The Report of GNSS Time Difference Monitoring

Haibo YUAN , Jihai ZHANG
Wei GUANG , NTSC China

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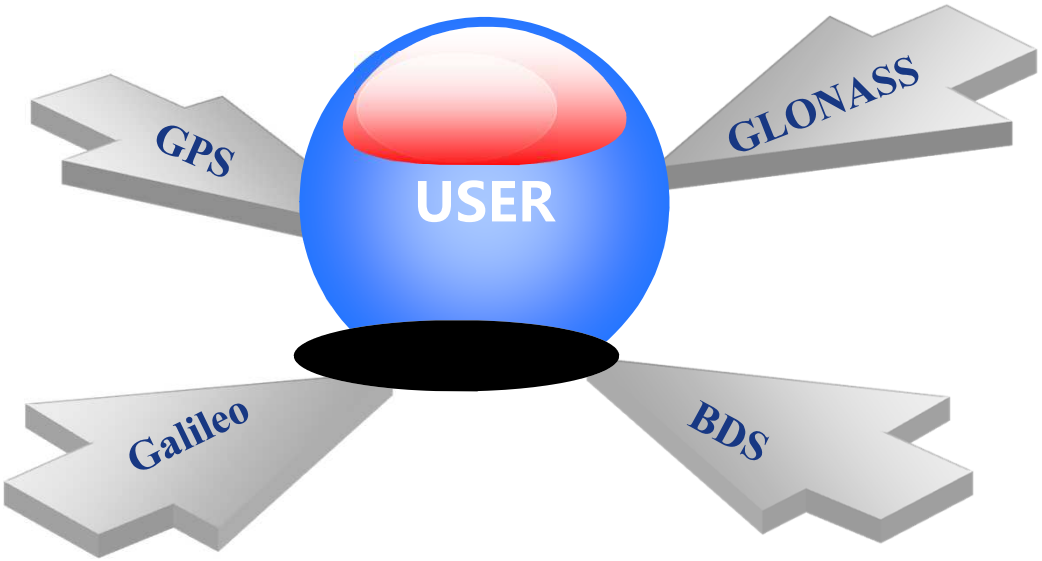
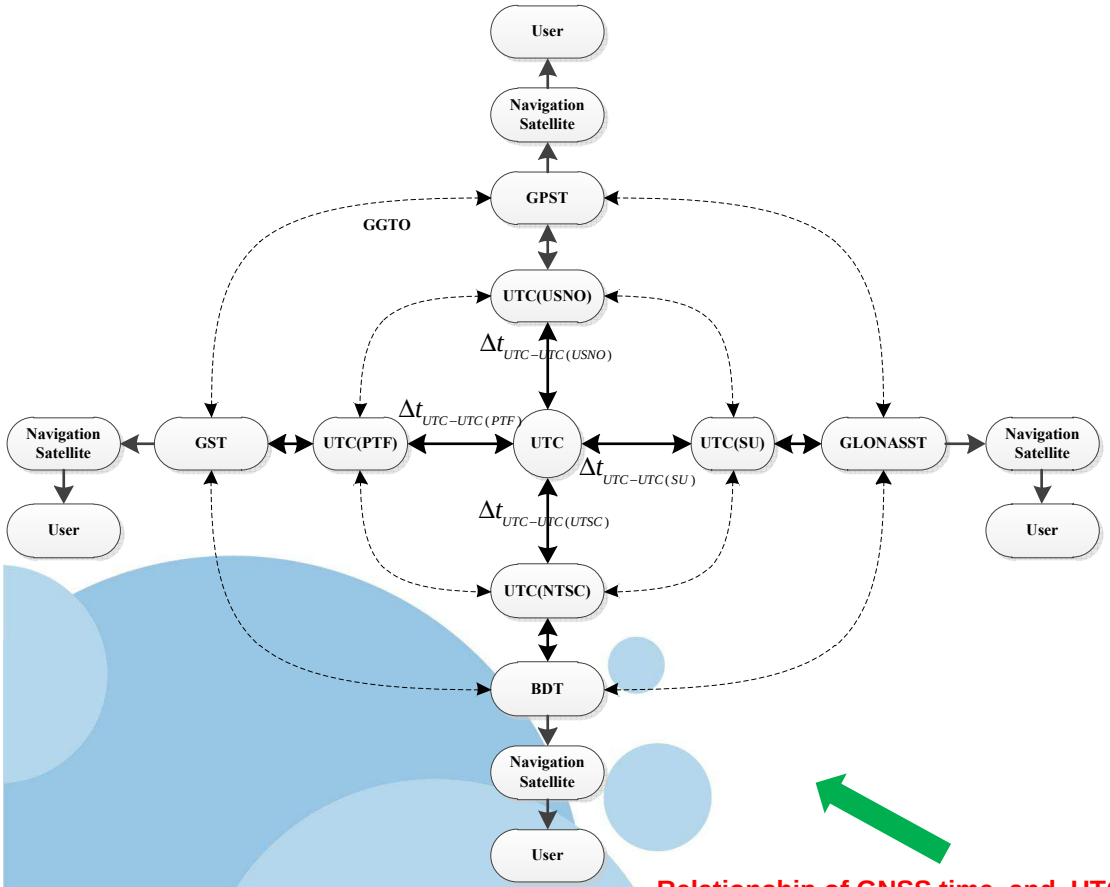
1. Background



- (1)It is necessary for GNSS compatibility and interoperability.
- (2)It will improve the consistency of time service by GNSS.
- (3)Improve the responsibility of GNSS provider , and transfer the work from user to the provider.

1. Background



Relationship of GNSS time and UTC

- Although all the GNSS system time are steered to UTC, the time difference between them can not be ignored. According to the plan(from template), GPS will broadcast the GGTO(up to 7 systems), Galileo has been broadcasting the GGTO between GPS and Galileo. GLONASS and BDS is planning to broadcast time difference between the different GNSS. (an agreement has been signed between GLONASS and BDS about that)

Galileo will update its template and broadcast the time difference between GST the other GNSS T ? I don't know!

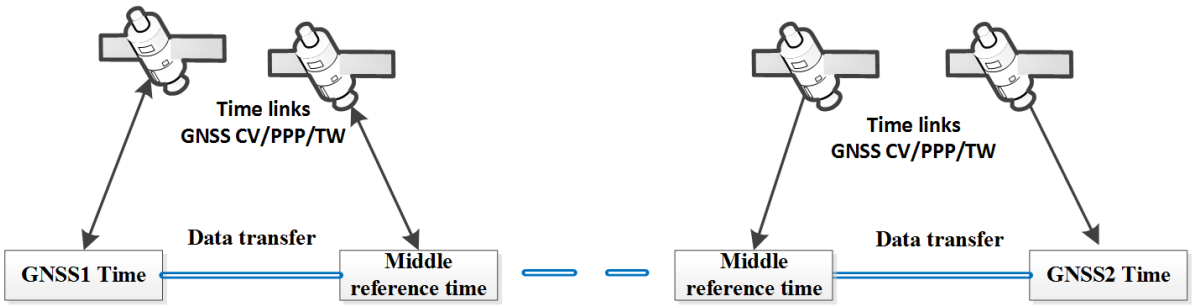
2. methods for GNSS time difference monitoring(time offset monitoring)

- time links method

– time links between GNSS time center

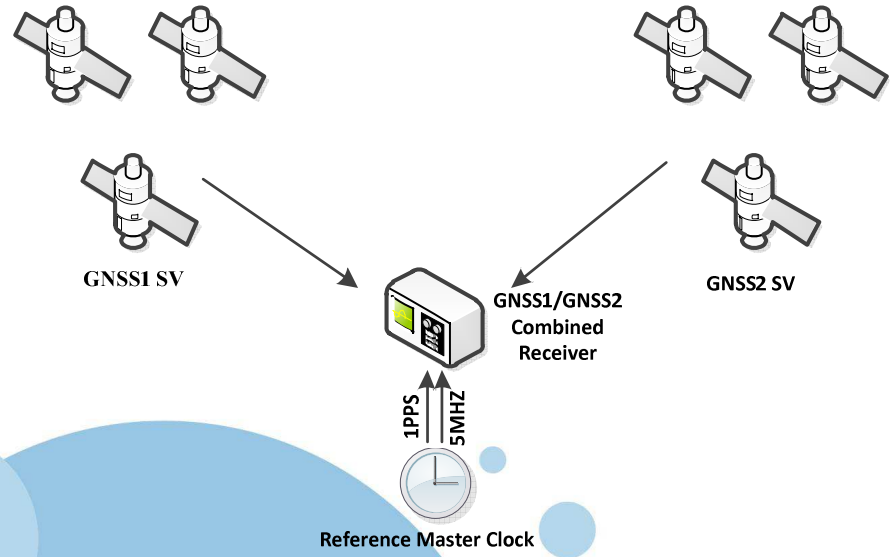
- Single Station/ Multi Stations method

-- GNSS high performance receiver



Advantage: most accurate, stable, reliability
Shortcomings:non-real time
results verifying

2. The Principle of SSGTDM



Principle of Single Station GNSS Time Difference Monitoring(SSGTDM)

High performance GNSS receiver

Real time data of RefT-GNSST

For example:

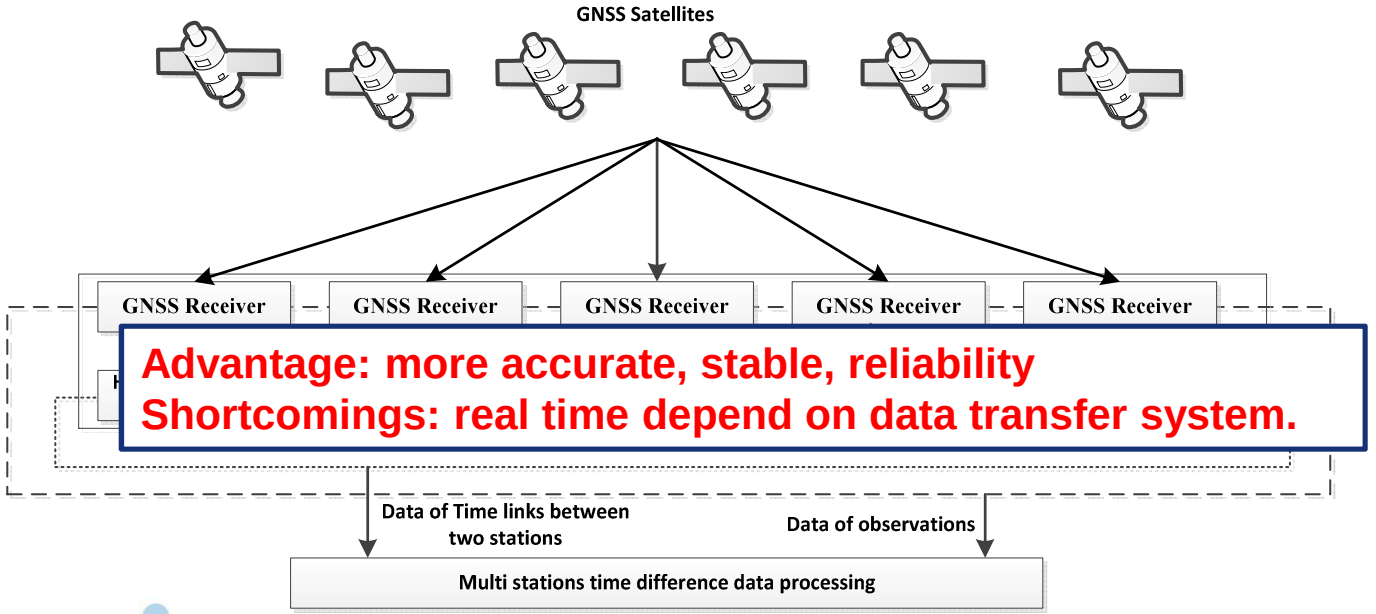
RefT-GLONASST

RefT-GPST

RefT-BDT

Advantage: real time, easy reality, accurate
Shortcomings: not very accurate

2. The Principle of MSGTDM



Ref1T-GNSS1T Ref1T-GNSS2T…

Ref2T-GNSS1T Ref2T-GNSS2T…

Ref1T-Ref2T(time links)

→ average the results

→ GNSS1T-GNSS2T

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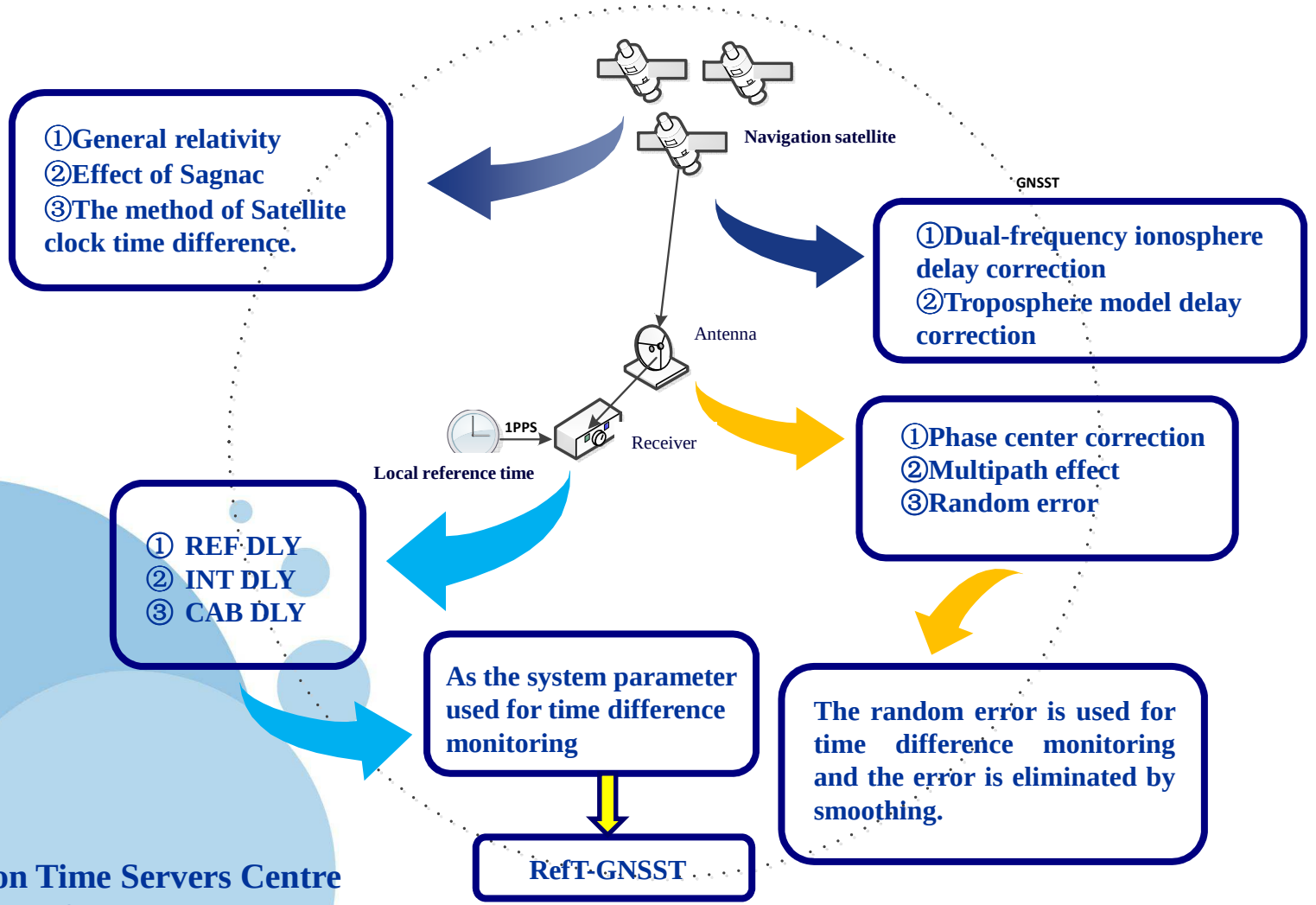
2. The Principle of Monitoring



2. The Principle of Monitoring

The traditional pseudo range observation equation：

$$P = \rho + cdt_r - cdT_s + d_{orb} + d_{trop} + d_{ion} + d_{mult} + \varepsilon$$

Correct the different time delay , then get the deviation between local time (reference time)and navigation system time：

$$\mathrm{Ref}T - \mathrm{GNSS}T = \frac{P-\rho}{C} + dT_s - \frac{d_{orb}+d_{trop}+d_{ion}+d_{mult}+\varepsilon}{C}$$

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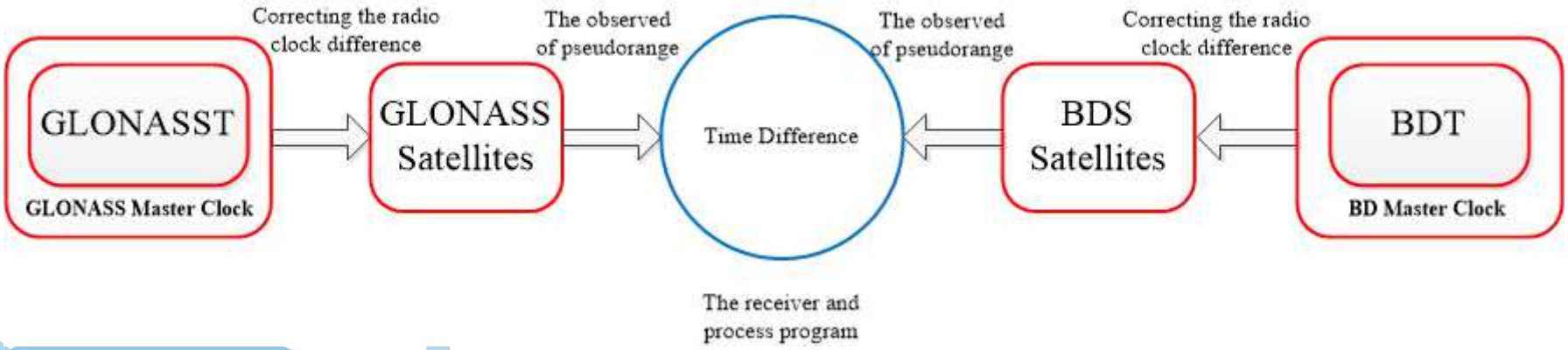
3. GLNT and BDT monitoring and Checking

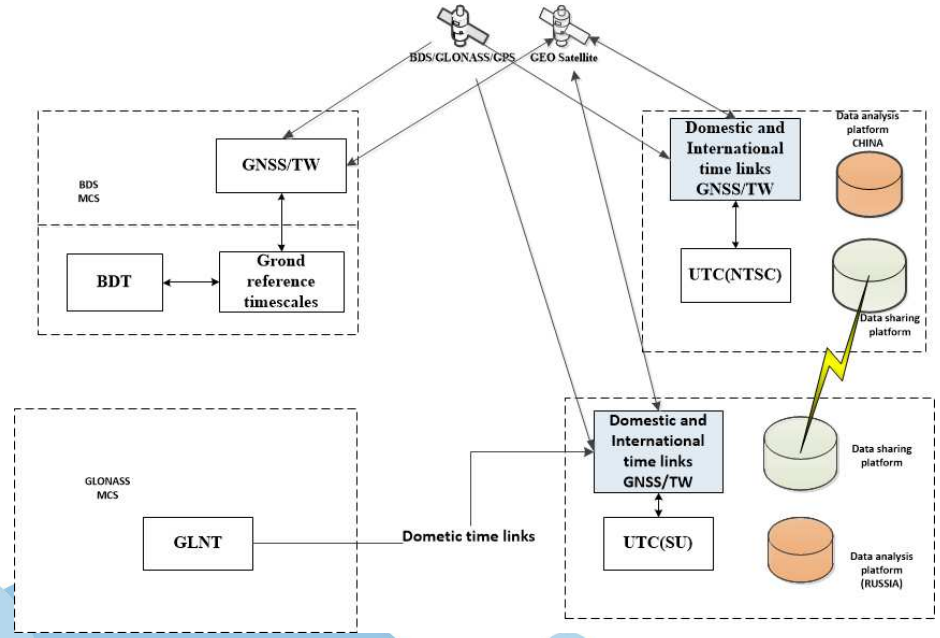
Example: BGTO (Time offset of the BDT and GLNT)



The $RefGLONASS$、$RefBDS$(the same description as CGGTTS format) are the time difference between local time and the satellite navigation system, then the time difference between two satellite navigation system can be calculated by:

$$GLNT - BDT = RefT - BDT - (RefT - GLNT) = RefBDS - RefGPS$$

3. GLNT and BDT monitoring (time links method) and the results verifying.



Time difference monitoring and checking system between GLONASS and BDS

The results of SSGTDM may be affected by many factors, such as ionosphere delay, troposphere delay, the performance of the receiver…

One not only must pay attention to the algorithm and technique, but also the devices choice.

The result of the time difference between the GNSS must be verified by the other methods.

Example: GLNT and BDT

UTC(SU)-UTC (International links)

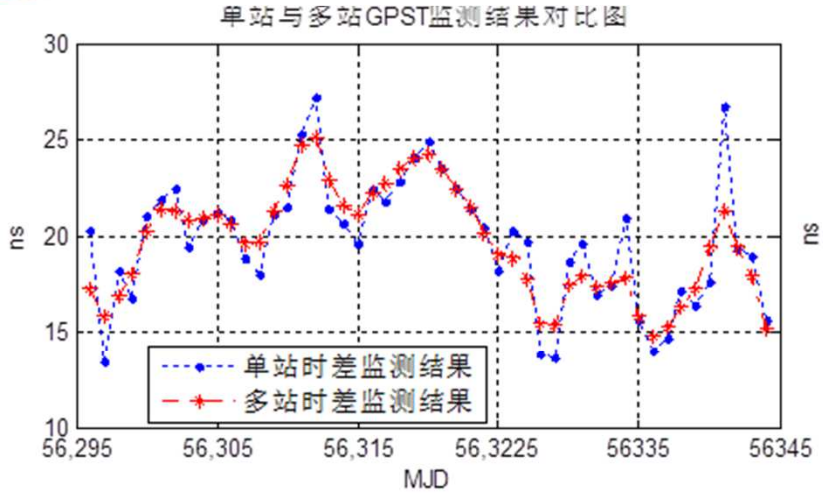
UTC(NTSC)-UTC(PTB) (International links)

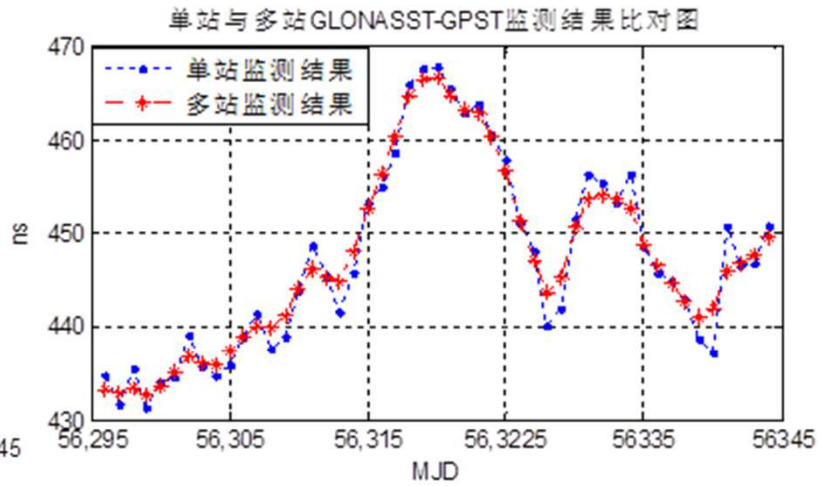
UTC(SU)-GLNT (Domestic links)

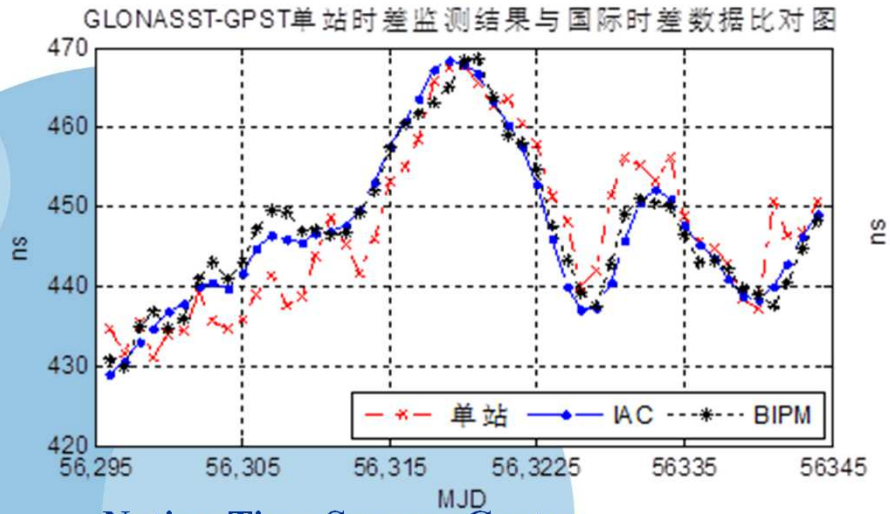
UTC(NTSC)-BDT(Domestic links)

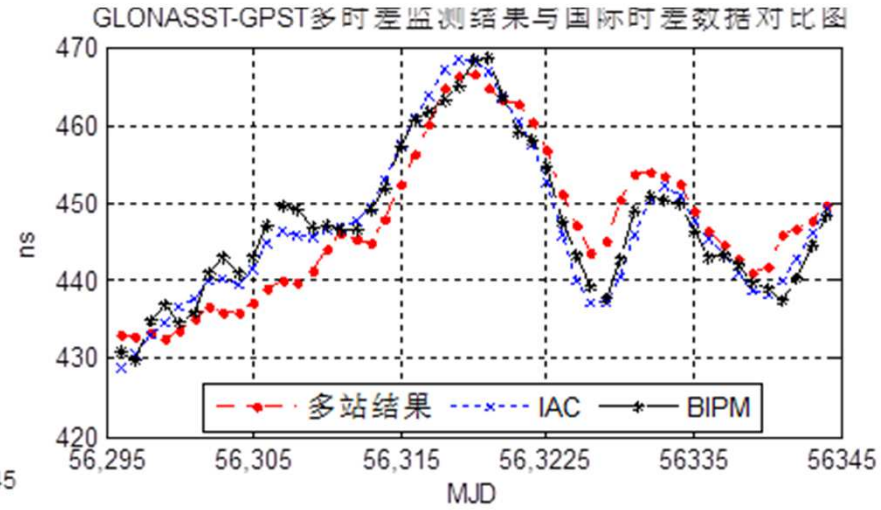
GLNT-BDT (Lagged) for checking / confirm

4. Test results and Analysis









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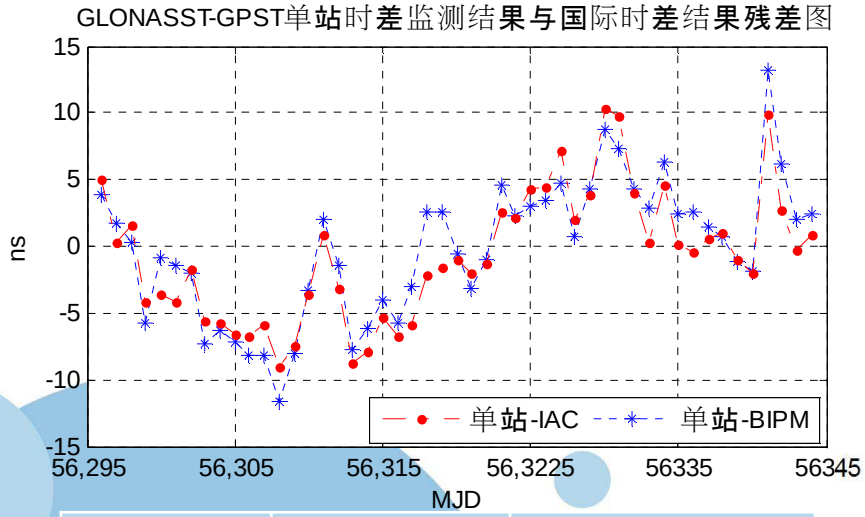
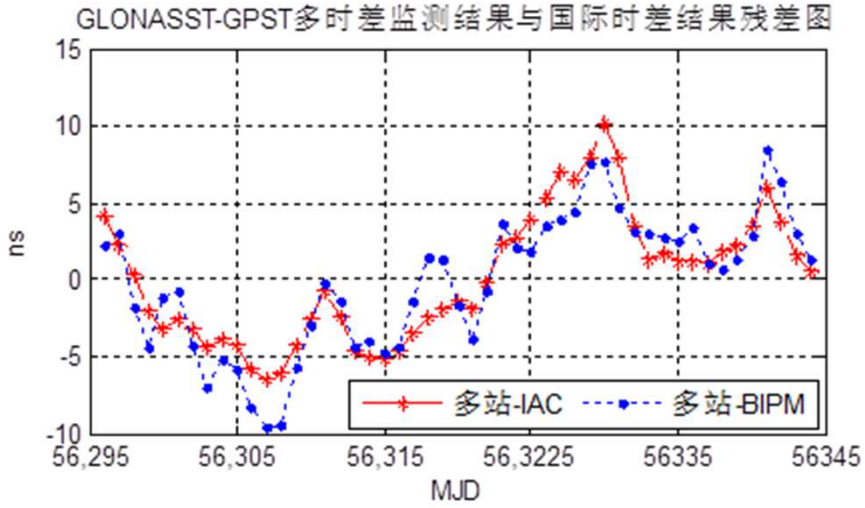
4. Test results and Analysis



	SS-BIPM	SS-IAC
STDEV	4.95	4.64



	MS-BIPM	MS-IAC
STDEV	4.22	4.08

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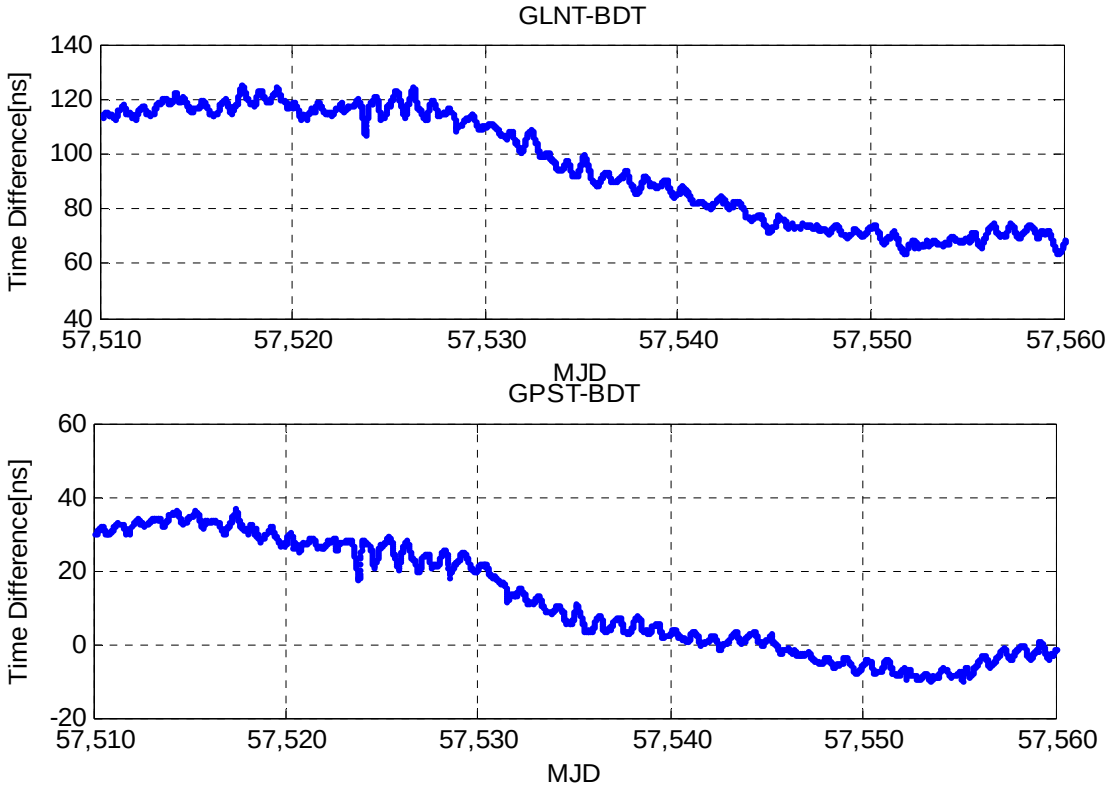
4. Test results and Analysis

- A new experiment is carried out based on a multi-mode dual frequency multi-channel receiver in NTSC with the single station monitoring method . The result is shown below:（calculated with GNSST-RefT(reference time, UTC(NTSC))）
- The purpose: To study the GNSS time difference forecast model.



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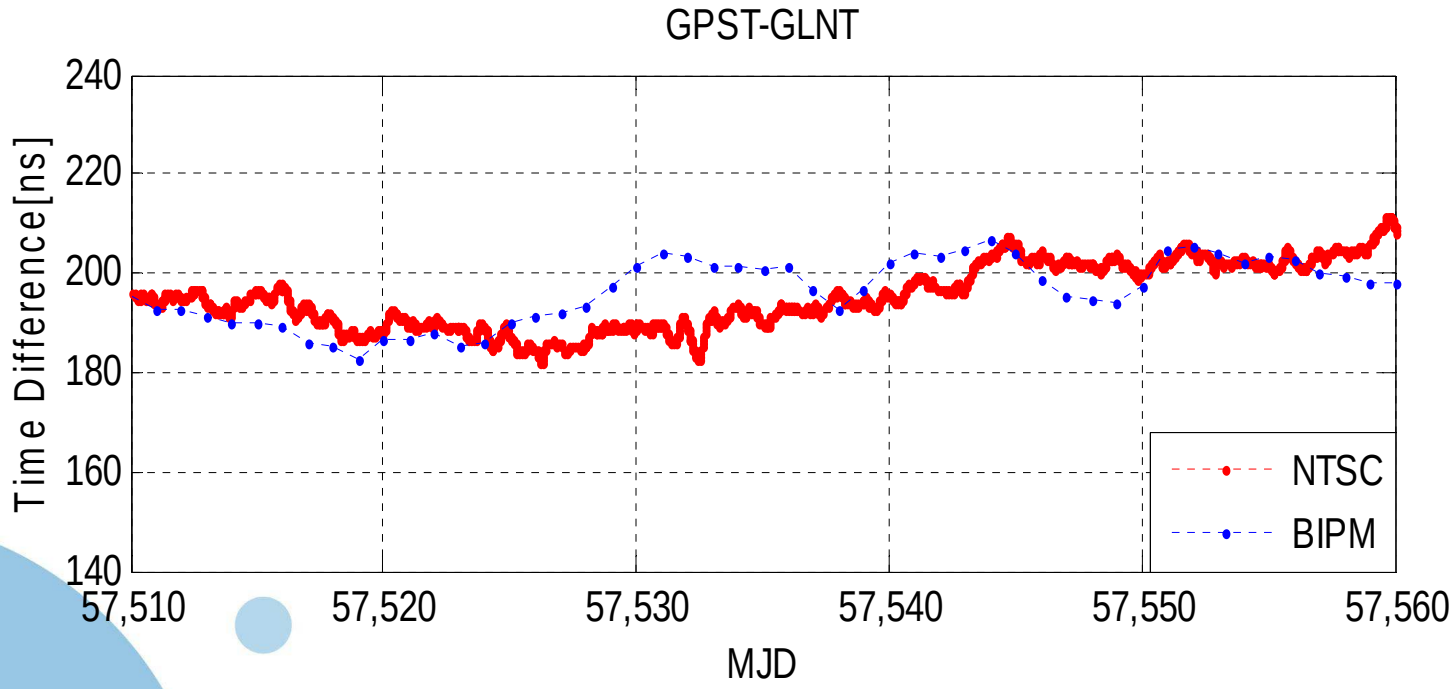

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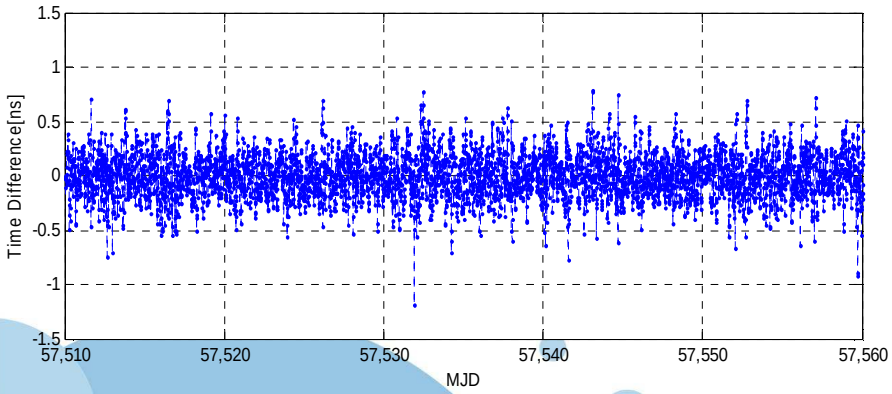
4. Test results and Analysis

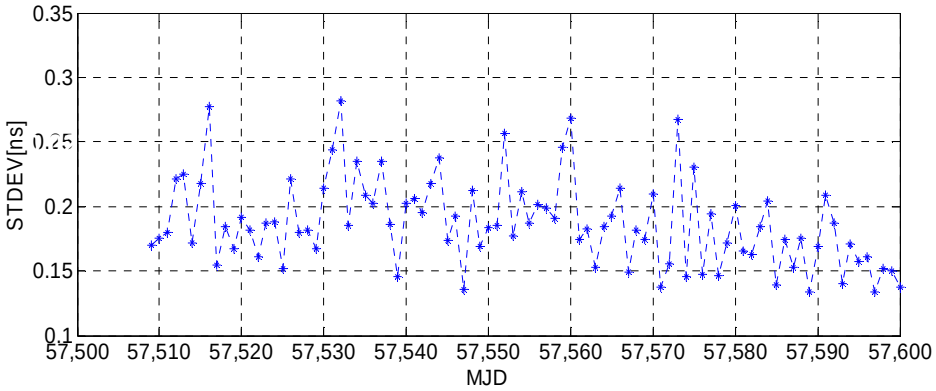
Equations used to predict the GGTO(BGTO) are quadratic model, and the original data is 4 hours , prediction window is 1 hour. Update every hour, slip the window.

- The forecast result of GPST-GLONASST



Avrage:0.027

The deviation between smoothed real value and forecast value



Average: 0.1981

The STDEV of everyday deviation

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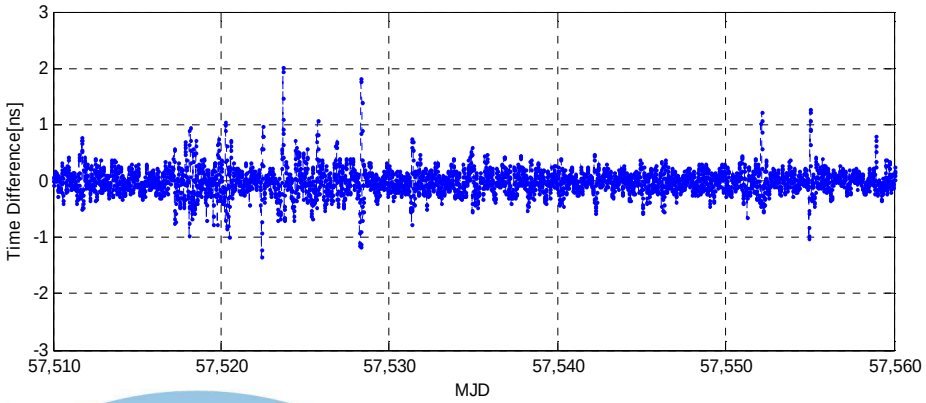
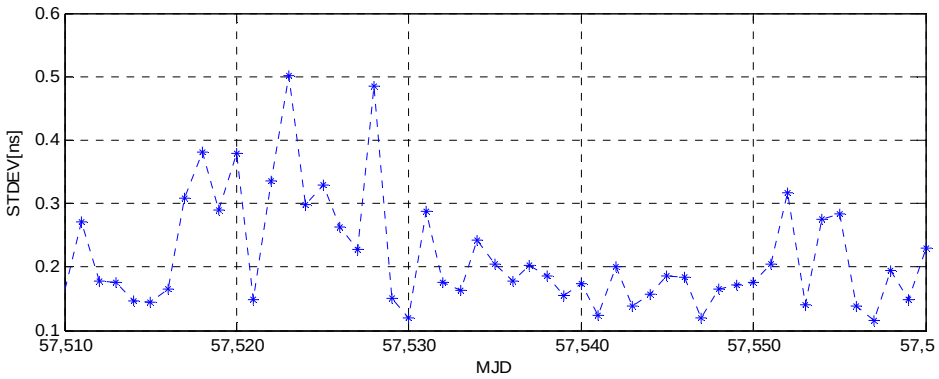
4. Test results and Analysis

- The forecast result of GPST-BDT



average -0.0073

The deviation between smoothed real value and forecast value



average 0.2174

The STDEV of everyday deviation

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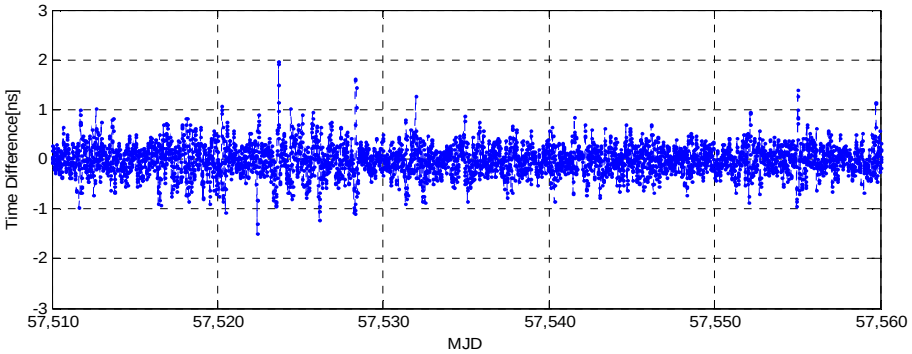
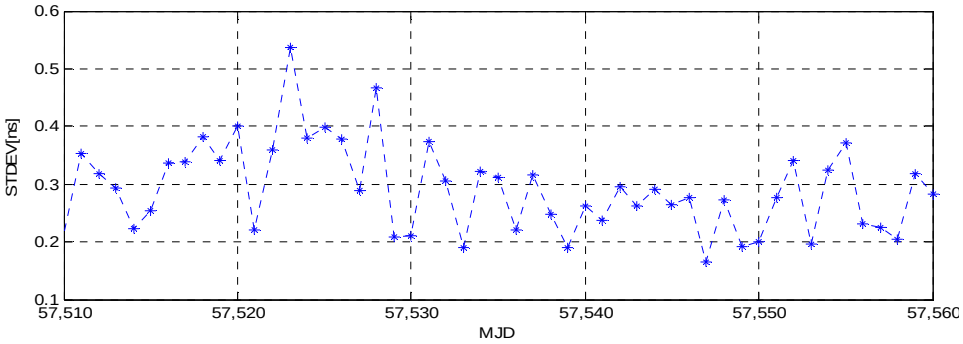
4. Test results and Analysis

- The forecast result of GLONASST-BDT



average -0.0100

The deviation between smoothed real value and forecast value



average 0.2918

The STDEV of everyday deviation

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5. Summary

- The principle of SSGTDM used in this test is available, though the precision might be affected by many factors.

- The equation adopted in the test is a quadratic model , but the linear model ? Which is the best? How many original data should be used in the construction of the forecast model ? How long can the model parameter be used (the forecast window)? …

So , more researches will be done in the future.

5. Summary

- We just did a simple test for the GNSS time offset monitoring, many test will be done to check and verify the validity of the principle.
- We can use the time links between GNSS ground time center, and indirectly calculate the time offset between two GNSS, check the results from the different methods.
- Time link calibration is also very important, all the time links used in the time offset monitoring must be calibrated accurately.
- So, I recommend that all individuals and organizations interested in this issue actively conduct relevant research and work together to promote the GNSS compatibility and interoperability.
- (GNSS PPP between UTC(NTSC) and UTC(SU), UTC(SU)-GLNT and UTC(NTSC)-BDT (domestic links))

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Thank You for Your Attention!

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