Consistency and impact of mixed receiver antenna phase centre models in regional GNSS networks

- EUREF Symposium 2019 -

Session :: Techniques: GNSS, Leveling, Combination

Institut für Erdmessung, Leibniz Universität Hannover

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Motivation - methodology for receiver antenna phase centre patterns

Multi-GNSS network processing and calibration values

- IfE ready for calibration of multi GNSS signals / frequencies (method `ROBOT`), systems and space segments (Galileo, Beidou, GPS L5) reach stable constellation

Combination and verification of calibration methods (`CHAMBER` – `ROBOT`)

- differences in calibration sets present [Aerts et al., 2013]
- uncertainties with dependency on processing scheme, calculated for PPP [Kersten et al., 2015] and [Kersten und Schön, 2016]

Questions

- Example of multi GNSS phase patterns from IfE?
- Is the *rule-of-thumb (<1 mm)* of different patterns justified for regional networks?
- Impact of mixed phase patterns on geodetic parameters in regional GNSS networks (mapping of error sources)?

Multi GNSS antenna pattern in field approach

Implementation and research at IfE

- receiver antenna calibration in the field with robot
- independent implementation for scientific purposes
- method: time differenced single differences on a short baseline

Estimation and validation of multi GNSS patterns

- first robot based multi GNSS pattern from IfE presented [Kröger et al., 2019a],
- available for research purposes in ANTEX format on LUH data repository [Kröger et al., 2019b]
- validation of patterns on a short baseline confirm implemented estimation [Breva et al., 2019]

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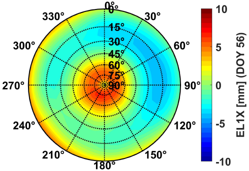
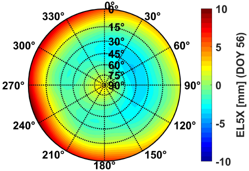
Field based multi GNSS receiver antenna patterns [Kröger et al., 2019a]

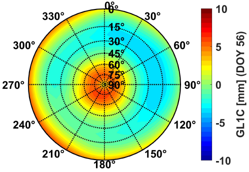
Leica AR25.R3 LEIT, RMS ≈0.5 mm



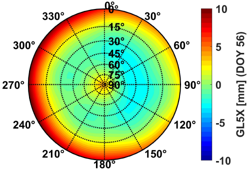
(a) GAL EL1X



(b) GAL EL5X

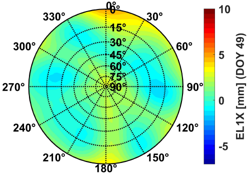


(c) GPS GL1C

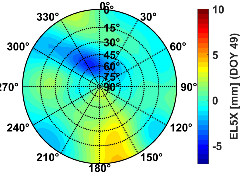


(d) GPS GL5X

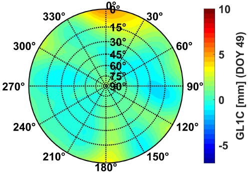
Novatel 703GGG.R2 NONE, RMS ≈0.5 mm



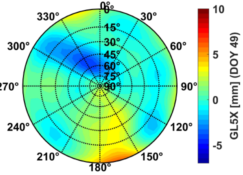
(e) GAL EL1X



(f) GAL EL5X



(g) GPS GL1C



(h) GPS GL5X

EPN station analysis - mixture of PCC

Availability of data

- multiple individual calibrations of **24** / **18** (**available** / **operational**) stations, available in the EPN[1]
- provided by Geo++ and Uni Bonn and published in `epn14.atx`

Research questions

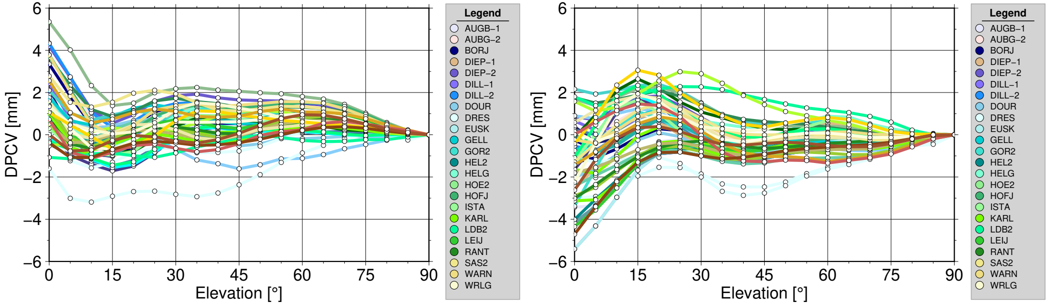
- verify a mixture (60% `ROBOT`, 40% `CHAMBER`) of antenna patterns on geodetic parameters
- verify the *rule-of-thumb (<1 mm)*

Methodology

- *observation domain:* differences of receiver antenna patterns
- *parameter domain:* analyse network solution of 17 EPN stations with consistent (1) robot-only, (2) chamber-only and (3) mixture (60%, 40%) – comparison to robot-only-solution

[1] ftp://epncb.eu/pub/station/general/indiv_calibrations/ [Bruyninx und Legrand, 2017]

Observation domain: receiver antenna patterns (chamber vs. robot)



(a) GPS/GLO L1 **(b)** GPS/GLO L2

Findings

- systematic differences exist between the calibration methods
- variations of approx. ±2 mm detected, higher deviations below 20° elevation angle

Parameter domain: impact on regional network

Research subject

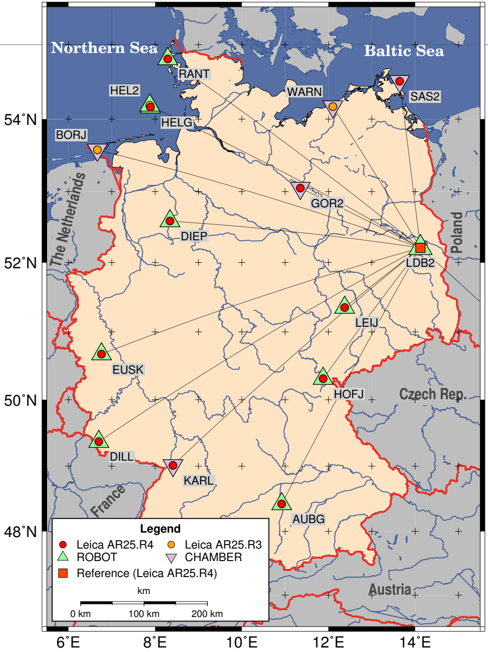
- BKG stations (15) in Germany and Turkey (1) with individual calibrations
- LDB2 (Lindenberg, Brandenburg) as reference (star-like network)
- medium baseline lengths: 200–600 km and one 1670 km

GNSS data processing

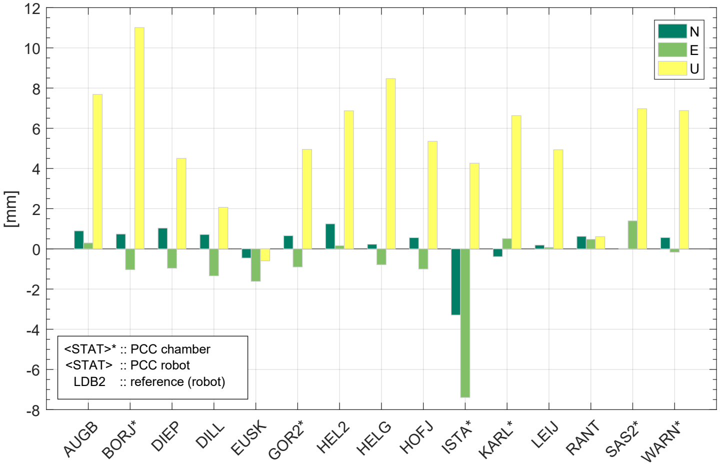
- Bernese 5.2 and CODE products
- troposphere: VMF, 1h resolution
- ambiguity strategies: QIF and Melbourne-Wübbena wide/narrow laning

Impact on parameter domain

- position, troposphere, ambiguities



Parameter domain: mixed antenna models (60% ROBOT, 40% CHAMBER)



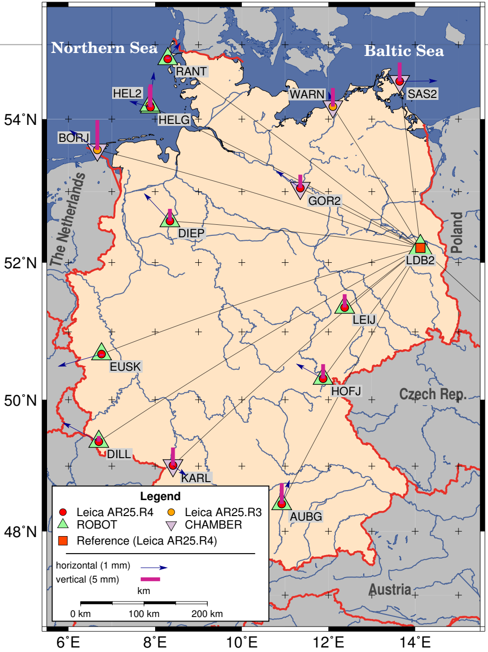
Mixed antenna models (60% ROBOT, 40% CHAMBER)

Position domain

- significant deviations on coordinates detected
- projection of uncertainties w.r.t. baseline length and orientation
- horizontal deviations <2 mm for most of studied cases
- vertical deviations between 5 mm and 11 mm

additional parameter dependencies

- tropospheric estimates differ by few millimetres
- magnitudes and number of ambiguities differ slightly



Summary and conclusion

Robot based field approach

- IfE provides independent multi GNSS and multi frequency calibrations (ROBOT)
- validation agrees with calculated single differences on the observation domain
- phase patterns provided on LUH data repository, doi: 10.25835/0075279

Observation domain - network solution

- calibration patterns in general agreement, however, deficiencies above 1 mm exist
- systematic deviations present, magnification for lower elevations (<20°) of up to 6 mm

Parameter domain - network solution

- consistent patterns in network (200–1670 km) lead to negligible deviations (<.5 mm)
- mixture of patterns (60% / 40%) show significant deviations of up to 11 mm in up component [BORJ] and 7.4 mm in horizontal component [ISTA] (depends on satellite constellation w.r.t. baseline)

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Positioning and Navigation Group

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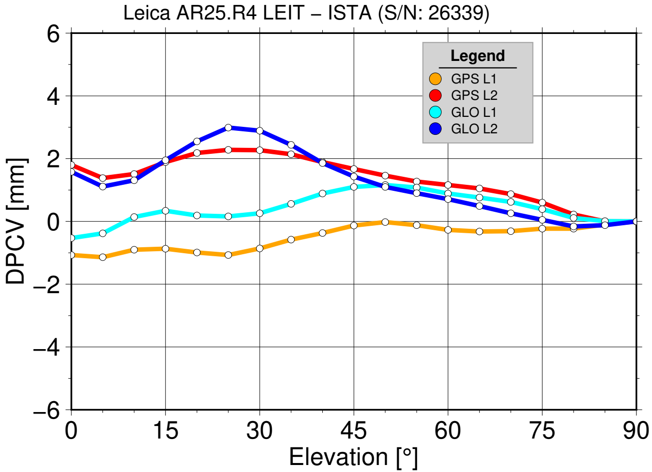
Observation domain: example ISTA (Istanbul, Turkey)



Observation domain: example ISTA (Istanbul, Turkey)