New approach for computing satellite clocks focused on testing general relativity with Galileo satellites

J. Miguel Juan, Jaume Sanz, Guillermo González-Casado, Adrià Rovira-García
Research group of Astronomy and Geomatics (gAGE)
Universitat Politècnica de Catalunya (UPC)
Campus Nord, E-08034 Barcelona, Spain

Contact person: J. Miguel Juan; jose.miguel.juan@upc.edu

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Abstract

The estimation of the fractional part of carrier phase ambiguities (also named phase biases) for satellites and receivers [1,2] is a key point in order to fix carrier phase ambiguities when processing un-differenced measurements. Initially, phase biases were introduced in order to allow users to achieve similar accuracies using PPP than those using differential techniques, as RTK, with the advantage that PPP can be applied globally, while RTK can only be applied over a regional area.

In the context of the ongoing ESA project General Relativity Experiment (GREAT), we are developing a new strategy to estimate accurate satellite clocks, which are the key element for testing the general relativity predictions, as well as other fundamental aspects of sciences.

In this work we show how phase bias estimates, i.e. unambiguous carrier phases, can also help to compute satellite corrections (in general) and clocks in particular. Indeed, based on the phase biases estimates, we present a new approach for computing satellite and receiver clocks that involves all the frequencies, instead of using just the ionospheric free combination, which is the usual way for estimating satellite and receiver clocks. Therefore, we are able to estimate, in the same process, satellite and receiver clocks and the different inter-frequency and inter-constellation biases.

We apply this new strategy for estimating clock and biases for receivers and for GPS and Galileo satellites, taking benefit from the stability of H-maser frequency standard on board of the Galileo satellites. The period considered in study involves 16 days of 2017, from day of year 284 to 299. During these days, the Galileo constellation had 17 satellites, which was enough to apply the strategy.

The main results can be summarized as:

- Unambiguous carrier phase measurements (i.e. very precise pseudoranges) can be obtained during the whole period of 16 days. This is thanks to the stability of the carrier phase biases during the whole period. As a consequence, and in spite each day the data is processed independently, the unambiguous phase measurements do not present discontinuities between days.

- While in the standard processing of combined GPS and Galileo data, clock daily solutions presents small jumps from day to day estimates (at the level of 0.1 ns for GPS and several tenths of a nanoseconds for Galileo), with our strategy, these jumps practically disappear thanks to the continuity of the phase measurements.

- The phase biases estimates, which in our strategy are done together with clocks, exhibit temperature depend variation for the L5 frequency of the GPS block IIF. This dependency was reported by some authors [3] using geometry free combinations.
- Finally, taking advantage from the high stability of the clocks on board of Galileo satellites, clock solutions using several strategies will be compared. From these comparisons, we will discuss how general relativity tests can benefit from these improved clock estimates.

References:

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