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Preliminary Application of Korean Observation for GLONASS Time Transfer

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Abstract. Remote clock comparison, also called Time Transfer has been conducted using GPS code measurements for three decades. GLONASS, another satellite navigation system, has been completed the constellation recently. And it has been possible to use GLONASS(GLObal Navigation Satellite System) for Time Transfer. In order to apply GLONASS code measurements for the remote clock comparisons, there have been several studies for recent decades and one of the most outstanding researches is conducted by Observatory of Belgium (ORB). ORB has announced the R2CGGTTS software, a tool to provide dual-frequency measurements in a format dedicated to time transfer named CGGTTS (Common GPS GLONASS Time Transfer Standard) and presented the combination of GPS and GLONASS into one unique time transfer solution based on All-in-View (AV). In this paper, we introduce the process of time comparison for GLONASS code measurements and show the results of R2CGGTTS software for Korean GLONASS code measurements.

Keywords: GLONASS, Time Transfer, GPS, UTC, Time Comparison, CGGTTS, RINEX

1 Introduction

As the international standard time, Coordinated Universal Time(UTC) is managed by the International Bureau of Weights and Measures(BIPM) which publishes monthly UTC in BIPM Circular T. UTC is generated by about 400 atomic clocks belonging to national timing laboratories worldwide. In order to compare the participating clocks, readings of each clock is transferred to the same reference. This operation is called as time transfer. GPS time transfer has been the most dominant techniques in UTC. With the completion of GLONASS constellation, GLONASS has been studied to participate in UTC generation recently. For Global Navigation Satellite System(GNSS) time transfer using GPS or GLONASS, Common View(CV) and AV are used. AV is the major technique for UTC generation [1].

GNSS time transfer is performed using clock offsets collected in a fixed format, called CGGTT [2]. These clock offsets represent the differences between the ground

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clock and the reference timescale of the GNSS. They are obtained from the pseudorange measurements, corrected for the signal travel time, for the troposphere and ionosphere delays, and for the relativistic effects. A smoothing is then performed over 13 min observation tracks. Starting with C/A code receivers, the method was upgraded to take advantage of the dual-frequency receivers measuring codes on both frequencies, which allows one to remove the ionosphere delays at the first order, thanks to the ionosphere free dual frequency combination [3].

In AV, each station computes the weighted average of the CGGTTS results, called RefSys, and thereafter computes the time link as the difference between the solutions obtained in the two stations. Some timing receivers directly provide the CGGTTS results, but for use of general geodetic receivers driven by an external clock for the time transfer application with the same standards, R2CGGTTS software was developed to compute the CGGTTS files from the raw observation data and navigation data by the GPS geodetic receivers in the RINEX format[4]. This software is currently used by most of the time laboratories for their participation in UTC and has been modified to combine GLONASS RINEX data last year.

In this paper, we introduce the differences between GLONASS and GPS and R2CGGTTS software modification for GLONASS observation briefly. And then we show the application results for GLONASS observation data of ORB. Then, we apply Korean GLONASS observation data to R2CGGTTS and present the application results.

2 Considerations for GLONASS observation

A major difference between the GLONASS and GPS constellations is that each GLONASS satellite transmits on a different frequency using a 15 channel frequency division multiple access technique. However, P3 is available as ionospheric free combination.

The CGGTTS results are computed using the broadcast navigation signals for the satellite ephemerides and clocks. While GPS navigation messages provide parameters of keplerian orbits in WGS84 every 2 hour, GLONASS navigation messages provide a set of positions and velocities in the PZ-90 every 30 minutes.

For the reference system, PZ-90 has been aligned to ITRF 2000 with an uncertainty of some centimeters. Therefore, no reference system conversion has to be applied since October 2007.

In addition, a time correction must be introduced. The observation files from geodetic receivers providing both GPS and GLONASS and GPS navigation file are dated in GPS time, while GLONASS broadcast navigation file use the GLONASS time, which is aligned on UTC. The two time scales GPS and GLONASS therefore differ by an integer number of leap seconds. This correction must be applied to convert the GLONASS ephemerides to GPS time.

Unlike GPS, GLONAS does not use close analytical formulae for computing SV position. Instead, GLONASS uses a state vector referenced to given epoch(tb). For computing the coordinates and velocity of a satellite at the moment t, numerical integration (4th Runge-Kutta method as defined in GLONASS ICD [5] over time(t-t_b) is used.

ORB provided the updated R2CGGTTS software for GLONASS time transfer as above. For identification of GPS and GLONASS Satellite vehicle(SV) numbers, one hundred is added to the GLONASS SV number in R2CGGTTS.

3 Application Results of Korean GLONASS observation

In order to utilize the GLOASS time transfer in South Korea, we analyzed R2CGGTTS software and applied GLONASS code measurements of Septentrio Geodetic receiver in KRISS(Korea Research Institute of Standards and Science) . To verify the software, we received the GLOASS raw data and CGGTTS results from BRUX time laboratory, execute the software with them and present the results. Figure 1 shows the comparisons between CGGTTS results of in ORB and CGGTTS results executed in Catholic University of PUSAN(CUP) for 28 March 2013 (MJD 56524). In R2CGGTTS software, Modified Julian Date(MJD) is used [6].

Figure 1 shows the time difference (measured in 0.1 nanosecond) between the laboratory reference clock and GLONASS system time, referred to the midpoint of the pass via a linear fit. Two results of ORB and CUP are almost identical and guarantee the software operates ordinarily in CUP.

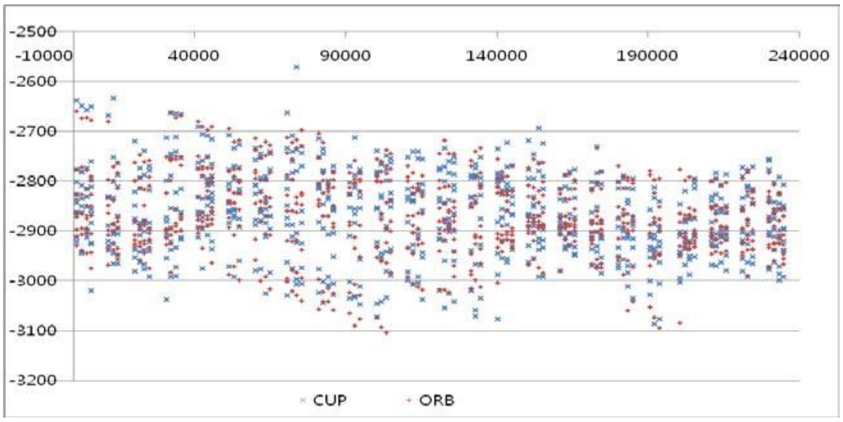

Fig. 1. RefSys comparison for BRUX RINEX data

We present GGTTS results from GLONASS observation and navigation messages collected in Korea for two consecutive days, MJD 56399 and 56400 in figure 2. Both of results show that the time offsets are very noisy comparing to BRUX results in figure 1.While time offsets of BRUX result seem to be stable at about average -285ns, time offsets of KRISS result are decreasing from about 40us to about -40us as time goes by.

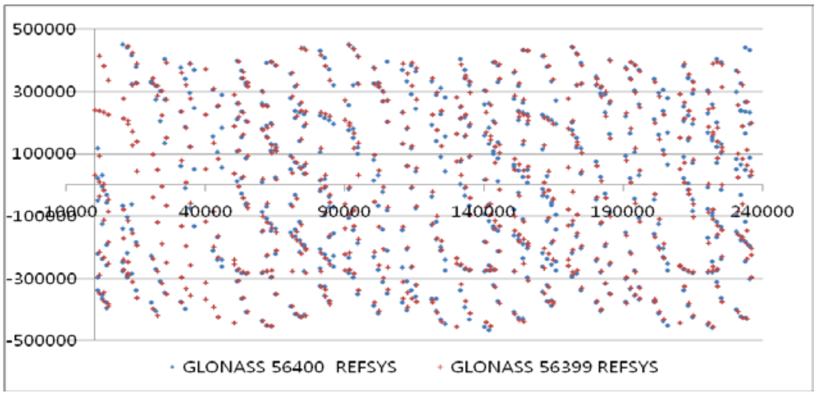

Fig. 2. RefSys comparisons of MJD 56399 and MJD 56400 Korean measurements.

4 Conclusion

We introduce the concept of time transfer and remote clock comparison using GNSS. GPS code measurement is the mostly used time transfer technique. As GLONASS constellation has been completed, there have been several studies to utilize GLONASS in the time transfer technique. Especially, ORB is the respective laboratory in this field and provides R2CGGTTS software for remote clock comparisons. In Korea, it is necessary to study and participate in this research area. As a preliminary study, we present the CGGTTS results from Korean observation data for GLONASS, which show very nosy patterns comparing to BRUX CGGTTS results. In further study, we plan to analyze the noisy pattern of clock offset and figure it out.

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