3D 6C elastic wave simulation

Lixia Sun, Yun Wang, Wei Li

As well known, the 6-component (6C) records of ground motion, including 3-component translation and 3-component rotation, are beneficial to determine the earthquake rupture and prediction of underground structures (Lee, et al. 2007; Sun, et al, 2018). So it is necessary to simulate and analyze the characteristics of wave motion in 6-components that we can utilize them to separate wave field, denoise or improve accuracy by joint inversion with multi-component seismic data.

We simulate the wave filed with the staggered grid finite difference method under the condition of 3-dimensional (3D) homogeneous elastic media, with the grid at a two-order time difference precision and 12-order space difference precision. Based on the first-order velocity-stress elastic wave equation, we use the absorbing boundary conditions in the bottom, right and left boundary with the method of splitting complete matching layer (SPML) to eliminate boundary reflection, and set the top boundary to be a free surface.

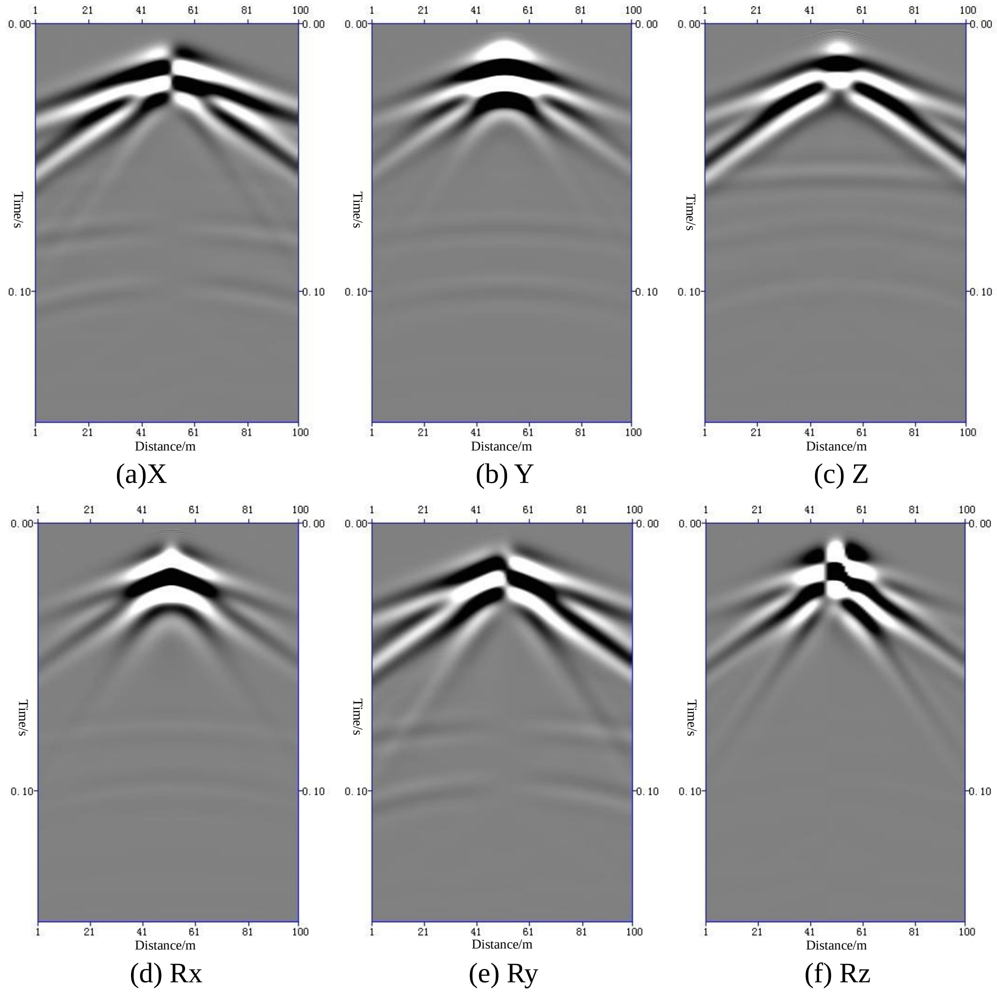
As illustrated in table 1, the model is defined as two-layer medium, with the size of 100m×100m×130m. The receivers are arrayed on the surface with 1m intervals, while the shot is at the depth of 5m underground. With a 50Hz Ricker wavelet separately loaded on the velocity, normal stress and shear stress, which represents the concentrated force source, the explosion source and shear source are simulated respectively; and 6C seismic records with different sources are shown in Fig. 1- Fig. 5.

Table 1. Parameters of 3D homogeneous elastic model

layer	thickness(m)	Vp(m/s)	Vs(m/s)	density(kg/m^3)
1	60	3000	1500	2400
2	70	4000	2000	2600

It can be clearly seen that there are straight-shaped direct waves, surface waves and hyperbolic reflected P waves, PS waves and S waves on all the six components under different sources. Comparing the similarities and differences of 6C, the energy of surface wave is strong on all components with visible dispersion. And the energy of P wave is stronger than that of S wave on Z components, contrary to the results on other components. Moreover, the reflected waves generated from the explosion source are more obvious than that generated from other sources. Besides, straight-shaped direct waves are in phase around the two sides of the seismic sources on X, Ry and Rz components with the Ricker wavelet loaded on v_x and shear stress.

The simulations of different types of sources show that both translations and rotations are helpful to understand ground motion entirely. It is interesting and meaningful to study multi-component wave fields and the rotational component may play a significant role in seismology.



Figiure 1   seismic records generated from the explosion source

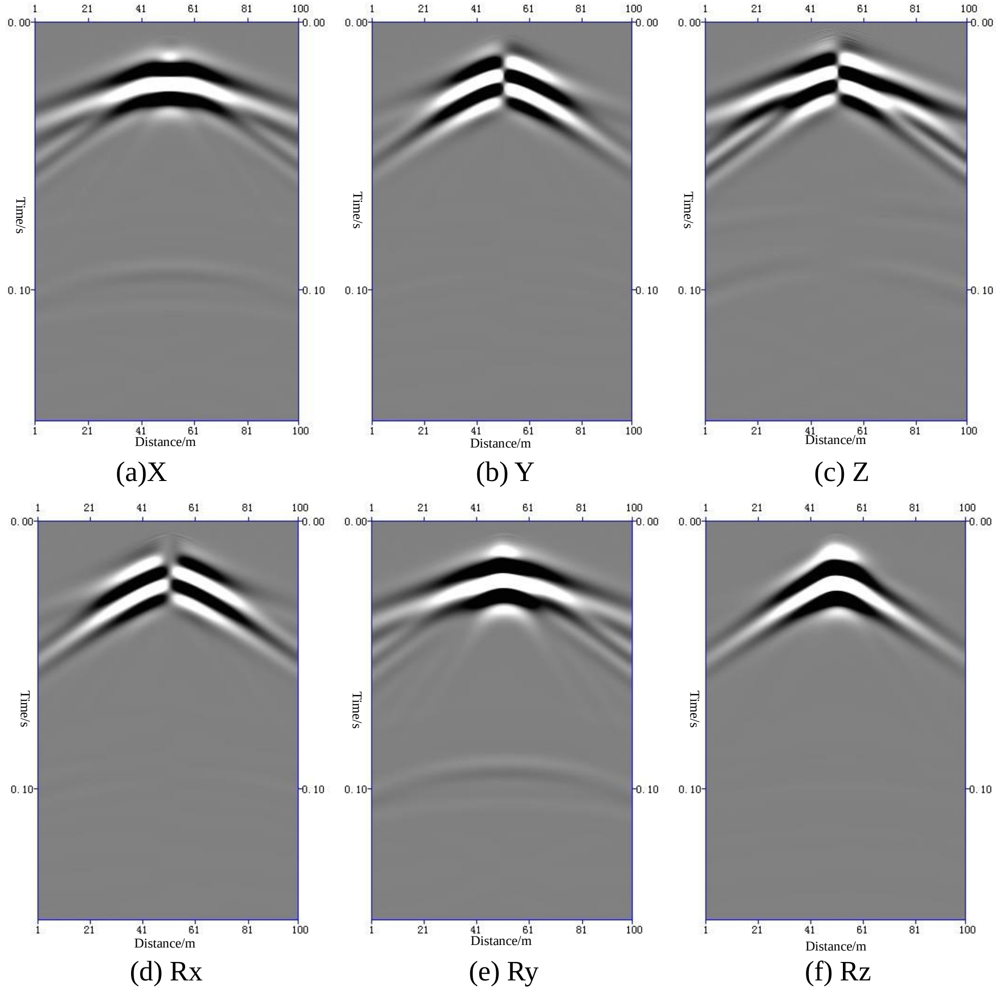
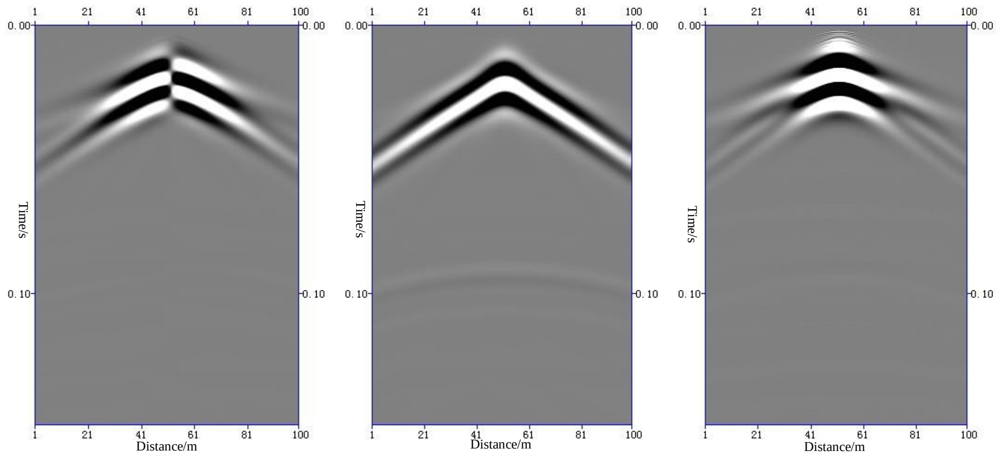
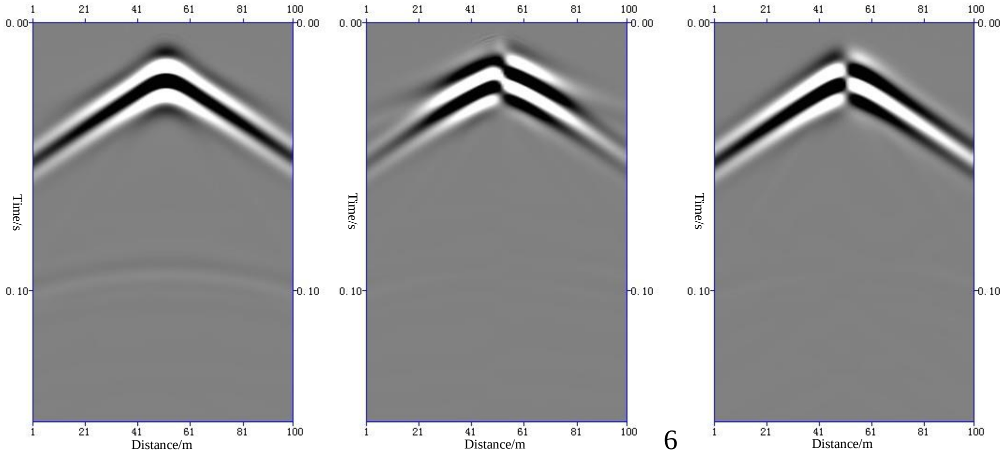


Figure 2 seismic records generated from the radial concentrated force source

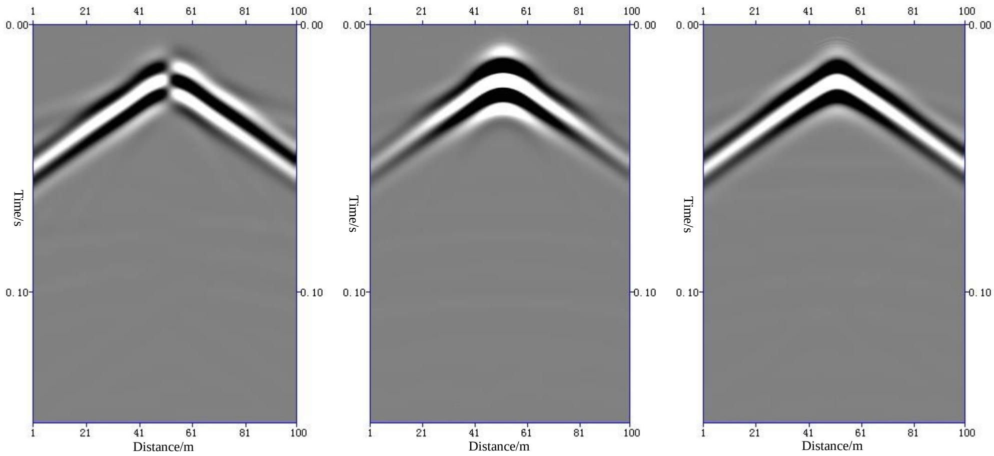


(a)X (b) Y (c) Z

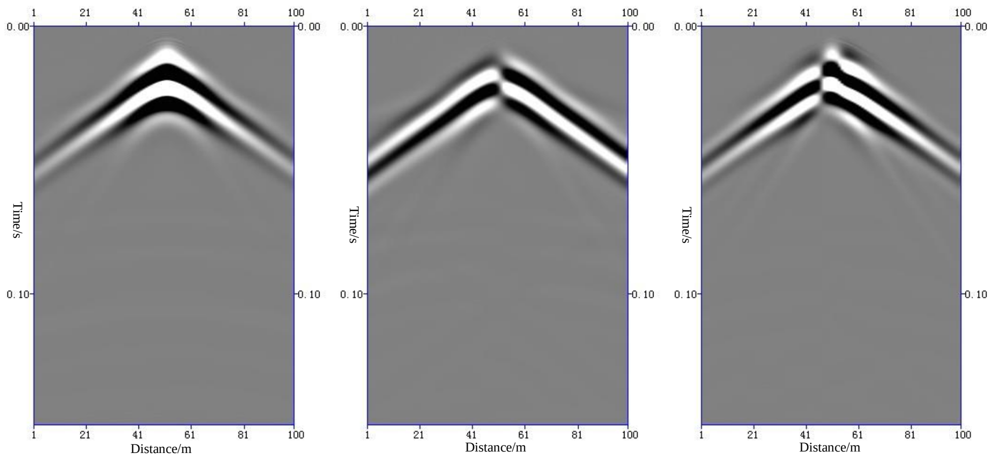


(d) Rx (e) Ry (f) Rz

Figure 3 seismic records generated from the transverse concentrated force source

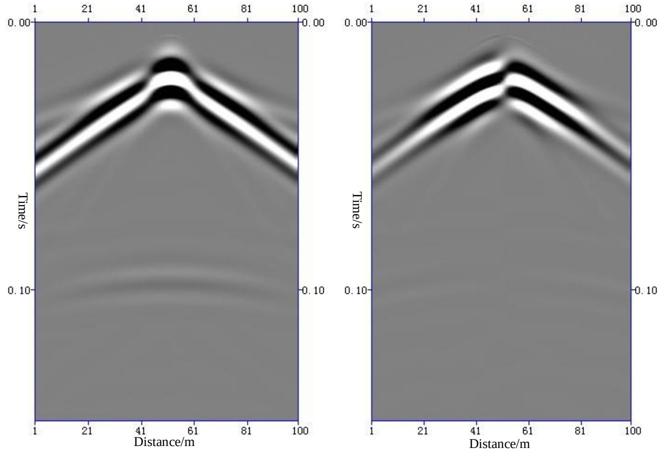


(a)X (b) Y (c) Z

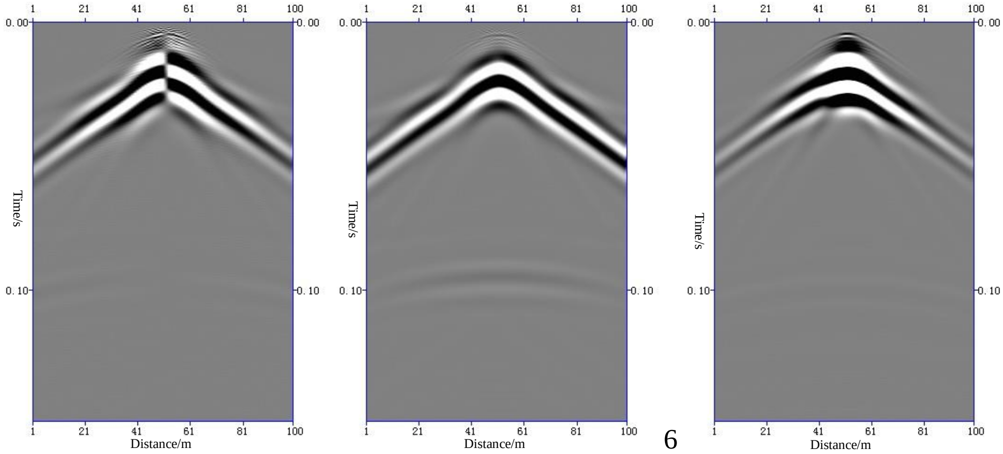


(d) Rx (e) Ry (f) Rz

Figure 4 seismic records generated from the vertical concentrated force source



(a)X (b) Y (c) Z



(a) Rx (b) Ry (c) Rz

Figure 5 seismic records generated from the shear source

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References

Lee W., Celebi M., Todorovska M. and Diggles M. 2007. Rotational seismology and engineering applications: Proceedings for the first international workshop, menlo park, california, USA—september 18 to 19, 2007. US Geol. Surv. Open File Rep **1144**.

Sun L., Zhang Z. and Wang Y. 2018. Six-component elastic-wave simulation and analysis, EGU General Assembly Conference Abstracts, p. 14930.