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Moment Tensor Inversion and Source Parameters Estimation of Earthquake Events in Kashmir Himalaya

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Introduction

Moment tensor studies using full waveform inversion depicts the forces responsible for displacement at earthquake source location and it is being done for seismically active region of north-western Himalaya which is bounded by MBT and MCT and regional N-S traversing *kishtwar* fault to determine focal mechanism process. These process are precursors for stress inversion and seismic hazard assessment. ISOLA software package developed by Sokos & Zahradnik (2003) used to do moment tensor inversion which computes Green's function based on discrete wavenumber method (Bouchon, 1981) and MT inversion through iterative deconvolution method (Kikuchi & kanamori,1991). Best solution is selected based on maximum correlation between observed and synthetic seismograms. Aside focal mechanism solution, it is possible to determine the stability parameters based on condition number, variance reduction factor, parameter related to MT components resolvability, uncertainty estimation that validate the selection of final focal mechanism solution.

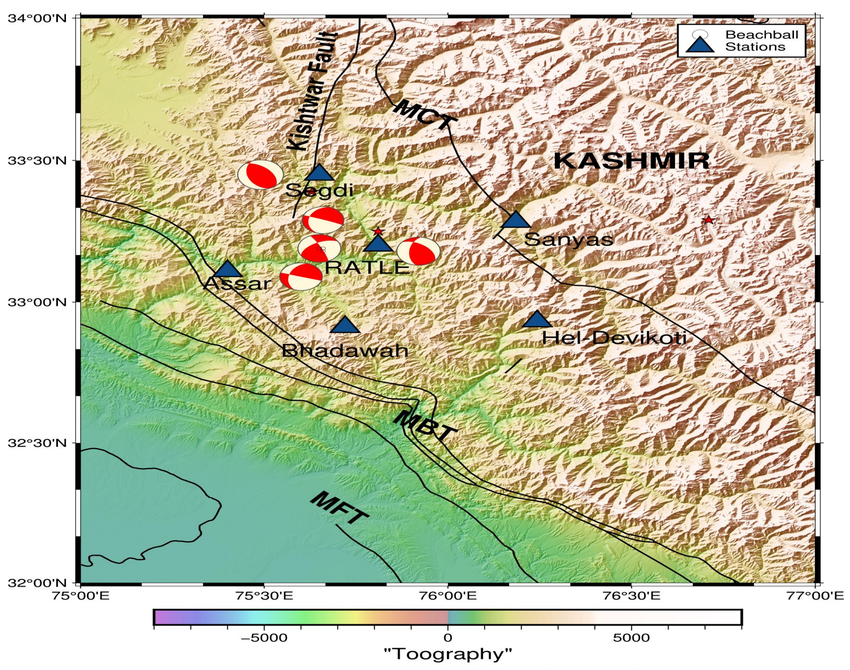
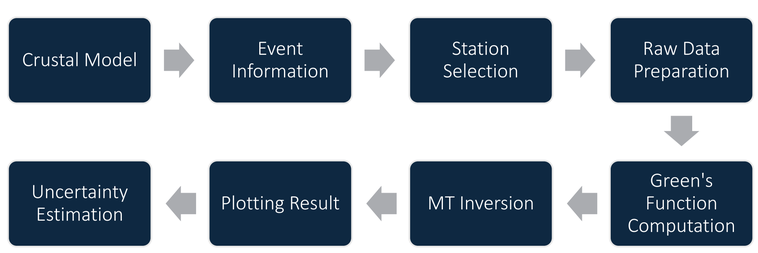


Figure 1. Geological map representing the major faults, installed seismic stations and focal mechanism of earthquake events

Dataset & Methodology

Earthquake data are recorded from six-stations network established in RATLE dam project within Kishtwar region of Kashmir Himalaya during 2022. Several earthquake events (M_L < 4.0) occurred in the local region are being processed and MT Inversion has been performed. Pre-processing of these raw earthquake data has been done utilizing SEISAN and SAC script. Green's function for the computation of synthetic seismogram has been developed using 1D velocity model for Kashmir region (Parija et. al, 2016). In this study, we used the **Isol**ated **A**sperties (ISOLA) software package that estimates focal mechanism solution from full-waveform moment tensor inversion. MT Inversion is conducted by minimizing the difference between observational and synthetic waveforms generated based on green's function through least square fitting. The focal mechanism solution is estimated from the moment tensor output and this output is optimized through spatiotemporal grid search to find the best fitting correlation between space and time.



Result

S. No.	Event date	Location	Mag.	Mw	Depth		Azimuth	Plunge	Strike	Dip	Rake	DC%	Corr	Varred
1	02/07/2022	33.19 N, 75.66 E	2.8	3.16	19.6	P-axis	163	32	287	90	-132	78.1	0.64	0.42
						T-axis	51	31	197	42	-1			
2	02/07/2022	33.19 N, 75.66 E	3.1	3.08	19.3	P-axis	173	40	291	87	-121	81.3	0.69	0.49
						T-axis	47	35	196	31	-6			
3	02/07/2022	33.19 N, 75.65 E	2.9	3.18	18.1	P-axis	103	17	335	82	34	70	0.80	0.65
						T-axis	203	29	240	56	171			
4	04/07/2022	33.18 N, 75.66 E	3.0	3.19	19	P-axis	253	2	186	53	123	97.6	0.69	0.48
						T-axis	158	64	319	48	55			
5	10/06/2022	33.39 N, 75.63 E	3.9	3.39	15	P-axis	58	4	159	42	106	80.6	0.69	0.48
						T-axis	170	79	318	50	76			

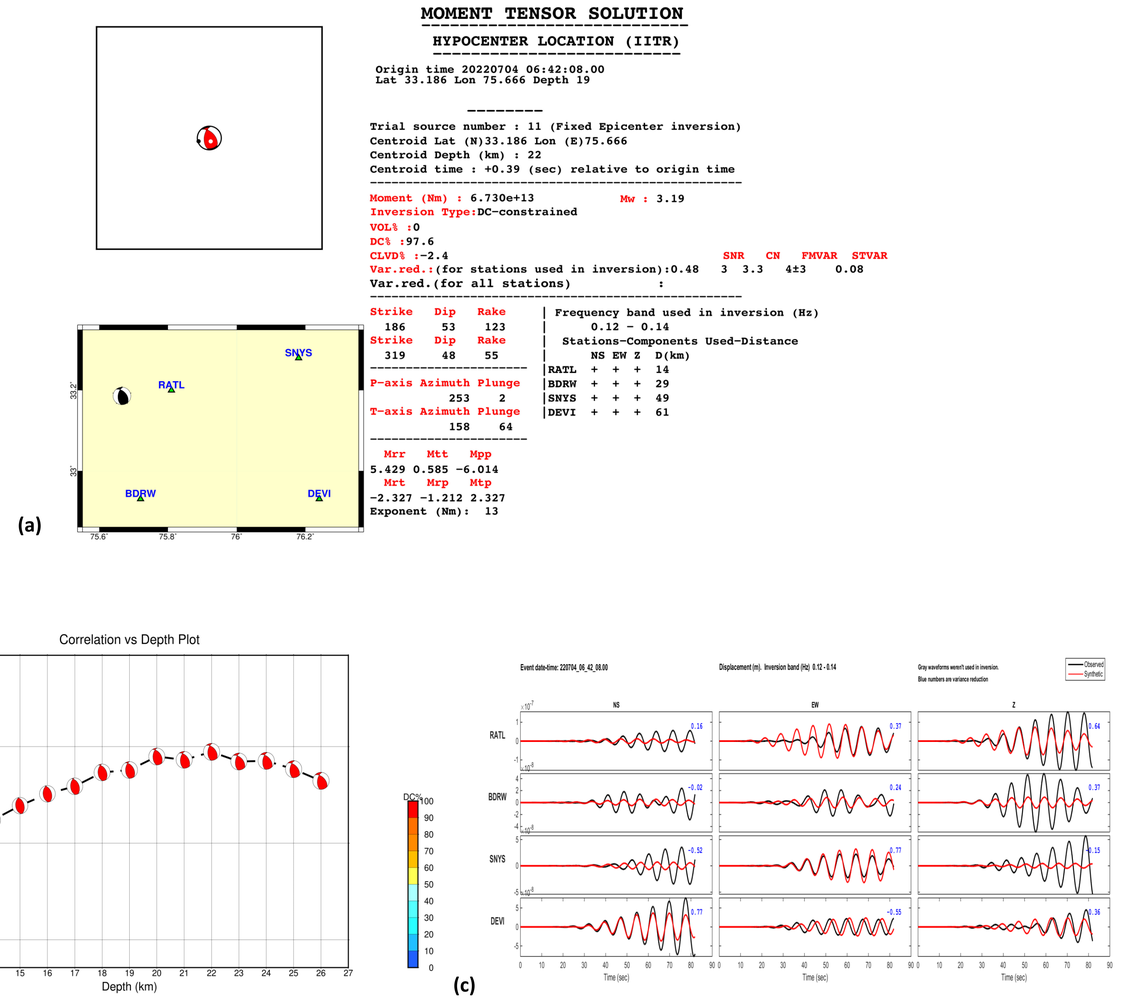
Table 1. Moment Tensor solution summary of five earthquake events occurred in Kishtwar region of north-western Kashmir Himalaya

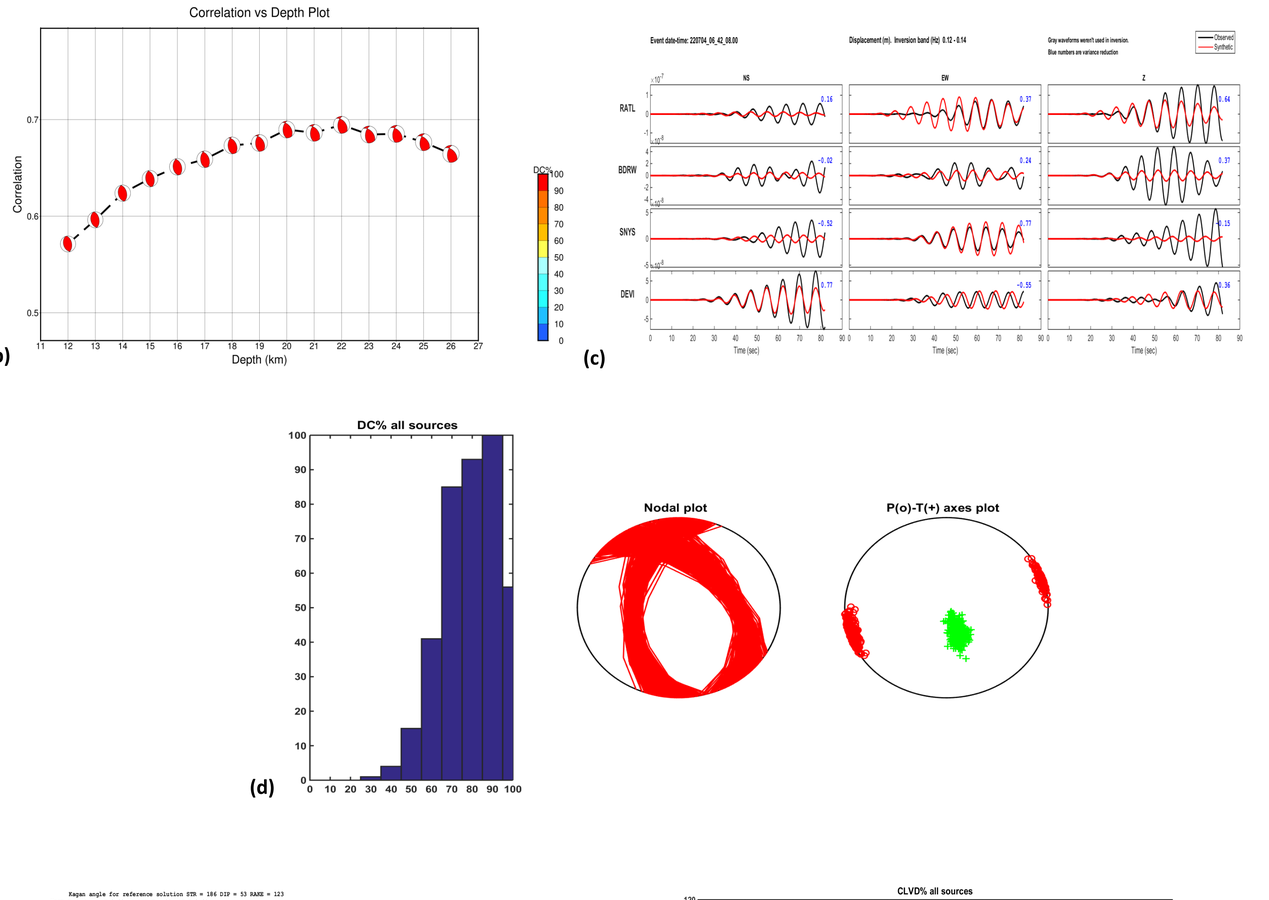
Acknowledgment

We are thankful to the Department of Earthquake Engineering, Indian Institute of Technology, Roorkee for providing the seismological station data for all my work and other essential facilities to effectively cover my research work here. Geological map is made by building PyGMT script and pre-processing of earthquake data is done using SEISAN and Seismic analysis code (SAC).

Results & Discussion

- The focal mechanism of five earthquake events in Kashmir region is determined using moment tensor inversion. Several frequency band for inversion has been tested and various stations combination is verified to find the most reliable outcome and best solution is selected based on good correlation between observed and synthetically generated seismograms, other parameters and plots representing the uncertainty, stability and resolvability of moment tensor components depicting the quality of solutions.
- The DC type fault displacement is generated in each events with small combination of non-shear CLVD mechanism. Beachball solution of these earthquake events are found to be reverse and strike slip mechanism, which is also satisfying the northward directio n thrusting of Indian plate thrusting.
- Determining moment tensor solution using fewer number of stations is complex task and quality solution need to be judged properly. These solution showing good correlation, low condition number (CN) and high variance reduction weights more reliability on the final faulting process and approving the exact fault plane responsible for the earthquake event.
- These focal mechanism solution in whole region in some way or other generalize the dominant mechanism and faults responsible for nucleation process and they prefer to current stress possibilities in the region and appropriate measure for seismic hazard analysis.





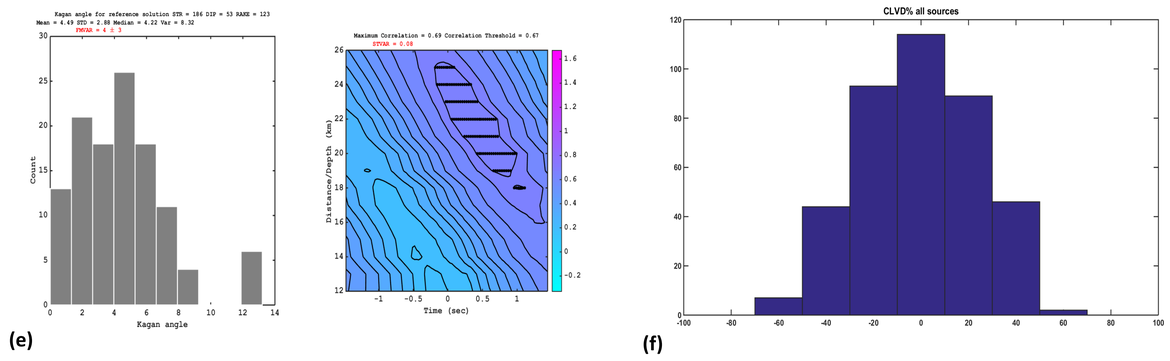


Figure 2. Moment tensor inversion result of earthquake event on 04/07/2022 (M_L -3.0). (a) Full solution summary of MT Inversion solution. (b) Correlation plot for various trial source position across the depth. (c) waveform fitting plot between observed (black) and synthetic seismogram (red) for all the four stations used. (d) DC% uncertainty histogram plot and other plot representing the P-axis (Red circle) and T-axis (Green cross) sign. (e) Kagan angle plot showing focal mechanism and space time variation (FM-STVAR). (f) CLVD % uncertainty histogram plot.

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