Kinematic Precise Point Positioning (PPP) Solution for Hydrographic Applications

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1. MOTIVATION

- Investigate the accuracy of kinematic PPP solution for the hydrographic applications for the Rivers.

- Prove the ability of Bernese software for PPP estimation in kinematic mode.
2. DGNSS vs. PPP

- Satellite clocks and orbits
- Satellite antenna phase centre
- Satellite phase wind up
- Ionosphere error
- Troposphere error
- Receiver clocks
- Receiver antenna phase centre
- Atmosphere tidal loading & ocean tidal effects.

Differential GNSS

- Using of only one GNSS receiver for positioning,
- Based on the ionosphere-free linear combination,
- Higher order ionospheric terms is recommended for precise applications,
- The ambiguity is no longer an integer (float solution), constant as long as no loss of lock in carrier phase,
3. PROCESSING PROCEDURE

Bernese Software
General Processing flowchart

MATLAB

Zero-Difference

DoubleDifference

Phase & Code Residual

Satellite Residual plot

PPP Kinematic coordinates

Kinematic Errors (E, N, ellip H)

Frequency histogram

SD

RMS error
4. DATA ACQUISITION

- Two kinematic trajectories on the Rhine River, Duisburg, Germany,
- GNSS antenna on the surveying vessel,
- Virtual SAPOS reference station.

<table>
<thead>
<tr>
<th>Data set</th>
<th>Year/DOY</th>
<th>Start time</th>
<th>End time</th>
</tr>
</thead>
<tbody>
<tr>
<td>First trajectory</td>
<td>2014/126</td>
<td>06 54 50</td>
<td>10 10 05</td>
</tr>
<tr>
<td>Second trajectory</td>
<td>2014/127</td>
<td>06 14 20</td>
<td>11 34 30</td>
</tr>
</tbody>
</table>

Photo by: Annette Scheider (IIGS)
4. DATA ACQUISITION

Layout of the second trajectory, © Google Earth [DOY: 127/2014]

Parameter | Model
--- | ---
Satellite system | GPS
Coordinate format | XYZ/LLh
Satellite clock | CODE/5 sec
Geodetic datum | ITRF2008
A priori troposphere model | Dry GMF/GPT
 | Wet GMF/GPT
 | Mapping Function GMF
Troposphere gradient | No
Ionospheric model | Linear ionospheric free combination
Satellite phase centre offsets | PCV.I08 (IGSO0 format)
Receiver phase centre offsets | PCV.I08 (IGSO0 format)
Tidal correction | IERS CONVENTIONS 2000
Nutation model | IAU2000R06
Sub-daily pole model | IERS2010
Ocean tidal loading | FES2004 model
Atmosphere tidal loading | Ray and Ponte 2003 model based on ITRF 2010
Elevation angle | 10°
Sampling interval | 5 seconds
5. RESULTS AND ANALYSIS

<table>
<thead>
<tr>
<th></th>
<th>East [m]</th>
<th>North [m]</th>
<th>height [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max.</td>
<td>0.65</td>
<td>0.015</td>
<td>0.713</td>
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<tr>
<td>Mean</td>
<td>0.022</td>
<td>-0.043</td>
<td>0.021</td>
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<tr>
<td>Min.</td>
<td>-0.163</td>
<td>-0.330</td>
<td>-1.152</td>
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<tr>
<td>RMS</td>
<td>0.064</td>
<td>0.047</td>
<td>0.071</td>
</tr>
<tr>
<td>SD</td>
<td>0.060</td>
<td>0.021</td>
<td>0.068</td>
</tr>
<tr>
<td>$SD_{95%}$</td>
<td>0.050</td>
<td>0.012</td>
<td>0.050</td>
</tr>
</tbody>
</table>
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<th>East [m]</th>
<th>North [m]</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Max.</td>
<td>0.064</td>
<td>0.228</td>
<td>0.180</td>
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<tr>
<td>Mean</td>
<td>-0.012</td>
<td>-0.012</td>
<td>0.026</td>
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<tr>
<td>Min.</td>
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<td>-0.307</td>
<td>-0.655</td>
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<tr>
<td>RMS</td>
<td>0.021</td>
<td>0.029</td>
<td>0.056</td>
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<tr>
<td>SD</td>
<td>0.017</td>
<td>0.026</td>
<td>0.049</td>
</tr>
<tr>
<td>$S_{EPPS}$</td>
<td>0.015</td>
<td>0.015</td>
<td>0.030</td>
</tr>
</tbody>
</table>
6. CONCLUSIONS

• Main goal of the study to investigate the kinematic PPP solution for hydrographic applications.

• First trajectory:
  • RMS 6.4 cm, 4.7 cm, 7.1 cm for East, North, Height.
  • $SD_{95\%}$ 5 cm, 1.2 cm, 5 cm for East, North, Height.

• Second trajectory:
  • RMS 2.1 cm, 2.9 cm, 5.6 cm for East, North, Height.
  • $SD_{95\%}$ 1.5 cm, 1.5 cm, 3 cm for East, North, Height.
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