Comparisons of Travelling-Wave Method and Difference Method for Calculating Rotational Components

Chang Chen, Yun Wang, Li-Xia Sun, Dong-Qing Li

China University of Geosciences, Beijing

Abstract

In the study of six-component seismology, there are two main methods to obtain the rotational components: recording the rotation directly by the rotational seismometers (Nigbor,1994;Takeo,1998;Liu et al.,2009), and indirectly calculating the rotational components with the translational components. Among the methods calculating rotational components, there are mainly two methods, differential calculation with dense station array; calculation with the Travelling-Wave Method. The second is practical in the six-component seismic data processing.

Since Newmark (Newmark,1969) put forward the basic idea of Travelling-Wave Method in the late 1960s, scholars have made extensive research on the principle and application. Through processing synthetic and real seismic data (Lin et al.,2008), this paper compares the difference of first arrivals between the rotational components calculated by Travelling-Wave Method and theoretical simulation or recorded by rotational seismometers, including waveform and phase in the time domain. And then the advantages, disadvantages and feasible conditions of this method are discussed.

In this paper, we firstly establish a horizontal layered isotropic homogeneous medium model and carry out elastic finite difference（Sun et al., 2018） simulation to compare the difference between the rotational components simulated theoretically and calculated by the Travelling-Wave Method. The normalized rotational accelerations are shown in Fig. 1. It can be seen that the calculated values is in good agreement with the synthetic values in the first arrival time, amplitude and phase. However, before normalization, it is found that there is a deviation in the absolute value of the rotational accelerations. And through comparing the trends of different traces, the deviation of the absolute value increases with the increase of the epicentral distance. That is, the deviation between the rotational components calculated values and the synthetic values

get larger as the source distance get farther. Also, we find that the calculated value of the rotational components is smaller than the measured value, and the rotational components calculated decays faster than the measured value. In the calculation of rotational components, the accuracy of Travelling-Wave Method is greatly affected by apparent wave velocity because it is regarded as a constant, and the difference of underground wave velocity and dispersion effect are not considered.

At last, we process the measured six-component seismic data by Two-point Difference Method. From the comparing diagrams between the measured values and the calculated values by the two methods as shown in figure 2, it is proved that Travelling-Wave Method has higher accuracy than the Two-point Difference Method which seriously relies on dense station array.

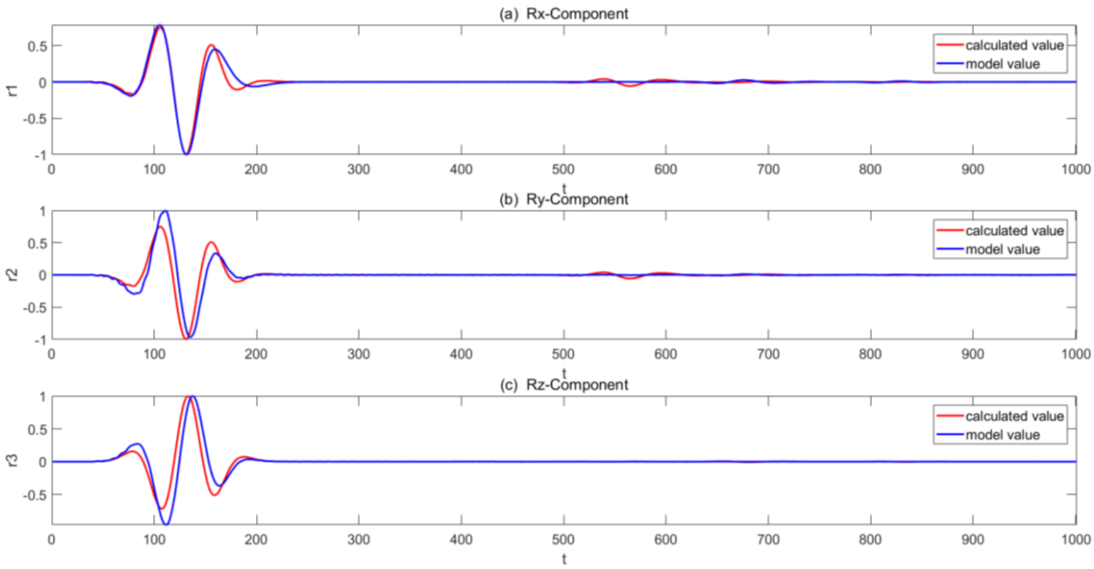

Fig1.Comparison Diagram of Normalized Rotational Acceleration Components of Simulation Data

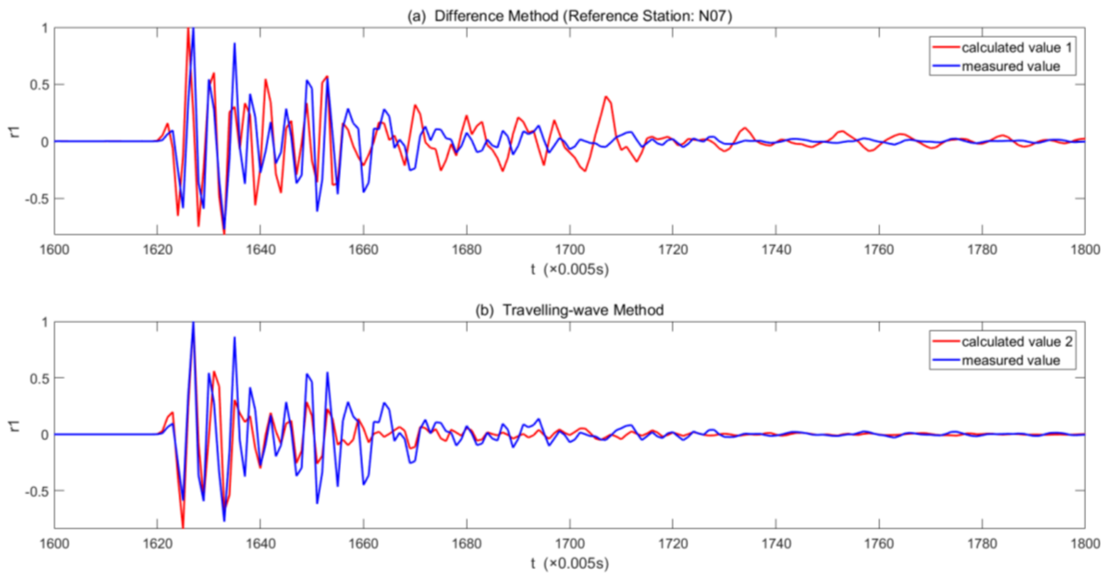

Fig2.Comparison of Rx-component of Normalized Rotational Acceleration Record(Station N06)

(a)Difference Method (Reference Station:N07);(b)Travelling-Wave Method

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Reference

Lin C J , Liu C C , Lee W H K . Recording Rotational and Translational Ground Motions of Two TAIGER Explosions in Northeastern Taiwan on 4 March 2008[J]. Bulletin of the Seismological Society of America, 2009, 99(2B):1237-1250.

Liu C C , Huang B S , Lee W H K , et al. Observing Rotational and Translational Ground Motions at the HGSD Station in Taiwan from 2007 to 2008[J]. Translated World Seismology, 2010, 99(2B):1228-1236.

Newmark N M. Torsion in symmetrical buildings [C]. Chile: Proc. Fourth World Conference on Earthquake Eng., 1969.

Nigbor R L . Six-degree-of-freedom ground-motion measurement[J]. Bulletin of the Seismological Society of America, 1994, 84(5):1665-1669.

Sun L, Zhang Z, Wang Y. 2018. Six-component elastic-wave simulation and analysis. EGU General Assembly 2018, Geophysical Research Abstracts Vol. 20, EGU2018-14930-1.

Takeo, Minoru. Ground rotational motions recorded in near-source region of earthquakes[J]. Geophysical Research Letters, 1998, 25(6):789-792.