Overview of the Working Group

• Jianghui GENG, PPP-AR WG Chair, Wuhan University

• Coordinate phase bias generation in the IGS to facilitate PPP ambiguity resolution

• Main goals of the Working Group
  • Investigates the interoperability of PPP-AR products from various analysis centers (ACs)
  • Analyze the feasibility and benefits of a modernized combination process considering the consistency of the satellite clock and bias products
  • Initiate a pilot project to expose the combined clock/bias solution to open testing and cross-validate the quality of ACs’ clock/bias solutions
Recommendations

• Encourage more ACs to provide quaternions whose temporal resolution should be at least equal to that of the clocks and number of decimal digits should be properly set
• Antenna PCO should be considered in DCB and Melbourne-Wübbena computations
• Routine clock/bias combination and visualization online to cross-validate AC products
• Consistent standard and modeling of group-delay variation patterns
• Study how to reduce and calculate day boundary discontinuities of integer clocks and their impact on time transfer
• Study how to produce high-quality BDS/QZSS phase bias products
**Progress since IGS 2022 Virtual Workshop (June 2022)**

- Attitude quaternions from each AC

<table>
<thead>
<tr>
<th>AC</th>
<th>Type</th>
<th>Phase bias</th>
<th>GNSS</th>
<th>Sampling rate (s)</th>
<th>Orbit</th>
<th>Clock</th>
<th>Quaternion</th>
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Progress since **IGS 2022 Virtual Workshop (June 2022)**

- Attitude quaternions: 16 decimal digits originally

The maximum PCO differences (mm) when reducing the decimal digits from 16 to 6:

- ΔX: 0.00745mm
- ΔY: 0.00511mm
- ΔZ: 0.00480mm
### Progress since IGS 2022 Virtual Workshop (June 2022)

- The maximum PCO differences (mm) after reducing quaternion decimal digits to 3, 5, 6 or 7

<table>
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<tr>
<th>Decimal digits</th>
<th>ΔX (mm)</th>
<th>ΔY (mm)</th>
<th>ΔZ (mm)</th>
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<tbody>
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<td>3</td>
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<td>4.792</td>
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<td>5</td>
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<td>7</td>
<td>0.000501</td>
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Progress since IGS 2022 Virtual Workshop (June 2022)

- IGSMail-8279: A new keyword ‘APC_MODEL’ is added to the ‘BIAS/DESCRIPTION’ in the format of ‘APC_MODEL igs20_WWWW.atx’ when APCs are applied to geometry-free biases.

```
+BIAS/DESCRIPTION
*KEYWORD________________________________________VALUE (S) ___________
  OBSERVATION_SAMPLING                         30
  PARAMETER_SPACING                             86400
  DETERMINATION_METHOD                          CO-ESTIMATED
  BIAS_MODE                                    ABSOLUTE
  TIME_SYSTEM                                  G
  RECEIVER_CLOCK_REFERENCE_GNSS                 G
  SATELLITE_CLOCK_REFERENCE_OBSERVABLES         G   C1W   C2W
  SATELLITE_CLOCK_REFERENCE_OBSERVABLES         R   C1P   C2P
  SATELLITE_CLOCK_REFERENCE_OBSERVABLES         E   C1X   C5X   C1C   C5Q
  SATELLITE_CLOCK_REFERENCE_OBSERVABLES         C   C2I   C6I
  SATELLITE_CLOCK_REFERENCE_OBSERVABLES         1   C1X   C2X
+APC_MODEL                                    IGS14_2233.ATX
-BIAS/DESCRIPTION
```

A relevant article by Wuhan and GA is under review.
Progress since **IGS 2022 Virtual Workshop (June 2022)**

- Routine clock/bias combination to cross-validate AC’s products (*under internal evaluation*)

- **MGEX products**
  - COD/GFZ/GRG/SHA/JAX/WUMr
- **GPS/GLONASS/Galileo/BDS-2/3**
- **Reference orbit** (*operational*)
  - WMC combination orbit by Wuhan
- **Reference attitudes** (*operational*)
  - by GROOPS
Progress since IGS 2022 Virtual Workshop (June 2022)

- Routine clock/bias combination to cross-validate AC’s products (e.g., Day 268, 2022)
Future Work

• Visualization of combination results on IGS websites
• Day boundary discontinuities of satellite phase clocks
• Standardization of group delay variations across Bias, PPP-AR and ionosphere WGs.
• Achieve multi-GNSS technical excellence
  • Coordinating the various multi-GNSS contributions to PPP-AR across all ACs
  • Advocate the benefit of multi-GNSS through case studies and demonstrations
Thank You!

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