Muzaffarabad Earthquake of October 8, 2005: Source Parameters using Empirical Green’s Function Technique

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Abstract
Source parameters of Muzaffarabad earthquake of October 8, 2005 were estimated using small events as Empirical Green’s Function, which include path, site and instrumental effect on P-waves. The relative source time functions (RSTF's) for the main event at different stations were estimated using iterative deconvolution method. Source parameters such as seismic moments at different stations vary from 1.08 to 9.07 x 10¹⁰ Nm with average value as 2.65 x 10¹⁰ Nm calculated from duration of RSTF's. The pulse width and amplitudes of RSTF’s variations with different azimuths show that rupture propagation were not unilaterally. Fault length as 72 km and rupture velocity as 3.5 km/s were calculated using directivity effects.

Introduction
In the morning of October 8, 2005 at 08:52 local time a mainshock occurred with magnitude Mₘ = 7.6 in Indus Kohistan Seismic Zone near Muzaffarabad (Figure 1). It is one of the largest earthquake in this region, which is recorded by world wide digital seismic networks. This earthquake provides the opportunity to study the source process and rupture mechanism along the Kashmir Thrust using broad band seismic data. The Empirical Green Function (EGF) method (Hartzell, 1978) was used for this study, which is very good tool for studying source process of an event when the detail earth structure is not known. Many authors have been studied source process using smaller event as Empirical Green Function (EGF) and deconvolve its seismogram with the main event (Muller, 1985; Frankel and Kanamori, 1983; Li and Thurber, 1988; Mori and Ammon et al., 1993). This method is applied to Muzaffarabad earthquake of October 8, 2005 for estimating source parameters.

Data analysis and processing
The broad band wave recordings of the mainshock of 8th October 2005 Muzaffarabad earthquake and its largest aftershock were obtained from IRIS stations. The main shock with its appropriate aftershock, that is have similar focal mechanism and lying in the vicinity of the main shock in shown table above.

GNI station raw data of the mainshock at left and its aftershock used as EGF is shown at right. Both signals were windowed and shifted so that to start with P-waves. We also remove the mean and taper the ends of the signals. Zero phase Gaussian filter were used to pass the frequencies lower then 0.3 Hz.

Technique
The relative source time function (RSTF) can be retrieved by deconvolving the mainshock seismogram with a small earthquake that have the similar radiation pattern and located close to the mainshock. The mainshock (Uₒ(x,ω)) and aftershock(Uₛ(x,ω)) seismograms at any point x and frequency ω can be expressed as,

\[ U(x,\omega) = S_p P(x,\omega) + R(x,\omega) + I(\omega) \]  

(1)

\[ U(x,\omega) = S_p P(x,\omega) + R(x,\omega) \]  

(2)

We divided 1by 2 to get RSTF of the mainshock Sₚm;

\[ \frac{U(x,\omega)}{U(x,\omega)} = \frac{S_p P(x,\omega) + R(x,\omega)}{S_p P(x,\omega) + R(x,\omega)} \]  

or

\[ \frac{U(x,\omega)}{U(x,\omega)} = S_p \]  

(3)

because EGF act as impulse function and the remaining parameters such as radiation pattern, location and instrument are same.

Directivity
Li and Thurber (1988) approach were used for directivity study,

\[ \tau = \left( \frac{L1V1}{L2V2} \right) \cos(\phi - \Delta \phi) \]  

(4)

where as L₁ and V₁ in rupture length and rupture velocity respectively, τ is the pulse width of RSTF A₀ to the azimuth of the station, φₒ is the p wave velocity, Mₒ and Mₛ is the mainshock and aftershock magnitude respectively.

Result and discussion
The RSTFs for all stations were obtained by deconvolution, but as the deconvolution is unstable and create some holes so, water level of 0.1% was used.

Conclusion
Rupture processes of the Muzaffarabad earthquake were very complicated and its propagation is not unilateral, because RSTF pulse amplitude variations are not uniformly varying with different azimuth.

Rupture length is little bit smaller as calculated from field observations.

References


