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Source Parameters Determination for Earthquakes in Greece using Regional Data

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ABSTRACT

Many moderate size earthquakes occur in the broader area of Greece which are recorded by the Seismological Network belonging to the Department of Geophysics and Geothermics of the University of Athens. These records are combined with data recorded from other Institutes in order to calculate source parameters. An inversion approach is applied, using only good quality broadband data, in order to quickly calculate the focal mechanism, the moment magnitude and the source depth. By the time the waveforms are available and the epicenter is known, the inversion procedure can be performed in near real time. Most of the records are modeled using data coming from a significant number of three component stations. This fact is very significant as it allows succeeding the best possible azimuthal coverage which is a first priority in waveform inversion studies. More than 280 earthquakes have been processed during the time period from January 2003 to April 2008. Before 2003 there are no solutions since there are no available regional data. For the largest earthquakes the source parameters calculated with regionally recorded waveforms are compared with those obtained by teleseismic results and are in good agreement. The catalogue and the inversion figures are available through the site of the Department of Geophysics and Geothermics.

Data Used and Inversion Method followed

In the present study synthetics for regional distances were generated using the reflectivity and frequency wavenumber summation technique proposed by Zeng and Anderson (1995). This code is based on the generalized reflection and transmission coefficient method and computes 10 fundamental green functions as it is described by Herrmann and Wang (1985). The methodology computes differential seismograms directly in a layered elastic half-space. First the medium velocity differential field is computed with respect to the velocity change in the layer and then it is multiplied with the original elastic wave field. The obtained differential waves propagate directly to the receiver using the generalized R/T matrix method. The synthetics are calculated using the discrete wavenumber summation and imaginary frequency technique (Bouchon, 2003). Then the 10 green functions are combined and produce the 3 components of motion: the tangential, radial and vertical component, as proposed by Jost and Herrmann (1989). The inversion of the waveforms is performed using the codes of Ichinose et al. (2003).

The obtained deviatoric moment tensor is decomposed in two parts: the Double Couple component and the CLVD. For the selected earthquakes we retrieved waveforms at epicentral distances of 0º – 10º with good signal to noise ratio. In the inversion approach data from the new seismological network of the University of Athens were used combined with data from stations operated by the Universities of Patras and Thessaloniki, Mednet, NOA, and Geofon. The selection of the original waveforms was always influenced by the factor that the selected data should be able to provide the best possible azimuthal coverage needed for waveform modeling. In all the studied events we used at least two stations, minimizing the effect of the uncertainty of the velocity model used along one single ray path. In many cases with good quality data more than 7 stations were used. The station identification codes, locations and instrument corrections are available on the Internet.

The next step after the data were downloaded was the instrument response correction. Next, the waveforms were integrated in order to produce pure displacement. The regional broad-band data were band-pass filtered in frequencies between 0.01-0.05 Hz for events with Mw > 5.0 and 0.02-0.05 Hz for events with Mw < 5.0. Horizontal components were rotated to radial and transverse. The three displacement components were cut in the same starting time (nearly 10 sec before the first arrival).

The results of the moment tensor inversion (Agalos et al., 2007), combined with maps are available on line through the www.geophysics.geol.uoa.gr site.

References

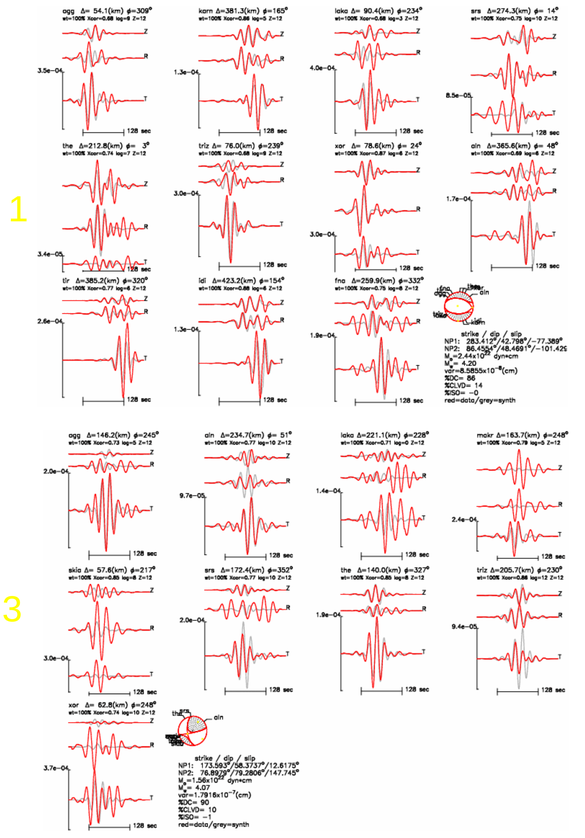
1) Agalos, A., Papadimitriou P., Voulgaris, N. and Makropoulos K. (2007). Source Parameters Estimation from Broadband Regional Seismograms for Earthquakes in the Aegean Region and the Gorda Plate. *Bulletin of the Geological Society of Greece, XXXX, 1032-1044.*
2) Bouchon, M., (2003). A review of the discrete wavenumber method, *Pure appl. geophys. 160, 445–465.*
3) Herrmann, T. and Wang, G. Y., (1985). A comparison of synthetic seismograms, *BSSA, 75, 41-56.*
4) Ichinose, Gene A., Anderson, John G., Smith, Ken D., and Zeng, Yuehua, (2003). Source parameters of Eastern California and Western Nevada Earthquakes from regional moment tensor inversion, *BSSA, 93, 61–84.*
5) Jost, M. L. and Herrmann, R., (1989). A student's guide to and review of moment tensors, *Seism. Res. Lett., 60, 37-57.*
6) Zeng, Y., and Anderson, J. G., (1995). A method for direct computation of the differential seismogram with respect to the velocity change in a layered elastic solid. *BSSA, 85, 300–307.*

Focal mechanism solutions for small earthquakes

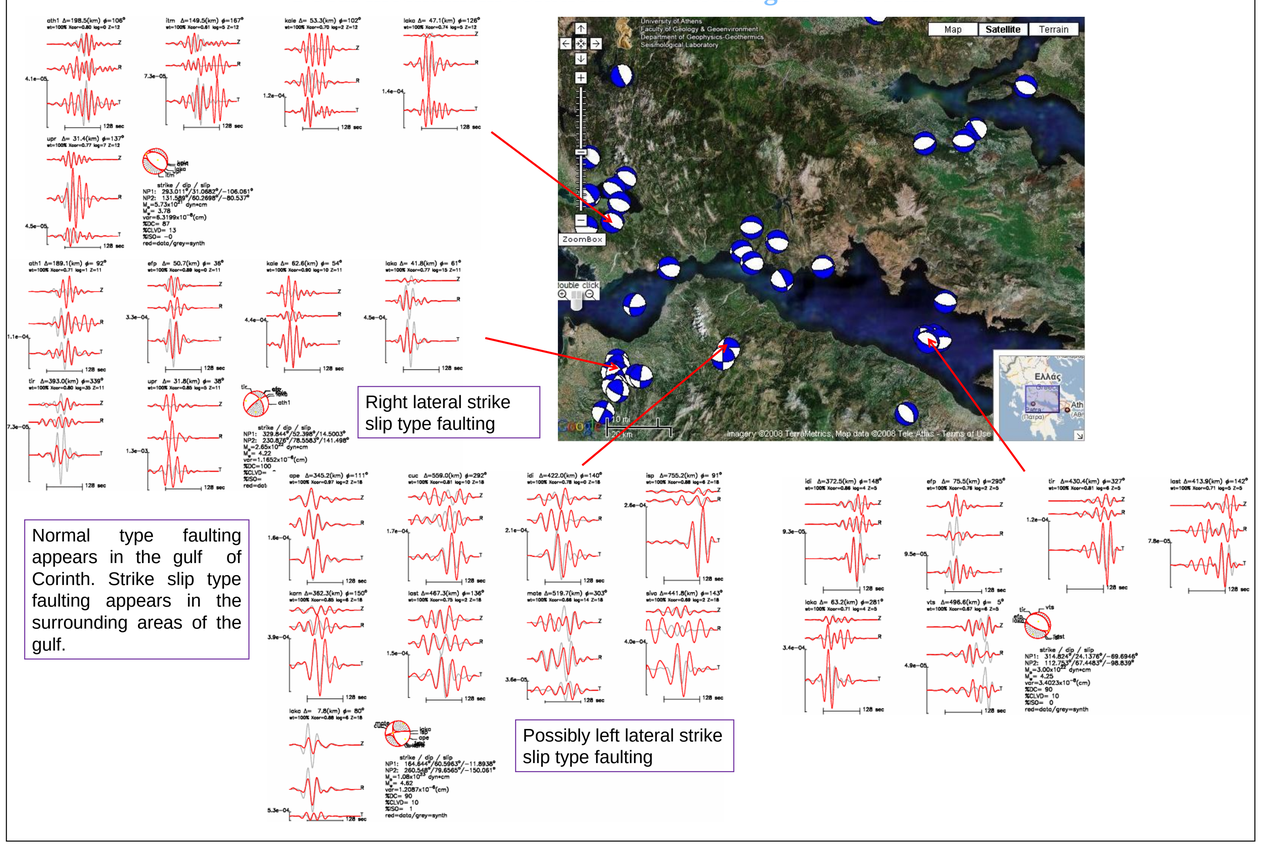
(1) Focal mechanism solution indicating normal type faulting for an earthquake of magnitude Mw=4.2 that occurred at 2008/06/25 near the town of Ag. Konstantinos, northwestern of Athens.

(2) Focal mechanism solution indicating right lateral strike slip motion for an earthquake of magnitude Mw=4.2 that occurred in the Northwestern part of Turkey at 2008/07/10

(3) Focal mechanism solution indicating right lateral strike slip motion for an earthquake of magnitude Mw=4.1 that occurred in the Northern Aegean Region at 2008/08/03

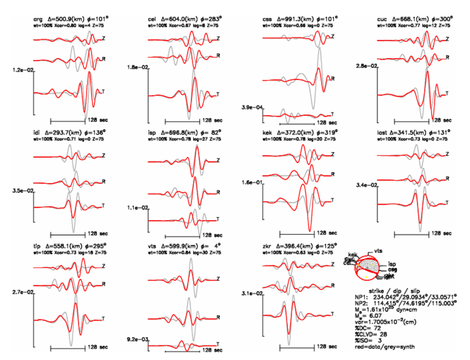


Focal mechanism solutions close to the gulf of Corinth

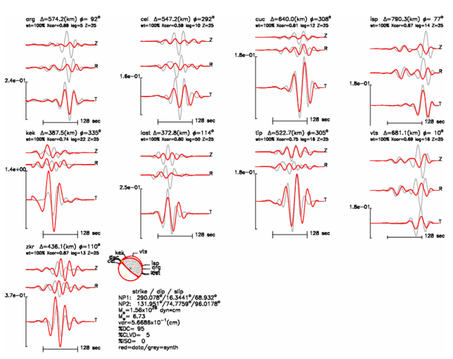


Recent Significant Earthquakes

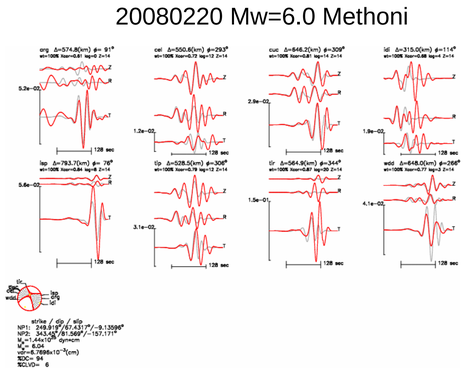
20080106 Mw=6.1 Leonidio



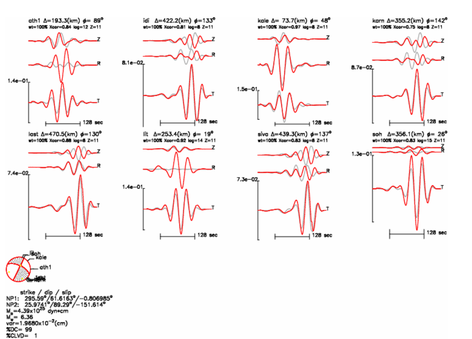
20080214 Mw=6.7 Methoni



20080220 Mw=6.0 Methoni

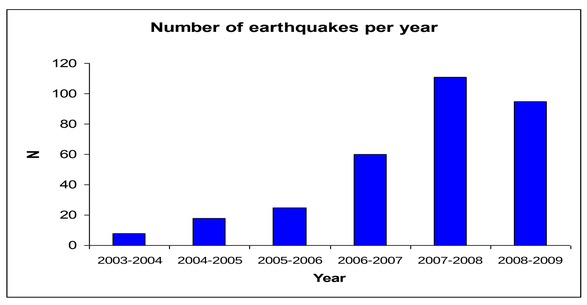


20080608 Mw=6.4 Andravida

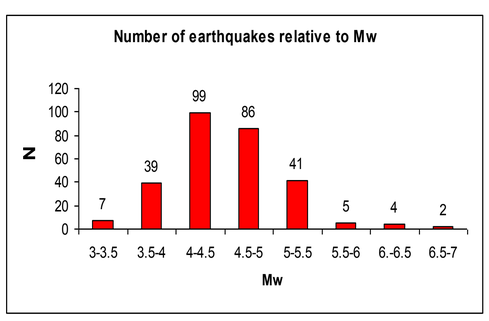


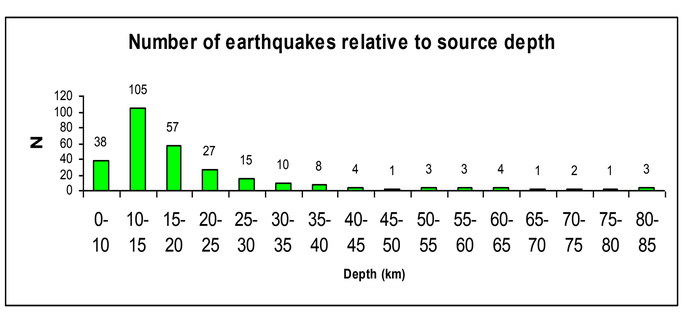
Statistics Results

Source parameters were calculated for 283 moderate size, mainly, earthquakes that occurred during the time period from June 2003 to April 2008 (time period of available recordings for moderate events). Before 2003 there were no available regional waveforms. Source parameters of 111 earthquakes were calculated between 2007-2008 but until July 2008 more than 90 events were modeled.



As it is presented in the next diagrams most of the studied earthquakes were of magnitude between 4 <Mw < 5 and at focal depths between 10 and 20 km. Usually earthquakes with magnitude smaller than Mw=4 had low signal to noise ratio and could not be modeled.



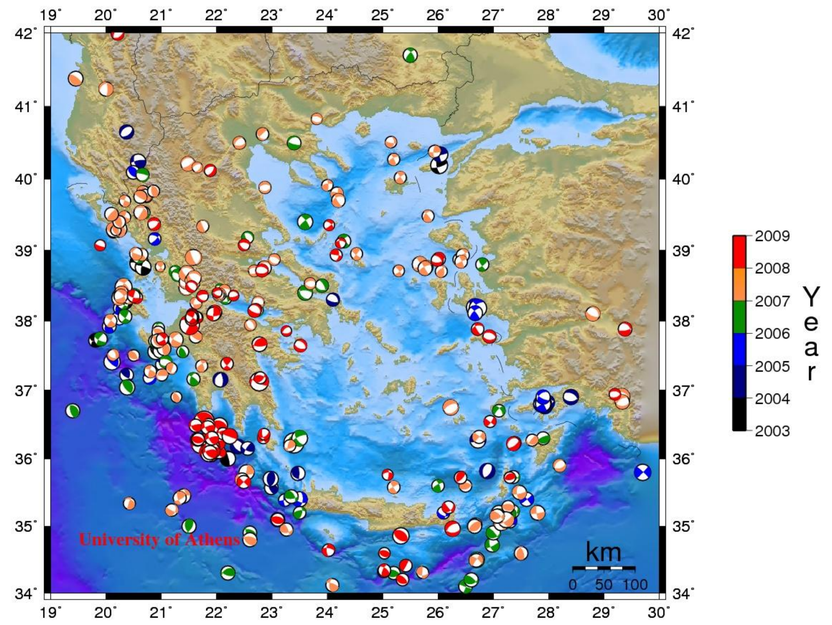


Moment Tensor Solutions for the time period 2003-2008

Results

Using the above mentioned methodology the following results were obtained:

- 283 focal mechanism solutions were calculated during the time period 2003-2008.
- The good quality of the solutions is succeeded using data from local and regional networks. For small earthquakes, data from at least three stations (3 component) were used, while usually more than 6 for stronger ones. The use of local data permits the calculation of moment tensor solutions for small events with Mw < 4. In most of the solutions the Double Couple component is high.
- Different type of mechanisms are constrained that can be related with the seismotectonic characteristics of the regions where they occurred.



Focal mechanism solutions during the time period 2003-2008. The color bar of the focal mechanisms represents the occurrence time of the earthquake.