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# Regional distance seismic moment tensors of nuclear explosions

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**Abstract**

Nuclear explosions, because of their known location, depth and theoretical source mechanism, provide a means to explore the resolution of non-double-couple and isotropic seismic moment tensors. We perform seismic moment tensor inversions on long-period (50–20 s), three-component velocity seismograms from the Caltech TERRAscope network and the Berkeley Digital Seismic Network (BDSN) to determine best-fitting double-couple, isotropic plus double-couple, deviatoric and full-moment tensor source mechanisms for the Little Skull Mountain Earthquake and three large ($M_L \geq 5.5$, $M_W \geq 4.5$) Nevada Test Site (NTS) nuclear explosions (JUNCTION, MONTELLO and BEXAR). The significance of solutions with higher degrees of freedom is evaluated using the *F*-test. The stability of the moment tensor solutions for variations in station configuration is investigated using a cross-validation method. Our results show that strongly non-double-couple seismic moment tensors and shallow source depth characterize the nuclear explosions. The full-moment tensor inversions recover a volume increase. However, our analysis indicates that the improvement in fit afforded by the extra degree of freedom is not statistically significant due to the similarity of the vertical compensated linear vector dipole (CLVD) and isotropic surface wave Green's functions at these periods. An isotropic plus double-couple source model was found to provide the same level of fit as the deviatoric moment tensor inversions. Determination of the nonisotropic source mechanism is not unique and we discuss our results with respect to the proposed source models for NTS. While the results of this study indicate that regional distance seismic moment tensor analysis is not suitable for directly discriminating nuclear explosions from earthquakes, the shallow source depth and non-double-couple seismic moment tensors obtained for these events suggest that it may be useful for identifying suspect events for further screening.


*Keywords:* Moment tensor; Nuclear explosion; Seismic inversion

## 1. Introduction

The discrimination of nuclear explosions from naturally occurring earthquakes at regional distances remains a difficult problem, particularly for the small to moderate magnitude range. Moderate-sized events will have few teleseismic recordings from the International Monitoring System (IMS) and, therefore, emphasis will necessarily be placed on studying data from the few stations that record a given event at regional to far-regional distances. Discriminants such as $m_b$:$M_S$, $M_0$:$M_L$ and various spectral ratios do show

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