Slip inversion with radiation-corrected empirical Green’ s functions

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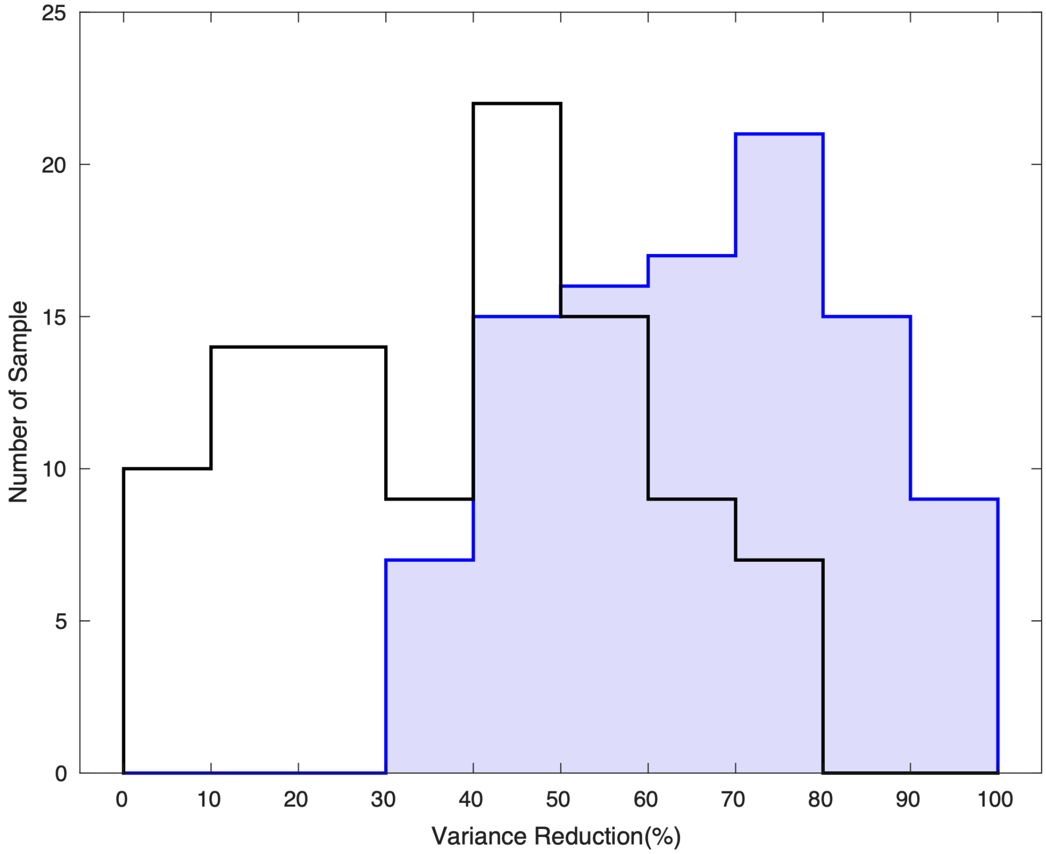
It is important to investigate earthquake source processes for understanding the underlying physics of earthquake ruptures and the background stress field. Slip inversion is a useful method to estimate earthquake source processes, in which spatial and temporal slip distribution is estimated so that its convolution with Green’ s function reproduces observed waveforms. Usually, the slip inversion is formulated as a least-square linear inversion problem to solve for slip amount at each subfault at each time-step to minimize the waveform misfit. While the ordinary slip inversion uses theoretical Green’ s functions calculated from a given velocity structure (e.g. Bouchon, 1981; Takeo, 1985), it is also popular to use real waveforms of a smaller earthquake with a similar mechanism in the vicinity as empirical Green’ s functions (eGf) (e.g. Hartzell, 1978). Although eGf has an advantage in accounting for the effect of the real complex velocity structure, the method requires a nearby earthquake with a similar mechanism whose waveforms can be used as eGf.

However, as far as the ray paths from two earthquakes mostly share the common ray path near each station, where most of the waveform complexity is determined, the waveform from one event with known mechanism can be potentially used as an eGf to analyze the other event with a slightly different mechanism at a slightly different location by correcting the effects of the radiation patterns. Thus, in this study, we develop a waveform inversion with the radiation-corrected eGf to extend the potential of slip inversion with eGf. Specifically, based on the ray theory, we can calculate the theoretical radiation patterns of the eGf event and those at each subfault of the target earthquake. Then, using the ratio of the radiation patterns at each station, we correct the amplitude of the eGf for each of P, SV, and SH waves.

We apply this new method to synthetic waveforms and compare the results with and without radiation correction under the same settings of source locations, source mechanisms, and station distribution. The following figure shows the distribution of variance reductions for 100 cases, in which source depths of mainshock and eGf event are 9.99km, the distance between the two events is randomly given between 0-10 km, and focal mechanisms (strike, rake, and dip) of two events are randomly given so that Kagan angle between them is 0-30 degrees. We used the velocity structure of JMA2001 (Ueno et al., 2002). The synthetic waveforms are calculated using fk application (Zhu and Rivera, 2002).

As a result, the correction of the radiation pattern improved the variance reduction. However, the variance reduction is not as high as 90-100%, even for synthetic tests. This is also the case in similar tests in a homogeneous half-space, suggesting that the reason for the discrepancy is the existence of relatively large converted or reflected waves at the surface, which have different radiations from the direct waves. Hence, there are still some limitations regarding the focal depth and the epicentral distance, but the radiation correction at least improved the inversion result and is certainly applicable for deep local events or far-field events, for which direct waves and converted or reflected waves are isolated well. We will also carry out synthetic tests on finite faults toward further application to real data.

Keywords: source process, slip inversion, empirical Green's function


Number of Sample
Variance Reduction(%)
0
5
10
15
20
25
0
10
20
30
40
50
60
70
80
90
100