GNSS Analysis Center at SHAO

陈俊平

junping.chen@shao.ac.cn
Content

- IGS data/products
- GNSS Analysis Center at SHAO
  - Post-Processing
  - Real-time GNSS
- Challenging tasks for GNSS Data Analysis
International GNSS Service (IGS)
IGS DATA

Active hourly sites [map]
Reference Frame stations ("IGS08") [map]
Reference Frame stations ("IGS08") [map] - core network
GPS/GLONASS stations [map]
Active high rate LEO sites [map]
All maps on [one page]
Real-Time Network [map], IGS-IP NTRIP Broadcaster

igscb.jpl.nasa.gov
## IGS Products

<table>
<thead>
<tr>
<th>Products</th>
<th>Latency</th>
<th>Orbit</th>
<th>Clocks</th>
<th>ERP</th>
<th>Sta-Position</th>
<th>Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final</td>
<td>10-14 day</td>
<td>2 cm</td>
<td>0.03 ns</td>
<td>0.03mas</td>
<td>3-8 mm</td>
<td>2-3 mm/y</td>
</tr>
<tr>
<td>Rapid</td>
<td>1 day</td>
<td>3 cm</td>
<td>0.05 ns</td>
<td>0.04mas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ultra Rapid (Prediction)</td>
<td>Real-time</td>
<td>5-10</td>
<td></td>
<td>0.01 ms</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
GPS Final Orbit

Final Orbits (AC solutions compared to IGS Final)

(smoothed)

http://acc.igs.org/
GPS Rapid Orbit

Rapid Orbits (AC solutions compared to IGS Rapid)

(smoothed)

http://acc.igs.org/

NOAA NGS, 18.07.2011 05:23 (GMT)
GPS Ultra-Rapid Orbit

Ultra Rapid Orbits (RT predictions compared to IGS Rapid)

http://acc.igs.org/
GIONASS Final Orbit

Final Orbits (AC solutions compared to IGLS Final)

http://acc.igs.org/
GLONASS Ultra-Rapid Orbit

Ultra Rapid Orbits (AC solutions compared to IGS Ultra)

http://acc.igs.org/
GPS Final clock

Final Clocks (AC solutions compared to IGS Final)

(time means)

http://acc.igs.org/
ERPs

IGS Rapid Pole Differences with IGS Final ERP

Other products
- Troposphere parameter
- Ionosphere map
- Reference frame
GNSS Analysis center at SHAO (SHA)
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- Platform for most of the GNSS research and projects
- Platform to validate and generate new knowledge
- International communication and regional service
- Facility to get access to measurements
- Facility to do routine data analysis
- Operational System to be flexible for multi-GNSS, multi-technique
- Developing and operating team
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GNSS Analysis center at SHAO (SHA)

- SHAO in-house funding, Cooperation projects
- Orbits, coordinate time series, troposphere
- SHAO-C(SHORD??) Software development
- GNSS data analysis at the SHAO
- Tech. Staff

......
**Integrated Solution**

- GNSS obs. IERS Bulletin Frame
- GNSS Modelling Parameterization Estimator
- System biases Para. Common Para. GPS Para. GLONASS Para. Galileo Para. ...
- Intergrator Orbit para.
- GPS Orbits GLONASS Orbits Galileo Orbits ...

**GNSS Analysis center at SHAO (SHA)**

- GNSS Preprocessing
- GNSS Obs. Equ.
- Normal Equ.
- Residual Editing Ambiguity fixing
- Orbit integration
Products of SHA

GNSS Orbits

- GPS+GLONASS
- Compared to IGS
- ~2 cm for GPS; ~5 cm for GLONASS
Products of SHA

GNSS Clocks

- GPS+GLONASS
- Compared to IGS
- ~0.05ns (1.5cm) for GPS; ~0.15ns (4.5cm) for GLONASS

![Graph showing RMS (ns) for GPS and GLONASS from DOY/2011 166 to 190]
Products of SHA

ERP
- GPS+GLONASS
- Compared to IGS

<table>
<thead>
<tr>
<th>POLE</th>
<th>0.03mas</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOD</td>
<td>0.01 ms</td>
</tr>
<tr>
<td>POLE-rate</td>
<td>0.2mas/day</td>
</tr>
</tbody>
</table>

![Diagram of ERP with XPOLE, YPOLE, and LOD over DOY/2011](image-url)
Real-time GNSS
实时GNSS处理系统

实时通信
数据流
- Ntrip通信
- 实时数据服务器(Server)
- 实时数据客户端(Client)

实时处理
GNSS软件
- 实时处理/后处理
- 多站网络解算/单站定位
- 提供实时产品

实时GNSS数据处理系统：Ge et al.; Chen et al. GFZ
Real-time Data Transfer

**GNSS data streaming with 1-Hz data rate:**
- Based on UDP (User Datagram Protocol)/TCP (Transmission Control Protocol) and Ntrip (Networked Transport of RTCM via Internet Protocol)
- Up to 100 data streams processed in parallel without problems
**GNSS Analysis center at SHAO (SHA): Real-time**

Main Process: real-time processing engine
Parameter: satellite/station clocks, ambiguities, coordinates

Process 1: Fast updating
Troposphere delay...

Process 2: Slow updating
Orbits, ERP, coordinates
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Orbits, ERP, coordinates
Real-time Validation

Linear table on the roof of Building A17, controlled station motion along the table

Chen et al. GFZ
Real-time Motion Monitoring

![Graph showing motion monitoring with RMS errors](image)

- **RMS=0.51 cm**
- **RMS=0.81 cm**
Real-time Motion Monitoring

Simulated „Earthquake“

- **PPP kinematic coordinate**
  - Horizontal 2~3 cm
  - Height ~5 cm

- **Kinematic coordinate in network solution**
  - Horizontal ~1 cm
  - Height 2-3 cm
Co-seismic Deformation

- 13 June, 2008, Mw 6.9 earthquake, EASTERN HONSHU, JAPAN
- Reference stations: PETS(Russia), SUWN(South Korea) and SHAO(China)
- MIZU: (~50 km away from epicenter)

- Orbits & ERP fixed to GFZ ultra-rapid products
- Estimation: Kinematic coordinates, ambiguities, satellite & receiver clocks and ZTDs

Chen et al. GFZ
Co-seismic Deformation

- Kinematic coordinates (a set of coordinates at each 1 second)
- Compare to coordinates from one day before
Challenging tasks
Huge network solution
Huge network solution (30 sat. 2 ambiguities/per sta/per sat)
Huge network solution (real-time)
Challenging topics

Multi-system solution
More Frequency, New Satellite System;
Biases issue; Reference issue

……

Multi-technique solution
More Observation, Integrated solution;
Local-ties; Parameterization

……
More frequencies

- Bias issue
Multi-GNSS

System time offset

Unified reference frame
Multi-GNSS

- Kinematic PPP
- 90 selected IGS reference station

GPS only

Dousa et al. GFZ
Multi-GNSS

- Kinematic PPP
- 90 selected IGS reference station

GPS + GLONASS

Stand. deviation: N=0.010 m  E=0.015 m  U=0.037 m  #2854  { 6}  Convergence time: 3.5 min

ANKR [EXT: M]

Dousa et al. GFZ
Multi technique

Geodetic Observatory at Wettzell, Germany

Steigenberger et al. DGFI
Multi technique

- SHAO: Sheshan Geodetic Observatory
Multi technique

Multi-technique solution
More Observation, Integrated solution;
  Local-ties; Parameterization

Unified Analysis
On the raw data level
Challenging topic: PPP Ambiguity fixing

- PPP ambiguity fixing

- Integer ambiguity resolution in PPP supports:
  - improved accuracy and high stability after TTFF

Dousa et al. GFZ
Challenging topics: high rate GNSS analysis

- Experiment at GFZ with two stations: A17D and TES2
- Data sampling: 10 Hz
- Kinematic solutions

Chen et al. GFZ
http://www.shao.ac.cn/shao_gnss_ac

Thank you!