GPS Solut (2013) 17:465–473
DOI 10.1007/s10291-012-0292-6

ORIGINAL ARTICLE

SBAS orbit and satellite clock corrections for precise point positioning

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Received: 21 May 2012 / Accepted: 7 September 2012 / Published online: 25 September 2012

Abstract The quality of real-time GPS positions based on the method of precise point positioning (PPP) heavily depends on the availability and accuracy of GPS satellite orbits and satellite clock corrections. Satellite-based augmentation systems (SBAS) provide such corrections but they are actually intended to be used for wide area differential GPS with positioning results on the 1-m accuracy level. Nevertheless, carrier phase-based PPP is able to achieve much more accurate results with the same correction values. We applied SBAS corrections for dual-frequency PPP and compared the results with PPP obtained using other real-time correction data streams, for example, the GPS broadcast message and precise corrections from the French *Centre National d'Etudes Spatiales* and the German *Deutsches Zentrum für Luft- und Raumfahrt*. Among the three existing SBAS, the best results were achieved for the North American wide area augmentation system (WAAS): horizontal and vertical position accuracies were considerably smaller than 10 cm for static 24-h observation data sets and smaller than 30 cm for epoch-by-epoch solutions with 2 h of continuous observations. The European geostationary navigation overlay service and the Japanese multi-functional satellite augmentation system yield positioning results with biases of several tens of centimeters and variations larger by factors of 2–4 as compared to WAAS.

Keywords GPS · Precise point positioning · Satellite-based augmentation systems

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Introduction

The method of precise point positioning (PPP, Zumberge et al. 1997) to compute receiving antenna positions from Global Navigation Satellite Systems (GNSS) observations has become popular in recent years. Usually, dual-frequency GNSS observations are processed using precise orbits and clock corrections from, for example, the International GNSS Service (IGS, Dow et al. 2009). These orbits and clock corrections are available for post-processing purposes with delays of at least several hours. Real-time IGS products are planned for the near future (Dow et al. 2009).

But already today several sources of real-time GNSS orbits and clock corrections exist. Not all of them are intended to reach the accuracies of IGS products and often they do not aim to be used in PPP-mode, but nevertheless they can be used successfully with these algorithms.

It was our main objective to test the correction data streams of the satellite-based augmentation systems (SBAS), namely the US-American Wide Area Augmentation System (WAAS, GPS WAAS PS 2008), the European Geostationary Navigation Overlay Service (EGNOS, Ventura-Traveset et al. 2006), and the Japanese Multi-functional Transport Satellite Satellite-based Augmentation System (MSAS, Nakaitani 2009). These wide area differential GPS (WADGPS) provide orbit, clock, and ionosphere correction data for North America, Europe, and Japan, respectively. The main objectives of these systems are providing integrity positioning with a safety-of-life quality and providing a better accuracy than stand-alone GPS of about 1–2 m (Ventura-Traveset et al. 2006). They are expected to be used with single-frequency code observations. We, however, used the SBAS orbits and clock corrections together with dual-frequency code and carrier phase observations to compute PPP results.