SnT 2025 8 SEPTEMBER ONLINE DAY 9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE
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Moment Tensor Inversion Analysis of DPRK6 Nuclear Event Using CTBTO/IMS Data

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CTBTO PREPARATORY COMMISSION | PUTTING AN END TO NUCLEAR EXPLOSIONS

INTRODUCTION AND MAIN RESULTS

The CTBT verification regime relies on global seismic monitoring to detect underground nuclear explosions. This study demonstrates how Moment Tensor (MT) inversion can support Expert Technical Analysis by providing information on depth, magnitude, and source mechanism.

Using IMS data, the 3 September 2017 DPRK test was analyzed with two inversion techniques, highlighting how ETA can provide States Parties with additional technical parameters to support their assessment of such events.

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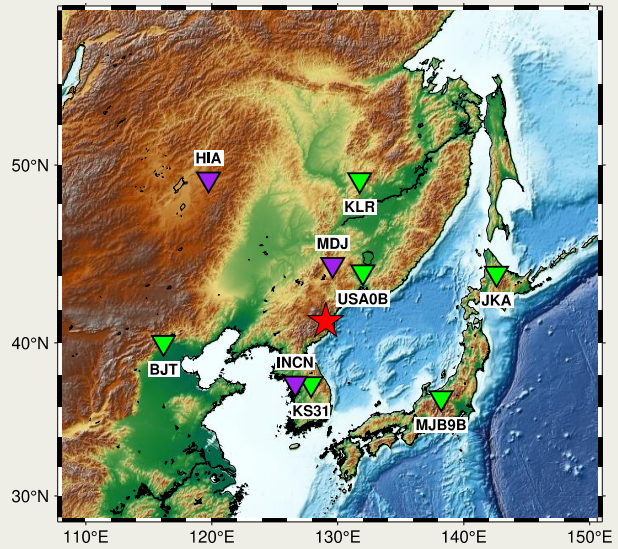
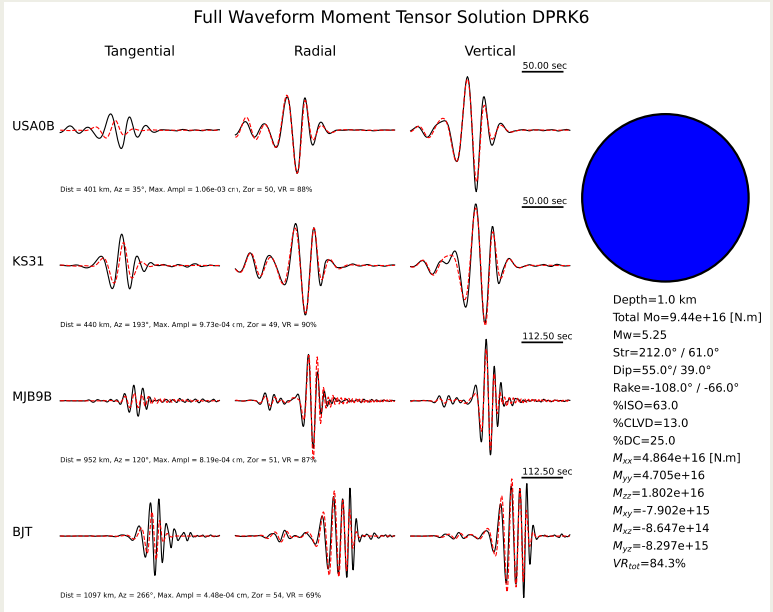
Introduction and Motivation

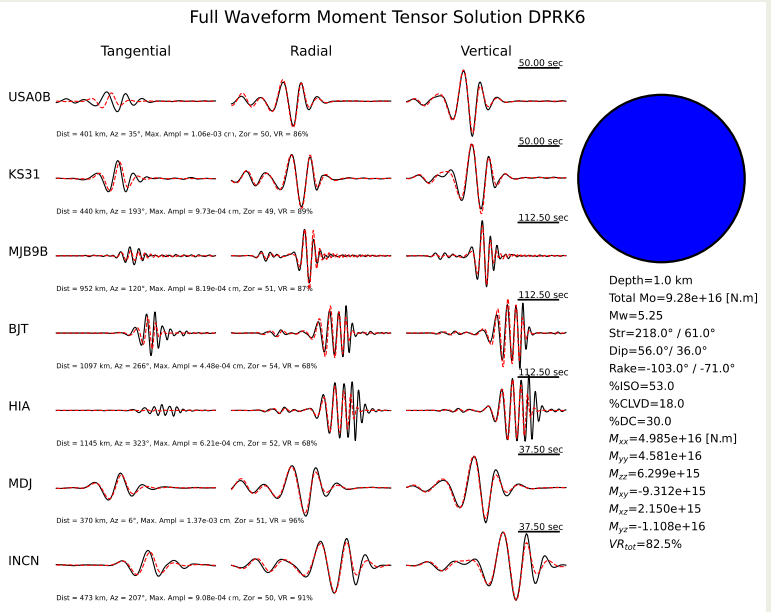
- The CTBT verification regime uses seismic monitoring through the International Monitoring System (IMS), a global network of stations, to detect and locate potential underground nuclear explosions.
- This study examines how Moment Tensor inversion, applied to IMS and complementary data, could help and support Expert Technical Analysis by constraining key source parameters such as magnitude, depth, and focal mechanism—thereby assisting States Parties in the assessment of detected events.



DPRK6 Event

- The IMS detected the declared nuclear test by the Democratic People's Republic of Korea (DPRK) on 3 September 2017 at 03:30:01 UTC (mb 6.1, Ms 4.9, IDC).
- Regional waveform data from six IMS stations (USRK, KSRS, MJAR, JKA, KLR, BJT) complemented by selected IRIS stations (MDJ, INCN, HIA, MAJO).
- Regional velocity models: MDJ2 (Ford et al., 2010) for most stations and SRN (Dreger et al., 2021) for MJAR/MAJO





Result using Time-Domain Moment Tensor Inversion - TDMT (Dreger, 2003), Data bandpass filtered (0.02–0.05 Hz) and integrated into displacement. Green's functions computed with Computer Programs in Seismology (Herrmann, 2013). Source depth fixed at 1 km (no better resolution given the frequency band analyzed).

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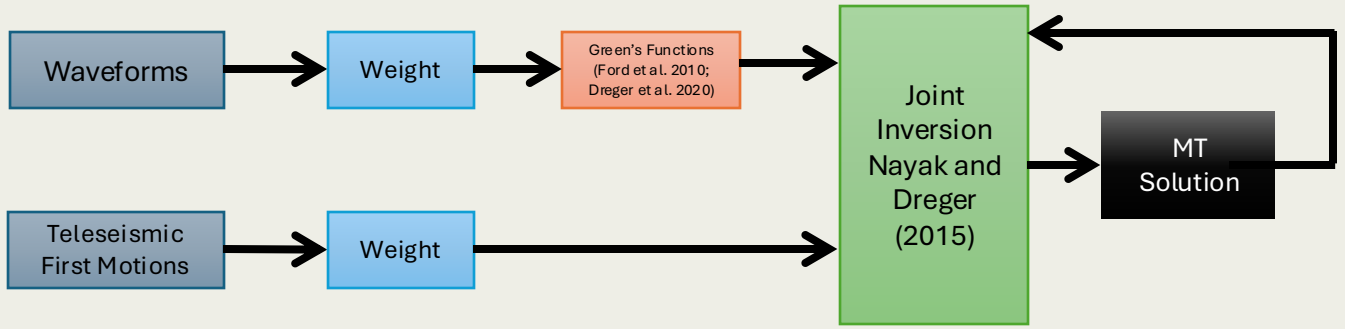
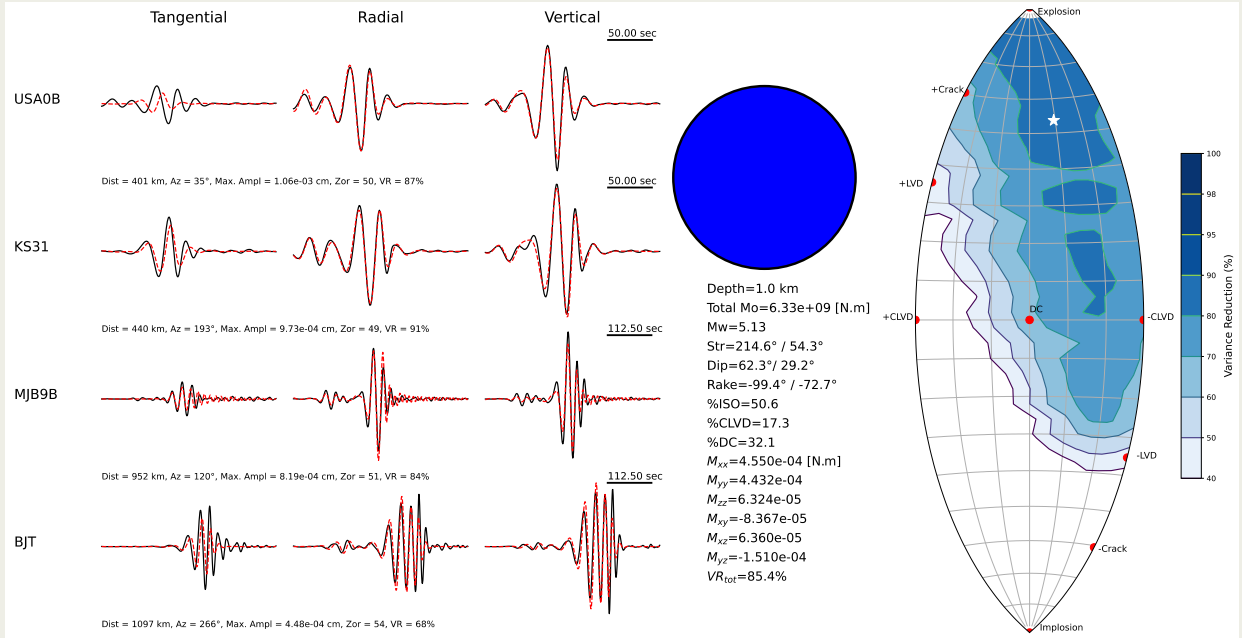
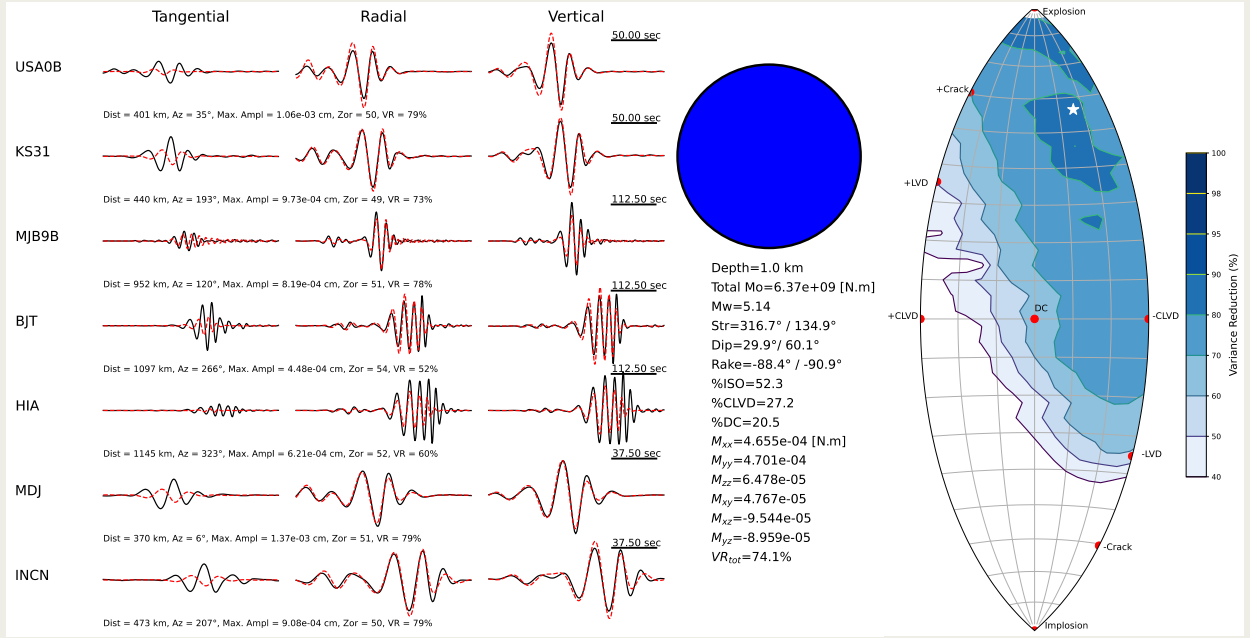
Moment Tensor Inversion: Network Sensitivity Solution

The joint inversion explores the space of MT solutions (grid search) and converges to an optimal solution that maximizes the fit with the waveforms and the first motion polarities.



NSS Solution (Only Waveforms)





- The space of possible solutions is broad, with over 6,000 solutions explored. Although highly isotropic sources provide the best fit, some deviatoric solutions also fit the data well.

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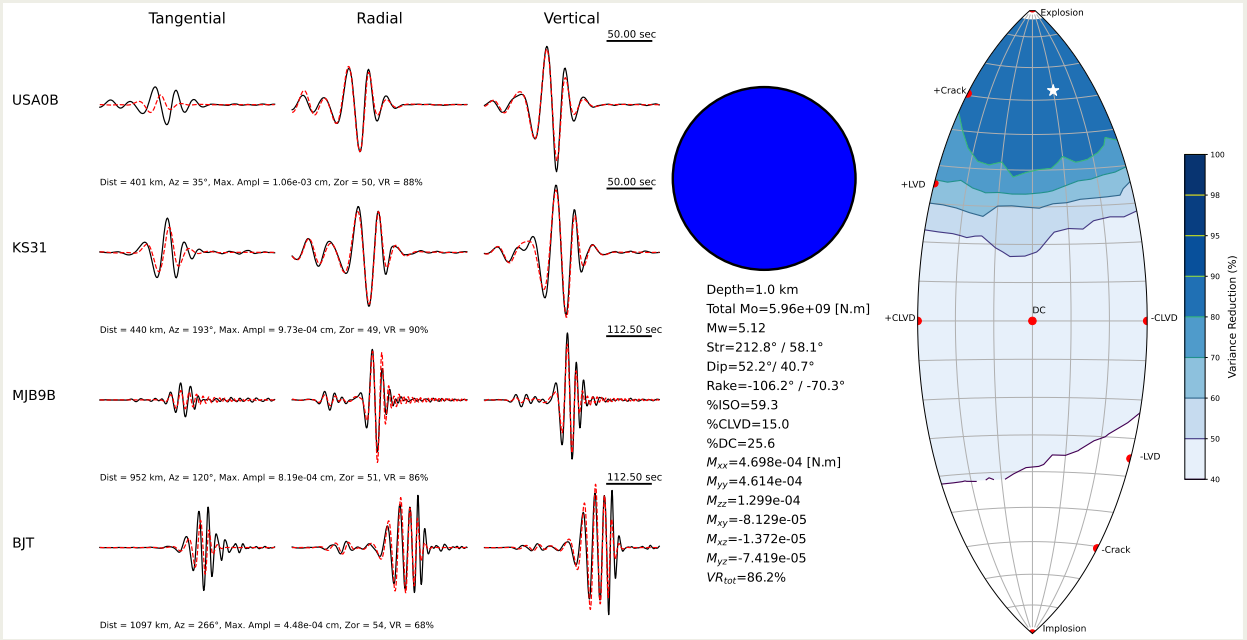
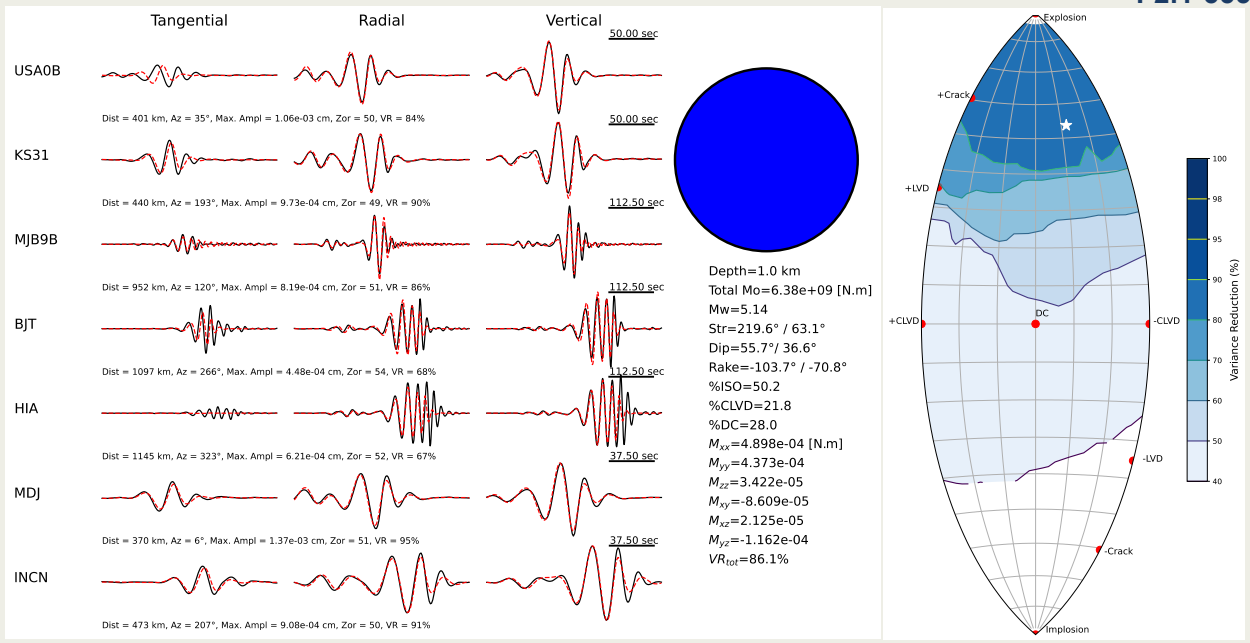
NSS Solution (Waveforms and First Motions)





- Eighty-one first motions from CTBTO stations help constrain the solution space. The result aligns with Chiang et al. (2018), Alvizuri & Tape (2018), and Chi-Durán et al. (2024).
- Highly isotropic solutions provide the best fit, with reduced uncertainty compared to using waveforms alone.

Conclusions

- The CTBTO/IMS network can reliably characterize the source mechanism of this declared nuclear test. It also enables further characterization of other detected events, provided high-quality data is available.
- Both inversion approaches are effective for ETA, assuming high-quality data and adequate regional and azimuthal station coverage. They also allow straightforward integration of external waveform data, and the results are easy to reproduce.
- NSS Joint inversion can incorporate more than just first-motion polarities; teleseismic waveform data, infrasound, and hydroacoustic data can further constrain the source-type space.

Data availability

- The IMS data used in this article are available to the IDC authorized users or via the vDEC platform at the CTBTO. More information on accessing the vDEC platform is available at www.ctbto.org/specials/vdec/.

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