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What we did until now:

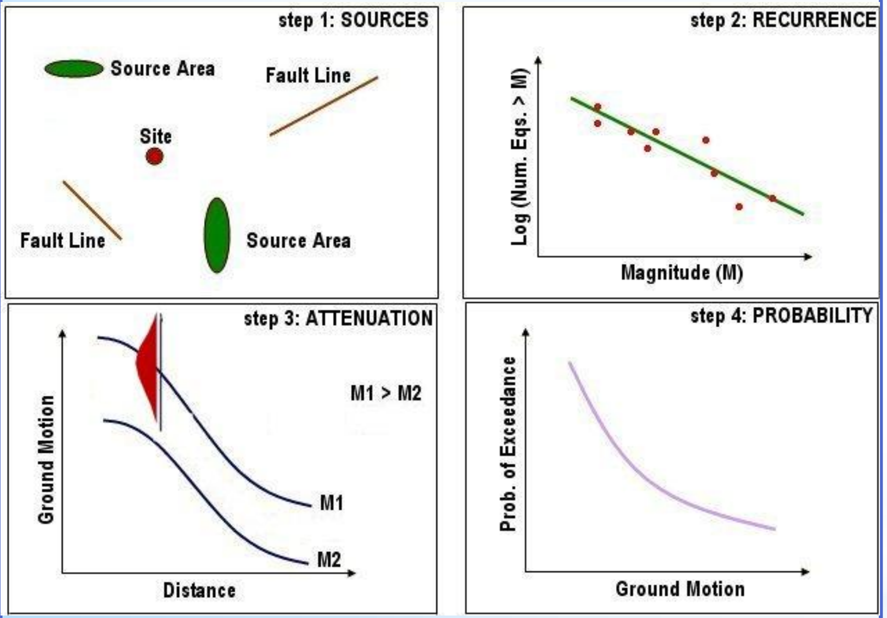
- To review the available bibliography regarding seismic hazard assessment at reginal and local scales;
- to evaluate methodologies to assess **Earthquake i**n order to assess the most reliable way to estimate the hazard.
- To select seismic hazard assessment methodologies applied to specific national case studies
- Modification/adaptation of existing seismic models to assess seismic hazard, based on local conditions and needs of the proposal for Turkey

Regional Scale: Marmara Region (Time Dependent - Time Independent)
- **ISTANBUL**
- **TEKİRDAĞ**

Local Scale: Turkey Region (Time -Independent and Deterministic)
- **SAMSUN**

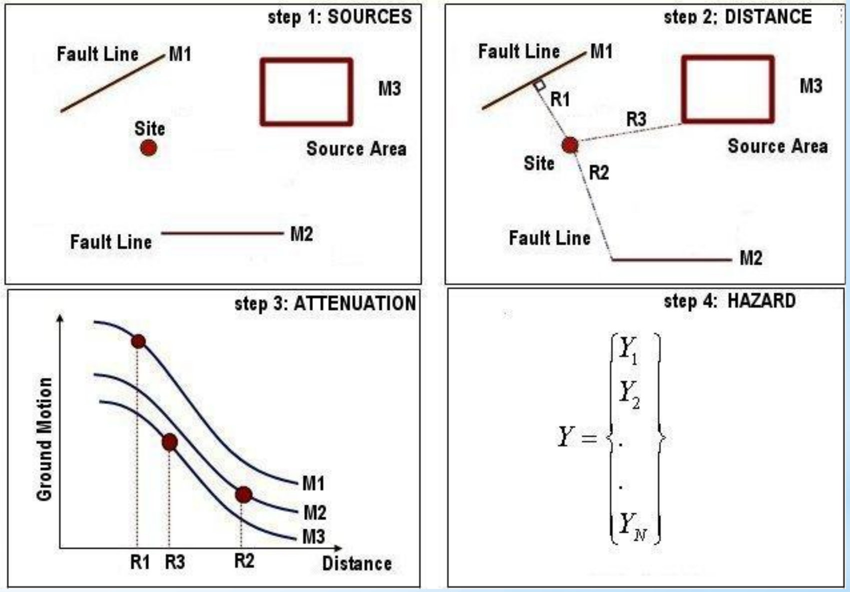
Seismic Hazard Analysis

- **Probabilistic SHA - PSHA**



Step of the analysis (1) Definiton of the seismic sources (2) earthquake recurrence characteristics for each source, (3) GMPEs with magnitude and distance, and (4) ground motions for specified probability of exceedance levels (calculated by summing probabilities ovel all the sources, magnitude and distances)

- **Deterministic SHA - DSHA**

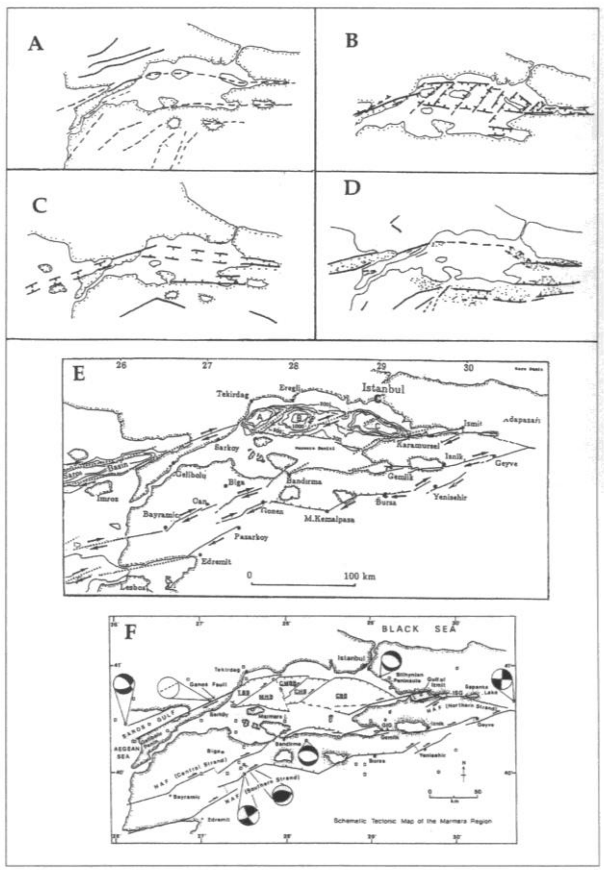


Step of the analysis (1) Definiton of the seismic sources (2) selection of a source to site distance parameter for each source zone, (3) Selection of the controlling earthquake (GMPEs with magnitude and distance), and (4) Definition of the hazard at site in terms of the ground motions produced at the site by the controlling earthquake.

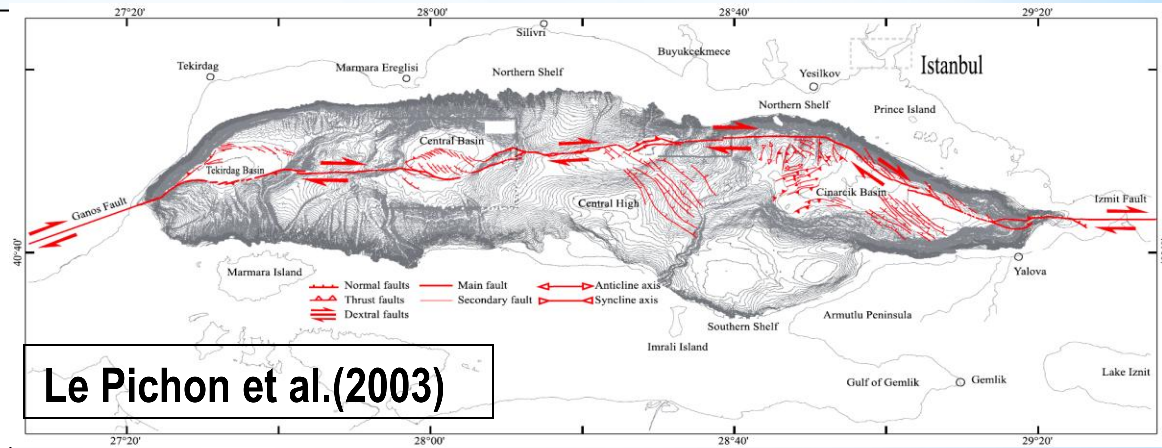
Seismic Hazard Assessment: <u>*For the Source Model:*</u>

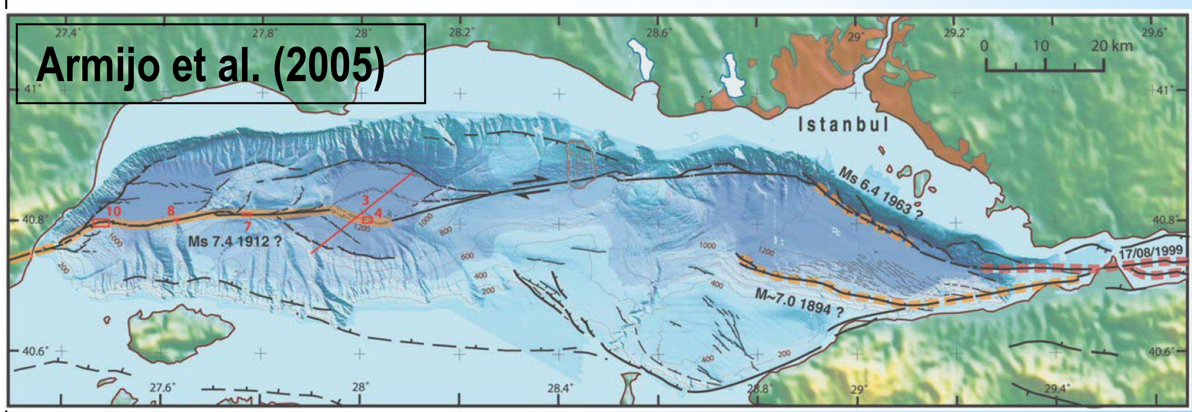
Tectonic Settings

The most prominent models are the “pull apart” model (A) proposed by Armijo et al. (2005) and the “single fault” model (B) proposed by Le Pichon et al. (2003).

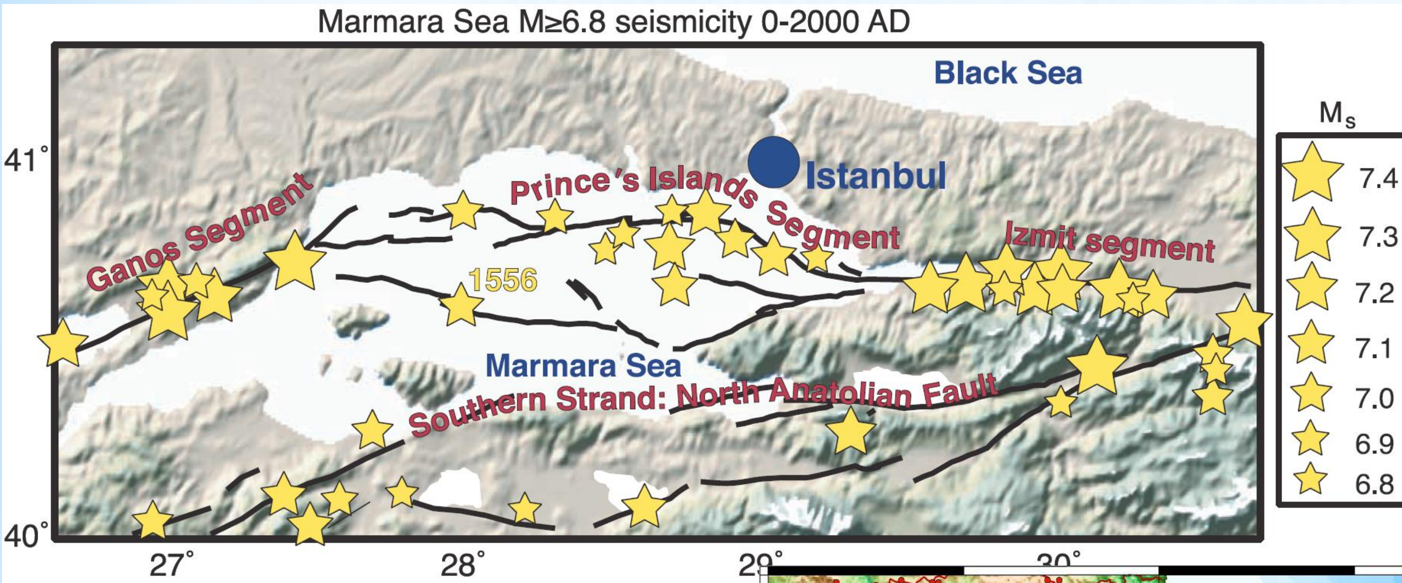


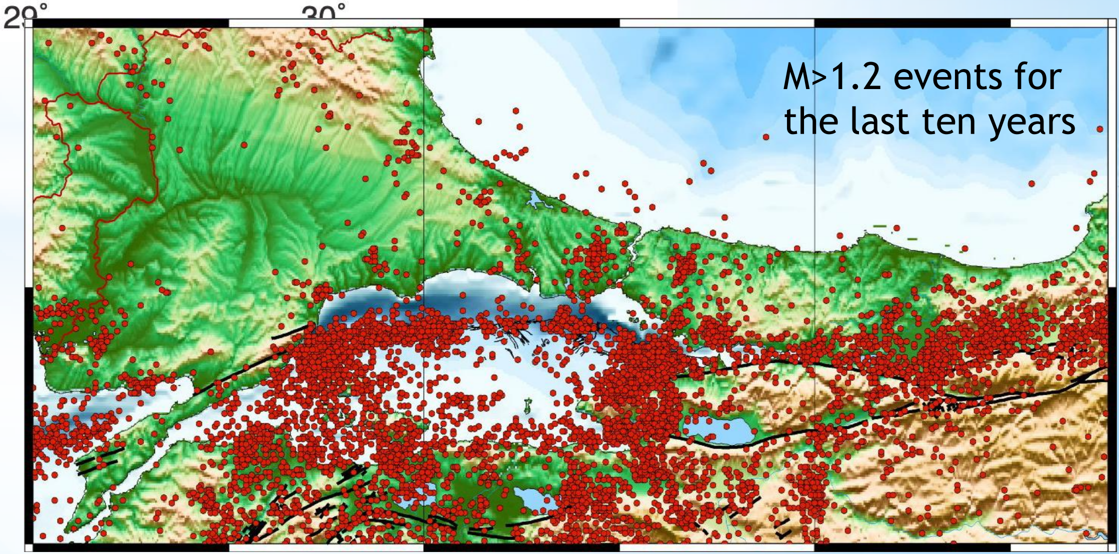
Comparison of the structural models suggested for the Marmara region. (a) Pınar (1943), (b) Pfannenstiel (1944), (c) Crampin and Evans (1986), (d) Şengör (1987), (e) Barka and Kadınsky-Cade (1988), f) Wong et al. (1995), Ergün and Özel (1995).



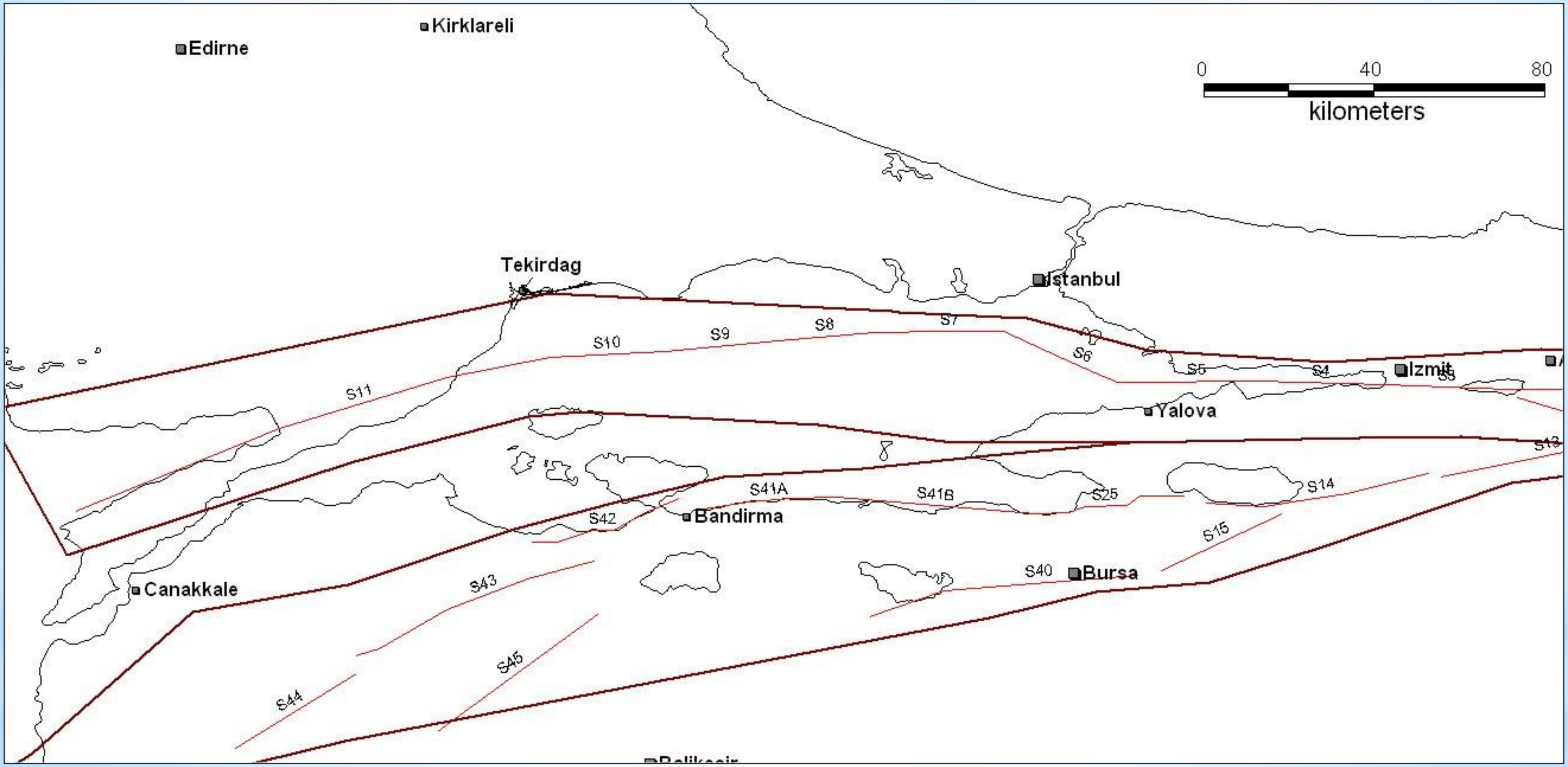


Seismic Hazard Assessment: *For the Source Model:* Distribution of Seismicity



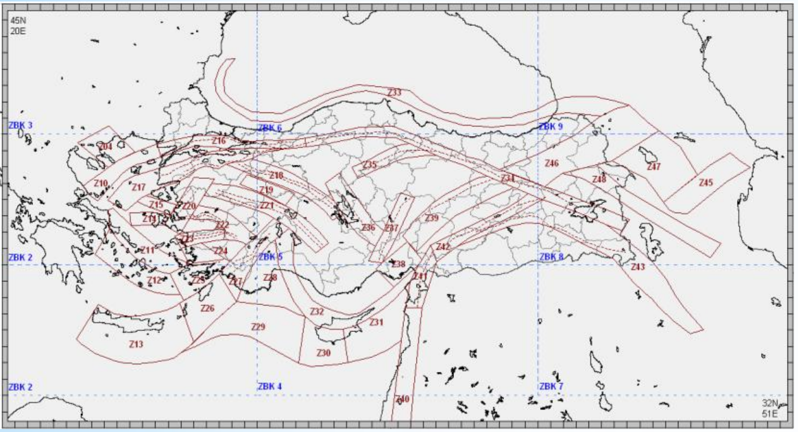


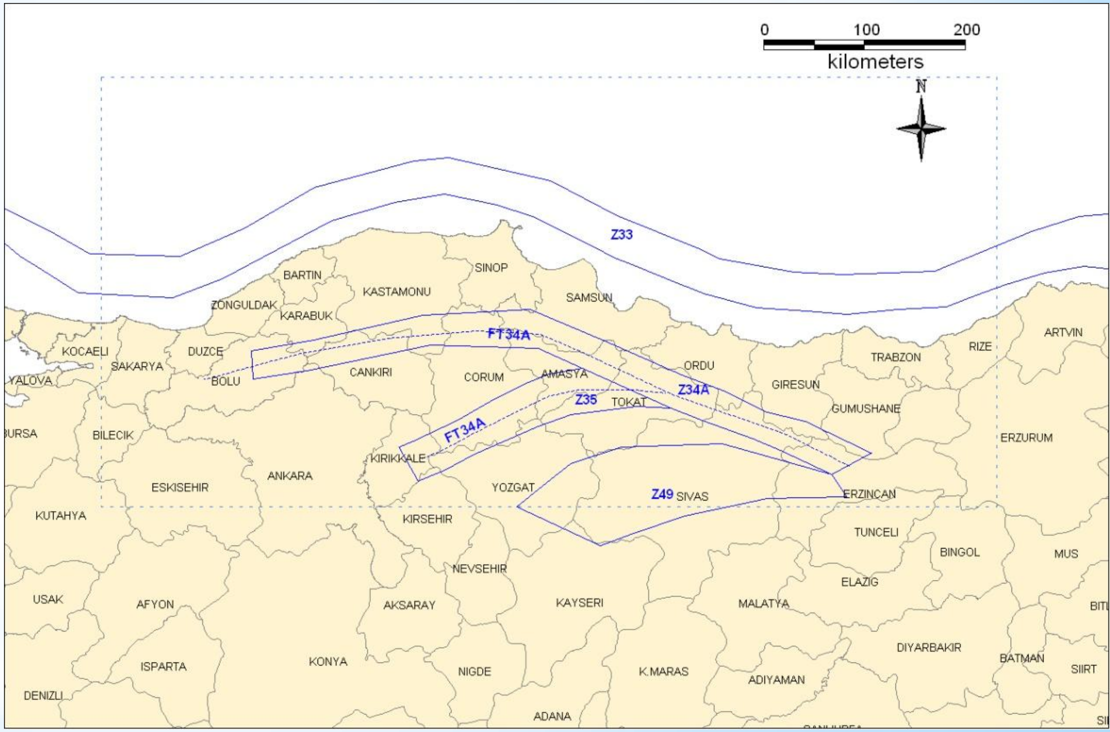
Seismic Hazard Assessment:
Source Model for Marmara Region:



Seismic Hazard Assessment: Source Model for Turkey

The seismic source zonation model of Turkey developed within the context of a project conducted for the Ministry of Transportation Turkey, aiming the preparation of an earthquake resistant design code for the construction of railways, seaport and airport. (DLH,





- The earthquakes with magnitude > 6.5 are assumed to take place on the linear zones (Purple line), whereas the smaller magnitude events associated with the same fault are allowed to take place in the surrounding larger areal zone(Green Line).
- In addition to linear and areal source zones, background seismicity zones are defined to model the floating earthquakes that are located outside these distinctly defined source zones and to delineate zones where no significant earthquake has taken place.

* ESTIMATION OF THE SOURCE SEISMICITY PARAMETERS AND PROBABILISTIC MODEL

The earthquake recurrence model for the fault segments

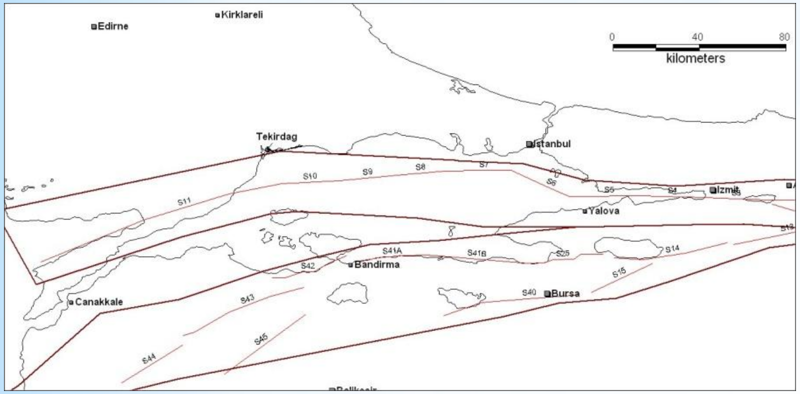
- **Poisson Model**
  - ✓ characteristic earthquake recurrence is assumed,
  - ✓ probability of occurrence of the characteristic event does not change in time
  - ✓ The annual rate is calculated as:

    R=1/ mean recurrence interval

- **Time Dependent (Renewal model)**
  - ✓ the probability of occurrence of the characteristic event increase s as a function of the time elapsed since the last characteristic event,
  - ✓ A lognormal distribution with a coefficient of variation of 0.5 is assumed to represent the earthquake probability density distribution.
  - ✓ The annual rate is calculated as:

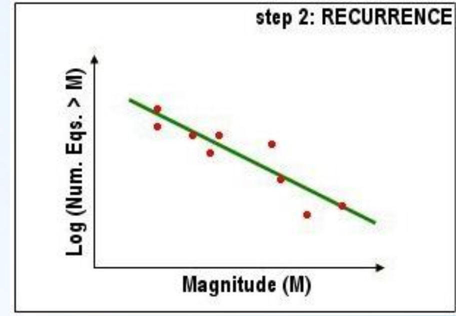
    Reff=-In(1-Pcond) / T

* ESTIMATION OF THE SOURCE SEISMICITY PARAMETERS AND PROBABILISTIC MODEL for (Time-dependent method - the Marmara region)



						Time dependent (Renewal)		Poissonian
Segment	Last Char. Eq.	"cov"	Mean Recurrence Time	Char. Magnitude	Time since Last Char. Eq.	50year Prob.	Annual Rate	Annual Rate
1	1999	0.5	140	7.2	15	0.08260	0.00172	0.0071
2	1999	0.5	140	7.2	15	0.08260	0.00172	0.0071
3	1999	0.5	140	7.2	15	0.08260	0.00172	0.0071
4	1999	0.5	140	7.2	15	0.08260	0.00172	0.0071
5	1894	0.5	175	7.2	120	0.39620	0.01009	0.0057
6	1754	0.5	210	7.2	260	0.41200	0.01062	0.0048
7	1766	0.5	250	7.2	248	0.34280	0.00840	0.0040
8	1766	0.5	250	7.2	248	0.34280	0.00840	0.0040
9	1556	0.5	200	7.2	458	0.41730	0.01080	0.0050
10	-	0.5	200	7.2	1012	0.33250	0.00808	0.0050
11	1912	0.5	150	7.5	102	0.44960	0.01194	0.0067
12	1967	0.5	250	7.2	47	0.03810	0.00078	0.0040
13	-	0.5	600	7.2	1012	0.17200	0.00377	0.0017
14	-	0.5	600	7.2	1012	0.17200	0.00377	0.0017
15	-	0.5	1000	7.2	1012	0.09790	0.00206	0.0010
19	1944	0.5	250	7.5	70	0.08750	0.00183	0.0040
21	1999	0.5	250	7.2	15	0.00450	0.00009	0.0040
22	1957	0.5	250	7.2	57	0.05750	0.00118	0.0040
25	-	0.5	1000	7.2	1012	0.09790	0.00206	0.0010
40	1855	0.5	1000	7.2	159	0.00092	0.00002	0.0010
41	-	0.5	1000	7.2	1012	0.09790	0.00206	0.0010
42	-	0.5	1000	7.2	1012	0.09790	0.00206	0.0010
43	1737	0.5	1000	7.2	277	0.01010	0.00020	0.0010
44	-	0.5	1000	7.2	1012	0.09790	0.00206	0.0010
45	1953	0.5	1000	7.2	61	-	-	0.0010
				Mmin - Mmax	**alpha**	**Beta**		
BCK Z16	-	-	-	5.0 - 6.9	1.2078	1.767	-	
Z17	-	-	-	5.0-6.6	1.5136	2.0954	-	

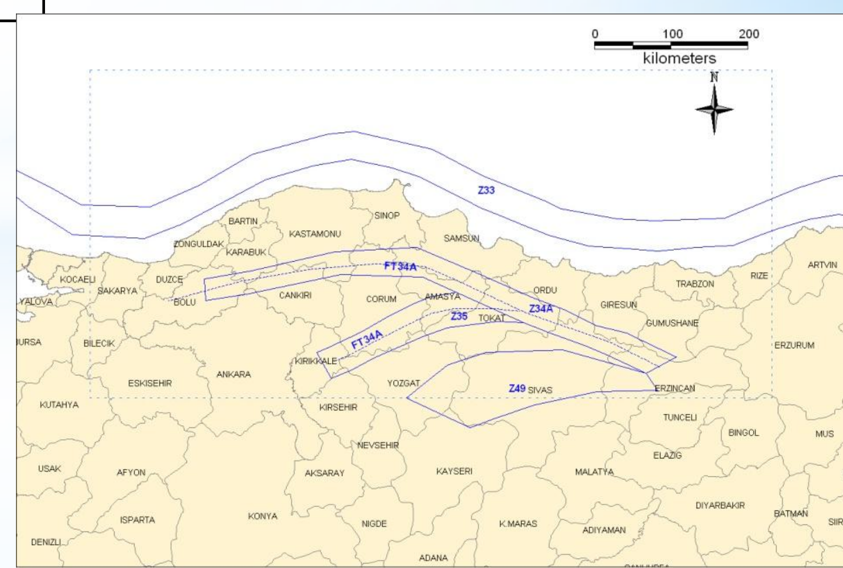
* ESTIMATION OF THE SOURCE SEISMICITY PARAMETERS AND PROBABILISTIC MODEL for time-independent model (Turkey)



N is the number of the earthquakes above the magnitude M in a given region and within a given period
"a " and "b" are regression constants.

$$\log N = a + b\ M$$

Source Zone No	Associated Fault	a	b	M_{min} - M_{max}
Z33	Black Sea Fault	3.8	0.9	5.0 - 7.3
Z34 Outside Zone	North Anatolian Fault Zone (NAF)	5	0.8	5.0 - 6.7
Z34 Inside Zone				6.8 - 7.9
Z35 Outside Zone	Alaca Ezine Pazari Fault	3.2	0.8	5.0 - 6.7
Z35 Inside Zone				6.8 - 7.9
Z49	Deliler Fault Zone	4.4	1	5.0 - 7.3
ZBK1	Background	5.13	1	5.0-6.5



* GROUND MOTION PREDICTION EQUATIONS

- GMPEs are used in earthquake hazard assessments predict ground motion parameters (such as peak ground acceleration –PGA; peak ground velocity –PGV and spectral accelerations -SA) as a function of source parameters (magnitude and fault mechanism), propagation path (fault distance) and site effects (site class). Site classes are generally based on shear wave velocity of soil media or code-based site class descriptions, such as NEHRP (2003). In almost all attenuation relationship studies the strong ground motion parameters are assumed to have a log-normal distribution and a random error term is provided with zero mean and a standard deviation

* For the PSHA investigations we will consider the following GMPEs for "active shallow region" with equal weights in the fault tree combination:
* Ground motion models
* for active shallow regions:
  - Akkar and Bommer (2009, rev:2010)
  - Boore and Atkinson (2008)
  - Chiou and Youngs (2008)
  - Campbell and Bozorgnia (2008)
  - Abrahamson and Silva (2008)

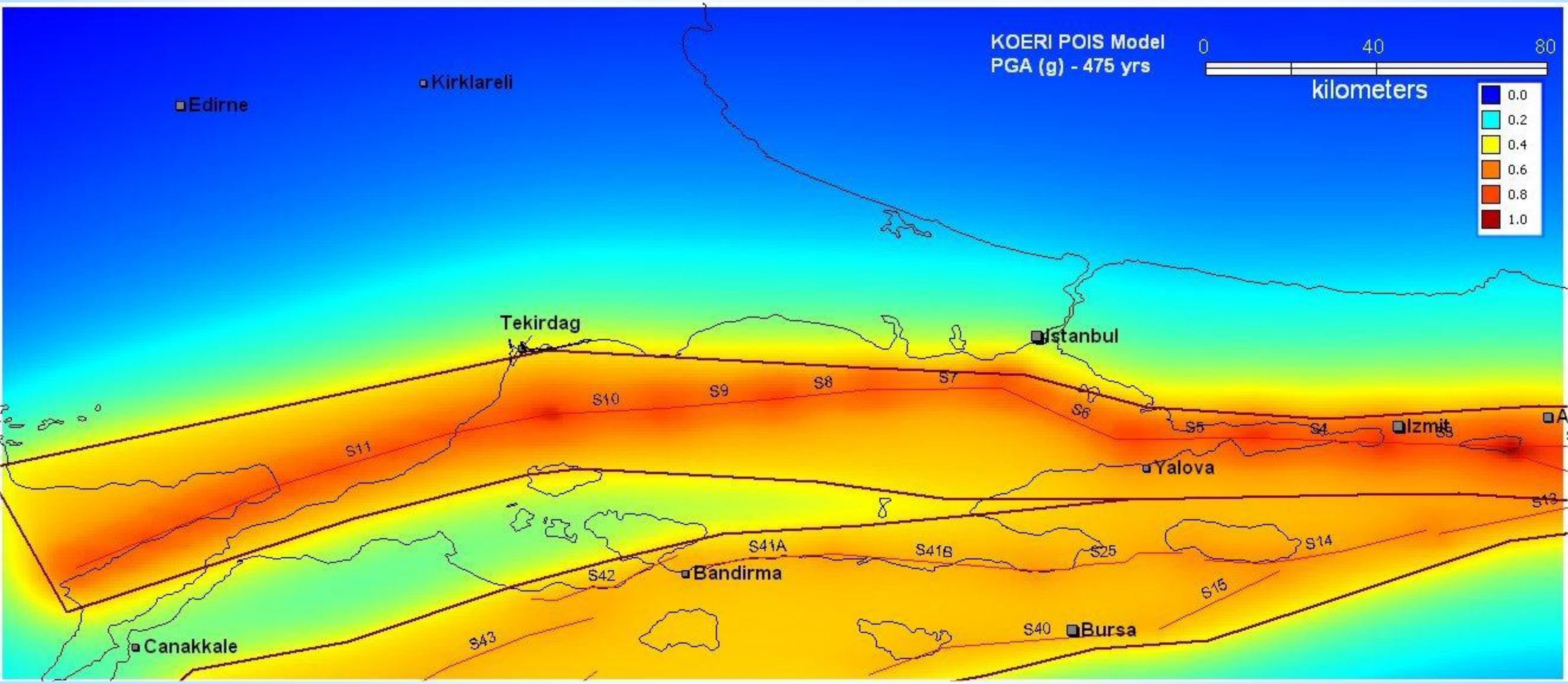
Ground Motion parameters:

* PGA
* Sa(T=0.2sec)
* Sa(T=1.0sec) for 72, 475, 2475 years
* return periods

Model	Area	Magnitude Range	Distance Range (km)	Period Range (s)	Site	Mechanism	Component
Abrahamson and Silva (2008)	California, Taiwan and other regions	Mw=5.0-8.0	Rrup = 0 – 200	0.01 – 10.0, PGA, PGV	Function of Vs30	N, R/T, S	GMRot150
Boore and Atkinson (2008)	California, Taiwan and other regions	Mw=4.27 – 7.9	Rjb = 0 – 280	0.01 – 10.0, PGA, PGV	Function of Vs30	N, R, S, U	GMRot150
Chiou and Youns (2008)	California, Taiwan and other regions	Mw=4.27 – 7.9	Rrup = 0.2 – 70	0.01 – 10.0, PGA, PGV	Function of Vs30	N, R, S	GMRot150
Campbell and Bozorgnia (2008)	California, Taiwan and other regions	Mw=4.27 – 7.9	Rrup = 0.07 – 199.27	0.01 – 10.0, PGA, PGV	Function of Vs30	N, R, S	GMRot150
Akkar and Bommer (2010)	European and Middle East	Mw=5.0-7.6	Rrup = 0 – 99	0.05-3.0, PGA,PGV	3 classes	N,R/T,S	GMEAN

ISTANBUL - TEKIRDAG

PGA map at NEHRP B/C boundary site class
for 10% probability of exceedence in 50 yr (Poisson model).



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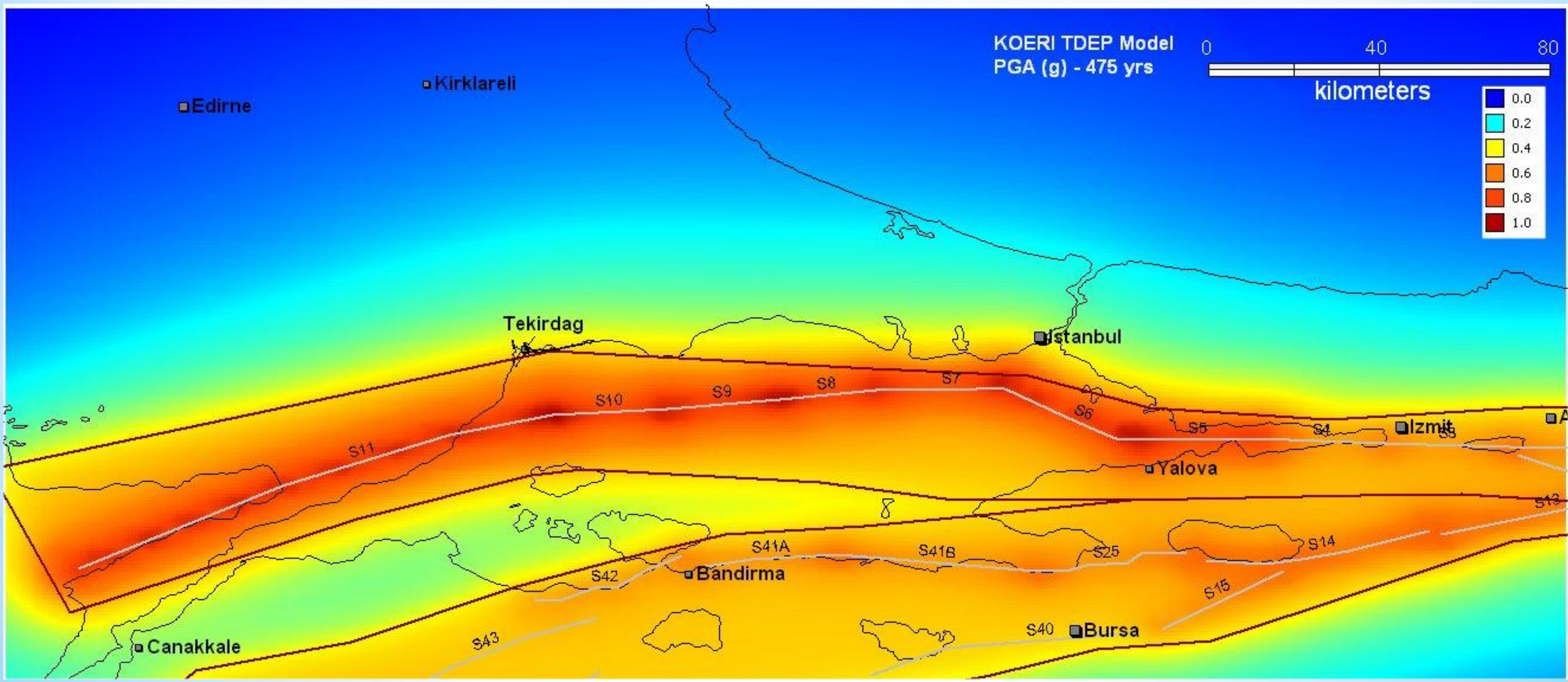
PGA map at NEHRP B/C boundary site class
for 10% probability of exceedence in 50 yr (Renewal model).



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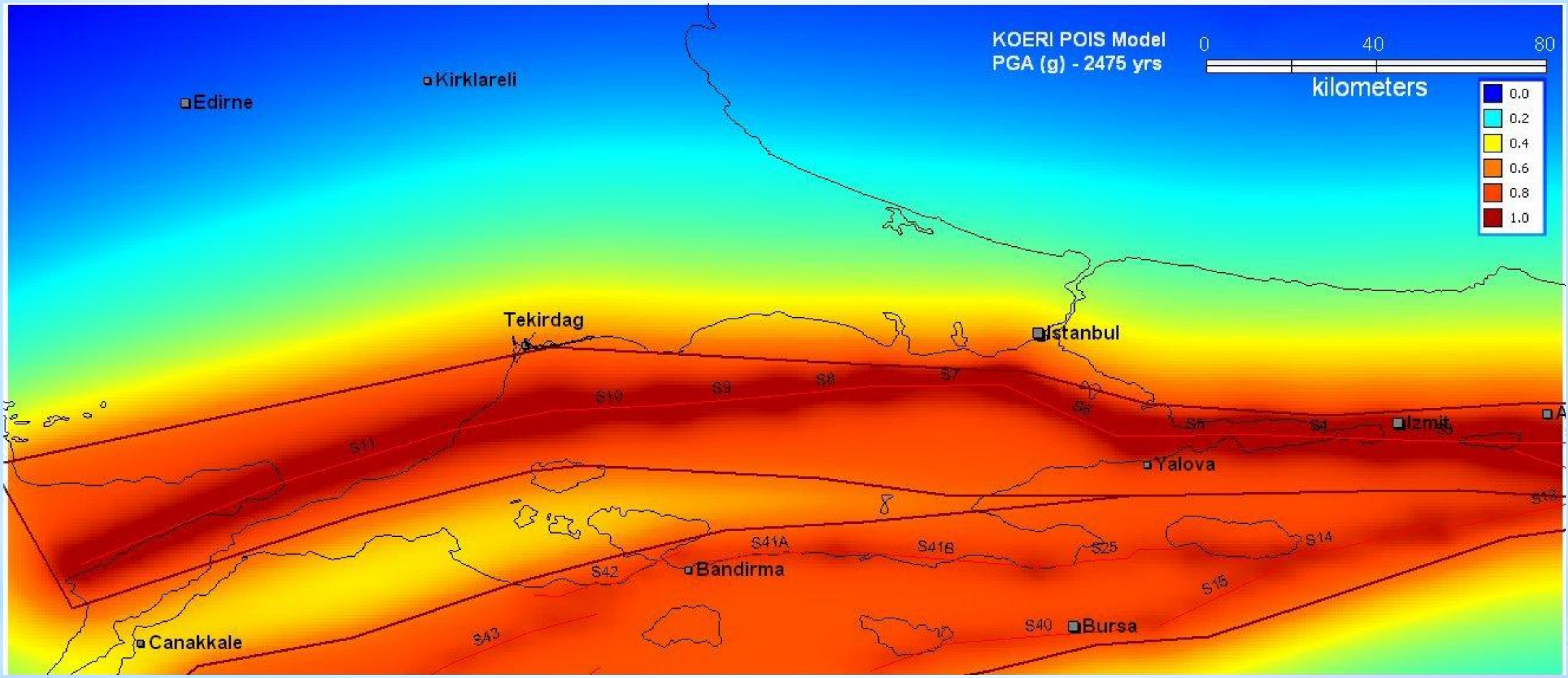
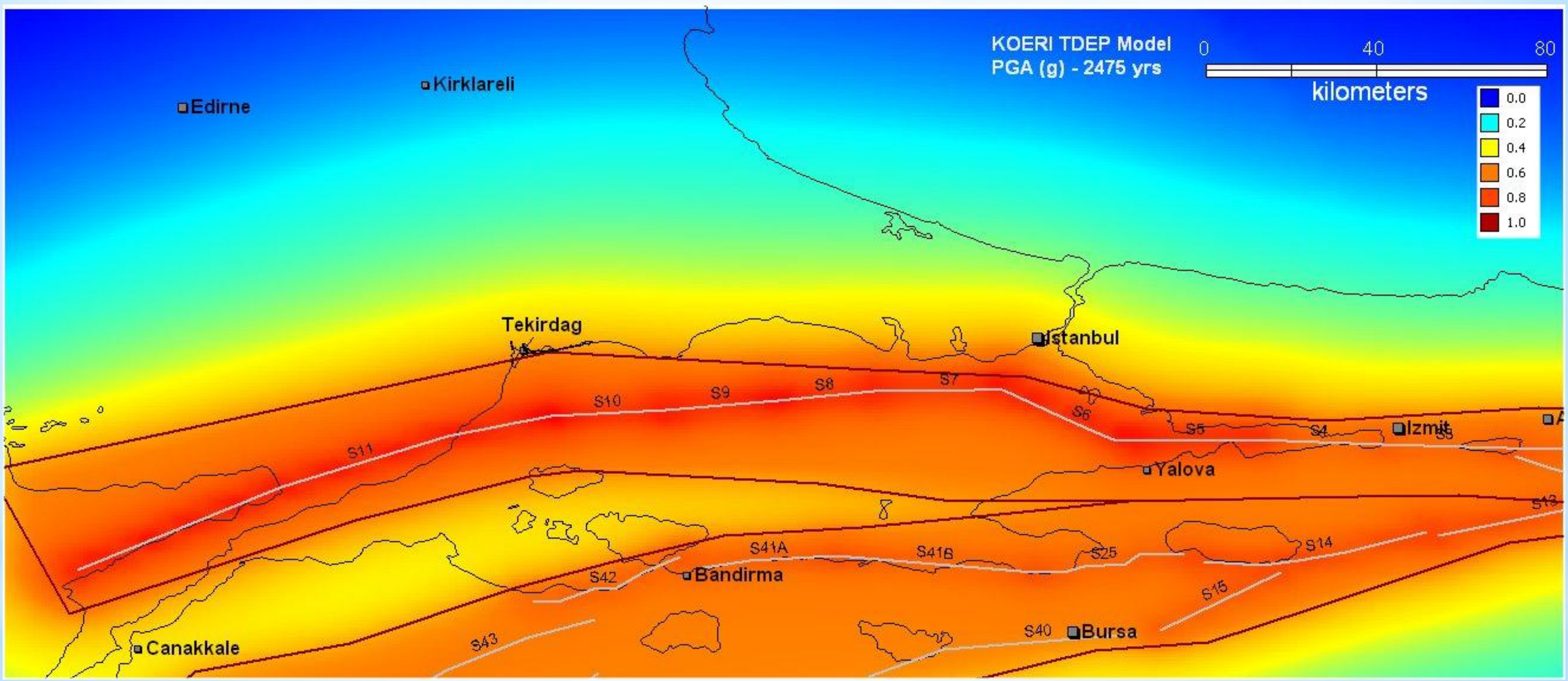
PGA map at NEHRP B/C boundary site class
for 2% probability of exceedence in 50 yr (Poisson model)



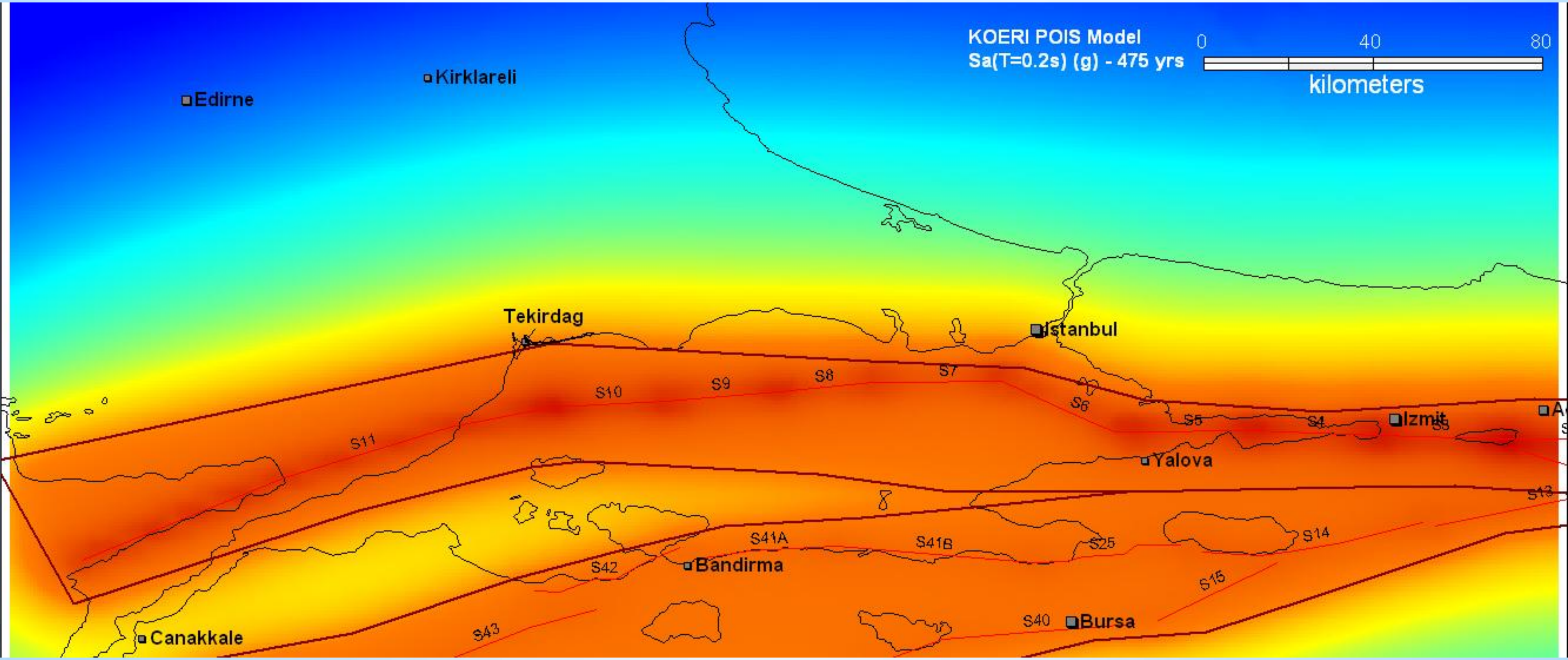
ISTANBUL - TEKIRDAG

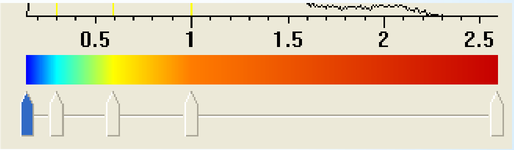
. PGA map at NEHRP B/C boundary site class
for 2% probability of exceedence in 50 yr (Renewal model).

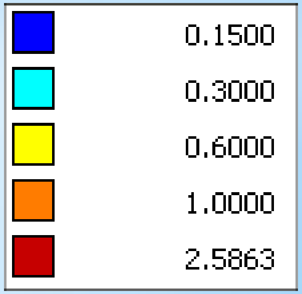


ISTANBUL - TEKIRDAG

Sa(T=0.2s) map at NEHRP B/C boundary site class
for 10% probability of exceedence in 50 yr (Poisson model).







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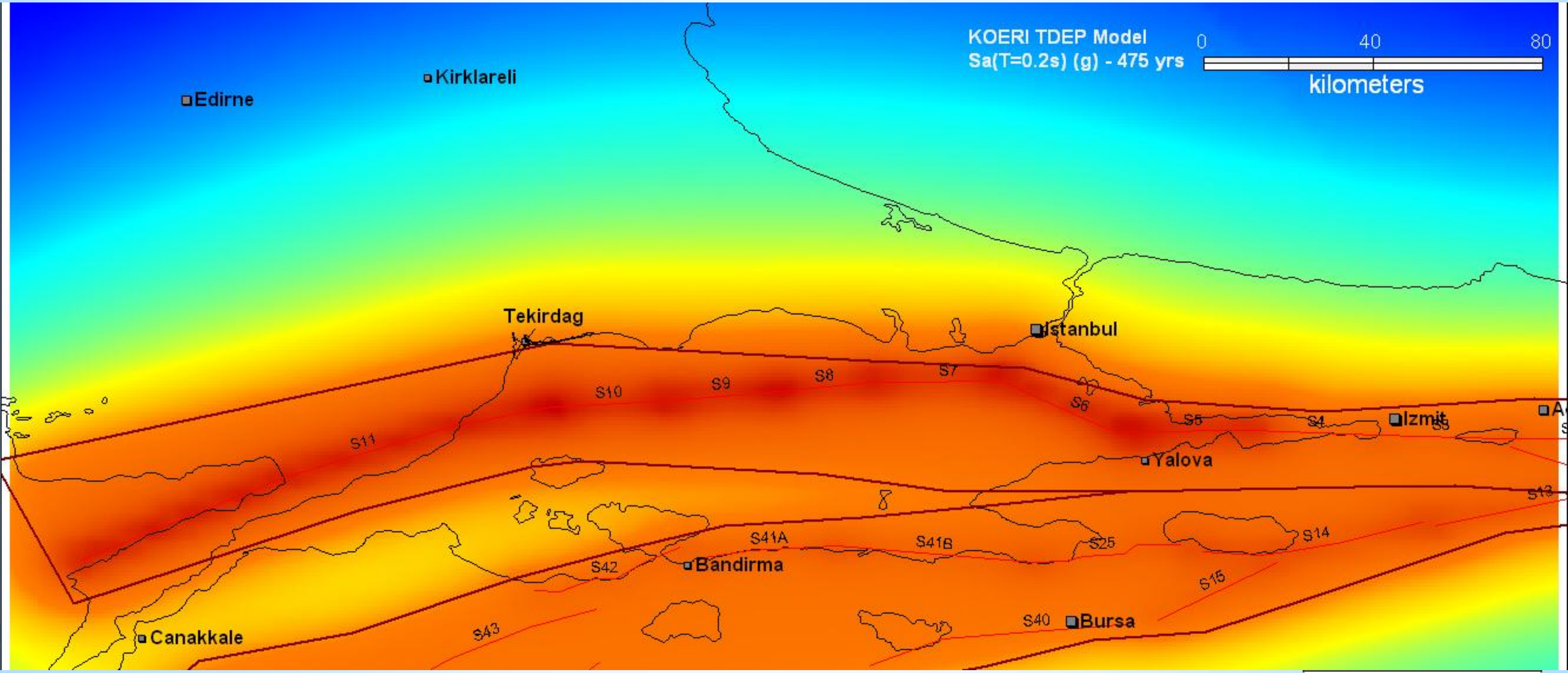
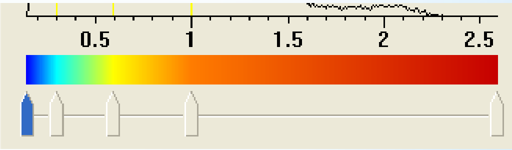
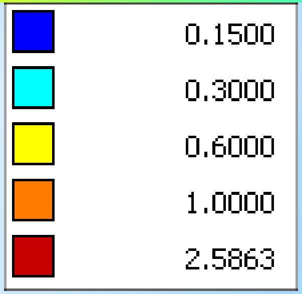
Project funded by the EUROPEAN UNION

Sa(T=0.2s) map at NEHRP B/C boundary site class for 10% probability of exceedence in 50 yr (Renewal model).

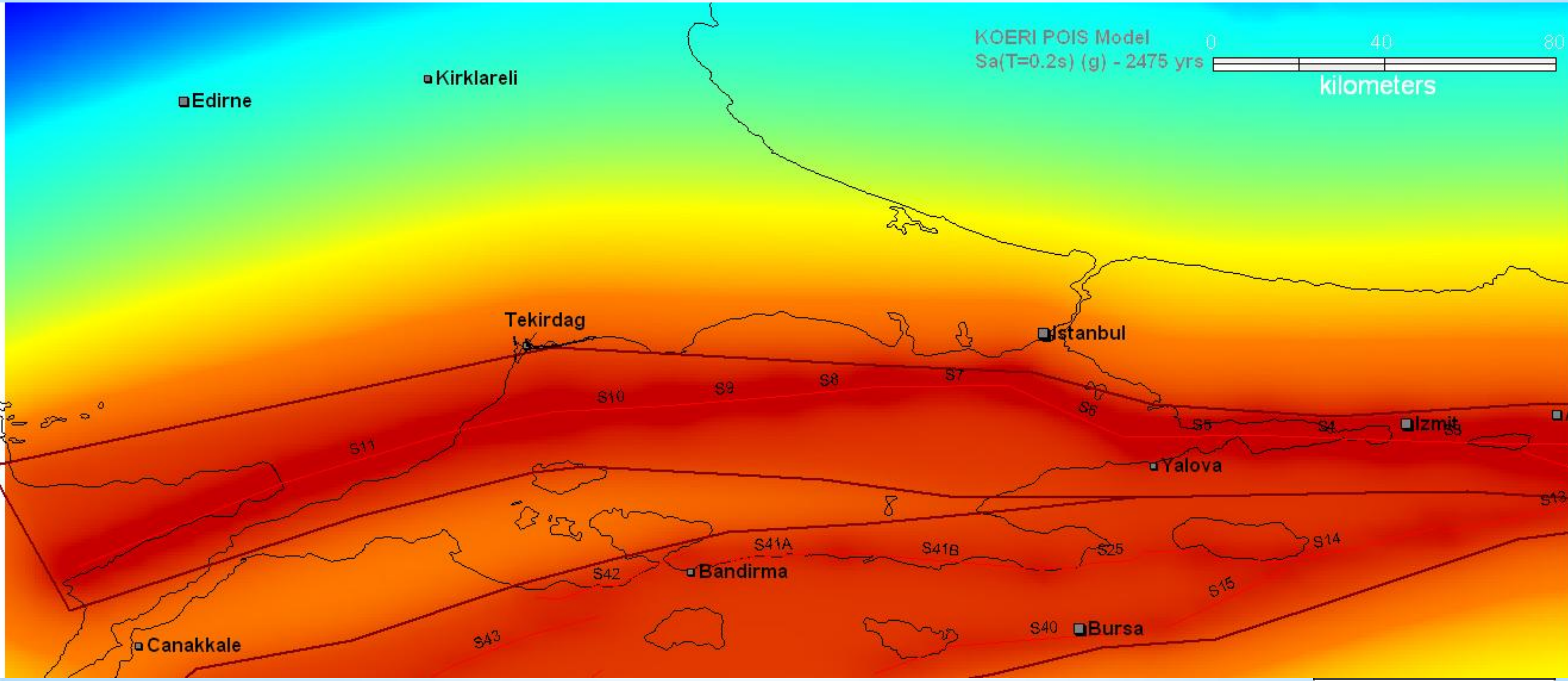


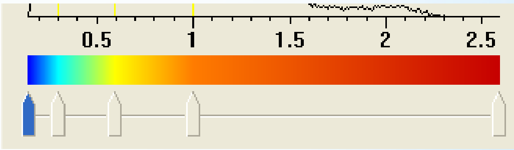


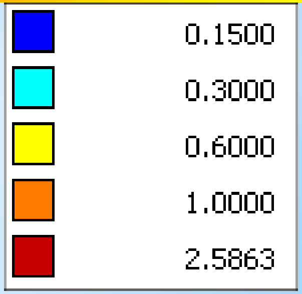


ISTANBUL - TEKIRDAG

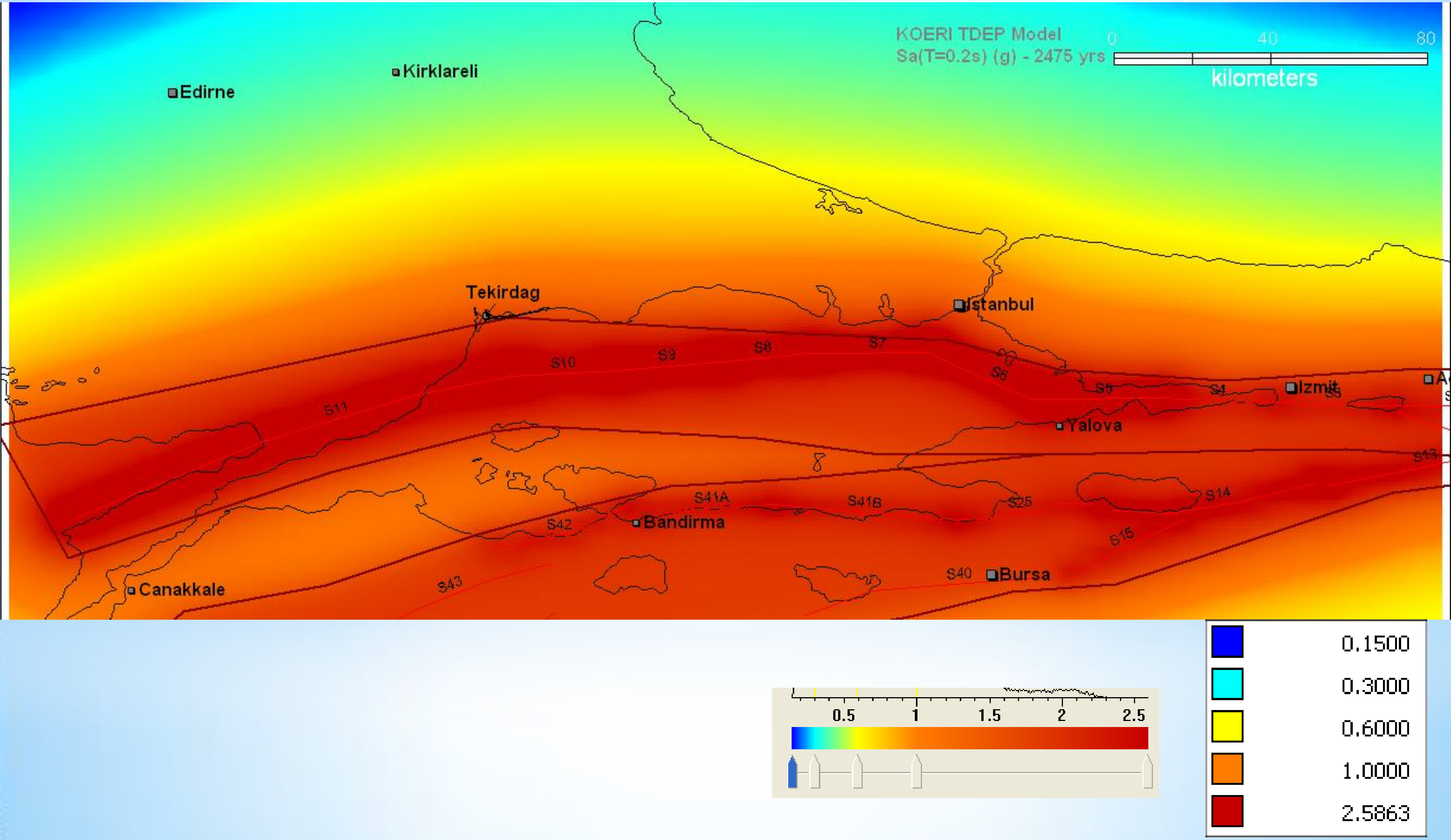
Sa(T=0.2s) map at NEHRP B/C boundary site class
For 2% probability of exceedence in 50 yr (Poisson model).



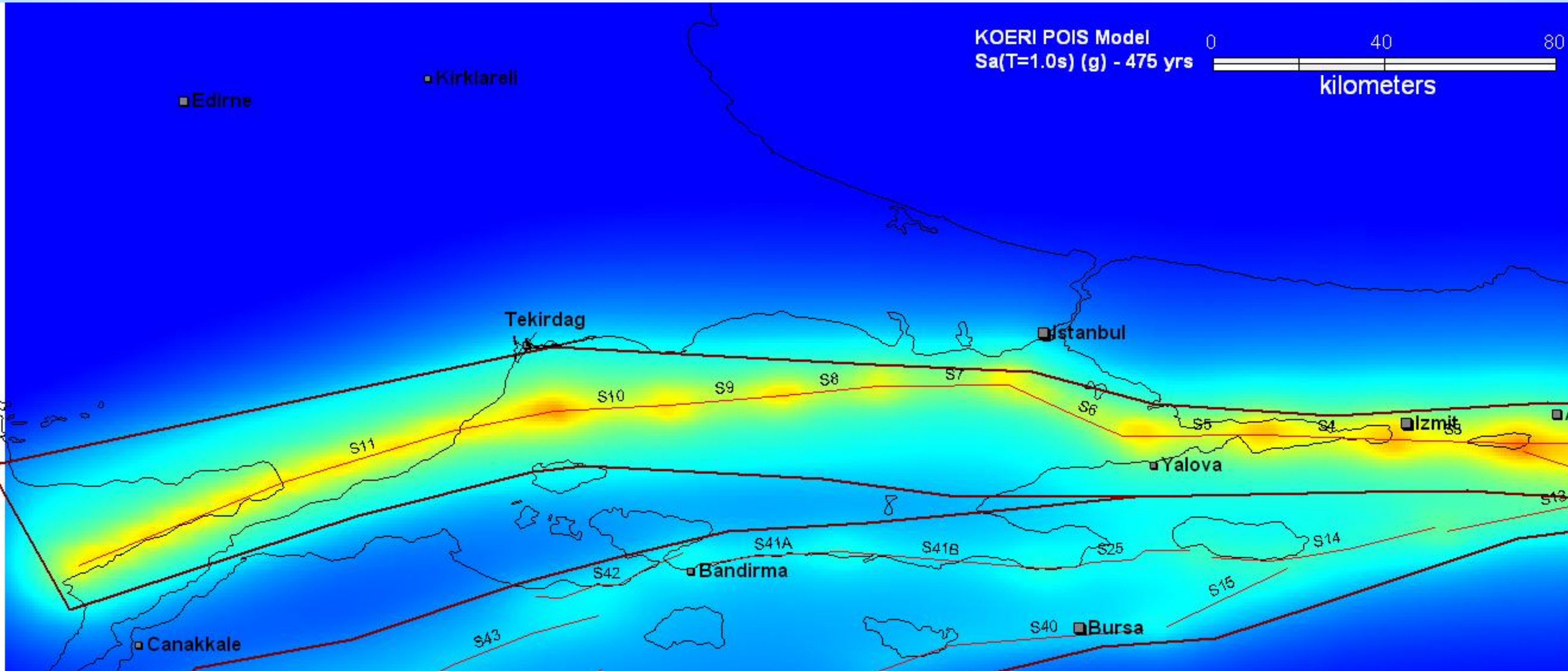


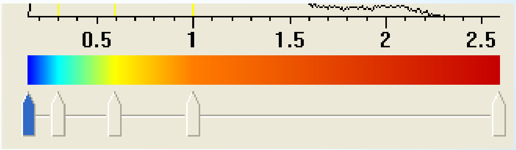


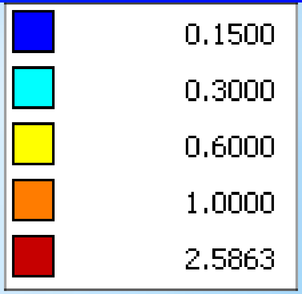
Sa(T=0.2s) map at NEHRP B/C boundary site class
For 2% probability of exceedence in 50 yr (Renewal model).



Sa(T=1.0s) map at NEHRP B/C boundary site class for 10% probability of exceedence in 50 yr (Poisson model).







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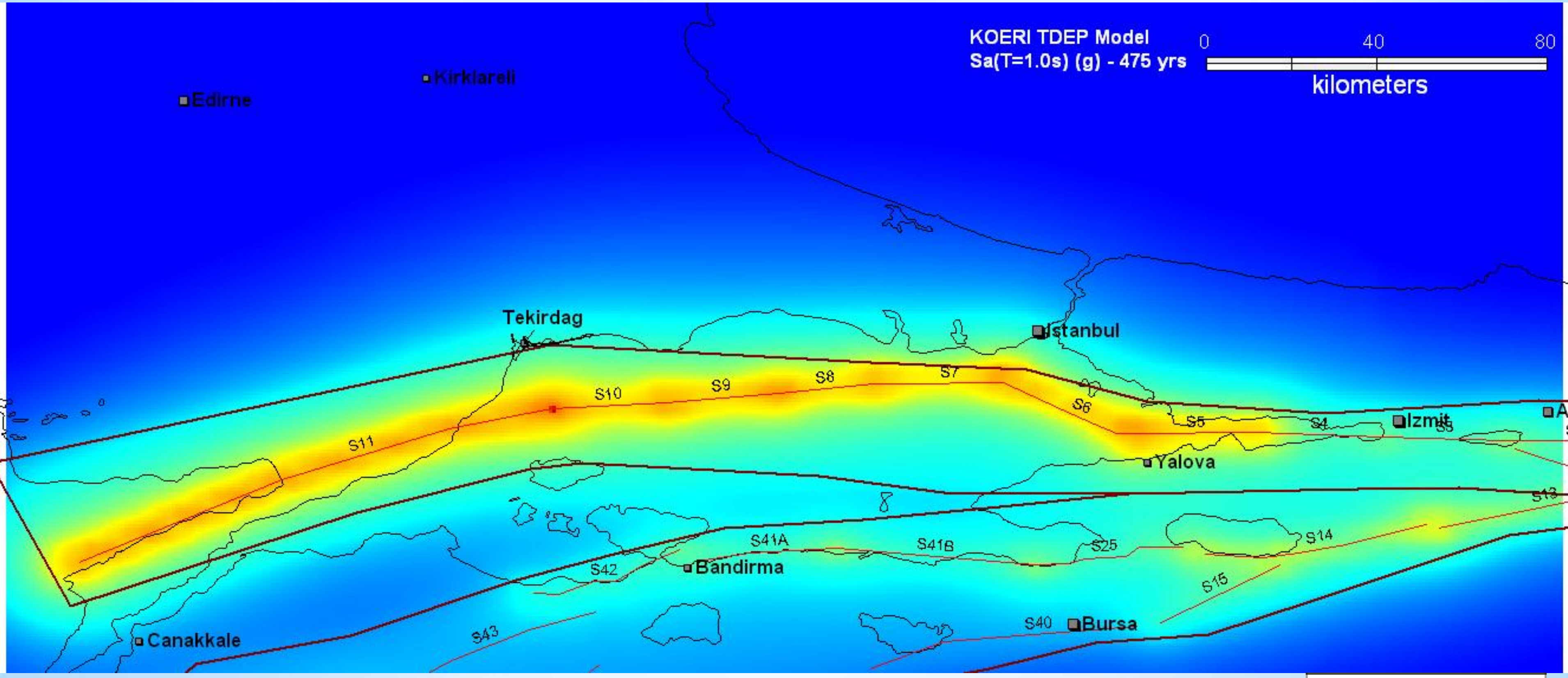
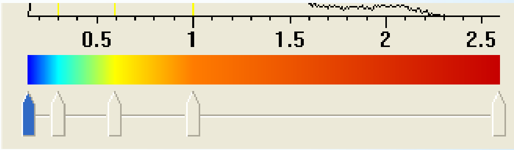
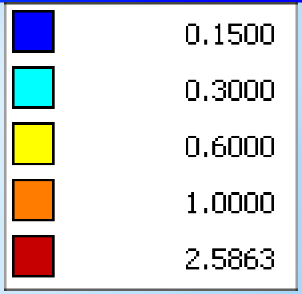


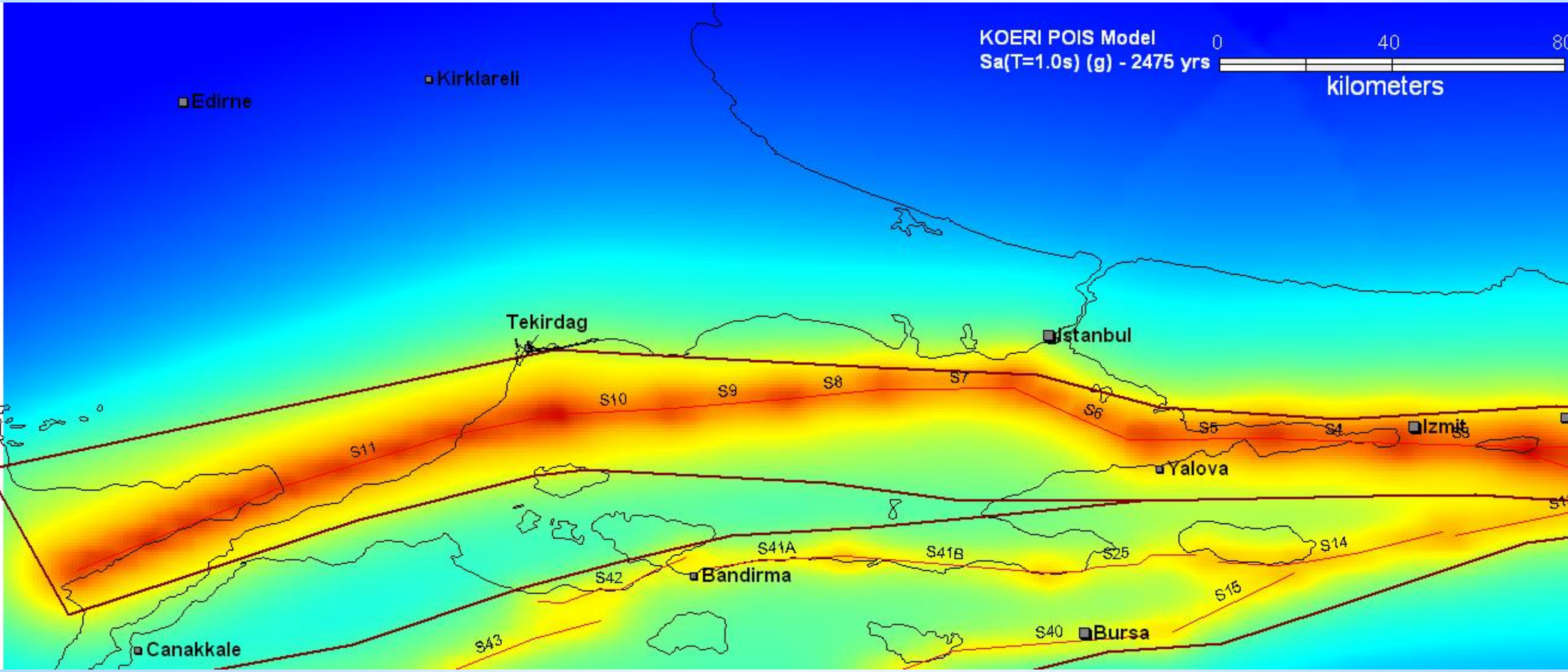


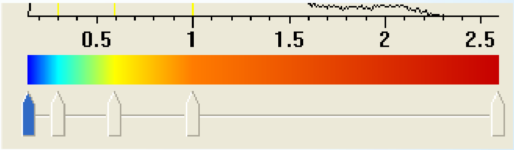


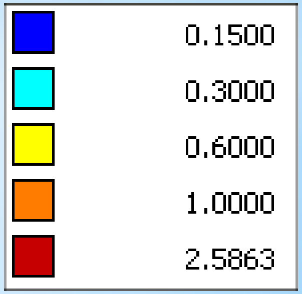
ISTANBUL - TEKIRDAG

Project funded by the EUROPEAN UNION

Sa(T=1.0s) map at NEHRP B/C boundary site class
For 2% probability of exceedence in 50 yr (Poisson model).







ISTANBUL - TEKIRDAG

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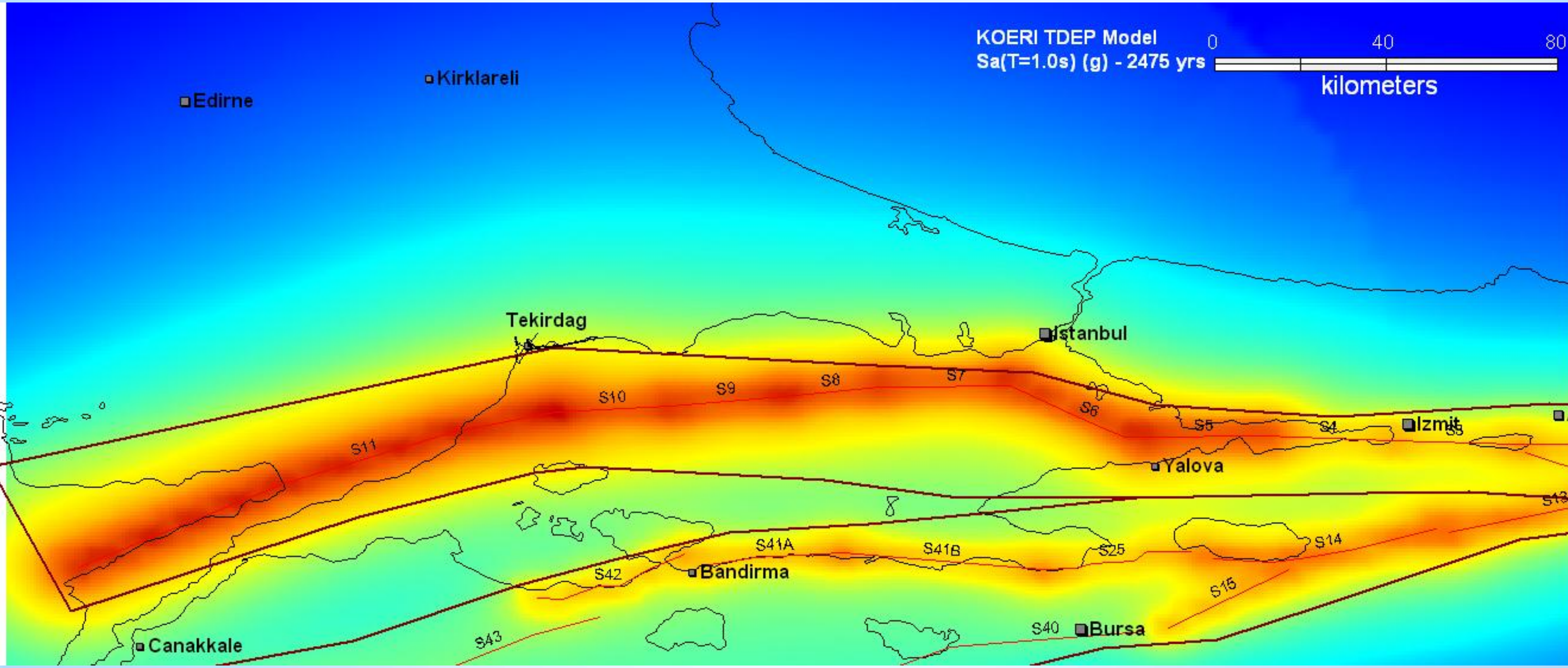
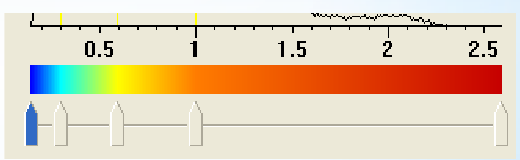
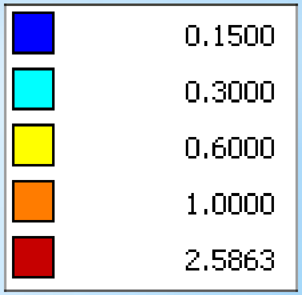
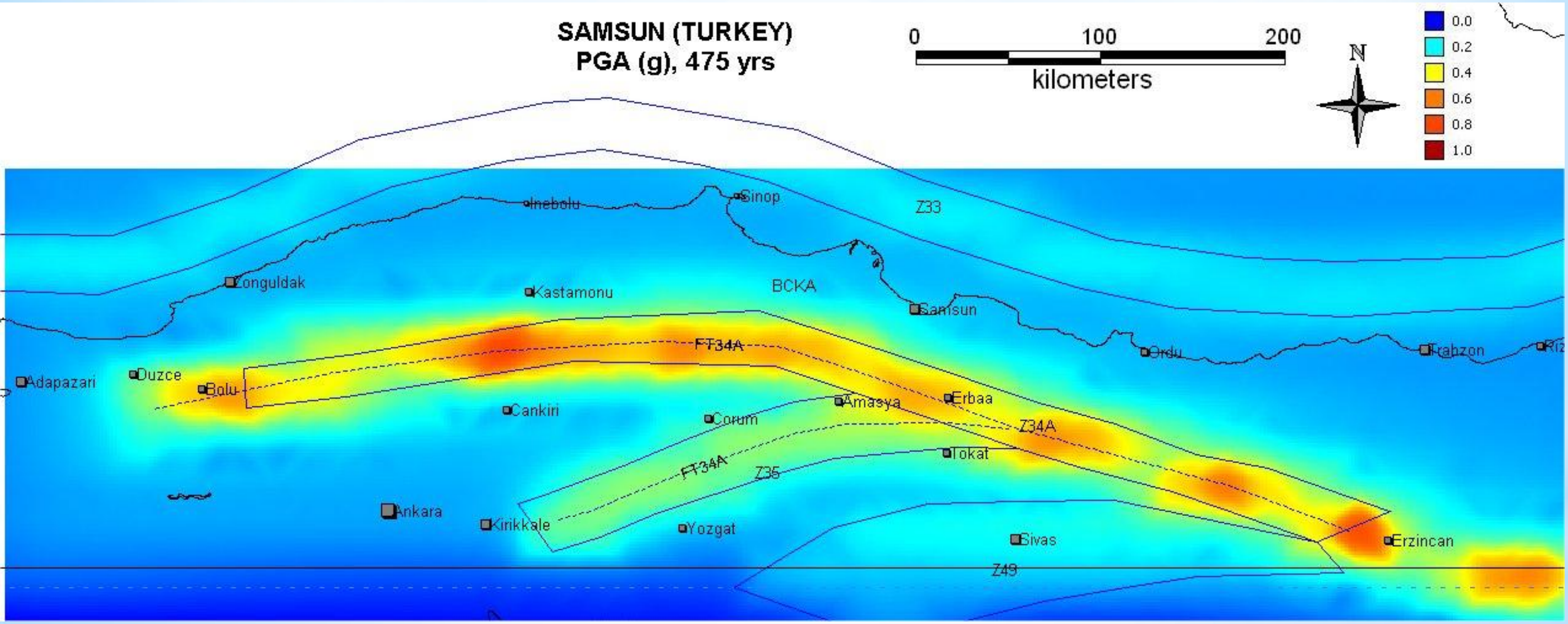






SAMSUN

PGA map at NEHRP B/C boundary site class
for 10% probability of exceedence in 50 yr (poisson model).



SAMSUN

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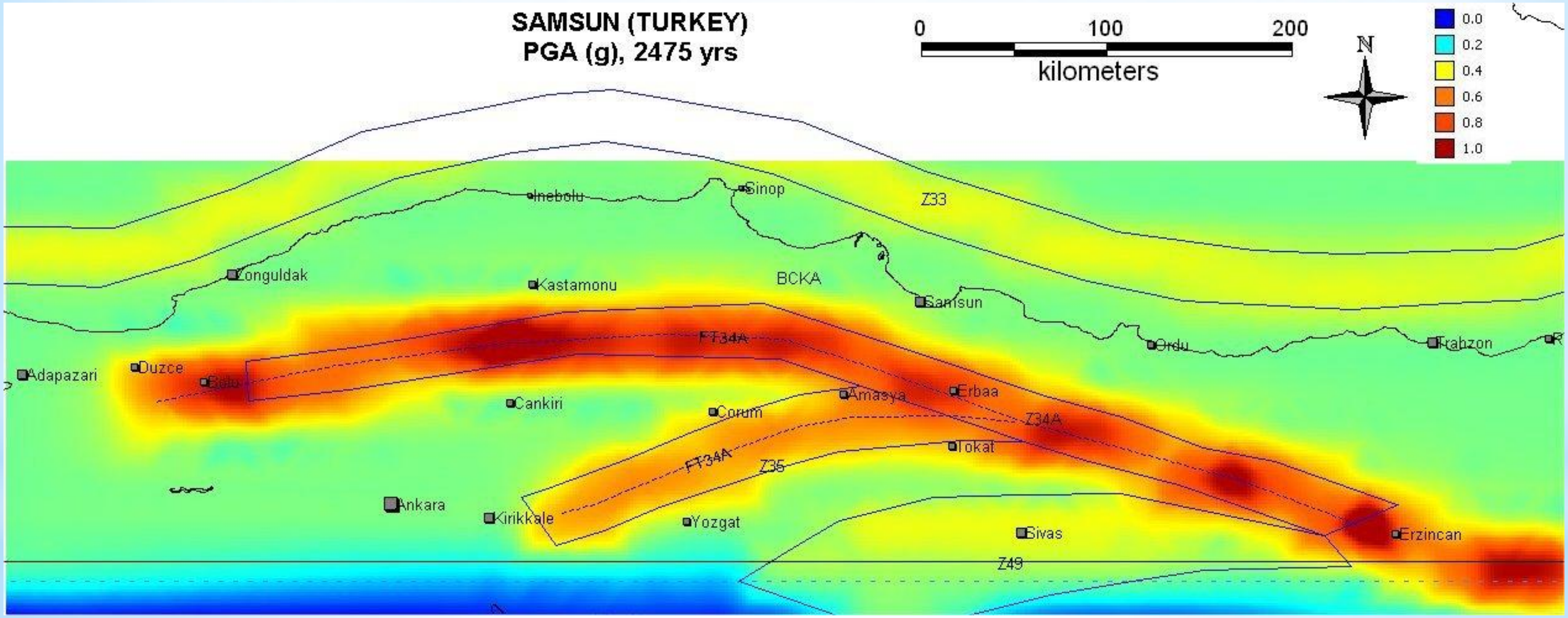
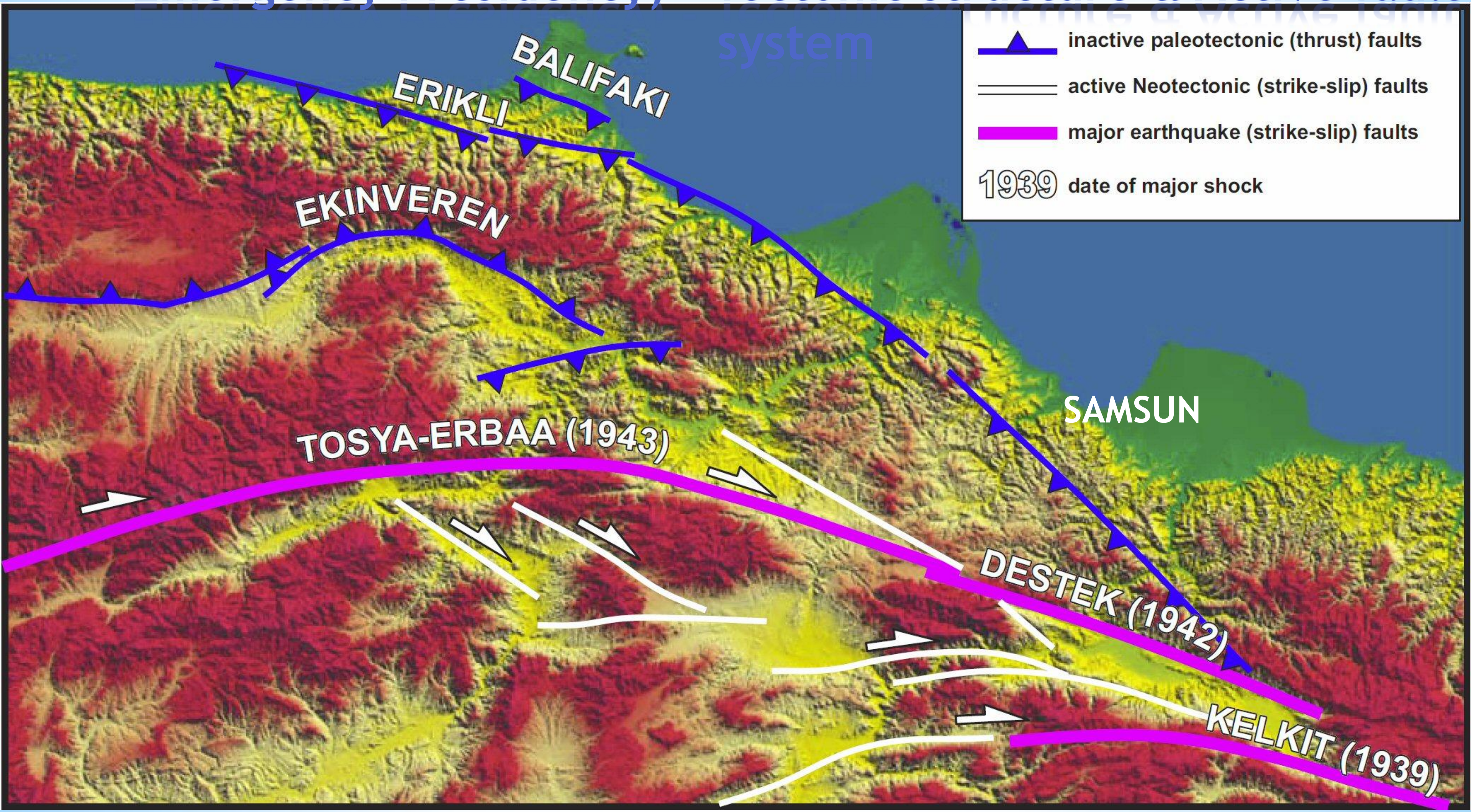
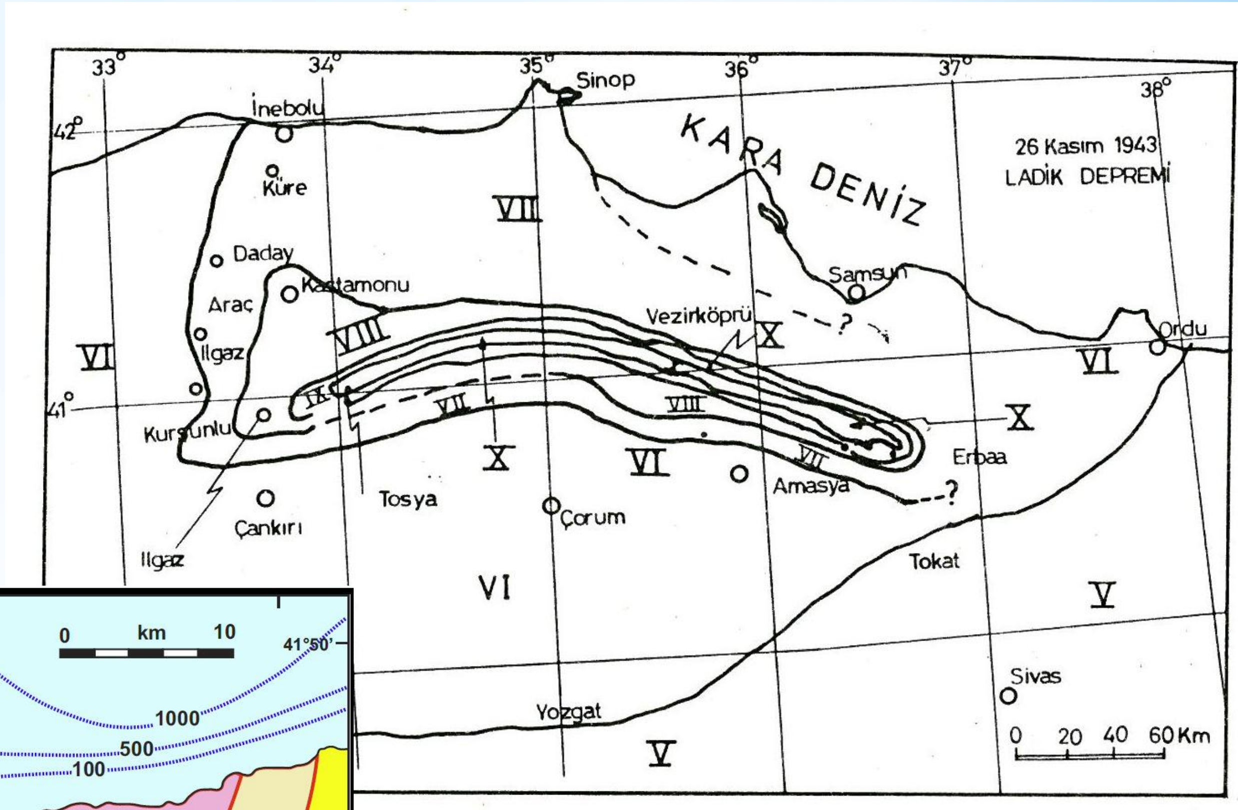


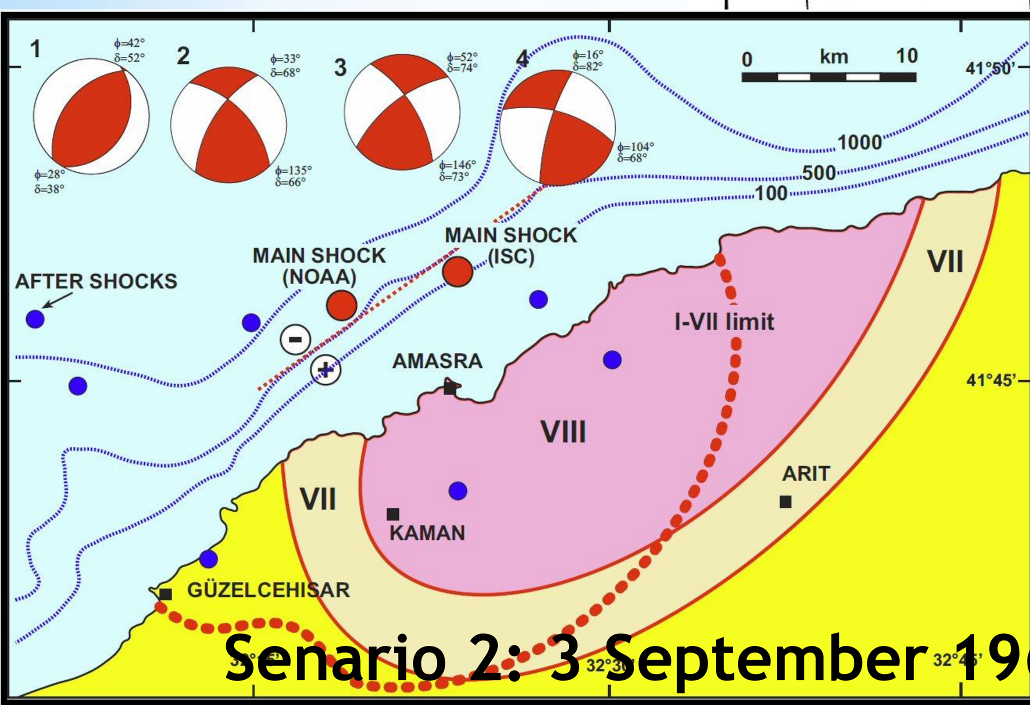
* Earthuake Risk Assessment for Samsun (BU& AFAD – Republic of Turkey Prime Ministry Disaster% Emergency Presidency) – Tectonic structure & Active fault system



Kaymakçı, 2009

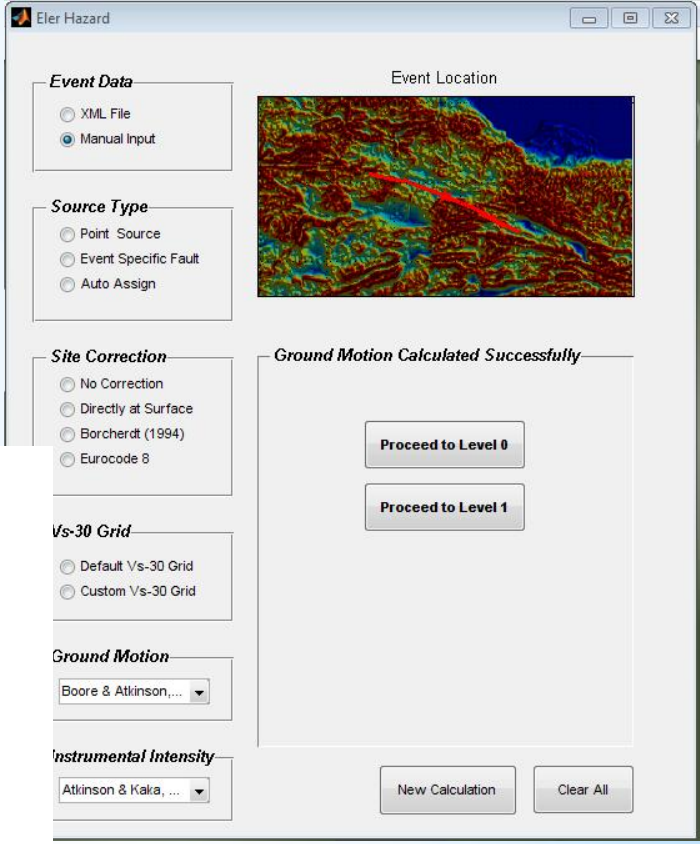
Senario 1 - 26 November 1943 LADİK EQ. Ms =7.2; Mw7.6

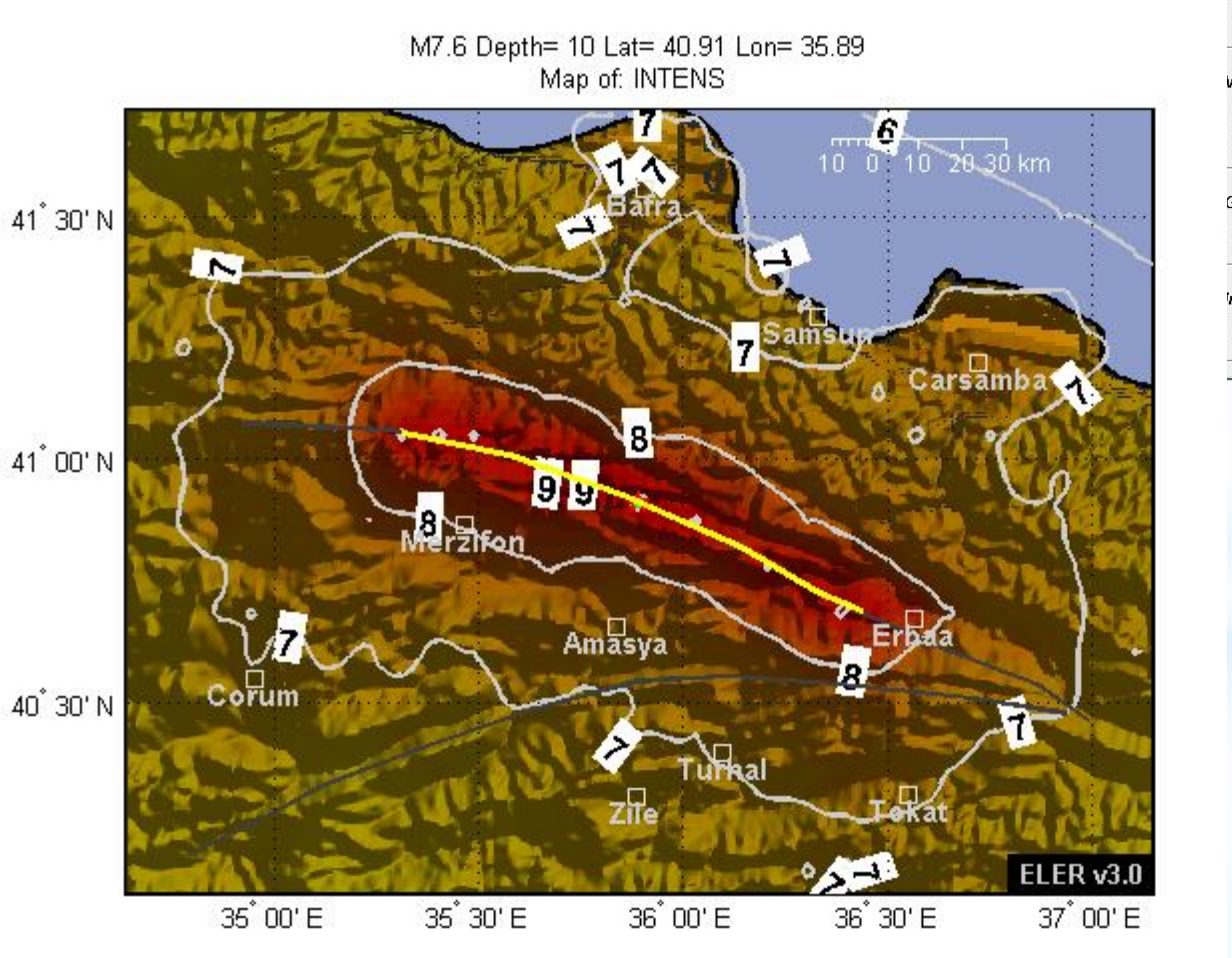




Senario 2: 3 September 1968 BARTIN EQ. Ms=6.6

Senario 1
Southern Samsun - Ladik Eq.
M7.6 - depth 10.0km – Rupture Length =105
Lat: 40.91
Lon: 35.89





Senario 2 –Bartin Eq. M6.6 Intensity Distribution

Project funded by the EUROPEAN UNION

THANK YOU FOR YOUR ATTENTION...