The Multi-Mode Time Transfer Based on GNSS

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The Content of Report

- ✓ **Background**
- ✓ **Principle of GNSS CV Time Transfer**
- ✓ **Results and Analysis**
- ✓ **Summary**

1. Background

- ✓ The standard GNSS time transfer technique was first used in 1984.
- ✓ GPS CV time transfer has been used by BIPM , in order to generate the International Atomic Time(TAI)

metrologia

International Reports

Technical Directives for Standardization of GPS Time Receiver Software

to be implemented for improving the accuracy of GPS common-view time transfer

experts from some of the principal timing centres along with some representation from the GPS manufacturing community. The Group is complementary to the Subcommittee on Time of the Civil GPS Service Interface Committee (CGSIC) which is mainly a forum

one of the most precise and accurate methods for time comparison between remote clocks on the Earth or in its close vicinity,

that this method has the potential for reaching an accuracy approaching 1 ns,

the need for removing the effects of Selective Availability (SA),

the lack of standardization in GPS timing receiving equipment,

the need for absolute as well as relative calibration of GPS timing receiving equipment,

D. W Allan: Allan's TIME, PO Box 66, Fountain Green, UT 84632, USA.
C. Thomas: Bureau International des Poids et Mesures, Pavillon de Breteuil, F-92312 Sèvres Cedex, France.

Metrologia, 1994, **31**, 69-79


```
GGTTS GPS DATA FORMAT VERSION = 01
REV DATE =    2008-3-14
RCVR = NTSCGPS-1 SN:NTSC01003
CH   = 8
IMS = 99999
LAB =     NTSC
X =   -1735234.67 m
Y =    4976845.85 m
Z =    3580528.79 m
FRAME = ITRF1996
COMMENTS = NO COMMENTS
INT DLY =  244.7 ns
CAB DLY =  148.3 ns
REF DLY =   37.8 ns
REF =   UTC(NTSC)
CKSUM = 4E
```

PRN	CL	MJD	STTIME	TRKL	ELV	AZTH	REFSV	SRSV	REFGPS	SRGPS	DSG	IOE	MDTR	SMDT	MDIO	SMDI	CK
			hhmmss	s	.1dg	.1dg	.1ns	.1ps/s	.1ns	.1ps/s	.1ns		.1ns.	1ps/s.	1ns.	1ps/s	
11	FF	54851	005000	780	536	510	-100305	-45	8	-56	12	78	101	9	60	4	24
20	FF	54851	005000	780	265	1258	-932102	-77	22	-87	17	47	180	-30	100	-3	2E
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17	FF	54851	005000	780	428	2879	-447179	45	2	54	15	100	119	-8	70	-3	2C
32	FF	54851	005000	780	229	958	-3022795	-27	-5	-55	21	10	206	-24	110	0	3E
11	FF	54851	012200	780	400	494	-100304	9	-9	0	12	78	126	17	81	15	2A
20	FF	54851	012200	780	355	1114	-932048	42	56	31	12	47	139	-12	93	-1	3A
4	FF	54851	012200	780	253	2220	3059279	127	-19	-7	16	43	188	-47	100	-4	2E

1. Background

“GGTTS” : the Group on GPS Time Transfer Standards

- GGTTS -V01 standard applies for GPS.
- CGGTTS -V02 standard applies for GPS + GLONASS
- CGGTTS –V2E standard applies for

  GPS + GLONASS**+Galileo+BeiDou+QZSS**

G-GPS R-GLONASS E-Galileo C-BeiDou J-QZSS

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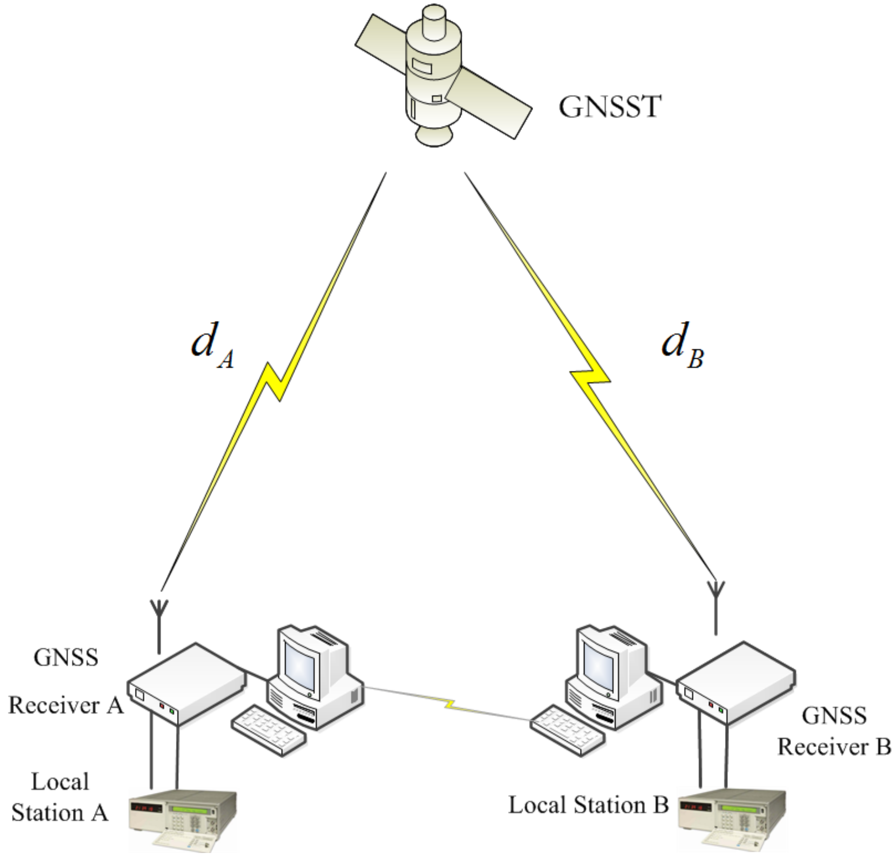
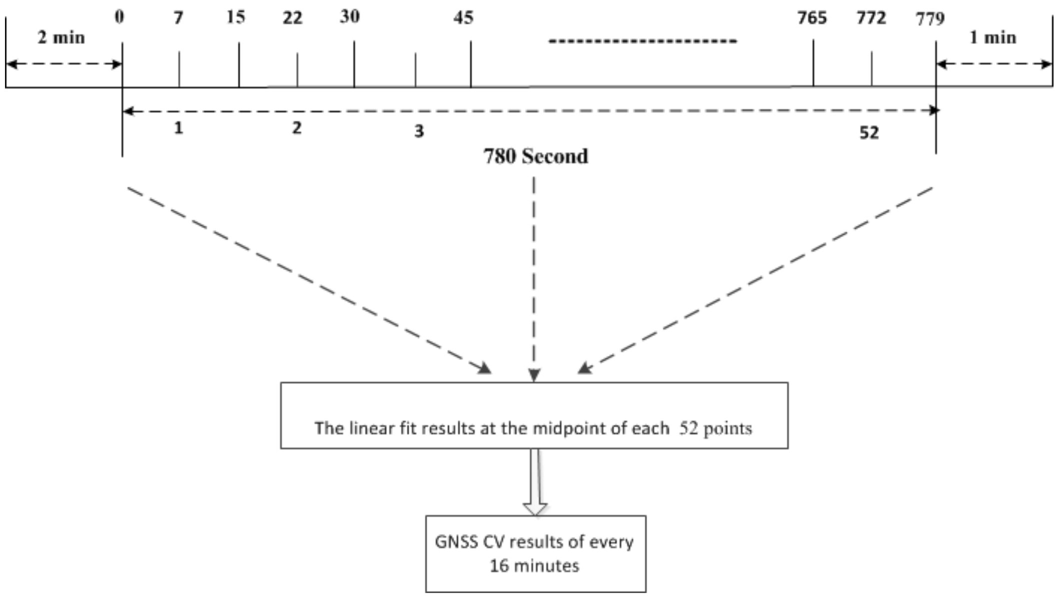
2. Principle of GNSS CV Time Transfer

- Connect the local clock (or UTC(k)) to a GNSS receiver,receive the navigation satellites signal,use the pseudorange measurements, obtain the time difference between the local clock and GNSS time scale.
- Measure time difference between the clocks or the two UTC(k).



2. Principle of GNSS CV Time Transfer



$$\bar{P}_i = P_i - c(INTDLY(f_i) + CABDLY - REFDLY)$$

where P_i is the pseudorange measurement on the frequency f_i,
c is the velocity of the light
$CABDLY$ is the signal group delay inside the antenna cable
$REFDLY$ is the time offset between the receiver internal clock and the local clock

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3. Results and Analysis

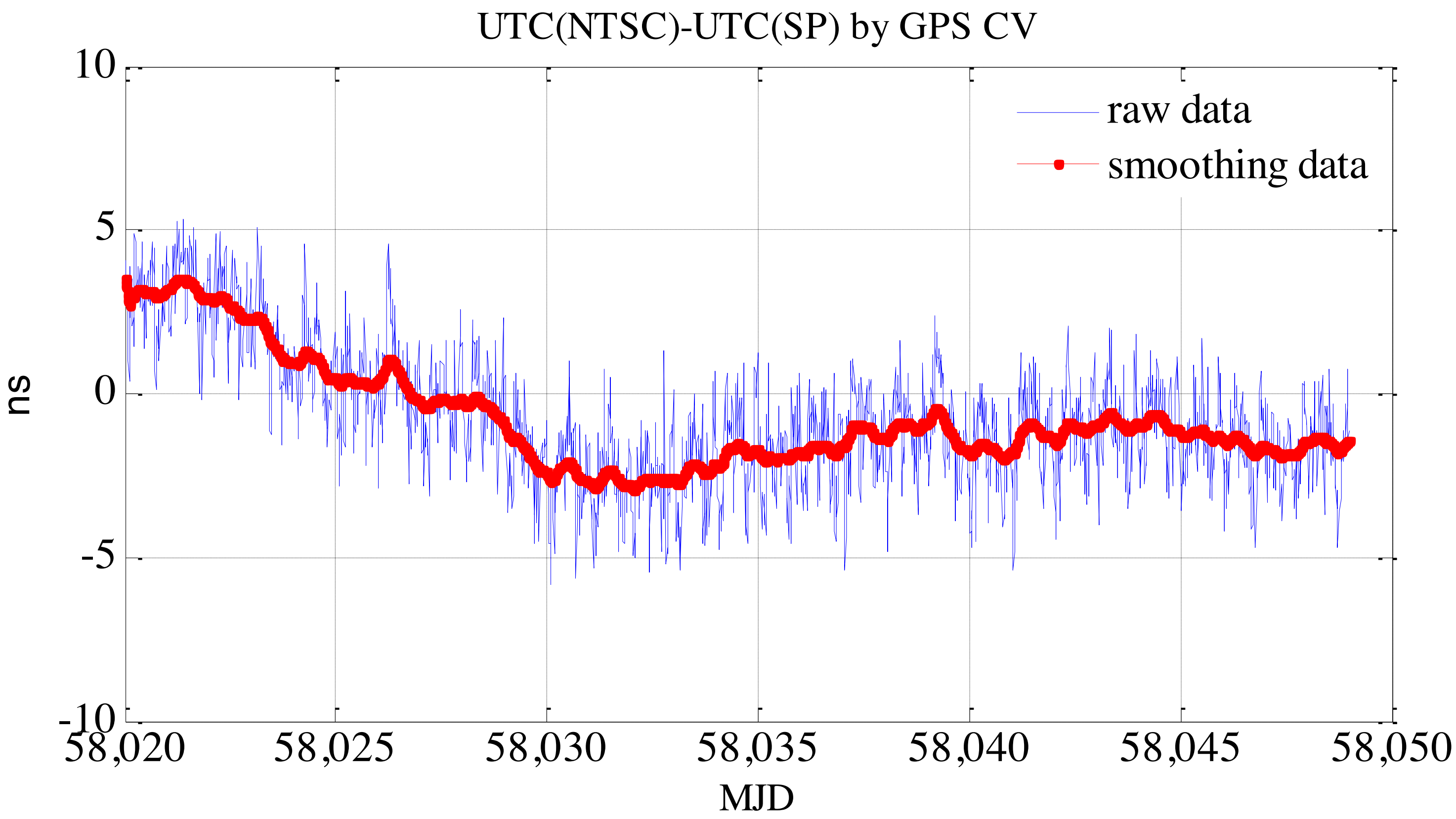
We develop a single-mode and multi-mode GNSS CV time transfer test (Eu-Asia).

The purposes of the test:

- ✓ Study how to use the CGGTTS –V2E standard in GNSS CV time transfer, during the new standard are applied in BIPM for calculating TAI.
- ✓ Clarify the different precision between single-mode and multi-mode GNSS CV time transfer.
- ✓ Support the test for multi-mode GNSS CV time transfer.

The type of receivers: Septentrio PolaRx 4TR(ORB)
Septentrio PolaRx 5TR(SP、NTSC)

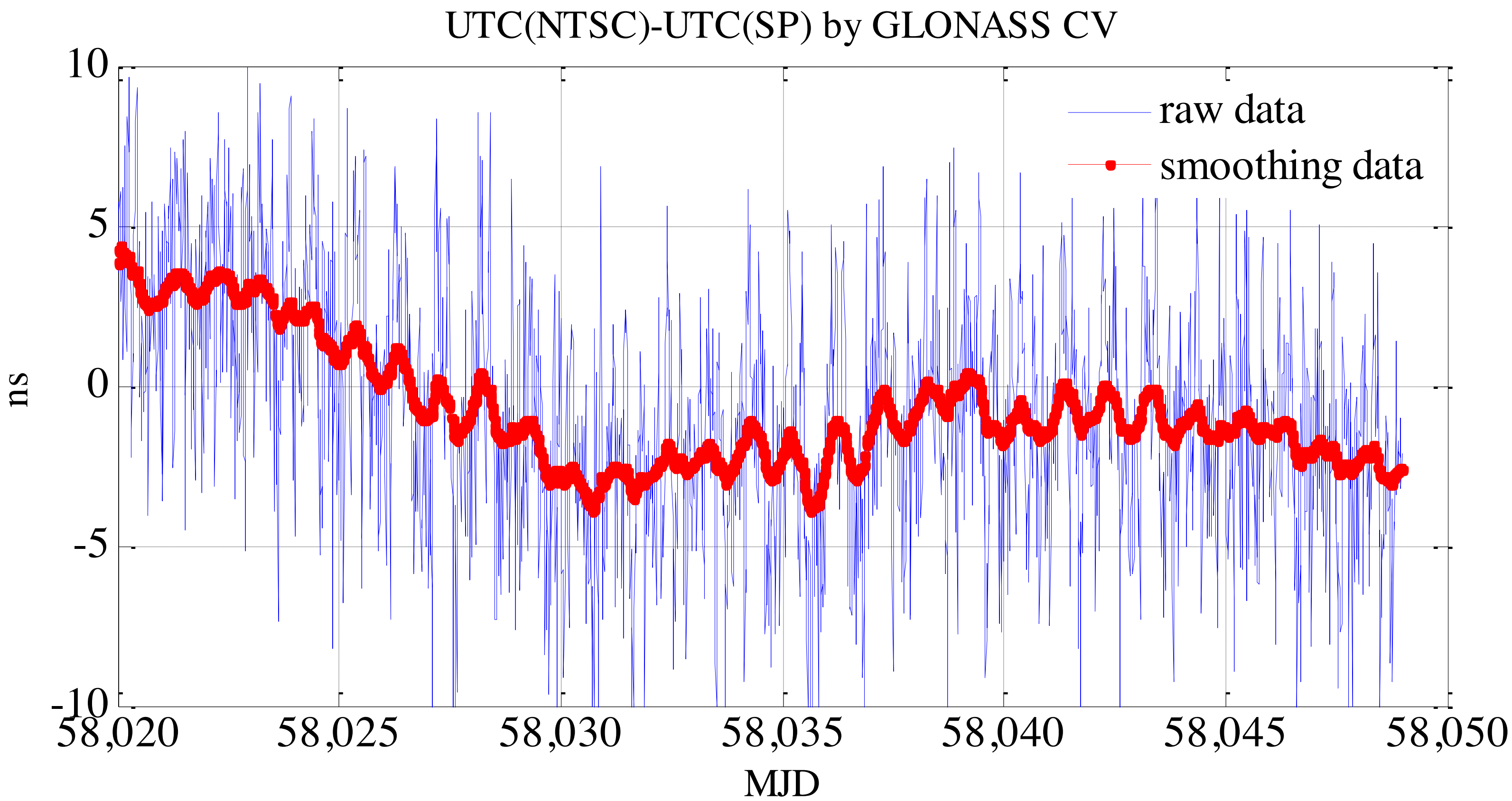
3. Results and Analysis (Date:2017.09.24—2017.10.23)



The results of UTC(NTSC)-UTC(SP) by GPS CV

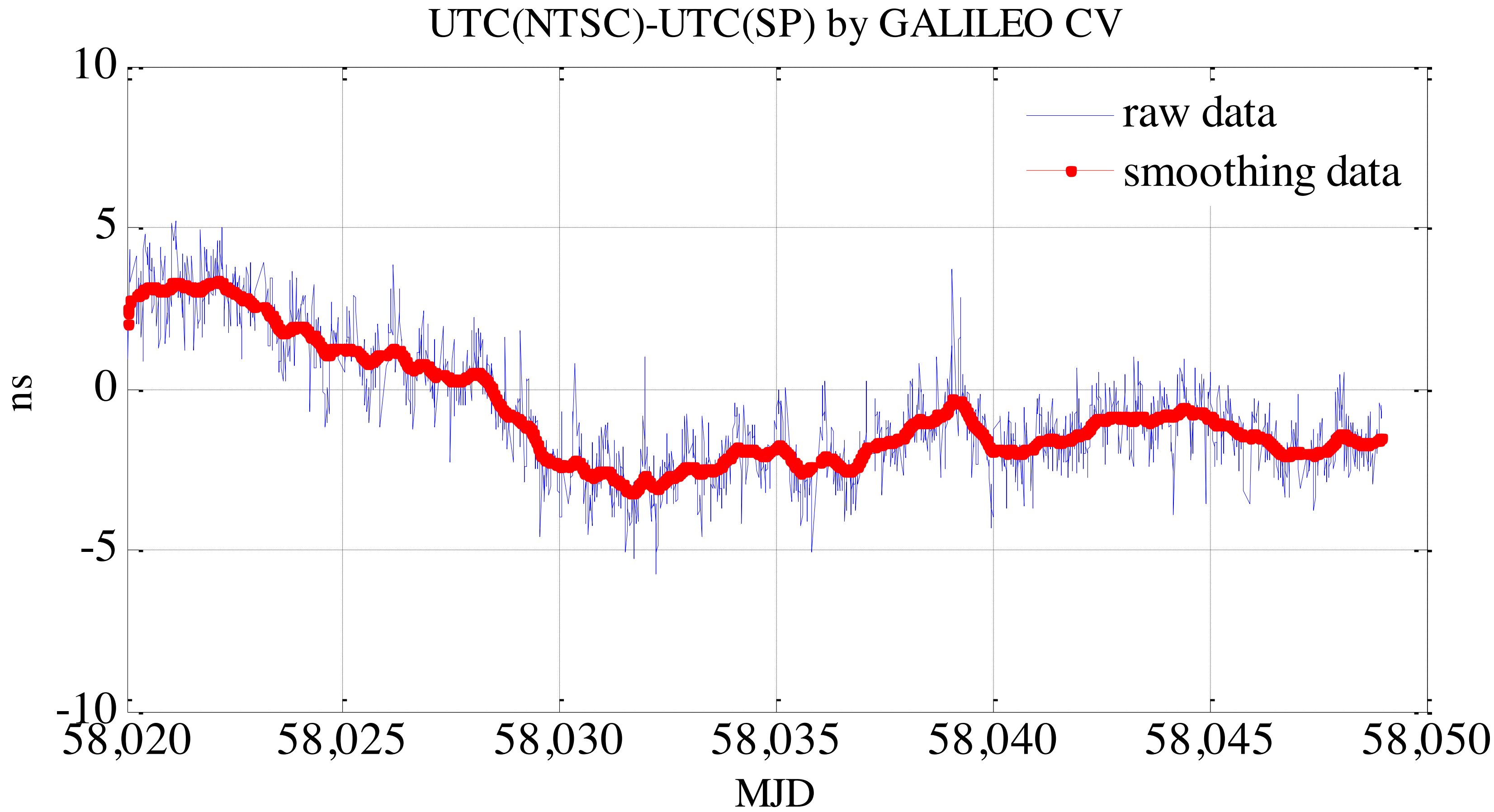
SP: Swedish National Testing and Research Institute, Sweden
NTSC: National Time Service Center of China, P.R.China

3. Results and Analysis (Date:2017.09.24—2017.10.23)



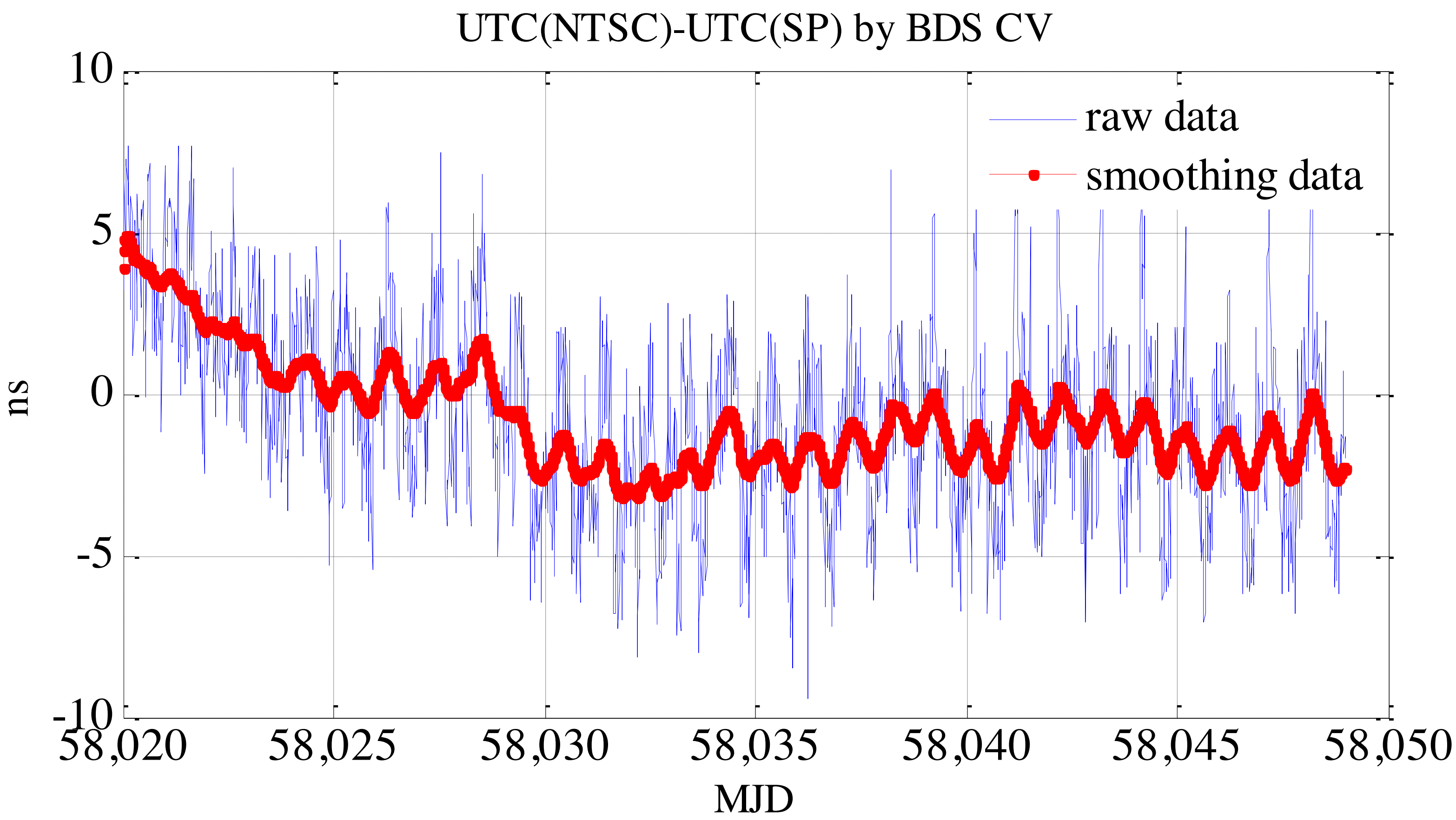
The results of UTC(NTSC)-UTC(SP) by GLONASS CV

3. Results and Analysis (Date:2017.09.24—2017.10.23)



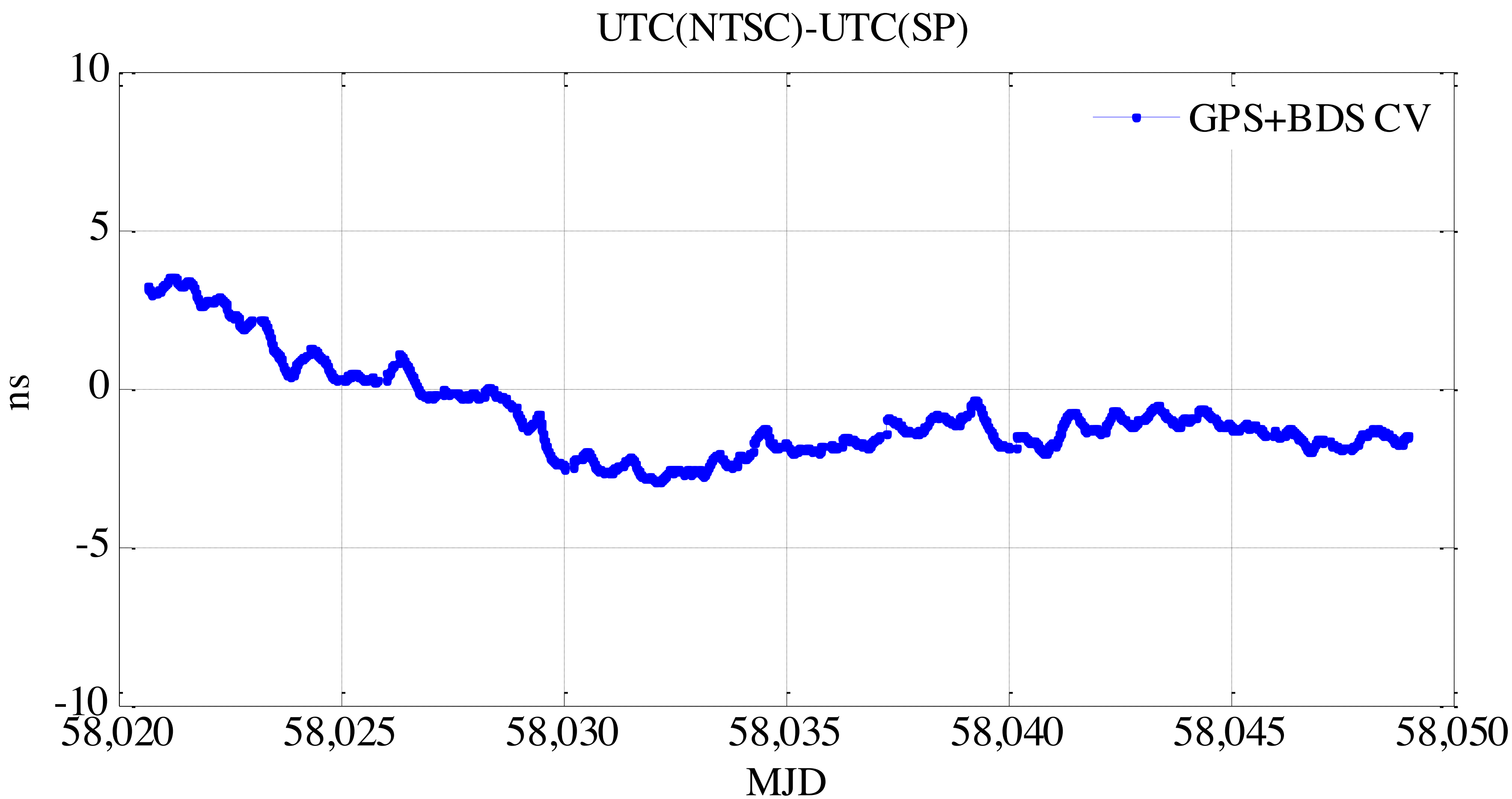
The results of UTC(NTSC)-UTC(SP) by GALILEO CV

3. Results and Analysis (Date:2017.09.24—2017.10.23)



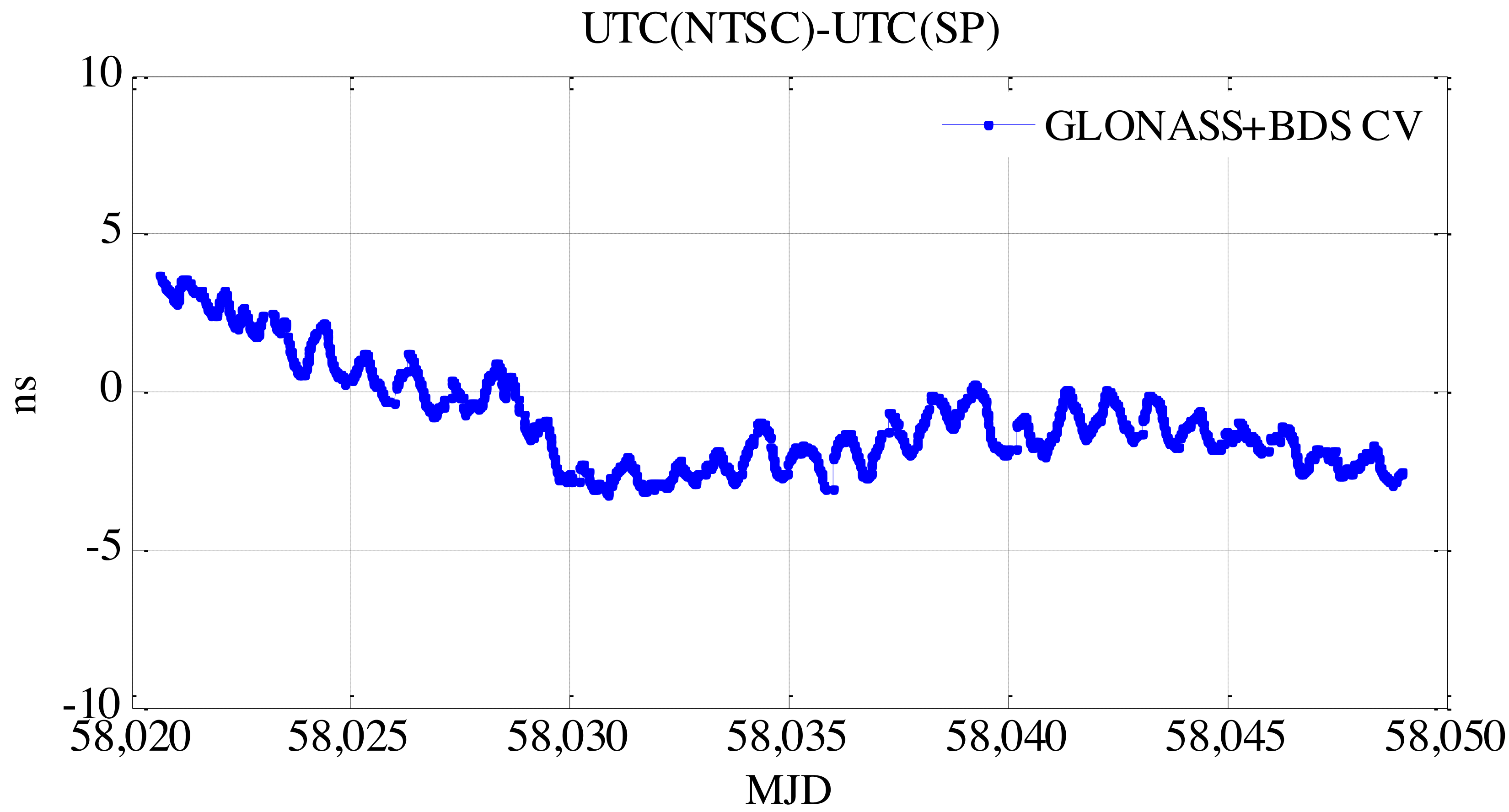
UTC(NTSC)-UTC(SP)	GPS	GLONASS	GALILEO	BDS
RMS(ns)	1.79	2.04	1.83	1.89

3. Results and Analysis (Date:2017.09.24—2017.10.23)



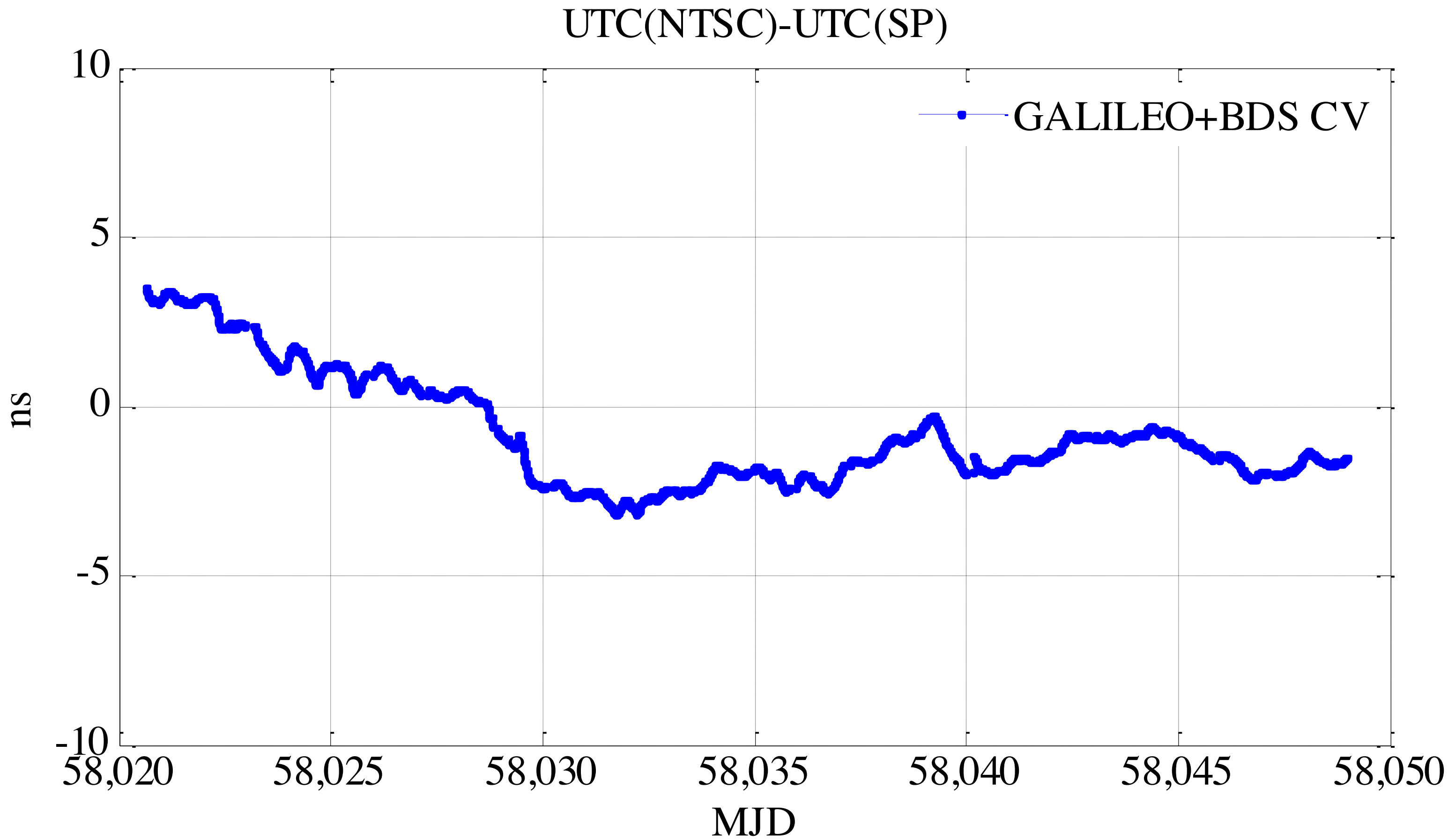
The results of UTC(NTSC)-UTC(SP) by GPS and BDS CV
---Weighted average alogrithm

3. Results and Analysis (Date:2017.09.24—2017.10.23)



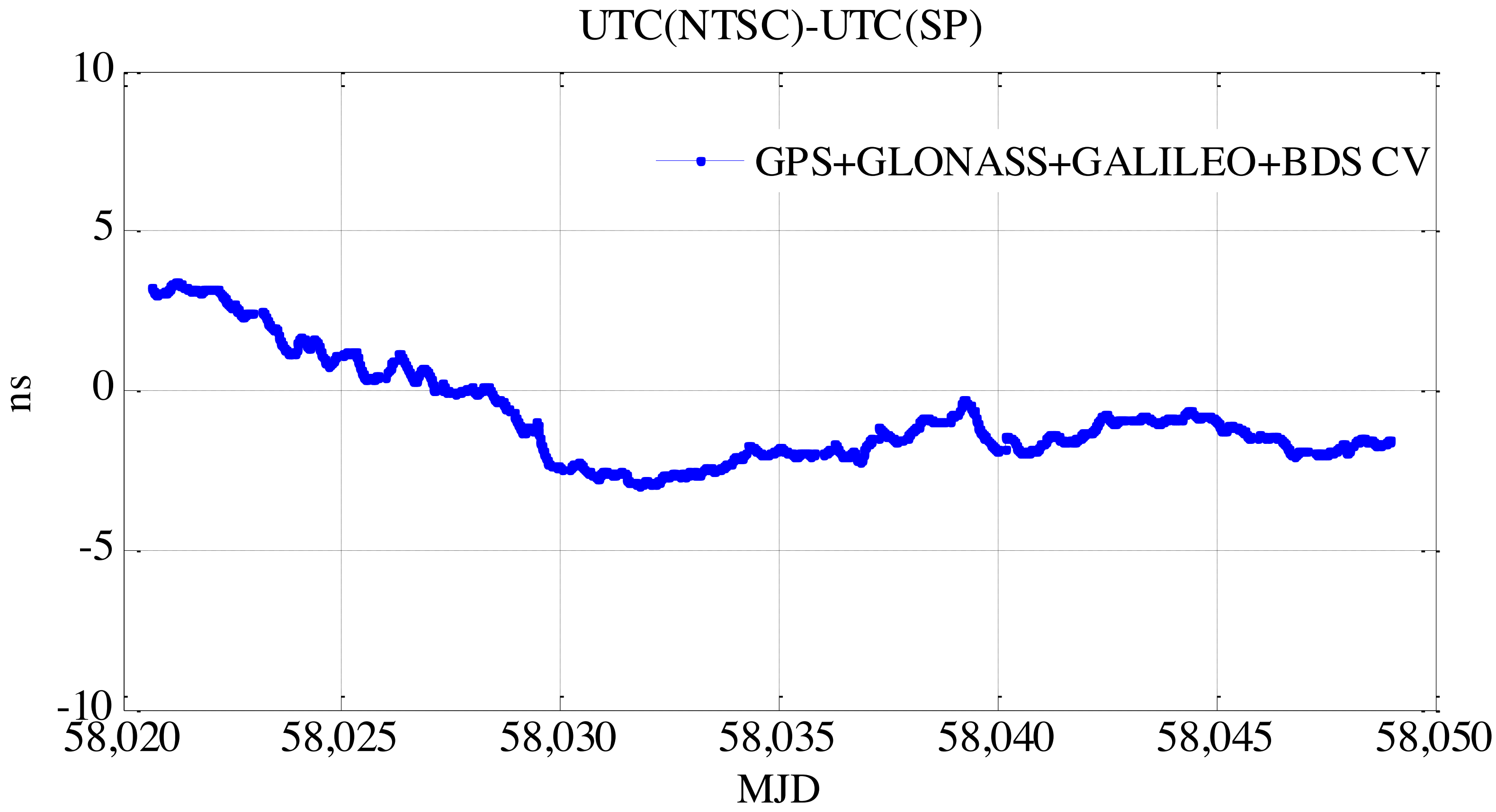
The results of UTC(NTSC)-UTC(SP) by GLONASS and BDS CV
---Weighted average alogrithm

3. Results and Analysis (Date:2017.09.24—2017.10.23)



The results of UTC(NTSC)-UTC(SP) by GALILEO and BDS CV
---Weighted average alogrithm

3. Results and Analysis (Date:2017.09.24—2017.10.23)



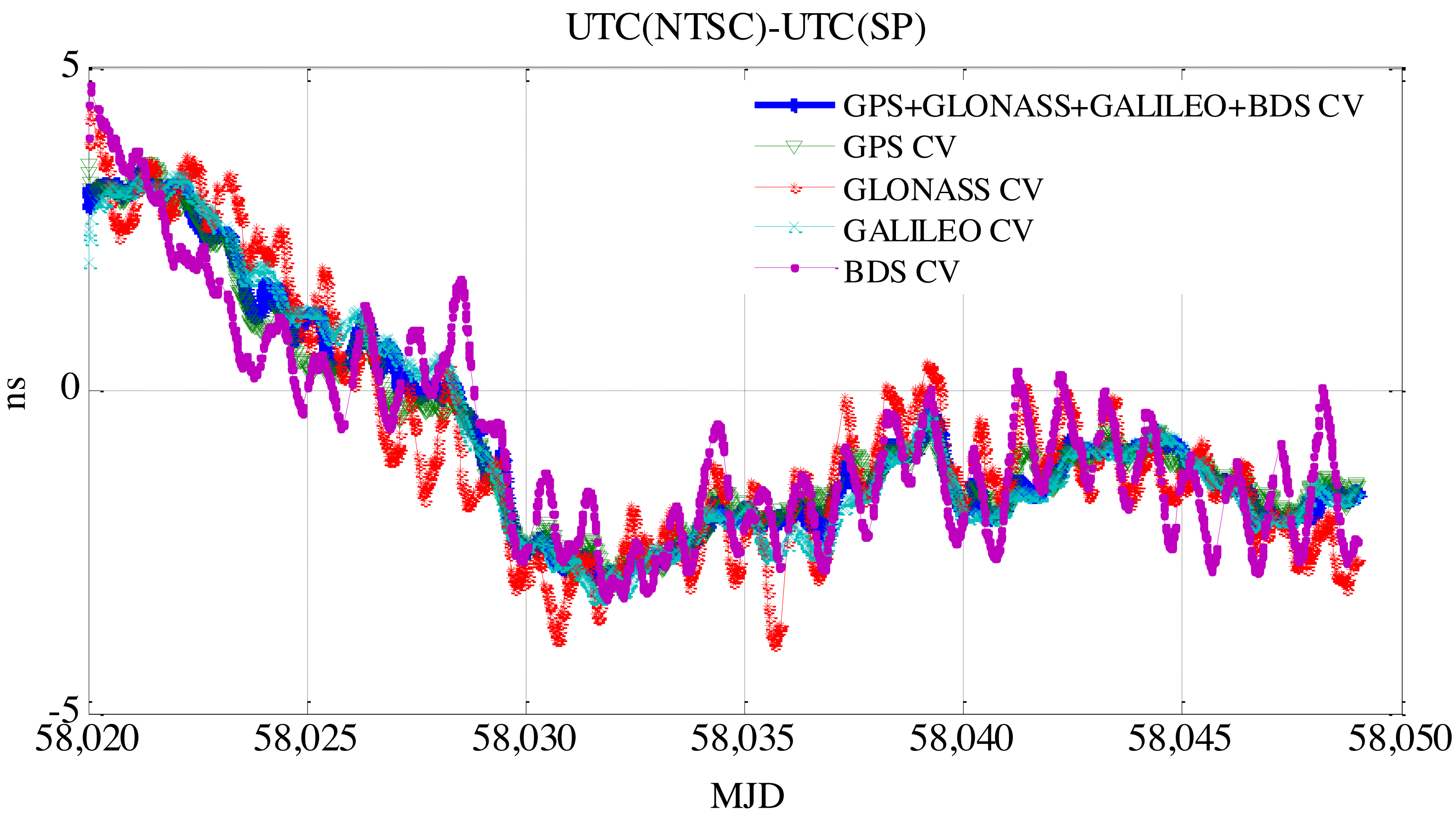
The results of UTC(NTSC)-UTC(SP) by GPS ,GLONASS ,GALILEO and BDS CV
---Weighted average alogrithm

3. Results and Analysis (Date:2017.09.24—2017.10.23)

NTSC-SP:

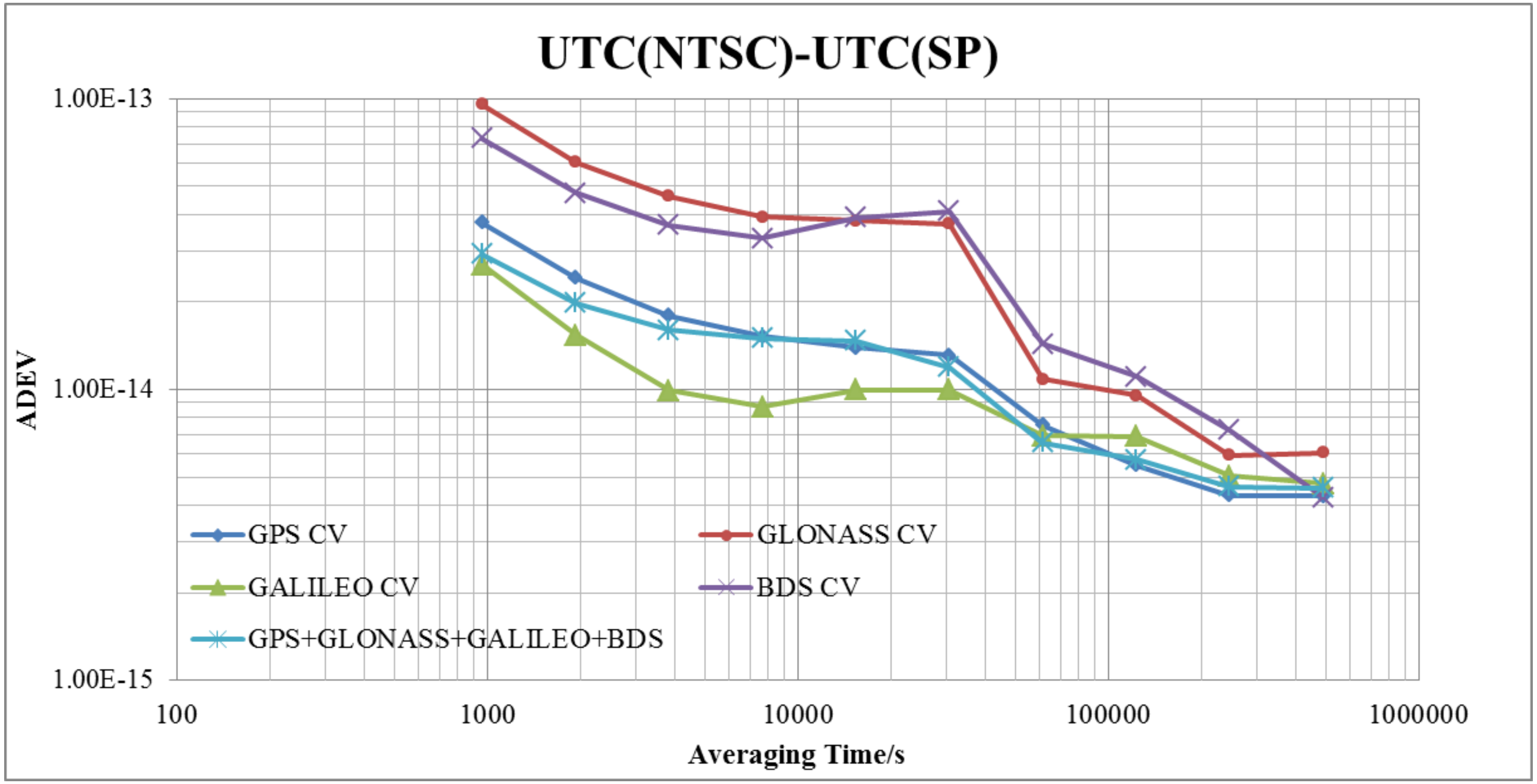
UTC(NTSC)-UTC(SP)	**GPS**	**GLONASS**	**GALILEO**	**BDS**
RMS(ns)	1.79	2.04	1.83	1.89
UTC(NTSC)-UTC(SP)	GPS+BDS	GLONASS+BDS	GALILEO+BDS	GPS+GLONASS+GALILEO+BDS
RMS(ns)	1.71	1.85	1.75	1.69

3. Results and Analysis (Date:2017.09.24—2017.10.23)



The comparative results by single-mode and multi-mode system

3. Results and Analysis (Date:2017.09.24—2017.10.23)



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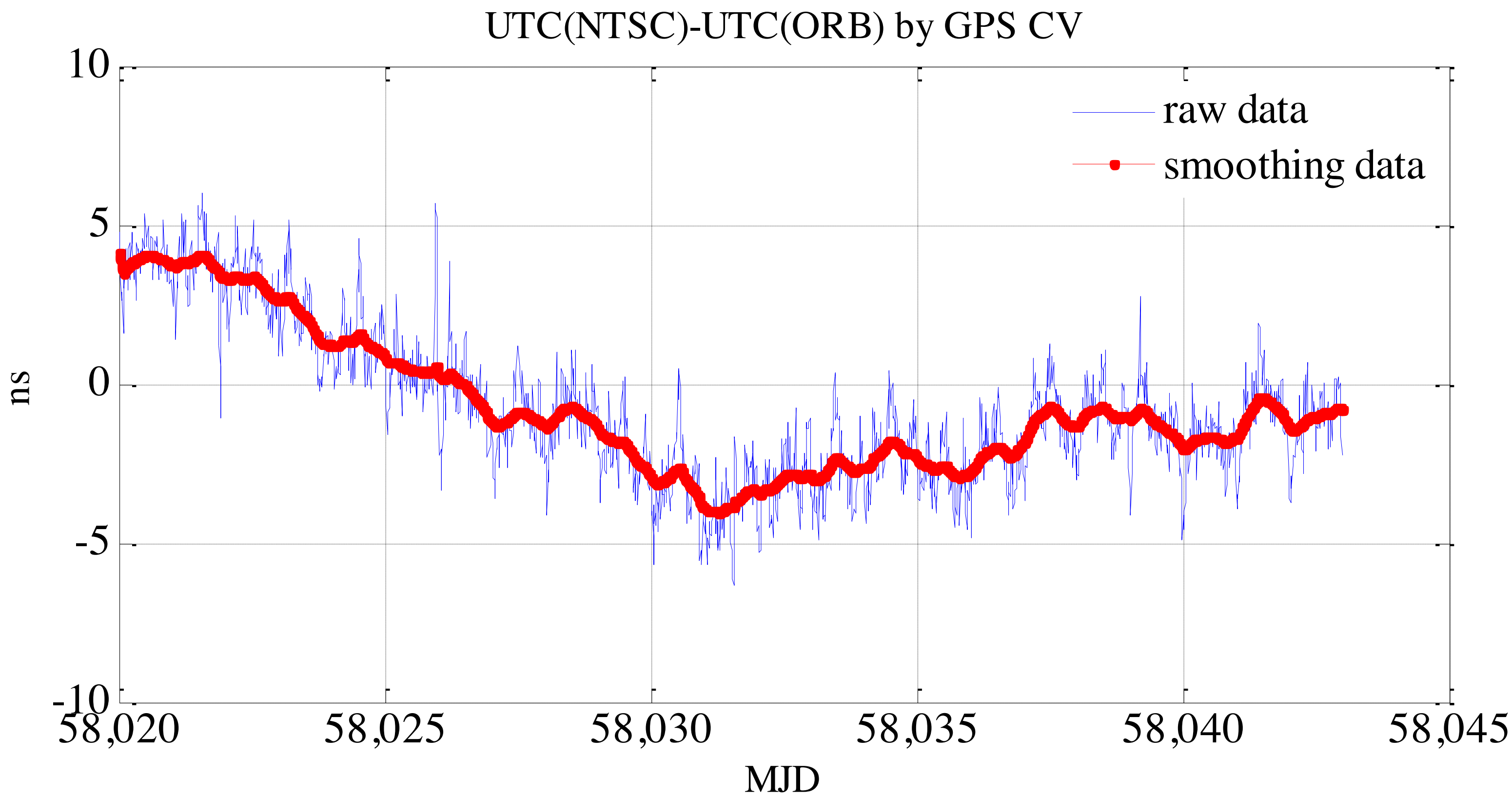
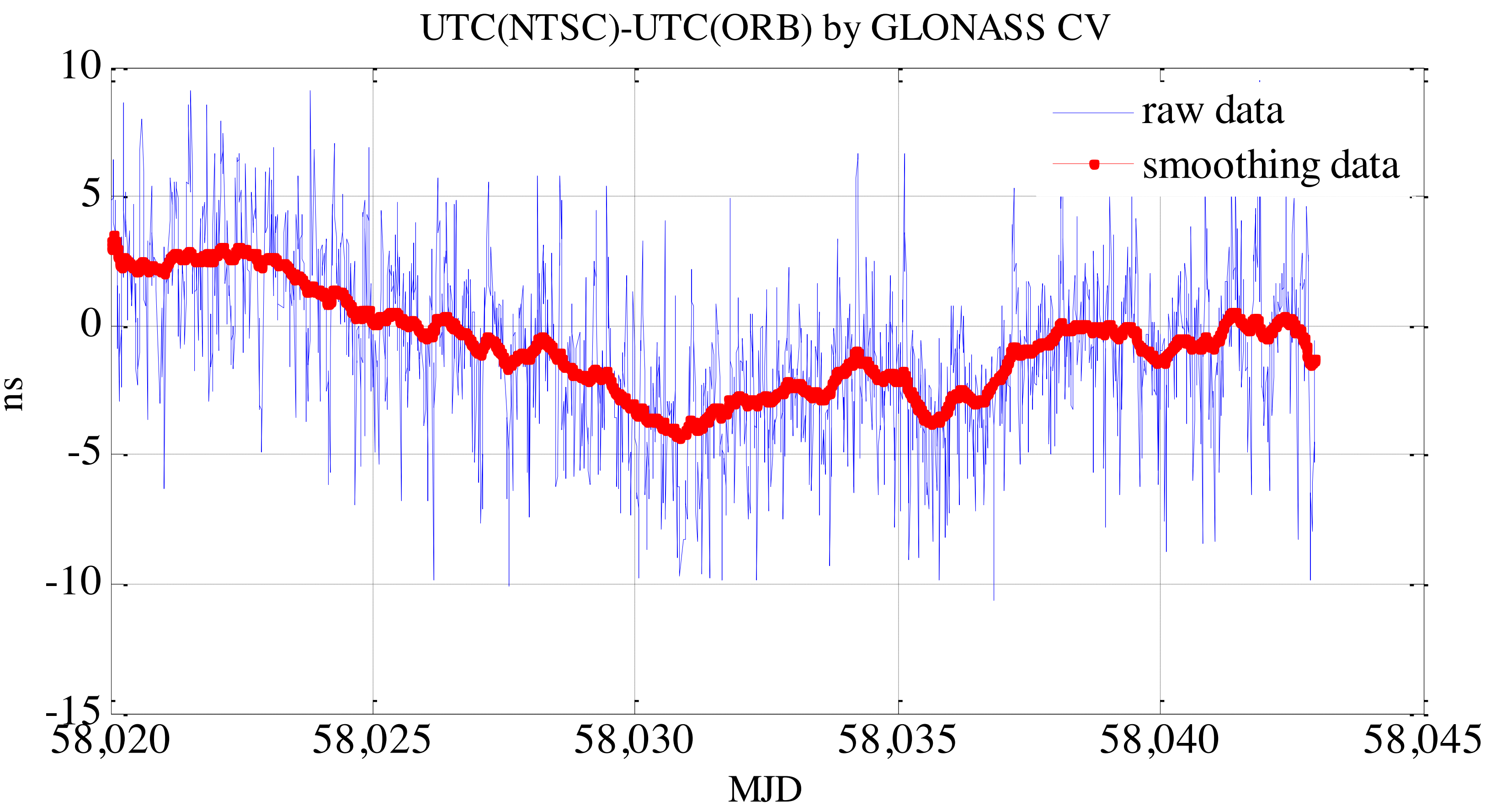


The results of UTC(NTSC)-UTC(ORB) by GPS CV

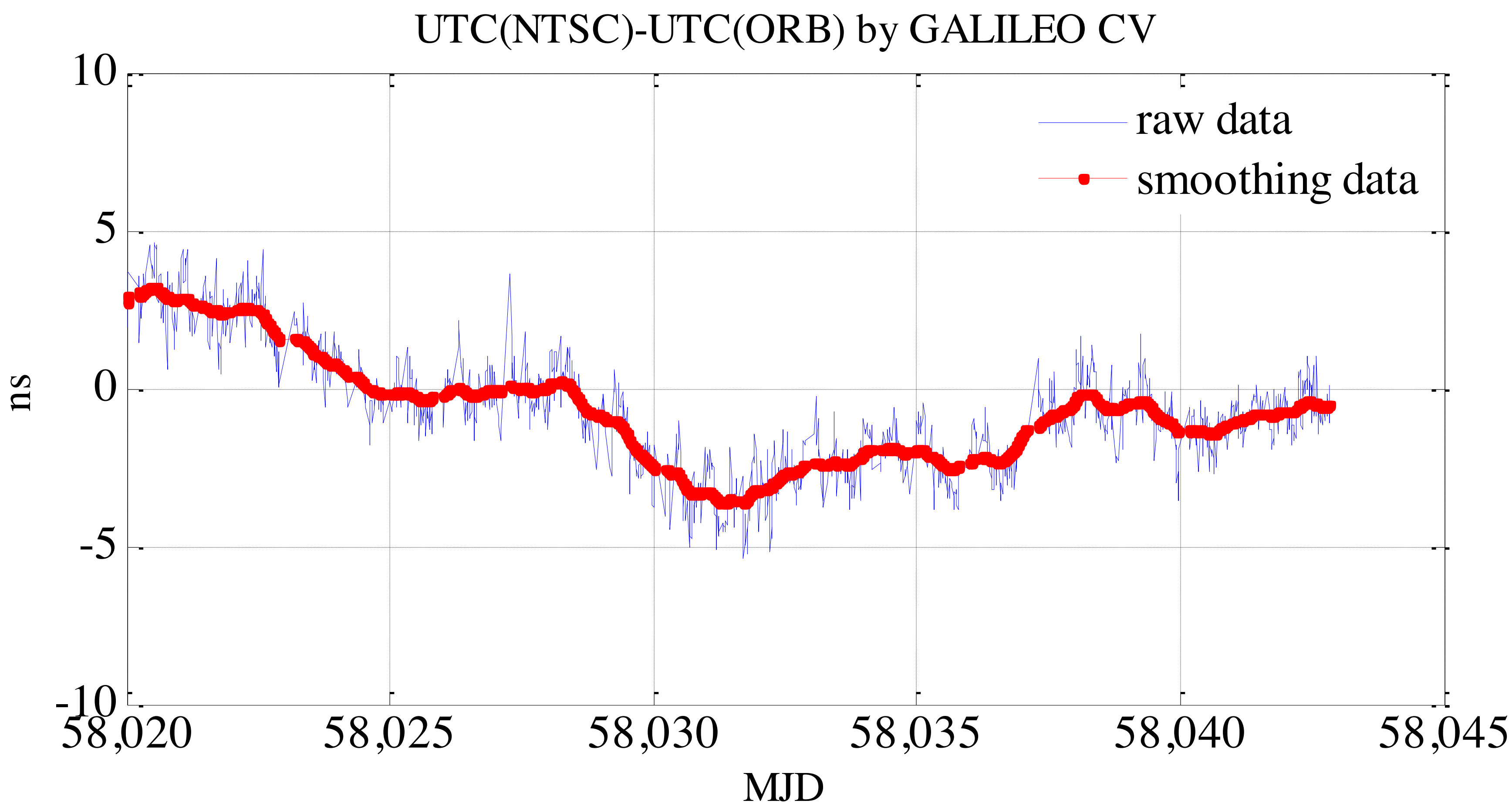
ORB: Observatoire Royal de Belgique, Belgium
NTSC: National Time Service Center of China, P.R.China

3. Results and Analysis (Date:2017.09.24—2017.10.23)



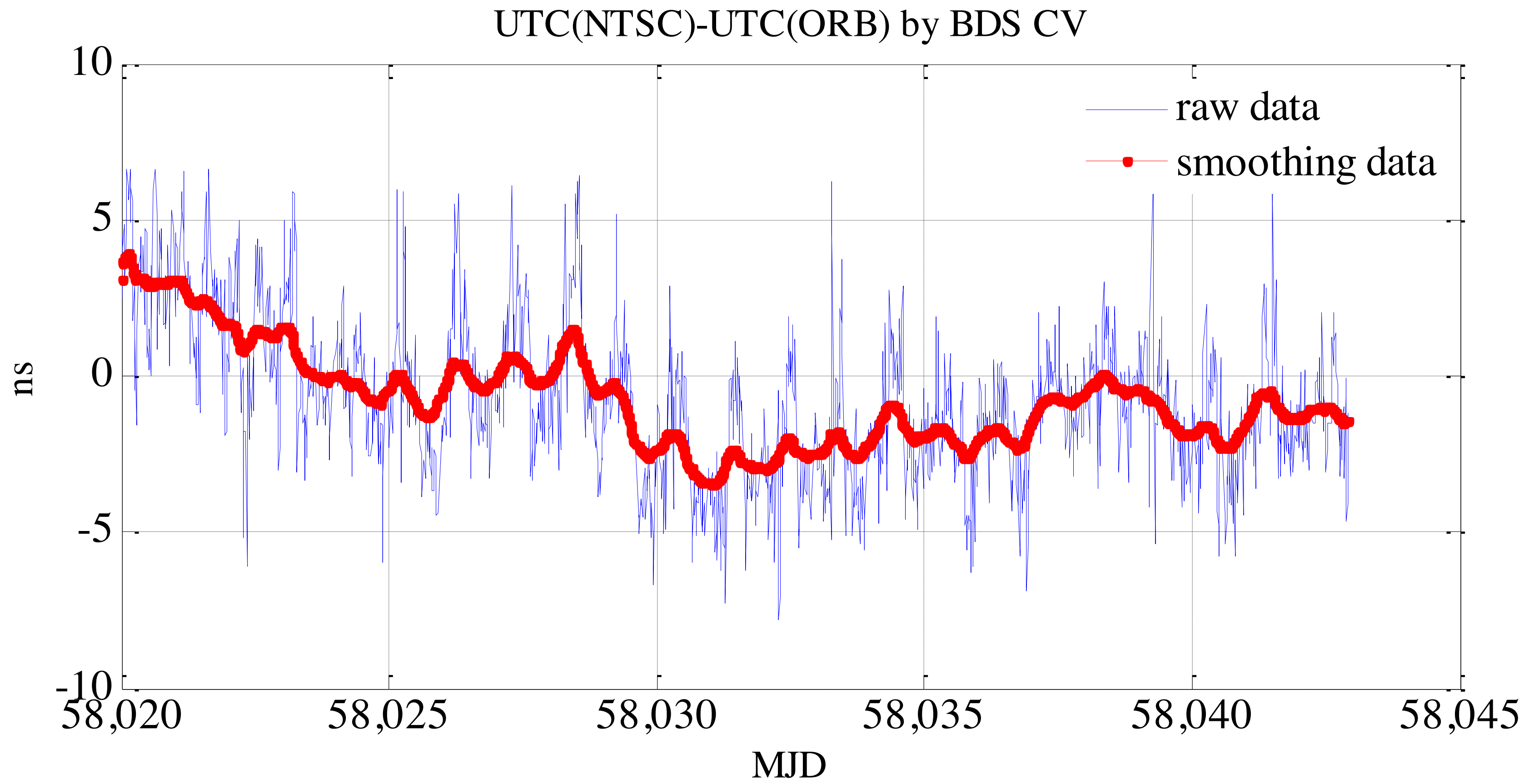
The results of UTC(NTSC)-UTC(ORB) by GLONASS CV

3. Results and Analysis (Date:2017.09.24—2017.10.23)



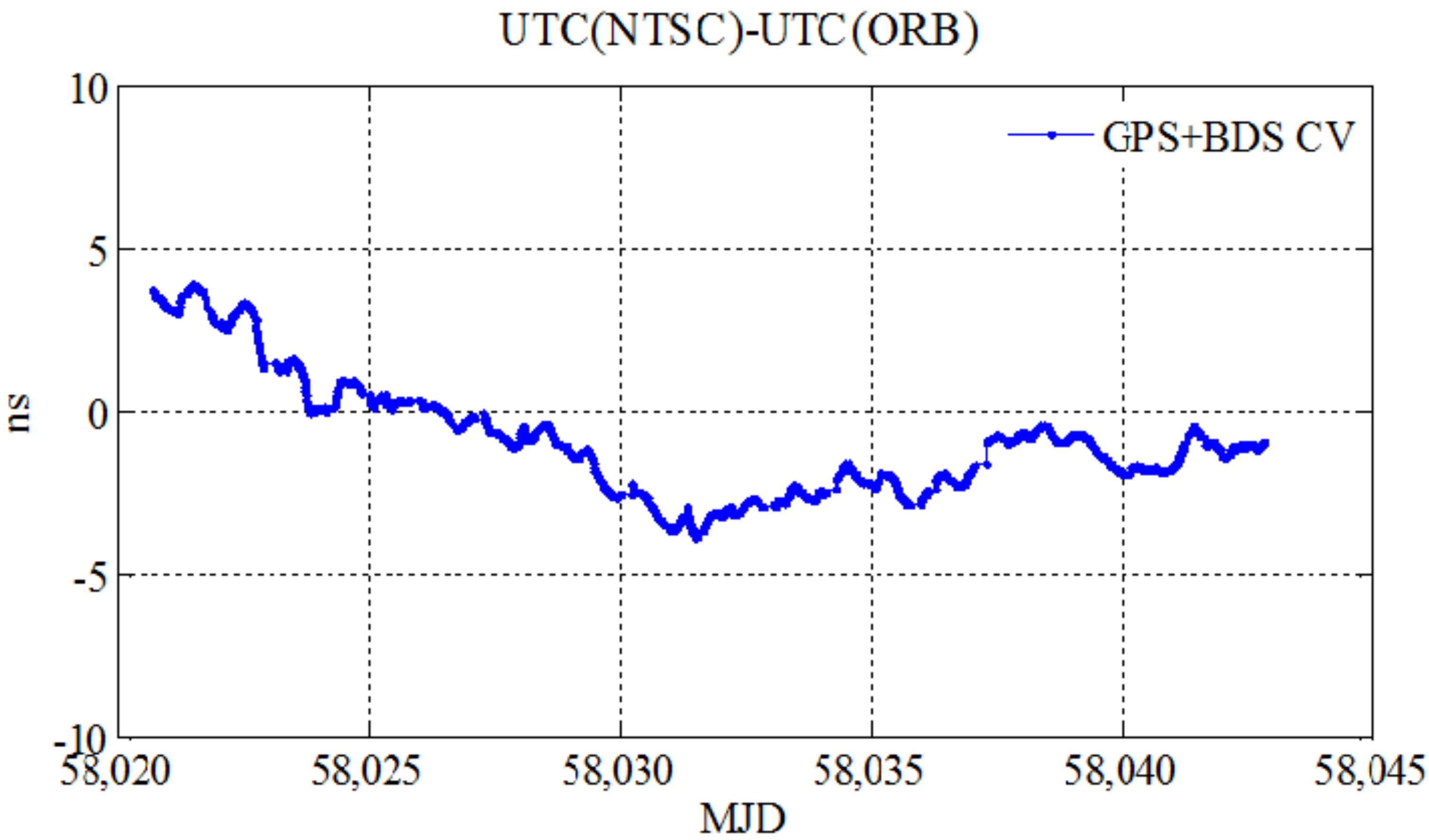
The results of UTC(NTSC)-UTC(ORB) by GALILEO CV

3. Results and Analysis (Date:2017.09.24—2017.10.23)



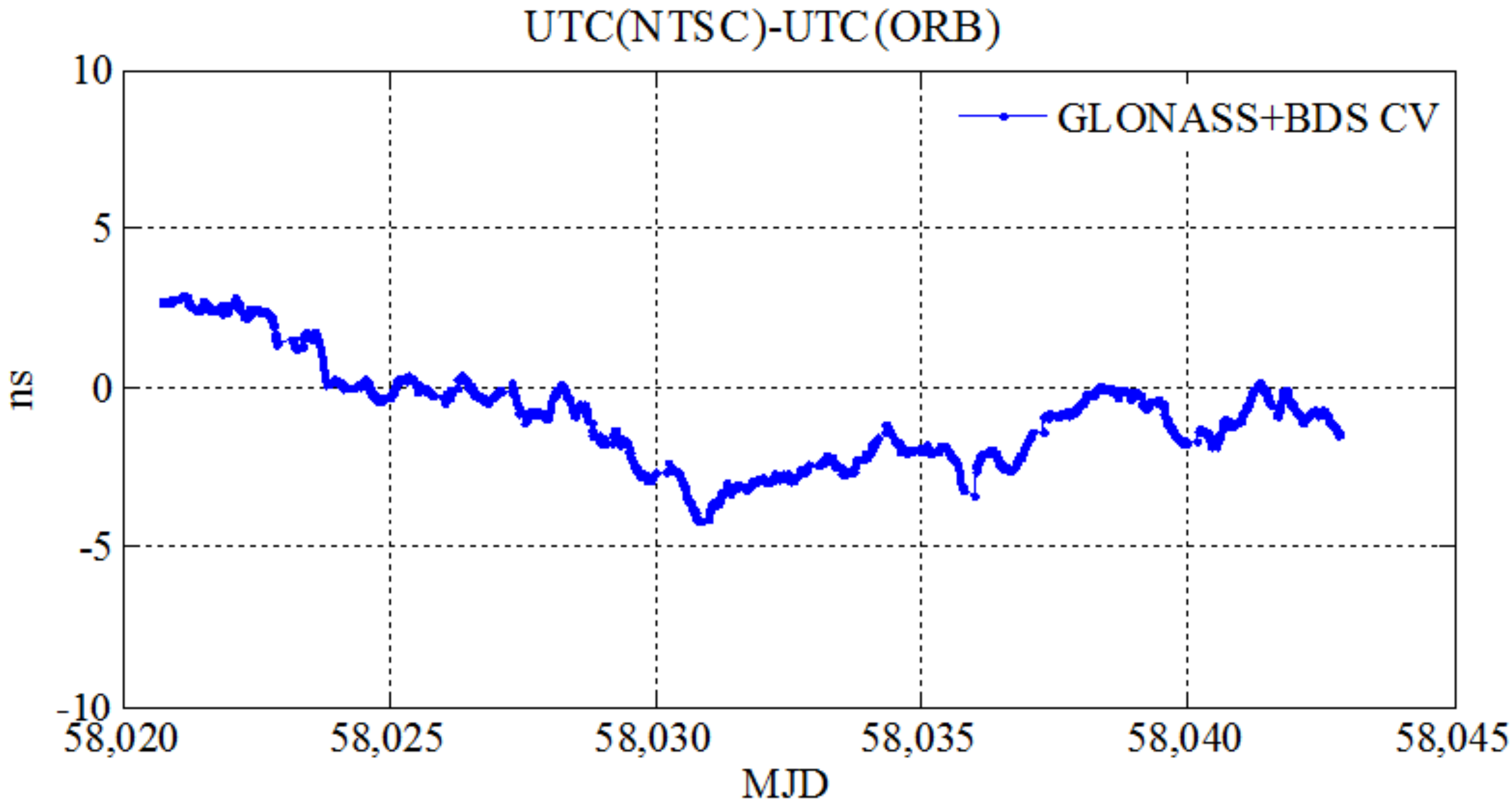
UTC(NTSC)-UTC(ORB)	GPS	GLONASS	GALILEO	BDS
RMS(ns)	1.75	2.15	1.70	2.02

3. Results and Analysis
(Date:2017.09.24—2017.10.23)



The results of UTC(NTSC)-UTC(ORB) by GPS and BDS CV
---Weighted average alogrithm

3. Results and Analysis (Date:2017.09.24—2017.10.23)



The results of UTC(NTSC)-UTC(ORB) by GLONASS and BDS CV
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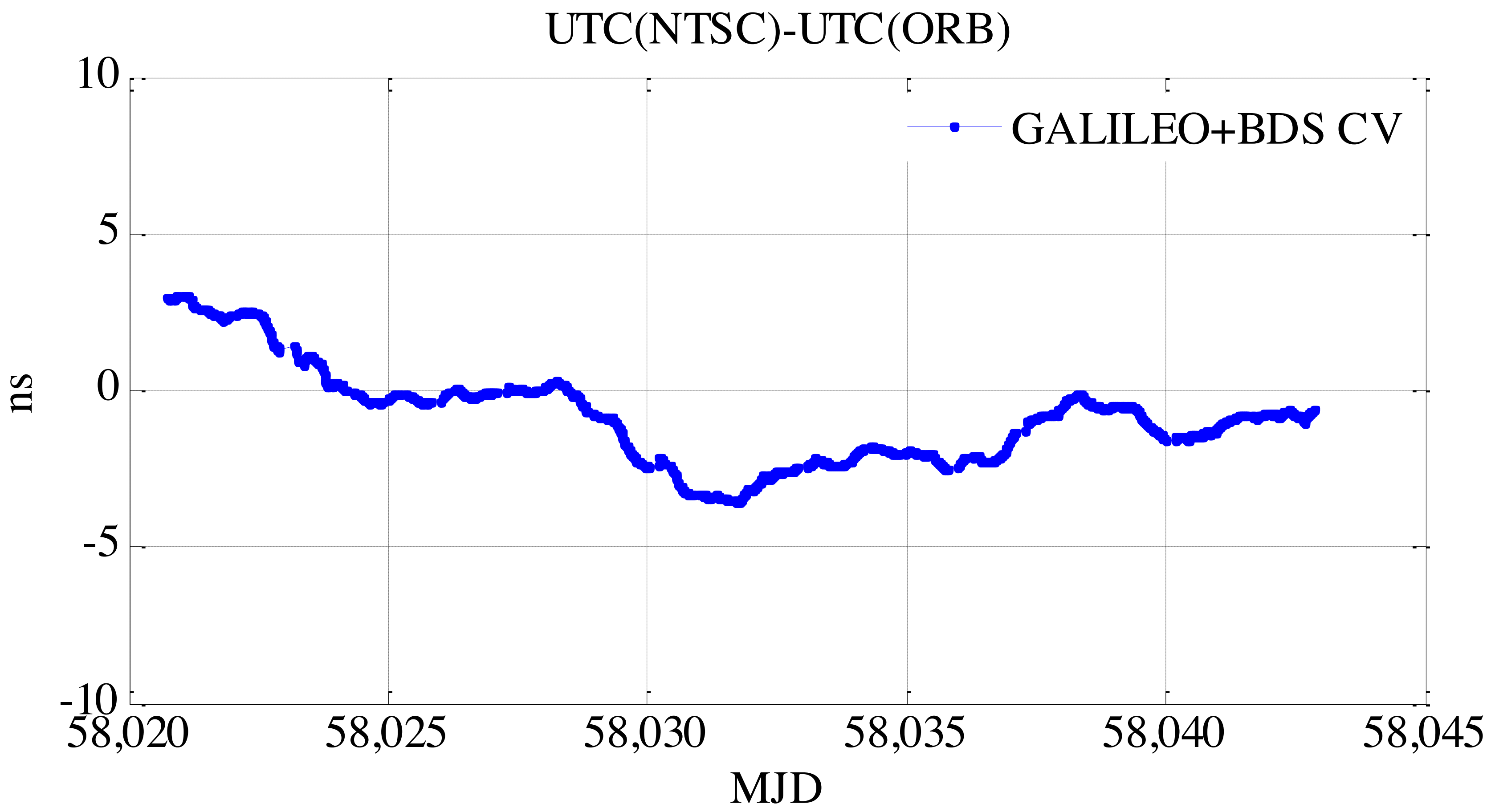

The results of UTC(NTSC)-UTC(ORB) by GALILEO and BDS CV
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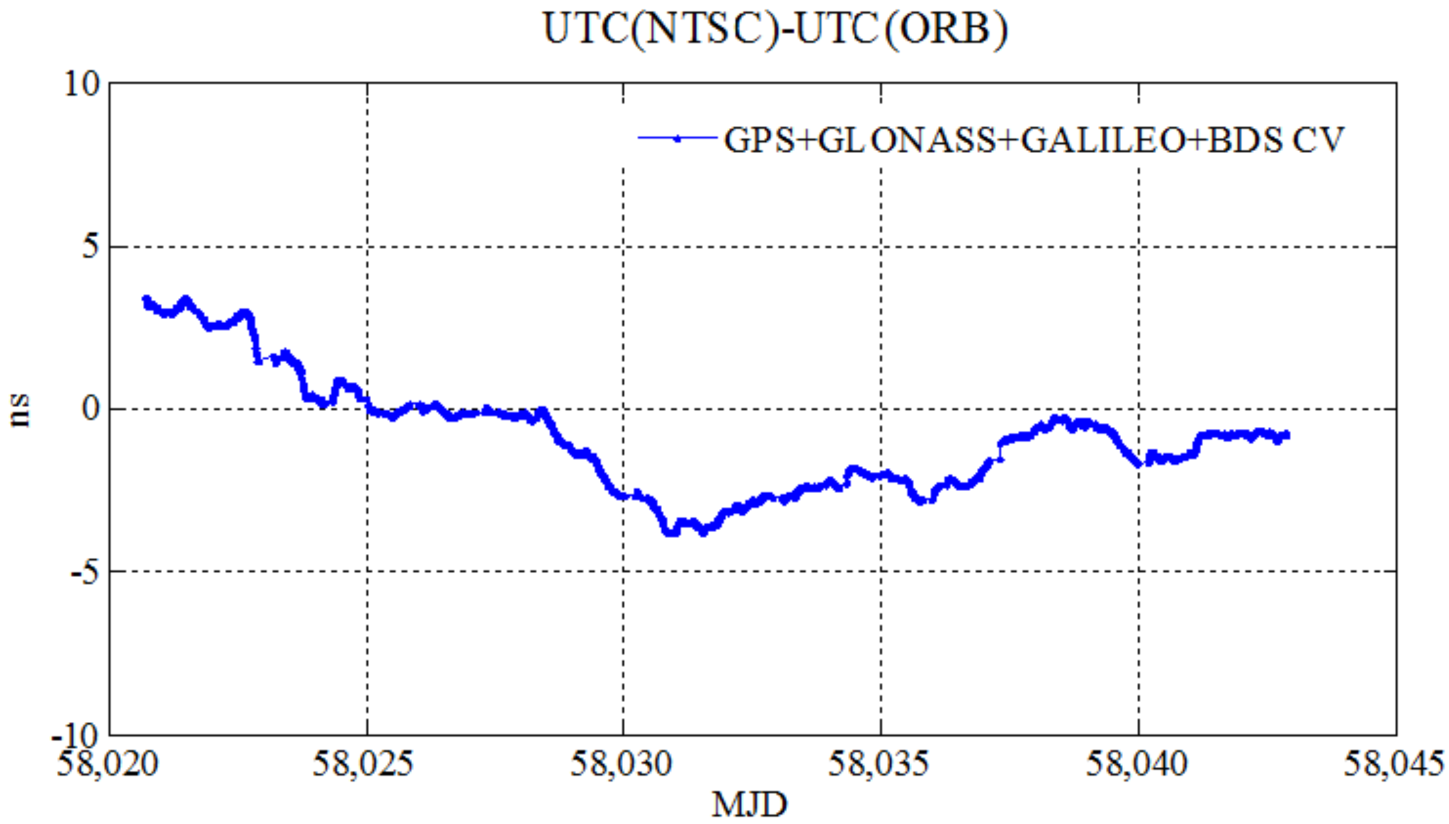
3. Results and Analysis (Date:2017.09.24—2017.10.23)



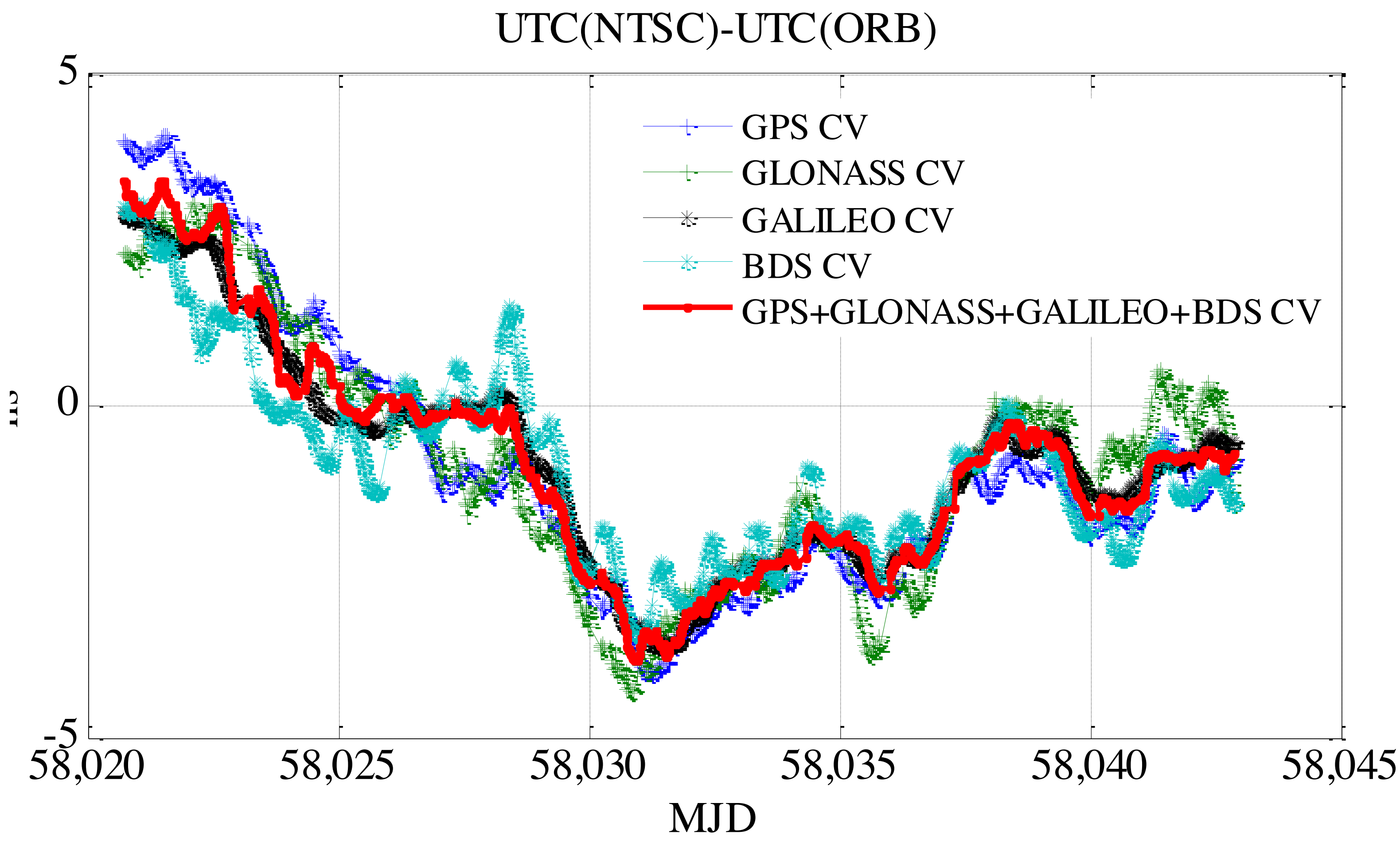
The results of UTC(NTSC)-UTC(ORB) by GPS ,GLONASS ,GALILEO and BDS CV
---Weighted average alogrithm

3. Results and Analysis (Date:2017.09.24—2017.10.23)

NTSC-ORB:

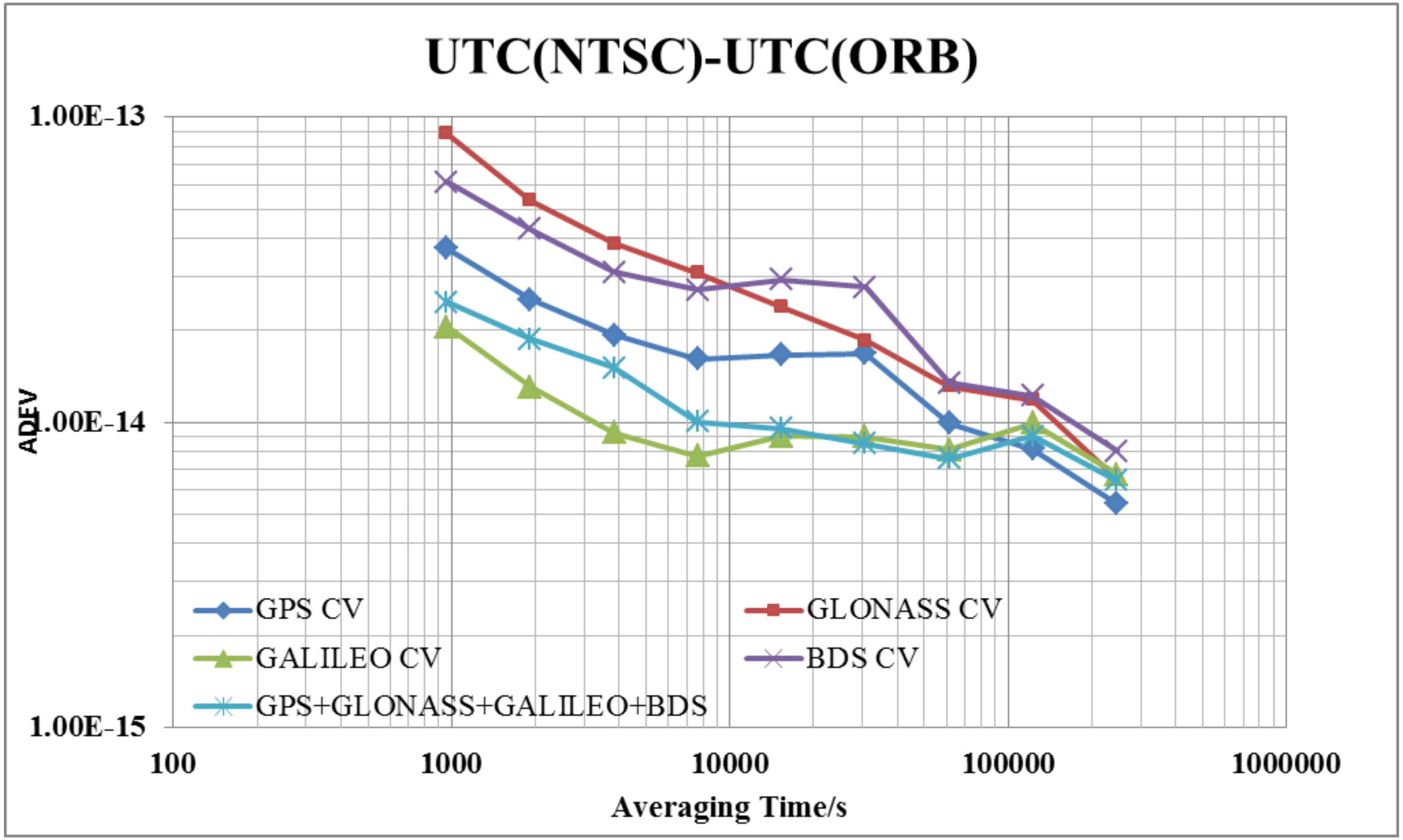
UTC(NTSC)-UTC(ORB)	GPS	GLONASS	GALILEO	BDS
RMS(ns)	1.75	2.15	1.70	2.02
UTC(NTSC)-UTC(ORB)	**GPS+BDS**	**GLONASS+BDS**	**GALILEO+BDS**	**GPS+GLONASS+GALILEO+BDS**
RMS(ns)	1.83	1.95	1.81	1.76

3. Results and Analysis (Date:2017.09.24—2017.10.23)



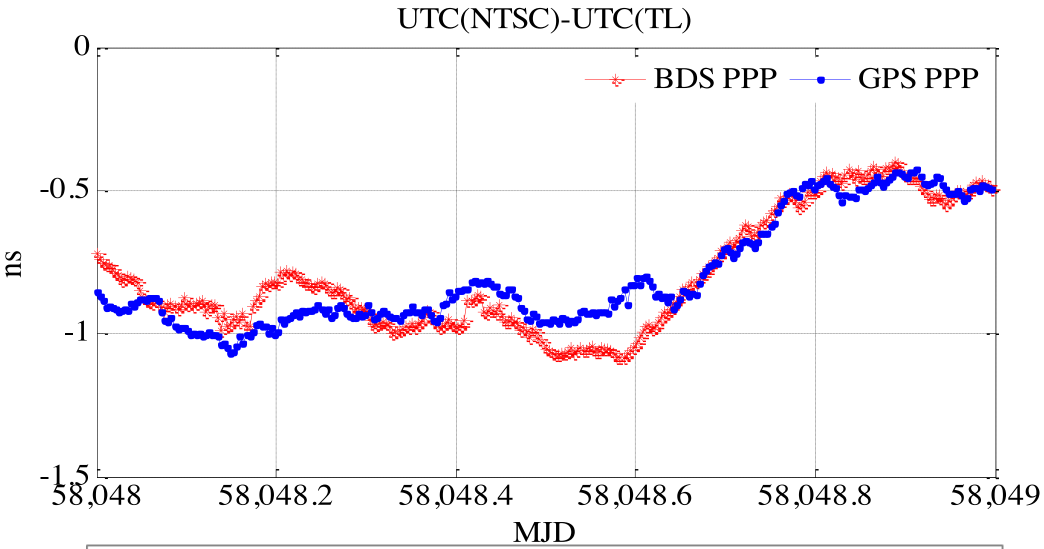
The comparative results by single-mode and multi-mode system

3. Results and Analysis (Date:2017.09.24—2017.10.23)

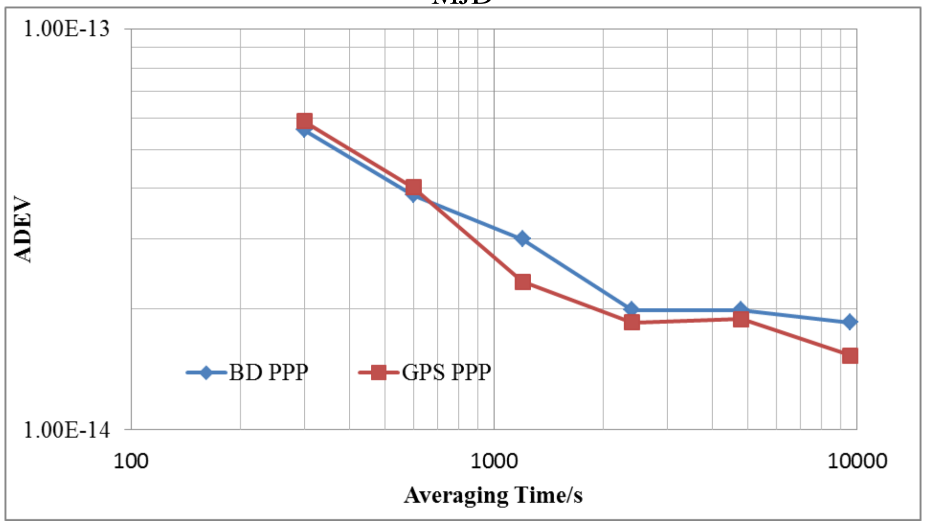


The comparative results by single-mode and multi-mode system

3. Results and Analysis (Date:2017.10.22)



- ✓ NTSC-TL : base line about 1600km
- ✓ The precise satellite orbit and clock products from IGS Multi-GNSS Experiment(MGEX) network, GFZ analysis center.



Tau(s)	BD PPP	GPS PPP
300	5.60E-14	5.89E-14
600	3.85E-14	4.03E-14
1200	2.99E-14	2.34E-14
2400	1.99E-14	1.85E-14
4800	1.99E-14	1.89E-14
9600	1.85E-14	1.53E-14

The comparative results of UTC(NTSC)-UTC(TL) by BDS PPP and GPS PPP

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4. Summary

- All the 4 GNSS systems can be used for high-precision long base line time transfer.

- The GNSS CV results based on multi-mode GNSS system is more reliable. Research on the new weighting algorithm for multi-system time transfer is ongoing.

- From the results of Galileo CV and GPS CV, the performance of satellite clocks is also one of the key factors that affect the accuracy of time transfer. (to be studied).

- BDS is being constructed, the precision of time transfer based on BDS will be improved step by step in the future.

Thank You for Your Attention!