Multi-GNSS Precise Point Positioning : Biases and Models

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For precise multi-GNSS data analysis, especially in the M-GEX campaign, the inter- and inner- system biases (ISB or IFB) are key parameters. There are no recommended/conventional models for the estimation of these bias parameters within the IGS community. As a matter of result, the GLONASS satellite clocks of IGS ACs differ in temporal reference frame or clock consistency. And the difference of the bias models and satellite clocks have impact on the Multi-GNSS precise point positiong (PPP) modeling. In the first part of this paper, we evaluate the GPS/GLONASS ISBs and GLONASS IFBs and their impacts on Multi-GNSS PPP using data of 74 IGS stations over 3 years. Precise ISB/IFB models are also derived and evaluated for each station.

The ISB/IFB are also key parameters in multi-GNSS precise point positioning (PPP), where traditional PPP analysis treats them as additional explicit parameters, which are defined as either epoch-wise unknows or session-wise constants. Based on the scaled sensitivity matrix (SSM) method, a quantitative approach for assessing parameter assimilation, we theoretically prove that ISB parameter is not correlated with coordinate parameters and it can be assimilated into clock and ambiguity parameters. Thus, removing ISB from PPP model does not affect coordinate estimation. Based on this analysis, we develop a simplified and unified model for multi-GNSS PPP, where ISB parameter does not need to be estimated and observations from different GNSS systems are treated in a unique way.

To verify the new model, we implement the algorithm to the self-developed software to process 1 year GPS/GLONASS data of 53 IGS (International GNSS Service) stations and 1 month GPS/BDS data of 15 IGS M-GEX (Multi-GNSS Experiment) stations. Two types of GPS/GLONASS and GPS/BDS combined PPP solution are performed, one is based on traditional model and the other implements the new model. RMSs of coordinate differences between the two type of solutions are 1.8, 3.1 and 2.6 µm for GPS/GLONASS static PPP, 2.5, 4.0 and 0.8 µm for GPS/BDS static PPP, and 13.8, 15.2 and 13.1 µm for GPS/GLONASS kinematic PPP in the North, East and Up components, respectively. Considering the millimeter-level precision of current GNSS PPP solutions, these statistics demonstrate equivalent performance of the new and simplified model as that of the traditional one.