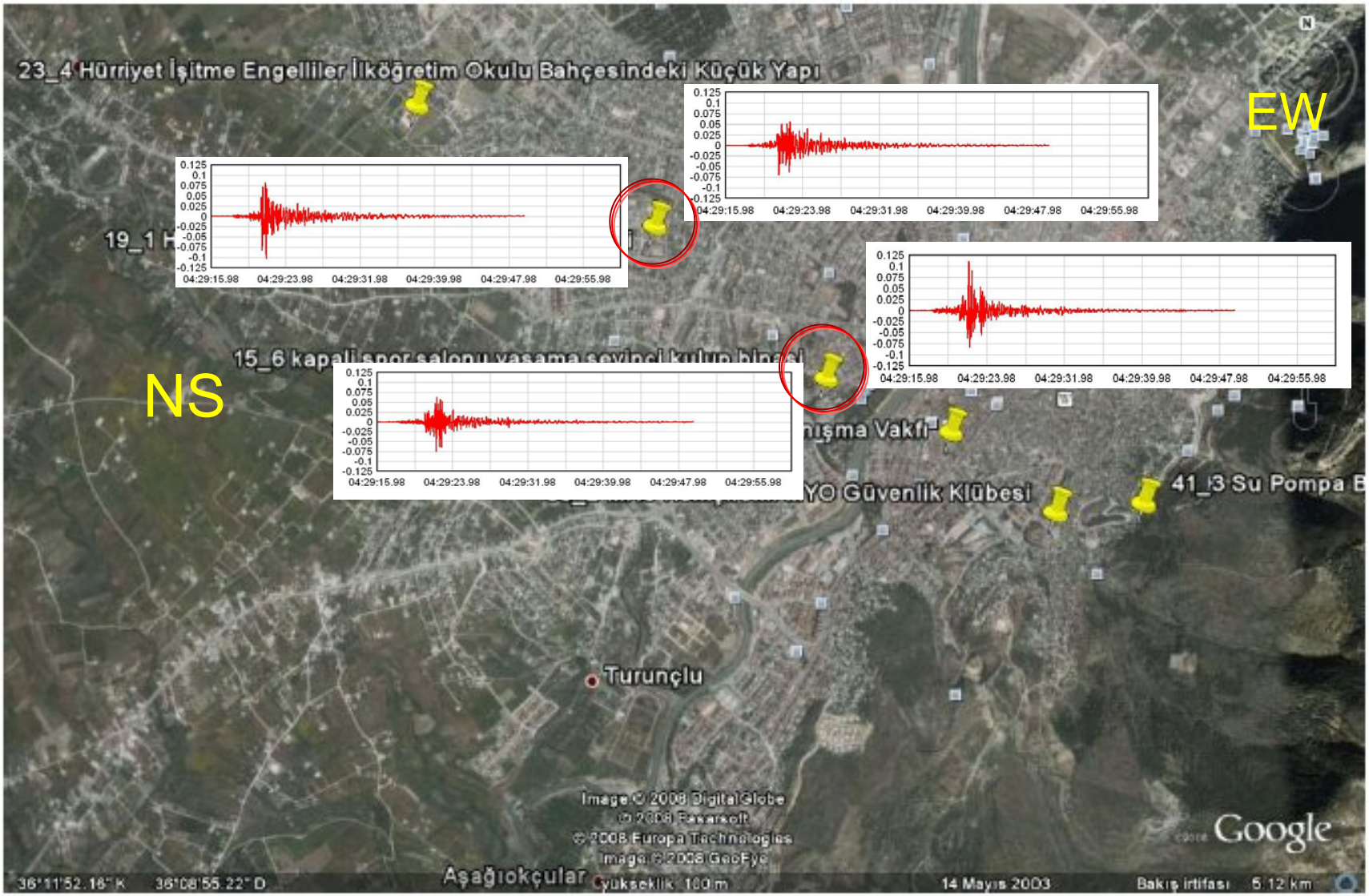
Şekil 5.19. İstasyon 6'nın oluşturulacağı yapının görüntüsü

Anaokulu		Atatürk Parkı		İşitme Eng. Okulu	
Kalınlık	**S-dalga hızı**	**Kalınlık**	**S-dalga hızı**	**Kalınlık**	**S-dalga hızı**
37 m	0.470 km/s	37 m	0.465 km/s	55 m	0.500 km/s
250 m	0.630 km/s	240 m	0.650 km/s	100 m	0.670 km/s
300 m	0.900 km/s	300 m	1.150 km/s	320 m	0.800 km/s
	2.000 km/s		2.000 km/s		2.000 km/s

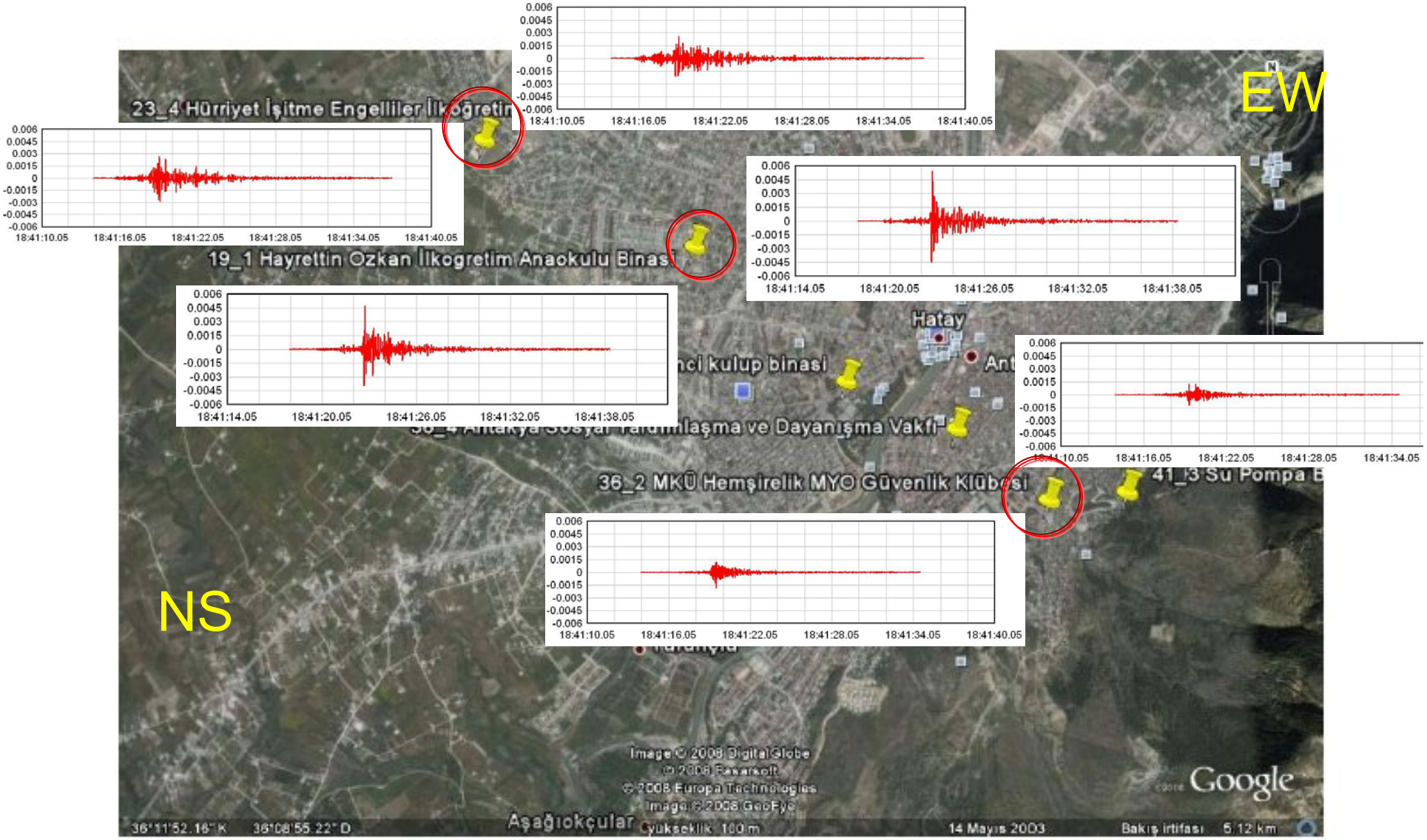




17 06 2009


23_4 Hürriyet İşitme Engelliler İlköğretim Okulu Bahçesindeki Küçük Yapı
EW
NS
15_6 kapalı spor salonu yaşama sevinci kulüp binası
41_3 Su Pompa B
YO Güvenlik Kübesi
Turunçlu
Aşağıokçular
Image © 2008 DigitalGlobe
© 2008 Europa Technologies
Google
14 Mayıs 2003
Bakış irtifası 5.12 km

14.07.2009


EW
NS
23_4 Hürriyet İşitme Engelliler İlkoğretim
19_1 Hayrettin Ozkan İlkogretim Anaokulu Binası
Hatay
36_2 MKÜ Hemşirelik MYO Güvenlik Kulübü
Aşağıokçular
Image © 2008 DigitalGlobe
© 2008 Europa Technologies
Google
14 Mayıs 2003
0.006
0.0045
0.003
0.0015
0
-0.0015
-0.003
-0.0045
-0.006
18:41:10.05
18:41:16.05
18:41:22.05
18:41:28.05
18:41:34.05
18:41:40.05
18:41:14.05
18:41:20.05
18:41:26.05
18:41:32.05
18:41:38.05

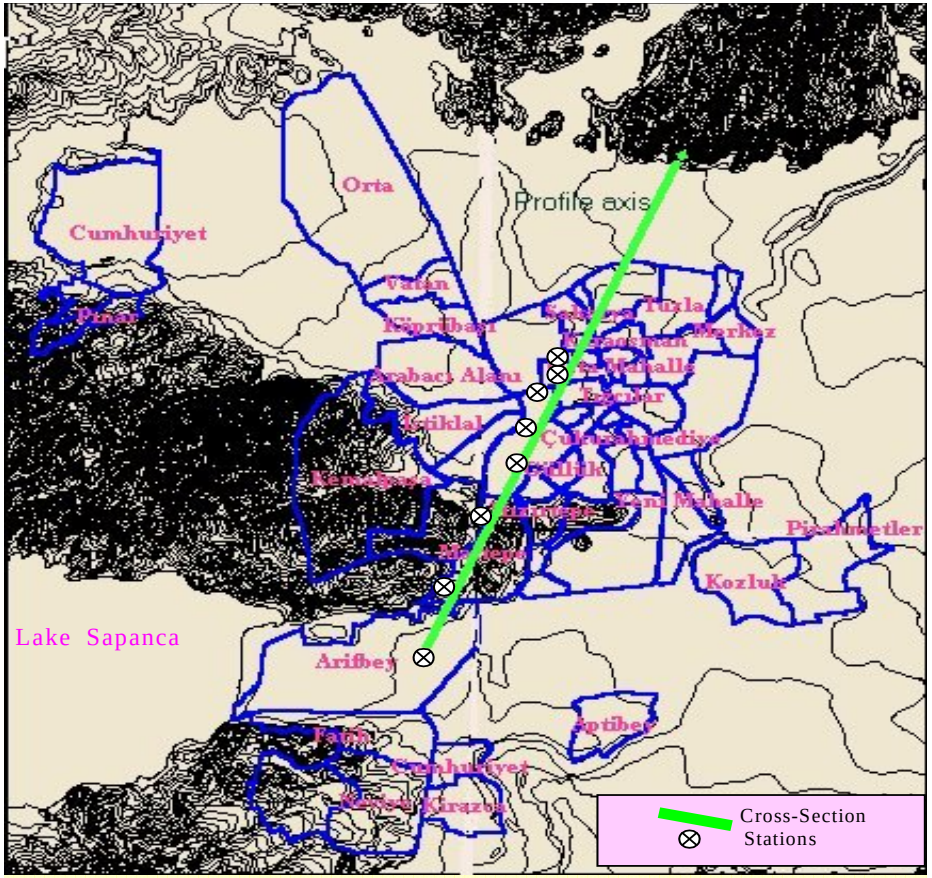
The records to be obtained will

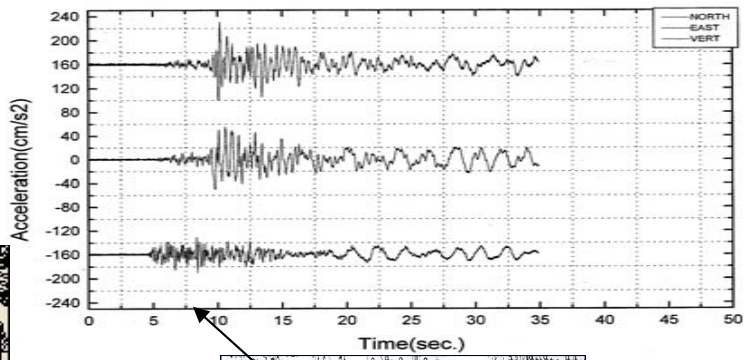
- allow for the visualization of the propagation of long-period ground motion in the basin

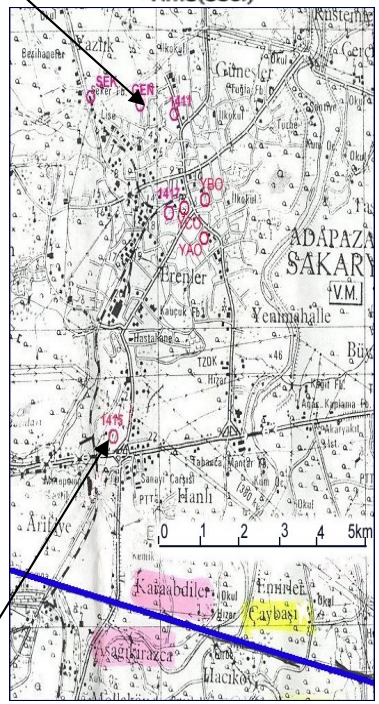
- show the development of surface waves at the basin edge

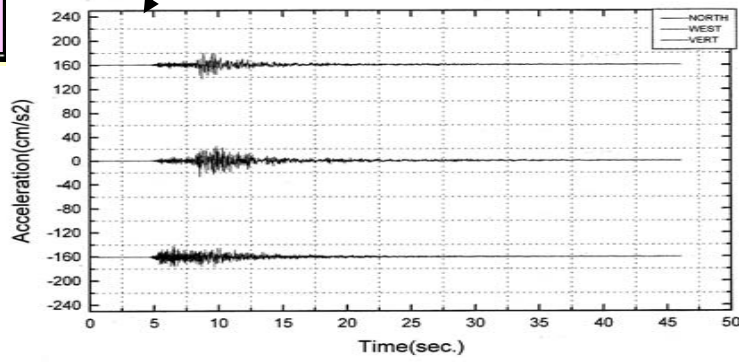
- enhance our capacity to realistically synthesize the strong ground motion in basin-type environments.

The case of Adapazarı, a shallow basin

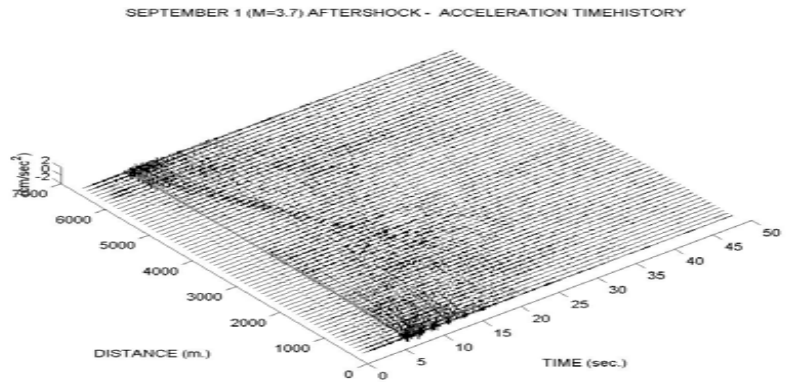


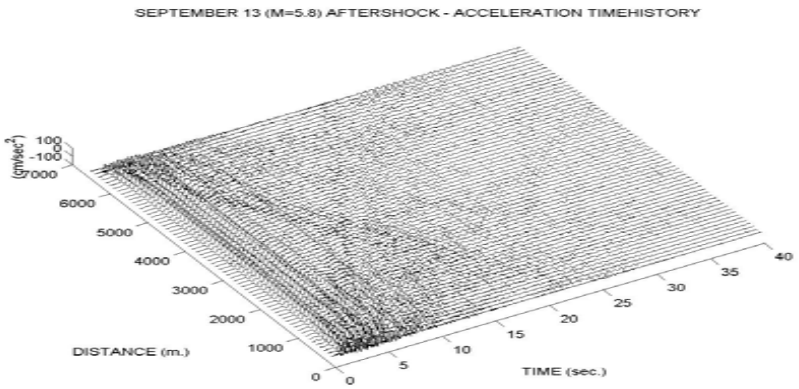


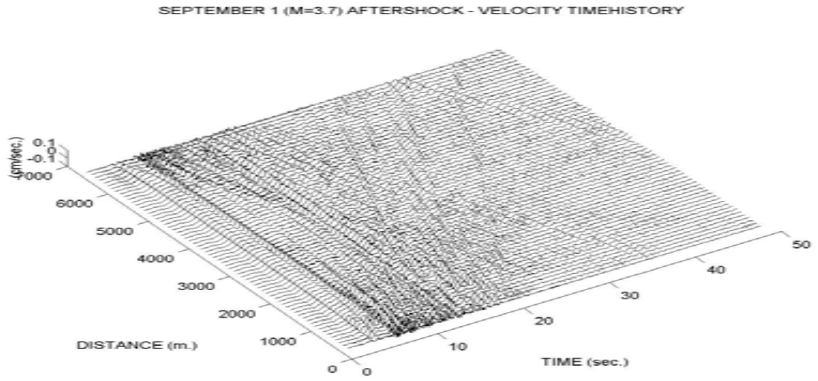


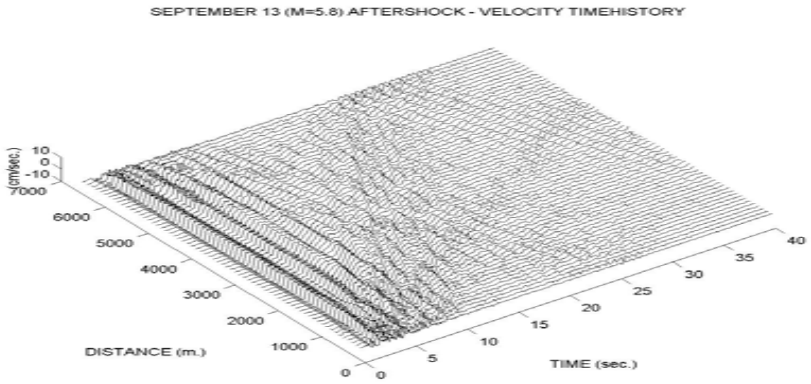


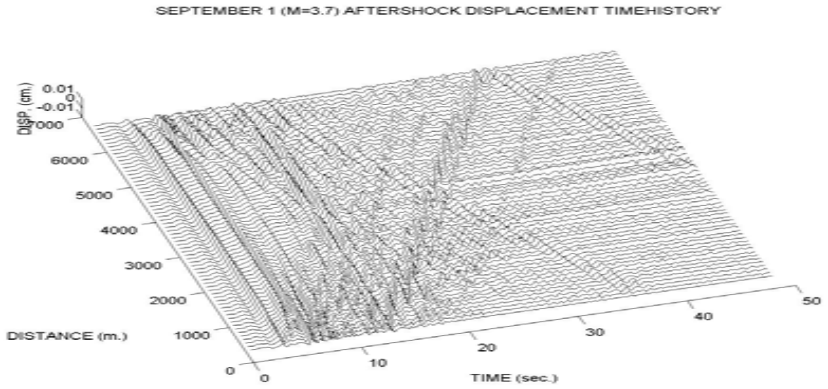
Adapazari region with local topography, green line represents the modelled cross-section, recording stations are indicated circled crosses

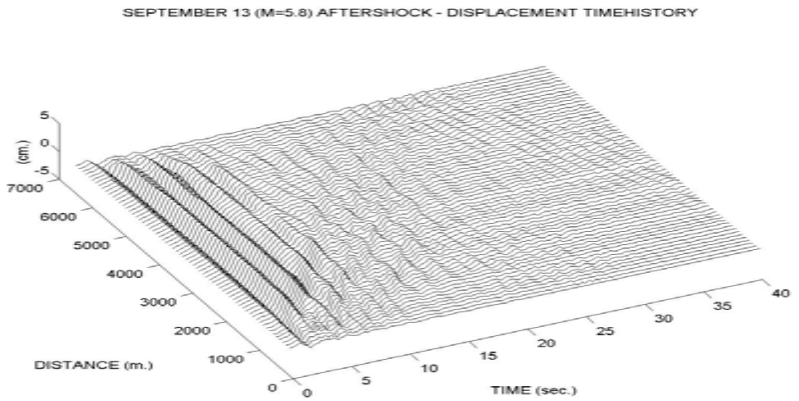






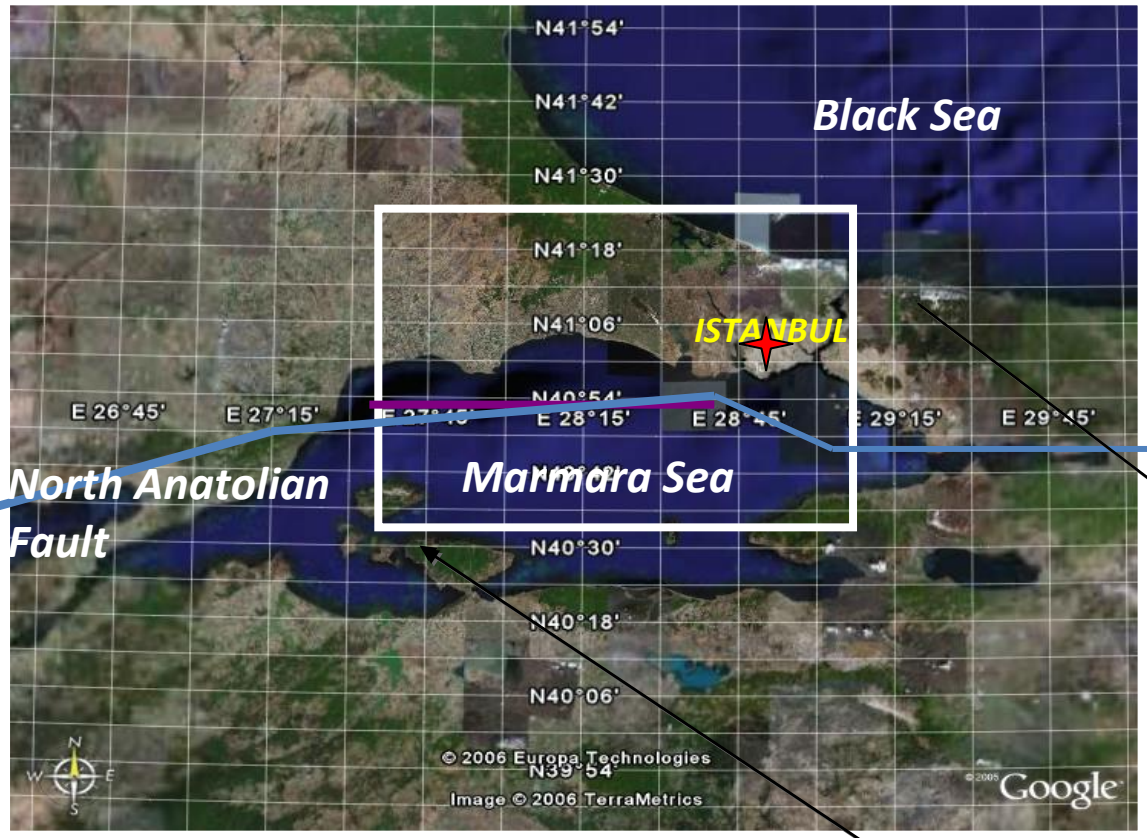




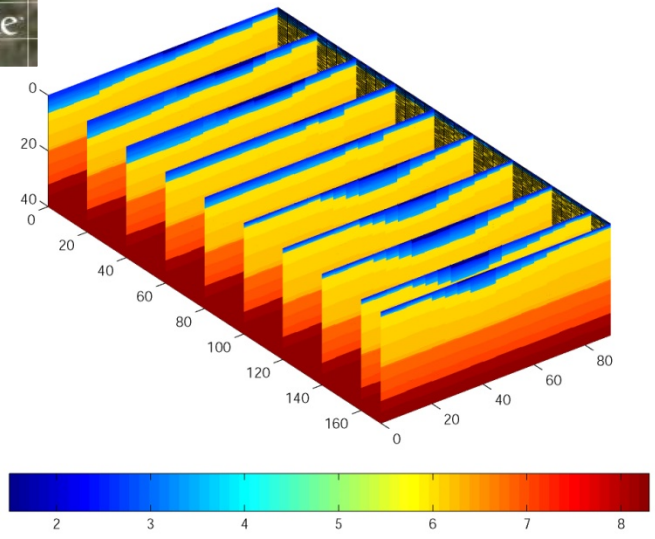


Acceleration, velocity and displacement time histories of weak and strong aftershocks From Beyen (2006)

Simulating for the expected Istanbul earthquake



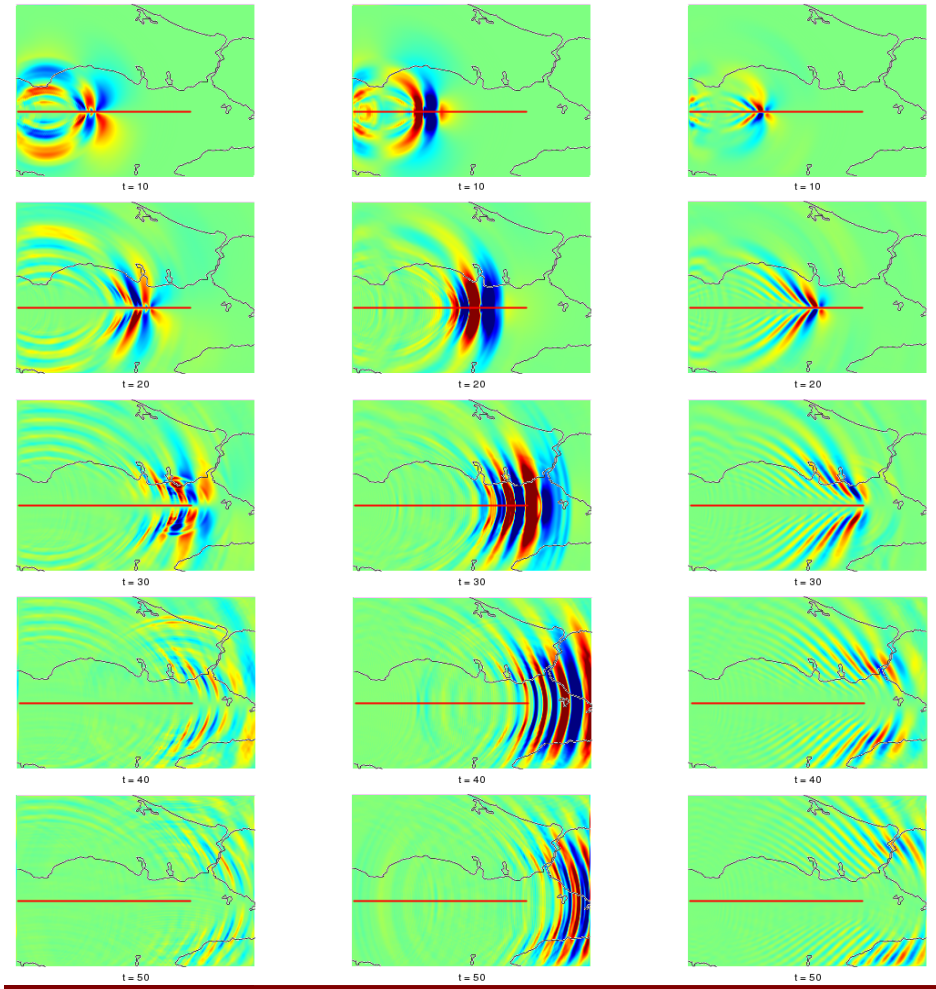
Deep basins



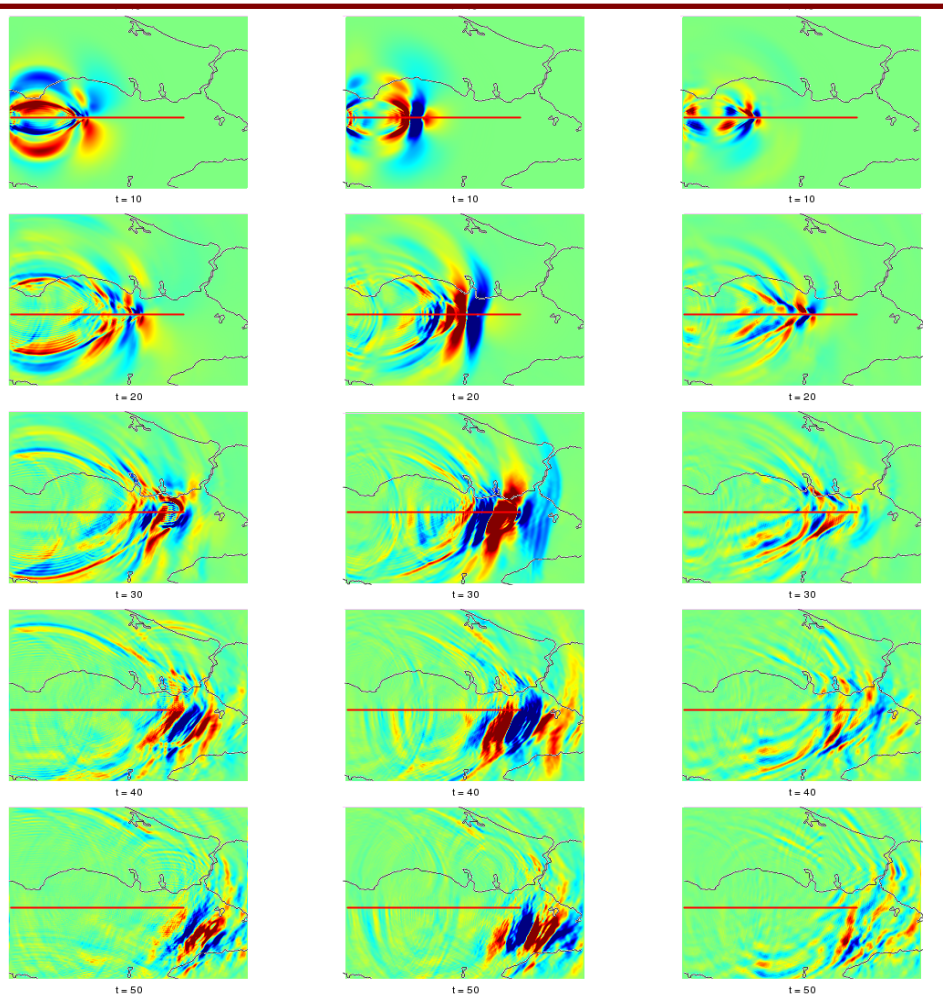
P-wave 3D velocity model

Wave Propagation in the Marmara Sea Region

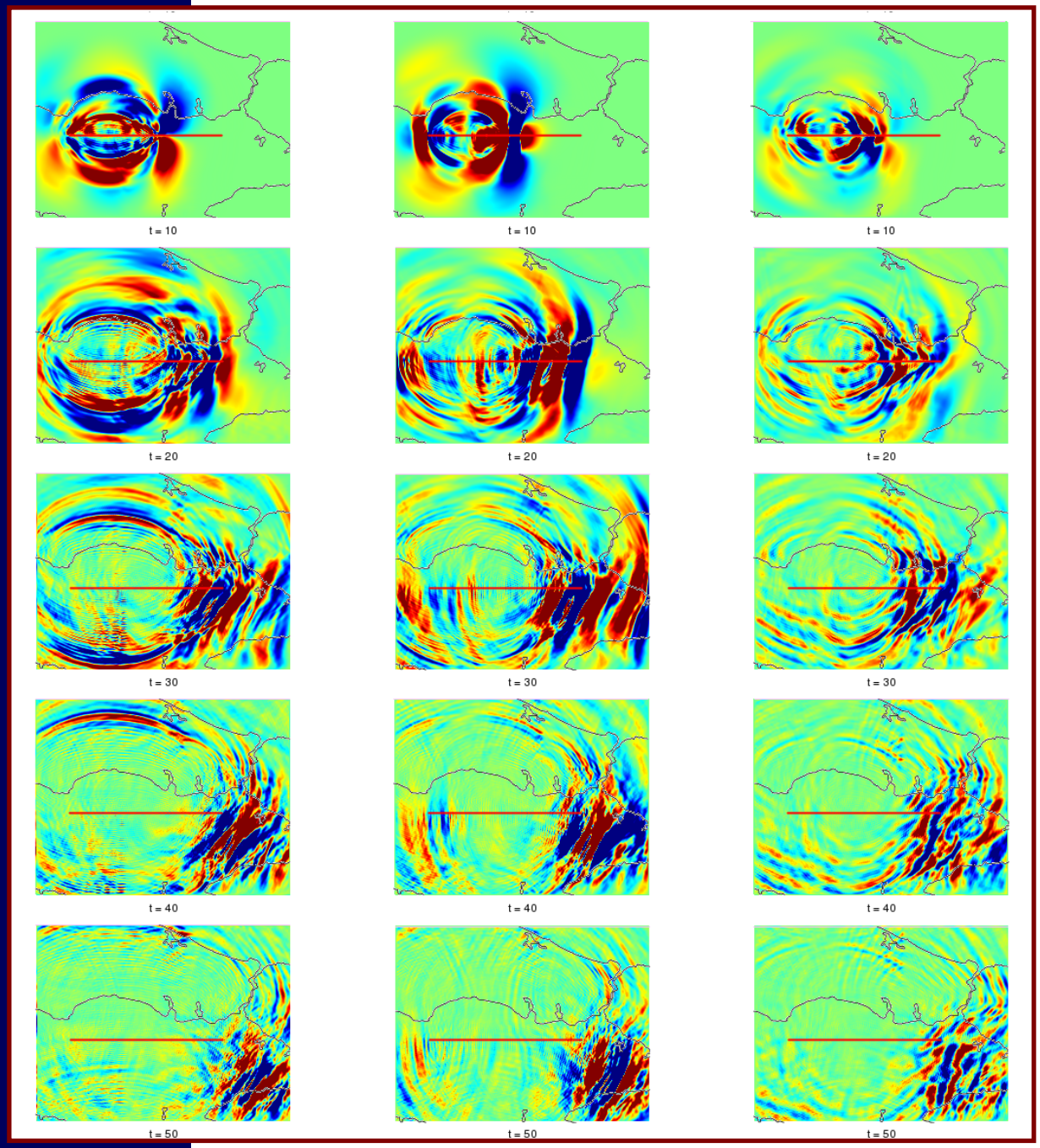
Effect of Velocity Models, 1D vs 3D



1D velocity model, Uniform Slip



3D velocity model, Uniform Slip

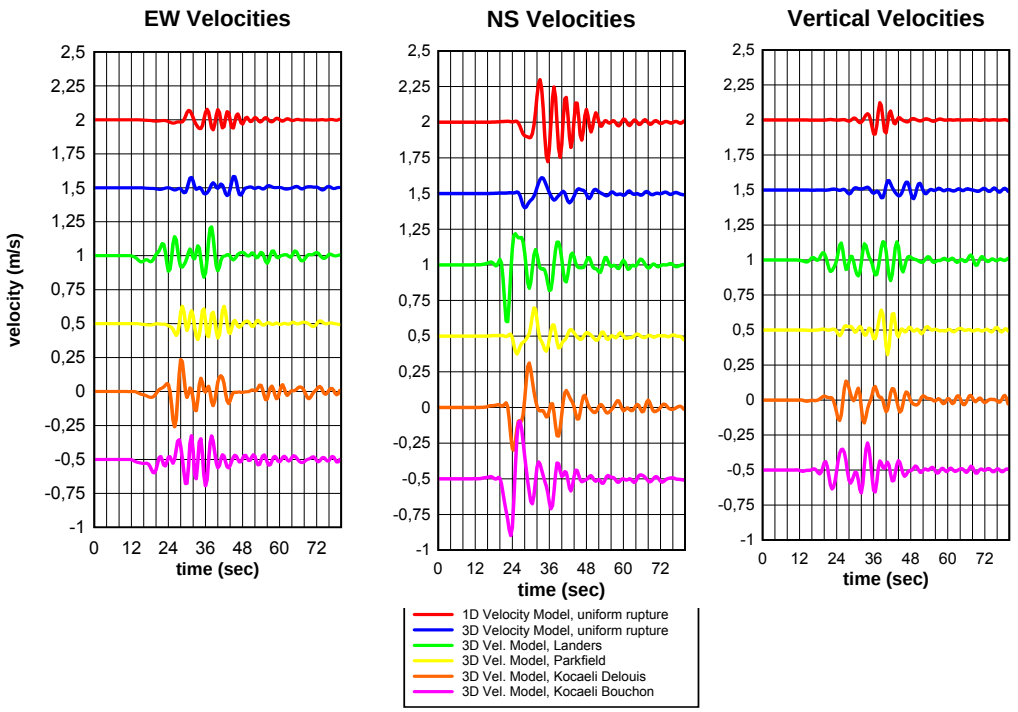


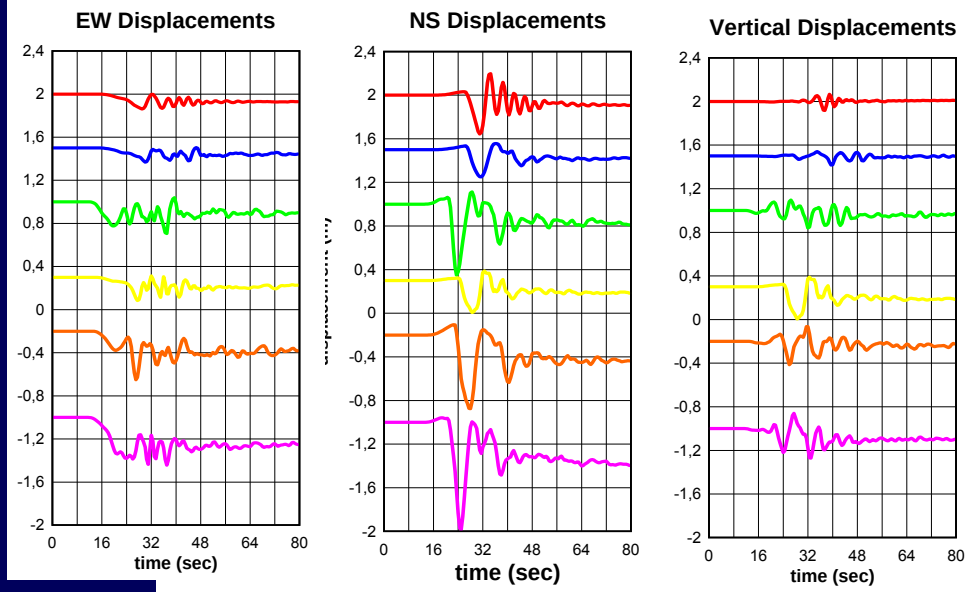
Wave Propagation in the Marmara Sea Region

3D velocity model,

Landers Eq Slip Model

Simulated Velocities and Displacements in the Old City of Istanbul obtained for assumed rupture scenarios





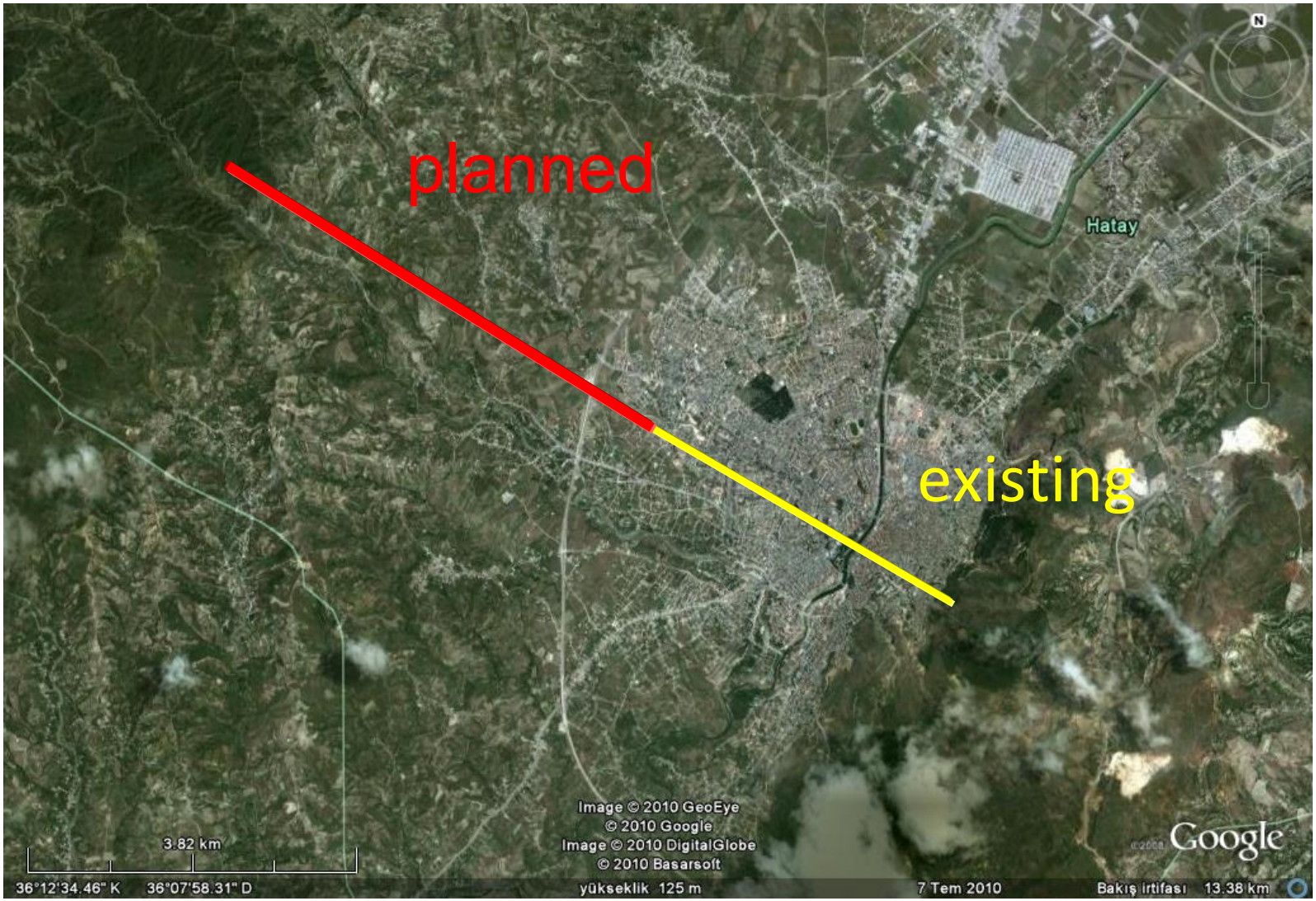
Planned activities:

- To increase the number of stations to ten to cross the whole-basin. Currently the coverage is half-way through the basin

- To improve site characterisation:

  (1) BH characterization of stations, down to 100 m whereever possible.

  (2) complete geophysical survey to assess the 2D velocity profile


planned
existing
Hatay
N
Image © 2010 GeoEye
© 2010 Google
Image © 2010 DigitalGlobe
© 2010 Basarsoft
Google
3.82 km
36°12'34.46" K 36°07'58.31" D
yükseklik 125 m
7 Tem 2010
Bakış irtifası 13.38 km

Thank you.


BOĞAZİÇİ ÜNİVERSİTESİ
1863

RECORDS

Date	Time	Lat	Lon	Depth	M
2010.04.01	04:41:15	36.3300	35.9472	3.9	3.3
ARSUZ-ISKENDERUN (HATAY)					
2010.03.08	01:28:56	36.658 K	36.275D	8.2	3.8
YAKACIK DÖRTYOL HATAY					
2009.06.17	07:29:12	36.0473	36.0198	10.4	4.5
SAMANDAĞ HATAY					