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ORIGINAL ARTICLE

Modeling and assessment of combined GPS/GLONASS precise point positioning

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Abstract A combination of GPS and GLONASS observations can offer improved reliability, availability and accuracy for precise point positioning (PPP). We present and analyze a combined GPS/GLONASS PPP model, including both functional and stochastic components. Numerical comparison and analysis are conducted with respect to PPP based on only GPS or GLONASS observations to demonstrate the benefits of the combined GPS/GLONASS PPP. The observation residuals are analyzed for more appropriate stochastic modeling for observations from different navigation systems. An analysis is also made using different precise orbit and clock products. The performance of the combined GPS/GLONASS PPP is assessed using both static and kinematic data. The results indicate that the convergence time can be significantly reduced with the addition of GLONASS data. The positioning accuracy, however, is not significantly improved by adding GLONASS data if there is a sufficient number of GPS satellites with good geometry.

Keywords GPS · GLONASS · PPP · Functional modeling · Stochastic modeling

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Introduction

Currently, the precise point positioning (PPP) technique is mainly limited to the use of GPS measurements. With newly available precise orbit and clock data for GLONASS satellites, additional GLONASS observations can be applied to augment GPS for improved positioning accuracy, reliability and availability using PPP. A few IGS analysis centers provide GLONASS precise orbit products on a regular basis, including CODE (Center for Orbit Determination in Europe, Switzerland), IAC (Information-Analytical Center, Russia), ESA/ESOC (European Space Operations Center, Germany) and BKG (Bundesamt für Kartographie und Geodäsie, Germany). But only two data analysis centers, namely IAC and ESA/ESOC, can provide post-processed GLONASS clock data (Oleynik et al. 2006), which, however, is expected to change with the improvements of the GLONASS constellation. IGS (International GNSS Service) also provides final GLONASS orbits by combining independent GLONASS orbits from different analysis centers (Weber et al. 2005). No IGS final precise GLONASS satellite clock corrections are available at this time due to the limited number of contributing centers (http://igsws.unavco.org/components/prods.html). In addition to IGS, a few commercial service providers such as Fugro, NavCom and Veripos also calculate GLONASS precise orbit and clock corrections based on their own reference station networks (Melgard et al. 2009; Dai and Hatch 2011; Rocken et al. 2011).

Cai and Gao (2007) investigated the processing of combined GPS and GLONASS observations in a PPP mode along with preliminary numerical results. Hesselbarth and Wanninger (2008) tested several different PPP processing strategies using kinematic observations. Both studies have demonstrated that adding GLONASS satellites to GPS can