Code/phase bias products at GFZ

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GFZMGX move to Un-Difference (UD) AR

Bias product:
- Since DOY 176 in 2021 GFZMGX provides code/phase bias and satellite attitude products (IGSmail).
- The code/phase bias are converted from wide/narrow-lane un-calibrated-phase-delay (UPD) and ionospheric DCB bias products from CAS. (Thank Simon and CAS).

Method:
1) In GFZ multi-GNSS POD processing float solution generated, then the fixed Double-Difference (DD) AR are added in NEQ as conditions with strong constrain.
2) the daily satellite/station UPDs are determined, and the ambiguities are fixed (adding strong constrain in NEQ).
3) The clock product absorbs the daily narrow-lane UPDs ➔ Integer clock
GFZMGX move to Un-Difference (UD) AR

Data Preprocessing → RINEX → POD: Ambiguity-float → Predicted orbit, clock, ERP → Double-differenced Ambiguity Fixing → DD Ambiguity-fixed Solution → GBM DD Product

Double-differenced Ambiguity Fixing → DD Ambiguity-fixed Solution → Orbit, Clock, ERP

Undifferenced Ambiguity Fixing → UD Ambiguity-fixed Solution → GBM UD Product

IGS Workshop 2022, Biases/Calibration & PPP-AR
Why UD AR in POD?

- In GNSS data processing the AR can improve POD
- Most POD software packages use the Double-Difference (DD) from independent baselines to do AR
- DD from shorter baseline reduce more errors from the global parameters (like ERP, satellite orbit+clock…) than longer baseline → better fix-rate
- In other word, the shorter baseline is less sensitive to the global parameters

- Longer baseline is better for POD.
- The Un-Difference (UD) AR connects all spacious ambiguities in a session.
- The float solution is zero-baseline solution.
- The code/phase bias are global parameters.
Orbit-overlap validation DD vs. UD

- DOY 001-150 in 2021, 140 stations, 5 min
- Ambiguity resolution for GPS, Galileo and BeiDou2/3 (IGSO+MEO)
- Three solutions with different AR constrain settings

<table>
<thead>
<tr>
<th></th>
<th>Ambiguity resolution</th>
<th>Baseline length</th>
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<tbody>
<tr>
<td>DD0</td>
<td>Double-differenced</td>
<td>0—2K km (80%)</td>
</tr>
<tr>
<td>DD3</td>
<td>Double-differenced</td>
<td>3K—4K km (90%)</td>
</tr>
<tr>
<td>UD</td>
<td>Undifferenced</td>
<td>---</td>
</tr>
</tbody>
</table>

6-hour orbit prediction

- DD0
- DD3
- UD

IGS Workshop 2022, Biases/Calibration & PPP-AR
Earth Rotation Parameters (ERP) validation

- ERP are compared with IGS final solution.
- Polar motion estimates significantly improved, especially the rates.
- No impact on LoD.
Day-boundary-discontinuity (DBD) of polar motion

- Polar motion DBD significantly reduced
- Mainly due to the improvement of polar motion rates
Conclusions & Outlook

- GFZMGX switched into UD since DOY 176 in 2021, provides integer clock, OSB/WL-UPD and satellite attitude.
- The impact on Earth center and station coordinate will be studied in the next step.
- In GNSS POD the UD AR can **improve** satellite orbit and polar motion significantly.

<table>
<thead>
<tr>
<th></th>
<th>GPS</th>
<th>GLOASS</th>
<th>Galileo</th>
<th>BDS2M</th>
<th>BDS3M</th>
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<tbody>
<tr>
<td>Along</td>
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<td>19%</td>
<td>13%</td>
<td>6%</td>
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<tr>
<td>Cross</td>
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<td>19%</td>
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<tr>
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<td>20%</td>
<td>12%</td>
<td>16%</td>
<td>24%</td>
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<table>
<thead>
<tr>
<th>x-pole</th>
<th>y-pole</th>
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</thead>
<tbody>
<tr>
<td>Offset</td>
<td>26%</td>
</tr>
<tr>
<td>Rate</td>
<td>27%</td>
</tr>
</tbody>
</table>

Improvement of (UD.vs.DD0) orbit overlap and EOP
Thank you for your attention
Backup
Orbit Precision: CJ (GEO/IGSO)

- Marginal impact on the orbit precision of GEO/IGSO satellite orbit precision
- GEO/IGSO have bad quality anyway
  - Tracking network
  - Solar radiation pressure modeling
- GEO/IGSO are less sensitive to ERP
Double-differenced (DD) Ambiguity Resolution

- **GNSS POD**

\[ \rho_r^s = |\mathbf{x}^s - \mathbf{R}_{t2c} \cdot \mathbf{x}_r| \]

\[ \mathbf{x}^s(t) = F(\mathbf{x}_0^s, \mathbf{v}_0^s, \mathbf{q}, t) + d\mathbf{x}^s \]

- **Double-differenced (DD) ambiguity resolution**

\[ \lambda \cdot \nabla \Delta N_{r1,r2}^{s1,s2} = \lambda_1 \cdot \nabla \Delta N_{r1,r2}^{s1,s2} - \lambda_W \cdot \nabla \Delta W_{r1,r2}^{s1,s2} \]