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Review on Source Type Diagrams

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Force system of earthquake is expressed by a symmetric moment tensor, assuming internal forces on a point source, and it has information of characteristic directions, source size, and source type. Although we often assume double couple as the source type, significant non-double-couple component including isotropic component is reported mainly for induced earthquakes or volcanic earthquakes. It is also known that combination of double couples may produce non-double-couple components. For discussion on source types, it is helpful to display them into some visual diagrams.

Since the information of source type has two degrees of freedom, it can be displayed on a two-dimensional flat plane. Although the diagram developed by Hudson et al. [1989] (HPR diagram) is popular, it is inconsistent with the concept of scalar moment [Aki and Richards, 2002]. This problem originates in the projection of a three-dimensional point (λ_1, λ_2, λ_3) on a cubic surface, where λ_1, λ_2, and λ_3 are eigenvalues of moment tensor.

Then, Chapman and Leaney [2012] developed a new diagram by combining spherical projection and stereographic projection (CL diagram). The spherical projection overcomes the problem of the HPR diagram, and the stereographic projection keeps areal density from a spherical surface to a flat plane. This diagram has an advantage that a straight line passing through the center corresponds to the mechanism obtained by combination of an arbitrary mechanism and a double couple, but the diagram is curved shape, and it does not suit for detailed discussions on non-double-couple component when the isotropic component is dominant.

In the present study, we developed another new rectangle diagram that overcomes difficulties of the HPR diagram and the CL diagram simultaneously (AOI diagram). After projecting (λ_1, λ_2, λ_3) on a spherical surface, we project it on a cylinder, keeping areal density. This diagram is an orthogonal system of the isotropic axis (the trajectory for varying isotropic component) and the deviatoric axis (the trajectory for varying deviatoric component while keeping its scalar moment). Since isotropic component represents the information from P-wave and deviatoric component represents the information from both P- and S-waves equivalently, the AOI diagram is consistent with the concept of seismogram analyses.

Since there is no source type diagram that is the best at everything, as well as map projection, it is important to use various diagrams taking account of their advantages and disadvantages. In the present study, we also provide examples of projecting a data set on different diagrams, and point out their apparent differences and important considerations.

Keywords: moment tensor, source type diagram, double couple, CLVD, isotropic deformation