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Baseline correction for near-fault ground motion recordings of the 2008 Wenchuan *Ms*8.0 earthquake

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Abstract: In this study, both records of a digital accelerometer and a seismograph at a far-field station for the 2008 *Ms*8.0 Wenchuan earthquake were analyzed, and a pulsive noise model for acceleration record was found. By comparing with the result of a rotary-table tilt test, we concluded that the noises in the acceleration records were caused by ground tilt as a result of rotational ground motion. We analyzed the key noises that may cause baseline offset, and proposed a baseline-correction scheme for preserving the long-period ground motion in accordance with specific pulse positions. We then applied this correction method to some near-field strong-motion acceleration records. The result shows that this method can obtain near-field ground displacements, including permanent displacements, in agreement with GPS data, and that this method is more stable than other methods.

Key words: strong ground motion; baseline correction; permanent displacement; rotational motion; tilt

1 Introduction

Modern strong-motion acceleration instruments have the advantages of high accuracy, broadband and low noises. However, their records still contain baseline offsets[1-3], although small, can produce exaggerated displacements by double integration of the recorded acceleration. Thus baseline corrections are necessary. The traditional baseline correction procedure uses a high-pass filter[4], which tends to filter out signals together with noises, and thus losing long-period ground motions, which are important to engineering studies. Later correction methods can retain long-period signals[2,5], but have not been applied widely for lack of some valid noise model to match them. Furthermore, in many cases the derived displacements are very sensitive to the parameters used in the correction[3].

Generally speaking, the displacement obtained from velocity data by single integration is more stable and conclusive than that derived from acceleration data by double integration, for the long-period error is smaller[6].

Many factors can lead to baseline offset, including ground tilt and rotation, mechanical or electrical hysteresis in the transducer system, background noises and analog-to-digital convertion. Trifunac and Todorovska[7] concluded that the permanent ground displacement could not be computed without knowledge of the rotational components of strong motion. Although special instruments are needed to record rotational components of earthquake motion, ground tilt can be estimated by applying a low-pass filter to the digital strong-motion recording[8].

In this paper, we report on a study of baseline correction for the acceleration data recorded for the *Ms*8.0

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Wenchuan earthquake on 12 May 2008 through estimation of ground tilt, while keeping the long-period signals of ground motion, including permanent displacement. We tried to find a crucial noise model by comparing data from an accelerometer and a seismometer located near each other.

2 Data

More than 420 digital strong-motion accelerograms were recorded for the Wenchuan earthquake by China National Strong Motion Observation Network. Most of the sensors installed at the network stations were SLJ-100 force-balance accelerometers[1]. The effective-frequency band was from 0 to 80 Hz, and the sampling frequency was 100 or 200 sps[9]. The seismographic velocity records we used were downloaded from the China Earthquake Network Center (http://www.csndmc.ac.cn/newweb/data.htm). But only records (including both acceleration and velocity data) obtained from the Quanzhou station can be used. The static GPS data we used came from Zhang et al[10], who also applied high frequency (1 Hz) GPS data to obtain dynamic ground deformation. However, due to power failure caused by the strong earthquake shaking, only high-frequency GPS data of 65 seconds were recorded[11].

The strong-motion stations and the GPS stations are shown in figure 1. The strong-motion station 051PXZ is only 100 meters from the GPS station PIXI, where the ground motions of the main shake were recorded relatively well. Therefore, it is important to compare the displacements obtained by GPS with those obtained from the accelerogram.

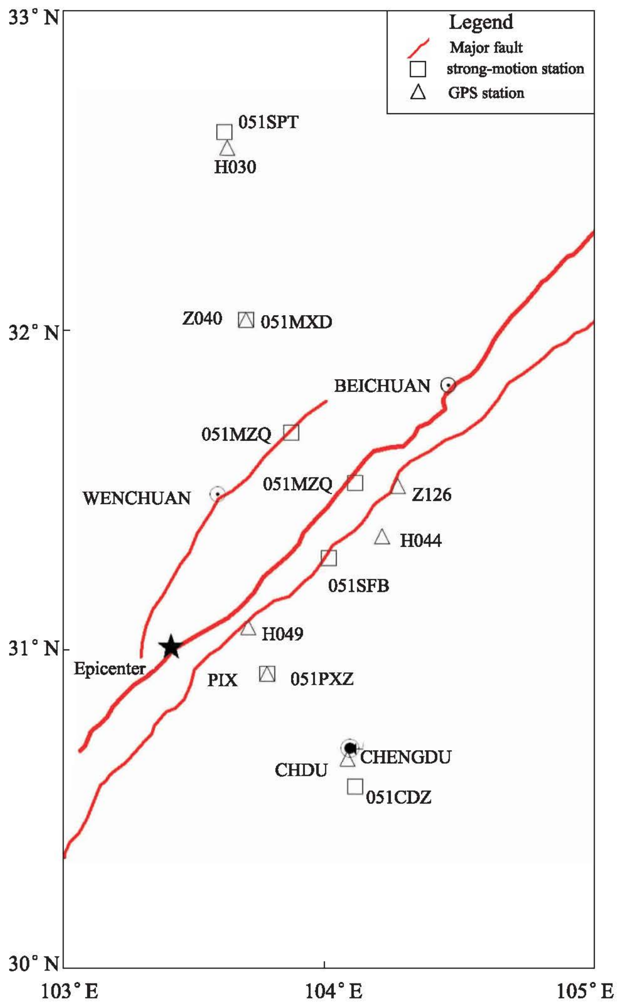

Figure 1 Sketch of Longmenshan thrust belt, strong-motion stations, and GPS stations

3 Correction schemes

3.1 Previous methods

With the development of digital accelerographs, the strong-motion records with high precision and broadband have been widely used. Seismologists attempt to apply these records to obtain the residual ground deformation and the fault rupture process by inversion. Since baseline offsets always exist in the records, these deflects must be corrected before the result is utilized.

A correction method widely applied was proposed by Iwan et al[2], who ascribes the source of the baseline offsets to some minute mechanical or electrical hysteresis in the transducer system that occurred when the acceleration exceeded about 50 cm/s^2. To correct for this offset, Iwan et al[2] proposed that two baselines showd be removed: a_m between times t_1 and t_2, and a_f from time t_2 to the end of the record (t_e in this paper); they selected t_1 and t_2, respectively, to be the times of first and last occurrences of acceleration that exceeds 50 cm/s^2. The level a_f is determined by a least-squares fit to the tail part of the velocity trace:

$$v_f(t) = v_0 + a_f t \quad (1)$$

Then, a_m is given by

$$a_m = v_f(t_2)/(t_2 - t_1) \quad (2)$$