Performance Evaluation of BeiDou Satellite Clocks in Orbit and Time Offset Monitoring

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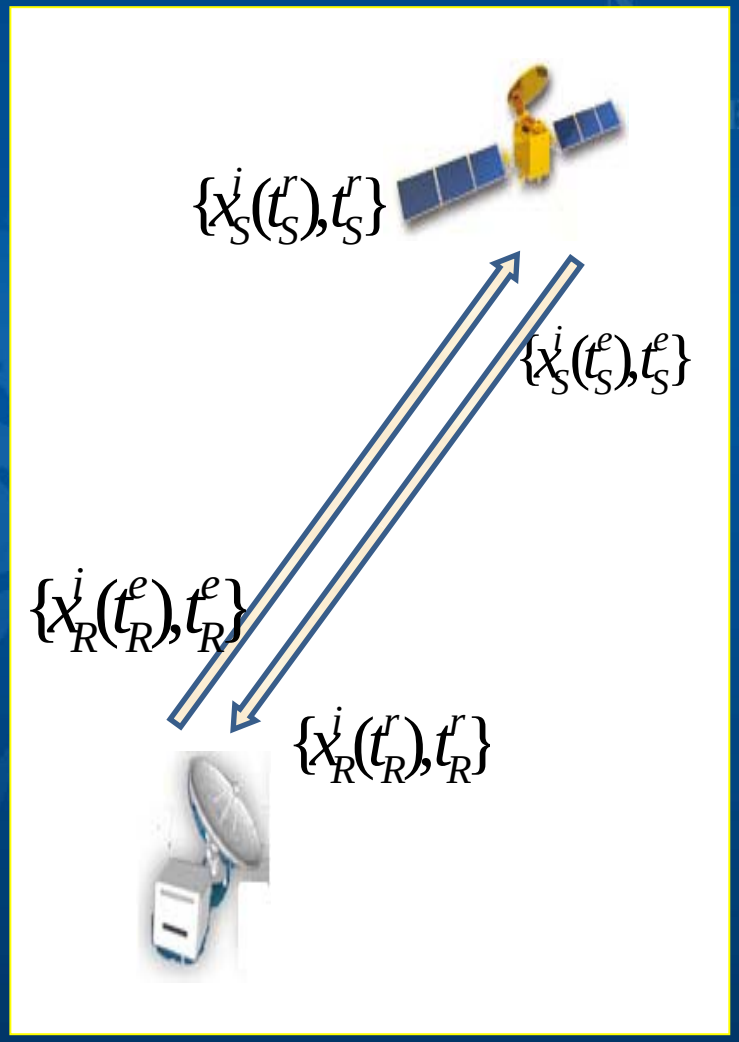
1、TWTT between satellites and stations

- Time synchronization of satellite clocks is the base of satellite navigation
- The main errors of satellite time synchronization are caused by time transfer and satellite clock prediction
- The prediction error of a clock is determined mainly by its frequency instability

1、TWTT between satellites and stations

- Two Way Time Transfer is used in BeiDou system
- The uncertanty of clock difference usually consists of random noises (type A) and a system bias(type B)
- The uncertainty of type A is less than 0.3ns, and that of type B is less than 1.5ns at present



2、Evaluation of Satellite Clock Stability

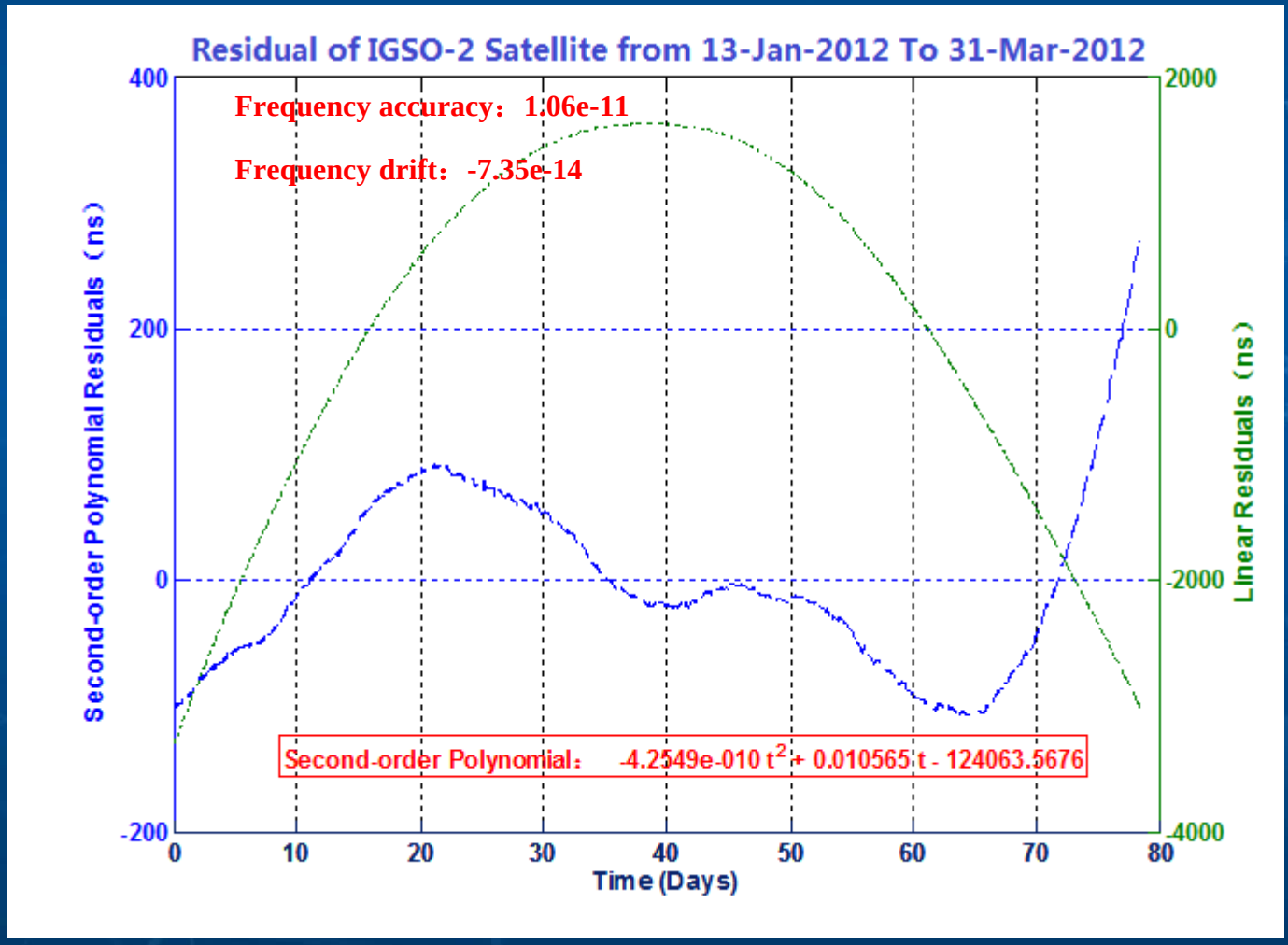
- The measurement errors and relativistic effects must be taken into account in satellite clock stability evaluation
- The following time model is used in BeiDou satellite clock prediction and its perfomance evaluation

$$x(t) \equiv T(t) - BDT(t)$$

$$= a_0 + a_1(t - t_0) + a_2(t - t_0)^2 + \xi(t) + \Delta t^p_{grav}$$

$$\Delta t^p_{grav} = -2\sqrt{\mu a}e \sin E / c^2 = -2\vec{x}_S \cdot \dot{\vec{x}}_S / c^2$$

2、Evaluation of Satellite Clock Stability



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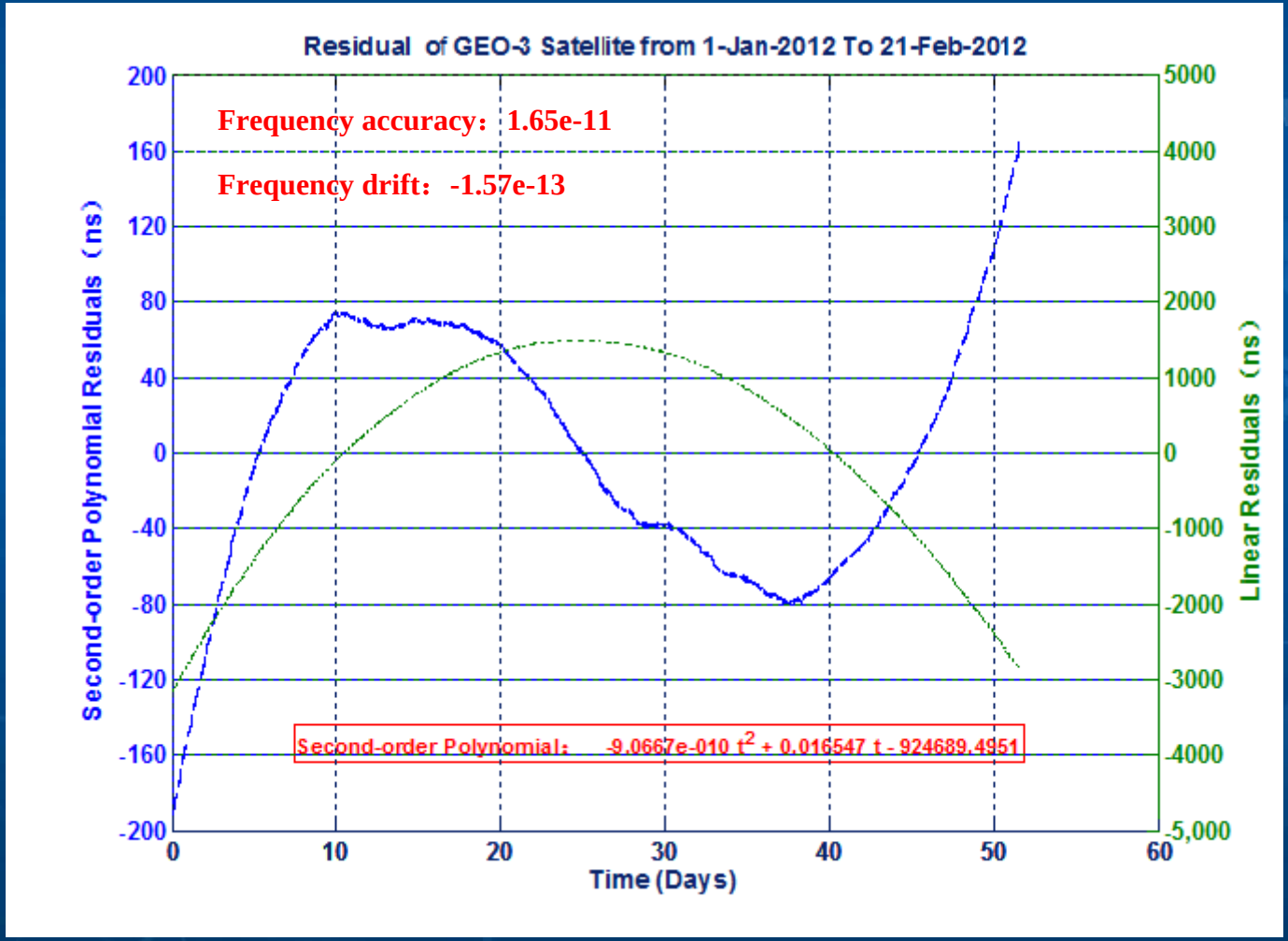

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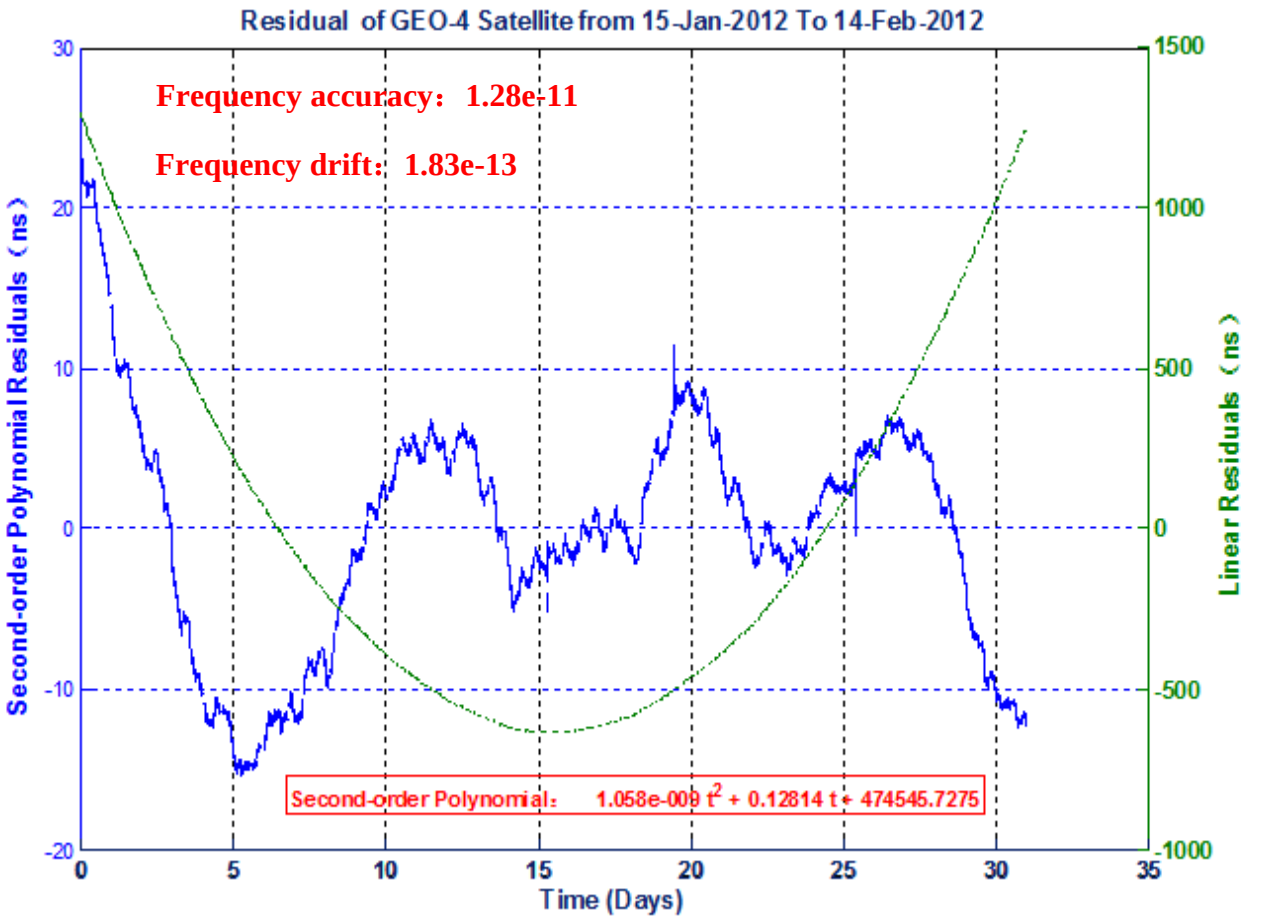

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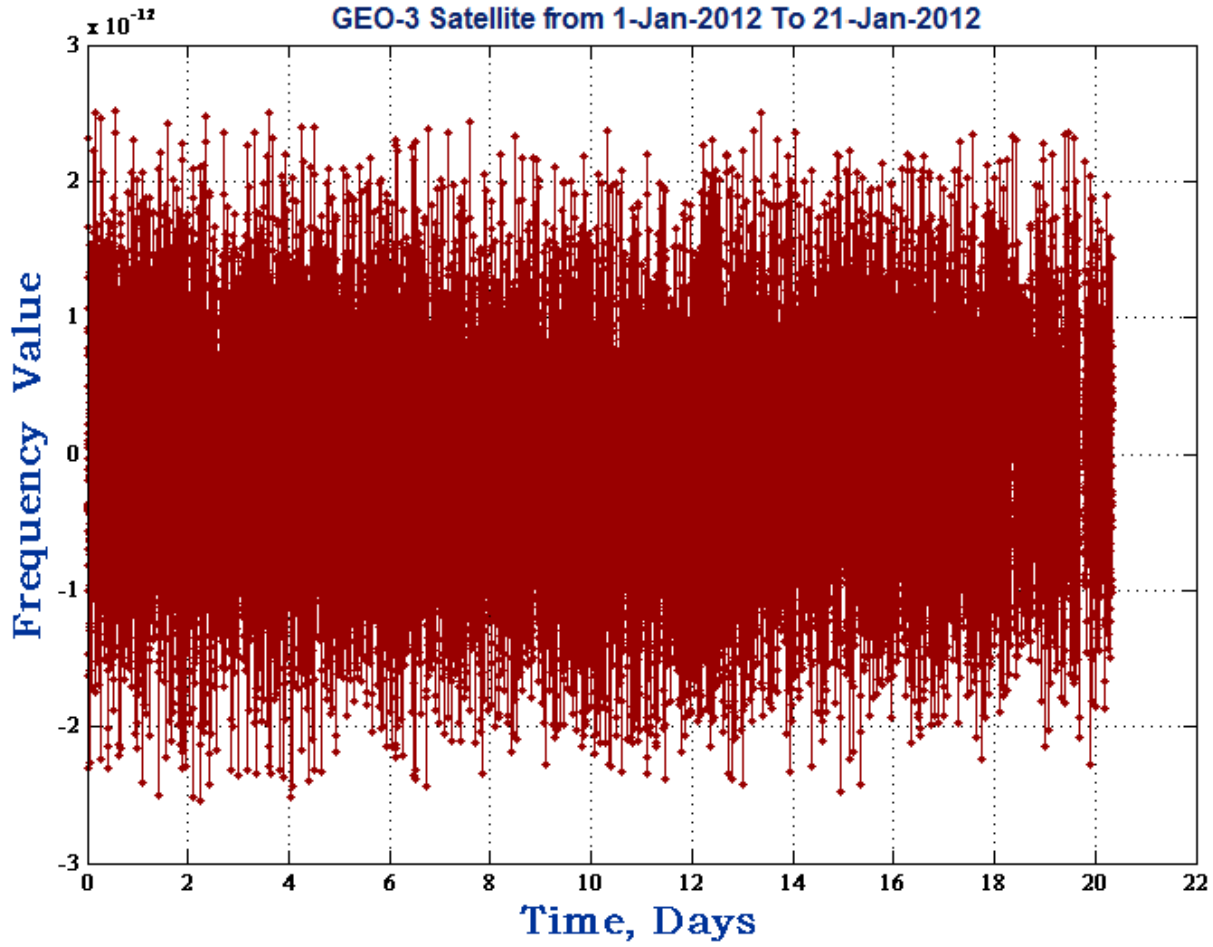

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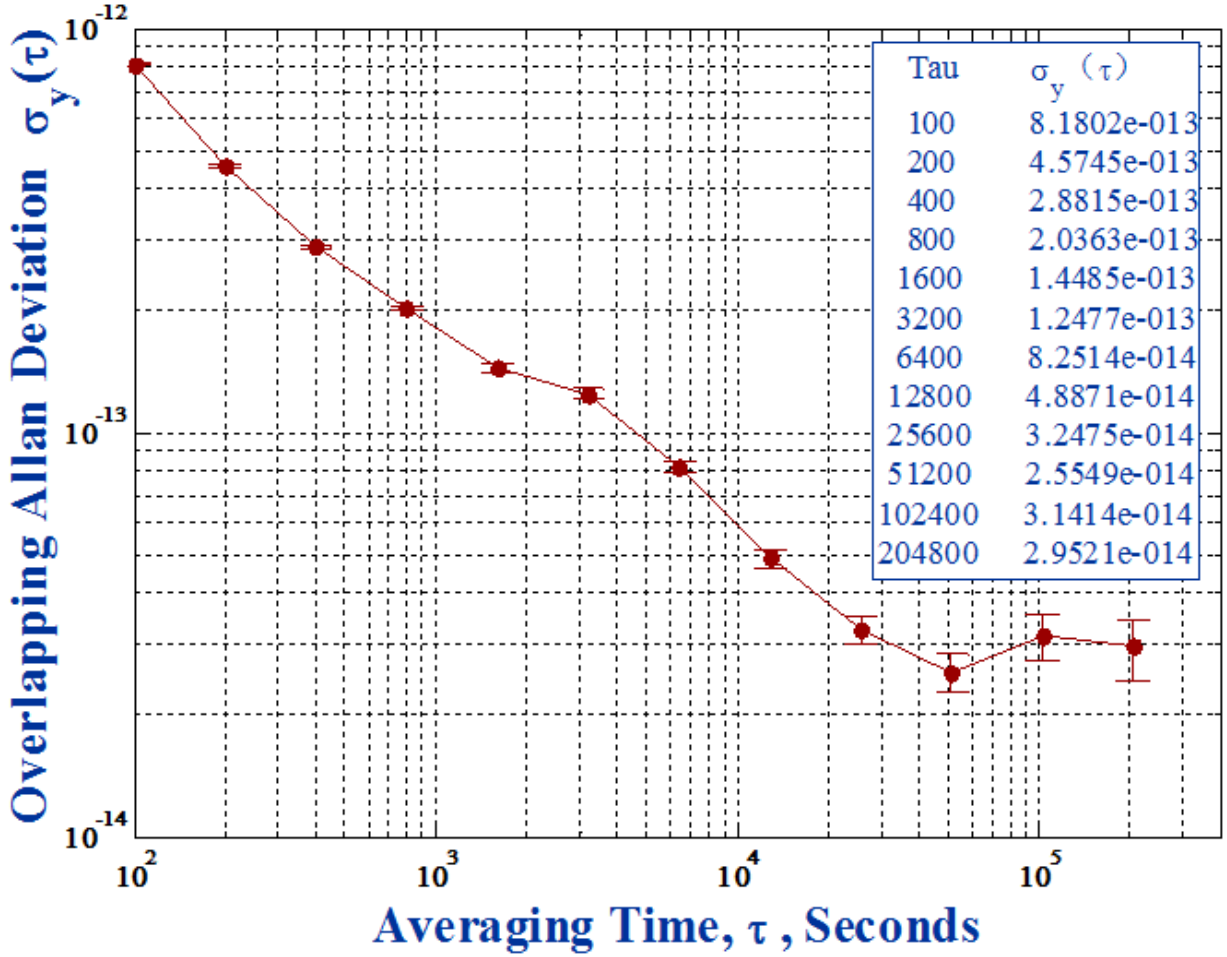

2、Evaluation of Satellite Clock Stability

Frequency stability of satellite clocks

	GEO-1	GEO-3	GEO-4	GEO-5	IGSO-1	IGSO-2	IGSO-3	IGSO-4	IGSO-5
Stability (10000s)	7.31E-14	5.52E-14	7.58E-14	9.17E-14	8.13E-14	5.95e-14	7.94e-14	8.53e-14	8.98e-14
Stability (1day)	6.71E-14	2.90E-14	3.83E-14	5.66E-14	9.38E-14	3.07e-14	2.53e-14	3.91e-14	4.45e-14

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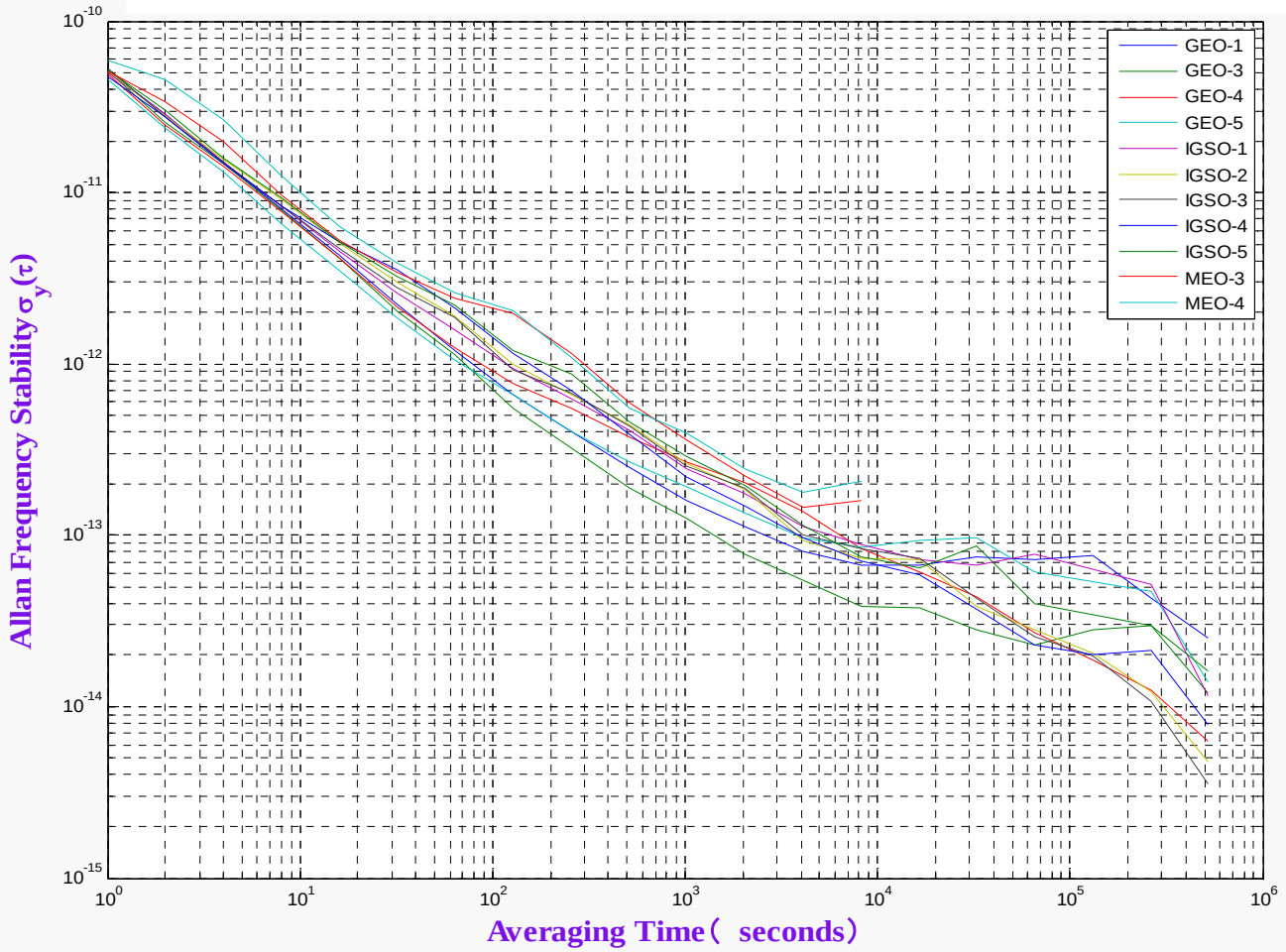
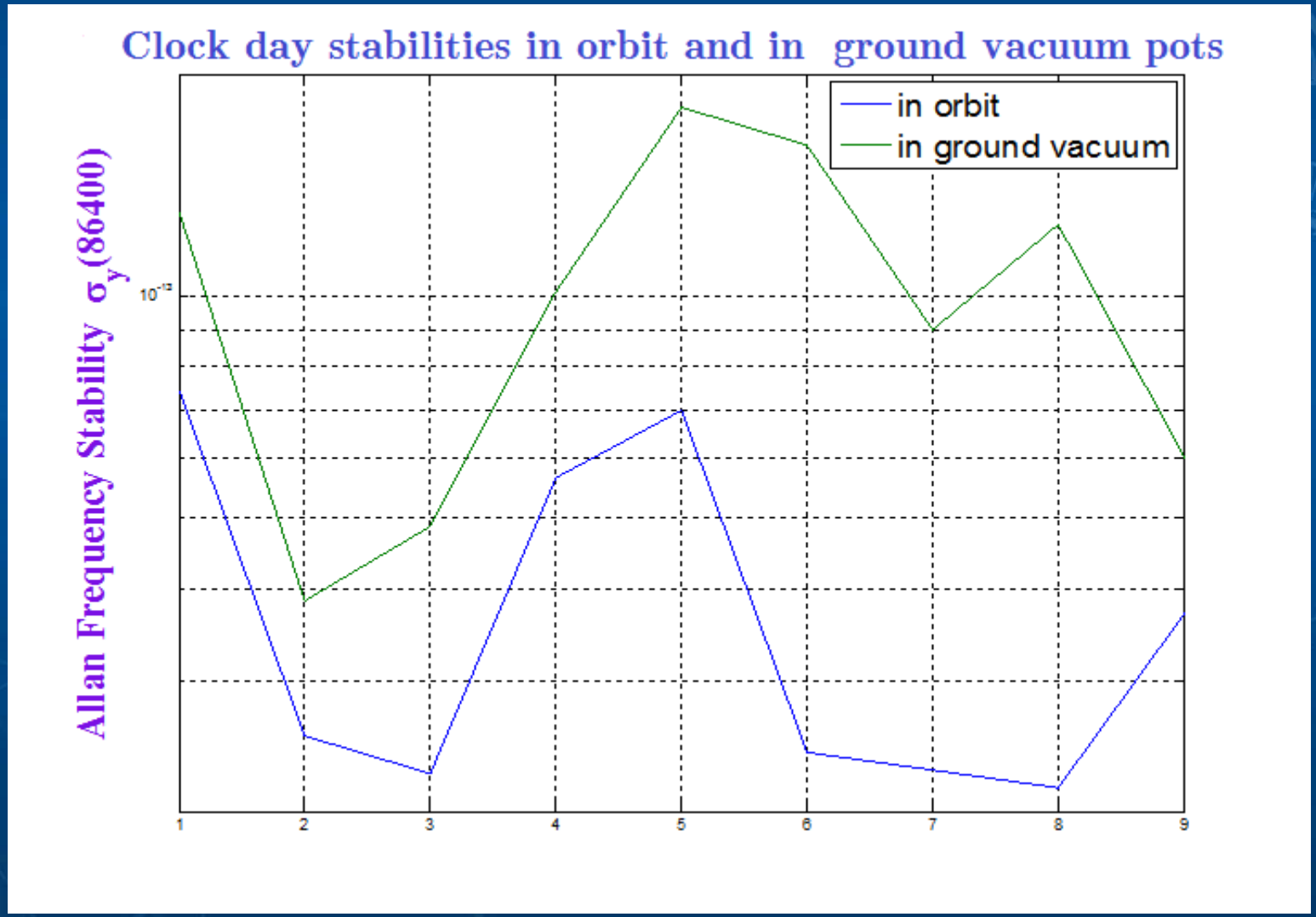


3、 Satellite clock performance in orbit



4、Time offset between GPS and Beidou

The time offset between BDT and GPST is monitored by a GPS multi-channel dual frequency receiver with reference signal of BDT

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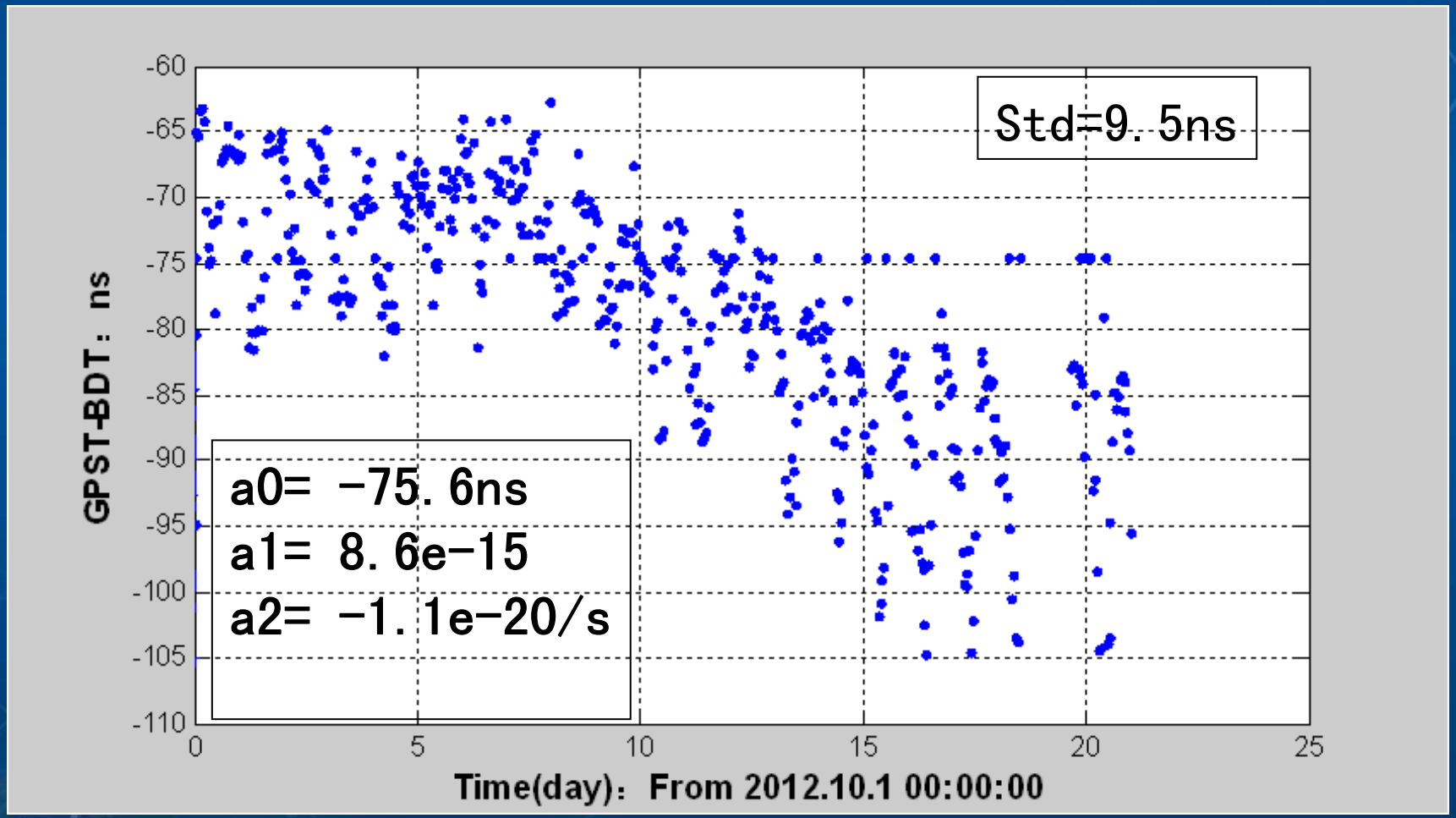

2012-10-01 to 2012-10-21

5、Summary

a) The type A uncertainty of TWTT between satellites and stations is less than 0.3ns, and type B is less than 1.5ns at present.

b) The frequency stability of BeiDou satellite clocks in orbit is about

3.8×10^{-14}~9.2×10^{-14} @10000s

2.2×10^{-14}~7.4×10^{-14} @1day

5、Summary

c) The performance of BeiDou satellite clocks in orbit is a little better than in the ground vacuum pots.

d) The time offset between GPS and BeiDou is less than 100ns, and the frequency offset is about 1e-14 in last month.

Thank you!