

BDS Real-time Precise Products from WHU and its application in NBASS

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IGS Workshop 2017

July 3-7, 2017, Paris, France

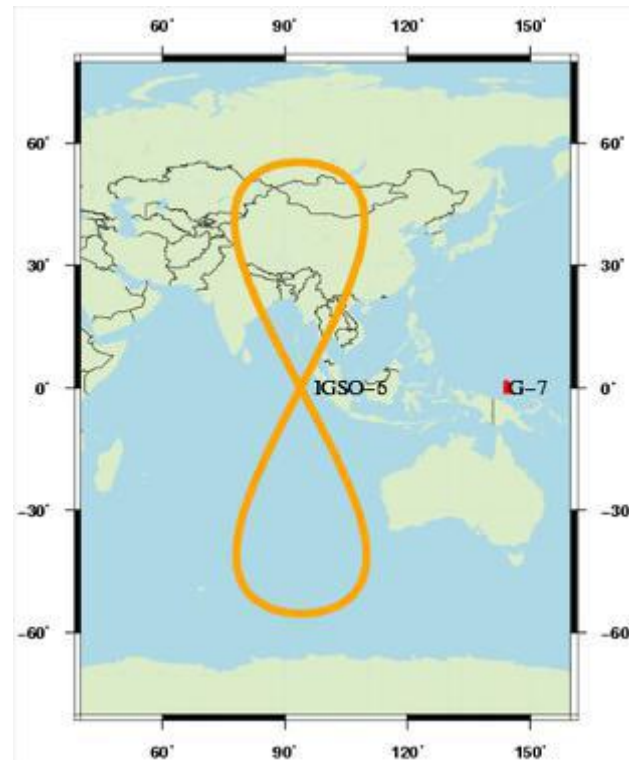
Outline

- Overview
- BDS Real Time Precise Products
- Application of Real-time PPP
- Summary

The Current Status of BDS

□ BDS-2

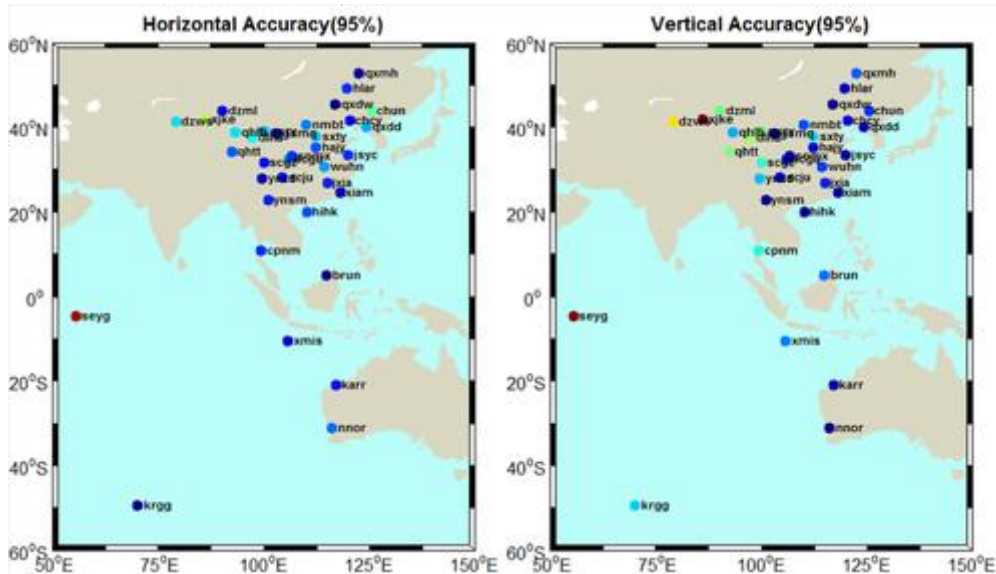
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BEIDOU IGSO 6	C017	2016-021A	Operational	C15/C13	~95° E; launched 2016/03/29; PRN switch from C15 to C13 on 2016/10/11
BEIDOU G7	C018	2016-037A	N/A	C17	launched 2016/06/12



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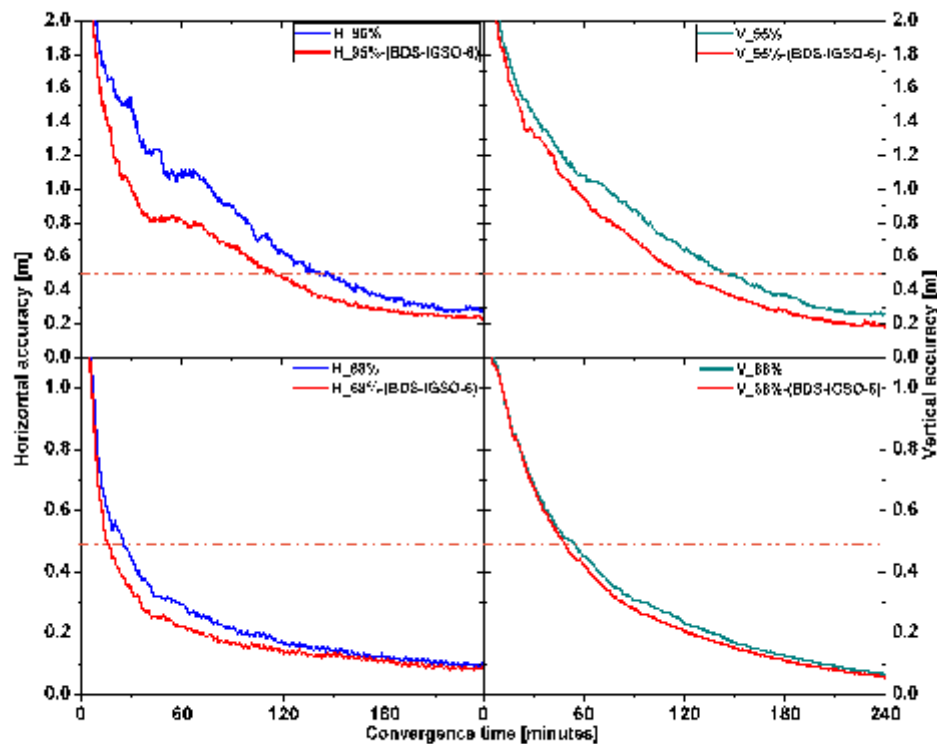


SPP	Horizontal	Vertical	
Accuracy (95%)	without IGSO-6	3.54m	6.09m
	With IGSO-6	3.34m	5.83m
Improvement	5.6%	4.3%	

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PPP		Horizontal	Vertical
Convergence time (95% < 0.5m)	without IGSO-6	142 min	146 min
	with IGSO-6	116 min	120 min
Improvement		18.3%	17.8%

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BEIDOU G7	C018	2016-037A	N/A	C17	launched 2016/06/12

□ BDS-3

Common Name	SVN	Int. Sat. ID	Status	PRN	Notes
BEIDOU I1-S	C101	2015-019A	Operational	C31	launched 2015/03/30
BEIDOU M1-S	C102	2015-037A	Operational	C33	Slot A06, launched 2015/07/30
BEIDOU M2-S	C103	2015-037B	Operational	C34	Slot A01, launched 2015/07/30
BEIDOU I2-S	C104	2015-053A	Operational	C32	launched 2015/09/29
BEIDOU M3-S	C105	2016-006A	N/A	C35	Slot B01; launched 2016/02/01

National BDS Augmentation Service System(NBASS)

□ Object

- Improving the **positioning performance** of the BDS
- Providing various precise location-based services

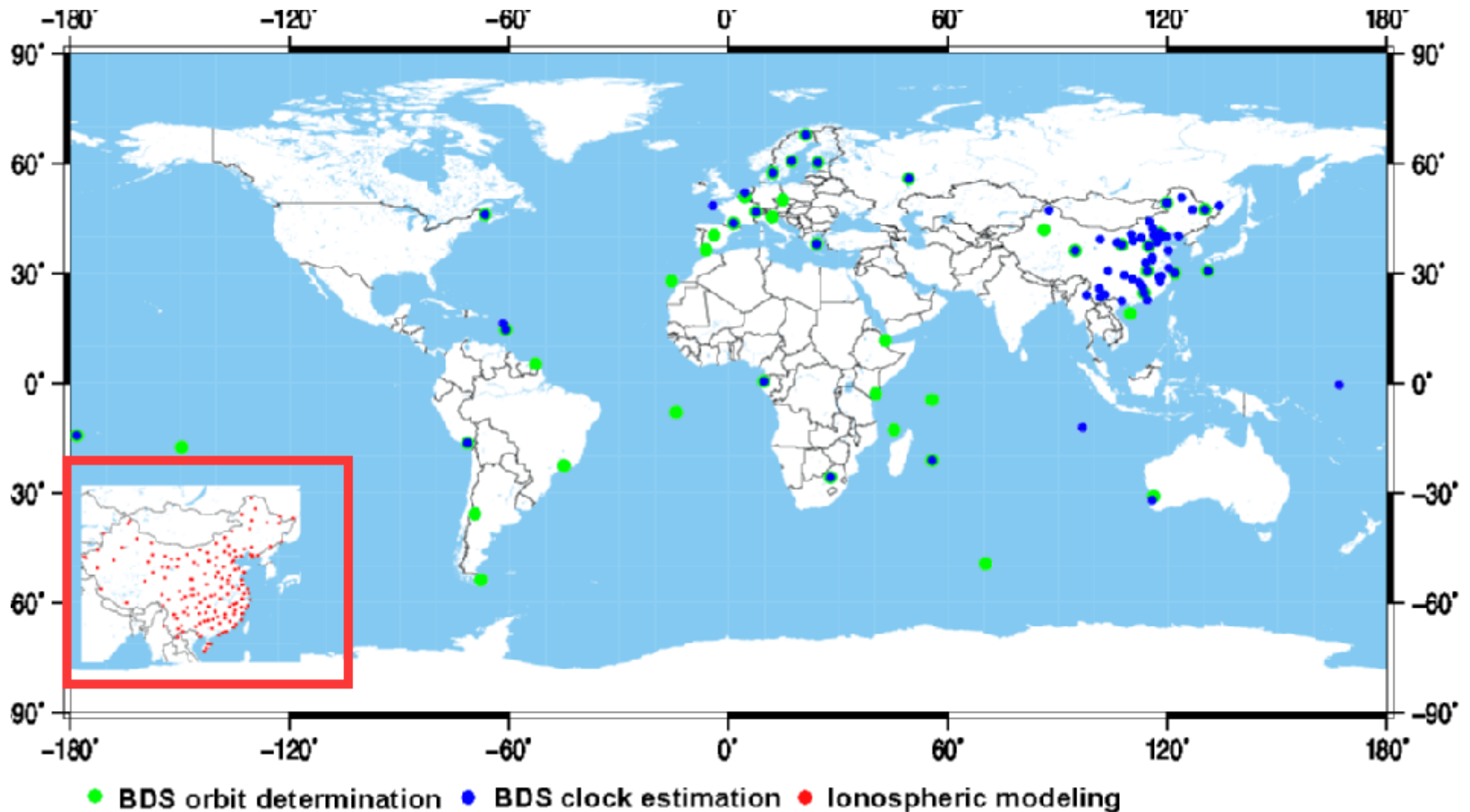
□ Infrastructure

- **150 BDS/GNSS reference stations** as Nationwide frame.
- **About 1200 BDS/GNSS** dense reference stations in special area.
- National data processing center, application service centers.

□ Augmented Satellite System

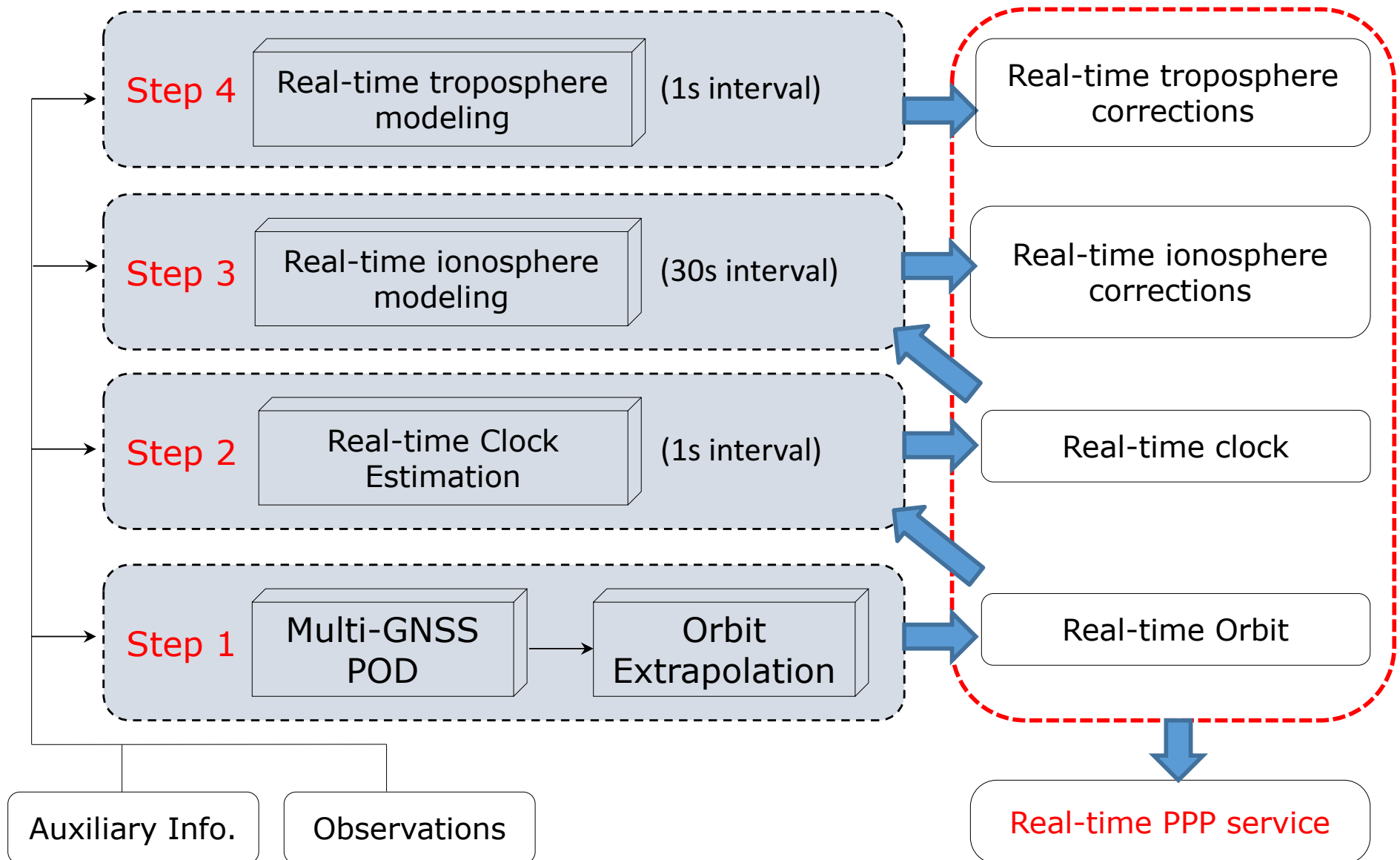
- **BDS, GPS, GLONASS, Galileo...**

Tracking Station Network for BDS RT-PPP Service



~72 stations for BDS ORB , ~92 stations for BDS CLK , ~150 stations for regional products

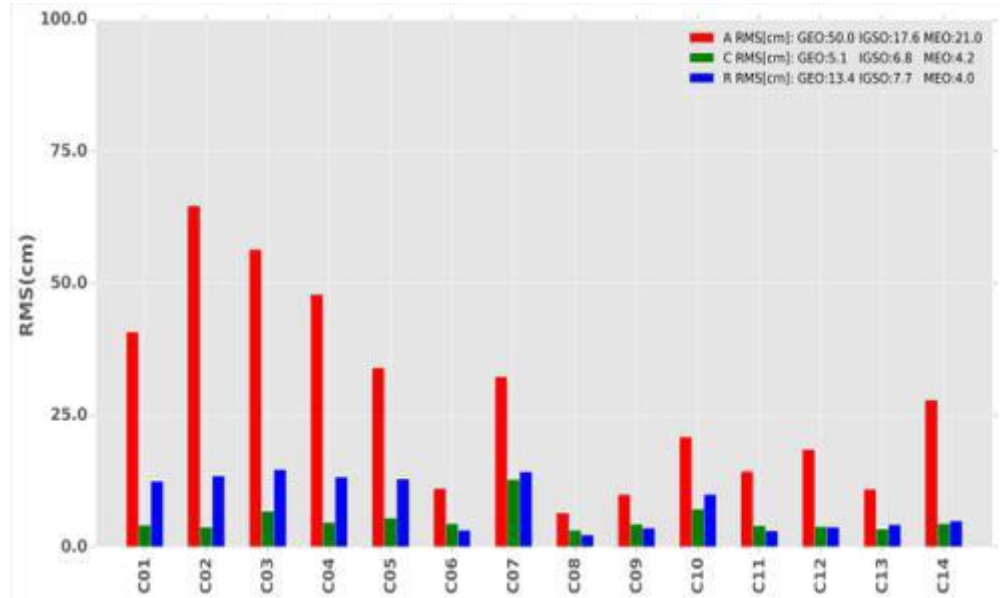
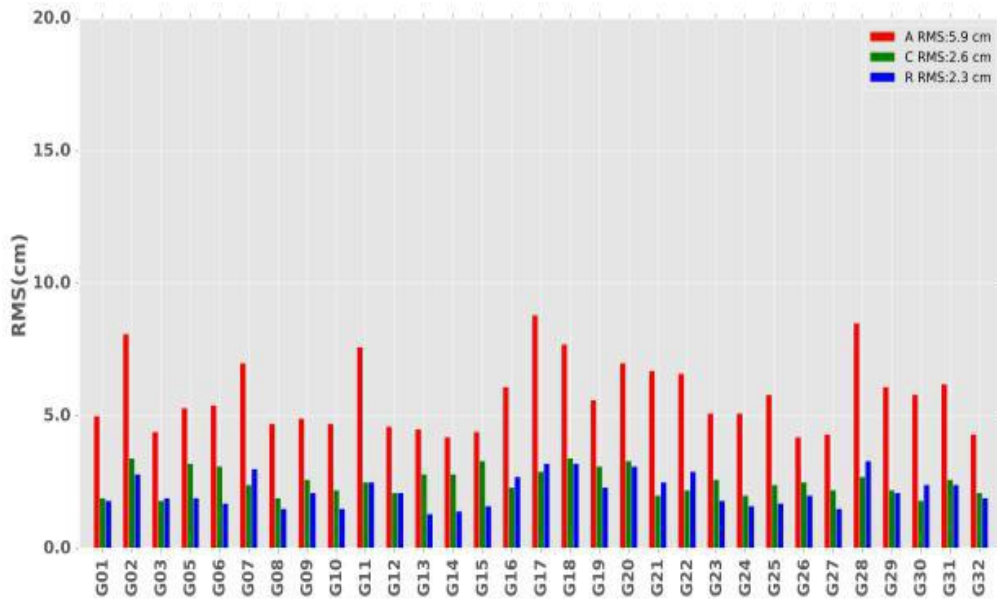
Principle of processing system



Outline

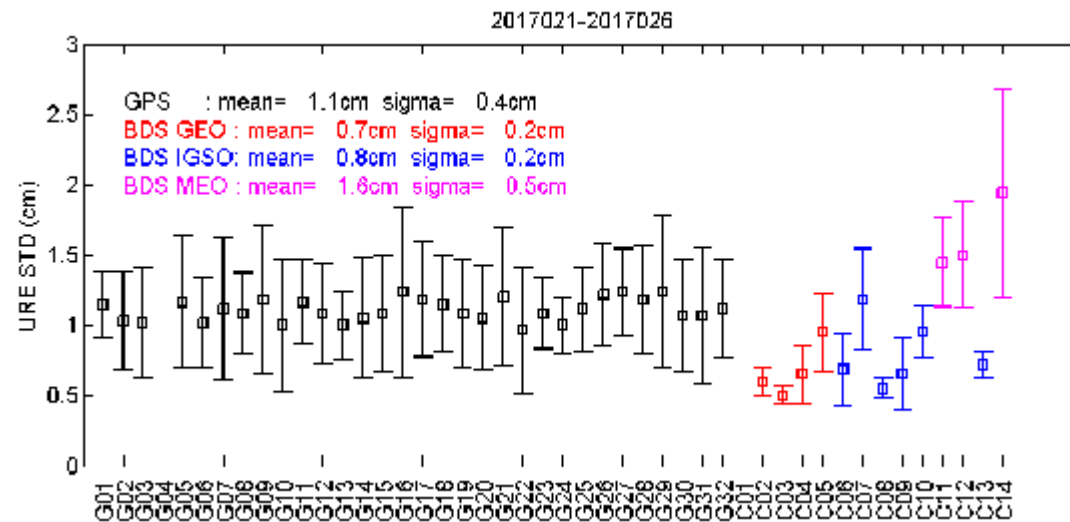
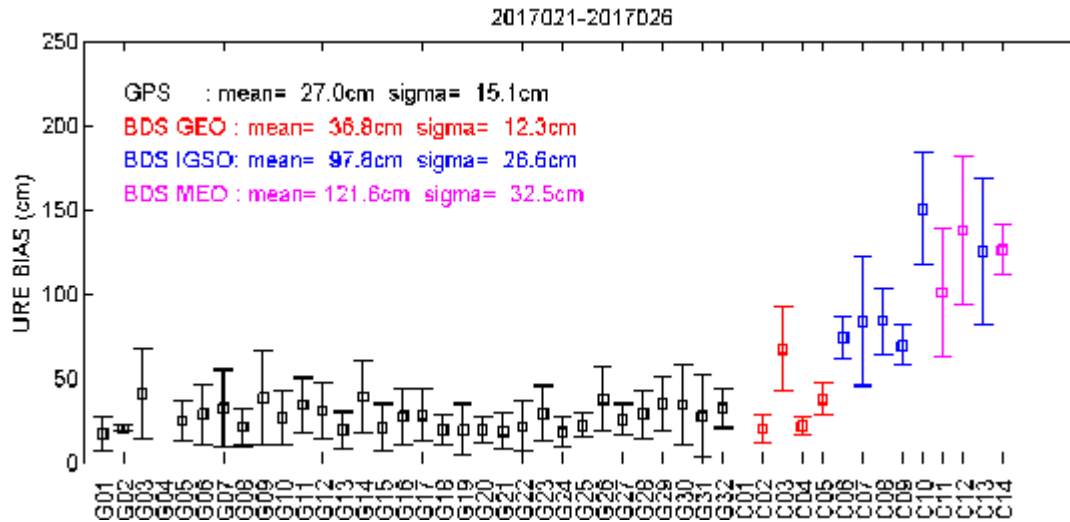
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Real-Time Satellite Orbit



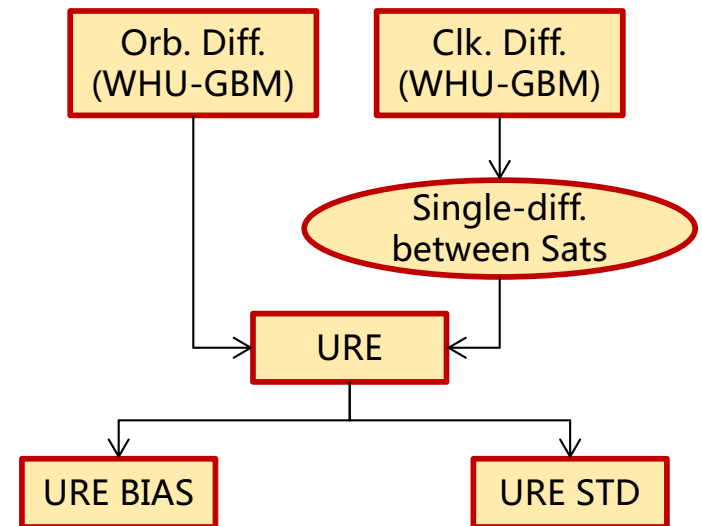
RMS (cm)	GEO	IGSO	MEO	GPS
A	50.0	17.6	21.0	5.9
C	5.1	6.8	4.2	2.6
R	13.5	7.7	4.0	2.3

Real-Time Precise Satellite Clock (URE)



$$URE = \sqrt{\alpha \cdot (dA^2 + dC^2) + \beta (dClk - dR)^2}$$

$$\begin{cases} \alpha = 0.01846081, \beta = 0.96308408 & \text{MEO} \\ \alpha = 0.0078296, \beta = 0.99214524 & \text{GEO/IGSO} \end{cases}$$

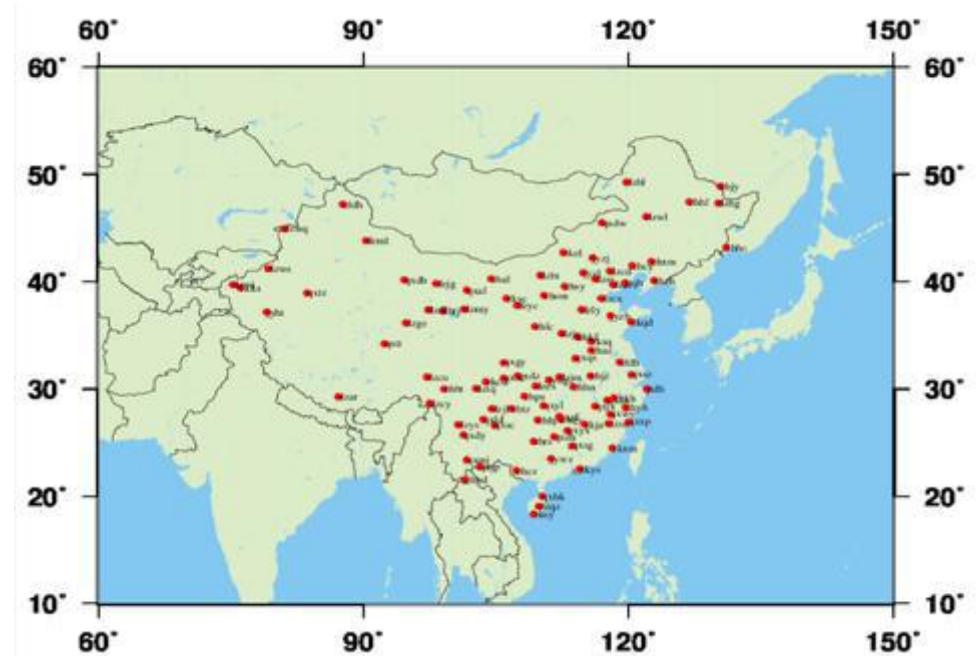


- Affect SPP accuracy
- Affect PPP accuracy
- Affect PPP convergence time

Real-Time CIM (China Ionosphere Map)

Strategy

Item	Value
Stations	~100
Interval	30 second
Coverage	E70~140, N10~60
Format	SSR
Observable	Carrier-phase smoothed pseudo-range GF
Modeling	5 degree SHF



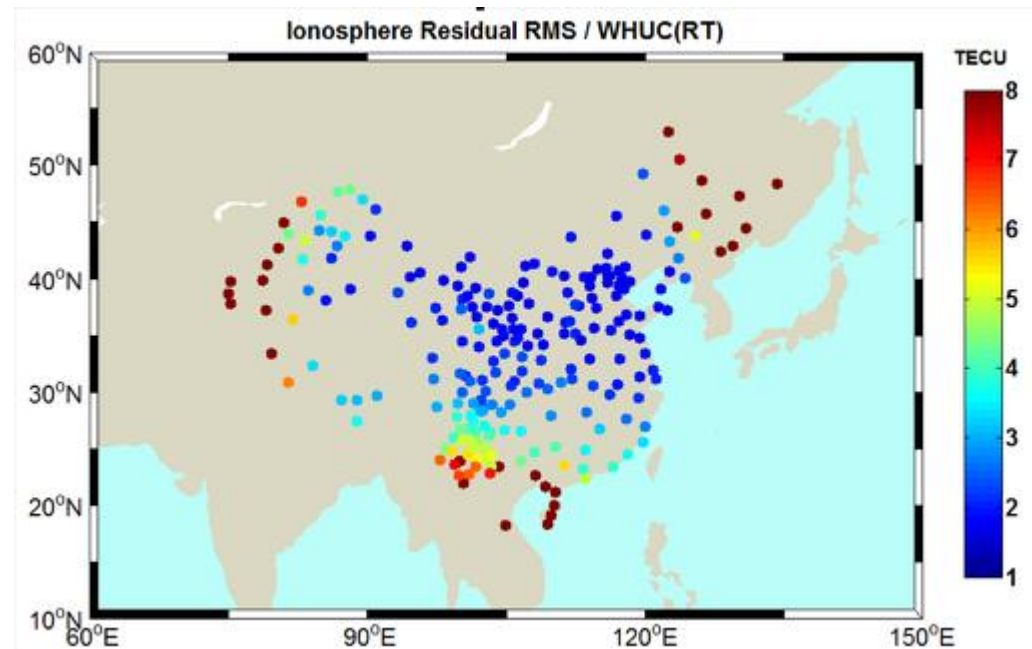
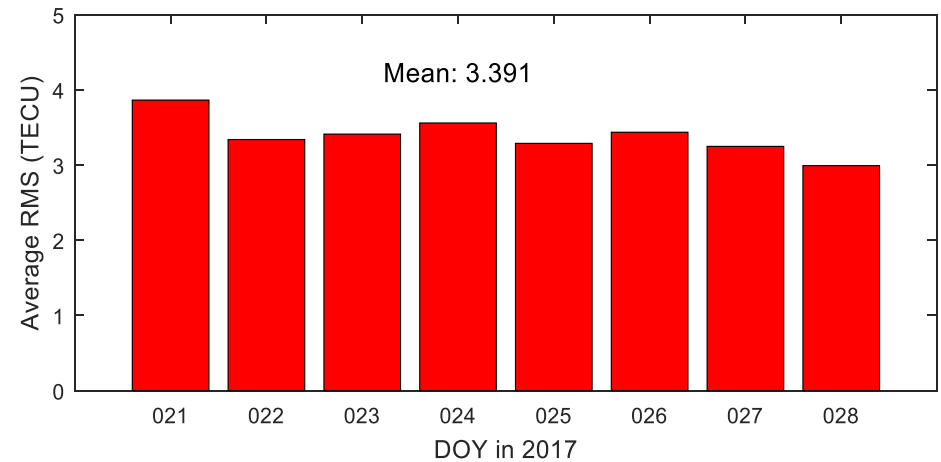
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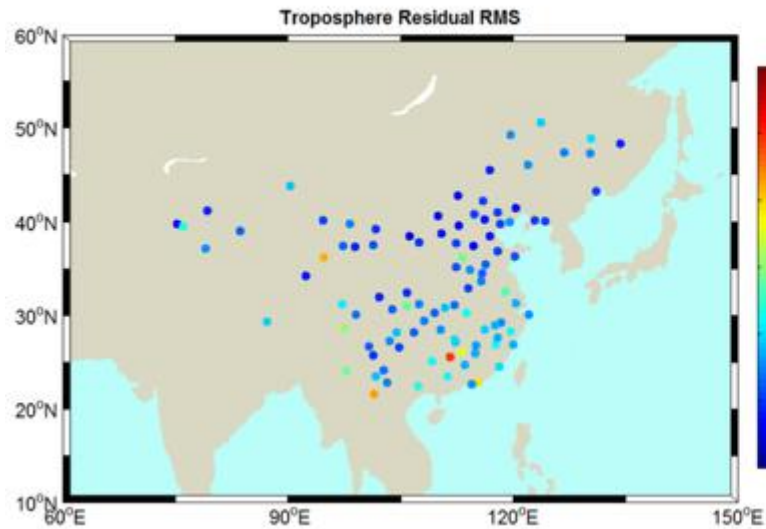
Assessment

Item	Value
Time	DOY 021~028, 2017
Station	~200
Reference	VTEC generated by PPP
RMS	3.4 TECU

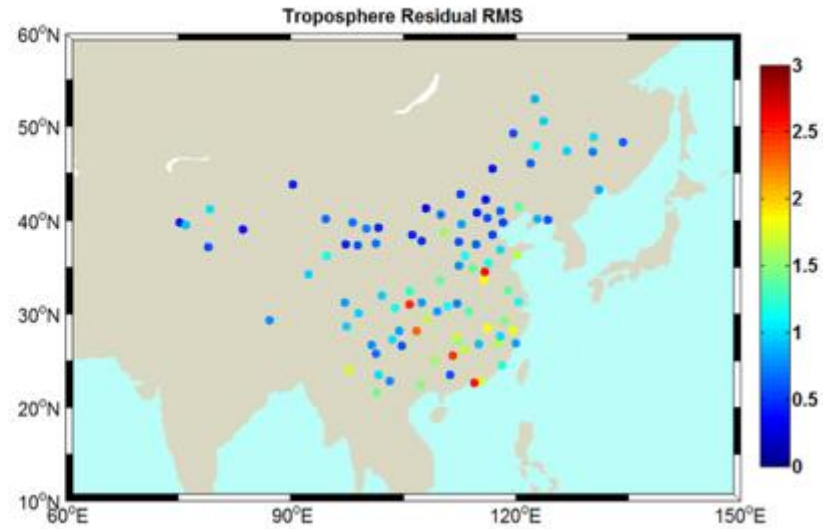


Initial result of Real-time Tropospheric Grid Point model (TGP)

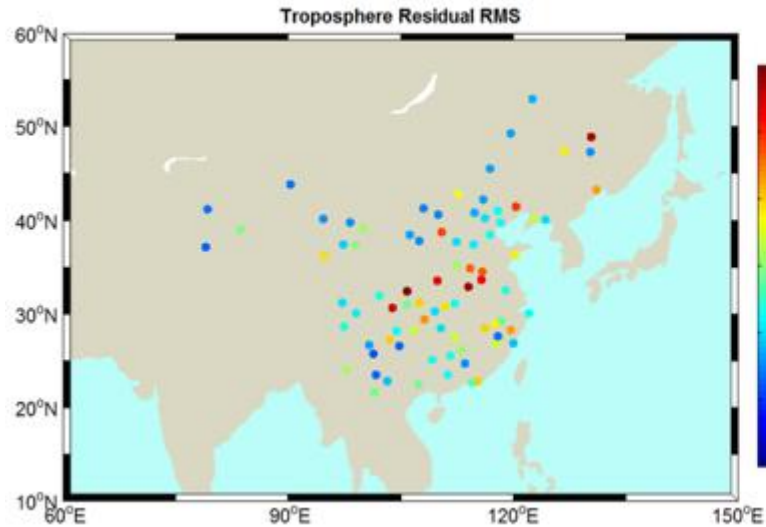
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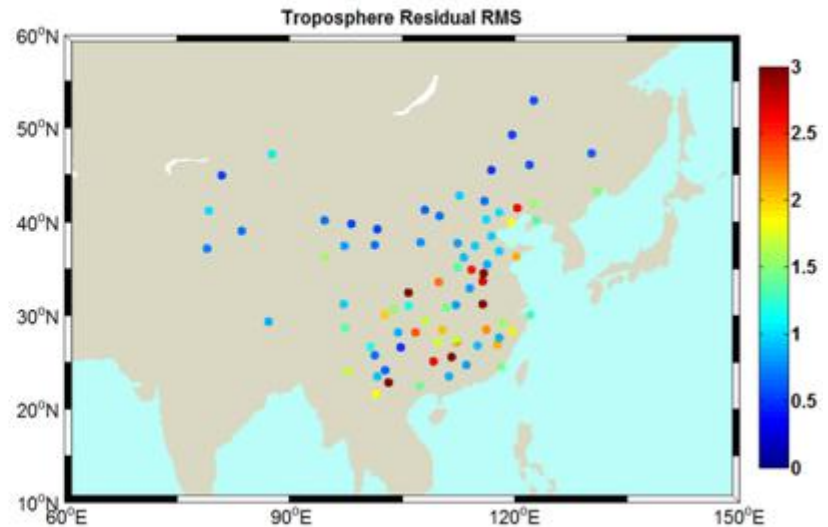
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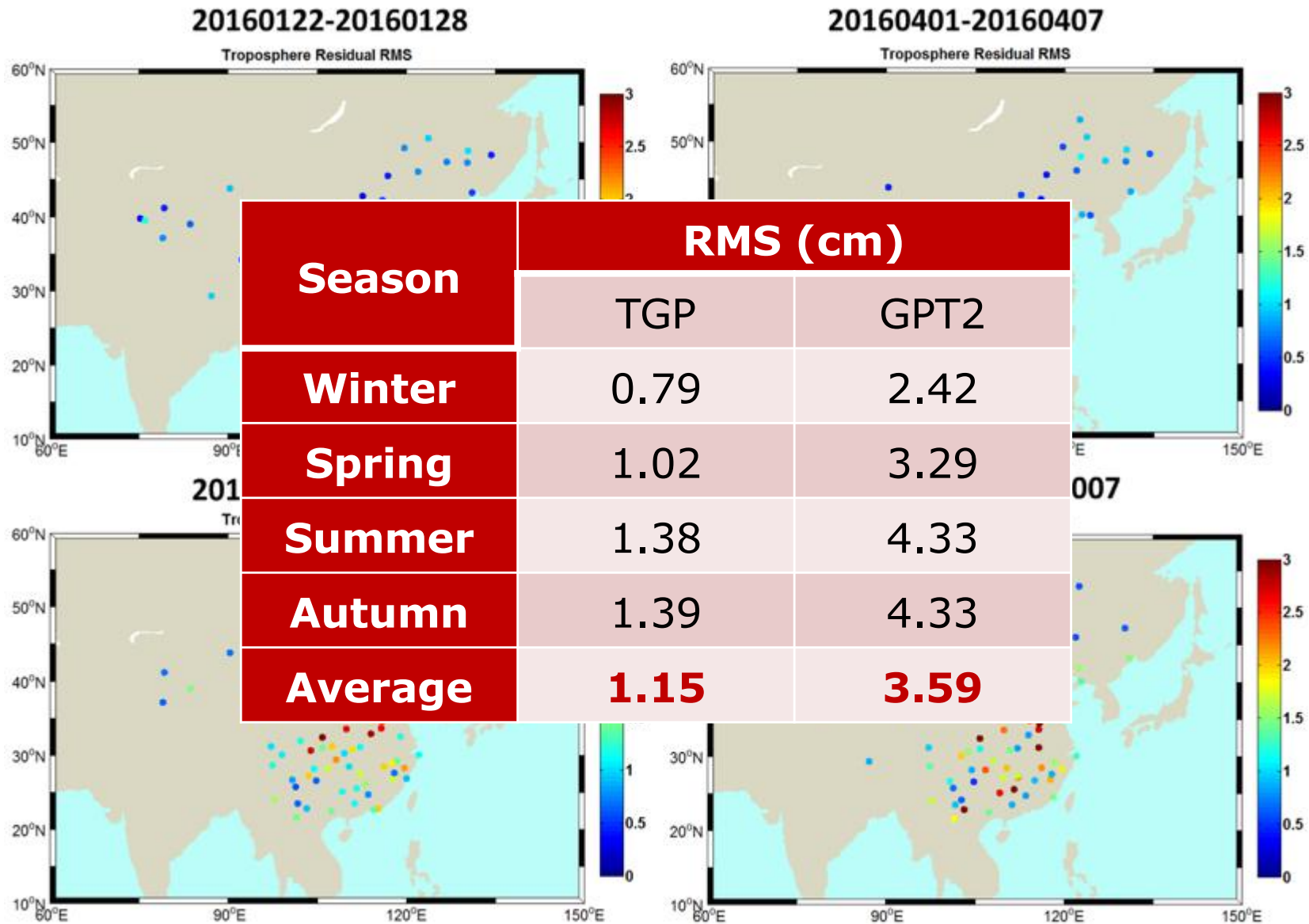
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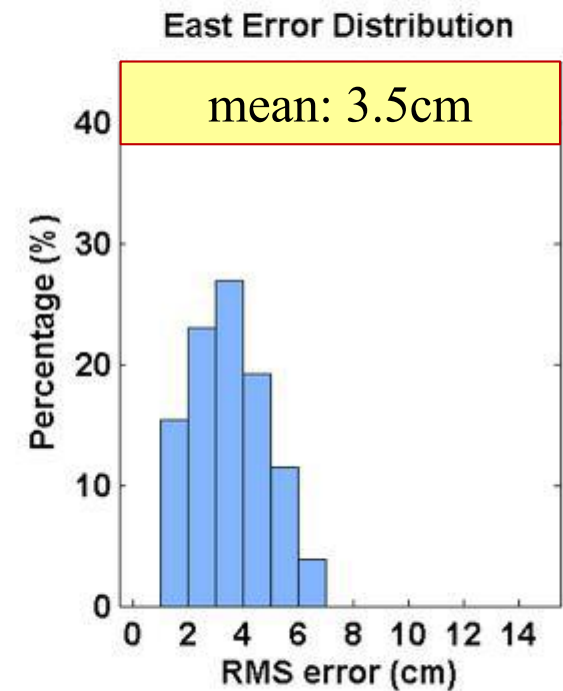
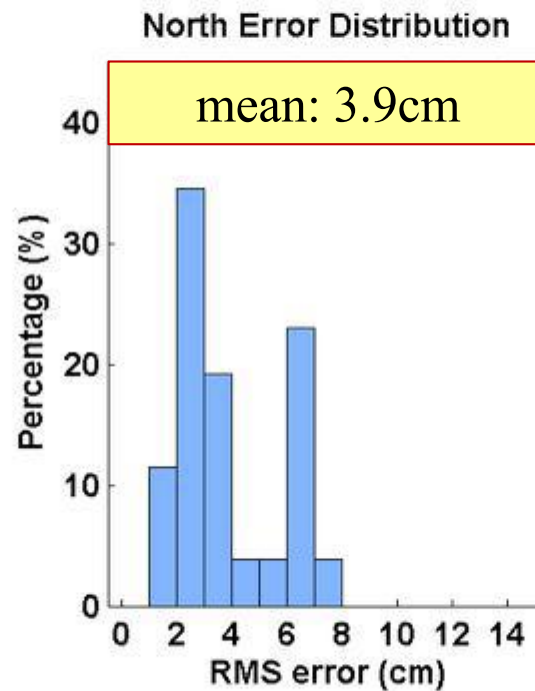
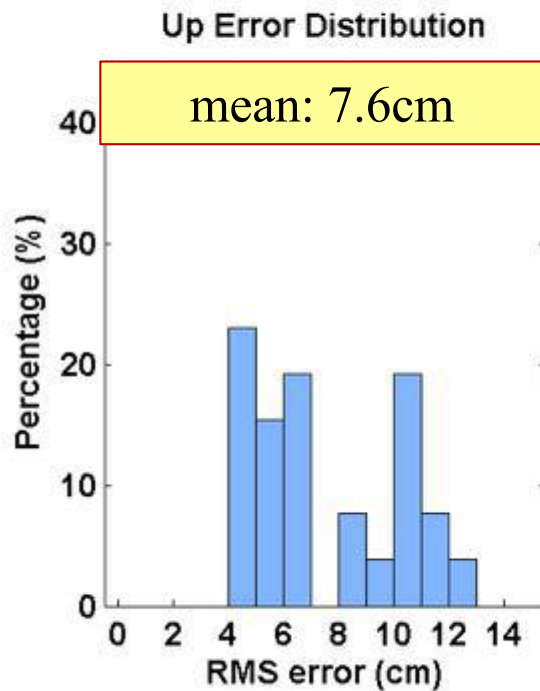
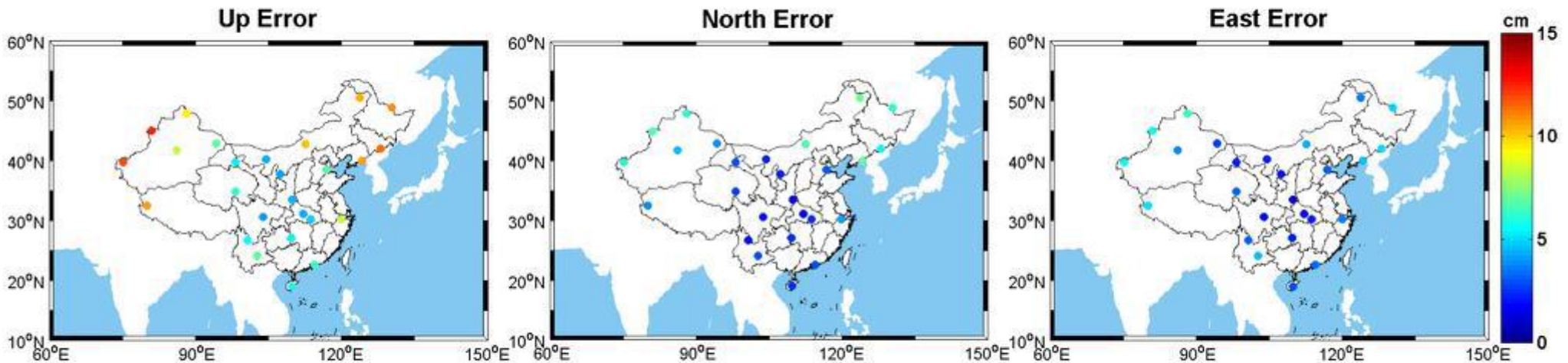
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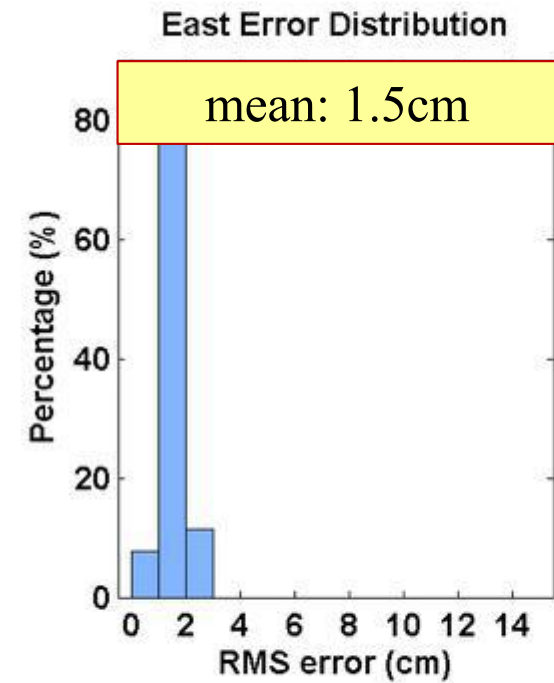
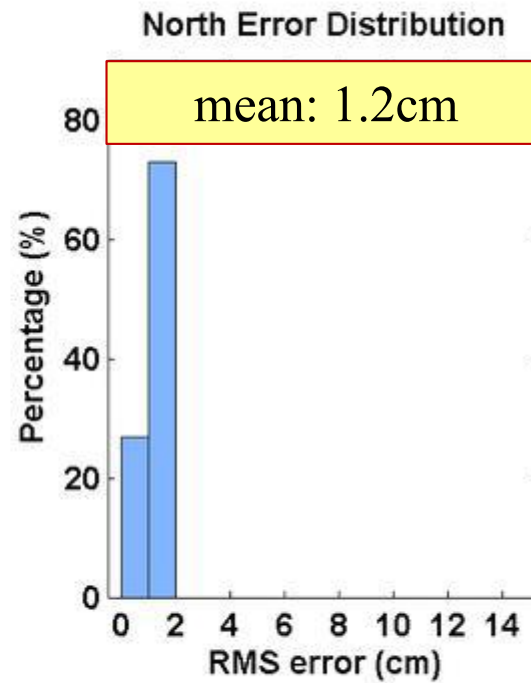
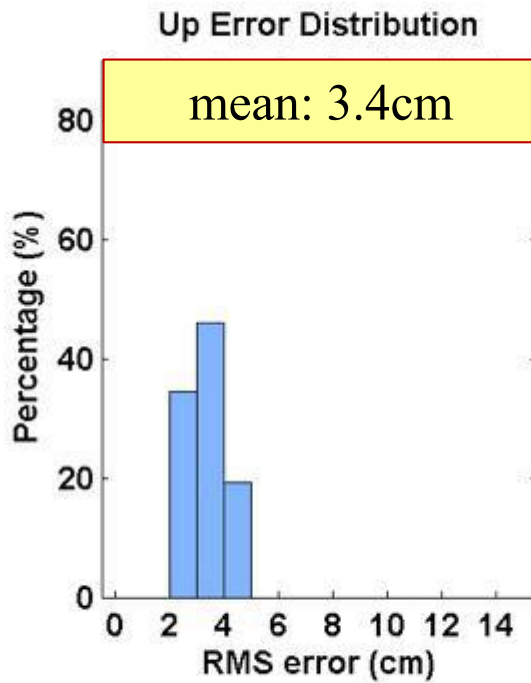
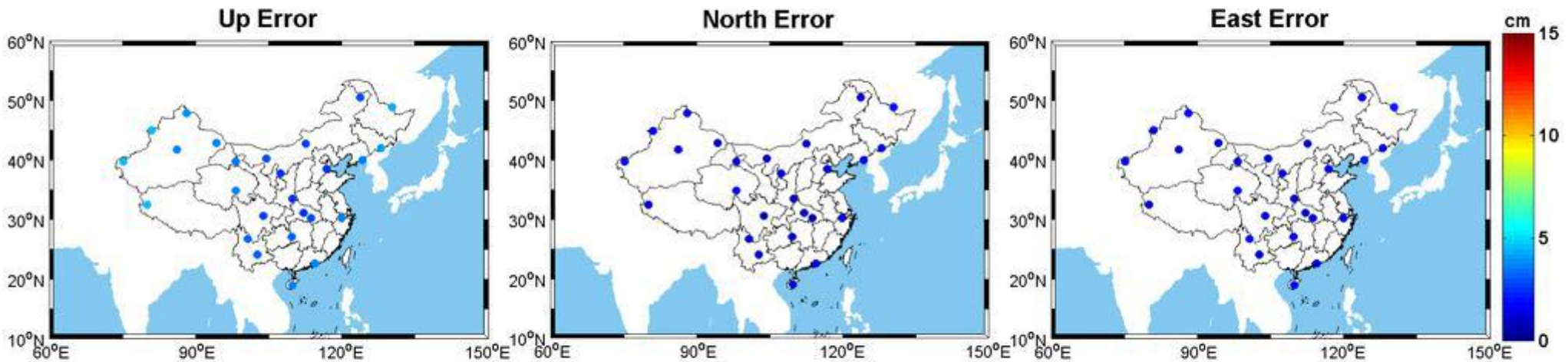
Details of the Real-Time experiment

- Stations: 26, distributed over China
- Session time: 20170121-20170128
- Accuracy
 - DF-PPP/SF-PPP/SF-SPP
- Convergence
 - DF-PPP/SF-PPP/DF-PPP with TGP

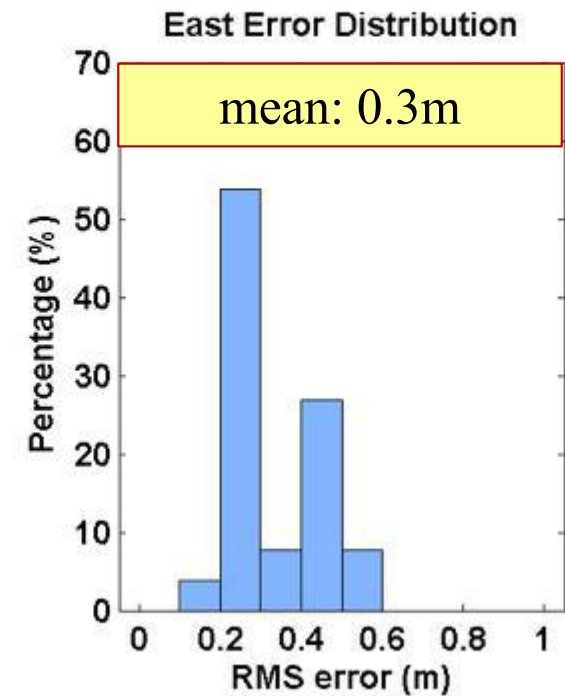
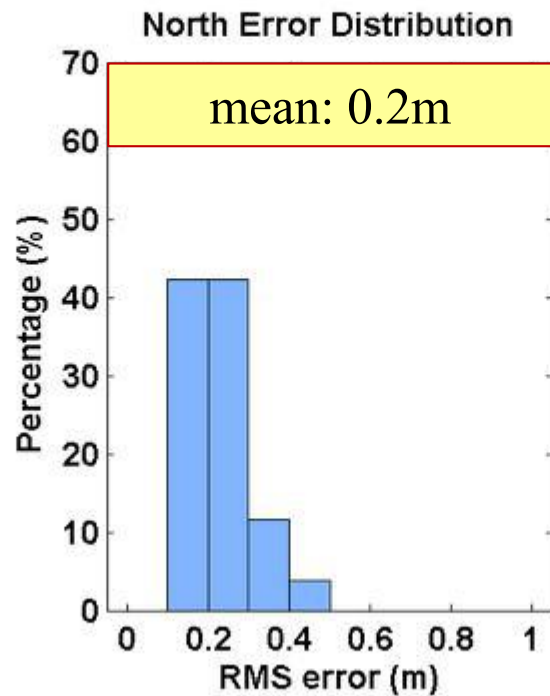
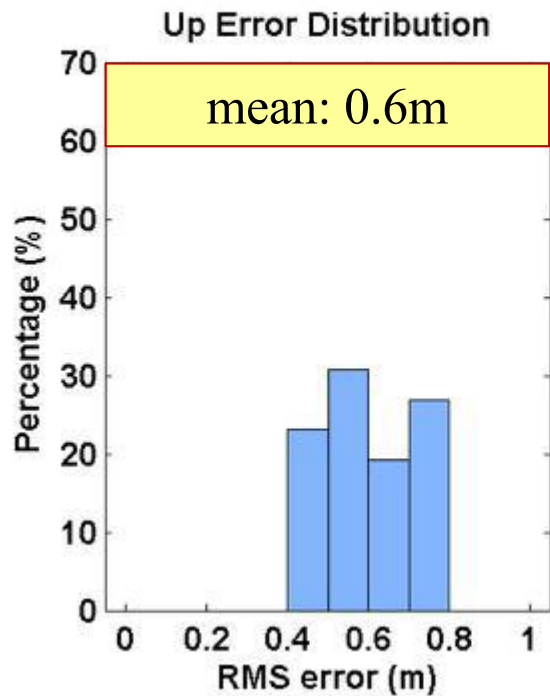
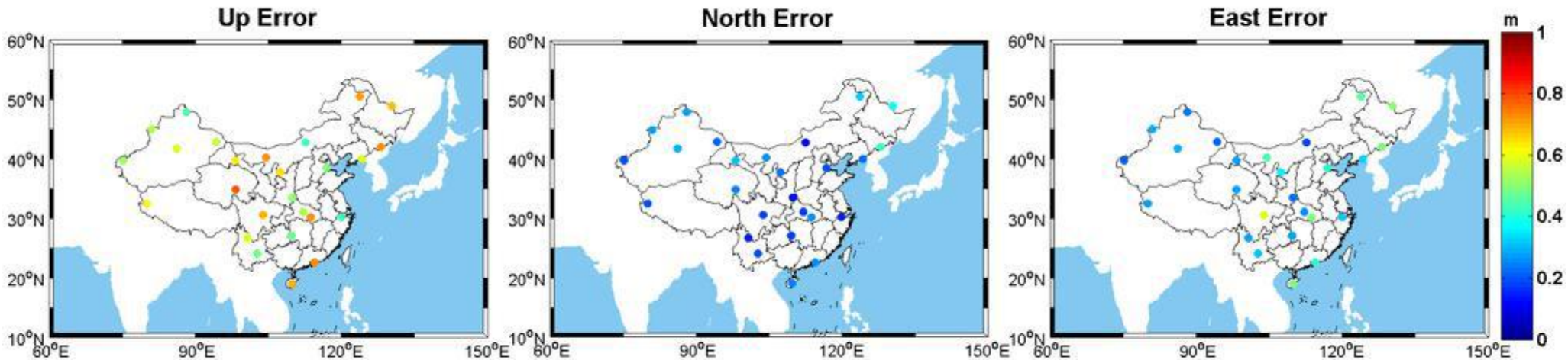
Real-time BDS DF-PPP Accuracy



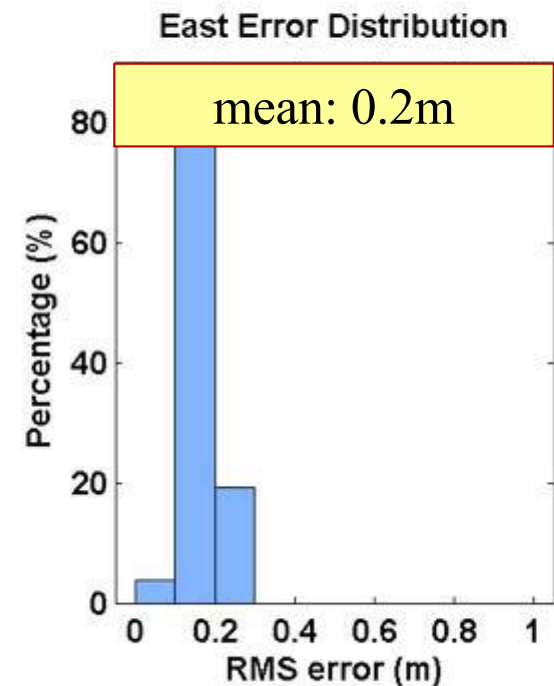
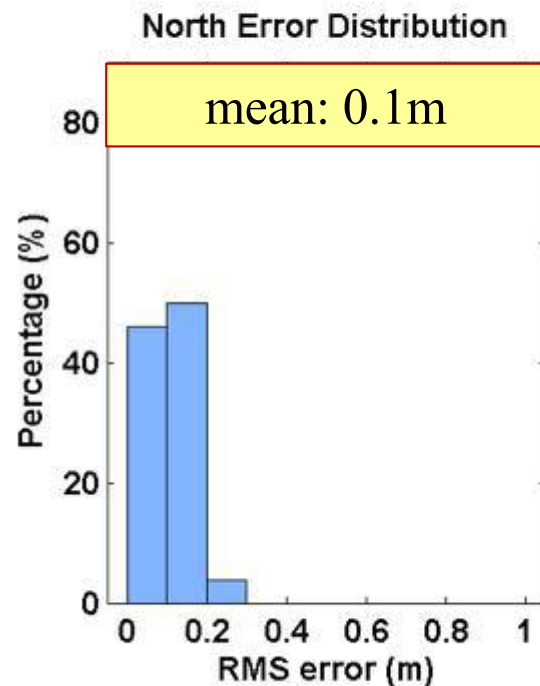
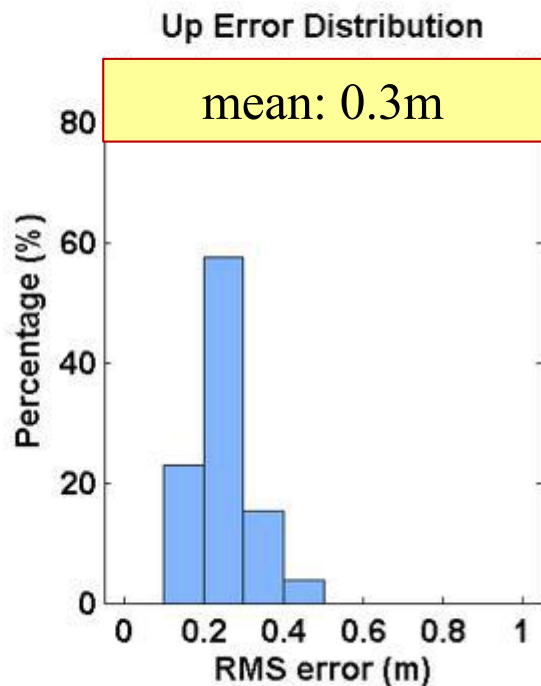
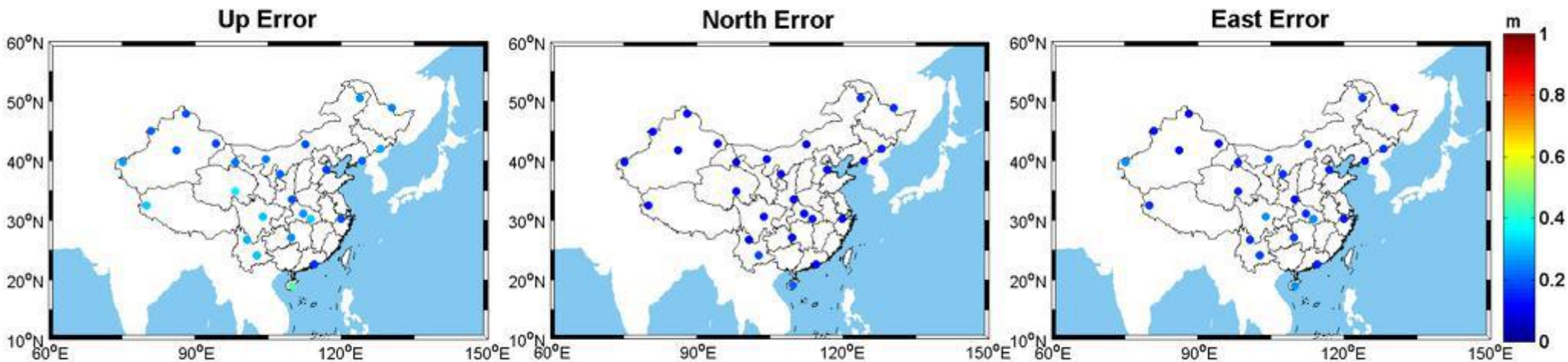
Real-time BDS+GPS DF-PPP Accuracy



Real-time BDS SF-PPP Accuracy

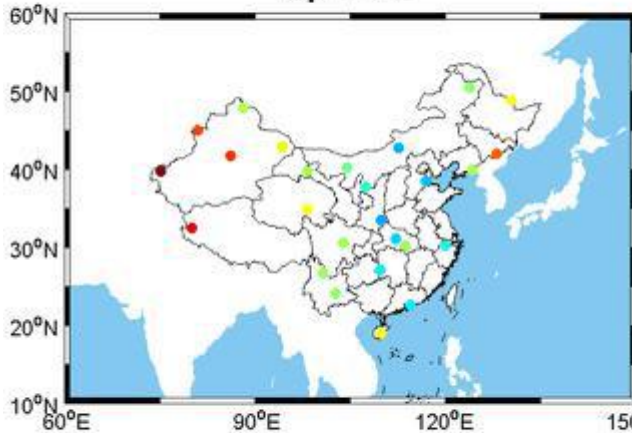


Real-time BDS+GPS SF-PPP Accuracy

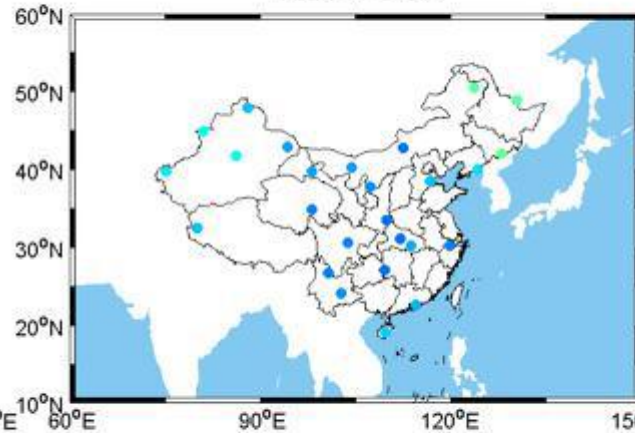


Real-time BDS SF-SPP Accuracy

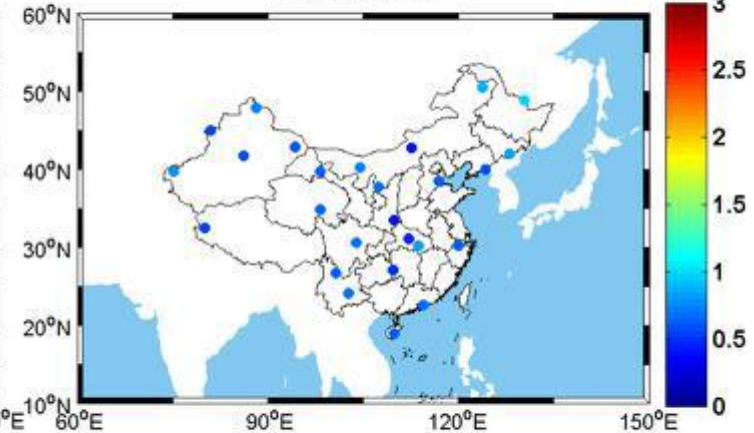
Up Error



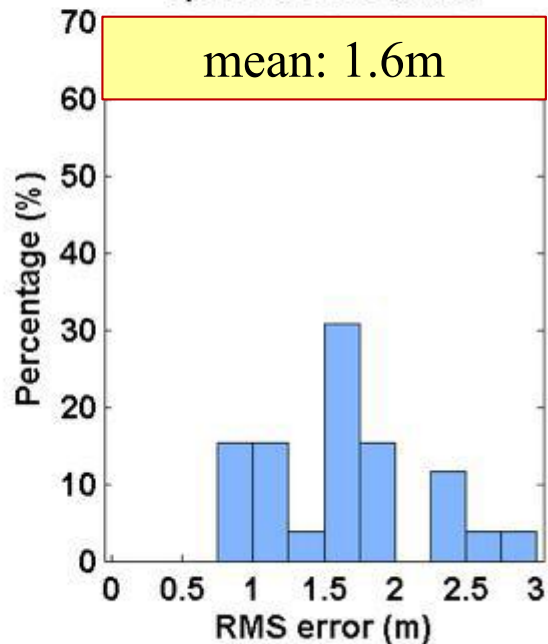
North Error



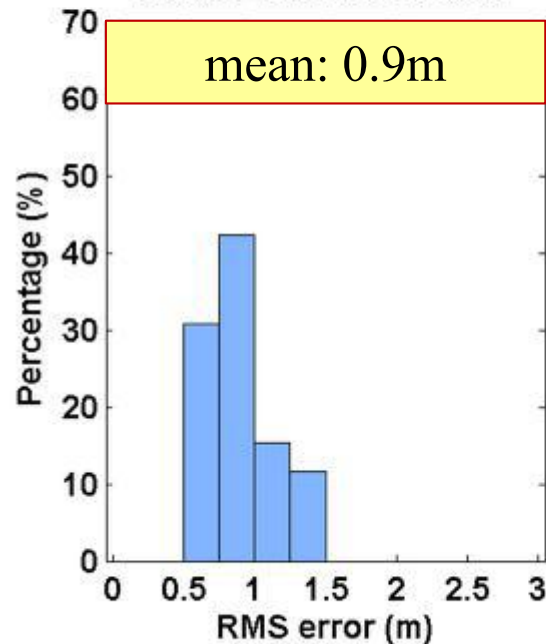
East Error



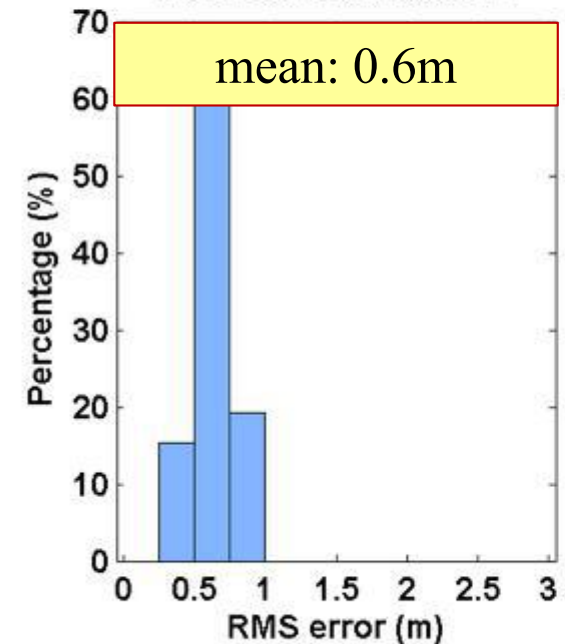
Up Error Distribution



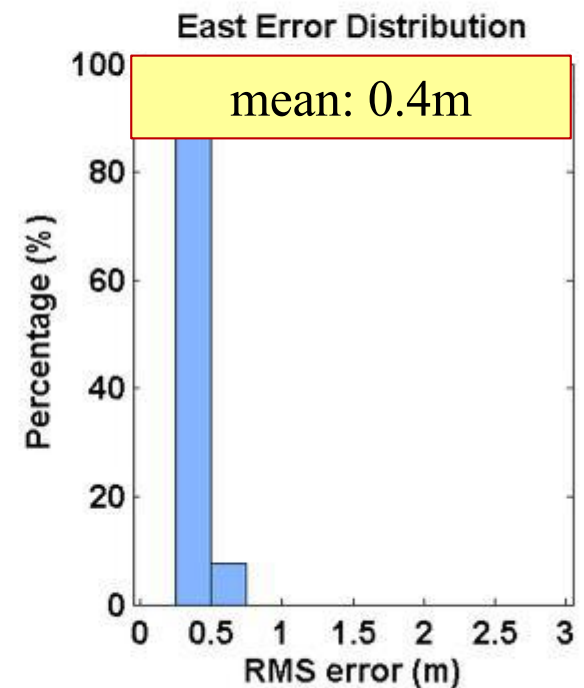
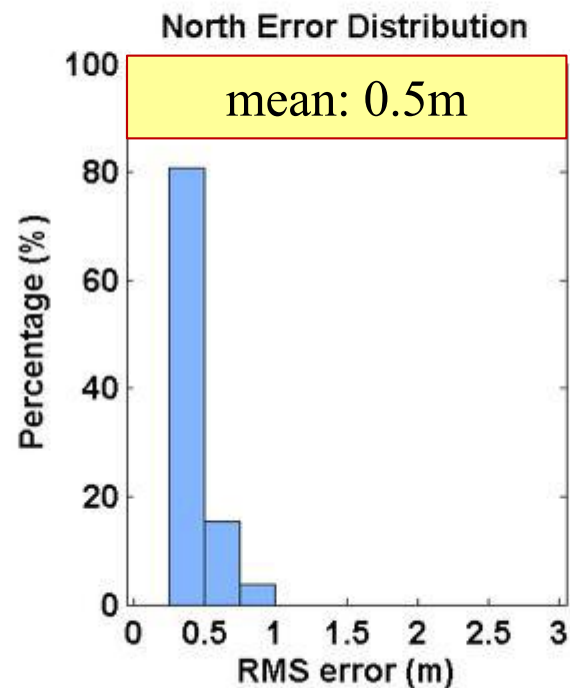
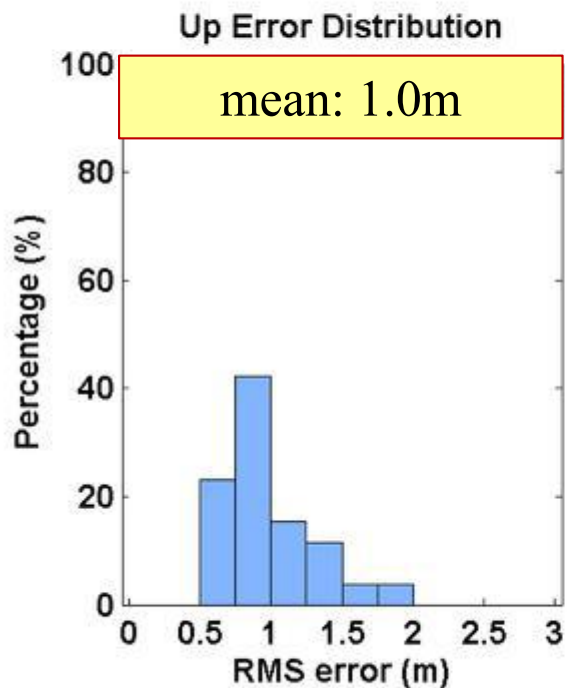
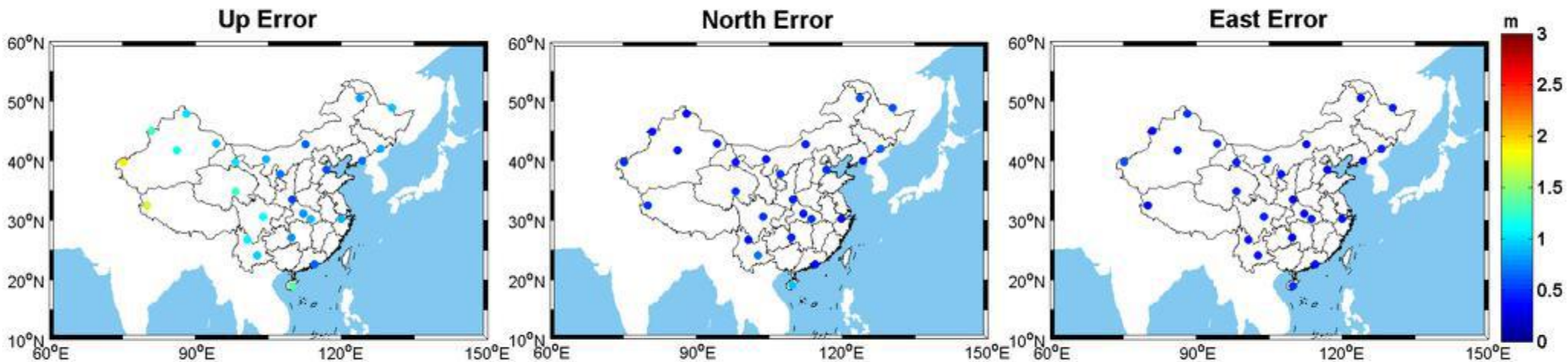
North Error Distribution



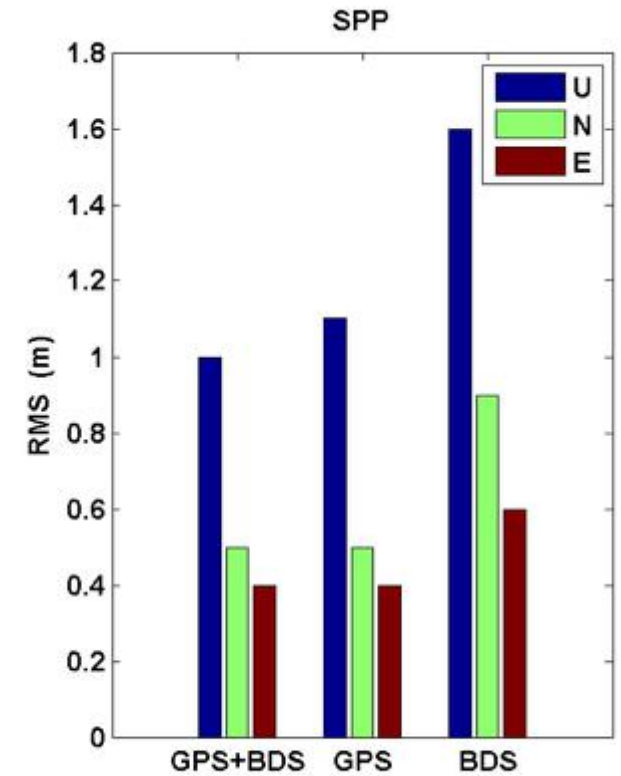
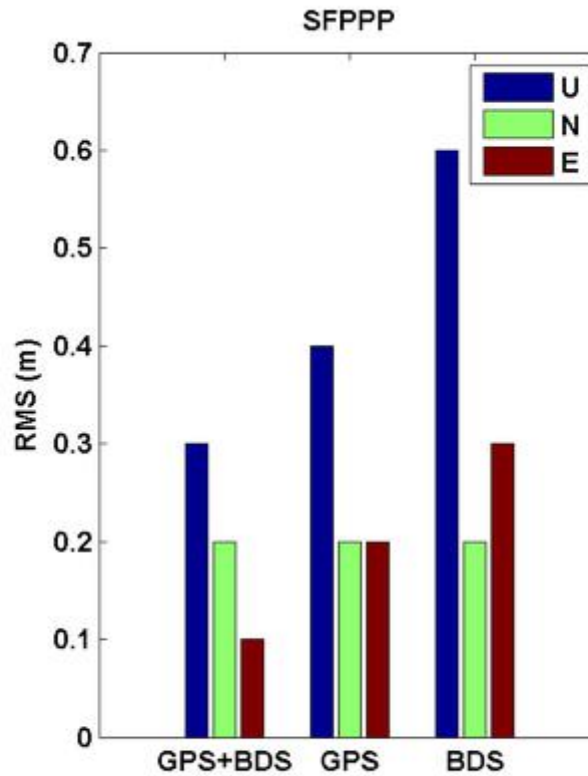
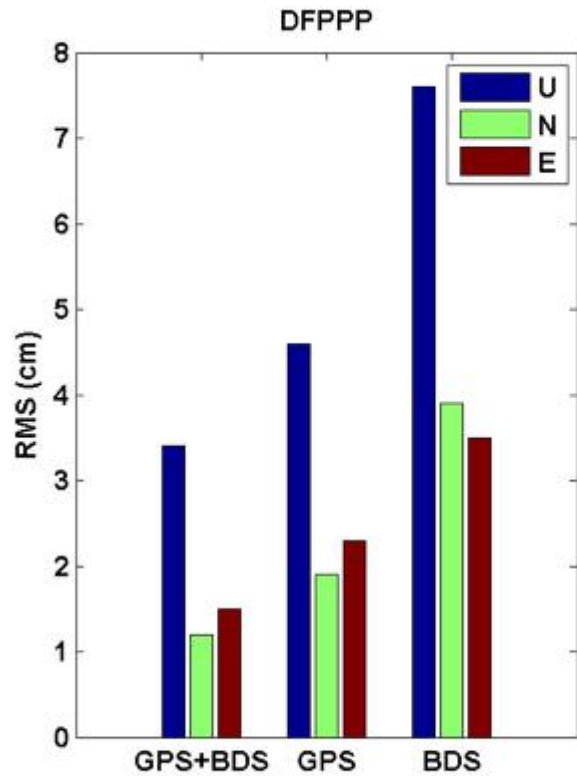
East Error Distribution



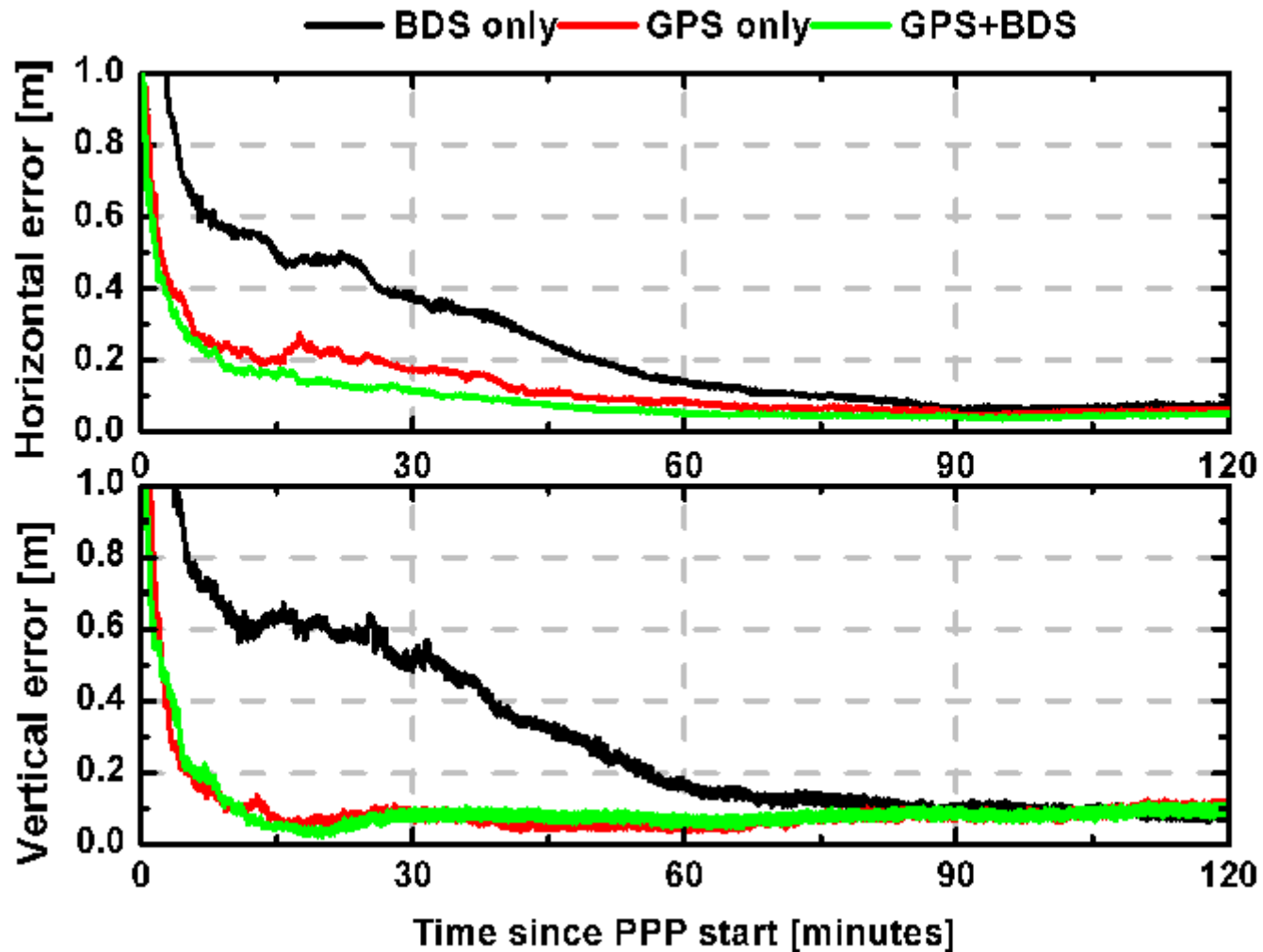
Real-time BDS+GPS SF-SPP Accuracy



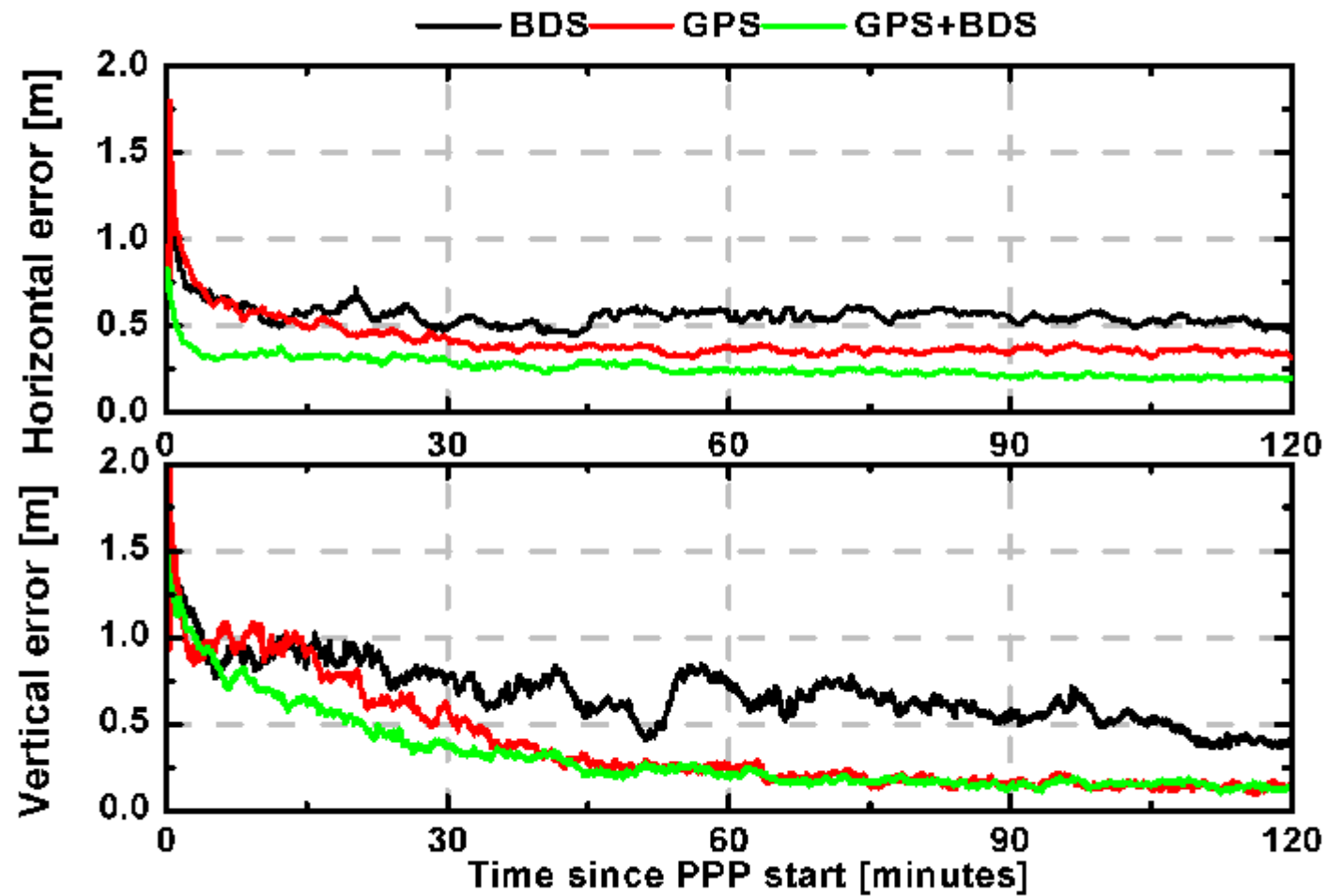
Result Analysis



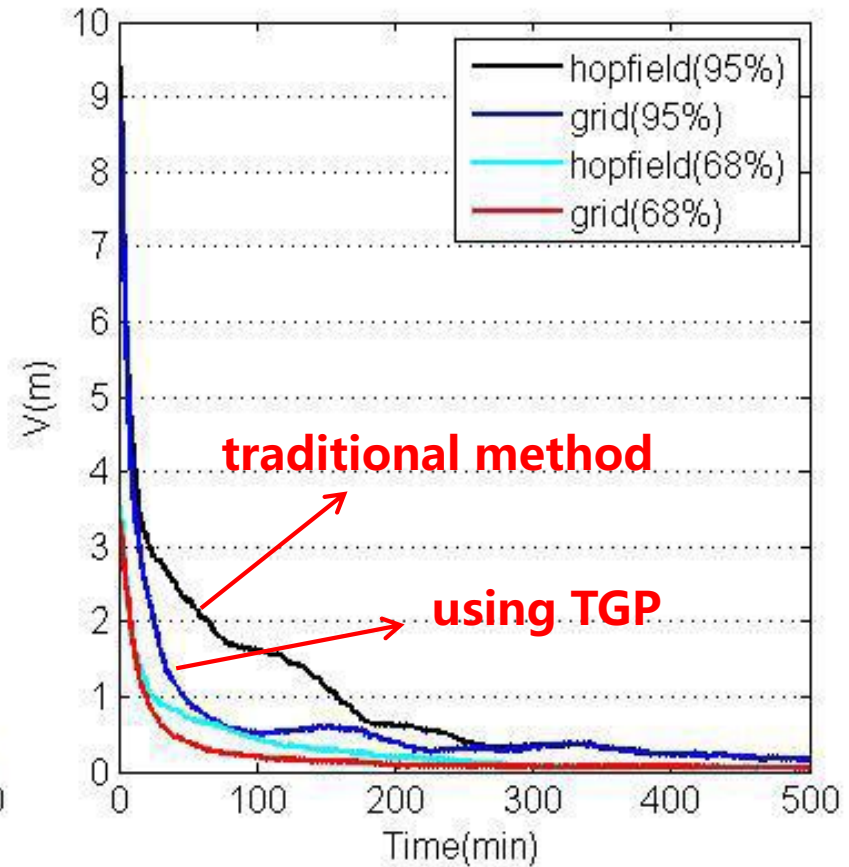
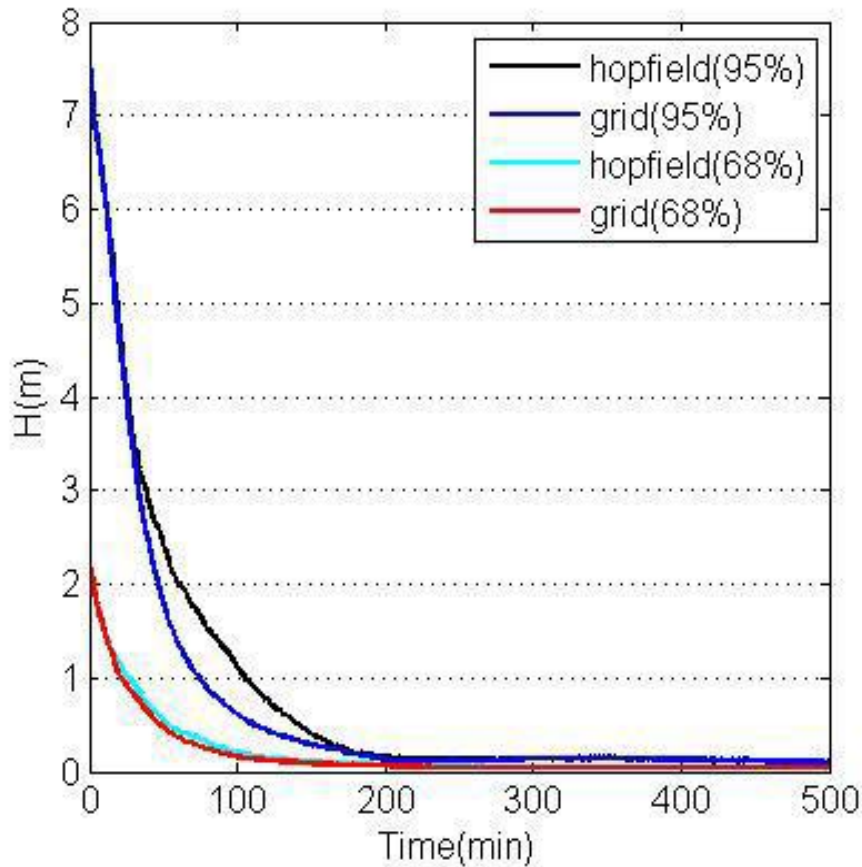
DF-PPP Convergence time



SF-PPP Convergence time



BDS DF-PPP Convergence time with TGP



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Summary

□ BDS Real-time Precise Products:

- Real-time Orbit : GEO 15cm(R) ; IGSO/MEO 10cm(R) , 30cm(3D)
- URE (Clock) : BIAS~1.0m , STD~2cm
- Real-time Ionosphere : ~3TECU , The precision of boundary area is a bit poor
- Real-time Troposphere : <1.5cm, Initial result

□ BDS Real-time PPP:

- DF-PPP : 10cm in horizontal, 20cm in vertical, convergence time ~60 mins
- DF-PPP : 0.6m in horizontal, 1.2m in vertical, convergence time ~5 mins
- SF-SPP : 2.0m in horizontal, 3.0cm in vertical, comparing with standard SPP, improvement is about 40% and ~50% in horizontal and vertical
- BDS positioning accuracy distribution with regional characteristics, its accuracy is worse than GPS in marginal area

□ The major Contribution of BDS/GPS Combination

- DF-PPP : ~20mins; SF-PPP : ~2mins

Thank You for Your attention!



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