中国测绘科学研究院
Chinese Academy of Surveying & Mapping

National GNSS/BDS CORS Services in China

Prof. Yamin Dang

Chinese Academy of Surveying & Mapping

E-mail: dangym@casm.ac.cn

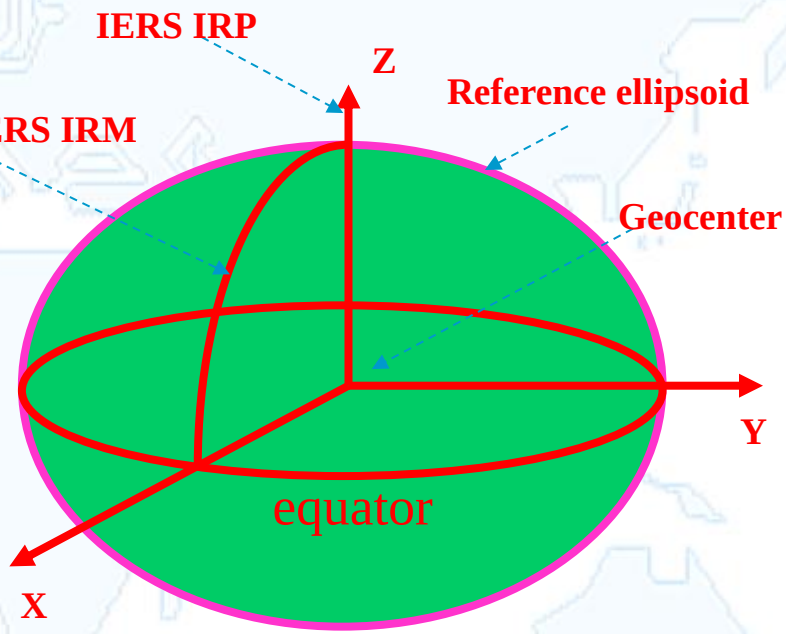
Outline

1. Reference Frame in China: CGCS 2000
2. GNSS/BDS CORS Service System
3. Wide Area CORS Service in China
4. Local Area CORS Service in China

1. Reference Frame in China: CGCS 2000

Definition of the CGCS2000 (China Geodetic Coordinate System 2000)

- A geocentric coordinate system, coincides with the IERS ITRS (International terrestrial reference system)
- The origin is the geocenter (the whole Earth body, including oceans and atmosphere)



Reference ellipsoid

a =6378137.0 m

$GM=3986004.418\times10^{8}m^{3}s^{-2}$

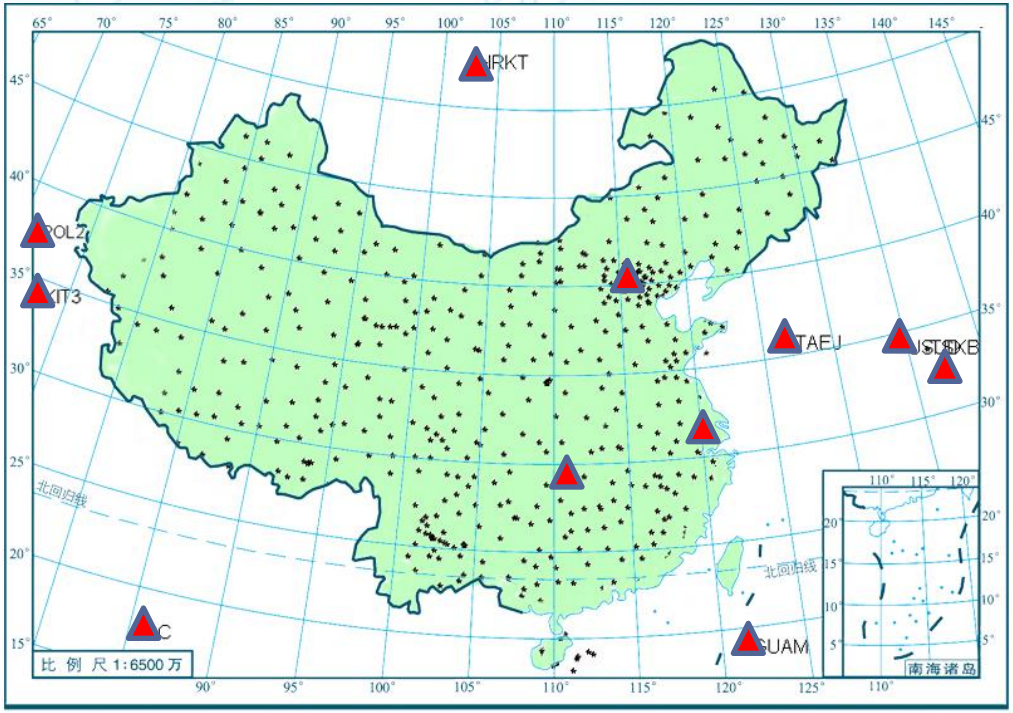
J2 = 1.082629832258

$\omega=7292115.0\times10^{-11}rad\ s^{-1}$

1. Reference Frame in China: CGCS 2000

Realization of the CGCS2000

- The orientation is aligned to ITRF97, at epoch 2000.0
- The CGCS2000 frame is constrained by 12 IGS CORS stations



▲ IGS CORS

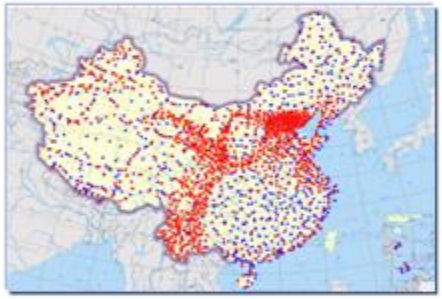
1. Reference Frame in China: CGCS 2000

Reference frame of the CGCS2000

➢ **Initial realization of the CGCS2000**

- **Fist level:** CORS network, including 25 CORS stations

- **Second level:** National GPS geodetic network 2000, over 2500 points



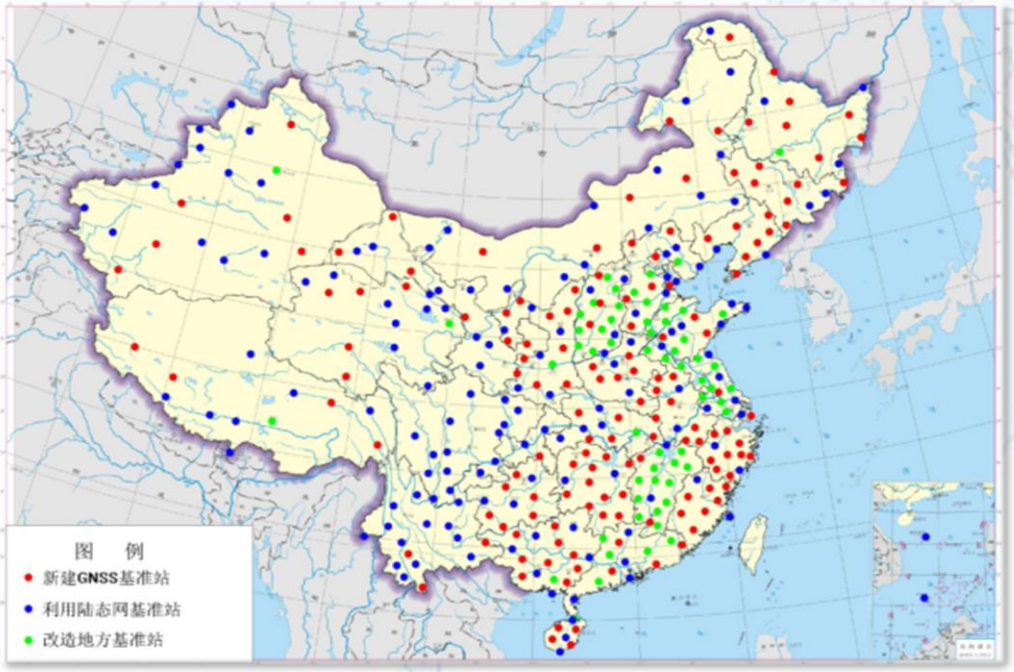
- **Third level:** National astro-geodetic network , over 50, 000 points

1. Reference Frame in China: CGCS 2000

Reference frame of the CGCS2000

➢**The extended frame of CGCS2000**

- **360 national CORS stations**
- **Over 1800 provincial CORS stations**

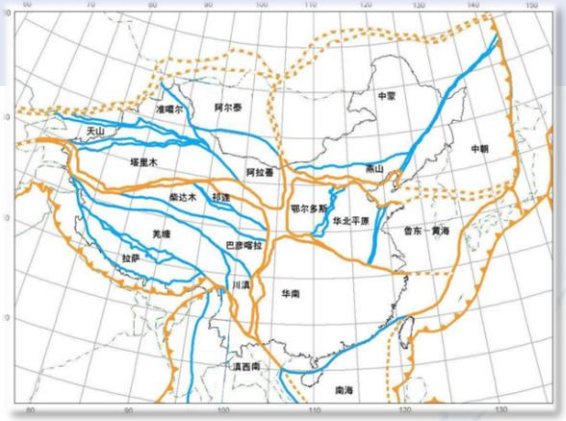


- **360 CORS stations were newly established by the China modern datum construction project**
- **1800 provincial CORS stations are utilized**

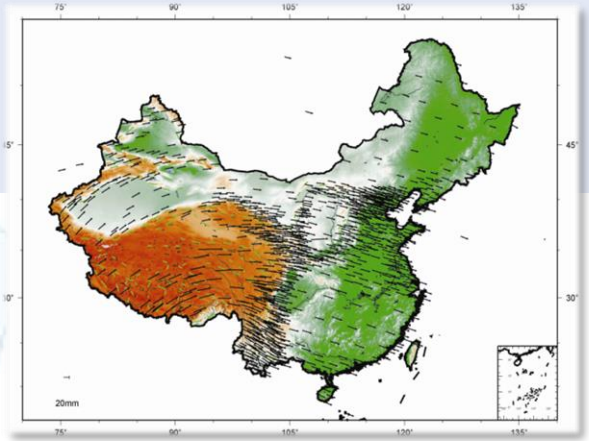
1. Reference Frame in China: CGCS 2000

CGCS2000 applications and services

- National basic surveying and mapping
- Datum transformation between national and provincial datum
- Hazard monitoring
- Scientific research
- Public services



China plate model



China crustal motion monitoring

Public users

2. GNSS/BDS CORS Service System

Global GNSS service, i.e., the International GNSS Service (IGS)

Global GNSS CORS Stations

Global GNSS Data Center

Global GNSS Data Analysis Centers

Service Network and Websites

IGS reference frame and products

- Station coordinates and velocities
- Orbit and clock products
- ERP (earth rotation parameter)
- Global ionosphere
- …

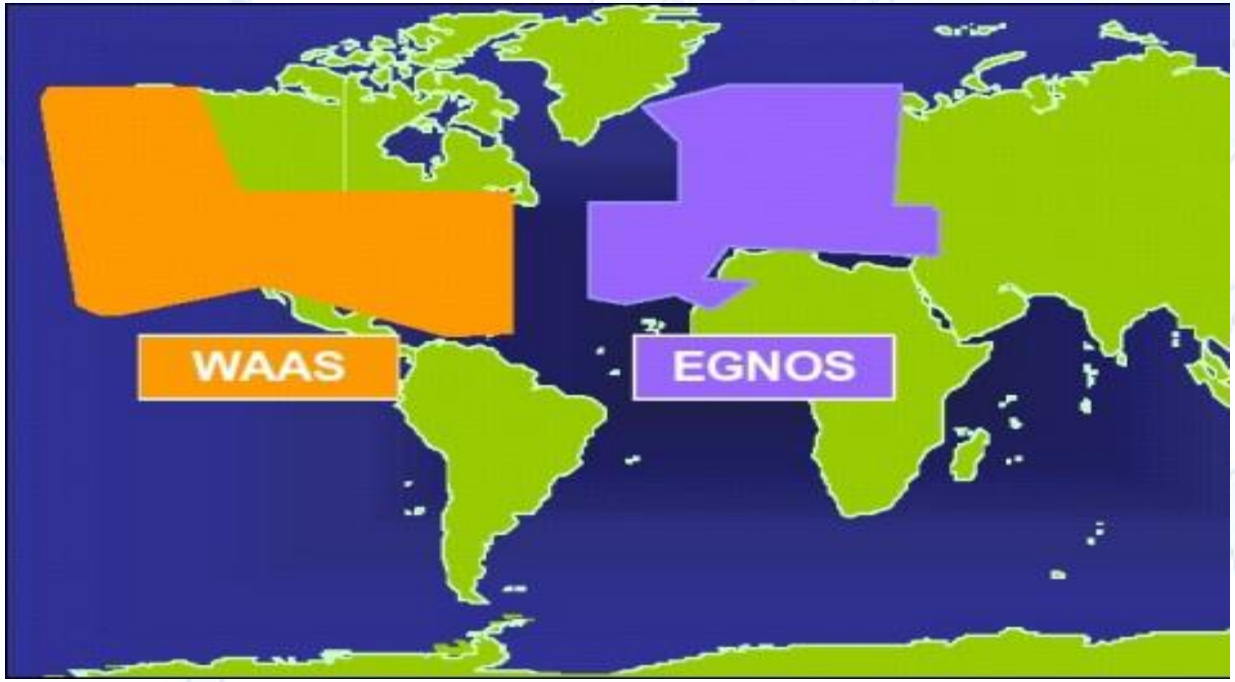
Releasing

Users, including scientific researchers, IERS, PPP users, industry users

2. GNSS/BDS CORS Service System

Regional GNSS services, including

- **GBAS (Ground-based Augmentation System)**
- **SBAS (Satellite-Based Augmentation System)**
  - **WAAS (Wide Area Augmentation System, USA)**
  - **EGNOS (European Geostationary Navigation Overlay Service, Europe)**



2. GNSS/BDS CORS Service System

GNSS/BDS CORS service systems in China

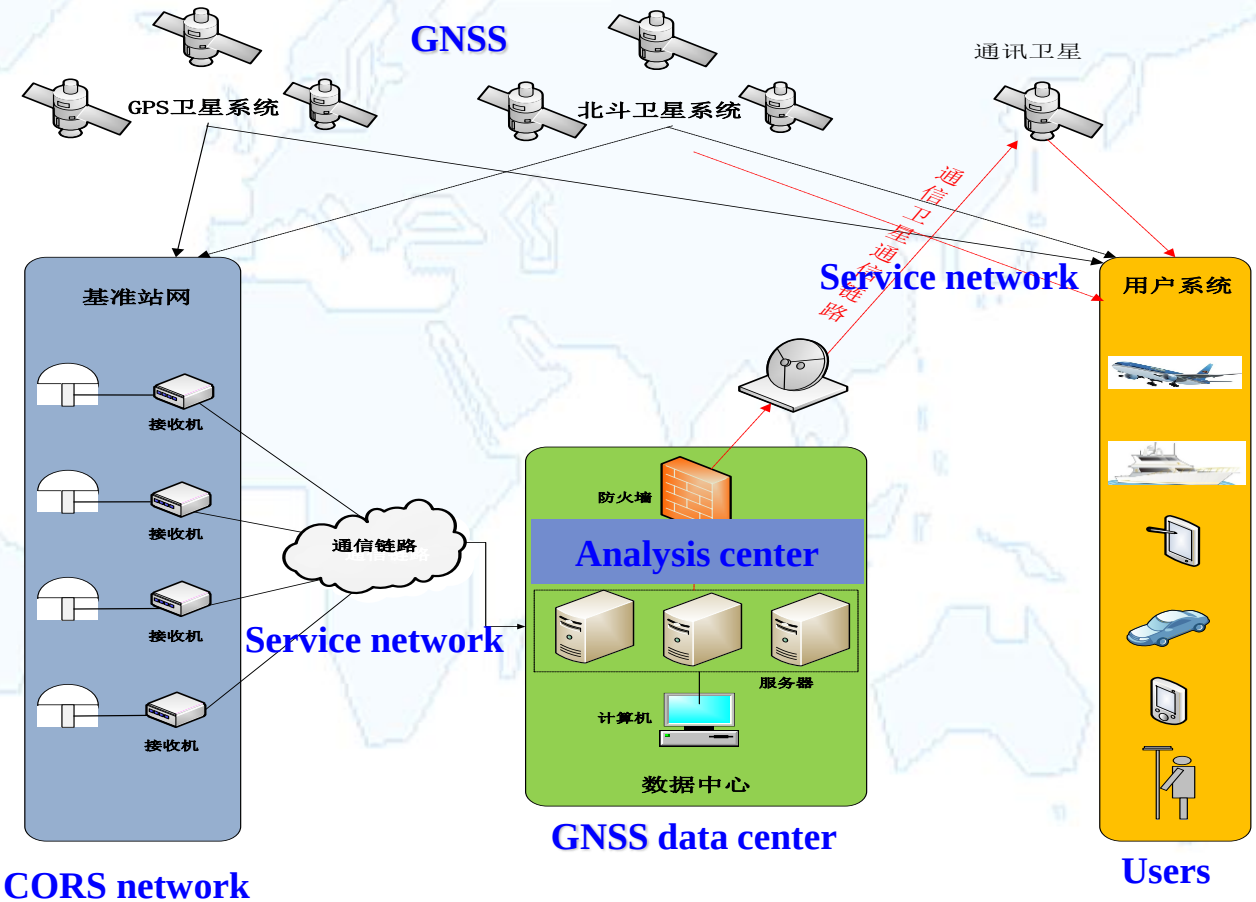
- **National GNSS/BDS CORS service** is GBAS-based and official–controlled, covering the mainland of China
- **Provincial services** is RTK(Real Time Kinematic)–based, covering most provinces in China
- **Commercial LBS (Location Based Service)**, developed by many companies

National CORS DC and AC located in NASG (National Administration of Surveying, Mapping and Geoinformation of China)

2. GNSS/BDS CORS Service System

China national GNSS/BDS CORS service system architecture

- National CORS network
- GNSS data center
- GNSS analysis center
- Service network
- Users



3. Wide Area CORS Service in China

National CORS network

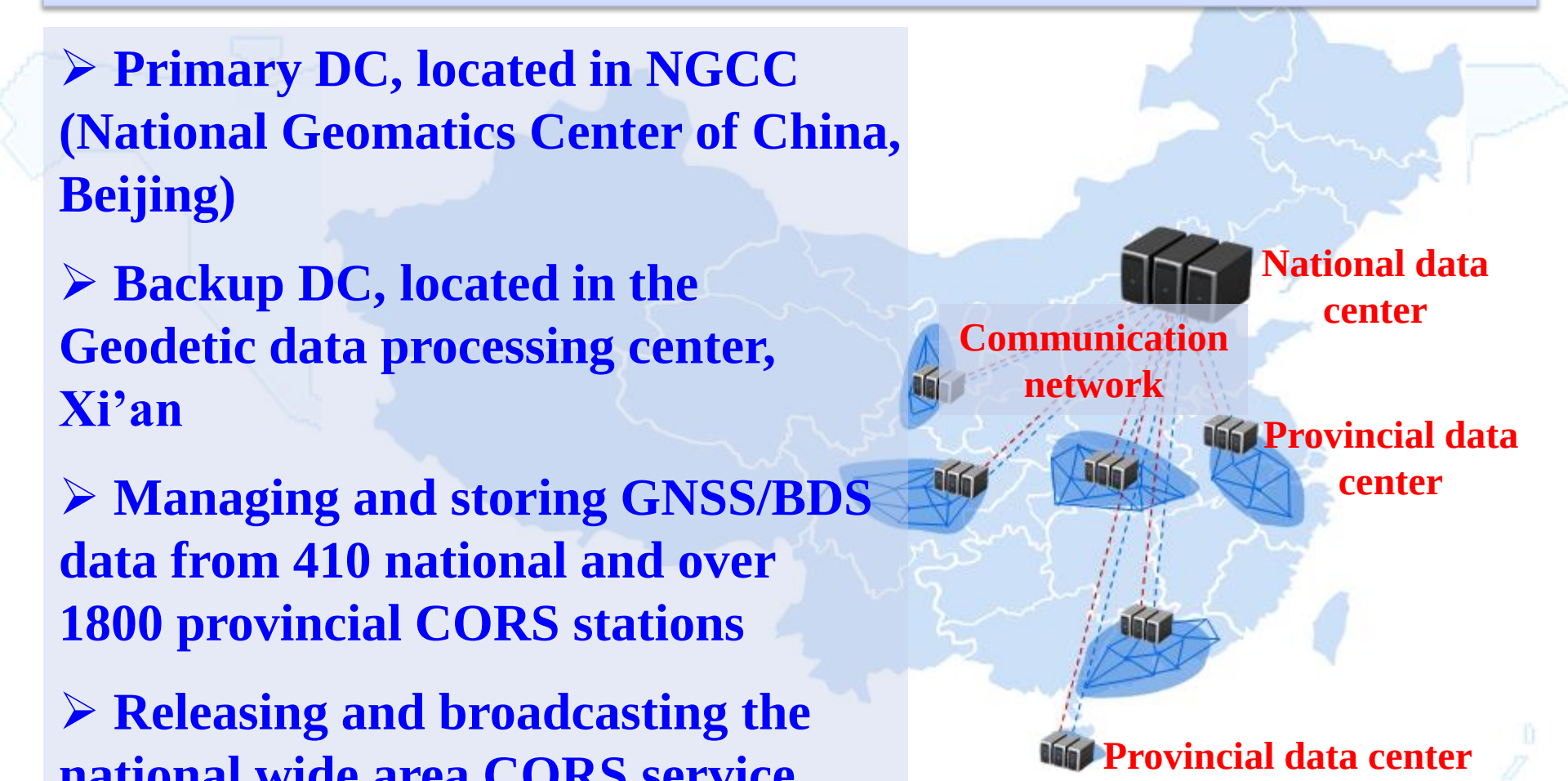
➢ **410 national CORS stations**

- **360 stations from the China modern datum construction project**
- **50 stations located in the China sea area**

3. Wide Area CORS Service in China

National GNSS data center (DC)

- Primary DC, located in NGCC (National Geomatics Center of China, Beijing)
- Backup DC, located in the Geodetic data processing center, Xi'an
- Managing and storing GNSS/BDS data from 410 national and over 1800 provincial CORS stations
- Releasing and broadcasting the national wide area CORS service



3. Wide Area CORS Service in China

National GNSS analysis center (AC)

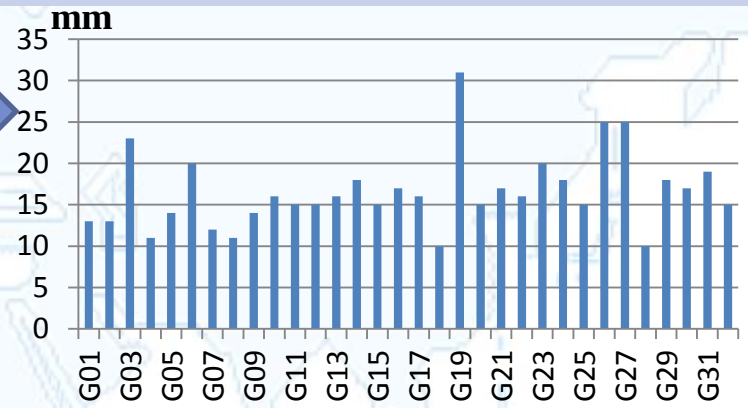
- Located in CASM (Chinese academy of surveying and mapping)
- Data analysis and processing
- Producing national wide area CORS service products, including
  - Station coordinates and velocities
  - Orbit and clock products
  - ERP (earth rotation parameter)
  - Ionosphere
  - …

3. Wide Area CORS Service in China

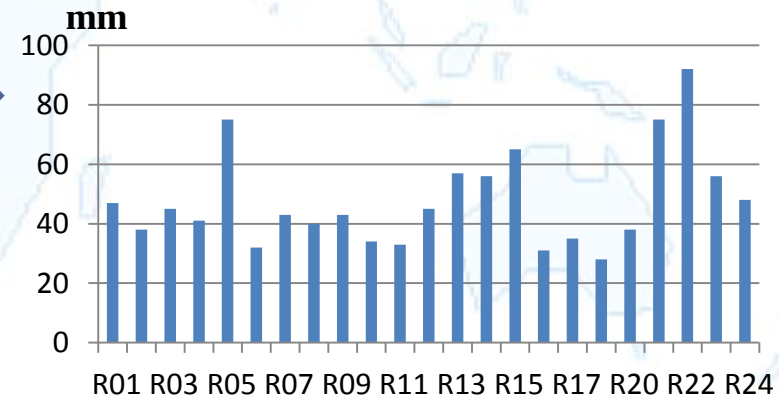
National GNSS analysis center (AC)

- **Real-time orbit using over 100 CORS stations**

GPS: 2cm, vs. IGS



GLONASS: 4cm, vs. IGS

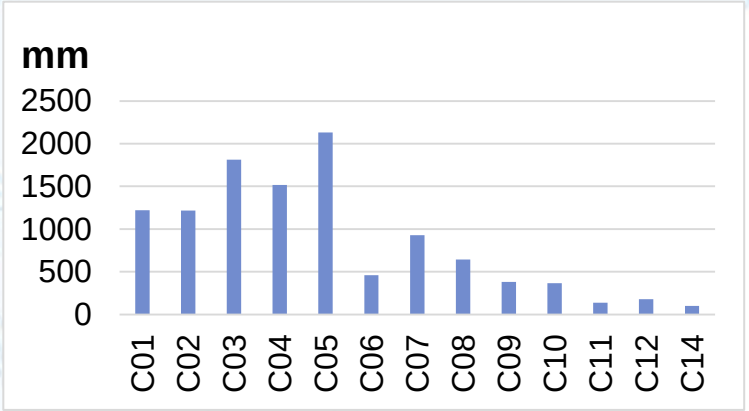


3. Wide Area CORS Service in China

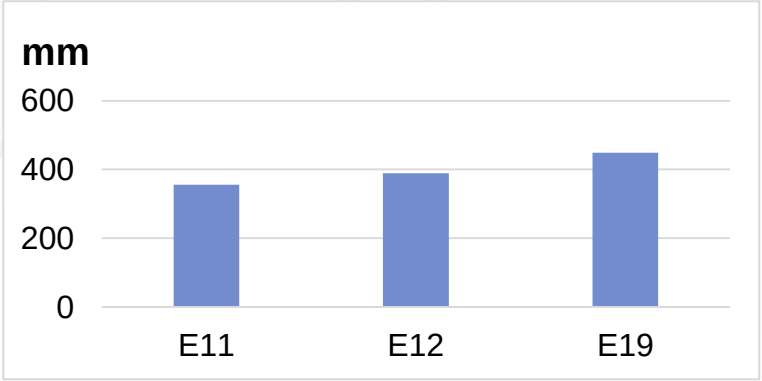
National GNSS analysis center (AC)

- **Real-time orbit using over 100 CORS stations**

BDS, VS. GFZ
GEO: 200cm
BDS IGSO/MEO: 15cm



GALILEO, 15cm, VS. GFZ

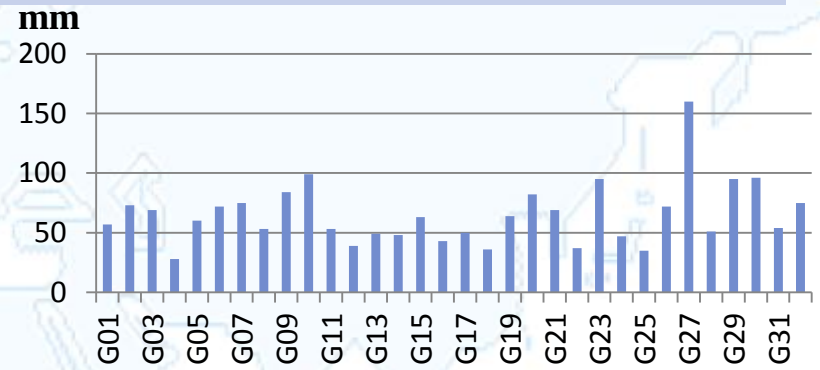


3. Wide Area CORS Service in China

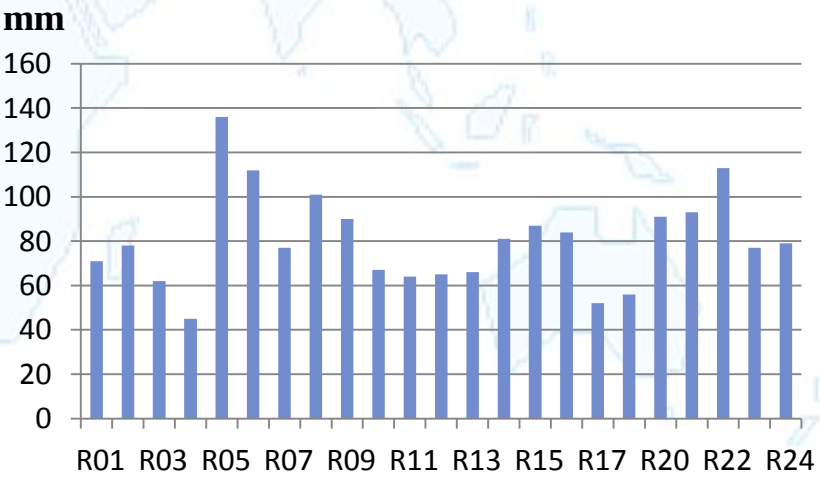
National GNSS analysis center (AC)

- **Real-time orbit (forecasting)**

GPS: 5cm, vs. IGS



GLONASS: 8cm, vs. IGS

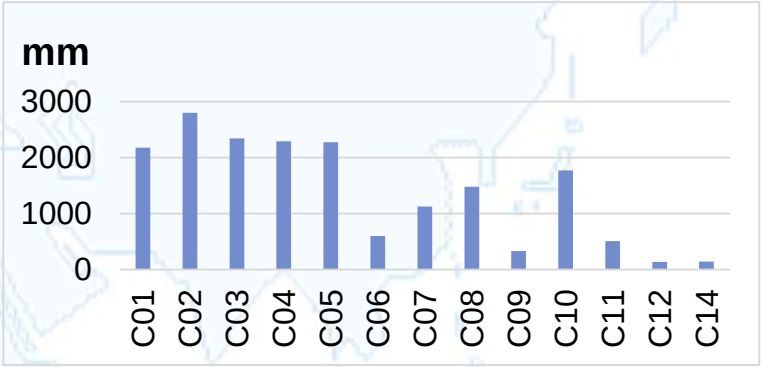


3. Wide Area CORS Service in China

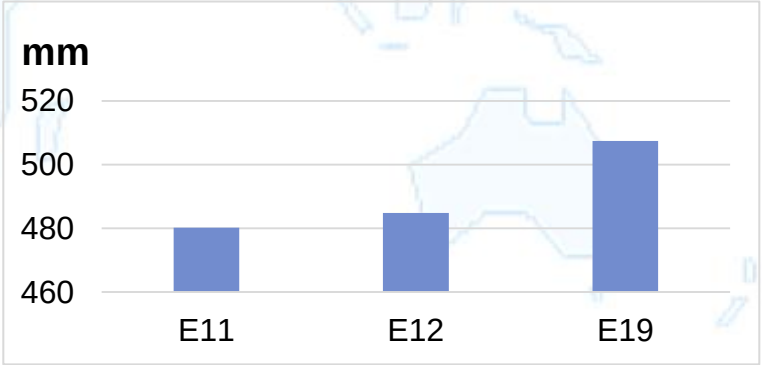
National GNSS analysis center (AC)

- **Real-time orbit (forecasting)**

BDS, VS. GFZ
GEO: 250cm
BDS IGSO/MEO: 25cm



GALILEO, 30cm, VS. GFZ

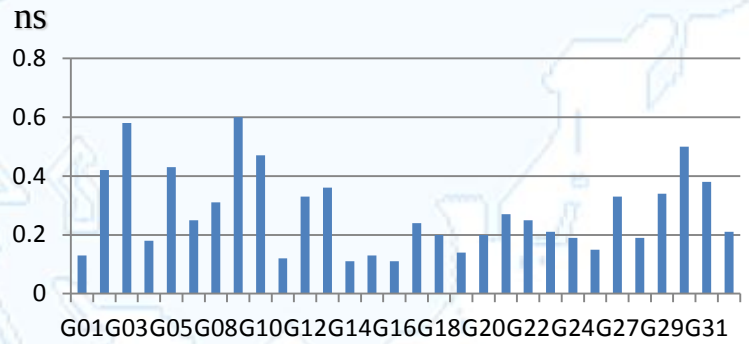


3. Wide Area CORS Service in China

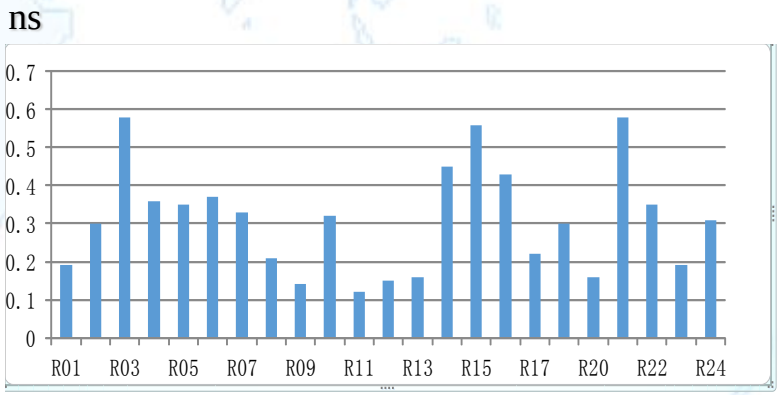
National GNSS analysis center (AC)

- **Real-time clock**

GPS: 0.25 ns, vs. IGS



GLONASS: 0.3 ns, vs. IGS

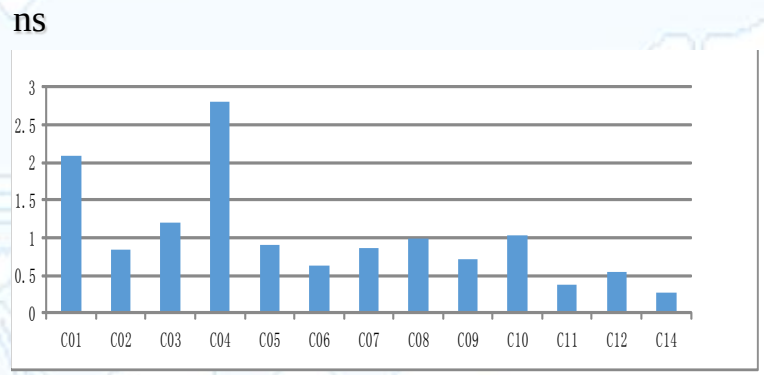


3. Wide Area CORS Service in China

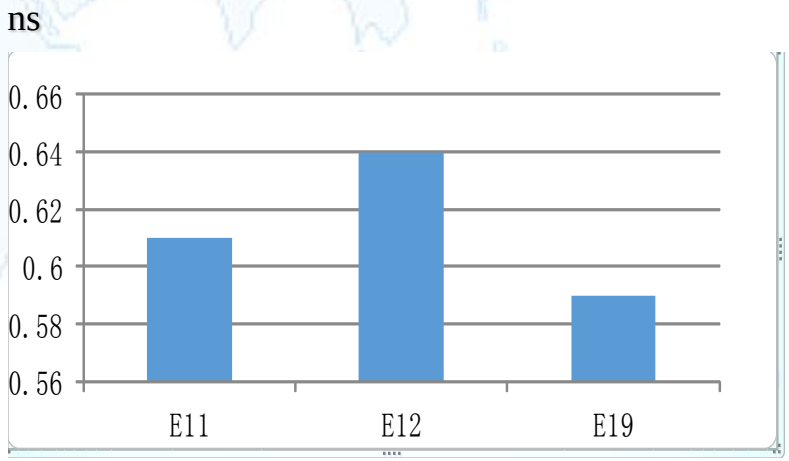
National GNSS analysis center (AC)

- **Real-time clock**

BDS, VS. GFZ
GEO: 0.5~4.5ns
BDS IGSO/MEO: 0.2~2.0 ns



GALILEO, 0.6 ns, VS. GFZ



3. Wide Area CORS Service in China

National GNSS analysis center (AC)

➢ Final orbit and clock

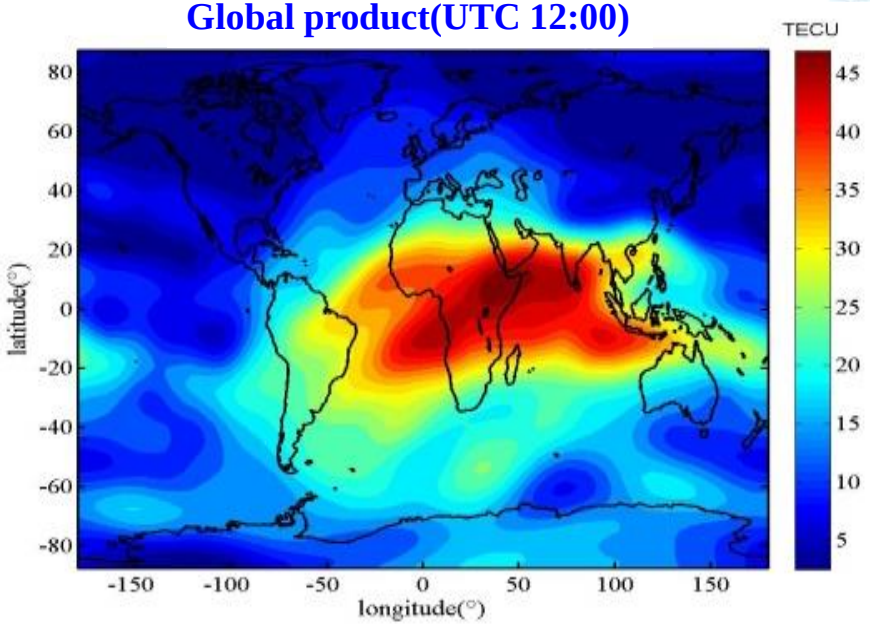
Product	Orbit (cm)	Clock (ns)	Delay
Fast	GPS:1.5	GPS:0.25	13 h
	BDS: MEO/IGSO:12; GEO:300	BDS:0.54	
	GLONASS: 3.9	GLONASS:0.48	
	GALILEO:9.7	GALILEO:0.27	
Final	GPS:1.2	GPS:0.16	10 day
	BDS: MEO/IGSO:10; GEO:250	BDS:0.48	
	GLONASS:3.3	GLONASS:0.39	
	GALILEO:6.3	GALILEO:0.22	

3. Wide Area CORS Service in China

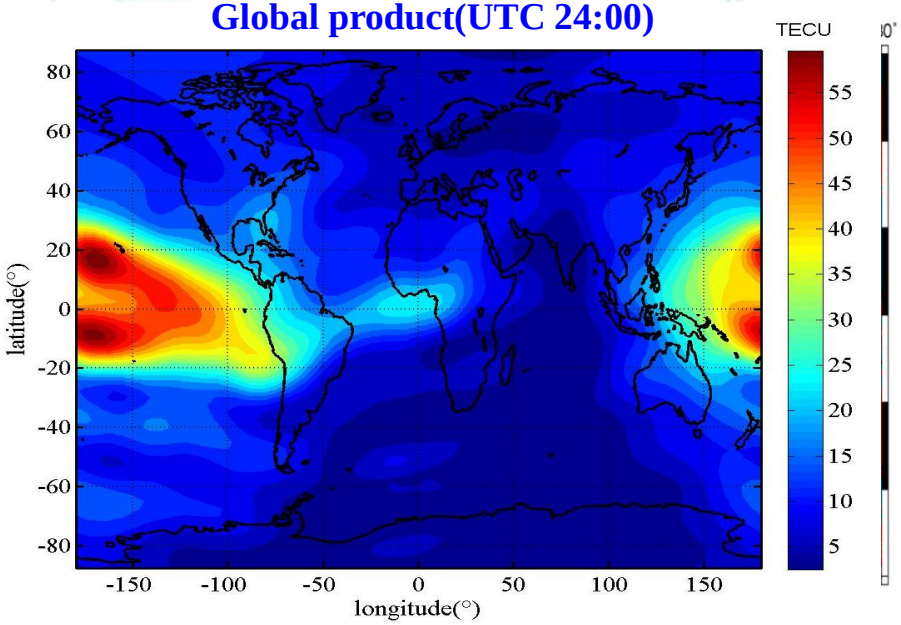
National data analysis center (AC)

- **Global ionosphere**
  - **Modeling： Spherical Harmonic Functions Model**
  - **Resolution: 2 hours, 5 degrees in longitude, 2.5 degrees in latitudes**
  - **Precision: 2-8 Tecu, compare with IGS**

Global product(UTC 12:00)



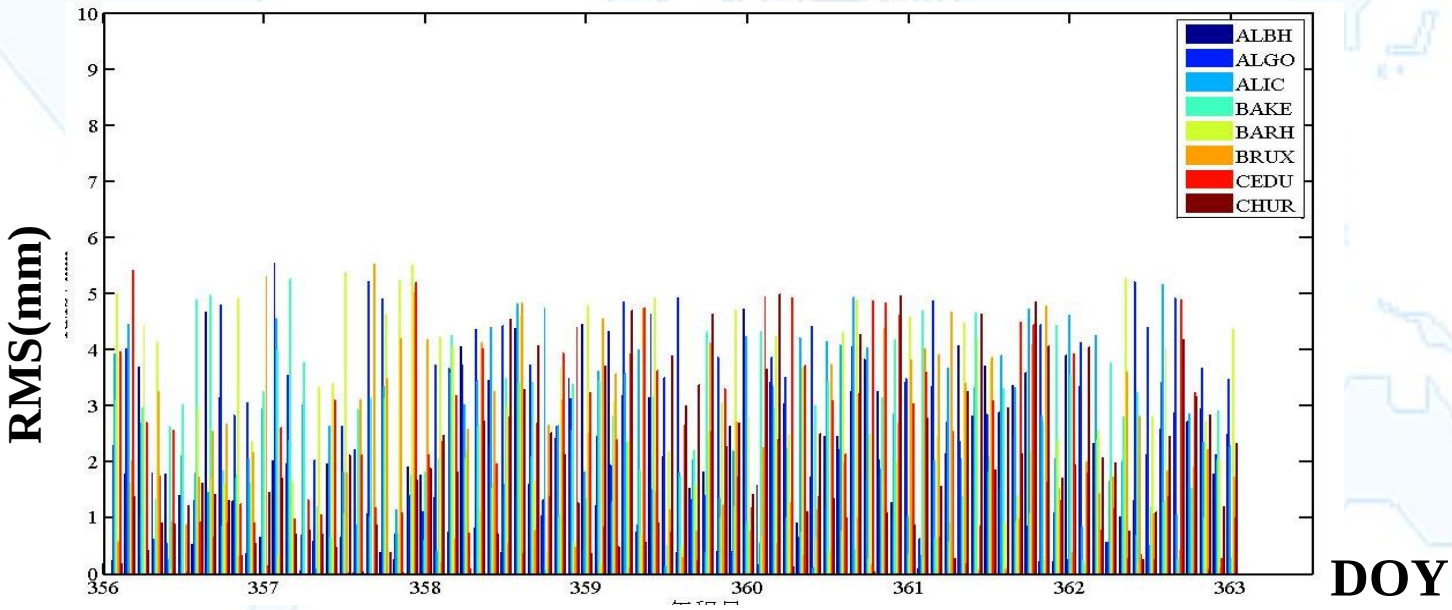
Global product(UTC 24:00)



3. Wide Area CORS Service in China

National data analysis center (AC)

- **Troposphere**
  - **Resolution: 2 hour**
  - **Precision: 6mm, VS. IGS**

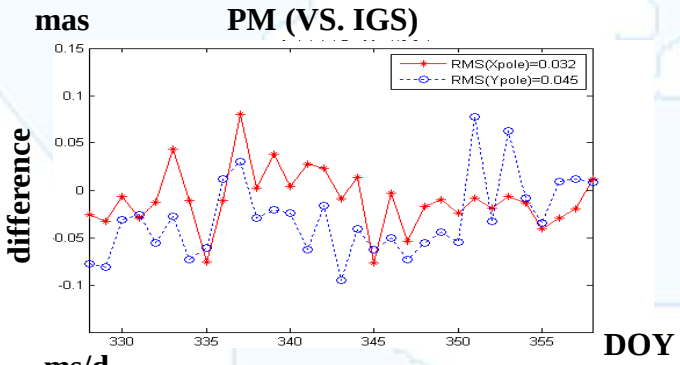


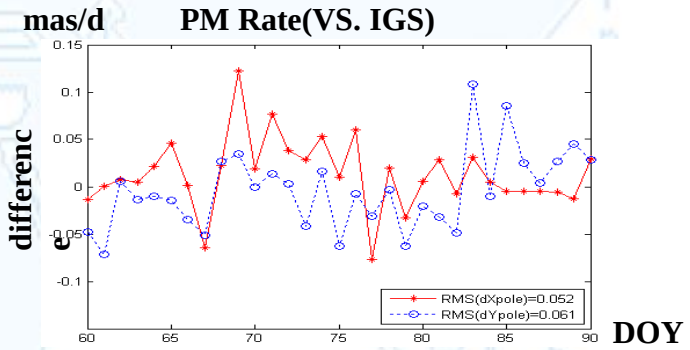
356-363 days of 2015, 8 CORS stations

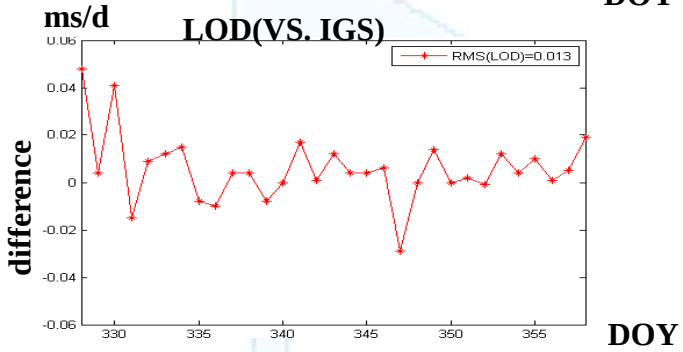
3. Wide Area CORS Service in China

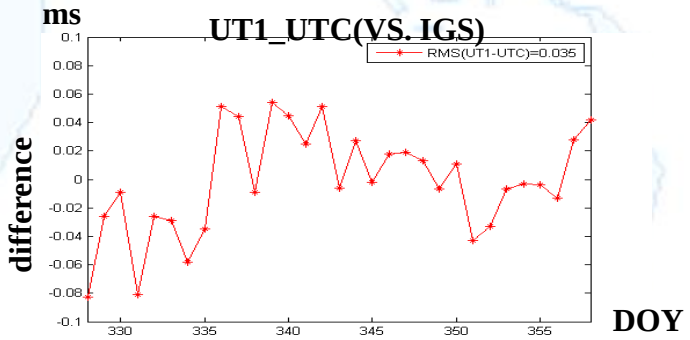
National data analysis center (AC)

- **ERP(Earth rotation parameter)**
  - **PM (pole motion), UTC, UT1-UTC products**
  - **Precision:**









3. Wide Area CORS Service in China

Service network

- **Communication between CORS station and the data center**
  - **A private network communication**
- **Communication between the data center and user via:**
  - **Internet /GPRS**
  - **Radio broadcasting**
  - **Websites**
  - **…**

3. Wide Area CORS Service in China

Terminal users

➢ **We developed a software package, compatible with multi-platforms including Windows, Windows mobile and Android**

- **Pseudo-range positioning precision is better than 2 meters**
- **PPP precision is from centimeters to decimeters**

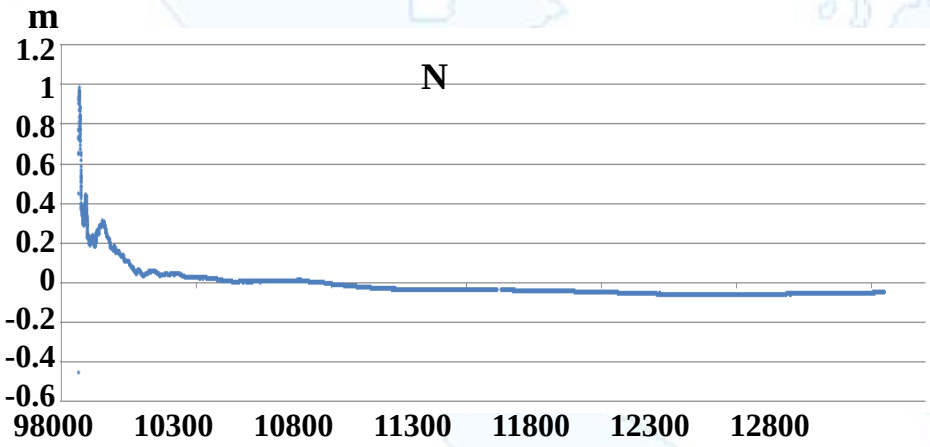
Software embedded in Windows mobile platform

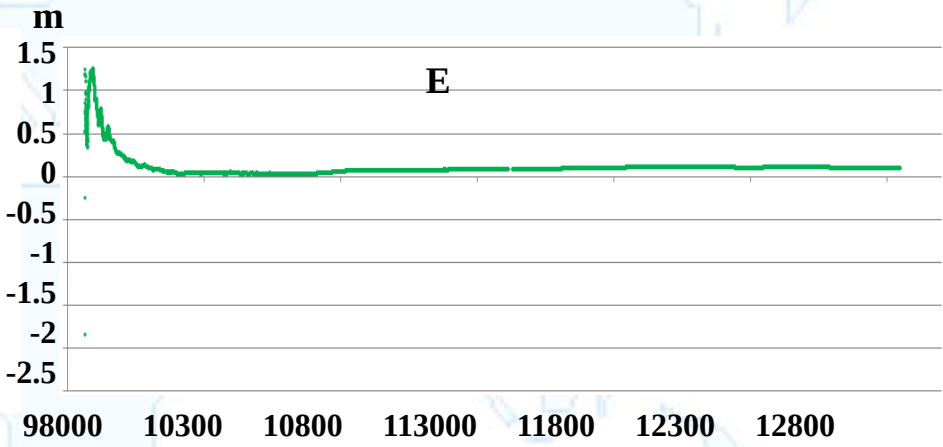
Software platform embedded in Android platform

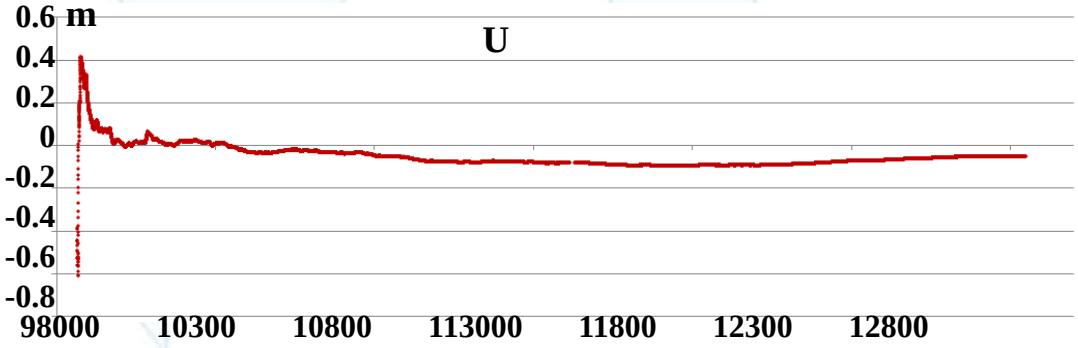
3. Wide Area CORS Service in China

Test 1: static positioning, geodetic receiver

- Tested in Gan Su province CORS network, 16/11/2015
- GPS positioning precision components are 0.08m, 0.07m and 0.12m, for N, E, U







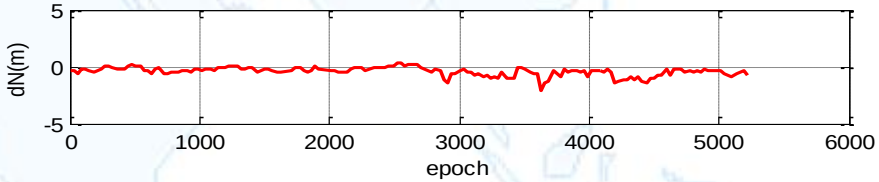
3. Wide Area CORS Service in China

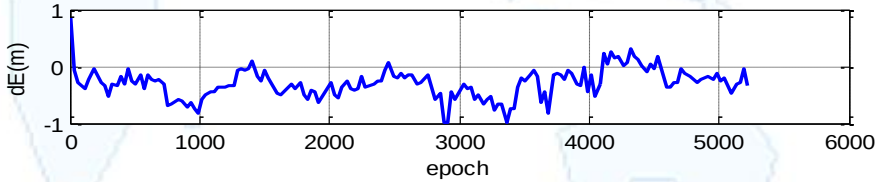
Test 2: kinematic positioning, hand-hold terminal

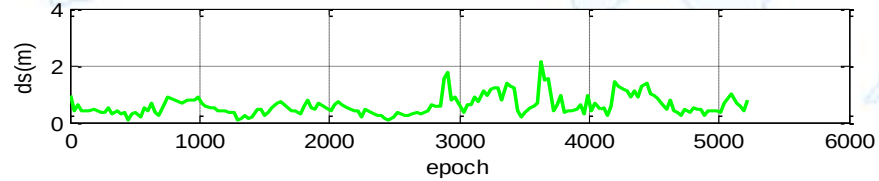
- Hand-hold terminal: MG858
- 24/11/2015, 1.5 hours observation
- GPS positioning precision components are 0.57m, 0.40m and 1.0m, respectively for N, E, U

Test field

MG858







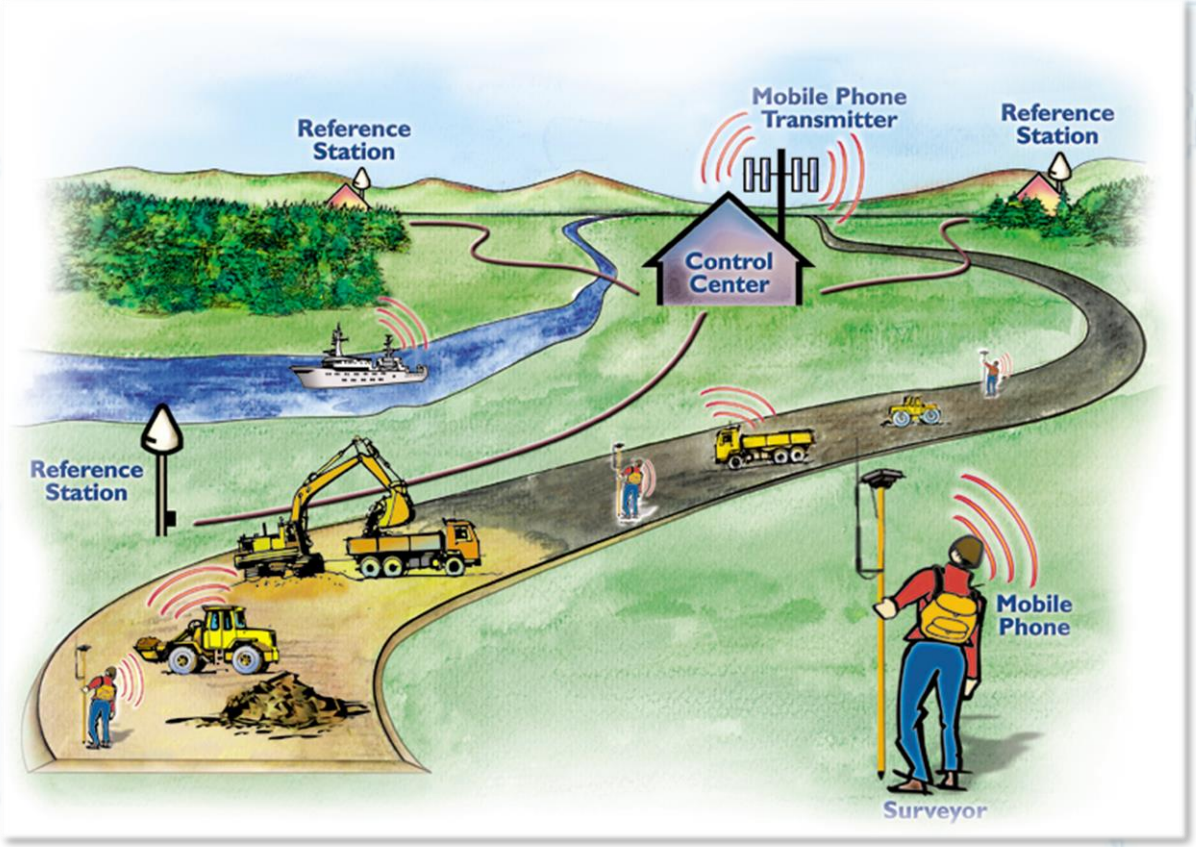
4. Local Area CORS Services in China

Local area CORS service system architecture(NRTK)

CORS stations

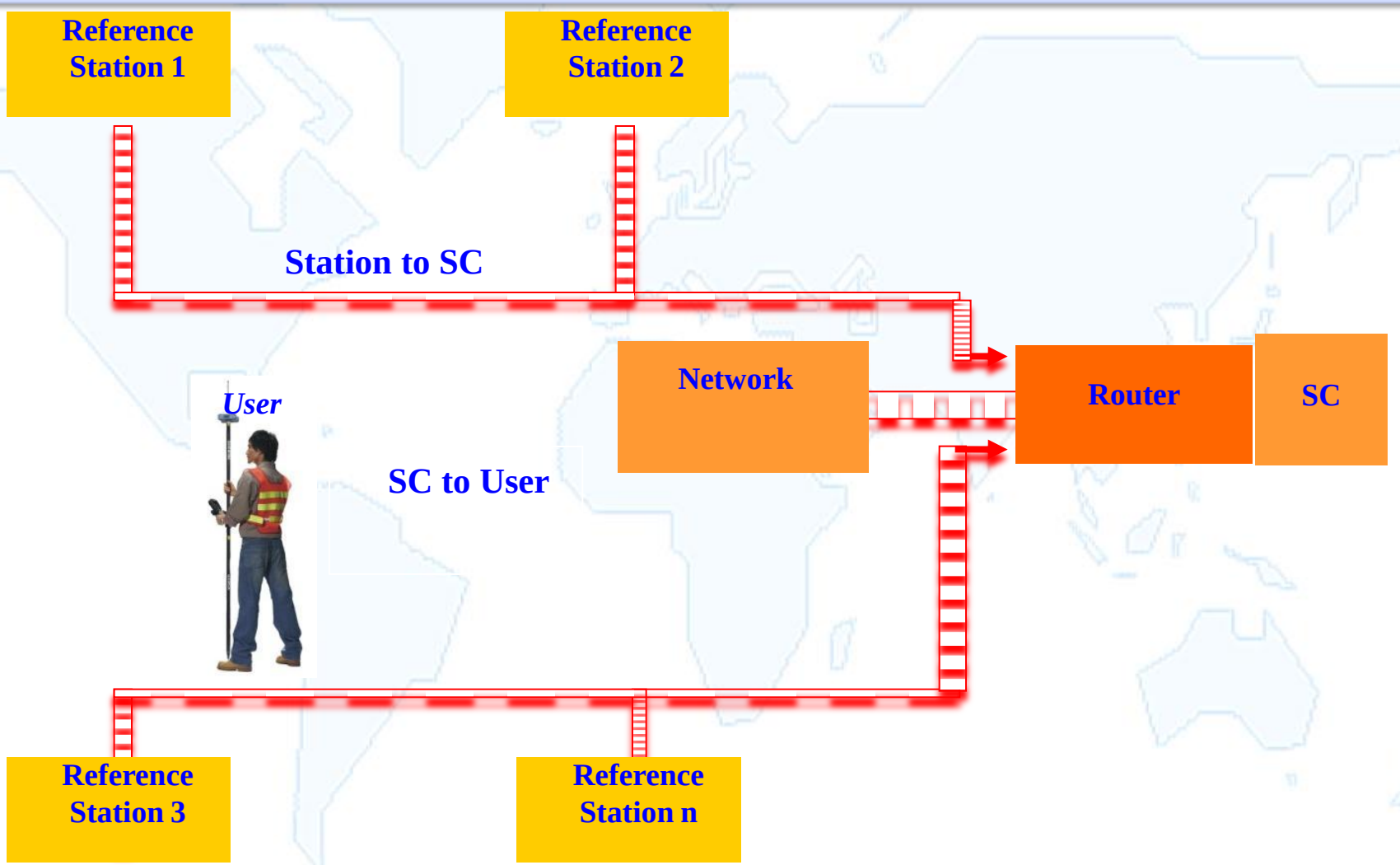
System center (SC)

Users



4. Local Area CORS Services in China

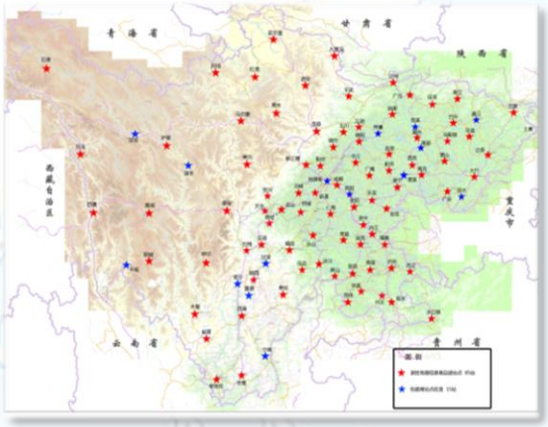
NRTK (Network RTK) data flow



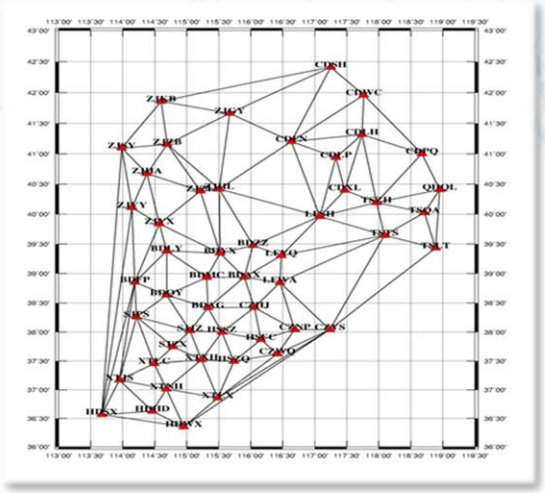
4. Local Area CORS Services in China

City/province CORS constructions in China

- Nowadays, more than 6000 CORS stations within China's mainland
- In the east coastal of China, average distance of the CORS network reach about 70km



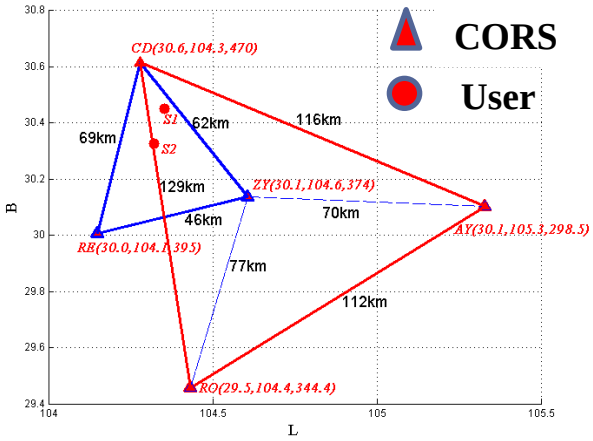
SiChuan CORS (over 100 GNSS/BDS station)



HeBei CORS

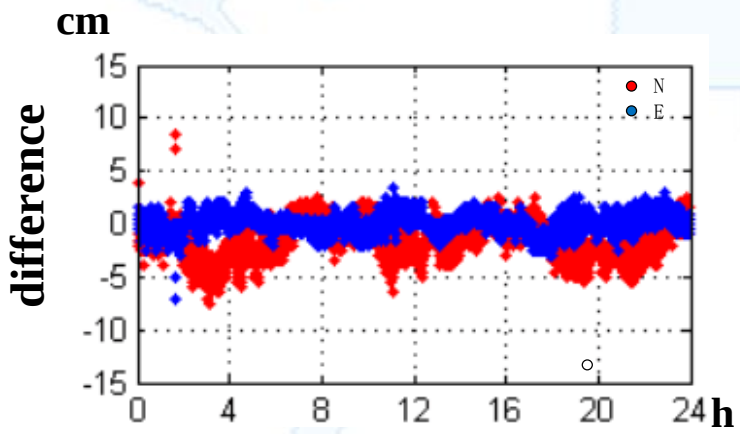
4. Local Area CORS Services in China

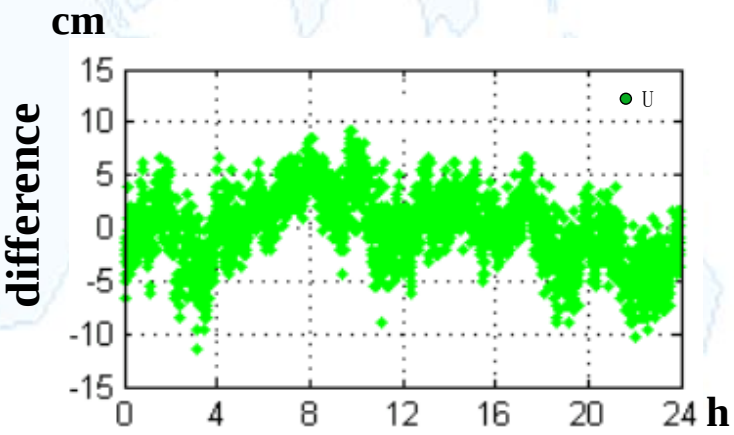
NRTK test1: Static positioning in Si Chuan CORS network



GPS positioning accuracy (RMS)

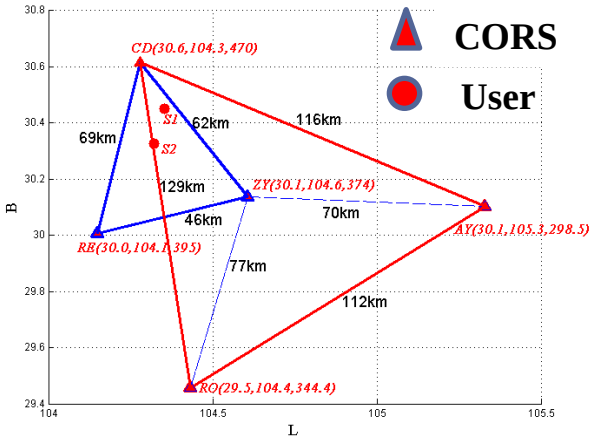
N(cm)	E(cm)	U(cm)
2.15	2.72	6.66





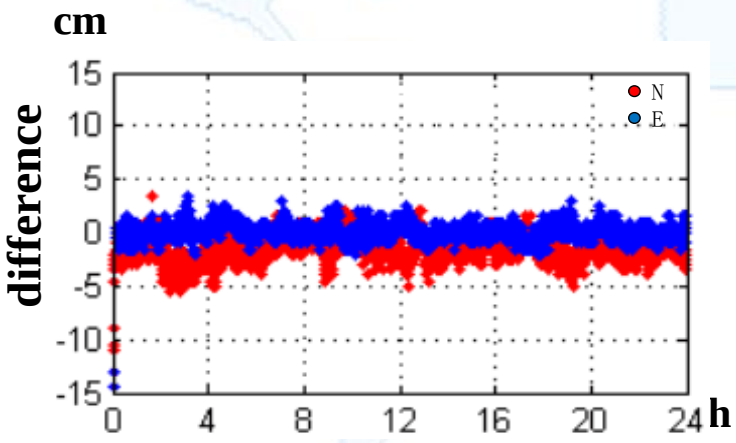
4. Local Area CORS Services in China

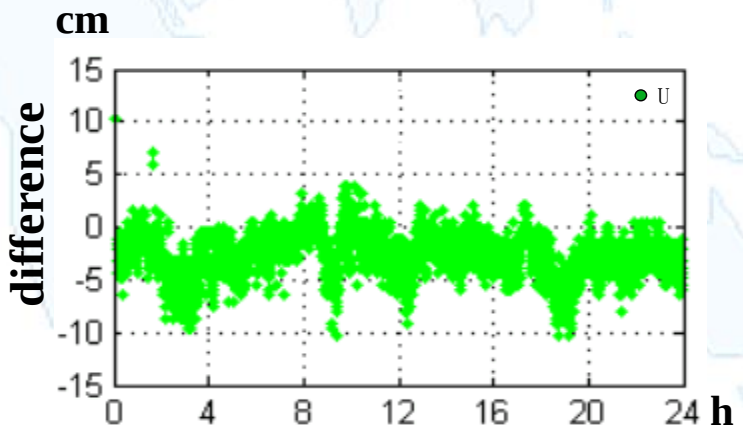
NRTK test1: Static positioning in Si Chuan CORS network



BDS positioning accuracy (RMS)

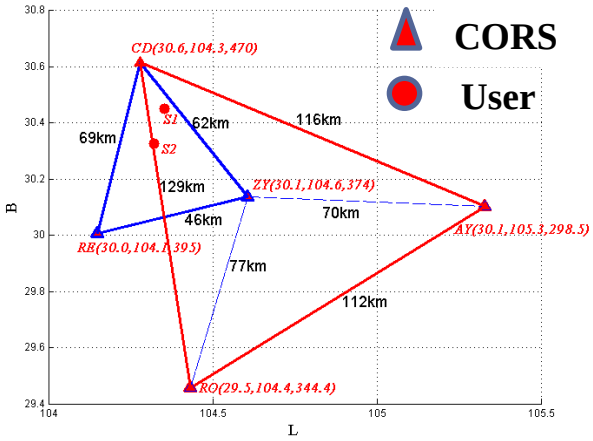
N(cm)	E(cm)	U(cm)
1.72	2.27	10.37





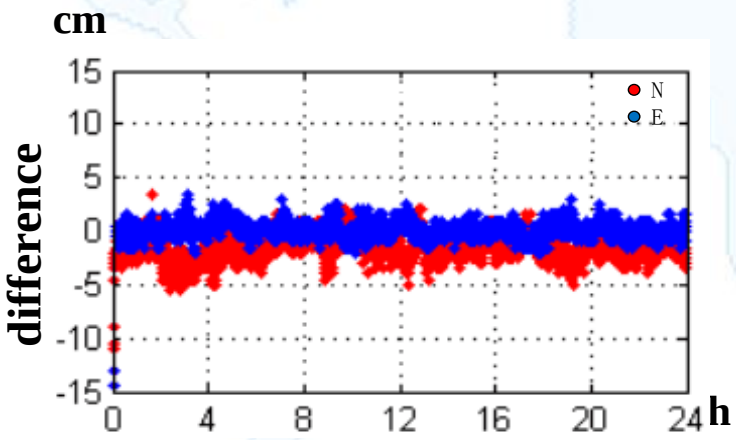
4. Local Area CORS Services in China

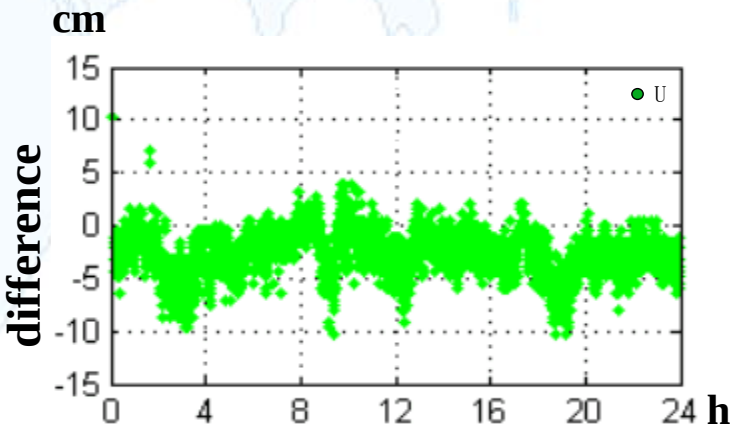
NRTK test1: Static positioning in Si Chuan CORS network



GPS/BDS positioning accuracy (RMS)

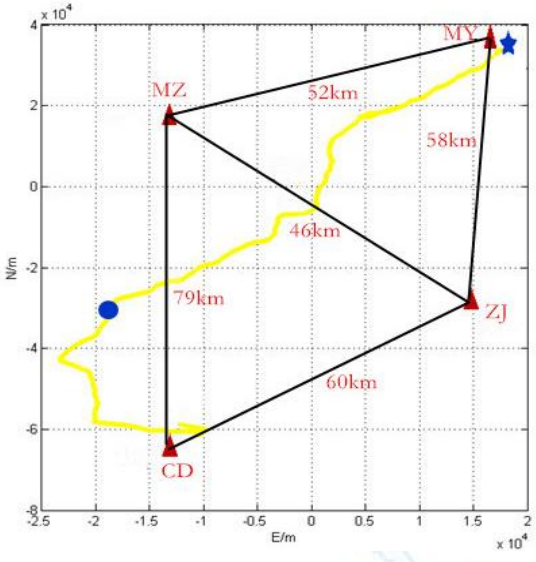
N(cm)	E(cm)	U(cm)
1.38	3.71	4.51





4. Local Area CORS Services in China

NRTK test 2: Kinematic positioning in Si Chuan CORS network

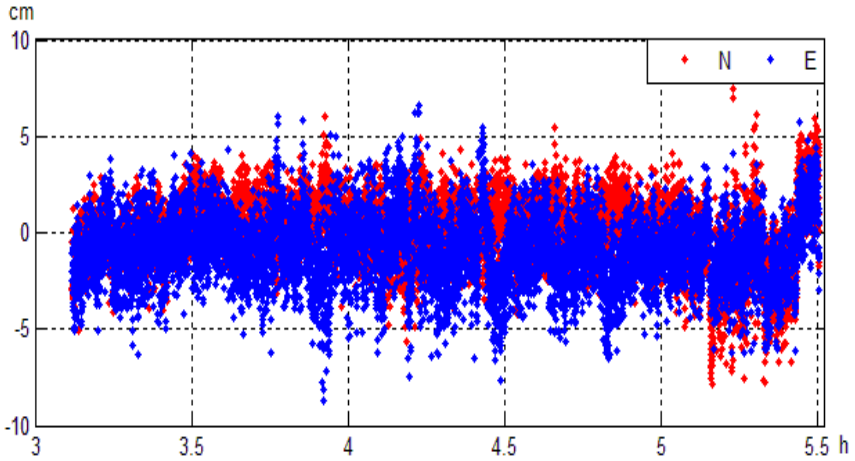


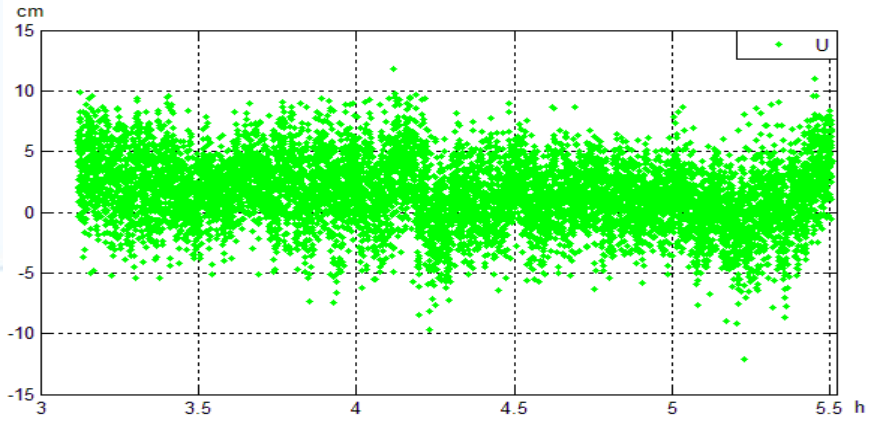
CORS

Route

GPS/BDS positioning accuracy (RMS)

N(cm)	E(cm)	U(cm)
3.06	2.5	5.30





Remarks

- Asia Pacific CORS service
  - Data sharing and collaborative data analysis
  - Producing Asia Pacific CORS frame and service products
  - Asia Pacific GNSS service network establishment
  - Service signal design and service standards
- Local area CORS services for Asia Pacific national/ prinvicial applications
  - NRTK

Thank You!