Землетрясения в Турции и Сирии 6 февраля 2023 г.: научный обзор и первые наблюдения

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02 марта 2023 г.

План выступления

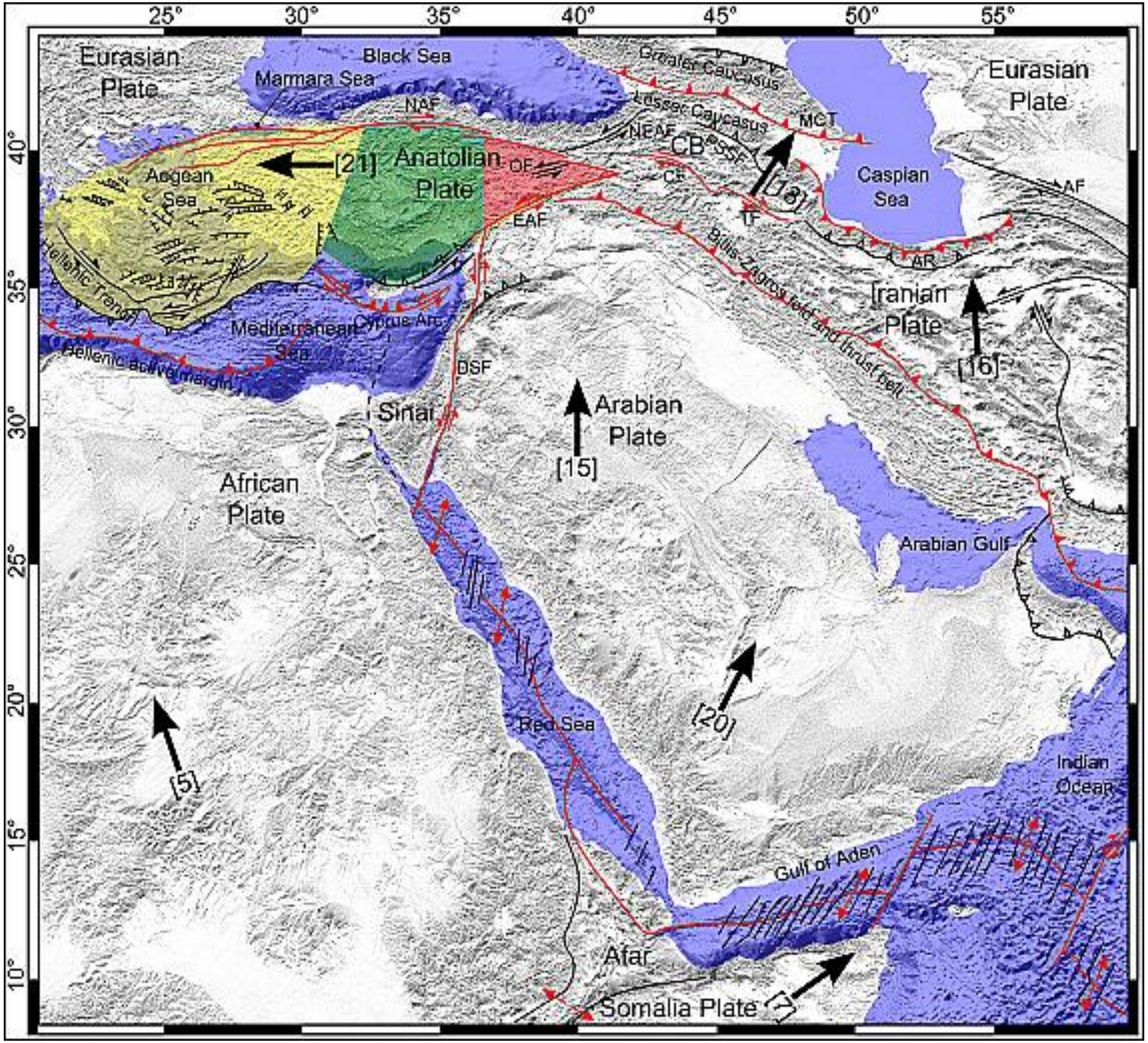
- Тектоническая обстановка и оценка сейсмической опасности
- Характеристика двух землетрясений 6 февраля 2023 г.
  - **Насколько сильные?**
  - **Насколько уникальные?**
  - Почему такое количество жертв?
- Первые результаты обработки наблюденных данных

Тектоническая карта

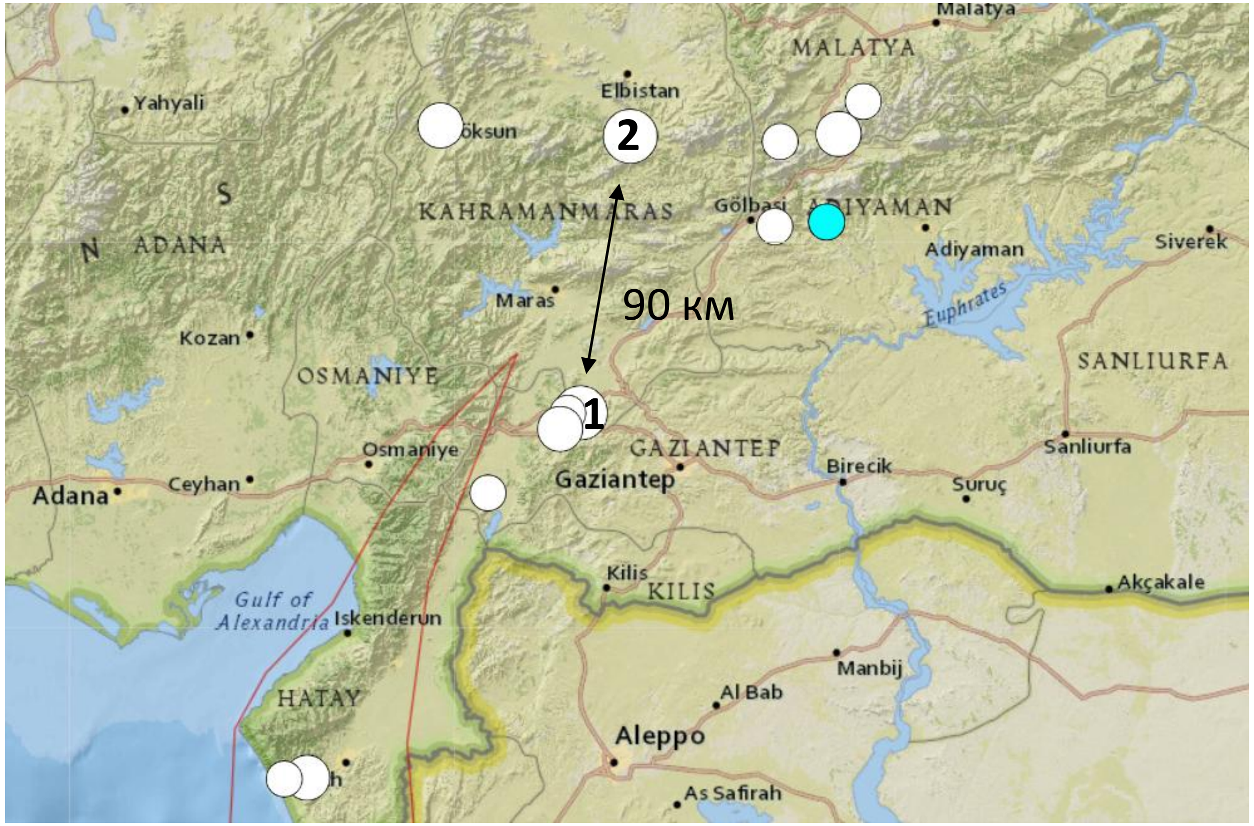
[Fraser, Vanneste, Hubert-Ferrari, 2010]

Стрелками обозначены
направления движения плит
по данным GPS
(относительно Евразии),
мм/год указаны в
квадратных скобках
[Reilinger et al., 2006]

По палеомагнитным данным и
толщине коры Анатолийская плита
Может быть условно разделена
на три области [Şengör et al., 1985]:
the west Anatolian extensional province,
the central Anatolian “Ova” province, and
the east Anatolian contractional province

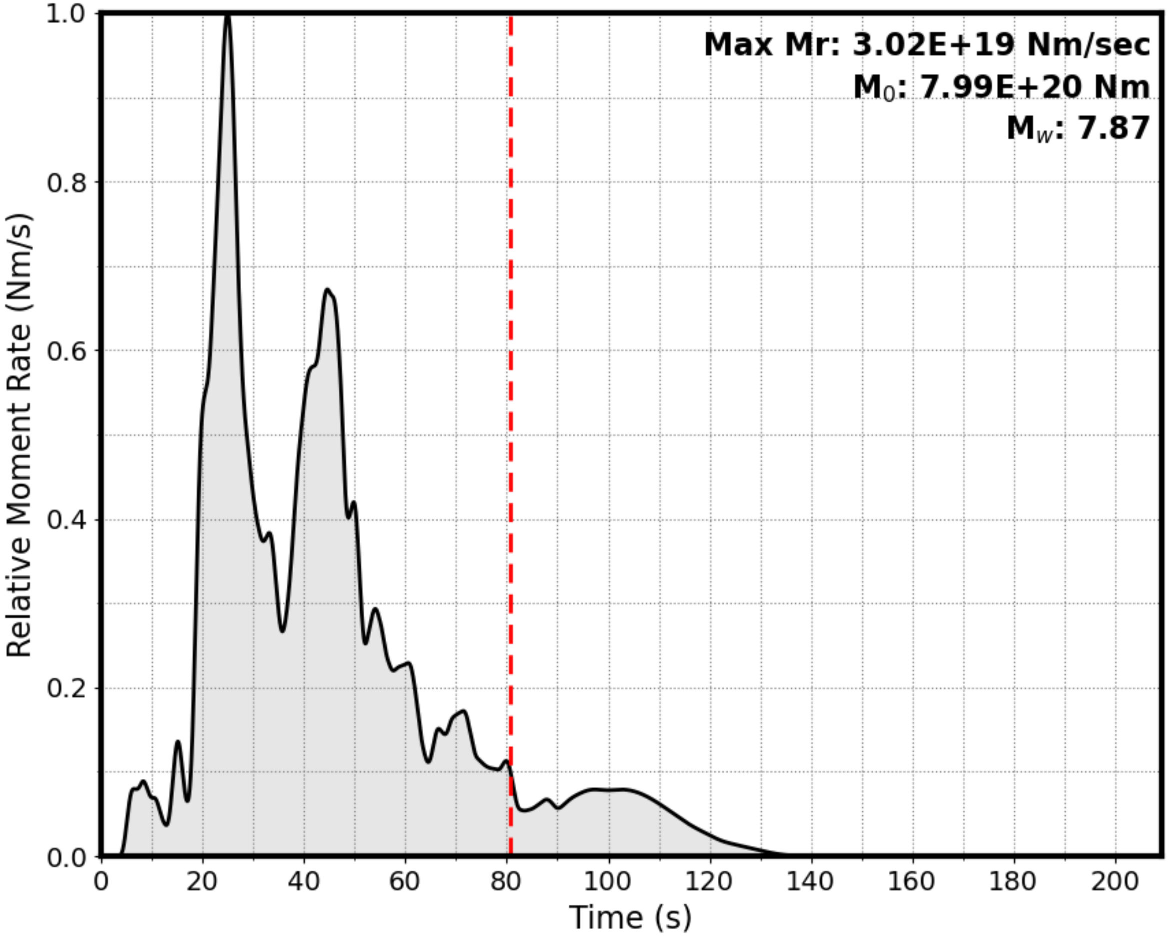

25°
30°
35°
40°
45°
50°
55°
40°
35°
30°
25°
20°
15°
10°
Eurasian Plate
Black Sea
Marmara Sea
NAF
Greater Caucasus
Lesser Caucasus
MCT
NEAF
CB
PSSF
Eurasian Plate
Caspian Sea
AF
Aegean Sea
[21]
Anatolian Plate
OF
CF
TF
[13]
EAF
AR
Iranian Plate
[16]
Hellenic Trench
Mediterranean Sea
Cyprus Arc
Bitlis Zagros fold and thrust belt
Hellenic active margin
DSF
Sinai
Arabian Plate
[15]
African Plate
Arabian Gulf
[20]
Red Sea
[5]
Indian Ocean
Gulf of Aden
Afar
Somalia Plate
[7]

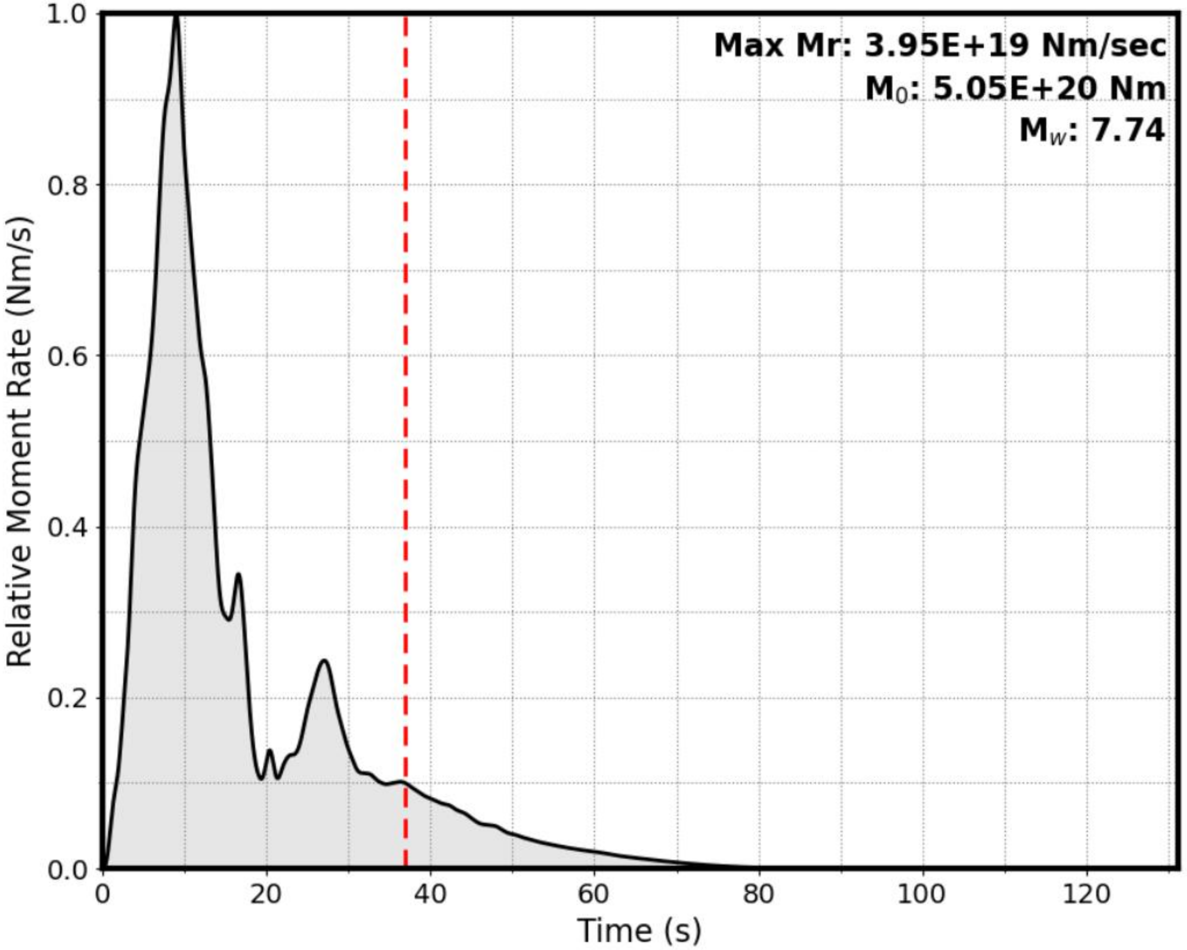
Основная характеристика землетрясений


Malatya
MALATYA
Yahyali
Elbistan
öksun
2
KAHRAMANMARAS
Gölbasi
ADIYAMAN
Adiyaman
Siverek
S
N
ADANA
Maras
90 км
Euphrates
Kozan
OSMANIYE
SANLIURFA
1
Osmaniye
GAZIANTEP
Gaziantep
Birecik
Sanliurfa
Adana
Ceyhan
Suruç
Kilis
KILIS
Akçakale
Gulf of Alexandria
Iskenderun
Manbij
HATAY
Al Bab
Aleppo
As Safirah
h

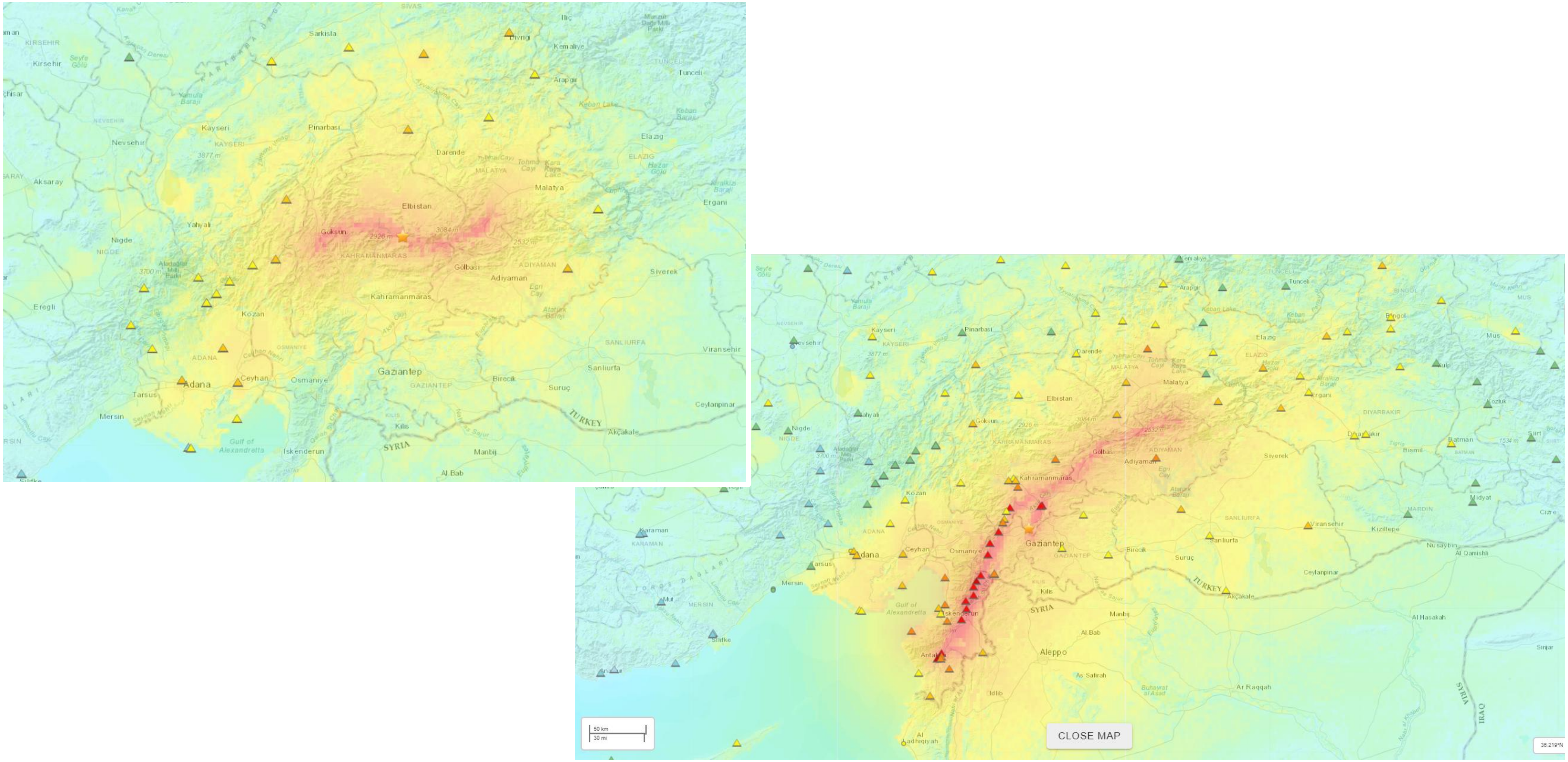
(1) 2023-02-06 **01:17:34** 37.225°N 37.021°E 10.0 km (± 1.8) depth $\boldsymbol{M_{ww}=7.8}$ ± 0.1 (USGS)	**(2)** 2023-02-06 **10:24:49** 38.024°N 37.203°E 10.0 km (± 1.8) depth $\boldsymbol{M_{ww}=7.5}$ ± 0.0 (USGS)
01:17:35 37.29°N 36.99°E 10 км $\boldsymbol{M_S=8.0}$ $mb=6.8$ $I_0=11.5$ (ФИЦ ЕГС РАН)	10:24:49 38.04°N 37.18°E 10 км $\boldsymbol{M_S=7.8}$ $mb=6.9$ $I_0=11\text{-}11.5$ (ФИЦ ЕГС РАН)
01:18:10 37.56°N 37.47°E 14.9 km (± 0.5) $M_S=7.8$ $\boldsymbol{M_w=7.8}$ Assumed half duration: 18.9 (GCMT)	10:24:59 38.11°N 37.22°E 12 km (± 0.0) $M_S=7.5$ $\boldsymbol{M_w=7.7}$ Assumed half duration: 17.9 (GCMT)

Очаговые функции (USGS)

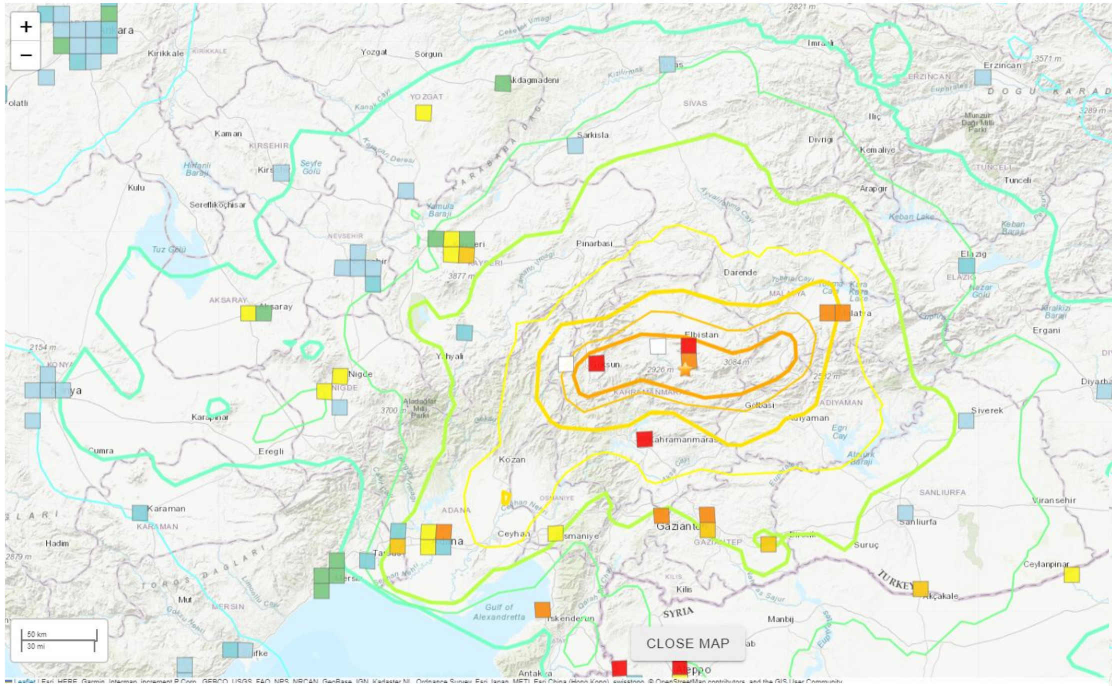




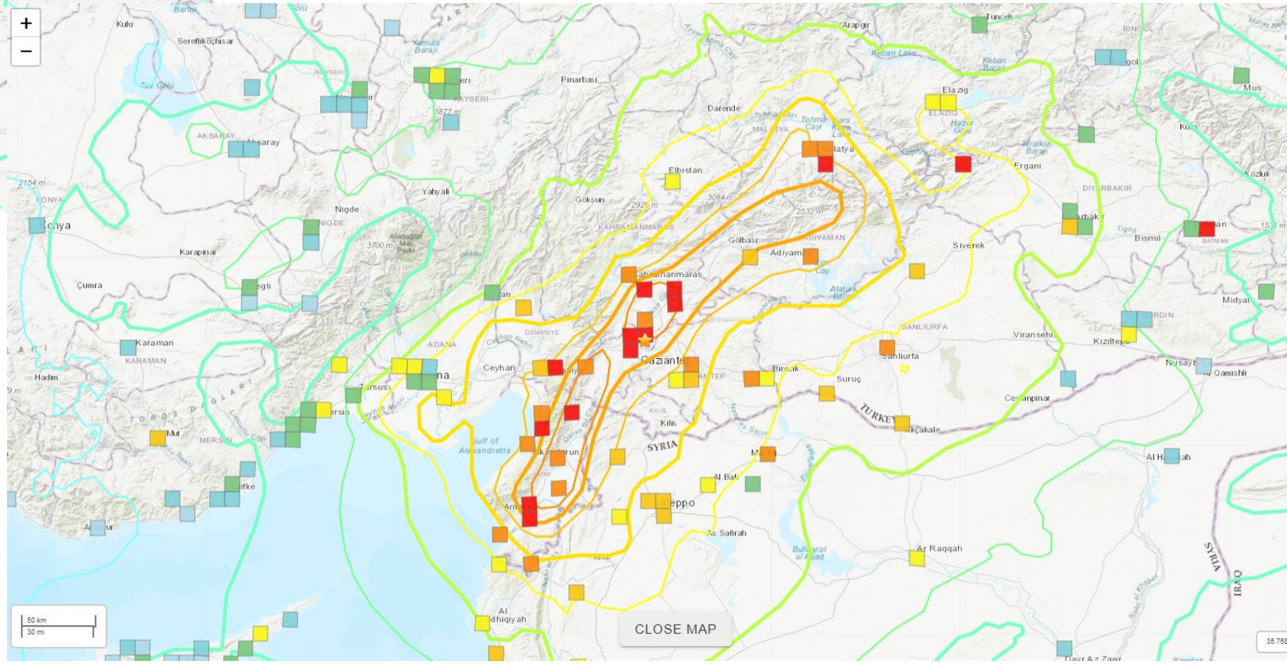
Макросейсмические карты двух землетрясений (USGS)


Sivas
Sarkisla
Divrigi
Kemaliye
Tunceli
Arapgir
Kirsehir
Kayseri
Nevsehir
Pinarbasi
Darende
Elazig
Malatya
Aksaray
Elbistan
Ergani
Yahyali
Goksun
2926 m
3084 m
2532 m
Nigde
Kahramanmaras
Golbasi
Adiyaman
Siverek
Eregli
Kozan
Viransehir
Gaziantep
Birecik
Sanliurfa
Adana
Ceyhan
Osmaniye
Suruc
Tarsus
Ceylanpinar
Mersin
Kilis
Turkey
Akcakale
Gulf of Alexandretta
Iskenderun
Syria
Manbij
Al Bab
Silifke
Karaman
Antakya
Aleppo
As Safirah
Idlib
Ar Raqqah
Al Hasakah
Diyarbakir
Batman
Bismil
Mardin
Kiziltepe
Nusaybin
Al Qamishli
Midyat
Siirt
Bingol
Mus
Cizre
Sinjar
Iraq
50 km
30 mi
CLOSE MAP
36.219°N

Макросейсмические карты двух землетрясений (USGS)

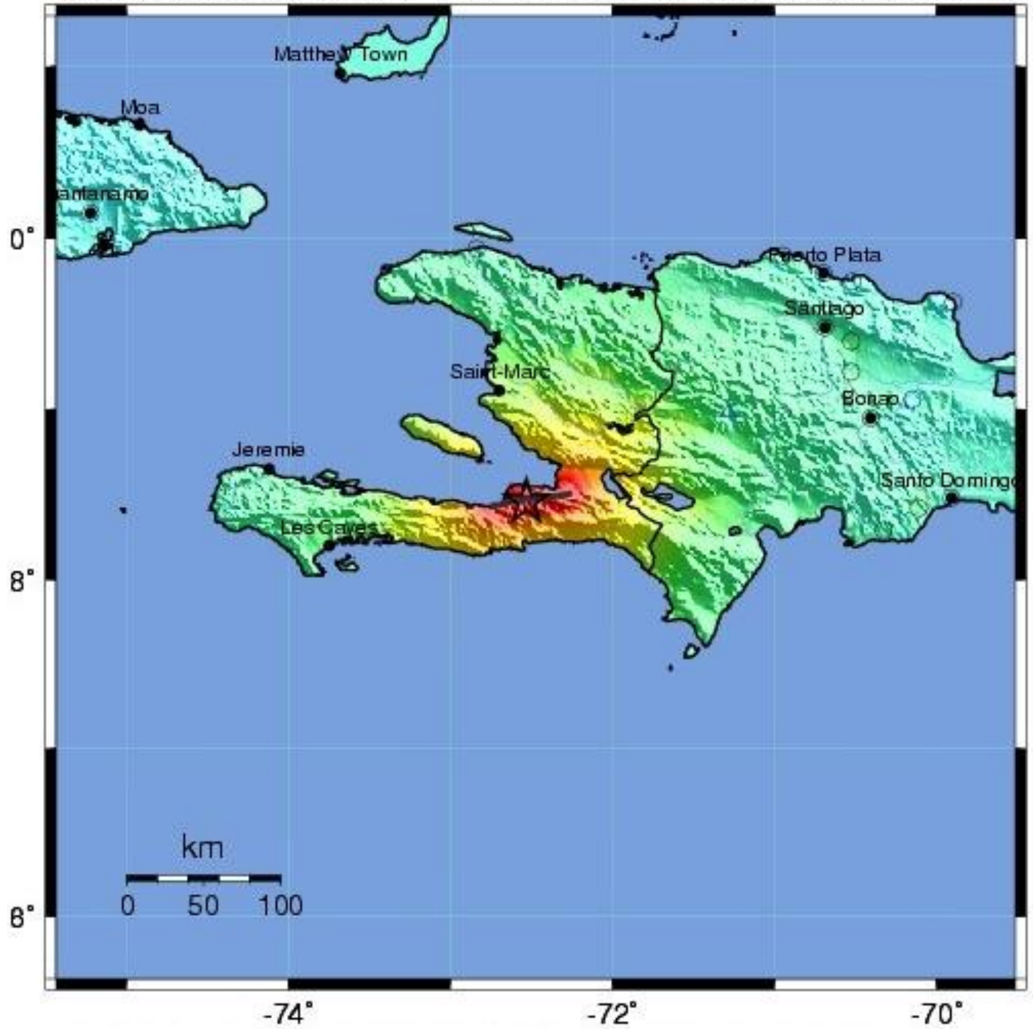


499 анкет



1919 анкет

USGS ShakeMap : HAITI REGION
Tue Jan 12, 2010 21:53:10 GMT M 7.0 N18.46 W72.53 Depth: 13.0km ID:2010rja6

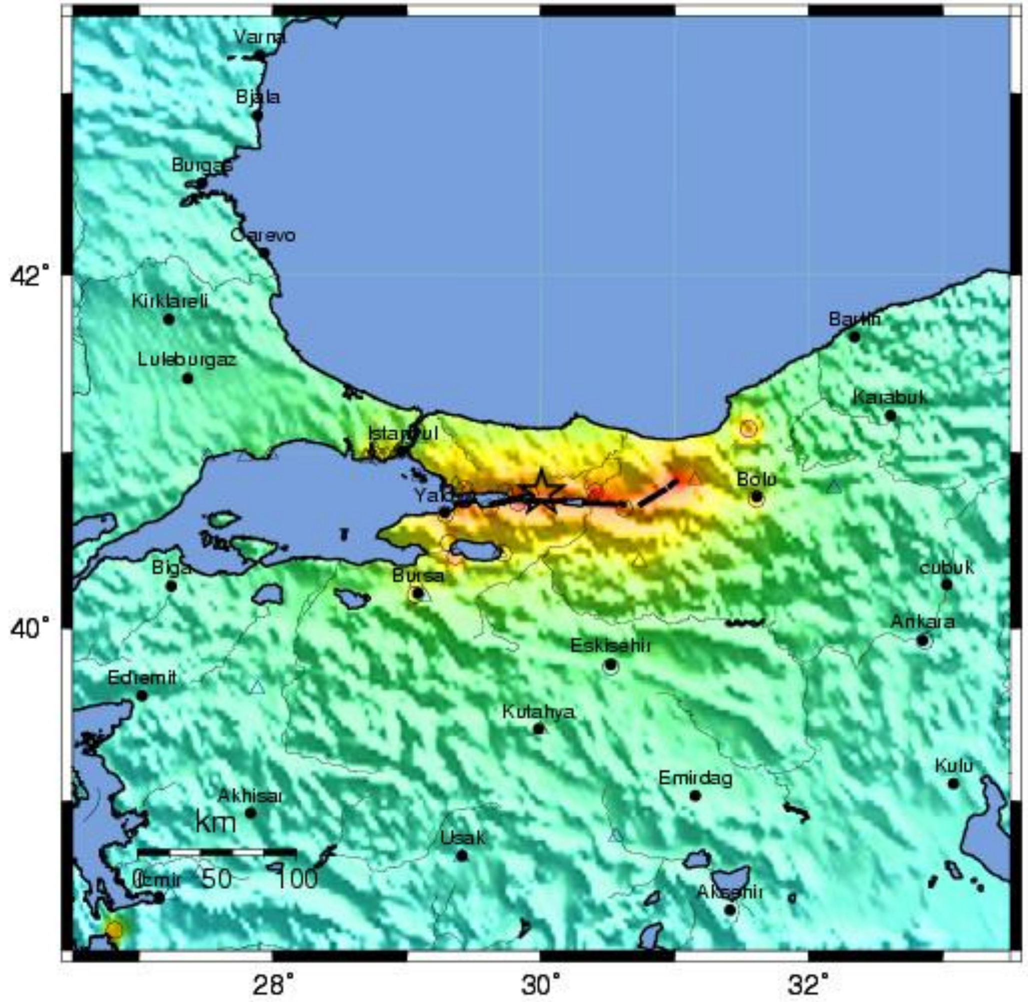


Matthew Town
Moa
antanamo
Puerto Plata
Santiago
Saint-Marc
Bonao
Jeremie
Santo Domingo
Les Cayes
km
0 50 100
0˚
8˚
8˚
6˚
-74˚
-72˚
-70˚

Map Version 7 Processed Wed Jan 13, 2010 06:53:11 PM MST -- NOT REVIEWED BY HUMAN

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

USGS ShakeMap : Kocaeli, Turkey
Tue Aug 17, 1999 00:01:39 GMT M 7.6 N40.77 E30.00 Depth: 13.3km ID:199908170001



Varna
Bjala
Burgas
Carevo
Kirklareli
Luleburgaz
Istanbul
Bartin
Karabuk
Bolu
Yalova
Biga
Bursa
cubuk
Ankara
Eskisehir
Edremit
Kutahya
Kulu
Emirdag
Akhisar
Usak
Izmir
Aksehir
km
0 50 100
42˚
40˚
28˚
30˚
32˚

Map Version 1.1 Processed Sat Nov 8, 2008 08:21:15 PM MST

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

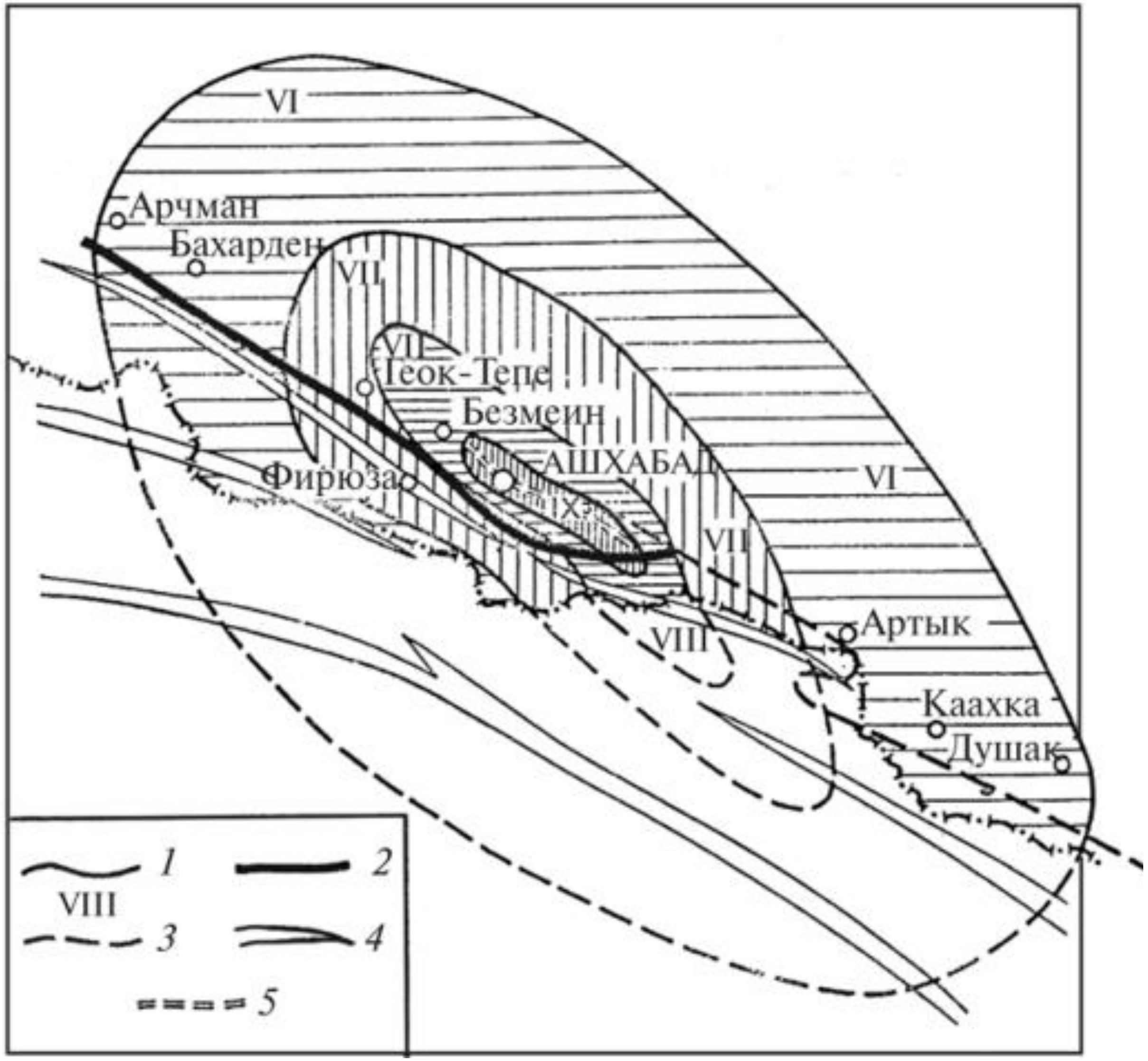
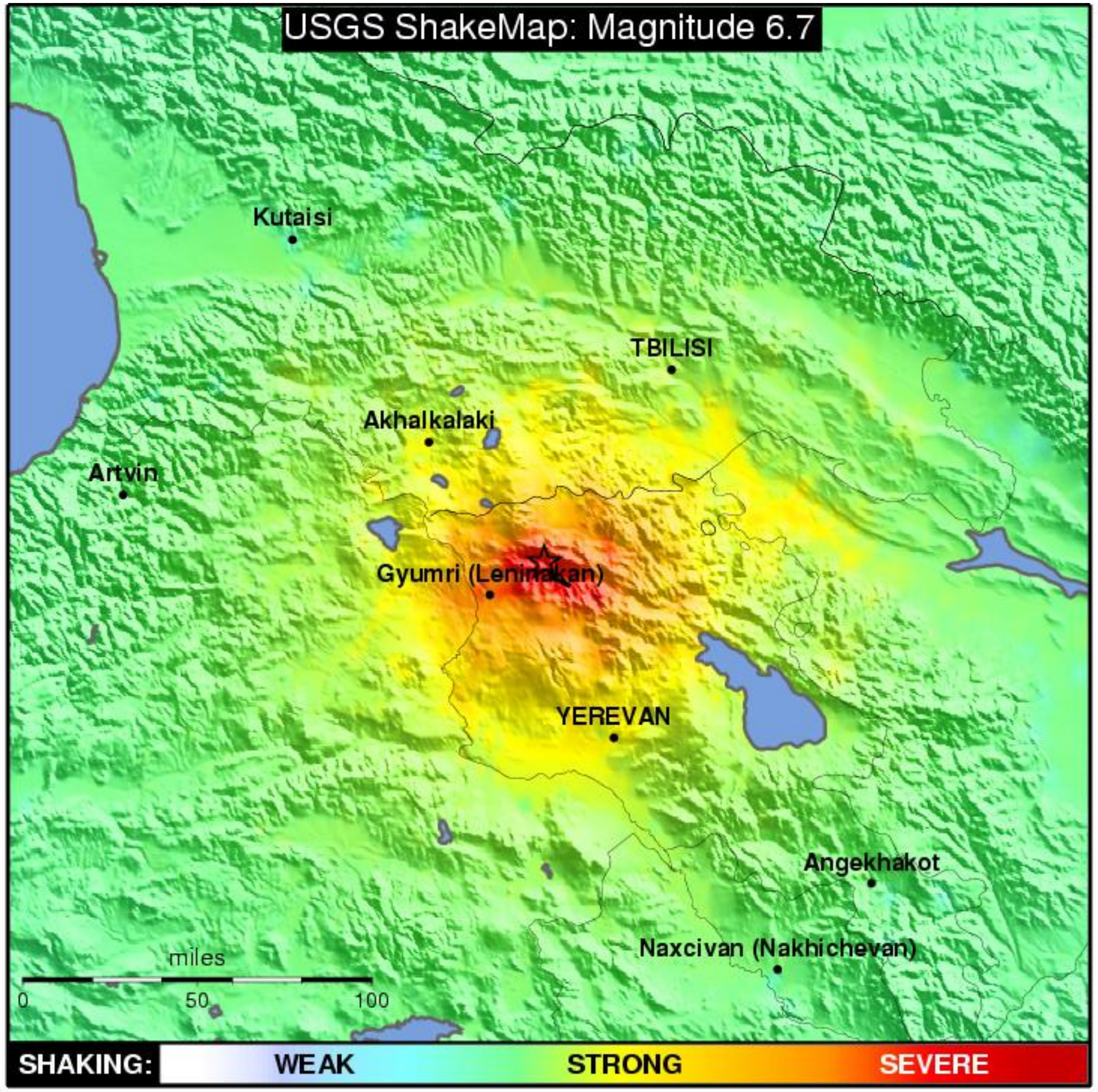

VI
Арчман
Бахарден
VII
VIII
Геок-Тепе
Безмеин
АШХАБАД
Фирюза
IX
VI
VII
VIII
Артык
Каахка
Душак
1
VIII
2
3
4
5

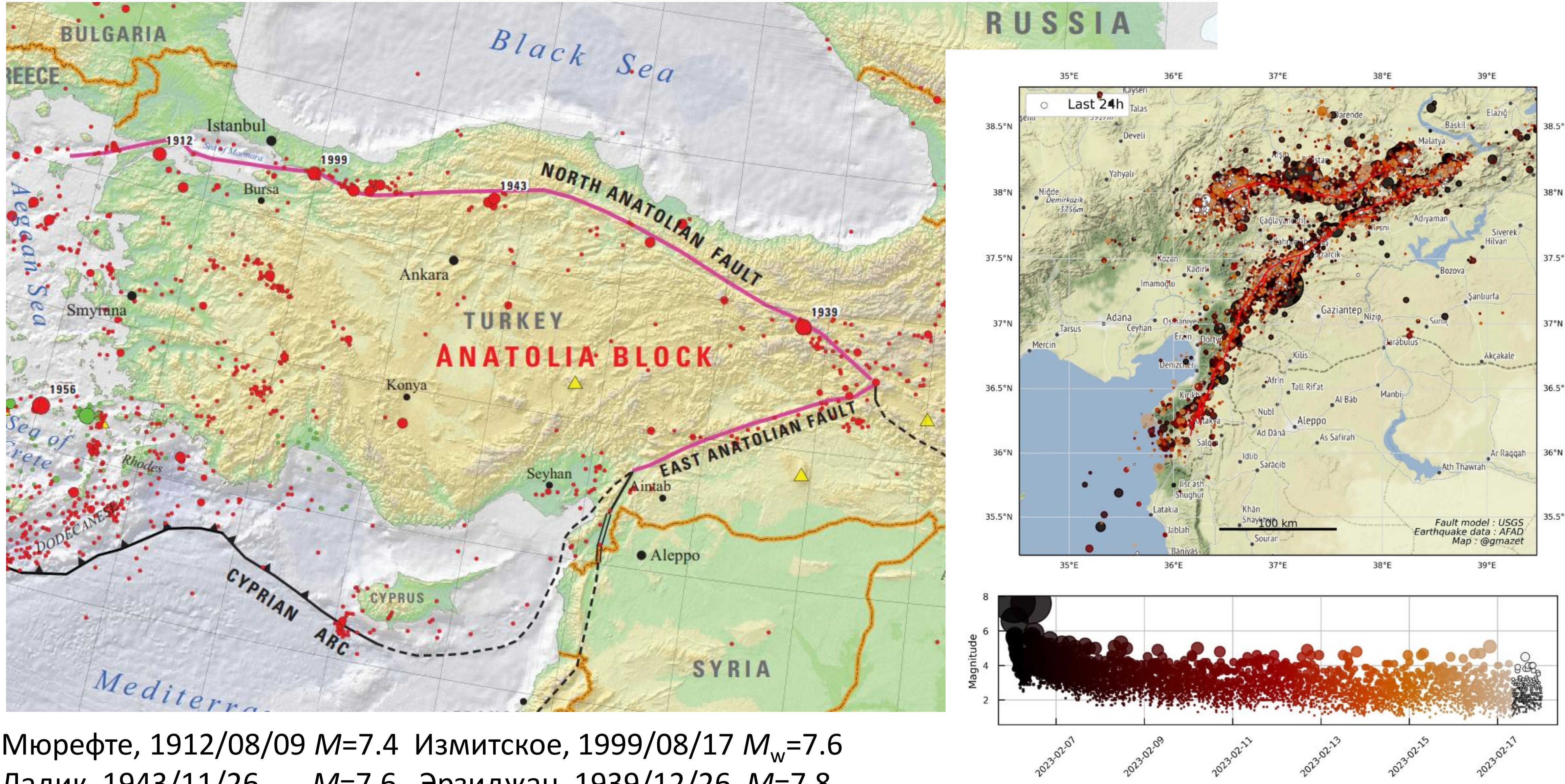
Схема изосейст **Ашхабадского землетрясения**
M=7.3, Н=18 км, 10.05.1948 г. [Медведев, Шебалин, 1967]


USGS ShakeMap: Magnitude 6.7
Kutaisi
TBILISI
Akhalkalaki
Artvin
Gyumri (Leninakan)
YEREVAN
Angekhakot
Naxcivan (Nakhichevan)
miles
0
50
100
SHAKING:
WEAK
STRONG
SEVERE

Map Version 1 Processed Mon Aug 25, 2008 05:38:46 PM MDT

Макросейсмическая карта **Спитакского землетрясения**
M=6.9, H=10 км, 07.12.1988 г.

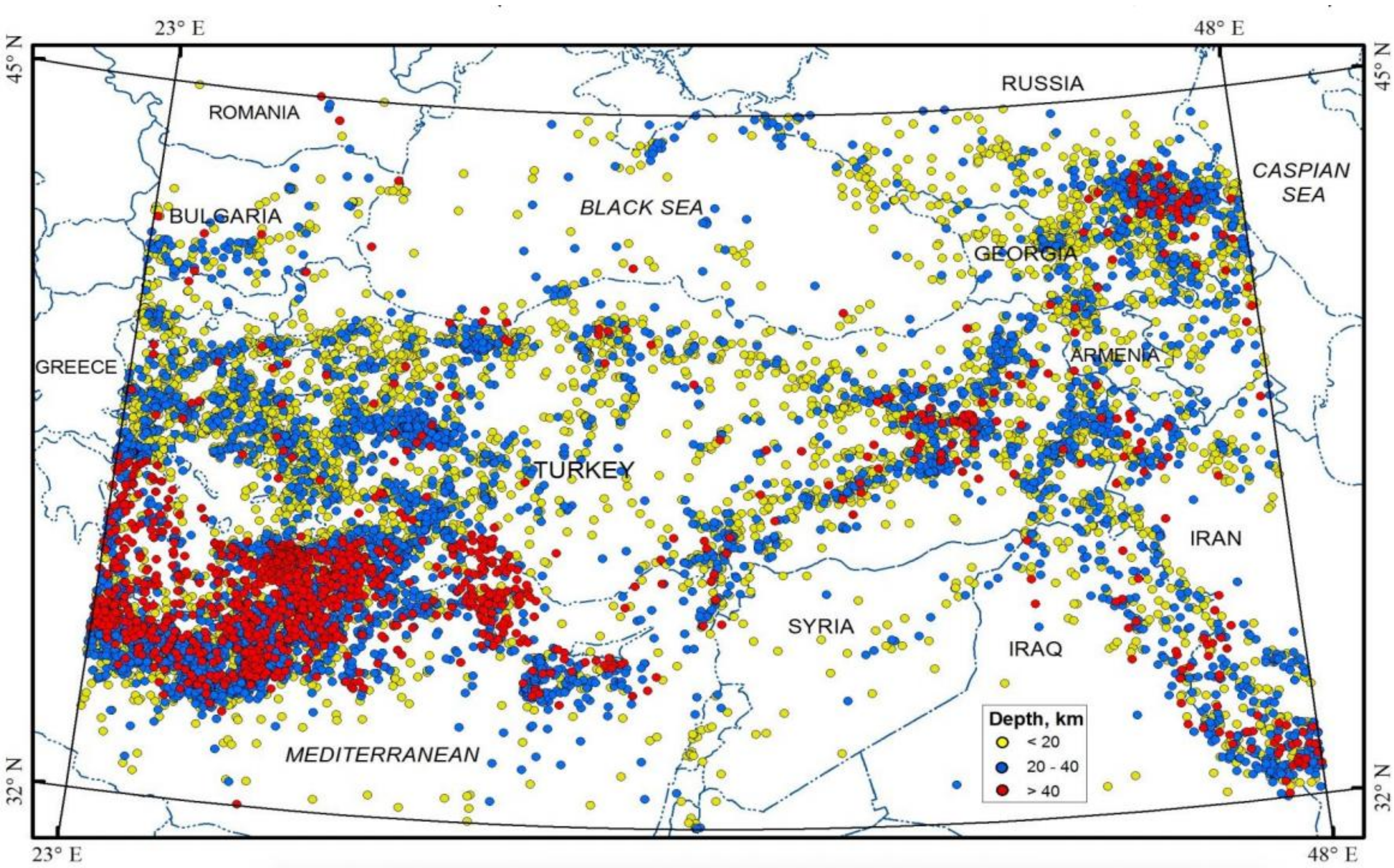
Сильнейшие землетрясения Турции и карта афтершоков


RUSSIA
BULGARIA
GREECE
Black Sea
Istanbul
Sea of Marmara
Bursa
1912
1999
1943
1939
1956
NORTH ANATOLIAN FAULT
EAST ANATOLIAN FAULT
Aegean Sea
Smyrana
Ankara
TURKEY
ANATOLIA BLOCK
Konya
Sea of Crete
Rhodes
DODECANESE
Seyhan
Aintab
Aleppo
CYPRIAN ARC
CYPRUS
SYRIA
Mediterra
Last 24h
35°E
36°E
37°E
38°E
39°E
38.5°N
38°N
37.5°N
37°N
36.5°N
36°N
35.5°N
Kayseri
Talas
Develi
Darende
Malatya
Elazığ
Baskil
Yahyalı
Niğde
Demirkazık 3756m
Çağlayancerit
Adıyaman
Kozan
Kadirli
Imamoğlu
Siverek
Hilvan
Bozova
Şanlıurfa
Adana
Ceyhan
Osmaniye
Tarsus
Mercin
Gaziantep
Nizip
Suruç
Jarabulus
Kilis
Akçakale
Denizciler
Dörtyol
Afrin
Tall Rifat
Al Bab
Manbij
Aleppo
Nubl
Ad Dana
As Safirah
Idlib
Saraqib
Ar Raqqah
Ath Thawrah
Jisr ash Shughur
Latakia
Jablah
Baniyas
Khan Shaykhun
Sourar
100 km
Fault model : USGS
Earthquake data : AFAD
Map : @gmazet
Magnitude
8
6
4
2
2023-02-07
2023-02-09
2023-02-11
2023-02-13
2023-02-15
2023-02-17

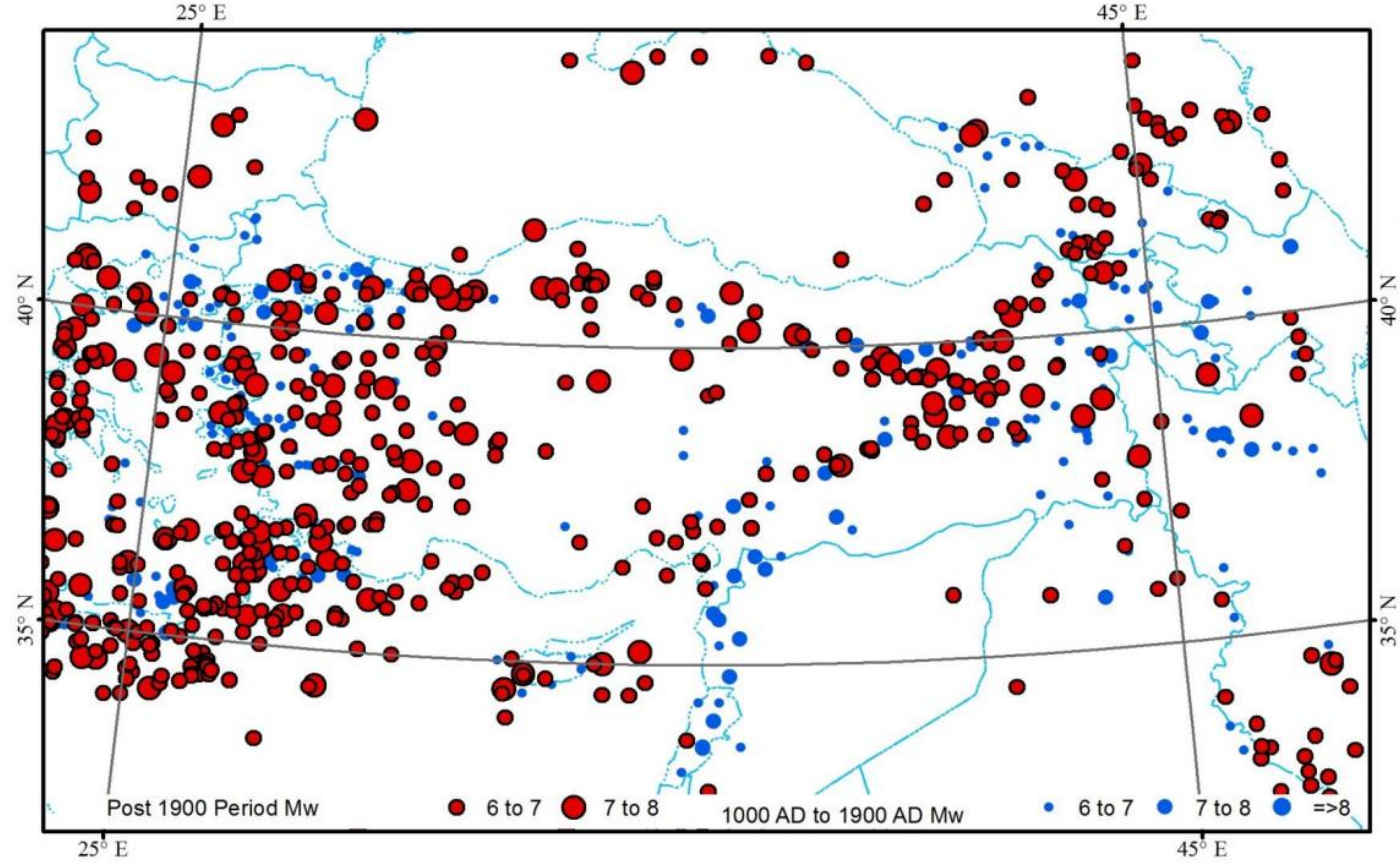
Мюрефте, 1912/08/09 M=7.4 Измитское, 1999/08/17 M_w=7.6
Ладик, 1943/11/26 M=7.6 Эрзиджан, 1939/12/26 M=7.8

[G. Mazet-Roux, 18.02.2023]

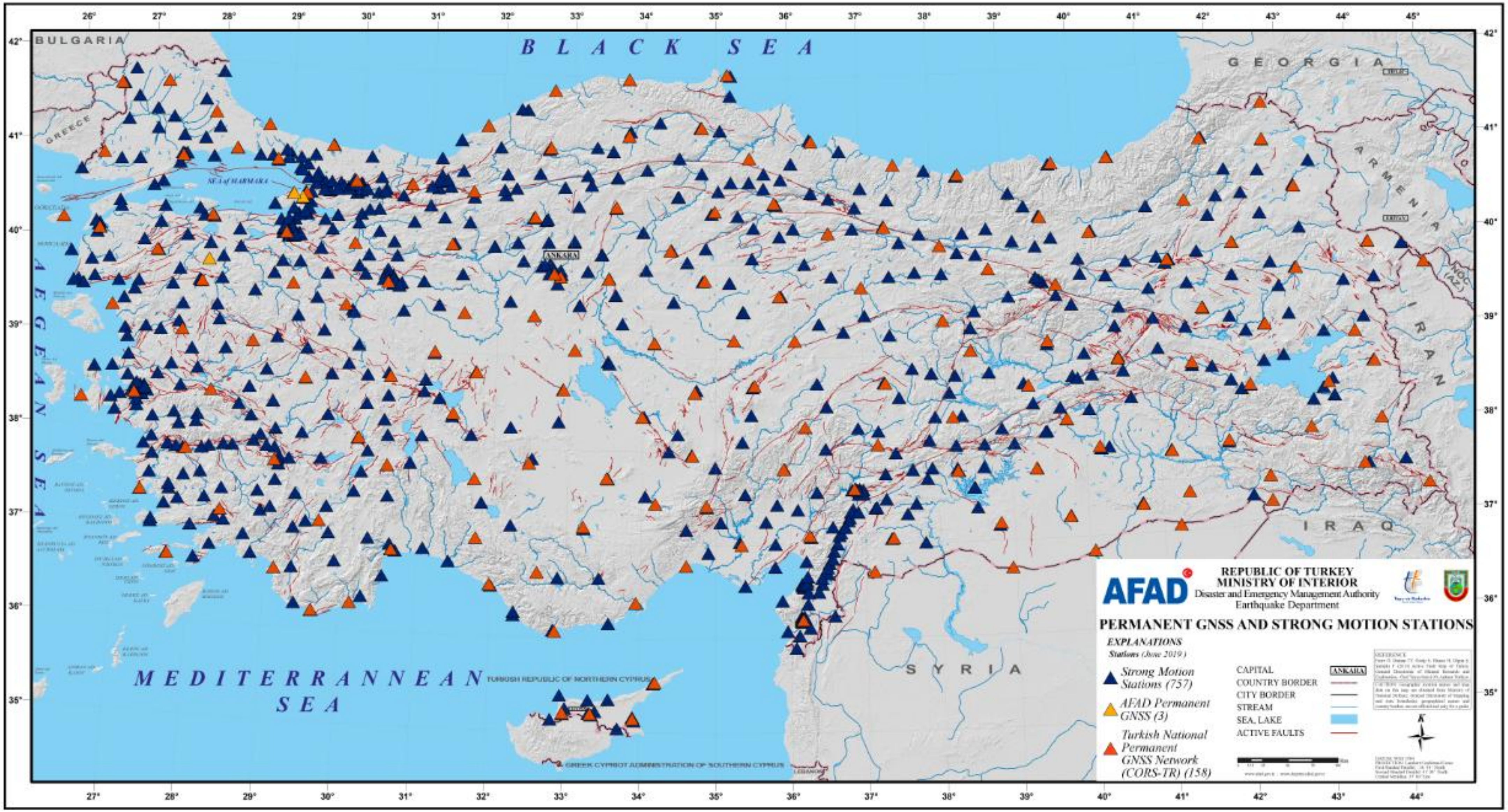
Сейсмичность Турции с 1900 [Kadirioğlu et al., 2016]


23° E
48° E
45° N
32° N
ROMANIA
BULGARIA
GREECE
BLACK SEA
RUSSIA
CASPIAN SEA
GEORGIA
ARMENIA
TURKEY
IRAN
SYRIA
IRAQ
MEDITERRANEAN
Depth, km
< 20
20 - 40
> 40

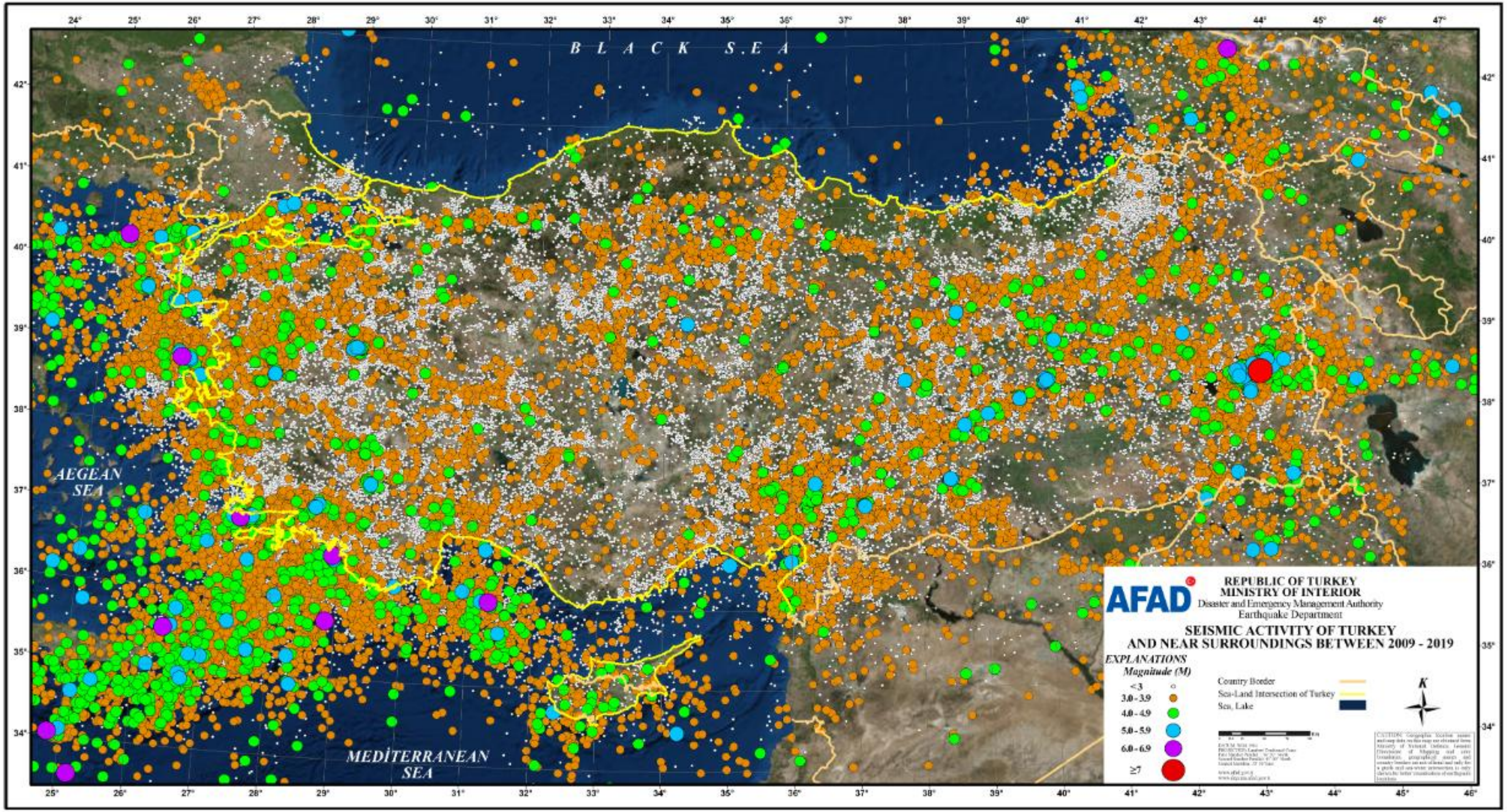
Сейсмичность Турции с *M*>6 [Kadirioğlu et al., 2016]


25° E
45° E
40° N
35° N
Post 1900 Period Mw
● 6 to 7
● 7 to 8
1000 AD to 1900 AD Mw
● 6 to 7
● 7 to 8
● =>8
25° E
45° E

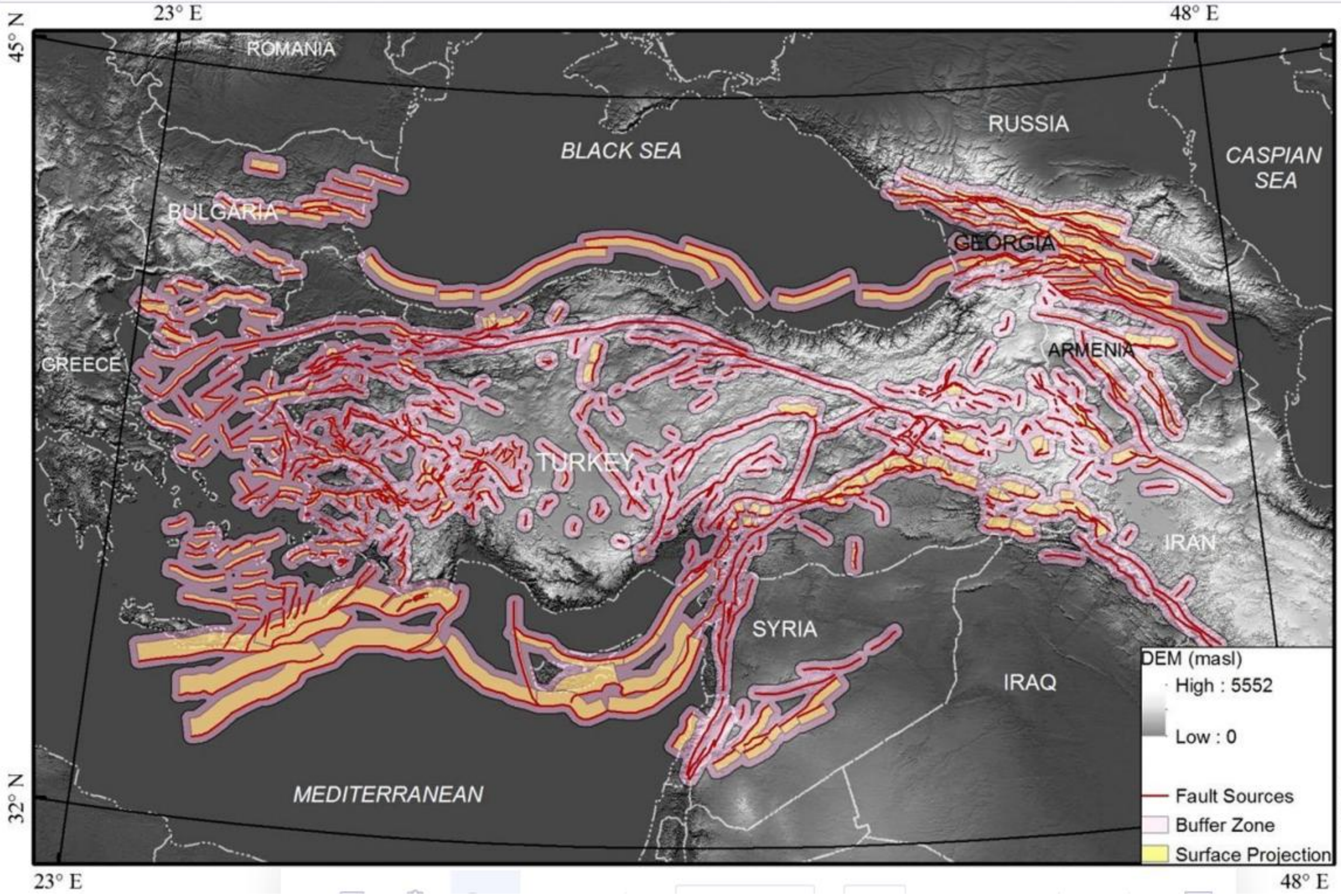
Сейсмические сети Турции [Alver et al., 2019]


BULGARIA
BLACK SEA
GEORGIA
ARMENIA
IRAN
IRAQ
SYRIA
GREECE
SEA of MARMARA
ANKARA
AEGEAN SEA
MEDITERRANEAN SEA
TURKISH REPUBLIC OF NORTHERN CYPRUS
GREEK CYPRIOT ADMINISTRATION OF SOUTHERN CYPRUS
LEBANON
AFAD
REPUBLIC OF TURKEY
MINISTRY OF INTERIOR
Disaster and Emergency Management Authority
Earthquake Department
PERMANENT GNSS AND STRONG MOTION STATIONS
EXPLANATIONS
Stations (June 2019)
Strong Motion Stations (757)
AFAD Permanent GNSS (3)
Turkish National Permanent GNSS Network (CORS-TR) (158)
CAPITAL
COUNTRY BORDER
CITY BORDER
STREAM
SEA, LAKE
ACTIVE FAULTS
26°
27°
28°
29°
30°
31°
32°
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
45°
35°
36°
37°
38°
39°
40°
41°
42°

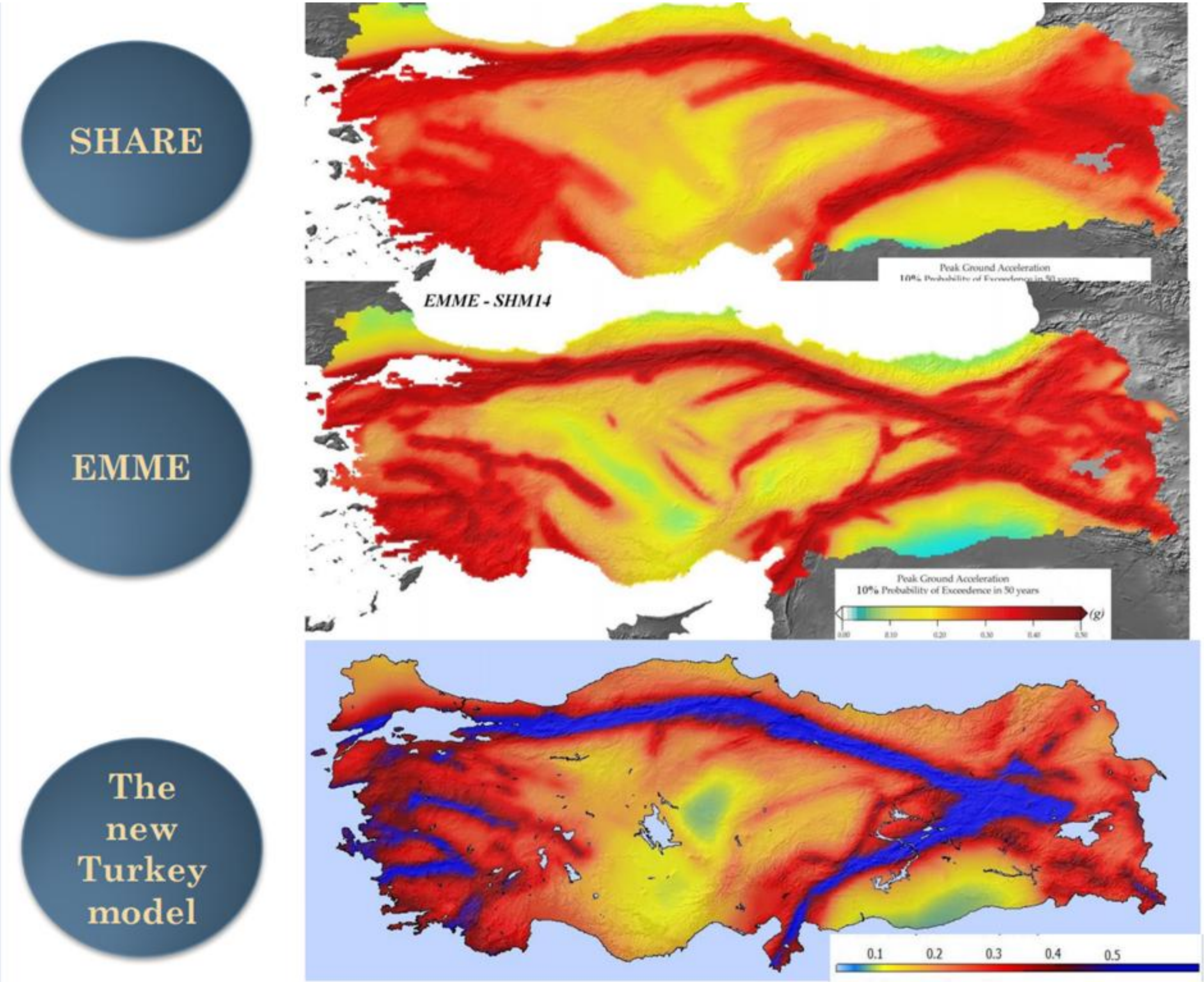
Сейсмичность Турции 2009-2019 [Alver et al., 2019]


BLACK SEA
AEGEAN SEA
MEDITERRANEAN SEA
AFAD
REPUBLIC OF TURKEY
MINISTRY OF INTERIOR
Disaster and Emergency Management Authority
Earthquake Department
SEISMIC ACTIVITY OF TURKEY
AND NEAR SURROUNDINGS BETWEEN 2009 - 2019
EXPLANATIONS
Magnitude (M)
<3
3.0 - 3.9
4.0 - 4.9
5.0 - 5.9
6.0 - 6.9
≥7
Country Border
Sea-Land Intersection of Turkey
Sea, Lake
K
24° 25° 26° 27° 28° 29° 30° 31° 32° 33° 34° 35° 36° 37° 38° 39° 40° 41° 42° 43° 44° 45° 46° 47°
34° 35° 36° 37° 38° 39° 40° 41° 42°

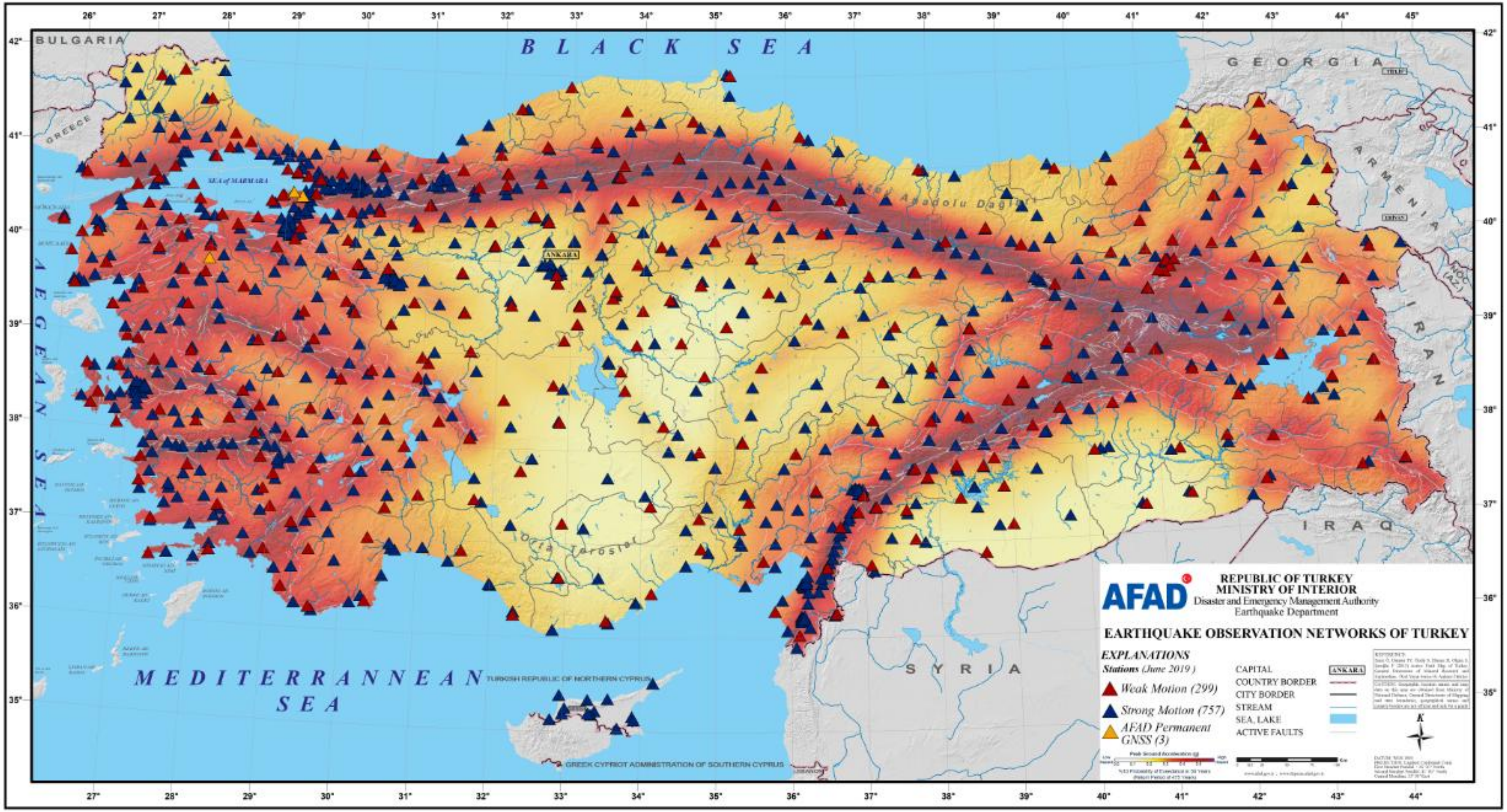
«Зоны ВОЗ» для Турции [Demircioğlu et al., 2017]


23° E
48° E
45° N
32° N
ROMANIA
BLACK SEA
RUSSIA
CASPIAN SEA
BULGARIA
GEORGIA
GREECE
ARMENIA
TURKEY
IRAN
SYRIA
IRAQ
MEDITERRANEAN
DEM (masl)
High : 5552
Low : 0
Fault Sources
Buffer Zone
Surface Projection

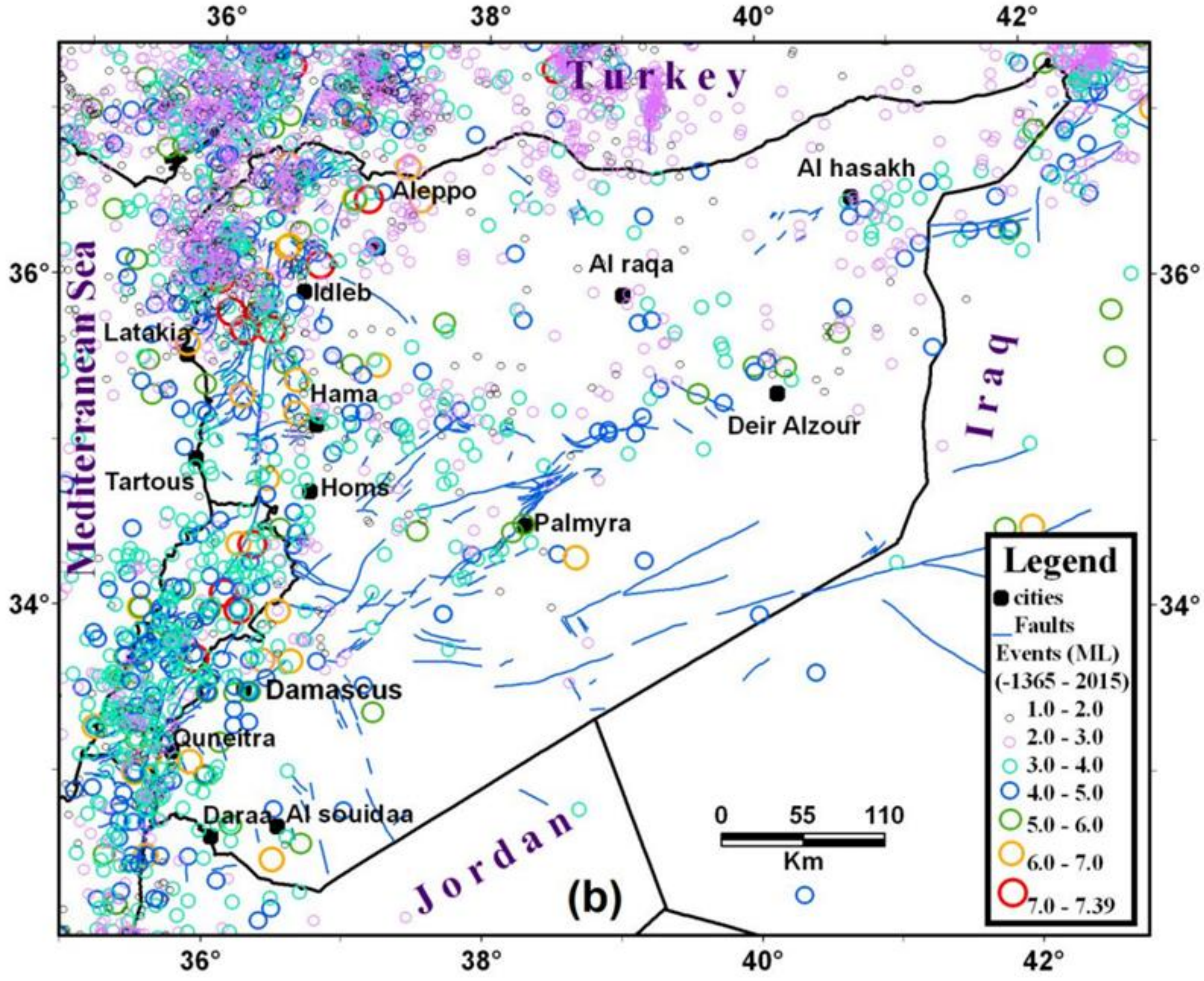
Карты сейсмической опасности Турции [Akkar et al., 2017]


SHARE
Peak Ground Acceleration
10% Probability of Exceedence in 50 years
EMME - SHM14
EMME
Peak Ground Acceleration
10% Probability of Exceedence in 50 years
(g)
0.00
0.10
0.20
0.30
0.40
0.50
The new Turkey model
0.1
0.2
0.3
0.4
0.5

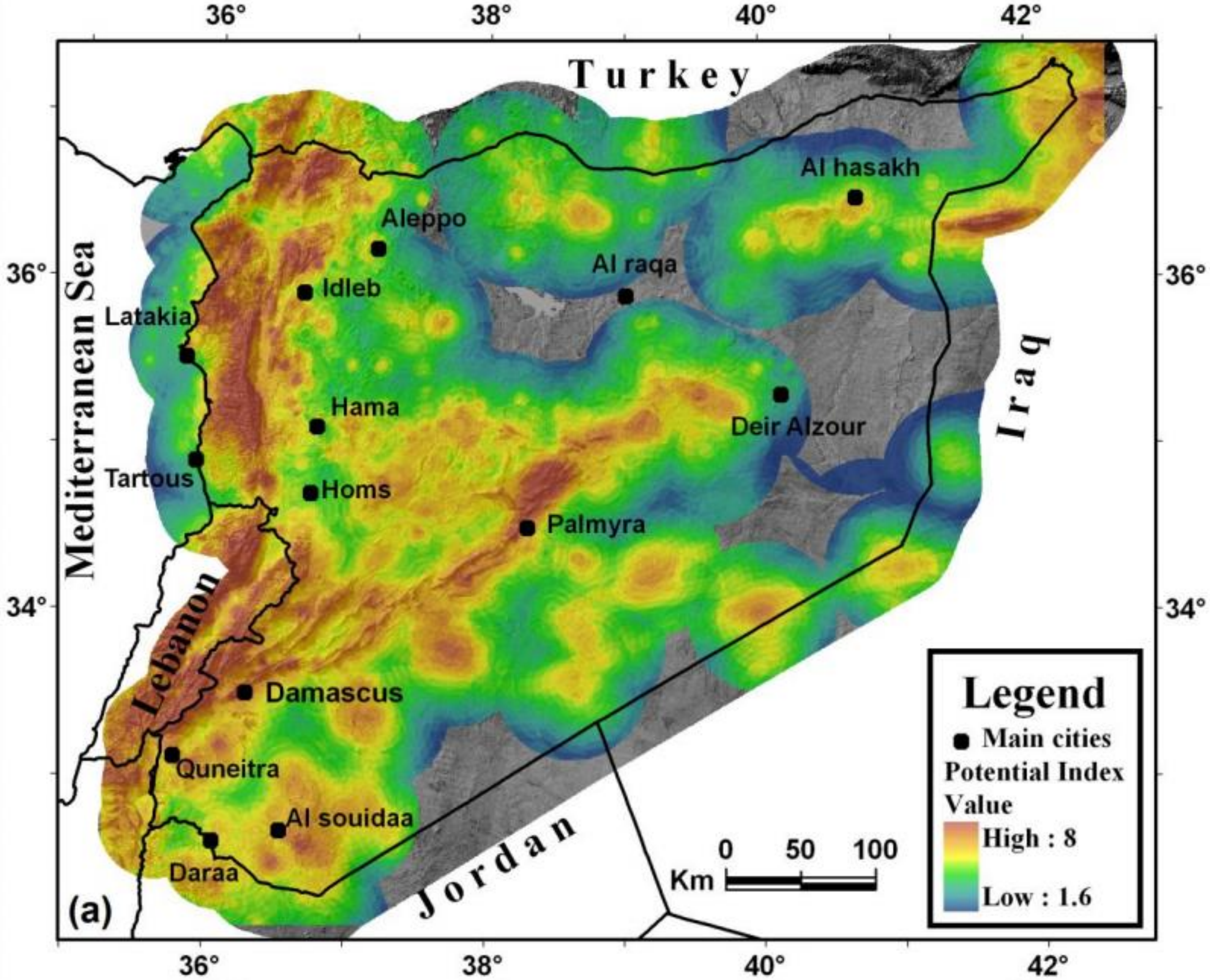
Сейсмическая сеть Турции [Alver et al., 2019]

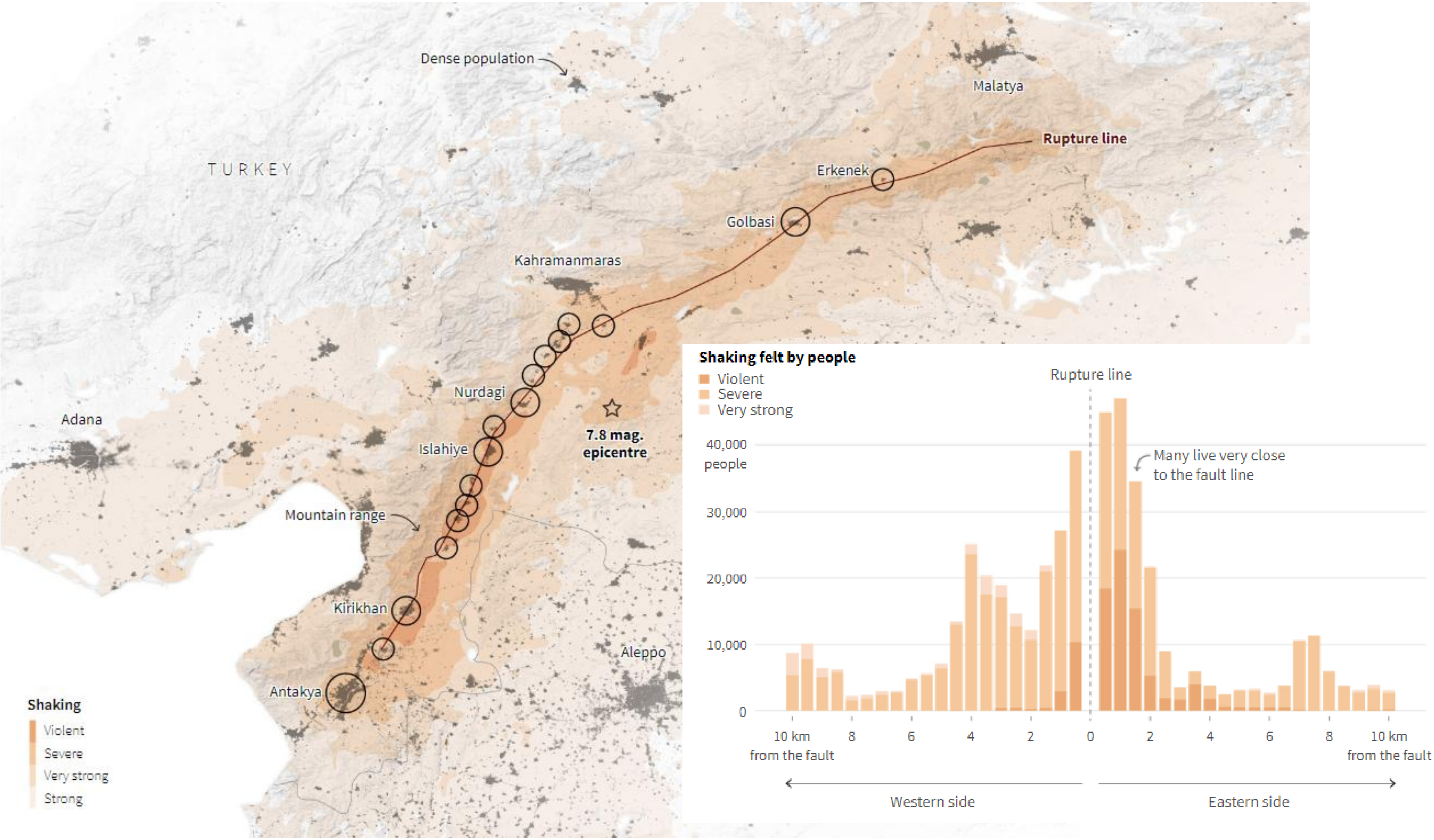

BLACK SEA
MEDITERRANNEAN SEA
AEGEAN SEA
SEA of MARMARA
BULGARIA
GREECE
GEORGIA
ARMENIA
IRAN
IRAQ
SYRIA
ANKARA
Kuzey Anadolu Dağları
Orta Toroslar
TURKISH REPUBLIC OF NORTHERN CYPRUS
GREEK CYPRIOT ADMINISTRATION OF SOUTHERN CYPRUS
AFAD
REPUBLIC OF TURKEY
MINISTRY OF INTERIOR
Disaster and Emergency Management Authority
Earthquake Department
EARTHQUAKE OBSERVATION NETWORKS OF TURKEY
EXPLANATIONS
Stations (June 2019)
Weak Motion (299)
Strong Motion (757)
AFAD Permanent GNSS (3)
CAPITAL
COUNTRY BORDER
CITY BORDER
STREAM
SEA, LAKE
ACTIVE FAULTS
Peak Ground Acceleration (g)
K
26°
27°
28°
29°
30°
31°
32°
33°
34°
35°
36°
37°
38°
39°
40°
41°
42°
43°
44°
45°
35°
36°
37°
38°
39°
40°
41°
42°

Сейсмичность Сирии [Ahmad, Singh, 2017]

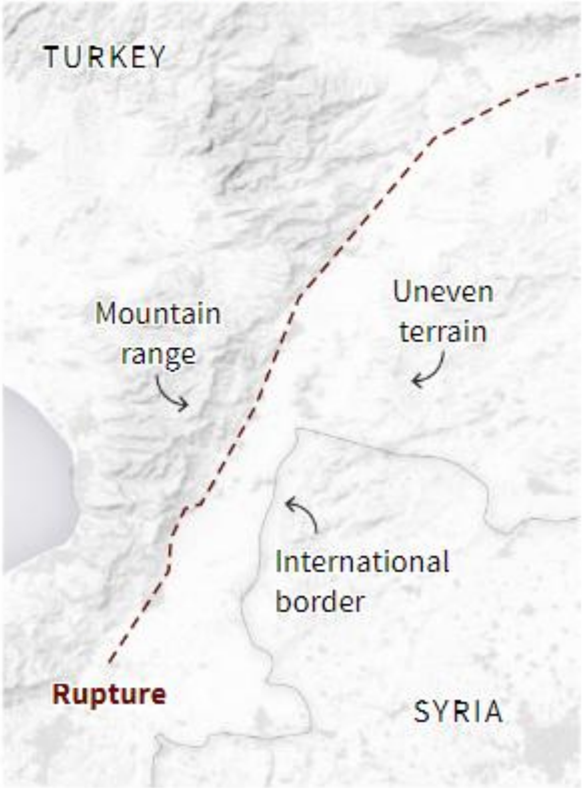

36°
38°
40°
42°
36°
34°
Turkey
Aleppo
Al hasakh
Al raqa
Idleb
Latakia
Hama
Deir Alzour
Tartous
Homs
Palmyra
Mediterranean Sea
Iraq
Damascus
Quneitra
Daraa
Al souidaa
Jordan
0
55
110
Km
(b)
Legend
cities
Faults
Events (ML)
(-1365 - 2015)
1.0 - 2.0
2.0 - 3.0
3.0 - 4.0
4.0 - 5.0
5.0 - 6.0
6.0 - 7.0
7.0 - 7.39

Карта сейсмической опасности Сирии [Ahmad, Singh, 2017]

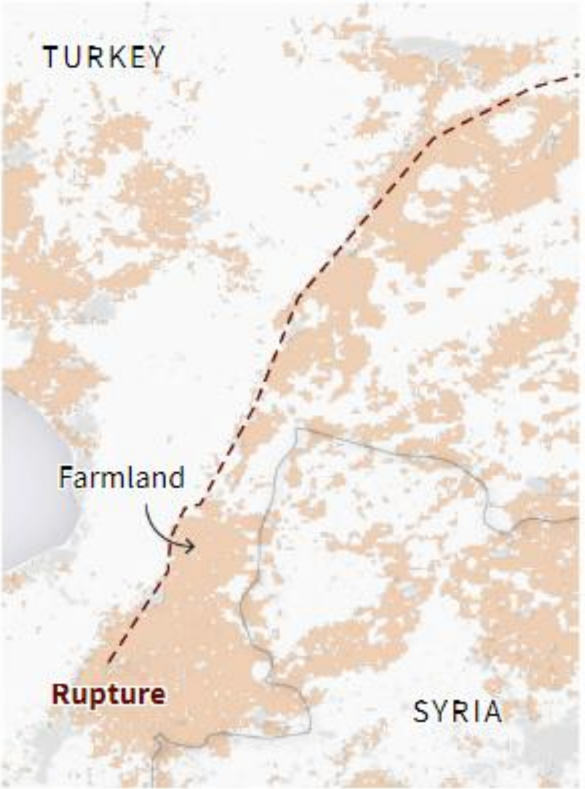

36°
38°
40°
42°
36°
34°
Turkey
Mediterranean Sea
Iraq
Lebanon
Jordan
Al hasakh
Aleppo
Al raqa
Idleb
Latakia
Hama
Deir Alzour
Tartous
Homs
Palmyra
Damascus
Quneitra
Al souidaa
Daraa
(a)
0 50 100
Km
Legend
Main cities
Potential Index Value
High : 8
Low : 1.6


Dense population
TURKEY
Malatya
Rupture line
Erkenek
Golbasi
Kahramanmaras
Nurdagi
Adana
Islahiye
7.8 mag. epicentre
Mountain range
Kirikhan
Aleppo
Antakya
Shaking
Violent
Severe
Very strong
Strong
Shaking felt by people
Violent
Severe
Very strong
Rupture line
40,000 people
30,000
20,000
10,000
0
Many live very close to the fault line
10 km from the fault
8
6
4
2
0
2
4
6
8
10 km from the fault
Western side
Eastern side

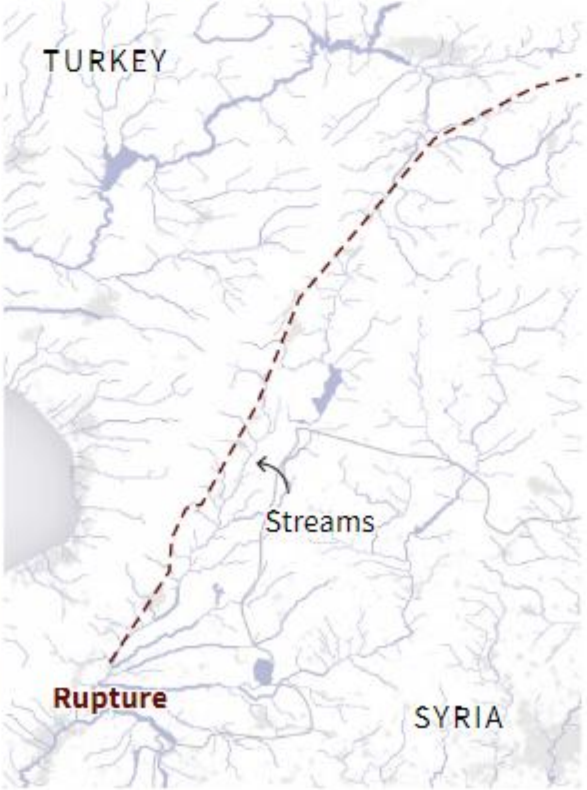
At the foot of mountains


TURKEY
Mountain range
Uneven terrain
International border
Rupture
SYRIA

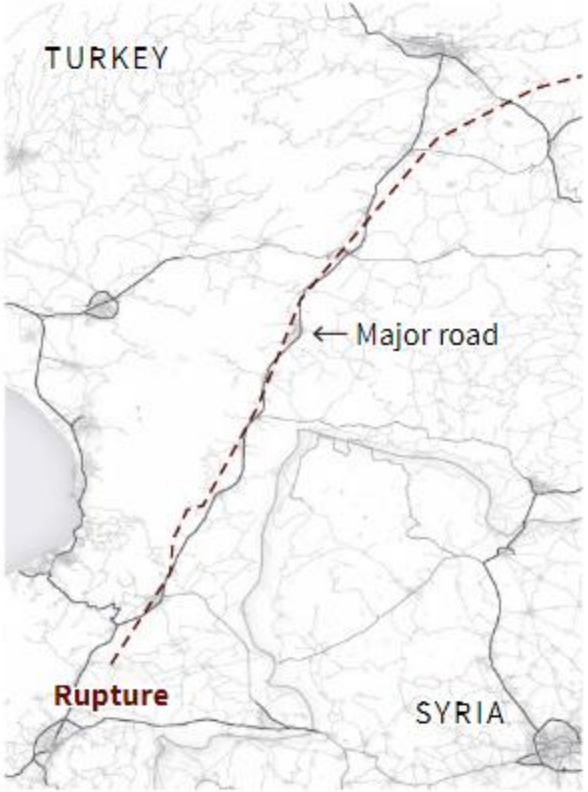
Along the edge of fertile land


TURKEY
Farmland
Rupture
SYRIA

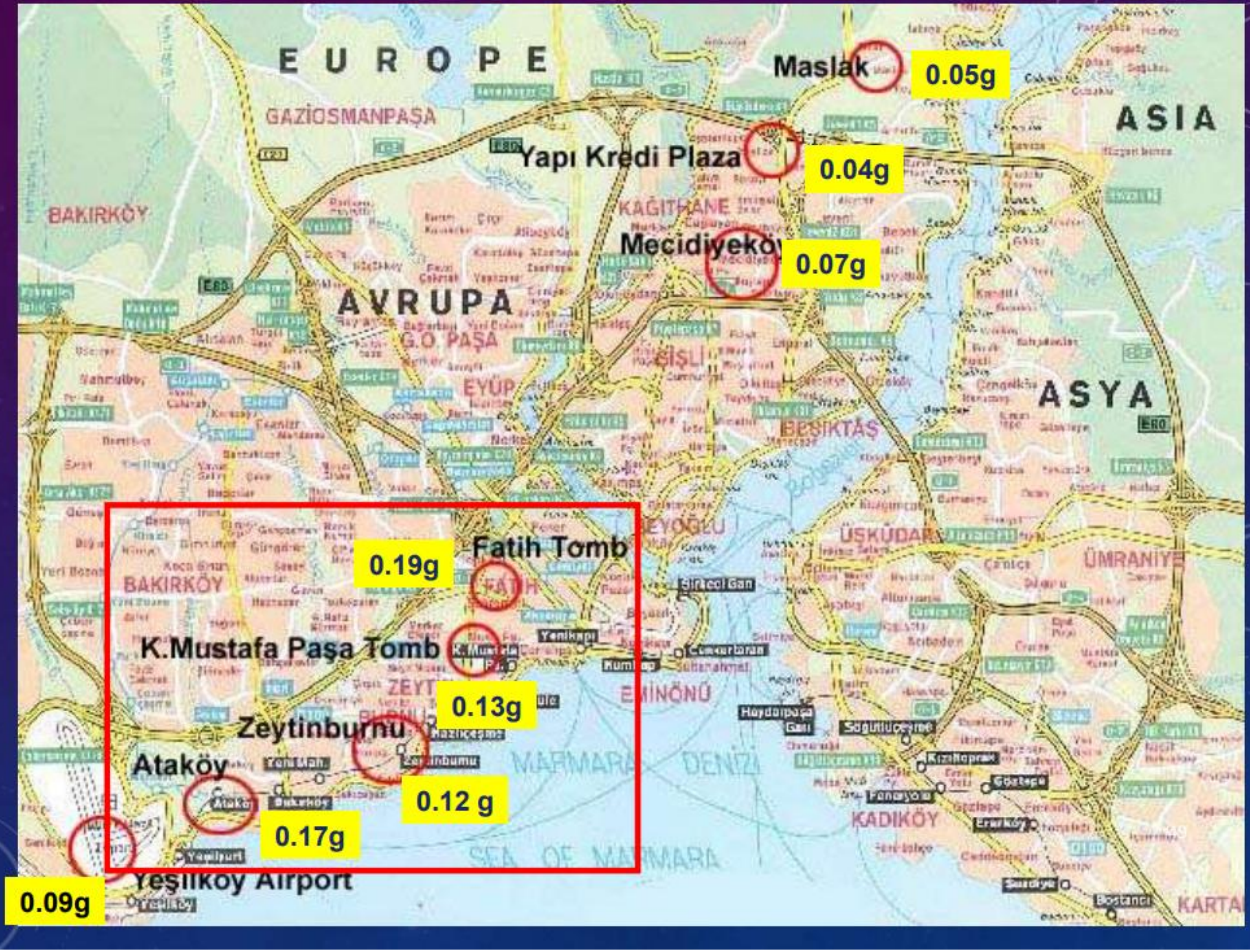
Access to water


TURKEY
Streams
Rupture
SYRIA

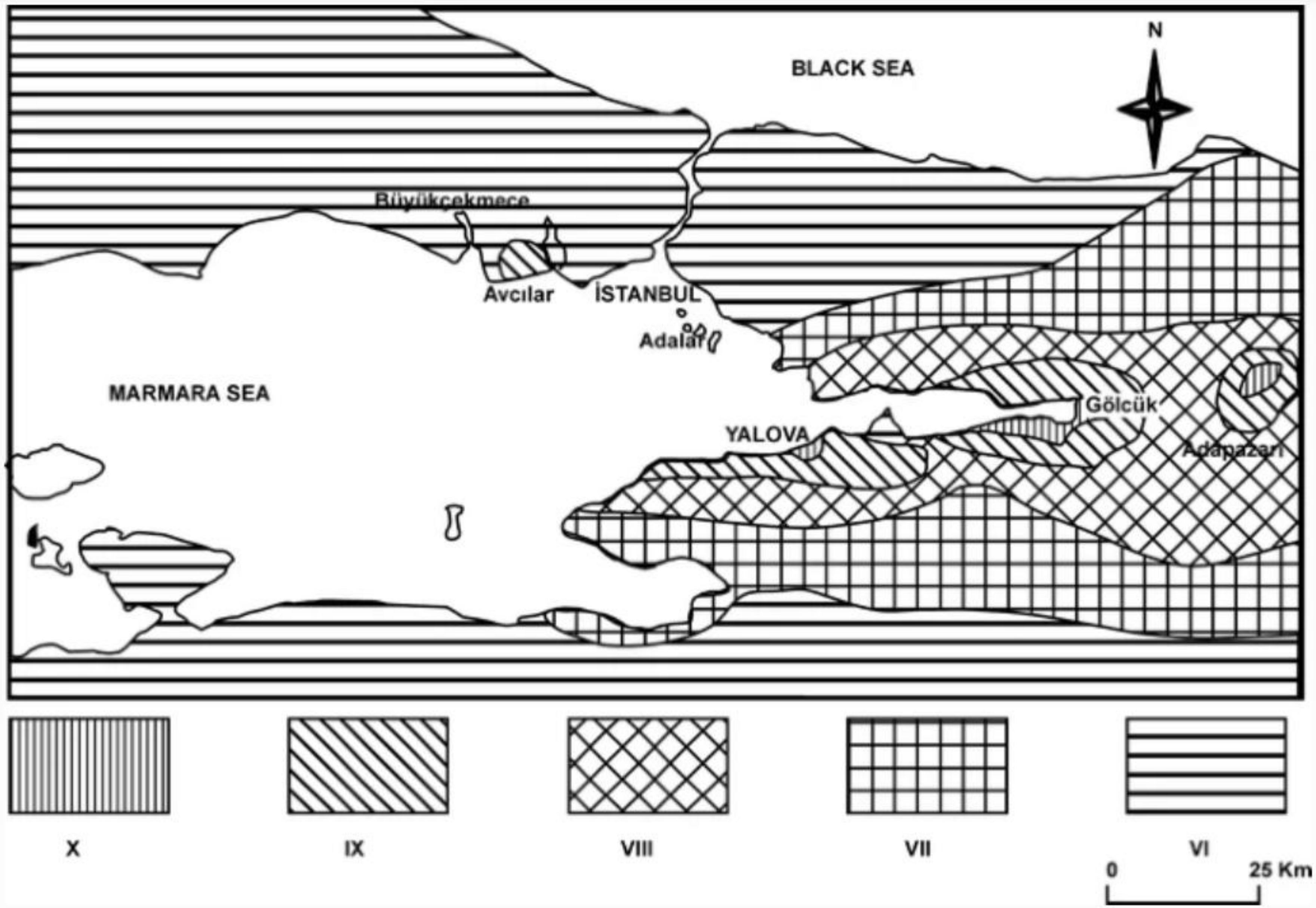
Road connectivity


TURKEY
← Major road
Rupture
SYRIA

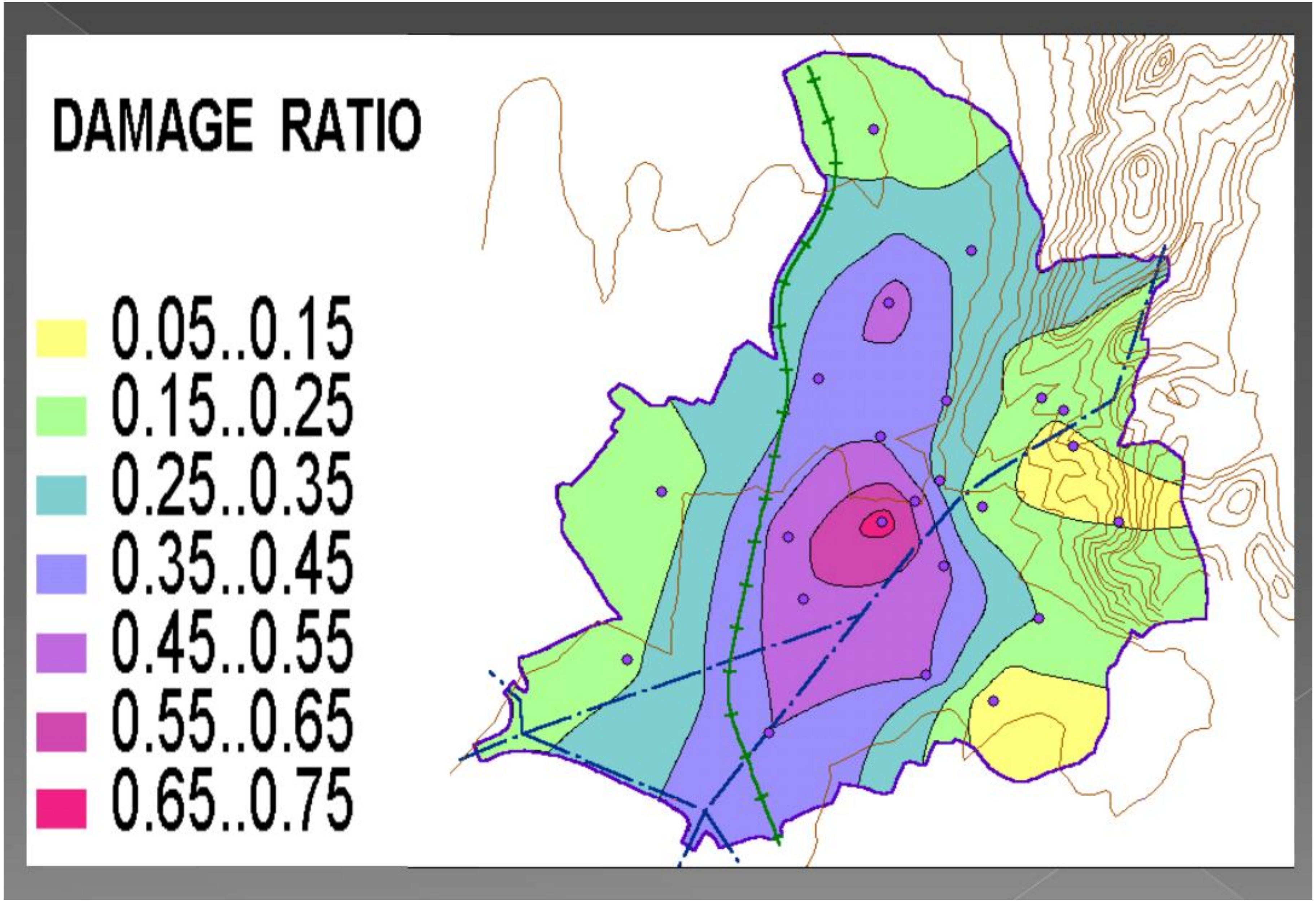
AUGUST 17, 1999 KOCAELI EARTHQUAKE ISTANBUL RECORDS


EUROPE
Maslak
0.05g
ASIA
Yapı Kredi Plaza
0.04g
GAZİOSMANPAŞA
BAKIRKÖY
KAĞITHANE
Mecidiyeköy
0.07g
AVRUPA
G.O. PAŞA
EYÜP
ŞİŞLİ
BEŞİKTAŞ
ASYA
BEYOĞLU
ÜSKÜDAR
ÜMRANİYE
Fatih Tomb
0.19g
FATİH
BAKIRKÖY
K.Mustafa Paşa Tomb
0.13g
EMİNÖNÜ
Zeytinburnu
Ataköy
0.12 g
0.17g
MARMARA DENİZİ
SEA OF MARMARA
KADIKÖY
Yeşilköy Airport
0.09g
KARTAL

[Atilla Ansal, 2016]


N
BLACK SEA
Büyükçekmece
Avcılar
İSTANBUL
Adalar
MARMARA SEA
YALOVA
Gölcük
Adapazarı
X
IX
VIII
VII
VI
0
25 Km

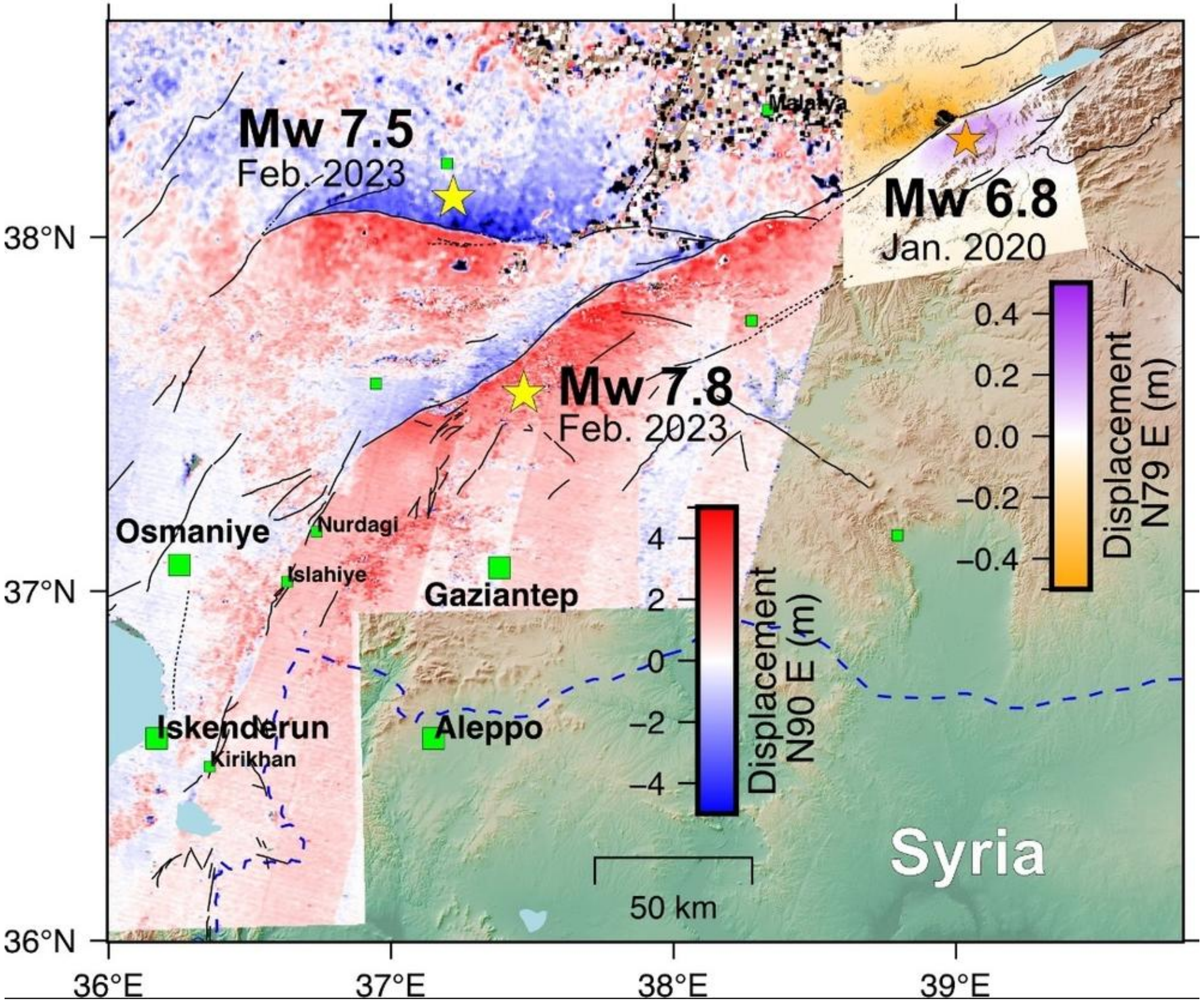
Iso-seismic map of 17 August 1999 Izmit earthquake (modified from Özmen 2000)

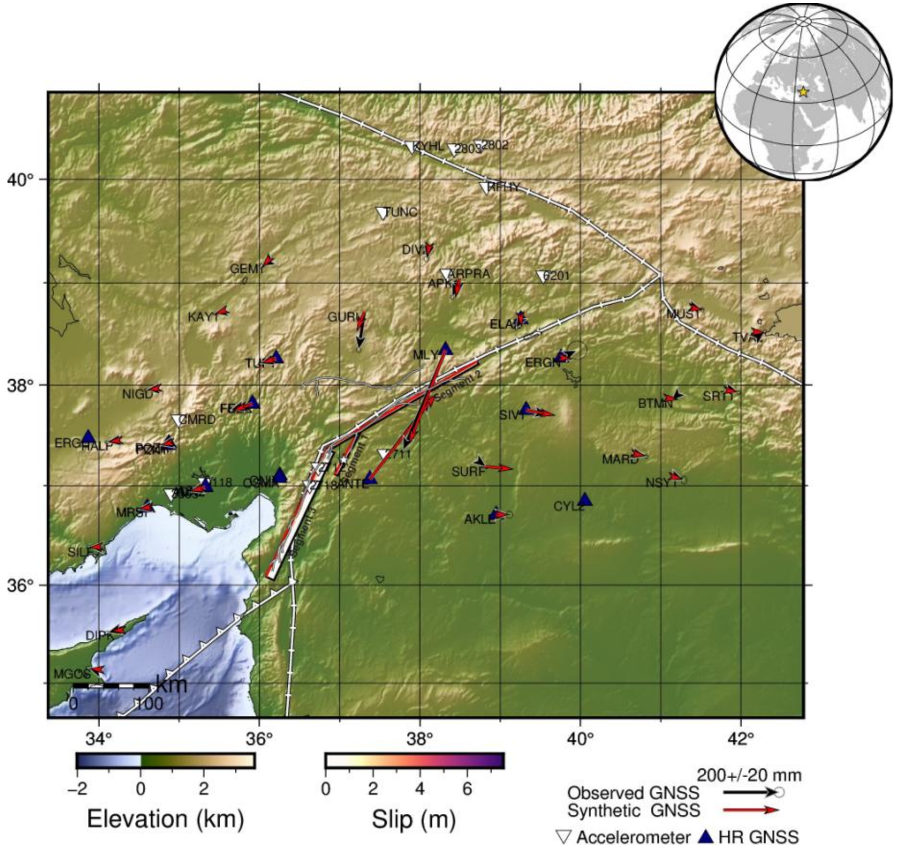

DAMAGE RATIO
0.05..0.15
0.15..0.25
0.25..0.35
0.35..0.45
0.45..0.55
0.55..0.65
0.65..0.75

Dinar earthquake
(01.10.1995
M_L = 5.9
M_w = 6.2)

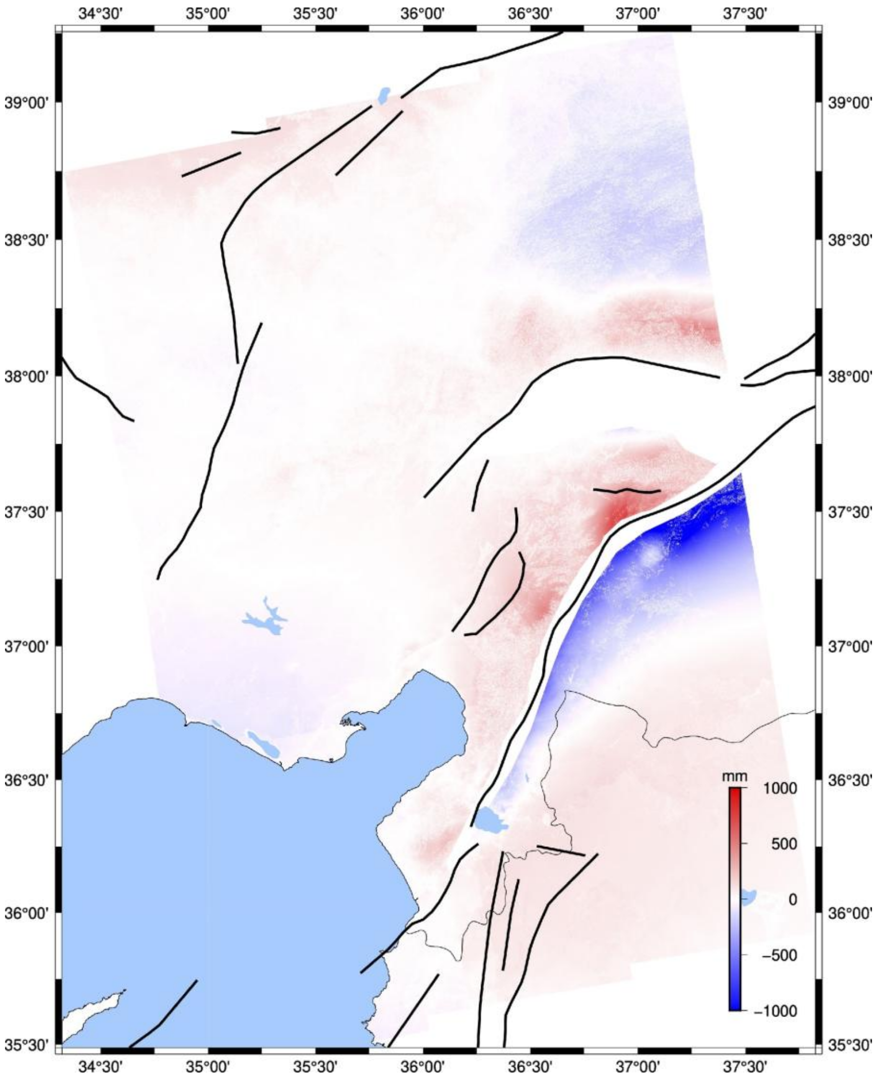
[Atilla Ansal, 2016]

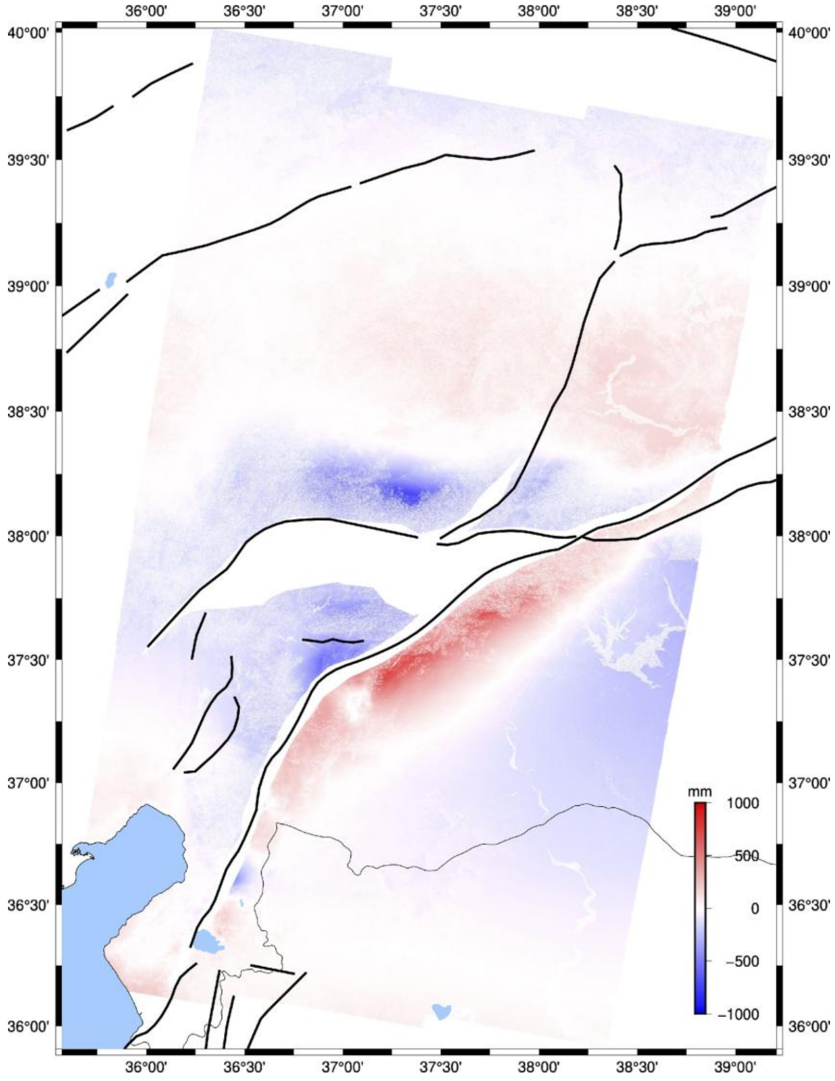
(1) Предварительная карта смещений по данным ГНСС
[Dr. Chris Milliner, Caltech, 15.02.2023]


Mw 7.5
Feb. 2023
Mw 6.8
Jan. 2020
Mw 7.8
Feb. 2023
Malatya
Osmaniye
Nurdagi
Islahiye
Gaziantep
Iskenderun
Kirikhan
Aleppo
Syria
50 km
Displacement N90 E (m)
4
2
0
−2
−4
Displacement N79 E (m)
0.4
0.2
0.0
−0.2
−0.4
38°N
37°N
36°N
36°E
37°E
38°E
39°E

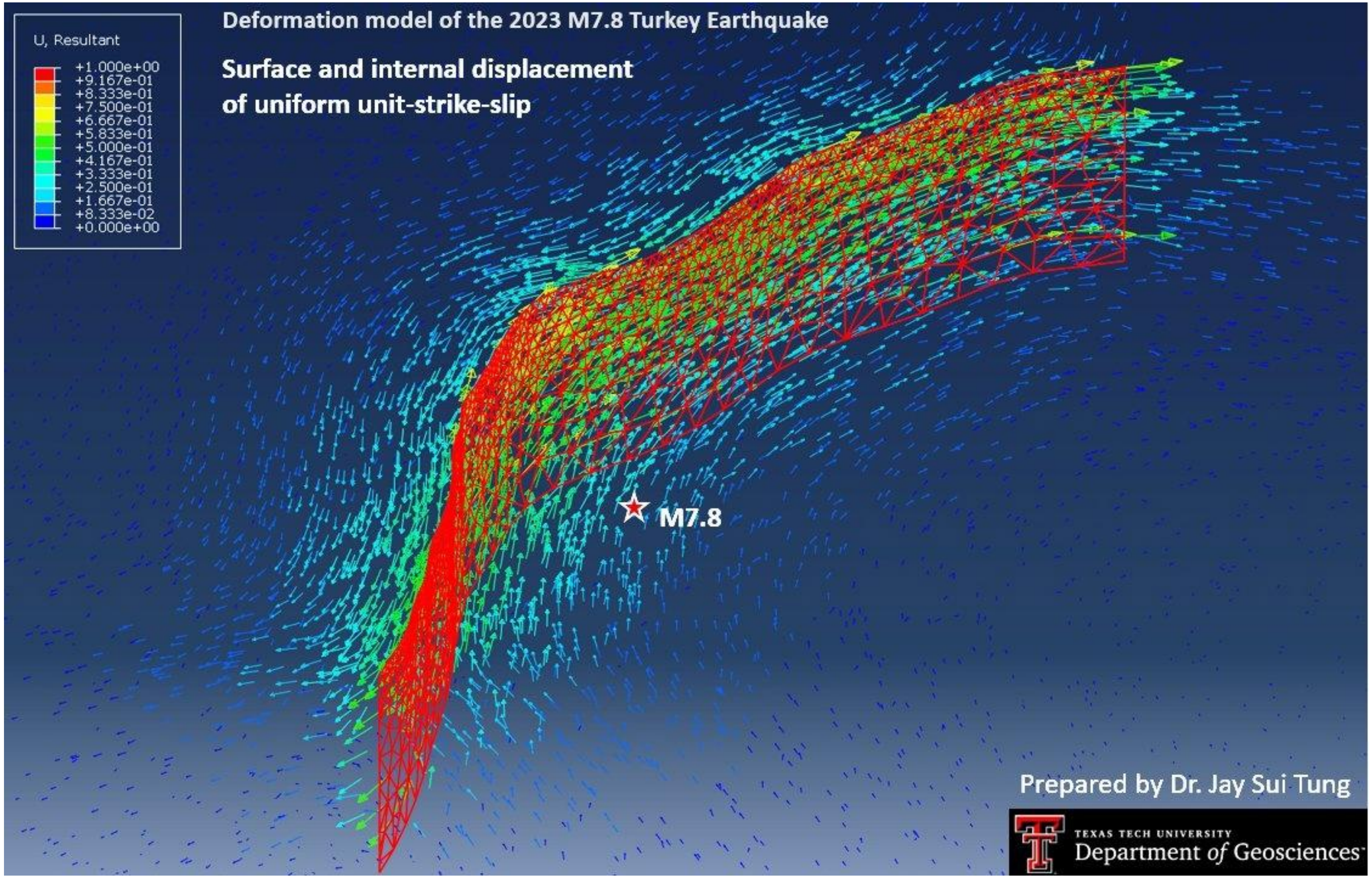

40°
38°
36°
34°
36°
38°
40°
42°
KYHL
2803
2802
RFHY
TUNC
DIVI
ARPRA
APKI
6201
GEMI
KAYI
GURL
ELAZ
MUST
TVAN
TUFK
MLYA
ERGN
NIGD
FEEK
CMRD
Segment 2
SIVT
BTMN
SRTI
ERGL
HALP
POZT
Segment 1
4711
SURF
MARD
3118
OSMA
ANTE
NSYI
MRSI
CYLZ
AKLE
Segment 3
SILF
DIPK
MGOS
km
0
100
Elevation (km)
−2
0
2
Slip (m)
0
2
4
6
200+/-20 mm
Observed GNSS
Synthetic GNSS
▽ Accelerometer
▲ HR GNSS

(2) Предварительные данные обработки данных спутника Sentinel 1A (28.01 и 09.02)
[Xiaohua Xu, University of Science and Technology of China, 28.02.2023]

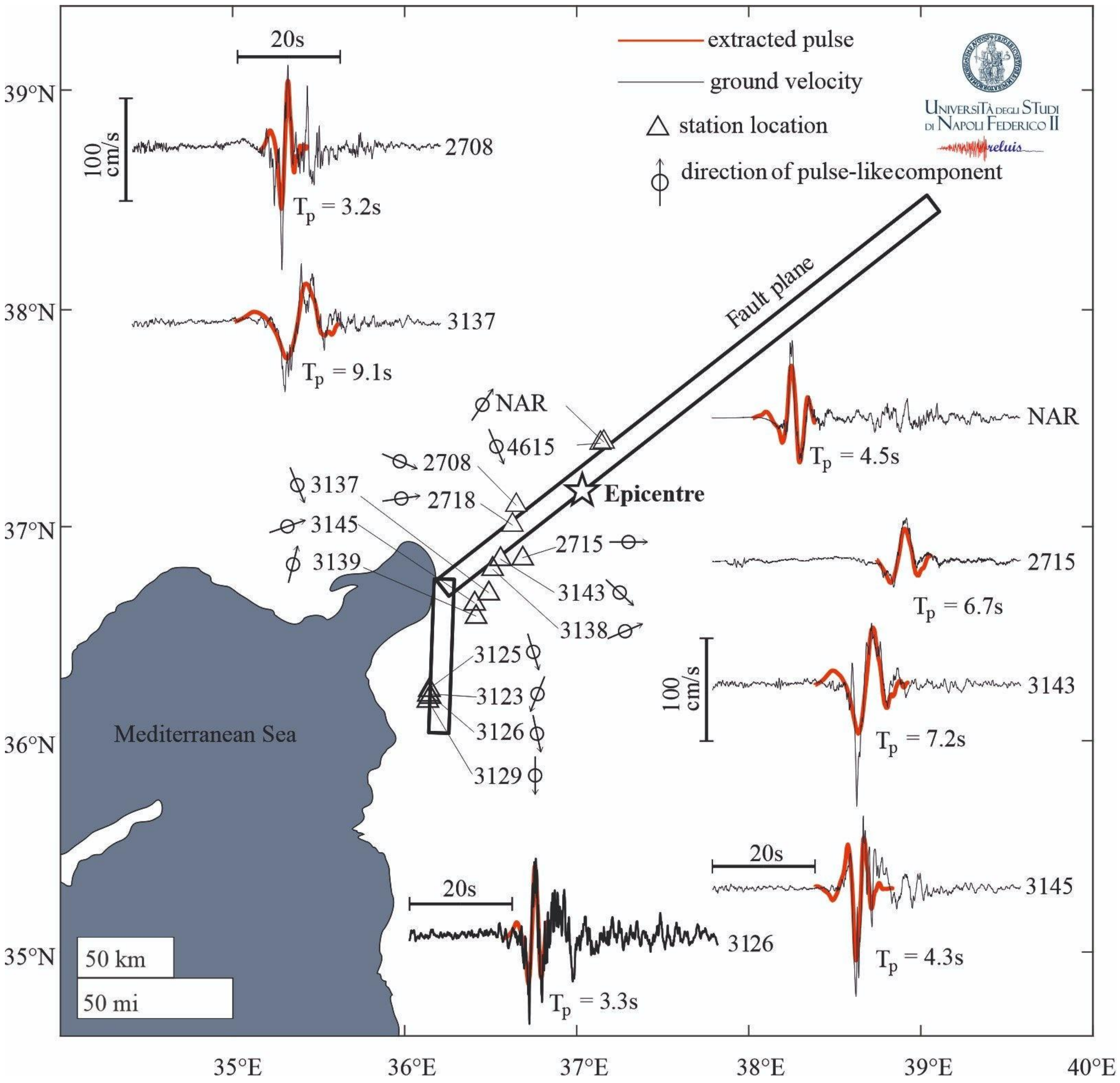

34°30'
35°00'
35°30'
36°00'
36°30'
37°00'
37°30'
39°00'
38°30'
38°00'
37°30'
37°00'
36°30'
36°00'
35°30'
mm
1000
500
0
−500
−1000


36°00'
36°30'
37°00'
37°30'
38°00'
38°30'
39°00'
40°00'
39°30'
39°00'
38°30'
38°00'
37°30'
37°00'
36°30'
36°00'
mm
1000
500
0
−500
−1000

(3) Предварительная модель косейсмических деформаций земной коры
[Jay Tung, Texas Tech University, 19.02.2023]

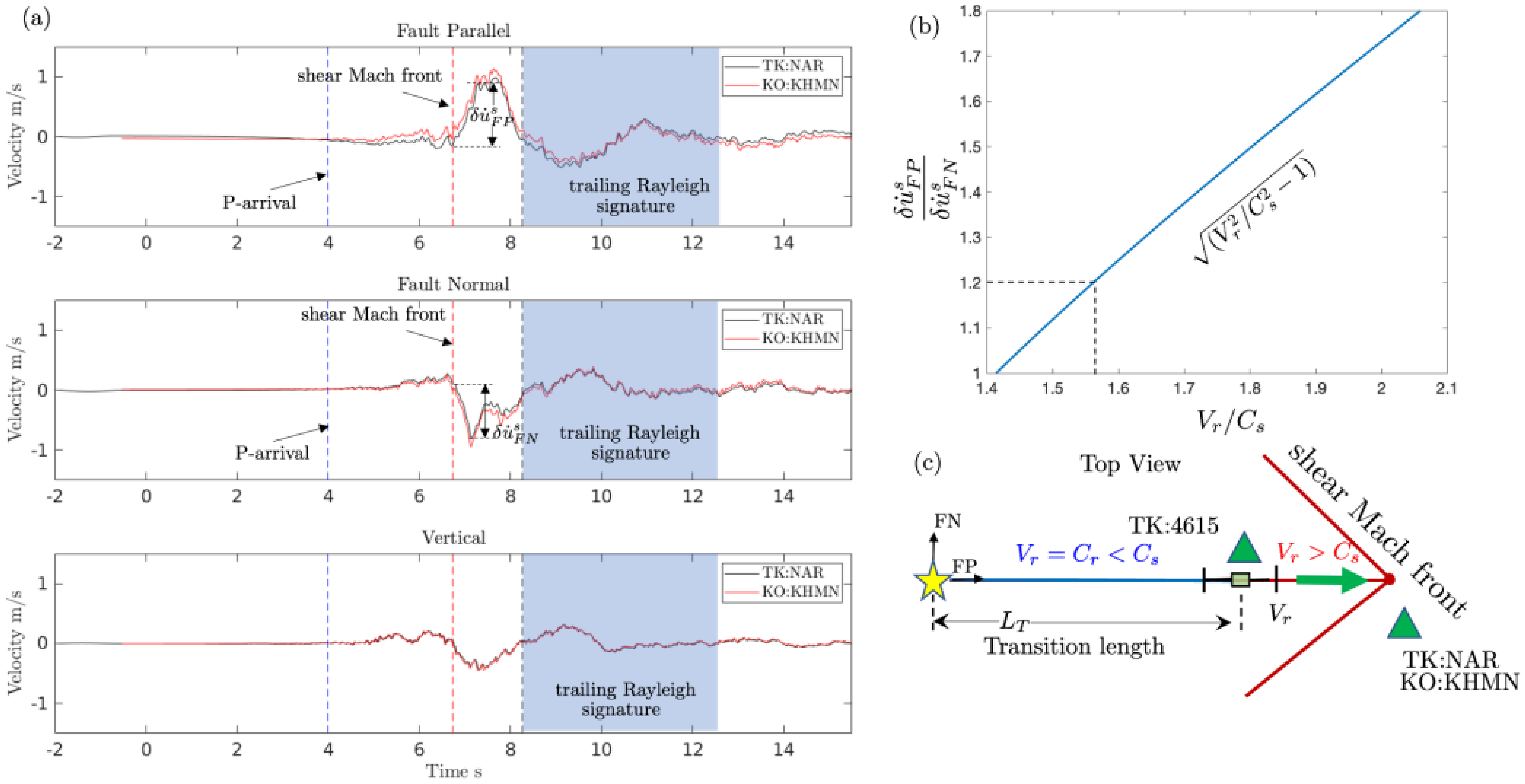

Deformation model of the 2023 M7.8 Turkey Earthquake
Surface and internal displacement
of uniform unit-strike-slip
U, Resultant
+1.000e+00
+9.167e-01
+8.333e-01
+7.500e-01
+6.667e-01
+5.833e-01
+5.000e-01
+4.167e-01
+3.333e-01
+2.500e-01
+1.667e-01
+8.333e-02
+0.000e+00
M7.8
Prepared by Dr. Jay Sui Tung
TEXAS TECH UNIVERSITY
Department of Geosciences

(4) Предварительные результаты по восстановлению модели очага, используя волновые формы [Prof. Iunio Iervolino, University of Naples Federico II, 19.02.2023]


20s
extracted pulse
ground velocity
station location
direction of pulse-like component
Università degli Studi di Napoli Federico II
reluis
39°N
38°N
37°N
36°N
35°N
100 cm/s
2708
T_p = 3.2s
3137
T_p = 9.1s
Fault plane
NAR
T_p = 4.5s
NAR
4615
2708
Epicentre
3137
2718
3145
2715
3139
3143
3138
2715
T_p = 6.7s
100 cm/s
3143
T_p = 7.2s
3125
3123
3126
3129
Mediterranean Sea
20s
3145
T_p = 4.3s
20s
3126
T_p = 3.3s
50 km
50 mi
35°E
36°E
37°E
38°E
39°E
40°E

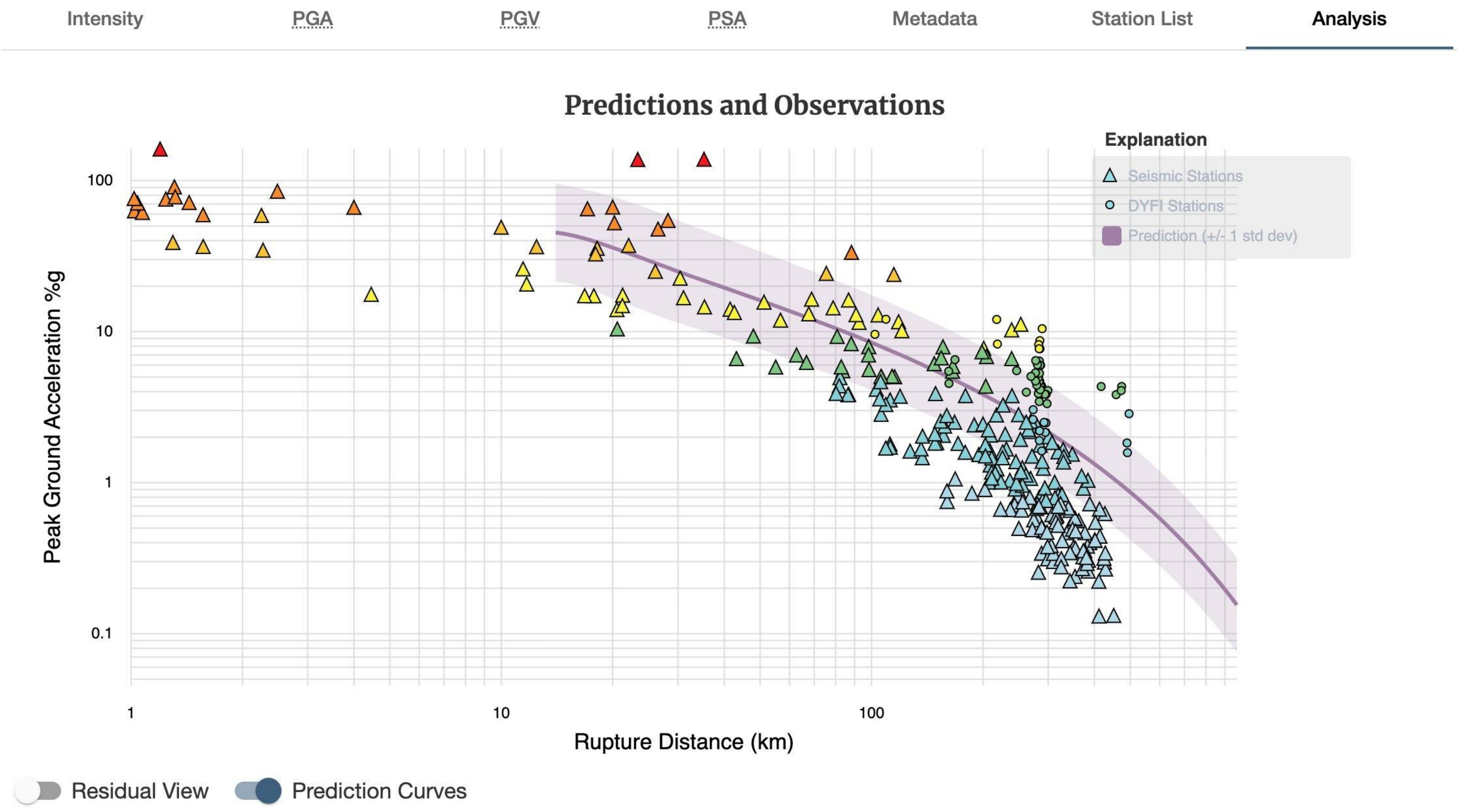
(5) Mw 7.8 – supershear earthquake! (https://arxiv.org/ftp/arxiv/papers/2302/2302.07214.pdf)

[Rosakis[1], Abdelmeguid[1], Elbanna[2,3] , Caltech, University of Illinois, 15.02.2023]



(6) Preliminary PGA vs Rupture Distance

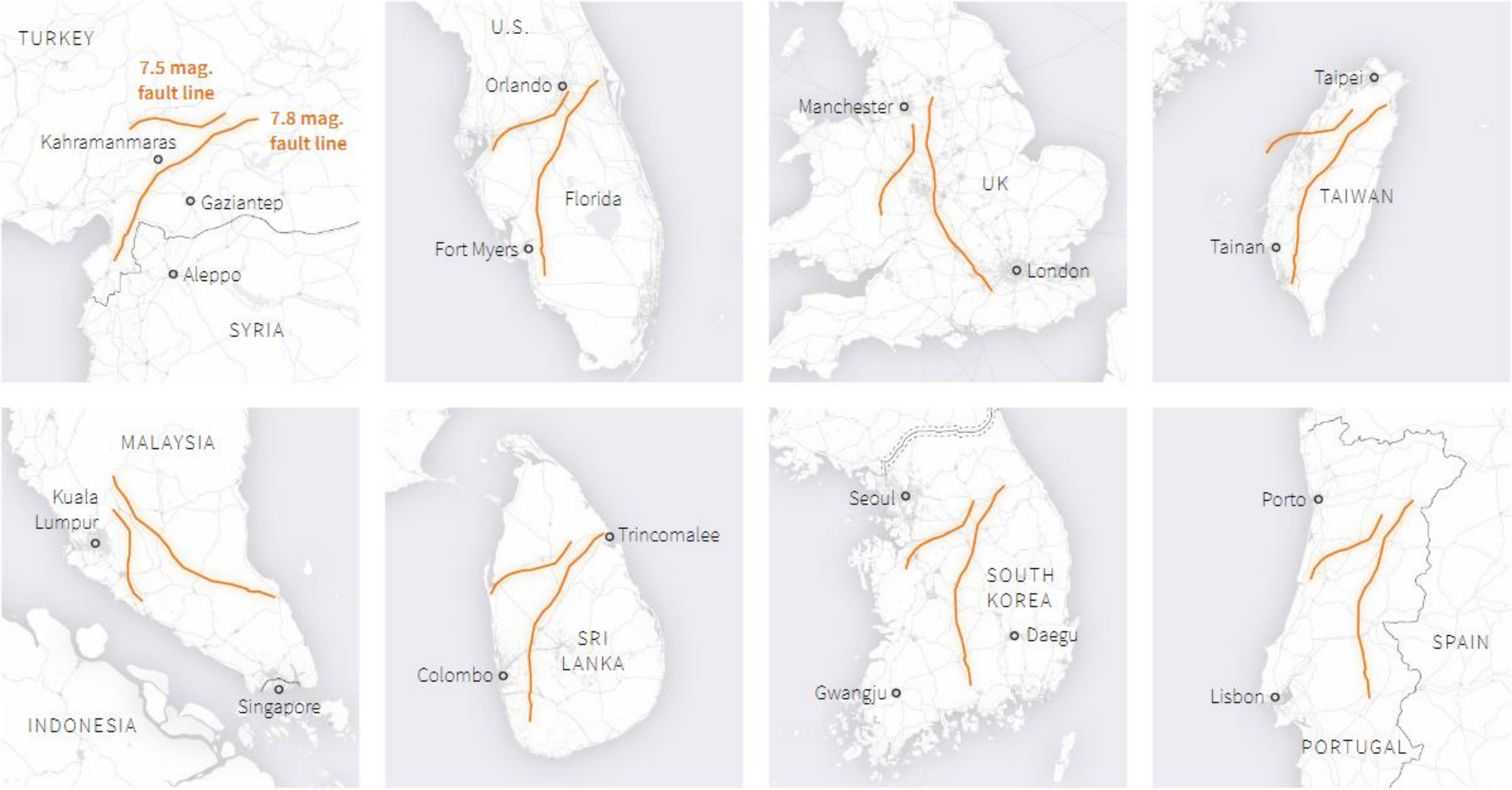
[Baoning Wu, University of Southern California, 15.02.2023]


Intensity
PGA
PGV
PSA
Metadata
Station List
Analysis
Predictions and Observations
Explanation
Seismic Stations
DYFI Stations
Prediction (+/- 1 std dev)
Peak Ground Acceleration %g
100
10
1
0.1
1
10
100
Rupture Distance (km)
Residual View
Prediction Curves

Благодарю за внимание!

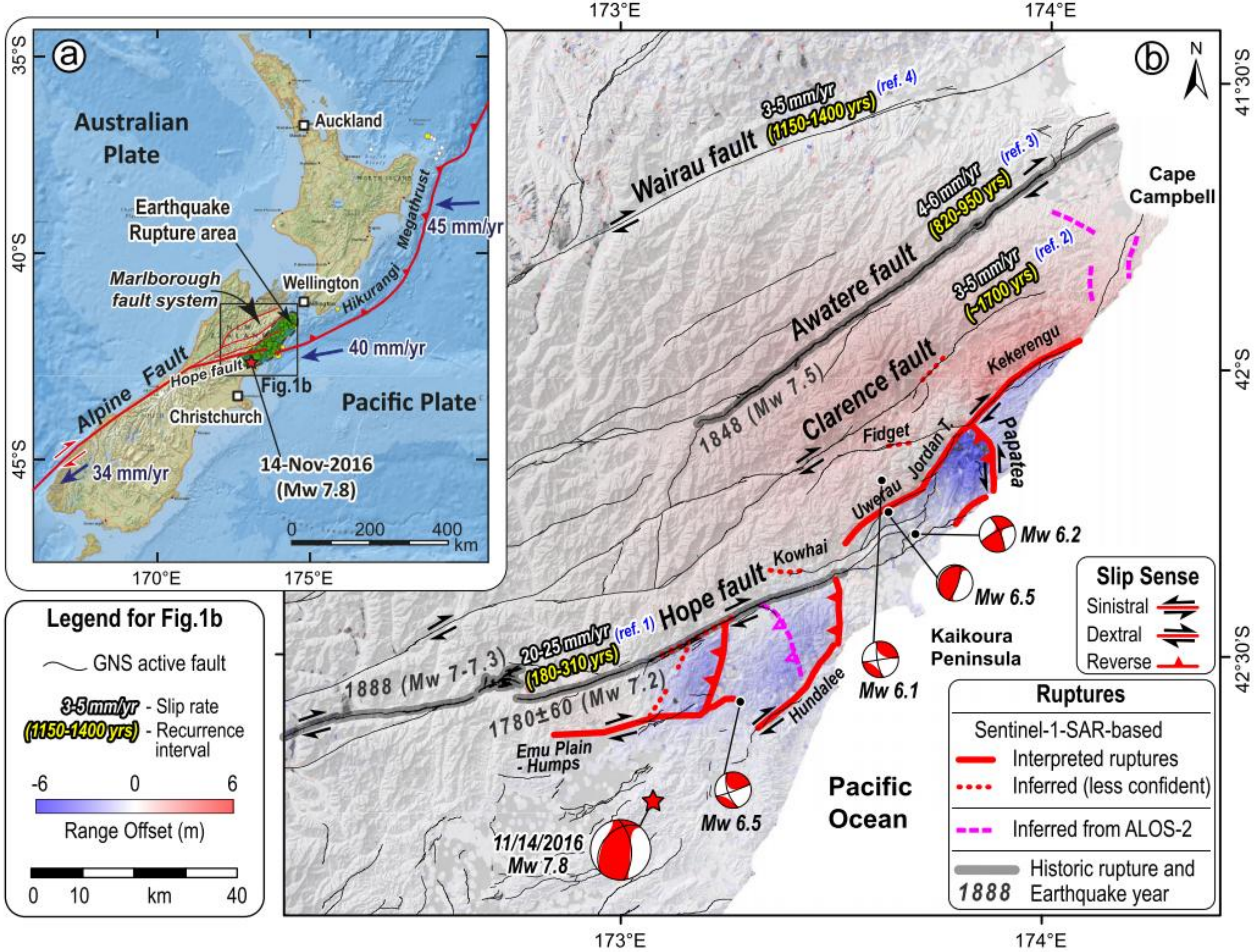
Сравнение очаговых зон с рядом небольших государств

https://www.reuters.com/graphics/TURKEY-QUAKE/RUPTURE/gdpzqdzwwvw/?s=09


TURKEY
7.5 mag. fault line
7.8 mag. fault line
Kahramanmaras
Gaziantep
Aleppo
SYRIA
U.S.
Orlando
Florida
Fort Myers
Manchester
UK
London
Taipei
TAIWAN
Tainan
MALAYSIA
Kuala Lumpur
Singapore
INDONESIA
Trincomalee
SRI LANKA
Colombo
Seoul
SOUTH KOREA
Daegu
Gwangju
Porto
SPAIN
Lisbon
PORTUGAL

Кайкоурское землетрясение

14.11.2016 (M = 7.8)


a
35°S
40°S
45°S
170°E
175°E
Australian Plate
Auckland
Earthquake Rupture area
Marlborough fault system
Wellington
Hikurangi
Megathrust
45 mm/yr
40 mm/yr
Alpine Fault
Hope fault
Fig.1b
Christchurch
Pacific Plate
34 mm/yr
14-Nov-2016 (Mw 7.8)
0 200 400 km
Legend for Fig.1b
GNS active fault
3-5 mm/yr - Slip rate
(1150-1400 yrs) - Recurrence interval
-6 0 6
Range Offset (m)
0 10 km 40
b
173°E
174°E
41°30'S
42°S
42°30'S
N
Wairau fault
3-5 mm/yr (1150-1400 yrs) (ref. 4)
Awatere fault
4-6 mm/yr (820-950 yrs) (ref. 3)
1848 (Mw 7.5)
Clarence fault
3-5 mm/yr (~1700 yrs) (ref. 2)
Cape Campbell
Kekerengu
Fidget
Jordan T.
Papatea
Uwerau
Kowhai
Hope fault
20-25 mm/yr (180-310 yrs) (ref. 1)
1888 (Mw 7-7.3)
1780±60 (Mw 7.2)
Emu Plain - Humps
Hundalee
Kaikoura Peninsula
Mw 6.2
Mw 6.5
Mw 6.1
Mw 6.5
11/14/2016 Mw 7.8
Pacific Ocean
Slip Sense
Sinistral
Dextral
Reverse
Ruptures
Sentinel-1-SAR-based
Interpreted ruptures
Inferred (less confident)
Inferred from ALOS-2
Historic rupture and
1888 Earthquake year

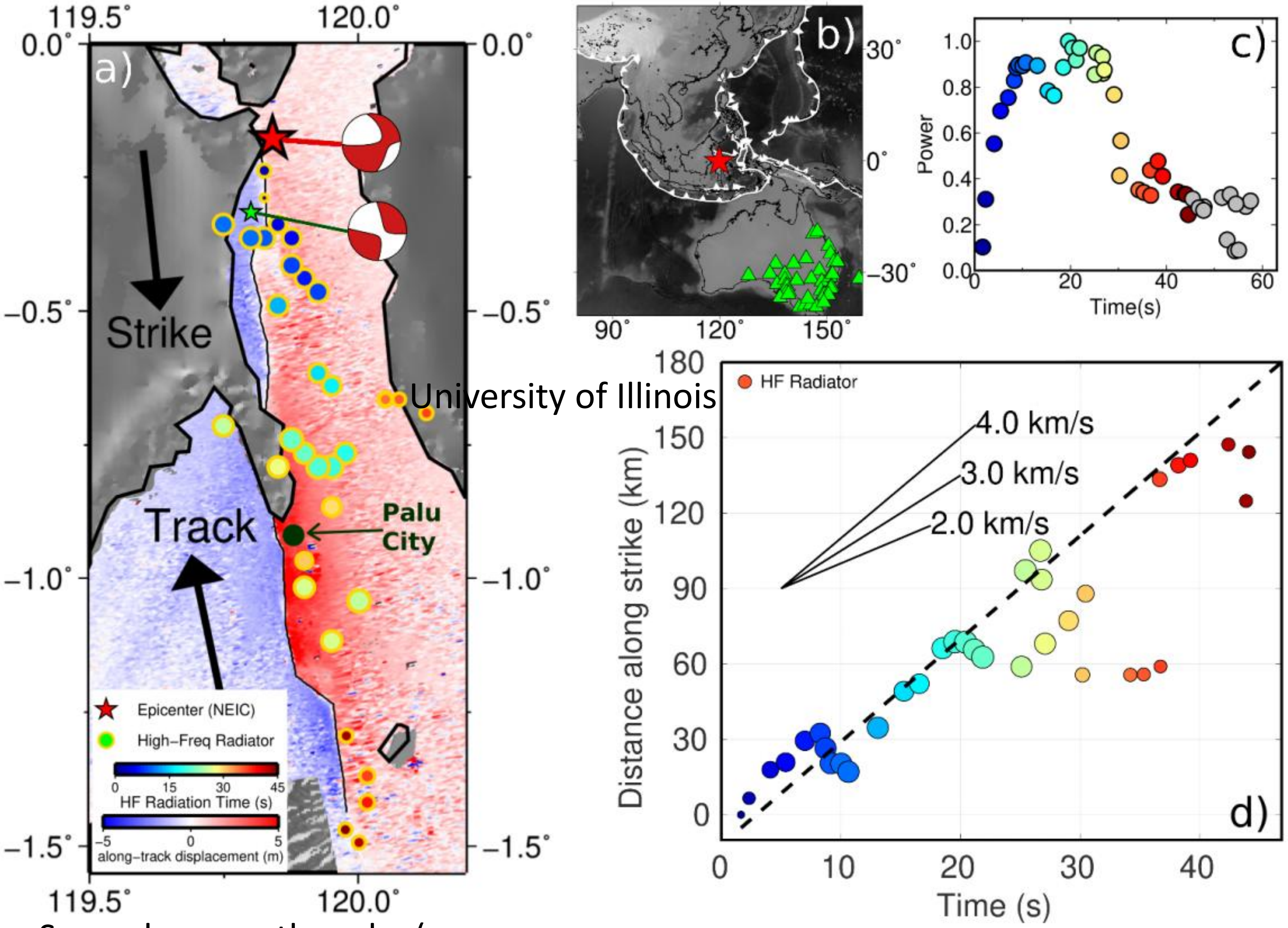
Впервые в очаговой зоне «сработали» разломы, которые находились на удалении в 15 км друг от друга
(до этого считали, что разломы, расположенные дальше 5 км, «сработаться» не могут
в процессе одного землетрясения)

Ближайшие населенные пункты

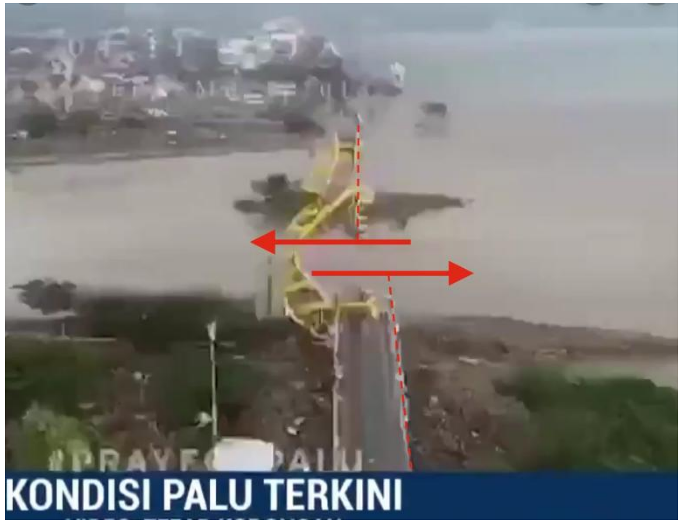
1. Nurdağı, Gaziantep, Turkey 26 km WSW Population: 12 827
2. Gaziantep, Gaziantep, Turkey 37 km ESE Population: 1 065 975
3. Pazarcık, Kahramanmaraş, Turkey 38.1 km NE Population: 23 850
4. Bahçe, Adana, Turkey 39.5 km W Population: 19 566
5. Kahramanmaraş, Kahramanmaraş, Turkey 40.8 km NNW Population: 376 045

1. Ekinözü, Kahramanmaraş, Turkey 4.2 km NNW Population: 6 298
2. Elbistan, Kahramanmaraş, Turkey 20.3 km N Population: 80 456
3. Çağlayancerit, Kahramanmaraş, Turkey 31.8 km SSE Population: 15 530
4. Afşin, Kahramanmaraş, Turkey 35.5 km NW Population: 39 613
5. Kahramanmaraş, Kahramanmaraş, Turkey 54.5 km SSW Population: 376 045

Землетрясение в Палу
28.09.2018 (M = 7.5)



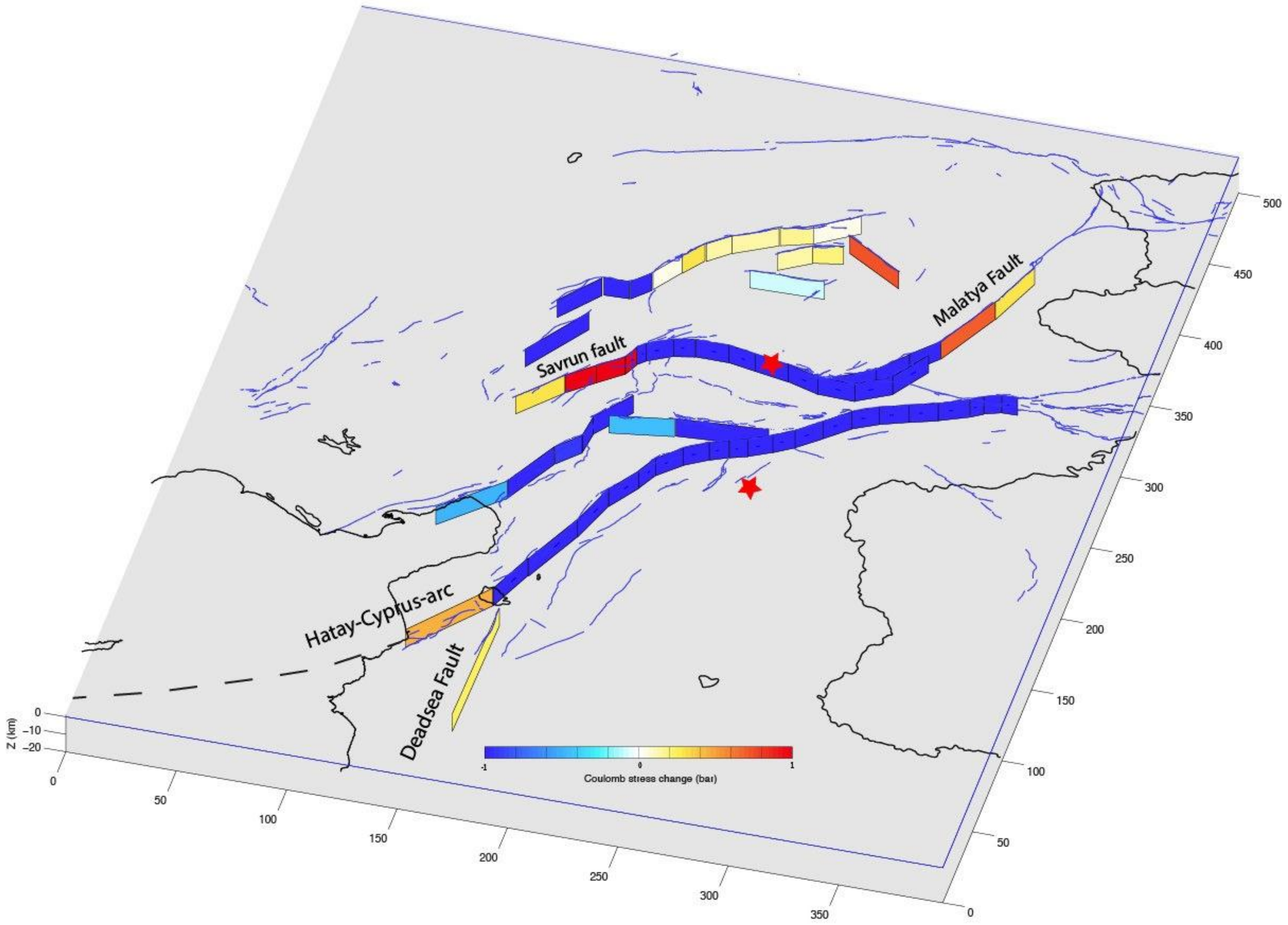
University of Illinois



#PRAYFORPALU
KONDISI PALU TERKINI

Supershear earthquake (землетрясение со скоростью разрыва выше скорости поперечных волн)

(6) Preliminary calculation of Coulomb static stress changes
[Ziyadin Cakir, Istanbul Technical University, 17.02.2023]


Savrun fault
Malatya Fault
Hatay-Cyprus-arc
Deadsea Fault
Z (km)
0
−10
−20
-1
0
1
Coulomb stress change (bar)
0
50
100
150
200
250
300
350
0
50
100
150
200
250
300
350
400
450
500