EVALUATING UNCERTAINTY IN THE DETERMINATION OF EARTHQUAKE MECHANISMS IN CENTRAL ZAGROS

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The Zagros mountain belt in southwestern Iran has resulted from the collision of Arabian Plate with the continental crust of Central Iran after the closure of the Neotethys Ocean. The region referred as central Zagros of Iran in this study includes the area located between 50°-55° longitude and 26°-30° latitude.

We present a new approach to resolve the isotropic component of the seismic moment tensor and its uncertainty. The methodology used is similar to iterative deconvolution technique, often used in teleseismic studies, but here adjusted for regional and local distances. The new version of ISOLA offers a special tool for this purpose (Sokos and Zahradnik, 2013).

We compute the uncertainty of the moment tensor, M, then map it into uncertainties of the strike, dip, and rake. The inputs are: source and station locations, crustal model, frequency band of interest, and an estimate of data error. The output is a six-dimensional (6D) error ellipsoid that indicates the uncertainty of the individual parameters of M. A dense network is able to resolve M well despite the large azimuthal gap. The moment tensor, M, describes any source of deformation in an elastic medium in terms of force couples.

All these methods provide families of acceptable solutions without specifying absolute confidence intervals. In this study we obtain an estimate of the uncertainty of M and then map the uncertainty of M into uncertainties of strike, dip, and rake. This method does not need the actual computation of synthetic ground motion; it is actually based on the analysis of the Green's functions.

We demonstrate how to compute the resolvability of the model parameters. We also show how these values can explain uncertainties of strike, dip, and rake. All over this paper we will present uncertainty regions, or error ellipsoids, rather than confidence regions as strictly defined in a statistical sense.

The errors of the model parameters σ (m) depend individually on the Green's functions G, on the data variance σ2d, and on the chosen Δχ2. In fact, the orientation and shape in model space of the error ellipsoid is estimated from the eigenvectors and eigenvalues of the matrix GTG. Data variance (σ2d) and Δχ2 scale the size of the ellipsoid. For a value of data error, the larger Δχ2 is, the larger the error ellipsoid and the more solutions are considered acceptable. In order to compute the error of the model parameters σ (m), we require the following information: station coordinates, location of the earthquake (epicenter and depth), crustal model and frequency band, an estimate of data error (σd), and a choice of Δχ2 (Zahradnik and Custodio, 2012).

We now present examples of the assessment of DC uncertainty for earthquakes in Central Zagros. The region is characterized by events of different focal mechanisms that generally occur at depths up to 20 km.

Table 1. The earthquake source parameters from waveform modelling which obtain in this study (N.S: number of station that used)

#	YYYYM MDD	Hour	Minute	Second	Lat. (deg)	Long. (deg)	Depth (km)	Mw	N. S.	F1 (Hz)	F2 (Hz)	F3 (Hz)	F4 (Hz)	S1 (deg)	D1 (deg)	R1(deg)	P-A (deg)		T-A (deg)	
																	Az	Pl	Az	Pl
1	20130409	16	32	32	28.50	51.70	17	4.6	4	0.04	0.05	0.08	0.09	62	49	4	24	26	278	30
										0.055	0.06	0.07	0.075				243	12	99	76
3	20130410	01	00	20	28.38	51.73	11	4.7	9	0.04	0.05	0.06	0.07	327	77	162	15	3	283	22
4	20130410	12	40	16	28.35	51.60	12	4.4	11	0.04	0.05	0.08	0.09	336	88	164	23	10	291	13
5	20131128	15	56	43	29.30	51.33	10	4.2	5	0.03	0.04	0.05	0.06	33	74	172	258	6	350	16
6	20140109	08	31	29	26.75	53.93	10	4.8	7	0.03	0.035	0.055	0.06	115	57	115	188	8	76	68
7	20121010	16	56	33	29.33	52.54	11	4.8	7	0.035	0.04	0.065	0.07	309	50	112	23	3	284	73
8	20130409	14	44	52	28.5	51.62	14	4.6	9	0.03	0.04	0.05	0.06	156	56	104	236	10	105	74

For 8 of the earthquakes in central Zagros, deviatoric moment tensor was inverted by using broadband data recorded by International Institute of Earthquake Engineering and Seismology (IIEES), Iranian Seimological Center (ISC) and Incorporated Research Institutions for Seismology (IRIS) Network. Figure 3 shows a map of the studied area, displaying the focal mechanisms.

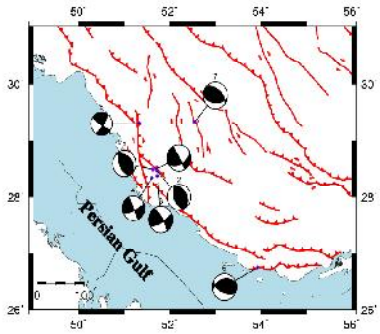
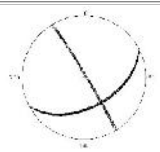
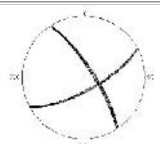
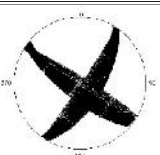
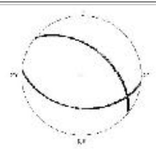
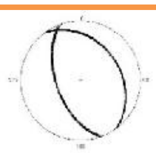
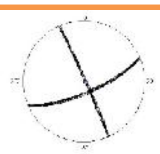
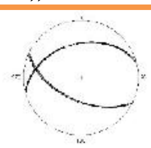
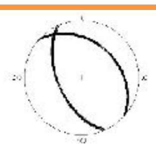


Figure 1. Map of the focal mechanisms

To check whether our blind guess of reliable focal mechanisms is good we adopt a criterion that the deviation between the best-fit solution and the reference solution is characterized by a K-angle <15°. The new version of ISOLA offers a special tool for this purpose.

Table 2. The same results plotted using the more familiar nodal lines

 K_{mean}=0.92 1))20130409	 K_{mean}=1.08 3))20140410	 K_{mean}=8.34 5))20131128	 K_{mean}=0.78 7))20121010
 K_{mean}=0.85 2))20130409	 K_{mean}=1.06 4))20130410	 K_{mean}=0.84 6))20140109	 K_{mean}=1.1 8))20130409

Our uncertainty analysis also indicates that, if more stations are available, the resolvability of the events can be as good as that of the event using less stations. A good azimuthal coverage is useful, but not always strictly necessary. More important than azimuthal coverage is a good S/N ratio in a sufficiently broad frequency band.

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