Geophysical Research Abstracts
Vol. 15, EGU2013-8302-1, 2013
EGU General Assembly 2013

Real-time coseismic displacements from tightly-integrated processing of high-rate GNSS and strong motion data

Xingxing Li (1), Maorong Ge (1), Yong Zhang (1,2), Rongjiang Wang (1), Jürgen Klotz (1), Jens Wickert (1), and Harald Schuh (1)

(1) The German Research Centre for Geosciences (GFZ), Potsdam, Germany (lixin@gfz-potsdam.de), (2) Institute of Geophysics, China Earthquake Administration, No. 5 Minzudaxue Nanlu, Beijing 100081, China

Precise point positioning (PPP), which can provide “absolute” coseismic displacements with respect to a global reference frame (defined by the satellite orbits and clocks) with a stand-alone GNSS receiver, is advantageous and being used more and more widely for high-rate GNSS seismology. Following the availability of real-time high-rate GNSS observations and precise satellite orbit and clock products, the interest in the real-time PPP technique has greatly increased to construct displacement waveforms and to invert for source parameters of earthquakes in real time. Furthermore, PPP ambiguity fixing approaches developed in recent years provide an important promise to overcome the accuracy limitation of the traditional PPP float solution and to achieve comparable accuracy with relative/network positioning.

The main weaknesses of current GNSS measurements are the lower sampling rates (1∼50Hz) and the larger high-frequency noise contribution compared to the seismic sensors. Strong motion sensors are able to sample at very high rates (e.g. 200Hz) and perform very well in the high-frequency range as it is much more sensitive to ground motions than GNSS receiver, especially in the vertical direction. However, the double integration is accompanied by unphysical drifts due to sensor rotation and tilt, hysteresis, and imprecision in the numerical integration process. GNSS and seismic instruments are mutually beneficial for geophysical applications because weaknesses of one observation technique are offset by strengths in the other.

In order to take full use of the complementary of GNSS and strong motion sensors, we propose an approach of integrating the strong motion data into the real-time ambiguity-fixed PPP processing. A tightly-integrated filter is developed to estimate coseismic displacements from raw GNSS phase and pseudorange observations and raw strong motion data. The performance of the proposed tightly-integrated approach was demonstrated using the collocated high-rate GNSS and strong motion data collected during the 2010, Mw 7.2 El Mayor-Cucapah earthquake(Mw 7.2, 4 April, 2010) in Baja California, Mexico. Taking advantage of the greater precision of the accelerometer observations, small-amplitude P-wave arrivals can be detected in the integrated solution. That is not detectable in the GNSS-only approach because of the reduced sensitivity of GNSS especially in vertical component. On the other hand, the seismic-only solution does not show the permanent co-seismic offset correctly, but it can be obtained from the integrated solution exactly. Furthermore, the proposed tightly-integrated algorithm can significantly improve the ability of resolving integer-cycle phase ambiguities in real-time scenarios, which is required to derive displacements with highest accuracy. Based on the integrated results, we detected the P-wave arrival, located the epicenter and estimated the magnitude. The P-wave-based earthquake parameters such as epicenter and origin time can be issued before the arrival of the destructive S-wave. The reliable estimation of the earthquake magnitude is an important contribution for earthquake early warning especially in case of large magnitude earthquakes.

Keywords: Real-time high-rate GNSS; strong motion sensor; tight integration; precise point positioning; PPP ambiguity fixing;