A priori gradients in the analysis of GPS and VLBI observations

Peter Steigenberger
GeoForschungsZentrum Potsdam

Volker Tesmer
Deutsche Geodätisches Forschungsinstitut, München

Johannes Boehm
Institute of Geodesy and Geophysics, TU Vienna
Troposphere Gradients in IERS Conventions

\[ D_L = m_h(e) \cdot D_{hz} + m_w(e) \cdot D_{wz} + m_g(e) \cdot \left[ G_N \cdot \cos(a) + G_E \cdot \sin(a) \right] \]

- \( m_{h,w} \) hydrostatic, wet mapping function
- \( D_{hz,wz} \) hydrostatic, wet zenith delay
- \( m_g \) gradient mapping function
- \( G_{N,E} \) north, east gradients
- \( a \) azimuth
Hydrostatic Troposphere Gradient Model

- Troposphere gradients in N/S direction show a latitude-dependent pattern.

Mean N/S gradients from 12 years of GPS data

Simple latitude-dependent gradient model:

\[ N_h = -0.5 \sin (2\lambda) \]
Global GPS Solutions (1)

- Global GPS network of 202 stations
- 1-day solutions for January 1994 – October 2005
- No-net-rotation condition of up to 98 stations w.r.t. IGb00

- Complete and homogeneous reprocessing with Bernese GPS Software by GFZ Potsdam and TU Dresden
- Pre-processing identical, final parameter estimation step repeated with different handling of troposphere gradients
Global GPS Solutions (2)

- Hydrostatic gradients mapped with GMFh
- Wet gradients mapped with GMFw
- Wet gradients are determined as piecewise linear functions with 24 hours parameter spacing (no constraints)

<table>
<thead>
<tr>
<th>Solution</th>
<th>hydr. gradients</th>
<th>wet gradients</th>
<th>Time period</th>
</tr>
</thead>
<tbody>
<tr>
<td>grdEST</td>
<td>___</td>
<td>✓</td>
<td>12 years</td>
</tr>
<tr>
<td>grdNO</td>
<td>___</td>
<td>___</td>
<td>1 year (2004)</td>
</tr>
<tr>
<td>grdMOD</td>
<td>✓</td>
<td>___</td>
<td>1 year (2004)</td>
</tr>
<tr>
<td>grdAPR</td>
<td>✓</td>
<td>✓</td>
<td>12 years</td>
</tr>
</tbody>
</table>
Hz Coordinate Differences: grdNO vs. grdMOD

Mean residuals of 7-parameter similarity transformations for 2004
Hz Coordinate Differences: grdEST vs. grdNO

Mean residuals of 7-parameter similarity transformations for 2004

5 mm
Hz Coordinate Differences: grdEST vs. grdMOD

Mean residuals of 7-parameter similarity transformations for 2004
Repeatabilities/TRF Solution

Mean coordinate **repeatabilities** of weekly solutions in 2004

<table>
<thead>
<tr>
<th></th>
<th>N [mm]</th>
<th>E [mm]</th>
<th>U [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>grdEST</td>
<td>1.6</td>
<td>1.6</td>
<td>5.4</td>
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<tr>
<td>grdNO</td>
<td>2.1</td>
<td>2.0</td>
<td>5.7</td>
</tr>
</tbody>
</table>

**Terrestrial Reference Frame solution** for grdEST and grdAPR

- Accumulation of 12 years of daily normal equations (station coordinates and polar motion)
- Datum definition:
  - no-net-rotation condition for coordinates and velocities w.r.t. IGb00
  - subset of stable IGb00 stations (without discontinuities)
Hz Coordinate Differences: grdEST vs. grdAPR

Residuals of a 14-parameter similarity transformation of the datum stations
Global VLBI Solutions

• VLBI software OCCAM 6.1 (LSM)
• 2699 daily sessions between 1984 and 2005
• 49 telescopes observing 1954 sources
• normal equations set up per sessions, accumulated with DOGS-CS
• NNT and NNR of 25 telescopes w.r.t. ITRF2000
• NNR of 199 stable sources (Feissel 2003) w.r.t. ICRF-Ext1
• Vienna Mapping Functions 1
Hydrostatic Gradients in VLBI Solutions

- Constant a priori gradients per station (GSFC, DAO 90-95)

- Residual (wet) gradients estimated as offset and rate per session with constraints of 0.5 mm and 2.0 mm/d
Estimation of Source Coordinates

Declinations and right ascensions of sources

Differences between DAO 90-95 and zero a priori gradients
Station Coordinates

Latitude and longitude components of stations

Differences between DAO 90-95 and zero a priori gradients
Summary

• Tropospheric gradients have a significant influence on the estimated station positions

• In GPS solutions, gradients are estimated unconstrained. Therefore, the impact of hydrostatic a priori gradients on estimated station positions is very small (0.1 mm) but systematic.

• In VLBI solutions, gradients are usually constrained to stabilize the equation system (in particular older sessions). Therefore, applying mean hydrostatic a priori gradients from a numerical weather model instead of using 0 a priori gradients yields to:

  - small (40 μasec) but systematic effect on declinations of source coordinates

  - small (< 2mm) effect on latitude components of southern hemisphere stations