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ORIGINAL ARTICLE

Fast estimation and analysis of the inter-frequency clock bias for Block IIF satellites

Haojun Li · Xuhua Zhou · Bin Wu

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Abstract The inter-frequency bias of PRN25 was noticed by the scientific community and considered to be caused by thermal variations. The inter-frequency bias leads to an apparent inter-frequency clock bias (IFCB), which could be obtained using the difference of two ionosphere-free phase combinations (L1/L2 and L1/L5). We present an efficient approach derived from the epoch-differenced strategy for fast estimation of IFCBs for Block IIF satellites. For the analysis, data from 32 stations from the IGS network spanning 10 months (DOY 213, 2011–153, 2012) are processed. The processing times show that the epoch-differenced method is more efficient than the undifferenced one. In order to study the features of IFCB, a harmonic analysis is performed by using a FFT (fast Fourier transformation), and significant periodic variations with the periods of 12, 6 and 8 h are noticed. The fourth-order period is determined by comparing the performances of the model with different periods. After determination, a harmonics-based function of order 4 is used to model the IFCB, and the single-day amplitudes and phases are estimated for the 10 months from a least squares fit. Based on the estimated results, the characterization of IFCB is discussed. The algorithm is incorporated into the MGPSS software developed at SHAO (Shanghai Astronomical Observatory, Chinese Academy of Sciences) and used to monitor the IFCB variations of GPS and COMPASS systems in near real time.

H. Li (✉) · X. Zhou · B. Wu
Shanghai Astronomical Observatory, Chinese Academy of Sciences, Shanghai 200030, People's Republic of China
e-mail: yanlhjch@126.com

H. Li · B. Wu
Shanghai Key Laboratory of Space Navigation and Position Techniques, Shanghai 200030, People's Republic of China

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Introduction

The Chinese COMPASS system, the modernized GPS satellites, the European Galileo system and the Japanese Quasi-Zenith Satellite System (QZSS) provide signals on three or more carrier frequencies. Some studies are carried out by using the real triple-frequency data (Hauschild et al. 2012a, b; Montenbruck et al. 2011a, b). An apparent inconsistency between three frequency carrier phases in the GPS systems was noted by the scientific community, which was understood to be caused a thermally dependent inter-frequency bias (Montenbruck et al. 2011a, b). The inter-frequency bias (IFB) of QZSS signal also is investigated by using the real data of the first QZSS satellite. The results show that there is no IFB variation in QZSS triple-frequency signals (Hauschild et al. 2012a).

In the current clock estimations (Hauschild and Montenbruck 2009; Bock et al. 2009; Ge et al. 2012; Li et al. 2010a, b), L1/L2-based ionosphere-free linear combination is normally used, and the impacts of IFBs exist in satellite clocks. Consequently, the satellite clocks derived from L1/L2 phase observations cannot be used for L1/L5-based precise point positioning (PPP) (Zumberge et al. 1997) without careful consideration of these biases. To enable a consistent use of L1/L2 clock products in L1/L5-based positioning and contribute to a better clock predictability at timescales of several hours, the inter-frequency clock bias (IFCB) of PRN25 has been estimated by using the undifferenced approach in Montenbruck et al. (2011a, b). With the developments of all the systems, the estimation of the satellite clock offset will be carried out as a routine