Guide to use the day-boundary discontinuity mitigated phase clock/bias rapid products from Wuhan University (WUM0MGXRAP)

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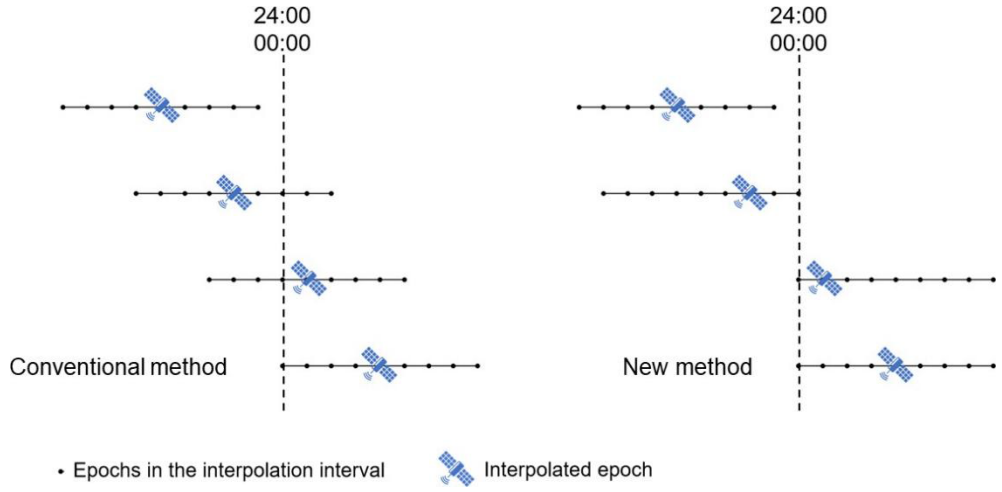
This guide is intended for PPP users who want to apply the WUM0MGXRAP products (including orbits, clocks, and biases) to PPP software other than PRIDE PPP-AR. Users must be able to modify their source code accordingly. Compared to conventional IGS products, the WUM0MGXRAP product offers additional orbit and clock estimates for each GPS, Galileo, and BDS satellite at the second midnight epoch (24:00:00) in both SP3 and CLK files. The continuity index at day boundaries, termed as **DOCB (Discontinuity of Orbits, Clocks, and Biases)**, is added to the newly defined section "SOLUTION/DAY_BOUNDARY_DISCONTINUITY" of the Bias-SINEX file. Though this new block has not been official and is still tentative, we take it as an attempt to facilitate end PPP users. In order to ensure optimal continuous data processing across day boundaries, users' PPP software must:

1）Read the estimates for the 24:00:00 epoch from the preceding day's product and the 00:00:00 epoch from the current day's product; next, prevent orbit and clock interpolations beyond day boundaries (*i.e.*, 24:00:00 or 00:00:00). This mechanism is illustrated in the following diagram. Taking orbit interpolation as an example, a conventional method (left) tend to place the interpolation position in the middle of the interpolation interval. However, in our proposed method (right), when the interpolation position falls on the preceding day, epoch 24:00:00 of that day's products should be used exclusively; when the interpolation position falls on the current day, the epoch 00:00:00 of this day's products should be used instead. Because the interpolation methods for orbit and clock products may differ, the compatibility of their individual interpolations might be compromised by the day-boundary discontinuities within orbits and clocks. However, this problem would be avoided by interpolating orbits/clocks within a day,

rather than across day boundaries.



2）Read the code/phase DOCBs from the Bias-SINEX file, and then compute the DOCBs for the specific signal choices of each satellite. If the DOCB exceeds a predefined threshold (*e.g.*, 0.10 cycle), the rapid products for this satellite cannot support continuous processing across day boundaries, and as a result, a reset of its corresponding ambiguities is necessary at the day boundary. The code and phase DOCBs in the Bias-SINEX file are defined as follows (refer to the Appendix for the meaning of this block):

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+SOLUTION/DAY_BOUNDARY_DISCONTINUITY
*DBD  SVN_ PRN STATION__ OBS1 OBS2 MIDNIGHT_AT___ MIDNIGHT_AT___ UNIT __ESTIMATED_VALUE____ _STD_DEV___
 DOCB G061 G02           C1C       2024:236:86400 2024:237:00000 ns                -0.08302     0.00000
 DOCB G061 G02           C1W       2024:236:86400 2024:237:00000 ns                -0.08891     0.00000
 DOCB G061 G02           C2W       2024:236:86400 2024:237:00000 ns                -0.10803     0.00000
 DOCB G061 G02           L1C       2024:236:86400 2024:237:00000 ns                 0.04775     0.00000
 DOCB G061 G02           L1W       2024:236:86400 2024:237:00000 ns                 0.04775     0.00000
 DOCB G061 G02           L2W       2024:236:86400 2024:237:00000 ns                 0.08832     0.00000
 DOCB G069 G03           C1C       2024:236:86400 2024:237:00000 ns                 0.05663     0.00000
 DOCB G069 G03           C1W       2024:236:86400 2024:237:00000 ns                 0.05034     0.00000
 DOCB G069 G03           C2X       2024:236:86400 2024:237:00000 ns                 0.09625     0.00000
 DOCB G069 G03           C2S       2024:236:86400 2024:237:00000 ns                 0.02823     0.00000
 DOCB G069 G03           C2L       2024:236:86400 2024:237:00000 ns                 0.09613     0.00000
 DOCB G069 G03           C2W       2024:236:86400 2024:237:00000 ns                 0.09413     0.00000
 DOCB G069 G03           C5X       2024:236:86400 2024:237:00000 ns                 0.06087     0.00000
 DOCB G069 G03           C5Q       2024:236:86400 2024:237:00000 ns                 0.15894     0.00000
 DOCB G069 G03           L1C       2024:236:86400 2024:237:00000 ns                -0.09861     0.00000
 DOCB G069 G03           L1W       2024:236:86400 2024:237:00000 ns                -0.09861     0.00000
 DOCB G069 G03           L2X       2024:236:86400 2024:237:00000 ns                -0.15594     0.00000
 DOCB G069 G03           L2S       2024:236:86400 2024:237:00000 ns                -0.15594     0.00000
 DOCB G069 G03           L2L       2024:236:86400 2024:237:00000 ns                -0.15594     0.00000
 DOCB G069 G03           L2W       2024:236:86400 2024:237:00000 ns                -0.15594     0.00000
 DOCB G069 G03           L5X       2024:236:86400 2024:237:00000 ns                -0.17982     0.00000
 DOCB G069 G03           L5Q       2024:236:86400 2024:237:00000 ns                -0.17982     0.00000
 DOCB G074 G04           C1X       2024:236:86400 2024:237:00000 ns                 0.06529     0.00000
```

For example, when a user selects “L1W”, “L2W”, “C1W” and “C2W” (or any other choices, namely all-frequency) as the clock/bias datum to enable PPP, the corresponding DOCBs (*i.e.*, d_{L1W}, d_{L2W}, d_{C1W}, and d_{C2W}) should be used to form their wide-/narrow-lane combinations for a specific satellite,

$$d_{\mathrm{WL}} = (f_1 \cdot d_{\mathrm{L1W}} - f_2 \cdot d_{\mathrm{L2W}}) - \frac{f_1 - f_2}{f_1 + f_2} \cdot (f_1 \cdot d_{\mathrm{C1W}} + f_2 \cdot d_{\mathrm{C2W}})$$

$$d_{\mathrm{NL}} = \frac{f_1^2 \cdot d_{\mathrm{L1W}} + f_2^2 \cdot d_{\mathrm{L2W}}}{f_1 - f_2}$$

where f_1 and f_2 are the frequencies of the selected dual-frequency observables, d_{L1W}, d_{L2W}, d_{C1W}, and d_{C2W} are in units of seconds, and d_{WL}, d_{NL} are in units of cycles. Then, users need to compare d_{WL} and d_{NL} with a predefined threshold (*e.g.*, 0.10 cycle). If d_{WL} or d_{NL} is larger than the threshold, the ambiguity parameter of that satellite is regarded as having a "jump" at the day boundary, and it should be reset to avoid degraded PPP results.

Appendix. SOLUTION/DAY_BOUNDARY_DISCONTINUITY Block (Optional)

Description:

This block contains the discontinuity of orbits, clocks, code/phase biases.

Contents:

SOLUTION/DAY_BOUNDARY_DISCONTINUITY DATA LINE		
Field	Description	Format
DBD	Discontinuity identifier. Available type is: 'DOCB': Discontinuity of orbits, clocks and code/phase biases across days. Mandatory field.	1X,A4
SVN	Satellite SVN code "CNNN": "C" - satellite system flag (according to RINEX3); "NNN" - SVN number (or GLONASS number).	1X,A4
PRN	Satellite PRN code "CNN": "C" - satellite system flag (according to RINEX3); "NN" - PRN number (or GLONASS slot number). IMPORTANT NOTE: To enable an unambiguous association of PRN and SVN numbers, BOTH values must be given if a bias refers to a specific satellite rather than a generic constellation.	1X,A3
Station Name Identifier	Station codes are encoded using a 9-character field (or a receiver group name). NOTE: For backward compatibility, left-aligned 4-character station codes are also permitted.	1X,A9
OBS1 and OBS2 Observable Codes	Observables used for estimating the biases. The observable codes have to be given according to the RINEX3 format definitions. The OBS2 field remains blank in	2(1X,A4)

	case of absolute (OSB) estimates and DOCB. IMPORTANT NOTE: Please be aware that distinction between - code (or pseudorange) and - phase biases is done on the basis of the given GNSS observable codes!	
Time	The second midnight epoch on the preceding day.	1X,I4.4, ':',I3.3, ':',I5.5
Time	The first midnight epoch on the current day.	1X,I4.4, ':',I3.3, ':',I5.5
Unit	DOCB estimates are given in the specified unit. Unit has to be 'ns' (nanoseconds) for code/phase biases;	1X,A4
DOCB Parameter Value	Computed (offset) value of the DOCB parameter.	1X,E21.6
DOCB Parameter Standard Deviation	Computed standard deviation for the DOCB parameter. NOTE: DOCB values taken over from an external source should be indicated with a zero value.	1X,E11.6