Activities on GNSS System Time Interoperability at NTSC

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Guideline

1. Introduction

2. Relationship between BDT and UTC(NTSC)

3.GNSS Time Offset Monitoring and Forecasting

4. GPST-GLONASST Application for Combination Positioning

1. Introduction

- In order to implement the traceability of BDT to UTC by using UTC(NTSC),time comparison links between BDS and NTSC including TW, GPSCV and BDSCV have been set up gradually since 2010.
- GPS, Galileo and BDS plan to broadcast the system time offset with other systems in their navigation information in order to support GNSS system time interoperability.
- BDS also promotes the system time interoperability vigorously.
  - In BSD ICD, the interfaces have been defined for system time offset forecast parameters with GPS, GLONASS, Galileo and so on.
- National Time Service Center has built a system time offset monitoring and forecast system for supporting the system time interoperability.

2. Relationship between BDT and UTC(NTSC)

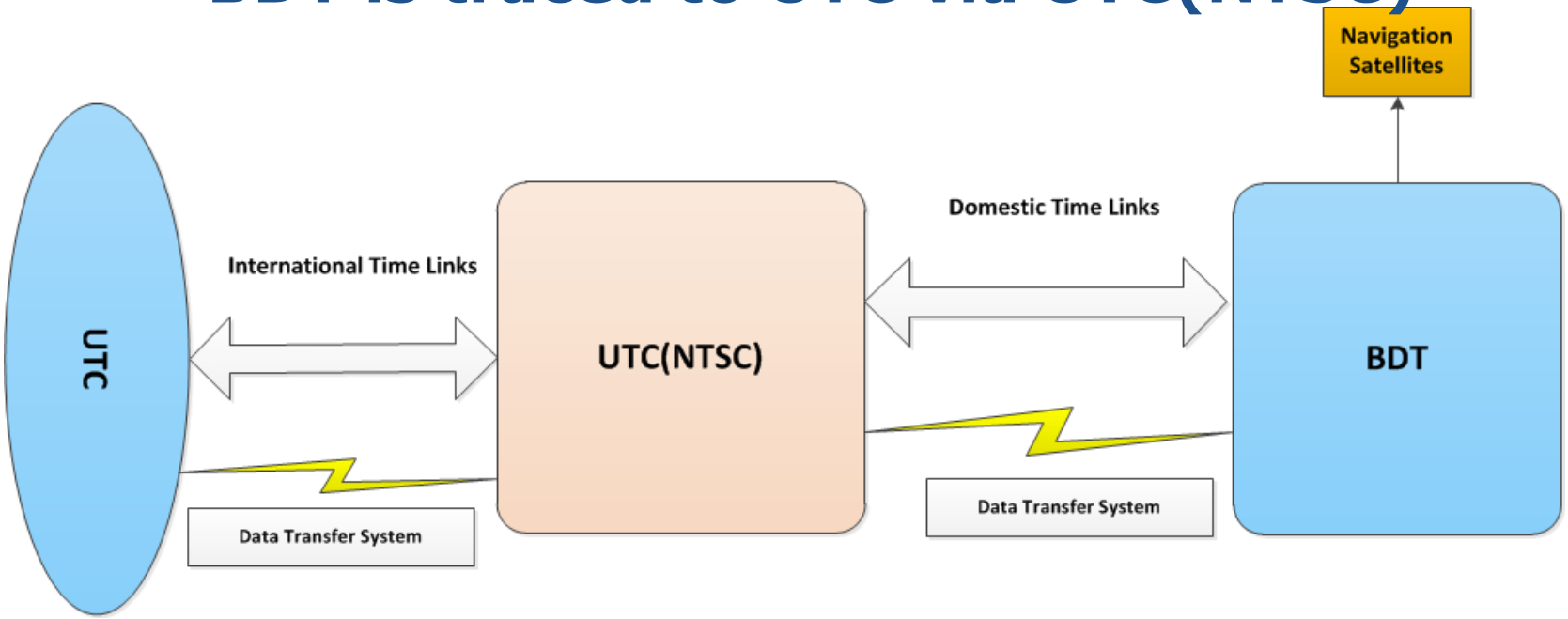
- Timekeeping of UTC(NTSC)

Clock Assembly

34 Cesium + 4 maser

2. Relationship between BDT and UTC(NTSC)

BDT is traced to UTC via UTC(NTSC)



- International Time Links ：TW Ku-band, GPS PPP, GPS CV
- Domestic Time Links：TW C-band， BDS CV, GPS CV

2. Relationship between BDT and UTC(NTSC)

- **Performance of the Time Links (Uncertainty)**

  - International :

    TWSTFT: 0.5ns (A)

    GPS PPP: 0.3ns (A)

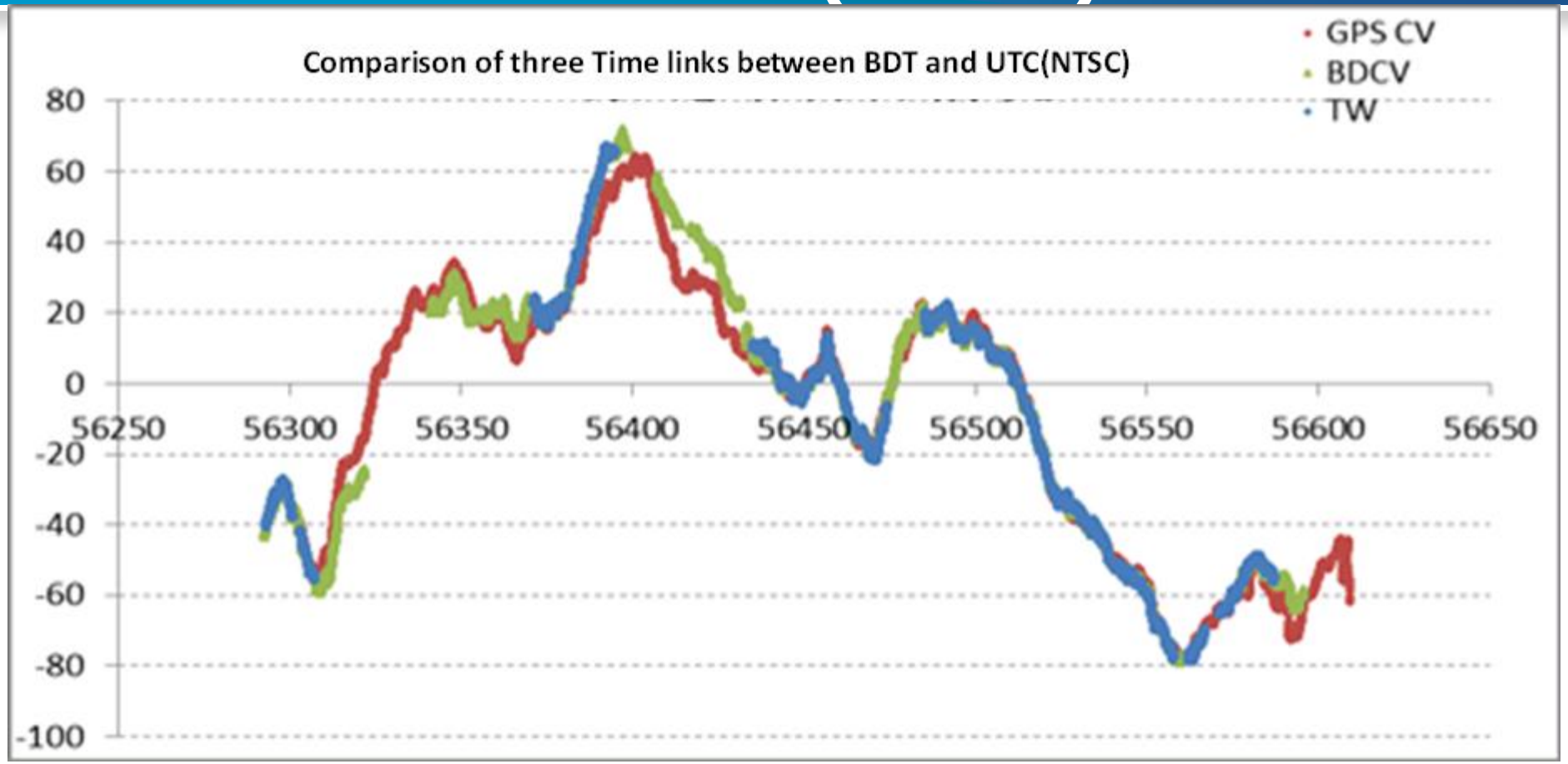
    GPS CV: 5ns (A+B)

  - Domestic :

    TWSTFT: 0.4ns (A)

    BDS/GPS CV: 5ns (A+B)

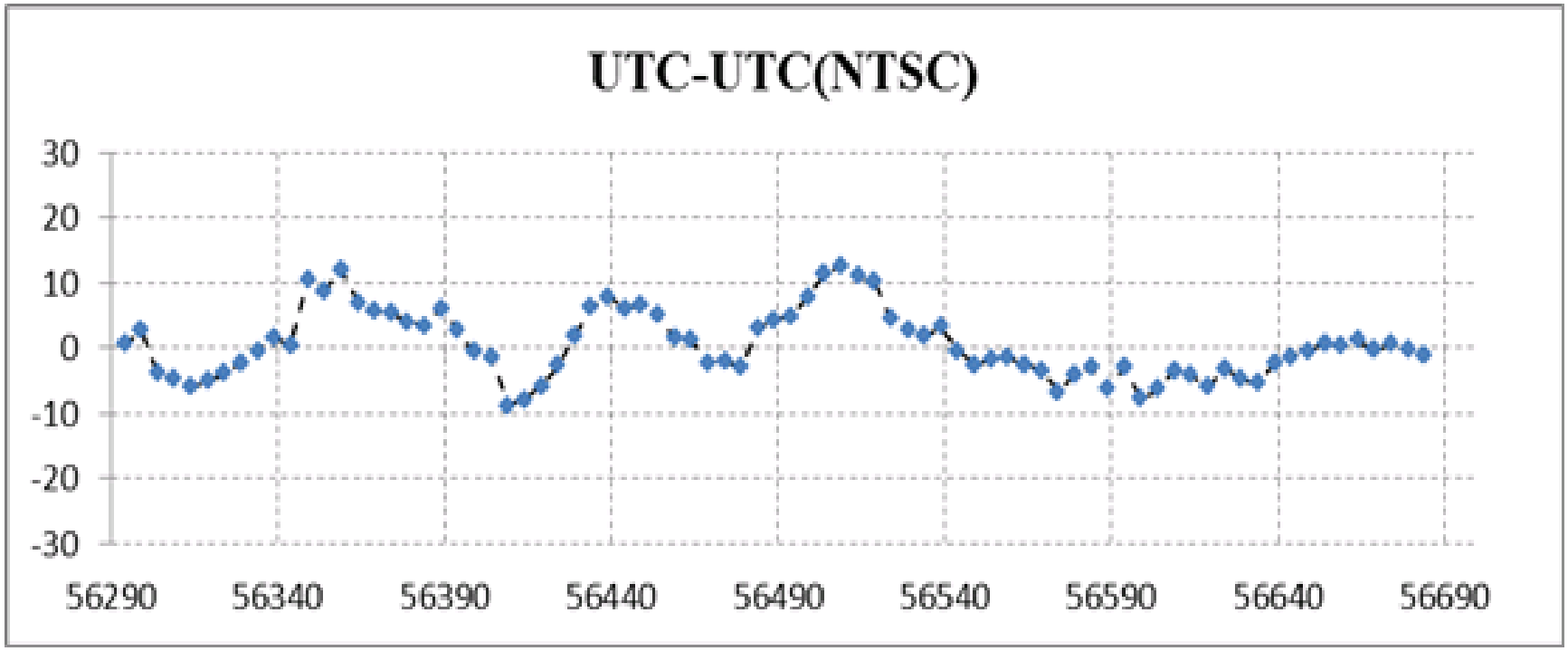
2. Relationship between BDT and UTC(NTSC)



- Comparison of different time links between BDT and UTC(NTSC) from November 2012 to December 2013 by TWSTFT C-band, GPS CV and BDS CV shows good consistency.

2. Relationship between BDT and UTC(NTSC)

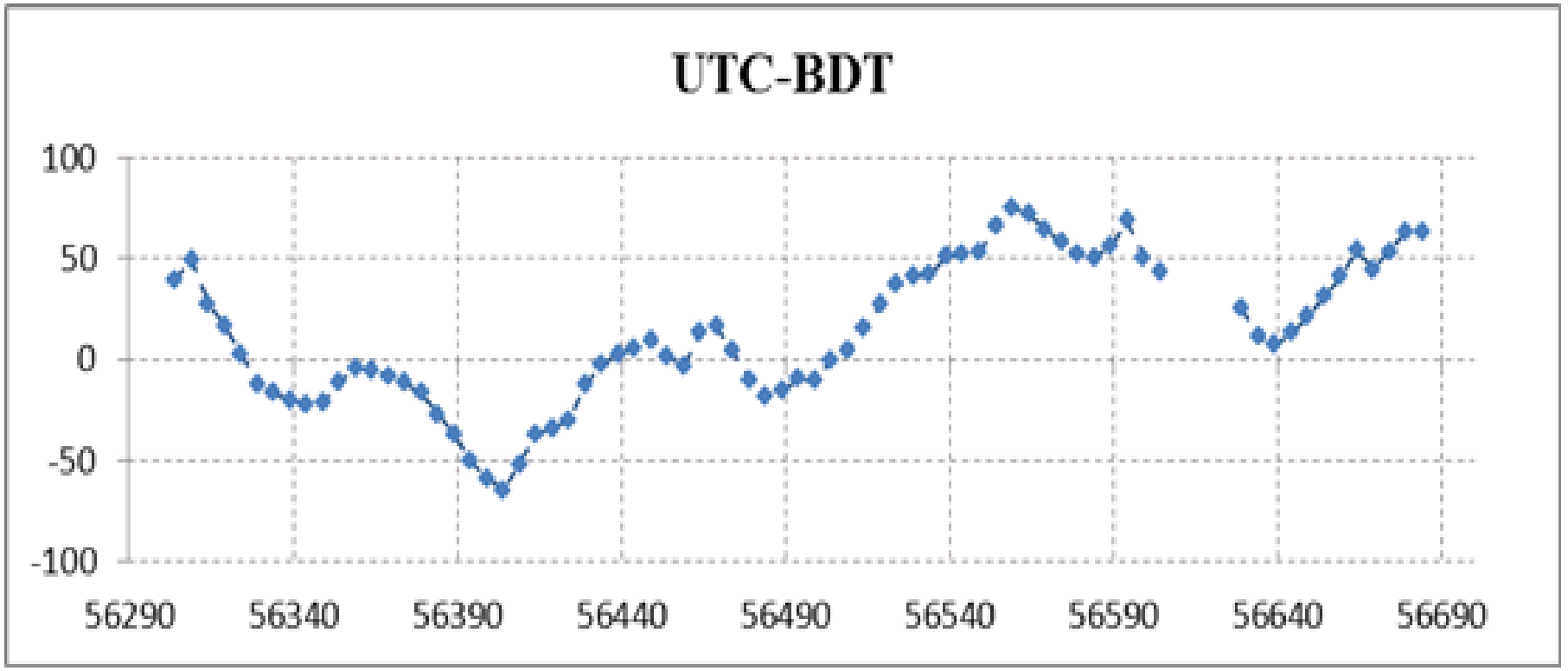
- Data sources：December 29th,2013~February 2th,2014
  (MJD=56290~56690)



- **UTC-UTC(NTSC) is kept within ±10ns**

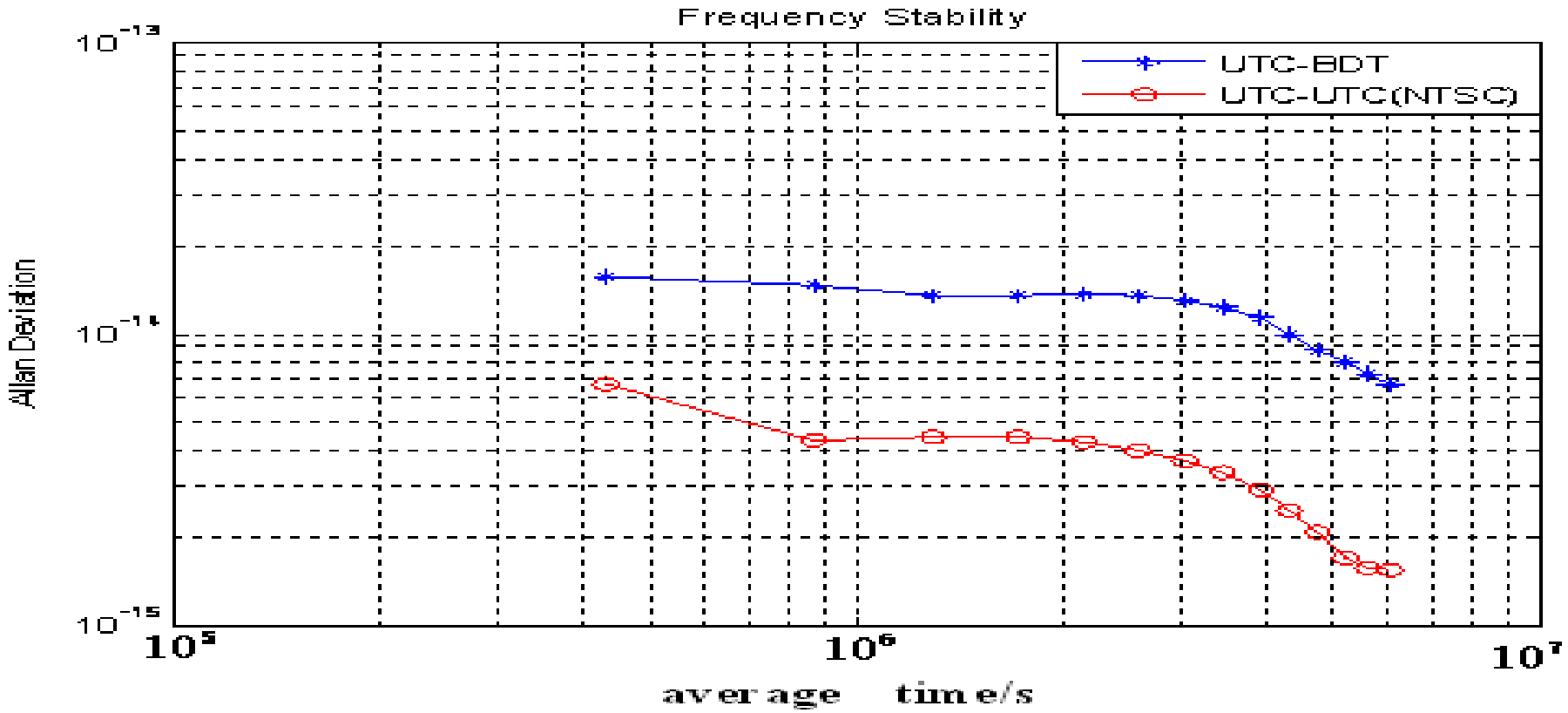
2. Relationship between BDT and UTC(NTSC)

UTC-BDT = [UTC-UTC(NTSC)] + [UTC(NTSC)-BDT]



- From above figure, we can see UTC-BDT is kept within 100ns.

2. Relationship between BDT and UTC(NTSC)

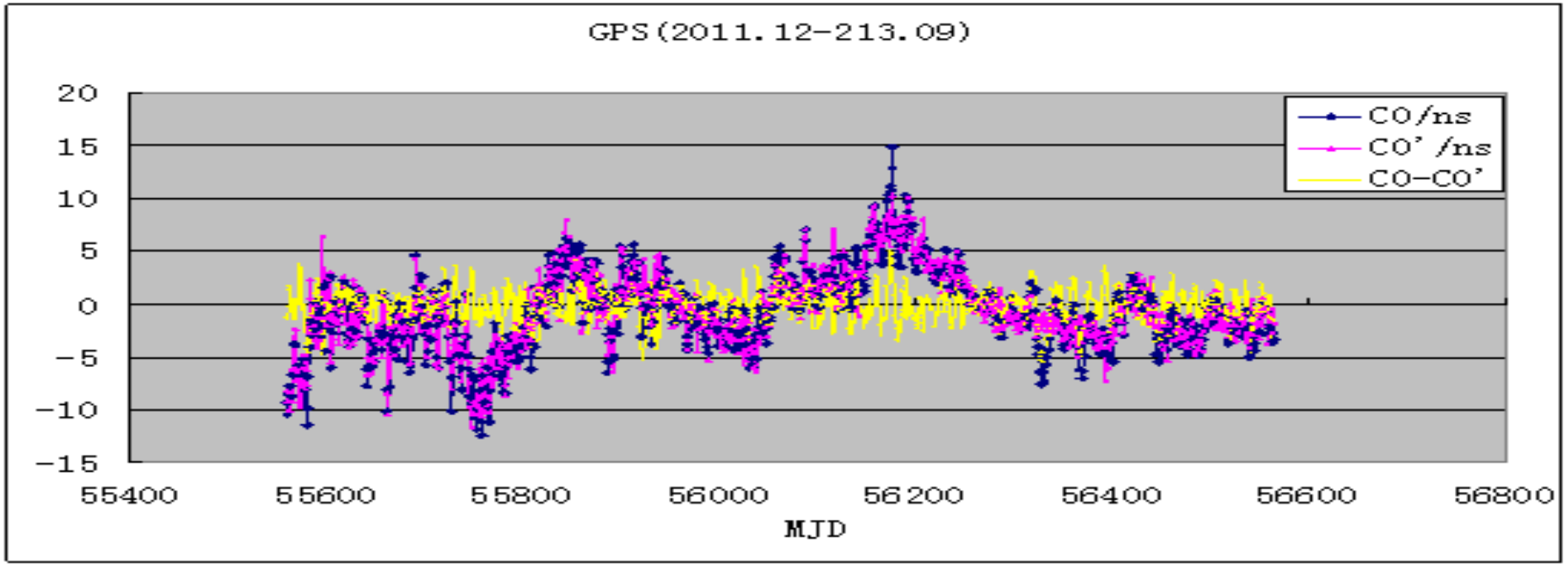


- Frequency stability of BDT: 5.8e-14(τ = 5 days)
- Frequency stability of UTC(NTSC): 6.7e-15 (τ = 5 days)

2. Relationship between BDT and UTC(NTSC)

- Compare with GPST traceability

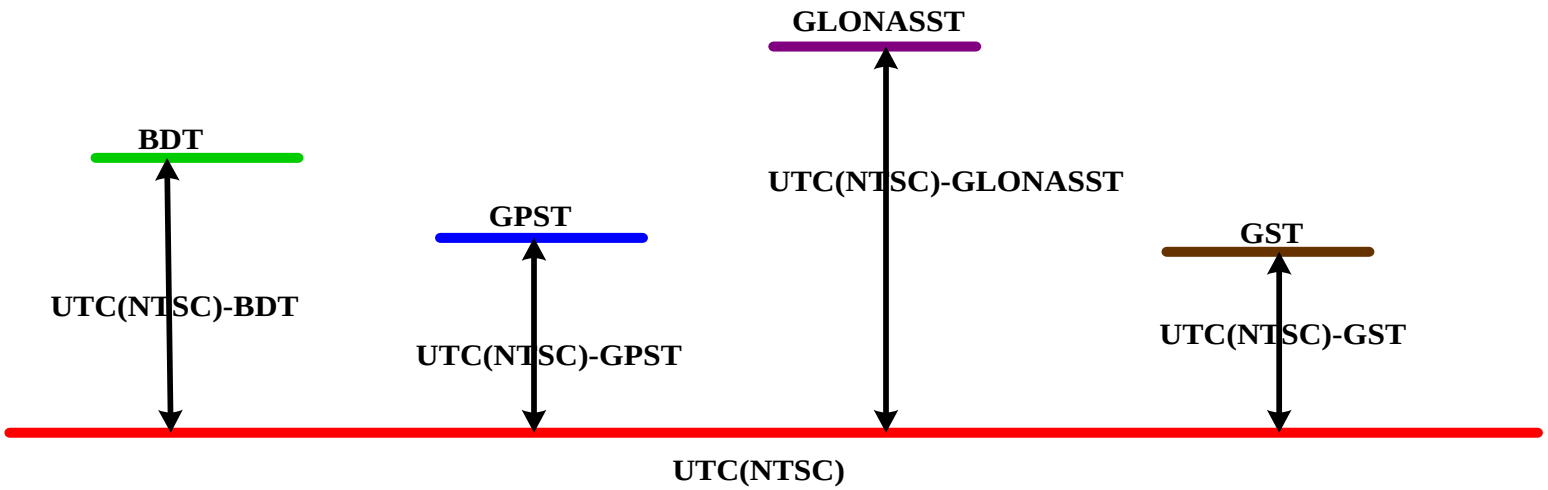
[UTC-GPS time] = -16 s +C0 , [UTC-UTC(USNO)_GPS] = C0'



C0 is in accordance with C0'. The C0- C0' offset is within ±5ns. It can verify the traceability of GPST to its time base。

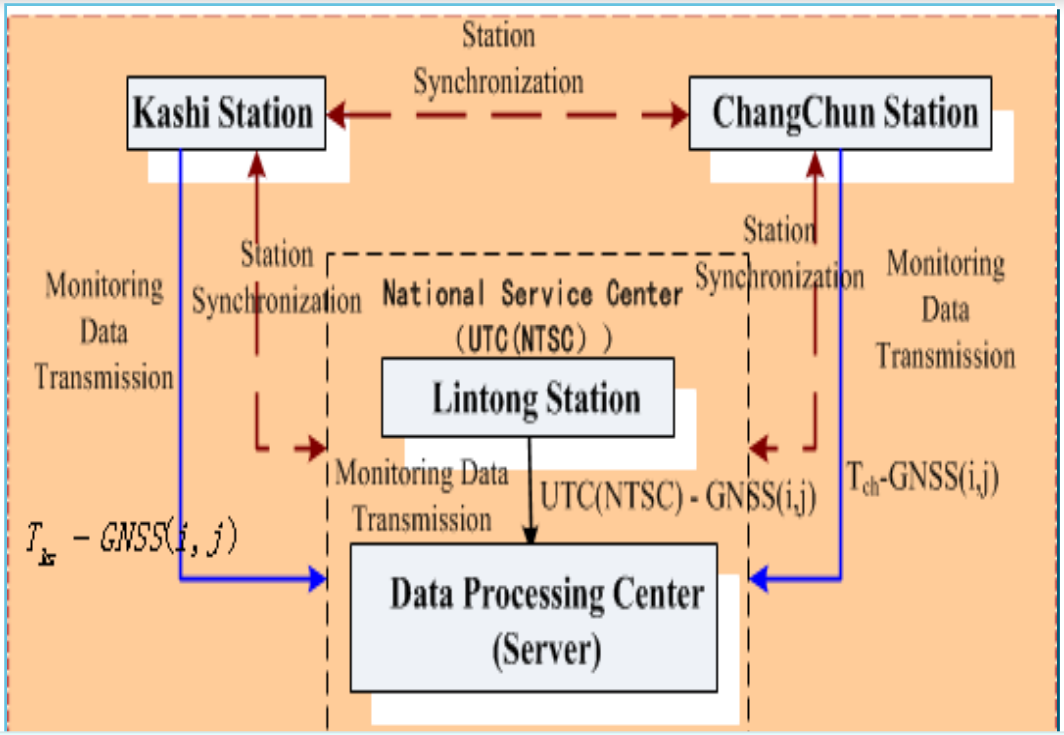
3. GNSS System Time Offset Monitoring and Forecasting

Fundamental of GNSS system time offset monitoring



- UTC (NTSC) is taken as medium time scale. Then system time offsets between GNSS time and UTC(NTSC) are monitored by GNSS SIS: UTC(NTSC)-BDT/GPST/GLONASST/GST
- In terms of each two monitored values, system time offset between two GNSSs can be derived, such as BDT-GPST
- Then system time offset prediction can be calculated.

3. GNSS System Time Offset Monitoring and Forecasting



Three stations

- Equipment
  - ✓ Cesium clock
  - ✓ Multi-GNSS Receiver
  - ✓ Time Interval Counter
  - ✓ Pulse and Frequency distribution unit
- Station monitoring software

One Data Processing Center

- ✓ Server
- ✓ Data integrated processing software

- Three stations, Lintong, Changchun and Kashi, have been set up and a multi-GNSS receiver is installed at each station
- Station time synchronization and remote data transmission are done in real time
- Receiver and antenna calibration are rigorously conducted

3. GNSS System Time Offset Monitoring and Forecasting

- The results of GNSS system time offset monitoring and forecasting are issued every day through Internet in the form of FTP file

ftp://210.72.145.14:21

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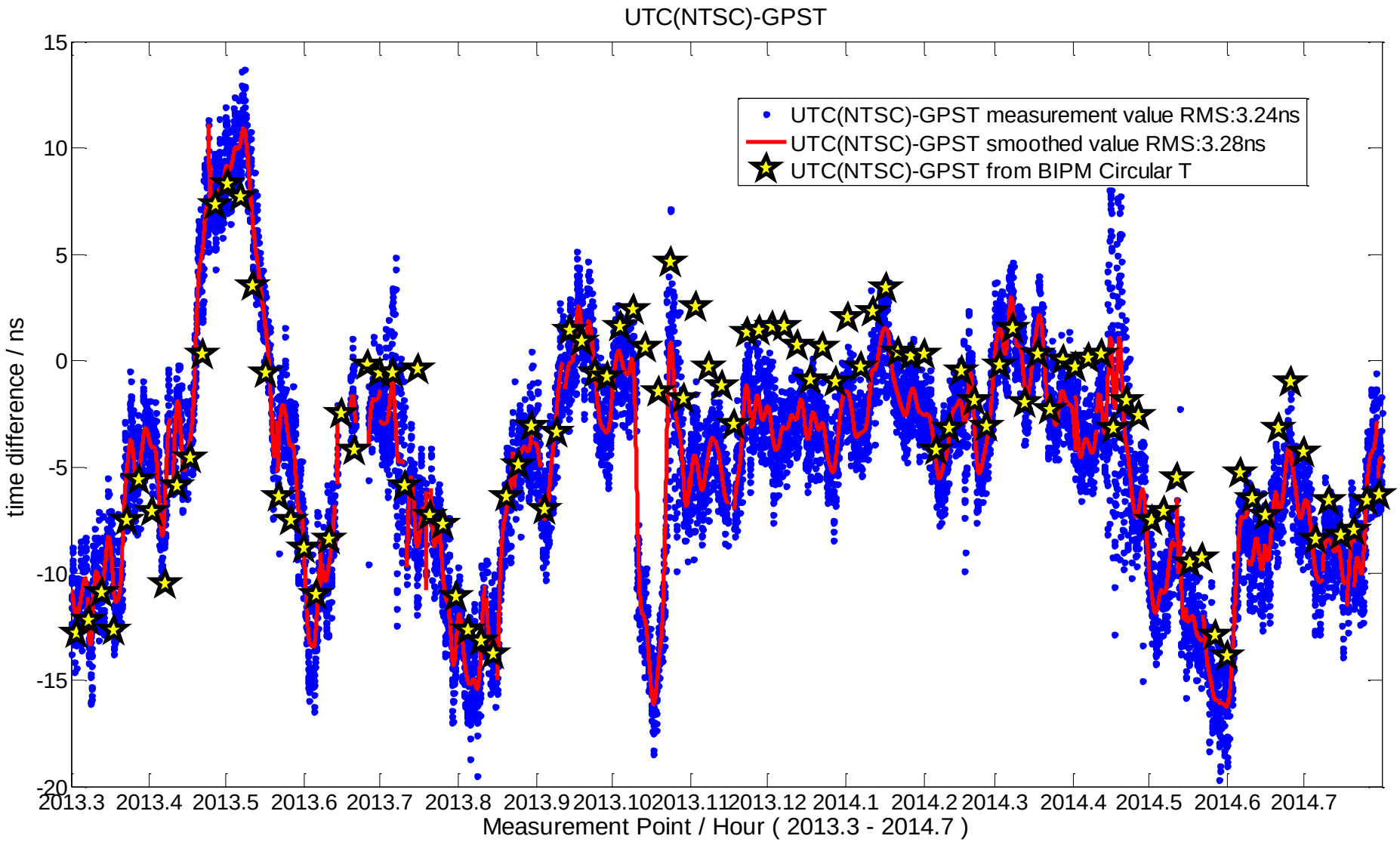

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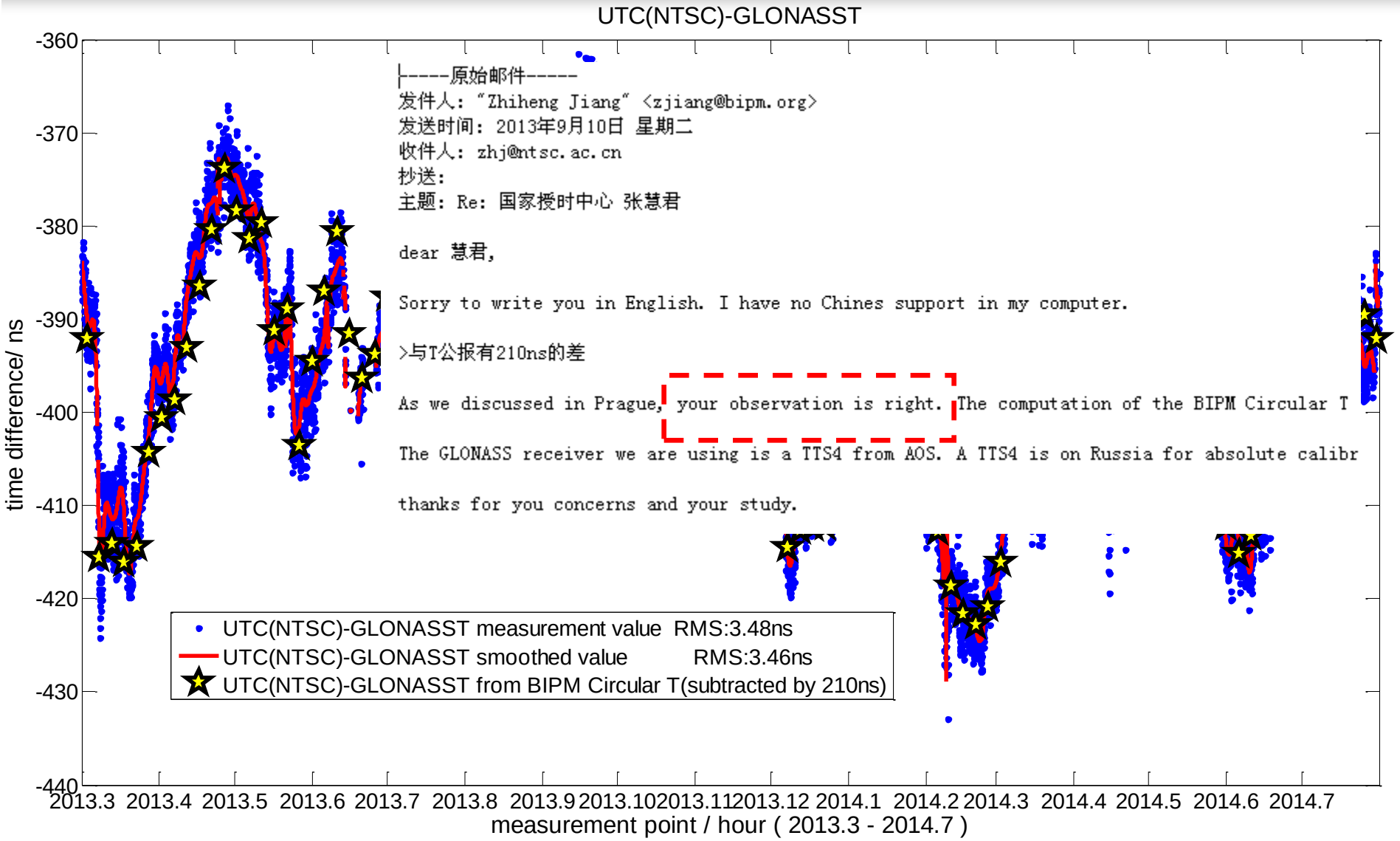

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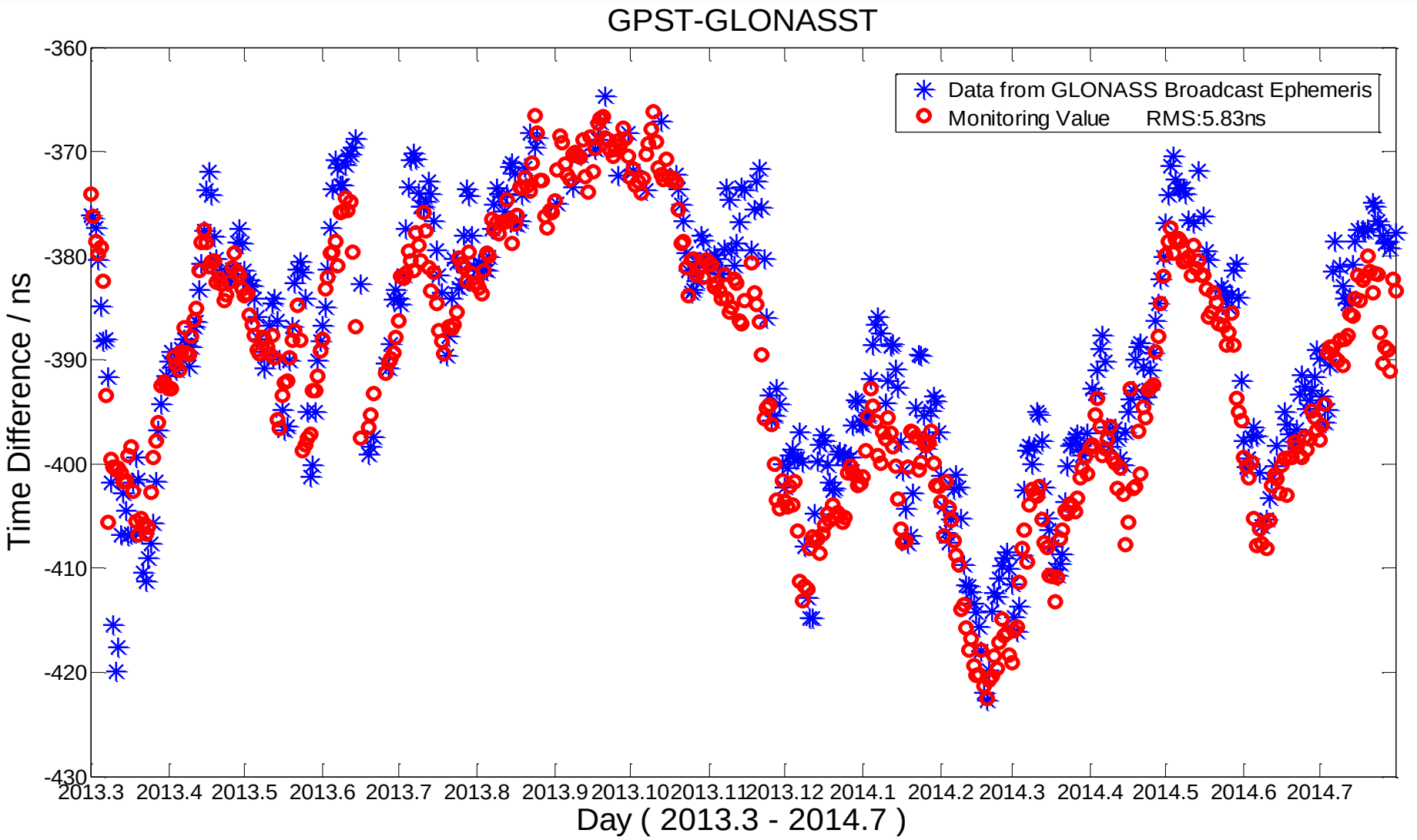

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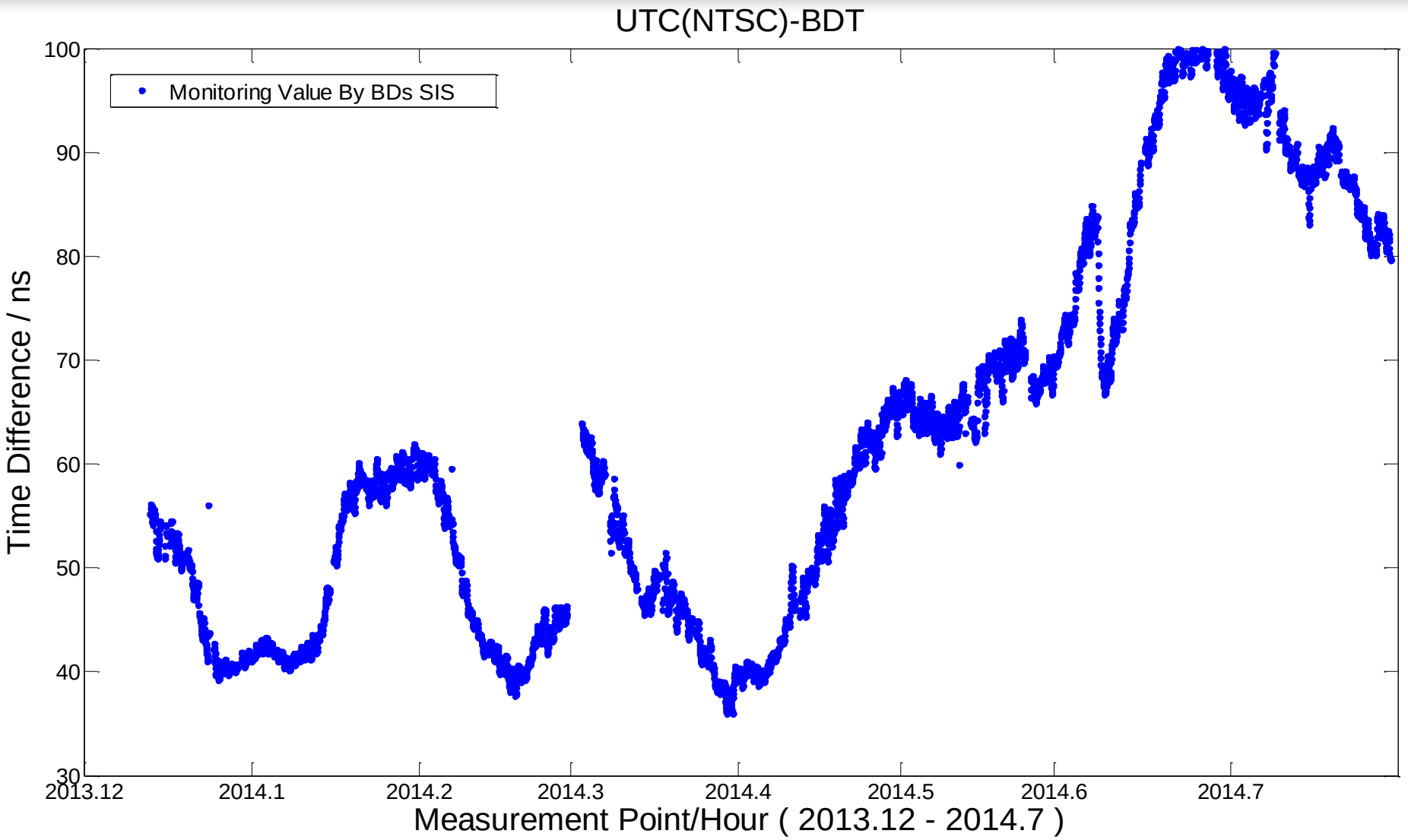


4. GPST-GLONASST - Applications for Combination Positioning

- **4**.1 the effect of GPST-GLONASST on combination positioning
- 4.2 Forecasting outcomes of GPST-GLONASST are applied to assist multi-GNSS positioning

4.1 the Effect of GPST-GLONASST on Combination Positioning

	GPS	GLONASS	GPS/GLONASS (user lever solution)	GPS/GLONASS (GPST-GLONASST is utilized)
10^0 cutoff				
GDOP	2.1	2.4	1.6	1.5
PDOP	1.8	1.9	1.4	1.3
20^0 cutoff				
GDOP	4.0	4.7	2.4	2.2
PDOP	3.6	3.8	2.2	2.0
30^0 cutoff				
GDOP	6.0	11.8	6.0	4.4
PDOP	5.6	11.0	5.3	4.0

4.1 the Effect of GPST-GLONASST on Combination Positioning

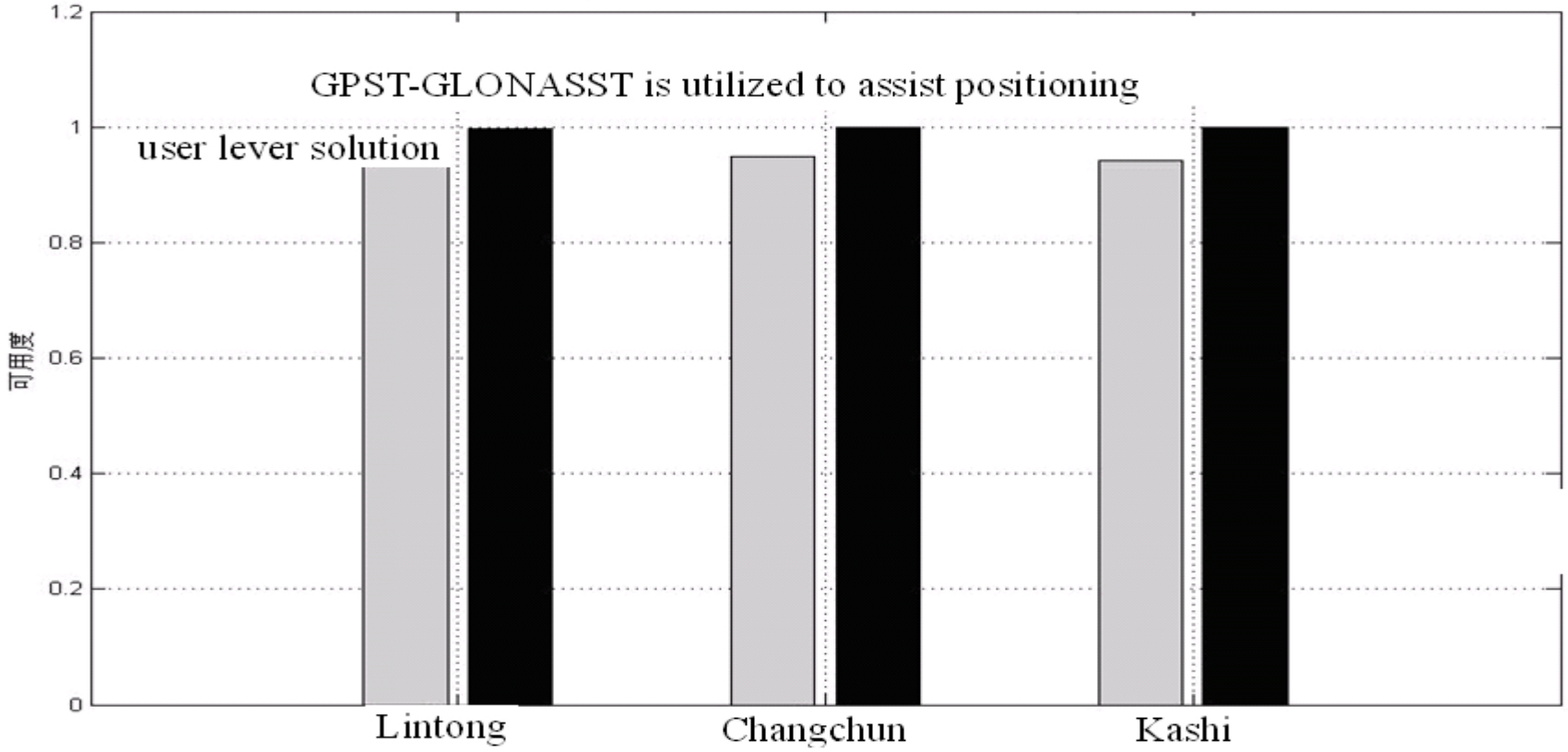
	GPS	GLONASS	GPS/GLONASS (user lever solution)	GPS/GLONASS GPST-GLONASST is utilized)
10^0 cutoff RMS(m)				
x	2.73	3.43	2.32	2.25
y	2.75	3.68	2.41	2.34
z	2.68	3.15	2.24	2.16
20^0 cutoff RMS(m)				
x	4.54	5.42	3.04	2.56
y	5.62	7.01	5.11	3.42
z	6.33	8.26	5.25	4.47
30^0 cutoff RMS(m)				
x	7.53	9.94	4.09	3.17
y	11.77	15.76	7.29	5.21

4.2 Forecasting Outcomes of GPST-GLONASST Are Applied to Assist Multi-GNSS Positioning

	PDOP distribution in one day (percentage)				
	PDOP≤6	**6<PDOP<39**	**PDOP≥39**	**PDOP minimum**	**PDOP maximum**
Lintong	**93.5%**	**6.3%**	**0.2%**	**2.07**	**45.7**
Changchun	**94.8%**	**5.2%**	**0**	**2.05**	**17.32**
Kashi	**94.2%**	**5.8%**	**0**	**2.02**	**11.74**

GPST-GlONASST forecast is adopted to assist combined positioning when PDOP is greater than 6 and less than 39,in order to meet positioning requirement.

4.2 Forecasting of GPST-GLONASST Is Applied to Assist Multi-GNSS Positioning



When using assist positioning,availability can be improved to nearly 100%

4.2 Forecasting of GPST-GLONASST Is Applied to Assist Multi-GNSS Positioning

	GPST-GLONASST User lever solution	GPST-GLONASST (Broadcasted by GLONASS)	GPST-GLONASST (forecasted outcomes)
Lintong station			
x	3.47	2.76	2.25
y	9.36	5.46	4.83
z	17.24	9.53	9.39
Changchu station			
x	5.81	4.23	3.86
y	15.32	5.42	4.77
z	19.7	7.39	6.83
Kashi station			
x	2.95	2.58	2.49
y	12.66	7.99	7.63
z	9.43	5.84	5.57


Thank You !