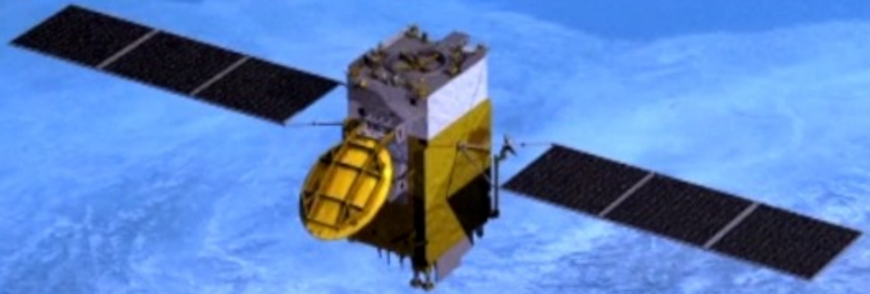
17th Meeting of the International Committee on Global Navigation Satellite Systems

Comparative Experiment and Analysis of Different GNSS Time Offset Monitoring Method



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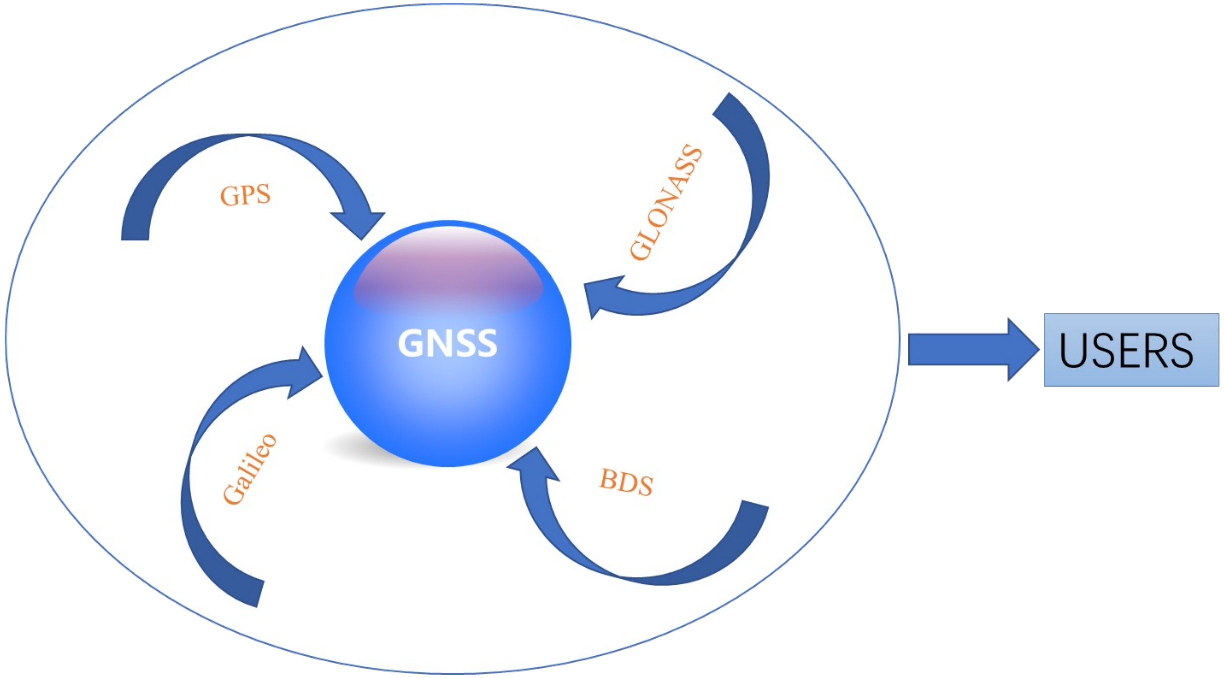
1. Background



- The GNSS time offset parameter can be obtained by different methods. For example, the GGTO based on the single-station method that we mentioned earlier.
- BIPM's GNSS Time offset monitoring method with UTC as an intermediate reference is also a reference idea.

- **(1) Necessary for GNSS compatibility and interoperability.**
- **(2) Will improve the consistency of time service by GNSS.**

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2. Methods for GNSS time offset monitoring

a) Single Station GNSS to GNSS time offset method, Single Station GGTO

（ Proposed by China in 2018）

Characteristics

High precision, strong real-time, easy to obtain

Broadcasted in message

Calculated by the user

requirements

High performance GNSS receiver, calibrated absolutely.

High performance reference time (UTC(k), accurate and stable vs UTC)

b) Direct calculation using the relevant parameters of broadcasted navigation messages with the pivot reference of UTC, GPTO

(To be proposed by BIPM)

Characteristics

Precision determined by the performance of UTC(k), easy to obtain(Calculated by user)

requirements

High performance GNSS receiver

High performance UTC(k)

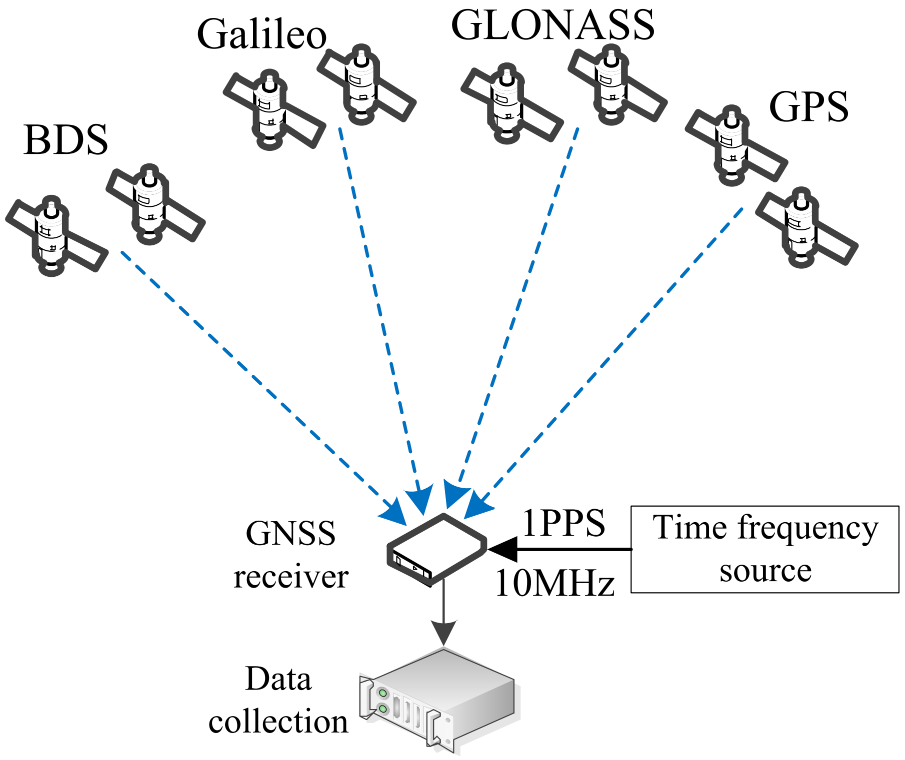
The UTC(k) of each navigation system time traced needs to be consistent.

The performance of UTC(k) itself and the traceability of GNSST to UTC(k) constraint the calculation results of this method.

2.1 Methods for GNSS time offset monitoring

Single station GGTO

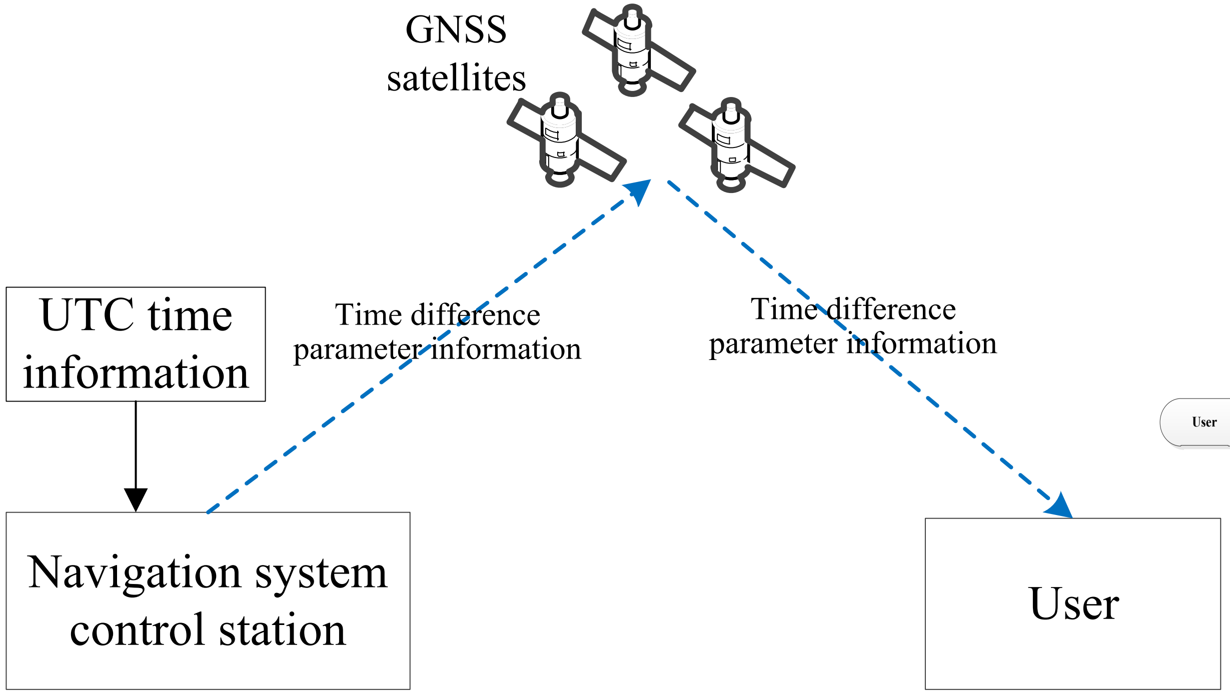
REVIEW

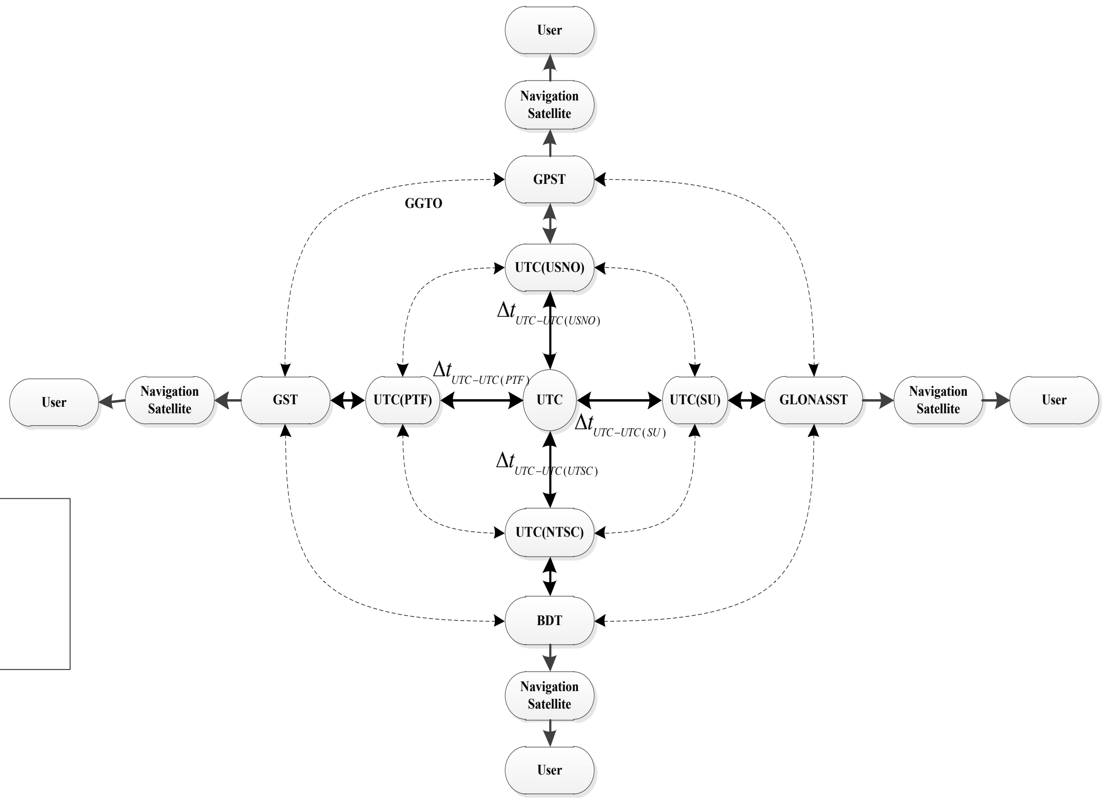


- High performance GNSS receiver
- Real time data of RefT-GPST , RefT-GLONASST, RefT-BDT, RefT-GST
- GPST-BDT, GLNT-BDT, GST-BDT,…..

2.2 Methods for GNSS time offset monitoring

GPTO with pivot reference of UTC





- High performance GNSS receiver
- Real time data of UTC-GPST , UTC-GLONASST, UTC-BDT, UTC-GST
- GGTO(GLO-GPS, GAL-GPS,…..)

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3. Some New Result

Experiment Demonstrates

- Single station --- Single station GNSS-to -GNSS Time Offsets (GGTO)

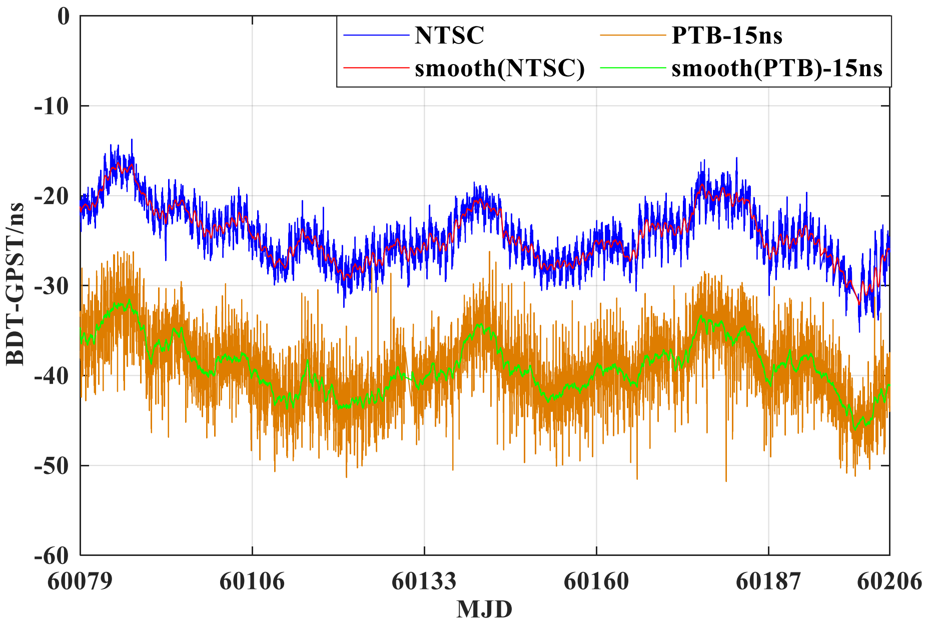
- Broadcast message---Time Offset calculating with the pivot reference of UTC
  Here, UTC is actually UTC(k), which is the reference for the time traceability of the navigation system. (GPTO)

- The new experiments date: May. 15, 2023 to Sep. 18, 2023 (about 4 months)

3.1 Some New Result

There is good consistency between different monitoring sites.

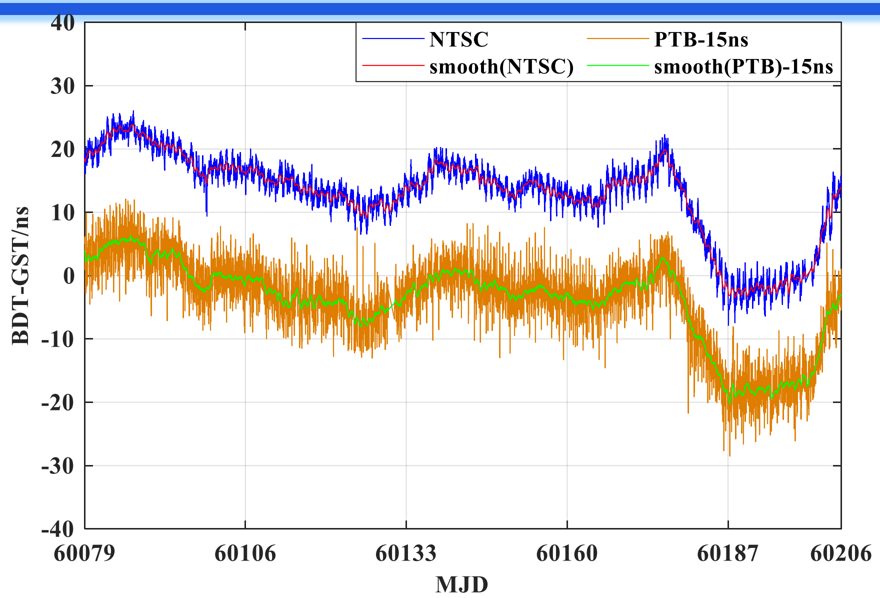
Single Station GGTO



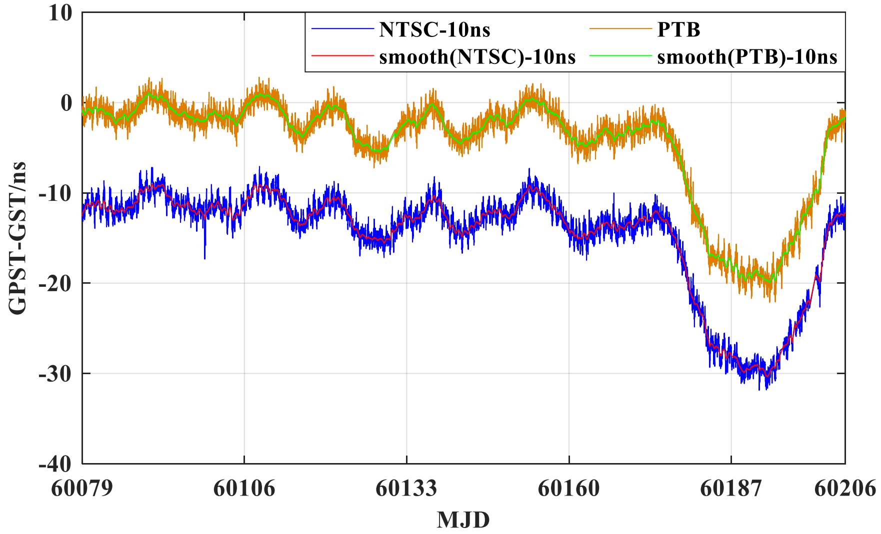
The time offset between BDT and GPST

The standard deviation of time offset

	BDT-GPST	BDT-GST	GPST-GST
NTSC	3.3245ns	6.5845ns	5.6355ns
PTB	3.9412ns	6.8498ns	5.7475ns



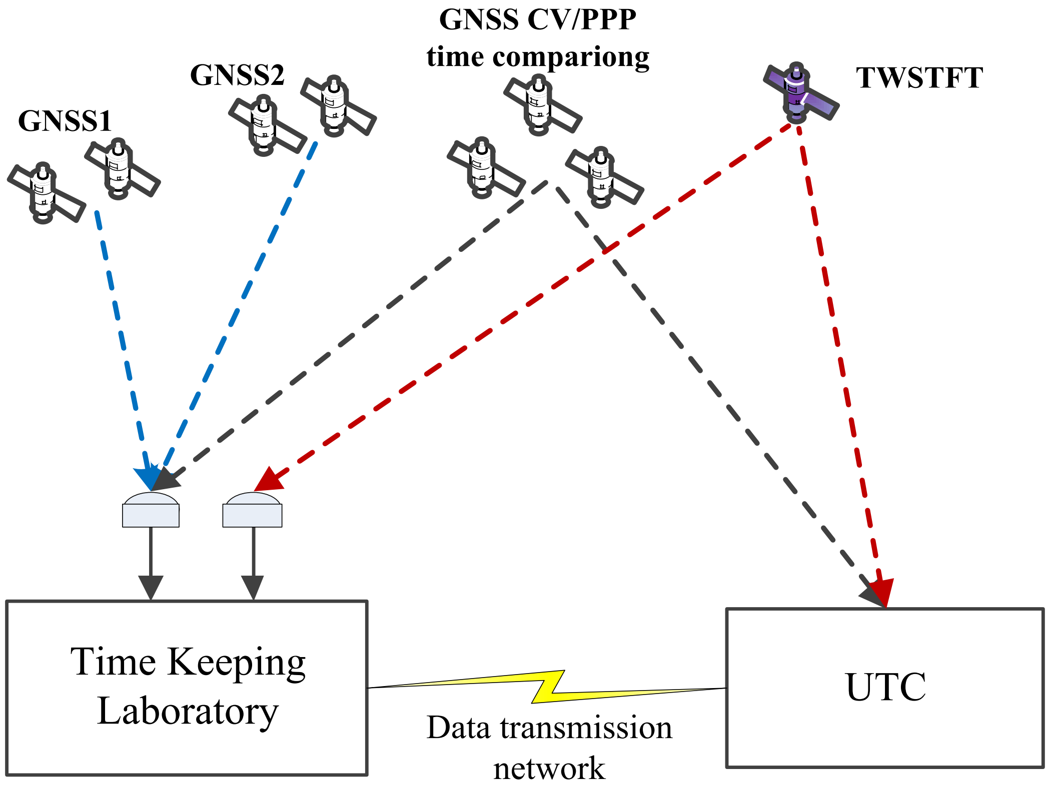
The time offset between BDT and GST



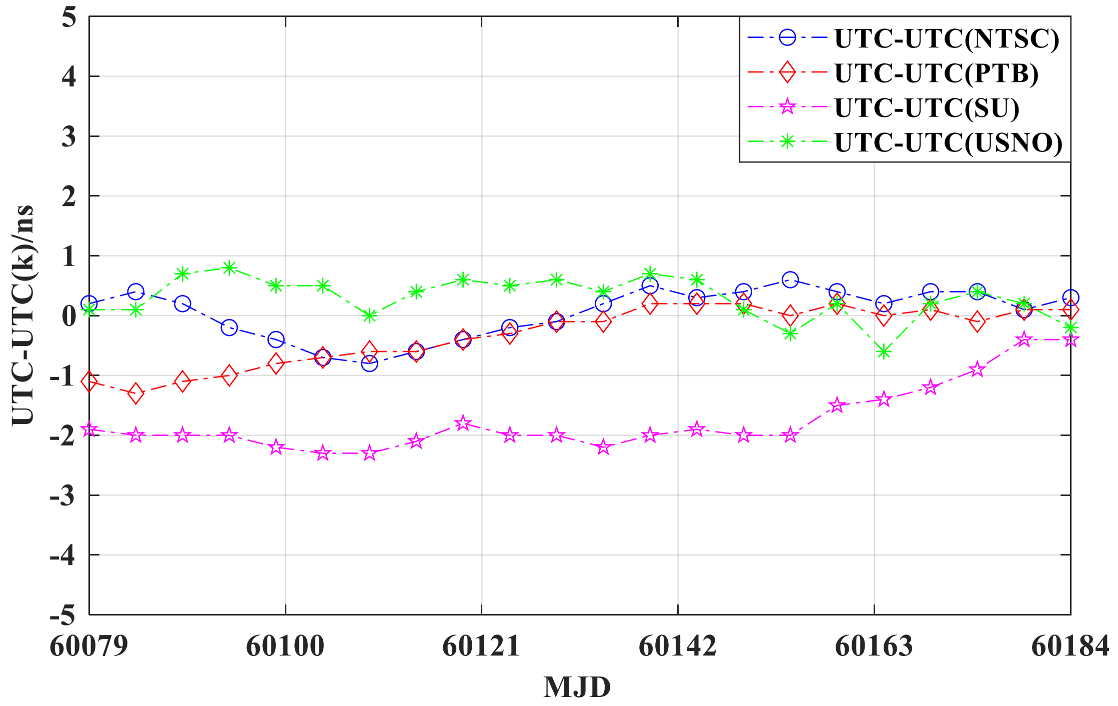
The time offset between GPST and GST

3.3 Some New Result

Broadcast message GPTO



The principle of UTC-GNSST based on time link



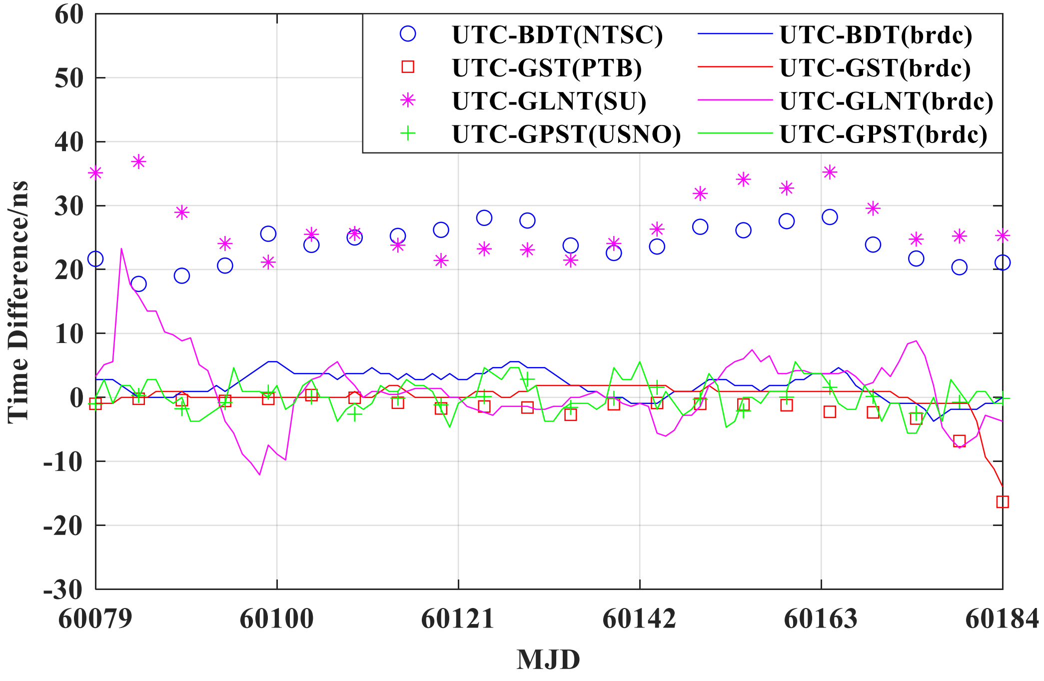
The time offset between UTC and UTC(k)

各系统UTC情况

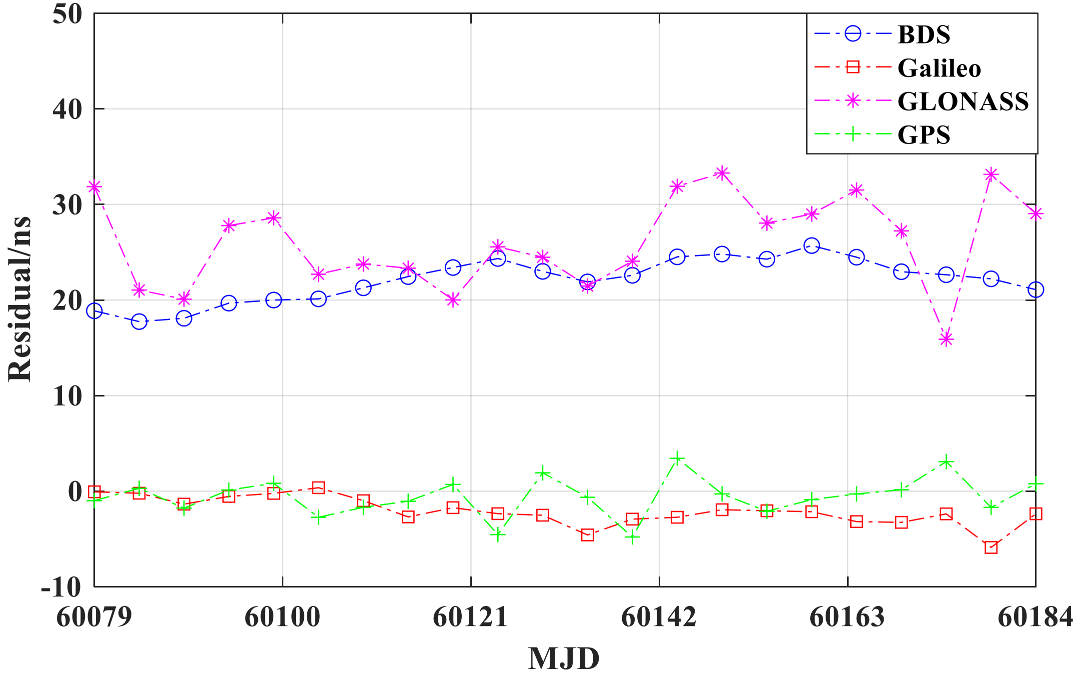
3.4 Some New Result

$$[UTC - GNSST]_{User} - [UTC_{GNSS}\text{-}GNSST]_{Brdc}$$

Broadcast message GPTO



The UTC-GNSST by monitoring and broadcasting



The residual of UTC-GNSST by monitoring and broadcasting

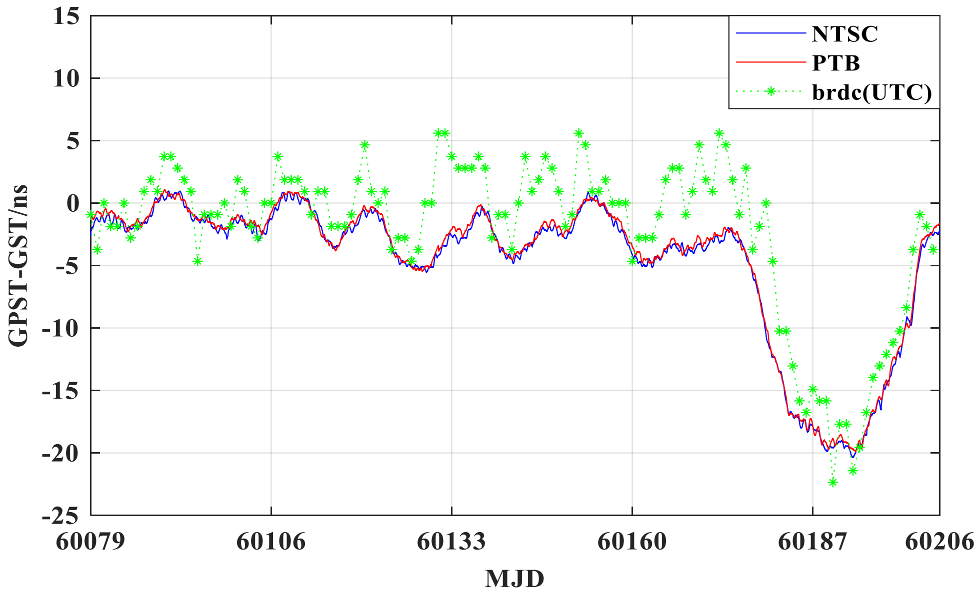
UTC(k) is the local implementation of UTC, when UTC(k) and UTC are in good agreement, if UTC(k) is considered to be UTC, we can use UTC as a pivot reference for GGTO calculation.

The residual statistics

	Mean value	STDEV	Peak-to-peak value
UTC-BDT	22.0987ns	2.2564ns	7.9545ns
UTC-GST	-2.0791ns	1.4869ns	6.2499ns
UTC-GLNT	26.0850 ns	4.8039ns	17.389ns
UTC-GPST	-0.5499ns	2.0478ns	8.2321ns

3.5 Some New Result

Broadcast message GPTO and Signal Station GGTO



The GPST-GST obtained based on povit UTC and single station method

The GPST-GST results monitored by the single-station method of NTSC and PTB have good consistency. The GPST-GST directly solved throuth the message with UTC /UTC(k) as reference is the same as the single-station method in trend, but the actual data still dispersed and the data fluctuates greatly.

The residual statistics

	STDEV	Peak-to-peak value
NTSC	2.5184ns	13.9553ns
PTB	2.4995ns	13.4626ns

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4. Summary

- The Single Station GGTO has the characteristics of strong real-time and high accuracy, which is more convenient for the subsequent generation of time offset and time offset model parameters between systems. The time offset information can be calculated at the user level, at the same time, the time offset parameters can be broadcast through navigation messages.
- The Broadcast message GPTO with UTC as reference also has the characteristics of strong real-time, but the accuracy of time Offset monitoring between systems is greatly affected by the system time traceability reference UTC (k), and can only be calculated at the user level, if the navigation system traceability reference UTC (k) has a high consistency with UTC, it can improve the GNSS time difference monitoring accuracy based on this method to a certain extent.
- The use of the Broadcast message GPTO can reduce the problems caused by future navigation message updates, but for GPS and BDS, the message design has considered the problem of time offsets between systems, so relevant fields have been reserved to support the time interoperability of the navigation system.

The two methods have their own advantages, however, through our analysis, at the same time for response to the proposal: Without opposing the BIPM proposal, the GPTO method can be adopted as a research work。 We recommend that GNSS provides continuously improve the performance of their UTC(k), reduce their biase from UTC. For the realtime GNSS time offsets mornitoring and the broadcast paramaters calculation , we still recommend the use of single-station GGTO technology.

Thank You for Your Attention!