Institut für Erdmessung

Leibniz Universität Hannover

Phase Center Corrections for new GNSS-Signals

- EGU General Assembly 2019 -

Session G1.3: High-precision GNSS: methods, open problems and Geoscience applications

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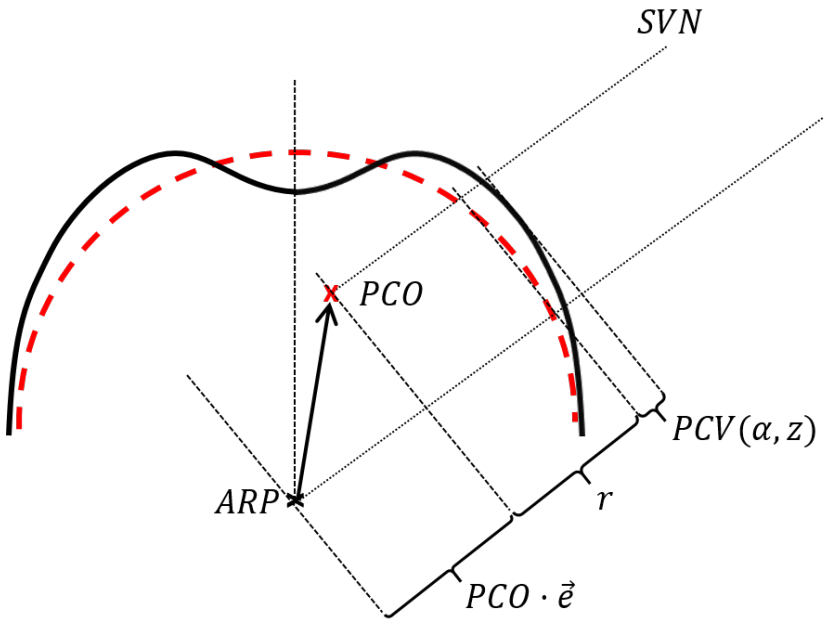
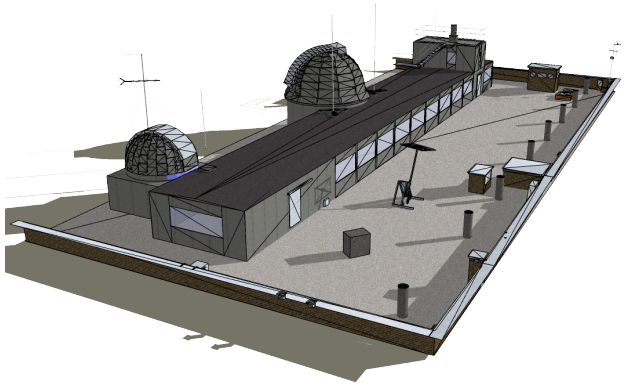
Motivation

- Phase center corrections (PCC) are mandatory for high accuracy GNSS applications
- PCC = - PCO $\cdot\vec{e}$ + PCV +r
- Provided by different institutions & methods
- Only L1- & L2 frequencies for GPS and GLONASS published by the IGS
- Partly chamber calibrations for Galileo and GPS L5 (EPN)



Calibration procedure - data acquisition

- Set-up: short baseline (≈ 8 m) and common clock (Stanford Rubidium FS725)
- Defined sequence of movements for the robot
- Tilting and rotating around fixed point in space
- Logging of raw GNSS data for each station and movements of robot with timestamps (orientation parameters)



Calibration Procedure - data analysis

- Finding corresponding observations on both stations where robot was not moving
- Building of time-differenced single differences (dSD)
- Most errors are cancelled out due to short baseline and short time period
- Modelling of the phase-wind up effect
- Modelling robot pose

Observations

Single differences contain only PCC of antenna under test and noise

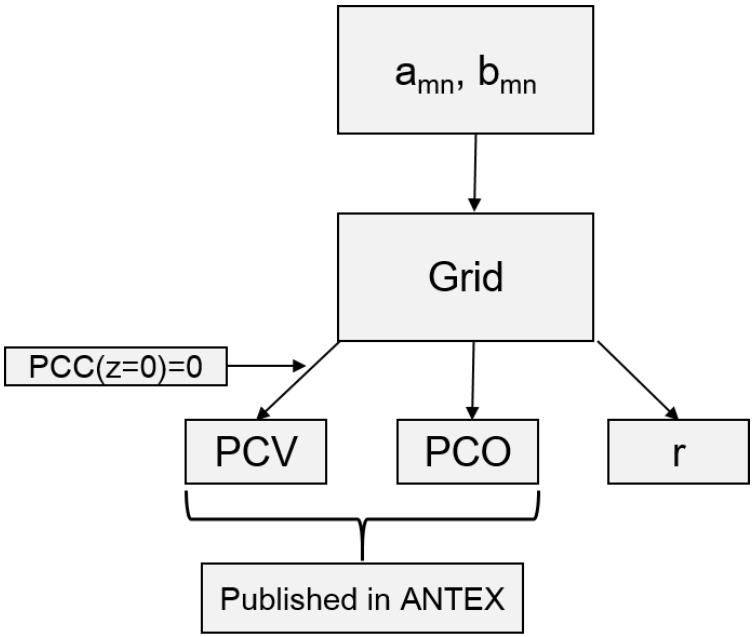
PCC estimation

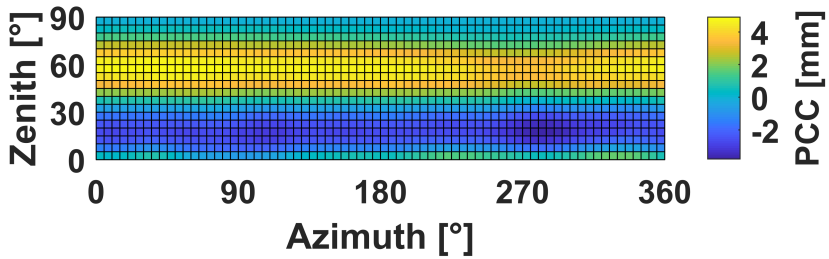
- Parametrisation of PCC by spherical harmonics (SH)
- Used degree m = 8 and order n = 8

$$\mathrm{PCC}(a^i, z^i) = \sum_{m=1}^{m_{max}} \sum_{n=0}^{m} \widetilde{P}_{mn}(cosz^i)(a_{mn}cos(n\alpha^i) + b_{mn}sin(n\alpha^i))$$

- Derivative with respect to the unknowns a_{mn} and b_{mn}
- Stacking of normal equation matrix over all visible satellites
- Odd parameters are constrained to zero (e.g. a_{21},b_{21},a_{30},...)

PCC estimation II





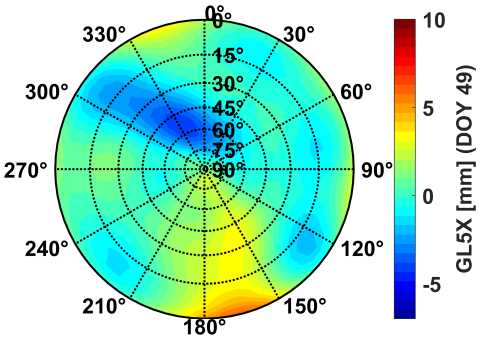
Calibration Results

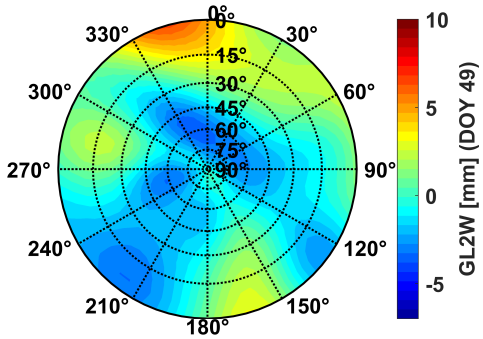
- Two geodetic antennas:
  - NOV703GGG.R2 (SN: 12420040)
  - LEIAR25.R3 LEIT (SN: 8360013)
- Each antenna calibrated four times:
  - NOV703: DOY 49, 50, 51 and 52
  - LEIAR25: DOY 56, 57, 59 and 60
- Calibrated frequencies:
  - GPS: C1C, L1C, L2W, L5X
  - Galileo: C1C, L1X, L5X

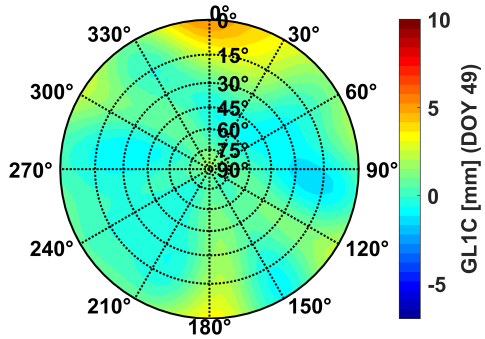
Comparison of calibrations

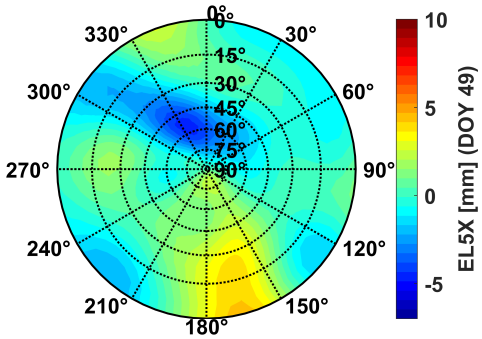
Calibrations have to be brought to common PCO and common datum

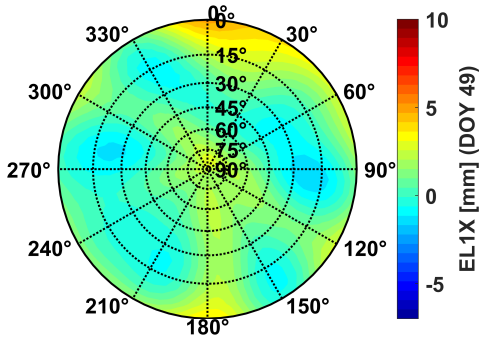
Estimated PCC: NOV703GGG - DOY 49 - PCO (0;0;59.27) [mm]



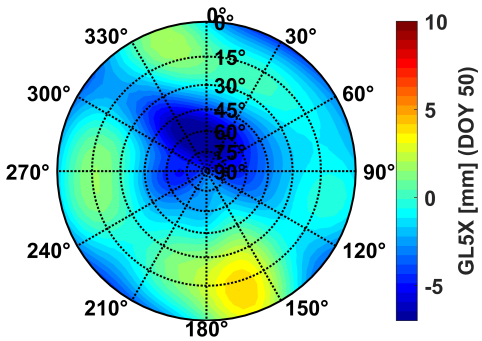


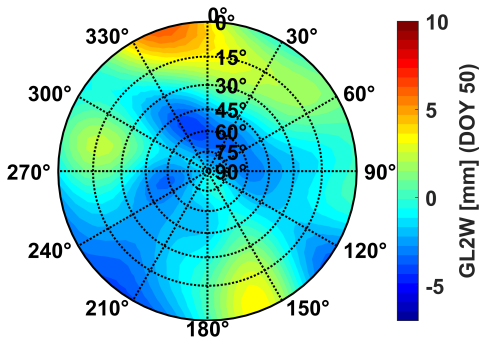


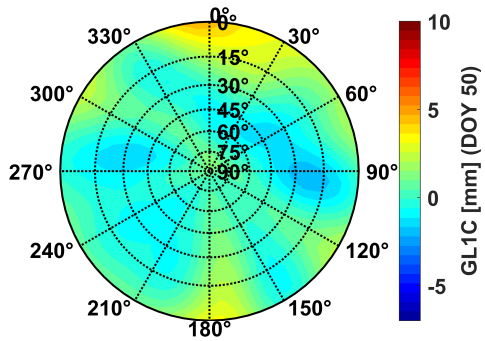


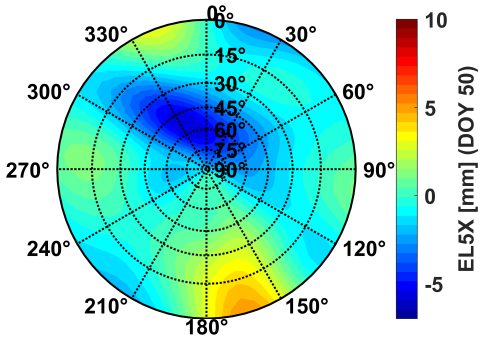


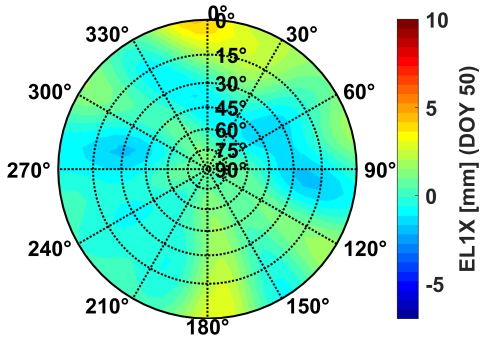
Estimated PCC: NOV703GGG - DOY 50 - PCO (0;0;59.27) [mm]



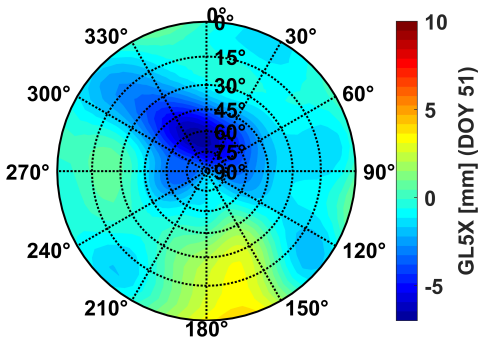


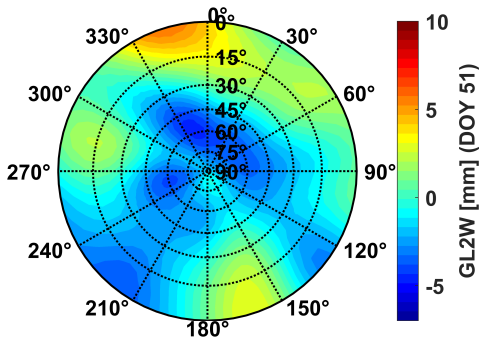


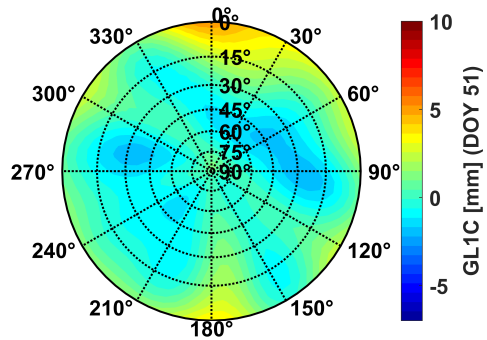


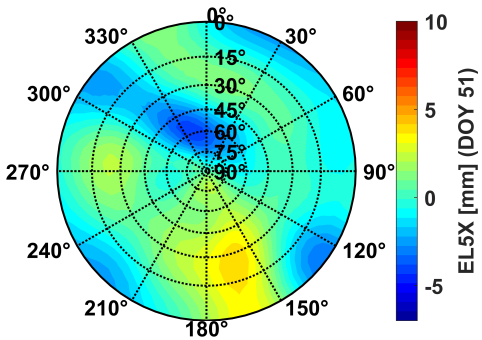


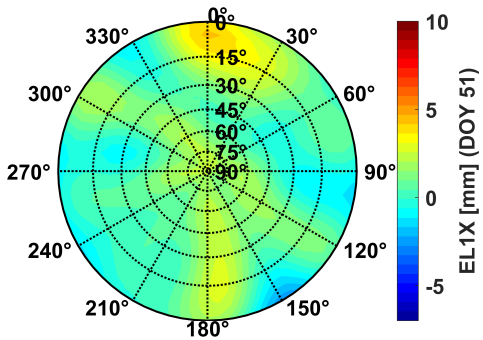
Estimated PCC: NOV703GGG - DOY 51 - PCO (0;0;59.27) [mm]



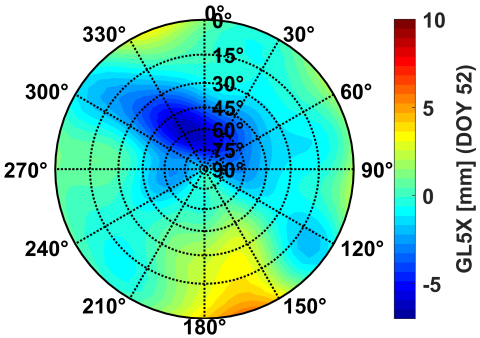


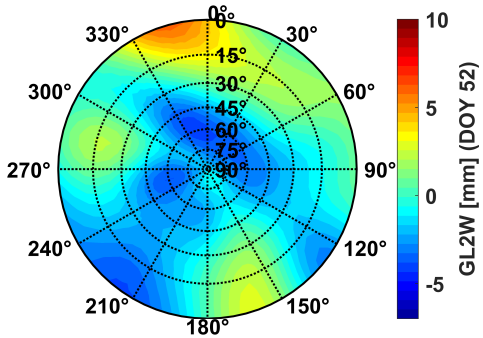


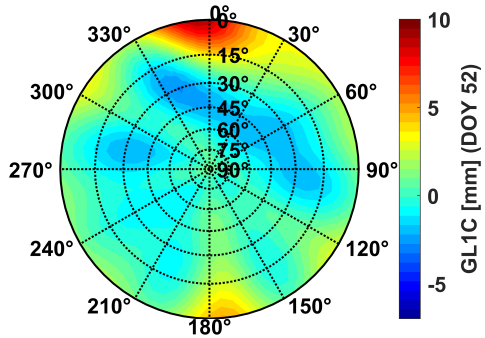


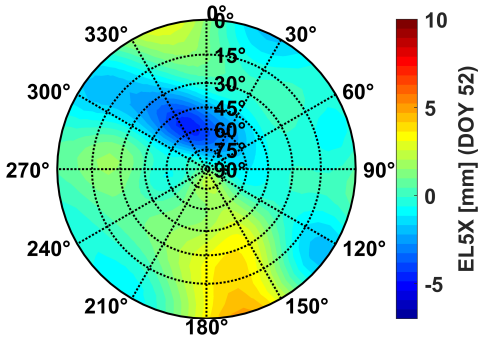


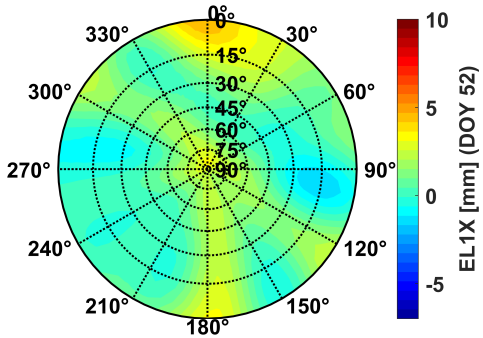
Estimated PCC: NOV703GGG - DOY 52 - PCO (0;0;59.27) [mm]



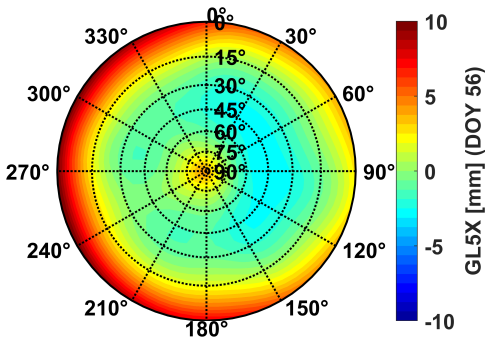


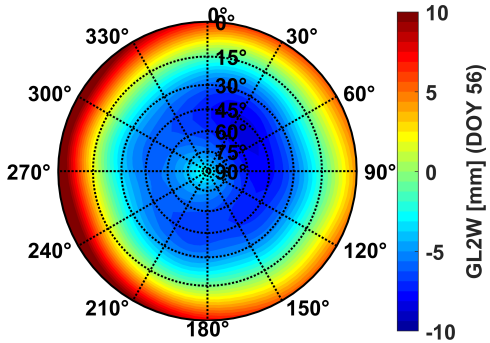


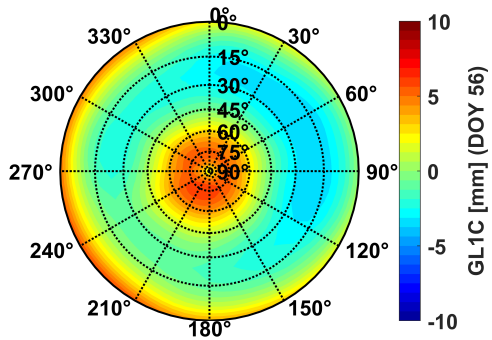


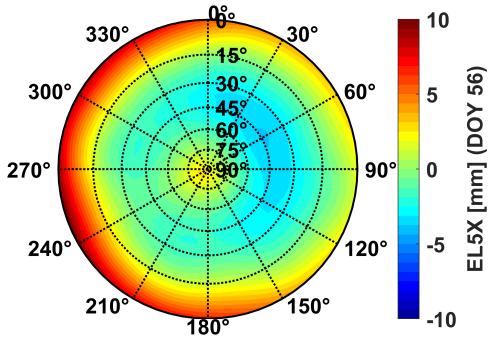


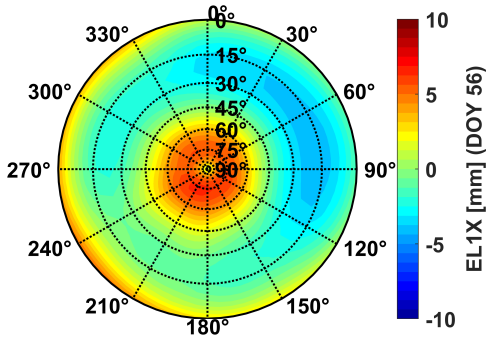
Estimated PCC: LEIAR25.R3 LEIT - DOY 56 - PCO (0;0;160.64) [mm]



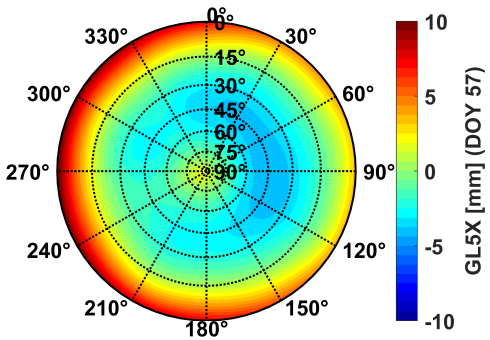


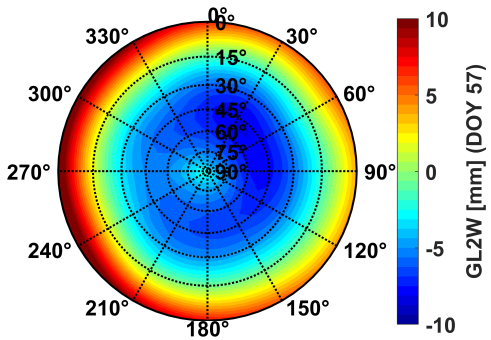


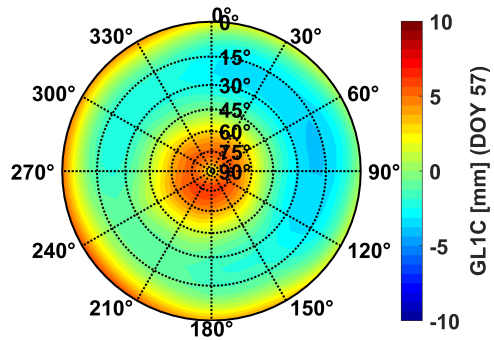


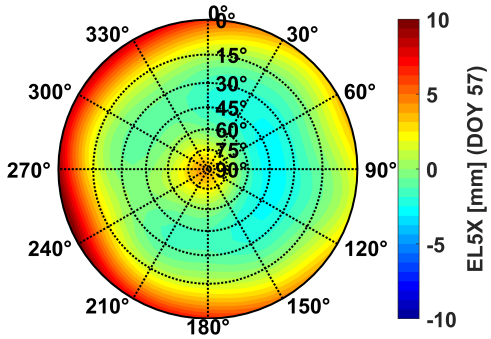


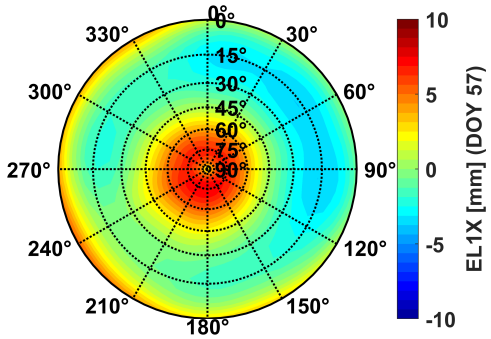
Estimated PCC: LEIAR25.R3 LEIT - DOY 57 - PCO (0;0;160.64) [mm]



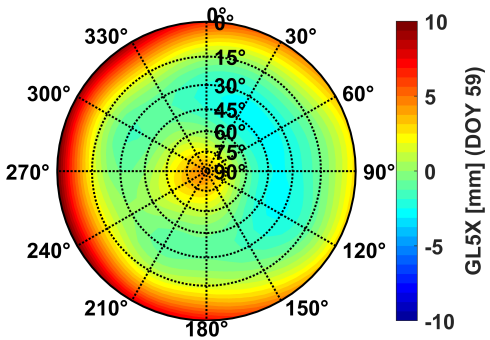


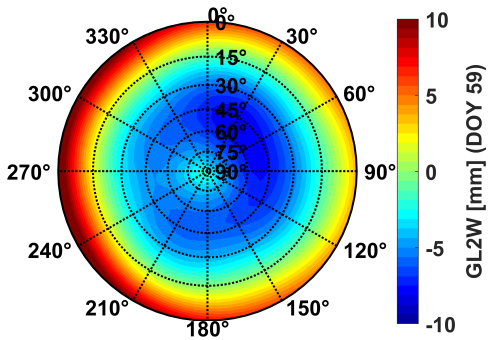


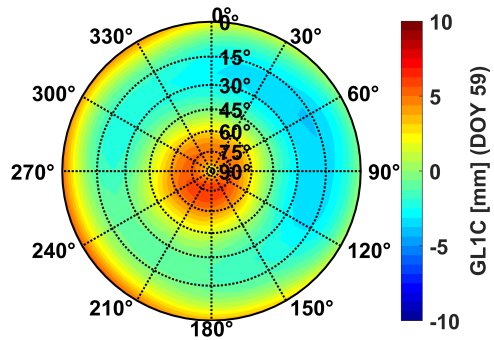


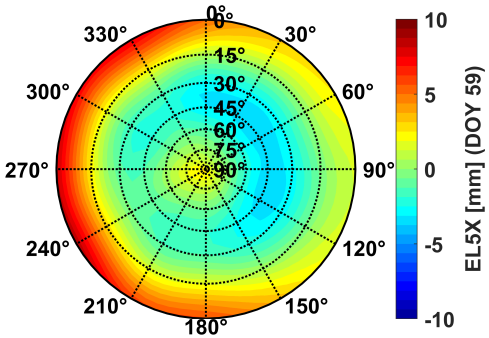


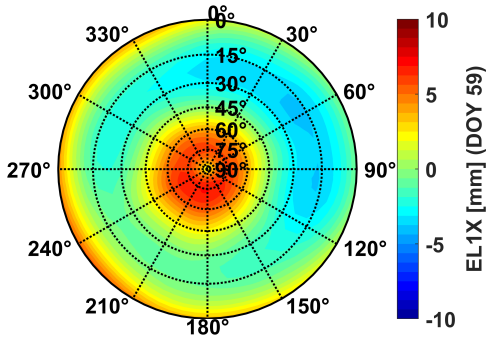
Estimated PCC: LEIAR25.R3 LEIT - DOY 59 - PCO (0;0;160.64) [mm]



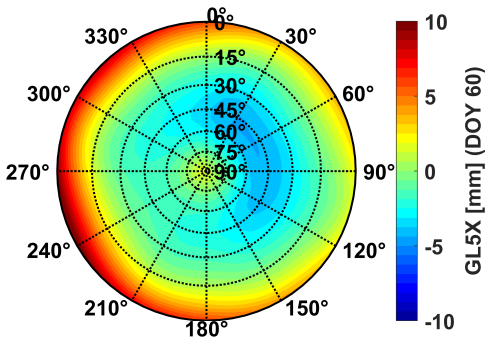


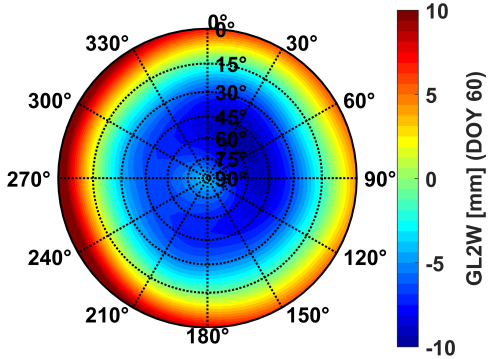


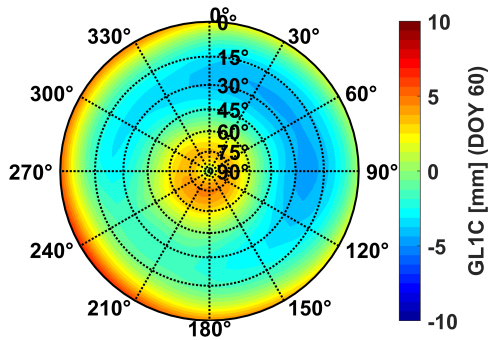


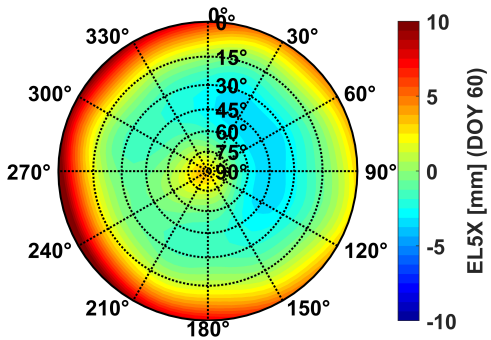


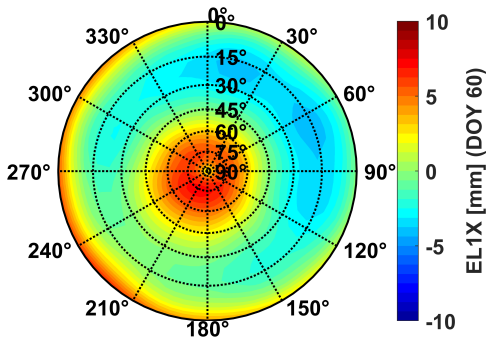
Estimated PCC: LEIAR25.R3 LEIT - DOY 60 - PCO (0;0;160.64) [mm]











Repeatability

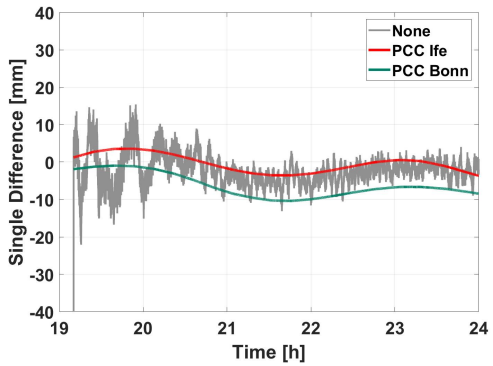
Antenna	Signal	∅ spread [mm]	∅ RMS [mm]
NOV703GGG.R2	GL1C	4.14	0.58
	GL2W	1.69	0.43
	GL5X	4.40	1.69
	EL1X	3.03	0.82
	EL5X	3.16	0.97
LEIAR25.R3 (LEIT)	GL1C	2.19	0.81
	GL2W	2.15	0.77
	GL5X	3.58	1.54
	EL1X	2.10	0.55
	EL5X	2.93	0.77

$$\text{spread} = \max(\text{PCC}_A - \text{PCC}_B) - \min(\text{PCC}_A - \text{PCC}_B)$$

$$\text{RMS} = \text{rms}(\text{PCC}_A - \text{PCC}_B)$$

Validation

- Experimental set-up: common-clock short baseline to calculate SD
- Multi-GNSS signals measurements from DOY39-DOY41
- Used antennas: NOV703GGG.R2 and LEIAR25.R3 LEIT
- Result for EL1X, PRN26:



Further results

Further validation results: Session G1.3 - High-precision GNSS: methods, open problems and Geoscience applications on poster EGU2019 #14143

Conclusion & Outlook

Conclusion

- IfE is ready for multi-GNSS multi-frequency calibrations
- Good repeatability: $\varnothing$ RMS $<$ 1 mm except for GL5X
- Validation shows a good agreement with the calculated SD

Outlook

- Calibration of further antennas
- Optimization of the calibration procedure
- Analyse of codephase variations (CPV)
- Extension to Beidou signals

Literature

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