VLBI-derived Earth Orientation Parameters generated at ESOC

ESOC - Navigation Support Office, Darmstadt, Germany

07/06/2018

10th IVS General Meeting (GM2018), Longyearbyen, Svalbard
Overview

• Motivation
• Current status of VLBI implementation in NAPEOS
• Validation concept
• First VLBI analysis results
• Conclusions
• Next steps
Motivation

ESOC’s Navigation Support Office has enhanced its processing capabilities for VLBI tracking data to

• complete ESOC’s capabilities in generating independent Earth Orientation Parameters (EOPs)
• contribute to the IVS service as an analysis centre
• enhance ESOC’s contribution to the IERS service with UT1-UTC and nutation products
• enable NAPEOS to combine all space-geodetic techniques at the observation level

Current implementation status allows estimation of EOPs

→ next slides will show first results
Status of VLBI implementation in NAPEOS

- Observation model fully implemented
- Data analysis based on NGS card files
  - Cable delay from NGS files used
  - Formal errors from NGS files used for observation weighting
  - Meteo data from NGS file used for modeling tropospheric dry zenith delay
- Partial derivatives for parameter estimation implemented
### Status of VLBI implementation in NAPEOS

<table>
<thead>
<tr>
<th>Parameter estimation enabled</th>
<th>Parameterization</th>
<th>Interval</th>
<th>Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>EOP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polar motion + rates</td>
<td>✓</td>
<td>offset + drift</td>
<td>24 h</td>
</tr>
<tr>
<td>dUT1</td>
<td>✓</td>
<td>constant</td>
<td>24 h</td>
</tr>
<tr>
<td>LOD</td>
<td>✓</td>
<td>constant</td>
<td>24 h</td>
</tr>
<tr>
<td>Nutation offsets</td>
<td>×</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Source coordinates</td>
<td>×</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Station coordinates</td>
<td>✓</td>
<td>constant</td>
<td>24 h</td>
</tr>
<tr>
<td>Station clocks</td>
<td>✓</td>
<td>piece-wise linear offset</td>
<td>6 h</td>
</tr>
<tr>
<td>Tropo</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wet zenith delays</td>
<td>✓</td>
<td>piece-wise linear offset</td>
<td>30 min</td>
</tr>
<tr>
<td>Gradients</td>
<td>✓</td>
<td>constant</td>
<td>24 h</td>
</tr>
</tbody>
</table>
How to validate VLBI processing of NAPEOS?

1. NGS files (R1 sessions)
2. NAPEOS
3. Sinex file (ESA)

O-C Residuals
Parameter estimates
How to validate VLBI processing of NAPEOS?

1. NGS files (R1 sessions)
2. NAPEOS
3. Sinex file (ESA)
4. O-C Residuals from VieVS
5. O-C Residuals from NAPEOS
6. Parameter estimates

→ Compare residuals
How to validate VLBI processing of NAPEOS?

NGS files (R1 sessions) ➔ NAPEOS ➔ Sinex file (ESA)

O-C Residuals from VieVS ➔ O-C Residuals ➔ Parameter estimates ➔ Sinex files (IVS ACs)

→ Compare residuals
→ Compare parameter estimates
How to validate VLBI processing of NAPEOS?

- NGS files (R1 sessions) → NAPEOS → Sinex file (ESA) → Combination (BKG) → Sinex files (IVS ACs)
- O-C Residuals from VieVS → O-C Residuals → Parameter estimates
- Compare residuals
- Compare parameter estimates
- Combination at NEQ level
How to validate VLBI processing of NAPEOS?

- Compare residuals
- Compare parameter estimates
- Combination at NEQ level

To validate
- Observation model
- Partial derivatives
- Parameterization
- Constraints
Validation results ... Combination (BKG)

- Combination at NEQ level
  - Sinex format ok (datum-free)
  - Combination only for some sessions possible
  - Several sessions could not be combined due to outliers in coordinate estimates
Validation results ... Parameter estimates

→ Compare parameter estimates
→ Combination at NEQ level
Estimated parameters ... dUT1 (w.r.t. C04)

RMS (ms)

- **ASI**: 0.015
- **IVS**: 0.023
- **BKG**: 0.022
- **GSF**: 0.032
- **ESA**: 0.030

😎 0.030  ESA
Estimated parameters ... LOD (w.r.t. C04)

RMS (ms/d)
- IVS: 0.029
- ASI: 0.031
- BKG: 0.034
- GSF: 0.030
- ESA: 0.046

Estimated parameters:
- LOD (w.r.t. C04)
  - IVS: 0.029 (ms/d)
  - ASI: 0.031 (ms/d)
  - BKG: 0.034 (ms/d)
  - GSF: 0.030 (ms/d)
  - ESA: 0.046 (ms/d)
Estimated parameters ... Polar motion (w.r.t. C04)

RMS (mas)

<table>
<thead>
<tr>
<th>Agency</th>
<th>XPO (mas)</th>
<th>YPO (mas)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVS</td>
<td>0.146</td>
<td>0.129</td>
</tr>
<tr>
<td>ASI</td>
<td>0.225</td>
<td>0.262</td>
</tr>
<tr>
<td>BKG</td>
<td>0.185</td>
<td>0.283</td>
</tr>
<tr>
<td>GSF</td>
<td>0.207</td>
<td>0.295</td>
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<tr>
<td>ESA</td>
<td>0.647</td>
<td>0.458</td>
</tr>
</tbody>
</table>
Estimated parameters... Station coordinates WETTZELL

<table>
<thead>
<tr>
<th></th>
<th>Longitude</th>
<th>Latitude</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASI</td>
<td>0.5</td>
<td>0.4</td>
<td>1.0</td>
</tr>
<tr>
<td>BKG</td>
<td>0.5</td>
<td>0.2</td>
<td>0.8</td>
</tr>
<tr>
<td>GSF</td>
<td>0.6</td>
<td>0.6</td>
<td>1.0</td>
</tr>
<tr>
<td>ESA</td>
<td>1.3</td>
<td>0.9</td>
<td>2.3</td>
</tr>
</tbody>
</table>
Validation results ... O-C Residuals

- O-C Residuals from VieVS

NAPEOS

O-C Residuals

→ Compare residuals
→ Compare parameter estimates
→ Combination at NEQ level

- **Before** parameter estimation
  → to validate observation model

- **After** parameter estimation
  → to validate parameterization, constraints, partial derivatives
O-C Residuals ... before parameter estimation

RMS (cm)

28.4 VieVS

11.7 ESA

→ observation model ok
O-C Residuals ... after parameter estimation

RMS (cm)

1.5
O-C Residuals ... after parameter estimation

RMS (cm)

1.5

ESA

1.1

VieVS

→ different parameterization.
→ different constraints
O-C Residuals ... after parameter estimation

RMS (cm)

1.5  ESA
1.4  VieVS (ESA par.)

→ similar parameterization
→ similar constraints
Conclusion

ESOC’s Navigation Support Office has continued its efforts towards VLBI data analysis

- First parameter estimates based on VLBI observations could be generated
- Comparison of O-C residuals with VieVS proves implementation of observation model is ok
- ESA residuals are at 1.5 cm level ( > 1 cm level of standard IVS solutions, but can be explained by parameterization differences)
- First attempt to combine ESA Sinex files at the IVS combination centre worked for some session, but not for all due to outliers in coordinate estimates
- Comparison of estimated parameters with other IVS ACs shows degraded repeatability for ESA solution

Points to problem in partials?
Next steps

• Continue discussing combination results with BKG
• Continue comparing parameter estimation on session-level with TU Vienna
• Check implementation of partials in NAPEOS

• We would like to consult with the IVS analysis groups to understand current issues in parameter estimation, and to avoid “the obvious”, as e.g.
  → Do not use baseline WETTZELL-WETTZ13N
  → Read sign for quasar declination separately \([-00 01 50.4137]\)
THANK YOU!

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