Geodetic VLBI observations for the CMONOC project

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Outline

- CMONOC project
- Chinese Geodetic VLBI observing system
- Future development
CMONOC project

- the National Key Scientific Infrastructure Project --- Crustal Movement Observation Network of China

<table>
<thead>
<tr>
<th></th>
<th>CMONOC-1</th>
<th>CMONOC-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction period</td>
<td>1998 ~ 2000</td>
<td>2008 ~ 2010</td>
</tr>
<tr>
<td>Permanent GNSS stations</td>
<td>27</td>
<td>260</td>
</tr>
<tr>
<td>Other GNSS sites</td>
<td>1000</td>
<td>2000</td>
</tr>
<tr>
<td>SLR stations</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Domestic VLBI obs.</td>
<td>No</td>
<td>8 sessions/year</td>
</tr>
</tbody>
</table>
CMONOC-1 stations
CMONOC-1 measurement

Velocity field relative to NNR-NUVEL1A Eurasia plate model (provided by Dr. Liu)
CMONOC-2: fiducial network stations
CMONOC-2: regional network stations
Goals of VLBI in CMONOC-2

- Establishing an operational geodetic VLBI observing system
  - Full functional system
  - Full compatible with international VLBI community
  - Operational in stand-alone mode with Chinese domestic stations
  - Routine service with product quality data

- Performing regular geodetic VLBI observations
  - Connection between global reference frame and Chinese regional network.

- Supporting navigation of future deep space missions in China
  - Precise Position measurement of tracking stations
  - EOP and reference radio sources measurement
Chinese geodetic VLBI observing system

- Shanghai station
- Urumqi station
- Foreign stations
- Kunming station
- Beijing station

- IVS observations
  - IVS correlators

- Stand-alone observations
  - Shanghai correlator

- SHAO data analysis center

- IVS data center
- CMONOC data center
Distribution of Chinese VLBI Network
Seshan25 station

- April, 2010
  - VLBA A4 analog system was upgraded with VSI interface to connected with Mark5B recorder, but Mark5A recorder was still remained for international e-VLBI and IVS sessions
  - CDAS & Mark5B+ was installed for the domestic observations

- December, 2010
  - Mark5A is not used for recording
Kunming station

- **January, 2011**
  - Began to participate in the domestic geodetic observations with CDAS

- **July, 2011**
  - Began to participate in IVS-T2 and IVS-APSG sessions with CDAS
  - To get more precise station coordinates on global scale.
  - To further validate the performance of CDAS in geodetic observations.
Urumqi station

- New S/X feed installed at Urumqi with wider frequency coverage: 8.0 ~ 9.0GHz

- X band SEFD measured by FS < 700
Fringe test for wider X band feed

- Fringe test was performed on the Sh-Ur baseline on Dec. 16, 2011
Shanghai correlation system

- correlator control system
  - SKED/SCHED/SATSKD interface
  - Scan-based processing

- MK5B playback capability

- observable extraction
  - flag, fringe fit, manual phase calibration, bandwidth synthesis, NGS format output
  - Graphic display, data quality statistic
Software architecture

- SCHED
- SATSKD
- SKED

- Observable Extraction
  - NGS
  - OCCAM

- CORRELATION
  - Decoded data
  - MK5B playback

- SKD2COR

- FITS-IDI generation
  - FITS-IDI
  - AIPS
Correlation system hardware
Platform for correlation

- Blade Cluster
  - 6 x Blade Server
  - Blade Configuration: 2xIntel Xeon 5570 (2.93G),
  - 12G DDR3 Memory,
  - 10GbE NIC with TOE && RDMA

- Storage
  - 3x10TB Raid, 10GbE NIC
MARK5 system

Mark5 data playback
30 disk modules, 8TBytes
Performance evaluation of the correlator

- 3 stations: ~800Mbps
- 5 stations: ~400Mbps
- 10 stations: ~140Mbps
Validation of CDAS performance

- MBD difference between ABBC and CDAS
## MBD comparisons

<table>
<thead>
<tr>
<th>Baseline</th>
<th>Band</th>
<th>ABBC error (ps)</th>
<th>DBBC error (ps)</th>
<th>MBD agreement (ps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sh-Km</td>
<td>S</td>
<td>106</td>
<td>46</td>
<td>105</td>
</tr>
<tr>
<td>Sh-Ur</td>
<td>S</td>
<td>110</td>
<td>140</td>
<td>157</td>
</tr>
<tr>
<td>Km-Ur</td>
<td>S</td>
<td>77</td>
<td>76</td>
<td>126</td>
</tr>
<tr>
<td>Sh-Km</td>
<td>X</td>
<td>35</td>
<td>31</td>
<td>52</td>
</tr>
<tr>
<td>Sh-Ur</td>
<td>X</td>
<td>73</td>
<td>115</td>
<td>131</td>
</tr>
<tr>
<td>Km-Ur</td>
<td>X</td>
<td>52</td>
<td>61</td>
<td>97</td>
</tr>
</tbody>
</table>
Chinese domestic observations

- Observing time
  - Lower priority than satellite tracking/IVS/EVN

- Observing mode
  - 128(data rate)-8(channel)-1(bit)
  - 256-16-1

- Observing sources
  - ~35 sources from ~80
  - ~65 sources from ~100

- Observing sessions
  - 6~12 very year
Data analysis of NGS output files

- So far ~15 domestic sessions have been performed

- Determination of site coordinates of Kunming
  - The result of the first IVS session agrees well with those of domestic sessions in ~1cm

<table>
<thead>
<tr>
<th>Obs.time</th>
<th>X (m)</th>
<th>Y(m)</th>
<th>Z(m)</th>
<th>Sx (m)</th>
<th>Sy (m)</th>
<th>Sz (m)</th>
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<tbody>
<tr>
<td>20100114 -1281152.8161</td>
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<td>20100810 -1281152.7970</td>
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<tr>
<td>20110720 -1281152.8016</td>
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</tr>
</tbody>
</table>

Adopted Kunming station velocity (m/yr) -0.0311 0.0007 -0.0182

- There is a systematic bias of ~ 5cm among different data analysis software
CDAS fringe test on 1Gbps geodetic obs.

- Jan.12, 2012
- Mark5B.16ch32MHz1bit
Summary

- After the new S/X band receivers installed at the middle of 2012, wider frequency coverage at X band (8.2-9.0GHz) will be used for experiments.

- The performance of CDAS on Mark5B 16ch32MHz 1bit mode should be improved.

- Produce better quality data by making further comparisons with the results of any other correlators
  - Improve software performance: clock jump, MBD delay ambiguity, graphic display, data quality statistic, et al.
  - Verify the algorithms in the software
Thank you!