GPS, Galileo and BeiDou inter-system biases estimation in relative positioning with code and phase pseudoranges

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Abstract

The recent increase in the number of Global Navigation Satellite Systems (GNSS) opens new perspectives in the field of high precision positioning. Particularly, the Chinese BeiDou satellite system and the European Galileo program have experienced major progress in 2015 and 2016 with the launch of 7 and 8 satellites respectively. Associated with the ongoing GPS modernization, many more frequencies and satellites are now available. Therefore, multi-GNSS relative positioning based on overlapping frequencies should entail better accuracy and reliability in position estimations. However, the differences between satellite systems induce inter-system biases (ISBs) inside the multi-GNSS equations of observation.

The combined use of L1 and L5 from GPS with E1 and E5a from Galileo, B2 from BeiDou and E5b from Galileo in zero baseline double differences (ZB DD) based on a unique pivot satellite is employed to resolve ISBs. This model removes all the satellite- and receiver-dependent error sources by differentiating and the zero baseline configuration allows atmospheric and multipath effects elimination.

An analysis of the long-term stability of ISBs (GPS- Galileo and Galileo - BeiDou) is conducted on various pairs of receivers over large time spans. The possible influence of temperature variations inside the receivers over ISB values is also investigated. Our study is based on the 6 multi-GNSS receivers (2 Septentrio PolaRx4, 1 Septentrio PolaRxS, 1 Septentrio PolaRx5 and 2 Trimble NetR9) installed on the roof of our building in Liege. The estimated ISBs are then used as corrections in the multi-GNSS observation model and the resulting accuracy of multi-GNSS positioning is compared to GPS, Galileo and BeiDou standalone solutions.