Positioning Performance of BeiDou Navigation Satellite System

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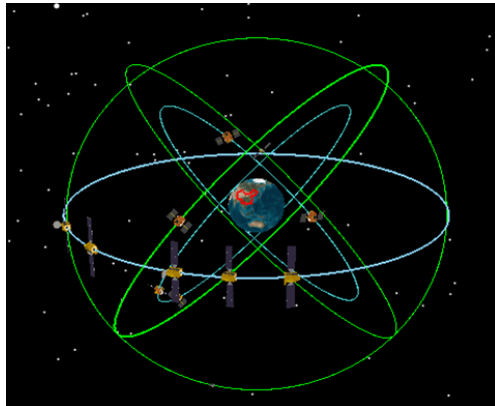**7th Meeting of the ICG, Beijing, China, 5-9, November 2012**

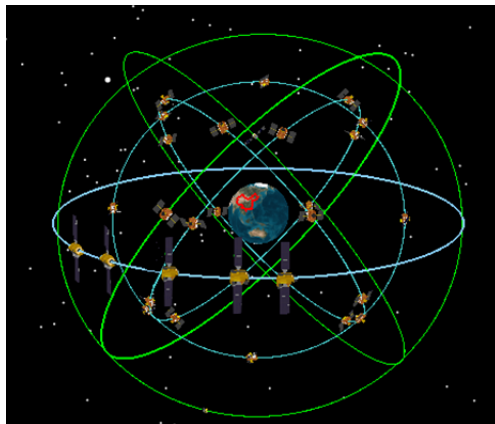# Status of BeiDou Navigation Satellite system

Sept.: 4GEO+5 IGSO+2MEO (In this presentation)

2012: 5GEO+5IGSO+4MEO (Operational Satellites, Regional Service)

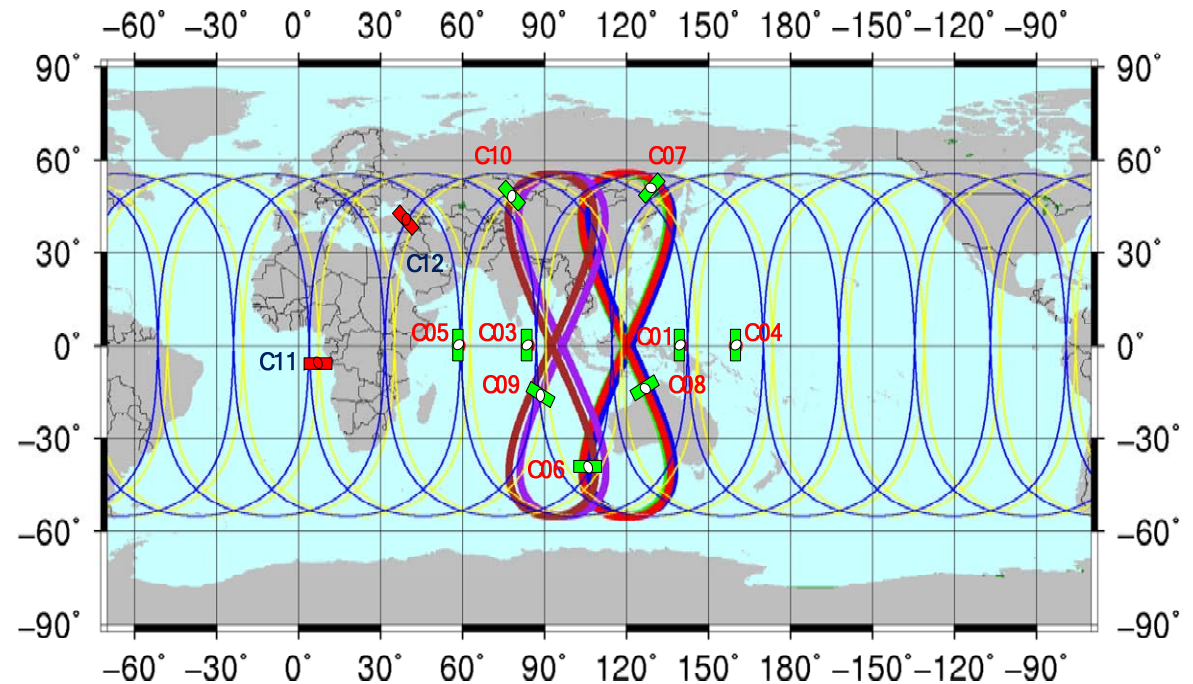**2020: 5GEO+3IGSO+27MEO (Operational Satellites, Global Service)**

2012

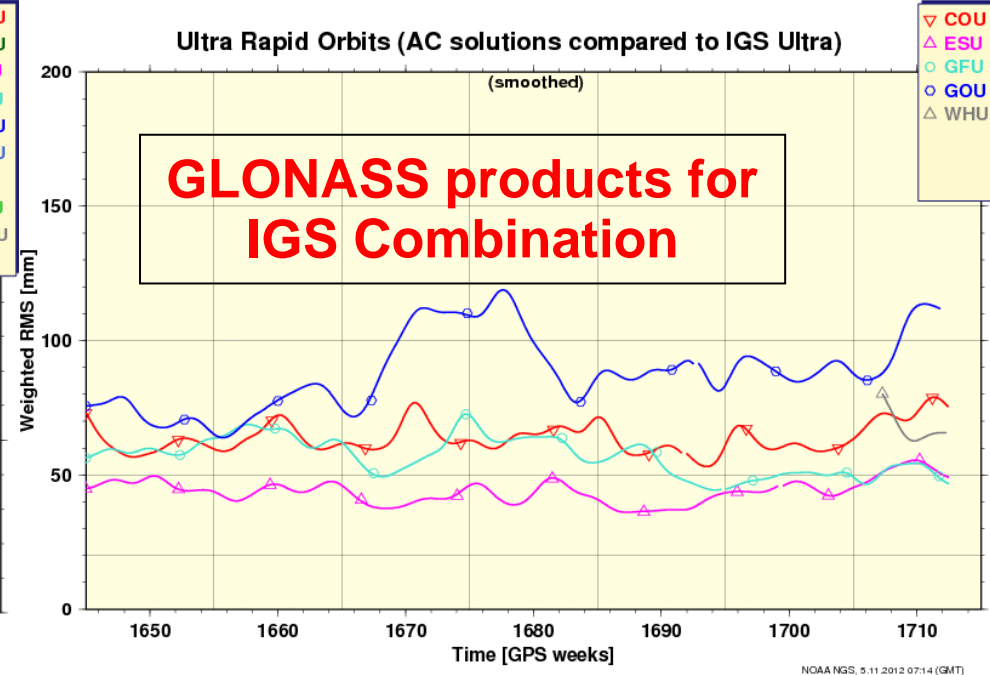**In this presentation**

2020

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7th Meeting of the ICG, Beijing, China, 5-9, November 2012

Precise Orbit&Clock Determination

Software used

GPS products for IGS Combination
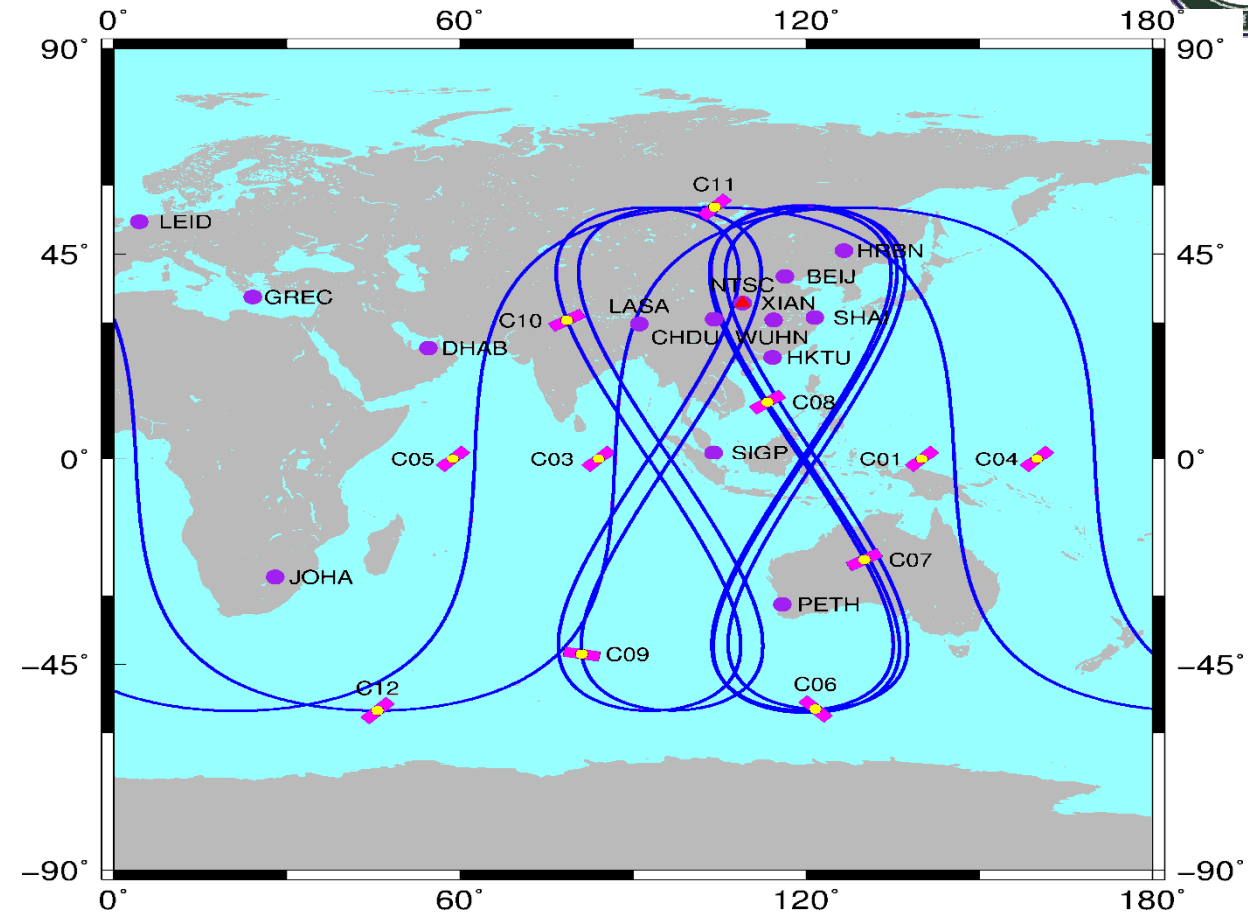
GLONASS products for IGS Combination
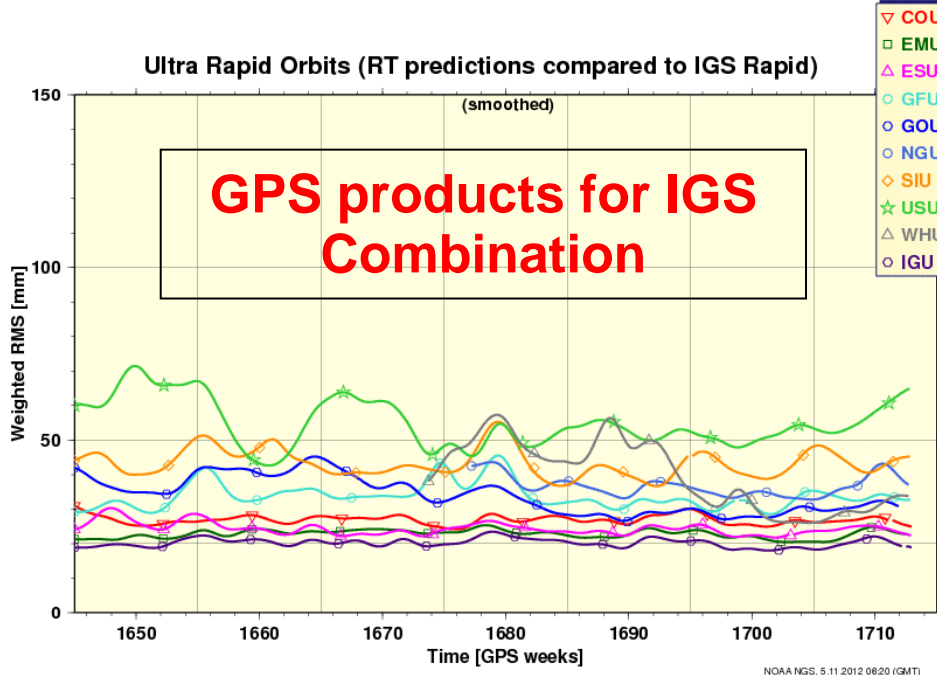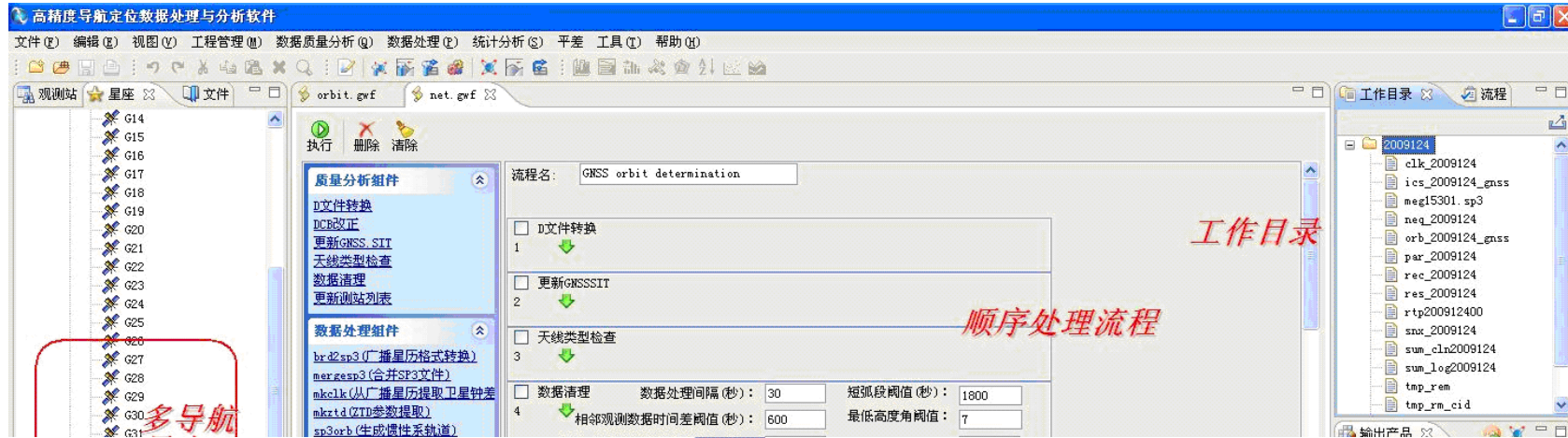
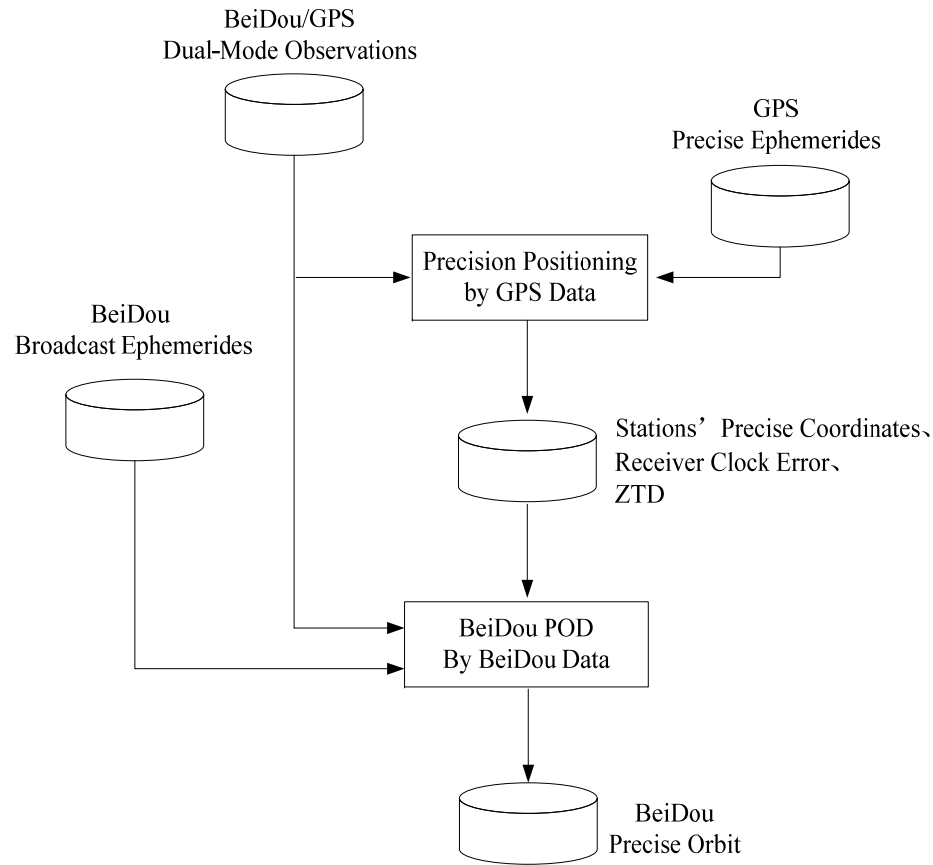# *Precise Orbit&Clock Determination*

Data used

Data from 15 stations

The COMPASS Experimental Tracking Network (CETN), which is operated by GNSS Research Center, Wuhan University (WHU) with cooperation of our research partners around the world.

Precise Orbit&Clock Determination

BeiDou/GPS
Dual-Mode Observations

GPS
Precise Ephemerides

Precision Positioning
by GPS Data

BeiDou
Broadcast Ephemerides

Stations' Precise Coordinates、
Receiver Clock Error、
ZTD

BeiDou POD
By BeiDou Data

BeiDou
Precise Orbit

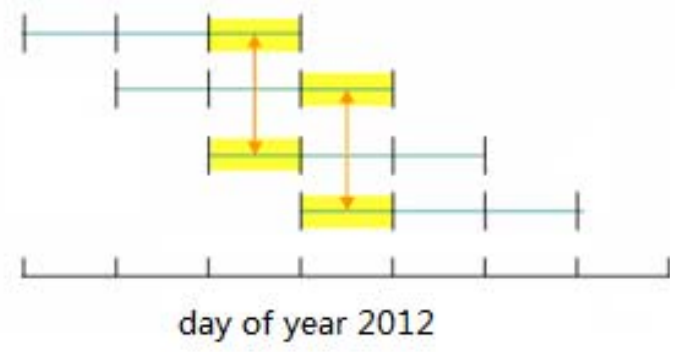| Parameters	Model	
	GPS Satellite	BeiDou Satellite
Station Coordinate	Estimated	Fixed
Receiver Clock Error	Estimated	Fixed, Inter-system Time bias estimated
ZTD Parameter	Estimated，SAAS + GMF，2 hours	Fixed
Satellite Orbit	Fixed，IGS Precise Ephemeris	Estimated
Satellite Clock Error	Fixed，IGS Precise Clock Error	Estimated
Gravity Field	EIGEN-CG03C (12X12)	EIGEN-CG03C (12X12)
N-Body perturbation	Sun, Lunar, Planetary	Sun, Lunar, Planetary
Tide	Solid Tide, Oceanic Tide(2010)	Solid Tide, Oceanic Tide(2010)
Solar radiation Pressure	BERN 9 parameters	BERN 9 parameters

Overlap difference

Results for 4GEO+5IGSO+2MEO
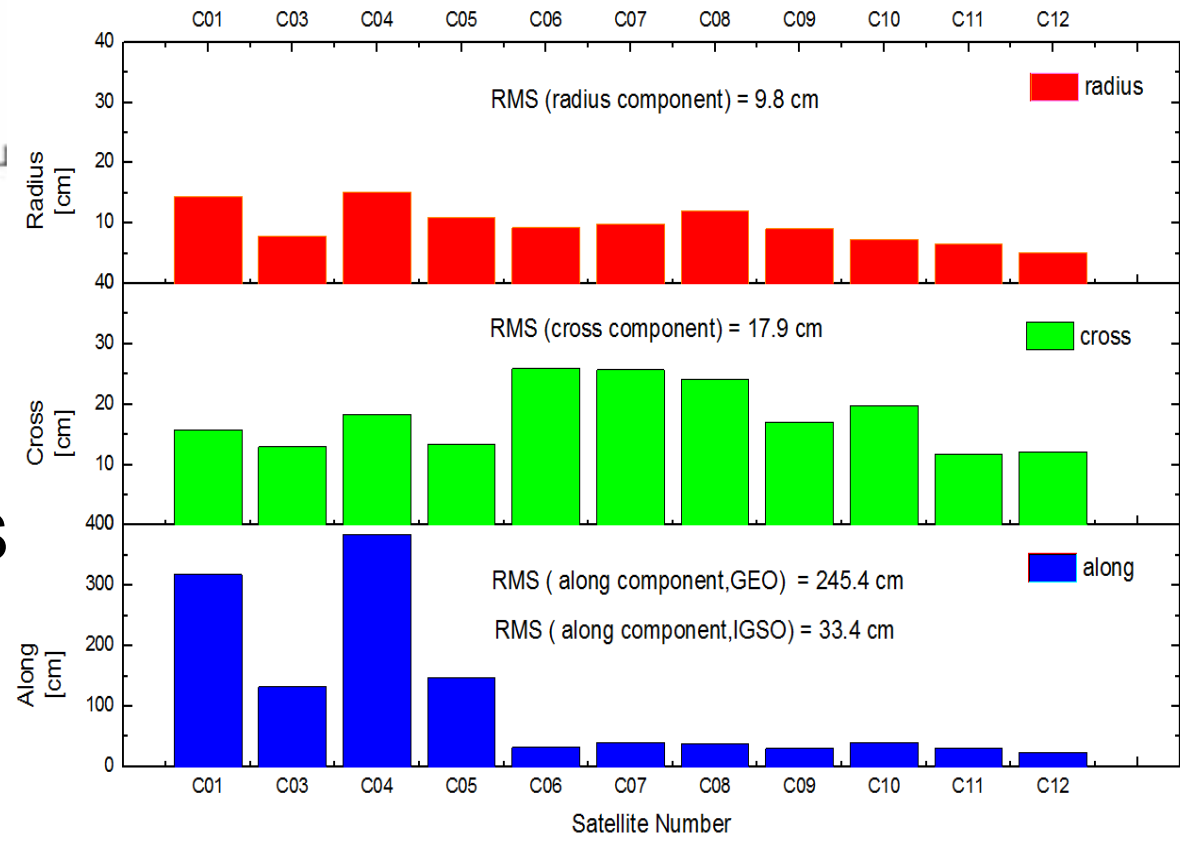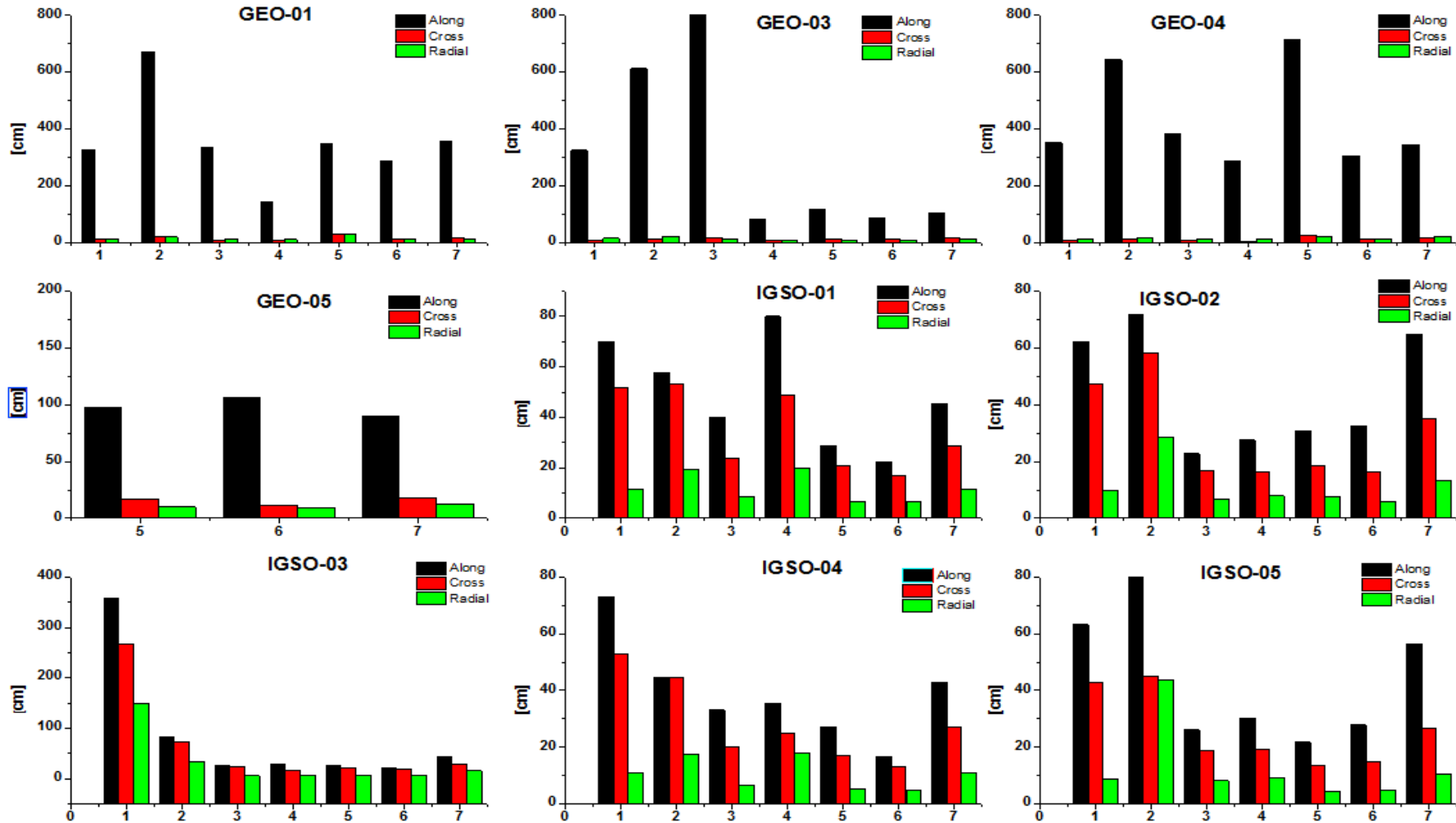
One month RMS

1-30,Sept. 2012
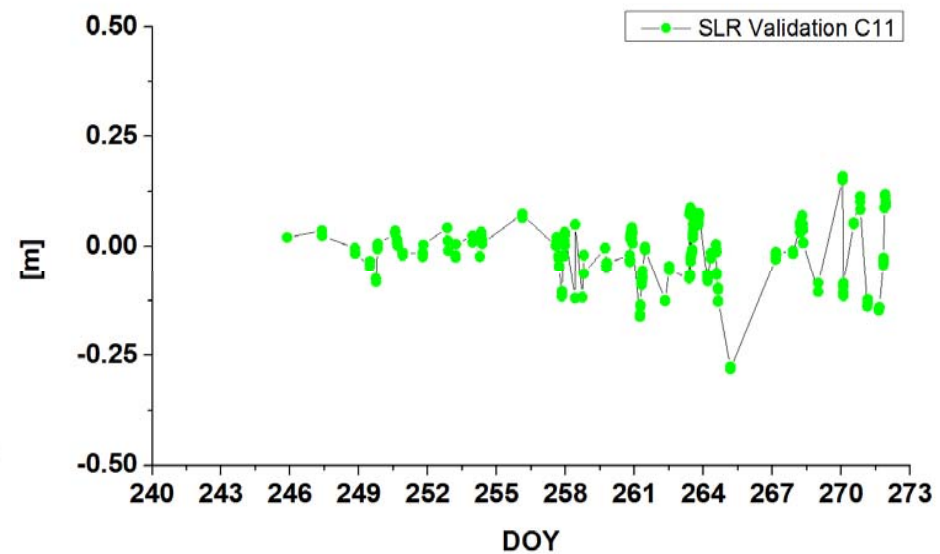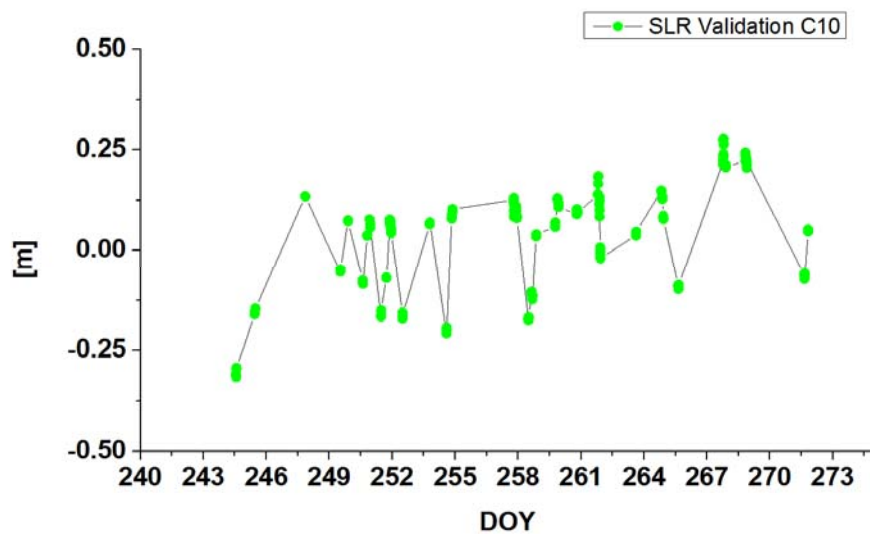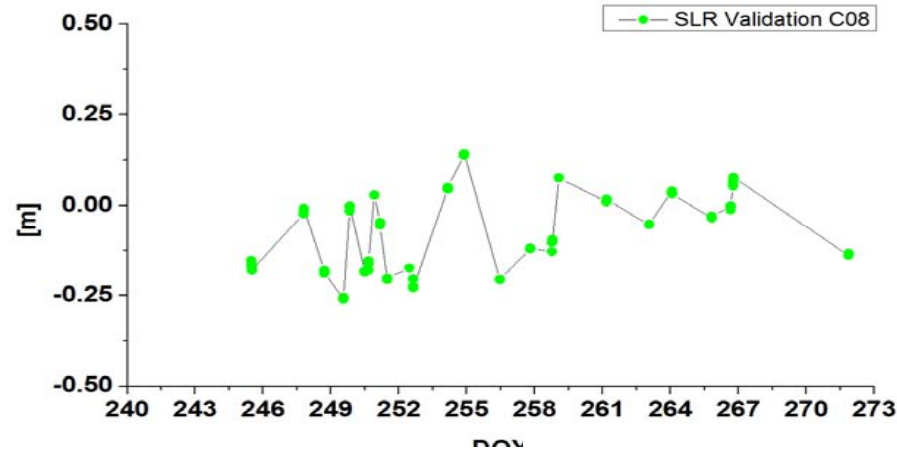
Precise Orbit&Clock Determination

SLR Validation
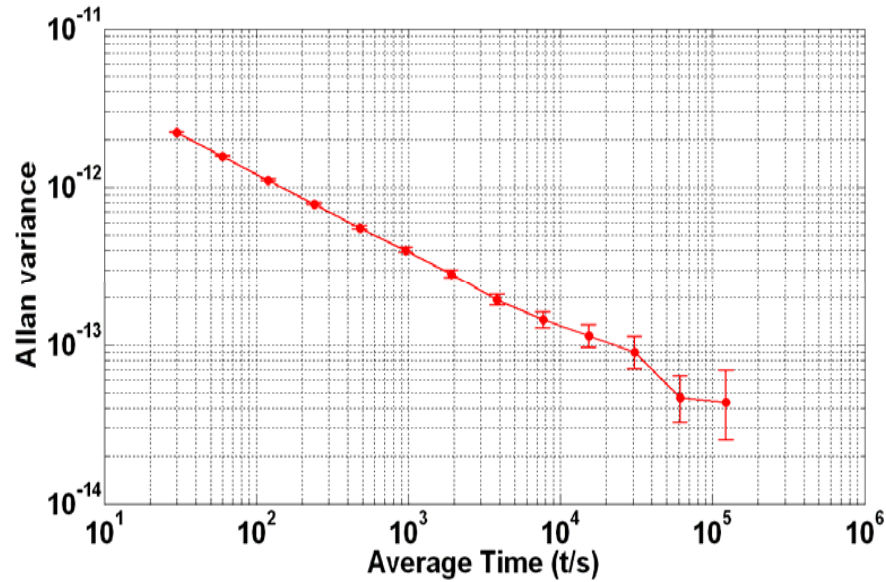
Allan Variance for GEO: CO3

Hadamard Variance for GEO: CO3
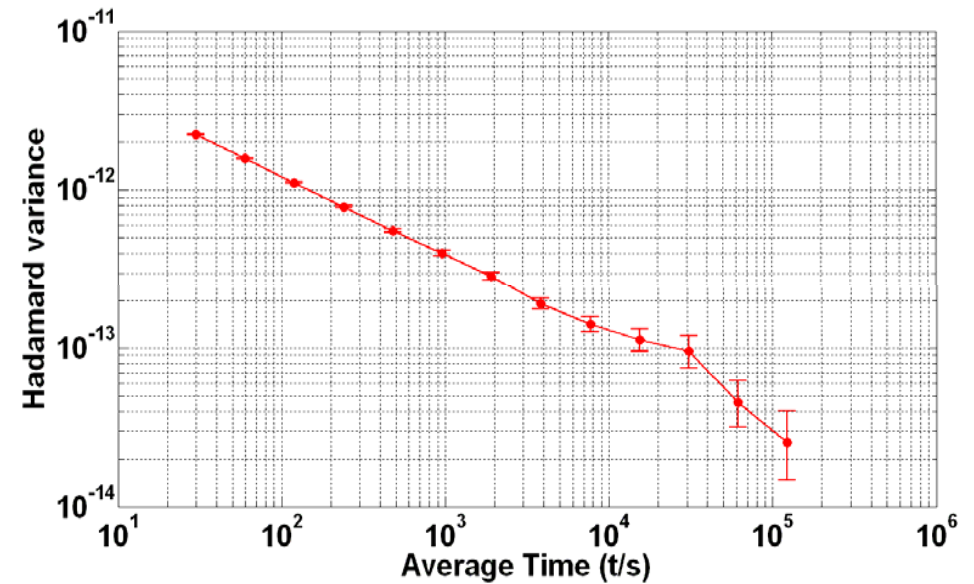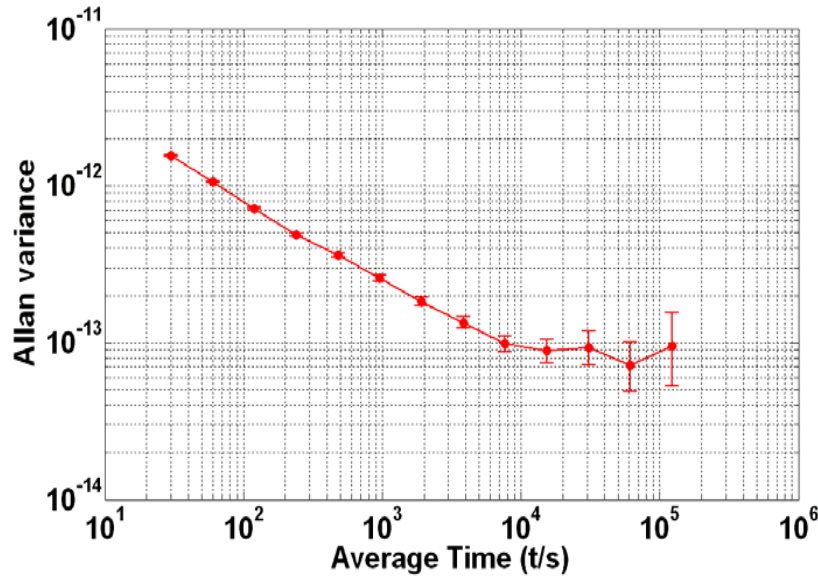
Hadamard Variance for IGSO: CO8

Allan Variance for IGSO: CO8
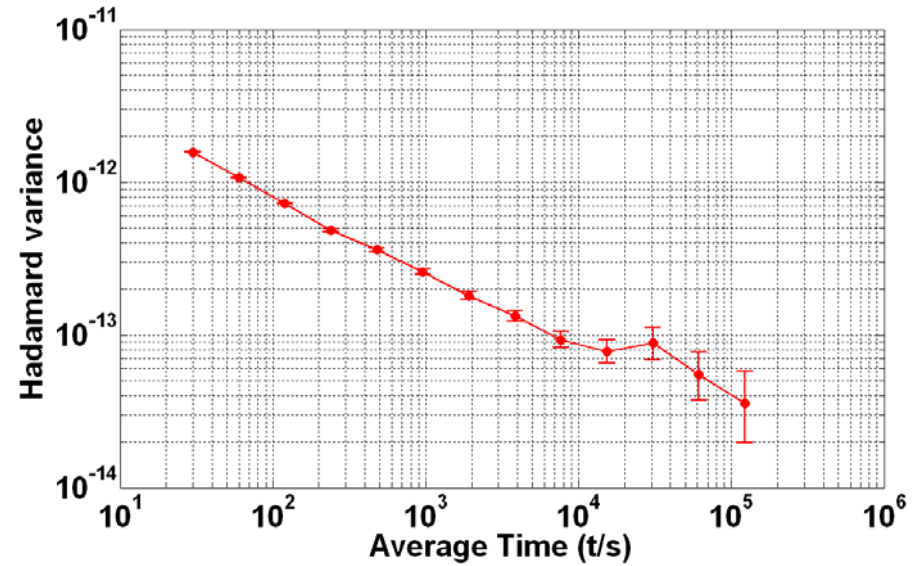
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SIS Accuracy

36000 km   6371 km
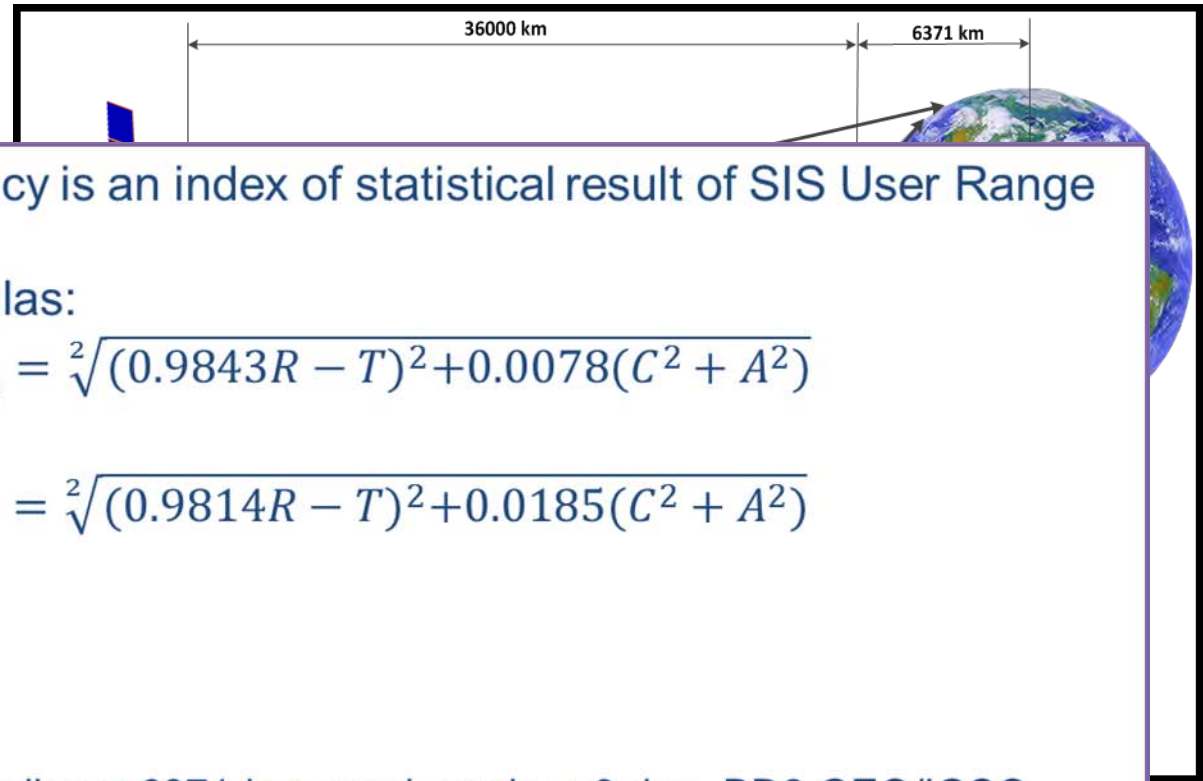
Signal in Space (SIS) Accuracy is an index of statistical result of SIS User Range Error (SIS URE)

Derived BD-2 SIS URE formulas:

$$URE^2_{BD2\,GEO/IGSO} = \sqrt[2]{(0.9843R - T)^2 + 0.0078(C^2 + A^2)}$$

$$URE^2_{BD2\,MEO} = \sqrt[2]{(0.9814R - T)^2 + 0.0185(C^2 + A^2)}$$

- -R: radial error
- -C: cross error
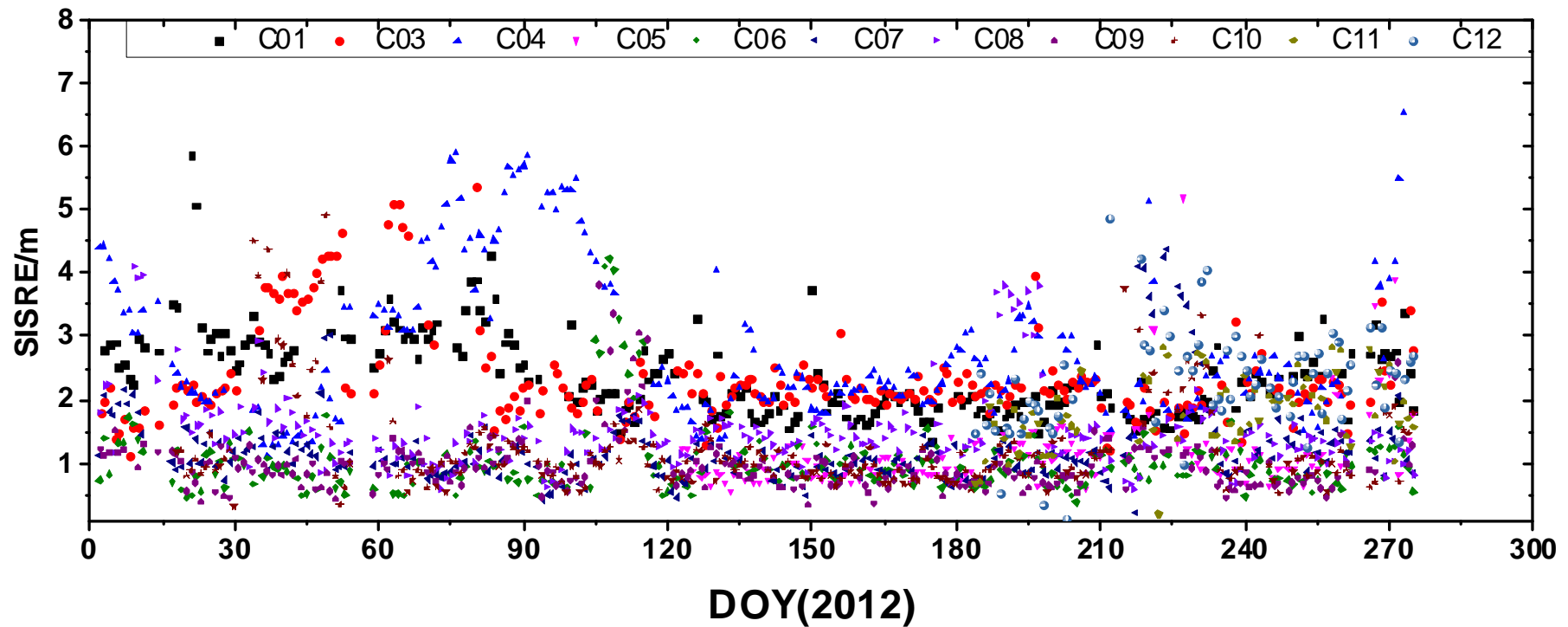- -A: along error
- -T : clock error

* assumed that   Earth Radius = 6371 km, mask angle = 0 deg, BD2 GEO/IGSO Altitude =36000 km , BD2 MEO Altitude =21500 km

SISRE of broadcast ephemeris

Positioning Performance of BeiDou
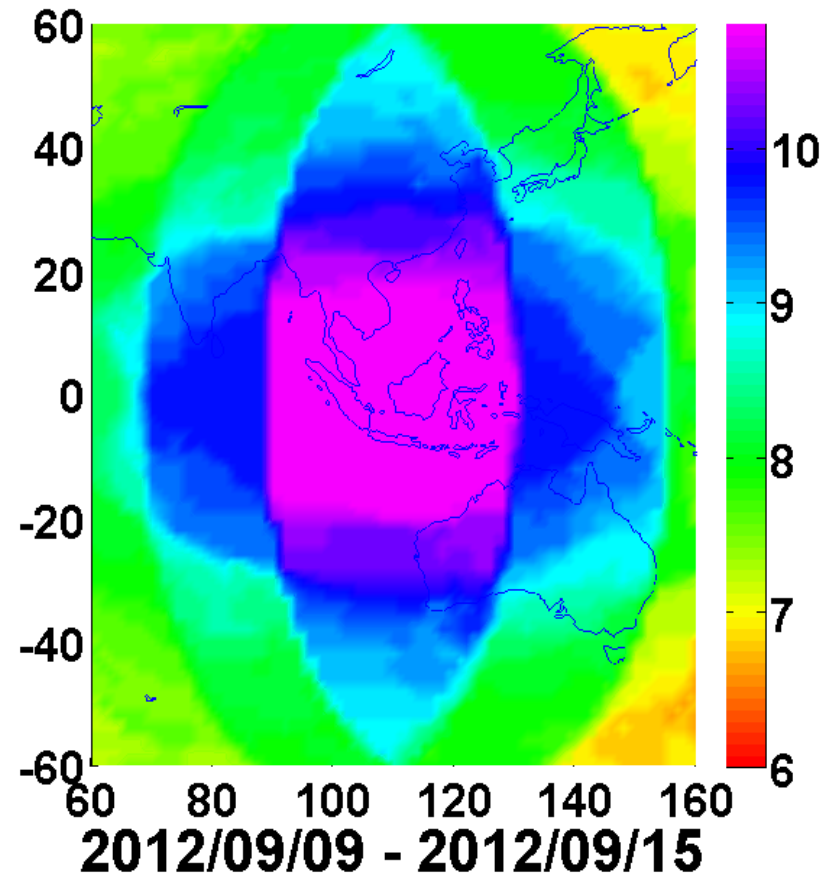
- **URE caused by Ionosphere parameters,   and**
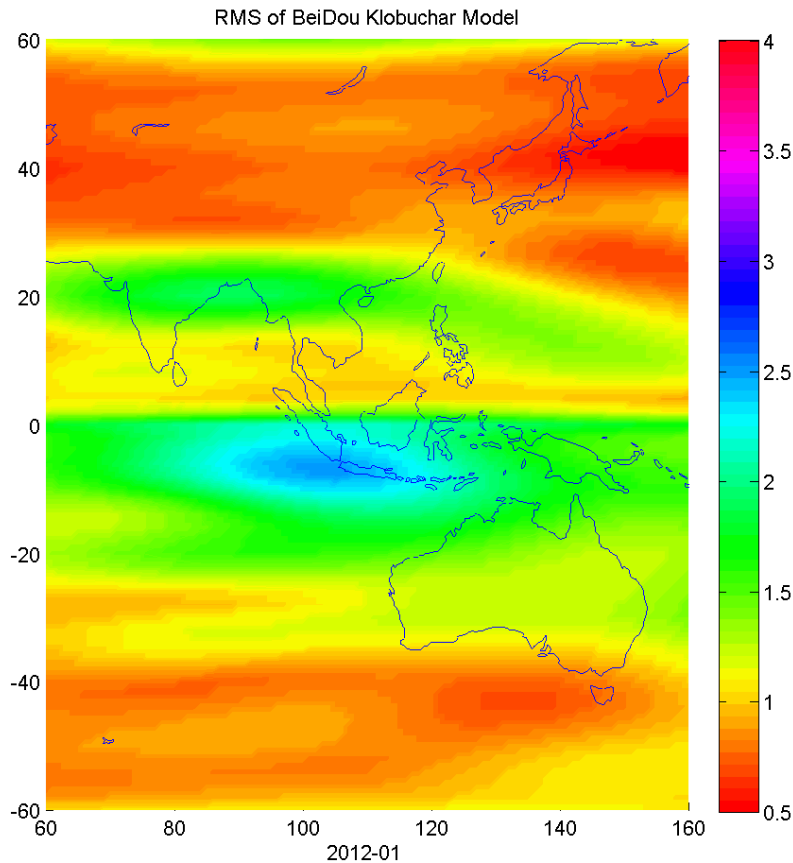
Ionosphere difference between model of
IGS and parameters from BeiDou

visible working satellites of
BeiDou with 4+5+2 satellites

Positioning Performance of BeiDou

PDOP(95%) Positioning Accuracy (95%)
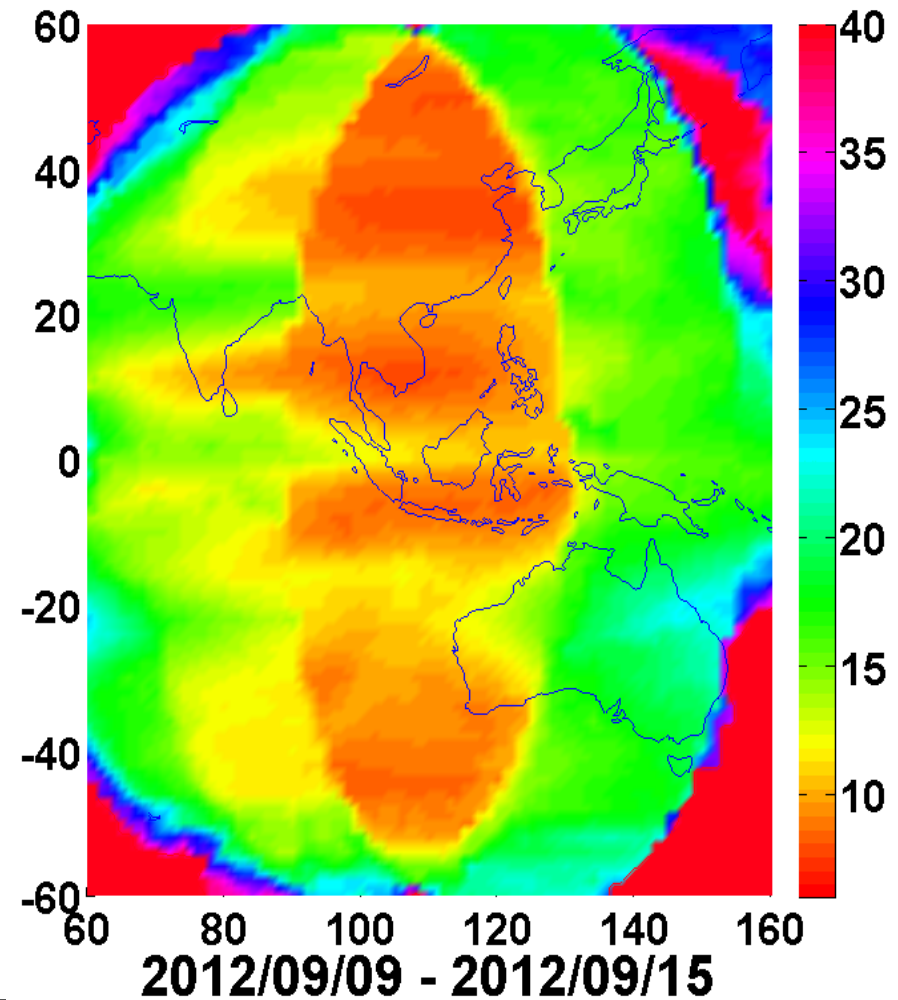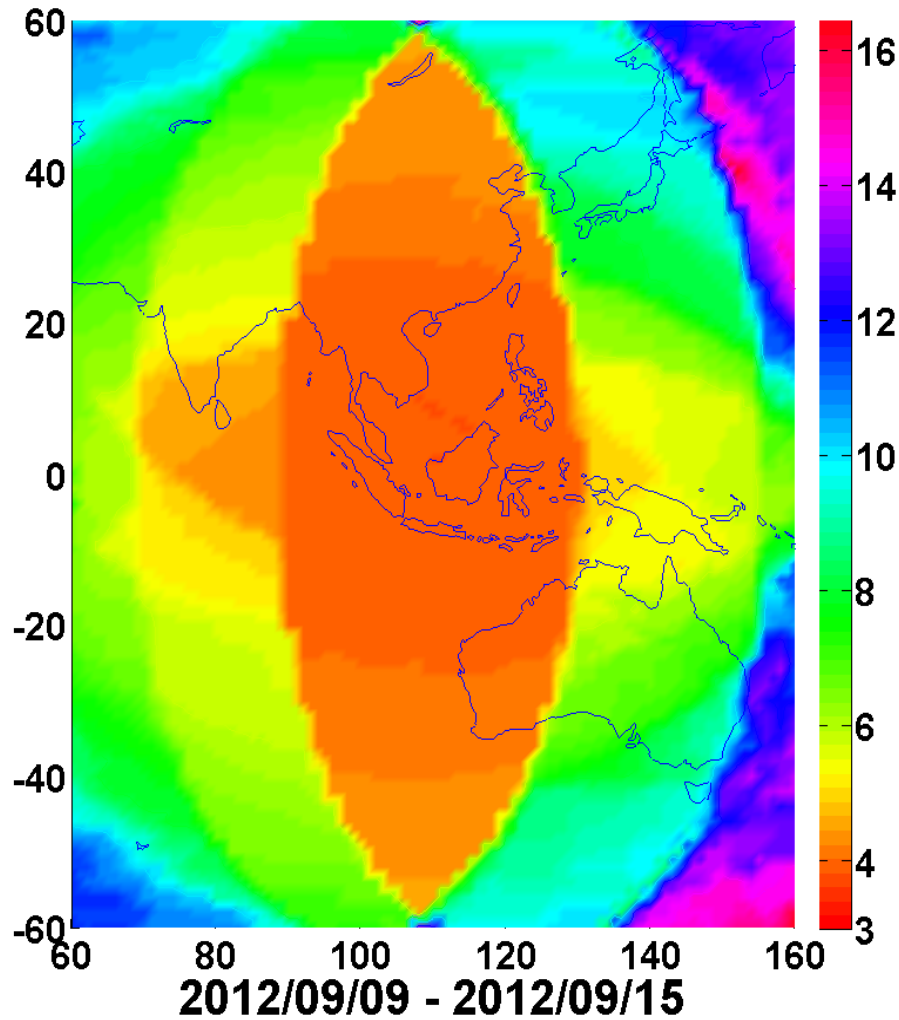
Positioning Performance of BeiDou

- **SPP results of Beijing Station (U:16->6m; EN:11->5m)**

BJF1 station SPP(B1)
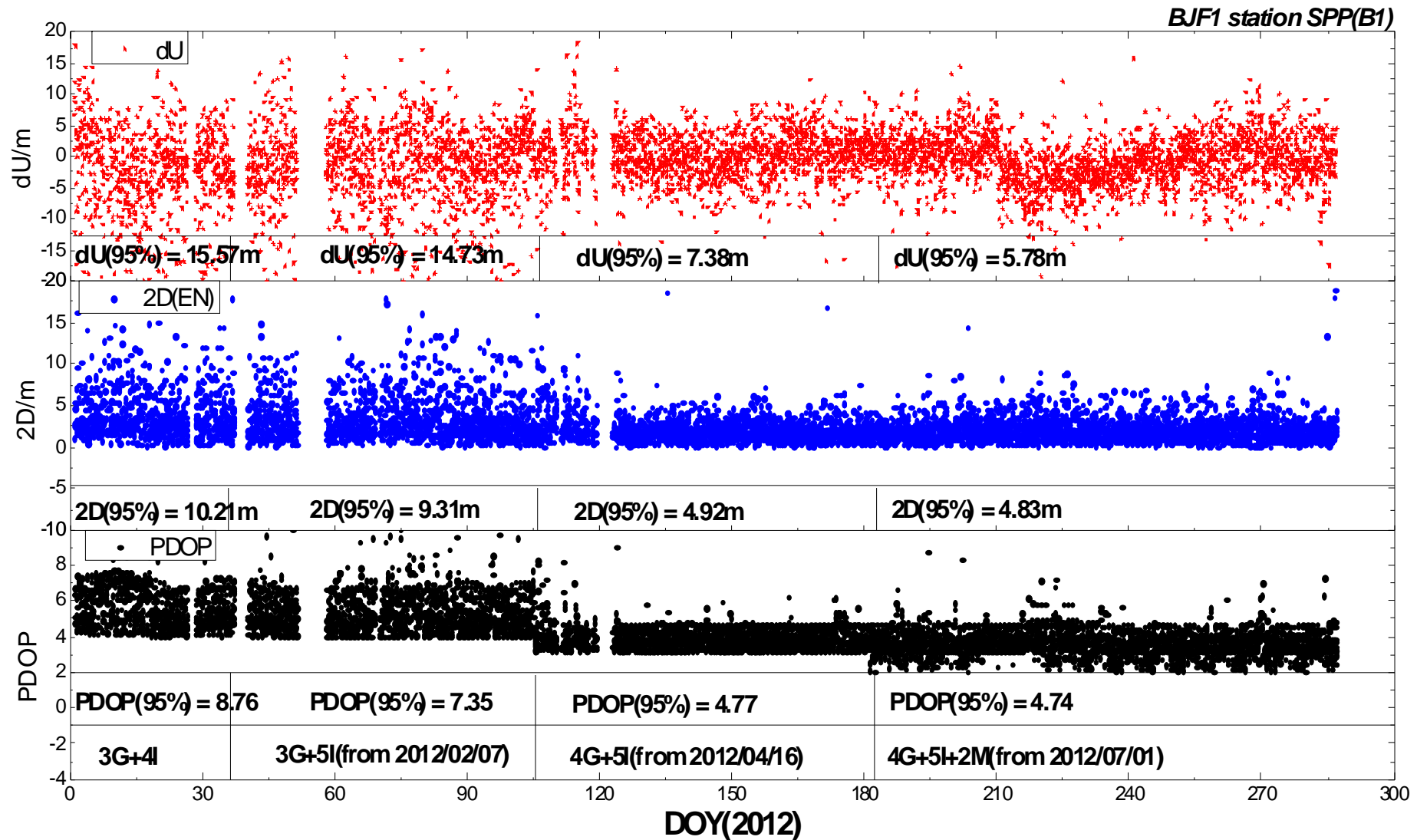
Positioning Performance of BeiDou

- **SPP results of Wuhan Station (U:15->10m; EN:8->5m)**

CENT station SPP(B1)

dU(95%) = 13.15m   dU(95%) = 15.15m   dU(95%) = 11.98m   dU(95%) = 9.98m

2D(95%) = 7.07m   2D(95%) = 7.05m   2D(95%) = 4.87m   2D(95%) = 5.03m

PDOP(95%) = 6.88   PDOP(95%) = 6.55   PDOP(95%) = 4.04   PDOP(95%) = 4.03

3G+4I   3G+5I(from 2012/02/07)   4G+5I(from 2012/04/16)   4G+5I+2M(from 2012/07/01)

DOY(2012)
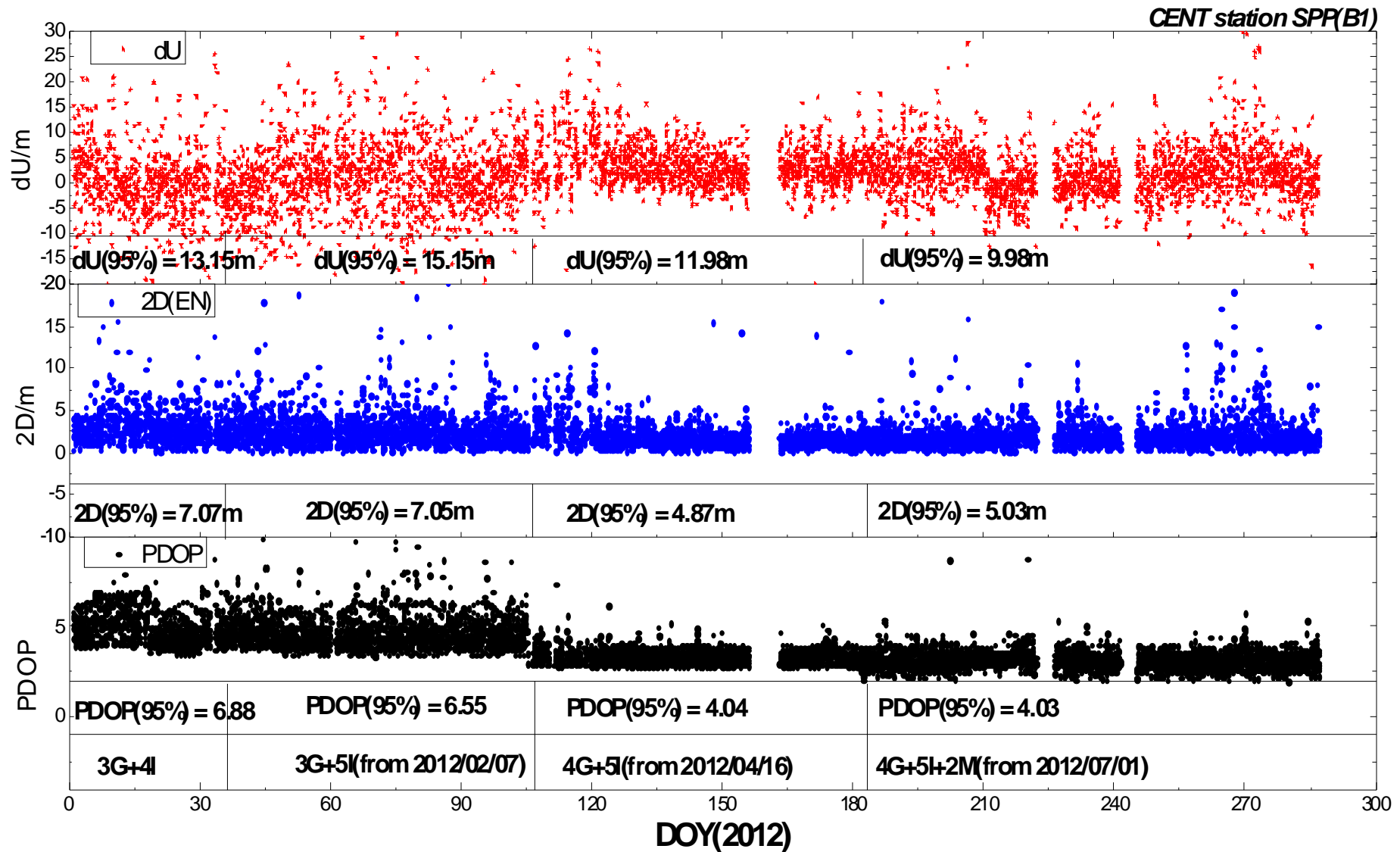
- **SPP results of Perth Station (U:15->10m; EN:8->5m)**
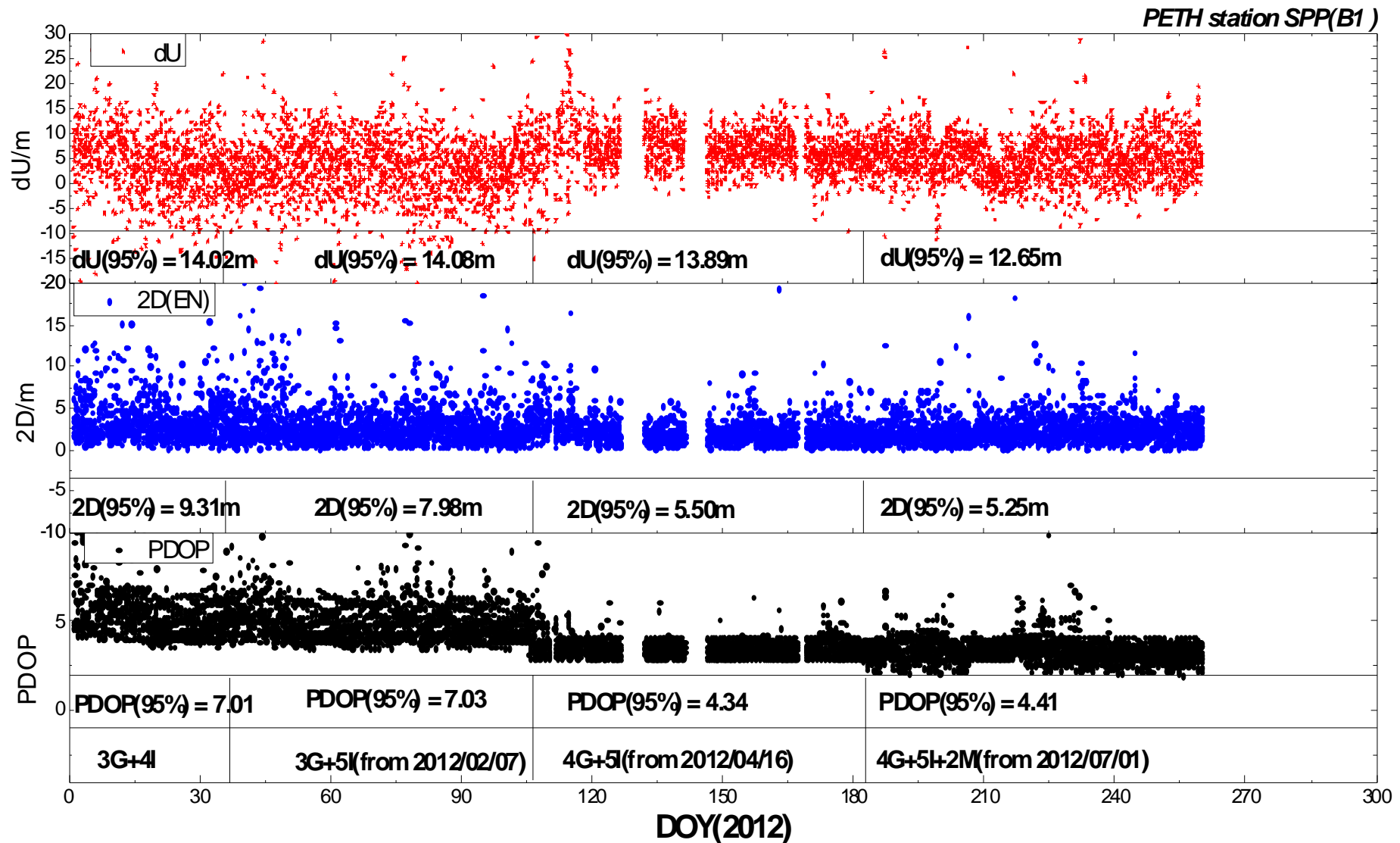
PETH station SPP(B1)

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Multi-GNSS Application

- **Navigation performance**

Stand alone results (single frequency)

the vertical direction accuracy seems to be significantly improved when

using GPS + Glonass + Beidou !

Multi-GNSS Application

- ## RTK performance

Multi-GNSS combination baseline kinematic resolutions

Multi-GNSS Application

- ## PPP performance
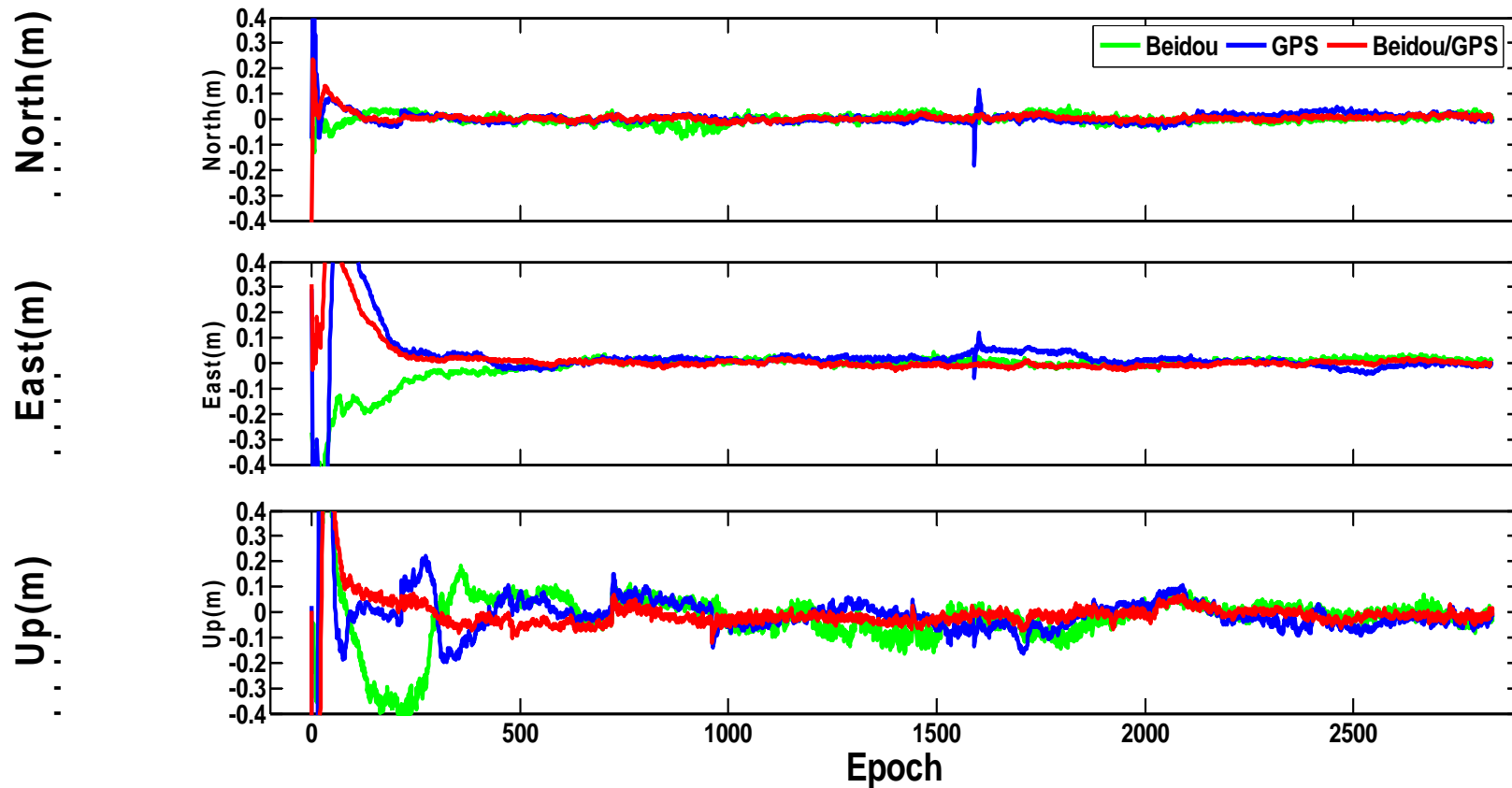
Summary

- ➢ POD of BeiDou, better than 10cm in redial direction

- ➢ For navigation users, 8-15 m(95%),Using BeiDou along, with 4GEO+5IGSO+2MEO constellation

- ➢ For navigation users, the Multi-GNSS combined results can be improved significantly compared with only one system used.

- ➢ Short baseline relative positioning, 1-3cm,using BeiDou only, and Kinematic relative positioning can be improved 20% by combining BeiDou and other GNSS, compared with other GNSS only

- ➢ PPP at cm lever using BeiDou precise O&C products, multi-GNSS PPP is more stable and with better accuracy.

Thanks for your attention!