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Inter-system biases estimation in multi-GNSS relative positioning with GPS and Galileo

Cecile Deprez and Rene Warnant
University of Liege, Belgium (cecile.deprez@ulg.ac.be)

The recent increase in the number of Global Navigation Satellite Systems (GNSS) opens new perspectives in the field of high precision positioning. Particularly, the European Galileo program has experienced major progress in 2015 with the launch of 6 satellites belonging to the new Full Operational Capability (FOC) generation. Associated with the ongoing GPS modernization, many more frequencies and satellites are now available. Therefore, multi-GNSS relative positioning based on GPS and Galileo 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. Once these biases estimated and removed from the model, a solution involving a unique pivot satellite for the two considered constellations can be obtained. Such an approach implies that the addition of even one single Galileo satellite to the GPS-only model will strengthen it.

The combined use of L1 and L5 from GPS with E1 and E5a 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-dependant error sources by differentiating and the zero baseline configuration allows atmospheric and multipath effects elimination. An analysis of the long-term stability of ISBs 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 5 multi-GNSS receivers (2 Septentrio PolaRx4, 1 Septentrio PolaRxS 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 and Galileo standalone solutions.