The Stability Analysis of GNSS Satellite DCB

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Outline

- Introduction
- GPS DCB analysis
- GLONASS DCB analysis
- BDS DCB analysis
- GALILEO DCB analysis

1. Introduction

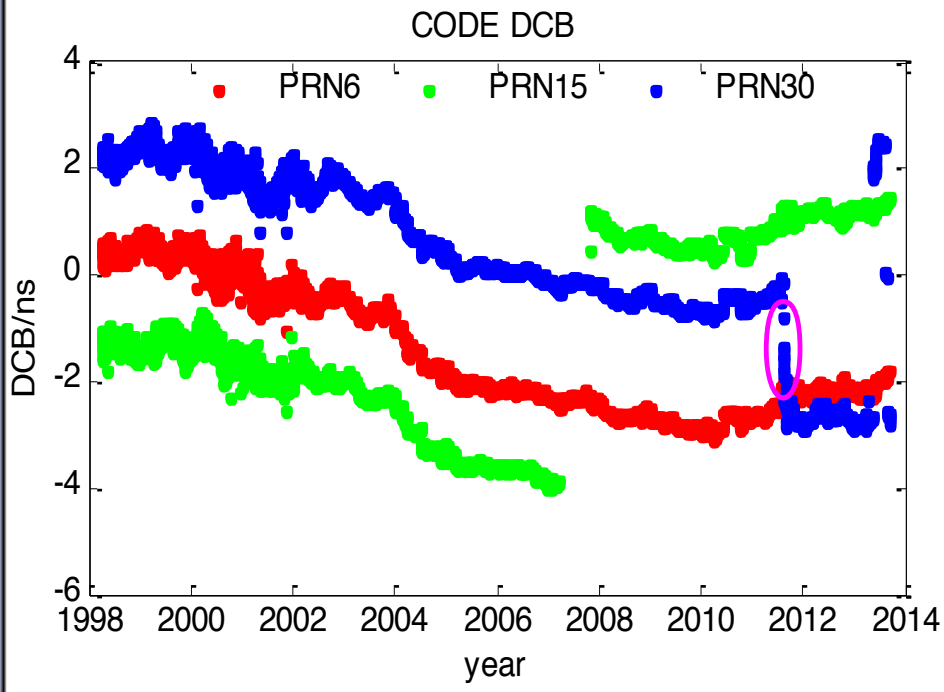
The instrumental differential code bias(DCB) is one of the important parameters for GNSS navigation, positioning and time service, and also the main source error of TEC estimation.

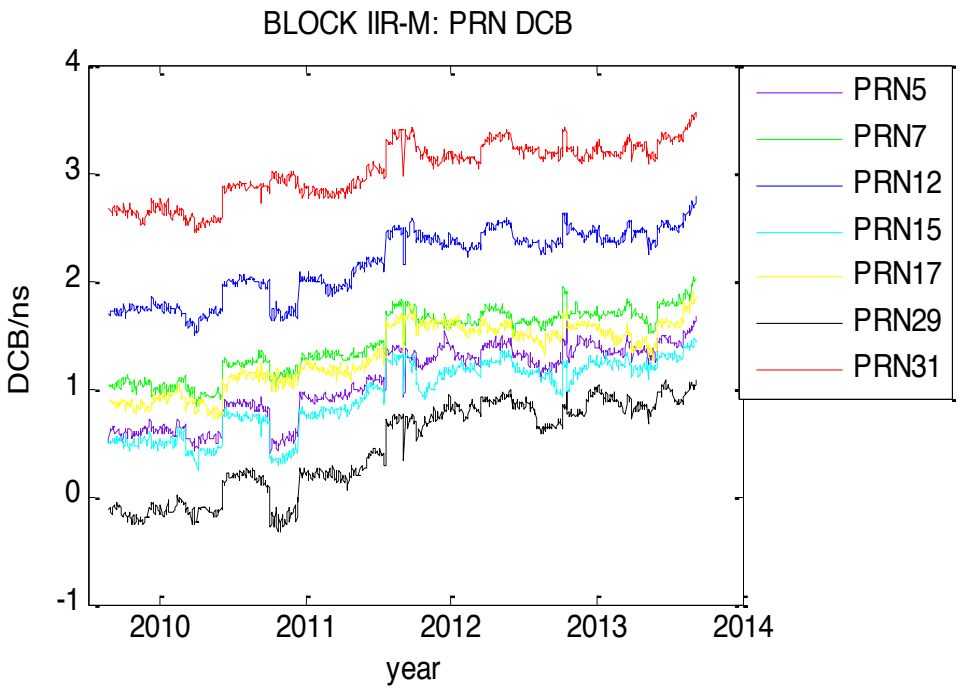
How stable these DCBs are? How often we need to re-estimate their values? How about the Galileo/BDS DCBs? Can we use monthly mean values for BDS/Galileo post-processing as GPS/GLONASS?.....

Here,the DCB series of GNSS main frequency from CODE and **SHAO iGMAS Analysis Center** are analyzed.

2.GPS P1P2 DCB Analysis

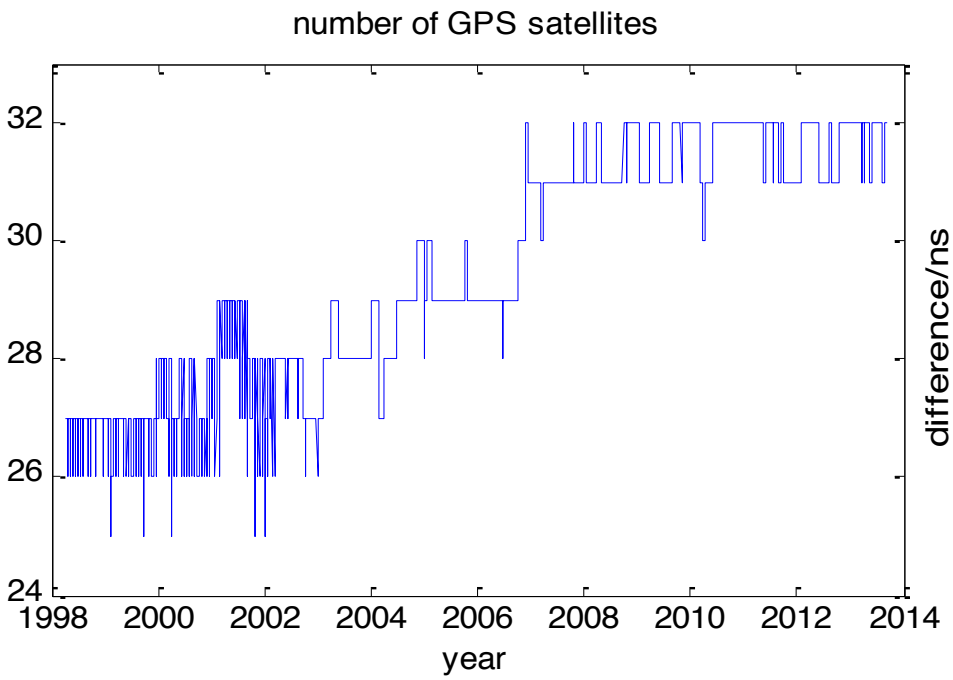
Original daily GPS satellite DCB from 1998 to 2013 from CODE

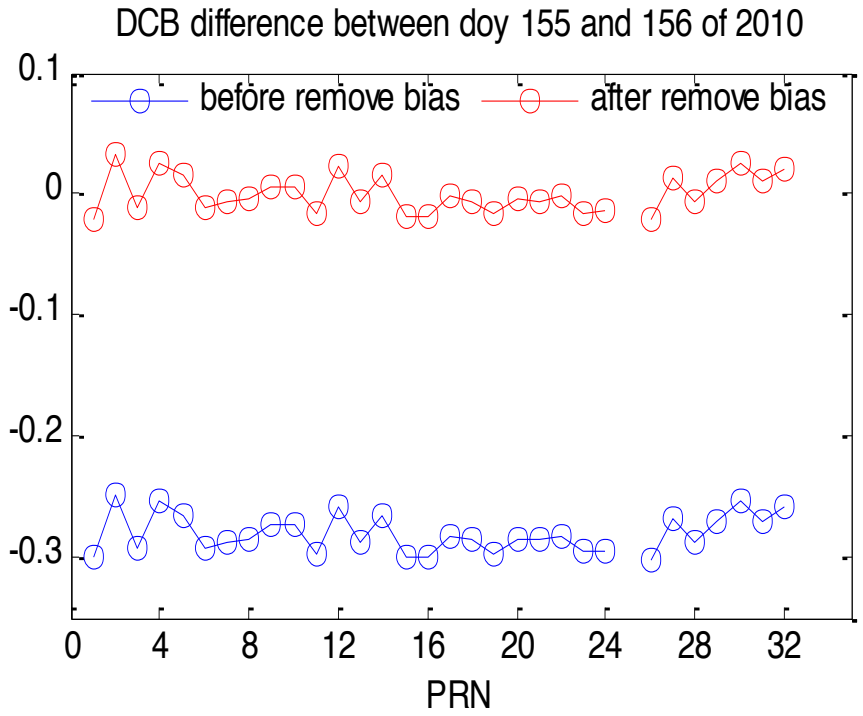




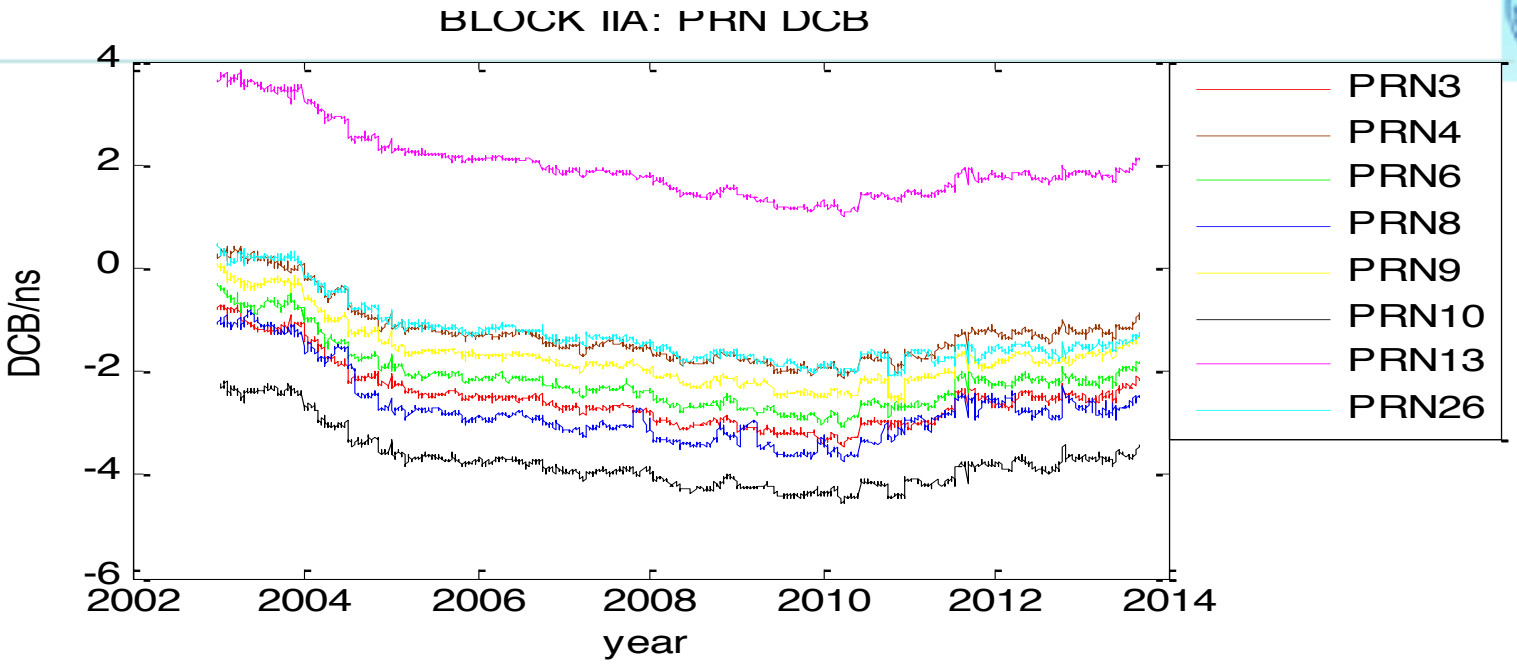
The DCB series are not so smooth with many jumps. What's that?

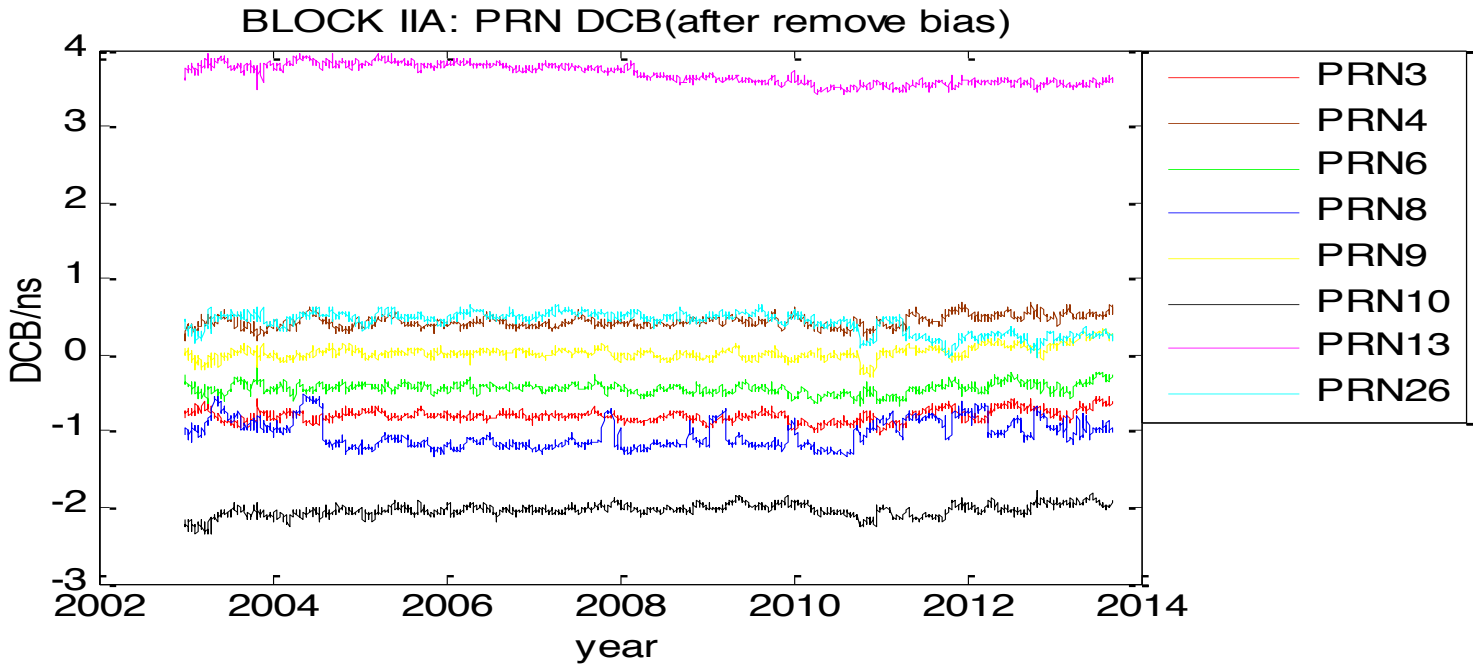
Why the variations are large before 2002?



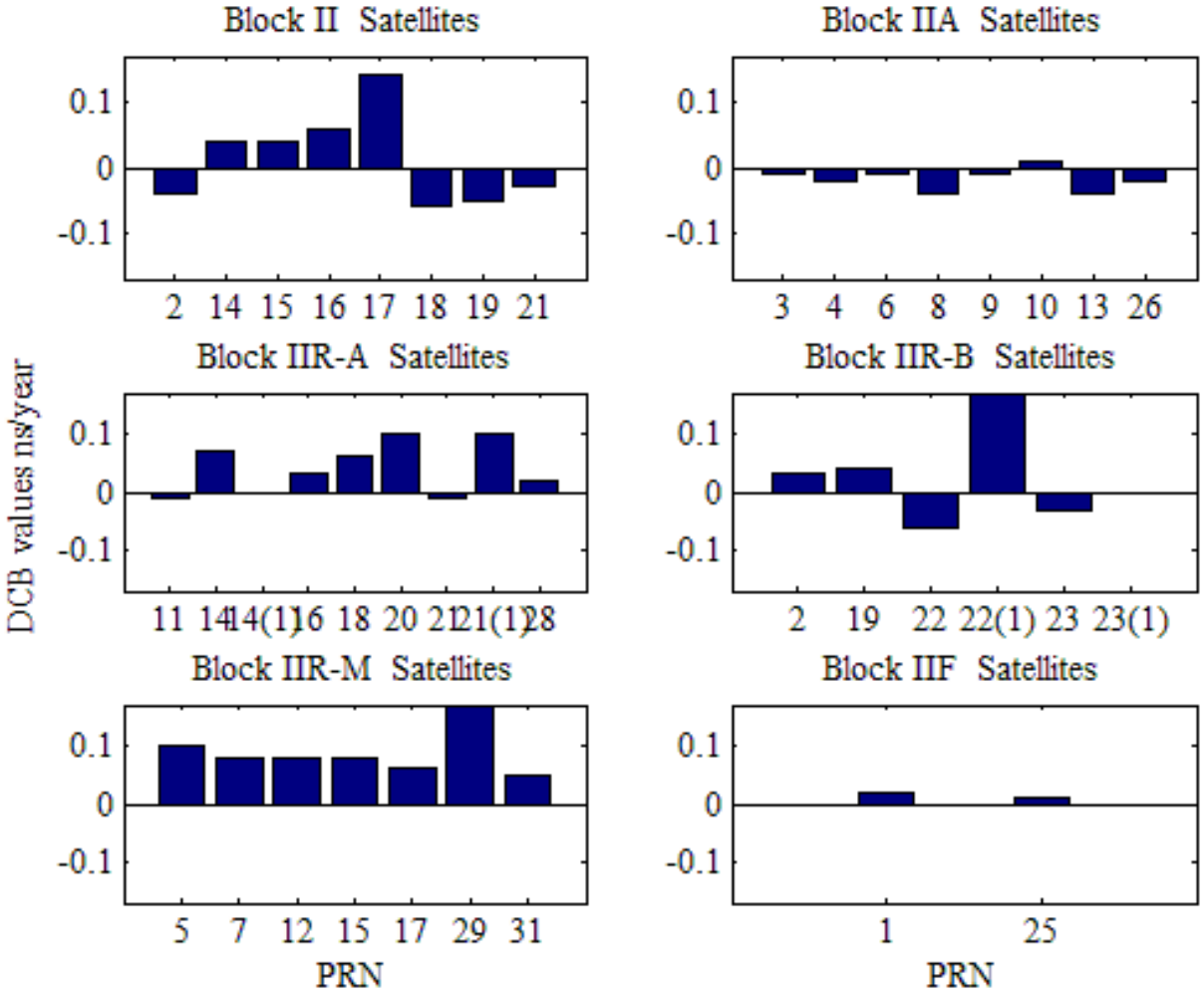


The GPS satellite numbers in ION/DCB calculation change at all times. There're artificial biases in DCB series due to the variation of satellite number.So,the biases have to be removed before the stability analysis.


BLOCK IIA: PRN DCB
DCB/ns
year
PRN3
PRN4
PRN6
PRN8
PRN9
PRN10
PRN13
PRN26

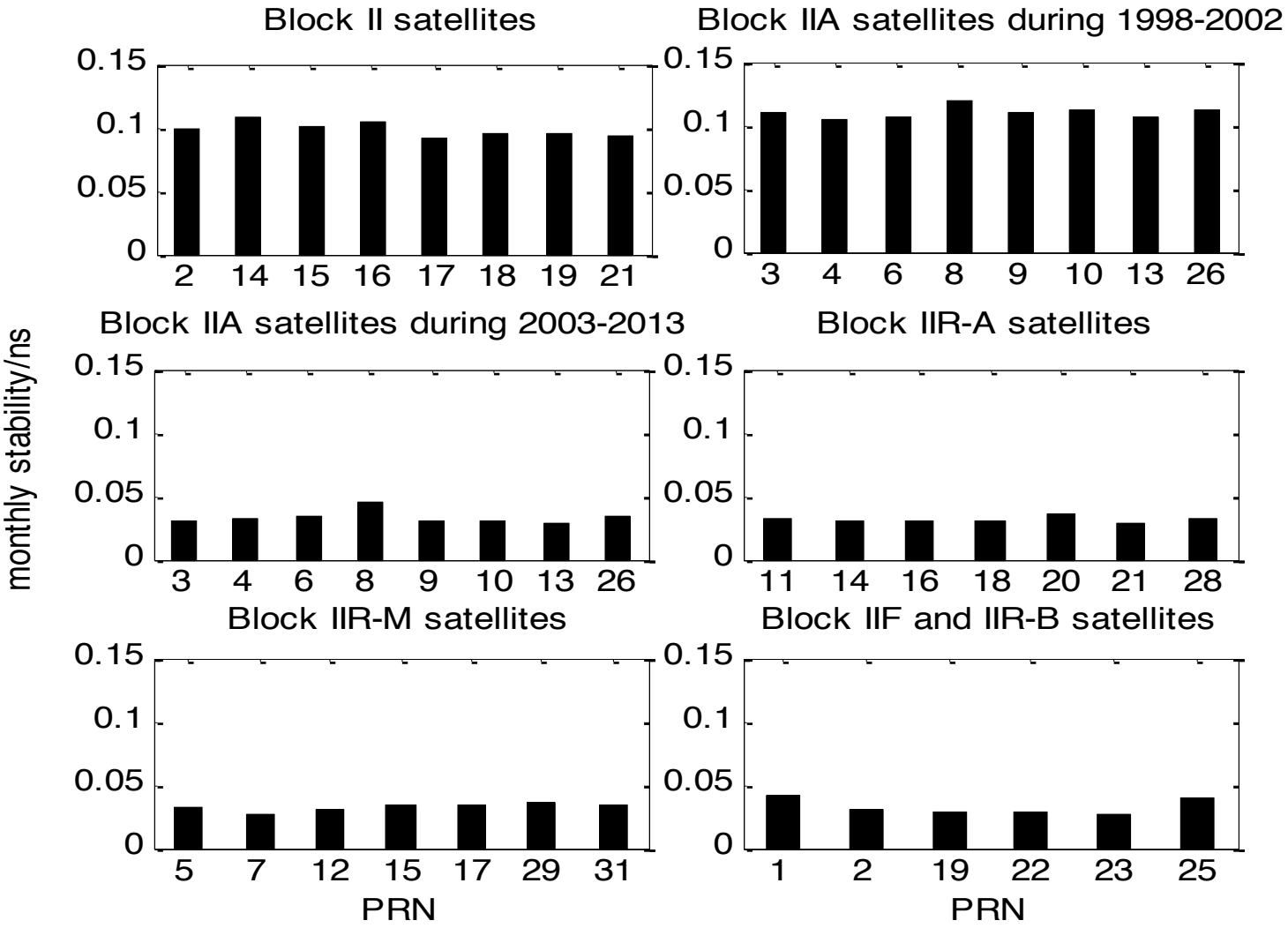

BLOCK IIA: PRN DCB(after remove bias)
DCB/ns
year
PRN3
PRN4
PRN6
PRN8
PRN9
PRN10
PRN13
PRN26

Long-term Stability of GPS P1P2 DCB



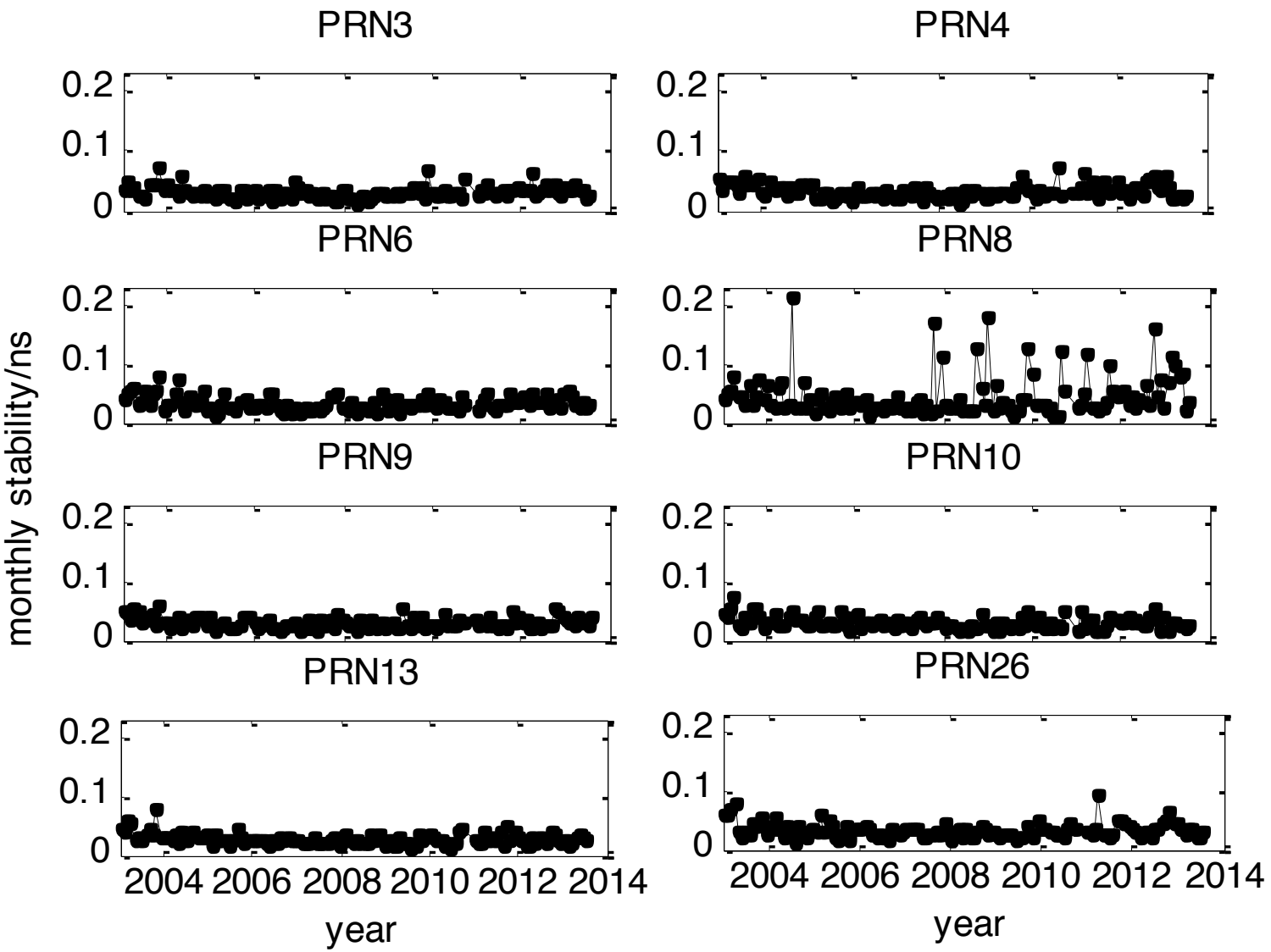
Linear trends of all GPS satellites during 2002-2013. Most GPS DCB long-term trend are less than 100ps.Block IIF and Block IIA DCBs are more stable .

Mean monthly stability of GPS satellite DCBs

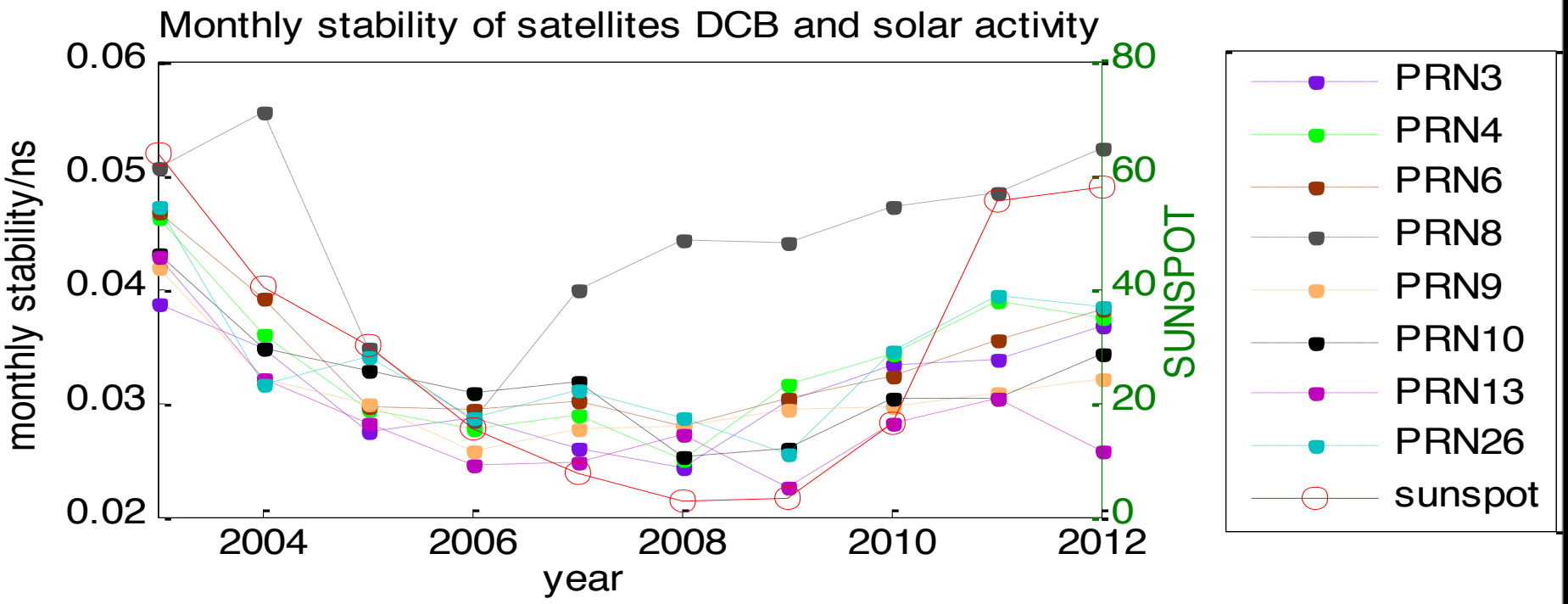


Block II and Block IIA(before 2002) with mean monthly stability about 100ps,Block IIA(after 2002) and other Blocks with less than 50ps.

Monthly variations of Block IIA satellite DCBs

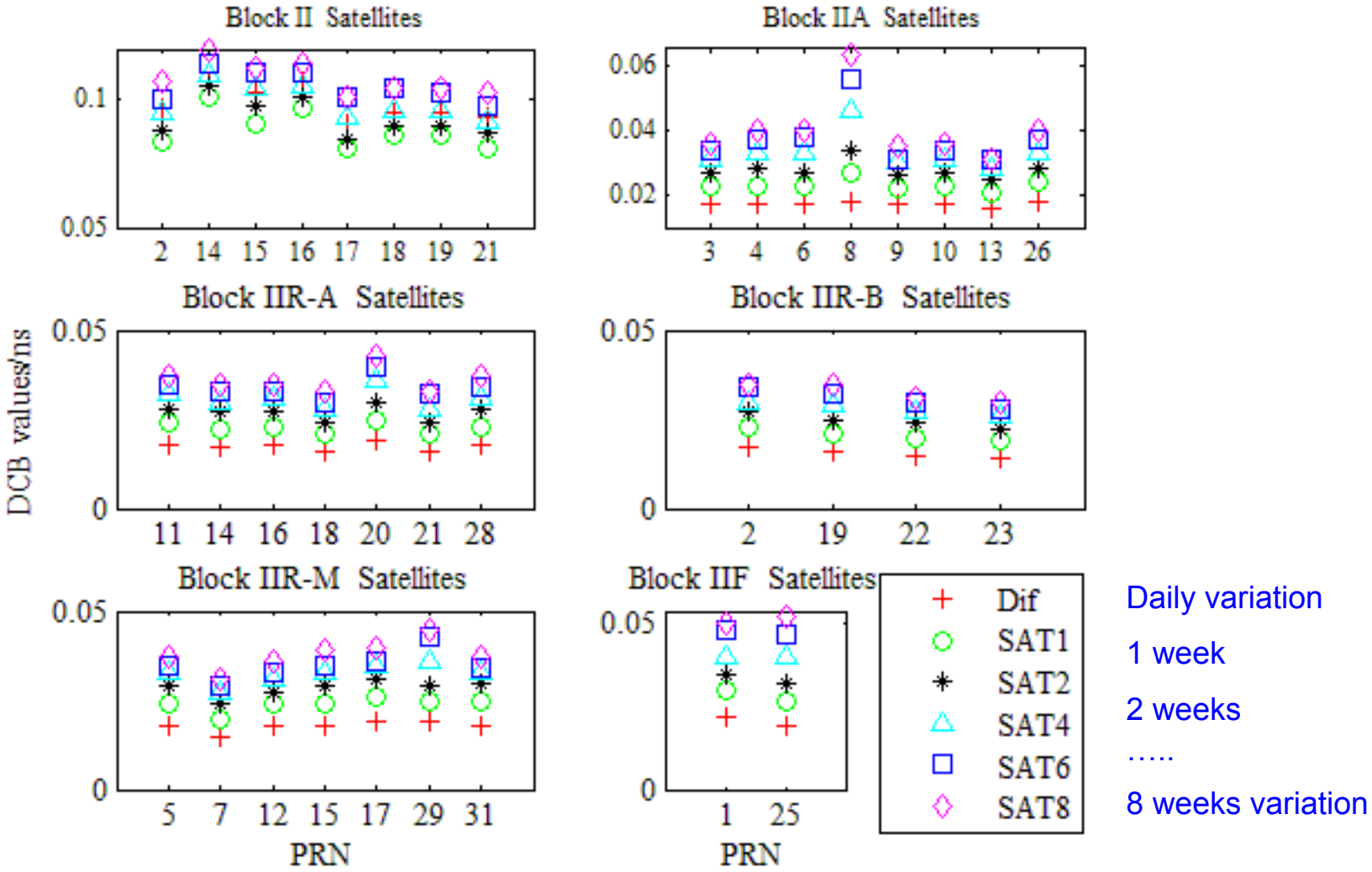


Most are less than 100 ps.



Variation of annual average of monthly stability of Block IIA satellite DCBs with yearly sunspot, though the amplitude is not two large.

Short-term stability of GPS P1P2 DCB



Daily variation

1 week

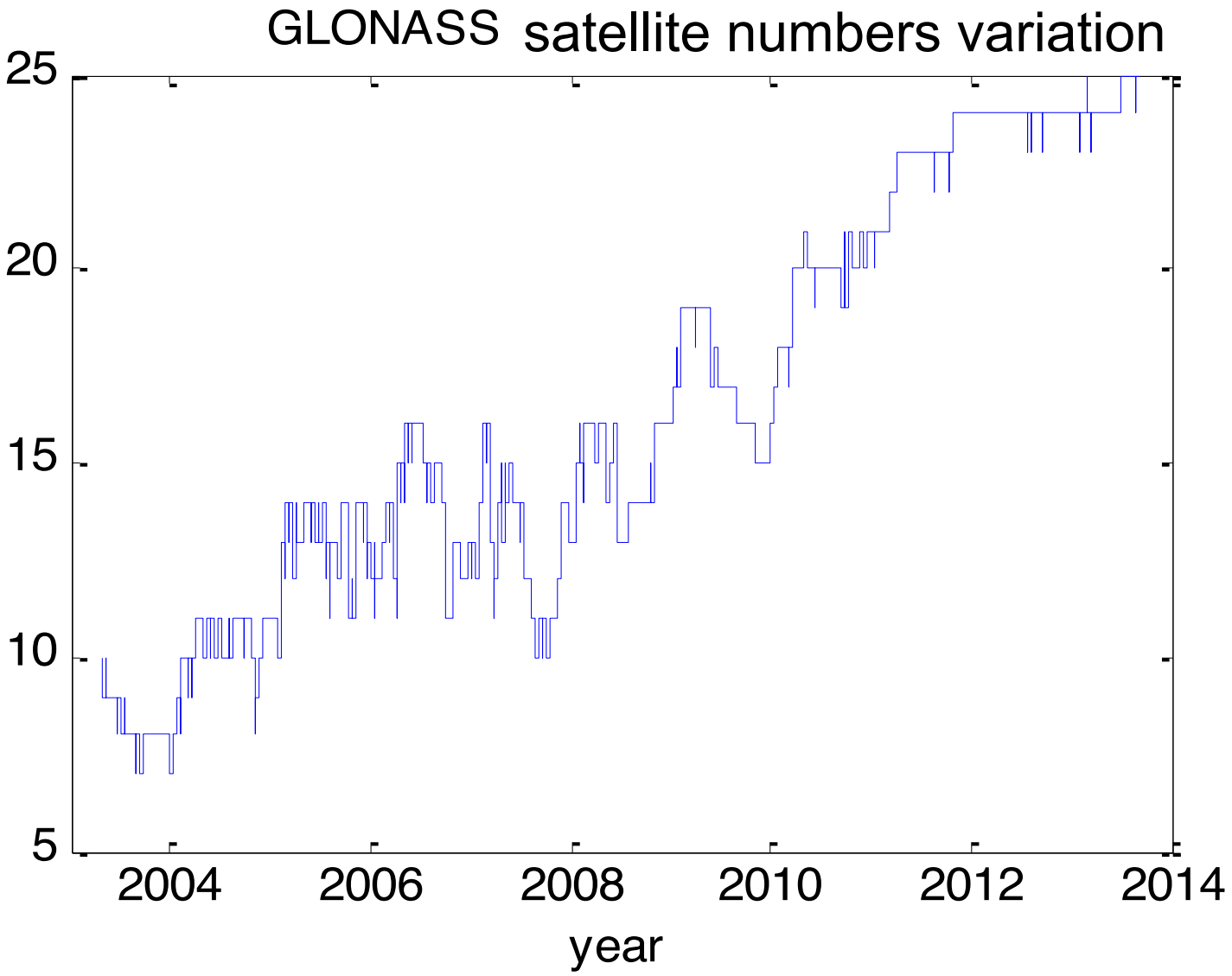
2 weeks

.....

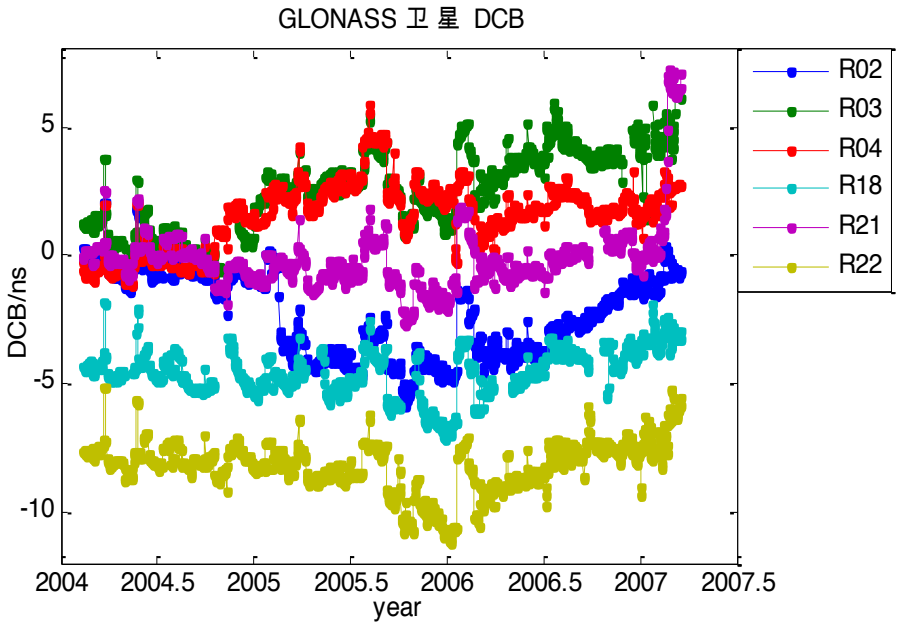
8 weeks variation

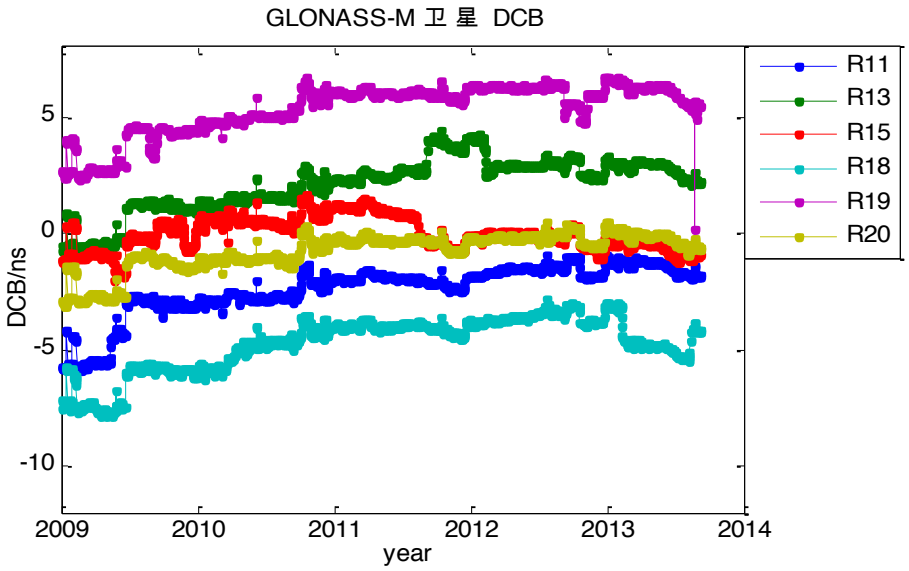
Dif between 4weeks and week : no difference for Block II, but large than other Blocks.Others: changed in 8~21ps with the statistic interval expand

3.GLONASS DCB Analysis

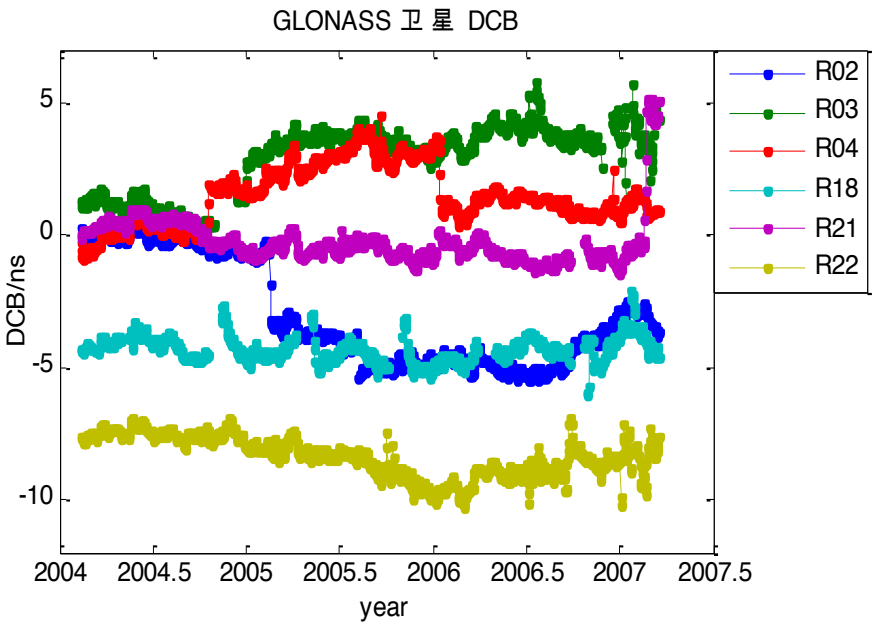


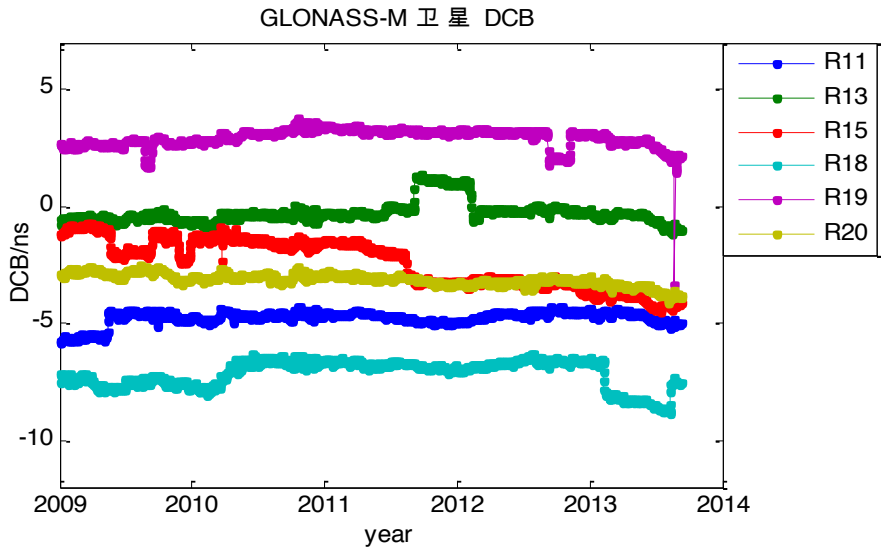
Before bias remove



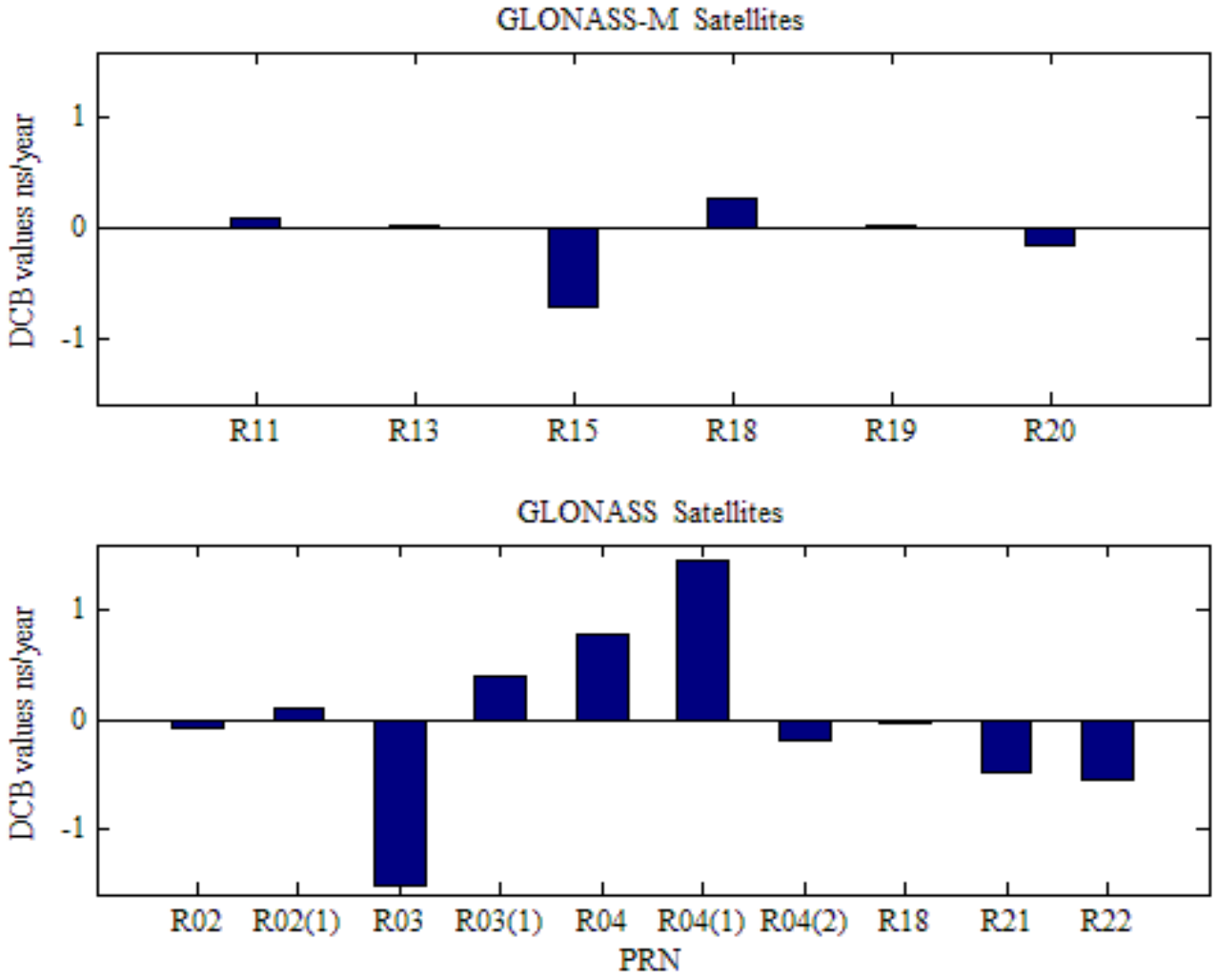


After bias remove



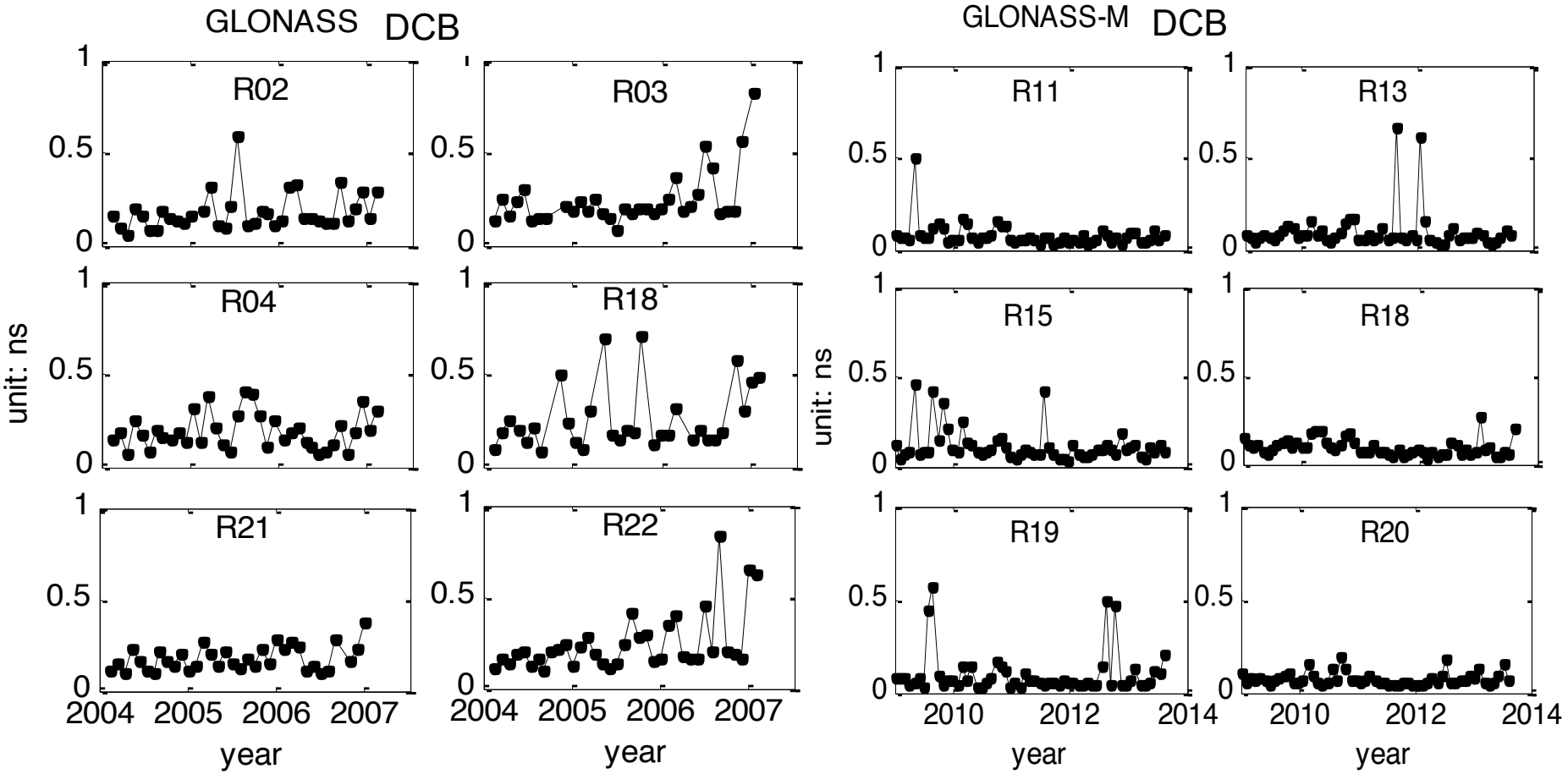


Long-term Stability of GLONASS P1P2 DCB



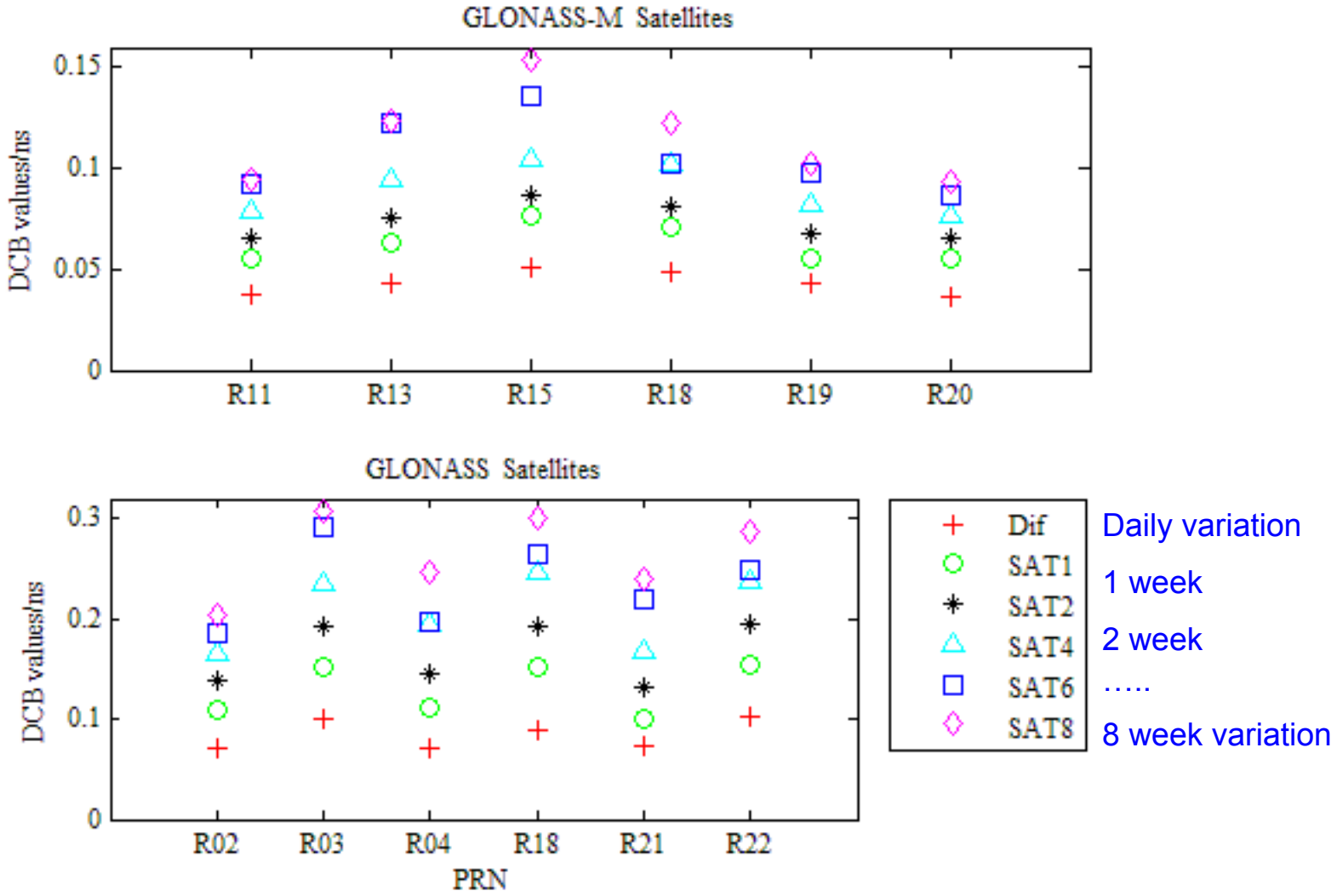
Some Glonass satellites have a little large long-term trend. Most Glonass-M are better than Glonass satellites.

Monthly variations of GLONASS satellite DCBs



Most are less than 200 ps.

Short-term stability of GLONASS P1P2 DCB

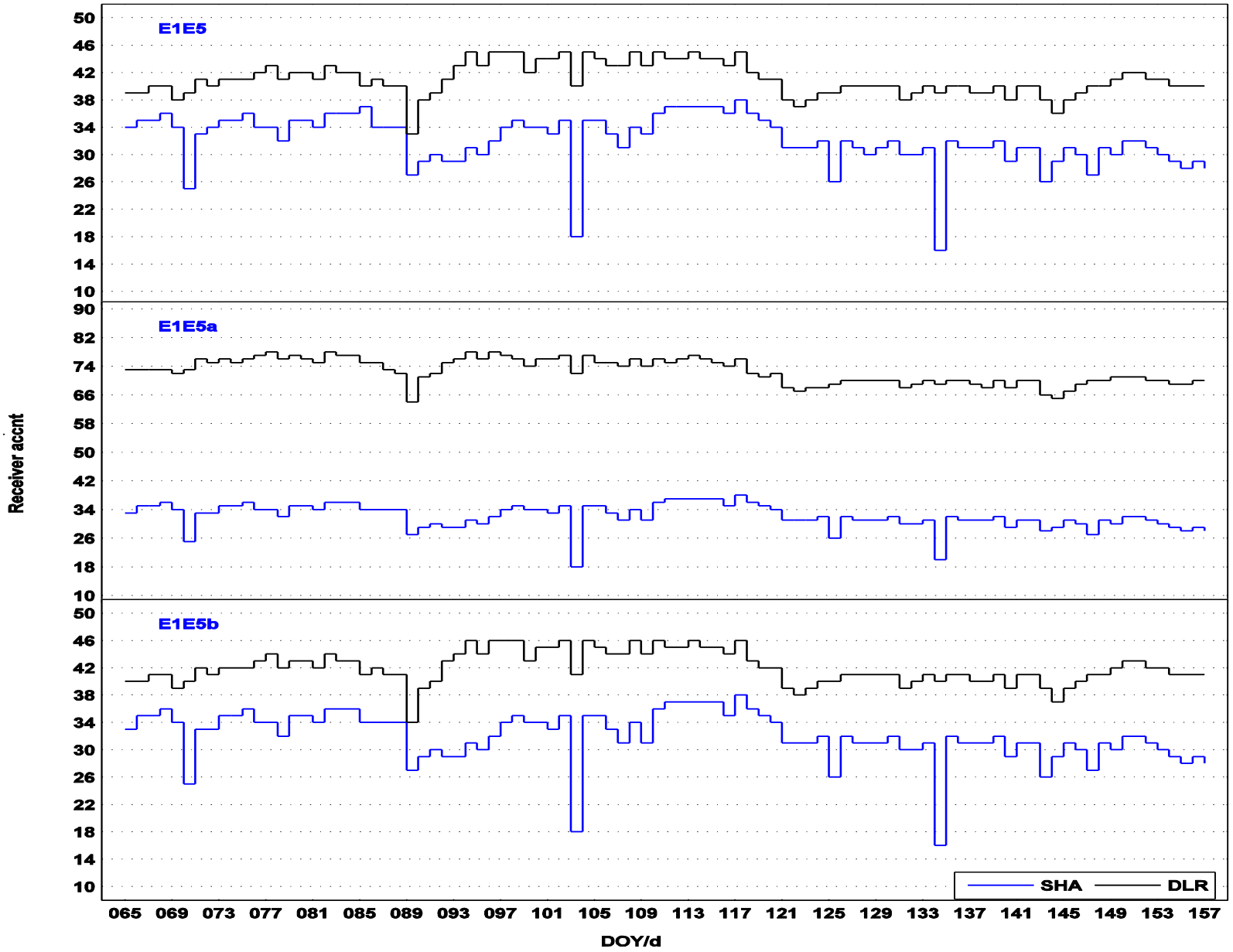


Dif between 4weeks and week: GLONASS 90-160ps,GLONASS-M 40~60ps

4. Galileo DCB Analysis

GAL E1-E5a DCBs for GPS/Galileo/BDS combined estimation mode determined as compared to DLR

The number of receivers involved in the estimation of GAL DCBs



Long-term Stability of Galileo DCB

DCB	E11	E12	E19
E1-E5	0.14	0.11	0.14
E1-E5a	0.17	0.13	0.16
E1-E5b	0.16	0.12	0.15

Standard deviations for GALILEO satellite differential code biases for the entire time series (units: ns)

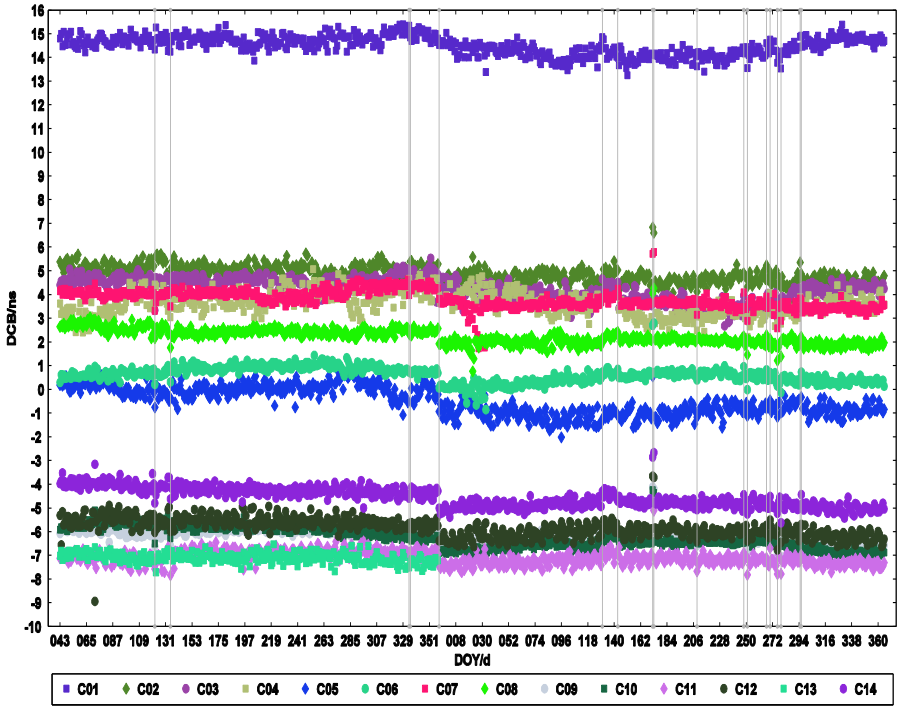
Short-term stability of Galileo DCB

Time ranged stability statistics (E1-E5, E1-E5a, and E1-E5b) differential code biases (unit: ns)

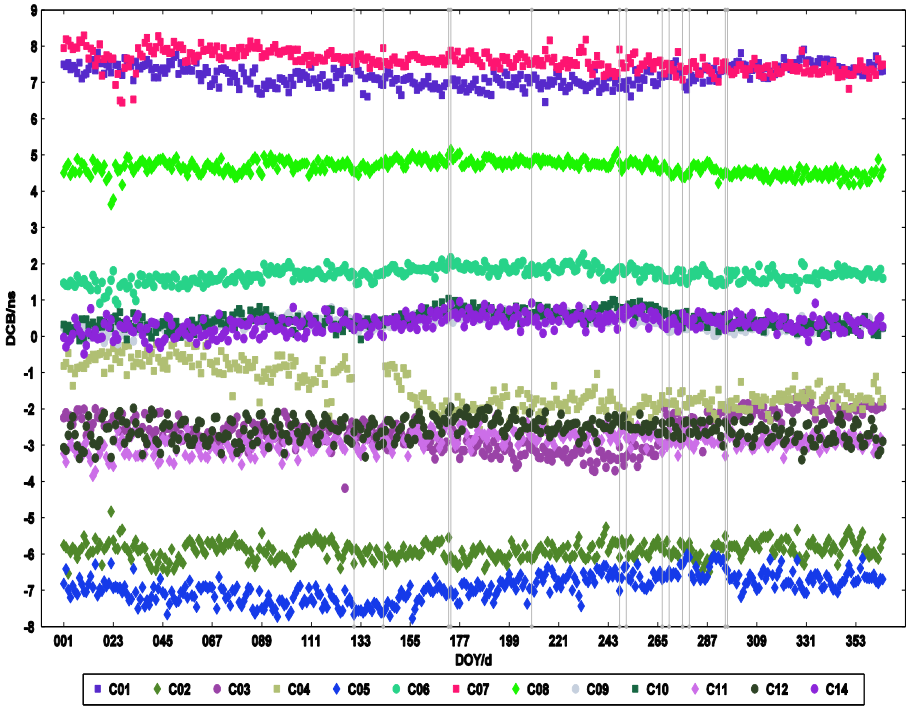
PRN	DCB	7d	14d	21d	28d	35d	42d
E11	E1-E5	0.13	0.13	0.13	0.13	0.15	0.13
	E1-E5a	0.16	0.16	0.16	0.16	0.18	0.16
	E1-E5b	0.15	0.15	0.15	0.15	0.17	0.15
E12	E1-E5	0.11	0.11	0.11	0.11	0.12	0.11
	E1-E5a	0.12	0.12	0.12	0.12	0.13	0.12
	E1-E5b	0.11	0.11	0.11	0.11	0.12	0.11
E19	E1-E5	0.13	0.13	0.13	0.14	0.15	0.13
	E1-E5a	0.14	0.15	0.15	0.15	0.16	0.15
	E1-E5b	0.14	0.14	0.14	0.14	0.16	0.14

Comparison of the STDs for the 4weeks and week interval shows that the maximal difference does not exceed 10ps for all satellite DCBs. This indicates it is practical to provide post users with monthly-averaged GAL satellite DCBs.

5. BDS DCB Analysis



(a) B1B2 DCBs (2014)



(b) B1B3 DCBs (2014)

Beidou satellite (DCBs) calculated together with ION GIM from GPS/BDS observations in SHAO iGMAS Analysis Center with about 40 BDS tracking stations.

Long-term Stability of BDS B1B2 DCB

Standard deviations for Beidou DCbs (units: ns)

TYP	GEO					IGSO					MEO			
PRN	C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11	C12	C13	C14
B1-B2	0.22	0.23	0.24	0.31	0.25	0.13	0.15	0.12	0.11	0.12	0.17	0.22	0.20	0.16
B1-B3	**0.23**	**0.21**	**0.33**	**0.36**	**0.24**	**0.15**	**0.18**	**0.15**	**0.14**	**0.17**	**0.22**	**0.28**	-	**0.20**

IGSO with the best stability, most less than 150ps ,GEO is the worst.B1B3 is a little big than B1B2.

Short-term stability of BDS B1B2 DCB

	PRN	7d	14d	21d	28d	35d	42d
GEO	C01	0.20	0.21	0.22	0.22	0.24	0.23
	C02	0.21	0.22	0.23	0.24	0.24	0.24
	C03	0.20	0.21	0.22	0.22	0.22	0.23
	C04	0.27	0.30	0.31	0.32	0.35	0.33
	C05	0.23	0.24	0.25	0.27	0.26	0.26
IGSO	**C06**	**0.13**	**0.14**	**0.14**	**0.15**	**0.16**	**0.15**
	C07	**0.15**	**0.16**	**0.16**	**0.18**	**0.20**	**0.19**
	C08	**0.13**	**0.13**	**0.14**	**0.14**	**0.14**	**0.15**
	C09	**0.10**	**0.11**	**0.11**	**0.11**	**0.12**	**0.11**
	C10	**0.11**	**0.12**	**0.12**	**0.13**	**0.13**	**0.13**
MEO	C11	0.17	0.17	0.17	0.17	0.18	0.18
	C12	0.24	0.25	0.25	0.26	0.27	0.27
	C13	0.18	0.18	0.18	0.19	0.19	0.19
	C14	0.16	0.17	0.16	0.17	0.17	0.17

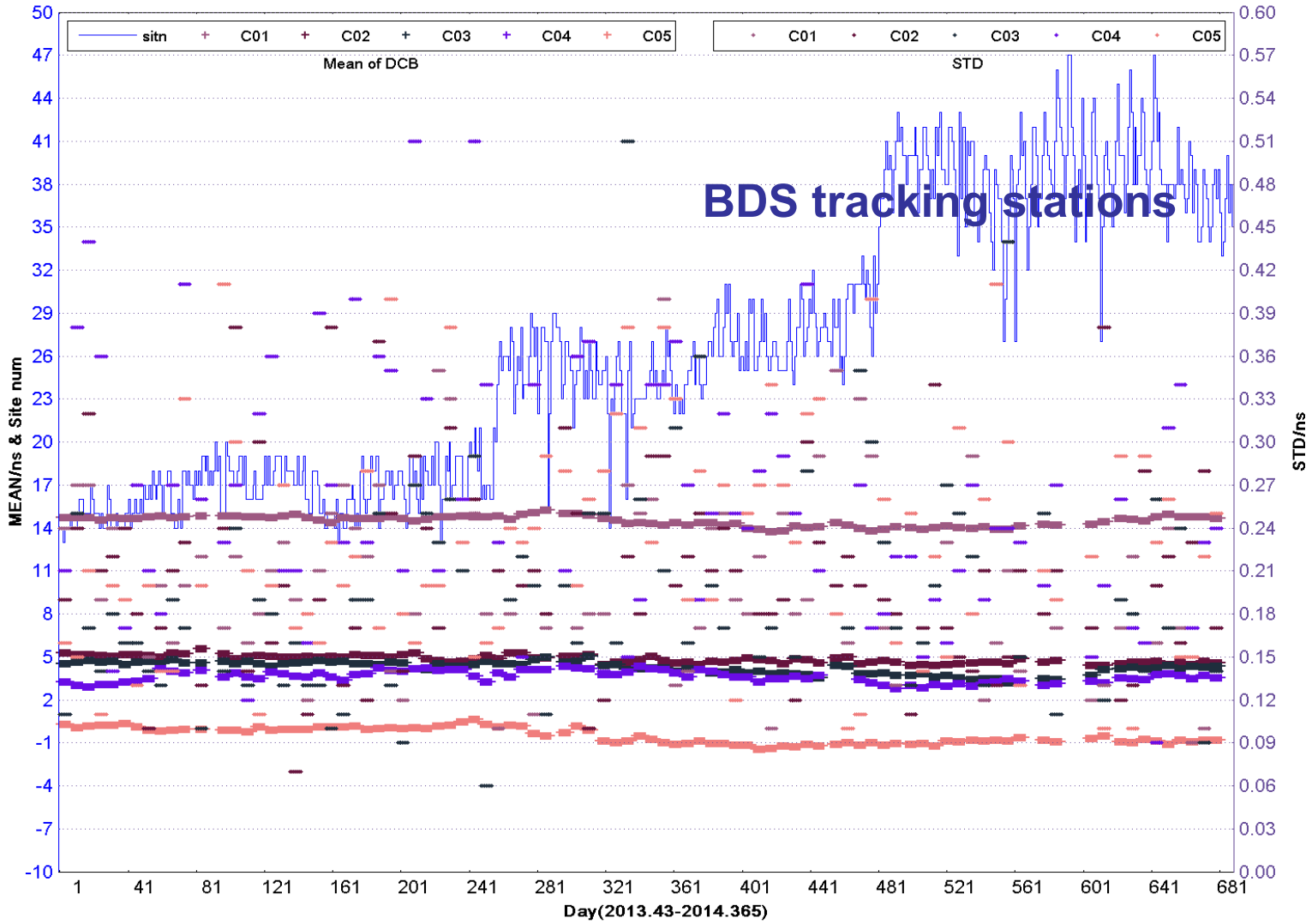
A comparison for the 4weeks and week interval showed that the STD differences did not exceed 60ps for all B1–B2 satellite DCBs .

Short-term stability of BDS B1B3 DCB

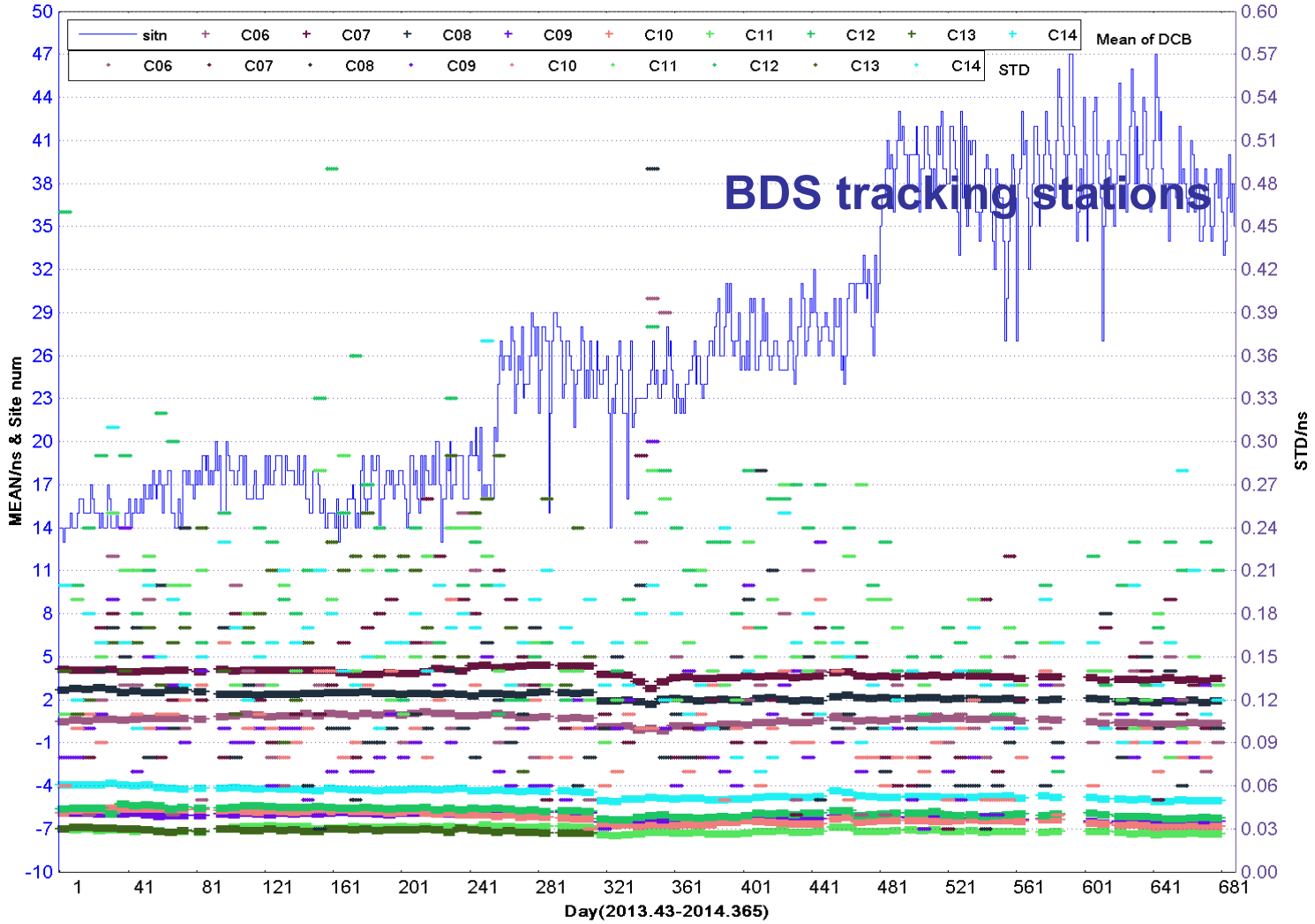
	PRN	7d	14d	21d	28d	35d	42d
GEO	C01	0.16	0.17	0.17	0.17	0.19	0.18
	C02	0.20	0.22	0.22	0.22	0.23	0.23
	C03	0.21	0.23	0.24	0.23	0.26	0.26
	C04	0.23	0.25	0.25	0.25	0.25	0.27
	C05	0.22	0.23	0.23	0.25	0.25	0.24
IGSO	**C06**	**0.13**	**0.13**	**0.14**	**0.15**	**0.15**	**0.14**
	C07	**0.17**	**0.19**	**0.19**	**0.21**	**0.20**	**0.20**
	C08	**0.12**	**0.13**	**0.13**	**0.13**	**0.15**	**0.14**
	C09	**0.10**	**0.11**	**0.11**	**0.11**	**0.12**	**0.12**
	C10	**0.13**	**0.14**	**0.15**	**0.14**	**0.15**	**0.16**
MEO	C11	0.20	0.20	0.20	0.20	0.21	0.20
	C12	0.27	0.26	0.26	0.26	0.26	0.26
	C14	0.20	0.20	0.20	0.20	0.21	0.21

Comparison for the 4weeks and week interval showed that the STD differences did not exceed 40ps for all B1–B3 DCBs.

This clearly illustrates the viability of using monthly-averaged BDS satellite DCB in BDS post-processing.



BDS GEO DCB stability with the tracking stations expandation



BDS IGSO/MEO DCB stability with the tracking stations expandation

Summary

- With present calculate method, there're biases in GNSS DCB series due to the satellite number changes.
- Before the stability analysis of DCB series estimated together with ionosphere, the biases have to be removed firstly.
- The stability of GNSS satellite DCB is correlated with the ground tracking network. BDS and Galileo DCB will be better if there're more stations.
- For BDS/Galileo,the monthly mean value can be used in post-processing.

THANKS !