TECHNISCHE UNIVERSITÄT DRESDEN

Centimeter-accurate GNSS positioning with smartphones

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Requirements

Centimeter-accurate GNSS positioning requires carrier phase observations whose ambiguities could be fixed to their true integer values. This is mostly done in baseline mode, i.e. by using a virtual or real GNSS reference station close by.

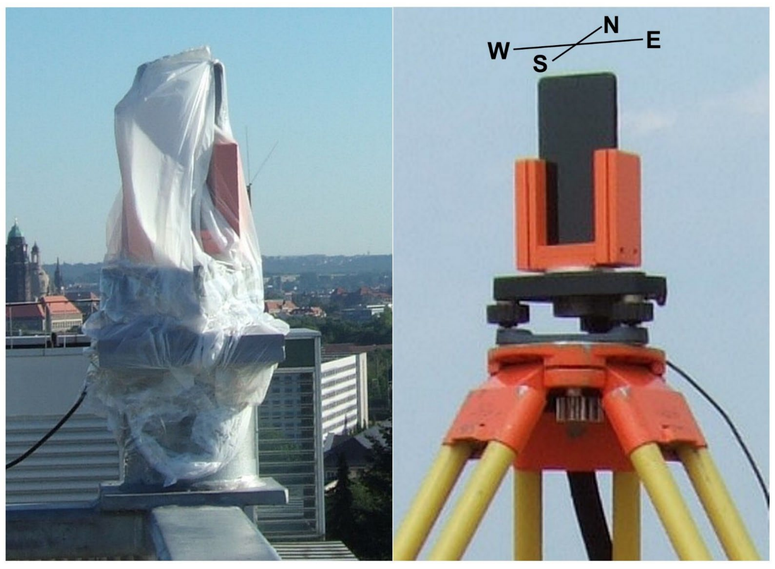
A few types of smartphones are capable of providing dual-frequency GNSS code and carrier phase observations. We tested three such phones:

- Huawei P30
- Xiaomi Mi8
- Samsung S20

and could demonstrate that centimeter-accurate positioning is feasible, at least under favorable conditions as e.g. little signal obstructions and low multipath.

Centimeter-accurate positioning also requires:

- set-up of the instrument in such a way that the eccentricities between GNSS antenna and point to be measured are accurately known, e.g. by a vertical set-up with pre-defined azimuthal orientation,
- pre-determination of the (frequency-dependent) antenna phase center by antenna calibration.

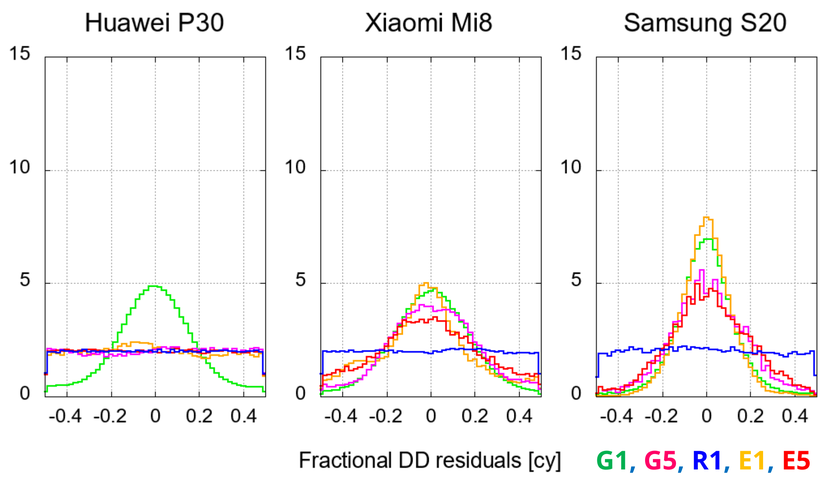


Integer ambiguities?

Providing dual-frequency carrier phase observations is not sufficient to enable centimeter-accurate positioning. The carrier phase observations need to be consistent in such a way that double-differenced (DD) carrier phase observations in baselines to reference stations have the property of integer numbers.

In order to test this characteristic, we used long-term static observations of known baselines and computed fractional double-difference carrier phase observations. Only if they show values close to zero cycles, integer ambiguity fixing may be achievable.

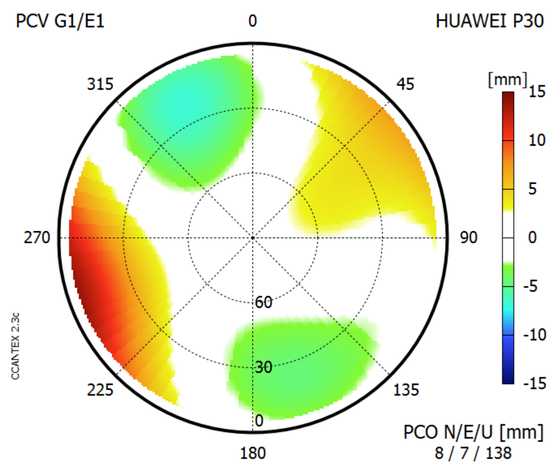
The results show that none of the 3 devices enable ambiguity fixing for GLONASS R1, Huawei P30 has the property of integer ambiguities on the 1st GPS frequency (G1) only, and Samsung S20 produces higher quality observations as compared to Xiaomi Mi8.



Antenna calibration

Antenna calibrations were performed in short baseline mode with a reference station close by which is using an absolutely calibrated antenna. The antenna to be calibrated, i.e. the smartphone, observed the GNSS signals in four azimuthal orientations. The height difference between reference antenna and the predefined antenna reference point of the smartphone was determined by levelling. As the results of the calibration, phase center offsets (PCO) and phase center variations (PCV) are obtained for each frequency.

Typically, the PCV do not exceed several mm and, thus, they can usually be ignored in the position computation. However, corrections for the PCO must be applied in order to achieve centimeter level coordinates.



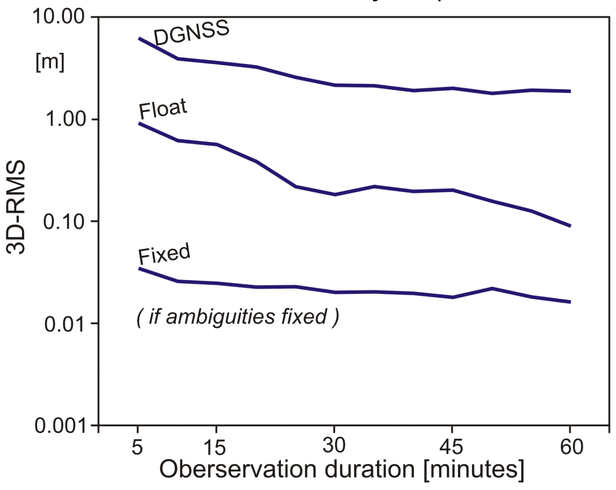
Results

Under favorable conditions the following accuracies (3D-RMS) can be achieved in differential baseline processing:

- several meters in code pseudorange processing (DGNSS),
- several decimeters with carrier phase observations but ambiguities unfixed (float solution),
- few centimeters with carrier phase observations if ambiguities could be fixed to their true integer values (fixed solution).

Performing static observations over a time span of 1 h improves these results to 1 - 2 m (DGNSS), 10 cm (float), 1 - 2 cm (fixed).

In comparison with results obtained by geodetic grade equipment, smartphone positioning results are roughly one order of magnitude less accurate. This difference is mainly attributed to the small and low-cost GNSS antennas used by the phones.



Figures:

Fig. 1: Vertical set-up of smartphone Huawei P30 with holder mounted on tribrach. Left: on roof-top with weather protection, right: in the field on a tripod, definition of the north orientation of the antenna.

Fig. 2: Distributions of fractional double-difference (DD) carrier phase residuals with a pronounced maximum at 0 cycles reveals the integer property of the carrier phase observations.

Fig. 3: Antenna calibration results consist of phase center offsets (PCO) and phase center variations (PCV).

Fig. 4: Achievable accuracy (3D-RMS) of static positioning over various durations of the observation sessions.

Publications:

[1] Wanninger, L., Heßelbarth, A. (2020): GNSS code and carrier phase observations of a Huawei P30 smartphone: quality assessment and centimeter-accurate positioning. GPS Solutions, 24:64. DOI: 10.1007/s10291-020-00978-z

[2] Heßelbarth, A., Wanninger, L. (2020): Towards centimeter accurate positioning with smartphones. European Navigation Conference (ENC). November 2020. IEEE Explore, DOI 10.23919/ENC48637.2020.9317392

[3] Heßelbarth, A., Wanninger, L. (2021): GNSS-Messungen mit Smartphones - Analyse der Beobachtung und cm-genaue Positionsbestimmung. Zeitschrift für Geodäsie, Geoinformation und Landmanagement, Heft 3/2021, 146:189-197. DOI: 10.12902/zfv-0355-2021