Comparison of AC GLONASS biases

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AC GLONASS bias files collected for comparison (GPS weeks 1666-1667)

- **COD** Center for Orbit Determination in Europe, AIUB, Switzerland
  - Bernese DCB
- **EMR** Natural Resources Canada, Canada
  - no GLONASS bias information (GLONASS biases ignored in GNSS clock analysis)
- **ESA** European Space Operations Center, ESA, Germany
  - bias-SINEX (first two days of GPS week 1666 missing)
- **GFZ** GeoForschungsZentrum, Germany
  - bias-SINEX
- **GRG** GRGS-CNES/CLS, Toulouse, France
  - modified Bernese DCB
- **IAC** Information-Analytical Centre, Russia
  - PBS format
- **JPL** Jet Propulsion Laboratory, USA
  - GIPSY time dependent parameter format (wrong weeks)
GLONASS bias data used for comparison

<table>
<thead>
<tr>
<th>AC</th>
<th>Format</th>
<th>Number of files</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>DCB</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>ESA</td>
<td>Bias-SINEX</td>
<td>12</td>
<td>2 missing days</td>
</tr>
<tr>
<td>GFZ</td>
<td>Bias-SINEX</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>GRG</td>
<td>Modified DCB</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>IAC</td>
<td>PBS</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>JPL</td>
<td>GIPSY format</td>
<td>7</td>
<td>not used due to late submission and wrong week</td>
</tr>
</tbody>
</table>
GLONASS biases as delivered by: COD
GLONASS biases as delivered by: ESA
GLONASS biases as delivered by: GFZ
GLONASS biases as delivered by: GRG

[Graph showing biases in ns for different days of the year 2011]
GLONASS biases as delivered by: IAC
Day-to-day repeatability/differences of GLONASS biases: COD
Day-to-day repeatability/differences of GLONASS biases: ESA
Day-to-day repeatability/differences of GLONASS biases: GFZ
Day-to-day repeatability/differences of GLONASS biases: GRG
Day-to-day repeatability/differences of GLONASS biases: IAC
Datum definition for GLONASS biases (1)
Datum definition for GLONASS biases (2)
Datum definition for GLONASS biases (3)
Datum definition for GLONASS biases (4)
Datum definition for GLONASS biases (5)

- Conclusion:
  - consistency of each AC GLONASS clock product is not affected by adding an arbitrary constant to:
    - all bias values referring to a particular GLONASS satellite
    - all bias values
  - we expect that differences between two sets of AC GLONASS clock corrections show similar differences for all bias values referring to a particular GLONASS satellite
- Comparison strategy:
  - form differences of corresponding satellite-station biases and subtract one constant (mean) for each satellite
AC GLONASS bias comparison: COD-ESA (1)
AC GLONASS bias comparison: COD-ESA (2) $\rightarrow$ sign changed
AC GLONASS bias comparison: COD-ESA (2) → sign changed
AC GLONASS bias comparison: COD-ESA (3) \( \rightarrow \) P1-C1 DCB corrected
AC GLONASS bias comparison: COD-ESA
AC GLONASS bias comparison: COD-GFZ
AC GLONASS bias comparison: COD-GRG
AC GLONASS bias comparison: ESA-GFZ
AC GLONASS bias comparison: ESA-GRG
AC GLONASS bias comparison: GFZ-GRG
## Summary of AC GLONASS bias comparison (1)

<table>
<thead>
<tr>
<th>AC</th>
<th>Median (ns)</th>
<th>Mean (ns)</th>
<th>Std (ns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD-ESA</td>
<td>0.01</td>
<td>0</td>
<td>0.79</td>
</tr>
<tr>
<td>COD-GFZ</td>
<td>0.02</td>
<td>0</td>
<td>1.33</td>
</tr>
<tr>
<td>COD-GRG</td>
<td>5.63</td>
<td>1.87</td>
<td>23.12</td>
</tr>
<tr>
<td>ESA-GFZ</td>
<td>0.01</td>
<td>0</td>
<td>1.34</td>
</tr>
<tr>
<td>ESA-GRG</td>
<td>4.14</td>
<td>1.29</td>
<td>20.63</td>
</tr>
<tr>
<td>GFZ-GRG</td>
<td>6.00</td>
<td>1.72</td>
<td>25.23</td>
</tr>
</tbody>
</table>
## Summary of AC GLONASS bias comparison (2)

<table>
<thead>
<tr>
<th>AC</th>
<th>Compared biases</th>
<th>Outliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD-ESA</td>
<td>17045</td>
<td>54</td>
</tr>
<tr>
<td>COD-GFZ</td>
<td>22618</td>
<td>0</td>
</tr>
<tr>
<td>COD-GRG</td>
<td>16759</td>
<td>97</td>
</tr>
<tr>
<td>ESA-GFZ</td>
<td>14997</td>
<td>51</td>
</tr>
<tr>
<td>ESA-GRG</td>
<td>12252</td>
<td>51</td>
</tr>
<tr>
<td>GFZ-GRG</td>
<td>15776</td>
<td>81</td>
</tr>
</tbody>
</table>
Datum definition for GLONASS biases

• Conclusion:
  - consistency of each AC GLONASS clock product is not affected by adding an arbitrary constant to:
    ▪ all bias values referring to a particular GLONASS satellite
    ▪ all bias values
  - we expect that differences between two sets of AC GLONASS clock corrections show similar differences (or differences with one common expectation value) for all bias values referring to a particular GLONASS satellite

• Comparison strategy:
  - form differences of corresponding satellite-station biases and subtract one constant (mean) for each satellite
  - change sign
  - apply station-specific GLONASS P1-C1 corrections
Inter-AC GLONASS bias offsets (per sat): COD-ESA
Inter-AC GLONASS bias offsets (per sat): COD-GFZ
Inter-AC GLONASS bias offsets (per sat): COD-GRG
Inter-AC GLONASS bias offsets (per sat): ESA-GFZ
Inter-AC GLONASS bias offsets (per sat): ESA-GRG
Inter-AC GLONASS bias offsets (per sat): GFZ-GRG
Summary and conclusions

- Best agreement (smallest std) could be achieved for the comparison between COD and ESA
  - with an overall std of 0.79 ns
  - resulting in a single-AC std of 0.56 ns
- Only 24 constants were necessary to compensate for the GLONASS bias datum definition specific to each AC
Definition of “GLONASS reference biases”
Proceeding towards an IGS-combined GLONASS clock product

- Standardization of datum definition for GLONASS interfrequency code biases
- Provision of associated GLONASS bias values (?)
  - corresponding sets of bias values could be retrieved from each set of AC GLONASS (satellite) clock corrections
- Realignment of AC GLONASS clock information (prior to IGS combination) if indicated
- Inclusion of GLONASS clock information in the IGS clock combination scheme (as it is implemented/available today)
- Open questions:
  - Treatment of receiver clock corrections with respect to GLONASS (?)