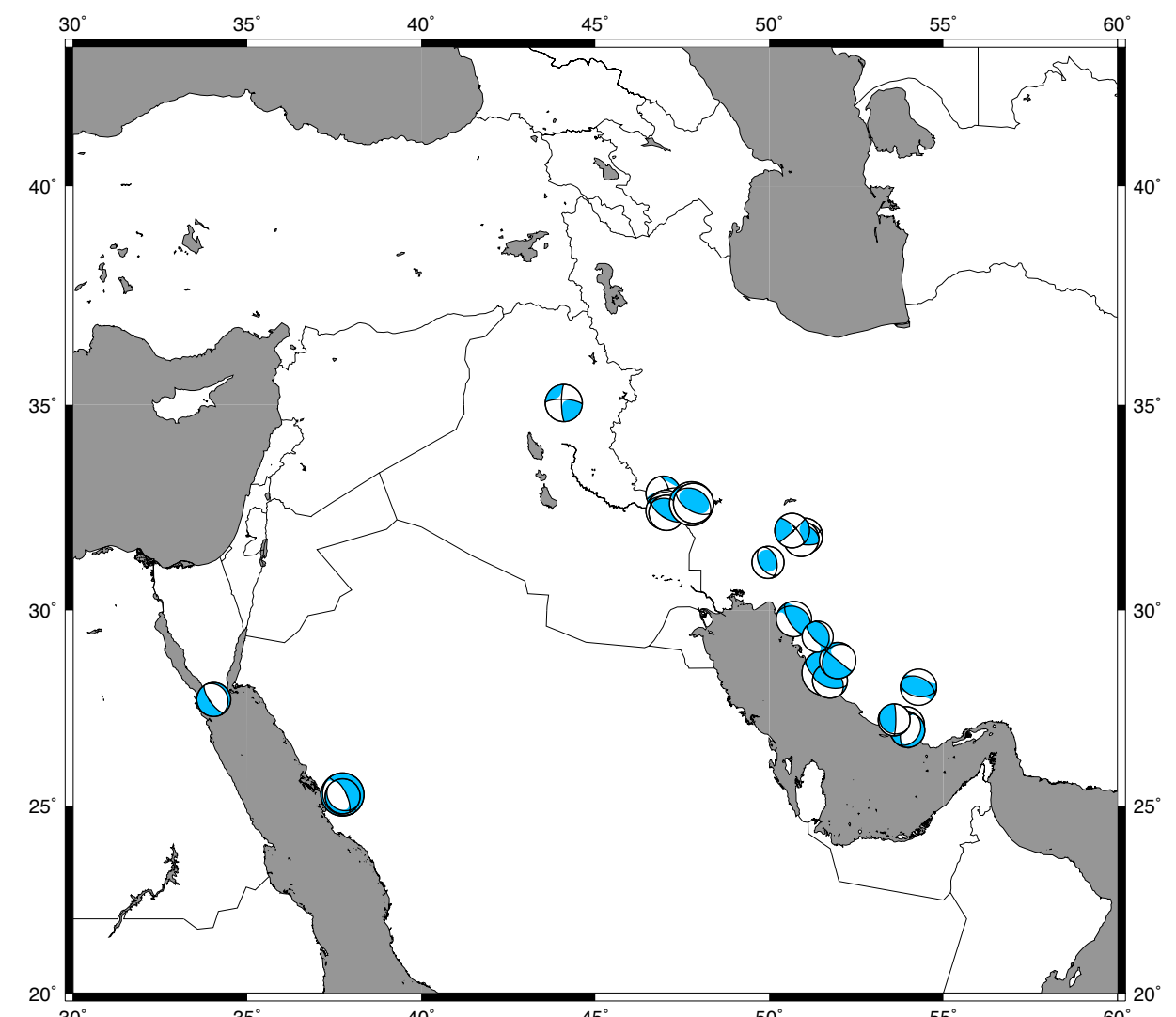




The use of regional distance long-period, complete waveform data to determine the seismic moment tensor is now a routine and reliable approach in determining the source mechanism of natural and manmade seismicity and may be used to identify or discriminate different types of seismic sources. Such source-type identification is important for better understanding the physics of earthquakes, geothermal and volcanic seismicity, seismicity in ice, as well as seismicity induced by anthropogenic activities such as mining, oil and gas operations, and explosions.

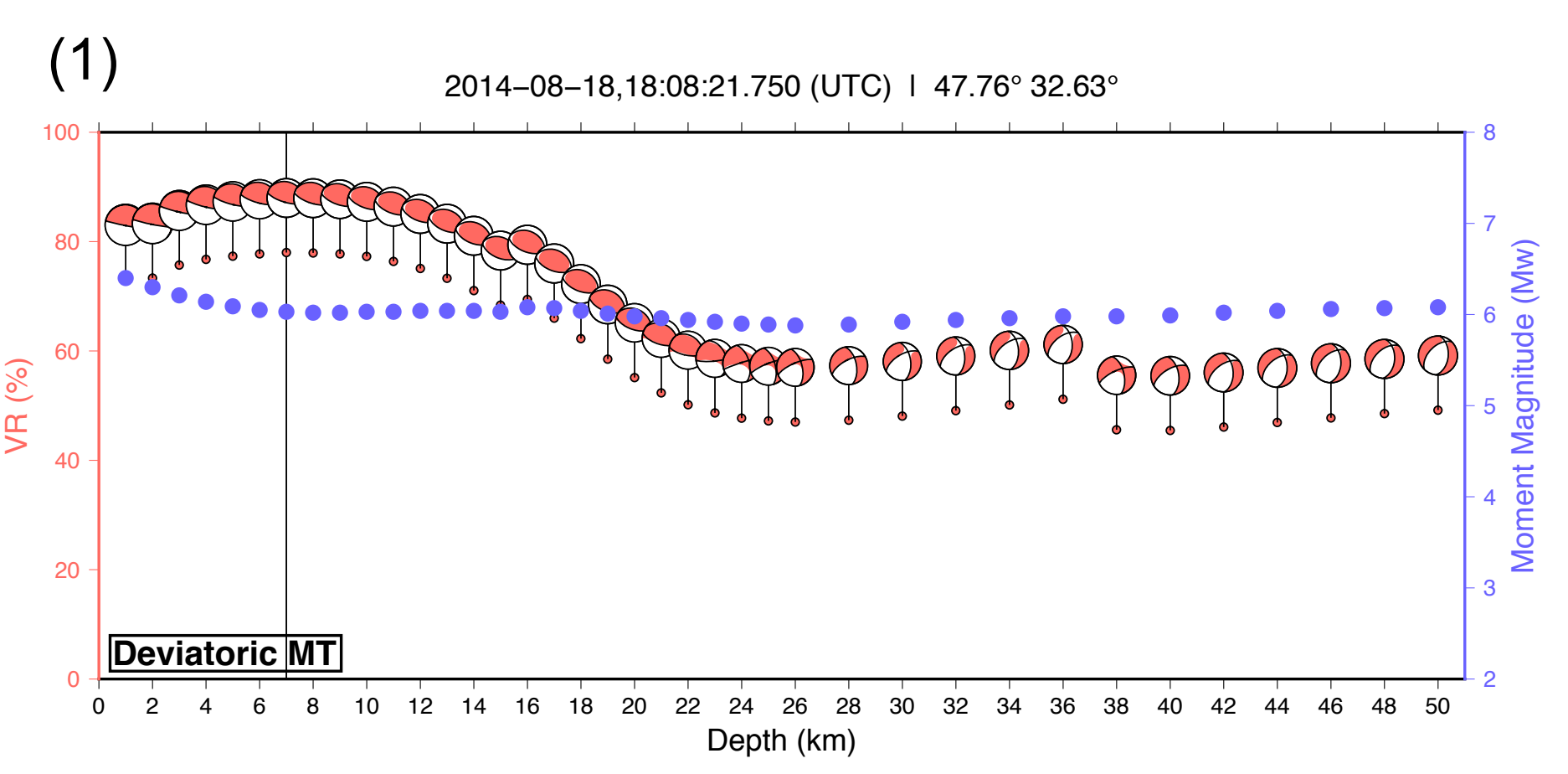
Methodology

- (1) Data processing to get absolute amplitudes
- (2) Green's functions to account for wave propagation
- (3) Deviatoric moment tensor inversion at various depths
- (4) Full moment tensor inversion at depth with highest goodness-of-fit
- (5) Network Sensitivity Solutions (NSS) to evaluate recovery of source-type and confidence in solution.



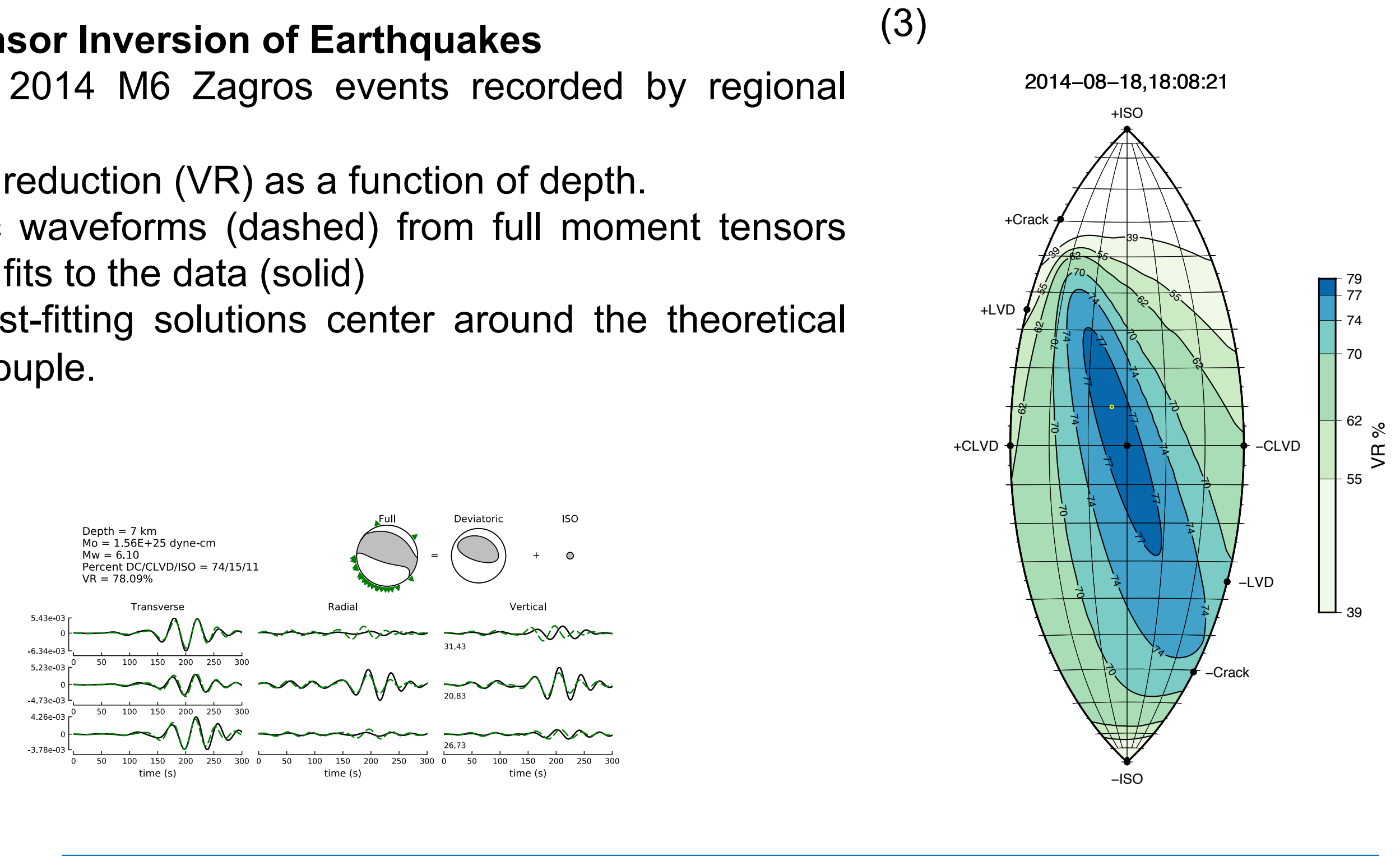
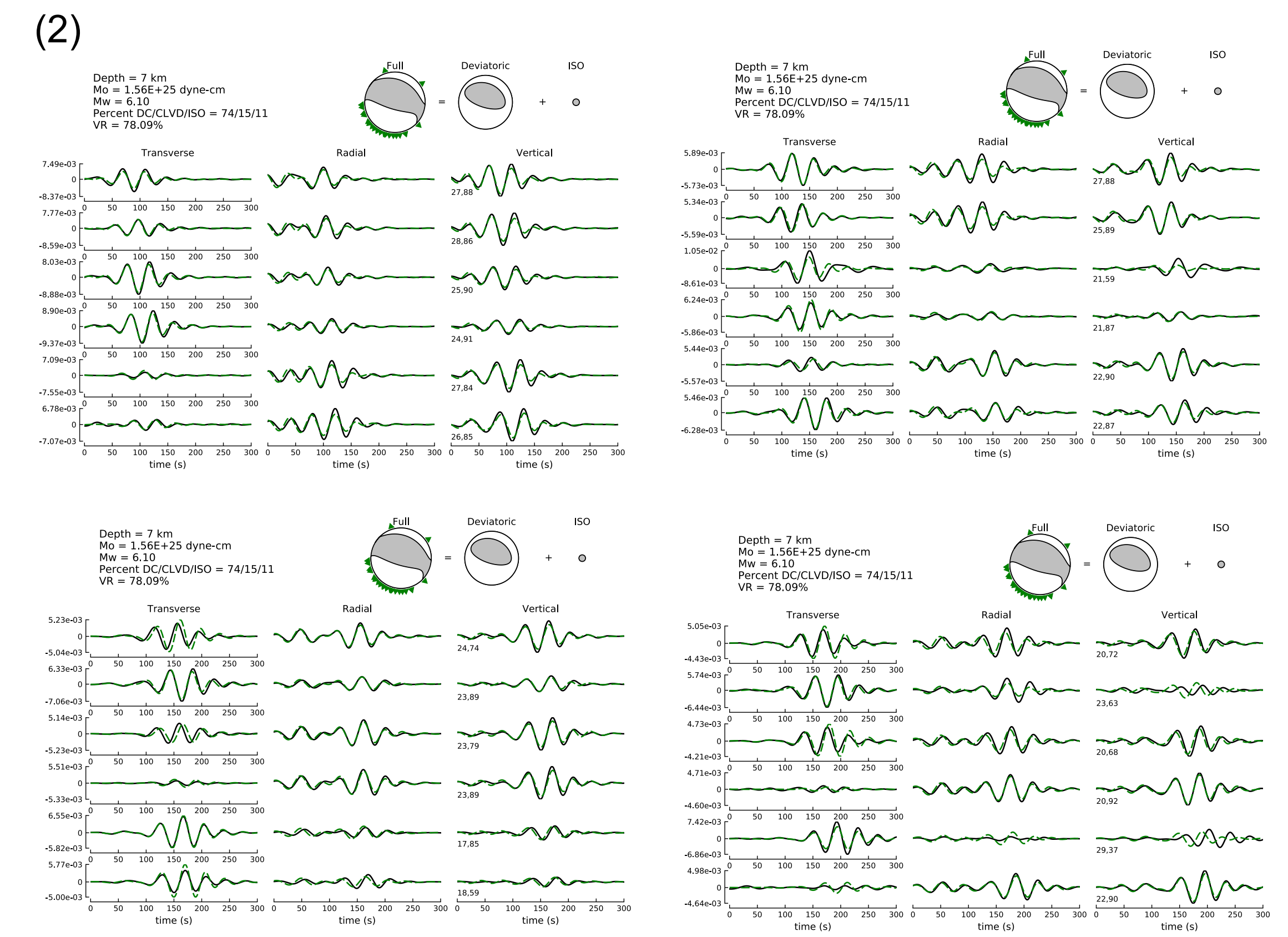
DATETIME	MSEC	JDATE	EVLO	EVLA	DEPTH	Mb	MT_DEPTH	Mo (Dev)	Mw (Dev)	Mo (Full)	Mw (Full)
2011-10-19:02:52.43	200	2011292	54.296	28.058	23.4	5.5	8	3.89E+23	5.03	4.08E+23	5.04
2012-03-05:06:50.37	940	2012065	44.095	35.042	32.1	4.6	21	5.56E+23	5.13	8.46E+23	5.25
2012-03-08:18:21.38	500	2012068	46.957	32.874	18	5.1	22	2.06E+23	4.84	2.79E+23	4.93
2012-04-20:01:21.07	540	2012111	47.023	32.511	10	5.1	8	4.81E+23	5.08	5.08E+23	5.10
2012-04-20:03:05.41	780	2012111	46.99	32.453	10	5	8	5.10E+23	5.11	5.20E+23	5.11
2012-04-21:05:25.98	410	2012112	47.049	32.407	10	5	7	2.29E+23	4.87	2.33E+23	4.88
2012-05-13:18:21.13	430	2012134	53.323	27.066	10	4.9	7	5.41E+23	5.12	5.44E+23	5.12
2012-06-08:16:15.14	800	2012160	50.705	29.784	14.6	5	8	2.31E+23	4.88	2.32E+23	4.88
2012-07-01:02:49.46	0	2012183	51.02	31.841	6.6	5	5	2.95E+23	4.95	3.58E+23	5.00
2012-09-06:03:43.40	90	2012250	53.97	26.96	16	5	7	1.60E+23	4.77	1.60E+23	4.77
2013-01-25:12:11.27	920	2013025	50.913	31.769	37.7	5	7	2.39E+23	4.88	2.42E+23	4.89
2013-04-09:11:52.49	920	2013099	51.593	28.428	12	5.9	8	2.73E+25	6.26	2.90E+25	6.27
2013-05-01:18:31.05	900	2013121	51.741	28.229	23.8	5.1	4	1.93E+23	4.82	1.97E+23	4.83
2013-05-23:22:44.56	900	2013143	53.588	27.221	18.1	5.2	12	4.61E+22	4.41	7.51E+22	4.55
2014-08-18:18:08.21	750	2014230	47.7628	32.6305	0	5.3	7	1.25E+25	6.03	1.56E+25	6.10
2014-08-20:10:14.16	770	2014232	47.8207	32.6394	18.7	5	16	2.23E+24	5.53	2.33E+24	5.55
2014-12-30:04:19.33	790	2014364	51.9659	28.7386	0	5.1	4	3.81E+23	5.01	4.77E+23	5.09
2016-03-31:07:15.18	550	2016091	50.6568	31.9721	16.5	4.5	19	1.81E+23	4.77	2.09E+23	4.85
2016-07-02:03:49.50	860	2016184	51.392	29.3414	28.6	4.5	10	3.02E+22	4.29	3.09E+22	4.29
2016-10-14:01:43.53	820	2016288	49.9636	31.1905	38.9	4.3	21	5.67E+22	4.47	6.34E+22	4.50
2009-05-19:17:35.01	70	2009139	37.74	25.291	5	5.7	5	9.10E+24	5.94	1.07E+25	5.99
2009-05-19:19:57.18	350	2009139	37.745	25.243	10	4.6	5	1.93E+23	4.82	2.17E+23	4.86
2012-01-30:17:04.28	210	2012030	34.0397	27.7453	25.4	4.5	12	1.25E+23	4.70	1.39E+23	4.73

A selection of M>4 earthquakes from 2009-2016 and moment magnitudes from deviatoric and full moment tensor inversions.



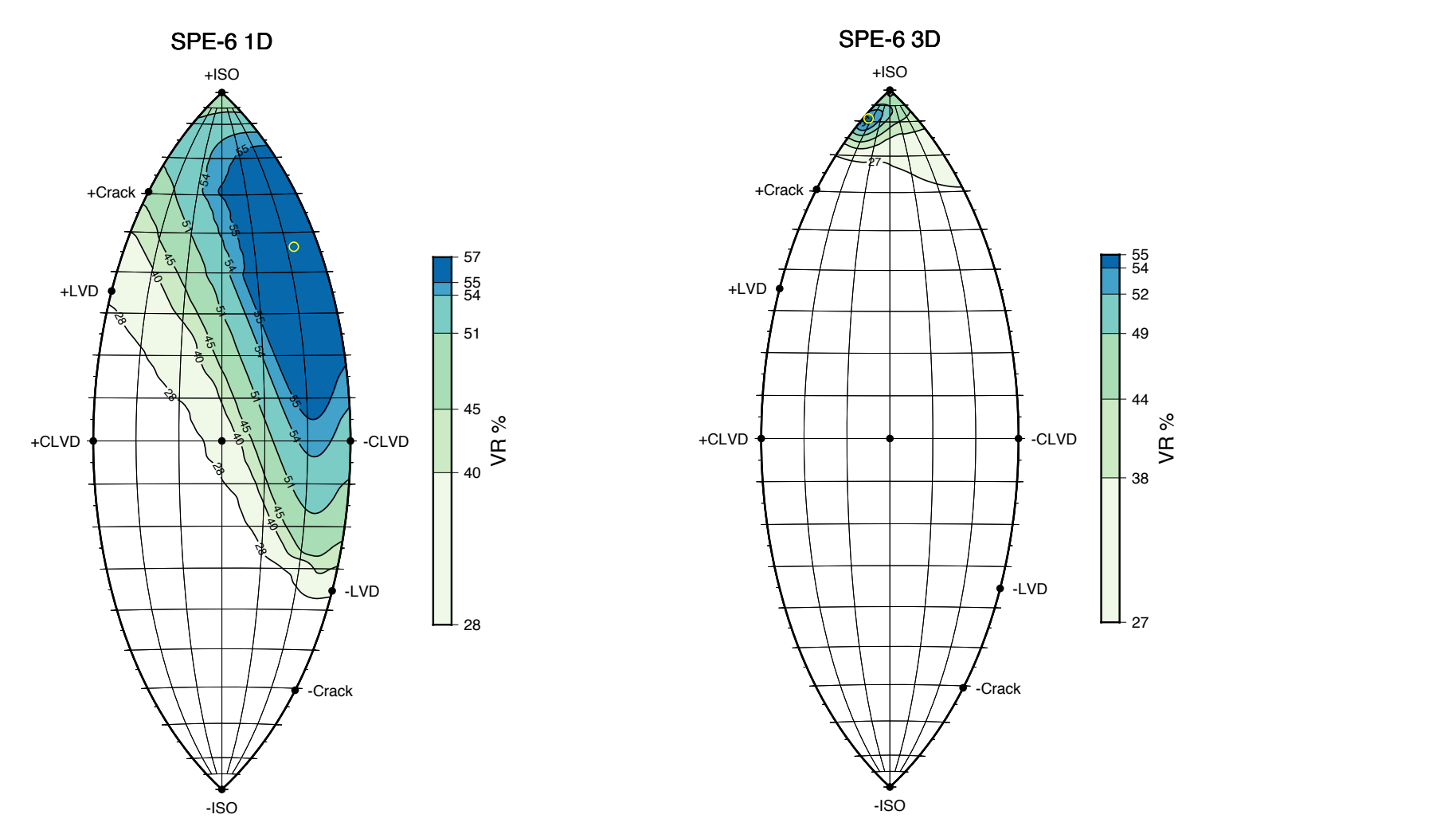
Moment Tensor Inversion of Earthquakes
Solution for 2014 M6 Zagros events recorded by regional networks.

- (1) Variance reduction (VR) as a function of depth.
- (2) Synthetic waveforms (dashed) from full moment tensors and their fits to the data (solid)
- (3) NSS. Best-fitting solutions center around the theoretical double-couple.

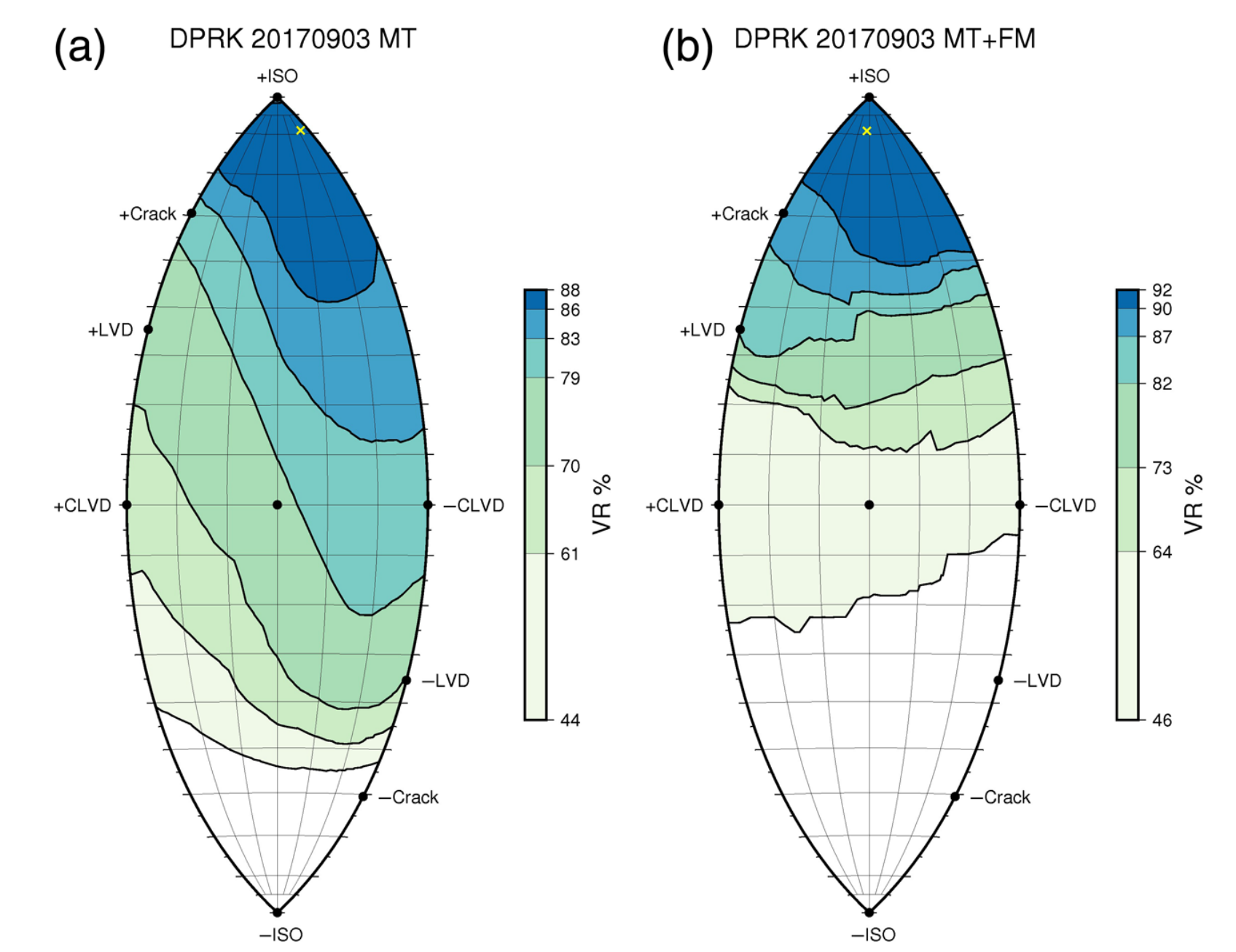
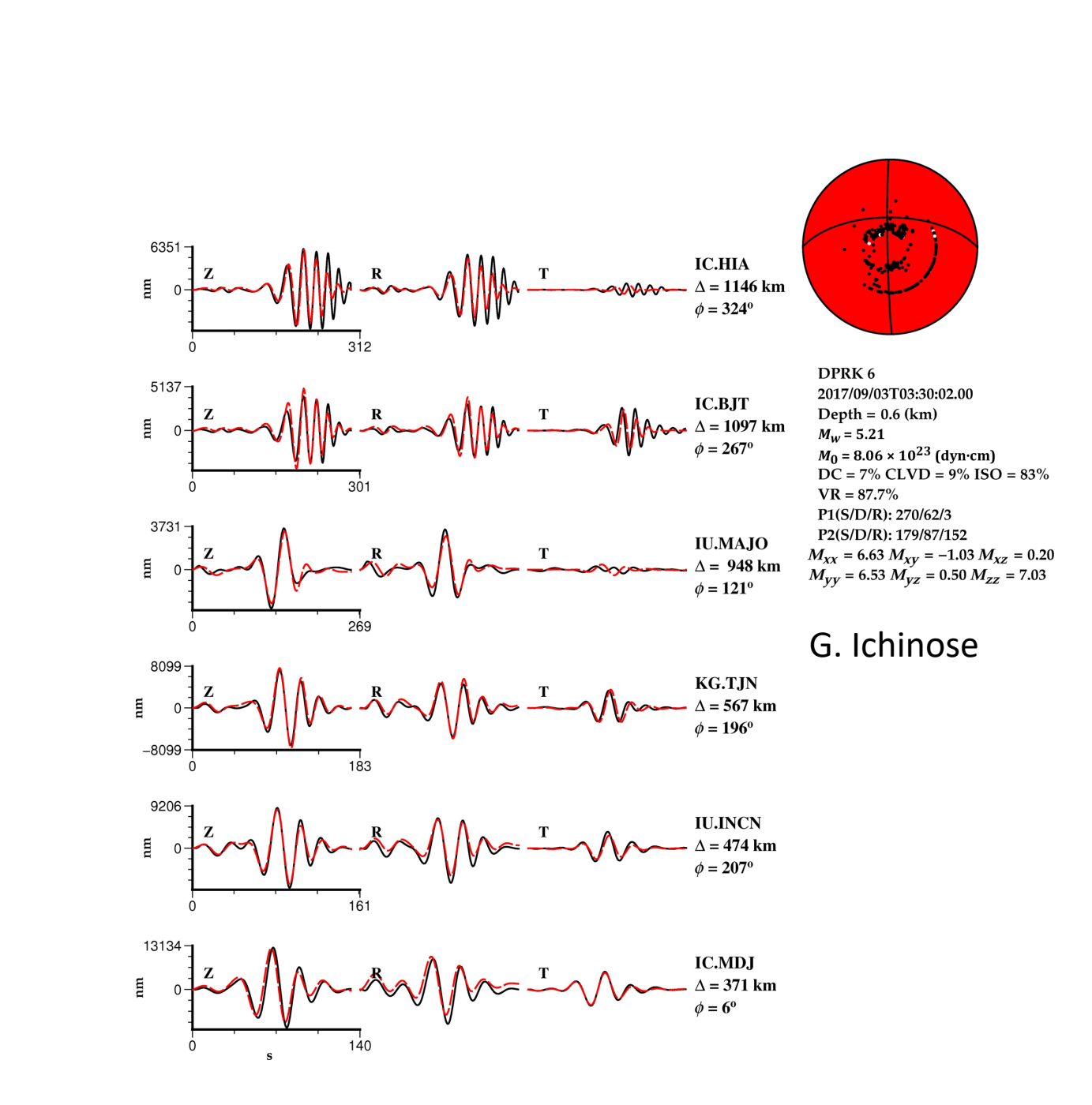


3D Moment Tensor Inversion of Chemical Explosions (2)

- Use of 1D Earth model results in incorrect solution for SPE-6
- NSSs show a reduction in source-type "uncertainty" from 1D to 3D
- Increased precision from 1D to 3D but solution may still be biased

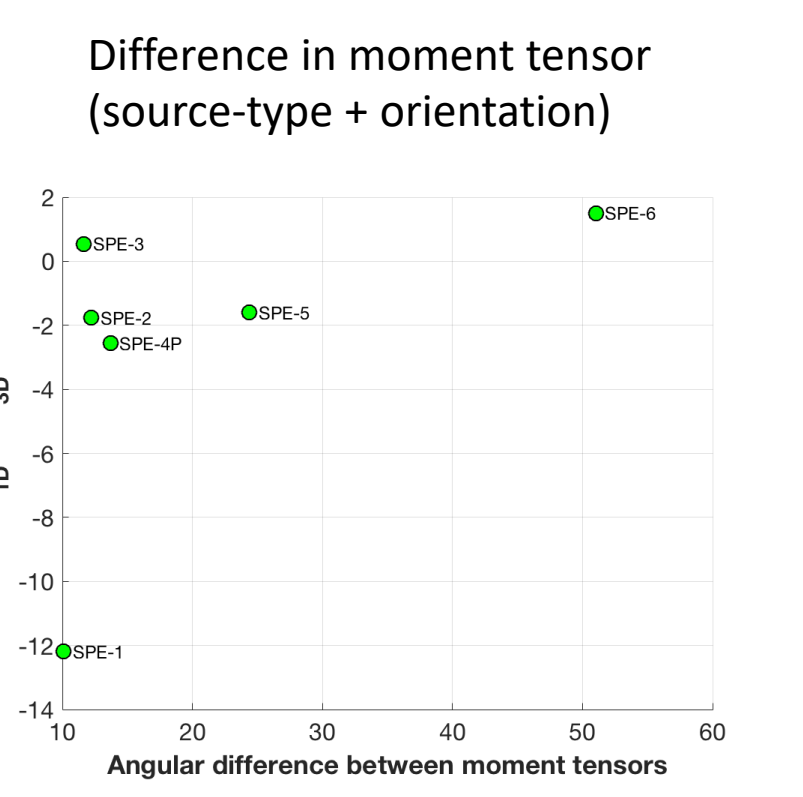
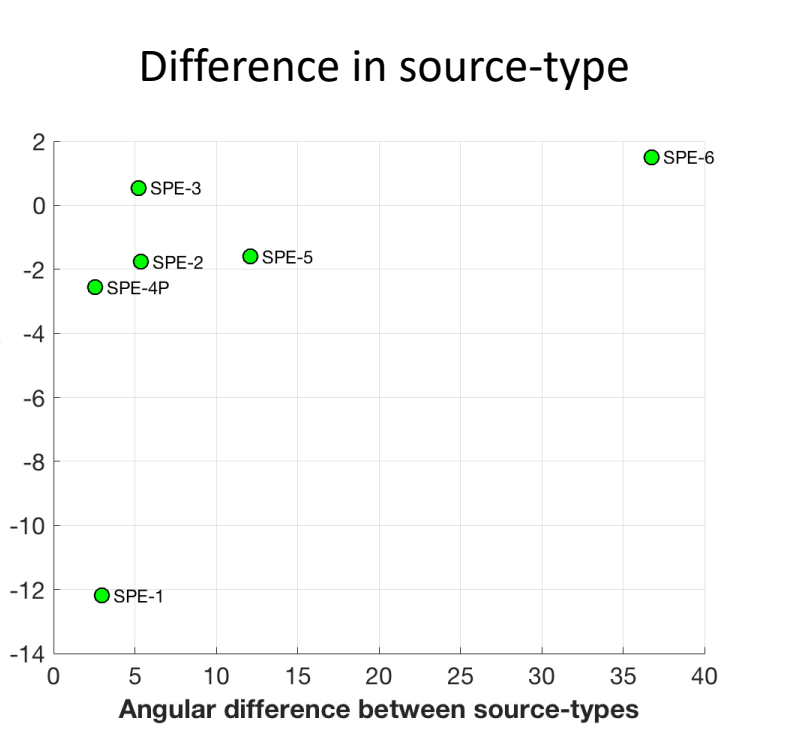
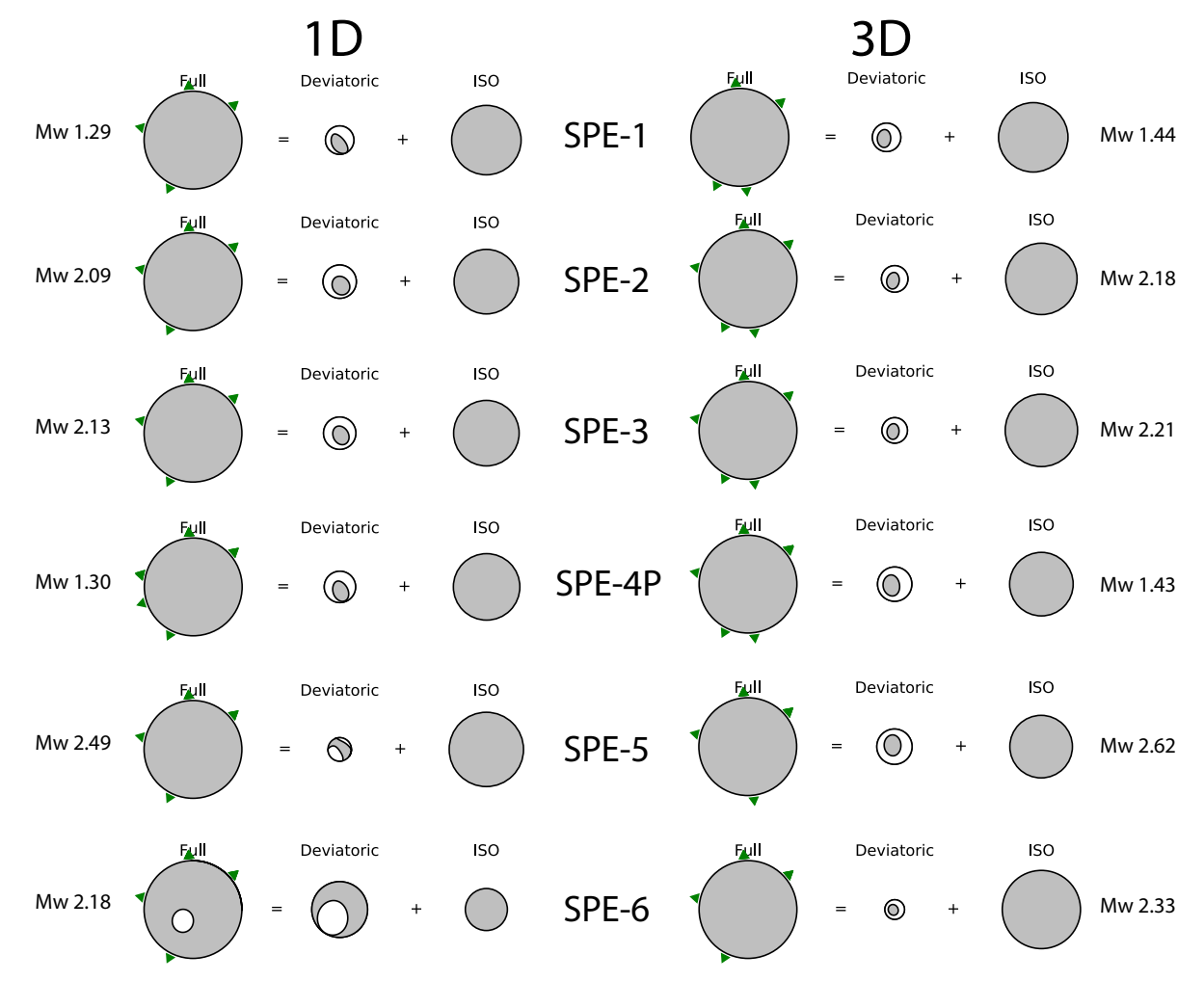
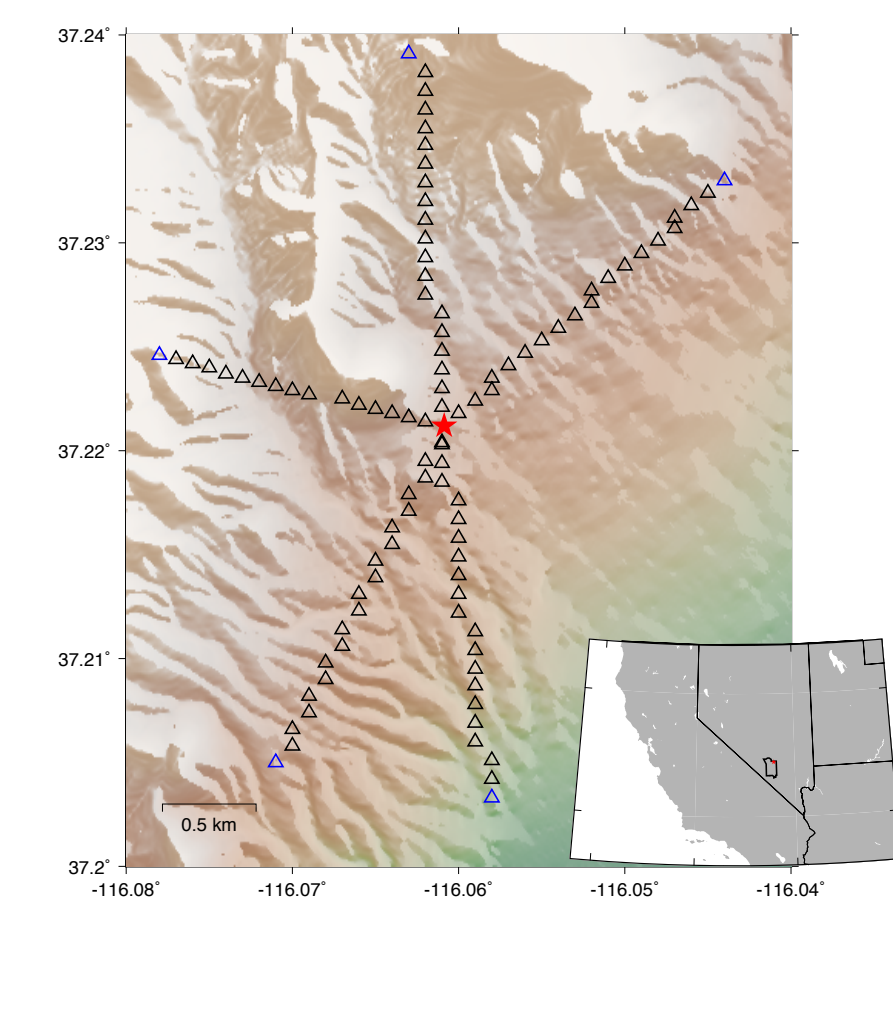


Moment Tensor Inversion of Explosions



MT solution for explosion has different NSS with best-fitting solutions closer to a theoretical explosion. An example shown above is the 3 September 2017 DPRK event. For this study we incorporated first motion polarities as additional constraint to eliminate a theoretical tradeoff between ISO and CLVD Rayleigh wave radiation patterns.

3D Moment Tensor Inversion of Chemical Explosions (1)



- (1) Explosions and earthquakes from Ford et al. (2009) and Chiang et al. (2018)
- (2) Source-types for all events presented here and M3 earthquakes near SPE. (dark blue). Red are explosions and light blue are earthquakes.

