On space ties for some LEOs

Rolf Koenig, Grzegorz Michalak, Hans Karl Neimayer
Content

• Motivation
• SLR residual statistics from GPS-based Low Earth Orbiter (LEO) Precise Orbit Determination (POD)
• SLR Center-of-Mass correction (CoM) estimation for GPS-based LEO orbits
Introduction

• GFZ generates operationally CHAMP, GRACE and TerraSAR-X Rapid Science Orbits (RSOs) based on on-board GPS tracking
• All satellites are complementarily tracked by SLR
• For RSO generation SLR is down-weighted to serve as QC
• Space ties:
  – Dynamic POD works on the CoM of the satellites
  – CoM offsets of the GPS antennae and the Laser Retro-Reflector (LRR) are given by the satellite builders
• We do have now a long-term RSO history available:
  – Check bias of RSO SLR residuals
  – Cross-check with independent CoM estimates from SLR data and fixed orbits
GFZ Rapid Science Orbits

• Two-step processing
  – Generate the GPS orbits and clocks from GPS ground data
    • A priori station coordinates ITRF2000(IGS00)
      – Minor changes in time (gross errors, velocities)
      – All solved for, a priori sigma 10 cm
    – Generate the LEO orbit from GPS on-board data
      • SLR down-weighted
        – Station coordinates ITRF2000, with minor changes in time
  
• Available next day
  – EOP issue
RSO SLR Residuals

All SLR stations

Monthly Mean (cm)

Year


CHAMP
GRACE-A
GRACE-B
TSX
RSO SLR Residuals

Yarragadee

Monthly Mean (cm)

Year


CHAMP  GRACE-A  GRACE-B  TSX
RSO SLR Residuals

Zimmerwald

Monthly Mean (cm)

Year


CHAMP  GRACE-A  GRACE-B  TSX
### RSO SLR Statistics

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Time Period</th>
<th>Mean (cm)</th>
<th>Std. Dev. (cm)</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHAMP</td>
<td>2002/05-2009/11</td>
<td>-1.2</td>
<td>5.4</td>
<td>298,883</td>
</tr>
<tr>
<td>GRACE-A</td>
<td>2004/10-2009/11</td>
<td>-0.0</td>
<td>4.8</td>
<td>215,694</td>
</tr>
<tr>
<td>GRACE-B</td>
<td>2004/10-2009/11</td>
<td>-0.7</td>
<td>4.8</td>
<td>204,999</td>
</tr>
<tr>
<td>TSX</td>
<td>2007/08-2009/11</td>
<td>-0.9</td>
<td>4.5</td>
<td>208,623</td>
</tr>
<tr>
<td>GRACE-A</td>
<td>2004/10-2006/05</td>
<td>-0.6</td>
<td>4.5</td>
<td>58,122</td>
</tr>
<tr>
<td>GRACE-A</td>
<td>2006/05-2009/11</td>
<td>0.2</td>
<td>4.8</td>
<td>158,598</td>
</tr>
</tbody>
</table>
## CoM Estimates from SLR to RSO

<table>
<thead>
<tr>
<th></th>
<th>Radial (cm)</th>
<th>Normal (cm)</th>
<th>Transversal (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHAMP</td>
<td>2.8</td>
<td>1.4</td>
<td>-0.4</td>
</tr>
<tr>
<td>GRACE-A</td>
<td>1.2</td>
<td>1.0</td>
<td>-3.0</td>
</tr>
<tr>
<td>GRACE-B</td>
<td>1.2</td>
<td>0.3</td>
<td>-5.0</td>
</tr>
<tr>
<td>TSX</td>
<td>2.0</td>
<td>2.6</td>
<td>0.6</td>
</tr>
<tr>
<td>GRACE-A JPL</td>
<td>0.7</td>
<td>-0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>GRACE-B JPL</td>
<td>0.4</td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>
Conclusions

- RSO shows a cm-level radial bias between SLR and GPS for all satellites
- An orbit comparison of TSX with GSOC shows no biases
- A GPS phase center offset as determined by ground field calibration (Montenbruck, 2008) would map strictly into 5.2 cm radial bias