Accuracy Assessment of High-rate GPS for Detection of Short-Term Motions

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We adopted an instrumental approach to assess the accuracy of high-rate GPS to detect transient, short-term (seconds to days) surface motions, such as those associated with glacial flow, surges, glacial earthquakes, active volcanoes, and in particular the seismic motions associated with earthquakes. We built an apparatus for translating a GPS antenna on a positioning table that is accurate to better than 0.1 mm in position, and thus provides the “ground truth” displacements for assessing the technique of high-sample-rate (~1 Hz) GPS. The GPS antenna attached to this positioning table undergoes simulated (seismic or other) motions of the Earth’s surface while collecting high-rate GPS data. Analysis of the time-dependent position estimates can then be compared to the ground truth, and the resultant GPS error spectrum can be measured. In Elosegui et al. [2006], we reported that millimeter-level accuracy can be achieved for GPS position determinations in high-sample-rate applications (Figure 1).

This work is an extension of Elosegui et al. [1996], in which we translated a GPS antenna in the horizontal plane at 1 mm/hr for more than 24 hours. By modeling the time-dependent position as a random walk and fitting a straight line to the stochastic estimates, they showed that the accuracy of the velocity estimates was dependent on the observing period and the baseline lengths. For example, for 24-hour data time spans, the root-mean-square (rms) horizontal and vertical velocity errors were less than 0.2 and 0.9 mm/hr, respectively, for baselines between 10 m and ~1000 km.

Figure 1. Results from ground-truth studies of the accuracy of the GPS-seismology technique of Elosegui et al. [2006]. A GPS antenna was installed on a high-accuracy positioning table, which was then used to simulate the motions of an earthquake. The programmed motion is shown in the figure by the blue line. The GPS data acquired during the simulated earthquake were analyzed to provide time-dependent determinations of site position, shown by the red dots. The error in the position estimate (green curve) over the 15-min span of the simulated earthquake has a maximum value of 10 mm and an rms value of 2.5 mm.