Review of the IGS Contribution to the ITRF

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Key Points of the IGS Contribution to the ITRF

1. Inter-Technique link: reinforcing the ITRF definition (origin, scale & orientation)

2. Determination of Post-Seismic Deformation Models

3. ITRF2014 Plate Motion Model

4. Polar Motion

5. ITRF Access & densification through the IGS Products

Illustrations from ITRF2014 results
## ITRF2014: Input data

<table>
<thead>
<tr>
<th>Service/Technique</th>
<th>Number of Solutions</th>
<th>Time span</th>
<th># of sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGS/GNSS/GPS</td>
<td>7714 daily</td>
<td>1994.0 – 2015.1 (21 yrs)</td>
<td>884</td>
</tr>
<tr>
<td>IVS/VLBI</td>
<td>5328 daily</td>
<td>1980.0 – 2015.0 (35 yrs)</td>
<td>124</td>
</tr>
<tr>
<td>ILRS/SLR</td>
<td>244 fortnightly</td>
<td>1980.0 – 1993.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1147 weekly</td>
<td>1993.0 – 2015.0 (35 yrs)</td>
<td>96</td>
</tr>
<tr>
<td>IDS/DORIS</td>
<td>1140 weekly</td>
<td>1993.0 – 2015.0 (22 yrs)</td>
<td>71</td>
</tr>
</tbody>
</table>
ITRF2014: GNSS

884 sites
1054 stations
1882 discontinuities
ITRF2014 colocation sites

- SLR-VLBI: 11
- SLR-DORIS: 11
- VLBI-DORIS: 12

# of local ties vectors between GNSS:

- DORIS: 103
- SLR: 56
- VLBI: 62
- Total: 221
1. Inter-Technique link: reinforcing the ITRF definition (orientation)

127 stations used in the alignment of ITRF2014 to ITRF2008 in Orientation

- GNSS: 93
- VLBI: 24
- SLR: 8
- DORIS: 2

From ITRF2014 to ITRF2008

<table>
<thead>
<tr>
<th>Solution</th>
<th>Tx mm</th>
<th>Ty mm</th>
<th>Tz mm</th>
<th>Scale ppb</th>
<th>Rx mas</th>
<th>Ry mas</th>
<th>Rz mas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offset ±</td>
<td>1.6 ±0.2</td>
<td>1.9 ±0.1</td>
<td>1.4 ±0.1</td>
<td>-0.02 ±0.02</td>
<td>0.000 ±0.006</td>
<td>0.000 ±0.006</td>
<td>0.000 ±0.006</td>
</tr>
<tr>
<td>Rate ±</td>
<td>0.0 ±0.2</td>
<td>0.0 ±0.1</td>
<td>0.0 ±0.1</td>
<td>0.02 ±0.02</td>
<td>0.000 ±0.006</td>
<td>0.000 ±0.006</td>
<td>0.000 ±0.006</td>
</tr>
</tbody>
</table>
1. Inter-Technique link : reinforcing the ITRF definition (Frame uncertainties)

Example:

Compare VLBI frame uncertainties within

SLR+VLBI_only combination: 16 LT vectors versus
ITRF2014 combination: 221 LT vectors

Uncertainties (formal errors) of the frame parameters

<table>
<thead>
<tr>
<th>Solution</th>
<th>Tx mm</th>
<th>Ty mm</th>
<th>Tz mm</th>
<th>Scale ppb</th>
<th>Rx mas</th>
<th>Ry mas</th>
<th>Rz mas</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLR+VLBI</td>
<td>±1.4</td>
<td>±1.2</td>
<td>±1.5</td>
<td>±0.20</td>
<td>±0.050</td>
<td>±0.067</td>
<td>±0.050</td>
</tr>
<tr>
<td>ITRF2014</td>
<td>±0.6</td>
<td>±0.6</td>
<td>±0.7</td>
<td>±0.10</td>
<td>±0.007</td>
<td>±0.007</td>
<td>±0.015</td>
</tr>
</tbody>
</table>
1. Inter-Technique link : reinforcing the ITRF definition (scale)

## VLBI vs SLR Scale Offset

<table>
<thead>
<tr>
<th>Solution</th>
<th>Scale at 2010.0 ppb</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>VLBI &amp; SLR co-locations, No GNSS</td>
<td>1.02 ± 0.20</td>
<td>11 sites (good distribution): 16 LT vectors, properly weighted</td>
</tr>
<tr>
<td>Rate</td>
<td>0.02 ± 0.02</td>
<td></td>
</tr>
<tr>
<td>ITRF2014</td>
<td>1.37 ± 0.10</td>
<td>All Tie SNX files properly weighted</td>
</tr>
<tr>
<td>Rate</td>
<td>0.02 ± 0.02</td>
<td></td>
</tr>
</tbody>
</table>
Modelling nonlinear station motions: Motivations

- Position time series of all stations exhibit periodic signals
- More than 100 sites are subject to Post-Seismic Deformation due to major earthquakes

Precisely modeling the above leads to more robust secular frame and site velocities.
2. Post-Seismic Deformations
Post-Seismic Deformations

- Fitting parametric models using GNSS/GPS data
  - at major GNSS/GPS Earthquake sites
  - Apply these models to the 3 other techniques at Co-location EQ sites

- Parametric models:
  - Logarithmic
  - Exponential
  - Log + Exp
  - Two Exp

Post-seismic deformation
3. ITRF2014 Plate Motion Model
ITRF2014: Horizontal velocity field

829 sites
Retained sites (all IGS sites) after selection

297 sites
11 Plates
Selection of the final model: Residuals

WRMS of fit: E: 0.26 mm/yr  
N: 0.26
4. ITRF2014 Polar Motion: Residuals
5. ITRF access & densification through the IGS Products

Some Facts

• GNSS Exponential Data Explosion
  • Local, National & Regional GNSS networks

• Using IGS Products provides Universal access to and densification of the ITRF

13,400 stations processed by NGL (Blewitt et al., 2015)

ITRF2014:
• 884 GNSS Sites
• Facilitates the alignment of the GNSS-based frames to the ITRF

More than 80% of National RFs are aligned to the ITRF (source: UN-GGIM GGRF questionnaire)
Conclusion

The fundamental contribution of the IGS to:

1. Reinforcing the ITRF frame definition (origin, scale & orientation)

2. ITRF2014 Post-Seismic Deformation Models

3. ITRF2014 Plate Motion Model

4. ITRF Polar Motion

5. ITRF Access & densification through the IGS Products