Fast estimation of real-time high-frequency precise satellite clock offset using multi-frequency and multi-constellation GNSS observations

Poster Session PS06 – Biases

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Introduction

The real-time estimation of precise satellite clock and its rapid update are essential guarantee to realize real-time positioning with high precision. The rapid development of GNSS and IGS Multi-GNSS Experiment (MGEX) provides us a great opportunity to estimate high-accuracy Multi-GNSS satellite clocks. However, A great number of ambiguity parameters are estimated simultaneously with satellite clocks, which makes the estimation pretty time-consuming. In this study, we aims at improving the computational efficiency of precise Multi-GNSS satellite clock estimation (PCE) using the “Carrier-range” observations proposed by Blewitt et al. (2010).

Processing strategy

The wide-lane and narrow-lane un-calibrated phase delays (UPD) could be resolved in advance form the Melbourne–Wübbena (MW) combinations and ionosphere-free carrier-phase (LC) combinations observed by a network of stations. With the accurate wide-lane and narrow-lane UPDs, both the wide-lane and narrow-lane ambiguities could be fixed, and the “Carrier-range” observations could be generated (Chen et al. 2014). Therefore, the pseudorange observations can be ignored in PCE processing and the satellite clocks estimated using the “Carrier-range” observations are referred to integer-recovery clocks (IRCs) (Geng et al. 2010).

Tracking network

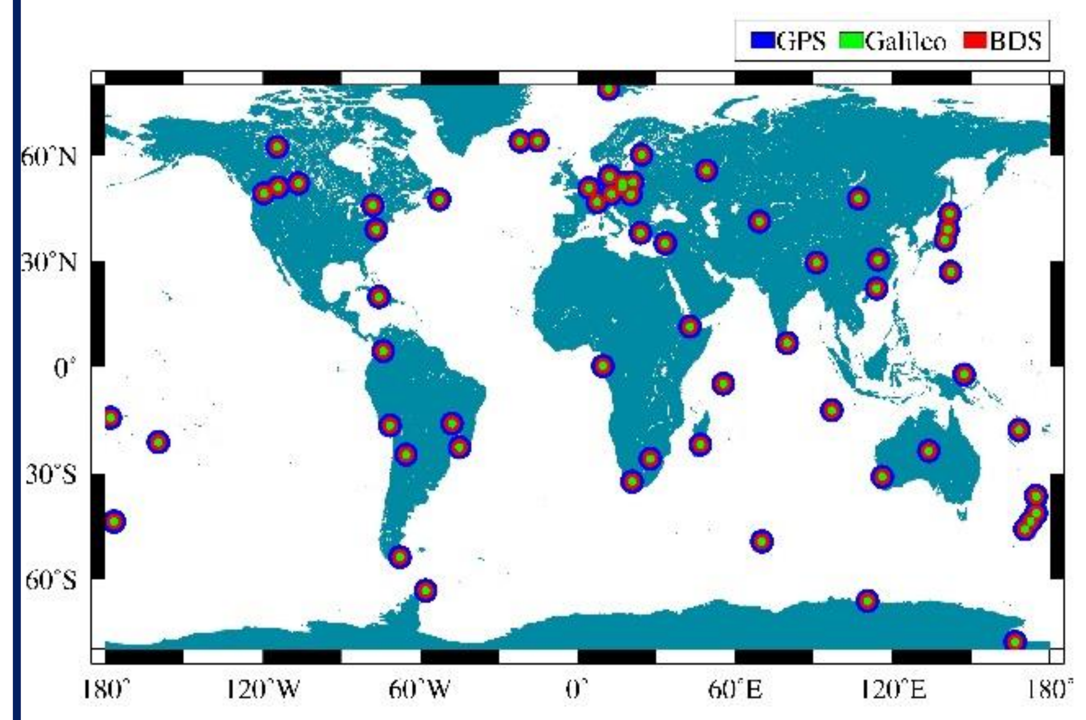

Fig. 1 Distribution of selected tracking stations and their supported constellations.

The MGEX was set up by the International GNSS Service (IGS) to track, collect, and analyze all available GNSS signals. By October 2018, the MGEX network has grown to almost 240 stations, among which 31 stations are capable of tracking BDS-3 B1I and B3I signals. All the available MGEX stations are continuously tracking the GPS, GLONASS and Galileo and 193 stations tracking BDS satellites. The distribution of the selected tracking stations and their supported constellations are shown in Fig 1.

Clock overlap

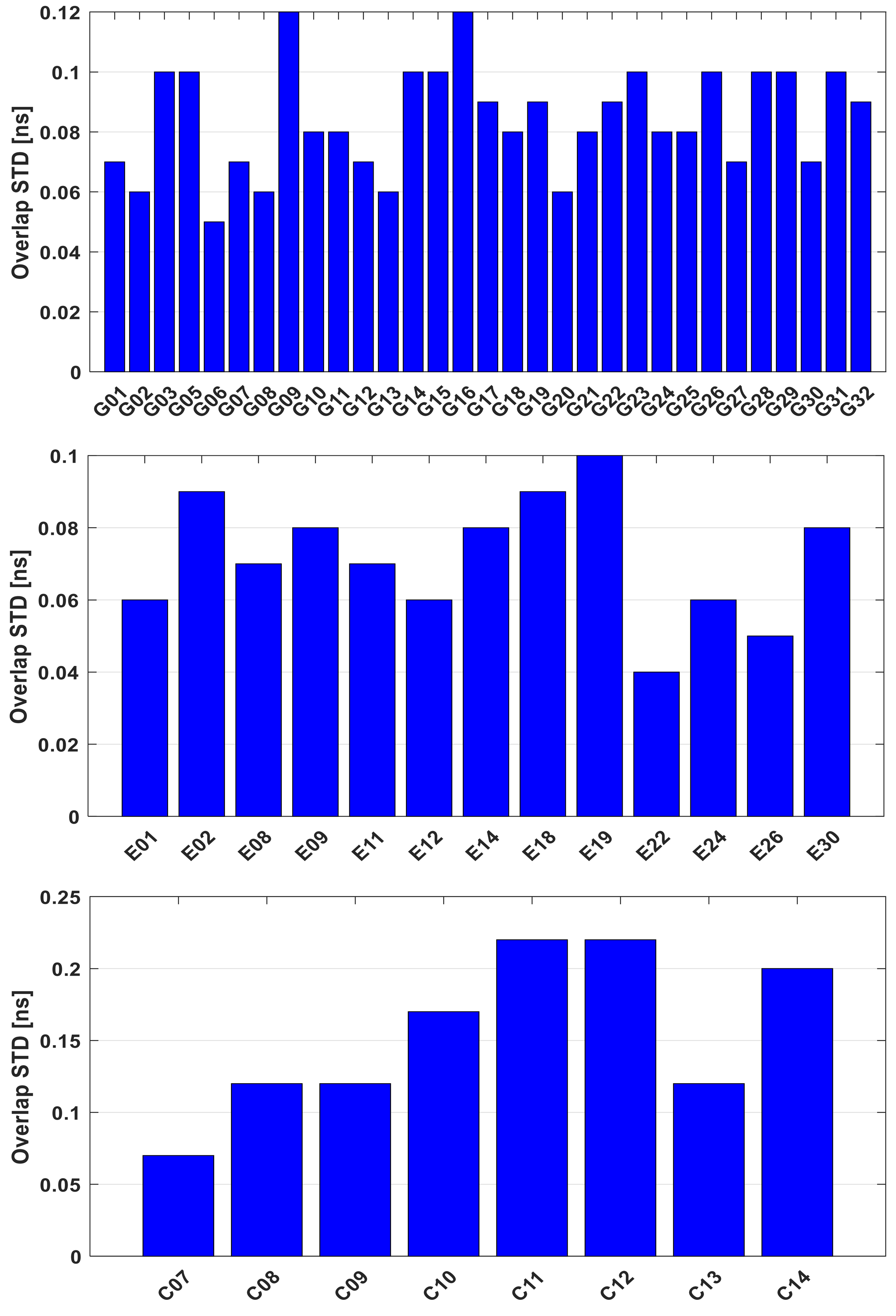

Fig. 2 24 h clock-overlap STD values for GPS, Galileo and BeiDou satellites

The 24 h overlap STD values of clock estimates are selected as one of the indicators with which to evaluate the influence of the integer-recovery clock performance. To eliminate the systematic errors of the clock-offset overlap, the clock time series are aligned to a reference satellite following the standard practice in IGS clock comparisons. The averaged 24 h clock-overlap STD values for GPS, Galileo and BeiDou satellites are shown in Fig. 1. It can be seen that the averaged 24 h overlap STD values of GPS and Galileo clocks exhibit good performance, most of which are less than 0.1 ns. However, the BDS clocks perform relatively worse than GPS and Galileo clocks whose mean overlap STD is 0.15ns.

References

Blewitt G, Bertiger W, Weiss J.P (2010) Ambizap3 and GPS Carrier-range: A New Data Type with IGS Applications. In Proceedings of IGS Workshop and Vertical Rates, Newcastle, UK, 28 June–2 July 2010.;

Geng J, Meng X, Dodson AH, Teferle FN (2010) Integer ambiguity resolution in precise point positioning: method comparison. J Geod 84(9):569-581;

Chen H, Jiang W, Ge M, Wickert J, Schuh H (2014) Efficient High-Rate Satellite Clock Estimation for PPP Ambiguity Resolution Using Carrier-Ranges. Sensors 14(12):22300-22312

PPP performance

Fig. 3 shows the positioning performance of static PPP of IRC and float solutions at stations BRAZ and ROAP on DOY 106, 2017. From Fig. 3, we can see that after applying the IRC products, both the convergence time and positioning accuracy is significantly improved.

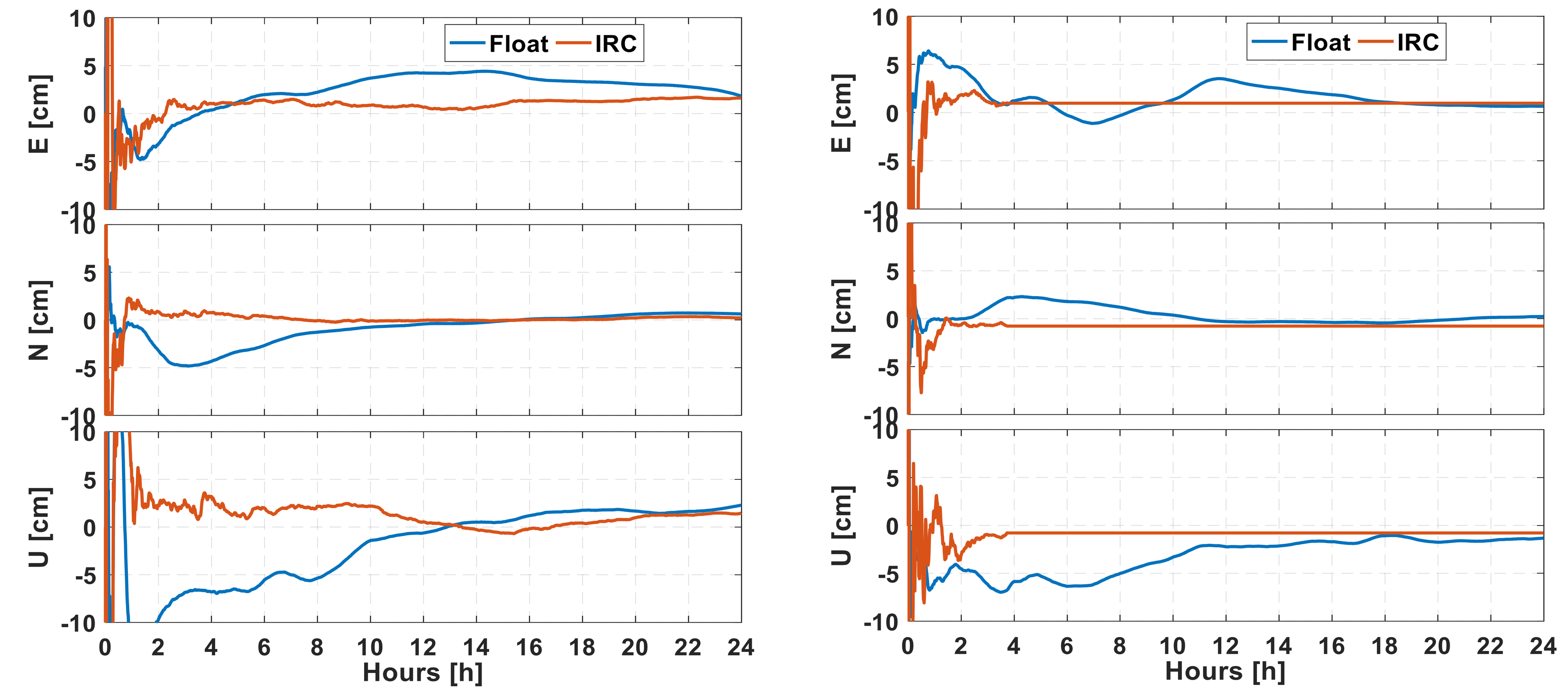

Fig. 3 Positioning performance of static PPP (BRAZ and ROAP station, DOY 106, 2017).

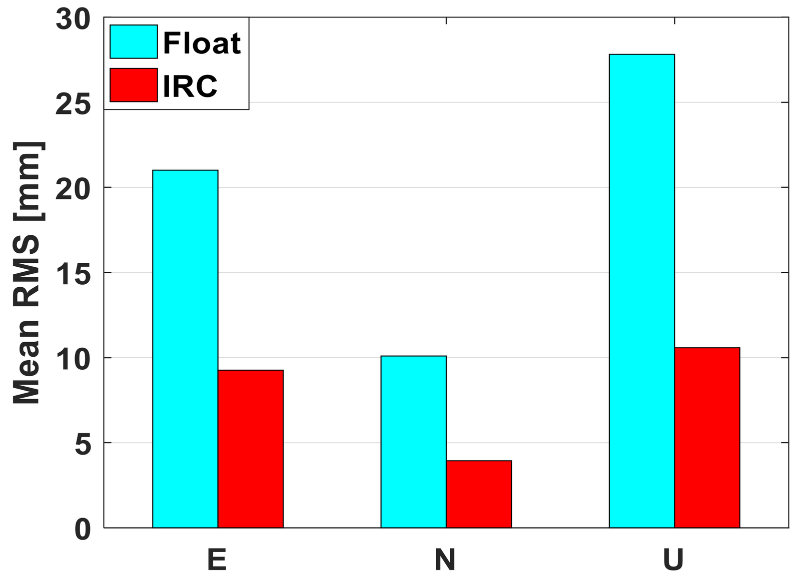

Fig. 4 Mean RMS values of PPP after convergence with IRC and Float solutions

The averaged RMS errors of static PPP based on IRC and float solutions are shown in Fig. 4. When IRC products are applied, the averaged positioning accuracy can reach 9.3, 3.9, and 10.6 mm, respectively, for the east, north, and up components, with an improvement of 55.9%, 61.0%, and 62.0% compared to the float solutions, respectively.

Conclusions

- The computational efficiency of precise clock estimation can be improved with the “Carrier range” observations.
- When applying the inter-recovered satellite clock products, both the convergence time and positioning accuracy is significantly improved.