Mechanism: Full Moment Tensor user guide

The program performs inversion of amplitudes of longitudinal (P) and transversal (S) seismic waves as 3-component vectors into the mechanism of the seismic source in the description of unconstrained moment tensor (MT). As such, it allows describe general dipole sources including isotropic components: e.g., it is suitable to retrieve the parameters of both a shear dislocation common at foci of tectonic earthquakes (described as a double-couple, DC) and volumetric sources as tensile cracks or cavity implosions. It provides the MT error estimate: evaluates the data covariance matrix based on standard deviations of individual components of P and S motion.
The application is designed preferentially for processing of seismic events induced by industrial activity (mining, hydro-fracture test in geothermal and oil wells etc.).

open in IS-EPOS PLATFORM

REFERENCES

CATEGORY Source Parameter Estimation

KEYWORDS Seismic event mechanism, Linear inversion of P an /or S amplitudes, Full moment tensor, Decomposition into elementary components

CITATION Please acknowledge use of this application in your work: IS-EPOS. (2019). *Moment Tensor - Single* [Web application]. . Retrieved from https://tcs.ah-epos.eu/

Introduction

The application 'Mechanism: Full Moment Tensor' inverts amplitudes of P and/or seismic phases complemented with the polarity signs, i.e. the particle motion vectors, into the mechanism in the standard moment tensor description (see, e.g., Aki, K., & Richards, P. G., 2002. *Quantitative seismology*. University Science Books). In the current implementation, it is joined with the application reading a seed file and picking the amplitude. If the seismograms processed represent velocity records, we need to pick the amplitude at each station in the peak-to-peak manner, i.e. from first peak of the phase to the second one, see Figure 1.

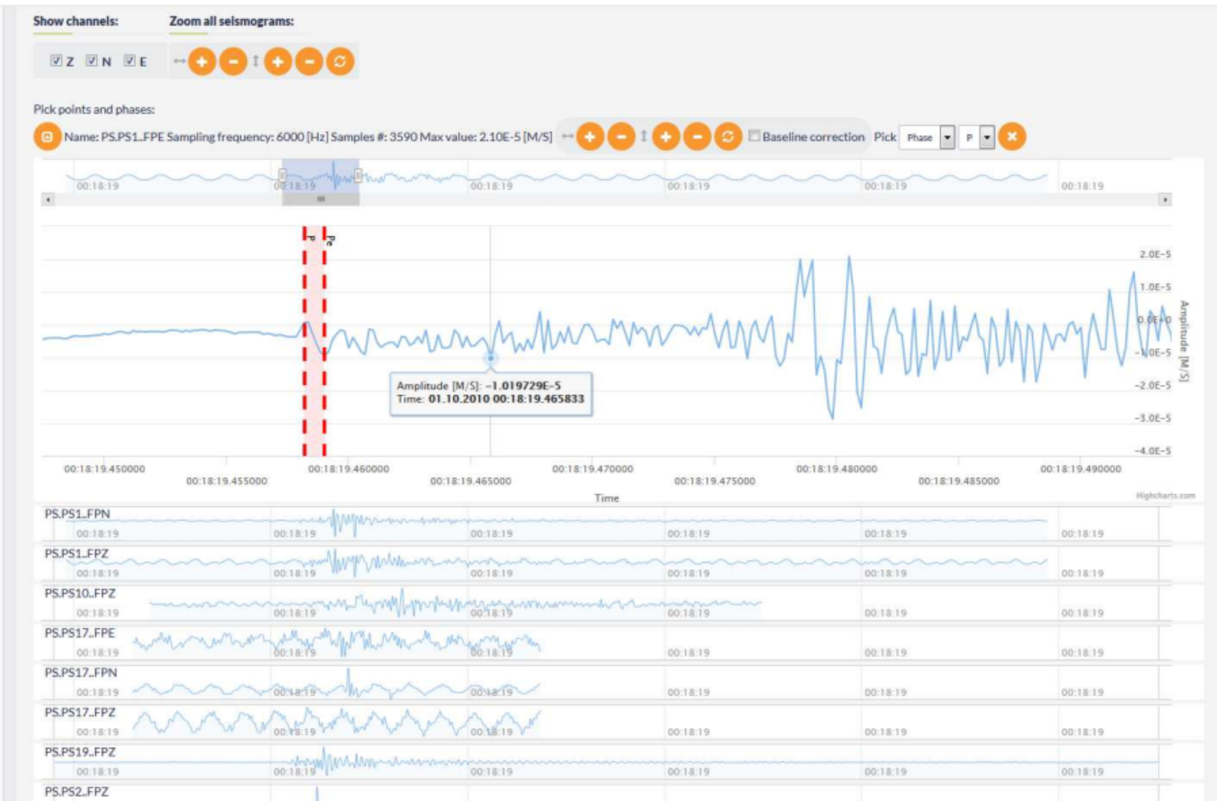

Figure 1. Example of picking of the amplitude of the P-wave from a velocity record.

The more data available, the more is the inverse task constrained. Therefore, it is reasonable to pick amplitudes from all the components of 3-component records. If however some of the components are not of sufficient quality, it is possible to skip them.

The unconstrained MT is the most comprehensive description of shear and non-shear sources and is the body force equivalent of a rupture that generates the same wave field in a continuous medium as an actual rupture. Thus, the MT is not a physical source but a substitute for real processes occurring within the focus. As a system of body forces, the MT is not a priori convenient for offering simple insight into processes within an earthquake focus. Therefore, it is generally decomposed into simple sources. The method of decomposition is not unique. The most common and widely used procedure is one that splits the general MT into isotropic and deviatoric portions (unique), and then splits the deviatoric portion into a double couple (DC) and a compensated linear vector dipole (CLVD) with a common major tension or pressure axis that is ambiguous (e.g., Julian, B. R., Miller, A. D., & Foulger, G. R., 1998. Non-double-couple earthquakes 1. Theory. *Reviews of Geophysics*, *36*(4), 525–549. https://doi.org/10.1029/98RG00716). Thanks to its generality, the MT is relevant to the fracturing of a solid body, including all of the modes of fracturing recognized within fracture mechanics and their combinations. However, since the MT does not describe the rupture itself but rather body force equivalents of actual rupturing, it also includes mechanisms that do not generally represent realistic physical sources. In other words, sometime the MT is needlessly general. In addition to rupture mode I (tensile fracturing) and rupture modes II and III (plane and anti-plane shear slip), combinations of forces that do not correspond to a physically feasible rupturing are also present. Therefore, for the simple rupturing expected within the foci of tectonic or induced earthquakes, the MT is unnecessarily complex, leading to more parameters than those relevant to simple rupture models. The principal advantage of the full MT approach is the linearity of the inverse task.

Each source mechanism inversion needs the knowledge of the response of the medium, the Green's function. It is a characteristics of the material of the zone depending, in addition, of the configuration of the source and the recording stations. Positions of the stations are obtained from the seed file of the records, coordinates of the source – the hypocenter – must be filled into the table: the latitude, longitude and the depth (Figure 2). For complex structures the evaluation of the Green's function may be difficult. For the sake of simplicity, here we apply the simplest model of the rock mass, namely an isotropic homogeneous medium described by the P and S wave velocities and its density. Regardless its triviality, it may be a good approximation for local underground configurations. The corresponding values of the velocities and the density should be put into the input table (Figure 2). The scaling factor serves for an optional modification of the orders of the Green's function throughout the inversion, the value 1 means no modification of the evaluated Green's function entering the inversion.

Step by Step

After the User adds the Application into his/her personal workspace, the window as shown in Figure 2 appears. The following files are necessary:

- *MiniSEED Waveform*
- *Network inventory*

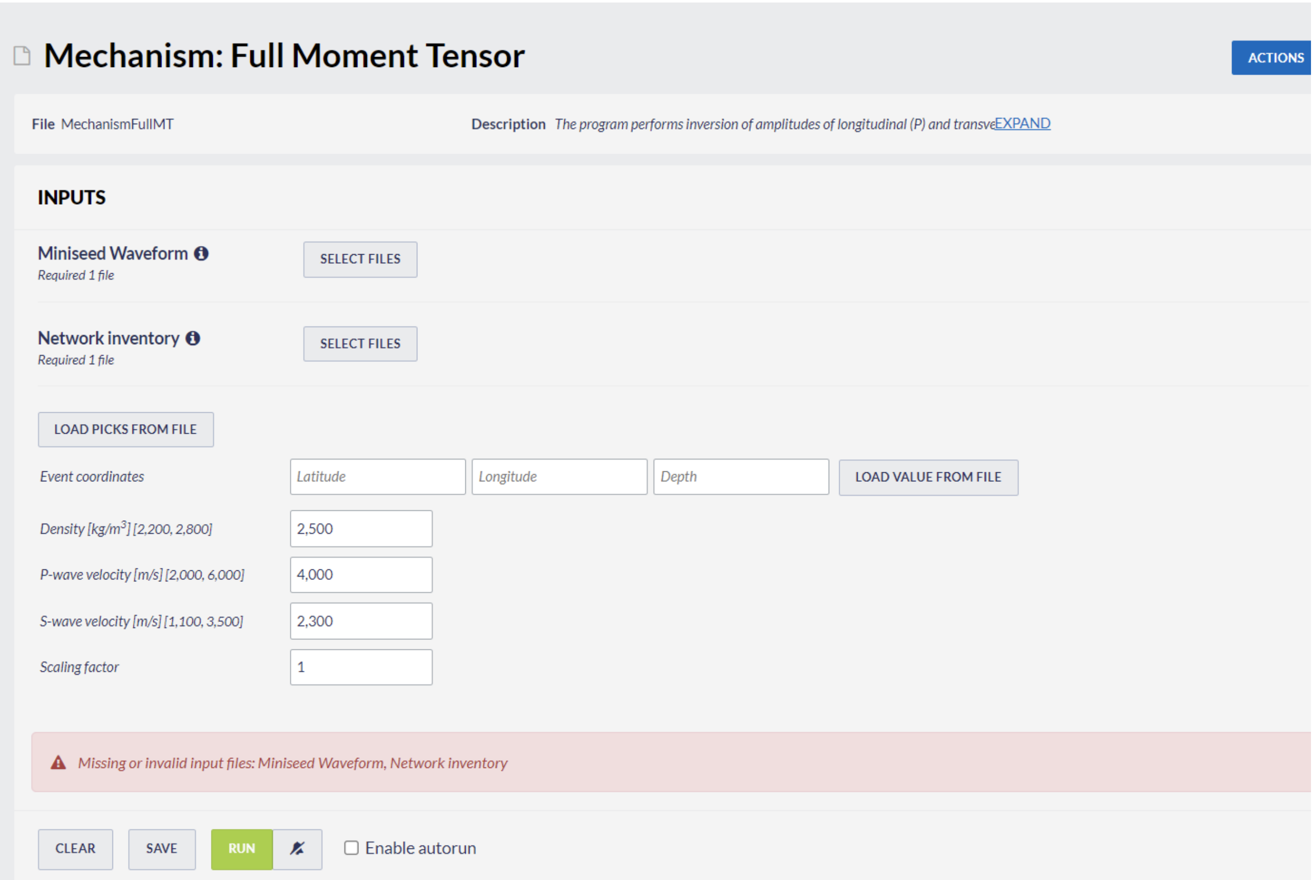

Figure 2. Input window of the "Mechanism: Full Moment Tensor" application.

For more thorough instructions regarding uploading necessary files, loading picks from file and picking see FOCI user guide.

The outputs of the application are presented in four sets:

(1) The match of the synthetic amplitudes generated for the resolved MT mechanism to the data at individual stations and components is presented in Figure 3.

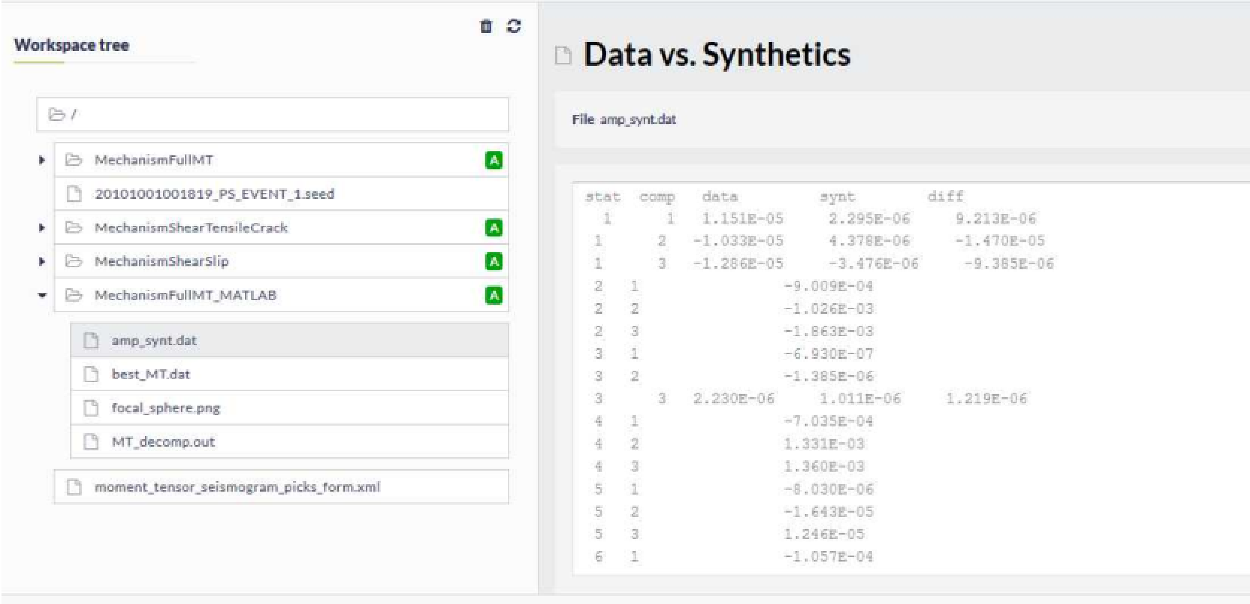

Figure 3. Comparison of synthetic amplitudes and the input data.

(2) The output values of the resolved MT components M_{11}, M_{12}, M_{13}, M_{22}, M_{23} and M_{33}, together with the normalized root mean square value describing the success of the inversion (the value 0 means the perfect fit of the synthetic amplitudes to the data, value 1 no fit), Figure 4.

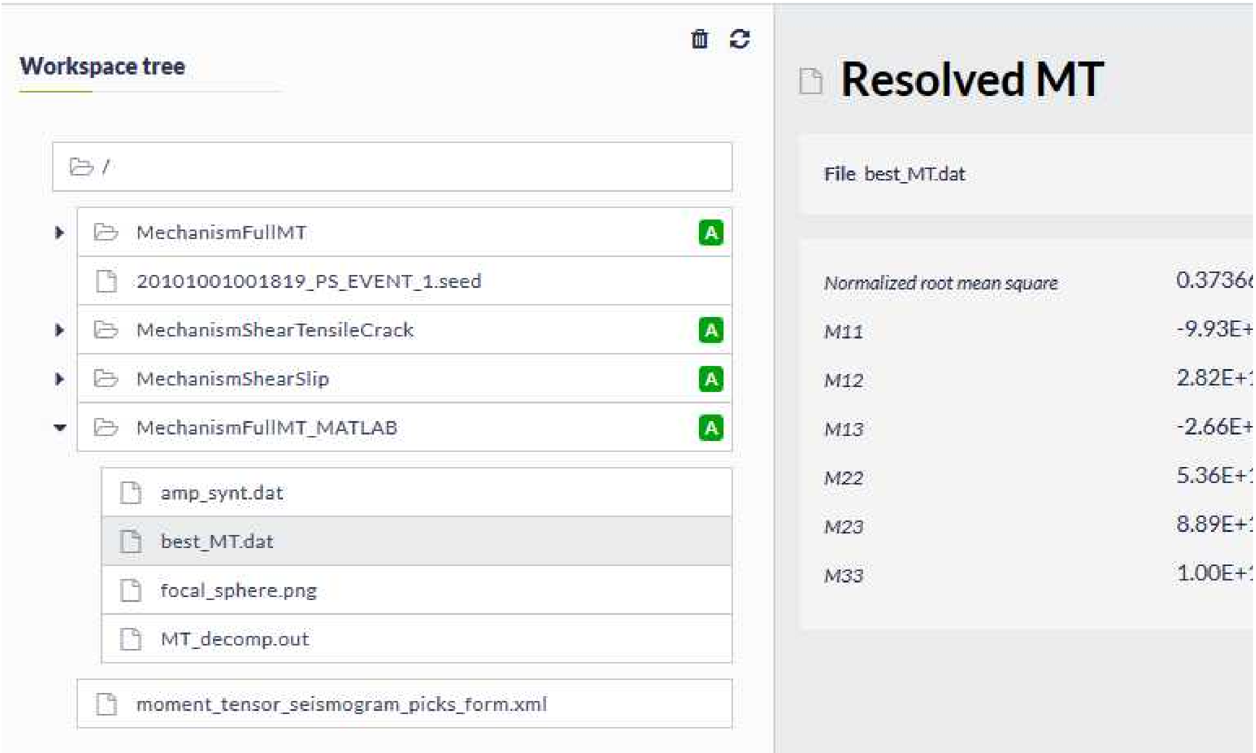

Figure 4. Resolved values of the moment tensor components.

(3) The plot of the mechanism in the traditional form of the display of zones of compression of the P-waves generated by the resolved mechanism (generalized "beach ball"), Figure 5.

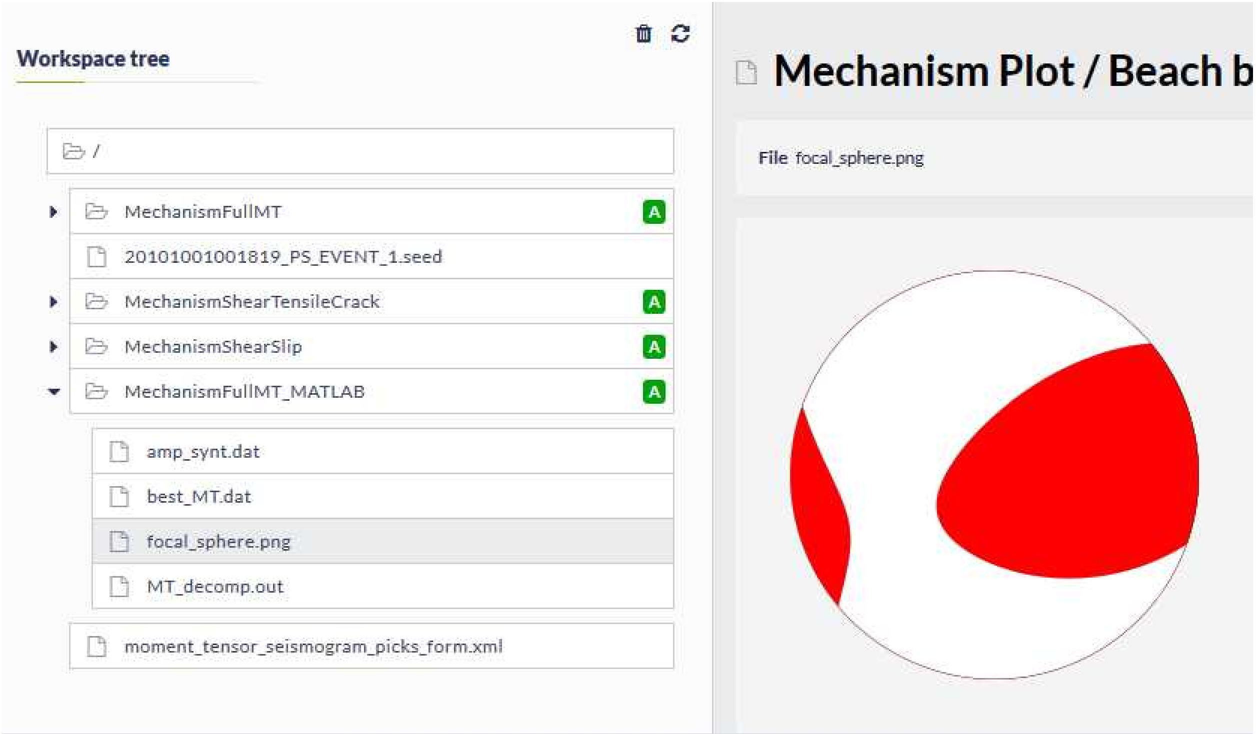

Figure 5. Plot of the mechanism in the generalized form of the traditional "beach ball".

(4) The decomposition of the moment tensor corresponding to the resolved STC mechanism into the volumetric (isotropic) component (V), the double-couple component (DC), and the compensated linear-vector dipole (CLVD). In addition, two equivalent sets of the dip, strike and rake angles corresponding to the resolved DC are presented (Figure 6).

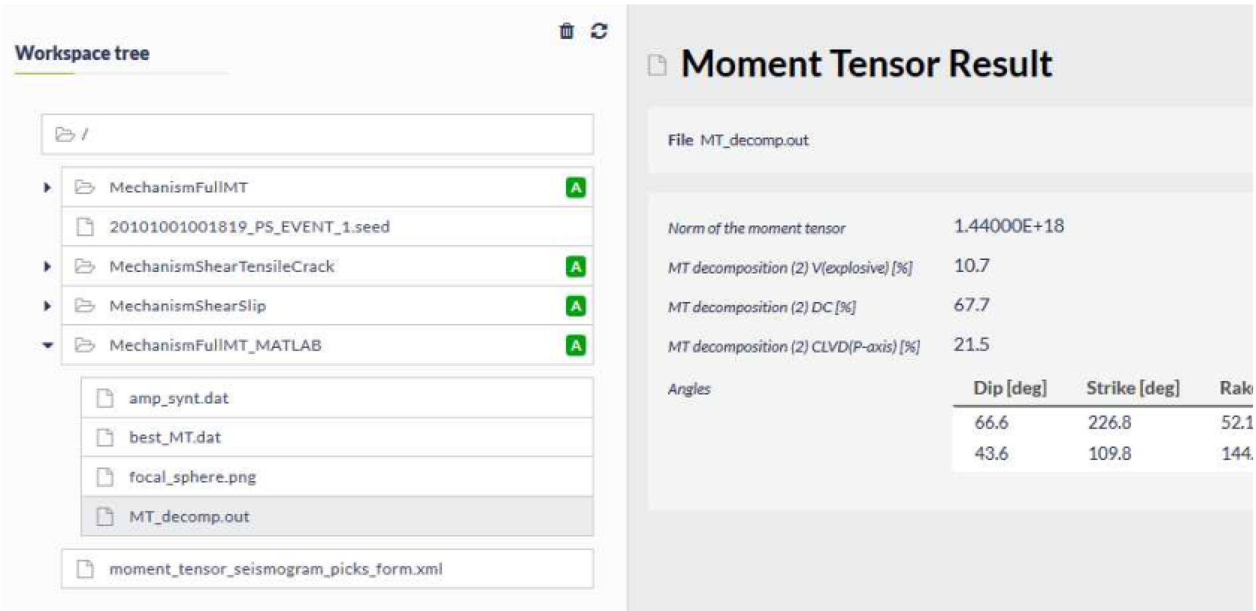

Figure 6. Decomposition of the resolved moment tensor.

Back to top

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