EUROPEAN SEISMOLOGICAL COMMISSION
33-rd GENERAL ASSEMBLY
August 19-24, Moscow, Russia
Seismology without boundaries

MONITORING OF THE 2011 MESSINIA (SW GREECE) SEISMIC SWARM

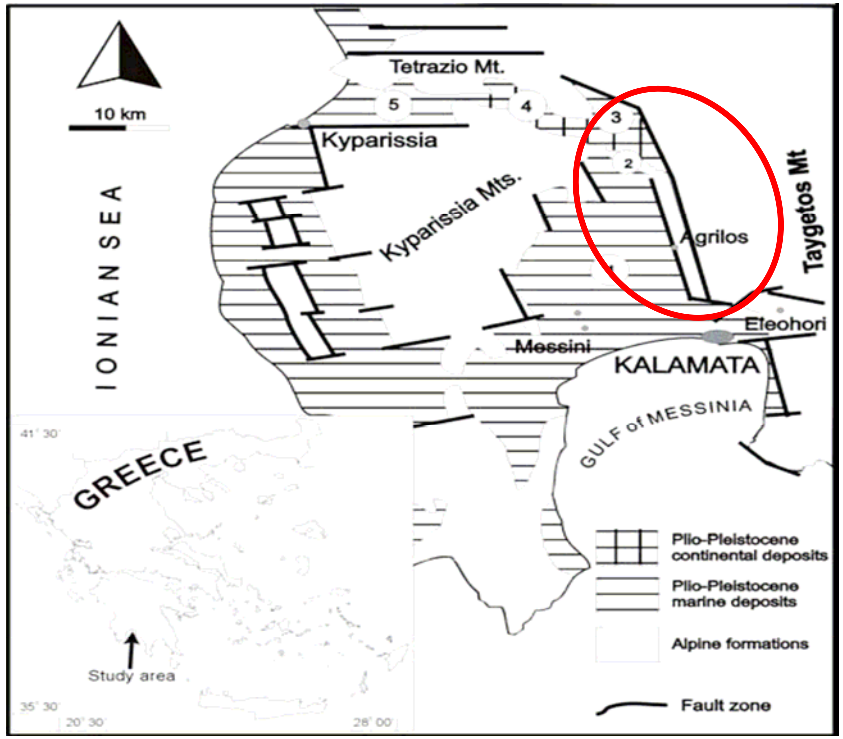
G. Chouliaras[1], I. Kassaras[2], G. Drakatos[1], A. Ganas[1], V. Kouskouna[2], A. Moshou[1], A. Agalos[1], A. Karakonstantis[2], P. Argyrakis[1] and K. Makropoulos[1]

1 - Institute of Geodynamics, National Observatory of Athens, Greece (http://www.gein.noa,gr)

2 - Department of Geophysics-Geothermics, University of Athens, Greece

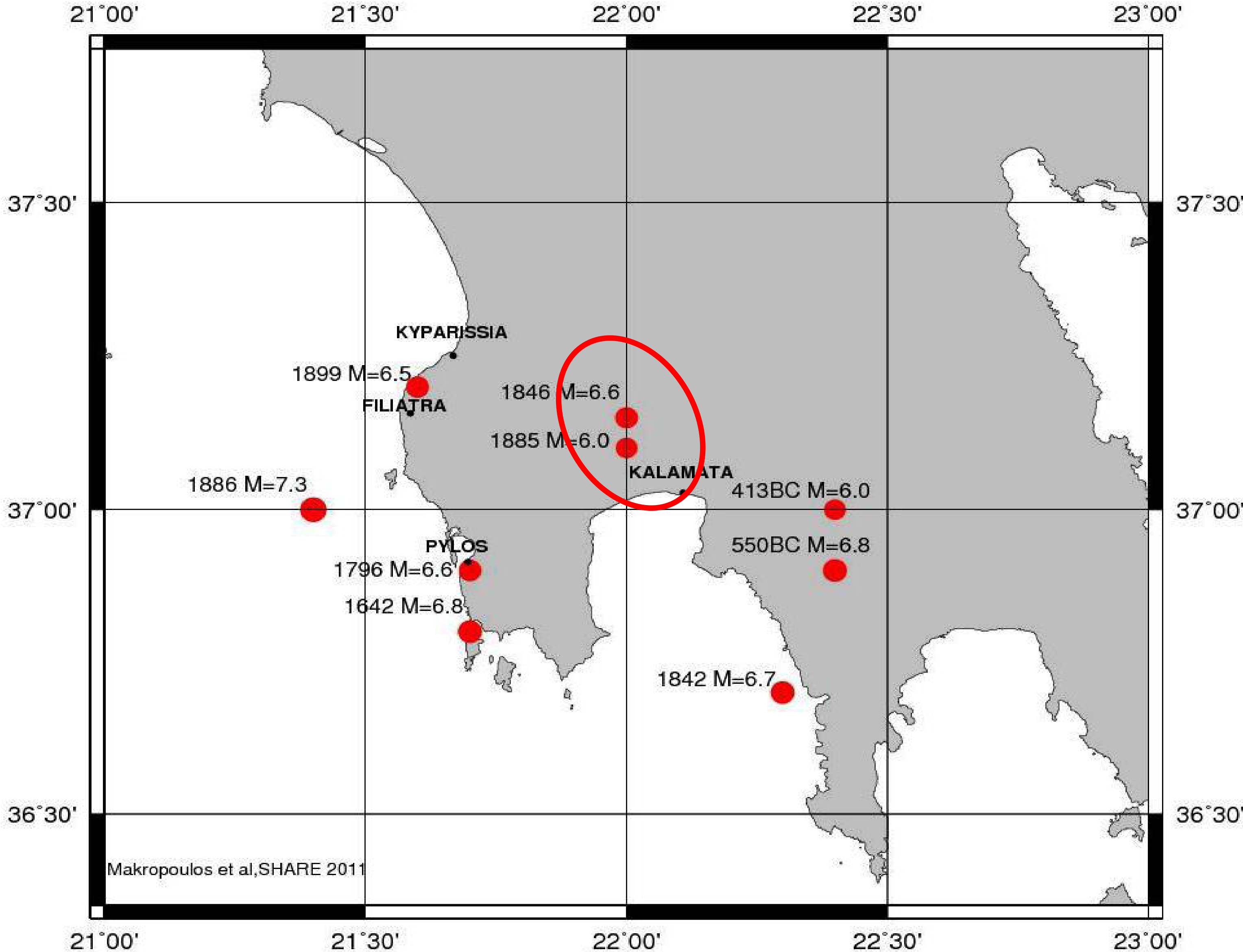
On 14 August 2011, a moderate earthquake with Mw=4.7, occurred near the town of Oixalia in the prefecture of Messinia (Southwestern Peloponnesus) and following this event a significant number of small and moderate size events occurred for many months, some causing minor structural damage and major discomfort in the local communities. In order to investigate this phenomenon the Institute of Geodynamics (National Observatory of Athens, NOA) and the Seismological Laboratory of the University of Athens (SL-UoA) installed a complementary local seismic array of 8 continuous recording 3-component instruments in the area, to enhance the local detectability of the National Broadband Seismological Network. More than 2000 events have been recorded during the last year and these have been relocated using the double difference algorithm (HypoDD). Moment tensor solutions have also been calculated for the 3 largest shocks (M>4.5) and for all recorded shocks of M>3.5 using both local and regional data, while for events of smaller magnitudes focal mechanisms were determined by first motion polarities. This analysis revealed the rupture of a normal fault with an NNE – SSW strike direction and dipping 50^0 WSW. The epicenters of the largest shocks are mapped in a low b-value region, indicative of a high local stress field.

Contributing projects : EPOS EUROPEANPLATEOBSERVINGSYSTEM

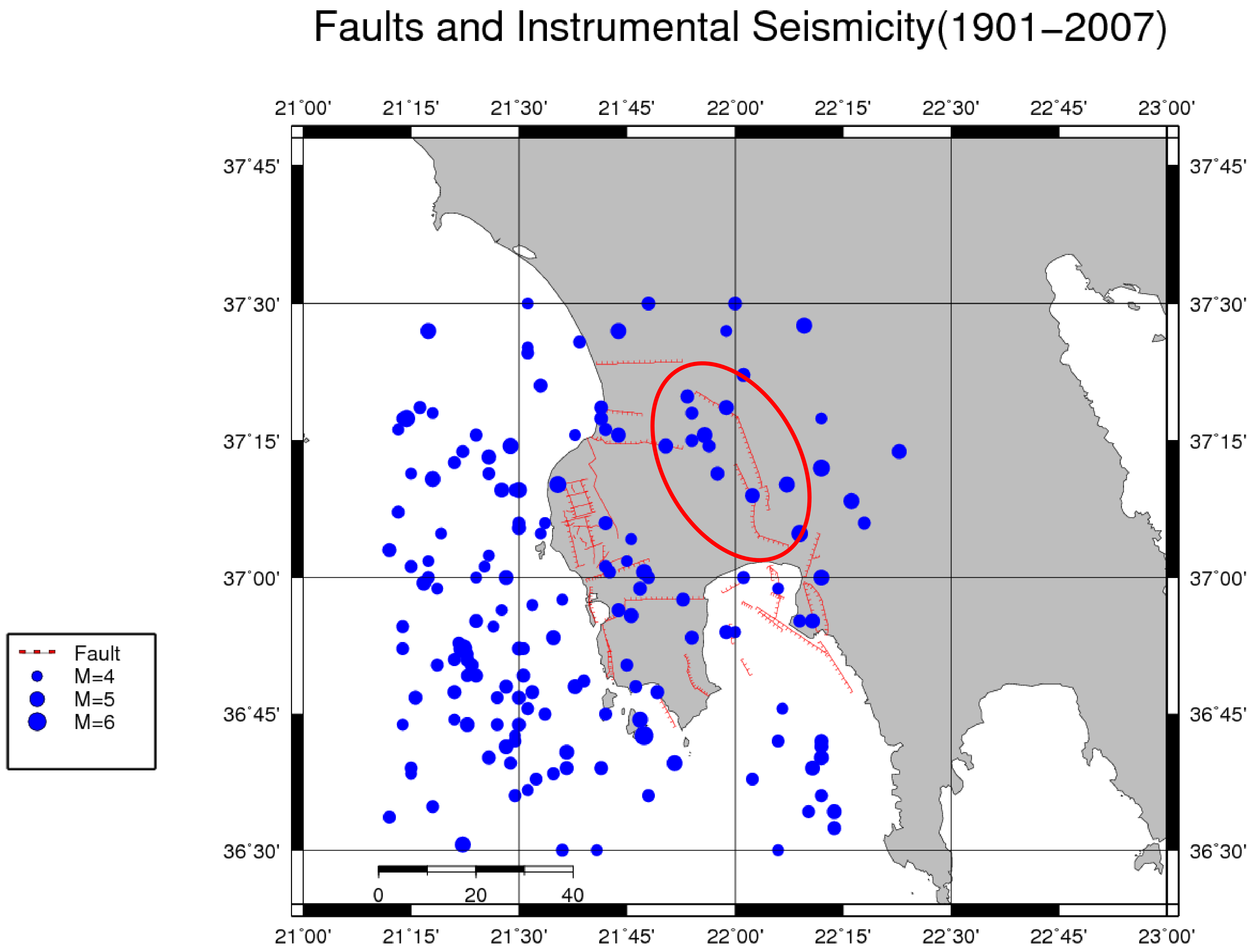


Tetrazio Mt.
10 km
5
4
3
2
Kyparissia
Kyparissia Mts.
IONIAN SEA
Agrilos
Taygetos Mt
Eleohori
Messini
KALAMATA
GULF of MESSINIA
GREECE
41° 30'
35° 30'
20° 30'
28° 00'
Study area
Plio-Pleistocene continental deposits
Plio-Pleistocene marine deposits
Alpine formations
Fault zone

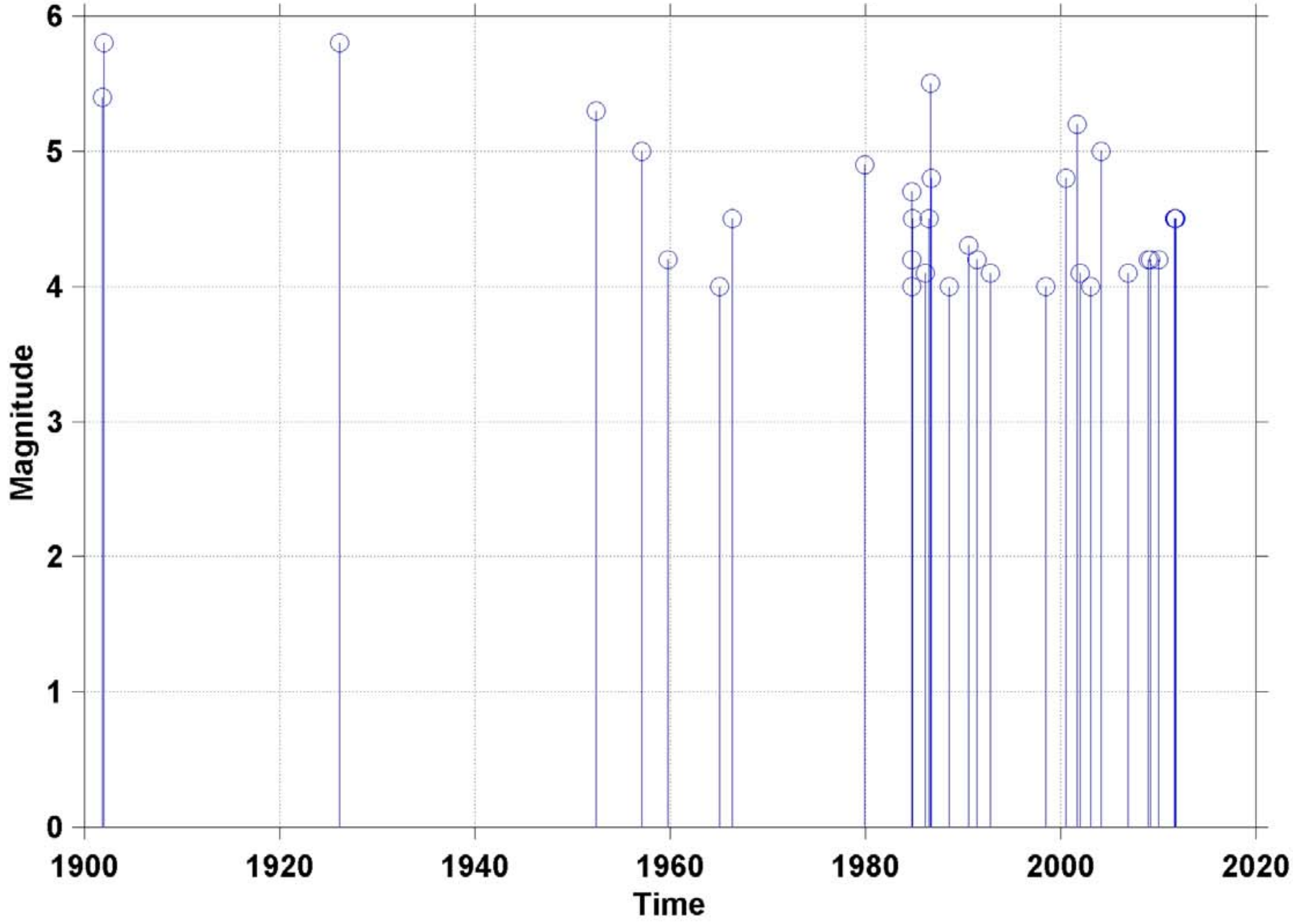
Historical Seismicity

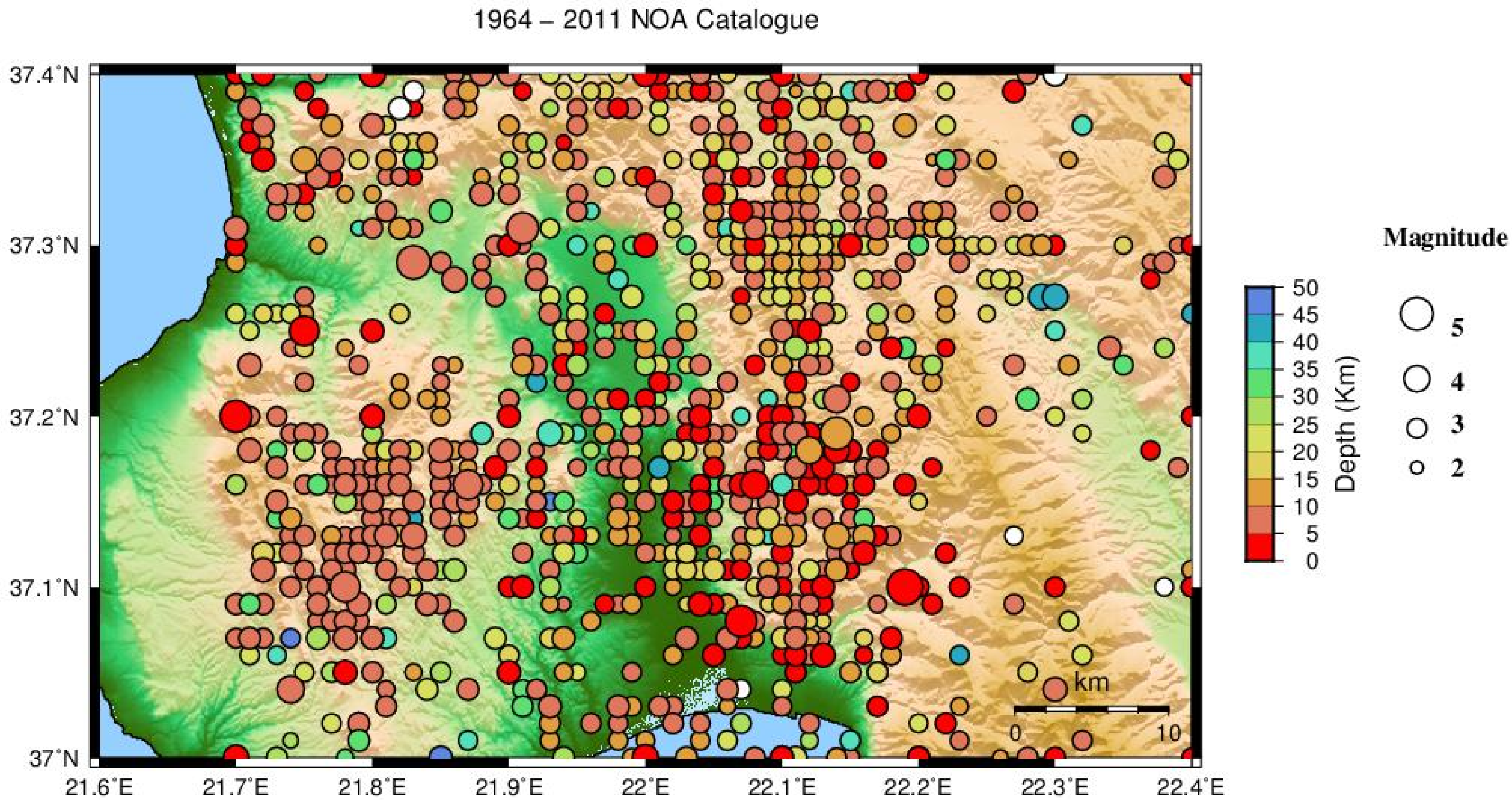


(Makropoulos et al., 2011)

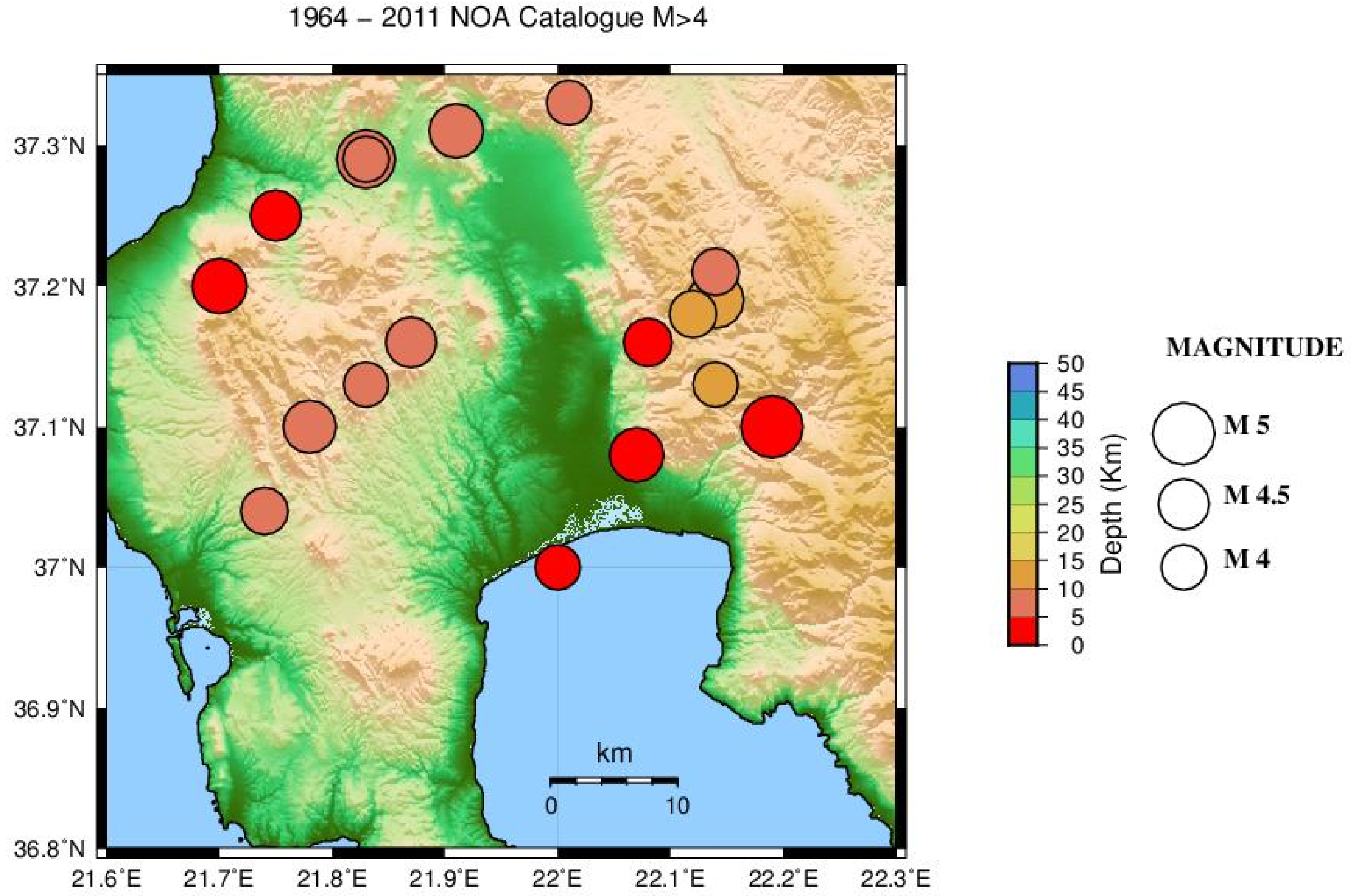

Faults and Instrumental Seismicity(1901–2007)
21˚00'
21˚15'
21˚30'
21˚45'
22˚00'
22˚15'
22˚30'
22˚45'
23˚00'
37˚45'
37˚30'
37˚15'
37˚00'
36˚45'
36˚30'
0
20
40
Fault
M=4
M=5
M=6

1900-2011 Instrumental Seismicity

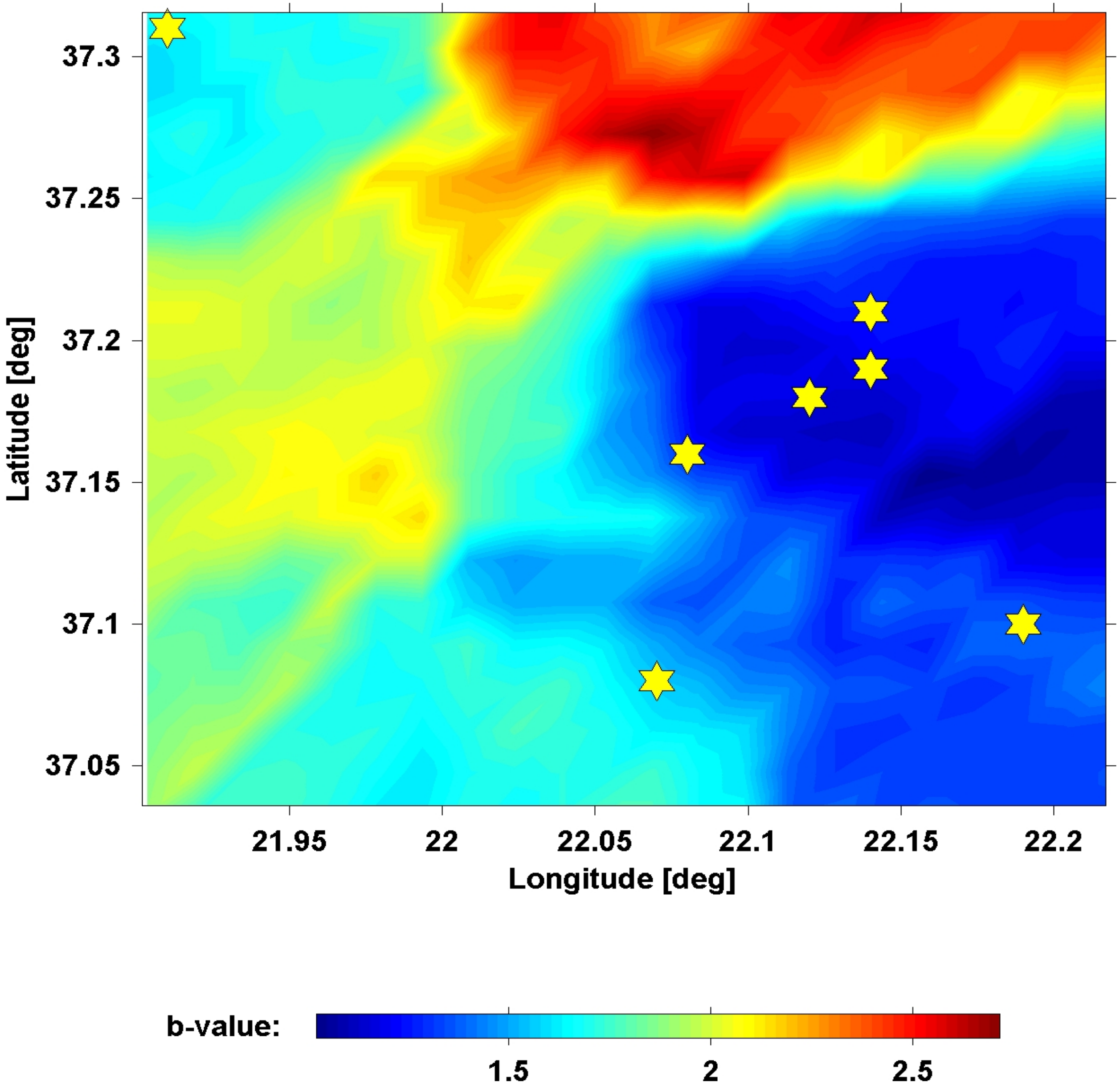




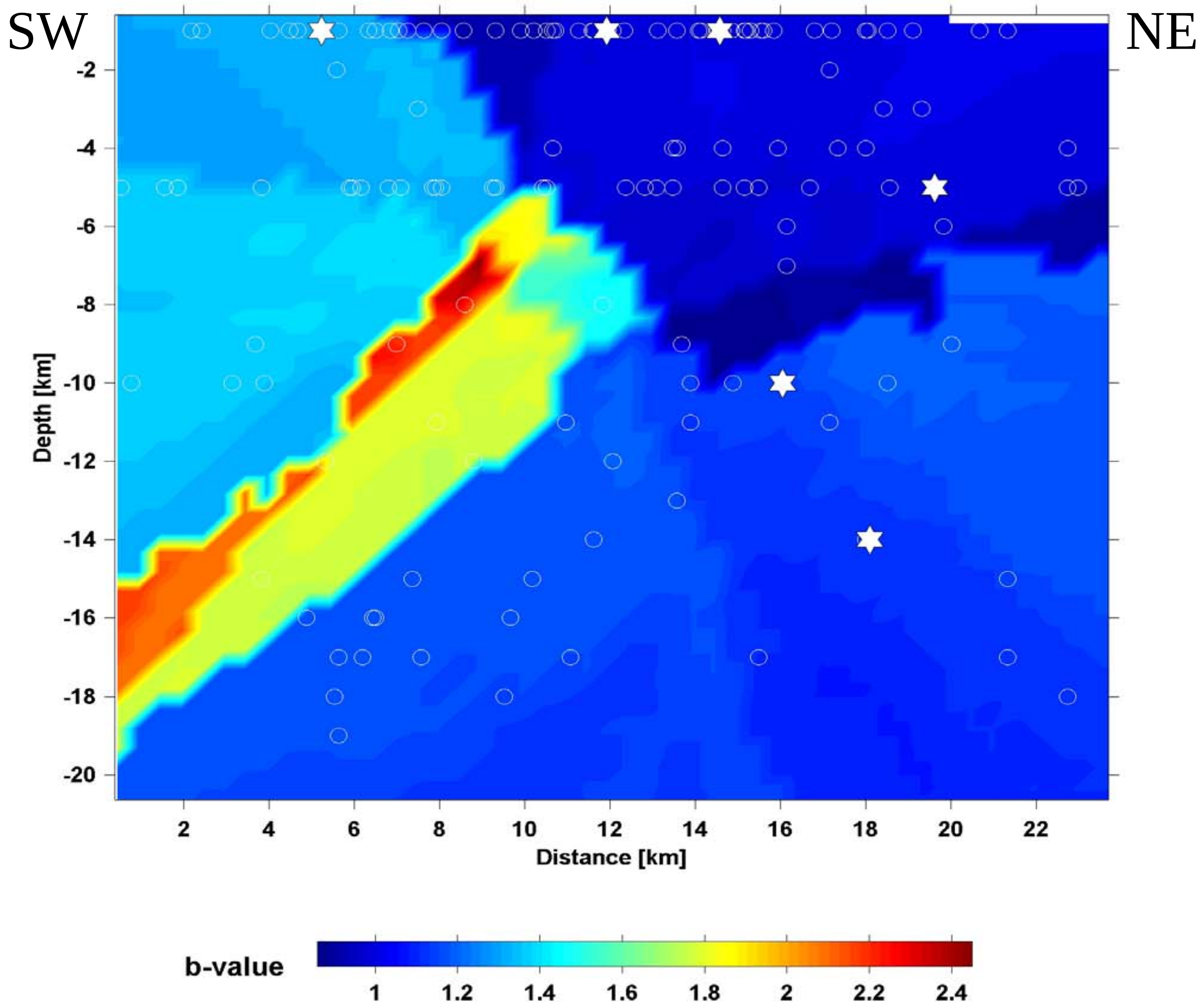
1964 – 2011 NOA Catalogue
37.4°N
37.3°N
37.2°N
37.1°N
37°N
21.6°E
21.7°E
21.8°E
21.9°E
22°E
22.1°E
22.2°E
22.3°E
22.4°E
km
0
10
Depth (Km)
50
45
40
35
30
25
20
15
10
5
0
Magnitude
5
4
3
2

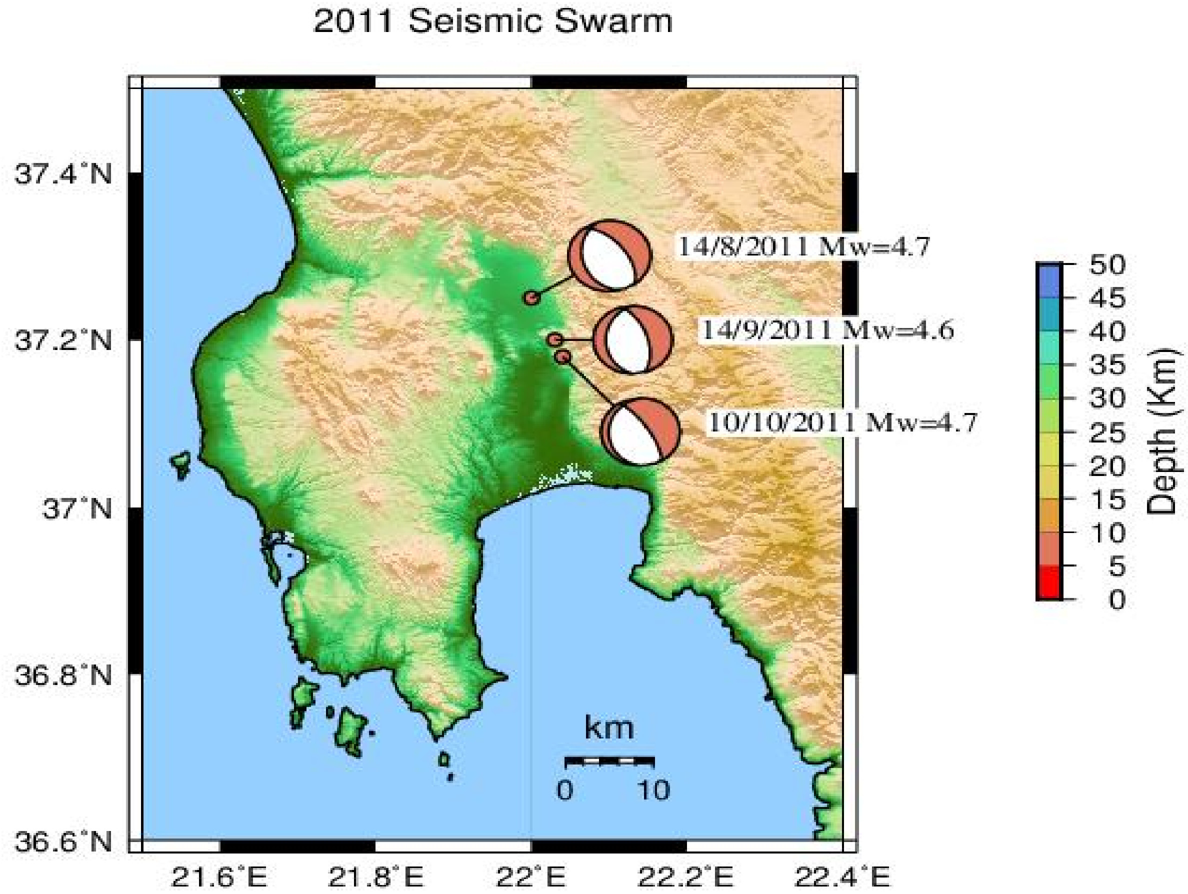

1964 – 2011 NOA Catalogue M>4
37.3˚N
37.2˚N
37.1˚N
37˚N
36.9˚N
36.8˚N
21.6˚E
21.7˚E
21.8˚E
21.9˚E
22˚E
22.1˚E
22.2˚E
22.3˚E
km
0
10
Depth (Km)
50
45
40
35
30
25
20
15
10
5
0
MAGNITUDE
M 5
M 4.5
M 4

b-value Profile, NOA Catalogue, 1964 - 2011



b-value Cross-Section, NOA Catalogue, 1964 - 2011




2011 Seismic Swarm
14/8/2011 Mw=4.7
14/9/2011 Mw=4.6
10/10/2011 Mw=4.7
37.4˚N
37.2˚N
37˚N
36.8˚N
36.6˚N
21.6˚E
21.8˚E
22˚E
22.2˚E
22.4˚E
km
0
10
Depth (Km)
50
45
40
35
30
25
20
15
10
5
0

Macroseismic Survey Results

Macroseismic effects due to the 2011 earthquake sequence were reported after the three largest events: 14/08/2011 (Mw=4.7), 14/09/2011 (Mw=4.6) and 10/10/2011 (Mw=4.7) by field investigations.

The **Macroseismic Intensity (EMS98)** was assessed for a total number of 42 localities in the epicentral area.

Vulnerability: The buildings in the area fall within vulnerability classes A-B and in a few cases class C was also identified in frames with manufactured stone units without earthquake-resistant design.

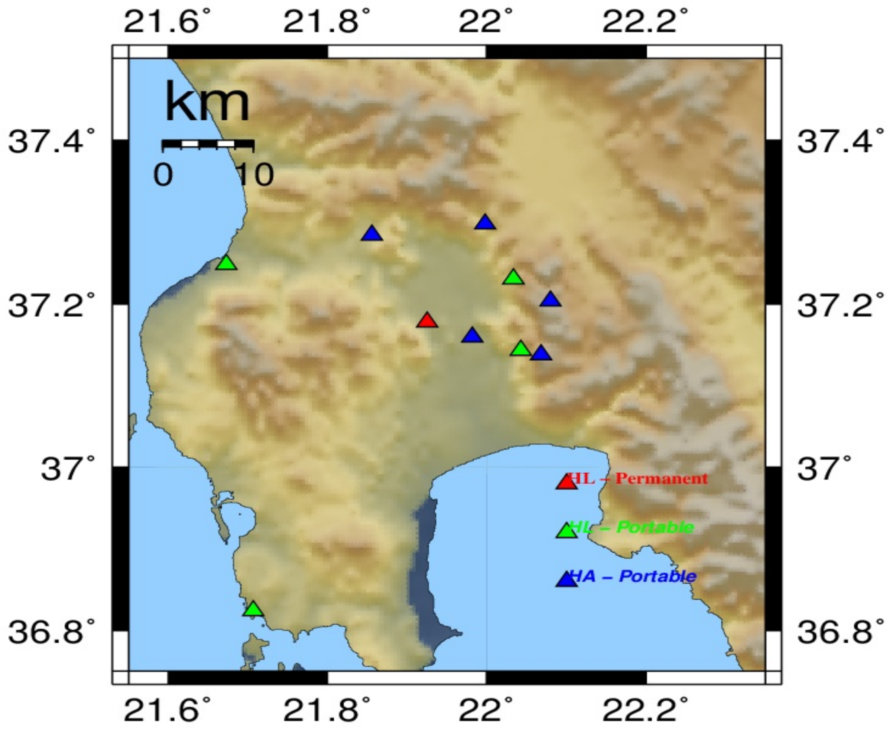
Damage: The damage observed varied mainly between grades 1 (no structural damage, slight non-structural damage) & 2 (slight structural damage, moderate non-structural damage). Hairline and substantial cracks, fall of small pieces of plaster and fall of loose stones from upper parts of buildings was most commonly observed.

In few localities substantial damage in one or two buildings of high vulnerability was observed. In the case of Katsaros village where cumulative maximum intensity 6-7 was assessed, one building suffered heavy damage. The maximum intensity= 6 was assessed for the event on 14/8/2011 while a cumulative maximum intensity = 6-7 was assessed after the event on 10/10/2011.

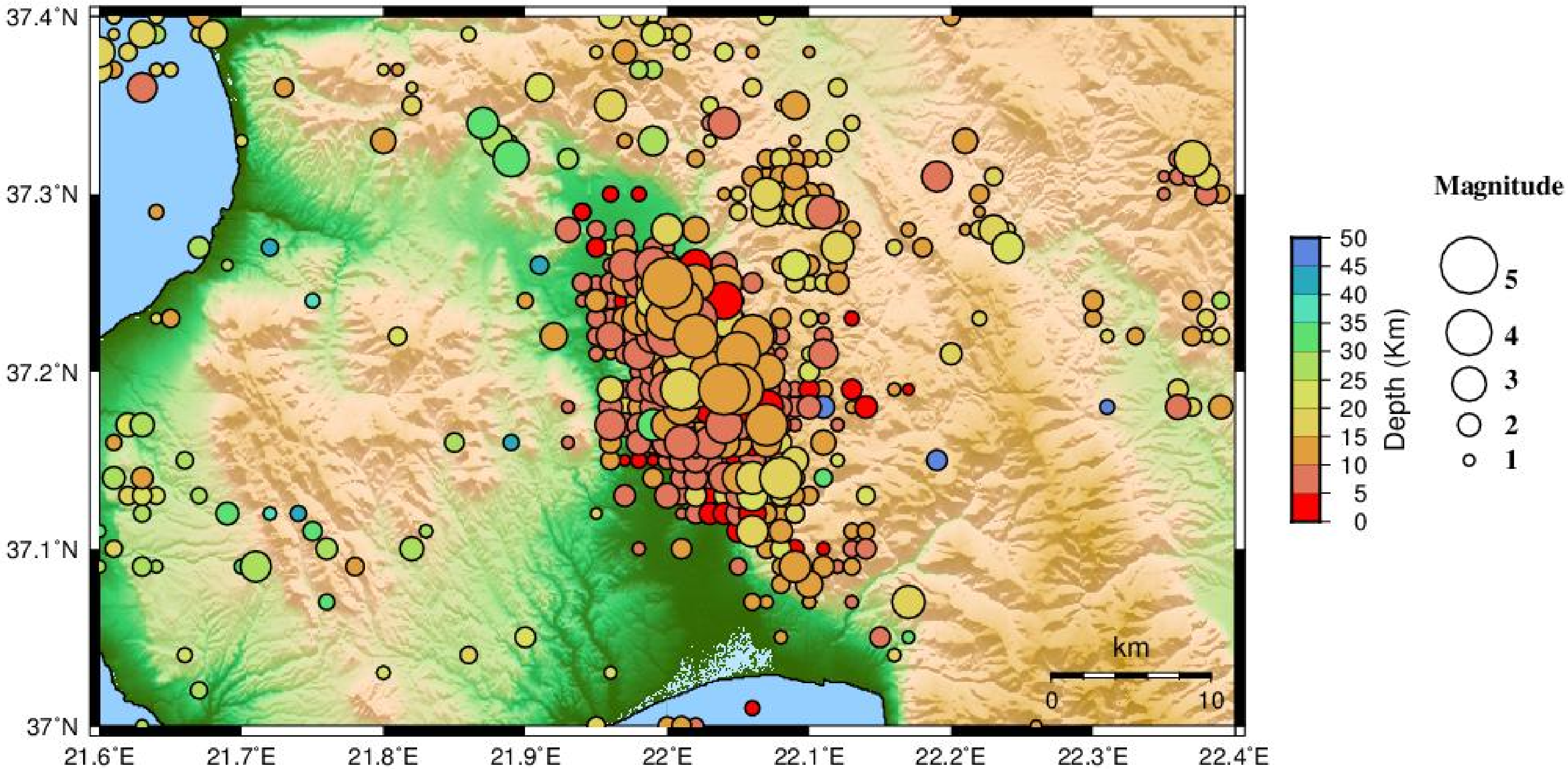
Deployment of a local seimographic network

- A local seismographic network was installed by NOA and NKUA in October 2011, comprising of 9 broadband 3-component instruments, complementary to the National Seismographic Network of Greece (HUSN).
- In total, about 1700 aftershocks were recorded and were initially located with **Hypoinverse** considering a regional velocity structure (GI-NOA).
- 83% of these aftershocks (1430 out of 1700) were relocated using **HypoDD** by minimizing the residuals between observed and calculated travel time differences for pairs of neighboring earthquakes at each station (double-differences).
- Recordings of the local network were employed to compute focal mechanisms of aftershocks. 130 fault plane solutions were determined using at least 6 P-waves manually. Uncertainty of nodal planes is $<10^o$.

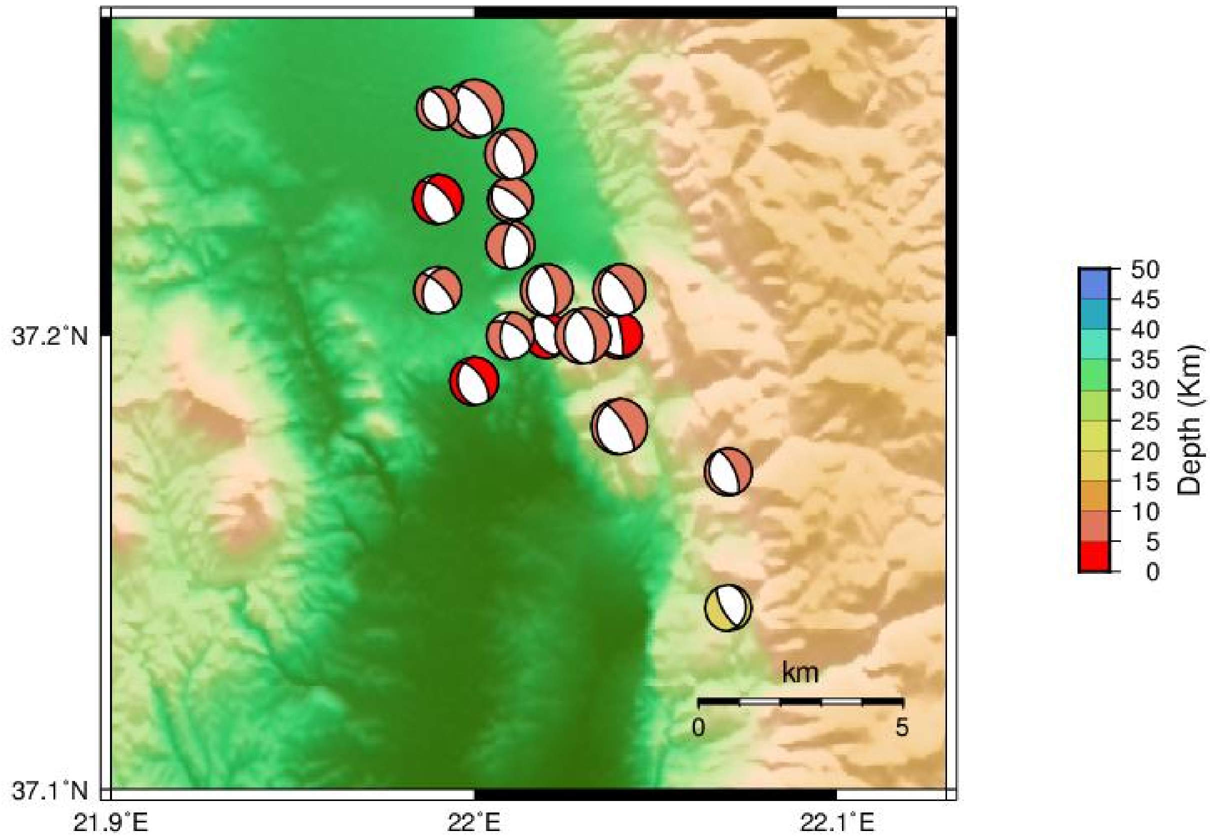
Seismological Networks



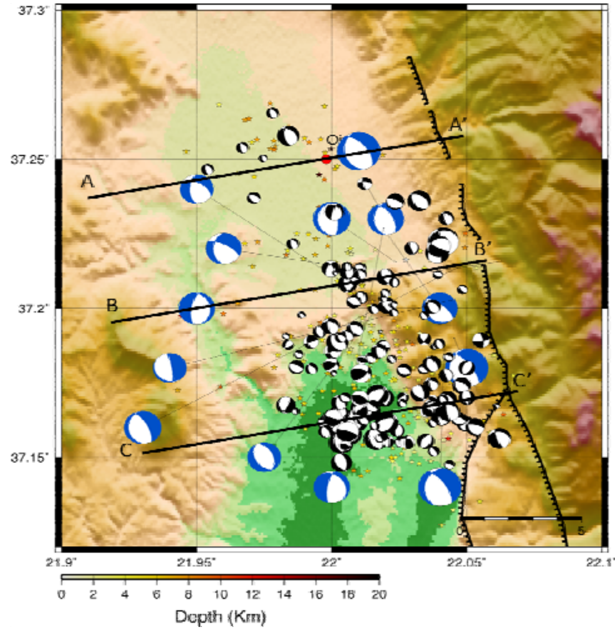
2011 – 2012 NOA Catalogue

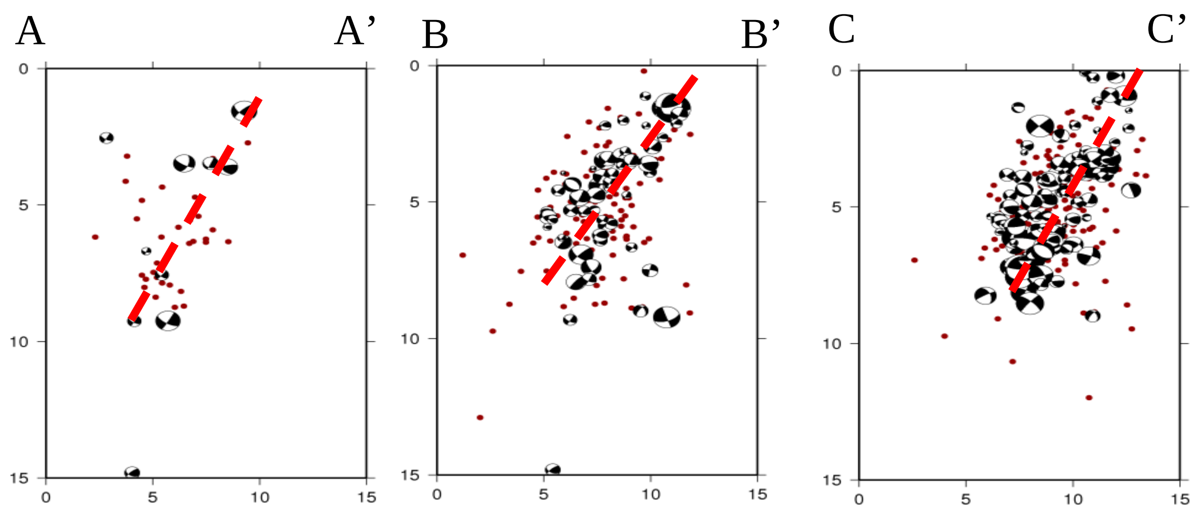


2011–2012 NOA Catalogue CMT's for M>3.5

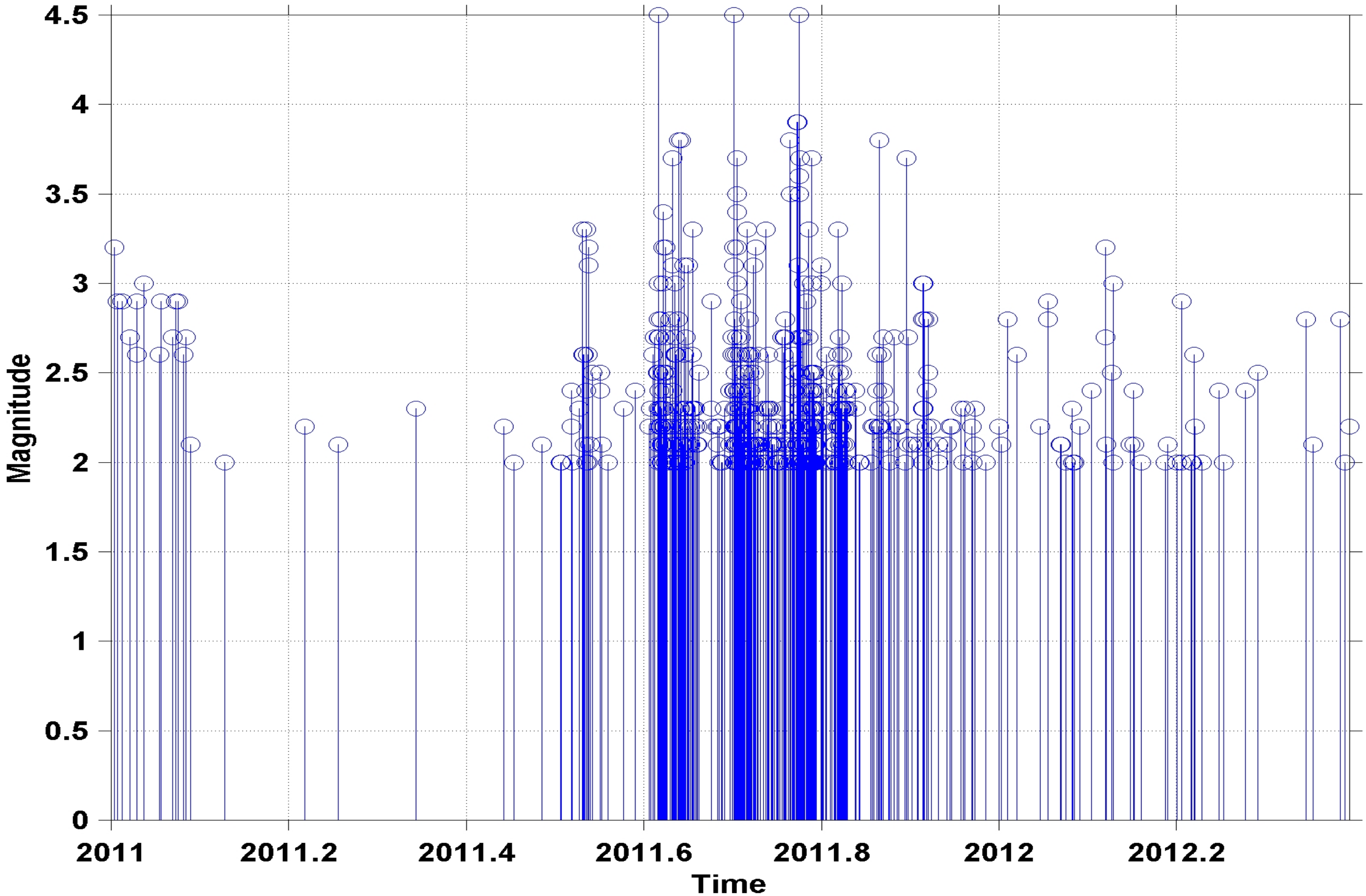


130 focal mechanisms and aftershocks corresponding to corrected and relocated events. Blue beachballs are regional MT solutions (GI-NOA). The majority of focal mechanisms show normal faulting at a depth range 0-10 km. Nodal planes orientations and cross sections AA', BB', CC' performed perpendicular to the main structures imply for a left lateral **fault plane striking N160 ^{0} and dipping 50 ^{0} WSW.**

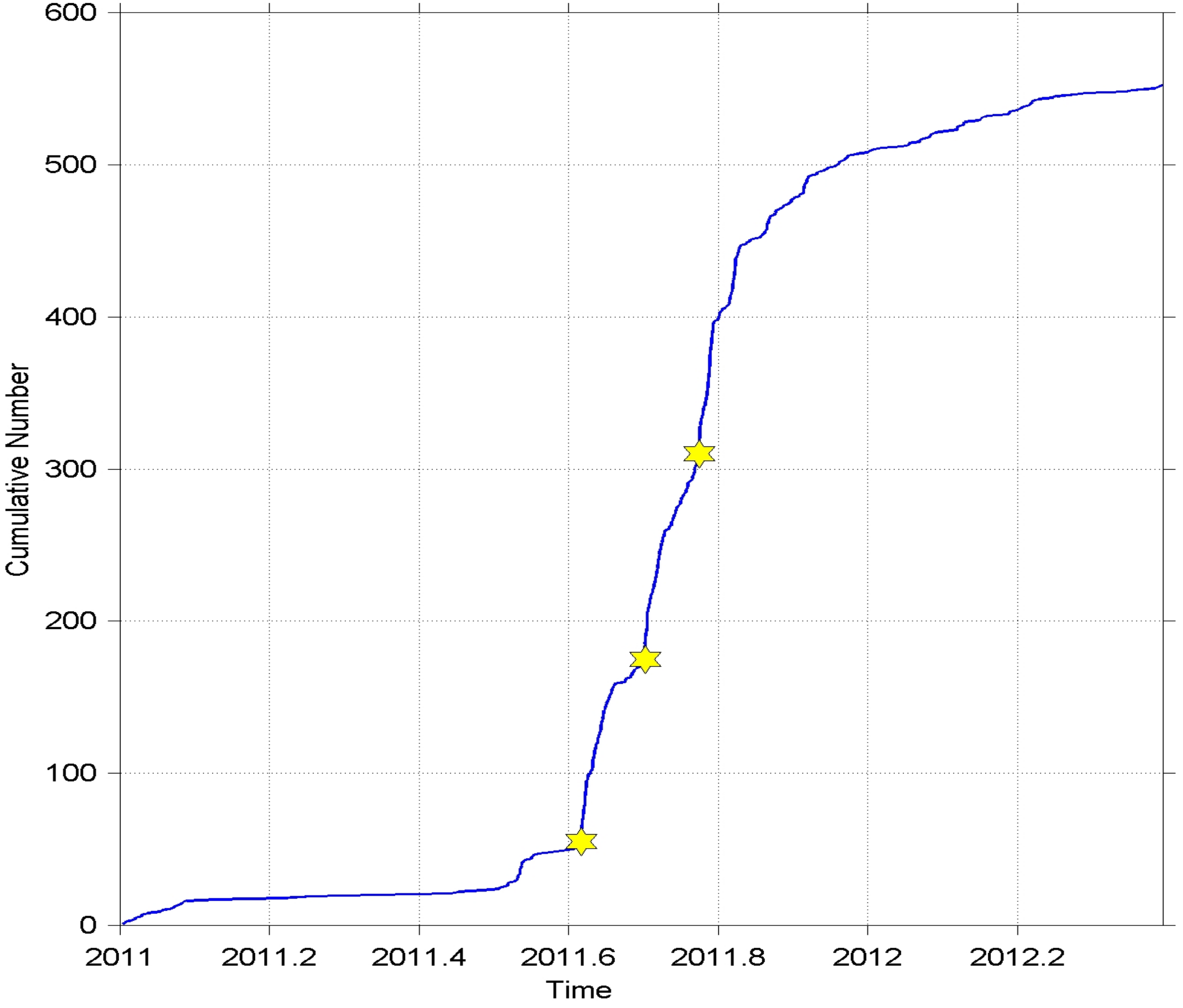




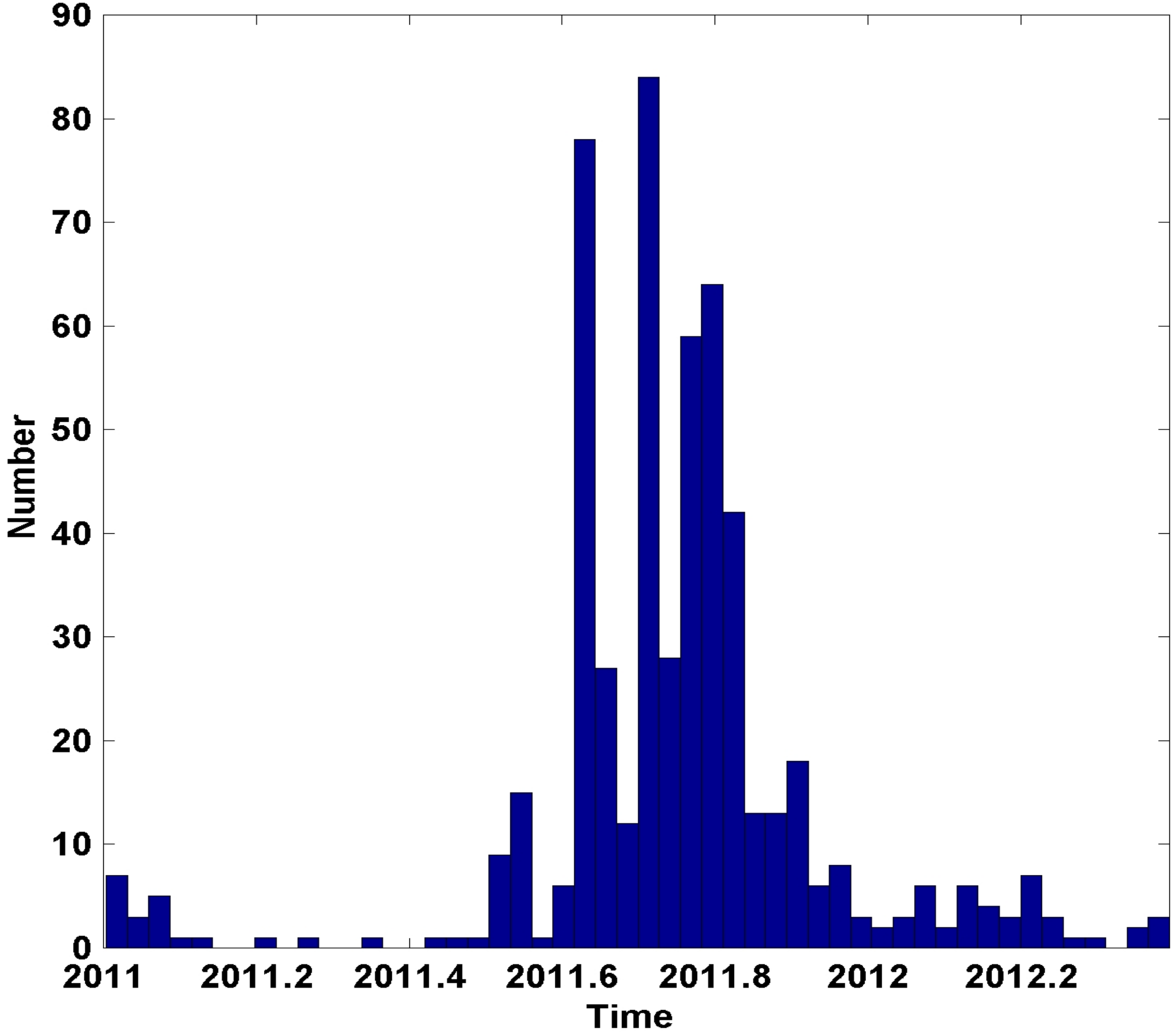
NOA Catalogue 2011 – 2012

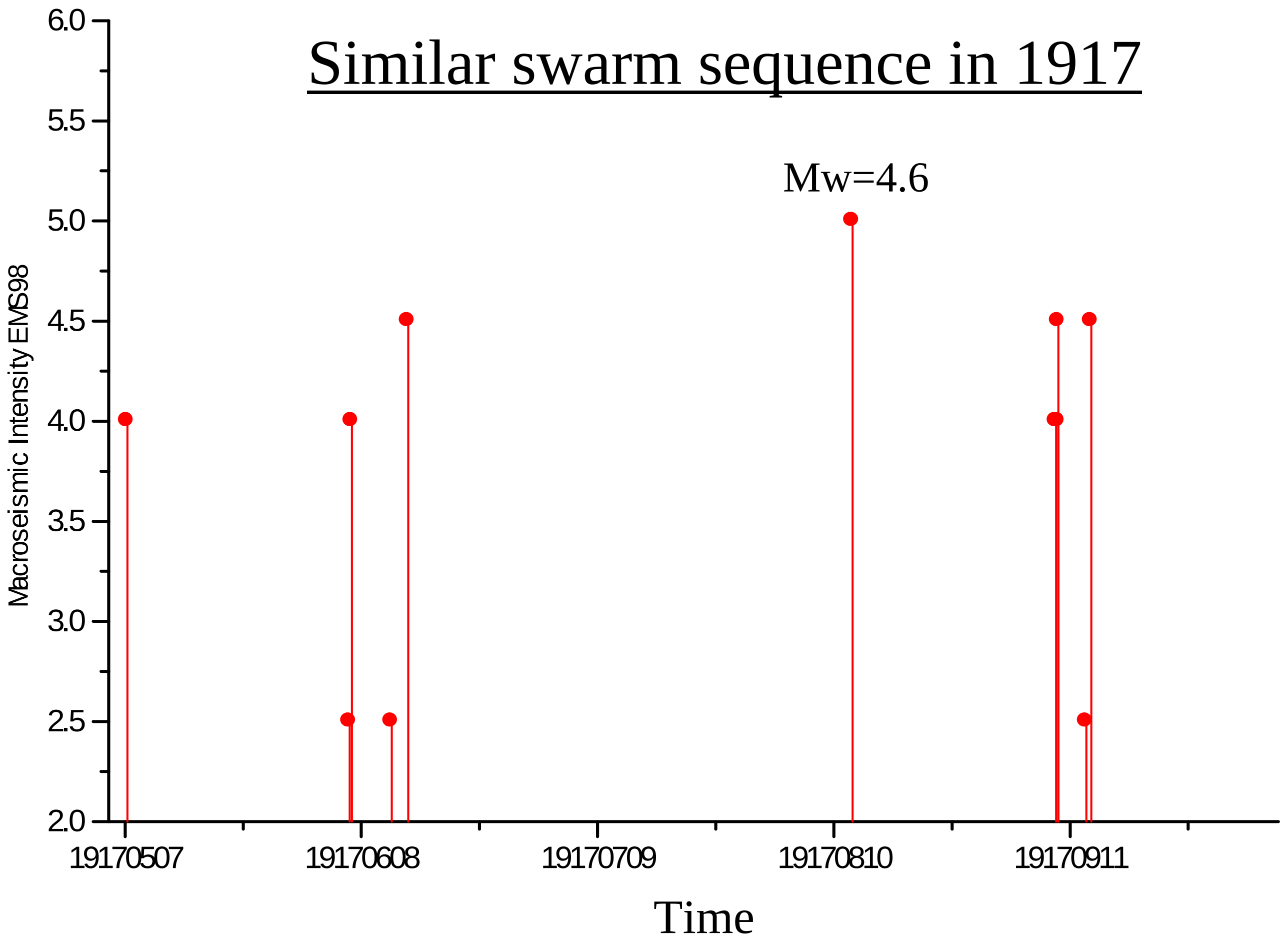


NOA Catalogue 2011 – 2012



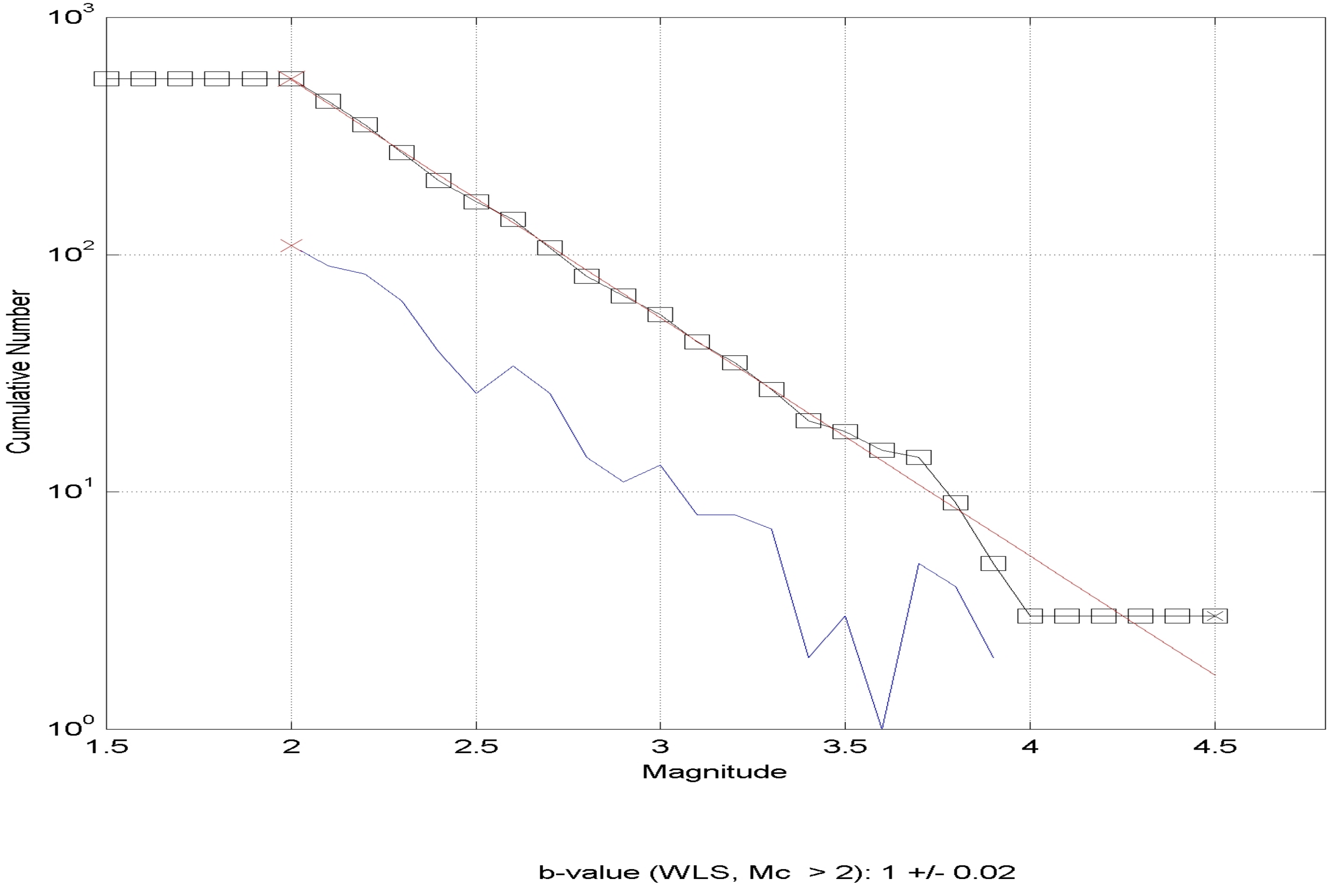
NOA Catalogue 2011 – 2012



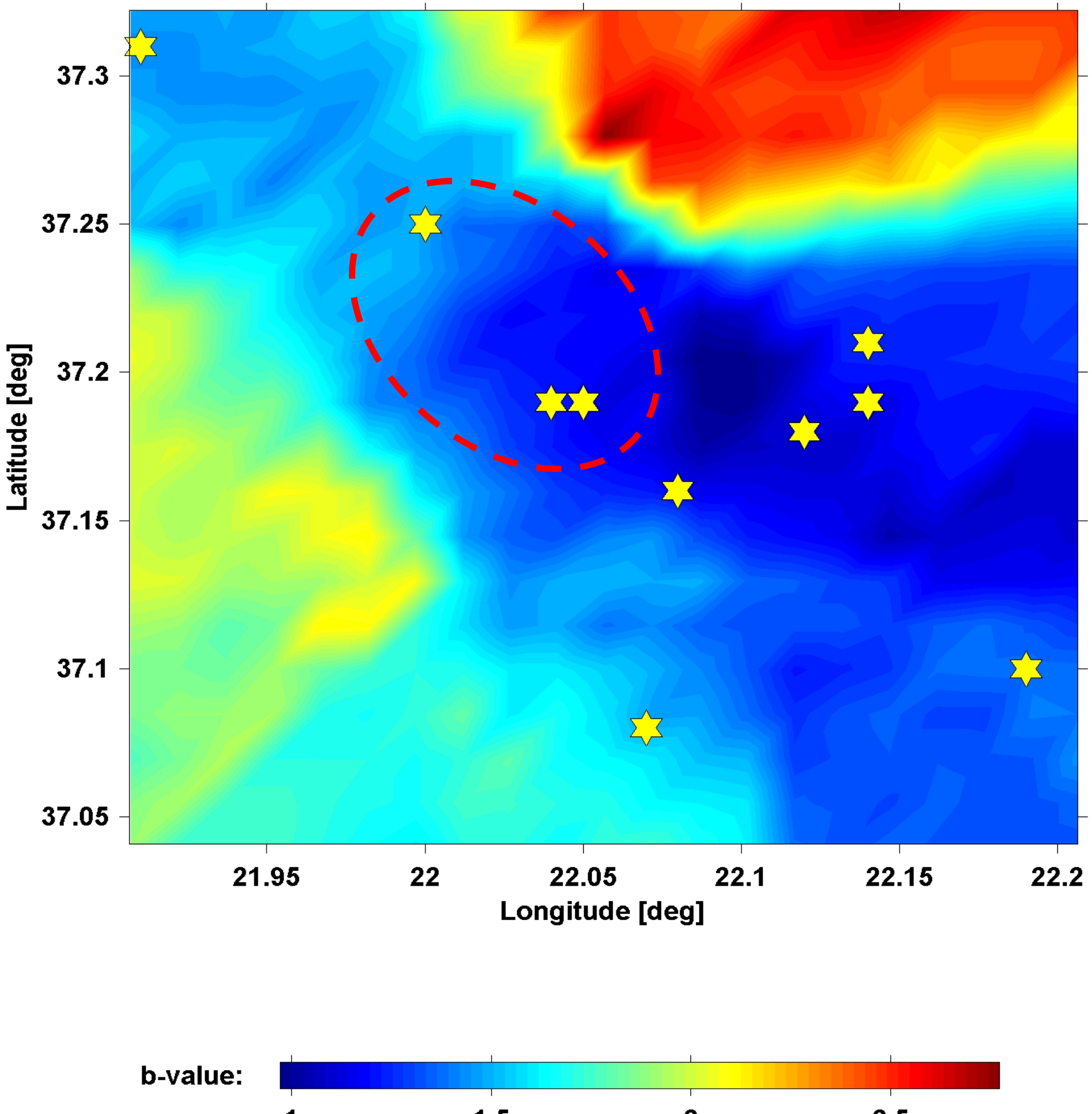


Similar swarm sequence in 1917
Mw=4.6
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
Macroseismic Intensity EMS98
19170507
19170608
19170709
19170810
19170911
Time

b-value, NOA Catalogue, 2011 - 2012

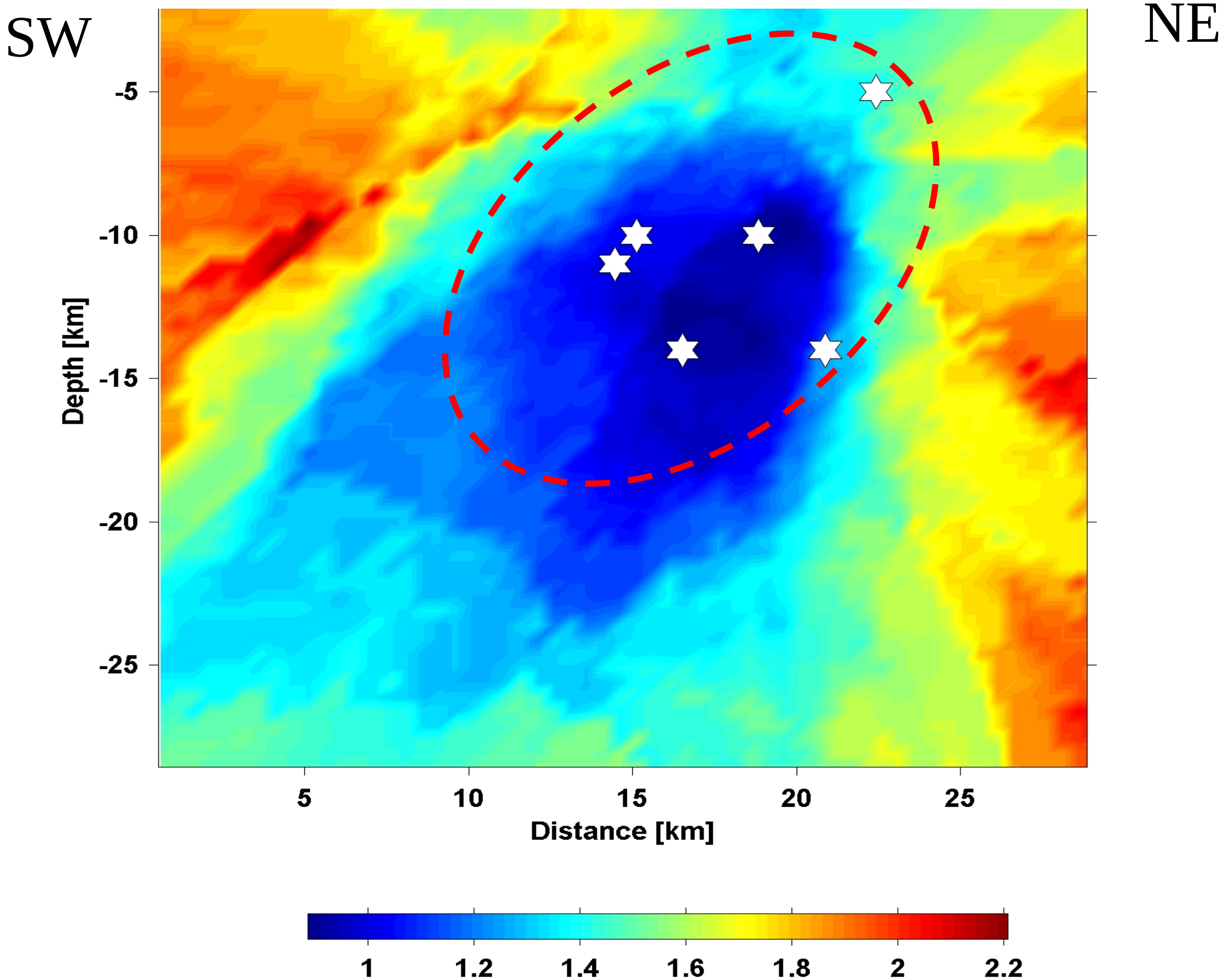


b-Value Profile, NOA Catalogue, 1964 – 2012



b-Value Cross Section (SW-NE)

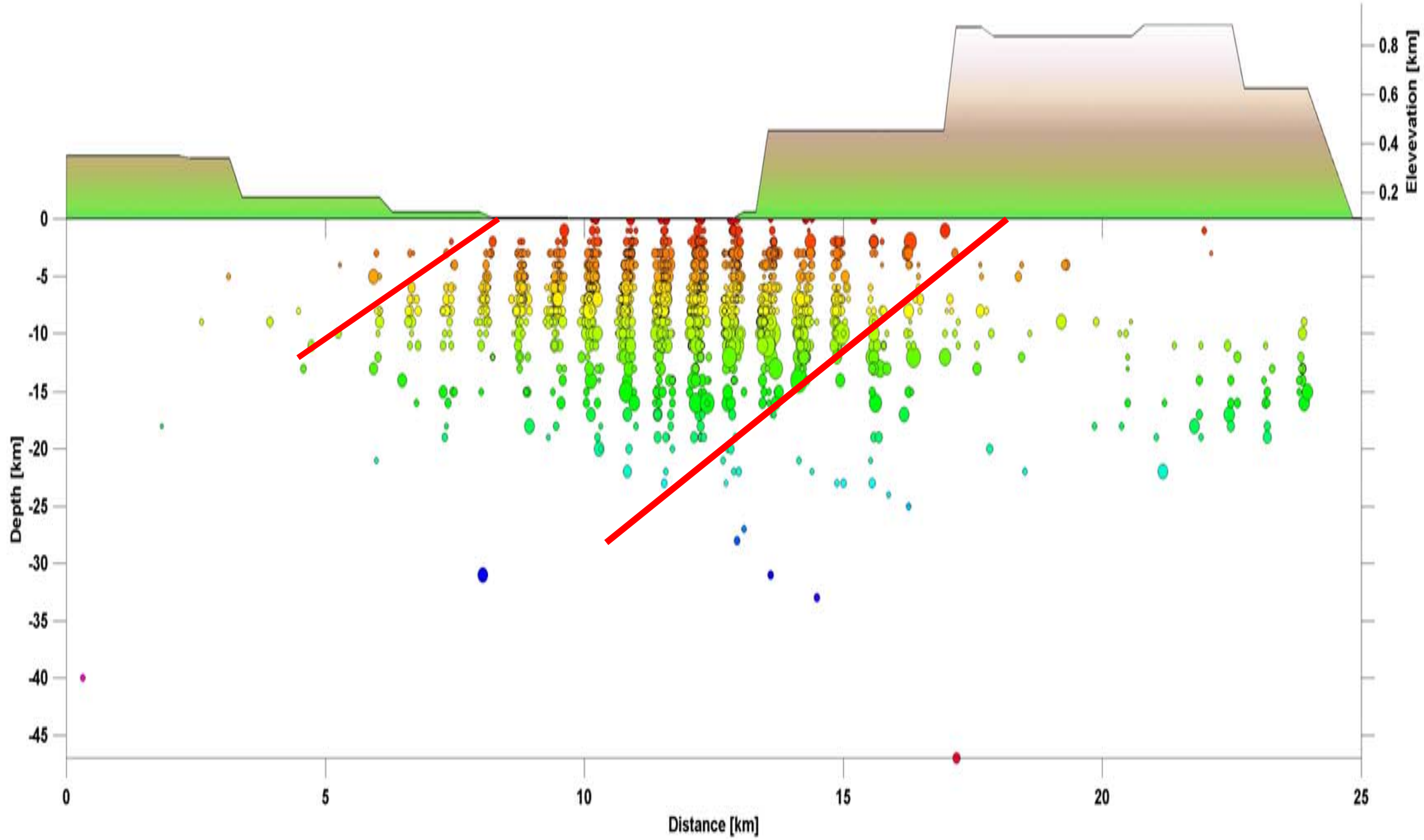
NOA Catalogue, 1964 – 2012



Cross Section SW-NE

NOA Catalogue 1964 - 2012

SW NE



Summary

- The area has suffered cumulative damages from previous strong earthquakes and the majority of houses and buildings have been constructed without earthquake resistant design.
- The instrumental seismicity catalog of NOA for this area does not report events larger than magnitude 5.5.
- A similar swarm occurred in 1917 lasting for many months, with a maximum magnitude of M=4.6.
- Aftershock relocations and the determined earthquake mechanisms reveal a normal fault plane striking N160^0 and dipping 50^0 WSW, parallel to the main tectonic structures of the area in the graben between Kyparisia Mt. and Taygetos Mt.
- Statistical analysis of NOA’ s earthquake catalog indicates that the strongest earthquakes of the area lie in a low-b value zone (high stress) trending NNW-SSW and dipping WSW which agrees with the determined fault plane orientation.
- The 2011 swarm appears to have penetrated a zone of higher b-values (low-stress) which has possibly acted as rupture propagation barrier in the past.
- The spatial mapping of b-values is a rich source of information about seismotectonics and may be used as a “ *stress meter* ” in earthquake hazard investigations.