The few-millimeter-precise reduction of the short-term noise in dual-frequency carrier-phase GPS positioning applied to the 1-Hz measurement of seismic displacement

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ABSTRACT

This study reduced the short-term noises appearing in the ionosphere-free combination of dual-frequency GPS receiver's measurements. It introduced the assumption of the short-term stability of the linear variation in ionospheric delays. The reduction was then realized by filtering the second-order temporal difference in the geometry-free combination of the measurements, where its typical time constant was chosen to be three minutes in this study.

This technique was applied to the high-rate, typically 1-Hz, precise point positioning (PPP) of a stationary GPS receiver. The magnitude of the short-term noise in the calculated position was successfully reduced to about three millimeters whereas that using the original ionosphere-free combination was about twice larger.

This study combined the above technique and a sidereal filter, the latter of which was intended to reduce the noisy variation in measurements with a period longer than several minutes. The method of a sidereal filter uses the reproducibility of the errors in the measurements of a stationary GPS receiver over consecutive days and is known effective to reduce the especially low-frequency noise of measurements.

This study demonstrated the positioning precision in measuring the surface wave induced by the 2008 Sichuan earthquake propagating to Usuda, Japan, whose GPS receiver was set at a distance of 3280 km from the epicenter. The measured maximum peak-to-peal amplitude of its oscillation was about 15 mm and 25 mm in horizontal and vertical directions, respectively.

Its PPP calculation used the final IGS ephemerides of GPS satellites and the CODE's 5-second-interval estimation of the clocks, the latter of which was temporally interpolated for the high-rate calculation. The interpolation error was considered to be lower than the measurement one which was reduced to few millimeters by this study's technique. The zenith tropospheric delay and the horizontal gradients were estimated posteriorly.

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