Insight into Earthquake Source Processes from Large Global Datasets

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Abstract

Most studies of earthquake source parameters give detailed information about individual earthquakes. A complementary approach is examining large datasets to gain insight into general properties of many earthquakes, rather than specifics for individual earthquakes. In the traditional formulation for inverse problems, such studies gain high stability - general properties - at the cost of low resolution - specifics for individual earthquakes. In one study we compared moment tensors in the USGS and the Global CMT Project catalogs. The differences are typically an order of magnitude larger than the reported errors, suggesting that the errors substantially underestimate the uncertainty. GCMT generally reports larger scalar moments than the USGS, with the difference decreasing with magnitude. This difference is larger and of opposite sign from that expected due to the different definitions of the scalar moment. Instead, the differences are intrinsic to the tensors, presumably in part due to different phases used in the inversions. A second study examines non-double-couple (NDC) components of moment tensors, which may reflect complex source processes for earthquakes in specific tectonic environments, the combined effect of double couple sources with different geometries, or artifacts of the inversion. A large dataset of moment tensors for earthquakes from three global and four regional catalogs shows that NDC components are essentially independent of magnitude for earthquakes with $2.9 < Mw < 8.2$, with a mean deviation from a double-couple source of ˜20%. The consistency suggests that most NDC components do not reflect complex rupture processes, which should be a greater effect for larger earthquakes because a significant NDC component requires substantially different geometry between portions of the rupture. Furthermore, there is essentially no difference in NDC components between earthquakes with different fault mechanisms, in different tectonic environments, or in different types of lithosphere. This consistency indicates that most NDC components do not reflect actual source processes, which would likely cause variability. Hence although some earthquakes have real NDC components, it appears that for most earthquakes, especially smaller ones, NDC components are likely to be artifacts of the inversion.

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Insight into Earthquake Source Processes from Large Global Datasets

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Abstract Text:

Most studies of earthquake source parameters give detailed information about individual earthquakes. A complementary approach is examining large datasets to gain insight into general properties of many earthquakes, rather than specifics for individual earthquakes. In the traditional formulation for inverse problems, such studies gain high stability - general properties - at the cost of low resolution - specifics for individual earthquakes. In one study we compared moment tensors in the USGS and the Global CMT Project catalogs. The differences are typically an order of magnitude larger than the reported errors, suggesting that the errors substantially underestimate the uncertainty. GCMT generally reports larger scalar moments than the USGS, with the difference decreasing with magnitude. This difference is larger and of opposite sign from that expected due to the different definitions of the scalar moment. Instead, the differences are intrinsic to the tensors, presumably in part due to different phases used in the inversions. A second study examines non-double-couple (NDC) components of moment tensors, which may reflect complex source processes for earthquakes in specific tectonic environments, the combined effect of double couple sources with different geometries, or artifacts of the inversion. A large dataset of moment tensors for earthquakes from three global and four regional catalogs shows that NDC components are essentially independent of magnitude for earthquakes with $2.9 < Mw < 8.2$, with a mean deviation from a double-couple source of ~20%. The consistency suggests that most NDC components do not reflect complex rupture processes, which should be a greater effect for larger earthquakes because a significant NDC component requires substantially different geometry between portions of the rupture. Furthermore, there is essentially no difference in NDC components between earthquakes with different fault mechanisms, in different tectonic environments, or in different types of lithosphere. This consistency indicates that most NDC components do not reflect actual source processes, which would likely cause variability. Hence although some earthquakes have real NDC components, it appears that for most earthquakes, especially smaller ones, NDC components are likely to be artifacts of the inversion.

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1. Rösler, B., Stein, S., & Spencer, B. D. (2021). Uncertainties in Seismic Moment Tensors Inferred from Differences between Global Catalogs. *Seismological Research Letters, 2.* Rösler, B. & Stein, S. (2021). *Consistency of Non-Double-Couple Components of Seismic Moment Tensors With Earthquake Magnitude and Mechanism. submitted to Seismological Research Letters.*

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