Rupture zones of large earthquakes, lithospheric coupling and seismic potential in the Hellenic Arc and Trench

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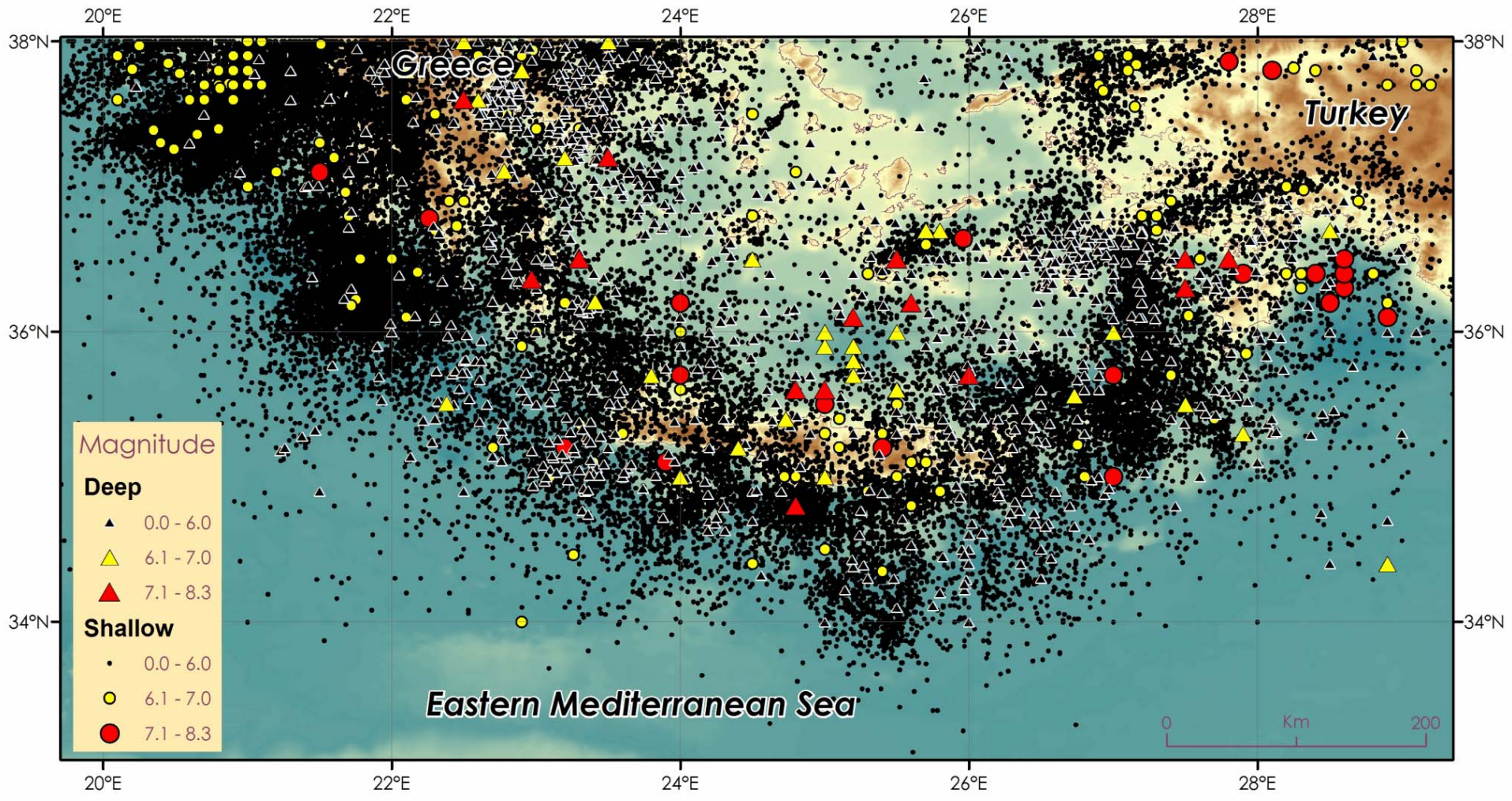
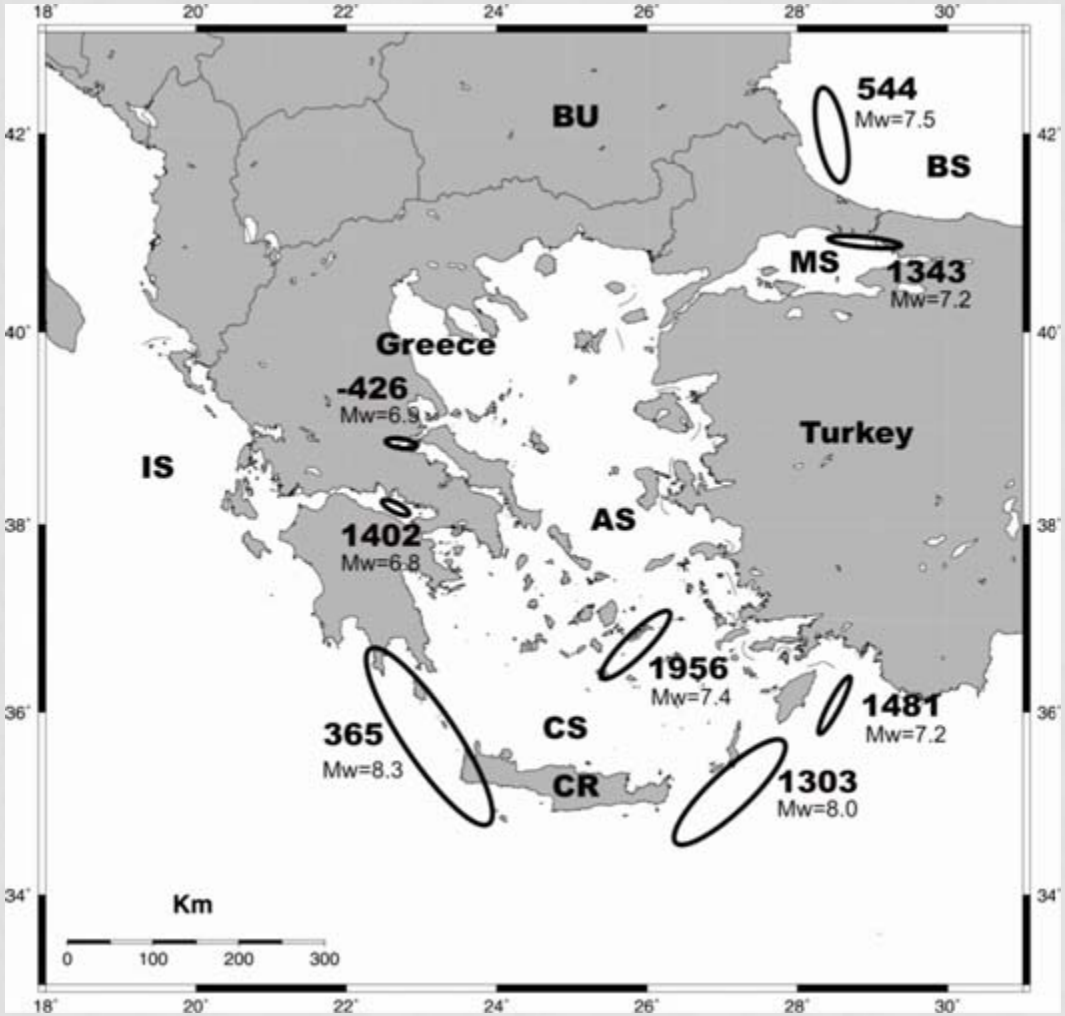
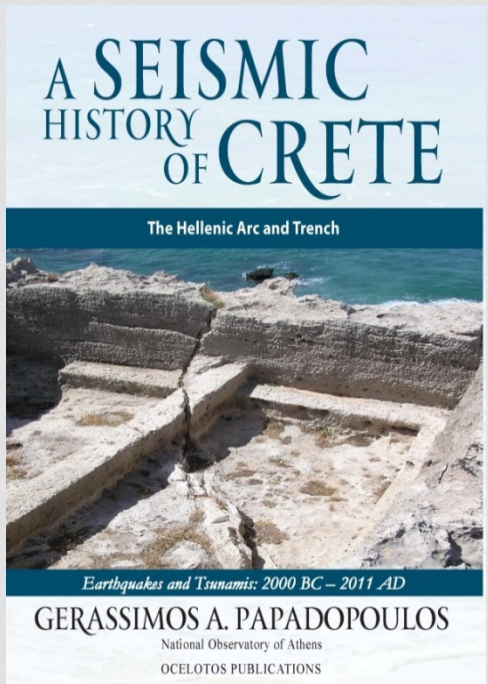
HELLENIC ARC & TRENCH SYSTEM:
THE MOST ACTIVE IN THE MEDITERRANEAN REGION

HELLENIC ARC SEISMICITY



LARGE TSUNAMIGENIC EARTHQUAKES





EARTHQUAKE CATALOGUES: 3 DATA SETS

- AD 350-1899 from revised historical catalogue

(our several publications of the last 15 years or so)

- 1900-1963

(Dept. of Geophysics, Univ. of Thessaloniki , based on NOA's records)

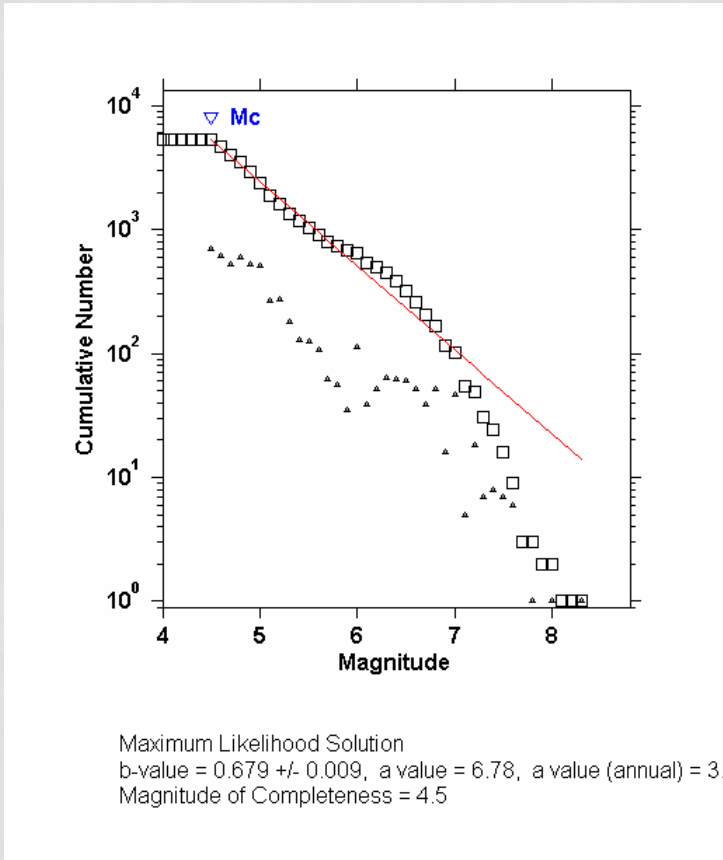
- 1964-June 2008

(NOA catalogue)

COMPLETENESS ANALYSIS

A new synthetic catalogue was constructed for $M_c \geq 4.5$

Time period	M_c
350 up to June	4.5
350 up to 1349	8.0
1350 up to 1800	7.0
1800 up to 1910	6.7
1911 up to 1963	5.1
1964 up to 2008	4.5

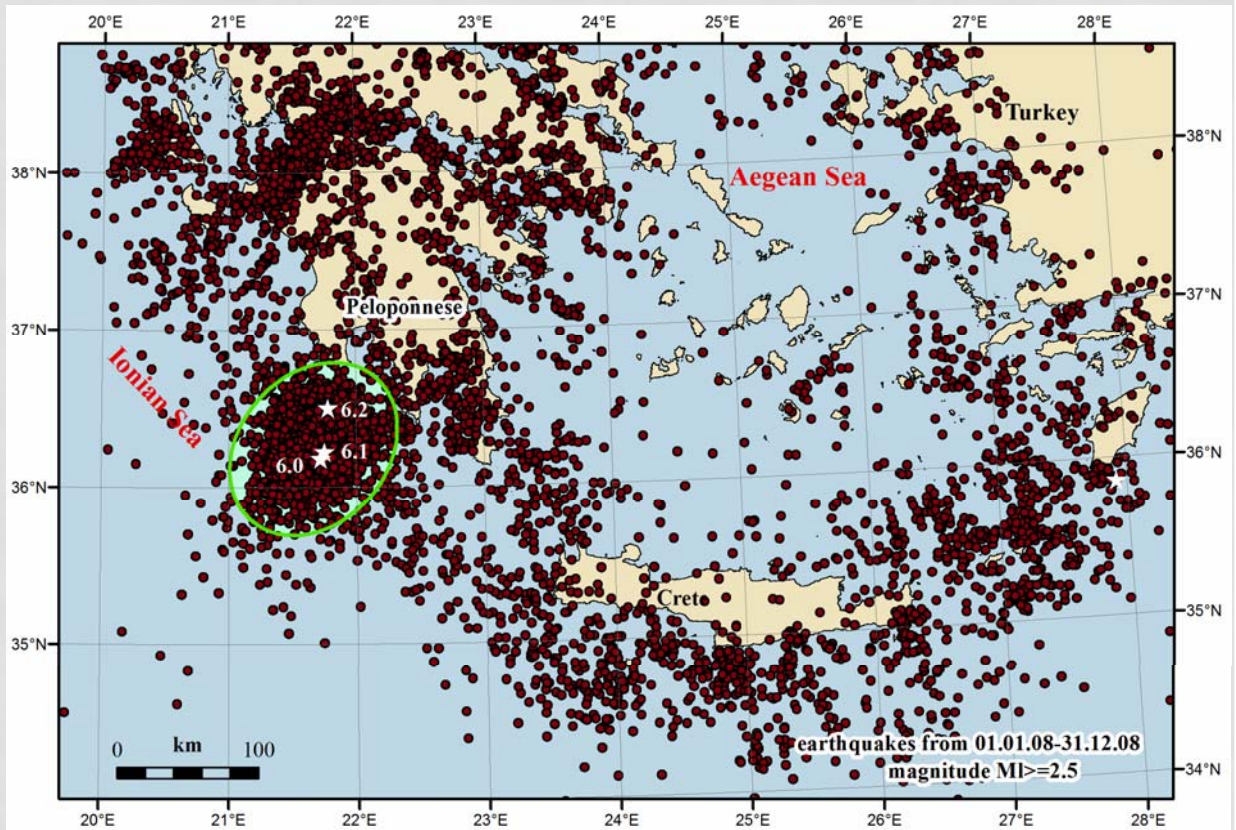


(tested on G-R by z-map toolbox, Wiemer, 1995)

METHONI EARTHQUAKE SEQUENCE

- 14 February 2008, 10:09 UTC, M_L=**6.2**
- 14 February 2008, 12:08 UTC, M_L=**6.1**
- 20 February 2008, 18:27 UTC, M_L=**6.0**

- Data from Institute of Geodynamic, NOA
- Data from 01.01.08 to 31.12.08

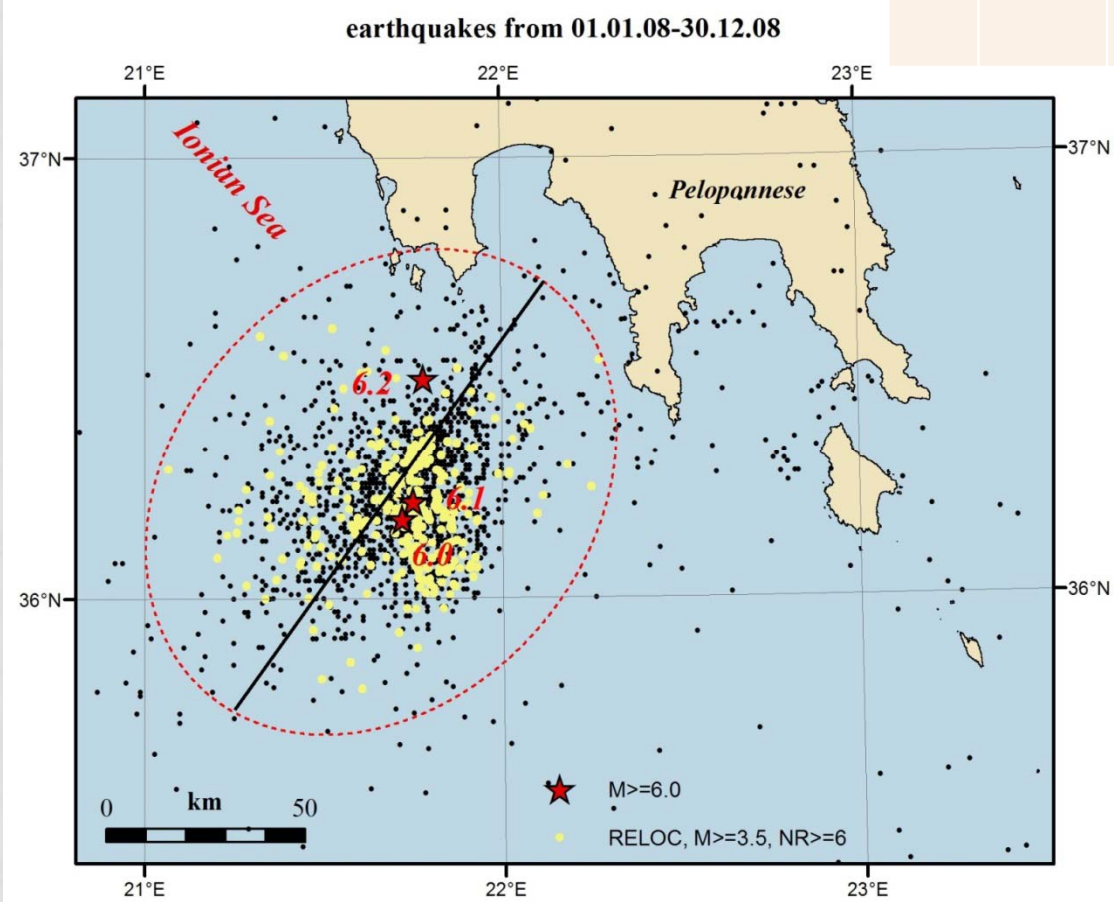


SEISMICITY RELOCATION

- Time interval used: 01.01.2008 – 31.12.2008
- Earthquakes of $M_L \geq 3.5$
- Number of station used for analysis: NR≥ 6
- Total number of events n=2508
- Relocation using HypoDD (Waldhauser & Ellsworth,2000)
- Various crustal velocity models were tested

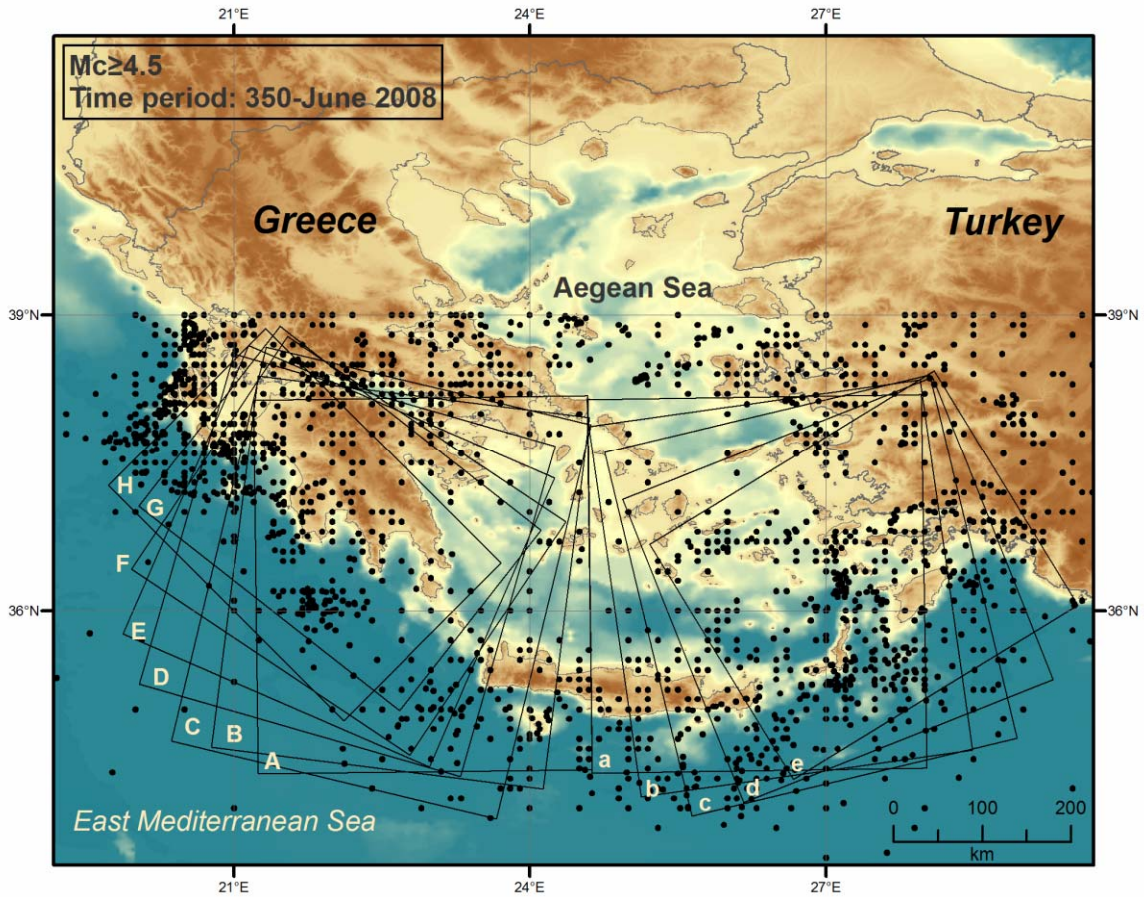
RELOCATED EVENTS

year	month	day	hour	month	lat	long	depth	M	
2008	2	14	10	9	36.50	21.71	38.86	6.2	NOA (reloc)
					36.50	21.78	41	6.2	NOA
2008	2	14	12	8	36.20	21.78	38.77	6.1	NOA (reloc)
					36.22	21.75	38	6.1	NOA
2008	2	20	18	27	36.16	21.72	19.34	6	NOA (reloc)
					36.18	21.72	25	6.0	NOA



Events relocated=429 ($M_L \geq 3.5$, NR≥6)

HELLENIC ARC SEGMENTATION



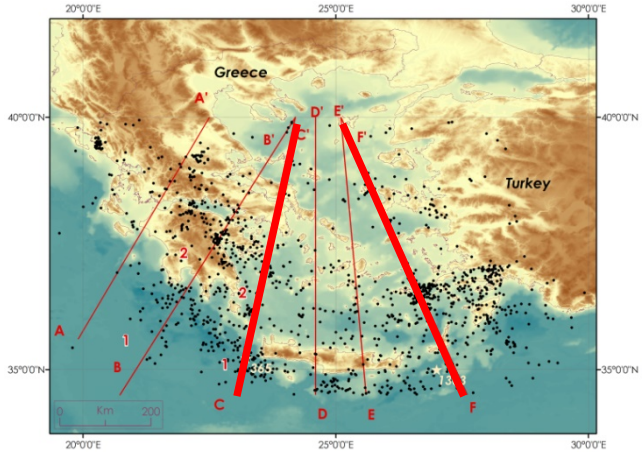
- Mc≥4.5
- AD350-June 2008

a. Both shallow and intermediate depth seismicity of the HAT

b. 8 segments East HAT (A-H)
5 segments West HAT (a-e)

c. Each profile covers an area of 150 km alongside allowing the selection of a relatively small number of segments with adequate earthquake samples in each segment

SEISMICITY PROFILES



- The Benioff zone could be reconstructed by a set of lines oriented along dip

CC' **a≈30°** and FF' **a≈40°**

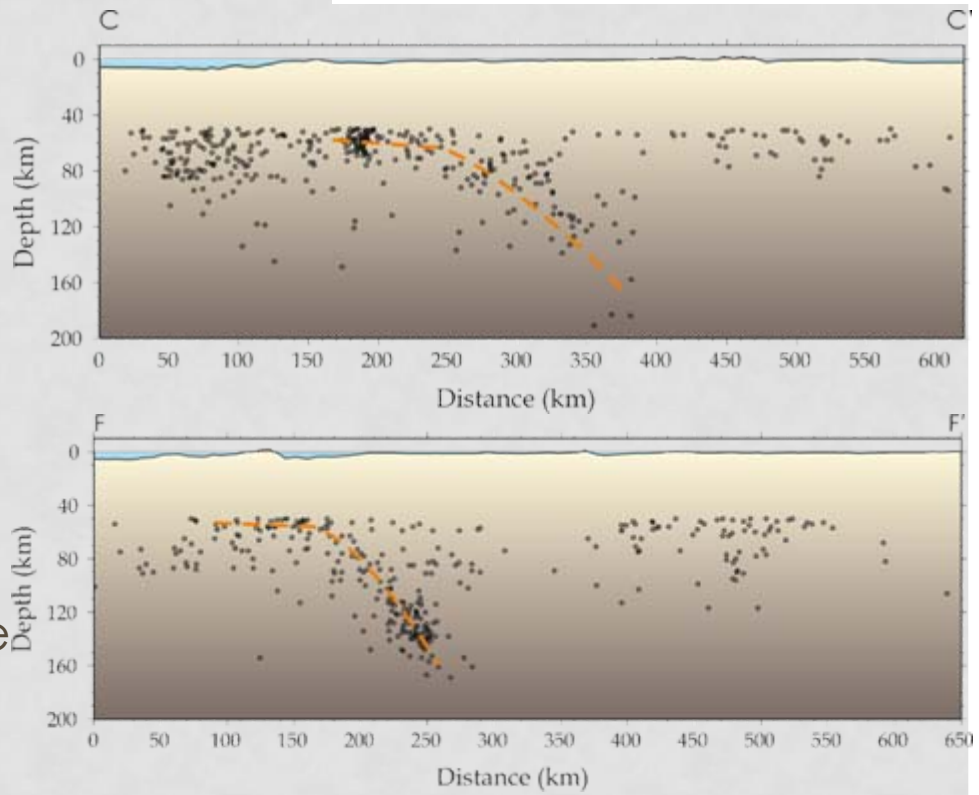
- Calculation of the mean dip ***d*** of the Benioff zone →

$$\sin^2 d = \sin^2 d_1 + \sin^2 d_2$$

where the E-W and N-S apparent dips, d_1 and d_2, are determined by least-squares fitting

- Calculation of the angle ***a*** between the horizontal projection of each slope direction and E-W axis →

$$\tan a = \sin d_2 / \sin d_1$$



Earthquakes of depth ≥ 60 km

SEISMIC SLIP

Seismic slip (Brune, 1968, 1970) $u = \frac{\sum M_o \sin\phi}{\mu L W}$

$\sum M_o$ Sum of earthquake moments for the synthetic catalogue

ϕ Fault dip **(=30° for West HAT and 40° for East HAT)**

μ Rigidity constant **(=2*10^{11}dyne/cm^2)**

L Fault length **(=300km)**

W Thickness of seismogenic layer **(=40km)**

$\log M_o = 1.5Mw + 15.66$ (Ambraseys, 1990, for European EQ's)

PLATE COUPLING/DECOUPLING APPROACH

- Decoupling $d = \frac{u'}{v}$
- Coupling $c = \frac{\bar{u}}{v}$
- Aseismic slip rate $u' = v - \bar{u}$

v Rate of plate motion (=**3 cm/year**)

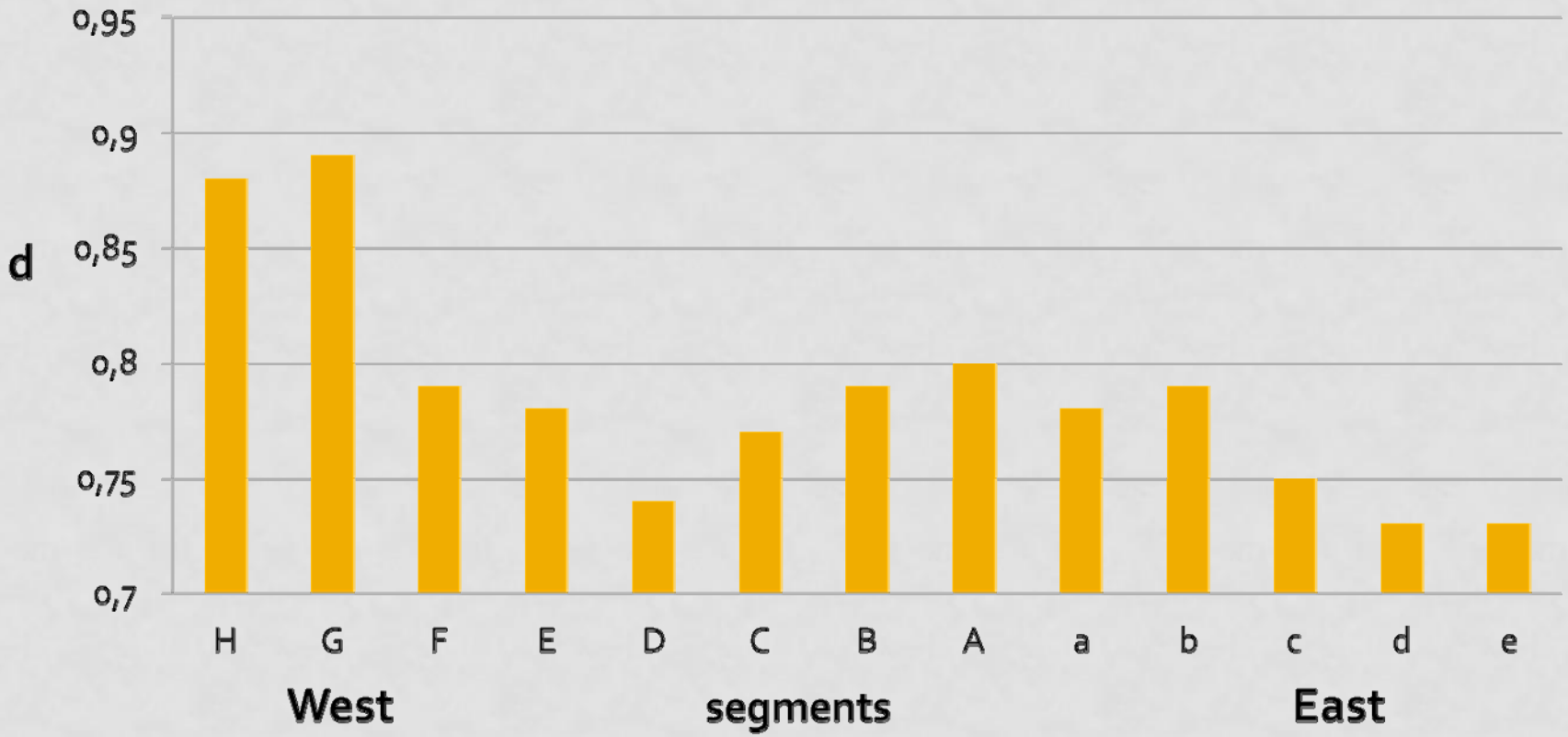
$\bar{u}$ Seismic slip rate

RESULTS

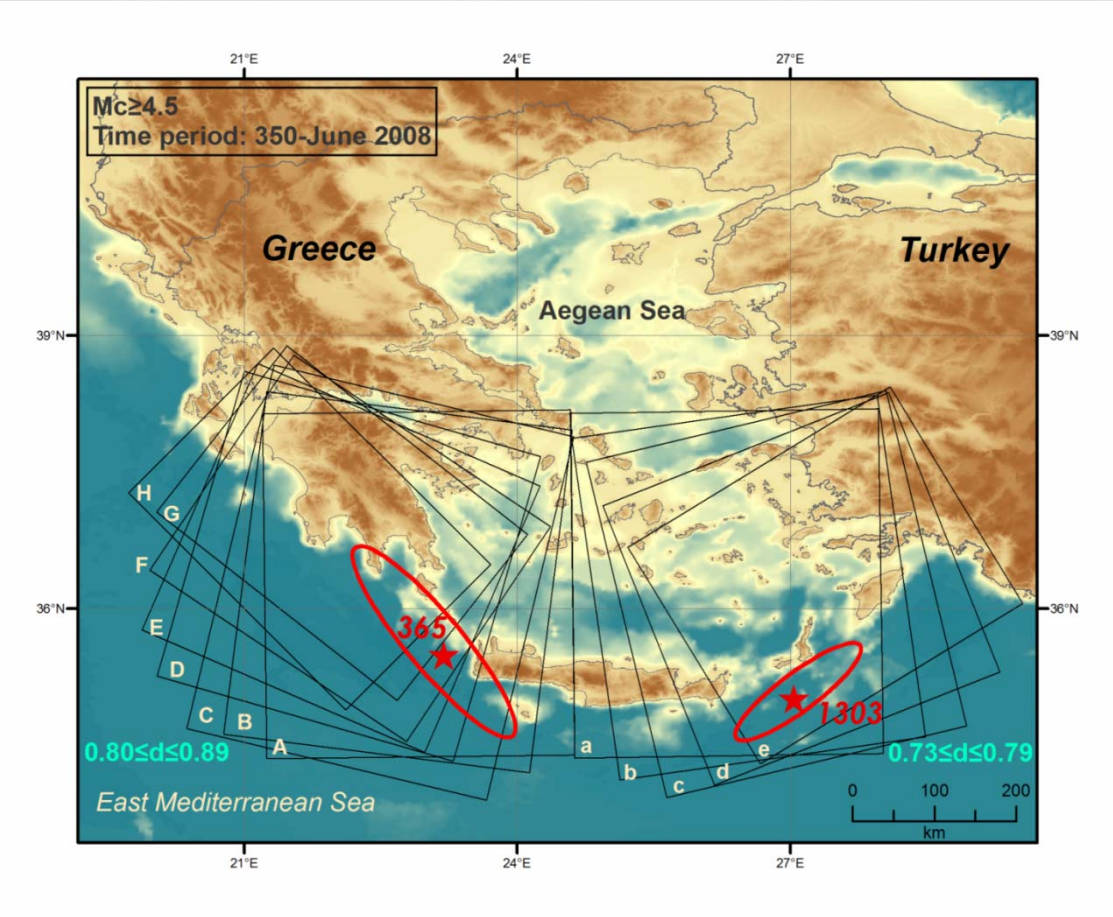
Sections WEST	φ	$\Sigma M_o * 10^{27}$ (dyne*cm)	u (cm) seismic slip	$\bar{u}$ (cm/yr) Seismic slip rate	u' (cm/yr) Aseismic slip	d decoupling	c coupling
H	30°	28.6	596.2	0.36	2.64	0.88	0.12
G	30°	27.4	517	0.34	2.66	0.89	0.11
F	30°	50.5	1051.4	0.63	2.37	0.79	0.21
E	30°	53.3	1110.6	0.77	2.33	0.78	0.22
D	30°	61.5	1282.4	0.69	2.23	0.74	0.26
C	30°	54.4	1143.6	0.69	2.31	0.77	0.23
B	30°	51.3	1068.8	0.64	2.36	0.79	0.21
A	30°	50	1015.6	0.61	2.39	0.80	0.20
EAST							
a	40°	41.8	1741.2	0.67	2.33	0.78	0.22
b	40°	39.3	1635.8	0.63	2.37	0.79	0.21
c	40°	46.9	1995.8	0.76	2.24	0.75	0.25
d	40°	50.5	2105.6	0.82	2.18	0.73	0.27
e	40°	50.9	2121	0.82	2.18	0.73	0.27

RESULTS

decoupling



RESULTS



- Mc≥4.5
- AD350-June 2008

Decoupling (d)

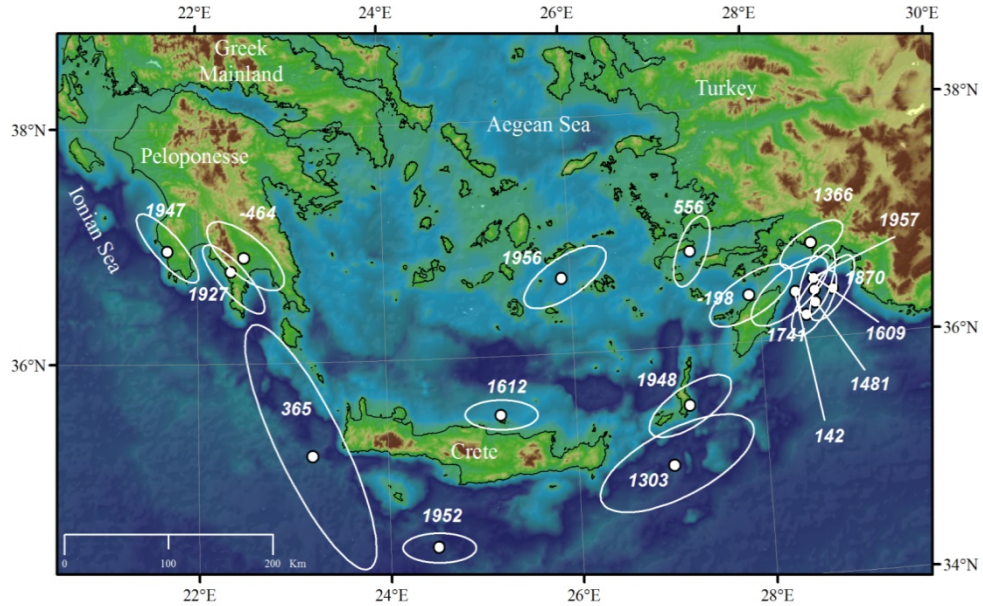
- **West HAT →**
  0.80≤ ***d*** ≤0.89
- **East HAT →**
  0.73≤ ***d*** ≤0.79

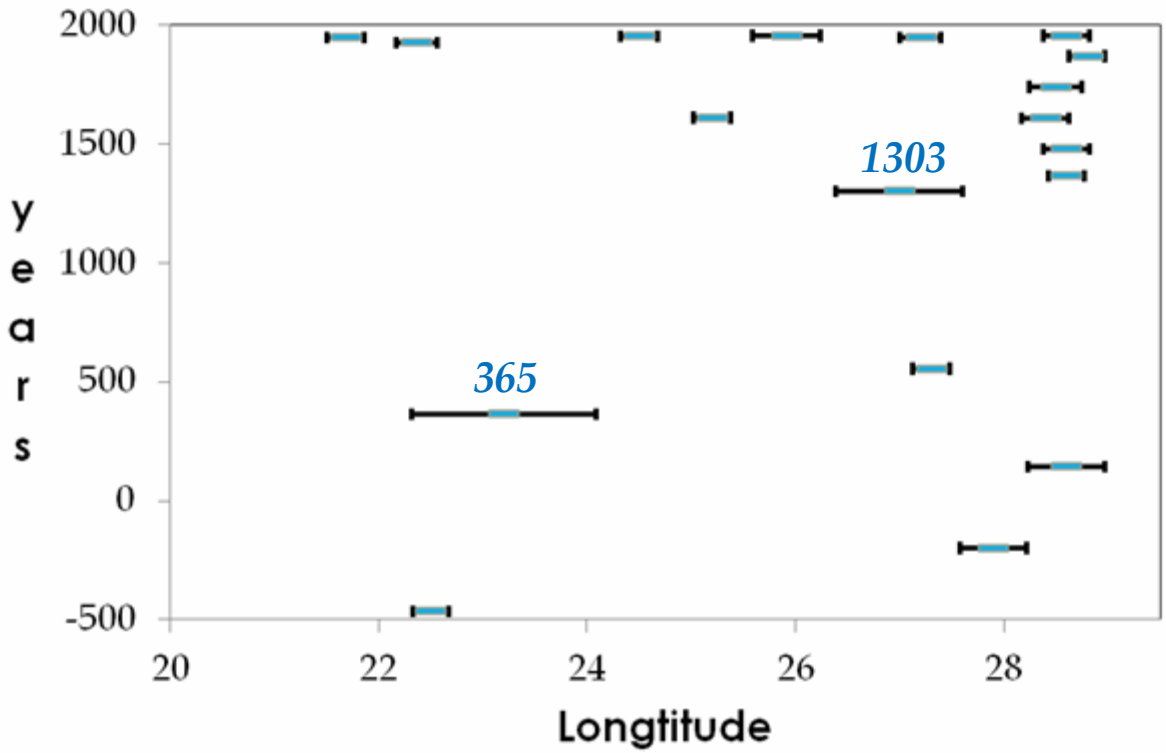
RESULTS

- 550B.C. up to 2008
- Mw/Ms ≥ 7.0
- 20°-30°S
- 34°-38°N

- log L = -1.49 + 0.47 Mw
- log W = -1.07 + 0.34 Mw

(Konstantinou et al, 2005)





PRELIMINARY RESULTS

- We have verified older results that large part (> 70%) of plate motion is taken up as aseismic slip.
- This may account for the long repeatability of very large earthquakes (365-type, 1303-type).
- In the eastern Hellenic arc segment (1303 earthquake) likely more strain has accumulated than in the western segment (365 earthquake).
- More research is needed to approach better repeat times of very large earthquakes.

THANK YOU