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ORIGINAL ARTICLE

Real-time clock offset prediction with an improved model

Guan Wen Huang · Qin Zhang · Guo Chang Xu

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Abstract The GPS orbit precision of the IGS ultra-rapid predicted (IGU-P) products has been remarkably improved since 2007. However, the satellite clock offsets of the IGU-P products have not shown sufficient high-quality prediction to achieve sub-decimeter precision in real-time precise point positioning (RTPPP), being at the level of 1–3 ns (30–90 cm) RMS in recent years. An improved prediction model for satellite clocks is proposed in order to enhance the precision of predicted clock offsets. First, the proposed prediction model adds a few cyclic terms to absorb the periodic effects, and a time adaptive function is used to adjust the weight of the observation in the prediction model. Second, initial deviations of the predictions are reduced by using a recomputed constant term. The simulation results have shown that the proposed prediction model can give a better performance than the IGU-P clock products and can achieve precision better than 0.55 ns (16.5 cm) in real-time predictions. In addition, the RTPPP method was chosen to test the efficiency of the new model for real-time static and kinematic positioning. The numerical examples using the data set of 140 IGS stations show that the static RTPPP precision based on the proposed clock model has been improved about 22.8 and 41.5 % in the east and height components compared to the IGU-P clock products, while the precisions in the north components are the equal. The kinematic example using three IGS stations shows that the kinematic RTPPP precision based on the proposed clock model has improved about 30, 72 and 44 % in the east, north and height components.

G. W. Huang (✉) · Q. Zhang
College of Geology Engineering and Geomantic,
Chang'an University, Xi'an 710054, Shaanxi, China
e-mail: huang830928@yahoo.com.cn

G. W. Huang · G. C. Xu
Department of Geodesy and Remote Sensing,
GeoForschungsZentrum (GFZ), 14473 Potsdam, Germany

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Introduction

It is well known that the real-time precise correction of the satellite clock error is indispensable for real-time GPS positioning since the broadcast ephemeris and the ultra-rapid predicted (IGU-P) products provided by the International Global Navigation Satellite System Service (IGS) are available for users in real-time GPS applications. Clock offset predictions in the broadcast ephemeris are modeled by a quadratic polynomial for each satellite. The model parameters, which are updated at least once a day, are used to predict the satellite clock offsets (IS-GPS-200D 2006). The IGU-P product is a part of the IGS ultra-rapid (IGU) products that covers 48 h of orbits and clock biases. The first 24 h of the orbits and the corresponding clock biases in the IGU products are obtained from observations, while the second 24 h are extrapolated (http://acc.igs.org/). The performance of orbit and clock predictions based on the broadcast parameters has been shown to be roughly 1.5 m and 5 ns RMS, and the accuracy of the IGU-P orbit and clock products is about 5 cm and 3 ns, respectively (http://acc.igs.org/igsacc_ultra.html). The IGU-P orbit precision has remarkably improved since the late 2007, but its clock products, which are still at about the same level as the broadcast clocks, have not shown high-quality prediction performance. The reason is that the satellite atomic clock in space is influenced by various factors such as