Nearly Real Time GNSS Time Transfer using MADOCA-PPP

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MADOCA-PPP service provides satellite orbits and clock offsets for real time positioning using PPP method. We evaluated the applicability of this service for near real time GNSS time transfer. The time transfer precisions with MADOCA-PPP were equivalent to those using IGS final products.

Keywords—GNSS time transfer, Multi-GNSS, QZSS

I. Introduction

lobal Navigation Satellite System (GNSS) is one of the powerful tools for remote atomic clock comparison. GNSS time transfer precision can be achived 10^{-15} level at 1-day by using precise point positioning (PPP) analysis with carrier phase observations [1]. Until now, highly precise GNSS time transfer has not been performed in real time because PPP method requires accurate satellite positions and clock offsets, which are provided by analysis center of International GNSS Service (IGS) [2] with a delay of several days.

Michibiki or Quasi-Zenith Satellite System (QZSS) as a regional navigation satellite system (RNSS) in Japan provides a new augmentation service named Multi-GNSS Advanced Orbit and Clock Argumentation (MADOCA) [3], and the service enables highly precise positioning using PPP method in real time. We evaluated the applicability of MADOCA-PPP products not only for positioning but also for time transfer in real time.

II. Time Transfer Experiments using MADOCA-PPP

We performed remote clock comparison between NICT headquarter located at Koganei, Tokyo and a backup station of Japan Standard Time (JST) in Kobe. The baseline length between two stations is about 600 km. Both stations equip hydrogen masers, and generate UTC(NICT) and CLK(KOBE) as stable time scales. Septentrio PolaRx5 TR receivers were used in both stations. Though MADOCA-PPP is broadcasted from QZSS satellites on L6 signal, we used the products presented on JAXA website for this experiment because we did not have a decoder for L6 signal. RTKLIB [4] was used as the PPP analysis software. GPS satellites were only used for this comparison, whereas MADOCA-PPP contains ephemerides of GLONASS and GALILEO in addition to GPS.

Figure 1 shows the time differences between UTC(NICT) and CLK(KOBE). The differences based on IGS ultra-rapid and final products were also shown as comparisons. The period is 19 days from June 27 to July 15 in 2022. Figure 2 shows the instabilities of each product. The stability of MADOCA-PPP was almost the same as those of IGS final. The values of 1-day instability were 9.7 x 10^{-16} with MADOCA-PPP and 9.5 x 10^{-16} with IGS final product. We suspect that these stabilities could

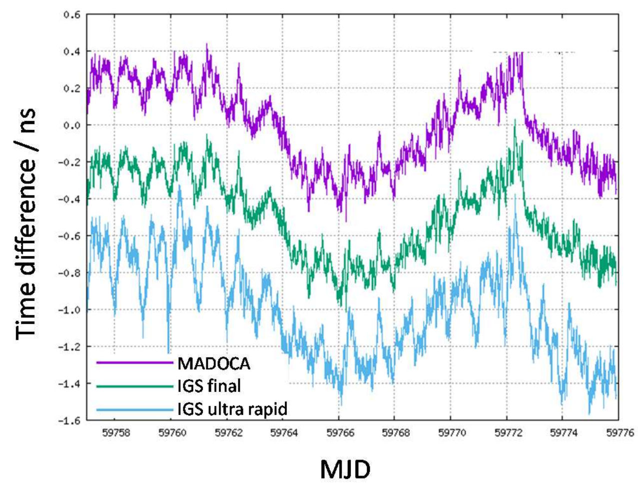

Fig. 1 Time difference UTC(NICT) − CLK(KOBE)

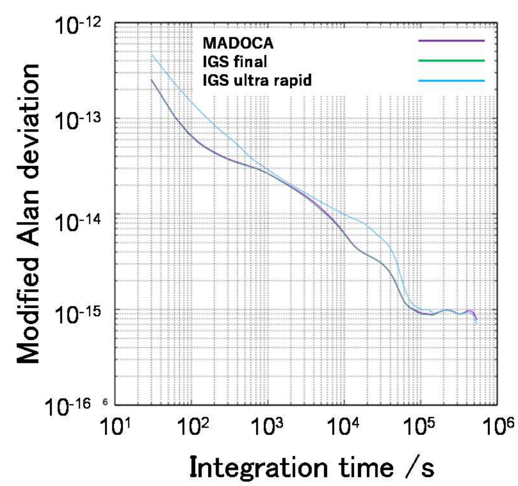

Fig.2 Instabilities in UTC(NICT)-CLK(KOBE)

be determined by limited by the instability of UTC(NICT) and CLK(KOBE).

III. Conclusions

We evaluated GNSS time transfer precision of MADOCA-PPP. The result was obtained in better precision than that of IGS ultra-rapid, and almost in similar level to that of the IGS final product. The behaviors of instability plot with IGS final and MADOCA-PPP were very similar. Since MADOCA-PPP covered is in Asia-Oceania Region, the usage of this service can be expected to establish a nearly real time clock comparison network using GNSS in the Asian in the future.

References

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