Beacon Satellite
SYMPOSIUM 2016

The Long Time Variation of the Estimated GPS Satellite Differential Code Bias and Its Possible Connection with ionosphere

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Outline

- Background and Motivation
- Data and Method
- Results

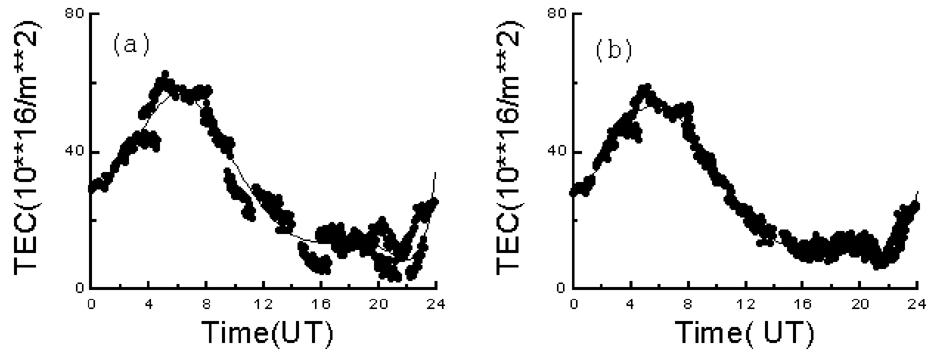
  1, day-to-day and annual variation of estimated DCBs

  2, long time variation of estimated DCBs
- Summary

Background and Motivation(1)

What are DCBs: the different time delays of the dual-frequency signals propagating through the satellite and receiver hardware.

Why to remove DCBs: the main error sources in the process to derive the TEC from GNNSS measurements.



The direct measuring DCBs in operation is almost impossible. Now, the traditional methods to estimate the DCBs based on the GPS observations from global, regional GPS stations, or from observation of single GPS station **under some assumptions.**

Background and Motivation(2)

DCB Estimation Assumptions:

1, the thin shell ionosphere: the ionosphere is compacted into a thin shell at an effective height surrounding the Earth. The height selection？

2, the ionosphere varies smoothly both temporally and spatially：

But the ionosphere frequently exhibits certain degree of “non-smooth” or “rough” temporal and spatial variability.

3, zero mean condition of satellites DCBs

From the DCBs estimated results, there are some featured variations, day to day, annual and “solar cycle”. The question is “are these variations real? If they are introduced by these assumption?

Data and Method（1）

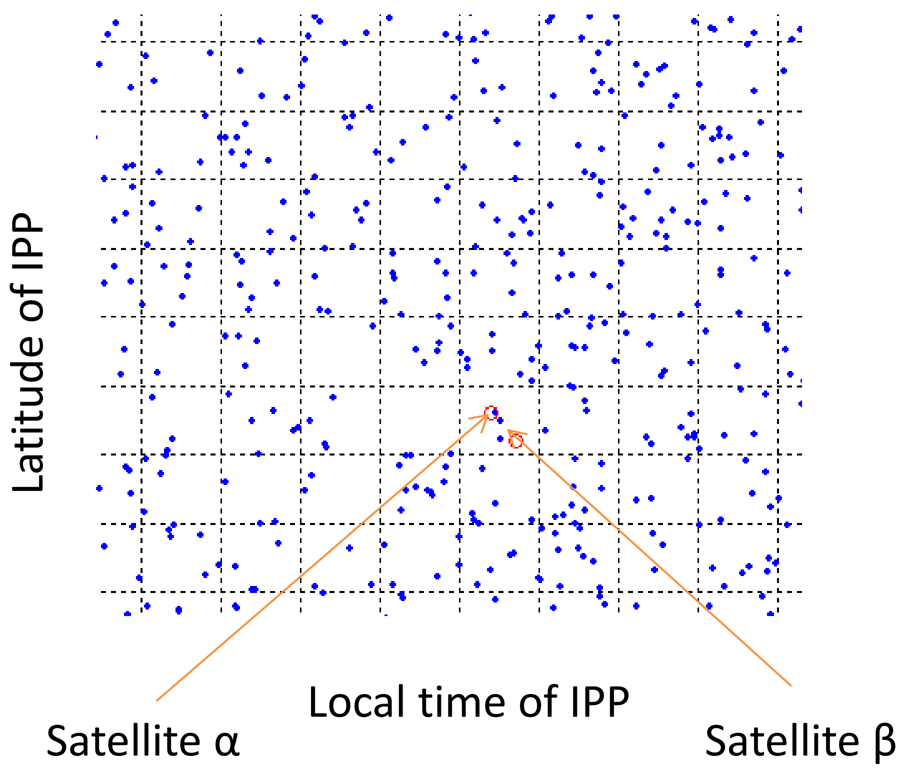
DCBs issued by CODE (ftp://ftp.unibe.ch/aiub/CODE/)
DCBs estimated based on single station observation with least-square method.

Assumptions to estimate the DCBs：

1. The effective height of the ionospheric thin shell is constant, 400 km；

2. The DCBs is constant in one day；

3. the ionospheric shell over the observational region is divided into a number of even meshes (0.1h×0.5°). the TECs derived from different satellite-receiver pairs in the same mesh is equal.



Data and Method（2）

$$(Slant\_TEC_{\alpha r} - B_{\alpha} - B_{r})\cos E_{ion\alpha r} = (Slant\_TEC_{\beta r} - B_{\beta} - B_{r})\cos E_{ion\beta r}$$

$$\alpha, \beta = 1, 2, \ldots\ldots, 32$$

$$\begin{pmatrix} \cdots & \cdots & \cdots & \cdots & \cdots \\ \cdots & -\cos E_{ion\alpha r} & \cdots & \cos E_{ion\beta r} & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots \end{pmatrix} \begin{pmatrix} \vdots \\ B_{\alpha} + B_{r} \\ \vdots \\ B_{\beta} + B_{r} \\ \vdots \end{pmatrix} = \begin{pmatrix} \vdots \\ \text{Slant\_TEC}_{\beta r}\cos E_{ion\beta r} - \text{Slant\_TEC}_{\alpha r}\cos E_{ion\alpha r} \\ \vdots \end{pmatrix}$$

$$B_t = B_s + B_r$$

$$\overline{B_t} = \overline{(B_s + B_r)} = \overline{B_s} + B_r$$

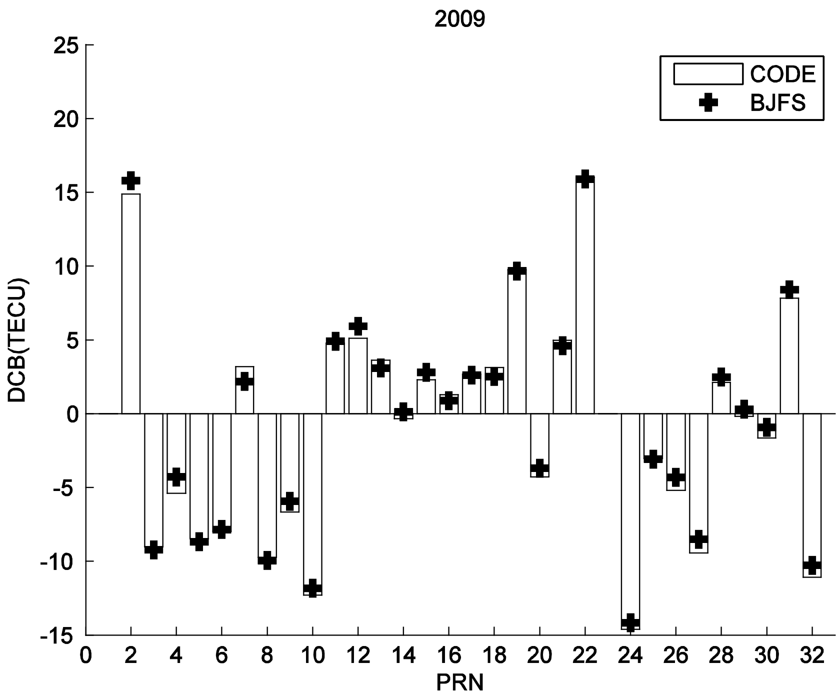
$$B_t - \overline{B_t} = B_s - \overline{B_s} = B_s$$

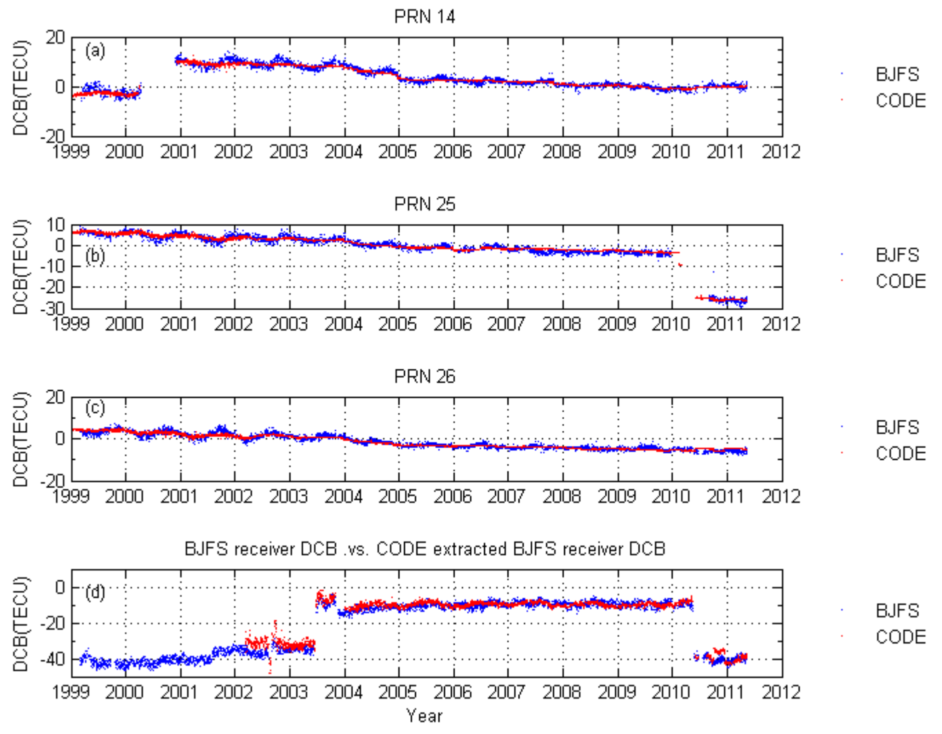
$\overline{B_s} \rightarrow 0$

To separate the satellites and receiver DCBs, the zero mean condition for satellites DCBs is used

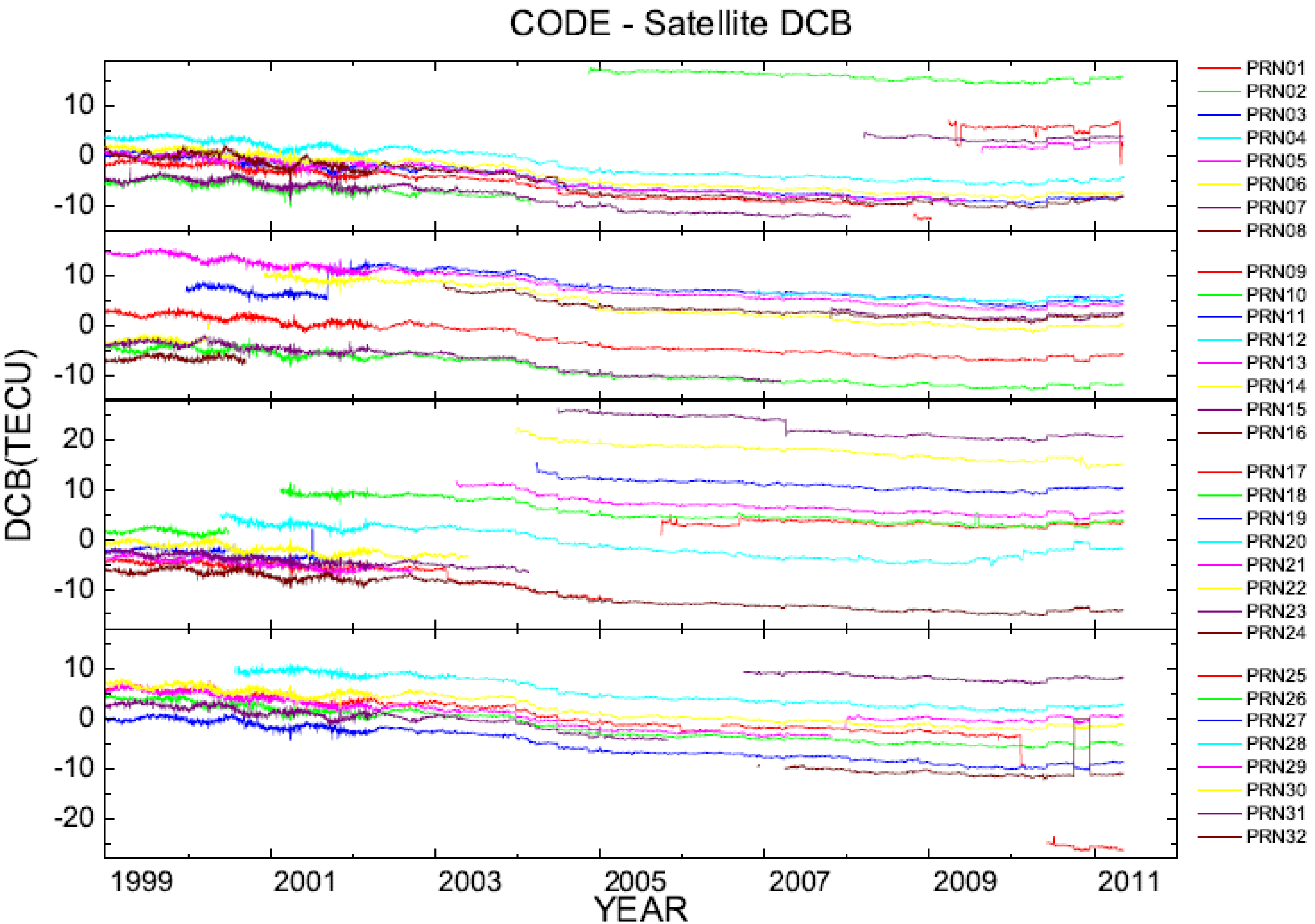
Data and Method（3）

Evaluation of our DCBs estimation method





Results:



CODE - Satellite DCB
DCB(TECU)
YEAR
1999
2001
2003
2005
2007
2009
2011
PRN01
PRN02
PRN03
PRN04
PRN05
PRN06
PRN07
PRN08
PRN09
PRN10
PRN11
PRN12
PRN13
PRN14
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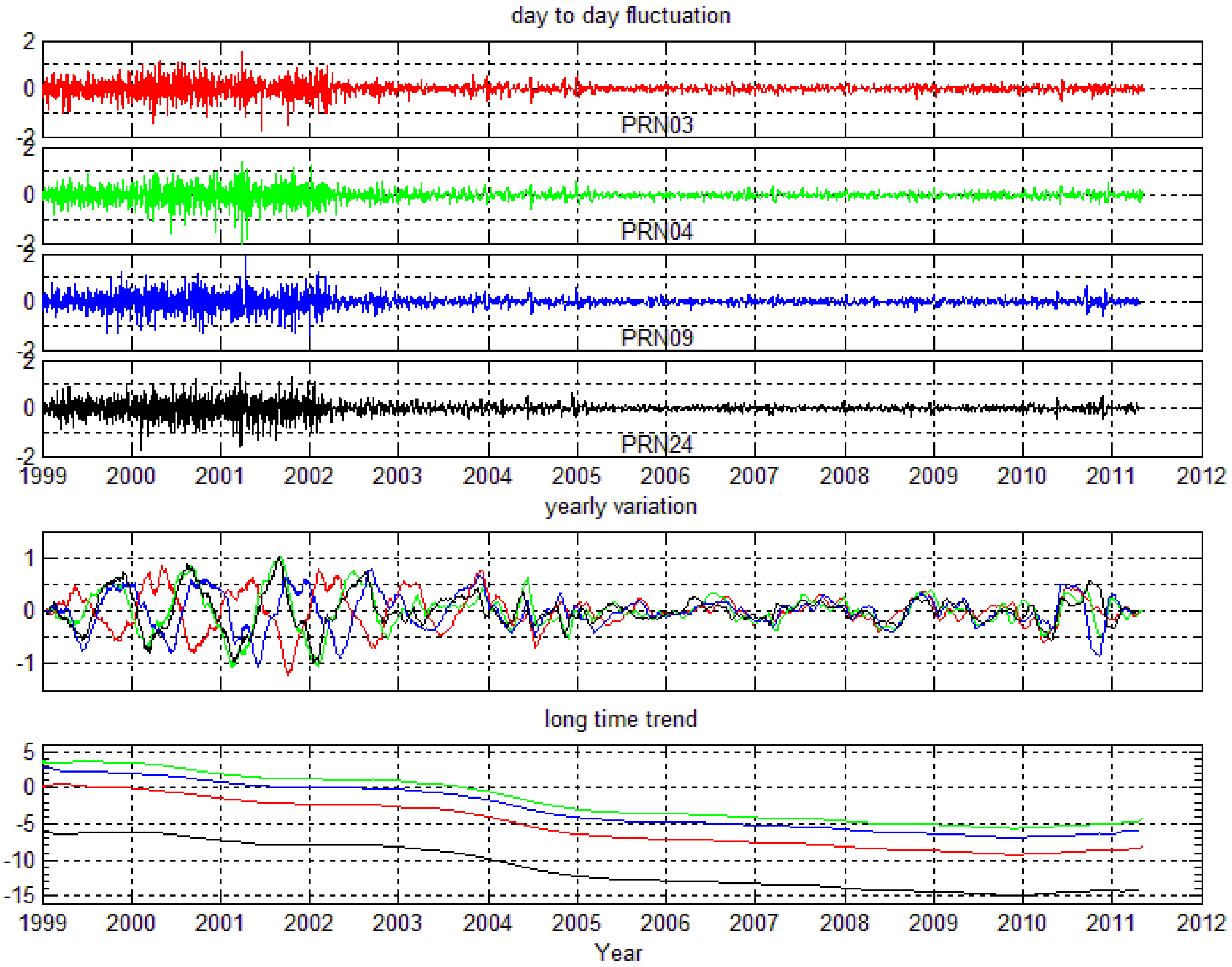
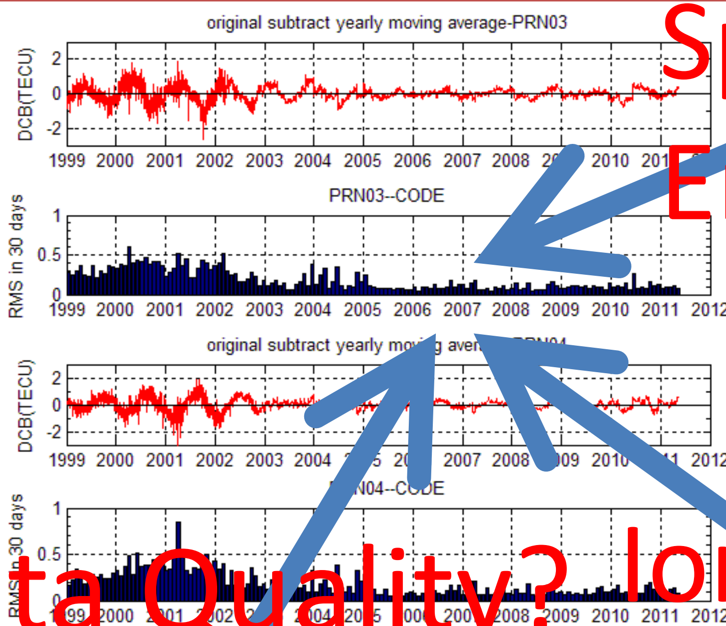
PRN31
PRN32

Three time scales variation.



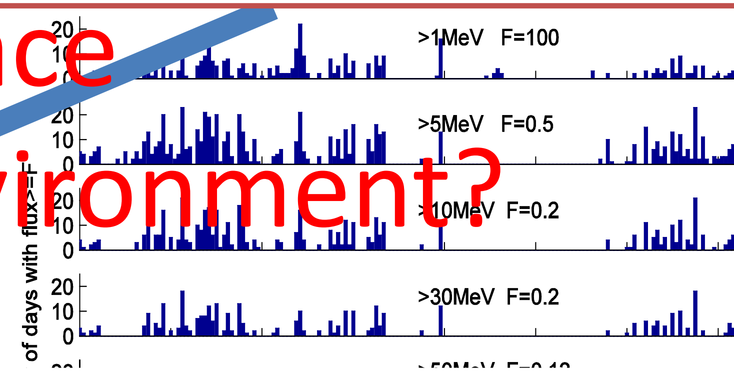
Results: Day to day and annual variation.

Space Environment?

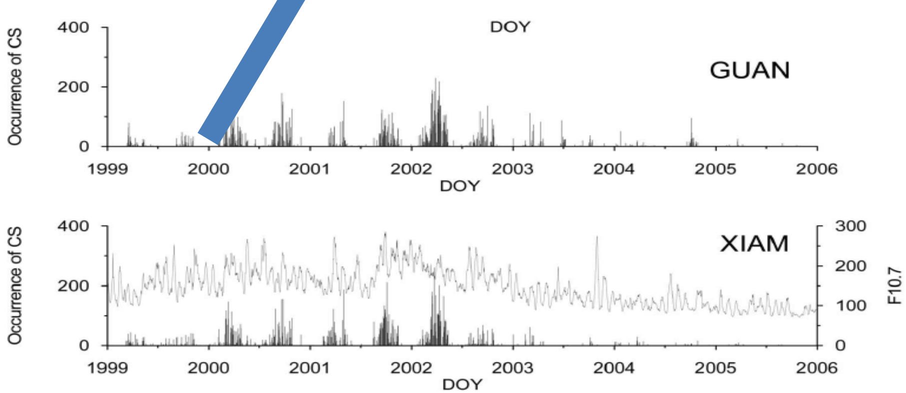


Data Quality? Ionospheric Variability?

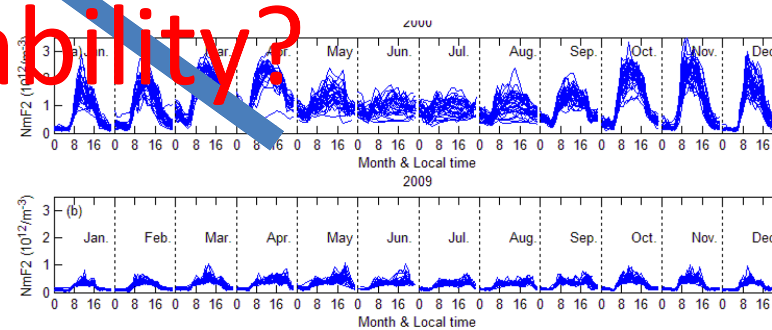
The DCB with long time detrending process for GPS satellites PRN 03 and 04 and its monthly RMS variation from 1999 to 2011



The number of days with the daily mean of proton flux of 4 channels (>1MeV, >1MeV, >10MeV, >30MeV,) exceeds the background threshold value with GOES satellite.

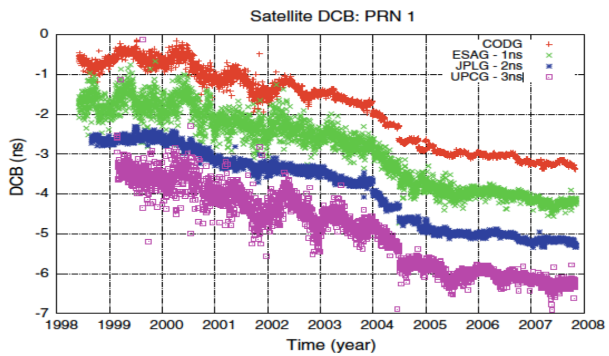


GPS Cycle slip occurrence in China low latitude from 1999 to 2006

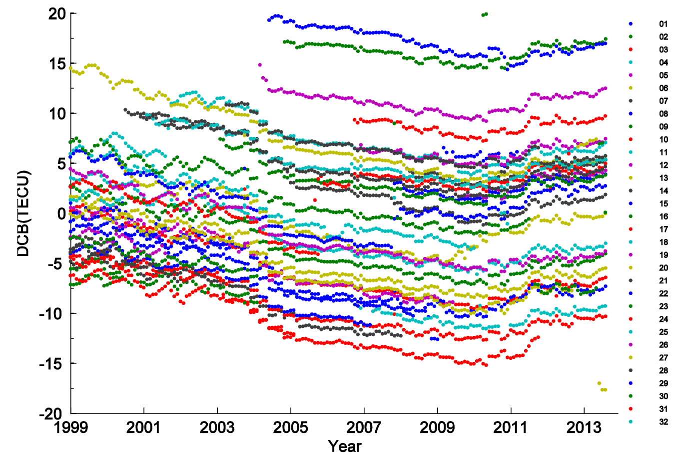


Diurnal variations of NmF2 for twelve continuous months in 2000 (a) and in 2009 (b) at Kokubunji ionosonde station

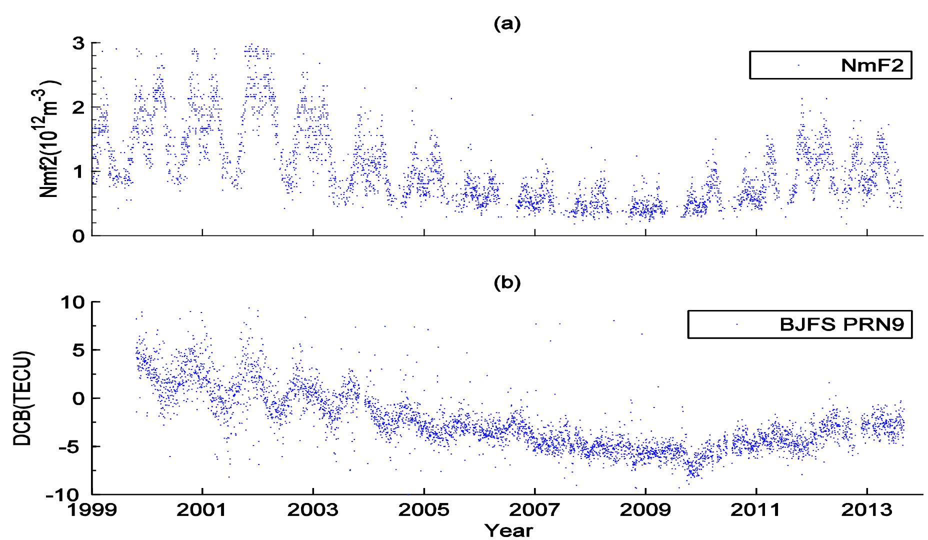
Result: Long time variation of satellite DCBs



Daily DCBs of PRN1 from four GPS communities. (from Hernández-Pajares et al., 2009

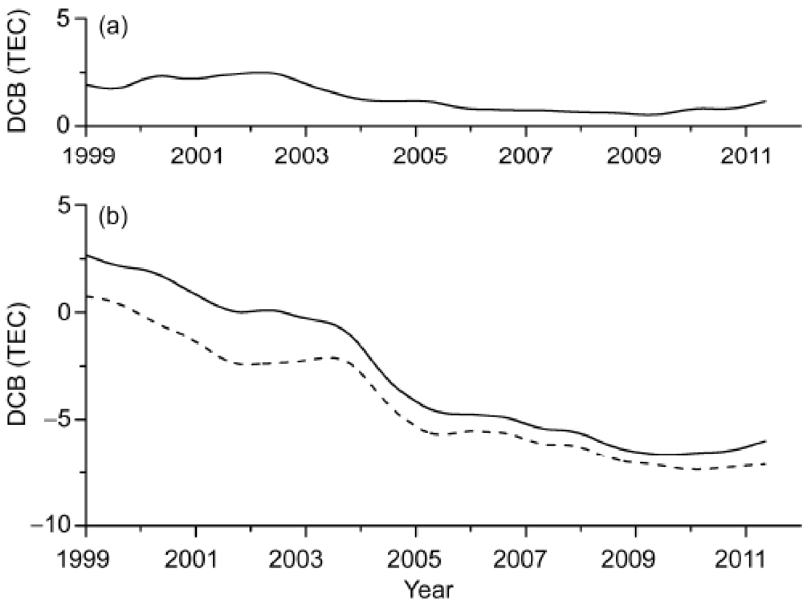


Monthly DCBs of all satellites issued by CODE



The estimated DCBs of PRN 9 from BJFS GPS station with our method and the NmF2 in middle latitude station (Kokubunji)

Result: long time variation of satellites DCB



$$B_t = B_s + B_r$$

$$\overline{B_t} = \overline{(B_s + B_r)} = \overline{B_s} + B_r$$

$$B_t - \overline{B_t} = B_s - \overline{B_s} = B_s$$

($\overline{B_s} \rightarrow 0$)

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The variation of the estimated GPS instrumental bias and its possible connection with ionospheric variability

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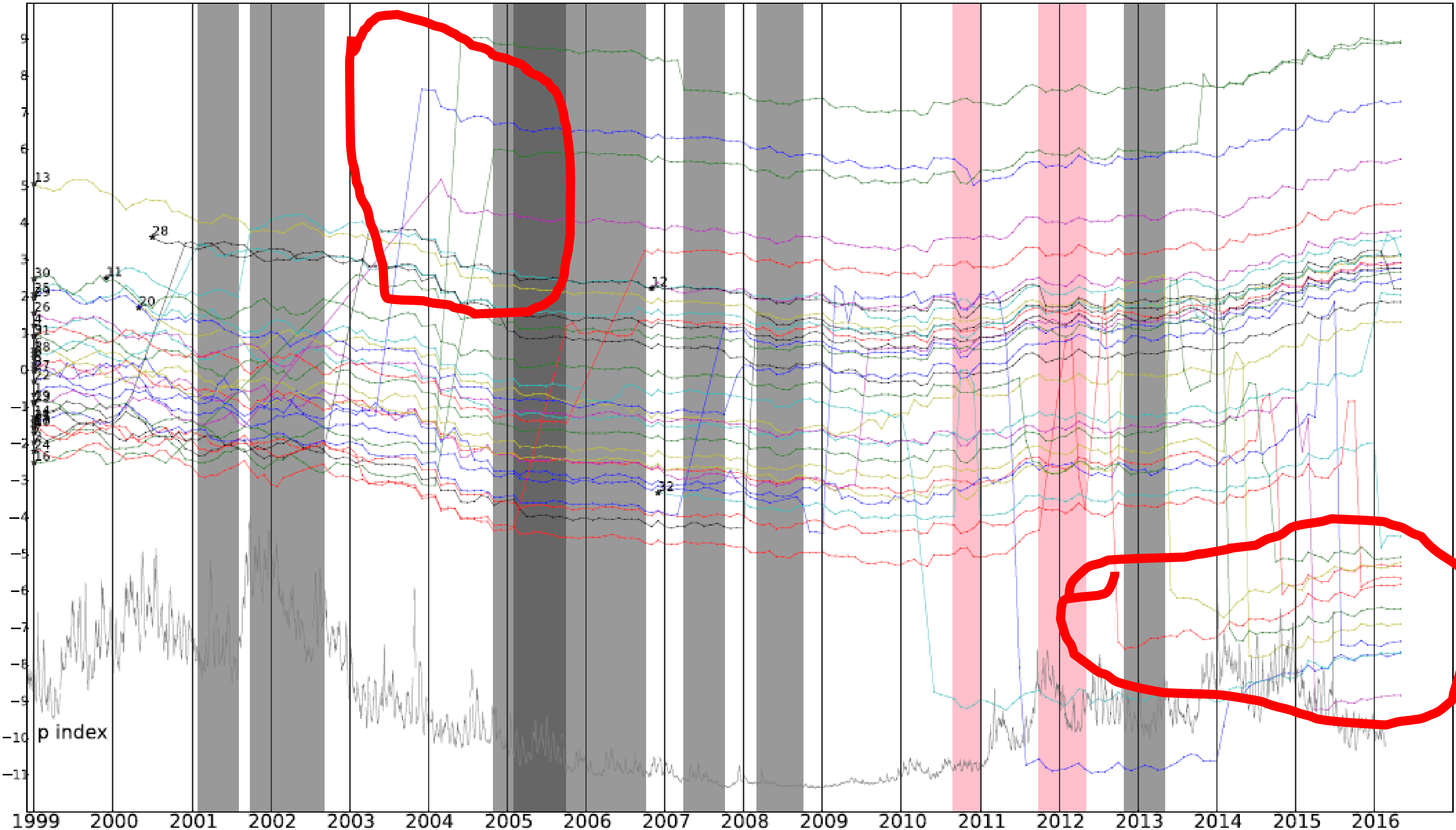
GPS Solut
DOI 10.1007/s10291-015-0437-5

ORIGINAL ARTICLE

Is the long-term variation of the estimated GPS differential code biases associated with ionospheric variability?

Jiahao Zhong · Jiuhou Lei · Xiankang Dou · Xinan Yue



9
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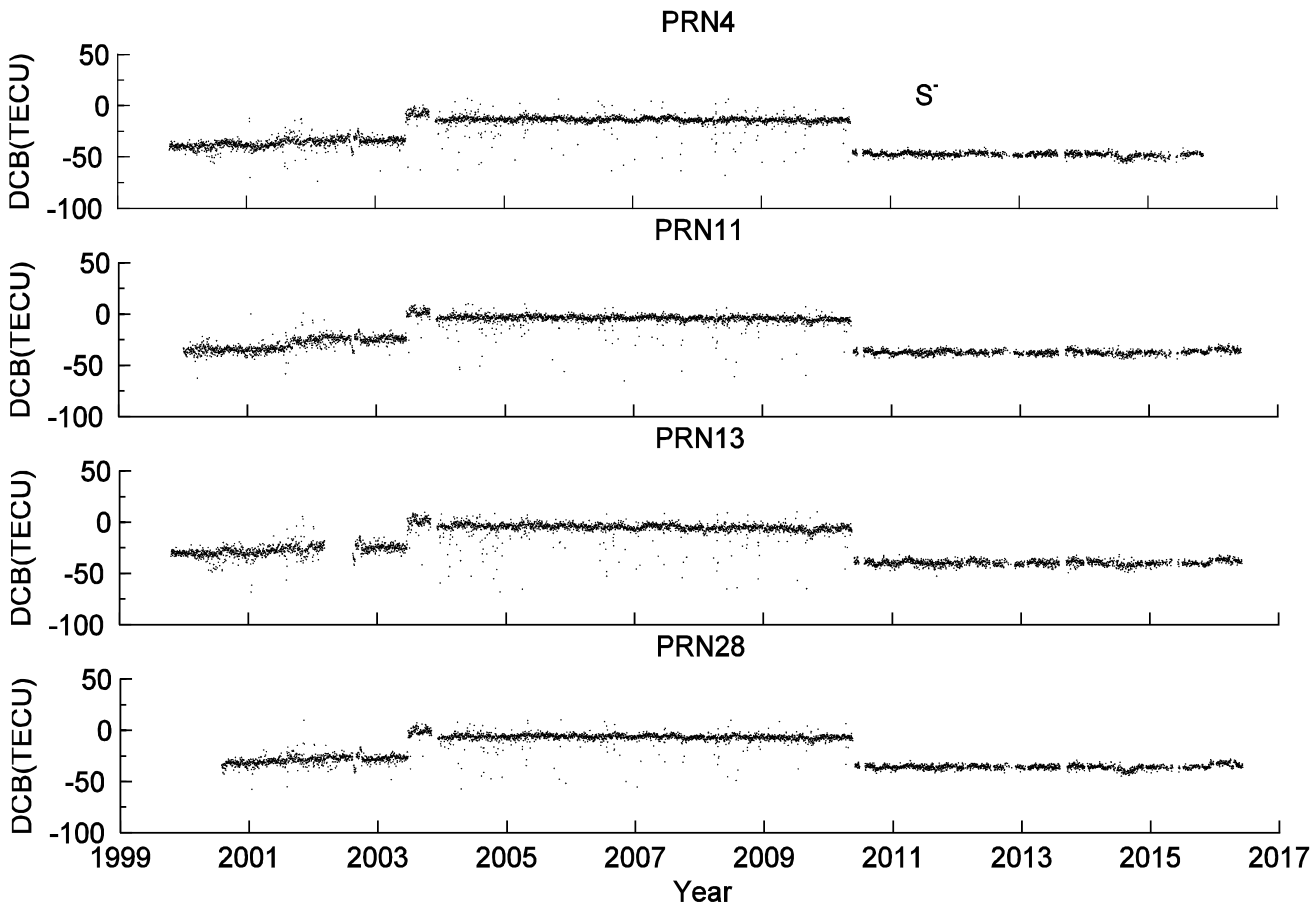
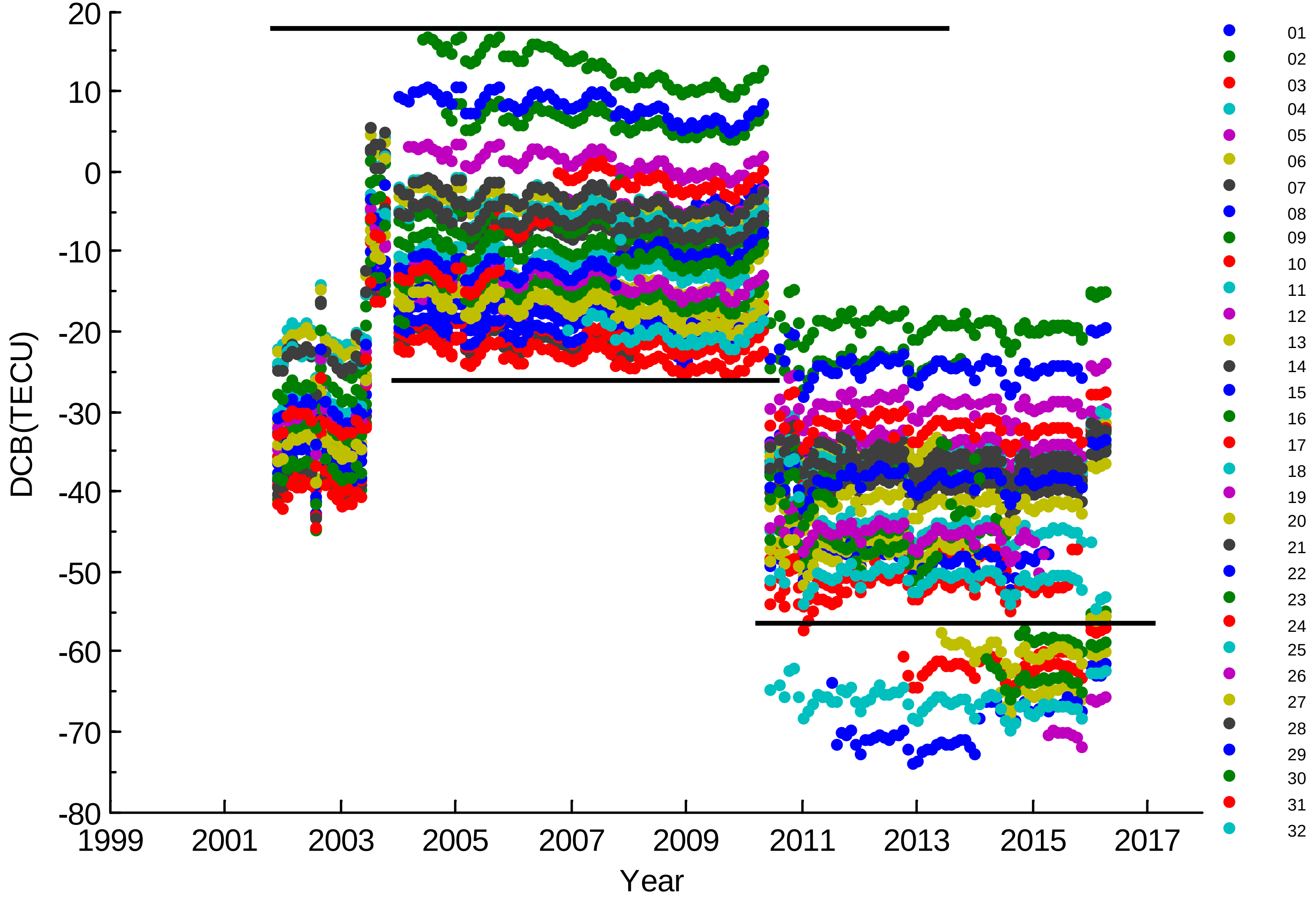
Results: DCBs （R+S）



For the TEC estimation from GPS data, the obtaining R+S DCBs simultaneously is necessary.

DCB(R+S) from CODE issued, BJFS



Summary

- the day-to-day and annual variation of estimated DCBs is possibly caused by ionospheric condition.
- The long time variation of the estimated satellites DCBs is caused mainly by the zero mean condition.
- The using of the satellites DCB should be evaluated, For the TEC estimation from GPS data, to obtain R+S DCBs simultaneously is necessary.

Thanks for your attention!
Grazie! XieXie!