Geophysical Research Abstracts, Vol. 7, 02359, 2005
SRef-ID: 1607-7962/gra/EGU05-A-02359

A method to measure finite-frequency amplitudes and travel times of teleseismic body waves

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We present a method to measure finite-frequency amplitude and travel time anomalies of P waves. The method features a matched filtering approach that models the first 20-30 seconds of a seismogram after a teleseismic P arrival. Matched filters for waveform fitting are needed especially in the case of shallow earthquakes: since the depth phases pP and sP arrive only a few seconds after the P pulse, recorded waveforms change as a function of distance and azimuth.

Given a set of broadband seismograms from a teleseismic event, we compute synthetic Green functions using published moment tensor solutions. We deconvolve the first 20-30 seconds of each seismogram with its Green function to obtain the broadband source time function. Subsequent convolution of Green functions with the source time function yields the predicted seismograms, or matched filters. Amplitude anomalies are defined as the multiplicative factors that minimize the RMS misfit between predicted and observed waveforms. The above procedure is implemented in an iterative fashion, which allows for joint inversion of source time function, amplitudes, and a correction to the moment tensor. We run this inversion for many different assumed source depths to determine the most likely depth, as indicated by the quality of waveform fits, and by the shape of the source time function.

Preceding the above procedure, an estimate of relative travel times is obtained by applying Van Decar and Crosson's cross-correlation method. To account for directivity effects in the source time function (especially in global data sets), we divide the data in clusters of similar seismograms and compute travel times and source time functions separately for each cluster. In a post-processing step we compute absolute travel times by time-aligning the different source time functions relative to each other, and also aligning each observed waveform with its matched filter. We obtain finite-frequency

amplitudes and travel times by bandpass-filtering observed broadband waveforms and their matched filters, and subsequently re-aligning the waveforms and recomputing the amplitudes in the chosen passbands.

We present the results of extensive synthetic tests that assess the accuracy and robustness of our method for global-scale data sets. We mimic scenarios of actual teleseimic events (mb = 5.9 to 6.9) as recorded on the GSN network under typical noise conditions. Time permitting, we will also present a regional scale data set of finite-frequency amplitudes and travel times anomalies for the Western U.S.