ETH zürich SPACE GEODESY

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Can Android Smartphones Contribute to GNSS Meteorology?

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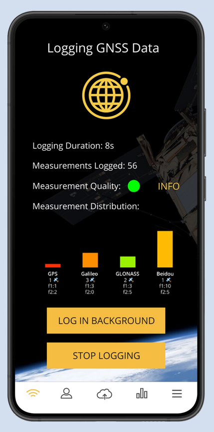
1 Introduction

- GNSS is an essential tool for troposphere monitoring. However, geodetic-grade receivers are too costly to be densely deployed
- Android smartphones can be used to collect raw GNSS data since the release of the Android 7 OS in 2016
- In this study, several smartphone GNSS datasets were collected and utilized to investigate its potential for GNSS meteorology



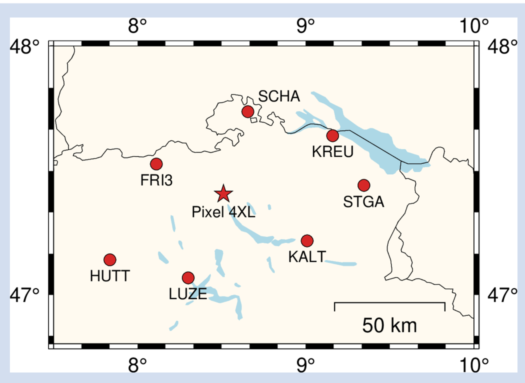
2 Data

- **Device:** A Google Pixel 4XL smartphone installed with the CAMALIOT app was used for data collection
- **Open-sky experiment:** 24-h data collection on the rooftop of the ETH campus *(2023-05-18)*
- **Car experiment:** 30-min static data collection outside and inside the car, respectively *(2024-04-17)*

Figure 1 Smartphone GNSS data collection **(a)** on a rooftop and **(b)** inside a car, respectively.

3 Method

- Software: The in-house PPPx software
- Constellations: GPS/GLONASS/Galileo
- PPP in static mode with factor graph optimization
- Troposphere: Estimated as a random-walk process
- Ionosphere: Interpolated with surrounding geodetic GNSS stations



4 Results

Open-sky experiment

- The data quality of PIXL is close to ETH2, especially for carrier phase
- The accuracy of ZTD estimation can reach approximately 6 mm

Table 1 GNSS data quality indicators for the smartphone on the rooftop.

Station	C/N_0 (dB-Hz)	Nsat	PDOP	Noise	
				code (m)	phase (mm)
ETH2	44.2	26.0	1.02	0.34	2.6
PIXL	41.9	21.4	1.07	3.25	4.4

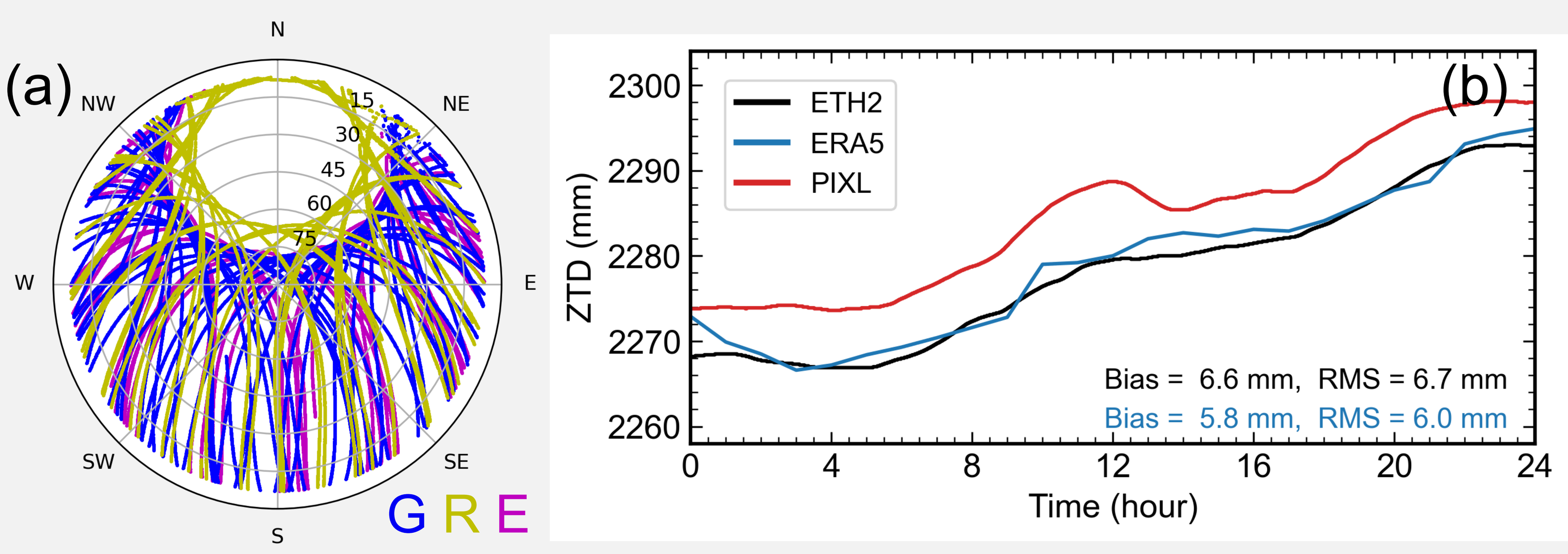
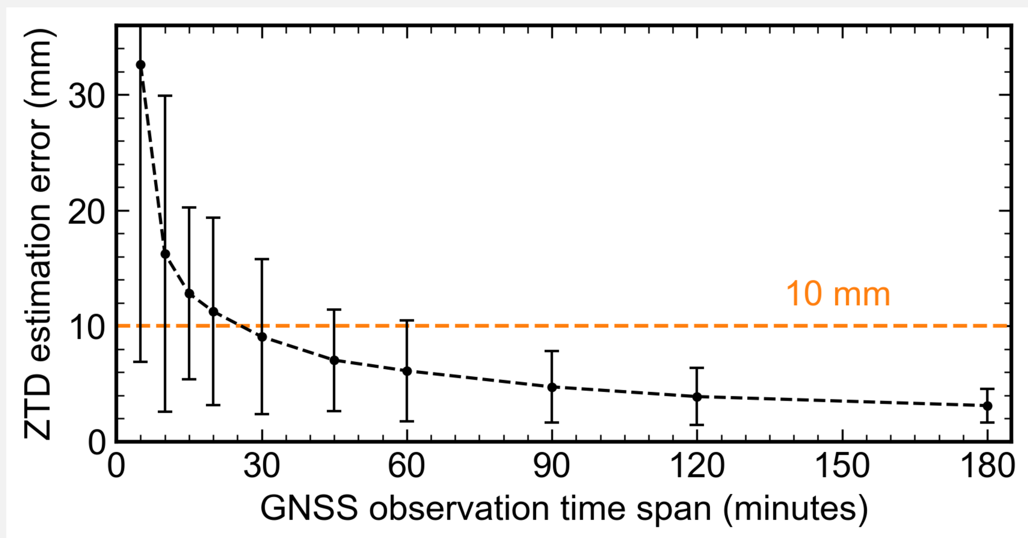


Figure 2 **(a)** Skyplot of observed GNSS satellites. **(b)** ZTD estimates derived from ETH2, ERA5 and PIXL.

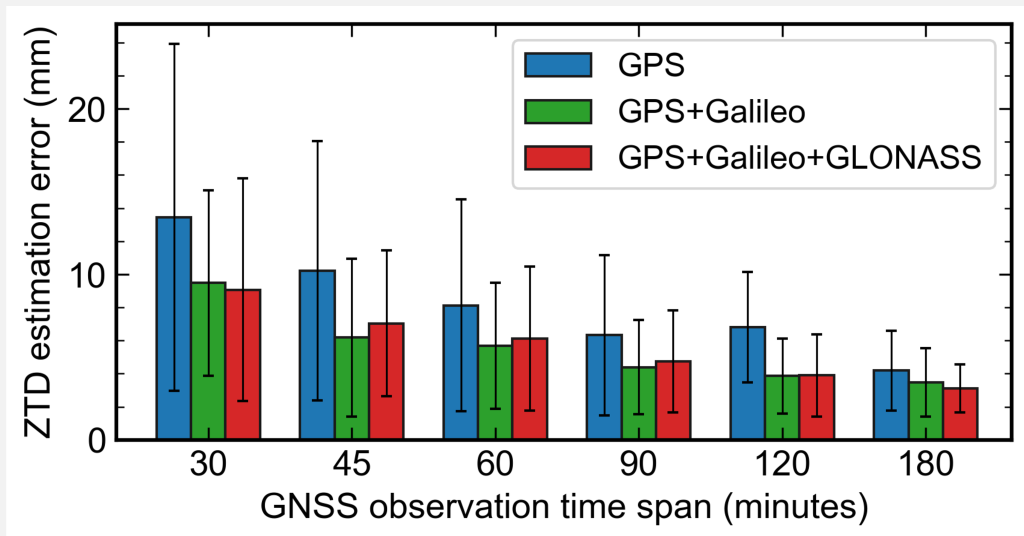
- The impact of observation time span on ZTD estimation accuracy



The 30-min observation time span is a good trade-off between smartphone battery life and the accuracy of ZTD estimation

Figure 3 The error of ZTD estimation using the PIXL multi-GNSS data (GRE) with varying observation time spans. The ZTDs derived from ETH2 served as reference and the bias was removed.

- The impact of multi-GNSS observation on ZTD estimation accuracy



Multi-GNSS observation can evidently improve the accuracy of ZTD estimation, especially when observation time span is short

Figure 4 The error of ZTD estimation using the PIXL data with different combinations of GNSS constellations.

Car experiment

- The windshield has limited impact on smartphone GNSS data
- Similar accuracy of ZTD estimation can be achieved

Table 2 GNSS data quality indicators for the smartphone outside and inside the car.

Setting	C/N_0 (dB-Hz)	Nsat	PDOP	Noise	
				code (m)	phase (mm)
Outside	44.1	22.2	1.03	2.73	2.8
Car	42.3	21.2	1.05	3.22	3.1

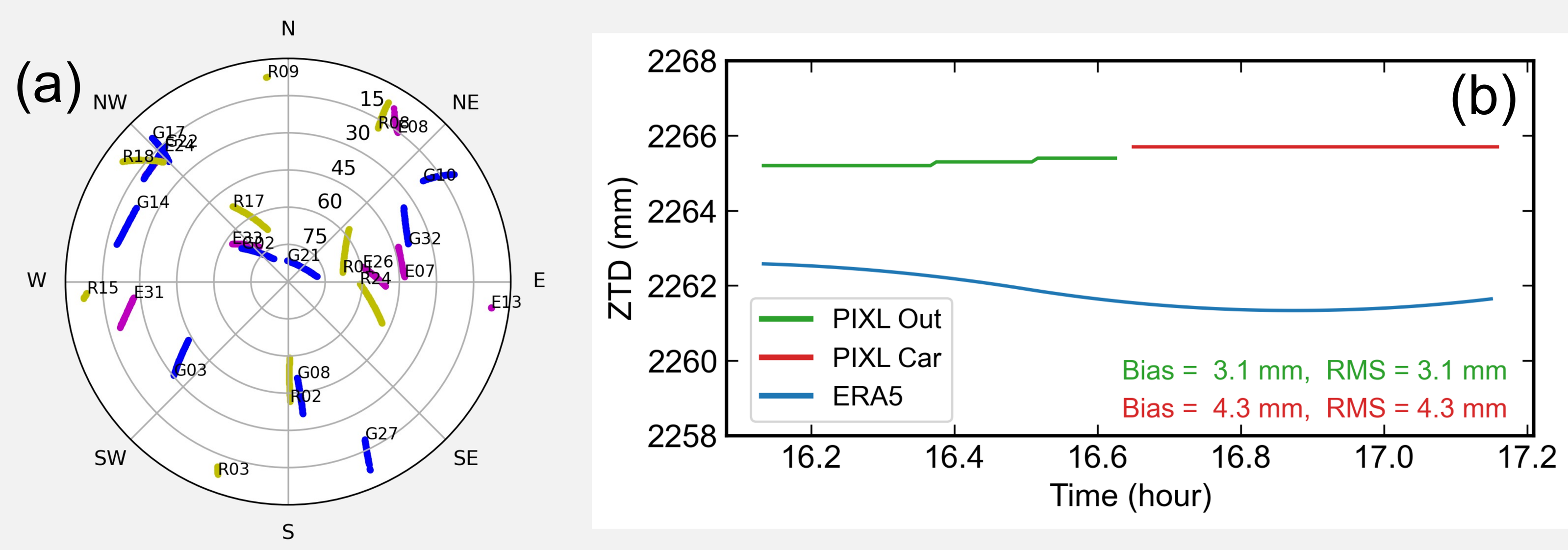


Figure 3 **(a)** Skyplot for data collection inside the car. **(b)** ZTD estimates derived from the PIXL data collected outside and inside the car, and model values from ERA5.

5 Conclusion

- The ZTD estimates derived from smartphone GNSS data can reach an accuracy better than 1 cm if dedicated processing strategies are applied.
- The smartphone GNSS data can potentially benefit tropospheric monitoring and weather forecasting, especially as embedded GNSS antennas and chips continue to improve in the future.

FOR MORE ...

Paper Software CAMALIOT