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Noise Characterization in BDS-3 Multi-Frequency Observables

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Outline

- ❑ Introduction
- ❑ Experimental Design
- ❑ Results
- ❑ Concluding Remarks

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Introduction

- Multiple BDS-3 satellites broadcast signals on different frequencies
  - Permits both system and inter-system compatibility and interoperability (Table 1)
  - Useful in satellite-based positioning

- However, noise characterization in BDS is limited to BDS -2
  - BDS-3 noise is comparatively analyzed with respect to GPS and Galileo constellations
  - Contribution of BDS-3, GPS, and Galileo on PPP

Table 1: Overview of BDS-3 service signals as of March 2022

Frequency	Observation Codes			MEO	IGSO	GEO	Compatibility
B1I	2I	2Q	2X	✓	✓	✓	B1 (BDS-2)
B3I	6I	6Q	6X	✓	✓	✓	B3 (BDS-2)
B1C	1D	1P	1X	✓	✓	-	L1 and E1 (GPS and GAL)
B2a	5D	5P	5X	✓	✓	-	L5 and E5a (GPS and GAL)
B2b	7D	7P	7Z	✓	✓	-	E5b (GAL)
B2a+b	8D	8P	8X	✓	✓	-	E5a+b (GAL)

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Experimental Design

Stations — 17 globally distributed (used for Multipath+SNR)
— 13 stations were used for PPP

DOY — 060 to 066 in 2022

Constellations — BDS-3, GPS, and GAL

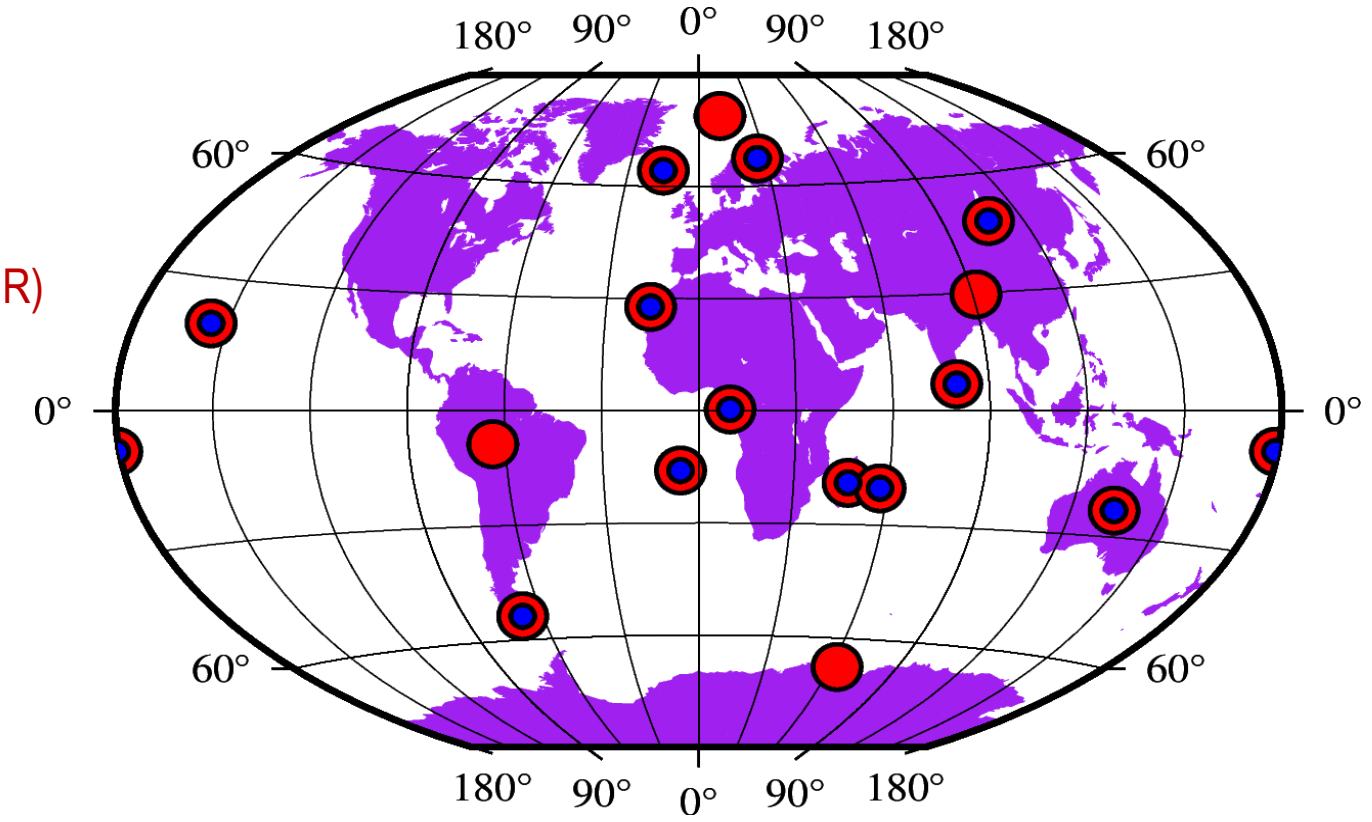

Figure 1: Distribution of the GNSS tracking stations for data processing

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Multipath and SNR Characterization

- Pseudorange multipath and SNR comparison
- Stations — 17 that can track BDS-3, GAL, and GPS frequency signals

Multipath / SNR

— ~ 40 cm / ~40 dBHz

— < 40 cm / ~40 dBHz

— ~ 40 cm / ~40 dBHz

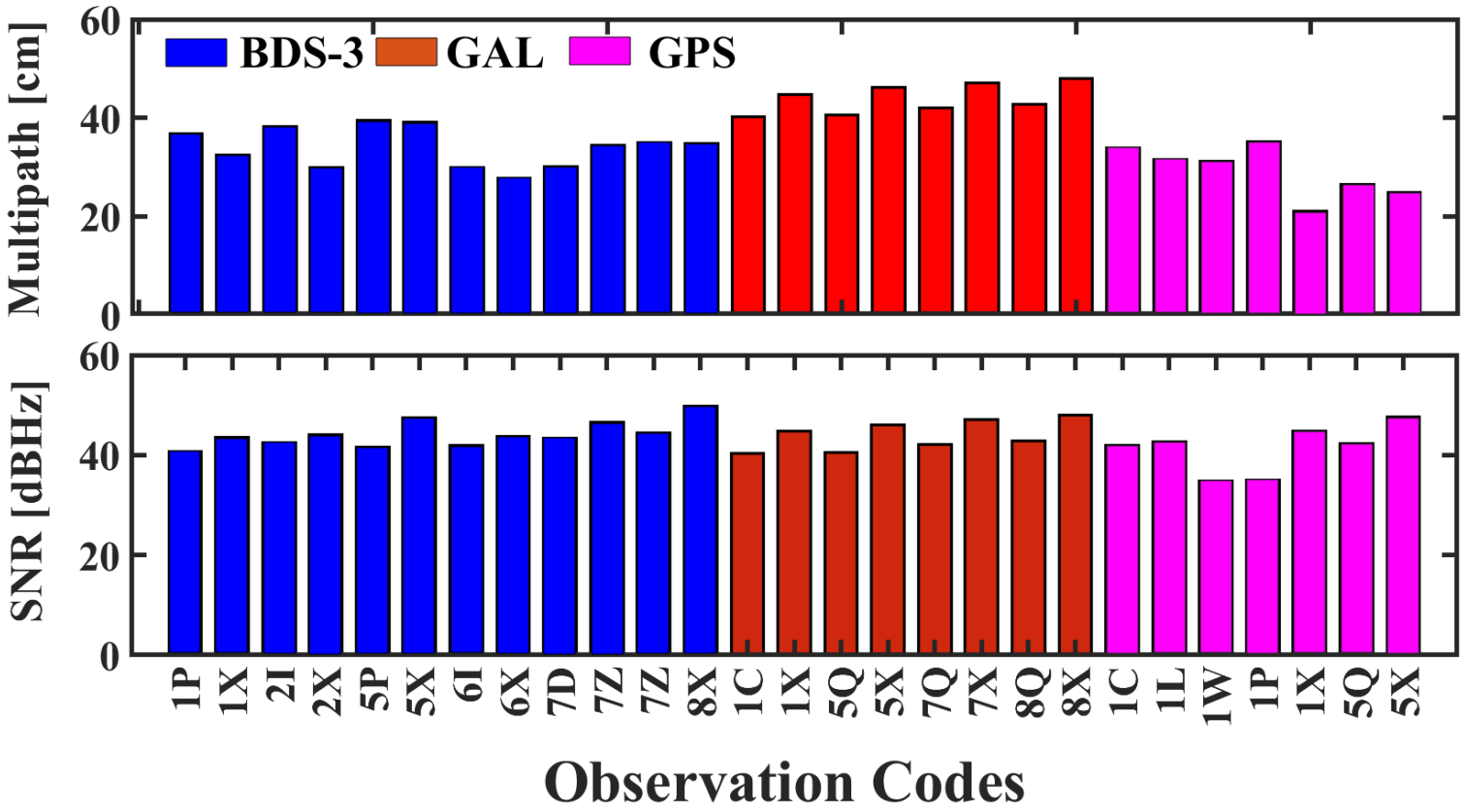
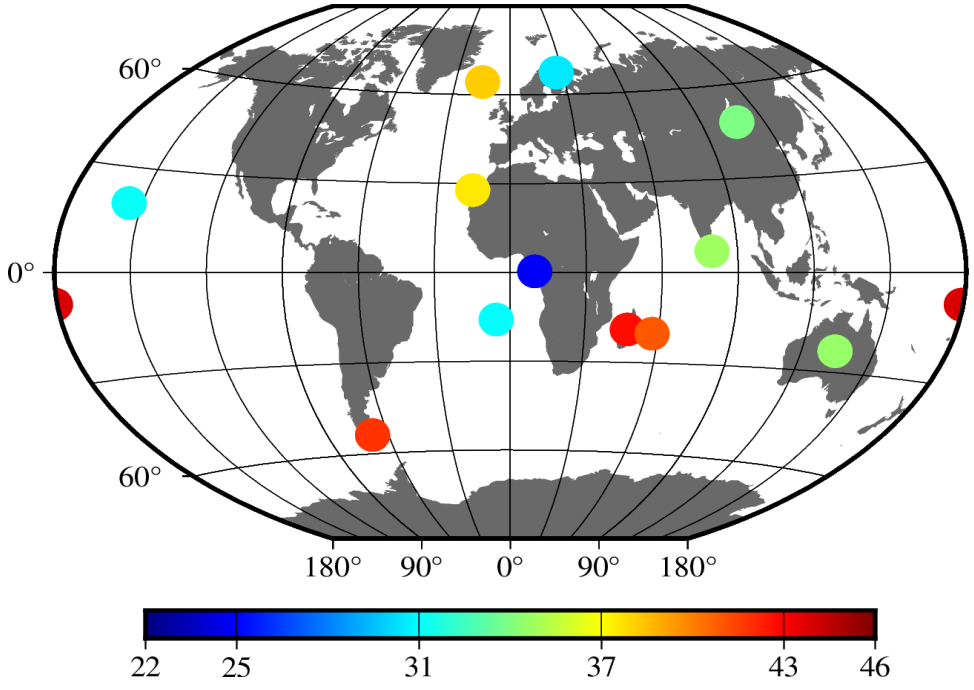


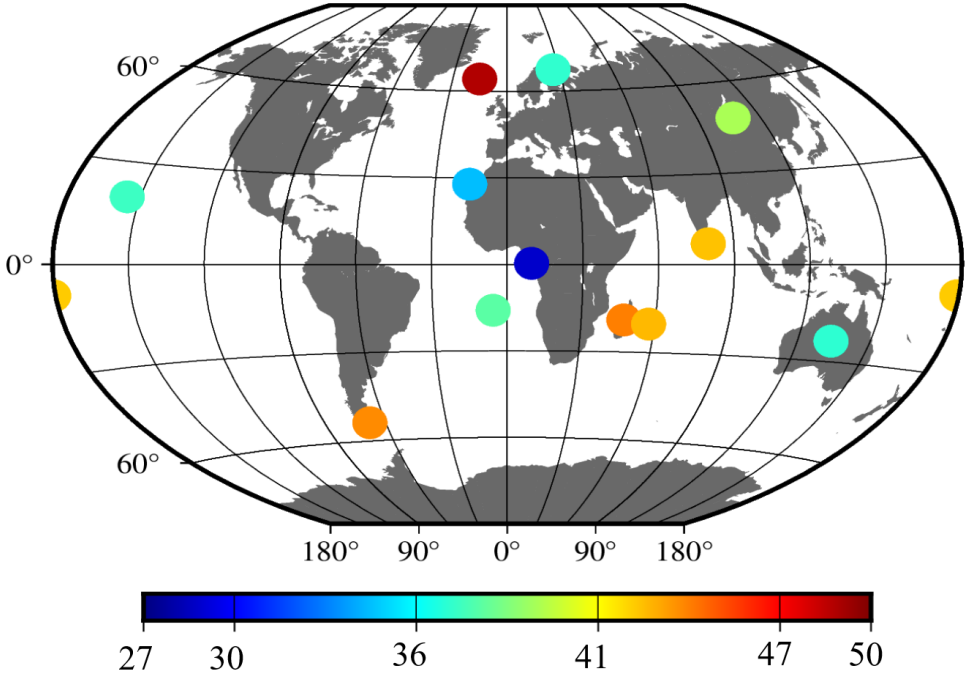
Figure 2: Code multipath and SNR comparison

Multipath Characterization

Pseudorange multipath comparison



B1C signal (cm).



B2a signal (cm).

Figure 3: Code multipath comparison

- Code multipath — range of 22 to 46 and 27 to 50 cm for B1C and B2a signals, respectively

SNR Characterization

SNR comparison — Interoperable Signals

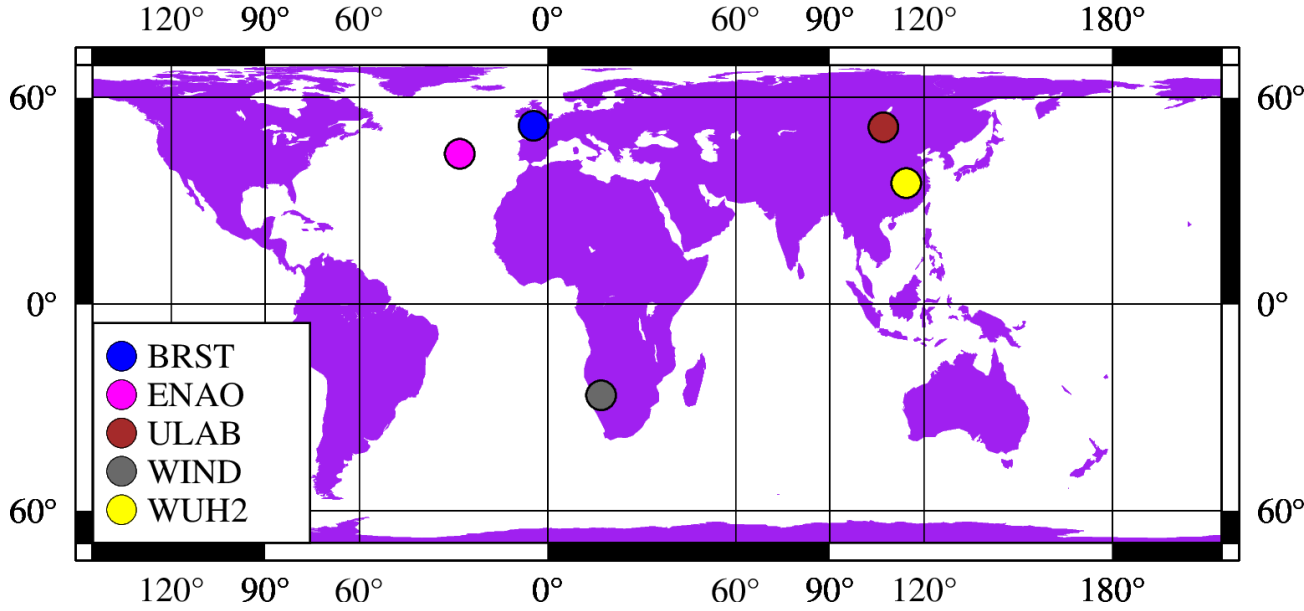
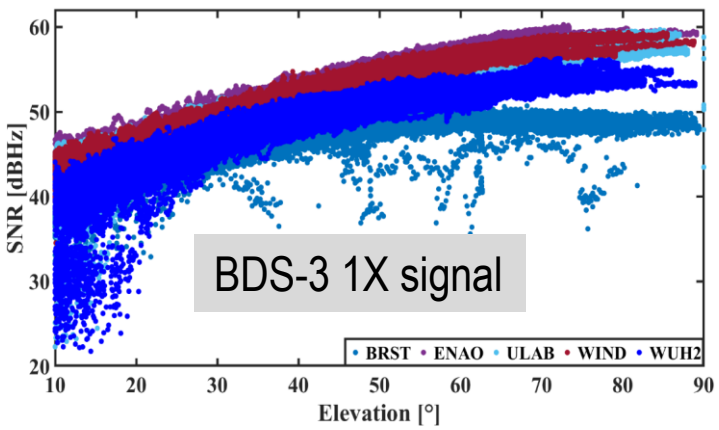
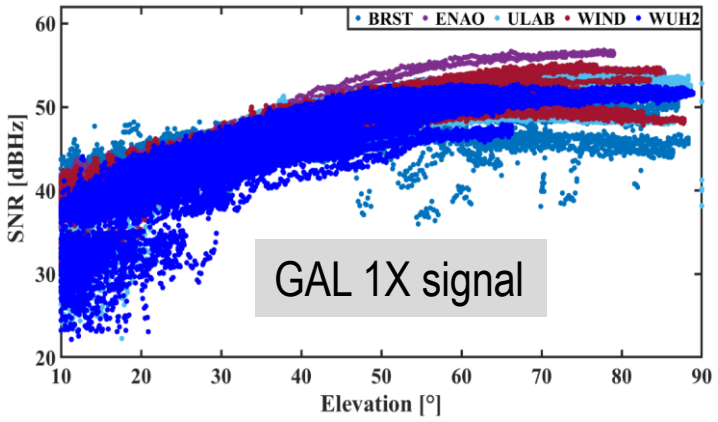


Figure 4: Stations with interoperable signals

- Averaged solution on DOY 060 (2022)
- Stations — 5 that can track BDS-3, GAL, and GPS frequency signals





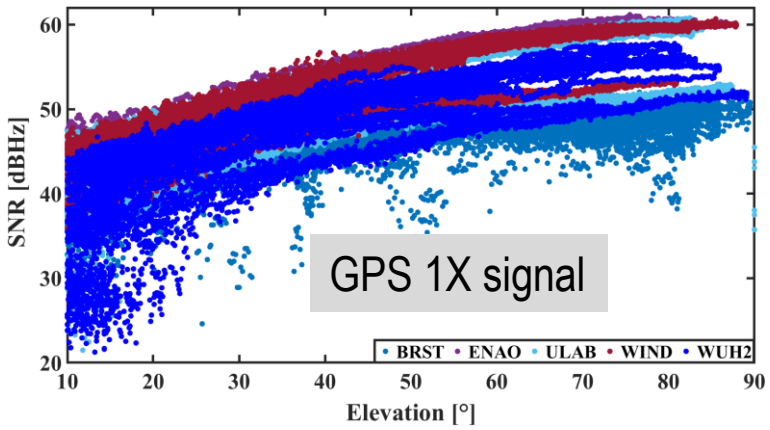


Figure 5: SNR comparison

PPP Performance

- STD: 25th, 50th and 75th Percentiles

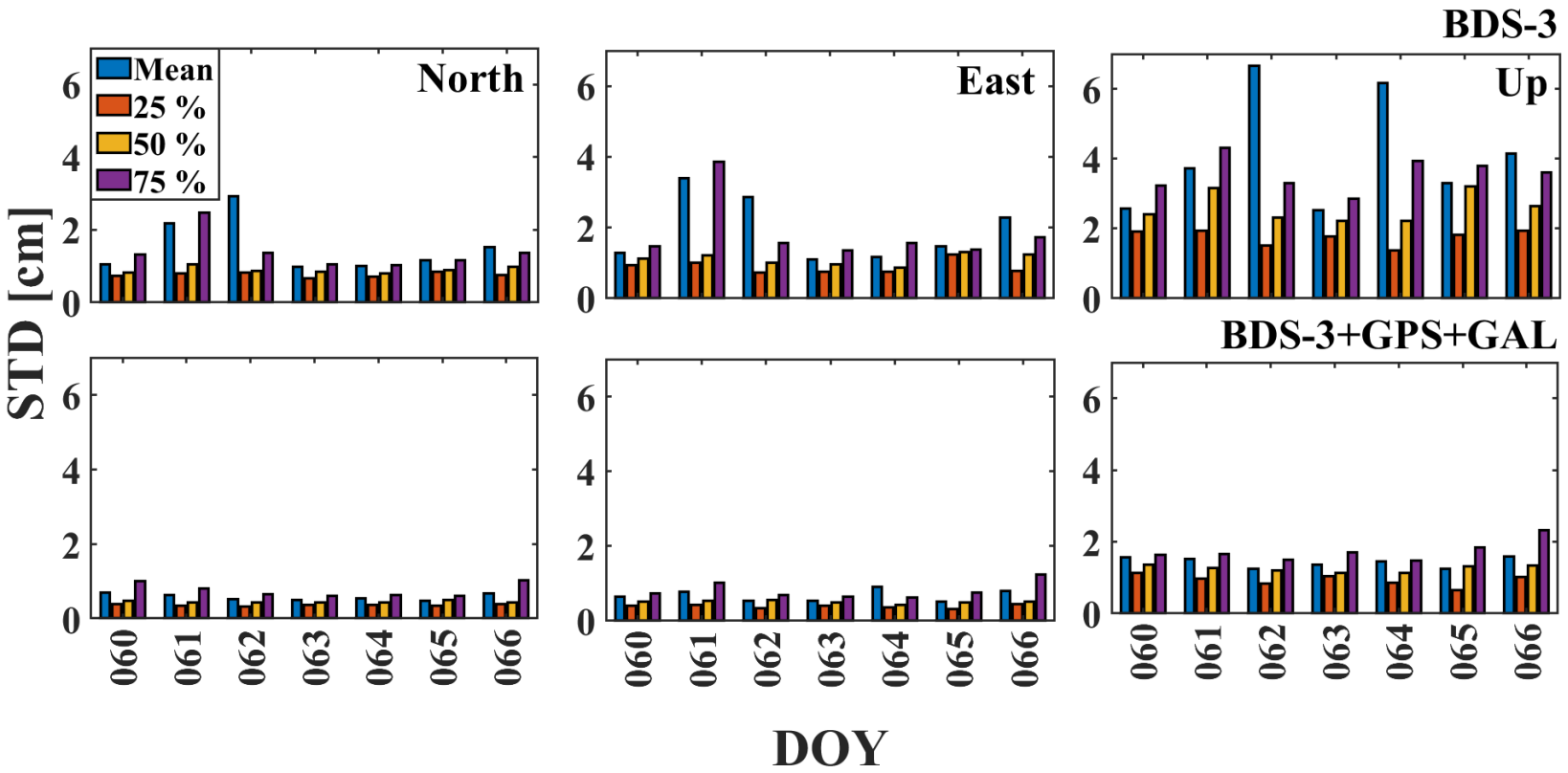


Figure 6: STD comparison

PPP Performance

- STD: 25th, 50th and 75th Percentiles

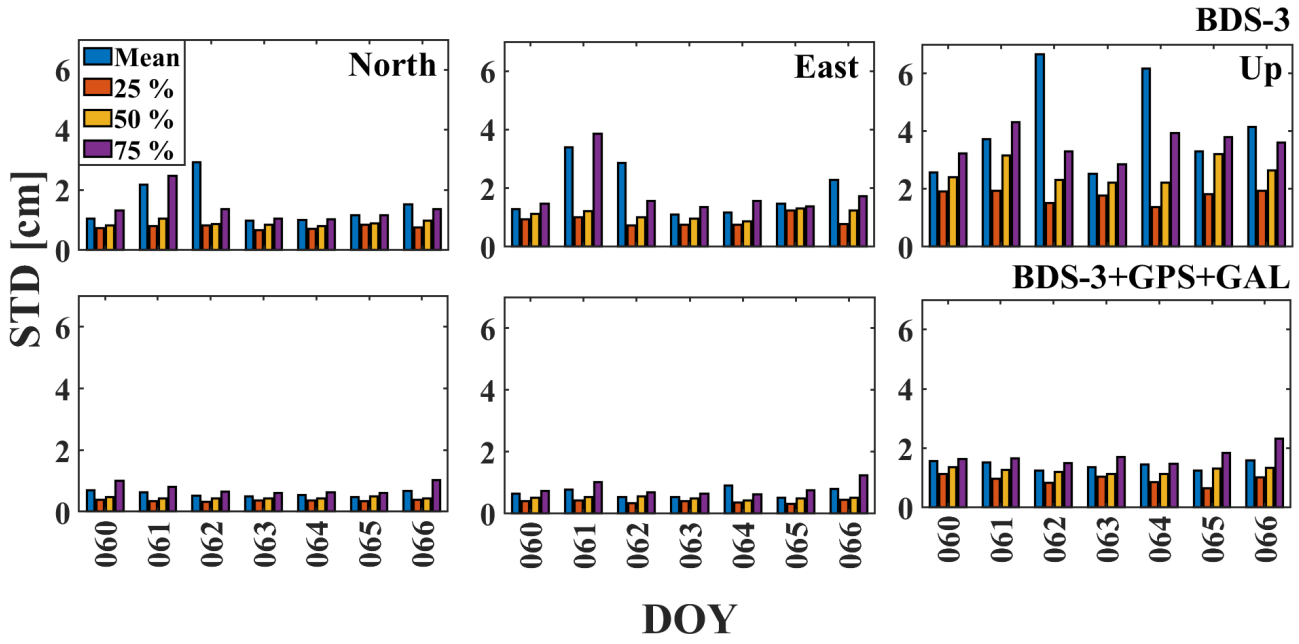


Figure 6: STD comparison

Table 2: PPP numerical statistics

	Mean (cm)	25%	50%	75%	Remark
BDS-3	1.55	0.76	0.90	1.40	North
	1.94	0.89	1.11	1.85	East
	4.58	1.76	2.60	3.58	Up
BDS-3+GPS+GAL	0.59 (62)	0.38 (50)	0.47 (48)	0.78 (44)	North
	0.67 (65)	0.39 (56)	0.51 (54)	0.82 (56)	East
	1.42 (69)	0.93 (47)	1.25 (52)	1.74 (51)	Up

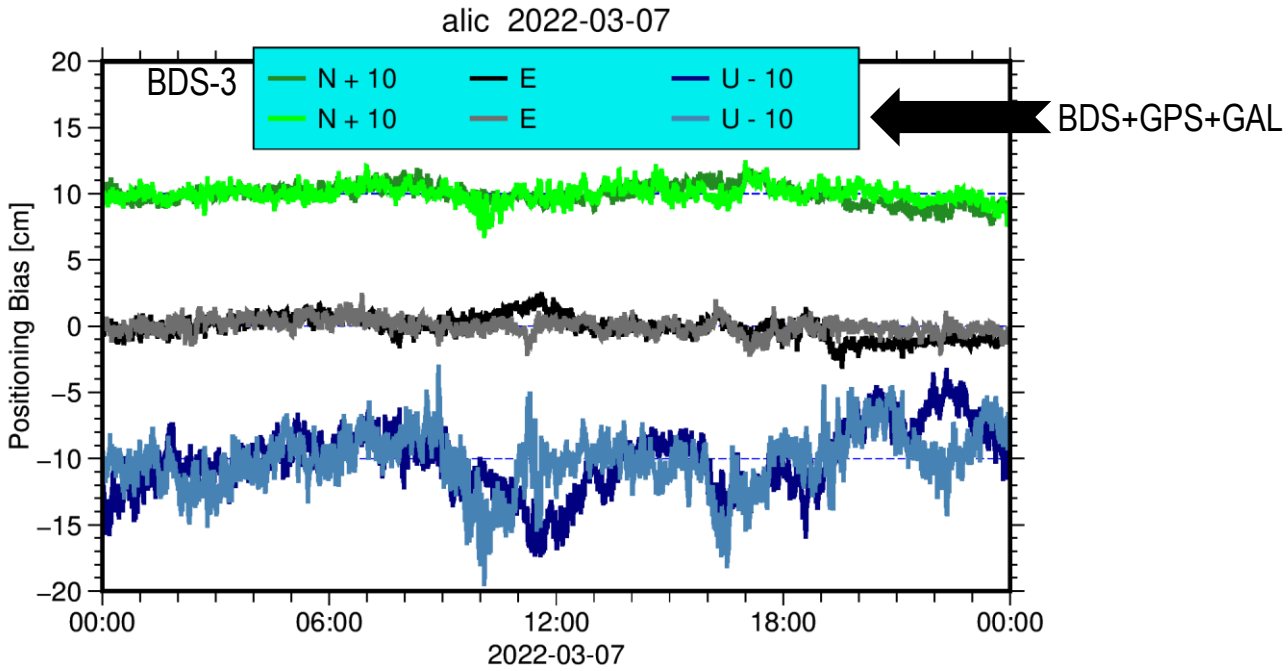


Figure 7a: Position time series at ALIC station

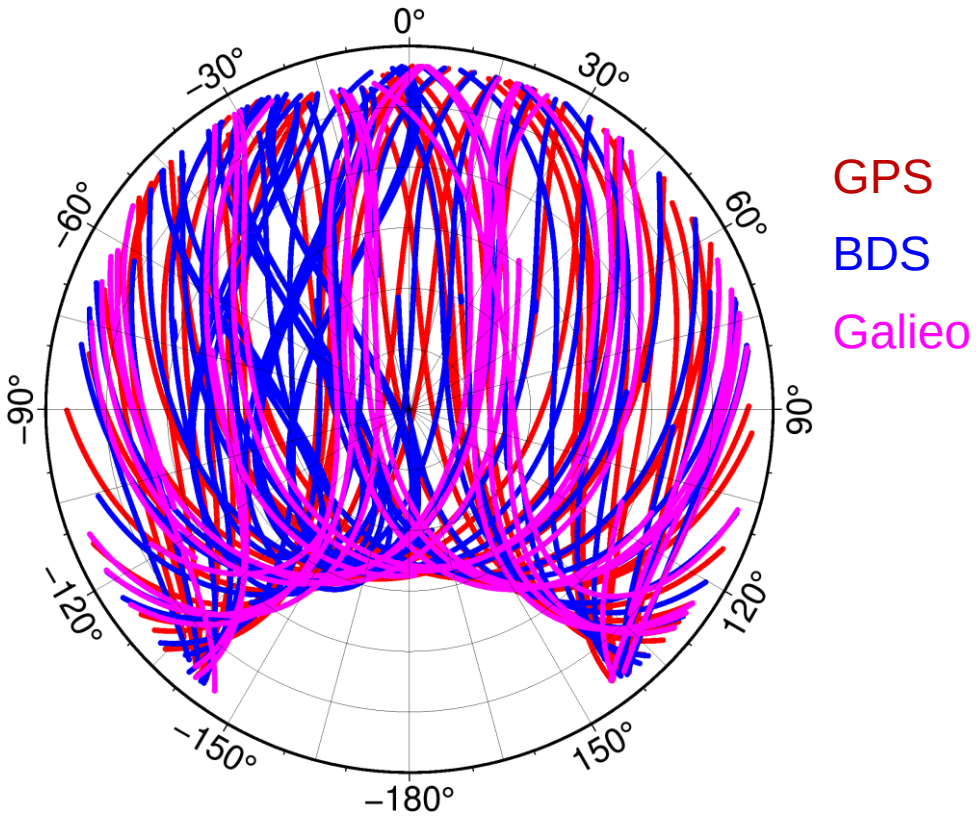


Figure 7b: SkyPlot for ALIC station on DOY 066 (2022)

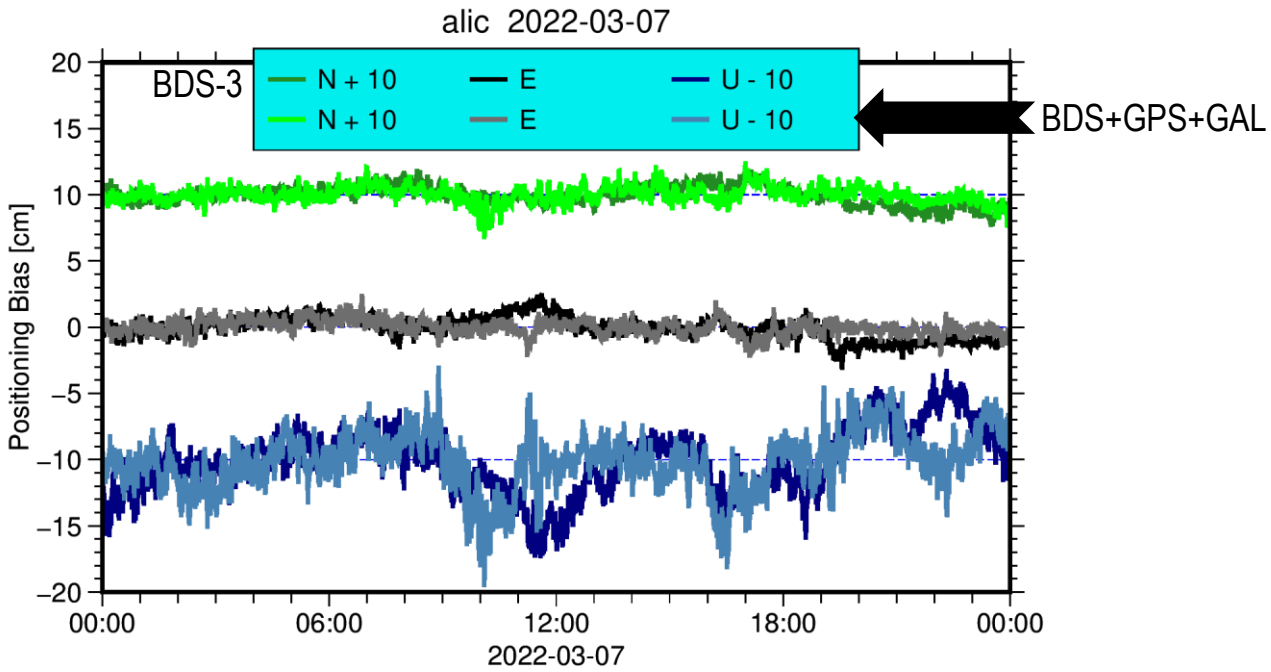


Figure 7a: Position time series at ALIC station

Table 3: Position time series comparison (cm)

Constellation	N	E	U
BDS-3	0.67	0.68	2.37
BDS+GPS+GAL	0.46	0.48	1.43

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Key Points

- Code multipath and SNR — comparable between the three constellations
- BDS-3 only can achieve cm-level precision in the daily solutions
- BDS-3 PPP — benefit from the less noisy modernized signals broadcast by GPS and GAL satellites
- What next? ➡ short and zero baseline tests

Need To Know More? [1]

End of Presentation

Further Details

[1] R. G. Suya, Y.-T. Chen, C. F. Kwong, P. Zhang, **Noise Characterization in BeiDou-3 Multi-Frequency Observables**, in: XXVII FIG Congress, Volunteering for the future-Geospatial excellence for a better living, 11-15 September, Warsaw, Poland, 2022. Available at: https://www.fig.net/fig2022/technical_program.htm