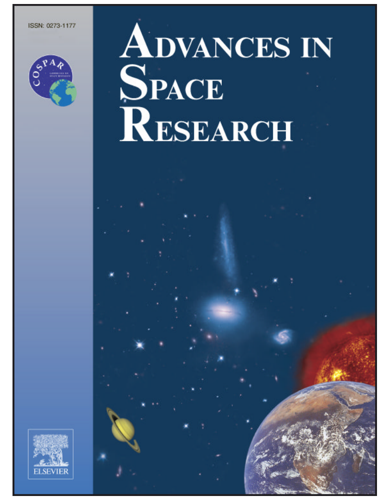
Accepted Manuscript



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PII: S0273-1177(17)30899-2
DOI: https://doi.org/10.1016/j.asr.2017.12.023
Reference: JASR 13556

To appear in: *Advances in Space Research*

Received Date: 2 March 2017
Revised Date: 12 December 2017
Accepted Date: 14 December 2017

Please cite this article as: Wang, S., Yang, F., Gao, W., Yan, L., Ge, Y., A New Stochastic Model Considering Satellite Clock Interpolation Errors in Precise Point Positioning, *Advances in Space Research* (2017), doi: https://doi.org/10.1016/j.asr.2017.12.023

A New Stochastic Model Considering Satellite Clock Interpolation Errors in Precise Point Positioning

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Abstract Precise clock products are typically interpolated based on the sampling interval of the observational data when they are used for in precise point positioning. However, due to the occurrence of white noise in atomic clocks, a residual component of such noise will inevitable reside within the observations when clock errors are interpolated, and such noise will affect the resolution of the positioning results. In this paper, which is based on a twenty-one-week analysis of the atomic clock noise characteristics of numerous satellites, a new stochastic observation model that considers satellite clock interpolation errors is proposed. First, the systematic error of each satellite in the IGR clock product was extracted using a wavelet de-noising method to obtain the empirical characteristics of atomic clock noise within each clock product. Then, based on those empirical characteristics, a stochastic observation model was structured that considered the satellite clock interpolation errors. Subsequently, the IGR and IGS clock products at different time intervals were used for experimental validation. A verification using 179 stations worldwide from the IGS showed that, compared with the conventional model, the convergence times using the stochastic model proposed in this study were respectively shortened by 4.8% and 4.0% when the IGR and IGS 300-s-interval clock products were used and by 19.1% and 19.4% when the 900-s-interval clock products were used. Furthermore, the disturbances during the initial phase of the calculation were also effectively improved.

Keywords: Precise point positioning; Atomic clock noise; Interpolation error; Stochastic model

1. Introduction

In 1997, Zumberge presented a new GNSS data processing model known as the precise point positioning (PPP) approach. The PPP approach has been extensively and continuously studied because it requires only one high-precision receiver in the positioning scheme, and there is no distance limit between the observation stations. PPP calculations require high-precision satellite orbit and clock products that are expressed continually by some nodes at regular intervals (Gao Y 2002; Jan Kouba and Héroux 2001). However, orbit and clock data inevitably require interpolation processing because the sampling interval of the receiver is generally different from those of the orbit and clock products. PPP uses undifferentiated data, that introduces influences from orbit and clock errors. These errors cannot be completely eliminated by the difference positioning model; thus, the influence of PPP remains entirely within the observations. Hence, any interpolation of the orbit or clock data will affect the PPP results (Yi C 2011; Yi et al. 2010).[1]

Currently, real-time precise positioning has become an intense research topic, but the intervals of precision products, for example, rapid and ultra products, are relatively low. Hence, satellite clock interpolation errors should be considered on the user end. Three-day arc solutions are used for orbit paths, while satellite orbits are relatively smooth; thus, satellite orbits are suitable for interpolation processing. The interpolation errors of satellite orbits are generally negligible compared with the original errors. If considered, these errors are system errors. However, satellite clocks exhibit some white noise characteristics that have large variations over short intervals; thus, interpolation processing can scarcely address the system errors when the sampling intervals in satellite clock error data are large. Different satellite clocks show different

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