TRF Implementation by Rigorous Combination of Space Geodetic Techniques

Zou Rong    Shi Chuang    Kuang Cuilin

GNSS Research Center, Wuhan University
Outline

- Introduction
- Data
- Mathematical Models
- Analysis of Results
- Conclusion
1. Introduction

The current realization of ITRF: ITRF 2000

---The non-linear motion parameters have to be included
---More new sites are available
---The achievements of IDS, IGS, ILSR, IVS
---Accurate local ties are attained

......

The forthcoming ITRF: ITRF 2005
The Future Realization of TRF

Rigorous Combination

Intra-techniques

Inter-techniques
Intra-techniques data sets are available for the combination

<table>
<thead>
<tr>
<th>Techniques</th>
<th>Analysis center</th>
<th>Software</th>
<th>Available time span</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>DORIS</td>
<td>IDS</td>
<td>GIPSY/OASIS</td>
<td>1993-2006</td>
<td>Weekly normal equations</td>
</tr>
<tr>
<td>GPS</td>
<td>IGS</td>
<td>sinex_combine</td>
<td>1999-2006</td>
<td>Weekly normal equations</td>
</tr>
<tr>
<td>SLR</td>
<td>ILRS</td>
<td>CoGeoS</td>
<td>1992-2006</td>
<td>Weekly normal equations</td>
</tr>
<tr>
<td>VLBI</td>
<td>IVS</td>
<td>Combine_sinex (GUIB)/dogs-cs (DGFI)</td>
<td>1980-2005</td>
<td>Session normal equation</td>
</tr>
</tbody>
</table>
data sets are used in this test

<table>
<thead>
<tr>
<th>Techniques</th>
<th>Analysis center</th>
<th>Software</th>
<th>Available time span</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>DORIS</td>
<td>IDS</td>
<td>GIPSY/OASIS</td>
<td>2003-2004</td>
<td>Weekly normal equations</td>
</tr>
<tr>
<td>GPS</td>
<td>IGS</td>
<td>sinex_combine</td>
<td>2003-2004</td>
<td>Weekly normal equations</td>
</tr>
<tr>
<td>SLR</td>
<td>ILRS</td>
<td>CoGeoS</td>
<td>2003-2004</td>
<td>Weekly normal equations</td>
</tr>
<tr>
<td>GFID</td>
<td>GSFC</td>
<td>VLBI analysis system Calc/Solve</td>
<td>2003-2004</td>
<td>Session normal equation</td>
</tr>
</tbody>
</table>
The Locations of DORIS Sites
The Locations of VLBI Sites
3. Mathematical Models

Validation:
- Checking the SINEX format
- Naming problems

Deconstraining
- Remove the aprior constraints

Reconsider the weighting problem for each AC/solution

Combination
- Combine SINEX solution in the normal equations level
Parameterization:
  - Add 7 Helmert transformation parameters for various techniques SINEXs in the combined normal equation

Datum definition
  - Add the global constraints into the combined normal equation

Solution
  - Residuals check, Outlier detection and processing
  - Statistical information

Iteration if necessary
Least Square Adjustment Formulas

\[
\begin{pmatrix}
X \\
Y \\
Z
\end{pmatrix}_X =
\begin{pmatrix}
T_X \\
T_Y \\
T_Z
\end{pmatrix}
_{(U,X)} + (1+m)
\begin{pmatrix}
1 & \omega_Z & -\omega_Y \\
-\omega_Z & 1 & \omega_X \\
\omega_Y & -\omega_X & 1
\end{pmatrix}
\begin{pmatrix}
X \\
Y \\
Z
\end{pmatrix}_U
\]

\[
V = \begin{bmatrix}
A & M & R & U
\end{bmatrix}^T \begin{bmatrix}
dX \\
T \\
\omega \\
m
\end{bmatrix} - f
\]

\[
\begin{bmatrix}
A^T PA \\
M^T PA & M^T PM \\
R^T PA & R^T PM & R^T PR \\
U^T PA & U^T PM & U^T PR & U^T PU
\end{bmatrix}
\begin{bmatrix}
dX \\
T \\
\omega \\
m
\end{bmatrix} =
\begin{bmatrix}
A^T Pf \\
M^T Pf \\
R^T Pf \\
U^T Pf
\end{bmatrix}
\]
Structure of Normal Equation
4. Results and Analysis

DORIS—Translation parameters

![Graphs of DORIS_TX, DORIS_TY, and DORIS_TZ parameters]
GPS—Translation parameters
SLR—Translation parameters

SLR_TX

SLR_TY

SLR_TZ
VLBI—Translation Parameters
6. Conclusion

- The realization of TRF by multi-technique should make full use of local-ties.

- The change of transformation parameters contain both true information (like geocenter variation) and systematic errors.

- The transformation parameters were estimated and the systematic errors of each SINEX solution were removed when making the combination.
Thanks for your attention!