Near-Real-Time GPS PPP for Time and Frequency Transfer

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GPS carrier phase time transfer is well known as a high-precision time and frequency transfer (TFT) method. GPS-CP adopts the Precise Point Positioning (PPP) technique in geodesy. PPP technique requires the precise GPS satellite orbits and clock offsets which has provided by several IGS analysis centers. Especially, rapid products and final products are usually used for TFT purpose, but they have a latency time. Therefore, we have to wait about 17 hours in case of rapid products, about 2 weeks in case of final products, when we analyze today's data. This latency is a critical fault of PPP, because other TFT technique like GPS-P3 and TWSTFT can provide the results in almost real-time.
In recent years, IGS launched the Real-Time Service (RTS) and has started providing a GNSS orbit and clock correction (hereafter real-time products) for the purpose of the real-time PPP. The accuracy of this real-time products have been monitoring at RTS web page. The satellite orbit and clock of real-time products is less than 5 cm and about 300 ps in RMS compared to rapid products respectively. The ultra-rapid products are more accurate than real-time products, and more frequently updated than rapid products, but ultra-rapid products have not been used for TFT. The real-time products is worth than ultra-rapid products at the specific field of TFT like the time link monitoring, because the real-time products can be use in real-time. In this study, we evaluated the accuracy of GPS-PPP time transfer using real-time products.
In the evaluation, we analyzed the common time link data with the common strategy (software (c5++) and models) using rapid products and real-time products separately. We didn't evaluate the real-time products at the real-time analysis. We used the two different real-time products which are provided by the different provider. One is the IGS real-time products which is provided by the IGS RTS. The IGS real-time products have been streaming (Ntrip protocol) from the several real-time analysis centers. This time, we chose the IGS03 (Kalman filter GPS+GLONASS combination) which has been provided from BKG. We received IGS03 and RTCM3EPH (Broadcast ephemeris) by using BKG Ntrip Client, and converted to clk and sp3 format in real-time. JAXA conducts real-time PPP experiment using the L-band experimental (LEX) signal from Michibiki. In this experiment, JAXA has developed Multi-GNSS orbit and clock estimator called MADOCA (Multi-GNSS Advanced Demonstration tool for Orbit and Clock Analysis) and, are providing the precise orbit and clock of GNSS by several ways (streaming, ftp, and LEX in the future). This time, we downloaded the daily sp3 file by ftp as second real-time products (MADOCA products), and used for the evaluation analysis together with IGS real-time clk file. NICT has several time links between NICT headquarters and the branches (Advanced ICT Research Institute and LF Standard Time and Frequency Transmission Stations (Ohtakadoya-yama, Hagane-yama)). In the evaluation, we analyzed the 9 months (from February 2015) data of these GPS time links. As a result of the evaluation, we confirmed that the time difference changes that were estimated using the real-time products (both IGS and MADOCA), were in good agreement with the results of using rapid products (also TWSTFT results). The difference of the results between rapid products and each real-time products were about 100 ps (IGS) and about 200 ps (MADOCA) in RMS. These differences are small enough to detect the irregular change caused by something trouble of the time links that have been monitored regularly. Therefore, these results show that the GPS PPP using real-time products has potential to monitor the time links. In the presentation, we report this evaluation in detail, and show an analysis strategy of the time link

monitoring by the near-real-time GPS PPP.

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