PPP-AR Pilot Project

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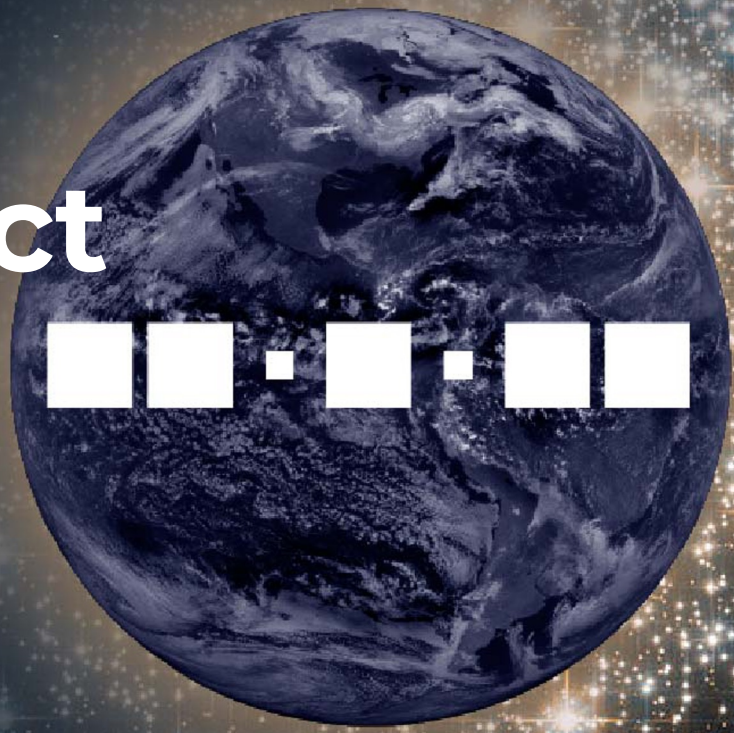
IGS INTERNATIONAL GNSS SERVICE

2024 Virtual Meeting



Outline

- Recent progress of IGS ACs' PPP-AR products over the past year
- One-year results of the routine PPP-AR product combination (Qiang Wen)
- Introduction of the HUM PPP-AR products (Xiang Guo)
- Preliminary assessment of ACs' 24:00:00 epoch products for addressing the day-boundary discontinuity issue (Qiang Wen)

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CODE's PPP-AR products

- CODE MGEX products include QZSS phase OSBs

```
OSB  J004 J03          L1C       2024:302:00000 2024:303:00000 ns          0.37913     0.00000
OSB  J004 J03          L1L       2024:302:00000 2024:303:00000 ns          0.37913     0.00000
OSB  J004 J03          L1X       2024:302:00000 2024:303:00000 ns          0.37913     0.00000
OSB  J004 J03          L1Z       2024:302:00000 2024:303:00000 ns          0.37913     0.00000
OSB  J004 J03          L2L       2024:302:00000 2024:303:00000 ns          0.66087     0.00000
OSB  J004 J03          L2S       2024:302:00000 2024:303:00000 ns          0.66087     0.00000
OSB  J004 J03          L2X       2024:302:00000 2024:303:00000 ns          0.66087     0.00000
OSB  J005 J04          L1C       2024:302:00000 2024:303:00000 ns         -0.37688     0.00000
OSB  J005 J04          L1L       2024:302:00000 2024:303:00000 ns         -0.37688     0.00000
OSB  J005 J04          L1X       2024:302:00000 2024:303:00000 ns         -0.37688     0.00000
OSB  J005 J04          L1Z       2024:302:00000 2024:303:00000 ns         -0.37688     0.00000
OSB  J005 J04          L2L       2024:302:00000 2024:303:00000 ns         -0.65723     0.00000
OSB  J005 J04          L2S       2024:302:00000 2024:303:00000 ns         -0.65723     0.00000
OSB  J005 J04          L2X       2024:302:00000 2024:303:00000 ns         -0.65723     0.00000
```

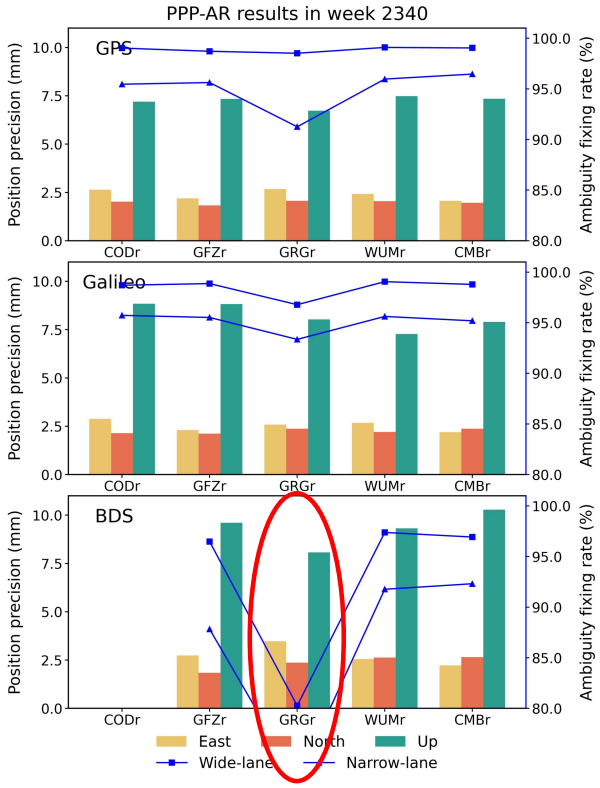
- Code OSBs on baseline frequencies are no longer zero values

```
OSB  G061 G02          C1C       2024:302:00000 2024:303:00000 ns         -9.3819      0.0064
OSB  G061 G02          C1W       2024:302:00000 2024:303:00000 ns        -11.1419      0.0000
OSB  G061 G02          C2W       2024:302:00000 2024:303:00000 ns        -18.3501      0.0000
OSB  G069 G03          C1C       2024:302:00000 2024:303:00000 ns          7.0522      0.0065
OSB  G069 G03          C1W       2024:302:00000 2024:303:00000 ns          7.7727      0.0000
OSB  G069 G03          C2L       2024:302:00000 2024:303:00000 ns         13.5046      0.0176
OSB  G069 G03          C2S       2024:302:00000 2024:303:00000 ns         13.0199      0.0138
OSB  G069 G03          C2X       2024:302:00000 2024:303:00000 ns         13.5708      0.0168
OSB  G069 G03          C2W       2024:302:00000 2024:303:00000 ns         12.8011      0.0000
```

GRG's PPP-AR products

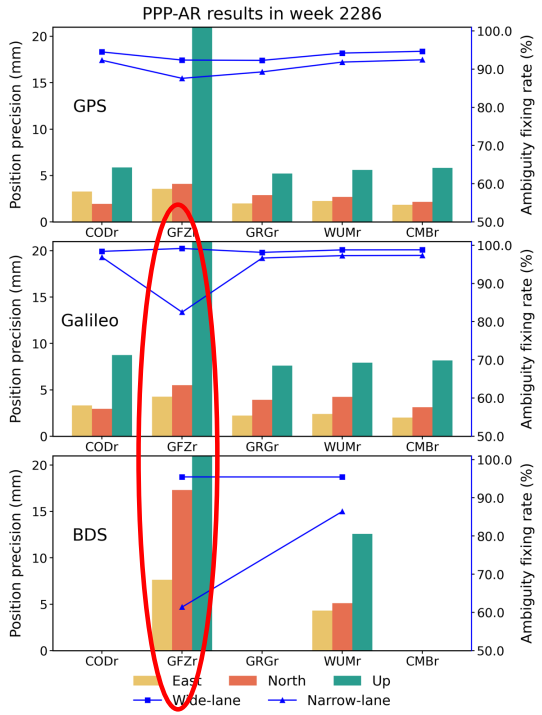
- GRG releases MGEX final products
- OPS rapid products change into standard Bias-SINEX format
- MGEX final and OPS rapid products include BDS phase OSBs, but lower fixing rates for C38/C39/C40 three IGSO satellites

```
OSB  C219 C37          C2I       2024:301:00000 2024:301:86399 ns          1.4476       0.8055
OSB  C219 C37          C6I       2024:301:00000 2024:301:86399 ns          2.4182       0.8423
OSB  C219 C37          L2I       2024:301:00000 2024:301:86399 ns         -4.3887       0.6944
OSB  C219 C37          L6I       2024:301:00000 2024:301:86399 ns         -6.6467       0.9808
OSB  C227 C41          C2I       2024:301:00000 2024:301:86399 ns         14.5187       0.8215
OSB  C227 C41          C6I       2024:301:00000 2024:301:86399 ns         21.8454       0.8609
OSB  C227 C41          L2I       2024:301:00000 2024:301:86399 ns        -18.5062       0.7077
OSB  C227 C41          L6I       2024:301:00000 2024:301:86399 ns        -28.0275       1.0024
OSB  C226 C43          C2I       2024:301:00000 2024:301:86399 ns        -26.9496       1.0107
OSB  C226 C43          C6I       2024:301:00000 2024:301:86399 ns        -41.0475       1.0444
OSB  C226 C43          L2I       2024:301:00000 2024:301:86399 ns         27.0744       0.8547
OSB  C226 C43          L6I       2024:301:00000 2024:301:86399 ns         41.0038       1.2376
```

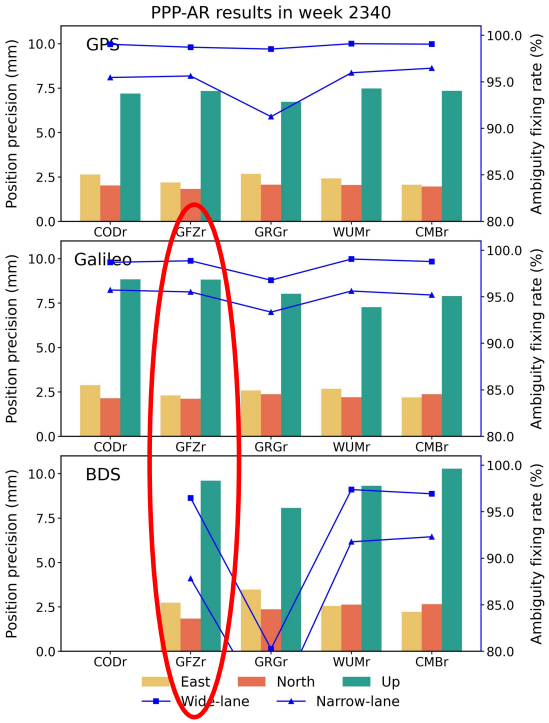


GFZ's PPP-AR products

- GFZ releases G/E/C phase OSBs in standard Bias-SINEX format
- Issues causing lower ambiguity fixing rates have been resolved



GPS week 2286



GPS week 2340

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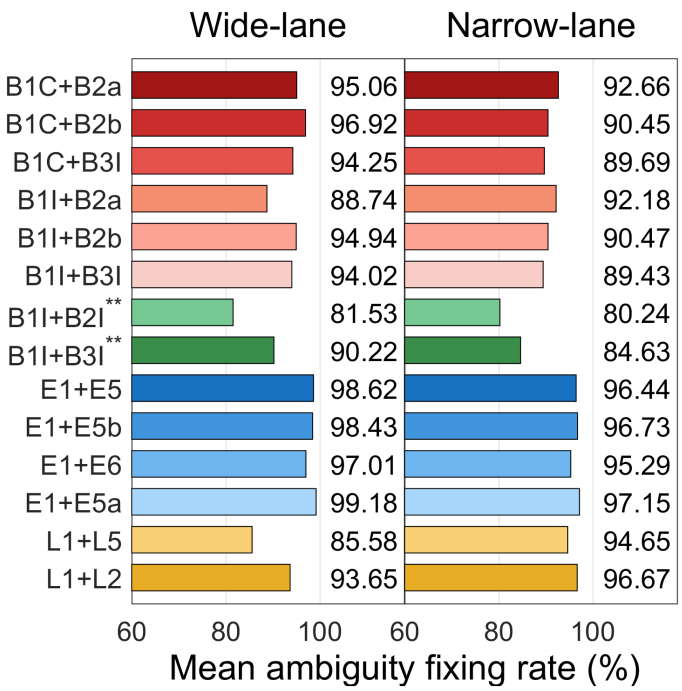
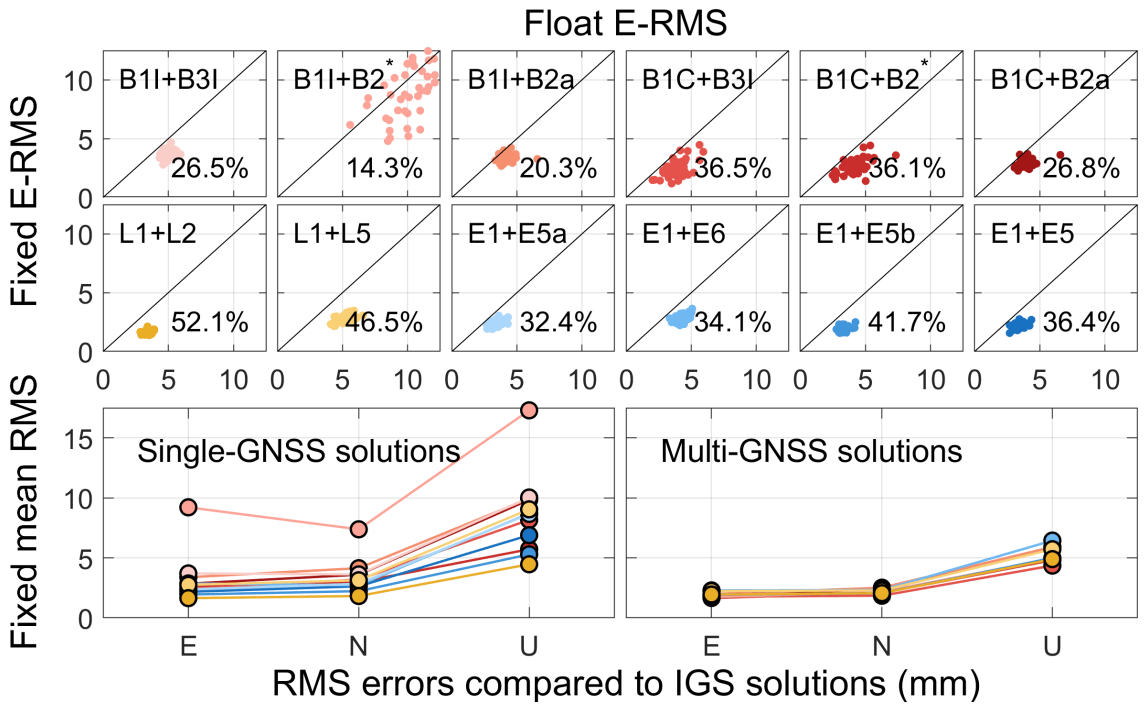
WUM's PPP-AR products

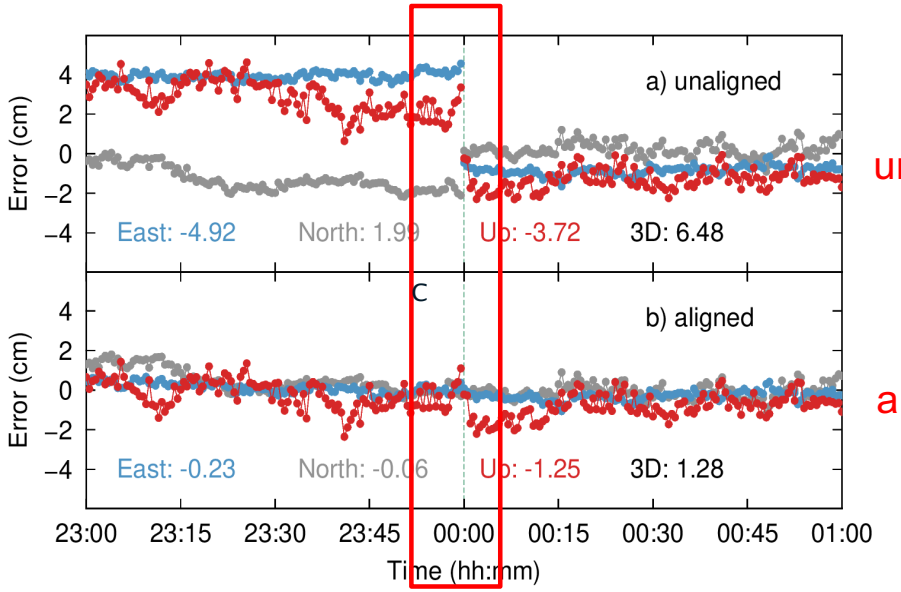
- WUM rapid and final products include all-frequency G/E/C phase OSBs





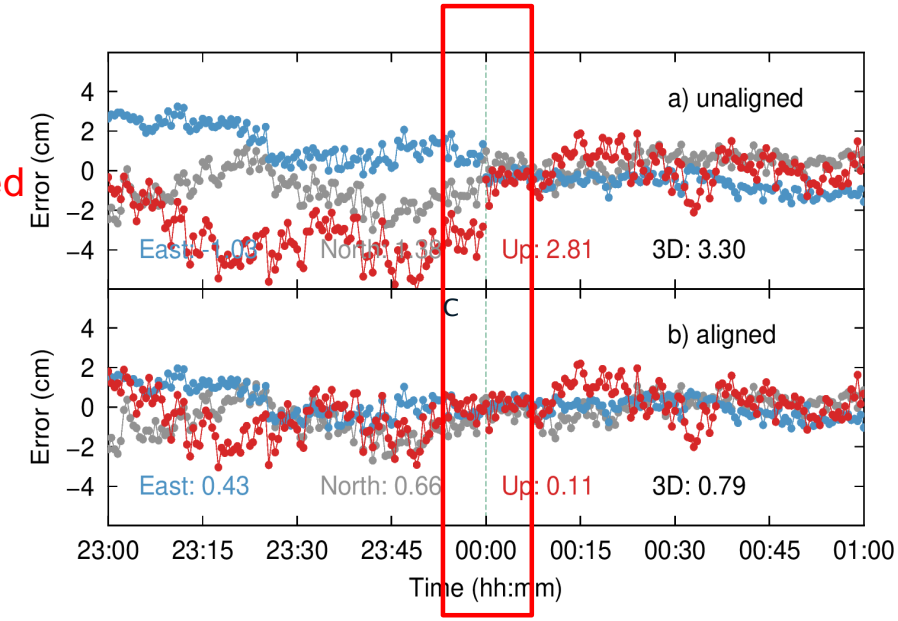
WUM's PPP-AR products

- WUM rapid products mitigate day-boundary discontinuity



unaligned

aligned



GPS-only 30 s data, DOY 230—231, 2023, ROAG

GPS-only 30 s data, DOY 204—205, 2023, NRC1

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HUST multi-GNSS products

Product name	Description
HUS0MGX*TML_yyyyddd*0000_01D_05M_ORB.SP3	Daily GNSS ephemeris at 5-min intervals in SP3d format, including accuracy codes derived from formal errors
HUS0MGX*TML_yyyyddd*0000_01D_30S_CLK.CLK	Daily GNSS clocks at 30-s intervals in RINEX-clock format (version 3.02)
HUS0MGX*TML_yyyyddd*0000_01D_30S_ATT.OBX	Daily GNSS attitudes at 30-s intervals in ORBEX format (version 0.09)
HUS0MGX*TML_yyyyddd*0000_01D_01D_OSB.BIA	Daily phase and code bias solutions corresponding to the clocks in Sinex-Bias format (version 1.00)
HUS0MGX*TML_yyyyddd*0000_01D_01D_ERP.ERP	Daily GNSS ERP (pole, UT1-UTC) solutions in IGS ERP format (version 2)

HUST: Huazhong University of Science and Technology, *P. R. China*

TML: FIN for final products with a latency of ~ 2 days
RAP for rapid products with a latency of ~ 12 hours

yyyyddd: year and day of year

HUST's products are available at: ftp://ggda.ac.cn/pub/mgex/products

Processing strategy

Item	Description
Software	Gravity and Orbit Determination Software (GODS) developed at HUST, from PANDA (version 2009)
Tracking stations	A subset of ~120 stations from the IGS/MGEX network, IGS20 reference frame realized through NNR and NNT minimum constraints applied to selected stations from the IGS20 core network
Basic observables	Undifference ionosphere-free (IF) phase and code for system G/R/E/C, 7° elevation cutoff, elevation-dependent data weighting 1/sin(e)
Orbit dynamics	Solar radiation pressure model: ECOM2 for GPS/GLONASS/BDS-3, ECOM1 for GALILEO and BDS-2. A priori model for Galileo from Montenbruck et al. (2015). A priori model for BDS-3 from Wang et al. (2019).
Specialties	● The HUST products are generated based on a rigorous data combination of four global GNSS systems (G/R/E/C), i.e., all parameters are adjusted within one step. ● The noise variances for each observation group (classified according to station and GNSS system) are derived from the variance component estimation and are used for a data weighting. ● The wide-lane (WL) fractional cycle biases (FCBs) are derived from HMW analysis and the narrow-lane (NL) FCBs are computed based on the IF ambiguities from the POD process and WL ambiguities from the HMW analysis. The WL and NL FCBs are converted into OSBs (Banville et al. 2020) and introduced to the POD process to obtain ambiguity-fixed clocks. ● The differential code biases (DCBs) are computed based on the pseudo STECs derived from an uncombined POD process. High order ionosphere delays in the observations are corrected with the STECs from the DCB computation.

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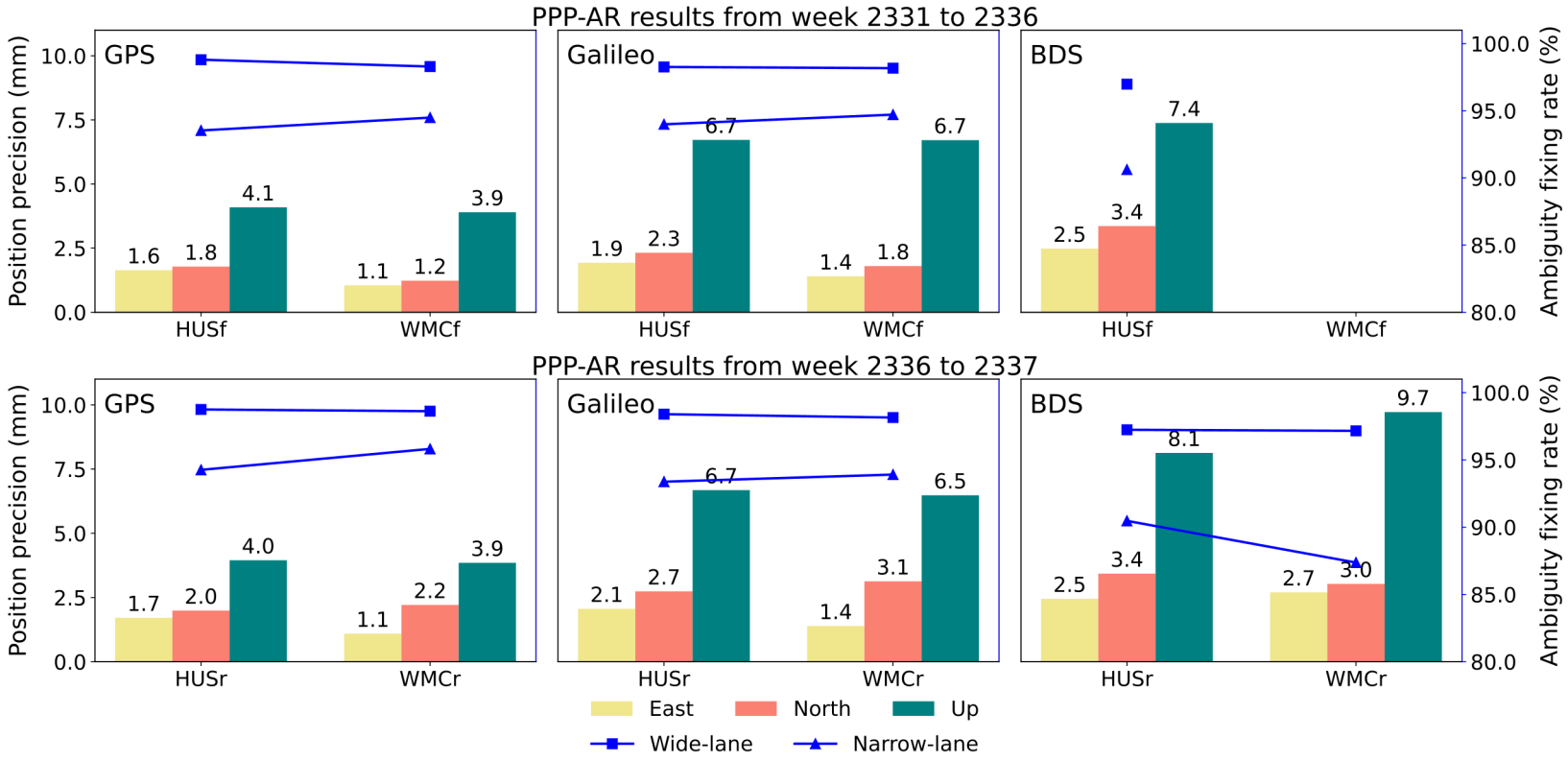
PPP-AR with PRIDE-PPPAR 3.0

10 globally distributed stations, 300-s sampling, daily static solution w.r.t. IGS daily Sinex products



GRACE-FO POD

KBR validation for GRACE-FO POD with single-receiver IAR

- The HUSf products (1.3&3.0 mm) are slightly inferior to the WMCf products (1.2&2.9 mm) for dynamic and kinematic POD
- The dynamic POD solutions with the HUSf (1.3 mm) and WMCf (1.2 mm) products are notably better than the official GNV1B products (1.8 mm)