WHU's Developments for the GPS Ultra-Rapid Products and the COMPASS Precise Products

C. Shi; Q. Zhao; M. Li; Y. Lou; H. Zhang;
W. Tang; Z. Hu; X. Dai; J. Guo; M.Ge; J. Liu

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University of Warmia and Mazury (UWM) Olsztyn, Poland

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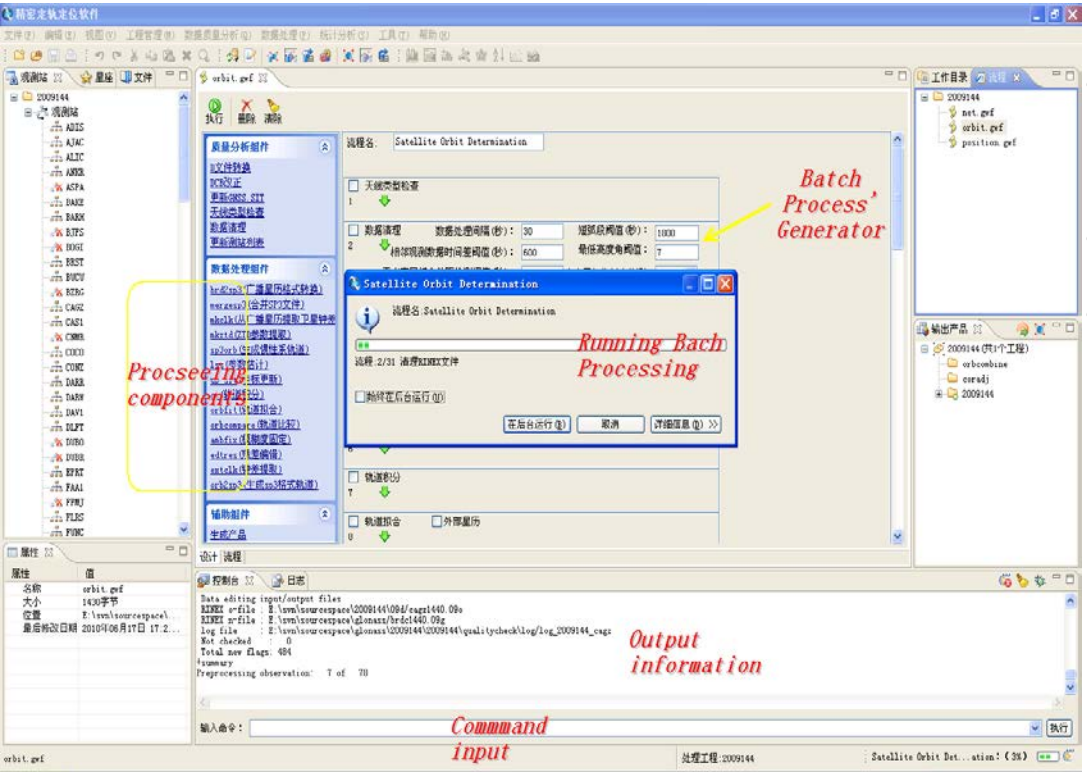
Outline

- Introduction of PANDA software
- Ultra-Rapid Products from WHU
- COMPASS Precise Products
- Summary

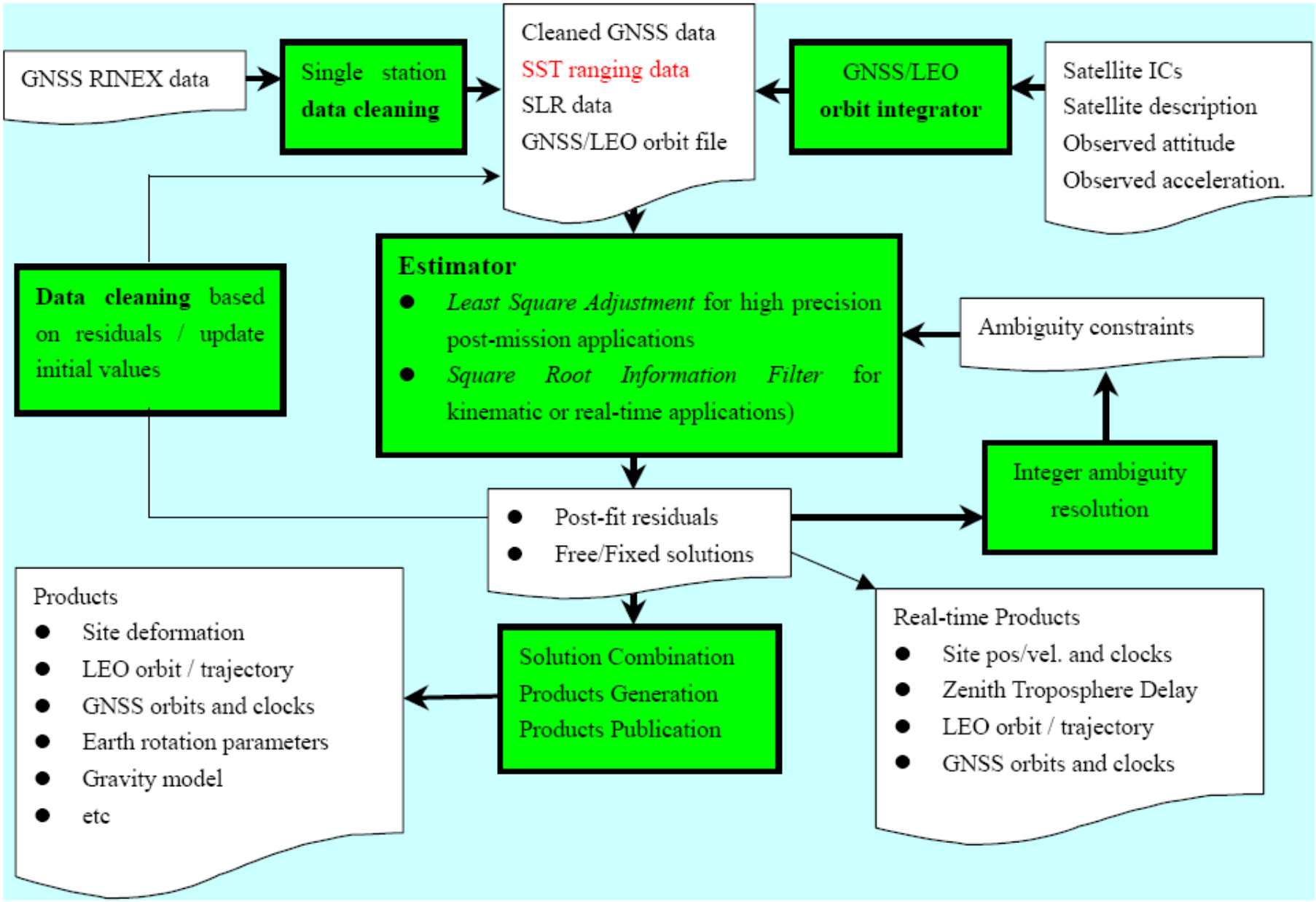
Software and Platform

PANDA : Positioning And Navigation Data Analyst



- To derive possible information from GNSS/SLR/ VLBI/DORIS data
- Real-time Processing function from 2007
- Current Applications
  - POD of GNSS (GPS, GLONASS, COMPASS, GALILEO)
  - POD of LEOs (CHAMP, GRACE, COSMIC, JASION, HY-2A,ZY-3)
  - Ionosphere Modeling
  - Huge Network data processing, PPP
  - SINEX Combination

PANDA System Structure



Ultra-Rapid Products from WHU

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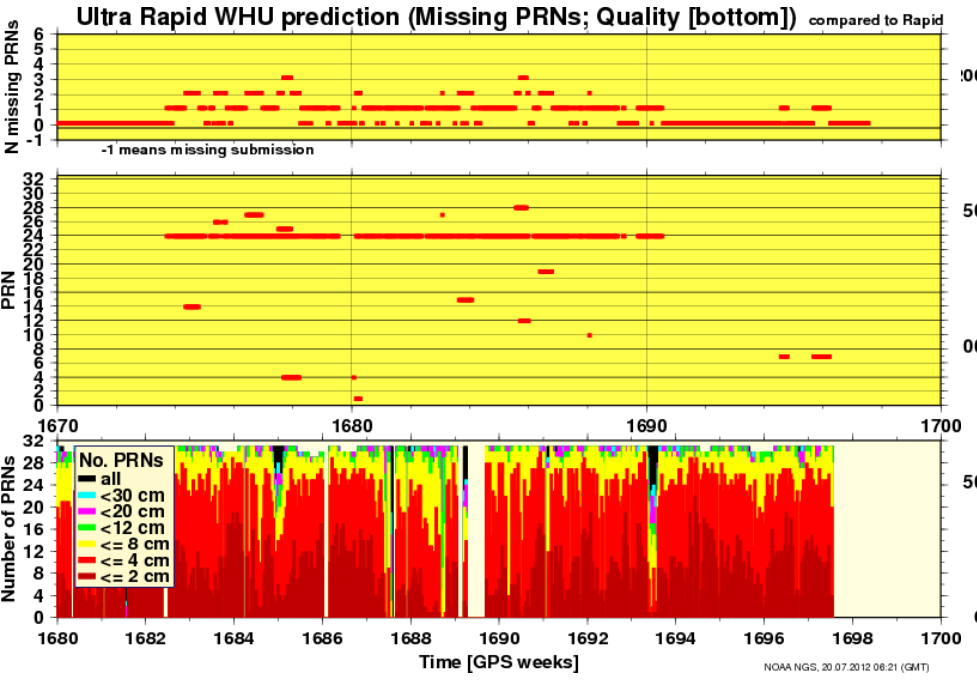
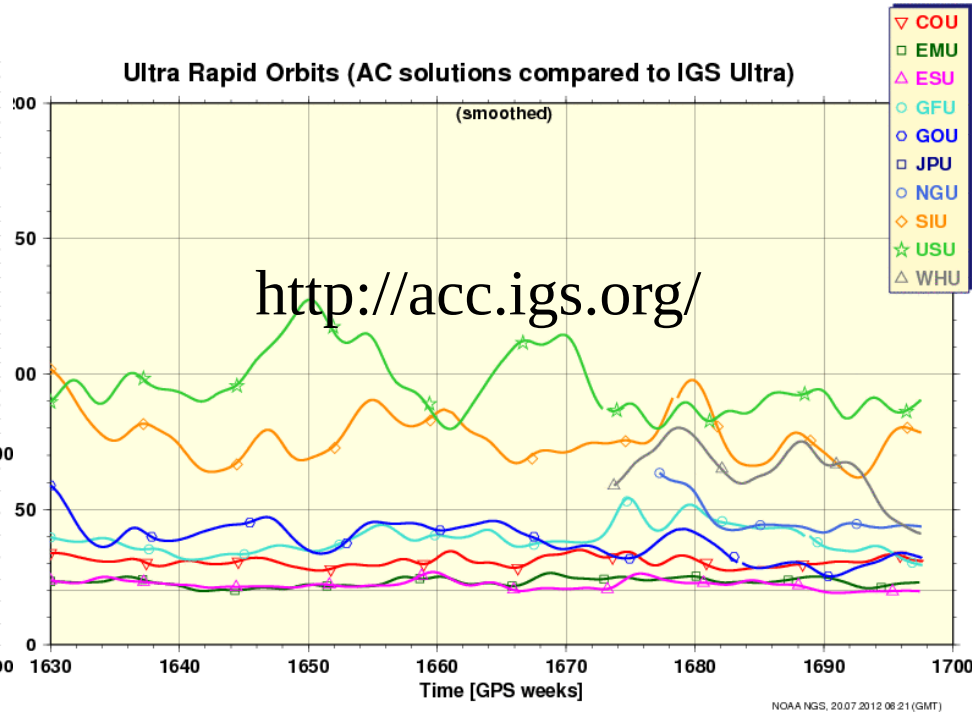
Analysis Strategy Summary

	ESTIMATED PARAMETERS (APRIORI VALUES AND CONSTRAINTS)
Adjustment	Weighted least squares algorithm
Station coordinates	All coordinates are estimated in the IGS08 realization of the ITRF2008. The datum is realized by tightly constraining the processed Reference Frame stations to their current coordinate values.
Satellite clock	solved for at each epoch (white noise process)
Receiver clock	solved for at each epoch (white noise process); one clock fixed and used as a time reference
Orbits	6 parameters for initial position and velocity 5 parameters for solar radiation pressure modeling,
	24 hours estimation and 24 hours prediction
Satellite attitude	yaw rate is estimated for BLOCK II/IIA/IIF satellites during shadow crossing
Troposphere	zenith delay: zenith delay parameters for each station with 1 hour intervals
	mapping function: wet Global Mapping Functions (GMF)
	zenith delay epochs: each integer hour
	gradients: north and east horizontal delay are estimated for each station in daily intervals
Ionospheric corrections	Not estimated (ionosphere free based analysis)
Ambiguities	ambiguities are fixed according to Ge et al.(2005)
Earth Orient.Parameters (EOP)	X and Y pole coordinates, and UT1 UTC represented with continuous piece wise linear function

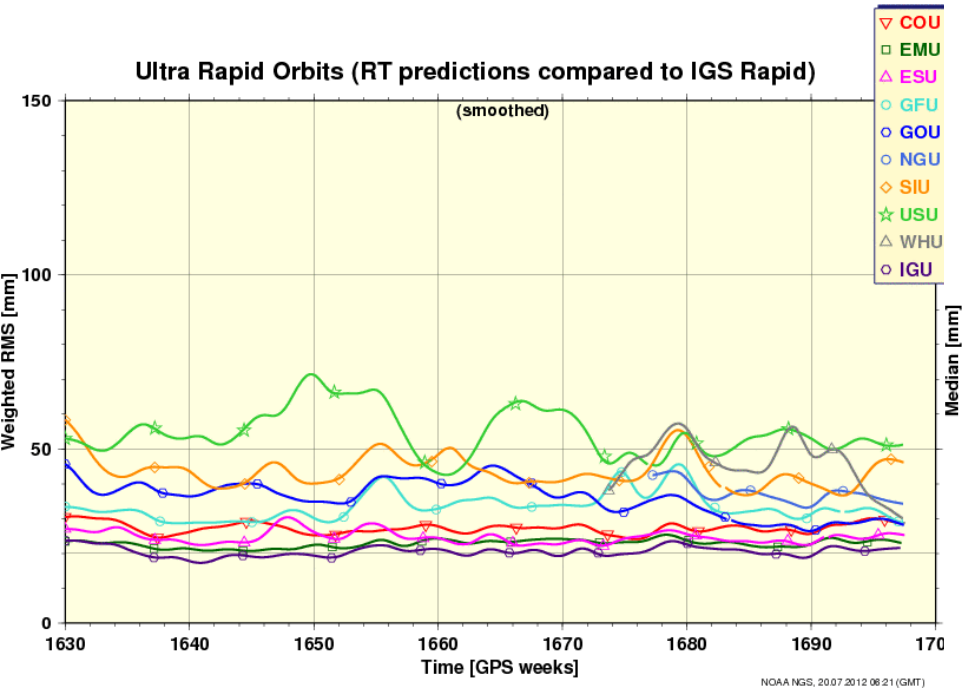
Ultra-rapid orbit Quality

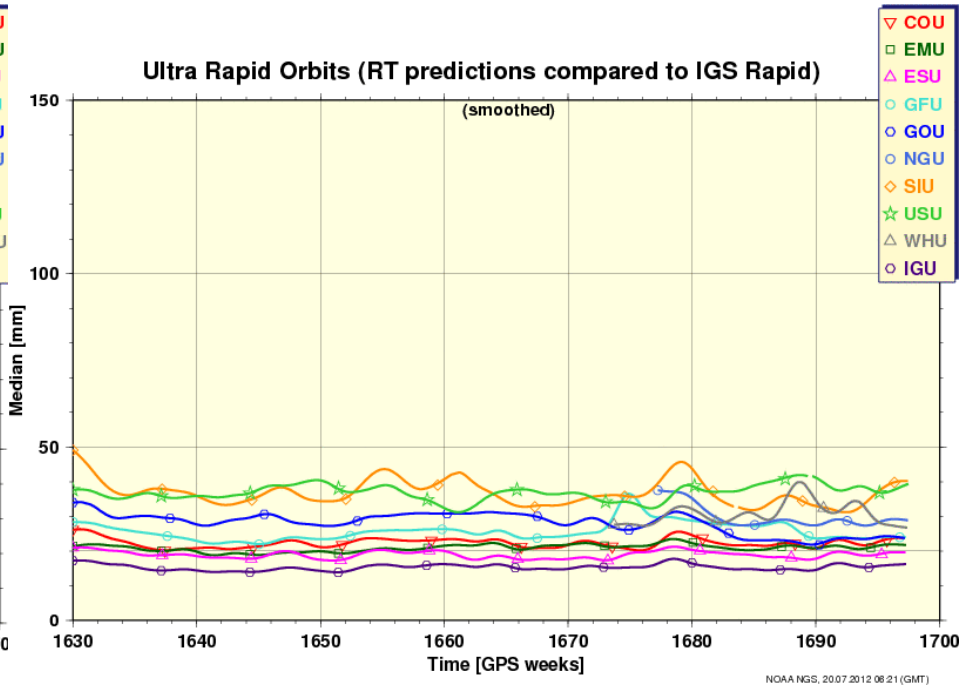




Better than 5cm compared with IGS ultra-rapid orbit

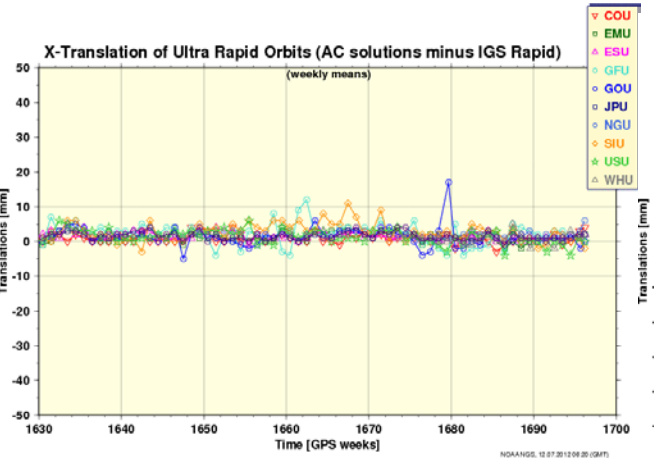
Ultra-rapid orbit precision compared with IGS Rapid

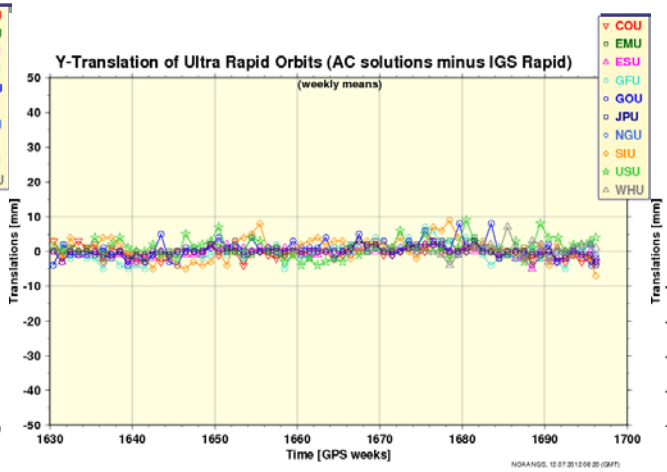


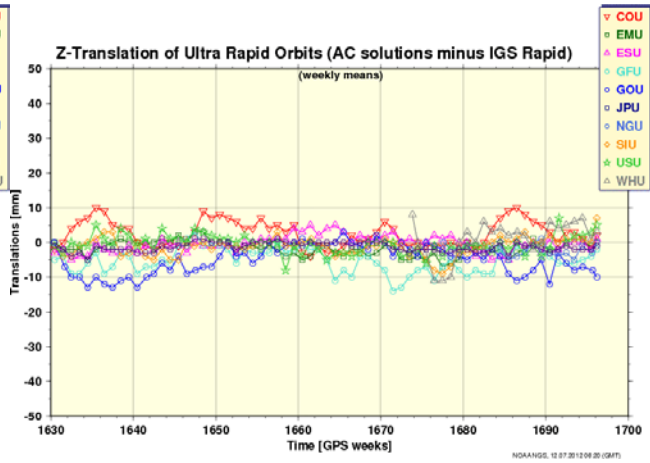


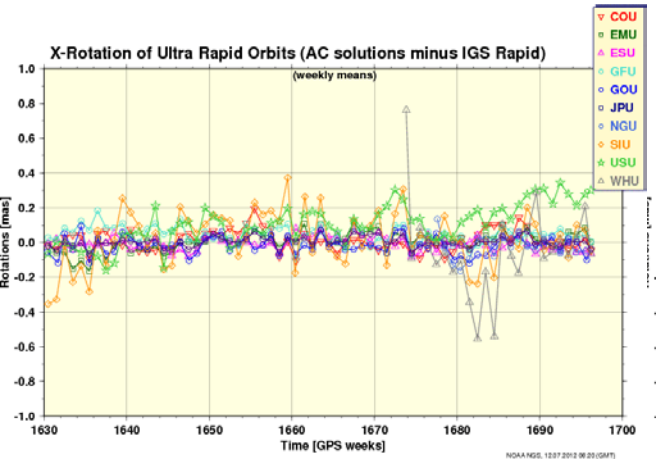
About 3cm compared with IGS rapid orbit

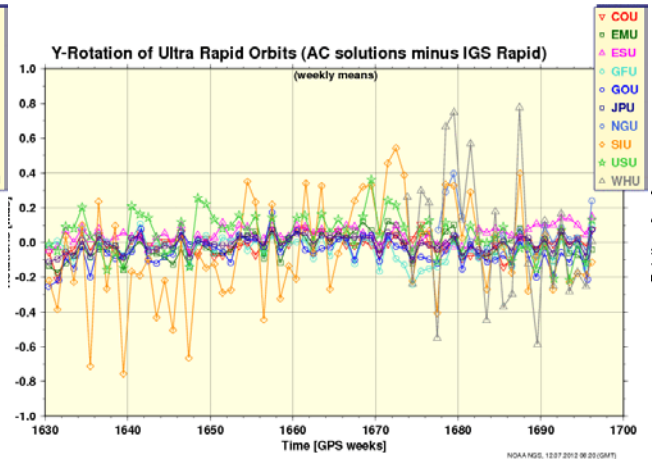
Orbit transformation results compared to Rapid orbit

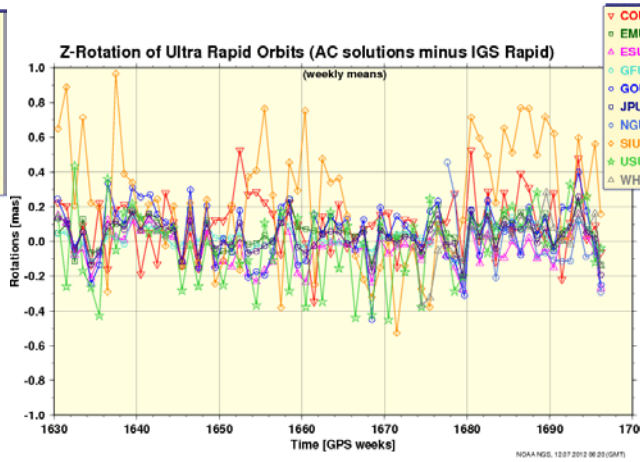












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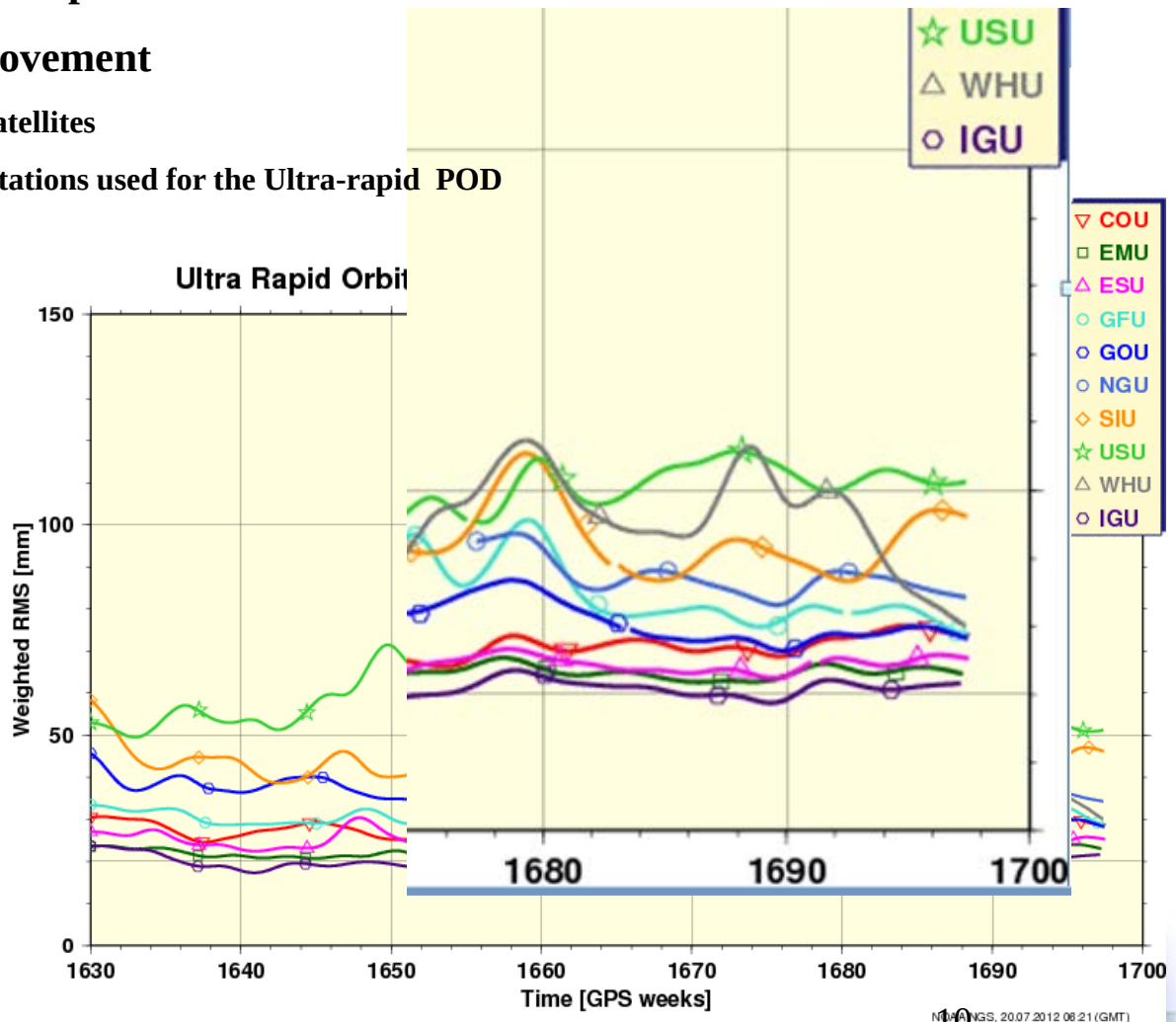
Improvement step by step

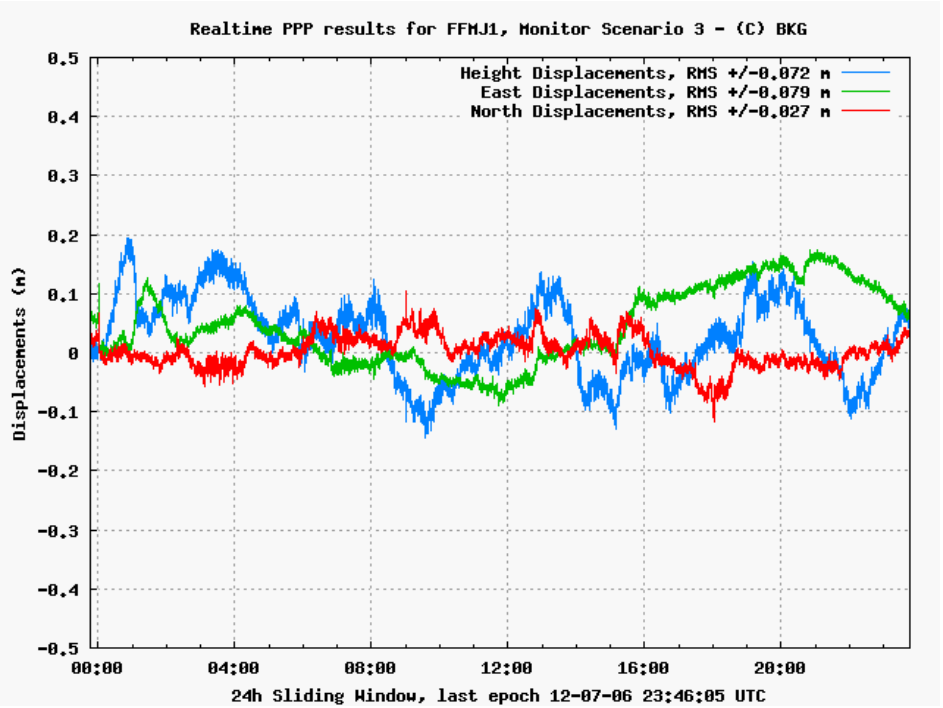
1) **Improvements of the Ultra-rapid orbits from WHU**

2) **Steps for continuous improvement**

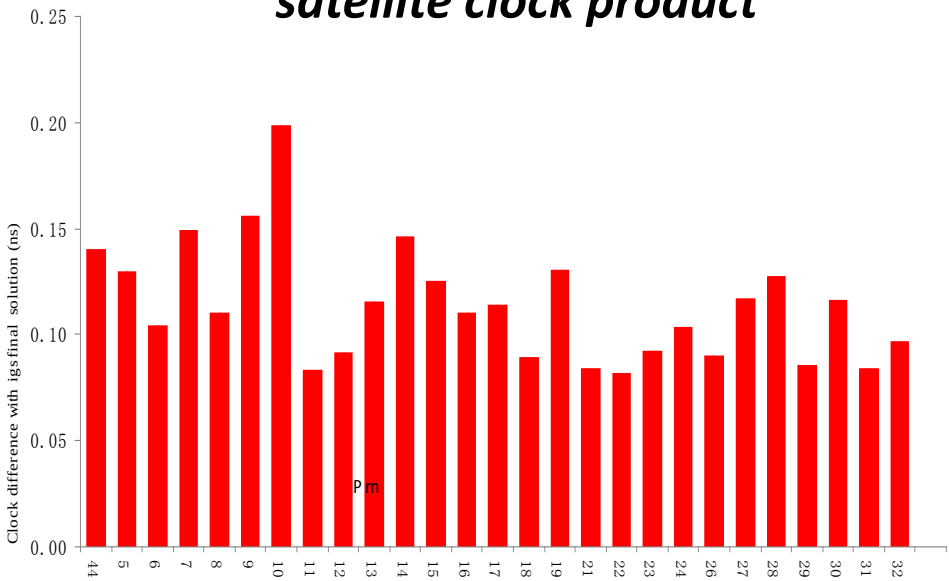
- **Prediction for the eclipse satellites**
- **New strategy for choosing stations used for the Ultra-rapid POD**
- **…..**



Application (real-time GPS products)



Statistical RMS of real-time satellite clock product

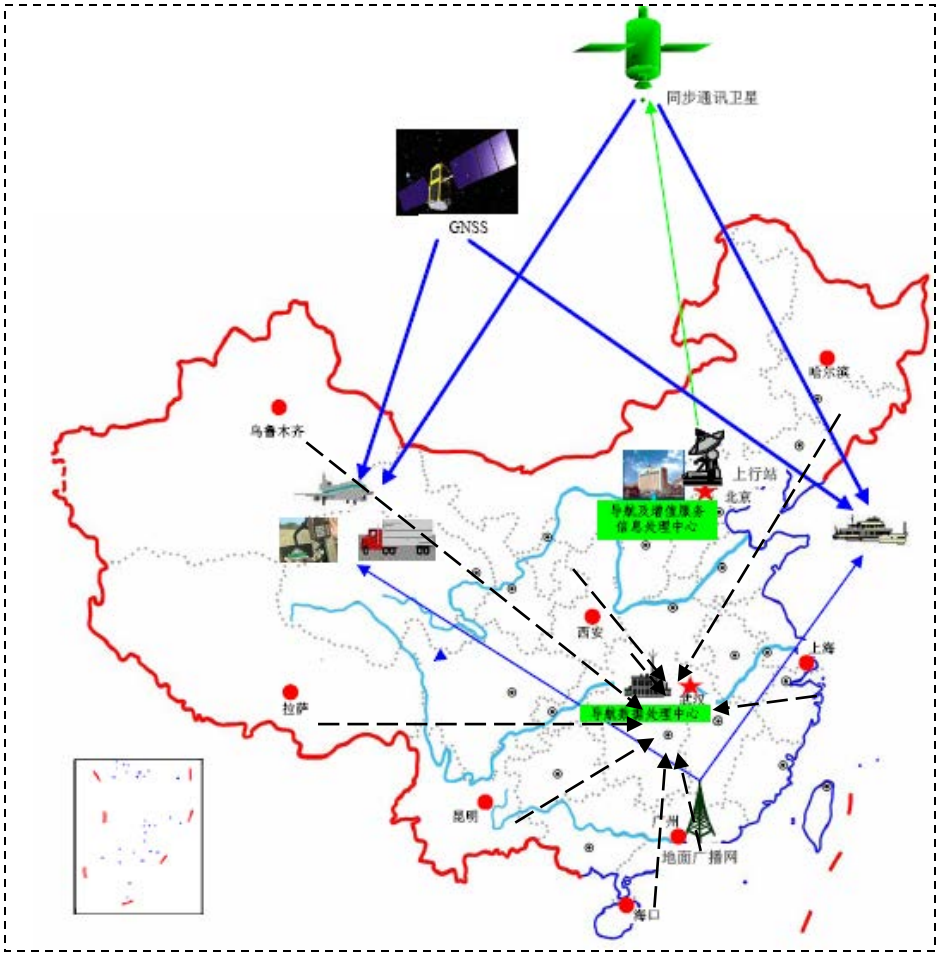


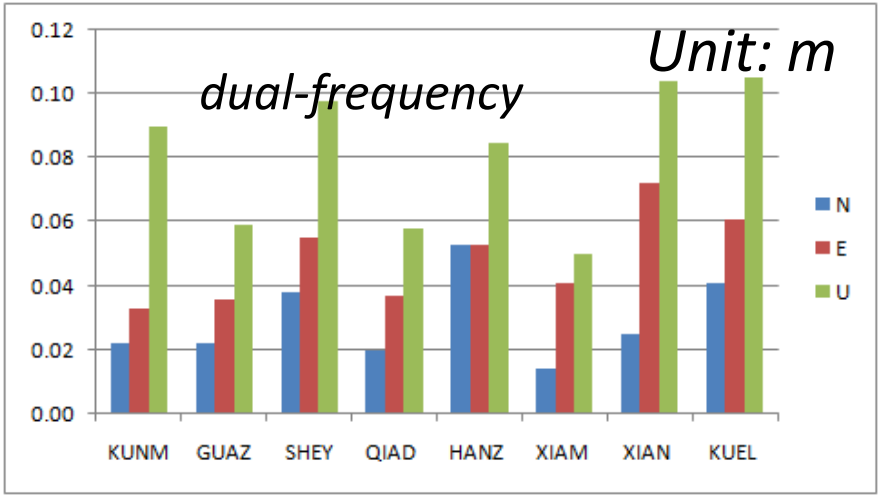
Clock Streams:CLK15 & CLK16

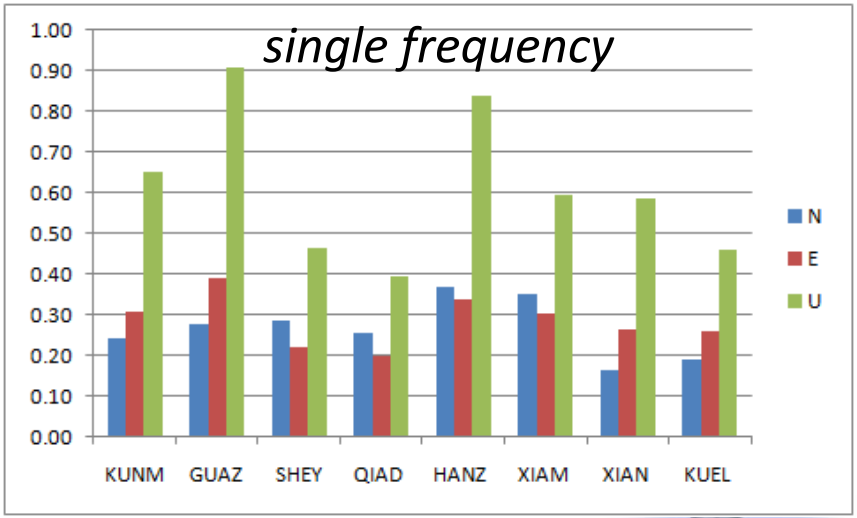
Real-time evaluation by BKG

http://igs.bkg.bund.de/ntrip/ppp#Scene3

Application (Augmentation Service System in China)







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COMPASS Precise Products

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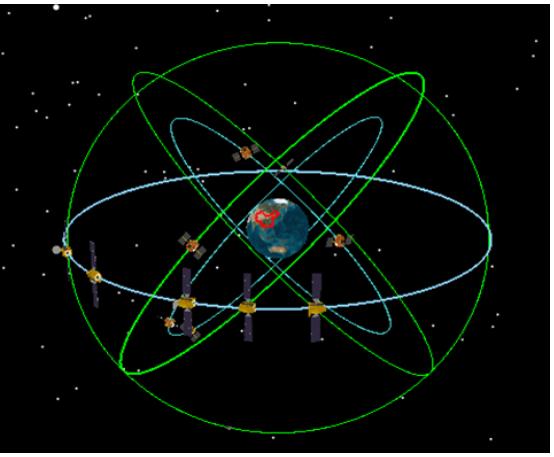
COMPASS Precise Products

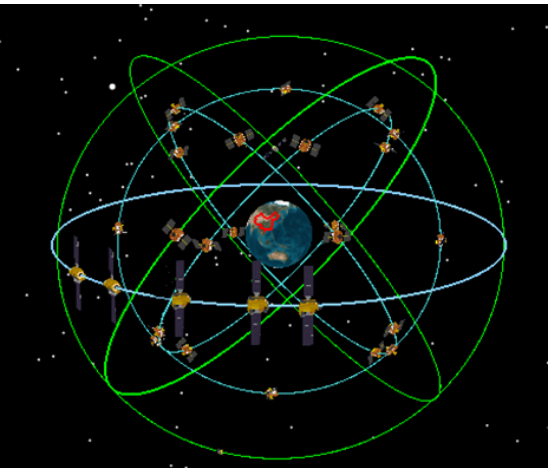
- **Status of COMPASS**
- **POD and SPP performance of COMPASS**
- **Precise positioning using COMPASS**
- **Plan for providing precise products of COMPASS**

Status of COMPASS

Current operational Satellites: 4GEO+5IGSO+2MEO
2012: 5GEO+5IGSO+4MEO（Regional Service）
2020: 5GEO+3IGSO+27MEO（Global Service）

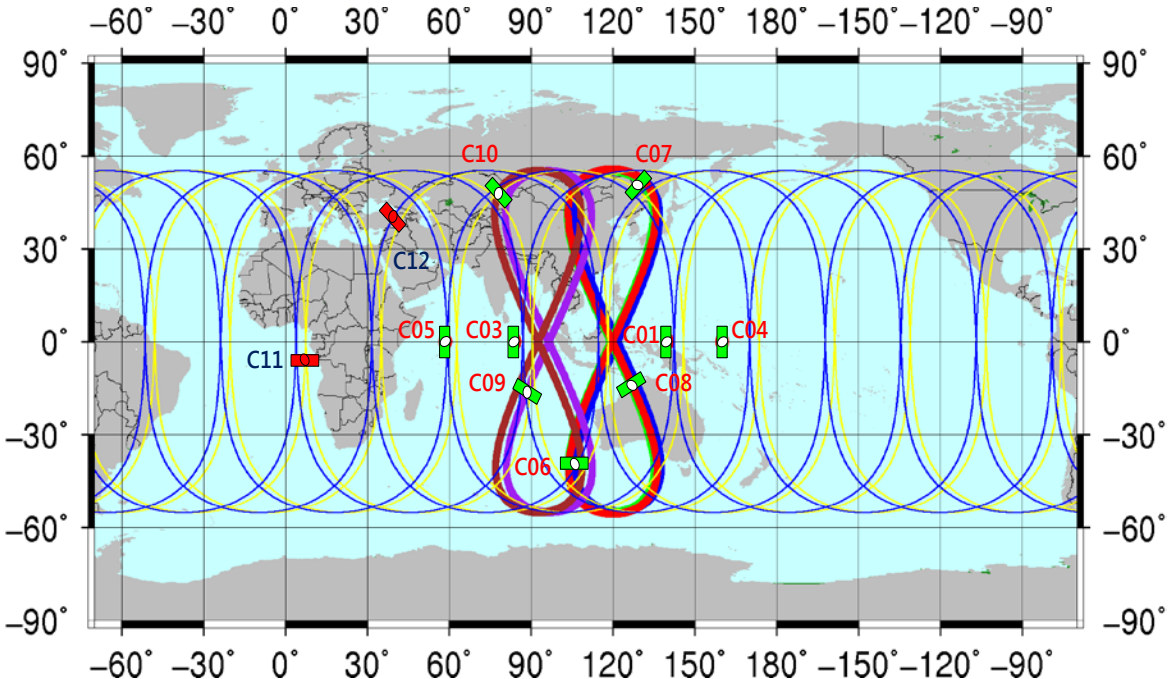


2012

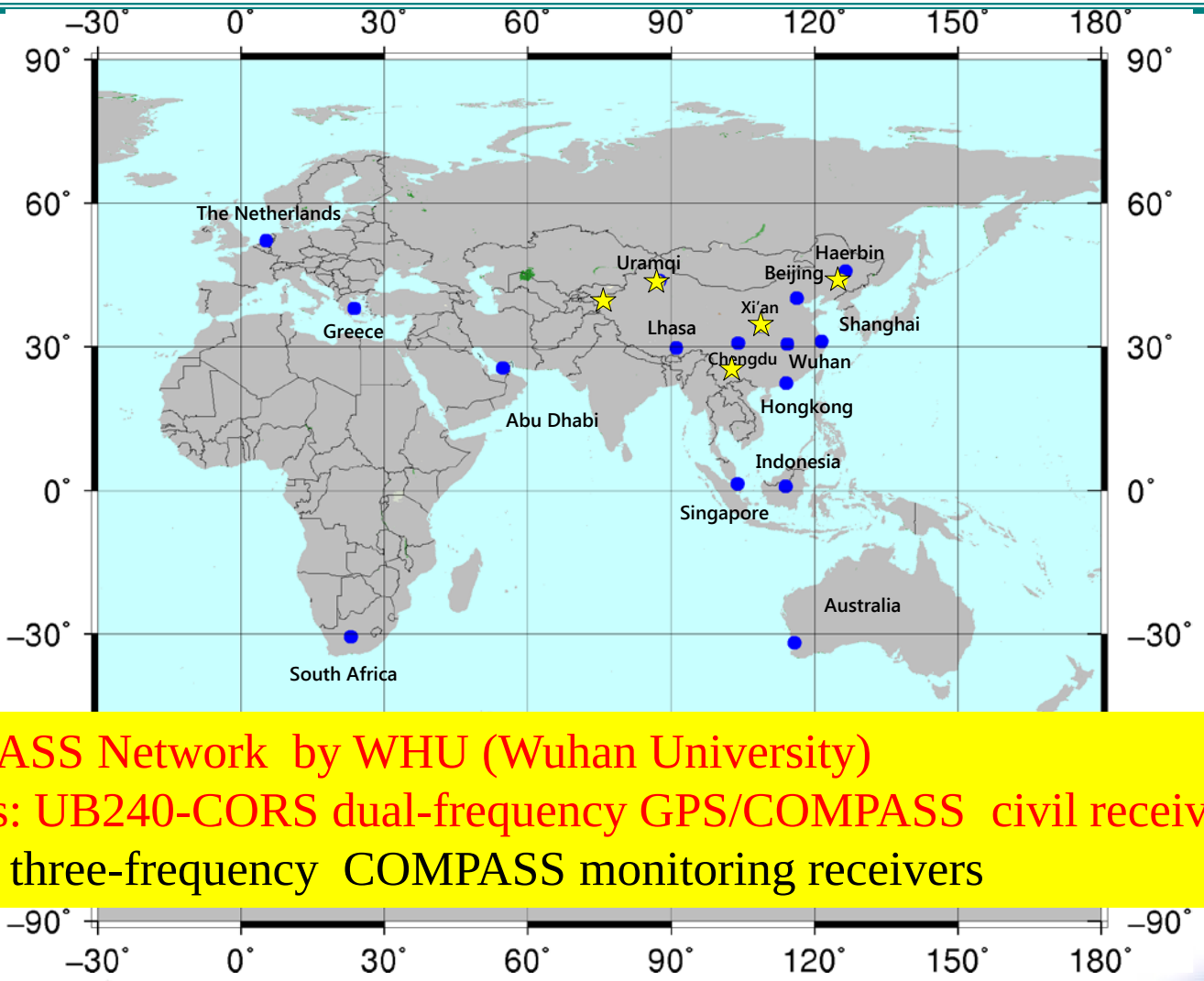


2020

July,2012



POD of COMPASS



COMPASS Network by WHU (Wuhan University)

17 sites: UB240-CORS dual-frequency GPS/COMPASS civil receivers

5 sites: three-frequency COMPASS monitoring receivers

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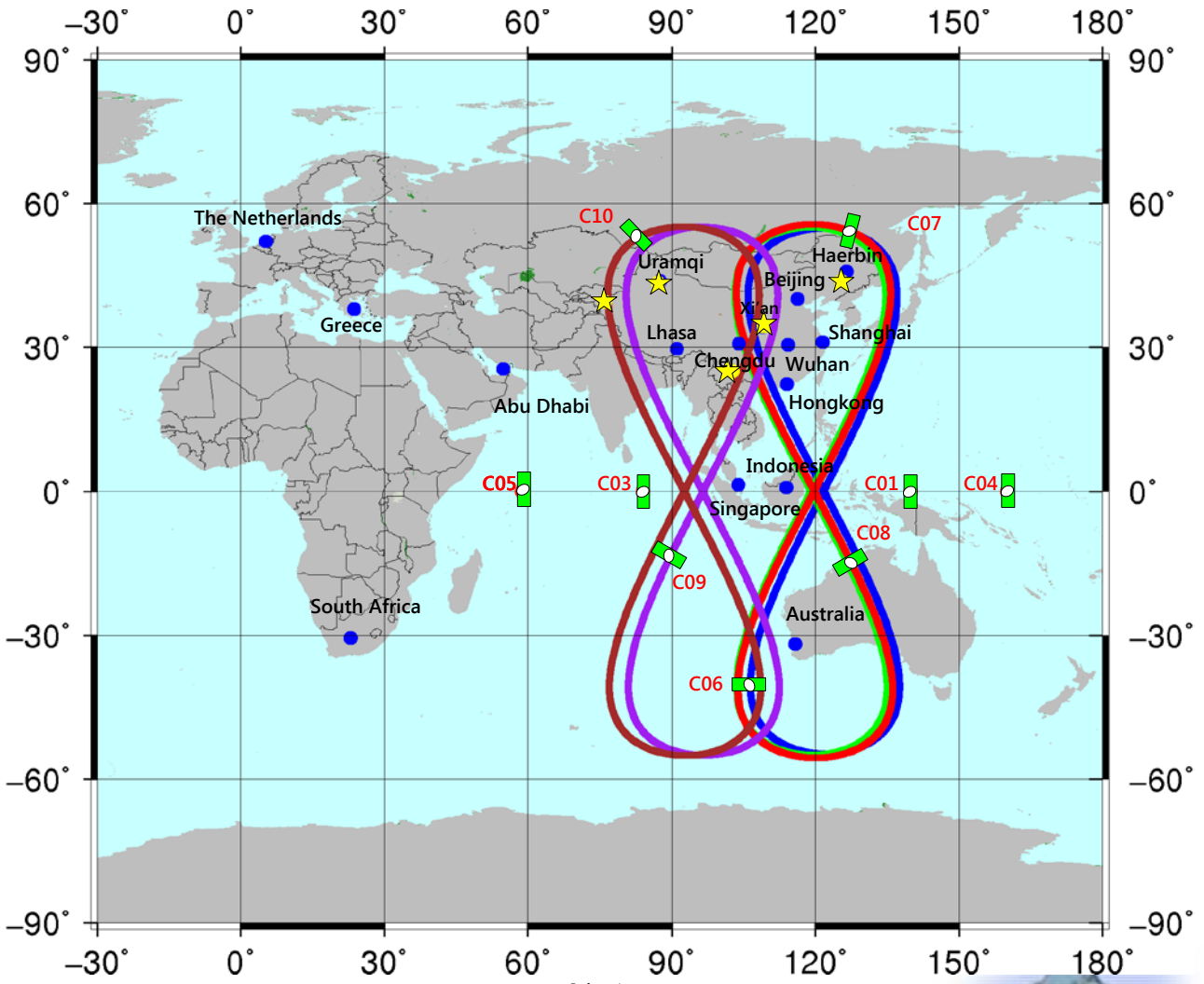
POD of COMPASS

- 4GEO+5IGSO
- 1-30,Jun,2012



Indonesia

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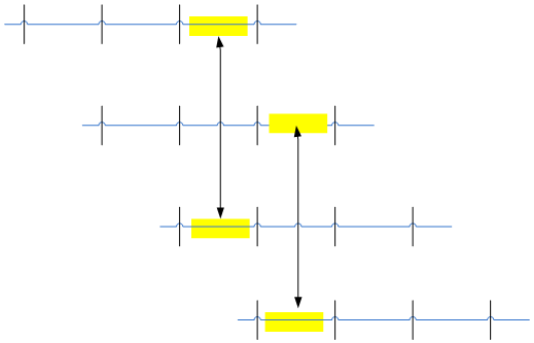
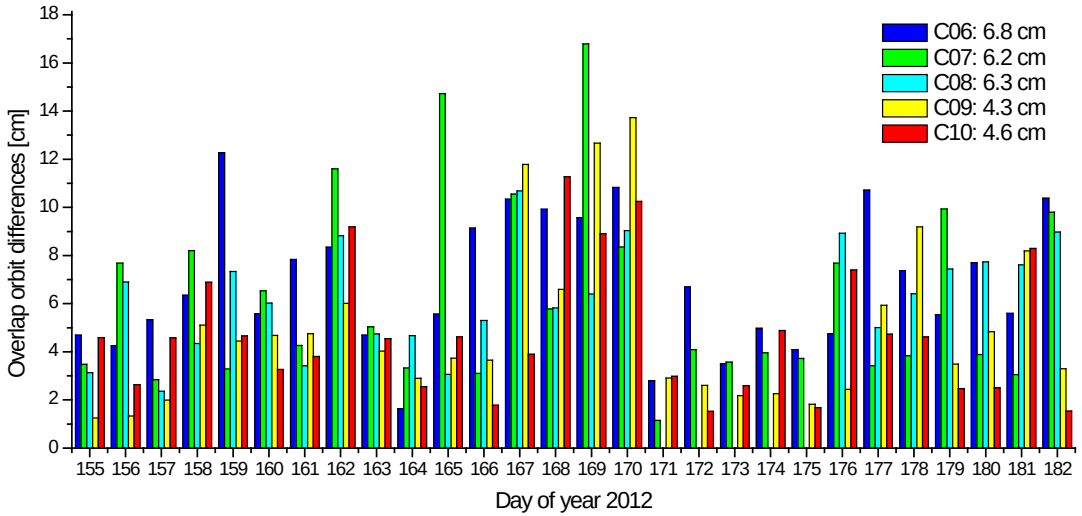
Precise Orbit Determination

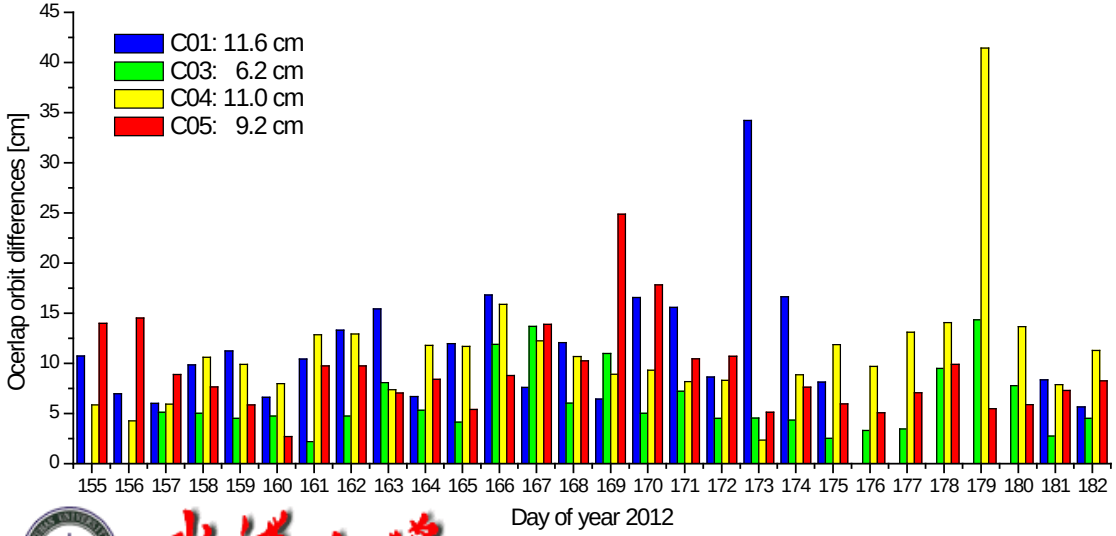
Data:2012.06.01
~2012.06.30

Parameters and Models	
Observation	LC and PC
Cut off elevation	10 degree
Data length/Sampling rate	3days/300s
EOP	Fixed to IERS
Ambiguity	float
Station coordinate	Constraint to IGS08
Relativistic effects	Yes
Station displacement	Solid earth, pole tide, ocean loading（IERS 2010）
Tropospheric delay	Saastamoinen + GMF, PWC
Ionospheric delay	Eliminated by using LC and PC
Satellite clock	white noise
Receiver clock	white noise
Orbit parameters	X、Y、Z、Vx、Vy、Vz Bern SRP（D_0、Y_0、B_0、B_C、B_S）

Orbit Overlap difference (Radial)

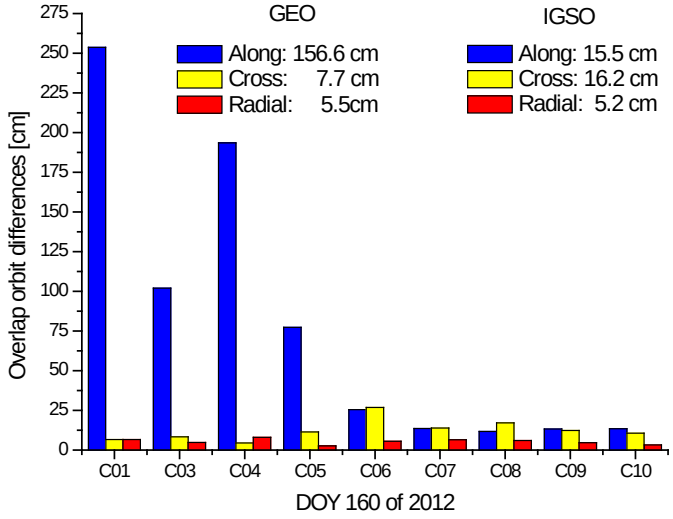


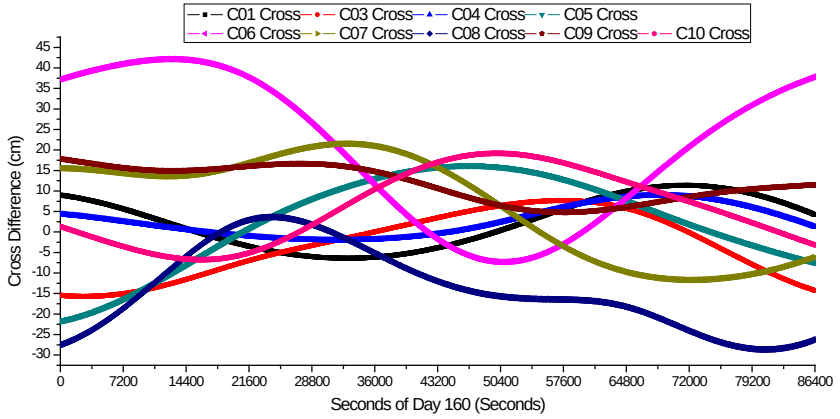


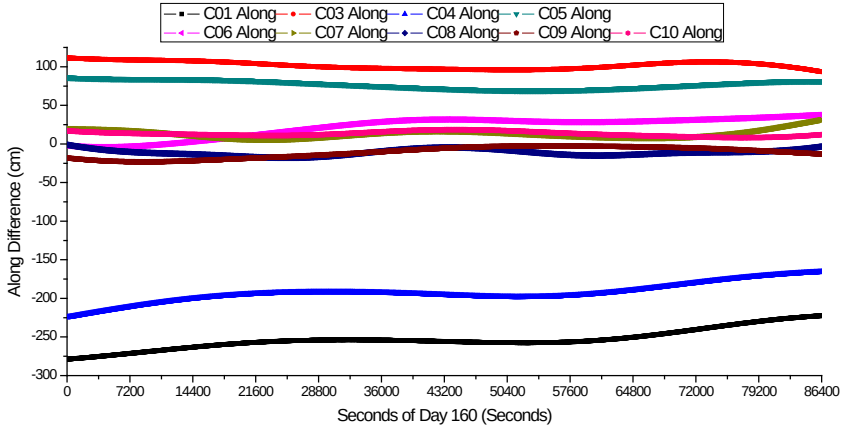


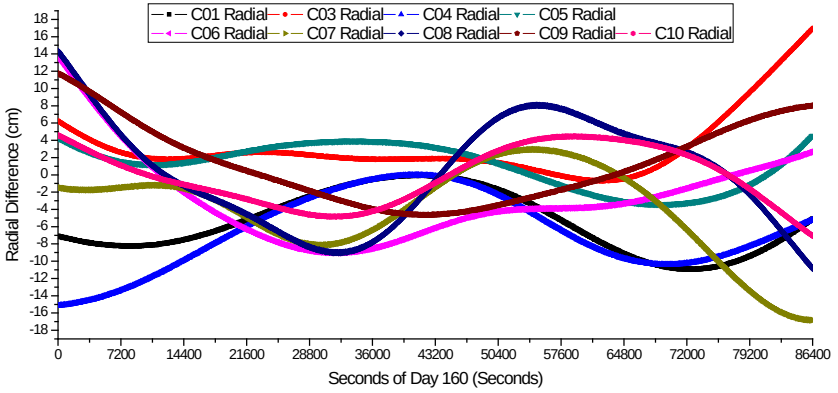
Radial RMS: 10cm

Orbit Overlap difference 3D (Jun, 2012)









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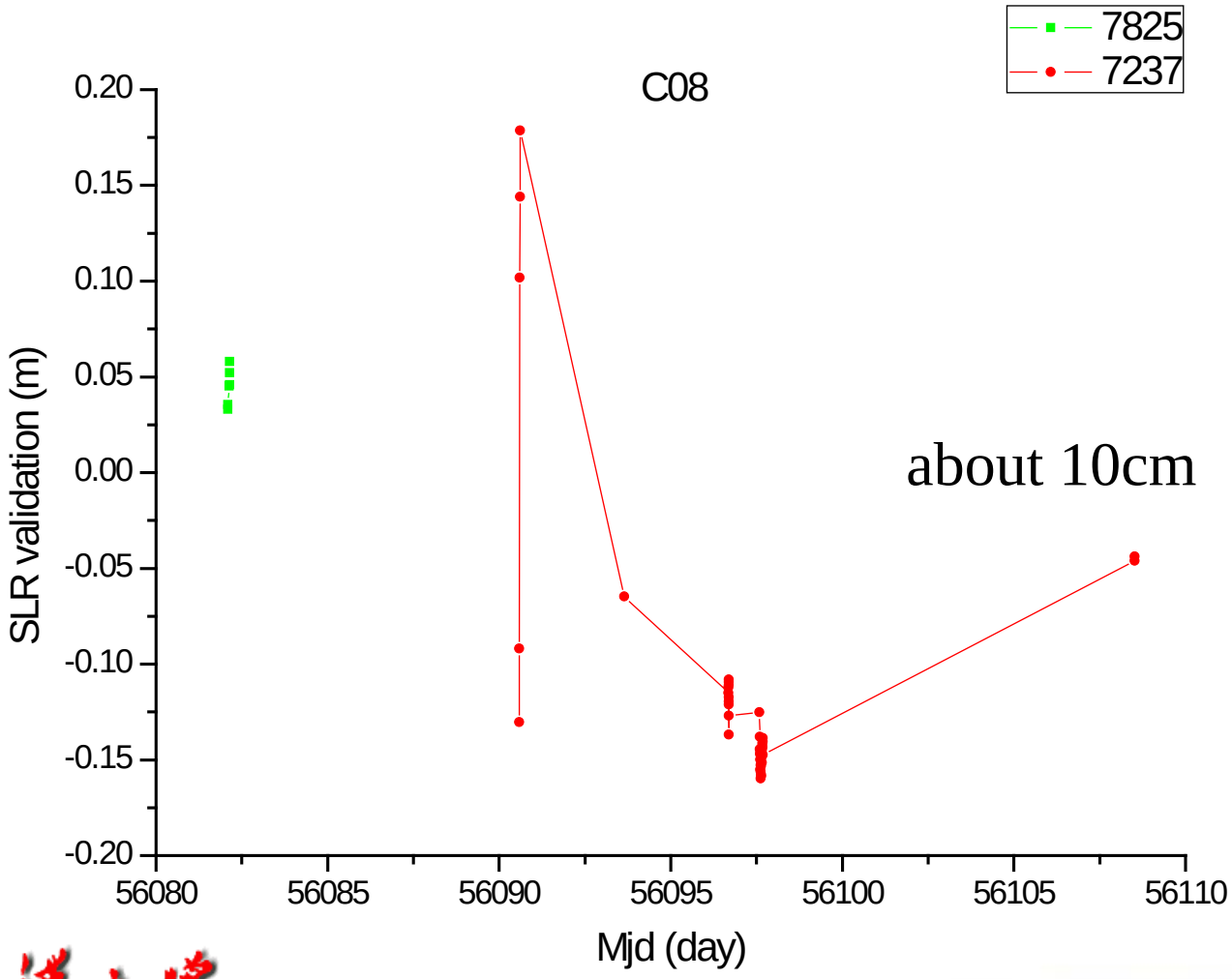
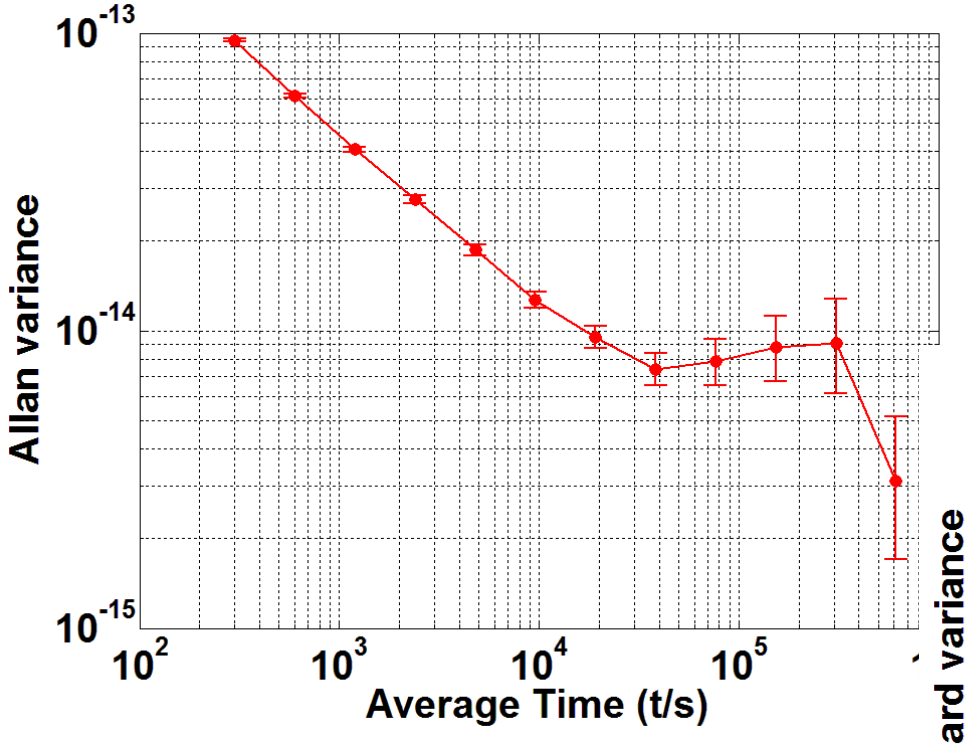
IGSO 3D RMS: 30cm

GEO: Biased in the Along direction

SLR Validation

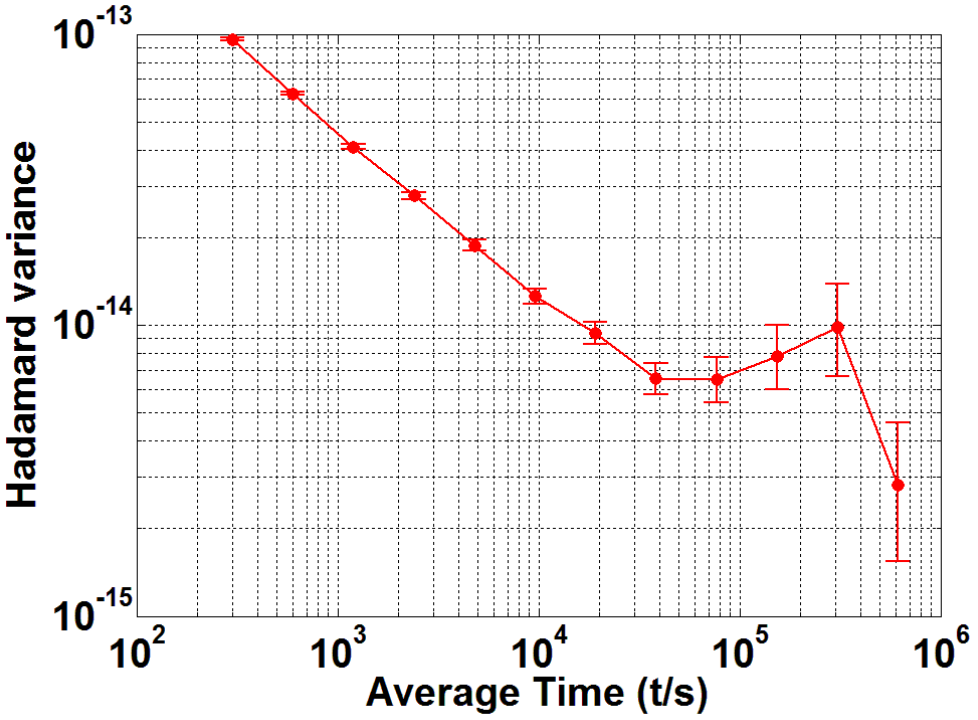


CLK Performance



Allan Variance for GEO: CO1

Hadamard Variance for GEO: CO1



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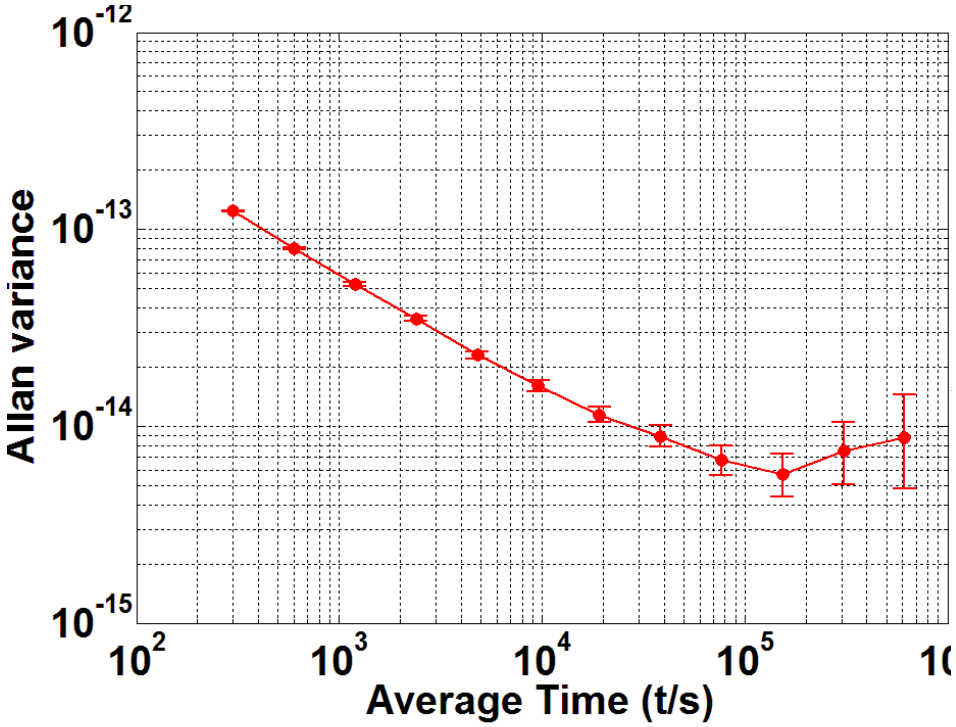
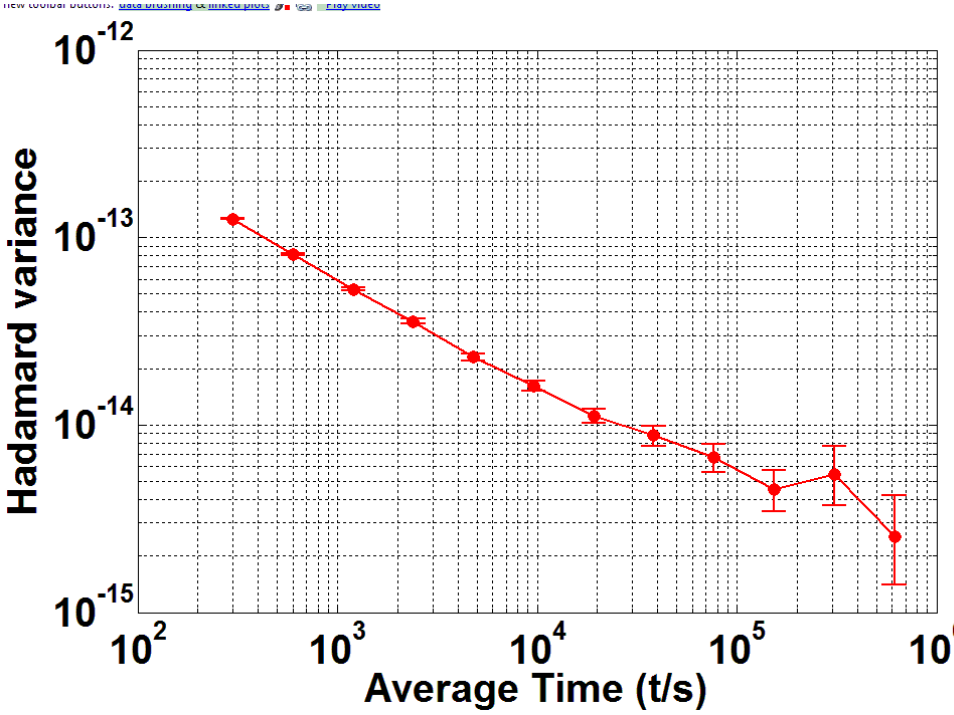
CLK Performance

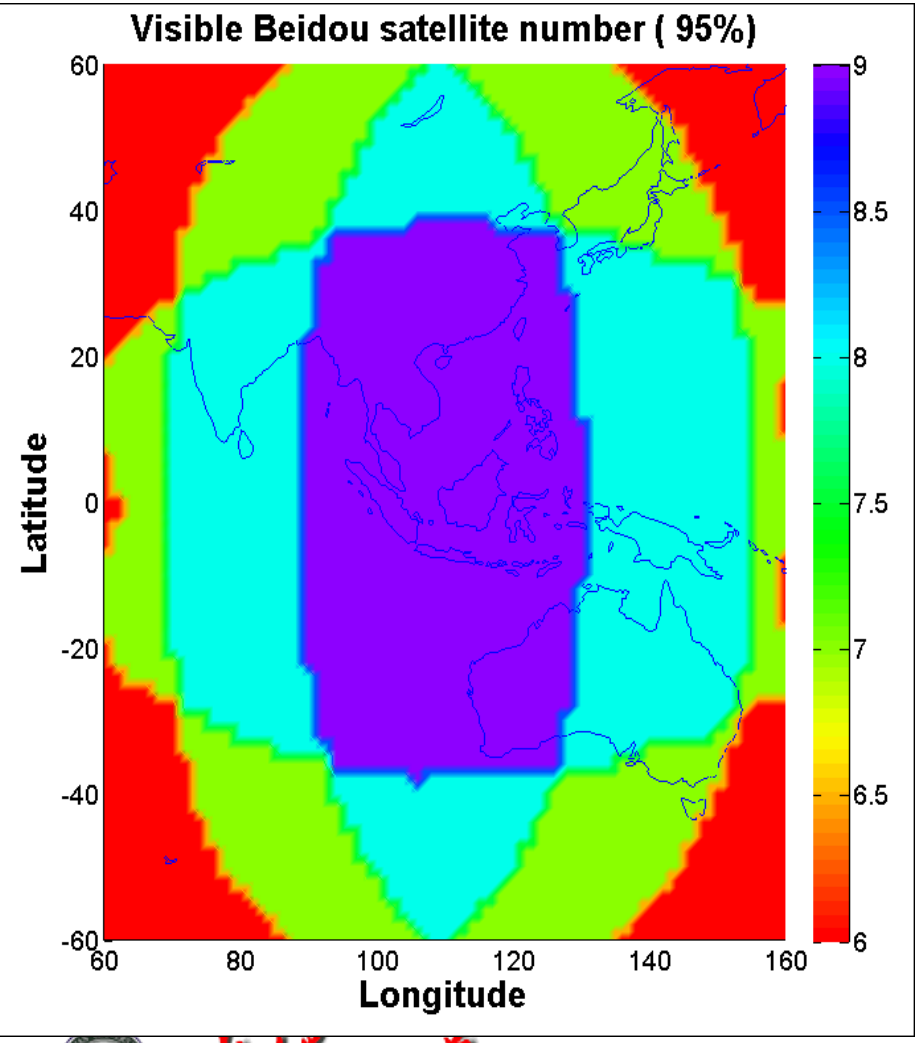


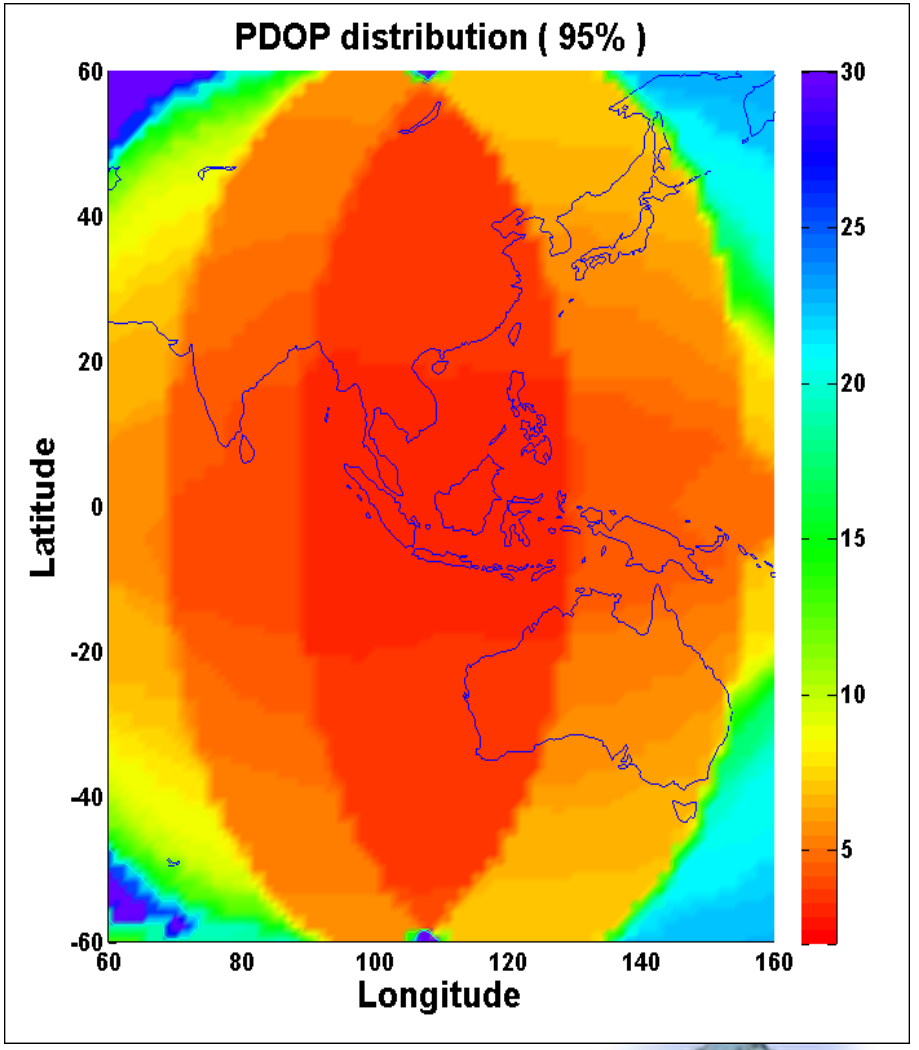
Allan Variance for IGSO: CO8

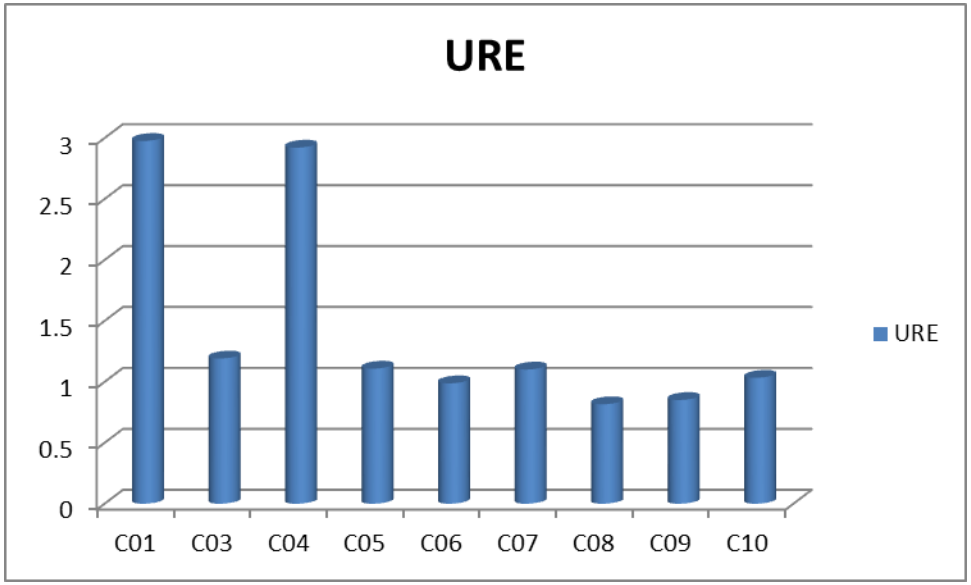
Hadamard Variance for IGSO: CO8

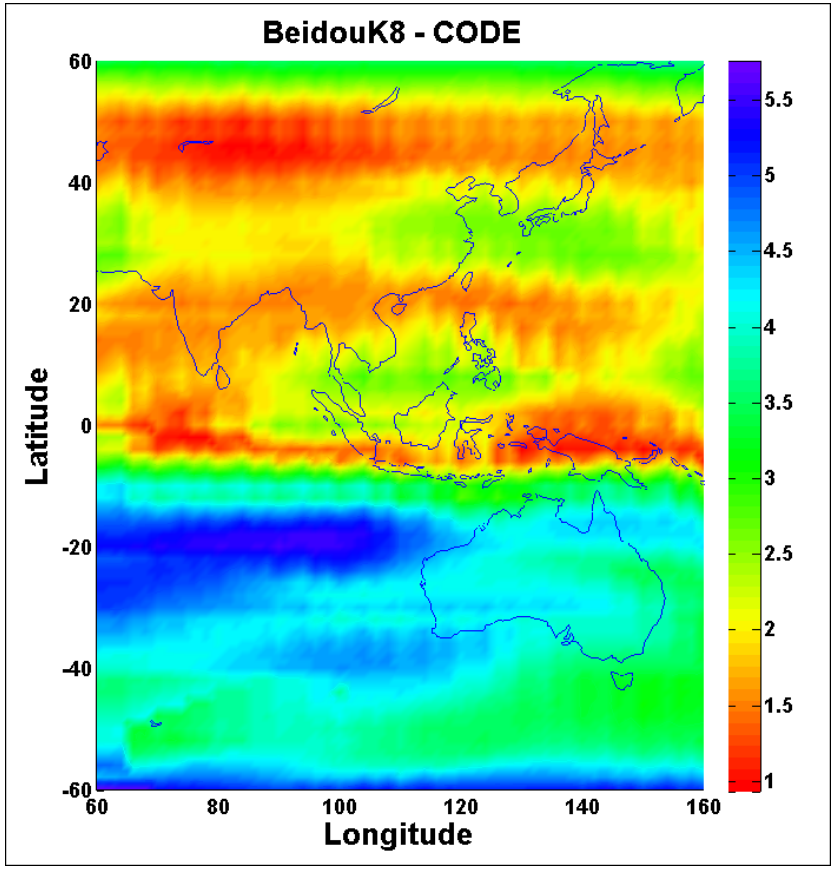


SPP performance of COMPASS(4GEO+5IGSO)







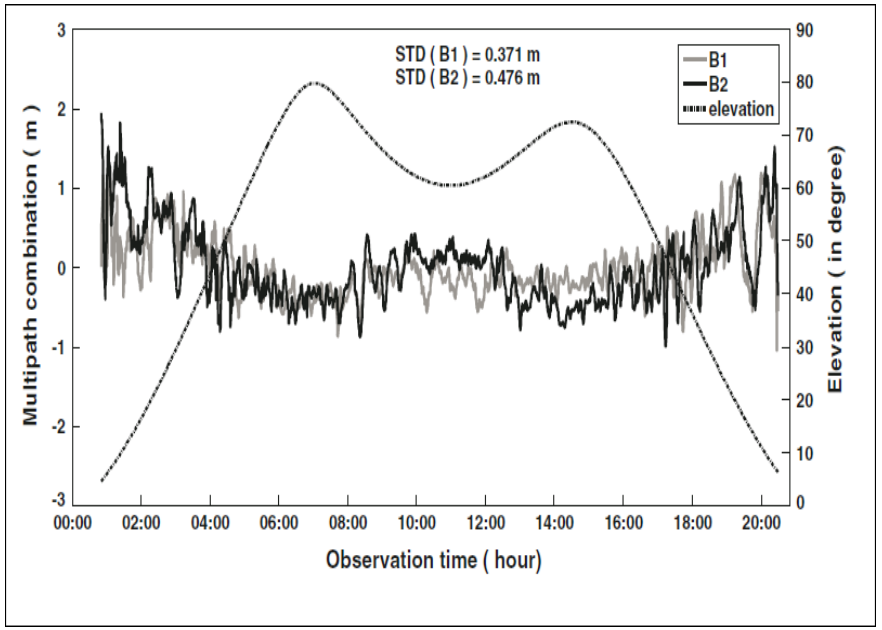


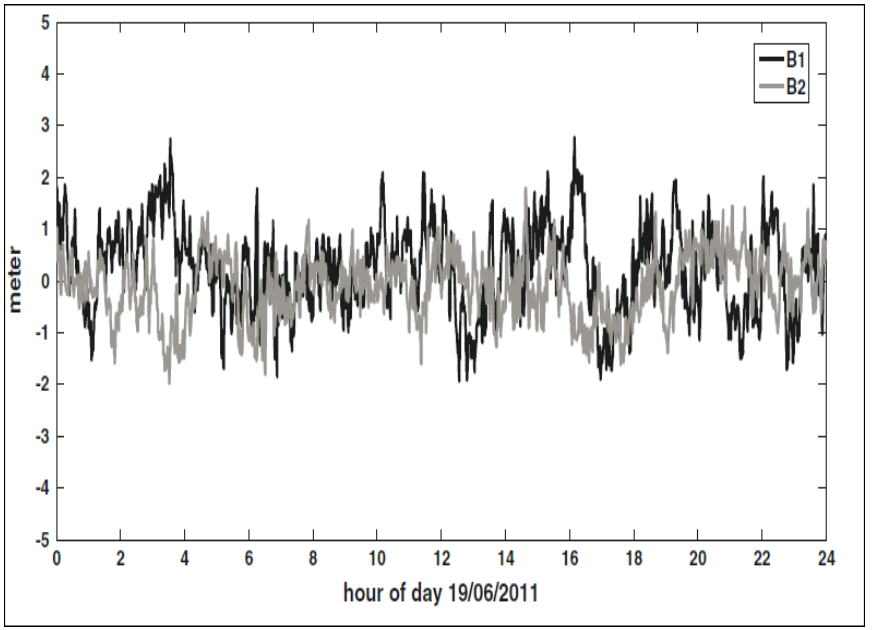
URE of broadcast ephemeris is about 1.5 meters, compared to the precise orbit products from Wuhan University

$$SISRE_{BD(GEO,IGSO)} = \sqrt{(Radius - CLK)^2 + \frac{1}{127}(Cross^2 + Along^2)}$$

Compared to CODE ionosphere model, the Beidou Klobuchar Ionosphere mode(BD K8) is better than 2.0 meter within northern hemisphere

SPP performance of COMPASS(4GEO+5IGSO)





The typical multipath effect is about 0.5 meter using UNICORE receiver

The receiver noise effect is about 0.5 with UNICORE receiver

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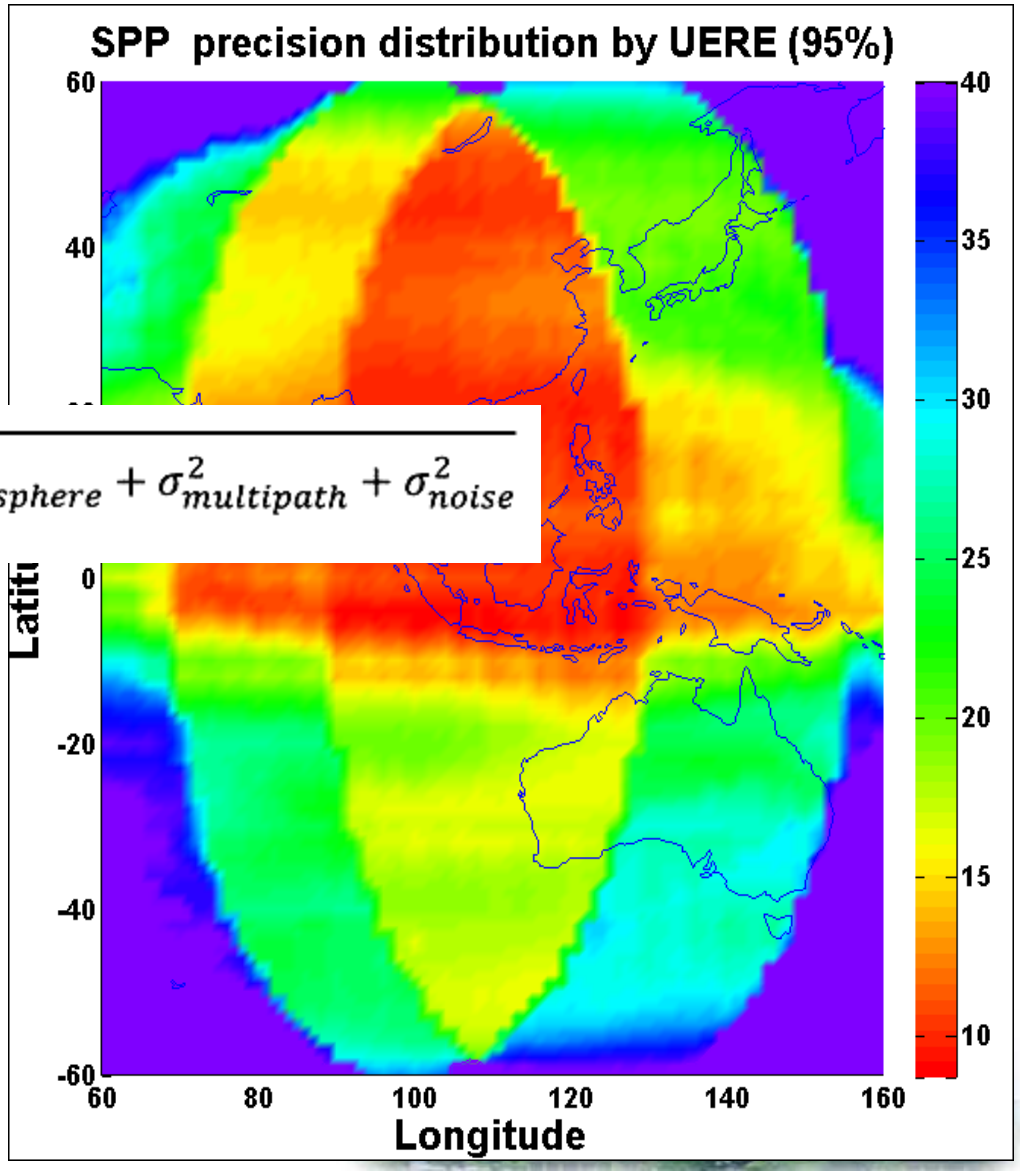
SPP performance of COMPASS(4GEO+5IGSO)

$$RMS_{SPP} = PDOP \times UERE$$

$$UERE = \sqrt{SISRE^2 + \sigma^2_{ionosphere} + \sigma^2_{tropsphere} + \sigma^2_{multipath} + \sigma^2_{noise}}$$



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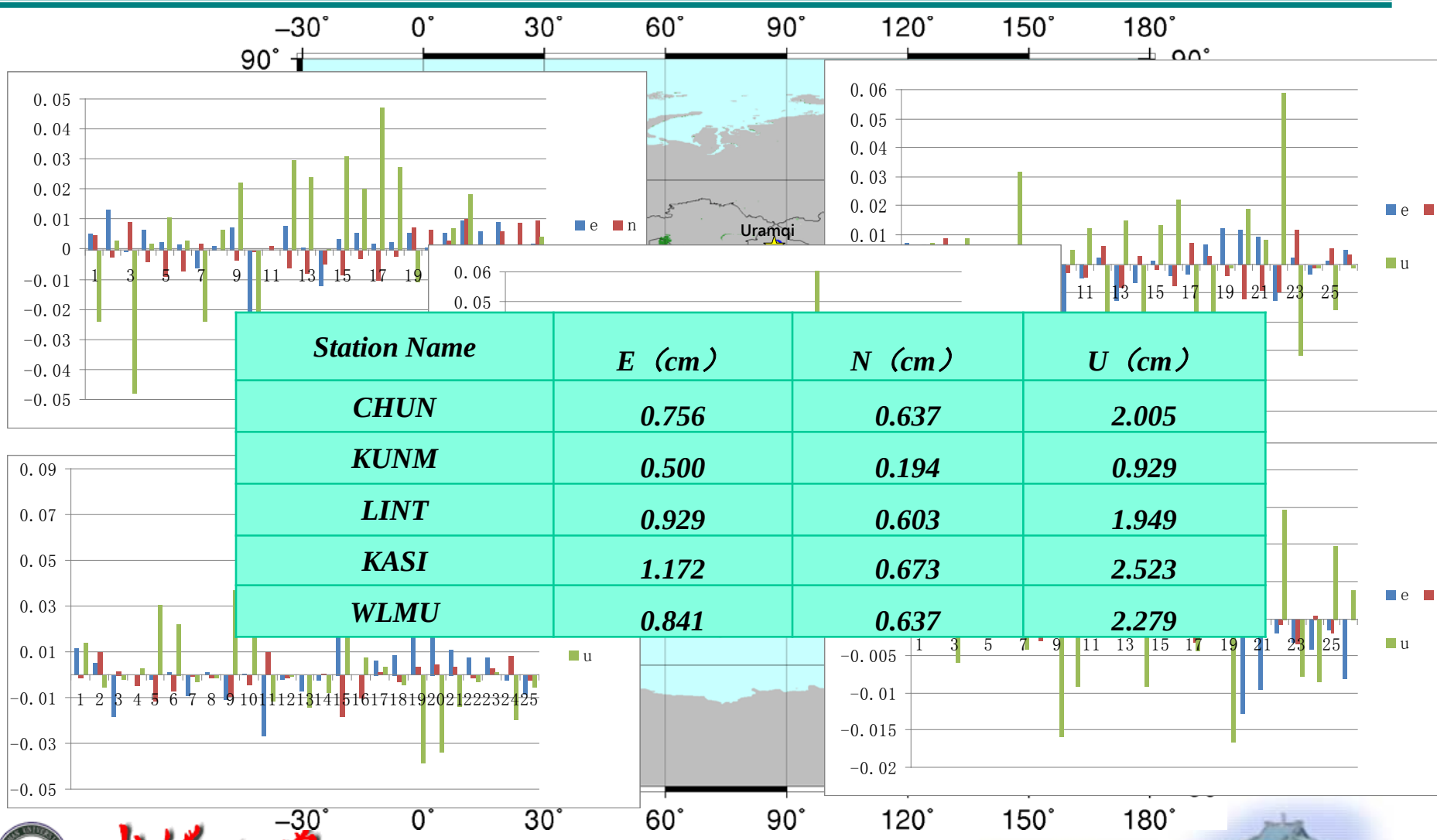
SPP performance validation

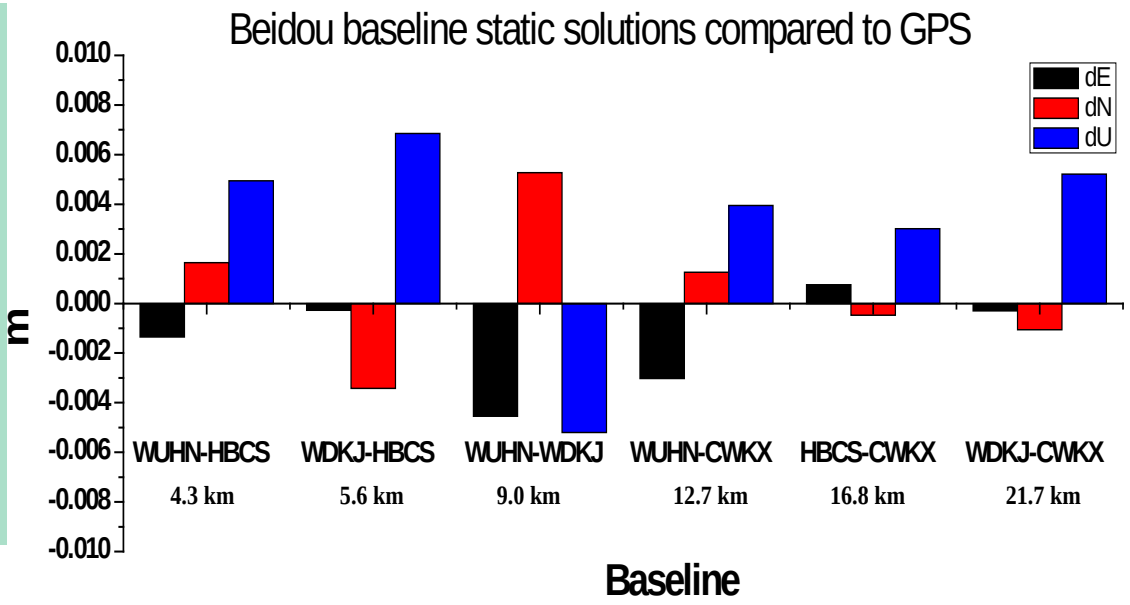
STATION	Performance of SPP (95%,m)	Validation using real data(95%,m)
BEIJ	8.87	8.22
WUHN	9.15	10.74
SHAO	9.64	10.92
XIAN	9.18	8.54
CHDU	7.60	9.311
HERB	12.45	12.48
HONK	6.79	5.726
ABDB	18.85	15.07
PERT	14.02	11.64

COMPASS PPP solutions

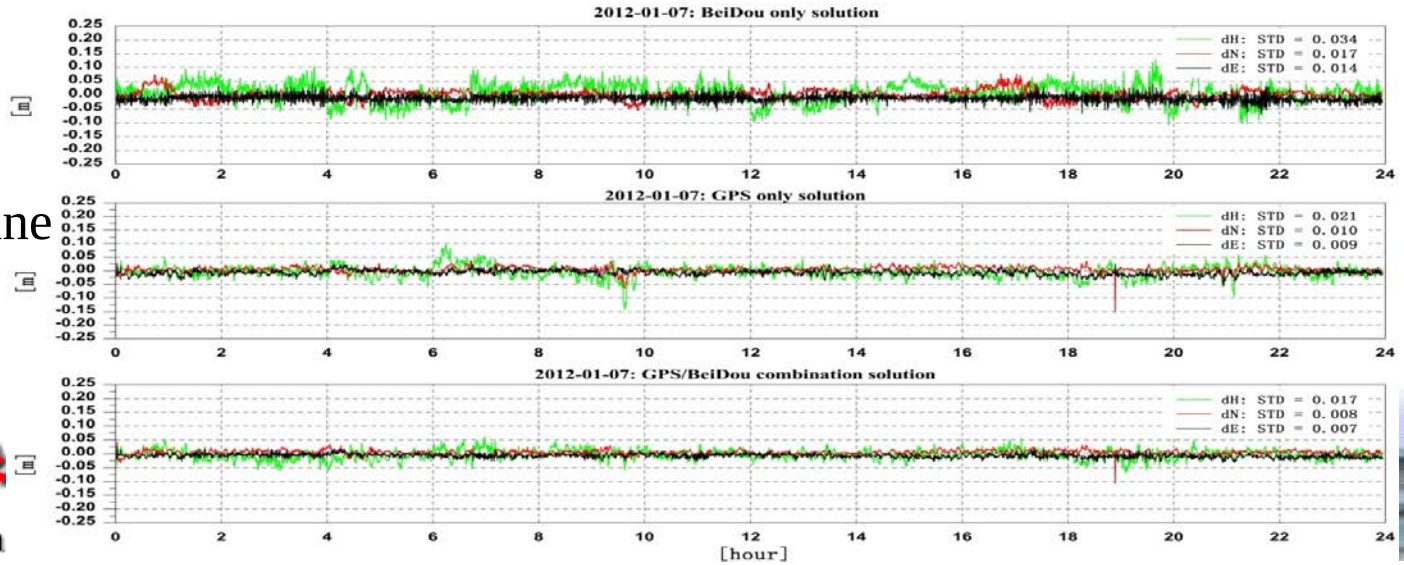


Station Name	E（cm）	N（cm）	U（cm）
CHUN	0.756	0.637	2.005
KUNM	0.500	0.194	0.929
LINT	0.929	0.603	1.949
KASI	1.172	0.673	2.523
WLMU	0.841	0.637	2.279

COMPASS baseline solutions



9km
Kinematic baseline



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Plan for COMPASS precise products

- Ultra-rapid products (Oct.,2012)
  - Orbit and Clock products
  - ZTD ,Ion.
  - coordinates
- Final products (Oct.,2012)
  - Orbit and Clock products
  - ZTD ,Ion.
  - coordinates
- Data : real-time stream(1s) and files(30s)
  - Partners access (Oct.,2012)
  - All users access (Jun., 2013), M-GEX
    - Agreements with the partners
    - Meet the guidelines of IGS

Summary

- Summary
  - PANDA software
    - Ultra-rapid、real-time products
    - COMPASS analysis
  - Ultra-rapid products from WHU
    - ～3cm compared with IGR
    - are used for real-time GPS clock products, Augmentation Service System in China
  - COMPASS results
    - orbit: ~10cm in radial
    - PPP 1~2cm compared with GPS solution
    - Comparing with GPS only, emerging Compass data could improve the accuracy of baseline kinematic solution about 10-20%
    - Precise COMPASS products will be available around Oct, 2012 from WHU.

Welcome to
4th Chinese Satellite Navigation Conference (CSNC2013)

May15~18, 2013, Wuhan University

http://www.beidou.org/english/paper

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Thank You for your attention!

The GNSS Research Center of Wuhan University
shi@whu.edu.cn zhaoql@whu.edu.cn lim@whu.edu.cn

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